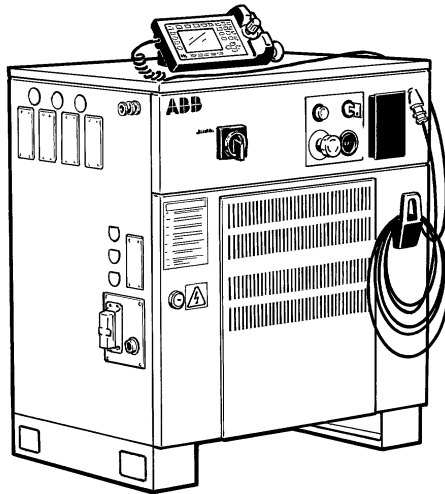# Product On-line Manual
IRB 1400

3HAC 2914-1
M98
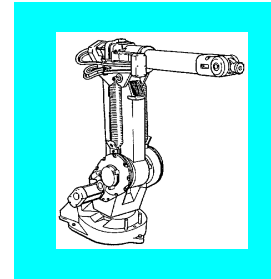
**Please Click the Picture
to continue**

ABB Flexible Automation

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MAIN MENU

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Product Specification RobotWare

Safety

CE-declaration

Configuration List

System Description

Installation and Commissioning

Maintenance

Troubleshooting Tools

Fault tracing guide

Circuit Diagram

Repairs

Spare parts

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Introduction

Introduction

1 How to use this Manual

This manual provides information on installation, preventive maintenance, trouble-shooting and how to carry out repairs on the manipulator and controller. Its intended audience is trained maintenance personnel with expertise in both mechanical and electrical systems. The manual does not in any way assume to take the place of the maintenance course offered by ABB Flexible Automation.

Anyone reading this manual should also have access to the User's Guide.

The chapter entitled System Description provides general information on the robot structure, such as its computer system, input and output signals, etc.

How to assemble the robot and install all signals, etc., is described in the chapter on Installation and Commissioning.

If an error should occur in the robot system, you can find out why it has happened in the chapter on Troubleshooting. If you receive an error message, you can also consult the chapter on System and Error Messages in the User's Guide. It is very helpful to have a copy of the circuit diagram at hand when trying to locate cabling faults.

Servicing and maintenance routines are described in the chapter on Maintenance.

2 What you must know before you use the Robot

- Normal maintenance and repair work usually only require standard tools. Some repairs, however, require specific tools. These repairs, and the type of tool required, are described in more detail in the chapter Repairs.

- The power supply must always be switched off whenever work is carried out in the controller cabinet. Note that even though the power is switched off, the orange-coloured cables may be live. The reason for this is that these cables are connected to external equipment and are consequently not affected by the mains switch on the controller.

- Circuit boards - printed boards and components - must never be handled without Electro-Static-Discharge (ESD) protection in order not to damage them. Use the carry band located on the inside of the controller door.

All personnel working with the robot system must be very familiar with the safety regulations outlined in the chapter on Safety. Incorrect operation can damage the robot or injure someone.

Introduction

3 Identification

Identification plates indicating the type of robot and serial number, etc., are located on the manipulator (see Figure 1) and on the front of the controller (see Figure 2).

The BaseWare O.S diskettes are also marked with serial number (see Figure 3).

Note! The identification plates and label shown in the figures below, only serves as examples. For exact identification see plates on your robot in question.

ABB Robotics Products AB
S-721 68 Västerås Sweden Made in Sweden

Type:	IRB 6400 M98
Robot version:	IRB 6400/2.4-150
Man. order:	XXXXXX
Nom. load	See instructions
Serial. No:	**6400-XXXX**
Date of manufacturing:	1997-XX-XX

Net weight
2,4.120 : 1870 kg	3.0-75 : 2010 kg
2,4-150 : 2010 kg	S/2,9-120 : 2240 kg
2,8-120 : 2010 kg	PE/2,25-75 : 1590 kg

Identification plate showing the IRB 6400

IRB 140(0)   **IRB 2400**   **IRB 4400**

IRB 640   **IRB 6400**   **IRB 840/A**
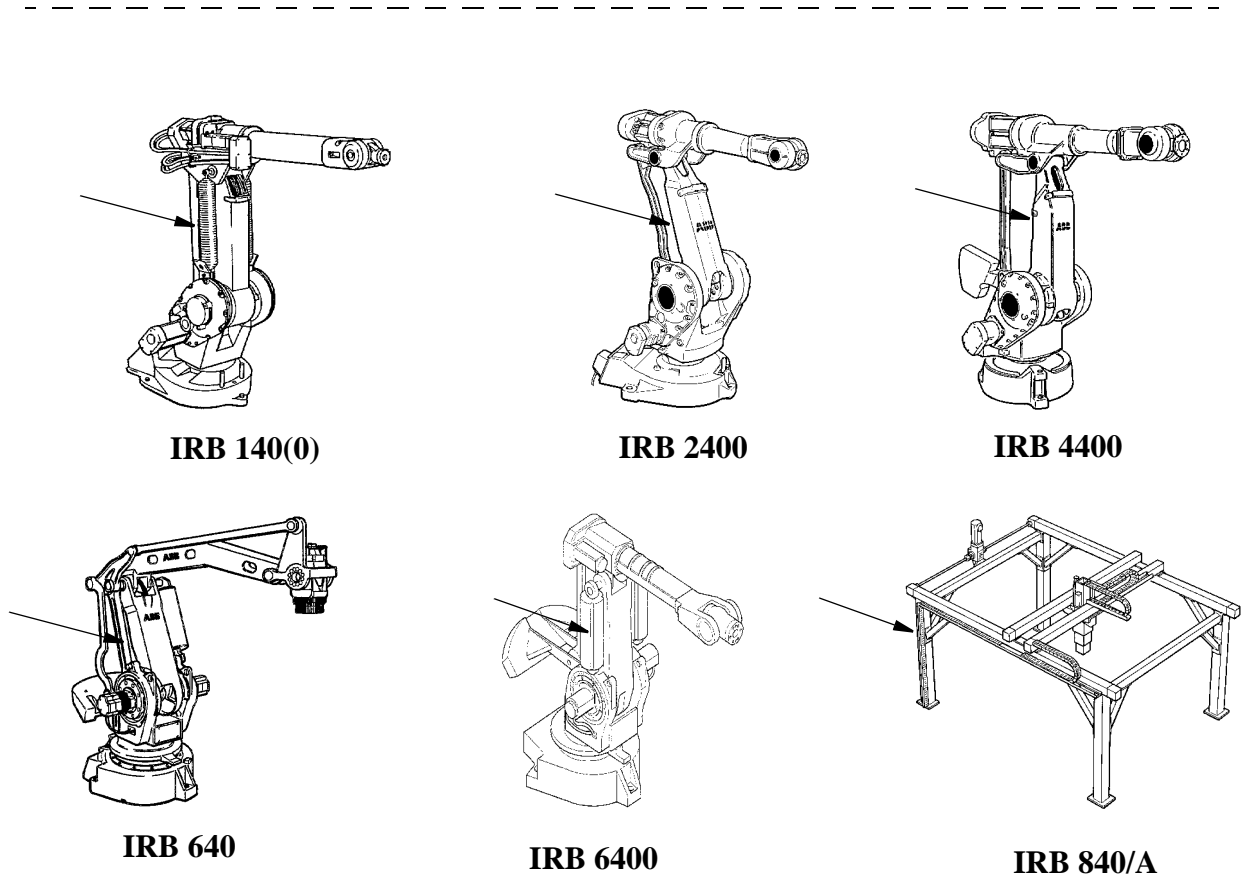
Figure 1 Example of identification plate and it's location on different manipulator types.

ABB Robotics Products AB	
S-721 68 Västerås Sweden Made in Sweden	
Type:	IRB 6400 M98
Robot version:	IRB 6400/2.4-150
Voltage: 3 x 400 V	Frequency: 50-60 Hz
Power:	7.2 kVA
Man. order:	XXXXXX
Re.No:	RXXXXXXXXXX
Serial. No:	**64-XXXXX**
Date of manufacturing:	1998-XX-XX
Net weight:	240 kg
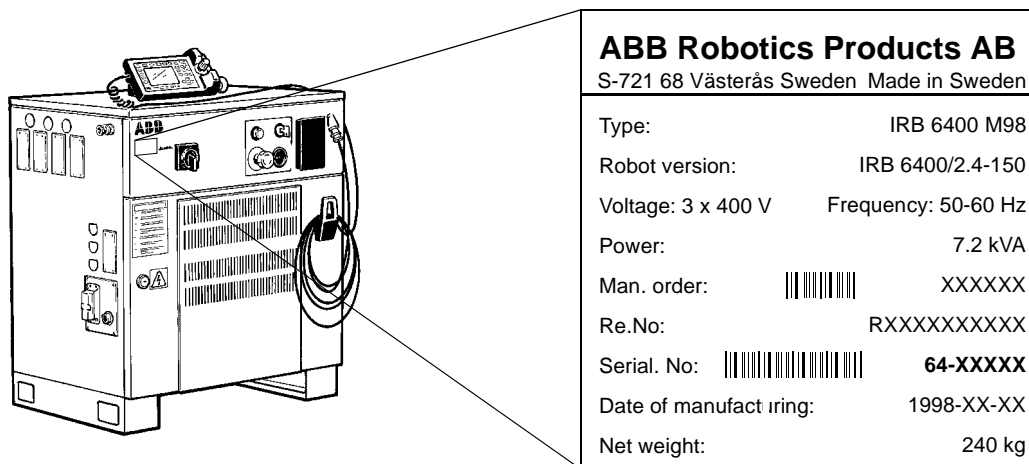
Figure 2 Identification plate on the controller.


```
64-00000
System Key S4C 3.1
Program No 3 HAB2390-1/03
Boot disk 1 (1)
```

Property of ABB Västerås/Sweden. All rights reserved. Reproduction, modification, use or disclosure to third parties without express authority is strictly forbidden. Copyright 1993. Restricted to be used in the controller(s) with the serial no as marked on disk.

ABB Robotics Products AB
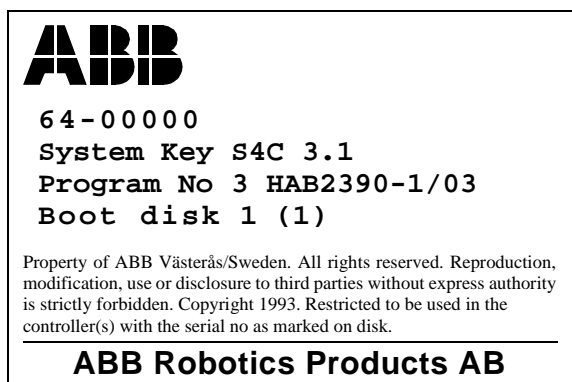
Figure 3 Example of a label on a BaseWare O.S diskette.

Introduction

CONTENTS

1 Introduction

Thank you for your interest in the IRB 1400. This manual will give you an overview of the characteristics and performance of the robot.

IRB 1400 is a 6-axis industrial robot, designed specifically for manufacturing industries that use flexible robot-based automation. The robot has an open structure that is specially adapted for flexible use, and can communicate extensively with external systems.

The robot is equipped with an operating system called BaseWare OS. BaseWare OS controls every aspect of the robot, like motion control, development and execution of application programs communication etc.

The functions in this document are all included in BaseWare OS, if not otherwise specified. For additional functionality, the robot can be equipped with optional software for application support - for example gluing and arc welding, communication features - network communication - and advanced functions such as multitasking, sensor control etc. For a complete description on optional software, see the Product Specification RobotWare.

All the features are not described in this document. For a more complete and detailed description, please see the User's Guide, RAPID Reference Manual and Product Manual, or contact your nearest ABB Flexible Automation Centre.

Different robot versions

The IRB 1400, as mentioned above, is available in two different versions:

- IRB 1400, for floor mounting
- IRB 1400H, for inverted mounting.

How to use this manual

The characteristics of the robot are described in Chapter 2: *Description*.

The most important technical data is listed in Chapter 3: *Technical specification*.

Note that the sections in chapter 2 and 3 are related to each other. For example, in section 2.2 you can find an overview of safety and standards, in section 3.2 you can find more detailed information.

To make sure that you have ordered a robot with the correct functionality, see Chapter 4: *Specification of Variants and Options*.

In Chapter 5 you will find accessories for the robot.

Chapter 6 contains an *Index*, to make things easier to find.

Introduction

Other manuals

The User's Guide is a reference manual with step by step instructions on how to perform various tasks.

The programming language is described in the RAPID Reference Manual.

The Product Manual describes how to install the robot, as well as maintenance procedures and troubleshooting.

The Product Specification RobotWare describes the software options.

2 Description

2.1 Structure

The robot is made up of two main parts: a manipulator and a controller.
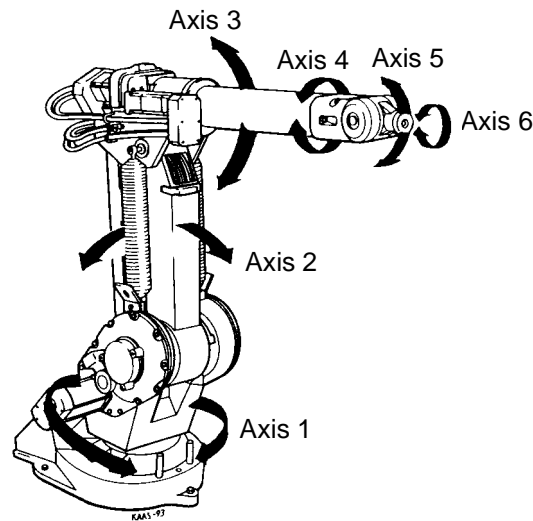

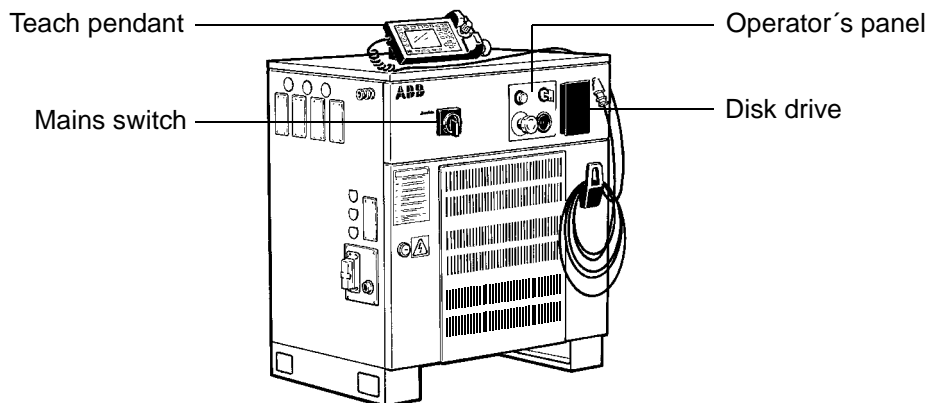*Figure 1 The IRB 1400 manipulator has 6 axes.*

Figure 2 The controller is specifically designed to control robots, which means that optimal performance and functionality is achieved.

The controller contains the electronics required to control the manipulator, external axes and peripheral equipment.

2.2 Safety/Standards

The robot complies fully with the health and safety standards specified in the EEC's Machinery Directives as well as ANSI/RIA 15.06-1992.

The robot is designed with absolute safety in mind. It has a dedicated safety system based on a two-channel circuit which is monitored continuously. If any component fails, the electrical power supplied to the motors shuts off and the brakes engage.

Safety category 3
Malfunction of a single component, such as a sticking relay, will be detected at the next MOTOR OFF/MOTOR ON operation. MOTOR ON is then prevented and the faulty section is indicated. This complies with category 3 of EN 954-1, Safety of machinery - safety related parts of control systems - Part 1.

Selecting the operating mode
The robot can be operated either manually or automatically. In manual mode, the robot can only be operated via the teach pendant, i.e. not by any external equipment.

Reduced speed
In manual mode, the speed is limited to a maximum of 250 mm/s (600 inches/min.). A speed limitation applies not only to the TCP (Tool Centre Point), but to all parts of the robot. It is also possible to monitor the speed of equipment mounted on the robot.

Three position enabling device
The enabling device on the teach pendant must be used to move the robot when in manual mode. The enabling device consists of a switch with three positions, meaning that all robot movements stop when either the enabling device is pushed fully in, or when it is released completely. This makes the robot safer to operate.

Safe manual movement
The robot is moved using a joystick instead of the operator having to look at the teach pendant to find the right key.

Over-speed protection
The speed of the robot is monitored by two independent computers.

Emergency stop
There is one emergency stop push button on the controller and another on the teach pendant. Additional emergency stop buttons can be connected to the robot's safety chain circuit.

Safeguarded space stop
The robot has a number of electrical inputs which can be used to connect external safety equipment, such as safety gates and light curtains. This allows the robot's safety functions to be activated both by peripheral equipment and by the robot itself.

Delayed safeguarded space stop
A delayed stop gives a smooth stop. The robot stops in the same way as at normal program stop with no deviation from the programmed path. After approx. one second the power supplied to the motors shuts off.

Restricting the working space
The movement of each of the axes can be restricted using software limits. Axes 1 and 2 can also be restricted by means of an adjustable mechanical stop. Axis 3 can be restricted using an electrical limit switch.

Hold-to-run control
"Hold-to-run" means that you must depress the start button in order to move the robot. When the key is released the robot will stop. The hold-to-run function makes program testing safer.

Fire safety
Both the manipulator and control system comply with UL's (Underwriters Laboratory) tough requirements for fire safety.

Safety lamp
As an option, the robot can be equipped with a safety lamp mounted on the manipulator. This is activated when the motors are in the MOTORS ON state.

2.3 Operation

All operations and programming can be carried out using the portable teach pendant (see Figure 3) and the operator's panel (see Figure 5).
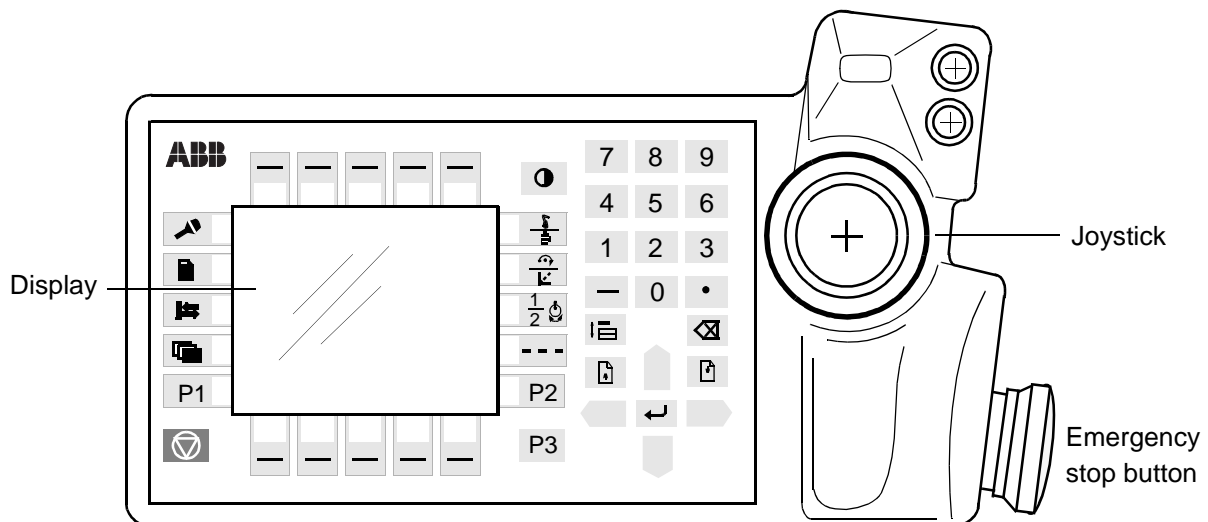
Figure 3 The teach pendant is equipped with a large display, which displays prompts, information, error messages and other information in plain English.

Information is presented on a display using windows, pull-down menus, dialogs and function keys. No previous programming or computer experience is required to learn how to operate the robot. All operation can be carried out from the teach pendant, which means that a specific keyboard is not required. All information, including the complete programming language, is written in English or, if preferred, some other major language.

Description
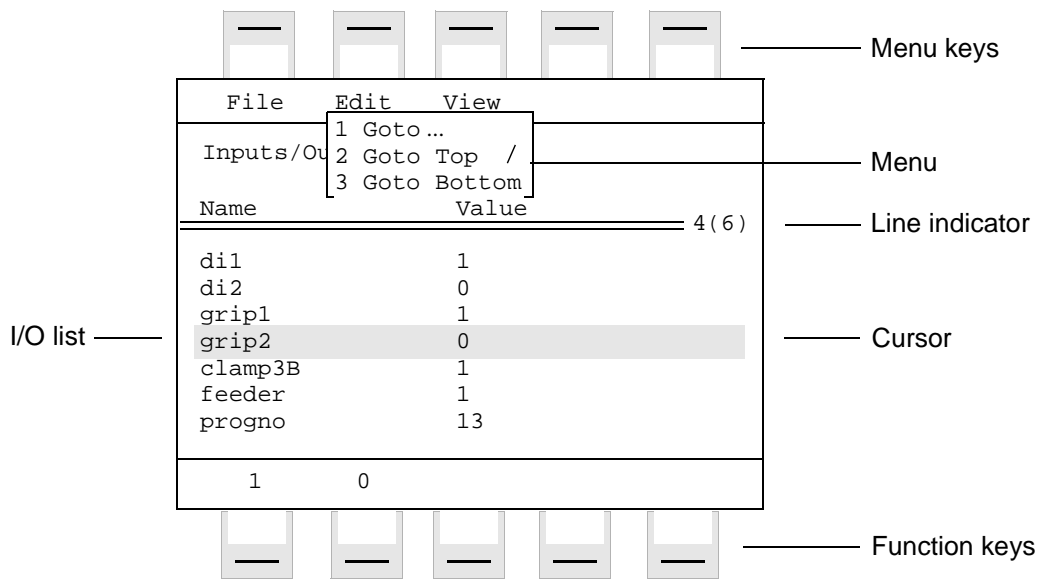
Figure 4 Window for manual operation of input and output signals.

Using the joystick, the robot can be manually jogged (moved). The user determines the speed of this movement; large deflections of the joystick will move the robot quickly, smaller deflections will move it more slowly.

The robot supports different user levels, with dedicated windows for:

- Production

- Programming

- System setup

- Service and installation

Operator's panel
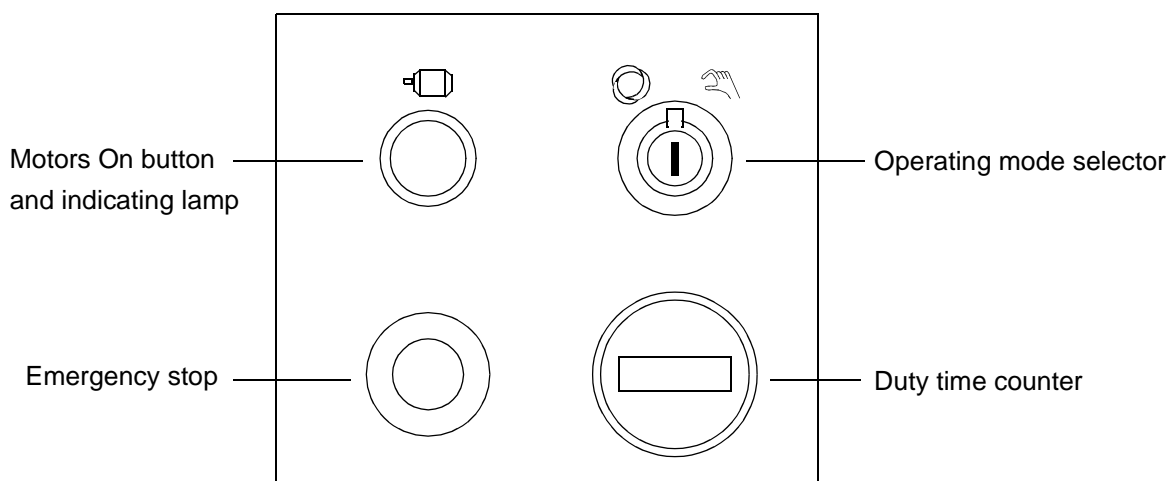
Figure 5 The operating mode is selected using the operator's panel on the controller.

Using a key switch, the robot can be locked in two or three different operating modes depending on chosen mode selector:

- • Automatic mode: Running production

- • Manual mode at reduced speed: Programming and setup
                                                Max. speed: 250 mm/s (600 inches/min.)

100% • Manual mode at full speed (option):   Testing at full program speed
       Equipped with this mode, the robot is
   not approved according to ANSI/UL

Both the operator's panel and the teach pendant can be mounted externally, i.e. outside the cabinet. The robot can then be controlled from there.

The robot can be remotely controlled from a computer, PLC or from a customer's panel, using serial communication or digital system signals.

For more information on how to operate the robot, see the User's Guide.

2.4 Installation

The robot has a standard configuration and can be operated immediately after installation. Its configuration is displayed in plain language and can easily be changed using the teach pendant. The configuration can be stored on a diskette and/or transferred to other robots that have the same characteristics.

There are two versions of IRB 1400, one for floor mounting and one for inverted mounting. An end effector, weighing a maximum of 5 kg, including payload, can be mounted on the robot's mounting flange (axis 6). Other equipment, weighing a maximum of 10 kg, can be mounted on the rear of the upper arm.

2.5 Programming

Programming the robot involves choosing instructions and arguments from lists of appropriate alternatives. Users do not need to remember the format of instructions, since they are prompted in plain English. "See and pick" is used instead of "remember and type".

The programming environment can be easily customised using the teach pendant.

- Shop floor language can be used to name programs, signals, counters, etc.

- New instructions can be easily written.

- The most common instructions can be collected in easy-to-use pick lists.

- Positions, registers, tool data, or other data, can be created.

Programs, parts of programs and any modifications can be tested immediately without having to translate the program.

The program is stored as a normal PC text file, which means that it can be edited using a standard PC.

Description

Movements

A sequence of movements is programmed as a number of partial movements between the positions to which you want the robot to move.

The end position of a movement is selected either by manually jogging the robot to the desired position with the joystick, or by referring to a previously defined position.

The exact position can be defined (see Figure 6) as:

- a stop point, i.e. the robot reaches the programmed position

or

- a fly-by point, i.e. the robot passes close to the programmed position. The size of the deviation is defined independently for the TCP, the tool orientation and the external axes.

Stop point   **Fly-by point**

User-definable distance (in mm)
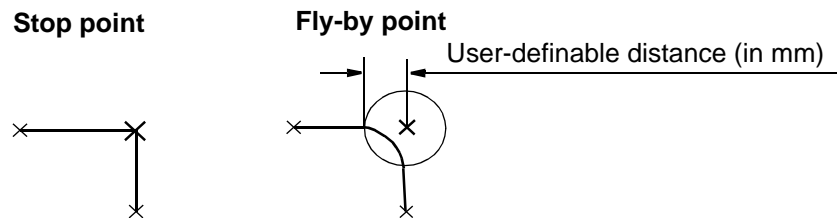
Figure 6 The fly-by point reduces the cycle time since the robot does not have to stop at the programmed point.The path is speed independent.

The velocity may be specified in the following units:

- mm/s

- seconds (time it takes to reach the next programmed position)
- degrees/s (for reorientation of the tool or for a rotation of an external axis)

Program management

For convenience, the programs can be named and stored in different directories.

Areas of the robot's program memory can also be used for program storage. This gives a very fast memory where you can store programs. These can then be automatically downloaded using an instruction in the program. The complete program or parts of programs can be transferred to/from a diskette.

Programs can be printed on a printer connected to the robot, or transferred to a PC where they can be edited or printed.

Product Specification IRB 1400 M98/BaseWare OS 3.1

Editing programs

Programs can be edited using standard editing commands, i.e. "cut-and-paste", copy, delete, find and change, undo etc. Individual arguments in an instruction can also be edited using these commands.

No reprogramming is necessary when processing left-hand and right-hand parts, since the program can be mirrored in any plane.

A robot position can easily be changed either by:

- jogging the robot with the joystick to a new position and then pressing the "ModPos" key (this registers the new position)

or by

- entering or modifying numeric values.

To prevent unauthorised personnel making program changes, passwords can be used.

Testing programs

Several helpful functions can be used when testing programs. For example, it is possible to:

- start from any instruction
- execute an incomplete program
- run one cycle
- execute forward/backward step-by-step
- simulate wait conditions
- temporarily reduce the speed
- change a position
- tune (displace) a position during program execution.

For more information, see the User´s Guide and RAPID Reference Manual.

2.6 Automatic Operation

A dedicated production window with commands and information required by the operator is automatically displayed during automatic operation.

The operation procedure can be customised to suit the robot installation by means of user-defined operating dialogs.

```
Select program to run:




Front A Front B Front C  Other   SERVICE
```
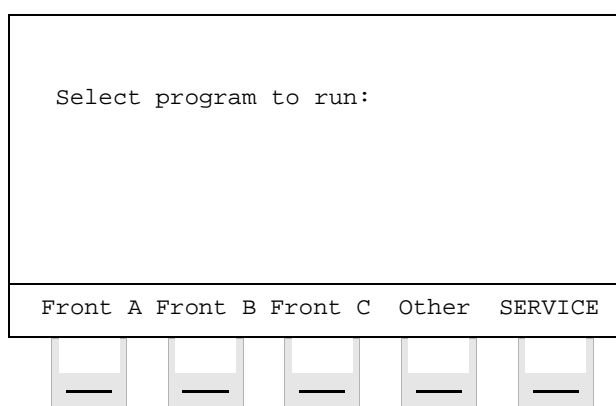
Figure 7 The operator dialogs can be easily customised.

A special input can be set to order the robot to go to a service position. After service, the robot is ordered to return to the programmed path and continue program execution.

You can also create special routines that will be automatically executed when the power is switched on, at program start and on other occasions. This allows you to customise each installation and to make sure that the robot is started up in a controlled way.

The robot is equipped with absolute measurement, making it possible to operate the robot directly from when the power is switched on. For your convenience, the robot saves the used path, program data and configuration parameters so that the program can easily be restarted from where you left off. Digital outputs are also set automatically to the value before the power failure.

2.7 Maintenance and Troubleshooting

The robot requires only a minimum of maintenance during operation. It has been designed to make it as easy to service as possible:

- The controller is enclosed, which means that the electronic circuitry is protected when operating in a normal workshop environment.

- Maintenance-free AC motors are used.

- Oil is used for the main gear boxes.

- The cabling is routed for longevity, and in the unlikely event of a failure, its modular design makes it easy to change.

- It has a program memory "battery low" alarm.

The robot has several functions to provide efficient diagnostics and error reports:

- It performs a self test when power on is set.

- Errors are indicated by a message displayed in plain language.
  The message includes the reason for the fault and suggests recovery action.

- A board error is indicated by an LED on the faulty unit.

- Faults and major events are logged and time-stamped. This makes it possible to detect error chains and provides the background for any downtime. The log can be read on the display of the teach pendant, stored in a file and also printed on a printer.

- There are commands and service programs in RAPID to test units and functions.

Most errors detected by the user program can also be reported to and handled by the standard error system. Error messages and recovery procedures are displayed in plain language.

Description

2.8 Robot Motion
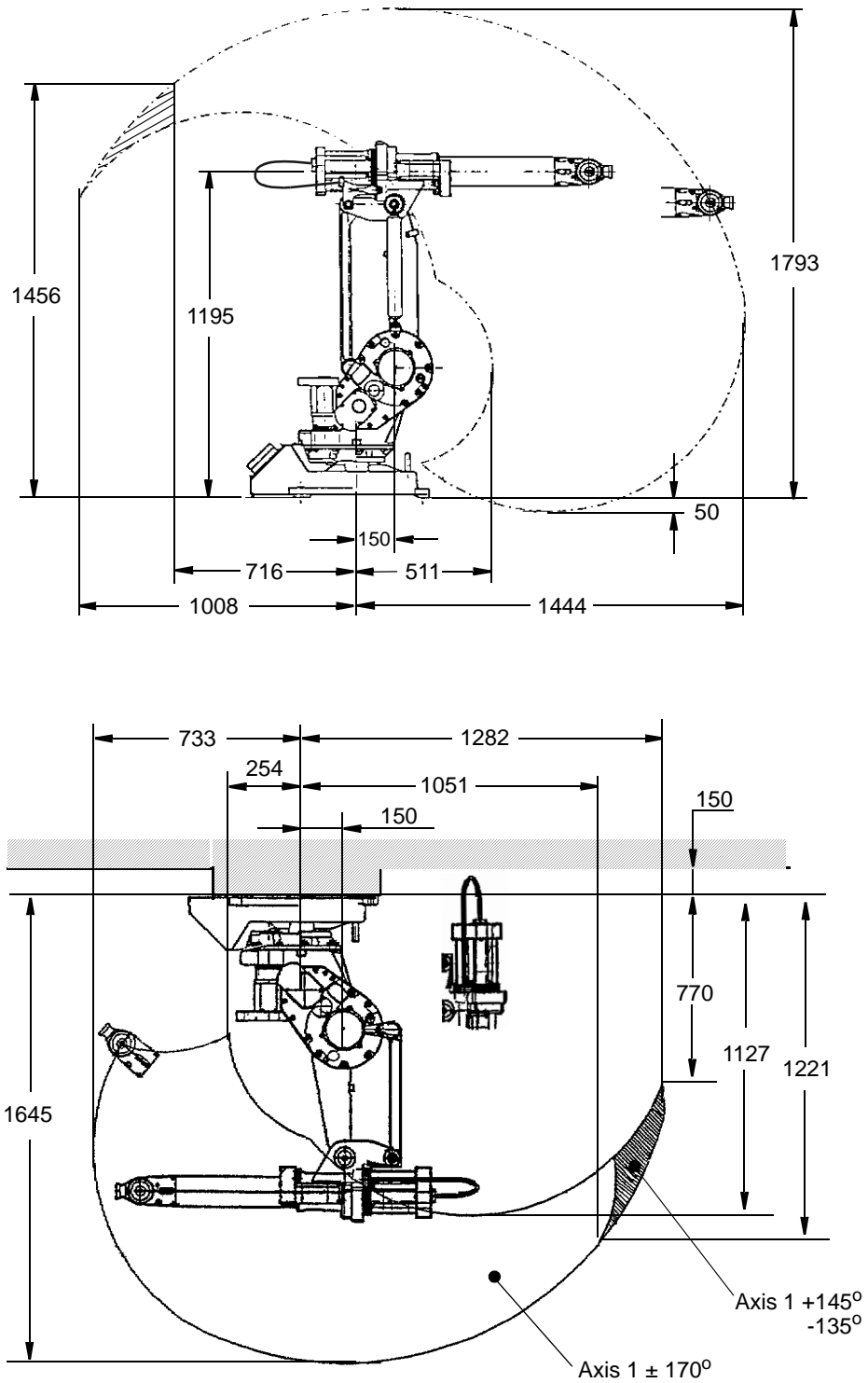
Figure 8 Working space of IRB 1400 (dimensions in mm).

Motion performance

The QuickMove^{TM} concept means that a self-optimizing motion control is used. The robot automatically optimizes the servo parameters to achieve the best possible performance throughout the cycle – based on load properties, location in working area, velocity and direction of movement.

- No parameters have to be adjusted to achieve correct path, orientation and velocity.

- Maximum acceleration is always obtained (acceleration can be reduced, e.g. when handling fragile parts).

- The number of adjustments that have to be made to achieve the shortest possible cycle time are minimized.

The TrueMove^{TM} concept means that the programmed path is followed – regardless of the speed or operating mode – even after an emergency stop, a safeguarded stop, a process stop, a program stop or a power failure.

The robot can, in a controlled way, pass through singular points, i.e. points where two axes coincide.

Coordinate systems
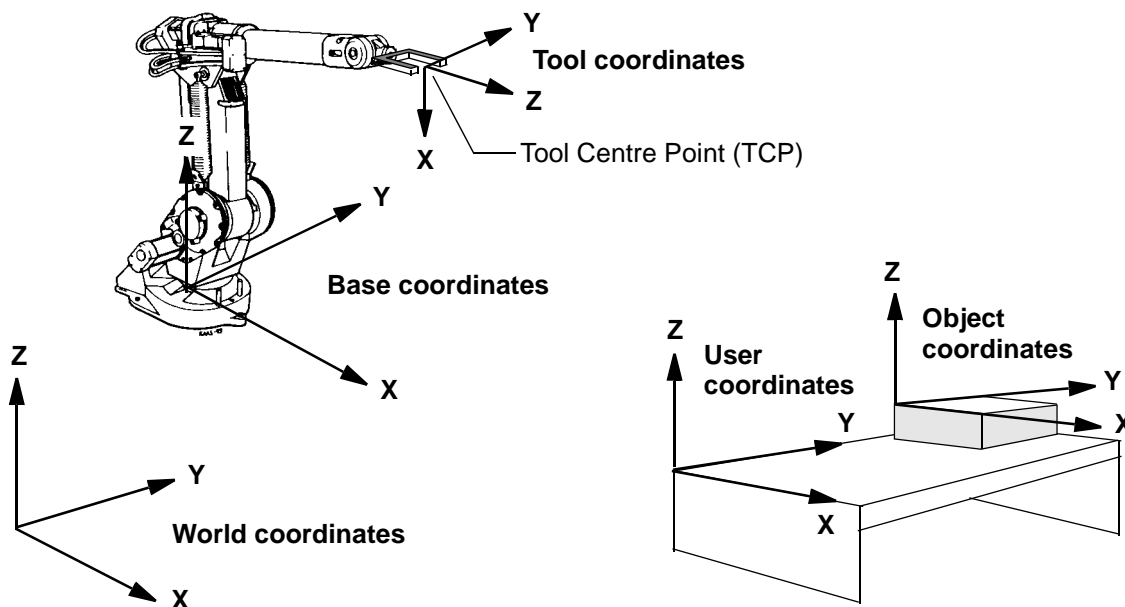
Figure 9 The coordinate systems, used to make jogging and off-line programming easier.

The world coordinate system defines a reference to the floor, which is the starting point for the other coordinate systems. Using this coordinate system, it is possible to relate the robot position to a fixed point in the workshop. The world coordinate system is also very useful when two robots work together or when using a robot carrier.

The base coordinate system is attached to the base mounting surface of the robot.

The tool coordinate system specifies the tool's centre point and orientation.

Description

The user coordinate system specifies the position of a fixture or workpiece manipulator.

The object coordinate system specifies how a workpiece is positioned in a fixture or workpiece manipulator.

The coordinate systems can be programmed by specifying numeric values or jogging the robot through a number of positions (the tool does not have to be removed).

Each position is specified in object coordinates with respect to the tool's position and orientation. This means that even if a tool is changed because it is damaged, the old program can still be used, unchanged, by making a new definition of the tool.
If a fixture or workpiece is moved, only the user or object coordinate system has to be redefined.

Stationary TCP

When the robot is holding a work object and working on a stationary tool, it is possible to define a TCP for that tool. When that tool is active, the programmed path and speed are related to the work object.

Program execution

The robot can move in any of the following ways:

- Joint motion (all axes move individually and reach the programmed position at the same time)
- Linear motion (the TCP moves in a linear path)
- Circle motion (the TCP moves in a circular path)

Soft servo - allowing external forces to cause deviation from programmed position - can be used as an alternative to mechanical compliance in grippers, where imperfection in processed objects can occur.

If the location of a workpiece varies from time to time, the robot can find its position by means of a digital sensor. The robot program can then be modified in order to adjust the motion to the location of the part.

Jogging

The robot can be manually operated in any one of the following ways:

- Axis-by-axis, i.e. one axis at a time
- Linearly, i.e. the TCP moves in a linear path (relative to one of the coordinate systems mentioned above)
- Reoriented around the TCP

It is possible to select the step size for incremental jogging. Incremental jogging can be used to position the robot with high precision, since the robot moves a short distance each time the joystick is moved.

During manual operation, the current position of the robot and the external axes can be displayed on the teach pendant.

Product Specification IRB 1400 M98/BaseWare OS 3.1

2.9 External Axes

The robot can control up to six external axes. These axes are programmed and moved using the teach pendant in the same way as the robot's axes.

The external axes can be grouped into mechanical units to facilitate, for example, the handling of robot carriers, workpiece manipulators, etc.

The robot motion can be simultaneously coordinated with a one-axis linear robot carrier and a rotational external axis.

A mechanical unit can be activated or deactivated to make it safe when, for example, manually changing a workpiece located on the unit. In order to reduce investment costs, any axes that do not have to be active at the same time can use the same drive unit.

Programs can be reused in other mechanical units of the same type.

2.10 Inputs and Outputs

A distributed I/O system is used, which makes it possible to mount the I/O units either inside the cabinet or outside the cabinet with a cable connecting the I/O unit to the cabinet.

A number of different input and output units can be installed:

- Digital inputs and outputs
- Analog inputs and outputs
- Remote I/O for Allen-Bradley PLC
- InterBus-S Slave
- Profibus DP Slave

The inputs and outputs can be configured to suit your installation:

- Each signal and board can be given a name, e.g. gripper, feeder
- I/O mapping (i.e. a physical connection for each signal)
- Polarity (active high or low)
- Cross connections
- Up to 16 digital signals can be grouped together and used as if they were a single signal when, for example, entering a bar code

Signals can be assigned to special system functions, such as program start, so as to be able to control the robot from an external panel or PLC.

The robot can work as a PLC by monitoring and controlling I/O signals:

- I/O instructions can be executed concurrent to the robot motion.
- Inputs can be connected to trap routines. (When such an input is set, the trap routine starts executing. Following this, normal program execution resumes. In most cases, this will not have any visible effect on the robot motion, i.e. if a limited number of instructions are executed in the trap routine.)

- Background programs (for monitoring signals, for example) can be run in parallel with the actual robot program. Requires option Multitasking, see Product Specification RobotWare.

Manual functions are available to:

- List all the signal values

- Create your own list of your most important signals

- Manually change the status of an output signal

- Print signal information on a printer

Signal connections consist of either connectors or screw terminals, which are located in the controller. I/O signals can also be routed to connectors on the upper arm of the robot.

2.11 Serial Communication

The robot can communicate with computers or other equipment via RS232/RS422 serial channels or via Ethernet. However this requires optional software, see the Product Specification RobotWare.

3 Technical specification

3.1 Structure

Weight:	Manipulator	225 kg
	Controller	240 kg
Volume:	Controller	950 x 800 x 540 mm

Airborne noise level:

The sound pressure level outside the working space	< 70 dB (A) Leq (acc. to Machinery directive 89/392 EEC)

Figure 10 View of the controller from the front and from above (dimensions in mm).
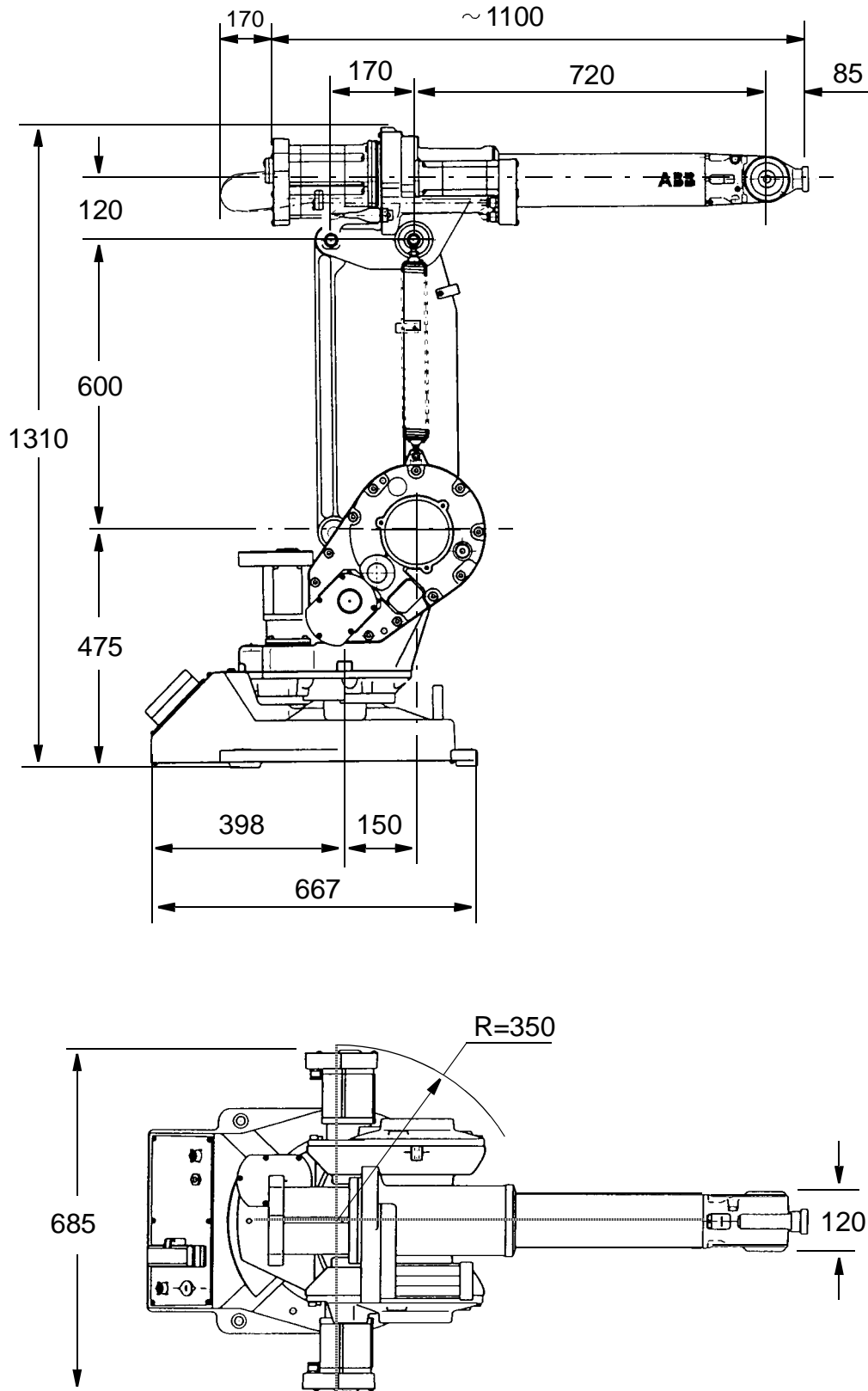
Figure 11 View of the manipulator (floor mounted version) from the side and above (dimensions in mm).
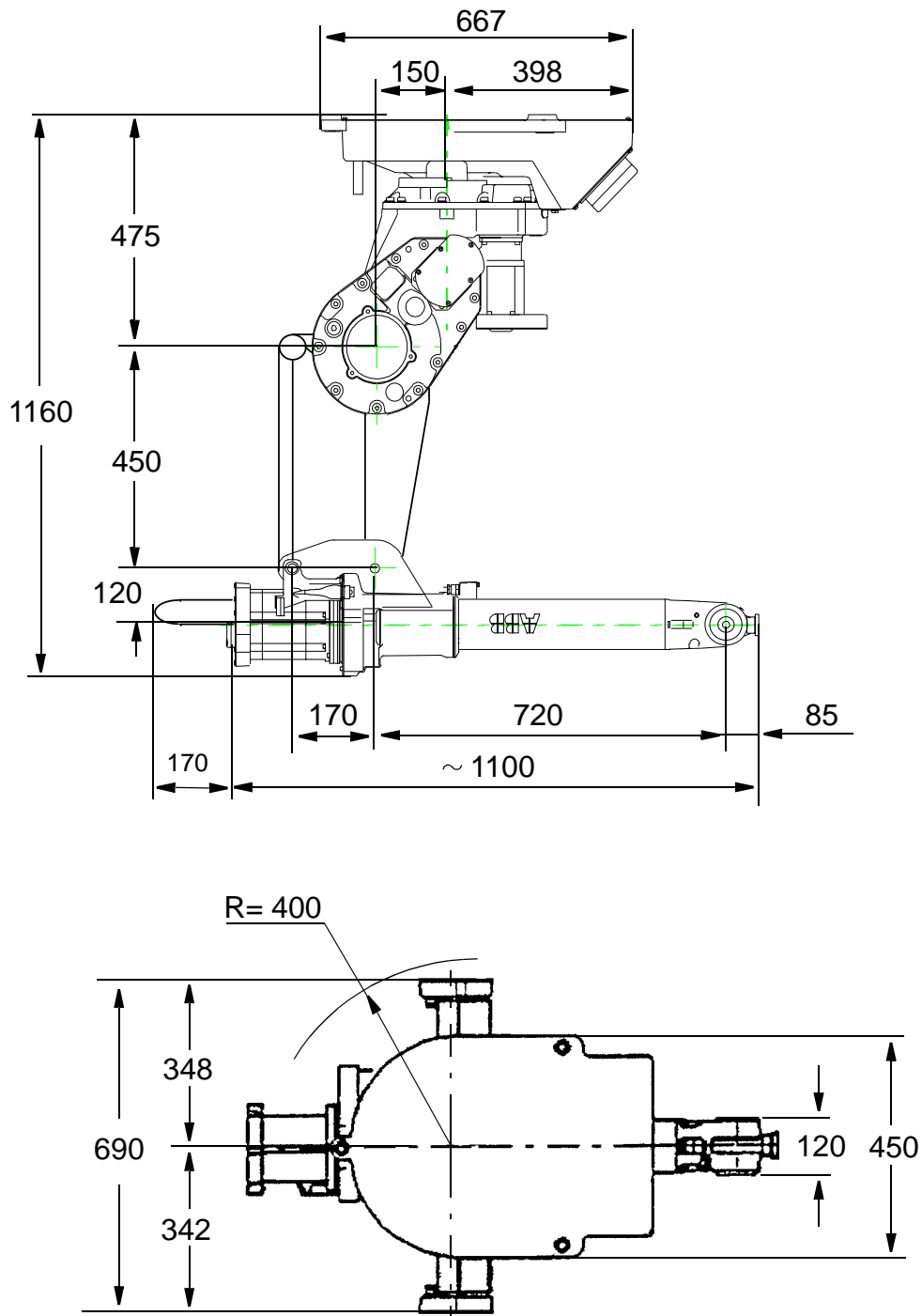
Figure 12 View of the manipulator (inverted mounted version) from the side and above (dimensions in mm).

3.2 Safety/Standards

The robot conforms to the following standards:

EN 292-1	Safety of machinery, terminology
EN 292-2	Safety of machinery, technical specifications
EN 954-1	Safety of machinery, safety related parts of control systems
EN 60204	Electrical equipment of industrial machines
IEC 204-1	Electrical equipment of industrial machines
ISO 10218, EN 775	Manipulating industrial robots, safety
ANSI/RIA 15.06/1992	Industrial robots, safety requirements
ISO 9787	Manipulating industrial robots, coordinate systems and motions
IEC 529	Degrees of protection provided by enclosures
EN 50081-2	EMC, Generic emission
EN 50082-2	EMC, Generic immunity
ANSI/UL 1740-1996 (option)	Safety Standard for Industrial Robots and Robotic Equipment
CAN/CSA Z 424-94 (option)	Industrial Robots and Robot Systems - General Safety Requirements

Safeguarded space stops via inputs

External safety equipment can be connected to the robot's two-channel emergency stop system in several different ways (see Figure 13).
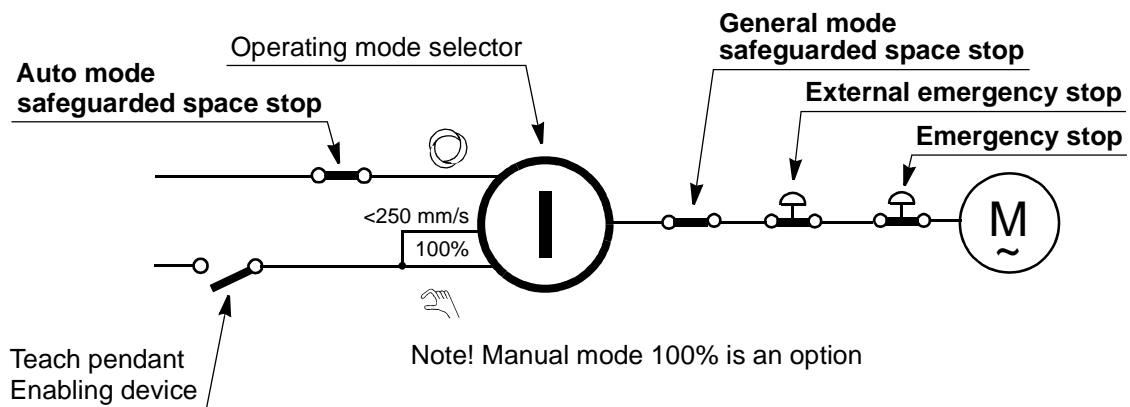
*Figure 13 All safeguarded space stops force the robot's motors to the MOTORS OFF state.
A delay can be connected to any safeguarded space stop.*

3.3 Operation
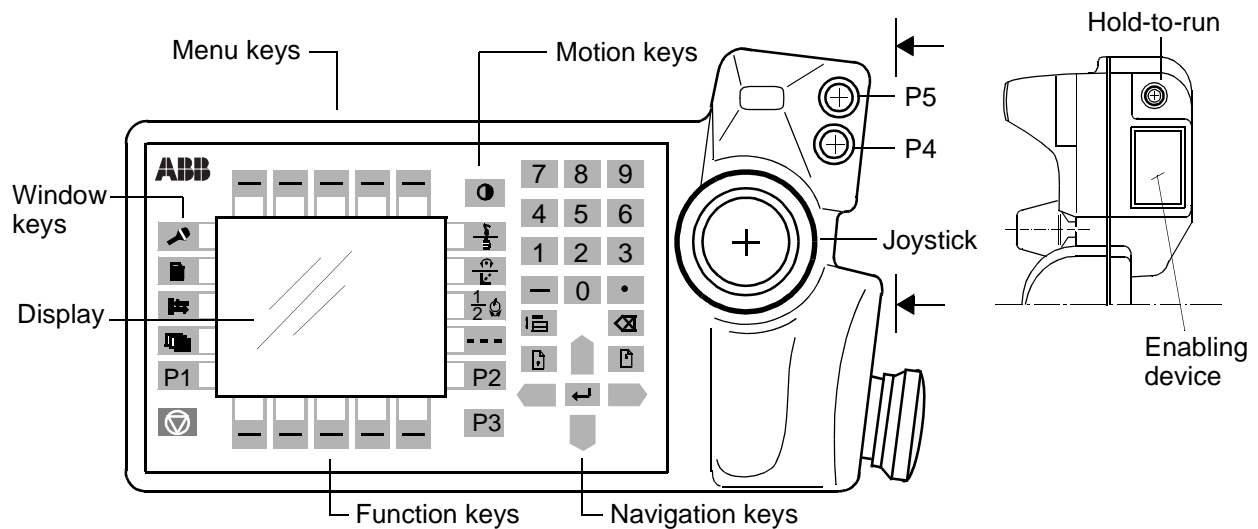
Figure 14 The teach pendant is very easy to use since any functions provided via the function and menu keys are described in plain language. The remaining keys can perform only one function each.

Display
16 text lines with 40 characters per line.

Motion keys
Select the type of movement for robot or external axis when jogging: linear movement, reorientation or axis-by-axis movement.

Navigation keys
Move the cursor and enter data.

Menu keys
Display pull-down menus.

Function keys
Select the commands used most often.

Window keys
Display one of the robot's various windows. These windows control a number of different functions:

- Jogging (manual operation)

- Programming, editing and testing a program

- Manual input/output management

- File management

- System configuration

- Service and troubleshooting

- Automatic operation

User-defined keys (P1-P5)
Five user-defined keys that can be configured to set or reset an output (e.g. open/close gripper) or to activate a system input (see chapter 3.10).

3.4 Installation

Operating requirements

Protection standards   IEC529

Explosive environments
The robot must not be located or operated in an explosive environment.

Ambient temperature
Manipulator during operation   +5°C (41°F) to +45°C (113°F)
Controller during operation   +5°C (41°F) to +52°C (125°F)
Complete robot during transportation and storage-25°C (13°F) to +55°C (131°F)

Relative humidity
Complete robot during transportation and storageMax. 95% at constant temperature
Complete robot during operation   Max. 95% at constant temperature

Power supply

Mains voltage   200-600V, 3p (3p + N for certain options), +10%,-15%

Mains frequency   48.5 to 61.8 Hz

Rated power (transformer size)   4.5 kVA - 14.4 kVA

Absolute measurement backup   1000 h (rechargeable battery)

Configuration

The robot is very flexible and can, by using the teach pendant, easily be configured to suit the needs of each user:

Authorisation   Password protection for configuration and program window
Most common I/O   User-defined lists of I/O signals
Instruction pick list   User-defined set of instructions
Instruction builder   User-defined instructions
Operator dialogs   Customised operator dialogs
Language   All text on the teach pendant can be displayed in several languages
Date and time   Calendar support
Power on sequence   Action taken when the power is switched on
EM stop sequence   Action taken at an emergency stop
Main start sequence   Action taken when the program is starting from the beginning

Program start sequence   Action taken at program start
Program stop sequence   Action taken at program stop
Change program sequence   Action taken when a new program is loaded
Working space   Working space limitations
External axes   Number, type, common drive unit, mechanical units
Brake delay time   Time before brakes are engaged
I/O signal   Logical names of boards and signals, I/O mapping, cross connections, polarity, scaling, default value at start up, interrupts, group I/O
Serial communication   Configuration

For a detailed description of the installation procedure, see the Product Manual - Installation and Commissioning.

Mounting the manipulator

Maximum load in relation to the base coordinate system.

	Endurance load in operation	Max. load at emergency stop
Force xy	± 1500 N	± 2000 N
Force z (floor mounting)	+2800 ± 500 N	2800 ± 700 N
Force z (inverted mounting)	- 2800 ± 800 N	-2800 ± 1000 N
Torque xy	± 1800 Nm	± 2000 Nm
Torque z	± 400 Nm	± 500 Nm
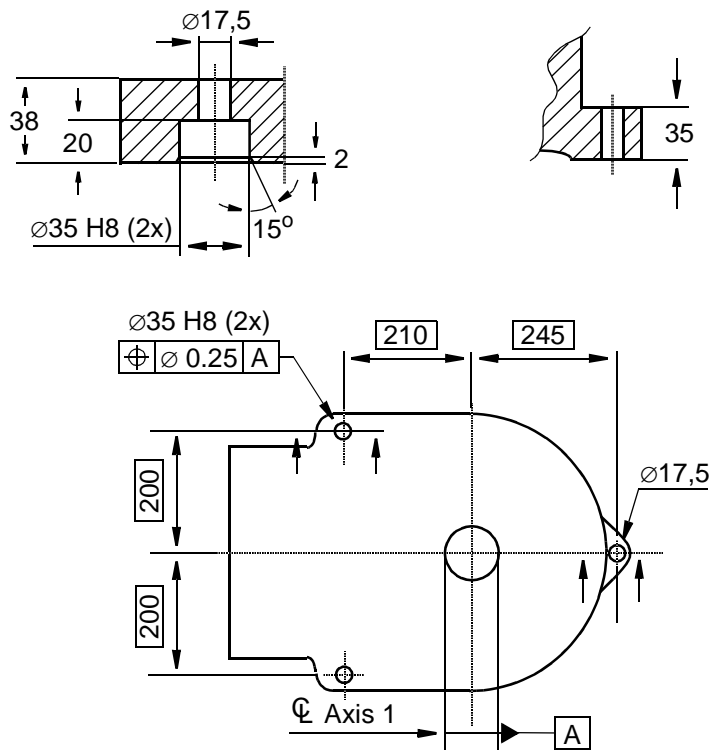
Figure 15 Hole configuration (dimensions in mm).

Technical specification

Load diagram
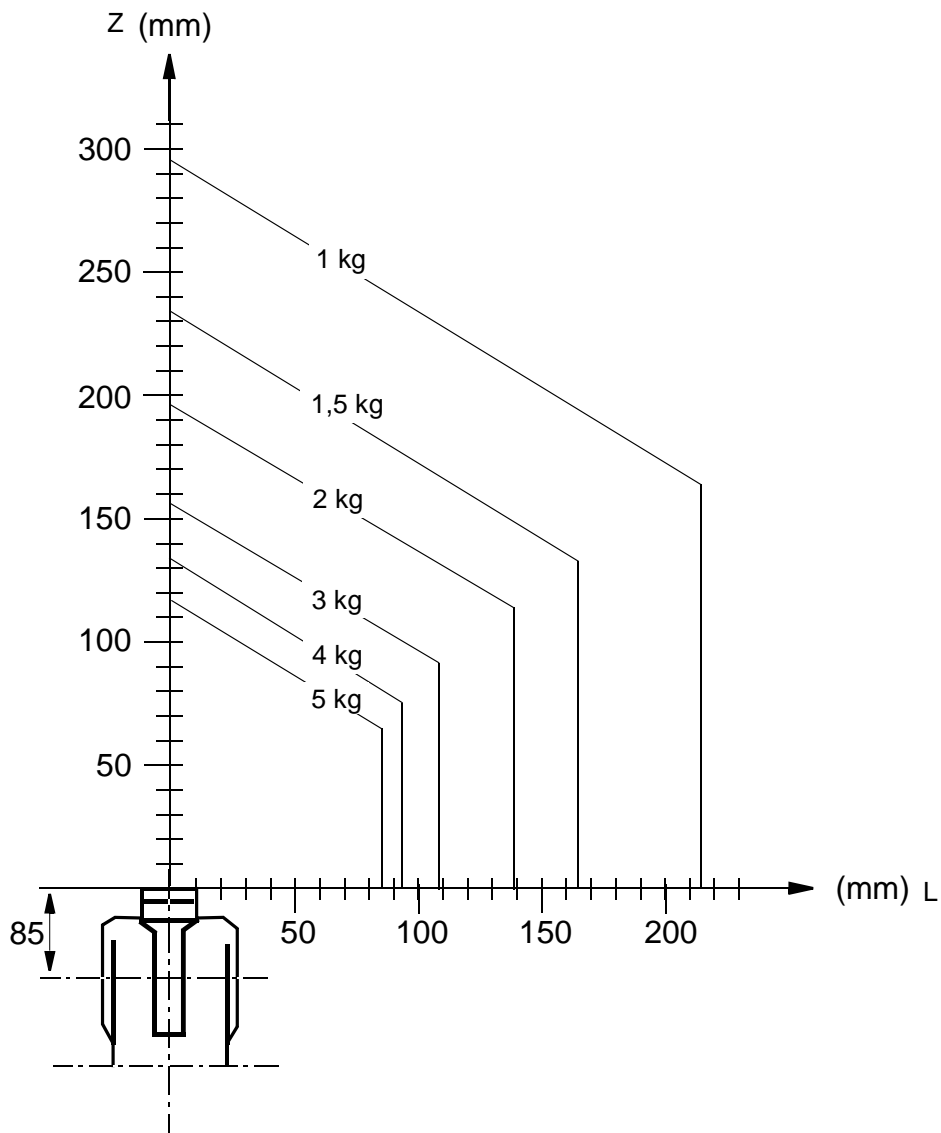
Z= see the above diagram and the coordinate system in Figure 9
L= distance in X- Y plane from Z-axis to the centre of gravity

J= max. 0.012 kgm^2

J= own moment of inertia, of the total handling weight

Figure 16 Maximum allowed weight for tool mounted on the mounting flange at different positions (centres of gravity).

Mounting of equipment
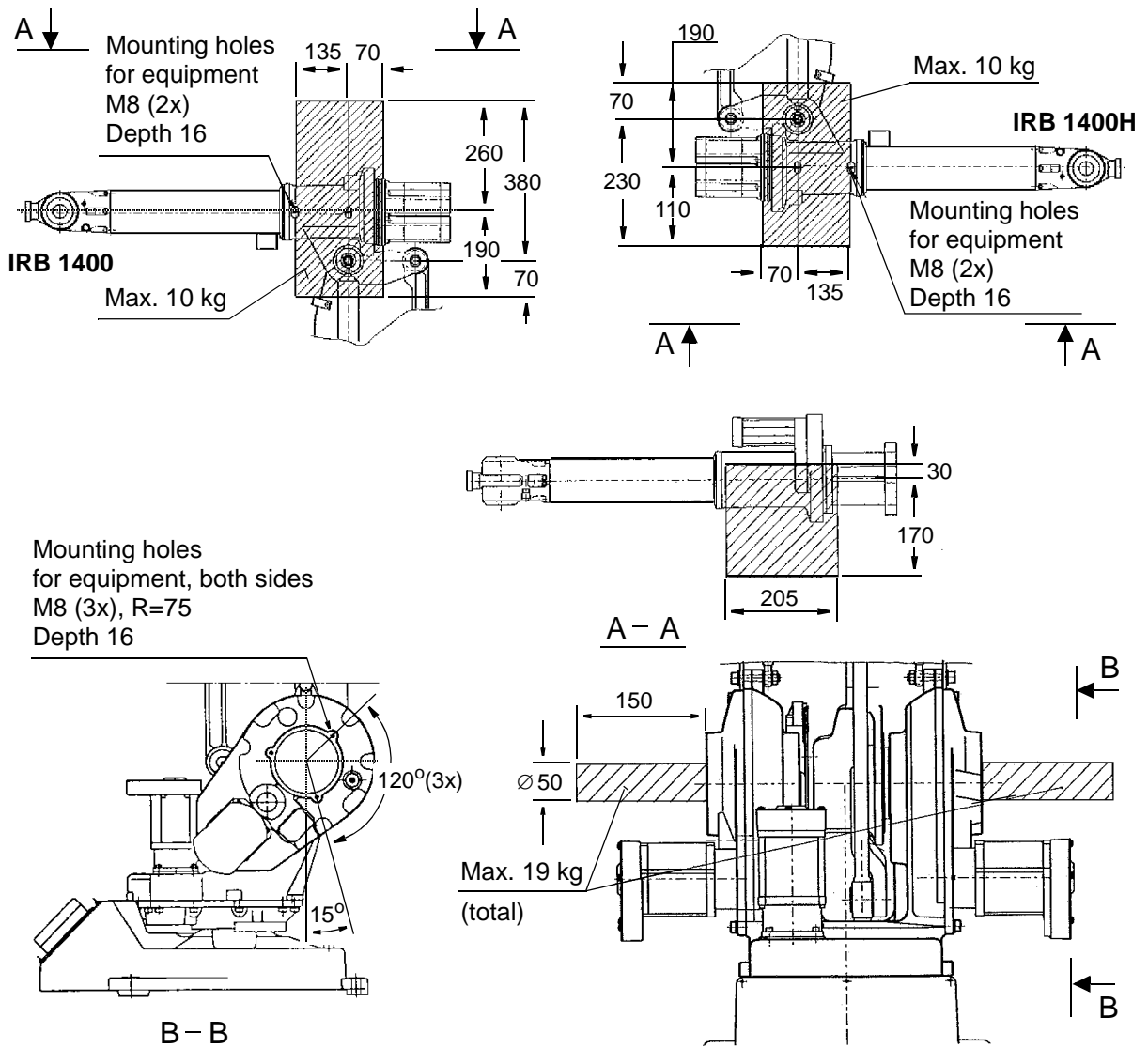
Figure 17 The shaded area indicates the permitted position (centre of gravity) for any extra equipment mounted (dimensions in mm).
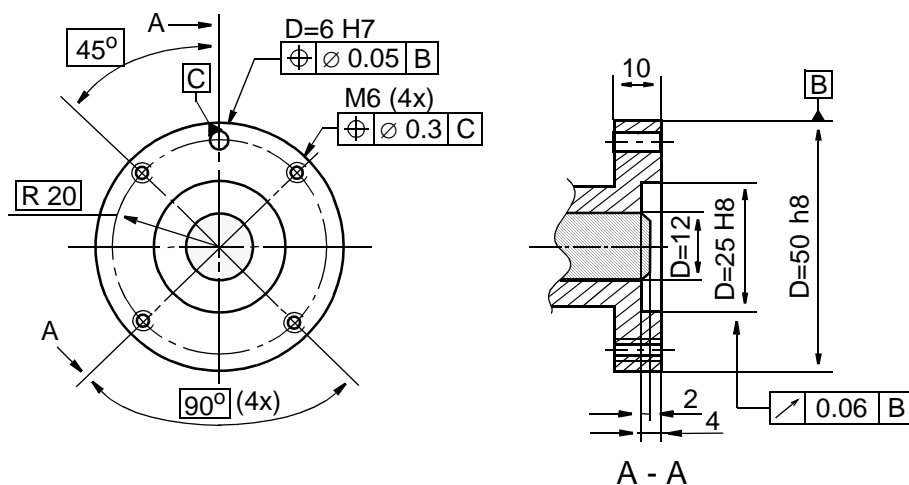
Figure 18 The mechanical interface, mounting flange (dimensions in mm).

3.5 Programming

The programming language – RAPID – is a high-level application-oriented programming language and includes the following functionality:

- hierarchial and modular structure

- functions and procedures

- global or local data and routines

- data typing, including structured and array types

- user defined names on variables, routines, inputs/outputs etc.

- extensive program flow control

- arithmetic and logical expressions

- interrupt handling

- error handling

- user defined instructions

- backward execution handler

The available sets of instructions/functions are given below. A subset of instructions to suit the needs of a particular installation, or the experience of the programmer, can be installed in pick lists. New instructions can easily be made by defining macros consisting of a sequence of standard instructions.

Note that the lists below only cover BaseWare OS. For instructions and functions associated with optional software, see Product Specification RobotWare.

Miscellaneous

|	
:=	Assigns a value
WaitTime	Waits a given amount of time
WaitUntil	Waits until a condition is met
comment	Inserts comments into the program
OpMode	Reads the current operating mode
RunMode	Reads the current program execution mode
Dim	Gets the size of an array
Present	Tests if an optional parameter is used
Load	Loads a program module during execution
UnLoad	Deletes a program module during execution

To control the program flow

ProcCall	Calls a new procedure
CallByVar	Calls a procedure by a variable
RETURN	Finishes execution of a routine
FOR	Repeats a given number of times
GOTO	Goes to (jumps to) a new instruction
Compact IF	If a condition is met, then execute one instruction
IF	If a condition is met, then execute a sequence of instructions
label	Line name (used together with GOTO)
TEST	Depending on the value of an expression ...

WHILE	Repeats as long as ...
Stop	Stops execution
EXIT	Stops execution when a restart is not allowed
Break	Stops execution temporarily

Motion settings

AccSet	Reduces the acceleration
ConfJ	Controls the robot configuration during joint movement
ConfL	Monitors the robot configuration during linear movement
VelSet	Changes the programmed velocity
GripLoad	Defines the payload
SingArea	Defines the interpolation method through singular points
PDispOn	Activates program displacement
PDispSet	Activates program displacement by specifying a value
DefFrame	Defines a program displacement automatically
DefDFrame	Defines a displacement frame
EOffsOn	Activates an offset for an external axis
EOffsSet	Activates an offset for an external axis using a value
ORobT	Removes a program displacement from a position
SoftAct	Activates soft servo for a robot axis
TuneServo	Tunes the servo

Motion

MoveC	Moves the TCP circularly
MoveJ	Moves the robot by joint movement
MoveL	Moves the TCP linearly
MoveAbsJ	Moves the robot to an absolute joint position
MoveXDO	Moves the robot and set an output in the end position
SearchC	Searches during circular movement
SearchL	Searches during linear movement
ActUnit	Activates an external mechanical unit
DeactUnit	Deactivates an external mechanical unit
Offs	Displaces a position
RelTool	Displaces a position expressed in the tool coordinate system
MirPos	Mirrors a position
CRobT	Reads current robot position (the complete *robtarget*)
CJointT	Reads the current joint angles
CPos	Reads the current position (*pos* data)
CTool	Reads the current tool data
CWObj	Reads the current work object data
StopMove	Stops robot motion
StartMove	Restarts robot motion

Input and output signals

InvertDO	Inverts the value of a digital output signal
PulseDO	Generates a pulse on a digital output signal
Reset	Sets a digital output signal to 0
Set	Sets a digital output signal to 1
SetAO	Sets the value of an analog output signal
SetDO	Sets the value of a digital output signal after a defined time
SetGO	Sets the value of a group of digital output signals
WaitDI	Waits until a digital input is set
WaitDO	Waits until a digital output is set
AInput	Reads the value of an analog input signal
DInput	Reads the value of a digital input signal

DOutput	Reads the value of a digital output signal
GInput	Reads the value of a group of digital input signals
GOutput	Reads the value of a group of digital output signals
TestDI	Tests if a digital input signal is set
IODisable	Disables an I/O module
IOEnable	Enables an I/O module

Interrupts

ISignalDI	Orders interrupts from a digital input signal
ISignalDO	Orders interrupts from a digital output signal
ITimer	Orders a timed interrupt
IDelete	Cancels an interrupt
ISleep	Deactivates an interrupt
IWatch	Activates an interrupt
IDisable	Disables interrupts
IEnable	Enables interrupts
CONNECT	Connects an interrupt to a trap routine

Error Recovery

EXIT	Terminates program execution
RAISE	Calls an error handler
RETRY	Restarts following an error
TRYNEXT	Skips the instruction that has caused the error
RETURN	Returns to the routine that called the current routine

Communication

TPErase	Erases text printed on the teach pendant
TPWrite	Writes on the teach pendant
TPReadFK	Reads function keys
TPReadNum	Reads a number from the teach pendant
ErrWrite	Stores an error message in the error log

System & Time

ClkReset	Resets a clock used for timing
ClkStart	Starts a clock used for timing
ClkStop	Stops a clock used for timing
ClkRead	Reads a clock used for timing
CDate	Reads the current date as a string
CTime	Reads the current time as a string
GetTime	Gets the current time as a numeric value

Mathematics

Add	Adds a numeric value
Clear	Clears the value
Decr	Decrements by 1
Incr	Increments by 1
Abs	Calculates the absolute value
Sqrt	Calculates the square root
Exp	Calculates the exponential value with the base "e"
Pow	Calculates the exponential value with an arbitrary base
ACos	Calculates the arc cosine value
ASin	Calculates the arc sine value

ATan/ATan2	Calculates the arc tangent value
Cos	Calculates the cosine value
Sin	Calculates the sine value
Tan	Calculates the tangent value
EulerZYX	Calculates Euler angles from an orientation
OrientZYX	Calculates the orientation from Euler angles
PoseInv	Inverts a pose
PoseMult	Multiplies a pose
PoseVect	Multiplies a pose and a vector
Round	Rounds a numeric value
Trunc	Truncates a numeric value

Text strings

NumToStr	Converts numeric value to string
StrFind	Searches for a character in a string
StrLen	Gets the string length
StrMap	Maps a string
StrMatch	Searches for a pattern in a string
StrMemb	Checks if a character is a member of a set
StrOrder	Checks if strings are ordered
StrPart	Gets a part of a string
StrToVal	Converts a string to a numeric value
ValToStr	Converts a value to a string

Memory

	Memory size	Instructions[1]
Program memory:		
Standard	2.5 MB[2]	7500
Extended memory 8 MB	6.0 MB[2]	18000
Mass storage[3]:		
RAM memory Standard	0.5 MB	3000
Extended 8 MB	4 MB	31000
Diskette	1.44 MB	15000

[1] Depending on type of instruction.

[2] Some software options reduce the program memory. See Product Specification RobotWare.

[3] Requires approx. 3 times less space than in the program memory, i.e. 1 MB mass memory can store 3 MB of RAPID instructions.

Type of diskette: 3.5" 1.44 MB (HD) MS DOS format.
Programs and all user-defined data are stored in ASCII format.

Memory backup
> The RAM memory is backed up by two Lithium batteries. Each battery has a capacity of 2-5 months power off time (depending of memory board size).
> A warning is given at power on when one of the batteries is empty.

3.6 Automatic Operation

The following production window commands are available:
- Load/select the program.
- Start the program.
- Execute instruction-by-instruction (forward/backward).
- Reduce the velocity temporarily.
- Display program-controlled comments (which tell the operator what is happening).
- Displace a position, also during program execution (can be blocked).

3.7 Maintenance and Troubleshooting

The following maintenance is required:
- Lubricating spring brackets every six months.
- Changing filter for the transformer/drive unit cooling every year.
- Greasing axes 5 and 6 every year.
- Changing batteries every third year.

The maintenance intervals depends on the use of the robot. For detailed information on maintenance procedures, see Maintenance section in the Product Manual.

3.8 Robot Motion

Type of motion		Range of movement
Axis 1	Rotation motion	$+170^o$ – -170°
Axis 2	Arm motion	$+70^o$ – -70°
Axis 3	Arm motion	$+70^o$ – -65°
Axis 4	Wrist motion	$+150^o$ – -150°
Axis 5	Bend motion	$+115^o$ – -115°
Axis 6	Turn motion	$+300^o$ – -300°
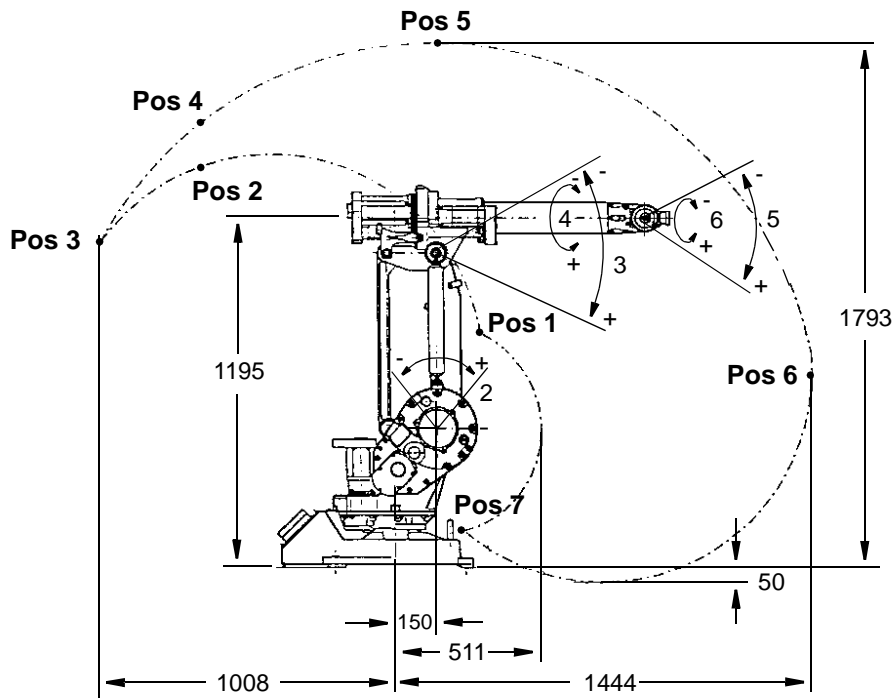
	Axis 2	Axis 3
Pos 1	-70°	$+70^o$
2	-70°	-35°
3	-70°	-65°
4	-43°	-65°
5	-6°	-65°
6	$+70^o$	-65°
7	$+70^o$	$+70^o$

Figure 19 The extreme positions of the robot arm.

Technical specification

Type of motion		Range of movement
Axis 1	Rotation motion	$+170^o$ – -170°
Axis 2	Arm motion	$+20^o$ – -100°
Axis 3	Arm motion	$+70^o$ – -65°
Axis 4	Wrist motion	$+150^o$ – -150°
Axis 5	Bend motion	$+115^o$ – -115°
Axis 6	Turn motion	$+300^o$ – -300°
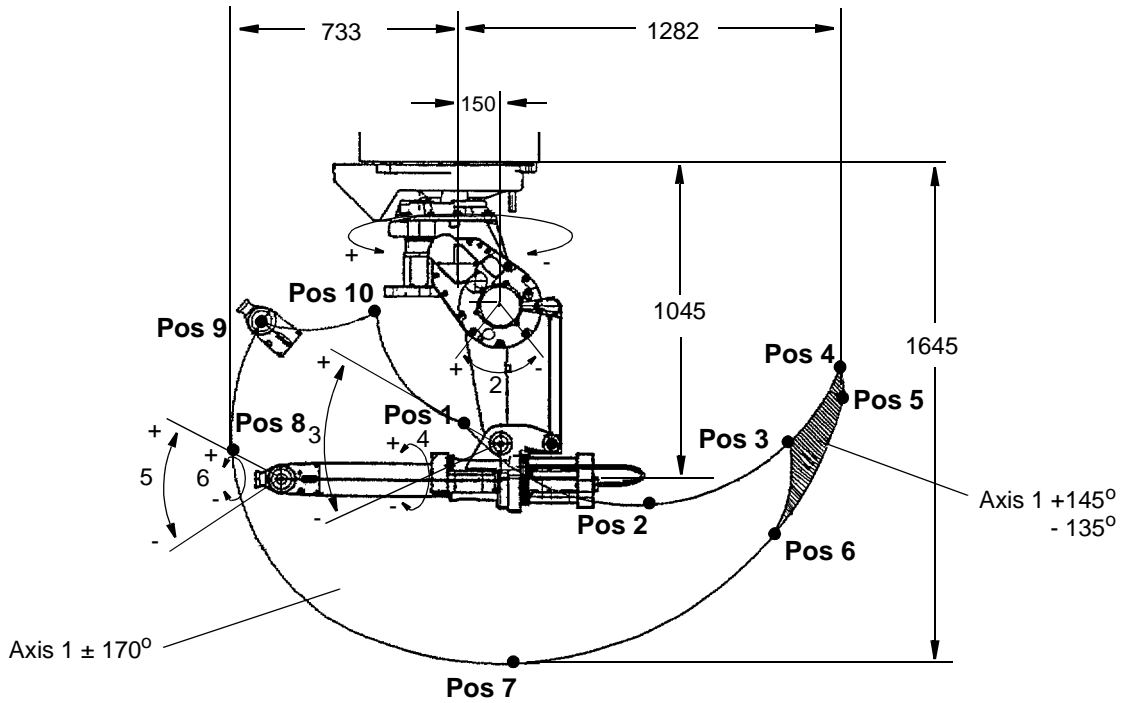
Pos	Axis 2	Axis 3
1	-100^0	$+70^0$
2	-100^0	$+20^0$
3	-100^0	-25^0
4	-100^0	-50^0
5	-85^0	-65^0
6	-60^0	-65^0
7	-10^0	-15^0
8	$+20^0$	-10^0
9	$+20^0$	$+20^0$
10	-30^0	$+70^0$

Figure 20 The extreme positions of the robot arm, inverted version (dimensions in mm).

Performance according to ISO 9283

At rated load and 1 m/s velocity on the inclined ISO test plane with all six robot axes in motion.

Unidirectional pose repeatability:
RP = 0.05 mm

Linear path accuracy:
AT = 0.45 - 1.0 mm

Linear path repeatability:
RT = 0.14 - 0.25 mm

Minimum positioning time, to within 0.2 mm of the position:
0.2 - 0.35 sec. (on 35 mm linear path)
0.45 - 0.6 sec. (on 350 mm linear path)

The above values are the range of average test-results from a number of robots. If guaranteed values are required, please contact your nearest ABB Flexible Automation Centre.

Velocity

Axis no.	IRB 1400	IRB 1400H
1	120°/s	130°/s
2	120°/s	130°/s
3	120°/s	120°/s
4	280°/s	280°/s
5	280°/s	280°/s
6	280°/s	280°/s

There is a supervision to prevent overheating in applications with intensive and frequent movements.

Resolution

Approx. 0.01° on each axis.

3.9 External Axes

An external axis is an AC motor (IRB motor type or similar) controlled via a drive unit mounted in the robot cabinet or in a separate enclosure. See Specification of Variants and Options.

Resolver	Connected directly to motor shaft
	Transmitter type resolver
	Voltage ratio 2:1 (rotor: stator)
Resolver supply	5.0 V/4 kHz

Absolute position is accomplished by battery-backed resolver revolution counters in the serial measurement board (SMB). The SMB is located close to the motor(s) according to Figure 21, or inside the cabinet.

For more information on how to install an external axis, see the Product Manual - Installation and Commissioning.

When more than three external axes are used, the drive units for external axis 4 and upwards must be placed in a separate cabinet according to Figure 21.
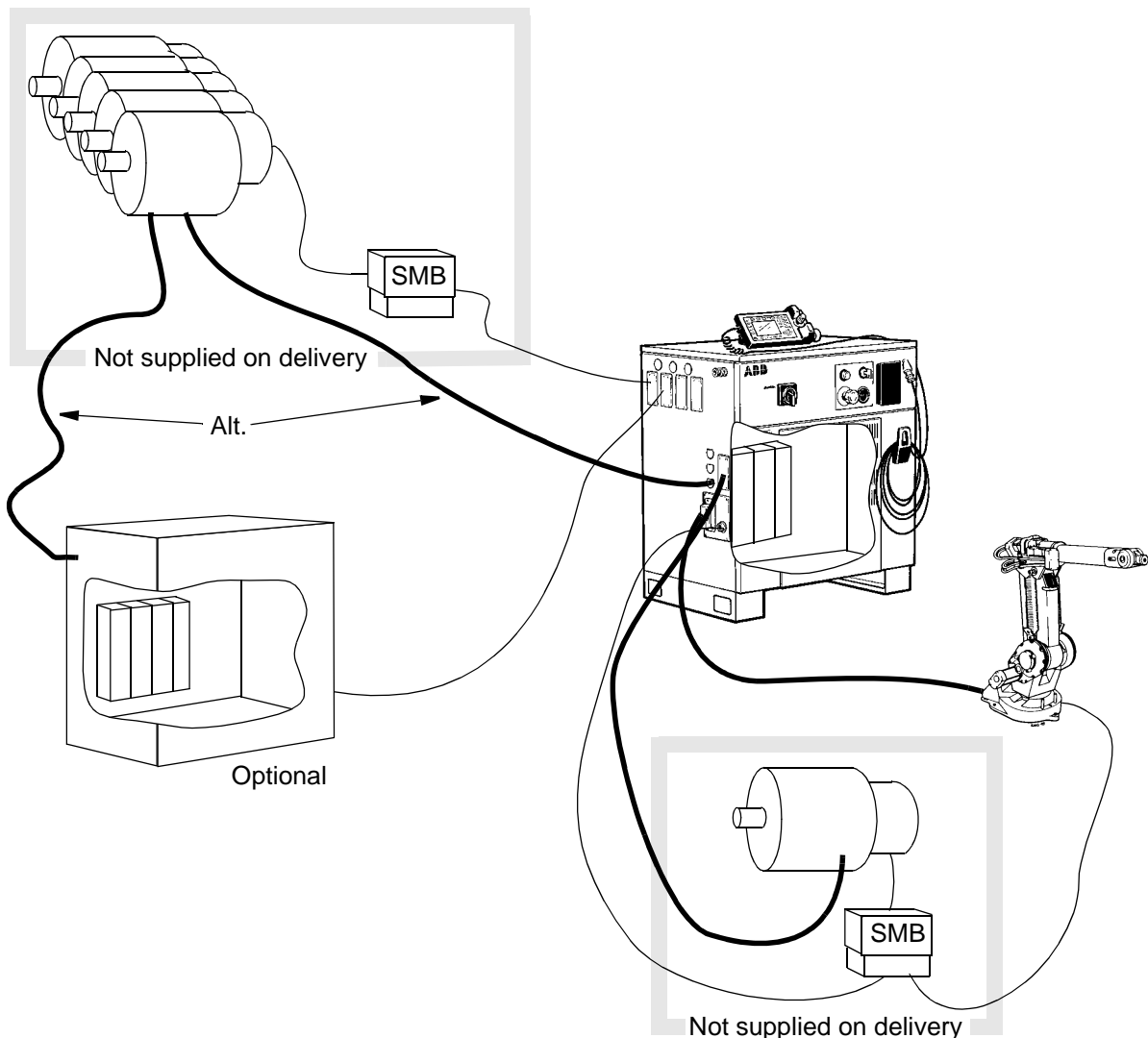

Figure 21 Outline diagram, external axes.

3.10 Inputs and Outputs

Types of connection

The following types of connection are available:

- "Screw terminals" on the I/O units.
- Serial interface for distributed I/O units.
- Air and signal connections to upper arm.

For more detailed information, see Chapter 4: *Specification of Variants and Options*.

I/O units

Several I/O units can be used. The following table shows the physical number of signals that can be used on each unit.

| Type of unit | Option no. | Digital | | Analog | | | Power supply |
		In	Out	Voltage intput	Voltage output	Current output	
Digital I/O 24 VDC	20x	16	16				Internal/External[1]
Digital I/O 120 VAC	25x	16	16				Internal/External
Analog I/O	22x			4	3	1	Internal
AD Combi I/O	23x	16	16		2		Internal/External[1]
Relay I/O	26x	16	16				Internal/External[1]
Remote I/O Allen Bradley	281	128[2]	128				
InterBus-S Slave	284-285	64[2]	64				
Profibus DP Slave	286-287	128[2]	128				
Simulated I/O[3]	Standard	100	100	30	30		
Encoder interface unit[4]	288-289	1					

1. The digital signals are supplied in groups, each group having 8 inputs or outputs.
2. To calculate the number of logical signals, add 2 staturs signals for RIO unit and 1 for Interbus-S and Profibus DP.
3. A simulated I/O unit can be used to form cross connections and logical conditions without physical wiring. No. of signals are to be configured.
4. Dedicated for Conveyor Tracking only.

Distributed I/O

The total number of logical signals is 512 (inputs or outputs, group I/O, analog and digital including field buses).

Max. total no of units*	20 (including one SIM unit)
Max. total cable length	100 m
Cable type (not included)	According to DeviceNet specification release 1.2
Data rate (fixed)	500 Kbit/s

* Max. four units can be mounted inside the cabinet.

Technical specification

Signal data

Permitted customer 24 V DC load   max. 6 A

Digital inputs 24 V DC	(options 20x/23x/26x)	
	Optically-isolated	
	Rated voltage:	24 V DC
	Logical voltage levels: "1"	15 to 35 V
	"0"	-35 to 5 V
	Input current at rated input voltage:	6 mA
	Potential difference:	max. 500 V
	Time delays: hardware	5−15 ms
	software	≤ 3 ms
	Time variations:	± 2 ms

Digital outputs 24 V DC	(options 20x/23x)	
	Optically-isolated, short-circuit protected, supply polarity protection	
	Voltage supply	19 to 35 V
	Rated voltage	24 V DC
	Output current:	max. 0.5 A
	Potential difference:	max. 500 V
	Time delays: hardware	≤ 1 ms
	software	≤ 2 ms
	Time variations:	± 2 ms

Relay outputs	(options 26x)	
	Single pole relays with one male contact (normally open)	
	Rated voltage:	24 V DC, 120 VAC
	Voltage range:	19 to 35 V DC
		24 to 140 V AC
	Output current:	max. 2 A
	Potential difference:	max. 500V
	Time intervals: hardware (set signal)	typical 13 ms
	hardware (reset signal)	typical 8 ms
	software	≤ 4 ms

Digital inputs 120 V AC	(options 25x)	
	Optically isolated	
	Rated voltage	120 V AC
	Input voltage range: "1"	90 to 140 V AC
	Input voltage range: "0"	0 to 45 V AC
	Input current (typical):	7.5 mA
	Time intervals: hardware	≤ 20 ms
	software	≤ 4 ms

Digital outputs
120 V AC   (options 25x)
        Optically isolated, voltage spike protection

Rated voltage		120 V AC
Output current:	max.	1A/channel, 12 A 16 channels or
	max.	2A/channel, 10 A 16 channels (56 A in 20 ms)
	min.	30mA
Voltage range:		24 to 140 V AC
Potential difference:	max.	500 V
Off state leakage current:	max.	2mA rms
On state voltage drop:	max.	1.5 V
Time intervals: hardware		≤ 12 ms
software		≤ 4 ms

Analog inputs   (options 22x)

Voltage Input voltage:		±10 V
Input impedance:		>1 Mohm
Resolution:		0.61 mV (14 bits)
Accuracy:		$\pm0.2\%$ of input signal

Analog outputs (option 22x)

Voltage Output voltage:		±10 V
Load impedance:	min.	2 kohm
Resolution:		2.44 mV (12 bits)
Current Output current:		4-20 mA
Load impedance:	min.	800 ohm
Resolution:		4.88 µA (12 bits)
Accuracy:		$\pm0.2\%$ of output signal

Analog outputs (option 23x)

Output voltage (galvanically isolated):		0 to +10 V
Load impedance:	min.	2 kohm
Resolution:		2.44 mV (12 bits)
Accuracy:		±25 mV $\pm0.5\%$ of output voltage
Potential difference:	max.	500 V
Time intervals: hardware		≤ 2.0 ms
software:		≤ 4 ms

Signal connections on robot arm

Signals	12	60 V, 500 mA

Technical specification

System signals

Signals can be assigned to special system functions. Several signals can be given the same functionality.

Digital outputs	Motors on/off
	Executes program
	Error
	Automatic mode
	Emergency stop
	Restart not possible
	Run chain closed
Digital inputs	Motors on/off
	Starts program from where it is
	Motors on and program start
	Starts program from the beginning
	Stops program
	Stops program when the program cycle is ready
	Stops program after current instruction
	Executes "trap routine" without affecting status of stopped regular program[1]
	Loads and starts program from the beginning[1]
	Resets error
	Resets emergency stop
	System reset
	Synchronizes external axes
Analog output	TCP speed signal

1. Program can be decided when configuring the robot.

For more information on system signals, see User's Guide - System Parameters.

3.11 Communication

The robot has two serial channels – one RS232 and one RS422 Full duplex – which can be used to communicate point to point with printers, terminals, computers and other equipment (see Figure 22).
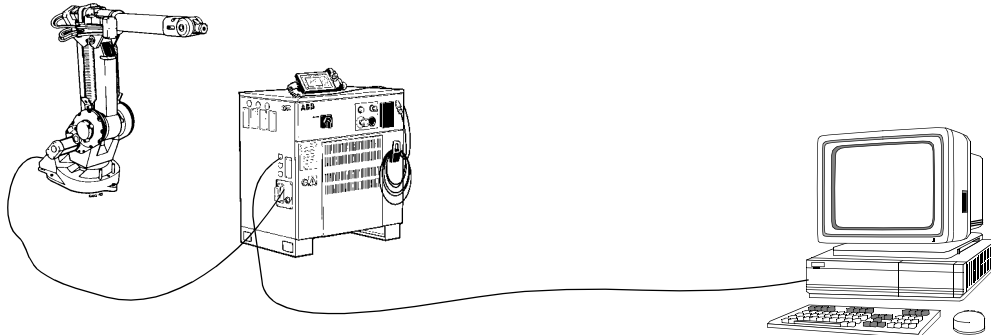
Figure 22 Serial point-to-point communication.

The serial channels can be used at speeds of 300 to 19200 bit/s (max. 1 channel with speed 19200 bit/s).

For high speed and/or network communication, the robot can be equipped with Ethernet interface (see Figure 23). Transmission rate is 10 Mbit/s.
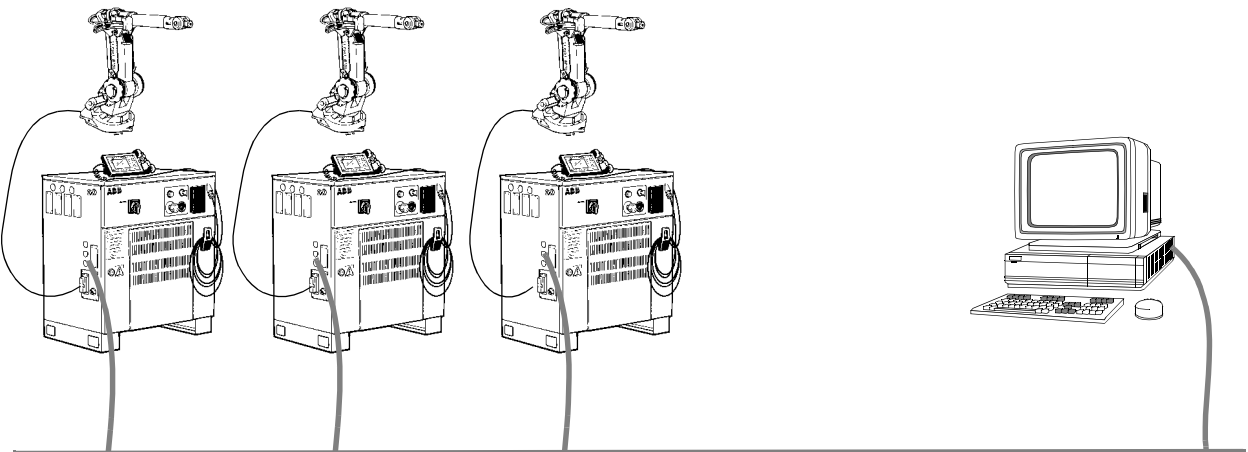
Figure 23 Serial network communication.

Character-based or binary information can be transferred using RAPID instructions. This requires the option Advanced functions, see Product Specification RobotWare.

In addition to the physical channels, a Robot Application Protocol (RAP) can be used. This requires either of the options FactoryWare Interface or RAP Communication, see Product Specification RobotWare.

Technical specification

4 Specification of Variants and Options

The different versions of and options for the IRB 1400 are described below.
The same numbers are used here as in the Specification form. For software options, see Product Specification RobotWare.

Note! Options marked with * are inconsistent with UL/UR approval.

020 ROBOT VERSIONS

021 IRB 1400
For floor mounting.
022 IRB 1400H
For inverted mounting.

040 APPLICATION INTERFACE

Air supply and signals for extra equipment to upper arm

04y Hose for compressed air is integrated into the manipulator. There is an inlet at the base and an outlet on the upper arm housing.

Connections: R1/4" in the upper arm housing and at the base. Max. 8 bar.
Inner hose diameter: 6.5 mm.

For connection of extra equipment on the manipulator, there are cables integrated into the manipulator's cabling.

Number of signals: 16 signals 49 V, 500 mA.
Connector on upper arm: Burndy 12-pin UTG 014-12S
Connector on robot base: Burndy 12-pin UTG 014-12P

One of the alternatives below, 045 or 67x, must be selected.

04z Control cabling to arc welding wire-feeder is integrated into the manipulator's cabling.
Control signals:
16 signals, 49 V, 500 mA
Connector on upper arm housing: Burndy 23-pin UTG 618-23PN
Connector on robot base: Burndy 23-pin socket UT001823SHT

Power signals:
12 signals, 300 V, 4 A
Connector on upper arm housing: Burndy 12-pin socket UTG 614-12SN
Connector on robot base: Burndy 12-pin UT001412PHT

This option is not available for IRB 1400H and not together with option 67x.

045 The signals are connected directly to the robot base. The cable from the manipulator to the controller is not supplied.

Specification of Variants and Options

**67x** The signals are connected to 12-pole screw terminals, Phoenix MSTB 2.5/12-ST-5.08, to the controller (see Figure 29). Only available with option 04y.

If 04y or 04z   If 67x
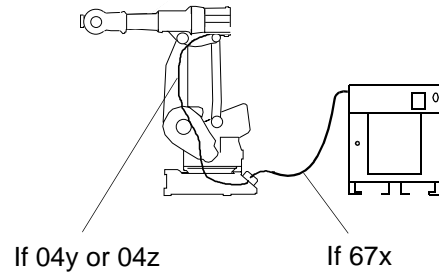
070 POSITION SWITCH

Switches indicating the position of axis 1. A design with two stationary switches is available. The switches are manufactured by Telemecanique and of type forced disconnect.

The two switches divide the working area of axis 1 into two fixed working zones, approx. 175º each. Together with external safety arrangement, this option allows access to one working zone at the same time as the robot is working in the other one.

07x The signals are connected to 12-pole screw terminals, Phoenix MSTB 2.5/12-ST-5.08, in the controller (see Figure 24).

Controller
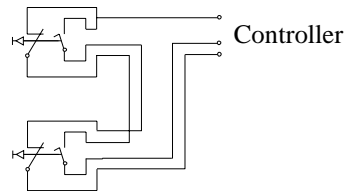
Figure 24 Connections of the switches.

081 Two switches, axis 1 stationary.

691 SAFETY LAMP

A safety lamp with orange fixed light can be mounted on the manipulator.
The lamp is active in MOTORS ON mode.

110 CABINET SIZE

111 Standard cabinet (with upper cover).

112 Standard cabinet without upper cover. To be used when cabinet extension is mounted on top of the cabinet after delivery.

114 With extended cover 250 mm.
The height of the cover is 250 mm, which increases the available space for external equipment that can be mounted inside the cabinet.

115 With cabinet extension, 800 mm.
A cabinet extension is mounted on top of the standard cabinet. There is a mounting plate inside. (See Figure 25).
The cabinet extension is opened via a front door and it has no floor. The upper part of the standard cabinet is therefore accessible.
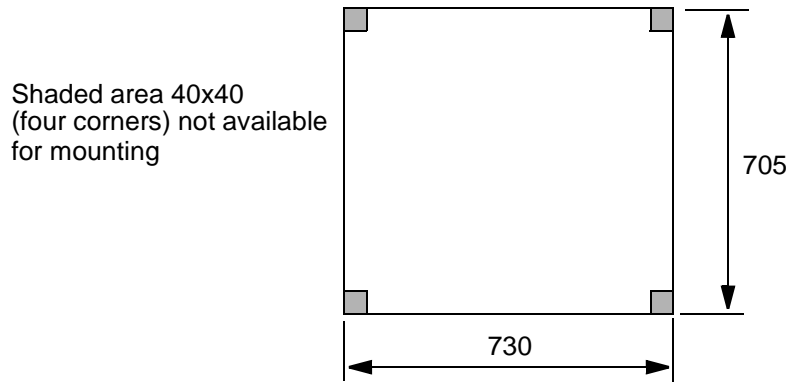This option cannot be combined with option 142.

Figure 25 Mounting plate for mounting of equipment (dimensions in mm).

120 CABINET TYPE

121 Standard, i.e. without Castor wheels.

122 Cabinet on Castor wheels.

130 CONNECTION OF MAINS

The power is connected either inside the cabinet or to a connector on the cabinet's left-hand side. The cable is not supplied. If option 133-136 is chosen, the female connector (cable part) is included.

131 Cable gland for inside connection. Diameter of cable: 11-12 mm.

133* 32 A, 380-415 V, 3p + PE (see Figure 26).
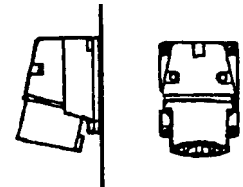
Figure 26 CEE male connector.

134 Connection via an industrial Harting 6HSB connector in accordance with DIN 41640.
35 A, 600 V, 6p + PE (see Figure 27).

136* 32 A, 380-415 V, 3p + N + PE (see Figure 26).
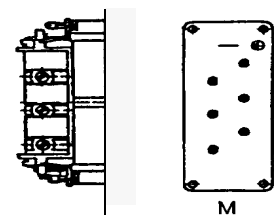
Figure 27 DIN male connector.

140 MAINS SWITCH

141* Rotary switch in accordance with the standard in section 3.2 and IEC 337-1, VDE 0113.

142 Rotary switch according to 141 with door interlock.

143 Flange disconnect in accordance with the standard in section 3.2. Includes door interlock.

Additions to the mains switch:

147/149 Circuit breaker for rotary switch. A 16 A (transformer 2 and 3) or 25 A (transformer 1) circuit breaker for short circuit protection of main cables in the cabinet. Circuit breaker approved in accordance with IEC 898, VDE 0660.

150 MAINS VOLTAGE

The robot can be connected to a rated voltage of between 200 V and 600 V, 3-phase and protective earthing. A voltage fluctuation of +10% to -15% is permissible in each connection.

151-174	Voltage	Voltage	Voltage
	200 V		
	220 V		
	400 V	400 V	
	440 V	440 V	
		475 V	475 V
		500 V	500 V
			525 V
			600 V

175 MAINS FILTER

The mains filter reduces the emission of radio frequency on the incoming power, to levels below requirements in the Machinery Directive 89/392/EEC. For installations in countries not affected by this directive, the filter can be excluded.

177-179 Mains filter

180 OPERATOR'S PANEL

The operator's panel and teach pendant holder can be installed either

181 Standard, i.e. on the front of the cabinet, or

182 External, i.e. in a separate operator's unit.
All necessary cabling, including flange, connectors, sealing strips, screws, etc., is supplied.
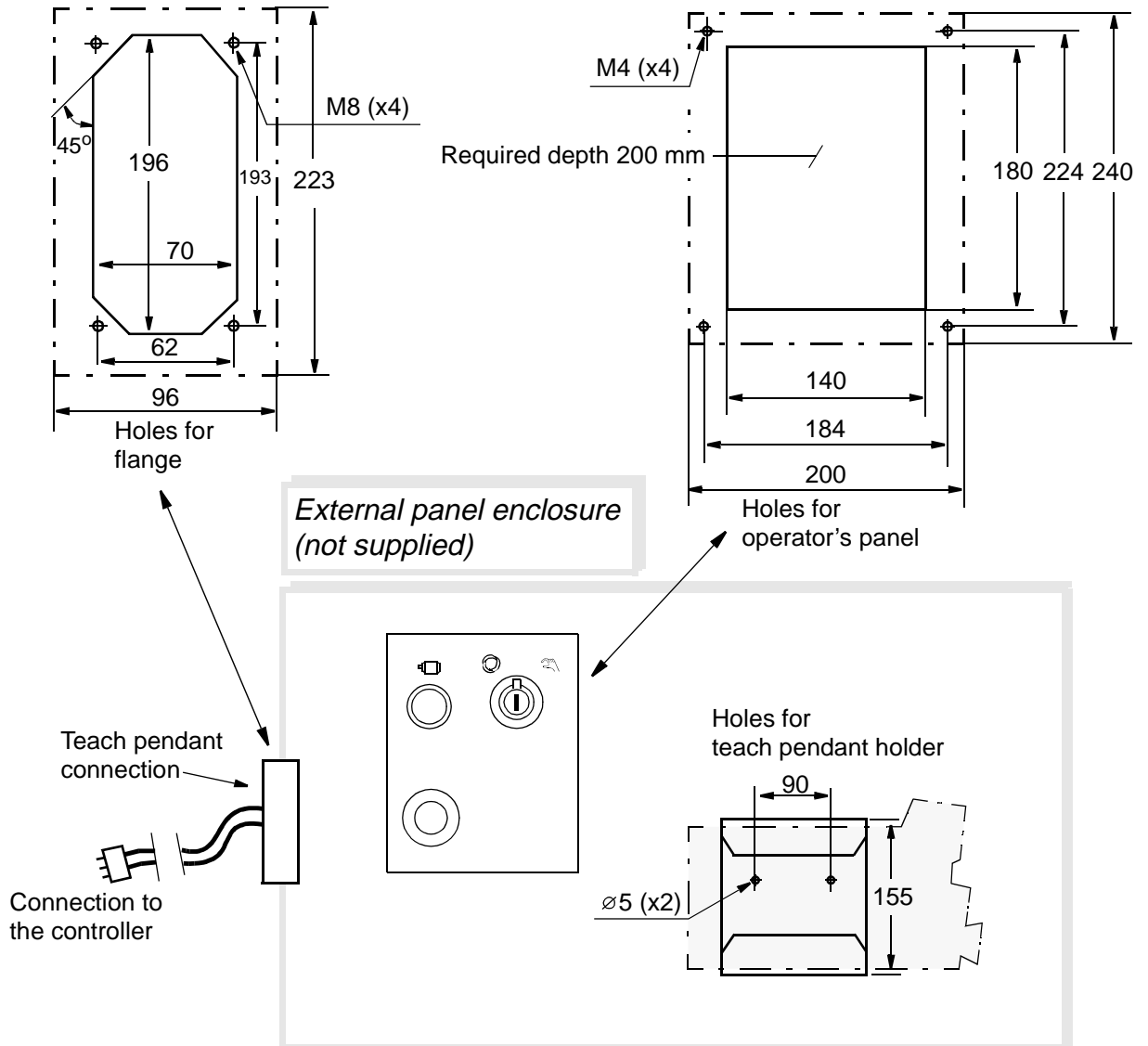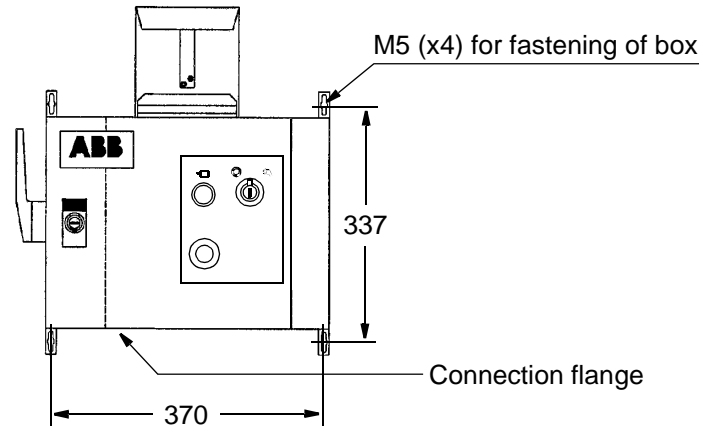External enclosure is not supplied.

Figure 28 Required preparation of external panel enclosure (all dimensions in mm).

183 External, mounted in a box,
(see figure on the right).

Cable length

185 15 m
186 22 m
187 30 m

190 OPERATING MODE SELECTOR

193 Standard, 2 modes: manual and automatic

191* Standard, 3 modes: manual, manual full speed and automatic.
This option is inconsistent with UL/UR approval.

200 I/O MODULES MOUNTED IN CABINET

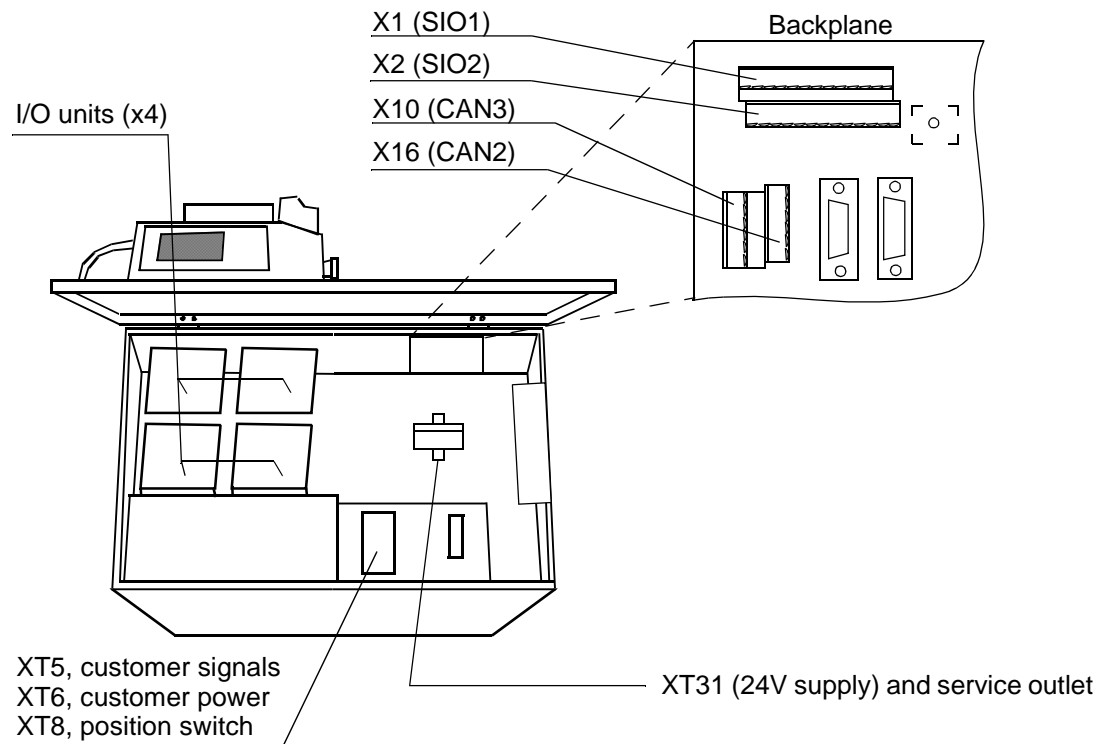The standard cabinet can be equipped with up to four I/O units. For more details, see Technical
Specification 3.10.

Figure 29 I/O unit and screw terminal locations.

20x Digital 24 VDC I/O: 16 inputs/16 outputs.

22x Analog I/O: 4 inputs/4 outputs.

23x AD Combi I/O: 16 digital inputs/16 digital outputs and 2 analog outputs (0-10V).

25x Digital 120 VAC I/O 16 inputs/16 outputs.

26x Digital I/O with relay outputs: 16 inputs/16 outputs.
Relay outputs to be used when more current or voltage is required from the digital outputs. The inputs are not separated by relays.

Connection of I/O

The signals are connected directly to the I/O modules in the upper part of the cabinet (see Figure 29). Connectors Phoenix MSTB 2.5/xx-ST-5.08 (MC 1.5/xx-ST-3.81 for option 22x) or equivalent are included:
Option 20x: 4 pieces of 10 pole connectors
Option 25x, 26x: 4 pieces of 16 pole connectors
Option 23x: 4 pieces of 10 pole + 1 piece of 6 pole connector

280 FIELD BUSES

For more details, see Technical Specification 3.10.

281 Allen-Bradley Remote I/O
Up to 128 digital inputs and outputs, in groups of 32, can be transferred serially to a PLC equipped with an Allen Bradley 1771 RIO node adapter. The unit reduces the number of I/O units that can be mounted in cabinet by one. The field bus cables are connected directly to the A-B RIO unit in the upper part of the cabinet (see Figure 29). Connectors Phoenix MSTB 2.5/xx-ST-5.08 or equivalent are included.

284 Interbus-S Slave
Up to 64 digital inputs and 64 digital outputs can be transferred serially to a PLC equipped with an InterBus-S interface. The unit reduces the number of I/O units that can be mounted in the cabinet by one. The signals are connected directly to the InterBus-S slave unit (two 9-pole D-sub) in the upper part of the cabinet.

286 Profibus DP Slave
Up to 128 digital inputs and 128 digital outputs can be transferred serially to a PLC equipped with a Profibus DP interface. The unit reduces the number of I/O units that can be mounted in cabinet by one. The signals are connected directly to the Profibus DP slave unit (one 9-pole D-sub) in the upper part of the cabinet.

288 Encoder interface unit for conveyor tracking
Conveyor Tracking, or Line Tracking, is the function whereby the robot follows a work object which is mounted on a moving conveyor. The encoder and synchronization switch cables are connected directly to the encoder unit in the upper part of the cabinet (see Figure 29). Screw connector is included. For more information see Product Specification RobotWare.

290 COMMUNICATION

As standard, the robot is equipped with one RS232 (SIO 1) and one RS422 (SIO 2) connector inside the cabinet. The connectors to be used (Phoenix MSTB 2.5/12-ST-5.08) are not included. See Figure 22 and Figure 29.

292 Ethernet (see Figure 23). Connectors: RJ45 and AUI on the board front.

294 Distributed I/O (CAN-bus) connection on the left wall.

390 EXTERNAL AXES DRIVES - INSIDE CABINET

The controller is equipped with drives for external axes. The motors are connected to a standard industrial 64-pin female connector, in accordance with DIN 43652, on the left-hand side of the cabinet. (Male connector is also supplied.)
The transformer 4.5 kVA is replaced with 7.2 kVA.

391 Drive unit T
The drive unit is part of the DC-link. Recommended motor type see Figure 30.

392 Drive unit GT
A separate drive unit including two drives. Recommended motor types see Figure 30.

394 Drive unit T+GT
A combination of 391 and 392.

395 Drive unit C
The drive unit is part of the DC-link. Recommended motor type see Figure 30.

396 Drive unit C+GT
A combination of 395 and 392.

398 Prepared for GT
Transformer 7.2 kVA. No drive units or cables are included.

385 EXTERNAL AXES MEASUREMENT BOARD

The resolver can either be connected to a serial measurement board outside the controller, or to a measurement board inside the cabinet.

386 Serial measurement board inside cabinet
Signal interface to external axes with absolute position at power on. The board is located in the cabinet and occupies one I/O unit slot. The resolvers are connected to a standard industrial 64-pin connector in accordance with DIN 43652, on the left-hand side of the cabinet.

387 Serial measurement board as separate unit

370 EXTERNAL AXES DRIVES - SEPARATE CABINET

If more external axes than in option 390 are to be used, an external cabinet can be supplied. The external cabinet is connected to one Harting connector (cable length 7 m) on the left-hand side of the robot controller.

Door interlock, mains connection, mains voltage and mains filter according to the robot controller. One transformer and one mains switch are included.

37M-O   Drive unit GT, for 2, 4, or 6 motors. Recommended motor types see Figure 30.

37P-Q   Drive unit ECB, for 3 or 6 motors. Recommended motor types see Figure 30.

Drive unit data	Max current	Rated current	Motor type[1]
G	6 - 30A $_{rms}$	16A $_{rms}$	S, M, L
T	7,5 - 37A $_{rms}$	20A $_{rms}$	S, M, L
E	5,5 - 27A$_{rms}$	8,4A$_{rms}$	S, M
C	2,5 - 11A $_{rms}$	5A $_{rms}$	S
B	1,5 - 7A $_{rms}$	4A $_{rms}$	S

1. Motors from ABB Flexible Automation/System Products.
   Types: S=small, M=medium, L=large

Figure 30 Motor selecting table.

420 SERVICE OUTLET

Any of the following standard outlets with protective earthing can be chosen for maintenance purposes.
The maximum load permitted is 500 VA (max. 100 W can be installed inside the cabinet).

421* 230 V mains outlet in accordance with DIN VDE 0620; single socket suitable for Sweden, Germany and other countries.

422* 230 V in accordance with French standard; single socket.

423* 120 V in accordance with British standard; single socket.

424 120 V in accordance with American standard; single socket, Harvey Hubble.

425* Service outlet according to 421 and a computer connection on the front of the cabinet. The computer connection is connected to the RS232 serial channel. Cannot be used if option 142 is chosen.

430 POWER SUPPLY TO SERVICE OUTLETS

431 Connection from the main transformer.
The voltage is switched on/off by the mains switch on the front of the cabinet.

432 Connection before mains switch without transformer.
Note this only applies when the mains voltage is 400 V, three-phase with neutral connection and a 230 V service socket.
Note! Connection before mains switch is not in compliance with some national standards, NFPL 79 for example.

433 Connection before mains switch with an additional transformer for line voltages 400-500 V and with a secondary voltage of 115 V, 4 A or 230 V, 2A.
Note! Connection before mains switch is not in compliance with some national standards, NFPL 79 for example.

439 Earth fault protection for service outlet.
To increase personal safety, the service outlet can be supplied with an earth fault protection which trips at 30 mA earth current. The earth fault protection is placed next to the service outlet (see Figure 29). Voltage range: 110 - 240 V AC.

470 DISK DRIVE COOLING

The disk drive normally works well at temperatures up to 40ºC (104ºF). At higher temperatures a cooling device for the drive is necessary to ensure good functionality. The disk drive will not deteriorate at higher temperatures but there will be an increase in the number of reading/writing problems as the temperature increases.

471 No

472 Yes

620 KIT FOR LIMITING WORKING SPACE

To increase the safety of the robot, the working range of axes 1, 2 and 3 can be restricted.

621 **Axis 1**
The working range of axis 1 can be limited. Using restriction stops, the working range can be limited from $+150^o/-150^o$ to the smallest working range which is $\pm50^o$ The restriction between 50° and 150° can be performed at any position by machining M10 holes and mounting the stops. The kit contains stops, screws and instructions.

622 **Axis 2**
By adding stop lugs, the working range of axis 2 can be restricted to $+50^o$ / -30° (for floor mounted version), -20° / -60° (for inverted mounted version).

623 **Axis 3, Floor mounted (NOT inverted version)**
Axis 3 can be restricted so that it cannot move above the horizontal line, alternatively can move a maximum of 10° above the horizontal line.

630 TEACH PENDANT LIGHTING

The teach pendant is, as standard, equipped with a sharp and clear display without back lighting. Back lighting is available as an option. The cable lenght for the teach pendant is 10 m. For extension cable, see option 660.

632 Without back lighting

631 With back lighting

640 CABLE MANIPULATOR – CONTROLLER

64x Internal connectors
The cables are connected directly to the drive units inside the cabinet via a cable gland on the left-hand side of the controller and to a connector inside the robot base.

65x External connectors
The cables are connected to 64-pin Harting connectors in accordance with DIN 43652, located on the left-hand side of the controller and on the base of the manipulator.

The cables are available in the following lengths:

7 m
15 m
22 m
30 m

660 EXTENSION CABLE FOR THE TEACH PENDANT

66x 10 m
This can be connected between the controller and the connector on the teach pendant's cable. A maximum of two extension cables may be used; i.e. the total length of cable between the controller and the teach pendant should not exceed 30 m. If external control panel (option 182 or 183) with 15 m cable is used, an extension cable is allowed, and the total cable length can be up to 35 m.

680 ADDITIONAL I/O UNITS

I/O units can be delivered separately. The units can then be mounted outside the cabinet or in the cabinet extension. These are connected in a chain to a connector (CAN 3 or CAN 2, see Figure 29) in the upper part of the cabinet. Connectors to the I/O units and a connector to the cabinet (Phoenix MSTB 2.5/xx-ST-5.08), but no cabling, is included. Dimensions according to the figure below. For more details, see section Technical Specification 3.10. External enclosure must provide protection class IP 54 and EMC shielding.

68A-F   Digital I/O 24 V DC: 16 inputs/16 outputs.

68G-H   Analog I/O.

68I-L   AD Combi I/O: 16 digital inputs/16 digital outputs and 2 analog outputs (0-10V).

68M-P   Digital I/O 120 V AC: 16 inputs/16 outputs.

Specification of Variants and Options

68Q-T   Digital I/O with relay outputs: 16 inputs/16 outputs.

68U   Allen Bradley Remote I/O

68V-X   Interbus-S Slave

68Y-Z   Profibus DP Slave
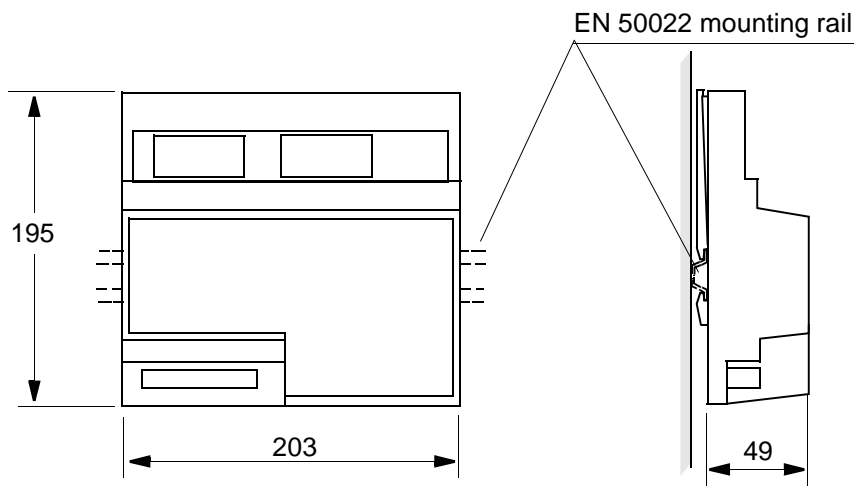
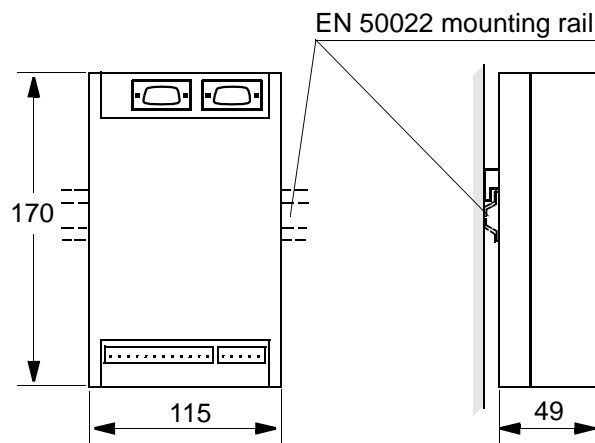**69A-B**   Encoder unit

Figure 31 Dimensions for units 68A-68T.

Figure 32 Dimension for units 68U-Z and 69.

720 EXTRA DOCUMENTATION

Gxy Product Manual IRB 1400, including Product Specification.

5 Accessories

There is a range of tools and equipment available, specially designed for the robot.

Software options for robot and PC

For more information, see Product Specification RobotWare.

Robot Peripherals

- Track Motion
- Tool System
- Motor Units

Accessories

CONTENTS

1 Introduction

RobotWare is a family of software products from ABB Flexible Automation designed to make you more productive and lower your cost of owning and operating a robot.

ABB Flexible Automation has invested many man-years into the development of these products and they represent knowledge and experience based on several thousand robot installations.

Within the RobotWare family there are five classes of products:

BaseWare OS - This is the operating system of the robot and constitutes the kernel of the RobotWare family. BaseWare OS provides all the necessary features for fundamental robot programming and operation. It is an inherent part of the robot but can be provided separately for upgrading purposes.

BaseWare Options - These products are options that run on top of BaseWare OS of the robot. They represent functionality for robot users that need additional functionality, for example run multitasking, transfer information from file to robot, communicate with a PC, perform advanced motion tasks etc.

ProcessWare - ProcessWare products are designed for specific process applications like welding, gluing and painting. They are primarily designed to improve the process result and to simplify installation and programming of applications. These products also run on top of BaseWare OS.

DeskWare - This is a set of Windows-based PC products for a wide range of uses like: creating robot programs, training people on how to use robots, keeping track of robot programs and on-line documentation. The purpose is to lower the indirect cost of owning a robot.

FactoryWare - By combining the power of PCs with robots, the possibilities are almost unlimited. The FactoryWare products are intended to be used in PCs connected to robots, on the factory floor or in the office. These tools can be typically used for such things as programmable operator interfaces, work monitoring or cell supervision.

2 BaseWare OS

Only a very superficial overview of BaseWare OS is given here. For details, see references in *Robot Documentation*.

The properties of BaseWare OS can be split up in five main areas: The Rapid Language and Environment; Exception handling; Motion Control; Safety; the I/O System.

2.1 The Rapid Language and Environment

The Rapid language is a well balanced combination of simplicity, flexibility and powerfulness. It contains the following concepts:

- Hierarchical and modular program structure to support structured programming and reuse.

- Routines can be Functions or Procedures.

- Local or global data and routines.

- Data typing, including structured and array data types.

- User defined names (shop floor language) on variables, routines and I/O.

- Extensive program flow control.

- Arithmetic and logical expressions.

- Interrupt handling.

- Error handling (for exception handling in general, see *Exception handling*).

- User defined instructions (appear as an inherent part of the system).

- Backward handler (user definition of how a procedure should behave when stepping backwards).

- Many powerful built-in functions, e.g mathematics and robot specific.

- Unlimited language (no max. number of variables etc., only memory limited).

- Windows based man machine interface with built-in Rapid support (e.g. user defined pick lists).

2.2 Exception handling

Many advanced features are available to make fast error recovery possible. Characteristic is that the error recovery features are easy to adapt to a specific installation in order to minimise down time. Examples:

- Error Handlers (automatic recovery often possible without stopping production).

- Restart on Path.

- Power failure restart.

- Service routines.

- Error messages: plain text with remedy suggestions, user defined messages.

- Diagnostic tests.

- Event logging.

2.3 Motion Control

TrueMove™

Very accurate path and speed, based on advanced dynamic modelling. Speed independent path. Flexible and intuitive way to specify corner zones (e.g. possibility to have separate zone sizes for Tool Centre Point (TCP) path and for tool reorientation).

QuickMove™

By use of the dynamic model, the robot always and automatically optimises its performance for the shortest possible cycle time. No need for manual tuning! This is achieved without compromising the path accuracy.

Coordinate Systems

A very powerful concept of multiple coordinate systems that facilitates jogging, program adjustment, copying between robots, off-line programming, sensor based applications, external axes co-ordination etc. Full support for TCP attached to the robot or fixed in the cell ("Stationary TCP"). Note that also joint coordinate movements (MoveJ) are recalculated when a coordinate system is adjusted.

Singularity handling

The robot can pass through singular points in a controlled way, i.e. points where two axes coincide.

Motion Supervision

The behaviour of the motion system is continuously monitored as regards position and speed level to detect abnormal conditions and quickly stop the robot if something is not OK. A further monitoring function, Collision Detection, is optional (see option "Load Identification and Collision Detection").

External axes

Very flexible possibilities to configure external axes. Includes for instance high performance coordination with robot movement and shared drive unit for several axes.

Big Inertia

One side effect of the dynamic model concept is that the system can handle very big load inertias by automatically adapting the performance to a suitable level. For big, flexible objects it is possible to optimise the servo tuning to minimise load oscillation.

Motion Control

Soft Servo

Any axis (also external) can be switched to soft servo mode, which means that it will adopt a spring-like behaviour.

2.4 Safety

Many safety concepts reside in hardware and are not within the scope of this document. However, some important software contributions will be mentioned:

Reduced Speed

In the reduced speed mode, the controller limits all parts of the robot body, the TCP and one user defined point (attached to the upper arm) to 250 mm/s (can be set lower). This limitation also works in joint system motion.

Motion Supervision

See *Motion Control*.

Authorisation

It is possible to limit the access to certain commands by assigning different passwords to four different user levels (operator, service, programmer, service & programmer). It is possible to define the commands available at the different levels.

Limited modpos

It is possible to limit the allowed distance/rotation when modifying positions.

2.5 I/O System

Elementary I/O

Robust and fast distributed system built on CAN/DeviceNet with the following features:

- Named signals and actions with mapping to physical signal ("gripper close" instead of "set output 1").
- Flexible cross connections.
- Up to 512 signals available (one signal = single DI or DO, group of DI or DO, AI or AO).
- Grouping of signals to form integer values.
- Sophisticated error handling.
- Selectable "trust level" (i.e. what action to take when a unit is "lost").
- Program controlled enabling/disabling of I/O units.
- Scaling of analog signals.
- Filtering.
- Polarity definition.
- Pulsing.
- TCP-proportional analog signal.
- Programmable delays.
- Simulated I/O (for forming cross connections or logical conditions without need the for physical hardware).
- Accurate coordination with motion.

Serial I/O

XON/XOFF or SLIP.

Memory I/O

RAM disk and floppy disk.

3 BaseWare Options

3.1 Advanced Functions 3.1

Includes functions making the following possible:

- Information transfer via serial channels or files.

- Setting an output at a specific position.

- Executing a routine at a specific position.

- Defining forbidden areas within the robot´s working space.

- Automatic setting of output when the robot is in a user-defined area.

- Robot motion in an error handler or trap routine, e.g. during automatic error handling.

- Cross connections with logical conditions.

Transferring information via serial channels

Data in the form of character strings, numeric values or binary information can be transferred between the robot and other peripheral equipment, e.g. a PC, bar code reader, or another robot. Information is transferred via an RS232 or RS485 serial channel.

Examples of applications:

- Printout of production statistics on a printer connected to the robot.

- Reading part numbers from a bar code reader with a serial interface.

- Transferring data between the robot and a PC.

The transfer is controlled entirely from the robot's work program. When it is required to control the transfer from a PC, use the option *RAP Communication* or *FactoryWare Interface*.

Data transfer via files

Data in the form of character strings, numerical values or binary information can be written to or read from files on a diskette or other type of mass storage/memory.

Examples of applications:

- Storing production statistics on a diskette or ramdisk. This information can then be read and processed by an ordinary PC.

- The robot's production is controlled by a file. This file may have been created in a PC, stored on a diskette, and read by the robot at a later time.

Fixed position output

The value of an output (digital, analog or a group of digitals) can be ordered to change at a certain distance before or after a programmed position. The output will then change at the same place every time, irrespective of the robot's speed.

Consideration can also be given to time delays in the process equipment. By specifying this time delay (max. 500 ms), the output is set at the corresponding time before the robot reaches the specified position.

The distance can also be specified as a certain time before the programmed position. This time must be within the deceleration time when approaching that position.

Examples of applications:

- Handling press work, to provide a safe signalling system between the robot and the press, which will reduce cycle times. Just as the robot leaves the press, an output is set that starts the press.

- Starting and finishing process equipment. When using this function, the start will always occur at the same position irrespective of the speed. For gluing and sealing, see *GlueWare*.

Fixed position procedure call

A procedure call can be carried out when the robot passes the middle of a corner zone. The position will remain the same, irrespective of the robot's speed.

Example of application:

- In the press example above, it may be necessary to check a number of logical conditions before setting the output that starts the press. A procedure which takes care of the complete press start operation is called at a position just outside the press.

World Zones

A spherical, cylindrical or cubical volume can be defined within the working space. When the robot reaches this volume it will either set an output or stop with the error message "Outside working range", both during program execution and when the robot is jogged into this area. The areas, which are defined in the world coordinate system, can be automatically activated at start-up or activated/deactivated from within the program.

Examples of applications:

- A volume is defining the home position of the robot.
  When the robot is started from a PLC, the PLC will check that the robot is inside the home volume, i.e. the corresponding output is set.

- The volume is defining where peripheral equipment is located within the working space of the robot.
  This ensures that the robot cannot be moved into this volume.

- A robot is working inside a box.
  By defining the outside of the box as a forbidden area, the robot cannot run into the walls of the box.

- Handshaking between two robots both working in the same working space.
  When one of the robots enters the common working space, it sets an output and after that enters only when the corresponding output from the other robot is reset.

Movements in interrupt routines and error handlers

This function makes it possible to temporarily interrupt a movement which is in progress and then start a new movement which is independent of the first one. The robot stores information about the original movement path which allows it to be resumed later.

Examples of applications:

- Cleaning the welding gun when a welding fault occurs. When a welding fault occurs, there is normally a jump to the program's error handler. The welding movement in progress can be stored and the robot is ordered to the cleaning position so that the nozzle can be cleaned. The welding process can then be restarted, with the correct parameters, at the position where the welding fault occurred. This is all automatic, without any need to call the operator. (This requires options *ArcWare* or *ArcWare Plus*.)

- Via an input, the robot can be ordered to interrupt program execution and go to a service position, for example. When program execution is later restarted (manually or automatically) the robot resumes the interrupted movement.

Cross-connections with logical conditions

Logical conditions for digital input and output signals can be defined in the robot's system parameters using AND, OR and NOT. Functionality similar to that of a PLC can be obtained in this way.

Example:

- Output 1 = Input 2 AND Output 5.

- Input 3 = Output 7 OR NOT Output 8.

Examples of applications:

- Program execution to be interrupted when both inputs 3 and 4 become high.

- A register is to be incremented when input 5 is set, but only when output 5=1 and input 3=0.

Product Specification RobotWare for BaseWare OS 3.1

RAPID instructions and functions included in this option

Open	Opens a file or serial channel
Close	Closes a file or serial channel
Write	Writes to a character-based file or serial channel
WriteBin	Writes to a binary file or serial channel
WriteStrBin	Writes a string to a binary serial channel
ReadNum	Reads a number from a file or serial channel
ReadStr	Reads a string from a file or serial channel
ReadBin	Reads from a binary file or serial channel
Rewind	Rewind file position
WZBoxDef	Define a box shaped world zone
WZCylDef	Define a cylinder shaped world zone
WZLimSup	Activate world zone limit supervision
WZSphDef	Define a sphere shaped world zone
WZDOSet	Activate world zone to set digital output
WZDisable	Deactivate world zone supervision
WZEnable	Activate world zone supervision
WZFree	Erase world zone supervision
StorePath	Stores the path when an interrupt or error occurs
RestoPath	Restores the path after an interrupt/error
TriggC	Position fix output/interrupt during circular movement
TriggL	Position fix output/interrupt during linear movement
TriggJ	Position fix output/interrupt during joint movement
TriggIO	Definition of trigger conditions for one output
TriggEquip	Definition of trigger conditions for process equipment with time delay
TriggInt	Definition of trigger conditions for an interrupt
MoveCSync	Position fix procedure call during circular movement
MoveLSync	Position fix procedure call during linear movement
MoveJSync	Position fix procedure call during join movement

3.2 Advanced Motion 3.1

Contains functions that offer the following possibilities:

- Resetting the work area for an axis.

- Independent movements.

- Contour tracking.

- Coordinated motion with external manipulators.

Resetting the work area for an axis

The current position of a rotating axis can be adjusted a number of complete turns without having to make any movements.

Examples of applications:

- When polishing, a large work area is sometimes needed on the robot axis 4 or axis 6 in order to be able to carry out final polishing without stopping. Assume that the axis has rotated 3 turns, for example. It can now be reset using this function, without having to physically rotate it back again. Obviously this will reduce cycle times.

- When arc welding, the work object is often fitted to a rotating external axis. If this axis is rotated more than one turn during welding, the cycle time can be reduced because it is not necessary to rotate the axis back between welding cycles.

Coordinated motion with multi-axis manipulators

Coordinated motion with multi-axis manipulators or robot carriers (gantries) requires the Advanced Motion option. Note that simultaneous coordination with several single axis manipulators, e.g. track motion and workpiece manipulator, does not require Advanced Motion.

Note! There is a built-in general method for defining the geometry for a manipulator comprising two rotating axes (see User's Guide, *Calibration*). For other types of manipulators/robot carriers, comprising up to six linear and/or rotating axes, a special configuration file is needed. Please contact your nearest ABB Flexible Automation Centre.

Contour tracking

Path corrections can be made in the path coordinate system. These corrections will take effect immediately, also during movement between two positions. The path corrections must be entered from within the program. An interrupt or multitasking is therefore required to activate the correction during motion.

Example of application:

- A sensor is used to define the robot input for path correction during motion. The input can be defined via an analog input, a serial channel or similar. Multitasking or interrupts are used to read this information at specific intervals. Based on the input value, the path can then be adjusted.

Independent movements

A linear or rotating axis can be run independently of the other axes in the robot system. The independent movement can be programmed as an absolute or relative position. A continuous movement with a specific speed can also be programmed.

Examples of applications:

- A robot is working with two different stations (external axes). First, a work object located at station 1 is welded. When this operation is completed, station 1 is moved to a position where it is easy to change the work object and at the same time the robot welds the work object at station 2. Station 1 is moved independently of the robot's movement, which simplifies programming and reduces the cycle time.

- The work object is located on an external axis that rotates continuously at a constant speed. In the mean time, the robot sprays plasma, for example, on the work object. When this is finished the work area is reset for the external axis in order to shorten the cycle time.

Friction Compensation

During low speed (10-100 mm/s) cutting of fine profiles, in particular small circles, a friction effect, typically in the form of approximately 0.5 mm "bumps", can be noted. Advanced Motion offers a possibility of compensating for these frictional effects. Typically a 0.5 mm "bump" can be reduced to about 0.1 mm. This, however, requires careful tuning of the friction level (see User's Guide for tuning procedure). Note that even with careful tuning, there is no guarantee that "perfect" paths can always be generated.

For the IRB 6400 family of robots, no significant effects can be expected by applying Friction Compensation.

Advanced Motion 3.1

External Drive System

With Advanced Motion, the possibility to connect off-the-shelf standard drive systems for controlling external axes is available. This can be of interest, for example, when the power of the available S4C drives does not match the requirements.

There are two alternatives:

- The Atlas Copco Controls´ stand alone servo amplifier DMC.

- The Atlas Copco Controls´ FBU (Field Bus Unit) that can handle up to three external drive units per FBU unit.
  These can be connected to analog outputs (+/- 10 V) or a field bus.
  The drive board can thus be of virtually any make and type.

For further information about DMC and FBU, please contact Atlas Copco Controls.

NOTE! The DMC/FBU must be equipped with Atlas Copco Controls option C.

RAPID instructions and functions included in this option

IndReset	Resetting the work area for an axis
IndAMove	Running an axis independently to an absolute position
IndDMove	Running an axis independently for a specified distance
IndRMove	Running an axis independently to a position within one revolution, without taking into consideration the number of turns the axis had rotated earlier
IndCMove	Running an axis continuously in independent mode
IndInpos	Checking whether or not an independent axis has reached the programmed position
IndSpeed	Checking whether or not an independent axis has reached the programmed speed
CorrCon	Activating path correction
CorrWrite	Changing path correction
CorrRead	Read current path correction
CorrDiscon	Deactivating path correction
CorrClear	Removes all correction generators

Product Specification RobotWare for BaseWare OS 3.1

3.3 Multitasking 3.1

Up to 10 programs (tasks) can be executed in parallel with the normal robot program.

- These additional tasks start automatically at power on and will continue until the robot is powered off, i.e. even when the main process has been stopped and in manual mode.
- They are programmed using standard RAPID instructions, except for motion instructions.
- They can be programmed to carry out various activities in manual or automatic mode, and depending on whether or not the main process is running.
- Communication between tasks is carried out via I/O or global data.
- Priorities can be set between the processes.

Examples of applications:

- The robot is continuously monitoring certain signals even when the robot program has stopped, thus taking over the job traditionally allocated to a PLC.
- An operator dialogue is required at the same time as the robot is doing, for example, welding. By putting this operator dialogue into a background task, the operator can specify input data for the next work cycle without having to stop the robot.
- The robot is controlling a piece of external equipment in parallel with the normal program execution.

Performance

When the various processes are programmed in the correct way, no performance problems will normally occur:

- When the priorities for the various processes are correctly set, the normal program execution of the robot will not be affected.
- Because monitoring is implemented via interrupts (instead of checking conditions at regular intervals), processor time is required only when something actually happens.
- All input and output signals are accessible for each process.

Note that the response time of Multitasking does not match that of a PLC. Multitasking is primary intended for less demanding tasks.

The available program memory can be divided up arbitrarily between the processes. However, each process in addition to the main process will reduce the total memory, see section 5.1.

3.4 FactoryWare Interface 3.1

This option enables the robot system to communicate with a PC using RobComm 3.0 or later versions (see *FactoryWare*). The FactoryWare Interface 3.1 serves as a run-time license for RobComm, i.e. the PC does not require any license protection when executing a RobComm based application. However, when developing such an application, a hardware lock and password are needed in the PC (design time license).

Older versions of RobComm will require RAP Communication in the robot and license protection in the PC (hardware lock and password for design and run-time, or only password for only run-time).

This option will also work with RobView 3.1/1 or DDE Server 2.3/1 (or later versions). Older versions work only with RAP Communication. In all cases RobView and DDE Server will require the hardware lock and password.

The Factory Ware Interface 3.1 includes the Robot Application Protocol (RAP), based on MMS functionality. The Robot Application Protocol is used for computer communication. The following functions are supported:

- Start and stop program execution

- Transfer programs to/from the robot

- Transfer system parameters to/from the robot

- Transfer files to/from the robot

- Read the robot status

- Read and write data

- Read and write output signals

- Read input signals

- Read error messages

- Change robot mode

- Read logs

RAP communication is available both for serial links and network, as illustrated by the figure below.

Product Specification RobotWare for BaseWare OS 3.1
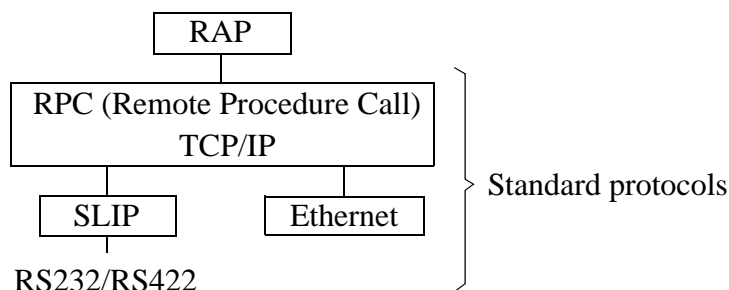
Examples of applications:

- Production is controlled from a superior computer. Information about the robot status is displayed by the computer. Program execution is started and stopped from the computer, etc.

- Transferring programs and parameters between the robot and a PC. When many different programs are used in the robot, the computer helps in keeping track of them and by doing back-ups.

- Programs can be transferred to the robot's ramdisk at the same time as the robot executes its normal program. When execution of this program has finished, the new program can be read very quickly from the ramdisk and program execution can continue. In this way a large number of programs can be handled and the robot's memory does not have to be so big.

RAPID instruction included in this option

SCWrite   Sends a message to the computer (using RAP)

3.5 RAP Communication 3.1

This option is required for all communication with a superior computer, where none of the FactoryWare products RobComm, RobView, or DDE Server, are used. It includes the same functionality described for the option Factory Ware Interface 3.1.

It also works for the FactoryWare products. For RobView and DDE Server, there is no difference from the FactoryWare Interface (except that the price is higher). For RobComm, in this case a license protection requirement in the PC is added.

Note that both FactoryWare Interface and RAP Communication can be installed simultaneously.

3.6 Ethernet Services 3.1

Information in mass storage, e.g. the hard disk in a PC, can be read directly from the robot. The robot control program can also be booted via Ethernet instead of using diskettes. This requires Ethernet hardware in the robot.

Examples of applications:

- All programs for the robot are stored in the PC. When a new part is to be produced, i.e. a new program is to be loaded, the program can be read directly from the hard disk of the PC. This is done by a manual command from the teach pendant or an instruction in the program. If the option RAP Communication or FactoryWare Interface is used, it can also be done by a command from the PC (without using the ramdisk as intermediate storage).

- Several robots are connected to a PC via Ethernet. The control program and the user programs for all the robots are stored on the PC. A software update or a program backup can easily be executed from the PC.

3.7 Load Identification and Collision Detection 3.1 (LidCode)

This option is only available for the IRB 6400 family of robots. LidCode contains two very useful features:

Load Identification

To manually calculate or measure the load parameters accurately can be very difficult and time consuming. Operating a robot with inaccurate load parameters can have a detrimental influence on cycle time and path accuracy.

With LidCode, the robot can carry out accurate identification of the complete load data (mass, centre of gravity, and three inertia components). If applicable, tool load and payload are handled separately.

The identification procedure consists of limited predefined movements of axes 3, 5 and 6 during approximately three minutes. The starting point of the identification motion pattern can be chosen by the user so that collisions are avoided.

The accuracy achieved is normally better than 5%.

Collision Detection

Abnormal torque levels on any robot axis (not external axes) are detected and will cause the robot to stop quickly and thereafter back off to relieve forces between the robot and environment.

Tuning is normally not required, but the sensitivity can be changed from Rapid or manually (the supervision can even be switched off completely). This may be necessary when strong process forces are acting on the robot.

The sensitivity (with default tuning) is comparable to the mechanical alternative (mechanical clutch) and in most cases much better. In addition, LidCode has the advantages of no added stick-out and weight, no need for connection to the e-stop circuit, no wear, the automatic backing off after collision and, finally, the adjustable tuning.

Two system outputs reflect the activation and the trig status of the function.

RAPID instructions included in this option

MotionSup	Changing the sensitivity of the collision detection or activating/deactivating the function.
ParIdRobValid	Checking that identification is available for a specific robot type.
ParIdPosValid	Checking that the current position is OK for identification.
LoadId	Performing identification.

3.8 ScreenViewer 3.1

This option adds a user window to display user defined screens with advanced display functions. The user window can be displayed at any time, regardless of the execution state of the RAPID programs.

User defined screens

The user defined screens are composed of:

- A fixed background with a size of 12 lines of 40 characters each. These characters can be ASCII and/or horizontal or vertical strokes (for underlining, separating or framing).
- 1 to 5 function keys.
- 1 to 4 pop-up menus containing from 1 to 10 choices.
- 1 to 30 display and input fields defined by:
    - Their position and size.
    - Their type (display, input).
    - Their display format (integer, decimal, binary, hexadecimal, text).
    - A possible boundary with minimum and maximum limits.

Example of a user defined screen. The ### represent the fields.

```
 SpotTim                 File                  View

 Program number: ###              Heat stepper: ###
                                   interpolated: ##

                 | CURENT (A) |
 PHASES    | T  | START | END  | Tolerance: ###%
 SQUEEZE   | ## |       |      | Force: ###daN
 PREHEAT   | ## | #### |       | Forge: ###daN
 COOLING   | ## |       | #### |
 ## HEAT   | ## | #### |       | Fire chck: ###
 COLD      | ## |       |      |
 LASTCOLD  | ## |       |      | Err allow: ###%
 POSTHEAT  | ## | #### | #### | Numb err: ###
 HOLD      | ## |       |      |


   Next           Prev.    (Copy)       Valid
```

ScreenViewer 3.1

Advanced Display functions

The user defined screens run independently of the RAPID programs.

Some events occur on a screen (new screen displayed, menu choice selected, function key pressed, field modified, ...). A list of user screen commands can be associated with any of these events, then when the event occurs, the command list will be executed.

A screen event can occur

- When a new screen is displayed (to initialize the screen contents).

- After a chosen interval (to refresh a screen).

- When a menu choice or a function key is selected (to execute a specific action, or change the screen).

- When a new value is entered in a field, or when a new field is selected (to execute some specific action).

The commands that can be executed on screen events are

- Reading/writing RAPID or I/O data.

- Reading/writing fields contents.

- Arithmetical (+, -, /, *, div) or logical (AND, OR, NOT, XOR) operations on the data read.

- Comparing data read (=, <, >) and carrying out a command or not, depending on the comparison result.

- Displaying a different screen.

Capacities

The user screens can be grouped in a screen package file under a specific name. Up to 8 packages can be loaded at the same time.

A certain amount of memory (approx. 50 kbytes) is reserved for loading these screen packages.

- The screen package to be displayed is selected using the far right hand menu "View" (which shows a list of the screen packages installed).

3.9 Conveyor Tracking 3.1

Conveyor Tracking (also called Line Tracking) is the function whereby the robot follows a work object which is mounted on a moving conveyor. While tracking the conveyor, the programmed TCP speed relative to the work object will be maintained, even when the conveyor speed is changing slowly.

Note that hardware components for measuring the conveyor position are also necessary for this function. Please refer to the Product Specification for your robot.

Conveyor Tracking provides the following features:

- A conveyor can be defined as either linear or circular.

- It is possible to have two conveyors connected simultaneously and to switch between tracking the one or the other.

- Up to 254 objects can reside in an object queue which can be manipulated by RAPID instructions.

- It is possible to define a start window in which an object must be before tracking can start.

- A maximum tracking distance may be specified.

- If the robot is mounted on a parallel track motion, then the system can be configured such that the track will follow the conveyor and maintain the relative position to the conveyor.

- Tracking of a conveyor can be activated "on the fly", i.e. it is not necessary to stop in a fine point.

Performance

At 150 mm/s constant conveyor speed, the TCP will stay within +/-2 mm of the path as seen with no conveyor motion. When the robot is stationary relative to the conveyor, the TCP will remain within 0.7 mm of the intended position.

These values are valid as long as the robot is within its dynamic limits with the added conveyor motion and they require accurate conveyor calibration.

RAPID instructions included in this option

WaitWObj	Connects to a work object in the start window
DropWObj	Disconnects from the current object

3.10 I/O Plus 3.1

I/O Plus enables the S4C to use non-ABB I/O units. The following units are supported:

- Wago modules with DeviceNet fieldbus coupler, item 750-306 revision 3.

- Lutze IP67 module DIOPLEX-LS-DN 16E 744-215 revision 2
  (16 digital input signals).

- Lutze IP67 module DIOPLEX-LS-DN 8E/8A 744-221 revision 1
  (8 digital input signals and 8 digital output signals).

For more information on any of these untis, please contact the supplier.

The communication between these units and S4C has been verified (this does not, however, guarantee the internal functionality and quality of the units). Configuration data for the units is included.

In I/O Plus there is also support for a so-called "Welder". This is a project specific spot welding timer, and is not intended for general use.

In addition to the above units, the I/O Plus option also opens up the possibility to use other digital I/O units that conform with the DeviceNet specification. ABB Robotics Products AB does not assume any responsibility for the functionality or quality of such units. The user must provide the appropriate configuration data.

4 ProcessWare

4.1 ArcWare 3.1

ArcWare comprises a large number of dedicated arc welding functions, which make the robot well suited for arc welding. It is a simple yet powerful program since both the positioning of the robot and the process control and monitoring are handled in one and the same instruction.

I/O signals, timing sequences and weld error actions can be easily configured to meet the requirements of a specific installation.

ArcWare functions

A few examples of some useful functions are given below.

Adaptation to different equipment

The robot can handle different types of weld controllers and other welding equipment. Normally communication with the welding controller uses parallel signals but a serial interface is also available.

Advanced process control

Voltage, wire feed rate, and other process data can be controlled individually for each weld or part of a weld. The process data can be changed at the start and finish of a welding process in such a way that the best process result is achieved.

Testing the program

When testing a program, welding, weaving or weld guiding can all be blocked. This provides a way of testing the robot program without having the welding equipment connected.

Automatic weld retry

A function that can be configured to order one or more automatic weld retries after a process fault.

Weaving

The robot can implement a number of different weaving patterns up to 10 Hz depending on robot type. These can be used to fill the weld properly and in the best possible way. Weaving movement can also be ordered at the start of the weld in order to facilitate the initial striking of the arc.

Wire burnback and rollback

These are functions used to prevent the welding wire sticking to the work object.

Fine adjustment during program execution

The welding speed, wire feed rate, voltage and weaving can all be adjusted whilst welding is in progress. This makes trimming of the process much easier because the result can be seen immediately on the current weld. This can be done in both manual and automatic mode.

Weld Guiding

Weld guiding can be implemented using a number of different types of sensors. Please contact your nearest ABB Flexible Automation Centre for more information.

Interface signals

The following process signals are, if installed, handled automatically by ArcWare. The robot can also support dedicated signals for workpiece manipulators and sensors.

Digital outputs	Description
Power on/off	Turns weld on or off
Gas on/off	Turns gas on or off
Wire feed on/off	Turns wire feed on or off
Wire feed direction	Feeds wire forward/backward
Weld error	Weld error
Error information	Digital outputs for error identification
Weld program number	Parallel port for selection of program number, or 3-bit pulse port for selection of program number, or Serial CAN/Devicenet communication

Digital inputs	Description
Arc OK	Arc established; starts weld motion
Voltage OK	Weld voltage supervision
Current OK	Weld current supervision
Water OK	Water supply supervision
Gas OK	Gas supply supervision
Wire feed OK	Wire supply supervision
Manual wire feed	Manual command for wire feed
Weld inhibit	Blocks the welding process
Weave inhibit	Blocks the weaving process
Stop process	Stops/inhibits execution of arc welding instructions
Wirestick error	Wirestick supervision
Supervision inhibit	Program execution without supervision
Torch collision	Torch collision supervision

Analog outputs	Description
Voltage	Weld voltage
Wire feed	Velocity of wire feed
Current	Weld current
Voltage adjustment	Voltage synergic line amplification
Current adjustment	Current synergic line amplification

Analog inputs (cont.)	Description (cont.)
Voltage	Weld voltage measurement for monitoring and supervision
Current	Weld current measurement for monitoring and supervision

RAPID instructions included in this option

ArcL	Arc welding with linear movement
ArcC	Arc welding with circular movement

4.2   ArcWare Plus 3.1

ArcWare Plus contains the following functionality:

- ArcWare, see previous chapter.

- Arc data monitoring.
  Arc data monitoring with adapted RAPID instructions for process supervision.
  The function predicts weld errors.

- Contour tracking.
  Path corrections can be made in the path coordinate system. These corrections
  will take effect immediately, also during movement between two positions. The
  path corrections must be entered from within the program. An interrupt or mul-
  titasking is therefore required to activate the correction during motion.

  Example of application:

  A sensor is used to define the robot input for path correction during motion. The
  input can be defined via an analog input, a serial channel or similar. Multitask-
  ing or interrupts are used to read this information at specific intervals. Based on
  the input value, the path can then be adjusted.

- Adaptive process control.
  Adaptive process control for LaserTrak and Serial Weld Guide systems. The
  tool provides the robot system with changes in the shape of the seam. These val-
  ues can be used to adapt the process parameters to the current shape.

RAPID instructions and functions included in this option

ArcKill	Aborts the process and is intended to be used in error handlers
ArcRefresh	Updates the weld references to new values
CorrCon	Activating path correction
CorrWrite	Changing path correction
CorrRead	Read current path correction
CorrDiscon	Deactivating path correction
CorrClear	Removes all correction generators
SpcCon	Activates statistical process supervision
SpcWrite	Provides the controller with values for statistical process supervision
SpcDump	Dumps statistical process supervision data to a file or on a serial channel
SpcRead	Reads statistical process supervision information
SpcDiscon	Deactivates statistical process supervision

4.3 SpotWare 3.1

SpotWare comprises a large number of dedicated spot welding functions which make the robot well suited for spot welding. It is a simple yet powerful program since both the positioning of the robot and the process control and monitoring are handled in one and the same instruction.

Cycle times can be shortened by means of closing the spot welding gun in advance, together with the fact that movement can commence immediately after a spot weld is completed. The robot's self-optimising motion control, which results in fast acceleration and a quick approach to the spot weld, also contributes to making cycle times shorter.

I/O signals, timing sequences and weld error actions can be easily configured to meet the requirements of a specific installation.

SpotWare functions

A few examples of some useful functions are given below.

Adaptation to different welding guns

Gun control (opening and closing) can be programmed freely to suit most types of guns, irrespective of the signal interface.

Adaptation to different weld timers

The robot can handle different types of weld timers. Normally communication with the weld timer uses parallel signals but a serial interface is also available for some types of weld timers.

Continuous supervision of the welding equipment

If the option Multitasking is added, supervision can be implemented irrespective of the spotweld instruction. For example, it is possible to monitor peripheral equipment even when program execution has been stopped.

Closing the gun

It is possible to start closing the spot welding gun before reaching the programmed point. By defining a time of closure, the gun can be closed correctly regardless of the speed of the robot. The cycle time is optimised when the gun is just about to close at the instant when the robot reaches the programmed point.

Constant squeeze time

Welding can be started directly as the gun closes, i.e. without waiting for the robot to reach its final position. This gives a constant time between gun closure and weld start.

Customised Move enable

The movement after a completed spot weld can be configured to start either on a user defined input signal or a delay time after weld ready.

Immediate move after Move enable

The robot moves immediately when enable is given. This is achieved by preparing the next action while waiting for the current weld to be completed.

Gun control

The system supports double guns, small and large strokes and gun pressure control. Several guns can be controlled in the same program.

Testing the program

The program can be run one instruction at a time, both forwards and backwards. When it is run backwards, only motion instructions, together with an inverted gun movement, are executed. The program can also be test run without connecting a weld timer or spot welding gun. This makes the program easier to test.

Rewelds

A function that can be configured to order one or more automatic rewelds or, when the program is restarted after an error, a manual reweld.

Process error routines

In the event of a process error, installation-specific routines, such as go-to-service position, can be ordered manually. When the appropriate routine has been performed, the weld cycle continues from where it was interrupted.

Manual welding independent of positioning

A spot weld can be ordered manually at the current robot position. This is implemented in a similar way as for program execution, i.e. with gun control and process supervision. It is also possible to order a separate gun control with full supervision.

Interface signals

The following process signals are, if installed, handled automatically by SpotWare.

Digital outputs	Description
start 1	start signal to the weld timer (tip 1)
start 2	start signal to the weld timer (tip 2)
close tip 1	close gun (tip 1)
close tip 2	close gun (tip 2)
work select	select work or retract stroke of the gun
program parity	weld program parity bit
reset fault	reset the weld timer
process error	operator request is set when an error occurs
current enable	weld inhibit to the weld timer
p2 request	set pressure 2
p3 request	set pressure 3
p4 request	set pressure 4
weld power	activate the weld power unit contactor
water start	activate water cooling

manual close gun	close gun manually
manual open gun	open gun manually
manual run process	run a complete spot weld
manual skip process	skip the ongoing action
manual new data	send data for the manual actions
process run	process is executed
inhibit move	block spot welding movement
weld error	weld ready timeout

Digital output groups	**Description**
program no.	weld program number
initiate	used for several weld timers

Digital inputs	**Description**
weld ready 1	weld, started with start 1, is finished
weld ready 2	weld, started with start 2, is finished
tip 1 open	the gun (tip 1) is open
tip 2 open	the gun (tip 2) is open
tip 1 retract	the gun (tip 1) opened to retract stroke
tip 2 retract	the gun (tip 2) opened to retract stroke
p1 OK	pressure 1 is reached
p2 OK	pressure 2 is reached
p3 OK	pressure 3 is reached
p4 OK	pressure 4 is reached
timer OK	the weld timer is ready to weld
flow OK	no problem with the water supply
temp OK	no over-temperature
current OK	the weld current is within permissible tolerances

User defined routines

The following routines are predefined but can be adapted to suit the current installation.

Routine	**Description**
preweld supervision	supervision to be done before welding
postweld supervision	supervision to be done after welding
init supervision	supervision to be done for a warm start
motor on action	action to be taken for Motors On
motor off action	action to be taken for Motors Off
process OK action	action to be taken for welding sensor OK
process error action	action to be taken for a process error
current enable action	action to be taken for current enable
current disable action	action to be taken for current disable
close gun	definition of gun closing
open gun	definition of gun opening
set pressure	definition of gun pressure setting
service close gun	error handling when gun pressure is not achieved
service open gun	error handling at timeout for gun opening
service weld fault	error handling at timeout for weld-ready signal

The option *Advanced functions* is included.

SpotWare 3.1

RAPID instructions included in this option

SpotL   Spot welding with linear movement

4.4 SpotWare Plus 3.1

In addition to the SpotWare functionality the robot can weld with up to four stationary welding guns simultaneously.

RAPID instructions included in this option

SpotML   Multiple spot welding with linear movement.

4.5 GlueWare 3.1

GlueWare comprises a large number of dedicated gluing functions which make the robot well suited for gluing and sealing. It is a simple yet powerful program since both the positioning of the robot and the process control are handled in one and the same instruction.

I/O signals and timing sequences can be easily configured to meet the requirements of a specific installation.

GlueWare functions

A few examples of some useful functions are given below.

Adaptation to different gluing guns

Both on/off guns and proportional guns can be handled. Furthermore, time delays can be specified for the gluing guns in order to obtain the correct thickness of glue or sealing compound and application at the specified time.

Two gluing guns

One or two gluing guns can be controlled. Up to two analog outputs can be controlled for each gun.

Velocity independent glue string thickness

The thickness of the glue string can be made independent on the robot's velocity by controlling the gluing gun with a signal that reflects the robot's velocity. When the robot velocity is reduced, the flow of glue will be automatically reduced. The robot can compensate for a gun delay of up to 500 ms, thanks to a proactive signal.

Flow change at a specific position

Flow changes (incl. start and stop) can be put into the programmed path, also where there are no programmed positions. These positions will remain fixed even when the velocity is changed, which makes the programming much simpler.

Global flow changes

The glue flow can be changed for the whole program just by changing one value.

Program testing without glue

Gluing can be temporarily blocked in order to be able to test the robot's movements without any glue flow.

Interface signals

When installed, the following process signals are handled automatically by GlueWare.

Analog outputs	Description
gun1 flow1	Glue flow reference gun 1
gun1 flow 2	Glue flow reference gun 1
gun2 flow1	Glue flow reference gun 2
gun2 flow 2	Glue flow reference gun 2

Digital outputs	Description
gun 1 on/off	glue off/on gun1
gun 2 on/off	glue off/on gun 2
overspeed error	the calculated value of an analog output signal is greater than its logical max. value
process error	error during gluing

User defined routines

The following routines are predefined but can be adapted to suit the current installation.

Routine	Description
preglue actions	activity to be carried out in the beginning of the glue string
postglue actions	activity to be carried out at the end of the glue string
power on action	activity to be carried out at power-on
restart action	activity to be carried out at program start
stop action	activity to be carried out at program stop
emergency stop action	activity to be carried out in the event of an emergency stop or other safeguarded space stop

The option *Advanced functions* is included.

RAPID instructions included in this option

GlueL	Gluing with linear movement
GlueC	Gluing with circular movement

4.6 PaintWare 3.1

PaintWare comprises a large number of dedicated painting functions which make the robot well suited for painting and coating operations. It is powerful, yet simple since both the robot positioning and the paint events are handled in one and the same instruction. All phases of the paint process are controlled, such as start, change, and stop painting, due to trig plane events.

The necessary structures for paint process data are predefined and organised as BrushData and BrushTables.

PaintWare is only avaliable with painting robots.

PaintWare functionality

When painting, the fluid and air flow through the spray gun is controlled to suit the part being coated and the thickness requirements. These process parameters are changed along the path to achieve optimum control of the paint equipment along an entire path. The paint process is monitored continuously.

A set of gun process parameters is called a Brush and it is possible to select different brushes during a linear paint instruction. A brush can contain up to five parameters:

Paint	The Paint flow reference.
Atom_air	The Atomising air reference.
Fan_air	The Fan air reference.
Voltage	The Electrostatic voltage reference.
Rotation	The Rotation speed reference (for rotational applicators).

The five parameters may go directly to analog outputs controlling the spray gun in an open loop system, or may go to dedicated I/O boards for closed loop gun control (IPS).

The Brushes are set up as an array, called a BrushTable. A specific BrushTable is selected with the instruction UseBrushTab.

The changing of brushes along a path is done using events in the PaintL instruction. The event data describes how a trig plane is located in the active object coordinate system. It also describes which brush to use when the path crosses the plane. Event data is included in all linear paint instructions as optional arguments. A maximum of ten events can be held within one PaintL instruction.

Data types included in this option

BrushData	Data for one brush: flow, atomising air, fan air, etc.
EventData	Data for one event: trig-plane (x, y or z), plane value and brush numberPaintL, PaintC, UseBrushTab,

RAPID instructions included in this option

PaintL	Paint along a straight path w/paint events
PaintC	Paint along a circular path
UseBrushTab	Used to activate (select) a brush-table.
SetBrush	Select a brush from the activated brush-table.

4.7 PalletWare

General

The PalletWare package is a set of Rapid modules and user screens, which perform basic operations related to a palletizing process. These operations include a number of services which can be called from a main program to perform pick and place operations for one or up to five palletizing tasks in parallel. For each such task a number of separate dynamic variables are used to describe and keep track of each on-going pallet operation. The PalletWare package is intended to work with Rapid modules generated from PalletWizard, a PC tool for off-line programming of pallet cycles.

Pallet cycles

Up to five different pallet cycles may be run in parallel, where a pallet cycle is the task to run a complete palletizing job for a pallet, i.e. to pick and place all products, including the pallet itself.

Each pallet cycle includes a number of layer cycles, where each layer cycle is the task to complete one layer with all the parts to be picked and placed in this layer.

Each layer cycle may further be broken down into a number of pick-place cycles, where each pick-place cycle is the task to pick one or several parts and place them on the pallet. Within each pick-place cycle there may be several pick operations, if parts must be picked in many separate operations. Similarly, there may be several place operations in each pick-place cycle.

Each layer may be either an in-feeder layer, where the products, e.g. boxes, are picked from an in-feeder, or a stack layer, where the product, e.g. an empty pallet, is searched and picked from a stack.

If several pallet cycles are run in parallel, then one complete pick-place cycle is always finished before a new one is started in another pallet cycle.

Pallet cell

The pallet cell may include any number of pallet stations, in-feeders and stacks for pallets, tier sheets or slip sheets. All such stations and stacks are defined as regards position, with an individual coordinate system (work object).

The palletizing robot is normally an IRB 6400 or IRB 640 but any robot type may be used. The tool to use may be a mechanical gripper or a tool with suction cups, possibly with separate grip zones for multiple picking and placing. Several different tooldata may be defined and used depending on the product dimensions and number of products.

Products

Any number of different products with different dimensions may be handled and placed in different patterns on the pallet. Each layer must have the same product only, but different layers on a pallet may have different products.

Products may be delivered on one or several in-feeders and placed on one or several different pallets.

For each separate product individual handling speeds and load data are used.

The dimensions and speeds of the products may be changed in run time, thus affecting all pick and place positions.

Movements, approach and retreat positions

All movements are calculated in run time and relative to the different coordinate systems defined for each station. Between stations, e.g. moving from an in-feeder to a pallet station, the robot may be forced to move up to safety height and to retract before moving towards the new station. While moving to the pick or place position, the robot will first move to an approach position and then to a prepick/place position. These horizontal and vertical distances for the approach positions, relative to the pick or place position, may be individually defined per product or station. In addition, the approach direction may be individually defined per pick or place position. These approach data may be changed in run time.

The picking and placing movements and the sequence to search different stacks for empty pallets or tier sheets may be customised if necessary.

User routines

A number of different user routines may be called at certain phases of the pallet cycle. These routines can be used for communication with external equipment, for error checking, for operator messages etc. Such user routines are grouped in three main groups according to when they are called in the pallet cycle. The groups are:

- Cycle routines, connected to the different cycles, i.e. pallet cycle, layer cycle, pick and place cycle. Each such cycle may have its own individual user routine at the beginning, at the middle and at the end of the cycle.

- Station access routines, connected to the different stations. A specific user routine may be called before (station-in routine) and after (station-out) a pick/place on a feeder or pallet station, e.g. to order the next products on the feeder.

- Pick stack routines, connected to stacks. Such routines are called to search and pick a product on the stack.

User screens

The user interacts with the program using menu driven screens on the teach pendant. These screens allow the following functions to be configured:

- Station menu gives access to the robot default parameters, the tool information, the pallet stations, stack stations and feeder station information.

- Product menu gives access to the information related to the different types of product: regular products, empty pallets.

- Cycles menu gives access to the current production status for the different lines.

PalletWare system modules

PalletWare consists of a number of system modules as listed below.

PalletWare Kernel: PAL_EXE.sys

  PAL_DYN.sys

  PAL_SCR.sys

Generated from PalletWizard: PAL_CELL.sys

  PAL_CYC.sys

Templates to be completed by the system integrator concerning work object data, tool data, user routines including communication with external equipment etc.:

  PAL_USRR.sys

  PAL_USRT.sys

Modules and code not included in PalletWare

In addition to the modules listed above, there are some modules which are not included in the PalletWare delivery, but which must be written by the system integrator for specific installations. These are:

- The "main" module, including the main routine. In this routine all logic for working with parallel and simultaneous pallet cycles must be coded by the system integrator, including code required for operator messages, error handling and product changes.

- A system module holding different operator dialogues, which may be called from the main routine in order to change or check pallet cycles or to handle error situations.

System requirements for option PalletWare

- Option ScreenViewer.

5 Memory and Documentation

5.1 Available memory

The available user memory for the different memory options is as follows:

Extended memory	Standard	+8 MB
Total memory	8+8=16 MB (option 402)	8+16=24 MB (option 403)
Program memory without options	2.5 MB (ram disk=0.5 MB)	6.0 MB (ram disk=4.0 MB)

Other software options reduce the available program memory as follows. Options not mentioned have no or small memory consumption (less than 10 kB). All the figures are approximate.

Option	Program memory	Ram disk	Remark
Base system	335 kB	145 kB (225 kB if memory option 403 is chosen)	
Multitasking	80 kB/task (including task 1)		
Advanced Functions	20 kB		
GlueWare	125 kB	30 kB	Including Advanced Functions
SpotWare	370 kB	55 kB	Including Multitasking with two spotware tasks (one process and one supervision task).
SpotWare Plus	390 kB	75 kB	Including Multitasking with two spotware tasks (one process and one supervision task).
SpotWare Plus	730 kB	75 kB	Including Multitasking with five spotware tasks (four process and one supervision task).
Load Identification and Collision Detection	80 kB	40 kB	

For RAPID memory consumption, see the RAPID Developer's Manual. As an example, a MoveL or MoveJ instruction consumes 236 bytes when the robtarget is stored in the instruction (marked with '*') and 168 bytes if a named robtarget is used. In the latter case, the CONST declaration of the named robtarget consumes an additional 280 bytes.

5.2 Teach Pendant Language

The robot is delivered with the selected language installed. The other languages are also delivered and can be installed.

5.3 Robot Documentation

A complete set of documentation consisting of:

- User's Guide, with step by step instructions on how to operate and program the robot. This manual also includes a chapter called Basic Operation, which is an introduction to the basic operation and programming of the robot, and is suitable as a tutorial.

- RAPID Reference Manual, a description of the programming language.

- Product Manual, a description of the installation of the robot, maintenance procedures and troubleshooting. The Product Specification is included.

If the Danish language is chosen, the RAPID Reference Manual and parts of the Product Manual will be in English.

6 DeskWare

6.1 DeskWare Office 3.0

DeskWare Office is a suite of powerful PC applications designed to reduce the total cost of robot ownership. These applications are organized into four different rooms:

- Programming Station
- Training Center
- Library
- Robot Lab

These rooms contain PC-based tools for training, programming, testing, and maintenance to address the fundamental needs of all robot owners. A comprehensive list of all applications in the DeskWare Office suite, organized by room, follows below.

- Programming Station
  - ProgramMaker application
  - ConfigEdit application
  - Online version of the S4 RAPID Reference Manual
- Training Center
  - QuickTeach application
  - QuickTeach Tutorial application
  - Online version of the S4 User's Guide
- Library
  - ProgramSafe application
  - ServiceLog application
  - Online versions of all S4 documentation
- Robot Lab
  - VirtualRobot application

To make navigating and launching applications easy, the graphical Office interface shown below was created.

To launch applications, the user clicks on corresponding "hot spots," enabled when the rooms are installed. When you launch DeskWare applications, you are in fact running the Virtual Controller - the actual S4 controller software - in your PC.
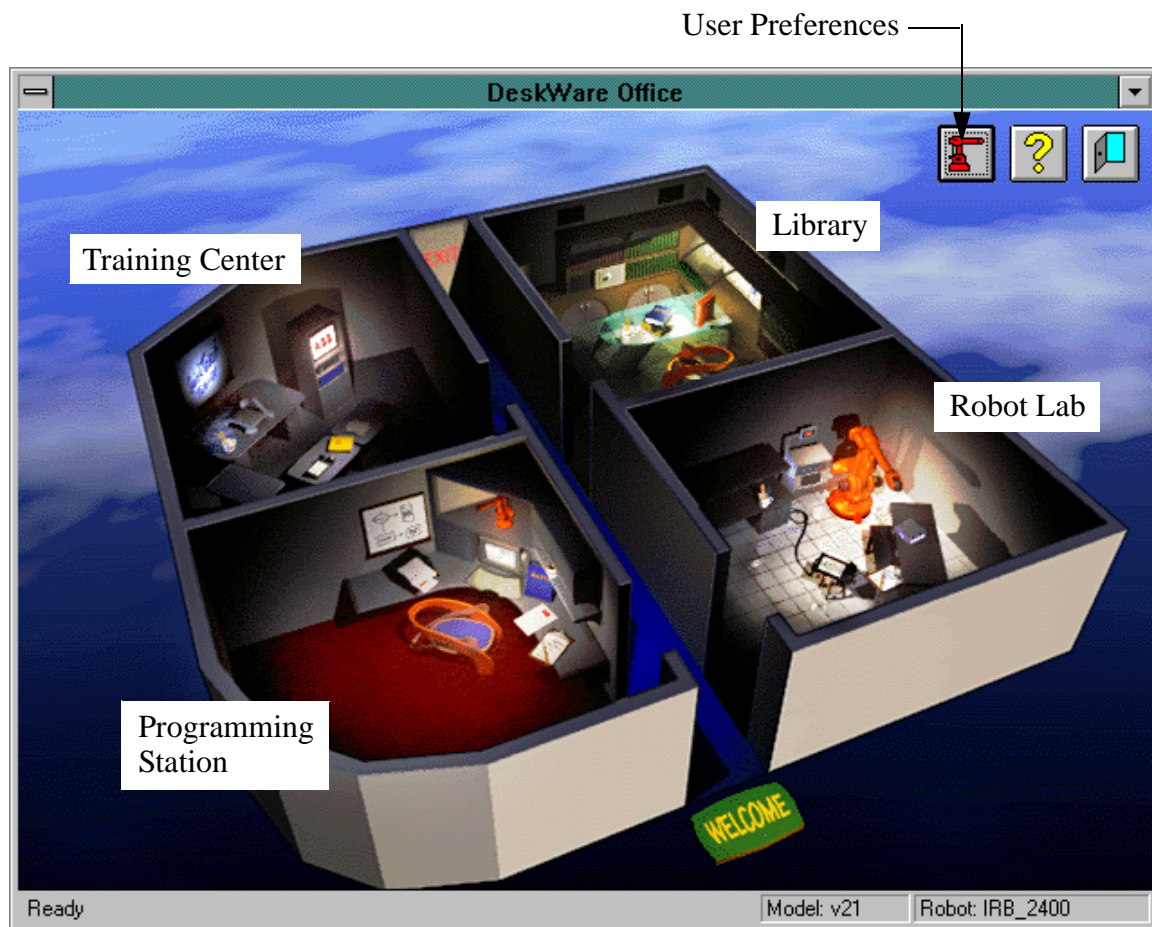
User Preferences

The "User Preferences" button is used to select robot and language options that apply to the entire application suite. Pressing this button displays the following dialog.

Select a robot

Configure the selected robot
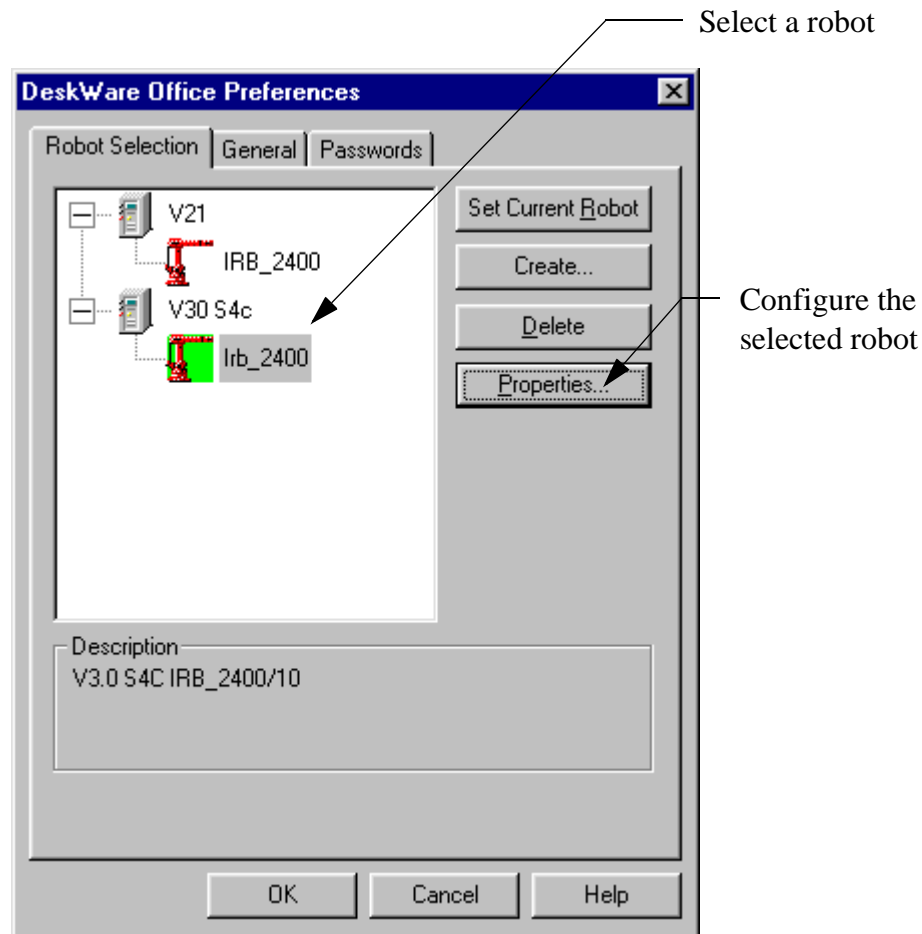
The following sections contain more detailed descriptions of the applications available in each room of the DeskWare Office suite.

PC System Requirements

- Pentium processor.

- 8 MB RAM memory, minimum for Windows 95; 16 MB RAM for Windows NT (32 MB RAM recommended).

- Windows 95 or Windows NT 4.0.

- 150 MB harddisk space.

- VGA compatible display (1024 x 768 recommended).

- CD-ROM drive.

- Microsoft compatible mouse.

6.2 Programming Station 3.0

Programming Station is a collection of software applications that assist the user in constructing and editing robot programs and configuration files on a PC.

Programming Station includes:

- ProgramMaker application.

- ConfigEdit application.

- Online version of the S4 RAPID Reference Manual.

ProgramMaker allows the user to create and edit robot programs on a PC, in the Windows environment.

ProgramMaker is a complete system for creating and editing RAPID programs for the S4 robot controller. ProgramMaker is unique, compared to other offline programming systems, as it embeds the functionality of the S4 robot controller and uses this capability to perform all robot controller-specific tasks. For example, you can configure the embedded S4 controller within ProgramMaker so that it represents the same I/O setup as your real robot. Then, when you program I/O-based statements, ProgramMaker checks to ensure that you refer only to those signals that are defined on your robot.

ProgramMaker can assume the functionality of different versions of the S4 controller, for example, V2.1 or V3.0, and behave in accordance with the features specific to that version of controller. This means you can see the same status and error messages in ProgramMaker as you see on the real robot.

ProgramMaker implements an advanced Windows user interface that permits you to develop RAPID programs quickly, easily, and without error. Unlike using a conventional text editor, ProgramMaker helps you write RAPID programs by creating instructions with a single command, providing default parameters in many cases automatically. For beginning programmers, ProgramMaker provides instruction-sensitive dialogs that make programming complex statements easy. For experts, ProgramMaker also offers the more conventional approach of text-based entry of RAPID program statements. Using either method, ProgramMaker guarantees that your programs will be valid when you load them into your robot.

You can set up ProgramMaker to assume the configuration of a specific robot controller. You do this using the Preferences dialog of Office. Configuration includes, for example, the specific version (V2.1, V3.0, etc.) of the robot controller, the software options installed on that controller (ArcWare, SpotWare, Serial RAP, etc.), and the amount of memory installed (10MB, 12MB, etc.). The Preferences dialog can be used to select a predefined configuration, or it can be used to create entirely new configurations through user-assisted dialogs or through direct import from the floppy disks shipped with your robot.

The following image illustrates some of the main features of the ProgramMaker user interface.

Editing of background tasks is supported with a tabbed Tree View.

Data View permits manipulation of program data in familiar "spreadsheet" context.

Code View allows creation and editing of user programs.

Graph View displays programmed points in a dynamic viewer.

Tree View provides a hierarchical view of RAPID modules.
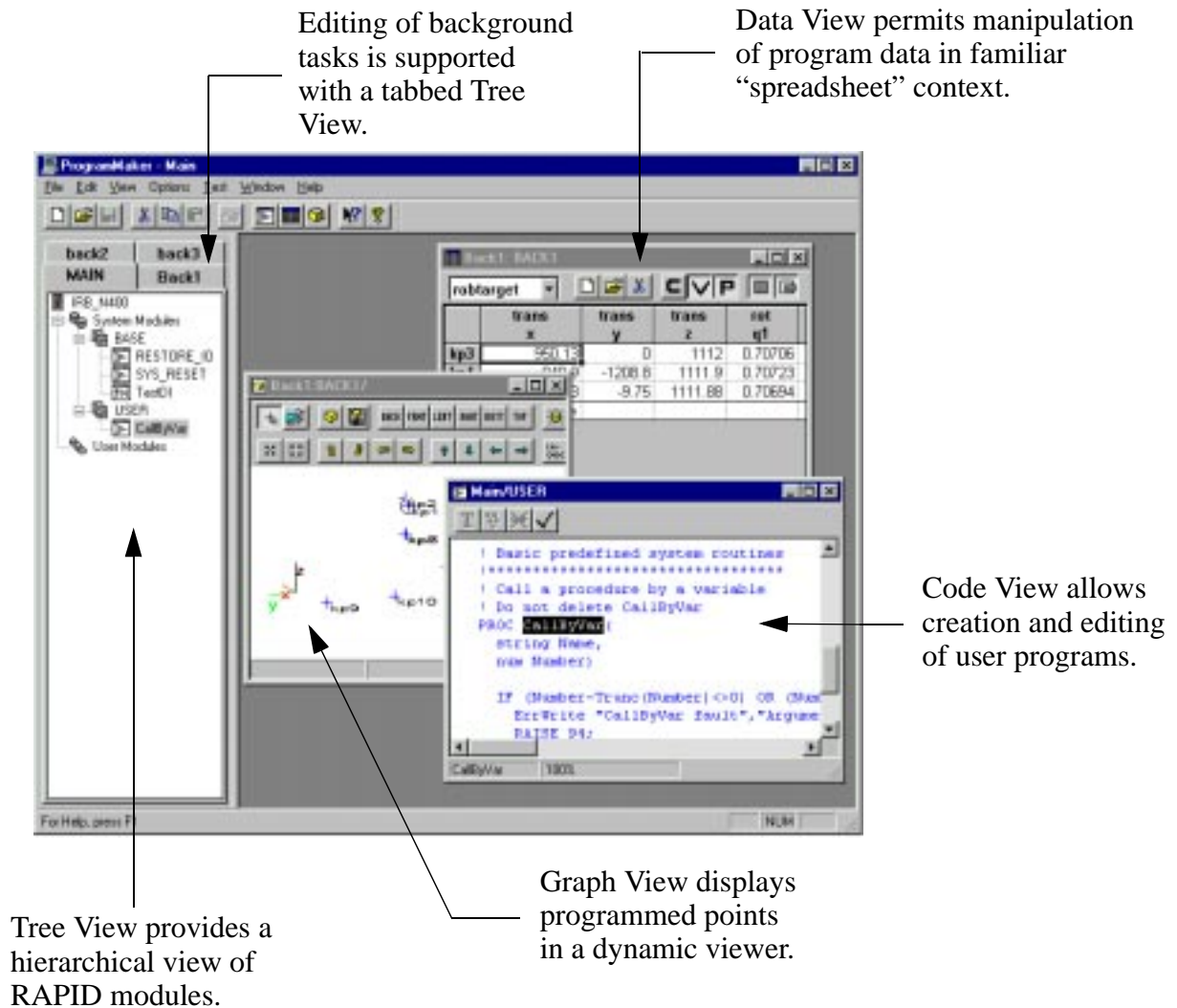
Some of the main features of ProgramMaker include:

- Ability to check for syntactic and semantic errors, as robot programs are created or edited.

- Program data is displayed in a familiar "spreadsheet" format which is Microsoft Excel compatible.

- Full support for RAPID array handling.

- Automatic declaration of referenced data.

- Positions can also be viewed as points in the Graph View.

- The Tree View allows the user to view and navigate robot program structure in a simple, logical manner.

- Syntax colorization in the Code View for enhanced usability.

- Multiple routines can be viewed and edited at the same time.

- Cut/Copy/Paste and Search/Replace features.

PalletWizard is a programming tool used for palletizing applications. It must be used in combination with PalletWare (i.e. the output generated from PalletWizard is used in conjunction with PalletWare).

PalletWizard is an integrated component of ProgramMaker, invoked from the 'Tools' menu.

PalletWizard allows the user to create and edit system modules, which define the layout of a palletizing robot cell with its different pallet stations, infeeders, stacks and tools, including the pallet composition (products, layers and layer patterns).

A robot cell for palletizing incorporates one palletizing robot, one or several pallet stations where products are placed and one or several infeeders, from which products are picked. The cell may also include one or several stacks, from which empty pallets or tier sheets are drawn.

Objects in a palletizing cell

The following objects and properties for a palletizing cell may be defined using PalletWizard:

- Robot
  - Speed without products
  - Acceleration without products
- Pallet Stations
  Several pallet stations may be defined, each with the following properties
  - Maximum and minimum height
  - Approach height
- Infeeders
  Several infeeders may be defined, each with the following properties
  - Maximum and minimum height
  - Approach height
  - Product alignment
  - Type of product
- Stacks
  Several stacks may be defined, each with the following properties
  - Maximum and minimum height
  - Approach height
  - Product alignment
  - Type of product

• Products
A number of different products, for example, boxes, pallets, tier sheets etc., may be defined, each with the following properties:

   - Size

   - Sides with labels

   - Robot speed and acceleration when carrying the product

   - Pick and place approach distances, vertically and horizontally

Pallet cycles

A number of different pallet cycles may be defined. A pallet cycle consists of palletizing a complete pallet (i.e. to pick and place all products, including the pallet itself).

Each pallet cycle includes a number of layer cycles. Each layer cycle consists of one complete layer with all the products to be picked and placed in this layer.

Each layer cycle may further be broken down in a number of pick-place cycles, where each pick-place cycle consists of picking one or several parts and placing them on the pallet. Within each pick-place cycle there may be several pick operations, if parts should be picked in separate operations. Similarly, there might be several place operations in each pick-place cycle.

A number of different layer cycles may be defined, including pick-place cycles. These layer cycles may then be freely used and combined in different pallet cycles (pallet compositions).

For each layer cycle the following properties may be defined:

   - The product to pick and place.

   - The infeeder to use. Several infeeders may be used, if necessary.

   - The pattern to use.

   - The pick-place cycles to use.

For each pattern the following properties may be defined:

   - The number of parts to place.

   - The position and orientation of each part. Part positions are always related to reference lines, freely positioned on the pallet. Any number of reference lines and positions are allowed. Label sides of the articles may be placed facing out.

   - The envelope of the pattern (i.e. the outer borders of the pattern).

Programming Station 3.0

For each pick-place operation the following properties may be defined:

- The number of pick operations

- The number of place operations

- The tool to be used. Different tool definitions may be used depending on the article to pick and the number of articles.

- The approach direction for pick and place operations

- The pick and place positions, related to the used pattern

For each pallet cycle the following properties may be defined:

- The pallet station to use. Several pallet stations may be used, alternately, if necessary.

- The pallet to use in the first layer.

- Orientation of the pallet in the pallet station

- Load alignment (i.e. alignment of the pattern envelope - front, center or back, left, center or right).

- The pallet composition for a complete pallet (i.e. specification of layer cycles to use in each layer).

User routines

It is possible to call different user routines in different phases of the pallet cycle. These user routines may be used for installation specific tasks, for example, communication with external equipment, operator messages, intermediate positions, etc. In PalletWizard, only the declarations of these user routines are created. The routine body, or RAPID code, can then be completed within ProgramMaker.

All routines are grouped in three main categories, according to when they are called in the pallet cycle. The groups are:

- Cycle routines, connected to the different cycles (pallet cycle, layer cycle, pick and place cycle). Each such cycle may have its own individual user routine in the beginning, in the middle, and at the end of the cycle.

- Station access routines, connected to the different stations. A specific user routine may be called before (station-in routine) and after (station-out) a pick/place action on a feeder or pallet station, for example, to order the next products on the feeder.

- Pick stack routines, connected to stacks. Such routines are called to search and pick a product on the stack.

Load data

Load data (load, center of gravity, and moment of inertia) is automatically set up by PalletWizard depending on the article dimensions, weight and number of articles in the tool.

Output from PalletWizard

PalletWizard generates three output files, which are loaded into a robot system running PalletWare.

ConfigEdit allows users to create and edit robot configuration files on a PC, in the Windows environment.

Some of the main features of ConfigEdit include:

- Support for all configuration domains.

- Standard configuration templates which can be customized.

- Cut/Copy/Paste functions.

- Help feature to explain configuration parameters.

PC System Requirements

- Pentium processor.

- 8 MB RAM memory, minimum for Windows 95; 16 MB RAM for Windows NT (32 MB RAM recommended).

- Windows 95 or Windows NT 4.0.

- 100 MB harddisk space.

- VGA compatible display (1024 x 768 recommended).

- CD-ROM drive.

- Microsoft compatible mouse.

6.3 Training Center 3.0

Training Center is a collection of PC software applications that assist the user in learning how to use the robot.

Training Center includes:

- QuickTeach application.

- QuickTeach Tutorial application.

- Online version of the S4 User's Guide.

QuickTeach is the actual teach pendant software running on a PC under Windows. Most things that can be done on the real teach pendant can also be done with QuickTeach, making QuickTeach an excellent training tool and eliminating the need to dedicate a robot for most training purposes.
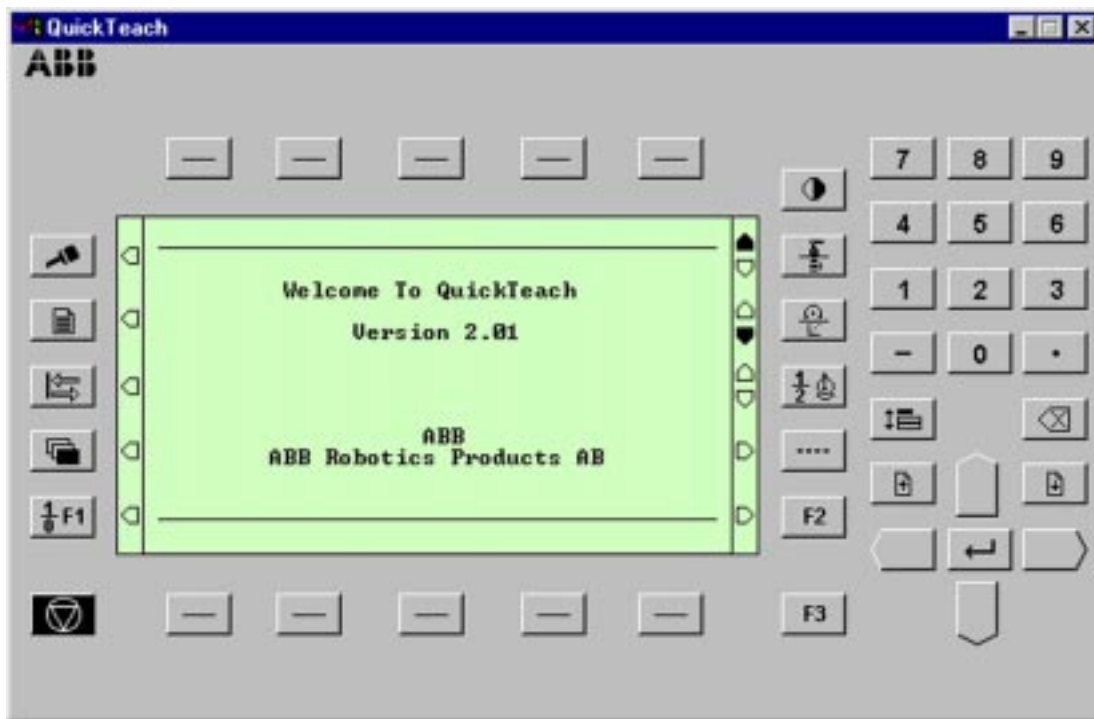
Some of the main features of QuickTeach include:

- Supports all languages that are supported by the robot controller.

- Can be configured to emulate the real robot (i.e. custom menus, software options, etc.).

- Can be used to create and edit robot programs; however, Programming Station is more efficient for this purpose.

QuickTeach Tutorial is a 45 minute tutorial that covers the basic operations of the teach pendant. The tutorial is supported in the following languages:

- English, French, German, Italian, Spanish and Swedish.

PC System Requirements

- Pentium processor.

- 8 MB RAM memory, minimum for Windows 95; 16 MB RAM for Windows NT (32 MB RAM recommended).

- Windows 95 or Windows NT 4.0.

- 100 MB harddisk space.

- VGA compatible display (1024 x 768 recommended).

- CD-ROM drive.

- Microsoft compatible mouse.

6.4 Library 3.0

Library is a collection of PC software applications that allow the user to store and retrieve important documentation related to the robot and auxiliary equipment.

Library includes:

- ProgramSafe application.

- ServiceLog application.

Online versions of all S4 documentation.

ProgramSafe allows the user to archive, catalog and retrieve robot programs and configuration files in the Windows environment.
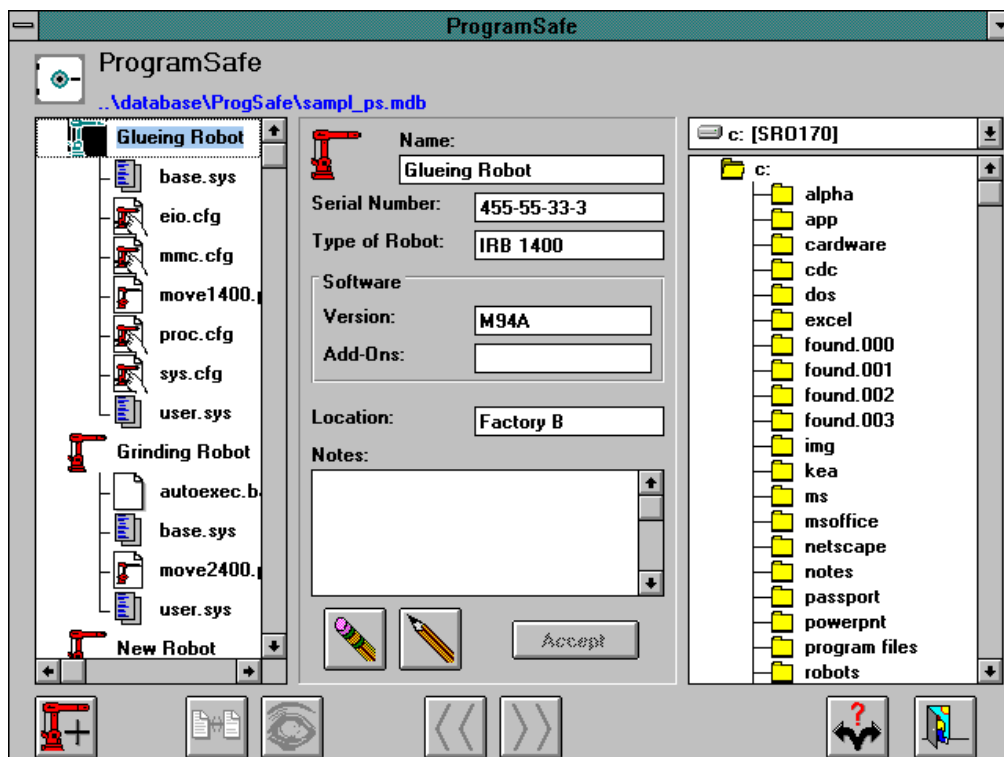
Some of the main features of ProgramSafe include:

- Associate RAPID program and configuration files with individual robots.

- Compare feature to find the differences between files or different versions of the same file.

- File printout feature.

ServiceLog allows the user to archive, catalog and retrieve robot programs and configuration files in the Windows environment.
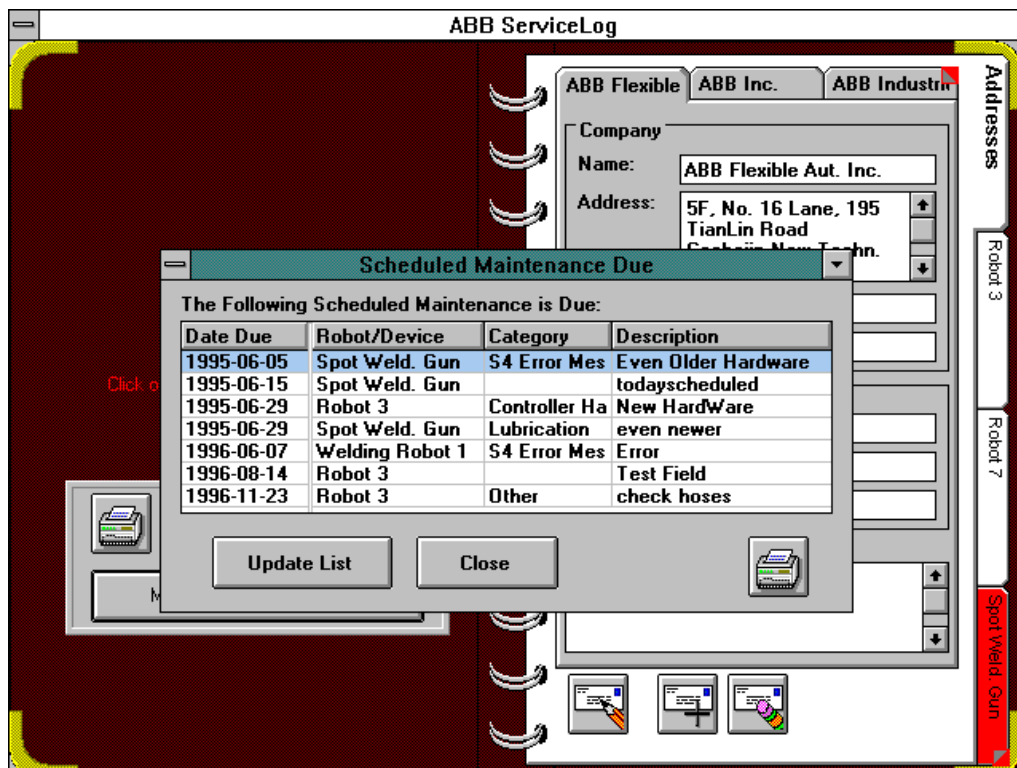
Some of the main features of ServiceLog include:

- Store maintenance information about robots and other workcell equipment.

- Store frequently used service-related names, addresses and phone numbers.

- Schedule future maintenance with automatic notification when due.

- ServiceLog data files are Microsoft Access compatible.

- User definable password protection with two security levels.

PC System Requirements

- Pentium processor.

- 8 MB RAM memory, minimum for Windows 95; 16 MB RAM for Windows NT (32 MB RAM recommended).

- Windows 95 or Windows NT 4.0.

- 30 MB harddisk space.

- VGA compatible display (1024 x 768 recommended).

- CD-ROM drive.

- Microsoft compatible mouse.

6.5 Robot Lab 3.0

Robot Lab includes a PC software application intended to assist the user in testing robot programs.

Robot Lab includes:

- VirtualRobot application.

VirtualRobot simulates ABB S4 robots on desktop computers. VirtualRobot can be used to test robot programs without having to occupy a real robot system.

The VirtualRobot application consists of three windows: the Teach Pendant, the I/O Simulator, and the Robot View. The Teach Pendant window simulates the S4 Controller Teach Pendant, the I/O Simulator window permits user manipulation of digital I/O signals, and the Robot View allows the user to observe the motion of the VirtualRobot as it executes robot programs. The user may choose to run VirtualRobot with or without the I/O Simulator and Robot View.

The VirtualRobot application assumes the functionality of the embedded S4 controller and can be configured with various memory and software options just like a real S4 controller using the Preferences dialog. Configuration includes, for example, the software options available to the controller (ArcWare, SpotWare, Serial RAP, etc.), the robot model (IRB1400H CEILING/DCLinkB, IRB6400C/B-150, etc.), the amount of memory installed in the controller (10MB, 12MB, etc.), and several other parameters. It should be noted that the VirtualRobot is only available for robot controller versions 2.1 and later. However, it is possible to test many programs for earlier controller versions using VirtualRobot version 2.1.

Robot Lab includes predefined configurations of the controller. The Preferences dialog can be used to select among defined configurations and to create entirely new configurations through user-assisted dialogs or direct import of configuration data from the floppy disks shipped with the robot.

The VirtualRobot I/O Simulator can be used to view and manipulate digital input and output signals during program execution. This feature is useful for testing robot programs that may set outputs or wait on certain input states before continuing. The VirtualRobot I/O Simulator automatically configures itself with the I/O boards and signals used by the selected robot.

In addition to dynamically displaying robot motion, the Robot View window includes a cycle time clock that displays time computed internally by the robot control system to provide an estimate of cycle time for the real robot.

This estimate does not contain settling time at fine points. By adding 200 ms per fine point, the cycle time accuracy will normally be within ±2 %.

The image below illustrates some features of the Robot View window.
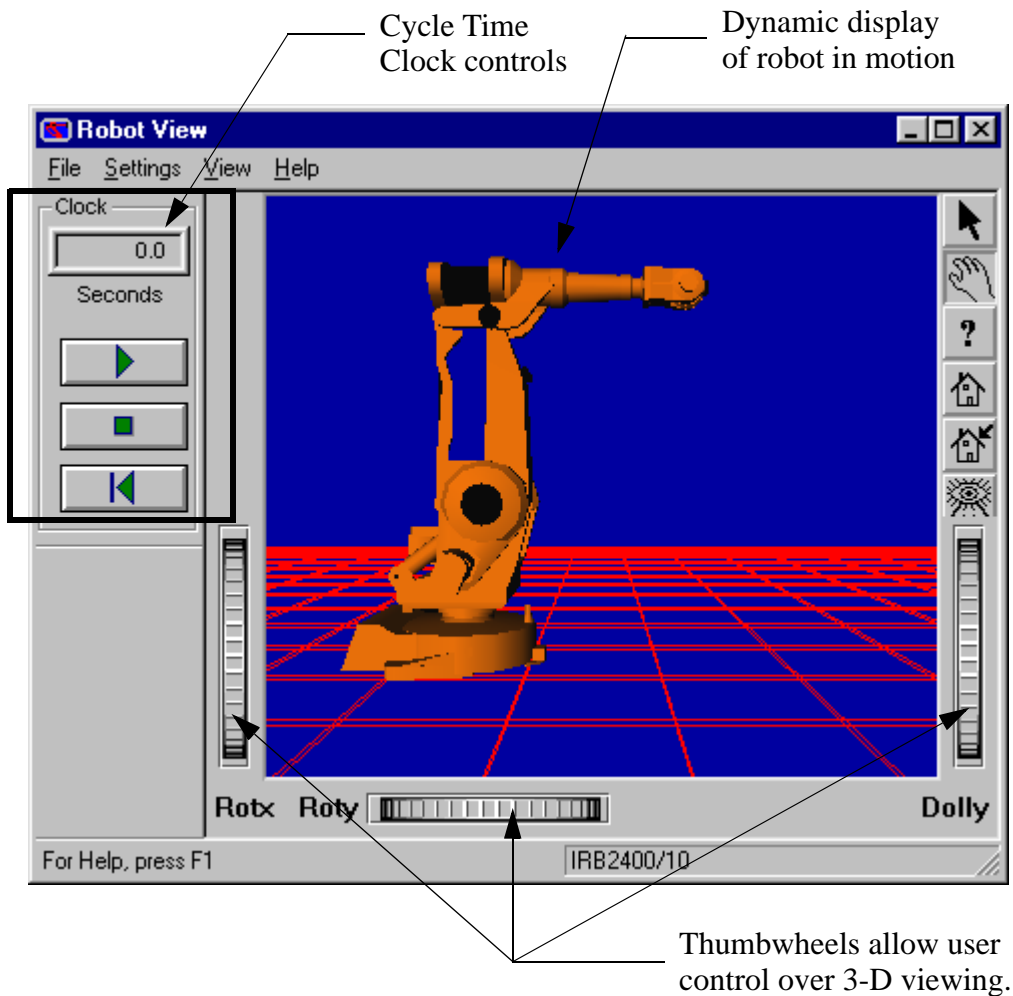
Cycle Time Clock controls

Dynamic display of robot in motion

Thumbwheels allow user control over 3-D viewing.

PC System Requirements

- Pentium processor.
- 8 MB RAM memory minimum, for Windows 95; 16 MB RAM for Windows NT (32 MB RAM recommended).
- Windows 95 or Windows NT 4.0.
- 100 MB harddisk space.
- VGA compatible display (1024 x 768 recommended).
- CD-ROM drive.
- Microsoft compatible mouse.

Robot Lab 3.0

Product Specification RobotWare for BaseWare OS 3.1

7 FactoryWare

7.1 RobComm 3.0

RobComm is a powerful toolkit for developing PC-based user interfaces for robot systems.

RobComm frees you from the underlying communication protocols, so you spend time designing a user interface, not writing communication software. Typical applications that would make use of RobComm include:

- File servers.

- Cell controllers.

- Statistical process control supervisors.

- Other applications where a graphical operator interface or remote process monitoring and control are desired.

RobComm is a collection of ActiveX Controls (OCXs). The operation of these controls is configured via the control's properties. RobComm includes three robot-specific OCXs: the Helper control, the ABB Button control, and the Pilot Light control. Together they present a flexible, comprehensive communication interface to the S4.

In designing PC user screens, these RobComm controls may be used in combination with Microsoft ActiveX controls and the thousands of other ActiveX controls available from third-party suppliers. In addition, the user application can be tested using the DeskWare VirtualRobot application (see section 6.5), permitting off-line verification of the operator interface and rapid deployment into production.

The User Application

Designed to leverage industry standard development tools, RobComm supports 32-bit Windows applications created with Microsoft Visual Basic, Visual C++, or Wonderware InTouch 7.0. Thus, users benefit from the wide availability of third-party components (known as ActiveX controls) that support these development environments, further reducing development time and effort.

Visual Basic is generally preferred for rapid development of user interface screens, whereas Visual C++ may be needed in complex installations that require integration with other programming libraries.

RobComm is designed such that multiple applications, including multi-threaded applications, can communicate with multiple S4 controllers without conflict. Applications developed with RobComm will work over a serial line to one robot, or over Ethernet to multiple robots.

Visual Basic source code for two sample applications is included to illustrate the use of RobComm and accelerate the learning curve.

RobComm 3.0

The two screens shown below, are examples of a Visual Basic application that uses RobComm to collect and display process statistics, error messages, and robot I/O and to enable remote program modification.
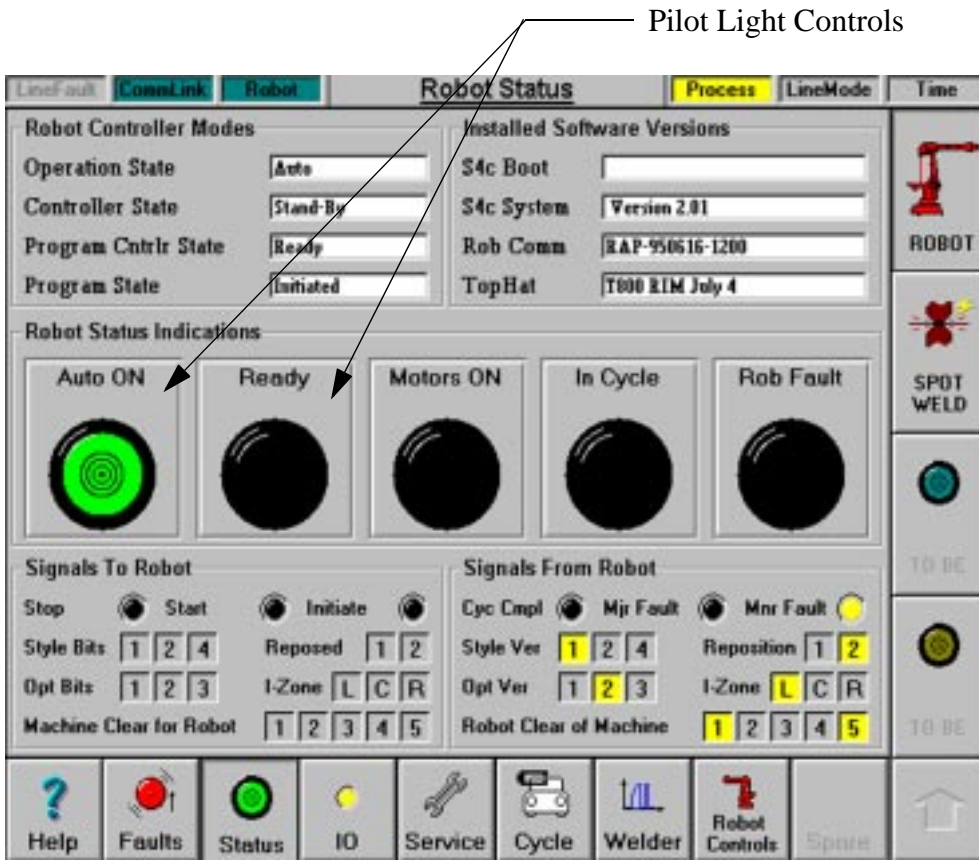
Pilot Light Controls
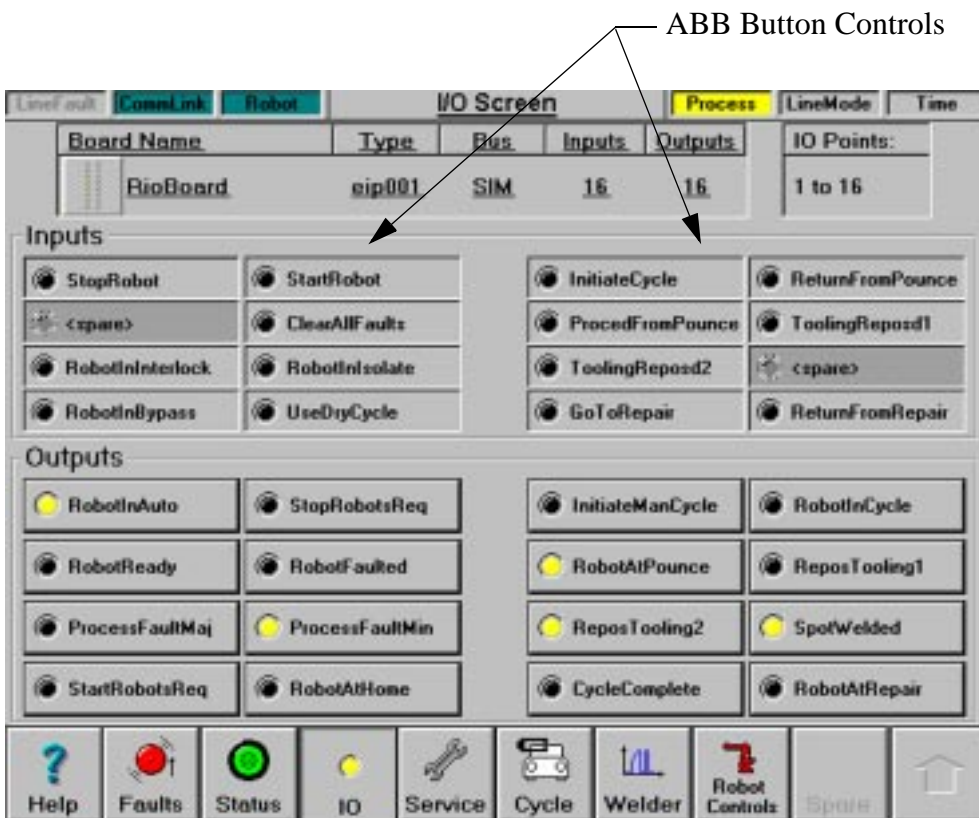
ABB Button Controls

Following is a brief description of each ActiveX control included the RobComm toolkit.

The Helper Control

This is the primary communication interface for RobComm. The Helper control is an invisible control that provides methods, properties, and events to expose the entire S4 communication interface.

The ABB Button Control

The ABB Button control is a derivative of the standard Windows button control. An ABB Button can be connected directly to a specific digital I/O signal in an S4 control. The Button control provides a simple way to view and modify a digital signal, and, in most cases, can be used without adding code to your application.

The display of the button can be configured via property settings to automatically update itself based on the current state of the communication link to the robot control and the state of the digital signal assigned to the button control. Optionally, you can display bitmaps, text strings, text colors, and/or background colors based on the signal state (on or off). The button action can be configured to turn a signal on, turn a signal off, toggle a signal, pulse a signal, or do nothing in response to a mouse click.

The Pilot Light Control

The Pilot Light control tracks the state of a specific digital signal. This control is configured via properties and requires no additional code.

The display of the Pilot Light is modeled after status lamps commonly used in hard-wired operator panels. The Pilot Light displays bitmaps to represent the on and off states of the associated signal. The user selects the on and off colors via properties. A Caption Property is used to label the Pilot Light.

When the communication link to the robot control is down, the Pilot Light automatically disables itself and re-enables itself when the communication link is restored.

PC System Requirements

- Pentium processor.
- 8 MB RAM memory minimum for Windows 95, 16 MB RAM for Windows NT (32 MB RAM recommended).
- Windows 95 or Windows NT 4.0.
- Microsoft Visual Basic, Visual C++, or Wonderware InTouch 7.0 (for application development).
- 20 MB free hard disk space.
- VGA compatible display (1024 x 768 recommended).

- CD-ROM drive.

- One or more network interfaces - any NDIS or ODI network adapter (for ethernet) or a serial port (for serial connection to one S4).

- A terminal server with SLIP protocol support is required for connections to multiple S4 controllers not equipped with an ethernet interface.

- Microsoft compatible mouse.

Robot Controller Requirements

- FactoryWare Interface (or RAP communication) installed. FactoryWare Interface is preferred as RAP communication requires run-time licensing on the PC.

- Ethernet interface hardware (optional).

- RobComm 3.0 can be used with all versions of BaseWare OS.

7.2 RobView 3.1

RobView is an end-user application that lets the customer visualise robot data in a PC. It also lets the user remotely operate robots from a PC and provides access to robot files for simple file transfer and back-up. RobView is Windows-based and easy to use.
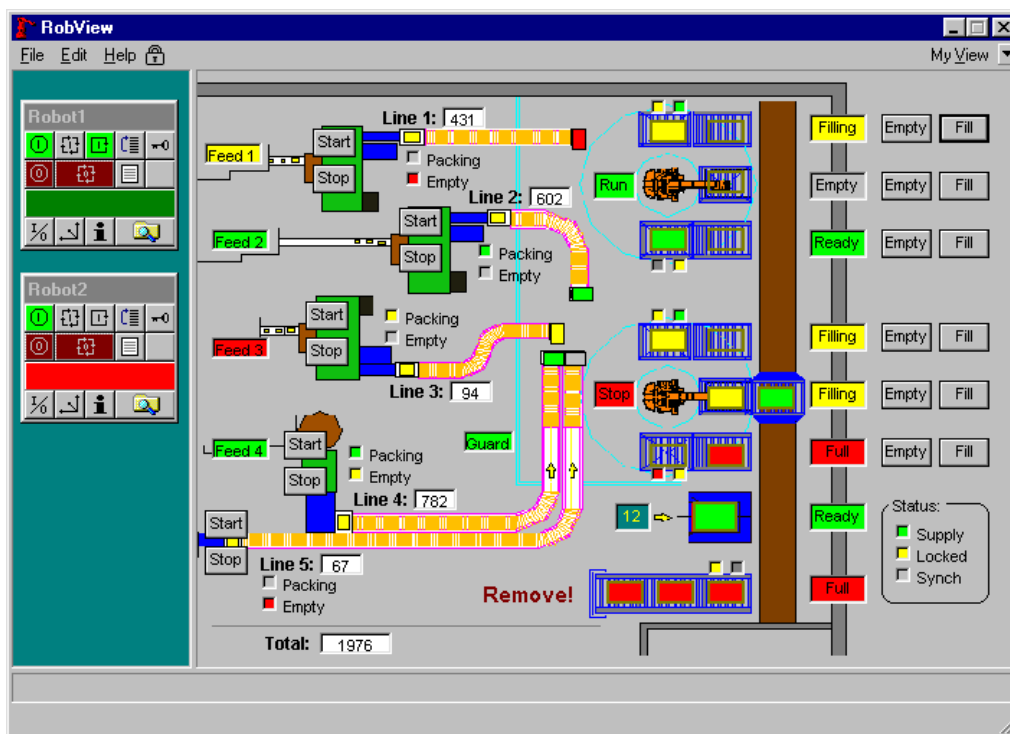
RobView comes as a ready to use application and is typically run in a PC on the factory floor, connected to one or more robots. RobView takes care of the PC to robot communication. The user can start working immediately, using the pre-defined features and buttons. He can also define his own buttons and signals.

A built-in user security system can be used to prevent accidental use by unauthorized persons.

Pre-defined controls

In RobView there are several pre-defined objects. They are configured for the user to operate robots, look at various robot status and perform file operations. Each robot is represented by a small robot-box on the screen.

The Robot Box

The ready-made robot-box provides the user with instant information about the most important status of the robot, like Motor power on, Program running and Robot mode. It also allows the user to remotely operate the robot with buttons for Motor Power On/Off, Load program, Run and Halt the program, and Start from the top of program.

A robot box may also be dragged out of the RobView window and made to float freely on the windows desktop, always visible to the user.

The user can ask for more detailed status by clicking on one of the buttons in the bottom row in the robot-box. He can also start the RobView File manager. The detailed status information that the user can ask for is presented in pre-defined windows as shown below.

Controller Information

A click on the Info button displays the system information. Here the user can see the available buffer space in the robot and information about the robot and its software.

I/O status

A click on the I/O status button displays the digital I/O boards with their input and output signals. The user can select I/O board by clicking on the left and right arrow-buttons at the bottom. The I/O signals are "alive" on the screen and follow the changes in the robot. The user can give the I/O signals his own names - specified for each card and for each robot.

Robot position

A click on the Position button displays the position status. The current position of the robot is displayed as well as the name of the selected tool and work object. The position data is updated as the robot moves.

File manager

When the user clicks on the File manager button in the Robot Box, the RobView File Manager window is displayed. With the RobView File Manager, maintaining the files in the robots and making back-up copies of programs is simple.
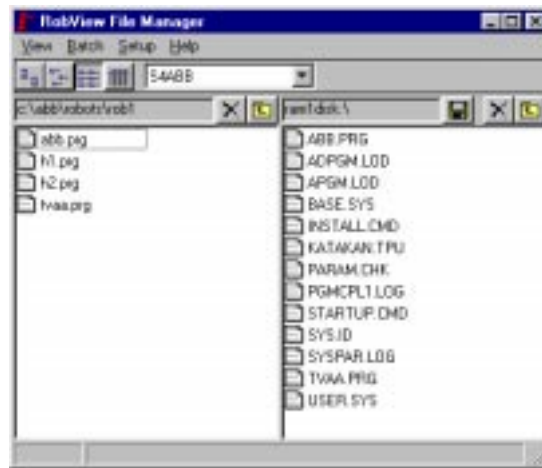
In the RobView File Manager, the user can see both the hierarchy of folders and files on the PC, and the files in the selected robot. This is especially useful for copying files using the familiar Windows "drag-and-drop" interface. The user can copy files and programs back and forth between the robot and the PC without interrupting production. Files can be renamed and deleted.

Batch operation

In the RobView File Manager there is a Batch menu where the user can make batch files for file-operations that are tedious and repetitive. A batch file can contain Put-, Get- and Delete-commands. This is useful for example for back-up purposes - a batch file can be started from a user defined button.

User defined controls

In addition to the robot box control that is ready to use, the user can customise RobView by defining his own views with lamps, signals, command buttons, etc. on the screen and link them to variables or I/O in the robot.

If the user, for example, wants to keep track of a RAPID variable in the robot, for example "PartsProduced", he just defines it on his screen and it will always be updated and display the correct value. The user can also edit a data field on the PC screen and have the value sent to the robot. In this way the user can prepare and send production data to his robots, e.g. number of parts to produce, type of part, etc., without interrupting production.

The user can build complete screens containing customised views of the production cell, including robots and external equipment with layout-drawings, command buttons, signals and display of data.

The layout drawings of the production-cell are made with a standard drawing program like Windows PaintBrush, or a drawing coming from for example AutoCad. These bitmap drawings are displayed in each view in RobView as a "background" for the robot boxes, buttons, data fields, etc.

The screen is split in two parts: the main part and the project part. The user can design his own controls in both parts of the window. The "main" part of the window contains one view that is active all the time. The "project" part of the window can have up to 32 different "pages" or views (screens), where one is visible at a time. The user can switch between the views by selecting them from a list or at the push of a button (the user can specify which button to press for which view). A view can also be selected automatically, based on a variable or I/O in a robot.

Controls are defined in easy to use dialogue boxes where the user selects how the controls will look on the screen. The same dialogues (under the Triggers tab) are also used to link the controls to variables in the robot.

Shape

By simple click-and-select, the user can define a rectangle, square, oval, circle, rounded rectangle, etc., set it to be filled or transparent, set the thickness of the border, set the colours, etc. More importantly, the shape can be linked to variables or digital I/O in the robot and made to change its colour, become invisible, etc., dependent on the value in the robot. The shape can even be made to move on the PC screen, dependent on the value of variables in the robot.

Label

A label can be a lot of different things: It can be as simple as plain text on the screen, or it can be an edit field displaying a value from the robot with the ability for the operator to edit the value and send it back to the robot. The user can define labels in any view.

The label can be linked to a variable or digital I/O in the robot to display the value (be that numbers or text) and can also change its fill colour, text colour or become invisible.

The user-input on a label (edit-field) can be protected, so that only qualified users are allowed to change data in the robot.

Command button

A command button can be used for a lot of different things: set or reset I/O's, clear a value of a variable, start a program, start a file transfer - its up to the imagination of the user.

The user can define command buttons in any view and specify one or more actions that is to occur when the button is operated. Command buttons can be protected, so that only qualified operators are allowed to operate them. A button can have a text and/or a bitmap.

In addition, also a button can be linked to variables or I/O in the robot and made to change its bitmap picture, the colour of the text or become invisible, dependent on the value in the robot.

Grid

A grid can be connected to both complex variables or arrays. It will dynamically updated the data field displaying the value of a robot variable, and has the ability to edit the value and send it back to the robot.

The user can define grids in any view. It is easy to set the size of the grid from the Grid property page. You may also define column and row header texts.

The user-input on a grid can be protected, so that only qualified users are allowed to change data in the robot.

Icon

The icon control is used for drawing a picture on any of the views. The picture files are typically bitmap files (.bmp) or icon (.ico) files that you for example have prepared with the Windows Paint application, or have exported from some other drawing program. The icon can be linked to a variable or digital I/O in the robot and made to change picture or become invisible dependent on the value of the robot variable.

Hot-Spot

Select the Hot-spot control to draw a hot-spot in any of the views. It is usually placed on top of other controls (e.g. Icon), to make RobView change view when you click on the hot-spot. The hot-spot is invisible in run mode.

Peripheral equipment

The user defined controls can also be linked to signals in peripheral equipment. This can be done in two ways: 1) By using spare I/O in the robot where signals from the peripheral equipment are connected so that RobView can reach them or 2) by using a dedicated DDE Server if one is available for the equipment in question, so that RobView can connect to the variables of that DDE Server and in this way be able to control and monitor the external equipment.

Multiple robots

RobView can be supplied with support for one or multiple robots. For use with one robot, the robot is connected directly to the serial port in the PC.

If the robots are equipped with a network option, they can be connected directly by ethernet to the networked PC.

RobView 3.1

For use with more than one robot with serial connections, a "terminal server" is needed in the set-up. This is a box with eight or more serial ports and an ethernet port. The robots are connected to the serial ports and the PC (with an ethernet board) to the ethernet port. The "ShivaPort" from Shiva (used to be called "SpiderPort") is an example of a good terminal server for this use.

PC System Requirements

The requirements for RobView will depend on the size of the installation and the number of robots. The descriptions below are recommendations only.

RobView for one robot

486 DX-66 minimum (Pentium recommended).

16 MB RAM memory or more.

10 MB free harddisk space.

Windows-95 or Windows/NT installed.

VGA compatible display (higher resolution recommended).

3.5" 1.44 MB diskette drive or CD rom.

Serial port or Network board.

RobView for multiple robots

Pentium 75 MHz (minimum).

16 MB RAM memory min. (more recommended).

10 MB free harddisk space.

Windows-95 or Windows/NT installed.

VGA compatible display (higher resolution and large screen strongly recommended).

3.5" 1.44 MB diskette drive or CD rom.

Network board (e.g. 3COM EtherLink III 3C509).

Alternatively a terminal server may be used.

Robot Controller Requirements

FactoryWare Interface 3.1 (or RAP Communication 3.1) installed.

Ethernet interface hardware (optional).

RobComm 3.1 can run with all versions of BaseWare OS.

Technical specification

Platform:	IBM/Intel based PC and compatibles
Operating system:	Microsoft Windows-95 or Windows/NT 4.0 (not included)
TCP/IP stack:	The generic Microsoft winsock.dll (not included, comes with Windows)
RPC:	Public domain Sun rpc.dll, ported to Windows/NT (included)
Software protection:	Access key, placed in printer port, with key-password. (Will run for five hour intervals without password or key)
User security:	Optional Log In functionality with user-id and user-password. Four user levels: View, Safe, Expert and "Programmer"

7.3 DDE Server 2.3

The DDE Server is a software building block that provides reliable, quick and accurate flow of information between robots and a PC. This is what the user needs if he wants to build his own customised user interface, using visualisation packages like for example "InTouch" from Wonderware.

The S4 DDE Server takes care of the communication with the robot, and presents the data in the industry standard DDE communication protocol. DDE stands for Dynamic Data Exchange. It is a communication protocol designed by Microsoft to allow Windows applications to send and receive data to/from each other. It is implemented as a client/server mechanism. The server application (like the ABB S4 DDE Server) provides the data and accepts requests from any other application that is interested in its data. An application that can "talk" the DDE "language" can communicate with the ABB robots via the S4 DDE Server. Examples of applications that do DDE communication are Microsoft "Excel" and "InTouch" from Wonderware.

The S4 DDE Server communicates with robots using the ABB RAP protocol. The S4 DDE Server maintains a database of the relevant variables in the robot and makes sure that these DDE variables are kept updated at all times. The application using the DDE Server can concentrate on the user interface and rely on the updated DDE variables. If new RAPID variables are introduced in the robot program, the DDE Server is able to create corresponding DDE variables "on-the-fly".

Functionality

The S4 DDE Server provides reading and writing of I/O, RAPID variables and robot system variables. It supports spontaneous messages from the robot (SCWrite), error messages, as well as file operations. A file batch functionality is also included.

Digital I/O

The user can read or write to the digital I/O signals in the robot. The S4 DDE Server supports both group-I/O and block-I/O transfer. This improves the speed significantly.

RAPID variables

The user can read or write to RAPID variables that are defined and declared as persistent (PERS). The S4 DDE Server supports strings and numbers as well as more complex data types like wobjdata, pos, speeddata and tooldata. The names of the variables are defined by the user.

SCWrite

The user can address persistent RAPID variables that are written by the robot to the DDE Server (using the SCWrite RAPID instruction). The S4 DDE Server supports strings and numbers as well as more complex data types like wobjdata, pos, speeddata and tooldata. The name of the variables are defined by the user.

A superior-computer-write variable is only updated when the SCWrite RAPID instruction is executed in the robot. The user includes the SCWrite instruction at points in his RAPID program where he wants this update to take place.

System variables

With the system variables the user can read various status of the robot controller (controller ready/executing, program loaded, the position of the robot, etc.). Writing to the system variables will turn the motor power on/off, load a program, run it, etc. The system variables are pre-defined in the S4 DDE Server.

Program variables

With the program variables the user can control the loading and execution of programs in the robot. The variables are pre-defined in the S4 DDE Server.

Error variables

With the error variables the user can read the various error messages generated by the robot. The variables are pre-defined in the S4 DDE Server.

File operations

With the file operation variables the user can perform the following file operations: get file, put file, delete file, rename file, get directory listing and batch operation. These are pre-defined in the S4 DDE Server.

Batch operation

The S4 DDE Server offers a batch facility for file operations. The user can specify several file operations in a batch file (text file) and the DDE Server will execute this file to do multiple file-upload, download, delete, etc. This is a feature that is used for performing repetitive, regular file operations like back-up. A log-file reports how the file operations went.

DDE Server 2.3

Communication link

The user can read the communication variable to get information about the communication link to the robot. It will tell the user if the robot is up and running and communicating with the PC. It is pre-defined in the S4 DDE Server.

Addressing the DDE variables

You may think of a DDE variable (item) as a placeholder for a variable in the S4 robot controller. An example: To connect a cell in an MS Excel worksheet to a digital output (ex: do1) in the S4 robot controller, you type:
=ABBS4DDE|ROB1!a_digio_raplong_do1 in the formula bar in Excel, and press enter. From now on the cell in Excel will show a "1" when do1 is on and a "0" when do1 is off.

Multiple robots

The DDE Server can be supplied with support for one or multiple robots. For use with one robot, the robot is connected directly to the serial port in the PC.

If the robots are equipped with a network option, they can be connected directly by ethernet to the networked PC.

For use with more than one robot with serial connections, a "terminal server" is needed in the set-up. This is a box with eight or more serial ports and an ethernet port. The robots are connected to the serial ports and the PC (with an ethernet board) to the ethernet port. The "ShivaPort" from Shiva (used to be called "SpiderPort") is an example of a good terminal server for this use.

PC System Requirements

The requirements for the DDE Server will depend on the size of the installation and the number of robots. The descriptions below are recommendations only.

DDE Server for one robot

486 DX-66 minimum (Pentium recommended).

16 MB RAM memory or more.

10 MB free harddisk space.

Windows-95 or Windows/NT installed.

VGA compatible display (higher resolution recommended).

3.5" 1.44 MB diskette drive or CD rom.

Serial port or Network board.

DDE Server for multiple robots

Pentium 75 MHz (minimum).

16 MB RAM memory min. (more recommended).

10 MB free harddisk space.

Windows-95 or Windows/NT installed.

VGA compatible display (higher resolution and large screen strongly recommended).

3.5" 1.44 MB diskette drive or CD rom.

Network board (e.g. 3COM EtherLink III 3C509)

Alternatively a terminal server may be used.

Robot Controller Requirements

FactoryWare Interface 3.1 (or RAP Communication 3.1) installed.

Ethernet interface hardware (optional).

RobComm 3.1 can run with all versions of BaseWare OS.

Technical specification

Platform:	IBM/Intel based PC and compatibles
Operating system:	Microsoft Windows-95 or Windows/NT 4.0 (not included)
TCP/IP stack:	The generic Microsoft winsock.dll (not included, comes with Windows)
RPC:	Public domain Sun rpc.dll, ported to Windows/NT (included)
Software protection:	Access key, placed in printer port, with key-password. (Will run for five hour intervals without password or key)

7.4 ScreenMaker 3.0

ScreenMaker is a software product that assists the user in creating and editing user screen package files in a PC. See the ScreenViewer option for description of the user screens.

This product offers the advantages of the Windows environment. Some of the main features of ScreenMaker include:

- Easy to edit representation of user screens (using a tree and a list view).
- User friendly modification commands (rename, properties, insert, delete, etc.) via toolbar, shortcuts and mouse right click menu.
- Preview of a screen as it will be displayed on the teach pendant (including the strokes and the fields).
- Gives exact memory size that the screen package takes up when loaded onto the controller.
- Ability to check the syntax of display commands.
- Standard cut, copy and paste functions.

PC System Requirements

- 486 DX-33 minimum (Pentium recommended).
- 8 MB RAM memory minimum for Windows 95, 12 MB RAM for Windows NT(16 MB RAM recommended).
- Windows 95 or Windows NT 4.0.
- 5 MB free harddisk space.
- VGA compatible display (1024 x 768 recommended).
- Microsoft compatible mouse.
- 3.5" 1.44 MB diskette drive.

CONTENTS

Safety

Safety

1 General

This information on safety covers functions that have to do with the operation of the industrial robot.

The information does not cover how to design, install and operate a complete system, nor does it cover all peripheral equipment, which can influence the safety of the total system.

To protect personnel, the complete system has to be designed and installed in accordance with the safety requirements set forth in the standards and regulations of the country where the robot is installed.

The users of ABB industrial robots are responsible for ensuring that the applicable safety laws and regulations in the country concerned are observed and that the safety devices necessary to protect people working with the robot system have been designed and installed correctly.

People who work with robots must be familiar with the operation and handling of the industrial robot, described in applicable documents, e.g. Users's Guide and Product Manual.

⚠ **The diskettes which contain the robot's control programs must not be changed in any way because this could lead to the deactivation of safety functions, such as reduced speed.**

1.1 Introduction

Apart from the built-in safety functions, the robot is also supplied with an interface for the connection of external safety devices.

Via this interface, an external safety function can interact with other machines and peripheral equipment. This means that control signals can act on safety signals received from the peripheral equipment as well as from the robot.

In the Product Manual/*Installation,* instructions are provided for connecting safety devices between the robot and the peripheral equipment.

2 Applicable Safety Standards

The robot is designed in accordance with the requirements of ISO10218, Jan. 1992, Industrial Robot Safety. The robot also fulfils the ANSI/RIA 15.06-1992 stipulations.

Safety

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3 Fire-Extinguishing

⚠ **Use a CARBON DIOXIDE extinguisher in the event of a fire in the robot (manipulator or controller).**

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4 Definitions of Safety Functions

Emergency stop – IEC 204-1,10.7

A condition which overrides all other robot controls, removes drive power from robot axis actuators, stops all moving parts and removes power from other dangerous functions controlled by the robot.

Enabling device – ISO 11161, 3.4

A manually operated device which, when continuously activated in one position only, allows hazardous functions but does not initiate them. In any other position, hazardous functions can be stopped safely.

Safety stop – ISO 10218 (EN 775), 6.4.3

When a safety stop circuit is provided, each robot must be delivered with the necessary connections for the safeguards and interlocks associated with this circuit. It is necessary to reset the power to the machine actuators before any robot motion can be initiated. However, if only the power to the machine actuators is reset, this should not suffice to initiate any operation.

Reduced speed – ISO 10218 (EN 775), 3.2.17

A single, selectable velocity provided by the robot supplier which automatically restricts the robot velocity to that specified in order to allow sufficient time for people either to withdraw from the hazardous area or to stop the robot.

Interlock (for safeguarding) – ISO 10218 (EN 775), 3.2.8

A function that interconnects a guard(s) or a device(s) and the robot controller and/or power system of the robot and its associated equipment.

Hold-to-run control – ISO 10218 (EN 775), 3.2.7

A control which only allows movements during its manual actuation and which causes these movements to stop as soon as it is released.

5 Safe Working Procedures

Safe working procedures must be used to prevent injury. No safety device or circuit may be modified, bypassed or changed in any way, at any time.

5.1 Normal operations

All normal operations in automatic mode must be executed from outside the safe-guarded space.

6 Programming, Testing and Servicing

The robot is extremely heavy and powerful, even at low speed. When entering into the robot's safeguarded space, the applicable safety regulations of the country concerned must be observed.

Operators must be aware of the fact that the robot can make unexpected movements. A pause (stop) in a pattern of movements may be followed by a movement at high speed. Operators must also be aware of the fact that external signals can affect robot programs in such a way that a certain pattern of movement changes without warning.

⚠ **If work must be carried out within the robot's work envelope, the following points must be observed:**

- The operating mode selector on the controller must be in the manual mode position to render the enabling device operative and to block operation from a computer link or remote control panel.

- The robot's speed is limited to max. 250 mm/s (10 inches/s) when the operating mode selector is in position < 250 mm/s. This should be the normal position when entering the working space. The position 100% – full speed – may only be used by trained personnel who are aware of the risks that this entails.

⚠ **Do not change "Transm gear ratio" or other kinematic parameters from the teach pendant or a PC. This will affect the safety function *Reduced speed 250 mm/s*.**

- During programming and testing, the enabling device must be released as soon as there is no need for the robot to move.

⚠ **The enabling device must never be rendered inoperative in any way.**

- The programmer must always take the teach pendant with him/her when entering through the safety gate to the robot's working space so that no-one else can take over control of the robot without his/her knowledge.

7 Safety Functions

7.1 The safety control chain of operation

The safety control chain of operation is based on dual electrical safety chains which interact with the robot computer and enable the MOTORS ON mode.

Each electrical safety chain consist of several switches connected in such a way that all of them must be closed before the robot can be set to MOTORS ON mode. MOTORS ON mode means that drive power is supplied to the motors.

If any contact in the safety chain of operation is open, the robot always reverts to MOTORS OFF mode. MOTORS OFF mode means that drive power is removed from the robot's motors and the brakes are applied.
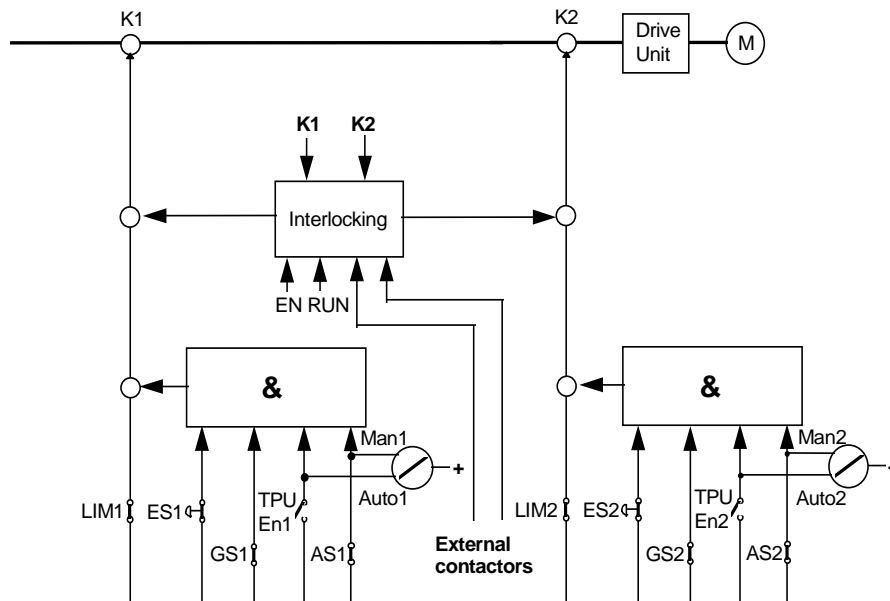
The status of the switches is indicated by LEDs on top of the panel module in the control cabinet and is also displayed on the teach pendant (I/O window).

After a stop, the switch must be reset at the unit which caused the stop before the robot can be ordered to start again.

The time limits for the central two channel cyclic supervisions of the safety control chain is between 2 and 4 second.

⚠️ **The safety chains must never be bypassed, modified or changed in any other way.**

7.2 Emergency stops

An emergency stop should be activated if there is a danger to people or equipment. Built-in emergency stop buttons are located on the operator's panel of the robot controller and on the teach pendant.

External emergency stop devices (buttons, etc.) can be connected to the safety chain by the user (see Product Manual/*Installation*). They must be connected in accordance with the applicable standards for emergency stop circuits.

Before commissioning the robot, all emergency stop buttons or other safety equipment must be checked by the user to ensure their proper operation.

⚠ **Before switching to MOTORS ON mode again, establish the reason for the stop and rectify the fault.**

7.3 Mode selection using the operating mode selector

The applicable safety requirements for using robots, laid down in accordance with ISO/DIS 10218, are characterised by different modes, selected by means of control devices and with clear-cut positions.

One automatic and two manual modes are available:

Manual mode:
< 250 mm/s - max. speed is 250mm/s
100% - full speed

Automatic mode: The robot can be operated via a remote control device

The manual mode, < 250 mm/s or 100%, must be selected whenever anyone enters the robot's safeguarded space. The robot must be operated using the teach pendant and, if 100% is selected, using Hold-to-run control.

In automatic mode, the operating mode selector is switched to ⊚ , and all safety arrangements, such as doors, gates, light curtains, light beams and sensitive mats, etc., are active. No-one may enter the robot's safeguarded space. All controls, such as emergency stops, the control panel and control cabinet, must be easily accessible from outside the safeguarded space.

Programming and testing at reduced speed

Robot movements at reduced speed can be carried out as follows:

• Set the operating mode selector to <250 mm/s

• Programs can only be started using the teach pendant with the enabling device activated.

The automatic mode safeguarded space stop (AS) function is not active in this mode.

Safety

Testing at full speed

Robot movements at programmed speed can be carried out as follows:

• Set the operating mode selector to 100%

• Programs can only be started using the teach pendant with the enabling device activated.

For "Hold-to-run control", the Hold-to-run button must be activated. Releasing the button stops program execution.

The 100% mode may only be used by trained personnel. The applicable laws and regulations of the countries where the robot is used must always be observed.

Automatic operation

Automatic operation may start when the following conditions are fulfilled:

• The operating mode selector is set to ◎

• The MOTORS ON mode is selected

Either the teach pendant can be used to start the program or a connected remote control device. These functions should be wired and interlocked in accordance with the applicable safety instructions and the operator must always be outside the safeguarded space.

7.4 Enabling device

When the operating mode selector is in the MANUAL or MANUAL FULL SPEED position, the robot can be set to the MOTORS ON mode by depressing the enabling device on the teach pendant.

Should the robot revert to the MOTORS OFF mode for any reason while the enabling device is depressed, the latter must be released before the robot can be returned to the MOTORS ON mode again. This is a safety function designed to prevent the enabling device from being rendered inactive.

When the enabling device is released, the drive power to the motors is switched off, the brakes are applied and the robot reverts to the MOTORS OFF mode.

If the enabling device is reactivated, the robot changes to the MOTORS ON mode.

7.5 Hold-to-run control

This function is always active when the operating mode selector is in the MANUAL FULL SPEED position. It is possible to set a parameter to make this function active also when the operating mode selector is in the MANUAL position.

When the Hold-to-run control is active, the enabling device and the Hold-to-run button on the teach pendant must be depressed in order to execute a program. When the button is released, the axis (axes) movements stop and the robot remains in the MOTORS ON mode.

Here is a detailed description of how to execute a program in Hold-to-run control:

• Activate the enabling device on the teach pendant.

• Choose execution mode using the function keys on the teach pendant:

     - **Start** (continuous running of the program)

     - **FWD** (one instruction forwards)

     - **BWD** (one instruction backwards)

• Wait for the Hold-to-run alert box.

• Activate the Hold-to-run button on the teach pendant.

Now the program will run (with the chosen execution mode) as long as the Hold-to-run button is pressed. Releasing the button stops program execution and activating the button will start program execution again.

For FWD and BWD execution modes, the next instruction is run by releasing and activating the Hold-to-run button.

It is possible to change execution mode when the Hold-to-run button is released and then continue the program execution with the new execution mode, by just activating the Hold-to-run button again, i.e. no alert box is shown.

If the program execution was stopped with the Stop button on the teach pendant, the program execution will be continued by releasing and activating the Hold-to-run button.

When the enabling device on the teach pendant is released, the sequence described above must be repeated from the beginning.

7.6 General Mode Safeguarded Stop (GS) connection

The GS connection is provided for interlocking external safety devices, such as light curtains, light beams or sensitive mats. The GS is active regardless of the position of the operating mode selector.

When this connection is open the robot changes to the MOTORS OFF mode. To reset to MOTORS ON mode, the device that initiated the safety stop must be interlocked in accordance with applicable safety regulations. This is not normally done by resetting the device itself.

7.7 Automatic Mode Safeguarded Stop (AS) connection

The AS connection is provided for interlocking external safety devices, such as light curtains, light beams or sensitive mats used externally by the system builder. The AS is especially intended for use in automatic mode, during normal program execution.

The AS is by-passed when the operating mode selector is in the MANUAL or MANUAL FULL SPEED position.

7.8 Limiting the working space

For certain applications, movement about the robot's main axes must be limited in order to create a sufficiently large safety zone. This will reduce the risk of damage to the robot if it collides with external safety arrangements, such as barriers, etc.

Movement about axes 1, 2 and 3 can be limited with adjustable mechanical stops or by means of electrical limit switches. If the working space is limited by means of stops or switches, the corresponding software limitation parameters must also be changed. If necessary, movement of the three wrist axes can also be limited by the computer software. Limitation of movement of the axes must be carried out by the user.

7.9 Supplementary functions

Functions via specific digital inputs:

• A stop can be activated via a connection with a digital input. Digital inputs can be used to stop programs if, for example, a fault occurs in the peripheral equipment.

Functions via specific digital outputs:

• Error – indicates a fault in the robot system.

• Cycle_on – indicates that the robot is executing a program.

• MotOnState/MotOffState – indicates that the robot is in MOTORS ON / MOTORS OFF mode.

• EmStop - indicates that the robot is in emergency stop state.

• AutoOn - indicates that the robot is in automatic mode.

8 Safety Risks Related to End Effectors

8.1 Gripper

If a gripper is used to hold a workpiece, inadvertent loosening of the workpiece must be prevented.

8.2 Tools/workpieces

It must be possible to turn off tools, such as milling cutters, etc., safely. Make sure that guards remain closed until the cutters stop rotating.

Grippers must be designed so that they retain workpieces in the event of a power failure or a disturbance of the controller. It should be possible to release parts by manual operation (valves).

8.3 Pneumatic/hydraulic systems

Special safety regulations apply to pneumatic and hydraulic systems.

Residual energy may be present in these systems so, after shutdown, particular care must be taken.

The pressure in pneumatic and hydraulic systems must be released before starting to repair them. Gravity may cause any parts or objects held by these systems to drop. Dump valves should be used in case of emergency. Shot bolts should be used to prevent tools, etc., from falling due to gravity.

9 Risks during Operation Disturbances

If the working process is interrupted, extra care must be taken due to risks other than those associated with regular operation. Such an interruption may have to be rectified manually.

Remedial action must only ever be carried out by trained personnel who are familiar with the entire installation as well as the special risks associated with its different parts.

The industrial robot is a flexible tool which can be used in many different industrial applications. All work must be carried out professionally and in accordance with applicable safety regulations. Care must be taken at all times.

10 Risks during Installation and Service

To prevent injuries and damage during the installation of the robot system, the regulations applicable in the country concerned and the instructions of ABB Robotics must be complied with. Special attention must be paid to the following points:

• The supplier of the complete system must ensure that all circuits used in the safety function are interlocked in accordance with the applicable standards for that function.

• The instructions in the Product Manual/*Installation* must always be followed.

• The mains supply to the robot must be connected in such a way that it can be turned off outside the robot's working space.

Safety

- The supplier of the complete system must ensure that all circuits used in the emergency stop function are interlocked in a safe manner, in accordance with the applicable standards for the emergency stop function.

- Emergency stop buttons must be positioned in easily accessible places so that the robot can be stopped quickly.

- Safety zones, which have to be crossed before admittance, must be set up in front of the robot's working space. Light beams or sensitive mats are suitable devices.

- Turntables or the like should be used to keep the operator away from the robot's working space.

- Those in charge of operations must make sure that safety instructions are available for the installation in question.

- Those who install the robot must have the appropriate training for the robot system in question and in any safety matters associated with it.

Although troubleshooting may, on occasion, have to be carried out while the power supply is turned on, the robot must be turned off (by setting the mains switch to OFF) when repairing faults, disconnecting electric leads and disconnecting or connecting units.

⚠ **Even if the power supply for the robot is turned off, you can still injure yourself.**

- The axes are affected by the force of gravity when the brakes are released. In addition to the risk of being hit by moving robot parts, you run the risk of being crushed by the tie rod.

- Energy, stored in the robot for the purpose of counterbalancing certain axes, may be released if the robot, or parts thereof, is dismantled.

- When dismantling/assembling mechanical units, watch out for falling objects.

- Be aware of stored energy (DC link) and hot parts in the controller.

- Units inside the controller, e.g. I/O modules, can be supplied with external power.

11 Risks Associated with Live Electric Parts

Controller

A danger of high voltage is associated with the following parts:

- The mains supply/mains switch
- The power unit
- The power supply unit for the computer system (55 V AC)
- The rectifier unit (260 V AC and 370 V DC. NB: Capacitors!)
- The drive unit (370 V DC)
- The service outlets (115/230 VAC)
- The power supply unit for tools, or special power supply units for the machining process

- The external voltage connected to the control cabinet remains live even when the robot is disconnected from the mains.

- Additional connections

Manipulator

A danger of high voltage is associated with the manipulator in:

- The power supply for the motors (up to 370 V DC)

- The user connections for tools or other parts of the installation (see *Installation*, max. 230 V AC)

Tools, material handling devices, etc.

Tools, material handling devices, etc., may be live even if the robot system is in the OFF position. Power supply cables which are in motion during the working process may be damaged.

12 Emergency Release of Mechanical Arm

If an emergency situation occur where a person is caught by the mechanical robot arm, the brake release buttons should be pressed whereby the arms can be moved to release the person. To move the arms by manpower is normally possible on the smaller robots (1400 and 2400), but for the bigger ones it might not be possible without a mechanical lifting device, like an overhead crane.

If power is not available the brakes are applied, and therefore manpower might not be sufficient for any robot.

Before releasing the brakes, secure that the weight of the arms not enhance the press force on the caught person.

13 Limitation of Liability

The above information regarding safety must not be construed as a warranty by ABB Robotics that the industrial robot will not cause injury or damage even if all safety instructions have been complied with.

14 Related Information

	Described in:
Installation of safety devices	Product Manual - *Installation and Commissioning*
Changing robot modes	User's Guide - *Starting up*
Limiting the working space	Product Manual - *Installation and Commissioning*

Safety

To the User

"Declaration by the manufacturer".
This is only a translation of the customs declaration. The original document (in English) with the serial number on it is supplied together with the robot

**Declaration by the manufacturer
as defined by machinery directive 89/392/EEC Annex II B**

Herewith we declare that the industrial robot

☐ IRB 1400   ☐ IRB 2000   ☐ IRB 2400   ☐ IRB 3000   ☐ IRB 3400

☐ IRB 4400   ☐ IRB 6000   ☐ IRB 6400   ☐ IRB 6400C   ☐ IRB 640

manufactured by ABB Robotics Products AB 721 68 Västerås, Sweden
with serial No.

Label with
serial number

is intended to be incorporated into machinery or assembled with other machinery to constitute machinery covered by this directive and must not be put into service until the machinery into which it is to be incorporated has been declared in conformity with the provisions of the directive, 91/368 EEC.

Applied harmonised standards in particular:

EN 292-1	Safety of machinery, basic terminology
EN 292-2	Safety of machinery, technical principles/specifications, emergency stop
EN 418	Safety of machinery, emergency stop equipment
EN 563	Safety of machinery, temperatures of surfaces
EN 614-1	Safety of machiney, ergonomic design principles
EN 775	Robot safety
EN 60204	Electrical equipment for industrial machines
prEN 574	Safety of machinery, two-hand control device
prEN 953	Safety of machinery, fixed / moveable guards
prEN 954-1	Safety of machinery, safety related parts of the control system
EN 50081-2	EMC, Generic emission standard. Part 2: Industrial environment
EN 55011 Class A	Radiated emission enclosure
EN 55011 Class A	Conducted emission AC Mains
EN 50082-2	EMC, Generic immunity standard. Part 2: Industrial environment
EN 61000-4-2	Electrostatic discharge immunity test
EN 61000-4-3	Radiated, radio-frequency, electromagnetic field immunity yest
ENV 50204	Radeated electromagnetic field from digital radio telephones, immunity test
EN 61000-4-4	Electrical fast transient/burst immunity test
ENV 50141	Conducted disturbences induced by radio-frequency fields, immunity test

Prepared	Responsible department	Title	Technical Provisions	
M Jonsson, 970904	SEROP/K			
Approved by,date	Take over department	Declaration by the manuf.		Page
K-G Ramström, 970905				1
Product Design Responsible				
Status				No.of pages
APPROVED		Tillverkardeklaration		1
ABB ABB Robotics Products		Document No 3HAB 3585-1		Rev. ind. 08

ABB ROBOTICS PRODUCTS AB　　　CONFIGURATION LIST

Robot type:　　　　　Revision:　　　　Manufact order no:　　Serial no:

For RAC:　　　　　　RAC Ref no:　　　　　　　　　Sales order no:

Tested and approved:　Date　　　　Name

MANIPULATOR:

CONTROL

ROBOT SY

Delivery fro

Delivery to

To the User

The Configuration List is an individual specification of the robot
system delivered regarding configuration and extent.

On delivery, the complete document is placed in the robot controller.

Acceptance by customer:　　_____

Customer information:　　　_____

Customer:

Address:

OPTIONS/DOCUMENTATION

QTY　　　OPTION/PARTNO　　　　REVISION　　　　DESCRIPTION

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1 Structure

The robot is made up of two main parts, manipulator and controller, described in sections 1.1 and 1.2.

1.1 Manipulator

It is equipped with maintenance-free, AC motors which have electromechanical brakes. The brakes lock the motors when the robot is inoperative for more than 1000 hours. The time is configurabble for the user.

The following figures shows the various ways in which the different manipulators moves and its component parts.
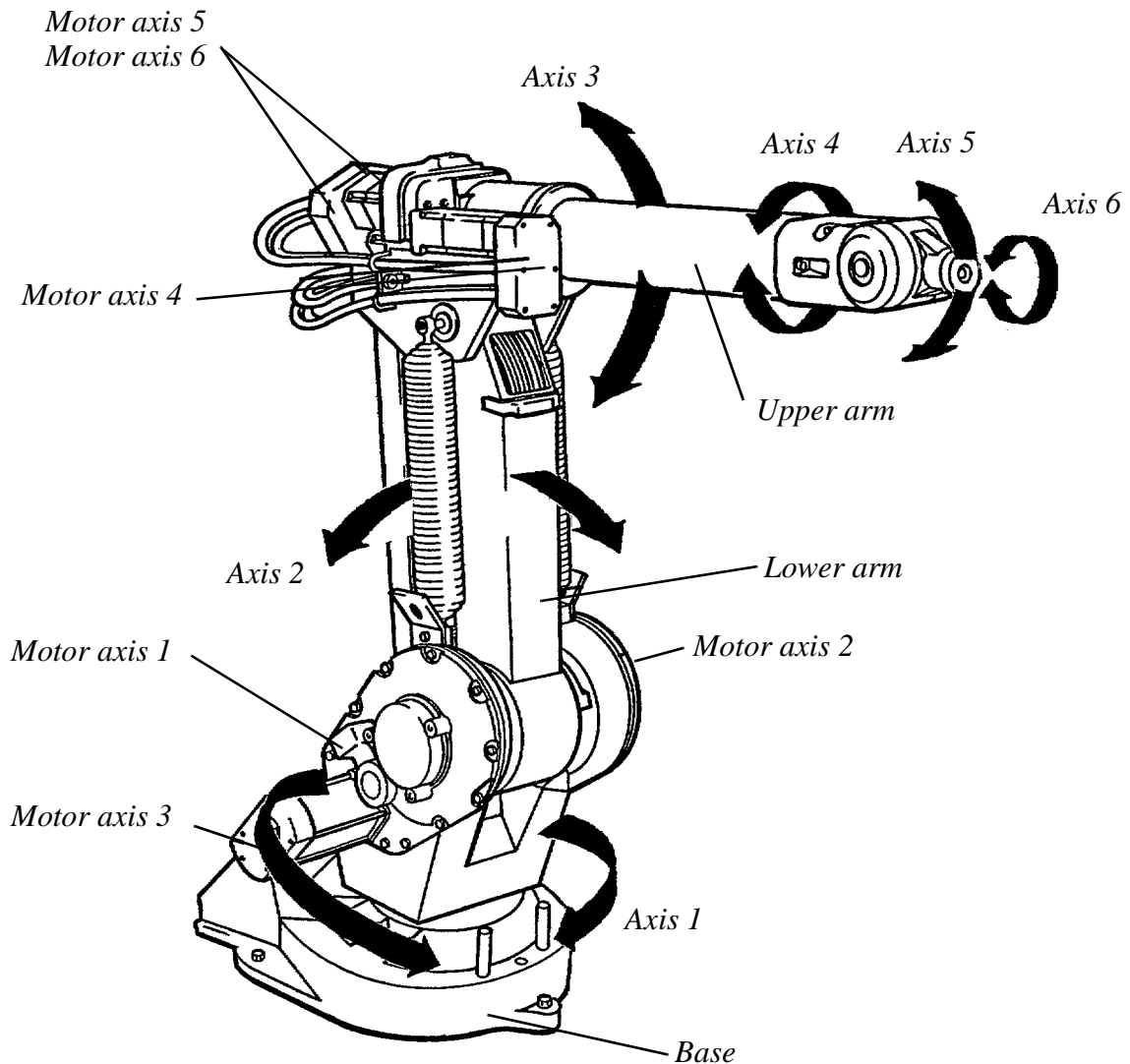
Figure 1 The motion patterns of the IRB 1400 and IRB 140.
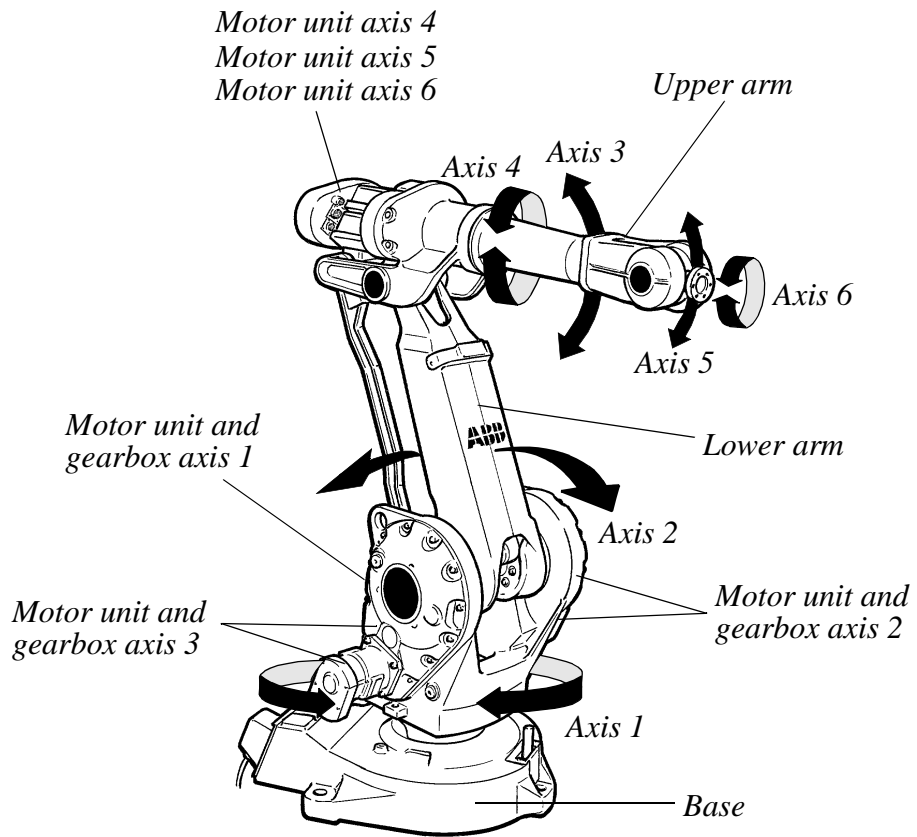
Figure 2 The motion patterns of the IRB 2400.
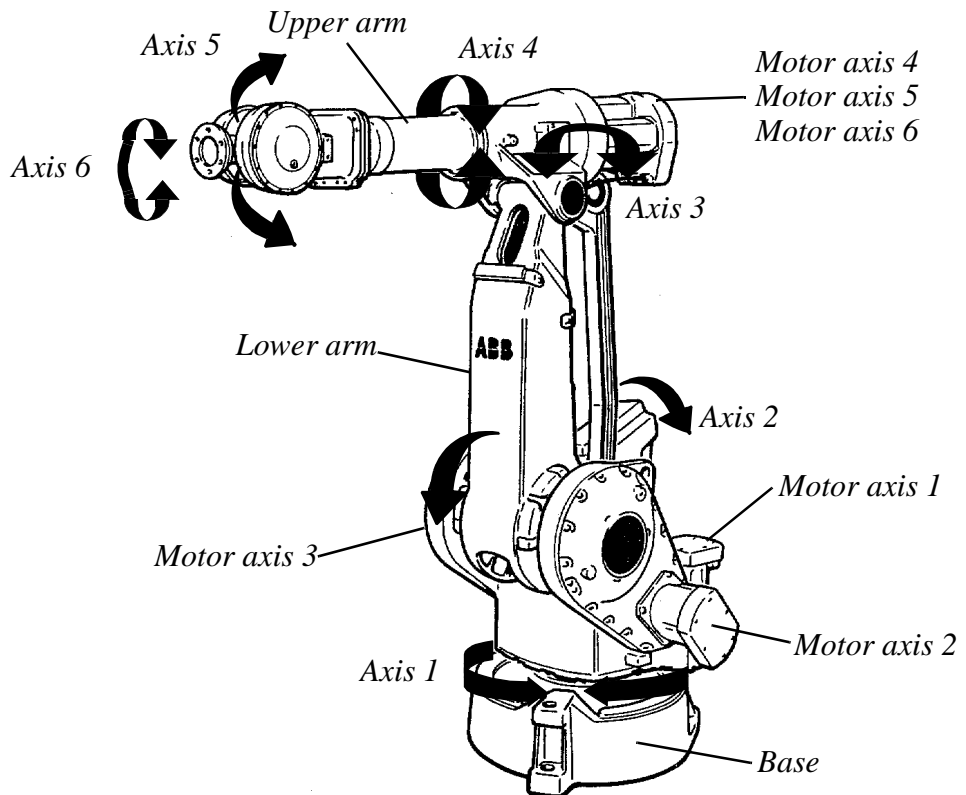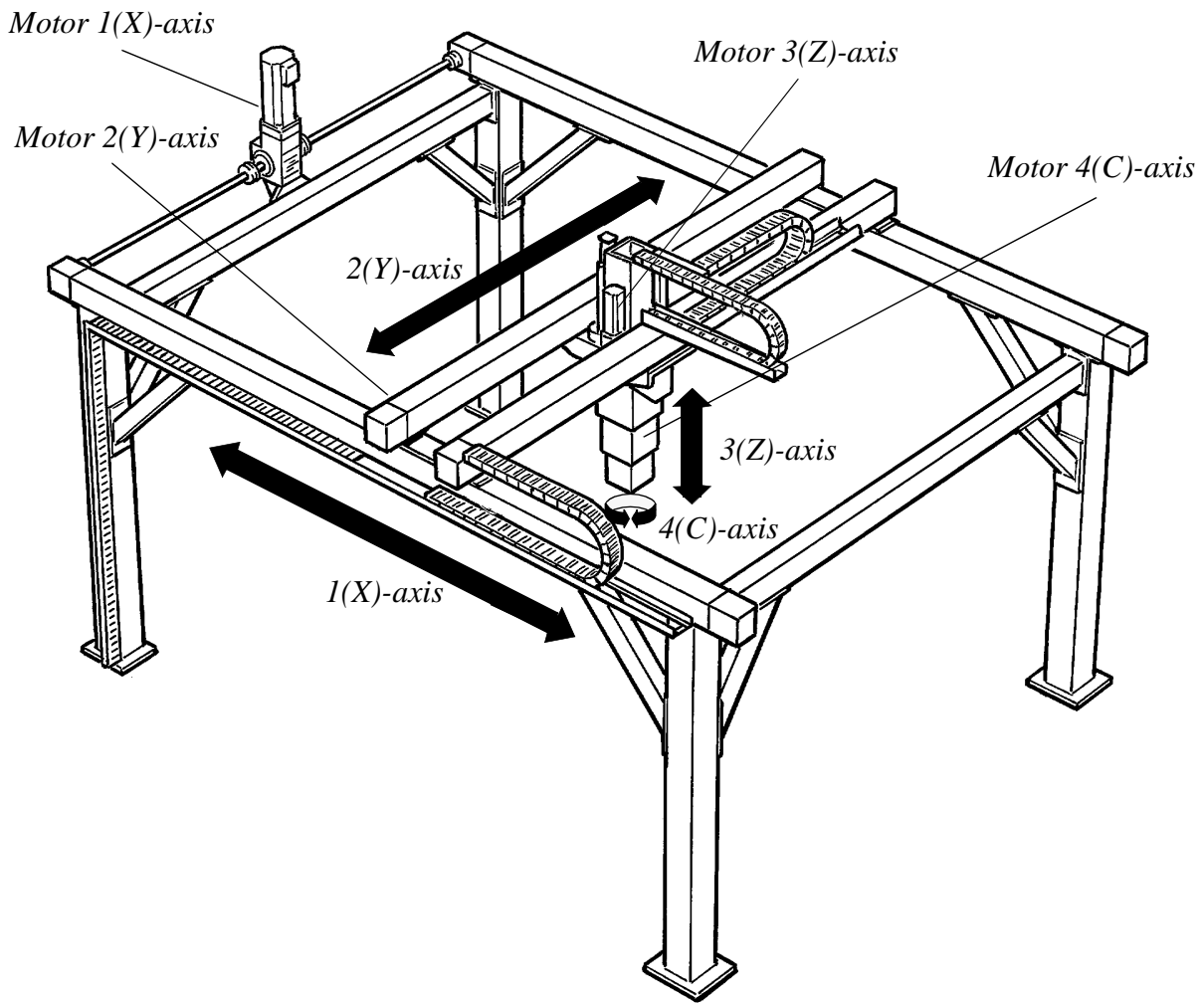

Figure 3 The motion patterns of the IRB 4400.

Axis 3

Upper arm

Motor axis 4

Motor axis 5

Axis 4

Motor axis 6

Axis 5

Axis 6

Motor axis 1

Axis 2

Motor axis 2

Motor axis 3

Lower arm

Axis 1

Base
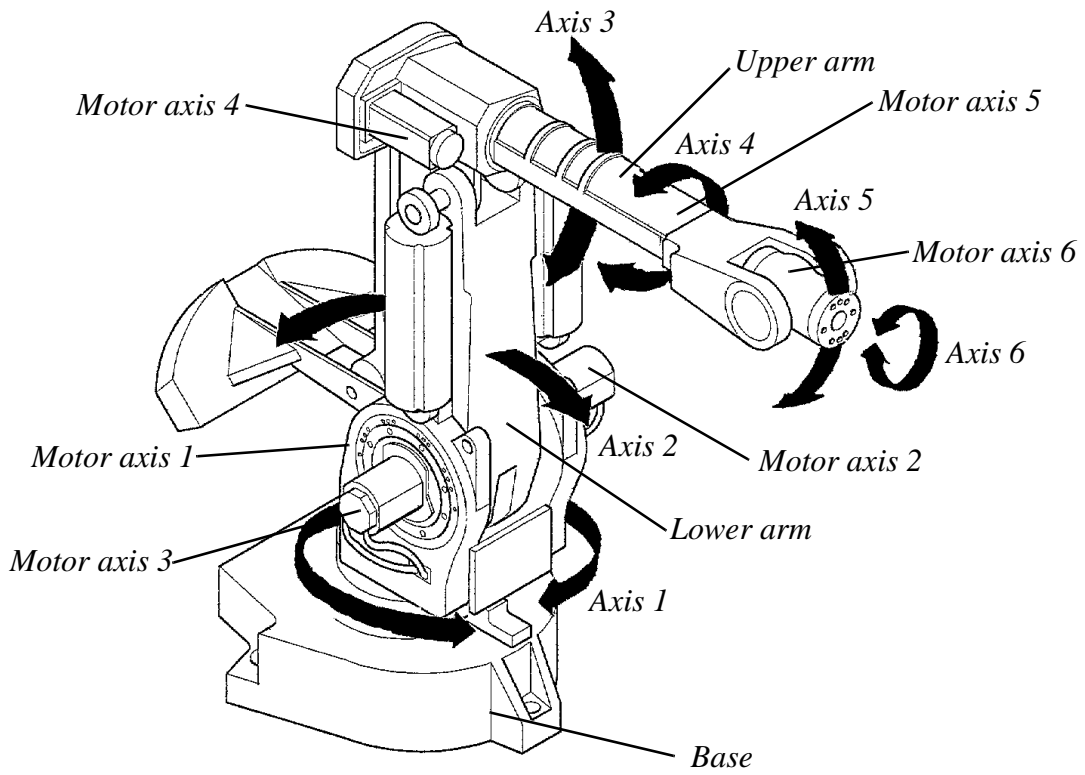
Figure 4 The motion patterns of the IRB 6400.

Axis 3

Upper arm

Motor axis 6

Axis 6

Axis 2

Motor axis 2

Motor axis 3

Lower arm

Motor axis 1

Axis 1
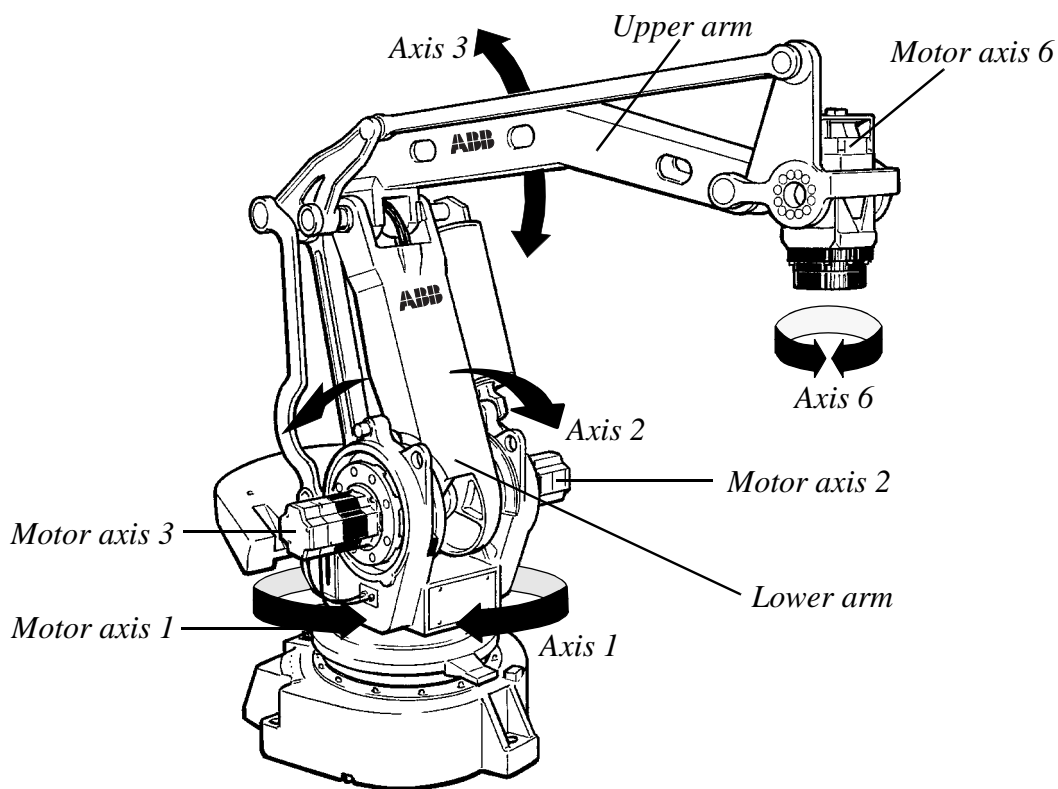
Figure 5 The motion patterns of the IRB 640.

Motor 1(X)-axis

Motor 3(Z)-axis

Motor 2(Y)-axis

Motor 4(C)-axis

2(Y)-axis

3(Z)-axis

4(C)-axis

1(X)-axis

Figure 6 The motion patterns of the IRB 840/A.

1.2 Controller

The controller, which contains the electronics used to control the manipulator and peripheral equipment, is specifically designed for robot control, and consequently provides optimal performance and functionality.

Figure 7 shows the location of the various components on the cabinet.
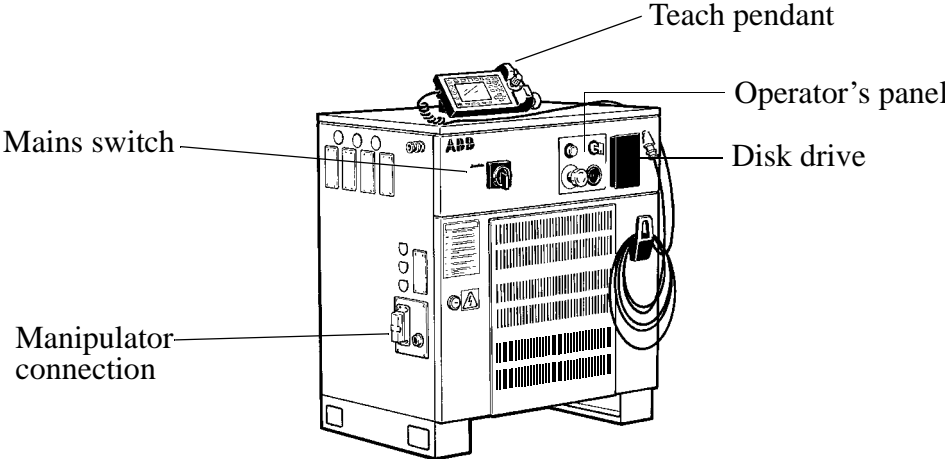
Figure 7 The exterior of the cabinet showing the location of the various units.

1.3 Electronics unit

All control and supervisory electronics, apart from the serial measurement board, which is located inside the manipulator, are gathered together inside the controller.
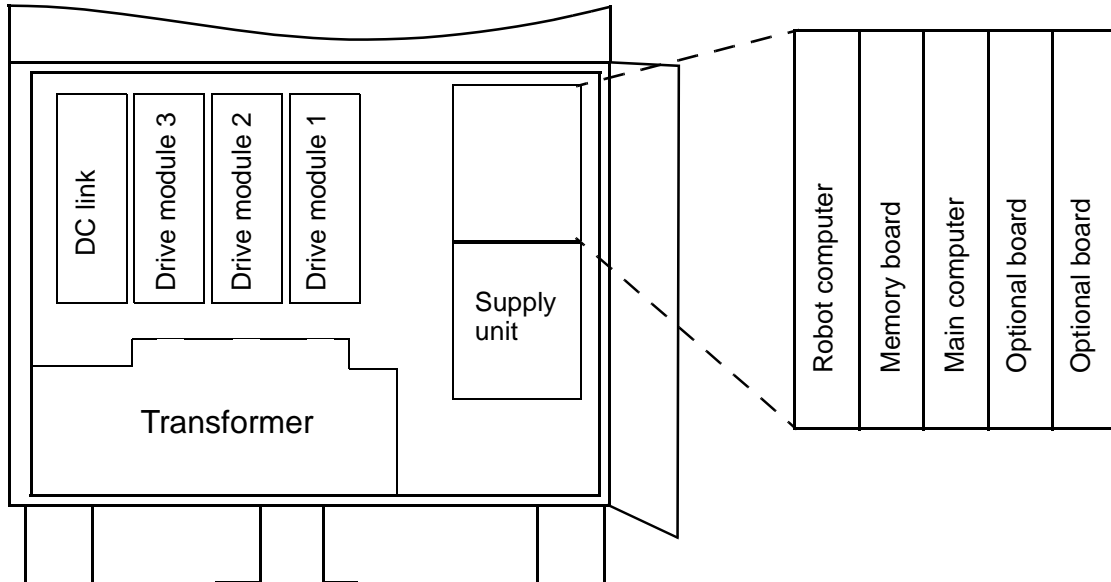
Figure 8 The location of the electronics boards and units behind the front door.

The computer unit (supply unit + board backplane) comprises the following parts:

- Robot computer board –
  contains computers used to control the manipulator motion and I/O communication.

- Memory board –
  contains extra RAM memory, there are three sizes, 8 and 16 MB.

- Main computer board –
  contains 8 MB RAM memory and the main computer, which controls the entire robot system.

- Optional boards-
  Communication boards, containing circuits for network and field bus communication.

- Supply unit–
  4 regulated and short-circuit-protected output voltages.

Drive system:

- DC link–
  converts a three-phase AC voltage to a DC voltage.

- Drive module –
  controls the torque of 2-3 motors.

When the maximum capacity for external axes is utilized, a second control cabinet is used. The external axes cabinet comprises AC connection, main switch, contactors, transformer, DC-link, drive module(s), and supply unit, but no computer unit.
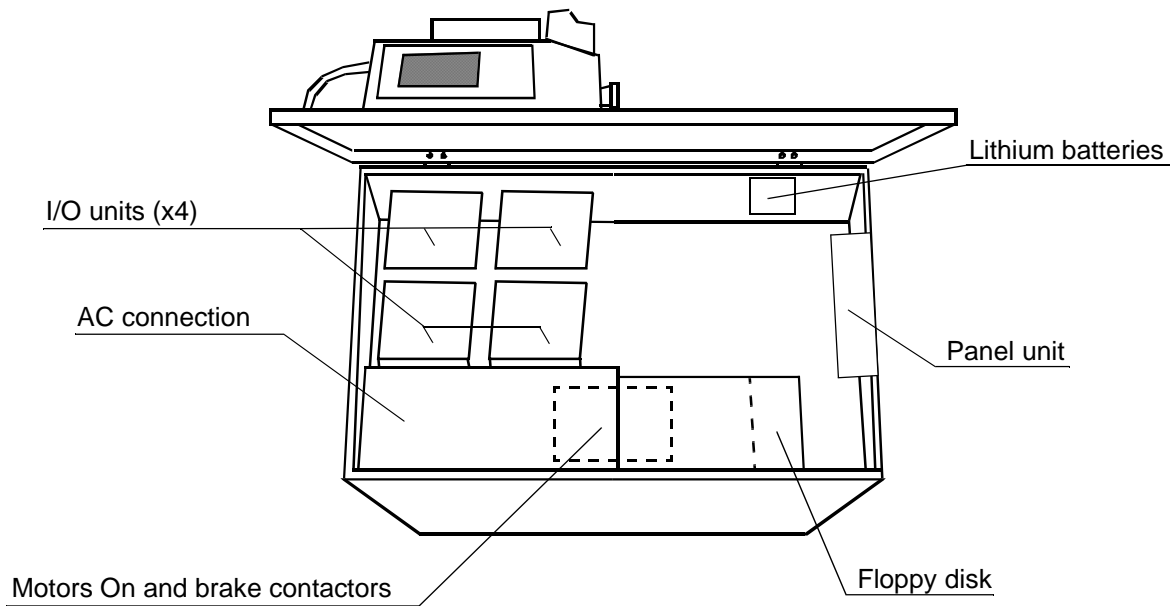
Figure 9 The location of units under the top cover.

• Lithium batteries for memory back-up.

• Panel unit –
  gathers and coordinates all signals that affect operational and personal safety.

• I/O units –
  enables communication with external equipment by means of digital inputs and
  outputs, analog signals or field buses.

  I/O units can alternatively be located outside the cabinet. Communication with
  robot data is implemented via a stranded wire CAN bus, which allows the units
  to be positioned close to the process.

• Serial measurement board (in the manipulator) –
  gathers resolver data and transfers it serially to the robot computer board. The
  serial measurement board is battery-backed so that the revolution information
  cannot be lost during a power failure.

2 Computer System

The computer system is made up of three computers on two circuit boards. The computers comprise:

- Main computer board –
  contains the *main computer* of the robot and controls the entire robot.

- Robot computer board –
  contains the *I/O computer* which acts as a link between the main computer, the world around and the *axis computer* that regulates the velocity of the robot axes.

To find out where the various boards are located, see Electronics unit on page 8.

The computers are the data processing centre of the robot. They possess all the functions required to create, execute and store a robot program. They also contain functions for coordinating and regulating the axis movements. Figure 10 shows how the computer system communicates with the other units.
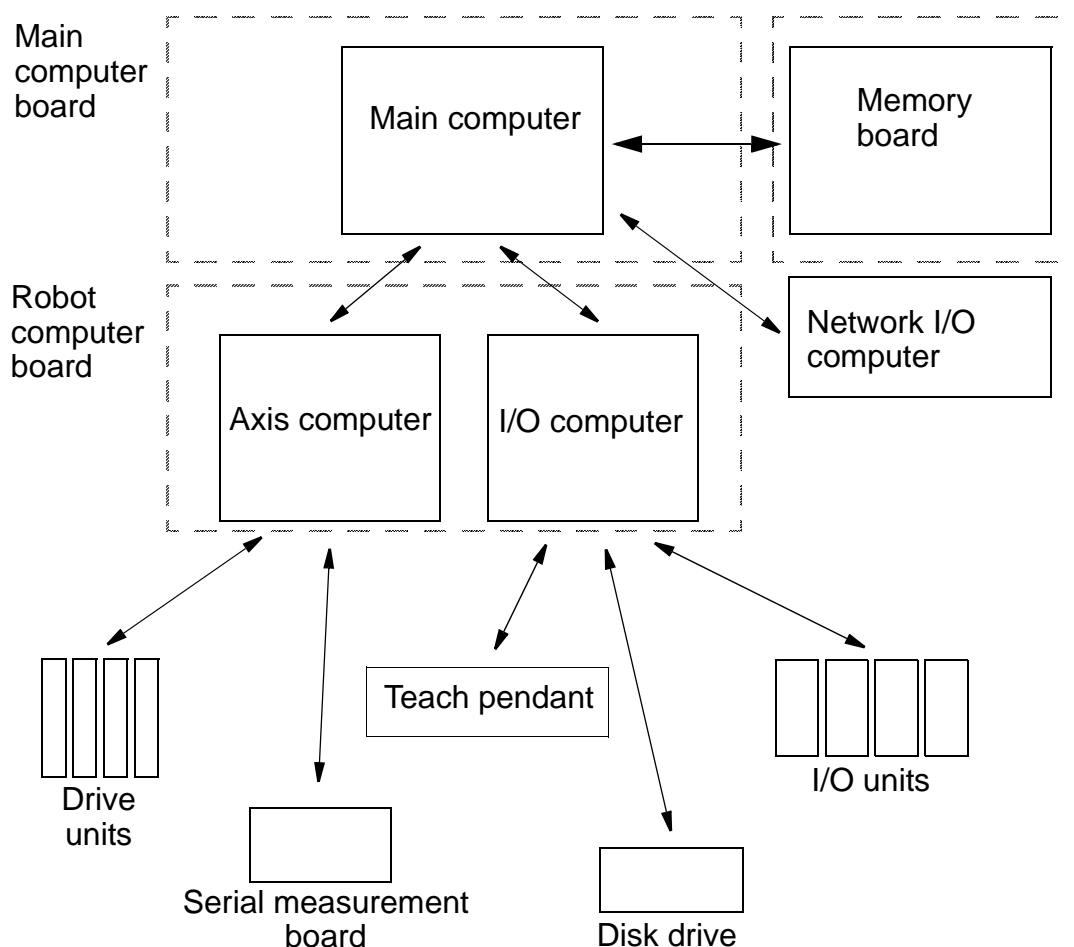

Figure 10 The interfaces of the computer system.

3 Servo System

3.1 Principle function

The servo system is a complex system comprising several different interacting units and system parts – both hardware and software. The servo function comprises:

- Digital regulation of the poses, velocity and motor current of the robot axes.

- Synchronous AC operation of the robot motors.

3.2 Regulation

During execution, new data on the poses of the robot axes is continuously received from the serial measurement board. This data is input into the position regulator and then compared with previous position data. After it has been compared and amplified, new references are given for the pose and velocity of the robot.

The system also contains a model of the robot which continuously calculates the optimal regulator parameters for the gravitation, the moment of inertia and the interaction between axes. See Figure 11.

3.3 Controlling the robot

An digital current reference for two phases is calculated on the basis of the resolver signal and a known relationship between the resolver angle and rotor angle. The third phase is created from the other two.

The current of the phases is regulated in the drive unit in separate current regulators. In this way, three voltage references are returned which, by pulse-modulating the rectifier voltage, are amplified to the working voltage of the motors.

The serial measurement board receives resolver data from a maximum of six resolvers and generates information on the position of the resolvers.

The following diagrams outline the system structure for AC operation as well as the fundamental structure of the drive unit.
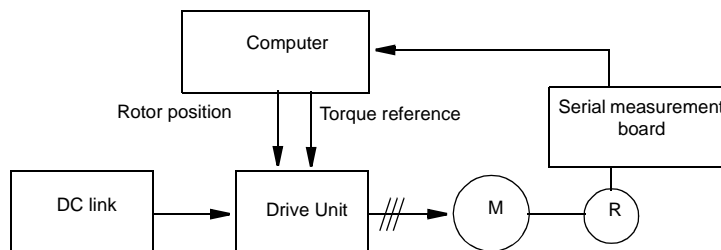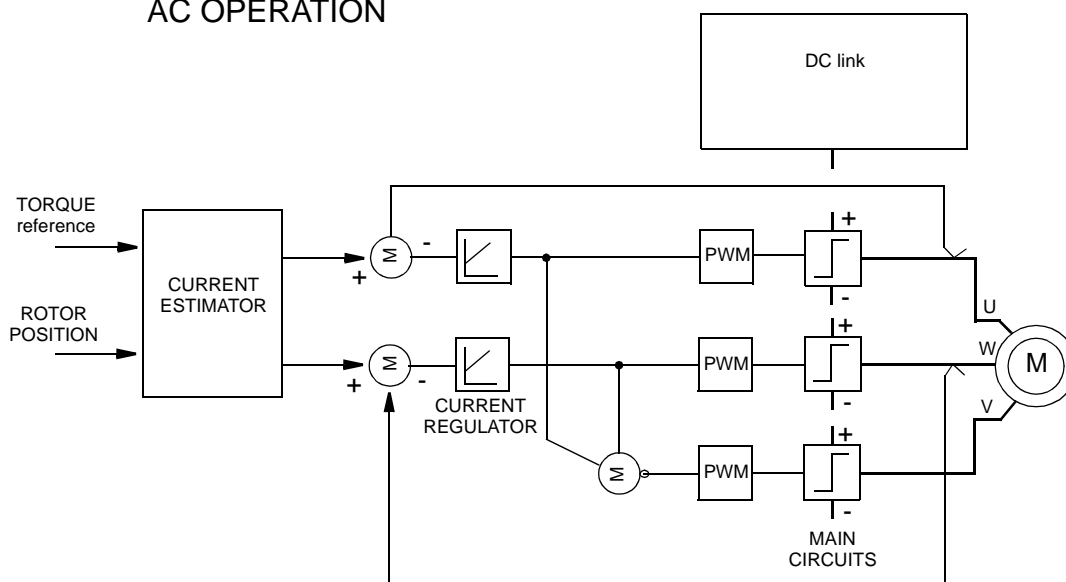

AC OPERATION

Figure 11 System structure for AC operation.

3.4 Overload protection

PTC resistance is built into the robot motors to provide thermal protection against over-loads. The PTC sensors are connected to an input on the panel unit which is sensitive to resistance level and which check that low resistance is maintained.

The robot computer checks the motors for overloading at regular intervals by reading the panel unit register. In the event of an overload, all motors are switched off.

4 I/O System

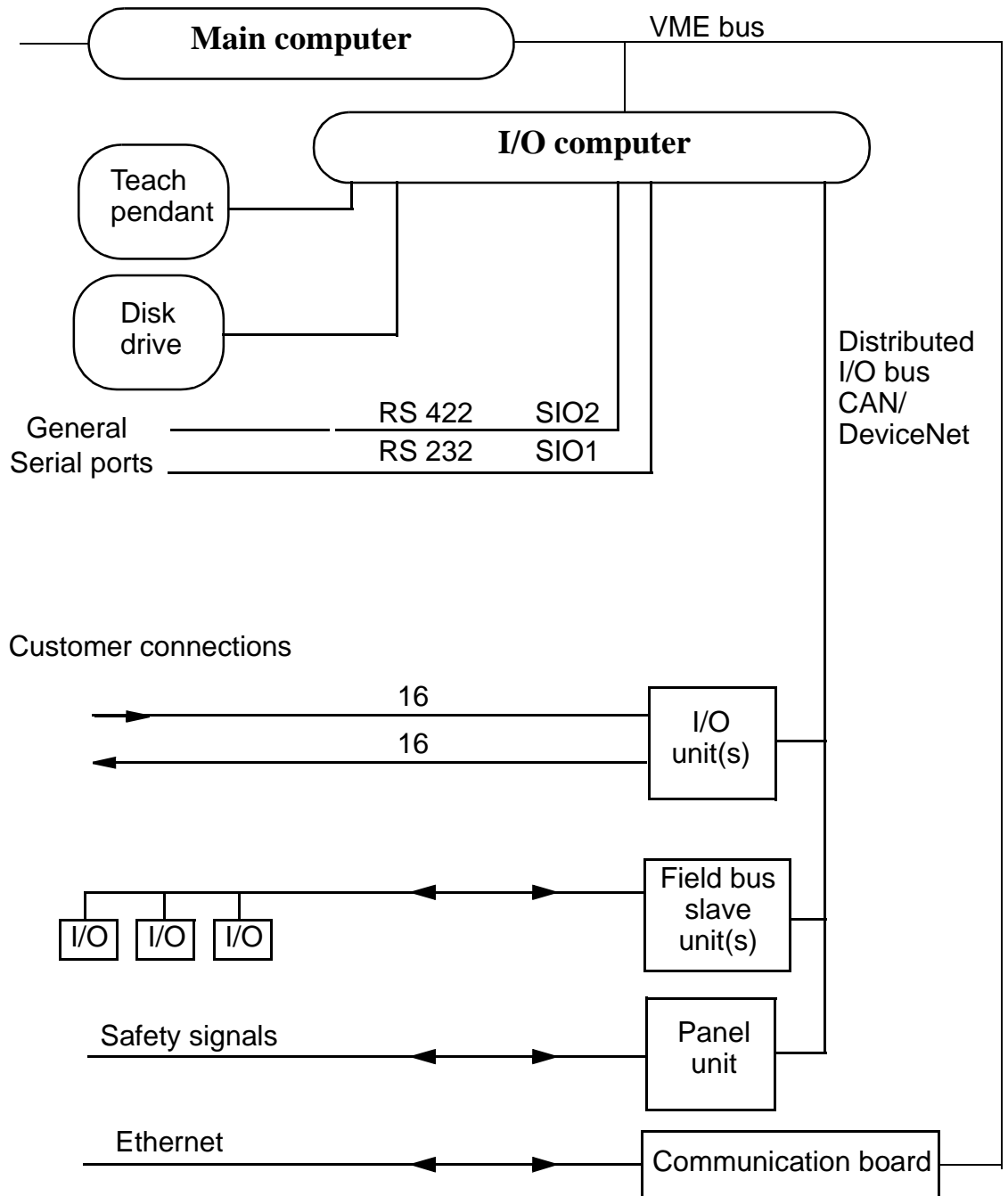Communicates with other equipment using digital and analog input and output signals.

Figure 12 Overview of the I/O system.

5 Safety System

The robot's safety system is based on a two-channel safety circuit that is continuously monitored. If an error is detected, the power supply to the motors is switched off and the brakes engage. To return the robot to MOTORS ON mode, the two identical chains of switches must be closed. As long as these two chains differ, the robot will remain in the MOTORS OFF mode.

Figure 13 below illustrates an outline principal circuit with available customer contacts.
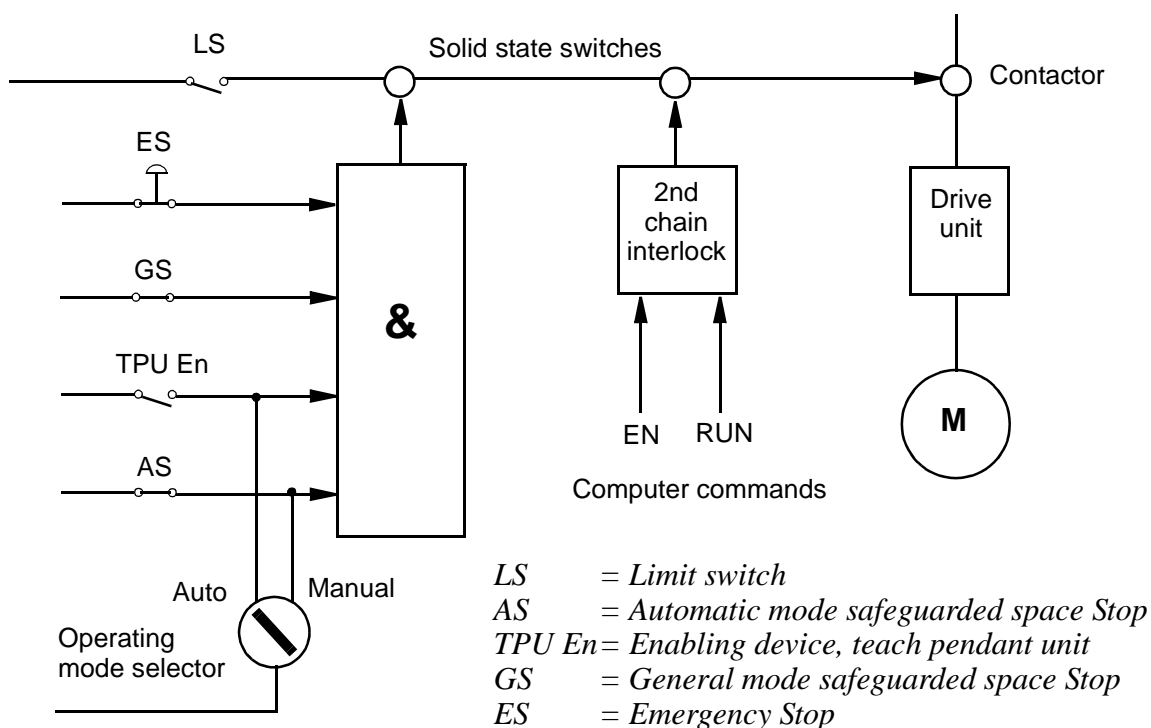

LS	= Limit switch
AS	= Automatic mode safeguarded space Stop
TPU En	= Enabling device, teach pendant unit
GS	= General mode safeguarded space Stop
ES	= Emergency Stop

Figure 13 Outline diagram of one of the safety circuits.

5.1 The chain of operation

The emergency stop buttons on the operator's panel and on the teach pendant and external emergency stop buttons are included in the two-channel chain of operation.

A safeguarded stop, AUTO STOP, which is active in the AUTO operating mode, can be connected by the user. In any of the MANUAL modes, the enabling device on the teach pendant overrides the AUTO STOP.

The safeguarded stop GENERAL STOP is active in all operating modes and is connected by the user.

The aim of these safeguarded stop functions is to make the area around the manipulator safe while still being able to access it for maintenance and programming.

If any of the dual switches in the safety circuit are opened, the circuit breaks, the motor contactors drop out, and the robot is stopped by the brakes. If the safety circuit breaks, an interrupt call is sent directly from the panel unit to the robot computer to ensure that the cause of the interrupt is indicated.

When the robot is stopped by a limit switch, it can be moved from this position by jogging it with the joystick while pressing the MOTORS ON button. The MOTORS ON button is monitored and may be depressed for a maximum of 30 seconds.

LEDs for ES, AS and GS are connected to the two safety circuits to enable quick location of the position where the safety chain is broken. The LEDs are located on the upper part of the panel unit. Status indication is also available on the teach pendant display.

5.2 MOTORS ON and MOTORS OFF modes

The principle task of the safety circuit is to ensure that the robot goes into MOTORS OFF mode as soon as any part of the chain is broken. The robot computer itself controls the last switches (ENABLE and MOTORS ON).

In AUTO mode, you can switch the robot back on by pressing the MOTORS ON button on the operator's panel. If the circuit is OK, the robot computer then closes the MOTORS ON relay to complete the circuit. When switching to MANUAL, the mode changes to MOTORS OFF, at which stage the robot computer also opens the MOTORS ON relay. If the robot mode does not change to MOTORS OFF, the ENABLE chain will break and the ENABLE relay is opened. The safety circuit can thus be broken in two places by the robot computer.

In any of the MANUAL modes, you can start operating again by pressing the enabling device on the teach pendant. If the circuit is OK, the robot computer then closes the MOTORS ON relay to complete the circuit. The function of the safety circuit can be described as a combination of mechanical switches and robot computer controlled relays which are all continuously monitored by the robot computer.

5.3 Safety stop signals

According to the safety standard ISO/DIS 11161 "Industrial automation systems - safety of integrated manufacturing systems - Basic requirements", there are two categories of safety stops, category 0 and category 1, see below:

The category 0 stop is to be used for safety analysis purposes, when the power supply to the motors must be switched off immediately, such as when a light curtain, used to protect against entry into the work cell, is passed. This uncontrolled motion stop may require special restart routines if the programmed path changes as a result of the stop.

Category 1 is preferred for safety analysis purposes, if it is acceptable, such as when gates are used to protect against entry into the work cell. This controlled motion stop takes place within the programmed path, which makes restarting easier.

All the robot's safety stops are category 0 stops as default.
Safety stops of category 1 can be obtained by activating the soft stop (delayed stop) together with AS or GS. Activation is made by setting a parameter, see User's Guide, section System Parameters, Topic: Controller.

5.4 Limitation of velocity

To program the robot, the operating mode switch must be turned to MANUAL REDUCED SPEED position. Then the robot's maximum velocity is limited to 250 mm/s.

5.5 ENABLE

ENABLE is a 24 V signal, generated in the supply unit. The signal is sent through the robot computer, to the panel unit.

The errors that affect the Enable signal are:

- In the supply unit; errors in the input voltage.
- In the robot computer; errors in the diagnostics or servo control program.
- In the drive unit; regulating errors and overcurrent.

5.6 24 V supervision

If the 24 V supply to the safety circuits drops out, the MOTORS ON contactors will drop out, causing the motors to switch off.

5.7 Monitoring

Monitoring is carried out using both hardware and software, and comprises the external part of the safety circuits, including switches and operating contacts. The hardware and software parts operate independently of each other.

The following errors may be detected:

All inputs from the safety circuits are linked to registers, which allows the robot computer to monitor the status. If an interrupt occurs in the circuit, the status can be read.

If any of the switch functions are incorrectly adjusted, causing only one of the chains of operation to be interrupted, the robot computer will detect this. By means of hardware interlocking it is not possible to enter MOTORS ON without correcting the cause.

6 External Axes

External axes are controlled by drive units, mounted either inside the controller or outside in a separate enclosure, see Figure 14.

The maximum of drive units mounted inside the controller is one or two, depending on robot type.

In addition to drive units from ABB, it is also possible to communicate with external drive units from other vendors. See Product Specification RobotWare for BaseWare OS 3.1.
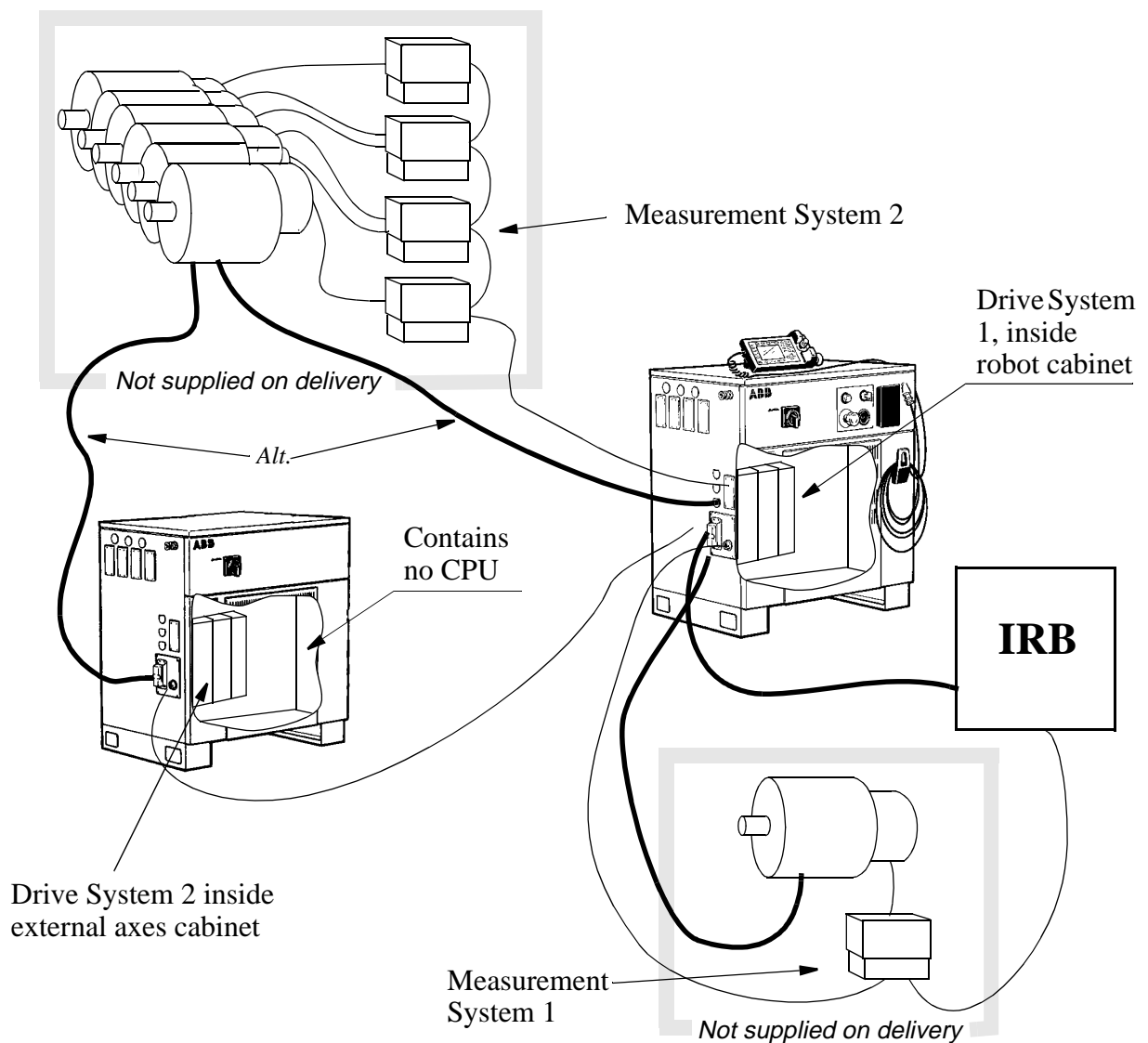

Measurement System 2

Drive System 1, inside robot cabinet

Not supplied on delivery

Alt.

Contains no CPU

IRB

Drive System 2 inside external axes cabinet

Measurement System 1

Not supplied on delivery

Figure 14 Outline diagram, external axes.

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Installation and Commissioning

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1 Transporting and Unpacking

NB:
Before starting to unpack and install the robot, read the safety regulations and other instructions very carefully. These are found in separate sections in the User's Guide and Product manual.

The installation shall be made by qualified installation personnel and should conform to all national and local codes.

When you have unpacked the robot, check that it has not been damaged during transport or while unpacking.

Operating conditions:

Ambient temperature	+5° to + 45° C (manipulator)
	+5° to + 52° C (controller)
Relative humidity	Max. 95% at constant temperature

Storage conditions:

If the equipment is not going to be installed straight away, it must be stored in a dry area at an ambient temperature between -25°C and +55°C.

When air transport is used, the robot must be located in a pressure-equalized area.

The net weight of the manipulator is approximately: 225 kg

The control system weighs approximately: 240 kg.

Whenever the manipulator is transported, axis 2 must be bent backwards and axis 3 positioned as low as possible.

1.1 Stability / risk of tipping

When the manipulator is not fastened to the floor and standing still, the manipulator is not stable in the whole working area. When the arms are moved, care must be taken so that the centre of gravity is not displaced, as this could cause the manipulator to tip over.

1.2 System diskettes

The diskettes in the box, fixed to the shelf for the teach pendant, should be copied (in a PC) before they are used. Never work with the original diskettes. When you have made copies, store the originals in a safe place.

Do not store diskettes inside the controller due to the high temperatures there.

1.3 Transport locking device

At delivey, axis 2 (= lower arm) is equipped with a transport locking device (see Figure 1).

⚠ **Remove the transport locking device before operating the robot.**

Transport locking device
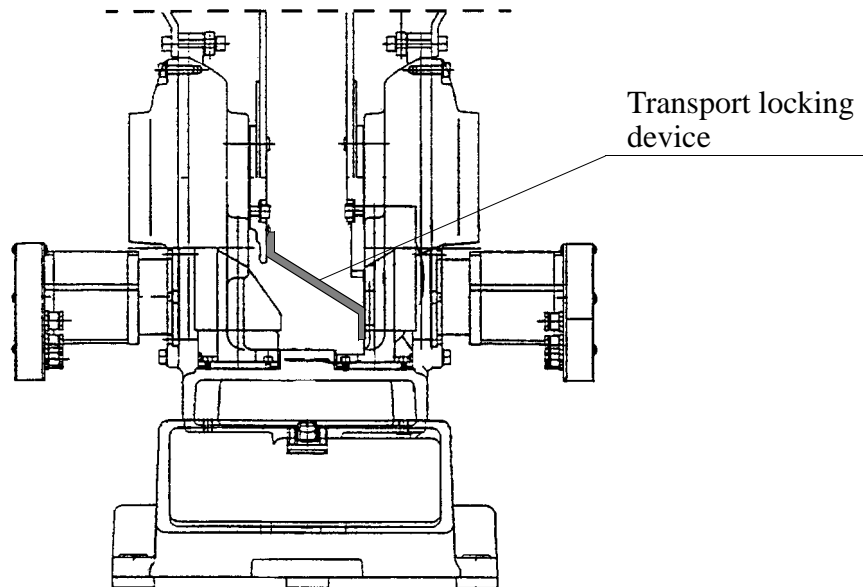
Figure 1 Transport locking device, axis 2.

2 On-Site Installation

2.1 Lifting the manipulator

The best way to lift the manipulator is to use lifting straps and a traverse crane. Attach the straps to the special eye bolts on the gear boxes for axes 2 and 3 (see Figure 2). The lifting strap dimensions must comply with the applicable standards for lifting.

⚠ **Never walk under a suspended load.**

Lifting eyes
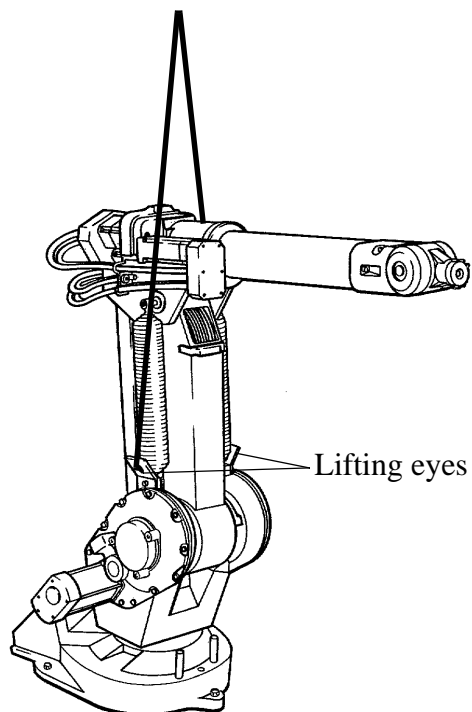
Figure 2 Lifting the manipulator using a traverse crane.

Use the four lifting devices on the cabinet or a fork lift when lifting the controller (see Figure 3).

If the controller is supplied without its top cover, lifting devices must <u>not</u> be used. A fork lift truck <u>must</u> be used instead.
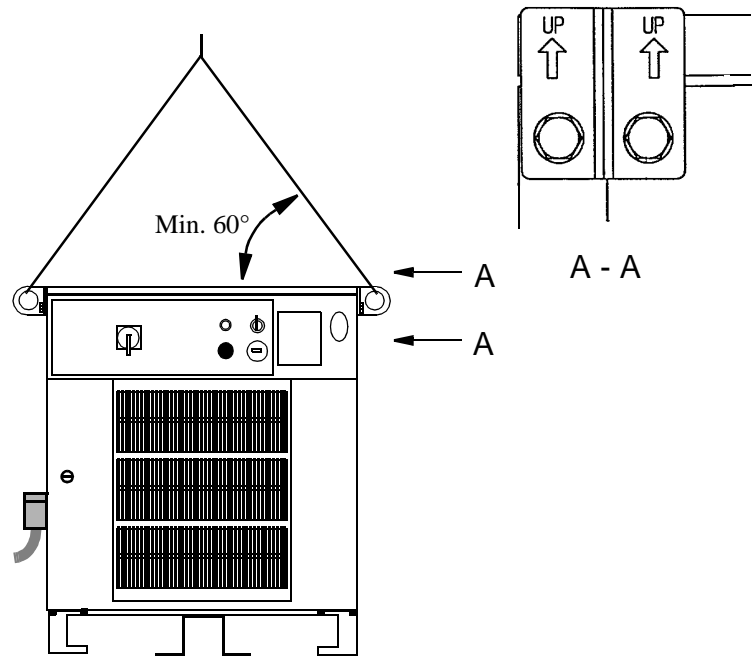
Figure 3 The maximum angle between the lifting straps when lifting the controller.

2.2 Turning the manipulator (inverted suspension application)

N.B! Only possible with IRB 1400H

A special tool is recommended when the manipulator is to be turned for inverted mounting (ABB article number 3HAB 3397-1).

The tool is attached to the outsides of the gearboxes for axes 2 and 3 using six (M8x25) bolts and washers. Tightening torque 25 Nm.

The manipulator is lifted with a fork lift or a crane (see Figure 4). Note also the positions of the arm system.

Fork lift)

appr. R=860′

M8x25 (x3) on both sides

Tool 3HAB 3397-1

appr. R=580
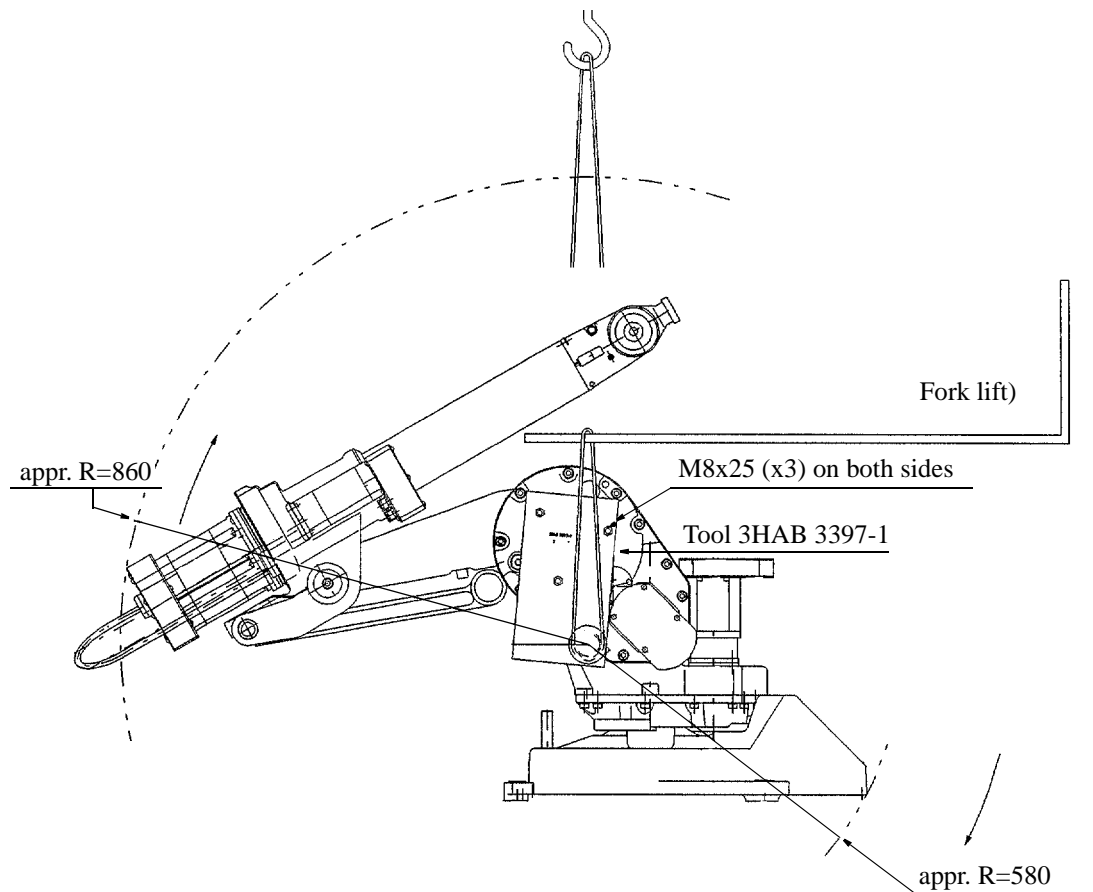
Figure 4 Turning the manipulator.

2.3 Assembling the robot

2.3.1 Manipulator

The manipulator must be mounted on a level surface with the same hole layout as shown in Figure 5. The levelness requirement of the surface is as follows:

.
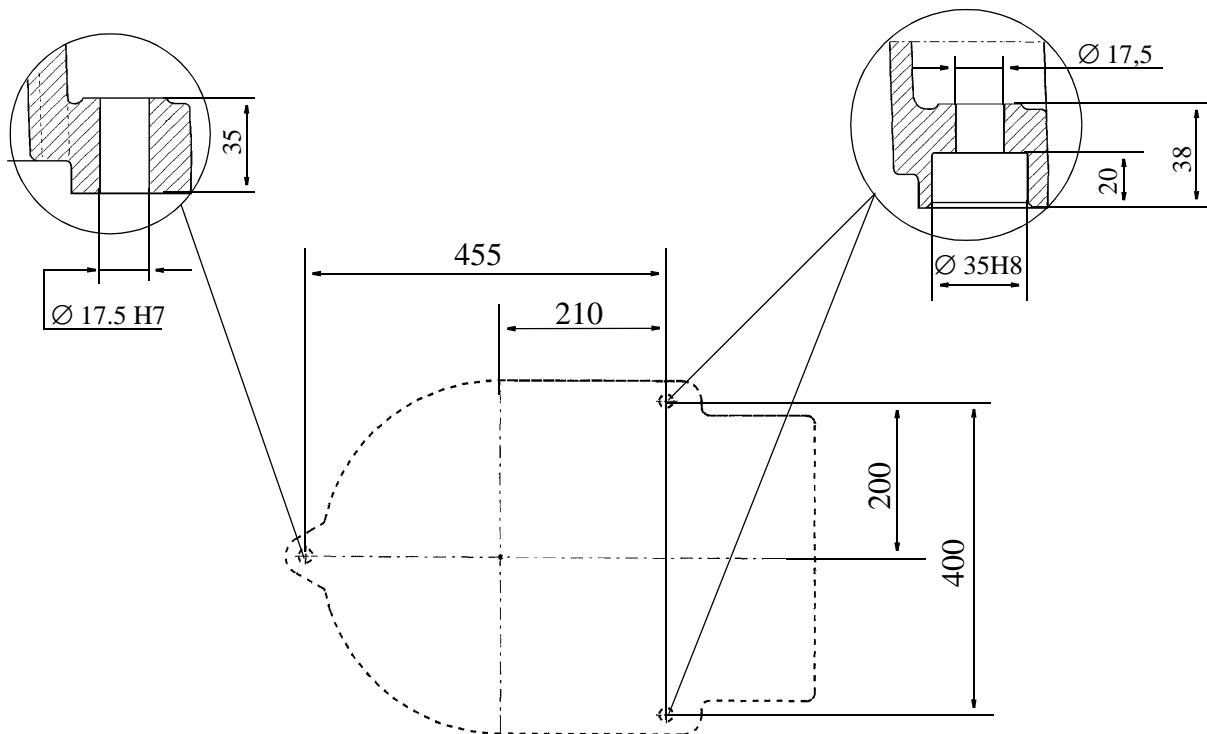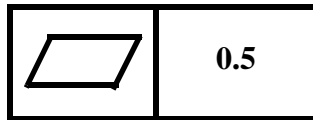
Figure 5 Bolting down the manipulator.

The manipulator is bolted down by means of three M16 bolts.

Suitable bolts: M16 8.8

Tightening torque: 190 Nm

Two guide sleeves, ABB art. no. 2151 0024-169, can be fitted to the two rear bolt holes, to allow the same robot to be re-mounted without having to re-adjust the program.

When bolting a mounting plate or frame to a concrete floor, follow the general instructions for expansion-shell bolts. The screw joint must be able to withstand the stress loads defined in Chapter 2.5 Stress forces .

2.3.2　Controller

Secure the controller to the floor using M12 bolts (aa shown in the hole layout below). See also Chapter 2.6 Amount of space required, before assembling the controller.
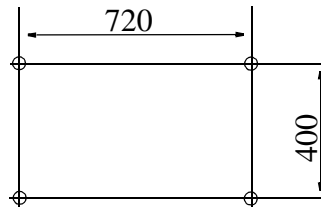
2.4　Suspended mounting

The method for mounting the manipulator in a suspended position is basically the same as for floor mounting.

With inverted installation, make sure that the gantry or corresponding structure is rigid enough to prevent unacceptable vibrations and deflections, so that optimum performance can be achieved.

2.5 Stress forces

2.5.1 Stiffnes

The stiffnes of the foundation must be designed to minimize the influence on the dynamic behaviour of the robot.
TuneServo can be used for adapting the robot tuning to a non-optimal foundation.

2.5.2 IRB 1400(H)

Force	Endurance load (In operation)	Max. load (Emergency stop)
Fxy	± 1500 N	± 2000 N
Fz (upright)	2800 ± 500 N	2800 ± 700 N
Fz (suspended)	- 2800 ± 800 N	- 2800 ± 1000 N
Torque		
Mxy	± 1800 Nm	± 2000 Nm
Mz	± 400 Nm	± 500 Nm

Fxy and Mxy are vectors that can have any direction in the xy plane.
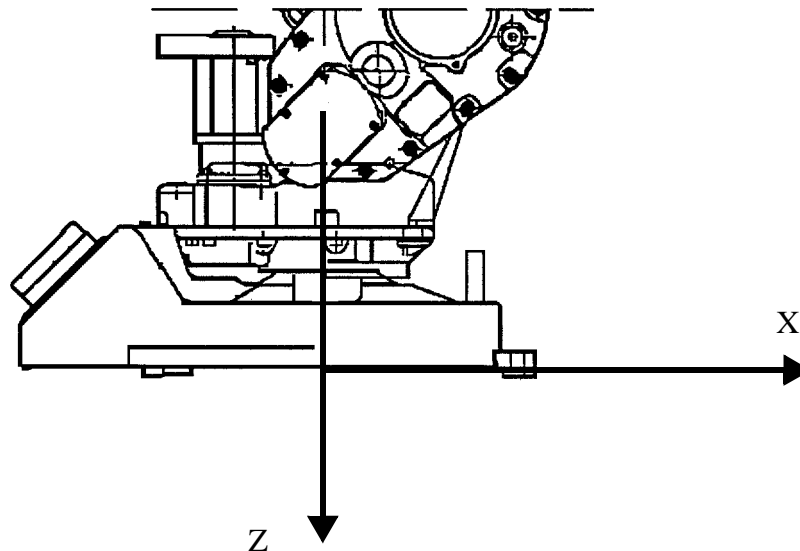
Figure 6 The directions of the stress forces.

2.6 Amount of space required

The amount of working space required to operate the manipulator and controller is illustrated in Figure 7 and Figure 8. The working range for axis 1 is +/- 170°.

⚠️ **NB: There are no software or mechanical limits for the working space under the base of the manipulator.**

2.6.1 Manipulator

IRB 1400
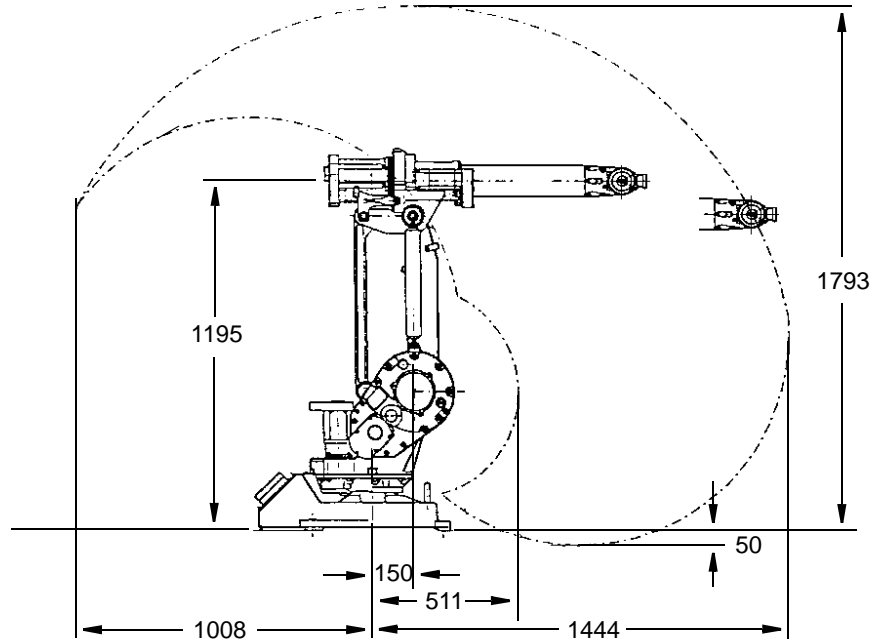
IRB 1400H
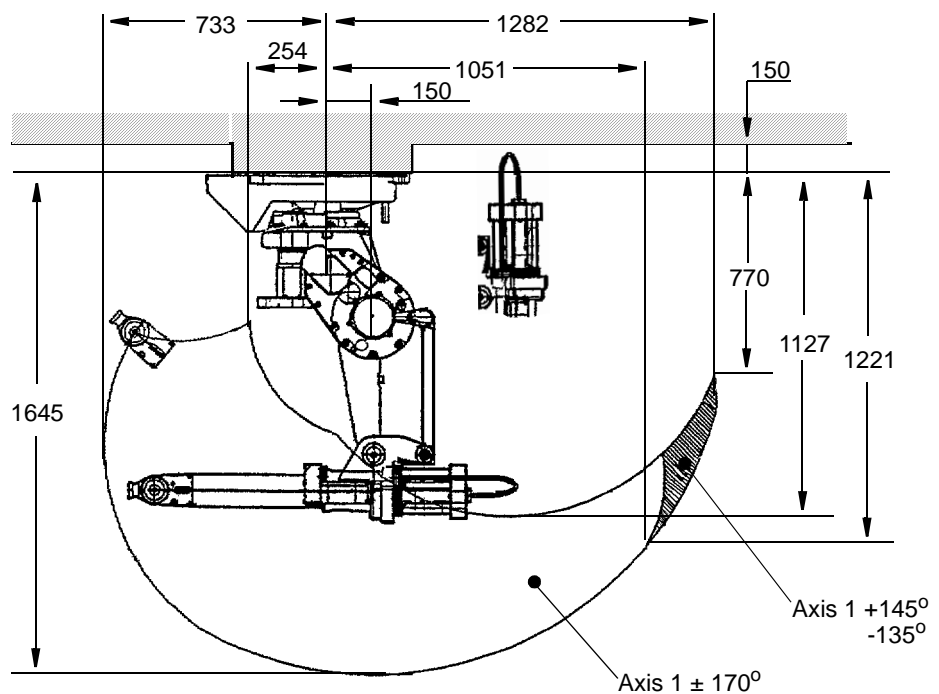
Figure 7 The amount of working space required for the manipulator.

2.6.2   Controller
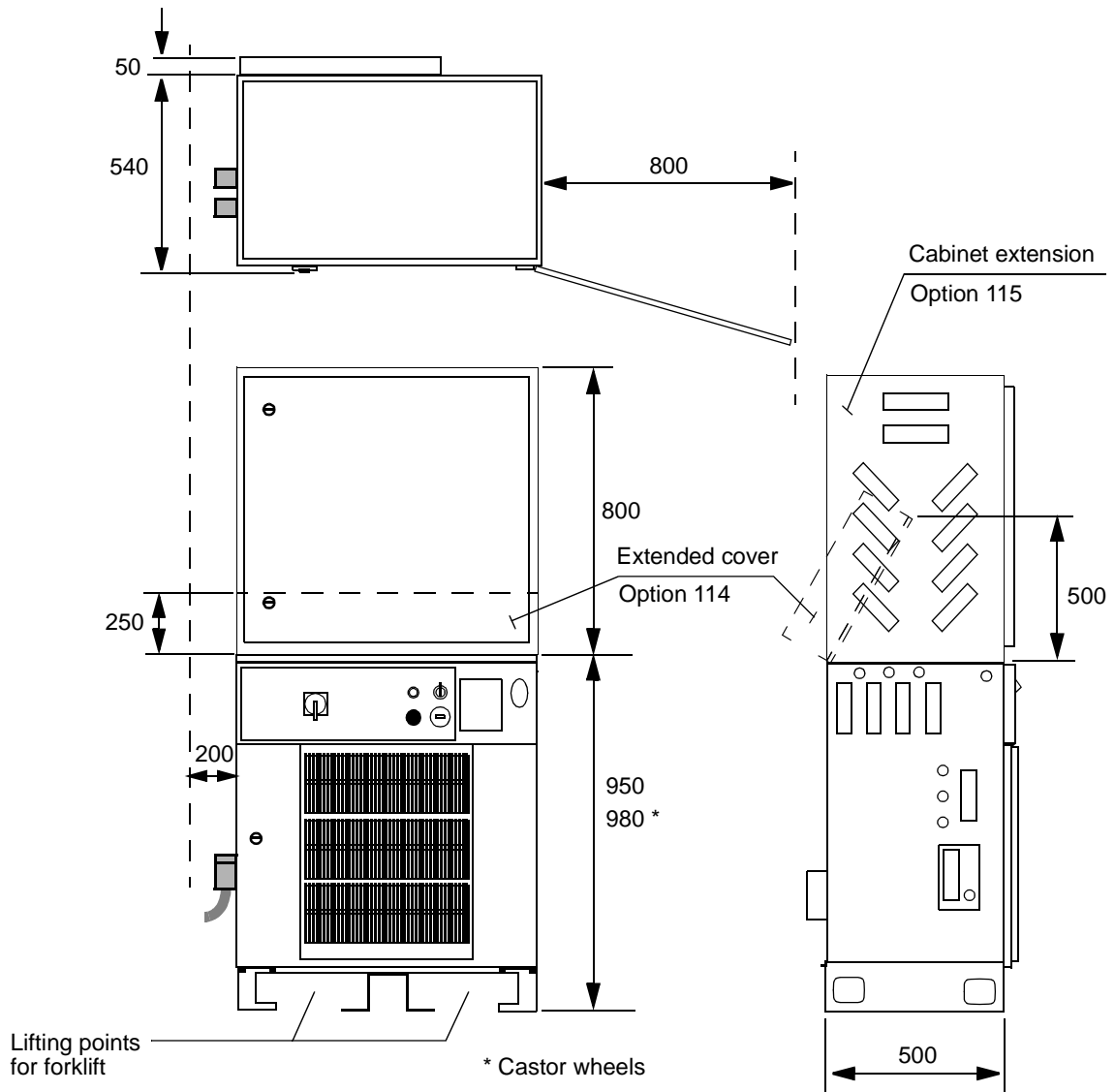
Figure 8 The amount of space required for the controller.

2.7 Manually engaging the brakes

All axes are equipped with holding brakes. If the positions of the manipulator axes are to be changed without connecting the controller, an external voltage supply (24 V DC) must be connected to enable engagement of the brakes. The voltage supply should be connected to the contact at the base of the manipulator or to the Burndy contact in the base under the cover if, option 640 is chosen (see Figure 9).

+24 V B8

0 V C10
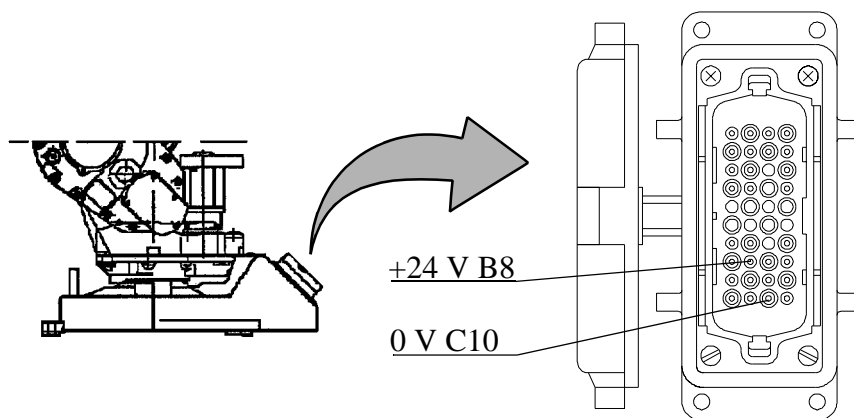
NOTE!
Be careful not to interchange the 24 V- and 0 V pins.
In they are mixed up, damage can be caused to a resistor and the system board.

Burndy contact: R1.MP4-6

0 V

+ 24 V DC
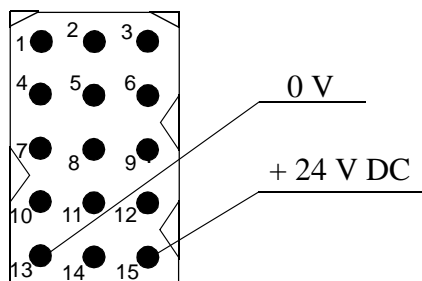
Figure 9 Connection of external voltage to enable engagement of the brakes.

⚠ **External power must be connected according to Figure 9. Incorrectly connected power can release all brakes, causing simultaneously movement of all axes.**

When the controller or the voltage supply is connected as illustrated above, the brakes can be engaged using the push-button on the manipulator, (see Figure 10).

⚠ **WARNING: Be very careful when engaging the brakes. The axes become activated very quickly and may cause damage or injury.**

Brake release button
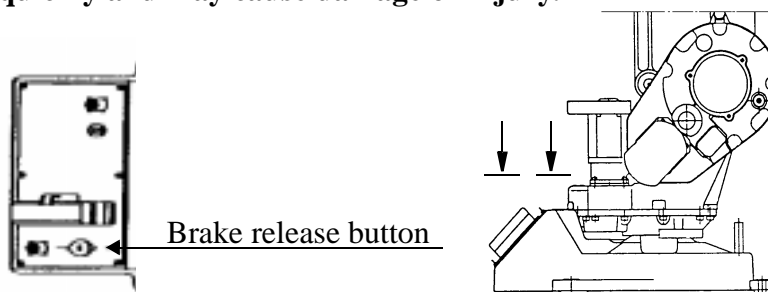
Figure 10 Location of the brake release button.

2.8 Restricting the working space

When installing the manipulator, make sure that it can move freely within its entire working space. If there is a risk that it may collide with other objects, its working space should be limited, both mechanically and using software. Installation of an optional extra stop for the main axes 1, 2 and 3 is described below.

Limiting the working space using software is described in the System Parameters in the User's Guide.

2.8.1   Axis 1

The range of rotation for axis 1 can be limited mechanically by fitting extra stop lugs to the base (see Figure 11).

Instructions for necessary machining and mounting are supplied with the kit.

⚠ **NB: The original stop lug must never be removed.**

Extra stop lug for axis 1
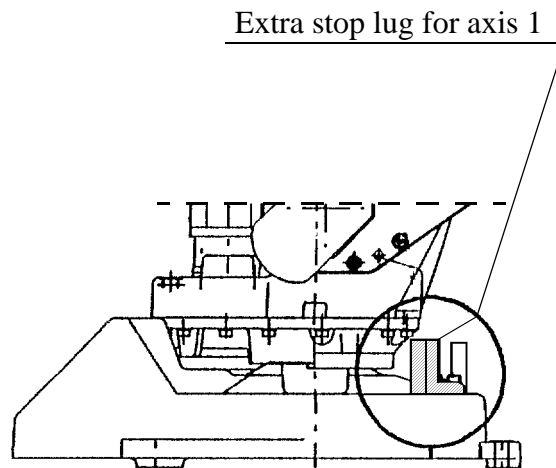
Figure 11 Mechanically limiting axis 1.

2.8.2   Axis 2

The working range of axis 2 can be limited mechanically by fitting extra stop lugs to the under arm (see Figure 12). The lugs limit the arm movements in intervals of 20°. (20° = 1 lug, 40° = 2 lugs, etc.)

Instructions for doing this are supplied with the kit.

Under arm

Extra stop lugs
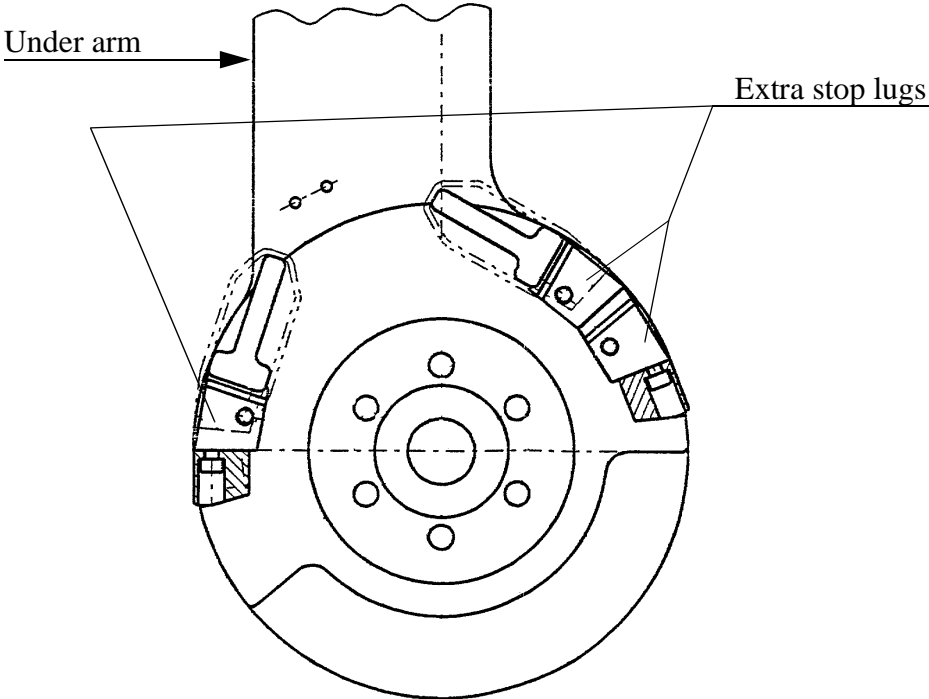
Figure 12 Mechanically limiting axis 2.

2.8.3   Axis 3

The working range of axis 3 can be limited mechanically by fitting a stop lug under the parallel arm (see Figure 13). Axis 3 is limited upwards to 0 or -10 degrees above the horizontal plane.

Instructions for doing this are supplied with the kit.
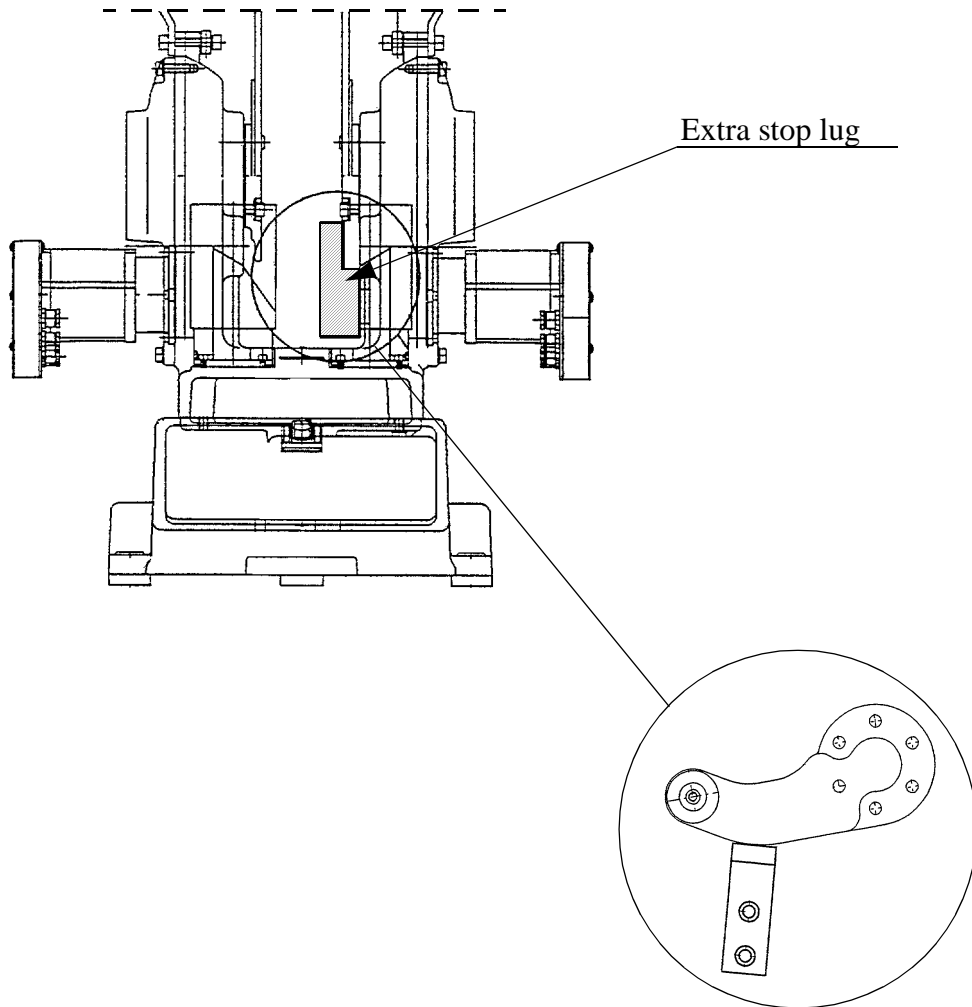
Extra stop lug

Figure 13 Extra stop lug for limiting axis 3.

2.9 Mounting holes for equipment on the manipulator

⚠ **NB:** *Never* **drill a hole in the manipulator without first consulting ABB Flexible Automation.**
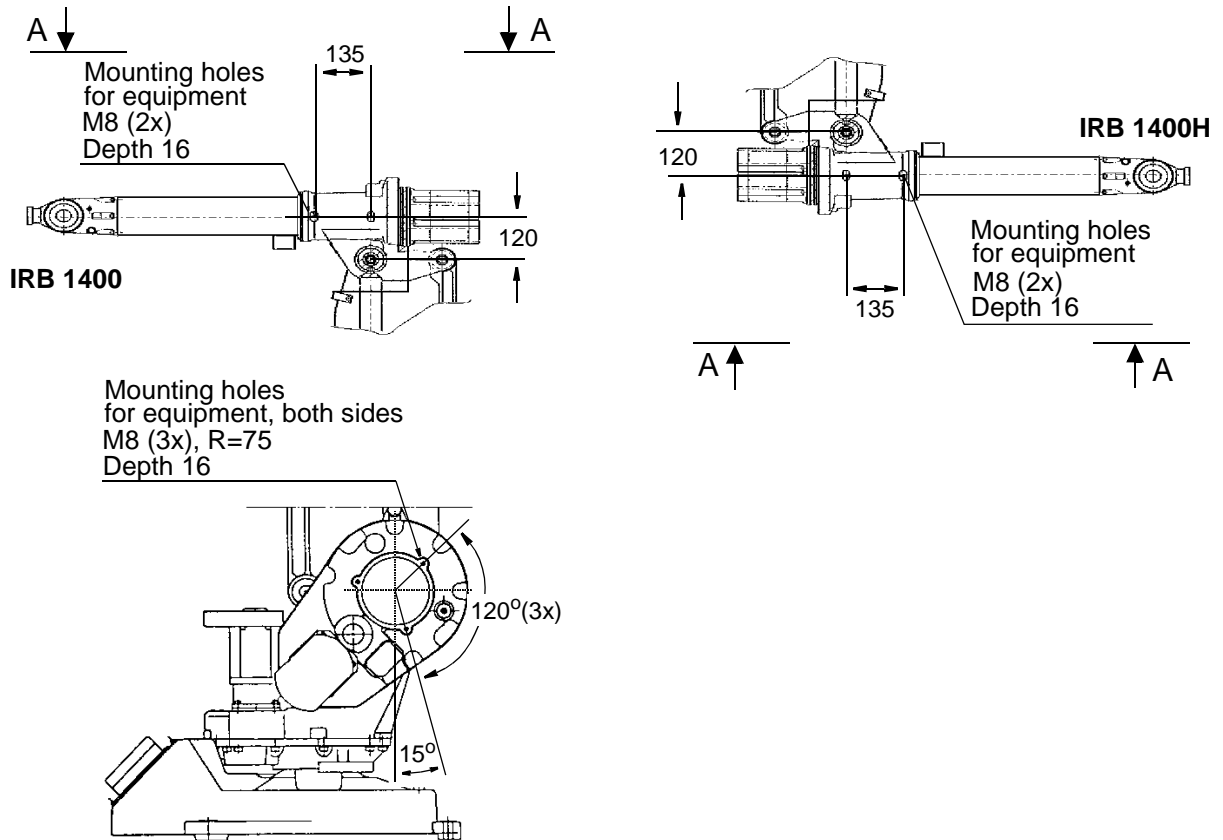
Figure 14 Mounting holes for customer equipment.

Figure 15 The mechanical interface (mounting flange).

2.10 Loads

Regarding load diagram, permitted extra loads (equipment) and locations of extra loads (equipment), see chapter 3.4 in Product Specification IRB 1400 (Technical specification). The loads must also be defined in the soft ware, see User´s Guide.

2.11 Connecting the controller to the manipulator

Two cables are used to connect the controller to the manipulator, one for measuring signals and the other for motor and brakes.

The connection on the manipulator is located on the rear of the robot base.

2.11.1　Connection on left-hand side of cabinet

The cables are connected to the left side of the cabinet using an industrial connector and a Burndy connector (see Figure 16). A connector is designated XP when it has pins (male) and XS when it has sockets (female). A screwed connection is designated XT.
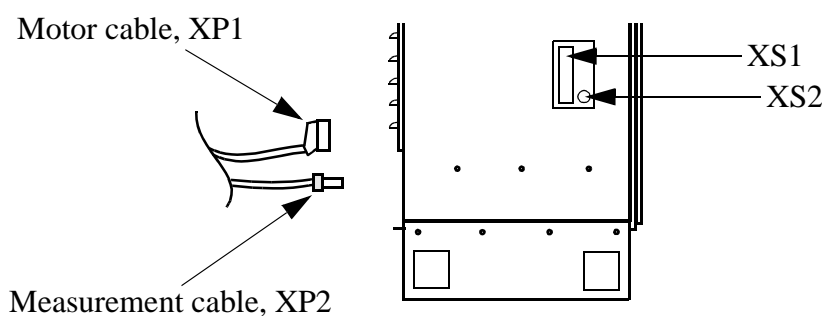
Figure 16 Connections on the cabinet wall.

2.12 Dimensioning the safety fence

A safety fence must be fitted around the robot to ensure a safe robot installation. The fence must be dimensioned to withstand the force created if the load being handled by the robot is dropped or released at maximum speed. The maximum speed is determined from the max. velocities of the robot axes and from the position at which the robot is working in the workcell. See Product Specification, section 3.8. The max. speed for a load mounted on the IRB 1400 is 5 m/s.

Applicable standards are ISO/DIS 11161 (see also chapter 3.13) and prEN 999:1995.

2.13 Mains power connection

⚠️ **Before starting to connect the mains, make sure that the other end of the cable is disconnected from the line voltage.**

The power supply can be connected either inside the cabinet, or to a optional socket on the left-hand side of the cabinet or the lower section of the front. The cable connector is supplied but not the cable. The mains supply cables and fuses should be dimensioned in accordance with rated power and line voltage, see rating plate on the controller.

2.13.1 Connection to the mains switch

A gland for the mains cable is located on the left cabinet wall. Pull the mains cable through the gland (see Figure 17).
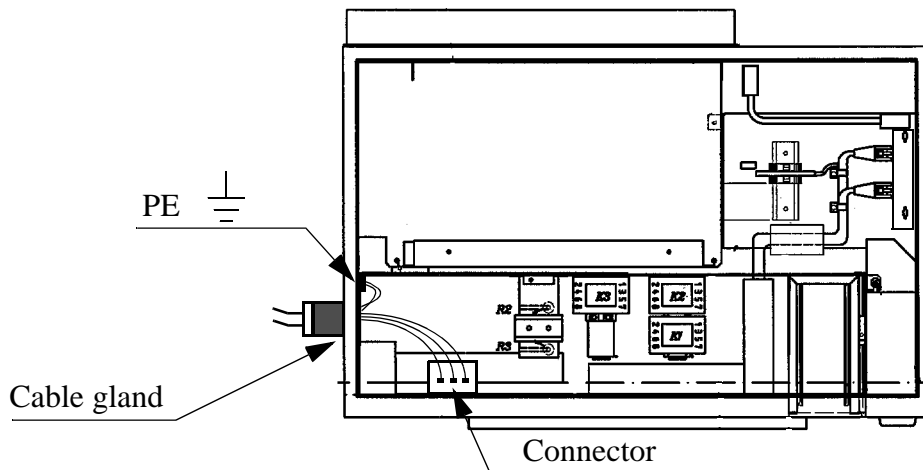
Figure 17 Mains connection inside the cabinet.

Connect as below (also see chapter 11, Circuit Diagram.):

1. Release the connector from the knob by **depressing the red button** located on the upper side of the connector (see Figure 17).

2. Connect phase   1 to L1   (N.B. Not dependent on phase sequence)
                     2 to L2
                     3 to L3
                     0 to XT26.N(zero is needed only for option 432)

   and protective earth to ⏚

NOTE!
Max. cunductor size is 6 mm^2 (AWG 10). Tighten torque 2.3-2.5 Nm.
Retighten after approx. 1 week.

3. Snap the breaker on to the knob again and check that it is fixed properly in the right position.

4. Tighten the cable gland.

5. Fasten the cover plate.

2.13.2   Connection via a power socket

You can also connect the mains supply via an optional wall socket of type CEE 3x16 and 3x32 A, or via an industrial Harting connector (DIN 41 640). See Figure 18.

Cable connectors are supplied (option 133 - 134).

CEE connector   DIN connector
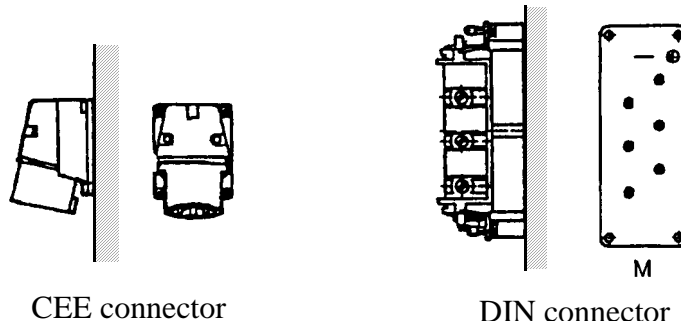
Figure 18 Mains connection via an optional wall socket.

2.14 Inspection before start-up

Before switching on the power supply, check that the following have been performed:

1. The robot has been properly mechanically mounted and is stable

2. The controller mains section is protected with fuses.

3. The electrical connections are correct and corresponds to the identification plate on the controller.

4. The teach pendant and peripheral equippment are properly connected.

5. That limiting devices that establish the restricted space (when utilized) are installed.

6. The physical environment is as specified.

7. The operating mode selector on the operator's panel is in Manual mode position.

When external safety devices are used check that these have been connected or that the following circuits in either **XS3** (connector on the outside left cabinet wall) or **X1-X4** (screw terminals on the panel unit) are strapped:

	XS3	Panel unit
External limit switches	A5-A6, B5-B6	X1.3-4, X2.3-4
External emergency stop	A3-A4, B3-B4	X1.9-10, X2.9-10
External emergency stop, internal 24 V	A1-A2, B1-B2	X1.7-8, X2.7-8
General stop +	A11-A12, B11-B12	X3.10-12, X4.10-12
General stop -	A13-A14, B13-B14	X3.7-8, X4.7-8
Auto stop +	A7-A8, B7-B8	X3.11-12, X4.11-12
Auto stop -	A9-A10, B9-10	X3.7-9, X4.7-9
Motor off clamping	A15-A16, B15-16	X1.5-6, X2.5-6

For more information, see Chapter 3.8, The MOTORS ON / MOTORS OFF circuit and Chapter 3.9, Connection of safety chains.

2.15 Start-up

2.15.1 General

1. Switch on the mains switch on the cabinet.

2. The robot performs its self-test on both the hardware and software. This test takes approximately 1 minute.

   If the robot is supplied with software already installed, proceed to pos. 3 below. Otherwise continue as follows (no software installed):

      - Connect the batteries for memory backup (see Figure 19).

Install the software as described in Chapter 4, Installing the Control Program.

Batteries

Connect the batteries to the connectors X3 and X4, situated below the batteries.
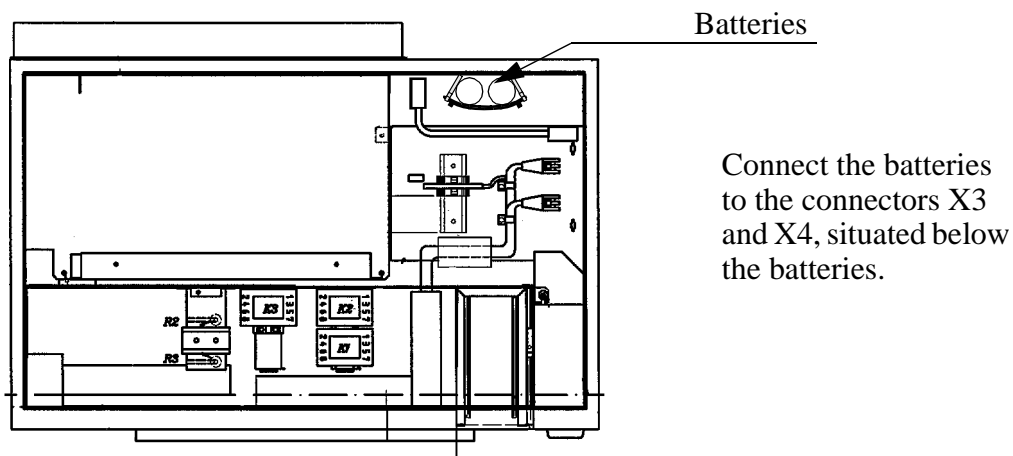
Figure 19 Location of batteries, view from above.

3. A welcome message is shown on the teach pendant display.

4. To switch from MOTORS OFF to MOTORS ON, press the enabling device on the teach pendant.

5. Update the revolution counters according to 2.15.2.

6. Check the calibration position according to section 2.15.3.

7. When the controller with the manipulator electrically connected are powered up for the first time, ensure that the power supply is connected for at least 36 hours continuously, in order to fully charge the batteries for the serial measurement board.

   After having checked the above, verify that

8. the start, stop and mode selection (including the key lock switches) control devices function as intended.

9. each axis moves and is restricted as intended.

10. emergency stop and safety stop (where included) circuits and devices are functional.

11. it is possible to disconnect and isolate the external power sources.

12. the teach and playback facilities function correctly.

13. the safeguarding is in place.

14. in reduced speed, the robot operates properly and has the capability to handle the product or workpiece, and

15. in automatic (normal) operation, the robot operates properly and has the capability to perform the intended task at the rated speed and load.

16. The robot is now ready for operation.

2.15.2   Updating the revolution counter

When pressing the enabling device on a new robot, a message will be displayed on the teach pendant telling you that the revolution counters are not updated. When such a message appears, the revolution counter of the manipulator must be updated using the calibration marks on the manipulator (see Figure 24).

Examples of when the revolution counter must be updated:

- when one of the manipulator axes has been manually moved with the controller disconnected.
- when the battery (on the manipulator) is discharged.
  (it takes 36 hours with the mains switch on to recharge the battery)
- when there has been a resolver error
- when the signal between the resolver and the measuring panel unit has been interrupted

WARNING:
Working inside the robot working range is dangerous.

Press the enabling device on the teach pendant and, using the joystick, manually move the robot so that the calibration marks lie within the tolerance zone (see Figure 24).

When all axes have been positioned as above, the revolution counter settings are stored using the teach pendant, as follows:

1. Press the **Misc.** window key (see Figure 20).
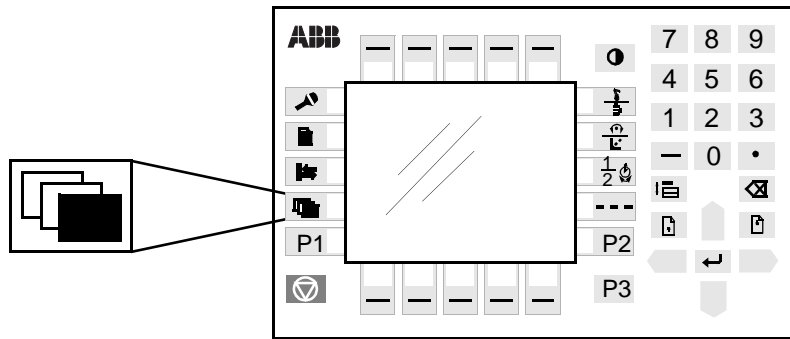
Figure 20 The Misc. window key from which the Service window can be chosen.

2. Select **Service** in the dialog box shown on the display.

3. Press Enter ⏎ .

4. Then, choose **View: Calibration**. The window in Figure 21 appears.

```
   File     Edit     View     Calib
 ─────────────────────────────────────
 Service Calibration

 Unit                    Status
 ══════════════════════════════ 1(1)

   IRB              Not rev. counter update




 ─────────────────────────────────────

 ─────────────────────────────────────
```

Figure 21 This window shows the status of the revolution counters.

If there are several units connected to the robot, these will be listed in the window.

5. Select the desired unit in the window, as in Figure 21. Choose **Calib: Rev. Counter Update**. The window in Figure 22 appears.

```
 ─────────────────────────────────────

 ─────────────────────────────────────
 Rev. Counter Update!
 IRB
 To calibrate, include axes and press OK.

       Axis                Status
 ════════════════════════════════ 1(6)
 X    1        Not updated Rev. Counter
 X    2        Not updated Rev. Counter
      3        Calibrated
      4        Calibrated
 X    5        Not updated Rev. Counter
 X    6        Not updated Rev. Counter

    Incl    All         Cancel    OK
 ─────────────────────────────────────
```

Figure 22 The dialog box used to select axes whose revolution counters are to be updated.

6. Press the function key *All* to select all axes if all axes are to be updated. Otherwise, select the desired axis and press the function key *Incl* (the selected axis is marked with an x).

7. Confirm by pressing **OK**. A window like the one in Figure 23 appears.

```
Rev. Counter Update!
IRB

The Rev. Counter for all marked axes
will be update.
It cannot be undone.

OK to continue?



                              Cancel     OK
```
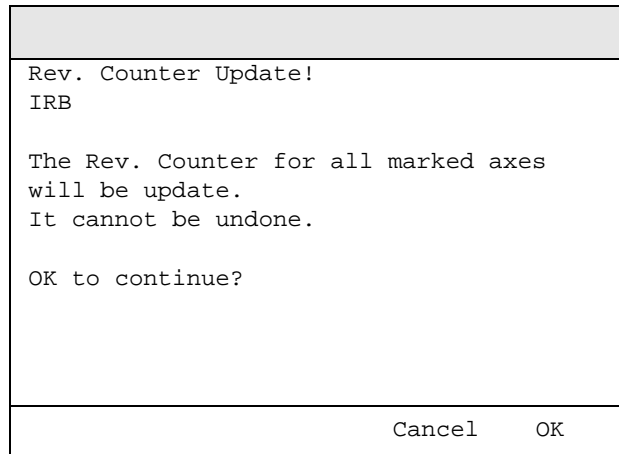
Figure 23 The dialog box used to start updating the revolution counter.

8. Start the update by pressing **OK**.

If a revolution counter is incorrectly updated, it will cause incorrect positioning. Thus, check the calibration very carefully after each update. Incorrect updating can damage the robot system or injure someone.

9. Check the calibration as described in Chapter 2.15.3, Checking the calibration posi-
   tion.

10.Save the system parametrs on floppy disk.
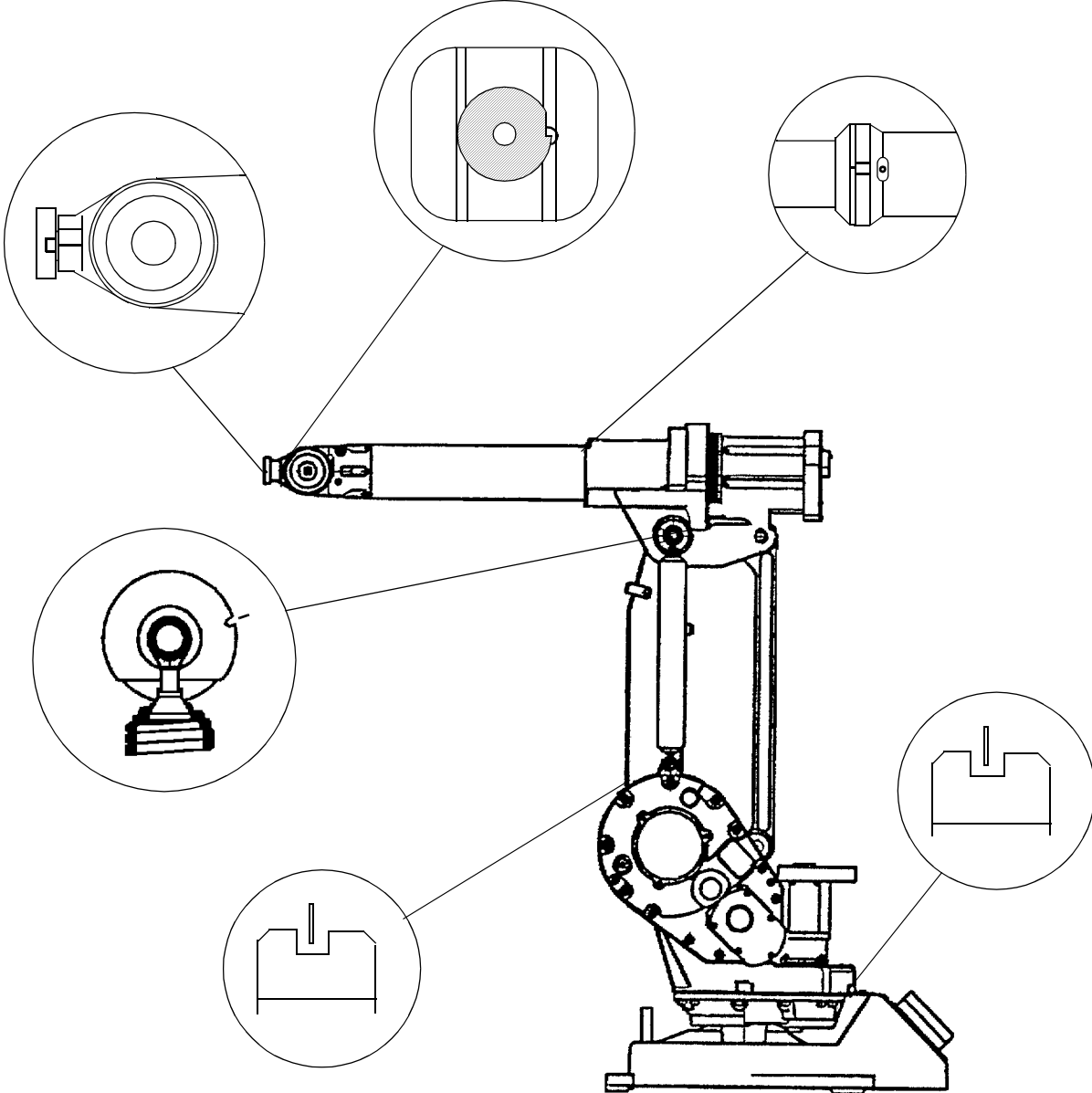
Figure 24 Calibration marks on the manipulator.

2.15.3 Checking the calibration position

There are two ways to check the calibration position and they are described below.

Using the diskette, Controller Parameters:

Run the program \ SERVICE \ CALIBRAT \ CAL 1400 (or 1400H) on the diskette, follow intructions displayed on the teach pendant. When the robot stops, switch to MOTORS OFF. Check that the calibration marks for each axis are at the same level, see Figure 24. If they are not, the setting of the revolution counters must be repeated.

Using the Jogging window on the teach pendant:

Open the Jogging window and choose running axis-by-axis. Using the joystick, move the robot so that the read-out of the positions is equal to zero. Check that the calibration marks for each axis are at the same level, see Figure 24. If they are not, the setting of the revolution counters must be repeated.

2.15.4 Alternative calibration positions

See chapter 12, Repairs.

2.15.5 Operating the robot

Starting and operating the robot is described in the User's Guide. Before start-up, make sure that the robot cannot collide with any other objects in the working space.

3 Connecting Signals

3.1 Signal classes

Power – supplies external motors and brakes.

Control signals – digital operating and data signals (digital I/O, safety stops, etc.).

Measuring signals – analog measuring and control signals (resolver and analog I/O).

Data communication signals – field bus connection, computer link.

Different rules apply to the different classes when selecting and laying cable. Signals from different classes must not be mixed.

3.2 Selecting cables

All cables laid in the controller must be capable of withstanding 70° C. In addition, the following rules apply to the cables of certain signal classes:

Power signals -Shielded cable with an area of at least 0.75 mm^2 or AWG 18. Note that any local standards and regulations concerning insulation and area must always be complied with.

Control signals – Shielded cable.

Measuring signals – Shielded cable with twisted pair conductors.

Data communication signals – Shielded cable with twisted pair conductors. A specific cable should be used for field bus connections.

CAN bus with DeviceNet for distributing I/O units;

Thin cable according to DeviceNet specification release 1.2, must be used, e.g. ABB article no. 3HAB 8277-1. The cable is screened and has four conductors, two for electronic supply and two for signal transmission.
Note that a separate cable for supply of I/O load is required.

Allen-Bradley Remote I/O;

Cables according to Allen-Bradley specification, e.g. "Blue hose", should be used for connections between DSQC 350 and the Allen-Bradley PLC bus.

Interbus-S:

Cables according to Phönix specification, e.g. "Green type", should be used for connections between the DSQC 351 and external Interbus-S bus.

Profibus DP:

Cables according to Profibus DP specification should be used for connections between the I/O unit DSQC 352 and the external Profibus DP bus.

3.3 Interference elimination

Internal relay coils and other units that can generate interference inside the controller are neutralised. External relay coils, solenoids, and other units must be clamped in a similar way. Figure 25 illustrates how this can be done.

Note that the turn-off time for DC relays increases after neutralisation, especially if a diode is connected across the coil. Varistors give shorter turn-off times. Neutralising the coils lengthens the life of the switches that control them.

+24 V DC   +0 V
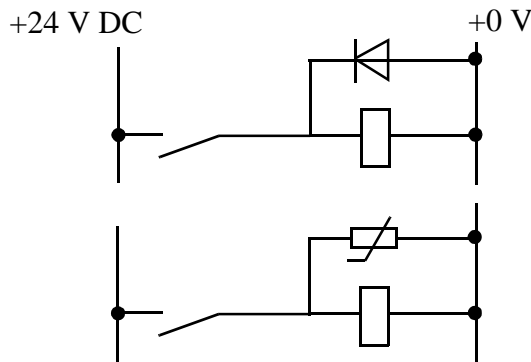
The diode should be dimensioned for the same current as the relay coil, and a voltage of twice the supply voltage.

The varistor should be dimensioned for the same energy as the relay coil, and a voltage of twice the supply voltage.

+24 V DC, or AC voltage   +0 V

R   C
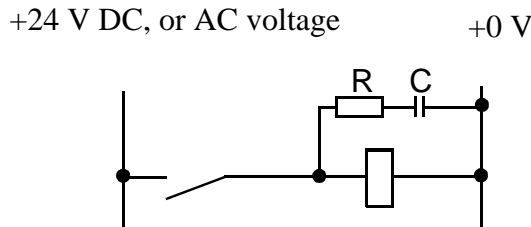
R 100 ohm, 1W
C 0.1 - 1 µF
> 500 V max voltage
125 V nominal voltage

Figure 25 Examples of clamping circuits to suppress voltage transients.

3.4 Connection types

I/O, external emergency stops, safety stops, etc., can be supplied on screwed connections or as industrial connectors.

Designation	
X(T)	Screwed terminal
XP	Male (pin)
XS	Sockets (female)

3.5 Connections

Detailed information about connection locations and functions will be found in chapter 11, Circuit Diagram.

3.5.1   To screw terminal

Panel unit and I/O units are provided wiyh keyed screw terminals for cables with an area between 0.25 and 1.5 mm^2. A maximum of two cables may be used in any one connection. The cable screen must be connected to the cabinet wall using EMC. It should be noted that the screen must continue right up to the screw terminal.
The installation should comply with the IP54 (NEMA 12) protective standard.

Bend unused conductors backwards and attach them to the cable using a clasp, for example. In order to prevent interference, ensure that such conductors are not connected at the other end of the cable (antenna effect). In environments with much interference, disconnected conductors should be grounded (0 V) at both ends.

3.5.2   To connectors (option)

Industrial connectors with 4x16 pins for contact crimping (complies with DIN 43652) can be found on the left-hand side or front of the cabinet (depending on the customer order) See Figure 26 and Figure 17.

In each industrial connector there is space for four rows of 16 conductors with a maximum conductor area of 1.5 mm^2. The pull-relief clamp must be used when connecting the shield to the case.

The manipulator arm is equipped with round Burndy/Framatome connectors (customer connector not included).

Bend unused conductors backwards and attach them to the cable using a clasp, for example. In order to prevent interference, ensure that such conductors are not connected at the other end of the cable (antenna effect). In environments with much interference, disconnected conductors should be grounded (0 V) at both ends.

When contact crimping industrial connectors, the following applies:

Using special tongs, press a pin or socket on to each non-insulated conductor.
The pin can then be snapped into the actual contact.
Push the pin into the connector until it locks.

Also, see instructions from contact supplier.

A special extractor tool must be used to remove pins from industrial connectors.

When **two** conductors must be connected to the same pin, both of them are pressed into the same pin. A **maximum** of **two** conductors may be pressed into any one pin.

Space for cable glands

Prepared for further
connectors

XS 3 (safety)

XS 5 (customer signals)

XS17,
CAN bus connector

XS 6 (customer power)

XS 7 (external axes)

XS 8, Position switch

XS 1, Motor cable

XS 2, Measurement system
cable
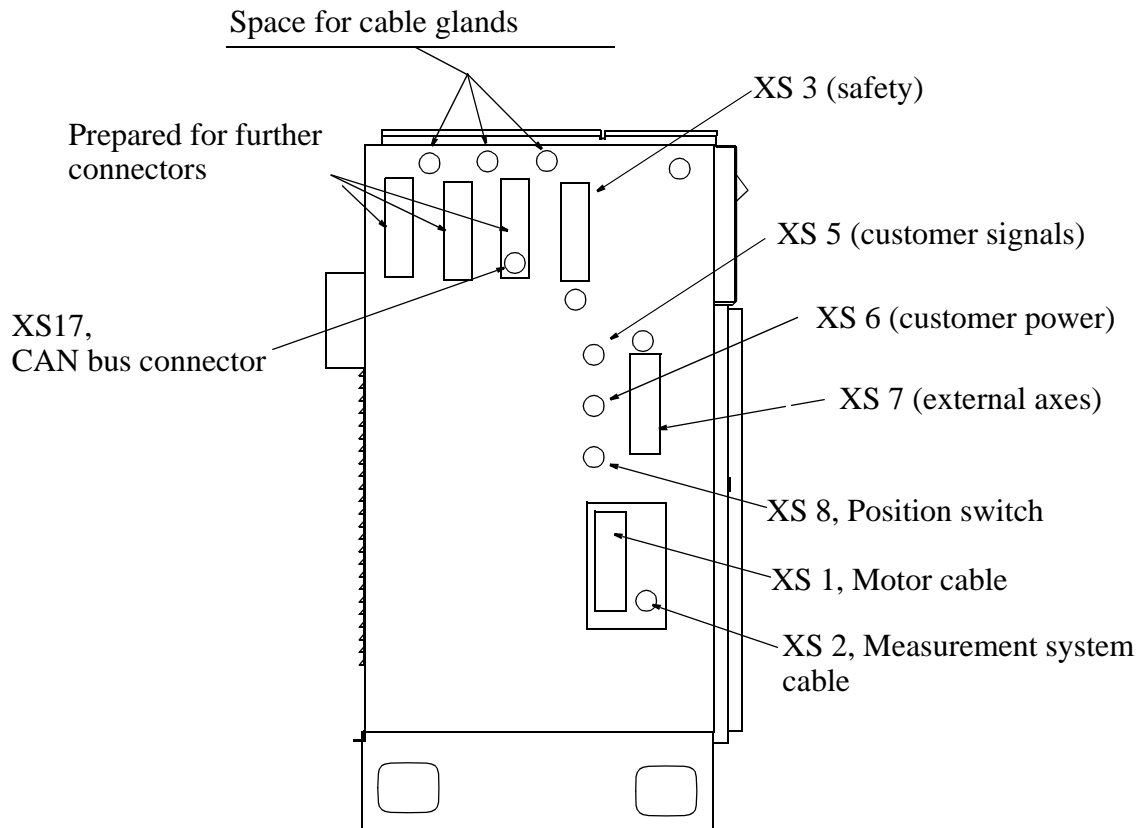
Figure 26 Positions for connections on the left-hand side of the controller.

3.6 Customer connections on manipulator

⚠ N.B.

When option 04y is chosen, the customer connections are available at the front of the upper arm.

Connections: R1/4" in the upper arm housing and R1/4" at the base. Max. 8 bar. Inner hose diameter: 6.5 mm.

For connection of extra equipment on the manipulator, there are cables integrated into the manipulator's cabling and one Burndy 12-pin UTG 014-12S connector on the upper arm housing.

Number of signals: 12 signals 60 V, 500 mA.
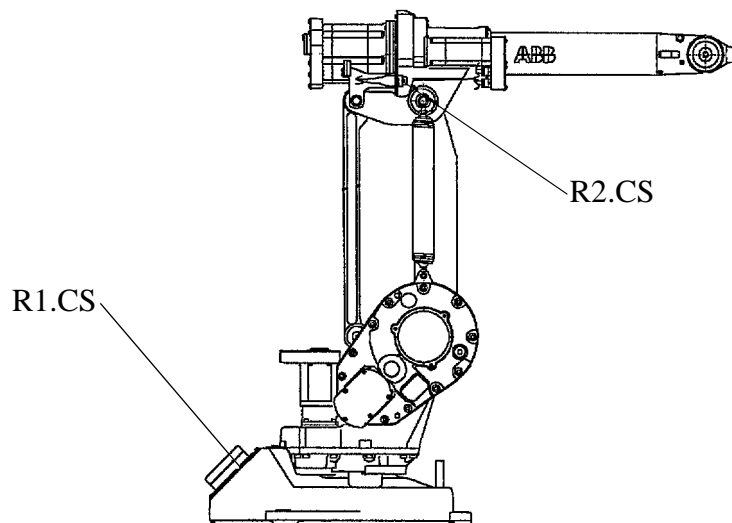
Figure 27 Location of customer connections.

To connect to power and signal conductors from the connection unit to the manipulator base and on the upper arm, the following parts are recommended:

Connector R2.CS. Signals, on upper arm. (Regarding **Pos** see Figure 28)
Pos	**Name**	**ABB art. no.**	**Type**	**Comments**
1	Socket connector	3HAA 2613-2	UTO 014 12 SHT	Burndy
2	Gasket	5217 649-64	UTFD 13B	Burndy
3	Socket	See below		
4	Pin connector 12p	3HAA 2602-2 5217 649-7	UTO 61412PN04 UTO 61412PN	Burndy EMC Burndy
5	Pin	See below		
6	Adaptor	3HAA 2601-2 5217 1038-3	URG 14 ADT UTG 14 AD	Burndy EMC Burndy
7	Cable clamp	5217 649-8	UTG 14 PG	Burndy
8	Shrinking hose Shrinking hose	3HAA 2614-2 5217 1032-4		Bottled shaped Angled

Connector R1CS. Signals, on the manipulator base. (Regarding **Pos** see Figure 28)
Pos	**Name**	**ABB art. no.**	**Type**	**Comments**
1	Pin connector 12p	3HAA 2599-2	UTG 014 12 P	Burndy
2	Gasket	5217 649-64	UTFD 14 B	Burndy
3	Pin	See below		
4	Socket con. 12p	3HAA 2600-2	UTO 61412 S	Burndy EMC
5	Sockets	See below		
6	Adaptor	3HAA 2601-2 5217 1038-3	URG 14 ADT UTG 14 PG	Burndy EMC Burndy
7	Cable clamp	5217 649-8	UTG 14 PG	Burndy
8	Shrinking hose Shrinking hose	3HAA 2614-2 5217 1032-4		Bottled shaped Angled

Name	ABB part no.	Type	Comments
Pin	5217 649-72	24/26	Burndy Machine tooling
	5217 649-25	24/26	Burndy Hand tooling
	5217 649-70	20/22	Burndy Machine tooling
	5217 649-3	20/22	Burndy Hand tooling
	5217 649-68	16/20	Burndy Machine tooling
	5217 649-10	24/26	Burndy Ground
	5217 649-31	16/20	Burndy Ground
Socket	5217 649-73	24/26	Burndy Machine tooling
	5217 649-26	24/26	Burndy Hand tooling
	5217 649-71	20/22	Burndy Machine tooling
	5217 649-69	16/18	Burndy Machine tooling
	5217 1021-4	DIN 43 652	Tin bronze (CuSu) 0.14 - 0.5mm^2 AWG 20-26
	5217 1021-5	DIN 43 652	Tin bronze (CuSu) 0.5 - 1.5mm^2 AWG 16-20
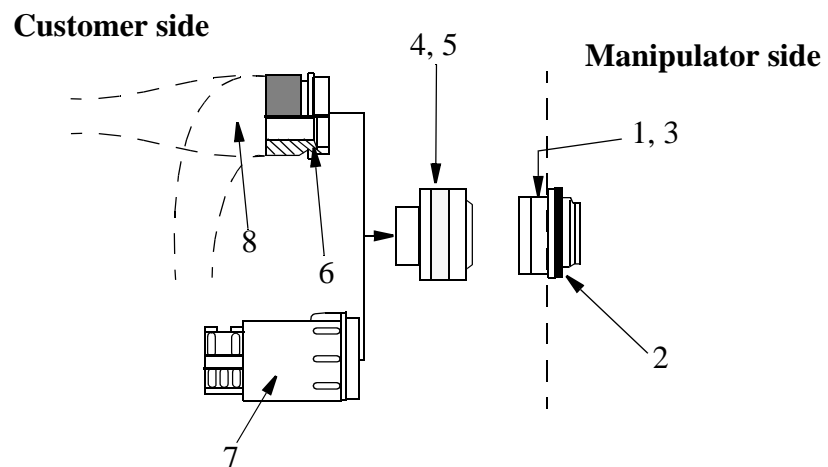
Figure 28 Burndy connector

3.7 Connection to screw terminal

Sockets with screwed connections for customer I/O, external safety circuits, customer sockets on the robot, external supply to electronics.

Signal identification	Location	Terminals
Safeguarded stop	Panel unit	X1 - X4
Digital I/O	I/O unit	X1 - X4
Combi I/O	I/O unit	X1 - X4, X6
Relay I/O	I/O unit	X1 - X4
RIO I/O	I/O unit	X1, X2
SIO 1, SIO 2	Backplane	X1, X2
CAN1 (internal unit)	Panel unit	X9
CAN 2 (manipulator, I/O units)	Backplane	X16
CAN 3 (external I/O units)	Backplane	X10
24 V supply (2 A fuse)		XT31
115/230 V AC supply		XT21

Location of socket terminals are shown below. See also circuit diagram, "View of control cabinet", for more details.
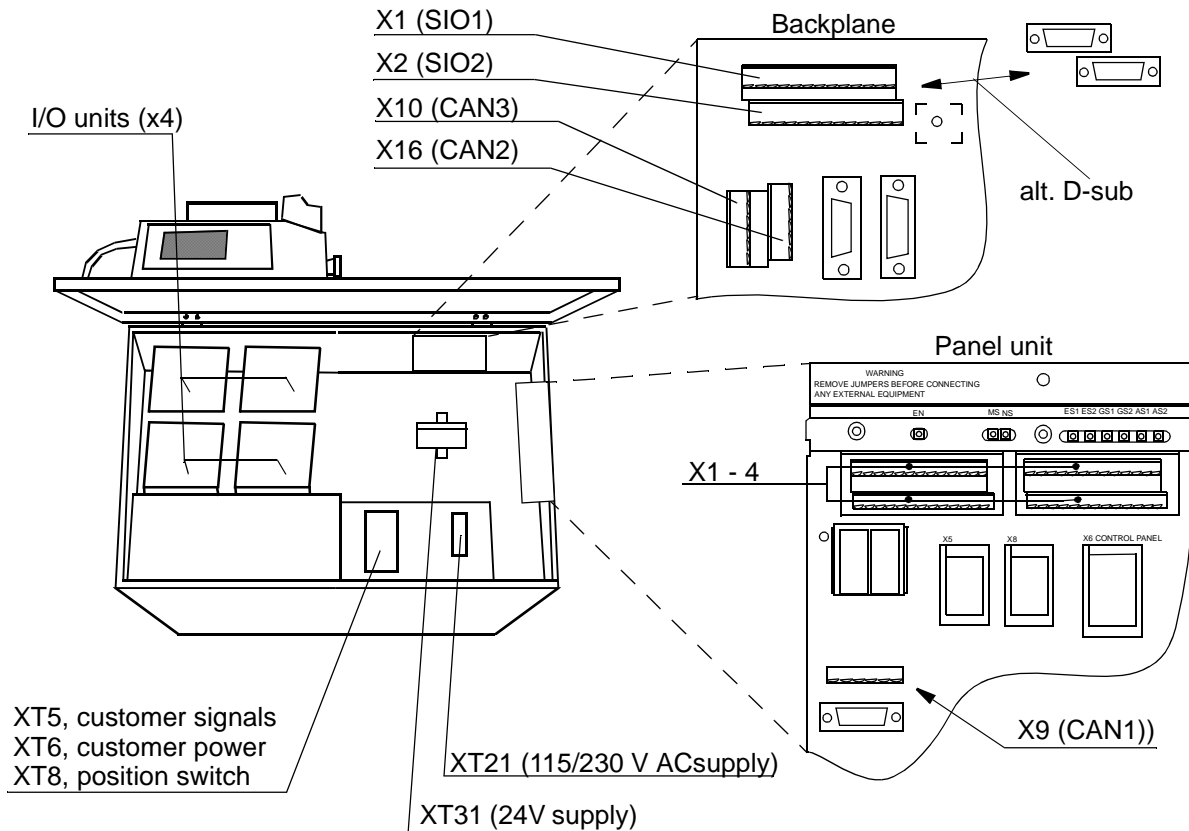
Figure 29 Screw terminal locations.

3.8 The MOTORS ON / MOTORS OFF circuit

To set the robot to MOTORS ON mode, two identical chains of switches must be closed. If any switch is open, the robot will switch to MOTORS OFF mode. As long as the two chains are not identical, the robot will remain in MOTORS OFF mode.
Figure 30 shows an outline principal diagram of the available customer connections, AS, GS and ES.

LS	*= Limit switch*
AS	*= Automatic mode safeguarded space Stop*
TPU En	*= Enabling device, teach pendant unit*
GS	*= General mode safeguarded space Stop*
ES	*= Emergency Stop*
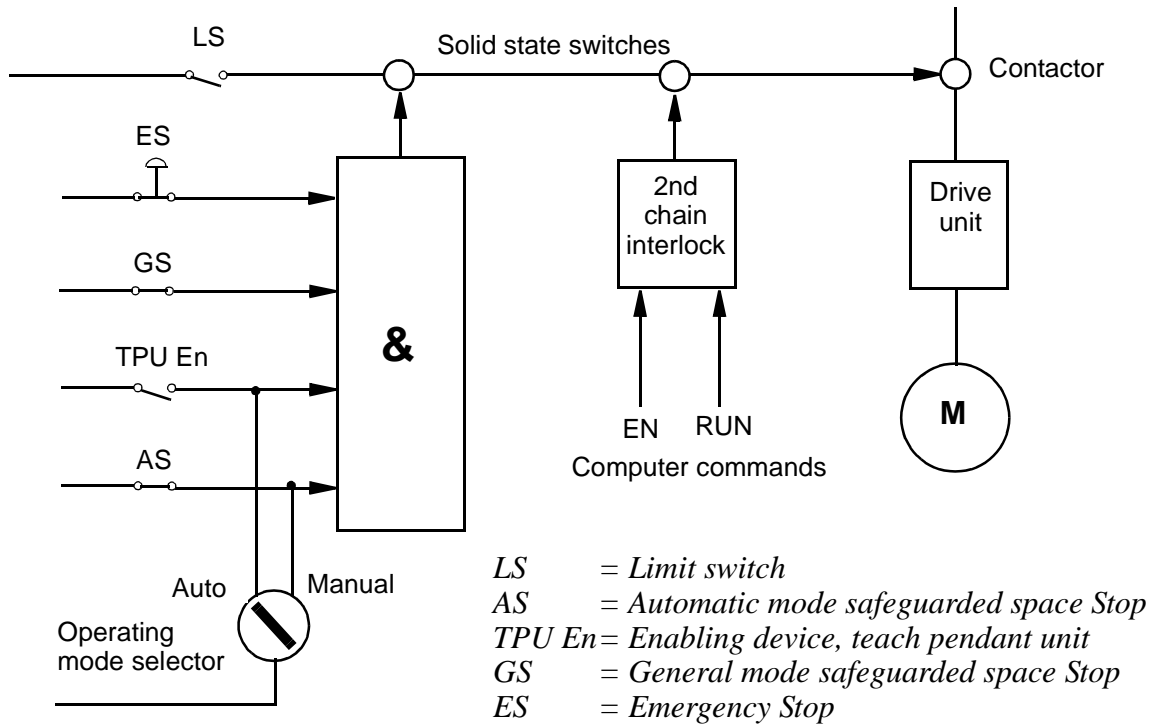
Figure 30 MOTORS ON /MOTORS OFF circuit.

3.9 Connection of safety chains

The diagram shows connections labeled:

24 V * X3:12 X4:12

Ext LIM1 X1:4 3 24 V

K1 0 V

see 3.9.1 ES1

X3:10 + Opto isol. GS1 8 -

11 + Opto isol. AS1 9 -

TPU En1

&

EN RUN Inter-locking K1 K2

Auto1 Man1

External contactors X2:5 6 CONT1 0 V
X1:5 6 CONT2 24 V

Ext LIM2 X2:4 3 0 V

K2 24V

see 3.9.1 ES2

X4:10 + Opto isol. GS2 8 -

11 + Opto isol. AS2 9 -

TPU En2

&

Auto2 Man2

Drive unit M

X3:7 * X4:7 0 V

*)
Supply from internal 24V (X3/X4:12) and 0 V (X3/X4:7) is displayed.
When external supply of GS and AS, X3/X4:10,11 is connected to 24 V and X3/X4:8,9 is connected to external 0 V

X1-X4 connection tables, see section 3.10.

Technical data per chain	
Limit switch: load max. V drop	300 mA 1 V
External contactors: load max. V drop	10 mA 4 V
GS/AS load at 24V	25 mA
GS/AS closed "1"	> 18 V
GS/AS open "0"	< 5 V
External supply of GS/AS	max. +35VDC min. -35VDC
Max. potential relative to the cabinet earthing and other group of signals	300 V
Signal class	control signals

Figure 31 Diagram showing the two-channel safety chain.

3.9.1 Connection of ES1/ES2 on panel unit

Supply from internal 24V (X1/X2:10) and 0V (X1/X2:7) is displayed. When external supply, X1/X2:9 is connected to ext. 24V and X1/X2:8 is connected to ext. 0V (dotted lines).
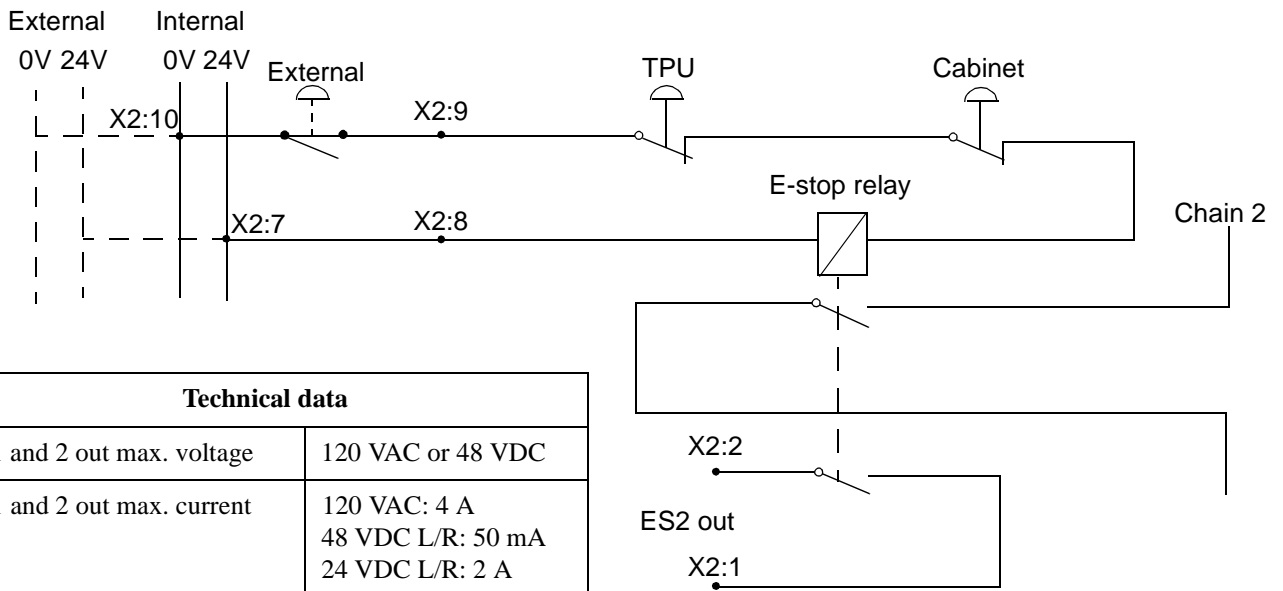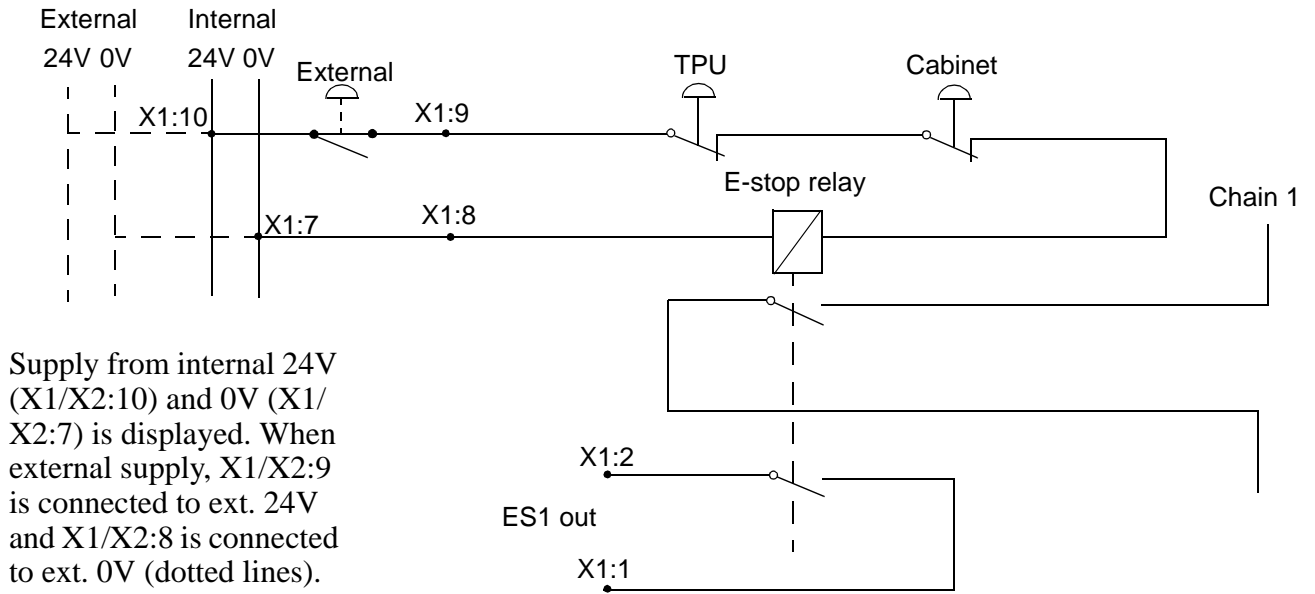
Technical data	
ES1 and 2 out max. voltage	120 VAC or 48 VDC
ES1 and 2 out max. current	120 VAC: 4 A 48 VDC L/R: 50 mA 24 VDC L/R: 2 A 24 VDC R load: 8 A
External supply of ES relays =	min 22 V between terminals X1:9,8 and X2:9,8 respectively
Rated current per chain	40 mA
Max. potential relative to the cabinet earthing and other groups of signals	300 V
Signal class	control signals

Figure 32 Terminals for emergency circuits.

3.9.2 Connection to Motor On/Off contactors
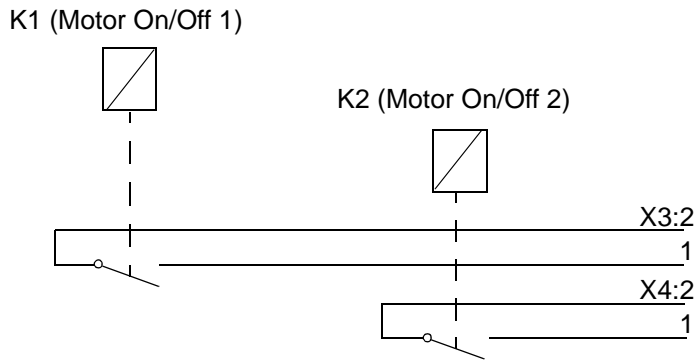
Technical data	
Max. voltage	48V DC
Max. current	4A
Max. potential relative to the cabinet earthing and other groups of signals	300V
Signal class	control

Figure 33 Terminals for customer use.

3.9.3 Connection to operating mode selector
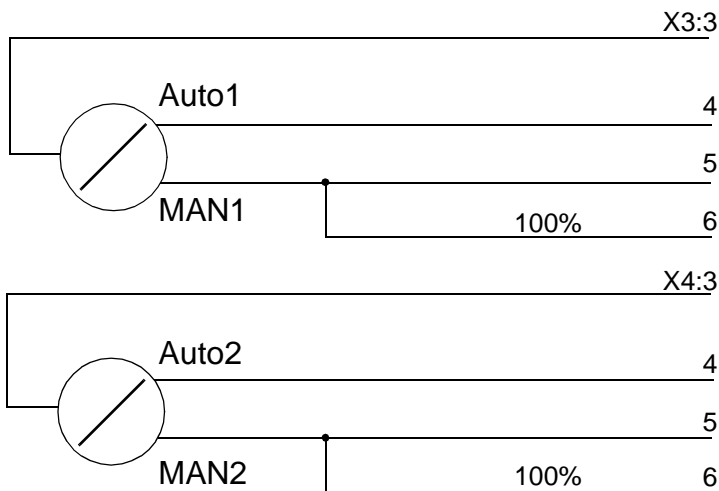
Technical data	
Max. voltage	48V DC
Max. current	4A
Max. potential relative to the cabinet earthing and other groups of signals	300V
Signal class	control

Figure 34 Terminals customer use.

3.9.4 Connection to brake contactor
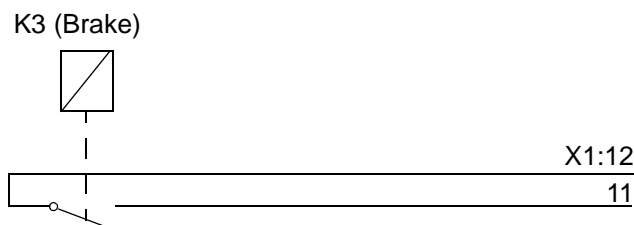
Technical data	
Max. voltage	48V DC
Max. current	4A
Max. potential relative to the cabinet earthing and other groups of signals	300V
Signal class	control

Figure 35 Terminal for customer use.

3.10 External customer connections

Customer contacts, on panel unit: X1- X4.

= jumper
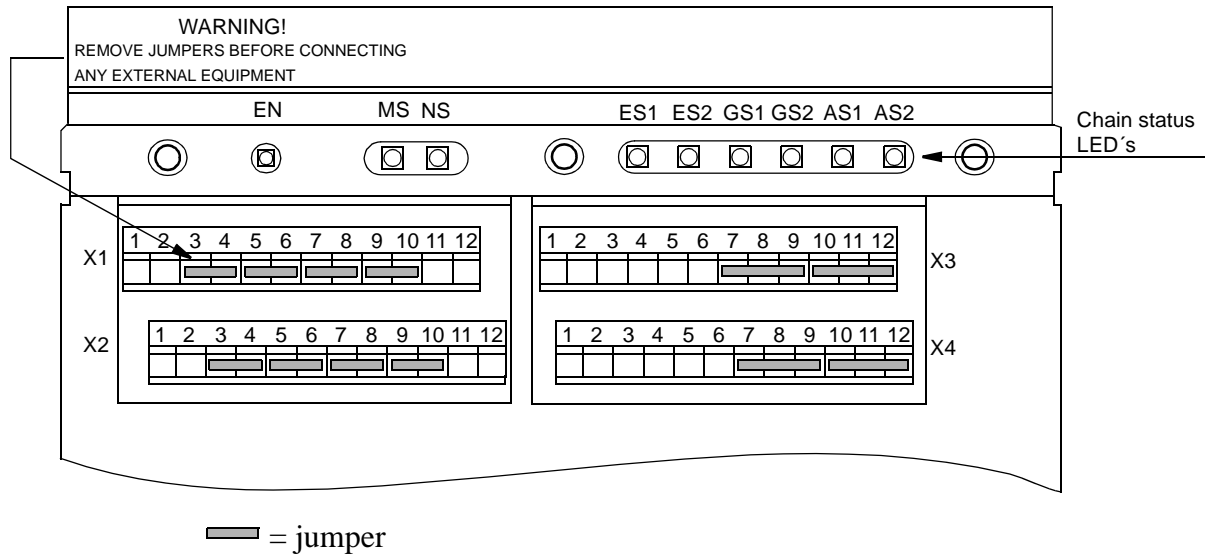
Customer connections: X1 - X4, located on the panel unit.
The signal names refer to the circuit diagram in chapter 11.

	X1	
Signal name	**Pin**	**Comment**
ES1 out:B	1	Emergency stop out chain 1
ES1 out:A	2	Emergency stop out chain 1
Ext. LIM1:B	3	External limit switch chain 1
Ext. LIM1:A	4	External limit switch chain 1
0V	5	0V external contactor 1
CONT1	6	External contactor 1
Int. 0V ES1	7	Internal supply 0V of emergency stop chain 1
Ext. 0V ES1	8	External supply 0V of emergency stop chain 1
Ext. ES1 IN	9	External emergency stop in chain 1
Ext. ES1 OUT	10	External emergency stop out chain 1
Ext. BRAKE B	11	Contactor for external brake
Ext. BRAKE A	12	Contactor for external brake

	X2	
Signal name	**Pin**	**Comment**
ES2 out:B	1	Emergency stop out chain 2
ES2 out:A	2	Emergency stop out chain 2
Ext. LIM2:B	3	External limit switch chain 2
Ext. LIM2:A	4	External limit switch chain 2
24V panel	5	24V external contactor 2
CONT2	6	External contactor 2
Int. 24V ES2	7	Internal supply 24V of emergency stop chain 2
Ext. 24V ES2	8	External supply 24V of emergency stop chain 2
Ext. ES2 IN	9	External emergency stop in chain 2
Ext. ES2 OUT	10	External emergency stop out chain 2
	11	Not used
	12	Not used

	X3	
Signal name	**Pin**	**Comment**
Ext. MON 1:B	1	Motor contactor 1
Ext. MON 1:A	2	Motor contactor 1
Ext. com 1	3	Common 1
Ext. auto 1	4	Auto 1
Ext. man 1	5	Manual 1
Ext. man FS 1	6	Manual full speed 1
0V	7	0V to auto stop and general stop
GS1-	8	General stop minus chain 1
AS1-	9	Auto stop minus chain 1
GS1+	10	General stop plus chain 1
AS1+	11	Auto stop plus chain 1
24V panel	12	24V to auto stop and general stop

X4		
Signal name	**Pin**	**Comment**
Ext. MON 2:B	1	Motor contactor 2
Ext. MON 2:A	2	Motor contactor 2
Ext. com 2	3	Common 2
Ext. auto 2	4	Auto 2
Ext. man 2	5	Manual 2
Ext. man FS 2	6	Manual full speed 2
0V	7	0V to auto stop and general stop
GS2-	8	General stop minus chain 2
AS2-	9	Auto stop minus chain 2
GS2+	10	General stop plus chain 2
AS2+	11	Auto stop plus chain 2
24V panel	12	24V to auto stop and general stop

3.11 External safety relay

The Motor On/Off mode in the controller can operate with external equipment if external relays are used. Two examples are shown below.
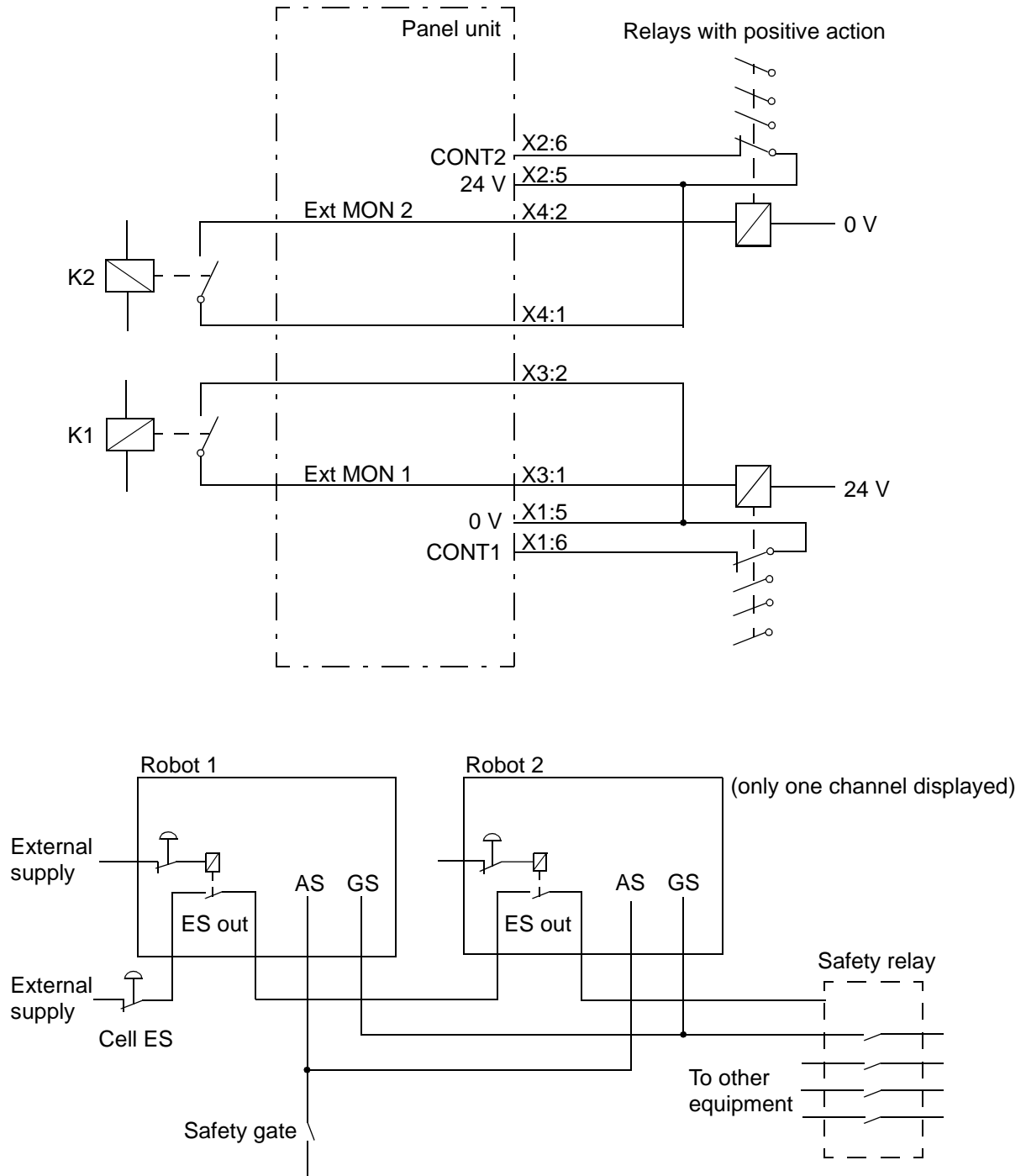
Figure 36 Diagram for using external safety relays.

3.12 Safeguarded space stop signals

According to the safety standard ISO/DIS 11161 "Industrial automation systems - safety of integrated manufacturing systems - Basic requirements", there are two categories of safety stops, category 0 and category 1, see below:

The category 0 stop is to be used when, for safety analysis purposes, the power supply to the motors must be switched off immediately, such as when a light curtain, used to protect against entry into the work cell, is passed. This uncontrolled motion stop may require special restart routines if the programmed path changes as a result of the stop.

Category 1 is to be preferred, if accepted for safety analysis purposes, such as when gates are used to protect against entry into the work cell. This controlled motion stop takes place within the programmed path, which makes restarting easier.

3.12.1   Delayed safeguarded space stop

All the robot's safety stops are as default category 0 stops.
Safety stops of category 1 can be obtained by activating the delayed safeguarded space stop together with AS or GS. A delayed stop gives a smooth stop. The robot stops in the same way as a normal program stop with no deviation from the programmed path. After approx. 1 second the power supply to the motors is shut off. The function is activated by setting a parameter, see User's Guide, section System Parameters, Topic: Controller.

Note! To ensure MOTORS OFF status, the activating switch must be kept open for more than one second. If the switch is closed within the delay, the robot stops and will remain in MOTORS ON mode.

3.13 Available voltage

3.13.1   24 V I/O supply

The robot has a 24 V supply available for external and internal use.

This voltage is used in the robot for supplying the drive unit fans and the manipulator brakes.
The 24 V I/O is not galvanically separated from the rest of the controller voltages.

Technical data

Voltage	24.0 - 26.4 V
Ripple	Max. 0.2 V
Permitted customer load	Max. 6 A (7.5 A if DSQC 374)
Current limit	Max. 18 A (12 A if DSQC 374)
Short-circuit current	Max. 13 A (average value)(~ 0 A if DSQC 374)

24 V I/O available for customer connections at:

XT.31.2   24 V (via 2 A fuse)
XT.31.1   for own fuses, max. fuse size is 2 A to ensure breaking at short circuit
                   Note! DSQC 374 can not trip any fuses.
XT.31.4   0 V (connected to cabinet structure)

3.13.2   115/230 V AC supply

The robot has a AC supply available for external and internal use.

This voltage is used in the robot for supplying optional service outlets.

The AC supply is not galvanically separated from the rest of the controller voltages.

Technical data

Voltage   115 or 230 V
Permitted customer load   Max. 500 VA
Fuse size   3.15 A (230 V), 6.3 A (115 V)

AC supply is available for customer connections at:

XT.21.1-5   230 V (3.15 A)
XT.21.6-8   115 V (6.3 A)
XT.21.9-13   N (connected to cabinet structure)

3.14 External 24 V supply

An external supply must be used in the following cases:

- When the internal supply is insufficient

- When the emergency stop circuits must be independent of whether or not the robot has power on, for example.

- When there is a risk that major interference can be carried over into the internal 24 V supply

An external supply is recommended to make use of the advantages offered by the galvanic insulation on the I/O units or on the panel unit.

The neutral wire in the external supply must be connected in such a way as to prevent the maximum permitted potential difference in the chassis earth being exceeded. For example, a neutral wire can be connected to the chassis earth of the controller, or some other common earthing point.

Technical data:

Potential difference to chassis earth: Max. 60 V continuous
                                              Max. 500 V for 1 minute

Permitted supply voltage: I/O units   19 - 35 V including ripple
                                 panel unit 20.6 - 30 V including ripple

3.15 Connection of extra equipment to the manipulator

Technical data for customer connections

Signals

Conductor resistance	<3 ohm, 0.154 mm^2
Max. voltage	50 V AC / DC
Max. current	250 mA

3.15.1   Connections on upper arm
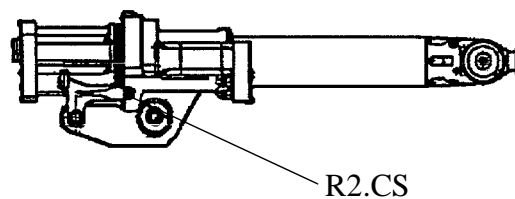
Figure 37   Customer connections on upper arm.

Signal name	Customer terminal controller, see Figure 29 (optional)	Customer contact on upper arm, R2	Customer contact on manipulator base (cable not supplied)
Signals			
CSA	XT5.1	R2.CS.A	R1.CS.A
CSB	XT5.2	R2.CS.B	R1.CS.B
CSC	XT5.3	R2.CS.C	R1.CS.C
CSD	XT5.4	R2.CS.D	R1.CS.D
CSE	XT5.5	R2.CS.E	R1.CS.E
CSF	XT5.6	R2.CS.F	R1.CS.F
CSG	XT5.7	R2.CS.G	R1.CS.G
CSH	XT5.8	R2.CS.H	R1.CS.H
CSJ	XT5.9	R2.CS.J	R1.CS.J
CSK	XT5.10	R2.CS.K	R1.CS.K
CSL	XT5.11	R2.CS.L	R1.CS.L
CSM	XT5.12	R2.CS.M	R1.CS.M

3.15.2   Connection of signal lamp on upper arm (option)

R3.H1 +
R3.H2 -
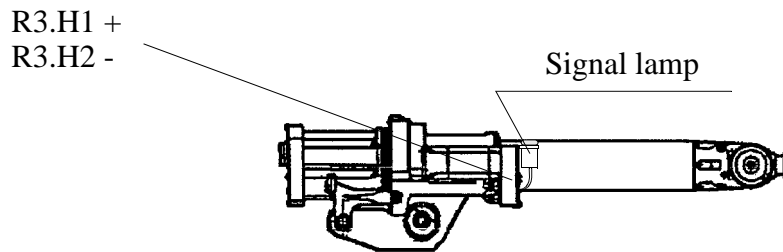
Signal lamp

Figure 38 Location of signal lamp.

3.16 Distributed I/O units

3.16.1   General

Up to 20* units can be connected to the same controller but only four of these can be installed inside the controller. Normally a distributed I/O unit is placed outside the controller. The maximum total length of the distributed I/O cable is 100 m (from one end of the chain to the other end). The controller can be one of the end points or be placed somewhere in the middle of the chain. For setup parameters, see User's Guide, section System Parameters, Topic: I/O Signals.

*) some ProcessWare reduces the number due to use of SIM boards.

3.16.2 Sensors

Sensors are connected to one optional digital unit.

Technical data

See Product Specification IRB 1400, chapter 3.10.

The following sensors can be connected:

Sensor type	Signal level	
Digital one bit sensors	High	"1"
	Low	"0"
Digital two bit sensors	High	"01"
	No signal	"00"
	Low	"10"
	Error status	"11" (stop program running)

3.16.3 Connection and address keying of the CAN-bus

Controller
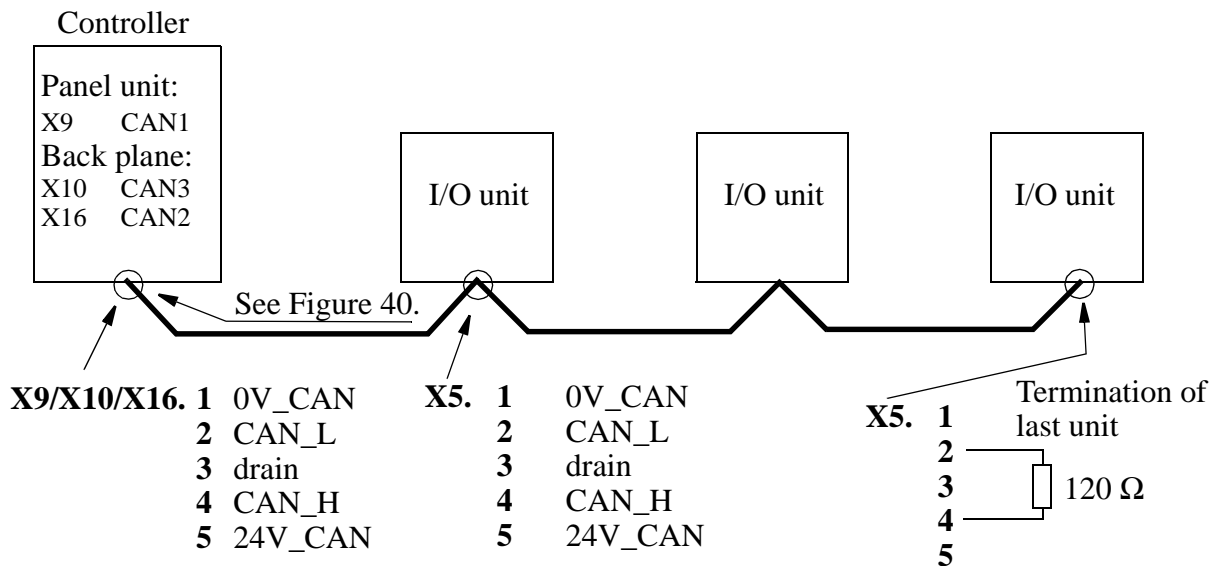
Figure 39 Example of connection of the CAN-bus

1. When the I/O unit is fitted <u>inside the control cabinet</u> (this is standard when choosing the options on the Specification form), its CAN bus is connected to CAN1, X9 on the panel unit (see 3.7). No termination is required when only CAN1 is used.

2. When the I/O unit is fitted <u>outside the control cabinet</u>, its CAN bus must be connected to CAN3, X10 on the backplane of the control cabinet.

3. When the I/O unit is fitted <u>on the manipulator</u>, its CAN bus must be connected to CAN2, X16 on the backplane of the control cabinet.

NOTE!
When only one of the X10/X16 is connected, the other must be terminated with 120 Ω.

⚠ **24V_CAN must not be used to supply digital inputs and outputs. Instead, they must be supplied either by the 24 V I/O from the cabinet or externally by a power supply unit.**

CAN3 (ext. I/O)
CAN2 (manip. I/O)
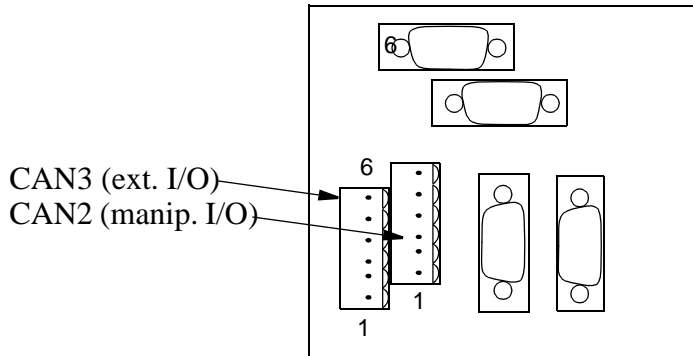
Figure 40 CAN connections on back plane.

DeviceNet Connector

Input and ID	Signal name	X5 Pin	Description
	V- 0V	1	Supply voltage GND
	CAN_L	2	CAN signal low
	DRAIN	3	Shield
	CAN_H	4	CAN signal high
	V+	5	Supply voltage 24VDC
	GND	6	Logic GND
	MAC ID 0	7	Board ID bit 0 (LSB)
	MAC ID 1	8	Board ID bit 1
	MAC ID 2	9	Board ID bit 2
	MAC ID 3	10	Board ID bit 3
	MAC ID 4	11	Board ID bit 4
	MAC ID 5	12	Board ID bit 5 (MSB)

ID setting

Each I/O unit is given a unique address (ID). The connector contains address pins and can be keyed as shown in Figure 41.

When all terminals are unconnected the highest address is obtained, i.e. 63. When all are connected to 0 V, the address is 0 (which will cause an error since address 0 is used by the Panel unit). To not interfer with other internal addresses, do not use address 0-9.
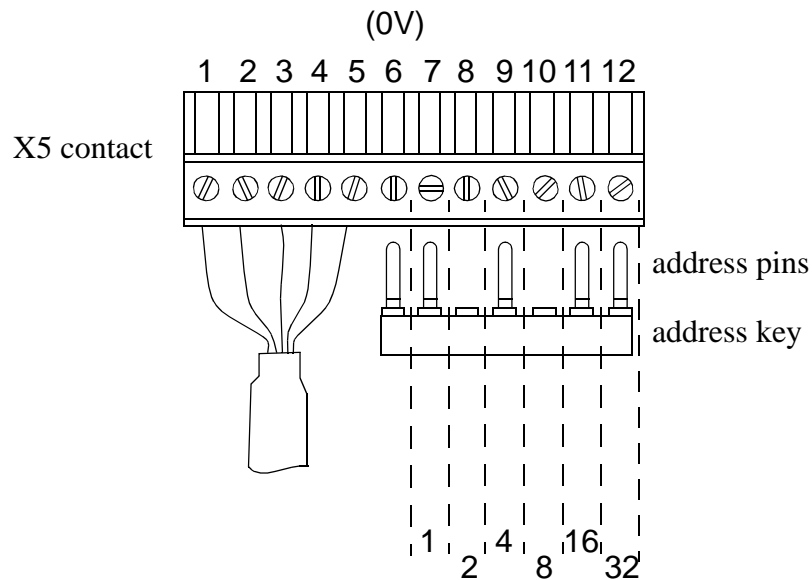
Example:

To obtain address 10:
cut off address pins 2 and 8, see figure.

To obtain address 25:
cut off address pins 1, 8 and 16.

Figure 41 Examples of address keying.

3.16.4   Digital I/O DSQC 328 (optional)

The digital I/O unit has 16 inputs and outputs, divided up into groups of eight. All groups are galvanically isolated and may be supplied from the cabinet 24 V I/O supply or from a separate supply.

Technical data

See Product Specification IRB 1400, chapter 3.10.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

CONNECTION TABLE
Customer contacts: X1 - X4

Unit function	**X1** Signal name	Pin	Customer conn.	**X2** Signal name	Pin
Opto. isol.	Out ch 1	1		Out ch 9	1
	Out ch 2	2		Out ch 10	2
	Out ch 3	3		Out ch 11	3
	Out ch 4	4		Out ch 12	4
	Out ch 5	5		Out ch 13	5
	Out ch 6	6		Out ch 14	6
	Out ch 7	7		Out ch 15	7
	Out ch 8	8		Out ch 16	8
	0V for out 1-8	9	0V	0V for out 9-16	9
	24V for out 1-8	10*	24V	24V for out 9-16	10*

*)
If supervision of the supply voltage is required, a bridge connection can be made to an optional digital input. The supervision instruction must be written in the RAPID program.

Unit function	X3		Customer conn.	X4	
	Signal name	**Pin**		**Signal name**	**Pin**
Opto. isol.	In ch 1	1	← ⟋ 24 V	In ch 9	1
	In ch 2	2		In ch 10	2
	In ch 3	3		In ch 11	3
	In ch 4	4		In ch 12	4
	In ch 5	5		In ch 13	5
	In ch 6	6		In ch 14	6
	In ch 7	7		In ch 15	7
	In ch 8	8		In ch 16	8
	0V for in 1-8	9	← 0 V	0V for in 9-16	9
	Not used	10		Not used	10

NOTE!
The input current is 5.5 mA (at 24V) on the digital inputs. A capacitor connected to ground, to prevent disturbances, causes a short rush of current when setting the input. When connecting outputs, sensitive to pre-oscillation current, a serial resistor (100 Ω) may be used.

3.16.5   AD Combi I/O DSQC 327 (optional)

The combi I/O unit has 16 digital inputs divided into groups of 8, and 16 digital outputs divided into two groups of 8. All groups are galvanically isolated and may be supplied from the cabinet 24 V I/O supply or from a separate supply.

The two analog outputs belong to a common group which is galvanically isolated from the electronics of the controller. The supply to the two analog outputs is generated from 24 V_CAN (with galvanically isolated DC/AC converter).

Technical data

See Product Specification IRB 1400, chapter 3.10.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

CONNECTION TABLE
Customer contacts: X1 - X4, X6
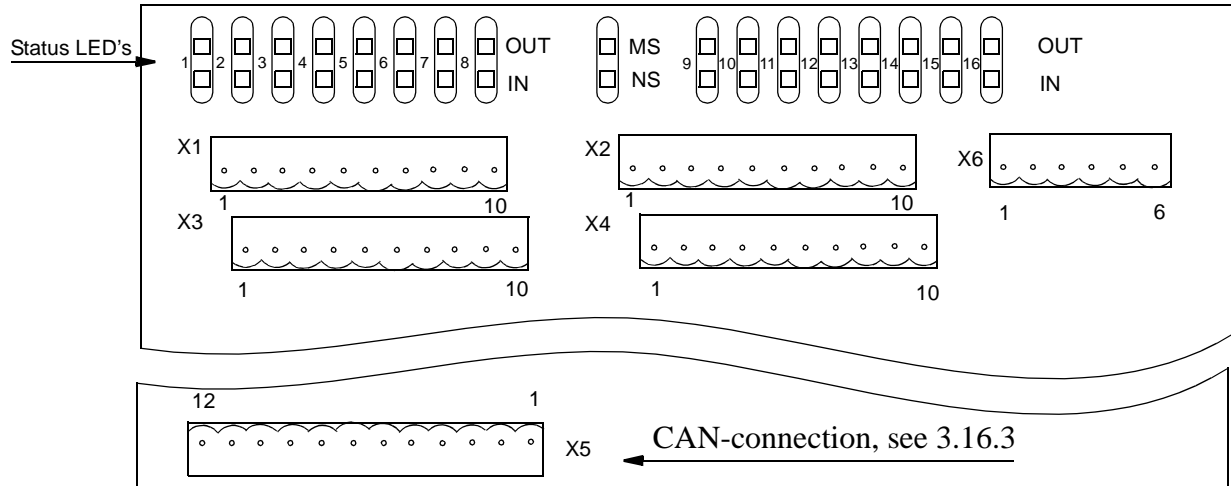
	X1			**X2**	
Unit function	**Signal name**	**Pin**	**Customer conn.**	**Signal name**	**Pin**
Opto. isol.	Out ch 1	1		Out ch 9	1
	Out ch 2	2		Out ch 10	2
	Out ch 3	3		Out ch 11	3
	Out ch 4	4		Out ch 12	4
	Out ch 5	5		Out ch 13	5
	Out ch 6	6		Out ch 14	6
	Out ch 7	7		Out ch 15	7
	Out ch 8	8		Out ch 16	8
	0V for out 1-8	9	0V	0V for out 9-16	9
	24V for out 1-8	10*	24V	24V for out 9-16	10*

*)
If supervision of the supply voltage is required, a bridge connection can be made to an optional digital input. The supervision instruction must be written in the RAPID program.

Unit function	X3		Customer conn.	X4	
	Signal name	**Pin**		**Signal name**	**Pin**
Opto. isol.	In ch 1	1	← ⟋ 24 V	In ch 9	1
	In ch 2	2		In ch 10	2
	In ch 3	3		In ch 11	3
	In ch 4	4		In ch 12	4
	In ch 5	5		In ch 13	5
	In ch 6	6		In ch 14	6
	In ch 7	7		In ch 15	7
	In ch 8	8		In ch 16	8
	0V for in 1-8	9	← 0 V	0V for in 9-16	9
	Not used	10		Not used	10

NOTE!
The input current is 5.5 mA (at 24V) on the digital inputs. A capacitor connected to ground, to prevent disturbances, causes a short rush of current when setting the input. When connecting outputs, sensitive to pre-oscillation current, a serial resistor (100 Ω) may be used.

X6		
Signal name	**Pin**	**Explanation**
AN_ICH1	1	For test purpose only
AN_ICH2	2	For test purpose only
0V	3	0V for In 1-2
0VA	4	0V for Out 1-2
AN_OCH1	5	Out ch 1
AN_OCH2	6	Out ch 2

3.16.6   Analog I/O DSQC 355 (optional)

The analog I/O unit provides following connections:

4 analog inputs, -10/+10V, which may be used for analog sensors etc.

4 analog outputs, 3 for -10/+10V and 1 for 4-20mA, for control of analog functions such as controlling glueing equipment etc.

24V to supply external equipment wich return signals to DSQC 355.

Technical data

See Product Specification IRB 1400, chapter 3.10.

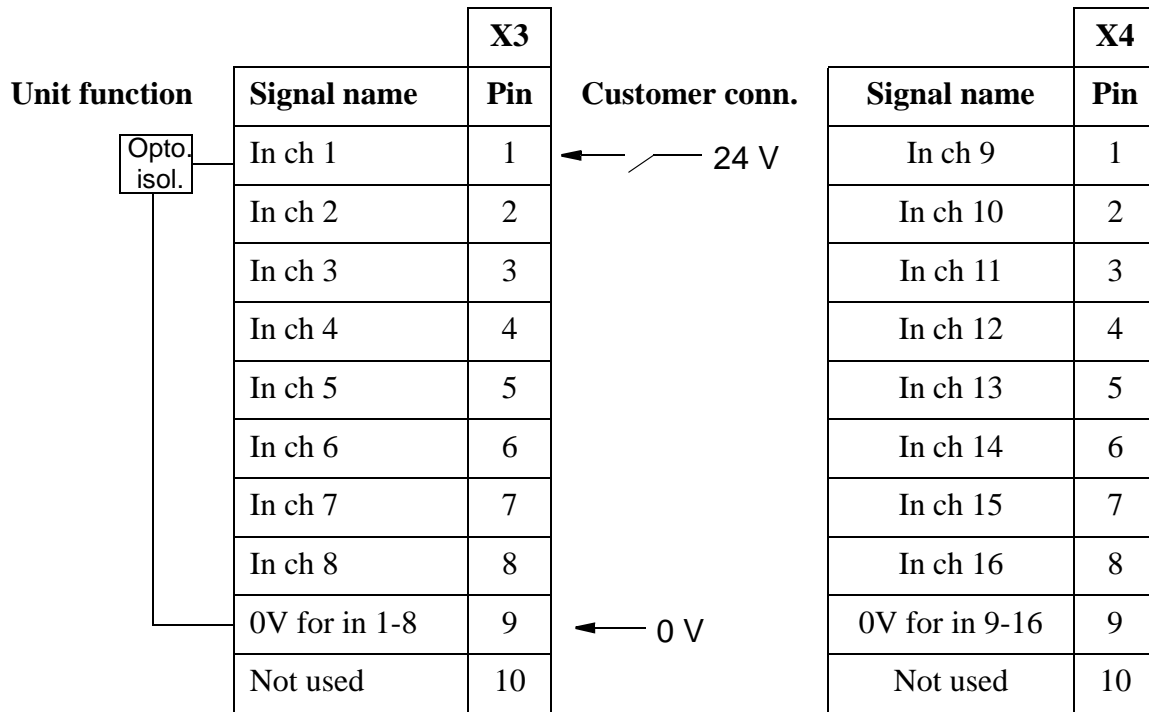*Further information*

For setup parameters, see User's Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

CONNECTION TABLE
Customer contacts: X1, X3, X 5 - X8

X8-Analog inputs   X7-Analog outputs

X5-DiviceNet input
and ID connector

Not to be used
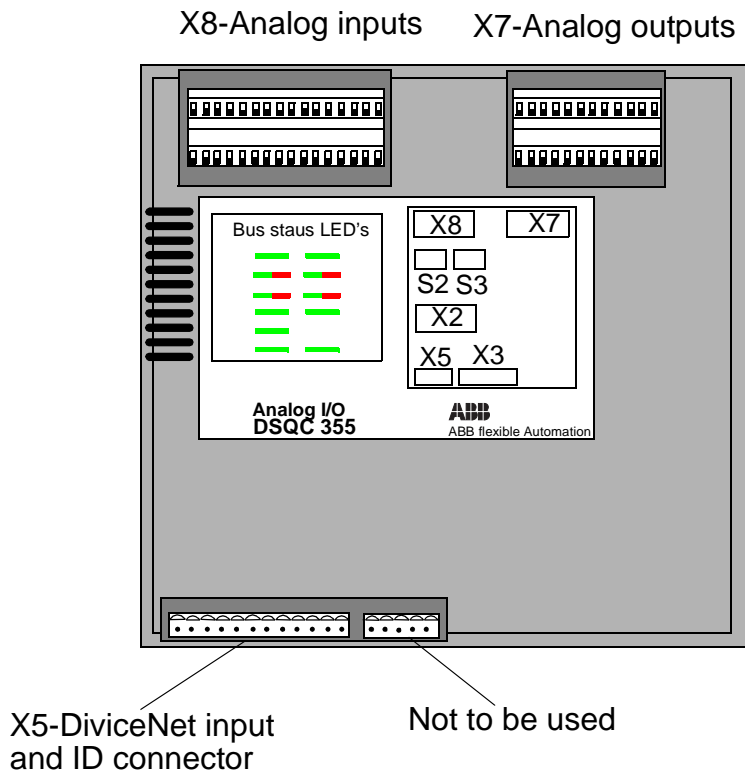
Figure 42 Analog I/O unit

Connector X5- DeviceNet connectors

See section 3.16.3 on page 51.

Connector X7 - Analog outputs

Signal name	Pin	Description
	X7	
Signal name	**Pin**	**Description**
ANOUT_1	1	Analog output 1, -10/+10V
ANOUT_2	2	Analog output 2, -10/+10V
ANOUT_3	3	Analog output 3, -10/+10V
ANOUT_4	4	Analog output 4, 4-20 mA
Not to be used	5	
Not to be used	6	
Not to be used	7	
Not to be used	8	
Not to be used	9	
Not to be used	10	
Not to be used	11	
Not to be used	12	
Not to be used	13	
Not to be used	14	
Not to be used	15	
Not to be used	16	
Not to be used	17	
Not to be used	18	
GND	19	Analog output 1, 0 V
GND	20	Analog output 2, 0 V
GND	21	Analog output 3, 0 V
GND	22	Analog output 4, 0 V
GND	23	
GND	24	

12   1

24   13

Connector X8 - Analog inputs

```
16                    1
 ■■■■■■■■■■■■■■■■
 ■■■■■■■■■■■■■■■■
32                   17
```
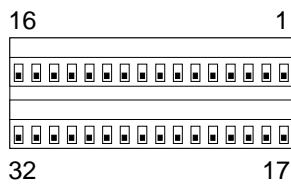
	X8	
Signal name	**Pin**	**Description**
ANIN_1	1	Analog input 1, -10/+10 V
ANIN_2	2	Analog input 2, -10/+10 V
ANIN_3	3	Analog input 3, -10/+10 V
ANIN_4	4	Analog input 4, -10/+10 V
Not to be used	5	
Not to be used	6	
Not to be used	7	
Not to be used	8	
Not to be used	9	
Not to be used	10	
Not to be used	11	
Not to be used	12	
Not to be used	13	
Not to be used	14	
Not to be used	15	
Not to be used	16	
+24V out	17	+24VDC supply
+24V out	18	+24VDC supply
+24V out	19	+24VDC supply
+24V out	20	+24VDC supply
+24V out	21	+24VDC supply
+24V out	22	+24VDC supply
+24V out	23	+24VDC supply
+24V out	24	+24VDC supply
GND	25	Analog input 1, 0V
GND	26	Analog input 2, 0V
GND	27	Analog input 3, 0V
GND	28	Analog input 4, 0V
GND	29	
GND	30	
GND	31	
GND	32	

3.16.7 Encoder interface unit, DSQC 354

The encoder interface unit provides connections for 1 encoder and 1 digital input.

The encoder is used for installation on a conveyor to enable robot programs to synchronize to the motion (position) of the conveyor.

The digital input is used for external start signal/ conveyor synchronization point.

Further information

User Reference Description Conveyor Tracking.
For setup parameters, see User's Guide, section System Parameters, Topic: Controller.
Circuit diagram, see chapter 11.

Customer terminals:
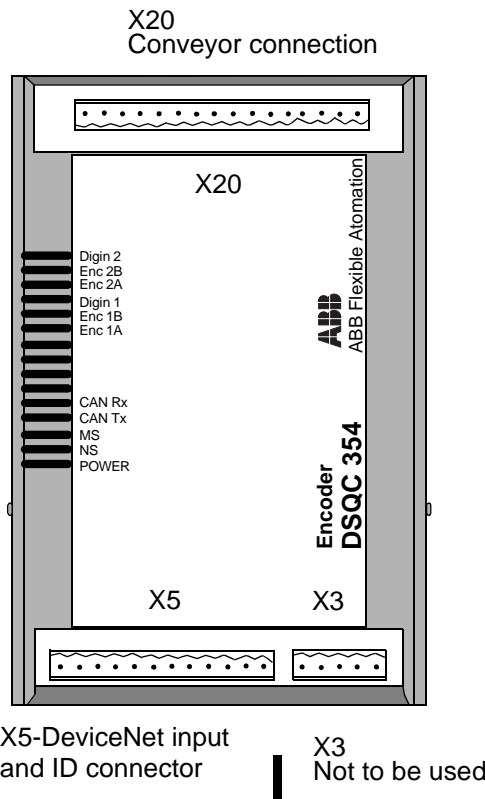
Device Net connector X5, see section 3.16.3 on page 51

Figure 43 Encoder unit, DSQC 354
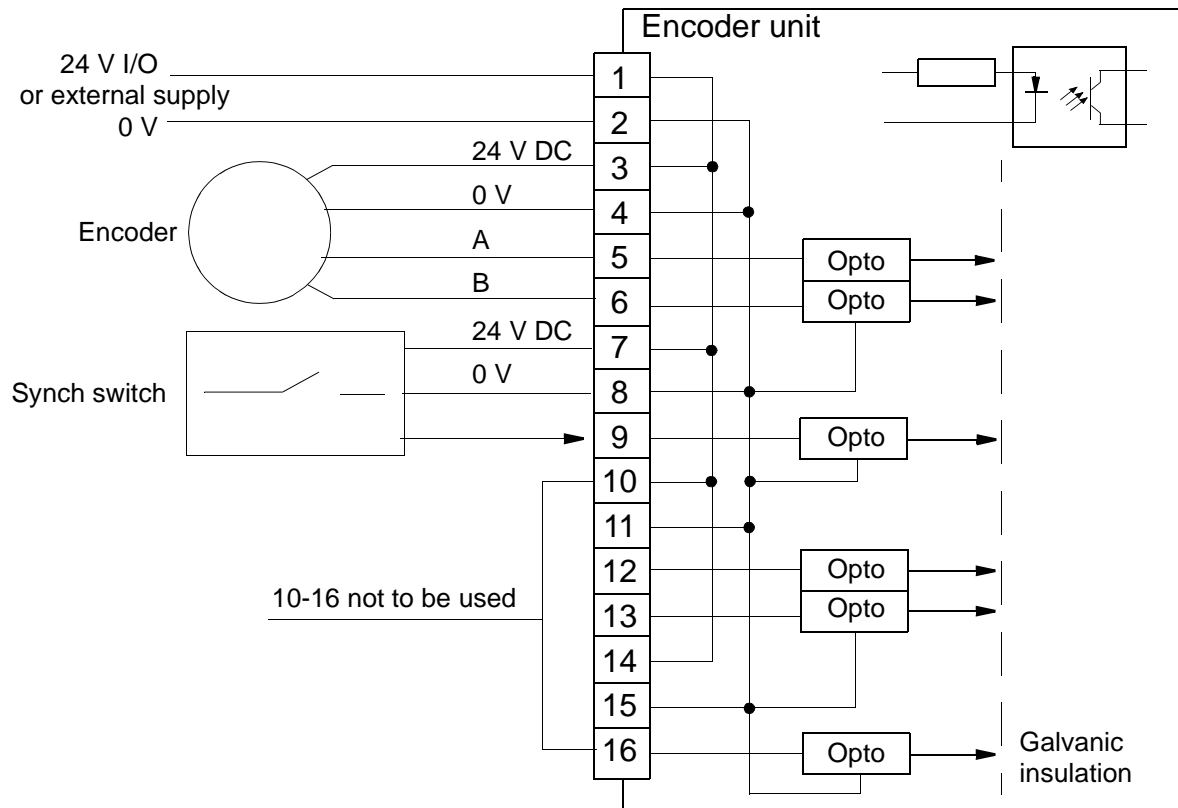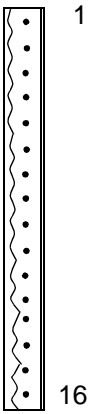
Figure 44 Encoder connections.

The wiring diagram in Figure 44 shows how to connect the encoder and start signal switch to the encoder unit. As can be seen from the illustration, the encoder is supplied with 24 VDC and 0V. The encoder output 2 channels, and the on-board computer uses quadrature decoding (QDEC) to compute position and direction.

Connector X20 - Encoder and digital input connections

Input and ID	Signal name	X20 Pin	Description
	24 VDC	1	24 VDC supply
	0 V	2	0 V
	ENC	3	Encoder 24 VDC
	ENC	4	Encoder 0 V
	ENC_A	5	Encoder Phase A
	ENC_B	6	Encoder Phase B
	DIGIN	7	Synch switch 24 VDC
	DIGIN	8	0V
	DIGIN	9	Synch switch digital input
	Not to be used	10	
	Not to be used	11	
	Not to be used	12	
	Not to be used	13	
	Not to be used	14	
	Not to be used	15	
	Not to be used	16	

3.16.8   Relay I/O DSQC 332

16 output relays each with a single Normal Open contact, independent of each other.

16 digital 24V inputs divided into groups of 8. The groups are galvanically isolated. Supply to customer switches can be taken either from the cabinet 24 V I/O or from a separate supply.

Technical data

See Product Specification IRB 1400, chapter 3.10.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

CONNECTION TABLE
Customer contacts: X1 - X4

Unit function	**X1**		Customer conn.	**X2**	
	Signal name	**Pin**		**Signal name**	**Pin**
	Out ch 1a	1	← supply	Out ch 9a	1
	Out ch 1b	2		Out ch 9b	2
	Out ch 2a	3		Out ch 10a	3
	Out ch 2b	4		Out ch 10b	4
	Out ch 3a	5		Out ch 11a	5
	Out ch 3b	6		Out ch 11b	6
	Out ch 4a	7		Out ch 12a	7
	Out ch 4b	8		Out ch 12b	8
	Out ch 5a	9		Out ch 13a	9
	Out ch 5b	10		Out ch 13b	10
	Out ch 6a	11		Out ch 14a	11
	Out ch 6b	12		Out ch 14b	12
	Out ch 7a	13		Out ch 15a	13
	Out ch 7b	14		Out ch 15b	14
	Out ch 8a	15		Out ch 16a	15
	Out ch 8b	16		Out ch 16b	16

Unit function	X3		Customer conn.	X4	
	Signal name	**Pin**		**Signal name**	**Pin**
Opto. isol.	In ch 1	1	← ╱ 24 V	In ch 9	1
	In ch 2	2		In ch 10	2
	In ch 3	3		In ch 11	3
	In ch 4	4		In ch 12	4
	In ch 5	5		In ch 13	5
	In ch 6	6		In ch 14	6
	In ch 7	7		In ch 15	7
	In ch 8	8		In ch 16	8
	0V for in 1-8	9	← 0 V	0V for in 9-16	9
	Not used	10		Not used	10
	Not used	11		Not used	11
	Not used	12		Not used	12
	Not used	13		Not used	13
	Not used	14		Not used	14
	Not used	15		Not used	15
	Not used	16		Not used	16

NOTE!
The input current is 5.5 mA (at 24V) on the digital inputs. A capacitor connected to ground, to prevent disturbances, causes a short rush of current when setting the input. When connecting a source (PLC), sensitive to pre-oscillation current, a serial resistor (100 Ω) may be used.

3.16.9   Digital 120 VAC I/O DSQC 320
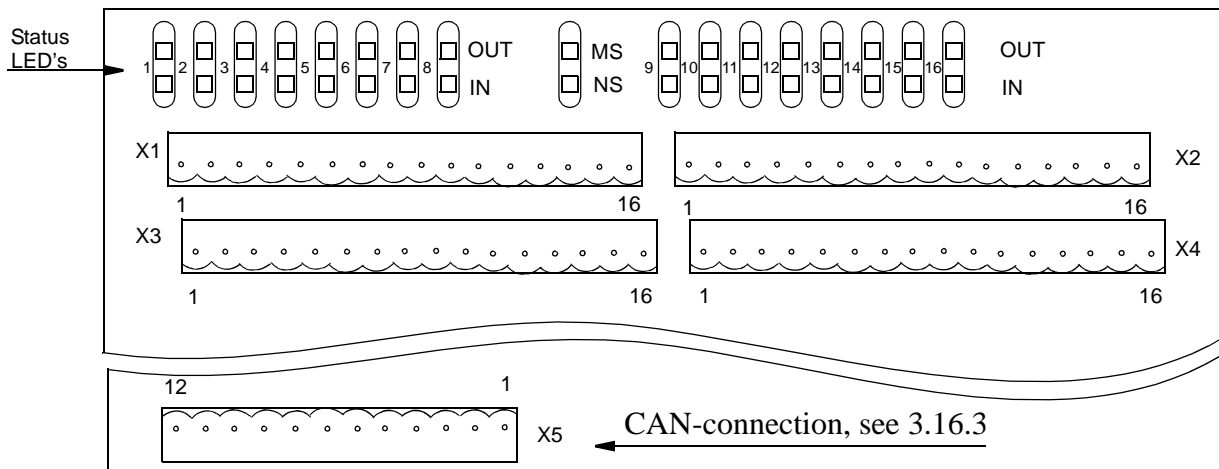
Technical data
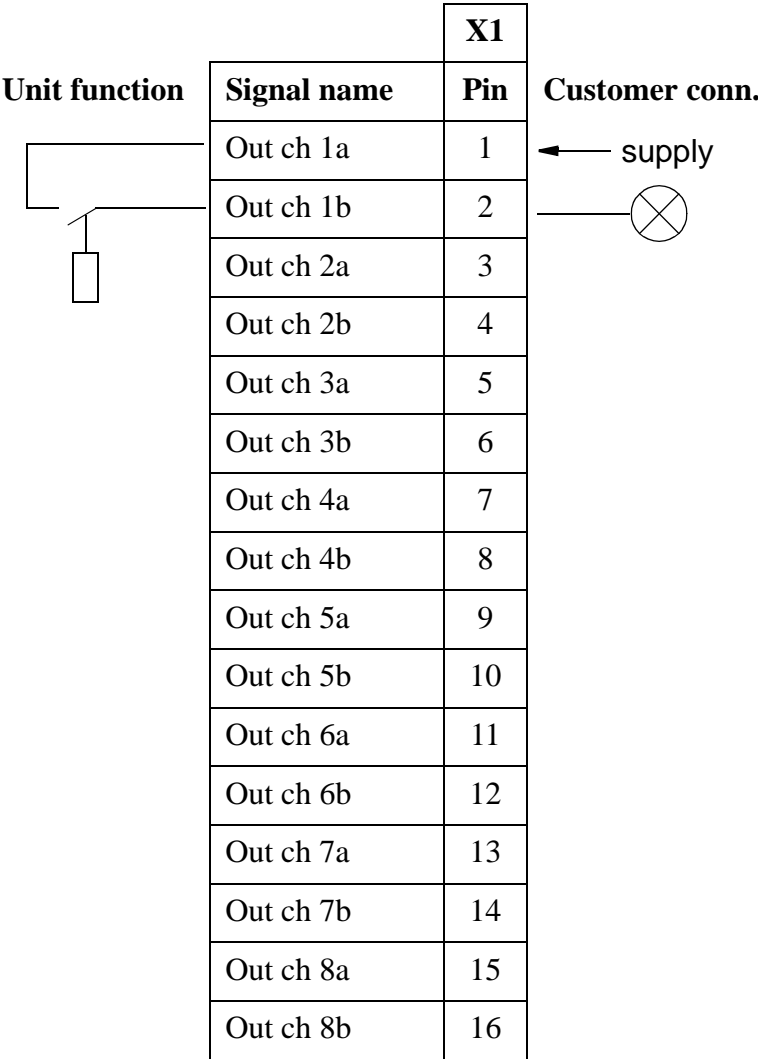
See Product Specification IRB 1400, chapter 3.10.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller.
Circuit diagram, see chapter 11.

CONNECTION TABLE
Customer contacts: X1 - X4

Unit function	X1		Customer conn.	X2	
	Signal name	**Pin**		**Signal name**	**Pin**
Opto isol. ◯	Out ch 1a	1	← AC supply	Out ch 9a	1
	Out ch 1b	2	→ ⊗	Out ch 9b	2
	Out ch 2a	3		Out ch 10a	3
	Out ch 2b	4		Out ch 10b	4
	Out ch 3a	5		Out ch 11a	5
	Out ch 3b	6		Out ch 11b	6
	Out ch 4a	7		Out ch 12a	7
	Out ch 4b	8		Out ch 12b	8
	Out ch 5a	9		Out ch 13a	9
	Out ch 5b	10		Out ch 13b	10
	Out ch 6a	11		Out ch 14a	11
	Out ch 6b	12		Out ch 14b	12
	Out ch 7a	13		Out ch 15a	13
	Out ch 7b	14		Out ch 15b	14
	Out ch 8a	15		Out ch 16a	15
	Out ch 8b	16		Out ch 16b	16

Unit function	X3		Customer conn.	X4	
	Signal name	**Pin**		**Signal name**	**Pin**
	In ch 1a	1	AC	In ch 9a	1
	In ch 1b	2	N	In ch 9b	2
	In ch 2a	3		In ch 10a	3
	In ch 2b	4		In ch 10b	4
	In ch 3a	5		In ch 11a	5
	In ch 3b	6		In ch 11b	6
	In ch 4a	7		In ch 12a	7
	In ch 4b	8		In ch 12b	8
	In ch 5a	9		In ch 13a	9
	In ch 5b	10		In ch 13b	10
	In ch 6a	11		In ch 14a	11
	In ch 6b	12		In ch 14b	12
	In ch 7a	13		In ch 15a	13
	In ch 7b	14		In ch 15b	14
	In ch 8a	15		In ch 16a	15
	In ch 8b	16		In ch 16b	16

Opto isol.

3.17 Field bus units

3.17.1 RIO (Remote Input Output), remote I/O for Allen-Bradley PLC DSQC 350

The RIO-unit can be programmed for 32, 64, 96 or 128 digital inputs and outputs.

The RIO-unit should be connected to an Allen-Bradley PLC using a screened, two conductor cable.

Technical data

See Product Specification IRB 1400, chapter 3.10 and Allen-Bradley RIO specification.
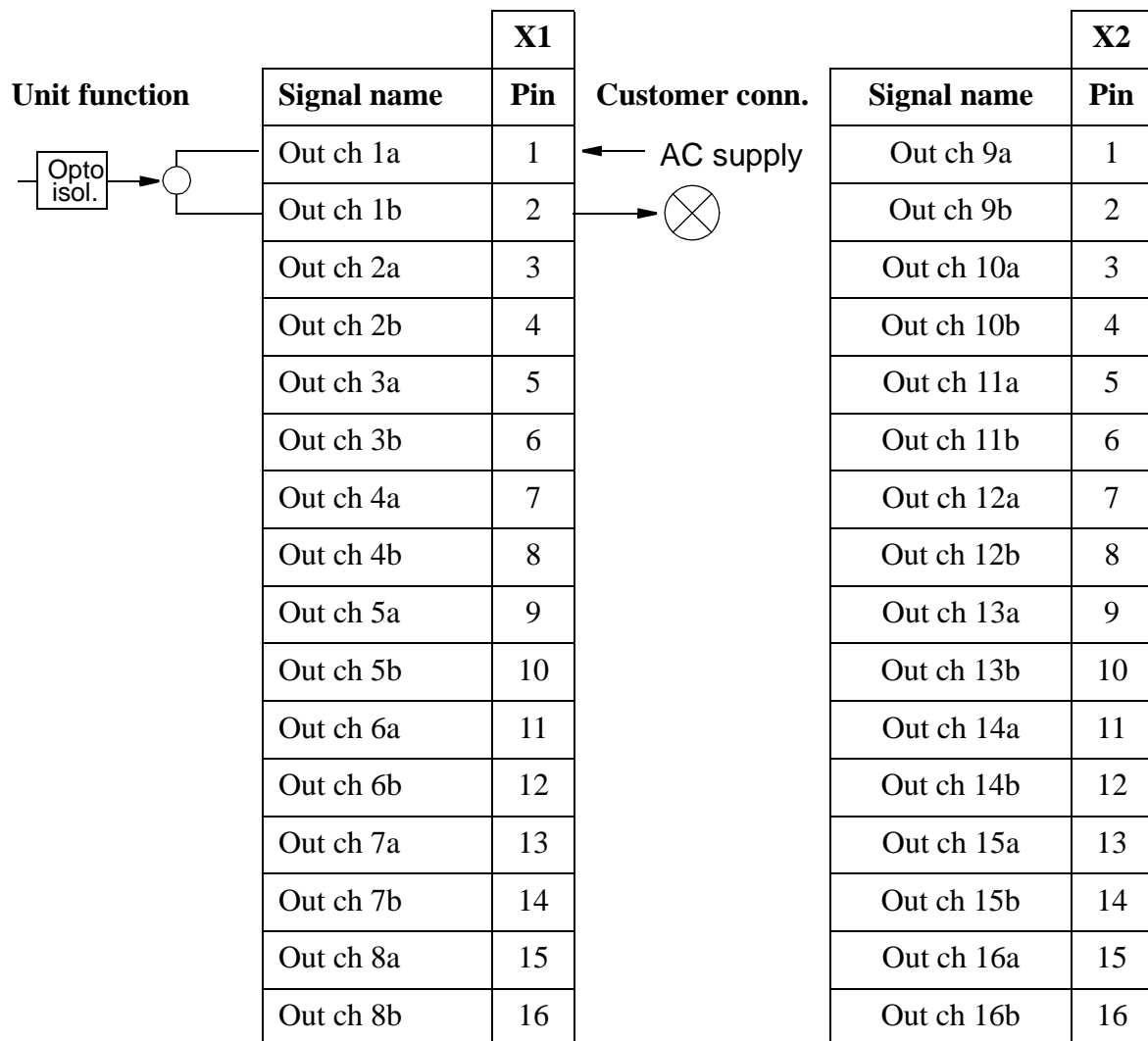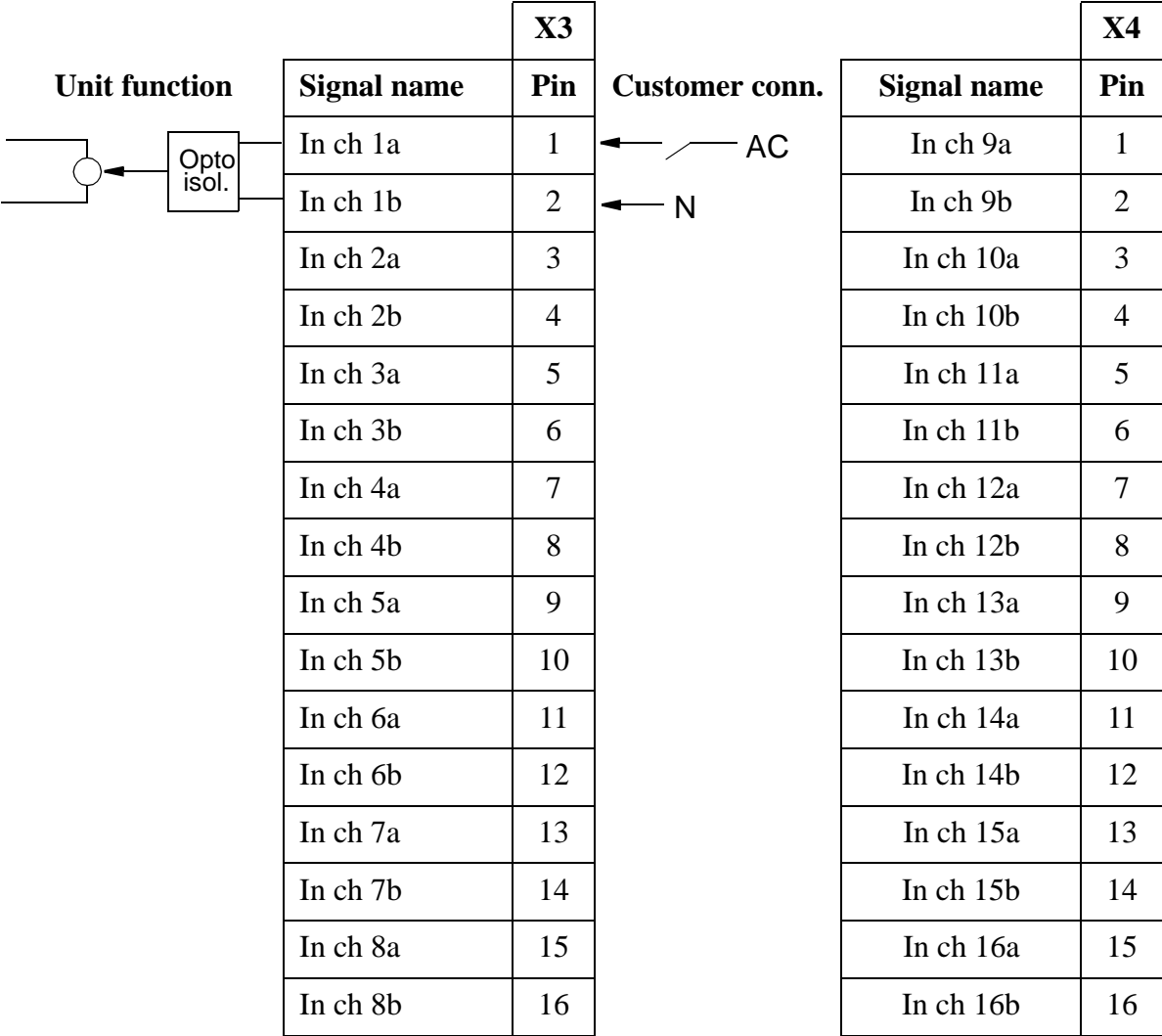
Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

Customer terminals: X8 and X9

<table>
<tr><td></td><td>X8</td><td></td></tr>
<tr><td>Signal name</td><td>Pin</td><td rowspan="5">Remote
I/O in</td></tr>
<tr><td>LINE1 (blue)</td><td>1</td></tr>
<tr><td>LINE2 (clear)</td><td>2</td></tr>
<tr><td>shield</td><td>3</td></tr>
<tr><td>cabinet ground</td><td>4</td></tr>
</table>

<table>
<tr><td></td><td>X9</td><td></td></tr>
<tr><td>Signal name</td><td>Pin</td><td rowspan="5">Remote
I/O out</td></tr>
<tr><td>blue</td><td>1</td></tr>
<tr><td>clear</td><td>2</td></tr>
<tr><td>shield</td><td>3</td></tr>
<tr><td>cabinet ground</td><td>4</td></tr>
</table>
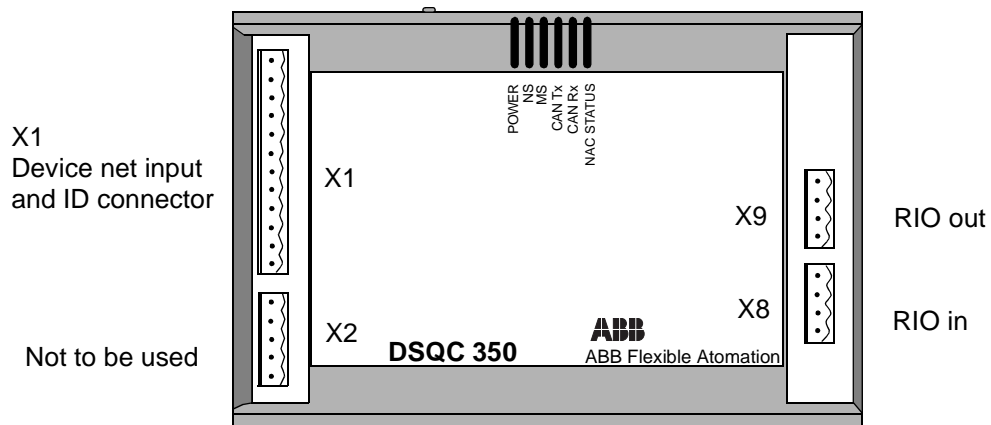
Device Net connector X1, see section 3.16.3 on page 51

Figure 45 RIO-unit

When the robot is last in a RIO loop, the loop must be terminated with a termination resistor according to Allen-Bradley's specification.

This product incorporates a communications link which is licensed under patents and proprietary technology of Allen-Bradley Company, Inc. Allen-Bradley Company, Inc. does not warrant or support this product. All warranty and support services for this product are the responsibility of and provided by ABB Flexible Automation.

RIO communication concept
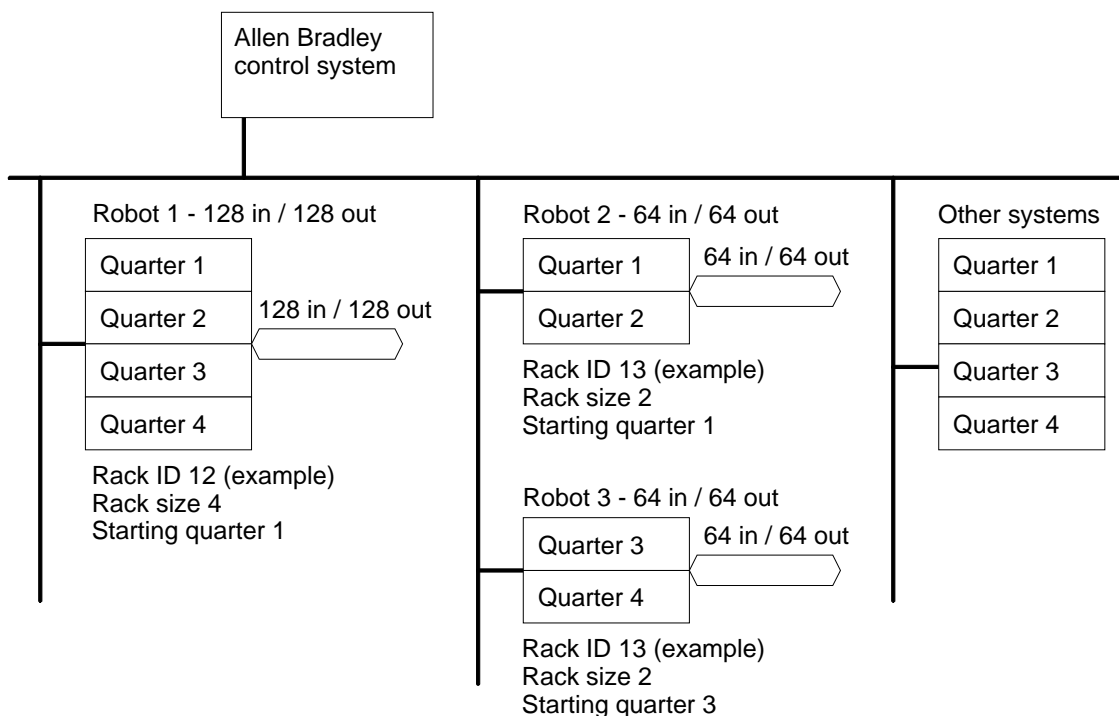
Figure 46 RIO communication concept - Principle diagram

The Allen Bradley system can communicate with up to 64 external systems. Each of these systems is called a Rack and is given a Rack Address 0-63. Basically, each robot connected to the Allen Bradley system will occupy 1 rack.

Each rack is divided into 4 sections called Quarters. Each quarter provides 32 inputs and 32 outputs and a rack will subsequently provide 128 inputs and 128 outputs.

A rack may also be shared by 2, 3 or 4 robots. Each of these robots will then have the same rack address, but different starting quarters must be specified.

The illustration above shows an example where Robot 1 uses a full rack while robot 2 and robot 3 share 1 rack.

The rack address, starting quarter and other required parameters such as baud rate, LED Status etc. are entered in the configuration parameters.

The robot may communicate with the Allen Bradley system only, or be used in combination with I/O system in the robot. For example, the inputs to the robot may come from the Allen Bradley system while the outputs from the robot control external equipment via general I/O addresses and the Allen Bradley system only reads the outputs as status signals.

3.17.2   Interbus-S, slave DSQC 351

The unit can be operated as a slave for a Interbus-S system.

Technical data

See Interbus-S specification.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

Unit ID to be entered in the Interbus-S master is 3. The lenght code depends on the selected data. Width between 1 and 4.

Customer terminals: see figure below regarding locations.
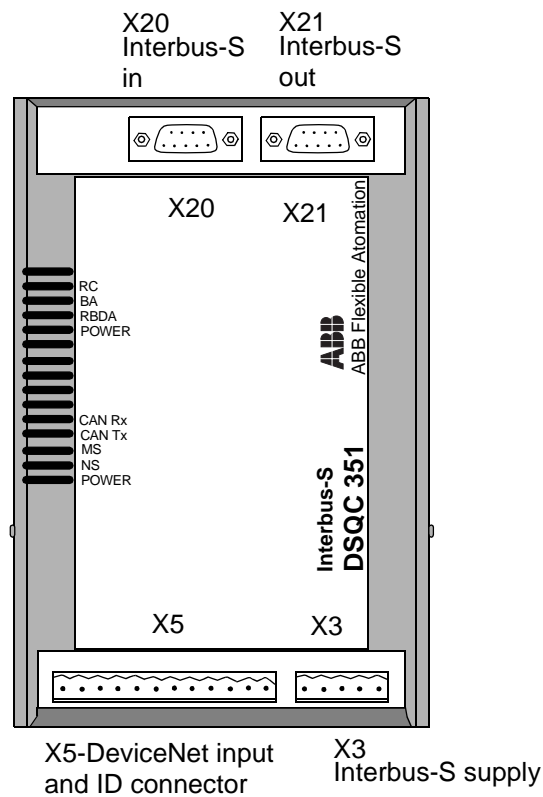
Device Net connector X5, see section 3.16.3 on page 51

Figure 47 Interbus-S, DSQC 351
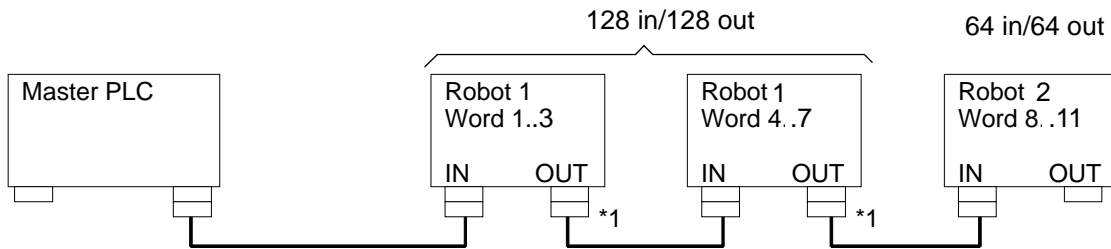
Communication concept

Figure 48 Outline diagram.
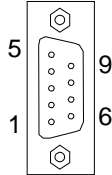
The Interbus-S system can communicate with a number of external devices, the actual number depends on the number of process words occupied of each unit. The robot can be equipped with one or two DSQC 351. The Interbus-S inputs and outputs are accessible in the robot as general inputs and outputs.
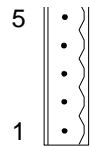
For application data, refer to Interbus-S, International Standard, DIN 19258.

*1
Note that there is a link between pin 5 and 9 in the plug on interconnection cable which is connected to the OUT connector for each unit. The link is used to inform the Interbus-S unit that more units are located further out in the chain. (The last unit in the chain does not have cable connected and thereby no link).

		X20	
Interbus-S IN	**Signal name**	**Pin**	**Description**
	TPDO1	1	Communication line TPDO1
	TPDI1	2	Communication line TPDI1
	GND	3	Ground connection
	NC	4	Not connected
	NC	5	Not connected
	TPDO1-N	6	Communication line TPDO1-N
	TPDI1-N	7	Communication line TPDI1-N
	NC	8	Not connected
	NC	9	Not connected

Interbus-S OUT	Signal name	**X21** Pin	Description
	TPDO2	1	Communication line TPDO2
	TPDI2	2	Communication line TPDI2
	GND	3	Ground connection
	NC	4	Not connected
	+5V	5	+5VDC
	TPDO2-N	6	Communication line TPDO2-N
	TPDI2-N	7	Communication line TPDI2-N
	NC	8	Not connected
	RBST	9	Synchronization
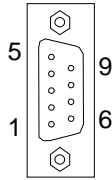
Interbus-S supply	Signal name	**X3** Pin	Description
	0 V DC	1	External supply of Interbus-S
	NC	2	Not connected
	GND	3	Ground connection
	NC	4	Not connected
	+ 24 V DC	5	External supply of Interbus-S
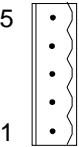
NOTE! External supply is recommended to prevent loss of fieldbus at IRB power off.

3.17.3   Profibus-DP, slave, DSQC352

The unit can be operated as a slave for a Profibus-DP system.

Technical data

See Profibus-DP specification, DIN E 19245 part 3.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: IO Signals. Circuit diagram, see chapter 11.

Customer connections

Figure 49 DSQC352, location of connectors

Communication concept

Figure 50 Profibus-DP communication concept

The Profibus-DP system can communicate with a number of external devices. The actual number depends on the number of process words occupied of each unit. The robot can be equipped with one or two DSQC352. The Profibus-DP inputs and outputs are accessible in the robot as general inputs and outputs.

For application data, refer to Profibus-DP, International Standard, DIN 19245 Part 3.

*1 - Note that the Profibus cable must be terminated in both ends.

		X20	
Profibus-DP	**Signal name**	**Pin**	**Description**
	Shield	1	Cable screen
	NC	2	Not connected
	RxD/TxD-P	3	Receive/Transmit data P
	Control-P	4	
	GND	5	Ground connection
	+ 5V DC	6	
	NC	7	Not connected
	Rxd/TxD-N	8	Recieve/Transmit data N
	NC	9	Not connected

		X3	
Profibus-DP supply	**Signal name**	**Pin**	**Description**
	0 V DC	1	External supply of Profibus-DP
	NC	2	Not connected
	GND	3	Ground connection
	NC	4	Not connected
	+ 24 V DC	5	External supply of Profibus-DP

Device Net connector X5, see section 3.16.3 on page 51.

3.18 Communication

3.18.1 Serial links, SIO

The robot has two serial channels, which can be used by the customer to communicate with printers, terminals, computers and other equipment (see Figure 51).

The serial channels are:

> - SIO1-
>   RS 232 with RTS-CTS-control and support for XON/XOFF,
>   transmission speed 300 - 19 200 baud.
>
> - SIO2-
>   RS 422 full duplex TXD4, TXD4-N, RXD4, RXD4-N,
>   transmission speed 300 - 19 200 baud.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller.
Circuit diagram, see chapter 11.
Product Specification IRB 1400, chapter 3.10.
Separate documention is included.when the option RAP Seriel link is ordered.
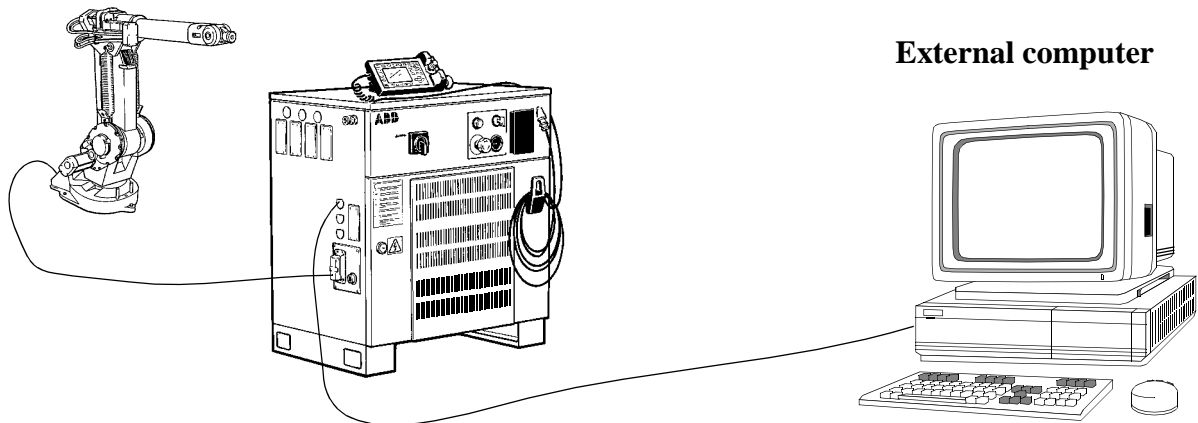
External computer

Figure 51 Serial channels, SLIP, outline diagram.

Customer terminals, on controller backplane:X1(SIO1) and X2(SIO2), see 3.7.

Two variants exits depending on backplane type.

Cable connectors with screwed connections (not supplied), type Phönix Combicon MSTTBVA 2.5/12-6-5.08. Keying of board connector according to circuit diagram, chapter 11.

DSCQ 330 (screw terminals)

X1			X2	
Pin	**Signal**		**Pin**	**Signal**
1	TXD		1	TXD
2	RTS N		2	TXD N
3	0V		3	0V
4	RXD		4	RXD
5	CTS N		5	RXD N
6	0V		6	0V
7	DTR		7	DATA
8	DSR		8	DATA N
9	0V		9	0V
10			10	DCLK
11			11	DCLK N
12			12	0V

DSQC 369 (D-sub connectors)

X1			X2	
Pin	**Signal**		**Pin**	**Signal**
1			1	TXD
2	RXD		2	TXD N
3	TXD		3	RXD
4	DTR		4	RXD N
5	0 V		5	0 V
6	DSR		6	DATA
7	RTS N		7	DATA N
8	CTS N		8	DCLK
9			9	DCLK N

Explanation of signals:
TXD=Transmit Data, **RTS**=Request To Send, **RXD**=Receive Data, **CTS**=Clear To Send, **DTR**=Data Terminal Ready, **DSR**=Data Set Ready, **DATA**=Data Signals in Half Duplex Mode, **DCLK**=Data Transmission Clock.

3.18.2   Ethernet communication, DSQC 336

The ethernet communication board has two options for ethernet connection.

Connector X4 is used for connection of twisted-pair Ethernet (TPE), or as defined in IEEE 802.3 : 10BASE-T. Maximum node-to-node distance 100 meter. The ethernet communication board has no termination for cable screen. Cable screen must be grounded at cabinet wall with a cable gland. 10BASE-T is a point-to-point net, connected via a HUB.

Connector X11 is used for connection of transceivers with AUI (Attachment Unit Interface). Typical use of this connector is connection of transceivers for 10BASE2 (CheaperNet, Thinnet, Thinwire Enet, - 0.2 inch, 50 ohm coax with BNC connector) or optical fibre net. Note the environmental conditions for the transceiver inside the controller, i.e. +70° C.

Technical data

See Ethernet specification.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller.
Circuit diagram, see chapter 11.
Separate documentation is included.when the option Ethernet services is ordered.

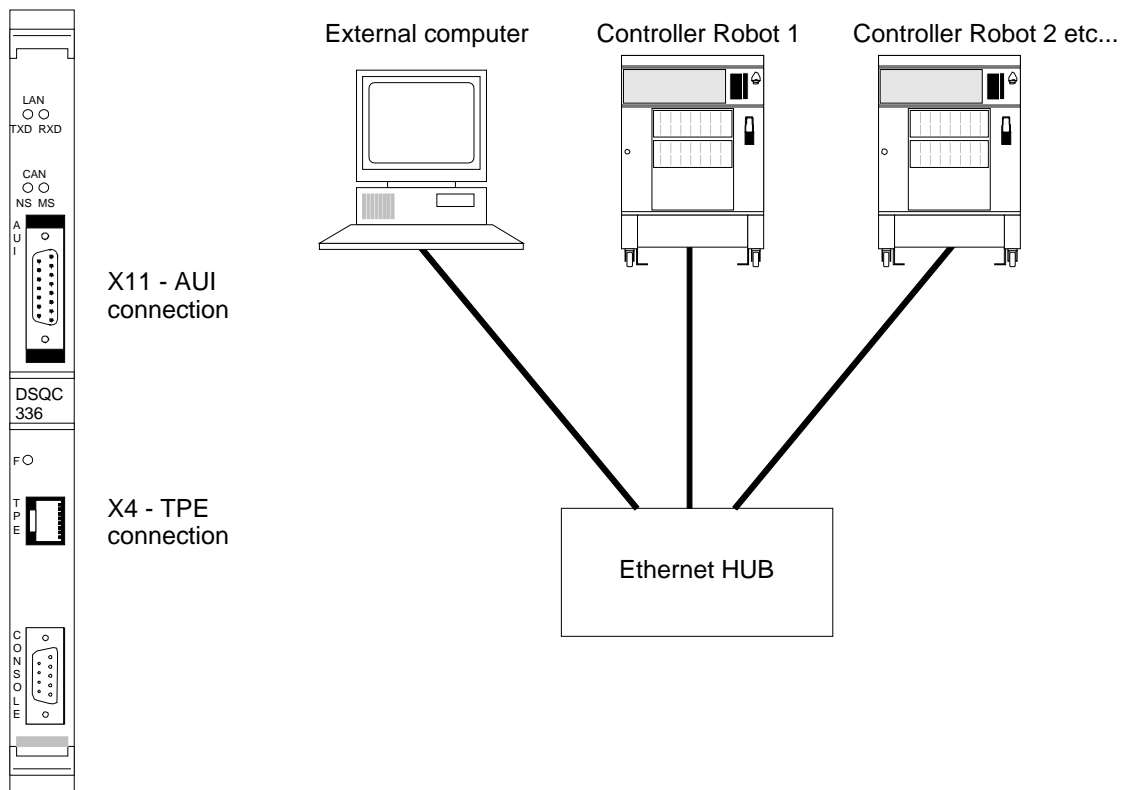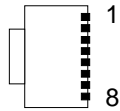**Customer terminals, on board front: X4 and X11**

Figure 52 Ethernet TCP/IP, outline diagram.

Connector X4 - Ethernet TPE connector

	X4	
Signal name	**Pin**	**Description**
TPTX+	1	Transmit data line +
TPTX-	2	Transmit data line -
TPRX+	3	Receive data line +
NC	4	Not connected
NC	5	Not connected
TPRX-	6	Receive data line -
NC	7	Not connected
NC	8	Not connected

Connector X11 - Ethernet AUI connector
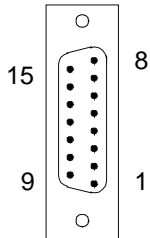
	X11	
Signal name	**Pin**	**Description**
GND	1	Ground connection
COLL+	2	Collision detection line +
TXD+	3	Transmit data line +
GND	4	Ground connection
RXD+	5	Receive data line +
GND	6	Ground connection
NC	7	Not connected
GND	8	Ground connection
COLL-	9	Collision detection line -
TXD-	10	Transmit data line -
GND	11	Ground connection
RXD-	12	Receive data line -
+12V	13	+12VDC
GND	14	Ground connection
NC	15	Not connected

3.19 External operator's panel

All necessary components are supplied, except for the external enclosure.

⚠ **The assembled panel must be installed in a housing which satisfies protection class, IP 54, in accordance with IEC 144 and IEC 529.**
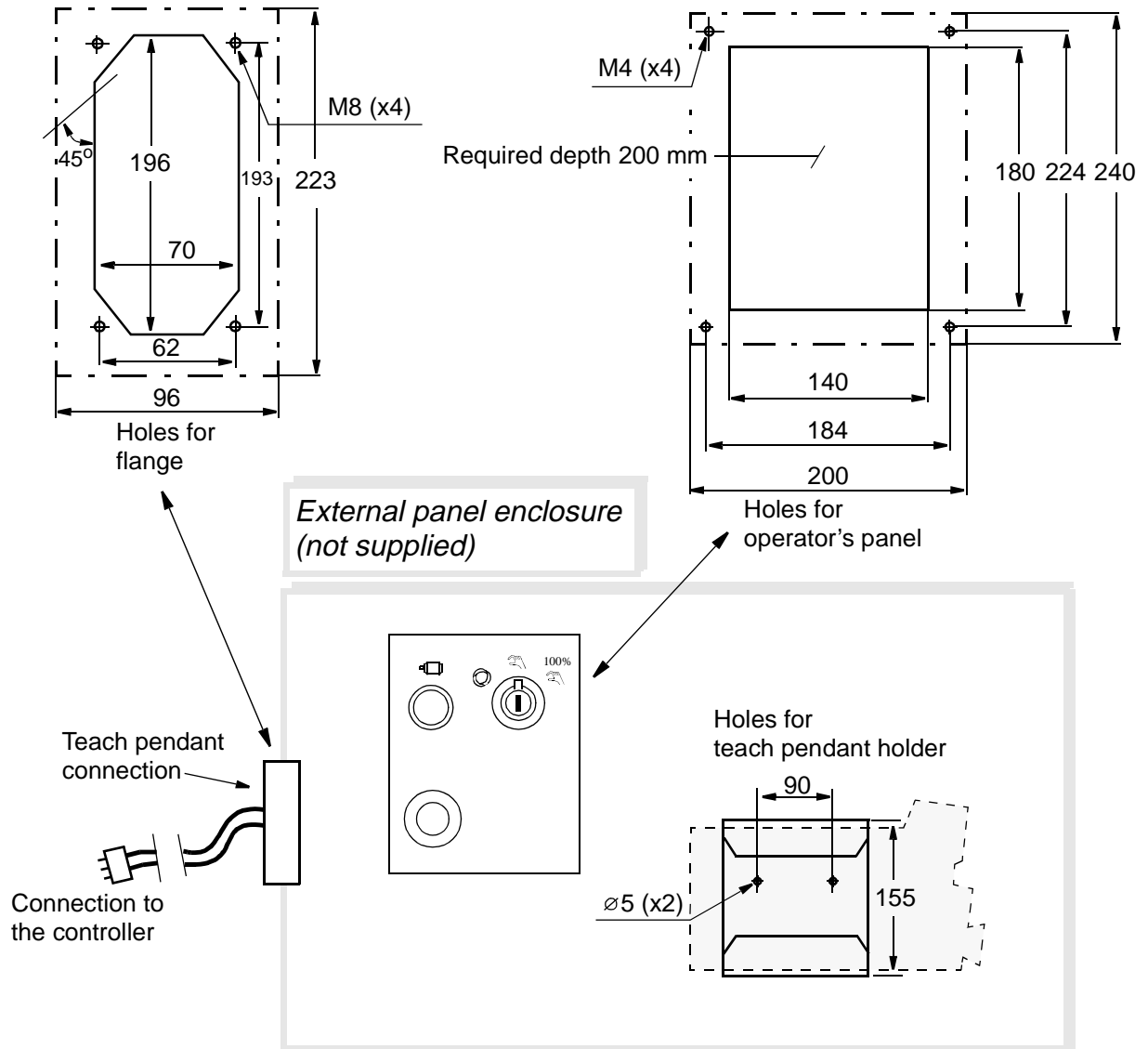

Figure 53 Required preparation of external panel enclosure.

4 Installing the Control Program

The robot memory is battery-backed, which means that the control program and set-tings (pre-installed) are saved when the power supply to the robot is switched off.

The robot might be delivered without software installed and the memory back-up bat-teries disconnected to ensure maximum battery capacity after installation.
If so, connect the batteries and start the installation according to 4.1.1.

4.1 System diskettes

- **Key disk** (one disk)
  Each robot needs an unique key disk with selected options and IRB type.
  Robots within the same family (i.e. different variants of the robot) can use the same key disk with a licence number.

- **System pack**
  BaseWare OS, all options and ProcessWare.

- **Controller parameters** (one disk)
  At delivery, it includes I/O configuration according to order specification.
  At commissioning all parameters are stored.

- **Manipulator parameters** (one disk)
  Includes sync. offsets from manufacturing calibration.

4.1.1 Installation procedure

1. Perform a cold start on the system.

2. Insert the "Key disk" when displayed on the teach pendant.

3. Follow information displayed on the teach pendant. Keep attention to prompted System pack disk number (all diskettes are not used at the same installation).

During the installation following menus appears:

- **Silent** = The installation follows the information on the Key disk.

- **Add Opt** =The installation follows the Key disk but further options, not included in the system pack, are possible to add.

- **Query** = Questions about changing language, robot type (within the same family), gain access to service mode, see User's Guide, System Parameters etc. are coming up. Makes it possible to exclude options but not add more than included in the Key disk.

⚠ **If Query is selected, make sure that the correct robot type is entered. If not, this will affect the safety function *Reduced speed 250 mm/s*.**

⚠️ **If Query is selected, make sure that all required options are installed. Note that some of these options also require installation of other options. Rejecting of proposed options during installation may cause an incomplete robot installation.**

4. The robot performs a warm start when installation is finished.

⚠️ **Wait until the welcome window appears on the display before doing anything. The warm start can take up to 2 minutes after the installation display ready.**

5. Load the specific installation parameters from the Controller Parameter disk or corresponding.

⚠️ **After the control program has been installed, the diskettes should be stored in a safe place in accordance with the general rules for diskette storage. Do not store the diskettes inside the controller to avoid damaged from heat and magnetic fields.**
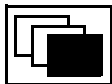
6. Conclude the installation with updating the revolution counters according to section 2.15.

4.2 Calibration of the manipulator

Calibrate the manipulator according to section 2.15.

4.3 Cold start

To install the control program in a robot already in operation the memory must be emptied. Besides disconnecting the batteries for a few minutes, the following method can be used:

1. Select the Service window

2. Select **File: Restart**

3. Then enter the numbers 1 3 4 6 7 9

4. The fifth function key changes to **C-Start** (Cold start)

5. Press the key **C-Start**
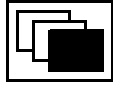
It will take quite some time to perform a Cold start. Just wait until the robot starts the Installation dialog, see 4.1.1.

⚠️ **Do not touch any key, joystick, enable device or emergency stop until you are prompted to press any key.**

4.4 How to change language, options and IRB types

(Valid for robots within the same family)

1. Select the Service window

2. Select **File: Restart**

3. Enter the numbers 1 4 7

4. The fifth function key changes to **I-Start**

Note!
Make sure that the **disk 3** from the System pack is inserted when installing BaseWare OS Plus or **disk 5** when installing BaseWare OS.

5. Press the key **I-Start**

6. Continue with following the text on the teach pendant.

Question about used DC-links and balancing units

You will get a question about used DC-link, below there is a list of avaible DC-links.You will find the article number for the DC-link on the unit inside the controller.

Type	Art. no.	Config id	Description
DSQC 345A	3HAB 8101-1	DC0	DC-link
DSQC 345B	3HAB 8101-2	DC1	DC-link
DSQC 345C	3HAB 8101-3	DC2	DC-link
DSQC 345D	3HAB 8101-4	DC3	DC-link, step down
DSQC 358C	3HAB 8101-10	DC2T	DC-link + single drive unit
DSQC 358E	3HAB 8101-12	DC2C	DC-link + single drive unit

For IRB 6400 you will also get a question on what type of balancing units that is used. For identification, please see label attached at the top of the units.

4.5 How to use the disk, Manipulator Parameters

The S4C controller does not contain any calibration information at delivery (Robot Not Calibrated shown on the teach pendant).

Once the Manipulator Parameter disk contents has been loaded to the controller as in one of the two cases described below, should a new parameter back-up be saved on the disk, **Controller Parameter**.
After saving the new parameters on the disk, **Controller Parameter** the **Manipulator Parameter** disk is no longer needed.

4.6 Robot delivered with software installed

In this case the basic parameters are already installed.

Load the calibration offset values from the disk, **Manipulator Parameters**.

1. Select **File: Add** or **Replace Parameter**.

Do not select Add new or **Load Saved Parameters.**

2. Press *OK*.

3. Save the new parameters according to section 4.8.

4.7 Robot delivered without software installed

In this case a complete cold start is necessary, remember to connect the back-up batteries.

The basic parameters are loaded at the cold start. The delivery specific I/O configuration is loaded from the disk, **Controller Parameters.**

1. Select **File:Add New Parameters**.

2. Press *OK*.

3. Load the calibration offset values from the disk, **Manipulator Parameters**.

4. Select **File:Add** or **Replace Parameter**.

Do not select Add new or **Load Saved Parameters.**

5. Press *OK*.

6. Save the new parameters according to section 4.8.

4.8 Saving the parameters on the Controller Parameter disk

1. Insert the disk, **Controller Parameter**.

2. Select **File:Save All As**.

For more detailed information regarding saving and loading parameters see User's Guide, System Parameters.

5 External Axes

5.1 General

External axes are controlled by internal or external (equals to non ABB) drive units. Internal drive units are mounted either inside the robot cabinet or in a separate external cabinet. External drive units are mounted in a user designed cabinet.

A maximum number of 6 external axes can be controlled by S4C. Internal drive units mounted in a separate cabinet cannot be combined with external drive units.

The drive and measurement systems each consist of two systems. Each system is connected to the CPU boards via a serial communication link.

A number of template configuration files are supplied with the system. The configuration files are optimum designed concerning system behaviour and performance of the axes. When installing external axes it is important to design installations, so a combination of standard files can be used.

Axes connected to Measurement System 1 can use Drive System 2 and vice versa. Allowed combinations - see configuration files section 5.3.5.
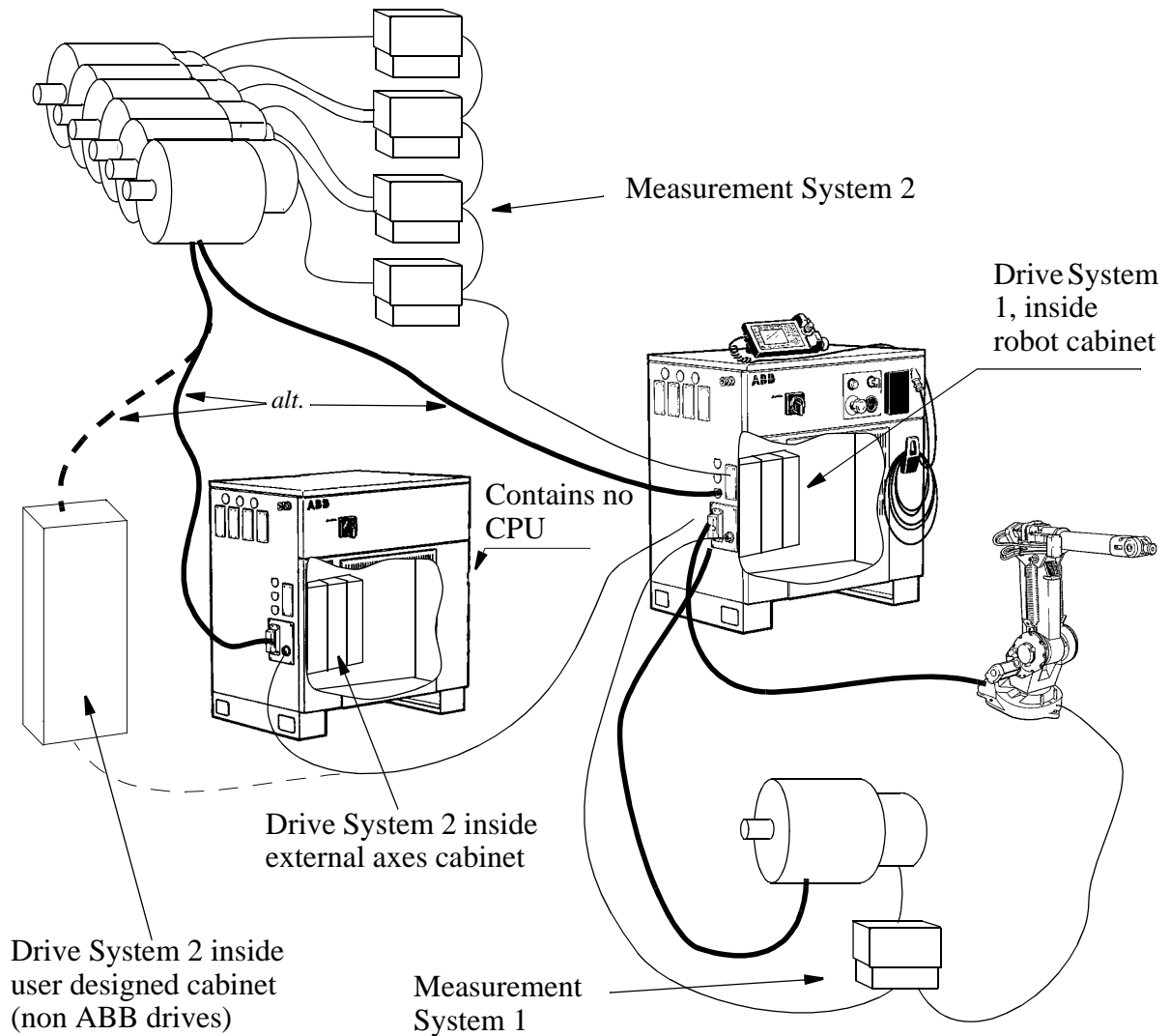
Figure 54 Outline diagram, external axes.

One extra serial measurement board (SMB) can be connected to Measurement System 1 and up to four to Measurement System 2. See Figure 54. One of the extra serial measurement boards of system 2 can be located inside the robot cabinet.

Max one external axis can be connected to Drive System 1. This axis is connected to the drive unit located in the DC-link. Up to six external axes can be connected to Drive System 2. Drive System 2 is in most cases located in a separate external cabinet.

For robots using only two drive units, as IRB1400 and IRB2400, a drive system 2 can be located in the robot cabinet. This mixed system is called Drive System 1.2 . Two axes can be connected to the drive module. In this case no external drive units or internal drive units mounted in a separate cabinet can be used.

5.2 Easy to use kits

A number of easy to use kits are available by ABB Flexible Automation AB. These kits contain all parts needed to install and operate external axes.
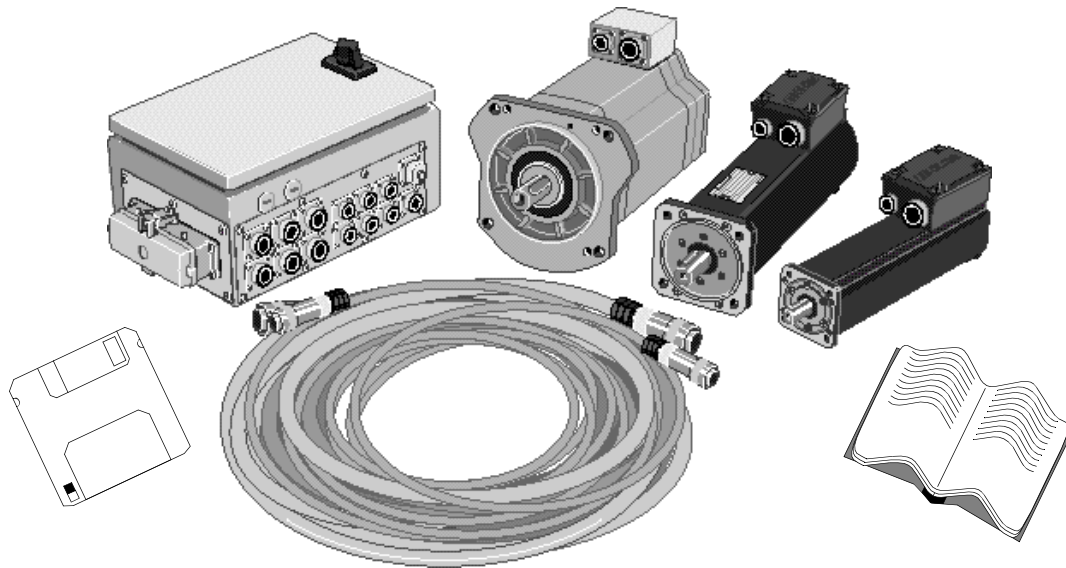
The kit contains:

- Motor/motors with brake and resolver. Different sizes of motors available.

- Gear boxes.

- Connection box with serial measurement board, manual brake release and terminal block for limit switches.

- All cables with connectors.

- Configuration file for easy software installation.

- Documentation

For more information see Product Specification Motor Unit from ABB Flexible Automation documentation.

5.3 User designed external axes.

5.3.1 DMC-C

Atlas Copco Controls stand alone servo amplifier DMC-C can be connected to Drive System 2, see Figure 55. Total of max 6 external axes can be installed.

.
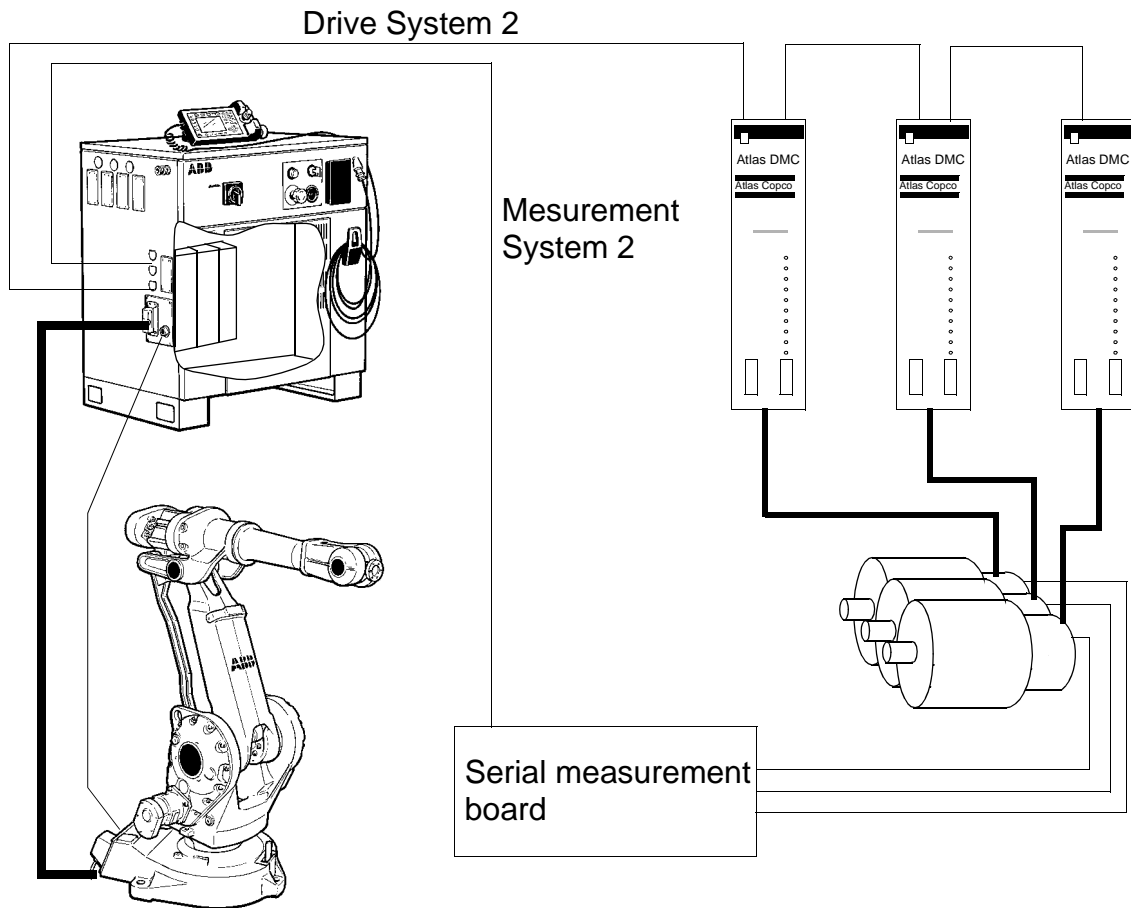
Figure 55 Servo amplifier, DMC.

Atlas Copco Controls provides the information on suitable motors and how to make installation and commissioning,

5.3.2   FBU

Atlas Copco Controls FBU (Field Bus Unit) can handle up to 3 external drive units, see Figure 56.
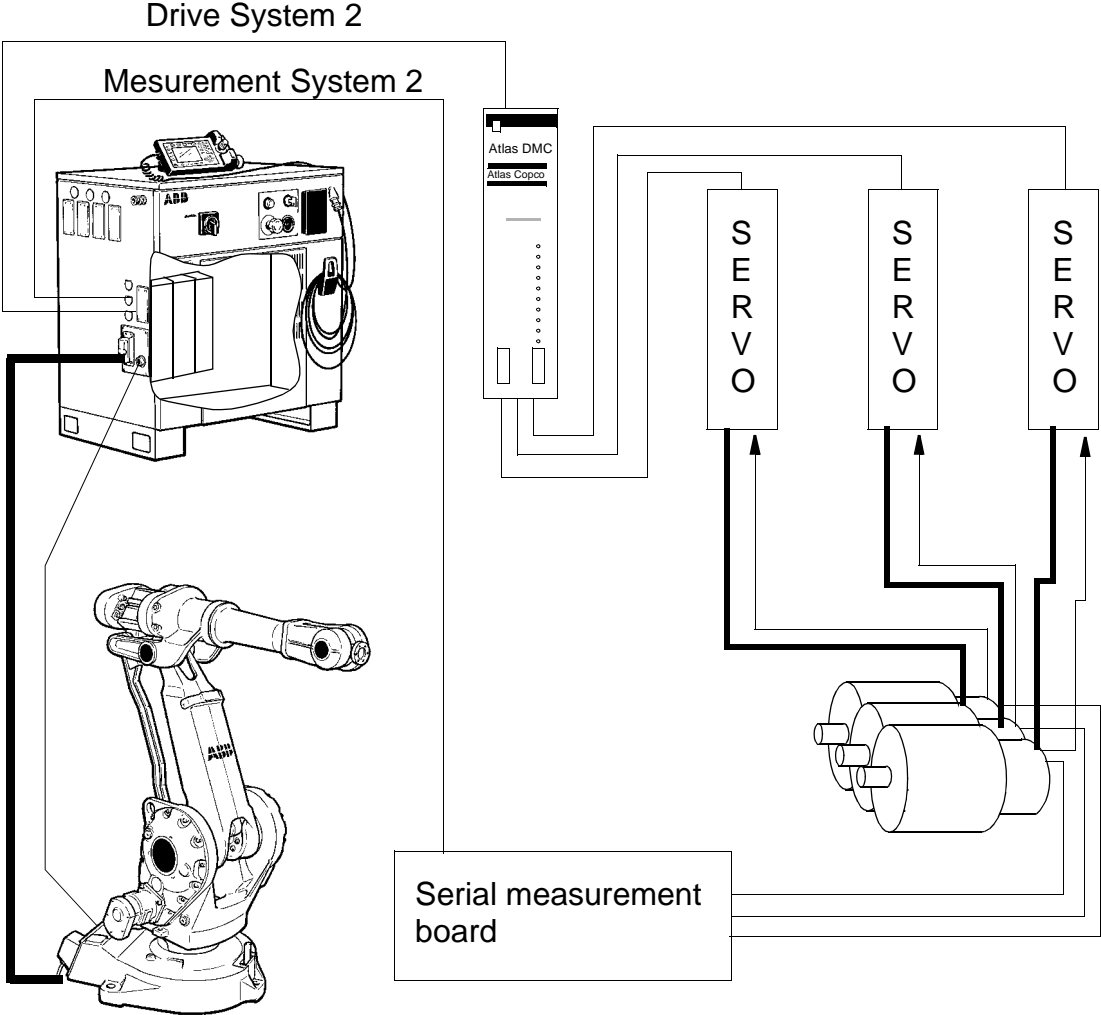
Figure 56 Field bus unit, FBU.

The drive units can be connected to analog speed reference outputs (+/- 10 V) or a field bus.

For further information about DMC-C and FBU contact Atlas Copco Controls.

5.3.3 Measurement System

There are two measurement system systems, 1 and 2. Each system is connected to the CPU board via a serial link. The serial link is of ring type with board 1 connected to CPU-board serial output. The last Serial Measurement Board (SMB) is connected to the CPU-board serial input.This link also supplies power to the SMB.

Measurement System 1 can consist of up to two SMB, one used for the robot manipulator, the other one for one external axis, normally a track motion. The external axis must be connected to node 4 and in the configuration file be addressed as logical node 7.

Measurement System 2 can consist of one to four SMB boards. The board numbering always starts with board 1. No gaps may occur in the number sequence. Every axis connected to a measuring system must have an unique node number. While the node number is the same as physical connection, the physical connection node must also be unique.

Each SMB has 6 connection nodes for resolvers. A battery supplies the SMB with power during power fail. If the axes move during power fail the internal revolution counters are automatically updated. After power on the system is ready for operation without any synchronization procedure.

A special configuration can be used with no robot connected. Only Measurement System 1 with one or two SMB may be used. Up to 6 external axes can be connected to those boards. See configuration files in Figure 70.

MEASUREMENT SYSTEM 1
configuration files MN4M1Dx

MEASUREMENT SYSTEM 2
configuration files MNxM2Dx
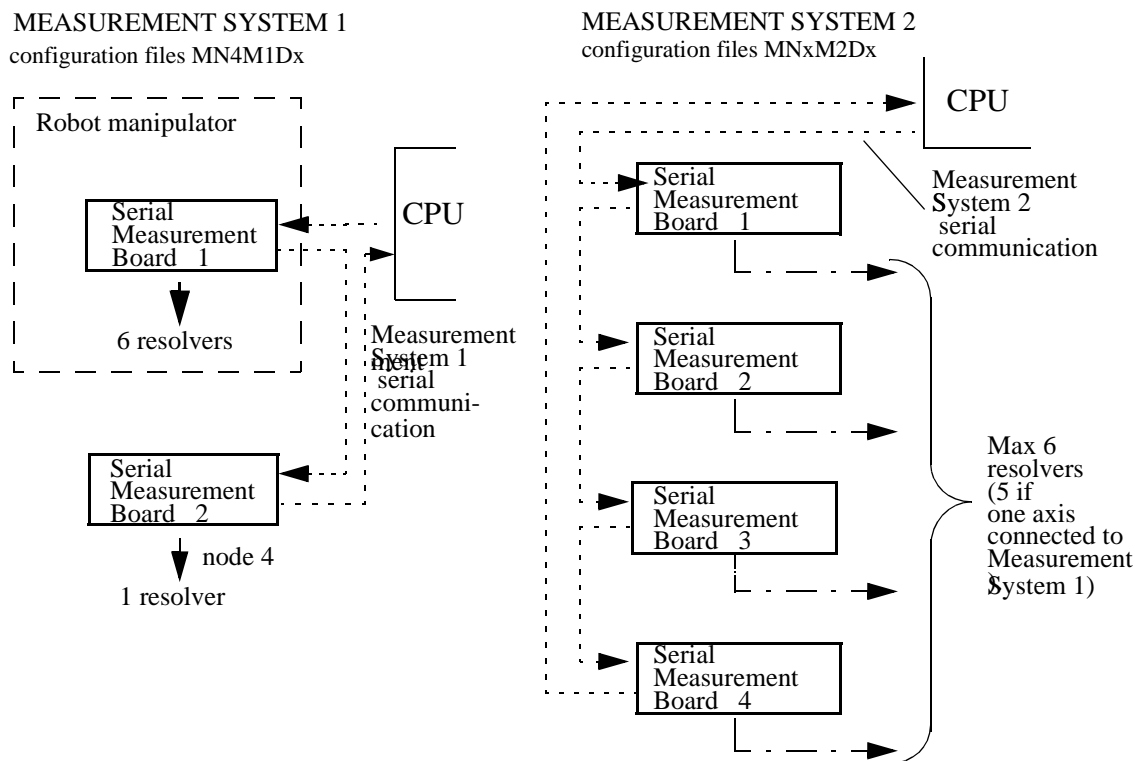
Figure 57 Measurement systems.

MEASUREMENT SYSTEM 1 (only external axes, no robot)
configuration files ACxM1D1
(Measurement System 2 may not be used
together with this configuration)
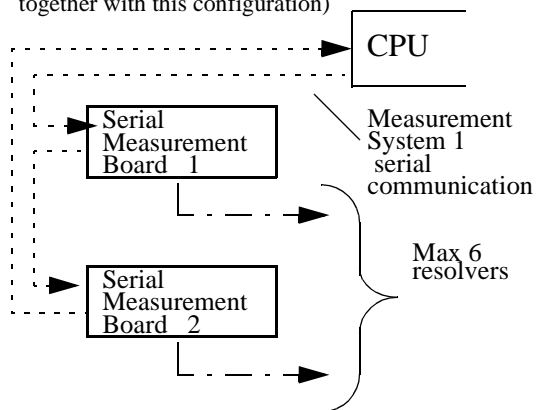
Figure 58 Measurement system 1.

Resolver

Each resolver contains two stators and one rotor, connected as shown in Figure 59.
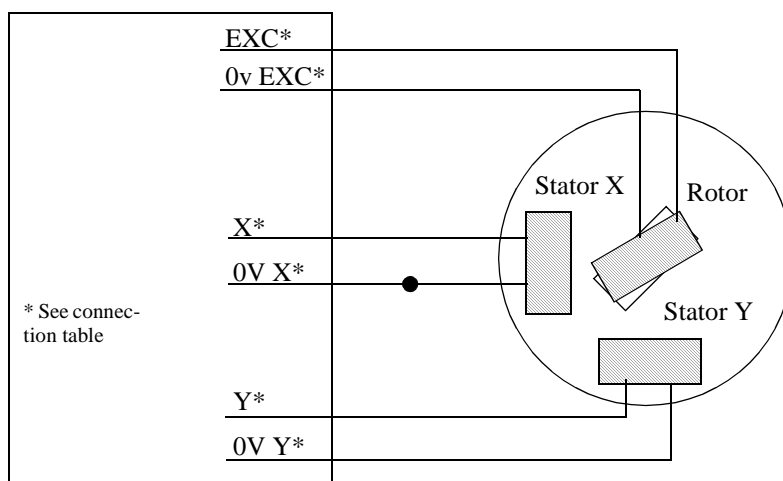
Figure 59 Connections for resolvers.

Technical data

Resolver	Integrated in motor of IRB type or art.no. 5766 388-5, size 11 Resolver must be approved by ABB for reliable operation.
Motor to resolver gear ratio	1:1, direct drive
Resolver cable length:	max 30 m (X, Y for each resolver) total max 70 m for EXC signals.

Cable: AWG 24, max 55pF/m, with shield.

The X, Y, 0V X and 0 V Y signals are used to connect resolvers to a serial measurement board.

The EXC, 0V EXC are used for common supply for all resolvers, parallel connected.

⚠️ **It is very important that the noise level on the measurement signals from the external axes is kept as low as possible, to prevent bad performance. Correct shielding and ground connections of cables, measurement boards and resolvers is essential.**

The cabling must comply with signal class "measurement signals" (see chapter 3.1, Signal classes).

The enclosure for external serial measurement board(s) must comply with enclosure class IP 54, in accordance with IEC 144 and IEC 529.

Resolver, connector on robot cabinet wall (option: 386 - External Axes Measurement Board, mounted inside robot cabinet)

XS27, Measurement System 2, board 1

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6
EXC1	A1	A3	A5			
0 V EXC1	A2	A4	A6			
EXC2				A8	A10	A12
0 V EXC2				A9	A11	A13
X	B1	B3	B5	B8	B10	B12
Y	C1	C3	C5	C8	C10	C12
0V X	B2	B4	B6	B9	B11	B13
0V Y	C2	C4	C6	C9	C11	C13

Resolver, connectors on Measurement Board DSQC 313

Contact/ point	R2.G	R2.SMB D-Sub 9 pin	R2.SMB 1-2 D-Sub 15 socket	R2.SMB 1-4 D-Sub 25 pin	R2.SMB 3-6 D-Sub 25 socket
1	+BAT	GND	GND	GND	GND
2	0V BAT	BATLD	0V EXC1	X1	X4
3		0V	0V EXC1	Y1	Y4
4		SDO-N	Y2	X2	X5
5		SDI-N	X2	Y2	Y5
6		+BATSUP	Y1	0V EXC1	0V EXC2
7		+24V	X1	0V EXC1	0V EXC2
8		SDO	-	0V EXC1	0V EXC2
9		SDI	EXC1	X3	X6
10			EXC1	Y3	Y6
11			0V Y2	X4	X3
12			0V X2	Y4	Y3
13			0V Y1	0V EXC2	0V EXC1
14			0V X1	0V X1	0V X4
15				0V Y1	0V Y4
16				0V X2	0V X5
17				0V Y2	0V Y5
18				EXC1	EXC2
19				EXC1	EXC2
20				EXC1	EXC2
21				0V X3	0V X6
22				0V Y3	0V Y6
23				0V X4	0V X3
24				0V Y4	0V Y3
25				EXC2	EXC1

| R2.SMB | R2.SMB 1-4 | R2.SMB 3-6 | R2.SMB 1-2 |

R2.G

Serial Measurement Board (SMB)
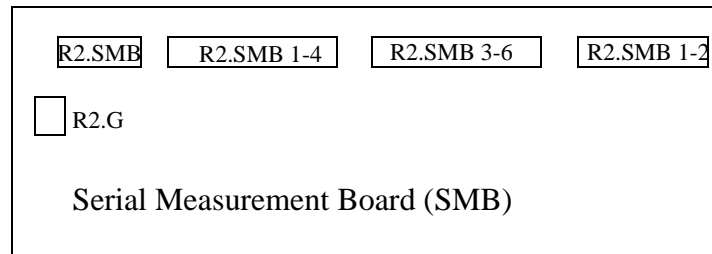
SDO   serial communication output
SDI   serial communication input
+BAT   battery +
0V BAT   battery 0 V
BATLD   not to be used
BATSUP   not to be used   EXC1   excitation power to resolver 1,2,3
+24 V   24 V power   EXC2   excitation power to resolver 4,5,6
0 V   0 V power   X1   Input x-stator node 1

5.3.4   Drive System

There are two drive systems 1 and 2. Each system is connected to the CPU board via a serial link. The link also supplies low voltage logic power to the rectifier and drive modules.

Each drive system has its own transformer. For information on fuses, power contactors etc. see documentation for the separate enclosure.

The rectifier DSQC 358C has in addition to its rectifier section also a drive inverter for one external axis. This rectifier can be used in all S4C robot cabinets except for those robots needing the DSQC 345D rectifier.

For robots using two drive units, an extra drive unit can be placed in the S4C robot cabinet. This drive unit is connected to the Drive System 2 serial communication link, but use the Drive System 1 rectifier. This combined system is called Drive System 1.2 .

If drive unit with three drive inverters (nodes) are used, axes with measurement node 1, 2, 3 or 4, 5, 6 may not be connected to the same drive unit.

If the function "common drive" is to be used, a contactor unit for motor selection is required.

As an option it's possible to use Atlas DMC of FBU. Those units are always connected to drive system 2 and measurement system 2. They CANNOT be combined with internal controlled drive units connected to drive system 2. Up to 6 external axis can be connected using DMC:s and/or FBU:s. In section 5.3.5 there is a complete list of template files for external controlled axes.

When designing the drive system following has to be checked:

- Max motor current, in order not to demagnetize the motor.
- Max/rated current from drive inverter.
- Max/rated current from drive unit (sum of all inverters on same drive unit)
- Max/rated current from dc-link
- Max/rated power for bleeder
- Max/rated power from transformer

Note: If the system contains axes with no stand by state (the axes will continue to be controlled while the brakes are activated for the robot), the max allowed power consumption of these axes are 0.5 kW.

Note:
For safety reasons, the power supply to the external motor must be switched off when the robot is in the MOTORS OFF mode.

Drive system configuration with one external axis at Drive System 1 in S4C robot cabinet and five to six axes at Drive System 2 installed in external cabinet.

DRIVE SYSTEM 1   DRIVE SYSTEM 2
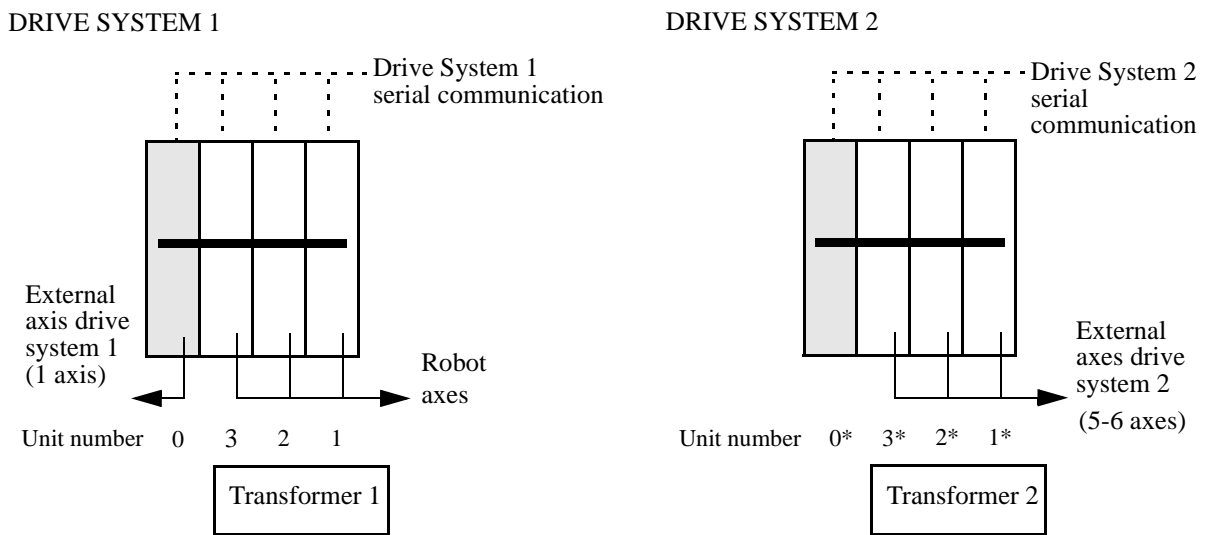
Figure 60 Drive systems with external cabinet.

Drive system configuration with one external axis at Drive System 1 and two or three axes at Drive system 2, all installed in the S4C robot cabinet.

Figure 61 Drive system installed in the S4C cabinet.

Technical data Drive System

	Max current (A)	Rated current (A)	Max bleeder power (kW)	Rated bleeder power (kW)	Min voltage (V)
DSQC 345C / DC2 DSQC 358C / DC2T DSQC 358E / DC2C	80	14.6	15.3	0.9	275
DSQC 345D / DC3	70	16.7	15.3	0.9	370

Figure 62 Rectifier units.

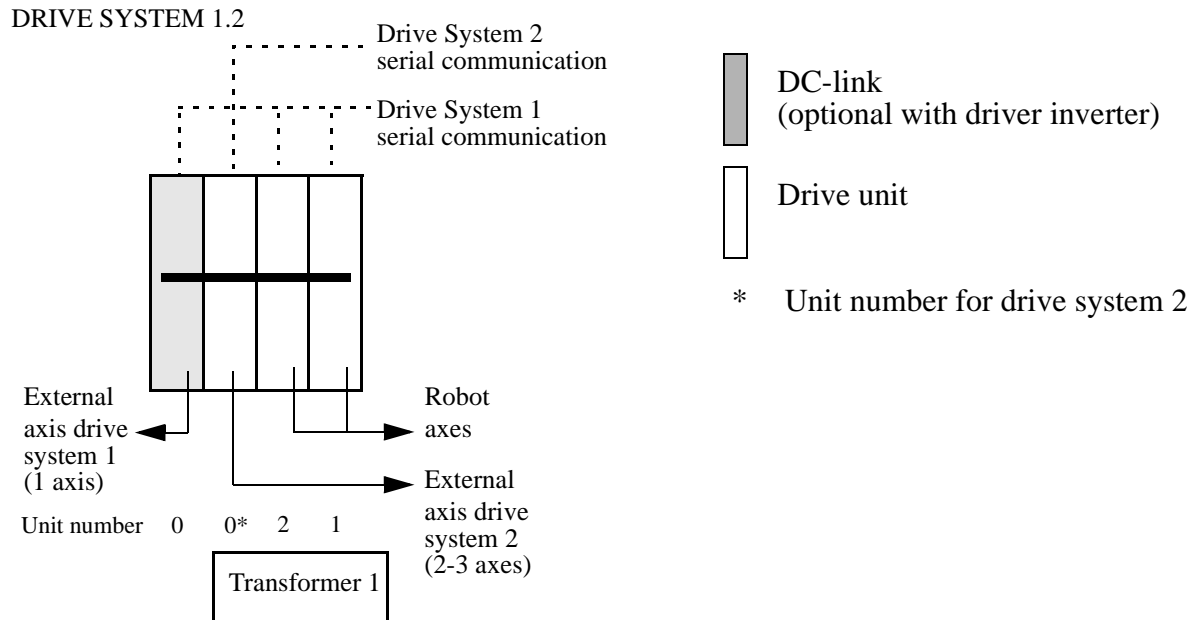| Unit type	Node 1	Node 2	Node 3	Total unit
DSQC 346A	3.25/1.6 A	3.25/1.6 A	1.5/1.0 D	8.0/4.2
DSQC 346B	6.7/3.2 B	3.25/1.6 A	1.5/1.0 D	11.45/5.8
DSQC 346C	11.3/5.3 C	11.3/5.3 C	6.7/4.0 B	29.3/12.1
DSQC 346G	29.7/16.5 G	36.8/20.0 T		66.5/30.0
DSQC 358C		36.8/20.0 T		36.8/20.0
DSQC 358E		11.3/5.3 C		11.3/5.3 C

Figure 63 Drive units, max. current (A RMS)/average current (A RMS).

Pin	Node	Phase
1 2 3	1 1 1	W V U
4 5 6	- - 3	- - W
7 8 9	- - 3	- - V
10 11 12	- - 3	- - U
13 14 15	2 2 2	W V U

Figure 64 Power connections, drive unit DSQC 346A, B, C   X2

Pin	Node	Phase
1 2 3	1 1 1	U V W
4 5 6	1 1 1	U V W
7 8 9	2 2 2	U U U
10 11 12	2 2 2	V V V
13 14 15	2 2 2	W W W

Figure 65 Power connections, drive unit DSQC 246G   X2

Pin	,Node	Phase
1 2 3	- - -	- - -
4 5 6	- - -	- - -
7 8 9	2 2 2	U U U
10 11 12	2 2 2	V V V
13 14 15	2 2 2	W W W

Figure 66 Power connections, drive unit DSQC 358C, E   X2

Motor connection to drive unit, external connector

Motor current R-phase (U-phase), S-phase (V-phase) and T-phase (W-phase) respectively.

Technical data

Motor

Technical data   AC synchronous motor
                                  3-phase, 4 or 6-pole

                                  ABB Flexible Automation can supply
                                  further information.

EXT PTC

This signal monitors the temperature of the motor. A high resistance or open circuit indicates that the temperature of the motor exceeds the rated level. If a temperature sensor is not used, the circuit must be strapped. If more than one motor is used, all PTC resistors are connected in series.
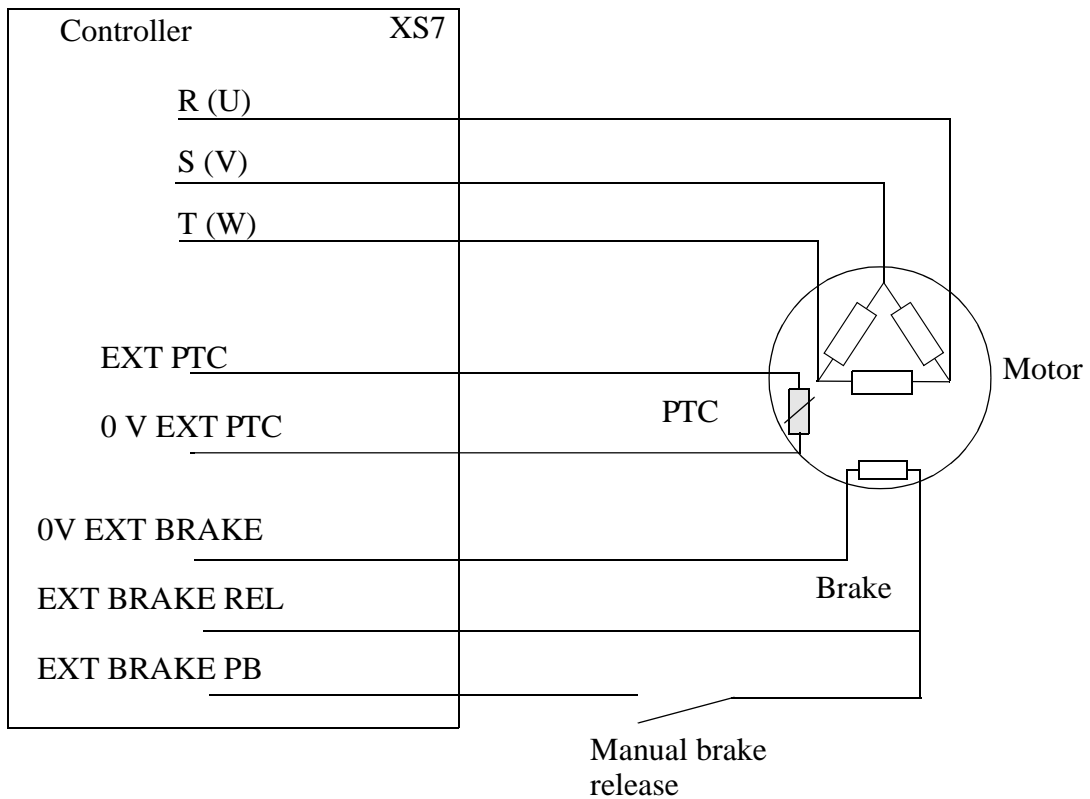

Figure 67 Connections of motor.

XS7, Connector on S4C robot cabinet wall (option: 391/392/394.)

Conn. Point	D	C	B	A
1	0V EXT PTC	M7 T	M7 S	M7 R
2	EXT PTC	M7 T	M7 S	M7 R
3	-	M7 T	M7 S	M7 R
4	PTC jumper 1	PTC jumper 2	LIM 2A	LIM 1A
5	PTC jumper 1	PTC jumper 2	LIM 2B	LIM 1B
6		M8 T	M8 S	M8 R
7		M8 T	M8 S	M8 R
8			BRAKE REL	BRAKE REL
9			0V BRAKE	BRAKE REL
10	-	0V BRAKE	0V BRAKE	BRAKE PB
11		M9 T	M9 S	M9 R
12		M9 T	M9 S	M9 R
13		M9 T	M9 S	M9 R
14				
15				
16				

Figure 68 Motor connections.

OPTION 391	Drive system	Drive Unit	Drive node	Node type
M7	1	0	2	T

OPTION 392	Drive system	Drive Unit	Drive node	Node type
M7	2	0	2	T
M8	2	0	1	G

OPTION 394	Drive system	Drive Unit	Drive node	Node type
M7	1	0	2	T
M8	2	0	1	G
M9	2	0	2	T

X7, Connector on external cabinet wall (options: 37x)

Conn. Point	D	C	B	A
1	0V EXT PTC	M7 T	M7 S	M7 R
2	EXT PTC	M7 T	M7 S	M7 R
3	-	M7 T	M7 S	M7 R
4	PTC jumper 1	PTC jumper 2	LIM 2A	LIM 1A
5	PTC jumper 1	PTC jumper 2	LIM 2B	LIM 1B
6	M10 R	M8 T	M8 S	M8 R
7	M10 R	M8 T	M8 S	M8 R
8	M10 S	M10 T	BRAKE REL	BRAKE REL
9	M10 S	M10 T	0V BRAKE	BRAKE REL
10	-	0V BRAKE	0V BRAKE	BRAKE PB
11	M12 R	M9 T	M9 S	M9 R
12	M12R	M9 T	M9 S	M9 R
13	M12 S	M9 T	M9 S	M9 R
14	M12 S	M11 T	M11 S	M11 R
15	M12 T	M11 T	M11 S	M11 R
16	M12 T	M11 T	M11 S	M11 R

OPTION 37M : axes M7-M8
OPTION 37N : axes M7-M10
OPTION 37O : axes M7-M12

	Drive system	Drive Unit	Drive node	Node type
M7	2	1	2	T
M8	2	1	1	G
M9	2	2	2	T
M10	2	2	1	G
M11	2	3	2	T
M12	2	3	1	G

OPTION 37P : axes M7-M9
OPTION 37Q : axes M7-M12

	Drive system	Drive Unit	Drive node	Node type
M7	2	1	1	C
M8	2	1	2	C
M9	2	1	3	B
M10	2	2	1	C
M11	2	2	2	C
M12	2	2	3	B

OPTION 37V : axes M7-M10
OPTION 37X : axes M7-M12

	Drive system	Drive Unit	Drive node	Node type
M7	2	1	1	C
M8	2	1	2	C
M9	2	2	2	T
M10	2	2	1	G
M11	2	3	2	T
M12	2	3	1	G

⚠ **Incorrect definitions of the system parameters for brakes or external axes may cause damage to the robot or personal injury.**

⚠ **Note:**
For safety reasons, the power supply to the external motor must be switched off when the robot is in the MOTORS OFF mode.

5.3.5   Configuration Files

In order to simplify installation of external axes a number of configuration files are delivered with the system. The configuration files are optimum designed concerning system behaviour and performance of the axes. When installing external axes it is important to design installations, so a combination of existent files can be used.

Four types of configuration files are delivered:

- Utility files for defining transformer and rectifier types in drive system 2.

- External axes files used for axes connected to a system with robot. File names MNxMyDz (**M**easurement **N**ode **x**, **M**easurement system **y**, **D**rive system **z**), see Figure 69.

- External controlled external axis. File names ENxM2D2 (**E**xternal **N**ode **x**, **M**easurement system **2**, **D**rive system **2**), see Figure 71.

- External axes files used in system without robot. File names ACxMyDz (**A**xis **C**ontrolled **x**, **M**easurement system **y**, **D**rive system **z**), see Figure 70.

For installing and change of parameter data, see the User's Guide, section System Parameters, Topic: Manipulator.

In order to have the possibility to read and change most of the parameters from the teach pendent unit, the system must be booted in **service mode**.

Configuration file	Logical axis	Measuring system		Drive system		
		System*	Node*	System*	Unit position	Node
MN4M1D1	7	1	4(7)**	1	0	2
MN4M1D2	7	1	4(7)**	2	1	2
MN4M1D12	7	1	4(7)**	2	0	2
MN1M2D1	8	2	1	1	0	2
MN1M2D2	8	2	1	2	1	1
MN1M2D12	8	2	1	2	0	1
MN2M2D1	9	2	2	1	0	2
MN2M2D2	9	2	2	2	2	2
MN2M2D12	9	2	2	2	0	2
MN3M2D1	10	2	3	1	0	2
MN3M2D2	10	2	3	2	2	1
MN3M2D12	10	2	3	2	0	1
MN4M2D1	11	2	4	1	0	2
MN4M2D2	11	2	4	2	3	2
MN4M2D12	11	2	4	2	0	2
MN5M2D1	12	2	5	1	0	2
MN5M2D2	12	2	5	2	3	1
MN5M2D12	12	2	5	2	0	1
MN6M2D1	7	2	6	1	0	2
MN6M2D2	7	2	6	2	1	2
MN6M2D12	7	2	6	2	0	2

Figure 69 Configuration files with default data.

* Parameter value must not be changed.

** Is connected physically to node 4 but the logical value in the system parameters must be 7.

Logical axis is used as the axis number in the RAPID instruction and for the teach pendent. Normally the robot use axes 1-6 and the external axes 7-12. The user can change the logical axis number to fit the new application. Only axes with unique axis numbers may be active at the same time.

If drive units with three inverters are used, note the limitation described under drive system.

Configura-tion file	Logical axis	Measuring system		Drive system		
		System*	Node*	System*	Unit position	Node
AC1M1D1	7	1	1	1	1	2
AC2M1D1	8	1	2	1	2	2
AC3M1D1	9	1	3	1	3	2
AC4M1D1	10	1	4	1	2	1
AC5M1D1	11	1	5	1	3	1
AC6M1D1	12	1	6	1	1	1

Figure 70 Configuration files with default data.

Configura-tion file	Logical axis	Measuring system		Drive system		
		System*	Node*	Sys-tem*	Unit position	Node
EN1M2D2	8	2	1	2	0	1
EN2M2D2	9	2	2	2	1	1
EN3M2D2	10	2	3	2	2	1
EN4M2D2	11	2	4	2	3	1
EN5M2D2	12	2	5	2	4	1
EN6M2D2	13	12	6	2	5	1

Figure 71 Configuration files with default data.

⚠ **Incorrect definitions of the system parameters for brakes or external axes may cause damage to the robot or personal injury.**

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Maintenance

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Maintenance

The robot is designed to be able to work under very demanding circumstances with a minimum of maintenance. Nevertheless, certain routine checks and preventative maintenance must be carried out at given periodical intervals, see the table below.

- The exterior of the robot should be cleaned as required. Use a vacuum cleaner or wipe it with a cloth. Compressed air and harsh solvents that can damage the sealing joints, bearings, lacquer or cabling must not be used.

- The control system is completely encased which means that the electronics are protected in any normal working environment. In very dusty enviroments, nevertheless, the interior of the cabinet should be inspected at regular intervals. Use a vaccuum cleaner if necessary. Change filter according to prescribed maintenance.

- Check that the sealing joint and cable bushings are really airtight so that dust and dirt are not sucked into the cabinet.

1 Maintenance Intervals

| | Prescribed maintenance | Check Twice/year | Check Once/year | Maintenance intervals | | |
				Every 2000 hrs or 6 months	Every 4000 hrs or 1 year	Others
MANIPU-LATOR	Mechanical stop axis 1		X[1]			
	Cabling		X[2]			
	Gears 1-4			Maintenance-free		
	Spring brackets Grease			X		
	Gears 5 and 6 Grease				X	
	Accumulator for measuring system Exchange					3 years[3]
CONTROL-LER	Filter for drive-system cooling	X[4]				
	Memory back-up Battery chenging					5 years[5]

1. Check that the "mechanical stop" is not bent.
2. Inspect all visible cabling. Change if damaged.
3. See section 2.4.
4. Change interval strongly dependent on the environment around the controll system. An extra dust filter for the cooling device is supplied with the robot.
5. See section 2.8.

2 Instructions for Maintenance

2.1 Oil in gears 1-4

The gearboxes are lubricated for life.

ABB's oil, art. no. 1171 2016-604, corresponds to:

BP:	Energol GR-XP 320	**Castrol:**	Alpha SP 320
Esso:	Spartan EP 320	**Klüber:**	Lamora 320
Optimol:	Optigear 5180	**Shell:**	Omala Oil 320
Texaco:	Meropa 320	**Statoil:**	Loadway EP

Floor-mounted

Volume of gear 1:	2 litres (0.53 US gallon)
Volume of gear 2-3:	1.5 litres (0.40 US gallon)
Volume of gear 4:	30 ml (0.008 US gallon)

Suspended:

Volume of gear 1:	2.7 litres (0.71 US gallon)
Volume of gears 2-3:	1.7 litres (0.40 US gallon)
Volume of gear 4:	30 ml (0.008 US gallon)

2.2 Greasing axes 5 and 6

Grease is pressed through the 3 nipples (1), see Figure 1. The tip nozzle of the greasing gun should be of type Orion 1015063, or equivalent.

Volume: 2 ml (0.00053 US gallon)
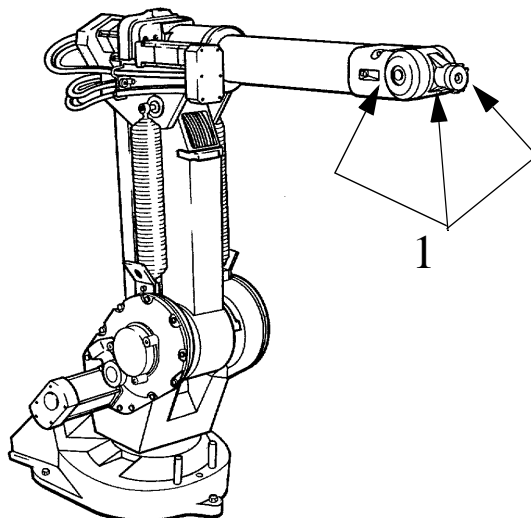
Figure 1 Greasing positions for axes 5 and 6.

Type of grease: ABB's art. no. 1171 4012-201, corresponds to:

ESSO Beacon 2	Shell Alvania Fett 2
BP Energrease	Castrol Speerol AP2
Mobil Mobilux 2	

2.3 Lubricating spring brackets

There are four lubrication places, located over and under the two balancing springs.

Type of grease: ABB's art. no. 3HAA 1001-294, corresponds to:

Optimol PDO

2.4 Changing the battery in the measuring system

The battery to be replaced is located inside the base under the flange cover (see Figure 2).

The robot is delivered with a rechargeable Nickel-Cadmium (Ni-Cd) battery with article number 4944 026-4.

The battery must never be just thrown away; it must always be handled as hazardous waste.

• Set the robot to the MOTORS OFF operating mode. (This means that it will not have to be coarse-calibrated after changing the battery.)

• Remove the flange cover. All connections on the flange cover, except for the signal contact for the serial link, R1.SMB, can be disconnected.

• Remove one of the screws and loosen the two other screws holding the serial measurement board. Push the unit to the side and remove it backwards. All cables and contacts must remain intact. Note the ESD-protection (ESD= Electrostatic Discharge).

• Loosen the battery terminals from the serial measuring board and cut the clasps that keep the battery unit in place.

• Install a new battery with two clasps and connect the terminals to the serial measuring board.

• Refit the serial measurement board, flange cover and connections.

• The Ni-Cd battery takes 36 hours to recharge; the mains supply must be switched on during this time.
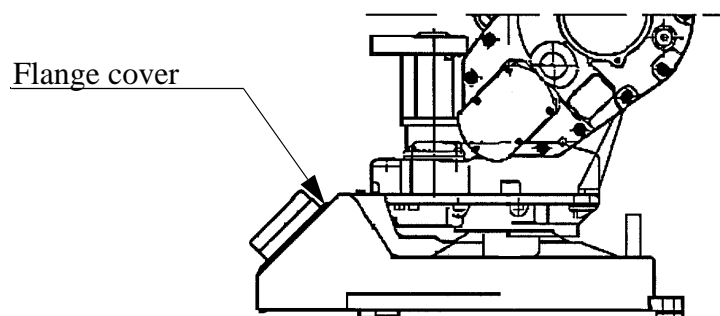

Flange cover

Figure 2   The battery is located inside the base under the flange cover.

Alternative battery

As an alternative to the Ni-Cd battery a lithium battery of primary type can be installed. The lithium battery needs no charging and has for that reason a blocking diode which prevents charging from the serial measurement board.

The benefit with a lithium battery is the lifetime, which can be up to 5 years in service, compare with the Ni-Cd battery's max life time of 3 years in service.

Two lithium batteries exists:

> - a 3-cell battery, art.no. 3HAB 9999-1

> - a 6-cell battery, art.no. 3HAB 9999-2

The life time of the lithium battery depends on how frequently the user switches off the power. The estimated max life time in years for the different lithium batteries and the recommended exchange interval is shown below:

User type:	Exchange 3-cell:	Exchange 6-cell:
1. Vacation (4 weeks) power off	every 5 years	every 5 years*
2. Weekend power off + user type 1	every 2 years	every 4 years
3. Nightly power off + user type 1 and 2	every year	every 2 years

* Because of material ageing the maximum life time in service is 5 years.

Voltage of batteries, measured at power off:

	Min	Max.
Ni-Cd	7.0 V	8.7 V
Lithium	7.0 V	-

Exchange of the battery is done according to the first section of this chapter.

2.5 Changing filters/vacuum cleaning the drive-system cooling

The article number of the filter is 3HAB 8028-1.

• Loosen the filter holder on the outside of the door by moving the holder upwards.

• Remove the old filter and install a new one (or clean the old one and re-install it).

• When cleaning, the rough surface (on the clean-air side) should be turned inwards. Clean the filter three or four times in 30-40° water with washing-up liquid or detergent. The filter must not be wrung out, but should be allowed to dry on a flat surface. Alternatively, the filter can be blown clean with compressed air from the clean-air side.

• If an air filter is not used, the entire cooling duct must be vacuum cleaned regularly.

2.6 Checking the mechanical stop, axis 1

Check regularly, as follows:

Stop pin:

> - that the pin is not bent.

If the stop pin is bent, it must be replaced by a new one. See chapter 13, section 2.4. The article number of the pin is 3HAB 3258-1.

2.7 Changing the battery for memory back-up

Type: Lithium Battery.

The article number of the battery is 3HAB 2038-1

The batteries (two) are located under the top cover to the right, at the top of the rear wall (see Figure 3).

Front view

Plan view
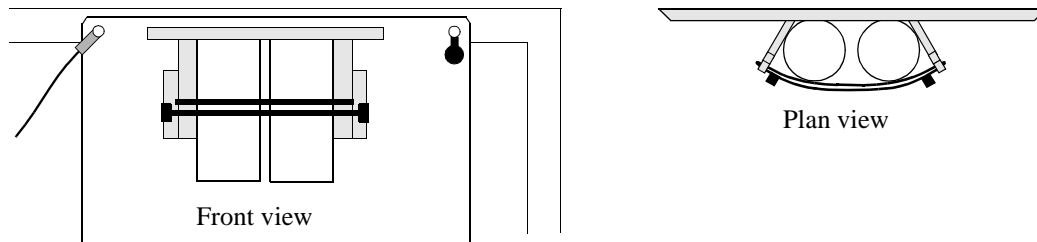
Warning:

- Do not charge the batteries. An explosion could result or the cells could overheat.
- Do not open, puncture, crush, or otherwise mutilate the batteries. This could cause an explosion and/or expose toxic, corrosive, and inflammable liquids.
- Do not incinerate the batteries or expose them to high temperatures. Do not attempt to solder batteries. An explosion could result.
- Do not connect positive and negative terminals. Excessive heat could build up, causing severe burns.

Warning:

Do not incinerate or dispose of lithium batteries in general waste collection, as there is a risk of explosion. Batteries should be collected for disposal in a manner that prevents short circuitting, compacting, or destruction of case integrity and the hermetic seal.

Figure 3 The location of the batteries on the computer unit.

- Note from the teach pendant which of the two batteries has expired and needs replacement.
- Loosen the expired battery terminal from the backplane.
- Remove the battery by loosening the clasps.
- Insert the new battery and fasten the clasps.
- Connect the battery terminal to the backplane.
- If <u>both batteries</u> must be replaced, make sure that the power is on. If not all memory content will be erased. A complete new installation of Robot Ware and parameters is then necessary, see Installation and Commissioning.

2.8 RAM Battery lifetime

The maximum service lifetime of the lithium battery is five years. The lifetime is influenced by the installed memory board type and by the lenght of time the system is without power.

The following table indicates the minimum time, in months, that memory will be held if the system is without power:

Memory board size	First battery	Both batteries
4 MB	6	12
6 MB	5	10
8 MB	6.5	13
16 MB	5	10

A battery test is performed during the following occasions:

1. System diagnistics (before softeware installation). Failing test results in one of the following messages on the display:

    - "Warning: Battery 1 or 2 < 3.3V" i.e. one of the batteries is empty.

    - "Error: Battery 1 and 2 < 3.3V" i.e. both batteries are empty.

2. Warm start. Failing test results in one of the following messages on the display:

    - 31501 Battery voltage too low on battery 1.

    - 31502 Battery voltage too low on battery 2.

    - 31503 Battery voltage too low on both batteries.

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Troubleshooting Tools

CONTENTS

Troubleshooting Tools

Generally speaking, troubleshooting should be carried out as follows:

- Read any error messages shown on the teach pendant display.
  What these messages mean is described in *System and Error Messages*.

- Check the LEDs on the units. See *Indication LEDs on the Various Units* page 14.

- Switch the power off and then on. When the robot is started up, a self diagnostic is run which detects any errors. The tests performed during the self diagnostic are described in the chapter *Diagnostics* page 3.

- Check the cables, etc., with the help of the circuit diagram.

1 Diagnostics

The control system is supplied with diagnostic software to facilitate troubleshooting and to reduce downtime. Any errors detected by the diagnostics are displayed in plain language with an code number on the display of the teach pendant.

All system and error messages are logged in a common log which contains the last 50 messages saved. This enables an "error audit trail" to be made which can be analysed. The log can be accessed from the Service window using the teach pendant during normal operation and can be used to read or delete the logs. All system and error messages available are listed in User's Guide.

The diagnostic programs are stored in flash PROM on the robot computer board. The diagnostic programs are executed by the I/O computer.

The control system runs through various tests depending on the start up mode:

Cold Start -
Cold starts occur normally only when the control system is started the first time, or when any computer board has been replaced, or when the batteries have been disconnected.

First, the test programs are executed by the robot computer (I/O computer) and the main computer. These tests and the test results are displayed on the teach pendant. If the tests do not indicate any errors, a message will appear on the display, requesting you to insert a system diskette into the disk drive. If, however, the diagnostics detect an error, a message will appear on the display and the test will be stopped until the user hits a key on the teach pendant or on a terminal connected to the front connector on the robot computer.

Warm Start -
is the normal type of start up when the robot is powered on. During a warm start, only a subset of the test program is executed. These tests and the test results are displayed on the teach pendant.

Another type of warm start, INIT, is carried out via a push button located on the backplane (see section 3). INIT is very similar to switching the power on. The tests that are run depend on whether or not the system is booted.
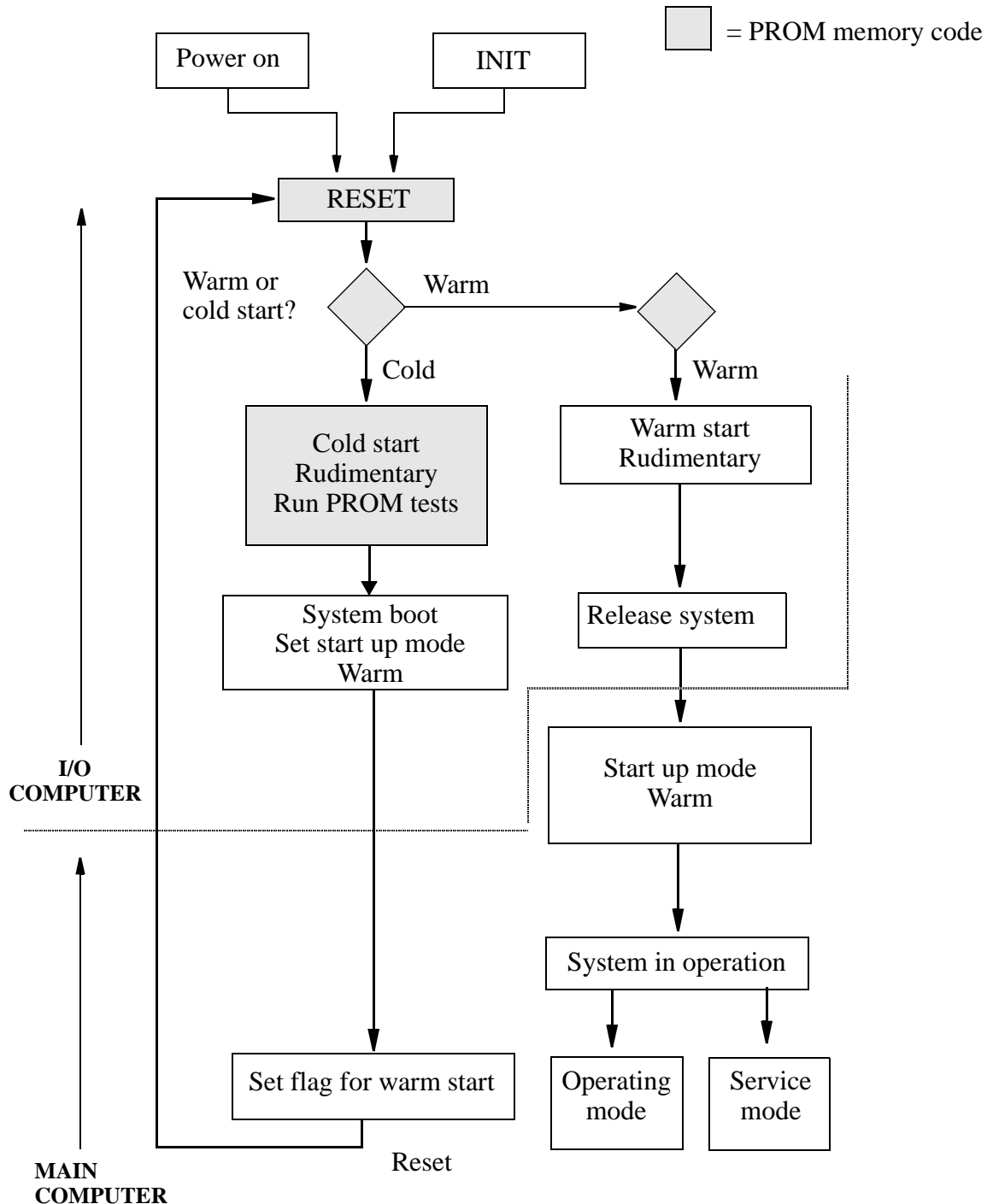
Troubleshooting Tools

Monitor Mode 2 -
is a test condition in which a large number of tests can be run. A detailed description will
be found in Chapter 1.2.

Under normal operating conditions, a number of test programs are run in the background.
The operating system ensures that the tests can be run whenever there is a time slot.

The background tests are not seen in normal circumstances, but will give an indication
when an error occurs.

Flow Chart of Diagnostic Software

```
┌──────────┐          ┌──────────┐        ▭ = PROM memory code
│ Power on │          │   INIT   │
└──────────┘          └──────────┘
       │                   │
       └────────┬──────────┘
                ▼
          ┌──────────┐
          │  RESET   │
          └──────────┘
                │
 Warm or        ◇────── Warm ──────────►  ◇
 cold start?    │                         │
              Cold                      Warm
                ▼                         ▼
      ┌──────────────┐          ┌──────────────┐
      │  Cold start  │          │  Warm start  │
      │  Rudimentary │          │  Rudimentary │
      │ Run PROM tests│         └──────────────┘
      └──────────────┘                  │
                │                        ▼
      ┌──────────────┐          ┌──────────────┐
      │ System boot  │          │Release system│
      │Set start up  │          └──────────────┘
      │ mode Warm    │                  │
      └──────────────┘                  ▼
                │                ┌──────────────┐
                │                │ Start up mode│
                │                │    Warm      │
                │                └──────────────┘
                │                        │
                │                        ▼
                │                ┌──────────────┐
                │                │System in     │
                │                │ operation    │
                │                └──────────────┘
                │                   │        │
                ▼                   ▼        ▼
   ┌──────────────────┐      ┌─────────┐ ┌─────────┐
   │Set flag for warm │      │Operating│ │ Service │
   │      start       │      │  mode   │ │  mode   │
   └──────────────────┘      └─────────┘ └─────────┘
              Reset
```

I/O COMPUTER

MAIN COMPUTER

1.1 Tests

Most of the internal robot tests are only run when the robot is cold started. All the tests can be run in Monitor Mode 2, as described in Chapter 1.2. Non destructive memory tests, checksum tests, etc., are only run when the robot is warm started.

Cold start tests in consecutive order.

IOC = Robot computer
AXC = Robot computer
MC   = Main computer

At every "power on", the IOC makes a destructive RWM test. If it fails, the IOC will flash the NS and MS front LEDs and stop the program running.

T1504: IOC Red LED off

T1005: IOC Memory test (RWM) Non Destructive

T1018: IOC Battery test

T1053: IOC IOC->AXC Access test

T1062: IOC IOC->AXC AM test

T1067: IOC IOC->AXC Memory test (RWM)

T1068: IOC IOC->AXC Memory test (RWM) R6 Global

T1069: IOC IOC->AXC Memory test (RWM) DSP

T1070: IOC Enable AXC->IOC Interrupts

T1061: IOC IOC->AXC Load AXC

T3001: AXC RWM test Dist.

T3002: AXC R6 Global RWM test

T3003: AXC DSP Double access RWM test

T3004: AXC DSP Data RWM test

T3020: AXC VME interrupt test

T3023: AXC Test channels output test

T1071: IOC Disable AXC->IOC Interrupts

T1046: IOC IOC->MC Access test

T1048: IOC IOC->MC AM test

T1050: IOC IOC->MC Memory test Destructive, Low win

T1506: IOC IOC->MC LED off

T1508: IOC IOC->ERWM LED off

T1512: IOC IOC->MC Load MC

T1509: IOC IOC->MC Release MC

T2002: MC Memory test (RWM) Destructive

T2010: MC Memory test (RWM) BM Destructive

T1510: IOC IOC->MC Reset MC

Warm start tests in consecutive order.

IOC = Robot computer

At every "power on", the IOC makes a destructive RWM test. If it fails, the IOC will flash the NS and MS front LEDs and stop the program running.

T1504: IOC LED off

T1005: IOC Memory test (RWM) Non Destructive

T1018: IOC Battery test

1.2 Monitor Mode 2

When the system is in Monitor Mode 2, a large number of tests can be run.

These tests must be performed only by authorised service personnel. It should be noted that some of the tests will cause activity on customer connections and drive systems, which can result in damage, accidents etc. unless suitable precautionary measures are taken. It is advisable to disconnect all the connections involved during these tests.

To ensure that all memory addresses are resetted after testing shall the system be cold started.

The test mode Monitor mode 2 can be run from the teach pendant and/or a connected PC/terminal.

1.2.1 Entering the test mode from the teach pendant

1. Press the backplane TEST button, see section 3.

2. Keep the button depressed.

3. Push the INIT button, see section 3 (keep the TEST button pressed in).

4. Keep the TEST button depressed for at least 5 sec. (after releasing of the INIT button).

5. The display will show the following:

**MONITOR MODE 2
if you proceed, system data will
be lost! Press any key to accept.**

6. Then enter the password: **4433221**.

1.2.2 Console connected to a PC

A PC with terminal emulation (see PC manual). The PC shall be set up for 9600 baud, 8 bits, no parity, and shall be connected to the Console terminal on the front of the robot computer board.

Connection table: Console terminal on robot and main computer

Console		
Pin	**Signal**	**Description**
2	RXD	Serial receive data
3	TXD	Serial transmit data
5	GND	Signal ground (0V)

Start up:

1. Connect the PC.

2. Turn on the power to the robot.

Entering the test mode from a PC/terminal:

1. Press the backplane TEST button, see section 3.

2. Keep the button depressed.

3. Push the INIT button, see section 3 (keep the TEST button pressed in).

4. Keep the TEST button depressed for at least 5 sec. (after release of the INIT button).

5. The display will show the following:

Troubleshooting Tools

MONITOR MODE 2
if you proceed, system data will
be lost! Press any key on the PC to accept.

6. Then enter the password: **ROBSERV.**

When the password has been entered (see above), a menu will be displayed, as shown below:

Welcome to Monitor Mode 2

1. Memory IO	(Tests the memory)
2. Serial IO	(Tests the serial channels)
3. Elementary IO	(Tests the IO units) *Not yet implemented*
4. DSQC 3xx (IOC)	(Tests the IO computer)
5. DSQC 3xx (AXC)	(Tests the axes computer)
6. DSQC 3xx (MC, ERWM)	(Tests the main computer and external memory boards)
7. System tests (MISC)	(System-related tests)
8. Auxiliary	(Special tests) *Not yet implemented*
9. Specific test	(Specific tests that can be run separately)

10. T1060 IOC System reset

Select test group and the test group menu will be displayed.

1. T9901 Memory IO

1. Up one level

2. FLOPPY
 1. Up one level
 2. T1039 IOC Floppy Format Test
 3. T1040 IOC Floppy Write/Read Test

3. IOC RWM
 1. Up one level
 2. T1516 TIOC RWM size
 3. T1005 IOC Memory test (RWM) Non destructive

4. AXC RWM
 1. Up one level
 2. T1067 IOC->AXC Memory test (RWM)
 3. T1068 IOC->AXC Memory test (RWM) R6 Global
 4. T1069 IOC->AXC Memory test (RWM) DSP
 5. T3001 AXC RWM test Destr
 6. T3002 AXC R6 Global RWM test
 7. T3003 AXC DSP Double access RWM test
 8. T3004 AXC DSP Data RWM test

5. MC/ERWM RWM
1. Up one level
2. T1517 MC/ERWM RWM size
3. T1047 IOC IOC->MC Memory test Destructive
4. T2002 MC Memory test (RWM) Destructive
5. T2010 MC Memory test (RWM) BM Destructive

6. PROM *(Not yet implemented)*

2. T9902 Serial I/O

1. Up one level

2. SIO 1 *(Not yet implemented)*

3. SIO 2
1. Up one level
2. T1029 IOC SIO2 RS422 loopback test
3. T1033 IOC SIO2 RS422 JUMPER test (Requires special hardware jumpers)

4. CONSOLE *(Not yet implemented)*

5. TPUNIT *(Not yet implemented)*

3. T9903 Elementary I/O (Not yet implemented)

4. T9911 DSQC 3xx (IOC)

1. Up one level

2. IOC CPU *(Not yet implemented)*

3. PROM *(Not yet implemented)*

4. RWM
1. Up one level
2. T1516 IOC RWM size
3. T1005 IOC Memory test (RWM) Non Destructive

5. RTC *(Not yet implemented)*

6. FDC
1. T9800 Up one level
2. T1039 IOC Floppy Format Test
3. T1040 IOC Floppy Write/Read Test

7. UART
    1. T9800 Up one level
    2. T1029 IOC SIO2 RS422 loopback test
    3. T1013 IOC TPUNIT RS422 loopback test
    4. T1033 IOC SIO2 RS422 JUMPER test (requires special hardware jumpers)
    5. T1022 IOC TPUNIT RS422 JUMPER test (Requires special hardware jumpers
                                        and must be run from terminal)

8. DMA *(Not yet implemented)*

9. VME *(Not yet implemented)*

10. Miscellaneous
    1. Up one level
    2. T1018 IOC Battery test startup
    3. T1060 IOC System Reset

11. LED
    1. Up one level
    2. T1503 IOC LED on
    3. T1504 IOC LED off
    4. T1518 IOC CAN LEDs sequence test

5. DSQC 3xx (AXC)

1. Up one level

2. AXC CPU *(Not yet implemented)*

3. RWM
    1. T9800 Up one level
    2. T1067 IOC IOC->AXC Memory test (RWM)
    3. T1068 IOC IOC->AXC Memory test (RWM) R6 Global
    4. T1069 IOC IOC->AXC Memory test (RWM) DSP
    5. T3001 AXC RWM test Dstr
    6. T3002 AXC R6 Global RWM test
    7. T3003 AXC DSP Double access RWM test
    8. T3004 AXC DSP Data RWM test

4. VME
    1. Up one level
    2. T1053 IOC IOC->AXC Access test
    3. T1062 IOC IOC->AXC AM test
    4. T3020 AXC VME interrupt test

5. Miscellaneous
    1. Up one level
    2. T1072 IOC IOC->AXC Reset AXC
    3. T1071 IOC Enable AXC->IOC Interrupts
    4. T1061 IOC IOC->AXC Load AXC
    5. T3018 AXC ASIC ID number
    6. T3019 AXC Board ID number
    7. T3023 AXC Test channels output test
    8. T1071 IOC Disable AXC->IOC Interrupts

6. DSQC 3xx (MC, ERWM)

1. Up one level

2. MC CPU *(Not yet implemented)*

3. RWM
    1. Up one level
    2. T1517 MC/ERWM RWM size
    3. T1047 IOC IOC->MC Memory test Destructive
    4. T2002 MC Memory test (RWM) Destructive
    5. T2010 MC Memory test (RWM) BM Destructive

4. LED
    1. Up one level
    2. T1505 IOC IOC->MC LED on
    3. T1506 IOC IOC->MC LED off
    4. T1507 IOC IOC->ERWM LED on
    5. T1508 IOC IOC->ERWM LED off
    6. T2501 MC LED on
    7. T2502 MC LED off

5. Duart *(Not yet implemented)*

6. VME
    1. Up one level
    2. T1048 IOC IOC->MC AM test
    3. T1046 IOC IOC->MC Access test

7. DMA *(Not yet implemented)*

8. Miscellanous
    1. Up one level
    2. T1512 LOAD MC DIAG
    3. T1509 ENABLE MC
    4. T1510 DISABLE (RESET) MC

Troubleshooting Tools

7. System tests (Misc.)

1. Up one level

2. Battery
    1. Up one level
    2. T1018 IOC Battery test startup

3. IOC->MC
    1. Up one level
    2. T1046 IOC IOC->MC Access test
    3. T1048 IOC IOC->MC AM test
    4. T1505 IOC IOC->MC LED on
    5. T1506 IOC IOC->MC LED off
    6. T1507 IOC IOC->ERWM LED on
    7. T1508 IOC IOC->ERWM LED off
    8. T1512 LOAD MC DIAG
    9. T1509 ENABLE MC
    10. T1510 DISABLE (RESET) MC
    11. T2501 MC LED on
    12. T2502 MC LED off

4. IOC->AXC
    1. T9800 Up one level
    2. T1062 IOC IOC->AXC AM test
    3. T1053 IOC IOC->AXC Access test
    4. T1072 IOC IOC->AXC Reset AXC
    5. T1070 IOC Enable AXC->IOC Interrupts
    6. T1061 IOC IOC->AXC Load AXC
    7. T3018 AXC ASIC ID number
    8. T3019 AXC Board ID number
    9. T3020 AXC VME interrupt test
    10. T3023 AXC Test channels output test
    11. T1071 IOC Disable AXC->IOC Interrupts

5. MC->AXC *(Not yet implemented)*

6. AXC->IOC *(Not yet implemented)*

7. VME *(Not yet implemented)*

8. RTC (Not yet implemented)

9. Reset password *(Re-boot required)*

10. Cold start *(Not yet implemented)*

8. Auxiliary (Not yet implemented)

9. Specific test

Specific test Txxxx
<Q> <q> or < > to quit
Enter test number Txxxx: T

10. IOC System reset (Not yet implemented)

All available tests have been defined in Chapter 1.1.

Troubleshooting Tools

2 Indication LEDs on the Various Units

2.1 Location of units in the cabinet

| DC link | Drive unit 3 | Drive unit 2 | Drive unit 1 | Supply unit | | Robot computer | Memory board | Main computer | Optional board | Optional board |

Transformer
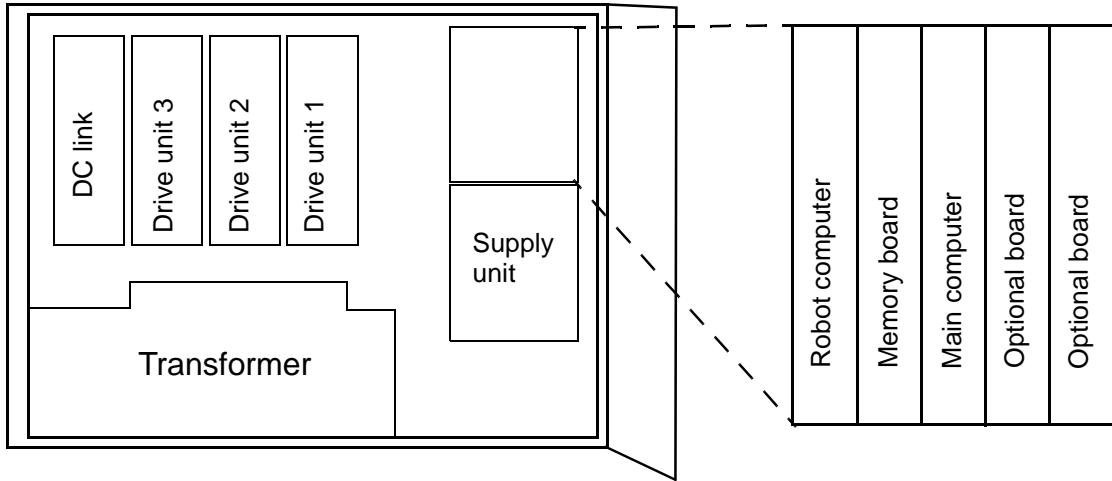
	IRB 1400	IRB 2400	IRB 4400	IRB 6400	IRB 640	IRB 840/A
Drive unit	*Axes*	*Axes*	*Axes*	*Axes*	*Axes*	*Axes*
1	1, 2, 4	1, 2, 4	1, 6	1, 6	1, 6	1(X), 6(C)
2	3, 5, 6	3, 5, 6	2, 4	2, 4	2, 3	2(Y), 3(Z)
3			3, 5	3, 5		
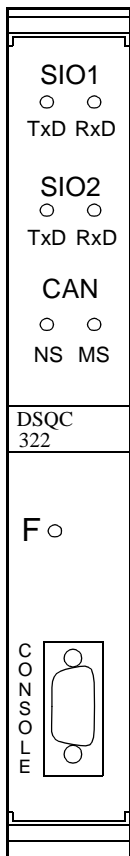
SIO1
○ ○
TxD RxD

SIO2
○ ○
TxD RxD

CAN
○ ○
NS MS

DSQC
322

F ○

C
O
N
S
O
L
E

2.2 Robot computer DSQC 363/373

Designation	Colour	Description/Remedy
F	Red	Turns off when the board approves the initialisation.
TxD	Yellow	See section 2.14.
RxD	Yellow	See section 2.14.
NS	Green/red	See section 2.14.
MS	Green/red	See section 2.14.

2.3 Main computer DSQC 361
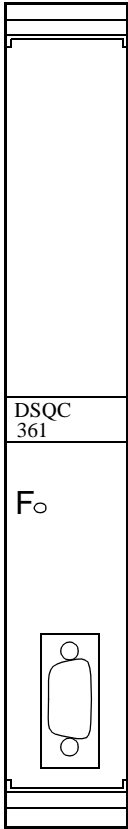
Designation	Colour	Description/Remedy
F	Red	Turns off when the board approves the initialisation.

2.4 Memory board DSQC 324/16Mb, 323/8Mb
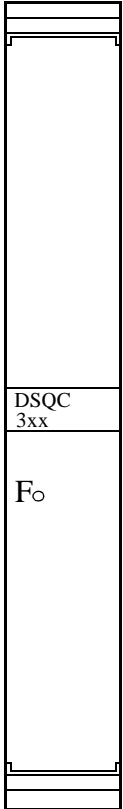
Designation	Colour	Description/Remedy
F	Red	Turns off when the board approves the initialisation.

2.5 Ethernet DSQC 336
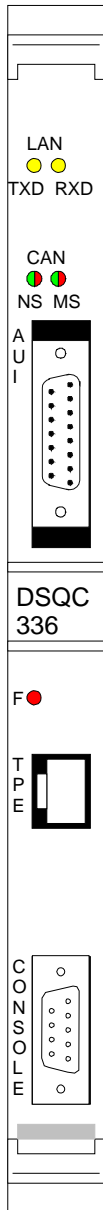
Designation	Colour	Description/Remedy
TxD	Yellow	Indicates data transmit activity. If no light when transmission is expected, check error messages and check also system boards in rack.
RxD	Yellow	Indicates data receive activity. If no light, check network and connections.
NS	Green/red	See section 2.14.
MS	Green/red	See section 2.14.
F	Red	Lit after reset. Thereafter controlled by the CPU. Light without message on display indicates a hardware fault preventing system from strating. By light and message on display, check message.

2.6 Power supply units

DSQC 334

X1

X5

AC OK

X2

X3
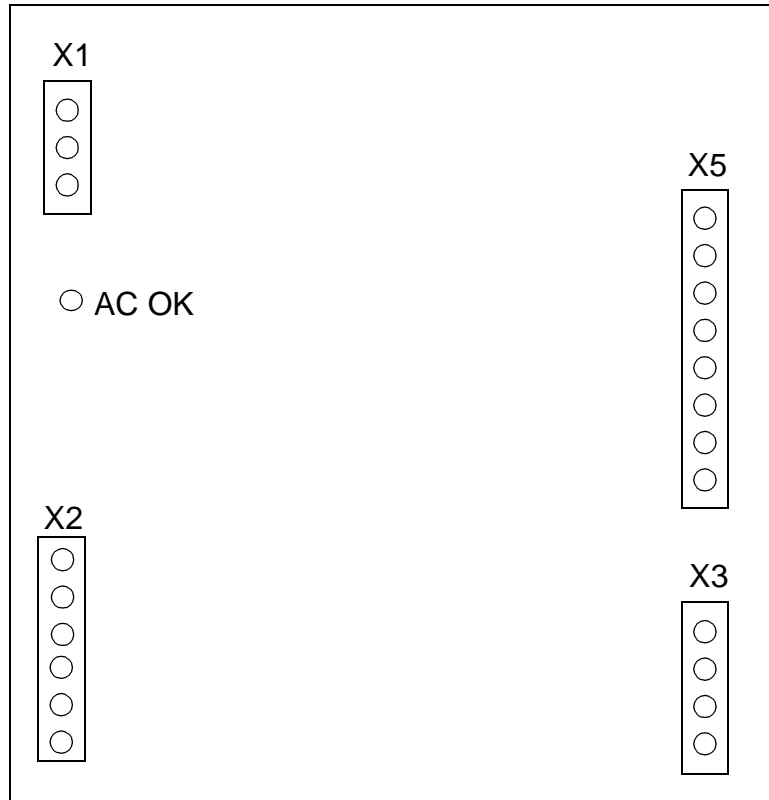
Designation	Colour	Description/Remedy
AC OK	Green	3 x 55V supply OK (start of ENABLE chain)

DSQC 374/365

New "standard" power supply unit DSQC 374, introduced week 826 (M98 rev. 1)

New "extended" power supply unit DSQC 365 introduced week 840.

Troubleshooting Tools

X1

X5

○ AC OK

○ 24 V I/O

X2

X3

X7

Only
DSQC 365
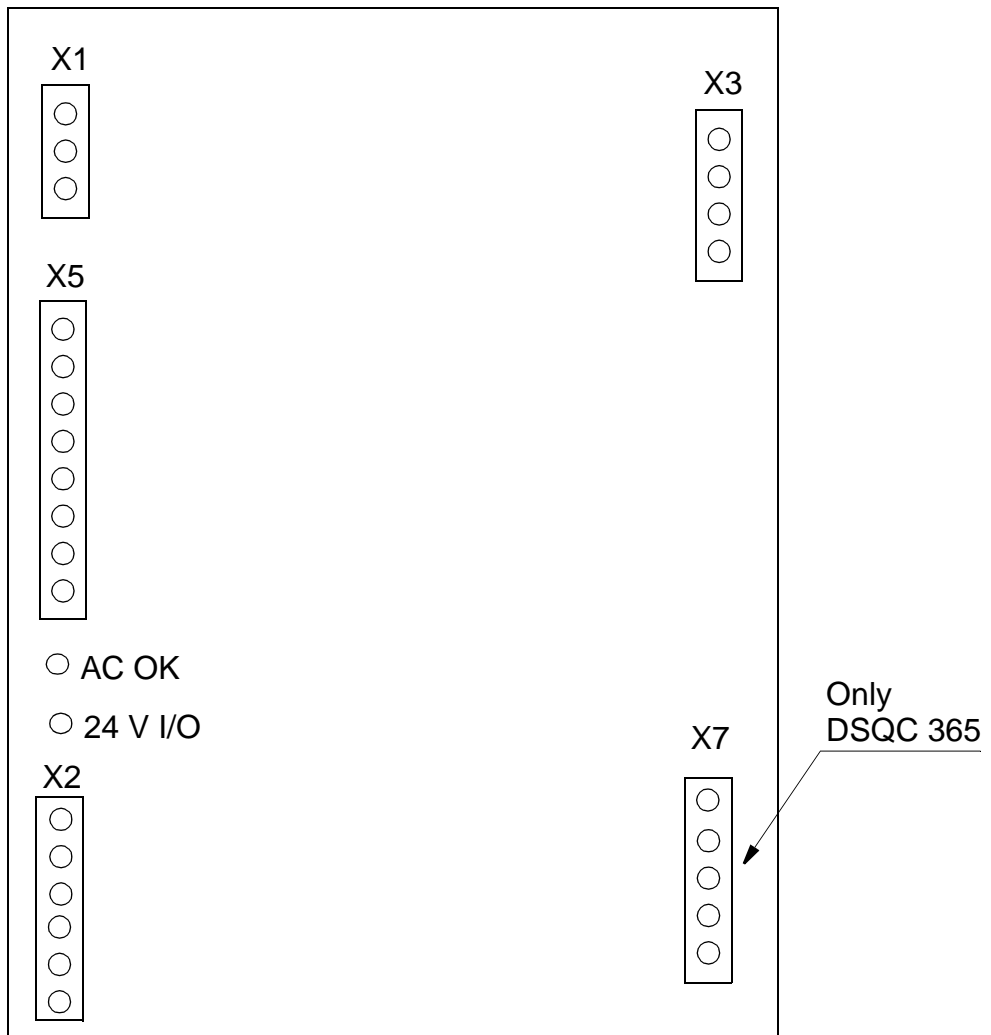
Designation	Colour	Description/Remedy
AC OK	Green	3 x 55V supply OK (start of ENABLE chain)
24 V I/O	Green	24 V I/O OK

2.7 Panel unit DSQC 331

WARNING!
REMOVE JUMPERS BEFORE CONNECTING
ANY EXTERNAL EQUIPMENT

EN   MS NS   ES1 ES2 GS1 GS2 AS1 AS2

Status LED's
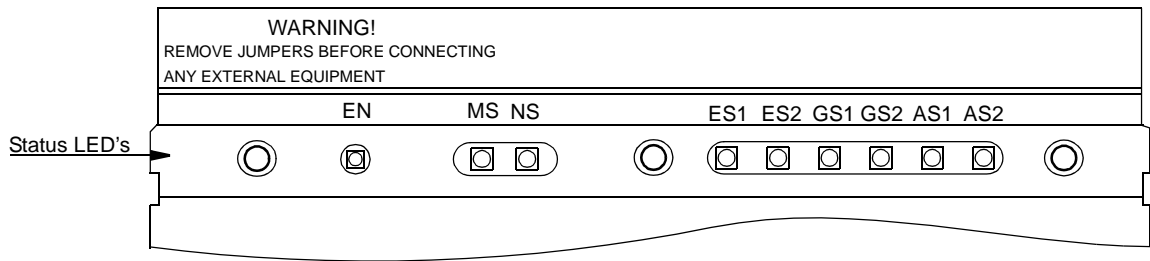
Designation	Colour	Description/Remedy
EN	Green	Enable signal from power supply and computers
MS/NS	Green/red	See section 2.14.
ES1 and 2	Yellow	Emergency stop chain 1 and 2 closed
GS1 and 2	Yellow	General stop switch chain 1 and 2 closed
AS1 and 2	Yellow	Auto stop switch chain 1 and 2 closed

2.8 Digital and Combi I/O units

All the I/O units have the same LED indications. The figure below shows a digital I/O unit, DSQC 328.

The description below is applicable for the following I/O units:

Digital I/O DSQC 328, Combi I/O DSQC 327,
Relay I/O DSQC 332 and 120 VAC I/O DSQC 320.
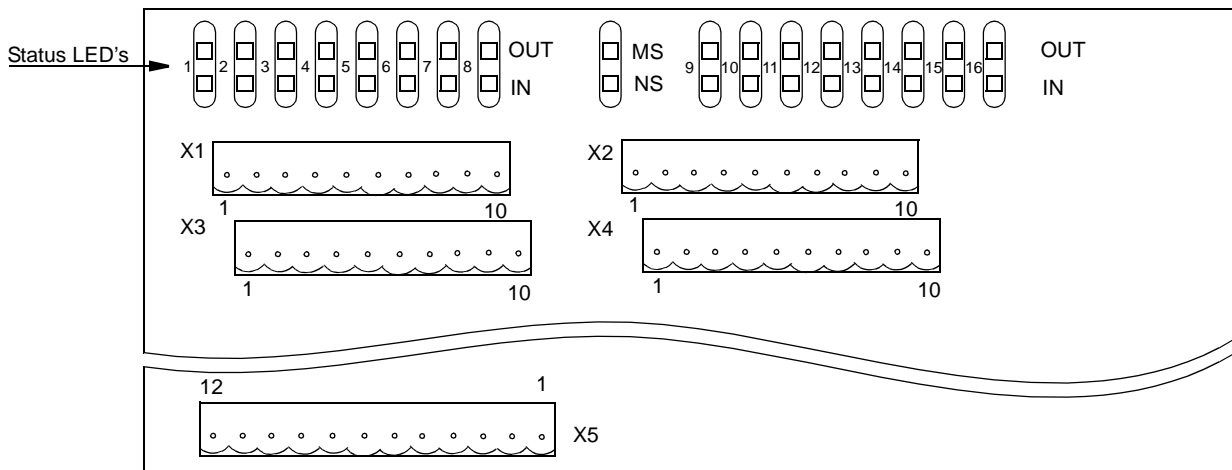
Designation	Colour	Description/Remedy
IN	Yellow	Lights at high signal on an input. The higher the applied voltage, the brighter the LED will shine. This means that even if the input voltage is just under the voltage level "1", the LED will glow dimly.
OUT	Yellow	Lights at high signal on an output. The higher the applied voltage, the brighter the LED will shine.
MS/NS	Green/red	See section 2.14.

2.9 Analog I/O, DSQC 355

Designation	Colour	Description/Remedy
NS/MS	Green/red	See section 2.14.
RS232 Rx	Green	Indicates the state of the RS232 Rx line. LED is active when receiving data. If no light, check communication line and connections.
RS232 Tx	Green	Indicates the state of the RS232 Tx line. LED is active when tranceiving data. If no light when transmission is expected, check error messages and check also system boards in rack.
+5VDC / +12VDC / -12VDC	Green	Indicates that supply voltage is present and at correct level. Check that voltage is present on power unit. Check that power is present in power connector. If not, check cables and connectors. If power is applied to unit but unit does not work, replace the unit.

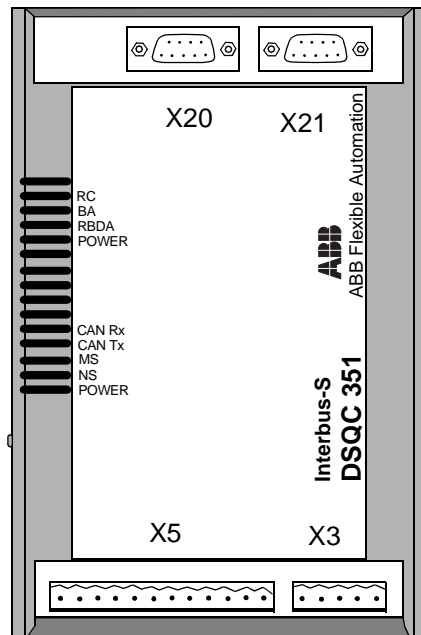### 2.10 Remote I/O DSQC 350, Allen Bradley
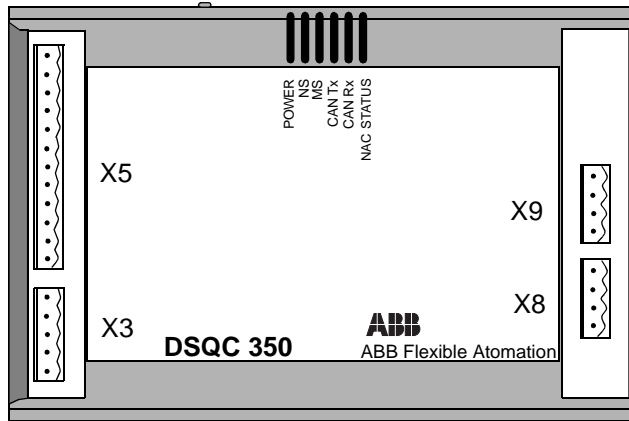
Bus status LED's

POWER

NS

MS

CAN Tx

CAN Rx

NAC STATUS

Designation	Colour	Description/Remedy
POWER-24 VDC	Green	Indicates that a supply voltage is present, and has a level above 12 VDC. If no light, check that voltage is present on power unit. That power is present in power connector. If not, check cables and connectors. If power is applied to unit but unit does not work, replace unit.
NS/MS	Green/red	See section 2.14.
CAN Tx/CAN Rx	Yellow	See section 2.14.
NAC STATUS	Green	Steady green indicates RIO link in operation. If no light, check network, cables and connections. Check that PLC is operational. Flashing green, communication established, but INIT_COMPLETE bit not set in NA chip, or configuration or rack size etc. not matching configuration set in PLC. If LED keeps flashing continuously, check setup

2.11 Interbus-S, slave DSQC 351
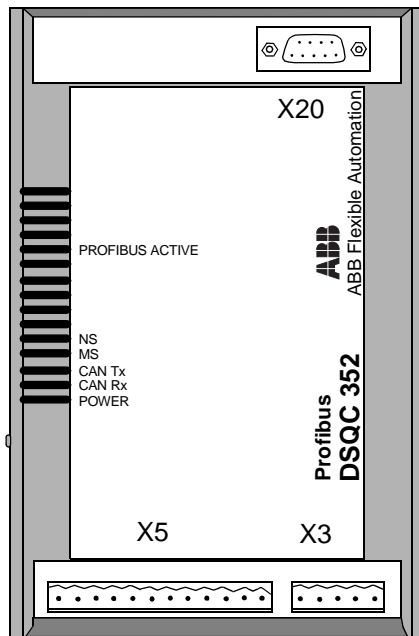
Bus status LED's

POWER
NS
MS
CAN Tx
CAN Rx

POWER
RBDA
BA
RC

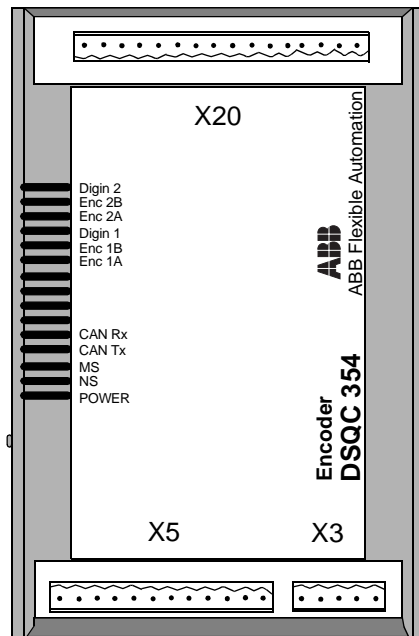| Designation	Colour	Description/Remedy
POWER-24 VDC	Green	Indicates that a supply voltage is present, and has a level above 12 VDC.
NS/MS	Green/red	See section 2.14.
CAN Tx/CAN Rx	Green/red	See section 2.14.
POWER- 5 VDC	Green	Lit when both 5 VDC supplies are within limits, and no reset is active.
RBDA	Red	Lit when this Interbus-S station is last in the Interbus-S network. If not as required, check parameter setup.
BA	Green	Lit when Interbus-S is active. If no light, check network, nodes and connections
RC	Green	Lit when Interbus-S communication runs without errors.

2.12 Profibus-DP, DSQC352

Bus status LED's

Profibus active ▮

NS ▮▮

MS ▮▮

CAN Tx ▮

CAN Rx ▮▮

Power ▮

Designation	Colour	Description/Remedy
Profibus active with	Green	Lit when the node is communicating the master. If no light, check system messages in robot and in Profibus net.
NS/MS	Green/red	See section 2.14.
CAN Tx/CAN Rx	Green/red	See section 2.14.
POWER, 24 VDC	Green	Indicates that a supply voltage is present, and has a level above 12 VDC. If no light, check that voltage is present in power unit.Check that power is present in the power connector. If not, check cables and connectors. If power is available at the unit but the unit does not function, replace the unit

2.13 Encoder interface unit, DSQC354

Designation	Colour	Description/Remedy
POWER, 24 VDC	Green	Indicates that a supply voltage is present, and has a level above 12 VDC. If no light, check that voltage is present on power unit. That power is present in connector X20. If not, check cables and connectors.If power is applied to unit but unit does not work, replace unit.
NS/MS	Green/red	See section 2.14.
CAN Tx/CAN Rx	Yellow	See section 2.14.
ENC 1A/1B	Green	Indicates phase 1 and 2 from encoder. Flashes by each Encoder pulse. By frequencies higher than a few Hz, flashing can no longer be observed (light will appear weaker). If no light, faulty power supply for input circuit (internal or external). Defective input circuit on board. External wiring or connectors, short circuit or broken wire. Internal error in unit. Constant light indi cates constant high level on input and vice versa. No light in one LED indicates fault in one encoder phase.

Troubleshooting Tools

DIGIN1	Green	Digital input. Lit when digital input is active. The input is used for external start signal/conveyor synchronization point. If no light, faulty limit switch, photocell etc. External wiring or connectors, short circuit or broken wire. Faulty power supply for input circuit (internal or external). Defective input circuit on board.

2.14 Status LEDs description

Each of the units connected to the CAN bus includes 2 or 4 LED indicators which indicate the condition (health) of the unit and the function of the network communication. These LEDs are:

All units

MS - Module status
NS - Network status

Some units:

CAN Tx - CAN network transmit
CAN Rx - CAN network receive

MS - Module status

This bicolour (green/red) LED provides device status. It indicates whether or not the device has power and is operating properly. The LED is controlled by software. The table below shows the different states of the MS LED.

Description	Remedy / Source of fault
<u>Off</u> No power applied to the device.	Check power supply.
<u>Green</u> Device is operating in a normal condition.	If no light, check other LED modes.
<u>Flashing green</u> Device needs commissioning due to configuration missing, incomplete or incorrect. The device may be in the Stand-by state.	Check system parameters. Check messages.
<u>Flashing red</u> Recoverable minor fault.	Check messages.
<u>Red</u> The device has an unrecoverable fault.	Device may need replacing.
<u>Flashing red/green</u> The device is running self test.	If flashing for more than a few seconds, check hardware.

Troubleshooting Tools

NS - Network status

The bicolour (green/red) LED indicates the status of the communication link. The LED is controlled by software. The table below shows the different states of the NS LED.

Description	Remedy / Source of fault
<u>Off</u> Device has no power or is not on-line. The device has not completed the Dup_MAC_ID test yet.	Check status of MS LED. Check power to affected module.
<u>Flashing green</u> Device is on-line, but has no connections in the established state. The device has passed the Dup_MAC_ID test, is on-line, but has no established connections to other nodes. For a group 2 only device it means that the device is not allocated to a master. For a UCMM capable device it means that the device has no established connections.	Check that other nodes in network are operative. Check parameter to see if module has correct ID.
<u>Green</u> The device is on-line and has connection in the established state. For a group 2 only device it means that the device is allocated to a master. For a UCMM capable device it means that the device has one or more established connections.	If no light, check other LED modes.
<u>Flashing red</u> One or more I/O connections are in the Time-Out state.	Check system messages.
<u>Red</u> Failed communication device. The device has detected an error that has rendered it incapable of communicating on the network. (Duplicate MAC_ID, or Bus-off).	Check system messages and parameters.

Module- and network status LEDs at power-up

The system performs a test of the MS and NS LEDs during start-up. The purpose of this test is to check that all LEDs are functioning properly. The test runs as follows:

- - NS LED is switched Off.

- - MS LED is switched On green for approx. 0.25 seconds.

- - MS LED is switched On red for approx. 0.25 seconds.

- - MS LED is switched On green.

- - NS LED is switched On green for approx. 0.25 seconds.

- - NS LED is switched On red for approx. 0.25 seconds.

- - NS LED is switched On red.

If a device has other LEDs, each LED is tested in sequence.

CAN Tx - CAN network transmit

Description	Remedy / Source of fault
Green LED. Physically connected to the Can Tx line. Flashes when the CPU is receiving data on the CAN bus.	If no light when transmission is expected, check error messages. Check system boards in rack.

CAN Rx - CAN network receive

Description	Remedy / Source of fault
Green LED. Physically connected to the Can Rx line. Flashes when the CPU is transmitting data on the Can bus.	If no light, check network and connections.

3 Measuring Points

3.1 Back plane

The backplane contains a maintenance plug (X9) for signals that are hard to reach. Other signals are measured at their respective connection points, which can come in very handy when troubleshooting (see Figure 1).
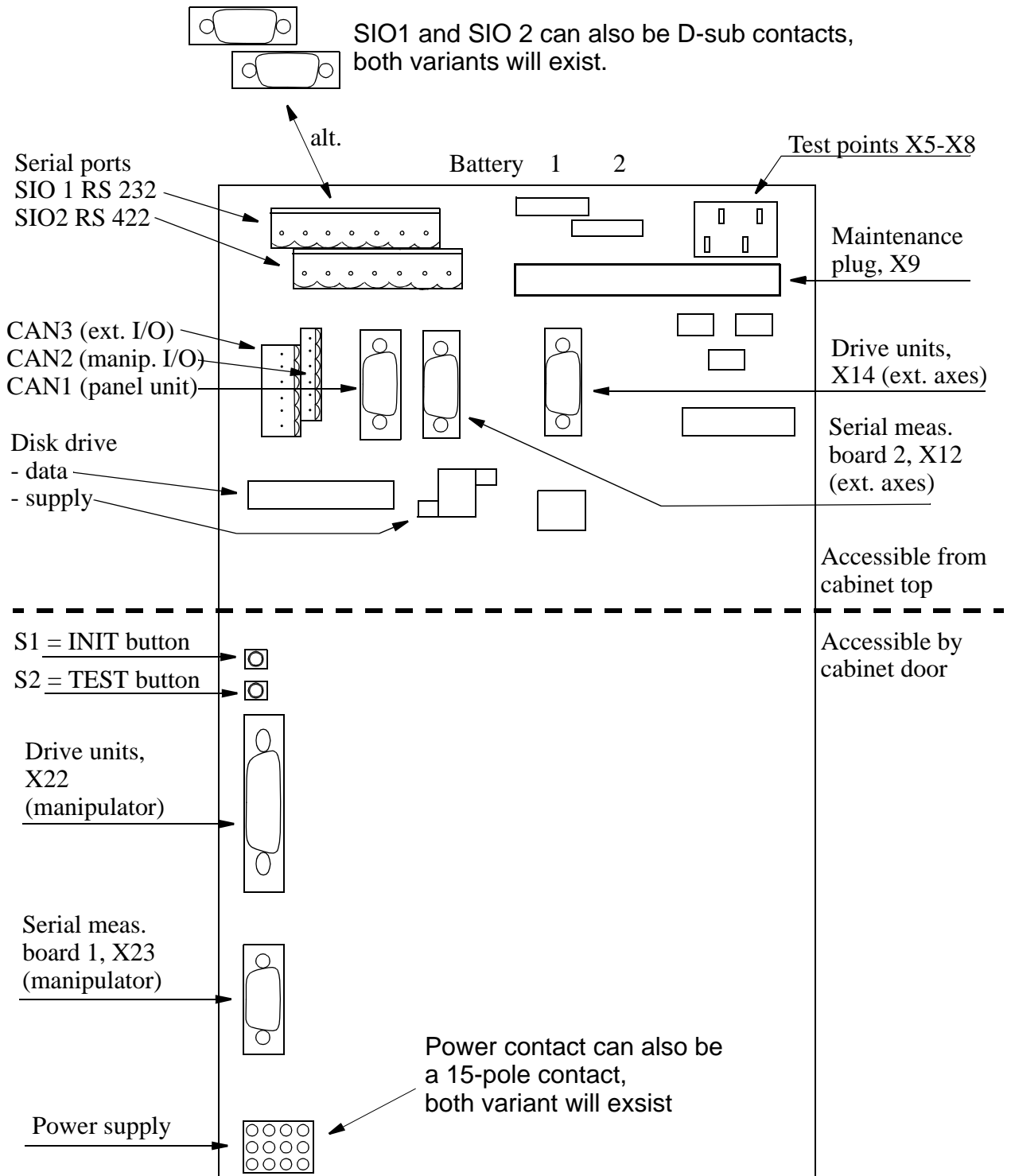

SIO1 and SIO 2 can also be D-sub contacts, both variants will exist.

alt.

Battery 1 2

Test points X5-X8

Serial ports
SIO 1 RS 232
SIO2 RS 422

Maintenance plug, X9

CAN3 (ext. I/O)
CAN2 (manip. I/O)
CAN1 (panel unit)

Drive units,
X14 (ext. axes)

Disk drive
- data
- supply

Serial meas.
board 2, X12
(ext. axes)

Accessible from
cabinet top

S1 = INIT button
S2 = TEST button

Accessible by
cabinet door

Drive units,
X22
(manipulator)

Serial meas.
board 1, X23
(manipulator)

Power contact can also be
a 15-pole contact,
both variant will exsist

Power supply

Figure 1 Back plane

3.2 Signal description, RS 232 and RS 422

RS 232

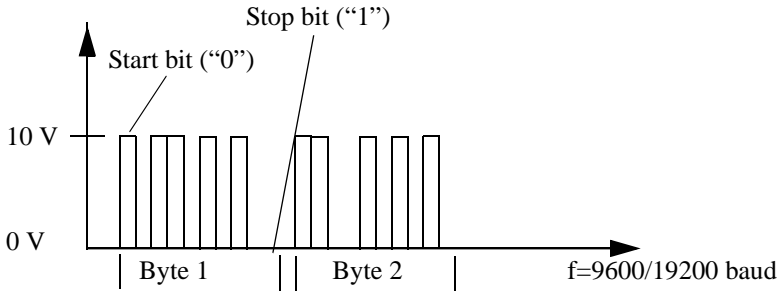| Signal	Explanation
TXD	Transmit Data
RXD	Receive Data
DSR	Data Set Ready
DTR	Data Terminal Ready
CTS	Clear To Send
RTS	Request To Send

Figure 2 Signal description for RS 232.

The transmission pattern can be single or bursts of 10 bit words, with one start bit "0", eight data bits (MSB first) and lastly one stop bit "1".

Troubleshooting Tools

RS 422

Signal	Explanation
TXD4/TXD4 N	Transmit Data in Full Duplex Mode
RXD4/RXD4 N	Receive Data in Full Duplex Mode
DATA4/DATA4 N	Data Signals in Half Duplex Mode
DCLK4/DCLK4 N	Data Transmission Clock

N.B! Only full duplex is supported.
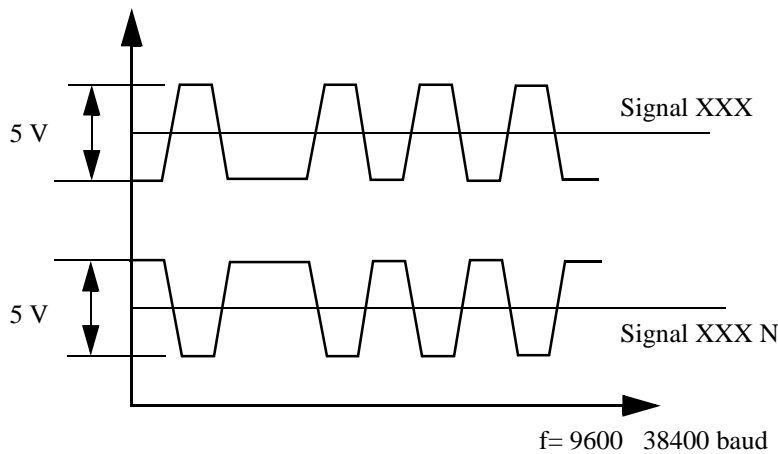
Figure 3 Signal description for RS 422, differential transmission.

When measuring the differential RS 422 signals, the oscilloscope should be set for AC testing. The data transmission has the same structure as RS 232, i.e. 1 start bit + 8 data bits + 1 stop bit, but the signals are differential. By looking at the "true" channel, it is possible to read the data.

If the types of signal as shown in the above diagram are obtained when measuring, this means that the drive circuits and lines are OK. If one or both of the signals do not move, it is likely that one or several line(s) or one or several drive circuit(s) is/are faulty.

3.3 X1 and X2 Serial links: SIO 1 and SIO 2

General serial interfaces: SIO 1 (X1) is an RS232 interface and
SIO 2 (X2) is an RS422 interface. Explanation of signals see 3.2.

Screw terminals

X1	
Pin	**Signal**
1	TXD
2	RTS N
3	0V
4	RXD
5	CTS N
6	0V
7	DTR
8	DSR
9	0V
10	
11	
12	

X2	
Pin	**Signal**
1	TXD
2	TXD N
3	0V
4	RXD
5	RXD N
6	0V
7	DATA
8	DATA N
9	0V
10	DCLK
11	DCLK N
12	0V

Troubleshooting Tools

D-sub connector

X1 Pin	Signal
1	
2	RXD
3	TXD
4	DTR
5	0 V
6	DSR
7	RTS N
8	CTS N
9	

X2 Pin	Signal
1	TXD
2	TXD N
3	RXD
4	RXD N
5	0 V
6	DATA
7	DATA N
8	DCLK
9	DCLK N

3.4 X9 Maintenance plug

3.4.1 Power supply

Supply voltages can be measured at the following points:

X9 Pin	Row A	Row C
28	ACOK	DCOK
29	+ 5V_TST	0V
30	+ 15V_TST	0V
31	15V_TST	0V
32	+ 24V_TST	0V

There is a 10 kΩ resistor between each power supply line and the test terminal to prevent damage by a short circuit.

ACOK: Follows the AC power input without delay. High (= 5V) when power is OK.

DCOK: Follows the supply unit energy buffer. After power on, DCOK goes high (=5 V) when output voltages are stable.

3.4.2 X9 VBATT 1 and 2

Battery back-up for the computer memory and the real time clock.

Voltage of batteries 1 and 2; the voltage must be between 3.3 V and 3.9 V.

X9		
Pin	Row A	Row C
7	VBATT1	VBATT2
8	0V	0V

3.4.3 Drive system

The signal interface with the drive system. It complies with the EIA RS 422 standard, which means that signal transmission is differential. See 3.2 (Figure 3).

X9		
Pin	A	C
16	DRCI1	DRCI1 N
17	DRCO1	DRCO1 N
18	DRCI2	DRCI2 N
19	DRCO2	DRCO2 N
20	0V	

The DRCO signals travel from the robot computer to the drive units.
The DRCI signals enter the robot computer from the drive units.

DRCI1/DRCO1 signals are connected to the internal drive system (backplane connector X22, see 3.1).

DRCI2/DRCO2 are connected to external placed drive units (backplane connector X14, see 3.1).

3.4.4 Measuring system

The signal interface with the serial measuring system. It complies with the EIA RS 422 standard, which means that signal transmission is differential, see 3.2 (Figure 3).

X9		
Pin	**A**	**C**
20		0V
21	MRCI1	MRCI1 N
22	MRCO1	MRCO1 N
23	MRCI2	MRCI2 N
24	MRCO2	MRCO2 N

The MRCO signals travel from the robot computer to the measuring boards.
The MRCI signals enter the robot computer from the measuring boards.

MRCI1/MRCO1 signals are connected to the IRB axes (backplane connector X23, see 3.1).

MRCI2/MRCO2 are used for external axes (backplane connector X12, see 3.1).

3.4.5 Disk drive

The signal interface with the disk drive; TTL levels "0" <=> 0V, "1" <=> +5V.

X9		
Pin	**A**	**Explanation**
9	RD N	Read Data, pulses. Data pulses when reading the diskette
10	WP N	Write Protect, static active low. Indicates whether or not the diskette is write protected.
11	DSKCHG N	Disk Change, static active low. Indicates whether or not there is a diskette in the unit.
12	WD N	Write Data, pulses. Data pulses when writing to the diskette.
13	SSO N	Side Select, static active low. Indicates which side of the diskette is active.
14	DIRC N	Direction in, static active low. Indicates that the heads are to move inwards.
15	0V	

X9		
Pin	**C**	**Explanation**
9	IP N	Index, pulses. One pulse per cycle, c. every 200 milliseconds.
10	TR00 N	Track 00, active low. Indicates that the heads are located at track 0 of the diskette.
11	MO N	Motor on, static low. Starts the motor in the selected unit.
12	WG N	Write Gate, pulses. Enables writing.
13	STEP N	Step, pulses. Steps the heads in the direction indicated by DIRC N.
14	HD N	High Density, static active low. Indicates that a 1.44 MB diskette is in the unit.
15	0V	

Troubleshooting Tools

Write frequency
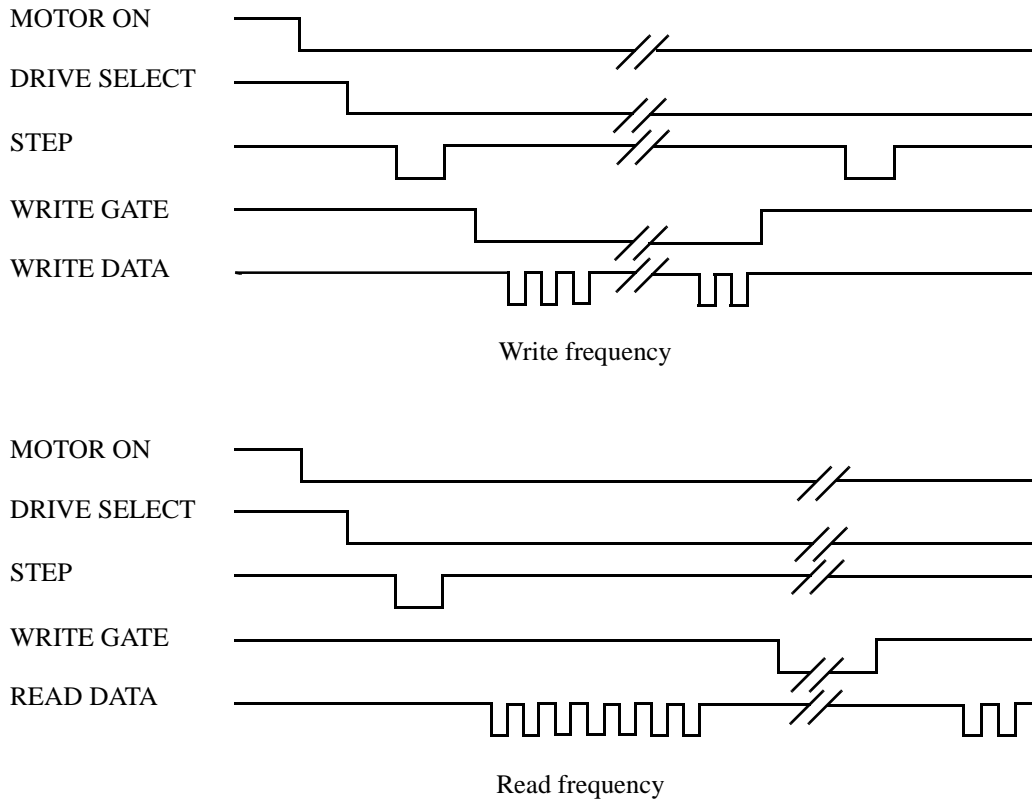
Read frequency

Figure 4 Diagram of write and read frequencies.

3.4.6 Teach pendant

The data transmission signal complies with the EIA RS 422 standard, see 3.2 (Figure 3).

X9		
Pin	**A**	**C**
6	DATA4=TP	DATA4-N=TP-N

3.4.7 CAN

X9		
Pin	**A**	**C**
25	CANRLY2 N	CANRLY3 N
26	CAN_H	CAN_L

CANRLY2 N and CANRLY3 N respectively:
0V when CAN 2 or CAN 3 is active (see Installation and Commissioning, section 3.17.3).

24V when CAN 2 and CAN 3 are disconnected (see Installation and Commissioning, section 3.17.3). In this case the backplane fixed termination resistor is connected in.

3.4.8 Safety

X9		
Pin	**A**	**C**
27	ENABLE9	SPEED

ENABLE 9:
5V when supply voltage is OK and the computers are OK (output from the robot computer to the panel unit; LED EN).

SPEED:
5V when one of the modes AUTO or MANUAL FULL SPEED is active (input to the robot computer from the panel unit).

Troubleshooting Tools

CONTENTS

Fault tracing guide

Product Manual

1 Fault tracing guide

Sometimes errors occur which neither refer to an error message nor can be remedied with the help of an error message.

To make a correct error diagnosis of these particular cases, you must be very experienced and have an in-depth knowledge of the control system. This section of the Product Manual is intended to provide support and guidance in any diagnostic work.

1.1 Starting Troubleshooting Work

Always start off by consulting a qualified operator and/or check any log books available to get some idea of what has happened, to note which error messages are displayed, which LEDs are lit, etc. If possible, look at the control system's error log; if there are any error messages there, it can be accessed from the Service menu. On the basis of this error information, you can start your analysis using the various tools, test programs, measuring points, etc., available.

Never start off by wildly replacing boards or units since this can result in new errors being introduced into the system.

When handling units and other electronic equipment in the controller, the wrist strap in the controller must be used to avoid ESD damage.

1.1.1 Intermittent errors

Unfortunately, intermittent errors sometimes occur and these can be difficult to remedy. This problem can occur anywhere in the robot and may be due to external interference, internal interference, loose connections, dry joints, heating problems, etc.

To identify the unit in which there is a fault, note and/or ask a qualified operator to note the status of all the LEDs, the messages on the teach pendant, the robot's behaviour, etc., each time that type of error occurs.
It may be necessary to run quite a number of test programs in order to pinpoint the error; these are run in loops, which should make the error occur more frequently.

If an intermittent error occurs periodically, check whether something in the environment in which the robot is working also changes periodically. For example, it may be caused by electrical interference from a large electric plant which only operates periodically. Intermittent errors can also be caused by considerable temperature changes in the workshop, which occur for different reasons.

Disturbances in the robot environment can affect cabling, if the cable screen connections are not intact or have been incorrectly connected.

1.1.2 Tools

Usually, the following tools are required when troubleshooting:

- Normal shop tools

- Multimeter

- Oscilloscope

- Recorder

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1.2 Robot system

In this instance the robot system means the entire robot (controller + manipulator) and process equipment.

Errors can occur in the form of several different errors where it is difficult to localise one particular error, i.e. where it is not possible to directly pinpoint the unit that caused the problem. For example, if the system cannot be cold-started, this may be due to several different errors (the wrong diskette, a computer fault, etc.).

1.3 Main computer DSQC 361 and memory board DSQC 323/324

The main computer, which is connected to the VME bus and the local bus of the memory board, looks after the higher-level administrative work in the control system. Under normal operating conditions, all diagnostic monitoring is controlled by the main computer. At start-up, irrespective of whether a cold or warm start is performed, the robot computer releases the main computer when the robot computer's diagnostics allows it and, following this, the main computer takes over the control of the system. The read and write memories of the main computer are battery-backed.

If the red LEDs on the main computer light up (or do not turn off at initialisation), either a critical system failure has occurred or the main computer board or memory board is faulty.

The memory board is an extension of the main computer memory.

The memory board has a LED, F, which is lit and turned off by the main computer.

If there is a memory error on one of these boards, an error code will be shown on the display, T1047 or T2010. These error codes also include a field called the At address, which in turn contains an hexadecimal code that indicates on which board the erroneous memory circuit is located.

When the error is in the *main computer*, the hexadecimal code is in the following range:

0 X 000000 - 0 X 7FFFFF

When the error is in the *memory board*, the code is above 0 X 800 000.

1.4 Robot computer DSQC 363

The robot computer, which controls the system's I/O, axis control, serial communication and teach pendant communication, is the first unit to start after a cold or warm start. The red LED on the front of the board goes off immediately when the system is reset and goes on again if an error is detected in the tests. As mentioned above, the robot computer releases the main computer when the preliminary diagnostics have given the go ahead-signal.

The read and write memories of the robot computer are battery-backed.

If the system does not start at all, and the LED on the robot computer goes on, the error is probably in the robot computer.

1.5 Panel unit DSQC 331

The DSQC 331 Panel unit controls and monitors the dual operation chain. Its status is also indicated by LEDs at the upper part of the unit.

Over temperature of the motors is monitored by PTC inputs to the board.

LED indications for DSQC 331

Marking	Colour	Meaning
EN	Green	Indicates "go ahead" from the control system
MS	Green/red	Module status, normally green, see also section 1.6
NS	Green/red	Network status, normally green, see also section 1.6
ES 1 and 2	Yellow	EMERGENCY STOP, chain 1 and 2 closed
GS 1 and 2	Yellow	GENERAL STOP switch, chain 1 and 2 closed
AS 1 and 2	Yellow	AUTO STOP switch, chain 1 and 2 closed

The LEDs are very useful when trying to locate errors in the operation chain. Unlit LEDs indicate the whereabouts of an error in the operation chain, making the error easy to locate in the system circuit diagram.

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1.5.1 Status of the Panel unit, inputs and outputs, displayed on the teach pendant

- Select the I/O window.

- Call up the *Units* list by choosing **View**.

- Select the **Safety** unit.

The location of the status signals are found in the circuit diagram, regarding Panel unit, where outputs are marked with ⟩——— and inputs with ———⟶

See the table below.

Outputs DO

Name	Meaning when "1" is displayed
BRAKE	Energise brake contactor (i.e. release brakes) and turn on duty time counter
MONLMP	Turn on LED in motor-on push button
RUN CH1	Energise motor contactor chain 1
RUN CH2	Energise motor contactor chain 2
SOFT ASO	Choose delayed turn off of auto stop
SOFT ESO	Choose delayed turn off of emergency stop
SOFT GSO	Choose delayed turn off of general stop

Inputs DI

Name	Meaning when "1" is displayed
AS1	Auto stop chain 1 closed
AS2	Auto stop chain 2 closed
AUTO1	Mode selector chain 1; Auto operation
AUTO2	Mode selector chain 2; Auto operation
CH1	All switches in chain 1 closed
CH2	All switches in chain 2 closed
EN1	Enabling device chain 1 closed
EN2	Enabling device chain 2 closed
ES1	Emergency stop chain 1 closed
ES2	Emergency stop chain 2 closed
ENABLE	Enable from backplane
EXTCONT	External contactors closed
FAN OK	Fan in power supply running
GS1	General stop chain 1 closed
GS2	General stop chain 2 closed
K1	Motor contactor, chain 1, closed
K2	Motor contactor, chain 2, closed
LIM1	Limit switch chain 1 closed
LIM2	Limit switch chain 2 closed
MAN2	Mode selector chain 2; Manual operation
MANFS2	Mode selector chain 2; Manual full speed operation
MANORFS1	Mode selector chain 1; Manual or manual full speed operation
MON PB	Motor-On push button pressed
PTC	Over temperature in motors of manipulator
PTC Ext.	Over temperature in external device
SOFT ASI	Delayed turn off of auto stop (read back of digital output)
SOFT ESI	Delayed turn off of emergency stop (read back of digital output)
SOFT GSI	Delayed turn off of general stop (read back of digital output)
TRFOTMP	Over temperature in main transformer
24V panel	24V panel is higher than 22V

1.6 Distributed I/O

I/O units communicate with the I/O computer, located on the robot computer board, via the CAN bus. To activate the I/O units they must be defined in the system parameters.

The I/O channels can be read and activated from the I/O menu on the teach pendant.

In the event of an error in the I/O communication to and from the robot, check as follows:

1. Is I/O communication programmed in the current program?

2. On the unit in question, the MS (Module status) and NS (Network status) LEDs must be lit with a fixed green colour. See the table below regarding other conditions:

MS LED is:	To indicate	Action
Off	No power	Check 24 V CAN
Green	Normal condition	
Flashing green	Software configuration missing, standby state	Configure device
Flashing red/green	Device self testing	Wait for test to be completed
Flashing red	Minor fault (recoverable)	Restart device
Red	Unrecoverable fault	Replace device

NS LED is:	To indicate	Action
Off	Not powered/not on-line	
Flashing green	On-line, not connected	Wait for connection
Green	On-line, connections established	
Red	Critical link failure, incapable of communicating (duplicate MAC ID, or bus-off)	Change MAC ID and/ or check CAN connection/cables

3. Check that the current I/O signal has the desired status using the I/O menu on the tech pendant display.

4. Check the I/O unit's LED for the current input or output. If the output LED is not lit, check that the 24 V I/O power supply is OK.

5. Check on all connectors and cabling from the I/O unit to the process connection.

1.7 Serial Communication

The most common causes of errors in serial communication are faulty cables (e.g. mixed-up send and receive signals) and transfer rates (baud rates), or data widths that are incorrectly set. If there is a problem, check the cables and the connected equipment before doing anything else.

The communication can be tested using the integral test-program, after strapping the input to the output. See chapter 9.

1.8 Drive System and Motors

The drive system, which consists of rectifier, drive unit and motor, is controlled by the axis computer, located on the robot computer board.
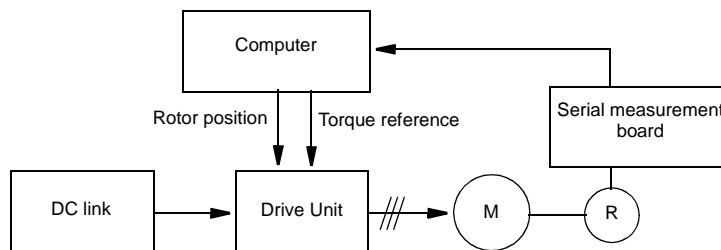
Figure 1 A schematic description of the drive system.

The drive system is equipped with internal error supervision. An error is sent on via the robot computer and can be read on the teach pendant display as an error message. An explanation of the available error messages can be found in the User's Guide, System and error messages, section 3, error no. 39XXX.

If a drive unit or rectifier is faulty, the unit should be replaced. Internal troubleshooting cannot be performed in the operating environment.

Fault tracing guide

1.9 Teach Pendant

The teach pendant communicates with the robot computer via a cable. This cable is also used for the +24 V supply and the dual operation chain.

If the display is not illuminated, try first adjusting the contrast, and if this does not help check the 24 V power supply.

Communication errors between the teach pendant and the I/O computer are indicated by an error message on the teach pendant.

For measuring points for the teach pendant communication signals, see chapter 9.

1.10 Measurement System

The measurement system comprises an axis computer, one or more serial measurement boards and resolvers. The serial measurement board is used to collect resolver data. The board is supplied from 24 V SYS via a fuse on the back plane. The board is located in the manipulator and is battery-backed. Communication with the axis computer takes place across a differential serial link (RS 485).

The measurement system contains information on the position of the axes and this information is continuously updated during operation. If the resolver connections are disconnected or if the battery goes dead after the robot has been stationary for a long period of time, the manipulator's axis positions will not be stored and must be updated. The axis positions are updated by manually jogging the manipulator to the synchro-nised position and then, using the teach pendant, setting the counters to zero. If you try to start program execution without doing the above, the system will give an alarm to indicate that the system is not calibrated.

Measuring points for the measurement system are located on the backplane, X9 Maintenance plug, see chapter 9 for more detailed information.

Note that it is necessary to re-calibrate after the resolver lines have been disconnected. This applies even if the manipulator axes have not been moved.

Transmission errors are detected by the system's error control, which alerts and stops program execution if necessary.

Common causes of errors in the measurement system are line breakdown, resolver errors and measurement board interference. The latter type of error relates to the 7th axis, which has its own measurement board. If it is positioned too close to a source of interference, there is a risk of an error.

1.11 Disk Drive

The disk drive is controlled by the I/O computer via a flat cable. The power is supplied by a separate cable.

Common types of error are read and write errors, generally caused by faulty diskettes. In the event of a read and/or write error, format a new, high quality diskette in the robot and check to see whether the error disappears. If the error is still present, the disk drive will probably have to be replaced. However, check the flat cable first.

NB: Never use diskettes without a manufacturer's mark. Unmarked, cheap diskettes can be of very poor quality.

If the disk drive is completely dead, check the supply voltage connection to the disk drive to see that it is +5 V, before replacing the drive.

Measuring points are available on the backplane: X9 Maintenance plug, see chapter 9. When replacing the disk drive, check that the strapping is set correctly on the unit. Compare with the faulty drive being replaced.

1.12 Fuses

There is one automatic three-phase 20 A fuse that supplies the DC-link in the **MOTORS ON** state, on the transformer. There is also a automatic three-phase 10 A fuse that supplies the power supply unit. There are also two fuses for customer AC supplies, one 3.15 A and one 6.3 A.

The backplane has four PTC resistance fuses:

- Serial measurement board 1
- Serial measurement board 2
- CAN2, manipulator I/O
- CAN3, external I/O

The fuses protect against 24 V short-circuits and return to the normal state when there is no longer a risk of short-circuiting.

The panel unit has one PTC fuse to protect the motor on chains. An open fuse is indicated on the teach pendant, see *Status of the Panel unit, inputs and outputs, displayed on the teach pendant* side 6, 24 panel.

The cabling from customer 24 V supply is protected by a 2A fuse on terminal XT31 in the upper compartment of the controller.

Note that the power supply unit DSQC 374 is provided with a short circuit energy limitation which makes the fuse unnecessary.

Fault tracing guide

ABB Flexible Automation AB

ABB

This chapter is not included in the On-line Manual.

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Repairs

CONTENTS

1 General Description

The industrial robot system comprises two separate units: the control cabinet and the manipulator. The IRB 1400 is also available in a suspended version, IRB 1400H.
Servicing the mechanical unit is described in the following sections.
Servicing the manipulator is described in this manual.
When service on the IRB1400H is contemplated, a decision must be made in each particular case whether the work can be carried out with the manipulator suspended or whether it must be removed and the work done on the floor.
Lifting and turning the manipulator is described in the Chapter entitled, Installation and commissioning.

When servicing the manipulator, it is helpful to service the following parts separately:

- The Electrical System

- The Motor Units

- The Mechanical System

The Electrical System is routed through the entire manipulator and is made up of two main cabling systems: the power cabling and signal cabling. The power cabling feeds the motor units of the manipulator axes. The signal cabling feeds the various control parameters, such as axis positions, motor revs, etc.

The AC Motor Units provide the motive power for the various manipulator axes by means of gears. Mechanical brakes, electrically released, lock the motor units when the robot is inoperative for more than 3 minutes during both automatic and manual operation.

The manipulator has 6 axes which makes its movements very flexible.

Axis 1 rotates the manipulator. Axis 2 provides the lower arm's reciprocating motion. The lower arm, together with the parallel arm and the parallel bracket, forms a parallelogram relative to the upper arm. The parallel bracket is mounted on bearings in the parallel arm and in the upper arm.

Axis 3 raises the upper arm of the manipulator. Axis 4, located on the side of the upper arm, rotates the upper arm. The wrist is bolted to the tip of the upper arm and includes axes 5 and 6. These axes form a cross and their motors are located at the rear of the upper arm.

Axis 5 is used to tilt and axis 6 to turn. A connection is supplied for various customer tools on the tip of the wrist in the turn disc. The tool (or manipulator) can be pneumatically controlled by means of an external air supply (optional extra). The signals to/from the tool can be supplied via internal customer connections (optional extras).

Note that the control cabinet must be switched off during all maintenance work on the manipulator. The accumulator power supply must always be disconnected before performing any work on the manipulator measurement system (measurement boards, cabling, resolver unit).

When any type of maintenance work is carried out, the calibration position of the manipulator must be checked before the robot is returned to the operational mode.

Take special care when manually operating the brakes. Make sure also that the safety instructions described in this manual are followed when starting to operate the robot.

1.1 Instructions for reading the following sections

The subsequent sections describe the type of on-site maintenance that can be performed by the customer's own maintenance staff. Some maintenance jobs require special experience or specific tools and are therefore not described in this manual. These jobs involve replacing the faulty module or component on-site. The faulty component is then transported to ABB Flexible Automation for service.

Calibration: The robot must be re-calibrated when a mechanical unit or part of one is replaced, when the motor and feedback unit is disconnected, when a resolver error occurs, or when the power supply between a measurement board and resolver is interrupted. This procedure is described in detail in Chapter 9, Calibration.

Any work on the robot signal cabling may cause the robot to move to the wrong positions.

After performing such work, the calibration position of the robot must be checked as described in Chapter 9, Calibration.

Tools: Two types of tools are required for the various maintenance jobs. It may be necessary to use conventional tools, such as sockets and ratchet spanners, etc., or special tools, depending on the type of servicing. Conventional tools are not discussed in this manual, since it is assumed that maintenance staff have sufficient basic technical competence. Maintenance jobs which require the use of special tools are, on the other hand, described in this manual.

Foldouts: The chapter on spare parts comes with a number of foldouts which illustrate the parts of the robot. These foldouts are provided in order to make it easier for you to quickly identify both the type of service required and the make-up of the various parts and components. The item numbers of the parts are also shown on the foldouts.

In the subsequent sections, these numbers are referred to in angle brackets < >. If a reference is made to a foldout, other than that specified in the paragraph title, the foldout's number is included in the numeric reference to its item number; for example: <5/19> or <10:2/5>. The digit(s) before the stroke refer to the foldout number.

The foldouts also include other information such as the article number, designation and related data.

NB: This manual is not considered as a substitute for a proper training course. The information in the following chapters should be used only after an appropriate course has been completed.

1.2 Caution

⚠ **The mechanical unit contains several parts which are too heavy to lift manually. As these parts must be moved with precision during any maintenance and repair work, it is important to have a suitable lifting device available.**

The robot should always be switched to MOTORS OFF before anybody is allowed to enter its working space.

1.3 Fitting new bearings and seals

1.3.1 Bearings

1. Do not unwrap new bearings until just before assembly, in order to prevent dust and grit getting into the bearing.

2. Make sure that all parts of the bearing are free from burr dust, grinding dust and any other contamination. Cast parts must be free from foundry sand.

3. Bearing rings, races and roller parts must not under any circumstances be subjected to direct impact. The roller parts must not be subjected to any pressure that is created during the assembly.

Tapered bearings

4. The bearing should be tightened gradually until the recommended pre-tensioning is attained.

5. The roller parts must be rotated a specified number of turns both before pre-tensioning and during pre-tensioning.

6. The above procedure must be carried out to enable the roller parts to slot into the correct position with respect to the racer flange.

7. It is important to position the bearings correctly, because this directly affects the service life of the bearing.

Greasing bearings

8. Bearings must be greased after they are fitted. Extreme cleanliness is necessary throughout. High quality lubricating grease, such as 3HAB 3537-1, should be used.

9. Grooved ball bearings should be greased on both sides.

10. Tapered roller bearings and axial needle bearings should be greased when they are split.

11. Normally the bearings should not be completely filled with grease. However, if there is space on both sides of the bearing, it can be filled completely with grease when it is fitted, as surplus grease will be released from the bearing on start up.

12. 70-80% of the available volume of the bearing must be filled with grease during operation.

13. Make sure that the grease is handled and stored correctly, to avoid contamination.

1.3.2 Seals

1. The most common cause of leakage is incorrect mounting.

Rotating seals

2. The seal surfaces must be protected during transportation and assembly.

3. The seals must either be kept in their original packages or be protected well.

4. The seal surfaces must be inspected before mounting. If the seal is scratched or damaged in such a way that it may cause leakage in the future, it must be replaced.

5. The seal must also be checked before it is fitted to ensure that:

    • the seal edge is not damaged (feel the edge with your finger nail),
    • the correct type of seal is used (has a cut-off edge),
    • there is no other damage.

6. Grease the seal just before it is fitted – not too early as otherwise dirt and foreign particles may stick to the seal. The space between the dust tongue and sealing lip should 2/3-filled with grease of type 3HAB 3537-1. The rubber coated external diameter must also be greased.

7. Seals and gears must be fitted on clean workbenches.

8. Fit the seal correctly. If it is fitted incorrectly, it may start to leak when pumping starts.

9. Always use an assembling tool to fit the seal. Never hammer directly on the seal because this will cause it to leak.

10. Use a protective sleeve on the sealing edge during assembly, when sliding over threads, key-ways, etc.

Flange seals and static seals

11. Check the flange surfaces. The surface must be even and have no pores. The evenness can be easily checked using a gauge on the fitted joint (without sealing compound).

12. The surfaces must be even and free from burr dust (caused by incorrect machining). If the flange surfaces are defective, they must not be used as they will cause leakage.

13. The surfaces must be cleaned properly in the manner recommended by ABB ROBOTICS.

14. Distribute the sealing compound evenly over the surface, preferably using a brush.

15. Tighten the screws evenly around the flange joint.

16. Make sure that the joint is not subjected to loading until the sealing compound has attained the hardness specified in the materials specification.

O-rings

17. Check the O-ring grooves. The grooves must be geometrically correct, without pores and free of dust and grime.

18. Check the O-ring for surface defects and burrs, and check that it has the correct shape, etc.

19. Make sure the correct O-ring size is used.

20. Tighten the screws evenly.

21. Defective O-rings and O-ring grooves must not be used.

22. If any of the parts fitted are defective, they will cause leakage.
    Grease the O-ring with 3HAB 3537-1 before fitting it.

1.4 Instructions for tightening screw joints

General

It is extremely important that all screw joints are tightened using the correct torque.

Application

The following tightening torques must be used, unless otherwise specified in the text, for all screw joints made of metallic materials.

The instructions do not apply to screw joints made of soft or brittle materials.

For screws with a property class higher than 8.8, the same specifications as for class 8.8. are applicable, unless otherwise stated.

Screws treated with Gleitmo

All screws in the manipulator that are tightened to a specified torque are treated with Gleitmo.

⚠️ **When handling screws treated with Gleitmo, protective gloves of nitrile rubber type should be used.**

Screws treated with Gleitmo can be unscrewed and screwed in again 3-4 times before the slip coating disappears. Screws can also be treated with Molycote 1000.

When screwing in new screws without Gleitmo, these should first be lubricated with Molycote 1000 and then tightened to the specified torque.

Assembly

Screw threads sized M8 or larger should preferably be lubricated with oil. Molycote 1000 should only be used when specified in the text.

Screws sized M8 or larger should be tightened with a torque wrench, if possible.

Screws sized M6 or smaller may be tightened to the correct torque by personnel with sufficient mechanical training, without using torque measurement tools.

1.5 Tightening torques

Screws with slotted or cross recessed head, property class 4.8

Dimension	Tightening Torque - Nm
	without oil
M2.5	0.25
M3	0.5
M4	1.2
M5	2.5
M6	5.0

Screws with hexagon socket head, property class 8.8

Dimension	Tightening Torque - Nm	
	without oil	with oil
M3	1	1
M4	2	2
M5	5.5	4
M6	10	9
M8	24	22
M10	48	45
M12	83	78
M16	200	190
M20	410	400
M24	750	740

2 Axis 1

2.1 Changing the motor of axis 1

See foldouts 1 and 5 (6 for IRB 1400H) in the list of spare parts.

The motor and the drive gear constitute one unit.

To dismantle:

1. Remove the cover of the motor.

2. Loosen connectors R4.MP1 and R4.FB1.

3. Remove the connection box by unscrewing <5/160>.

4. Note the position of the motor before removing it.

5. Loosen the motor by unscrewing <1/10>.

To assemble:

6. Check that the assembly surfaces are clean and the motor unscratched.

7. Release the brake, apply 24V DC to terminals 7 and 8 in the 4.MP1 connector.

8. Install the motor, tighten screws <1/10> using a torque of approximately 2 Nm.

   ### *Note the position of the motor*

9. Adjust the motor in relation to the gear in the gearbox.

10. Screw the 3HAB 1201-1 crank tool into the end of the motor shaft.

11. Make sure there is very small play by turning axis 1 at least 45°.

12. Tighten screws <1/10> using a torque of 8.3 Nm ±10%.

13. Connect the cabling.

14. Calibrate the robot as specified in Chapter 9, Calibration.

Tightening torque:

The motor attaching screws, item10:   8.3 Nm ±10%

2.2 Changing the gearbox

Axis 1 gearbox is of the conventional type, manufactured with a high degree of precision and, together with the gearboxes for axes 2 and 3, forms a complete unit.

The gearbox is not normally serviced or adjusted.

Note:
If the gearbox on any of the axes 1, 2 or 3 is changed, the whole unit must be changed.

See foldout 1 (6 for IRB 1400H) in the list of spare parts.

To dismantle:

1. Remove the motors in axes 1, 2 and 3 as in sections 2.1, 3.1 and 4.1.

2. Remove the cabling and serial measuring boards as in Chapter 6, Cabling.

3. Remove the tie rod as in Chapter 4.4, Changing the tie rod.

4. Remove the radius rod as in Chapter 4.3, Dismantling the radius rod.

5. Remove the equalizer springs as in Chapter 3.5, Dismantling the equalizer springs (not valid for IRB 1400H).

6. Dismantle the upper arm as in Chapter 4.5, Dismantling the complete upper arm.

7. Dismantle the lower arm as in Chapter 3.3, Dismantling the lower arm.

8. Place the remaining parts of the manipulator upside-down on a table or similar surface and remove the bottom plate <1/5>. See Figure 1.

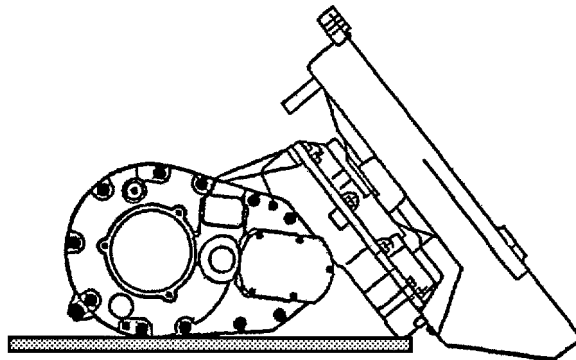⚠ **Make sure that the foot is stable.**

Figure 1 How to position the foot when dismantling axes 1, 2 and 3.

9. Undo screws <1/4>.

10. Separate the base from the gear unit.

To assemble:

11. Place a new gear unit on the table.

12. Raise the base.

13. Screw in the screws <1/4> together with their washers <1/3>. Tighten using a torque of 68 Nm ±10%.

14. Replace the bottom plate <1/5> using screws <1/7>.

15. Turn the foot.

16. Replace the lower arm as in Chapter 3.3, Dismantling the lower arm

17. Replace the radius rod as in Chapter 4.3, Dismantling the radius rod.

18. Replace the upper arm as in Chapter 5.4, Dismantling the tubular shaft and changing bearings.

19. Replace the cabling as in Chapter 6, Cabling and Serial Measurement Boards.

20. Replace the tie rod as in Chapter 4.4, Changing the tie rod.

21. Replace the equalizer springs as in chapter 3.5, Dismantling the equalizer springs (not valid for IRB 1400H).

22. Calibrate the robot as in Chapter 9, Calibration.

Tightening torque:

Screwed joint of base/gear unit, item <4>:   68 Nm ±10%

2.3 Position indicator in axis 1 (optional)

See foldouts 3 and 4 (6 for IRB 1400H) in the list of spare parts.

To dismantle:

1. Remove the flange plate <4/138>.

2. Loosen the connector R1.LS.

3. Dismantle the two limit switches <3/174>.

4. Loosen the cables from the switches.

5. Remove the cabling through the base.

To assemble:

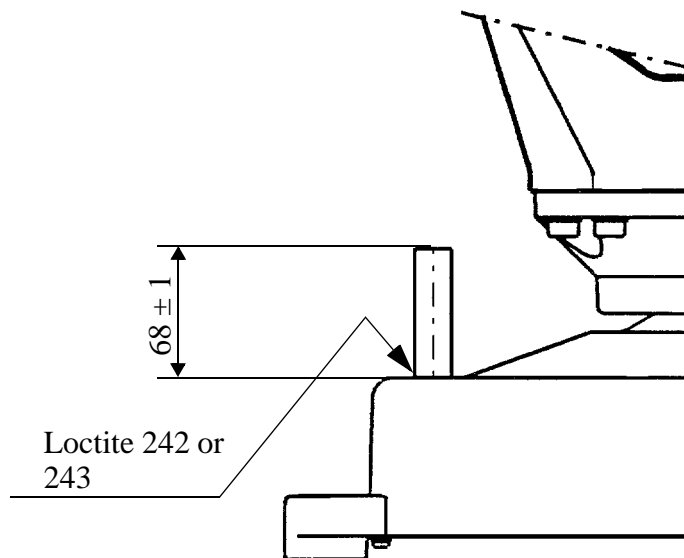6. Assemble in the reverse order.

2.4 Replacing the mechanical stop

See foldout 1 in the list of spare parts.

If the stop pins are bent, they must be replaced.

Remove the old stop pin.

Fit the new pin as illustrated in the diagram below.

68 ± 1

Loctite 242 or 243

3 Axis 2

3.1 Changing the motor of axis 2

See foldouts 1 and 5 (6 for IRB 1400H) in the list of spare parts.

The motor and the drive gear constitute one unit.

To dismantle:

⚠ **Lock the arm system before dismantling the motor; the brake is located in the motor.**

1. Remove the cover of the motor.

2. Loosen connectors R3.MP2 and R3.FB2.

3. Remove the connection box by unscrewing <5/160>.

4. Note the position of the motor before removing it.

5. Loosen the motor by unscrewing <1/10>. **N.B. The oil will start to run out.**

To assemble:

6. Check that the assembly surfaces are clean and the motor unscratched.

7. Release the brake, apply 24 V DC to terminals 7 and 8 on the R3.MP2 connector.

8. Install the motor, tighten screws <1/10> to a torque of approximately 2 Nm.

    Note the position of the motor

9. Adjust the motor in relation to the drive in the gearbox.

10. Screw the 3HAB 1201-1 crank tool into the end of the motor shaft.

11. Make sure there is no play.

12. Tighten screws <1/10> to a torque of 8.3 Nm ±10%.

13. Fill with oil. See Chapter 8, Maintenance.

14. Connect the cabling.

15. Calibrate the robot as specified in Chapter 9, Calibration.

Tightening torque:

The motor's fixing screws, item10: 8.3 Nm ±10%

3.2 Changing the gearbox

Axis 2 gearbox is of a conventional type, manufactured with a high degree of precision and, together with the gearbox for axes 1 and 3, forms a complete unit.

The gearbox is not normally serviced or adjusted.

Note:
If the gearbox of any of the axes 1, 2 or 3 needs to be changed, the whole unit must be changed.

See foldout 1 in the list of spare parts.

To dismantle:

See Chapter 2.1.

3.3 Dismantling the lower arm

See foldouts 1 (6 for IRB 1400H) in the list of spare parts.

To dismantle:

1. Remove the equalizer springs as in Chapter 3.5, Dismantling the equalizer springs (not valid for IRB 1400H).

2. Remove the cabling down to axis 1 as in Chapter 6, Cabling and Serial Measuring Boards.

3. Dismantle the upper arm as in Chapter 4.5, Dismantling the complete upper arm.

4. Attach the crane to the lower arm.

5. Remove the radius rod as in Chapter 4.3, Dismantling the radius rod.

6. Loosen screws <1/13>.

7. Take off the lower arm.

To assemble:

8. Transfer the damping element and calibration marking to the new lower arm.

9. Lift the lower arm into position.

10. Fix the lower arm to gear 2 using screws <1/13> and tighten them to a torque of 68 Nm ±10%.

⚠ **To prevent clicking during operation of the robot, grease the bearing seating of the radius rod in the lower arm.**

11. Replace the radius rod as in Chapter 4.3, Dismantling the radius rod.

12. Replace the upper arm as in Chapter 4.5, Dismantling the complete upper arm.

13. Replace the equalizer springs as in chapter 3.5, Dismantling the equalizer springs (not valid for IRB 1400H).

14. Replace the cabling as in Chapter 6, Cabling and Serial Measurement Boards.

15. Calibrate the robot as in Chapter 9, Calibration.

Tightening torque:

Screwed joint of lower arm/gear 2, item <13>:   68 Nm ±10%

3.4 Changing the bearings in the upper arm

See foldout 1 (6 for IRB 1400H) in the list of spare parts.

To dismantle:

1. Loosen the upper bracket of the tie rod as in Chapter 4.4, Changing the tie rod.

2. Unscrew screws <13> which hold the radius rod to gear 3.

3. Remove the bearings from the radius rod.

To assemble:

4. Fit new bearings to the radius rod.

5. Replace the radius rod using screws <13> and tighten to a torque of 68 Nm ±10%.

6. Attach the upper bracket of the tie rod as in Chapter 4.4, Changing the tie rod.

7. Calibrate the robot as in Chapter 9, Calibration.

Tightening torque:

Screwed joint of radius rod/gear 3, pos. <13>:   68 Nm ±10%

3.5 Dismantling the balancing springs

See foldouts 1 and 2 in the list of spare parts.

NOTE! Not valid for IRB 1400H.

To dismantle:

1. Place the lower arm in a vertical position.

2. Loosen the locking nut <1/76>.

3. Release the spring using tool 3HAB 1214-6 and undo screw <1/13> at the same time.

⚠ **If the tool 3HAB 1214-6 is not available, but there are two persons, then the spring can be released manually.**

4. Unscrew <2/65> in the upper bracket of the spring.

5. Remove the springs.

To assemble:

6. Before installing new springs, make sure that the distance between the attachment points is correct, see Figure 2. Lock the link heads using Loctite 242 or 243.
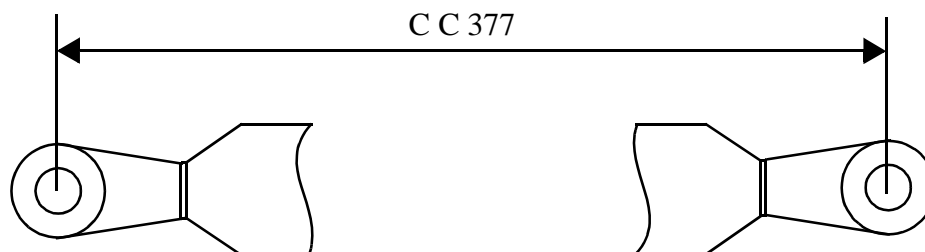

Figure 2 Distance between the attachment points.

7. Lubricate the link heads with grease.

8. Attach the springs to the top bracket using screws <2/65> and tighten to a torque of 68 Nm ±10%.

9. Pull the springs down using tool 3HAB 1214-6 and attach screws <1/13>, together with lifting lug <1/23> and washer <1/17>.

10. Attach the locking nut <1/76>.

Tightening torque:

Screws of upper bracket, position <65>:   68 Nm ±10%.

4 Axis 3

4.1 Changing the motor of axis 3

See foldouts 1 and 5 (6 for IRB 1400H) in the list of spare parts.

The motor and the drive gear constitute one unit.

To dismantle:

1. Remove the cover of the motor.

2. Loosen connectors R5.MP3 and R5.FB3.

3. Remove the connection box by unscrewing <5/160>.

4. Note the position of the motor before removing it.

5. Loosen the motor by unscrewing <1/10>. **N.B. The oil will start to run out.**

To assemble:

6. Check that the assembly surfaces are clean and the motor unscratched.

7. Release the brake, apply 24 V DC to terminals 7 and 8 on the 4.MP1 connector.

8. Install the motor, tighten screws <1/10> to a torque of approximately 2 Nm.

   Note the position of the motor

9. Adjust the motor in relation to the drive in the gearbox.

10. Screw the 3HAB 1201-1 crank tool into the end of the motor shaft.

11. Make sure there is no play.

12. Tighten screws <1/10> to a torque of 8.3 Nm ±10%.

13. Fill with oil. See Chapter 8, Maintenance.

14. Connect the cabling.

15. Calibrate the robot as specified in Chapter 9, Calibration.

Tightening torque:

The motor's fixing screws, item 10: 8.3 Nm ±10%

4.2 Changing the gearbox

Axis 3's gearbox is of a conventional type, manufactured with a high degree of pre-cision and, together with the gearbox for axes 1 and 2, forms a complete unit.

The gearbox is not normally serviced are adjusted.

Note:
If the gearbox of any of the axes 1, 2 or 3 needs to be changed, the whole unit must be changed.

See foldout 1 in the list of spare parts.

To dismantle:

See Chapter 2.1.

4.3 Dismantling the parallel arm

See foldout 1 (6 for IRB 1400H) in the list of spare parts.

To dismantle:

1.   Loosen the upper bracket of the tie rod as in Chapter 4.4, Changing the tie rod.

2.   Unscrew screws <13> which fix the parallel arm to gear 3.

3.   Remove the bearings from the parallel arm.

To assemble:

4.   Fit the bearings on the parallel arm.

5.   Replace the parallel arm using screws <13> and tighten to a torque of 68 Nm ±10%.

6.   Attach the upper bracket of the tie rod as in Chapter 4.4, Changing the tie rod.

7.   Calibrate the robot as in Chapter 9, Calibration.

Tightening torque:

Screwed joint of parallel arm/gear 3,item <13>:   68 Nm ±10%

4.4 Changing the tie rod

See foldout 2 in the list of spare parts.

To dismantle:

⚠ **Lock the upper arm in a horizontal position with the help of a crane or similar.**

1. Unscrew screw <74>.

2. Undo the two screws for fixing the cabling bracket of the upper arm housing. Fold back the cabling bracket.

3. Screw the screw <74> back into the shaft <71>.

4. Carefully knock the shaft out.

5. Remove housing <72>.

6. Unscrew <70> on the lower bracket.

7. Carefully tap the rod off the shaft.

8. Change the bearings.

To assemble:

9. Fit bearings on the parallel arm.

10. Make sure you replace the rod the correct way up. See foldout 1 (1:1).

11. Install grommets: (3 x) <68> and (1 x) <75>.

    Note: grommet <75> is bevelled and must be inserted the right way up in the lower bearing.

12. Place the lower bearing of the tie rod on the parallel arm.

13. Screw in screw <70> and its washer <69>. Lock using Loctite 242 or 243.

14. Replace shaft <71>. **N.B. Do not forget the sleeve <72>.**

15. Mount washer <73> and tighten the shaft using a temporary screw, M8x35.

16. Replace this screw by screw <74> and mount the cable bearer <163>. Lock using Loctite 242 or 243.

4.5 Dismantling the complete upper arm

See foldout 2 in the list of spare parts.

To dismantle:

⚠️ **Attach a crane to the upper arm.**

1.   Unscrew the upper bracket of the tie rod as in Chapter 4.4, Changing the tie rod.

2.   Loosen the connectors of the motors of axes 4, 5 and 6.

3.   Disconnect the connection box from the motors.

4.   Detach the equalizer springs as in Chapter 3.5, Dismantling the balancing springs (not valid for IRB 1400H).

5.   Undo the KM nuts <64>.

6.   Remove washers <63> and shims <61-62> on the same side as axis 3.

7.   Attach the withdrawing tool 3HAB 1259-1 and pull the axes off.

To assemble:

8.   Raise the upper arm into assembly position.

9.   Install shaft spindles <59> (both sides), use two temporary screws M10x90.

10. Insert bearings <60> (both sides) using tool 3HAB 1200-1 and screws <65>.

11. Detach the tool and tighten the screws once more, only to prevent rotation of the axis when the KM nut is tightened.

     N.B. Assemble the same side as axis 2 first.

12. Mount two washers <63> and calibration washer <50>.

13. Tighten using the KM nut <64>.

14. Attach the measuring instrument 3HAB 1205-1 to the shaft spindle on axis 3.

     N.B. If measuring instrument 3HAB 1205-1 is not available, you can use a micrometer thickness gauge.

15. Hold the tool against the shoulder of the shaft spindle and measure the dimension "A". See Figure 3.
     (If you are not using the measuring instrument, tighten using the KM nut and, before measuring with the micrometer thickness gauge, then undo it again.)
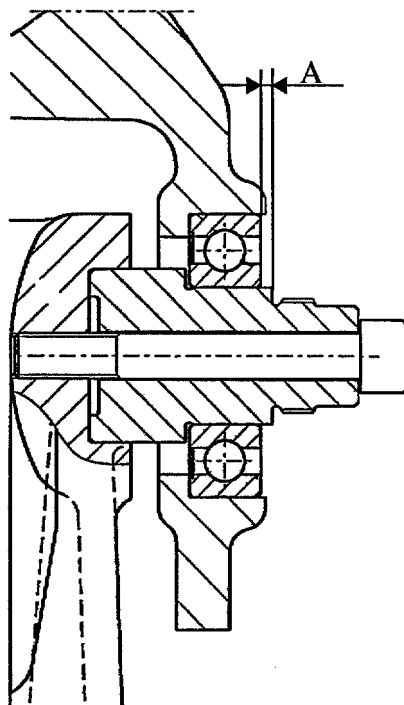
Figure 3 Measuring the shim thickness when preloading the bearing.

16. Make a note of the dimension "A". Fit one washer <63> and shims <61-62> and, using the micrometer, measure the thickness so that the total thickness is 0.10 - 0.20 mm more than the noted dimension "A". This will result in a preloading of the bearing of 0.10 - 0.20 mm.

17. Fit the shims and washer and tighten the KM nut <64>.

18. Replace the upper attachment of the tie rod as in Chapter 4.4, Changing the tie rod.

19. Replace the equalizer springs as in Chapter 3.5, Dismantling the balancing springs (not valid for IRB 1400H).

20. Reconnect the connection boxes and the cabling.

21. Calibrate the robot as in Chapter 9, Calibration.

22. Undo the KM-nut on the axis 2 side, just to be able to adjust the calibration washer <50>.

23. If the old armhouse is mounted, adjust the calibration washer according to the punch mark. If the armhouse is new adjust the washer according to Figure 4 and make a new punch marks for axes 3 and 4, according to chapter 9.2.
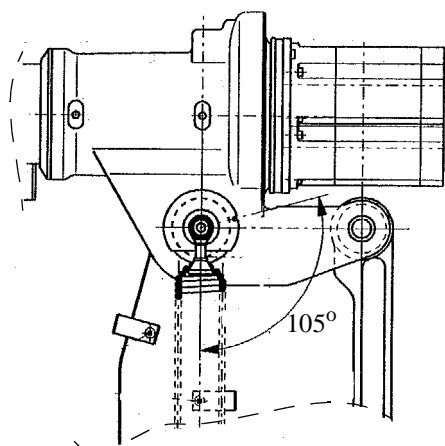
Figure 4 Calibraion mark for axis 3.

Tools:

Pressing tool for bearings:	3HAB 1200-1
Measuring instrument:	3HAB 1205-1
Withdrawing tool for shaft spindles:	3HAB 1259-1

5 Axis 4

5.1 Changing the motor

See foldouts 5 and 8 in the list of spare parts.

The motor and the drive gear constitute one unit.

Position the arm system in such a way that the motor of axis 4 points upwards.

To dismantle:

1. Remove the cover of the motor.

2. Loosen connectors R3.MP4 and R3.FB4.

3. Remove the connection box by unscrewing <5/160>.

4. Note the position of the motor before removing it.

5. Loosen the motor by unscrewing <8/23>.

To assemble:

6. Check that the assembly surfaces are clean and the motor unscratched.

7. Put O-ring <8/21> on the motor.

8. Release the brake, apply 24 V DC to terminals 7 and 8 on theR3.MP4 connector.

9. Install the motor, tighten screws <8/23> to a torque of approximately 2 Nm.

    Note the position of the motor

10. Adjust the position of the motor in relation to the drive in the gearbox.

11. Screw the 3HAB 1201-1 crank tool into the end of the motor shaft.

12. Make sure there is a small clearance.

13. Unscrew one screw at a time, apply Loctite 242 or 243 and tighten to a torque of 4.1 Nm ±10%.

14. Connect the cabling.

15. Calibrate the robot as in Chapter 9, Calibration.

Tightening torque:

The motor's fixing screws, item <23>:   4.1 Nm ±10%

Tool:

Crank tool for checking the play: 3HAB 1201-1

5.2 Changing the intermediate gear including sealing

See foldout 8 in the list of spare parts.

To dismantle:

1.   Dismantle the wrist as in Chapter 7, The Wrist and Axes 5 and 6.

2.   Dismantle the drive mechanism as in Chapter 7.2, Dismantling the complete drive mechanism of axes 5 and 6.

3.   Dismantle the motor of axis 4 as in Chapter 5.1, Changing the motor.

4.   Remove the cover <25>.

5.   Undo screws <18> fixing the large drive gear <17> and dismantle it.

     N.B. Put the shims in a safe place.

6.   Undo screws <12>.

7.   Push the intermediate gear out of the arm housing.

To assemble:

8.   Grease the seating of the arm housing to provide radial sealing.

9.   Push the gear unit down into the arm housing.

10. Screw in screws <12> together with their washers <13> and pull the gear down.

11. Mount the drive gear <17> using screws <18> and tighten to a torque of 8.3 Nm ±10%.

     N.B. Do not forget to insert shims <14, 15, 16> under the drive gear.

12. Tighten screws <12> to a torque of approximately 5 Nm.

13. Bend the pinion towards the large drive gear and then rotate it around the tubular shaft a couple of times so that the clearance in the gears can adjust itself in relation

to the highest point of the large drive gear.

14. Then tighten screws <12> to a torque of 20 Nm ±10%.

15. Check the clearance in relation to the tightening torque.

16. Replace the cover <25> using screws <26>. Use a drop of Loctite 242 or 243.

17. Position the manipulator so that the tubular shaft points upwards.

18. Fill (30 ml) oil into the gear of axis 4. See Maintenance of IRB 1400.

19. Install the motor of axis 4 as in Chapter 5.1, Changing the motor.

20. Install drive mechanism <28> as in Chapter 7.2, Dismantling the complete drive mechanism of axes 5 and 6.

21. Replace the wrist as in Chapter 7, The Wrist and Axes 5 and 6.

22. Calibrate the robot as in Chapter 9, Calibration.

Tightening torque:

Screws for the large drive gear, item <18>:   8.3 Nm ±10%

Screws for the intermediate gear of axis 4, item <12>:   20 Nm ±10%

5.3 Dismantling the drive gear on the tubular shaft

See foldout 8 in the list of spare parts.

To dismantle:

1. Dismantle the wrist as in Chapter 7, The Wrist and Axes 5 and 6.

2. Dismantle the drive mechanism as in Chapter 7.2, Dismantling the complete drive mechanism of axes 5 and 6.

3. Dismantle the motor of axis 4 as in Chapter 5.1, Changing the motor.

4. Remove the cover <25>.

5. Unscrew screws <12> that hold the intermediate gear in place.

6. Unscrew screws <18> that hold the large drive gear <17> and then dismantle it.

   N.B. Put the shims from under the drive gear in a safe place.

To assemble:

Shim between drive gear <17> and the rear bearing <3>.
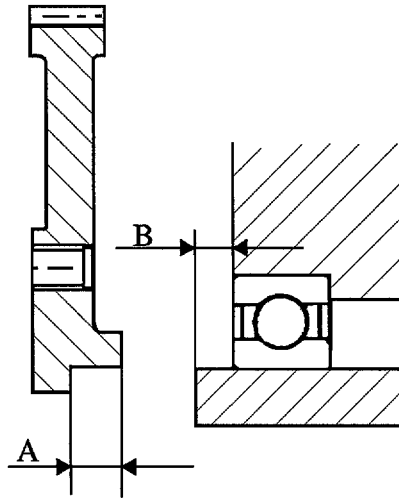Shim thickness = B - A + 0.05 mm, see Figure 5.

Figure 5 Measuring the shim thickness of the drive gear of axis 4.

7.   Install the drive gear using screws <18> and tighten to a torque of 8.3 Nm ±10%.

N.B. Do not forget the shims.

8.   Screw screw <19> and 2 washers <20> into the drive gear. Lock using Loctite 242 or 243.

9.   Mount the intermediate gear as in Chapter 5.2, Changing the intermediate gear including sealing.

10.   Lubricate the drive gear with grease (30 g).

11.   Install the motor of axis 4 as in Chapter 5.1, Changing the motor.

12.   Replace the cover <25> using screws <26>. Lock using a drop of Loctite 242 or 243.

13.   Mount the drive mechanism as in Chapter 7.2, Dismantling the complete drive mechanism of axes 5 and 6.

14.   Mount the wrist as in Chapter 7.1, Dismantling the wrist.

15.   Calibrate the robot as in Chapter 9, Calibration.

Tightening torque:

Screws of drive gear, item <18>:   8.3 Nm ±10%

5.4 Dismantling the tubular shaft and changing bearings

See foldout 8 in the list of spare parts.

To dismantle:

1.   Dismantle the drive gear as in Chapter 5.3, Dismantling the drive gear on the tubular shaft.

2.   Push out the tubular shaft.

To assemble:

3.   Fit a new bearing <3> on the tubular shaft using tool 6896 134-V.

4.   Push the tube into the housing of the upper arm.

5.   Insert the rear bearing <3> using tool 6896 134-JB.

6.   Mount the drive gear as in Chapter 5.3, Dismantling the drive gear on the tubular shaft.

7.   Calibrate the robot as in Chapter 9, Calibration.

Tools:

Pressing tool for front bearing: 6896 134-V

Pressing tool for rear bearing: 6896 134-JB

6 Cabling and Serial Measuring board

6.1 Changing serial measuring boards

See foldout 4 in the list of spare parts.

To dismantle:

1. Remove flange plate <138>.

2. Cut tie around bundle <144>.

3. Unscrew the serial measuring board <135> using screws <7>.

4. Remove the board and loosen the contacts.

To assemble:

5. Assemble in the reverse order.

6.2 Changing the cabling in axes 1, 2 and 3

See foldouts 3 and 4 (7 for IRB 1400H) in the list of spare parts.

To dismantle:

1. Remove the cover of the motors.

2. Remove the flange plate <4/138>.

3. Loosen connectors R1.MP, R2.FB1-3.

4. Cut tie around bundle and detach the cable brackets.

5. Detach the cable guides <3/104 and 105> and undo screws <3/149>.

6. Loosen the connectors in the motors.

7. Disconnect the connection boxes in the motors.

8. Feed the cabling up through the middle of axis 1.

To assemble:

9. Assemble in the reverse order.

6.3 Changing the cabling in axes 4, 5 and 6

See foldouts 2, 3 and 4 (6 for IRB 1400H) in the list of spare parts.

To dismantle:

1. Remove the cover of the motors.

2. Remove the flange plate <4/138>.

3. Loosen connectors R2.MP4-6 and R2.FB4-6, including customer connector R1.CS (if there is one) and the air hose.

4. Detach the cable guides <3/104, 105>.

5. Loosen the cable brackets <3/149> between gears 2 and 3 and cut the tie around them.

6. Feed the cabling and air hose up through axis 1.

7. Loosen the cable bracket on the lower arm and undo screws <3/147>.

8. Undo screw <2/74> which fixes the shaft of the tie rod.

9. Disconnect the connection boxes in the motors.

10. Loosen the remaining cable brackets and remove the cabling.

To assemble:

11. Assemble in the reverse order.

7 The Wrist and Axes 5 and 6

The wrist, which includes axes 5 and 6, is a complete unit, comprising drive units and gears. It is of such a complex design that it is not normally serviced on-site, but should be sent to ABB Flexible Automation to be serviced.

ABB ROBOTICS recommends its customers to carry out only the following servicing and repair work on the wrist.

 • Grease the wrist according to the table in the chapter on maintenance.

7.1 Dismantling the wrist

See foldouts 1 (6 for IRB 1400H) and 9 in the list of spare parts.

To dismantle:

1.   Remove the 2 plastic plugs on the rear of the wrist.

2.   Release the brake in axes 5 and 6.

3.   Rotate axes 5 and 6 so that you can see screws <9/15> in the clamping sleeve through the hole.

4.   Disconnect the clamping sleeve.

5.   Undo screws <1/53> and remove the wrist.

To assemble:

6.   Mount the wrist, tighten screws <1/53> to a torque of 8.3 Nm ±10%.

     Note! The grease nipple on the tilt house should be pointing against the base when the axis 4 is in the calibration position.

7.   Screw the clamping sleeves together using screws <9/15>.

8.   Replace the plastic plugs.

9.   Calibrate the robot as in Chapter 9, Calibration.

Tightening torque:

Screwed joint of wrist/tubular shaft, item <1/53>: 8.3 Nm ±10%

7.2 Dismantling the complete drive mechanism of axes 5 and 6

See foldouts 8 and 9 in the list of spare parts.

To dismantle:

1. Dismantle the wrist as in section 7.1.

2. Loosen the connectors on the motors of axes 5 and 6.

3. Undo screws <8/29>.

4. Squeeze the drive shafts (<9/1>) together at the tip of the tubular shaft, in order that they can pass through the tube.

5. Pull out the complete drive mechanism of axes 5 and 6.

To assemble:

6. Install the drive mechanism in the tubular shaft.

7. Tighten screws <8/29> to a torque of 8.3 Nm ±10%.

8. Insert the cabling.

9. Mount the wrist as in section 7.1.

Tightening torque:

Screwed joint of the drive mechanism, item <8/29>: 8.3 Nm ±10%

7.3 Changing the motor or driving belt of axes 5 and 6

See foldout 9 in the list of spare parts.

To dismantle:

1. Dismantle the wrist as in section 7.1.

2. Dismantle the drive mechanism as in 7.2.

3. Undo screws <9> and remove the appropriate motor.

4. If the driving belt is to be changed, both motors must be removed.

5. Undo screws <9> and remove plate <7>.

To assemble:

6.   Install the driving belts.

7.   Mount the plate <7> using screws <9>.

   N.B. Do not forget the nuts of the motors.

8.   Install the motors.

9.   Push the motors in sideways to tension the belts. Use tool 3HAA 7601-050.
     Tighten screws <9> to a torque of 4.1 Nm.

10. Rotate the drive shafts. Check the tension on the belt.

11. Install the drive mechanism as in section 7.2.

12. Mount the wrist as in section 7.1.

13. Calibrate the robot as in Chapter 9, Calibration.

Tightening torque:

Screws for motors and plate, item <9>:   4.1 Nm.

Tool:

To adjust the belt tension: 3HAA 7601-050

7.4 Measuring play in axes 5 and 6

Axis 5.

Axis 4 shall be turned 90°. The maximum accepted play in axis 5 is 4.7 arc.minutes
when loading axis 5 with a moment of 4.8 Nm in one direction, unloading to 0.24 Nm
and start measuring the play, loading in the other direction with 4.8 Nm unloading to
0.24 Nm and reading the play. This correspond to play of 0.27 mm on a radius of 200
mm when the load is F=40 N and 2 N on radius 120 mm.
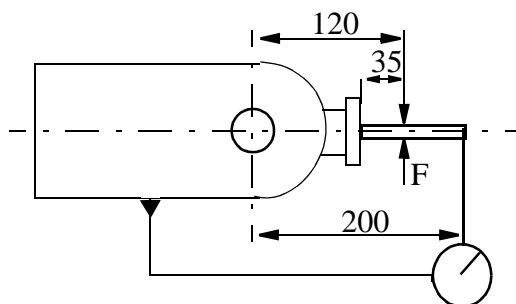
Axis 6.

The maximum accepted play in axis 6 is 12.8 arc.minutes when loading axis 6 with a moment of 4.2 Nm in one direction, unloading to 0.2 Nm and start measuring the play, loading in the other direction with 4.2 Nm unloading to 0.2 Nm and reading the play. This correspond to a play of 0.37 mm on a radius of 100 mm when the load is F=42 N and 2 N.
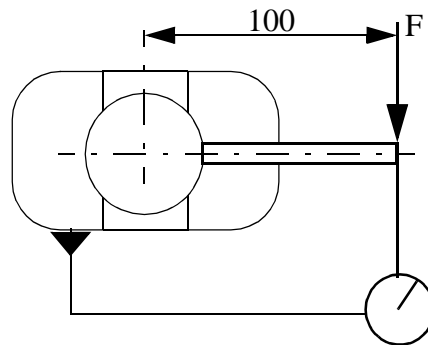
8 Motor Units

General

Each axis of the manipulator has its own motor unit, comprising:

- a synchronous motor

- a brake (built into the motor)

- a feedback device.

There are a total of six motors mounted in the manipulator.

The power and signal cables are run to the respective motor from the cable connector points on the manipulator. The cables are connected to the motor units by connectors.

The drive shaft of the electric motor forms a part of the gearbox of the manipulator axis. A brake, operated electromagnetically, is mounted on the rear end of the motor shaft and a pinion is mounted on its drive end. The brake releases when power is supplied to the electromagnets.

N.B.
There is a feedback device mounted on each motor unit. The device is installed by the supplier of the motor and should never be removed from the motor.
The motor need never be commutated.

The commutation value of the motors is: 1.570800.

The motor, resolver and brakes are regarded as one complete unit.

9 Calibration

General

The robot measurement system consists of one feedback unit for each axis and a measurement board which keeps track of the current robot position. The measurement board memory is battery-backed.

The measurement system needs to be carefully calibrated (as in Chapter 9.1) if any of the resolver values change. Resolver values change when any

- part of the manipulator that affects the calibration position is replaced.

The system needs to be coarsely calibrated (as in Chapter 9.2) if the contents of the revolution counter memory are lost. The memory may be lost if:

- the battery is discharged.

- a resolver error occurs

- the signal between the resolver and measurement board is interrupted.

9.1 Adjustment procedure using calibration equipment (fine calibration)

The axes are calibrated in numerical order, i.e. 1 - 2 - 3 - 4 - 5 - 6.

1.   Move the robot to the calibration position, corresponding to the calibration marks, as shown in Figure 17.

2.   Calibrate all the axes as described below.
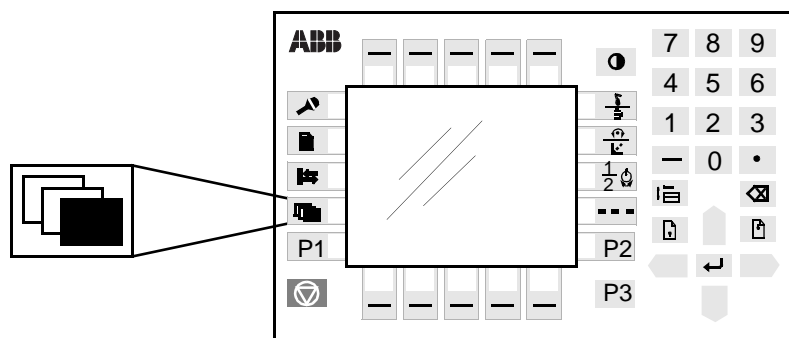
3.   Press the **Misc.** window key (see Figure 6).

Figure 6 The Misc. window key.

4.   Choose **Service** from the dialog box that appears on the display.

5. Press **Enter**   ⏎ .

6. Choose **View: Calibration**. The window shown in Figure 7 appears.

```
    File    Edit    View    Com

 Service Commutation

 Mech Unit              Status
                                    1(4)

 Robot                  Not Calibrated




```

Figure 7 The window shows whether or not the robot system units are calibrated.

The calibration status can be any of the following:

- **Synchronized**
  All axes are calibrated and their positions are known. The unit is ready for use.

- **Not updated Rev. Counter**
  All axes are fine-calibrated but the counter on one (or more) of the axes is NOT updated. That axis or axes must therefore be updated as described in Chapter 9.2.

- **Not calibrated**
  One (or more) of the axes is NOT fine-calibrated. That axis or axes must therefore be fine-calibrated as described in Chapter 9.1.

7. If there is more than one unit, select the desired unit in the window in Figure 7. Choose **Calib: Calibrate** and the window shown in Figure 8 will appear.

.

```
 Calibration!
 Robot
 To calibrate, include axes and press OK.

      Axis                Status
                                    1(6)
 X     1          Not Fine Calibrated
 X     2          Not Fine Calibrated
       3              Fine Calibrated
       4              Fine Calibrated
 X     5          Not Fine Calibrated
 X     6          Not Fine Calibrated


    Incl    All          Cancel    OK
```

Figure 8 The dialog box used to calibrate the manipulator.

8. Press the function key *All* to select all axes, if all axes are to be calibrated. Otherwise, select the desired axis and press the function key *Incl* (the selected axis is marked with an x).

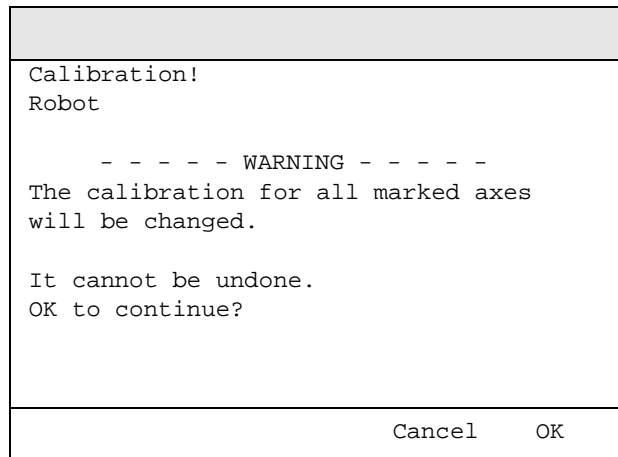9. Confirm your choice by pressing *OK*. The window shown in Figure 9 appears.

```
Calibration!
Robot

     - - - - - WARNING - - - - -
The calibration for all marked axes
will be changed.

It cannot be undone.
OK to continue?


                        Cancel    OK
```

Figure 9 The dialog box used to start the calibration.

10. Start the calibration by pressing *OK*.

    An alert box is displayed during the calibration.
    The Status window appears when the fine calibration is complete. The revolution counters are always updated at the same time as the calibration is performed.
    The robot is now roughly calibrated.

11. Remove the protective plate from the reference surface on the manipulator base.

12. Attach the calibration tool for axis 1 on the guide pin underneath the gearbox, see Figure 10.
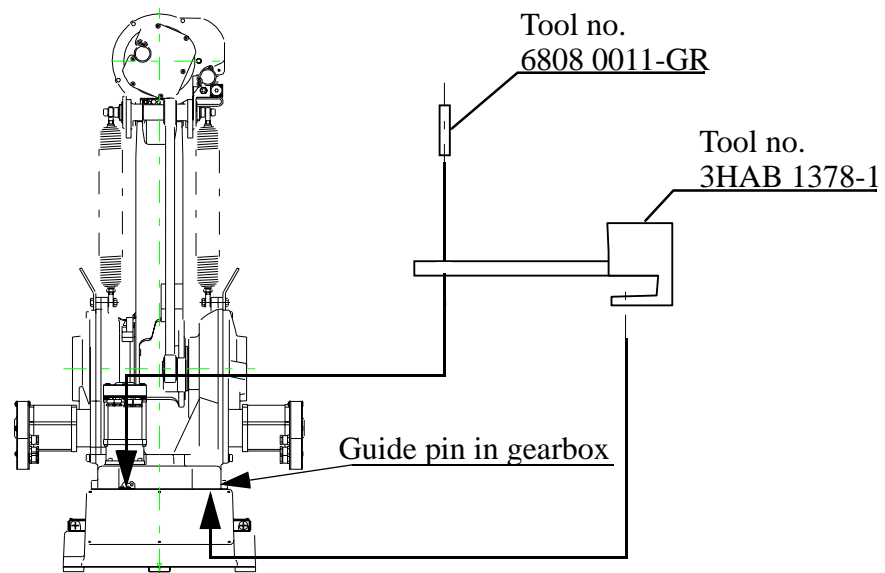

Tool no. 6808 0011-GR

Tool no. 3HAB 1378-1

Guide pin in gearbox

Figure 10 <calibration of axis 1.

13. Release the brakes and move the manipulator manually so that the tool 6808 0011-GR can be located in the guide hole on the reference plane.

14. Update axis 1 *only*, as described above.

15. Remove the calibration too for axis 1.

16. Fit the reference plane no. 6808 0011-GM on the foot.

17. Calibrate the sensors against each other, using the reference plane surface. See Figure 11. The sensors must be calibrated every time they are used for a new direction.
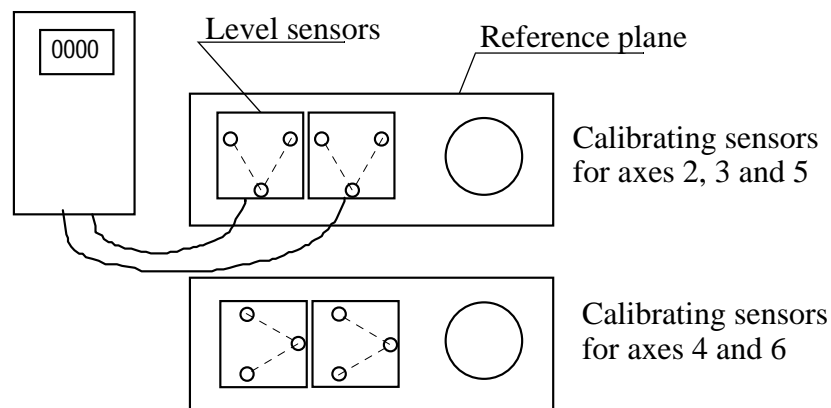

Figure 11 Calibrating the sensors.

18. Fit the angle shelf no. 6808 0011-LP on the lower arm. Adjust the angle of the shelf, with the help of the sensors, before starting calibration.

19. Fit the angle shelf no. 6808 0011-GU on the turning disc.

20. Position the sensors as shown Figure 12, for axis 2.

21. Run the manipulator so that the instrument shows 0 ±16 increments (0.4 mm/m).

22. Update axis 2 as described above. ***Remove the sensors.***

23. Select the Program window and open the file CAL1400 on the Controller Parameter disk. Run the program and select Calib: Cal3. The robot will now move itself to the position for calibration of axis 3.

24. Put the sensors on the shelf and jog the robot to the calibration position, 0±16 increments. See Figure 12.

25. Update axis 3, as described above. ***Remove the sensors.***

26. Run the calibration program 4A on the system diskette.

27. Calibrate the sensors for a new direction. See Figure 11.

28. Run axis 4 to the correct position as indicated by the instrument, 0 ±32 increments.

29. Update axis 4 as described above. ***Remove the sensors.***

30. Run the calibration program 4B.

31. The robot will now be standing in the correct position.

32. Update axis 4 as described above.

33. Calibrate the sensors for a new direction. See Figure 11.

34. Put the sensors on the shelf and run the robot so that axis 5 comes to the correct calibration position, 0 ±32 increments. See Figure 12.

35. Update axis 5 as described above.

36. Calibrate the sensors for a new direction. See Figure 11.

37. Adjust axis 6, 0 ±32 increments. See Figure 12.

38. Update axis 6 as described above.

39. Save the calibration values on the system diskette, Set up. Select SYSTEM PARAMETERS and choose **File: Save all as;** SYSPAR Directory; OK; OK.

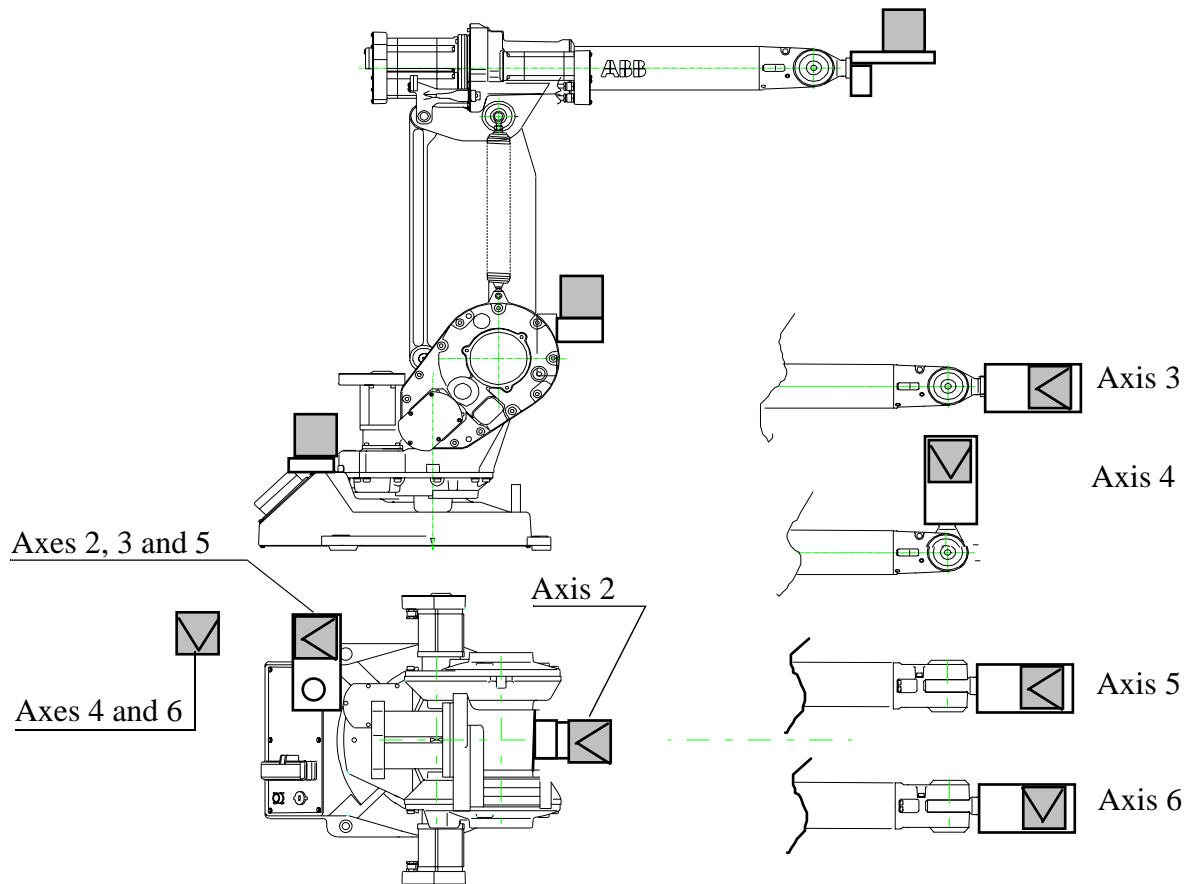40. Change the values on the plate, located underneath the plate <4/138>.

Figure 12 Calibration directions.

Calibration plate and calibration marks

41. The calibration positions for axes 1, 2, 3 and 4 are marked using a punch mark tool, 3HAB 1232-1.

42. Check the calibration position as specified in Chapter 9.3.

43. Save the system parameters on a floppy disk.

9.2 Setting the calibration marks on the manipulator

When starting up a new robot, a message may be displayed telling you that the manipulator is not synchronised. The message appears in the form of an error code on the teach pendant. If you receive such a message, the revolution counter of the manipulator must be updated using the calibration marks on the manipulator. See Figure 17.

Examples of when the revolution counter must be updated:

- when the battery unit is discharged

- when there has been a resolver error

- when the signal between the resolver and the measuring system board has been interrupted

- when one of the manipulator axes has been manually moved without the controller being connected.

It takes 36 hours of operation to recharge the battery unit.

If the resolver values must be calibrated, this should be done as described in the chapter on Repairs in the IRB 1400 Product Manual.

⚠ **WARNING**
Working in the robot work cell is dangerous.

Press the enabling device on the teach pendant and, using the joystick, manually move the robot so that the calibration marks lie within the tolerance zone (see Figure 17). N.B. Axes 5 and 6 must be positioned together.

Note that axis 6 does not have any mechanical stop and can thus be calibrated at the wrong face-plate revolution. Do not manually operate axes 5 and 6 before the robot has been calibrated.

When all axes have been positioned as above, the values of the revolution counter can be stored by entering the following commands on the teach pendant:

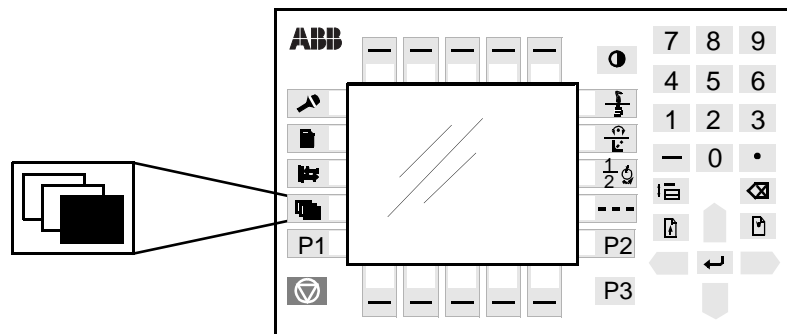1. Press the **Misc.** window key (see Figure 13).

Figure 13 The Misc. window key from which the Service window can be chosen.

2. Select **Service** in the dialog box shown on the display.

3. Press Enter [↵] .

4. Then, choose **View: Calibration**. The window shown in Figure 14 appears.

```
    File    Edit    View    Calib

  Service Calibration

  Mech Unit            Status
  ═══════════════════════════════ 1(4)

   Robot              Unsynchronized




```

Figure 14 This window shows whether or not the robot system units are calibrated.

5. Select the desired unit in the window, as in Figure 14.
    Choose **Calib: Rev. Counter Update**. The window shown in Figure 15 appears.

```
  ┌─────────────────────────────────┐
  │                                 │
  │ Rev. Counter Updating!          │
  │ Robot                           │
  │ To update, include axes and press OK. │
  │                                 │
  │      Axis            Status     │
  │ ═══════════════════════════ 1(6)│
  │ X    1      Not updated Rev. Counter │
  │ X    2      Not updated Rev. Counter │
  │      3      Calibrated           │
  │      4      Calibrated           │
  │ X    5      Not updated Rev. Counter │
  │ X    6      Not updated Rev. Counter │
  │                                 │
  │   Incl    All        Cancel   OK │
  └─────────────────────────────────┘
```

Figure 15 The dialog box used to select the axes for which the revolution counter must be updated.

6. Press the function key *All* to select all axes, if all axes are to be updated. Otherwise, select the desired axis and press the function key *Incl* (the selected axis is marked with an x).

7. Confirm by pressing *OK*. A window similar to the one in Figure 16 appears.

```
Rev. Counter Updating!
Robot

The Rev. Counter for all marked axes
will be changed.

It cannot be undone.
OK to continue?



                              Cancel    OK
```
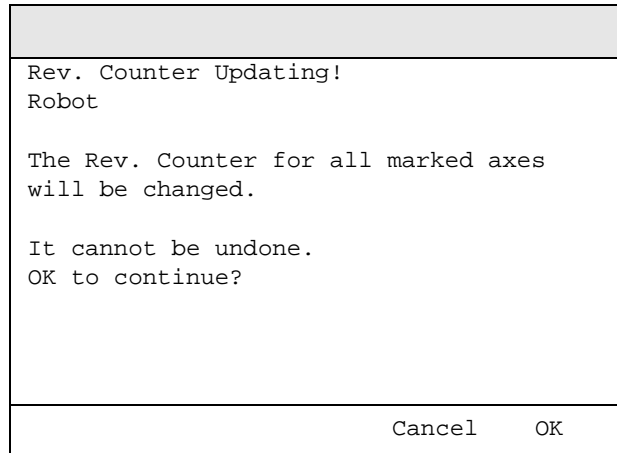
Figure 16 The dialog box used to start updating the revolution counter.

8. Start the update by pressing *OK*.

If a revolution counter is incorrectly updated, it will cause incorrect positioning. Thus, check the calibration very carefully after each update. Incorrect updating can damage the robot system or injure someone.

9. Check the calibration as described in Chapter 9.3

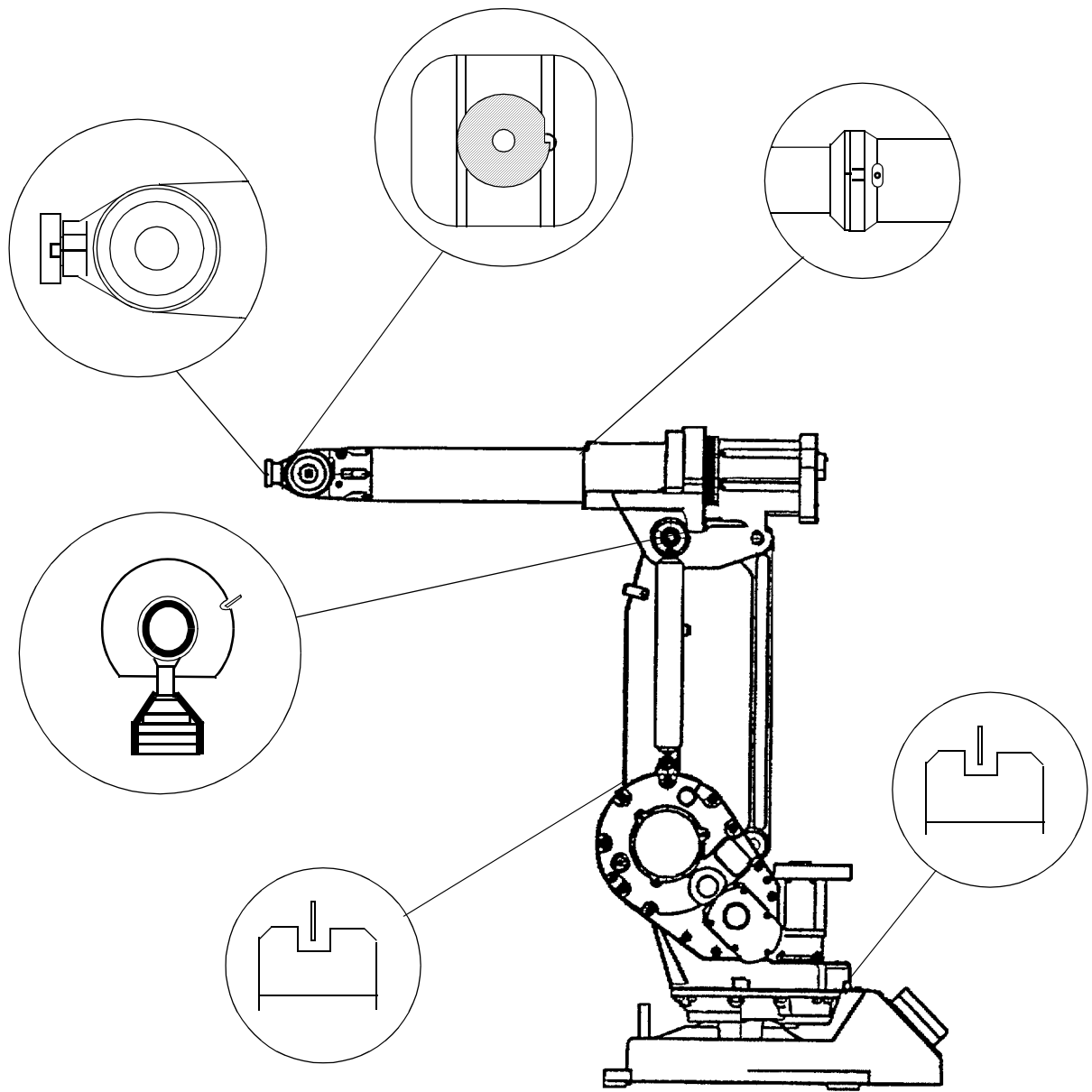10. Save the system parameters on a floppy disk.

.

Figure 17 Calibration marks on the manipulator.

9.3 Checking the calibration position

There are two ways to check the calibration position; both are described below.
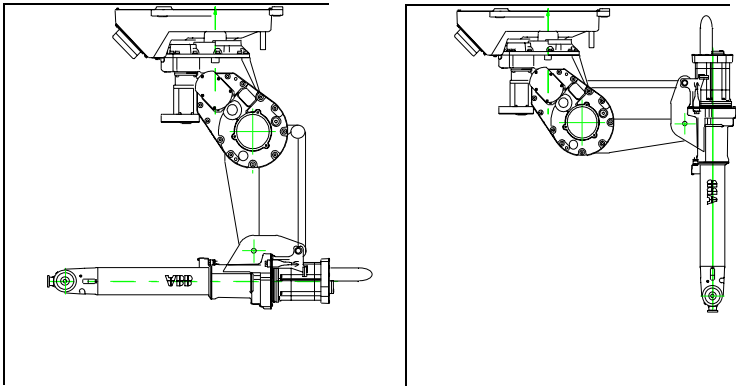
Using the diskette, Controller Parameters:

Run the program \ SERVICE \ CALIBRAT \ CAL 1400 (or 1400H) on the diskette, fol-low intructions displayed on the teach pendant. When the robot stops, switch to MOTORS OFF. Check that the calibration marks for each axis are at the same level, see Figure 17. If they are not, the setting of the revolution counters must be repeated.

Using the Jogging window on the teach pendant:

Open the Jogging window ![icon] and choose running axis-by-axis. Using the joystick, move the robot so that the read-out of the positions is equal to zero. Check that the cal-ibration marks for each axis are at the same level, see Figure 17. If they are not, the setting of the revolution counters must be repeated.

9.4 Alternative calibration positions

The robot must have been calibrated with calibration equipment at calibration position 0 for all axes (the robot is delivered with calibration position 0), see Figure 18, before it can be calibrated in the alternative position.

Axis	2	3	2	3
Calibration prog.	Normal		Hanging	
Cal pos	0	0	- 1.570796	- 1.570796

Figure 18 Calibration positions.

Note!
If the final installation makes it impossible to reach the calibration 0 position, an alter-native calibration position must be set before installation.

1. Run the calibration program CAL1400 on the Controller Parameter disk. Select Normal position, check the calibration marks for each axes.

2. Run the calibration program again and select the desired calibration position (Hanging), see Figure 18.

3. Change to the new calibration offset for axes 2 and 3, as follows:

    - Select the window SERVICE;

    - **View: Calibration**;

    - **Calib: Calibrate**;

    - Select axes 2 and 3

    - Then confirm by pressing *OK* two times.

4. Change to the new calibration offset on the label, located under the flange plate on the base. The new calibration offset values can be found as follows:

    - Select the window SYSTEM PARAMETERS;

    - **Types: Motor**;

    - Select axes 2 and 3;

    - Press Enter ⏎

    - Note the Cal offset value.

5. Change to the new calibration position on axes 2 and 3, as follows:

    - Select the window SYSTEM PARAMETERS;

    - **Topics: Manipulator**;

    - **Types: Arm**;

    - Select axes 2 and 3;

    - Change Cal pos to -1.570796. The angle is in radians, see Figure 18.

6. Restart the robot by selecting **File: Restart**.

7. Mark the new calibration position for axes 2 and 3 with the punch marker.

8. Save the system parameters on a floppy disk.

9.5 Calibration equipment

Calibration tools:	axis 1	6808 0011-GR and 3HAB 1378-1
	reference, foot	6808 0011-GM
	axis 2	6808 0011-LP
	axes 3, 4, 5 and 6	6808 0011-GU, Rev. 3
	level indicator	6807 081-D
Marking equipment:		3HAB 1232-1

9.6 Operating the robot

How to start and operate the robot is described in the User's Guide. Before start-up, make sure that the robot cannot collide with other objects in the working space.

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