DATASHEET

OPUS ONE

compact*Ride*

32 Channel GPS/AGPS Receiver Module

compact*Ride* is a compact high-sensitivity, low-power GPS/AGPS module that integrates e*Ride*'s hardware measurement platform (MP) into a single, compact and easy to integrate SMD device. Combined with e*Ride*'s powerful navigation software running on a host microprocessor, the module offers a complete high performance GPS receiver.

compact*Ride* is based on OPUS ONE technology and includes the Prelude ONE RF Receiver IC, OPUS ONE Baseband IC, a saw filter, the TCXO and various matching and peripheral components in a small form factor suitable for a broad spectrum of GPS applications where performance, cost and time to market are prime considerations.

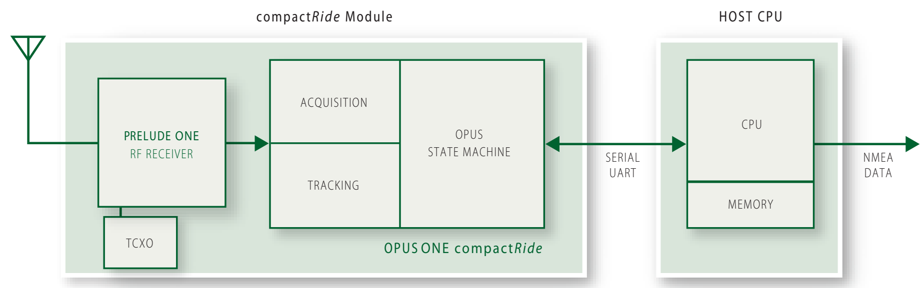

Figure 1: compact*Ride* Block Diagram

Features

- Supports GPS L1 band (1575.42 MHz) C/A code
- Highest indoor sensitivity of -157 dBm (typ) with active antenna achieving (both acquisition & tracking)
- 44,000 effective correlators very efficiently used to achieve fast TTFF and high sensitivity
- Fast TTFF of typically 2.5 secs when hot and 38 secs from cold
- Typical position accuracy of 3 m outdoors and 15 m indoors
- Works in both Autonomous mode and Assisted-GPS (MS-Based) mode
- Host interface via a simple serial port
- Navigation software requires less than 6 MIPS and runs as a background process on the host CPU
- Update rate of 1 Hz (also can integrate for 2.5 secs when indoors)
- 3.0 V and 1.2 V Supply Voltages
- Typical power dissipation is 125 mW
- Small 14.0 x 18.5 mm footprint, QFN type package for ease of assembly
- Operating temperature: -40˚C to +85˚C
- Compatible with Pb-free solder processing

Target Applications

- Wireless Handheld Devices (Smart Phones, Personal trackers)
- Mobile Computing (PDA, PND, Car Navigation, Multimedia Players)
- Industrial Applications (Machine to Machine, Automatic Vehicle Locator, Marine, Timing)

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Version History

Version	Contents Change	Date
00A	Initial Release	2007.08.24

1 Introduction

1.1 Product Features

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1.2 Block Level Diagram

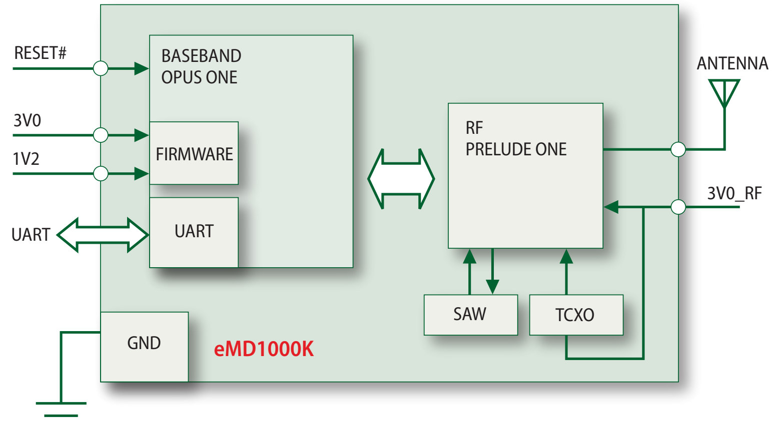


Figure 2: compact*Ride* Block Level Diagram

1.3 Module Floor Plan

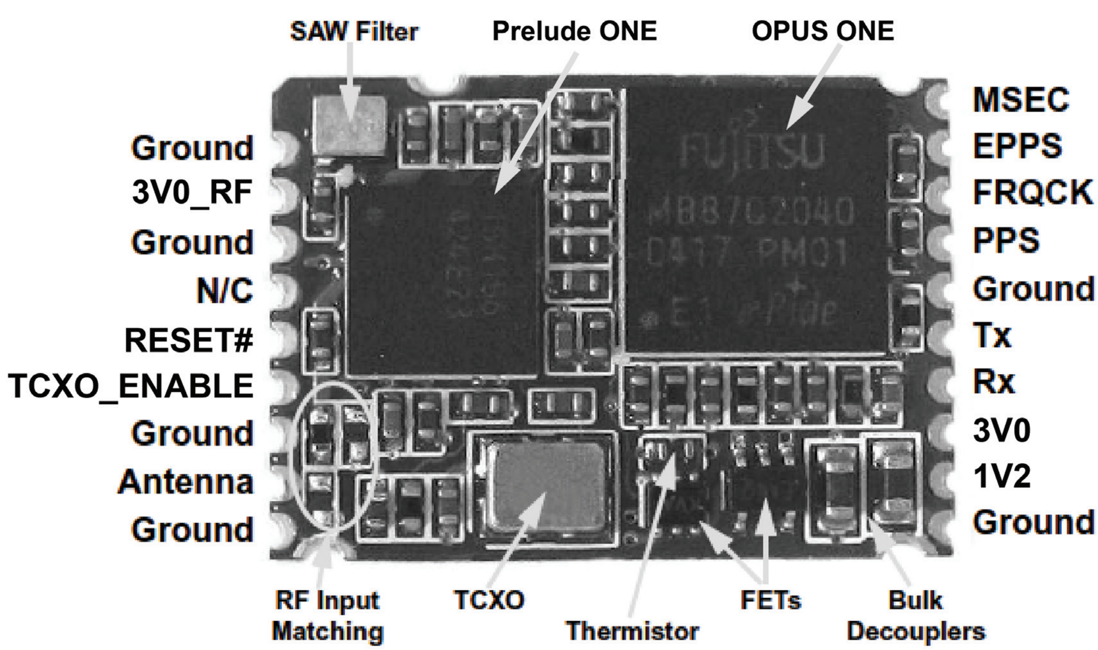


Figure 3: compact*Ride* Floor Plan

1.4 Module Design Overview

All digital signals and power pins are on the right-hand side of the module, and all RF signals and power pins are on the left-hand side. This ensures that all potential sources of noise are constrained on the right-hand side, as far away from the sensitive RF input as possible. The only exception to this is the TCXO_ENABLE and RESET# pins. Under normal conditions both TCXO_ENABLE and RESET# are static signals, so should not radiate significant noise.

Where possible, all sensitive signals have ground pins adjacent to them to ensure that return currents are closely coupled to the signal path, thus reducing ground loops to a minimum. The antenna input and the 3.0 V RF supply have ground pins either side of them to further minimize the inductance of the signal path, and to provide some element of signal shielding.

The digital power supply bulk decoupling capacitors are located as close to the input pins as possible. Current flow and noise will be greatest in the 1.2 V supply, so its capacitor is located closest to the supply pins.

OPUS ONE is rotated so that the signal I/O pins are positioned as close to the component or pin they are connecting to as possible to minimize tracking. The majority of the pins that need to be connected to Prelude ONE are located on the left-hand side of the package, and most of the power switching and digital I/O signals (such as the TXD and RXD pins) are located on the bottom and right-hand side of the package. This makes for ideal routing to Prelude ONE, which is positioned to the left of OPUS ONE, and leaves the board clear of sensitive tracking to position the power switching FETs below OPUS ONE, and route the I/O signals out to the edge of the board to the right of OPUS ONE.

Prelude ONE is rotated so as to position the RF input on the left side, as far away from the digital side of the board as possible. This also puts the SAW filter in the top left corner of the board, some way from the digital section. The sign and magnitude signals (IS to QM, IM to QS) from Prelude ONE to OPUS ONE now only need to route the minimum distance between the two adjacent edges. Finally, the TCXO can be located towards the center of the bottom edge, close to the REFin pin of Prelude ONE. This places the TCXO next to its power switch FET, and means that the thermistor can be placed next to it without having to route the noisy TCO tracks a significant distance across the board.

2 Functional Description

2.1 Usage Modes

The following sections detail the target functionality and performance.

The compact*Ride*/OPUS ONE receiver can be set up to perform in two possible modes:

2.1.1 Autonomous Mode

In this mode, compact*Ride* will decode Navigation data from Satellites only. It therefore needs a good signal strength (to as low as -146 dBm) while decoding for first fix. TTFF in this mode is slowest as compact*Ride* decodes the complete ephemeris data at 50 bps (the rate at which the GPS satellites transmit its signal), which can take up to ~30 secs. Once compact*Ride* has received ephemeris and Almanac data (i.e. become hot), then it can go on to supply fix measurements indoors with sensitivity down to -157 dBm. An application/user may supply some time or location assistance, if available (e.g. handset time or approximate estimate of location currently in use), or may use previous run data (as long as the "off" time is not too long and the navigation data (ephemeris, valid 6 hours at most) has not expired), resulting in improved TTFF.

2.1.2 Assisted Mode

Either on wake-up from autonomous mode, or upon a request for a fix after current aiding data has expired (ephemeris is valid for 6 hours, and refreshed every two hours), compact*Ride* shall request Navigation data from the aiding server via the implemented interface (SMS, WAP, TCP/IP, RRLP, etc.) using any aiding-data format (3GPP/2, IS801, etc.). compact*Ride* will continue to supply fixes and update its ephemeris/almanac as time permits and without further resource/help from the aiding server. Therefore assistance can be good for hours.

Assisted, MS-Based mode of operation achieves the fastest TTFF.

compact*Ride* aiding interface is independent of the aiding server. e*Ride* Inc. has a worldwide reference network and can supply the aiding server to any operator and/or infrastructure companies.

3 General Performance

3.1 Performance Summary

Receiver Type	OPUS ONE compact*Ride* 32 Channel L1, C/A Code 1 Hz Update Rate		
Accuracy		Outdoor[1]	Indoor[2]
		3.0 m CEP	15.0 m CEP
Time to First Fix (TTFF)		Outdoor[1]	Indoor[2]
	Cold	38 s	N/A
	Warm	36 s	N/A
	Hot	2.5 s	9 s
Sensitivity	Cold Acquisition	-143 dBm	
	Warm Acquisition	-146 dBm	
	Hot Acquisition	-155 dBm	
	Tracking	-155 dBm	
Operational Limits[3]	Altitude	18,000 m	
	Velocity	515 m/s	

[1] Simulator test with all signals at -130 dBm
[2] Simulator test with all signals at -150 dBm
[3] Based on the CoCom specification

3.2 Time to First Fix and Sensitivity

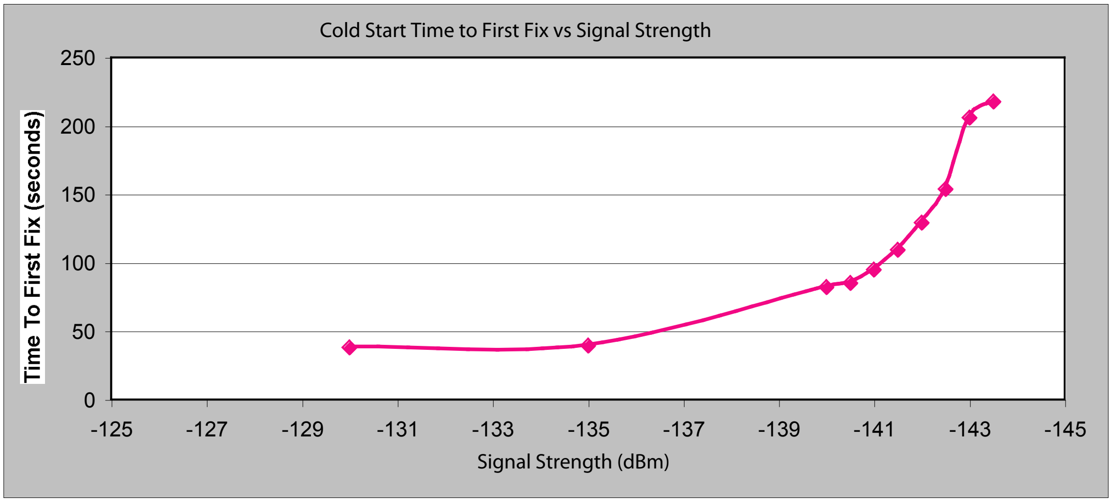


Figure 4: Cold Start Time to First Fix

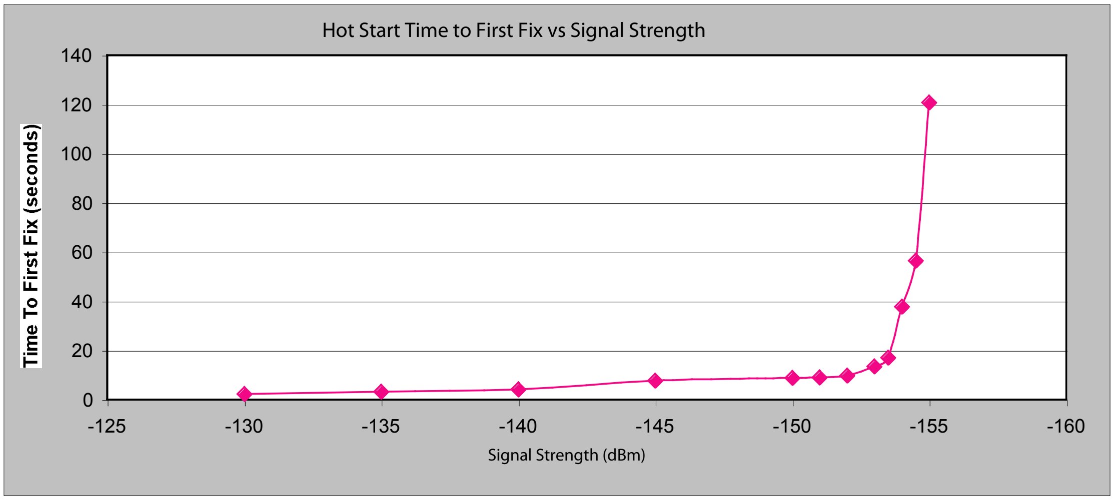


Figure 5: Hot Start Time to First Fix

3.3 Static Position Accuracy

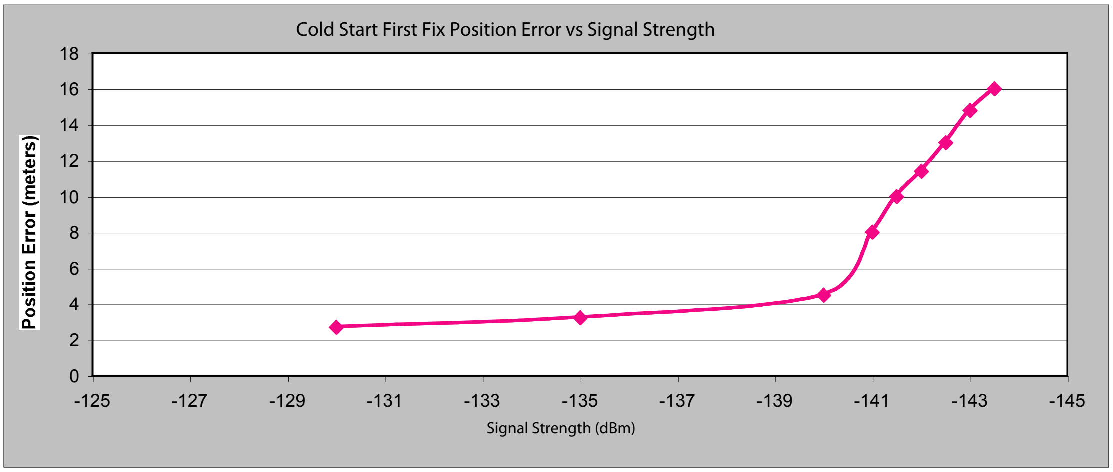


Figure 6: Cold Start First Fix Position Error

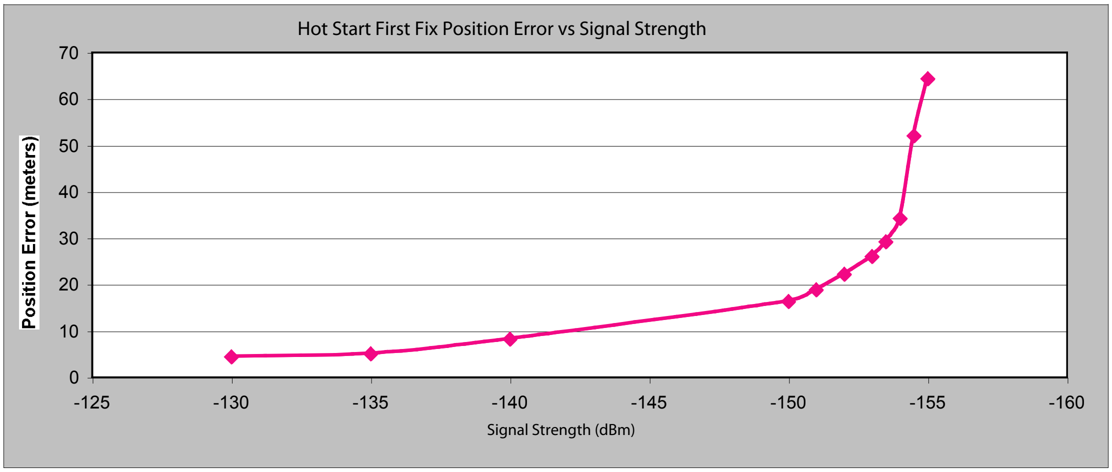
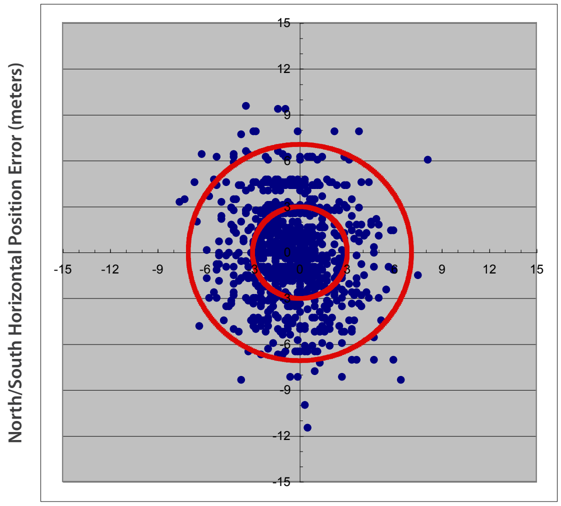


Figure 7: Hot Start First Fix Position Error

First Fix Outdoor[1] Position Accuracy

50 CEP: 3.00 meters 95 CEP: 7.07 meters

Number of First Fixes: 1020

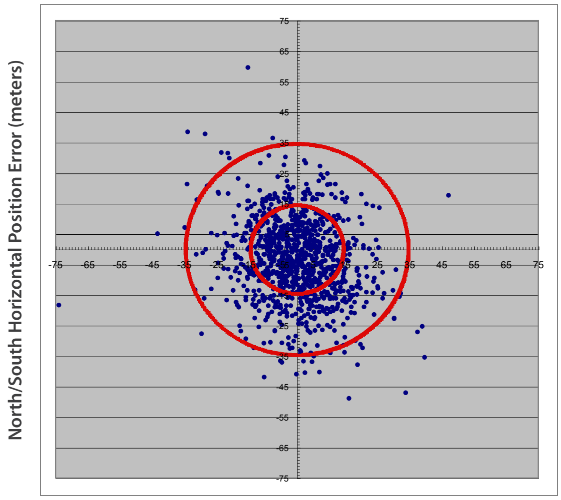


[1] Simulator test with all signals at -130 dBm

First Fix Indoor[1] Position Accuracy

50 CEP: 14.47 meters 95 CEP: 34.62 meters

Number of First Fixes: 1020



[1] Simulator test with all signals at -150 dBm

Figure 8: First Fix Outdoor and Indoor Position Accuracy

4 Electrical Characteristics

4.1 Pin Description

4.1.1 Pin Outline

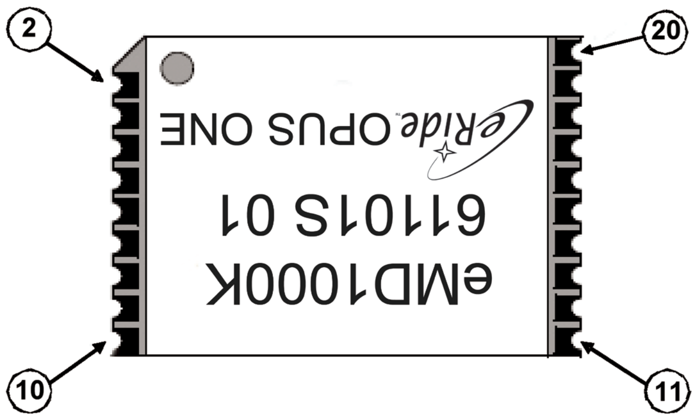


Figure 9: Module Top View

4.1.2 Pin Description

Pin	Label	Input/Output	Function	Note
2	GND	Power	Ground	
3	3V0_RF	I	External 3V0 supply for Prelude One and the TCXO	Decouple to ground. Filter supply with inductor if a common 3V0 supply is used for both Prelude ONE and OPUS ONE.
4	GND	Power	Ground	
5	NC		Unused	Do not connect
6	RESET#	I	Reset	0 = Reset, 1 = Active
7	TCXO_ENABLE	I	TCXO power supply FET gate	0 = TCXO enabled
8	GND	Power	Ground	
9	ANT	I	Antenna input	
10	GND	Power	Ground	
11	GND	Power	Ground	
12	1V2	Power	External 1.2 V supply for OPUS ONE	Decouple to ground
13	3V0	Power	External 3V0 supply for OPUS ONE	Decouple to ground
14	RXD	I	UART Input	
15	TXD	O	UART output	
16	GND	Power	Ground	
17	PPS	O	Pulse per second output	
18	FRQCK	I	Accurate reference frequency input	Internal pull-down
19	EPPS	I	External pulse per second input	Internal pull-down
20	MSEC	O	1 msec output	

4.2 Absolute Maximum Rating

Item	Symbol	Min	Max	Unit
Supply Voltage	1V2	-0.5	1.8	V
	3V0	-0.5	4.0	V
	3V0_RF	-0.5	4.0	V
Signal Input Voltage	V_I	-0.5	3V0 + 0.5	V

4.3 Recommended Operating Conditions

4.3.1 DC Supply

Item	Symbol	Min	Typ	Max	Unit
Supply Voltage	3V0	2.7	3.0	3.6	V
	3V0_RF	2.85	3.0	3.15	V
	1V2	1.15	1.2	1.25	V

4.3.2 Power Consumption

4.3.2.1 Module Power Consumption

3V0=3.24 V, 3V0_RF=3.24, 1V2=1.24 V, GND=0 V

Mode	Typ	Unit
Sleep	< 1	mW
Standby	20	mW
Search	180	mW
Track (outdoors)	125	mW
Track (indoors)	160	mW

4.3.2.2 Current Draw

Pin	Condition	Mode	Typ	Peak	Unit
3V0	@ 3.00 V	Sleep	< 1	1	uA
		Standby, Search, Track	3	10	mA
3V0_RF	@ 3.00 V	Sleep	< 0.001	2	mA
		Standby	2	5	mA
		Search, Track	30	45	mA
1V2	@ 1.20 V	Sleep	< 1	1	uA
		Standby	6	15	mA
		Search	60	120	mA
		Track (indoors)	25	120	mA
		Track (outdoors)	50	120	mA

4.3.3 Power Mode Transitions

4.3.3.1 Power-On Sequence

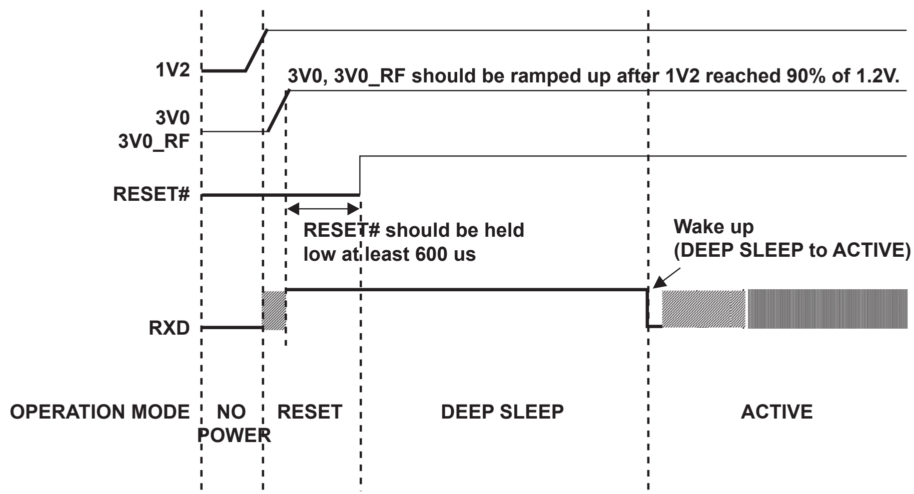


Figure 10: Initial Power-On Sequence Diagram

Power up of eMD1000K is relatively simple and following this power sequence is recommended (see Figure 10).

1. Apply 1V2
2. Apply 3V0 and 3V0_RF
3. Deassert RESET# signal
4. Send serial commands on RXD

4.3.3.2 Power-Off Sequence

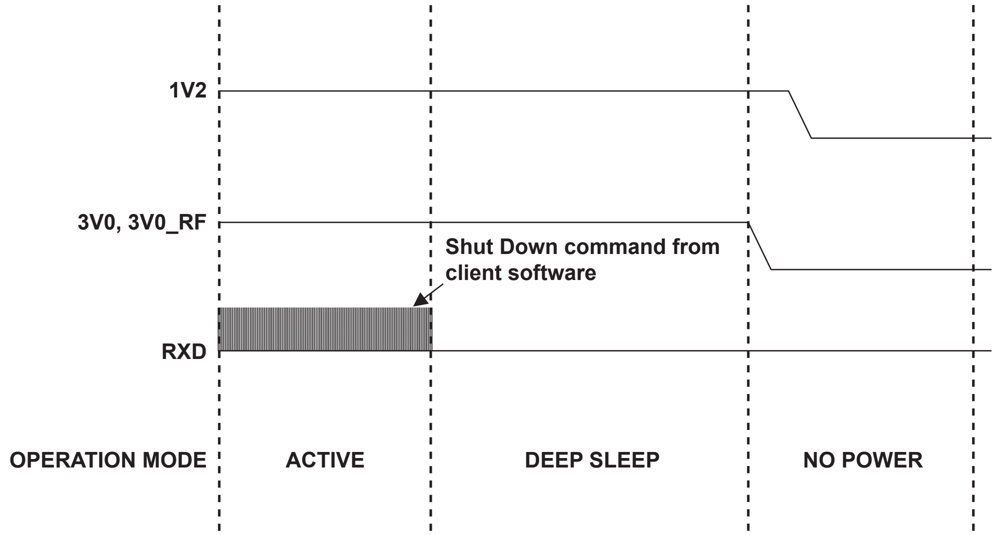


Figure 11: Power-Off Sequence Diagram

Power down of eMD1000K should follow this power sequence (see Figure 11).

1. Shutdown command sent by e*Ride* Client software on RXD
2. Remove 3V0 and 3V0_RF
3. Remove 1V2

4.3.3.3 Other Power Mode Transitions

Transitioning between Active, Standby, and Deep Sleep modes is accomplished by serial commands from the e*Ride* client software.

4.3.4 Operating Power Modes

	3V0_RF	3V0	1V2	RESET#	TCXO_ENABLE
Active	Y	Y	Y	NOT ASSERTED	ASSERTED
Standby	Y	Y	Y	NOT ASSERTED	ASSERTED
Deep Sleep	Y	Y	Y	NOT ASSERTED	ASSERTED
RESET	N	Y	Y	ASSERTED	ASSERTED
CLK OFF	Y	Y	Y	NOT ASSERTED	NOT ASSERTED
No Power	N	N	N	X	X

4.3.5 DC Characteristic of I/O Cells

3V0=2.7~3.3 V, 1V2=1.15~1.25 V, GND=0 V

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input	V_{IL}	–	-0.3	–	0.8	V
	V_{IH}	–	2.0	–	3V0	V
Output	V_{OL}	3.3 V output IOL=100 uA	0	–	0.2	V
	V_{OH}	3.3 V output IOH=-100 uA	3V0 - 0.2	–	3V0	V

4.4 RF Section

(Ta=25°C)

Item	Symbol	Specification			Unit	Notes
		Min	Typ	Max		
RF input frequency	f_{RFin}	–	1575.42	–	MHz	
Input impendance	Z_{in}	–	50	–	Ω	
DC Supply	3V0_RF		3.0		V	

To achieve optimal sensitivity performance for the compact*Ride* module it's necessary to use an active antenna or add an external LNA in front of the GPS receiver.

4.5 Interface Section

Figure 12: Interface Block Diagram

5 Mechanical Specifications

5.1 Package Outline

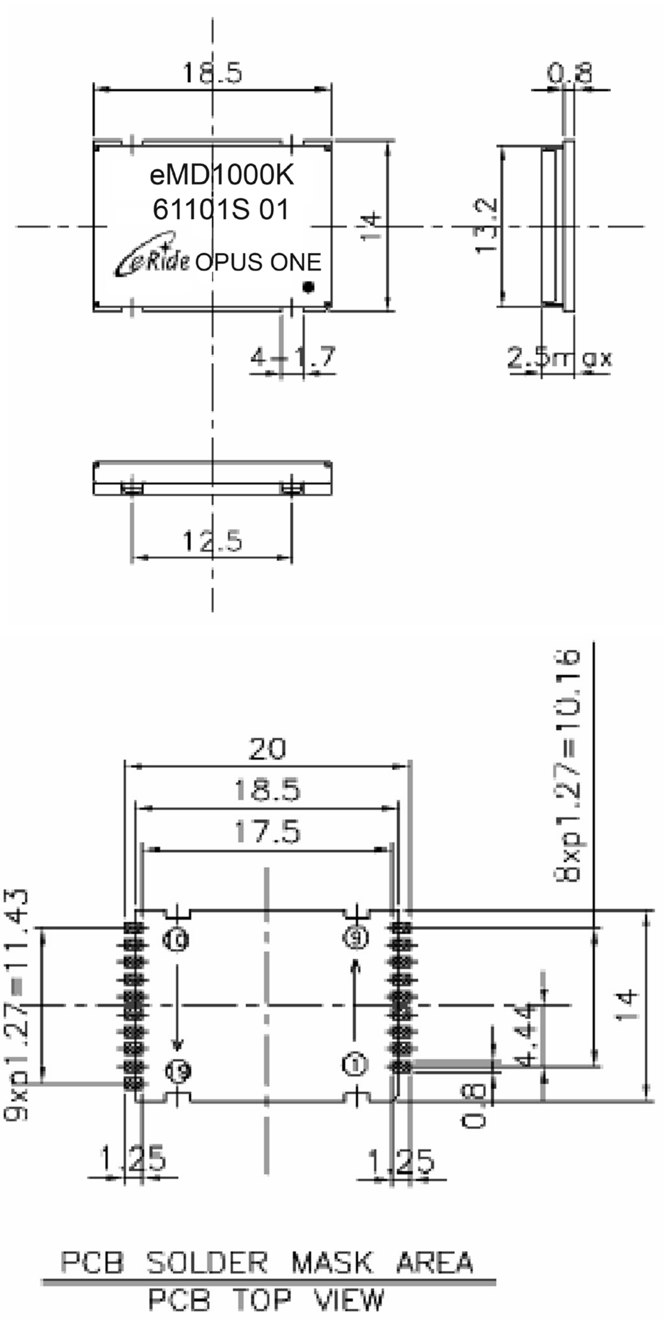


Figure 13: Package Outline

5.2 Marking Description

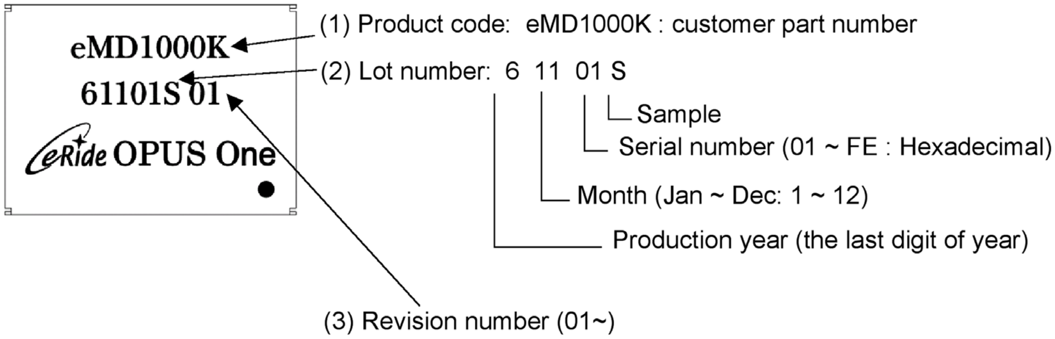


Figure 14: Marking Description

6 Software Specifications

6.1 Control Software

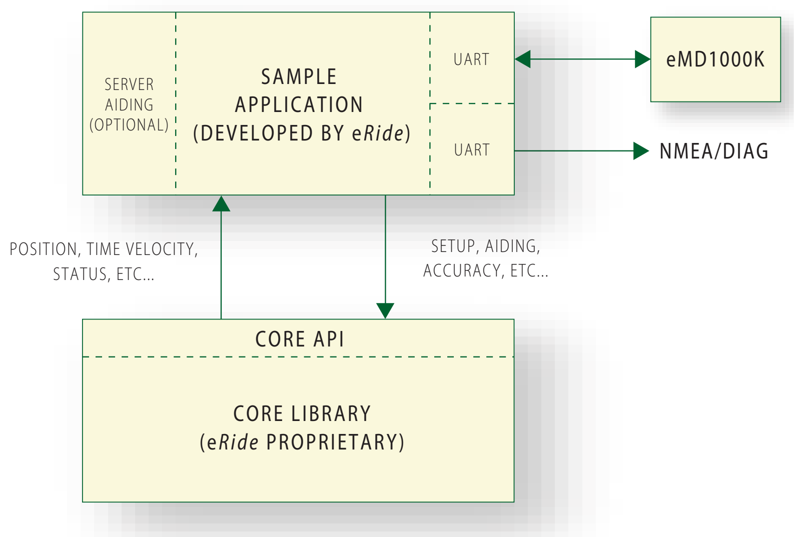


Figure 15: Control Software Block Diagram

6.1.1 Core Library

e*Ride*'s core library is an OS independent C library that contains all the functionality of the GPS client layer. The library is shipped with the product and is to be installed on the host CPU. The software runs as a single-threaded background process that requires no real-time interrupts, host libraries or RTOS from the host.

The core library contains the software required to control the compact*Ride* module and compute position, velocity, and time (PVT) from the data received from the module. The library interfaces with the user's application and operating system through the Core Functional API. This interface allows the application to configure the core to start/stop, and which run/stop mode to be in (e.g. hot start, standby mode, etc). The interface also passes PVT and satellite information from the core to the application.

Although the core library is OS independent, certain functionality is assumed and required on the platform. Specifically, the functionality includes:

1. Receiving of data from eMD1000K via interrupt-driven UART
2. Sending of data to the UART connected to the eMD1000K
3. Sleep for a specified time (specified in milliseconds)
4. Sending of data to the UART connected to the debug port, or to file (optional)
5. Reading of a system timer (optional)

6.1.2 Sample Application

Along with the core library, each compact*Ride* module is shipped with a sample application. This application runs on the host CPU as an event-driven background process. The sample application serves as an interface between the user and the core library, and between the core library and the operating system. The application will convert the PVT information from the core (via Core Functional API) into standard NMEA[1] and output standard NMEA sentences[2] back to the user.

While the sample application contains most of the functionality required to run the core, and output NMEA data, the user is required to make any changes to allow the Sample Application to run on the host operating system. This typically includes correctly configuring serial ports and user-desired parameters.

e*Ride* OPUS ONE GPS Library API, Application Programming Interface/Developer's Guide eTM-1100B0001 clearly explains the proprietary APIs in detail and e*Ride* can provide this upon request.

[1] NMEA specification 0183 compliant
[2] GSA, GGA, RMC, GSV, GLL, and GSA sentences generate

6.1.3 Diagnostic Feature

The core library provides a facility to output GPS diagnostic data via either a debug port or write to a file by a compile-time configuration in the sample application. The purpose of the diagnostic feature is to allow the customer to collect information e*Ride* can use to replicate the user's GPS session. This powerful tool allows e*Ride* and the user to diagnose problems, make library improvements (enhancements, bug fixes, configuration changes, etc.), or gain visibility into any problem scenario.

Once the feature is enabled, the user can collect the diagnostic data by configuring the application to output the diagnostic data through a serial port (separate serial port from user interface port suggested) and storing the output to a file, or by writing the data directly to a file in the application. The user should then send the data, along with a description of the problem to e*Ride* customer support for diagnosis.

6.2 System Requirements

6.2.1 UART Configuration

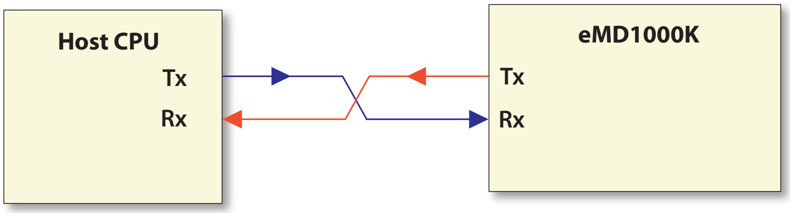


Figure 16: UART Connection Diagram

The eMD1000K is configured to use the Universal Asynchronous Receiver Transmitter (UART) transport layer interface. The following table contains the required configuration:

Parameter	Value
Baud Rate	57.6 Kbps
Flow Control	None
Parity	Odd
Stop Bits	1
Data Bits	8
Logic Level High	3.0 V
Logic Level Low	0.0 V
Required Buffer Size	2048 Bytes[3]

Table 1: Required UART configuration for communication with eMD1000K

[3] Software buffer size assuming UART interrupt is serviced by host processor and application/core is allowed 6 Mips or more.

6.2.2 Code, Data, Processor Requirements

Parameter	Minimum Value	Comment
ROM Available	256 K	Usage estimated. Actual value depends on core library version, compiler, and target platform.
RAM Available	128 K	Usage estimated. Actual value depends on core library version, compiler, and target platform.
MIPS Allocated	6 Mips	Usage estimated. Actual value depends on core library version, compiler, and target environment.
UART Driver	1 UART 2048 Kbyte storage	See table 5.2 a for detailed requirements.
Flash Memory[4]	4 K byte	Contains previous run information during device power-off

Table 2: Minimum system requirements for guaranteed performance

[4] Not required for system operation, but provides additional performance benefits

7 Application Circuit and Reference Design

7.1 Application Circuit

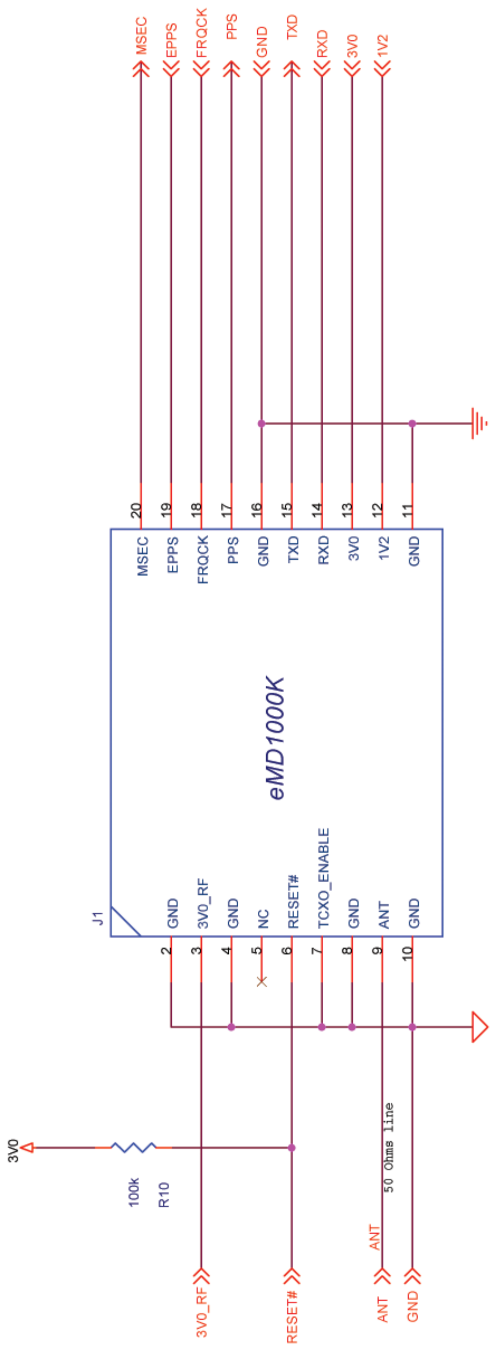


Figure 17a: Application Circuit

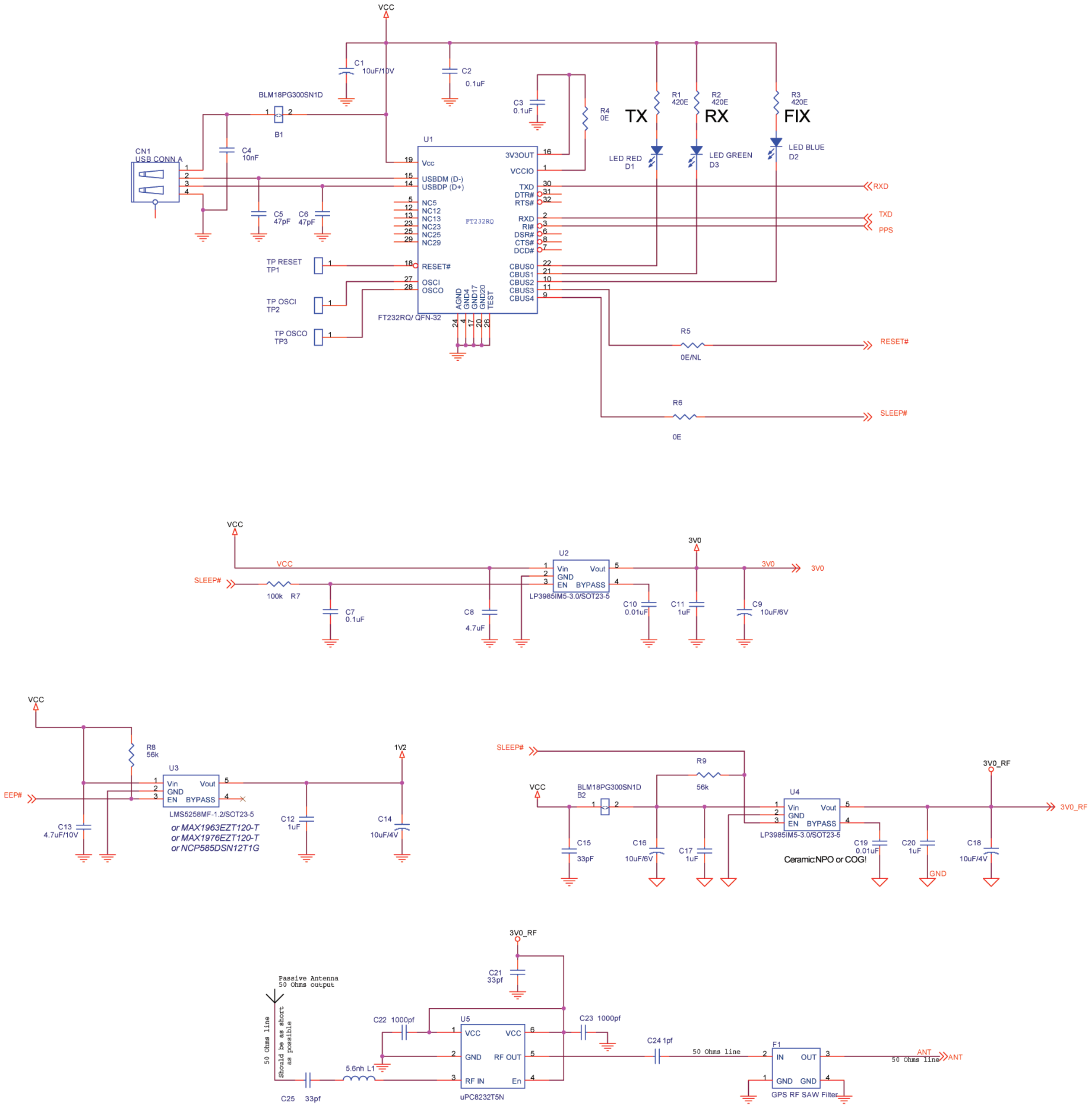


Figure 17b: Application Circuit Continued

Note 1: The DC power supplies to 3V3, 1V2, and 3V0_RF must conform to the electrical characteristics specified in Sections 3.1 and 3.2 for minimum, maximum, and typical voltages, stability, and maximum current supply capability. Components meeting these specifications are recommended in the following section.

7.2 Recommended Components

		Approved Vendor List	
Component	**Purpose**	**Part Number**	**Manufacturer**
3.0 V Regulators	OPUS Power Supply RF Power Supply	LP3985IM5-3.0/SOT23-5	National Semiconductor
1.2 V Regulator	OPUS Power Supply	LMS5258MF-1.2/SOT23-5	National Semiconductor
SAW Filter	RF Noise Reduction	SF14-1575UU01	Kyocera
Ferrite Bead	Noise Suppression	BLM18PG300SN1D	Murata

7.3 Application Reference Design

A complete application reference design package, consisting of the following items, is available from e*Ride* by requesting part number eRD-1000KA001.

- Schematics
- PCB layout
- BOM/AVL
- DataSheets for other components of the reference design

8 Environmental Specifications

8.1 Temperature Range

Items	Symbol	Min	Typ	Max	Unit
Storage Temperature	T_{stg}	-40		+85	ºC
Operating Temperature	T_{opr}	-40	25	+85	ºC

9 Packing and Product Handling

9.1 Carrier Tape and Reel Dimensions

Carrier Tape: 25.5 mm (width) x 26.4 m

Reel Dimension: Φ330 x 37.5

Quantity per reel: 1 K

Weight of reel gross/net: G.Weight: 3 KG, N.Weight: 3.5 KG

- Net Weight : 1.3 kg based on 1K (7.8 kg based on 6 K)

- Gross Weight : 3.1 kg based on 1K (18.6 Kg based on 6 K)

9.2 Component Orientation for Tape and Reel

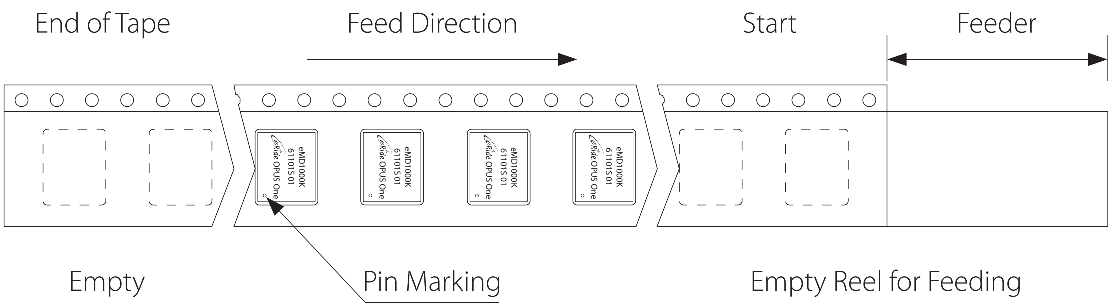
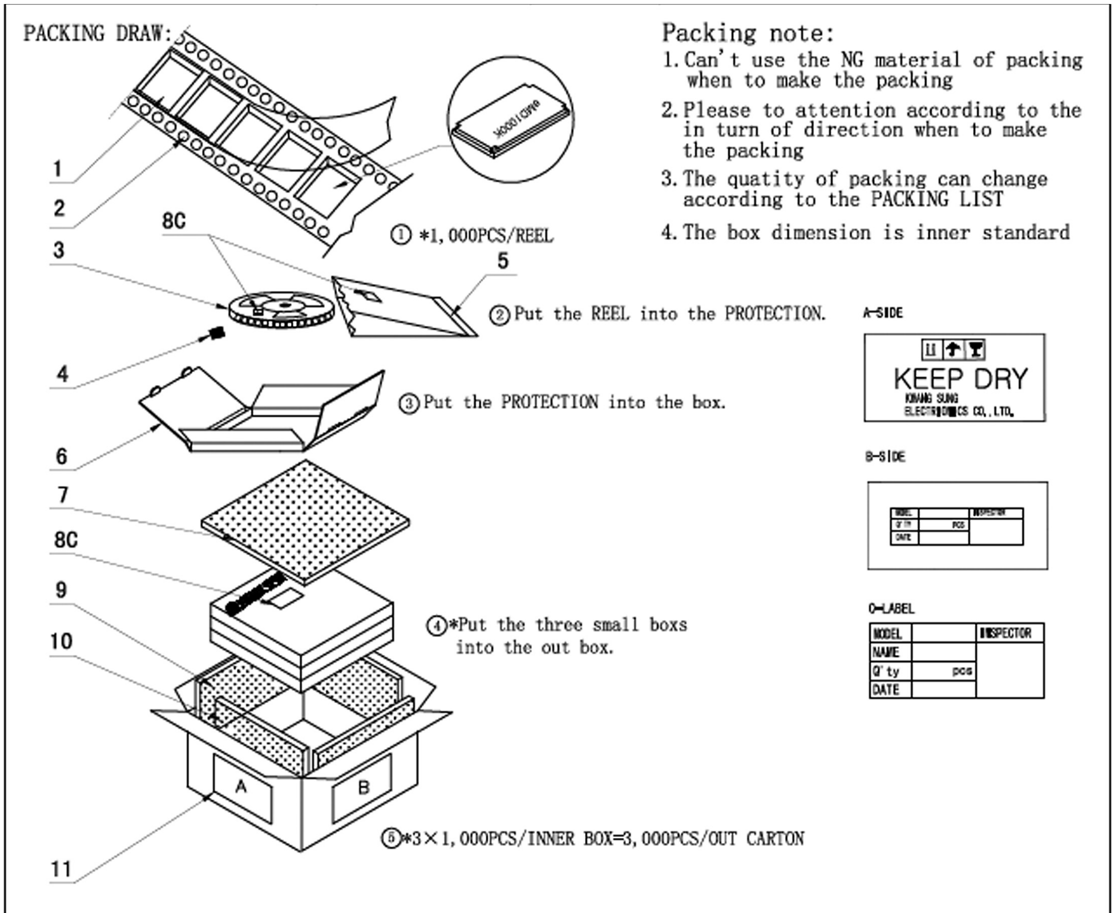


Figure 18: Component Orientation

9.3 Packaging and Delivery



UNITS:mm

NO	ERP. CODE NO.	NAME	PART NO.	SPEC	Q'TY	MARK	REASONABLE REVISIONS	DATE
12		TAPE	60mmx30yd	60mmx30yd(T=0.046)	3150mm			
11		BOX CARTON	DW-2,WAVE-BA	430x430x170	1PCS			
10		FROTH BOARD	ST-003	425x165x20	2PCS			
9		FROTH BOARD	ST-002	385x165x20	2PCS			
8		LABEL	7x3.5	7X35mm(TAPE)	7PCS			
7		PAD	ST-001	425x425x20	2PCS			
6		BOX INNER	SW-1,WAVE-B	405x405x40	3PCS			
5		BARRIER BAG		420x460x0.25	3PCS			
4		SILICAGEL	5G	50x40x5G	3PCS			
3		REEL PLASTIC	REEL32	Φ330x37.5	3PCS			
2		CARRIER TAPE	CART44-04	W25.5x1000PCS	26.4M			
1		COVER TAPE	COVT44	W32.0	26.4M			

Figure 19: Packing Draw

9.4 Reflow Profile

Profile Feature	Pb-Free Assembly
Average ramp-up rate (Tsmaxto Tp	3°C/second max.
Preheat • Temperature Min (Tsmin) • Temperature Max (Tsmax) • Time (Tsminto Tsmax) (ts)	 150 °C 200 °C 60-180 seconds
Time maintained above: • Temperature (T_L) • Time (t_L)	 217 °C 60-150 seconds
Peak Temperature (Tp)	See Table 1
Time within 5°C of actual Peak Temperature (tp)[2]	20-40 seconds
Ramp-down Rate	6 °C/second max.
Time 25°C to Peak Temperature	8 minutes max.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.

Note 2: Time within 5 °C of actual peak temperature (tp) specified for the reflow profiles is a "supplier" minimum and "user" maximum.

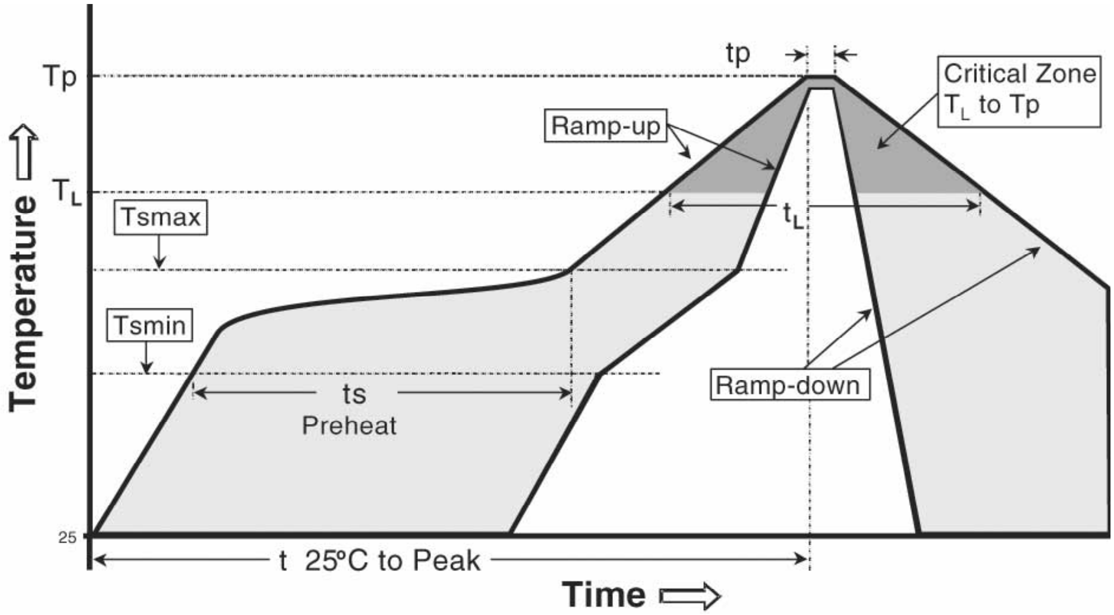


Table 3: Pb-free Process - Package Peak Reflow Temperatures

Package Thickness	Volume mm^3 < 350	Volume mm^3 350 - 2000	Volume mm^3 > 2000
< 1.6 mm	260 °C *	260 °C *	260 °C *
1.6 mm - 2.5 mm	260 °C *	250 °C *	245 °C *
> 2.5 mm	250 °C *	245 °C *	245 °C *
* Tolerance: The device manufacturer/supplier shall assure process compatibility up to and including the stated classification temperature at the rated MSL level			

Extracted from IPC/JEDEC J-STD-020C, reference full specification for more details.

9.5 ESD Sensitivity

Follow guidelines as per IPC/JEDEC J-STD-020C.

9.6 RoHS Compliance

eMD1000 products are compliant with the European Union Directive 2002/95/EC Restriction on the Use of Hazardous Substances (RoHS). All designated products have Pb-free terminals.

10 Ordering Information

Part Number	Package	Supplying Form
eMD1000K	18.5 x 14.0 x 2.5 mm 20 pins fully assembled module	• 25.5 mm wide embossed Tapping • Pin two indicates opposed direct of pull out of tape • Quantity: 1 K pieces/reel

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