ELTECdata # 102

Frequency Dependency in Pyroelectric Detectors Incorporating a Voltage Follower

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Electrical Time Constant

The effective electrical time constant of the circuit is:

$$\tau_e = RC$$

where

- τ_e = Electrical Time Constant [seconds]
- R = Resistance of the load resistor;
- C = Capacitance of the sensing crystal plus strays: usually 30 picofarads for single crystal and parallel dual detectors.

And the electrical breakpoint is:

$$\text{Electrical Breakpoint} = f_e = \frac{1}{2\pi\tau_e} \text{ [Hz]}$$

The time constant of an RC circuit is also useful dealing with a transient event. Viewing this as a step function, the rise time (defined as the time from a 10% to 90% of final-value) is about $2.2\tau_e$ = 2.2 (RC).

Although the response from maximum will decrease to 37% in 1 RC-time constant, for a second fast transient occurring within 1% of the τ_e, the distortion due to 'leakage' will also be less than 1%. This shows that sometimes a long τ_e can be advantageous.

Response beyond the effective bandwidth (electrical break) decreases as 1/f (the sensitivity in the flat region times the reciprocal of the frequency of interest, i.e. at -20 dB per decade).

Thermal Time Constant

When the sensing element is in thermal equilibrium, there is no output from the detector (a pyroelectric device responds only to a change). The time it takes for the detector to thermalize to a step input is called the Thermal Time Constant.

Viewed as a limiting factor, the thermal time constant has the reverse effect on frequency response of the electrical time constant. As temperatures change slowly, the detector is fighting the thermalization of the crystal to produce an output. Thus the thermalization time serves to limit frequency response until the thermal break is reached.

$$\text{Thermal Breakpoint} = f_t = \frac{1}{2\pi\tau_T} \text{ [Hz]}$$

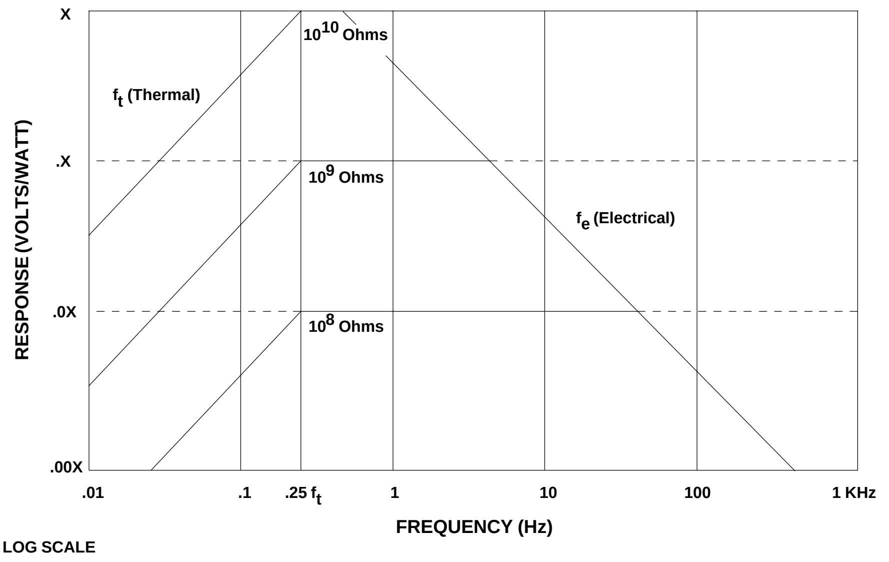
where:

- τ_T = **Thermal Time Constant** (usually 0.65 seconds for most loop mounted crystals and 0.032 seconds for most hard-mounted laser detectors)

Response below the thermal break decreases as f, i.e. at -20 dB per decade.

The overall frequency response of the detector is then the result of the thermal limiting factor (τ_T) and the electrical parameter (τ_e). This responsivity is essentially flat in the region between f_t and f_e ($f_e > f_t$). If $f_e < f_t$ (with large load resistors, R), then f_e establishes the low frequency limit and the breakpoints are merely exchanged (both electrical and thermal are symmetrical and independent).

FREQUENCY DEPENDENCY OF RESPONSE AS A FUNCTION OF LOAD RESISTOR VALUE (WITH C = 30 PICOFARADS)



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Please note that neither the electrical or thermal time constant can be tightly controlled in production due to internal component tolerances and interactions.

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