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FREQUENCY DEPENDENCY IN PYROELECTRIC DETECTORS INCORPORATING A VOLTAGE FOLLOWER

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The effective electrical time constant of the circuit is:

$$\text{Electrical Time Constant} = t_e = RC$$

where:

R = Resistance of the load resistor;
C = Capacitance of the sensing crystal plus strays: usually 30 picofarads for single crystal and parallel dual detectors.

The effective rise time (response from 10% to 90% of maximum) is:

$$\text{Rise time} = \frac{\text{time constant (electrical)}}{3} = \frac{t_e}{3}$$

And the frequency breakpoint is:

$$\text{Electrical Breakpoint} = f_e = \frac{1}{2(\pi)\, t_e} \text{ [Hz]}$$

where:

t_e = Time Constant (RC)

The response to a transient event (step function) will be accurate (within 1%) as long as the event occurs within a period equal to or greater than the electrical time constant.

Response beyond the effective bandwidth (capacitive break) decreases as 1/f (the sensitivity in the flat region times the reciprocal of the frequency of interest, i.e. -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 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. Namely, at pure DC there is no thermal change and thus no output. 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.

$$\text{Thermal Breakpoint} = f_t = \frac{1}{2(\pi)\, t_t} \text{ [Hz]}$$

where:

t_t = **Thermal Time Constant** (usually 0.65 seconds for most ELTEC 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 product of the thermal limiting factor (t_t) and the electrical parameter (t_e). This responsivity is essentially flat in the region between f_t and $f_e (f_t < f_e)$. If $t_e < t_f$ (with large load resistors, R), then f_e establishes the low frequency limit and the breakpoints are merely exchanged (both electrical and thermal $f(f)$ are symmetrical and independent.

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