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Notes On Apparent Temporal Baseline Shifts From Pyroelectric Detectors

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When a pyroelectric detector attains thermal equilibrium, the output of the detector is "zero". The equilibrium is dynamic in the sense that the detector base, can and window are always radiating infrared to the sensing crystal which is itself radiating. Thus assuming no conductive/convective heat transfer, the net radioactive exchange is also zero.

A change in the thermal environment of the detector will naturally change the temperature of the detector. If the rate of change is well below the thermal and electrical time constants of the detector, no signal will be produced. (The developed charge on the electrodes will leak to ground as it is produced.)

It is often said that a pyroelectric detector produces a signal only if it experiencing a change. It is well to note that a rapid and steady warming (or cooling) of the detector is equitable to a series of step changes in one direction. If there were an identical detector with the sensing crystal "blinded" to external radiation, it would be responding only to the ambient change and its signal could be inverted and subtracted from the output of the first detector for an combined output representative only of the pulse. (Actually, Eltec's Model 405, 407 and Model 446 Thermally Compensated Detectors operate much as described).

For detectors receiving strong pulses of radiation, the situation is more difficult. First, the detector is a finite mass composed of materials with different specific heats and different thermal conductivities. At one extreme, by analogy, pulsing a flashlight at the moon from earth increases the temperature of the moon only by a trivial and indeterminate amount.

At the other extreme is a larger detector with the sensing crystal heat sunk to a metal base. Assuming an extended series of high energy pulses (all of equal energy), the output of the detector would behave as follows: The first pulse strikes and produces a specific output. Before the detector crystal and thermal mass can dissipate the energy absorbed, a second pulse strikes. The output from the second pulse strikes. The output from the second pulse represents the magnitude of the pulse plus a baseline increase. After a series of pulses, the crystal/thermal mass assembly achieves equilibrium and the initial baseline is restored.

Dependencies/Qualifications: If the combination of pulse energy and repetition rate infuse energy to the crystal/mass assembly faster than it can be dissipated the assembly will increase in temperature until damage occurs. Also note that different applications dictate different detector designs. In some detectors the crystals are elevated above the substrate by thin gold wires to thermally isolate the crystal. This greatly increases the thermal time constant of the crystal and brings a corresponding increase in responsivity to weak radioactive inputs. However, this thermally- isolated design will show greater baseline shifts than a laser detector with a heat-sunk crystal. Also note that the electrical termination of the leads from the electrodes on the crystal introduce their own modification of the transfer function and time dependencies (Crystal capacitance in conjunction with load resistance).

What is the detector user to do? First, be aware that a thermal detector involves thermal time constants, heat dissipation, etc. Second, after examining the specific application, choose a detector with best thermal design for the application. Third, test the system changing, in turn, ambient temperature, pulse intensity, and repetition rate such that the actual parameters of the intended application are bracketed and appropriate normalization of the data can be made.