

### Tech Note: Effects of Polarity on High Voltage Bias of Photomultipliers

Photomultiplier tubes - also called photomultipliers or PMTs – continue to be the most common light detection and amplification devices employed in scintillation detectors.

As with all electronic devices, applying the proper bias supply voltage is required for the correct operation and optimal performance of a PMT. This applies not only to the proper voltage amplitude but to the proper voltage polarity as well.

#### Positive High Voltage

Positive High Voltage is the historical standard bias supply for almost all scintillation detectors that employ a PMT as the scintillation light detection device.

An advantage of POS HV is that one can combine signal and + HV over a single lead as is done for most counters. POS HV is the industrial standard for spectroscopy devices. Many counters and multichannel analyzers (MCAs) are only compatible with POS HV. ALL digital bases are only compatible with POS HV.

Positive High Voltage means that in the voltage divider schematic, a so-called separation capacitor C2 is needed as shown in the picture below. Usually, this capacitor has a value of 1 nF.

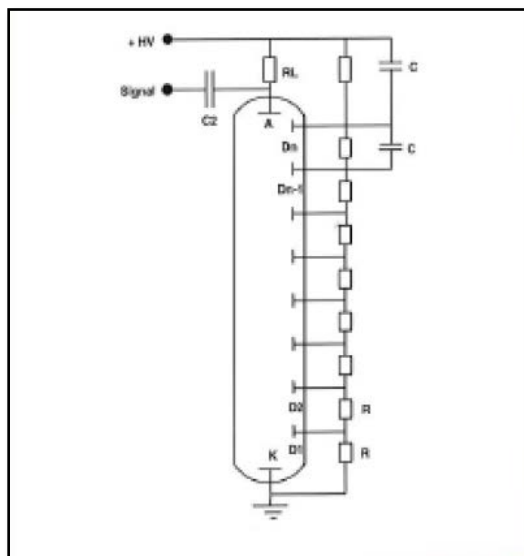


Figure 1. Voltage Divider Configured for Positive HV

This means that the charge pulse from the anode is fed out via a capacitor. This implies that the anode signal - which is basically negative due to the charge of the electrons - will obtain a small positive swing (overshoot) above the baseline. The signal, in fact, becomes what is referred to as “bipolar”. Each swing through Zero is called a “pole” in the signal.

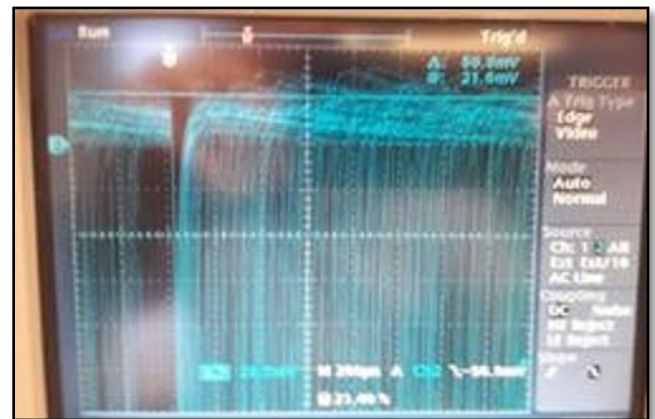
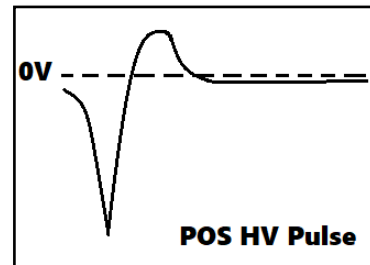
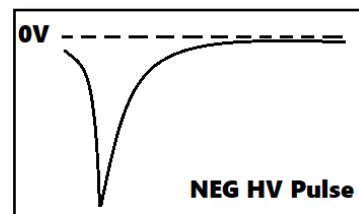


Figure 2. Oscilloscope trace illustrates the effects of poles on fast signals from a detector output signal using POS HV.

#### Negative High Voltage

Negative High Voltage is the standard bias supply for PMT applications where DC current measurement is required (like many Hamamatsu applications for instance).



With high count rates, pole-zero cancellation is needed to retain spectral stability. This is accomplished with an analog spectroscopy amplifier or digital amplifier. This pole-zero cancellation is more easily achieved, and

generates a better signal, from NEG HV bias rather than POS HV.

Also, in the case of fast signals, a purely negative signal is preferred if the anode signals are terminated with 50 Ohms as is typical in many electronics. A DC-coupled signal (NEG HV) is preferred.

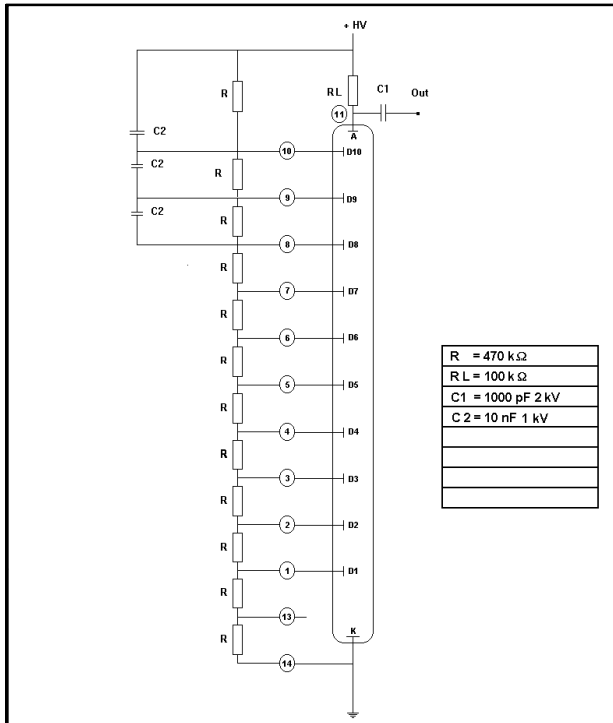


Figure 3. Voltage Divider Schematic Configured for Negative HV. (Note the anode signal is DC coupled to the output.)

In pulse shape discrimination (PSD) one examines the exact shape of the pulse tail. For this purpose, purely negative pulses are also preferred.

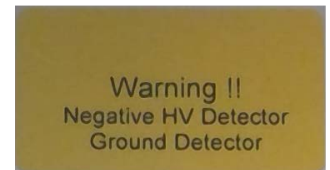
It should be noted that detectors can also be used in “Current” mode in which case one measures the anode DC current of the PMT. This makes sense when the rates are very high but then there is no energy discrimination. This method of measurement is only possible when the cathode is at a negative potential (NEG HV).

Despite the benefits that have been described, NEG HV bias does have drawbacks.

One must take extra precautions with NEG HV. Very careful design of the detector is more important for NEG HV since any possible high voltage leakage to ground contacts must be eliminated. The outside of the PMT is at negative potential via a conductive coating or mu-metal foil, and all possible (surface) leakage currents are to be avoided. Sometimes this is not easy since space may be limited.

A 14-pin detector wired for NEG HV (ground connected to pin 12 or via an external wire) can also be used at POS HV but not the other way around!

However, if a POS HV 14-pin detector is connected to a base wired for NEG HV, the outside of the detector becomes live high voltage. Therefore, all NEG HV detectors should carry safety/advisory labels.



Sample warning labels shown above.

Positive High Voltage bias supply and Negative High Voltage bias supply have their distinct benefits and drawbacks. BNC provides both configurations to satisfy the requirements of a broad range of scintillation detector applications.

See [www.berkeleynucleonics.com](http://www.berkeleynucleonics.com) for additional details and support.