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TO DETECTOR CAPACITANCE VARIATIONS

William W. Goldsworthy

February 21, 1967
Where charge-sensitive amplifiers are employed for amplifying nuclear-induced pulses from solid-state detectors, the gain shift accompanying detector capacitance change can introduce considerable instability. In the usual charge-sensitive amplifier in which only negative feedback is employed to stabilize the solid-state detector's capacity instability, one can not fully compensate for these instabilities because of the lack of infinite open-loop gain in the charge-sensitive feedback loop. If however a small amount of positive feedback correction is applied around a portion of the feedback amplifier, as described by Hahn and Mayer, one can obtain almost perfect compensation of these detector capacitance variations. This partial positive-feedback correction can be used on most existing charge-sensitive amplifiers with only minor modifications. Using a simplified version of Hahn's method, we have modified several preamplifiers at Lawrence Radiation Laboratory, Berkeley to employ this positive-feedback correction.

Corrective positive feedback was applied by feeding a small portion of the feedback loop's output back to the anode, collector, or drain of the loop's input stage. Figure 1 shows a typical charge-sensitive loop in which this positive-feedback correction has been
applied. No additional modification of circuit parameters is generally needed in existing preamplifiers, since the large resistance value needed for positive-feedback correction will have negligible effect on operating levels. Almost perfect capacitance-variation compensation is attainable if the value of the positive feedback resistor $R_x$ is carefully chosen. If the value of $R_x$ is too low, overcorrection will result where an increase in detector capacitance will produce increases in output-pulse amplitude. No degradation in energy resolution or gain stability was apparent with this partial positive-feedback compensation. Stability improvements in the presence of detector capacitance variations can approach two orders of magnitude by careful adjustment of $R_x$.

Although a cascode-input-stage amplifier is shown in fig. 1, compensation can be just as easily applied to other charge-sensitive amplifier arrangements. One such preamplifier, the Tennelec TC 130, was successfully compensated by connecting a compensating network from the base of $Q_4$ to the emitter of $Q_6$. The exact size of $R_x$ can be easily determined by using a pulse generator, a fixed 100-pF capacitor attached to an input plug, an amplifier, and a pulse-height analyzer. Observation of the spectral shift of the pulse-generator position on the pulse-height-analyzer display indicates directly the degree of compensation as the fixed capacitor is placed in parallel with the charge-sensitive amplifier's input.

Several advantages result from detector capacitance-shift compensation. These are the ability to change solid-state detectors without the necessity of readjusting amplifier gain, the ability to vary bias voltage without effecting pulse output amplitude, improved detector and
bias stability, and greatly improved stability under extreme radiation-level conditions.

Footnotes and References

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Figure Caption

Fig. 1. Charge sensitive amplifier employing positive feed-back compensation.
Fig. 1

Solid-state detector

F.E.T.

Pos. feedback compensations

Bootstrap

Output

Q1

Q2

Rx

Q3

Rf

Cf

Det. bias

Test pulser

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