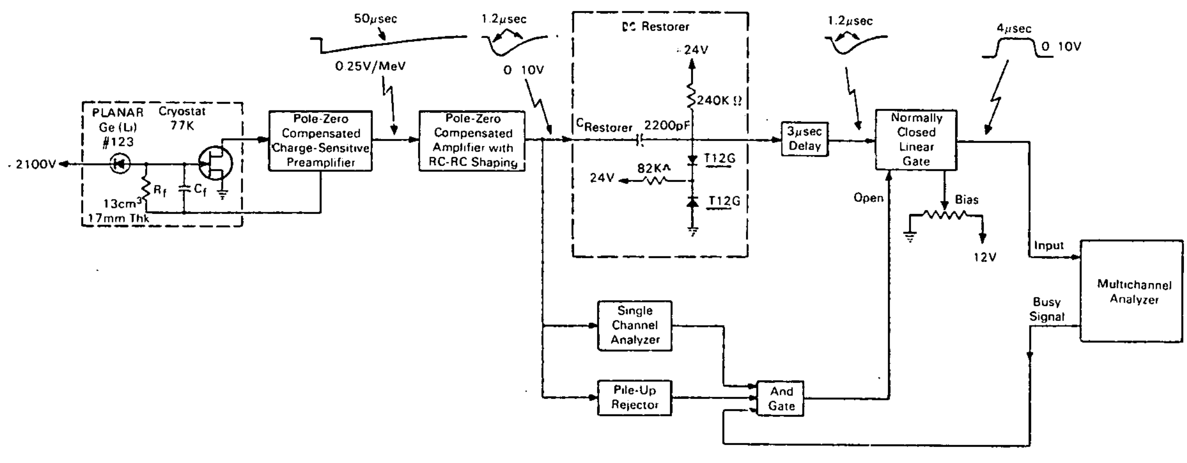
AEC-NASA TECH BRIEF

Multichannel Analyzers at High Rates of Input



Spectrometer system for use at high rates, employing a commercial multichannel analyzer preceded by a gating system

The problem:

Improvement of the quality of data from conventional multichannel analyzers that introduce considerable spectral distortion at high rates of input.

The solution:

When used in conjunction with a well-designed gating system incorporating pole-zero compensation, pileup-rejection, and baseline-restoration, almost any multichannel analyzer having an adequate number of channels can achieve very good resolution at high rates of input. A gating system was added to a conventional Ge(Li) gamma-ray spectrometer. When the input rate was increased from 1,000 to 50,000 pulses per second, the resolution at 1.33 Mev changed only from 3.3 to 3.7 kev, with a spectral shift of 0.08%. These figures should be compared with those for the original ungated spectrometer: resolution increase from 3.3 to 30.0 kev and shift of 3.2%. Furthermore, gating improved the peak-to-continuum ratio by an order of magnitude at 50,000 pulses per second. At a gross input rate of 100,000 pulses per second obtained from a mixture of ^{60}Co and ^{137}Cs sources, the gated system resolved the 1.33-Mev gamma-ray peak to 3.5 kev with a spectral shift of 0.1%.

How it's done:

The detector is a 13-cm^3, 17-mm-thick, lithium-drifted planar germanium [Ge(Li)] diode. The input stage of the preamplifier is a cooled FET that is directly coupled to the detector. The coupling networks in the preamplifier are pole-zero compensated, so that the output is virtually a pure, singly differentiated pulse, decaying with a 50-μsec time constant.

The main amplifier, which also incorporates pole-zero compensation, provides single RC integrating and differentiating time constants of 1.2 μsec. The amplifier output pulse is passed through a simple baseline-restorer with a time constant selected for

(continued overleaf)

best resolution at medium rates. The signal is delayed 3 μsec and presented to the input of a linear gate; it is directly coupled from the restorer through the gating circuit.

The linear gate is opened only when (i) the pulse amplitude falls within the window specified by the single-channel analyzer, (ii) the pileup-rejector fails to detect pulse-shape distortion due to pileup, and (iii) the multichannel analyzer is not busy processing a previous pulse. When the gate opens, the pulse is stretched at its peak amplitude, partially biased off, and amplified to a level suitable for analyzer input. Thus the linear gate serves also as a biased amplifier free of rate and pulse-shape problems. Not only does it restrict the analyzer input to relatively low rates, but also it partially derandomizes the inputs (through the action of the busy signal), thus guaranteeing a substantial quiet period preceding every pulse presented to the analyzer. This quiet time is always greater than 35 μsec: sufficient time for the analyzer's adequate recovery.

The usefulness of this spectrometer at high rates is due to the properly designed gating system which allows only a relatively low rate of *selected* pulses to impinge on the input circuitry of the multichannel analyzer. The high-rate features in the gating system and amplifying chain have these principal effects:

1) Pole-zero compensation, particularly in the main amplifier, substantially improves resolution and reduces tailing.

2) Pileup-rejection significantly reduces the rate-contributed continuum at high rates.

3) The baseline-restorer, preceding and directly coupled to the linear gate, is of paramount importance: it all but eliminates spectral shift and produces the major improvement in resolution.

Notes:

1. For additional details see W. L. Brown, W. A. Higinbotham, G. L. Miller, R. L. Chase, Eds., *Publ. 1593* (Nat. Acad. Sci.—Nat. Res. Council, Washington, D. C., 1969).
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Patent status:

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