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CHARGE-SENSITIVE PREAMPLIFIERS

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ABSTRACT

A technique is described for reducing the time-constant of a charge-sensitive amplifier without reducing the size of the feedback parameters.

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At high counting rates, pulse pile-up effects in preamplifiers give rise to energy resolution loss in nuclear spectroscopy systems. The preamplifier characteristics most likely to produce these energy resolution losses are excessively long pulse fall time, poor differential linearity, and multiple differentiation.

When charge-sensitive preamplifiers are employed to amplify pulses emanating from solid-state detectors, pulse lengths of a millisecond or longer can be easily developed. These long pulse lengths result from the high feedback resistance values employed for low-noise preamplifier performance.

At low counting rates these long pulses create few problems. However at higher counting rates the shift in bias level produced in the various amplifier stages handling these long pulses prior to first differentiation can produce changes in amplification as pulse tails pile one on top of another.

Many designers have reduced pulse length by inserting a moderate time constant differentiator early in the amplifier system. This arrangement, however, leads to the production of undesirable multiple differentiation in an amplifier system. It seems far better to attack this problem of pulse length directly in the charge-sensitive input amplifier loop.

The typical charge-sensitive detection arrangement shown in fig. 1, is modified in fig. 2 to attack the long-time-constant problem.

In fig. 1 the value of R_1 can easily be 1000 MΩ for best low-noise performance, and the value of C_1 will be in the vicinity of 1 pF for adequate stable charge sensitivity.

With these parameters the time constant and resulting pulse length can easily exceed 1 millisecond, which is undesirable from the standpoint of high rate operation. One solution to reducing this long time constant without changing the value of R_1 is to provide feedback for the resistive element R_1 of the charge-sensitive loop from a later point in the amplifier system as shown in fig. 2 while providing charge-dependent feedback in the normal manner with C_1.

This arrangement, which requires dc coupling throughout, will shorten the time constant by the amount of the additional gain used. In a typical case this will permit the input time constant to be reduced from 1000 to 50 microseconds, with an extra gain of only 20. With this technique differential linearity problems will be greatly minimized but should nevertheless not be neglected. Improvement should be pursued by employing high ratios of open to closed loop gain for all feedback amplifier stages, adequate dynamic range, and low-output impedance drive capabilities for the preamplifier output.

FIGURE CAPTIONS

Fig. 1. Conventional arrangement of charge-sensitive amplifier.

Fig. 2. Modified arrangement of charge-sensitive amplifier which permits shortened time constant.

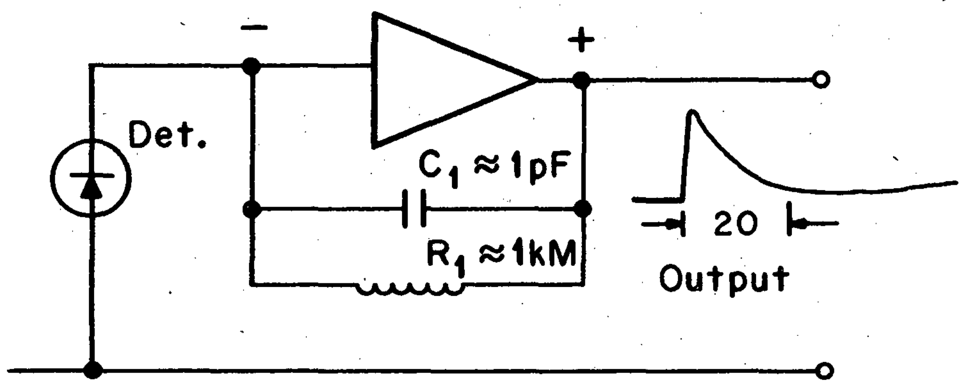

Fig. 1

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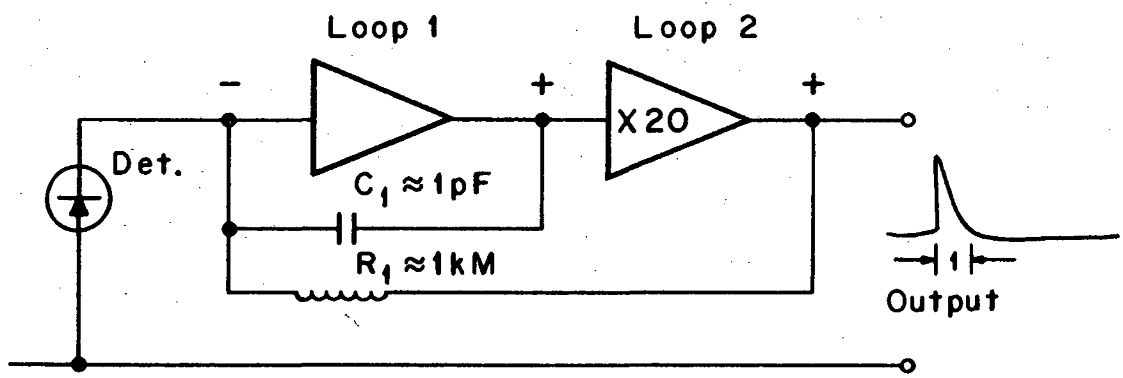

Fig. 2

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