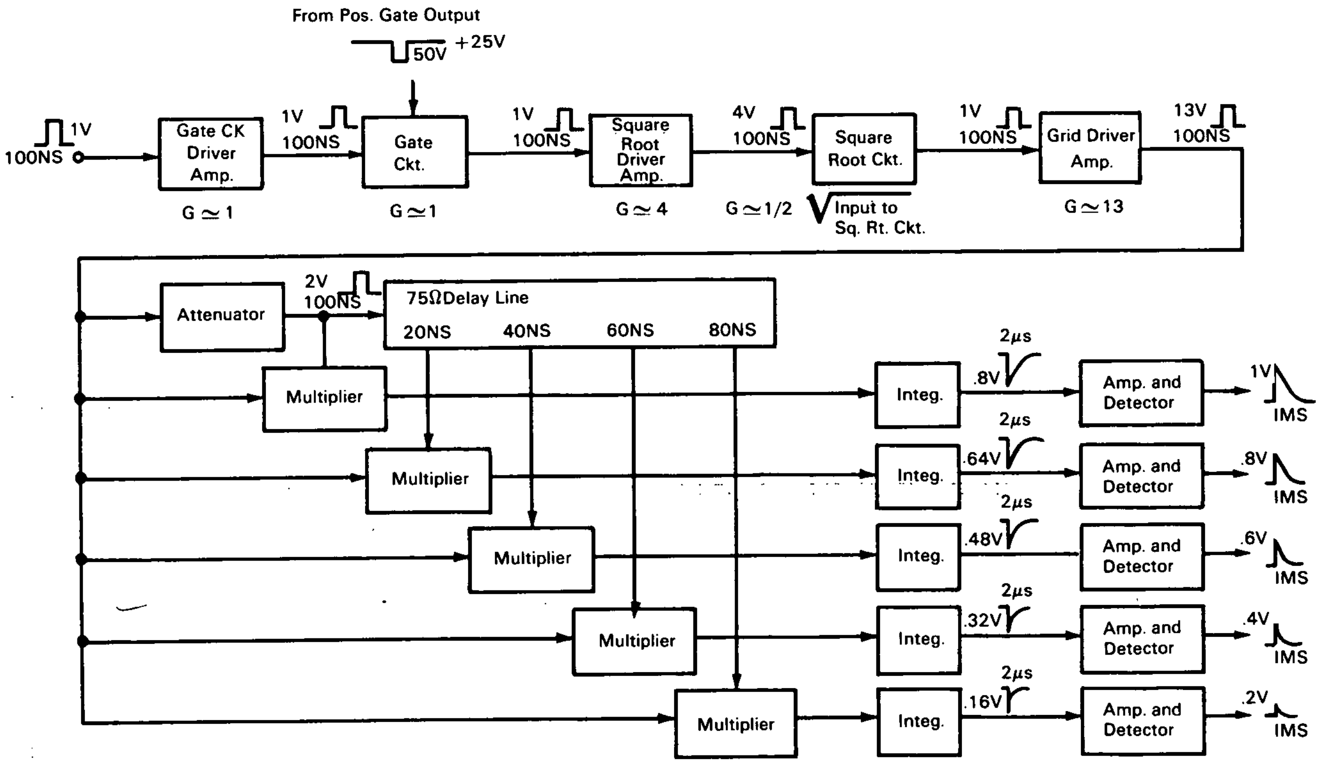
NASA TECH BRIEF

Accuracy of Laser Measurements Improved by Pulse Autocorrelator Electronic System



The problem:

To develop a method which permits the dispersion effect of a disturbed laser signal to be discriminated from background noise. Laser signals are of very short duration. As they travel through mediums having a varying refractive index, they may undergo multipath dispersion, and the disturbed pulses at the receiver become difficult to differentiate from a noisy background. The application of lasers to communications and measurements encounters variable mediums of this nature.

The solution:

A laser pulse autocorrelator that is an electronic multiplier and integrator network, based on the

(continued overleaf)

autocorrelation mathematical function and designed to detect multipath arrivals of gaussian-shaped signal pulses. The autocorrelation function is time-dependent and can be determined by integrating, for many occurrences, the product of a received pulse and its delayed replicas. Thereby, the autocorrelation function of the disturbed pulses can be resolved from a noisy background, whereas a single pulse could not be distinguished. This electronic system represents a convenient method for accurately determining important parameters of a transmitted pulsed laser signal.

How it's done:

The autocorrelator is constructed to detect the multipath arrivals of laser signal pulses. The modules (attenuator, multipliers, integrators, etc.) perform electronically the arithmetic operations required for evaluation of the autocorrelation integral.

Two conditions are assumed in the operation: (a) Only positive signals are autocorrelated, and (b) the integrators of the practical autocorrelator have finite storage times (4 microseconds) that are long as compared to the duration time of the individual signal pulses (100 nanoseconds), but are short as compared to the pulse repetition rate (100 pps). Therefore, each incoming signal pulse is individually autocorrelated, and the autocorrelation coefficient outputs for a particular pulse are not functions of the autocorrelation coefficients of any previous pulses.

The incoming signal (shown as a 100-nanosecond, 1-volt square pulse) enters the autocorrelator at the gate circuit drive amplifier. The purpose of this emitter-follower amplifier is to present a high impedance load to the signal source. The signal then passes into the gate circuit. The purpose of the gate circuit is to permit the free passage of signal pulses while preventing the passage of noise pulses.

The signal then passes through the square-root driver amplifier and square-root circuit, and is amplified to a high level by the grid driver amplifier. At this point, part of the signal is attenuated and fed to the delay line, where it is tapped off at various delay points and fed to the low level control grids of the multipliers. The main output of the grid driver amplifier is fed directly to the high level screen grids of the multipliers.

The multiplier outputs are then fed to the integrators, which in turn produce output pulses whose heights are proportional to the integral of the multiplier outputs. Finally, to permit the recording of the integrator outputs by audio FM machines, the integrator output pulses are stretched by the amplification and detection circuits.

Notes:

1. The delay times (arguments) for the five autocorrelation coefficient outputs of the autocorrelator were chosen as 0, 20, 40, 60, and 80 nanoseconds. The reason is that pulses emitted by a laser transmitter are approximately gaussian in shape, and have a pulse width on the order of 100 nanoseconds. It would be difficult to resolve multiple arrivals of these pulses for which the delay time between arrivals was less than 20 nanoseconds. Also, for this specific problem, it is improbable that delay times would exceed 80 nanoseconds.
2. Calibration of the entire autocorrelator is achieved by feeding a train of 100-nanosecond, 1-volt square pulses into the autocorrelator, and then adjusting the gain control potentiometers on the amplification and detection circuits so that the five outputs are proportional to the corresponding theoretical values.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77001
   Reference: B67-10338

Patent status:

No patent action is contemplated by NASA.

Source: S. J. Campanella
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