Physical Sciences

Lidar Luminance Quantizer

Commercial applications include 3D terrain mapping, urban reconnaissance, facial recognition, and robotic vision.

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This innovation addresses challenges in lidar imaging, particularly with the detection scheme and the shapes of the detected signals. Ideally, the echoed pulse widths should be extremely narrow to resolve fine detail at high event rates. However, narrow pulses require wideband detection circuitry with increased power dissipation to minimize thermal noise. Filtering is also required to shape each received signal into a form suitable for processing by a constant fraction discriminator (CFD) followed by a time-to-digital converter (TDC). As the intervals between the echoes decrease, the finite bandwidth of the shaping circuits blends the pulses into an analog signal (luminance) with multiple modes, reducing the ability of the CFD to discriminate individual events.

The lidar luminance quantizer (exemplified in Figure 1) resolves the amplitude, amplitude slope, and temporal characteristics of a luminance echo at the instants the signal crosses a plurality of thresholds. The system is comprised of an n-bit flash quantizer with 2^n-1 high-speed, non-latched comparators, and a k-bit time-to-digital converter (TDC) with 2^k quanta. Each comparator's output is encoded into amplitude (S_{A+}, S_{A-}) and temporal (S_T) data, the latter relative to the illuminating laser flash instant. S_{A+} and S_{A-} are the encoded amplitudes of positive and negative slewing points respectively. When a comparator detects that a threshold has been crossed, it latches the outputs of the amplitude encoder and the TDC as binary words S_{A+} or S_{A-}, and S_T. The interval S_T is the round-trip time from laser emission to detection by a particular comparator. In Figure 1, the S_A and T registers are cascades of parallel k-bit temporal data, n-bit amplitude data, and 1-bit slope sign data, clocked by the associated comparator output so that the data is streamed asynchronously between laser flash instants. The ensemble of measurements allows decomposition of a scene's luminance versus time so that the modes can be resolved resulting in greater image detail. This scheme differs from photon-counting lidar detection systems in that the echoes are quantized in both amplitude and time. An exemplary timing diagram for a complex wave-shape is shown in Figure 2 for a 3-bit amplitude quantization.

The invention is unique in that it combines a slew sensitive flash digitizer function with a temporal encoder to digitize the echoes in the amplitude, derivative, and time domains. Its operation is synchronous with respect to the laser flash instants, but the measured amplitude and temporal points output from the encoder occur asynchronously between flashes. Each threshold crossed is paired with a TDC output value for a plurality of outputs per clock period, unlike a traditional flash digitizer where only one word is output per clock period. This function can be viewed as an equivalent ultra high-speed digitizer in that the amplitude measurements within a clock period can be resolved temporally by the TDC at a very fine level.

This work was done by Gerard Quilligan, Jeffrey DuMonthier, and George Suarez of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15815-1
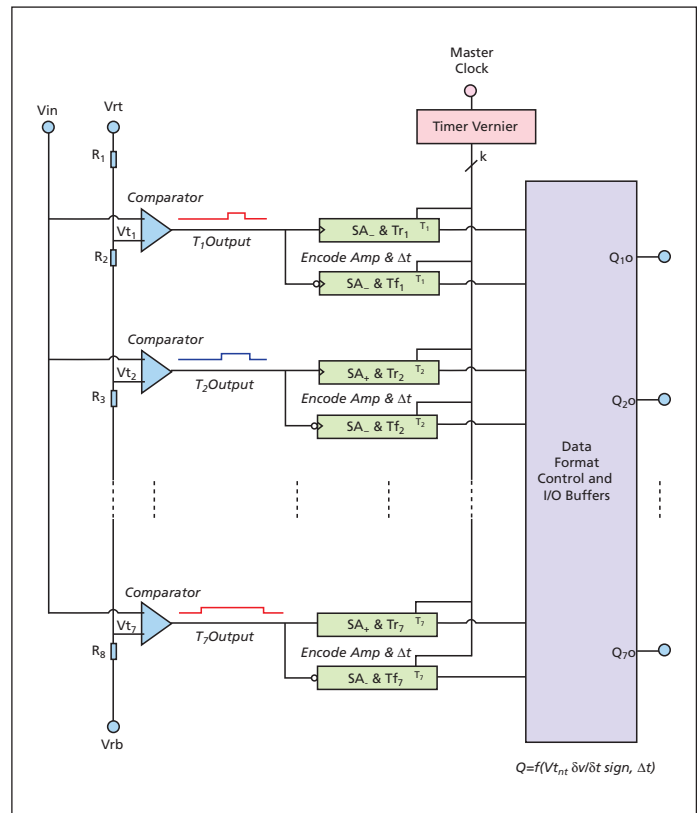

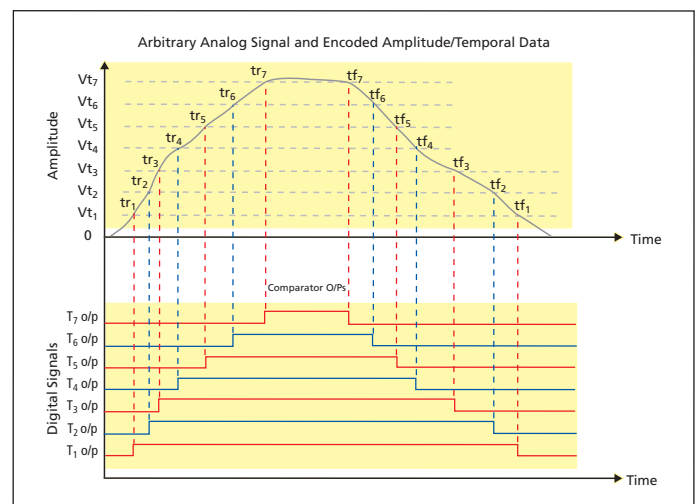Figure 1. Exemplary 3-bit amplitude/k-bit temporal **Lidar Luminance Quantizer** block schematic.

Figure 2. Exemplary 3-bit amplitude/k-bit **Temporal Quantization** of an arbitrary analog signal.