Pulse Modulation Measurements with Osci11oscopes

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Introduction

Pulse modulation is widely used in data-communications and electronic warfare applications. Both resolution in radar, and transmission rates in communications are improved as modulation rates become faster. Currently, pulse modulation is being combined with other forms of modulation to enhance both system performance and efficiency. However, as pulse rates improve, it becomes increasingly more difficult to find equipment capable of accurately characterizing or verifying the performance of the pulse modulation system, especially when classified signals are involved. This paper describes equipment requirements and responses necessary to identify pulse modulation signals.

Pulse Modulation/Demodulation

All critical pulse modulation performance measures are time domain characteristics. As shown in Figure 1, time parameters and level parameters completely characterize the waveform.

In the past, a high speed pulse demodulator was required in order to view the pulse shape on an analog scope, pulse trained engineers were needed to interpret the Waveform displayed. The pulse demodulator contained a fast detector to indicate when a pulse was present, plus a difficult to build 1inear modulator that could accurately reproduce the shape of the pulse. Parasitic capacitance, detector /load capacitance, broadband video amps, and the detectors square law region all contributed to make recognizing a signal difficult.

If pulse modulation is combined with frequency or phase modu1ation, the problem of identifying a signal becomes even more complicated. The demodulator and any preamplifiers must have minimal phase-modulation-to-amplitude modulation conversion, which rules out tunable amplifiers and filters. Filters with good transient response are required to avoid distorting the pulse edges. Also, the measurement system must have the same sensitivity at all carrier frequencies used, giving it better performance characteristics then the unit to be tested.

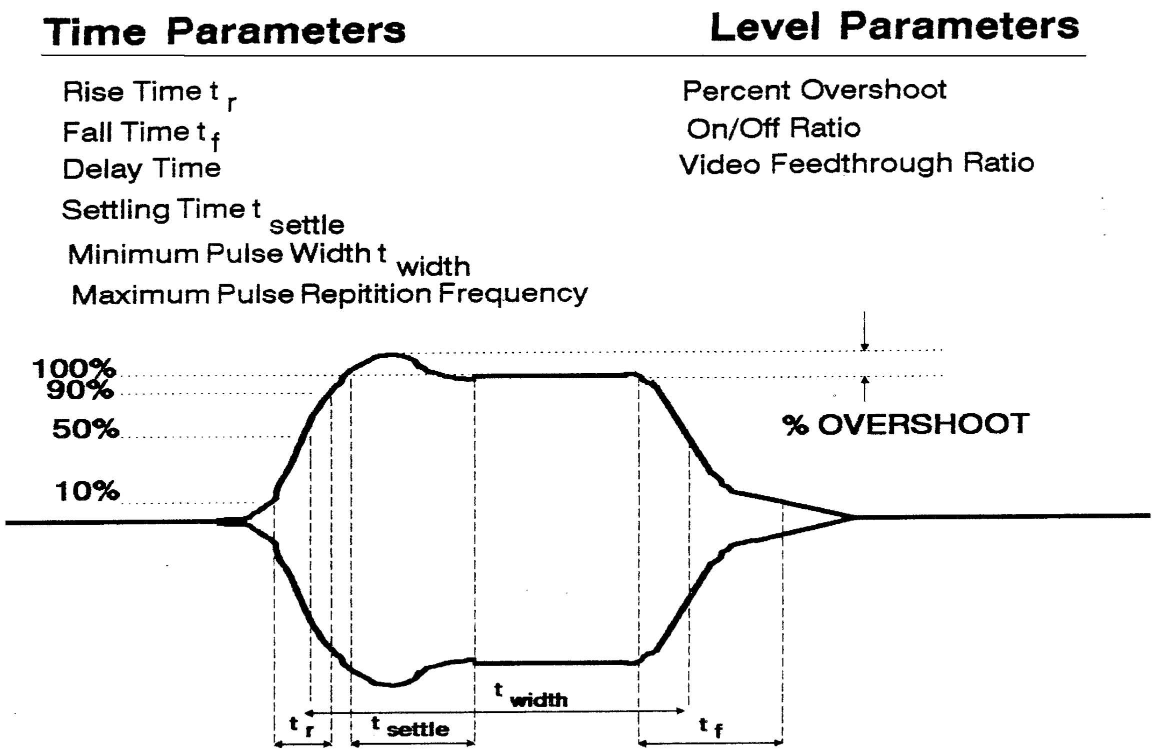

Figure 0 - Time Domain Pulse Characteristics

Digitizing Oscilloscopes

A digitizing osci11oscope demodulates the pulse-modulation envelope directly without any additional hardware. This is accomplished by digitizing the RF signal directly in its envelope mode. The scope demodulates an RF burst by reproducing the waveform's envelope. As the waveform is sampled, each of the acquired points are time tagged via repetitive sampling and compared with any previously stored points of the same time reference. If the latest sample is greater then the corresponding maximum or less than the minimum, the appropriate memory is updated to reflect the new extreme.

Repetitive samplers are characterized by having an analog bandwidth that exceeds their sample rate. Digital scopes usually use a sample and hold circuit prior to the A/D converter. This gives the relatively low-speed A/D converter time to digitize fast- slew-rate signals. Repetitive samplers reconstruct the signal basically by taking multiple looks at a waveform.

If the RF is not phase-locked to the modulation signal, the envelope is detected, since a sample eventually is acquired on both a minimum and maximum peak for each of the time references stored previously. Therefore, while using the envelope mode, aliasing or frequency hopping does not distort the waveform, because the minimum and maximum valued contain the information needed to reproduce the envelope. Within the envelope, we are not concerned with the relative phase of the signal, only the amplitude extremes.

Signals that are very close in phase to the sample clock or that have been undersampled, may be reproduced incorrectly by a digitizing system. Two samples per period are required to prevent under sampling, which limits the maximum single-shot analog bandwidth to half the sampling frequency. Therefore, the effective sample frequency, defined as the reciprocal of the timing resolution, must be considered. As long as the signal to be digitized remains below ha1f the effective sampling frequency, then no alasing occurs.

Output Results

The upper trace produced by envelope-mode digitization corresponds to the output of an ideal positive peak detector, with the lower trace corresponding to the output of a negative peak detector. Once stored in the digital scopes memory, the scopes waveform math functions and measurement routines can be utilized. Twice the mean (no divide by two capability) of the upper and 1ower envelopes is the video feed through, found by having the oscilloscope add the two traces together.

The modulation drive signal is the fast trigger source. Using it allows the pulse delay to be measured when looking at communications and EW systems. This allows the digital oscilloscope to accurately measure rise-and-fall time, overshoot, pulse width, pulse-repetition frequency, and peak-to-peak voltage. With markers, functions, and special measure commands, the scope can also find the settled carrier level, settling time, pu1se delay, on/off ratio, and video feedthrough.