Trend and track: Two useful oscilloscope diagnostic tools

Arthur Pini - January 14, 2018

An oscilloscope's track and trend features add two measurement-based math functions that you can use to gain insight into measurements. Trend is a plot of measured parameter values in the order the measurements were made, using measurement event number as a horizontal value. Track is a plot of measured parameter value versus time. These functions allow a series of measurements to be handled as a waveform. These two functions let your oscilloscope perform data logging, investigate functional relationships between measured values, locate anomalies in long data records, and even demodulate angle modulated or pulse-width modulated signals.

Both trend and track are based upon the oscilloscope's measurement parameters, of which most oscilloscopes offer about twenty-five. Measurement parameters include frequency, amplitude, and rise/fall time. The oscilloscope keeps track of these measured values and uses them to display statistics of the parameter values. It also permits these values to be plotted as trend and/or track.

Figure 1 shows an example of how to use trend or track functions. The acquired trace (yellow in upper grid) is a pulse-width modulated (PWM) signal. Parameter P1 measures the cycle-by-cycle pulse width over the acquired waveform. Parameter statistics include the minimum (2.698 ns) and maximum (49.3 ns) pulse widths, plus the mean and standard deviation of all the values. There are 100 cycles in the acquired waveform (100 k samples) and the pulse width of each cycle is measured and reported in the statistical data.

The bottom trace (blue) is the trend of the pulse width measurement. It contains the 100 pulse-width measurement values in the order they were taken. Each dot on that trace represents one value. The number of values in a trend plot is typically user selectable, often from 2 to 1,000,000 in a 1-2-5 progression. The trend plot and the source waveform are synchronous in this example because the trend plot length, 100 values, matches the number of cycles of the source waveform, but that's not always the case.

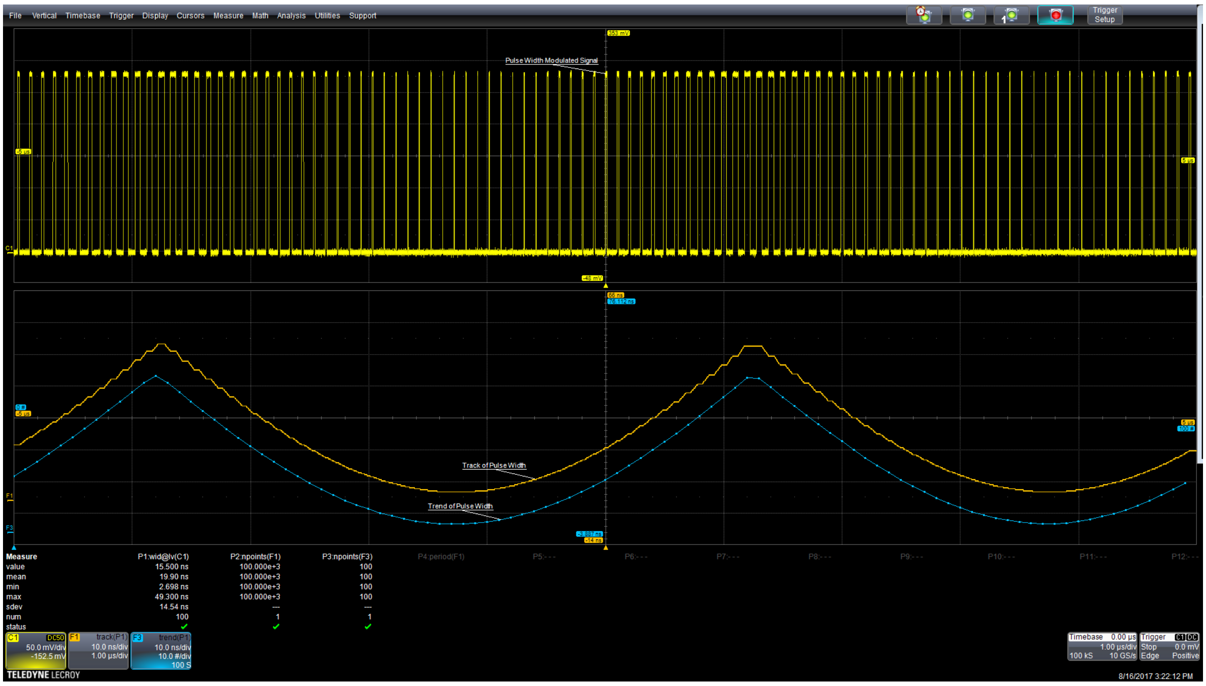

Figure 1 A trend and a track of pulse width derived from a pulse width modulated waveform.

The center trace (orange) is the track of pulse width. That waveform contains the same 100 k points as the acquired waveform. Each measurement value is upsampled to match the duration of each cycle of the source waveform. Track plots are always synchronous with the source waveform.

Due to the time-synchronous nature of the track function, you can use it to demodulate signals like this PWM waveform. By tracking the parameter frequency, you can use it to also demodulate a frequency-modulated (FM) or phase modulated (PM) signal.

Data logging

The trend function is great for data logging. Consider the measurement in **Figure 2**.

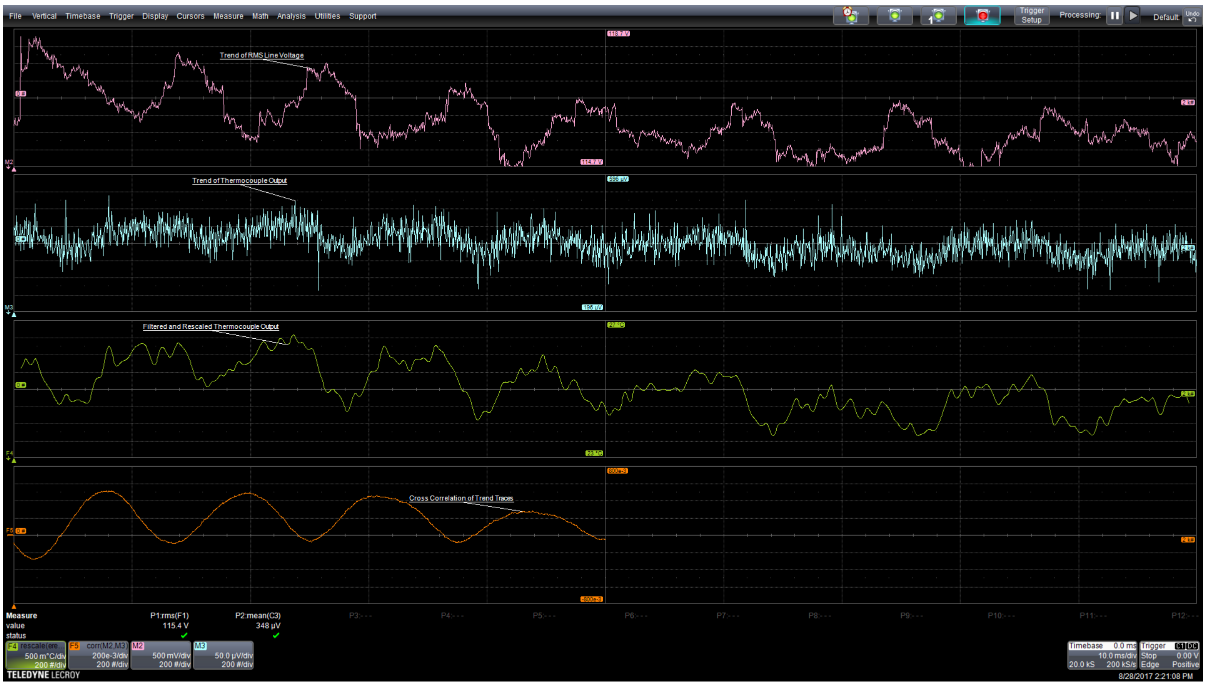

Figure 2 A data logging example recording variation in RMS line voltage and room temperature. Trigger hold-off is used to space readings every 5 s.

The top trace is the trend of RMS line voltage. Trigger hold-off is used to insert a 5 s delay between each measurement. The second trace from the top is the trend of a thermocouple output. The thermocouple output is filtered and rescaled to read in degrees C in the math trace F4 (third trace from the top). The entire display represents 2,000 measurements taken 5 s apart, that's a 2.7-hr. interval.

The line voltage drops when an air conditioning system turns on, followed by a slight drop in temperature. The whole process is periodic. This is verified by cross correlating the raw trend waveforms and is shown in the bottom trace. The periodicity is clearly shown in the correlation function and is about every 252 measurements or about every 20 min.

Demodulation using track

In some applications, it's helpful to demodulate an angle-modulated signal. For example, in measuring the frequency response of a phase locked loop (PLL), you can use the track function to see the variation in phase at the PLL's input and output. **Figure 3** shows the PLL frequency response measurement.

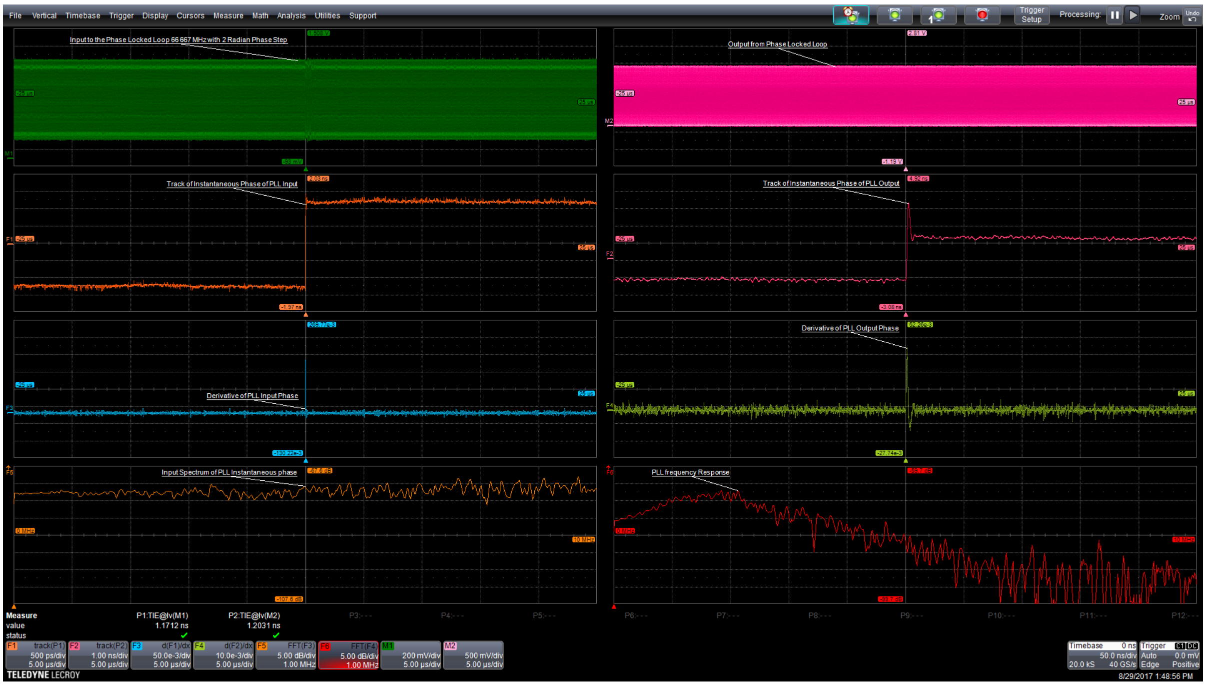

Figure 3 Use the track of time interval error to demodulate the phase modulated input and output to a PLL.

The frequency response of any device can be measured by exciting it with a step function, differentiating the step response and taking the Fast Fourier Transform (FFT) of that response. In **Figure 3**, the upper left trace is the PLL input: a 66.67 MHz sine with a 2 radian phase step at the mid-point of the waveform. The time interval error (TIE) of the waveform is measured in measurement parameter P1. TIE measures the time between the measured position of a waveform edge or threshold crossing and the ideal location of that edge. TIE is essentially a signal's instantaneous phase. The track of TIE for the PLL input is shown in the second trace from the top on the left side of **Figure 3**. The TIE's track demodulates the phase modulated input. The phase step in the center of the input waveform is plainly evident.

The trace in the upper right is the PLL's output. Measuring the TIE of the PLL output and using track to demodulate phase lets you see the PLL’s effect on the phase step. See the second trace from the top on the right side of Fig. 3. The track function gives views of the phase variation of both the PLL's input and output. The track function provides a view of the phase variation that's not apparent in the source traces, which is important because the PLL is a phase sensitive device.

A signal's frequency response is usually measured using an impulse function as an input signal. Differentiating the step response yields the impulse response. The third set of traces show the demodulated PLL input and output signal on both the left side and right side of Fig. 3, respectively.

The bottom left trace in Fig. 3 shows an FFT of the PLL's impulse response. Note that it is a basically flat response. The FFT of the PLL output impulse response, in the bottom right trace, shows the PLL's frequency response. Technically, the frequency response is the complex ratio of the output to the input FFTs, but because the input is spectrally flat, the output spectrum approximates the PLL's frequency response.

Trend or track?

Trend is the function of choice for data logging. The trend trace only contains one point per measured value so it is very memory efficient. Track is required if you need to perform a time-dependent operation such as the FFT or filtering on the trace. It's also useful to trace anomalous measurement readings back to the source trace because the track remains time synchronous with the source trace. It does this at the expense of using more samples in the function.

Trend and track functions let you view the history of individual parameter measurements. By making a series of measurements a waveform in its own right, you can apply the oscilloscope’s math and analysis tools to learn a great deal more about the process being measured. This can significantly reduce troubleshooting and debugging time.

—*Arthur Pini has over 50 years' experience in electronics test and measurement.* See all of his EDN oscilloscope articles.

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