Basic Radar Measurements

Demodulating and Measuring Radar Pulses

APPLICATION BRIEF

LAB WM781

August 13, 2009

Summary

Radar signals utilize a variety of modulation methods including amplitude, frequency and phase modulation. LeCroy's Demodulate math function allows users to quickly demodulate and measure key pulse parameters of the radar signal.

Pulsed radar systems utilize a variety of modulation schemes including amplitude, frequency and phase modulation. LeCroy WavePro 7Zi and WaveMaster 8Zi oscilloscopes can easily capture and demodulate pulse waveforms and allow detailed measurements on the detected waveform characteristics.

Figure 1 illustrates a set of basic radar measurements. The RF pulse is acquired as shown in the top trace. Trace F1 shows the amplitude envelope of the pulse extracted using the oscilloscope's demodulate math function. Demodulate is an optional math function that supports demodulation of amplitude, frequency, and phase modulated signals. A zoom view of the RF pulse (Trace Z1) is overlapped by the demodulated envelope (Trace F2) in the third grid from the top. This allows an evaluation of the fidelity of the detection process. The bottom trace shows the spectrum of the pulsed waveform centered at the carrier frequency of 1 GHz with a span of 100 MHz.

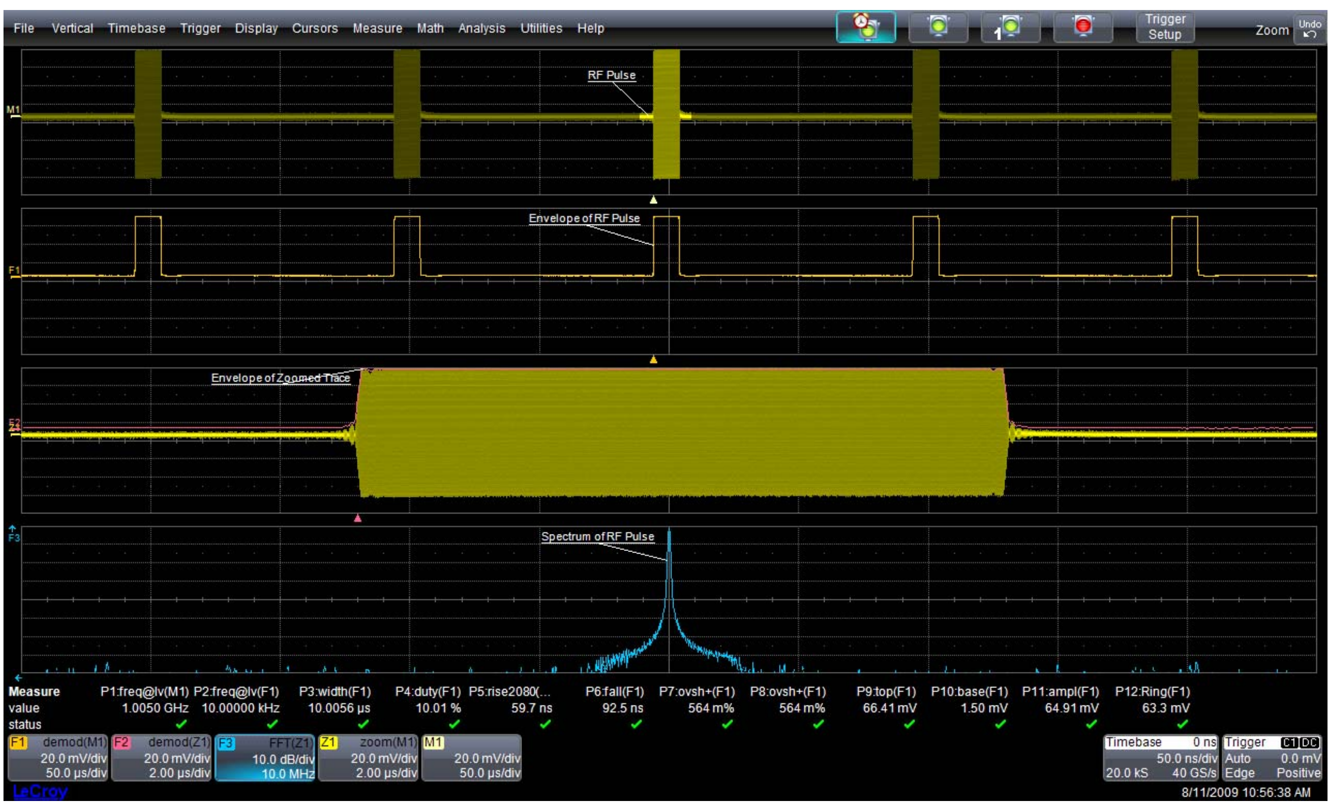

***Figure 1*:** Demodulating the RF pulse envelope and measuring key pulse parameters.

Measurement parameters P1 through P12 read key pulse characteristics. P1 shows the carrier frequency. This is needed in order to setup the demodulate function. P2 reads the pulse repetition frequency. The remaining parameters include duty cycle, rise and fall times, overshoot, top, base, amplitude, and ring amplitude. These are just a small selection of the over 150 total parameters available in a LeCroy oscilloscope.

Let's take a look at another example. In Figure 2 we have a pulse which is phase modulated using Barker Codes. The function F1 uses demodulate to compute the amplitude envelope of the RF pulse. This shows amplitude spikes where the Barker codes cause a change in phase. Function F2 is phase demodulating the same RF pulse and shows the phase changes due to the coding. Note that in areas outside the RF pulse the phase shows a random variation, this is normal. As before, the bottom trace is the spectrum of the RF pulse showing the effects of the phase modulation.

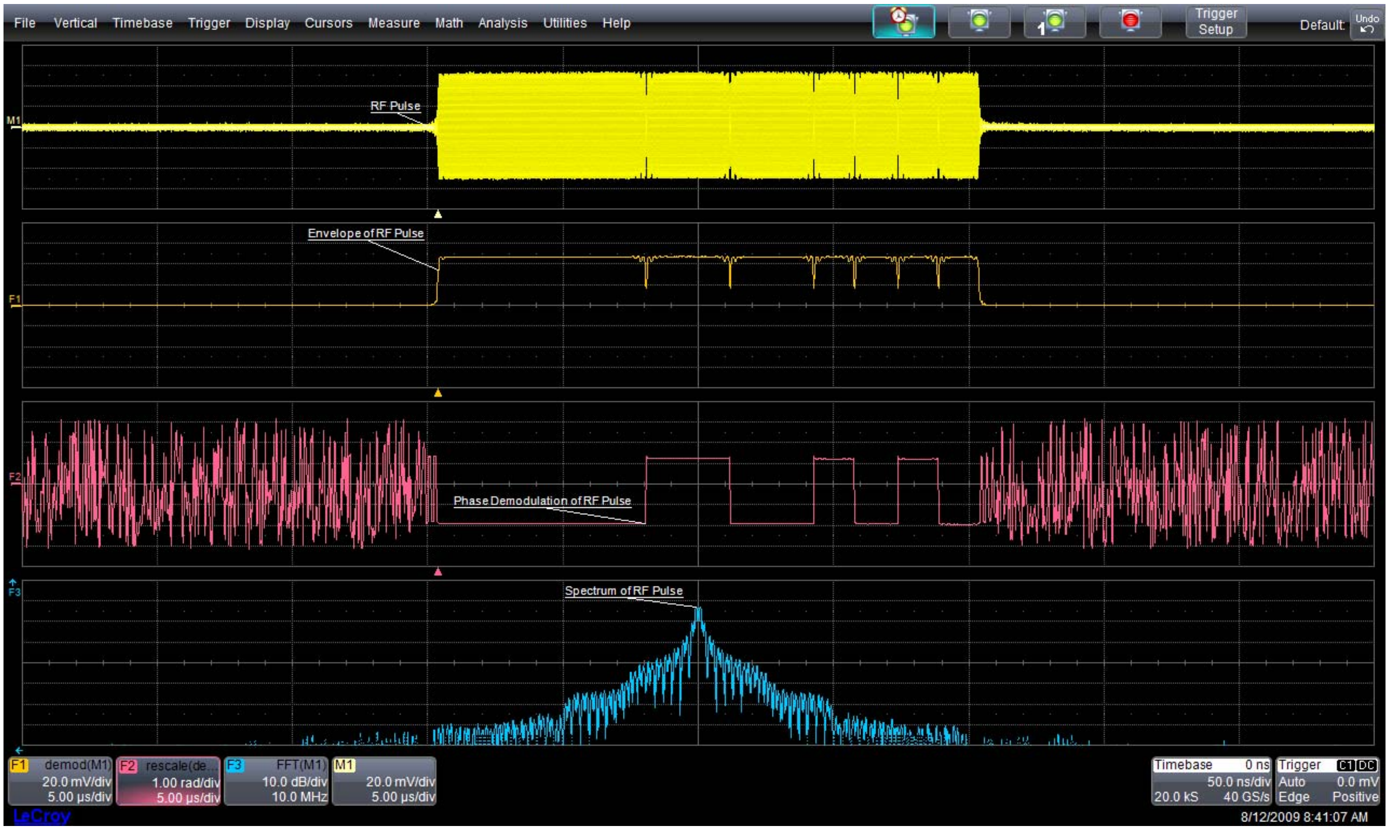

Figure 2: A Barker Coded Radar Pulse along with the amplitude and phase demodulated waveforms

The dialog box for setting up the demodulate function is shown in Figure 3. In addition to specifying the type of modulation it also requires the carrier frequency for phase and frequency modulation. The decimation field controls reducing the over-sampling in the acquired waveform. This reduces computation time and simplifies the post detection filter. This low pass filter is controlled via the 'Bandwidth' and 'Max # of Taps' fields shown in the dialog box. The 'PM Scale' entry allows the user to set the vertical scale increment on the final display.

The final example uses frequency demodulation to detect and display a pulse modulated with an FM chirp. This is shown in Figure 4. The chirp is a linear variation in the carrier frequency of the RF pulse as can be seen in the trace F2. This is confirmed in the spectrum display in trace F3. In this case the demodulate function uses FM demodulation as shown in Figure 5. In most cases the default values work well and the only critical need is to enter the correct carrier frequency. This, as we saw in Figure 1 can be measured directly.

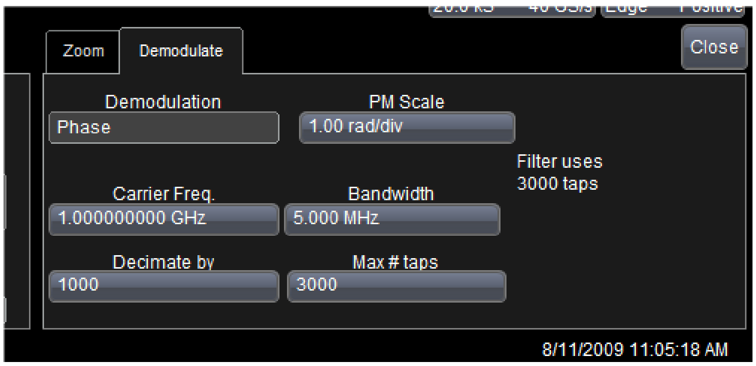

Figure 3: The dialog box for setting up the demodulate function

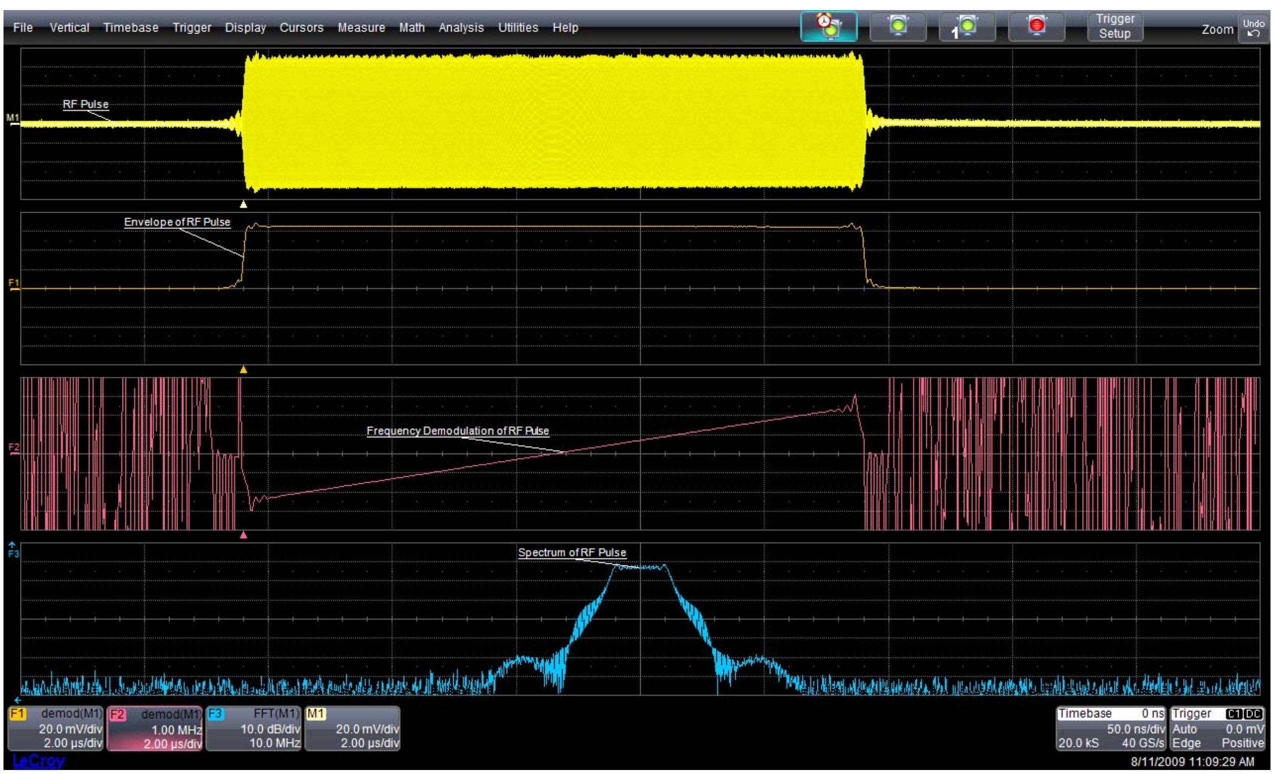

Figure 4: The demodulation of a frequency modulated chirp.

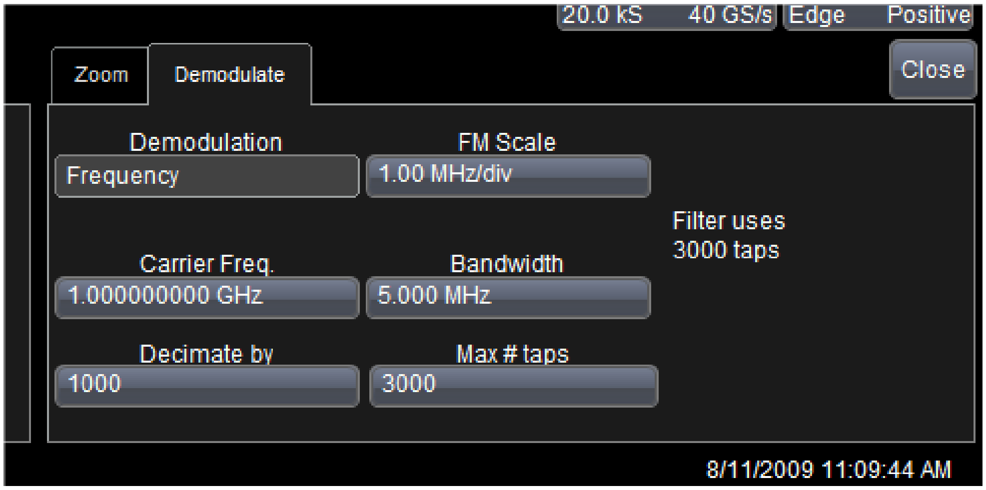

Figure 5: The demodulate dialog box with the setup for frequency demodulation

LeCroy demodulate math function offers an easy to use way of making some very basic radar measurements requiring amplitude, frequency or phase demodulation. It does this without the need of external software.