Modulation Analysis - FM

Using Jitter And Timing Functions To Analyze FM signals

The Jitter and Timing Analysis (JTA) option functions are ideal for extracting the modulating waveform from a frequency modulated (FM) signal. The frequency deviation of the carrier, the modulation frequency, and the modulation index can all be determined from the demodulated waveform.

The analysis of a 10 MHz FM signal with a 20 kHz sinewave modulation and 100 kHz deviation is shown in figure 1. The acquired frequency modulated waveform is shown in the upper trace (CH2). The JTA function JitterTrack Frequency is used to obtain a function of instantaneous frequency vs. time shown in trace A. The sinusoidal modulation is clearly evident. Averaging is applied to improve the signal to noise ratio and the resultant modulation signal is displayed in trace B. Measurement parameters read the maximum and minimum value of the modulation waveform which contain the maximum and minimum frequency excursion or deviation (about ± 110 kHz). The mean value is the nominal carrier frequency. The frequency of the modulation waveform (20 kHz) is the modulation frequency. The FM modulation index is the ratio of deviation to modulating frequency (about 5:1 for this example).

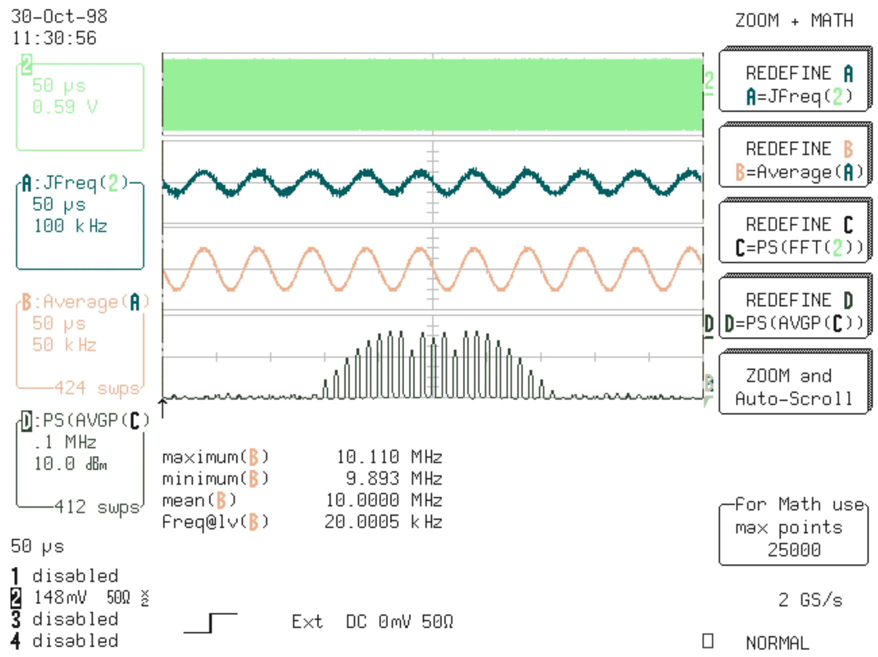

Figure 1 Analysis of an FM signal using both JitterTrack frequency (Jfreq) and the FFT

The lower trace in this waveform is the averaged fast Fourier transform (FFTAVG). In this case it has been expanded about the 10 MHz carrier and shows the sideband structure of the FM waveform with a horizontal scale factor of 100 kHz/division and a resolution bandwidth (Δf) of 2kHz.

Another approach for demodulating the FM waveform is to measure the phase variation of the signal as a function of time and to scale and differentiate the phase to obtain the frequency variation. This approach is illustrated in figure 2. The instantaneous phase is obtained using the JitterTrack Interval function shown in trace A. This time interval error function compares the waveform threshold crossing to a reference frequency and produces a plot of time error vs. time. The error can be expressed in absolute time or normalized to the period of the reference frequency and read out in unit intervals. The rescale math function is used to convert from time interval error to phase in radians. The multiplicative constant required to convert time interval error in unit interval (UI) to radians is $1/2\pi = 0.159155$ and is applied in trace B.

The rescaled phase function can now be differentiated to obtain the instantaneous frequency as a function of time. This is accomplished in trace C. Note that in order to reduce the generation of noise in the differentiation process the number of points in the calculation is reduced to 250 using the Zoom + Math menu as shown in the figure.

Trace C is rescaled in trace D to add the nominal frequency (10 MHz) which was removed in the time interval analysis. Both waveforms are overlaid in the lowest grid. Measurement parameters read the same parameters discussed in the first example and yield similar numeric results.

The second technique is more effective for FM analysis on waveforms with smaller frequency deviations. The time interval error measurement usually exhibits a higher signal to noise ratio than the JitterTrack Frequency.

It should be obvious that the JTA functions, augmented by the full featured math processes available in LeCroy digital oscilloscopes, allow users to extract both frequency and phase variations as functions of time. These functions serve as the basis for modulation analysis within the scope.

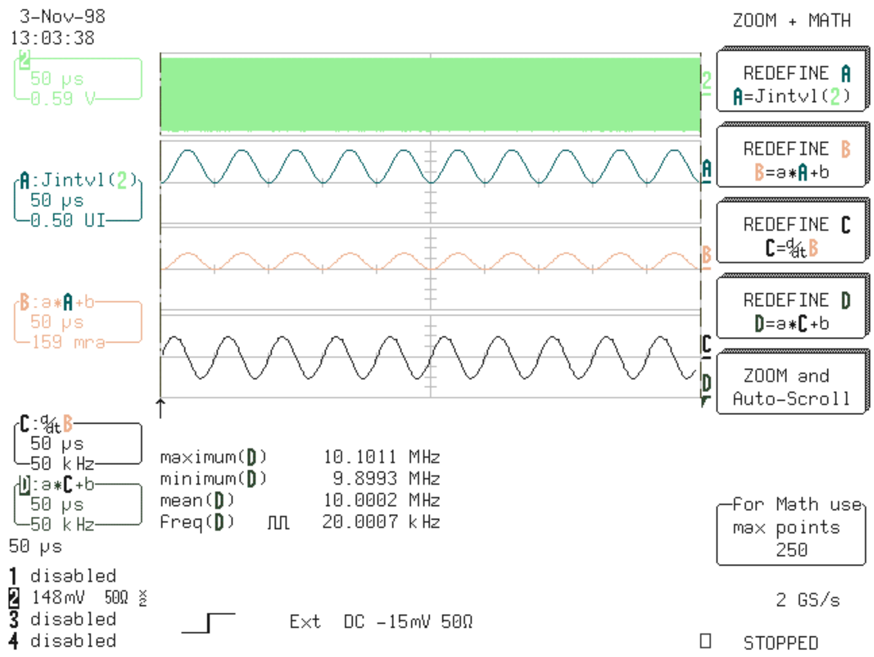

Figure 2 – Deriving the modulation waveform using the time interval error function (Jinterval)