Application Note/Product Note/Case Study

Application examples for the ultrafast digitizers of the M5i.33xx series

The five models of the M5i.33xx-x16 digitizer series, with 10 GS/s maximum sampling rate, over 3 GHz bandwidth and 12-bit resolution, are well matched to a broad range of RF and high-speed digital applications.

Application 1: Measuring RADAR pulses

One such RF application is radar analysis. Figure 1 shows an example of acquiring a 1 GHz, phase modulated radar pulse.

Figure 1: A 1 GHz phase modulated radar pulse (upper left) with the demodulated phase information (lower left). The frequency spectrum of the pulse (upper right) and a horizontally expanded view of the spectrum (lower right)

The radar pulse is acquired with the maximum sampling rate of 10 Giga Samples per second (GS/s) shown on the Spectrum Instrumentations SBench 6 measurement software. The phase modulation is a bi-phase Barker code intended to improve the range resolution of the radar. They are a sequence of numbers of different lengths of +1 and -1. The acquired data was transferred to MATLAB where the phase demodulation was performed, and the demodulated signal imported back into SBench6. A software development kit (SDK), that includes drivers that allow common third-party analysis software like LabView and MATLAB to control and communicate with the digitizer, is included. The digitizer also can transfer the data at up to 12.8 GB/s via the PCI Express x16 interface to the PC system or do a direct transfer to a CUDA GPU for custom processing. These interfaces provide the ability for further advanced analysis.

The Fast Fourier Transform (FFT) of the acquired signal shows the frequency spectrum of the signal. As expected, it has a peak at the carrier frequency of 1 GHz. A horizontal zoom expansion of the FFT at the carrier frequency shows the spectral broadening due to the phase modulation.

In this application the long record length of up to 8 GSamples is also very useful to study tracking histories of up to 800 ms at the 10 GS/s maximum sampling rate. The measured pulse has a duration of 20 us and, at a 10 kHz pulse repetition frequency of 10 kHz, about 8000 such pulses can be acquired in each record.

Application 2: Analyzing quadrature-modulated communication-signals

Communications measurements are another application area where the M5i.33xx-x16 series digitizers can be employed. Most communications systems use a variety of quadrature modulation schemes to efficiently encode data. Figure 2 illustrates an analysis of an 8PSK modulated 1 GHz carrier.

Figure 2: The time and spectral analysis of a 1 GHz carrier quadrature modulated by an 8PSK signal. The upper left trace is the acquired 8PSK signal. Traces to the right are horizontal zooms of that trace. The low left trace shows the spectrum of the signal with expanded views of it to the right.

A 20 us length of the acquired 8PSK signal is shown in the upper left trace in the SBench 6 display. Below that trace is the frequency spectrum of the signal. The spectrum shows a peak at the carrier frequency of 1 GHz with its modulation envelope. The third harmonic of the carrier at 3 GHz is visible and attenuated by about 36 dB from the carrier peak. The bottom center trace shows an expanded view of the spectrum. Cursors measure the offset of the closest modulation sideband to the carrier frequency. The cursor readout, shown in the info panel to the left, reads the sideband offset as 160 MHz from the carrier frequency. The modulation envelope for an unfiltered pulsed waveform would have a sin(x)/x shape. The 8SPK signal has been low pass filtered with a raised root cosine filter with a bandwidth of 20 MHz. This is shown in the expanded spectrum view in the bottom right trace. The cursors measure the nominal bandwidth of the filter. The frequencies above the 20 MHz cutoff are eliminated from the modulated signal spectrum so the sidebands appear only within 20 MHz of the carrier and sampling nulls.

The top center trace is an expanded view of the acquired time signal. The ripples are due to the data modulation. The spacing between two adjacent narrow peaks provides insight to the data rate of 40 MBaud. The 160 MHz spacing between the modulation sidebands indicates an additional sampling process at four times the data rate, or 160 MHz. Looking at the highly expanded view of the 8PSK signal in the top right trace you can see the granularity in signal between phase breaks. The cursors are set to measure the time period between phase breaks, and it turns out to be 6.2 ns, or a frequency of 160 MHz. So, the 40 MBaud modulation is band limited to 20 MHz and sampled again at 160 MHz before being broadcast.

The acquired RF carrier was demodulated externally to SBench 6, using proprietary vector signal analysis software, and then the resultant in-phase and quadrature components are re-imported back into SBench 6 for additional analysis and display. Figure 3 provides an example of the results.

The I component is shown in the upper left trace, the Q component is shown below the I component.

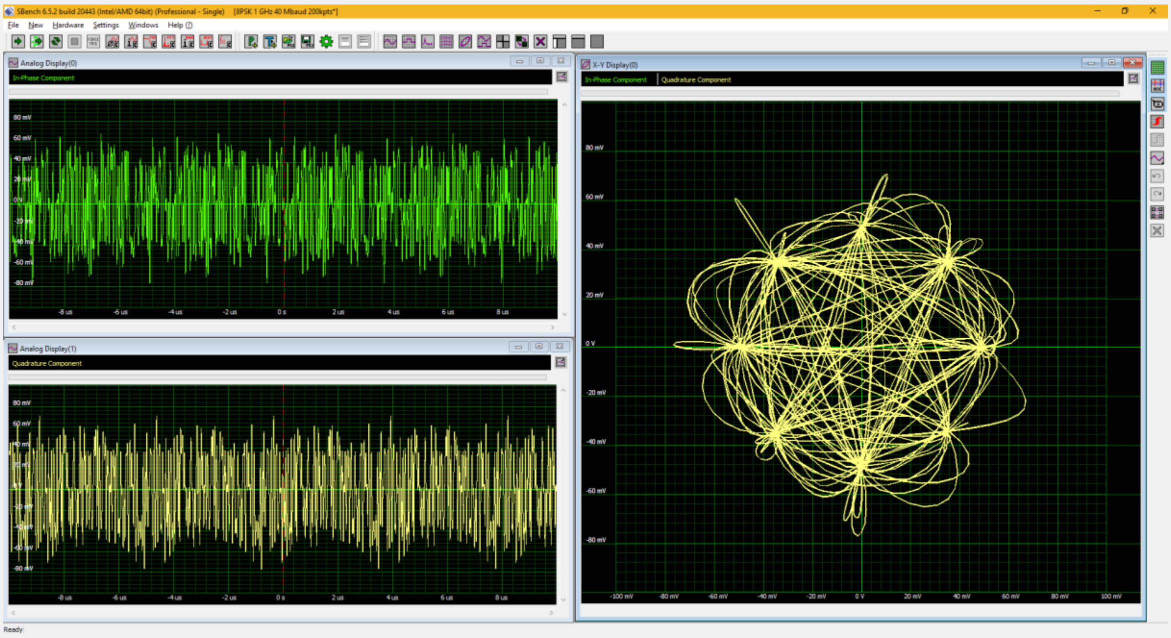

Figure 3: The in-phase (I) and quadrature (Q)components of the demodulated signals. Cross plotting the I and Q signals yields the state transition or trajectory diagram.

The 8PSK signal encodes three bits into every symbol producing eight possible data values per symbol. The I and Q values translate into phase and magnitude information. The phase and amplitude value of each of these states can be shown in a plot of the I signal versus the Q signal, what is known as a constellation diagram. The state transition or trajectory diagram (in the right-hand trace) shows the transition paths between data states. Each trajectory starts and ends at one of the eight data states. The data states occur at eight phases of 0, 45, 90, 135, 180, 225, 270, and 315 degrees. The state transition diagram provides a quick way of evaluating the 8PSK signal generation. Asymmetry and skew of the underlying constellation indicate errors in signal generation.

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Application 3: Analyzing DDR 2 memory data signals

High speed digital physical layer signals can also be acquired by the M5i.33xx-x16 series digitizers. The bandwidth of a digital signal is dependent on the rise time of the pulses which is a function of the clock rate. The general rule of thumb is that the measurement bandwidth of the measurement system should be five times the clock frequency of the digital system. You can see this in the example shown in Figure 4 showing the acquisition and analysis of a double data rate (DDR 2) memory data signal. DDR memories use three digital signals to read and write data into the device; the signals are clock, strobe, and data. The data signal is shown in the figure.

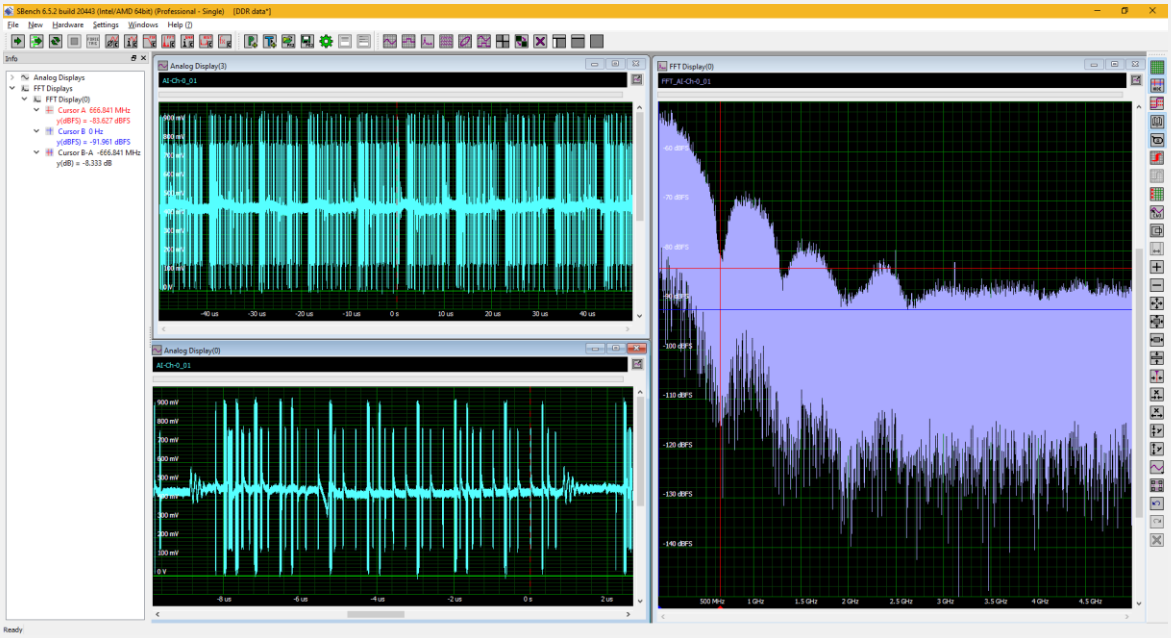

Figure 4: The data signal for a DDR2 memory has a complex structure. The FFT spectrum shows significant energy out to about 3 GHz.

The acquired data signal is shown in the upper left trace. A horizontally expanded view of the signal is shown in the lower left trace. The FFT spectrum of the data signal is shown in the right-hand trace. As expected, the spectrum has a Sin(x)/x envelope due to the pulse-like nature of the digital signal. The device is clocked at 333 MHz. As the name implies, DDR memory operations occur at twice the clock rate. The nulls in the spectrum occur at 666 MHz and integer multiples of that frequency. The spectrum shows considerable energy out to about 3 GHz.

The range of applications for the M5i.33xx-x16 series digitizers are very broad. The three examples shown offer insight into the possibilities that exist.