BANDWIDTH ENHANCEMENT OF SINGLE-SHOT DATA ACQUISITION SYSTEMS BY DECONVOLUTION OF SYSTEM RESPONSE

John F. Aurand, Paull E. Patterson, Charles A. Frost
Sandia National Laboratories / High-Power Electromagnetics Department
MS 1153, PO Box 5800 / Albuquerque, NM 87185-1153

Abstract

Procedures have been developed [1] for enhancing the effective bandwidth of single-shot measurement systems. One procedure characterizes the transfer function of the measurement system hardware, and the other is a software compensation technique to deconvolve this transfer function from the acquired data. The example shown employs a Tektronix SCD-5000 Transient Digitizer, with a -3 dB bandwidth improvement of 4.5 times, to over 15 GHz.

System Characterization

Each of the components of a single-shot data acquisition system (coaxial cabling, delay line, and waveform recorder) is band-limited, and thus degrades the acquired waveform. The measurement system hardware is modeled as a cascaded frequency-domain transfer function, and if mismatch S parameters are assumed negligible, then the transfer function can be formed as the ratio of the input and output signal spectra. Step time-domain excitation is used to characterize the entire system as one network, permitting simple and rapid evaluation of the measurement hardware.

The excitation step pulse is generated with a Picosecond Pulse Labs 4015B Pulse Generator (9 V, 15 ps), and it is measured with two systems: the single-shot SCD-5000 system, and a wider-bandwidth sampling system consisting of a Tektronix CSA-803 sampling oscilloscope with 20-GHz SD-26 Sampling Head. This sampled waveform is taken as the input excitation pulse, and the transfer function of the single-shot system is then formed as the ratio of the FFT spectra of these two waveforms.

For the example system, the hardware had a -3 dB bandwidth of 3.2 GHz (and a step-response risetime of 109 ps), and an effective bandwidth after deconvolution of 15.2 GHz (and a risetime of 23 ps). These transfer functions are shown in Fig. 1 below.

Data Compensation

Once the transfer function of the single-shot system hardware has been characterized, then subsequent compensation of desired data is performed by post-processing. This software performs data acquisition over an IEEE-488 (GPIB) bus from the SCD-5000 to a host personal computer, and then deconvolution processing. The FFT spectrum of the acquired signal is divided by the system transfer function, and then an inverse FFT is used to compute the compensated time-domain input signal. If necessary, any one of several lowpass filtering algorithms may then used to reduce the deconvolution noise.

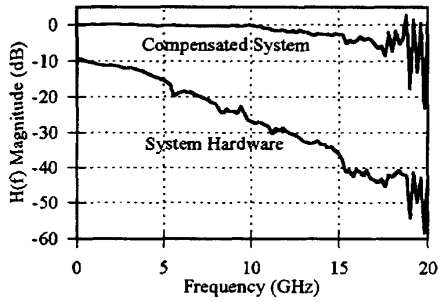

Fig. 1 - Raw Hardware and Compensated Transfer Functions of SCD-5000 Measurement System

Considering the difficulties associated with deconvolution of noisy data, these procedures have yielded stable, low-noise results. This success is due to careful consideration of many signal processing details and fundamental hardware parameters.

Conclusions

Bandwidth-enhancement techniques have been developed for single-shot data acquisition systems. The transfer function of the system hardware is characterized using step time-domain excitation, and robust data compensation algorithms implement frequency-domain deconvolution of that transfer function from the acquired data. These techniques are most applicable to data acquisition systems with waveform recorders which have significant oversampling rates and well-behaved frequency rolloff.

Reference

[1] P.E. Patterson, J.F. Aurand, C.A. Frost, 15-GHz Bandwidth Enhancement of Transient Digitizers In a Portable Data Acquisition System, Sandia National Labs Technical Report, SAND93-2280, Feb. 1994.