Pulse generator calibration for the dissemination of pulse standards

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This paper describes how to calibrate the frequency response of a pulse generator using a sampling oscilloscope which is traceable to basic physical quantities. Various correction techniques and covariance-based uncertainty analysis are provided. This method can be used by calibration labs to calibrate high-speed oscilloscopes.

Traceable measurement is usually established by the calibration hierarchy. The Oscilloscopes owned by calibration labs are calibrated by the National Measurement Institutes (NMI) [1] and then the oscilloscopes owned by industries are calibrated by calibration labs. NMIs including the KRISS (NMI in Korea) calibrate oscilloscopes using a photodiode (PD) whose magnitude and phase response is calibrated using an electro-optic sampling (EOS) technique [2]. The EOS-PD technique is accurate but too complex to be used at calibration labs. We have developed more easy method to calibrate oscilloscopes using a 50 GHz pulse generator.

We measured the pulse signal of a 50 GHz generator with voltage magnitude of -0.7 V using a 67 GHz sampling oscilloscope. Acquired waveforms have systematic timebase distortion (TBD) that causes errors in the time at which signal is sampled. It is the characteristics inherent in the sampling oscilloscopes that use the equivalent-time sampling technique. The TBD is estimated and corrected by use of ODRPACK and iterative LSQ (Least Square fitting).

After correction for TBD, a total of 100 waveforms are averaged and Fourier transformed. The result is represented as V_s in (1).

$$V_g = \frac{V_s}{h}\left(1 - \Gamma_g \Gamma_s\right) \tag{1}$$

, where Γ_g and Γ_s are the input impedance of the generator and the oscilloscope, respectively. h denotes the frequency domain representation of the oscilloscope impulse response. The calibrated frequency response of the pulse generator, V_g, determined from (1) will be presented at the Conference.

The measurement uncertainty is estimated using the Monte Carlo simulation. A 10,000 simulated data for V_s are generated from the covariance matrix using the Matlab function which generate multi-variate normal random numbers. The covariance matrix of the input impedances are obtained with the technique described in [3].

We have a plan to disseminate this method to the calibration labs.

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