0.1-10 GHz CMOS Voltage Standard

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***Abstract*- We discuss the development of a sinusoidal CMOS voltage standard. The standard incorporates a FET power sensor that transfers the voltage measured at a primary standards laboratory to a user's laboratory. We anticipate an absolute accuracy of about 10 mV at frequencies up to 10 GHz.**

SUMMARY

We discuss the development of a sinusoidal CMOS voltage standard for calibrating at-speed IC test equipment such as electron-beam voltage probes. The standard will be fabricated at a commercial foundry. The calibrated microwave voltages will be impressed on sub-micrometer transmission lines.

Characterization of the voltage standard begins with a coaxial reference calibration. A calibrated power meter is connected at the coaxial reference plane and the RF power is measured at each frequency. We measure the reflection coefficient of the power meter at the same time and use this information to correct the power data.

Next we perform a second-tier scattering-parameter calibration on the chip and measure the characteristic impedance of the transmission line and the scattering parameters of the probes, the on-chip power sensor, and other artifacts on the chip. Finally, we apply a known power at the coaxial reference plane and calculate the RF voltages at various points in the circuit. A measurement of the power sensor's response to this RF power allows these voltages to be reproduced easily in another laboratory.

The inset in Figure 1 shows a micrograph of the FET power sensor embedded in a short section of microstrip. The FET is biased through the microwave probe head and separate needle probes. A microwave signal delivered through the probe head causes a change in the FET's drain current proportional to the delivered power.

Figure 1 shows an uncalibrated measurement of the detector responsivity $\Delta I_{ds}/\Delta P_{rf}$ versus frequency, where I_{ds} is the drain current and P_{rf} is the microwave power. Standing waves in the circuit accentuate the frequency variability of this uncalibrated result. The sensor responsivity is linear with power up to at least 100 μW.

We performed a simple test of the sensor's minimum power resolution, which is approximately 0.05 μW at 10 GHz. The sensor's voltage resolution in a 50 Ω system, and hence our transfer precision, is less than 1 mV.

The absolute accuracy with which we can measure the voltage on the chip during the initial characterization is limited by the scattering parameter calibration to within about 10 mV. This is much larger than our anticipated transfer precision and will therefore dominate the standard's uncertainty.

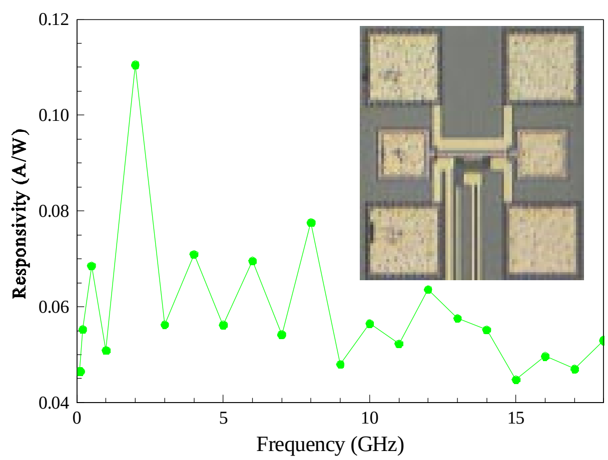

Figure 1. Power sensor (inset) and its measured responsivity at 100 μW.