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Joseph F. Keithley Award Talk: Microwave Measurements of Mesoscopic Devices

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Typical measurements of mesoscopic devices at low temperatures suffer from annoyingly low speeds and the presence of excess low-frequency noise that can try the experimentalist's patience. Even though these devices are not well-matched to the fifty ohm world of microwaves, the ability to listen to signals coming from a cryogenic nanostructure with a wideband amplifier at gigahertz frequencies has proven quite beneficial. These techniques can be surprising precise and powerful, allowing access to high-speed dynamics, the collection of information from wideband signals such as noise, and an entry into the domain of quantum electrical signals. I will review some of our early experiments at Yale in this area, especially the development of the Radio-Frequency Single-Electron Transistor (RF-SET), which is still the most sensitive electrometer known. Today we find that microwave measurements are proving highly beneficial for solid-state quantum computing, which in turn is leading to a new wave of capabilities for generating and measuring microwave signals at the single photon level.