

Development and Applications of Josephson Arbitrary Waveform Synthesizers

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Abstract—NIST has been developing Josephson-junction-based circuits for precision measurement applications for over forty years, especially for quantum-based dc and ac voltage standards that synthesize signals up to 100 kHz [1, 2]. The programmable Josephson voltage standard (PJVS) and the Josephson Arbitrary Waveform Synthesizer (JAWS) are provided worldwide as NIST Standard Reference Instruments to measurement institutes. We recently developed two new RF signal sources, called VHF and RF JAWS, which produce accurate voltage signals up to 50 MHz for RF power calibration [3] and for multi-tone modulated waveforms at 1 GHz [4]. The digitally synthesized programmable signals generated by all of these JAWS sources have inherent voltage accuracy, amplitude linearity, and signal purity due to the perfectly quantized voltage pulses generated by the Josephson junctions in the circuits. They improve the calibration of RF electronics because their accuracy is quantum-based. We have also demonstrated superconducting Josephson pulse generator (JPG) circuits that produce 8-fold multiplied quantized Josephson pulses. We used them to control and characterize superconducting qubits [5]. JPGs provide accurate, reproducible signals that don't require calibration, unlike room-temperature-generated signals. JPG controllers may help to enhance the scalability of superconducting quantum processors. I'll describe the latest measurements and applications for these devices and systems while emphasizing the locking ranges of circuit bias parameters that demonstrate their quantum nature.

Keywords (Index Terms)—*Josephson Devices, Josephson Junction, Microwave Device, RF, Voltage Standard*

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