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IN SI-1

Applications of Josephson Arrays to Voltage Metrology

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For the past 10 years NIST has been developing the next generation of voltage standard systems based on arrays of normal-metal barrier Josephson junctions. The first step that enabled these new systems was the demonstration that superconducting-normal metal-superconducting (SNS) junctions could be made with sufficient uniformity to yield superconducting Josephson array circuits with tens of thousands of junctions. The success of these SNS junctions led to the first stable dc programmable Josephson voltage standard, of which there are now 4 systems currently in operation at 3 different national metrology laboratories. We also have been developing a Josephson digital-to-analog converter that can be used for ac voltage metrology and for precision voltage waveform synthesis, which we call the Josephson Arbitrary Waveform Synthesizer. Both the dc programmable system and the waveform synthesizer are being developed for metrology applications -- to calibrate and characterize high-performance dc, audio, and rf electronic instruments, like spectrum analyzers, digital-to-analog and analog-to-digital converters, amplifiers, and power meters. Although these systems can produce dc and ac voltages with state-of-the-art accuracy, we would like to achieve higher practical voltages for these applications. We hope to accomplish this by vertically stacking the junctions and thereby increasing the junction density. We have made significant progress in understanding the physics of high-density arrays and have demonstrated uniform arrays of 10-junction stacks. Most recently we have demonstrated circuits with over 60,000 junctions, which allowed us to more than double our dc output voltage from 1.1 V to 2.6 V. Finally, we are also applying our precision waveform synthesis techniques to create a new electronic-based temperature standard. We create precision pseudo-noise voltage waveforms over a 1 MHz bandwidth in order to precisely characterize the power vs frequency response of low noise amplifiers that measure the Johnson noise of resistors at fixed-point temperatures.

keywords : Josephson array, voltage standard, microwave, Johnson noise, waveform synthesis