Road to AC voltage standard leads to important junction

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After 10 years of research, the National Institute of Standards and Technology (NIST) has unveiled the world's first precision instrument for directly measuring alternating current (AC) voltages. The instrument is being tested for use in NIST's low-voltage calibration service, where it is expected to increase significantly the measurement precision of industrial voltmeters, spectrum analyzers, amplifiers and filters.

Described July 14 at the Conference on Precision Electromagnetic Measurements in Turin, Italy,* the patented instrument** is based on the same "Josephson junction" technology used in NIST's widely used direct current (DC) voltage standards, offering high precision based on quantum physics. A Josephson junction consists of two superconducting pieces of metal separated by a thin insulator or normal metal. When a fixed DC voltage is applied across it, a junction responds by generating an AC current that oscillates like a wave at a frequency exactly proportional to the applied voltage.

The new instrument uses arrays of junctions to generate AC pulses in precisely measured voltage units over a range of audio frequencies. Arbitrary waveforms can be generated at different voltage levels for different applications. The new standard would establish an entirely new method for AC voltage metrology. Until now, AC voltage calibrations have been performed indirectly, by measuring the heat delivered by an instrument to a resistor, and comparing that measurement to the heat delivered by a known DC voltage. At low voltages (such as 2 millivolts), the new AC Josephson junction voltage standard should improve

measurement accuracy as much as 1,000-fold.

The concept for the new device was co-invented by researchers at NIST and Northrop-Grumman in the mid-1990s.*** A number of innovations since then have led to the first practical system. For instance, to increase the output voltage, NIST developed "nano-stacked" arrays of Josephson junctions, in which the spacing between junctions is reduced to less than 100 nanometers by stacking the junctions on top of each other. Using this technique NIST can make programmable voltage standard integrated circuits with over 130,000 junctions on a single chip. The new AC instrument currently has a maximum output of 100 millivolts; NIST researchers hope eventually to increase that level to 1 volt.

*S.P. Benz, C.J. Burroughs, P.D. Dresselhaus, T.E. Lipe and J.R. Kinard. 2006. 100 mv AC-DC transfer standard measurements with a pulse-driven AC Josephson voltage standard. Presented at Conference on Precision Electromagnetic Measurements, July 9-14, Turin, Italy.

**S.P. Benz, C.J. Burroughs, C.A. Hamilton, T.E. Harvey. U.S. Patent 6,236,344 (issued 5/22/01) "AC And DC Bipolar Voltage Source Using Quantized Pulses."

*** J.X. Przybysz, S.P. Benz, C.A. Hamilton, A. Worsham. U.S. Patent 5,812,078 (issued 9/22/98) "Josephson Junction Digital to Analog Converter for Accurate AC Waveform Synthesis."

Source: NIST