

Modern AC Josephson voltage standards at PTB

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Abstract - The use of Josephson junction series arrays for AC applications has significantly extended in recent years. This progress is caused by improvements of both fabrication technology and measurement procedures. An important breakthrough in the development of a robust fabrication process was the implementation of Josephson junctions with a barrier of $\text{Nb}_x\text{Si}_{1-x}$. This co-sputtered barrier material enables the nearly independent tuning of the critical current density and the normal state resistance over a wide range. As the characteristics of these overdamped junctions can be adjusted for different frequency ranges, series arrays for both versions of AC Josephson voltage standards can be realised by NbSi barrier junctions, namely binary-divided arrays for operation at 70 GHz and pulse-driven arrays operated with short current pulses at clock frequencies in the 10 GHz range.

Binary-divided arrays for output voltages of up to 20 V consist of nearly 140,000 junctions in double stack technology. The transients between the constant-voltage steps of binary-divided arrays prevent the synthesis of pure AC waveforms. Therefore, their application is often based on sampling methods only, using the flat constant-voltage steps and removing the transients in between. In contrast, pulse-driven arrays make the direct synthesis of pure arbitrary waveforms possible (Josephson Arbitrary Waveform Synthesizer, JAWS). Higher harmonics are suppressed by more than 110 dBc. As a simultaneous operation of several arrays is very complex, the output voltage is presently limited to roughly 200 mV for two arrays operated in parallel; each array consists of about 6,000 double-stacked junctions. While binary-divided arrays are typically used for applications from DC to the kHz range, the AC waveforms of pulse-driven arrays range from about 10 Hz to 100 kHz or even up to 1 MHz.

The present state of AC Josephson voltage standards for applications at PTB and some results are presented and discussed.

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Keywords - Voltage standard, Josephson voltage standard, Josephson junction, overdamped junction, junction series array, NbSi junction barrier, binary-divided array, pulse-driven array, Josephson Arbitrary Waveform Synthesizer.