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Session YC07 - Electromagnetic Devices and Applications.
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[YC07.04] Precise frequency measurements using a superconducting cavity stabilized oscillator

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Many physics experiments call on improved resolution to better define the experimental results, thus improving tests of theories. Modern microwave technology combined with high-Q resonators can achieve frequency readout and control with resolutions up to a part in 10^18. When the physical quantity in question in the experiment can be converted to a frequency or a change in frequency, a high-stability microwave oscillator can be applied to obtain state-of-the-art precision. In this work we describe the overall physical concepts and the required experimental procedures for optimizing a high-resolution frequency measurement system that employs a high-Q superconducting microwave cavity and a low-noise frequency synthesizer. The basic approach is to resolve the resonant frequencies of a high-Q (Q > 10^10) cavity to extremely high precision (one part in 10^17-10^18). Techniques for locking the synthesizer frequency to a resonant frequency of the superconducting cavity to form an ultra-stable oscillator are described. We have recently set up an ultra-high-vacuum high-temperature annealing system to process superconducting niobium cavities, and have been able to consistently achieve Q > 10^9. We have integrated high-Q superconducting cavities with a low-noise microwave synthesizer in a phase-locked-loop to verify the frequency stability of the system. Effects that disturb the cavity resonant frequency (such as the temperature fluctuations and mechanical vibrations) and methods to mitigate those effects are also considered. Applicability of these techniques to experiments will be discussed, and our latest experimental progress in achieving high-resolution frequency measurements using the superconducting-cavity-stabilized-oscillator will be presented.

Part Y of program listing

superconduction