MICROWAVE FREQUENCY DISCRIMINATOR WITH A COOLED SAPPHIRE RESONATOR FOR ULTRA-LOW PHASE NOISE*

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We have developed a Sapphire Phase Stabilizer (SPS) to meet current and future microwave oscillator phase noise requirements. The SPS employs a high Q, X-band sapphire dielectric "whispering gallery" mode resonator as a discriminator to stabilize a quartz crystal oscillator. At 7.9449 GHz with a loaded Q of 6 million we previously reported an "open loop" discriminator noise floor (referred to 100 MHz) of approximately $S_\phi(f) = -110$ dB/f^3(/Hz) for offset frequencies from f = 1 Hz to f = 1 kHz. While the previous tests used an untuned sapphire element, our system is designed to operate critically coupled at 8.1000 GHz with a loaded Q of 15 million at 77 Kelvin. Advantages of this system include a simplified electronic configuration and consequent reduced phase noise.

A 3-stage methodology has been developed to provide the accurate frequency tuning required. Additionally, implementation of mode coupling control methods developed last year allows a loaded Q between 11 and 15 million along with reproducible coupling to only one of two nominally degenerate modes. Implementation of control loops and final integration of the present system design including suppressed-carrier phase sensing circuitry are expected to make possible a phase noise floor for the discriminator of approximately $S_\phi(f) = -130$ dB/f^3(/Hz). Projected closed loop phase noise performance operating as a SI'S is -120 dB/f^3 to -130 dB/f^3 at 100 MHz.

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