MAR10-2009-000110

Abstract for an Invited Paper
for the MAR10 Meeting of
the American Physical Society

Joseph F. Keithley Award For Advances in Measurement Science Talk: Precision Noise Measurements at Microwave and Optical Frequencies[1]

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The quest to detect Gravitational Waves resulted in a number of important developments in the fields of oscillator frequency stabilization and precision noise measurements. This was due to the realization of similarities between the principles of high sensitivity measurements of weak mechanical forces and phase/amplitude fluctuations of microwave signals. In both cases interferometric carrier suppression and low-noise amplification of the residual noise sidebands were the main factors behind significant improvements in the resolution of spectral measurements. In particular, microwave frequency discriminators with almost thermal noise limited sensitivity were constructed leading to microwave oscillators with more than 25dB lower phase noise than the previous state-of-the-art. High power solid-state microwave amplifiers offered further opportunity of oscillator phase noise reduction due to the increased energy stored in the high-Q resonator of the frequency discriminator. High power microwave oscillators with the phase noise spectral density close to -160dBc/Hz at 1kHz Fourier frequency have been recently demonstrated. The principles of interferometric signal processing have been applied to the study of noise phenomena in microwave components which were considered to be "noise free". This resulted in the first experimental evidence of phase fluctuations in microwave circulators. More efficient use of signal power enabled construction of the "power recycled" interferometers with spectral resolution of -200dBc/Hz at 1kHz Fourier frequency. This has been lately superseded by an order of magnitude with a waveguide interferometer due to its higher power recycling factor. A number of opto-electronic measurement systems were developed to characterize the fidelity of frequency transfer from the optical to the microwave domain. This included a new type of a phase detector capable of measuring phase fluctuations of the weak microwave signals extracted from the demodulated femtosecond light pulses with almost thermal noise limited precision. The experiments which followed showed that microwave signals of exceptional spectral purity could be generated from the frequency stabilized lasers

[1]Australian Research Council