Active Complementary Coupled Resonator for Low Phase Noise X-band Oscillator

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This work presents a novel active complementary coupled resonator for X-band low phase noise oscillator which operates at 10GHz. The active resonator is based on a complementary coupled resonator (CCR) proposed recently using substrate integrated waveguide (SIW) technology. The complementary coupled resonator is essentially a complementary version of a conventional microstrip coupled line resonator. Incorporated with SIW[1], the complementary coupled resonators can be excited at its differential mode. In this case, the equivalent magnetic currents on the slots flow in the opposite directions; therefore, radiation loss can be minimized and hence a high Q resonator can be achieved. Simulated and measured results show that the unloaded Q of the passive CCR is around 250-300.

For an oscillator, it is crucial to have a high Q resonator to achieve a low phase noise. In order to further increase the Q of the CCR, in this work we present an active version of CCR that can significantly enhance the resonator's unloaded Q and can be used to realize a low phase oscillator operating at X-band. Fig.1 shows the geometry of a two-port passive CCR whose resonance is at 10GHz. Simulated results show that the unloaded Q of the passive CCR is around 260 at 10GHz. Based on the passive CCR, if we connect one of the two ports to an active device, we are able to enhance the resonator's Q by providing it with energy from DC[2]. The schematic of the active CCR is shown in Fig. 2, in which a common-gate transistor (NE3210S01) is connected to the passive CCR. The circuit simulation shows that the active resonator can have a much higher unloaded Q of around 3000 at 10GHz when the transistor is drain-biased at 2V. Incorporating the reported novel resonator, 10GHz oscillator is built for the verification of the inventing approach. The improvement in phase noise performance can be optimized by harmonics-injection locking techniques, which will be discussed in the full length version of paper. The measured phase noise is better than -115dBc/Hz at 1 MHz offset; technology can be extended for millimeter wave applications.

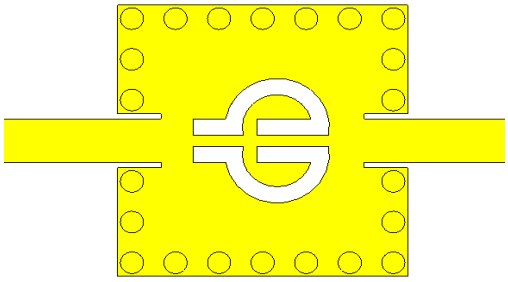

Fig. 1: A two-port passive complementary coupled resonator (CCR).

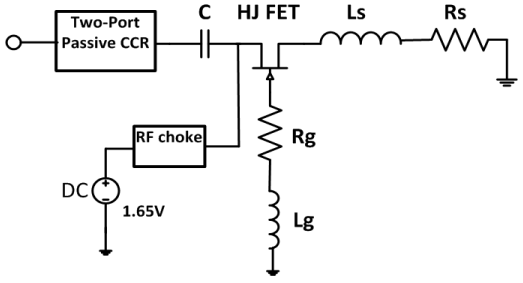

Fig. 2: The schematic of active complementary coupled resonator. (C=0.4pF, R_g=100Ω, L_g=4.2nH, L_s=5nH, and R_s=5Ω)

[1] F. Giuppi, A. Georgiadis, A. Collado, M. Bozzi, and L. Perregrini, "Tunable SIW cavity backed active antenna oscillator," *Electron. Lett.*, vol. 46, no. 15, pp. 1053–1055, Jul. 22, 2010.

[2] C.-Y. Chang and T. Itoh, "Microwave Active Filters Based on Coupled Negative Resistance Method," *IEEE Trans. Microwave Theory and Techniques*, Vol. 38, No. 12, pp. 1879-1884, December 1990.