0.18μm CMOS 技術における DGS 構造による実現される仮想インダクタンスの比較検討

Comparative Study of Virtual Inductors Realized by Defected Ground Structures for VCO Applications in 0.18 μm CMOS Technology

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Abstract

We analyze the quality factor of three different types of defected ground structure (DGS) resonators including a series resonance in addition to the parallel one. Then, we implement the resonators to design high-performance K-band VCOs in 0.18 μm CMOS Technology and finally, a low phase noise VCO at K-band is introduced.

Index Terms—Defected Ground structure, CMOS, on-chip, phase noise, series resonance, VCO.

1. INTRODUCTION

Design of spiral-inductors based Complementary Metal-Oxide-Semiconductor (CMOS) circuit elements at Ku-band and higher encounters difficulty due to the sudden deterioration of the quality (*Q*-) factor and the self-resonance of spiral inductors. To mitigate this problem particularly of a voltage controlled oscillator (VCO) design, various types of high *Q*-factor inductor [1-3], high resistivity substrate [4], proton bombardment techniques [4], and substrate removal by post micromachining [4] were proposed. However, all of these techniques require complicated post-processing of the CMOS wafer which may increase the cost. In this abstract, we discuss three DGS structures to realize a high Q-factor virtual inductance in 0.18 μm CMOS technology and their employment in the design of low phase-noise *K/Ku*-band VCOs.

2. DESIGN AND ANALYSIS OF HIGH Q-FACTOR DGS

A DGS etched on the ground plane below a 50-Ohms microstrip line (MSL) interrupts the electromagnetic field (EM) producing notches [3], and this can be interpreted as a virtual series inductor of high Q-factor [4]. To investigate this, two types of DGS on 1-poly 6-metal (1P6M) 0.18 μm CMOS technology as shown in Fig. 1 is analyzed. An H-shape DGS consists of two current loops in parallel which makes the equivalent inductance (L_{EQ}) of the DGS to be half of the inductance of each loop so that the unloaded *Q*-factor (Q_U) is degraded. To mitigate this problem, we designed a square-shaped DGS as shown in Fig. 1(b) where H-shape DGS is first halved and then area of the square-shaped DGS is made equal to the original H-shape DGS. As shown, the square-shape DGS has only one current loop, and L_{EQ} will be the same as the inductance of each loop of an H-shape DGS. Both of these DGS can be modeled using the equivalent circuit shown in Fig. 1(b). The square-shape DGS resonator has a higher

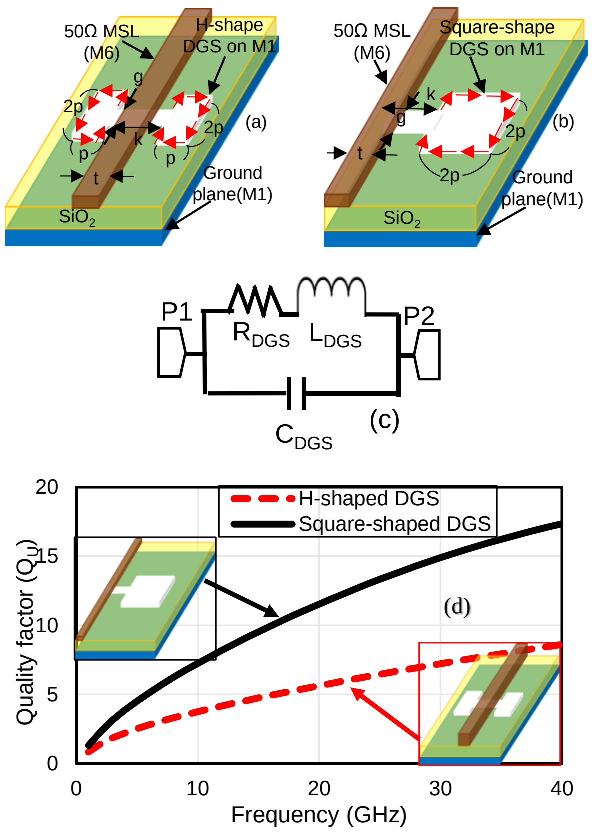

Fig 1. (a) H-shape DGS (b) Square-shape DGS (c) Equivalent circuit (d) Comparison of Q_U.

inductance and Q_U than that of the H-shape DGS as compaed on Fig 1(d). The optimized value of p,g, t, and k are 50 μm, 15 μm, 14 μm, and 25 μm, respectively.

When the feeding MSL is cut from the middle, the DGS can produce both the resonance/series resonance and anti-