IDEC Chip Design Contest

Design of Radiation-Hardened Circuit Blocks in RF Transceiver

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I. Introduction

◆ **Radiation Effects on Circuits and Systems:**

➢ **Single-Event Effects (SEE) :** Momentary transient

➢ **Total Ionizing Dose (TID):** Long-term degradation

◆ **Impact on LNAs and VCOs:**

➢ **LNA:** Matching frequency shifts, risk of failure.

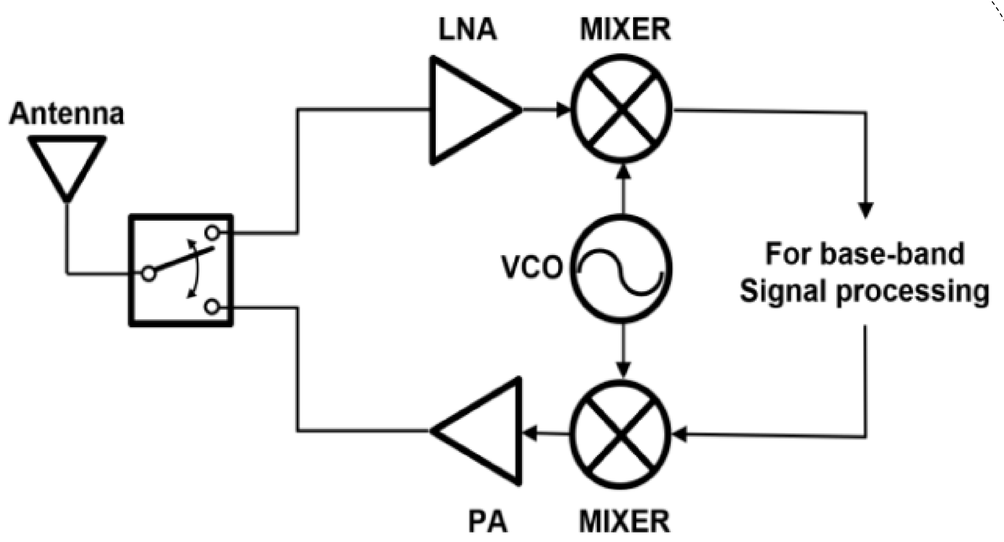
➢ **VCO:** Output frequency changes, system malfunction.

◆ **Radiation-Hardening Strategies**

➢ **Wideband LNA Design:** Mitigates mismatch from radiation.

➢ **LC-Tank VCOs**: Withstand TID with frequency tunability.

➢ **SOI Technology**: Improves radiation resistance.

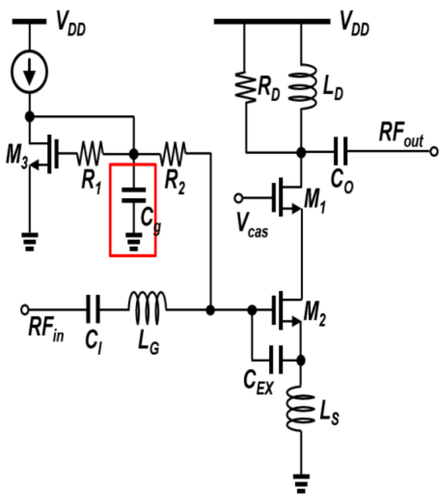


Block diagram of a radiation-hardened transceiver

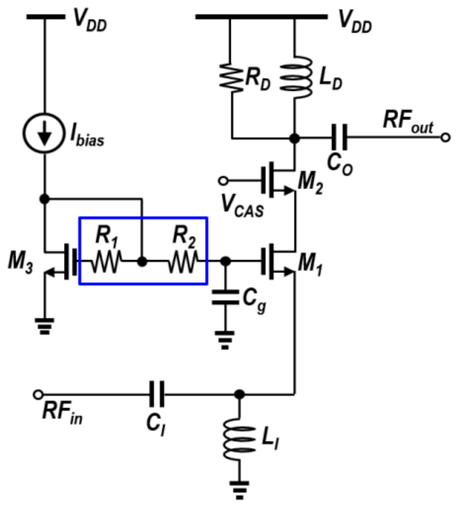
II. Circuit Design

• Proposed LNA Design

To mitigate SEE effects, capacitors were added into the CS LNA and resistors into the CG LNA, increasing the time constant at critical nodes to suppress voltage peaks, while balancing area and noise considerations.



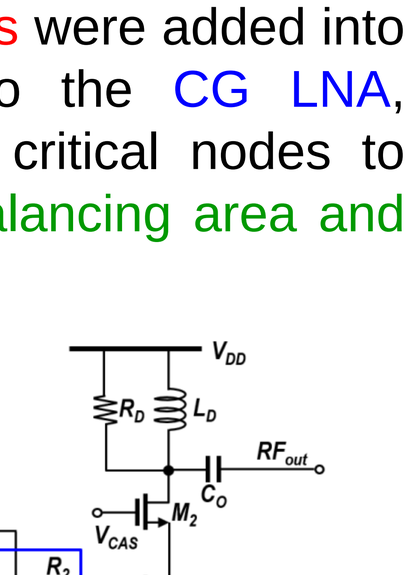
RHBD CS LNA circuit schematic



RHBD CG LNA circuit schematic

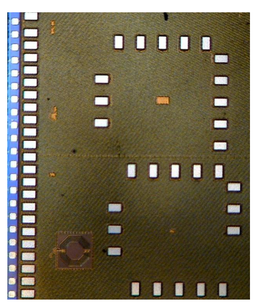
• Proposed VCO Design

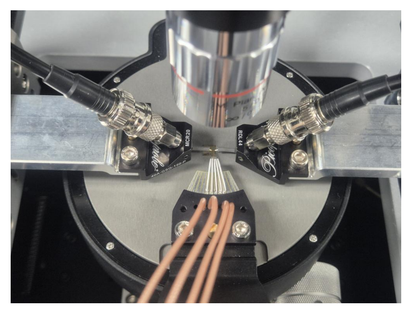
In the proposed LC-VCO, the varactor cap(C_V) is connected to ground, allowing SET-induced transient currents to flow to GND instead of V_{tune}, thereby improving the frequency stability of the oscillator.



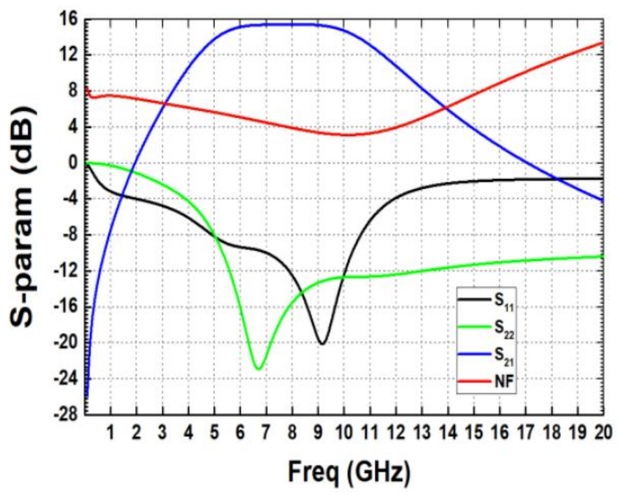
RHBD VCO circuit schematic

III. Measurement Setup



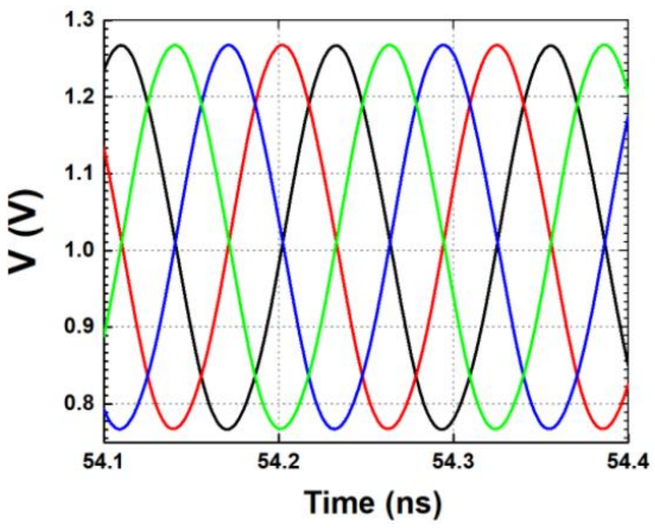


IV. Result



S-parameter, Noise Figure of LNA

The LNA achieves S_{11} below –10 dB from 6.8 to 10.3 GHz, consistent S_{22} from 5.5 to 20 GHz, a noise figure of 3.5 dB, and a gain of 15.4 dB.



Output voltage of voltage-controlled oscillator

The VCO achieves 810 MHz frequency tuning with a phase noise of –95.7 dBc/Hz in the X-band.

※ Double exponential current pulse :

The transient current, modeled by a double exponential function, exhibits a sharp negative peak due to a single-event effect (SEE)