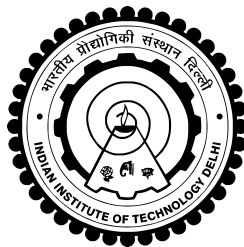


**CHARGE CONTROLLED OSCILLATORS
AND THEIR APPLICATION IN
FREQUENCY SYNTHESIZERS**

ROOHIE KAUSHIK



**Department of Electrical Engineering
Indian Institute of Technology Delhi
March 2017**

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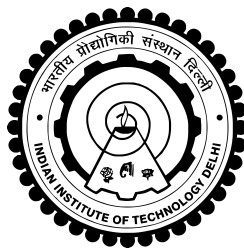
by

ROOHIE KAUSHIK

Department of Electrical Engineering

Submitted

in fulfillment of the requirements of the degree of Doctor of Philosophy
to the



Indian Institute of Technology Delhi

March, 2017

To my loving *MOTHER* –

My foundation, strength and motivation

This thesis is a gift to her.

Certificate

This is to certify that the thesis entitled “**Charge Controlled Oscillators and their Application in Frequency Synthesizers**”, being submitted by **Miss. Roohie Kaushik** for the award of the degree of **Doctor of Philosophy** to the Department of Electrical Engineering, Indian Institute of Technology Delhi, is a record of bonafide work done by her under our supervision and guidance. The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any other degree or diploma.

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Abstract

Tunable LC-oscillators, have been extensively used in RF communication systems. It can be used as a local oscillator for a mixer, or for generation of signals with frequencies in multiples of reference signals. Conventional tunable LC-oscillators are either voltage-controlled oscillators (VCOs) or digitally-controlled oscillators (DCOs). VCOs are tuned by changing the capacitance of a varactor in an LC-tank. DCOs are digitally tuned by switching on/off capacitors in an LC-tank.

In this dissertation we introduce a novel idea of frequency of oscillation as a function of charge. This new category of LC-oscillators is termed as charge-controlled oscillators. A charge-controlled oscillator consists of a Gaussian surface around the inductor of the LC-tank. The charge held inside this Gaussian surface remains conserved (or constant), which decides the frequency of oscillation. The charge remains constant unless it is disturbed by some external source or it has a path to leak. Four different configurations of charge-controlled oscillators are explored in this thesis. The designs were implemented in a $0.13\ \mu\text{m}$ CMOS process. Two such charge-controlled oscillators were fabricated and the figure-of-merits of the fabricated charge-controlled oscillators are 179 dB and 163.4 dB, oscillating at 3.5 GHz and 3 GHz respectively.

In this thesis we also introduce frequency synthesizers built around a charge-controlled oscillators. The use of charge-controlled oscillators removes the need of an explicit loop-filter. The desired loop-filter transfer function can be designed into the charge-pump and charge-controlled oscillator. The analysis of such frequency synthesizers with examples

is also discussed. Further, an all-digital phase locked loop (ADPLL) based on a charge-controlled oscillator is also demonstrated. ADPLLs designed with charge-controlled oscillators are significantly simpler than the conventional ADPLLs.

Quadrature charge-controlled oscillators have also been described. Conventionally quadrature outputs were generated by coupling two identical VCOs. We show here that conventional way of generating quadrature phase fails in case of charge-controlled oscillators. The quadrature phases can be generated by using a single LC-tank with distributed inductance and capacitance in a charge-controlled oscillator.

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