

Abstract

Key words: Complementary Inverters (CI), Complementary Current Mirror Inverters (CCMI), Diode Loaded Complementary Inverters (DLCI), Differential pair, Push-pull inverters, Complementary Bipolar Inverter Cells (CBIC), Voltage Controlled Oscillators (VCO), Current Controlled Oscillators (CCO), Programmable oscillator, Phase Locked Loops (PLL), Synchronous oscillator, Quadrature oscillator, Noise suppressor, Analog multiplier, Zero-IF architecture, paging receiver, QPSK modulator, harmonic generator.

The present thesis deals with the study of different forms of complementary bipolar inverter cells which can be cascaded in ring form to realize voltage/current controlled oscillators (VCO/CCO). These VCOs/CCOs would provide a wide tuning range and operate at a low voltage/current.

Four such inverters using complementary bipolar transistors, namely, npn driver-pnp current source load inverter, Complementary Inverter (CI), Complementary Current Mirror Inverter (CCMI) and Diode Loaded Complementary Inverter (DLCI) have been analyzed (Chapter II). VCOs were obtained by cascading combination of CI and CCMI in ring configuration. The frequency tuning was achieved either by varying the supply voltage or by changing the current of a constant current source connected at the emitters of npn transistors of the complementary configuration. All these inverters can work at a low supply voltage of ± 0.6 volts and draw very little power in the absence of input signal. The results indicate that complementary inverters have high gain and large time delay whereas complementary current mirror inverters and diode loaded complementary inverters have large bandwidth, small time delay and small gain. A maximum of 150 KHz/mV frequency variation and maximum oscillation frequency of 65 MHz were obtained from a VCO realized using a 3 stage CCMI.

Complementary bipolar inverters in differential pair configuration, have been realized from a basic cell by programming only the

metal mask. A small signal analysis of the different Complementary Bipolar Inverter Cells (CBIC) have been presented (Chapter III) to study the effectiveness of the cells in applications as VCO and frequency tracking networks. An even/odd number of such CBICs have been connected in ring form to realize CCOs which would provide push-pull outputs, quadrature outputs and enable digital control using a DAC. A frequency variation over nearly two decades was obtained over a current change of 2 mA.

VCOs/CCOs have been fabricated in monolithic form after optimizing the process technology using the available simulators - SUPREM-II for process, BIPOLE-II for device and PSPICE for circuit (Chapter IV). A VCO chip using combination of CI and CCMI have been realized on a general purpose analog bipolar array chip by configuring only the metal mask. On the other hand, transistor level masks were generated to realize the CCO chip using CBIC in push-pull configuration. The frequency variation with current was linear for the case of double current source inverter VCO.

Phase Locked Loop (PLL) circuits have been implemented using VCOs/CCOs studied in this dissertation (Chapter V). Quadrature/multiphase signal generator circuit has been realized using differential pair of inverters. The use of these quadrature oscillators in some modern telecommunication circuits, e.g., radio paging receivers using zero-IF architecture, $\pi/4$ differential QPSK modulator, for generation of harmonic signals etc. have been demonstrated. The results of fabrication of a 4-quadrant analog multiplier chip, which is frequently used in communication circuits (e.g. phase detector in PLL), has been included in the same chapter.

Frequency locking oscillators have been realized using the inverters in push-pull configuration (Chapter VI). A large signal analysis of the inverter chains have been presented and the locking behaviour for different modes have been studied. The rejection of noise and interference components outside the locking bandwidth has been demonstrated using a synchronous oscillator employing CBIC. A study has been made on optical control of VCOs and the results of optical tuning of the oscillators have been reported.