

A Direct Injection-Locked QPSK Modulator Based on Ring Voltage Controlled Oscillator

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ABSTRACT: QPSK or Quadrature Phase-Shift Keying is a higher order modulation scheme used in digital modulation. A direct injection locked QPSK modulator uses VCO for minimize the area of the conventional modulator. In this project injection locking scheme is used since injection locking has an advantage in phase-noise reduction of oscillators with a very simple circuit topology. By using proposed simple modulator many blocks removed so that total area is reduced. The proposed quadrature phase-shift keying (QPSK) was fabricated in 90 nm CMOS, occupies less area.

KEYWORDS: CMOS, injection locking, modulator, quadrature phase-shift keying (QPSK), ring voltage-controlled oscillator (VCO).

I. INTRODUCTION

In satellite or telecommunication system, modulation is the process of conveying a message signal over a medium. To extend the range of the analog signal or digital data, we need to transmit it through a medium other than air. The process of converting information so that it can be successfully transmitted through a medium is called modulation. We are working with QPSK modulation which is kind of a digital modulation. Before going into the main focus we shall have a brief discussion on modulation, different types of modulation and the analysis of it.

II. DIRECT INJECTION-LOCKED QPSK MODULATOR

Fig. 1(a) shows conventional QPSK modulator based on a quadrature-output PLL, which employs many RF blocks such mixers, digital-to-analog converters (DACs), and filters for quadrature mixing [6]. As a consequence, this structure consumes large area and power to generate quadrature outputs and quadrature mixing.

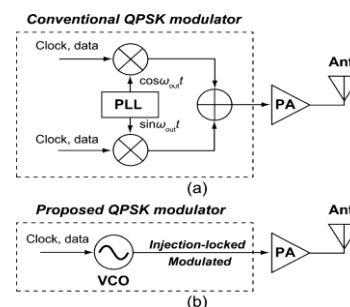


Fig. 1. (a) Conventional, and (b) proposed direct injection-locked QPSK modulator.

In [7-8], injection locking was employed to generate phase-locked clocks based on ring VCOs. The phase modulation was achieved in other blocks such as a power amplifier (PA) and a phase multiplexer (MUX) using the phase-locked clocks. Also, in [3], the phase modulation was directly achieved by adjusting the self-resonant frequency of an LC VCO addition to phase locking with injection locking and by using a polarity swap circuit.

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Proposed QPSK modulator is shown in Fig. 1(b), which uses characteristics of injection locking such as phase locking and *mixing*. Phase locking and modulation are achieved by using pulses from the clock and by using the data which is synchronized with the clock, respectively. Compared with it in [3], the simple and small one can be achieved since the proposed QPSK modulator only uses a ring VCO and phase-modulated pulse injection.

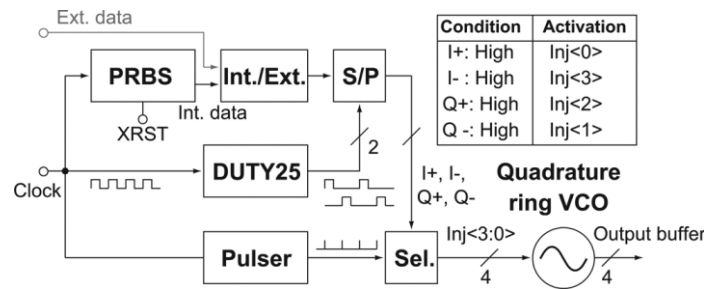


Fig.2 Block diagram of the proposed QPSK modulator

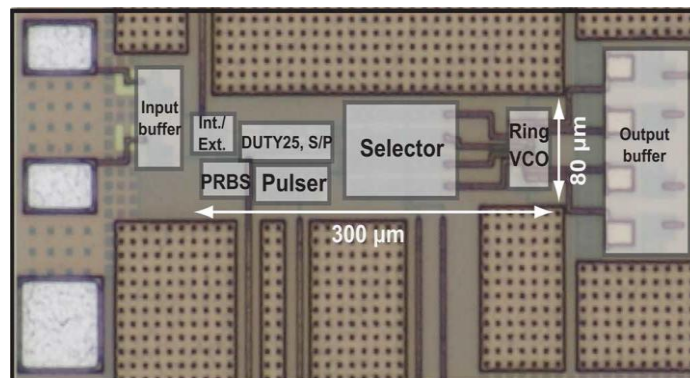


Fig. 3. Micrograph of the proposed QPSK modulator.

Fig.3. depicts a micrograph of the proposed QPSK modulator with blocks containing input buffer, PRBS(pseudo-random bit sequence generator) , Pulsar, selector ,ring VCO and output buffer.

Fig. 2 depicts a detailed block diagram of the proposed QPSK Modulator. It consists of a duty-25% pulse generator (DUTY25) from the clock, a serial to parallel circuit (S/P),an internal/external data selector, and an internal pseudo-random bit sequence (PRBS) generator with a sequence length of $2^7 - 1$.

In this letter, the internal data generated by the PRBS generator was used in the measurement when XRST is high. The blocks mentioned above have a role to demultiplex the serial input data into the parallel sequences. It also contains a ring VCO, a pulser, and a pulse selector. The pulse selector selects injection pulses according to the parallel data sequences (I+, I-, Q+,Q-) as shown in the table of Fig. 2. As a result, phase-modulated pulses are injected into the VCO.

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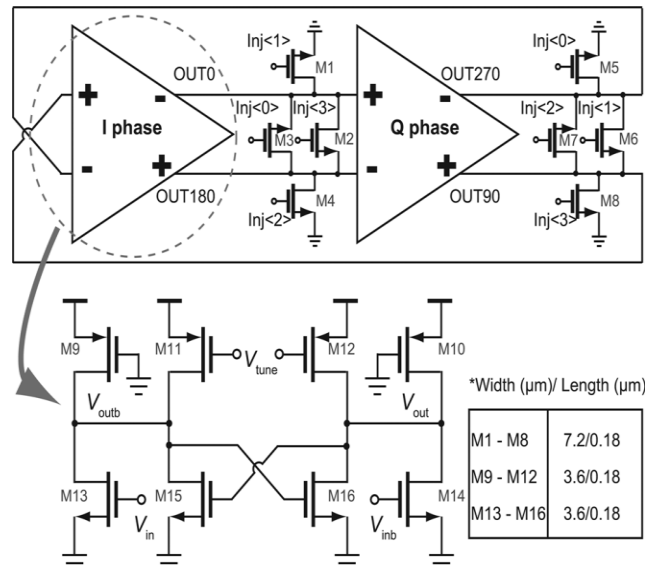


Fig.4 Proposed two-stage differential ring VCO. All transistors have standard bulk connections (nMOS: Ground, pMOS: Supply)

Fig.4 shows the proposed two-stage quadrature ring VCO. The injection signal is input into both I-phase and Q-phase delay cell in the form of rail-to-rail pulses for sub harmonic injection locking, which are generated by the internal NAND-based pulser. The pulser can control the pulse width by tuning the control voltage, and generate pulses shorter than 100 ps. In this proposed ring VCO, nMOS switches (M1, M4, M5, M8) between the output node and the ground as well as nMOS switches (M2, M3, M6, M7) between the differential outputs are applied. It is to provide the phase shift with injection pulses to I- and Q-phase outputs simultaneously. The delay cell of this ring VCO contains an nMOS latch that generates a delay by positive feedback in order to satisfy the oscillation condition. In other words, the latch has a role of keeping the oscillation even with I/Q pulse injection. The pMOS resistive loads are used for tuning the output oscillation frequency. The delay cell only contains eight MOSs for simplicity.

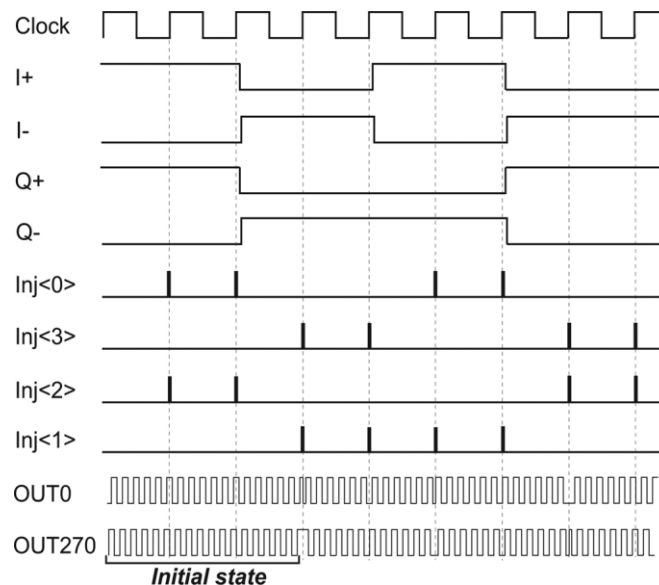


Fig. 5 Waveforms in the modulator when the VCO is supposed that it is injection-locked and modulated by I+, I-, Q+ and Q-

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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Fig.5. shows the mechanism of the proposed QPSK modulator. It shows waveforms of the input clock, and the parallel data sequences I+, I-, Q+, Q-, the injection pulses (INJ (3:0)), and the VCO outputs when it is supposed that the VCO output frequency (f_{out}) is integer-multiples of clock frequency (f_{ref}). Firstly, supposed that the initial state is the state locking to the injection pulses of INJ (0) and INJ (2). It is determined by the timing of injections and phase imbalance among the outputs in real world oscillator systems only when sufficiently short pulses are injected.

III. CIRCUIT DESIGN

A. VOLTAGE CONTROLLED OSCILLATORS

Voltage controlled oscillators (VCOs) are the Electronic circuits which are used for high speed clock generation, channel selection, frequency modulation and demodulation in various communication circuits. In the modern communication system, there is a calculated gap between the adjacent channels for the efficient use of frequency spectrum. Therefore, in order to avoid interference and noise problem, the characteristics of an oscillator are of much importance. Among the compilation of signals, oscillator must be able to detect the desired signal. Hence VCO is a critical component of frequency synthesizer circuits and PLLs.

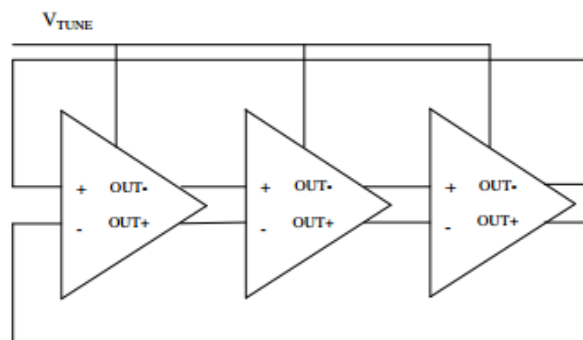


Fig 6 Differential ring VCO

Like any oscillators, a VCO may be considered as an amplifier and a feedback loop. For the circuit to oscillate the total phase shift around the loop must be 360 degrees and the gain must be unity. In case of ring oscillators, the delay stages or cells are connected back to back. If there are N delay stages, the frequency of oscillation is given by $f=1/2Nt_d$ where t_d is the delay of one delay cell. The less number of delay cells with less propagation delay can increase the frequency of oscillation.

B. PHASE LOCKED LOOP

Phase-locked loops are widely employed in radio, telecommunications, computers and other electronic applications. They can be used to demodulate a signal, recover a signal from a noisy communication channel, generate a stable frequency at multiples of an input frequency (frequency synthesis), or distribute precisely timed clock pulses in digital logic circuits such as microprocessors. Since a single integrated circuit can provide a complete phase-locked-loop building block, the technique is widely used in modern electronic devices, with output frequencies from a fraction of a hertz up to many gigahertz.

A phase-locked loop or phase lock loop (PLL) is a control system that generates an output signal whose phase is related to the phase of an input signal. While there are several differing types, it is easy to initially visualize as an electronic circuit consisting of a variable frequency oscillator and a phase detector. The oscillator generates a periodic signal. The phase detector compares the phase of that signal with the phase of the input periodic signal and adjusts the

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

oscillator to keep the phases matched. Bringing the output signal back toward the input signal for comparison is called a feedback loop since the output is 'fed back' toward the input forming a loop.

Keeping the input and output phase in lock step also implies keeping the input and output frequencies the same. Consequently, in addition to synchronizing signals, a phase-locked loop can track an input frequency, or it can generate a frequency that is a multiple of the input frequency. These properties are used for computer clock synchronization, demodulation, and frequency synthesis.

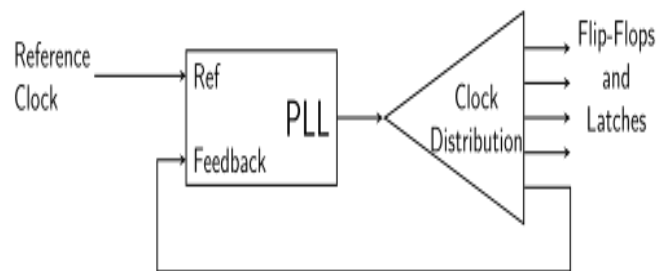


Fig 7 PLL Block

Typically, the reference clock enters the chip and drives a phase locked loop (PLL), which then drives the system's clock distribution. The clock distribution is usually balanced so that the clock arrives at every endpoint simultaneously. One of those endpoints is the PLL's feedback input. The function of the PLL is to compare the distributed clock to the incoming reference clock, and vary the phase and frequency of its output until the reference and feedback clocks are phase and frequency matched.

PLLs are ubiquitous—they tune clocks in systems several feet across, as well as clocks in small portions of individual chips. Sometimes the reference clock may not actually be a pure clock at all, but rather a data stream with enough transitions that the PLL is able to recover a regular clock from that stream. Sometimes the reference clock is the same frequency as the clock driven through the clock distribution, other times the distributed clock may be some rational multiple of the reference.

III. SIMULATION RESULTS

Fig.8 depicts a simulation waveform of the QPSK modulator with the signals of Injection, reset and data. Rest of the Fig.9 gives the waveform with injection high with various data. Fig. 10 Injection value given as 0 so there is no injected voltage to VCO, No data available in result.

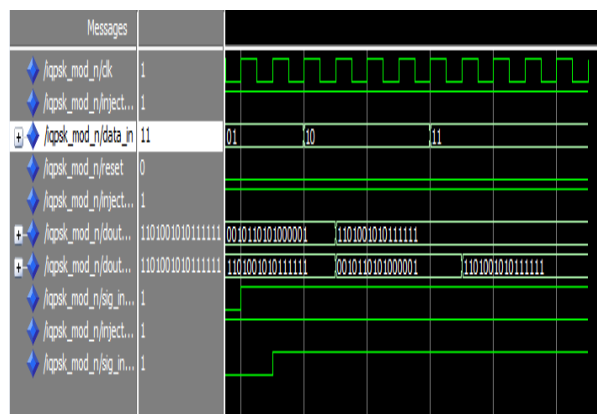


Fig.8 Simulation result with injection high

International Journal of Innovative Research in Science, Engineering and Technology

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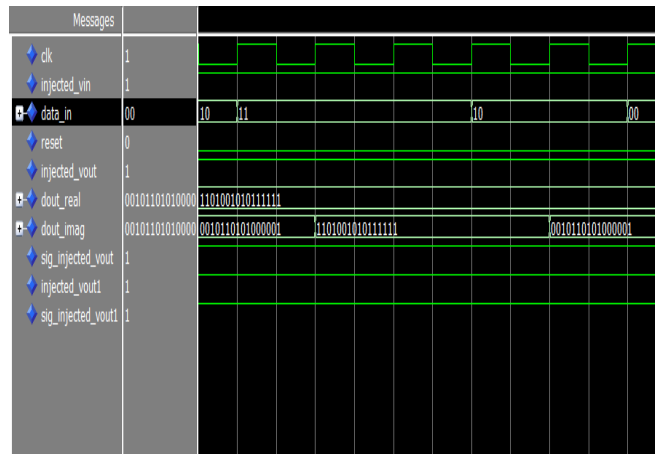


Fig.9 Simulation result with injection high, variety of data

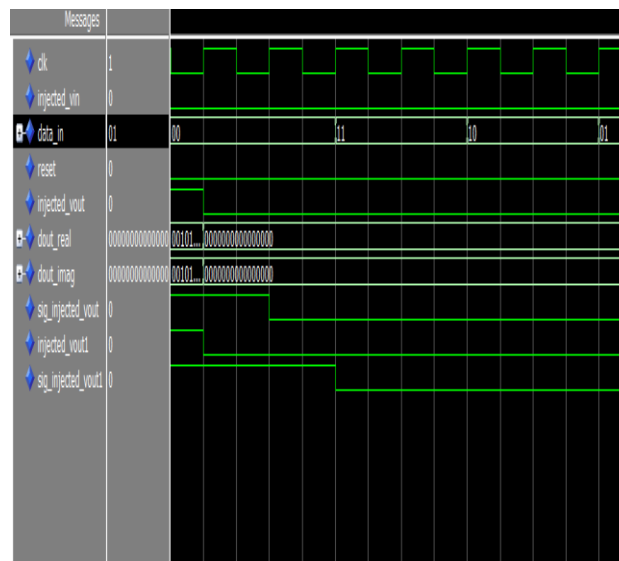


Fig.10 Simulation result with no injection

IV. CONCLUSION

Direct Injection locked QPSK modulator is proposed by replacing many blocks in conventional modulator such that mixers, analog-to-digital converters and filters so that area of the proposed modulator is reduced. By eliminating inductor and other PLL blocks, a simple and scalable QPSK modulator is achieved.

REFERENCES

- [1] T.Kowsalya and Dr.S.Palaniswami (2014) 'A Clock Control Strategy Based clustering Method For Peak Power And Rms Current Reduction' in Journal of Theoretical and Applied Information Technology Vol. 63 No.2 © 2005 - 2014 JATIT & LLSISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195 459
- [2] T.Kowsalya and Dr.S.Palaniswami(2012) ' Decoupled SRAM Cell with Bit Line Decoupled Current Mode Sense Amplifier' Published in European journal of Scientific Research in volume 84 issue 2 Aug 2012
- [3] S.Anu and Mrs.T.Kowsalya "Low Power FSK Modulation and Demodulation using VHDL" International Journal of Advances in Engineering Science and Technology Nov 2014".

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

- [4] S. Ye, L. Jansson, and I. Galton, "A multiple-crystal interface PLL with VCO realignment to reduce phase noise," *IEEE J. Solid-State Circuits*, vol. 37, no. 12, pp. 1795–1803, Dec. 2002.
- [5] J. Lee and H. Wang, "Study of subharmonically injection-locked PLLs," *IEEE J. Solid-State Circuits*, vol. 44, no. 5, pp. 1539–1553, May 2009.
- [6] S. Diao, Y. Zheng, Y. Gao, S. Cheng, X. Yuan, M. Je, and C. Heng, "A 50-Mb/s CMOS QPSK/O-QPSK transmitter employing injection locking for direct modulation," *IEEE Trans. Microw. Theory Tech.*, vol. 60, no. 1, pp. 120–130, Jan. 2012.
- [7] J. Bae, K. Song, H. Lee, H. Cho, and H.-J. Yoo, "A low-energy crystal-less double-FSK sensor node transceiver for wireless body-area network," *IEEE J. Solid-State Circuits*, vol. 46, no. 2, pp. 416–423, Feb. 2011.
- [8] Q. Zhu and Y. Xu, "A 228 m 750 MHz BPSK demodulator based on injection locking," *IEEE J. Solid-State Circuits*, vol. 46, no. 2, pp. 416–423, Feb. 2011.
- [9] B. Razavi, *RF Microelectronics*. Upper Saddle River, NJ, USA: Prentice-Hall, 1998.
- [10] M. M. Izad and C. Heng, "A 17 pJ/bit 915 MHz 8PSK/O-QPSK transmitter for high data rate biomedical applications," in *IEEE CICC Dig.*, Sep. 2012, pp. 1–4.
- [11] H.-C. Chen and W.-K. Lee, "Battery-less ASK/O-QPSK transmitter for medical implants," *Electron. Lett.*, vol. 48, no. 17, pp. 1036–1038,