A CMOS Direct-Digital BPSK Modulator Circuit

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Abstract-The study presents a 0.18 µm CMOS binary phase-shift keying (BPSK) modulator circuit optimized for high data rates with minimized power consumption and a compact layout. Operating at 2.4 GHz, the modulator utilizes an active balun and complementary common-gate switches to provide efficient BPSK modulation, achieving data rates of up to 200 Mbps with excellent carrier suppression and minimal phase and amplitude errors.

I. INTRODUCTION

Direct-digital modulation is gaining traction for its potential cost-effectiveness and performance benefits, particularly in mobile communications. BPSK modulation is widely used in systems like CDMA 2000, GPS, and RFID. Standard methods of BPSK modulation include reflection-type topologies [1], Gilbert-cell mixers [2], and ring-mixers [3]. Many modulators rely on passive transmission-line couplers, which require high carrier frequencies to achieve on-chip scalability; however, this is challenging in CMOS due to silicon's low resistivity, which causes significant transmission losses at high frequencies. An alternative approach uses an active balun to produce a 180° phase shift, making it better suited to CMOS applications [4].

The modulator's block diagram (Figure 1) illustrates a balun for single-ended to differential conversion and two complementary switches,controlled by baseband data.

Previously, implementations with a passive balun and MEMS switches [5] had limited data rates due to the MEMS' slow switching. Other designs improved speed but lacked monolithic integration [6]. Utilizing the unlicensed 2.4 GHz band with CMOS offers cost advantages and the potential for a system-on-chip design, combining RF/microwave and baseband circuitry for additional savings.

This paper details a 0.18 µm CMOS direct-digital BPSK modulator suitable for mobile applications, with the circuit design covered in Section II, followed by measurements in Section III, and conclusions in Section IV.

II. PRINCIPLE OF GENERATION

The document presents a CMOS-based direct-digital BPSK modulator designed for mobile communication applications, such as CDMA, GPS, and RFID, using a 0.18 µm CMOS process. The modulator converts a 2.4 GHz single-ended microwave signal into a balanced signal with a 180° phase shift via an active balun, which avoids the need for large passive components and enhances on-chip compatibility. Complementary common-gate

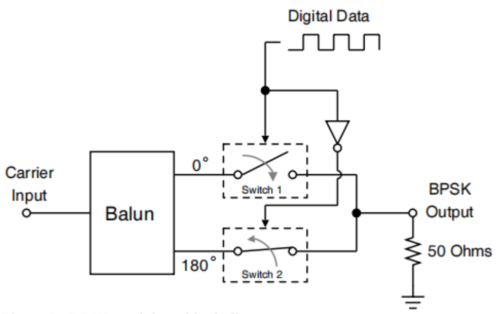

Figure 1. BPSK modulator block diagram

FET switches, controlled by digital data inputs, toggle between the balun outputs to produce BPSK modulation. This design enables a compact, low-power layout with a high input reflection coefficient (-13 dB) and low insertion loss, achieving data rates up to 200 Mbps with minimal phase (≤1°) and amplitude (≤0.1 dB) errors.

III. IMPLEMENTATION

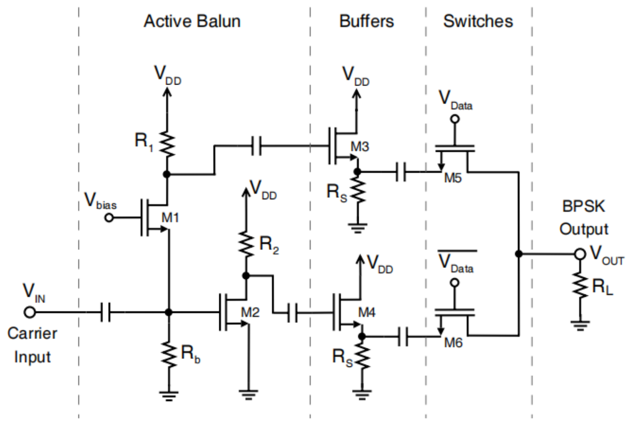

Figure 2. CMOS BPSK modulator circuit

The implementation of the CMOS-based direct-digital BPSK modulator relies on a compact 0.18 µm CMOS circuit layout, integrating an active balun and common-gate FET switches to perform modulation. The active balun generates a balanced output from a single-ended 2.4 GHz carrier input, providing the necessary 180° phase shift with high-frequency performance, while minimizing chip area compared to traditional passive baluns. Common-gate switches are used with complementary control voltages to select between the balun outputs, based on the digital data input, thus achieving phase shifts that correspond to binary data values. This configuration allows for efficient switching, carrier suppression, and low power consumption, with a total power requirement of 7.2 mW. The circuit design is further optimized by including source-follower buffers that maintain impedance isolation between the balun and the output switches. A detailed illustration of this circuit is provided in Figure 2 of the document.

IV. ISSUES & IMPROVEMENTS

Challenges include balancing amplitude and phase, which are mitigated by the active balun's design. The use of complementary switches minimizes data-rate-dependent power losses. Further work can explore improving the input reflection coefficient for wider application in high-impedance system.

V. CONCLUSION & FUTURE SCOPE

This compact BPSK modulator demonstrates the feasibility of CMOS-based solutions for wireless applications in the unlicensed 2.4 GHz band. Future enhancements could address performance at higher frequencies and further minimize power usage for mobile applications

VI. REFERENCES.

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