A 60-GHz Digitally-Controlled Phase Modulator with Phase Error Calibration

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1 Introduction

The 9-GHz unlicensed bandwidth available worldwide between 57 GHz and 66 GHz has drawn a great interest in the past few years owing to its capability of achieving high-data-rate (e.g. several gigabits per second) short-range wireless communications, such as the streaming of uncompressed high-definition video, wireless replacement of next-generation wired interconnects, and fast movie or video game download from kiosk [1]. To realize several gigabits per second wireless communication at 60 GHz, an accurate phase modulator with small phase errors is necessary for the system [2].

2 Circuit Design

A 60-GHz digitally-calibrated phase modulator is designed as shown in Fig. 1. The topology of combined passive phase shifter and phase inverter is adopted for reducing the chip area and insertion loss while attaining the 360° phase tuning range. The passive phase shifter is implemented using varactor-loaded transmission line with coarse- and fine- tuning bits. The down-conversion mixer, whose RF and LO ports are connected to the input and output of the modulator respectively, is utilized for phase calibration. The basic principle of phase calibration is that the output voltage of a down-conversion mixer has a DC component whose value is a fixed function of the phase difference of the input signals having the same frequency, as depicted in Fig. 2. The phase calibration can be accomplished by adjusting the fine-tuning bits in the passive phase shifter until the mixer outputs the desired DC voltage, the value of which corresponds to the correct output phase. In order to demonstrate the phase calibration capability of the proposed modulator, Fig. 3 shows the output phase simulation result of the passive phase shifter for nominal 0° and 45° settings at different frequencies. The calibration bits are swept to compensate the phase errors of the nominal 45° phase shifting outputs.

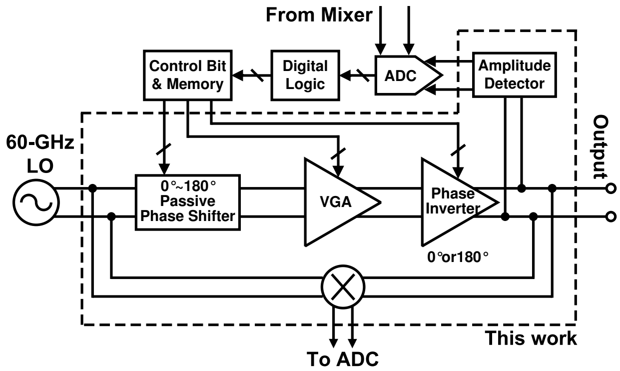

Fig. 1 The proposed phase modulator

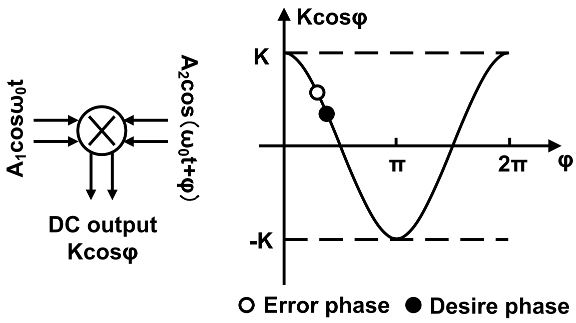

Fig. 2 The basic phase calibration principle

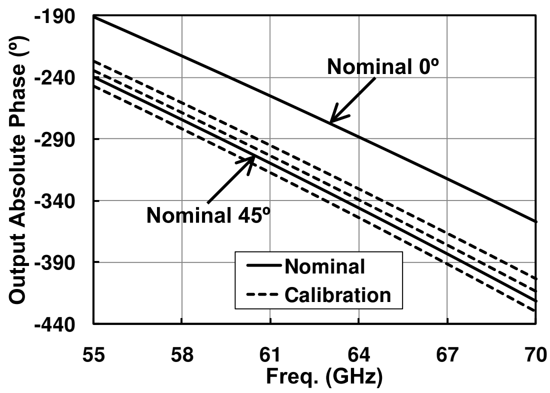

Fig. 3 The nominal and calibrated output phase of the passive phase shifter versus operation frequency

3 Conclusions

In this paper, a digitally-assisted phase calibration technique is presented. Based on the technique a 60-GHz phase modulator with phase error compensation is designed, achieving the phase tuning range of 360°. The phase accuracy of the modulator can be greatly improved over PVT variations by using the proposed technique.

Acknowledgment

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