

THE DESIGN OF A SERIAL MSK MODEM

by

LARRY N. PHILLIPS

B. S., Kansas State University, 1978

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Electrical Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

Approved by:

Ronald R. Hummel

Major Professor

SPEC
COLL
LD
2668
.R4
1980
PS4
C.2

TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION	1
II. DESCRIPTION OF MSK	2
Msk in General	2
Serial MSK	9
III. DESCRIPTION OF MODEM	14
Modulator	14
Demodulator	19
Support Circuitry	21
IV. PERFORMANCE OF THE MODEM	30
Envelope	30
Power Spectrum	30
Bit Error Performance	30
V. CONCLUSIONS	36
REFERENCES	38
ACKNOWLEDGEMENTS	39

**THIS BOOK
CONTAINS
NUMEROUS PAGES
WITH DIAGRAMS
THAT ARE CROOKED
COMPARED TO THE
REST OF THE
INFORMATION ON
THE PAGE.**

**THIS IS AS
RECEIVED FROM
CUSTOMER.**

LIST OF FIGURES

Figure	Page
1. Binary Bit Stream Split into Even and Odd Bit Streams . . .	3
2. OQPSK Modulator	4
3. MSK Waveforms	7
4. MSK Amplitude Spectrum	8
5. Block Diagram of SMSK Modulator and Demodulator	10
6. Amplitude Spectrum of SMSK	13
7. Block Diagram of Experimental SMSK Modem	15
8. SMSK Modulator Circuit	16
9. SMSK Demodulator Circuit	19
10. Amplitude Response of Suboptimum SMSK Filter	20
11. The Channel	22
12. Block Diagram of Frequency Multiplier	23
13. Frequency Multiplier Circuit	25
14. Phase-Shifter Circuit	26
15. Bandpass Filter Circuit	28
16. Zero-Crossing Detector	29
17. Photographs of SMSK Modem Envelope and Power Spectrum . . .	31
18. Calculated Suboptimum SMSK Envelope	32
19. Calculated Suboptimum SMSK Power Spectrum	33
20. Bit Error Rate Curve for Ideal and Suboptimum SMSK	35

CHAPTER I

INTRODUCTION

The spectral congestion in the radio frequency (RF) band as a result of increased demand for digital transmission channels has inspired a search for more efficient signaling techniques. The goal is to use as little transmitter power and channel bandwidth as possible without sacrificing error rate performance. The efforts to realize this goal have led to the development of several spectrally efficient digital transmission schemes. These schemes include quadrature phase-shift keying (QPSK), offset QPSK (OQPSK), and minimum shift keying (MSK) [1].

MSK represents a special case of frequency shift keying (FSK) because the frequency separation between the two signaling frequencies is only half that of conventional orthogonal FSK [1], [3]. For this reason, MSK is often referred to as fast FSK. MSK sometimes goes by the name of continuous phase FSK (CPFSK) because of its continuous phase characteristic. This phase continuity and a constant envelope make MSK attractive [1].

This report will consider the MSK signaling scheme, and the primary focus will be on the design of a serial MSK (SMSK) modulator and demodulator (modem). This type of MSK was first described by Amoroso and Kivett [2].

CHAPTER II
DESCRIPTION OF MSK

MSK in General

It has been shown that MSK conceptually resembles OQPSK [1]. Instead of rectangular pulses modulating the in-phase and quadrature channels of a carrier as in OQPSK, sinusoidal pulses modulate the two channels in MSK. First, OQPSK will be reviewed; then, its relationship to MSK will be shown.

As shown in Figure 1, a binary bit stream at a rate of $\frac{1}{T}$ where T is the bit time, has been split into two binary bit streams: one containing only even bits, $b_i(t)$; and one containing only odd bits, $b_q(t)$. When the even bit stream is offset from the odd bit stream by T seconds and these offset bit streams, $b_{i0}(t)$ and $b_{q0}(t)$, modulate the in-phase and quadrature channels of a carrier, the sum of the two modulated signals is OQPSK. Figure 2 illustrates this process. Now, if $b_{i0}(t)$ and $b_{q0}(t)$ are shaped into sinusoidal pulses, as seen in Figure 3, then the resulting waveform at the output of the summer in Figure 2 will be MSK [1]. The mathematical description of MSK is then

$$s_{\text{MSK}}(t) = b_{i0}(t)\cos(2\pi f_c t)\cos\left(\frac{\pi t}{2T}\right) + b_{q0}(t)\sin(2\pi f_c t)\sin\left(\frac{\pi t}{2T}\right) \quad (1)$$

Recalling that

$$\cos\alpha \cos\beta = \frac{1}{2}\cos(\alpha-\beta) + \frac{1}{2}\cos(\alpha+\beta)$$

$$\sin\alpha \sin\beta = \frac{1}{2}\cos(\alpha-\beta) - \frac{1}{2}\cos(\alpha+\beta)$$

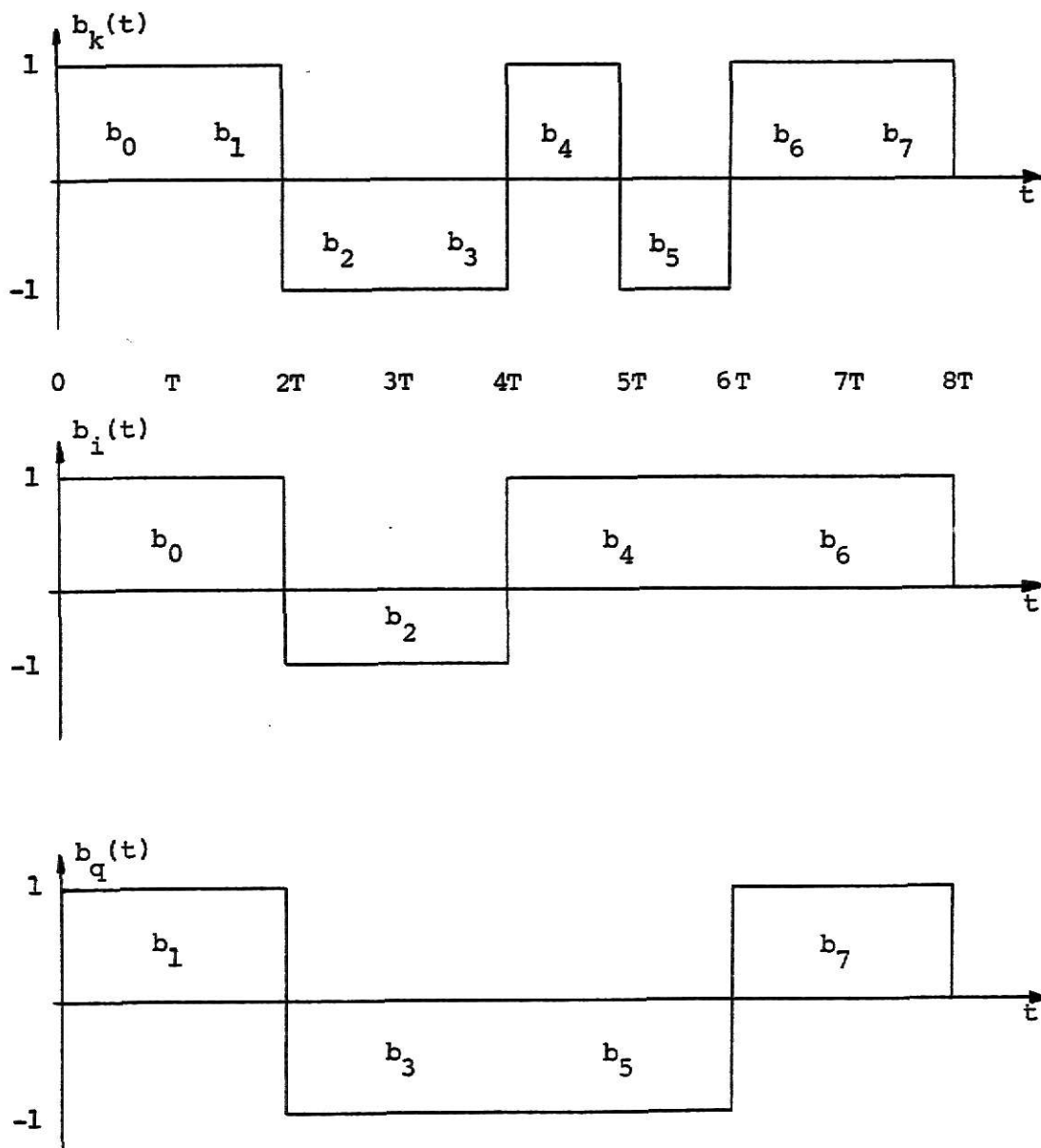


Figure 1. Binary Bit Stream Split into Even and Odd Bit Streams.