# Simulation and Analysis of MSK System based on SystemView

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**Abstract:** In digital communication, in order to reduce the influence of non-linear factors and bandwidth limitation in the channel, the minimum frequency shift keying (MSK) digital modulation technology is deeply discussed, and the simulation circuit diagram of MSK system is designed based on System View simulation platform, and the dynamic simulation and result analysis of MSK system are carried out. The simulation results show that MSK can not only keep the modulated phase continuous to reduce side lobes, but also keep the envelope constant. It has the advantages of narrow bandwidth, concentrated spectrum main lobe energy, fast sidelobe roll-down attenuation and high bandwidth utilization.

**Keywords:** MSK; System simulation; System View

## 1. Introduction

Choosing different digital modulation methods to meet the needs of different transmission channels under the condition of limited channel bandwidth is the key content of digital communication research. When there are non-linear factors and bandwidth constraints in the channel, the digital signal with variable amplitude will recover the out-of-band frequency components that have been taken into account when it passes through the channel, and the phenomenon of spectrum spread will occur. In order to avoid this phenomenon and satisfy the requirement of frequency resource limitation, the modulated signal is required to have constant envelope and minimum power spectrum occupancy [1]. The key of modern digital modulation technology is the continuity of phase change, so as to reduce the occupancy of frequency. Minimum frequency shift keying (MSK) is a new modulation technology with continuous phase, which can not only improve the bandwidth utilization, but also improve the spectrum characteristics of FSK. At present, this modulation mode is mainly used in some modern military communications.

SystemView is a signal-level system simulation software designed and developed by ELANIX Company in the United States. It is mainly used in the design and Simulation of circuit and communication systems. It can meet the design and simulation requirements of different levels from digital signal processing, filter design to complex communication systems. It is so far dedicated to dynamic system simulation. Excellent software, especially in the field of communication system analysis and design, has broad application prospects [2].

This paper summarizes the simulation steps of SystemView in communication system, establishes the mathematical model of MSK system, designs the circuit diagram of system simulation, and analyses the simulation results.

## 2. Simulation Steps of Communication System based on System View

Using System View development platform to carry out the simulation experiment of communication system, the following steps can be taken:

Establish mathematical model: According to the principle of communication system, determine the overall function and the function of each part, analyze the relationship between the functional modules of each part, establish the mathematical model of communication system and draw the composition block diagram.

Designing simulation circuit: According to the system composition block diagram, the corresponding signal source symbol library, operator symbol library, function symbol library and receiver symbol library are selected from the symbol library of System View, and the communication system circuit diagram is designed according to the system composition block diagram.

Setting related parameters: According to the system performance requirements, setting and adjusting the corresponding parameters of each module.

Operation simulation analysis results: system operation simulation, dynamic display and analysis of simulation results through analysis window.

## 3. Mathematical Model of MSK System

In digital communication, although OQPSK and $\pi$ /4-QPSK signals eliminate the phase jump of QPSK signal 180o, they do not fundamentally solve the problem of envelope fluctuation caused by phase jump. If the envelope fluctuation signal passes through a non-linear circuit, the spectrum broadening phenomenon will occur, which will easily lead to error code, thus affecting the communication quality. Compared with PSK modulation, MSK has the advantages of narrow bandwidth, concentrated spectrum main lobe energy, fast side lobe roll-down and attenuation, and high frequency band utilization, and has been applied more and more widely.

MSK is a special form of FSK. Its frequency difference satisfies the minimum frequency difference of two orthogonal frequencies, and requires the phase continuity of the FSK signal. Its frequency difference $\Delta f = f1 - f2 = 1/2Tb$, that is, the modulation index is 0.5.

The signal expression of MSK is:

$$SMSK(t) = A\cos[\omega_c t + \phi_k(t)] = A\cos\left[\omega_c t + \frac{\pi}{2T_b} a_k t + x_k\right] \quad (1)$$

Among them, $\omega_c$ :carrier angular frequency, $T_b$ : symbol width of binary baseband signal, $a_k$ : binary information 1 or 0, where $a_k = \pm 1$; $x_k$ :carrier phase constant of the K symbol remains unchanged for the duration of the symbol, and $\varphi_k(t)$ :continuous phase function changing with time.

In order to maintain phase continuity, the following formula should be established whent=kTb:

$$\varphi_{k-1}(kT_b) = \varphi_k(kT_b) \quad (2)$$

Substituting this formula into (1) can be obtained:

$$x_k = x_{k-1} + (a_{k-1} - a_k)\frac{k\pi}{2} = \begin{cases} x_{k-1} \\ x_{k-1} \pm k\pi \end{cases}, \text{可} = 0,1,2,.... \quad (3)$$

The formula shows that the carrier phase constant $x_k$ of the k-th symbol is not only related to the value of the current symbol, but also to the value of the previous symbol and its phase constant.

The orthogonal expansion of MSK is as follows:

$$\begin{aligned} &SMSK(t) \\ &= A\cos\left[\omega_c t + \frac{\pi}{2T_b} a_k t + x_k\right] \quad (4) \\ &= A\cos x_k \cos\left(\frac{\pi}{2T_b} t\right)\cos\omega_c t - Aa_k \cos x_k \sin\left(\frac{\pi}{2T_b} t\right)\sin\omega_c t \end{aligned}$$

Thus, the modulation block diagram of MSK can be obtained, as shown in Figure 1.

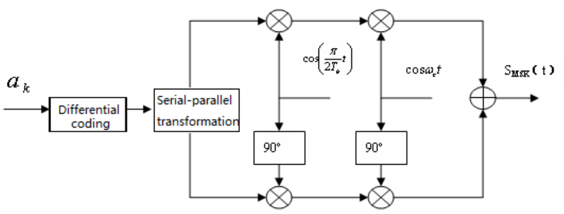



**Figure 1. Principle block diagram of MSK modulator**

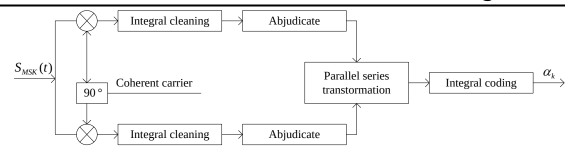



**Figure 2. Principle block diagram of MSK coherent demodulator**

Like FSK, MSK can be demodulated by discriminator or coherent demodulation. The block diagram of coherent demodulation is shown in Figure 2.

## 4. MSK System Simulation based on System View

### 4.1. Design of simulation circuit diagram for MSK modem

According to the schematic diagram, the simulation circuit diagram of MSK system based on System View is designed as shown in Figure 3.

Simulated circuit diagram of MSK modulator: In System View simulation, random 0,1 binary digital baseband signal is simulated by binary pseudo-random code sequence SN Seq; the input baseband signal is differentially coded; and then serial-parallel transformation is carried out: it is divided into I and Q channels, and interlaced with each other by one symbol width, and then used. The weighting function cos () and sin () weights the I and Q data respectively, then modulates the two data with orthogonal carrier respectively, and finally generates MSK signal by adder. The parameters of each symbol are set as shown in the MSK modulator section of Figure 3.

The simulation circuit diagram of MSK demodulator: The coherent demodulation process of MSK is shown in the MSK demodulator section of Figure 3. Firstly, MSK signal is divided into two channels and demodulated coherently by orthogonal carrier (same frequency and phase with the input), and then by cleaning integral and sampling judgment, the two signals are converted in parallel and in series, and differential decoding is performed to restore the original digital baseband signal.

### 4.2. Simulated signal waveform and its result analysis

Running the above simulation diagram, the relevant waveforms of the modulator in Figure 4. and the demodulator in Figure 5. can be obtained. From the waveform of Figure 4. It can be seen that the differential codes (upper left) and input differential codes (lower left) of the original codes are intuitively seen by the differential coder. The I and Q signal waveforms (upper right) and Q input (lower right) obtained by series-parallel transformation show that the phase of MSK signal is continuous. From the waveform of Figure 5. We can see that the I and Q waveforms of the two signals are separately cleaned and sampled by the receiver, and the output waveforms of the differential code and the demodulated output waveforms of the differential decoding are obtained after the parallel-series conversion. Through these intuitive results, it is easy to compare and analyze the input and output signals. Figure 4. Gives the waveform comparison between the original code and the demodulated output signal and their spectrum. From the waveform, the original code and the output waveform are delayed by time, and the spectrum comparison shows that the spectrum of the demodulated waveform is output on the basis of the original code spectrum. Partial noise was added.

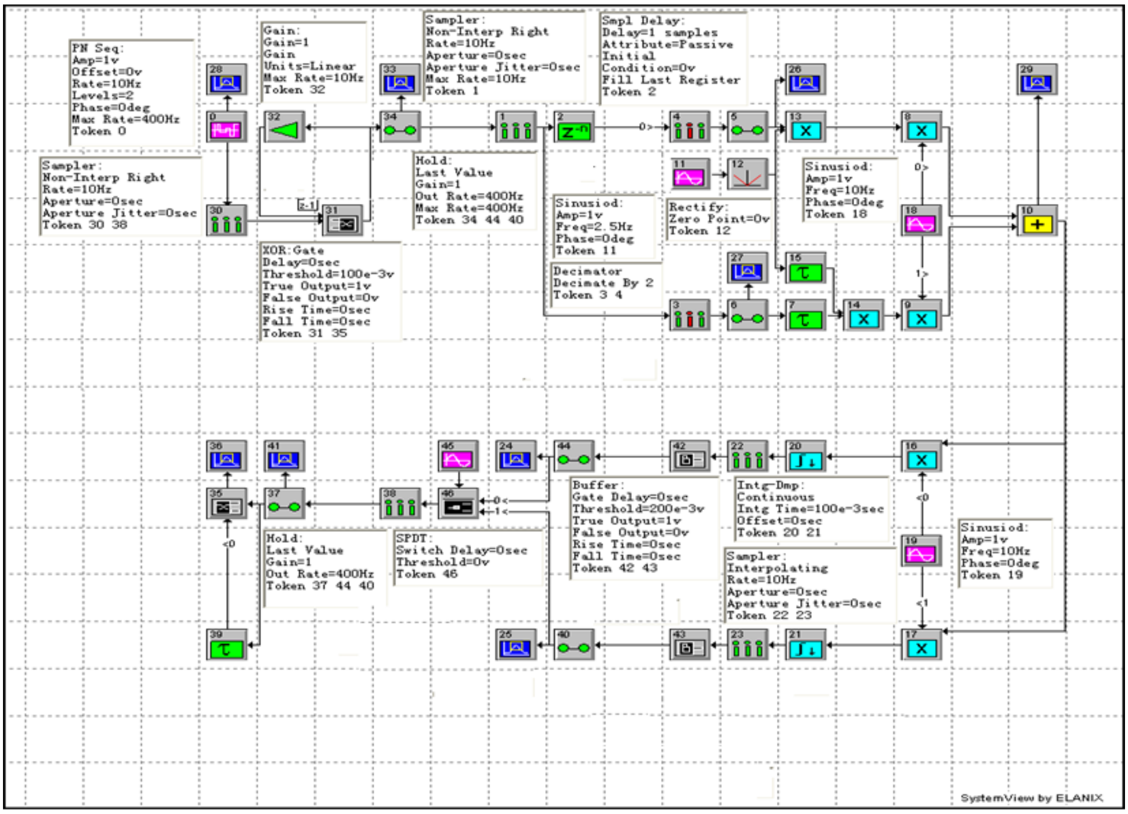
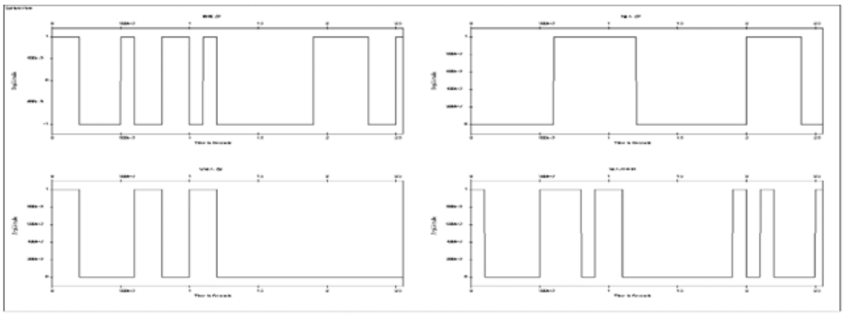
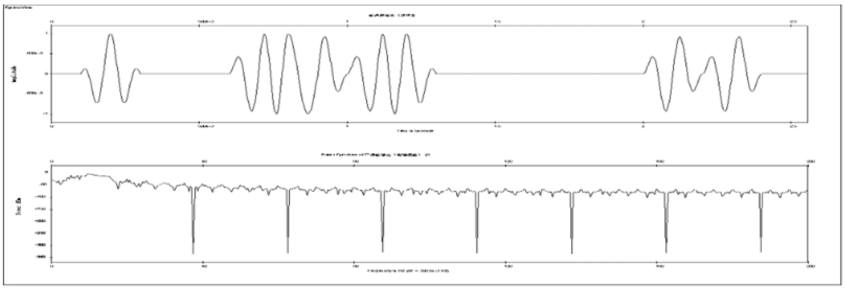



**Figure 3. MSK modem simulation circuit diagram**

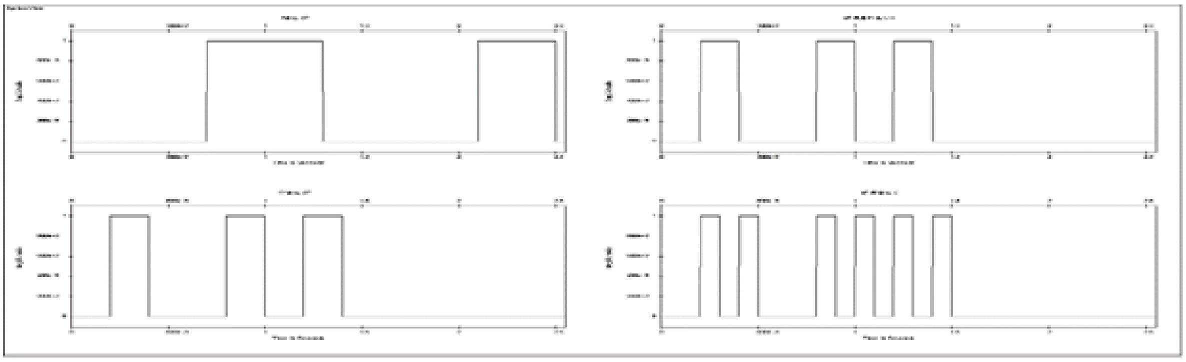


The source code (upper left), input differential code (lower left), I input (upper right) and Q input (lower right)



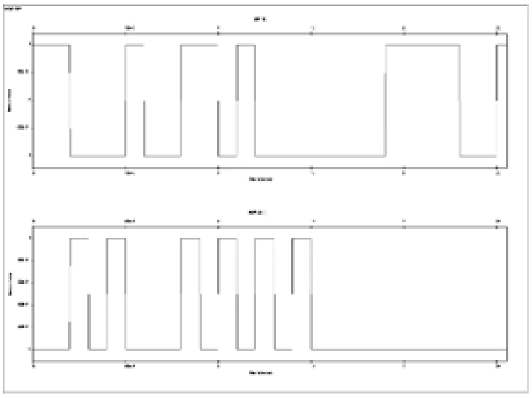
MSK Signal and Its Spectrum

**Figure 4. MSK modulator correlation waveform**

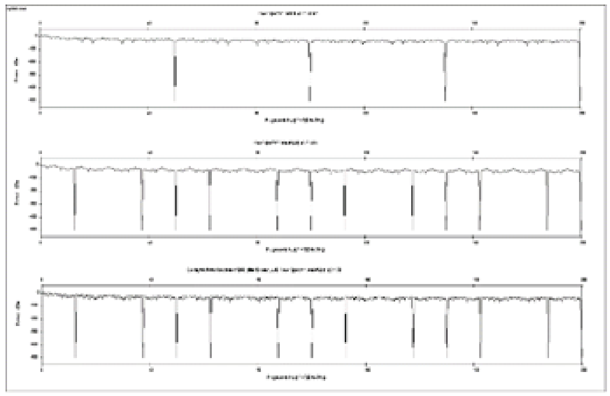


I output (upper left) and Q output (lower left) Q output (upper right) and Q demodulation output (lower right)

**Figure 5. MSK demodulator correlation waveform**



Comparison of the output of source code and Q demodulation



Spectrum comparison between source code and Q demodulation output

**Figure 6. Comparison of source code and output waveform**

## 5. Conclusion

MSK modulation is a new type of digital modulation technology, especially when there are non-linear factors and bandwidth limitations in the channel, the modulation technology has better performance. Through the analysis of the principle of modulation and demodulation circuit of MSK system and the design of simulation circuit diagram of MSK system based on System View platform, the waveform of modulation and demodulation can be analyzed intuitively and dynamically, which provides a preliminary basis for the practical development of hardware.

## 6. Achnowledgment

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