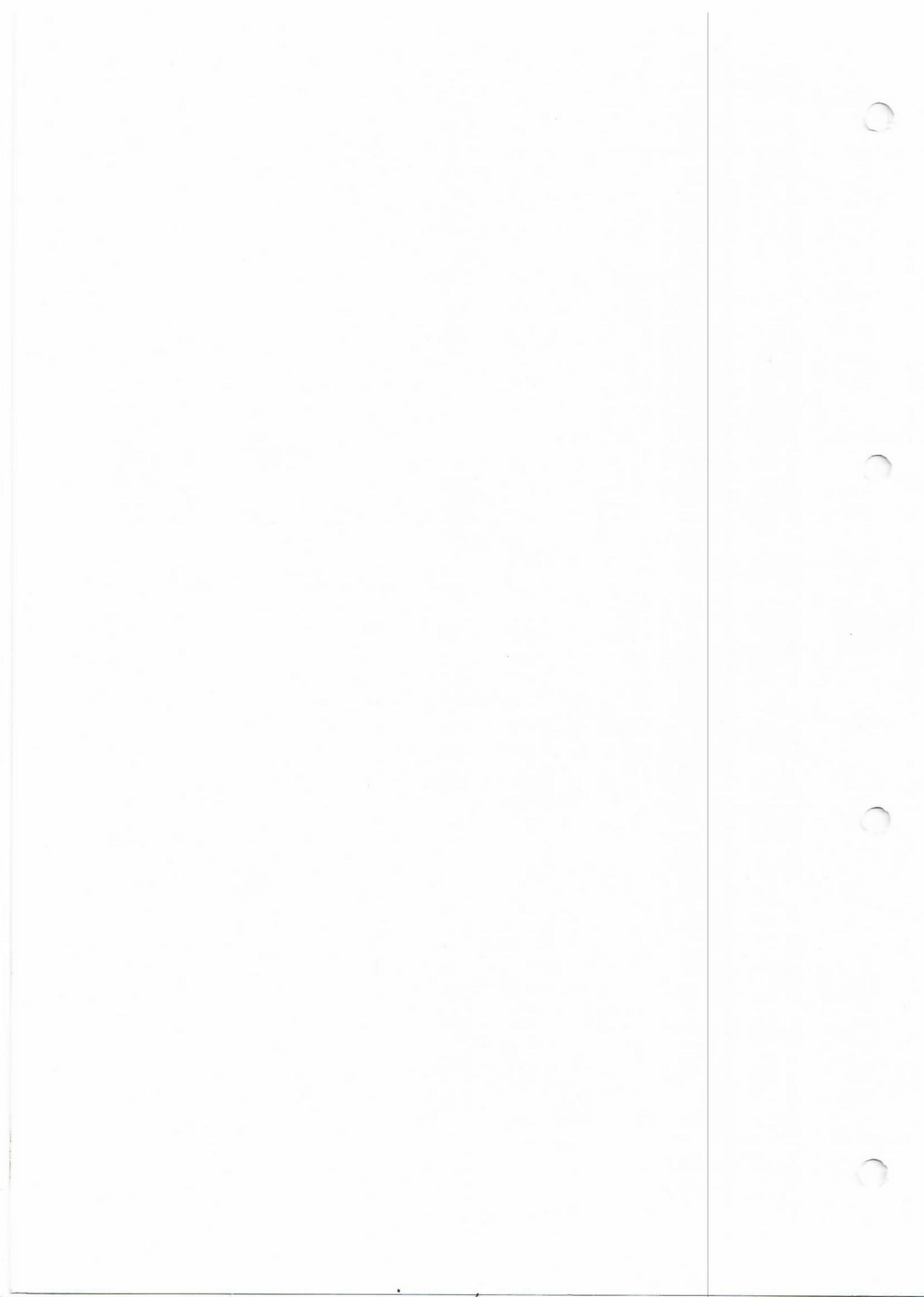


# Chapter 13

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## FSK MODULATORS

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### 13.1 OBJECTIVES

1. Understanding the principle of frequency-shift keying (FSK) modulation.
2. Measuring FSK signals.
3. Implementing an FSK modulator with LM566.

### 13.2 DISCUSSION OF FUNDAMENTALS

In digital transmission repeaters can regenerate digital signals and improve the ability against noise interference, and the use of encoding techniques can provide debugging and correction functions. But digital signals often occur distortions due to its high-frequency components are easily attenuated for a long distance transmission. To improve this disadvantage, a particular processing (modulation) is need for this purpose. Frequency-shift keying (FSK) is a type of FM in which the modulating signal (digital signal) shifts the output between two predetermined frequencies - usually termed the mark and space frequencies. The relationship between FSK and digital signals is shown in Fig. 13-1. The FSK frequency  $f_1$  corresponds to the digital input high, and the  $f_2$  represents the digital low.

FSK technique is widely used for the transmission of Teletype information. FSK standards have evolved for the years. For radio Teletype, the frequency of 2124Hz represents mark or 1, and 2975 Hz represents space or 0.

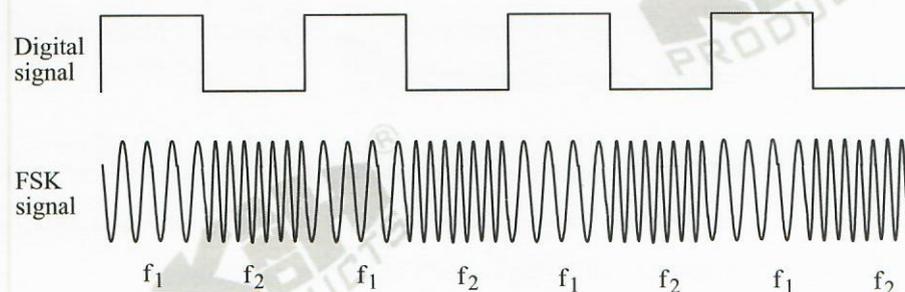


Fig.13-1 Relationship between digital and FSK signals

For data transmission over telephone and landlines, the commonly used frequencies are:

space = 1270 Hz

mark = 1070 Hz

and

space = 2225 Hz

mark = 2025 Hz

Notice that the frequency difference (gap) of FSK signal equals 200 Hz.

The FSK modulator is used to convert the digital signal (square wave) into the analog signal having two different frequencies corresponding to the input levels. In this experiment, we use the frequencies of 1070 Hz and 1270 Hz to represent space and mark, respectively. A voltage-controlled Oscillator (VCO) can easily generate these two frequencies. A practical FSK modulator using the LM566 VCO is shown in Fig.13-2. In such cases, the oscillating frequency of LM566 can be found by

$$f_0 = \frac{2}{R_{10}C_5} \left( \frac{V_{cc} - V_{in}}{V_{cc}} \right)$$

where  $V_{cc}$  is the power voltage applied to LM566 pin 8, and  $V_{in}$  is the VCO control voltage applied to pin 5.

If  $V_{cc}$  is constant, proper values of  $R_{10}$ ,  $C_5$  and  $V_{in}$  are determined to generate the LM566 output frequencies  $f_0$  of 1072 Hz and 1272 Hz. In practice, the limitations of using LM566 VCO are as follows:

$$2 \text{ k}\Omega \leq R_{10} \leq 20 \text{ k}\Omega$$

$$0.75 \leq V_{in} \leq V_{cc}$$

$$f_0 \leq 500 \text{ kHz}$$

$$10 \text{ V} \leq V_{cc} \leq 24 \text{ V}$$

To generate the frequencies of 1070 Hz and 1270 Hz exactly, the digital input levels, such as TTL levels 0V and 5V must be converted to proper voltage levels before applying to the input of VCO. The level shifter ( $Q_1$  and  $Q_2$ ) provides this purpose. The  $Q_1$  acts as a NOT gate. In other words, when  $Q_1$  input is high (5V), then  $Q_1$  conducts and the output goes to low (about 0.2V) causing the  $Q_2$  to cutoff. If  $Q_1$  input is low (0V), the  $Q_1$  is OFF and its output rises to high (5V), and thus the  $Q_2$  conducts. When the  $Q_2$  is OFF, the input voltage of VCO is given by

$$V_1 = \frac{VR_2}{VR_2 + R_6} V_{cc}$$

and the output frequency of VCO is  $f_1$ . When  $Q_2$  conducts, the input voltage of VCO is

$$V_2 = \frac{VR_1 // VR_2}{(VR_1 // VR_2) + R_6} V_{cc}$$

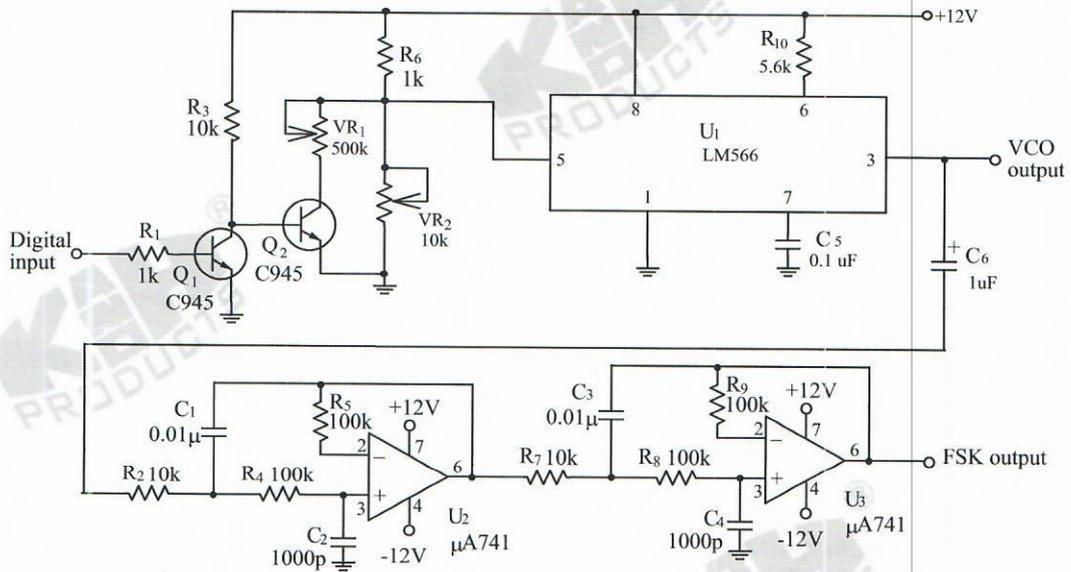


Fig.13-2 FSK modulator circuit.

and the output frequency is  $f_2$ . Therefore the output frequencies  $f_1 = 1270$  Hz and  $f_2 = 1070$  Hz can be obtained by carefully adjusting the  $VR_1$  and  $VR_2$  values. Both  $U_2$  and  $U_3$  are the second-order low-pass filters. The fourth-order low-pass filter formed by cascading these filters is used to filter the high-frequency harmonic components on the output of LM566 and therefore the FSK modulated signal is obtained.

If the FSK modulated signal mentioned above is desired to transmit by an antenna, a mixer is required to modulate the signal to the frequency range in RF band.

### 13.3 EQUIPMENT REQUIRED

- 1 - Module KL-96001
- 2 - Module KL-94003
- 3 - Oscilloscope

### 13.4 EXPERIMENTS AND RECORDS

#### **Experiment 13-1 FSK Modulator**

- 1. Locate the FSK modulator circuit on Module KL-94003.
- 2. Connect 5Vdc to digital signal input (I/P). Using the oscilloscope, observe the LM566 output frequency (pin 3) and adjust  $VR_2$  to obtain the frequency of 1070Hz, and then record the result in Table 13-1.
- 3. Using the oscilloscope, observe and record the FSK output signal in Table 13-1.
- 4. Connect digital signal input (I/P) to ground (0V). Using the oscilloscope, observe the LM566 output frequency (pin 3) and adjust  $VR_1$  to obtain the frequency of 1270Hz, and record the result in Table 13-1.
- 5. Using the oscilloscope, observe and record the FSK output signal in Table 13-1.
- 6. Set the output of signal generator to TTL level and the frequency of 200 Hz and then connect the output to the digital signal input (I/P). Using the oscilloscope, observe and record the input, LM566 output (pin 3), and FSK output signals in Table 13-2.
- 7. Change the output frequency of signal generator to 5kHz and repeat step 6.

Table 13-1

Input Signal	LM566 (pin 3) Output Waveform	FSK Output Waveform
0 V		
5 V		

Table 13-2

Input Frequency	200 Hz	5 kHz
Input Waveform		
LM566 (pin3) Output Waveform		
FSK Output Waveform		

## 13.5 QUESTIONS

1. Describe the operations of  $Q_1$ ,  $Q_2$  and LM566.
2. Describe the functions of  $VR_1$  and  $VR_2$ .
3. If the input frequency is higher than the FSK frequency, does the FSK modulator operate normally?