(11) FSK MODULATORS

1. OBJECTIVES

(1) Understanding the principle of frequency-shift keying (FSK) modulation.

(2) Measuring FSK signals.

(3) Implementing an FSK modulator with LM566.

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 Figure 11-1. 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.

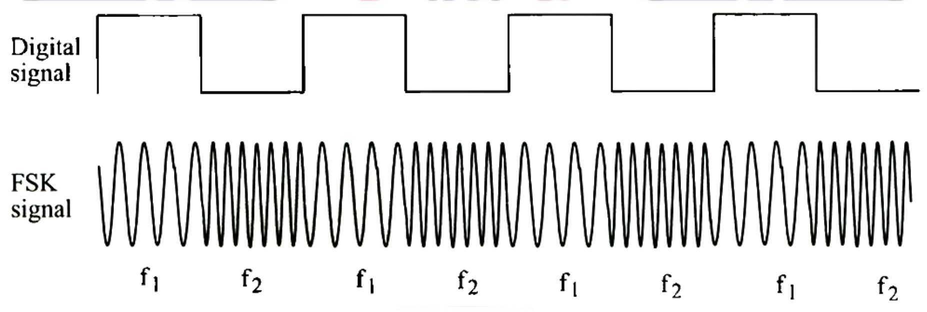

Figure 11-1 Relationship between digital and FSK signals

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 Figure 11-2. 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 Vcc is the power voltage applied to LM566 pin 8, and Vin is the VCO control voltage applied to pin 5.

If Vcc is constant, proper values of R10, C5 and Vin are determined to generate the LM566 output frequencies fo of 1072 Hz and 1272 Hz. In practice, the limitations of using LM566 VCO are as follows:

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

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

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

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

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 (Q1 and Q2) provides this purpose. The Q1 acts as a NOT gate. In other words, when Q1 input is high (5V), then Q1 conducts and the output goes to low (about 0.2V) causing the Q2 to cutoff. If Q1 input is low (0V), the Q1 is OFF and its output rises to high (5V), and thus the Q2 conducts. When the Q2 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 f1. When Q2 conducts, the input voltage of VCO is

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

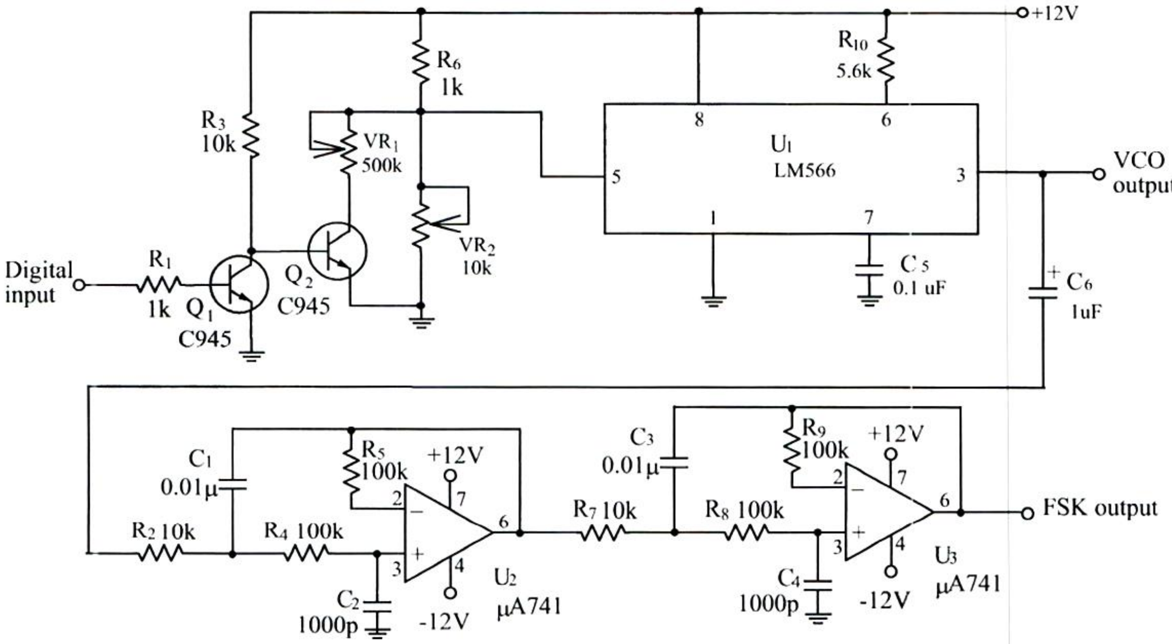

Figure 11-2 FSK modulator circuit

and the output frequency is f2. Therefore, the output frequencies f1=1270Hz and f2=1070Hz can be obtained by carefully adjusting the VR1 and VR2 values. Both U2 and U3 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.

3. Equipment Required

(1) Module KL-96001

(2) Module KL-94003

(3) Oscilloscope

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 (l/P). Using the oscilloscope, observe the LM566 output frequency (pin 3) and adjust VR2 to obtain the frequency of 1070Hz, and then record the result in Table 11-1.

(3) Using the oscilloscope, observe and record the FSK output signal in Table 11-1.

(4) Connect digital signal input (I/P) to ground (0V). Using the oscilloscope, observe the LM566 output frequency (pin 3) and adjust VR1 to obtain the frequency of 1270Hz, and record the result in Table 11-1.

(5) Using the oscilloscope, observe and record the FSK output signal in Table 11-1.

(6) Set the output of signal generator to TTL level and the frequency of 200Hz 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 11-2.

(7) Change the output frequency of signal generator to 5kHz and repeat step 6.

Table 11-1

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

Table 11-2

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

5. QUESTIONS

(1) Describe the operations of Q1, Q2 and LM566.

(2) Describe the functions of VR1 and VR2.

(3) If the input frequency is higher than the FSK frequency, does the FSK modulator operate normally?