# BINARY FREQUENCY SHIFT KEYING (BINARY FSK) MODULATOR

## OBJECTIVES:

1. To observe the operation of a linear integrated-circuit function generator.
2. To observe the operation of a binary frequency shift keying modulator.
3. To observe the operation of a linear integrated-circuit binary frequency shift keying modulator.

## INTRODUCTION:

Frequency shift keying (FSK) is a relatively simple, low-performance form of digital modulation. Binary FSK is a form of FSK where the input signal can have only two different values (hence the name binary). Binary FSK is a constant-envelope form of angle modulation similar to conventional frequency modulation except that the modulating signal varies between two discrete voltage levels (i.e., 1's and 0's) rather than with a continuously changing value, such as a sine wave. Binary FSK is the most common form of FSK. With Binary FSK, the center or carrier frequency is shifted (deviated) by the binary input signal. Consequently, the output from an FSK modulator is a step function in the frequency domain. As the binary input signal changes from a logic 0 to a logic 1 and vice versa, the FSK output signal shifts between two frequencies; a mark or logic 1 frequency and a space or logic 0 frequency.

In this experiment the XR-2206 monolithic function generator is used for the FSK modulator. The block diagram for the XR-2206 function generator is shown in Figure 22-1.

## MATERIALS REQUIRED:

*Equipment:*

1 - protoboard
1 - dual dc power supply (+12 V dc and -1 to + 3 V dc)
1 - medium frequency function generator (100 kHz)
1 - standard oscilloscope (10 MHz)
1 - assortment of test leads and hookup wire

*Parts List:*

1 - XR-2206 function generator
1 - 3.9 k-ohm resistor
3 - 4.7 k-ohm resistors
1 - 6.8 k-ohm resistor
1 - 10 k-ohm resistor
1 - 47 k-ohm resistor
1 - 1 k-ohm variable resistor
1 - 10 k-ohm variable resistor
1 - 0.001 μF capacitor
2 - 1 μF capacitors
1 - 10 μF capacitor

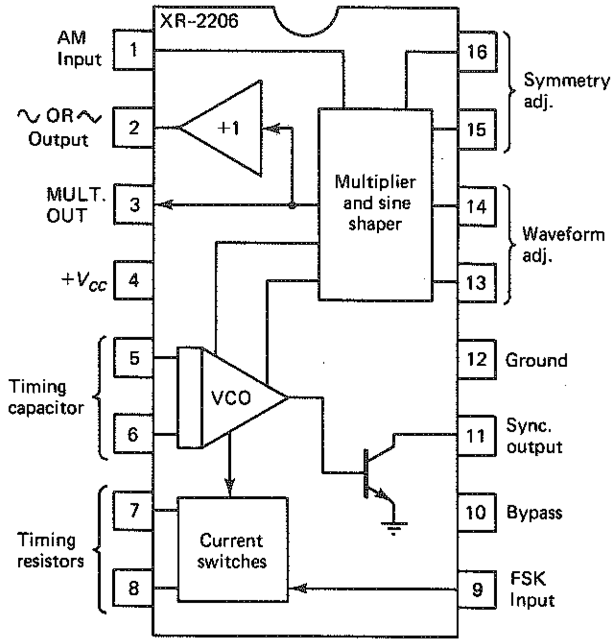


FIGURE 22-1 XR-2206 function generator block diagram.

## SECTION A Frequency Shift Keying – Sweep Mode

In this section the XR-2206 function generator operating in the sweep mode is used to produce binary FSK. In the sweep mode, the XR-2206 function generator output frequency is proportional to the input voltage. However, with binary FSK, the input signal is a binary waveform that simply changes between two discrete voltage levels. Therefore, the output frequency simply shifts or deviates between two frequencies (a mark frequency and a space frequency) with changes in the input signal voltage. The schematic diagram for the FSK modular circuit used in this section is shown in Figure 22-2.

## Procedure

1. Construct the binary FSK modulator circuit shown in Figure 22-2 (set $R_2$ to its midrange).

2. With the dc control voltage ($V_C$) set to 0 V, adjust $R_3$ until a sine wave with minimum distortion is observed at $V_{out}$.

3. Adjust $R_2$ until an unmodulated carrier frequency $f_c$ = 100 kHz is observed at $V_{out}$.

4. Adjust the dc control voltage to +1 V dc (logic 1), and record the output mark frequency ($f_m$).

5. Adjust the dc control voltage to -1 V dc (logic 0), and record the output space frequency ($f_s$).

6. Replace the dc bias supply with a function generator, and set the output of the function generator to a 10 kHz, 2 Vp-p square wave (i.e., ±1 V).

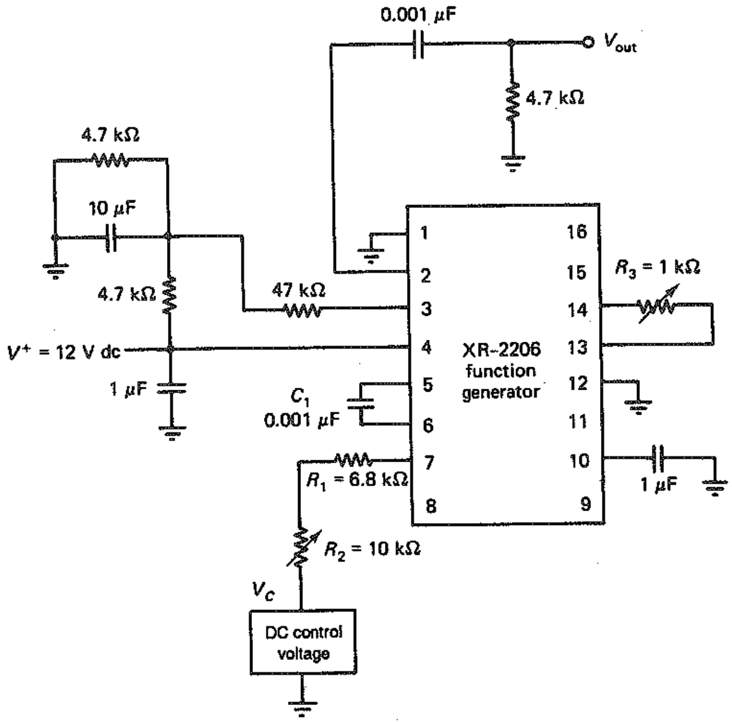


FIGURE 22-2 FSK generation, sweep mode.

7. Observe the binary FSK waveform at $V_{out}$ (it may be necessary to adjust the function generator output frequency slightly to achieve a stable FSK waveform).

8. Sketch the digital waveform observed at the function generator output and the binary FSK waveform observed at the output of the modulator ($V_{out}$).

9. Describe the relationship between the two waveforms sketched in step 8.

10. Measure the mark and space frequencies, and calculate the modulation index using the following formula.

$$m = \frac{|fm - fs|}{fb}$$

where

$m$ = modulation index (unitless)
$fm$ = mark frequency (hertz)
$fs$ = space frequency (hertz)
$fb$ = binary input bit rate (20 kbps)

11. Using a Bessel table, determine the number of significant side frequencies, and sketch the output frequency spectrum for the FSK waveform observed in step 7.

12. Determine the minimum bandwidth required to propagate the FSK signal.

13. Determine the baud rate.

14. Vary the function generator output frequency and describe what effect varying it has on the FSK waveform.

15. Vary the amplitude of the function generator output voltage and describe what effect varying it has on the FSK waveform.

## SECTION B Frequency Shift Keying – Timing Resistor Mode

In this section the XR-2206 function generator operating in the timing resistor mode is used to generate binary FSK. The schematic diagram for the FSK modulator circuit used in this section is shown in Figure 22-3. In the timing resistor mode, the XR-2206 is operated with two separate timing resistors ($R_1$ and $R_2$) connected to timing pins 7 and 8, respectively. Depending on the voltage level of the input signal on pin 9, either $R_1$ or $R_2$ is connected to the internal VCO. If pin 9 is open circuited or connected to a voltage greater than or equal to the switching voltage, $R_1$ is activated. If pin 9 is connected to a voltage less than the switching voltage, $R_2$ is activated. The switching voltage varies between +1 and +2 volts depending on the specific chip, with 1.4 V being a typical value. Therefore, if a binary digital signal that varies above and below approximately 1.4 V is applied to pin 9, the function generator output signal is keyed between two frequencies (mark and space). In essence, the VCO free-running frequency is switched (as opposed to deviated) between the mark and space frequencies at a rate that is equal to the rate of change of the binary input signal. This method of generating FSK is sometimes called frequency switch keying.

### Procedure

1. Construct the binary FSK modulator circuit shown in Figure 22-3.

2. With the dc control voltage disconnected, adjust $R_3$ until a sine wave with minimum distortion is observed at $V_{out}$.

3. Calculate the mark and space frequencies using the following formulas.

$$f_m = \frac{1}{R_1C_1} \qquad f_s = \frac{1}{R_2C_1}$$

4. Determine the actual mark frequency by setting the dc bias voltage to +3 V dc and measuring the frequency of the waveform at $V_{out}$.

5. Determine the actual space frequency by setting the dc bias voltage to 0 V and measuring the frequency of the waveform at $V_{out}$.

6. Determine the switching voltage by slowly increasing the magnitude of the control voltage until the output switches from the space to the mark frequency.

7. Place a function generator in series with the dc control voltage, and set the amplitude of the function generator output voltage to 3 Vp-p and the dc control voltage to 1.5 V dc. Set the function generator output frequency to a 10 kHz square wave.

8. Observe the FSK output waveform at $V_{out}$ (it may be necessary to adjust the function generator output frequency to observe a stable FSK waveform).

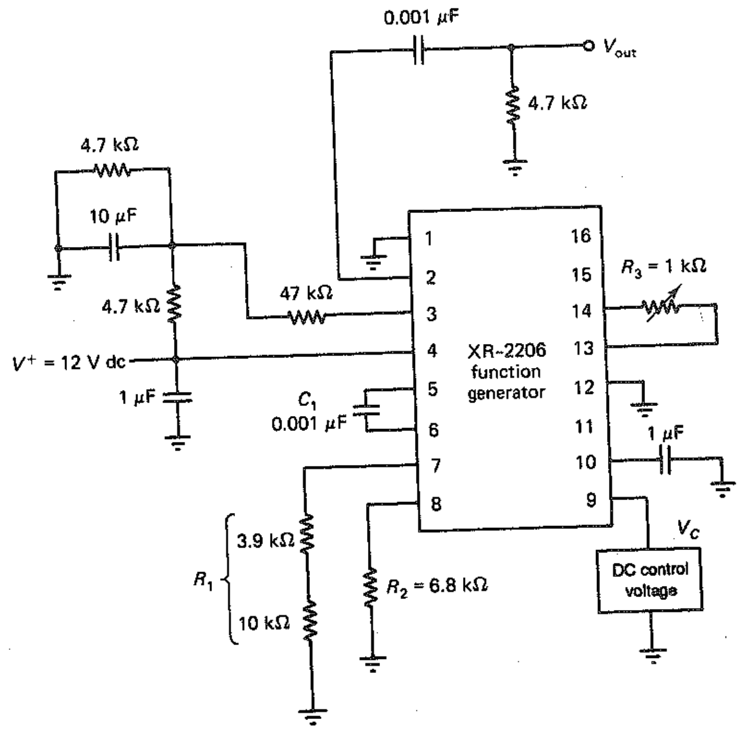


FIGURE 22-3 FSK generation, timing resistor mode.

9. Sketch the binary waveform observed at the function generator output and the FSK waveform observed at the modulator output ($V_{out}$).

10. Describe the relationship between the two waveforms sketched in step 9.

11. Determine the baud rate.

12. Vary the function generator output frequency and describe what effect varying it has on the FSK waveform.

13. Vary the amplitude of the function generator output voltage and describe what effect varying it has on the FSK waveform.

## SECTION C Summary

Write a brief summary of the concepts presented in this experiment on binary frequency shift keying modulators. Include the following items.

1. The basic concept of binary FSK modulation.
2. The sweep frequency mode of generating binary FSK.
3. The timing resistor mode of generating binary FSK.
4. The relationship between the amplitude of the binary input voltage and the binary FSK waveform in both the sweep frequency and timing resistor modes of operation.
5. The relationship between the frequency of the binary input voltage and the binary FSK waveform in both the sweep frequency and timing resistor modes of operations.
6. The relationship between the bit and baud rates with binary FSK.