# Chapter 11
# ASK Modulator

## 11-1 : Curriculum Objectives

1.  To understand the operation theory of the amplitude shift keying (ASK) modulation.

2.  To understand the signal waveform of the ASK modulation.

3.  To implement the ASK modulator by using MC 1496.

4.  To understand the methods of testing and adjusting the ASK modulation circuit.

## 11-2 : Curriculum Theory

In the wireless digital communication, it is not easy to transmit the digital data directly. This is because it needs to pass through the modulator and modulate the carrier signal in order to send the signal effectively. One of the easiest ways is to use the different data stream to change the amplitude of carrier, this kind of modulation is called amplitude modulation, and we call it as amplitude shift keying (ASK) modulation in digital communication.

Figure 11-1 is the basic circuit diagram of ASK modulator. Let the input data be 5 V, when the signal pass through the buffer, the switch S 1 will switch to point A, at this time the ASK output waveform is $f_l$. When the input data is 0 V, when the signal pass through the buffer, the switch S I will switch to point B, at this time the ASK output waveform is DC 0 V. The above-mentioned is the basic theory of ASK modulation.

ASK modulation signal can be expressed as

$$x_{ASK}(t) = A_i \cos(\omega_c t + \phi_0); \quad 0 \le t \le T, i = 1, 2, \cdots, M \qquad (11\text{-}1)$$

$\omega_c$: Cutoff frequency.

$\phi_0$: Phase

In equation (11-1), the values of amplitude $A_i$ have M types of possible change, the $\omega_c$ and $\phi_0$ denote the cutoff frequency and phase, respectively. If we choose M =2 , the $X_{ASK}(t)$ signal will transmit the binary signal, therefore, the values of A are $A_1 = 0$ and $A_2 = A$ , A is the arbitrary constant so we can obtain the binary ASK modulated signal waveform as shown in figure 11-2. When input logic is 1, then the signal is transmitted out; when the input logic is 0, then no signal is transmitted, so this also called on-off keying (OOK), this type of method is used in the past time.

In this chapter, we utilize 2206 IC waveform generator and MC1496 multiplier to produce the modulated ASK signal. First of all lets introduce the characteristics of 2206 IC. 2206 IC is a waveform generator, which is similar to 8038 IC. Figure 11-3 is the circuit diagram of the ASK modulator by using 2206 IC. In figure 11-3, resistors R2, R5 comprise a voltage divided circuit. The main function of the voltage divided circuit is to let the negative voltage waveform of the 2206 IC operates normally. The oscillation frequency of 2206 IC is determined by resistor $R_I$ and the resistor located at pin 8. Its

oscillation frequencies are $f_1 = 1/2\pi R_1 C$, $f_2 = 1/2\pi RC$ where R is the resistor at pin 8. If R = ∞, then frequency $f_2$ equal to zero. There is an internal comparator in 2206 IC. Assume that when the input is 5 V, the output frequency is $f_1$, and when the input is 0 V, the output frequency is $f_2$. We can utilize the TTL signal at pin 9 to control the output frequency to be $f_1$ or $f_2$. This type of structure is similar to the structure in figure 11-1. Therefore, by using the characteristic of this structure, we can achieve ASK modulation easily.
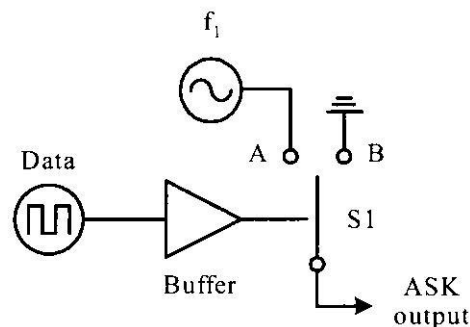
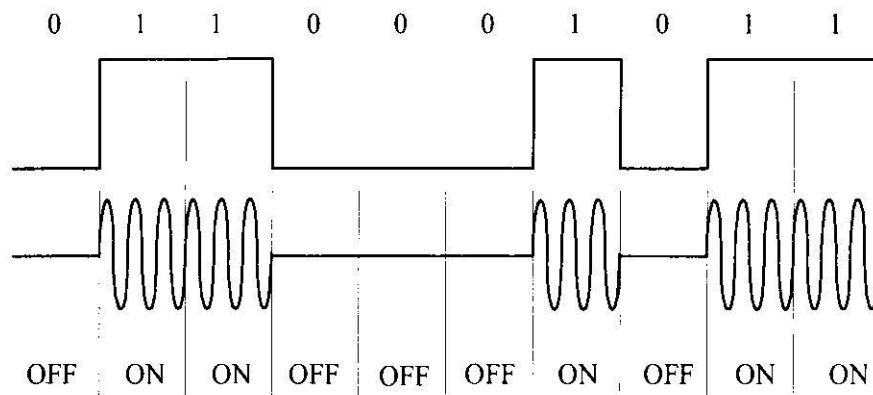Figure 11-1  Basic circuit diagram of ASK modulator.

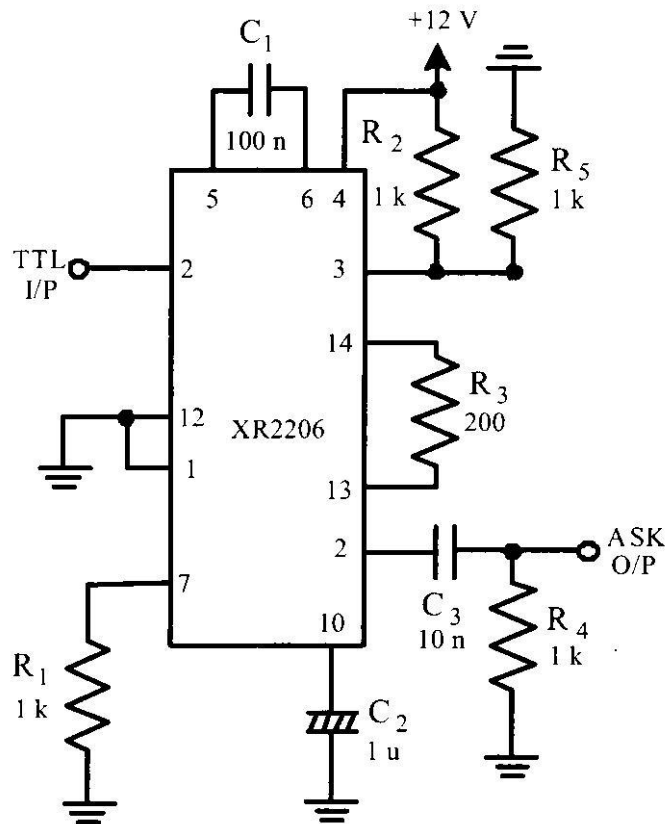Figure 11-2  ASK modulation signal waveform.



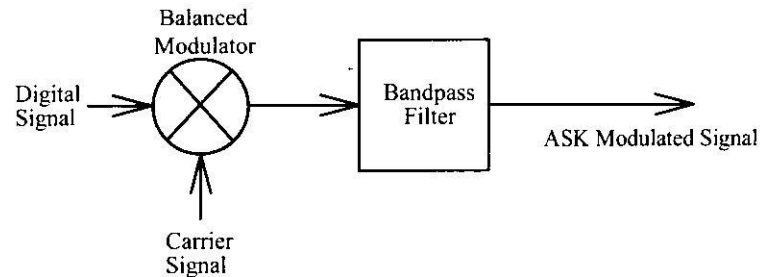Figure 11-3  Circuit diagram of ASK modulator by using 2206 IC.

Figure 11-4  The basic block diagram of ASK modulator.

Figure 11-4 is the basic block diagram of ASK modulator, which the balanced modulator can meet the objectives of amplitude modulation, and the bandpass filter will remove the high frequency signal to make the ASK signal waveform perfectly. We use the MC1496 to implement the balanced modulator in this experiment. Figure 11-5 is the internal circuit diagram of MC1496, where $D_1$, $R_1$, $R_3$, $Q_7$ and $Q_8$ comprise a current source, it provides DC bias current to $Q_5$ and $Q_6$. The $Q_5$ and $Q_6$ comprise a differential amplifier, which is used to drive the $Q_1$, $Q_2$, $Q_3$ and Q4 to become double differential amplifiers. The data signal is inputted between pin 1 and pin 4. The carrier signal is inputted between pin 8 and pin 10. The gain of balanced modulator is inputted between pin 2 and pin 3, which is controlled by the resistor between pin 2 and pin 3. The range of bias current of the amplifier is determined by the resistor connected at the pin 5.
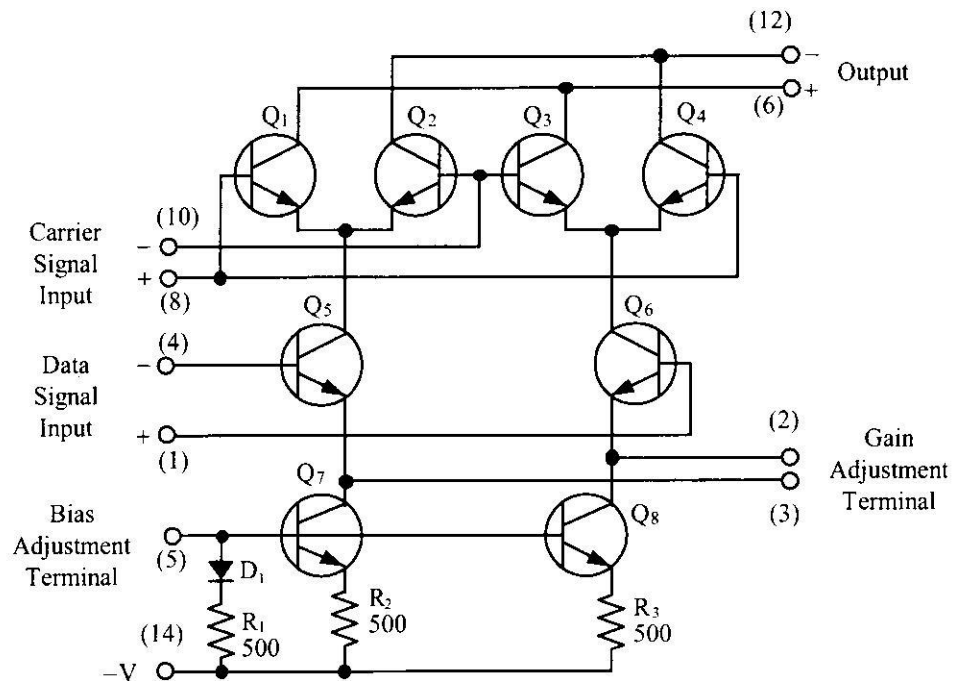
Figure 11-3  Internet circuit diagram of MC1496.

Figure 11-6 is the circuit diagram of ASK modulation, which the MC 1496 comprises a balanced modulator. The carrier signal and data signal are single-ended input. The carrier signal is inputted at pin 10 and the data signal is inputted at pin 1. $R_{13}$ and $R_{14}$ determine the gain and the bias current of this circuit, respectively. If we adjust $VR_1$ or the data signal amplitude, it can prevent the ASK modulation signal from distortion. Slightly adjust $VR_2$ will avoid the asymmetric of the signal waveform. The pin 12 of balanced modulator will send the output signal to uA741. The $C_3$, $R_{17}$, $R_{18}$ and $R_{19}$ comprise a bandpass filter to remove the high frequency signal, so that the ASK signal waveform will become more perfect.
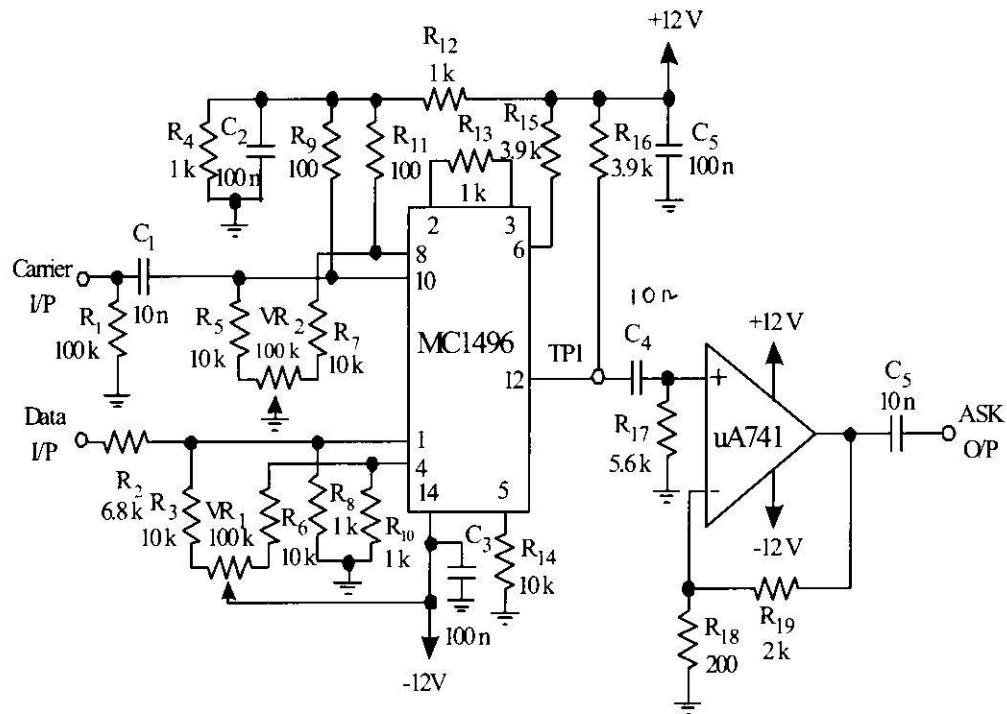
Figure 11-6  Circuitdiagram of ASK modulator by using MC1496.

## 11-3 : Experiment Items

### Experiment 1: XR 2206 ASK modulator

1. Refer to figure 11 -3, R, = 1 kΩ or refer to figure DCT 11- 1 on GOTT DCT-6000-06 module. Let J2 be short circuit and J3 be open circuit.

2. Let the two terminal of I/P be short circuit and JP1 be open circuit, i.e. at the data signal input terminal (Data I/P), input 0 V DC voltage. By using oscilloscope, observe on the output signal waveform of ASK signal (ASK O/P), then record the measured results in table 11-1.

3. Let the two terminal of I/P be open circuit and JP1 be short circuit, i.e. at the data signal input terminal (Data I/P), input 5V DC voltage. By using oscilloscope, observe on the output signal waveform of ASK signal (ASK O/P), then record the measured results in table 11-1.

4. At the data signal input terminal (Data I/P), input 5V amplitude, 100 Hz TTL signal. By using oscilloscope, observe on the output signal waveform of ASK signal (ASK O/P), then record the measured results in table 11-1.

5. According to the input signal in table 11-1, repeat step 4 and record the measured results in table 11-1.

6. Refer to figure 11 -3, $R_I$ = 5100 or refer to figure DCT 11-1 on GOTT DCT-6000-06 module. Let J2 be open circuit and J3 be short circuit.

7. According to the input signal in table 11-2, repeat step 2 to step 4 and record the measured results in table 11-2.

## Experiment 2: MC 1496 ASK modulator

1.  Refer to figure 11-6 or refer to figure DCT11-2 on GOTT DCT-6000-06 module.

2.  At the data signal input terminal (Data I/P), input 5 V amplitude, 500 Hz TTL signal. Then at the carrier signal input terminal (Carrier I/P), input 1V amplitude and 20 kHz sine wave frequency.

3.  By using oscilloscope, observe on the output signal waveform of the modulated ASK signal (ASK O/P ). Adjust $VR_1$ until the signal does not occur distortion. Then adjust $VR_2$ to avoid the asymmetry of the signal. Finally record the output signal waveform of the balanced modulator (TP1) and the ASK O/P in table 11-3.

4.  According to the input signal in table 11-3, repeat step 2 to step 3 and record the measured results in table 11-3.

5.  At the data signal input terminal (Data I/P), input 5V amplitude, 1 kHz TTL signal. Then at the carrier signal input terminal (Carrier I/P), input 400 mV amplitude and 20 kHz sine wave frequency.

6.  Follow the adjustment in step 3, then record the output signal waveform of the balanced modulator (TP1) and the ASK O/P in table 11-4.

7.  According to the input signal in table 11-4, repeat step 5 to step 6 and record the measured results in table 11 -4.

8.  At the data signal input terminal (Data I/P), input 5 V amplitude, 1 kHz TTL signal. Then at the carrier signal input terminal (Carrier I/P), input 400 mV amplitude and 100 kHz sine wave frequency.

9. Follow the adjustment in step 3, then record the output signal waveform of the balanced modulator (TP1) and the ASK O/P in table 11-5.

10. According to the input signal in table 11-5, repeat step 5 to step 6 and record the measured results in table 11-5.

## 11-4 : Measured Results

Table 11-1  Measured results of ASK modulator by using 2206 IC.

| Input Signal | 0 V (I/P SC , J1 OC) | 5V (J1 SC , I/P OC) |
|---|---|---|
| J2 SC<br>J3 OC | | |

| Input Signal | 100 Hz | 200 Hz |
|---|---|---|
| J2 SC<br>J3 OC | | |

Table 11-2  Measured results of ASK modulator by using 2206 IC.

| Input Signal | 0 V (I/P SC , J1 OC) | 5V (J1 SC , I/P OC) |
|---|---|---|
| J2 OC<br>J3 SC | | |

| Input Signal | 100 Hz | 200 Hz |
|---|---|---|
| J2 OC<br>J3 SC | | |

Table 11-3  Measured results of ASK output signal waveforms by varying the data signal frequency. ($V_c$ = 400 m$V$ . $f_c$ = 20 kHz)

| Input Signal | Data I/P | TP1 |
|---|---|---|
| $V_p$ = 5 V $f_{Data}$ = 500 Hz | | |
| | ASK O/P | |
| | | |

Table 11-3  Measured results of ASK output signal waveforms by varying the data signal frequency. (continue) ($V_c$ = 400mV . $f_c$ = 20 kHz)

| Input Signal | Data I/P | TP1 |
|---|---|---|
| $V_p$ = 5 V<br>$f_{Data}$ = 1 kHz | | |
| | ASK O/P | |
| | | |

Table 11-4  Measured results of ASK output signal waveforms by varying the carrier signal frequency.

($V_C$ = 400 mV . $f_{Data}$ = 1 kHz)

| Carrier Signal Frequencies | Carrier I/P | TP1 |
|---|---|---|
| 20 kHz | | |
| | ASK O/P | |
| | | |

Table 11-4  Measured results of ASK output signal waveforms by varying the carrier signal frequency.

(continue) ($V_C$ = 400 m$V$ . $f_{Data}$ = 1 kHz)

| Carrier Signal Frequencies | Carrier I/P | TP1 |
|---|---|---|
| 50 kHz | | |
| | ASK O/P | |
| | | |

Table 11-5  Measured results of ASK output signal waveforms by varying the carrier signal frequency.

($f_C$= 100 kHz . $f_{Data}$ = 1 kHz)

| Carrier Signal Frequencies | Carrier I/P | TP1 |
|---|---|---|
| 400 mV | | |
| | ASK O/P | |
| | | |

Tab1le 11-5  Measured results of ASK output signal waveforms by varying the carrier signal frequency.

(continue) ($f_C$= 100 kHz . $f_{Data}$ = 1 kHz)

| Carrier Signal Frequencies | Carrier I/P | TP1 |
|---|---|---|
| 1 V | | |
| | ASK O/P | |
| | | |

## 11-5 : Problem Discussion

1.    In figure 11-6, what are the functions of μA741, C3, R17, R18 and R19?

2.    In figure 11-6, what are the purposes of $VR_1$ and $VR_2$ ?

3.    In figure 11-6, what are the purposes of $R_{13}$ and $R_{14}$ ?