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Experiment # (5)

ASK modulation

Prelab:

1. In figure 5.6, what are the purposes of VR_1 and VR_2?
2. In figure 5.6, what are the purposes of R_{13} and R_{14}?
3. Why we use modulation to transmit the baseband signals?

Experiment Objectives:

1. To understand the operation theory of Amplitude Shift Keying (ASK).
2. To understand the signal waveform of the ASK modulation.
3. To implement the ASK modulator by using XR2206 IC and MC1496.
4. To understand the methods of measuring and adjusting the ASK modulation circuit.

Experiment 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 5.1 is the basic circuit diagram of ASK modulator. Let the input data be 5V, when the signal pass through the buffer, he switch S1 will switch to point A, at this time the ASK output waveform is f_1. When the input data is 0V, when the signal pass through the buffer, the switch S1 will switch to point B, at this time the ASK output waveform is DC 0V. the above-mentioned is the basic theory of ASK modulation.

ASK modulation signal can be expressed as:

$$X_{ASK}(t) = A_i \cos(W_c t + \emptyset_o); \qquad 0 \leq t \leq T, \qquad i=1,2,\ldots\ldots,M \qquad (5.1)$$

W_c : Cutoff frequency.

$\emptyset_o$: Phase

In equation (5.1), the values of amplitude A_i have M types of possible change, the W_c and $\emptyset_o$ 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 5.2. 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 experiment, we utilize 2206 IC waveform generator and MC1496 multiplier to produce the modulated ASK signal. First of all let's introduce the characteristics of XR2206 IC. XR2206 IC is a waveform generator, which is similar to 8038 IC. Figure 5.3 is the circuit diagram of the ASK modulator by using 2206 IC. In figure 5.3, the resistor R_2 and R_5 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 XR2206 IC is determined by resistor R_1 and the resistor located at pin 8. Its oscillation frequencies are:

$$f_1 = \frac{1}{2\pi\sqrt{R_1 C_1}}$$

$$f_2 = \frac{1}{2\pi\sqrt{R C_1}}$$

Where R is the resistor at pin 8. If R=∞, then the frequency f2 equal zero. There is an internal comparator in 2206 IC. Assume that when the input is 5 V, the output frequency is f1, and when the input is 0 V, the output frequency is f2. We can utilize the TTL signal at pin 9 to control the output frequency to be f1 or f2. This type of structure is similar to the structure in figure 5.1. Therefore, by using the characteristic of this structure, we can achieve ASK modulation easily.

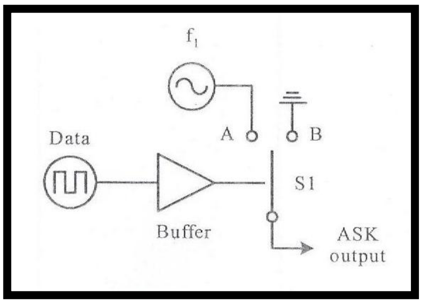

Figure 5.1 Basic circuit diagram of ASK modulator.

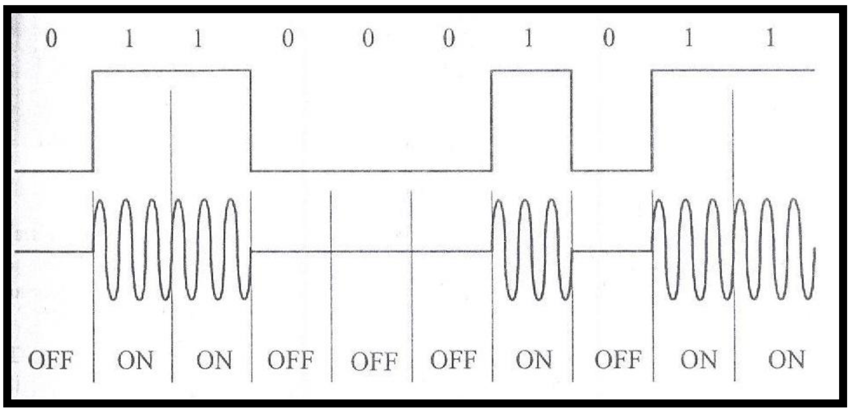

Figure 5.2 ASK modulation signal waveform.

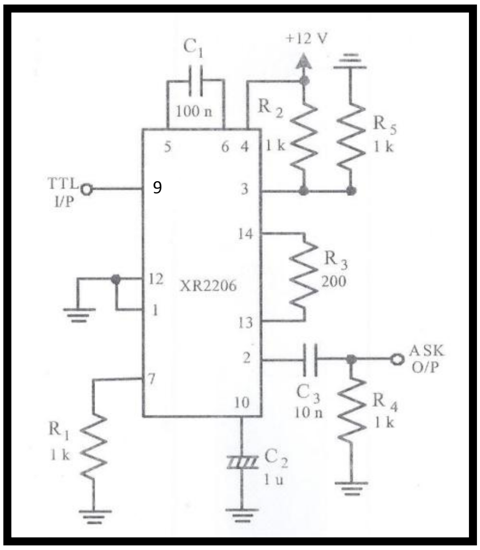

Figure 5.3 Circuit diagram of ASK modulator by using 2206 IC.

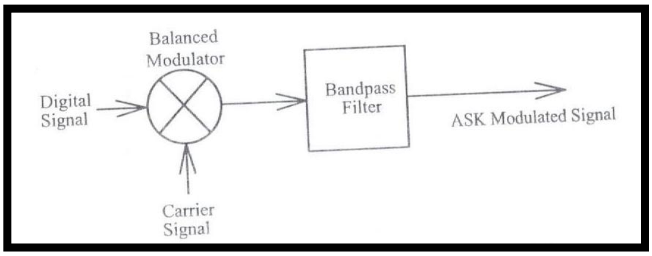

Figure 5.4 The basic block diagram of ASK modulator.

Figure 5.4 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 5.5 is the internal circuit diagram of MC1496, where D1, R1, R2, R3, Q7 and Q8 comprise a current source, it provides DC bias current to Q5 and Q6. The Q5 and Q6 comprise a differential amplifier, which is used to derive the Q1, Q2, Q3, 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 pin 5.

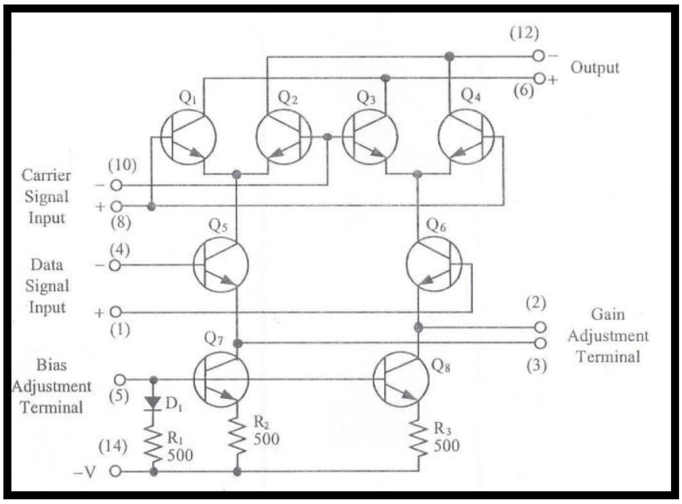

Figure 5.5 Internal circuit diagram of MC1496

Figure 5.6 is the circuit diagram of ASK modulation, which the MC1496 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. R13 and R14 determine the gain and the bias current of this circuit, respectively. If we adjust VR1 or the data signal amplitude, it can prevent the ASK modulated signal from distortion. Slightly adjust VR2 will avoid the asymmetric of the signal waveform. The pin 12 of balanced modulator will send the output signal to uA741. The C3, R17, R18 and R19 comprise a bandpass filter to remove the high frequency signal, so that the ASK signal waveform will become more perfect.

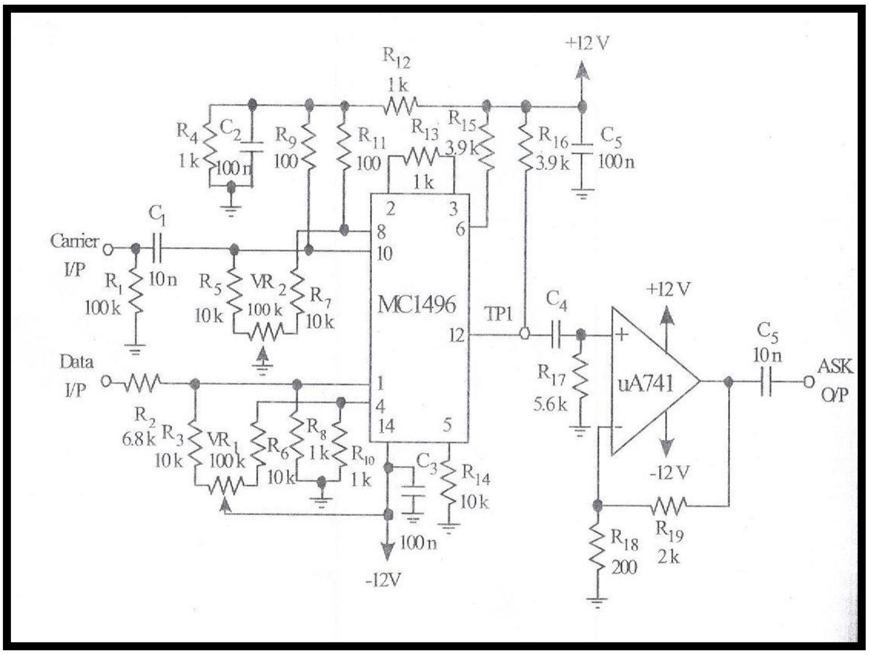

Figure 5.6 Circuit diagram of ASK modulator by using MC1496.

Experiment items:

Experiment 1: XR 2206 ASK modulator.

1. Refer to figure 5.3, R_1 = 1 kΩ or refer to figure DCS11-1 on ETEK DCS-6000-06 module. Let J2 be short circuit and J3 be open circuit.
2. Let the two terminals of I/P be short circuit and J1 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 5.1.
3. Let the two terminals of I/P be open circuit and J1 be short circuit, i.e. at the data signal input terminal (Data I/P), input 5 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 5.1.
4. At the data signal input terminal (Data I/P), input 5 V 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 5.1.
5. According to the input signal in table 5.1, repeat step 4 and record the measured results in table 5.1.
6. Refer to figure 5.3, R_1 = 510 Ω or refer to figure DCS11-1 on ETEK DCS-6000-06 module. Let J2 be open circuit and J3 be short circuit.
7. According to the input signal in table 5.2, repeat step 2 to step 4 and record the measured results in table 5.2.

Experiment 2: MC1496 ASK modulator.

1. Refer to figure 5.6, or refer to figure DCS11-2 on ETEK DCS-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 400 mV 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 VR1 until the signal does not occur distortion. Then adjust VR2 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 5.3.
4. According to the input signal in table 5.3, repeat step 2 to step 3 and record the measured results in table 5.3.
5. 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 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 5.4.
7. According to the input signal in table 5.4, repeat step 5 to step 6 and record the measured results in table 5.4.

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 5.5.
10. According to the input signal in table 5.4, repeat step 5 to step 6 and record the measured results in table 5.4.
11. According to the input signal in table 5.5, repeat step 8 to step 9 and record the measured results in table 5.5.

Measured results:

Table 5-1 Measured results of ASK modulator by using 2206 IC

Input Signal	Output signal waveforms	
	0 V (I/P SC, J1 OC)	5 V (I/P OC, J1 SC)
J2 SC J3 OC		
Input signal	100 Hz	200 Hz
J2 SC J3 OC		

Table 5-2 Measured results of ASK modulator by using 2206 IC

Input Signal	Output signal waveforms	
	0 V (I/P SC, J1 OC)	5 V (I/P OC, J1 SC)
J2 OC J3 SC		
Input signal	100 Hz	200 Hz
J2 OC J3 SC		

Table 5-3 Measured results of ASK output signal waveforms by varying the data signal frequency (Vc = 400 mV, fc = 20 kHz)

<table>
<tr><td>Data signal frequencies</td><td>Data I/P</td><td>TP1</td></tr>
<tr><td rowspan="3">Vp = 5 V
f_{Data} = 500 Hz</td><td></td><td></td></tr>
<tr><td colspan="2">ASK O/P</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="4">Vp = 5 V
f_{Data} = 1 kHz</td><td>Data I/P</td><td>TP1</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">ASK O/P</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Table 5-4 Measured results of ASK output signal waveforms by varying the data signal frequency (Vc = 400 mV, f_{Data} = 1 kHz)

<table>
<tr><td>Carrier signal frequencies</td><td>Carrier I/P</td><td>TP1</td></tr>
<tr><td rowspan="3">20 kHz</td><td></td><td></td></tr>
<tr><td colspan="2">ASK O/P</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="4">50 kHz</td><td>Carrier I/P</td><td>TP1</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">ASK O/P</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Table 5-5 Measured results of ASK output signal waveforms by varying the data signal amplitude (fc = 100 kHz, f_{Data} = 1 kHz)

<table>
<tr><th>Carrier signal amplitudes</th><th>Carrier I/P</th><th>TP1</th></tr>
<tr><td rowspan="3">400 mV</td><td></td><td></td></tr>
<tr><td colspan="2">ASK O/P</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="4">1 V</td><td>Carrier I/P</td><td>TP1</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">ASK O/P</td></tr>
<tr><td colspan="2"></td></tr>
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