Faculty of Engineering

Electrical Engineering Department

Communication II Lab (EELE 4170)

Lab#5 ASK Modulation &Demodulation

Objectives:

1- To understand the operation theory of Amplitude Shift Keying (ASK) modulation & demodulation.
2- To understand the signal waveform of the ASK modulation.
3- To implement the ASK modulator by using XR2206 IC and MC1496.
4- To implement the non-coherent and coherent ASK demodulator.

Theory:

1. ASK Modulation

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.

ASK modulation signal can be expressed as:

$$X_{ASK}(t) = A_i \cos(w_c t + \emptyset_0) \ \ , 0 < t < T, i = 1,2,3, \dots\dots\dots\dots, M \qquad (5.1)$$

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(1). 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.

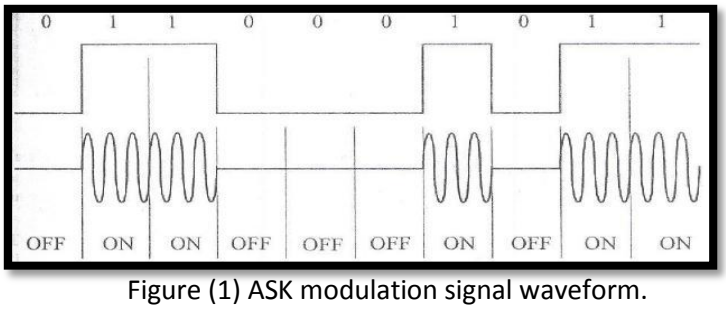

Figure (1) ASK modulation signal waveform.

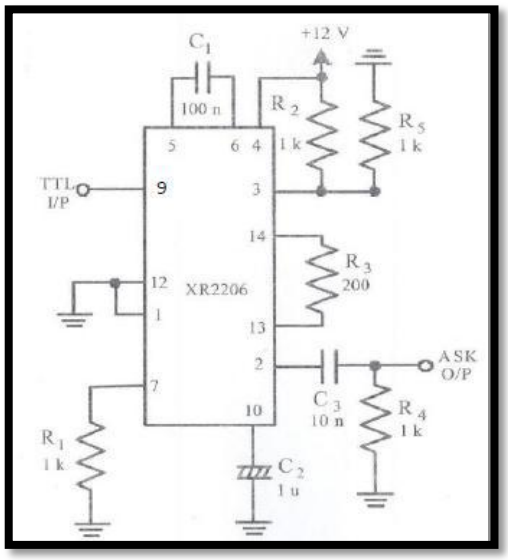

Figure (2) Circuit diagram of ASK modulator by using 2206 IC.

ASK modulator by using 2206 IC :

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 (2) is the circuit diagram of the ASK modulator by using 2206 IC. In figure (2), the resistor R2 and 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 XR2206 IC is determined by resistors R1&R and the resistor located at pin 7 and the resistor R at pin 8. Its oscillation frequencies are: $f_1 = \frac{1}{2\pi R_1 C}$ & $f = \frac{1}{2\pi RC}$.

If R=∞, then the frequency f equal 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. We can utilize the TTL signal at pin 9 to control the output frequency to be $f1$ or f. Therefore, by using the characteristic of this structure, we can achieve ASK modulation easily.

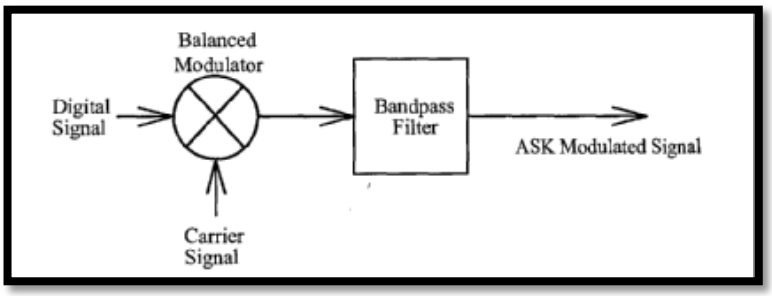

Figure (3) The basic block diagram of ASK modulator.

ASK modulator by using MC 1496 :

Figure (3) 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 (4) 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.

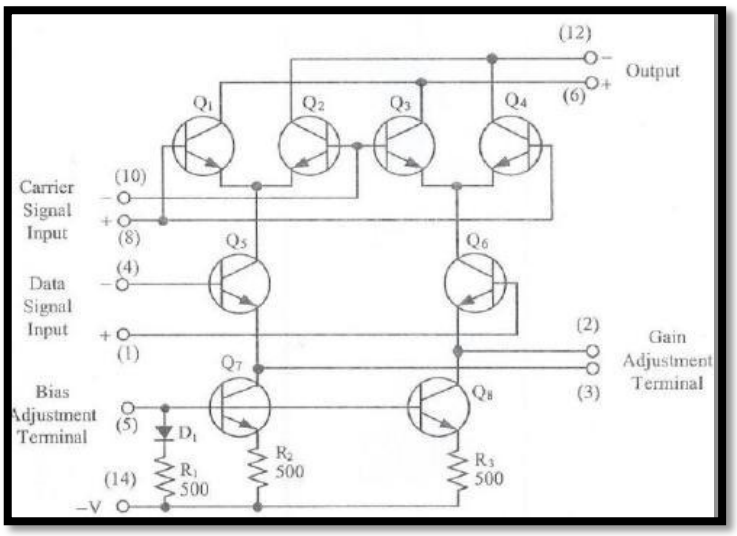

Figure (4) Internal circuit diagram of MC1496.

Figure (5) 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.

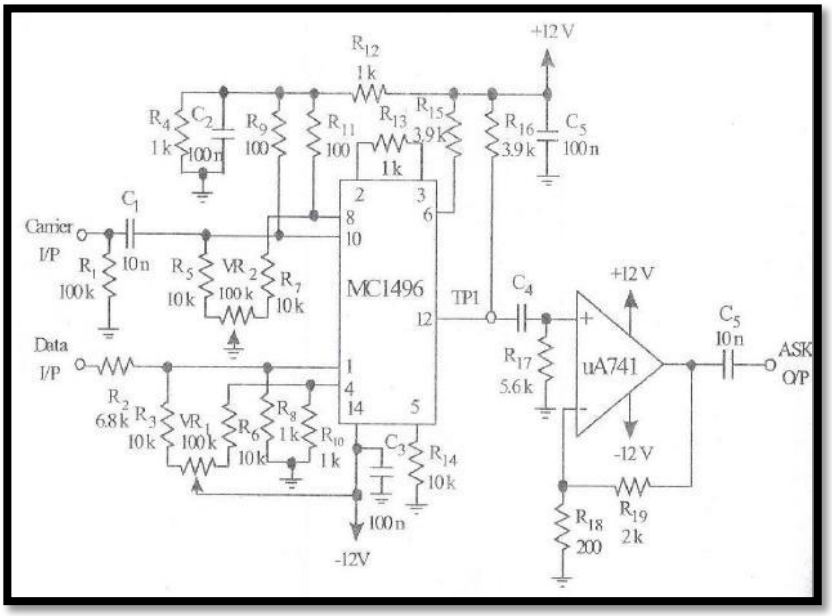

Figure (5) Circuit diagram of ASK modulator by using MC1496.

2. ASK Demodulation

Figure (6) shows the theoretical diagram of ASK demodulation. There are two methods to design the ASK demodulator, which are asynchronous detector and synchronous detector. We will discuss these two types of ASK demodulator in this experiment.

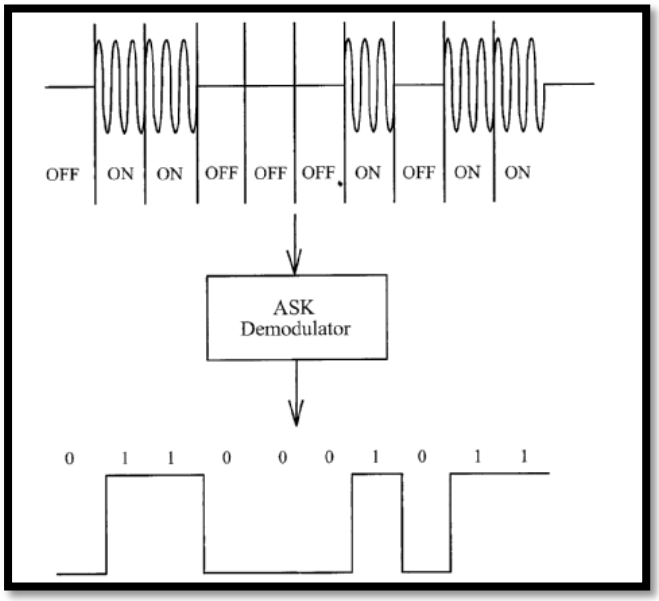

Figure (6) Theoretical diagram of ASK demodulation.

Asynchronous ASK Detector:

Figure (7) is the block diagram of asynchronous ASK detector. This structure is a typical asynchronous ASK detector. When the ASK signal pass through the rectifier, we can obtain the positive half wave signal. After that the signal will pass through a low-pass filter and obtain an envelope detection. Then get rid of the DC signal, the digital signal will be recurred.

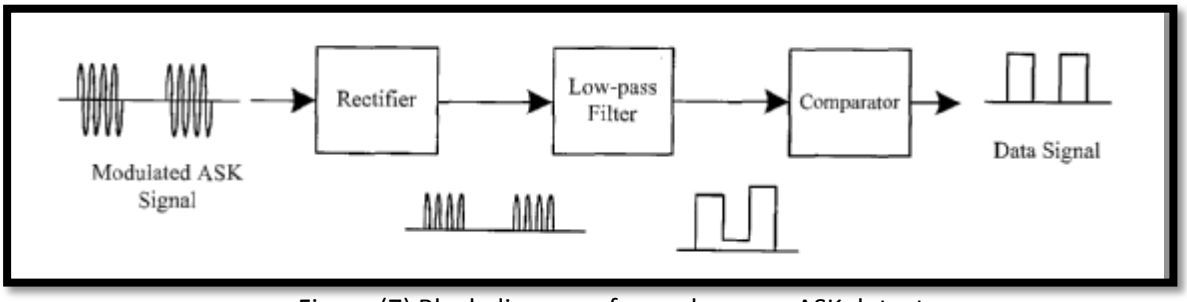

Figure (7) Block diagram of asynchronous ASK detector

Figure (8) is the circuit diagram of asynchronous ASK detector, which R1, R2 and µA741 comprise an inverting amplifier to amplify the input signal. Then D1 is the rectifying diode to make the modulation signal passes through D1 half wave rectifier. R3 and C1 comprise a low-pass filter. µA74 1, VR1, D2, R4 and C2 comprise a comparator, therefore, the output terminal can demodulate the digital demodulated signal.

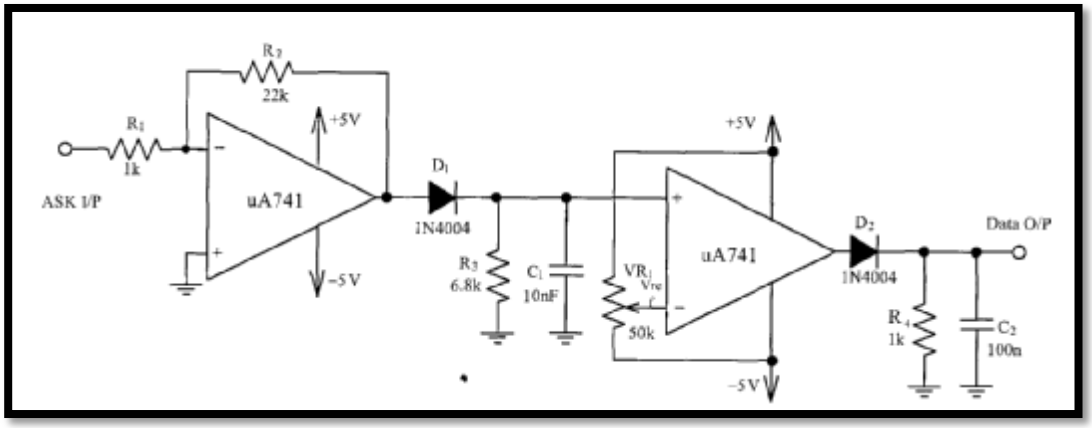

Figure (8) Circuit diagram of ASK asynchronous detector.

Synchronous ASK Detector:

We have mentioned before that we can use synchronous detector to design the ASK demodulation. This experiment utilizes the structure of square-law detector and the block diagram is shown in figure (9).

Let $X_{ASK}(t)$ be the ASK modulated signal, which is

$$X_{ASK}(t) = A_i \cos(w_c t + \emptyset_0) \ \ , 0 < t < T, i = 1,2,3, \dots \dots \dots \dots, M$$

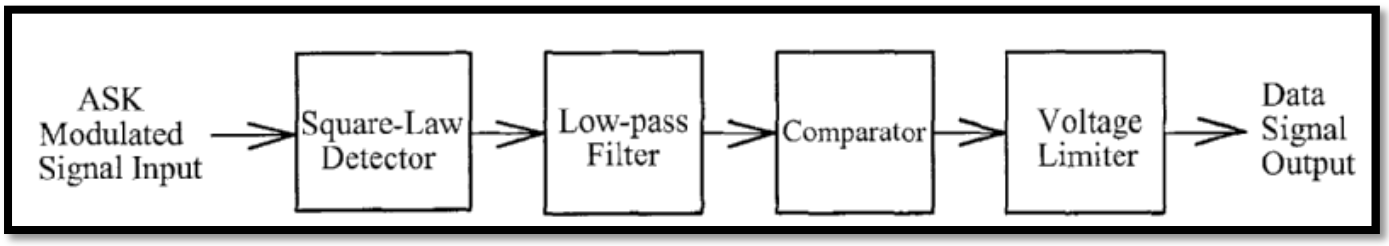

Figure (9) Basic block diagram of ASK demodulator.

When we input the ASK modulated signal to the two terminals of balance modulator, then the output signal of balanced modulator can be expressed as

$$X_{out}(t) = K * X_{ASK}(t) * X_{ASK}(t)$$

$$X_{out}(t) = K * A_i^2 \cos^2(w_c t + \emptyset_0)$$

$$X_{out}(t) = \frac{KA_i^2}{2} + \frac{KA_i^2}{2}\cos(2w_c t + 2\emptyset_0)$$

Where *k* represents the gain of balanced modulator. The first term of equation is the data signal amplitude and the second term is the 2nd harmonic of the modulated signal. From the output signal $X_{out}(t)$, if the first data signal amplitude receives the demodulated ASK signal, this means that the data signal can be recovered correctly.

We utilize MC 1496 balanced modulator to design the square-law detector as shown in figure (10).

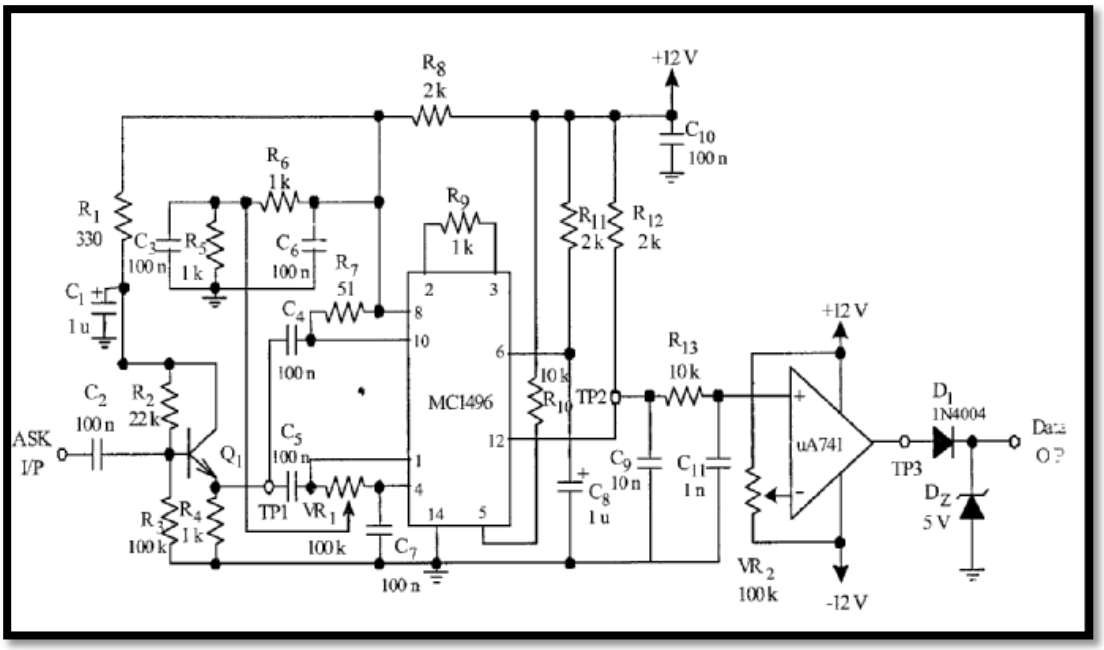

Figure (10) Circuit diagram of ASK synchronous detector.

VR1 controls the input ranges of modulated ASK signal and the output signal of MC1496 (pin 12). The C9, C11 and R13 comprise a low-pass filter, which the objective is to remove the 2nd harmonic of modulated ASK signal. The first term in the equation is the data signal amplitude part, which can be recovered by using the comparator and voltage limiter comprised by µA741,VR2,D1 and D2.

Practical Parts:

1. Use DCS-6000-06 module (XR 2206 modulator) to modulate Data signal 100 Hz TTL.

2. Use DCS-6000-06 module (MC 1496 modulator) to modulate Data signal 100 Hz TTL and 20 KHz sine wave carrier signal.

3. To demodulate the modulated output signal of the first part use the non coherent demodulation.

4. To demodulate the modulated output signal of the second part use the coherent demodulation with the same carrier frequency.