

AMPLITUDE MODULATION RECEIVER

In communication systems, a modulating signal (information signal) modulates the carrier, and the modulated carrier is transmitted. Demodulation or detection is the process of recovering the modulating signal (information signal) from the modulated carrier. The amplitude demodulation can be classified into two categories of synchronous and asynchronous demodulation.

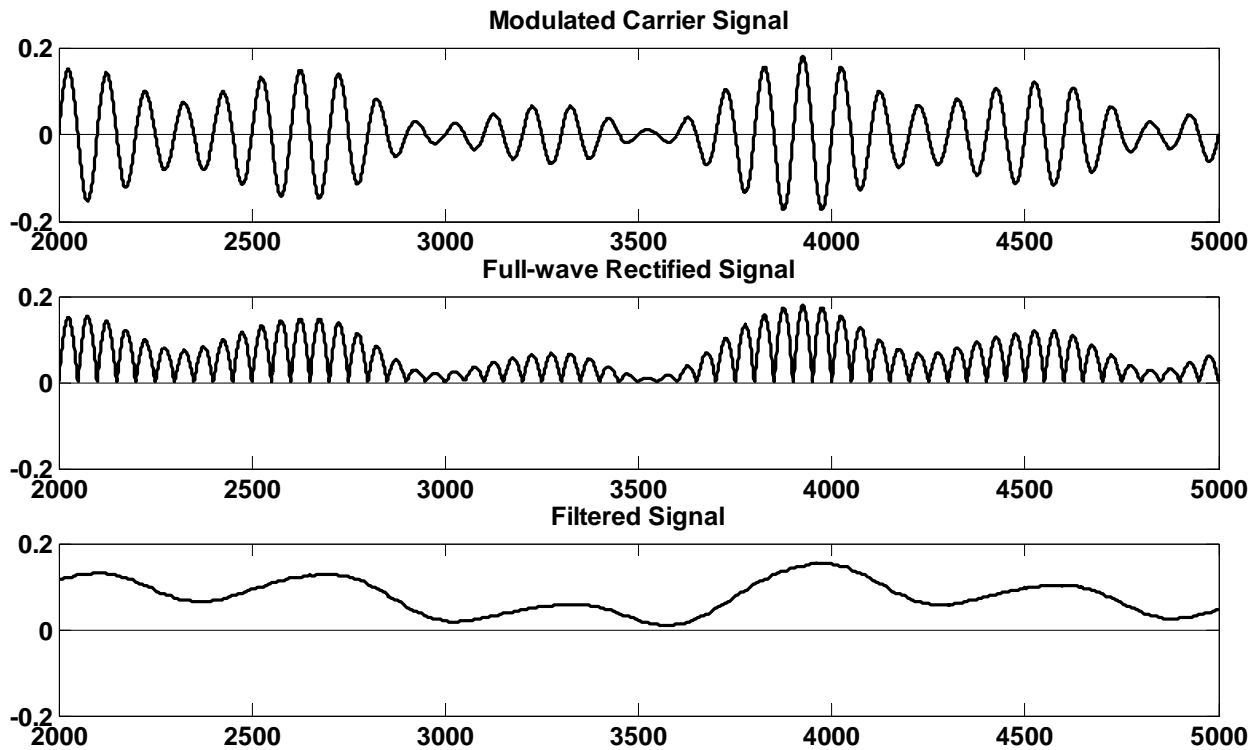


Figure 6.1: Demodulation of the modulated carrier at the receiver

Asynchronous demodulation is usually employed for amplitude modulated carrier signals whose modulation index is less than 1. First, the received signal is full-wave rectified, then the result is low-pass filtered to eliminate the carrier frequency and its harmonics, that gives us the modulating signal. It is important to select the parameters of the low pass filter carefully so that carrier is rejected and modulating signal is recovered without excessive distortion.

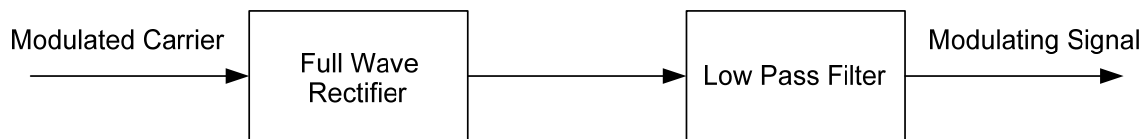


Figure 6.2: Rectification and filtering of received modulated carrier

Finally the average value (DC) is removed from the filtered signal, giving us an approximation of original modulating signal. A half-wave rectifier can also be used, in which case the design of the low pass filter needs to be changed. Can you guess the change in the important parameters of the low pass filter when half-wave rectification is used in the design?

The FlexTrainer provides the option to perform the experiment of amplitude demodulation. Select the experiment of Amplitude Modulation on trainer 1 (acting as transmitter) and Amplitude Demodulation on trainer 2 (acting as receiver). Connect the signal generator to input channel-A of trainer 1. Connect the output channel-A of trainer 1 to input channel-A of trainer 2. Observe the demodulated signal from trainer 2 on the oscilloscope by connecting output channel-A of trainer 2 to the oscilloscope. The modulated signal from trainer 1 can also be observed on the oscilloscope by connecting output channel-B of trainer 1 to the oscilloscope. Figure 6.3 shows the circuit arrangement for this experiment.

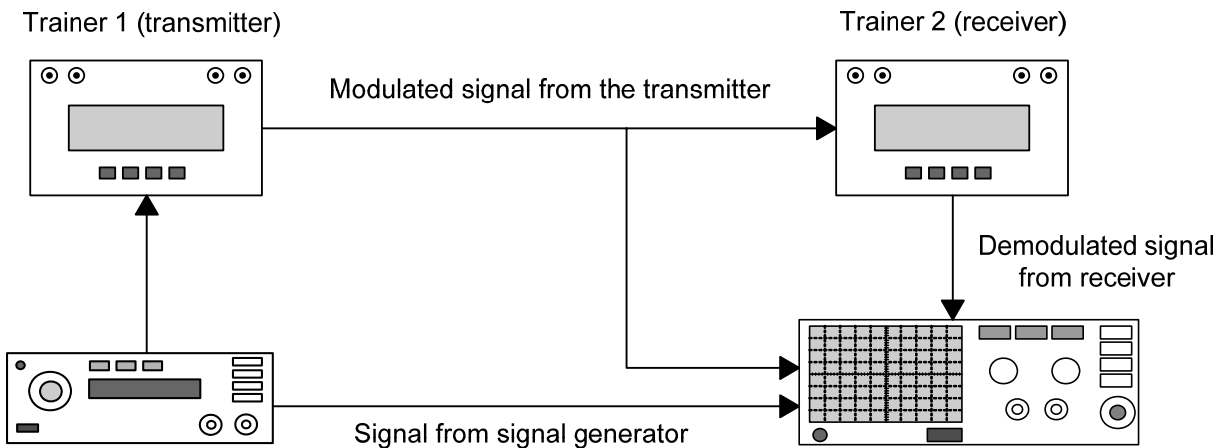


Figure 6.3: Circuit layout

After the input signal is full-wave rectified, this signal is filtered using low pass filter (LPF). The FlexTrainer provides four low pass filters. You can select and apply one of these filters and observe its effects. On the oscilloscope you can see the original input, the modulated signal and the demodulated signal at the output terminal of trainer 2.

As previously mentioned, the design of low pass filter is very important. Figure 6.4 shows the frequency responses of four low pass filters available in this experiment with cutoff frequencies of 2 kHz, 4 kHz, 6 kHz and 8 kHz. Their cutoff frequencies are marked by bold dashed lines.

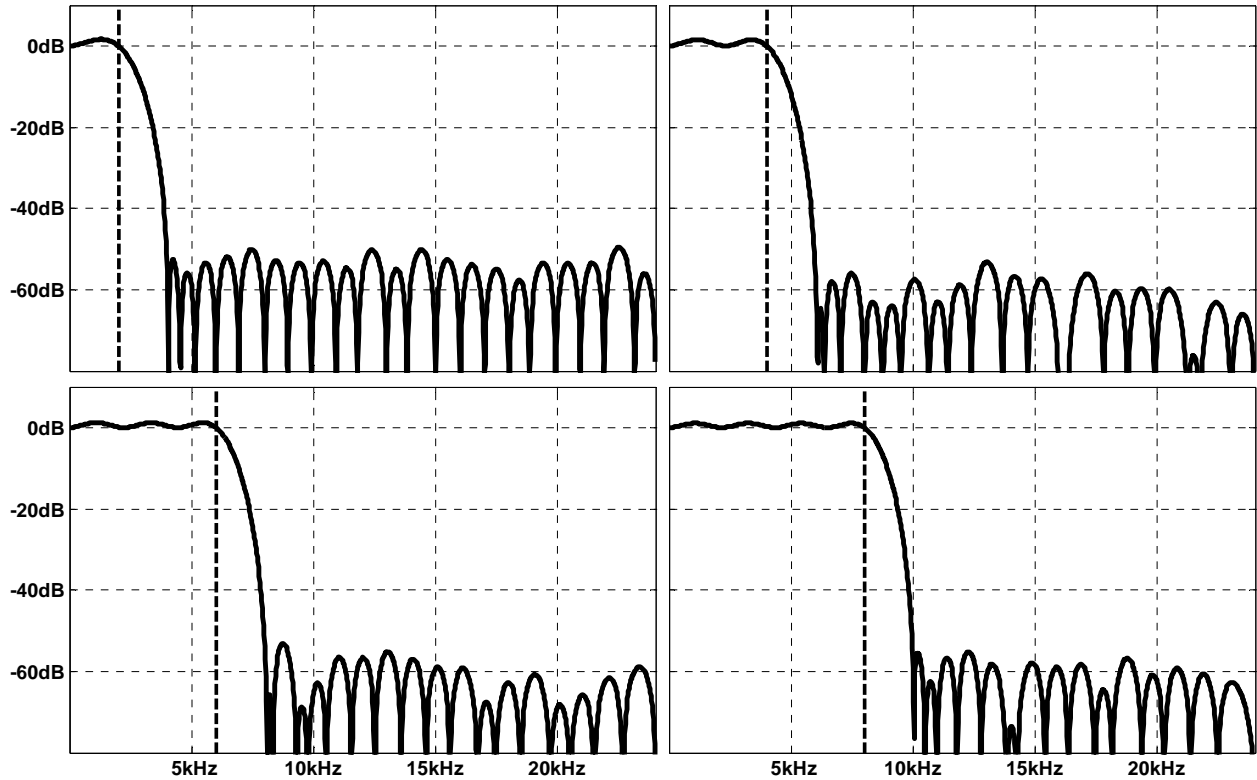


Figure 6.4: Frequency responses of low pass filters

Carefully observe the frequency response of available low pass filters and write down your general observations about the comparative pass band flatness and stop band ripple of these filters.

Apply a triangular modulating signal of frequency about 200-300 Hz from the signal generator. Select carrier frequency of 2 kHz from trainer 1. Observe the effect of the four filters on the modulated signal. Get an insight of how the signal becomes almost zero at the frequencies where filter frequency response becomes zero. Write down your observations

Change the applied modulating signal to a square waveform with frequency of 200-300 Hz from the signal generator. Select carrier frequency of 2 kHz from trainer 1. Again observe the effect of the four filters on the modulated signal. Explain how the four filters effect different waveforms of same frequency. Pick a suitable filter for the demodulation of this signal.

Generate a triangular modulating signal with a frequency of 1000-2000 Hz from the signal generator. Select carrier frequency of 6 kHz from trainer 1. Observe the effect of the four filters on the demodulated signal. Compare the demodulated signal with the signal input to trainer 1. With which filter you obtained the best and the worst result and why?

Change the applied modulating signal to a square wave with a frequency of 1000-2000 Hz from the signal generator. Select carrier frequency of 6 kHz from trainer 1. Observe the effect of the four filters on the demodulated signal. Compare the demodulated signal with the signal input to trainer 1. How do the filters affect different waveform signals? Choose a suitable filter for the demodulation of this signal.

Now generate a signal of 100Hz from the signal generator. Select modulation index of 30% and carrier frequency of 2 kHz from trainer 1. Observe the effect of all four filters on the demodulated output. Write down your observations below.

Apply a signal of 500Hz from the signal generator. Select carrier frequency of 2 kHz from trainer 1. Gradually change the modulation index from trainer 1. Changing the modulation index will change the amplitude of the recovered signal accordingly. Can you establish some relationship between modulation index and amplitude of received signal?

Now observe the effect of carrier frequency on the recovered signal. First filter gives poor response at 1 kHz but the response improves significantly at a frequency of 3 kHz. Increasing the carrier frequency to 6 kHz again gives a very good recovered signal. Why is it so?

Now change the carrier frequency and repeat the procedure for different filters. Write down your analysis.

If you observe the full wave rectified version of the amplitude modulated signal at the receiver side you will observe the lower portion of rectified signal is not constant rather it fluctuates above zero DC level. This occurs because of the mismatch in the two master clocks. Codec sampling rate is $48 \text{ kHz} \pm 20 \text{ p.p.m.}$. Therefore there will be a mismatch in

clocks of transmitter and receiver of 40 p.p.m at worst which results in the above mentioned deterioration. Figure 6.5 shows the effect of mismatch in the two master clocks. The result of rectification of such a waveform is also shown.

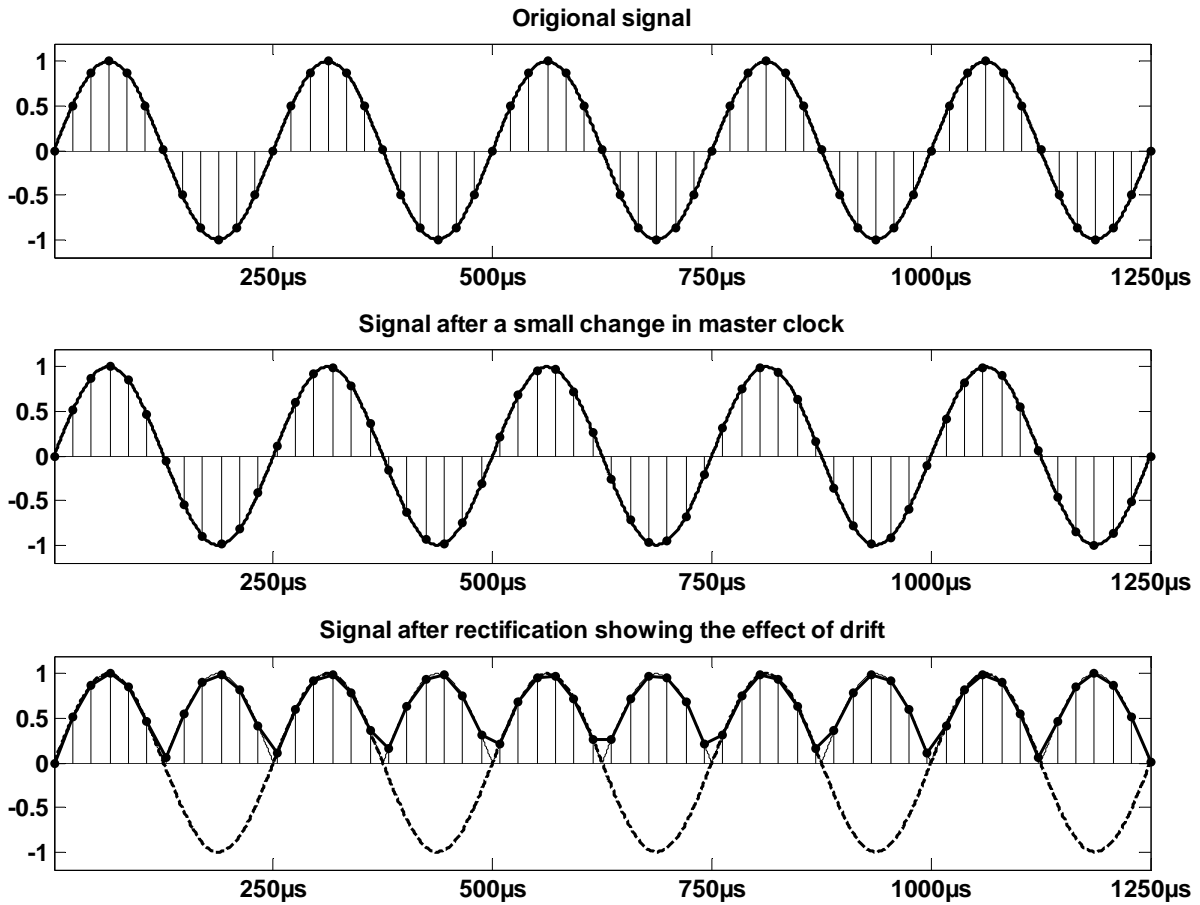
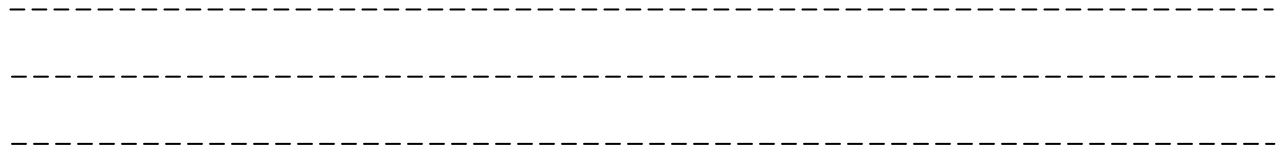


Figure 6.5: Effect of mismatch in the two master clocks and result of rectification

This effect is prominent at higher frequencies e.g. 8 kHz where the number of samples per cycle is just 6. The probability of presence of a sample near the zero crossing is less which results in the fluctuations in the DC level of full wave rectified output. The remedy for this is to increase the number of samples that are used to construct the full wave rectified waveform i.e. to effectively increase the sampling frequency. Interpolation is the technique used in the trainer to capture more samples to construct a better rectified output. In the trainer, there is an option to select interpolation on or off. Observe the waveform with and without interpolation and record your observations below



It should be kept in mind that the result of interpolation is visible in the filtered waveform. The interpolated waveform after full wave rectification cannot be observed because the actual codec operating frequency is 48 kHz.