AM & DSB-SC Modulation and Detection

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***Abstract*—This paper examines and discusses some electrical communication modulation methods with the detection of modulation. Such methods include amplitude modulation double sideband suppressed carrier modulation. Each were used as a means to familiarize the use of the modular backplane system. Amplitude modulation and double-sideband suppressed carrier modulation and demodulation methods were observed along this system to produce the report.**

I. Introduction and Objectives

With control of the received signal, it is possible to manipulate inputs with Amplitude modulation (AM) and Double-sideband suppressed-carrier transmission (DSB-SC). These processes either are respectively able to decipher an informational signal over noise or develop a simple approximation to the spectrum of a waveform. Experiments can be made clear with theses processes if they are done through the fully modular backplane system (MBS).

II. Background and Relevant Theory

A. Amplitude Modulation

Modulation is a process used to carry information to a desired destination. In this case, a carrier signal can be modulated by the amplitude of the signal. Comparatively, amplitude modulation is simple to implement, can be easily demodulated, and a low cost to electronically manufacture. Unfortunately, amplitude modulation is not efficient in power usage and uses twice the normal bandwidth of a signal frequency. This modulation is additionally prone to high levels of exterior noise from amplitude-based signals.

$$s(t) = g(t)cos(\omega_c t) \tag{1}$$

$$g(t) = A_c(1 + m(t)) \tag{2}$$

A carrier frequency, in Amplitude Modulation, is manipulated by the amplitude of the information waveform. Additionally, the frequency of the modulated signal changes into three different components of upper and lower frequency band siding one frequency f_c. As such, amplitude modulation output contains modulated AM "sidebands" [1]. As shown in Equation 1, the amplitude modulation signal is known as the carrier wave, consisting of the cosine of the frequency of the carrier and the $g(t)$ envelop detailed by Equation 2.

B. AM Demodulation

In order to demodulate an amplitude modulated signal, the envelop of the modulated circuit must be detected using the envelope detector circuit. The circuit displays in Figure 1.

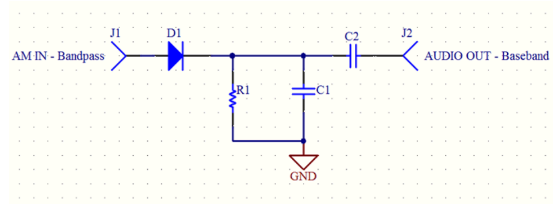

Fig. 1. Passive Envelope Detector Circuit

C. DSB-SC Modulation

In Amplitude Modulation, the modulated wave consists of the carrier wave and two sidebands. The modulated wave has the information only in the sidebands as a band of frequencies. These bands contain power, which are represented with lower and higher frequencies of the carrier frequency. The transmission of a signal that contains two sidebands in the carrier with suppressed power is named Double Sideband Suppressed Carrier (DSB-SC) when the saved power is distributed to the two sidebands.

Essentially, Double-sideband suppressed-carrier transmission transmission places frequencies symmetrically above and below the carrier frequency which is produced by amplitude modulation. Here the carrier amplitude is reduced to the lowest possible level, indicating suppression. Amplitude modulation results in both carrier and message signal transmitted with poor efficiency. In DSBSC, however, the carrier wave is suppressed and the efficiency is produced at near 100%.

D. Multi-tone Modulation

If the message signal contains more than one frequency component then the resulting modulated signal is referred to as a multi-tone modulated signal. Modulation of this type of message signal is called multi-tone modulation.

III. Procedure

This experiment involved generating an AM wave with carrier frequency of 600 kHz and modulation frequency 1 kHz. Through the envelop detector, the carrier frequency of 20kHz was given a modulation frequency of 10 Hz. The modulation depth was then varied from 10% to 120%. For each modulation depth, the input and output waveforms were observed. Comparisons between the pure tone and modulated frequency were made. On the next procedure, the multi-tone audio system was observed where experiments with various carrier and modulation depth produced corresponding changes with amplitude modulation. A DSBSC signal for demodulation was processed in Part 2 to recreate the original message signal. The carrier frequency was varied to show the effect on demodulation. As a final process, the output modulations were found by plotting the FFT and spectrum in MATLAB.

IV. Results and Discussion

A. Part 1 - Single-Tone AM Detection

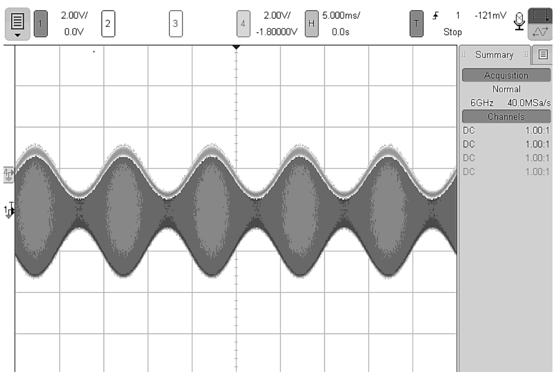

Fig. 2. Single-Tone Modulation Depth at 60%

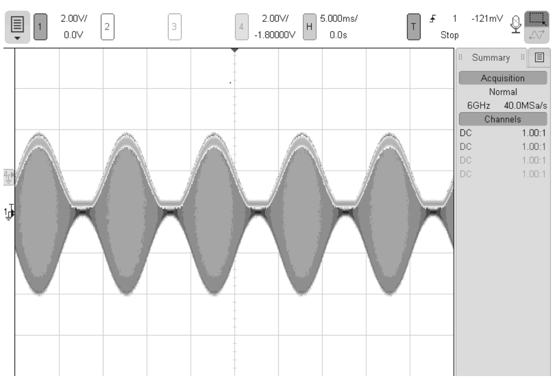

Fig. 3. Single-Tone Modulation Depth at 100%

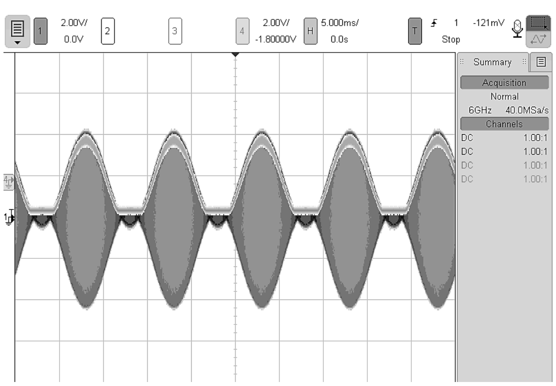

Fig. 4. Single-Tone Modulation Depth at 120%

Modulation depth was varied from 10% to 120% and plotted next to the modulation signal. As shown in Figures 2 to 4. Comparing the signal with the pure tone of the same frequency shows that as the depth increases, the signal enters a 180°phase reversal between the periods of the signal. When the modulation index a modulation depth of 100%, the carrier level falls to zero and rises to twice non-modulated level, anything above this, obtains the phase reversal.

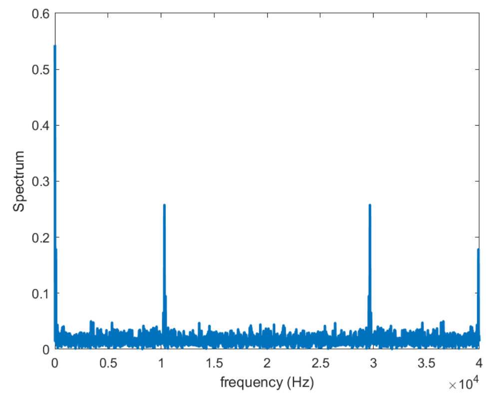

Fig. 5. Modulated Depth of 60%

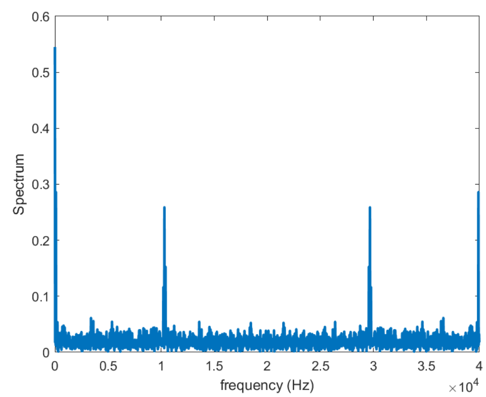

Fig. 6. Modulated Depth of 100%

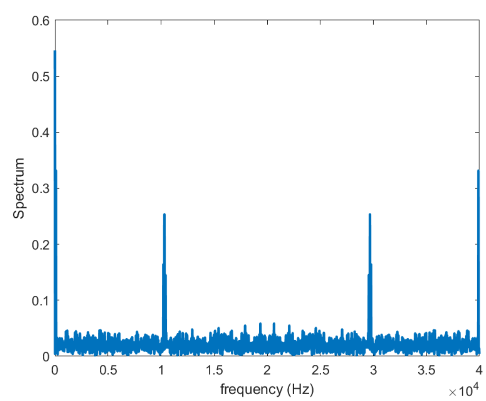

Fig. 7. Modulated Depth of 120%

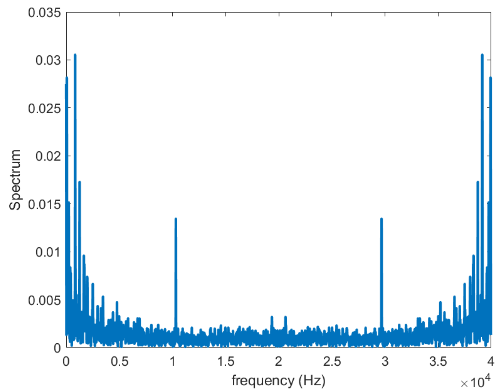

Fig. 8. Spectrum of audio.

Modulated systems are provided to compare with the spectrum of the audio provided in Figure 8. Here the modulated depth is provided based on the data produced by the system of changing depth modulation. Figure 5 to 7.

B. Part 1 - Multi-Tone AM Detection

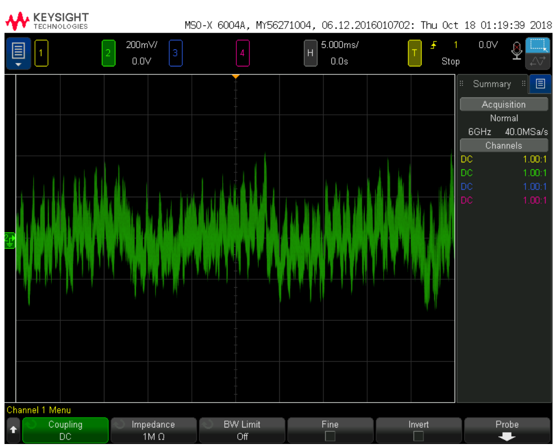

Fig. 9. Sample of left audio signal.

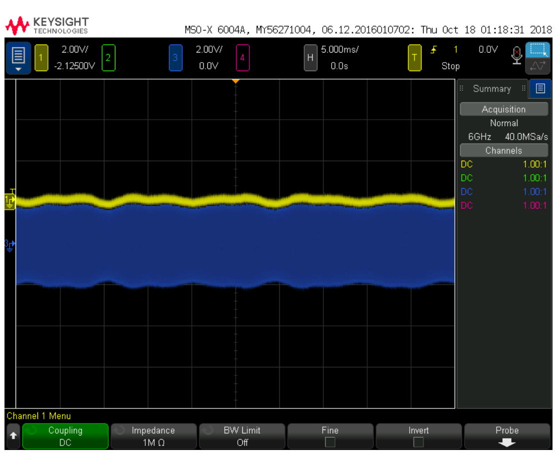

Fig. 10. Modulated signal with envelop referenced for Figure 9

A sample of audio signal is shown in Figure 9 was modulated with the envelop of the signal displayed above the modulated signal in Figure 10. In this experiment, the recorded signal of Figure 10 shows a noise ripple of the left audio channel. $\frac{1}{RC}$ values of 10.6 kHz did not match the 11 kHz signal of the carrier. As such the values of the low pass filter is too small.

Envelops of the spectrum are provided and generated in MATLAB with varying modulation depth. Figure 11 to 13. Additionally, the modulated scopes from the audio spectrum are provided to find a trend that increase the sidebands of each signal as the depth increases.

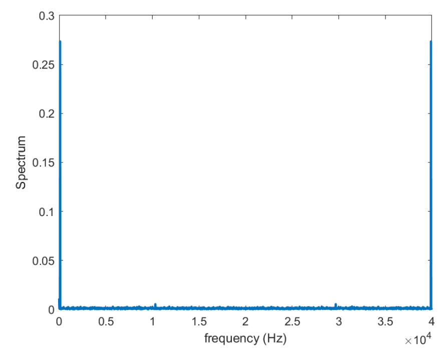

Fig. 11. FFT of signal with modulation depth of 30

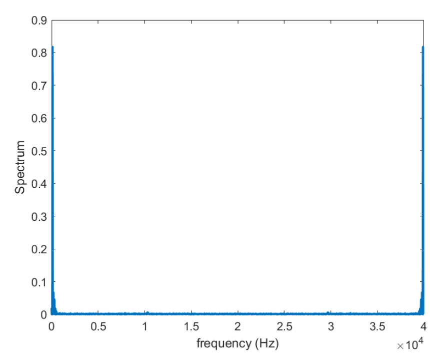

Fig. 12. FFT of signal with modulation depth of 100

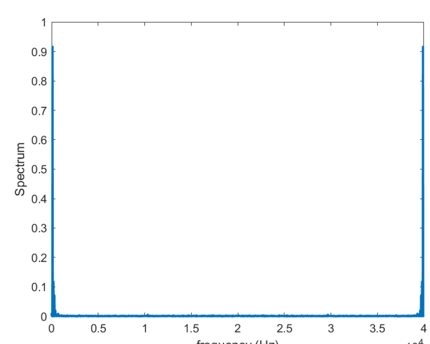

Fig. 13. FFT of signal with modulation depth of 120

C. Part 2

Figure 14 and 15 display the efficiency characteristics of the DSBSC modulation process. At a higher frequency for the DSBSC, the signal produces less noise at the aplitudes of the message signal.

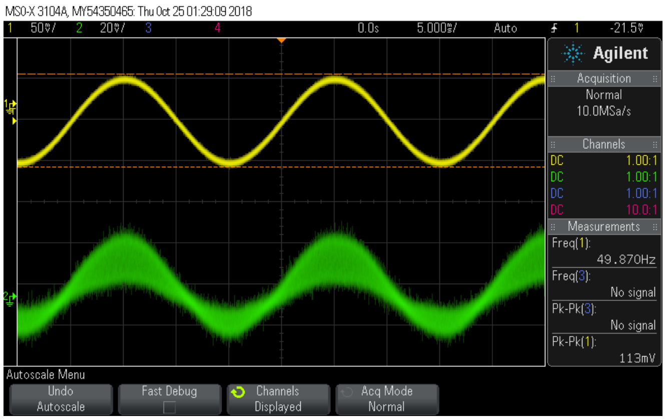

Fig. 14. Audio Output of Part2 waveform

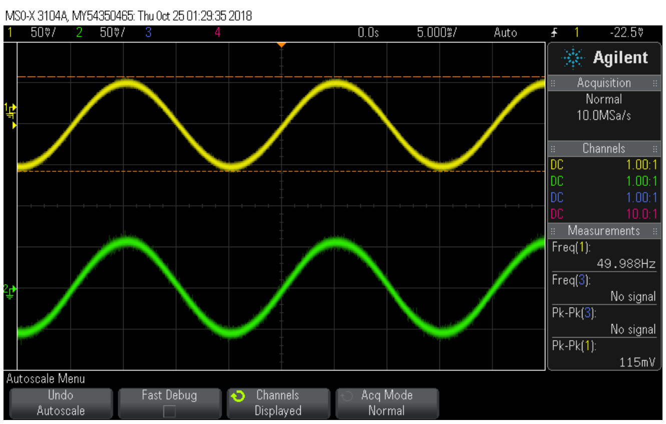

Fig. 15. Audio Output of Part2 waveform

Figure 14 and 15 display that the increase in carrier frequency decreases the noise of the demodulated signal.

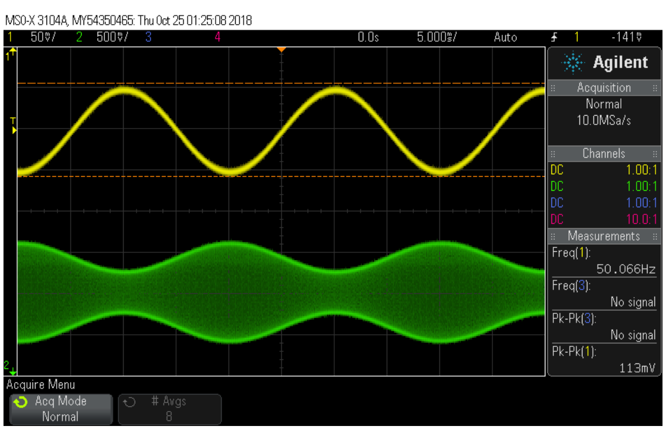

Fig. 16. Original and modulated signal with 180 °shift

Audio from the multi-tone projections were taken to show only one side of the AM modulated wave and notably does not match with the period of the wave. Here, the spectrum has changed by a 180°phase shift.

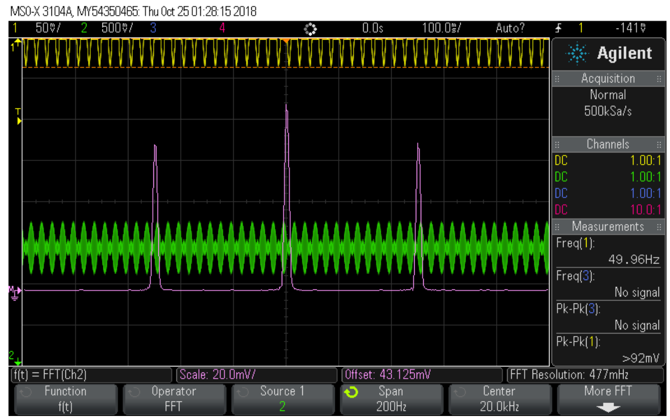

Fig. 17. Audio Output of Part2 waveform

The spectrum of the waveform is provided with the fft of the signal to display the change in modulated signal in line with the demodulated signal.

V. Conclusions

Conclusively, the effects of amplitude and DSBSC modulation on a carrier waveform were observed both graphically and audibly. Graphically, amplitude modulated resulted in a sinusoidal that changed with modulation depth and processed characteristics that changed the phase with depth above 100%. DSBSC phase modulation showed suppression of the AM signal. Demodulation of the signals displayed an increase in noise as the carrier decreased in frequency. FFTs of each signal displayed appropriate to the modulation of the signals requested.

References

[1] L. W. Couch, Digital and analog communication systems, 8th ed. Upper Saddle River, N.J: Prentice Hall, 2013.

[2] Zsolt Papay, Technical University of Budapest (TUB),"Experiments in Gaussian White-noise Generation," HP Test and Measurements Educator's Corner, http://www.home.agilent.com/upload/cmc_upload/All/Exp65.pdf.