ECE478 Lab 5 Report

DSB-SC Modulation and Demodulation using TIMS and MATLAB

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ABSTRACT:

The following lab explores amplitude modulation (AM) via TIMS modules, more specifically DSB-SC modulation.

DSB-SC Generation

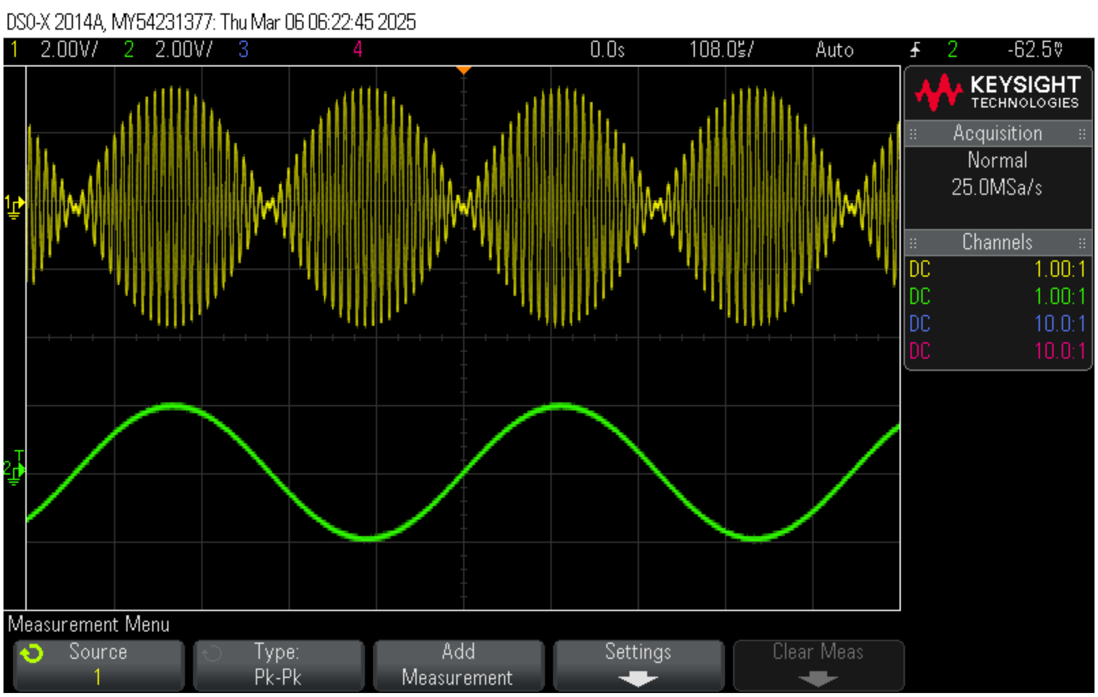

Figure 1: 2kHz Message and DSB-SC Signal

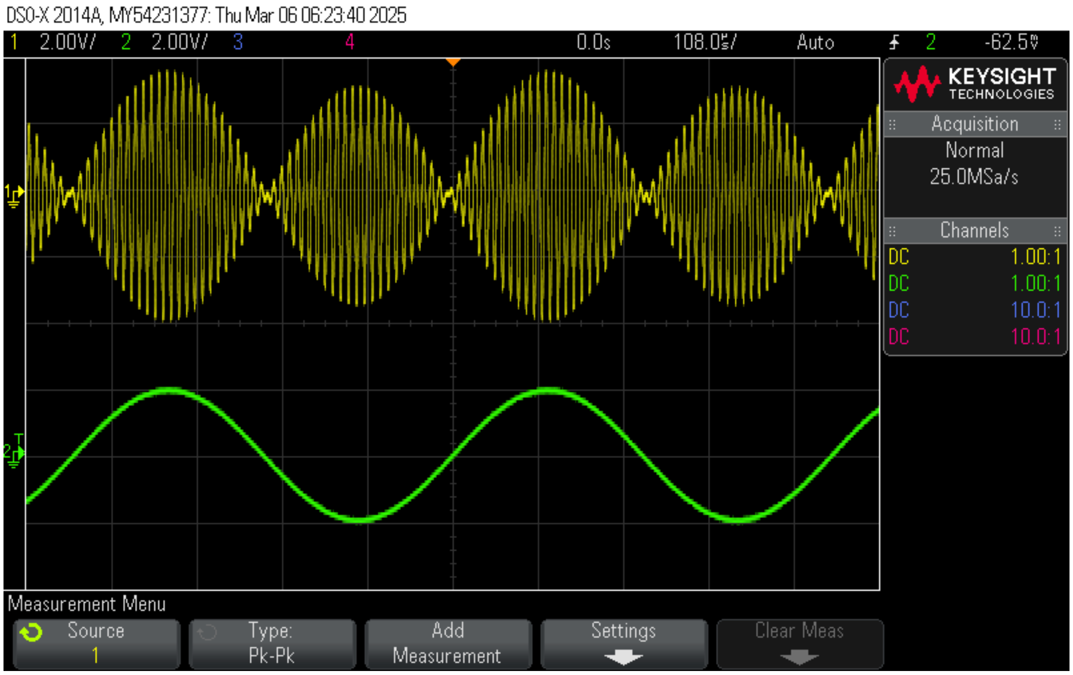

Figure 2: Product of Carrier & Message Plus Carrier; 2kHz Message Signal

Carrier Acquisition – PLL

PLL stands for Phase-Locked Loop.

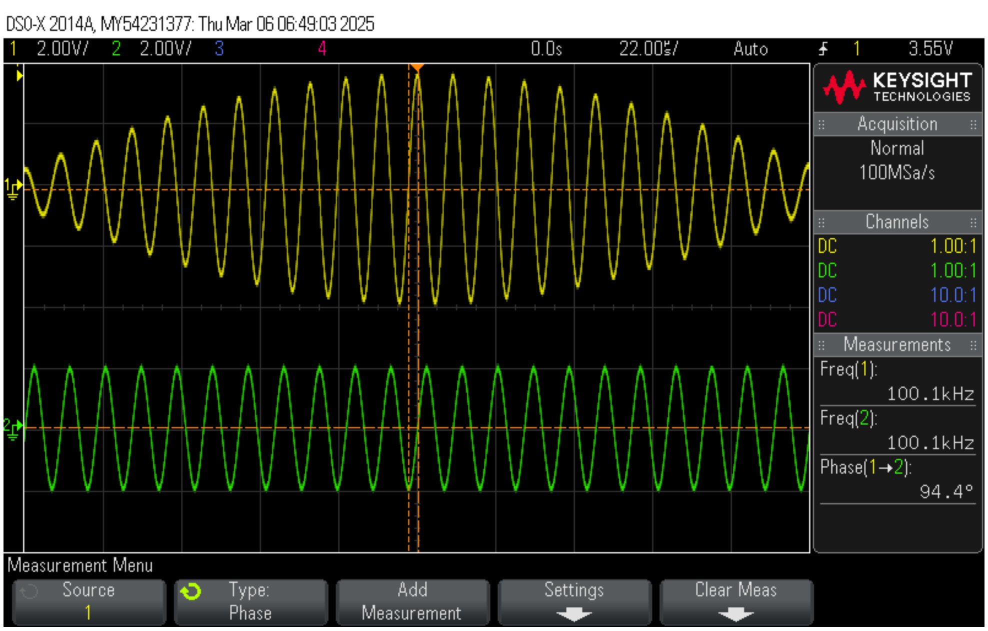

Figure 3: 90-degrees Out of Phase PLL

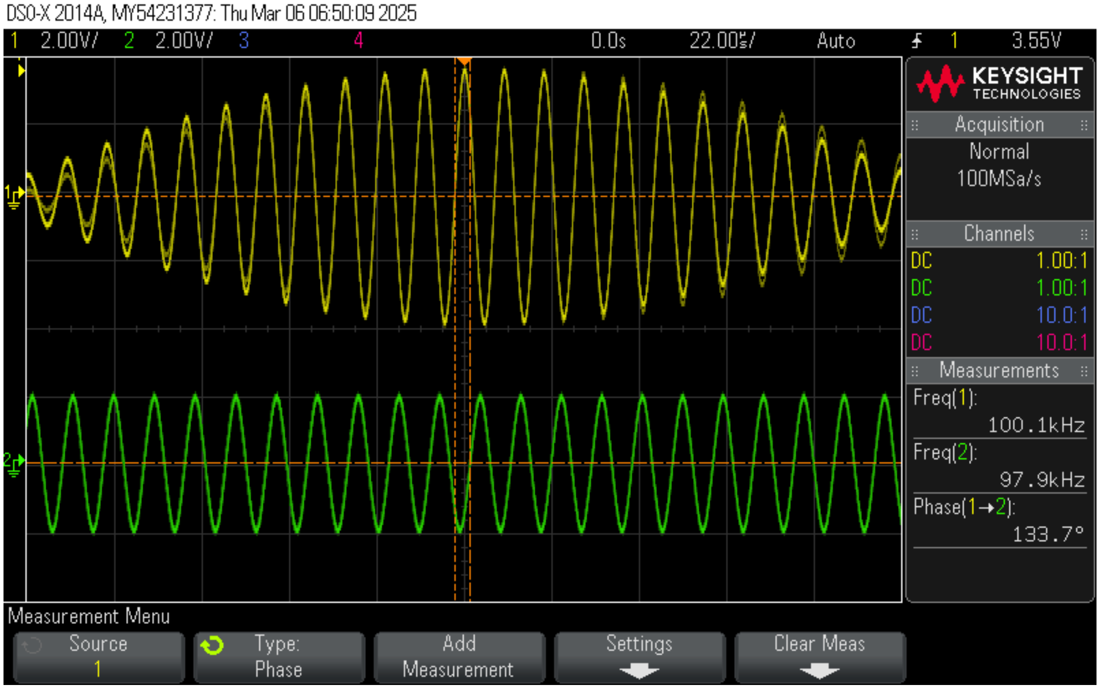

Figure 4: Low-Side PLL at 133.7-degrees out of phase

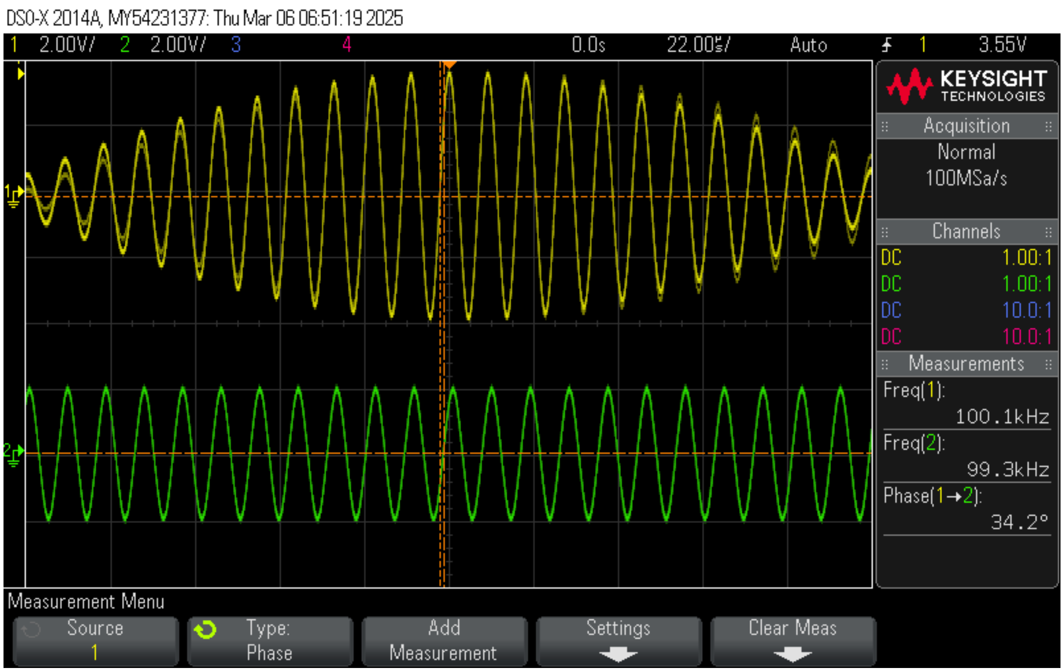

Figure 5: High-Side 34.2-degrees out of phase

Figure 6: Removed pilot carrier with g part of Adder

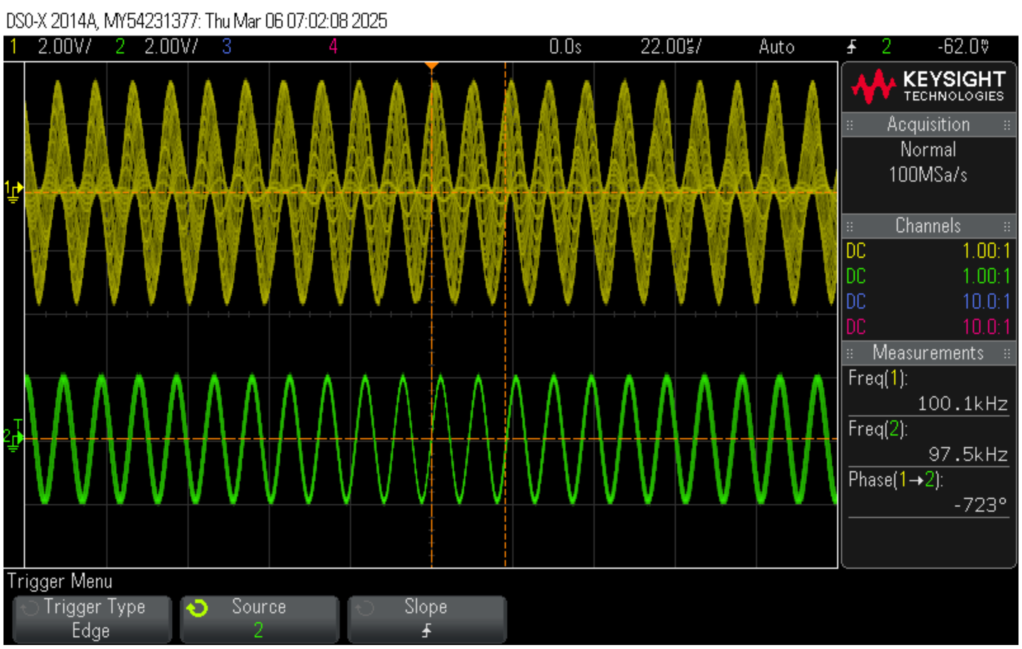

Figure 7: Removed pilot carrier without g part of Adder

As we can see, the carrier is still acquired even without the pilot carrier for the single-tone message.

Product Demodulation

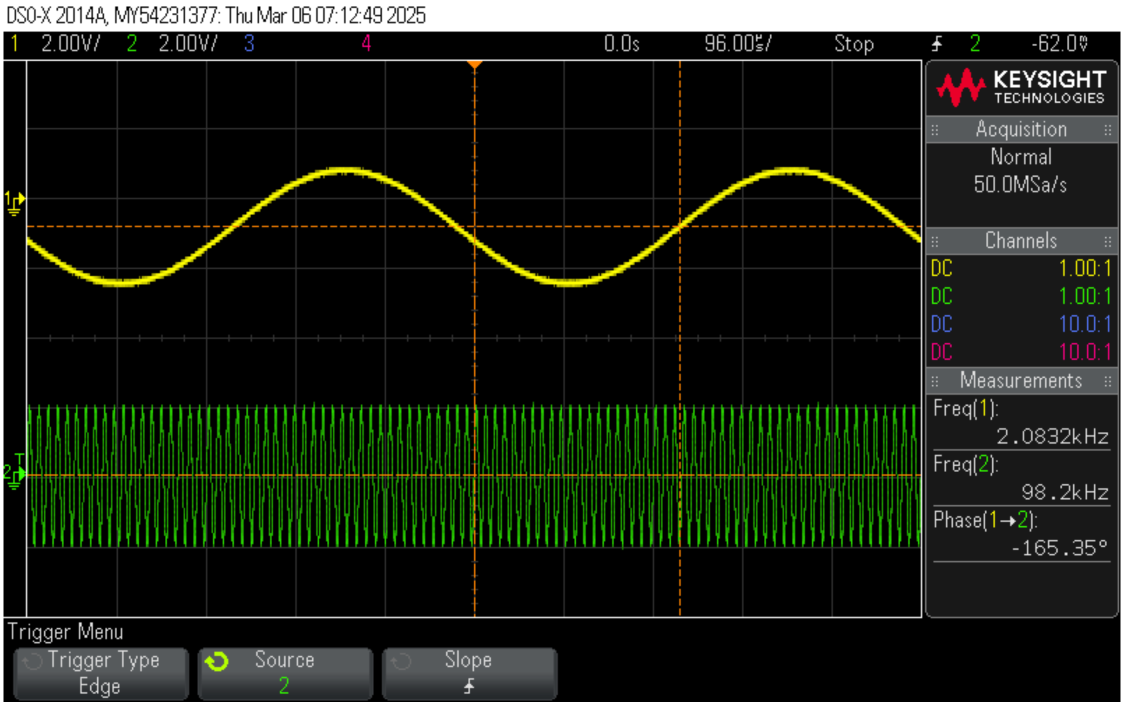

Figure 8: "Stolen Carrier" Demodulation

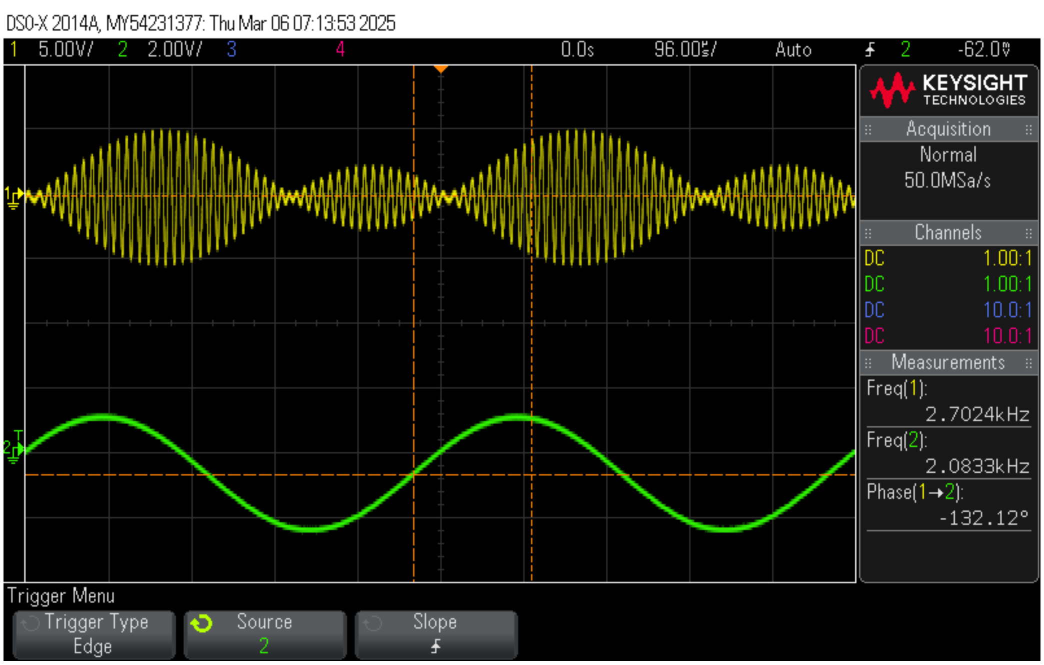

Figure 9: Demodulated Message against DSB-SC Signal

Below shows the same demodulation but using the non-synchronous carrier from the VCO.

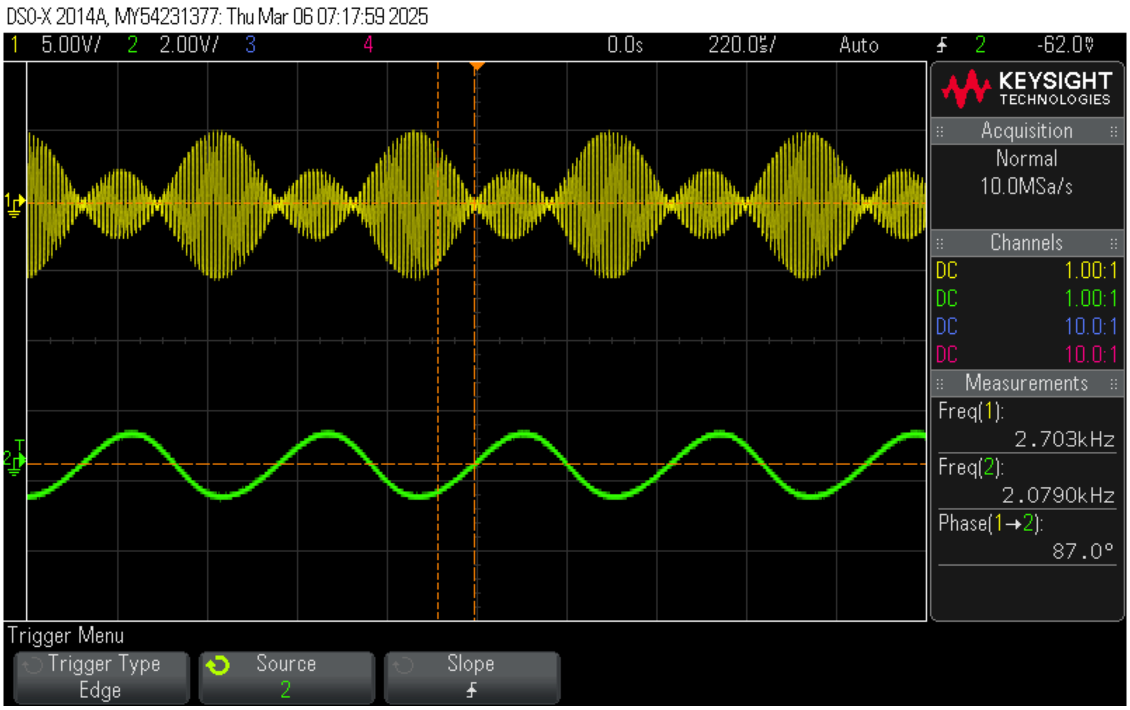

Figure 10: Demodulated message with VCO carrier

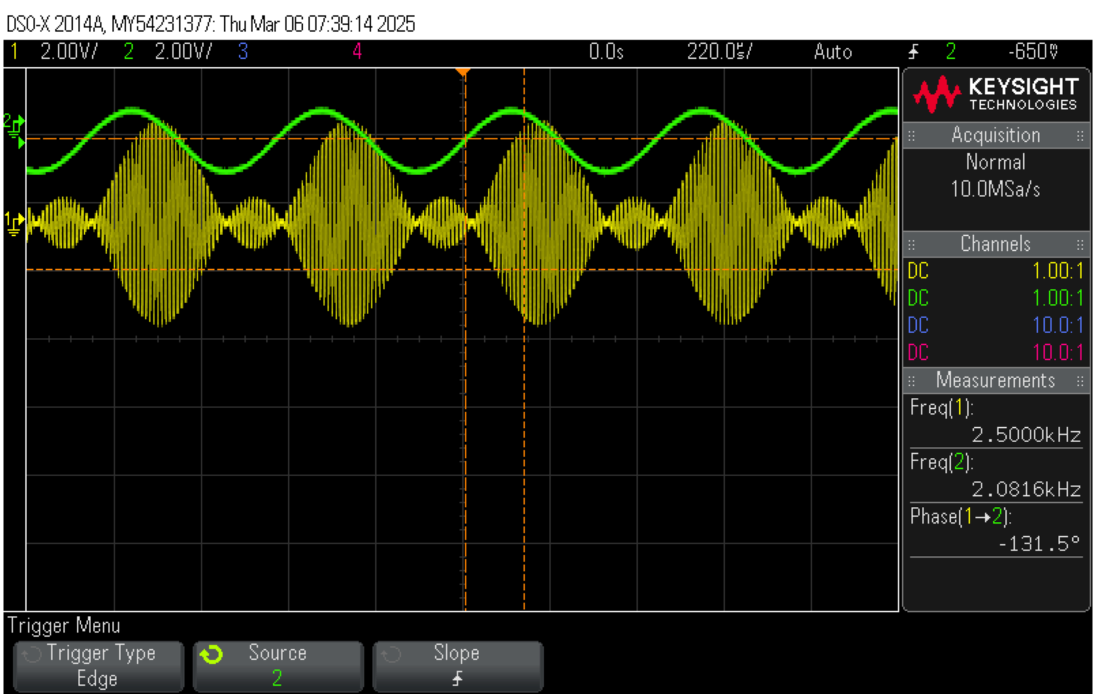

Figure 11: Demodulated message from over-modulated AM signal

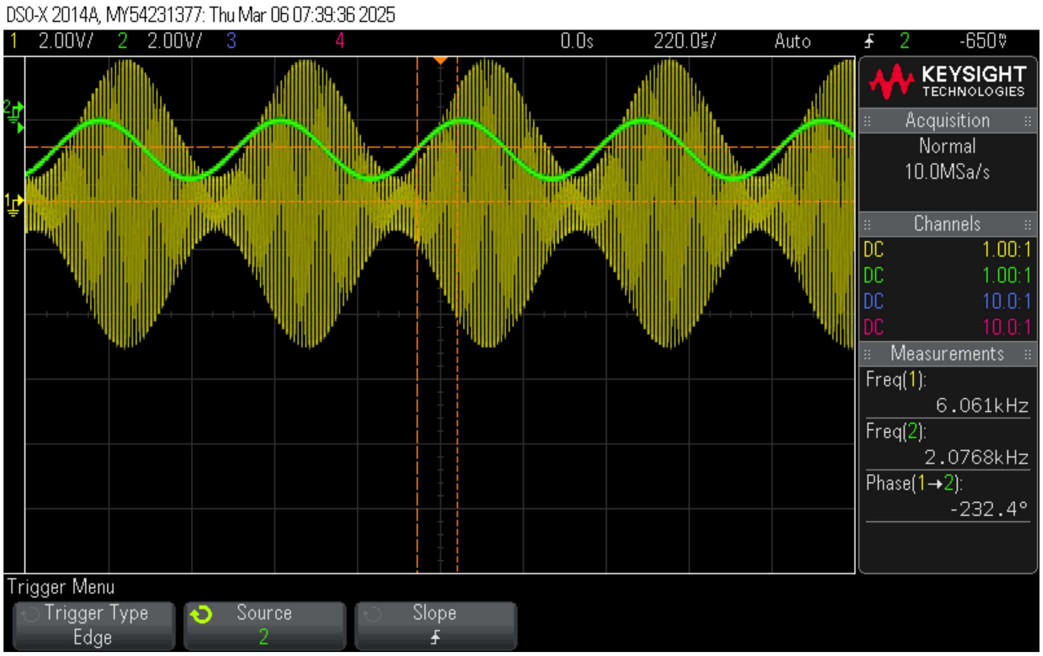

Figure 12: Demodulated message from under-modulated AM signal

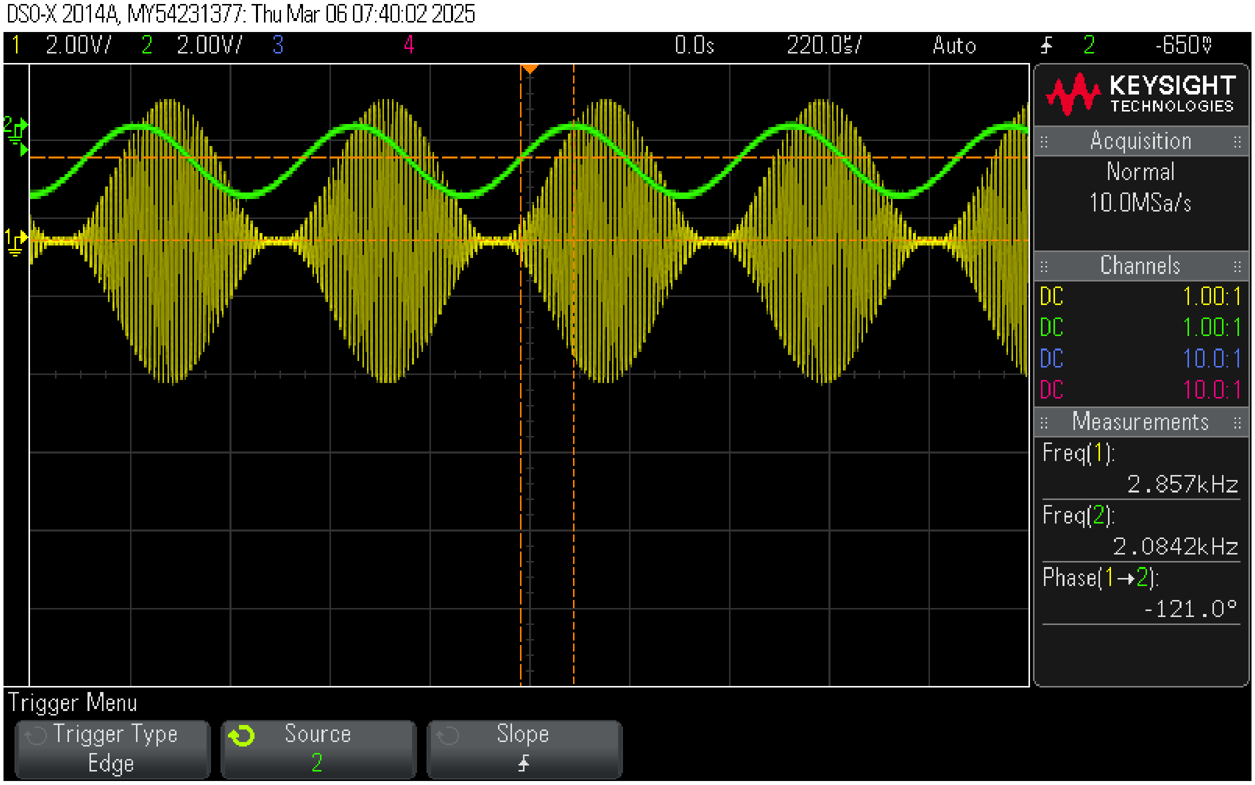

Figure 13: Demodulated message from 100% modulated AM signal

MATLAB Design Problem

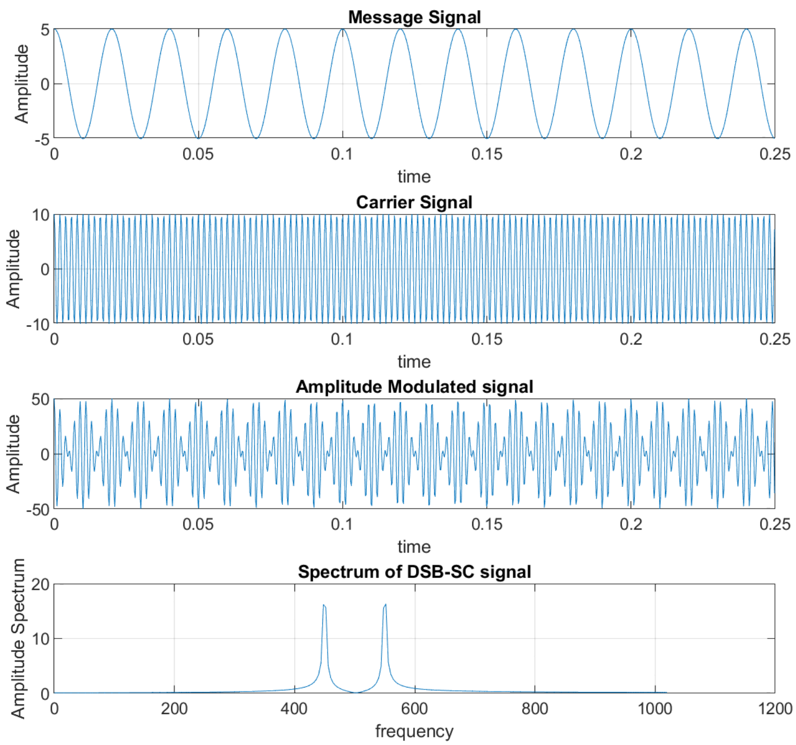

Figure 14: Example 1, 50Hz Message, 500Hz Carrier

```
>> design
Enter frequency of first tone signal (f1) (e.g. f1 = 50) = 50
Enter frequency of second tone signal (f2) (e.g. f2 = 50) = 70
Enter frequency of third tone signal (f3) (e.g. f3 = 50) = 90
Enter carrier frequency (fc) (fc>>fm) (e.g. fc = f1,2,3×10) = 500
```

Figure 15: Design Problem Inputs

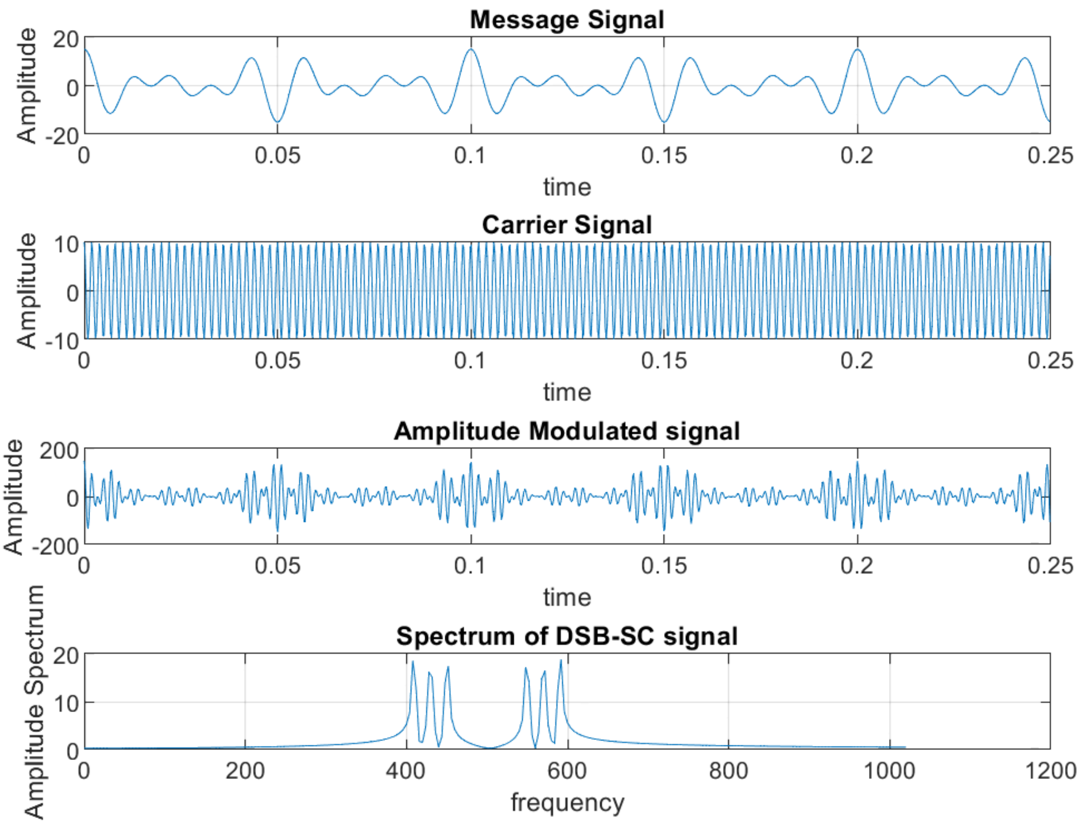

Figure 16: Multi-Tone Message DSB-SC Modulation

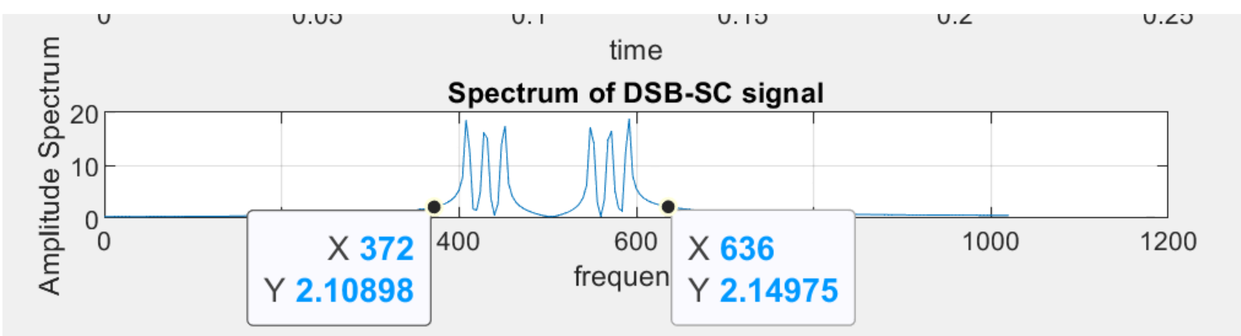

Figure 17: Approximate Bandwidth of Multi-Tone DSB-SC

The approximate bandwidth of the multi-tone DSB-SC signal is 264-Hz.

We know that the Rayleigh Energy theorem can calculate the power of our signal, which is the average of the sum of the amplitude spectrum:

```
power = sum(F.^2)/N;
disp(power);
```

Figure 18: MATLAB implementation of Rayleigh Energy Theorem

```
>> design
Enter frequency of first tone signal (f1) (e.g. f1 = 50) = 50
Enter frequency of second tone signal (f2) (e.g. f2 = 50) = 70
Enter frequency of third tone signal (f3) (e.g. f3 = 50) = 90
Enter carrier frequency (fc) (fc>>fm) (e.g. fc = f1,2,3×10) = 500
    7.3242
```

Figure 19: Calculated Power

The calculated power is 7.3242, which if dissipated through a 1-ohm resistor, would be 7.3424-Watts.

To demodulate the signal, a simple envelope detector would be insufficient as the DSB-SC signal has zero-crossings, so the demodulated signal would be completely corrupted. To demodulate this signal, we would need a coherence detector.

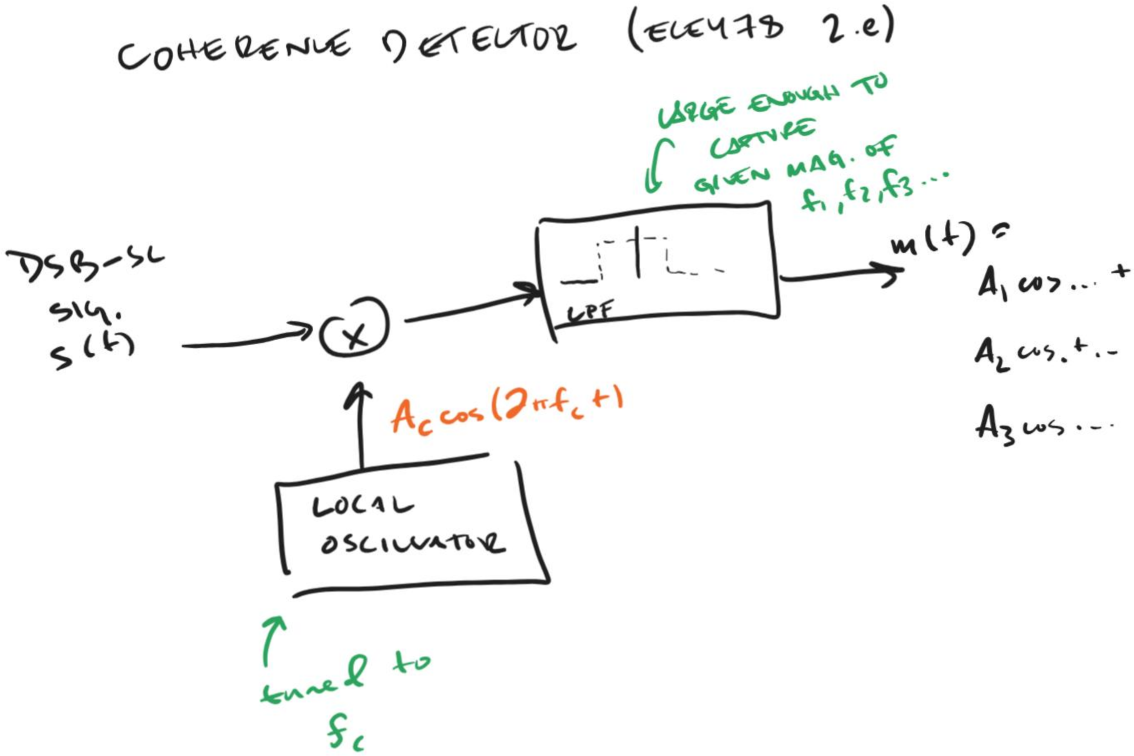

Figure 20: Coherence Detector Design

By multiplying by the carrier from the local oscillator, we can get the message at the baseband, and shifted to $2f_c$ and $-2f_c$, where the high-frequency versions of the signal are removed via a low-pass filter (LPF) and we are left with the original message m(t).

Overall, the DSB-SC modulator and demodulator use less power than the more primitive AM modulator and demodulator from previous experiments, but the DSB-SC scheme is much more complex than the AM scheme. However, even though the DSB-SC scheme is more complex, and not overly so, being more efficient in transmission (and the same in bandwidth use) we can save energy that would otherwise be wasted. This is an improvement for the economic and environmental impacts of the design, if it was physically implemented. Socially, communications are vital, so making them more efficient is critical in providing the most efficient and effective communications service possible.