EE3TR4 Lab 2   DSBSC Modulation

Work in pairs for both the lab and the pre-lab portions.   Hand in one report per group, in the assignment slot in ITB A110.   Late penalty is 10% per week.

In this lab we get to look at the waveforms involved in double sideband suppressed carrier (DSB/SC) modulation systems, for a sinusoidal message signal.   We will use special circuit boards that form a modulated DSB/SC carrier signal from a 64 KHz sinusoidal carrier and a 4KHz sinusoidal message signal. A block diagram of the circuit board is shown in Figure 1. The fully detailed schematic is shown in Figure 2. Note that the 4 kHz message is derived from the 64kHz carrier by converting the sinusoidal carrier to a square wave, dividing the frequency by 16, and then low-pass filtering the resulting square-wave output to generate the 4kHz sinusoidal message.   The modulated waveform is also demodulated to recover the original message, by multiplying the modulated DSB/SC signal by the same 64 KHz carrier.

In this lab, we analyse signals in the time and frequency domains.   Thus, we use the frequency domain display on the scopes.   If you do not know how to use this feature, consult the scope manual or ask the TAs for assistance.

Note that this circuitry is not ideal.   The multipliers are quite sensitive to variations and imbalances in the surrounding resistor values.   Due to temperature shifts and aging, these variations are inevitable.   As a result, the waveforms you observe will appear somewhat different from what you expect.   But this behaviour is part of the life of an electronic engineer-- electronic circuitry is never ideal.

Pre-Lab Exercises

1. Learn your material on DSB/SC modulation.

2. Write a matlab program which gives the following outputs:

      a)   A plot of s(t) corresponding to a DSB/SC waveform for a 64 KHz carrier and a 4 KHz sinusoidal message, in both the time and frequency domains.

      b)   Plot the DSB/SC signal in both the time and frequency domains when a carrier component is added to the signal.   Consider the following cases: 1) The carrier power is 50% of the total power in the two sidebands, 2) the carrier power is 3 times the total power in the two sidebands, and 3) the carrier power is more than 3 times the power in the sidebands.

      c)   A plot of the resulting signal, in both the time and frequency domains, when s(t) (with no carrier) is again multiplied by $\cos(2\pi f_c t)$.

3.   For each of the above cases in part 2, give the underlying theoretical development.

4. Study the circuit diagrams (especially Figure 1) so that you can understand how the signals are generated, and know what the waveforms should look like at the various test points.   You should also have a feeling what happens when each of the potentiometers are varied.

1. Transmit Section

Please note the following terminology that is used in the following:
TP means "test point".   This is a point on the circuit board you can place your scope probe.
PT means "potentiometer".   These can be varied to create various effects.   Refer to the circuit diagrams in Figs. 1 and 2 to see where these are located.

Set the signal generator to a 64 kHz, ±10Volt sinusoidal waveform.   Apply the signal generator and the power supply to the board.   The message signal m(t) appears at test point 2 (TP2).   The multiplier output (i.e., the DSBSC signal s(t)) appears at TP3.   Observe s(t) in both the time and frequency domains on the scope.   Use the Hanning window function for the frequency domain display.   Note that the scope display is not ideal– an impulse appears as a lobe with a finite width.

a) Write a brief description comparing your observed DSBSC waveform from the scope and the matlab output, in both the time and frequency domains.   Give a brief explanation of the theory.   If a printer is available in the lab, print the observed waveform from the scope.   Otherwise, don't try to copy the observed waveforms to paper manually.

b) By varying potentiometer PT1, test the DSBSC signal for linearity.   Compare with your theoretical predictions.

c) Ideally, the DSBSC signal contains no carrier component.   But, inevitably, some carrier component will always leak through the multiplier.   The carrier component of the DSBSC wave can be varied by adjusting PT2.   Vary this potentiometer and observe the effect on the signal in both the time and frequency domains.   Write a brief description comparing your observed time and frequency domain signals with your matlab plots for a DSBSC wave with carrier added.   Support your description with appropriate theoretical analysis.

d) From the perspective gleaned above, what is the difference between a sinusoidally modulated DSBSC wave, and a 100% sinusoidally modulated AM wave.   (You will note that superficially, they appear almost the same!).

e) Explain how the 4KHz message signal is generated by the board.   What is the advantage of generating it this way?

2. Receive Section

Here, the DSBSC signal is multiplied again in the time domain by exactly the same carrier. The second multiplier output appears at TP4, and the final demodulated output appears at TP5.   The waveform at TP4 may have to be adjusted using PT3 so that it more closely agrees with your matlab predictions.

a) Again, write a brief description comparing the observed waveform at TP4 with that obtained from matlab, in both the time and frequency domains.   You will note the observed waveform has a somewhat unusual shape. Support your descriptions with theoretical analysis.

b) What operation is performed on the second (receiver) multiplier output to extract the final demodulated signal?   Explain how this operation is performed on our circuit boards.

c) Comment on the similarity of the demodulated output to the original message.   What can be done to

improve the similarity?

d) By varying PT1, test the linearity of the overall modulator/demodulator section.