Daffodil International University
Department of Electrical and Electronic Engineering
EEE 316: Communications Engineering Laboratory

EXPERIMENT NO: 03

NAME OF THE EXPERIMENT: Study of DSBSC modulation

Objective and Theory

DSBSC is a modulation system similar but different to AM (which was explored in Experiment 1).

Like AM, DSBSC uses a microphone or some other transducer to convert speech and music to an electrical signal called the *message* or *baseband* signal. The message signal is then used to electrically vary the amplitude *of* a pure sine wave called the *carrier.* And like AM, the carrier usually has a frequency that is much higher than the message's frequency.

Figure 1 below shows a simple message signal and unmodulated carrier. It also shows the result of modulating the carrier with the message using DSBSC.

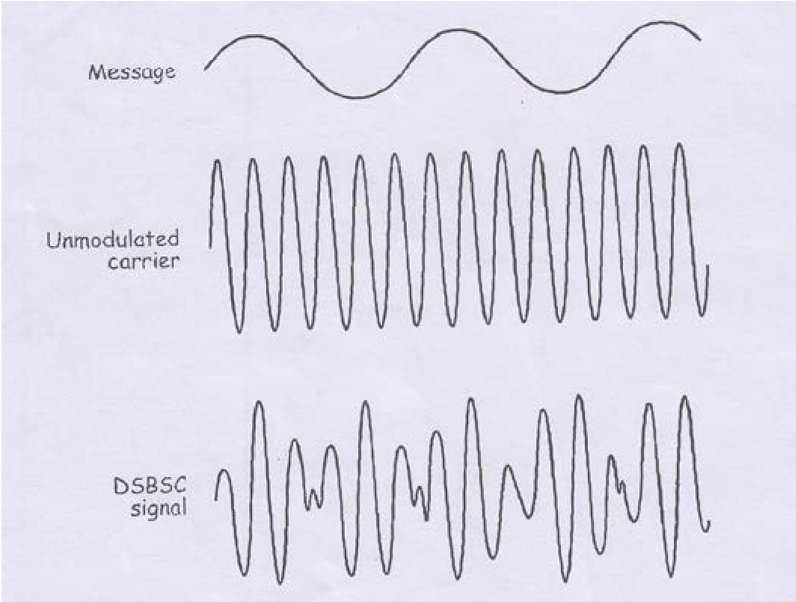

Figure: 01

So far, there doesn't appear to be much difference between AM and DSBSC. However, consider Figure 2 below. It is the DSBSC signal at the bottom of Figure 1 but with dotted lines added to track the signal's envelopes (that is, its positive peaks and negative peaks). If you look at the envelopes closely you'll notice that they're not the same shape as the message as is the case with AM (see Experiment 4 page 4-3 for an example).

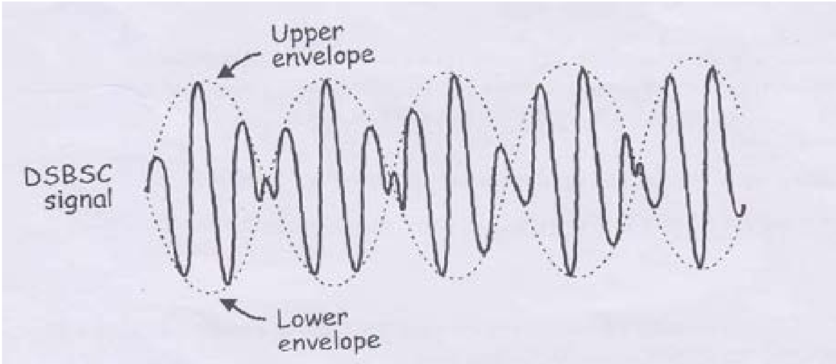

Figure: 02

Instead, alternating halves of the envelopes form the same shape as the message as shown in Figure 3 below.

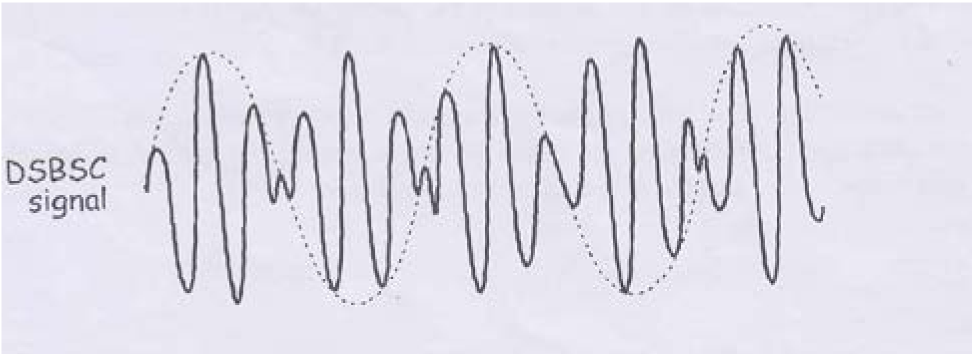

Figure: 03

Another way that DSBSC is different to AM can be understood by considering the mathematical model that defines the DSBSC signal:

$$DSBSC = the\,message \times the\,carrier$$

Do you see the difference between the equations for AM and DSBSC? If not, look at the AM equation in Experiment 4 (page 4-3).

When the message is a simple sine wave (like in Figure 1) the equation's solution (which necessarily involves some trigonometry) tells us that the DSBSC signal consists of two sine waves:

- One with a frequency equal to the sum of the carrier and message frequencies
- One with a frequency equal to the difference between the carrier and message frequencies

Importantly, the DSBSC signal doesn't contain a sine wave at the carrier frequency. This is an important difference between DSBSC and AM.

That said, as the solution to the equation shows. DSBSC is the same as AM in that a pair of sine waves is generated for every sine wave in the message. And, like AM, one is higher than the unmodulated carrier's frequency and the other is lower. As message signals such as speech and music are made up of thousands of sine waves, thousands of pairs of sine waves are generated in the DSBSC signal that sit on either side of the carrier frequency. These two groups are called the sidebands.

So, the presence of both sidebands but the absence of the carrier gives us the name of this modulation method - double-sideband, suppressed carrier (DSBSC).

The carrier in AM makes up at least 66% of the signal's power but it doesn't contain any part of the original message and is only needed for tuning. So by not sending the carrier, DSBSC offers a substantial power saving over AM and is its main advantage.

The experiment

In this experiment you'll use the Emona Telecoms-Trainer 101 to generate a real DSBSC signal by implementing its mathematical model. This means that you'll take a pure sine wave (the message) that contains absolutely no DC and multiply it with another sine wave at a higher frequency (the carrier). You'll examine the DSBSC signal using the scope and compare it to the original message. You'll do the same with speech for the message instead of a simple sine wave.

Following this, you'll vary the message signal's amplitude and observe how it affects the carrier's depth of modulation. You'll also observe the effects of modulating the carrier too much.

It should take you about 50 minutes to complete this experiment.

Equipment

- Emona Telecoms-Trainer 101 (plus power-pack)
- Dual channel 20MHz oscilloscope
- Two Emona Telecoms-Trainer 101 oscilloscope leads
- Assorted Emona Telecoms-Trainer 101 patch leads

Procedure

Part A
Generating a DSBSC signal using a simple message

1. Gather a set of the equipment listed above.

2. Set up the scope per the instructions in Experiment 1. Ensure that:

• The Trigger Source control is set to the CHJ (or IN7) position.
• The Mode control is set to the CHJ position.

3. Connect the set-up shown in Figure 4 below.
Note: Insert the black plugs of the oscilloscope leads into a ground (GND) socket.

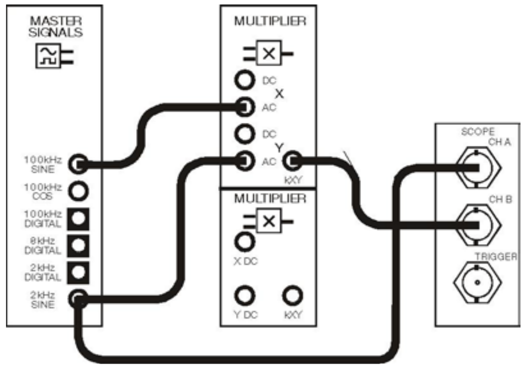

Figure: 04

The set-up m Figure 4 can be represented by the block d1agram in Figure 5 below. It implements the entire equation: $DSBSC \ = \ the\ message \times \ the\ carrier.$

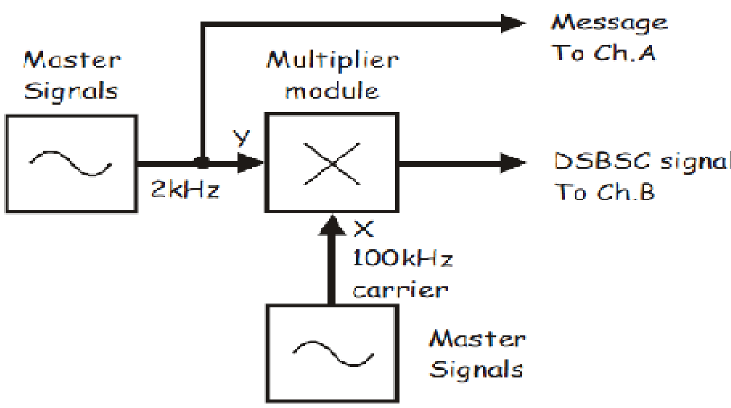

Figure: 05

With values, the equation is:

$$DSBSC \ = \ 4Vp - p\ 2kHz\ sine \ \times \ \ 4Vp - p\ 100kHz\ sine.$$

4. Adjust the scope's Timebase control to view two or so cycles of the Master Signals module's 2 kHz SINE output.

5. Set the scope's Mode control to the DUAL position to view the DSBSC signal out of the Multiplier module as well as the message signal.

6. Set the scope's Channel 1 Vertical Attenuation control to the 1V/div position and the Channel 2 Vertical Attenuation control to the 2V/div position

7. Draw the two waveforms to scale.

Use the scope's Channel 1 Vertical Posttion control to overlay the message with the DSBSC signal's envelopes and compare them.

Question 1

What feature of the Multiplier module's output suggests that it's a DSBSC signal? Tip: If you're not sure about the answer to the questions, see the prelim1nary d1scussion.

Question 2

The DSBSC signal is a complex waveform cons1sting of more than one signal. Is one of the signals a 2 kHz sinewave? Explain your answer.

Question 3

For the given inputs to the Multiplier module, how many sinewaves does the DSBSC signal consist of, and what are their frequenc1es?

Question 4

Why does this make DSBSC signals better for transmission than AM signals?

Part B - Generating a DSBSC signal using speech

This experiment has generated a DSBSC signal using a sine wave for the message. However, the message in commercial communications systems is much more likely to be speech and music. The next part of the experiment lets you see what a DSBSC signal looks like when modulated by speech.

9. Disconnect the plugs to the Master Signals module's *2 kHz SINE* output

10. Connect them to the Speech module's output as shown in Figure 6 below.

    Remember: Dotted lines show leads already in place.

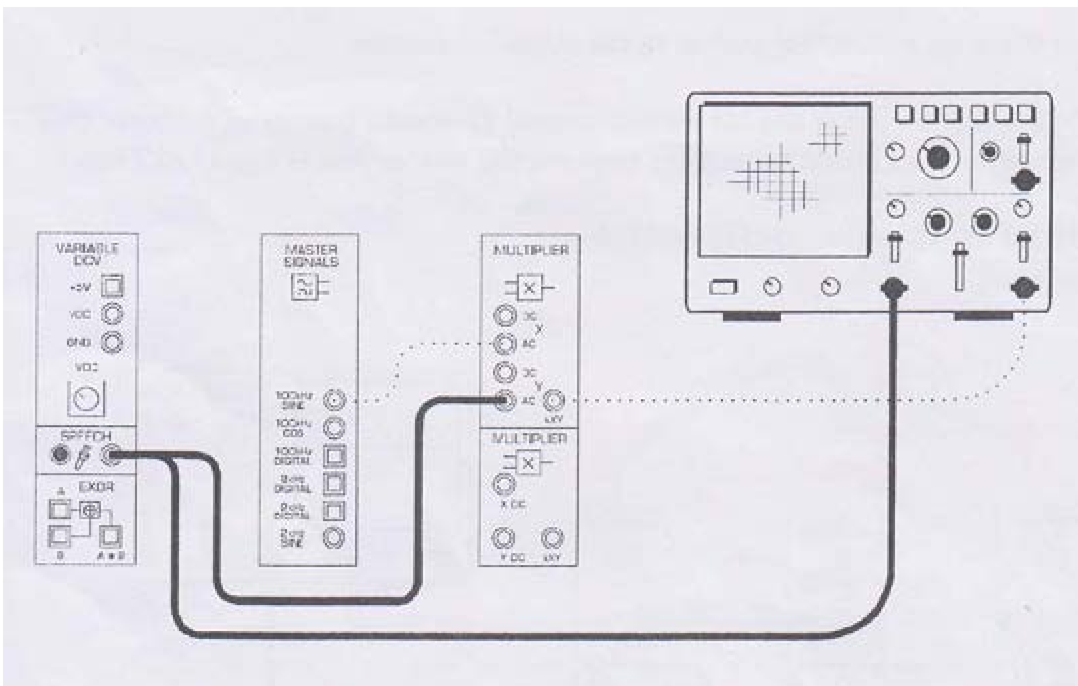

Figure: 06

11. Set the scope's Timebase control to the 2 ms/div position.

12. Talk, sing or hum while watching the scope's display.

Question 5

Why isn't there any signal out of the Multiplier module when you're not talking, whistling, etc?

Part C - Investigating depth of modulation

It's possible to modulate the carrier by different amounts. This part of the experiment lets you investigate this.

13. Return the scope's Timebase control to the 0.lms/div position.

14. Locate the Buffer module and set its Gain control to about a quarter of its travel (the control's arrowhead should be pointing to where the number nine is on a clock's face).

15. Modify the set-up as shown in Figure 7 below

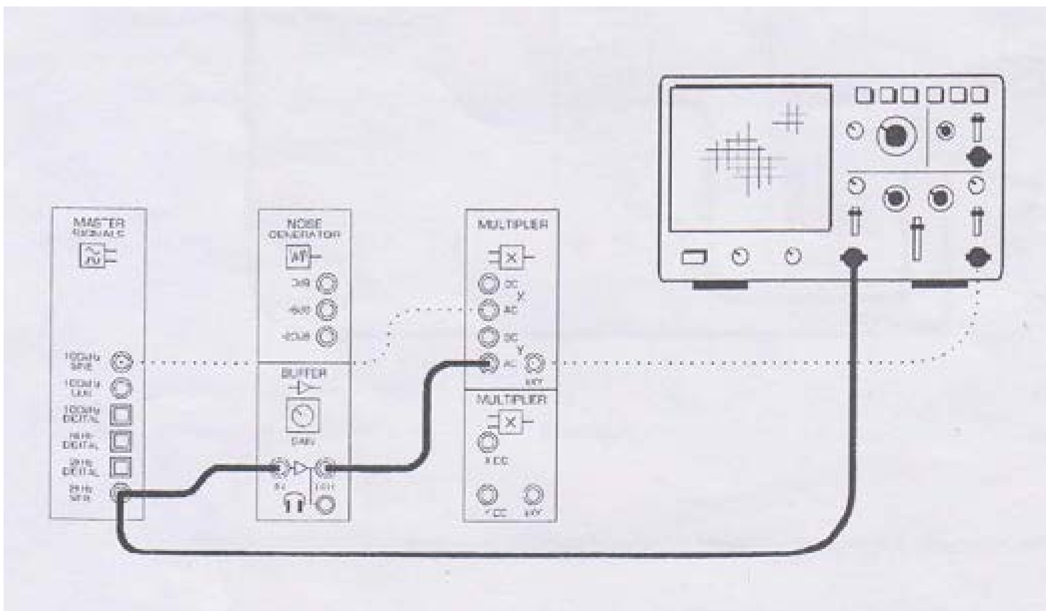

Figure: 07

The set-up in Figure 7 can be represented by the block diagram in Figure 8 below. The Buffer module allows the message signal's amplitude to be adjustable.

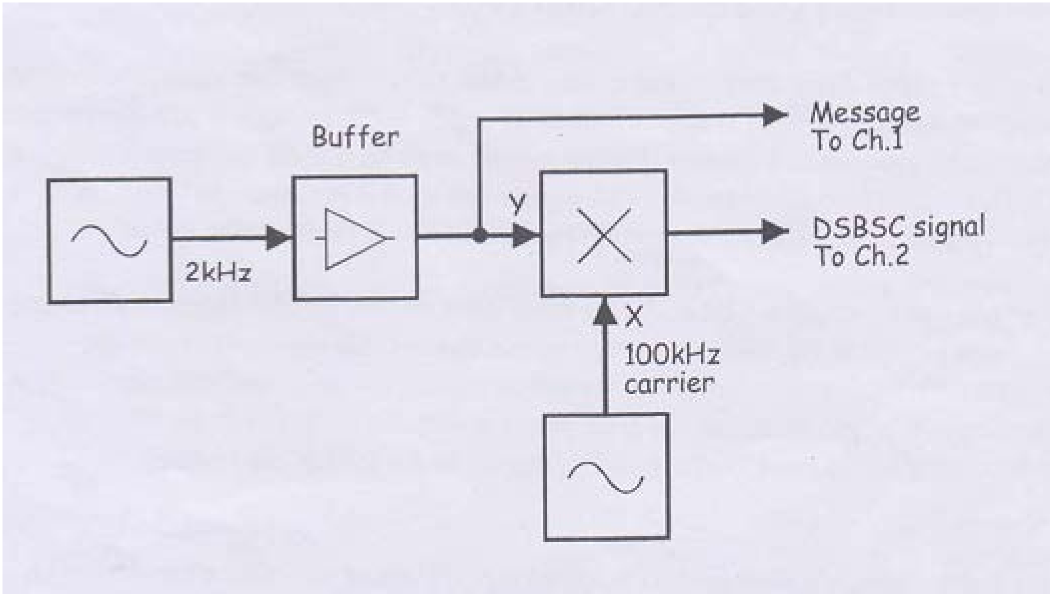

Figure: 08

Note: At this stage, the Multiplier module's output should be the normal DSBSC signal that you sketched earlier.

Recall from Experiment 4 that an AM signal has two dimensions that can be measured and used to calculated modulation index (m). The dimensions are denoted Pond Q. If you've forgotten which one is which, take a minute to read over the notes at the top of page 4-14 before going on to the next step.

16. Vary the message signal's amplitude a little by turning the Buffer module's Gain control left and right a little. Notice the effect that this has on the DSBSC signal's P and Q dimensions.

Question 6

Based on your observations in step 16, when the message's amplitude is varied?

- o neither dimensions P or Q are affected
- o only dimension Q is affected
- o only dimension P is affected
- o both dimensions P and Q are affected

On the face of it, determining the depth of modulation of a DSBSC signal is a problem. The modulation index is always the same number regardless of the message signal's amplitude Th1s is because the DSBSC signals Q dimension is always zero.

However, this isn't the problem that it seems. One of the main reasons for calculating on AM signal's modulation index is so that the distribution of power between the signal's carrier and its sidebands con be calculated. However, DSBSC signals don't have a carrier (remember, it's suppressed). This means that all of the DSBSC signal's power is distributed between its sidebands evenly. So there's no need to calculate a DSBSC signal's modulation index.

The fact that you can't calculate a DSBSC signal's modulation index might imply that you can make either the message or the carrier as large as you like without worrying about over- modulation. This isn't true. Making either of these two signals too large can still overload the modulator resulting in a type of distortion that you've seen before. The next part of the experiment lets you observe what happens when you overload a DSBSC modulator.

17. Set the Buffer module's Gain control to about half its travel and notice the effect on the DSBSC signal.

Note: If there is no effect, turn up the gain control a little more.

18. Draw the new DSBSC signal to scale.

Question 7

What is the name of distortion?