

Name: _____

Class: _____

19 - Binary phase shift keying

Experiment 19 - Binary Phase Shift Keying

Preliminary discussion

Experiments 17 and 18 show that the AM and FM modulation schemes can be used to transmit digital signals and this allows for the channel to be shared. As digital data forms the message instead of speech and music, it is preferred that these two systems are called ASK and FSK instead.

Recall that ASK uses the digital data's 1s and 0s to switch a carrier between two amplitudes. FSK uses the 1s and 0s to switch a carrier between two frequencies. An alternative to these two methods is to use the data stream's 1s and 0s to switch the carrier between two phases. This is called *Binary Phase Shift Keying* (BPSK). Figure 1 below shows what a BPSK signal looks like time-coincident with the digital signal that has been used to generate it.

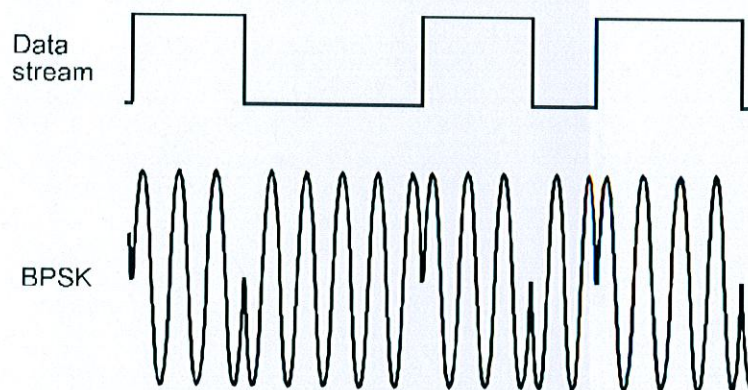


Figure 1

Notice that, when the change in logic level causes the BPSK signal's phase to change, it does so by 180° . For example, where the signal is travelling towards a positive peak the change in logic level causes it to reverse direction and head back toward the negative peak (and vice versa).

You may find it difficult to see at first but look closely and you'll notice that alternating halves of the BPSK signal's envelopes have the same shape as the message. This indicates that BPSK is actually *double-sideband suppressed carrier* (DSBSC) modulation. That being the case, BPSK generation and the recovery of the data can be handled by conventional DSBSC modulation and demodulation techniques (explained in Experiments 6 and 9 respectively).

With a choice of ASK, FSK and BPSK you might be wondering about which system you'll most likely see. All other things being equal, BPSK is the best performing system in terms of its ability to ignore noise and so it produces the fewest errors at the receiver. FM is the next best and AM is the worst. On that basis, you'd expect that BPSK is the preferred system. However, it's not necessarily the easiest to implement and so in some situations FSK or ASK might be used as they are cheaper to implement. In fact, FSK was used for cheaper dial-up modems.

The experiment

For this experiment you'll use the Emona DATEx to generate a BPSK signal using the Multiplier module to implement its mathematical model. Digital data for the message is modelled by the Sequence Generator module. You'll then recover the data using another Multiplier module and observe its distortion. Finally, you'll use a comparator to restore the data.

It should take you about 40 minutes to complete this experiment.

Equipment

- Personal computer with appropriate software installed
- NI ELVIS II plus USB cable and power pack
- Emona DATEx experimental add-in module
- Three BNC to 2mm banana-plug leads
- Assorted 2mm banana-plug patch leads

Procedure

Part A - Generating a BPSK signal

A BPSK signal will be generated by implementing the mathematical model for DSBSC modulation. For more information on this, refer to the preliminary discussion of Experiment 6.

1. Ensure that the NI ELVIS II power switch at the back of the unit is off.
2. Carefully plug the Emona DATEx experimental add-in module into the NI ELVIS II.
3. Set the *Control Mode* switch on the DATEx module (top right corner) to *PC Control*.
4. Connect the NI ELVIS II to the PC using the USB cable.

Note: This may already have been done for you.

5. Turn on the NI ELVIS II power switch at the rear of the unit then turn on its *Prototyping Board Power* switch at the top right corner near the power indicator.
6. Turn on the PC and let it boot-up.
7. Launch the NI ELVISmx software.

8. Launch the DATEx soft front-panel (SFP) and check that you have soft control over the DATEx board.
9. Locate the Sequence Generator module on the DATEx SFP and set its soft dip-switches to 00.
10. Connect the set-up shown in Figure 2 below.

Note: Insert the black plugs of the oscilloscope leads into a ground (GND) socket.

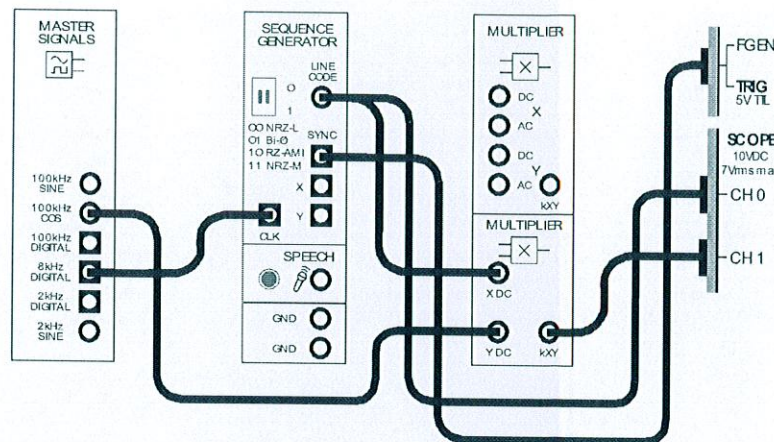


Figure 2

This set-up can be represented by the block diagram in Figure 3 on the next page. The Sequence Generator module is used to model a digital signal and its SYNC output is used to trigger the scope to provide a stable display. The Multiplier module is used to generate the BPSK signal by implementing its mathematical model.

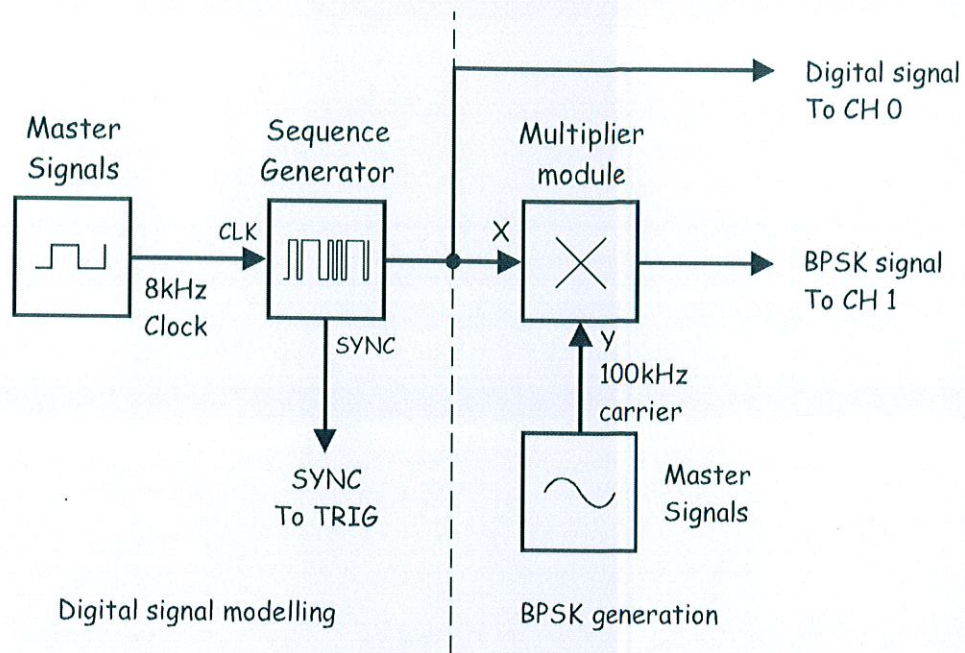


Figure 3

11. Launch and run the NI ELVIS II Oscilloscope VI.
12. Set up the scope per the procedure in Experiment 1 with the following changes:
 - *Scale* control for Channel 1 to $2V/div$ instead of $1V/div$
 - *Input Coupling* controls for both channels to *DC* instead of *AC*
 - *Timebase* control to $100\mu s/div$ instead of $500\mu s/div$
 - *Trigger Type* control to *Digital* instead of *Edge*
13. Activate the scope's Channel 1 input to observe the *Sequence Generator* module's output and the BPSK signal out of the *Multiplier* module.
14. Compare the signals.

Question 1

What feature of the BPSK signal suggests that it's a DSBSC signal? **Tip:** If you're not sure, see the preliminary discussion.

It's clear that something happens when the *Sequence Generator*' module's output changes logic level but it's difficult to see exactly what it is at this resolution. The next few steps allow you to get a better look.

15. Modify the set-up as shown in Figure 4 below.

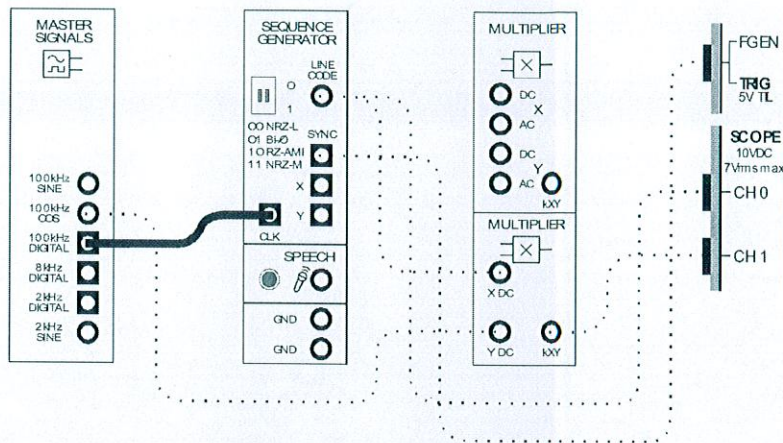


Figure 4

16. Set the scope's *Timebase* control to the $10\mu\text{s}/\text{div}$ position.

Note: The NI ELVIS II is being operated at close to the limits of its specifications and so the *Master Signals* module's 100kHz *COS* output looks a little triangular. However, the display is sufficient to see what occurs when the *Sequence Generator* module's output changes logic level.

Question 2

What happens to the BPSK signal on the data stream's logic transitions?



Ask the instructor to check your work before continuing.

Part B - Demodulating a BPSK signal using a product detector

As BPSK is really just DSBSC (with a digital message instead of speech or music), it can be recovered using any of the DSBSC demodulation schemes. The next part of the experiment lets you do so using a product detector.

17. Return the Sequence Generator module's *CLK* input to the Master Signals module's *8kHz Digital* output.
18. Set the scope's *Timebase* control to the *200 μ s/div* position.
19. Locate the Tuneable Low-pass Filter module on the DATEx SFP and turn its soft *Cut-off Frequency Adjust* control fully clockwise.
20. Set the Tuneable Low-pass Filter module's soft *Gain* control to about the middle of its travel.
21. Modify the set-up as shown in Figure 5 below.

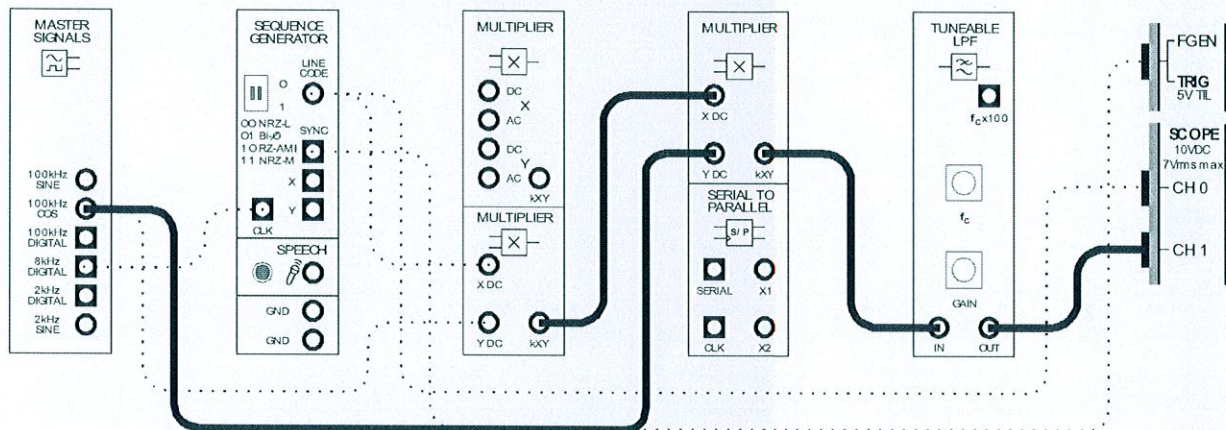


Figure 5

The BPSK generation and demodulation parts of the set-up can be represented by the block diagram in Figure 6 on the next page. The second Multiplier and the Tuneable Low-pass filter module are used to implement a product detector to recover the digital data from the BPSK signal.

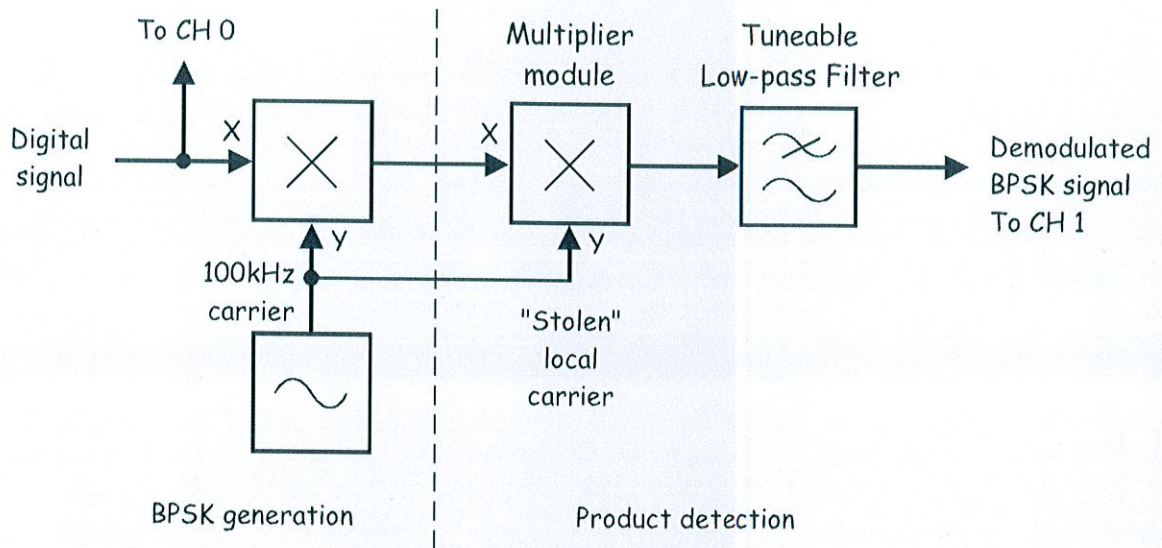


Figure 6

22. Compare the digital signal with the recovered digital signal.

Question 3

Why is the recovered digital signal not a perfect copy of the original?

Question 4

What can be used to "clean-up" the recovered digital signal?



Ask the instructor to check your work before continuing.

Part C - Restoring the recovered data using a comparator

Experiment 16 shows that the comparator is a useful circuit for restoring distorted digital signals. The next part of the experiment lets you use a comparator to clean-up the demodulated BPSK signal.

23. Launch and run the NI ELVIS II Variable Power Supplies VI.
24. Set the Variable Power Supplies' positive output to 0V.
25. Modify the set-up as shown in Figure 7 below.

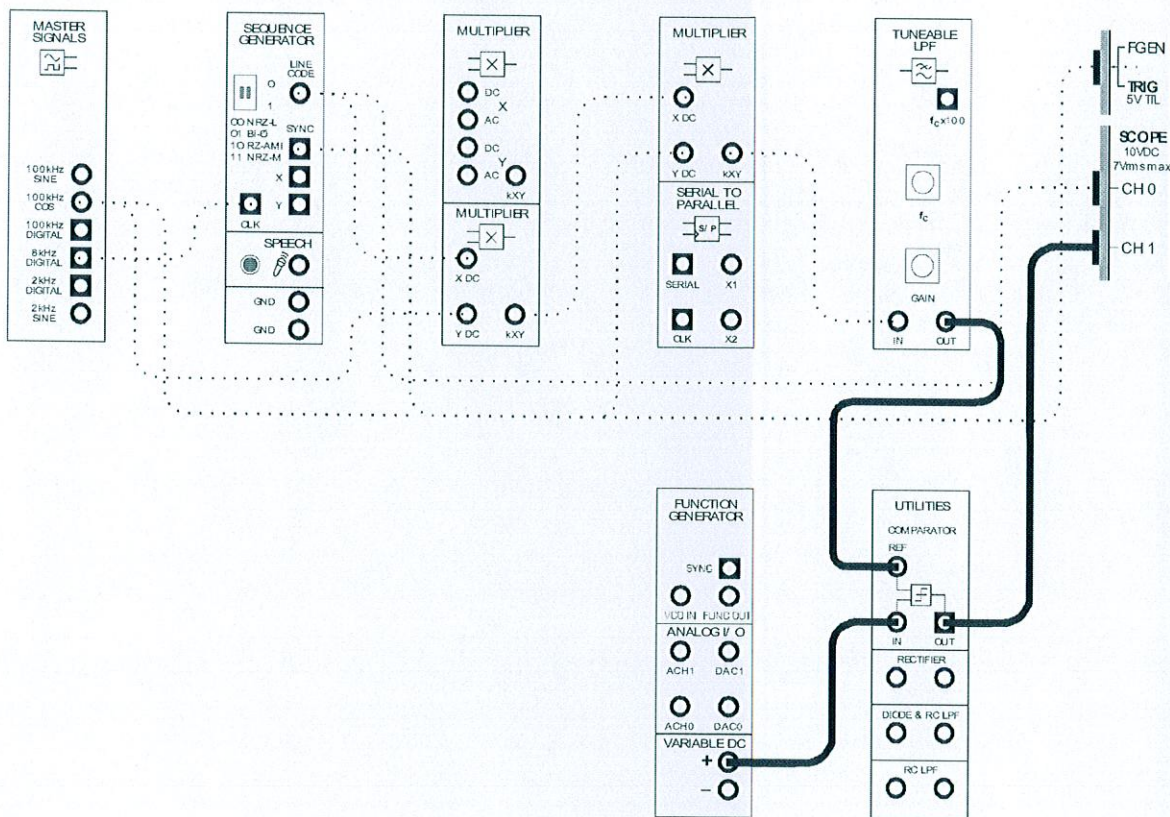


Figure 7

The BPSK generation, demodulation and digital signal restoration parts of the set-up can be represented by the block diagram in Figure 8 below.

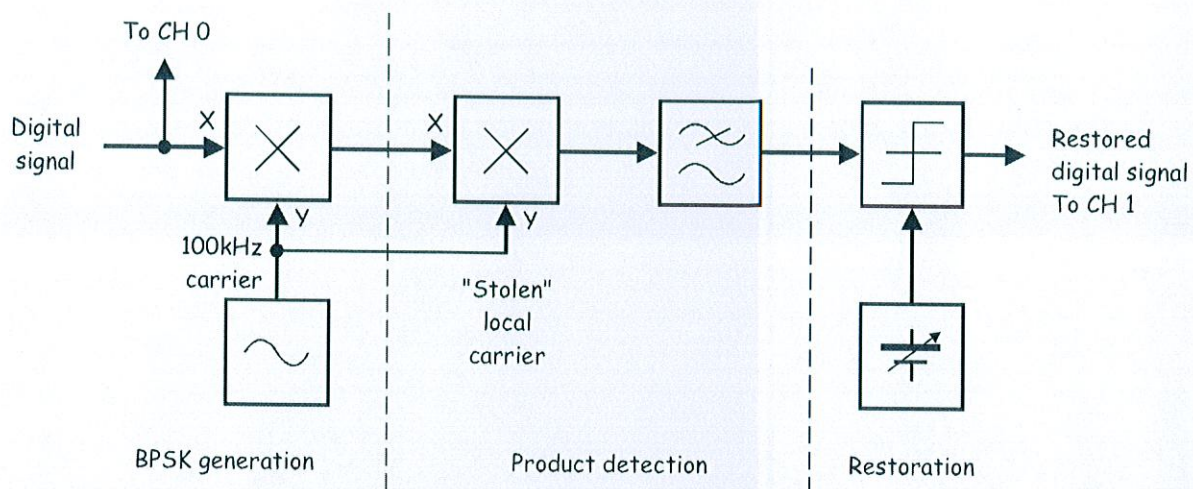


Figure 8

26. Compare the signals. If they're not the same, adjust the Variable Power Supplies positive output soft *Voltage* control until they are.



Ask the instructor to check your work before finishing.