Name: ______________________

Class: ______________________

18 - Frequency shift keying

Experiment 18 - Frequency Shift Keying

Preliminary discussion

Frequency division multiplexing (FDM) allows a channel to be shared among a set of users. Recall that this is achieved by superimposing the message onto a carrier signal inside the user's allocated portion of the radio-frequency spectrum. Recall also that any of the analog modulation schemes can be used to transmit digital data in this way. When frequency modulation (FM) is used it is known as *binary frequency shift keying* (BFSK or more commonly just FSK).

One of the reasons for using FSK is to take advantage of the relative noise immunity that FM enjoys over AM. Recall that noise manifests itself as variations in the transmitted signal's amplitude. These variations can be removed by FM/FSK receivers (by a circuit called a *limiter*) without adversely affecting the recovered message.

Figure 1 below shows what an FSK signal looks like time-coincident with the digital signal that has been used to generate it.

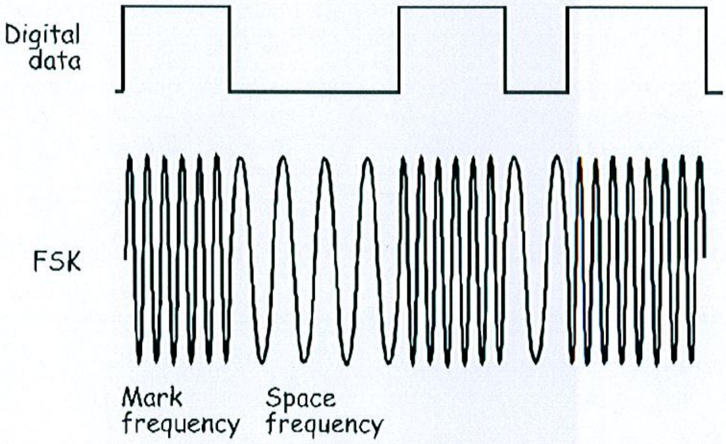

Figure 1

Notice that the FSK signal switches between two frequencies. The frequency of the signal that corresponds with logic-0s in the digital data (called the *space frequency*) is usually lower than the modulator's nominal carrier frequency. The frequency of the signal that corresponds with logic-1s in the digital data (called the *mark frequency*) is usually higher than the modulator's nominal carrier frequency. The modulator doesn't output a signal at the carrier frequency, hence the reference here to it as being the "nominal" carrier frequency.

FSK generation can be handled by conventional FM modulator circuits and the *voltage-controlled oscillator* (VCO) is commonly used. Similarly, FSK demodulation can be handled by conventional FM demodulators such as the *zero crossing detector* (refer to the preliminary discussion of Experiment 12 for an explanation of this circuit's operation) and the *phase-locked loop*. Alternatively, if the FSK signal is passed through a sufficiently selective filter, the two sinewaves that make it up can be individually picked out. Considered on their own, each signal is an ASK signal and so the data can be recovered by passing either one of them through an envelope detector (refer to the preliminary discussion of Experiment 8 for an explanation of the envelope detector's operation).

The experiment

For this experiment you'll use the Emona DATEx to implement the VCO method of generating an FSK signal. Digital data for the message is modelled by the Sequence Generator module. You'll then recover the data by using a filter to pick-out one of the sinewaves in the FSK signal and demodulate it using an envelope detector. Finally, you'll observe the demodulated FSK signal's distortion and 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 an FSK signal

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 and run the NI ELVIS II Function Generator VI.

9. Adjust the function generator using its soft controls for an output with the following specifications:

   - Waveshape: Sine
   - Frequency: 10kHz
   - Amplitude: 4Vpp
   - DC Offset: 0V
   - Modulation Type: FM

10. Connect the set-up shown in Figure 2 below.

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

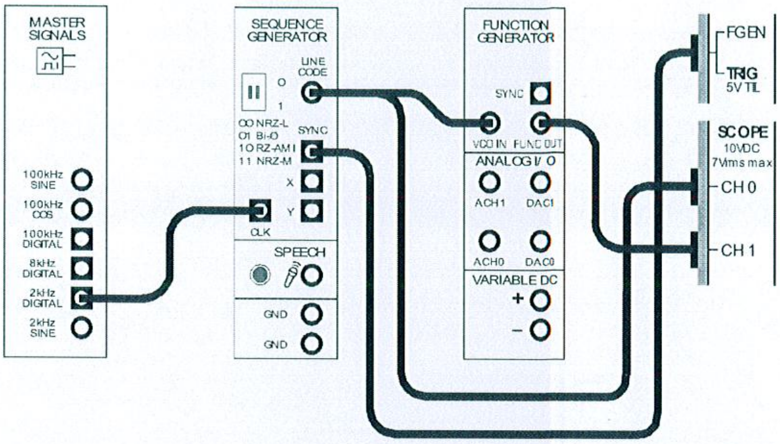

Figure 2

This set-up can be represented by the block diagram in Figure 3 below. 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 function generator's VCO facility is used to generate the FSK signal.

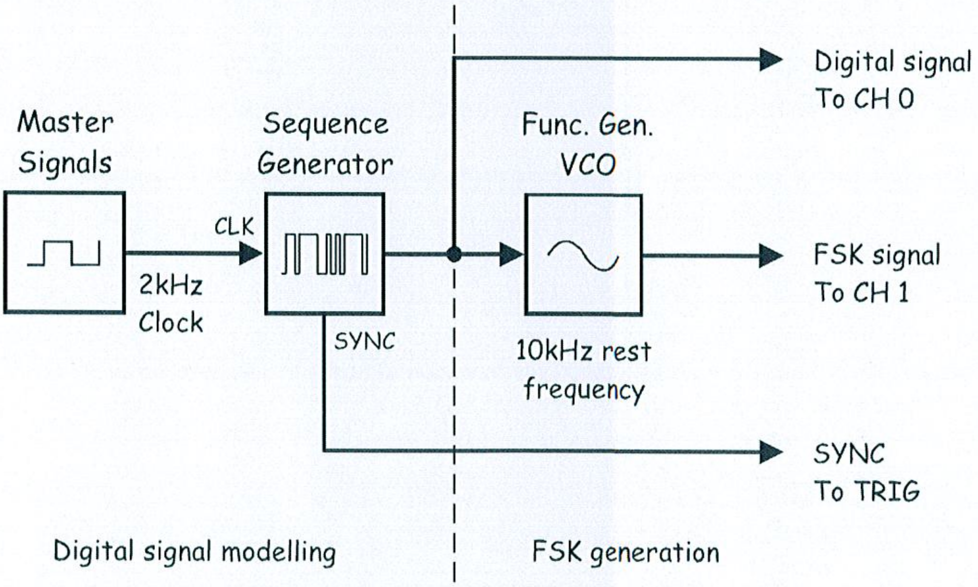

Figure 3

11. Launch the DATEx soft front-panel (SFP) and check that you have soft control over the DATEx board.

12. Locate the Sequence Generator module on the DATEx SFP and set its soft dip-switches to 00.

13. Launch and run the NI ELVIS II Oscilloscope VI.

14. Set up the scope per the procedure in Experiment 1 with the following change:

    - *Trigger Type* control to *Digital*

15. Activate the scope's Channel 1 input to observe the Sequence Generator module's output and the FSK signal out of the VCO.

    Note: Ensure that the scope's *Timebase* control is set to the *500μs/div* position.

16. Compare the signals.

Question 1
What's the name for the VCO output frequency that corresponds with logic-1s in the digital data? **Tip:** If you're not sure, see the preliminary discussion.

Question 2
What's the name for the VCO output frequency that corresponds with logic-0s in the digital data?

Question 3
Based on your observations of the FSK signal, which of the two is the higher frequency? Explain your answer.

Ask the instructor to check
your work before continuing.

Part B - Demodulating an FSK signal using filtering and an envelope detector

As FSK is really just FM (with a digital message instead of speech or music), it can be recovered using any of the FM demodulation schemes. However, as the FSK signal switches back and forth between just two frequencies we can use a method of demodulating it that cannot be used to demodulate speech-encoded FM signals. The next part of the experiment lets you do this.

17. Locate the Tuneable Low-pass Filter module on the DATEx SFP and turn its soft *Cut-off Frequency Adjust* control fully clockwise.

18. Turn the Tuneable Low-pass Filter module's soft *Gain* control fully clockwise.

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

    Note: Remember that the dotted lines show leads already in place.

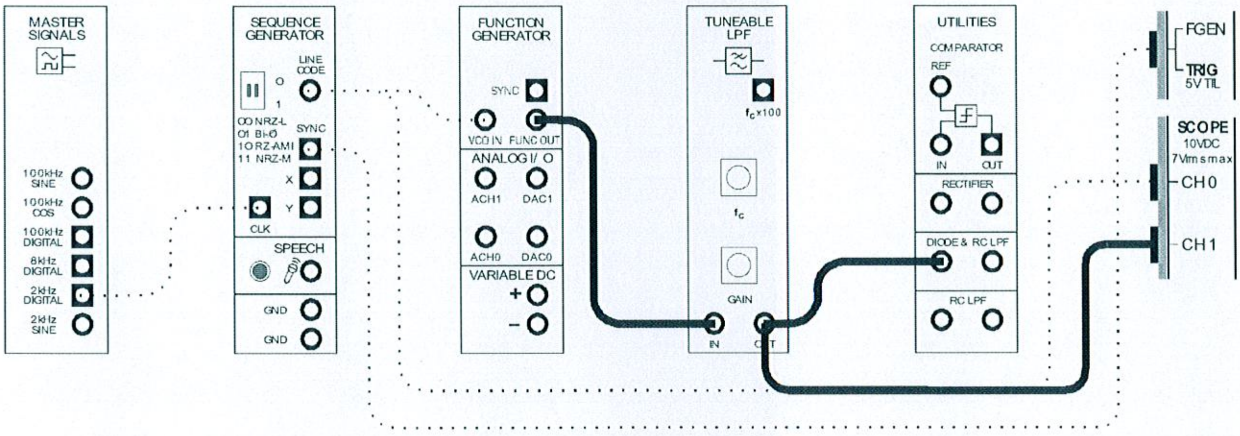

Figure 4

The FSK generation and demodulation parts of the set-up can be represented by the block diagram in Figure 5 on the next page. The Tuneable Low-pass Filter module is used to pick out one of the FSK signal's two sinewaves and the DIODE and RC LPF on the Utilities module form the envelope detector to complete the FSK signal's demodulation.

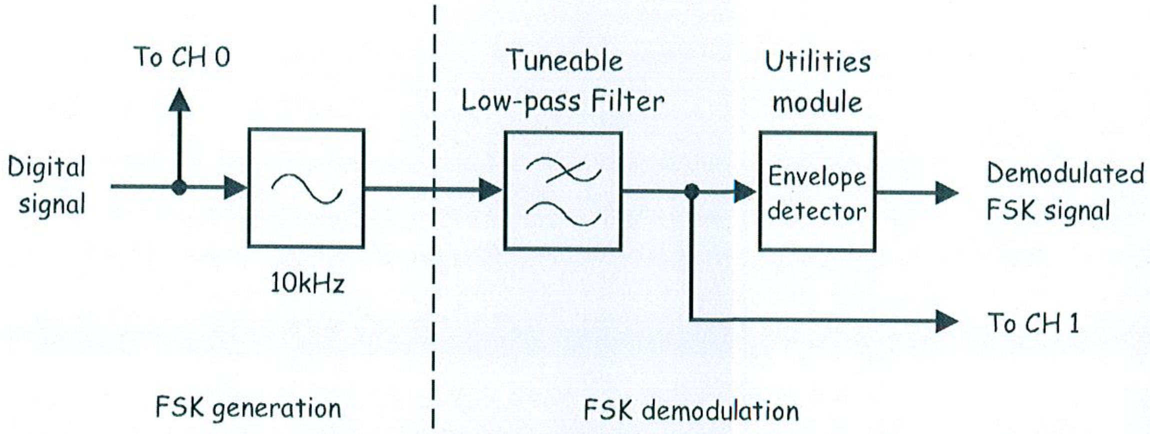

Figure 5

20. Slowly turn the Tuneable Low-pass Filter module's soft *Gain* control *Cut-off Frequency Adjust* control anti-clockwise until the higher (mark) frequency is reduced to zero but with the lower (space) frequency unaffected.

21. Compare the digital signal and the filter's output.

Question 4
Which of the FSK signal's two sinewaves is the filter letting through?

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Question 5
What does the filtered FSK signal now look like?

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☑ Ask the instructor to check your work before continuing.

22. Modify the set-up by connecting the scope's Channel 1 input to the envelope detector's output as shown in Figure 6 below.

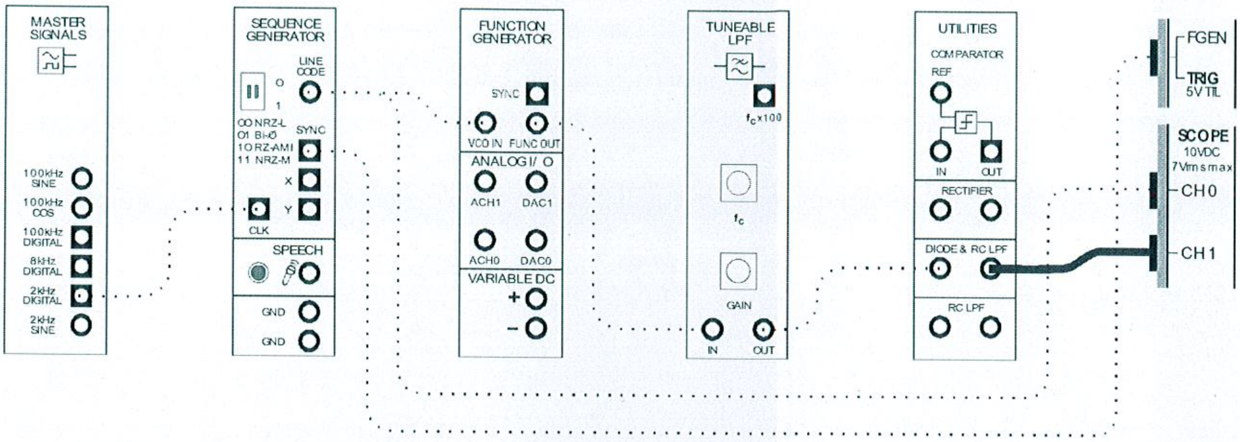

Figure 6

23. Compare the original digital signal with the recovered digital signal.

Question 6

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 FSK signal.

24. Launch and run the NI ELVIS II Variable Power Supplies VI.

25. Set the Variable Power Supplies' positive output to 0V.

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

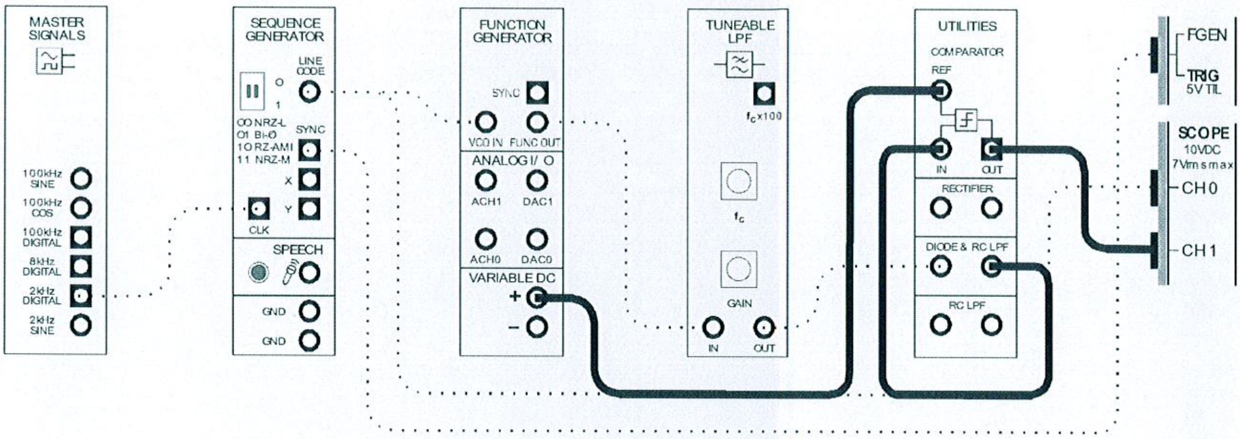

Figure 7

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

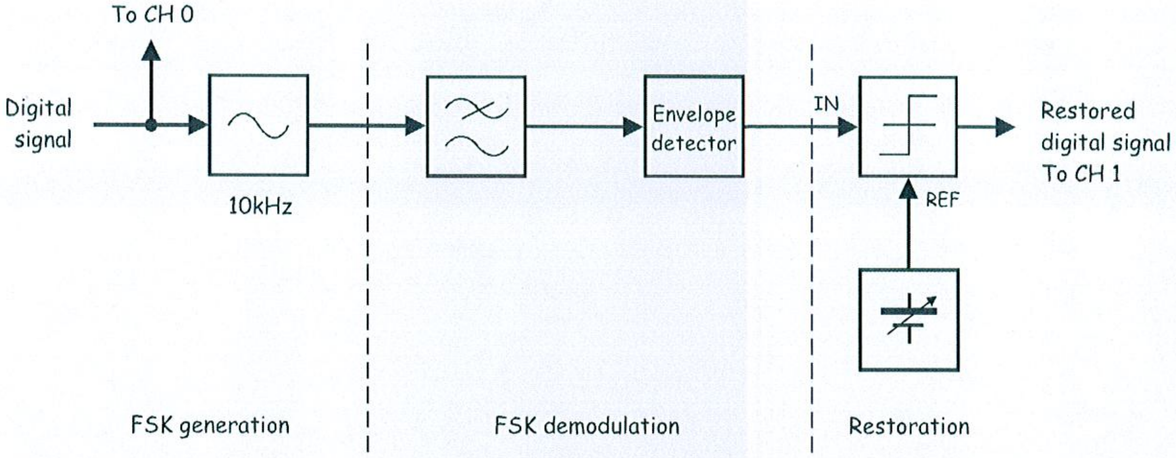

Figure 8

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

    Note: This will require fine adjustment of the reference voltage close to zero volts.

Question 7
How does the comparator turn the slow-rising voltages of the recovered digital signal into sharp transitions?

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☑ Ask the instructor to check your work before finishing.