EXPERIMENT 2:
Frequency Shift Keying (FSK)

1) OBJECTIVE

Generation and demodulation of a frequency shift keyed (FSK) signal

2) PRELIMINARY DISCUSSION

In FSK, the frequency of a carrier signal is modified in a discrete manner depending on the value of a modulating symbol. Binary FSK is the most common form of FSK where a pair of discrete frequencies are used to transmit binary information. Figure 1 illustrates a binary FSK signal (lower), together with the modulating binary sequence (upper).
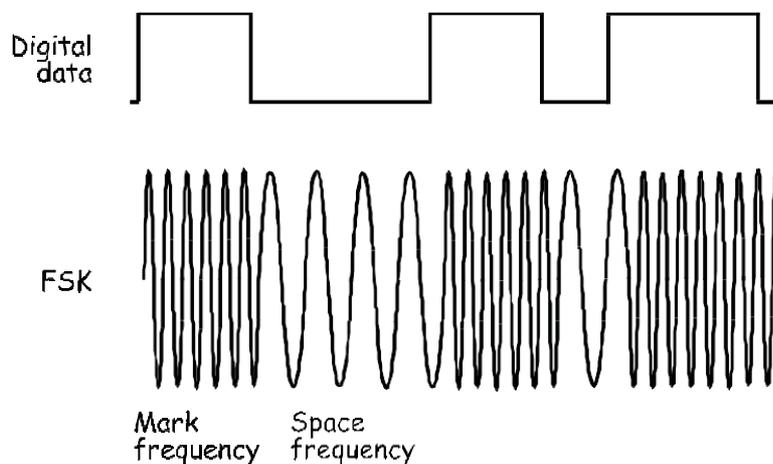

Figure 1: an FSK signal (below) and the message (above)

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 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.

3) LAB WORK

In this experiment you'll use the Emona Telecoms-Trainer 101 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.

Equipment

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

Procedure

Part A - Generating an FSK signal

1. Locate the VCO module and set its Gain control to about half its travel.
2. Set the VCO module's Frequency Adjust control to about a quarter of its travel (about the position of the number 9 on a clock face).
3. Set the VCO module's Range control to the LO position.
4. Locate the Sequence Generator module and set its dip-switches to 00.
   Tip: To do this, push both switches up
5. Connect the set-up shown in Figure 2 below.

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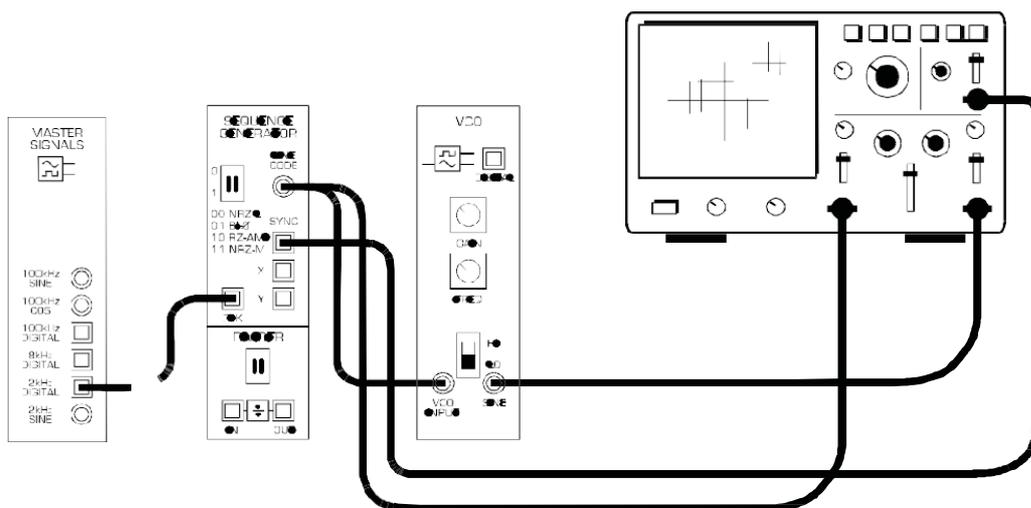

Figure 2: the set-up for an FSK signal generation

The set-up in Figure 2 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 VCO module is used to generate the FSK signal.
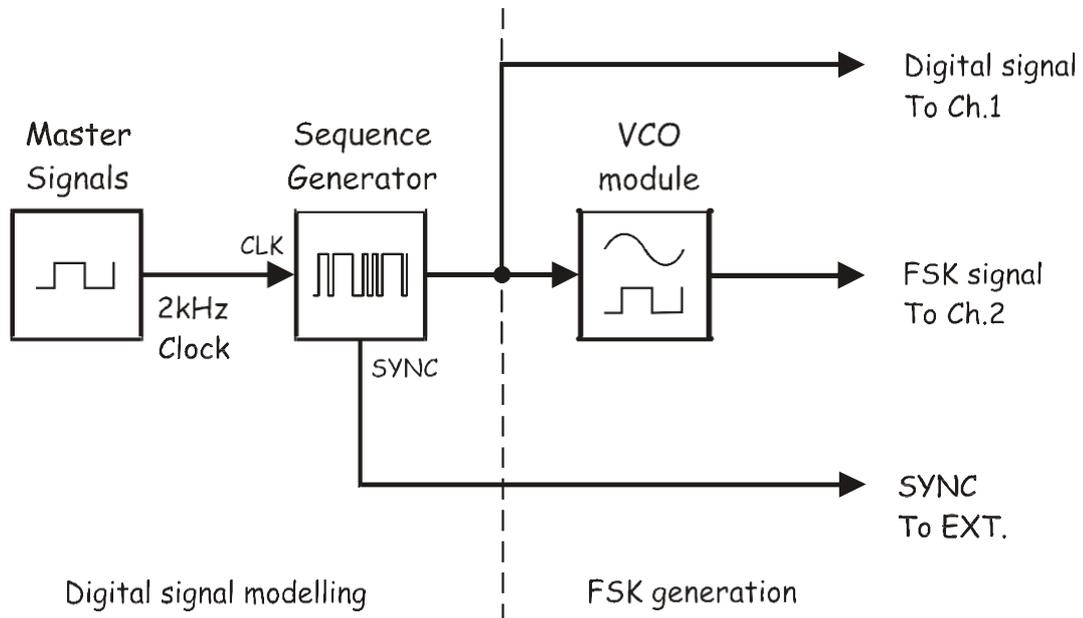

Figure 3: block diagram of Figure 2

1. Set the scope's Time base control to the 0.5ms/div position.
2. Set the scope's Mode control to the DUAL position to view the Sequence Generator module's output and the FSK signal out of the Voltage Controlled Oscillator module.
3. Compare and sketch the signals.

Note: If the sinewaves in the FSK signal roll too much, turn the VCO module's Frequency Adjust control a little left or right to stabilize it.

Part B - Demodulating an FSK signal using filtering and an envelope detector
As FSK is really just FM (with a digital message), 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.

1. Turn the VCO module's Frequency Adjust control to about the position of the number 2 on a clock face.
2. Locate the Tunable LPF module and turn its Cut-off Frequency Adjust control fully clockwise.
3. Turn the Tunable LPF's Gain control fully clockwise.
4. Modify the set-up as shown in Figure 4.

Note: Remember that the dotted lines show leads already in place. Also, the left most modules have been cut-off to fit the drawing on the page.
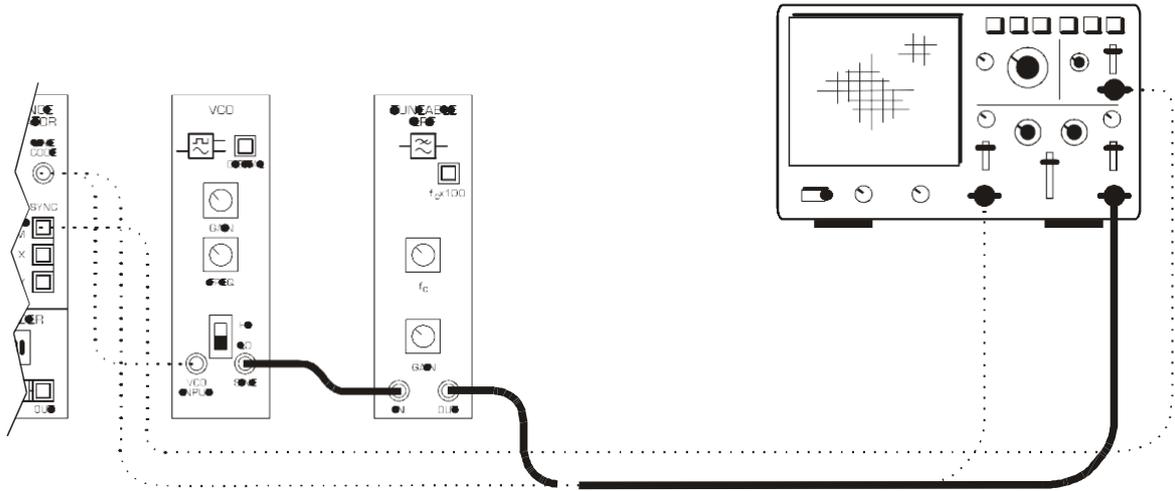
Figure 4: the set-up for a binary FSK demodulation

The FSK generation and demodulation parts of the set-up can be represented by the block diagram in Figure 5 below. The Low-pass filter module is used to pick out one of the FSK signal's two sinewaves and the RECTIFIER and BASEBAND LPF combination form the envelope detector to complete the FSK signal's demodulation.
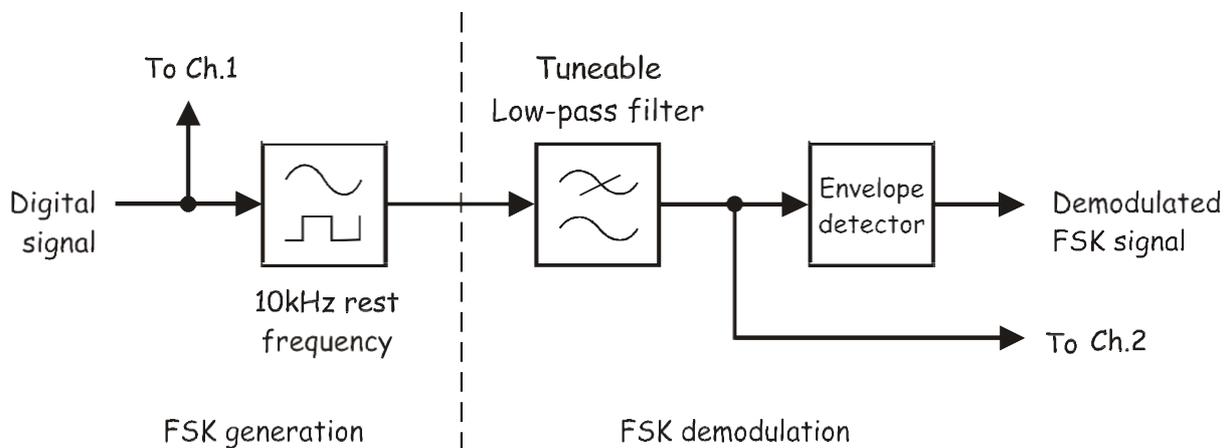

Figure 5: an FSK generation and demodulation

5. Turn the Tunable LPF's Cut-off Frequency Adjust control slowly from fully clockwise until the higher frequency component of the FSK signal becomes equal to zero, as shown in Figure 6.
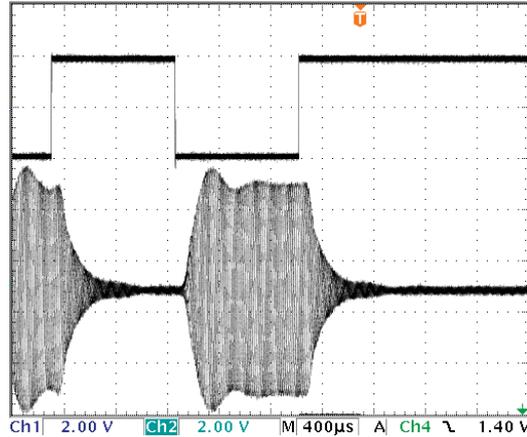
Figure 6: Filtering the FSK signal

6. Compare and sketch the digital signal and the filter's output. These should be visible as Ch.1 and Ch.2 on the scope display.

Question 1

Which of the FSK signal's two sinewaves is the filter picking out (passes through)? What does the filtered FSK signal look like?

Envelope Detection:

The envelope detector used in this experiment differs from the simple DIODE & RC LPF. In this experiment we use a combination of the RECTIFIER followed by the BASEBAND LPF.

Part C - Restoring the recovered data using a Comparator

In this part, a comparator will be used to clean-up the demodulated FSK signal.
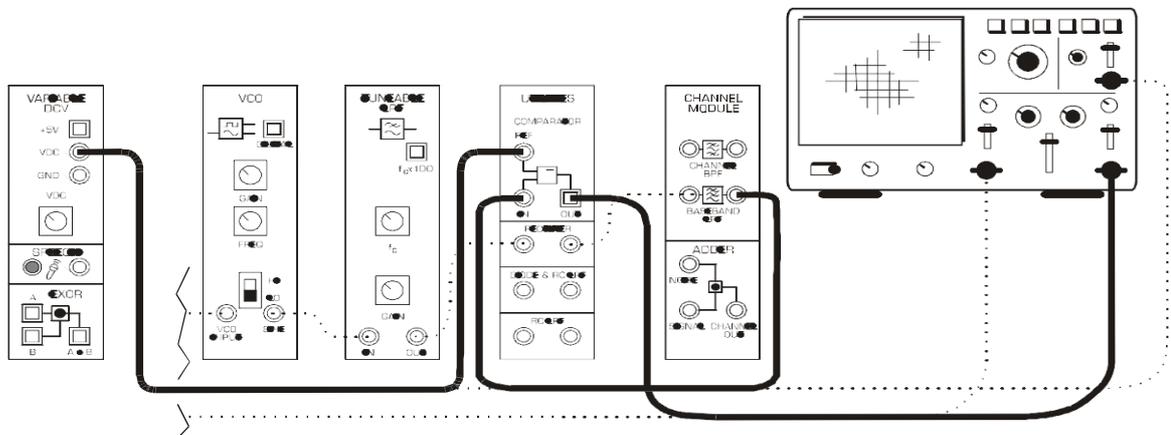
1. Modify the set-up as shown in Figure 8 below.

Figure 8: the set-up for a digital signal restoration

The FSK generation, demodulation and digital signal restoration parts of the set-up can be represented by the block diagram in Figure 9 below.
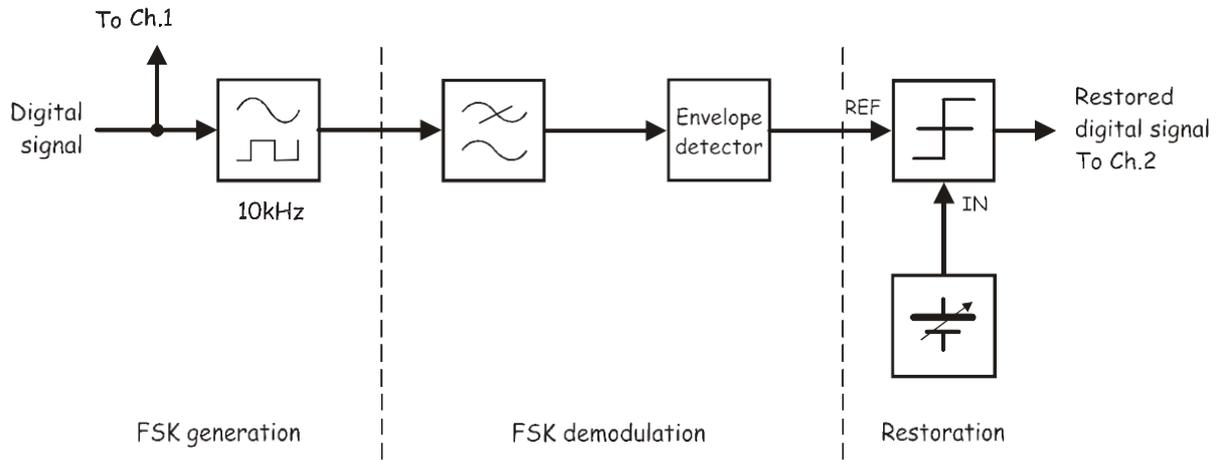

Figure 9: an FSK generation, demodulation, and digital signal restoration

2. Note the amplitude of the filtered signal into the Comparator. It varies from about 0 volts to a maximum level.
3. Set the Variable DCV module's Variable DC voltage output to a level which is half of the level noted. This signal is setting the threshold voltage of the Comparator.
4. Compare and sketch the original digital signal and the recovered digital signal out of the Comparator. If they are not the same vary the Variable DCV module's Variable DC control slightly until they are.

Question 2
How does the comparator turn the slow rising voltages of the recovered digital signal into sharp transitions?