Name: ______________________

Class: ______________________

17 - Amplitude shift keying

Experiment 17 - Amplitude Shift Keying

Preliminary discussion

An essential part of electronic communications and telecommunications is the ability to share the channel. This is true regardless of whether the channel is copper wire, optical fibre or free-space. If it's not shared then there can only ever be one person transmitting on it at a time. Think about the implications of this for a moment. Without the ability to share, there could only be one radio or TV station in each area. Only one mobile phone owner could use their phone in each cell at any one time. And there would only be the same number of phone calls between any two cities as the number of copper wires or optical fibres that connected them.

So sharing the channel is essential and there are several methods of doing so. One is called *time division multiplexing* (TDM) and involves giving the users exclusive access to the channel for short periods of time. On the face of it, this type of sharing might seem impractical. Imagine giving all mobile phone users in a cell just a minute or so to make their call then having to wait until their turn comes around again. However, TDM works well when the access time is extremely short (less than a second) and the rate of the sharing is fast. This allows multiple users to appear to have access all at the same time.

TDM is used for digital communications and is achieved by interleaving the users' data. That is, a portion of one user's data is transmitted followed by a portion of the next user's data and so on. Unfortunately, there's a catch. If the message is real-time information that cannot afford to be delayed (like digitally encoded speech) then, as the number of users increases, so must the data's bit-rate. However, Experiment 16 has shown that doing so increases the likelihood of the channel's bandwidth distorting the signal causing errors at the receiver.

Another method of sharing the channel is called *frequency division multiplexing* (FDM) and involves giving the users exclusive and uninterrupted access to a portion of the channel's radio frequency spectrum. To transmit their message the user must superimpose it onto a carrier that sits inside their allocated band of frequencies. This method is used by broadcast radio and television to share free-space.

FDM is also used for digital communications and uses the same modulation schemes available to analog communications including: AM, DSBSC and FM. When AM is used for multiplexing digital data, it is known as *amplitude shift keying* (ASK). Other names include: *on-off keying*, *continuous wave* and *interrupted continuous wave*.

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

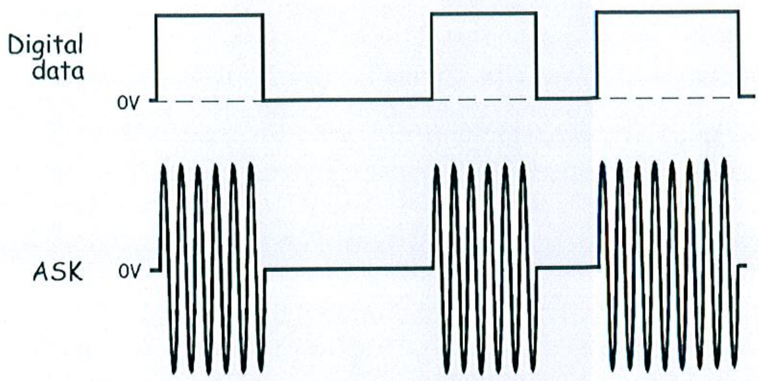

Figure 1

Notice that the ASK signal's upper and lower limits (the *envelopes*) are the same shape as the data stream (though the lower envelope is inverted). This is simultaneously an advantage and a disadvantage of ASK. Recovery of the data stream can be implemented using a simple envelope detector (refer to the preliminary discussion of Experiment 8 for an explanation of the envelope detector's operation). However, noise on the channel can change the envelopes' shape enough for the receiver to interpret the logic levels incorrectly causing errors (analog AM communications have the same problem and the errors are heard as a hiss, crackles and pops).

ASK can be generated by conventional means like the one modelled in Experiment 5. Here you'll examine the operation of an alternative method that involves using the digital signal to switch the carrier's connection to the channel on and off.

The experiment

For this experiment you'll use the Emona DATEx to generate an ASK signal using the switching method. Digital data for the message is modelled by the Sequence Generator module. You'll then recover the data using a simple envelope detector 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 an ASK 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. Connect the set-up shown in Figure 2 below.

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

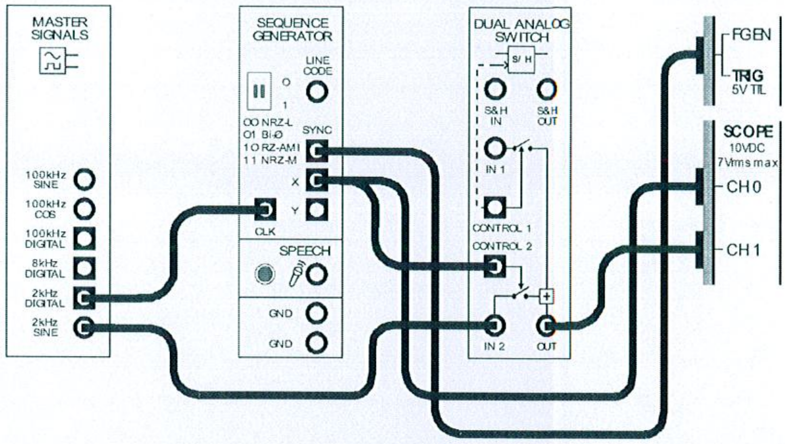

Figure 2

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 Dual Analog Switch module is used to generate the ASK signal.

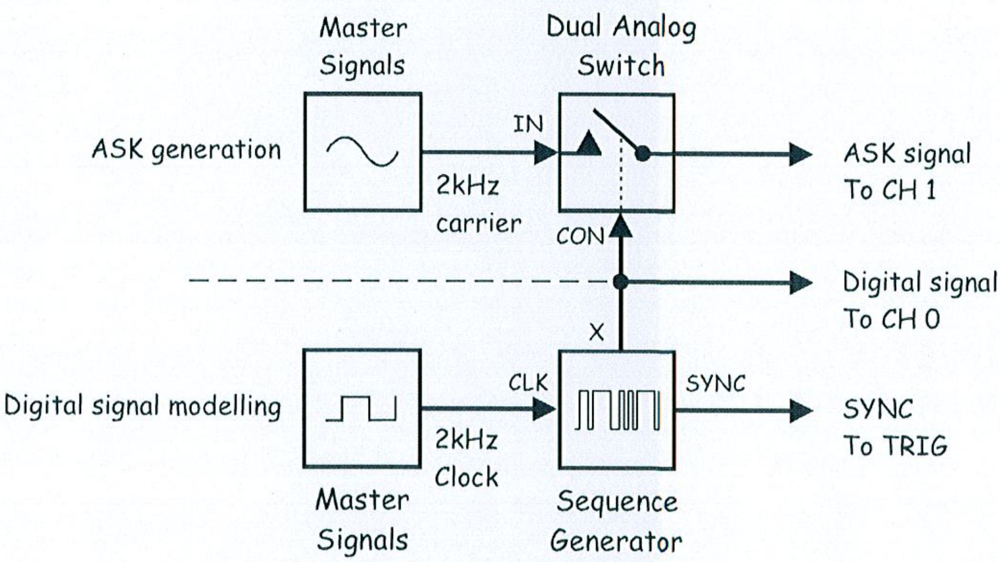

Figure 3

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

10. Set up the scope per the procedure in Experiment 1 with the following changes:

- Scale control for Channel 0 to *2V/div* instead of *1V/div*
- *Input Coupling* controls for both channels to *DC* instead of *AC*
- *Timebase* control to *1ms/div* instead of *500µs/div*
- *Trigger Type* control to *Digital* instead of *Edge*

11. Activate the scope's Channel 1 input to observe the Sequence Generator module's output and the ASK signal out of the Dual Analog Switch module.

12. Compare the signals.

Question 1
What is the relationship between the digital signal and the presence of the carrier in the ASK signal?

Question 2
What is the ASK signal's voltage when the digital signal is logic-0?

Ask the instructor to check your work before continuing.

Notice that the ASK signal's carrier and the Sequence Generator module's clock are the same frequency (2kHz). Moreover, notice that they're from the same source - the Master Signals module.

This has been done to make the ASK signal easy to look at on the scope. However, it makes the set-up impractical as a real ASK communications system because the carrier and the data signal's fundamental are too close together in frequency. For reasons explained in Experiment 8 (see pages 8-11 and 8-12), this makes recovering the digital data at the receiver difficult if not impossible.

Ideally, the carrier frequency should be much higher than the bit-rate of the digital signal (which is determined by the Sequence Generator module's clock frequency in this set-up). The next part of the experiment gets you to set the carrier to a more appropriate frequency. In the process, the Dual Analog Switch module's output will look more like a conventional ASK signal.

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

    Remember: Dotted lines show leads already in place.

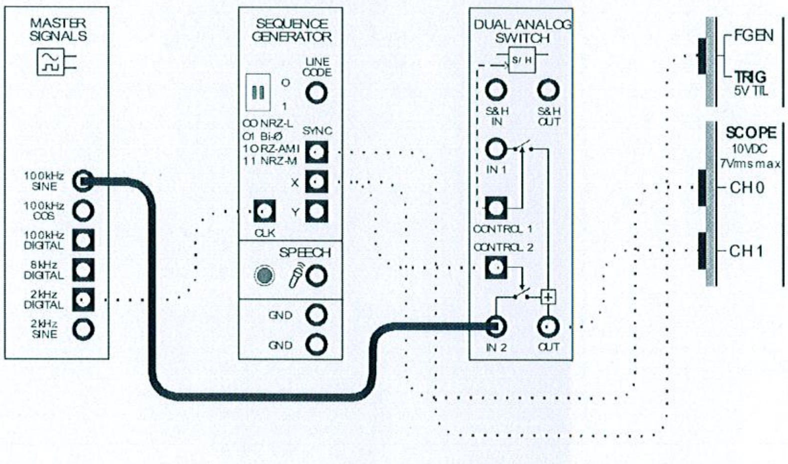

Figure 4

This set-up can be represented by the block diagram in Figure 5 below.

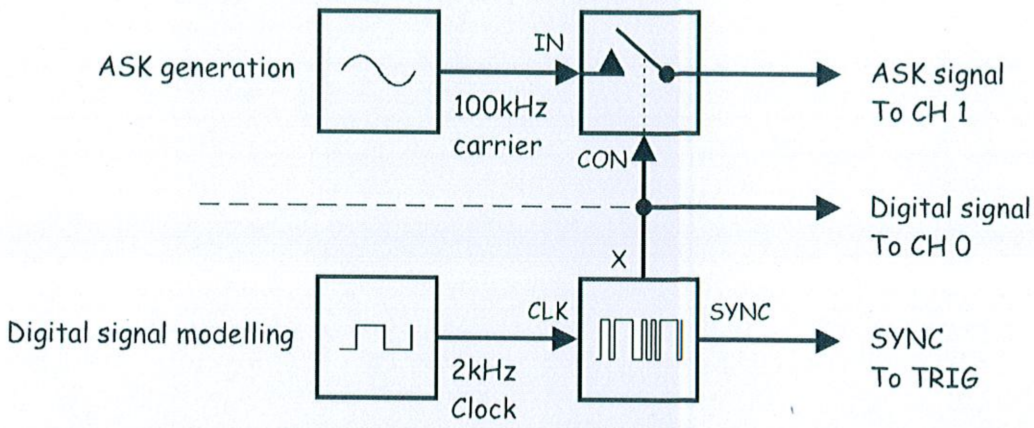

Figure 5

14. Compare the signals.

Question 3
What feature of the ASK signal suggests that it's an AM signal? **Tip:** If you're not sure, see the preliminary discussion.

Ask the instructor to check your work before continuing.

Part B - Demodulating an ASK signal using an envelope detector

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

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

16. Locate the Tuneable Low-pass Filter module on the DATEx SFP and turn its soft *Gain* control fully clockwise.

17. Turn the Tuneable Low-pass Filter module's soft *Cut-off Frequency Adjust* control fully clockwise.

18. Modify the set-up as shown in Figure 6 below.

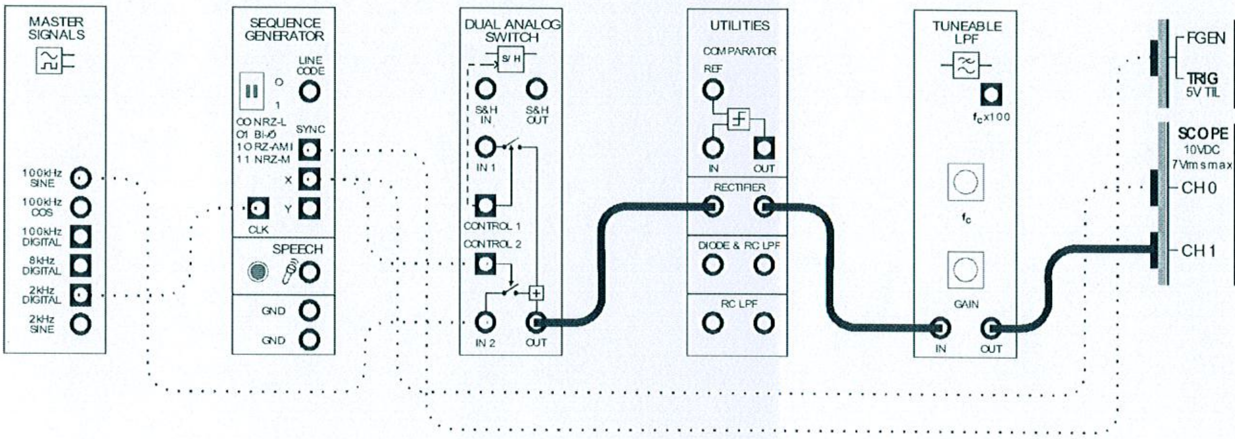

Figure 6

The ASK generation and demodulation parts of the set-up can be represented by the block diagram in Figure 7 on the next page. The rectifier on the Utilities module and the Tuneable Low-pass filter module are used to implement an envelope detector to recover the digital data from the ASK signal.

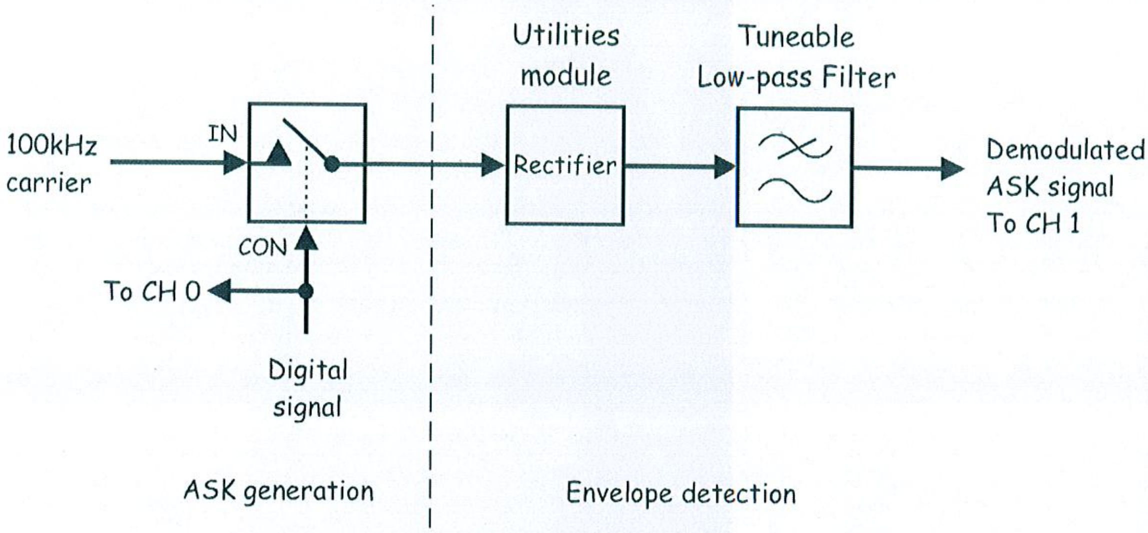

Figure 7

19. Compare the original and recovered digital signals.

Tip: If necessary, adjust the scope's Channel 1 *Scale* control for a better comparison between the signals.

Question 4
Why is the recovered digital signal not a perfect copy of the original?

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Question 5
What can be used to "clean-up" the recovered digital signal?

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Ask the instructor to check your work before continuing.

Part C - Restoring the recovered digital signal 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 ASK signal.

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

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

22. Modify the set-up as shown in Figure 8 below.

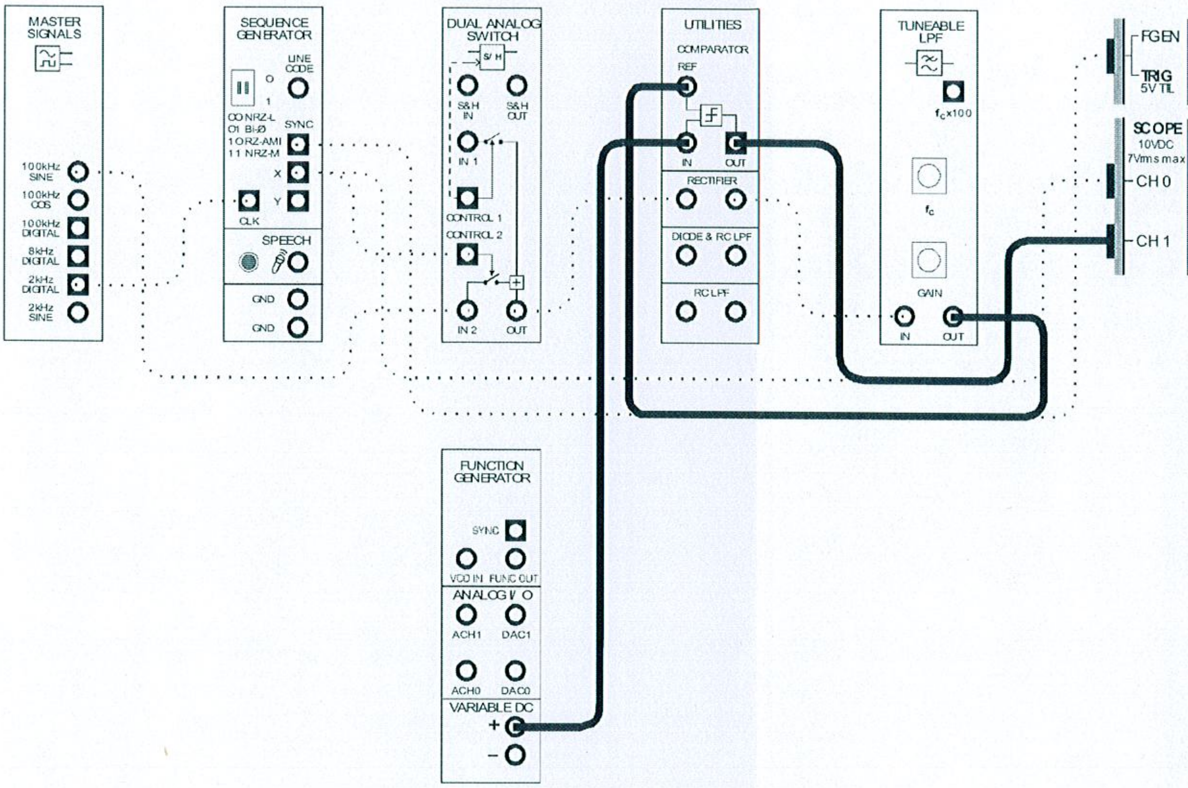

Figure 8

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

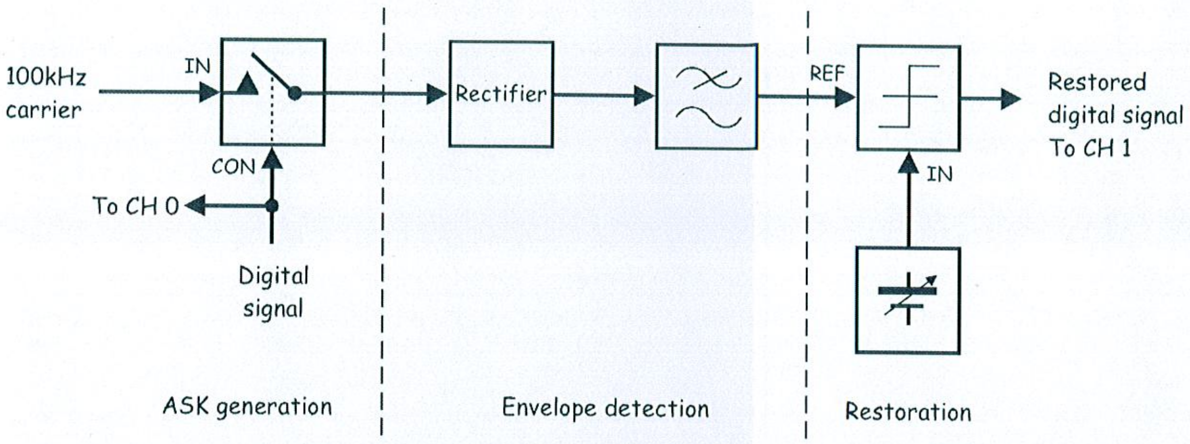

Figure 9

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

Question 6

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.