Equipment:

Each lab group requires:

XLR Socket for monitoring the received signal

Scope and BNC to crocodile lead

Breadboard setup

- Set of Wires for connecting things
- Multimeter
- 5V Power Supply (for line driver experiment)
- Breadboard
- 75176 RS-485 Line Driver

Experiment A:

- 120 ohm resistor
- Square wave generator, 5V TTL
- Data Sheet: 75176 Driver

Experiment B:

- Square wave generator, 5V TTL
- Data sheet: showing frequency response and slew rate of a RS-485 line transceiver

Experiment C:

- The lab will provide one DMX control surface
- DMX splitter and set of DMX cables to each lab work area.
- DMX shielded XLR leads

DMX Communications

This is a series of 3 exercises that explore the balanced line interface and the DMX Signal. The exercises should be done sequentially.

The course web site resources contain additional information that is useful.

Activity A. The RS-485 Bus

This activity is to familiarise yourself with the signal waveform using an oscilloscope and observe the operation of differential transmission.

The driver data sheet provides information on operation of the driver chip.

A separate sheet describes the frequency response and slew rate of a RS-485 line transceiver. This may be useful in explaining the shape of the waveforms that you observe when using the line driver at higher baud rates.

The DMX cable specification states that the cable transmitting data must have 3 wires. One ground, one positive (A) and one negative (B) connection. Logically a digital signal of 1 will be sent when the potential of the positive wire is greater than the potential of the negative wire and a signal of 0 will be sent when the situation is reversed. The ground wire in the cable is usually used as a noise shield offering two benefits: Noise will be of the same phase and magnitude in both wires and voltage degradation will be equal in both wires.

In most cases it is recommended that a 5 pin XLR cable is used for DMX applications, although in many cases the more robust 3 pin connector is used. The end of the cable must have a 120 (or 110) ohm resistor attached to prevent data corruption. Without termination resistors, reflections of fast driver edges can cause multiple data edges that can cause data corruption.

The DMX standard uses EIA-485 (formerly RS-485 or RS485). This is an electrical specification of a half-duplex, multipoint serial connection. The standard specifies differential signalling. The difference between the voltage on the pair of wires (A,B or A+/A-) convey the data. One polarity of voltage indicates a logic 1 level, the reverse polarity indicates a logic 0 level. The difference of potential between A and B must be different by at least 0.2 volts for valid operation, but any applied voltages between +12V and -7V is allowed at the sender.

You will be provided with a RS-485 line driver, the 75176. This is a well-known chip, that has seen faithful use in many pieces of DMX equipment. Familiarise yourself with the specification of this chip. Since the RS-485 bus supports two-way transmission, you need to ensure the tri-state control inputs to the chip select **transmit** mode, and place the receiver in the high-impedance mode.

- •Connect the data side of the driver chip to a 5V square wave generator (e.g. 10 kHz). Ensure you understand the output waveform on both the differential outputs (A,B).

- •Increase the signal to 250 kHz and then 1 MHz. What happens when you increase the frequency? (consult the driver data sheet and think about why the output waveform changes).

- •Place a 120 ohm resistor across the balance line, does this change the output waveform?

- •Place a second 120 ohm resistor also across the balance line, does this change the output waveform?

Activity B: Interface Loopback

This activity builds on the work in activity A.

The activity uses the line driver chip in a configuration commonly known as loopback, in which the output of the transmit part of the line driver is fed to the input of the receive part of the line driver. This configuration checks correct operation of both parts of the chip.

(a) Connect the two signals from line driver differential output to the two input channels of the oscilloscope.
(b) Use the signal generator to send a 60 kHz TTL a square wave into the Data Input (DI) pin. This will generate the corresponding balanced differential output signal at the cable interface.
(c) Enable and disable the transmit interface using the DE pin and observe the resulting effect on the differential output.
(d) Note the resulting waveforms.

Note that the chip internally connects the differential output and input signals together. You do not need to do this.

(e) Change the connection to channel 2 of the scope so that it shows the received TTL signal (RO).
(f) With transmit interface enabled, enable and disable the receive interface using the -RE pin and observe the resulting effect on the differential output.
(g) Measure the receive propagation delay through the receiver. Note the resulting waveforms. How long is the propagation delay? Is this value reasonable? (check the data sheet for the line driver).

(h) Repeat the above using a square wave frequency that illustrates the slew-rate limiting by the driver chip.
(i) Note the resulting waveforms.

Recording your work

To complete the exercise you must provide a set of labeled diagrams that capture the following (ensure your diagrams clearly label the axes and units for each of the waveforms).

- Provide a sketch showing the pair of balanced outputs (transmit) from the line driver chip for a 60 kHz signal.
- Provide a sketch showing the input and output (transmit) and waveforms using the line driver chip and note the chip propagation delay.
- Provide a sketch that illustrates the slew-rate limiting by the driver chip.

Please retain a copy of your diagrams for your own revision.

Activity C: DMX Frame Reception

The goal of this activity is to explore the complete DMX frame waveform.

The start of a DMX packet should be indicated by a break of 88uS or greater followed by a Mark After Break, MAB, of 8uS or greater. This break is used by the receiver to start reception of the DMX slots. The MTBF, Mark Time Between Frames can be up to 1 second. The MTBF is set high. The initial slot will contain a code which will inform the receiver what sort of data is going to follow and what will be controlled. For example lighting equipment will have a start code of zero. For other systems other start codes can be used. The start of a DMX packet should be indicated by a break of 88uS or greater followed by a Mark After Break, MAB, of 8uS or greater. This break is used by the receiver to start reception of the DMX slots. The MTBF, mark time between frames is from just above 0 second up to 1 second. The MTBF is set high.

Each DMX512 frame comprises a start code to identify the frame type and up to 512 eight-bit values, between 0 and 255, so one cable typically controls 512 device attributes. The initial slot will contain a code which will inform the receiver what sort of data is going to follow and what will be controlled. For example lighting equipment will have a start code of zero. For other uses other start codes can be used. This signal is sent at the start of each frame and consists of an extended break, followed by a Mark signal.

- Connect the DMX cable to a controller and observe the DMX waveform on a scope. A DMX splitter may be used to replicate the waveform on multiple cable segments, allowing each group of students to have a copy of the waveform.
- Check that you understand the waveform that is presented on the scope:
  - Can you identify the Start of the frame? It may help for you to use the start/stop button of a digital scope to freeze the waveform.
  - Can you identify the control slot (first character after the synchronisation break)?
  - Calculate the baud period, and hence deduce the duration of a slot. Is this value confirmed on the scope?
- Note the waveform for other slots
  - Slot 1 is set to 50% (0x80), slot 2 is set to 25% and slot 3 is set to 100%, can you verify the values in each case? (recall that data within a byte is sent lsb-first).
- Select a number values for slot 4, can you capture this also on the scope?
- Note that there is no precise timing between adjacent slots, when using asynchronous communication.

Recording your work

To complete the exercise you must provide a set of labeled diagrams that capture the following (ensure your diagrams clearly label the axes and units for each of the waveforms).

- Provide a sketch showing the start of the DMX waveform, the break, MAB and first two slots.
- Provide a sketch recording the waveform when sending a value of 0x00
- Provide a sketch recording the waveform when sending a value of 25%

Please retain a copy of your diagrams for your own revision.