Experiment 4
Digital Communication Link

Objectives

1. To show how data represented by data words can be sent as a digit stream, one bit at a time and reconstructed at a distant receiver.

2. To show that analogue signals can be converted to data words and sent by this process.

3. To show that communication can be accomplished in this way.

Equipment

Feedback Digital Communications Systems modules: 297A, 297H, 297K, 297M.
Function Generator
Oscilloscope

Procedure

Important

Keep the Spectrum Analyser **unconnected** unless you are told otherwise.

A. Establishing the data source

1. With power switched on, connect the Data Source Module to oscilloscope as shown in Figure E4.1.

2. On the Data Source Module, set the "Format" switch to "8-bit" and the "Data Source" to "Push buttons". This sets the module to output 8 data bits for each word, and the word is determined by the setting of the eight push buttons.

3. Put a jumper between "160 kHz" and "clock-in" on the Data Source Module. The 160 kHz clock determines the bit rate at the output of the Data Source Module. Without this connection, no binary data will be produced at the output.

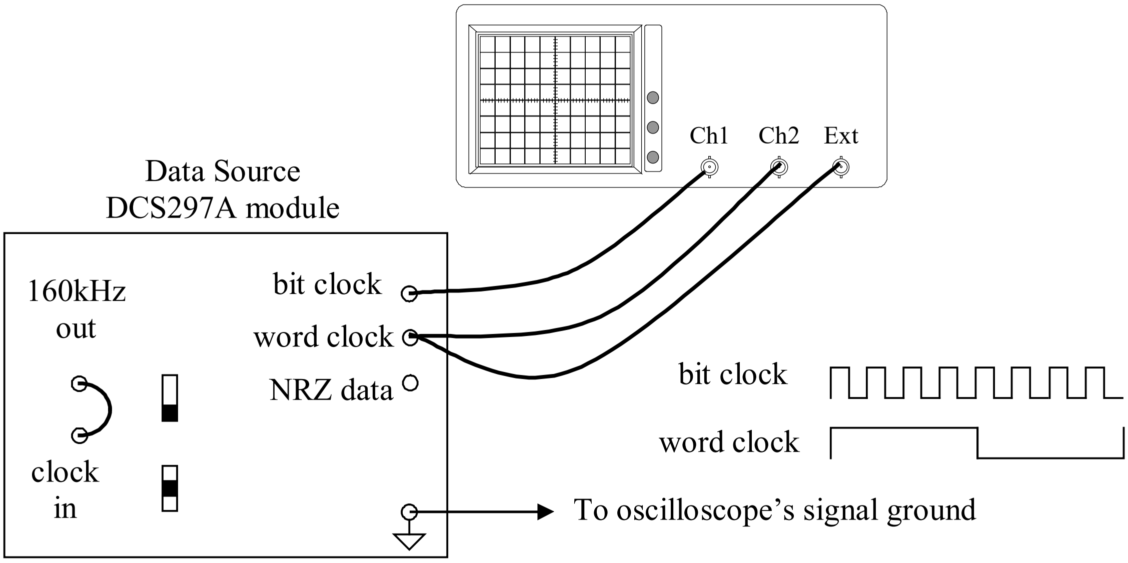

Figure E4.1 Observation of the bit clock and word clock

4. To view the signals on the scope, depress the "autoset" button or manually set the oscilloscope as follows:
   (i) CH1 and CH2 DC-coupled
   (ii) VOLTS/DIV = 5 V/Div
   (iii) TIME/DIV = 10 us/Div
   (iv) TRIGGER SOURCE = EXT, positive going edge

   On the oscilloscope, adjust the time/div knob and the "horizontal position" knob until you see the 8 cycles of the bit clock and 1 cycle of the word clock as shown in Figure E4.1.

   CH1 shows the BIT CLOCK which determines the rate at which bit signals will be generated.

   CH2 is the WORD CLOCK which marks the start of a WORD (eight bits).

   Question 1: What is the clock frequency of the bit clock and word clock?

   Frequency of bit clock: ______________________________

   Frequency of word clock: ______________________________

5. Refer to Figure E4.1 and connect the "NRZ data" to CH2. Also connect the word clock to "Ext" on the oscilloscope. Using the row of black push-buttons on the Data Source Module, set up the binary pattern **01001100**.

   Observe the NRZ data waveform in CH2. To observe the NRZ data waveform correctly ensure that the following steps are carried out:

(i) Ensure that you have connect the word clock to "Ext" on the oscilloscope.
(ii) Press "autoset".
(iii) On the oscilloscope, press the "trig menu" button and set the trigger source to "Ext".
(iv) Zoom in, using the sec/div knob, to view only 8 bits for both the NRZ data and bit clock waveforms.
(v) Using the "horizontal position" knob move the "trigger arrow" at the centre of the oscilloscope's display until it is at the extreme left of the display where it will become horizontal.
(vi) Use the "measure" button to measure values in the waveforms like period, frequency, peak-to-peak voltage if required.

The CH2 waveform is now a simple form of digital signal in which a stream of "bits" is sent, one after the other. The word set up on the push buttons presents all eight bits of the word at once, "in parallel". They are applied to a "parallel to serial converter". This sends each of the input bits in turn to the "NRZ data" output, timed by the bit clock.

6. Set the word using the push buttons to **01110100**. Record the waveform of CH1 and CH2 accurately.

B. Sending an analogue signal digitally

1. In order to send an analogue signal, it must first be converted into digital form. This is called analogue-to-digital Conversion (ADC).

   Set the <u>data source switch to ADC now</u> so that the bits of the signal are now determined not by the push buttons but by a voltage, at the "analogue input" socket.

   Prior to connecting the analogue input, use the small "**zero**" knob to adjust the data word to **10000000** while shorting the "analogue input" to ground. Remove the shorting wire.

2. Set the function generator to produce a 2 V DC signal.

3. Connect the function generator output to the "analogue input" and earth terminals of the DCS297A. Observe the waveform of the 8 bits NRZ data output on oscilloscope CH1.

4. Sketch the NRZ data waveforms.

5. Reset the function generator to produce a 1.5 V_{pp} **sine** waveform at 0.01 Hz with DC = 0 V.

6. Observe the NRZ data output.

   Note: The NRZ data output is changing continuously as the ADC encodes different samples of the input and each sample is converted to a different digital output.

C. Receiving digital words

1. Add the data **receiver** module **DCS297H**, by placing it to the right of data source. Connect the two together and set the two switches on the data receiver as shown in Figure E4.2.

   Note that the "received data" lamps in the receiver module now show the same patterns as are being sent from the source.

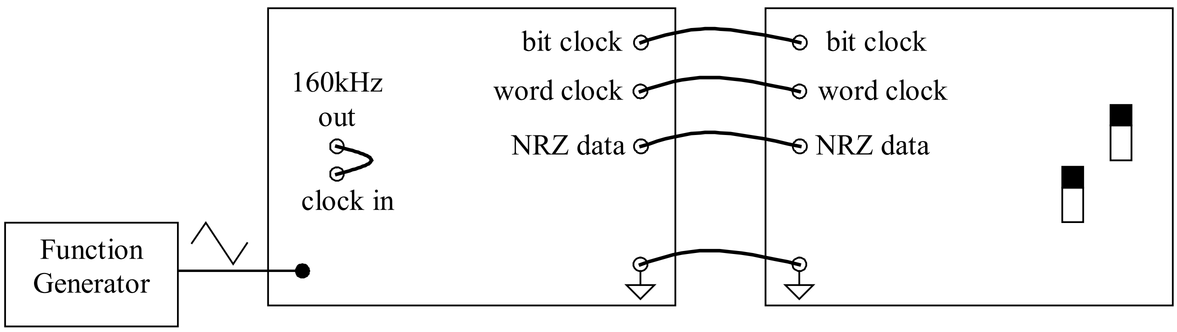

Figure E4.2 Receiving digital words.

D. Obtaining an analogue output

1. If the output is to be presented to an analogue device, the received word has to be processed by a digital-to-analogue converter (DAC).

2. Change the oscilloscope connections:

   (i) CH1 to analogue input of Data Source

(ii) CH2 to analogue output of Data Receiver

Increase the frequency of the input signal (Function Generator) to 100 Hz.

Press “autoset” and you should see an analogue output which is a reasonable copy of the original input. What you have is a simple digital communication system.

3. Increase frequency of the input signal (Function generator) to 2 kHz.
4. Using the spectrum analyser, observe and sketch the spectrum of the reproduced signal i.e. the analogue output.