Experiment 6
Pulse Code Modulation (PCM)

Objective

To examine the operation of a PCM encoder and decoder.

Equipment

1 PCM Module 296F
2 Power Supplies
Oscilloscope
Function Generator

Important Notice

The PCM Module 296F MUST be connected as follows:

Red to +15 volts
Green to 0 volts (GND)
Black to -15 volts

Introduction

PCM is a very well known type of digital pulse modulation system which provides the basis for voice coding in Integrated Services Digital Network (ISDN). The PCM Module 296F is a useful learning module. It contains both a PCM encoder and a PCM decoder. Figure E6.1 shows the Module 296F.

Procedure

Important

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

PCM Encoding and Decoding of the 296F Module

1. Referring to Figure E6.1, set the 3 bit/4 bit switch to the 4 bit position. Set encoder's clock to SLOW. Plug the 296F Module to the power supply.

2. Observe that the output of the latch stops at a value for a long interval. Record this value.

   Value of the latch's output = ____________ .

What is the analogue voltage level represented by this latch output?

Analogue voltage level = ____________ .

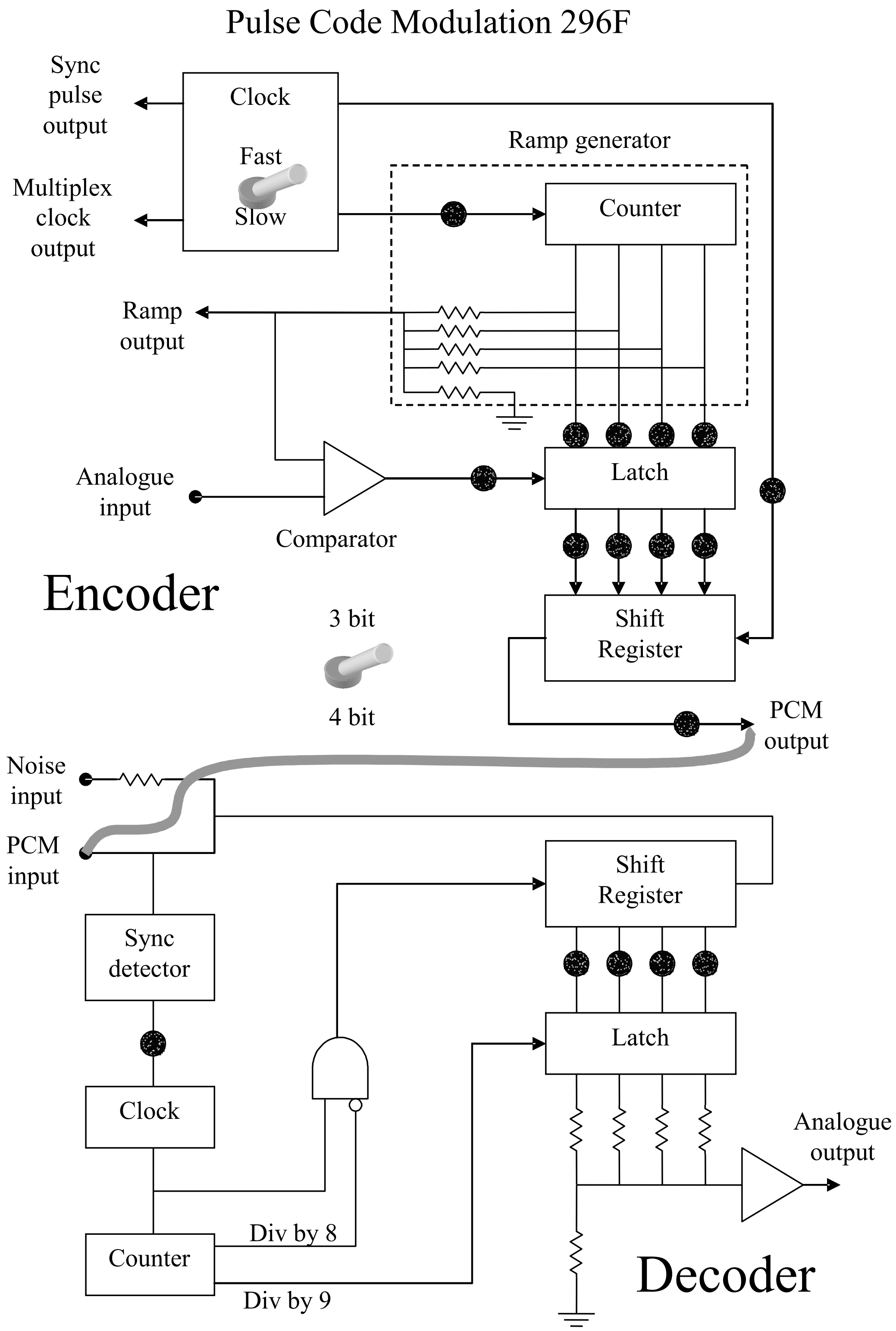


Figure E6.1 PCM Encoder and Decoder module (296F)

Note: The counter counts in binary numbers, and the four bits, which are displayed on the lamps above, on which, at successive counts, we can see in turn all the binary numbers from 0000 to 1111. The indicator lamps indicate a logic `1' state when lighted. The most significant bit is at the left of the counter.

3. Connect the `ramp output' to oscillosope CH1. Set encoder's clock to **FAST**. Press Autoset and use the time/div knob to observe 3 or 4 cycles of the ramp output signal. Sketch the ramp output signal as displayed on the oscilloscope, labelling its minimum and maximum voltage levels and the step size

4. Determine the following values for the 'ramp output'' signal.

   a) the sampling interval: ________________

   b) the sampling frequency: _________________

   c) the maximum input frequency that can be handled by the system: _________________

   d) Explain your answer in part c) above.

5. Note: A comparator is used to make a continuous comparison between the changing ramp voltage and that of the analogue signal. The latter is attenuated by a factor of 0.35 before it is input to the comparator i.e. 1 volt input appears as 0.35 volt to the input of comparator. When the comparator operates, it delivers a `1' output if the attenuated analogue input voltage is more positive than the ramp, and a `0' if the attenuated analogue signal is lower that the ramp. A `1' signal from the comparator causes the 'latch' circuit to transfer the data at its input to its output. Thus if the attenuated analogue signal exceeds the ramp signal each count of the counter appears at the output of the latch. If on the other hand the ramp signal exceeds the attenuated analogue signal, the counter outputs, although presented to the latch are not accepted by it and the latch output remains steady, until the count of zero is reached, when it is reset.

6. Set encoder clock to SLOW. Connect the function generator output to the analogue input of the DCS 296F module.

7. Generate the DC voltage shown in the table, observe and record the digital output at the latch for the DC input voltage below:

DC input voltage	Digital Output of latch
-1.4 V	
+1.6 V	

8. The binary number, represented by the four bits held in the latch output when the counter reaches the count of 15, is a digitally encoded equivalent of the analogue signal at some time during the current count.

9. The encoded number must be sent into the transmission system with a particular bit pattern so that it can be sorted out at the far end. The 296F Module uses the following bit pattern:

0 0 **A B C D** 0 0 1 1 1 1 1 1 1 1

where the four bits A, B, C, D, represent the encoded number being sent.

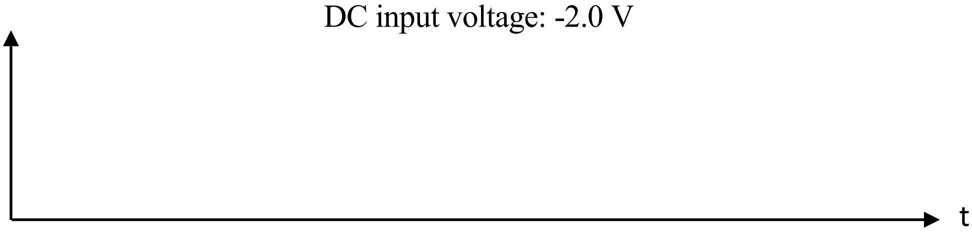
10. Set encoder's clock to **FAST**.

11. With the 'ramp output' signal connected to oscilloscope CH1, connect the PCM output to CH2. Connect the **`SYNC' pulse output** at the top left corner of the Module to Oscilloscope EXT input. Set the trigger source to EXT using the TRIG Menu.

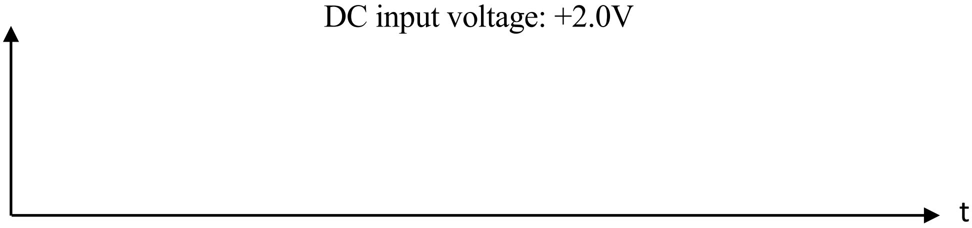
12. Adjust the DC voltage output from the function generator to –2 V and +2 V. For each case, observe the PCM output signal, then record the PCM transmitted bit and draw the signal displayed on the oscilloscope.

DC input voltage	PCM transmitted bit pattern
-2.0 V	
+2.0 V	

DC input voltage: -2.0 V



DC input voltage: +2.0V



13. **Reset the DC value to 0 V first and disable the "gate" button.** Change the function generator output to a 2 kHz sine wave with amplitude of 1.5 V_{pp} .

14. Connect the analogue input of the encoder to oscilloscope CH1.

15. Connect the `PCM output' of the encoder to the PCM input of the decoder.

16. Connect the analogue output of the decoder to oscilloscope CH2.

17. Press Autoset on the oscilloscope. Compare the original signal (CH1) and the reproduced signal at the end of the whole PCM communication chain (CH2).

    Are they similar? ________________

18. Using the spectrum analyser, observe and sketch the spectrum of the reproduced signal (up to a frequency range of 50 kHz), i.e. the analogue output of the **decoder**.

Important

Make sure that you have set the input signal voltage level as instructed before connect the signal to the spectrum analyser.