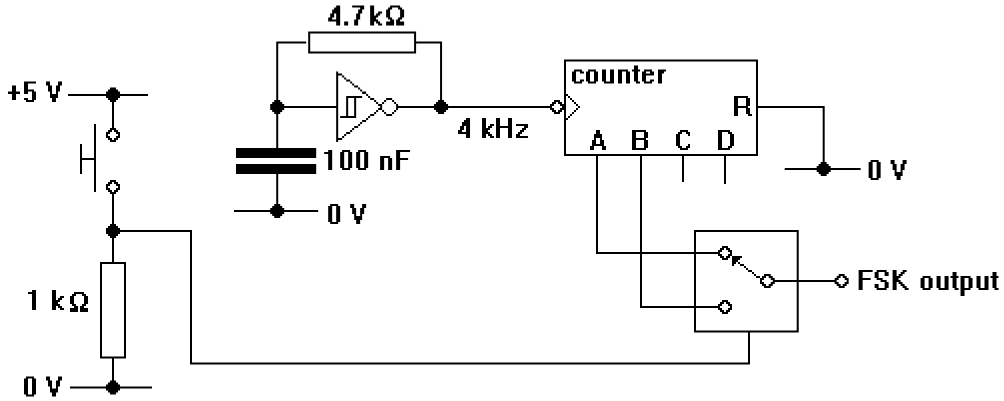
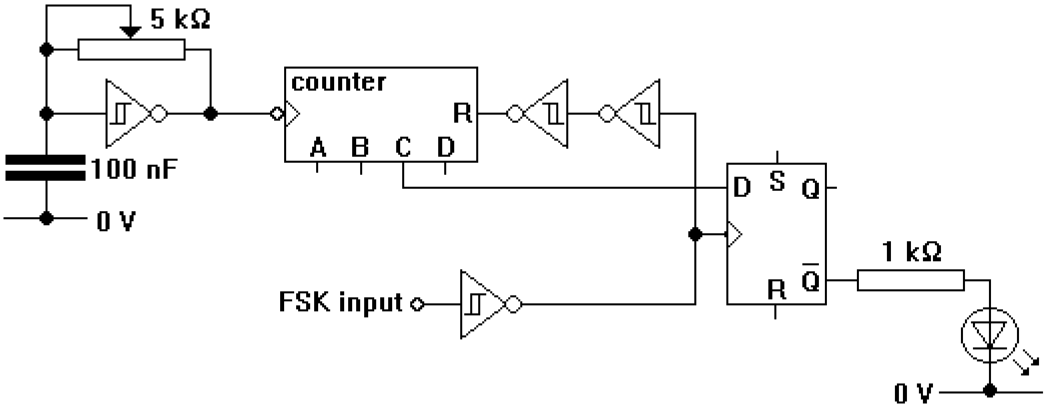
An FSK transmission system

1 Assemble the FSK transmitter circuit shown below.



2 Use an oscilloscope to check that the FSK output switches between 2 kHz and 1 kHz as you press and release the switch.

3 Assemble the FSK receiver shown below. Make sure that both set and reset pins of the flip-flop are held low.



4 Use an oscilloscope to set the frequency of the relaxation oscillator to exactly 3/2 that of the FSK transmitter oscillator. If in doubt, go for 6.0 kHz.

5 Connect the transmitter to the receiver. If all is well, the LED should glow only when you press the switch. In any case, use a double-beam oscilloscope to monitor the signals at the FSK input and C. Adjust the frequency of the receiver oscillator to achieve optimum behaviour for the system.

6 Replace the switch with a variable frequency relaxation oscillator, like the one shown above. Use a 10 F capacitor so that its frequency can be varied between 50 Hz and 500 Hz. It will send the worst-case signal of 10101010 ......

7 Use trial and error to establish the maximum rate at which your system can reliably transmit information between receiver and transmitter. You should be able to get up to 1000 bps if you get the right frequency for the oscillator in the receiver circuit!

Investigating sampling distortion with SAMPLE

SAMPLE.XLS is a spreadsheet. It allows you to enter the amplitude and frequency of a sinusoidal signal and then see the consequences of sampling it with an analogue-to-digital converter which has a specified sampling rate and word length.

1 Load up the spreadsheet. Enter a signal with an amplitude 800 mV and a frequency of 250 Hz. Sample it with 16-bit words at a rate of 32 kHz.

2 Press F9 to update the calculations. Then look at the output waveform.

3 Find out what happens to the waveform when the word length is reduced to 8-bit, 4-bit and 2-bit in turn.

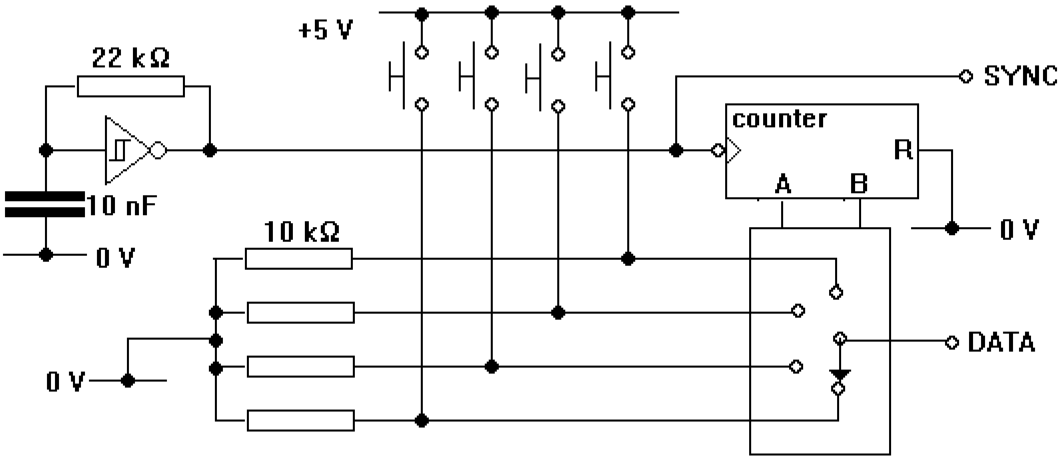
4 The range of the converter is a fixed 2 000 mV. Calculate the resolution of the converter when it uses a 4-bit word. Confirm your value by measuring the smallest step in the waveform for a 4-bit word.

5 Set the word length to a fixed 8 bits. See what happens to the output waveform when the sampling frequency is halved. Keep halving the sampling frequency until the output waveform no longer has a frequency of 250 Hz.

6 The sampling rate must be at least twice the frequency of the signal for error-free transmission of the signal frequency. For a variety of different signals, check that this rule is correct.

A simple t.d.m. system

You will need a partner for this experiment. One of you will assemble the transmitter shown below, as follows.

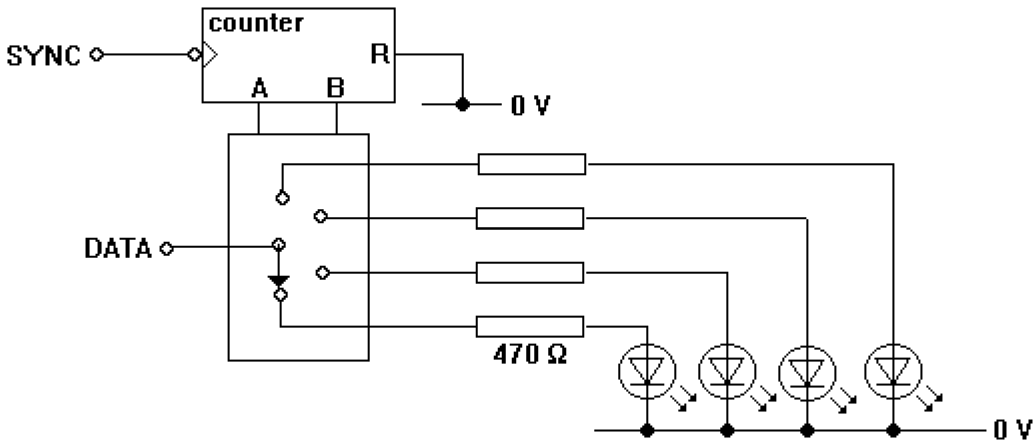


1 Assemble the oscillator first. Use a c.r.o. to check that it has a frequency of about 10 kHz.

2 Now add the rest of the circuit above. Check that A and B have frequencies of about 5 kHz and 2.5 kHz respectively.

3 Use a c.r.o. to investigate how the signal at DATA depends on the state of the four switches in the transmitter circuit above.

Meanwhile, your partner needs to assemble the receiver circuit below, on a separate breadboard. Both systems must use ground as 0 V.



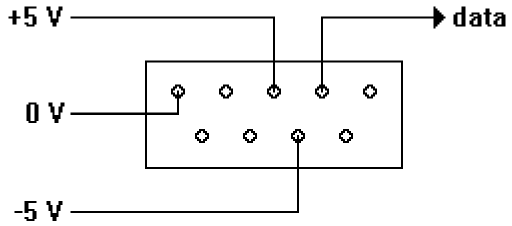
4 Connect SYNC and DATA to the receiver circuit. If all is well, each LED should respond to one (and only one) of the switches in the transmitter.

5 The system you have built uses two wires to transmit four separate one-bit words along two cables. Adapt it so that it sends three separate two-bit words along three cables.

Serial transmission

You will need access to a storage oscilloscope and a computer mouse for this experiment.

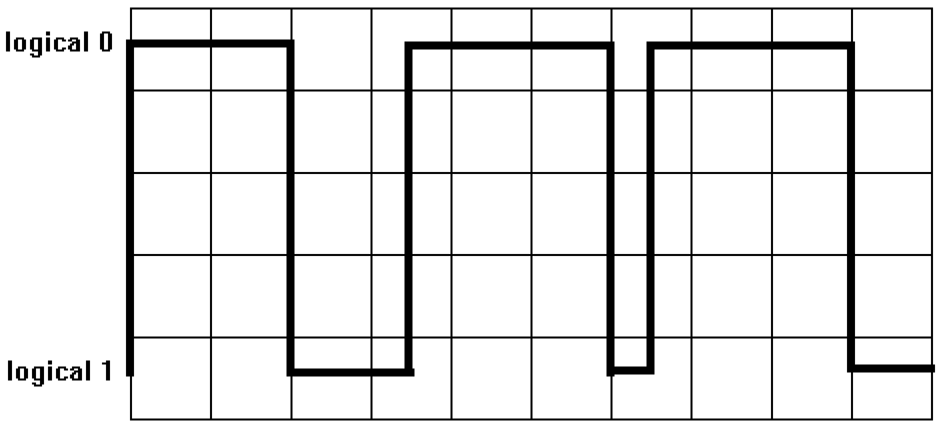
1 The diagram shows the power supply connections needed for the mouse, looking into the nine-pin plug which fits into the serial port of a PC. You can make the connections by sticking bared wire into the sockets.



2 Connect the data line to a c.r.o. Turn off the timebase, so that you see a spot on the screen. If all is well, the data line should sit at -5 V (the serial equivalent of logical 1) and pulse to +5 V each time the mouse is clicked or moved.

3 Set up the storage oscilloscope as follows:
trigger on a rising edge,
capture and display 25 ms of signal,
deal with signals between -5 V and +5 V.

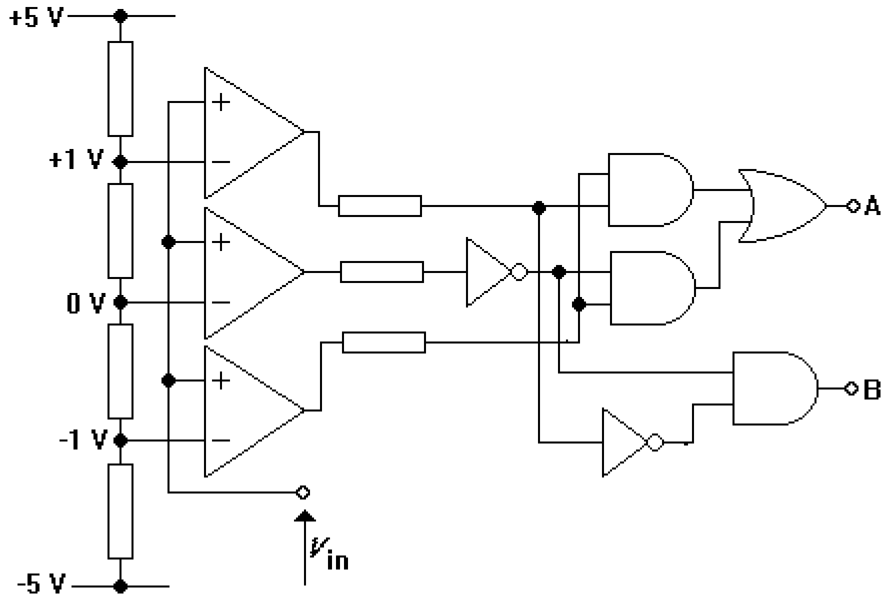
4 Left-click the mouse, without moving it. If all is well, you should capture a word transmitted in serial form, similar to the one shown below.



5 By capturing the serial signals produced by clicking and moving the mouse, determine the following:
the time needed to transmit a single bit,
the length of the word being transmitted,
the maximum rate at which these words can be fed out,
if there is a parity bit at the end of the word.

A flash converter

The diagram shows a flash converter. It codes the input voltage V_{in} as shown in the table.



voltage range	output BA
above +1.0 V	01
+1.0 V to 0 V	00
0 V to -1.0 V	11
below - 1.0 V	10

Your task is to design and test a flash converter which codes its input voltage according to the table below. The series of instructions will guide you through the process in stages.

voltage range	output BA
above +1.5 V	11
+1.5 V to +1.0 V	10
+1.0 V to +0.5 V	01
below +0.5 V	00

1 Put together a resistor chain to give you reference voltages at +0.5 V, +1.0 V and +1.5 V. Test it with a voltmeter.

2 Use a 5 k potentiometer and a 4.7 k resistor to make a voltage which can be varied between 0.0 V and +2.5 V. Test it.

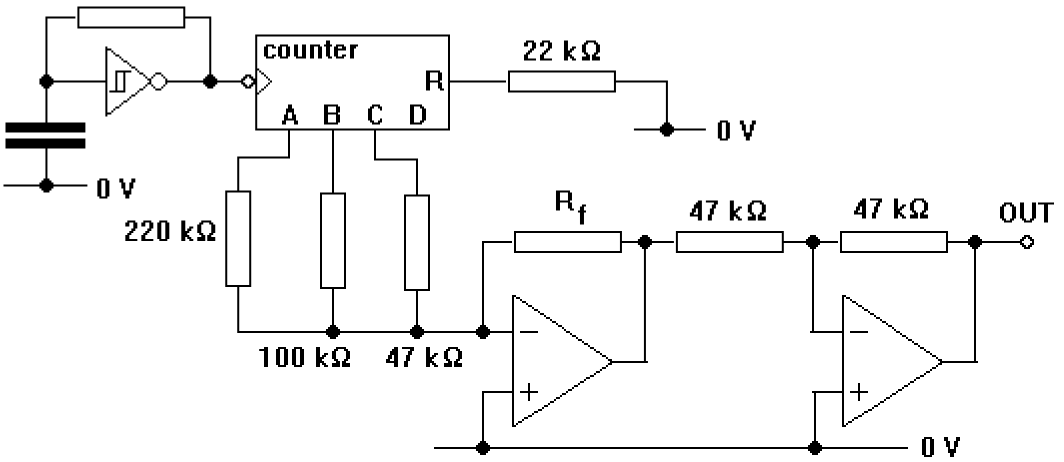
3 Assemble a chain of three op-amps to compare your reference voltages with the variable voltage.

4 Design a logic system to combine the three op-amp outputs to generate the two-bit word required. Use 10 k series resistors to protect the logic gate inputs.

5 Test the whole system, using LEDs to show the state of the output word.

Generating a voltage ramp

The circuit shown below should generate a nice stepped ramp voltage at OUT. The counter injects binary words into a three-bit digital-to-analogue converter.



1 Assemble the oscillator and 4024 counter. Select components for the oscillator which give it a frequency of about 1 kHz.

2 Use a c.r.o. to check that the signals at the counter outputs A, B and C are as they should be.

3 Calculate a value for R_f which will result in OUT rising in steps of 0.5 V.

4 Assemble the digital-to-analogue converter.

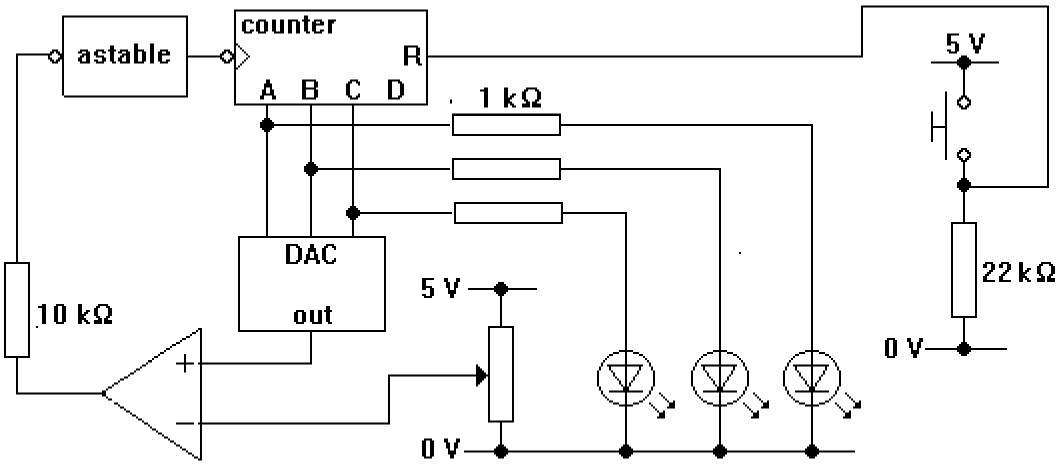
5 Study the signal at OUT with a c.r.o. Sketch the waveform.

6 If you have time, adapt the circuit so that it ramps downwards, instead of upwards.

7 Don't destroy the digital-to-analogue converter if you are intending to do the analogue-to-digital converter practical.

A three-bit ADC

The digital-to-analogue converter (DAC) in the analogue-to-digital converter circuit below is the same as the one you assembled for the previous experiment (generating a ramp voltage).



1 Construct the astable from a pair of NOR gates and an *RC* network. Select components which give it a frequency of about 1 Hz. Test it by holding its input low.

2 Add the 4024 counter and three LEDs. Check that they count up in binary when the astable input is held low.

3 Construct the rest of the circuit.

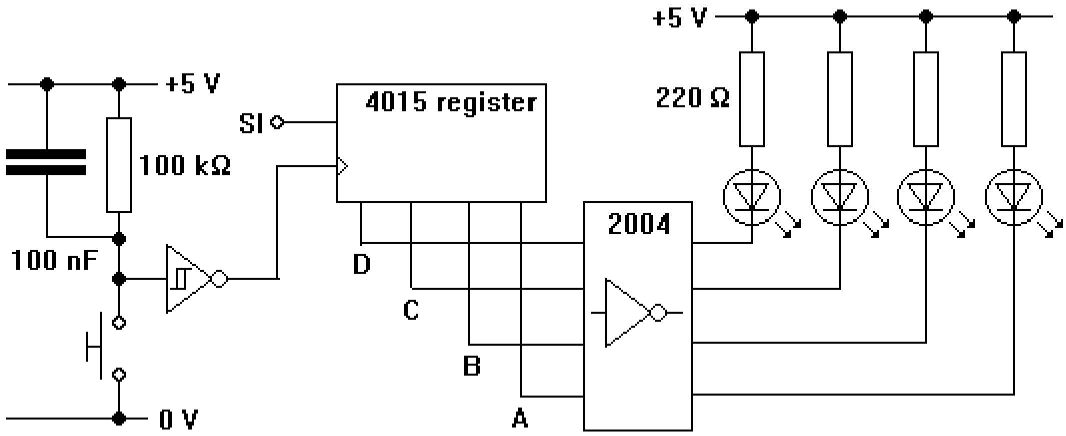
4 Set the wiper of the potentiometer to about 1.5 V. Press the switch and release it. If all is well, the LEDs should settle at the binary for 3 or 4.

5 Speed up the oscillator to 1 kHz.

6 Draw up a table to show the range of voltages for each binary number displayed on the LEDs. Explain how the circuit works.

Generating sequences with shift registers

You are going to assemble and test a system which uses a shift register to generate various sequences. The initial circuit is shown below.



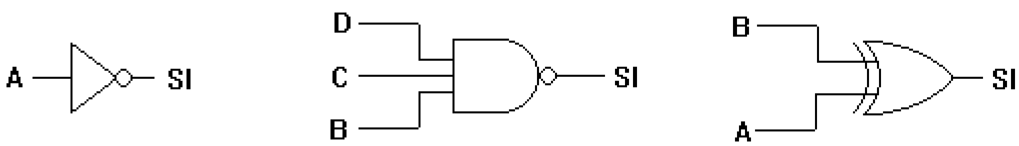
1 Assemble the pulse generator at the left. Check that its output goes high each time that the switch is pressed.

2 Add the 4015 shift register, drivers and LEDs. Hold the reset pin on the shift register low.

3 Connect the serial input SI to +5 V. Press the switch a few times. If all is well, the outputs should all go high one after the other.

4 Connect SI to 0 V. Press the switch a few times and admire the LEDs going off one after the other.

5 The diagram below shows three different ways of feeding the register outputs back to the serial input SI. Try each one in turn, noting the sequence of 1s and 0s they produce at A.



6 Predict the sequence of signals at A if $SI = \overline{D + C}$. Then assemble the circuit and verify that your prediction is correct.