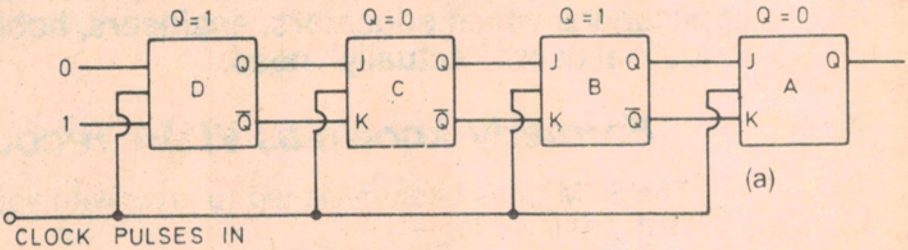
DIGITAL ELECTRONICS BY EXPERIMENT part 8

A SHIFT REGISTER is a set of flip-flops, each of which can be set by its PRESET terminal to store a 1 or 0, so that the whole set stores a "word" (complete number). For example, four flip-flops could store numbers such as 0101, 1000, 1101, and so on. In addition, we can apply clock pulses to all of the flip-flops and so cause the stored numbers to shift from one flip-flop to the next in line on each clock pulse; several designs make this possible in either direction (right-left shift).

Fig. 2 shows an example of this in action. We start with the number 1010 stored, so that LEDs on the B and D outputs will be lit. The input of the first flip-flop is connected with J=0; K=1, so that at the clock pulse its Q output will change to zero. The two outputs of the first flip-flop, however, are connected to the J and K inputs of the next flip-flop in line (compare the Johnson counter, which is very simply obtained from a shift register). With J=1 and K=0 on the second flip-flop, from the outputs of the first, the clock pulse will cause the output of flip-flop C to change from 0 to 1. Similarly, with Jb=0, Kb=1, flip-flop B is forced to change from 1 to 0, and flip-flop A is forced to change from 0 to 1. The effect is as if a zero had been forced in at the left-hand side and has caused all of the stored numbers to shift one place along.



CLOCK PULSE	QD	QC	QB	QA
0	1	0	1	0
1	0	1	0	1
2	0	0	1	0
3	0	0	0	1
4	0	0	0	0

(b)

Fig 1. A shift register made up from J-K flip-flops. (a) Arrangement of the flip-flops. (b) Truth table, showing the effect of clock pulses.

A Simple Shift Register

Use the two 7476 J-K flip-flops (Fig. 2) on your blob-board to make up a four-stage shift register. Connect the clock inputs to one of the spare pads of the blob-board, and run a line from this pad to the output of the slow oscillator or the debounced switch. Blob short connecting wires from each Q output to the next J input, and from each Q output to the next K input. Blob a wire from Ja to the earth line, leaving Ka floating. Connect the reset pins to a reset line (a spare blob-pad) and then to the reset switch so that pressing the reset switch will earth the reset pins. Finish off by connecting LEDs and

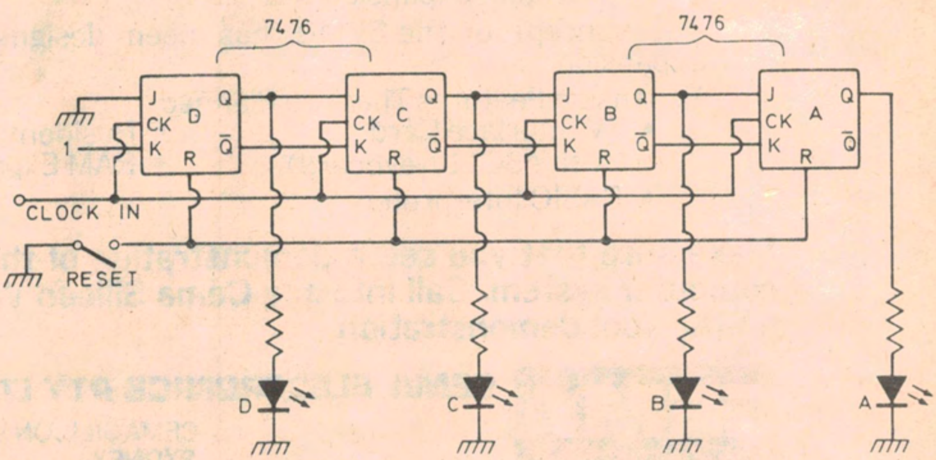


Fig 2. Connections of 7476 flip-flop to form a shift register on the 8-IC Blob-board.

resistors so that the state of each Q output can be read.

Now switch on. One or more of the LEDs may light, but can be extinguished by using the reset switch. Now set up a number by using the preset terminals. By temporarily bridging from each preset pin to earth, using a wire bridge, set two of the flip-flops to 1, preferably so that 1010 is stored. Next apply clock pulses and observe what happens; this is easier to follow if the debounced switch is used.

Now switch off, and disconnect Ja from earth. Connect Ja to Qd and Ka to $\bar{Q}$d. Switch on again, reset, and set to a display of 1010 again. Now apply clock pulses. What happens? Can you see the possible applications for storing a sequence of operations, such as a traffic lights sequence?

Types of Shift Register

The shift register made up using 7476s can be used as a PISO or SIPO type. PISO means parallel in, serial out, the information is set up on each flip-flop, perhaps at the same time, and is read out in sequence, one digit for each clock pulse. In a SIPO shift register (serial in, parallel out), a number of clock pulses equal to the number of flip-flops is applied at the same time as a varying signal (0 to 1) applied at the input J-K terminals, starting with an empty register. With the register filled, the voltages at the Q terminals can be read (using LEDs for example) in parallel. Each type is important; we need numbers in parallel form for operations such as addition, but in serial form for transmitting down a single wire, or for recording on tape. We can, of course, have SISO (serial in-serial out) and PIPO (parallel in- parallel out) shift registers, and a set of flip-flops can be arranged to act in any one of these ways.

The 7494 Shift Register

This has been chosen as one example (Fig. 3) of the very wide variety of shift registers that are available. Like most integrated shift registers, it is constructed using the clocked S-R type of flip-flops, but the action is the same as that of our J-K flip-flop model; the schematic of the IC is shown in Fig. 4. Four flip-flops are used, with a common clock to each, and a clear input which will reset each flip-flop. A serial input is also available.

The interesting feature of the 7494, however, is the gated parallel inputs labelled 1A, 2A, 1B, 2B and so on. These act through a set of gates on the preset inputs of the flip-flops, so that they are independent of the clock

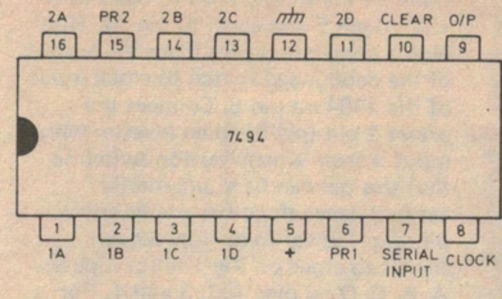


Fig 3. Pinouts of the 7494

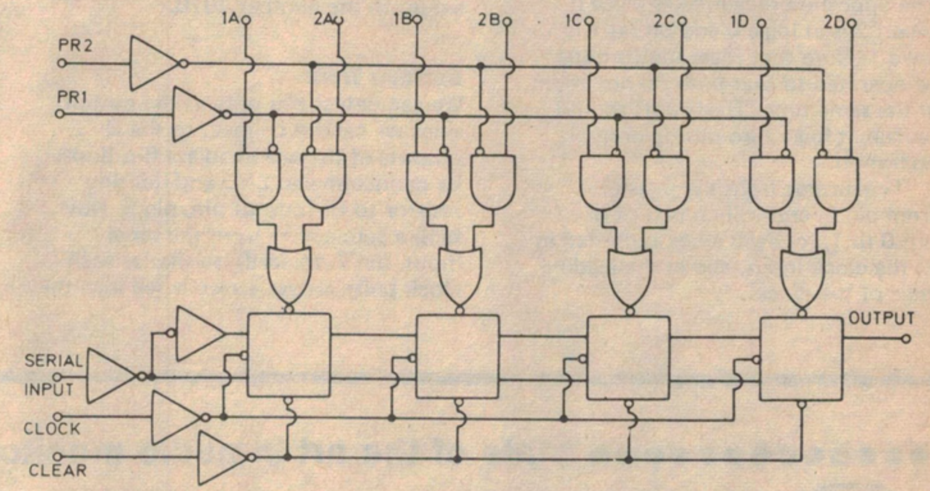


Fig 4. Schematic diagram of the 7494 shift register. Compare the number of flip-flops gates and inverters in this single chip with the number of packages needed to make this from 7400's and 7476's.

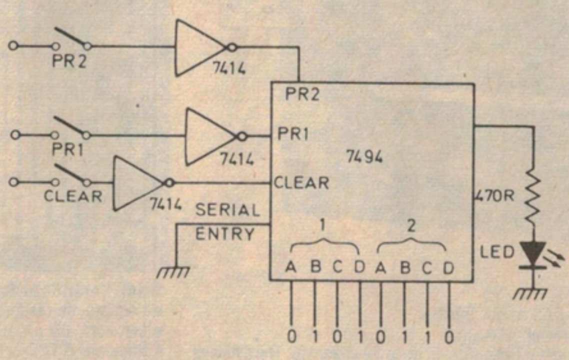


Fig 5. Connecting up the 7494 on the blob-board. Note that inverters have to be used on each switched line, as the preset and clear lines must be held at logic 0 for normal operation.

pulses. The gating is arranged so that either one or the other set of inputs can be "read" into the register. For example, imagine that the inputs with the 1 prefix are each connected to a signal input, 0 or 1, and that the inputs with the prefix 2 are each connected to another set of signals. We can use the pins marked preset 2 and preset 1 now to select which set of inputs is chosen and placed in the register.

Imagine that preset 1 is at logic 1 and the preset 2 is at logic 0. Because of the inverters connected to the preset inputs, all the inputs with the 1 prefix are gated through to the OR gates which control the flip-flop presets. Because all the inputs with the 2 prefix are gated out, there will be no input from these gates. The opposite process takes place if preset 2 is at logic 0 and preset 1 is at logic 1. Note that these inputs must be operated so that both do not enter at the same time. The inputs should remain at logic zero during normal operation.

The output from the register is from pin 9, and will consist of one bit, 0 to 1, for each clock pulse fed in to the clock input, and at the leading edge of the clock.

Blob-board Work

Connect the supply lines to the 7494, +5V to pin 5 and earth to pin 12. Now blob a connecting wire from the output of the debounced switch to clock input of the 7494 on pin 8. Connect the preset 1 pin (pin 6) to an inverter whose input is from a push-button switch so that this pin can be momentarily earthed; leave the other preset entry pin (pin 15) earthed. Now set up signals to enter on the 1-set of inputs, A, B, C, D on pins 1, 2, 3 and 4. For example, we can connect pins 1 and 3 to logic 1, and pins 2 and 4 to logic 0, so setting up the number 1010. This will be entered when the PR1 pin is momentarily set to 1 by the inverter and switch, and the flip-flops will be set up to the number 1010.

Detector Work

We can detect this only at the output, since we cannot connect to the Q outputs of the intermediate flip-flops, by connecting an LED and limiting resistor to the output pin, pin 9. Now blob a connection from the serial input, pin 7, to earth, so that as each clock pulse arrives a zero is fed into the first stage of the register. This ensures that the register stores 0000 after four clock pulses.

One Clock

Now switch on, and press the enter switch briefly. Use the clock switch to apply four clock pulses, and note the output on each pulse. The contents of the register should now be 0000, so that further clock pulses will not produce any "1" output. Another entry can be made by pressing the entry switch at any time. By connecting the second set of entry pins, and using the second pre-enter (PR2) pin, we can enter another number. Connect up the second set of entry pins (16, 14, 13, 11) to give another number, and connect up the PR2 (pin 15) terminal to the output of another spare inverter. Connect another push-button switch between the inverter input and the earth line, and try out the circuit again, entering the second number (after clearing) by pressing the enter switch momentarily. Check that this number is then read out at the output when the register is clocked.