OUTBOARD MOTOR

A special type of electric motor called a 'stepper' motor is used to power the Workshop robot. Stepper motors are favoured for computer control because they use logic signals to control their speed and rotation through discrete steps and are thus ideally suited to digital control.

The construction of a stepper motor is very different from that of a normal motor. To understand the principles of operation we shall consider how a simplified stepper motor works. In our example (see the diagram headed 'One Step At A Time') there are two set of windings ('a' and 'b') on the stator and two pairs of electromagnetic poles on the rotor. In the motors that are used in the Workshop robot there are more stator windings and more rotor poles than our example shows.

The only problem with this convenient form of motor control is that the motor consumes as much current when stationary as it does when in motion. In addition, it cannot be rotated at high speed — the different coils cannot energise and de-energise quickly enough. However neither of these problems is significant in our robot application.

Our simplified motor is capable of turning in steps of 45° only. Additionally, the direction of rotation cannot be controlled. The motors used in the robot, however, have four sets of coils that are energised in pairs, and the rotor also has many more coils than our example shows. This means that the direction of rotation may be controlled and that the step angle is reduced to 7.5°. To achieve this accurate stepwise rotation, the four coils must be energised in a particular and complicated sequence as follows:

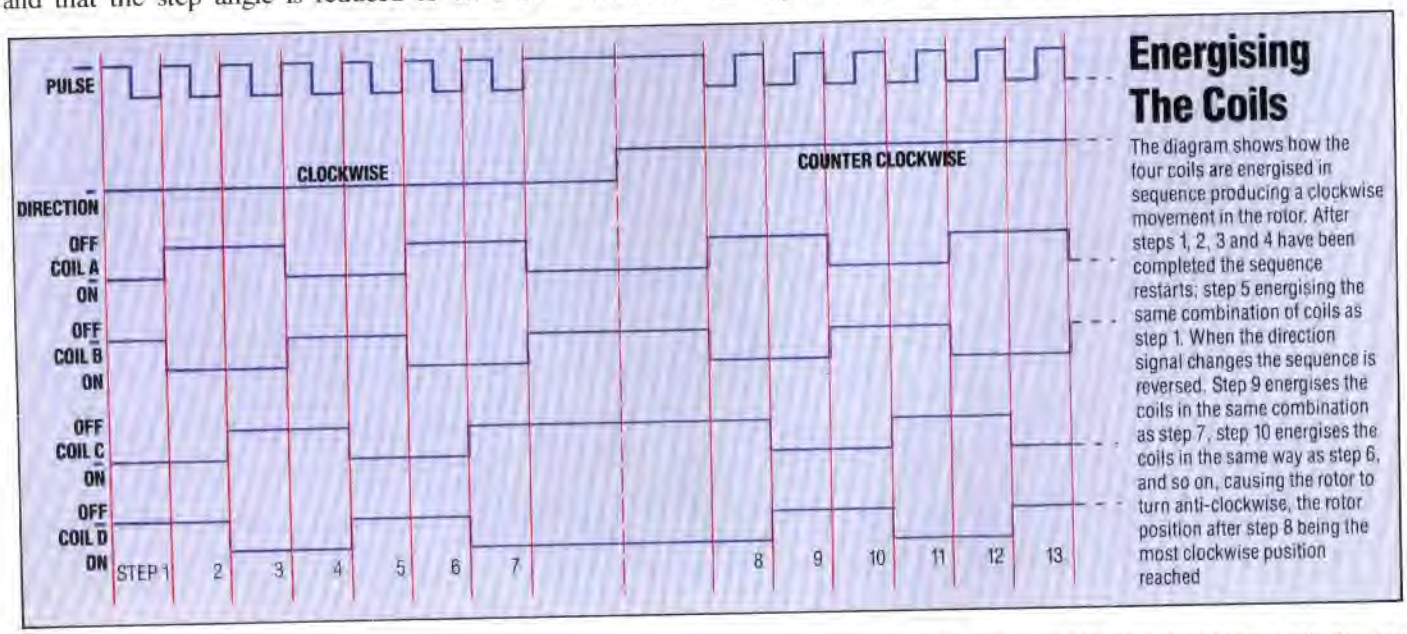
Stator Coils Energising Sequence Table

Step	Coil A	Coil B	Coil C	Coil D	
1	on	off	on	off	
2	off	on	on	off	
3	off	on	off	on	
4	on	off	off	on	
5	on	off	on	off	etc

This sequence of energisation could be provided by software, using four bits of the user port to control the four coils. However, this requires some complicated programming and BASIC could certainly not produce these control sequences quickly enough. A simpler method is to use a chip that has been specially designed for the control of stepper motors — the SAA 1027. This contains the output drivers and all the logic circuits to energise the coils in the correct order to drive a stepper motor.

To rotate the motor through one step, a single pulse from the user port is required, with a further signal line being needed to determine the direction of rotation. The chip contains input stages to detect the changes in the three inputs: a pulse to rotate the motor one more step, a reset input, and a direction input that reverses the stator coils energising sequence. The inputs are fed into a bi-directional counter circuit to produce the correct output sequence to the stator coils.

Finally, the chip also contains a power output driver stage that can handle up to 500mW. The inclusion of this stage means that the motor can be



Energising The Coils

The diagram shows how the four coils are energised in sequence producing a clockwise movement in the rotor. After steps 1, 2, 3 and 4 have been completed the sequence restarts; step 5 energising the same combination of coils as step 1. When the direction signal changes the sequence is reversed. Step 9 energises the coils in the same combination as step 7, step 10 energises the coils in the same way as step 6, and so on, causing the rotor to turn anti-clockwise, the rotor position after step 8 being the most clockwise position reached