

DIY KIT 94. STEPPER MOTOR DRIVER

This circuit illustrates the complex operations that can go on inside modern dedicated integrated circuits. The circuit uses a bi-directional digital rotary encoder from Bourn to step a unipolar stepper motor; one click on the encoder steps the stepper motor one step (or half a step as described below.) This discrete motion can of course then be geared up or down to suit your particular purpose. The stepper motor is not supplied in the kit. Six wire unipolar stepper motors are readily obtainable for a couple of \$US. The kit is not designed for 4 wire, bipolar steppers.

In this kit, we are using a preprogrammed PIC microcontroller (uC) and a dedicated stepping motor driver IC, UCN5804B to replace what would have formerly been a board full of discrete gates such as AND, OR, NOT, etc. followed by a set of power transistors.

The microcontroller

The PIC16C54 microcontroller takes the input from a mechanical encoder and converts it to two separate signals: pulse and direction. As the encoder is turned it generates two square waves which are in quadrature - 90 degrees apart. By doing a bit of mathematical manipulation, the microcontroller then works out how far the encoder has turned and in what direction.

Once the direction and magnitude of the rotation has been worked out in the uC, it is sent out as pulse and direction signals to pins 7 and 6, respectively of the UCN5804 stepper motor driver IC.

The Driver

The 5804 stepper driver is one of those marvellous devices that makes life so easy you wonder how you managed to get along without it. There was a very good article on stepping motors and the use of the 5804 in *Electronics Australia* Oct & Nov '94. The Links page of our website (<http://www.kitsrus.com>) lists several on-line sources of information about stepper motors.

The driver will operate six - wire motors at up to 35V and 1.25A. The step input is to pin 7 and direction goes to pin 6 of the 5804. Pins 9 and 10 on the PIC control one phase and half step operation, respectively. Pins 1 - 8 are the connections to the stepping motor. Five & eight wire steppers can be adapted to use this kit; see Kit 113 documentation which can be downloaded from our website.

Half step and single/double phase refer to methods of operating stepping motors. In one phase operation only one coil attracts the rotor at a time. This is also referred to as wave drive. Alternately, two phase drive energises two adjacent phased in each rotor detent position giving much better torque and speed characteristics.

Half step operation is a combination of one and two phase drives causing the rotor to take twice as many steps per revolution. For a more detailed explanation see the Allegro data sheet on the UCN5804 which can be got from Allegro (www.allegromicro.com) or from our own website. Kit 113 also has a more detailed discussion. The

documentation for Kit 113 may also be downloaded from our website at <http://www.kitsrus.com>.

Digital Contacting Rotary Encoder

Also called Digital Panel Control, a Bit Switch, Grey switch or Digital Switch, rotary encoders provide a pair of digital Grey-coded signals that allow a uC to determine the speed & direction of the rotation of a shaft. (For example, a computer mouse uses two digital encoders to track the x & y axis movements of a ball in it.) The PIC16Cxx Applications Handbook by Parallax has a section (Section 4) on the details of these encoders. The advantage of the encoder is that it permits the direct entry of digitised analog data into a digital circuit without A/D conversion. The data sheet (zipped pdf file) of the ECW1J Bourne digital contacting encoder used in this kit can be obtained from our web page at

<http://www.kitsrus.com/soft.html>

The circuit

There is surprisingly little to the circuit. The encoder input is to pins 17 and 18 of the micro and the pins are pulled high by R4 and R5 until grounded by the encoder. The supplied encoder is a 24 cycle type which will actually generate 96 pulses per revolution.

The microcontroller is a PIC 16C54 and this is run using an RC oscillator as a clock input. The RC in question is C1 and R3 and the values chosen give a clock speed of about 3 MHz. Note that simply changing R3 will raise or lower the clock speed and consequently speed up or slow down the motor. The source code is available for downloading from our website.

Both the uC and the driver 5804 IC's run on 5V and this is provided by a standard 78L05 regulator together with capacitors C2 - C4. Interestingly, the driver actually runs on 5V despite the fact that the motor side can handle up to 35V.

There is provision for continuous rotation of the stepping motor. Pin 11 of the PIC is pulled to ground by R6. Connecting this pin to 5V will result in the motor rotating at its maximum speed.

It may seem strange to pull pins 1 and 2 of the uC up with R1 and R2, but there are good reasons for it. The software depends on these pins being high as they are part of port a which is the encoder input port. They are not connected directly to the 5V rail for a rather subtle reason: the port assignments are all done in software so that the relevant pin can be input or output. The problem is that when there is a bit of electrical noise around the port assignments can be corrupted resulting in, say, pin 1 trying to pull the supply rail down to ground. Exit one microcontroller.

Construction and testing

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The voltage regulator and chip sockets are installed and the circuit is powered up. Check for correct voltages at the power supply pins of the micro and the driver.

Put in all the resistors and power it all up again. Check that all the pins that are pulled up are at 5V and all the pulled down pins are at ground potential. Note to add the Link required situated between the two IC's.

The encoder has three pins. The center pin is the earth pin. Use some wire to connect the 3 pins to the 3 pin terminal block on the PCB. It does not matter which way around the X & Y terminals are connected.

There are two SPDT switches on the board to select half step and one/two phase. Connecting pins 9 and 10 to G, ground, will give two phase drive. Note that connecting both to +V turns off the motor.

Put in the driver IC and solder up the stepping motor leads to finish the job. If you are having trouble identifying the leads then get out your multimeter and set it to ohms. There should be two sets of three leads.

Solder one center lead to pin 2 of the 5804 brought out to the 6-pin header and the other two leads A & B to pins 1 and 3, the order is not important. The other center lead then goes to pin 7 and the remaining leads C & D go to pins 6 and 8.

You should find that turning the encoder once will rotate the motor twice for two phase drive, assuming a 48 step motor. Connect the Continuous Rotation pads and the motor should spin happily.

As the motor is spinning, try varying the supply voltage. This will make the motor run more roughly or smoothly. Stepping motors are very sensitive to supply voltage variations. Try the same thing while turning the encoder, you will quickly get a feel for stepping motor quirks.

If It Does Not Work

First check that the SPDT switches are not both in the +V position. That turns off the motor. Second check that the IC's are in the correct way around. Finally the problems must be the connection of the stepper motor to the harness. A detailed explanation of how to get the correct connections is given in Kit 113 documentation. Make sure the pins A B C D from the stepper motor are matched with the overlay. The + common from each winding goes to pins 2 & 5 of the six-pin harness. See the schematic for a detailed connection pattern.

PARTS LIST - Kit 94

| | | | |
|-----------------------------------|----------------|-------|-------|
| 78L05 regulator | Q1 | ..... | 1 |
| 16C54-RC/P PIC | IC1 | ..... | 1 |
| UCN5804B IC | IC2 | ..... | 1 |
| 16 pin IC socket | ..... | ..... | 1 |
| 18 pin IC socket | ..... | ..... | 1 |
| Bourne Rotary encoder ECW1J | ..... | ..... | 1 |
| SPDT switch | ..... | ..... | 2 |
| 3 pole terminal block | ..... | ..... | 1 |
| 2 pole terminal block | ..... | ..... | 1 |
| 6 wire harness/socket | ..... | ..... | 1 set |
| Capacitors: | | | |
| 15pF ceramic | C1 | ..... | 1 |
| 100nF mono .2" pitch | C2 C4 | ..... | 2 |
| 1000uF/35V | C3 | ..... | 1 |
| Resistors 5%, carbon film: | | | |
| 12K | R1 R2 R6 | ..... | 3 |
| 5K6 | R3 | ..... | 1 |
| 1K5 | R4 R5 | ..... | 2 |
| K94 PCB | ..... | ..... | 1 |

Software

The source code for Kit 94, the data sheet (pdf format) for the UCN5804 driver and the documentation for Kit113 (giving more information on unipolar stepper motor connections & ballast resistors) is available on the software download page our website, <http://kitsrus.com>

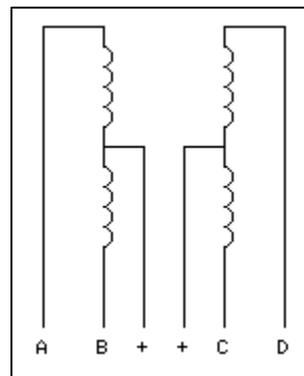


Figure 1. Six wire stepper motor. Five & eight wire stepper motors can be wired to this form to be used with Kit 94.

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