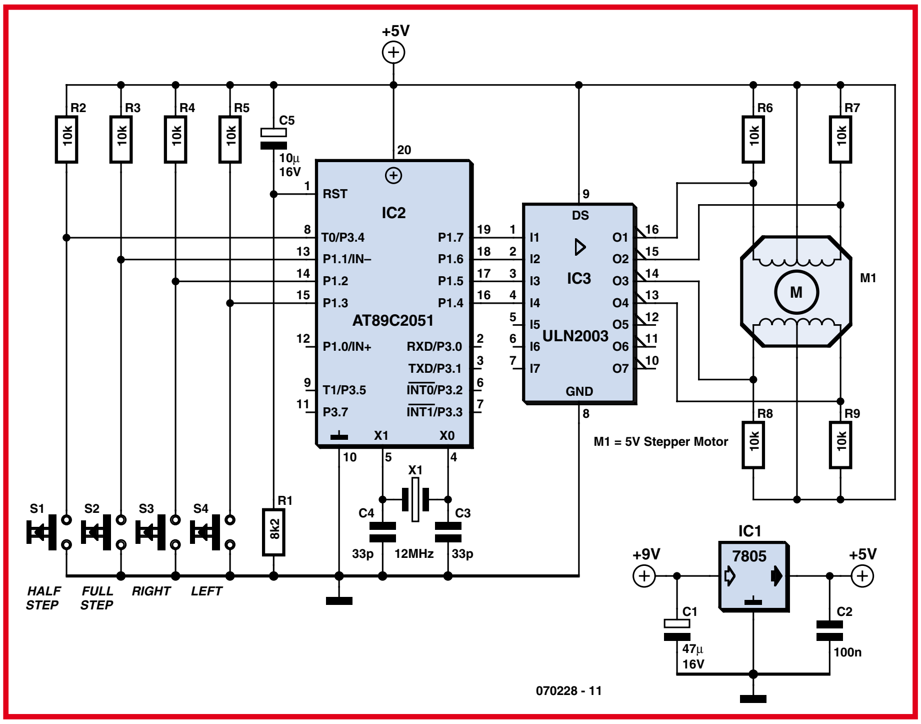
Complete Stepper Motor Driver



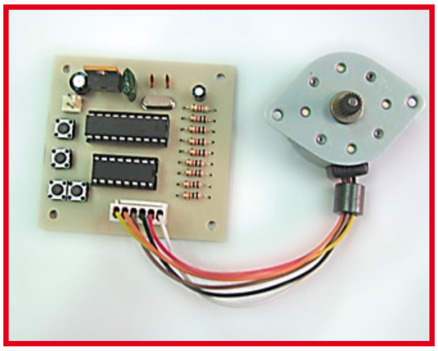


Table 1	
Step angle (degrees)	Steps per revolution
0.72	500
1.8	200
2.0	180
2.5	144
5.0	72
7.5	48
15	24

Hesam Moshiri

With this circuit you can make a stepper motor do just about anything it will need to do in robotics application: rotation to the left or right, in full-step or half-step mode.

Stepper motors convert electrical pulses into mechanical movement. In applications like hard disks, printers and photocopiers (to mention but a few), stepper motors are used for rotation and/or accurate position control of mechanical assemblies. Every stepper motor has one permanently magnetic axle called the *rotor*. This is surrounded by a fixed part called the *stator*. Usually, stepper motors have four stator wires with two or one common wire, which is normally connected to the positive supply voltage.

By applying a controlled sequence of pulses to the individual stator windings, the rotor will start to rotate. Stepper motors may differ in size, shape, power, supply voltage, cost, accuracy, and so on, but importantly in the number of steps that make up one complete spindle revolution. This property also determined the step angle as shown in **Table 1**.

For example for a motor specified as having a 1.8-degree angle, 360 / 1.8 = 200 pulses for a complete spindle revolution.

Two pulsing schemes are available to drive the motor: 'full-step' or 'half-step'. The two modes are summarized in **Table 2** and **Table 3** respectively.

Applying half-step pulses to the motor will increase the accuracy at which the spindle can be turned. In the case of our 1.8-

Table 2. Full-step mode.

Rotation to the right (cw)	Step	Winding A	Winding B	Winding C	Winding D	Rotation to the left (ccw)
↓	1	1	0	0	0	↑
	2	0	1	0	0	
	3	0	0	1	0	
	4	0	0	0	1	

Table 3. Half-step mode.

Rotation to the right (cw)	Step	Winding A	Winding B	Winding C	Winding D	Rotation to the left (ccw)
↓	1	1	0	0	0	↑
	2	1	1	0	0	
	3	0	1	0	0	
	4	0	1	1	0	
	5	0	0	1	0	
	6	0	0	1	1	
	7	0	0	0	1	
	8	1	0	0	1	

degree angle motor, half-step driving then requires 400 steps per revolution.
Another important advantage of half-step pulsing is more motor power, which usually translates in more torque.
The circuit of the motor driver is designed around an Atmel microcontroller type AT89C2051 ticking at 12 MHz and one high voltage/high current Darlington transistor array type ULN2003.
The motor drive pulses generated by the microcontroller under firmware control are fed to the ULN2003 via four port lines P1.4 through P1.7. The motor's stator windings are connected to the corresponding output pins on the ULN2003. The ULN2003 can supply up to 500 mA on each output pin. Note that a 5-V stepper motor is used in this circuit.
The source code file and the firmware (hex file) for the AT89 micro may be downloaded free of charge from the Elektor website as archive # **070228-11.zip**.
After constructing your circuit, power it up. Press the Full Step or Half Step button. Then press Left or Right and you will see your motor start to rotate using the mode selected. You can change between full and half step at any time.
All this is based on the assumption that you have wired up your motor correctly. The AT89 source code contains a number of directions to help you 'change wires' in software rather than by soldering and getting confused by the different wire colours.
In practice, you will notice that full-step mode yields higher spindle speed with low motor torque, whereas half-step mode is good for increased torque and accuracy, at the cost of speed. That is why stepper motors powering wheels etc. are controlled such that they start and end their operation in half-step mode, with full step mode in between to achieve maximum speed.

(070228-I)