REMOTE-CONTROLLED STEPPER MOTOR

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Here is a stepper motor system wherein the direction of rotation of the stepper motor (in clockwise and anticlockwise directions) can be controlled remotely. Besides, the speed can also be controlled locally.

Stepper motor basics

A stepper motor converts electrical pulses into specific rotational movements. The movement created by each pulse is precise and repeatable.

Stepper motors have teeth on both the rotor and the stator. Torque is generated by alternately magnetising the stator teeth electrically, and the permanent magnet rotor teeth try to align up with the stator teeth.

The coils are arranged around the circumference of the stator in such a way that if they are driven with square waves which have a quadrature phase relationship between them, the motor will rotate. A transition of either square wave causes the rotor to move by a small angular 'step,' hence the name 'stepper motor.'

The size of this angular step is dependent on the teeth arrangement of the motor, but a common value is 1.8 degrees, or 200 steps per revolution. Speed control is achieved by simply varying the frequency of the square waves.

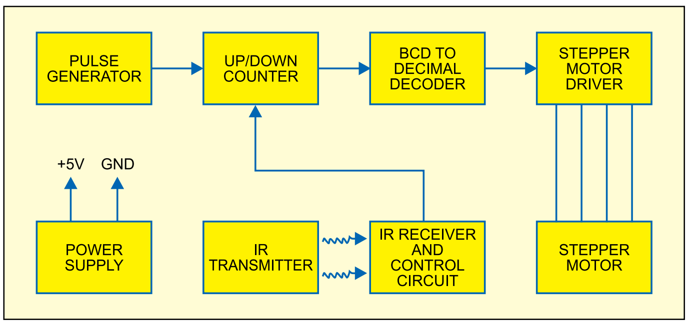

Fig. 1: Block diagram of IR remote control system for stepper motor

System overview

Fig. 1 shows the block diagram of the IR remote control system for the stepper motor. The pulse generator provides clock pulse to the up/down counter. The four parallel BCD outputs of the counter are converted into one-of-ten active-high outputs by the BCD-to-decimal decoder. The decoded outputs are fed to the stepper motor driver to drive the stepper motor.

The 38kHz infrared signal transmitted by the IR transmitter is received by the IR receiver to control the direction of rotation of the stepper motor. The pulse generator can control the speed of the motor.

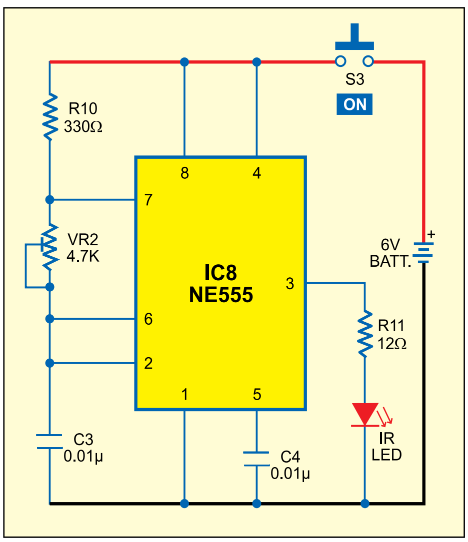

Fig. 2: IR transmitter

Circuit description

IR transmitter. Fig. 2 shows the circuit of the IR transmitter. The transmitter circuit, powered by a 6V battery, is built around timer NE555 (IC8), which is wired as an astable multivibrator having a frequency of around 38 kHz.

The frequency of the astable is decided by resistor R10, preset VR2 and capacitor C3. Preset VR2 is used to set the frequency to 38 kHz. The output of IC8 is fed to an infrared LED via current-limiting resistor R11. When switch S3 is pressed, the IR LED trans-

PARTS LIST

Semiconductors:

IC1	- TSOP1738 IR receiver module
IC2	- CD4013 dual D-type flip-flop
IC3, IC8	- NE555 timer
IC4	- CD4029 up/down counter
IC5	- CD4028 BCD-to-decimal decoder
IC6	- ULN2803 Darlington pair driver
IC7	- CD40106 NOT gate
IC9	- 7805C 5V regulator
T1	- BC547 npn transistor
D1-D10	- 1N4148 switching diode
BR1	- 500mA bridge rectifier
LED1	- Red LED
LED2	- Green LED
	- IR LED

Resistors (all ¼-watt, ±5% carbon):

R1, R6, R7, R10	- 330-ohm
R2	- 1-kilo-ohm
R3-R5	- 10-kilo-ohm
R8	- 3.3-kilo-ohm
R9	- 5.6-kilo-ohm
R11	- 12-ohm
VR1	- 100-kilo-ohm preset
VR2	- 4.7-kilo-ohm preset

Capacitors:

C1	- 1µF, 16V electrolytic
C2-C4	- 0.01µF ceramic disk
C5	- 1000µF, 16V electrolytic
C6	- 0.1µF ceramic disk

Miscellaneous:

X1	- 230V AC primary to 3V-0-3V, 350mA secondary transformer
S1, S2	- Push-to-on switch
Battery	- 6V battery
	- Stepper motor

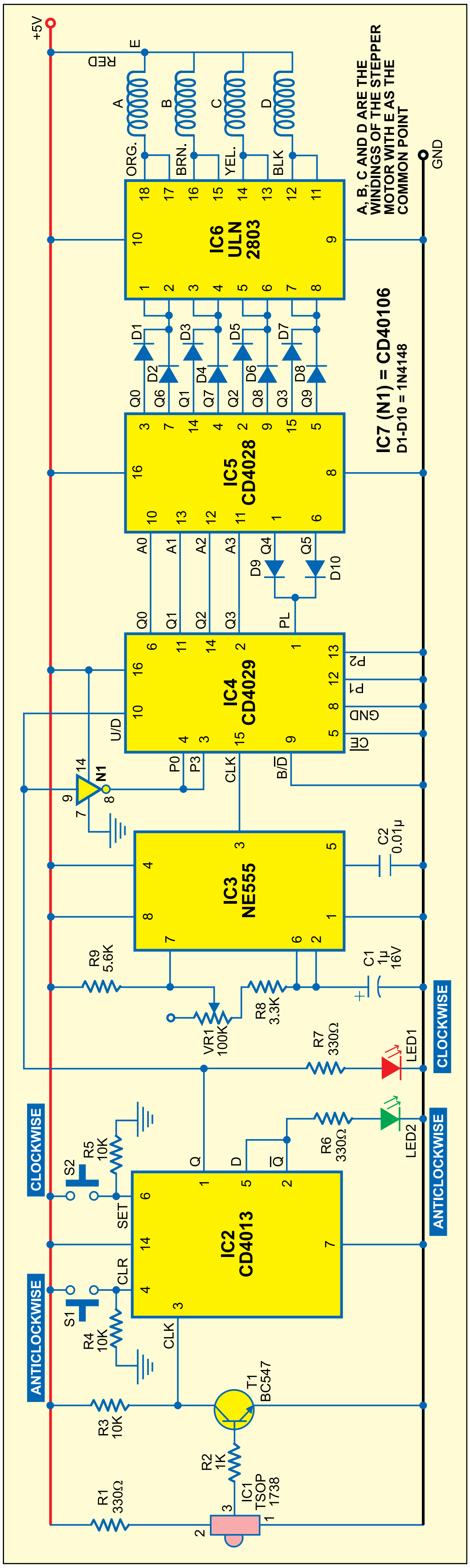

Fig. 3: IR receiver-cum-stepper motor driver circuit

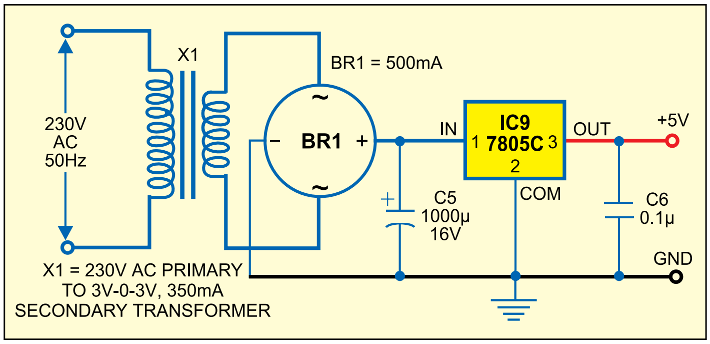

Fig. 4: Power supply

mits 38kHz modulated infrared signal.

Receiver-cum-stepper motor driver. Fig. 3 shows the circuit of the receiver-cum-stepper motor driver. The transmitted 38kHz modulated signal is received by infrared receiver module TSOP1738 (IC1) and it outputs a clock pulse to D-type flip-flop CD4013 (IC2) via transistor T1.

IC2 accepts data when its clock input is low and transfers it to the output on the positive-going edge of the clock. IC2 is configured as a toggle flip-flop as its Q output is connected to 'D' input. Thus when TSOP1738 receives a signal from the transmitter, it clocks IC2 and its Q output changes from high to low and vice versa on alternate clock inputs. Consequently, the state of Q output of IC2 controls the direction of the stepper motor. When Q output is high the stepper motor rotates in clockwise direction, and when Q output is low the stepper motor rotates in anti-clockwise direction. The direction of rotation can also be controlled manually by setting Q output high or low with the help of switches S2 and S1, respectively.

Set and Reset pins (pins 4 and 6) are normally pulled down by resistors R4 and R5, respectively. These are also connected to switches S1 and S2, respectively. LED1 and LED2 indicate the clockwise and anticlockwise direction of rotation of the stepper motor. The Q output of IC2 controls the up/down pin and parallel input pins P0 and P3 of IC4 (CD4029).

Timer NE555 (IC3) is configured as an astable multivibrator whose frequency is determined by resistors R8 and R9, preset VR1 and capacitor C1. Preset VR1 is used to vary the frequency and consequently the speed of the stepper motor.

IC3 provides clock input to up/down counter IC CD4029 (IC4). IC CD4029 is a presettable up/down counter that counts in either binary or decade mode depending on the voltage level applied at its B/D̄ pin. The B/D̄ input (pin 9) of IC4 is grounded to configure it as decade counter.

Counter IC4 advances one count for low-to-high transition of the clock pulse when its CE and PL pins are low. It counts up when its up/down input is high, and vice versa. The count-enable input (pin 5) and preset inputs P1 and P2 are grounded, while the parallel-load input pin (PL) is controlled by Q4 and Q5 output pins of IC5. Q0 through Q3 outputs of IC4 are connected to A0 through A3 inputs of IC5 (CD4028).

IC CD4028 is a 4-bit BCD-to-one-of-ten active-high output decoder. BCD inputs A0 through A3 make the selected output high, while the other nine outputs remain low.

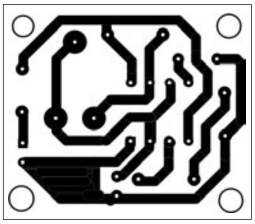

Fig. 5: Actual-size, single-side PCB for IR transmitter

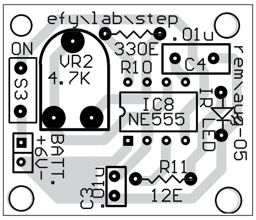

Fig. 6: Component layout for the transmitter PCB

When the Q output of IC2 goes high, the counter (IC4) is enabled for up counting with parallel inputs P0 and P3 going low. Decoder (CD4028) outputs Q0 through Q3 go high one after another according to IC4 outputs. When Q4 output of IC5 goes high, the 0000H parallel input data at P0 through P3 pins is loaded into the CD4028 (IC4). The counter starts counting afresh in up mode.

When Q output of IC2 goes low, the counter (IC4) is configured for down counting and its parallel inputs P0 and P3 become high. In down counting mode, Q9 down through Q6 outputs of the decoder (IC5) go high one after another. As soon as Q5 output of the decoder goes high, the 1001H parallel input data is loaded into the counter and it again starts counting down from Q9 through Q6.

The four outputs Q0 through Q3, and Q6 through Q9, of IC5 are ORed via diodes D1 through D8 driving the stepper motor in clockwise or anti-clockwise direction. The four ORed outputs of IC5 are connected to eight input pins (two each in parallel) of IC ULN 2803. The combined waveforms for clockwise and anti-clockwise rotation are shown in Fig. 9.

IC ULN2803 consists of eight Darlington-pair driver transistors. It is basically an inverter that when fed with positive input generates negative output. Stepper motor coils A, B, C and D are connected to output pins 17-18, 15-16, 13-14 and 11-12 of ULN2803, respectively, with their common terminal E connected to the 5V power supply.

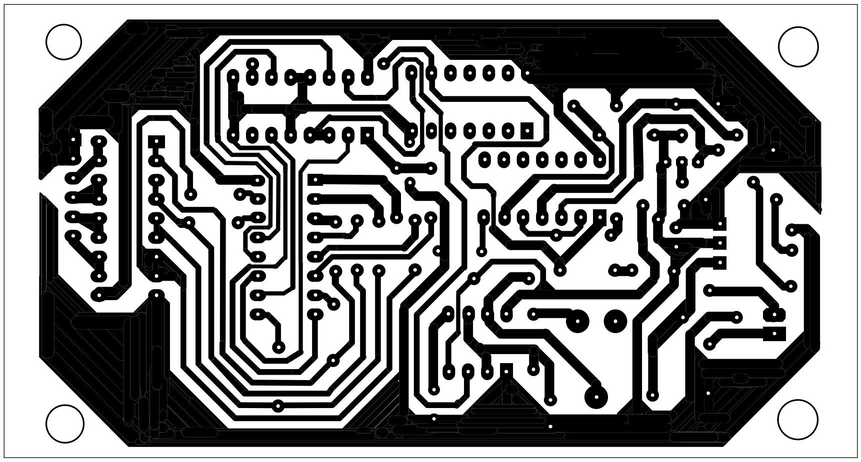

Fig. 7: Actual-size, single-side PCB for IR receiver-cum-stepper motor driver circuit

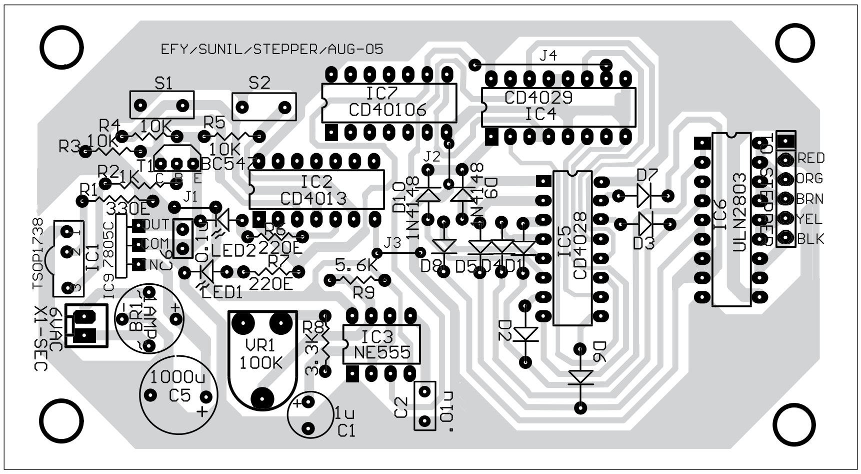

Fig. 8: Component layout for the receiver-cum-driver PCB

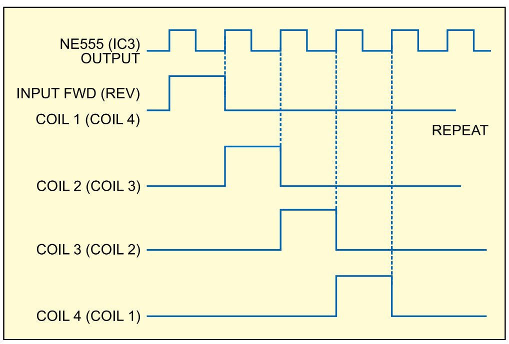

Fig. 9: Combined waveforms for clockwise and anti-clockwise rotation

The low output of IC ULN2803 provides path for the current and the coils energise one by one to rotate the stepper motor in clockwise/anticlockwise direction.

Power supply. Fig. 4 shows the circuit of the power supply. The AC mains is stepped down by transformer X1 to deliver a secondary output of 3V-0-3V, 350 mA. The transformer output is rectified by bridge rectifier BR1, filtered by capacitor C5 and regulated by IC9 to provide 5V regulated supply. Capacitor C6 bypasses any ripple in the regulated output.

Construction

Actual-size, single-side PCB layouts for the IR transmitter and receiver-cum-stepper motor driver circuits (Figs 2 and 3) are shown in Figs 5 and 7, and their component layouts in Figs 6 and 8, respectively.

Mount bases for the ICs on the PCB so that these can be removed easily when required. Normally, six wires of different colours are available for connection to the stepper motor. The colour code for connecting the stepper motor coils to the driver outputs is shown in Fig. 3. ●