Kit 67. DC SPEED CONTROLLER

There are three ways to vary the speed of DC motors:

- use a gear-box.
- use a series resistor. Measure the current drawn by the motor and then calculate the value of a series resistor needed to drop the voltage applied to the motor. Less voltage means the motor will slow down. The problem with this method is that the current drawn by the motor increases as the load on the motor increases. More current means a larger voltage drop across the series resistor and therefore less voltage to the motor. The motor now tries to draw even more current, resulting in the motor stalling.
- by applying the supply voltage to the motor for a variable amount of time, eliminating the series dropping effect. This is the method used in this kit.

How It Works
The circuit uses two timer/oscillators connected as a Pulse Width Modulator. The chip used is an nmos dual timer/oscillator, NE556. This IC has two 555 timers in one 14-pin IC package.

One 555 (IC1:B) is configured as an astable oscillator. The output frequency of the trigger pulses is given by:

$f = 1.44 / ((R_3 + 2R_4)C_2)$, or about 410Hz.

The time period for the high output is given by

$T_{HIGH} = 0.69(R_3 + R_4)C_2$ seconds.

And, the low output by $T_{LOW} = 0.69R_4C_2$ seconds.

The second 555 (IC1:A) is configured for Pulse Width Modulation. It is set up in monostable mode. It is triggered with the continuous pulse train from the first 555. However, by also applying a DC voltage to pin 3 the comparator reference levels will be changed from their nominal levels of one-third & two-thirds of the supply voltage. This has the effect of modulating the pulse width as the control voltage varies.

The control voltage is supplied via transistor Q1, which is configured as an emitter-follower. This means that the emitter output voltage follows the base input voltage (less 0.6 volt base-emitter drop). This configuration gives us a low output impedance voltage source with which to drive the control input of the timer. This makes the control voltage less susceptible to the loading effect of the timer control input.

The output from the timer is a continuous stream of pulses whose width is controlled by the voltage level applied to the control voltage input. This modulated output drives a power darlington transistor, Q2, which is used to switch the voltage to the DC motor.

The maximum ON time of the output pulse, and therefore maximum motor speed, can be set by changing the value of resistor R1. Increasing the value lowers the maximum motor speed. The end stop resistor R1 may be replaced by a link if desired.

The motor is always connected to the 3 pole terminal block, pins + and -. If the motor is driven with the same power supply as the controller then insert link LK1. If separate power supplies are used to drive the controller and the motor, then remove link LK1 and connect the positive motor power supply lead to the EXT pin. Make sure that the ground lines from each supply are tied together.

Construction
First check that you have all the components. Check each component against the Listing given on the next page. Make sure to get the orientation of the diode and electrolytic capacitor correct. The bar on the diode is the cathode and corresponds with the bar on the overlay printed on the circuit board.

It is generally easiest to add and solder the lowest height components first to the PCB. Then add the taller components. Note there are two links to add to the board. If the motor and the controller use the same power supply (5V - 15V) then add the third link to the board. When you add the TIP122 bend the legs 90° using needle nosed pliers. Do not just push it over with your fingers as this may break the IC case. Before you solder the TIP122 put the heatsink into place underneath it with the screw & nut fastened. Use some heatsink paste if you have it.

10K potentiometer. This is mounted from the back through the hole on the right of the board. Screw it down with the nut. Use some of the wires from the resistors to attach the three pins from the pot to the 3 pads marked with the circles on the overlay. We have not included a knob with the kit so that you can attach the one you like best, or use a spare one if you have it.

Operating Specifications
V_{CC} : 5V - 16V. This is the operating range of the 556 IC.

DC motor: Up to 100V at a maximum of 5A. This comes from the operating specifications of the TIP122 switching transistor.

If the motor runs in the same range as V_{CC} then both the Speed Controller & the motor can be run from the same power supply. Connect the link on the PCB. If the motor runs at a higher voltage then do not connect the link. Connect the motor external supply to the terminal block and tie the ground lines together.

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What To Do If It Does Not Work
Check the orientation of the diode, the IC and the electrolytic capacitor. Did you make the 3 connections from the potentiometer pins to the pads? Did you add the two or three links depending on whether or not you used the same power source for the motor as the controller? Check that all the resistors are in their correct positions. If you have a CRO or frequency meter check the output on pin 9 of the 556.

Component Problems.
In developing this project we found two interesting problems. We did not solve either of them because we found other solutions. However, we mention them here for your reference in case you want to extend this circuit.

Nmos/cmos 556. We tried to use cmos 556 IC's in this circuit (because they are more widely available & cheaper) we had inconsistent results. Cmos 556 from different suppliers acted differently. Some did not vary the width of the output pulse uniformly over the range. They had two output ranges all within the one turn of the potentiometer. Nmos 556 IC's always worked as expected. So we have stayed with the nmos versions. Two separate cmos 555's may be another solution but we did not try it.

FET/Darlington Switching. Power FET's were the first choice for this project. However, we also found that some power FET's also did not work consistently with some DC motors that we had in our junk box. Specifically one commercial kit using a MTP3055 FET did not work with some small toy motors while it did work with other bigger motors. We never worked out why. However, we found the Darlington TIP 122 to be quite reliable with all motors tested so we stayed with it.

COMPONENTS

Resistors 5% 1/4W:		
10R brown black black	R1	1
470R yellow violet brown	R2	1
33K orange orange orange	R3	1
2K2 red red red	R4 R7	2
8K2 grey red red	R5	1
1K 1Watt R6 black brown red		1
10K potentiometer & nut		1
1N4004	D1	1
100nF 104 monocap	C1 to C7	7
100uF/25V electrolytic	C8	1
Heatsink (HS110)		1
Nmos LM/NE556	IC1	1
TIP122 Darlington Transistor	Q2	1
BC547 Transistor	Q1	1
SPDT switch		1
14 pin IC socket		1
Nut & screw		1 set
Two pole terminal block		1
Three pole terminal block		1
Kit 67 PCB		1
Large Box & screws		1

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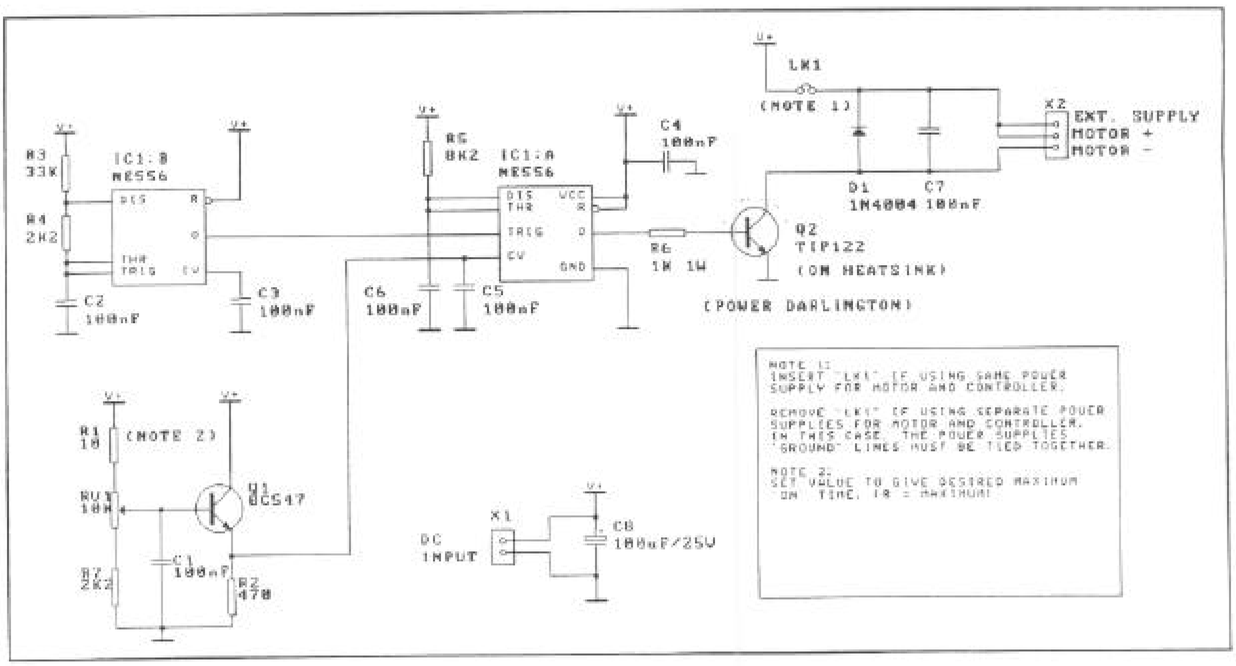
http://kitsrus.com



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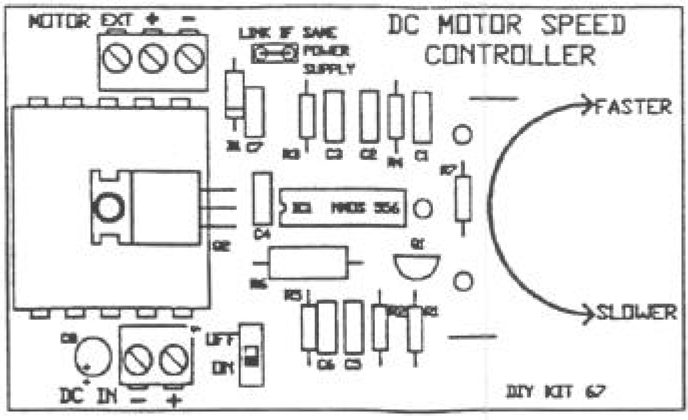

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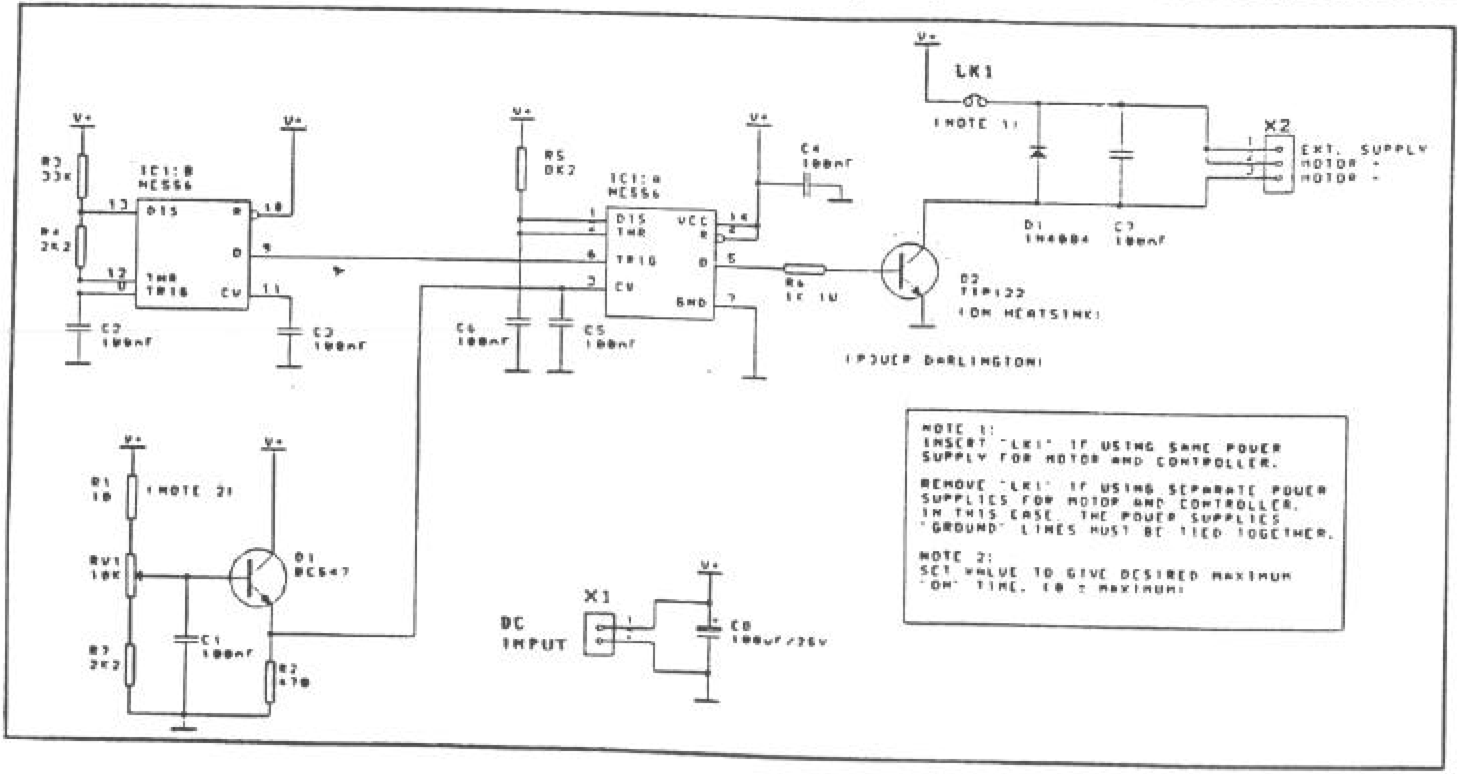

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