A simple speed regulator for miniature dc electric drills

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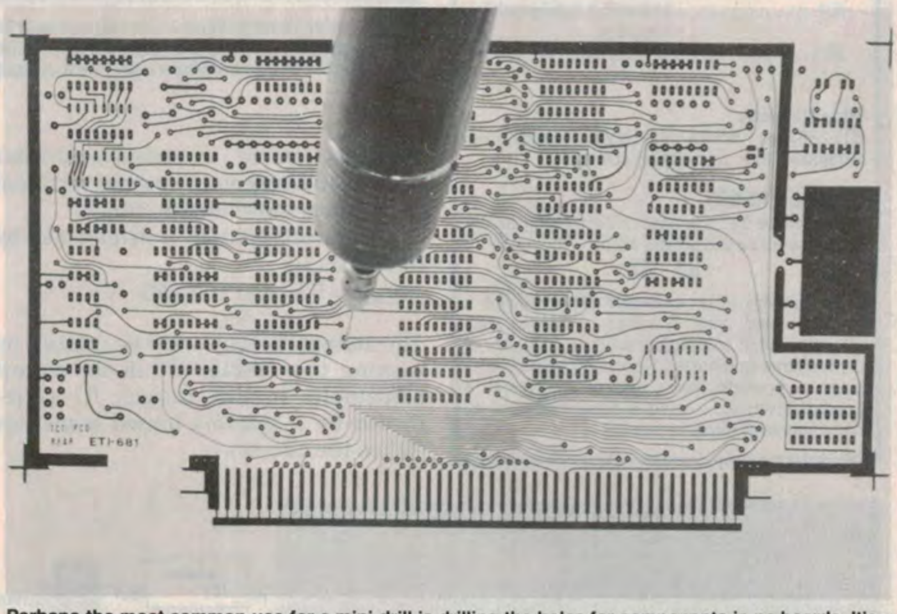
Mini-drills are inexpensive, handy and widely used amongst electronic hobbyists, servicemen and technicians. Their one drawback is poor speed regulation under load. This simple circuit fixes that!

'MINI-DRILLS' are widely used by a whole range of hobby and craft enthusiasts — electronics hobbyists, technicians, etc, finding them very useful for drilling holes in pc boards, deburring holes in panels and similar applications. Many mini-drills locally available incorporate a 12 Vdc motor and have a chuck speed of around 6000 to 10 000 rpm. Unfortunately, this tends to drop dramatically when you're trying to drill a pc board — particularly if it's a fibreglass pc board. Many are meant to be operated from batteries, often at a reduced voltage (and lower chuck speed, but fast enough for many applications). Operation is best with fresh batteries but the motor stall current can be as much as one amp. Operating current may be 200 mA or more under a reasonable load. The output voltage of most dry batteries 'sags' rather a lot under such loading owing to their internal resistance and the drill speed drops accordingly. The drill bit's efficiency therefore drops alarmingly and all of a sudden you have difficulty drilling the hole.

This project consists of a dc supply which senses the load on the drill motor by sampling the current drawn, then boosting the supply output to maintain the motor speed under load.



Perhaps the most common use for a mini-drill is drilling the holes for components in pc boards. It's a time-consuming job unless your drill has a suitably high chuck speed (over 6000 rpm) and good speed regulation.

The problem, the solution

What causes the speed of the motor to drop when it is loaded? Normally, a fairly constant voltage is applied to the motor from either a battery or a fixed voltage power supply. When the motor is run without any load the speed increases until the power consumption is exactly sufficient to cover losses in the motor. When a load is placed on the motor, the speed drops, back-emf reduces and the difference between the back-emf and the supply voltage increases. This causes the motor current to increase. A new reduced speed is reached when the losses of the motor and the power delivered to the load equal the increased power consumption. Since the motors in these mini-drills generally have a fixed flux magnetic field (i.e: permanent magnet stator), to increase the speed to the unloaded speed (or to increase the speed at all) the supply voltage to the motor must be increased. ▶

Project 258

The circuit used in this project employs a standard three-terminal positive voltage regulator IC and a transistor differential pair in a feedback circuit to increase the output of the regulator under load. An LM340T5 (National Semiconductors) regulator was used here. A 7805 could equally well be used.

How's it used? Well, the output voltage of a 5 V three-terminal positive voltage regulator can be increased by returning the 'reference' (REF.) pin to the junction of a resistive divider connected between the output terminal and 0 V, as shown in the circuit.

The output voltage is determined by the formula:

$$V_{out} = 5\ \mathrm{V} + \left(\frac{5}{R_2} + I_Q\right) R1$$

The output voltage can be varied by making the resistor R1 in the circuit adjustable. In this project, R1 is replaced by a suitably biased transistor (Q1 in the circuit).

PARTS LIST — ETI 258

Resistors	all ½W, 5% unless noted
R1, R2	470R
R3	0R22, 5 W
R4, R5	100k
R6	220R
RV1	10k
Capacitors	
C1	2200u/25 V electro.
Semiconductors	
D1-D5	1N4004 or similar
Q1, Q2	BC547
IC1	LM340T/5 3-terminal regulator
ZD1	12 V, 400 mW or 1 W zener

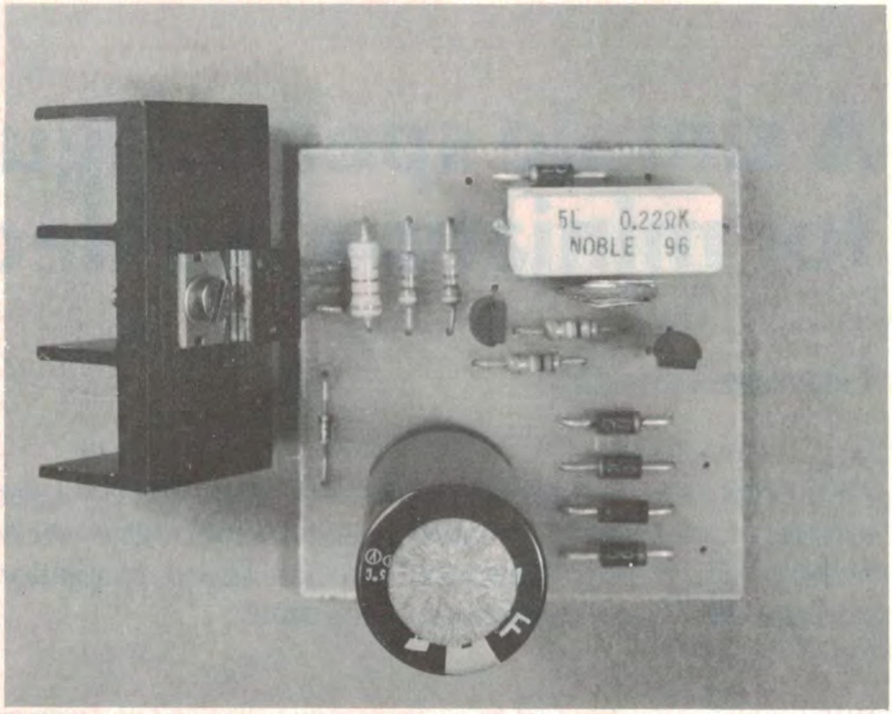
Miscellaneous
ETI-258 pc board; 12-14 Vac supply (i.e: plugpack); wire; zippy box to suit, etc.

Price estimate

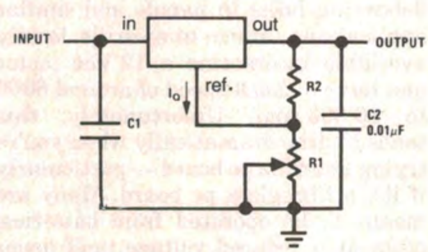
We estimate that the cost of purchasing all the components for this project will be in the range:

$6 - $8

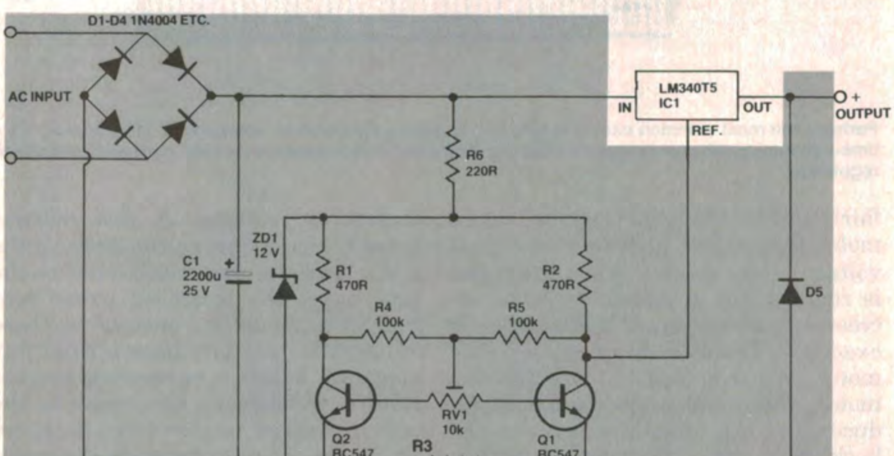
Note that this is an **estimate** only and **not** a recommended price. A variety of factors may affect the price of a project such as — quality of components purchased, type of pc board (fibre-glass or phenolic base), type of front panel (if used) supplied etc — whether bought as separate components or made up as a kit.



Construction is very simple — as you can see! The pc board is not absolutely essential, but convenient. The trimpot, RV1, visible just adjacent to the 0.22 ohm 5W resistor (R3), is adjusted to provide a nominal 12 Vdc at the output terminals under no load. Adjustment is relatively non-critical.

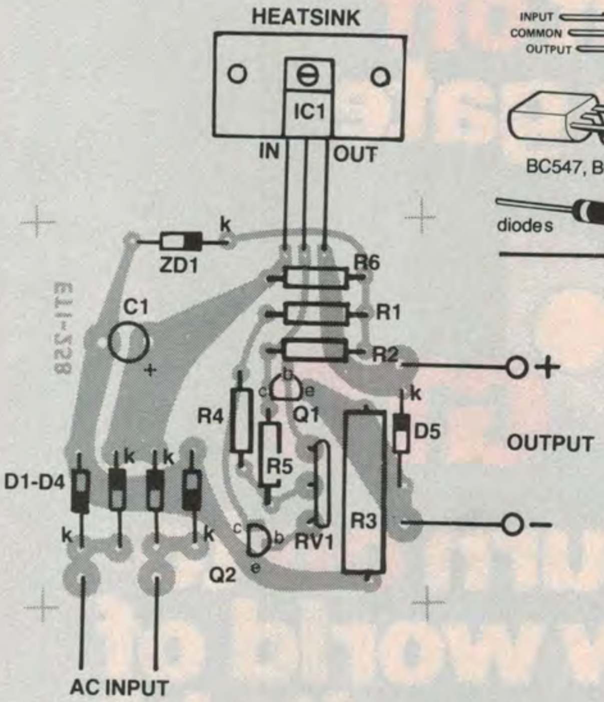


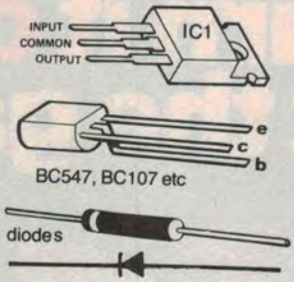
Showing how a three-terminal regulator can be arranged to have an adjustable output. The variable resistor, R1, here is replaced by a transistor in our regulator circuit below left.



Construction

Construction is quite straightforward, no tricks here. Using our pc board will ensure you have a compact unit that can be conveniently tucked somewhere out of harm's way. The pc board is not essential, however. Layout is not really critical, but keep all leads to and from IC1 short to prevent high frequency oscillation. If you have trouble with the latter, a 10n ceramic or greencap capacitor soldered directly between the output and reference pins of IC1 will cure the problem, although we didn't find it necessary. But that's getting ahead of ourselves!





Construction is best tackled by mounting all the resistors, diodes and transistors on the pc board first — leaving R3 till last as it's a bulky item. Watch the orientation of the diodes and transistors as usual. Mount C1 next. Mount IC1 last of all and then attach a small heatsink to it.

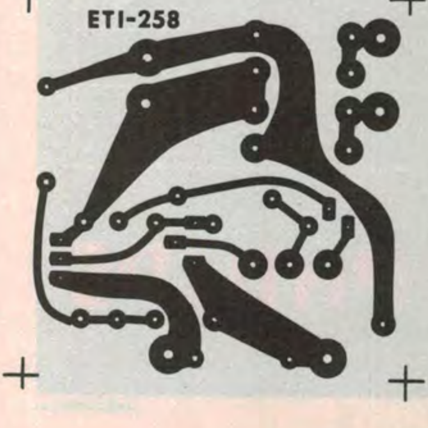
The completed unit can be housed in any convenient box or case, to suit yourself.

Supply input

The project may be supplied from any transformer, or a plugpack, that will deliver between 9 Vac and 12 Vac at 200 to 500 mA, or up to 1 A. A transformer such as the ubiquitous model 2155 (e.g: Arlec AR-2155 or Dick Smith M-2155, etc.) will do the job nicely using the 9.5 V tap.

A dc plugpack may be used if you leave out D1-D4 and connect the plugpack's output directly across C1 (watch the polarity!). A 12 Vdc plugpack rated at 200 mA or more would be suitable.

Although the mini-drill we used originally ran off two 1.5 V batteries (i.e: 3 V) it ran quite happily from our speed regulator. If you have to use the drill for prolonged periods, rest it at intervals so that the motor temperature does not rise too high. ●



HOW IT WORKS — ETI 258

A conventional bridge rectifier (D1 to D4) and capacitor-input filter (C1) provides dc input to the regulator circuit consisting of IC1 and Q1, Q2 plus associated components. Output with no load is set by adjusting RV1 for a nominal 12 Vdc at the output terminals. With the drill connected and operating the voltage drop across R3 causes Q2 to conduct more. As Q1 and Q2 are connected as a differential pair, the collector current through Q1 will decrease. This results in an increasing collector voltage on Q1. The reference pin of IC1 will be raised to a higher voltage with respect to the −ve line and the output voltage will increase.

Diode D5 is fitted to protect IC1 against back-emf spikes from the motor. There is no need to worry about the IC suffering damage from this source as it is internally protected. If you stall the motor, the maximum current delivered will be limited by IC1, which is internally protected to limit at a maximum current of 1 A.

Different voltage motors can be accommodated by changing the reference zener, ZD1.