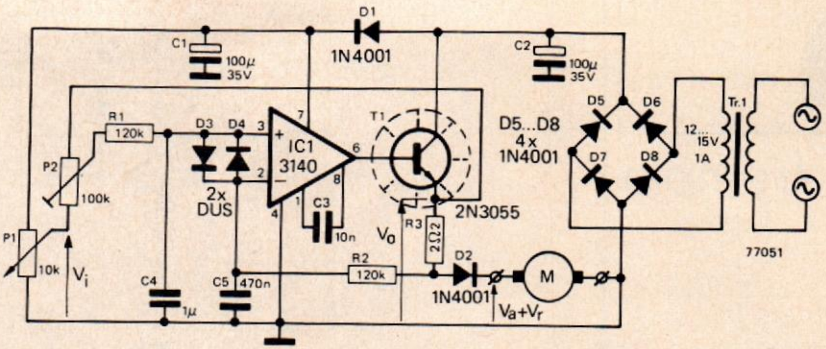
17

model speed control



The disadvantage of most simple speed controllers for model trains or cars is that they simply supply the motor with a fixed voltage. Consequently the speed does not remain constant, since the model slows down when climbing gradients and speeds up when going downhill. With model trains the setting of the control knob to maintain a particular speed also varies with the load that the engine is pulling.

The circuit described here eliminates this problem by monitoring the motor speed and keeping it constant for a given control setting, irrespective of load. The circuit will operate with most models which use a DC permanent magnet motor.

The terminal voltage of a motor consists of two components, the back e.m.f. generated by the motor and the voltage dropped across the armature resistance. The back e.m.f. is proportional to the motor speed and so motor speed can be sensed by measuring it, but the problem is to separate the back e.m.f. from the resistance voltage. If an external resistor is connected in series with the motor then, since the same current flows through it and through the armature resistance, the voltage drop across the series resistor will be proportional to the drop across the armature resistance. In fact if the two resistances are equal then the two voltages will be equal, and the voltage across the series resistor can be subtracted from the motor voltage, leaving only the back e.m.f. The circuit monitors the back e.m.f. and adjusts the motor current so that, for a given control setting, the back e.m.f., and hence the motor speed, remains constant.

To simplify the description of the circuit it is assumed that P2 is set to its mid-position and that R3 is equal to the armature resistance of the motor.

The motor voltage is the sum of the back e.m.f. V_a and the voltage dropped across the internal resistance V_r. Since a voltage V_r is dropped across R3 the output voltage V_o equals $V_a + 2\,V_r$. The voltage at the inverting input of IC1 is $V_a + V_r$, and that at the non-inverting input is $V_i + \frac{V_a + 2V_r - V_i}{2}$.

These two voltages are equal,

i.e. $V_a + V_r = V_i + \frac{(V_a + 2V_r - V_i)}{2}$

Simplifying this equation gives $V_a = V_i$, which means that the back e.m.f. is always kept equal to the control voltage, so the motor runs at constant speed for a given setting of the speed control P1. P2 is used to compensate for the fact that R3 may not be equal to the armature resistance, by varying the amount of positive feedback to the non-inverting input.

To set up the circuit a model is run and P2 is adjusted until the speed just remains constant on gradients and with different loads. If P2 is turned too far towards P1 then the model will slow down, but if P2 is turned too far in the opposite direction then the model will actually go faster when climbing a gradient. If the controller is to be used with several different models then they must obviously all be fitted with similar motors, otherwise the circuit would require readjustment whenever a different model was used.

The output transistor T1 should be fitted with a heatsink of around 4°C/watt.