

SIMPLE PWM THROTTLE

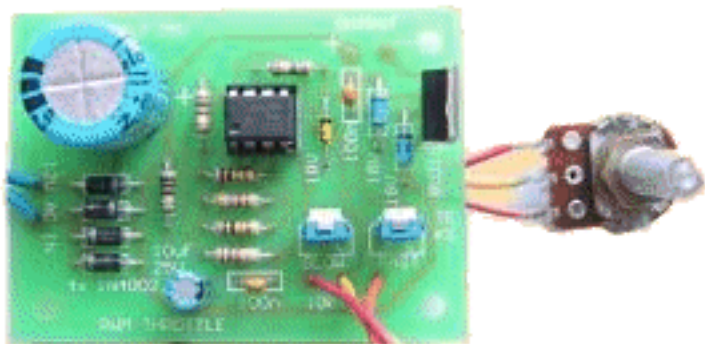
This kit is available from:

Talking Electronics

email Colin Mitchell:

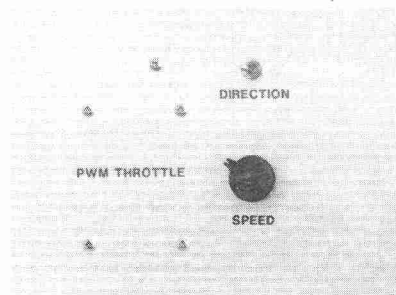
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PWM THROTTLE

A simple, high performance throttle, featuring a PWM FET output and a voltage controlled input.



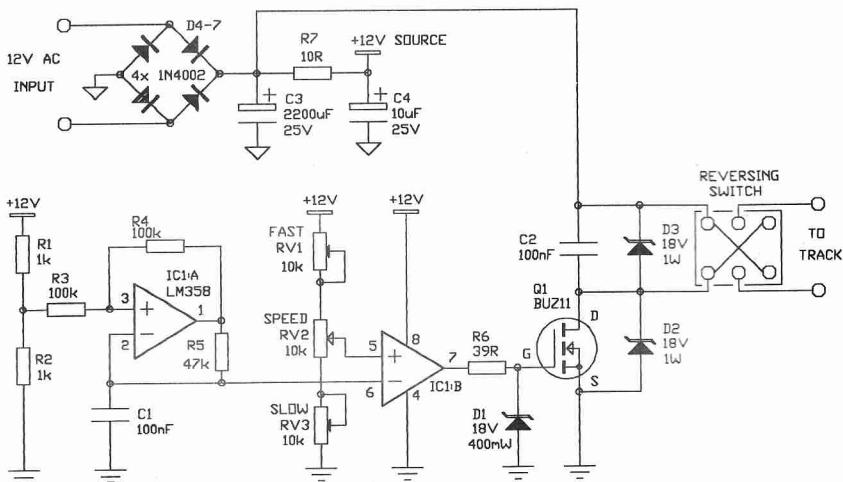
The simplest version of the PWM throttle. It has two controls: speed and direction.

Not having enough throttles is one of the most frustrating things for a railway modeller. The main lines each require their own, and it is really handy to have at least one more to use for shunting. If you have set up the layout to have blocks, you may even like one per block.

This project is a simple but versatile throttle. It features a pulse width modulated FET output and a voltage controlled input. I have always found PWM throttles to be more effective at starting trains, and prefer them to alternative types of throttle. As for the voltage controlled input, if all you want is a simple throttle, all you have to do is connect a pot to it.

Alternately, if you want a throttle with momentum, it can be easily achieved by the addition of an electro, a resistor and a switch. More complex brake and throttle arrangements can be lashed up with a few components. Using the basic momentum circuit, it is possible to remove the speed control pot altogether, using two push buttons in its place, one for accelerating, and one for braking.

If computer control is what you are after, the throttle may be controlled either by a digital to analog converter, or by selecting different voltage levels from a divider chain using



The PWM Throttle circuit diagram.

4051 analog multiplexer. In the second case, there will be only eight speeds available, but if the momentum circuit is used, it will smooth out the steps, making the transitions from one speed to the next undetectable. The reversing switch will need to be replaced by a relay. The Remote Relay Unit from Electronics for Model Railways No.1 is ideal. If you decide to go with the D/A converter, it is worth noting that an additive DC mixer will be required between the D/A converter and the throttle input, because the throttle input is offset by a few volts.

ABOUT THE CIRCUIT

IC1:A, an LM358 op-amp, is wired as an oscillator. Its function is very similar to that of an oscillator based 40106. Initially C1 will be uncharged, holding pin 2 (the inverting input) of the comparator at 0V. R1 and R2 form a voltage divider, generating a 6V reference that is fed via R3 to pin 3 (the non-inverting input) of the comparator. As the non-inverting input has a higher voltage on it than the inverting input, the output of the comparator will be HIGH (about 12V). This is where the second voltage divider, consisting of R3 and R4, comes into play. One end of R3 is connected to 6V. The output of the comparator is holding one end of R4 at 12V. Therefore the junction of R3 and R4, and pin 3 of the comparator, is at 9V.

C1 is charged via R5 until the voltage across it reaches just over 9V. As the voltage on the inverting input of the comparator is now higher than its non-inverting input, the output will swing LOW, taking the end of the R3/R4 voltage divider with it. This means that pin 3 will now be held at 3V; halfway between 6V and 0V.

C1 will now discharge via R5 until the voltage across it is just under 3V. As the voltage on the non-inverting input is again higher than that on the inverting input, the output of the comparator will swing HIGH, starting the cycle over again.

25% PULSE WIDTH



50% PULSE WIDTH

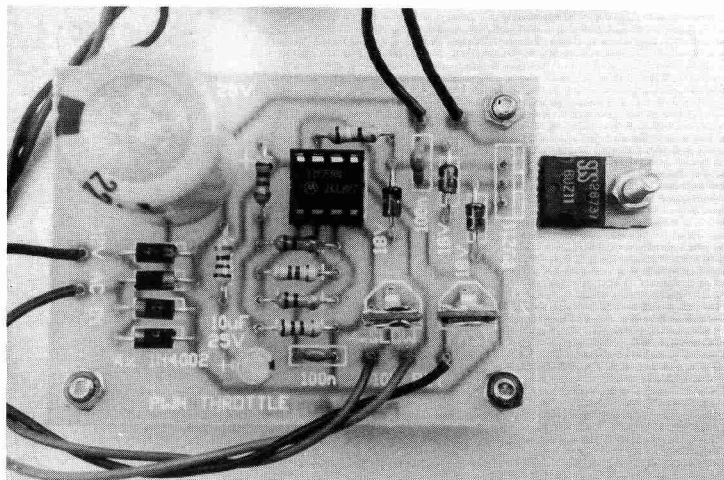


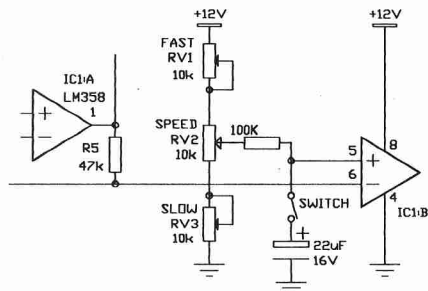
75% PULSE WIDTH



This simple diagram should help you understand the principle of PWM. The three lines represent the inputs and output of the PWM comparator. The triangle wave is fed to the inverting input of the comparator. The straight line represents the control voltage that is fed to the non-inverting input of the comparator. Where it is with respect to the triangle wave determines what the output waveform will be. The rectangular wave shown for each case is the resulting output.

The voltage across C1 will therefore ramp up and down between about 3V and 9V. The waveform generated is very close to a triangle wave. This waveform is fed into pin 6, the inverting input of the second comparator IC1:B. Pin 5, the non-inverting input is the speed controlling input of the throttle. When the voltage at this pin is below 3V, the output (pin 7) of the comparator will be LOW, keeping the FET switched off. If the voltage is moved up to just over 3V, every time the voltage across C1 goes down to 3V, the comparator output will swing HIGH briefly, switching on the FET. If the voltage fed into pin 5 is moved up to 6V, the





The simple momentum modification.

duty cycle of the output will be at 50%. If the voltage is taken up above 9V, the output of the comparator will stay HIGH, keeping the FET switched on.

The output of the PWM comparator is fed to the gate of the FET via R6. There is an 18V zener across the source/gate junction of the FET. This zener limits the voltage fed to the gate of the FET to 18 volts and also snubs any spikes over 18 volts that may be induced on the gate via the internal capacitive coupling of the gate with the load current path inside the FET itself.

Any spikes generated by the motor, or wheel to track connection are snubbed by D2, D3, C2 and the internal reverse biased integral body diode in the FET itself.

The FET's worst enemy in a circuit like this is the voltage spike. Make sure all of your locomotives still have their TVI capacitors in place across their motors. Adding 100nF capacitors at a couple of strategic locations around the track would also help.

PARTS LIST

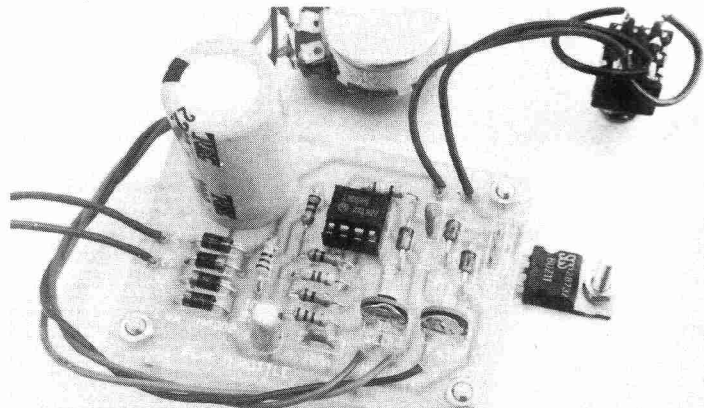
- 1- 10R
- 1- 39R
- 2- 1k
- 1- 47k
- 3- 100k
- 2- 10k Mini Trimpots
- 1- 10k Pot

- 2- 100nF Monoblocks
- 1- 10uF 25V Electro
- 1- 22uF 25V Electro
- 1- 2200uF 25V Electro

- 1- 18V 400mW Zener
- 2- 18V 1W Zener
- 4- 1N4002 Diodes
- 1- BUZ11 MOSFET
- 1- LM358 Op-amp
- 1- 8 pin IC Socket
- 1- Nut and Bolt
- 1- TO-220 Mounting Kit
- 1- DPDT Toggle Switch
- 1- PWM THROTTLE PCB

The throttle can handle loads of 1 to 2 amps. There is no provision on the board for adding extra FETs.

The circuit has no overload protection. I have tested the unit into a short circuit with no problems. However I would recommend using a 50W car headlamp bulb in series with



the output of the throttle. The headlamp bulbs are still the best short circuit protection that anyone has come up with for model railways. Just remember that the lamp itself is an overload, so switch off the throttle as soon as you can, then go look for your short circuit.

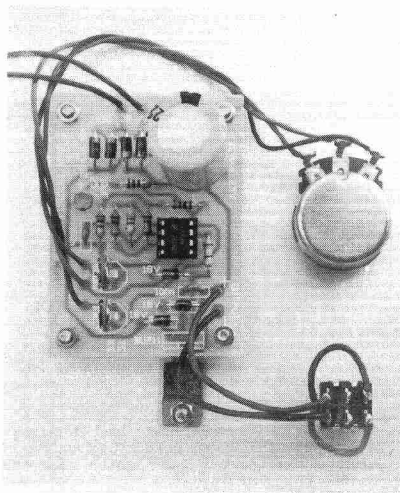
CONSTRUCTION

The throttle is constructed on a printed circuit board measuring 65mm by 48mm. The overlay on the PCB shows component location and orientation. The orientation of the FET is represented by a line through the symbol on the side that the metal surface or tab should face. Zeners are represented by their zener voltage. The size of the zener drawn on the overlay indicates the wattage. The larger symbol is for 1W devices.

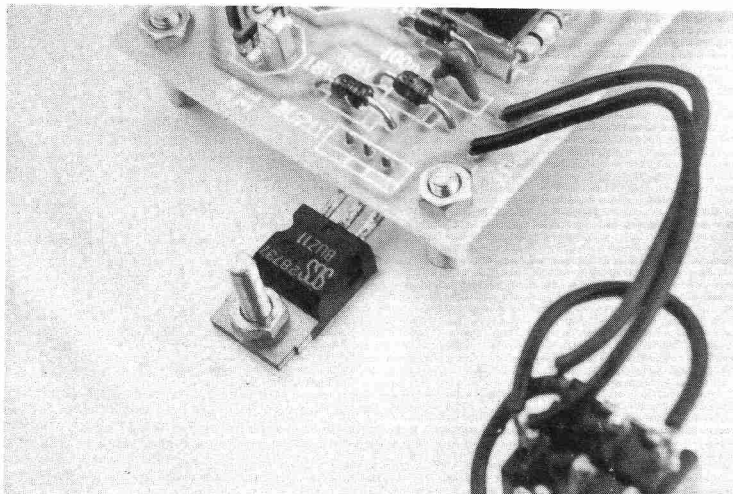
Install all of the low profile components such as the socket, the resistors and diodes, followed by the taller components. The FET is a static sensitive device and should be handled with care. Make sure that your soldering iron is properly earthed to prevent any static build up on it. It is also a good idea to earth yourself when handling the FET, but if this is impractical, at least touch something that is earthed to discharge any static before handling it.

A heatsink will help keep the FET cool. I mounted my FET from the underside of the PCB so I could bolt it to the aluminium sheet on which I mounted my throttle. Use an insulating kit if you do this. Refer to the wiring diagram when you are wiring the pot and reversing switch.

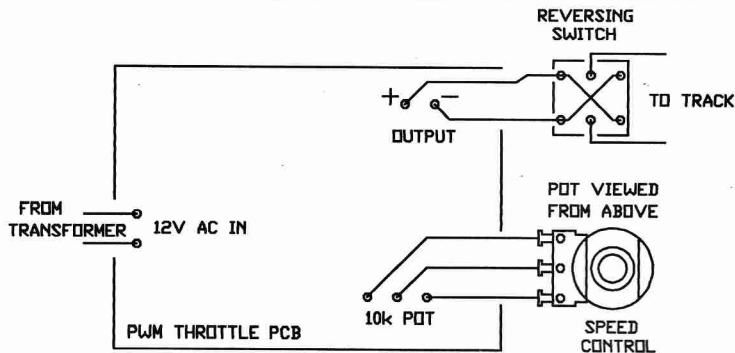
If you wish to experiment with momentum, there is a simple circuit diagram that shows where to connect the components. If you are into computer control, you will have to work out your own interface circuits, as there is no way I can detail all the possibilities.



The complete wiring of the simple version of the throttle. The output to the tracks is from the centre two terminals on the switch.

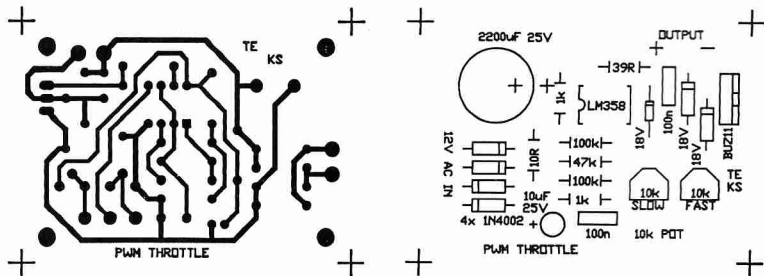
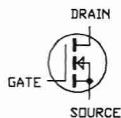
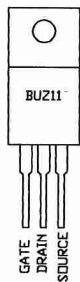


A close up of the FET showing how it is mounted on the sheet of aluminium. Note the use of an insulating kit.



Above is the wiring diagram for the simple throttle while to the right is the pinout of the BUZ11 FET. Remember that the FET is a static sensitive device.

Set up is simple. Connect a small 12V motor to the output of the throttle. Turn the speed control pot to minimum. Adjust the trimpot marked "SLOW" until the motor starts, then back off again until it stops. If the motor is still making a slight humming sound, adjust the pot until the sound stops too. Maximum speed is set using the "FAST" trimpot. Set it to what you find gives you the best range of control with the speed control pot. It does not have to be set to maximum. When you have done this, go back and check the minimum setting again. The two trimpots are interactive, so it is possible that it may now be slightly out of adjustment.



The PC artwork for the PWM Throttle.