

WALK-AROUND THROTTLE

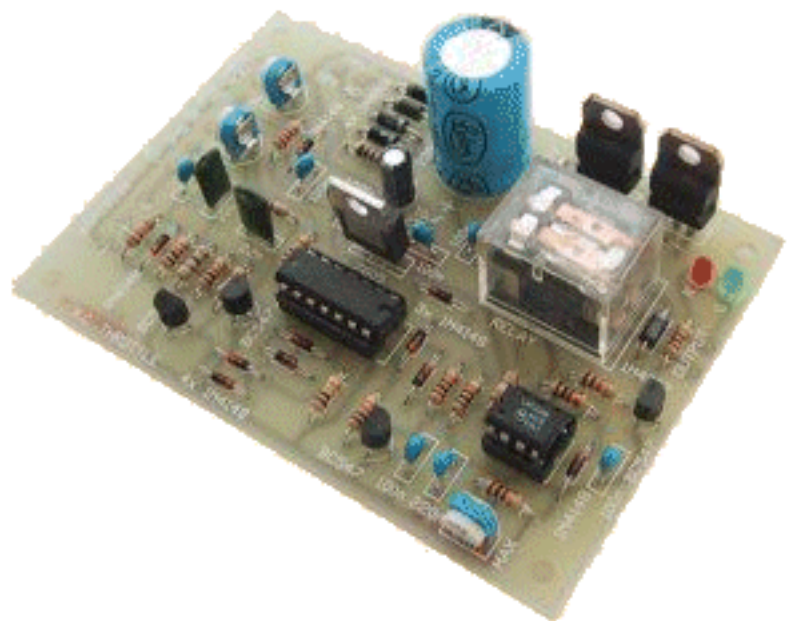
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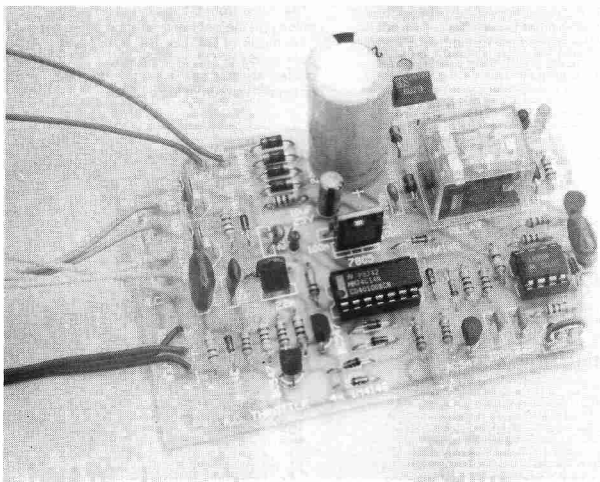
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WALK-AROUND THROTTLE

Tired of being tethered to your layout? Perhaps you'd like to watch your trains from a different vantage point. Gain some freedom of movement with this radio controlled throttle.



On large layouts, walk-around throttles are popular because they allow the driver to stay with his train, monitoring its progress better than he could from some remote location. Walk-around throttles vary a lot in design from simple throttles that must be plugged into the layout at various locations, right through to real "wireless" control systems where the driver is totally unrestricted in his movement.

While the simple plug in arrangement is cheap and does work, it has some disadvantages. The obvious one is being tethered to the layout. Another is unless you have a throttle specially designed for the purpose, the train will stop every time you unplug the controller.

Wireless type controllers overcome these problems, allowing full control of the train from any location on the layout. There are two systems that can be employed; infra-red or radio. This article describes how to adapt a commercial radio control set to use as a walk around throttle.

The radio link is provided by the radio control unit. The circuit described here is a throttle that is compatible with the pulse system used by the radio gear, and is actually an adaptation of a successful MOSFET electronic speed controller that has been used in radio controlled buggy racing. Note that these buggies are not the cheap affairs that can be picked up at a supermarket, but rather specialist racing machines that are usually priced at over \$500.

Don't let that price scare you. Now that the radio controlled buggy fad is dying, second-hand two channel radio

sets can be picked up quite cheaply. Often they are for sale with worn out buggies. The unit in the photographs cost me only \$20, including a buggy that had been chewed by the owner's pet Alsatian. The radio gear was fine.

I have bought a few sets of second-hand radio gear. The only problems I have found with them is that sometimes the servo that was used for steering has been damaged. This project doesn't use the servos anyway. Just don't buy a unit that has been used in a boat. If the receiver looks as if it has been wet, there is a good chance that it will be corroded inside. This applies to the receivers from buggies too!

I should point out here that this unit is designed for R/C gear that uses the positive pulse system. Most of the common brands do. I have used this throttle with Futaba, Kraft, Technipus and JR radios. Don't try to use it with the radio control set out of a child's toy buggy. You'll never get it to work.

ABOUT THE CIRCUIT

The radio controlled throttle is made up of several smaller blocks, each quite easy to understand.

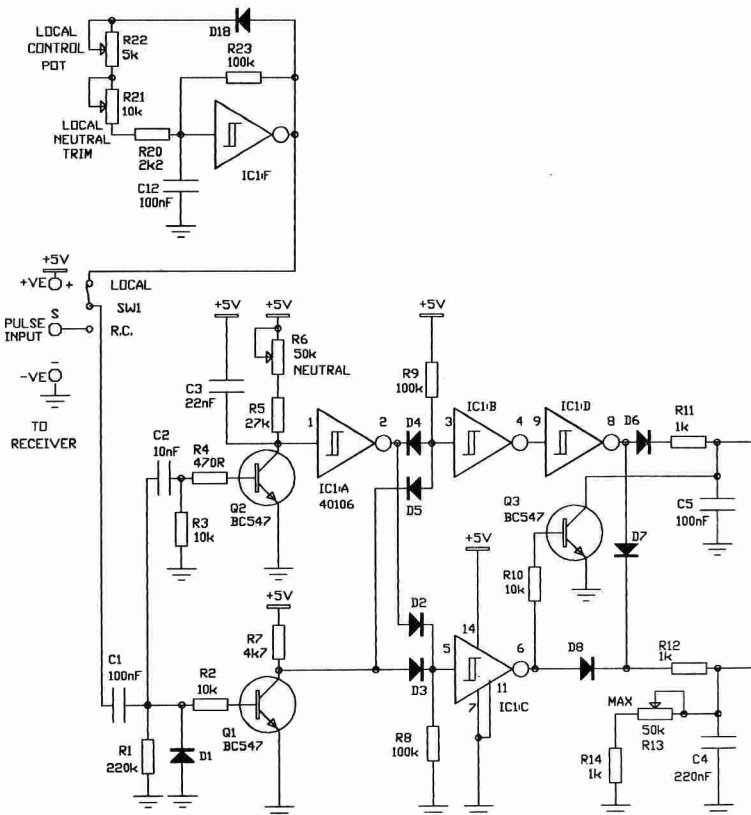
The R.C. transmitter sends control information to the receiver as a string of width modulated pulses. The receiver sorts these out and sends them to the correct servo. The radio controlled throttle is connected in place of one of these servos.

The throttle runs off 12V AC. The AC is rectified and smoothed by D14-17 and C8. R19 and C9 provide decoupling for the control circuitry. VR1 and its associated components, C10 and C12 provide regulated 5 volts for the radio control receiver and the throttle's pulse processing circuits. The receiver is designed to run on five or six volts, so the regulator is essential.

The decoded pulse train from the receiver is fed to the throttle via SW1 and C1. This capacitor blocks any constant logic High signal a receiver may output when first switched on or when the transmitter is switched off or out of range. This prevents the train from running away at maximum throttle. At most, the train would lurch for a second before coming to a standstill.

Under normal circumstances C1 will pass the pulse train through to R2 and C2. C2 puts a very short spike on the base of Q2, which turns it on briefly, charging C3. C3 then discharges through R5 and R6. This pulse is cleaned up and inverted by IC1:A to give a positive going pulse. This pulse is adjusted by trimpot R6 so it is the same length as the pulse from the receiver when the transmitter stick or knob is in the neutral position. This pulse is the neutral reference pulse.

The pulse from C1 is also inverted by Q1. The inverted pulse and the neutral reference pulse are fed into an AND gate made of D4, D5, R9, IC1:B and IC1:D and a NOR gate made of D2, D3, R8 and IC1:C. When both of the pulses are the same length, the outputs of both these gates will remain at logic LOW.



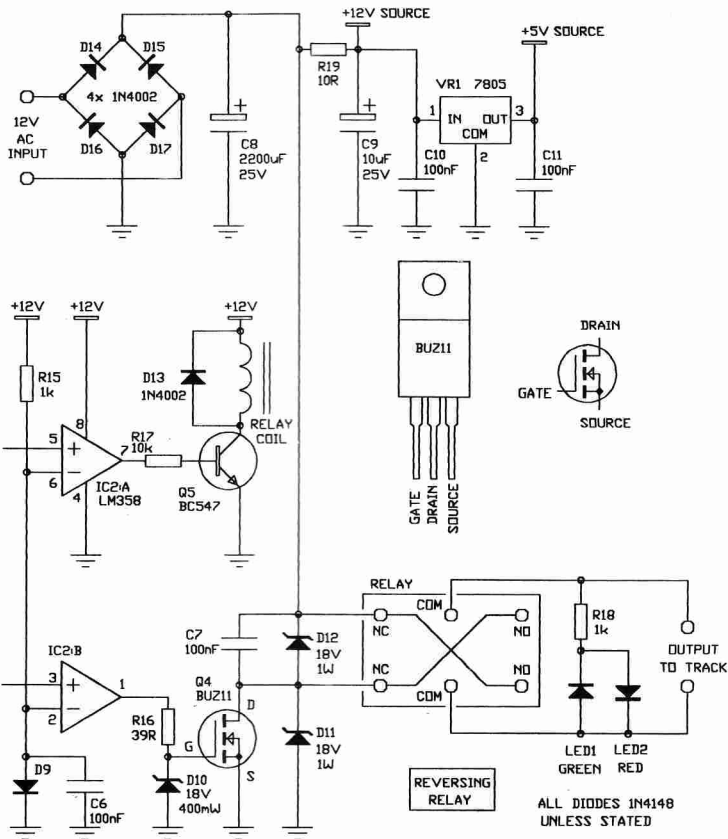
The R.C. throttle circuit diagram.

When the pulse from the receiver becomes longer than the neutral reference pulse, a narrow pulse, equal to the difference in the pulse lengths, is passed through to D8 and R10. This turns on Q3 briefly ensuring that C5 is discharged. (more on this later) and charges up C4 via R12. The pulse will vary in length according to the position of the transmitter stick or throttle knob and thus represent the speed required. Depending on the length, C4 will be charged different amounts. It then discharges more slowly through R13 and R14. The resultant ramp is fed to half of IC2, which is wired as a comparator. The 0.6 volt reference voltage being fed to the inverting input of the comparator is generated by D9, R15 and C6.

When the voltage across C4 is greater than 0.6 volts the output of the comparator will be high. R13 is adjusted so

that at full throttle on the transmitter stick or throttle knob, the voltage across C4 does not fall below 0.6V, thus giving a constant HIGH out of the comparator. The output of the comparator is hence a variable mark/space ratio, continuously variable between 0 and 100%. This pulse train, with appropriate buffering, makes an ideal PWM (Pulse Width Modulation) speed controller.

The corresponding reverse circuit functions in the much the same manner except for a couple of minor differences. The first is that the AND gate passes the difference in pulse length when the incoming pulse is shorter than the neutral pulse. The pulse is passed through to R12 and C4 via D7. This gives the same 0 to 100% PWM control as described above. The second difference is that instead of discharg-





The modified transmitter. The crystal is visible below the control knob.

ing C5 by switching on Q3, the circuit actually charges it via D6 and R11.

As soon as the voltage across C5 is greater than 0.6V, (which is almost instantly) the output of IC2:A goes HIGH, switching on Q5 and closing the relay. The relay is wired as a reversing switch and is between the FET output of the PWM controller and the output to the track.

As there is no discharge resistor on C5, Q3 is required to discharge it when forward is selected again.

A FET has been used as the output device of the throttle. It requires very little current to switch on as it is a voltage

driven device. This makes it easy to connect directly to the comparator. To switch on a FET a voltage of 4 to 20 volts must be applied to the gate with reference to the source. The higher the voltage the more current the FET can switch. A voltage over 20 volts will destroy the FET.

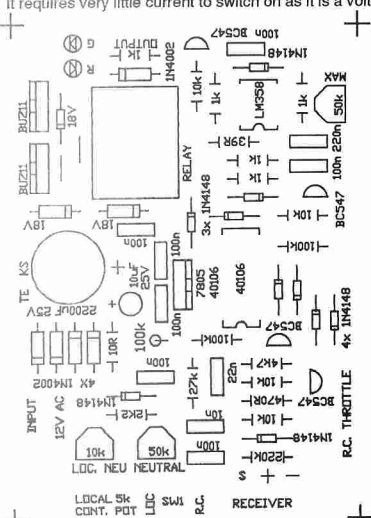
You will notice that IC2 is powered from the 12 volt rail. This is so that the FET can be turned on hard. If a 5 volt signal was used, the FET would not be turned on very hard, or in some cases, it would not be turned on at all.

The output of the PWM comparator is fed to the gate of the FET via R16. 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.

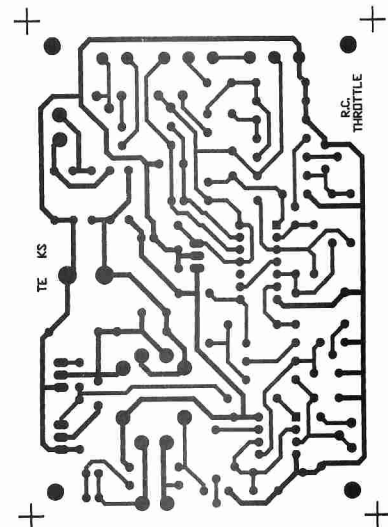
When the FET is on, the circuit to the train's motor is completed. Any spikes generated by the motor, or wheel to track connection are snubbed by D12, C7 and the internal reverse biased integral body diode in the FET itself.

Provision has been made for a second FET, should someone wish to use the throttle for larger scales. Each FET is rated at around 35 amps at 25 degrees C. Don't let this fool you. The FET leads, and the printed circuit tracks would never handle the current. The throttle as shown is good for 1 to 2 amps. I would not recommend more than a five amp load if two FETs are used. And of course if you do this, you will need to beef up the power supply.

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.



The PCB artwork for the R.C. Throttle.



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.

The final section of the circuit to look at is the local control. SW1 switches between the pulse train from the receiver and the pulse train generated by this oscillator. This oscillator effectively emulates the pulse train of the radio control system, allowing the throttle to be used from a fixed position should it be necessary.

If you are not using the transmitter, switch it off. Transmitters are capable of inducing pulse trains in other circuits. They can cause control problems if taken too close to other circuitry, and can introduce an audible noise in amplifiers.

Remember that you are on a shared radio band. There are numerous crystals available, giving you a range of channels to choose from, but if someone else is using your channel, show some consideration. You will be close enough to your receiver to swamp their signal, but in doing so, you may interfere with the control of their model, and this leads to buggies driving down drains, planes dropping from the sky and so on.

CONSTRUCTION

The speed controller is constructed on a printed circuit board measuring 101mm by 70mm. The overlay on the PCB shows component location and orientation. The orientation of the FETs are 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.

Install the two links first. Next install all of the low profile components such as the sockets, the resistors and diodes, followed by the taller components. IC1 and the FET are static sensitive devices 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.

Solder the rainbow cable that runs to the receiver next. The brown or black wire goes to the small pad marked "-". The red wire goes to the pad marked "+" next to it. The orange or other coloured wire goes to the other end of the PCB to the pad marked "S". The plugs used on the receivers vary from brand to brand, as does the order in which these wires are. Plugs can be bought as spare parts usually with a length of cable included, but they can be very expensive. The plug could be cut from a servo but doing so will disable servo. Alternately, a small 3 pin 0.1 inch spaced socket can be used in most cases, one of the exceptions being the old Futaba plug.

On all the radio systems mentioned earlier, the red wire is positive, the black or brown wire is negative, and the other wire, be it white, blue or orange, is the signal wire. If you are unsure, open the receiver and trace the wires from the receiver's battery to the PCB.

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.

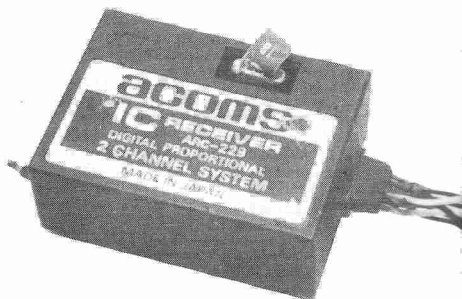
I replaced one of the joy-sticks on my transmitter with a pot, as I felt it was more convenient than the joy-stick. It is

PARTS LIST

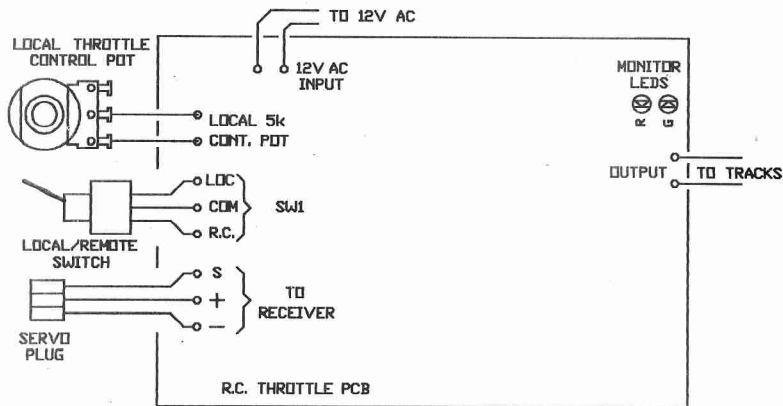
- 1- 10R
- 1- 39R
- 1- 470R
- 5- 1k
- 1- 2k2
- 1- 4k7
- 4- 10k
- 1- 27k
- 3- 100k
- 1- 220k
- 1- 5K Linear Pot
- 1- 10k mini trimpot
- 2- 50k mini trimpots

- 1- 10nF
- 1- 22nF
- 7- 100nF Monoblock caps
- 1- 220nF Monoblock cap
- 1- 10uF 25V Electro
- 1- 2200uF 25V Electro

- 1- 18V 400mW Zener
- 2- 18V 1W Zeners
- 10- 1N4148
- 5- 1N4002
- 4- BC547 Transistors
- 1- BUZ11 FET
- 1- 7805 regulator
- 1- LM358 Dual Op-Amp
- 1- 40106 Hex Schmitt Inverter
- 1- Green 3mm LED
- 1- Red 3mm LED
- 1- 12V DPDT RELAY
- 1- 14 pin IC socket
- 1- 8 pin IC socket
- 1- SPDT Toggle Switch
- 1- R.C. THROTTLE PCB



The R.C. receiver.



This diagram shows how to wire the R.C. Throttle.

not simply a matter of using a pot the same value as the one in the joy-stick because joy-sticks use only 90 degrees of the pot's travel. The joy-stick must be removed from the transmitter and the pot's travel measured with a multi-meter. I found mine to use about 1k of travel on a 5k pot. It was offset from one end by about 1k9. So I used a 1k pot with a 1k8 resistor on one end of it and a 2k2 on the other. It all adds up to 5k and the transmitter worked fine. The joy stick on my transmitter was easily removed by undoing four screws. Unfortunately, more often than not, the joy-sticks are integral with the case, so it requires some creative hacking to adapt the case to take a pot.

If you prefer, it is a simple matter to remove the spring return from the back of the joy-stick. This will stop the stick centring as soon as you release it. A small friction pad can be arranged to stiffen the joy-stick if required. Some transmitters actually have provision for this on the back of the joy-stick.

If you wish to use two throttles with one receiver, that is one per channel, leave out 5 volt wire from the second throttle to the receiver.

SET UP

In order to set up the throttle it is necessary to monitor its output. There are two LEDs on the printed circuit board, near the relay, to give a visual indication of the output. A small 12 volt electric motor will also help in the adjustment.

Connect the throttle to your radio gear and switch on the transmitter. Centre the throttle knob. Adjust R6, which is marked by "NEUTRAL" on the PCB, so that neither LED is illuminated. Connect the electric motor across the output of the throttle. Now move the throttle knob on the transmitter to about 7/8ths of travel and adjust R13 (marked "MAX" on the PCB) until the motor is running just under the fastest speed that it will go. You can judge its speed by listening to the sound it is making. This sets the full throttle position.

If the LEDs do not light, or one of them stays lit the whole time, go back and check the construction and wiring. If the

Neutral pot has an effect, but you are not able to get the LEDs to go out, increase the value of R5 to 47k. This will only be necessary if the transmitter pulses are exceptionally long. Alternately if they are exceptionally short, reduce the value of R5 to about 10k. If the maximum speed setting is a problem, increase R14 to 10k or 22k.

Now that you have the throttle adjusted to the transmitter, switch SW1 across to the "LOCAL" position. With the local throttle knob centred, adjust the "Local Neutral" trimpot (R21) until both LEDs are off.

This completes the set up of the throttle.

Now where is Kimi's toy car?