

ECONOMY POWER SUPPLY

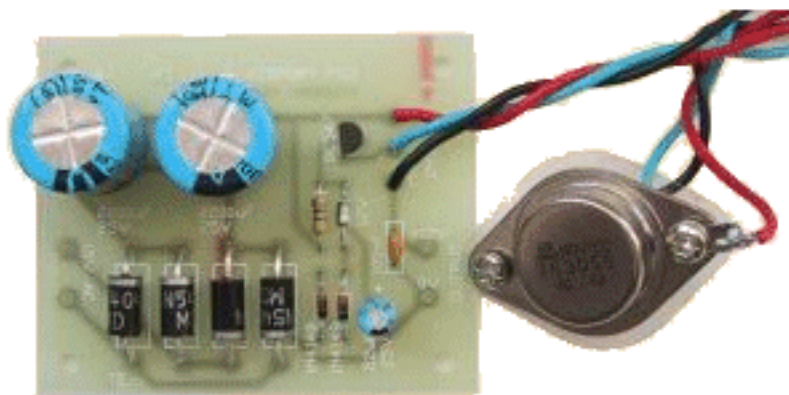
This kit is available from:

Talking Electronics

email **Colin Mitchell:**

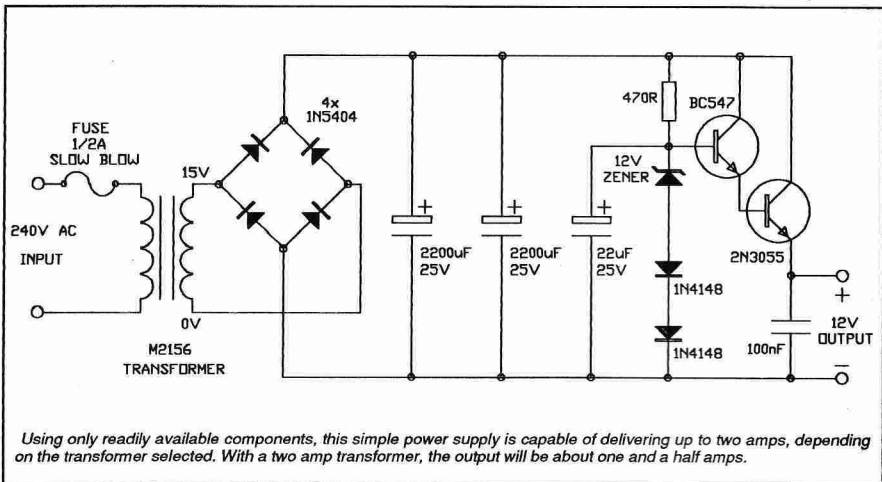
talking@tpg.com.au

for pricing and postage.



ECONOMY POWER SUPPLY

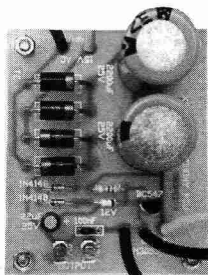
Electronic projects require smoothed, regulated power to function correctly. The DC output available from the auxiliary outputs of a train controller is neither, making it unsuitable. This simple project will provide power for many accessories without breaking the bank, so you can spend more on your real interest, trains.



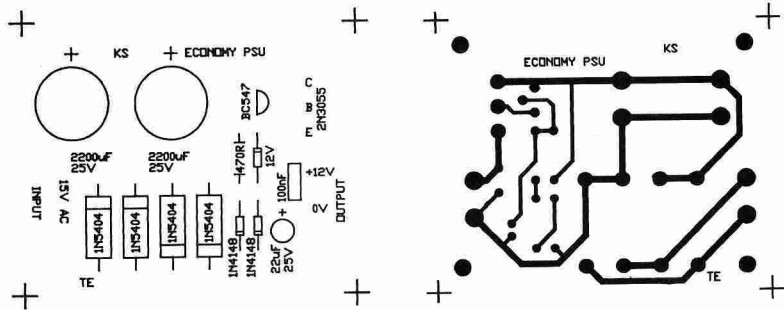
Electronic projects are sensitive to the supply on which they are run. Unlike lamps, they will not run on AC and when the AC is rectified to DC, it must be smoothed to allow the project to work properly.

There are some circuits in this book that include their own simple power supplies. The diesel sound generators are one example. The throttles, too, include their own simple power supplies. However, projects such as the signalling system, the servo drivers, the delay module and the tunnel extender require a regulated power supply to function correctly.

CMOS chips can not be run on more than 18 volts. This is their maximum limit. Any more and they literally explode, so it is wiser to keep the voltage well below this limit. 12 volts is a good choice, as apart from being well below the CMOS limit, this voltage is also suitable for grain of wheat lamps. The power supply must also be able to provide enough current to run several projects, perhaps a complete signalling system and a couple of accessories. I consider a supply capable of delivering 1 to 2 amps to be adequate. Any higher and the design of the supply can become tricky. Better heatsinking is required, and some form of overload protection becomes mandatory. The components required also become expensive and are often not available at hobbyist shops. It is better to use several smaller supplies.



All components except for the transformer, fuse and power transistor fit neatly on the printed circuit board. Once again construction is so simple that beginners should have no trouble assembling it. The 15 volt AC input from the transformer is at the top of the board. The regulated 12 volt output is at the bottom. The connections to the transistor are at the bottom right. Each pad is clearly marked.



The printed circuit artwork and overlay. Refer to the overlay when you are assembling the power supply. Take particular care to get the diodes and electrolytic capacitors the right way around.

As a power supply is not really an interesting project to build and has no potential as a display item, I have kept the circuit as simple and cheap as possible. It still contains all vital circuit sections, but its performance could be considered crude when compared with expensive up-market items. Its output voltage is fixed at roughly 12 volts, but may vary a little with load. It has no overload protection, so it will try to power a short circuit. But should it become damaged, repair will be cheap and easy.

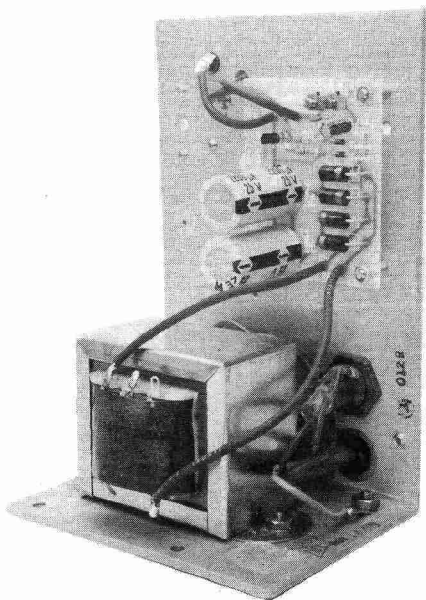
ABOUT THE CIRCUIT

First the mains voltage is reduced to a usable level by the transformer. The 15 volts AC is then rectified by the diode bridge. What we now have is un-smoothed DC, much like the output supplied on some commercial train controllers. This un-smoothed DC is then fed to the electrolytic capacitors. The capacitors charge on the voltage peaks of the un-smoothed DC, then discharge into the load during the gap between the peaks. This smooths the DC. The voltage will still fluctuate a little during the charge/discharge cycle, so further smoothing, or regulating is required.

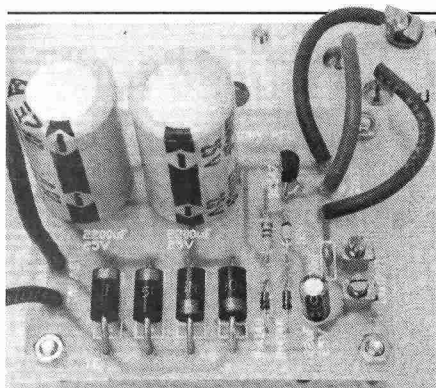
This is where the other components come in. They form a simple zener regulator. The heart of the circuit is the 12 volt zener diode. When a zener diode is reverse biased (fed backwards) it will not conduct until its maximum voltage is reached. At this point the zener will begin to conduct. The zener chosen here begins to conduct at approximately 12 volts.

The 470R and zener form a simple voltage regulator on their own. The 470R resistor provides the zener diode with a current limited supply and the zener will begin to conduct, maintaining 12 volts across itself. The current available for driving a load at this point is very small, only a few milliamps, but is enough to drive a small transistor.

The two transistors, each wired as emitter followers, form a simple darlington current amplifier. Each will try to keep its emitter voltage at 0.6V below that of its base. The first transistor is needed because the gain of the



I built my supply on a piece of aluminium that I had in my junk-box. It provides adequate cooling for the transistor.



second transistor, the power transistor, is not very high. Between them they have a gain of approximately 2000, or higher if a more sensitive power transistor is used. This means that for 1 milliamp present at the base of the first transistor, 2 amps will be available at the emitter of the power transistor, if an appropriate transformer is used.

As each transistor stage loses 0.6V the output of the regulator would be 12V minus 1.2V or 10.8 volts. By inserting two 1N4148 signal diodes (forward biased!) in line with the zener, we are able to lift the output back up to 12 volts. Each 1N4148 has a voltage drop across it of 0.6V, giving a total of 1.2 volts, perfectly compensating for the 1.2 volts lost by the transistors.

PARTS LIST for the PCB

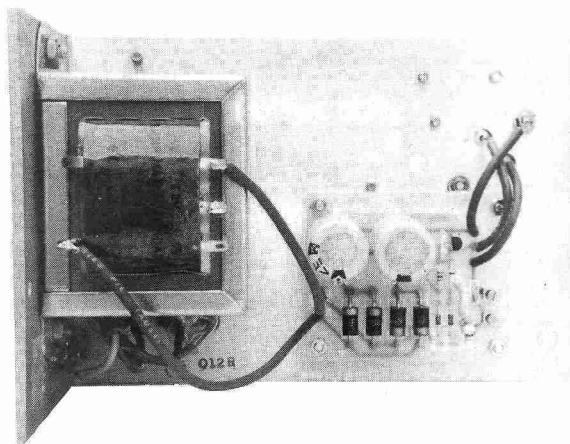
- 1- 470R 1/4W resistor
- 1- 100nF monoblock cap
- 1- 22uF 25V electrolytic.
- 2- 2200uF 25V electrolytics
- 4- 1N5404 diodes
- 2- 1N4148 diodes
- 1- 12V 400mW zener
- 1- BC547 transistor
- 1- 2N3055 transistor
- 1- TO-3 insulating kit
- 1- Tag for collector
- 1- Economy PSU PCB
- 2- Nuts, bolts and washers
- Thermal grease

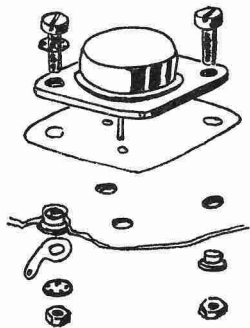
EXTRAS

- 1- M2156 15V 2A transformer
- 1- Mains lead
- 1- Fuse holder
- 1- 1/2A slow blow fuse
- 1- Tag for earth
- PCB Mounting hardware
- Wire
- Terminal block
- Sheet of aluminium

CONSTRUCTION

I built my supply on a piece of aluminium that had once been part of a power supply for another piece of equipment. It provides adequate heatsinking for the power transistor, as well as a convenient place to mount all of the other components. The transformer chosen for the job is the M2156. It provides taps for 6, 9, 12 and 15 volts AC at 2 amps, and is readily available. Any other 15 volt, 2 amp





This is how to mount the power transistor. Only two small dabs of silicon heatsink grease are required, one on each side of the mica washer. The insulating bushes are pushed into the aluminium from below and the bolts put through them from above. The left hand bolt provides the connection to the transistor's case, which is its collector. Star washers are used to ensure a good connection. After assembly, check between the transistor and aluminium with a multimeter to make sure you don't have a short.

transformer should work as well. Note that due to a quirk of rectification, only 1.4 amps DC will be available at the output of the supply.

Why? When a transformer's output is rectified and smoothed, the output voltage will be equal to the peak voltage of the transformer, rather than the RMS voltage at which it is rated. The peak voltage is approximately 1.4

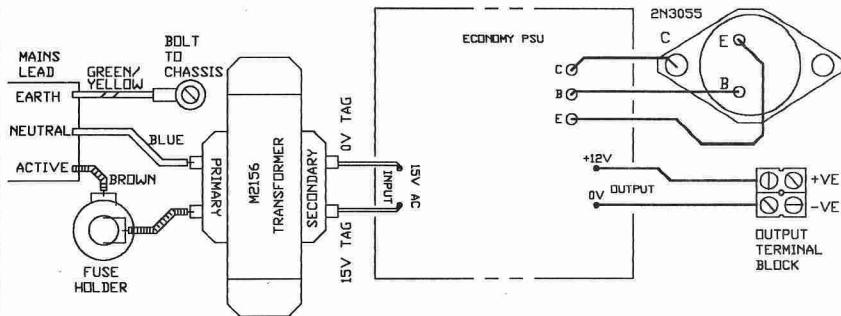
times higher than the RMS voltage. (The exact figure used is the square root of 2. However, diode losses will also have an effect, reducing this voltage.) As a transformer can only supply a certain amount of power, 30VA (volt amps) in this case, there must be a corresponding drop in the current available. Therefore, the DC current available is 2 amps divided by the square root of 2, or approximately 1.4 amps. You can try to pull more power out of the supply, but the output voltage will drop and the transformer will overheat and eventually burn out.

Connect the mains lead to it, using a terminal block if the transformer is the type with flying leads. If you wish, you can put a fuse in the active line. Mine uses a 1/2 amp slow blow type. Make sure that you properly anchor the mains lead to prevent it from being torn from the transformer tags or the terminal block. Earth the aluminium sheet. Insulate any bare mains connections with heat-shrink tubing. Mount the transformer so that connections can easily be made to its secondary.

Drill holes for the transistor and printed circuit board in the sheet of aluminium, making sure you don't leave any of the swarf amongst the wiring. Don't position the transistor so that it will be covered by the printed circuit board as this will make wiring difficult. You can use the blank printed circuit board as a drilling template. The mica washer makes a good template for the transistor. Don't drill through it, but rather use it to mark the holes with a pencil.

Next mount the 2N3055 power transistor using an insulating kit. Apply the heatsink grease very sparingly. It is only meant to fill any tiny gaps between the mica washer, transistor and heatsink. Too much of it is detrimental. Don't forget to put a tag under one of the nuts for the connection to the transistor collector. With a multimeter, check to see that you have done the job right. The transistor should be fully isolated from the aluminium. It is also a good idea to check your mains and earth wiring before you power it up.

Next, assemble the printed circuit board, taking care with the polarities of all components except for the resistor and



This diagram shows how to wire the power supply. Use a star washer between the earth lug and the aluminium sheet to make sure that the oxidation layer on the aluminium is punctured. Use another between the lug and the nut. When bolting down the transformer, use star washers under both the bolt heads and nuts, to ensure good earthing. Insulate all mains connections with heat-shrink tubing. Make sure the mains cable is firmly secured with a cable clamp.

100nF capacitor. The 3 amp diodes have rather heavy leads. Do not bend the leads close to the body of the diode, as you may break the diode in the process. It is not a good idea to use pliers to bend the diode leads, but rather gently curve them with your fingers.

With the board sitting where it will be mounted, cut and strip some wires for connection to the power transistor and transformer. You may also like to run the output of the supply to some form of connector or terminal block. Solder the wires to the printed circuit board, then mount it using some short spacers. Make sure that none of your component leads have been left so long that they touch the aluminium. Now solder the wires to the transformer, transistor and your terminal block. Take care with the base and emitter connections to the power transistor. It is easy to swap them if you are not careful.

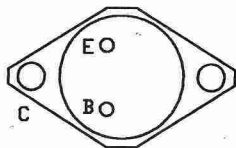
POWERING IT UP

Before you apply mains to the power supply, check and re-check all of your wiring. With mains, you don't get a second chance. Any wire or connection that looks less than perfect must be done again.

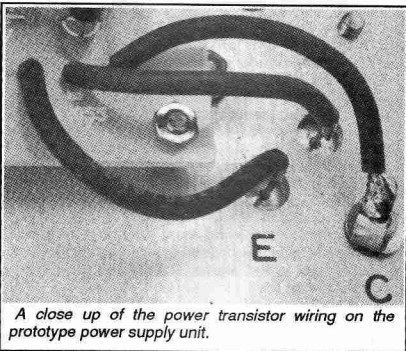
When you are satisfied that all is in order, place it on the bench and plug it in. Switch it on. It should hum quietly. Check the output with a multimeter. It should read somewhere between 12 and 14 volts. If it doesn't, go back and check your wiring and assembly, particularly the orientation of the zener and two 1N4148 diodes. Nothing should be getting hot either.

With the meter still connected, put a load across the output. A 12 volt, 21 watt indicator lamp from a car is ideal. The output voltage should stabilize around 11.5 to 12 volts. If it does, everything is working alright, and you can install the unit on your layout. Install it in a way that nobody can accidentally grab a mains connection, even if it is insulated. A shield of aluminium or wood could be fashioned for it.

When the unit is not in use for extended periods of time, over night for example, switch it off.



This diagram shows the connections to the 2N3055 power transistor when viewed from below. Some devices have the lead designators stamped into their metal bases. The collector is the metal case.



A close up of the power transistor wiring on the prototype power supply unit.



How can you stop them poking your layout?