CONVERTING COMPUTER POWER SUPPLIES

There are a number of computer power supplies out of early computers that are being sold very cheaply as there is no requirement for these supplies in the computer market. These supplies are switch mode and some can be converted to produce 13.8 volts DC with sufficient current output to run amateur equipment There have been a number of articles produced over the last ten years, written by amateurs around the world who have been successful in producing a modification to these supplies to produce 12Volts or 13.8 Volts. Each of these articles explain how to modify a computer power supply to obtain a 12 volt or 13.8 volt output, but each article produces a slightly different modification. After carefully examining these articles and buying a few computer power supplies I have came up with a modification which has been simplified but with excellent results. At the time of writing I have been concentrating on using Seasonic 200 watt power supplies, but I feel that other computer supplies that use a control IC type TL949 or KA7500B may be able to be modified without much difficulty.

RADIO COMMUNICATION ARTICLE

In July 1992 edition of Radio Communication on page 50 there was an article on the conversion of a computer switch mode power supply. Below is a reprint of the article. This article is referred to in a number of subsequent articles on other methods of modifying the power supplies. My method of modification is different once again but uses some of the principles described in this article so it is worth while reading.
TRANSLATED AND EDITED BY ERWIN DAVID, G4LQI
A 12V 20A switch-mode supply suitable for powering a 100W HF transceiver can be obtained by modifying a four-voltage PC computer supply; these are available cheaply in the surplus trade. Udo Theinert, DL2YEO shows how in CQ-DL 4/92.

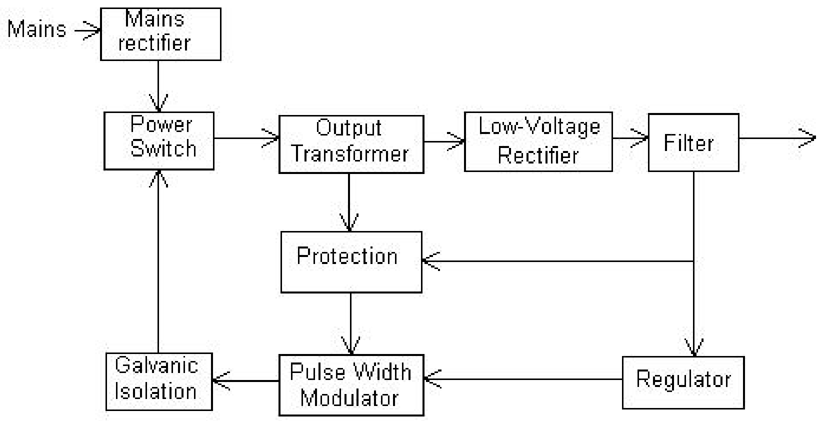

Fig 1: Block Diagram of a power supply with primary switching.

I HAD ACQUIRED an unbranded working PC switched-primary power supply board, measuring 14x10x5cm and weighing 350g. Depending on the PC model, these are rated anywhere between 150 and 240W total continuous output. I had no specifications, but estimated from the size of the components that mine was designed for the usual +5V at 20A, +12V at 8A, -5V at 0.5A and -12V at 0.5A, 205W in total. At a typical efficiency of 75% this means a dissipation of only 68W. I was pleased to note that the wire of the 12V transformer secondary was of the same gauge as that of the 5V 20A winding. The switching frequency is approx. 33kHz. Fig I is a block diagram of the modified PSU.

REGULATION

THE ERROR AMPLIFIER in IC1, TL494CN, (Fig 2} compares the actual +5V output voltage with an on-chip reference and adjusts the set-point for the pulse width modulator accordingly. The modulator sends alternate pulses to the driver transistors TR3 and TR4 (Fig 3). Increased loading on the 5V output makes for wider pulses; lighter loading causes narrower pulses. As there is a finite minimum pulse width, a minimum load of 0.1A is required; it is provided by a bleeder resistor. As L4a and L4c are wound on a common core with L4b, the +/-12V outputs are also included in the regulation loop. Several protective circuits are included. Excessive primary current or short-circuiting of the -5V and 12V causes immediate power-down via the 'protection' input of IC1.

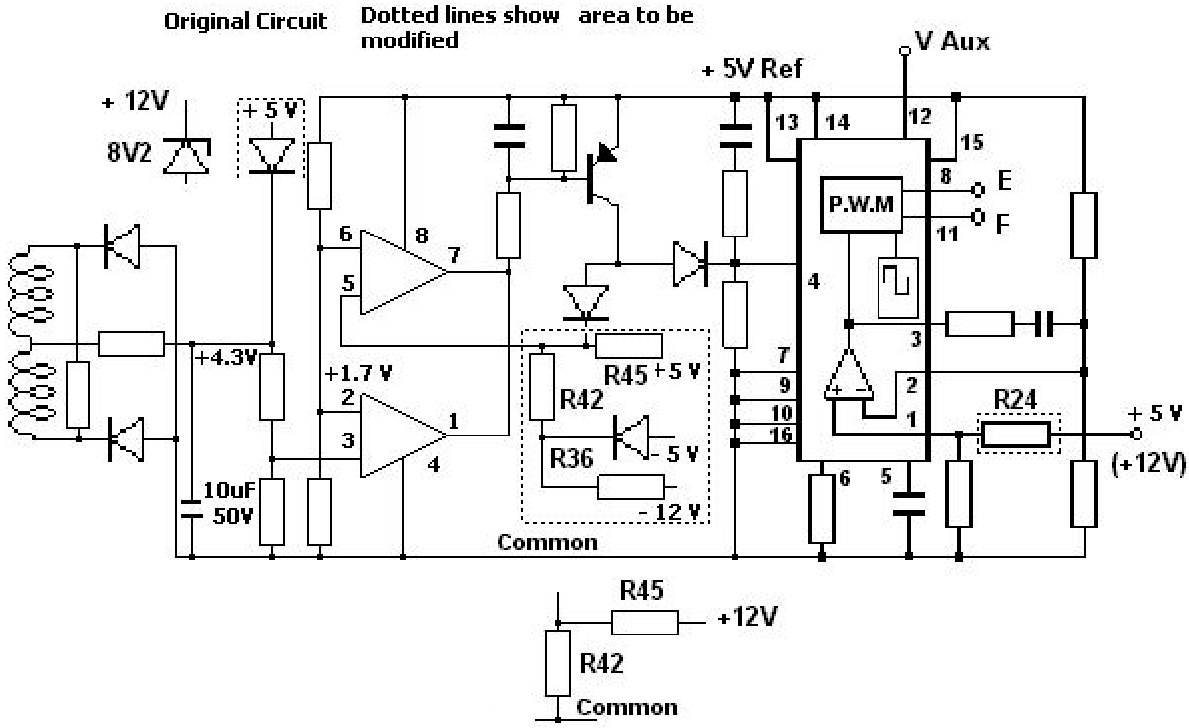

Fig 2: The regulation and protection circuitry

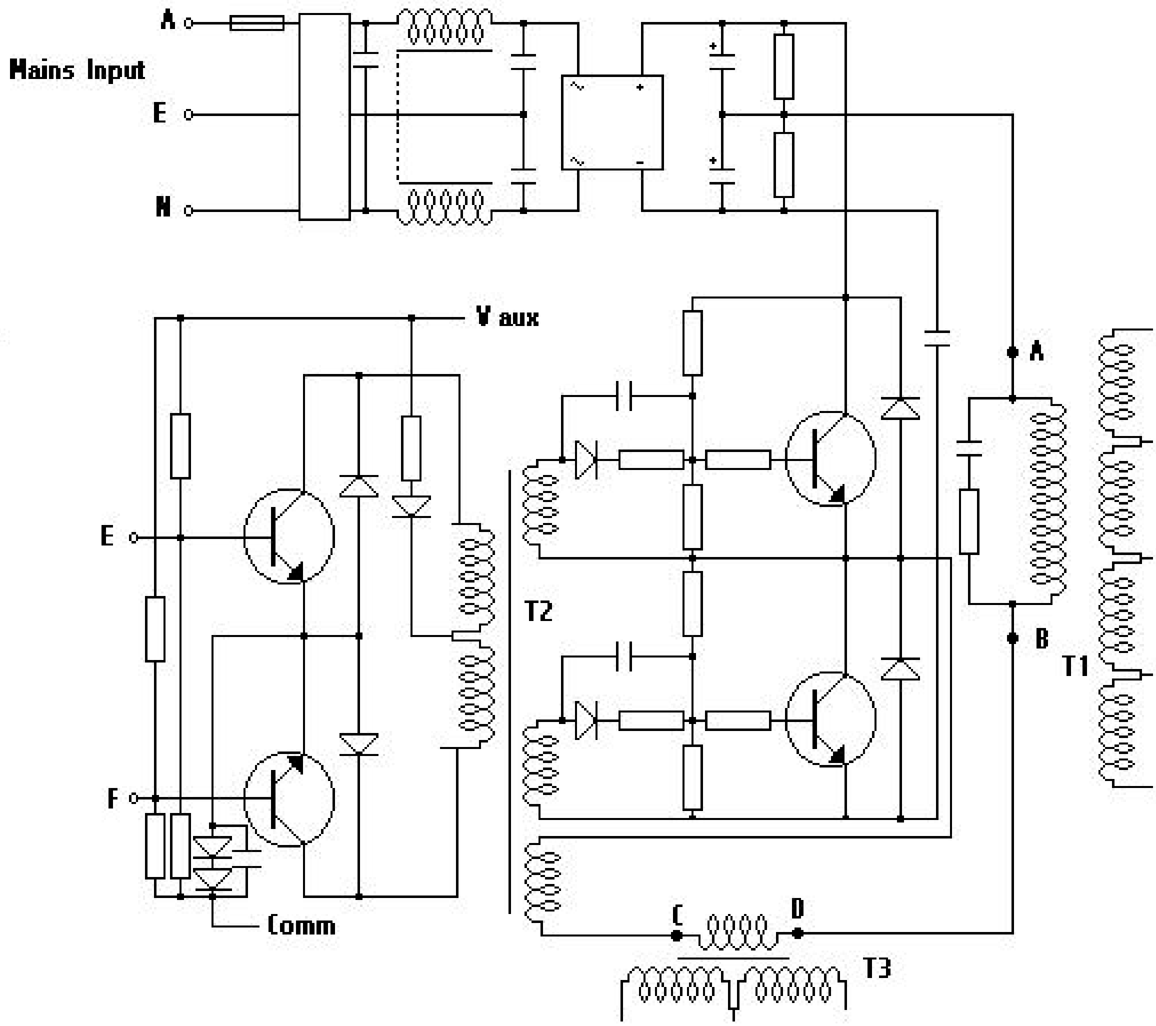

Fig 3: The primary side: mains filter, mains rectifier, power switches and drivers.

CAUTION -- MAINS Voltage Exposed

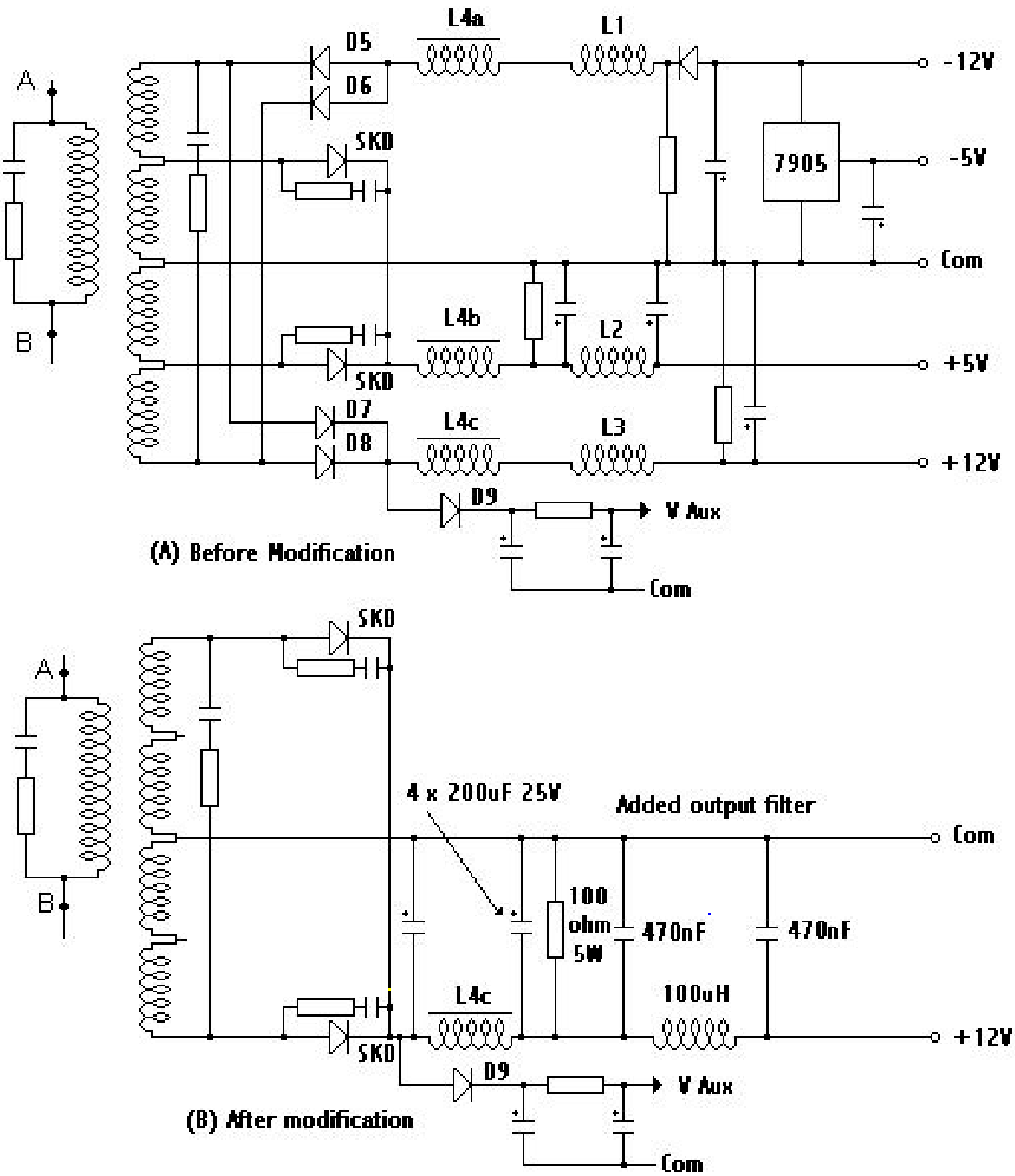

Fig 4: Secondary rectification and filtering: (A) as found in the original power supply, and (B) after modification

THE MODIFICATIONS

THE INTENT IS FOR all of the available power at the 12V secondary of T1 to be rectified, regulated, protected and filtered to provide a single output of 12VDC at 205W, or more if possible.

* First, unsolder and remove all components on the secondary side of T1 (Fig 4a) which provided the rectification, filtering and regulation of the four output voltages, leaving on that part of the board only the three RC members, the Schottky rectifier SKD and the components of the auxiliary power supply Vaux '

* Reconstruction of the output section (Fig 4b) is as follows:

*Break the PCB tracks between SKD and the 5V secondary of T1 and reconnect SKD to the 12V secondary.

*To modify L4 for 12V at 20A, remove windings L4a,b,c, counting turns of L4c. Rewind with a single winding, turn count as old L4c but wire thickness as old L4b. Replace L4

*Install the forementioned 100~ 5W bleeder and 4x2200pF 4x2200pF/25VDC electrolytic capacitors (8000pF are required but four small capacitors in parallel have less inductive impedance than one big one). Wire as in Fig 4b

*Replace the sheet-metal heat sink on SKD with a bigger, ribbed one to ensure adequate cooling at continuous full output

*Other changes are required in the regulator and protection circuit, see Fig 2

*Replace D16 in the output current limiting circuit with an 8.2V Zener.Replace R24 with one of higher value (approx 4x), 18kQ in the prototype, to make the voltage at the (+) input of the error amplifier (IC 1 pin 1) equal to 2.5V, ie half the 5V reference voltage when the output is 12V [1].

*Adapt the voltage divider in the short-circuit protection circuit. Remove D14 and R36 and connect the bottom of R42 to common. Replace R45 with one of higher value to keep the voltage across R42 below the cut-out value of 1.7V under normal operation. In the prototype, with R42=1k5, I chose R45=lSk~.

Warning: Mains voltage appears on some of the components in Fig 3 during normal operation. Appropriate insulation and shock protection during test, adjustment and use are imperative.

*Replace the 220,F smoothing capacitors C1 and C2 in the primary rectifier by 470,F/ 200V units. This reduces the primary ripple, which helps output regulation at full load.

*Improved cooling of the power switching transistors TR1 and TR2 increases the continuous output capability from 205 to 240W, ie from 17 to 20A at 12VDC.

TESTINGTHE FOLLOWING QUESTIONS remained to be answered: What regulation could I expect during load steps from 1A (receive) to 17A (transmit) and back? I connected as a load two 95W car headlight bulbs. That did not provide a load supply to cycle on and off! Substitution of proper highwattage resistors for the bulbs showed that the regulation could handle these large load steps, up or down, with output voltage excursions not exceeding 0.15V. Would harmonics of the switching frequency interfere with HF reception? Yes, a 33kHz raster covered all HF bands with S-meter readings of S5 on 80m down to S2 on 10m. As I was testing the board in a metal box, the HF radiation could only get out on the mains cable and/or output leads. The insertion of an additional standard mains filter (Fig 3) and a home-brew pi-filter in the output (Fig 4b) rendered the interference inaudible.

OPERATION

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THE MODIFIED PSU WAS permanently installed in the speaker cabinet that matches my transceiver.

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Mains and 12V leads exit from its back, which also carries an on-off switch and the additional mains filter. A green LED power-on indicator was inserted in the front panel. I had installed a small blower just in case, but found it superfluous; at the low duty cycle of CW and SSB, none of the components is getting hot.

The power supply has been used for six months now and has given no problems. It performs as well as much heavier, more expensive supplies with a 50Hz transformer and linear regulation. [1] Note: DL2YEO assumed 220VAC mains. Switch-mode power supplies generally will work off 220V -10% to 240V +10% mains. On UK 240VAC it should be possible to get 13.8V output by increasing R24 some more- G4LQI.

CONVERTING COMPUTER POWER SUPPLIES

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Radio and Communications November 1998 and December 1998 contain a two part article on building a 13.5 Volt 20 Amp Switch-mode Power Supply written by Phil Harman VK6APH. This article Explains in great detail how the power supply works.

I will not reproduce the full article as some of the details are from the original article from Radcom which was reproduced in the previous QSP. The explanation on how the chopper transistors work could be very helpful in trying to understand some of the basics.

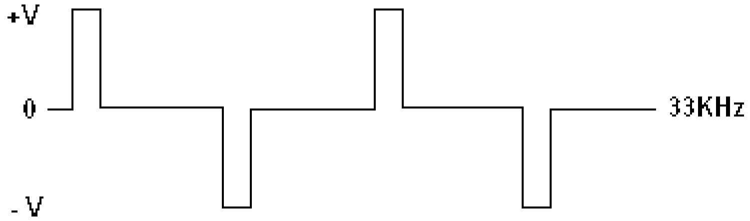
The incoming mains is rectified in a full-wave bridge and applied to a smoothing capacitor. This results in a DC voltage equal to the peak of the 240 Volt AC mains, ie 240 x 1.414 = 340 V.
This DC voltage is then converted into a high frequency AC, typically 33 KHz, and applied to the primary of a step down transformer which also provides isolation from the 240 Volt mains.

The simplified Chopper circuit shows how the chopper transistors are simply considered as high speed switches operating at a switching rate of 33KHz. The full circuit of the AC to DC Conversion using chopper transistors appeared in the previous edition of QSP. If you compare these two circuits you should be able to recognize how the circuit can be simplified for basic explanation purposes.

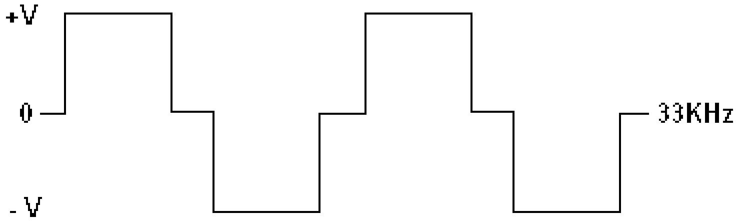
There are two filter capacitors connected in series across the DC output of the bridge rectifier. Each capacitor will charge up to half the output voltage. In theory, each capacitor will have a charge of 170 Volts across it. When TR1 (One switching chopper transistor) switches on, current will flow through the primary of the transformer (T1) in the direction shown (B to A). When the other transistor (TR2) switches on , TR1 will switch off and the current through the primary of the transformer(T1) will reverse and flow from A to B. The current through the primary of T1 will therefore alternate at a frequency determined by the switching rate of the chopper transistors.

The time the chopper transistor turns on is determined by the width of the pulse out of the regulator IC. There appear to be a number of ICs that have the same pin connections but made by different manufacturers. They are:- TL494, KA7500B, MB3759, IR3MO2. Pins 8 and 11 are the pulse outputs.

The pluses are varied in width depending on the load placed on the power supply.

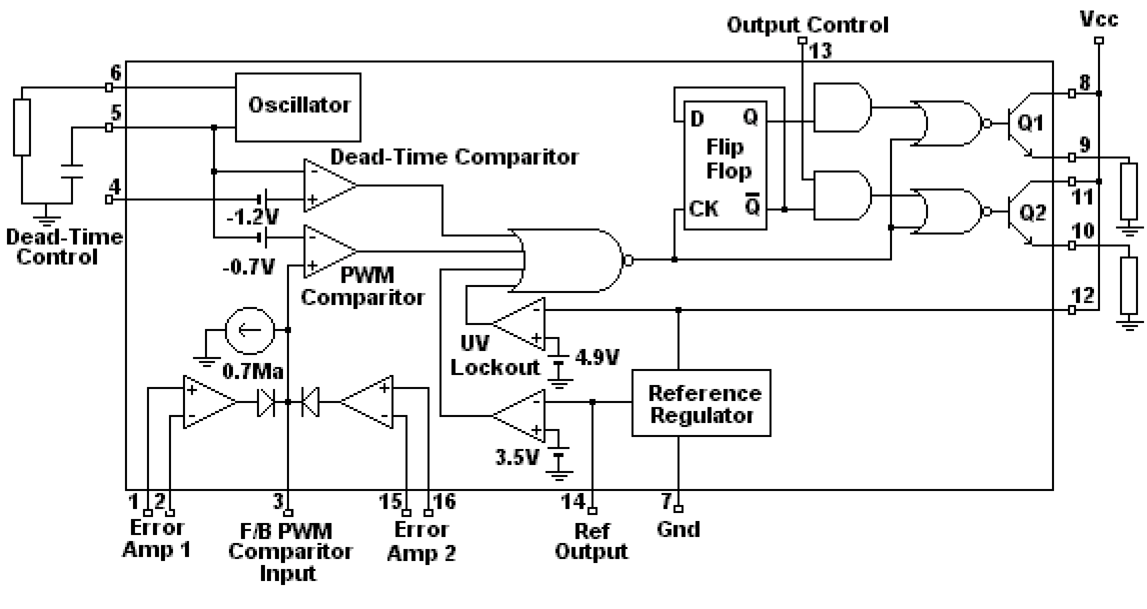


Voltage across T1 Primary - Light Load



Voltage across T1 Primary - Heavy Load

The width of the pulse is varied by the regulator IC to regulate the output voltage of the power supply to attempt to maintain a constant voltage as the load is varied. This is achieved by feeding a sample of the output voltage to pin 1 of the IC. It is fed through a suitable value resistor so that 2.5 Volts is fed to pin 1 when the power supply is developing the required output voltage. The voltage on pin 1 is compared to a reference voltage on pin 2 which is set to 2.5 Volts also. If the voltage on pin 1 attempts to change then the width of the 33KHz drive pulses to the chopper transistors will vary and hold the voltage on pin 1 to 2.5 Volts and therefore regulate the output voltage. The IC develops a reference voltage of 5 Volts which is then voltage divided down to 2.5 Volts to feed to pin 2 of the IC.
The 33KHz switching frequency is developed within the IC simply by using a resistor capacitor combination.



Pin 6 is earthed through a suitable resistor and pin 5 is connected through a suitable capacitor to earth.

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REGULATOR I.C.

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The above diagram shows what is inside the regulator IC. In the top left hand corner there is an oscillator whose frequency is determined by the resistor and capacitor combination connected to pins 5 and 6. The oscillator output is fed via a comparator to one input of a four input NOT OR gate. This facility is called a Dead-Time Comparator. If the voltage applied to pin 4 is low, the oscillator output is connected to the NOR gate. When pin 4 receives a high voltage, the comparator open circuits the oscillator feed and the output of the IC is switched off. This facility is used to provide over voltage and/or over current overload protection by causing the IC to switch off it's output.

There are two comparators that can be used to drive another comparator that is used as a pulse width modulator by controlling one input to the NOT OR gate. When the IC is used in the computer power supply only one of error amps is used. A reference voltage of 2.5 volts is usually applied to pin 2 and pin 1 is connected to a voltage divider which is used to sample the output voltage which is to be regulated.

The IC contains a reference Regulator which produces a 5.0 Volt reference. This voltage is compared using two comparators to ensure the voltage is within limits otherwise the NOR gate is disabled and the IC output will be switched off.

The NOR gate output is used to drive a Flip Flop Multivibrator. The Flip Flop outputs are fed through two input AND gates and two input NOR gates to drive transistors which produce sufficient current output.

The Flip Flop Multivibrator has a normal and inverted output so that two outputs of opposite phase are produced. The other input to the AND gates can be used as a control for the output. In the computer power supply circuit this pin 13 is usually returned to the 5 Volt reference. The two NOR gate have their other inputs fed from the four input NOR gate.

Features listed in the data sheet show the following:- Internal regulator provides a stable 5V reference supply trimmed to 5%. Uncommitted output TR for 200 mA sink or source current.
<P>Output control for push pull or single ended operation. Variable duty cycle by dead-time control (pin 4). Complete Pulse Width Modulation control circuit. On-chip oscillator with master or slave operation. Internal circuit prohibits double pulse at either output.

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CONVERTING A COMPUTER POWER SUPPLY

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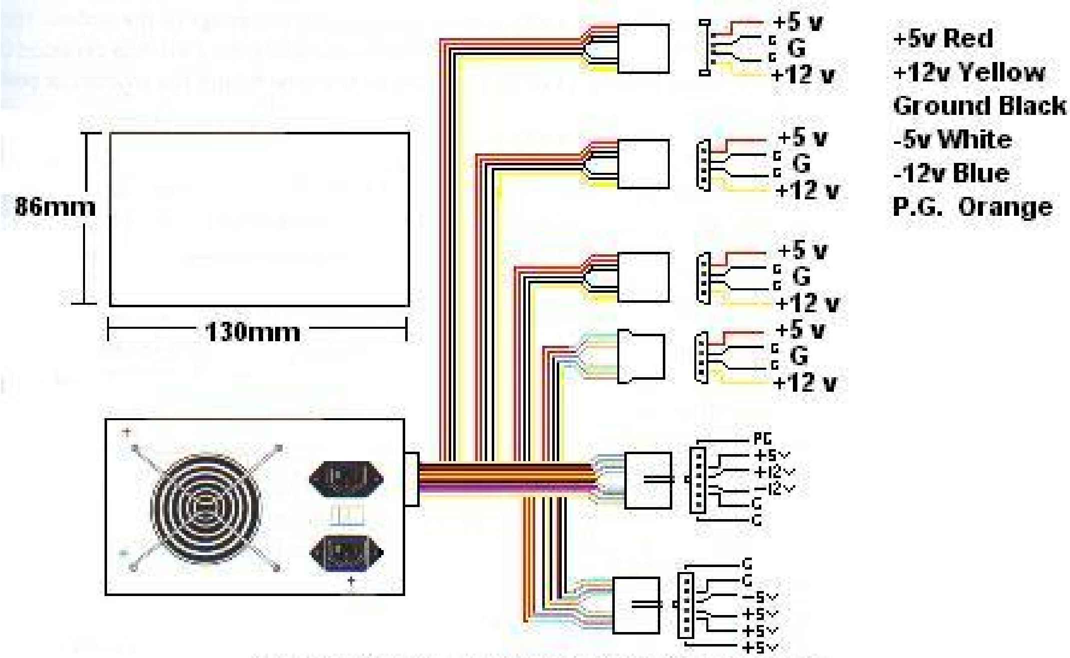
A Switched -mode 200 watt Computer Power Supply may be able to be converted to produce 13.8 volts output with the capability of delivering up to 20 Amps. The power supply has very good regulation with both over voltage and over current protection. Not all 200-watt power supplies lend themselves to easy conversion to 13.8 volts output.

The type of Computer Power Supply that has been easy to modify is a LPX or PS/2 type supply containing a 16 pin regulator IC of one of the following types: - KA7500B, TL494, MB3759, IR3MO2

The above Integrated Circuits all have the same pin connections although being made by different



Typical 200watt Power Supply connections

manufacturers.

After you have been successful in obtaining a suitable power supply, the first thing to do is to try out the supply and determine if it is working. A careful examination of the power supply should reveal a lead, which contains a push button switch. This lead should be examined to ensure that the insulation is intact and there are no bare wires showing. This switch is the main off and on switch for the power supply and is connected in the 240 volt AC input circuit so it is essential that there is no possibility of accidentally contacting the mains voltage when testing the power supply. The rear of the power supply should be examined and should contain an IEC Male Chassis plug and an IEC Female Chassis socket. Depending on the manufacturer of the power supply there pwr be a slide switch between these mains plugs and sockets. If there is a slide switch ensure it is in the 240-volt position and not in the 110-volt mode as testing the supply while the switch is set for the incorrect voltage could cause the power supply to fail.

A suitable mains power cord will be required to plug from a power point to the three-pin mains socket on the power supply. The power supply should be fitted with an IEC Male Chassis plug. The matching mains cord is an IEC Power Lead as shown in the Jaycar and Dick Smith catalogues as PS-4106. These cords are quite expensive if bought brand new. A good second hand cord pwr be obtained from the Sunday Computer Markets for approximately $1.

The supply normally provides the following outputs: -
+ 5 volts 20 Amps (eight Red wires shared over six sockets), +12 volts 8 amps, -5 volts 0.5 Amp
- 12 volts 0.5 Amp

The power supply pwr not work if there is no load connected so it is recommended that you put a suitable load on the +5 volt output. A good starting point is to load up a + 5 volt output to 5 Amps.
If you check on the leads and associated connectors you will find about eight red wires. These all are + 5 volt outputs. The black wires are the common or ground return for the outputs. If you find a couple of two millimetre pins they will plug into one of the four pin sockets that have a + 5 volt and a +12 volt output. (A red wire two black wires and a yellow wire)

A suitable load would be a one ohm 25 watt resistor (5 volts x 5 amps = 25 watts). Using 5 only 4.7 ohm 5 watt resistors connected in parallel could make this up. These can be obtained from Jaycar for 30 cents each. After you parallel the five resistors they should be connected to the two mm.pins and connected to a red wire and a black wire of one of the four pin sockets.

It is recommended that you connect a digital Multimeter across one of the other four pin sockets using the red and black wire output. To ensure you get an accurate voltage reading it is recommended that you check the wiring form and ensure the meter is connected to a socket that is wired straight from the power supply. Some power supplies have two sets of four pin sockets connected off the same red and black wires from the power supply. The second socket should not be used for the voltage measurement as there will be a voltage drop across the lead resistance that will be passing the current to the load and therefore you will not be reading the terminal voltage of the power supply.

When you are satisfied that you have a suitable load resistance connected across a red and black wire and a suitable high impedance voltmeter connected across another set of red and black wires, it now time to consider switching on your power supply.

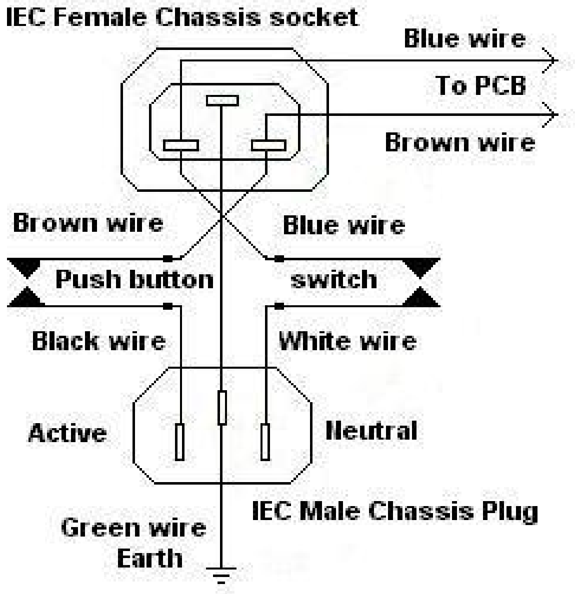
It is recommended that the push button on and off switch be turned on before switching the mains power point after the IEC power cord is connected from the power point to the power supply. The switch should not be touched after the mains voltage is applied to the power supply for safety reasons.

The power supply should start up and the cooling fan in the rear of the power supply should be heard running quietly. The Voltmeter should be reading +5 Volts. This would indicate that the power supply is working satisfactory. The exact reading on the voltmeter pwr not be precisely +5 volts, as it must be remembered that the supply is designed to power a computer and only produces voltages within specification when all the loads are applied.

This test should be sufficient to consider that the power supply is in a suitable condition to undertake modification to change it's output to 13.8 volts. It would be an advantage if the current overload threshold could be determined but to test this function the power supply would need to be fully loaded and this can be difficult to obtain. The current overload protection test can be performed after the necessary modifications have been carried out.

After you are satisfied that your power supply is working before you start your modification, you can turn off the supply and remove the mains power cord and the test load. It is now time to remove the four screws holding the metal case together. The top and side section of the case can now be removed. The case should now show the inside of the rear plate containing the cooling fan; the IEC chassis plug and above this plug an IEC chassis socket. Between these mains plugs and sockets there pwr be a slide switch. This slide switch allows the power supply to be operated off 110 volts AC or 240 volts AC. There pwr be two wires from the slide switch, which terminate on to the printed circuit board either directly or via a socket.

One end of the cord that has the push button switch mounted on one end should be connected between the mains plugs and sockets. The cord should contain five wires. A black wire and a white wire coming from the rear of the IEC Male chassis plug. A blue and a brown wire connected to the IEC Female Chassis socket. The fifth wire out of the cord should be a green wire and is connected to the metal case to make a good ground connection. Off the same point on the IEC Female Chassis socket should be another two wires, which connect to the printed circuit board via a small plug and socket. These two wires pwr be blue and brown or red and black and are the mains connection to the printed circuit board. Remember that there is a two-pole switch between the mains plug on the rear of the power supply and the connection to the printed circuit board.



Original wiring As viewed from the rear

The above diagram shows the wiring from the mains plugs and sockets to the push button switch and connection to the printed circuit board as viewed looking from within the case. The cord that connects to the push button switch usually has a green wire within it that is connected to the case by a solder lug and a nut and bolt.

It is recommended that at this stage the two wires that plug into the printed circuit board be unplugged from the board. If the two wires that cone from the slide switch between the mains plugs and sockets are soldered on to the printed circuit board, they can be cut off, as they are not required when working the power supply from a 240-volt AC input.

There should be two wires from the cooling fan, which pwr be connected to the printed circuit board using a small plug and socket. If this is correct, then the wires can be simply unplugged from the board at the moment. If they are soldered directly to the board they should be cut from the board but leaving a few millimeters of wire on the board for later identification.

The printed circuit board should be held in place with four screws, which can now be removed. The printed circuit board should be able to be removed from the case by firstly lifting up the main wire form and grommet of the red, black, yellow, white and orange wires. The cord to the push button switch can be lifted up after the grommet is loosened. The printed circuit board and attached wires should now be able to be slid clear to the main case.

It is recommended that the printed circuit board be given a good dusting to remove any accumulated dust that has built up on the components and the board. The cooling fan could need a good cleaning and if necessary remove it from the case by unscrewing the four mounting screws. The blades will probably be quite dirty.

The printed circuit board assembly should be carefully examined. If the board is checked from the printed circuit side it should be seen that one section of the printed circuit is separated from the other section. One section should contain all the components that are directly connected to the 240-volt AC mains. This section should be able to be identified by two large electrolytic capacitors of 200-volt rating. Along side of the capacitors will be a rectangular block, which is the bridge rectifier. There pwr be some inductances and capacitors as well as a 25-mm tubular fuse. There should be a two-pin plug that was connected to the two wires that came from the IEC Female Chassis Socket. This portion of the board will not be touched during any modification.

The other portion of the printed circuit board will need to be carefully examined to identify the + 5 volt outputs which can be found by observing where all the eight red wires are soldered on to the board. If you look closely at the printed board track you should be able to see where the track connects to a couple of 10 volt electrolytic capacitors and some small inductors as well a large toroidal coil. Close to the toroidal coil will be what appears to be a large flat pack semiconductor mounted on to a large heat sink. This flat pack semiconductor is a Schottky Diode assembly, probably a CTB-34, which is two diodes sharing a common Cathode and rated at 40 amps and is the main rectifier for the +5 volt.
. You should be able to find a track from the + 5 volt output going over in the direction of the main regulator Integrated circuit.

The group of yellow wires soldered to the printed circuit board is the +12 volt output. The printed track from this output should go the 16 volt electrolytic capacitor and a small inductor and eventually to a winding on the large toroidal coil. Nearby should be another flat pack semiconductor assembly. This one is much smaller than the Schottky diode assembly previously noted is. This assembly pwr be connected to another heat sink or portion of the other heat sink. This pack is usually a CTL-22S, which are two silicon diodes sharing a common Cathode rated at 10 Amps. It is the main rectifier assembly for the +12 volt output.

The orange wire should be connected to the printed circuit board and marked as P.G.
The white wire should be connected to the printed circuit board and is the - 5volt output.
The blue wire should be connected to the printed circuit board and is the - 12 volt output

THE SIMPLE MODIFICATION

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Parts Required 2x10k-ohm 1/4 watt resistors 1x1.8K-ohm 1/4 watt resistor

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25 turn 5K-ohm potentiometer, 1x 100 ohm 10 watt resistor

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small pieces of vero board, 1x RED Terminal, 1x BLACK Terminal

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After you have clearly identified all of the above outputs it is time to start the modification.
The simple modification involves using all the +12 volt components including the CTL-22S silicon diode pack. With this modification the limiting factor determining the maximum output current is the current rating of the silicon diodes, which is this case is 10 amps. If more current is drawn from the power supply there is a danger of exceeding the diode rating and causing the power supply to fail.

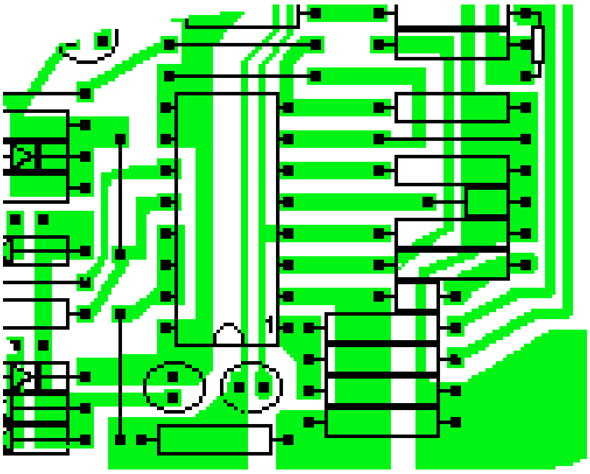
The basic modification results in sampling the +12 volt output instead of the + 5 volt output. A sample of the + 12 volt output is fed back to pin 1 of the Regulator Integrated Circuit to control the regulation. This sample can be arranged so that the output is regulated to 13.8 volts by suitable adjustment of the resistors used to develop the voltage applied to pin 1 of the I.C.

The other part of the modification is to develop a +5 volt line from the +13.8 volt output by using a zener diode, silicon diode and load resistor. This new +5 volt is then used to replace the original + 5 volts that is monitored by the over voltage control circuit.

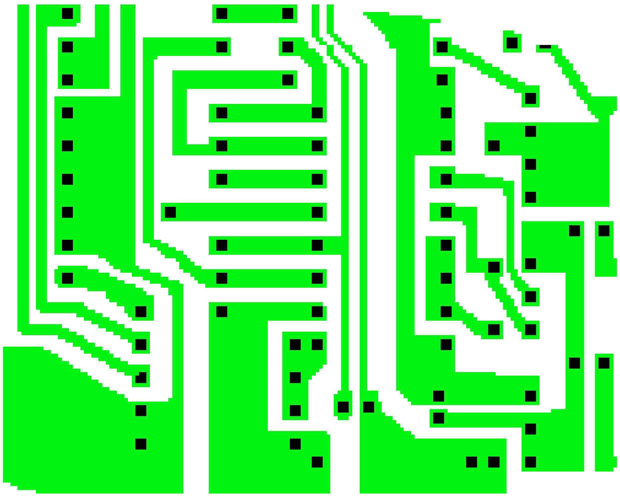
If the simple modification is to be done, all the blue, white, yellow, orange and red wires can be unsoldered. Remove most of the black wires leaving only three attached to the printed circuit board. These three black wires will be used as the ground connection for your 13.8 volt output. Three red wires are then soldered to the printed circuit board in place of three of the yellow wires where the original +12 volt output was located.

The next procedure is very important. You will have to identify pin 1 of the Regulator Integrated Circuit. There could be up to two 16 pin I.Cs on the printed circuit board. Check the coding on the I.C. with a strong light. One I.C. should have markings that are similar to the list given at the start of this article. The numbering pwr not be identical. This I.C. is the one you will need to identify the pin connections. If there is another I.C. on the board it is possibly an LM339. You pwr find an 8 pin I.C. which could be an LM393. Or in some instances just a few transistors.
These components are used to form the over current and over voltage control circuitry which is used to control pin 4 of the main Regulator Integrated Circuit. Each manufacturer has a different method of controlling pin 4 so the modification will not involve changing any of the circuit around this function except to change the +5 volts that is sampled by the circuit. More information on this will follow later.

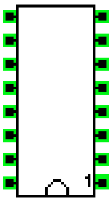
Hopefully by now you have identified the main Regulator Integrated Circuit. The next step is to trace out the circuit that comes from pin 1. Looking down at the I.C. from the component side of the board the I.C should have an identification mark on it at one end. This is usually a small cut out section along one edge. This is the reference end of the I.C. The pins are numbered in an anticlockwise direction from this reference end. Pin 1 is the closest pin on the right hand side to the reference end.
The numbering up the right hand side goes from pin 1 to pin 8 and then from pin 9 directly across from pin 8 down the left hand side to pin 16 at the reference end.



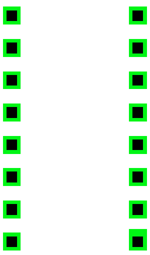
If you look at the component structure around the I.C. you will notice a number of quarter watt resistors, a couple of small capacitors, a few diodes and a number of straps. The next stage is to try and reconstruct the wiring going to pin 1. This pwr involve some strapping so you need to be careful find the complete external circuit connected to pin 1. Turn the board over and look at the printed circuit side. Can you identify the I.C. from this side? It will look like a symmetrical row of 8 solder points across from another similar row. Remember when looking from this side the pin numbers will now be reversed. The pin 1 to 8 row will be on the left hand side while the pin 8 to 16 will be on the right hand side.



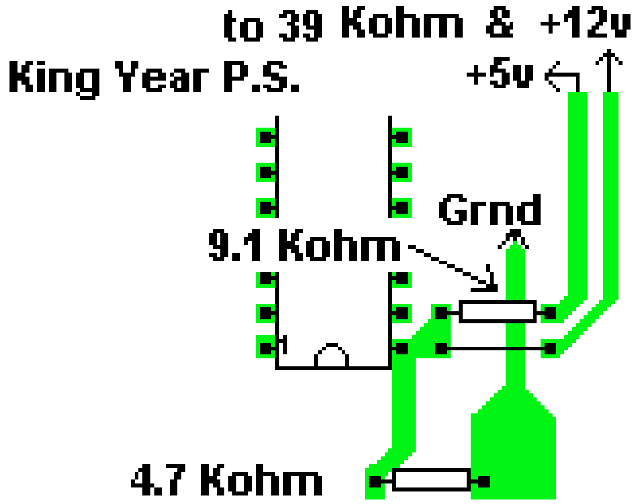
The above diagram is portion of the component side of a typical board. Note pin 1 of the I.C.
This is the underside of the same section. Can you identify the pins of the I.C.



Below is a template of the I.C. as seen from the component side. It pwr help you trace out the circuit connected to pin 1.



The next diagram is a template of the pins of the I.C. as viewed from the print side. It pwr be helpful in identifying the external circuit of pin 1 of the I.C.



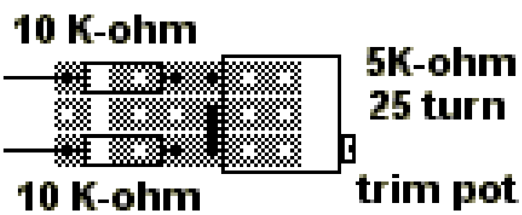
You should find a resistor from pin 1 to ground. In most instances this resistor is a 4.7 Kohm. There should be another resistor from pin 1to the +5 volt track. This resistor could be a 9.1 Kohm if there is another resistor from pin 1 to the +12 volt track. This resistor could be a 39 Kohm resistor.
Above is the circuit for pin 1 of a King year power supply. The 39K-ohm resistor is where the +12volt supply main feed is located on the other end of the board.

After you have drawn out the external circuit for pin 1 of the I.C. and are satisfied you have identified the components, you should be at the stage of making the first modification. This involves arranging the external circuit of pin 1 so as to develop 2.5 volts when sampling the 13.8 volt output. This is achieved by firstly identifying the value of the resistor connected to ground. In most instances it should be a 4.7K-ohm. The resistor connecting pin 1 to the +5 volt track can be removed. The resistor connecting pin 1 to the +12 volt output has to be changed so that when the output is 13.8 volts the voltage on pin 1 is 2.5 volts. This involves some simple ohms law calculation to determine the value of this resistor. If there is only a resistor to earth and a resistor to +5 volts, the resistor to the +5 volt line should be removed and replaced with a suitable value resistor returned to the +12 volt output which after the modification will rise to 13.8 volts if the resistor value is correct.

CALCULATING THE SAMPLING RESISTOR

The current in the external circuit of pin 1 can be calculated by knowing the value of the resistor to ground or earth. When the circuit is regulating correctly, the voltage on pin 1 will be 2.5 volts. If the resistor is 4.7K-ohm, the current will be the voltage divided by the resistance which will be 2.5 volts divided by 4.7K-ohms.

The value of the sampling resistance can now be calculated by realizing that the voltage across the resistance will be the difference between the 13.8 volts and the 2.5 volts on pin 1. This voltage will be 11.3 volts. The resistance is calculated by using ohms law where the resistance equals the voltage divided by the current. It this example the calculation will be 11.3 multiplied by 4.7 divided by 2.5. The answer will be in K-ohms and is 21.244.

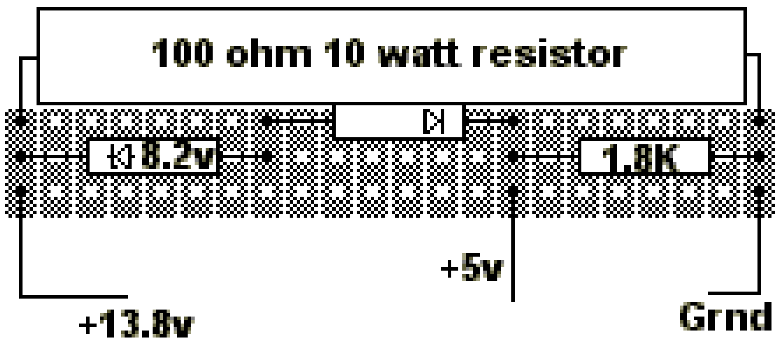


Sampling resistor assembly

It is recommended that this resistance be made variable so that the output voltage can be finely adjusted to the exact voltage required. Normal preset potentiometers should not be used as any intermittent contact could cause major problems with the supply. It has been found that a 25 turn potentiometer of 5K-ohm in series with two 10K-ohm resistors makes a good combination when mounted on a small piece of vero board and inserted into the board in place of the original quarter watt resistor.
If you have a 13.8 volt source available (9 x 1.5 volt AA Cells), it can be used to preset the 5K-ohm pot. to the correct value. Connect the positive output of your 13.8 volts to the point where the +12 volt output appears on the board and connect the negative output of your 13.8 volt source to ground on the board. Using a high impedance multimeter preferably a digital multimeter connected with the positive lead to pin 1 and the negative lead to ground, the voltage can be adjusted by the potentiometer until you read +2.5 volts on pin 1. This will be close enough for when you finish the modification and power up the supply. Final adjustment should only involve minor changes to the potentiometer setting to get the exact output voltage of 13.8 volts. If you cannot read a voltage that can be adjusted with the potentiometer, you probably have made a mistake in your modification and you will need to retrace your steps to find the mistake.

If your power supply is using a value other than 4.7K-ohm to ground from pin 1 you have two choices. One choice is to change the resistor to 4.7K-ohms and then proceed as above, or do all the calculations using the value of resistance on your board.

PRODUCING +5 VOLTS FROM THE 13.8 VOLT OUTPUT



"pwr83.gif"
The next modification involves producing a +5 volt source to feed to the over voltage protection circuit which drives pin 4 of the regulator Integrated Circuit. This involves the use of a suitable zener diode to drop the 13.8 volts down to 5 volts. The zener would have to drop 8.8 volts. As the preferred value for a suitable zener is only 8.2 volts, a silicon diode is used to drop 0.6 volt. A suitable load resistor is then required to ensure the zener diode regulates at the correct voltage.
The above diagram shows a method of connecting the zener diode, the silicon diode and a 1.8K-ohm resistor together to develop a +5volt output from the +13.8 volt output. The 100 ohm 10 watt resistor is necessary to provide a minimum load on to the power supply to ensure it starts up without any external load. This assembly can be mounted across the Red and Black output terminals that are to be fitted to the power supply.

The +5 volts that has been produced from the 13.8 volt output can now be used to provide +5volts in place of the original +5 volt output from the unmodified supply. All that is necessary is to locate the +5 volt track that runs from the main output point on the power supply to near the regulator integrated circuit. This track should be cut and a wire run from the new +5 volts to the I.C. side of the cut track. This will mean that the over voltage control circuit will be using this new +5 volt source. If the output tries to rise above 13.8v then the +5volt will rise also and eventually reach the point where the voltage overload protection circuit drives pin 4 positive and causes the power supply to cease to produce any output.

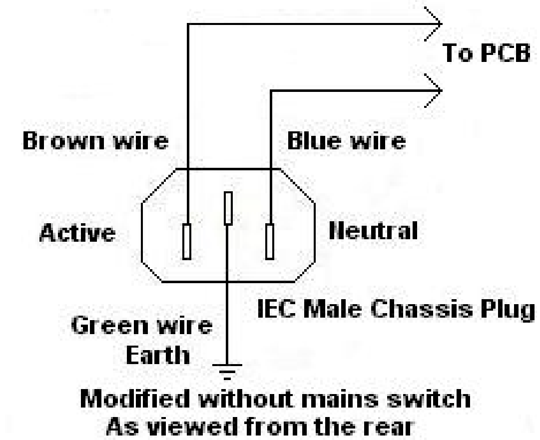
Two suitable Terminals, one Red and one Black should be mounted on to the case with suitable spacing and insulation. The printed circuit board can now be screwed back into the case. The three red wires from the printed circuit board should be connected to the Red terminal using a solder lug. The three Black wires should be connected to the Black terminal in a similar manner using a solder lug. Suitable terminals can be obtained from Dick Smith Electronics. See catalogue part numbers P1731 and P1733 called Banana Sockets Large at $2.00 each.

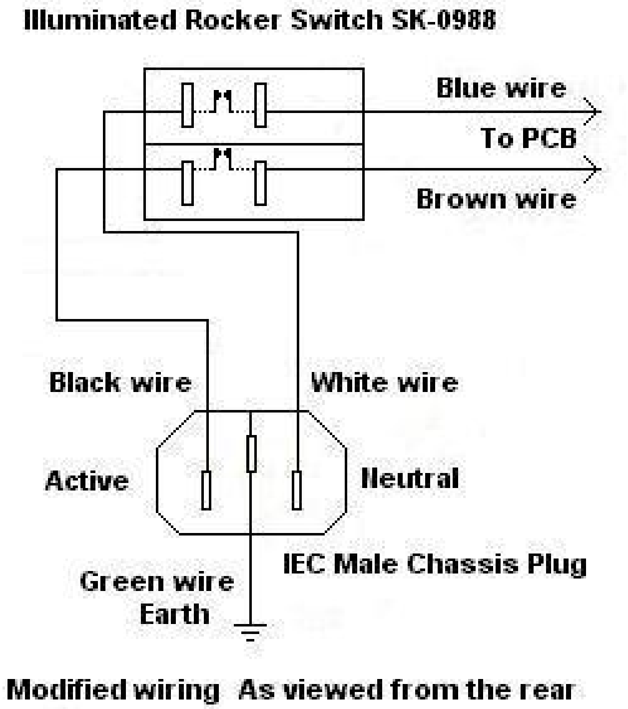
MODIFYING THE MAINS CONNECTION

Any modification to the 240 Volt AC circuitry should be performed by a qualified person. This portion of the power supply can be very dangerous and even the smallest mistake could cause serious injury and even death.

The power supply could be reassembled and used without any further modification, but having the mains switch just dangling free on the end of a cord could also be considered potentially dangerous if there is any insulation failure. Remember you only have to contact 240 volts AC to receive a potentially fatal electric shock.

A simple modification to the mains circuit would be to simply remove the switch and disable the IEC female Chassis Socket and connect the two mains leads that plug into the printed circuit board to the IEC Male Chassis plug. If a mains switch is required on the power supply, a suitable 240-volt illuminated rocker switch could be fitted in place of the IEC Female Chassis Socket. Jaycar has a suitable switch, which is catalogue number SK-0988 for $1.95. An aluminum backing plate could be cut to mount the switch.





OTHER OPTIONAL MODIFICATIONS

A LED could be wired across the 13.8-volt output using a 5 mm 2 volt LED and a 620-ohm series resistor and installed adjacent to the output terminals.

Four small rubber feet could be fitted to the bottom of the case.

PRECAUTIONS

- Make sure the case provides full protection and ensure that if there are holes in the case where the printed circuit board or other components can be touched, they are covered.

DO NOT APPLY THE MAINS TO THE POWER SUPPLY WITH THE CASE OPEN EVEN WITH THE INTERNAL MAINS SWITCH ON THE OFF POSITION.

Do not apply a short circuit to the output terminals as this pwr destroy the mains chopper transistors.
The current overload circuit should be tested before using the power supply.

TESTING

If you do not have a suitable load to thoroughly test the power supply after modification, then simply bring it along to the next BARC meeting and complete testing will be done for you, including current overload protection.

COMPUTER POWER SUPPLIES CONTINUED

A number of club members have managed to get a Computer Power Supply to convert to produce 13.8 Volts output. The manufacturers of these supplies have all been different. I have suggested that the modification centre around the circuit of pin 1 of the regulator IC. The supplies all should use a regulator IC of one of the following type:- KA7500B, TL494,MB3759, or IR3MO2.

Pin 1 and Pin 2 are the two inputs of a voltage comparitor. It has been found that in nearly all power supplies examined, pin 2 has been supplied with a reference voltage of 2.5 volts. This has been derived by using two equal value resistors in series from the +5 Volt reference from pins 13, 14,and 15 of the regulator IC. Pin 2 is connected to the junction of the two resistors thus producing 2.5 Volts. The two equal value resistors have been 4.7 Kohms in most instances.

One supply examined used the +5 volt reference and only one 4.7 Kohm series resistor, therefore the reference voltage applied to pin 2 was +5 Volts. The modification requires the voltage applied to pin 1 to equal the voltage applied to pin 2 for full regulation to take place.

Most manufacturers use the normal +5 volt output to develop the control voltage applied to pin 1. Some manufacturers also use the normal +12 volt output to control the voltage applied to pin 1 also.
The modification requires the voltage applied to pin 1 to come from the new +13.8 volt output. This involves using a suitable voltage divider circuit from +13.8 volt output to ground using two resistors with pin 1 being fed from the junction of the two resistors. In most instances the voltage divider consists of a 4.7 Kohm resistor from ground to pin 1 then a series resistor of 21.3 Kohms to +13.8 Volts. This 21.3 Kohm resistor can be made variable to allow for fine adjustment of the 13.8 Volt output.

One recommendation is to use three resistors to make up the 21.3 Kohm resistor. One 10 Kohm resistor is connected in series with a 25 turn 5 Kohmtrim pot followed by another 10 Kohm resistor . The trimpot is strapped to provide a two terminal variable resistor. This combination allows for the value of the resistor to be set between 20 Kohms and 25 Kohms depending on the adjustment of the 5 Kohm trimpot.

A 25 turn trimpot is recommended so that the resistance is varied in a smooth manner. If a normal 270 degree trimpot is used the resistance value can be unsteady as the pot is adjusted and can cause the power supply to switch off.

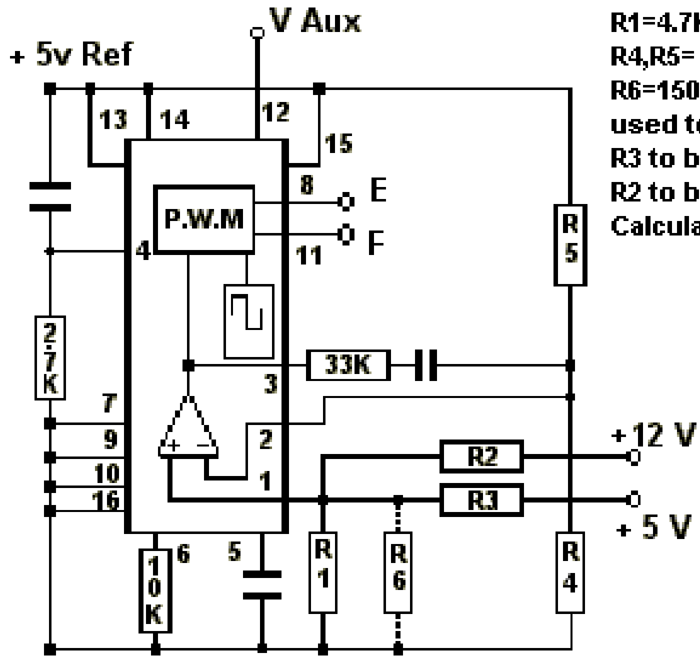
If the power supply uses a resistor value other than 4.7 kohms then the value of the other series resistor to the new output voltage will have to be a different value to the above example. In some supplies the resistor from pin 1 to ground has been 3.9 Kohms. The value of the new resistor added between pin 1 and the new output voltage should be then 17.6 Kohms. A series combination a 5 Khom resistor, a 5 Kohm trimpot and a 10 Kohm resistor can be used to make up the 17.6 Kohm resistor.

In the case of the power supply where pin 2 is connected to +5 Volts reference, pin 1 had a 18 Kohm resistor to ground. The series resistor to the new 13.8 volt output should be 31.7 Kohms which can be made up of an 18 Kohm resistor, a 5 Kohm trimpot and a 10 Kohm resistor.

So by now it should be obvious that not all power supplies are the same, but the principle still applies. It is suggested that to determine the normal reference voltage that the manufacturer has applied to pin 2 of the regulator IC, you pwr need to do some preliminary tests before you proceed with your modification.

An easy method of determining the voltages on the regularor IC without having to power it up and take readings which is certainly not recommended is to follow the next procedure. Do not apply power to your power supply. Simply remove the cover and apply a DC voltage of 12 to 13.8 volts to the yellow and black leads of the unmodified power supply. This will allow the regulator IC to have a suitable voltage fed to pin 12, which is the Auxiliary voltage that is necessary for the IC to develop it's +5 volt reference voltage on pins 13,14 and 15.

You can start by checking this voltage and ensuring it is approximately +5 Volts. Some ICs produce a slight variation of the +5 Volts but the important thing is that this voltage is regulated and will remain a constant reference. After you have confirmed that the IC has produced the reference voltage, you can now check the voltage on pin 2 of the IC. This voltage reading will allow you to determine what voltage has to be connected to pin 1.



Regulator IC Circuit

R1=4.7Kohm or 3.9Kohm or 18Kohm
R4,R5= 4.7Kohm or 3.9Kohm
R6=150Kohm or 100Kohm or nil, trim res. used to adjust the +5 Volt output
R3 to be removed
R2 to be adjusted to produce 13.8 volts
Calculation of $R2=\frac{E}{I}$

Where E =13.8V-Pin 1 Voltage

$$I=\frac{\text{Pin 1 Voltage}}{R1}$$

$$R2=\frac{13.8V-\text{Pin 1 Voltage}}{\frac{\text{Pin 1 Voltage}}{R1}}$$

Typical Calculation where R1=4.7K and Pin1 V=2.5

$$R2=\frac{(13.8-2.5)\times 4.7K}{2.5} = 21.24K$$

As you can see all you pwr have to do is to apply some simple maths. Using Ohms Law if your power supply uses some different values of resistors. Don't forget to check what voltage your power supply uses on pin 2.

As shown in the above diagram, some manufacturers use an extra resistor of a large value across R1 to adjust the +5 Volt output to get it within specification. In our calculations R6 can be removed or ignored.

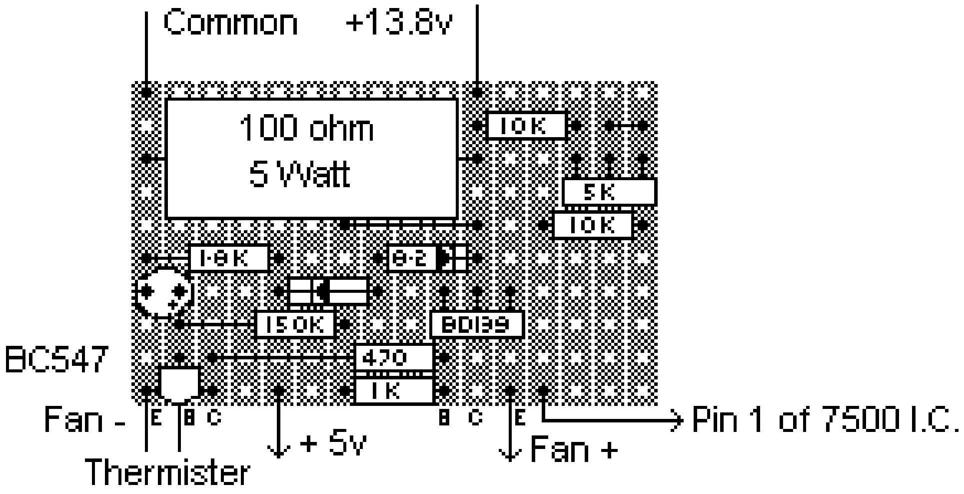
I failed to mention in last months article as to what to do about reconnecting the fan. The fan is normally run off 12 Volts. When the output is increased to 13.8 Volts the fan tends to become a bit noisy. It can be slowed down by using a small value resistor in series with it. I have experimented with resistors from 10 ohms to 33 ohms.

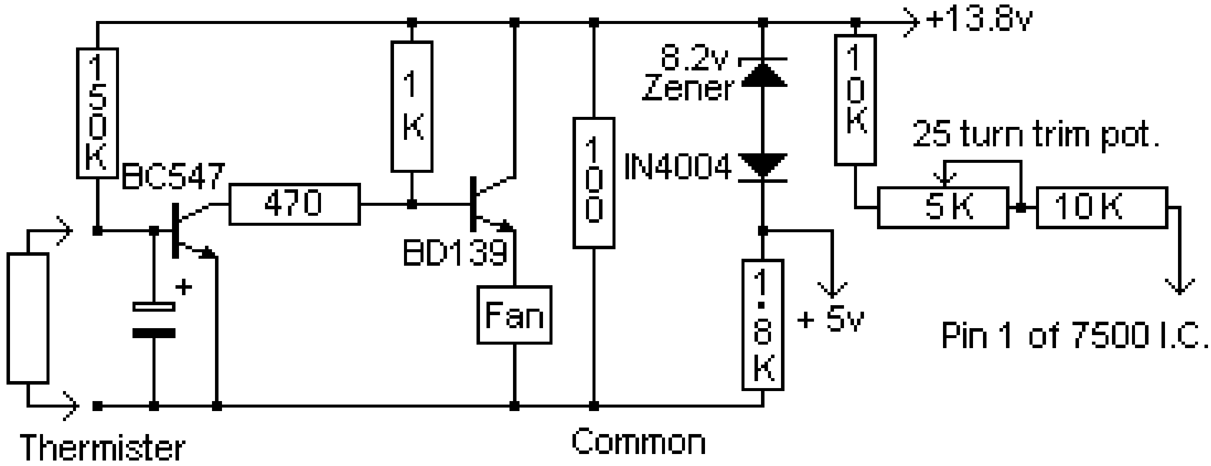
I have experimented with a circuit to control the fan by using a negative temperature Thermister and two transistors. I will include this circuit in the next edition as well as a veroboard layout for mounting all the components necessary for the complete modification of the power supply. This includes the 100 ohm 10 Watt load resistor, the 8.2 Volt Zener Diode, the silicon diode and load resistor to develop the +5 Volts for the Voltage overload circuit as well as the fan circuitry.

Modifying Computer Power Supplies

There are always better ways to do things. I have come up with what I consider is an improved way to modify a computer power supply to produce 13.8 volts. The theory is still the same. The improvement is in the physical method used.

Instead of using a small board to mount the 5 Kohm trimpot and associated resistors, building a small board to mount the 100 ohm load resistor and including a zener diode with a series silicon diode and load resistor, all of this is built on to one board. Included, as an added extra is a small circuit to control the speed of the fan.

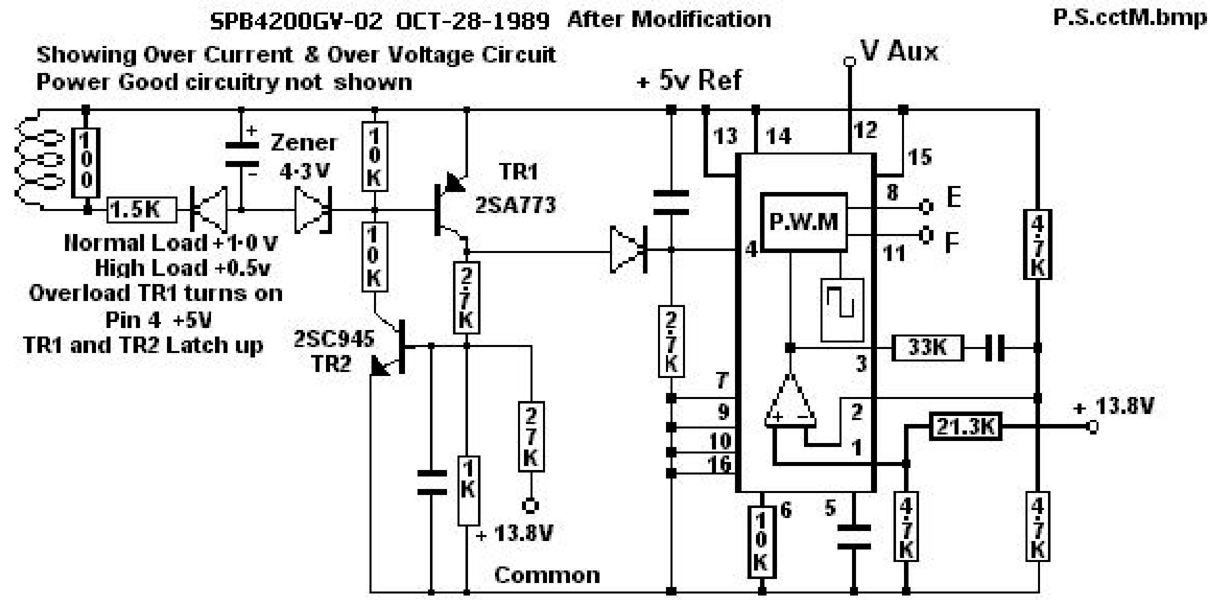


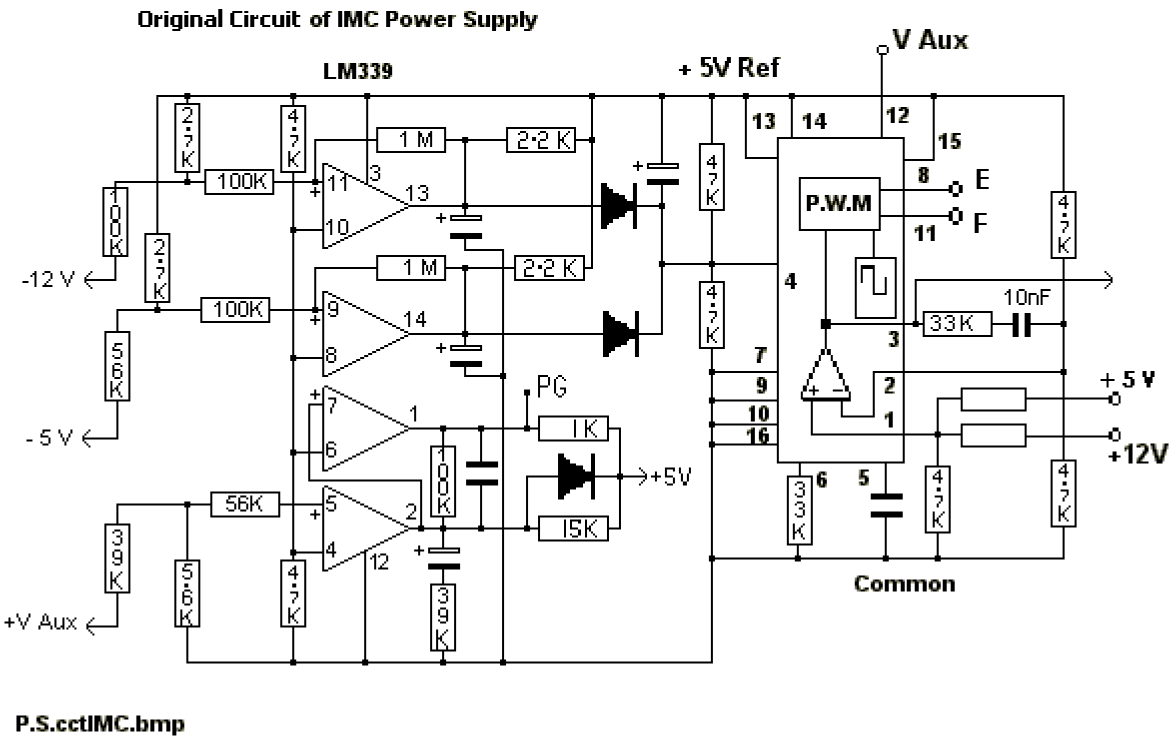


The above diagram shows how to use a small piece of veroboard to mount all the components. The veroboard is 16 tracks wide by 10 holes high. There is no need to cut any track if the components are installed as shown in the diagram. There only two straps used to join some of the tracks. Counting from the left, track 15 is joined to track 16, two holes from the top. Track 7 is joined to track 11, five holes from the top. The only things to watch is that you mount the transistors with their Emitter, Base and Collectors the right way around, also mount an electrolytic capacitor with the positive lead connected to the Base of the BC547. This electrolytic capacitor can be almost any value with a voltage rating of a few volts. I used a 1uf/50-volt capacitor because it was available and quite small.
The transistors were simply ones I had in the junk box. The BC547 could be replaced with almost any low power general use silicon NPN transistor. The BD139 can be replaced with a higher power general silicon NPN transistor also.

The thermistor used is one I bought from Dick Smith Electronics. It is Catalogue number R1895 and has a resistance of 100Kohms at 25 centigrade. It has a negative temperature coefficient and therefore as the temperature increases it's resistance falls and turns off the BC457 which turns on the BD139 and increases the voltage applied to the fan. The thermistor should be mounted on or very close to the heatsink where the main low voltage diodes are mounted.

The veroboard can be mounted on to the two output terminals of your modified power supply with the left hand lead of the 100 ohm 5 watt resistor connected to the negative terminal and the right hand lead connected to the positive terminal.





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The above circuits are examples of the differences in the over voltage and over current circuits used by different manufacturers. Some manufacturers do not use a current transformer and use a circuit that feeds into pin 3 of the IC for current overload.