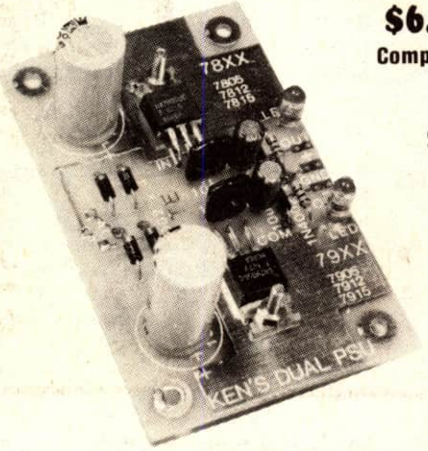
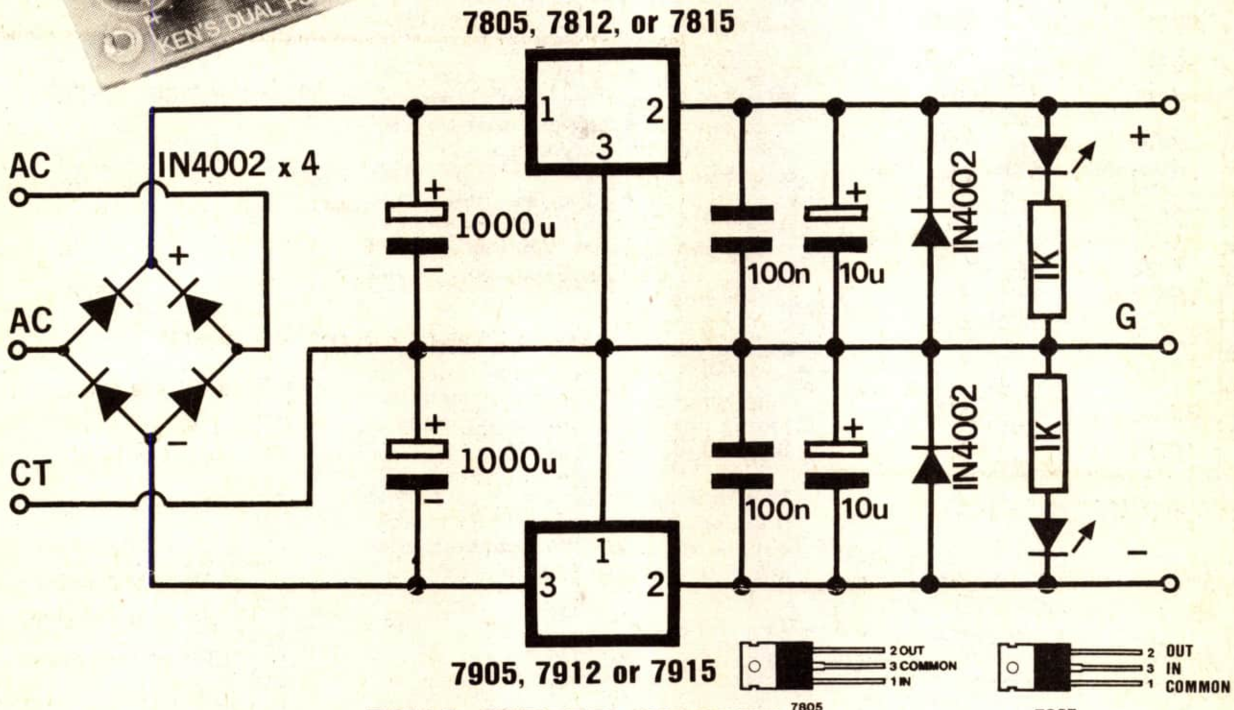
KEN'S DUAL POWER SUPPLY



$6.90
Components

$3.30
PC Board



DUAL SUPPLY CIRCUIT

'Necessity is the mother of invention.

That's how this project came to be.

It's a simple 500mA power supply providing a positive and negative rail with an output voltage which is governed by the voltage of the regulator you use.

The PC layout is somewhat simplified by the fact that the board acts as the heatsink. It will dissipate a total of 5 watts for a rise of 75°C. This equates to 2.5 watts per regulator and will give a 600mA output when the voltage-difference between input and output is 4 volts.

If this voltage difference increases, the output current must be reduced to prevent overheating. If you don't understand this, it is discussed later in the article.

The main need for a simple dual power supply was born when Ken began designing synthesiser projects for future issues of TE. These were basically audio projects and they required both positive and negative rails.

As no dual supply is readily available on the market at a low price, he had to assemble one on Matrix board each time he needed a supply. After producing more than 7 of these, he decided it was time to present a PC design for TE. He could then take a PC board from stock and run up a supply in double-quick time.

This project is the result of specific needs and also fills a gap for a simple dual supply using the minimum of components.

PARTS LIST

2 - 1k ¼watt
2 - 100n ceramic or greencap

6 - 1N 4002 diodes

2 - 10mfd 16v electrolytics
2 - 1000mfd 25v electrolytics

1 - 7815 regulator (positive)
1 - 7915 regulator (negative)

2 - 3mm red LEDs

2 sets nuts and bolts
small amount of thermal grease
15cm hook-up wire, 6 colours

1 - DUAL PSU PC BOARD

1 or 2 - 2155 transformers
or 6672 transformer (see text).

It is mainly designed as a +15v and −15v circuit but can be used as a single 5v or 15v supply. It can even be used with different value regulators however this is not recommended as the power lost in the lower-voltage regulator will determine the maximum current.

Because there are a number of options for output voltages, it is necessary to know what you are doing and what parts will be required, before starting.

We will cover 4 possibilities and show which transformer is required. If you use the wrong transformer or the wrong tappings, you will fail to get the full voltage and current.

The two transformers we have selected are the 2155 and 6672.

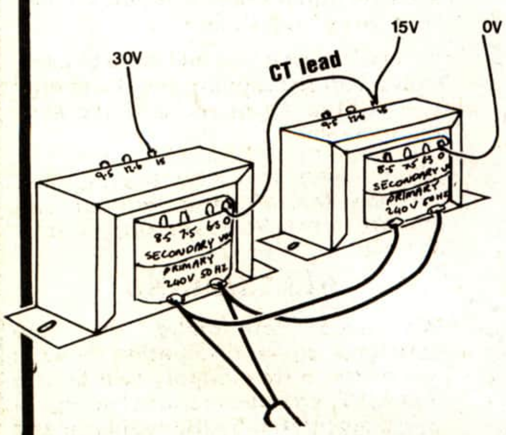
Although they are not ideal designs, the are the cheapest and most readily available.

The 2155 is a 15v types, rated at 1 amp. These are AC values and later in the text you will see how this current rating must be reduced for DC conditions.

The 6672 is a 30v type @1 amp. Again, these are AC values.

In effect, two 2155's are equal to one 6672 transformer.

When using two 2155's, they must be connected as shown in the diagram. This is called PHASING and will produce a transformer equal to a single 30v winding. When phasing is correct, the voltage between the 0v tap on one transformer and the 15v tap on the other will be 30v. If the phase is incorrect, the output voltage will be zero across these terminals.



PHASING TWO 2155 TRANSFORMERS

To produce the correct phasing, the 240v inputs on each transformer are connected in parallel and the secondary terminals are connected in series. We are assuming that the primary and secondary of both transformers are wound in the same direction.

HOW THE CIRCUIT WORKS

The 4 diodes form a full-wave bridge rectifier but the operation of this bridge and the transformer is a little different to normal.

If we take the case of plus and minus 5v using a single 2155 transformer, we can explain the operation as follows:

Take the positive half of the supply. The 7805 sees the transformer as two separate windings and receives a pulse of energy from one of the windings and one of the diodes near the 7805 during the first half of the AC cycle. During the second half of the cycle, the other winding supplies energy to the 7805 via one of the lower diodes.

At the same time, the alternate winding of the transformer is supplying power to the negative regulator via the other two diodes in the bridge.

This means both windings of the transformer are delivering throughout the cycle and two of the diodes are in use at any one time.

+15v −15v MODE

This is the most useful mode for this project. It provides and ideal positive and negative rail voltage for op-amps and other dual-rail chips.

To supply this voltage you will need two 2155's or a 6672 transformer. See the notes on phasing two 2155's to obtain the 0v - 15v - 30v outputs.

SINGLE +15v SUPPLY

In this mode a single 2155 transformer will be needed and one link must be made on the board as follows:
The two lower diodes are connected at their anodes and this point is connected to the CT hole on the board with a jumper wire.

The 0v and 15v tappings of the 2155 are connected to the other 2 input lines. The output is taken from the +ve and ground terminals.

SINGLE 5v MODE

This mode requires a single 2155 transformer plus the link as described in the previous mode. The 0v and 7.5v tapping on the 2155 are used for this mode to prevent the positive regulator overheating.

+5v −12v MODE

Whenever two different voltage regulators are used in this circuit, the lower voltage regulator will have a considerably reduced output current. This is due to the input voltage to the board being high to suit the other regulator. It is not possible to adjust the taps so say 7.5v for the lower voltage regulator and 12.5v for the high regulator. This is because the regulators take it in turns to receive a pulse of energy from each winding.

In this case the 12.5v winding on two 2155's must be used. This gives a very high voltage differential across the 5v regulator and will limit the output current to:

$$= \frac{2.5}{12.5\sqrt{2} - 5}$$

$$= \frac{2.5}{12}\text{Amp}$$

$$= 210\,\text{mA}$$

AN OVERALL LOOK AT THE PC BOARD

This dual power supply project uses a double-sided PC board. This enables the regulators to be bolted directly onto the PC board so that no additional heat-fins are required for currents up to 500mA.

This provides a slight saving in cost and leaves your supply of heatsinks for high current appplications.

The input to the board is designed for a centre-tapped transformer. You may not think a 2155 has a centre tap but this can be created by connecting the 7.5v tap to the CT connection on the PC board. When using a 6672, the centre voltage terminal is the 15v tap. The zero-volts and highest voltage tap are each taken to holes near the 'AC' identification. This gives us 3 input lines as found on a centre-tapped transformer.

The positive regulator goes in the 78xx position and the negative regulator in the 79xx position. They cannot be reversed or swapped over!

Nor will the board work with 2 positive or 2 negative regulators. You will notice the 'IN, COMMON and OUT' terminals are in different positions for the positive and negative regulators. This makes them non-operational in the wrong location.

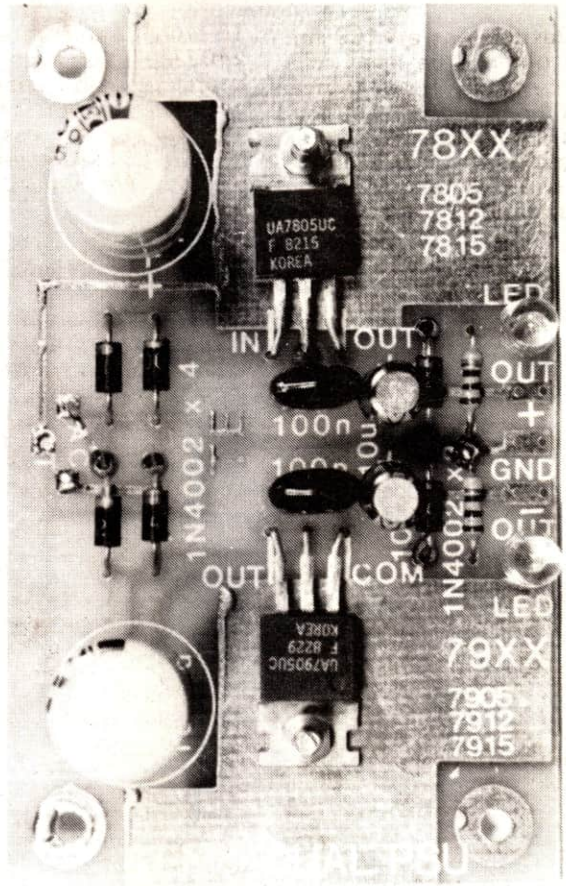
The 100n capacitor prevents high frequency oscillations from occurring. The 10mfd electrolytic on the output provides a small amount of filtering.

The resistor and LED provide an indication of the size of the output voltage and when the power is applied.

The two diodes across the output are extremely important. They provide short-circuit protection in case the positive lead is connected to the negative terminal. If this were to occur, the current limiting inside the regulators would not detect the short and both would be damaged if the diodes were not present.

The way they operate is very clever.

The lower diode becomes forward biased when the positive is connected to the negative and thus it forms a short-circuit to turn on the 7815. The same occurs with the upper diode and the 7915. Thus we save two regulators from being destroyed for the cost of a couple of diodes.



The complete layout with 7808 and 7905 fitted.

CURRENT RATING

We consider the maximum current is 600mA for each of the regulators. This maximum coincides with two other design factors. They are:
1. The maximum current rating of the transformer and the maximum wattage which can be safely dissipated by the regulator and its heat fin.

We obtained the max. dissipation by loading our prototype until the temp of the regulator reached max. We then reduced the current and re-tested the temp of the regulator. You can generally judge the correct temp of the regulator by feeling it with your fingers. You should be able to touch it for at least 5 seconds. At this temp, the output current was measured as well as the voltage across the input and output terminals. These are the results:
Input voltage: 9v
Output voltage: 5v
Current: 625mA.

This gives (9 - 5) x .625 = 2.5 watts. This is the power lost in the regulator and it must be transferred to the heat fin to prevent the regulator from over heating.

The other factor which determines the maximum current available at the output of a power supply is the rating of the transformer. We hear so much about the rating of a 2155 as being 15v at 1 amp. But little do we realize this rating is an AC value.

Working out the DC current rating is quite complex and we will approach it in a simple way.

The power rating of a 2155 is obtained by multiplying the secondary volts by the current. This gives 15v x 1 amp = 15VA. This is 15 volt-amps but for a simple discussion we can call it 15 watts. This is the power rating of the transformer.

Now let's see what happens when we connect the transformer to a full-wave bridge rectifier circuit. The DC voltage which appears across the bridge circuit is $15\sqrt{2}$ volts DC. We readily accept and appreciate the higher voltage which appears across these circuits but fail to take into account the fact that the current rating must be reduced by the same ratio to maintain the value of 15 watts.

This means the output current must be reduced by the ratio:

$$\frac{15}{15\sqrt{2}}$$

This gives us 700mA max for the DC condition. This is a far cry from the 1 amp we so readily accept and expect.

The transformer will deliver higher currents if the load is increased however the output voltage will fall with the result that the regulator may drop out of regulation.

This will means you will have to use a higher voltage tapping and the energy lost in the heatsink will increase dramatically.

When using the 7.5v tapping and drawing 600mA, this project will operate very reliably for long periods of time.

HEATSINKING

We have determined that the maximum power dissipation for each rail of the power supply will be 2.5 watts. When this amount of energy is being dissipated by the regulator and PC heatsink, the regulator is still cool enough to be touched on its plastic case with your finger.

Because the copper fin on the PC board is very thin, it is essential that the regulator be adequately heat-sinked. This involves filing the surface of the board to remove any of the bumps and the use of heat-sinking compound. This compound is absolutely necessary if you wish to run the regulator for longer than 10 minutes at greater than 100mA.

The nut and bolt used for the regulator must be brass or steel to conduct the heat to the other side of the PC board.

If you wish to increase the dissipation, an additional heatfin will be required. The critical part of the fin is the thickness of the material between the regulator and the PC board. This part has the greatest effect on conducting the heat from the regulator to the free air. (Free air is normal air. You can also have fan forced air). A piece of aluminium bent into an L shape will be suitable provided it offers a flat surface to the regulator and PC board. The maximum dissipation with this type of arrangement is 5 - 6 watts.

CONSTRUCTION

The first components to be mounted are the two regulators. File the surface of the PC board to remove any high spots. Place a very small amount of heat conducting grease on the back of the positive regulator and fit its three leads into the holes next to the 78xx identification on the PC board. Use a 1/8" or 6BA nut and bolt to tighten the regulator onto the board. Watch the grease ooze out from around the sides of the regulator. Repeat with the negative regulator.

The board is now ready for mounting the rest of the components. All the parts should be pushed firmly onto the board so that they almost touch it. We still see projects sent in by readers with parts high above the board. And it always looks very messy. In this project there is an exception. The two 1000mfd electrolytics can be kept slightly above the board so that the heat from the fin is not conducted into the electrolytic itself. If they were to get too hot, they would dry out and lose their capacitance.

Solder the lands on the top of the PC board. The last items to connect are three leads to the input (say yellow, white and blue) and three leads to the output (red, black and green).

Mount the board on 4 standoffs and it is now ready to be tested.

TESTING THE UNIT

We will assume you have used the most common voltage regulators giving a +15v and +15v supply, however the same procedure will apply to any arrangement.

Firstly the power supply is tested under NO LOAD conditions. Place a 47ohm or 100ohm ¼ watt resistor in each of the two outside input lines. Make sure the 3 output leads are not shorting together.

Switch on the AC and note the two output indicator LEDs will illuminate. The two protection resistors should also remain cold throughout this test. If they get hot or burn out, a fault will exist. Fix the fault immediately.

Remove the two protection resistors and wire the input directly to the transformer.

The best way of determining the current capability of the power supply is to connect a specific load to the output. The most accurate arrangement is to use one or more wire wound resistors to dissipate the heat. If you have 8R2 10R or 15R in either 5watt or 10watt sizes, they will be ideal. Globes or motors do not give a very reliable indication of the current flow as they draw a varying current according to the load or brightness. And the current will vary enormously with only a slight change in voltage.

For a 15v regulator, you can use three 8R2 resistors in series for an accurate determination of the 7815 current and a globe on the other regulator for an approximate load.

At 600mA, the regulators can still be touched with a finger while the nut and bolt is a better conductor and will be too hot to touch.

If everything is working correctly, the test load can be removed and the PSU connected to a project.

I hope you find it as handy as we have.