Assembly Manual

Low Voltage Battery Cut-out

K-3124

(for cars and boats)

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DICK SMITH ELECTRONICS

ACN 000 908 716

KIT

Build this simple little gadget, and avoid getting caught out with a flat battery during your holidays. It simply connects into a 12V accessory's power line, and shuts off the flow if the battery's voltage drops to a dangerously low level.

The scenario may be familiar to many readers: you park your vehicle (or anchor the boat), extract a few cold 'lemonades' from the 12V-powered refrigerator and relax to watch the sun go down.

Unfortunately, the next time that you even consider how the battery may have coped with the five or so amps demanded by the fridge over an extended period, the sun has risen again and it's time to move on. And — you guessed it — there's not enough energy left in the battery to start the engine. So there you stay, until help arrives...

Of course, this is just one possible scenario. There are a whole range of situations where a 12V accessory can surreptitiously exhaust the battery's charge. Some will just cause a minor inconvenience, while others can place you in a dangerous predicament.

Our new low voltage cut-out unit offers a solution to the problem by continuously monitoring the battery's condition, and disconnecting the load *before* there is the potential for 'starting troubles'.

While the most accurate way of determining a car battery's state of charge is to test each cell with a specialised device such as a Hydrometer (which derives a good/bad reading from the condition of the cell's acid), the overall terminal voltage can also give quite a reasonable indication. For example, if the voltage is around say 12.5V it's safe to assume that a substantial charge remains, and the battery should have no difficulty in starting an engine.

On the other hand, a battery with terminal voltage of 11.5V would probably have a very restricted current capability and insufficient energy to drive a heavy load.

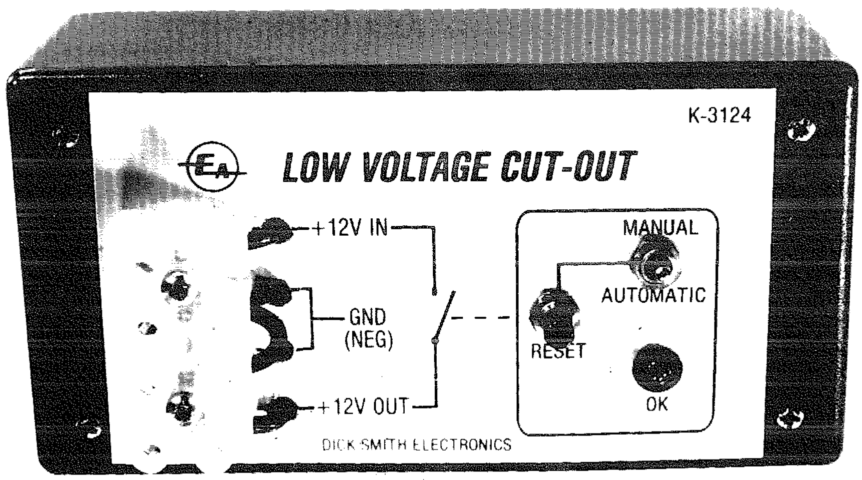
In the cut-out unit we've elected to make this drop-out voltage adjustable over a nominal range of 10.9V to 11.9V, as set by an internal trimpot. This allows the unit to be fine tuned for each installation, depending upon the minimum acceptable level of battery charge.

We've also arranged the circuit to restore power to the load automatically when the battery voltage has returned to around 12.6V, indicating that the cells have been recharged or high-current charging is taking place from say, a vehicle's alternator.

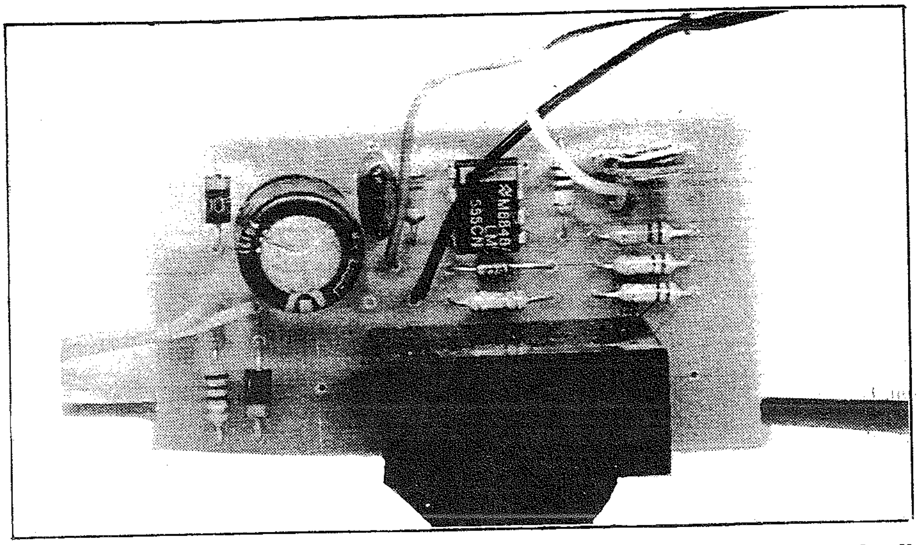
With this feature you can leave the battery management up to the cut-out unit, which both connects and disconnects the accessory in response to the battery's state of charge. By the way, while the 12.6V 'reset' level should suit virtually all circumstances, it can be altered by just changing the value of a couple of the circuit's resistors — see later for more details.

There are circumstances however where the automatic reset feature may not be desirable. Imagine for a moment that the battery in question is near the end of its useful life, and exhibits a relatively high internal resistance. In this case, when the cut-out unit has disconnected the load in the normal manner, the input voltage may immediately rise — causing the unit to reset, and therefore connect the load again. The voltage will then fall, and so on...

While this is an unlikely event (chances are that the voltage will not return to a greater level than 12.6V), the cut-out unit would continuously drop the load in



Text and illustrations courtesy of Electronics Australia



The PCB is really quite small and could be installed inside a 12V accessory itself, rather than in the plastic case as supplied.

and out, which may not impress some fridge compressors for example. Also, a similar situation could develop due to resistance in the accessory's wiring and connectors, rather than in the battery itself. In any case, the cut-out unit offers an alternative *manual* reset mode to cope with such complications.

When this mode is selected on the unit's 'automatic/manual' switch, the load is disconnected in response to a low input voltage in the usual way, but is not reconnected as the input rises above the 12.6V 'reset' level. In fact, it will remain in its 'dropped-out' state until the front panel's RESET button is pushed, where the load will be reconnected — if the input voltage is above the current cut-out level. That is, the RESET button will only cause the circuit to 'latch' if the battery has recovered to some degree.

Aside from that, the low voltage cut-out unit offers an 'OK' LED on the front panel to indicate that the load is indeed connected, and a simple terminal strip connector for the input/output wiring to help make the installation a simple process. It's also very reliable, and only draws around 12mA from the supply once it has disconnected the load. And importantly, the unit uses standard low-cost components and is extremely easy to build.

Circuit description

As you can see from the schematic diagram, the cut-out unit's circuit is based around our old friend the 555 timer IC. The 555 is a logical choice for the job — as in so many other utility-type circuits — since it offers a flipflop with voltage-dependent setting and resetting actions, the ability to switch a relatively high load current, and a stable yet versatile internal circuit design.

In our case the 555 is arranged in a fairly standard configuration, where the threshold and trigger pins (6 and 2 respectively) are tied together and both sense the incoming voltage.

Since the trigger input normally *sets* the 555's internal flipflop as the voltage drops below 1/3Vcc, and the threshold pin *resets* the flipflop as it rises above 2/3Vcc, the circuit behaves as an inverting Schmitt trigger between pins 2 and 6, and the output at pin 3.

In our circuit however, the 555's control voltage (CV) input is held at 5.1 volts by the action of ZD1 and its associated resistor R5, which effectively overrides the chip's internal voltage divider (see Fig.1). This now means that the flipflop will be *set* when the input level falls below 2.55V, and *reset* when the inputs are above 5.1V — regardless of any moderate changes in the voltage at pin 8 (Vcc).

So when the input voltage is above the 'threshold' level (5.1V), the 555's output (pin 3) will fall to energise RLA, which in turn connects the DC supply voltage to the output load.

Conversely, power to the load is removed when the 555 is *set*, as the input level at pins 2 and 6 falls below 2.55V (the 'trigger' level).

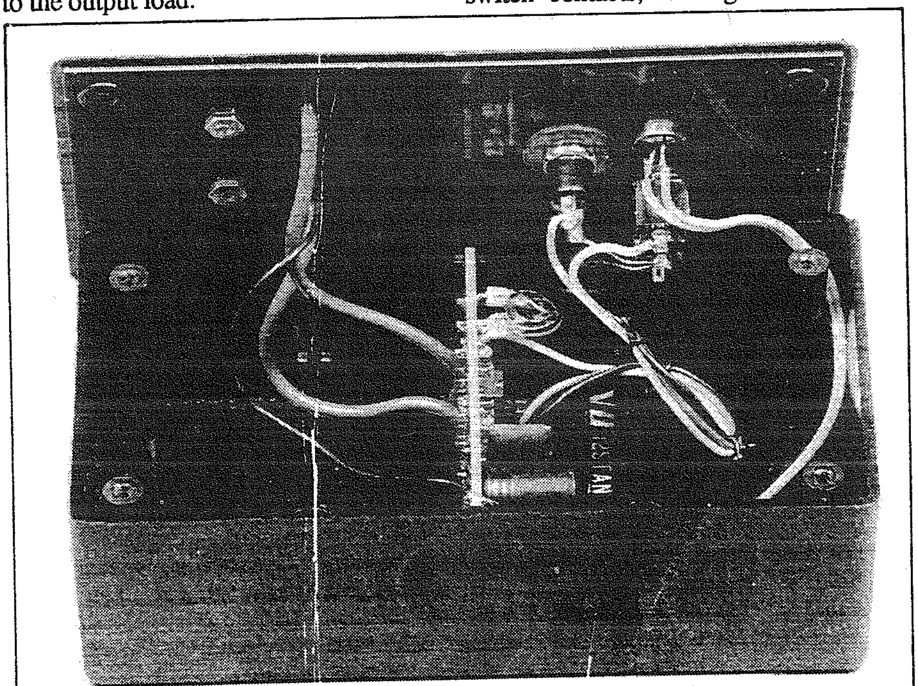
The actual input supply rail is applied to this level-detecting scheme (at pins 6 and 2), via isolating diode D1 and the voltage divider formed by R1, R2 and R3. Note however that when the 555 is in its normal *reset* state (relay energised), pin 7 is effectively shorted to ground potential via the chip's internal 'discharge' transistor, thereby connecting RV1 and R6 in parallel with R3.

As a result, if RV1 is adjusted for its minimum value (0 ohms) and the 555 is indeed reset, the 2.55V trigger level at pin 2 is met as the source voltage falls below about 11.9V. On the other hand, if RV1 is set to its maximum resistance, the 555's flipflop will be set as the input voltage drops below around 10.9V. So ultimately, the circuit's relay will drop-out if the input voltage falls below the range of 11.9 to 10.9 volts, depending upon the setting of RV1.

Once the 555's flipflop has been *set* (relay de-energised), the internal discharge transistor at pin 7 will be turned off, disconnecting RV1 and R6 from the input voltage divider circuit.

Since the divider is now composed of just R1, R2 and R3, the 5.1V upper threshold point will be reached only when the input voltage has risen to about 12.6V, where the flipflop will again be *reset* and the relay energised to connect the load. This is in fact the operation of the cut-out unit when in its 'automatic' mode.

When the 'manual' mode is selected on SW1, the 555's discharge pin is grounded continuously through the switch contacts, leaving RV1 and R6



Inside the completed unit. Note that the PCB is held in place by the case's mounting slots, and the 12V in/out wires are soldered to the corner side of the board.

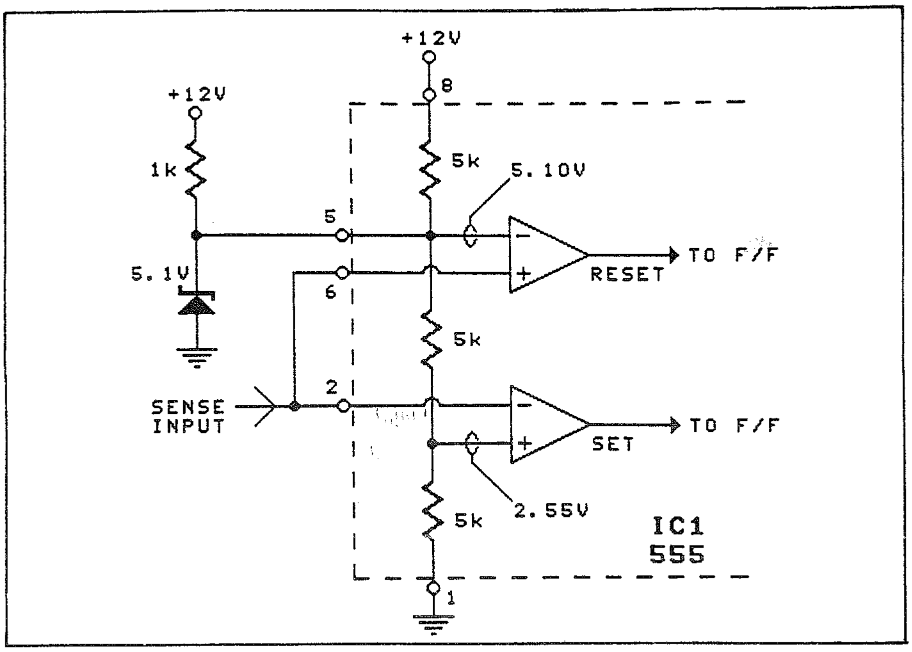


Fig.1: The voltage at which the threshold input (pin 6) resets the 555's internal flipflop is fixed by the 5.1V zener diode at the CV input (pin 5). Due to the 555's internal voltage divider, the trigger input (pin 2) will therefore set the flipflop at 2.55V.

permanently in circuit. This means that while the triggering or low voltage drop-out process will operate in the same manner — since when the flipflop is *reset*, SW1 performs the same function as the discharge transistor at pin 7 — the 555 will not be reset until the input voltage reaches a theoretical figure of about 22V. So in practice, the circuit cannot automatically reset, and the relay will not reconnect power to the load.

This is of course where the manual reset button comes into play. While the 555's master reset function at pin 4 is normally disabled in our circuit by the pull-up resistor R4, the reset button (SW2) can pull this point to ground potential when required. When this occurs, the 555's flipflop is reset, pin 3 goes low to energise RLA, and power is reapplied to the load.

If however the voltage at pins 2 and 6 is less than the 2.55V trigger point at this time, the 555 will immediately *set* once the button is released, and the load will again drop out. So in effect, the resetting action will only last as long as the reset button is pressed, if the input voltage is below the 'drop-out' level. Normally though, you would only be pushing the reset button once the battery (input) voltage has returned to a suitably high level.

Note that LED1 and its associated limiting resistor (R7) are connected across the relay coil, so that when the 555's output (pin 3) is low the 'OK' LED illuminates to indicate that the battery is in a healthy state, and the relay is energised. Also, D2 has been included to quelch any back-swing voltage generated as the relay coil is de-energised.

Finally, C1 and C2 have been included to help stabilise the circuit's supply rail during fluctuations in the input voltage. C1 has been selected as a large value (1000uF) so that during any *short-term* reductions in the input voltage, D1 will become reverse biased and the supply rail will be maintained from the capacitor's stored charge.

If this heavy filtering was not included, the cut-out unit would tend to disconnect the output in response to momentary line fluctuations or 'drop-outs', such as that produced when some other 12V accessory is activated. This would be a particular problem when the unit is in the manual mode, where the relay would remain de-energised until the reset button is pressed.

As it stands however, the main section of the circuit (supplied by C1) will tend to ignore the drop-out, and the 555's output (pin 3) will remain at a low level. C2, by the way, is intended to bypass any stray RF energy which may enter via the input line.

Construction

Building the low voltage cut-out unit should be quite a straightforward affair. Virtually all of the components are mounted on one small PCB measuring 62 x 35mm, with the remaining parts fitted on the lid of the unit's case. First check that the PCB will fit into the vertical mounting slots of the case, if not the PCB may require some light filing.

Begin construction by installing the PCB pins and all of the lower profile components into the PCB (coded 921vc1), while paying particular attention to the orientation of any polarised parts as shown in the component overlay.

Once the relay has been fitted, add lengths of light-duty hookup wire to all of the external connection pads on the PCB, except for the +12V IN and +12V OUT points at the base of the relay. These should be formed with suitable lengths of heavy-duty hookup wire, and terminated on the copper side of the PCB.

Next, we can now prepare the front panel. Using the Front panel label supplied, mark and drill the 9 required holes. Then install the switches and LED (but not the terminal strip) in the case lid, and connect these components to the light-duty wires as shown in the overlay diagram. Note that a small wire link is needed between SW1 and SW2 - a component leg offcut is quite suitable for the job.

Then pass the two heavy-duty wires and the GND (NEG) wire through their matching holes in the lid, and terminate their ends in the terminal strip. The strip can now be bolted to the front panel and a short (heavy-duty) wire link added between the two GND (NEG) connections. As it happens, it's much easier to neatly pass the wires though the holes in the case lid *before* the terminal strip is bolted in place.

As you can see from the associated photographs, the PCB is designed to fit into the vertical mounting slots of a standard plastic case.

This avoids the need for messy PCB mounting hardware, allows for a much

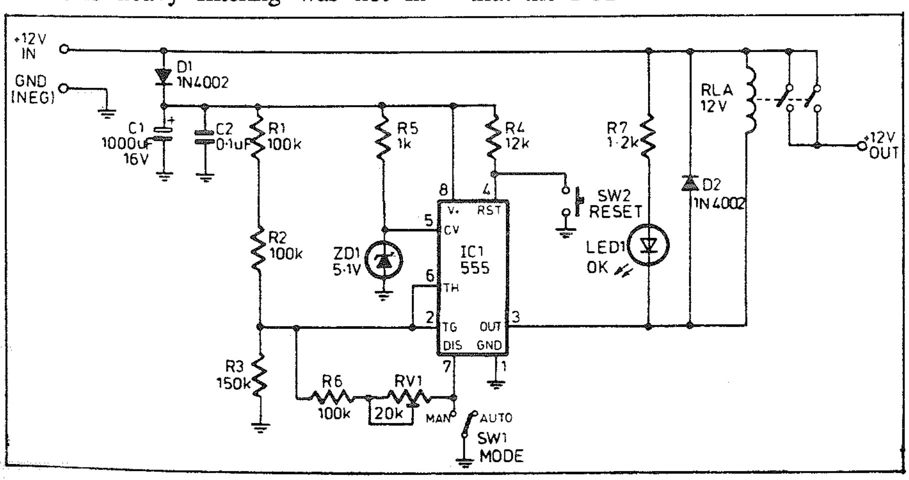


Fig.2: The circuit is very simple thanks to the 555 timer IC. Its trigger and threshold inputs are used to sense the low and high input voltage points, respectively.

easier installation method, and makes for simple access when servicing or adjustment is needed.

Testing & installation

The easiest (and best) way to test the newly completed cut-out unit is to connect a variable power supply to the +12V IN and GND (NEG) terminals, select the automatic reset mode, and slowly increase the supply's output voltage. If you started from a low voltage, the 'OK' LED should illuminate (with a coincident 'click' from the relay) once the level has reached around 12.6V.

Then if the trimpot (RV1) is near the centre of its travel, the 'OK' LED should extinguish (with another 'click' from the relay) as the input voltage falls below about 11.5V.

Now perform the same tests with the cut-out unit in its manual mode. In this case note that once the relay has dropped out in response to a low input voltage, it can only be re-energised by pushing the reset button.

In turn, the reset switch should only have a permanent effect on the relay once the input voltage has risen *above* the lower cutout point (greater than say 11.5V). When the voltage is below this level, the relay should only hold in for as long as the reset button is pushed.

Once you are satisfied that the cut-out unit is performing correctly, it can be installed in its final location. The most convenient way to mount the device in place is to simply bolt or screw the main body of the case into position, then install the lid and attached PCB assembly into the box.

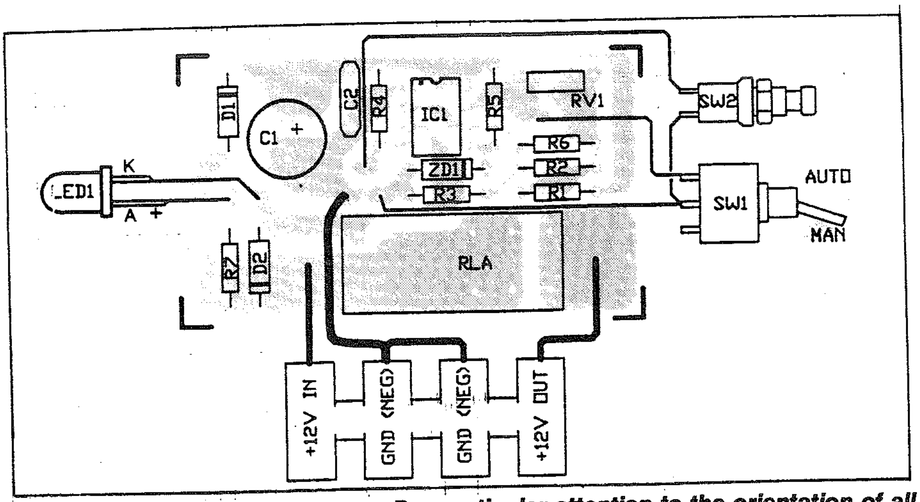
When it comes to adjusting RV1 (the lower cut-out level) however, leave the PCB in position and just move the lid far enough to one side for sufficient access to the trimpot.

As you would expect, the unit is simply wired 'in-line' with the accessory it is intended to control. If the accessory is connected with a two-core cable, this can be cut and the 'battery' side of the break wired to the cut-out unit's input connections (+12V IN and the matching GND (NEG) terminal).

Similarly the 'accessory' section of the cable is wired to the appropriate output terminals (+12V OUT and its GND (NEG) point. **Note ,however, that you must take particular care to maintain the correct polarity to the accessory unit, or it may be permanently damaged.**

Also check that the cut-out unit is receiving the correct voltage polarity, or its new career will be ended before it has even started!

Alternatively, the accessory could be connected via just one wire (+12V), with its return path (negative) completed through a vehicle's metal chassis for example. In this case, the single wire can pass though the cut-out unit's relay contacts via the usual '+12V IN' and '+12V OUT' terminals, and an additional wire connected between one of the GND (NEG) terminals and the vehicle's chassis.



The component overlay diagram. Pay particular attention to the orientation of all polarised parts.

Parts List

Resistors (all 0.25W 5%)

R1	100k (brn-blk-yel)	☐
R2	100k (brn-blk-yel)	☐
R3	150k (brn-grn-yel)	☐
R4	12k (brn-red-org)	☐
R5	1k (brn-blk-red)	☐
R6	100k (brn-blk-yel)	☐
R7	1.2k (brn-red-red)	☐
RV1	20k Trimpot	☐

Capacitors

C1	1000uF 16/25VW Electro	☐
C2	0.1uF/100nF/104k Greencap	☐

Semiconductors

IC1	555 Timer	☐
LED 1	5mm Green LED	☐
ZD1	5.1V 400mW 1N751 Zener Diode	☐
D1	1N4002/4 Power Diode	☐
D2	1N4002/4 Power Diode	☐

Miscellaneous

1 x PCB 62 x 35mm. coded 92lvc1	☐
1 x Zippy box (UB3)	☐
1 x Front panel label	☐
1 x SPDT Toggle switch (SW1)	☐
1 x P/Button Mom. switch (SW2)	☐
1 x relay 12V 10A DPDT (RLA)	☐

LED bezel & ring; 4-way connector; IC socket; PCB pins; light & heavy duty hookup wire; cable ties; solder; screws and nuts.

Note that this extra wire only carries the small 'return' current for the cut-out unit, and can be formed with light-duty wire.

Adjustment & mods (optional)

While RV1 will adjust the unit's cut-out voltage over a moderate range, its actual setting will depend upon the conditions at the installation itself, and what you consider to be a sufficient charge remaining in the battery.

For example if the accessory is a refrigerator in a four-wheel-drive vehicle, it would be wise to set the trimpot for a relatively high cut-out voltage (say 11.9V), so that a reasonable battery healthy battery will have trouble turning over some of the more burly 4WD motors, if its terminal voltage is much below 12V.

On the other hand, there may be a much smaller motor involved such as the auxiliary unit in a small sailing yacht, which should be considerably easier to start. In this case you should be able to set RV1 to a lower cut-out voltage, and effectively allow the accessory to run for a longer period from a given battery charge.

The cut-out unit's automatic reset voltage is fixed at around 12.6V, which should suit most situations. In practice, the battery voltage will rise to at least 13V (typically 13.8V) once the motor has been started, since the alternator will immediately begin to charge the battery at a high current. However you may wish to alter this figure if say, the battery is charged by solar cells alone.

In this situation the battery's terminal voltage is unlikely to rise above the 12.6V level — despite being in a healthy state of charge — since the solar cells can only deliver a very modest charging current. To lower the automatic reset point to say 12.2V, try changing R1 to 68k, R2 to 120k, and R6 to 82k.

Of course, there may be a situation where the cut-out unit's reset voltage needs to be *higher* than the standard setting. In this case changing just R1 to 120k brings the automatic reset point up to about 13.3V.

By the way, in both of the above cases the unit's cut-out voltage (as set by RV1) is changed by a proportional amount. For example, in the latter modification the drop-out level can be set between around 12.6 and 11.6 volts. However, if you generally need a wider range of adjustment for RV1, try increasing its value to 50k and dropping R6 to 82k or 68k.

Take some care with the adjustment though, since you could end up with a dropout voltage setting which is actually *higher* than the automatic reset voltage.

Assembly Manual

UNIVERSAL POWER SUPPLY

K-3435

PCB & Instruction Only

PLEASE READ DISCLAIMER CAREFULLY AS WE CAN ONLY GUARANTEE PARTS AND NOT THE LABOUR CONTENT YOU PROVIDE

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DICK SMITH ELECTRONICS

Mini Short Form Kit

There is more than one way to skin a cat they reckon, and the same applies to designing a power supply. This small board enables you to obtain + 15V, − 15V or ± 15V DC from a number of different transformer and rectifier combinations.

It's a problem that has confronted us on a number of occasions over the years; many circuits require ± 15V DC rails or one or the other and, in each case, a suitable printed circuit board has to be designed. So we decided to solve this problem for a number of different transformer combinations.

One common situation is when you are powering a circuit from a 12VAC plugpack transformer but you want ± 15V rails, using 3-terminal regulators. Sounds difficult? Nope, piece of cake. Just use two half wave rectifiers to obtain the positive and negative rails and then follow with the regulators.

Or maybe you have a more conventional situation with a 12VAC transformer such as the Ferguson PF2851 (or equivalent). To obtain 15V DC the circuit is the same. But if you have a 30VAC centre-tapped transformer you then use a bridge rectifier, followed by the filter capacitors and 3-terminal regulators.

Anyway, you get the general idea. We are presenting one PCB pattern and showing how to use it in four different ways, depending on what your requirements are and what transformer you are using. Actually, there are other options and we'll mention those later.

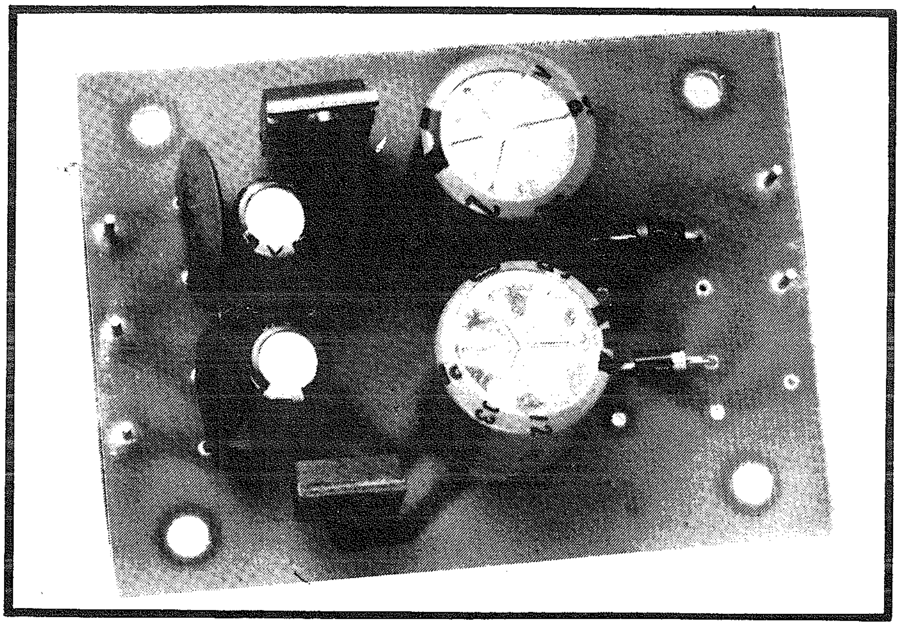
The board measures 71 x 52mm (code 04106881) and was used for the first time in the Studio 200 Stereo Control Unit, part two of which is featured elsewhere in this issue. We'll be using it again in a few months' time.

The circuit variations

Fig.1 shows the first circuit situation presented above and could be used with a 12VAC plugpack or with any chassis mounting transformer with an output voltage or 12 to 15 volts AC. You can regard the circuit in two ways. First, as two half-wave rectifiers, D1 and D2, producing filtered but unregulated DC supply rails of ± 18-22V, depending on the transformer secondary voltage.

The other way of regarding the circuit of Fig.1 is as a conventional half-wave voltage doubler circuit which has been "centre-tapped" at the junction of the two 1000μF capacitors. Either way, the result is the same.

Because D1 and D2 function as



This version of the universal power supply board uses half-wave rectifiers and two 3-terminal regulators to give ± 15 rails (see Fig.1). Note that the LED indicator circuit was added after this photo was taken.