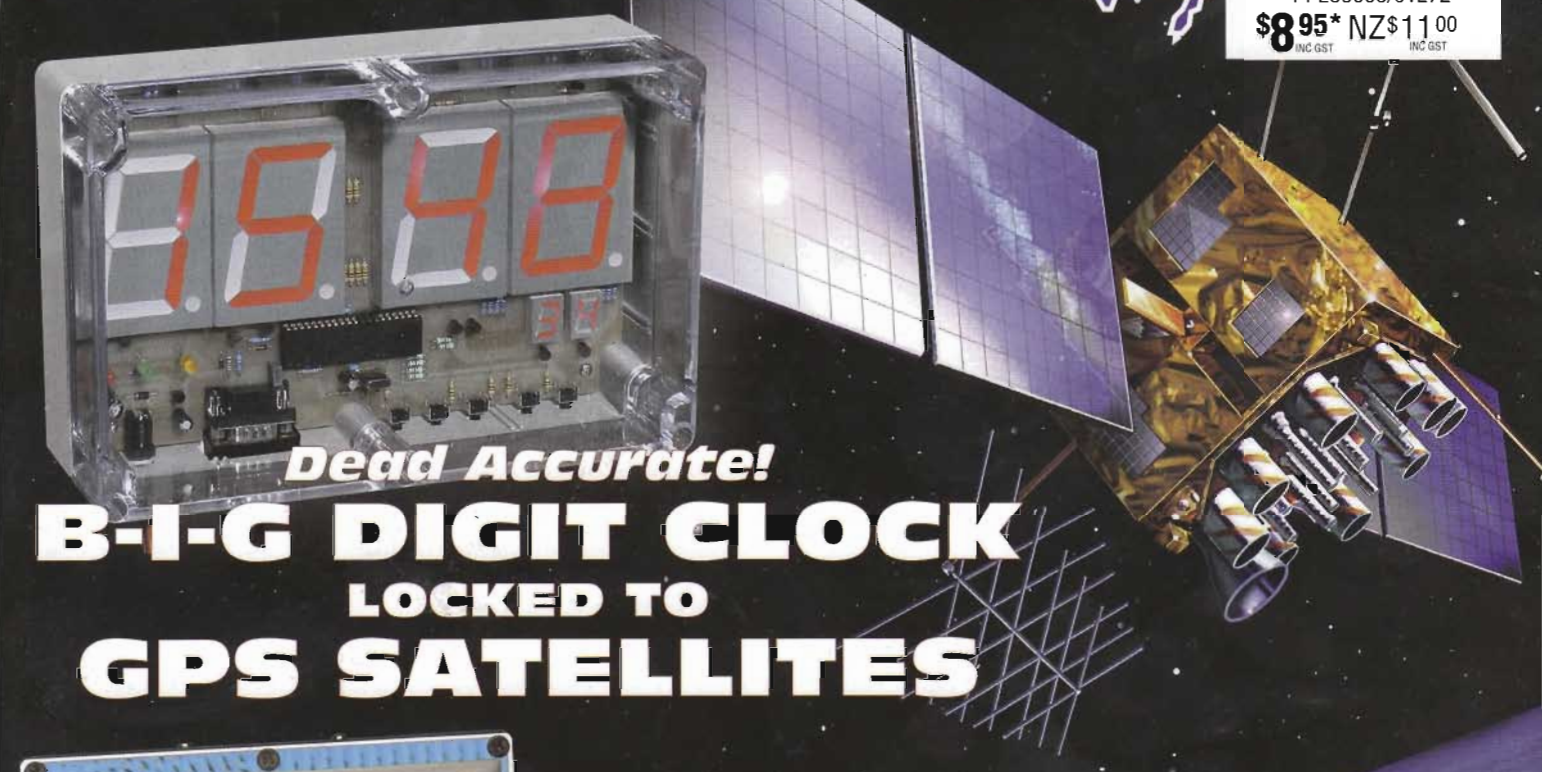
SILICON CHIP

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Contents

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SILICON CHIP

Features

12 Tech Support: Terror Tales From The Front Line
You wouldn't believe some of the idiotic calls that computer tech support people get; but then again you just might – by Barrie Smith

16 HID Lamps: Out Of The Car & Over Your Shoulder
It's taken a while but high-intensity discharge (HID) lamps are now available in hand-held spotlights. Here's a look at Jaycar's ST-3369 – by Ross Tester

70 Why Calibrate Your Test Equipment?
If you work in industry, it's vital that your test equipment is correctly calibrated. Here's why – by Tony Tong

72 How To Draw Circuit Schematics In Protel Autotrax
Here's an easy way to make your circuit diagrams look good – by Rick Walters

Projects To Build

20 Dead-Accurate 6-Digit GPS-Locked Clock, Pt.1
Looking for a digital clock that's always dead accurate? This one is locked to GPS time signals, so it never needs setting or adjusting – by Jim Rowe

36 230VAC 10A Full-Wave Motor Speed Controller
It gives smooth control from near zero to full speed on electric drills, routers, circular saws & other appliances with universal motors – by John Clarke

62 Precision 10V DC Reference For Checking DMMs
Check your DMM's accuracy with this simple device. It provides a precision 10V DC reference that's accurate to within ±3mV – by Jim Rowe

80 UHF Remote 2-Channel 230VAC Power Switch
Long range (80-metres) unit uses pre-built UHF transmitter & receiver modules to make it easy to build – by Branco Justic & Ross Tester

88 Input Attenuator For The Digital Audio Millivoltmeter
Extend the range of the SILICON CHIP Digital Audio Millivoltmeter with this easy-to-build switched input attenuator – by Jim Rowe

Special Columns

30 Circuit Notebook
(1) 12V Regulated Inverter Supply; (2) Solar Panel Tracker Uses LED Sensors; (3) Picaxe-Based Solar HWS Boost Control; (4) 3-Stage Dimmer For Mountain Bike Light; (5) Reticulation Valve Locator; (6) Overvoltage Protection For DC Loads; (7) Preamplifier For Speed Controller

57 Serviceman's Log
The real meaning of eternity – by the Serviceman

92 Vintage Radio
The Astor Football GR/GRP 3-Valve TRF Receiver – by Rodney Champness

Departments

2 Publisher's Letter
4 Mailbag
29 Order Form
79 Product Showcase
96 Ask Silicon Chip
99 Notes & Errata
102 Market Centre



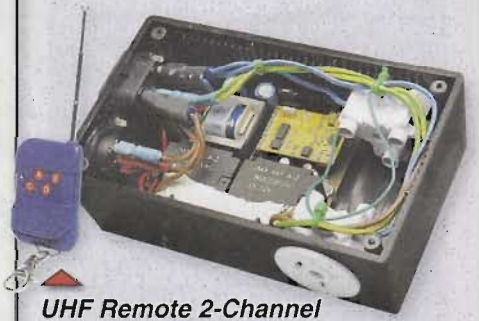
Dead-Accurate 6-Digit GPS-Locked Clock – Page 20.



230VAC 10A Motor Speed Controller – Page 36.



Precision 10V DC Reference For Checking DMMs – Page 62.



UHF Remote 2-Channel Mains Switch – Page 80.



Input Attenuator For The SC Digital Audio Millivoltmeter – Page 88.

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Publisher's Letter

High-speed broadband network could be a white elephant



So the Federal Government has proposed a completely new optical fibre broadband network. Whoopee! All those people who are dissatisfied with their present internet connections will no doubt be salivating at the prospect of such a high-speed, high capacity network? Or will they? And what will they use it for?

In the days after the initial release there have been numerous questions raised about the huge projected cost to build it, its overall coverage of the population and the projected monthly charges. At the time of writing this editorial, there is simply not enough detailed information to make an informed comment. Nor has any of the enabling legislation been drawn up and nor do we know if it will be passed in its proposed form or whether it may be changed so much that the result bears little resemblance to the original proposal.

But in spite of the lack of detail, there are a number of concerns that do need to be addressed before the project gets too far down the track. The first question revolves around the huge projected cost of $43 billion, which is an order of magnitude larger than the $4.7 billion government contribution to the originally proposed broadband tender. This means that the project will have enormous financial costs even before a single customer has signed up. It also means that the monthly charges will need to be quite high, perhaps as high as $150 to $200 according to some analysts. You would need to be a very committed user to pay that much.

Second, we would need to be assured that there would be no significant differences between download and upload speeds, as there are with the present broadband system. Fast download speeds are all very well if you are downloading movies but business wants fast upload speeds as well, for a wide range of applications.

Third, there is a big question over whether we need a fibre-optic network at all, in addition to the existing cable networks. With the ever-increasing speeds available from wireless networks, why have another cable network running down the streets of the nation. And is the new fibre-optic network likely to be above ground, like the present Optus network? Surely not! Many developing nations are choosing to bypass conventional wired networks for phone and internet and have gone straight to wireless systems.

Overall, I have a very bad feeling concerning this plan. Is it likely to be another financial disaster like the 1980s PayTV debacle? Is the government trying to come good on an election promise when it should quietly leave the whole field to private enterprise? And are we going to end up with another government-sponsored monopoly like Telstra was?

Finally, if the government is all that keen to build big infrastructure projects, why not build something really tangible such as the long-proposed Very Fast Train (VFT) project? This would not only provide a very important high-speed link between the eastern state capitals of Brisbane, Sydney, Canberra & Melbourne but would also help reduce Australia's oil import bill and thus the balance of payments. It would also reduce our overall greenhouse gas emissions – something which is supposedly a big concern to the Federal Labor Government.

In suggesting the Very Fast Train project, I am mindful of the pitfalls of such government-sponsored infrastructure such as the Alice Springs to Darwin railway which is over-burdened with debt. However, the VFT project would potentially serve a very large population along its proposed route and there would be countless benefits apart from the railway itself.

Leo Simpson

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Basslink temperature limit

In your Publisher's Letter for the March 2009 issue you question the temperature rating of the Basslink Tasmanian converter station.

In fairness to the Basslink designers it should be pointed out that the nearest weather station with long-term records is Low Head which has had an all-time peak temperature of 29.5°C. The Basslink station is quite close but inland from Low Head, which is right on the coast, so it was reasonable to allow an extra 5.5 °C for its maximum design temperature.

The Victorian converter station has a higher temperature rating and did not limit.

Graham Shepherd,
via email.

Silly legislation in South Australia

The School Zone Speed Alert described in the April 2009 issue is a very clever piece of engineering. Unfortunately, I do not think there will be many made in South Australia – see the accompanying photo.

The South Australian Government only implements the standard "Australian Road Rules" when it suits them. The school signage used to be 40km/h with the times of the day listed as in the other states but some of our smart politicians decided they knew best and changed the speed limit to 25km/h, whenever children are present. I have contacted the RAA (our motoring body here) about this anomaly but they said even though it was wrong, they couldn't get the government to listen.



It is very confusing trying to spot a child (it would seem to be at any time of the day or night), as there are usually many cars parked near school crossings.

Ron Mills VK5XW,
Rosslyn Park, SA.

Comment: that is stupid, isn't it? It means that if a child is on the footpath but hidden behind a car, you could be booked for speeding.

Powakaddy battery charger information

Perhaps I can point E. W. in the right direction re the Powakaddy battery charger (Ask SILICON CHIP, February 2009, page 96). Firstly, he is correct in assuming the charger needs a battery connected before it produces any output. But if there are alligator clips fitted, this unit has been modified. There would normally be a special connector to fit into a Powakaddy connector which is fitted to the top of the battery. This prevents reverse connection.

The two "extra" wires should incorporate some sort of temperature sensing device but I am not sure what it is. I recently modified one of these chargers to use Anderson Connectors. The original cable is of moulded construction and the sensing device is embedded into it, in close proximity to the positive and negative leads. It almost seems to be sensing the wire temperature, as it is nowhere near the battery. I carefully fitted the new connectors, making sure the sensor returned to its original position.

If the original is special wire that raises temperature rapidly in an overcurrent situation and the sensor has been destroyed by a previous modification, then E.W. has a problem and could be left with so much scrap metal. I don't like the chances of getting a schematic from the makers (UK) or the

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Changes to RS-232C converter

I want to suggest two changes to the circuit of my port-powered RS232C-to-current loop converter, published in the Circuit Notebook pages of the April 2009 issue. These changes are necessary to make it work with some current loop interfaces such as the Cassette Tape Interface for Microcomputers (from "Electronics Australia", April 1977) which need the voltage across the SEND output to go below 0.6V for a logic level of 1.

The changes are as follows:

(1) LED1 in the SEND side of the circuit drops too much voltage and must be replaced by a link.

(2) The 10kΩ resistor in the SEND side of the current loop circuit must be replaced by a 150Ω resistor.

Andrew Partridge,
Toowoomba East, Qld.

local agent in Australia. All Powakaddy parts are still available and I think they are regarded as "throw away" devices. I have found their electronics to be extremely reliable which is just as well, as I have to "fly blind" and fortunately have had very little trouble with the actual boards.

Bob Rayner,
Willow Vale, NSW.

Comments about Tempmaster Mk2

I have a couple of comments about the Tempmaster Mk2 thermostat project in the February 2009 issue of SILICON CHIP. This is a fantastic project but I want to improve its reliability.

Firstly, the use of a 3.5mm socket and plug for the sensor is definitely a bad idea. I have used these and the 6.5mm version in the past and they are fine for projects where a permanent connection is not wanted, a good connection is not critical and where the plug is removed and refitted often.

Because of bad design though, the earth connection which is the case of the plug (normally) and the mount of the socket (normally) is not a spring connection so they rely on pressure from the tip connection to also put pressure on the barrel of the plug (still a poor connection but if the plug and socket are kept clean, it works – just). However, in the case of the stereo version there is a springy connection on one side for the tip and another on the other side for the ring, thus there is no pressure on the barrel or earth connection.

For their intended use with headphones which are inserted and removed often, this poor connection matters little. I'm sure most people who use headphones know of the poor connection whenever the plug is wriggled. All varieties of the stereo version have the same defect, weather it's 2.5mm, 3.5mm or 6.25mm, but there are versions that do have a springy earth connection.

In the Tempmaster the problem is twofold. First, the signal is low-level DC instead of higher level AC so

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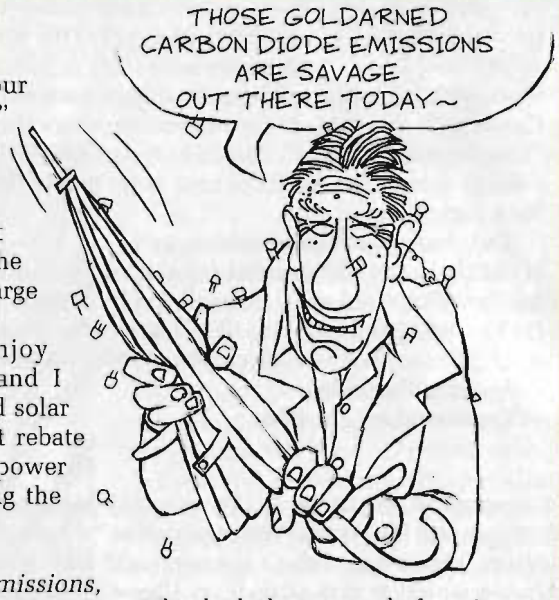
Proof-reading is a problem

Just had to mention your "carbon diode emissions" at the end of the second last paragraph of your Publisher's Letter. That's right . . . diode! I'm not surprised they would be the equivalent of two very large coal-fired power stations!

Anyway I always enjoy reading your magazine and I think if we all get grid-fed solar systems with government rebate you won't need any more power stations due to it covering the peak power load.

(B. J., via email).

Comment: carbon diode emissions, eh? That just shows that we read what we want to read. Four people checked that page before it was printed.



the connection is much more critical as AC can still work through a dirty connection via capacitance. The DC signal would also promote electrolysis, making things even worse. Second, once connected, it would rarely be unplugged and thus the self-cleaning action of plugging in and out would not occur.

The solution is to use the ring connection for the earth, as this too is a springy connector. If I was constructing it though, I would solder the sensor permanently to the circuit board. Then there would never be a problem as this project would most likely be built, plugged in and then hidden away, never to be seen again (as long as it behaves itself).

My second comment applies to using the Tempmaster with an inverter. You mentioned Dr Tom Chalko's comment about poor efficiency of the older version because of a high quiescent current. I would have thought any quiescent current would be undesirable, no matter how small, as the inverter would have to run continuously to just feed the device in standby.

If a purely mechanical thermistor were used then the quiescent current would be zero, allowing the inverter to shut down into standby mode and draw little power. However, mechanical thermistors are highly inaccurate and so are not a good solution.

It just doesn't make sense to step a low DC voltage up to 230V AC then back to a low DC voltage (just think of all the inefficiencies involved). If the inverter system is 12V, then a simple solution would be to run the electronics directly from the 12V battery, allowing the inverter to shut down between cooling cycles.

Philip Chugg,
Launceston, Tas.

Comment: we take your point about possible unreliability of the 3.5mm jack connection. Possibly a better solution would be to connect the sensor via a 2-way screw terminal block.

As far as the quiescent current is concerned, our suggested arrangements for connection shown on page 33 of the article should solve that problem. Your suggestion to run the Tempmaster from the main 12V battery is shown in (B) on page 33.

Compact fluorescent lamps don't save much power

Regarding the Publisher's Letter in the February 2009 issue, I agree with

Alternative theory of cylinder deactivation

I have an alternative theory about the principle of switching off cylinders in petrol engines, as described in the January 2009 Honda article. You mentioned, in answer to a reader's letter, that it is about reducing the pumping losses of the engine. I don't believe this to be entirely accurate. I thought that the theory behind this is that economy is improved because the remaining active cylinders are working with higher compression.

I read somewhere (and I thought it was in SILICON CHIP actually a long time ago but I wasn't able to find it) that the thermal efficiency of an internal combustion engine is directly proportional to compression. That is, when combustion happens under compression, more of the energy converted is mechanical. Therefore when a petrol engine is under light load/low throttle conditions, it is working with low compression and thus lower thermal efficiency.

Hypothetically, if two identical petrol cars, with the exception of engine sizes, with one a 2-litre engine and the other a 5-litre engine, were both travelling at 80km/h), the 2-litre car would use less fuel. The reason is that the 5-litre vehicle is working with proportionately less throttle and therefore has less fuel/air charge in the combustion chambers and so is operating with less compression than the 2-litre vehicle.

The concept of switching off cylinders would be to effectively reduce the size of the engine, meaning that the throttle has to be opened wider, thus keeping the compression higher.

This would not apply to diesel engines where the air intake is always non-restricted. The throttle on a diesel varies the amount of fuel delivery only and these engines always operate at maximum compression.

Diesels have a 2-fold advantage in terms of efficiency:
(1) They have much higher compression than petrol engines, resulting in greater thermal efficiency and;
(2) More importantly, this high compression is maintained under light load/low throttle conditions.

Pumping loss in petrol engines in terms of pure physics is a very real loss but then consider this: when the engine is producing a high vacuum under low throttle and there is more energy lost during each intake stroke, you would think that the compression stroke immediately following would be easier and may even be assisted by this vacuum just after "BDC", which would somewhat compensate for this loss.

I did a little experiment once while driving and that was to switch the engine off while in gear (in a manual transmission car) and let the momentum of the car turn the engine over. I compared the braking effect of the engine with my foot on and off the accelerator. There was no perceivable difference.

If pumping losses were significant, this would surely result in the engine being harder to turn over with minimum accelerator and therefore have a more noticeable braking effect. So I think that in practice, pumping loss is probably quite low and in fact may be entirely non-existent due to the energies required for the intake and compression strokes balancing and cancelling out.

So the primary reasoning behind the cylinder deactivation technology, I think, is more about maintaining higher compression.

Grant Saxton,
Cambridge, NZ.

Comment: your ideas about more air/fuel mixture being available to the effectively smaller engine are correct. However, it still comes back to pumping losses and perhaps we should have explained that point in more detail.

In effect, any engine sucking air through a partially open throttle is a very inefficient pump and if the throttle opening can be increased or the amount of mixture is distributed over fewer cylinders, the effect is a reduction in pumping losses.

you 100%. Nobody in government understands much about science or electricity. Sure CFLs light use less energy than incandescents but has anyone looked at the facts. CFLs cannot be dimmed, cannot be used with automatic switching devices and give off an awful colour in some cases.

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Mailbag: continued

Global warming and SMDs

I think you have a superb magazine. I keep them all and find much enjoyment in reading them again, even years afterwards.

I have two points of concern though. First, you take the view in your Publisher's Letter (February 2009) that governments should "wait and see" as far as climate change is concerned. You don't seem to take global warming seriously. I enjoy the editorials, so I'll be glad if you can reassure me you are not as irresponsible about this as it appears.

Second, I am disappointed that an SMD chip is used in a design when a similar DIP package is available. I do understand the argument that was put forward in your SMD article (March 2008) that some ICs are available only in SMD packages but I think a little effort can be made to use normal DIPs when possible.

SMDs are not made for the average hobbyist and soldering them is tricky, by your own admission. In the design for a 1W Luxeon LED supply (January 2004), an SMD IC is used where a DIP package could have been used, such as used by the same author in the Starpower LED Driver (May 2004).

I am aware that the two ICs are not the same, eg, the MAX1676 can operate at lower voltages, etc. However I am sure that a switchmode LED driver can be designed around the MC34063, for example, without compromising too much. It might need a few extra components and require a few more battery cells for a higher voltage but at least the majority of hobbyists, whom I'm sure prefer not to solder SMDs, would then be up to the job.

Unlike us, the electronic shops which sell components and kits are quite capable of investing in an SMD soldering machine. If there is no option but to use SMD components in a design, they can sell the PC board with the SMD chip already in place. We will do the rest. I am willing to pay more to avoid the SMD hassles.

Frederik Wentzel,
Mindarie, WA.

Comment: as far as man-made climate change is concerned, we are yet to be convinced. We simply do not know enough about climate in order to make any long-term predictions. Just recently, a group of scientists announced that they now think that the Indian Ocean might play a bigger part in determining Australia's climate than the El Nino and La Nina effects in the Pacific Ocean.

Nor is the risk of bleaching of the Great Barrier Reef solely due to warming – runoff from farms etc seems to be a much bigger factor. The melting of the Antarctic ice shelves is a concern but then again, glaciers have been receding for thousands of years.

In any case, until the major economies decide to do something about climate change, there is little point in Australia strangling its economy with a carbon-trading scheme, particularly as we and the rest of the world head into recession. However, there is much to be done in making the economy more efficient.

Another important point is that incandescents present a pure resistance to the supply, ie, their power factor is unity. CFLs are essentially a small switchmode power supply (SMPS) and present a capacitive load with a power factor of about 0.5. As you know, SMPS introduce harmonics and noise and waveform distortion which the supply authorities struggle to constantly correct. If we replace millions of lamps at PF = 0.5, we add lots of reactive energy to the system which has to be corrected; not by the consumer but by the supply authority.

Another point you made concerned the savings. Some lamps are used so intermittently and any saving made by replacing them with low—power CFLs is negligible. In my opinion, LEDs are the real power saver but are still not fully developed.

We cannot ban incandescents yet; not for long time. What about stage lighting, photography and cars (headlights and driving lights)? I think governments need to get real and get informed.

Sal Sidoti,
Strathfield, NSW.

Comment: some CFLs are dimmable. Secondly, the ban on importing incandescents is already in force and that is why so many retailers now have little stock left.

Digital TV time coding is inconsistent

I wonder can anyone enlighten me as to why and how the ABC on both ABC1 and ABC2 encode the time in their broadcast signal. I have two hard disk recorders, one a Tevion, the other a Medion. The Medion gets the time correct, the Tevion and our Panasonic HDTV set show the time on both ABC channels as Eastern Standard Time, but all other channels show it as the correct daylight saving time.

There is no option to change it as the embedded time signal over-rides any manual setting. To record a program I have to set the start time one hour earlier and on the Tevion at least it is impossible to record a non-ABC channel program immediately followed by an ABC one as they both appear to have the same time. It doesn't worry me too much but I am curious.

Rod Cripps,
Parkdale, Vic.

Comment: we have also noticed that the time encoding of many digital programs is inconsistent on the EPG panels.

DIY wiring horror story

I read with interest the debate concerning DIY electrical wiring and thought this might interest other readers.

Over 20 years ago my in-laws moved house to Yeronga in Brisbane. Their new home was a 1960s brick and timber 2-story house. On settlement, my mother-in-law decided to give the house a good clean before any furniture was moved in. I received a call about 10AM from my mother-in-law asking if I could fix the vacuum cleaner, as it was not working very well.

On arrival the vacuum cleaner was turned on but it was running very slowly. My first thought was the motor had worn brushes. So I picked it up and took it to the kitchen bench and plugged it in to have a better look at it. To my surprise it ran perfectly. So I took it back to the power point it was plugged into and it ran slow. I got my multimeter out to check the power point and accidentally set it to DC and was surprised to see 48V DC. I flipped the meter over to AC and got nothing. My test lamps did not light but I got a bit of a spark when I disconnected them, which was odd.

So I undid the power point from the wall and found telephone wires on the Active and Neutral. I then decided to check all the power points in the house and discovered that a number of telephones in the bedrooms were plugged into power points using 3-pin plugs! On inspection these power points were connected to telephone wires as well. I cut the 3-pin plugs off the telephones, as this could have been really dangerous if plugged into a power point wired for 240VAC.

Now as the saying goes "but there is more". The house-cleaning contractor had arrived and he was washing under the upper eaves and broke one of those 1960s circular dome ceiling lights. The only way I could get to this light was from inside the roof space. Fixing the light was easy but what I found could have electrocuted anyone in the roof space. These lights were home handyman-wired as well and used the four terminals of the bayonet fitting from the insides of batten holders as wire connectors.

Worse still, Elastoplast had been used to tape them up and it was now wet from the ingress of the water used on the external house cleaning. A subsequent check of the wiring in the ceiling meant that I spent the remaining of the day in the roof sorting it all out.

As an electrician, I do have some sympathy regarding non-electricians doing some things provided that the correct methodology and testing is used. What bothers me is that the former owner of this house was a civil engineer and should have known better. I think this is the stumbling block where people can't make the judgement to leave some things to the

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Includes 5 quantities of each Value.
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Includes 20 quantities each value
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Mailbag: continued

Solar panel will not top up car battery



The accompanying photo shows a solar powered battery charger commonly sold at various hardware outlets and alternative lifestyle fairs. Note that the connector is a cigarette lighter plug and yet these devices are advertised as able to keep your battery topped up while parked.

Many cars (perhaps most or all) do not allow a connection between the battery and the cigarette lighter while the engine is not running or the accessory switch on, so I imagine that many non-technically minded folk are plugging these devices into the lighter socket and believing that it is trickle-charging their battery.

The instructions make no mention of any required modifications to the car's wiring to achieve this goal. The panels themselves seem to be quite reasonable value and effectively charge battery power tools, etc.

Graham Lill,
Hobart, Tas.

Comment: you are correct. As far as we can determine, in most cars the cigarette lighter and accessory sockets are switched off and therefore disconnected from the battery when the keys are removed from the ignition. The only way that these solar panels can charge the battery is via an additional cigarette-lighter socket connected to a circuit which is permanently energised, such as for the cabin lights or the horn, preferably via a suitable fuse, say 1A.

The concept is good but unless you make the changes noted, it won't work. The solar panel in your photograph appears similar to one sold by Jaycar (Cat. MB-3501) however they point out that it requires a separate socket or clip leads.

professional, not because they can't afford to pay for a qualified person but because they won't pay. I need to also point out that I have worked with many engineers who would make very good electricians and who also know when to get help.

Neil Bruce,
Tarragindi, Qld.

Comment: we are surprised that the DC voltage on the phone lines was able to run a vacuum cleaner at any speed. Telephone lines have an impedance of 600Ω so if indeed, the motor was running, something else was happening to provide the necessary power.

We still think that if the right information about DIY electrical wiring was made available by the authorities, as it is in New Zealand, such instances of dangerous wiring would be greatly diminished. Instead, in Australia, the authorities give out no information and wave a big stick.

Feedback on Programmable Time Delay Flash Trigger

I was most excited by your Photo Flash Delay Trigger project in the February 2009 issue. But there is one input to it I would like to see and that is a beam breaker circuit.

One thing many professional film cameras (such as my 1988 Nikon F4) had, and which no digital camera (I can find anyway) has today, was "Trap Focus". That is where the photographer would focus his camera in a given spot and the subject would automatically take their own picture when they hit the focus zone.

This was most commonly done in

sports and wildlife photography, car racing, etc. Alas, these old features are now missing. Articles abound in old photography magazines of simple electronic beam "trap focus" triggers for cameras or flashes but none have the excellent sophistication and timing delays of your sound flash trigger.

Your project is great for photographing breaking and exploding things, etc but how would it handle, say, an owl just about to alight on a nest? There are times when silence may be golden but also essential. Also there is often no time to spend adjusting the sound sensitivity levels in many situations, where you may only get one shot.

Imagine dropping a dart on a balloon and trying to get the point just piercing the surface. This would not work with the sound trigger, as the bang would come ever so slightly after so you could spend ages adjusting the sensitivity.

So please, please, can you add a beam-breaking trigger to this project?

Sandy Barrie,
Honorary Life Member,
Australian Institute of Professional Photographers.

Comment: as it happens we have the exact project coming very soon. It can be used on its own or in conjunction with the Programmable Time Delay Flash Trigger.



DAB on the wane in the UK

I was delighted to learn from your editorial in the February issue that New Zealand has rescinded their ban on incandescent lamps. I think the Australian Government is out of touch with reality with their ban on the sale of incandescent lamps. In my house, we might have three lights on in the occupied areas with other lights such as toilet, hallway and stairs turned on for the few minutes they are required. Compact fluorescent lamps take too long to get going to be of any use in these applications.

Similarly, the exterior lights which are controlled by PIRs are also incandescent as they too are only on for 10 minutes at a time. Thus, my typical lighting load might be at the most 300W and more typically two 60W lamps and one 40W fluorescent, ie, about 160W.

Compare this to the fan heaters we use in winter which draw 2200W and it is pretty obvious that going to compact fluorescent lighting may not actually save much energy – particularly if you have to wait several minutes for the CFLs to warm up and give usable light. I also understand that CFLs do not like being turned on and off quickly – this is exactly how many of the lights in my house are used.

I enjoyed the article on Digital Radio but would like to make the following points. In the UK, the DAB system is seen to be on the way out, with networks closing down and licences being allowed to lapse. There is also the sting that the networks which are still going are moving to DAB+ which uses a different method of audio encoding, so all the older DAB radios will be rendered obsolete.

One comment I read was that this was a really good way to upset the so-called "early adopters" who bought the early expensive DAB receivers. Also DRM seems to be going nowhere. I have only heard of three DRM receivers (apart from the software ones, such as Dream, which run on a PC using a sound card) and they are not widely available as well as still having some software issues. They are also quite power hungry. Now there is talk of moving to DRM+. DRM also causes interference to analog stations. Until there are cheap power-efficient digital receivers which are close in cost to the current AM shortwave radios, I can't see DRM getting anywhere.

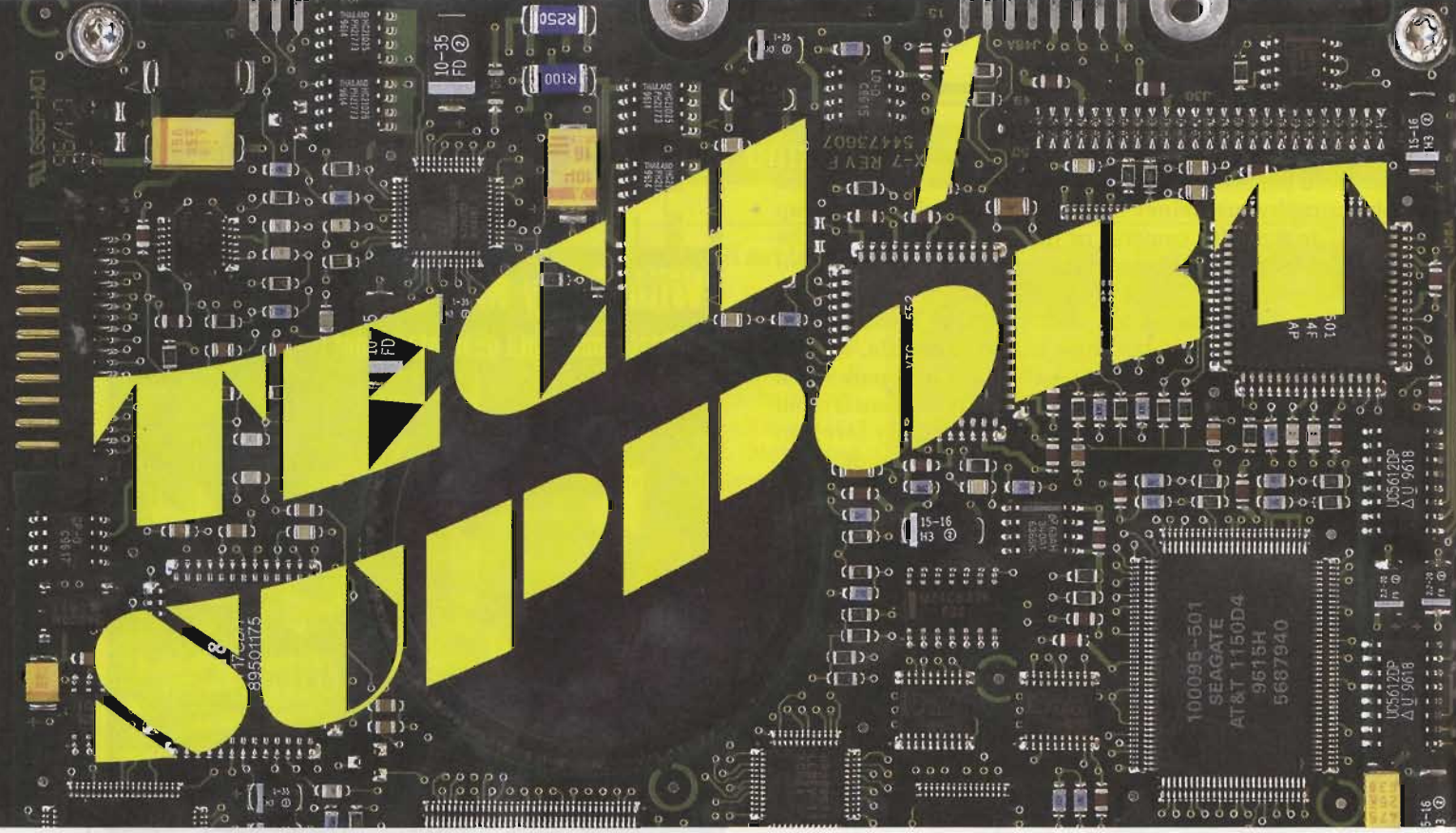
I thoroughly enjoyed the article on 2.4GHz DSS radio control systems. It has been quite a while since I last read about radio control in an electronics magazine.

Finally, I have a question regarding the "Improved Universal Motor Speed Controller (Mk2)" featured in the February 2009 issue. Why can't you feed this circuit via a bridge rectifier? That way you can switch the pulses at 100Hz and it would still be pulsating DC.

As a result, you would get almost the full range of power to the motor, yet you can still measure the motor back-EMF in the time before the Triac triggers. Doing this would eliminate the need for the "full speed" switch. You could also eliminate diode D1 in this case. So what am I missing?

David Williams,
Hornsby, NSW.

Comment: if you had a full-wave rectifier, the SCR would never turn off and control would be lost. To get full range speed control, you need a more complicated design, as is featured in the speed control project starting on page 36 in this month's issue. SC



I speak of the Tech Support people, those unsung heroes of the technical turmoil that surrounds all of us in this challenging world of the 21st century.

I make no claim to the following Terror Tech Tales being original – many of them have been "doing the rounds" for years. But they can all handle re-telling!

Terror Tech Tales

Often the early days are the worst.

Customer: "Do I need a computer to use your software?"

TS: "Aagh!"

Followed by:

TS: "I need you to right-click on the Open Desktop."

Customer: "OK."

TS: "Did you get a pop-up menu?"

Customer: "No."

TS: "Ok. Right click again. Do you see a pop-up menu?"

Customer "No."

TS: "Ok, sir. Can you tell me what you have done up until this point?"

Customer: "Sure, you told me to write 'click' and I wrote 'click'."

Should have got a medal!

Software problems can sometimes lead to a greater awareness with the general public. This is an actual conversation that occurred between a customer and a Tech Support operator. (He later got fired for his responses!).

TS: "May I help you?"

Customer: "Yes, I'm having trouble with WordPerfect."

TS: "What sort of trouble?"

Customer: "Well I was just typing, and all of a sudden the words went away"

TS: "Went away?"

Customer: "They disappeared."

TS: " So what does your screen look like now?"

Customer: "It's blank; it won't accept anything when I type."

TS: "Are you still in WordPerfect or did you get out? Can you see the C: prompt of the screen?"

Customer: "What's a sea-prompt?"

TS: "Never mind. Can you move your cursor around the screen?"

Customer: "There isn't any cursor: I told you, it won't accept anything I type."

TS: "Does your monitor have a power indicator?"

Customer: "What's a monitor?"

TS: "It's the thing with the screen on it that looks like a TV. Does it have a little light that tells you when it's on?"

Customer: "I don't know?"

TS: "Well, look on the back of the monitor and find where the power cord goes into it. Can you see that?"

Customer: "Yes, I think so."

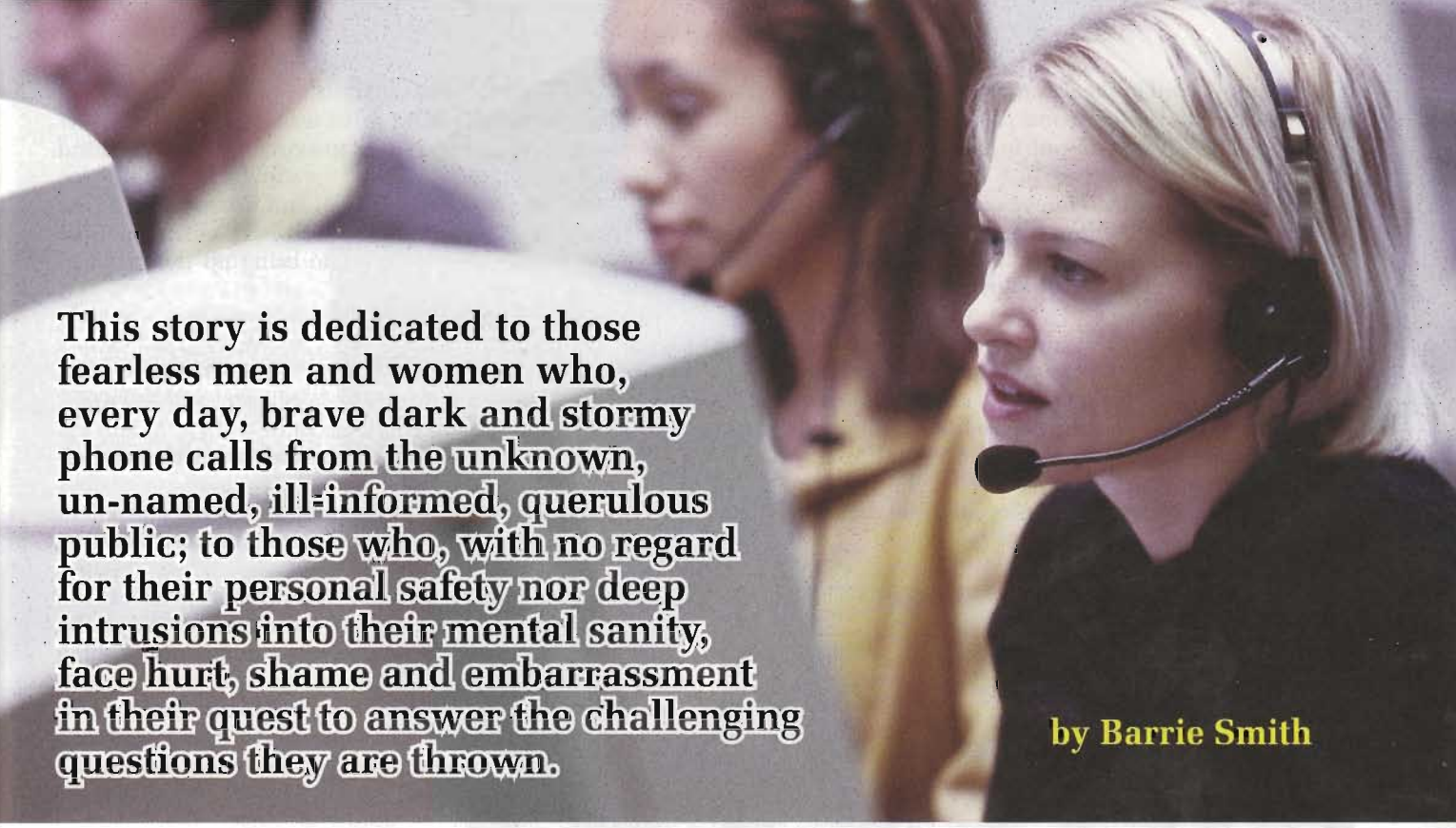
TS: "Great. Follow the cord to the plug, and tell me if it's plugged into the wall."

Customer: "Yes it is."

TS: "When you were behind the monitor, you may have noticed that there were two cables plugged into the back of it, not just one. I need you to look back there again and find the other cable."

Customer: "I can't reach it because I can't see it because it's dark."

TS: "Dark?"



This story is dedicated to those fearless men and women who, every day, brave dark and stormy phone calls from the unknown, un-named, ill-informed, querulous public; to those who, with no regard for their personal safety nor deep intrusions into their mental sanity, face hurt, shame and embarrassment in their quest to answer the challenging questions they are thrown.

by Barrie Smith

Customer: "Yes the office light is off, and the only light I have is coming in from the window."

TS: "Well, turn on the office light then."

Customer: "I can't, because there's a power failure,"

TS: "A power... a power failure? OK, we've got it licked now. Do you still have the boxes and manuals and packing stuff your computer came in?"

Customer: "Well, yes I keep them in the closet."

TS: "Good. Go get them, and unplug your system and pack it up just like it was when you got it. Then take it back to the store you bought it from."

Customer: "What do I tell them?"

TS: "Tell them you're too $@#^%&! stupid to own a computer"

D-u-m-b stupid!

Some companies face angry (read 'dumb') customers more than others. Compaq Computers had a bad time a while ago. Here are some incidents.

At one time Compaq considered changing the command "Press Any Key" to "Press Return Key" because of the flood of calls asking where the "Any" key is.

One Compaq technician received a call from a man complaining that the system wouldn't read word processing files from his 5¼-inch diskettes. After trouble-shooting for magnets and heat failed to diagnose the problem, it was found that the customer labelled the diskettes then rolled them into the typewriter to type the labels.

Another customer called Compaq Tech Support to say her brand-new computer wouldn't work. She said she unpacked the unit, plugged it in, and sat there for 20 minutes waiting for something to happen. When asked what happened when she pressed the power switch, she asked "What power switch?"

And Dell Computer had a bad run some time back.

Back in the days when floppy disks were floppy and drives had a "door" to close, the technician advised a customer to put his troubled floppy back in the drive and close the door. The customer asked the tech to hold on, and was heard putting the phone down, getting up and crossing the room to close the door to his room.

Another customer called to say he couldn't get his computer to fax anything. After 40 minutes of trouble-shooting, the technician discovered the man was trying to fax a piece of paper by holding it in front of the monitor screen and hitting the "Send" key.

Yet another customer called to complain that his keyboard no longer worked. He had cleaned it by filling up his bathtub with soap and water and soaking the keyboard for a day, then removing all the keys and washing them individually.

One technician received a call from a customer who was enraged because his computer had told him he was "bad and an invalid". The tech explained that the computer's "bad command" and "invalid" responses shouldn't be taken personally.

An exasperated caller to Tech Support couldn't get her new computer to turn on. After ensuring the computer was plugged in, the technician asked her what happened when she pushed the power button. Her response, "I pushed and pushed on this foot pedal and nothing happens." The 'foot pedal' turned out to be the computer's mouse.

Then IBM had a bad trot. . .

One customer had trouble installing software and rang for support.

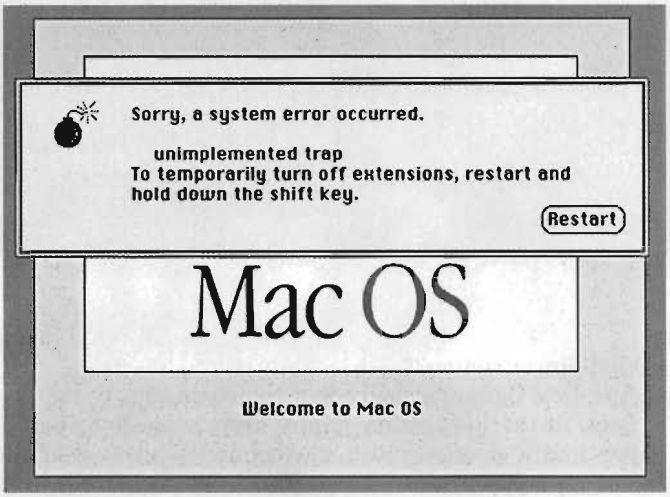
Customer: "I put in the first disk and that was OK. It said to put in the second disk and I had some problems with the disk. When it said to put in the third disk I couldn't even fit it in ..."

TS: "When you see the screen command say 'Insert Disk 2', you have to remove Disk 1 first.

Don't let a Mac user ever tell you they never need to contact Tech Support. Here's one anecdote from the Apple orchard.

TS: "At 3:37 a.m. on a Sunday, I had just looked at the clock to determine my annoyance level, when I received a frantic phone call from a new user of a Macintosh Plus.

"She had taken her entire family out of the house and was calling from her neighbour's. She had just received her first system error and interpreted the picture of the bomb on the screen as a warning that the computer was going to blow up!"



Apple Tech Support sometimes faces the unfaceable.

TS: "What operating system are you running?"

Student: "Huh?"

TS: "Do you have a Mac or a PC?"

Student: "Um, I don't know."

TS: "Ok. What does the screen look like?"

Student: "It's yellow."

Me: "Ok. What does it say on the computer CPU?"

Student: "What's that?"

TS: "The big grey box."

Student: "It doesn't say anything."

TS: "Never mind that ... do you have a little 'Start' button at the bottom of the monitor?"

Student: "Monitor?"

TS: "The thing that looks like a TV screen sitting on the grey box."

Student: "Oh! That! No. No start button."

TS: "Ok. Is there a little apple symbol anywhere on the screen?"

Student: (very puzzled) "Why would I have fruit on my computer?"

Today's computers are easily capable of multi-tasking but sometimes the public expects too much.

A senior telecommunications administrator at one company recalls a request from a user looking for another coffee holder for his computer: "I asked him what he meant by another coffee holder and he said, 'You know, the one that pops out of the PC."

He thought the CD-ROM drive was a cup holder.

Sometimes the support goes to extremes — in the mind of the caller.

TS: "OK, let's press the Control and Escape keys at the same time. That brings up a task list in the middle of the screen. Now type the letter 'P' to bring up the Program Manager."

Customer: "I don't have a 'P'."

TS: "On your keyboard."

Customer: "What do you mean?"

TS: "'P' on your keyboard."

Customer: "I'm not going to do that!"

Computer companies aren't the only ones to face perplexing calls either.

A woman called the Canon help desk with a problem with her printer. The tech asked her if she was "running it under Windows."

The woman then responded, "No, my desk is next to the door. But you have the answer — the man sitting in the cubicle next to me is under a window, and his is working fine."

Even simple problems can perplex customers.

Customer: "I have a huge problem. A friend has placed a screen saver on my computer, but every time I move the mouse, it disappears."

And:

TS: "Click on the 'my computer' icon on the left of the screen."

Customer: "Your left or my left?"

Sometimes the customer wants the process to be real simple.

Customer: "One of my friends gave me an ImageWriter printer and a keyboard. He said he gave me all the cables, but I can't figure out how to connect them. Am I missing something?"

TS: "Well, a computer would help."

Customer: "You mean this keyboard isn't a word processor?"

TS: "No ma'am, its just an input device."

Customer: "Then I need to buy a computer, right?"

TS: "Yes."

Customer: "Do you think I'll need a monitor, too?"

Some people want to make simple tasks, like making backups, even simpler.

A system administrator for a company remembers when files were small, hard drives were small and backups were made with PC Tools which could be done using less than ten 3.5-inch disks for all the most important directories.

One day the CEO of a company was asked by the administrator if he had done his monthly backup of his computer data. He said he had, and had even been able to improve the backup process. He'd discovered he didn't have to change disks if he just answered 'Yes' to all the "Is it ok to overwrite this floppy disk?" prompts. He was overwriting backup disk #1 with the data for backup disk #2, then overwriting that with the data for backup disk #3, and so on. Boy, it sure saved on floppies.

And then there are people who go looking for trouble.

This sounds ridiculous, but it actually happened to a Tech Suport person in a chain computer store.

Customer: "Hi, I'd like to buy a virus."

TS: "You really don't want a virus on your computer.

What you need is anti-virus software."

Customer: "No, my son told me I need a virus, and that's what I'd like."

TS: "No worries. You don't need to buy a virus – you can just connect to the internet and download one."

It's not just computers that give problems. Peripherals are in there too.

A customer called in with modem problems.

TS: "Ok, we're going to check your modem settings. First thing we need to do is make sure all programs are closed."

Customer: "How do I know if everything is closed?"

Me: "Make sure all windows are closed."

Customer: "But I'm in the basement. I don't have any windows here."



Sometimes there are quick fixes.

One operator had a call from a customer who was complaining that when she typed, the wrong letters came up on the screen. After some investigation, it was revealed that she had pried off all the letter key caps off her keyboard and rearranged them in alphabetical order.

Keyboards can be a forest of trouble.

TS: "Now press the spacebar."

Customer: "Return bar?"

TS: "No, space bar. Space."

Customer: "I have an Enter bar, Return bar, and a Shift key?"

TS: "No, space. Space bar. The long horizontal key."

Customer: (confused sounds).

TS: "OK. See your c, v, b, n, and m keys?"

Customer: "Yes..."

TS: "Right under them."

Customer: "Oh."

Then some people have trouble with the most basic things in computing.

TS: "Ok, Bob, type a capital 'B', then press enter."

Customer: "A capital B?"

TS: "Right, capital 'B' as in Bob."

Customer: "Capital 'B' as in Bob?"

TS: "Exactly. Capital B as in Bob!"

Customer: (long pause) "That's the one with two loops, right?"

TS: "Now let's type in the password where it says password."

Passwords can be a puzzle.

Customer: "My password is HSD13...."

TS: "No, don't tell me your password, just type it in. And remember, those letters are in capitals."

Customer: "And the numbers, would those be capitals too?"

We all know the dos and don'ts of computing. One of these is never to eat or drink near a PC.

This plaintive call for help was mailed to a Tech Support desk:

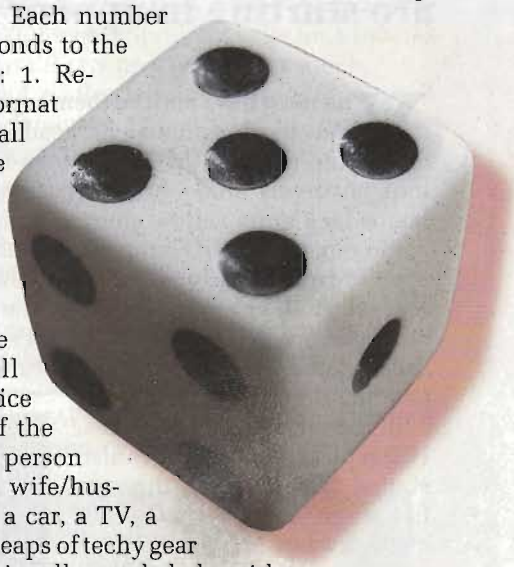
I spillced coffcee cincto my kcey boardc.c As a rcesulct, c's gcet inctermixcced with cwactever I ctypce. Plcease replace mcy kceyboard. ccthanks.

Help for the Help Line

The question I ask is: how do the tech support people cope?

When asking tech support specialists on how they got through the average day of dumb questions, the results were interesting. In order to remain sane, they often resorted to surprisingly unorthodox ways of dealing with the constant barrage of obnoxious users and technical foul-ups. Here's one.

"When taking technical support calls, always be sure to have a dice with you. This will become your single most valuable tool in diagnosing customer support issues, regardless of the technology or problem. Simply listen to the customer describe the issue, roll the dice, and Bang! — problem solved. Each number on the dice corresponds to the appropriate advice: 1. Reboot computer. 2. Format hard drive. 3. Reinstall software. 4. Cycle power. 5. Update required. 6. Return for repair."



Next time

Rememember, the next time you call Tech Support the voice on the other end of the line may be a real person just like you with a wife/husband, family, dogs, a car, a TV, a digital camera and heaps of techy gear that he or she occasionally needs help with to get it running properly.

And these days, occasionally, they might even understand the English language.

NEXT MONTH:

We'll have a look at the more serious side of Tech Support and how the major companies deal with the biggest problem of all – the loose nut on the keyboard. SC

HIDs: out of the car and over your shoulder!

by Ross Tester

It's taken a while but at last, High Intensity Discharge (HID) lamps are starting to appear in places other than just in car headlights.

You must have noticed them as you drive along: alongside a conventional car headlight (ie, filament type and probably of the tungsten-halogen variety) they look positively blue – or is it that even tungsten-halogen lamps look quite yellow alongside them?

More recently, HID lamps have started to filter down to the more mundane type of vehicle, although it's true to say that even today they are not as popular as tungsten-halogen lamps as original equipment. That's almost certainly because of cost, where auto manufacturers look to save every cent possible.

In the auto accessory stores, HID replacement kits have also started to make their presence felt, even if at a premimum over "normal" lamps. Still, the margin between the two is ever-decreasing.

For those who have been driving around with their eyes closed, HID lamps offer several advantages. For a start, they are brighter. At the same time, they require less energy from the car's electrical system. These two facts alone mean they are much more efficient. But they also offer significantly longer life (3000 vs 700-1000 hours) and studies have shown they actually make night driving safer.

For an explanation on how HIDs work, refer to the articles in our February 1999 and/or May 2003 issues

HID Spotlights

We wondered how long it would be before HID lamps started making inroads into "hand-held" spotlights. We say hand-held with a grain of salt (or perhaps a full shaker!). The ones we are talking about are more "luggable" than hand-held – which is why they invariably have a shoulder strap! You know, the type of spotlights you see in your local auto accessory store offering "a million" candlepower – or maybe even *ten million* candlepower. When you're talking those numbers, who is going to argue?

Just think, though, how much light ten million candles would



There's no denying it's a HID! Jaycar were never ones to hide their light under a bushel . . . (ouch!)

produce. A tad more than one of these spotlights? Yeah, we think so too! By the way, 1 lumen roughly equates to 12.57 candlepower, so does one of these "ten million" babies put out more than 795,000 lumens (10,000,000/12.57)? Hmmm . . . maybe not!

However, this type of spotlight *is* very bright and is ideal for, camping, 4WD'ing, nocturnal animal observation/hunting and so on. They are also used by emergency services, police and rescue organisations, etc.

But we digress: a recent SILICON CHIP advert for Jaycar Electronics got our attention when it claimed to be the first spotlight with a HID lamp. This we just had to see.

So as soon as stock actually arrived in the country, Jaycar Electronics sent us one to examine. It arrived with the battery already charged so we were able to use it immediately.

Incidentally, the rechargeable battery gives about 50 minutes of continuous use and it recharges either from a mains plugpack or a car cigarette lighter lead, both of which are supplied. It weighs in at a rather hefty 3.8kg so the comments we made before about luggability certainly apply.

First impressions count – and to say we were impressed is an understatement. Yes, it had a very bright, very blue/white light – just like the automotive versions. In fact, it hurt to look into the beam (but no-one would be silly enough to do that, would they?).

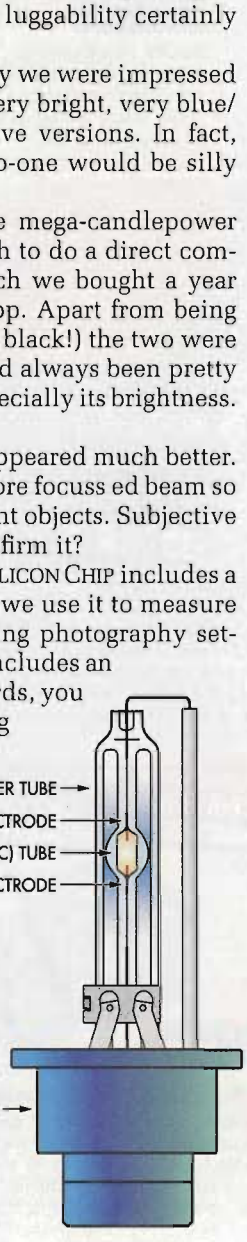
Fortunately, we had one of those mega-candlepower quartz/halogen spotlights with which to do a direct comparison. It's an Arlec RT10000 which we bought a year or so ago from a local auto parts shop. Apart from being bright yellow (the Jaycar one is basic black!) the two were quite similar in size and weight. We'd always been pretty impressed with its performance – especially its brightness. It was great to take camping!

Well, the HID model from Jaycar appeared much better. What's more, it appeared to have a more focuss ed beam so it was even better at lighting up distant objects. Subjective reaction was fine – but could we confirm it?

Part of the photographic setup at SILICON CHIP includes a very accurate Minolta Flash Meter – we use it to measure the output of our studio strobe during photography settings. This meter (fortunately!) also includes an "ambient light" setting – in other words, you can measure the amount of light falling on a subject without flash. And our experience is that it is dead accurate.

Placing the light meter at a set distance from each of the two spotlights, we found that the HID model was exactly one *f*-stop brighter than the quartz halogen model.

For those not into photography, the difference between any two *f*-stops is double or half the amount of light. So instead of a subjective "yes the HID is brighter" we could now confirm it was twice as bright!



A typical HID bulb showing its construction.

Power consumption was also significantly lower with the Jaycar HID, as you would expect. It was rated at 35W, whereas the Arlec has a Philips H4 halogen lamp rated at 100W – virtually three times the current draw from the 12V, 7Ah battery.



Which one would we choose?

Just on light levels alone, we'd choose the HID model over the quartz halogen model any time. Except for one tiny detail: the HID models are also about twice the price. Our Arlec spottie sells at the local Super Cheap Auto store for about $89.00 (every now and then it's on special, save 10%). The Jaycar ST-3369 HID Spotlight sells for $165. So for twice as bright, you'll pay nearly twice as much.

Actual rated output of the Jaycar HID model is 3300 lumens, or 262 candlepower. It just goes to show how ludicrous the claims of those ten million candlepower spotties really are!

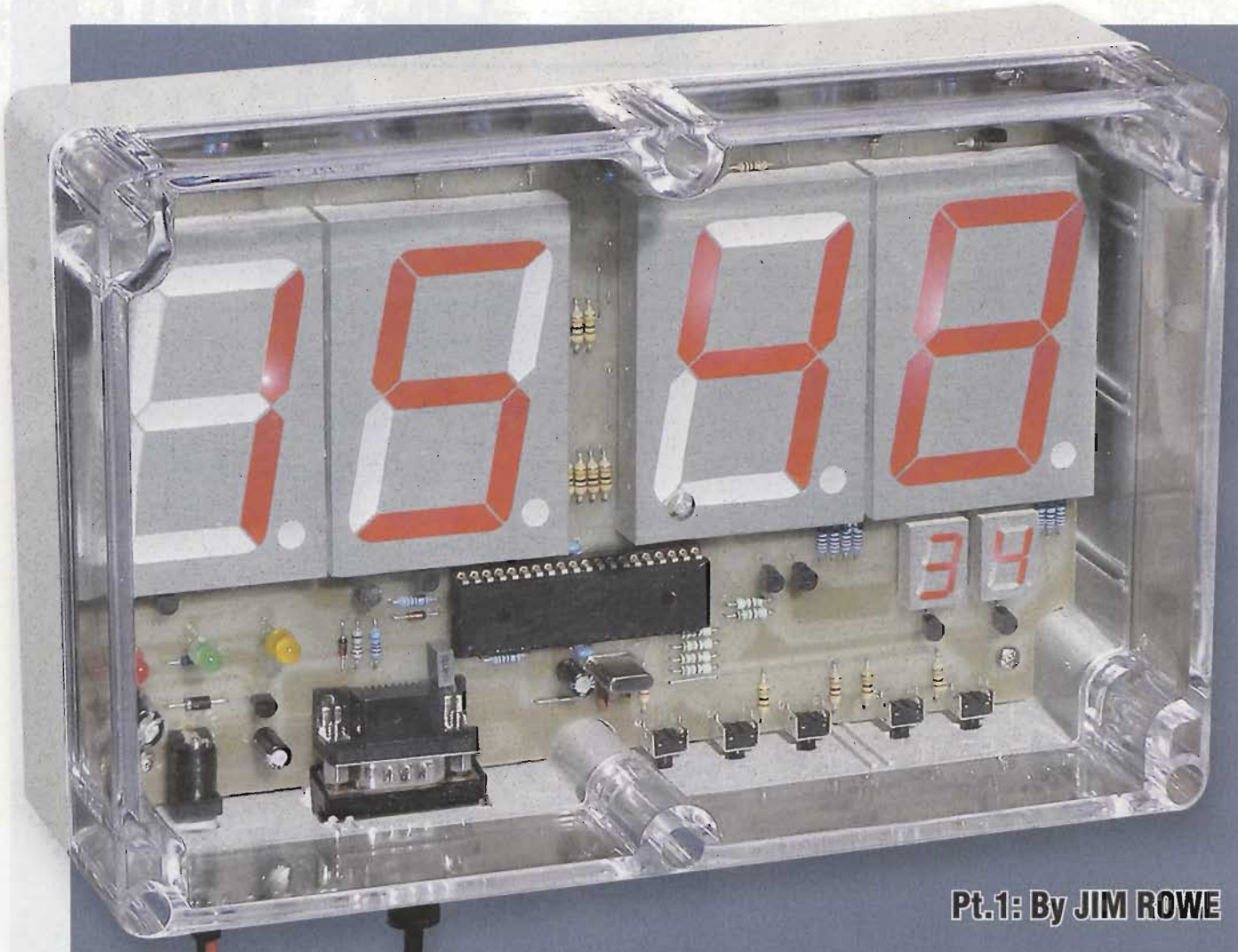
Is it worth the extra?

Obviously, that depends on your application and whether you need the performance. But for our purposes, we would suggest that the HID model gives you so much more that it is well worth paying the premium that it commands.

Jaycar Rechargeable 35W HID spotlight (Cat ST-3369) –$165 at all Jaycar Electronics stores



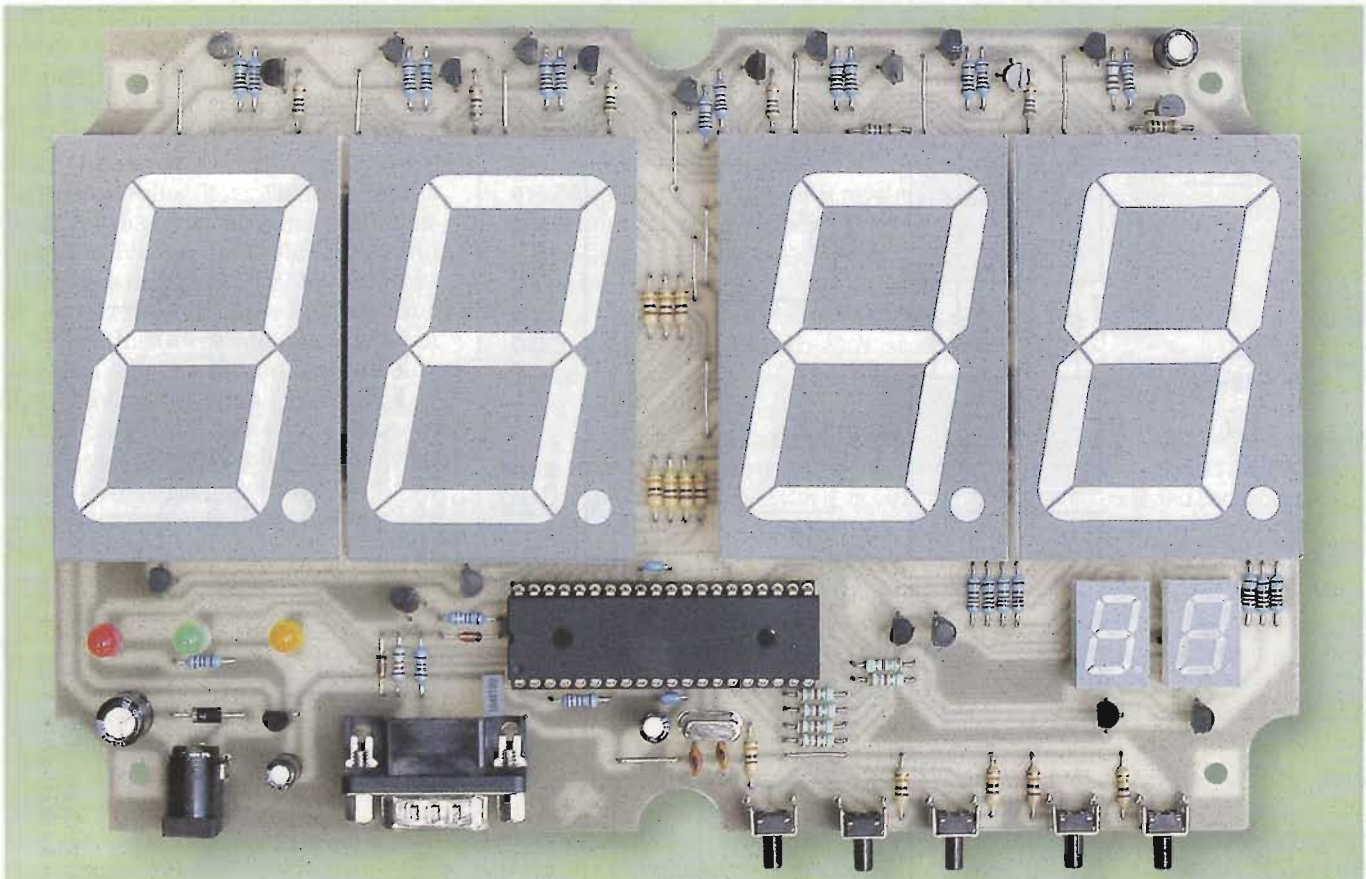
This photo shows the actual HID bulb in the Jaycar ST-3369 HID Spotlight.



Pt.1: By JIM ROWE

Build A 6-Digit GPS clock

Looking for a digital clock that's always dead accurate? This one derives its time signals from the GPS (Global Positioning Satellite) system, so it never needs setting or adjusting. It features big, bright 58mm-high digits for the hours and minutes, plus smaller digits to indicate the seconds.



The main board uses 58mm-high 7-segment displays for the hours and minutes readouts plus smaller 13mm-high digits to indicate the seconds. The GPS time signals are derived either from a small add-on module to be described next month or from the GPS-Based Frequency Reference (see text).

IN THE March 2009 issue, we featured a GPS-controlled analog clock that's proving very popular. Strictly speaking though, this wasn't a GPS clock but a "GPS-corrected" clock.

Basically, an external module carrying a PIC processor and an EM-408 GPS module was used to replace the clock's own crystal oscillator drive. The PIC processor provides the timing signals for the clock and the GPS module is then used to re-synchronise the clock once every 44 hours.

By contrast, this digital clock is permanently locked to the GPS time signals and always displays the correct time. It can display UTC time (Universal Time Co-ordinated), local standard time or local daylight saving time, all at the touch of a button.

The digital clock display described here can derive its GPS time signals from the GPS-Based Frequency Reference described in the March-May 2007 issues of SILICON CHIP. However, you don't have to go to the expense of building the GPS-Based Frequency Reference. Instead, you can use the above-mentioned EM-408 GPS module on a small PC board which can be housed in the same case as the display board to form a self-contained clock. This will be described in Pt.2 next month.

GPS Frequency Reference

The GPS-Based Frequency Reference described in the March-May 2007 issues already displays UTC time on its small LCD readout. In order to get your local time, you have to mentally add (or subtract) the appropriate offset for your particular time zone and also add another hour if your state or region is currently observing daylight saving.

As it turned out, many readers were more interested in the timekeeping aspects of the GPS-Based Frequency Reference, rather than its very accurate frequency outputs. They also wanted a much larger display that could be read at a distance. And they wanted the display to automatically show both local standard time and local daylight saving time.

The GPS-corrected clock in the March 2009 issue only added to the interest, with more readers asking for a GPS Digital Clock. So here it is.

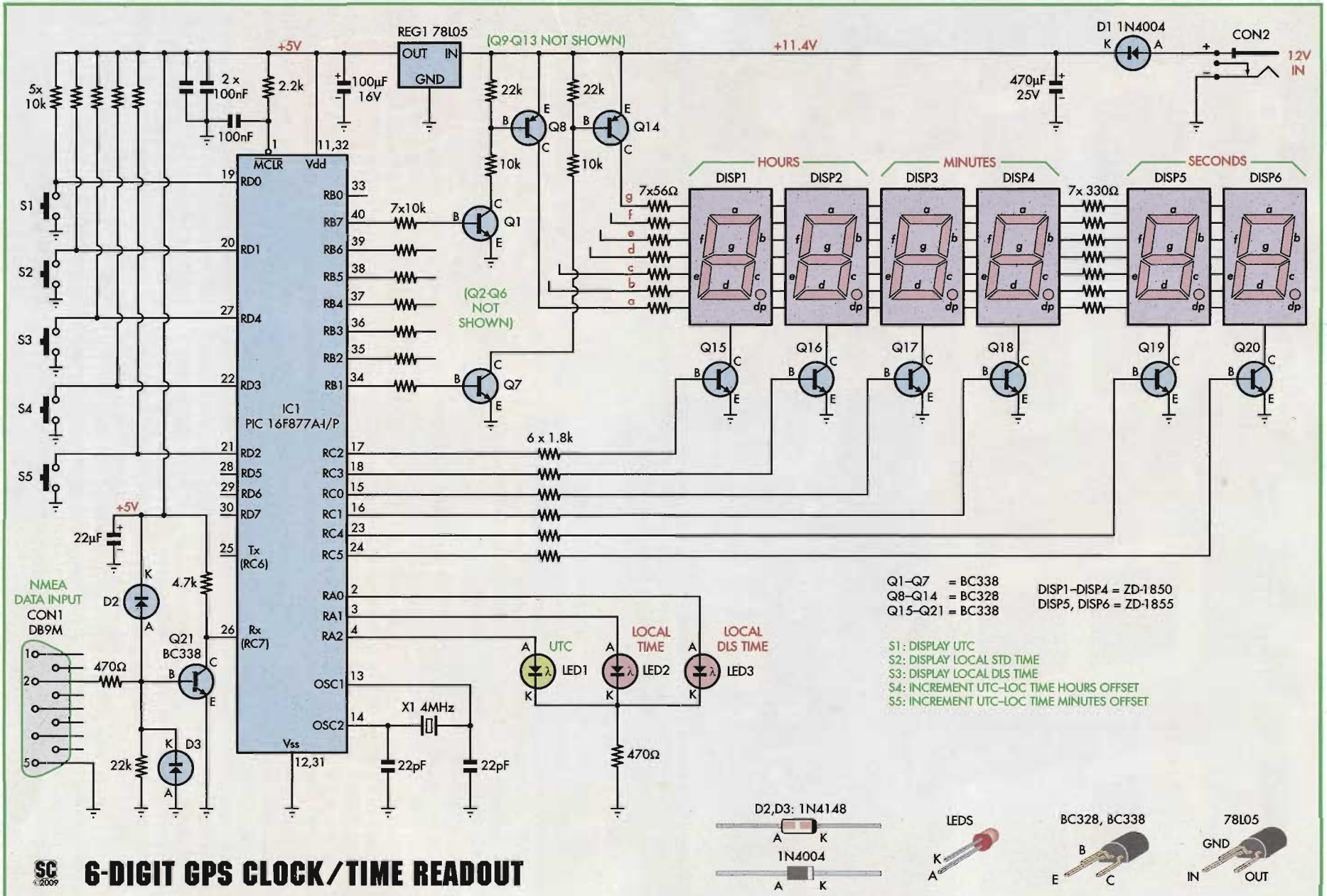
It uses a microcontroller to calculate both standard and daylight saving times and display the result on a bright 6-digit LED display. "Jumbo" 7-segment 58mm-high digits are used for the hours and minutes indication, while 13mm-high digits provide the seconds indication.

In operation, the circuit is designed to accept the "NMEA 0183" data stream output from the external GPS receiver module. The microcontroller then extracts the UTC time information and uses it to work out the local standard and daylight saving times.

You decide whether UTC, local standard time or daylight saving time is displayed simply by pressing one of the three time-select buttons. The two remaining buttons are used only once, to initially set the UTC-local time offset.

How it works

Refer now to Fig.1 for the circuit



6-DIGIT GPS CLOCK/TIME READOUT

Fig.1: the circuit is based on a PIC16F877A microcontroller. This processes the NMEA 0183 serial data from the GPS receiver module (at its pin 26 input) and drives six 7-segment LED displays in multiplex fashion. Switches S1-S3 select the time format, while S4 & S5 are used to initially set the offset from UTC time.

details. It employs the microcontroller (IC1), six 7-segment LED displays, 21 transistors, five pushbutton switches and a handful of other parts.

Virtually all of the work is done by the programmed PIC16F877A-I/P microcontroller (IC1). This accepts the NMEA 0183 serial data stream from the GPS receiver module (via CON1) and processes the data's GPRMC sentences to extract the UTC time information.

From this information it works out the equivalent local standard and daylight saving times and continuously updates all three times in its memory. When you select which time you want to display (using switches S1, S2 or S3), it displays that time continuously on LED displays DISP1-DISP6.

The PIC runs from its own internal clock oscillator which has its frequency set by a 4MHz crystal (X1) connected between pins 13 & 14. The two 22pF capacitors provide the correct loading for the crystal, to ensure reliable starting of the oscillator.

The displays are driven by the microcontroller in multiplex fashion via transistors Q1-Q20. Q1-Q14 are driven by outputs RB1-RB7 and in turn drive the display segments (a-g). Q15-Q20 drive the common display cathodes. These transistors are switched by IC1's RC0-RC5 outputs.

LEDs1-3 indicate which time mode is currently being displayed. These LEDs are directly driven by IC1's RA0-RA1 outputs and have a common 470Ω current-limiting resistor.

In greater detail, the NMEA 0183 serial data stream from the GPS receiver module arrives at pin 2 of DB9M connector CON1. Because it has the same polarity as normal RS-232C data, it's passed through a simple inverter stage based on transistor Q21 and then fed into pin 26 (RC7/Rx) of the microcontroller. This pin is the data input for the micro's USART module.

By the way, if you want to see what the NMEA 0183 data stream from a GPS receiver looks like, a sample is shown in Fig.2. This shows three of the sentences sent out by a typical GPS receiver every second, at 4800bps.

The sentence which begins with the ID "$GPRMC" is the one we are interested in here. It's provided by just about all GPS receivers and contains the UTC time data we want right "up front" (ie, in the first field following the ID code). In the GPRMC sentence shown, the UTC time field is 231034, which indicates that the UTC time at that instant was 23 hours, 10 minutes and 34 seconds. The current date information is also visible near the end of the sentence, ie, "120309", indicating March 12, 2009.

In this project the program running in the PIC extracts this UTC time information from each GPRMC sentence and saves it in memory. It then works out the equivalent local standard time, by adding the time offset for your time zone (this information is initially fed in via switches S4 & S5) and this is also saved. And finally, it works out the corresponding daylight saving time and saves this as well.

Once all three times have been updated, the program in IC1 then checks to see which time standard is currently being displayed. It then displays this time on displays DISP1-DISP6, driving the display segment lines from its RB1-RB7 PORTB via transistors Q1-Q14.

As indicated earlier, the individual 7-segment displays are switched on and off in sequence via transistors Q15-Q20. These are driven by IC1's RC0-RC5 PORTC pins.

As part of its operation, the program also scans switches S1-S5. If a switch has been pressed, it pulls its correspond input (RD0-RD4) low and this is detected by the program. As a result, IC1 either changes the display mode setting (S1-S3 pressed) or changes the stored time offset setting (S4-S5 pressed).

The new settings are then saved in the PIC's EEPROM memory, so they are not lost if the power is removed.

Power supply

Power for the circuit is derived from a 12V DC plugpack supply and this is applied to the circuit via DC connector CON2 and reverse polarity diode D1. The resulting 11.4V (nominal) rail is then filtered using a 470µF electrolytic capacitor and used to power the 7-segment displays DISP1-DISP6.

The PIC microcontroller and inverter stage Q21 operate from a +5V rail. This is derived from the +11.4V

Building A Self-Contained Clock

You don't need to build the GPS-Based Frequency Reference described in the March-May 2007 issues of SILICON CHIP. Instead, you can derive the required NMEA 0183 data from a low-cost GPS receiver module and use that to drive the display readout.

In particular, the GlobalSat EM-408 receiver module is ideal for this application. This GPS module was also used by Geoff Graham in the GPS-Synchronised Analog Clock described in the March 2009 issue and is readily available.



The GlobalSat EM-408 GPS module.

It's quite easy to use the EM-408 GPS module. Accordingly, we have produced a compact add-on board containing this module which connects directly to the display unit. It can either fit inside the same case as the display board (and be wired directly to it) or installed in a separate case and connected via the DB9 connector.

An advantage of the EM-408 GPS module is that it has a self-contained antenna and is extremely sensitive. As a result, it works perfectly well indoors without the need for an external antenna and associated cabling.

The add-on GPS module will be described in Pt.2 in the June 2009 issue of SILICON CHIP.

NMEA 0183 DATA STREAM

```
$GPRMC,231034,A,3356.3399,S,15108.2790,E,000.0,010.0,120309,012.6,E*63
$GPGGA,231034,3356.3399,S,15108.2790,E,1,10,1.0,57.3,M,19.6,M,,*65
$GPGSV,3,3,11,23,45,051,43,25,60,156,45,28,18,320,36*4F
```

Fig.2: three of the sentences sent out each second by a typical GPS receiver. The one starting with "$GPRMC" has the UTC time information.

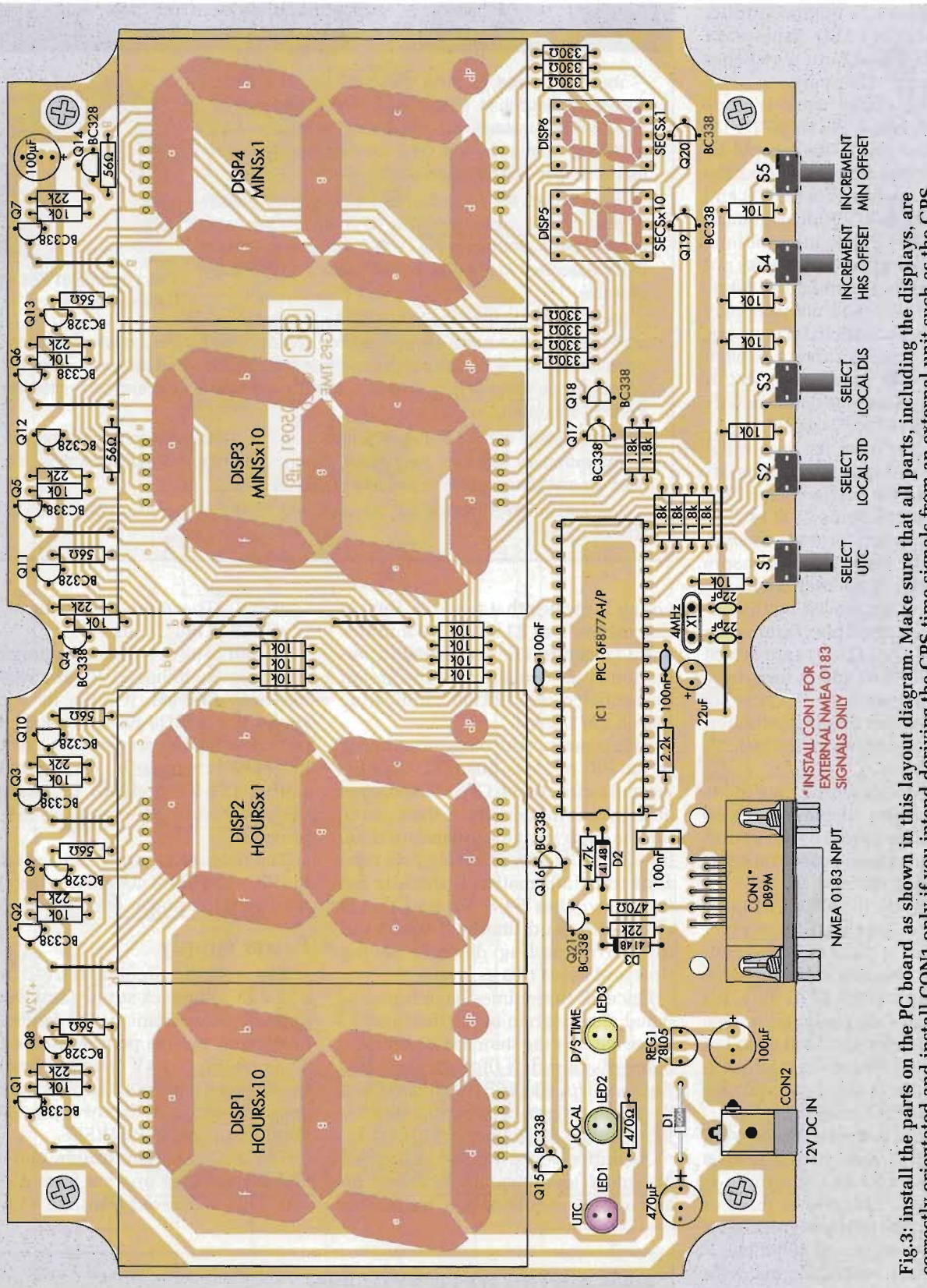


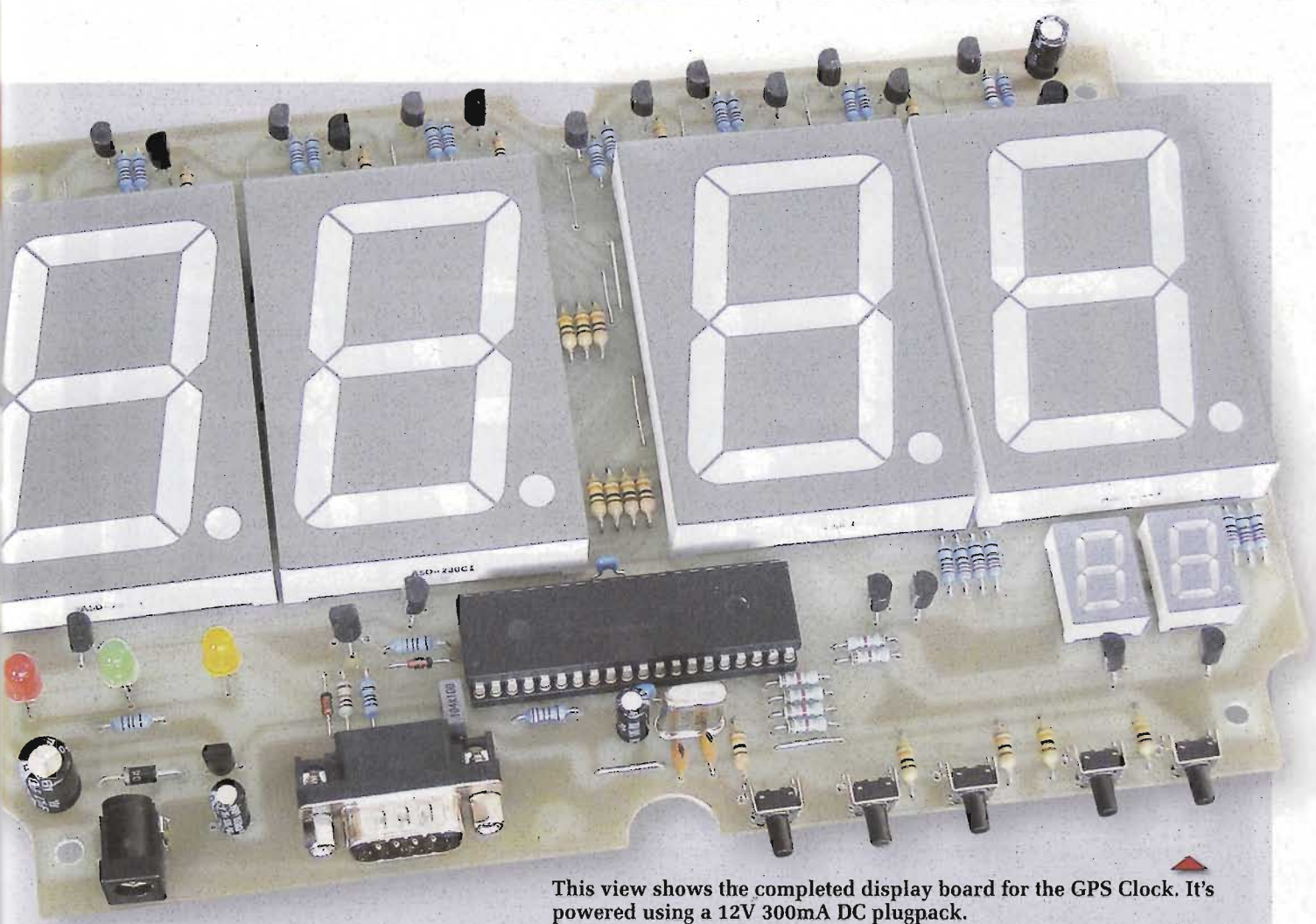
Fig.3: install the parts on the PC board as shown in this layout diagram. Make sure that all parts, including the displays, are correctly orientated and install CON1 only if you intend deriving the GPS time signals from an external unit such as the GPS Frequency Reference.

line via 3-terminal regulator REG1, a low-power 78L05 device. A 100µF capacitor filters the output of the regulator, with additional filtering provided by a 100nF capacitor.

That's all there is to it. Now let's look at the construction.

Construction

As shown in the photos, all the display circuitry is mounted on a single PC board. This fits snugly inside the a standard plastic enclosure with a clear lid. The PC board measures 211 x 135mm and is coded 04105091.



This view shows the completed display board for the GPS Clock. It's powered using a 12V 300mA DC plugpack.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	7	22kΩ	red red orange brown	red red black red brown
❑	19	10kΩ	brown black orange brown	brown black black red brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	6	1.8kΩ	brown grey red brown	brown grey black brown brown
❑	2	470Ω	yellow violet brown brown	yellow violet black black brown
❑	7	330Ω	orange orange brown brown	orange orange black black brown
❑	7	56Ω	green blue black brown	green blue black gold brown

Fig.3 shows the parts layout. Begin by carefully inspecting the PC board for any etching defects. Check also that the four corner mounting holes are drilled to 3mm.

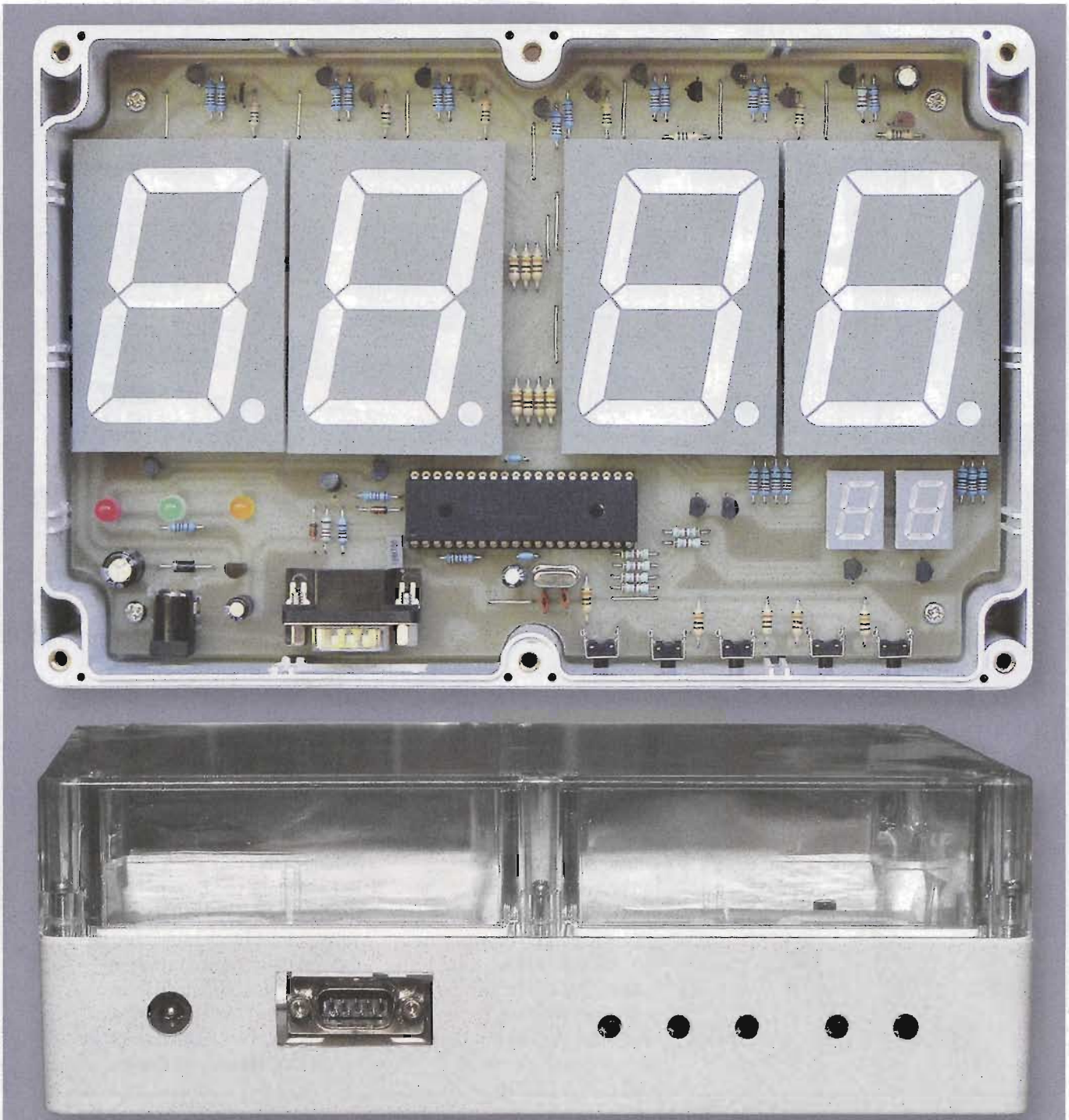
That done, the next step is to fit the 12 wire links and the resistors. Table 1 shows the resistor colour codes but check each one with a digital multimeter before installing it, just to make sure.

Follow these parts with the capacitors – first the non-polarised ceramics and the MKT unit, then the four larger electrolytics. The latter are polarised, so make sure you fit them with the polarity shown on Fig.3. Crystal X1 can then be installed, followed by diodes D1-D3 (watch their polarity!).

CON1, CON2 and the five mini pushbutton switches S1-S5 are next on the list. **However, note that you will only have to install CON1 (the DB9 connector) if you are using an external source for the GPS time signals (eg, the GPS-Based Frequency Reference).** If you build the add-on GPS module to be described next month, it can fit inside the same case as the display board and be wired directly to it.

Next, install the 40-pin socket for IC1. Make sure you fit the socket with its "notched" end to the left, to guide you when you later plug in the micro itself. Regulator REG1 can then be installed, taking care to orientate it exactly as shown.

The 21 transistors are next on the list. Note that these are a mixture of BC338 NPN and BC328 PNP types, so take care here. The BC338's are used for Q1-Q7 and Q15-21, while the



If you intend using an external source of GPS time signals, then the display board can be installed in the bottom of the case as shown in the top photo. Holes are drilled/cut along one side (see photo above) to provide access to the switches, DC power socket and DB9 connector.

BC328's are used for Q8-Q14. If you accidentally swap any of these transistors you'll get some strange results, like missing segments or digits.

After the transistors, fit the four Jumbo displays DISP1-DISP4, followed by the two smaller displays DISP5 & DISP6. These are all polarised and it's important to fit each one with its decimal point LED at lower right. We don't actually use the decimal points in this design but if you don't fit each display correctly, it simply won't work.

Make sure that each display is sitting flush against the PC board before soldering its pins.

The three indicator LEDs (LED1-LED3) are next on the list. These are mounted vertically, with their cathode leads towards the bottom of the board and their bodies about 10mm above the board so that they're clearly visible. Use a red LED for LED1, a green LED for LED2 and an orange/yellow LED for LED3.

Once the LEDs have been fitted,

It's not long ago that a really accurate time display based on a caesium-beam "atomic clock" was something only standards labs could consider. The rest of us had to rely on time signals from shortwave or VLF radio stations, which gave only "reasonable" accuracy.

This all changed when the US military set up its Global Positioning System (GPS). That's because every GPS satellite contains two caesium-beam clocks, which are used to ensure the system's navigational accuracy. These satellites broadcast an updated digital UTC (Universal Time Co-ordinated) time signal every second, which means that you can obtain an extremely accurate time display simply by decoding the time information from a GPS receiver.

This includes the receivers used inside GPS navigator devices. As a result, many such units can either display the time continuously or on demand.

all that remains to finish your GPS time display board is to plug the programmed PIC micro (IC1) into its socket. Take care to plug it in with its notched pin1 end towards the left, as shown on the parts layout diagram. The completed board assembly can then be placed aside while you prepare the enclosure.

Preparing the enclosure

Fig.4 shows the drilling details for the case. **Note, however, that this diagram applies only if you are mounting the unit in the base of the case and feeding in the GPS time signals via CON1 (the DB9 connector) from an external source.** If you elect to build the add-on GPS module (described in Pt.2) and install it in the same case, this will require a slightly different mounting arrangement for the display board (details next month).

As shown in Fig.4, all the holes are along one side of the base. You have to drill five 5mm holes for the switches plus a 10mm hole to provide access to the DC power socket. In addition, a 34 x 16mm cut-out is necessary to access the on-board DB9M connector.

You can either use Fig.4 to mark out the case for drilling or it can be copied and temporarily attached to the side of the case for use as a drilling template. Use a small pilot drill to drill each hole first, then carefully enlarge it by stepping up the drill size. The 10mm hole is best enlarged to size (from about 5mm) using a tapered reamer.

The square cut-out is made by drilling a series of small holes around the inside perimeter, then knocking out the centre piece and carefully filing the job to a neat finish.

The PC board can now be installed in the case. To do this, first position four M3 x 6mm untapped spacers on top of the four corner mounting pillars moulded into the bottom of the enclosure. That done, you then have to slowly lower the board into the case without disturbing these spacers.

Note that you will have to angle the switch side of the board down as its lowered into the case, so that the switch actuators go through their holes. Once it's in position, secure the board in place by fitting an M3 x 10mm machine screw to each corner position. Fig.5 shows the details.

All that remains now is to attach the clear top of the enclosure, using the six screws supplied. There's no real need to fit the supplied rubber sealing strip between the two halves of the enclosure but you can fit it if you wish.

Putting it to work

No adjustments are required – it's just a matter of feeding in the serial data from the GPS module described next month (or from the GPS-Based Frequency Reference) and applying power. You'll need a standard DB9M-DB9F serial cable to make the connection to CON1. In addition, a 12V DC plugpack capable of supplying at least 160mA will be necessary to power the unit (eg, a 12V DC 300mA unit).

As soon as power is applied, the displays should begin indicating UTC time (this can take anywhere from a few seconds up to about 40s), with LED1 lighting to show that this is the current display mode. This is the default start-up mode when the unit is powered up for the very first time.

Assuming that it's working so far, try pressing S2. LED2 should now begin glowing instead of LED1 and the displays should swing over to

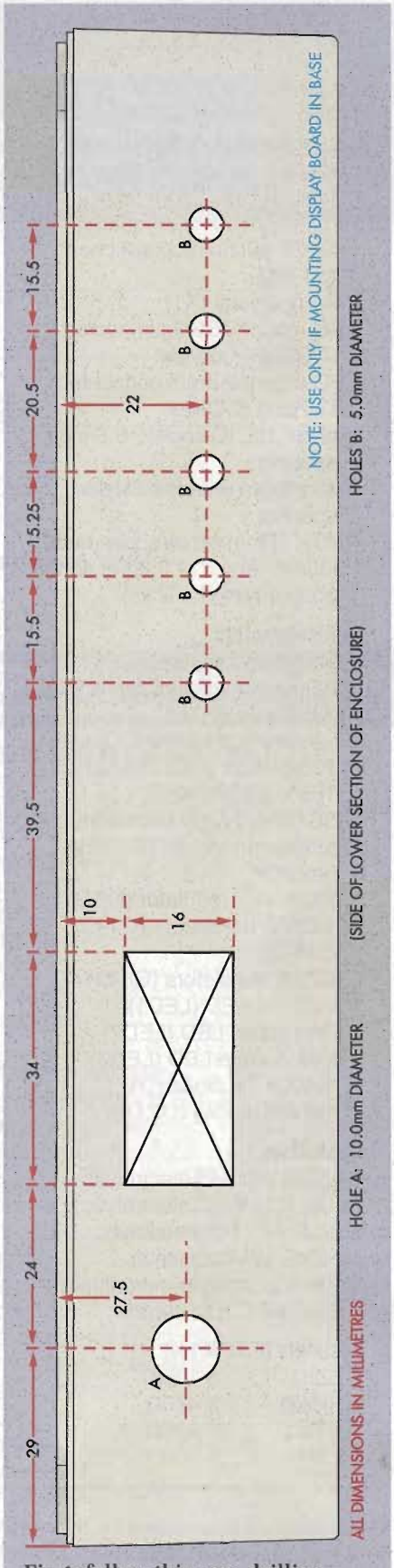


Fig.4: follow this case drilling diagram only if you intend feeding in the GPS time signals from an external source – see text.

Parts List

1 PC board, code 04105091, 211 x 135mm
1 polycarbonate enclosure, 222 x 146 x 75mm with clear lid (Jaycar HB-6258 or similar)
5 PC-mount 90° momentary mini SPST pushbutton switches (S1-S5)
1 4MHz crystal (X1)
1 PC-mount DB9M connector (CON1) – see text
1 PC-mount 2.5mm concentric DC plug (CON2)
1 40-pin DIL IC socket, 0.6-inch spacing
4 M3 x 6mm untapped Nylon spacers
4 M3 x 10mm screws, pan head
1 300mm length of 0.7mm tinned copper wire (for links)

Semiconductors

4 7-segment displays (CC) with 58mm high digits (Jaycar ZD-1850) (DISP1-4)
2 7-segment displays (CC) with 13mm high digits (Jaycar ZD-1855) (DISP5-6)
1 PIC16F877A-I/P microcontroller programmed with 0410509A.hex (IC1)
1 78L05 +5V regulator (REG1)
14 BC338 transistors (Q1-Q7, Q15-Q21)
7 BC328 transistors (Q8-Q14)
1 5mm red LED (LED1)
1 5mm green LED (LED2)
1 5mm orange LED (LED3)
1 1N4004 1A diode (D1)
2 1N4148 diodes (D2,D3)

Capacitors

1 470µF 25V RB electrolytic
2 100µF 16V RB electrolytic
1 22µF 16V RB electrolytic
1 100nF MKT polyester
2 100nF multilayer monolithic
2 22pF NPO disc ceramic

Resistors (0.25W 1%)

7 22kΩ	6 1.8kΩ
19 10kΩ	2 470Ω
1 4.7kΩ	7 330Ω
1 2.2kΩ	7 56Ω

local standard time. Initially, this will be local standard time for eastern Australia (EAST), because that is also the default setting (ie, an offset of +10 hours). However, this offset can be easily changed to suit your own time zone, as detailed shortly.

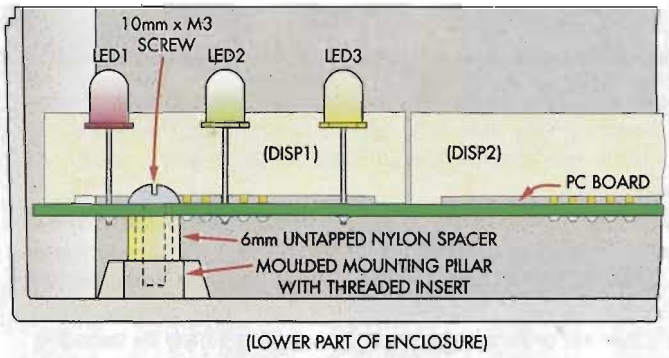


Fig.5: the display board is mounted inside the case on 6mm untapped Nylon spacers and secured using M3 x 10mm machine screws.

For the present, just try pressing S3. This should bump the time forward by an hour to show local daylight saving time. Of course, this third time variant may or may not be of any interest to you, depending on both the time of year and whether your region observes daylight saving. If you live in Queensland or the Northern Territory, for example, you won't need to worry about daylight saving time.

What if you live in a state or region of Australia other than the eastern states, or in another country altogether, where the time zone is quite different? In that case, how do you set the display's offset so it will display the correct local standard and daylight saving times for your location?

In practice, it's quite easy – just briefly press switch S2 (so that the unit shows local standard time), then press S4 a number of times until the hours indication is correct for your local time (NOT daylight saving time).

You'll find that each time you press S4, the display will blink and the hours indication will increment by one – up to a maximum of 23, when the hours display will drop back to 00 and then begin climbing again.

In most cases, repeatedly pressing S4 (to get the correct hours indication for local time) is all you need to do to set the offset from UTC. However, if you live in places like South Australia or the Northern Territory, where the offset has a 30-minute component as well, you'll also need to press S5. This increments in 30-minute steps, so you'll only have to press it once.

As a matter of interest, we've prepared a table (Table 2) showing the offsets for all states and regions of Australia plus those for New Zealand, various countries in Asia, regions in the USA and Canada and a few others. Alternatively, look up your timezone on **http://worldtimezone.com**.

UTC-LOCAL STD TIME OFFSETS	
STATE, REGION OR COUNTRY	OFFSET (HOURS)
New South Wales (except Broken Hill)	+10
Queensland, Victoria, Tasmania, ACT	+10
South Australia, NT, Broken Hill	+9.5
Western Australia	+8
Papua New Guinea	+10
New Zealand, Fiji	+12
Indonesia (West, East)	+7, +8
China, Hong Kong, Taiwan, Singapore	+8
Japan, Korea	+9
India	+5.5
Pakistan	+5
Saudi Arabia, Dubai	+3
Russia (West – East)	+3, +4 – +11, +12
South Africa	+2
France, Spain, Italy, Scandinavia	+1
United Kingdom, Portugal	0
USA and Canada (West – East)	–4, –5, –6, –7, –8
Mexico	–6
Argentina, Brazil	–3
Columbia, Ecuador, Peru	–5
For further information visit http://worldtimezone.com	

Table 2: this table shows the offsets from UTC time for various regions throughout the world.

In most cases, the offset is simply a certain number of hours, depending the longitude east or west of the Greenwich meridian which is used to reference UTC. Only in a small number of cases does the offset involve minutes as well as hours (eg, South Australia and the Northern Territory, where the offset is 9 hours and 30 minutes).

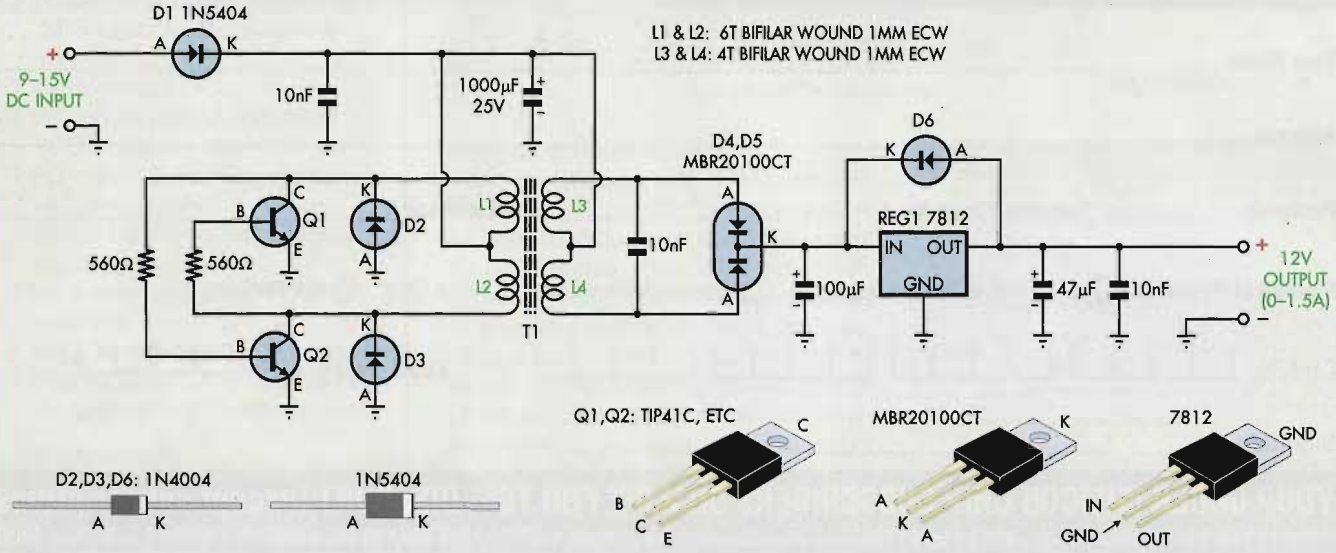
Saving the settings

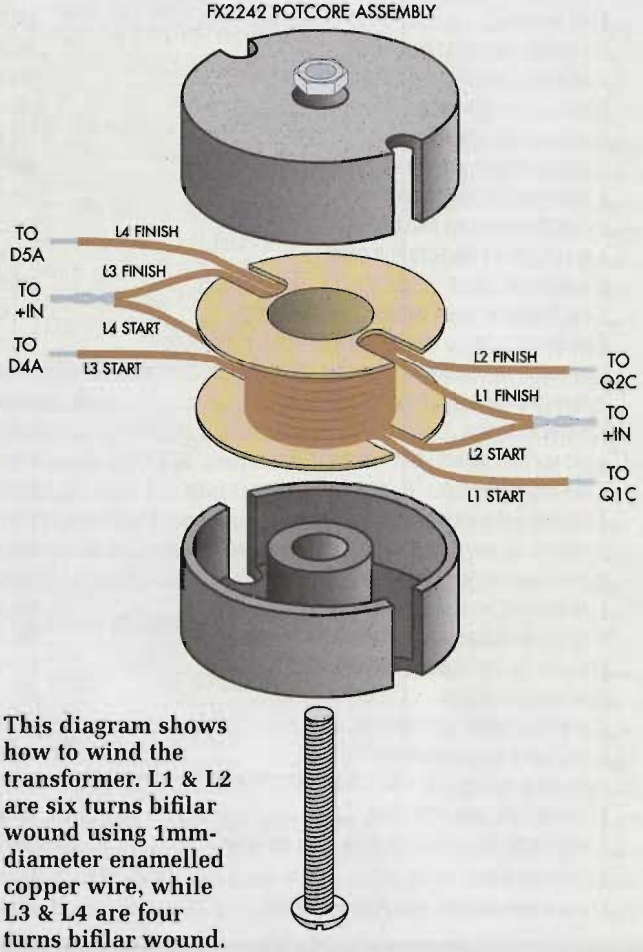
Each time you press any of the five switches S1-S5, the micro not only responds in the desired way but also saves the current settings in its non-volatile EEPROM memory. This means that once set, you don't have to reset the offset again even if the power is lost. The only time you do have to reset the offset is if you move to a location in a different time zone.

Next month, we'll describe the add-on GPS module. SC

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.





This diagram shows how to wind the transformer. L1 & L2 are six turns bifilar wound using 1mm-diameter enamelled copper wire, while L3 & L4 are four turns bifilar wound.

12V regulated inverter supply

When running 12V electronic devices from lead-acid battery banks, the voltage to the appliance can vary from below 11V with discharged batteries, to well above 14V during charging. Many appliances will not tolerate such a wide fluctuation and may perform poorly or be damaged.

This step-up inverter, combined with a 12V fixed regulator, is a good solution. Q1 & Q2, together with the ferrite pot-core transformer, comprise a DC-to-AC inverter. The turns ratio steps down the input voltage by about 30%. The square wave output voltage is rectified and added to the input DC voltage. The stepped up DC is then fed to a 7812 12V regulator (REG1).

The specified regulator will supply 1.5A at 12V out, from any input into the inverter between 9V and 15V, with the inverter making up the shortfall. Current requirements are kept to a minimum by not having the inverter supplying the total current.

By substituting a higher rated linear regulator, up to 5A can easily be supplied by this simple circuit. The transistors can be almost any general-purpose power type while the twin diode (D4/D5) is a high-speed device commonly found in defunct computer power supplies. Normal rectifier diodes can be used with a slight decrease in efficiency. The same comment applies to D2/D3. D6 is a protection diode and any 3A type will be suitable.

By slightly modifying the turns ratio, and substituting the linear regulator, 24V devices can be operated from a 12V supply. Laptops requiring around 18V can be powered as well.

Dayle Edwards,
Westland, NZ. ($40)

Solar panel tracker uses LED sensors

Jim Hewson is this month's winner of a Peak Atlas Test Instrument

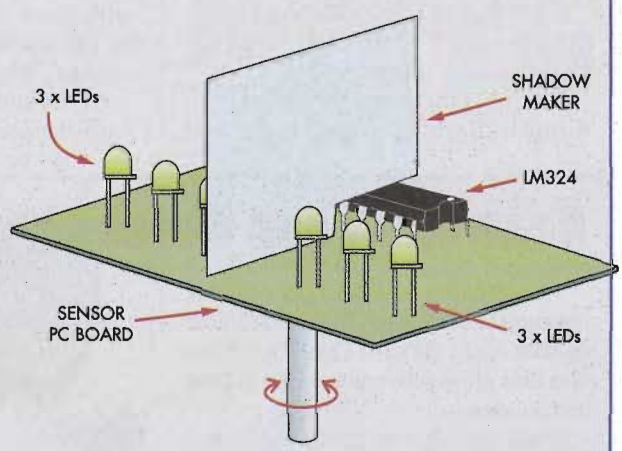
You may have seen solar-panel tracking circuits which used light-dependent resistors (LDRs) or opto-transistors but this circuit uses ordinary LEDs as the optical sensors. In this case, green LEDs were found to be the most sensitive to sunlight and those with a wider viewing angle were most suited to this application.

A string of six green LEDs has its centre point referenced to half the 12V supply by a voltage divider consisting of two 82kΩ resistors. The top and bottom outputs of the LED string are buffered by unity gain op amps IC1a & IC1b and then fed to a mixer stage involving op amp IC1c followed by variable gain stage IC1d which is again referenced to the half-supply voltage divider.

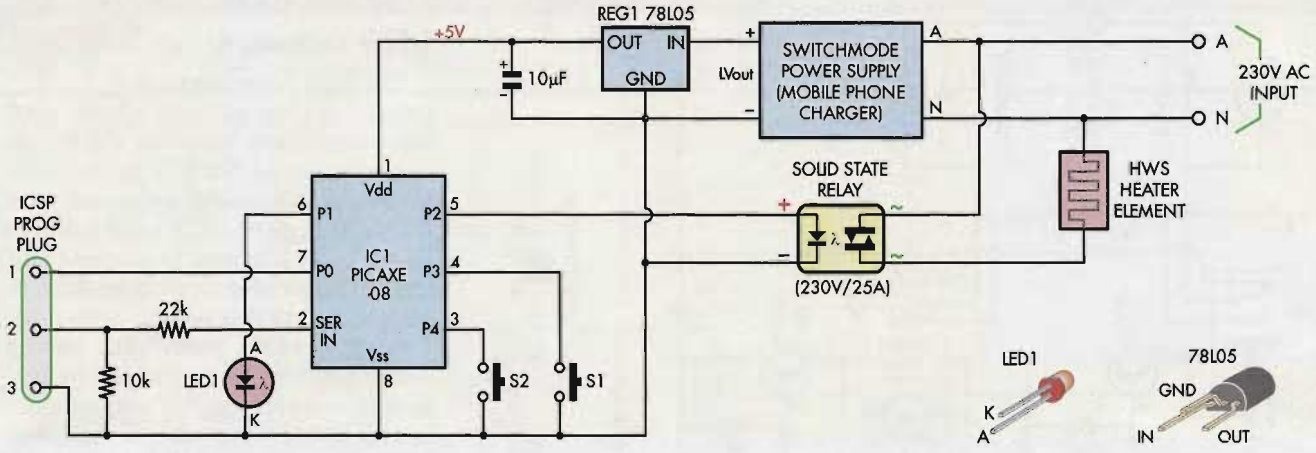
The output of IC1d is fed to a window comparator comprising two 741 op amps. Trimpot VR3 adjusts the dead band between the two comparators both of which drive a transistor and relay to operate the windscreen motor which drives the panel. Microswitches limit the drive at the end of the solar panel's range.

The LEDs were protected from ultraviolet with sunglass lenses while the PC board was coated with epoxy resin to protect it from the rain.

Jim Hewson,
Kyneton, Vic.



Above: this diagram shows how the tracker panel is made. It uses two groups of three green LEDs separated by an opaque sheet (or "shadow maker"). In operation, the panel adjusts to keep both sets of LEDs evenly lit.



PICAXE-based solar HWS boost control

This circuit was developed to allow a short boost for a solar HWS when the temperature is below that required but you don't want to heat up the whole tank to the thermostat setting. With the normal connections, the thermostat keeps the whole tank at the set temperature whether needed or not. This wastes power if the hot water is not required.

With this circuit, the element is only turned on when required. Pushing the SET button S1 once or twice in two seconds gives one or two hour's boost. Pushing three times in the two seconds locks it on until the timer is reset. Holding the button for one second resets the timer.

Note that in the locked-on condition, the HWS thermostat still controls the tank temperature.

The LED indicates the timer condition by flashing twice if in the first of a 2-hour boost period or once if in the one-hour period. This happens every 10 seconds. In the locked-on condition, the LED stays lit.

Rather than heating the water in the evening for a shower in the morning, then allowing it to cool overnight, there is a delayed start option. This will cause the heating to start six hours (or programmed to that of your choice) after the timer is set. This is indicated by a long flash preceding the short flashes that show how long it is set to run for.

For delayed start, press and release the delay button S2. The LED will flash to acknowledge. The heating time must be set within five seconds or the delayed start is reset. Select heating time by pressing button S1 (SET) once or twice. For the time leading up to the start, the LED will have a 300ms flash followed by 100ms flashes to indicate the set running time.

At the end of the delay period, the long flashes will stop and normal indications resume. A solid-state relay (SSR) has been used as it can be powered directly from the PICAXE. A 250VAC-rated SSR is available from Jaycar (Cat. SY-4084).

Because the circuit uses minimal power, a phone charger is sufficient to power it. This can be plugged into a power point mounted in the box with the SSR and PICAXE circuit (assembled on Veroboard). The main switch in the meter box can be switched off in summer when this circuit is not required.

Note that any modifications to fixed 230VAC wiring to hot-water systems can only be made by a licensed electrician. Note also that references to pin 3 & pin 4 in the HWSboost.BAS listing are to the PICAXE output pins and not to the physical pins of the 8-pin chip.

Colin Carpenter,
Mosman Park, WA. ($40)

Footnote: the HWSboost.BAS software listing can be downloaded from the SILICON CHIP website.

Contribute And Choose Your Prize

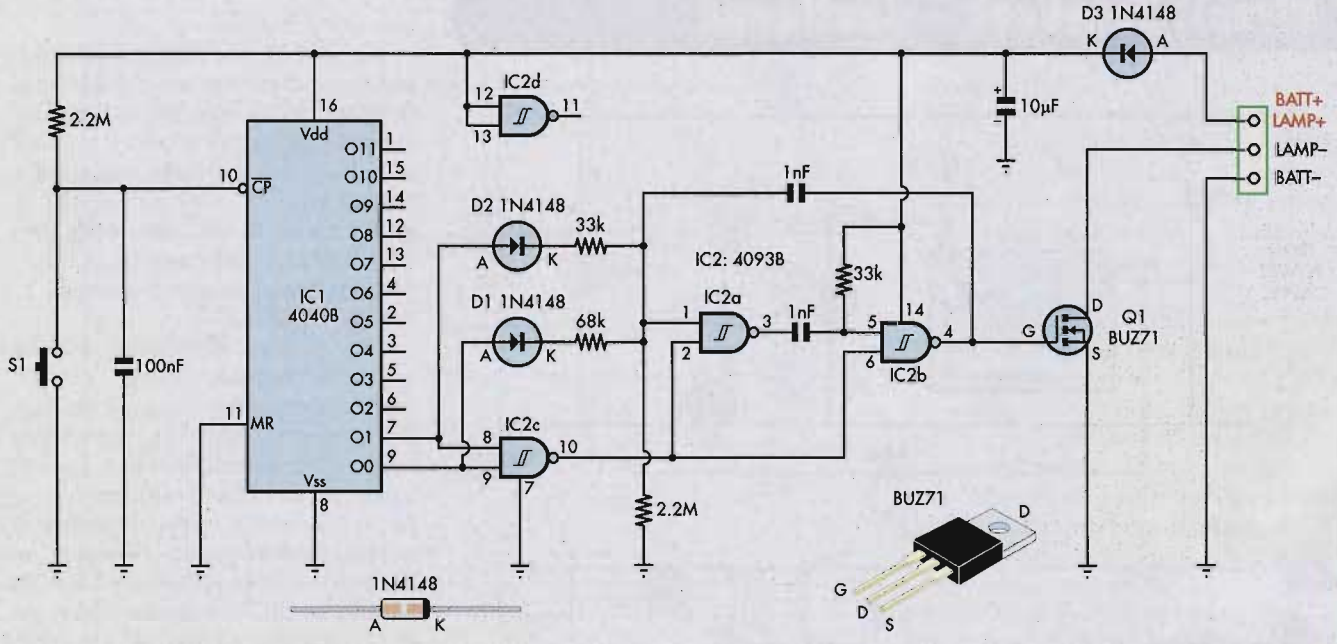
As you can see, we pay good money for each of the "Circuit Notebook" items published in SILICON CHIP. But there are four more reasons to send in your circuit idea.

Each month, the best contribution published will entitle the author to choose the prize: an LCR40 LCR meter, a DCA55 Semiconductor Component Analyser, an ESR60 Equivalent Series Resistance Analyser or an SCR100 Thyristor & Triac Analyser, with the compliments of Peak Electronic Design Ltd – see www.peakelec.co.uk



So now you have even more reasons to send that brilliant circuit in.

You can either email your idea to silicon@siliconchip.com.au or post it to PO Box 139, Collaroy, NSW 2097.



3-stage dimmer for mountain bike light

Riding a mountain bike on a forest trail after dark requires a strong source of light, lest a tree branch, rock, hole or other obstacle appears without warning. The usual bike light employs a helmet-mounted 50W halogen lamp powered from a 12V 4Ah sealed lead-acid battery in a backpack. However, full brightness isn't required all the time so this circuit provides three brightness levels and a very low off-state current.

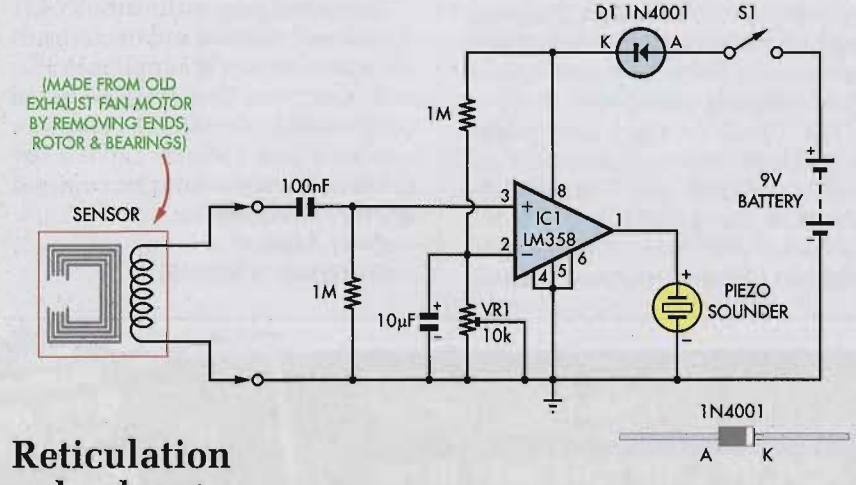
The 4040 binary counter IC1 is incremented each time switch S1 is pressed. As IC1 is clocked, its outputs control the amount of current fed into a simple astable multivibrator oscillator made up of gates IC2a & IC2b. This enables oscillation but also controls the duty cycle of the oscillator.

The oscillator output controls Mosfet Q1 to drive the lamp.

On power-up, all counter outputs are low and pin 9 goes high to feed current via diode D1 and the 68kΩ resistor to pin 1 of IC2a. This provides an oscillator duty cycle of about 33%. On the second count, pins 9 & 7 are high and the oscillator duty cycle is increased to around 50%. On the third count, the output of IC2c activates to stop the oscillator in the high state, resulting in a 100% duty cycle. The above four states repeat on subsequent counts. The lamp brightness is directly related to the oscillator duty cycle.

The Mosfet should remain cool at all brightness levels.

Doug Brown,
New Farm, Qld. ($40)



Reticulation valve locator

This circuit was developed to locate domestic 24VAC reticulation solenoids. The valves are housed in plastic enclosures but over time had become buried under lawn or ground cover.

As shown, the circuit uses one half of an LM358 dual op amp (IC1) as a non-inverting comparator. It monitors the output from a sensor made from the field winding and laminated iron core of an old exhaust fan motor. The sensor picks up the magnetic field from the solenoids when they are energised with 24V AC.

Trimpot VR1 (10kΩ) is used as a sensitivity control.

The sensor was attached to a short length of broom handle and is used with a sweeping motion, similar to that used with a conventional metal locator. It was successful in locating energised valves buried to 300mm below the soil surface.

Alan Doust,
Erskine, WA. ($35)

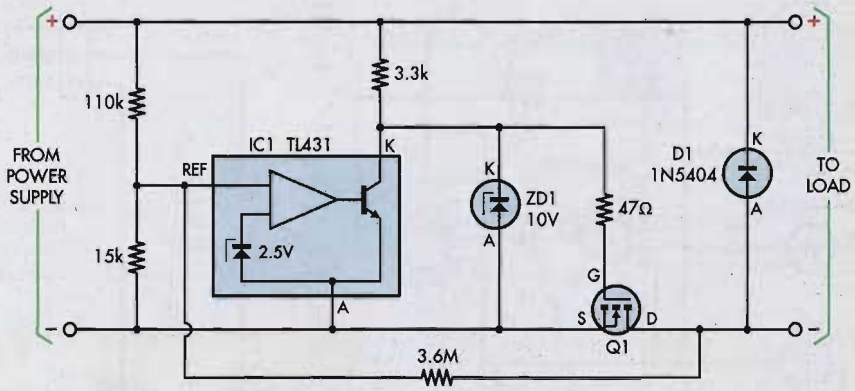


FIG.1

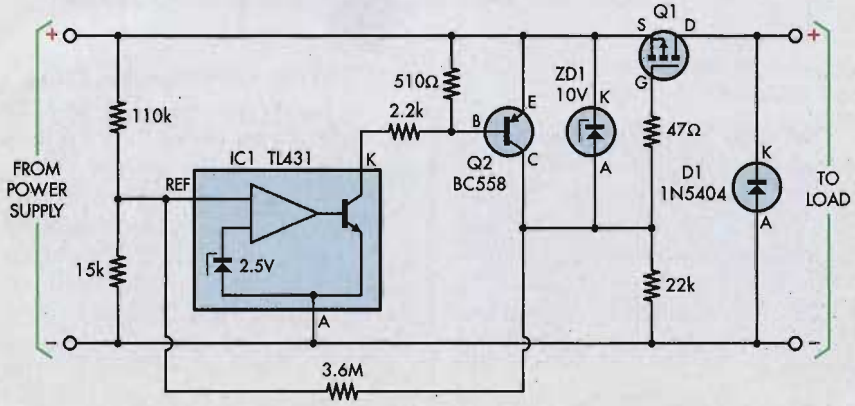
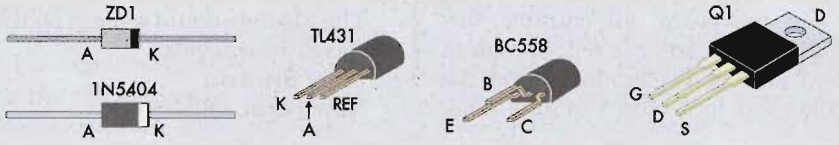


FIG.2



Over-voltage protection for DC loads

The popular Triac or SCR crowbar circuit has long been used for over-voltage protection. An over-voltage triggers the crowbar, shorting out the supply. The fuse then blows or the supply current limits to protect the load.

This works but then you have to switch off the supply and maybe replace the fuse to restart. This can be a real nuisance, particularly if you have a badly behaved power supply with a surge at power on.

The circuit in Fig.1 cuts power to the load and automatically re-connects when the over-voltage condition has passed, ie, no fuses are blown and there is no need to reset the circuit when the overload condition has passed.

IC1 is a TL431 adjustable shunt regulator used here as a voltage level detector. With the resistor values shown, the supply is cut off at about 21V. For other voltages, replace the 110kΩ with a value calculated to give 2.5V at TL431's reference pin. The 3.6MΩ resistor applies positive feedback and hence hysteresis to speed switching.

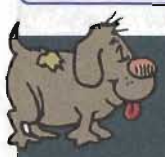
The N-channel Mosfet can be any with suitable voltage, current and on resistance ($R_{DS(on)}$) ratings. It may need a heatsink, depending on the load current and $R_{DS(on)}$. For example, an IRF540 with an $R_{DS(on)}$ of .044Ω should have a heatsink at currents more than 5A. However, an IRF1405 with an RDS(on) of .0053Ω should be OK for currents in excess of 10A without a heatsink. The Mosfet's voltage rating should exceed the input voltage (including spikes).

D1 is only required to suppress the back-EMF from inductive loads. If your supply voltage is less than about 10V, use a logic-level Mosfet such as the FDP7030L (available from Worldwide Electronic Components).

If you want a common negative rail between the power supply and load, then use the circuit in Fig.2. The P-channel Mosfet could be an IRF9540. It should have a heatsink at currents above about 3A. In this circuit, the input voltage should be limited to well below the ratings of the TL431 (37V) and the Mosfet.

Very often, you can find the TL431 IC voltage reference and its clones in switchmode power supplies in PCs and monitors. The uPC1093 is an equivalent to the TL431. They are available from Futurlec and Rockby Electronics: www.futurlec.com and www.rockby.com.au

Peter Reed,
Fullarton, SA. ($45)

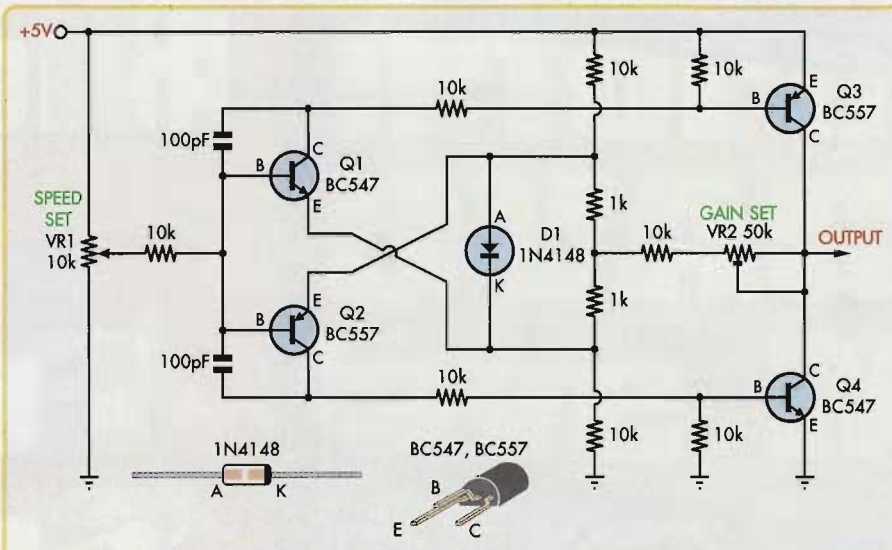


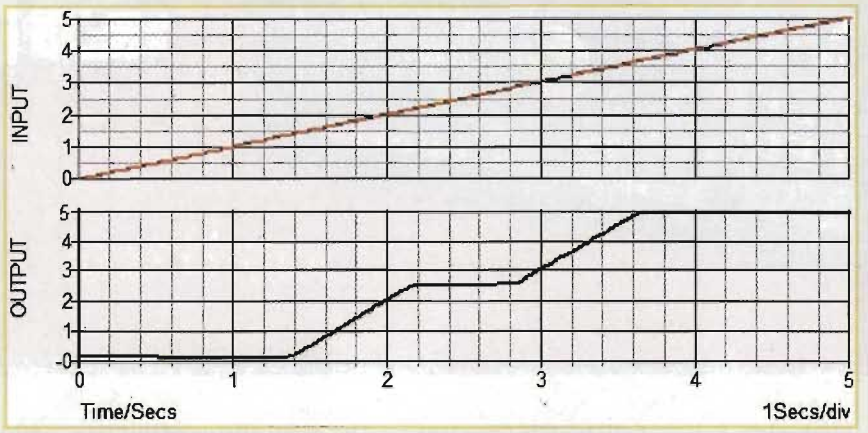
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Preamplifier for speed controller

This circuit was designed to fix a problem that occurs with a particular motor speed controller used in battery-operated scooters. This controller uses a potentiometer feeding into a microprocessor. As is common with speed controllers of this type, the centre position of the pot defines the motor neutral or off state. Clockwise or anticlockwise rotation of the pot then signals the controller to set the motor speed in forward or reverse direction, respectively, in proportion to the angle of rotation.

The problem was that the pot was somewhat worn and consequently the speed control was more than usually touch-sensitive at the centre wiper position. The slightest vibration of the pot or even electrical noise induced externally into the circuit was liable to set the motor creeping backward or forward, even with the pot in the neutral position.

One design constraint, not unusual for this kind of controller, is that the maximum angle of rotation of the wiper is limited mechanically to about 20% of the theoretical maximum of 300° or so of rotation. Furthermore, this particular controller employs an unconventional and expensive pot with a custom taper (rotation versus resistance) to compensate for the reduced mechanical rotation.

Replacing the worn pot with one identical to that of the original to fix the over-sensitivity problem was not practical because suitable replacement pots are not readily available in Australia. One solution was to replace the pot with a standard linear type and insert a CMOS op amp gain stage between the pot and the controller to preserve the full speed range. This worked but adjusting the pot for neutral position was critical, even with the new pot.

The accompanying discrete component circuit solved the problem nicely. This has a linear input-output response except near the centre of its input range, where the circuit gives a constant (flat) output (zero gain response) over an input range of approximately ±0.5V. The latter was more than enough to counter the effects of mechanical vibration and electrical noise; adjustment for neutral position was no longer critical.

The circuit works as follows: the emitters of input transistors Q1 and Q2 are biased by the 1kΩ and 10kΩ resistor network so that they are offset with respect to the input by approximately 250mV. Although strictly not necessary for circuit operation, diode D1 ensures that the Q1 and Q2 can never be simultaneously turned on, regardless of the speed potentiometer (VR1) setting.

When VR1's wiper is within about 400mV of half-supply voltage, all four transistors are turned off, because the base-emitter voltages applied to Q1 and Q2 are less than the input turn-on voltages for these transistors. In this state, the output sits at mid-supply voltage as determined by the voltage divider network of 1kΩ and 10kΩ resistors.

Q1 begins to conduct when the input voltage goes more than about 400mV above the mid-point voltage. When this happens, Q3 turns on as well and so Q1 & Q2 form a simple 2-transistor amplifier. Conversely, Q1 is turned off and Q2 turned on when the input voltage drops to less than about 400mV below the mid-point voltage, and so now transistors Q2 & Q4 take over.

The feedback network involving trimpot VR2, combined with relatively high transistor gain, ensures a linear response for input voltages above and below 400mV of half-supply voltage, until the output stage saturates.

The accompanying graph shows the typical output characteristic. The output stability (freedom from spurious oscillations) is good and the output range is essentially the full rail-to-rail voltage. The current drawn by the circuit is 700µA or so at 5V input, which is less than would be drawn by a typical dual CMOS op amp package.

Herman Nacinovich, Gulgong, NSW. ($50)



Hig Fu Sp

by JOHN CLARKE

Our last Motor Speed Controller, published in February 2009, utilised a simple phase-control circuit which works reasonably well with most universal motors. However, there are some applications where a wider and smoother control range is required.

One shortcoming of the February 2009 design is that the maximum speed from the motor when under speed control is significantly reduced. So for an electric drill that normally runs at say 3000 rpm, the maximum speed might be reduced to around 2200 rpm. This is inevitable with a controller circuit that effectively half-wave-rectifies the 230VAC mains waveform to give a maximum output voltage of around 160V RMS.

The second drawback of the February 2009 design has to do with low speed control. While the circuit does allow your drill or other appliance to run at quite low speeds, the result leaves much to be desired. There isn't much torque available and the speed regulation is poor. This means that if you're operating the drill at a low speed and you put a reasonable load on it, its speed will drop right away or it may stall completely.

Worse still, the motor will tend to "cog", caused by erratic firing of the Triac within the Drill Speed Controller, so that the motor receives intermittent bursts of power. An electric motor that is cogging badly is virtually useless and the only cure is to increase the speed setting – and this rather defeats the purpose if you want to operate at low speed.

This new SILICON CHIP Motor Speed Controller overcomes these drawbacks. The design does not use phase-control circuitry but uses switch-mode power supply techniques to produce an outstanding controller for universal brush-type motors.

By the way, before we go further we should point out that virtually all mains-powered power tools and appliances use universal motors. These are series wound motors with brushes.

And most power tools will do a better job if they have a speed control. For example, electric drills should be slowed down when using larger drill bits as they make a cleaner cut.

Similarly, it is useful to be able to slow down routers, jigsaws and even circular saws when cutting some materials, particularly plastics. The same applies to sanding and polishing tools and even electric whipper snip-

Features:

- Full control of motor speed from near zero to maximum
- Speed regulation under load
- Smooth low-speed motor operation
- Rated for universal motors rated up to 2300W
- Over-current protection and limiting
- Fuse protection
- Rugged earthed diecast case
- Interference suppression filter

h Performance 230VAC 10A ll-Wave Motor eed Controller

This full-range Motor Speed Controller will give smooth control from near zero to full speed on electric drills, routers, circular saws, lawn edgers, food mixers – in fact, any appliances with universal (brush-type) motors.

ers are less likely to snap their lines when slowed down.

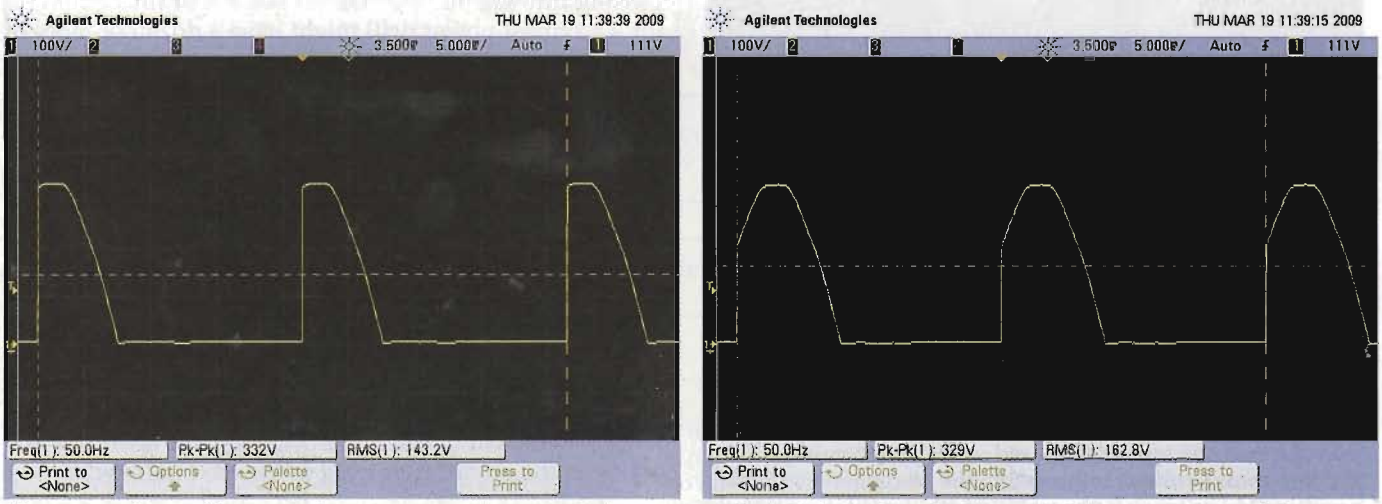
Phase control

Before we continue, we should explain what we mean by phase control so we can illustrate the benefits of the new circuitry.

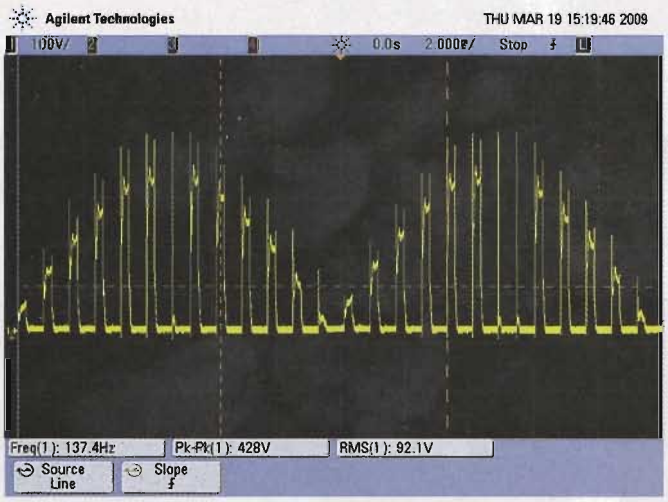
As you know, the mains (AC) voltage closely follows a sine wave – it starts at zero, rises to a peak, falls back to zero, then does the same thing in the opposite direction. This repeats over and over – and does it 50 times each second (50Hz). A motor connected to the mains uses all of the energy it can take from each "cycle" and it runs at its maximum speed.

But what if you were able to stop the motor receiving energy until, say, half way through each cycle? Obviously, with less energy available to power it the motor would not run as fast. If you were able to vary the time during each half cycle when power was applied, you would have a variable speed control. This then is the basis of "phase control"

Allow power very early in the cycle and it runs fast. Al-



These waveforms illustrate the operation of a typical phase-controlled SCR. In Fig.1 (left) the SCR is triggered fairly late in the positive half-cycle, so the motor voltage is just 143V RMS and it runs at a relatively low speed. Compare this with Fig.2, right, where SCR is triggered earlier in the half-cycle and the RMS value rises to 163V. Hence the motor runs faster.



This series of scope screen grabs show the voltage waveforms applied to the motor at progressively higher speed settings. Fig.3 (above) is the lowest setting with very short pulses from the IBGT delivering just 92V RMS to the motor.

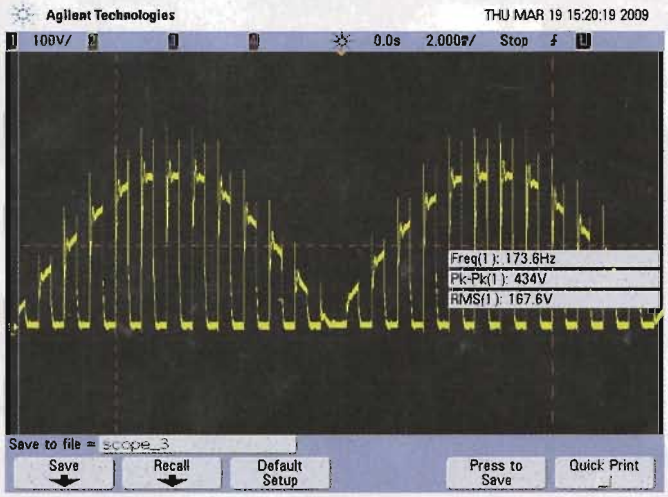


Fig.4 shows a significantly higher speed setting (167V RMS) with the IGBT being switched on with longer pulses. Each time the IGBT turns off it causes a significant voltage spike due to the back-EMF produced by the motor inductance.

low power very late in the cycle and it runs slowly.

The term "phase control" comes about because the timing of the trigger pulses is varied with respect to the phase of the mains sine wave.

It doesn't just work with some types of motors – it has also been the basis of incandescent lamp dimmers and even heater controls for many decades (it doesn't work on most forms of fluorescent nor compact fluorescent bulbs).

The oscilloscope waveform of Fig.1 shows the chopped waveform from a phase-controlled SCR circuit when a motor is driven at a slow speed.

Fig. 2 shows the waveform from an SCR speed control at a higher setting. The motor has 163V applied to it while at the low setting (Fig.1) the motor has 143V applied.

These examples show only the positive half of the mains waveform being used, as is the normal case with a phase- controlled SCR circuit. This automatically limits the amount of power which can be delivered to the motor – one half cycle is wasted. So this means that in a phase-control circuit the range of speed control is severely limited at the top end.

For the motor to run at full speed, it would need to be fed with both the positive and negative half-cycles of the 50Hz mains waveform. Normally this is not possible with an SCR circuit (which is, effectively, a controlled diode which therefore only conducts in one direction). While it is possible with a Triac, it is difficult to achieve without a complex circuit.

Another big problem with conventional phase-controlled circuits is that the trigger pulse applied to the Triac or SCR is very short and if this corresponds with the instant when the brushes hit an open-circuit portion of the commutator, no current will flow and consequently, the motor will miss out on a whole cycle of the mains waveform. This problem is more critical at low speed settings and is one of the reasons for the "cogging" behaviour referred to earlier.

Incidentally, the sparks you see when you look into a universal (brush-type) motor are mostly caused by brushes passing through an open-circuit section of the commutator – a typical power drill might have a dozen or more of these which keep the motor windings separate.

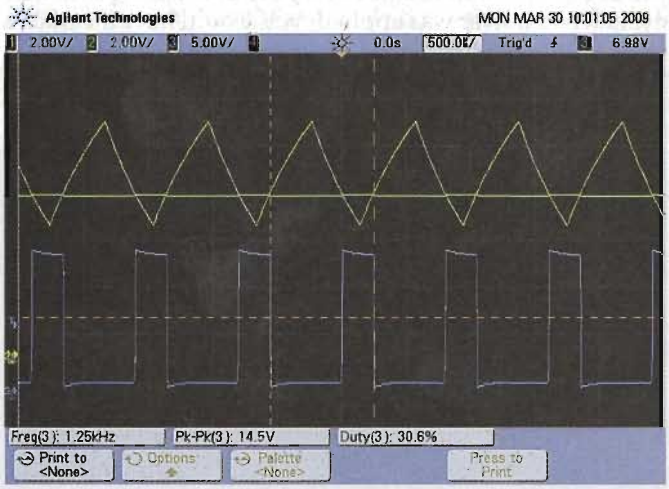


Fig.7: These waveforms show the interaction of the triangle waveform and the speed voltage. The triangle waveform at the top is compared to the speed voltage, the horizontal voltage intersecting the triangle wave. The resulting lower trace is the pulse width modulation signal from the comparator. The comparator output is fed to the gate driver IC2 and Q2 and Q3 that then drives the IGBT.

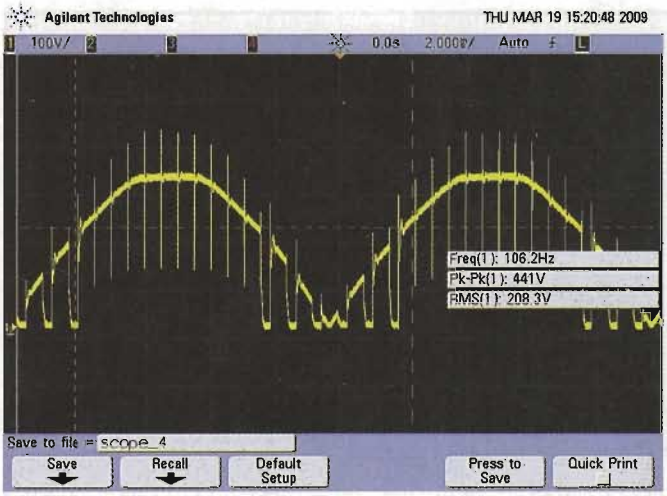
Speed regulation

Most phase-controlled SCR speed control circuits incorporate a form of feedback that is designed to maintain the speed of the motor under load. When the motor is loaded, the back-EMF (electromotive force) produced by the motor drops and the circuit compensates by triggering the SCR earlier in the mains cycle. This helps to drive the motor at the original speed.

In practice, the back-EMF generated by most series motors when the SCR is not conducting is either very low or nonexistent. If there is any back-EMF it is produced too late after the end of each half-cycle to have a worthwhile effect on the circuit triggering in the next half-cycle.

Pulse-width modulation

As we mentioned, the new SILICON CHIP speed control



Similarly, Fig.5 shows an even higher speed setting with now 208V RMS being delivered to the motor by the IGBT. Motor speed would already be higher than that capable of a phase-controlled circuit and shows how good this circuit is!

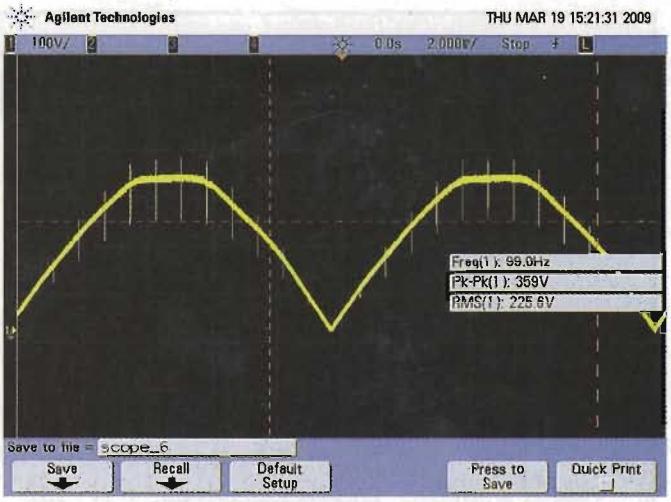


Fig.6: here the IGBT is virtually full-on delivering maximum voltage to the motor. However, the RMS voltage reads lower, due to the fact that the spikes which were present in the earlier waveforms are no longer there to confuse the scope.

circuit uses Pulse Width Modulation (PWM) and a different feedback method for speed regulation that effectively solves the problems above associated with phase control.

Fig.3 and Fig.4 shows the voltage waveforms applied to the motor at high and low speed settings. What happens is that we rectify the mains voltage and then chop it up at a switching rate of about 1.25kHz using a high-voltage IGBT (Insulated Gate Bipolar Transistor). For the high-speed setting the pulses applied to the motor is relatively wide (Fig.3) while at the low speed setting, the pulses are very narrow (Fig.4).

There are 12 pulses during each half-cycle, so the motor receives a more continuous stream of current compared to when driven via phase control. As a result, the motor operates very smoothly over the whole of its speed range.

For speed regulation the circuit does not rely upon back-EMF from the motor. Instead, it monitors the current through the motor and adjusts the pulse width to maintain the motor speed. If the current rises, indicating that the motor is under load, then the pulse width is widened to maintain motor speed.

Block diagram

Fig.8 shows the basic circuit arrangement. The 230VAC input waveform is fed through a filter and full-wave rectified. The resulting positive-going waveform is fed to one side of the motor. The other motor terminal is switched on and off via IGBT Q1.

Switching of the IGBT is under the control of comparator IC1a, which compares the speed setting required (as set by VR1) against a triangle waveform generator. If the speed voltage is high relative to the triangle waveform, then the com-

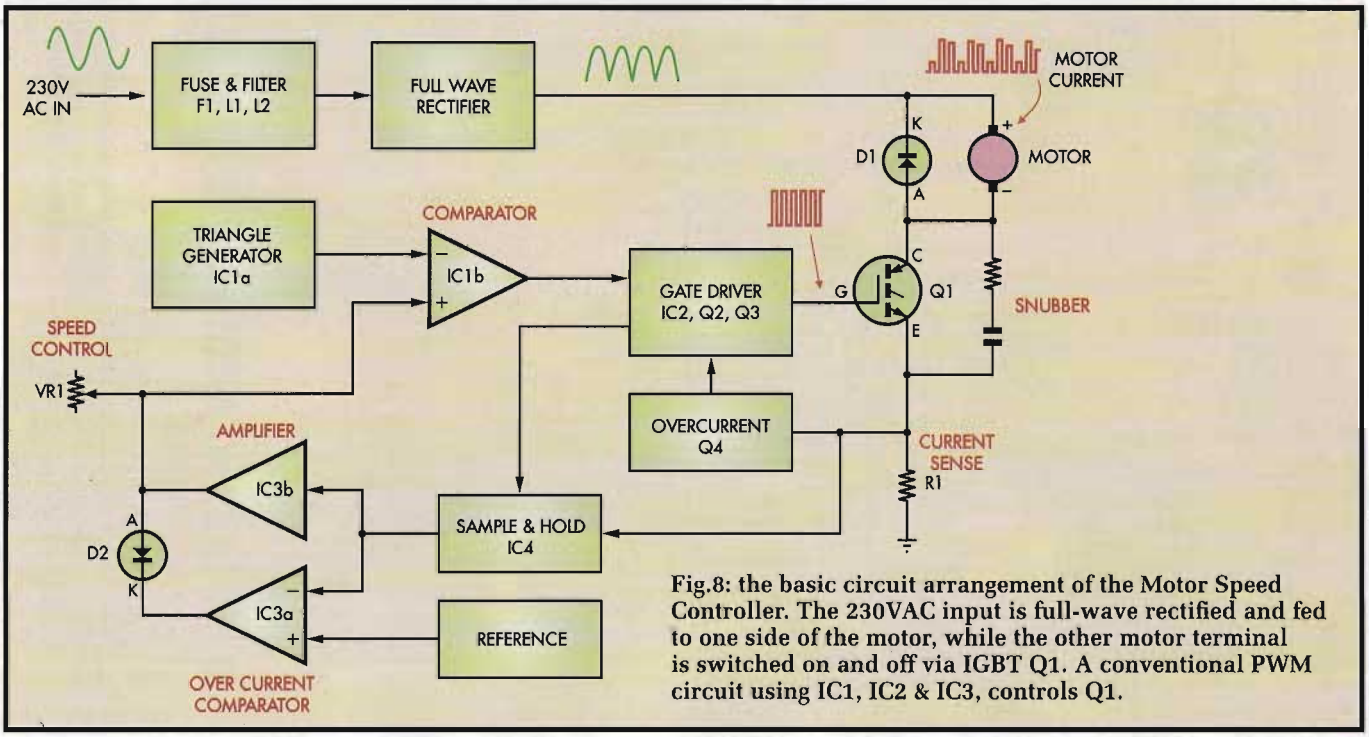


Fig.8: the basic circuit arrangement of the Motor Speed Controller. The 230VAC input is full-wave rectified and fed to one side of the motor, while the other motor terminal is switched on and off via IGBT Q1. A conventional PWM circuit using IC1, IC2 & IC3, controls Q1.

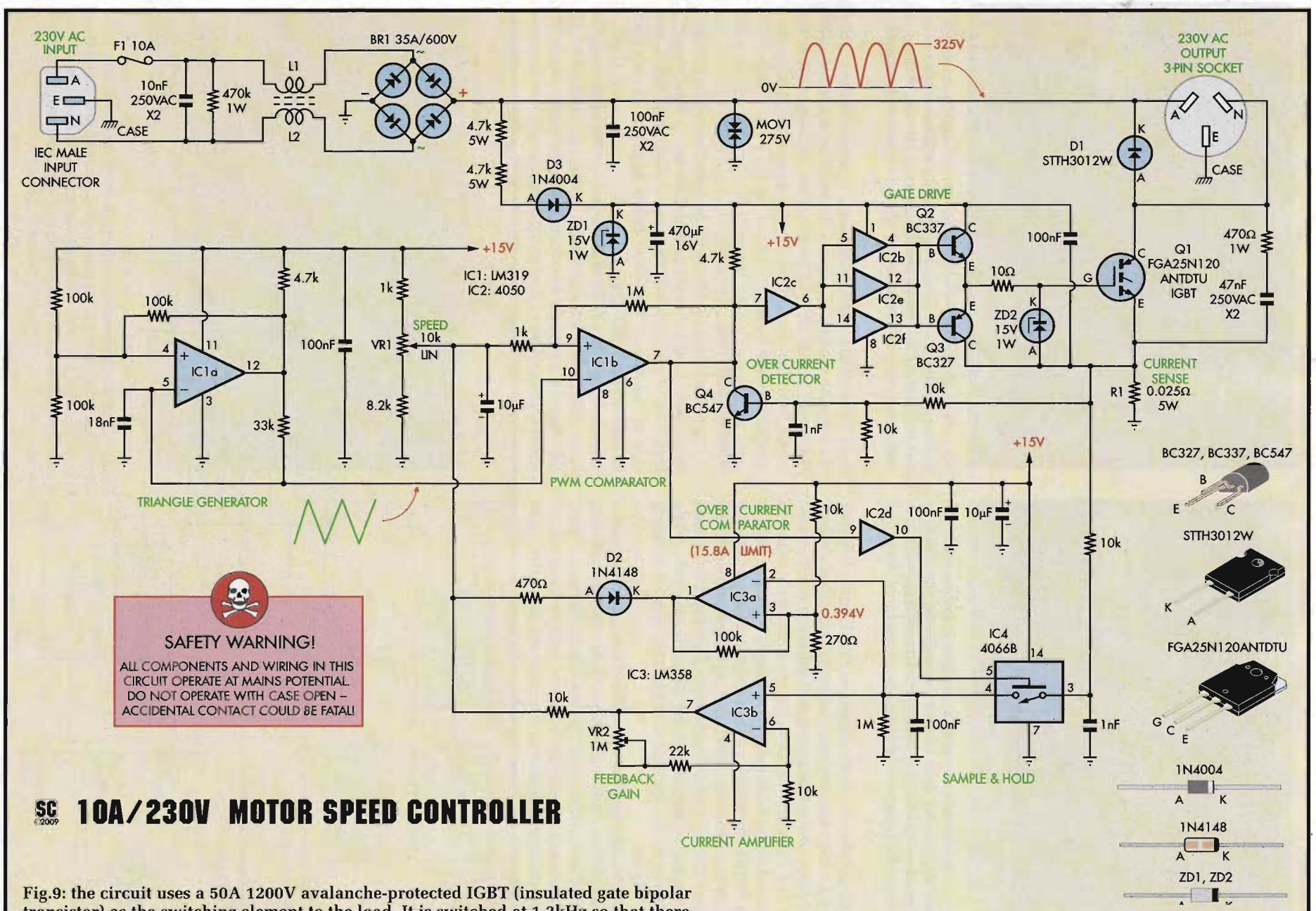


Fig.9: the circuit uses a 50A 1200V avalanche-protected IGBT (insulated gate bipolar transistor) as the switching element to the load. It is switched at 1.2kHz so that there are about 12 on and off cycles for each half-cycle of the 50Hz 230VAC mains supply.

parator will produce wide pulses at its output. Conversely, a lower speed voltage will reduce the pulse width.

This operation can be seen in the scope waveforms of Fig.7. The triangle waveform at the top is compared to the speed voltage, the horizontal voltage intersecting the triangle wave. The resulting lower trace is the pulse-width-modulation signal from the comparator. The comparator output is fed to the gate driver (IC2 and transistors Q2 and Q3) that then drives the high voltage IGBT (Ql).

Diode D1 is a fast-recovery type to conduct the motor current when Q1 is switched off. The snubber across Q1 prevents excessive voltage excursions across it.

Resistor R1 monitors the current flow through the motor when Q1 is on and the resulting voltage generated is sampled using switch IC4. This sampling occurs whenever Q1 is on.

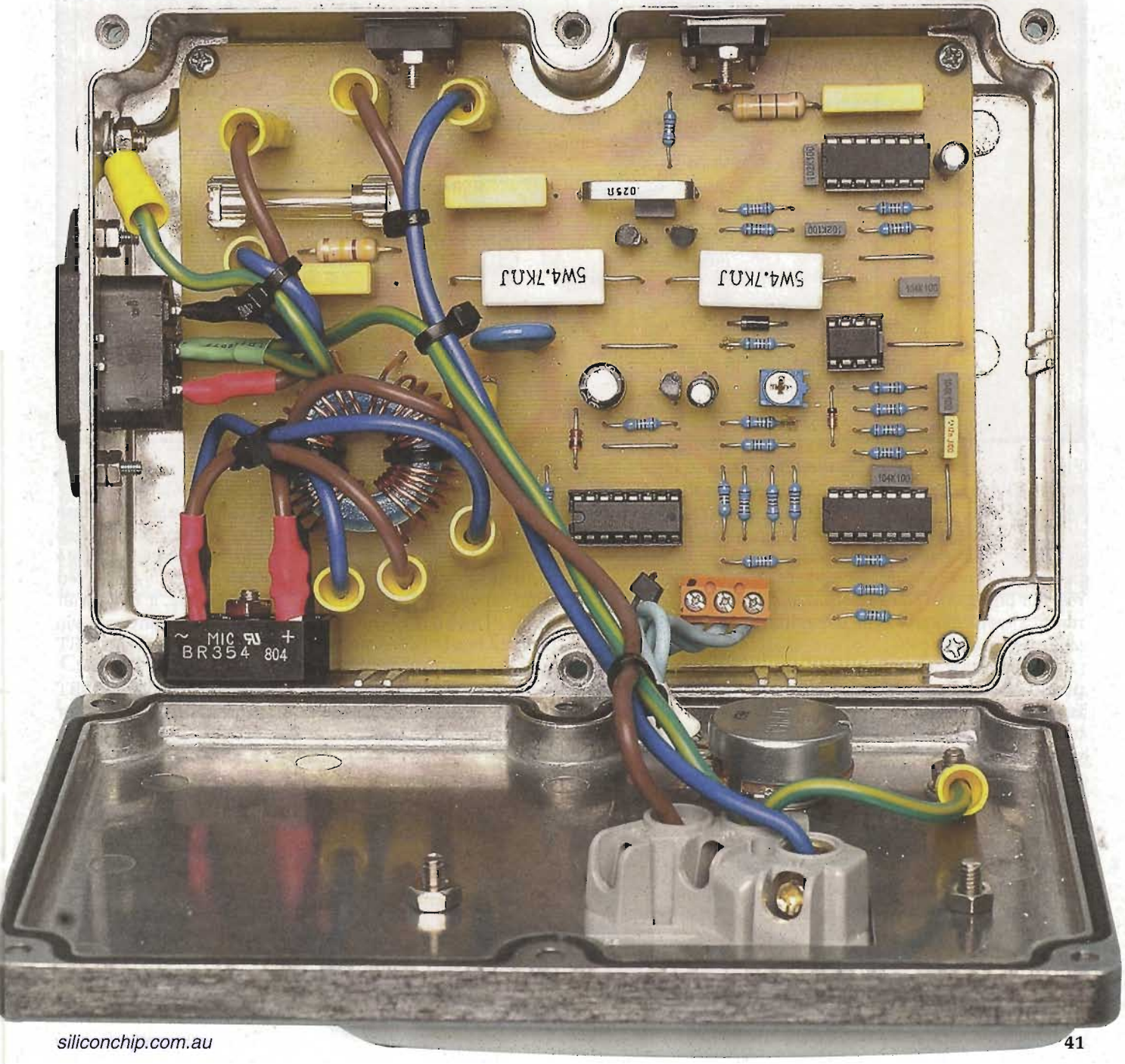
Excessive current drawn by the motor is detected by transistor Q4, used as an over-current detector to switch off the IGBT gate drive if current exceeds about 48A.

IC3a amplifies the voltage from R1 and applies it to the speed pot. This operates such that an increase in motor current, as the motor is loaded and slows down, leads to an increase in the output from IC3a. This in turn increases the speed setting from VR1, resulting in an increase in the voltage applied to the motor.

IC3b also monitors the voltage produced from R1 via IC4 and compares it against a reference voltage. If the voltage from R1 exceeds the reference threshold, IC3b's output goes low and reduces the speed pot voltage via diode D2. This reduces the voltage applied to the motor and provides current limiting. Current limit is set at 15.8A.

Circuit description

The circuit for the Motor Speed Controller is shown in



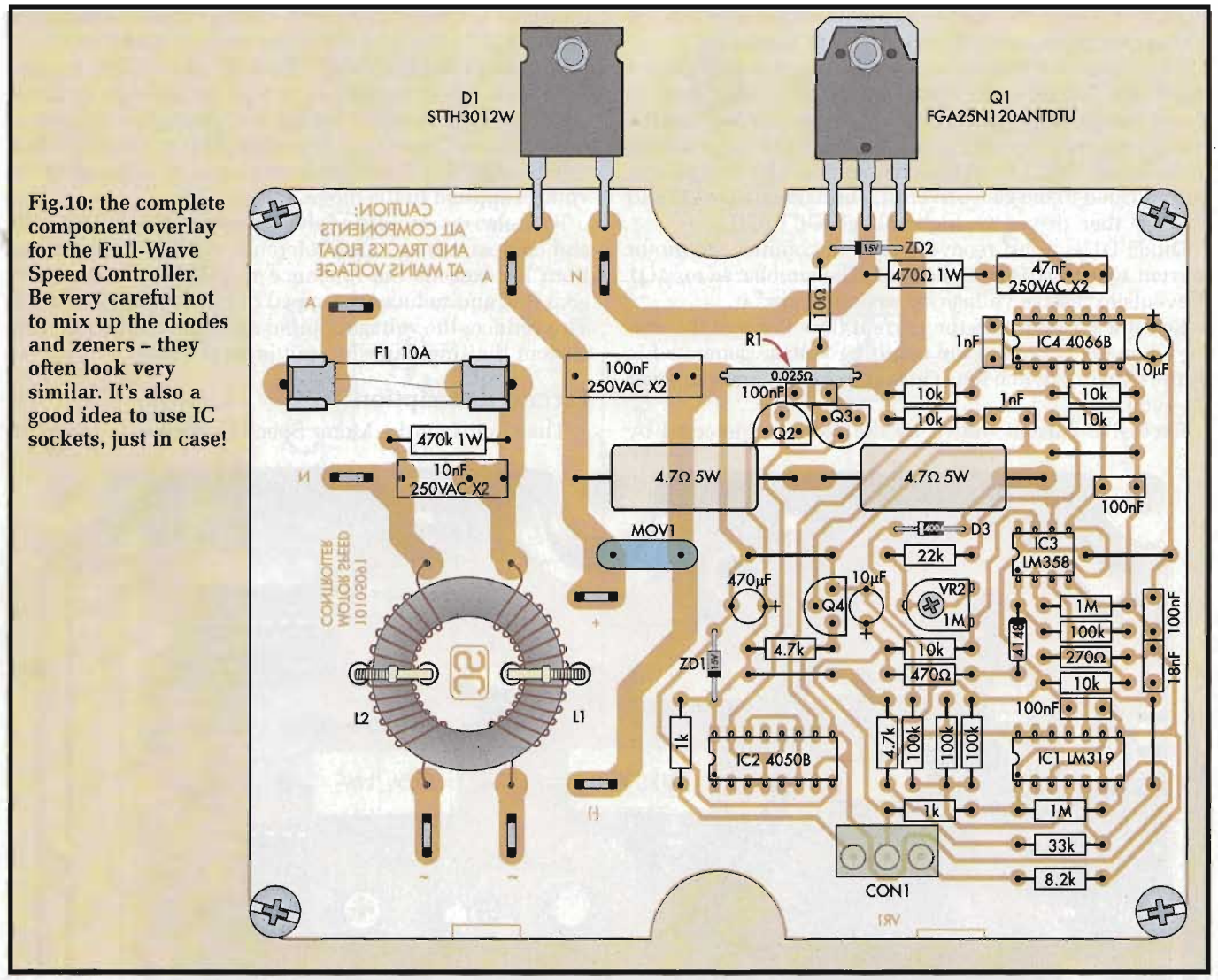


Fig.10: the complete component overlay for the Full-Wave Speed Controller. Be very careful not to mix up the diodes and zeners – they often look very similar. It's also a good idea to use IC sockets, just in case!

Fig. 7. It comprises four ICs, three low current transistors, several diodes, resistors and capacitors plus the high voltage IGBT, Q1.

IC1b is a comparator that forms the triangle waveform generator. It is wired as an oscillator where the 18nF capacitor at pin 5 is charged and discharged via the 33kΩ resistor connected to the output at pin 12. The triangle or ramp waveform across the capacitor has an amplitude of about 5V peak-to-peak.

Comparator IC1a compares the triangle waveform at pin 10 with the speed voltage at pin 9, as set by VR1. VR1 is part of a voltage divider with a 1kΩ resistor connecting to the +15V rail and an 8.2kΩ resistor to 0V. The speed voltage from VR1 is filtered with a 10µF capacitor to prevent any sudden changes in level and this voltage is monitored by the inverting input (pin 9) of IC1a via a 1kΩ resistor.

The 1MΩ resistor between pin 9 and the pin 7 output provides positive feedback to give a small amount of hysteresis in the comparator action. This is to prevent oscillation of the comparator output when changing levels.

The pin 7 output of IC1a drives buffers IC2c and IC2d. IC2c drives three paralleled buffers, IC2b, IC2e & IC2f. These in turn drive emitter-followers Q2 and Q3 to provide a high current drive capability to charge and discharge the gate of the high voltage IGBT Ql. The gate of Q1 is protected from excessive drive voltage using with ZD2, a 15V zener diode. The high voltage can be impressed on the gate via capacitance between the gate and collector when the IGBT switches off.

Several circuit features combine to ensure that the IGBT can safely switch high levels of current through the motor load.

First, there is a snubber network comprising a 470Ω resistor and 47nF capacitor connected in series across the IGBT's source and drain. Second, there is the fast recovery diode D1. Third, there is a 275VAC metal oxide varistor (MOV) connected across the output of the bridge rectifier. These measures combine to damp any spike voltages that

Warning!

(1) The entire circuit of this motor speed controller floats at 230VAC – and is potentially lethal. Do not build it unless you know exactly what you are doing. DO NOT TOUCH ANY PART OF THE CIRCUIT WHILE IT IS PLUGGED INTO A MAINS OUTLET and do not operate the circuit outside its metal case or without its lid on.

(2) This circuit is not suitable for induction motors or shaded pole motors used in fans – see text.

Parts List – Full Wave Universal Motor Speed Controller

1 PC board, code 10105091, 112 x 142mm
1 metal diecast case, 171 x 121 x 55mm
1 front panel label, 168 x 118mm
1 powdered iron core, 28 x 14 x 11mm (L1,L2)
1 single switched mains power outlet
1 10A IEC mains lead
1 IEC male chassis connector with mounting holes
1 3-way PC-mount screw terminal block with 5.08mm spacing (CON1)
8 6.35mm PC-mount male spade connectors with 5.08mm pin spacing
8 6.35mm insulated female spade quick connectors with 4-6mm wire diameter entry
2 5.3mm ID insulated quick connect crimp eyelets with 4-6mm wire diameter entry
1 knob
1 16-pin DIP IC socket
2 14-pin DIP IC sockets
1 8-pin DIP IC socket
2 3AG PC-mount fuse clips
1 10A 3AG fast blow fuse (F1)
2 M4 x 10mm screws (Earth connections)
2 M4 x 15mm screws (GPO Mounting)
1 M4 x 20mm countersunk screw (BR1 mounting)
5 M4 nuts
2 M4 star washers
2 M3 x 12mm countersunk screws (for IEC Connector)
2 M3 x 15mm screws (for Q1 and D1)
4 M3 nuts
3 3/16" x 6mm screws (PC board to case)
4 stick-on rubber feet
8 100mm cable ties
2 TO-3P Silicone insulating washers
1 300mm length of blue 10A mains wire
1 300mm length of brown 10A mains wire
1 300mm length of green/yellow 10A mains wire
1 100mm length of 0.8mm tinned copper wire
1 1.1m length of 1mm enamelled copper wire
1 45mm length of black 5mm heatshrink tubing
1 45mm length of red 5mm heatshrink tubing
1 15mm length of green 5mm heatshrink tubing
1 45mm length of white 3mm heatshrink tubing

Semiconductors
1 LM319 dual comparator (IC1)
1 4050 hex CMOS buffers (IC2)
1 LM358 dual op amp (IC3)
1 4066 quad CMOS analog switch (IC4)
1 BC337 NPN transistor (Q2)
1 BC327 PNP transistor (Q3)
1 BC547 NPN transistor (Q4)
1 FGA25N120ANTDTU NPN 50A 1200V TO-3P IGBT (Q1) (Farnell cat 149-8965)
1 STTH3012W 30A 1200V TO-247 ultrafast recovery diode (D1) (STMicroelectronics)
1 1N4148 signal diode (D2)
1 1N4004 1A 400V diode (D3)
2 15V 1W zener diodes (ZD1,ZD2)
1 35A 600V bridge rectifier (BR1)
1 S14K275 275VAC metal oxide Varistor (MOV1)

Capacitors
1 470µF 16VW PC electrolytic
2 10µF 16VW PC electrolytic
1 100nF 250VAC X2 class MKT polyester
4 100nF 63V MKT polyester
1 47nF 250VAC X2 class MKT polyester
1 18nF 63V MKT polyester
1 10nF 250VAC X2 class MKT polyester
2 1nF 63V MKT polyester

Resistors (0.25W, 1%)

2 1MΩ	1 470kΩ 1W	4 100kΩ
1 33kΩ	1 22kΩ	6 10kΩ
1 8.2kΩ	2 4.7kΩ	2 4.7kΩ 5W
2 1kΩ	1 470Ω 1W	1 470Ω
1 270Ω	1 10Ω	

1 low ohm shunt resistor 0.025Ω, 1%, 5W (OAR5 – R025F1) (TT Electronics)
1 10kΩ 25mm linear potentiometer (VR1)
1 1MΩ horizontal trimpot (VR2) (Code 105)

would otherwise occur every time the IGBT switched off.

Current monitoring

R1 is a used to monitor the current flow through the motor and IGBT, Q1. Transistor Q4 directly monitors the current via a voltage divider comprising two 10kΩ resistors in series. At about 48A there is about 1.2V across R1 and the base of Q4 is at 0.6V. The transistor conducts and pulls the IC1a comparator output low to disconnect drive to the IGBT. Thus Q4 provides for transient current limiting.

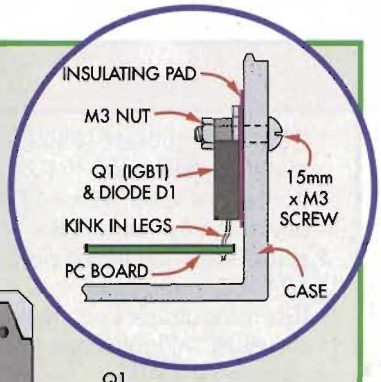
Voltage developed across R1 is also fed through a low pass filter consisting of a 10kΩ resistor and 1nF capacitor to one side of IC4, a 4066 analog switch. This is the sample-and-hold circuit and IC4 is switched on to sample the voltage across R1 each time the IGBT is switched on. IC4's gate signal comes from comparator IC1a and is buffered by IC2d. The sampled signal from R1 is stored using the 100nF capacitor and discharged over a 100ms period with a 1MΩ resistor.

The sampled voltage from IC4 is fed to two op amps, IC3a & IC3b. IC3b amplifies the voltage by about 100 when VR1 is set to maximum and 3.2 when set to minimum. IC3b acts to vary the DC level fed to comparator IC1b from VR1 and thereby compensates for speed variations in the motor.

IC3a acts as a comparator, comparing the sampled voltage from R1 with a 394mV reference voltage at its pin 3. If the current through R1 rises above 15.76A, the voltage across the resistor equals the 394mV reference and the output of IC3a goes low and pulls pin 9 of IC1b low via diode D2 and a 470Ω resistor. This has the effect of greatly reducing the motor drive voltage and so it limits the current.

Power for the circuit is derived directly from the 230VAC mains. Fuse F1 protects against shorts while the 10nF capacitor in conjunction with L1 & L2 prevents switching artefacts from the IGBT and motor being radiated back to the mains wiring.

Fig.11: the complete wiring diagram of the Motor Speed Controller. Follow this wiring exactly – including the earthing detail. It is very important that the case and lid be separately earthed, as shown here. Note also that all parts of the circuit, including the terminals of VR1, float at 230VAC.
Inset at right is the mounting arrangement for both D1 and Q1, which mount on the inside of the case with insulating washers. Their legs must be kinked outwards slightly so they sit flush on the case wall.



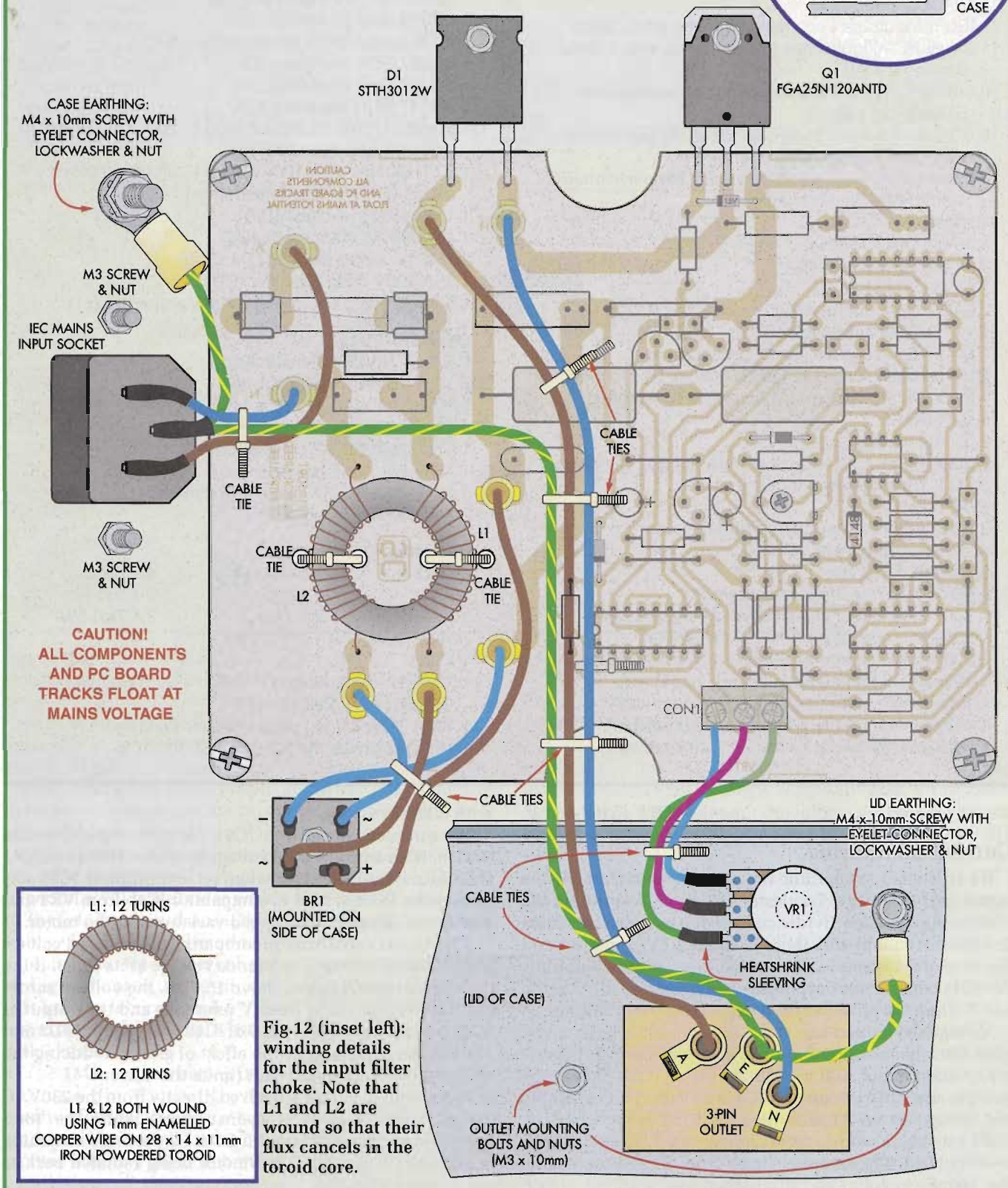
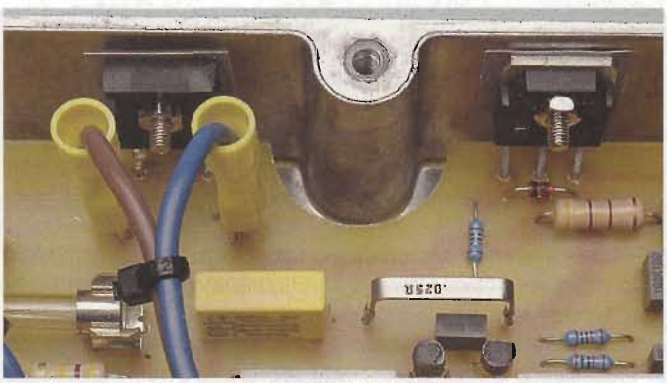


Fig.12 (inset left): winding details for the input filter choke. Note that L1 and L2 are wound so that their flux cancels in the toroid core.



A close-up photo of the input (IEC socket) wiring, fuse, choke and bridge rectifier. All mains leads are terminated in quick-connect terminals.



Similarly, a close-up of the IGBT (right) and fast recovery diode (left). These devices do not require an insulating bush but definitely do need an insulating washer, as seen here.

BR1 is a bridge rectifier with a 600V 35A rating. The bridge provides the circuit with the positive full-wave rectified mains voltage and this is lightly filtered using a 100nF 250VAC capacitor. Power for the low voltage circuitry is derived via two series 4.7kΩ 5W resistors, diode D3 and the 15V zener diode ZD1. A 470uF capacitor across the 15V zener smooths the DC while diode D3 prevents the capacitor from discharging when the mains voltage falls to below 15V every half cycle. The result is a regulated 15V supply.

Construction

The Motor Speed Controller is constructed on a PC board coded 10105091 and measuring 112 x 142mm. It is housed in a diecast case measuring 171 x 121 x 55mm. The PC board has cut-outs to match the shape of the case.

Begin construction by checking the PC board. There should not be any shorts or breaks between tracks. If there are any problems, repair these as necessary.

Similarly, if the cutouts in the sides of the PC board have not been shaped, they should be cut and filed before any components are assembled.

A large semicircular cutout is required on both the long sides of the board. Also you will need to round off the corners of the board. Make sure the PC board fits into the case before starting assembly.

Following the overlay diagram shown in Fig.10, begin by inserting and soldering in the wire links and then the resistors, using the accompanying table for the colour codes. The two 5W resistors should be inserted so that they stand a millimetre above the PC board to allow cooling. When the Drill Speed Controller is operating, each resistor will be dissipating about 2.7W so would run quite hot to the touch.

When inserting diode D2 and D3 and zener diodes ZD1 and ZD2, take care with their orientation and be sure to place each type in its correct place. D1 is installed later.

We used IC sockets for the ICs. Be sure to install these the correct way around with the notch facing the direction shown on the overlay. Transistors Q2-Q4 can now be inserted, again taking care to place each in its correct position.

Capacitors can be installed next. The accompanying capacitor table shows the various codes that are used to indicate the capacitance values of the polyester capacitors. The electrolytic capacitors must be oriented with the correct polarity.

L1 & L2 are windings wound on a single powdered iron toroidal core as shown in Fig.12. Each winding is wound using 12 turns of 1mm enamelled copper wire with the shown direction.

While the exact number of turns is not critical, it is important that both windings have the same number of turns and that they are wound in the directions as shown. The wire ends can be soldered to the PC board after they have been stripped of insulation using some fine abrasive paper, or a sharp hobby knife. After soldering, secure the toroid to the PC board with two plastic cable ties. These wrap around the core and through holes in the PC board. (It is important not to secure the toroid with lengths of wire; these could make a shorted turn around the toroid).

Fuse F1 is mounted in fuse clips that are installed into the PC board as shown. Clip the fuse into the clips first (lugs to the outer ends of the fuse) then insert them into the PC board and solder in position – this hopefully ensures that

Capacitor Codes

Value	µF value	IEC code	EIA code
100nF	0.1µF	100n	104
47nF	.047µF	47n	473
18nF	.018µF	18n	183
10nF	.01µF	10n	103
1nF	.001µF	1n0	102

Resistor Colour Codes

No.	Value	4-Band Code(1%)	5-Band Code (1%)
❑ 2	1MΩ	brown black green brown	brown black black yellow brown
❑ 1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑ 4	100kΩ	brown black yellow brown	brown black black orange brown
❑ 1	33kΩ	orange orange orange brown	orange orange black red brown
❑ 1	22kΩ	red red orange brown	red red black red brown
❑ 6	10kΩ	brown black orange brown	brown black black red brown
❑ 1	8.2kΩ	grey red red brown	grey red black brown brown
❑ 2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑ 2	1kΩ	brown black red brown	brown black black brown brown
❑ 2	470Ω	yellow violet brown brown	yellow violet black black brown
❑ 1	270Ω	red violet brown brown	red violet black black brown
❑ 1	10Ω	brown black black brown	brown black black gold brown

What Motors Can Be Controlled?

We've noted elsewhere in this article that the vast majority of power tools and appliances use so-called universal motors. These are series wound motors with brushes. But how do you make sure that your power tool or appliance is a universal motor and not an induction motor? As we also said before, induction motors must not be used with this speed controller.

One clue is that most universal motors are quite noisy compared to induction motors. However, this is only a guide – it's certainly not foolproof.

In many power tools you can easily identify that the motor has brushes and a commutator – you see sparking from the brushes and that settles the matter. But if you can't see the brushes, you can also get a clue from the nameplate or the instruction booklet.

OK, so how do you identify an induction motor? Most induction motors used in domestic appliances will be 2-pole or 4-pole and always operate at a fixed speed which is typically 2850 rpm for a 2-pole or 1440 rpm for a 4-pole unit. The speed will be on the nameplate. Bench grinders typically use 2-pole induction motors.

Note that this speed controller must NOT be used with power tools, etc, which already have a speed controller built into the trigger.

One final point: if you are using this controller with a high power tool such as a large circular saw or 2HP router, it will not give the same kick when starting.

Because of the current limiting, the motor will take a few seconds to come up to full speed. Normally though, if you want to use the appliance at full speed, it is better not to use the Speed Controller at all.

you don't solder them in the wrong way around.

Solder in the eight 6.4mm PC-mount spade connectors to the PC board for the mains wiring connections, along with the 3-way screw terminal connector for the potentiometer connecting wires.

D1 and Q1 are the last components to be soldered to the PC board. Solder them in so their metal flanges are towards the edge of the PC board and their full-length leads extending about 1mm below the PC board.

All that is left are bridge BR1, diode D1 and IGBT Q1, all of which mount on the inside walls of the case when the PC board is in place.

Mounting the hardware

First of all, mark out the hole position for the IEC connector and earth screw in the end wall of the case. The IEC connector mounts in the horizontal centre, about 6mm down from the top.

As you can see in our photographs, about 1mm of the top of the end-wall channel is left when the hole is made.

The IEC hole is made by drilling a series of small holes around the perimeter of the desired shape, knocking out the



Another view of the completed dimmer, very close to same size. The front panel artwork is printed overleaf, or it can be downloaded from siliconchip.com.au.

piece and filing to shape.

Insert the PC board into the case and mark the mounting hole positions for diode D1, IGBT Q1 and bridge rectifier BR1. Note that the leads for D1 and Q1 must be kinked outward slightly so that the metal flange of each device is parallel to and in contact with the side of the case.

Drill out the holes for these three components Holes are also required in the lid for the GPO, VR1 and the earth terminal.

All holes must be deburred on the inside of the cas e with a countersinking tool or larger drill to round off the sharp edge of the hole and in the case of D1 and Ql, prevent punch-through of the insulating washers.

Attach the PC board to the case with the 3/16" screws. Note that we do not use a screw in the corner where BR1 mounts. BR1 effectively holds the PC board in place here. Secure D1 and Q1 to the case with a screw, nut and insulating washer. The arrangement for this is shown in the inset in Fig.11.

After mounting D1 and Q1, check that the metal tabs of the devices are isolated from the case by measuring the resistance with a multimeter. The meter should show a very high resistance measurement between the case and any of the diode and IGBT leads.

The complete wiring diagram is shown in Fig.11. The earthing details of the case are most important since the IGBT, fast recovery diode D1 and potentiometer, VR1, are all at mains potential yet are attached to the case. If the insulating washers or the insulation of the potentiometer were to break down, the case would be live (ie, at 230VAC) if it was not properly earthed.

For the same reason, the case lid must also be separately earthed, also as shown in Fig.11.

The bridge rectifier (BR1) is secured to the case with a 4mm screw and nut. It does not require an insulating washer between its body and the case.

All mains wiring must be done using 10A mains-rated (ie 250V) wire. Wiring for the potentiometer must also be mains rated but it does not need to be 10A rated. The IEC connector must be wired using the correct wire colours with brown for the Active, blue for the Neutral and green/yellow striped wire for the Earth. Use quick-connectors for the mains wiring connection to the PC board connectors. Wires to the IEC connector need to be insulated with heatshrink tubing covering all exposed metal.

Troubleshooting the Motor Speed Controller

If the speed controller does not work when you apply power, it's time to do some troubleshooting.

First, a reminder: **all of the circuit is connected to the 230V AC mains supply and is potentially lethal.** This includes the tabs of Dl and Ql, the terminals of potentiometer VRl – in fact, all other parts. Do not touch any part of the circuit when it is plugged into a mains outlet. **Always remove the plug from the mains outlet before touching or working on any part of the circuit.**

If the live circuit ***must*** be worked on, it must be operated via a 1:1 mains isolation transformer. We're only saying that because it is safer but we'd still prefer you didn't do it.

Before going any further, give you PC board another thorough check (using a magnifying glass?). Kit suppliers tell us that at least 99% of problems are due to wrong or swapped components, right components in the wrong way around and, of course, the "biggie": poor soldering (or even completely missed solder joints).

If you are 110% sure your Speed Controller isn't suffering from any of these maladies, it's time to get more technical!

Fortunately, there ***is*** a safe way to check most of the circuit and that is to operate it from a low voltage (12V) DC supply.

Naturally, before you remove the lid you would have already disconnected the 230V mains lead **(don't just turn it off, unplug it!)**. The supply is connected with the positive connecting to the anode of diode D3 and the negative connecting to the anode of ZD1 (the anodes are the ends opposite the striped end on the diode body).

Before you connect the supply, measure it to make sure it is not exceeding **14V** – if it does, you're liable to blow up the 15V zener diode.

With power applied, a multimeter connected with the negative lead to the negative supply can be used to test voltages. Firstly, check that there is 11.4V on pin 1 of IC2 and pin 11 of IC1. IC3 should have 11.4V on pin 8. Similarly pin 14 of IC4 should also have 11.4V.

Voltage on the wiper of VR1 should be adjustable from 4.86V to 10.79V or similar by rotating the potentiometer to its full extremes. The same voltage range should be seen at pin 9 of IC1a.

Pin 7 of IC3a should be close to 0V. Pin 1 of IC3b should be at about 9V or more.

With the meter still set to read DC volts, the triangle wave can be measured and should provide approximately a half supply reading, in this case about 5V. If your meter can read a AC volts at 1kHz, then the meter can be set to read ACV. The reading will be around 1.5ACV.

Similarly, when the multimeter is set to read DC volts the pulse width drive can be checked. On the output of IC1a at pin 7, the DC volts should be adjustable from 0V to close to 11V when VR1 is altered from minimum to maximum. The same voltage range should be available at the pin 4, pin 12 and pin 15 output of IC2. A slightly lower voltage range will be available on the gate of Q1.

If the gate voltage remains at 0V, then suspect a damaged IGBT, a shorted ZD2 or open circuit 10Ω resistor.

Measuring the resistance between IGBT pins is a simple way to check it. If there is a short circuit between collector and emitter, or if the gate is shorted to the emitter, then the IGBT is faulty.

Diode (D1) operation can be checked using the diode test on your multimeter. In any case there should not be a short circuit measured between anode and cathode.

Be sure to remove the 12V supply and replace the lid before reconnecting to the mains.

Incidentally, **do not try to monitor the waveforms with an oscilloscope unless you know exactly what you are doing.** Ideally it needs with a scope with true differential inputs or a mains isolation transformer. The waveforms in Fig.7 can only be measured using a low-voltage DC supply, as detailed above.

You must not connect the earth terminal of a scope probe to any part of the circuit.

If you do, you are likely to cause severe damage to the circuit and possibly to the scope as well!

For the earthing, solder two earth wires from the IEC connector with one terminating to the earth eyelet and the other running to the power outlet earth terminal. Another green/yellow earth wire runs between the earth connection on the power outlet and the earth eyelet on the lid. The earth eyelets are secured with M4 screws, a star washer and nut.

Wire up the potentiometer, again using 250VAC rated wire. The reason for voltage rating this is to ensure that in the worst-case scenario and a mains-voltage-carrying wire lets go inside the case (eg, it unsolders due to heat), a bare end contact with one of the pot wires will not allow mains to "punch through" lesser-rated wire insulation.

Finally, hold the wiring in place using cable ties as shown – also to minimize the possibility of loose wires contacting something they shouldn't.

Note that the Active and Neutral wires running to the GPO socket should not be allowed to lie near to the potentiometer wiring. Instead have these wires lie on the Q1 side of R1 when the lid is closed. Failure to observe this wiring arrangement may cause the controller to power the motor with sudden bursts of speed.

This is to minimise the possibility of the high voltage switching signal on the Neutral wire being induced into the potentiometer wiring.

Testing

Before you power up the circuit, insert the ICs into their respective sockets, taking care with their orientation. Set trimpot VR2 to its mid-position – this setting should give good performance with most motors.

Now, check all of your wiring very carefully against the overlay and wiring diagram. Also check that the case and lid are connected to the earth pin of the power socket.

If you are satisfied that all is as it should be, screw the lid onto the case.

Do not be tempted to operate the Drill Speed Controller without the lid in place AND screwed in position – it's not worth the risk.

The easiest way to test the circuit operation is to connect a load such as an electric drill. Apply power and check that you can vary the drill speed with VR1. Some motors may require adjustment of VR2 for best speed regulation, which must be done on a trial-and-error basis. Disconnect power from the mains wall outlet (or unplug the IEC connector) before removing the lid, adjust VR2 very slightly and replace the lid.

In practice, if VR2 is adjusted too far clockwise, the motor will tend to be overcompensated when loaded and will actually speed up. It may even hunt back and forth between a fast and slow speed. If this happens, readjust VR2 anticlockwise for best results.

If you are using a drill for example, at fairly low speed, the motor should not slow down by much as you put a reasonable load on it.

At the risk of sounding repetitive, remove the plug from the mains outlet before making any changes to VR2 and replace the lid before reconnecting power. SC

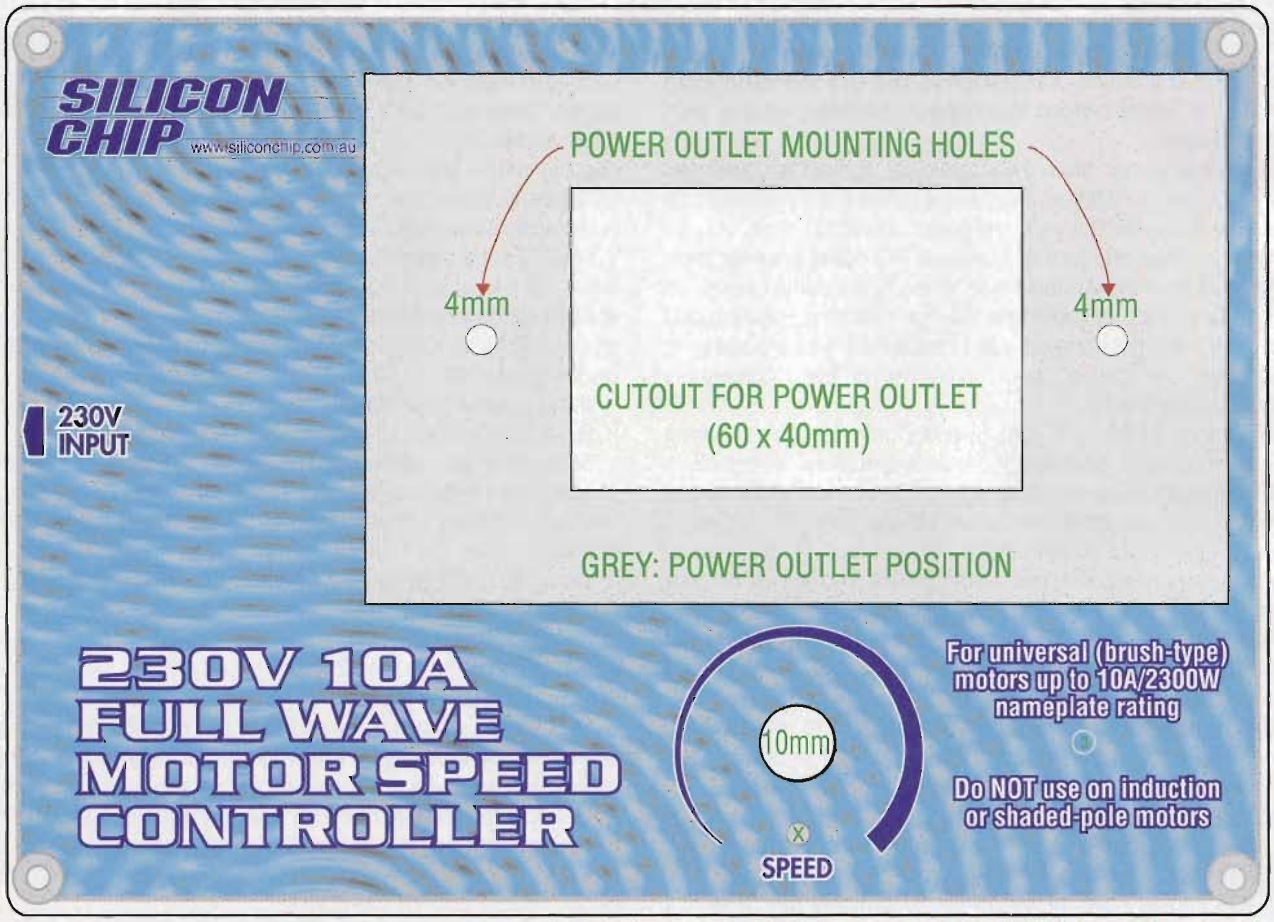


Fig.13 : same-size artwork for the front panel. A photocopy of this can also be used as a drilling/cutting template.

x: 3mm pot locating hole drilled from lid underside – does not need to go all the way through lid.

SERVICEMAN'S LOG

PCs – the real meaning of eternity

They used to say that God invented cricket to teach Englishmen the meaning of eternity. Personally, I think that this could also easily apply to PCs. Certainly, I've had my fair share of problems with them over the years.

Items Covered This Month

- PowerMac G4 M8570
- Bosch Capacitor Discharge Ignition Box
- Conia CLCD1930 DVD LCD TV-DVD Combo
- 1966 Tandberg Series 6X Reel-to-Reel Tape Recorder
- Samsung LA32R51B TV set

I have dabbled with PCs using Microsoft Windows for more years than I care to admit. And as time has gone on, I have found hardware and software problems increasingly difficult to resolve but perhaps that's just me. "Help" is a dirty word in the computer industry and engaging technical support is often a good way to waste a good chunk of your life. It really is quite surprising how often the problem is "a third party issue".

Many people are now taking their courage in both hands and moving to Linux. It's not only free but comes with a wide range of applications and provided it's properly set up, is very secure when it comes to browsing the Internet.

In my case, I have been moving slowly but inexorably towards Apple Mac which I find works extremely well. Unfortunately, most Macintoshes are expensive if you buy new but there are plenty of good secondhand units on eBay, etc.

The minimum requirements are a G4 motherboard with a 1GHz processor, 512MB of RAM, a decent hard disk drive, a DVD player and Operating System 10 (OSX). This operating software line started in 2001 with OSX 10.0 Cheetah and has progressed through to the current OSX 10.5 Leopard.

The number of Macintosh models can be very confusing but you can find out about your particular machine if you enter its serial number into the Apple Support Website. Alternatively, you can download a program called "MacTracker".

One of my favourites is the 2002 PowerMac G4 M8570 with Mirror Drive Doors. This model comes well-featured, with plenty of options and accessories available. Some even come with a dual processor and they can also use Bluetooth keyboards and mice (by adding an optional card), as well as WiFi with Airport and Airport Extreme cards.

Recently, I encountered two of these models that wouldn't boot. When you pressed the power button they would light up momentarily but that was then followed by lots of nothing!

By unplugging everything in sight, I soon deduced that it was the power supply that was at fault. Of course, at this juncture, technical support would tell you to go and get a new one which costs a motza. That's the main problem with a Mac – if it fails, repairs can be expensive.

In view of this, I decided to give it a go. To remove the power supply, you open the side of the computer with a ring tab and unscrew the Phillips-head screw on the opposite wall inside. Then you unscrew the chrome hex screw on the rear panel. The power supply will then slide forward and then out.

You then have to unplug P1 from the motherboard and the power leads to the DVD player and hard drives.

The power supply is a Samsung P58 (Apple p/n: 614-0224) PSCF-401601B(C) Rev A. To switch it on, you have to connect the green lead (pin 11) of P1 to the black lead (pin 12). A quick check showed that the only voltages available were the 5V and 25V standby rails on pins 1 (violet) and 14 (white) respectively.

To dismantle the power supply, you first remove the cover. The PC board is then removed by undoing a further three brass screws and unplugging the twin fans and the power lead. It can then be lifted clear by squeezing the plastic clip in the centre of the board.

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~"HELP" IS A DIRTY WORD IN THE COMPUTER INDUSTRY & ENGAGING TECHNICAL SUPPORT IS A GOOD WAY TO WASTE A GOOD CHUNK OF YOUR LIFE...

The soldering wasn't exactly brilliant but there didn't appear to be any dry joints. However, just to make sure, I resoldered any that looked even remotely suspect.

My suspicion was that the problem was due to failing electrolytic capacitors. There are about 20 of these on the board and some of these are difficult to access without further disassembly. However, I figured that the more difficult they were to access, the more likely it was that the fans couldn't cool them. And that in turn meant that these were the ones that were most likely to be faulty.

In this power supply, you have to remove a sub-board in the primary circuit to gain access to these parts. There are five capacitors involved: three on the main board (C139 56µF 35V, C141 47µF 25V and C137 56µF 35V) and two on the sub-board (C129 22µF 50V and C130 10µF 50V).

I replaced all these, along with C207 (470µF 16V) for good measure, and then reassembled the unit and plugged it in. That fixed the problem and a few quick checks on the old parts revealed that C139, C141 & C137 were all well down in capacitance.

Changing the same capacitors in the other power supply got it going again too.

Bosch CDI for a Porsche

Included amongst the potpourri of the stuff that I fix are assorted car computers and other automotive gadget controllers. These invariably come in from nearby workshops and are usually simply marked "faulty". More often than not, I don't know the fault symptom and sometimes I don't even know the exact function of the device unless I contact the mechanic.

Because they're made to such a high standard, dry joints are unlikely in such equipment. However, they do happen, especially around relay terminals and crystals. Liquid damage and corrosion are rare too, as the PC tracks are covered with a thick lacquer. However, if a module has been submerged or had liquid drip into its housing, then it's not unusual for trouble to occur around multi-way plug connectors, often just where you can't reach!

The most common problem is leaky electrolytic capacitors. Unfortunately, these can be difficult to replace because the boards are multi-layer. In addition, the protective lacquer can make it difficult to remove faulty parts and suck out the residual solder inside the holes.

If a capacitor has been leaking, then the electrolyte has to be cleaned up and any damaged tracks repaired. In such cases, I use a glass-fibre pen to scrape the lacquer off the track, along with any corrosion. The board is then cleaned and the tracks coated with a layer of solder to strengthen and protect them. If a track has broken, then this also involves fitting a wire link to serve as a bridge.

Because you are usually unable to test the module on the spot, you have to err on the side of caution and treat everything with suspicion. This often involves replacing some parts unnecessarily but that's better than having the unit come back.

Recently, I was given a Bosch capacitor discharge ignition (CDI) box (Part No. 0 227 300 004) which I later discovered was from an early (1970) Porsche 911. The message attached to the box said that it was "running at the wrong speed", whatever that meant.

Undoing four screws removes the top cover and exposes the PC board. The whole device was built like a brick outhouse and it used conventional discrete components. Unfortunately, no circuit diagram was available, nor could I find one on the Internet.

I picked the brains of several colleagues and the consensus was that it was likely to be a capacitor and/or the SCR that was at fault. As a result, I started with the only electrolytic capacitor in the box (C2) and also



two high-voltage capacitors – C1 (1µF 250V) and C8 (unmarked). However, I could not fault them.

C8 measured 1.4µF on my capacitance meter. This is the capacitor that feeds the ignition coil in the car so I decided to replace it. After a lot of thought, I selected a 1.5µF 400V polyester type and fitted it in place.

That involved first disconnecting about 20 leads and removing the PC board. It also involved drilling out the rivet that held the original clamp and then gluing the new capacitor to the case.

While I had the board out, I did some DC measurements and used a Digital Analyser to check the semiconductors. First, I checked TO-3 NPN power transistor T1. This is marked RCA H8146 61019 but I could not find this in my reference books or on the web. Fortunately, it measured OK, with an h_{fe} of 45. Similarly, the stud mounted SCR (Th1) measured OK too.

Without a circuit or a car to try it on, I sent it back for testing but it boomeranged within a few days with the same complaint. I must say that I really wasn't all that keen to fix this CDI unit but I was persuaded that it was really important as replacements were not locally available. Instead, it would mean sending this CDI to America for an exchange unit, which would not be cheap. US freight costs are extremely expensive.

At this stage, there was nothing for it but to trace out the complete circuit. I did this in stages, first drawing a picture of the component side and then the track side of the board. From there, I was able to start drawing the interconnections and after an awful lot of drawing and redrawing, I eventually came up with the complete circuit diagram. I was then able to figure out how the circuit worked.

Now that I had the circuit, I decided to mock the unit up on the bench with a distributor and a coil so that I could tell whether the unit was working or not. Before doing that though, I connected a 12V portable battery to the unit and found that I could hear a loud whistle from transformer T1. I also measured +436V on the cathode of D7, so that meant that the DC converter stage was working. I then poured some super glue into the winding former in an attempt to reduce the noise but it made no difference.

The workshop that sent the unit in lent me a compatible distributor so that I could apply the correct switching waveform to the pickup sensor (via pin7 of the plug) but no matter what I did, it was obvious that the SCR (Th1) wasn't firing. However, DC measurements showed that the correct supply rails were supplied to each stage, including the +6.8V set by ZD2.

Next, I discovered that the front-end Darlington pair (T2 & T3) were functioning correctly but T4 was not responding. To switch it on, I had to bias its base to ground with an 8.2kΩ resistor. So what was going on?

By now, I had checked just about every component in the unit except the yellow WIMA polyester/polycarbonate capacitors. I can honestly say that I can not recall ever having had a failure in this type of capacitor but in this case, the evidence was pointing at one or all of them.

As a result, I removed C4 (15nF), C5 (10nF) and C6 (10nF) and installed new ones. And that was it. Running the distributor now produced a very

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The faulty Bosch CDI unit was rigged up on the bench with a distributor & coil so that it could be tested. The problem took a lot of man-hours to track down.

healthy spark which was a huge relief to all concerned.

Vintage tape recorder

Amongst all the stuff that comes into the workshop there is a smattering of vintage restoration. Once such item was a 1966 Tandberg Series 6X reel-to-reel hybrid tape recorder. This one didn't look too bad for its 43 years but the mechanics weren't working.

The reason for this was quite simple – the pinch roller was badly perished and the main belt had broken in several places.

I managed to purchase a scanned copy of the service manual via the web and this gave me the part numbers. Unfortunately, the only place I could get a new pinch roller from was the US. This was a high-precision unit but the cost was US$85 plus US$35 for overseas shipments. That worked out to be about $A170 for one lousy pinch roller!

My client, Stephen, is a farmer by trade and really couldn't justify this cost, so we looked around for alternatives. He is a resourceful chap and finally came around to the idea of making one himself.

The first thing he had to do was find the right sort of material. He initially tried rubber mallets (too hard) but then, after a good look around, came up with a rubber doorstop.

Because of its softness, rubber can be a difficult substance to shape using ordinary tools. However, he solved that problem by freezing it, which made it harder and thus much easier to work with. He did this by placing it in the kitchen freezer overnight. Then, by using a canned pressure-pack freezer, he was able to keep the rubber cold enough to shape it into the roller's correct dimensions and drill a hole so that it fitted the original shaft snugly.

The result was quite good and it was left to me to refit the new pinch roller into the Tandberg. As it turned out, this was one of the most difficult pinch roller replacements I have ever done and I lost quite a lot of hair fitting it.

The next problem was obtaining a 600mm-long 3.5mm-diameter round belt. In the end, Stephen found a source of O-ring vulcanised rubber and purchased a length just over 600mm long. He then cut it to size, rested the ends in the groove of a piece of wood and used superglue to connect the clean cut ends together in a butt joint. This was left to set for 12 hours and this again produced a good result.

Refitting the belt restored the mechanical operation of the old Tandberg which then functioned normally.

The grey nomad

A "grey nomad" brought in his dead Conia CLCD1930 LCD TV-DVD Combo unit when his campervan made a pit-stop in our neighbourhood. He was mumbling something about someone connecting the wrong DC power lead to it. However, he wasn't very specific and I got the impression that it was a subject best avoided – at least in front of his wife.

My immediate thought was that the ring-in lead had probably reversed the polarity at the DC plug and that this had killed it. I kept this to myself though, since there was really no way of knowing until I opened it up.

This unit is a bit messy to disassemble, since the LCD panel in one section of the cabinet and the rest of the set is assembled into the other half. When I connected a 12V supply, nothing was happening. However, I could measure 12V into the main board but there was no 5V rail. That was my first clue.

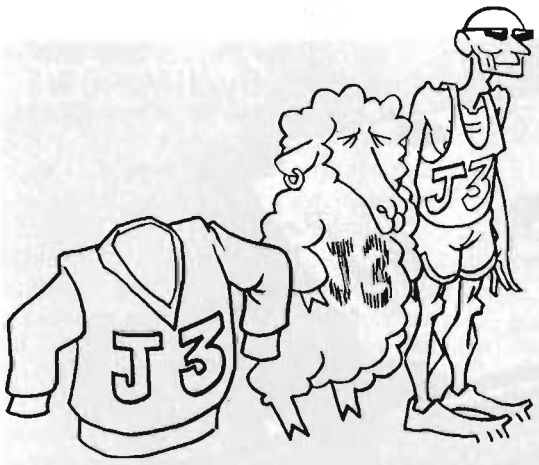
I traced the 12V rail to two 5V DC-DC converter ICs (U3 and U13). These are 8-pin sub-miniature surface-mount ICs (ACT4080SH). Unfortunately, I wasn't able to find any data on these chips but you didn't need to be Einstein to figure out that they were stuffed. There were tiny cracks or holes in their bodies, so they definitely needed replacing.

Next, I checked out the inverter power supply board and found that the surface-mounted fuse F1 was open circuit. This was linked using a thin strand of copper wire. I also checked the DVD player circuitry but that looked OK.

Having got that far, I tried in vain to hunt down substitutes for the DC-DC converters. However, not only could I not find any but I couldn't even discover their pin connections. Eventually, I did find an email address for Conia spare parts and managed to order a new motherboard for the TV.

When it arrived I fitted it and switched it on. The fluoros all lit up and the remote control switched the red standby LED to blue but there was no picture, no sound and no DVD playback. Furthermore, there was an alarming hissing noise coming from the SVA display panel, as though it was arcing.

I initially suspected the inverter power supply for the backlights as they operate at high voltage but then I discovered that the arcing noise ceased when I disconnected the 30-pin J7 data plug to the display panel itself. There are no high voltages on this connection, yet the rustling/arcing noise was on the display driver panel.



REPLACEMENT JUMPERS

Things were looking bleak. It was beginning to look as though the real problem might be the display itself, in which case I had badly misdiagnosed.

It was while I was mulling over all the things that might have got wrong that I noticed a small difference between the replacement board and the original. On the replacement, there was a row of jumpers marked J1-J3 which allowed you to select +5V, +12V and +3.3V and this one was set to 3.3V.

By contrast, the original board had only a soldered link to select +5V. I moved the jumper on the new board to +5V and reconnected all the other leads before switching the set on again. The arcing noise was now gone and much to my relief, a picture quickly appeared.

When I retuned the set, the sound followed suit. And as I quickly discovered, the DVD player also worked when it was selected in the menu.

Samsung LA32R51B

Last month I wrote about a Samsung LA32R51B TV with a blown power supply. The two main electrolytic capacitors (CP823 & CP824) would literally explode after the set had been on for about 30 minutes.

Apart from the first time when collateral damage ruined the PF9001 24V controller IC for the backlight inverters, any subsequent damage was limited to these two main electros and the 6.3A main fuse. I initially attributed the problem to the voltage-doubling circuit but subsequently discovered that it was the power factor control circuit that was the culprit.

To prove this, I decided to remove this circuit or at least part of it. The circuit consists of a 45A 600V UFS Series N Channel IGBT Mosfet strapped across the +350V rail. This Mosfet is controlled by IC802S (ICE1PCS02) which is fed +15V and monitors the current in the +350V rail. I figured that removing the IC would prevent the Mosfet from switching on.

Unfortunately, I was wrong because the Mosfet promptly blew up! As you can no doubt appreciate, I was by now somewhat nervous of these loud bangs. Anyway, I removed the Mosfet and then ran the set, monitoring the +350V rail for about 12 hours. I then replaced the Mosfet, the control ICs and four small electrolytic capacitors around IC802S.

That finally fixed the problem. SC

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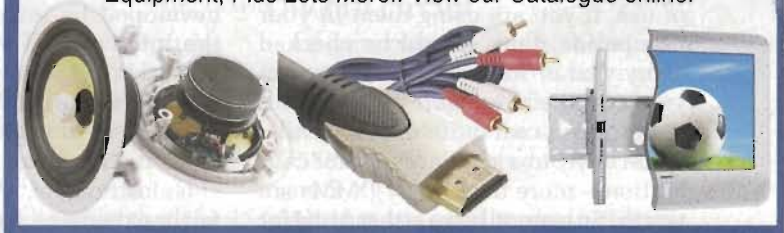
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By JIM ROWE

Precision 10V DC reference for checking DMMs

Have you ever checked the calibration of your digital multimeter? Yeah, we know – you haven't because there is no easy (read cheap) way of doing it. But now you can with this precision DC voltage reference that can be built in a few hours. Without any need for adjustment it will provide you with a 10.000V DC source accurate to within ±3mV, ie, an accuracy of ±0.03%.

MOST OF US DON'T ever get our DMMs calibrated, though they do drift out of calibration over years of use. If you are using them in your occupation, they should be checked every year or so – otherwise how can you trust the readings?

But it can cost quite a bit to send a DMM away to a standards lab for calibration – more than many DMMs are worth. So generally we either hope for the best or simply buy a new DMM if we suspect that our existing meter has drifted too far out of calibration.

Back in the 1970s when DMMs first became available, the only practical source of an accurately known DC voltage was the Weston cell, a wet chemical "primary cell" which had been developed in 1893 and had become the international standard for EMF/voltage in 1911 (see panel). It produced an accurate 1.0183V reference which could be used to calibrate DMMs and other instruments.

Unfortunately, Weston cells were fairly expensive and few people had direct access to one for meter calibration. As a result, most people tended to use a reasonably fresh mercury cell as a "poor man's" voltage reference. Fresh mercury cells have a terminal voltage very close to 1.3566V at 20°C and this falls quite slowly to about 1.3524V after a year or so. Silver oxide cells can also used for the same purpose, having a stable terminal voltage very close to 1.55V.

Of course, batteries of any kind have a tendency to obey Murphy's Law and usually turn out to have quietly expired before you need them. And although mercury and silver oxide cells have quite a long life, especially if you use them purely as a voltage reference, they certainly aren't immune to this problem. Which means that these batteries make a pretty flaky

voltage reference, at best.

Fortunately, in the 1980s semiconductor makers developed a relatively low-cost source of stable and accurately predictable DC voltage: the precision monolithic voltage reference (PMVR). This is a kind of up-market relative of the familiar 3-terminal voltage regulator IC. Like 3-terminal regulators, PMVRs produce a regulated DC output voltage when they are fed with unregulated DC power.

The Analog Devices AD588 device we're using in this new voltage reference project incorporates a number of recent advances in PMVR technology. These include an ion-implanted "buried" zener reference diode plus high-stability thin-film resistors on the wafer, which are laser trimmed to minimise drift and provide high initial accuracy.

It also incorporates highly stable on-chip op amps which are configured to allow Kelvin connections to the load and/or external current boosters, for driving long lines or high current loads.

Block diagram

You can see what's inside the AD588 in the block diagram of Fig.1. The voltage reference cell is at upper left, consisting of the "buried" zener (6.5V) and its current source together with op amp A1. All the resistors (R1-R6) are high-stability thin-film resistors, laser trimmed to allow the gain of A1 to be set to a high degree of precision – so the cell's basic output voltage (between pins V_{HI} and V_{LO}) is initially set to 10.000V ±3mV (for the AD588JQ/AQ version we use here), without any external adjustment.

Temperature compensation inside the cell also gives the basic voltage reference a very low temperature drift coefficient: typically ±2ppm/°C. In addition, resistors R4 and R5 can be configured to provide a very accurate "centre tap" for this voltage, allowing the chip to be used as a precise source of ±5.000V ±1.5mV.

Although this basic untrimmed initial accuracy of the AD588 (10.000V ±0.03%) is quite good enough for calibrating the majority of low-cost DMMs, the chip can also be trimmed very easily to improve its accuracy by a factor of greater than 10 times – ie, to an accuracy around ±0.002%.

This is done by connecting the GAIN ADJ pin to a 100kΩ trimpot, connected between the V_{HI} and V_{LO} terminals. The pot allows the gain of A1 to be adjusted for a very small output voltage range (approximately -3.5mV to +7.5mV) without any adverse effect on temperature stability. Of course, in order to take advantage of this trimming feature, you must have access to an even higher precision voltage reference, to compare it with.

Op amp A2 is used to allow accurate "ground sensing", ensuring that the external system ground is accurately held at the same potential as V_{LO}. And op amps A3 and A4, which are internally compensated, are provided to act as output buffers for the V_{HI} and V_{LO} voltages, as well as providing for a full Kelvin (ie, remote sensing) output connection.

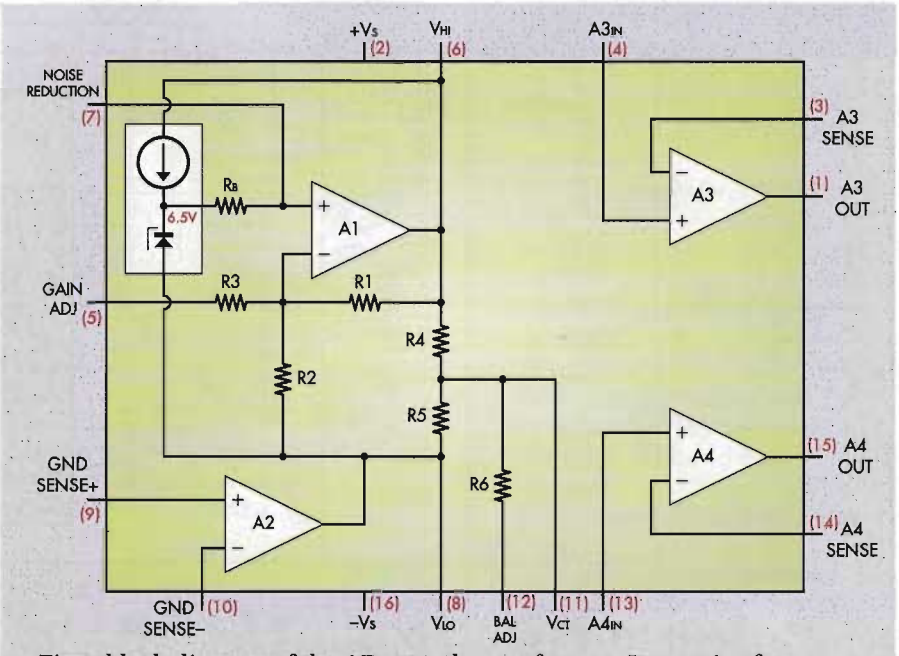


Fig.1: block diagram of the AD588 voltage reference. It contains four op amps (A1-A4) plus a "buried" zener and its current source to provide the voltage reference cell.

Specifications

Output voltage: 10.000V DC

Sensing: internal or remote sensing to compensate for output cable voltage drop

Basic accuracy: ±0.03% (±3mV) without adjustment, ±0.002% after optional trim adjustment and calibration

Long term drift: <15ppm per 1000 hours, mostly in first year of operation

Temperature coefficient: 3ppm/°C between -25°C and +85°C

Maximum output current: 10mA

Noise on output: less than 6mV RMS

Load regulation: less than ±50μV/mA for loads up to 10mA

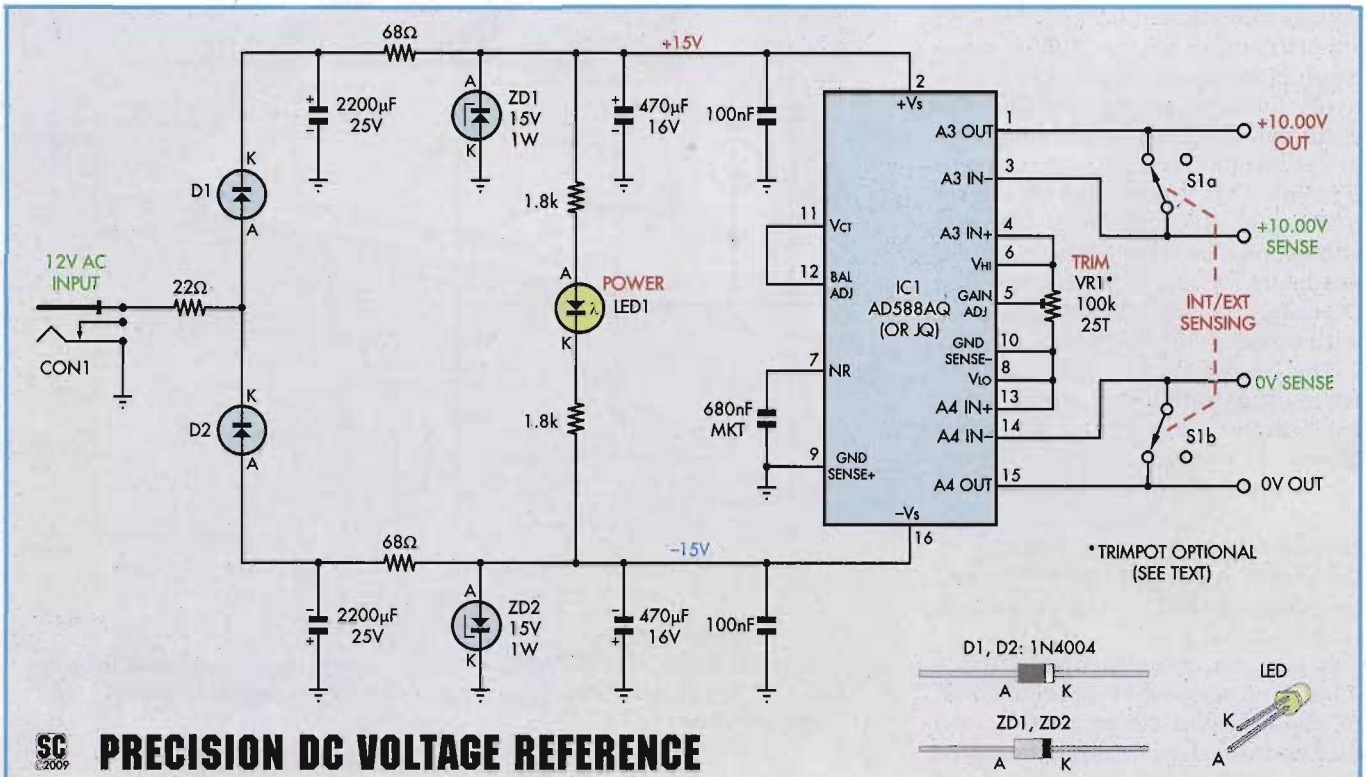
Supply line regulation: less than 200μV/V

Power supply: 12V AC, current drain <60mA

The full circuit

As you can see from the circuit schematic of Fig.2, there's not a great deal in our new precision voltage reference apart from the all-important AD588 chip (IC1). This does just about everything.

All that we need to do in the rest of the circuit is provide it with a moderately regulated and filtered power source of ±15V and also make its buffered output voltage available, either at the main local terminals or at



PRECISION DC VOLTAGE REFERENCE

Fig.2: the circuit uses the AD588 precision voltage reference (IC1) and not much else. Diodes D1 & D2 function as half-wave rectifiers and feed zener diodes ZD1 & ZD2 to provide ±15V rails for the IC.

the end of a cable connecting a remote load to them.

The power supply configuration is quite straightforward and uses a half-wave rectifier circuit to produce each DC supply rail from a 12V AC input (which can be a 12V 500mA AC plug-pack). Diodes D1 & D2 form the rectifiers, with filtering provided by two 2200µF electrolytic capacitors. Zener diodes ZD1 and ZD2 (both 15V types) then provide moderate regulation for the two supply rails, in conjunction with the two 68Ω series resistors.

A small amount of additional filtering is provided by two 470µF electrolytics, together with 100nF bypass capacitors at the supply pins for IC1. Note that power indicator LED1 is connected directly between the two supply rails, in series with two 1.8kΩ current-limiting resistors.

The connections for IC1 itself are fairly easy to follow. The 680nF capacitor connected to ground from the NR pin (7) is included to provide additional low-pass filtering of any noise generated by the AD588's buried zener. It works in conjunction with series resistor RB, as shown in Fig.1.

Op amp A3 inside IC1 is used as the positive voltage output buffer, with its non-inverting input (pin 4) connected directly to V_{HI} (pin 6). The inverting input (pin 3) is brought out to the external positive sense terminal (for remote sensing) and also to S1a, which allows it to be connected directly to the positive output (pin 1) for local sensing.

Op amp A4 is connected in the same way, as the negative output voltage buffer. Here, the op amp's non-inverting input (pin 13) is connected directly to the reference cell's V_{LO} output (pin 8), while the inverting input (pin 14) is brought out to the negative sense terminal for remote sensing and also to S1b, to connect it directly to the negative output (pin 15) for local sensing.

So what is the purpose of the "optional" trimpot VR1? That is for trimming the AD588's output voltage

What This Voltage Reference Cannot Do

While this 10V DC reference is very handy if you want to check the DC accuracy of your digital multimeter, it cannot tell you anything about your DMM's accuracy in its other modes such as DC and AC current, AC voltage and resistance. So just because you have done a simple check on the DC voltage accuracy, don't let it lull you into a false sense of security that everything is well with your DMM.

In fact, it is possible that this 10V DC reference may alert you to the fact that your DMM has drifted well away from its initial calibration which may have been pretty good when you purchased it. How many years ago was that?

If you are using DMMs in your occupation, they should be calibrated every year or so, otherwise you cannot really trust the readings. Moreover, if you have dropped your multimeter, it definitely should be suspected, particularly if its internal calibration is performed by tweaking potentiometers. Let's face it, most DMMs get dropped from to time – that's just normal.

If you need a full performance verification of all functions and ranges for your work then that is best performed by an accredited calibration laboratory.

For information and a quote on DMM calibration, contact Trio-Smartcal on 1300 134 091. **www.triosmartcal.com.au**

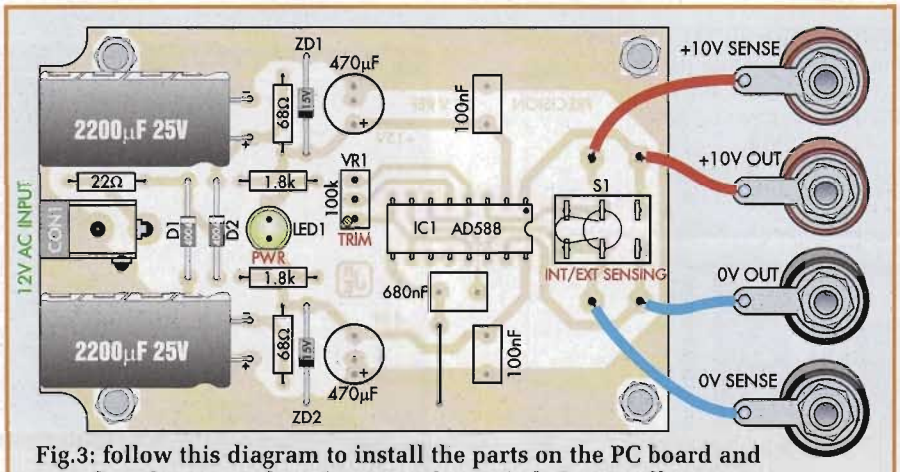
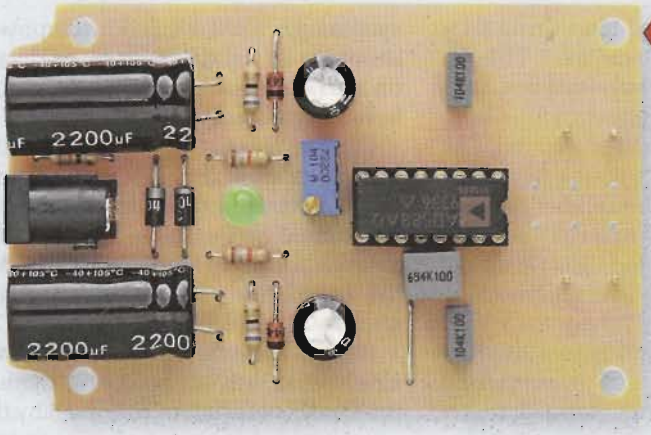


Fig.3: follow this diagram to install the parts on the PC board and complete the external wiring. Note that switch S1 actually mounts on the lid of the case and not directly on the PC board – see text.



This view shows the completed PC board with the optional trimpot (VR1) in position. Install VR1 only if you intend calibrating the unit against a high-precision 10V reference.

to higher precision than its "out of the box" ±3mV rating. We have made provision for the trimpot to be added to the PC board for this purpose but there is no point in fitting the trimpot unless you have access to a very high precision 10V reference.

AD588 availability

That's about it regarding circuit operation. However, before we move on to discuss the project's construction, a quick word about versions of the AD588 chip and its availability.

Analog Devices apparently make five different versions of the AD588, one in a small outline (SOIC-W) SMD package and the others in 16-pin ceramic DIL packages. The four CERDIP devices have different initial error, temperature range and temperature coefficient values. They range from the AD588BQ with 1mV of initial error, a -25°C to +85°C range and 1.5ppm/°C tempco down to the AD588JQ with 3mV of initial error, 0-70°C range and 3ppm/°C tempco. The AD588BQ is the most expensive (as you would expect), while the AD588JQ is the least expensive.

None of the versions of the AD588 seems to be readily available in Australia, especially in one-off quantities. However, we were able to find one supplier who was able to supply the mid-range AD588AQ version (3mV max initial error, -25°C to +85°C range and 3ppm/°C tempco) for A$28.50 each (at the time of writing) plus postage. The supplier concerned is Futurlec, which is based in Broadmeadow NSW but does all of its business via the web.

So Futurlec is our recommended source for the AD588AQ. You can order this part via their website at www.futurlec.com (item number AD-588JN).

Parts List

1 diecast aluminium box, 111 x 60 x 54mm (Jaycar HB-5063 or similar)
1 PC board, code 04305091, 84 x 53.5mm
1 DPDT on-on mini toggle switch (S1)
1 2.5mm PC-mount DC power socket (CON1)
1 16-pin machined IC socket
2 binding post terminals, red
2 binding post terminals, black
4 M3 x 25mm tapped metal spacers
4 M3 x 6mm screws, countersink head
4 M3 x 6mm screws, pan head
1 100kΩ 25T top adjust trimpot (optional – see text)
1 150mm length blue hookup wire
1 150mm length red hookup wire
1 100mm length 0.7mm tinned copper wire

Semiconductors

1 AD588AQ or AD588JQ voltage reference (IC1) – available from Futurlec (see text)
2 15V 1W zener diode (ZD1,ZD2)
1 5mm green LED (LED1)
2 1N4004 1A diodes (D1,D2)

Capacitors

2 2200µF 25V RB electrolytic
2 470µF 16V RB electrolytic
1 680nF MKT metallised polyester
2 100nF MKT metallised polyester

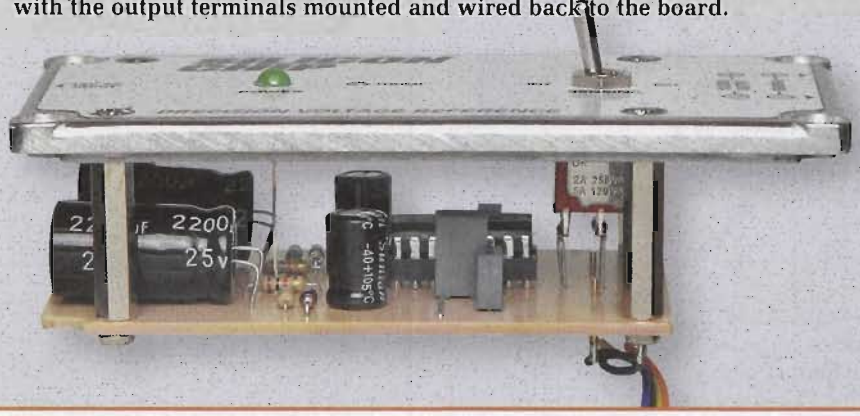
Resistors (0.25W 1%)

2 1.8kΩ 1 22Ω
2 68Ω

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	1.8kΩ	brown grey red brown	brown grey black brown brown
❑	2	68Ω	blue grey black brown	blue grey black gold brown
❑	1	22Ω	red red black brown	red red black gold brown

Below: the PC board is "hung" off the lid of the case on M3 x 25mm tapped metal spacers and secured using M3 x 6mm screws. Note the "extension" leads attached to the switch terminals. At right is the view inside the case with the output terminals mounted and wired back to the board.





If you want to build the unit with the highest possible precision and performance, this can be done by using the BQ or KQ versions of the AD588. You may be able to order these from Futurlec but be warned: the BQ version is considerably more expensive than the AQ version we have specified and the KQ version is probably much more expensive as well.

Construction

Apart from the output terminals, virtually all the components are mounted on a single PC board measuring 84 x 53.5mm and coded 04305091. This fits inside a diecast aluminium box (111 x 60 x 54mm), which provides both shielding and physical protection. The output and remote sensing terminals are all mounted on one end of the box, while the internal/external sensing switch (S1) is mounted directly on the lid, with short wire leads connecting it to the PC board – see photos.

The PC board itself is mounted on the back of the lid and is supported via four M3 x 25mm tapped metal spacers. Unlike switch S1, the power indicator LED (LED1) mounts directly on the board and protrudes through a hole in the lid.

Fig.3 shows the parts layout on the PC board and the external wiring. Note that trimpot VR1 is optional, as mentioned earlier. Note also that IC1 should not be soldered directly into the board but plugged into a high-quality 16-pin DIL socket.

Begin the assembly by installing the single wire link on the board, then fit the five fixed resistors, followed by the

Voltage Standards: A Brief History

From 1905 to 1972, the national standard of EMF or voltage used by the USA was the Weston Cell, a wet chemical primary cell or "battery" developed in 1893 by Edward Weston, of Newark in New Jersey. Weston had improved on an earlier "voltage standard" cell which had been invented by English engineer Josiah Latimer Clark in 1873. Weston cells were adopted as the International Standard for EMF/voltage in 1911.

Weston's cell had a cadmium-mercury amalgam anode, a pure mercury cathode, a paste of mercurous sulphate as the depolariser and a saturated solution of cadmium sulphate as the electrolyte. It was built in an H-shaped glass container, with the anode at the bottom of one "leg" and the cathode in the other leg. The electrical connections to the two electrodes were made by platinum wires fused through the glass at the bottom of the legs.

The Weston cell provided an accurate 1.0183V reference with a very low temperature coefficient – much lower than Clark's earlier cell. However, like the Clark cell, it could supply virtually no current and could only be used to provide a reference voltage for high-resistance measuring circuits like the classical "potentiometer" (a kind of bridge which compared a known proportion of an unknown voltage against the reference voltage, so no current flowed when the two voltages were "in balance").

Weston cells were used as the US and International standards for EMF/voltage until 1972, when a new standard came into use: the Josephson Junction Voltage Standard (JJVS). This operates on a very different principle: the phenomenon of quantum-mechanical tunnelling currents which flow between two weakly coupled superconductors separated by a very thin insulating layer.

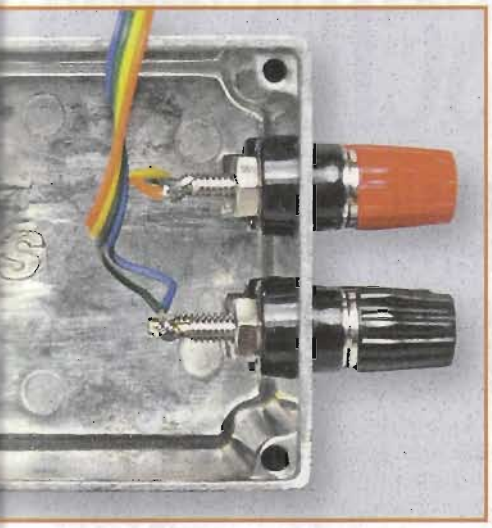
This is known as a Josephson junction and the current is known as the Josephson current – after British physicist Brian David Josephson who had predicted the effect in 1962. An improved version of the JJVS was subsequently developed In the 1980s: the Josephson Array Voltage Standard or JAVS.

By the way, because Josephson junctions and arrays depend on superconductivity for their operation, they must be operated in a liquid nitrogen environment at 77K (-196°C).

Essentially, a JAVS forms a frequency-to-voltage converter, whose conversion factor is exactly reproducible (the agreed figure is 0.4835979GHz/μV). Because frequency can be measured extremely accurately using caesium-beam and caesium fountain standards, the JAVS therefore provides a practical voltage standard of similar accuracy. In fact, the estimated accuracy of current JAVS 10.0V voltage standards is typically quoted as ±0.017ppm.

More information on the Weston Cell can be found in Weston's original US patent (No. 494,827), available on the US Patent Office website.

Further information on the Josephson effect, JJVS and JAVS standards can be found on **http://en.wikipedia.org/wiki/Josephson_effect** and at **http://www.nist.gov/eee1/**



three non-polarised MKT capacitors. The four electrolytic capacitors can then go in. Be sure to orientate these as shown in the overlay diagram and note that the two 2200µF electros are mounted on their side, with their leads bent at right-angles to go through their respective holes in the PC board.

Follow these parts with diodes D1 & D2 and zener diodes ZD1 & ZD2. LED1 can then be installed. It mounts vertically with the bottom of its plastic body about 22mm above the board surface. Be sure to install all these parts with the correct orientation.

If you are going to use optional trimpot VR1, it can also now be fitted. It must be installed with its adjustment screw at lower left (this is to align it with the adjustment hole drilled in the lid).

The PC board assembly can now be completed by installing the DC power socket (CON1) and the socket for IC1. Orientate the socket with its notched end towards the right, as shown in Fig.3. Leave IC1 out for the time being.

Preparing the case

Fig.4 shows the drilling details for the case. Note that the larger holes are best made by using a small pilot drill to start with and then carefully reaming each hole out to its correct size.

Once you have drilled all the holes, mount the output terminals in place and tighten their mounting nuts firmly to prevent them from later coming loose. That done, solder a short length (say 75mm) of insulated hookup wire to the solder spigot at the rear of each terminal, ready to make the connections to the PC board.

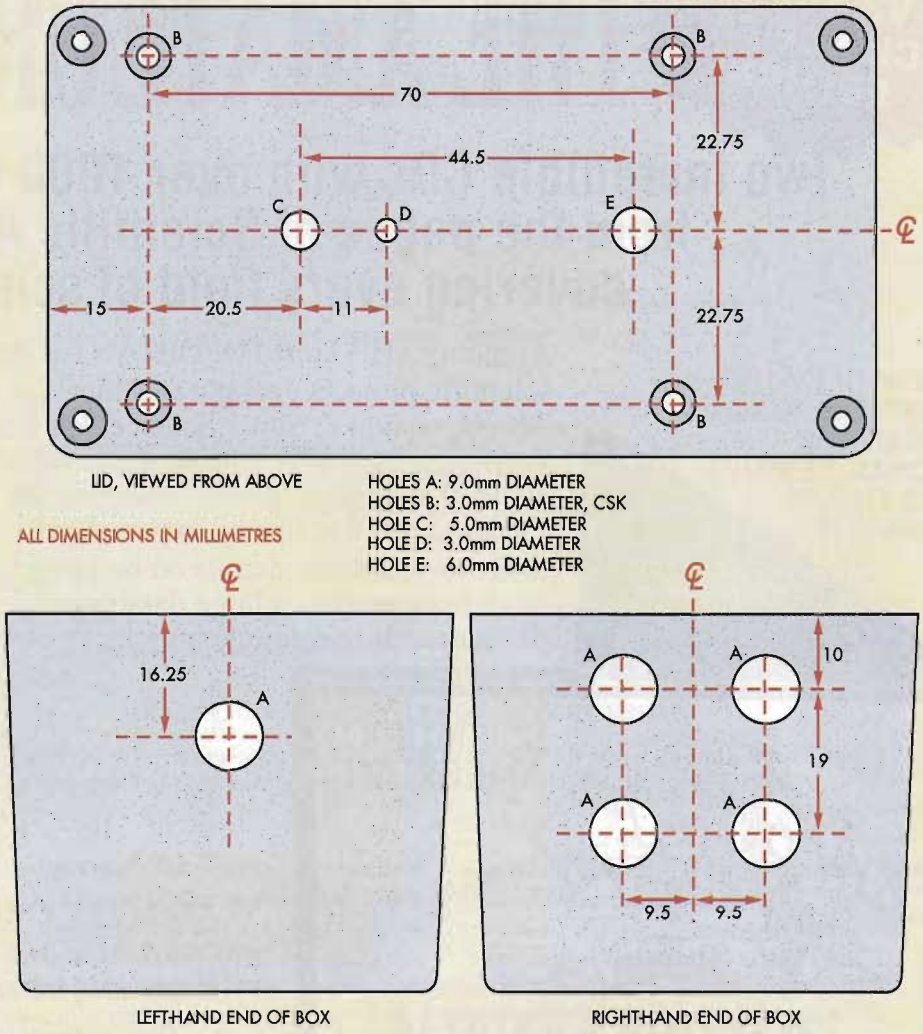


Fig.4: the drilling details for the case. Use a pilot drill to start the larger holes then step the up to the correct size using a larger drill and a tapered reamer.

Next, attach the front-panel label to the lid. This label can be made by downloading the artwork from the SILICON CHIP website, printing it out and then covering it with a protective self-adhesive transparent film. Attach the label using a thin smear of silicone sealant, then cut out the holes using a sharp hobby knife.

Toggle switch S1 can now be mounted in position on the lid. Tighten its mounting nut firmly, then fit six 15mm lengths of tinned copper wire to its connection lugs (these leads later pass through their corresponding holes in the PC board). Loop the end of each wire through the hole in its switch lug before soldering, to make sure these joints can't come adrift when the outer ends of the wires are soldered to the board pads.

The next step is to attach an M3 x 25mm tapped metal spacer to each corner of the PC board. Secure these using four M3 x 6mm pan-head machine screws, then install the leads between the output terminals and their corresponding PC board pads – see Fig.3.

IC1 can now be plugged into its socket. Be sure to orientate it correctly and make sure that all its pins go into the socket – ie, not down the outside of the socket or folded under the IC itself. The PC board can then be attached to the lid.

Note that the extension wires fitted to switch S1 must all pass through their matching holes in the PC board, while LED1 must pass through its corresponding hole (C) in the lid. Secure the board to the lid using four countersink-head M3 x 6mm screws, then solder the six switch leads to their board pads.

The unit can now be completed by

fastening the lid/PC board assembly to the box using the screws supplied.

Using it

There are no adjustments to be made to the Precision Voltage Reference if you don't have access to a very high precision voltage source to calibrate it against. As stated previously, without calibration, it will operate with better than ±3mV precision, as provided by the AD588AQ chip itself.

In that case, it's merely a matter of switching S1 to the internal sensing position and applying power (12V AC) to CON1. LED1 should light immediately to show that the unit is operating and 10.000V ±3mV will now be available at the upper output terminals, ready for checking your DMM or whatever.

This "internal sensing" configuration is the one to use for most simple jobs like DMM calibration, with the DMM input leads connecting directly to the Precision Voltage Reference's upper output terminals.

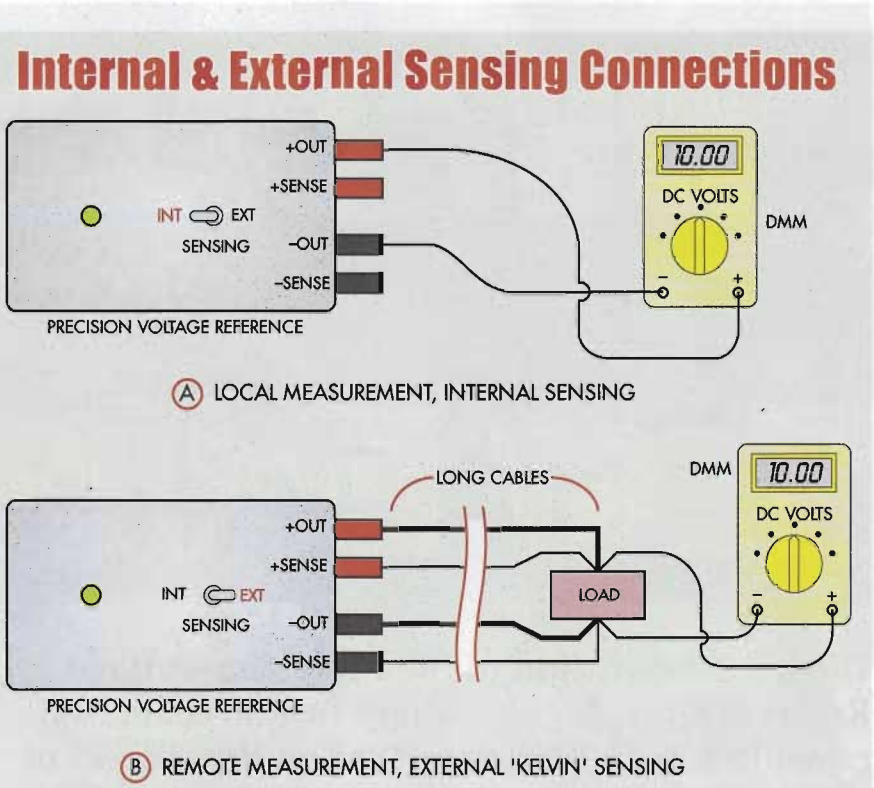


Fig.5: how to connect the Precision DC Voltage Reference for both local (A) and remote (B) measurements (the latter compensates for cable losses).

Cable compensation

The only occasions when it's preferable to use external sensing or "Kelvin connections" will be when you are supplying the unit's voltage to a load at the end of a cable and the load is drawing sufficient current to introduce a significant voltage drop due to the cable resistance.

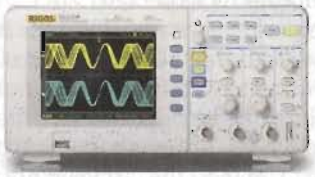
In such situations, you'll need to extend the output sensing terminals of the Precision Voltage Reference to the load end of the cable via a second pair of leads as shown in Fig.5. Then S1 is switched to the external sensing position, so that the AD588 senses the output voltage right at the load end of the cable rather than at its own end. As a result it will maintain the load voltage at the correct 10.000V, compensating for the cable drop.

All of the foregoing also applies if you build the unit with trimpot VR1 and/or use an AD588BQ/KQ for higher precision. The only complication in these latter situations is that you'll need to compare the output of the Precision DC Voltage Reference with a higher precision source and adjust VR1 to trim its output as close as possible to 10.0000V before you can put it to use. SC

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WHY CALIBRATE your TEST EQUIPMENT?

During preparation of the Precision Voltage Reference project elsewhere in this issue, we consulted with Trio Smartcal on the subject of calibration. This article gives a brief overview.

By TONY TONG

You have invested in test equipment to allow you to measure something. It could be a multimeter to measure a power supply voltage, an oscilloscope to measure waveform amplitude or a spectrum analyser to measure RF power at a given frequency, etc. In any of these cases the big question is "how important is the result you get from your test equipment to you and your company?"

Many people consider calibration to be a necessary evil. However the implications and cost of using an inaccurate item of test equipment can be much greater.

For example, let's take a production maintenance technician who is troubleshooting electronic control systems. Typically his multimeter has not been checked since new (several years ago) and has had a hard life in his toolbox, being dropped a few times. It now reads 5% low.

He is checking a control board for the manufacturing line and is checking the 5V board supply which has a tolerance of ±5% but it happens to be faulty and is high by 7%. The board is acting erratically but his meter tells him the supply is OK, comfortably inside tolerance. The technician then spends another four hours looking elsewhere for the problem. Not only does this cost the company money for his time but production has been down for four more hours and this cost the company $40,000 in lost output.

In a recent case here at TRIO Smartcal, we had a customer who was setting up CCTV systems. He owned a well-respected brand of TV signal generator, about three years old. He never suspected it to output anything other than the specified signals. He had set up several hundred systems in the last year and felt that his waveform monitor (not the signal generator) was out of spec because it was not showing the picture he expected.

We performance-verified the monitor and found it was well within spec. It turned out that the signal generator was out of spec instead and he had probably set up every system incorrectly for at least the last year; not what he wanted to hear!

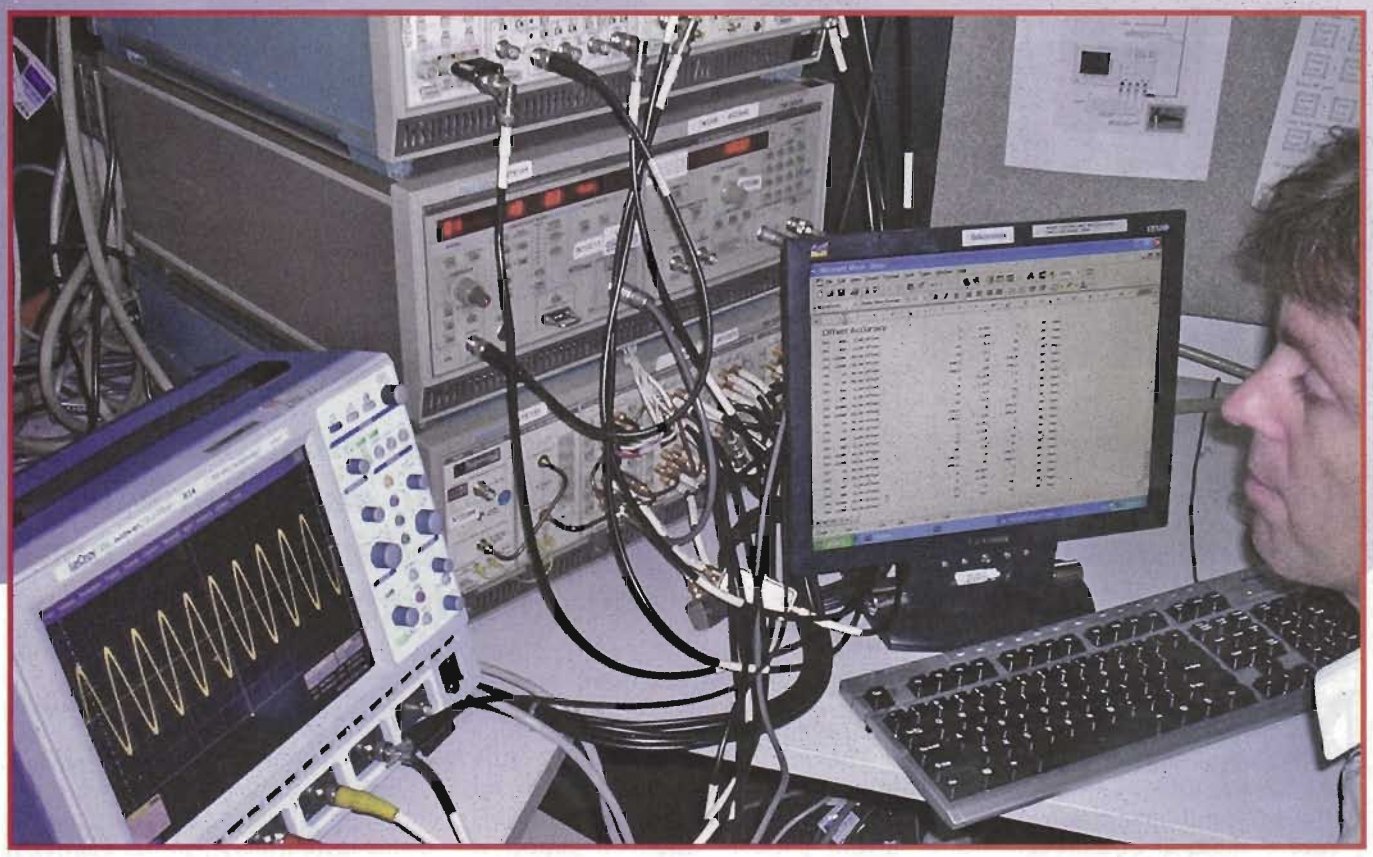
Any measuring instrument should have its performance verified regularly if it is going to be used to measure something that you rely on. And regularly does not mean annually, as many people believe. However most test equipment manufacturers do recommend annual performance verification. The cost of verifying performance and calibrating can be quite small compared to the cost of rectifying problems caused by faulty measurements from inaccurate equipment.

So, how do we minimise the cost of calibration? There are several ways and one or more may be applicable to your situation:

(1) IDENTIFY WHICH items of your equipment need to be calibrated. This sounds obvious but often equipment that has been superseded or not required for current operations is still being calibrated every year, just because no-one has looked into what is required. Items that are not to be calibrated should be labelled "Accuracy Not Verified – Do not use to verify performance".

(2) YOU CAN USE your calibrated equipment to check your non-calibrated equipment, provided that the calibrated equipment specifications are typically 4-10 times better than the un-calibrated item. This is called the Test Uncertainty Ratio (TUR). Measure the parameter with the calibrated equipment and then verify that the non-calibrated units indicate similar readings. This will increase confidence in the non-calibrated equipment without increasing calibration costs. More info on TUR can be found at **http://www.agilent.com/metrology/uncert.shtml**

(3) FIND OUT if your calibration provider offers various levels of calibration and select the best fit for your equipment. If you run a laboratory doing calibration work for your customers or your lab is NATA-accredited, then you will need



a full NATA report. This is an expensive option but you get a test report from an accredited lab.

If you need to comply with ISO9001, then a traceable calibration with data is all you need. For those instruments where you like to know they are within specification but don't need the full traceable calibration with data, then a Performance Verification or "Mini Cal" is a lower cost option.

(4) YOU CAN EXTEND the calibration interval. This applies if you have an instrument which has been calibrated annually for many years with good tracking records to its performance. Then you can make use the past data reports, to identify several key measurements, extract them from the report into a spreadsheet and graph them against the published specification limits. This will allow you to predict the rate of drift.

Armed with this information, you can confidently set extended calibration intervals. An example is a meter with a specification limit of 1% as a 1-year specification. Its initial cal data shows it to be -0.5%, the next cal shows the error to be 0%. The third cal shows the error as +0.5%. Hence, the drift is +0.5% per year so we can expect it to be out of specification at the next calibration interval.

If the drift was only .025%, we could predict six years (from -0.5% to +1.0%) drift and extend the calibration interval accordingly. If you buy an instrument that comes with a factory "cal-report" you already have one of the reference points needed to predict drift.

Doubling the calibration interval would halve your costs for calibrating this item without impacting on the quality of the measurement.

(5) TAKE OUT a calibration contract. It is often possible to take out a calibration contract with your service provider. This is normally taken for 1-3 years and discounts are available for equipment quantity and for length of contract. You may also get additional benefits, including fixed prices for the contract period.

You also reduce the delays and internal cost of creating multiple purchase orders and billing events. This also improves the turnaround times due to the elimination of delays for quoting and sending purchase orders. It also allows the annual calibration costs to be budgeted more accurately, which improves your expenses forecasting.

(6) TAKE OUT LIMITED calibration. This allows you to match your instrument's verified performance to only that which you need. You do not pay for calibration tests you do not require. A case in point was an RF signal generator used in a laboratory. It was used in a test rack to perform only one test yet the user was getting a full calibration done every year.

When the generator was tested for only the required signal, the cost dropped by 75%. This was without compromising the traceability or quality for the measurements needed for the specified task. All that was required was a label indicating that the instrument had a limited calibration. Supplementary information concerning limited calibration of the unit should be made available for a person who uses it.

(7) FINALLY, YOU CAN arrange to have an expert from your calibration provider visit your facility. He can recommend ways to reduce your calibration costs and to improve measurement quality. There is usually a charge for this service which is waived if you proceed with a calibration contract/plan.

For further information or a quote for calibration contact Trio Smartcal on 1300 134 091. **www.triosmartcal.com.au** SC

Give your circuit that PROFESSIO

When it comes to contributed projects or circuits, there are few things more frustrating than finding the circuit has been drawn (apparently) by "a thumbnail dipped in tar" – or near equivalent. Here's an easy way to make them look good!

Not only do poorly presented circuit diagrams increase the likelihood of errors, they also make it more difficult to understand the basic circuit operation.

And if those at SILICON CHIP cannot understand it, how are readers going to?

The Editor will be much more impressed by a neatly laid out diagram with standardised symbols, all components at right-angles and all the components in scale.

How do you do it?

Many years ago Protel had a circuit drawing package called Schematic. Unfortunately it was less than acceptable – the frustration and poor results with this program prompted me to think about an alternative.

The one I use might sound a little unusual at first glance. It's the Protel Autotrax PCB (Printed Circuit Board) layout package which of course is intended to lay out PC boards. But I find gives excellent results when drawing circuits – and as a bonus is quite easy to use.

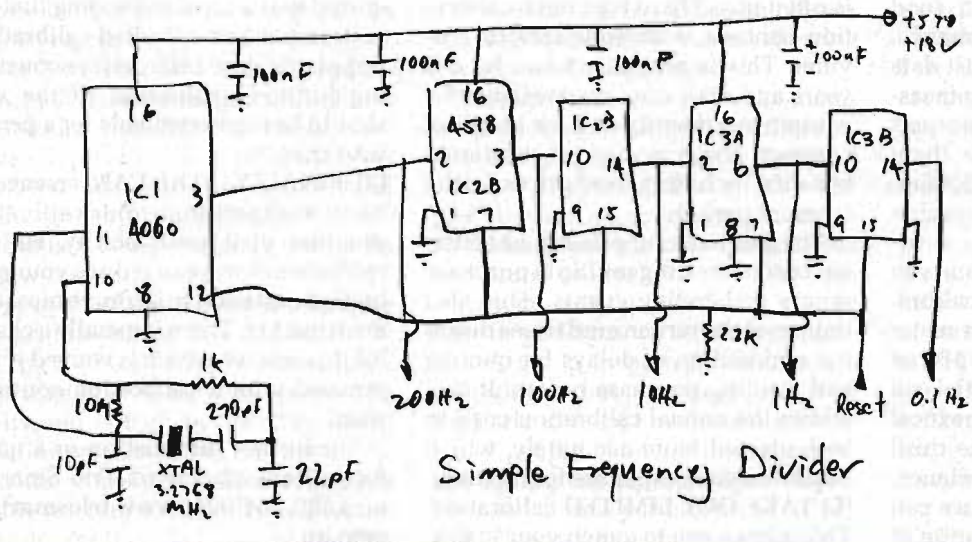
An even bigger bonus is that it won't cost you anything. Now well and truly superseded, Protel Autotrax can be downloaded free from www.altium.com/altium/altiumsite/community/downloads/altium-freeware-end-user-license-agreement/en/auto-trax.cfm.

If you find entering all that a bit daunting, simply go to www.altium.com and go to the "community" tab, thence "downloads"!

This program was covered quite thoroughly (mainly in its normal PC board layout mode) in the February, March & April 2004 editions of SILICON CHIP. So I won't go into all that detail again but will cover aspects of using it as a circuit drawing program.

Briefly, though, you need to know that Protel Autotrax has two parts – the first, the part you actually "draw" with, is called **TRAXEDIT.EXE**. When you want to print out your masterpiece, you'll need the second part, called **TRAXPLOT.EXE**.

However, be warned: as Autotrax is getting pretty long in the tooth (it's



Which one looks better? This one or the one on the right? Unfortunately, the example at left is a positive masterpiece compared to some which we see!

diagrams NAL look!

by Rick Walters

been around since the 1980s) video and printer drivers can be problematic. In fact, we seldom use Traxplot – at SILICON CHIP we work mostly with EPS (encapsulated Postscript) files and use a little utility called "GRABEPS" which converts Autotrax (*.PCB) files directly into *.EPS files.

Grabeps can be downloaded from www.electronicsaustralia.com.au.

Before you start

Firstly we need a dedicated directory which I have (for obvious reasons) called SCHEMATI (DOS-based programs cannot use directory or file names with more than eight characters).

If you don't know how to create a directory (now also called folders), check the side panel. Create your directory and call it SCHEMATI or whatever 8-letter name you desire.

It should now appear listed alphabetically under the C: drive. We have placed all the files you will need in a directory called SCHEMATI. Log onto www.siliconchip.com.au/downloads, find the folder labelled SCHEMATI in the May 2009 section and click or double-click on it. It will open, showing a single zipped file. Download and save it to c:\schemati.

You will need to unzip them before use – in the majority of cases, double-clicking on a *.ZIP file will bring up the appropriate unzip utility – but if it doesn't, there are numerous zip/unzip utilities which you can download from the web.

Drawing a circuit

Drawing a circuit, especially a large and/or detailed one, is not a simple task. Some of the larger ones you see in SILICON CHIP may take many hours, or even days, to draw.

As well as showing the interconnections between the various devices the drawing tries to group relevant components in reasonably close proximity, as well as tending to flow from left to right with inputs on the left and outputs on the right.

The area where this often does not hold true is that we tend to bring power

Will Autotrax work on XP and VISTA?

Being a DOS-based program, Protel Autotrax performs best on a computer operating under DOS.

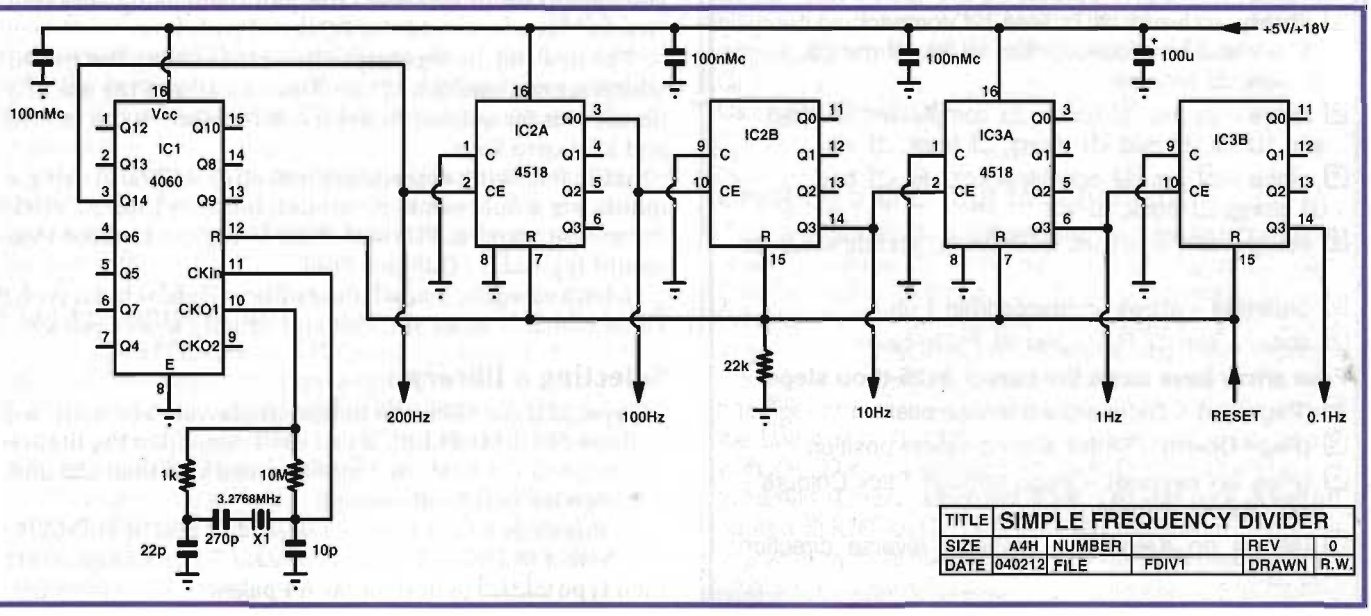
However, that is not to say it won't operate under a Windows command prompt because, in most cases, it certainly will.

We have had no major problems using Protel Autotrax on PCs running Windows 98, 2000, ME and XP. As Rick Walters has mentioned in this article, drivers for particular printers and video cards might be something of a problem; however (so far!) not for us.

You might have noticed that the list above doesn't mention Windows Vista. This is a whole new ballgame because it works quite differently to the earlier operating systems.

Unfortunately we haven't had the opportunity to test Autotrax on Vista before going to press (like many organisations, our computers primarily operate under Windows XP).

There is a fair amount of discussion on the net about operating old DOS programs under Vista – the majority suggest that using a program called DOSBox (or several similar programs) will allow you to use most DOS-based software on a Vista machine.



Protel Autotrax key commands

As an (old!) DOS program, Autotrax relies extensively on keyboard commands instead of mouse clicks. Actually, this works rather well, especially as you get more skilled in using the program. Most of the letter codes are pretty-much self explanatory. The commands in red are the ones you'll use the most for circuits (you can virtually ignore the rest unless, of course, you're drawing PC boards!)

How they work

Typing the **first character** (as shown in **bold** below) brings up the options list (which follows). For example, when you type [B] (block) you will see a number of options. When you type the second letter, particular option is invoked.

So [B][D] would be block define (ie, tell Autotrax where the block is), [B][M] would be block move and so on. [B][R] (block read) and [B][W] (block write) allow you to save a block as a file and read it back as a component. This is useful where, for example, you may have six seven segment decoders driving six LED displays. You draw it once, write it out to a file, then read it back five times and place it.

The Autotrax commands

- [B] **block** – allows you to "block off" areas of your diagram and do something with them: [D] define, [H] hide, [M] move, [C] copy, [I] inside delete, [O] outside delete, [R] read, [W] write.
- [C] **current** – gives a list of the current setup
- [D] **delete** – [A] arc, [C] component, [F] fill, [H] highlight, [P] pad, [S] string, [T] track, [V] via
- [E] **edit** – [A] arc, [C] component, [P] pad, [S] string, [T] track, [V] via
- [F] **file** – [L] load, [S] save, [Q] quit, plus many more
- [G] **grid** – [S] snap: 25, [V] visible: 100
- [H] **highlight** – [C] connection, [D] duplicate, [R] reset
- [I] **information** – [D] dimensions, [C] components, plus others
- [J] **jump** (to) – [C] component, [C] location, [C] net, [O] origin, [P] pad, [S] string
- [L] **library** – [A] add, [B] browse, [C] compact, [D] delete, [E] explode, [F] file, [L] list, [M] merge, [N] new, [R] rename
- [M] **move** – [A] arc, [B] break, [C] component, [D] drag end, [F] fill, [P] pad, [S] string, [T] track, [V] via
- [P] **place** – [A] arc, [C] component, [F] fill, [P] pad, [S] string, [T] track, [V] via
- [S] **setup** – all the options for drawing, already setup for you
- [U] **undelete** – allows undeletes from 1 up
- [Z] **zoom** – see [PgUp] and [PgDn] below

Four arrow keys move the cursor in 25-thou steps

- [PgUp] **(Page Up)** – Zoom around mouse position
- [PgDn] **(Page Down)** – Shrink around mouse position
- [+] **(Plus on keypad)** – steps through Track Colours – Red - Yellow - Brown
- [-] **(Minus on Keypad)** – steps in reverse direction to [+]

in on the right hand side.

An additional benefit of Autotrax is that the IC pins are numbered with the pin function near the number. This prevents transcription errors when going from an IC data book to draft circuit to final circuit.

We will explain how to draw the Simple Frequency Divider Circuit on page 72. Start the program by clicking (or double-clicking) on the "Traxedit" shortcut in the Schemati folder. The shortcut tells Windows to run the program in a window but it actually boots to full screen.

Once TRAXEDIT is loaded it appears on the opening screen as AUTOTRAX with "Press a key to continue". Having pressed, you are presented with a light grey screen with a grid of white dots.

Across the bottom of the screen (similar to the Windows Taskbar) is a yellow bar with letters and numbers similar to the following:

X:2000 – Y:1200 mils – L:Top Layer – a block of colour – P:Round 50 – T:20 – S:60 – G:25.

In order these mean:

X and Y show the mouse co-ordinates at startup,
L is the layer you are working on,
The block of colour (Red, Brown or Yellow) indicates the colour of the track you will draw on the screen,
P indicates the pad type and size,
T is the track width,
S is the string size and
G is the grid step.

If you are using the bottom layer, the yellow block of colour melts into the yellow background, so you won't be able to see it.

You will note that after the Y position is the word mils, which means 1/1000 of an inch, usually abbreviated to "thou." (however, for clarity, we generally leave the full stop out – ie, "thou").

Even with metrication, most components are based on an imperial measurement – all through-hole ICs, for example, have pins 100-mils (0.1") apart.

Below the X: as you select functions a prompt will appear to assist you.

Drawing a circuit is much the same as "drawing" a PC board pattern. Instead of pads and physical components, you select circuit symbols. You join them using very fine "tracks", as you would the PC board pads etc.

The first step in drawing a circuit is to define the area in which we can operate. While Autotrax allows the use of a mouse it is far quicker to use a combination of the mouse and keyboard keys.

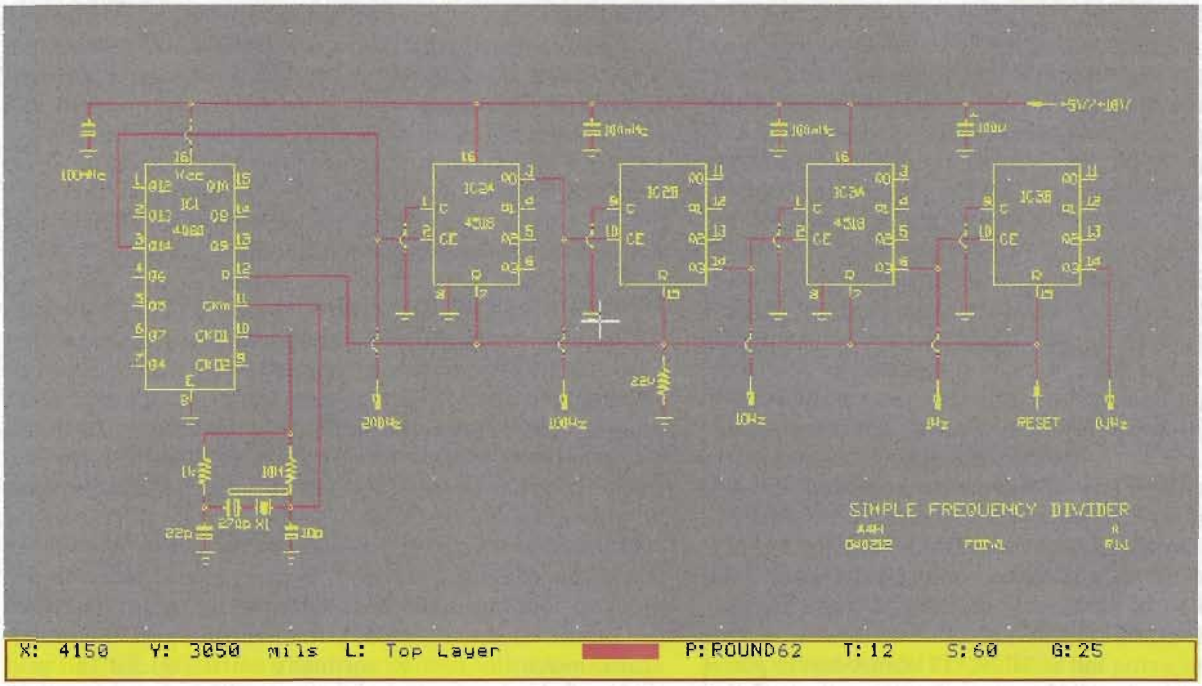
In the following description (selecting a library) using a mouse we would click the mouse, move to Library, click the mouse, move to File and click. Using the keyboard we would type [L][F] (Library File).

In both cases the loaded library file will show but it is obvious which is more efficient and usually much quicker.

Selecting a library

Type [L][F] (or click the mouse as above). Normally we will use SCHEMATI.LIB. If you can't remember the library name, press the keyboard question mark [?] then [Enter] and the libraries will be displayed.

At this stage you only have two, IC.LIB and SCHEMATI.LIB. Select SCHEMATI.LIB. Type [P][C] (Place Component) then type [A][4][H] (a horizontal A4 page).



This screen grab shows what you will see running Autotrax. The type of information you get on screen (bottom strip) is explained in the text. The nearly-completed circuit diagram is that which is shown in its printed-out form on P73.

Every time you place a component you are asked for a COMPONENT DESIGNATOR then a COMMENT. For this component we want neither, so just press Enter, which gives you a blank. Locate the A4H outline at 0,0 then press Enter, then right click or press Esc (escape). Now type L E (Library Explode). The prompt on the bottom line will read SELECT COMPONENT.

Move the mouse into the rectangle then click or press Enter. This will leave a brown outline of the A4 page area in which our circuit will need to be contained. You will be asked to confirm.

We explode the library item to turn it into primitives which means that Autotrax sees the brown outline as just that and not a component, otherwise we would end up with a lot of components inside a component and a myriad of problems. Right click or press Esc to exit LE.

Placing the title block

Next we place the title block but before we do so you need to zoom the active display, so press the End key on the keypad twice. This should just about fill the screen with the brown surround. Press P C (Place Component) then overtype A4H with TITLE. Again no designator or comment!

Move it where you prefer it. It's normal practice to place it at the bottom right (as you can see). We will come back and enter some details later but let's keep placing components.

Placing components

Overtype TITLE with CAP. Again, if you don't know the name of the component type a question mark, then press Enter. A list of components will be displayed. My approach is to keep the component name as short as possible, as long as it is recognisable and identifiable.

Why waste time and effort typing CAPACITOR when CAP will do? (But don't be caught using names like "trans" – it could be a transistor, a transformer, a transducer, a transmogrifier, a transcombobulator . . .)

As this is the first capacitor we type C 1 for the component designator, then press Enter. For comment we type the value of the capacitor, 1 0 0 N M C for a 100nF monolithic ceramic & press Enter.

The capacitor symbol will appear and can be moved about with the mouse. A left click will place it. Repeat

Creating a directory (folder) in XP

Click or double-click (depending on how your computer is set up) on the My Computer shortcut on your desktop. Click or double-click again on the C: drive (mine is called WINDOWS_XP) but yours will possibly be named differently. Click on FOLDERS to divide the screen. Move the mouse to a blank area on the right hand panel and Right-click. Move down to NEW, pause a moment, then across and up to FOLDER. Left-click and a folder called "New Folder" will be created. While New Folder is hilighted blue, type SCHEMATI. This name should now appear alphabetically listed in the left hand panel under C:

Close My Computer.

Creating a shortcut to schematic

Click or double-click (depending on how your computer is set up) on the My Computer shortcut on your desktop. Click or double-click again on the C: drive (mine is called WINDOWS_XP) but yours will probably be named differently. Find the SCHEMATI directory you have created. Click on it to open it and the files will be listed in the right hand panel. Hover over those named TRAXEDIT and find the one that is TRAXEDIT with no suffix (blue bar at top with XP). The size should be 170kB. Right click and move to SEND TO then move to DESKTOP and click. It will be named SHORTCUT TO TRAXEDIT. You can rename it if you wish by right clicking and moving to Rename.

the sequence twice. The capacitors will be sequentially numbered and the description repeated. Next we will place the electrolytic, so instead of CAP overtype E L E C T R O. It will need to be designated C4, as we have changed the component type, and the comment will be 100u.

Now place the other three capacitors (CAP) 22p, 270p and 10p. The crystal identity is XTAL, the designator X1, the comment 3.2768MHz.

Rotating a component

You will notice that both the crystal and the 270pF capacitor are rotated by 90° – but we don't use special components.

If *placing* the component, pressing the spacebar will rotate it 90°; if it is *already placed* press M C (Move Component), click on it, then press the spacebar. Each press rotates the component by 90° so four presses brings it back to where you started!

Next place the three resistors. Their identity is RES, the first designator R1 and the comment 1k, then 10M & 22k respectively. As previously explained, there are two libraries: IC.LIB and SCHEMATI.LIB.

We have been using the SCHEMATI library but to place ICs we have to use the IC library as there is a limit to the number of components that a library can hold. Right click to release PC then type L F (Library File), press Enter & C:\SCHEMATI\SCHEMATI.LIB will show. Type I C, then press Enter.

There is no need for the .LIB suffix but you may include it if you wish. If you type L L (Library List) you will get a list of all the ICs in the library. Press Enter to exit LL.

Placing integrated circuits

We wish to P C (Place Component) 4060, designator IC1, comment 4060. Position it towards the LHS (you can always move it later). Now PC 4518A, IC2A, 4518 to the right of IC1. PC 4518B IC2B, (blank) to the right of IC2A.

Where an IC consists of two or more elements within the one package (as in the 4518 above which is a dual decade counter) I make it a practice to only identify the A element with the type number. If you label them all, then at a quick glance you might count four 4518s in the circuit instead of two.

Repeat the layout for IC3A & IC3B. Your ICs will not be numbered or identified. Press Esc, then E C (Edit Component).

Identifying integrated circuits

Click on IC1 the 4060, click on DESIGNATOR in the panel, Enter, move down to HIDE, click, move to SHOW and click. Follow with three right clicks or three Escs. IC1 will now be displayed above 4060.

Do the same for IC2A & B and IC3A & B. Esc from EC and type M S (move String). Ensure the task bar displays yellow then click on IC1 and position it to between Q12 & Q13. Position 4060 between Q13 & Q14. Then move and position the titles for IC2 & IC3.

You can identify any component but I usually don't identify resistors, capacitors and other miscellaneous bits.

Now all the ICs are placed we need to go back to our SCHEMATI.LIB so press Esc (or right click) to get out of Move String then L F, SCHEMATI.LIB then Enter.

We now have to place 13 ground symbols (GND) and nine jumpers (JMP) but these are best left until later. For the best appearance, ensure all the tops of the ICs are on the same Y grid (ours is 4100). If not type M C (move component) then move the mouse to the inside of the component and click. Move it to the required location and click to lock it in place. You are again prompted by the taskbar.

NOTE! You can only move components when the red or yellow colour bar is displayed on the taskbar. They will not move if the brown bar is showing.

Drawing the connections

Connections between components (remember, we are using "tracks") are always drawn in red. Draw the trace from IC1/3 to IC2/2. If you are still in move component mode, press Esc (or right click), ensure that you have the red bar in the taskbar then type P T (Place Track). The track width has been set to 20 thou in the initial setup you downloaded and the visible grid to 100 thou The actual step increment using the mouse or the four arrow keys on the keyboard is 25 thou.

Move your mouse to the line from pin 3 and click. Move the mouse to the left until you reach the grid then click again, move the mouse vertically until you hit the grid again, click, across, click, down, click then across to pin 2 of IC2A, click. Now press Esc (or right click). This disconnects the track from the mouse. You may need to zoom to the area you are working in (plus key on keyboard).

Next move the mouse to IC1 pin 12, click and draw the track to IC2 pin 7, clicking each time you want to change direction. Right click to decouple the track from the mouse. If you have previously laid out PC boards using Autotrax these instructions will be instinctive.

Now join IC2b pin 15 to the junction of IC1/12 and IC2/7 and then to IC3/7 and IC3/15. Connect IC2A/3 to IC2B/10, IC2A/14 to IC3/2 and IC3/6 to IC3/10.

Now draw the supply rail at the top of the ICs. Start at the left and click to go towards IC1/16. Stop 50 thou past the grid dot, then right click to break the track, move the mouse down 100 thou and draw the track to the IC. Go back up and join the pin 16s on IC2 and IC3, then continue the track towards the right hand side. Right click twice (once to release the track, the second to exit from PT) then type P C (place component).

Placing miscellaneous components

Type J O I N (Enter) accept its ID (Enter) and ensure the comment is blank (Enter) them move your mouse to the supply line above IC1/16. Click and a dot will appear.

Move the mouse above IC2A/16 and click three times, then place it. Another three clicks in the same vertical plane as 100Hz and place, then three clicks and so on, for each join. Next the four on the reset line, then the four on the CE (clock enable) inputs. Knowing you need three for the crystal area place three at random there.

The jumpers are placed in a similar manner. Type P C, when you see JOIN displayed type J M P (jumper). Place the nine jumpers in like manner making sure the tracks run right up to the start of the arc. The reason for this will be explained shortly. Finally place the six ARROWS. They will initially point to the right, so the RESET one will need one press of the SPACEBAR to rotate it 90°, the others will need three presses (270°). The COMMENT for each arrow is 200Hz, 100Hz etc.

Using M C (move component) place the resistors, capacitors and crystal (click on each component, move it, then click again to place it) in their correct locations. Now draw the connections to pins 10 and 11 in IC1. The ground symbol is GND so these (13) can now be placed and the tracks drawn.

Checking the layout

To check your circuit for continuity and connections place the mouse on the +5V/18V arrow and type H N (highlight Net). All the Pin 16s should be connected.

The connections are obvious on this simple circuit but in a complex one it is much harder to check. Place the mouse on IC1 pin 3 and type H N. The track should be continuous to 200Hz following the jumper. This is why you need to take the track right up to the jumper arc to ensure continuity.

Filling in the title block

Type P S (Place String), type S I M P L E F R E Q U E N C Y D I V I D E R, click and move it to the title space, then click to release it. The text will be too small (60 thou) so E T (Edit Text) and try 80. Still a bit too small? 90 should just fit. Type A 4 H and move it to the SIZE window, then fill in REV(ISION), DATE and DRAWN. File is the name you will use to save the circuit.

If you use Autotrax to lay out your PC boards ensure that the circuits are saved in the SCHEMATI directory and the PC boards in a different directory, as both have the suffix PCB and if you give them the same name (which is logical) and put them in the same directory, one will overwrite the other.

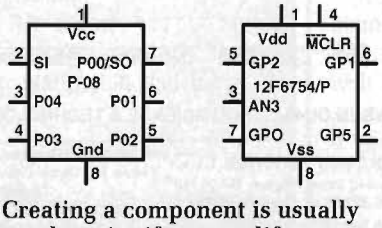
Creating a component

While you have a wide range of components available you will probably need additional items in due course.

As an example, in the January 2009 issue of SILICON CHIP, John Clarke used a 12F6754/P microprocessor. We don't have one in the library, but looking at the device it is an 8-pin integrated circuit similar to a PIC08. So we would "create" a new IC using that.

Move the mouse to blank area of the screen, (making sure you have IC LIB selected) type P C (Place Component) PIC08 then press ⏎ or (right click). Then L E (Library Explode), confirm yes. Press the plus key until you see Top Overlay and the red or brown bar change to yellow (bottom centre of screen). Type D S (Delete String), selecting each description in turn. Next type M S (Move String) then select and place the pin numbers in the correct position.

Finally type P S (Place String). The top left corner displays what you are typing. Pressing Enter places the text under the control of the mouse. Locate it and click to lock it in place. If you want to move any strings then M S and click will let you place them.



Creating a component is usually much easier if you modify an existing one. Don't forget to rename it!

Once you are satisfied type B D (Block Define). Click and move the mouse diagonally to encompass the device and click. You are now asked for a reference point. For this device I would use the left tip of the wire from GP2 and a similar place for all ICs.

When placing the device in a circuit the mouse is located at the reference point and you should always put this point on a grid dot. Having defined the block it has to be saved to the library. Type L A (Library Add). You will be asked for a name, then Autotrax checks to ensure this is not a duplicate name then asks you to confirm the new name.

Before deleting the block place the new component and make sure you are happy with it. Then type D C (Delete Component) and click on the one just placed (unless you plan to use it), then type B I (Block Inside Delete) and confirm Yes, then when asked "all layers", type A (ie, B I Y A).

Backup File

Protel periodically backs up the file you are working on. With a modern computer it happens so quickly you are unaware of the save. The file is named TRAXEDIT.ABK. (which stands for AutoBacKup). Should you have a computer crash, lockup or a power failure, once you are running again, delete the file you were working on (FDIV1.PCB) or rename it (FDIV1.BAK) then rename TRAXEDIT.

Printing your circuit

In the drive for bigger, better and bloated programs, support for old DOS-based software and printers is rapidly (and probably not unreasonably) disappearing. Protel was written to interface to brands of serial and parallel printers which were popular at that time but now obsolete. Most desktop computers and some laptops still have a parallel output port but not for much longer, as new motherboards are phasing it out. In a recent magazine issue only four of the ten units reviewed had a parallel port.

If you have a parallel port on your computer and you own an HP deskjet printer with parallel input, you are ready to roll.

Protel's output program is called Traxplot. You can create a shortcut to it as we described for Traxedit. It appears that all HP deskjets support laser 300 DPI (HP640c, HP649c & HP948c all do) and the plot setup is for these printers. My old HP649c packed up recently and on the advice of my cartridge supplier, I went to the local Salvation Army depot and purchased both an HP640c and an HP948c. They were quite expensive though: $5.00 each with both black & colour cartridges fairly full!

The print parameters are set up, so pressing F L (File Load) will give you C:\SCHEMATI*.PCB. Press ENTER and select FDIV1.PCB. The file will load. Press ⏎ (escape) o get back to the FILE menu then move down to print. Press ⏎ or click. You will be asked to confirm PRINT, so click or press y. A few seconds later you should have a printout of your masterpiece.

If you don't have an HP printer various other methods of printing were discussed in the April 2004 issue. An updated version of Ghostscript has recently been released.

So what do WE use?

We are often asked which software we use to draw SILICON CHIP circuit diagrams.

We use Corel Draw but don't use Corel's symbols. We have an extensive component library which we have drawn up over many years (in fact, we created the Corel Draw library from the pen-and-ink component library which we drew when we started the magazine).

As we imply above, Corel Draw does contain its own electronic component symbol library (among many other libraries). There is nothing wrong with using this library if you want to – we just believe ours looks much better!

The latest version of Corel Draw (X4) is a fairly expensive package (~$500-$800 or more, depending where you get it) but we've seen earlier versions (eg V11) legitimately downloadable from the net for very cheap prices (eg, $US60!) – and you'd be able to do almost as much with an earlier version.

ABK as FDIV1.PCB. When loaded, you will see that you have only lost a few minutes' work. If you wish you can load each of the files and compare them.

Bill of Materials (BOM.EXE)

Once you have finished drawing your circuit you can generate a bill of materials – or what we would call a parts list. The Simple Frequency Divider circuit produced the following BOM. It has been compressed to take less space.

FDIV1.PCB 9:21 9-1-2009 Bill of Material Summary
Page : 1

DESCRIPTION	QUAN.	COMPONENT DESIGNATOR(S)			
	43	A1	A2	A3	A4
A5		A7	A8	A9	A10
A11		A12	A13	A14	A15
A16		A17	A18	A19	A20
A21		A22	A23	A28	A29
A31		A32	A33	A34	A35
A36		A37	A38	A39	A40
A41		A42	A43	A45	A46
A48		A49	IC2B	IC3B	
+5V/+18V	1	A30			
0.1HZ	1	A27			
1HZ	1	A26			
1K	1	R1			
3.2768MHZ	1	X1			
10HZ	1	A25			
10M	1	R2			
10P	1	C7			
22K	1	R3			
22P	1	C5			
100HZ	1	A24			
100NMC	3	C1	C2	C3	
100U	1	C4			
200HZ	1	A47			
270P	1	C6			
4060	1	IC1			
4518	2	IC2A	IC3A		
RESET	1	A44			

Obviously we can extract the components (R, C, X & IC) from the list. SC

MORNSUN

NEW

HIGH-PERFORMANCE HIGH RELIABILITY
DC-DC/AC-DC converter

DC-DC Fixed Input,Isolation,Regulated

Ultra thin IF_RN/RT-1W



SIZE:19.5x6.6x4.5(mm)

- 1W mini ultra thin
- Input: 5VDC
- Output: 5VDC
- Isolation voltage: 3000VDC

DC-DC Wide Input,Isolation,Regulated

Ultra Miniature WRA/B_LT-3W



SIZE:23.86x13.7x7.5(mm)

- Wide(2:1) Input Range
- Input: 12VDC/24VDC/48VDC
- Output: WRA:±5VDC/±12VDC/±15VDC
  WRB:3.3VDC/5VDC/12VDC/15VDC
- Isolation voltage: 1500VDC

AC-DC Converter

LI24



- Universal input voltage: 90~264VAC, 50/60Hz/120~370VDC
- Output: 5VDC/12VDC/24VDC
- DIN-Rail Package

- Products include AC-DC、DC-DC、LED Driver、IGBT Driver、Isolated Amplifiter、Isolated Safety Barrier
- Power range : 0.1W - 60W
- Isolation voltage:1000VDC - 12000VDC / 2500VAC-4000VAC
- Input range: ±10% - Ultra-wide(4:1) input range
- Power density up to 8.5W/cm³
- Package style: SIP、DIP、SMD、DIN Rail

cULus CE RoHS SGS ISO9001:2000 ISO 14001 OHSMS 18001

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Please visit our website for detailed datasheets: www.mornsun-power.com www.mornsun.cn

PRODUCT SHOWCASE

Internode signs up as Basslink's first ISP customer

National broadband company Internode has signed an agreement to use the new Basslink fibre-optic cable to significantly increase its data backhaul capacity between Tasmania and the mainland. (See Basslink feature in September 2008 SILICON CHIP).

The Basslink deal increases Internode's data capacity across Bass Strait by more than 150%. It also provides greater certainty of uninterrupted services for Tasmania by creating a redundant data path. Internode expects to start using the new Basslink service before the middle of this year.

It makes Internode even more attractive to Tasmanian customers who can continue to enjoy the same level of broadband performance and range of services that their customers get in the rest of the country.

As well as virtually halving the cost of backhauling data across Bass Strait, the Basslink service will allow Internode to exploit economies of scale as they grow.

Internode has signed a three-year contract with Basslink for an initial data capacity of 622MB (megabits) per second. The company expects this to increase to more than one gigabit within the first year.

Contact:
Internode
150 Grenfell Street Adelaide, SA 5000
Tel: 13 66 33 **Fax:** 1300 396 633
Website: www.internode.on.net

Store'N'Go micro USB flash drives from Verbatim



Verbatim's new Store 'n' Go Micro USB drives provide storage of up to 8GB of data. Measuring only 30mm long, 12mm wide and 2mm thick, the drives weigh a miniscule 1.2 grams and are designed to be attached to a key ring, PDA or cell phone, enabling data to be carried with unlitmate convenience. The new drives come in a range of vibrant colours and are available now in capacities of 2GB (orange), 4GB (green) and 8GB (purple).

Priced from $13.95, they offer read and write speeds of up to 30MB/sec and 13MB/sec for the 4GB and 8GB devices and up to 19MB/sec and 9MB/sec for the 2GB device.

To achieve capacities of 2, 4 and 8GB in such an ultra-small, ultra-portable form factor, Verbatim Store 'n' Go Micro USB drives feature new system-in-package (SIP) technology. SIP technology encapsulates all of the electronic components into a single miniaturised and sealed unit. As a result, the tiny drives resist water, dust, physical shock, electrostatic discharge (ESD) and are small enough and tough enough to take almost anywhere.

Contact:
Verbatim Australia
6 Weir St, Glen Iris, Vic 3146
Tel: (03) 9823 0999 **Fax:** (03) 9824 7011
Website: www.verbatim.com.au

Mornsun's 78-series replacements



Mornsun's K78xx-500 & K78xx-1000 series are the latest generation of high efficiency switching regulators, ideally suited to replace the LM78 linear series (they are pin-compatible).

The K78 series are a single output DC/DC converter with a super-wide input range (about 6.5~32 VDC). Outputs are 3.3V, 5V, 6.5V, 9V, 12V and 15V, with 500mA rated output current (78xx-500) and 1A (K78xx-1000). Efficiency is up to 96%.

With short-circuit, over temperature protection, the versatile series is the perfect replacement of LM78 series, with high power density, very low ripple/noise and mini profile (SIP-3 package). The manufacturers claim there is no need for any heatsinks.

The K78 series can convert positive to negative voltage only by connected two capacitors.

In a nutshell, the K78 series offer superior security, higher efficiency, better performance and wider applications.

Contact:
Digital Linear & Passive Compon.
8 Manor Dve, Wellington Pt, Qld 4160
Tel: (07) 3207 1398 **Fax:** (07) 3207 5160
Website: www.dlpc.com.au

Tektronix NZ Distributors

In our review of the new Tektronix DPO/MSO2000 mixed-signal oscilloscope last month (P76), we neglected to mention that Nichecom are the Tektronix distributors in New Zealand.

So for our NZ readers, you don't have to make that overseas call – contact Nichecom in Wellington and they will be glad to assist!

Contact:
Nichecom Ltd
1 Lincoln Ave, Tawa, Wellington 5028 NZ
Tel: (04) 232 3233
email: tektronix@nichecom.co.nz

Stainless Steel Pressure Transmitters

The NP-430A series of stainless steel pressure transmitters from Ocean Controls has been developed for general industrial applications including refrigeration technology.

It can be used with most gases, excluding ammonia. Protection is IP67.

Pressure ranges are from 0.2-120bar with an accuracy better than 1% FS. Response time is less than 10ms (up to 99%) It can stand 150% FS overload, with rupture pressure 300% FS.

Power supply is 12-28VDC, with 2-wire signal output of 4-20mA. Electrical connection is Packard type. The wetted parts are stainless steel with a ceramic diaphragm and Nitrile NBR O-ring.

Unit price is $149 +GST.



Contact:
Ocean Controls
3/24 Wise Ave, Seaford Vic 3198
Tel: (03) 9782 5882 **Fax:** (03) 9782 5517
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UHF Remote Dual 2

If you're looking for a mains "switch" which can be operated from some distance away, this low-cost, simple project could be just what you want. With a UHF remote control and two switched "channels", it needs very little power thanks to the use of latching relays.

There are countless applications – especially with colder weather coming on – where it would be nice to turn mains devices on and off remotely.

Imagine being able to switch something on and off without having to go close to it – outside in the wind and rain, for example. Imagine being able to control two devices, completely independently.

You're imagining exactly what this device does. It has an IEC mains input connector (so uses a standard IEC power cable) and two standard 3-pin mains sockets, into which any mains devices (up to 2300W total) can be plugged and controlled.

It's housed in a standard plastic case with the only other control an on/off switch.

The number of channels you construct is optional. The prototype was made with two channels but if your application only needs one channel, you simply leave a relay and a few other components out.

It's a true remote "switch" – you press one button on the pre-built UHF remote control keyring transmitter to turn one of the relays on, then press another to turn it off. The transmitter has four buttons on it, therefore it can control two channels.

It has a nominal range of up to about 80 metres, perhaps more and this should be more than enough for most applications. But this range can be significantly extended with an optional module, which we will look at a little later.

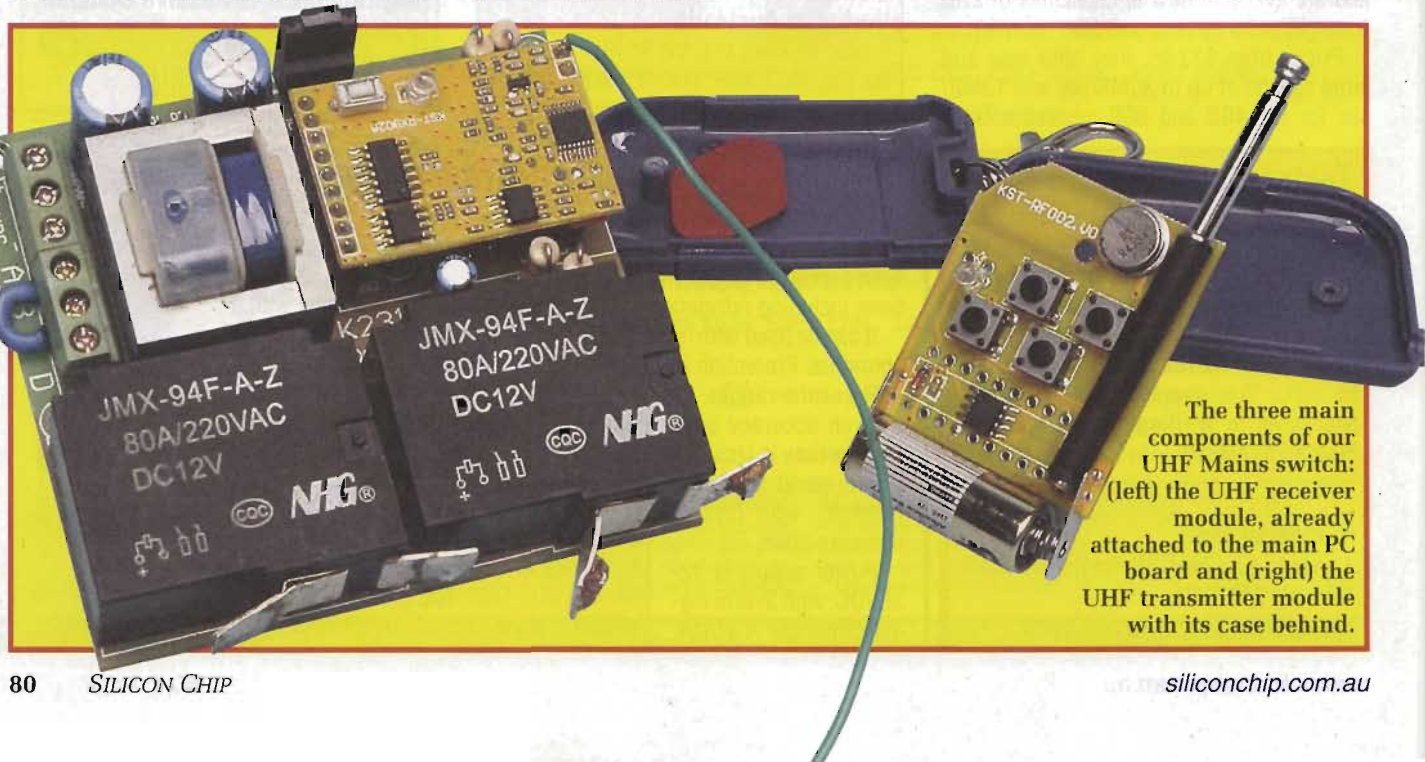
And speaking of relays, they're not your garden-variety types. Each has a contact rating of 80A – much more than is available from a standard power outlet (10A).

But more importantly, they're latching relays which only require a short-term power pulse to turn them on or off. The advantage of this is that once actuated, no power is required to keep the relay "pulled in" – so you don't waste a lot of power if something needs to be left on for a length of time. We explain how latching relays work in a separate panel.

Like the transmitter, the UHF receiver module is pre-built, thus avoiding any setup problems.

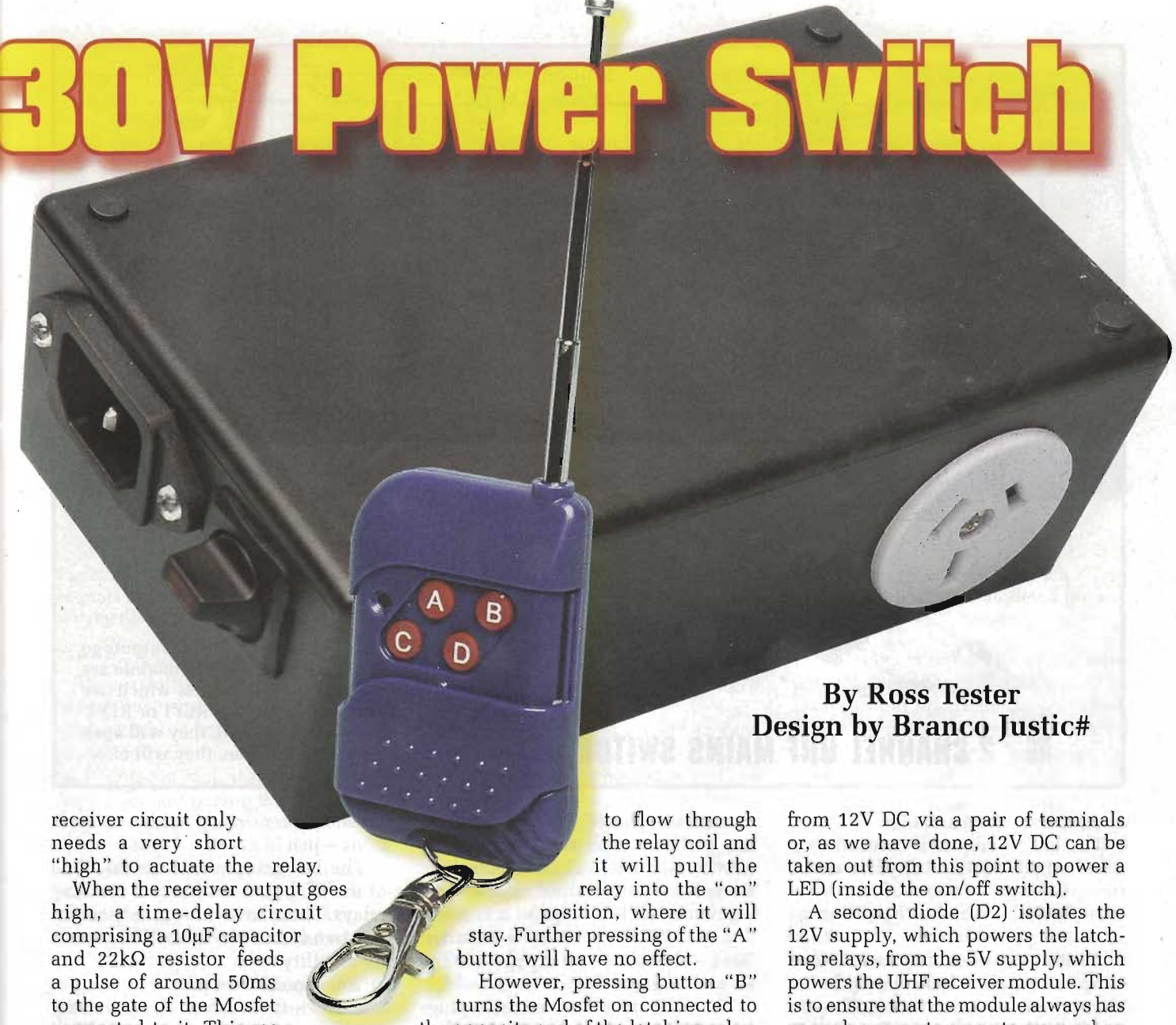
How it works

The UHF keyring transmitter has four pushbuttons, labelled A, B, C and D. When any of these are pressed, a pulse train is sent to the receiver module, it is decoded and the corresponding receiver output will go high. While the pulse train is sent while ever the transmitter button is pressed the



The three main components of our UHF Mains switch: (left) the UHF receiver module, already attached to the main PC board and (right) the UHF transmitter module with its case behind.

230V Power Switch



By Ross Tester
Design by Branco Justic#

receiver circuit only needs a very short "high" to actuate the relay.

When the receiver output goes high, a time-delay circuit comprising a 10µF capacitor and 22kΩ resistor feeds a pulse of around 50ms to the gate of the Mosfet connected to it. This momentarily turns the Mosfet on, grounding the end of the latching relay to which it is connected.

Each end of latching relay is also connected to 12V via a 47Ω 1W resistor, so when a Mosfet is turned on, the coil is energised.

You might think that a 1W resistor is not enough in this application but it hardly raises a sweat, due to the fact that the turn-on and turn-off pulses are so short.

Note that a Mosfet is connected to each end of the latching relay and only one of the two Mosfets will have any effect at any given time, depending on which way the latching relay is set.

If, for example, the latching relay is in the "off" position and button "A" is pressed, the Mosfet will enable current to flow through the relay coil and it will pull the relay into the "on" position, where it will stay. Further pressing of the "A" button will have no effect.

However, pressing button "B" turns the Mosfet on connected to the opposite end of the latching relay, so current flows through the coil in the opposite direction. This causes the relay to switch over to the "off" position and stay there – and again, further pressing of button "B" will have no effect.

Transmitter buttons "C" and "D" and the second relay operate in exactly the same way.

The circuit is powered by a half-wave rectifier (D1 and C1) circuit running from an on-board 9V AC transformer. This transformer has a split primary and can therefore be connected for 230V or 115V operation. For 230V operation the transformer primaries are connected in series; for 115V they would be connected in parallel.

The circuit can also be powered from 12V DC via a pair of terminals or, as we have done, 12V DC can be taken out from this point to power a LED (inside the on/off switch).

A second diode (D2) isolates the 12V supply, which powers the latching relays, from the 5V supply, which powers the UHF receiver module. This is to ensure that the module always has enough power to operate even when the relay coils are actuated.

Normal (standby) current is around 14mA but for the 50ms or so that the relays are being powered, the current rises to around 600mA.

One thing we haven't mentioned is that the UHF receiver must be "trained" to recognise the specific transmitter you are using, otherwise they won't work together. We'll do this as part of the testing procedure a little later.

Construction

With the exception of the mains input/output sockets and the power switch/LED, all components mount on a double-sided PC board coded K231A

 # Oatley Electronics Pty Ltd

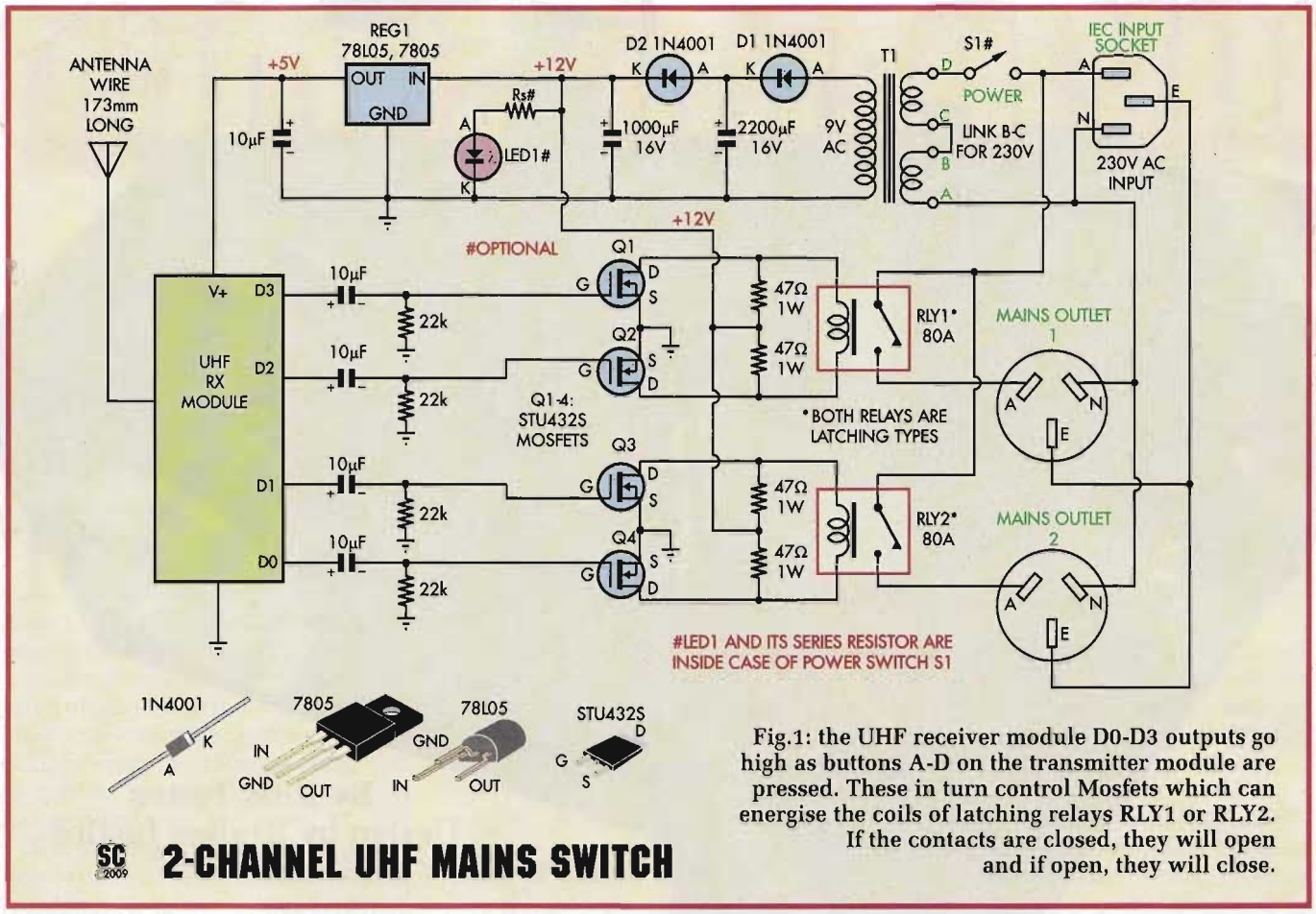


Fig.1: the UHF receiver module D0-D3 outputs go high as buttons A-D on the transmitter module are pressed. These in turn control Mosfets which can energise the coils of latching relays RLY1 or RLY2. If the contacts are closed, they will open and if open, they will close.

2-CHANNEL UHF MAINS SWITCH

and measuring 79 x 73mm.

The entire project is housed in a standard all-plastic utility box measuring 95 x 157 x 53mm. It's a fairly tight fit in this box but it will all go in, as our photos show.

As normal, make sure your PC board is up to scratch – there should be no shorted or broken tracks. They're unlikely these days but it pays to check.

The first thing to do before starting construction is to carefully remove the braided output leads from the two latching relays. Unfortunately, they are not insulated nor are the really long enough to do much with.

We cut them very close to the relay terminals with sharp sidecutters, then (later) used the remaining copper braid as a handy solder point for the mains wiring.

We also found it necessary to bend the right-angle terminals back about 45° so the board would easily fit into the case later on. Take care when cutting these off and bending because the terminals are relatively easy to damage.

That done, you can now proceed to assemble the PC board. Start with the resistors and small capacitors (watch polarity – all the electrolytic are polarised) then the diodes and 5V regulator. While the regulator is specified as a 78L05, we used a standard 7805 – either may be supplied in the kit and both are fine.

The UHF receiver module plugs into a 9-pin header socket mounted on the top side of the PC board – solder the socket in now but don't plug in the module yet.

Also solder in the three 2-way terminal blocks (it snaps together to form one 6-way). Make sure the wire connection side goes towards the edge of the PC board.

Solder the two larger capacitors (2200µF and 1000µF) and the power transformer in at the same time. The two capacitors are a fairly tight fit and may need a bit of juggling to place alongside the power transformer. The transformer will only go in one way – the primaries towards the edge of the PC board.

When the transformer is soldered in, it's a really good idea to glue a strip of insulating plastic over the top of the transformer primary solder connections – just in case!

The last components on this side of the PC board are the two latching relays. These have three pins to solder in – two connect to the coil but one is for stability only.

You should have only four components left – the Mosfets. These are very small – in fact, they're surface-mount devices but fortunately the spacing is quite wide so these should present no problems in soldering.

The close-up photo shows best how these devices are mounted. Use a clean hot iron but don't keep apply heat for any longer than necessary.

Finally, solder a 173mm length of thin insulated hookup wire to the "antenna" position on the UHF module and then plug the module into its header-pin socket on the PC board.

Training and testing

It's easiest to check the project before mounting it in its box – and it's quite safe to do so because we will check it with a 12V DC power supply. And while we're about it, we will "train" the receiver to work with

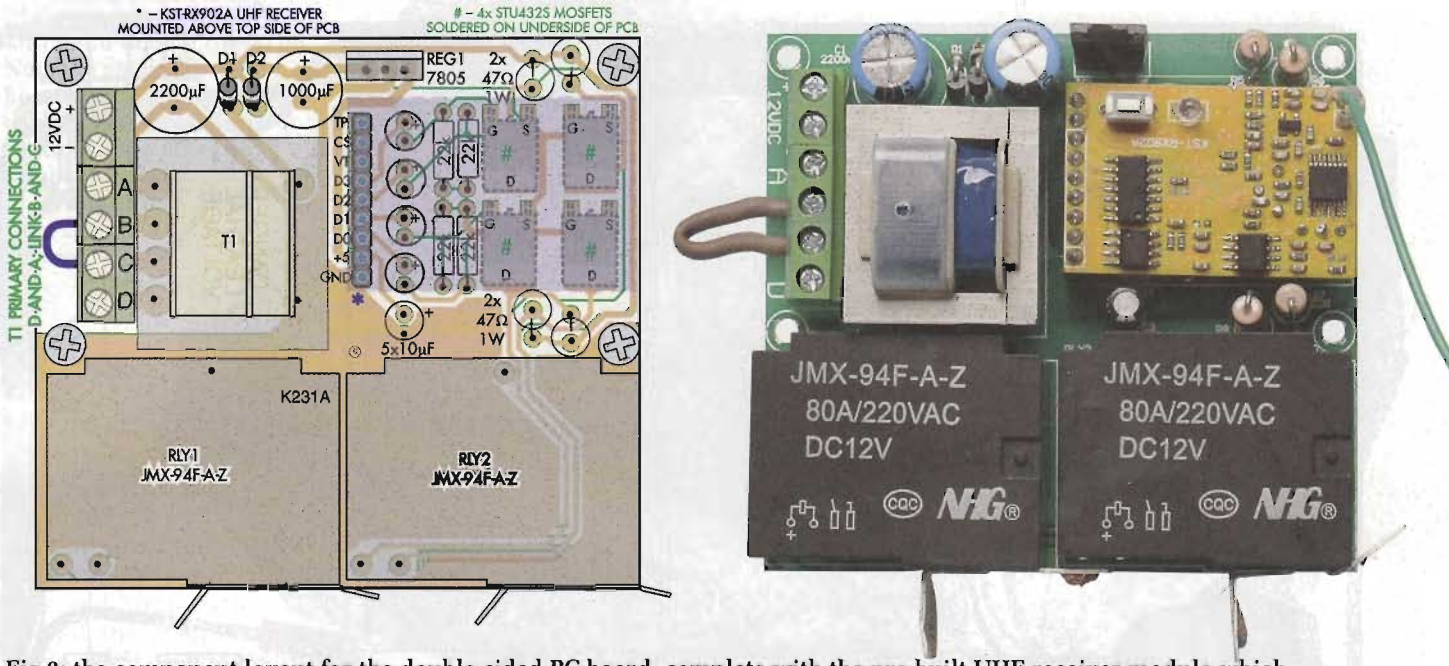


Fig.2: the component layout for the double-sided PC board, complete with the pre-built UHF receiver module which mounts on a header pin socket above the board. Compare this with the same-size photo at right and the completed project wiring diagram overleaf (Fig.3). The terminals pointing down need to be bent to the left at about 45°.

your transmitter.

Before doing so, however, it's wise to give the board a thorough examination, checking for bad solder joints, misplaced or mis-oriented components, etc. In fact, it's even better to have a second person do this for you because you're likely to see what you want to see!

If satisfied everything is correct, connect a 12V battery or power supply to the upper two terminals on the terminal block (+ towards the edge of the PC board).

There is a white pushbutton on the UHF module – push it and hold it down until the red LED on the UHF module goes out. Now press button "A" on the keyring transmitter until the red LED flashes.

Your keyring transmitter is now matched to your receiver.

When you press button A or C on the transmitter two things should happen: (1), you should see the red "acknowledge" LED on the UHF receiver module flash, and (2) you should hear a quite distinct "thunk" from one or other of the relays as it switches over.

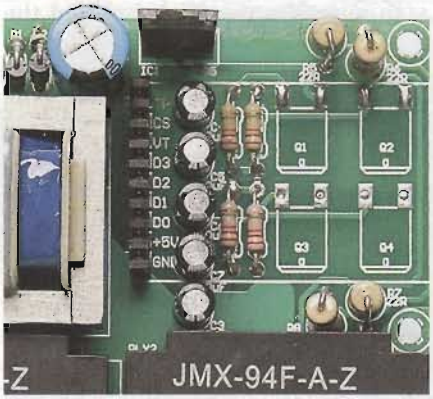
Pressing the B or D buttons should achieve exactly the same result as the relay releases.

If you connect a multimeter (low Ohms range) across one of the relay contacts, you should be able to confirm it closes and opens as you press buttons A then B. If it doesn't, try buttons C and D – you might be across the wrong relay!

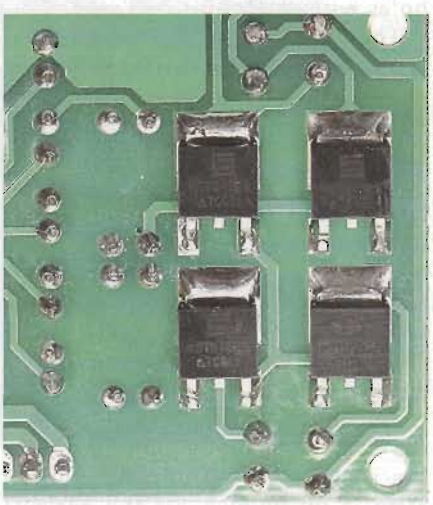
If everything checks out, you're ready to mount the PC board in its case, along with the input/output connectors and on/off switch.

If not, you need to go back over your component placement and soldering.

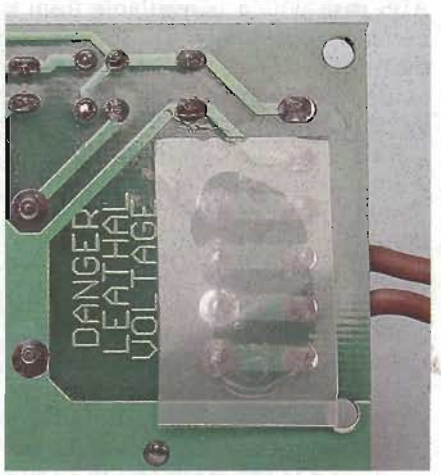
If the red acknowledge LED lights when you press a transmitter button that suggests the power supply is fine but if you don't hear the relay



Above is the area of the top side of the board normally hidden by the UHF receiver module. This also shows the row of header pin sockets into which the UHF receiver module plugs. Note the regulator (top of pic) is in this case a 7805 – a 78L05 could also be used.



A close-up of the underside of the same section of board, showing the mounting of the four STU 432S Mosfets.



It's a good idea to glue some heavy plastic insulation over the mains terminals of the PC board . . . just in case. It's not just leathal, it's lethal!

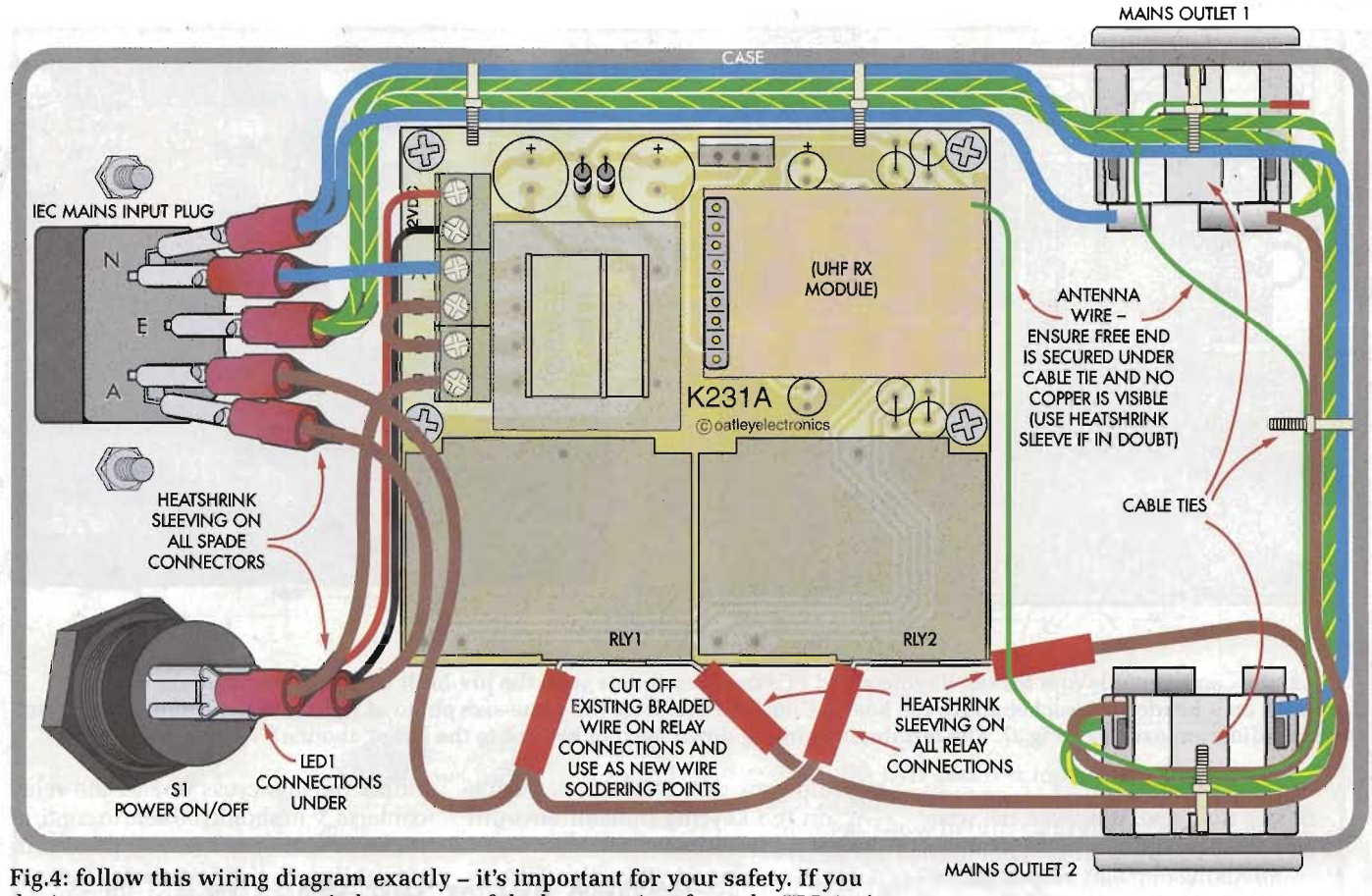


Fig.4: follow this wiring diagram exactly – it's important for your safety. If you don't want to use a power switch, run one of the brown wires from the IEC Active terminal directly to the D terminal on the PC board – and also leave out the 12V wiring to the LED.

thunk, the problem is either in the time delay R/C network, the Mosfets or the relay.

If the red acknowledge LED doesn't light at all, the problem is in either the 5V regulator section or in the UHF receiver module itself.

Mounting in the case

We used a 95 x 157 x 53mm (UB1) ABS case which is available from a number of suppliers. Ensure you get the all-plastic variety (including lid), ie, don't use one of these cases with an aluminium lid.

It's a pretty tight fit in this box but it does all go in, as our pictures show. The PC board mounts in the bottom of the case with the input and output connectors above it.

Four holes need to be made in the case. On one end, only a few millimetres down from the case top edge, are the IEC mains input connector and the on/off switch with its integral LED.

On each side of the case, at the opposite end to the input, are the 3-pin mains outlet sockets. These mount as close as practical to the end of the case to give as much room as possible inside for wiring.

Use photocopies of the cutout diagrams (Fig.5) as templates for drilling the holes. That's exactly how we cut the appropriate sized and shaped holes – we glued photocopies of the diagrams to the case, then drilled a number of fine (say 2-3mm) holes on the inside of the lines. We then pushed the middles out and smoothed the holes with small files.

The 20mm hole for the on/off switch is round, so this was drilled as large as possible then enlarged with a tapered reamer (although the above method would work just as well).

You'll also need to drill two 3.5mm holes alongside the IEC connector for its mounting screws (use the IEC connector itself to ascertain their position) and four more in the bottom of the case for the PC board mounting screws.

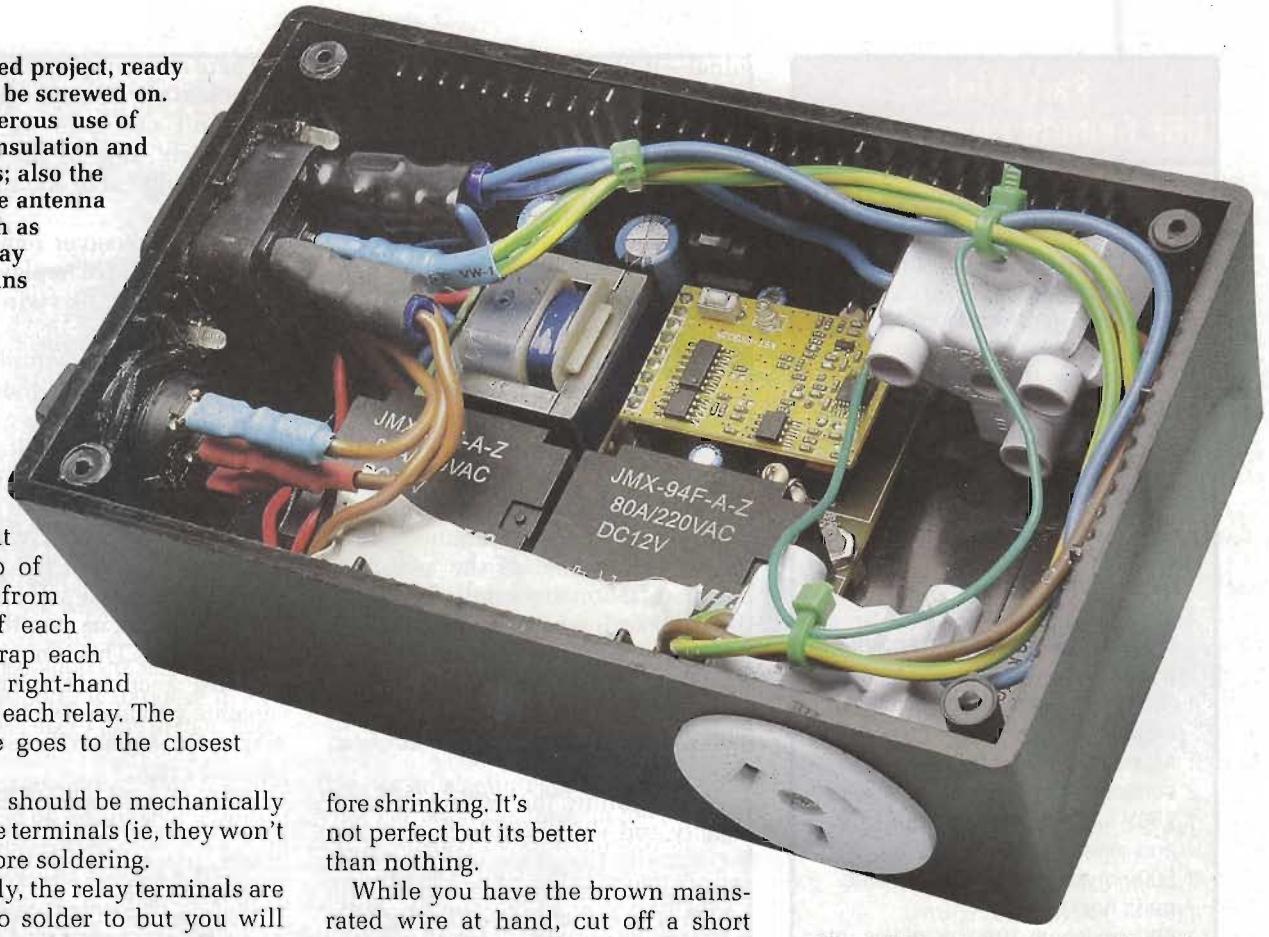
The actual PC board position is quite critical because it must allow room for the other components inside the case. It actually mounts under the sockets, sitting on four nuts to raise it up enough for the Mosfets soldered underneath. It also sits hard up on the edge of the case so that the relay terminals will fit in (bent back 45°, as mentioned earlier). We used the PC board itself to carefully mark the mounting hole positions but as a guide, if you put the first hole 20mm from the left (inside) edge and 5mm down from the case wall, with the remaining four holes on a 73 x 36mm rectangle, you should be pretty-well spot on!

In all cases, the PC board and the IEC mounting screws are Nylon to maintain insulation between inside and outside of the case. The nuts inside may be either Nylon, steel or brass. But don't put the board in the case just yet – you need to connect wires to the relay terminals first.

Connecting it up

Start by wiring from the relay terminals back to the input and output sockets, as these are the hardest to do. Use 10A, mains-rated (250VAC) wire as you are switching the Active power lines. You'll need one length around 100mm long and one around 200mm long.

Incidentally, the easiest way to get such wire is to strip it from a discard-



The completed project, ready for the lid to be screwed on. Note the generous use of heatshrink insulation and cable clamps; also the routing of the antenna wire as much as practical away from the mains wiring.

ed mains lead!

Bare about 35mm or so of insulation from one end of each wire and wrap each around the right-hand terminals of each relay. The shorter wire goes to the closest socket.

The wires should be mechanically secure on the terminals (ie, they won't fall off!) before soldering.

Fortunately, the relay terminals are quite easy to solder to but you will require a reasonable amount of heat to adequately solder the wires on.

The other two terminals (bent 45°) are wired in parallel with another length of brown mains wire, prepared and soldered in a similar way.

Ideally, the terminals and wiring should be insulated – we used a length of large diameter heatshrink, slit down the middle, which we wrapped around the two relays (and their terminals) before shrinking. It's not perfect but its better than nothing.

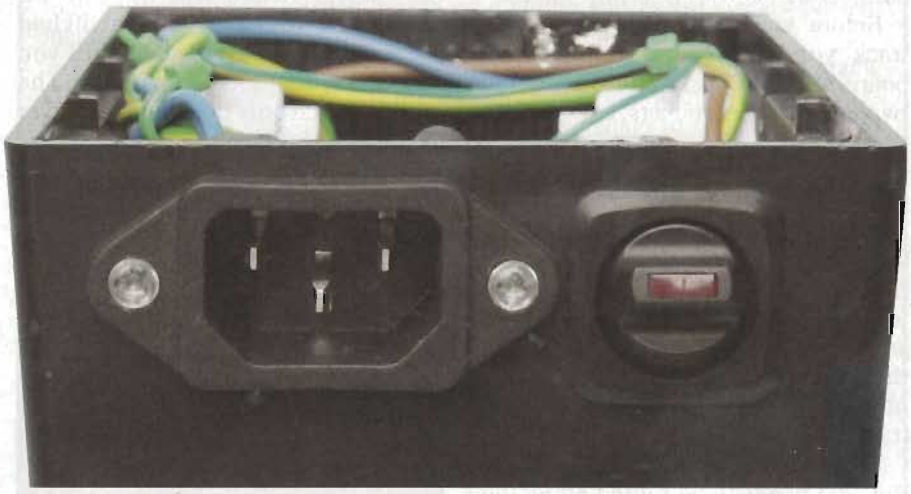
While you have the brown mains-rated wire at hand, cut off a short length (~25mm) and bare 5mm at each end. Assuming you're wiring for 230V, one end is secured in terminal B of the six-way terminal block and the other in terminal C.

Make sure no bare strands poke out of the terminal block.

Put the PC board aside for a moment while you wire the IEC input and the mains switch (if fitted) plus the mains outlets.

The IEC connector and mains switch need to be fitted to the case before you connect to them but the two outlets can be done outside the case – in fact, they have to be to gain access to the grub screws.

Follow the wiring diagram exactly, including the heatshrink insulation over the various spade connectors. Start with the IEC connector earth ter-



The end-on shot of the case shows the mounting of the IEC mains input connector and the on-off switch with its internal LED. Be sure to use Nylon screws for the IEC connector (as well as for the PC board mounting) to ensure insulation integrity is maintained. For the same reason, an all-plastic switch is used.

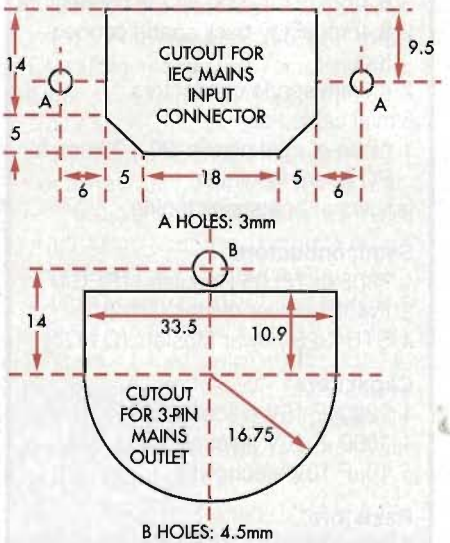


Fig.5: same-size cutout details for the IEC connector (as seen at left) and the 3-pin mains sockets (as seen in above photo).

Parts List – UHF Remote Power Switch

1 double-sided PC board, code K231a, 79 x 73mm*
1 UB1 (157 x 95 x 53mm) ABS utility case ***with ABS lid.***
1 TX01 UHF receiver/decoder module*
1 TX9 4-button UHF keyring rolling-code transmitter
2 JMX-94F-A-Z SPST 80A latching relays*
1 PC-mounting mini mains transformer, 9V secondary*
3 2-way pc-mounting screw terminal blocks (forms 1 x 6-way)*
1 9-way male header pin strip*
1 9-way female header pin socket strip*
1 IEC mains input socket, screw-mounting type
1 mains lead with IEC plug
2 surface-mount 3-pin mains outlets
1 250V 1A switch with integral LED and resistor (optional)
1 500mm length 10A brown mains-rated hookup wire
1 500mm length 10A blue mains-rated hookup wire
1 500mm length 10A green/yellow mains-rated hookup wire
1 175mm length hookup wire (for antenna)
1 50mm length red/black mini figure-8 (or individual red and black – for LED
6 10mm M3 nylon screws
6 M3 nuts
3 6.4mm crimp-type spade connectors
2 6.4mm piggy-back spade connectors
2 4.8mm spade connectors
5 mini cable ties
1 piece of rigid plastic, 20 x 30mm, for PC board insulation
lengths of heatshrink tubing

Semiconductors*
1 7805 or 78L05 Regulator (REG1)
2 IN4001 power diodes (D1,2)
4 STU432S power Mosfets (Q1-Q4)

Capacitors*
1 2200µF 16V electrolytic
1 1000µF 16V electrolytic
5 10µF 10V electrolytic

Resistors*
4 22kΩ 1/4W 4 47Ω 1W

* These components form K321B Kit

minal – it has two green/yellow earth wires crimped inside one spade connector. These other end of these two wires screw into the earth terminals on the mains outlets.

You will note that we used a couple of "piggy back" 6.4mm spade connectors on the Active and Neutral IEC connector terminals. The Neutral has three blue wires, one screwing into each of the mains outlets "N" positions and one terminal "A" on the terminal block on the PC board. Brown wires connect the IEC Active terminal to the on/off switch and to the paralleled relay terminals.

Another brown wire connects from the other terminal of the switch to terminal "D" on the terminal block on the PC board, while the + and – LED terminals on the switch connect to the + and -12V terminal block positions. There is a series resistor inside the switch so the LED can be connected directly to 12V.

Again, follow the wiring diagram exactly and you shouldn't go wrong. Incidentally, the reason we are specific about which terminal is wired with which wire is that connecting the blue wire (Neutral) to terminal "A" keeps the brown wire (Active) as far away from the 12V supply as possible.

Because mains wiring is involved, all of the spade connectors really need to be crimped with a ratchet crimper – the "plier" type of crimper really doesn't apply enough pressure to adequately crimp the cables. If you don't have a ratchet crimper, it's a good idea to solder the wires to any spade connectors (as well as crimp them).

Before you get too far down the track, you will need to insert the PC board into the case, along with the two mains outlet sockets, to complete the wiring.

Dressing the cables

Where mains wiring is involved, we must assume the worst-case scenario where, somehow, a wire lets go (eg, it unsolders due to heat, or is not screwed in properly, etc). This being the case, we must assure the wire cannot flail around and contact something it shouldn't.

Therefore, all of the wiring within the case needs to be routed along the edges and fastened together with small cable ties. Small cable ties are very cheap ($2 a bag at bargain stores!) so don't scrimp on them

There are a couple of handy mounting holes on the mains outlets (which we don't use here as the outlets "sandwich" around the case) which make handy cable tie anchors – see the photos.

The UHF receiver requires a short length (173mm) of hookup wire for its antenna. Ideally, this wire should also be mains-rated.

One thing that would concern us about this wire is if there were any strands of copper poking out the end. Just to be on the safe side, we covered the end of the wire in a short length of heatshrink and made doubly sure it was secured properly.

You will note in the photographs that this antenna wire is also kept away, as much as possible, from the mains wiring. This is not just for safety reasons; keeping the antenna wire separate will also give the receiver its maximum sensitivity and therefore greatest range.

When you are satisfied that the project is wired as shown in our diagrams, place the lid on the box and screw it in place.

Now connect the power and turn it on. The LED inside the switch should glow, indicating you have 12V – and when you press "A" or "C" on the transmitter you should again hear that "thunk". Press "B" or "D" to turn it off, then connect a mains device such as a lamp or other easy-to-recognise device to either of the power outlets and check that you can turn it on and off via the transmitter.

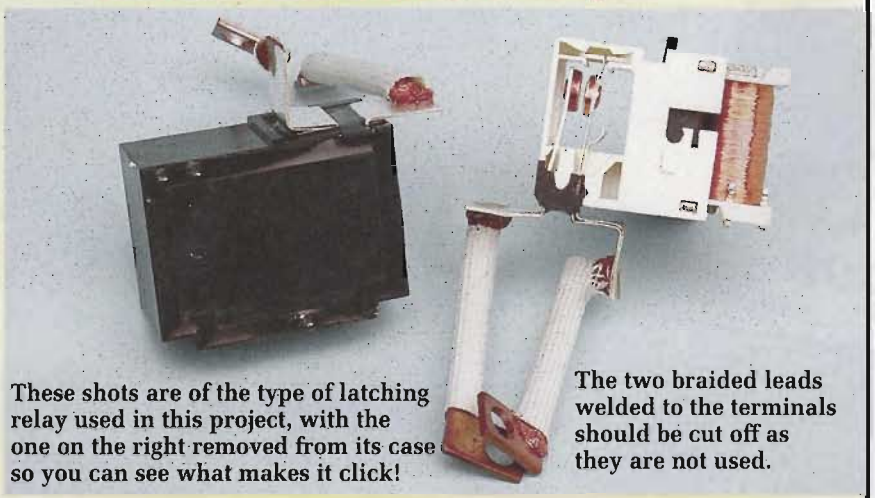
Finally, remember that turning off the power switch will not turn off any device which is being switched – it stays in its current state until you switch it with the key transmitter. The power switch only disconnects power to the UHF Switch.

Where from, how much?

This project was developed by Oatley Electronics, who retain copyright on the design & PC board.

The K231B Kit, which includes the UHF receiver and all on-board components sells for $49.00 inc GST
The TX9 transmitter, including keyring case, sells for $16.00 inc GST
Freight is $7.00 per order
web: www.oatleyelectronics.com.au
or (02) 9584 3563

What is a latching relay?



These shots are of the type of latching relay used in this project, with the one on the right removed from its case so you can see what makes it click!

The two braided leads welded to the terminals should be cut off as they are not used.

This explanation comes from our December 2006 issue but we thought it would be opportune to repeat it, as a latching relay is not something that you come across every day. In fact, even those "in the trade" may not understand the operation nor purpose of a latching relay.

First, a conventional relay operation: this has an electromagnet, formed by a coil wound on a laminated iron core. While current flows through the coil, a magnetic field is created which attracts a spring-loaded steel armature towards the iron core. The armature either pushes or pulls electrical contacts towards or away from each other, making or breaking a circuit (and in most relays, both – breaking one circuit then making another). When the current stops, the magnetic field collapses, so the armature springs back and the contacts revert to their normal state.

A latching relay is much the same, except that once the armature has switched over to the opposite position, it will stay there, even when the current through the coil stops. It will only switch back the other way when told to by the controlling circuit. You could even disconnect the latching relay from the circuit completely and it would still stay in the last-set position.

A good analogy is a standard switch: you push the lever one way and it stays there until you push it the other way. The difference is that instead of a finger pushing or pulling a lever, you have the magnetic field pushing or pulling the armature. The armature may be held in place by a permanent magnet or it may be mechanically latched, based on a spring and detent system (which, incidentally, is how most switches stay in the selected position).

Another analogy is a bistable multivibrator or flipflop – it has two stable states, neither of which has any pre-eminence over the other.

Latching relays may have two coils – one switching to one position, the second switching to the other – or it may have a single coil, where the current is reversed through the coil to switch to the opposite state. This is the type of latching relay used in this project.

It is a common misconception that latching relays do not consume power when energised. Although current is not required through the coil to hold the armature in position, current will still flow if applied, negating the reason for using a latching relay over a conventional relay. Therefore, a short pulse of current is normally used to actuate it, just as in this project.

Where conventional relays have "normally open" (NO) and "normally closed" (NC) positions, latching relays with changeover contacts don't – because there is no "normal" position. In our case, the relay is a SPST type so, like a switch, the contacts are either open or closed (off or on, if you like).

Finally, no relay coil suppression diodes can be used on a single-coil latching relay because of the polarity reversal. Therefore the voltage rating of any switching transistor (or Mosfet in this case) must be high enough to safely handle the sp-ike which occurs when current ceases and the magnetic field collapses.

Want *really* long range (2km or so!)?

Oatley Electronics have available a tiny (27 x 20mm) add-on transmitter module which is claimed to increase the range of the TX-09 transmitter from tens of metres to kilometres.

It's the TX-03 module, which also operates under Australian LIPD (licence-exempt) regulations.



There are only three connections required – data (which can be taken from the antenna output), power (3V or 5V) and ground. It will operate from 315MHz - 433.92MHz and from -40° to +80°. Oatley's RRP is $16.00

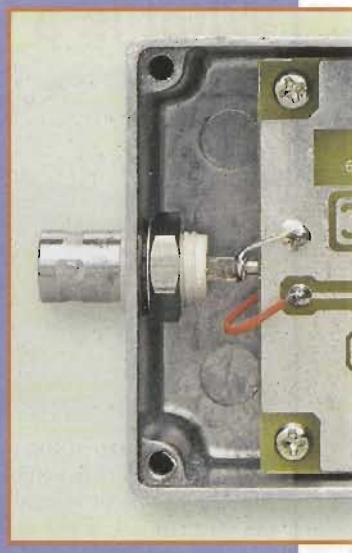
The manufacturer of the TX-03 states that the transmit power is 15dBm, which equates to 32mW. Presumably this is at the upper end of the specified operating voltage range (3-12V).

The maximum legal output power of LIPD devices in the 433MHz band is 25mW, so (again presumably) the transmitter would need to be operated at the lower end of the supply voltage range to remain legal. Indeed, Oatley Electronics warn that operating at 5V may exceeed the legal limit. Therefore, we suggest operating only from 3V. Oatley claim a range of 2km+ at 3V and 4km+ at 5V.

Naturally, the TX-03 module will not fit inside the keychain transmitter case so you will have to make other arrangements to mount it and also power it. The telescopic whip antenna can be unsoldered from the TX-01 PC board and a short wire used to connect that point to the "Data" input on the TX-03. While the TX-01 has a 12V battery, using this would result in too much transmitter power, as described above.

Unfortunately, despite extensive searching, we have been unable to obtain any further specifications for the Chinese-made TX-03. SC





By JIM ROWE

Input attenuator for the Digital Audio Millivoltmeter

If you'd like to be able to use our Digital Audio Millivoltmeter to measure AC voltages up to 140V RMS, this add-on project is the answer. It's a simple switched input divider which lets you add 40dB, 20dB or 0dB of attenuation ahead of the meter at the touch of a knob.

THE DIGITAL AUDIO Millivoltmeter described in the March 2009 issue of SILICON CHIP can measure signals over a 79dB range, from about 160µV (-76dBV) up to 1.41V RMS (+3dBV). This is fine for low-level measurements but does make the meter unsuitable for measuring higher level signals.

With the benefit of hindsight, we could have built a switched input divider right into the meter itself. However, this would have involved a tight squeeze to fit the additional switch and components into the PC board and box and the front panel would have been very crowded as well.

Anyway, to increase the measured voltage range, we have designed this little "outboard" switched input attenuator. It's designed to be connected ahead of the Digital Audio Millivoltmeter's unbalanced input via a short BNC cable.

There's no need for cable swapping to remove it when you are measuring small signals, either – because it incorporates a "straight through" (0dB) switch position as well. So once it's built and connected to the input of the meter, its own input connector effectively becomes the meter's unbalanced input.

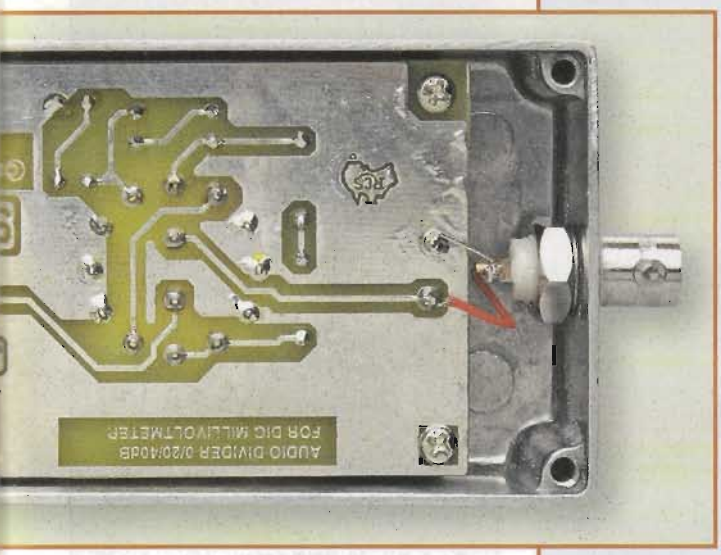
Simple circuit

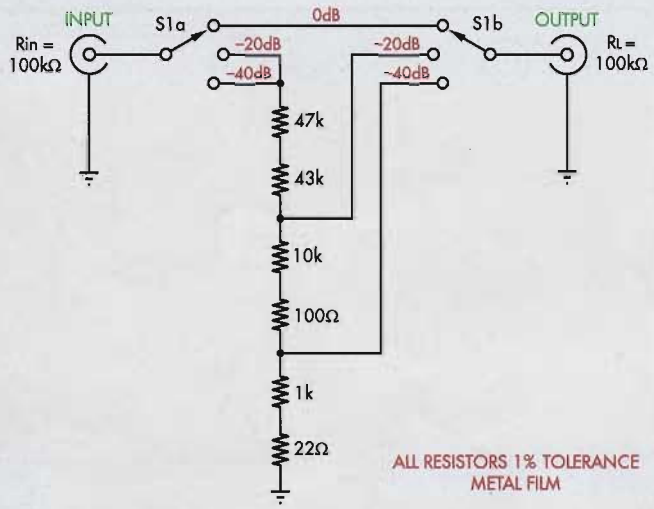
There's very little in the attenuator, as you can see from the circuit schematic (Fig.1). A 2-pole switch is used to switch the input signal either straight through to the output (0dB) or via one of two taps on the resistive divider.

The upper tap gives a 10:1 division (-20dB), while the lower tap gives a 100:1 division (-40dB). As a result the first position of the switch leaves the millivoltmeter's own ranges unchanged, while the next position effectively subtracts 20dB from the meter readings and extends its "full scale" reading to 14.1V RMS or +23dBV.

Similarly, the third switch position subtracts 40dB from the meter readings and extends its measurement capability out to 141V RMS (+43dBV).

Note that the meter readings don't take this added attenuation into ac-





SC ©2009 AUDIO INPUT DIVIDER 0/-20/-40dB

Fig.1: the circuit is simply a switched resistive attenuator network, with double-pole switch S1 selecting between the 0dB, -20dB (10:1 division) and -40dB (100:1 division) positions.

count, because there's no way for the PIC micro inside the meter to know how much extra attenuation is being applied. So you have to add the 20dB or 40dB to the readings yourself and/or multiply the millivolt readings by either 10 or 100 as appropriate. That doesn't involve a great deal of mental maths though.

Now before you ask, we'll clear up a few points about the resistor values used in the divider. Do they make allowance for the shunting effect of the meter's own input resistance? Yes, they do.

If you care to work it out, you'll find that the division ratios of 10:1 and 100:1 are only correct when the output of the attenuator is loaded with 100kΩ (ie, the input resistance of the millivoltmeter). The ratios are then within 0.1% of their nominal 10:1 and 100:1 values – which is close enough considering we are using 1% tolerance resistors.

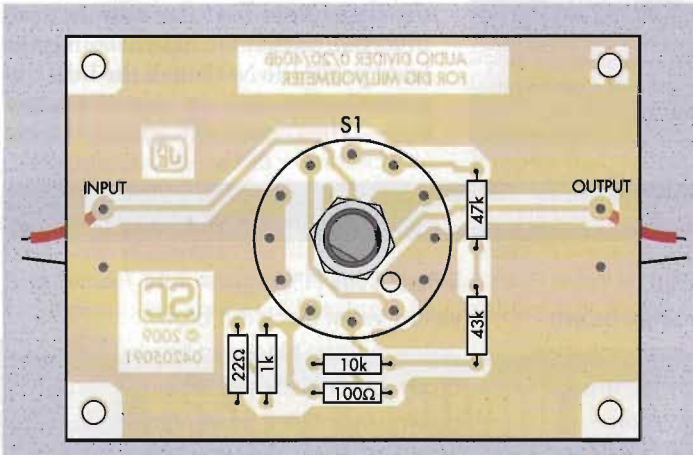
The input resistance of the input divider/millivoltmeter combination also remains very close to the nominal 100kΩ figure for the meter itself. Clearly, it's exactly the same in the 0dB switch position but even in the other two positions it is still within 2%.

Construction

Most of the parts are mounted on a small PC board measuring 76 x 53.5mm and coded 04205091. This is designed to fit inside a standard small diecast aluminium box measuring 111 x 59 x 30mm. This box provides shielding and physical protection. It also matches the larger diecast box used for the millivoltmeter itself.

There's plenty of space inside the box for the BNC input and output connectors, which are both insulated single-hole mounting types. As shown in one of the photos, the board assembly itself mounts centrally in the bottom of the box and is secured via four M3 x 15mm tapped spacers. Note that metal spacers and screws must be used to secure the board because one of the spacers is used to connect the box to the PC board earth copper.

Note also that the other three spacers and screws make no contact with the board earth copper. This is done to prevent the formation of earth loops.



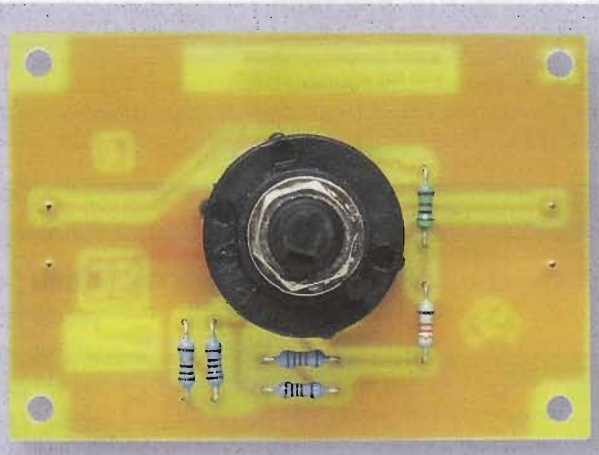


Fig.2 (left): position the parts on the PC board as shown here and install PC stakes on the copper side at the external wiring points. At right is the completed board – it should only take a few minutes to assemble.

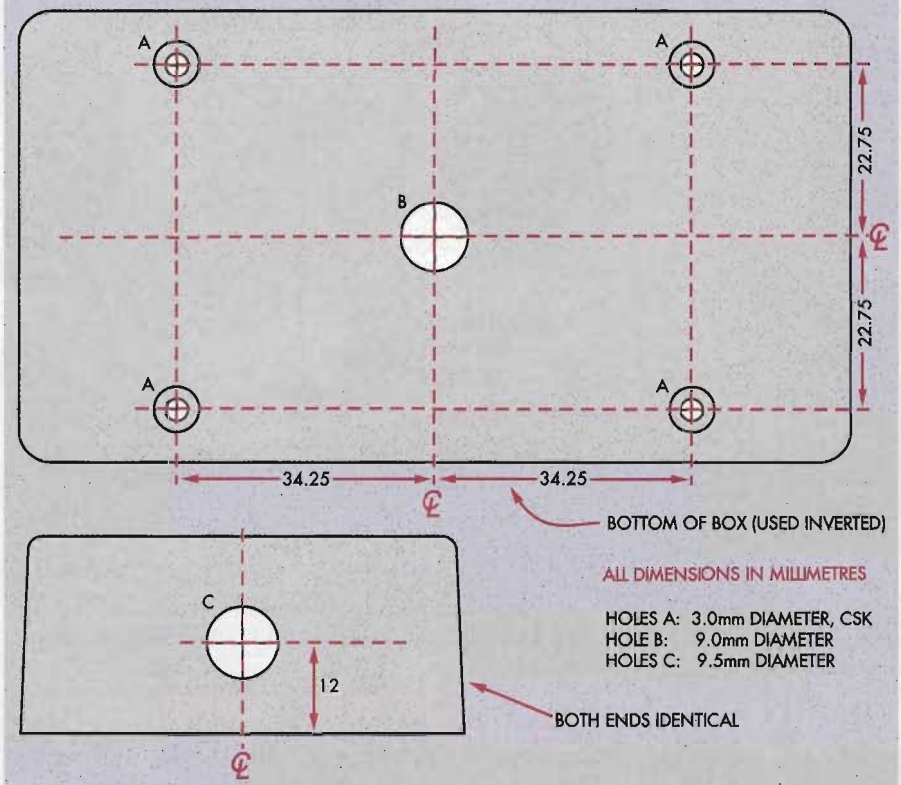


Fig.3: this diagram shows the drilling details for the metal case. Note that the bottom of the box is used as the front panel, so be sure to drill holes "A" & "B" in the base (NOT the lid).

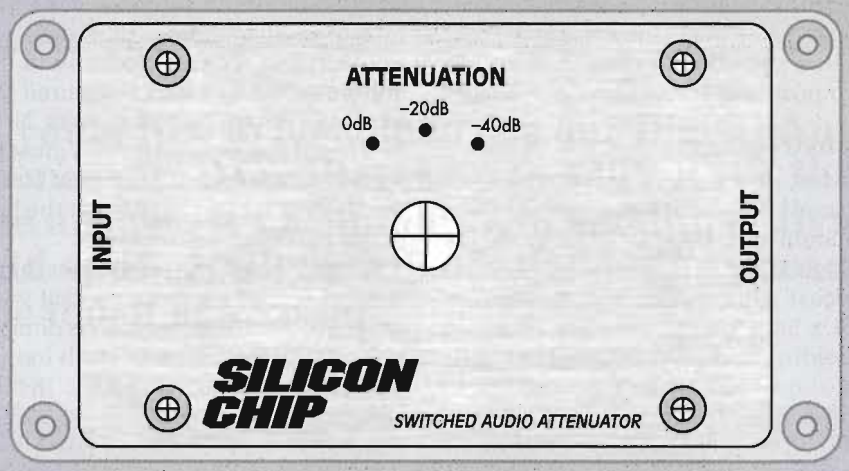


Fig.4: the front-panel artwork is attached to the base of the case. It can either be photocopied or you can download it from our website and print it out.

Parts List

1 PC board, code 04205091, 76 x 53.5mm
1 diecast aluminium box, 111 x 59 x 30mm
1 2-pole 6-position rotary switch
1 small instrument knob
2 BNC connectors, insulated single hole mounting
4 M3 x 15mm tapped metal spacers
4 M3 x 6mm screws, pan head
4 M3 x 6mm screws, countersink head
4 1mm PC board terminal pins
4 stick-on rubber feet
Light-duty hook-up wire

Resistors (0.25W 1%)

1 47kΩ	1 1kΩ
1 43kΩ	1 100Ω
1 10kΩ	1 22Ω

Fig.2 shows the parts layout on the PC board. There's just the six resistors and the switch, so assembly will only take a few minutes. Cut the switch shaft to a length to suit the knob before fitting it to the PC board.

The connections between the input and output BNC connectors and the PC board are made via short lengths of hookup wire. We fitted PC board pins to the board (from the copper side) to make these connections a little easier.

Wiring up the attenuator should be very easy – see Figs.2 & 5. The whole job should take you no more than an hour or so, including the time to drill and ream the holes in the box.

Fig.3 shows the drilling details for the case. **Note that the case is used inverted, so that the base becomes the front panel (do NOT drill the lid).** Use a small pilot drill to start the larger holes, then carefully enlarge them

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	43kΩ	yellow orange orange brown	yellow orange black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	22Ω	red red black brown	red red black gold brown

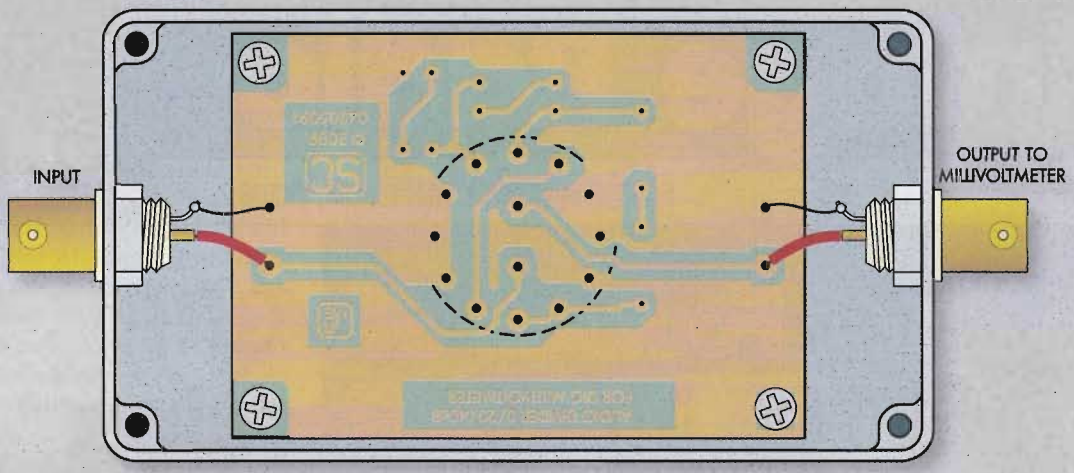


Fig.5: the PC board is fitted with M3 x 15mm tapped spacers and mounted upside down in the base of the case. The BNC sockets are then wired by running leads to the PC stakes on the board.

to the correct size using a tapered reamer.

Fig.4 shows a full-size artwork for the attenuator's front panel. It can either be photocopied onto an adhesive-backed label or you can download the artwork from our website and print it out. This can then be covered with self-adhesive clear plastic film (to resist discolouration due to finger grease) and attached to the base (use a thin smear of silicone sealant to attach the label if it doesn't have an adhesive backing). Cut out the holes for the switch and the PC board mounting screws using a sharp hobby knife.

Next, move the end-stop washer on the rotary switch to the correct location for three switch positions. Do not initially refit the nut after doing this, though – just refit the lockwasher for the time being (the combined height of the switch and lockwasher above the PC board is very close to 15mm, so they match the four M3 x 15mm tapped mounting spacers).

Countersink-head M3 x 6mm screws should now be used to secure the four M3 x 15mm tapped spacers to the base. The PC board can then be fitted in position and secured using M3 x 6mm pan-head screws. That done, fit the nut to the switch and attach the knob to the switch shaft.

Finally, secure the lid in position (this now becomes the base of the case). It's also a good idea to fit four small adhesive-backed plastic or rubber feet to the box lid, to prevent scratches to bench-tops or any other surface the device is placed on.

That's it. Once your add-on attenuator is finished, your Digital Millivoltmeter will be able to make measurements over a 96dB range: from 160µV to just over 140V RMS. SC



The unit can be switched to give -0dB, -20dB or -40dB of attenuation. Fit the base (ie, the lid) with rubber feet to prevent scratches to desk-tops.

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Vintage Radio



By RODNEY CHAMPNESS, VK3UG

The Astor Football GR/GRP 3-Valve TRF Mantel Receiver



Manufactured around 1948, the Astor GR/GRP receiver was nicknamed "Football" because of its cabinet shape. It's a low-cost 3-valve TRF set designed for tough times.

"WIRELESS" RECEIVERS were initially all tuned radio frequency (TRF) types. The superheterodyne circuit was not invented until Major Edwin Armstrong developed the concept during World War 1. Superhet receivers are more complex than TRF receivers but have many advantages where high performance is required.

By contrast, TRFs were traditionally used where cost, non-critical performance and simple circuit design were important. Many TRF radios are easy to operate but those using regeneration require operating skills that many non-technical listeners find hard to acquire. Although TRFs are rarely seen these days as domestic receivers, they are still used in the form of super-regenerative receivers for such things as garage door openers.

Most receivers manufactured from the mid-1930s onwards were superhets but manufacturers occasionally produced a simple, cheap TRF set to satisfy the low-cost end of the market. The Astor GR/GRP is one such example.

The Astor Football (GR, GRP)

The Astor "Football", as it is affectionately known, is a small, 3-valve, economy mantel broadcast receiver produced around 1948. "Football" wasn't its official name but the cabinet is around the same size and shape as an Australian Rules football, hence the unofficial nickname given to the set by users and collectors. It was intended for use as a kitchen or bedroom radio; anywhere radio signals were strong.

The Football's bakelite cabinet came in a few colours, with brown and cream being the most common. The cabinet is made in two parts, which are separated by undoing three screws, two underneath the cabinet through rubber buffers and the other through the back. However, the design leaves something to be desired, as the thread that goes through the cabinet to the rear retaining nut fouls the 6G8G valve and makes it difficult to replace the back.

To transport the set, four fingers are inserted through the back section of the case and it is then carried that way. However, an antenna is required for decent reception and the 5.2-metre permanently connected antenna doesn't lend itself to easy portability.

The set can have either of two type numbers: GR or GRP. GR refers to a set that uses a 50Hz power transformer and a 5Y3GT rectifier, whilst GRP refers to a set that uses a 40Hz transformer and a 6X5GT rectifier. Apart from that, the two sets are identical.

Circuit details

Because it is a TRF set, the Astor Football's circuit is quite simple. However, in order to obtain reasonable performance, reflexing is used to gain extra sensitivity. Fig.1 shows the circuit details.

The input tuned circuit (29, 13, 33, 34) is quite conventional, with no automatic gain control (AGC) voltage applied to a 6G86 RF valve. As shown,

the input signal from the antenna is amplified by the 6G8G and passed on to another tuned circuit (30, 12, 33 & 35). It then goes via an RC network to a detector diode in the 6G8G. The end of the untuned winding not connected to the 6G8G's plate is bypassed to earth via capacitor 6.

The detected audio signal is fed through resistor 18, capacitor 4 and resistor 16 to the grid of the 6G8G. The residual RF from the detector is largely filtered out by capacitor 9. Capacitor 8 prevents the audio and bias signals from being shunted to earth by the tuned circuit.

The 6G8G amplifies the audio as well as the RF signal. In the plate circuit, the untuned winding of the tuned circuit does not impede the audio signal. As far as the audio signal is concerned, there is only the plate load resistor (22) in circuit. The audio is developed across this resistor and applied via capacitor 3 to the grid of a 6V6GT audio output valve.

The 6V6GT amplifies this audio signal and applies it to a speaker transformer which in turn drives a 5-inch (125mm) loudspeaker. Note that there is no negative feedback in the audio circuitry, in keep with the Astor's role as an economy receiver.

The power supply is quite conventional, with either a 6X5GT or a 5Y3GT acting as a full-wave rectifier. The 6X5GT appears only to have been used in the units supplied with a power transformer intended for 40Hz operation. At the time this set was produced, Perth (WA) apparently had 40Hz mains while most of the rest of Australia had 50Hz mains.

Note that the 6.3V dial lamp is run from a 5V tapping on the heater winding in order to extend its life. Another point of interest is that the receiver's power consumption is around 35W, which is almost the same as most 5-valve sets of the era.

There is no conventional volume control. Instead, the volume is controlled by the back-bias system. This can be varied anywhere between -2V and -22V and is applied to the variable-mu 6G8G valve. The more bias, the less amplification.

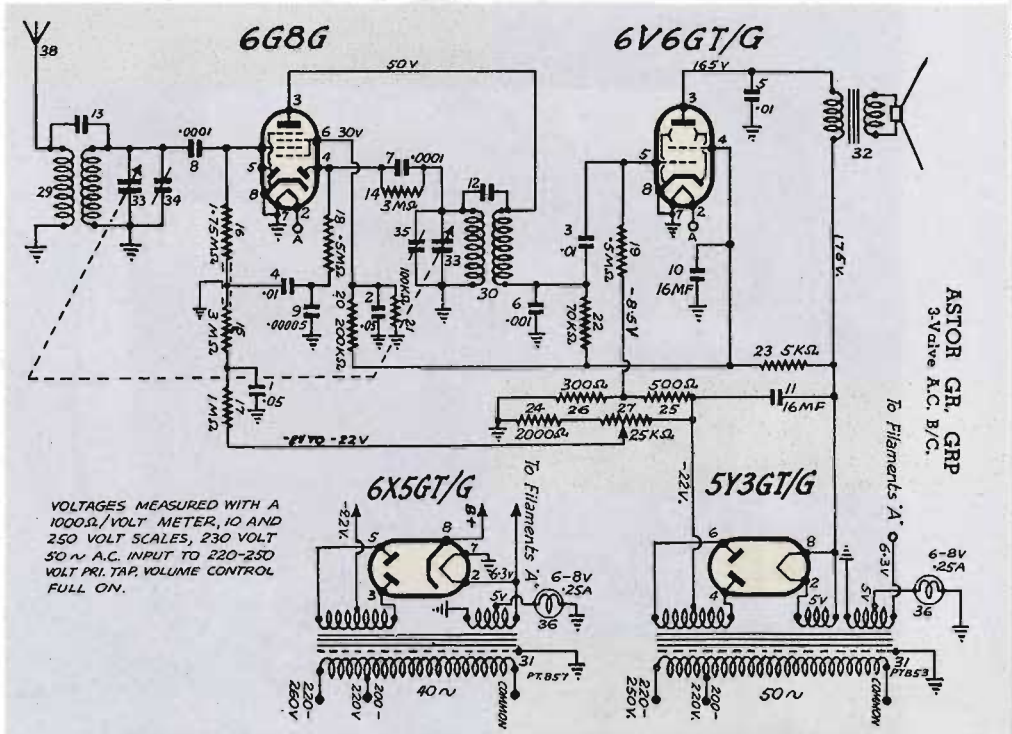
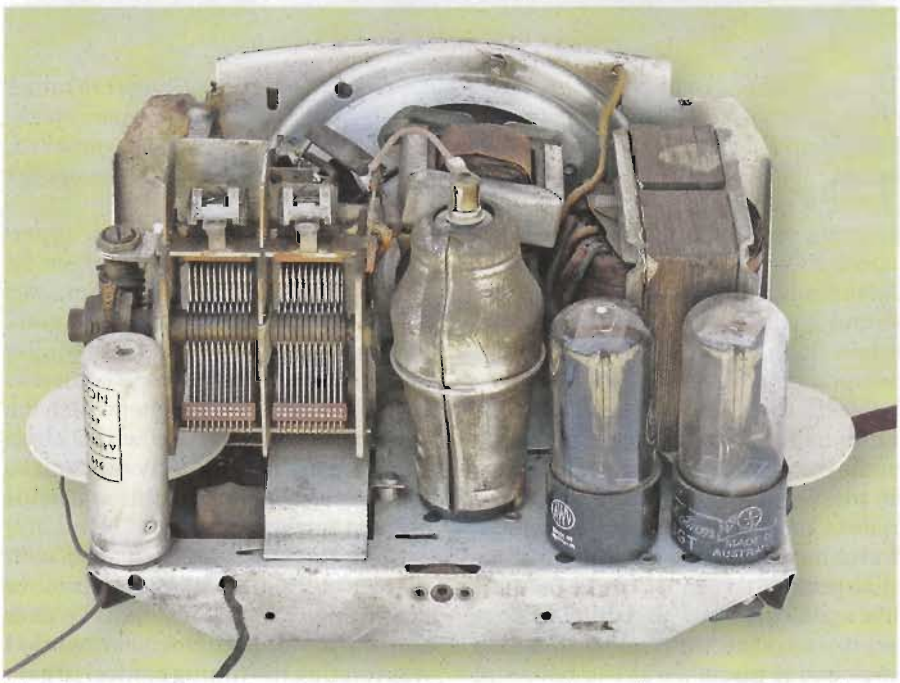


Fig.1: a 3-valve TRF circuit is used in the Astor GR/GRP receiver, with the 6G8G valve functioning as a reflexed RF and audio stage.



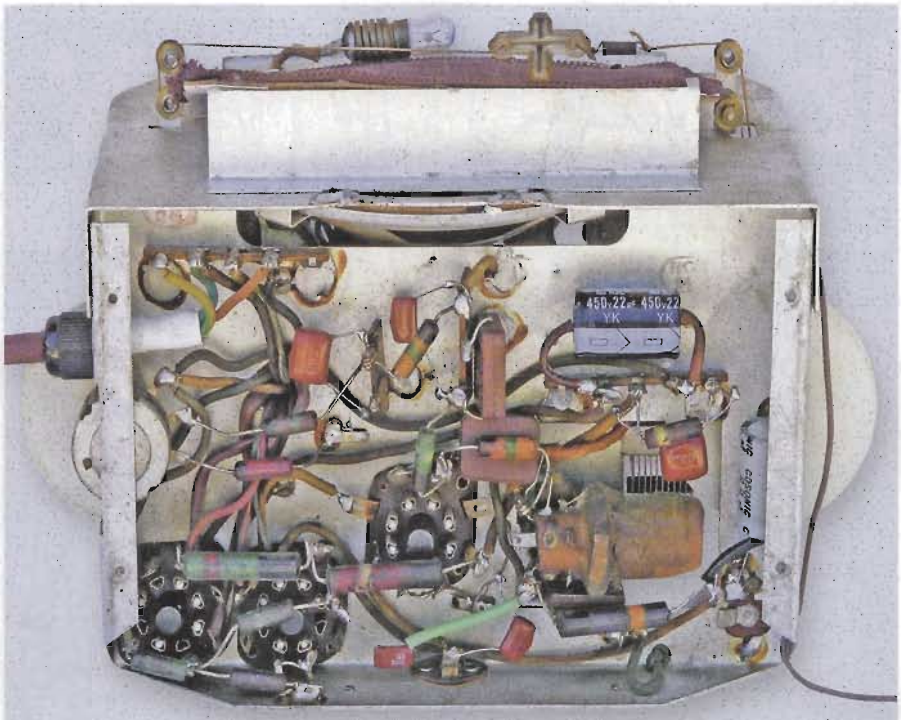
The above-chassis parts are close together but can be easily accessed once the valves have been removed. Note the metal shield on the 6B8G8 RF valve.

Restoring the GR

This particular receiver had been largely restored when it was given to me on loan. First, the bakelite cabinet was in good order and required no attention. Second, all the paper capacitors, one electrolytic filter capacitor and a couple of wires with perished insulation had been replaced. And third, the 2-core figure eight power lead had been replaced with a 3-core type.

The wires that had been replaced were bright blue and looked out of place. As a result, I replaced them with brown hook-up wire which looked similar to the original wiring.

The next thing I noticed was that the cardboard speaker cloth template was much the worse for wear. There were a couple of choices here – either



This view shows the underside of the chassis with the restoration nearly completed. Among other things, the mains cord should be rewired, so that its earth lead is attached to a crimp eyelet lug which is then securely bolted to the chassis (the soldered tag-strip connection to chassis shown here could become faulty, due to the joint going "cold").

I could make a new template out of thick cardboard or I could patch up the original by gluing strips of cardboard to it.

In the end, I decided to repair the existing template although in retrospect it would have been better to have made a new one. Of course, I only found some suitable cardboard after I had finished repairing the original template but that's always the way.

Next, the light-coloured speaker cloth had rotted so I replaced it with some new material. This was glued in place using Tarzan's Grip. Unfortunately, I only had dark-brown cloth, so I also had to change the colour of the dial pointer so that it could be seen. This was changed to white using a white-out correction pen and does not look out of place.

Parts layout

The parts under the chassis are all quite accessible, so the set is easy to service. The layout however, is something of a dog's breakfast. Because the set has relatively low gain, parts placement is not overly critical, although personally I like to see all components related to the operation of a particular section grouped together.

Above the chassis, things are rather different and there is little spare space. However, with the valves removed, all parts can be easily accessed for service.

This particular radio had apparently been used in a kitchen, as fat and grime were evident on the chassis and various components. This gunk was removed from the chassis (after removing the valves) using a kerosene-soaked kitchen scourer, after which the chassis was wiped down with a clean cloth. Kerosene is slightly oily and so some remains on the chassis and helps prevent further rusting.

Next, the knobs were cleaned with soapy water and a nailbrush to remove the finger grime that had built up over many years of use. However, while I was rotating the tuning control to gain access to all sections of the knob, I noticed that the fibre gear that drives the tuning capacitor has several badly damaged teeth. This means that tuning from one end of the dial to the other will eventually strip these rather delicate teeth.

This is an area of weakness in some Astor receivers but fortunately, a member of the HRSA makes replacement gears.

While looking at the dial-drive mechanism, I also noticed that all the pulleys that the dial cord runs over are riveted into place. This means that none are free to turn, which places further stress on the dial-drive mechanism but not on the fibre gear-drive, thankfully.

This is not an isolated incident as a previous Football that I serviced had exactly the same riveted dial-pulley problem. What's more, its a problem that cannot be easily overcome. Having said that, it's worked for around 60 years with no real problems, so it really isn't worth worrying about. Still, it really was a cheapskate method of constructing the dial-drive mechanism.

Trying it out

Having finished the repairs, I powered the set up while monitoring the various voltage rails. Everything was normal except for the plate voltages which came up slightly higher than shown on the circuit. However, this is understandable as the voltages marked on the circuit were obtained with a mains voltage of 230V AC while mine is 245V AC (despite the fact that the official voltage these days is 230V).

I had expected the radio to work properly from the outset but my confidence was misplaced. Instead, its performance was extremely poor and there was noticeable hum in the audio. So I had some troubleshooting to do.

First, I connected an electrolytic capacitor across each of the electros in the power supply in turn, to determine if one of these was faulty. This quickly showed that capacitor 10 was indeed faulty and this was confirmed when I checked it on my capacitance meter.

I replaced it with a 22µF 350V electrolytic capacitor, which I hid under the chassis. The old capacitor was simply disconnected but left in place to keep the set looking as authentic as possible.

With the new capacitor, the performance improved markedly, although it still wasn't brilliant. This isn't exactly a high-performance set but the performance was still well down compared to the one I had previously restored.

With the various voltages being relatively close to specification, I knew that the 5Y3GT rectifier valve was in good order. As a result, I tried replacing the 6V6GT audio output valve

but this gave no change. However, when I replaced the 6G8G, the set's performance improved dramatically. The original 6G8G was obviously well past its use-by date!

Alignment

All that was left now was to touch up the alignment. Alignment is a task that many newcomers to vintage radio endeavour to steer clear of and indeed, aligning some receivers is quite a task. Sets like the AWA 7-band series or a Barlow Wadley XCR-30, for example, can be quite a challenge.

By contrast, the Astor Football is extremely easy to align, with only three adjustments involved.

There is a standard procedure for aligning the receiver but for the average collector, a somewhat simpler method also works extremely well. First, connect the antenna that's normally used to the receiver, then adjust the dial pointer position for equal overshoot at each extremity of the dial. That done, tune to the low-frequency end of the dial and use a signal generator to check that the set is tuned to about 535kHz.

If you don't have a signal generator, just tune to a station that's close to the low-frequency end of the dial.

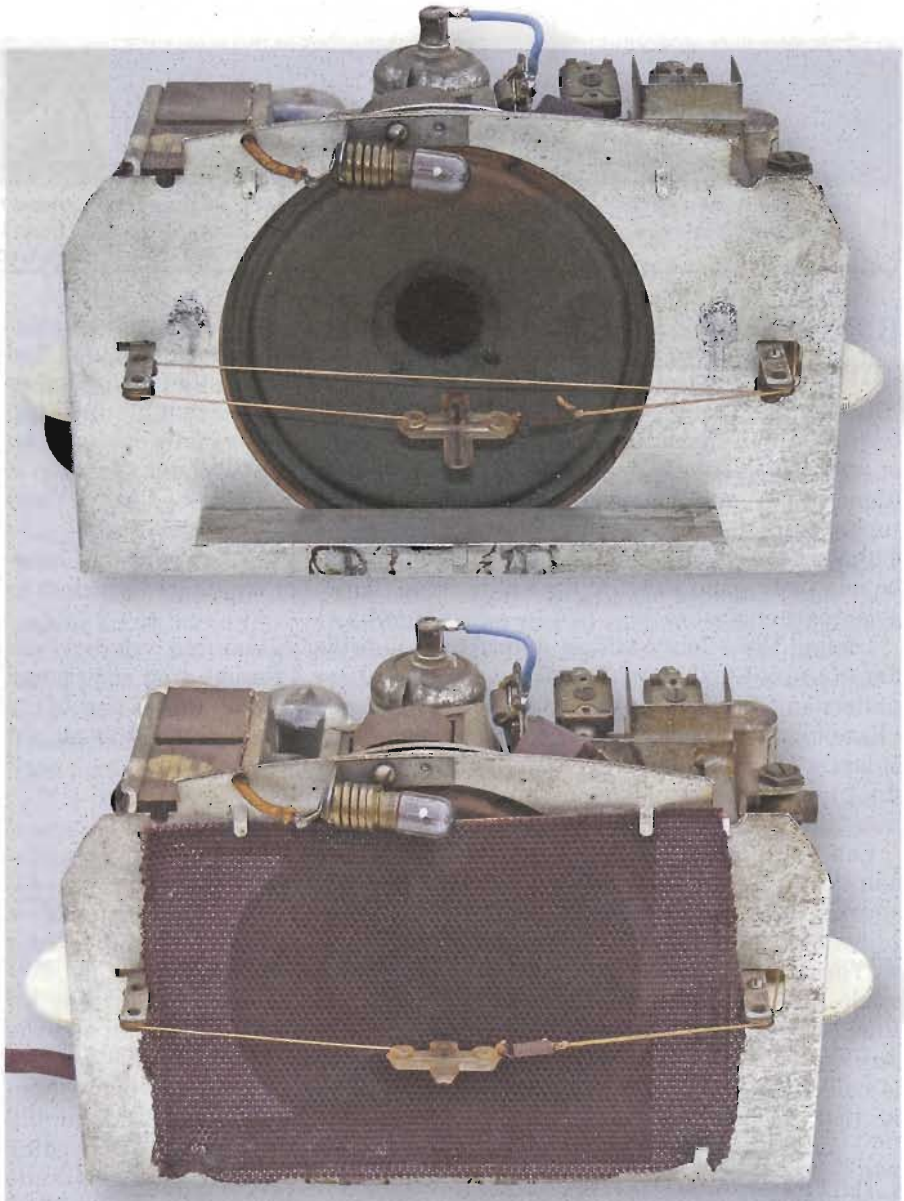
Because there is no adjustment to set the lowest frequency received, some sets may not tune down to 535kHz due to tolerances in the tuned circuit components. If so, there's not much you can do about it – just accept it.

The tuning should now be adjusted to 1400kHz or to a station that's close to this frequency. The dial is not marked with frequency indications so it will be necessary to check the station frequencies in order to do this.

Regardless as to whether a signal generator or a radio station is used as the signal source, the alignment procedure is the same. If the signal is received at a lower indicated frequency on the dial than where it should be, it will be necessary to screw both trimmer capacitors in to increase their capacitance. This will gradually move the tuning further up the dial, towards the correct spot.

Conversely, if the station appears higher up the dial that it should, reduce the trimmer capacitances. In both cases, it's only a matter of adjusting the trimmers to peak the signal at its correct dial location.

The selectivity of a TRF set mainly depends on the frequency that's tuned. In the case of the Football, the selectivity is about 10kHz at the low-frequency end (ie, at around 550kHz) and about 30kHz at the high-frequency end (ie, around 1400kHz). This is one of the deficiencies of TRF sets; ie, the higher the frequency tuned, the worse the selectivity.



These views show the front of the chassis without the speaker cloth (top) and with the new speaker cloth attached (bottom).

Summary

The Astor GR /GRP football is very much an economy set and corners were cut in its design, as shown by the dial-pulley arrangement. Basically, it is an uncomplicated TRF set with reflexing around the 6G8G. However, don't be put off by the idea of reflexing, as it is not a troublesome area in this set.

If there are problems, it is only necessary to measure the values of the various components in this section to determine where the problem lies.

The set is easy to work on below the chassis, although not quite so easy on top. It is dead simple to align but not very sensitive. However, for its intended use as a kitchen or bedroom set in a suburban environment, its performance is quite adequate.

There are few, if any, problems with this set that cannot be easily fixed. For this reason alone, it would make an ideal first restoration project.

In short, the Astor football is a favourite with many collectors and is well-worth having in a collection, as it was one of the last domestic TRF valve designs to be sold in Australia. SC

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Battery amplifier for single loudspeaker

I'm trying to source an amplifier to take the output signal of my MP3 player and drive a single 8-ohm speaker (rated at 40W max). I want to be able to run the amplifier from batteries or from a plugpack and I want the amplifier to be relatively small so I can place it in a compact enclosure.

I found the Mighty Midget amplifier (SILICON CHIP, March 2002) but I understand this is no longer available. I have found other amplifier modules at Jaycar Electronics but these require dual supply rails, making it much more difficult to use batteries.

Can you please suggest a suitable amplifier? Since I only have a single speaker, can I use a smaller rated amplifier than 40W? (G. W., via email).

● The Mighty Midget can still be made. The PC board can be purchased from RCS Radio (www.rcsradio.com.au), while the TDA1562Q amplifier IC is available from Dick Smith Electronics (Cat. ZA-2098).

Charging controller current query

I saw the Charging Controller for 12V Lead Acid Batteries in the Circuit Notebook pages of the August 2008 issue and am wondering what the circuit's own power consumption is. The reason for this question is that I have a small solar panel that produces up to 100mA in full sun. Its open-circuit voltage is in the order of 22V which is probably not much good for 12V car batteries. (T. T., via email).

● The quiescent current of the Charging Controller would be very close to 13mA.

Note that this current is drawn from the battery, although your solar panel will need to supply this as part of the charging current, when the circuit turns on transistor Q1.

Problem with Radar Speed Gun

I hope you can help me with a problem I am having with the Radar Speed Gun Mk.2, (SILICON CHIP, November & December 2006). The kit went together very well and appears to be working apart from the fact that I am not getting any waveform from TP2. The article says that this should give a train of narrow positive-going pulses with a peak-to-peak amplitude of about 11.5V.

The 38kHz oscillator is oscillating and I am getting the correct waveforms on pins 1, 2 & 3 of IC8, yet there is nothing on pins 9 & 11 (TP2).

All three digits of the display are working and I am getting an 11.4V negative peak display on TP3. The headphone output gives a fluctuating audible sound as I move my hand to and from the microwave head unit, indicating that the head is working OK.

I tried replacing both IC7 (4020B) and IC8 (4073B) but this has not corrected the problem. I have checked and double-checked everything many times but am unable to find the reason I am not getting a waveform at TP2.

I would be grateful if you are able to suggest what might be the problem. (D. P., Leeds, UK).

● If you are getting digits other than zeroes displayed on the three 7-segment displays, this suggests that your timebase section is actually working as it should and that there are actually pulses present at TP2, even though your scope is not able to show them. They are quite narrow, by the way (only a few tens of nanoseconds).

We suggest that you look for waveforms at the Q and Q-bar outputs of IC3b (pins 15 and 14) and also at pin 1 of IC3a. If you find square waves at these points, it means that those narrow pulses really are present at TP2 and everything is indeed operating as it should.

Bigger capacitors for Ultra-LD amplifier

I am building two of your Ultra-LD MK.2 135W amplifier modules and have a question. The recommended power supply shows six 4700µF capacitors for a total of 14,100µF per side. I wonder whether it would be OK to increase these capacitors to larger values.

I was thinking of upwards of 10,000µF for each capacitor, for a total of 30,000µF per side. What are your thoughts? (P. S., Flossmoor, Illinois, USA).

● You could increase the capacitance if you wish but there will be negligible change to the performance.

Magnetic Cartridge Preamp Equalisation

I am constructing the Magnetic Cartridge Preamplifier described in your August 2006 issue. As a slight variation on the design, I wish to use a 12-position switch to select between all the equalisation curves because I have a number of different 78 RPM record types. However, to save space, I would like to leave the level potentiometer out and replace it with a trimpot or fixed resistors.

If I do this, when I switch between the various equalisation settings, will the level vary so much that I will need to re-adjust it for each setting? If this is the case, I will need to include the level control but if this is not the case, I can leave it out. (C. R., Tuebingen, Germany).

● Generally, the equalisation curves are set to provide a similar output level when the curve correctly matches the recording. However, because 78 RPM recordings from different manufacturers each used their own standards, there will be some variation in level and you may need to use the level control.

Confusion Over Knock Sensors & Duty Cycle

I have read your publication "Performance Electronics For Cars" and I am interested in injector duty cycle. I have the impression that when an engine runs on high duty cycle, a certain injector keeps spraying fuel even when the relevant intake valve is still closed while its cylinder covers the other three strokes.

My question: is the fuel sprayed sucked into the adjacent cylinder or distant cylinders, inevitably at the intake stroke, and would this affect the mixture of the other cylinders in particular or all cylinders in general?

Please also advise me regarding the knock sensor. I obtained some test info off the internet for my 1992 Mazda 929. It specifies the voltage at the ECU end of a knock sensor should be less than 1V (tested with the ignition on) yet I measured 8.87V. I suspect this faulty knock sensor causes my engine to run extremely rich. I have measured the duty cycle range from 91-96% and the frequency range from 32-46Hz when the engine is idling.

Please confirm whether my suspicion is correct or if something else is causing the problem. I also tested the engine coolant temperature sensor, the oxygen sensors and the airflow meter sensor. They are all in working order.

Because of the problem, I have not been able to drive on petrol – I drive on LPG only. (H. L., via email).

● A faulty knock sensor would not make the engine run rich. When an engine knocks, the timing is retarded by the ECU, rather than enriching mixture. A faulty knock sensor may affect fuel consumption because the timing is retarded and fuel combustion may not be complete.

The DC voltage from the knock sensor is not much of an indication of its condition although 8.87V is an unusually high voltage. These sensors are typically piezoelectric and do not develop a DC voltage but an AC signal with engine noise.

If the injector duty cycle you measure is 91-96% at idle then we suspect you are measuring the "off" period of the injector. So the actual duty cycle at idle would in fact be 4-9% which still seems a little high. A 91% duty cycle would only be obtained when the engine is under load, not at idle.

A 100% duty cycle does mean the injectors are open all the time. Generally, each injector controls the fuel to each cylinder although the mixture in the inlet manifold is available for any cylinder that has its inlet valve open.

If you are not certain about your car's electronics and it is not performing as it should, we suggest that you take it to a reliable mechanic and have it fully serviced.

Advice on X2 capacitor selection

I have built a few amplifiers and have been putting an X2 capacitor across the primary of the power transformer to stop noises (cracking sound) when turning the amplifier off. My question is, is this a dangerous practice and can this damage the amplifier if the value is too large, say 0.47µF, due to it forming a resonant circuit say?

Is there a way to determine the correct value if this is an appropriate practice? (D. H., via email).

● 0.47µF is too large and will cause a very high initial switch-on current, depending on the instant of switch-on and the peak mains voltage at that time. If the mains switch is a single-pole unit, it is better to place the capacitor across the switch. This means that it has no voltage across it when the unit is operational.

A typical value to stop switch-off "cracks" would be 10-22nF 250VAC.

Comparing our premium amplifiers

Your 20W Class-A and the 135W Ultra-LD Mk.2 are interesting amplifiers. Can you give some information about their sound? Are they very similar or has the Class-A design some advantage in this regard?

According to your measurements, there shouldn't be much between them. But you don't say anything about the sound in the articles. (E. P., Soderkoping, Sweden).

● Both amplifiers are extremely good but the Class-A unit still has a slight edge. Mind you, you can only pick this if you have very good speakers (and discerning ears!) and you take the signal directly from a good-quality CD player with no intervening preamplifier. In fact, most people would have a hard time picking the difference if you ran double-blind tests.

Having said that, the much higher power output of the bigger amplifier will be a distinct advantage if you have a large listening room or speakers that are not particularly efficient. This is most important if you are listening to music with a very wide dynamic range.

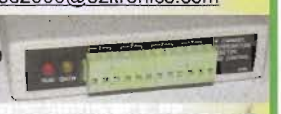
So if you have a small room and reasonably efficient speakers, go for the Class-A amplifier for the very best listening experience. Otherwise, choose the Ultra-LD Mk.2 – we have had many reports that readers are very pleased with it.

Composite video problem

I have a radioteletype terminal that outputs 1V composite video. When originally connected to old green/amber monitors the text generated by the terminal was OK on screen but now when connected to either an LCD monitor or CRT with composite (yellow RCA) in, the first few characters on the lefthand side are missing.

A friend has an identical terminal

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Electronic Ignition On Vintage Car

I have a 1932 Alvis 12/50 car and am considering fitting electronic ignition. I see being able to keep the spark timing more precise as a great benefit.

The drive to the current magneto has quite a lot of backlash and I think the timing should be set from the crankshaft (flywheel) to get it more precise. I'd imagine using a Hall-effect sensor looking at a peg or hole on the flywheel rim. Timing an electronic system off the existing magneto drive wouldn't give very much improvement!

I'm sure you've been asked this kind of thing a million times, but would your Programmable High-Energy Ignition System be suitable for my situation, please?

I'd want to hide the box and coil and then feed the plugs from the distributor cap of the magneto (any backlash, etc at this position wouldn't matter). Any problems with this?

At present, the ignition timing can be adjusted via a rotary hand control on the steering column. I'd like to keep this feature. Would it be possible to set up the system to have manually-controlled timing around a basically fixed setting, eg, with the hand-controller operating a rheostat or something? I'd only need about 20-30° of variation at the most.

It's a 4-cylinder 4-stroke engine. Would I need a half-speed signal? I don't think an extra spark approaching non-firing TDC would matter at all. There's virtually no valve overlap anyway! It doesn't rev very fast so four sparks per rev shouldn't be too demanding!

Are there any reasons why this sort of ignition wouldn't be advisable for an old engine like mine? If the "standard" arrangement would be OK, I'd probably buy a set from Jaycar.

I want to keep my old car fairly authentic but see no harm in utilising some more up-to-date technologies. (R. T., via email).

● You could trigger off the flywheel if necessary but then the ignition would need to be set for an 8-cylinder engine and have the wasted spark. As you say, the low RPM means that this will not be a problem. An adjustable spark can be had using a potentiometer (wiper) connected to the knock sensor input with a potentiometer providing a voltage between 0V and 5V. The supply (5V) can be obtained from the circuit where the MAP sensor supply is provided.

and has the same problem with various displays.

One suggestion was to try a widescreen display but the same problem occurs. The characters are not hidden by the escutcheon but instead cropped some distance in from the lefthand side of the screen. I don't believe a monitor with image position adjustments will solve the problem, as the video is apparently being clipped by the processing circuitry in the monitor. Unfortunately, there are no adjustments in the terminals to correct the problem.

Another suggestion was that a monitor capable of underscan was needed or a means of adjusting the composite signal to achieve that. (D. V., via email).

● It is probably stating the obvious but this is a problem of incompatible video signal standards. Your RTTY terminal would probably be designed to deliver video with a horizontal scan rate of 15,750Hz and a field rate of 60Hz. However, a modern monitor may expect signals at much higher sweep and field (refresh) rates.

The best approach would probably be to use a video monitor which can accept NTSC composite video signals.

Bogus amplifier comparison in hifi shop

I have recently built the Ultra-LD Mk.2 ThermalTrak Amplifier kit with no major dramas.

I took it to the local hifi shop to put it through its paces up against some of the big boys (NAD, Monarch, Krell etc). I was told by the shop owner that the amplifier was lacking in dynamics in the low-frequency region. It has two 300VA toroidals (one per module) and 13,000μF of capacitance per supply rail.

What are your ideas on this problem and a potential fix, if possible? (S. G., via email).

● There is nothing wrong with your amplifier. If built as described, it will have a frequency response which is absolutely flat to well below 10Hz. In fact, it is only -3dB at 4Hz; way below normal program content and below what any CD, SACD, DVD or any other program source can deliver.

Even if it was absolutely flat to DC, you could not get any more bass out of your amplifier unless you deliberately bass-boosted the program source. In fact, did you notice any deficiency in the sound quality of your amplifier compared to the commercial units? Our bet is that your amplifier sounded equally as good, if not better.

Such hifi dealers do their reputation great harm by engaging in such nonsense. In fact, why expose yourself to such gobbledegook? You must know they are not really interested in the truth. They are only interested in selling you a high-priced commercial amplifier.

Display problem on digital tacho

I have constructed the Digital Tachometer featured in the April 2000 edition. I followed the test and calibration section and the voltages from the regulator are correct. The tacho has been set according to these instructions.

The problem is that the display will not show anything when 12V is applied. If I lightly touch the common emitter junctions of transistors Q1-Q4 the display will light as it should and then I can set the tacho using S1-S3. It is frustrating to be so close to having it finished but still not usable, as the finished kit looks excellent.

I am not familiar with the 18-pin chip but the problem suggests that maybe there is some grounding problem? The battery voltage is a bit low at 9V but the unit can be set OK. Is the main 18-pin chip sensitive to static? Any help would be appreciated. (P. M., via email).

● Check that you have used BC328 transistors for Q1, Q2 & Q3 and a BC338 for Q4. Check the connections to IC2b from the transistor emitters to IC2b's pin 6 input and the LDR connec-

tion to pin 5. With the LDR shorted, the display should be at full brightness. VR1 sets display brightness.

ACT has all-day school speed zones

I am writing in relation to the article "School Zone Speed Alert" that was published in the April 2009 issue. On page 37 under the heading "What It Does" it quotes the times during which the "School Zone" is effective as being 08:00 to 09:30 and 14:30 to 16:00.

This may be correct for some states (including NT?) but not all. The article seems to "imply" that these times are "common throughout Australia". However, in the ACT "School Zones" operate *all day*.

I live in Queanbeyan and have on occasion either worked in the ACT or had to cross the border to go shopping and from memory believe that their School Zones operate from 08:00 to 16:00 with NO gap between 09:30 and 14:30.

As such, would the existing program handle this or would it need to be reprogrammed with a location (ie, the state or territory in which it will be used). In the latter case, this could possibly based on a variant of the state's STD code, keeping in mind, for example, that the ACT and NSW share the 02 STD code and the same situation may also exist for Vic/Tas & SA/NT. An alternative code might be to simply assign 0 to the ACT, 1 to NSW, 2 to Qld, etc. (P. M., Karabar, NSW).

- The School Zone Speed Alert should be able to cope with a single 8-hour school zone such as you advise operates in the ACT, simply by setting the start and finish times for one of the two zones provided to the appropriate times, say 08:00 and 16:00. The other time zone could be ignored (ie, left at its default settings) or could be set to the same start and finish times if you wish.

Another option would be to set the "AM" zone start and finish to 08:00 and 12:00 and the "PM" zone start and finish to 12:00 and 16:00 – so the two zones are contiguous.

No reprogramming of the PIC's firmware should be required. SC

Notes & Errata

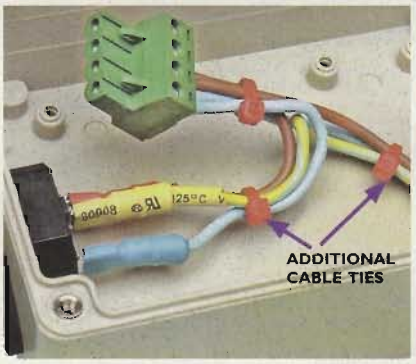
Dual-Booting With Two Hard Drives, January 2009: the command given for opening the *menu.lst* file in both step 3 on page 15 and step 2 on page 17 is incorrect. It should read: **sudo gedit /boot/grub/menu.lst** (ie, there must be a space after "gedit").

Serviceman's Log, March 2009: on page 56, the web address given to obtain the anti-spyware program "Ad-Aware" is incorrect. It should be **www.lavasoft.com** Note that a freeware version is available.

Note also that this software is from Lavasoft, not Grisoft as stated in the article.

GPS Synchronised Clock, March 2009: in Fig.1 & Fig.2, the 3V & 5V markings for the GPS voltage selection are reversed. To set the circuit to 3.3V, to suit the EM-408 module, the jumper must be placed on the pair of pins nearest the PIC microcontroller, ie, opposite to that shown in the photographs.

Multi-Function Remote Controlled Lamp Dimmer, April 2009: to further secure the mains wiring, we recommend that an additional cable tie be added to secure the Active, Neutral & Earth leads immediately after the connections to the IEC socket (see



above photo). A second cable tie can then be added to secure the leads going to the GPO socket.

School Zone Speed Alert, April 2009: when setting the current time or any of the speed zone start or finish times, take care to end the setting process using a second press of the same pushbutton switch S1-S5 used to begin that setting process.

If you accidentally press another of these switches, the firmware may "lock up" and you'll need to unlock it by pressing the reset button S10 and holding it down for about five seconds. You will then have to reset both the current time and any of the start and finish times that have been customised, because resetting causes a return to all of the default values.

WARNING!

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Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine.

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