SILICON CHIP

FEBRUARY 2009
ISSN 1030-2662
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Contents

SILICON CHIP

Vol.22, No.2; February 2009 www.siliconchip.com.au

Features

12 Digital Radio Is Coming, Pt.1
Digital radio starts in Adelaide, Brisbane, Melbourne, Perth & Sydney on 1st May, with 71 radio stations on 10 DAB+ transmitters. Here's a rundown on this complex and completely new radio broadcast medium – by Alan Hughes

16 Review: LeCroy Waverunner 104Mxi Digital Scope
This high-end 4-channel scope operates under Windows XP and can be operated using either a USB mouse or via its touch screen – by Leo Simpson

34 2.4GHz DSS Radio Control Systems
Digital spread spectrum (DSS) radio control systems are revolutionising the model radio control scene. Here's a look at the technology – by Bob Young

Projects To Build

22 Tempmaster Electronic Thermostat Mk.2
Use it to convert a chest-type freezer into an energy-efficient fridge or to convert a fridge into a wine cooler. It can also control 12V fridges & freezers, as well as heaters in hatcheries and fish tanks, plus lots more – by Jim Rowe

40 10A Universal Motor Speed Controller, Mk.2
It can be used with power tools & appliances rated up to 10A and is suitable for use with brush-type universal motors as used in small lathes, electric drills, grass trimmers, circular saws, routers, nibblers & jigsaws – by John Clarke

62 Programmable Time Delay Flash Trigger
Interested in special effects photography? You can capture some great action shots with this programmable flash delay unit – by Jim Rowe

78 Multi-Purpose Car Scrolling Display, Pt.3
Pt.3 this month describes how the unit is connected to a car and how it is used. We also describe the simple command-line program that's used to drive it – by Mauro Grassi

Special Columns

57 Serviceman's Log
Oh Goody! A CRT Set To Fix – by the TV Serviceman

85 Circuit Notebook
(1) Tricks With A 4017 Chaser; (2) Low-Power Analog Computer; (3) Loud Repeater For Traffic Indicators; (4) Semiconductor Evaluator For Scope; (5) Bedside Lamp Controller

90 Vintage Radio
The Australian Army Signals Museum – by Rodney Champness

Departments

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



Tempmaster Electronic Thermostat Mk.2 – Page 22.



2.4GHz Digital Spread Spectrum Radio Control Systems – Page 34.



10A Universal Motor Speed Controller – Page 40.



Programmable Time Delay Flash Trigger – Page 62.

SILICON CHIP
www.siliconchip.com.au

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SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 003 205 490. ABN 49 003 205 490. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Printing: Hannanprint, Noble Park, Victoria.

Distribution: Network Distribution Company.

Subscription rates: $89.50 per year in Australia. For overseas rates, see the order form in this issue.

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ISSN 1030-2662
*Recommended and maximum price only.

Publisher's Letter

New Zealand has lifted the ban on incandescent lamps



Back in December last year, the New Zealand government reversed the ban on incandescent lamps. What an incredibly sensible thing to do! The overall difference in the energy consumption New Zealanders would have achieved in avoiding incandescent lamps and using more efficient types such as compact fluorescent lamps instead would hardly amount to much anyway. The same comment would apply much more forcefully to Australian energy consumption, given that our economy is so energy-intensive, with our large-scale mining and agricultural sectors. But I wonder if there is much likelihood of our Government also reversing the ban? Very little, I would think. That would be too sensible.

Whether or not the Government does have a rethink may be irrelevant now in any case. Incandescent lamps are becoming difficult to obtain, particularly as some major retailers seem to have abandoned them and even major hardware chains such as Bunnings seem to be reducing their range. My advice to readers is that you should stock up on incandescents, particularly the harder-to-get types. In years to come, you may well have to replace many of your lamp fittings because of this silly edict and as everyone should be well aware, it will make precious little difference to your annual energy consumption.

We also note that the UK government is reported to be instituting a ban on power hungry plasma TVs. The New Zealand government has also rejected this approach, arguing that consumers should make their own choice, after they have been provided with the necessary information. Again, this is eminently sensible. But New Zealand is in a temperate zone and not nearly as cold as England. In the UK, a big plasma set would merely cause a slight reduction in the amount of central heating which is typically required for eight or nine months of the year. The fact that big plasma sets can function as room-warmers could be regarded as a bonus!

One has to ask the question: "Why do Governments feel that it is necessary to introduce these silly edicts, supposedly in the interest of reducing energy consumption?" Is it merely to be seen to be "doing something" in the face of the advancing terrors of global warming? Undoubtedly that is true but we think there is also a "kill joy" component to all of this. You cannot have a big plasma TV or big 4-wheel drive, or even a big house (a McMansion perhaps?) for that matter, because these things use more energy. Never mind that that consumers implicitly know that already and are quite prepared to pay for it.

Realistically, governments around the world have to face up to the fact that making large reductions in carbon dioxide emissions is difficult and very expensive. More importantly, obtaining such reductions in particular sectors of the economy can have many ramifications which were initially not apparent. In any case, with much of Europe presently freezing in the depths of winter, they might welcome some global or at least, local, warming.

So how should governments proceed? Given that much of the interpretation of long-term weather records is extremely difficult and the forecasting of future trends is almost impossible, Governments probably could take the prudent approach as far as climate change is concerned and just "wait and see".

On the other hand, there is a great deal more certainty about oil and gas energy which is likely to become much more expensive in the future. In this case, governments need to ensure that their nations always have a secure supply of energy in the future. If that means making major reductions in energy consumption, then that is wise.

But that does not mean banning incandescent lamps and big plasma TV sets.

Leo Simpson

MAILBAG



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Wiring standards should be observed

I have several comments to make about the contents of recent issues.

(1) The October 2008 article describing the use of the old microwave for exposing PC boards had a glaring error in the wiring. AS:NZS3000 states in several places that green/green and yellow wiring shall only be used for earth and nothing else – no exceptions.

The picture clearly shows several green/yellow wires used for power, and supposedly made OK by using a little bit of coloured sleeve or perhaps red insulation tape. This is an example of why we need licensed electrical people.

I was taken back that you actually published such a picture. It may have been more prudent to send the project photos to the author and ask him to make the project comply with the standards, then resubmit the project to you. Publishing such a project certainly isn't as professional as you have been in the past.

(2) Australia is now a signatory to the International Standards organisation and as such, we are now obliged (indeed have to) accept equipment made to standards that apply in different parts of the world. I want to draw your attention to several potential outcomes of such acceptances.

Some years ago I was wiring up a small solar system, consisting of three 24V 175W panels, a small 24V battery bank and an inverter. Before turning on the solar circuit breakers, it is my practice to run a meter over the panels at the circuit breaker board and check the open-circuit voltage, the short-circuit current of each panel and the wiring continuity.

Imagine my surprise when I measured about 65V across the open-circuit breaker. Checking the wiring of the solar panel showed that the black wire was **positive**, not negative, while the white wire was negative. Hence the readings of 42V open-circuit on the array plus about 26V from the battery. Subsequent investigation revealed that this is the standard in Japan and we have to wear it. You have been warned.

I service various pieces of electrical equipment and have also found that the Chinese standard is as follows: Green – Active; Black – Earth; White – Neutral. In Japan, it is as follows: Black – Active; White – Neutral; Green – Earth. Since we are signatories to these international treaties, we must accept their appliances under threat of legal action in the World courts.

(3)With regard to the letter on solar

Freeview digital channels will be more of the same

I refer to the current promotions of Freeview on television and I have read the ABC press release of July 17th 2008 at **http://www.abc.net.au/corp/pubs/media/s2306264.htm#**

I note that a total of 15 channels will be available in 2009 with the addition of extra standard definition channels. I am wondering about the value of this when (presently) most of the networks, particularly the commercial channels, run programming identical to their analog transmissions with very few exceptions. Unless substantial amounts of different programming will be broadcast on these extra standard definition channels, I hardly see the point of their introduction.

The present SD channels available, generally the commercial networks, are hardly worth viewing as far as programming is concerned. The only advantage is picture clarity but even then, signal dropouts can be frequent, making digital television for those without the best terrestrial location or the best antenna something of a pain and analog is sometimes the better alternative.

So what will change with the introduction of additional SD channels in regard to programming to make viewing digital television worthwhile? If an extra channel just means more of the same analog material being broadcast as it is now, then I don't see the point of the exercise. The advertising promises so much but is likely to deliver little if the present digital services are any guide, although ABC2 does provide good alternative programming. Channels 7, 9 & 10 however provide very few alternatives, so what will change?

Peter Cahill,
Westmead, NSW.



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Cylinder deactivation a clever marketing scam

I read your article about Honda's new cylinder deactivation and couldn't help thinking this is the most clever marketing scam I have seen for awhile. Think about it: if it takes 40kW to push an 1800kg car along at 100km/h, the number of cylinders does not matter. It will still use the same amount of air and fuel to produce 40kW. The reason a little 3-cylinder car uses less fuel is less weight, less rolling resistance, less aerodynamic drag and less friction from the smaller drivetrain. Honda has addressed none of these.

I suspect the light on the dash which indicates V6, V4 or 3-cylinder mode probably saves more fuel as it changes the driver's behaviour, which has the biggest effect on fuel consumption.

Honda claims to have fuel economy of 10.0l/100km with cylinder deactivation. A quick check of other cars of a comparable size without VCM are as follows:

- Toyota Aurion 3.5 V6: *9.9l/100km*
- Jaguar XF 3.0 V6: *10.5l/100km*
- Nissan Maxima J31 ST-L XTronic CVT 3.5 V6: *10.8l/100km*
- Mercedes Benz C-Class 3l V6: *9.6l/100km*
- Ford Mondeo MA XR5 2.5l 5-cyl: *9.5l/100km*

I notice that cars with a 6-speed transmission (which the Honda does not have) had better fuel economy.

Warrick Smith,
Numurkah, Vic.

Comment: you have missed the point of the story. Because cylinders are deactivated, it reduces pumping losses in the motor and that is what improves fuel economy. Sure, the fuel economy would be far better if the car was lighter, had less drag etc and a smaller motor.

However, as alluded to in the conclusion of the article, we think Honda have missed the boat on their VCM. If they had kept the engine to three litres and the weight of the car the same, the fuel economy would have been considerably better. At 177kW, the power of the previous 3-litre motor is more than adequate for normal motoring.

power in Ask Silicon Chip, November 2008, I agree that it's not usually practical to operate air-conditioners from solar but we do. Our system is 4.5kW solar, 5kW inverter (20kW 1/2 hour), 48V 50kWh battery bank, etc. It runs two houses with air-conditioning, fridges, freezers, electric frypans, etc. We do have a 6.5kVA standby generator for bad weather but one doesn't use A/C in the rain – usually.

The reason for spending in excess of $70K on our solar system was that when we passed through the Hunter Valley and saw the destruction that is being caused by the power stations we decided we did not want to be a part of that. As well, we are doing our bit for the planet.

While solar installations in most mobile homes can't usually cope with A/C, it is possible. I helped a mate to build a mobile home and we used 1200Ah sealed batteries (24V) and 16 175W solar panels. We also fitted a 160A alternator to the bus with two PL60 regulators. His split system A/C works well on solar; just as well, as he is in northwest Australia at present.

Peter Laughton,
Tabulam, NSW.

No future in hydrostatic transmissions

I read your comments about hybrid vehicles and hydrostatic transmissions in the Publisher's Letter of the December 2008 issue. However, when you suggest the use of hydrostatic transmissions, you are simply swapping one set of problems for another.

Hydrostatic transmissions have high fluid flow (high current) so the resistance losses are a big problem with the oil. The accumulator storage is simply compressed air with its associated heat losses and highly variable pressures. The actual storage densities are less than that for lead-acid batteries. They do not come anywhere near the energy density of modern lithium type batteries.

The load on a small diesel engine driving an hydraulic accumulator is far from constant as the pressure in the accumulator varies from 100%

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Mailbag: continued

down to the lowest usable pressure of around 10%. For the same engine charging a battery, the voltage remains relatively constant.

When complete systems are compared, battery/electric has higher energy density, relatively constant power availability and higher efficiency but with one significant drawback – the life of the batteries. Note, however, that any vessel containing a compressed gas has to be checked periodically and then replaced with time.

When accumulator hydrostatic and compressed air systems are compared for small vehicles like cars, the fully compressed air system turns out to be more efficient, with lower weight and cheaper in the long run. So why not go for that rather than hydrostatic?

Bruce Withey,
Mylneford, NSW.

Comment: we think the big advantage of hydrostatic or compressed air systems could be that you can repeatedly cycle the system down to a small percentage of its capacity – something you cannot do with batteries. This largely negates the fact that batteries may have much higher energy densities.

Shocking lamp experience

A few years ago we purchased two new marble bedside lamps. They have an on/off switch with an inbuilt dimmer. One of the lamps recently blew, so I went to replace it. I received a severe electric shock in the process. I had the unit turned off at the dimmer switch and I partly gripped the metal stem of the globe in making sure it was screwed in securely.

I traced the wiring and found that what had happened was that the polarity had been reversed inside the moulded male plug. The negative was being switched with the active being alive at all times. The moulded plug had each blade marked A or N but the wiring was reversed. They were made in China!

I thought that other readers might benefit from my experience.

Barry A. Smith,
Peregian Springs, Qld.

S-VHS recording clarification

I am replying to Mr Nicholls' letter on page 8 of the January 2009 issue. Mr Nicholls quite correctly states that I implied his JVC VCR played back Teletext because of its built-in timebase corrector. What I also said was that most if not all S-VHS recorders needed the help of a TBC. In other words, "most if not all" concedes that there are exceptions and Mr Nicholls' set-up obviously falls into this category, for what reason one can only speculate. With so many variables involved, it is foolish to be dogmatic.

It may be possible to duplicate the system but equal performance could not be guaranteed so should not be advised. Both Teletext decoders and VCRs do have fairly wide tolerances, particularly VCRs where jitter and long-term timebase errors are seldom if ever speci-

More info on fixing car horns

I have an answer to the question posed by K. C., of Wangaratta, in the January 2009 issue. K. C. asks about the horn on a 1978 Falcon ute. SILICON CHIP is correct when they advised about cleaning and adjusting the horn's electrical contacts. However, the fault may also lie within the steering column.

If memory serves, behind the steering wheel is a spring-loaded pin with a diameter of around 5mm and usually made of brass. This pin rubs on a circular contact affixed to the steering wheel itself and gives the electrical connection to the horn switch.

This system was usually negative switching, that is, the horn is fed positive via the fuse panel and then grounded through the steering wheel connections. If the pin and/or contact ring are badly worn, there will be no ground connection and hence no horn.

The steering wheel must be removed to access these parts. This must be done with the correct wheel puller, not a hammer! Once the steering wheel has been removed, you will see the pin and circular contacts. The circular contact is fitted to the back of the steering wheel.

Remove the wire from the back of the pin, then carefully remove the "C" clip while keeping one finger on the head of the pin, otherwise the pin and its spring will leap out and never be found again. Remove the pin, replace the new pin in the same hole and ensure the spring is also in that hole. Then press the pin through, replace the "C" clip and refit the wire.

By the way, the above job is reasonably straightforward. My car is a 2004 Holden and getting to its horn contacts took me just over an hour. On modern cars, the airbag, cruise control and on-wheel radio controls make removing the steering wheel a lengthy process!

Dave Sargent,
Maryborough, Qld.

fied on domestic units. I trust this has cleared up any misunderstanding.

Victor G. Barker,
Gorokan, NSW.

Comment on AEVA article

Thank you for your coverage of the AEVA electric vehicle field day in the December 2008 issue. It should help to promote the increasing use of electric vehicles by enthusiasts.

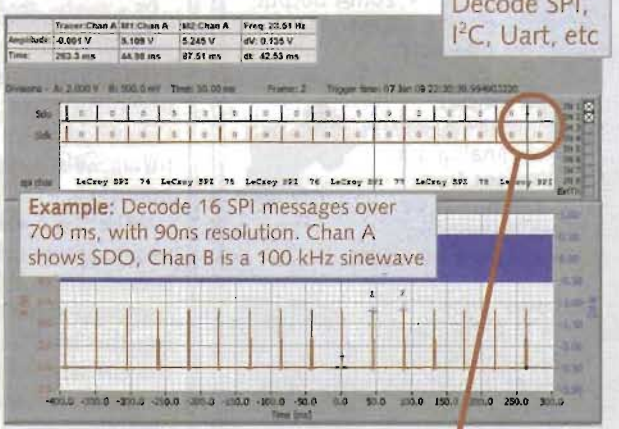
A couple of things to note – all of the motors seen fitted to the cars were DC series motors manufactured by either of two US companies: Advanced DC Motors or Netgain Motors Inc. Neither motor can be operated in shunt mode because the voltage on the field, when connected in series mode, is only about 2V (at up to a few hundred amps). A separate field winding would be necessary for shunt connection and this is not provided.

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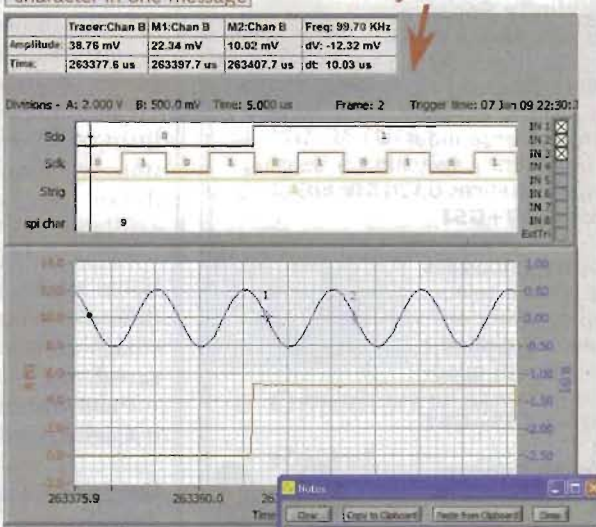


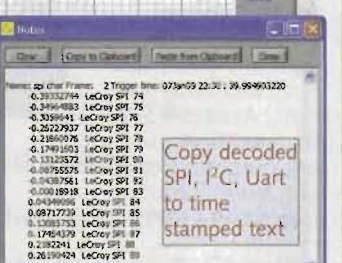
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See the Silicon Chip review – October 2008, p10-13

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Mailbag: continued

Series motors are not easy to operate as generators and this is one of the reasons why none of the cars on show are fitted with regenerative braking. The other reason is that only about 5-10% of a typical journey's consumed energy can be recovered during braking and returned to the battery. It's just not worth the added circuit complexity.

Almost all cars were converted to electric power for commuting by one person – the owner. Carrying a full load of passengers or a payload is not a requirement. Donor cars are thus selected for their capacity to carry batteries, without concern for the space taken up.

Most DIY electric cars do not have power steering because of the constant power drain which would arise from having a separate electric motor driving the hydraulic pump all the time the car was being driven. The Holden Combo conversion has factory-fitted electric power steering (EPS) which draws appreciable current only when the driver changes the direction of the front wheels at low speeds. At higher speeds it draws no current; the steering is entirely manual. As a result, average power drain is very low.

Car manufacturers are increasingly fitting EPS to their new models to improve fuel consumption, so more donor cars with EPS will become available to EV enthusiasts.

LEDs for tail, brake and indicator lights are fairly expensive and hence difficult to justify on an EV for the small amount of electrical power saved.

Peter Stuart,
Carlingford, NSW.

Honda's cylinder deactivation

I have just finished reading your article about Honda's engine with cylinder deactivation, in the January 2009 issue. I would have thought that the energy requirement for a car travelling, (whether climbing, accelerating or coasting) would be the same whether the engine had 3, 4 or 6 cylinders. Any power loss through engine friction etc will still be there with the deactivation of the cylinders. So I don't really see the point, especially if the engine is going to run so roughly on three or four cylinders that it needs to have active engine mounts.

I am tempted to think this is just going to be the latest marketing fad (clean green cars, yeah right) but Honda do some amazing work with their Formula 1 engines, so I will wait and see.

Tony Brazzale,
Lakes Entrance, Vic.

Comment: it is true that the energy required for moving a car is the same regardless of how many cylinders are operating. The point is that with cylinders deactivated, there are less pumping losses in the engine and therefore it uses less fuel. In the long run, the increased engine complexity may well be a drawback.

Query over salt solution

I entirely agree with your article (December 2008, page 36) showing that a $300 gadget for checking the salt level in pools is unnecessary. And the claim that such a meter also checks total dissolved solids is optimistic, to say the least. It merely assumes that all the dissolved solids are electrolytes and gives the ppm of sodium chloride which would have the observed conductance. Non-electrolytes like sugar, or more relevantly urea from human sources, will not be included.

However, may I comment on your method of preparing the standard reference solution? I find general agreement that the volume measure "one teaspoon" in all English-speaking countries is 5ml, so your "half teaspoon" measure is presumably 2.5ml. Now I took a typical dispenser of table salt like the one you picture and poured it into a chemical measuring cylinder to the 50ml level, then weighed this on a chemical balance. The result was 53.80g. So its apparent density is 1.08g/ml.

This converts your half teaspoonful to 2.7g, which may well be near enough to 3g for this far from critical application. However, some readers may not have a set of (standard?) measuring spoons and may think

Loop antenna works well to improve AM reception

It was good to see an article about how to improve AM reception by using a loop antenna. I have been using one for a couple of years at my workplace and the difference it makes is amazing. It lifts AM reception in my open plan office environment, surrounded by computers and other electronic equipment, from unlistenable to very usable.

It only relies on inductive coupling from the large rectangular loop (15 turns of wire on a polystyrene box lid) to the Sony radio's internal ferrite rod. The radio has a good audio frequency response on AM, so cutting down wideband noise is important for good sound. The loop antenna is very sensitive to orientation, requiring careful rotation to get the best results for each station and small adjustments of the 200pF variable capacitor to peak the signal.

Also in that article, there was mention of "a hard-hitting earthquake awareness TV program" recently broadcast in NZ, about the importance of communications after a disaster. I am working with the Critical Infrastructure Project at Geoscience Australia.

This is a project funded by the Attorney General's Department, concerned with the interdependencies of Australia's critical infrastructure (Communications, Banking and Finance, Energy and Water). Further information can be found about this project at: http://www.ga.gov.au/ausgeonews/ausgeonews200509/cip.jsp



We are mapping and modelling the facilities used by the broadcasting and telecommunications sector, and their vulnerabilities, to predict how this critical infrastructure will behave during and after natural disasters such as earthquakes and cyclones, so public service broadcasts can continue to be made.

Dr Adrian Whichello,
Infrastructure Engineer,
Critical Infrastructure Project,
Geoscience Australia,
Canberra, ACT.

an ordinary teaspoon will do. I have measured the weight of salt (at level filling) held by several of my kitchen teaspoons, finding 2.4-2.8g, so half of one of these would be only 1.2-1.4g. I realise that few households have any weighing device sensitive to 0.1g but many digital kitchen scales are sensitive to 1g. So why not weigh out 50g of salt, which should be accurate within 2%, dissolve it in water and make it up to 1 kg on the scales? Mix well and weigh out 60g of this liquid.

That contains your 3g of salt and can now be diluted to 1 litre to make your standard solution. Or if you haven't a trustworthy litre measure, again make it up to 1kg on the scales. (The density of the final solution is within 0.2% of that of pure water.)

As to the electrical aspect of the article, I would remark that although the method you use is good enough for the purpose, a DC resistance measurement with carbon electrodes is not the method of choice for electrolyte conductance. Polarisation of the electrodes tends to give higher resistance readings.

Again I stress that this does not invalidate your method, as such errors will largely cancel between the sample and reference. However, for accurate measurements, an alternating current bridge using a 1kHz supply at say 500mV would be used, with provision for simultaneous capacitance balancing.

Measuring granular solids by volume is at best an unreliable way of

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estimating mass. A single crystal of sodium chloride has a density of 2.16g/ml, yet the fine-grained table salt that I used has an apparent density only half of that. Furthermore, my 50ml in the measuring cylinder packed down to 45ml on repeated bumping of the cylinder on the table. This increases the apparent density to 1.20g/ml, somewhat higher than the internet figure you quote. But you can't easily pack down a teaspoon.

In general I have found that numerical data from the internet cannot be trusted unless they come from authoritative websites like government research institutes. For example, the website for Cheetham Salt Ltd (**www.poolquip.com.au**), a major supplier of pool salt, gives the melting-point of sodium chloride as 8010°C, 10 times the actual 801°C, and a similar tenfold error in the boiling-point, given as 14,130°C. But to make up for these errors, they quote the solubility in water as 35.7g per 1100ml; that should be per 100ml.

Robin Stokes
Armidale, NSW.

Comment: the conductivity meter featured in the article may well have used an AC bridge but we were unable to determine that with our very limited testing and we did not do an internal inspection.

Servicing a belt-drive turntable

The recent article by the Serviceman encouraged me to repair my old Philips GA 212. I proceeded slightly differently, removing the goo with cardboard strips cut to size, so that only a thin layer of black sticky goo remains.

When cleaning my greasy hands with a special soap (here named "BLITZ Rosa", by van Baerle Chemical, Muenchenstein, Switzerland and sold in drugstores), I noticed that the substance literally dissolved the goo. So I wet a cloth and rubbed a little BLITZ into it, then the goo could be rubbed off, even on the capstan, where it took a bit more patience.

In the meantime, I found out that using isopropyl alcohol (normally used for cleaning the keyboard) does the cleaning job very well also. By the way, the belt can be ordered at **http://www.turntableneedles.com**

Kubli Hans,
Frenkendorf, Switzerland.

Anderson connectors for DC

I have been reading the mail regarding the use of normal mains power boards for "Extra Low Voltage" (ELV) applications.

Personally, I do not like the idea of using standard 3-pin plugs and sockets for ELV use. I use the 2-pin "T-polarised" plugs and sockets readily available from most electrical "wholesalers" in surface mount, plug ends and socket ends (look just like 3-pin plugs and sockets). These are often cheaper than some of the plugs and sockets supplied by auto parts shops.

I am now also converting to the "Anderson" type connectors (available at least from Jaycar) as there is now a 30A version and as it is "sexless" (there is no separate male or female part) it makes it much more flexible.

Ray Saegenschnitter, VK3UCB,
Mectronic Rural Services,
Huntly, Vic. SC

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Digital Radio



Digital radio broadcasts will finally start in Adelaide, Brisbane, Melbourne, Perth and Sydney on 1st May with 71 radio stations (ABC, SBS & commercial) on ten DAB+ transmitters. This is the first of a series of articles giving you the details on this complex and completely new radio broadcast medium.

Digital radios will have excellent sound quality and a lot of features that are not available on the existing radios we have listened to over many decades.

For example, to select a station you will pick its name from a list. There will be no need to tune across a band. If you are in a car and move out of digital signal range, the receiver will automatically select another digital, FM or AM signal containing the same program. When you move back within range, the receiver will automatically switch back to the digital signal.

Timeshift will be available so you can delay listening to broadcasts, just as you can right now with TV if you have a suitable recorder. And while many existing radio programs can be downloaded as Podcasts, most digital radios will have flash RAM cards to store programs.

So you will be able to timeshift, "rewind" and pause the programs while recording and "fast forward" after the recording is complete.

And just as digital TV has an electronic program guide (EPG) so too will digital radio. EPG will allow automatic recording of programs within the radio.

Other features

- **Dynamic Label Segment (DLS)**

DLS will show text information on a screen. This could be telephone numbers, website addresses, track-now-playing and announcer names. A maximum of 128 characters can be displayed at a time.

- **Multimedia Object Transfer (MOT) Slideshow**

This will include product shots, studio web cams, weather maps, album cover information, stock market graphs, racing information and just about any information that can be conveyed as a simple graphic image. A 320 x 240 pixel JPEG image can be transmitted every 9 – 15 seconds.

- **Multimedia Object Transfer (MOT) Broadcast Website (BWS)**

BWS allows for the transmission of a series of HTML files (along with corresponding graphic images) to receivers that have a built-in web browser. This allows the user to search the downloaded files. If a receiver has a built-in back-channel (for example, a GPRS enabled mobile phone with a DAB+ radio), it could access links that would take it to the outside world. If there are a lot of requests for files then delays will result due to the restricted download capacity.

- **Traffic Information**

Traffic conditions will be transmitted to the car navigation system so

Is Coming...

by Alan Hughes

that the driver can be routed around obstructions. The navigation system will need compatible firmware.

- **Conditional Access**

DAB+ is capable of controlling who is able to decode the signal. This can enable narrow-casting to specific private audiences and to Pay Radio. This can also apply to data only. Over the air firmware upgrades for particular receivers would need to use conditional access.

- **Radio for the deaf & hard of hearing**

17% of the Australian population (3.6 million people) have a significant hearing loss. The text capability will enable speech to be subtitled. This applies to emergency announcements, news bulletins, current affairs, talks and phone-in programs. The MOT capability (see above) would allow the display of Auslan (sign language) icons.

- **Multilingual – SBS Radio and Ethnic Broadcasters**

1.3 million people do not use English at home and 4.4 million were not born in Australia. The text capability could be used to add English subtitles to foreign language programs. This could help the foreign language speakers learn to read English and the converse is true.

Let us now look at the various types of digital radio broadcasting.

Types of Digital Radio

- Digital Audio Broadcast DAB+ is transmitted in VHF TV band 3 (containing TV channels 6 – 12) or using the 1.4GHz 'L' band. Note that this system is incompatible with the DAB system used in Canada and the UK. A number of countries, including the UK, put nine radio stations on a single transmitter but this produced sound quality worse than FM stereo.
- DAB+ is 3.5 times more efficient in compression than DAB and so the sound quality should not be reduced. In addition DAB+ uses Reed-Solomon error correction to reduce the possibility of gaps in the sound that you hear. All new DAB receivers must be able to decode DAB+ in Europe.
- DRM (Digital Radio Mondiale) is used throughout Europe and parts of Asia. It uses the AM bands of MF and HF (Short Wave) and in DRM+, the FM band as well. Coverage is from a community to a continent. It's used by Radio New Zealand International to cover the Pacific Ocean.
- HDRadio is a system which adds a digital sound signal to an existing AM or FM broadcast. This does not work as well as those above. This system involves patent rights to the Infinity Corporation and is used only in the USA. DAB+ & DRM do not have system patent rights.
- Radio programs on digital TV signals. Examples of these can be found on ABC and SBS digital TV broadcasts. The disadvantage of these program signals is that you need a digital TV receiver to obtain them and they are unsuitable for use in car radios.
- Internet radio is available throughout the world. This is not a public system and is subject to internet costs. Internet radio is also unsuitable for wide area reception.

Channel allocations

Fig.1 shows the proposed channel allocations for DAB+. All transmitters will have a maximum of 50kW (effec-

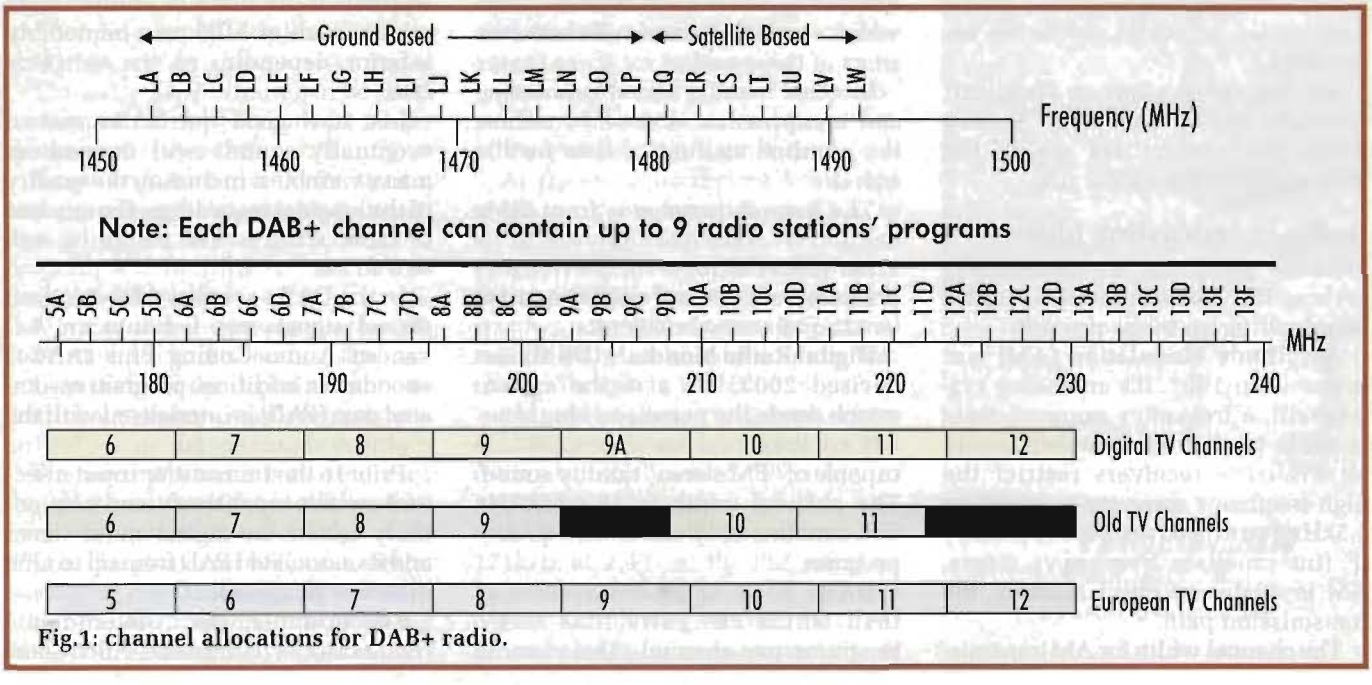


Fig.1: channel allocations for DAB+ radio.

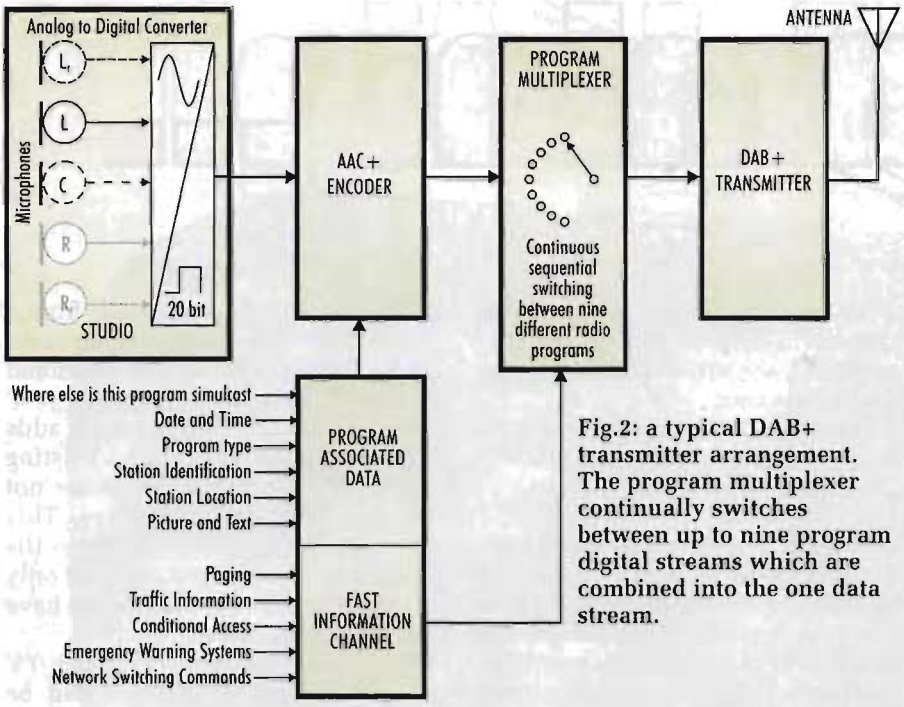


Fig.2: a typical DAB+ transmitter arrangement. The program multiplexer continually switches between up to nine program digital streams which are combined into the one data stream.

tive radiated power) using vertically polarised antennas. Note that not all transmitters will be at full power in all directions. This is to avoid interference problems to television reception outside the listening area.

City	Channels
Adelaide	9B, 9C
Brisbane	9A, 9C
Melbourne	9A, 9C
Perth	9B, 9C
Sydney	9A, 9C
Hobart	12B, 12D

Note that Hobart will start in the next round which is yet to be announced.

All transmitters are on Broadcast Australia towers except in Sydney where the transmitters are on the Willoughby TXAustralia site.

Radio broadcasting history

Before going further, let's briefly review the development of radio broadcasting up to the present.

Amplitude Modulation (AM) was invented in 1901. It's an analog system with a frequency range of 30Hz to 9kHz (or better), however nearly all available receivers restrict the high frequency response to less than 4.5kHz due to their use of rudimentary IF (intermediate frequency) stages. AM is unable to reject noise in the transmission path.

The channel width for AM transmissions is 18kHz, due to the upper and lower sidebands of the modulation.

Frequency Modulation (FM) was invented 1933. It's an analog system with a frequency range of 30Hz to 15kHz. Multiplexed stereo was added in the 1960s. Provided there is enough signal, noise is well suppressed. The channel width is 200kHz.

Despite the number of FM stations, even its future is not assured. The UK, for example, has announced it will switch off FM radio broadcasting in 2020.

Digital Audio Broadcast (DAB) was devised in 1987. It's a digital system which sends the perceived characteristics of the sound.

In other words, signal processing and compression is used to reduce the required amount of data for the signal.

The frequency range is from 20Hz to 20kHz. The channel width is 1.536MHz which can carry five stereo programs with sound quality equivalent to FM stereo broadcasts.

Digital Radio Mondiale (DRM) was devised 2002. It's a digital system which sends the perceived characteristics of the sound (see above). DRM is capable of "FM stereo" quality sound. The channel width is 18 or 20kHz and contains only one music quality program.

DAB+ is an upgraded version of DAB which can carry nine stereo programs per channel. The channel width is 1.536MHz. The Europeans have now mandated that all new radios must be able to decode DAB+ signals.

DRM+ is an upgraded version of DRM which extends the transmission frequency range from 30MHz to 120MHz. The channel width is 100kHz. This system would be suitable in the vacated analog TV channels 1, 2 and the FM radio band.

Even if AM and FM radio transmission continues as we know it, to receive DAB+ and DRM+ signals all existing radio receivers will eventually need to be replaced with digital radios capable of DAB+ and DRM+ reception.

DAB+ transmission

In studios and on compact discs, analog signals are converted to digital in the recording process and on playback the digital signal is converted back to analog. Such digital signals are very high quality but require data rates of up to 3 Mbits/second. So much data will not fit into existing radio channels.

Many digital recording systems greatly reduce the amount of data required by storing only those parts of the signal which the brain "perceives". Such digital standards include digital radio, MPEG 2 & MPEG 4 for TV, DVD & Blue-Ray sound, AC3 (Dolby Digital) sound and MP3 & MP4 used in iPod devices.

Some of these standards sound very good and can be regarded as almost equivalent to the CD audio while others, such as MP3, can be notably inferior, depending on the sampling rate.

Just how good the DAB+ system eventually sounds will depend on many variables, including the quality of the original recordings, the amount of data compression, sampling rate and so on.

In the DAB+ system, AES standard digital signals are fed into an Advanced Audio Coding Plus (AAC+) encoder. In addition, program associated data (PAD) is interleaved with the digitised sound signal.

Prior to the transmitter input a second switch repetitively and sequentially selects the digital audio signal and its associated PAD from up to nine different programs.

For example, the "Government" transmitter will include ABC Local

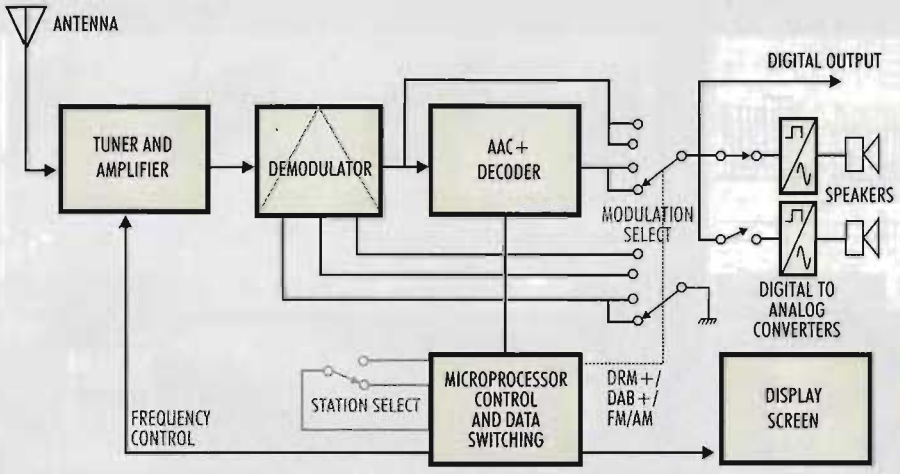


Fig.3: here's the counterpart DAB+ receiver. The microprocessor takes data from the AAC+ decoder according to the selection by the listener. Depending on signal strength, the output may be DAB+, FM or even AM in origin.

Radio, Radio National, ABC Classics, JJJ, PNN and SBS.

A DAB+ VHF transmitter will convert the combined signal to the transmission frequency and increase the power fed to the antenna near the top of a tower to radiate the signal to the receivers.

Fig.2 shows how up to nine different radio programs are combined into the one DAB+ transmission.

DAB+ reception

In a DAB+ receiver, the signal from the antenna is filtered to select the channel requested by the listener. The signal is amplified and then fed to the demodulator. The demodulator converts IF signal back into the data signal which is similar to the output of the program multiplexer shown above.

The same logic circuit can be used to demodulate all broadcast radio systems.

If you are tuned to a DAB+ station and provided the signal level is sufficient for good reception, the selected program is demultiplexed and fed to the AAC+ decoder.

The decoder output can either be converted back into analog and fed into speakers or the digital output can feed a home theatre amplifier, particularly if 5.1 sound is being broadcast.

The microprocessor is also fed with the alternate frequency information from the program-associated data (PAD). The processor will monitor the quality of the DAB+ signal and also monitors the frequencies containing an identical program (ie, from FM and AM broadcasts). A single tuner does this by tuning to the DAB+ and alternate frequencies at a rate which is too high to be noticed.

If the DAB+ quality is insufficient, the next option will be selected. When DAB+ reception returns to acceptable levels, the sound signal will be switched back.

Fig.3 shows the much-simplified schematic of a DAB+ receiver. Depending on signal quality, you might be listening to DAB+ DRM, FM or even AM.

Broadcast Efficiency

Channel width is spectrum "real estate" and has an ACMA auctionable price. Effective radiated power is based on actual transmitter power but with the efficiency of the transmitter antenna system factored in.

Transmitter power consumption depends on its efficiency and the power of the air conditioning required.

At the most inefficient level, AM radio transmits a carrier which contains no program information; all the program information is in the 9kHz sidebands. This is a fixed power which is one-quarter of the power level transmitted with the loudest sounds. The channel width is 18kHz.

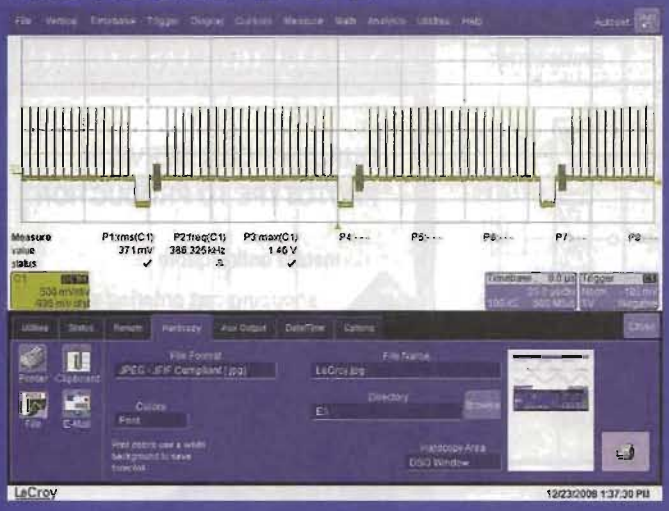
FM radio uses a channel width of 200kHz, corresponding to the maximum frequency deviation of ±100kHz.

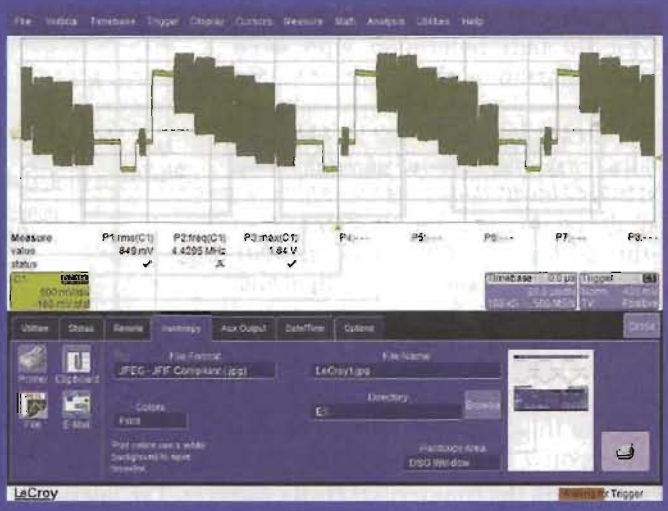
DAB+ bandwidth per channel is 171kHz at 2.4% of the FM effective radiated power per program.

Next month we give more details of how the DAB+ system works. SC

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By Leo Simpson

LeCroy WaveRunner 104Mxi 1GHz Oscilloscope

LeCroy's WaveRunner 104Mxi is a 4-channel digital oscilloscope which operates under Windows XP. You can configure and run the scope using either a USB mouse or via the touch screen. In fact, most of the time you can completely ignore the front panel controls and just use the mouse.

I WILL BE honest. When I first turned on the LeCroy WaveRunner 104Mxi I did not realise it had a Windows XP interface. LeCroy do not make a big fuss about it in their literature; in fact they hardly mention it at all.

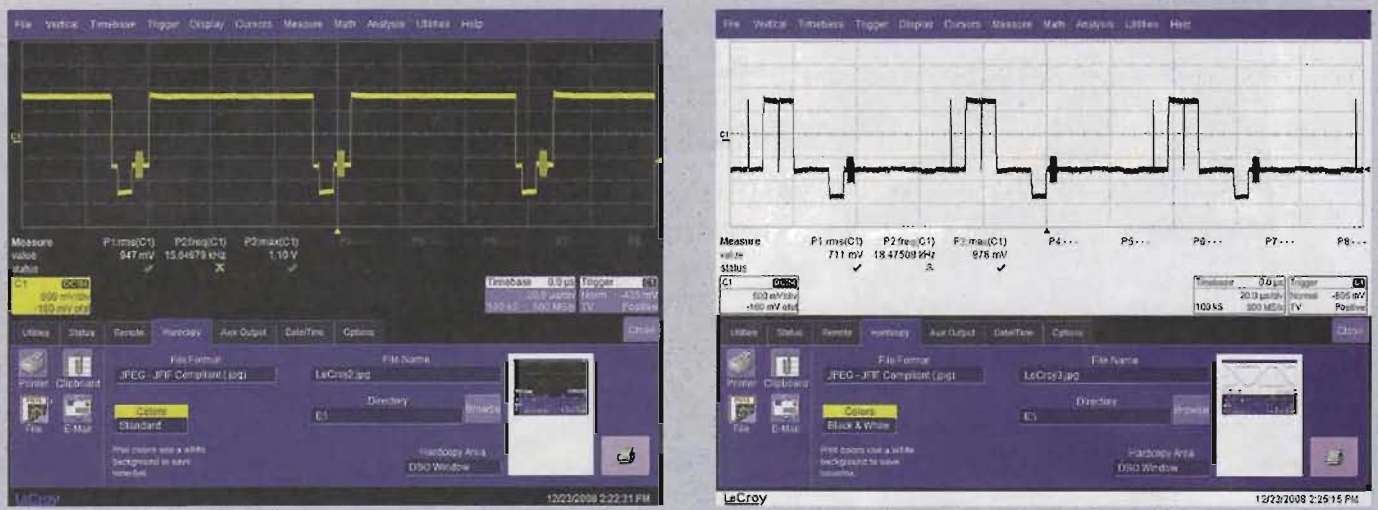
So when I had to do a quick waveform measurement recently and I knew I had to take a look at the LeCroy I just grabbed it and set it up on my desk, ready to do the measurement. I switched it on, hooked up a couple of probes and hit the Autoset button. This gave me a waveform on the screen, as you would expect, but when I came to do the measurements I was bushed – OK, where are the measurement controls?

I will admit that just like everyone else, I had not looked at any instruction manual – who does that? (In fact, I did not find the instruction manual until some days later – in the back pocket of the scope). But then in a moment of enlightenment, I touched the screen and found that I could do everything that way. There are the usual drop-down Windows menus along the top of screen – it all works. It's not the first Windows oscilloscope I have come across but I seem to remember that the others I have come across are not as intuitive as the LeCroy.

By the way, LeCroy probably don't want you to put your greasy paws on the touch screen so they have provided a little slide-out wand which you can use instead. After using that for a couple of minutes, I thought that a USB mouse would be a better way and sure enough, when I dived back into the packaging, the local distributors, Vicom, had provided one. Plugging that into the front panel immediately lets you do everything via the mouse.

The layout of the scope's front panel looks fairly conventional until you start looking for a particular feature such as how to set up triggering. This throws you into a display whereby you select parameters via the wand or mouse. But back to the scope itself. The screen itself is a 10.4-inch (26.4cm) SVGA LCD with a resolution of 800 x 600 pixels. This improves considerably if you connect an external monitor which can give a stated maximum resolution of 2048 x 1536 pixels (4:3 aspect ratio). When connected to a widescreen LCD monitor, we were able to set it to 1920 x 1200 pixels. We will come back to the operation of the external monitor later.

Below the scope screen is a line of five BNC sockets; one each of the four input channels and one for an external



These four scope grabs from the LeCroy 104Mxi portray a range of video waveforms from the Pocket A/V Generator presented in the June 2006 issue. All but one show the scope traces reversed out of white background. This saves toner when printing the scope grabs and makes it easier to read the on-screen measurements.

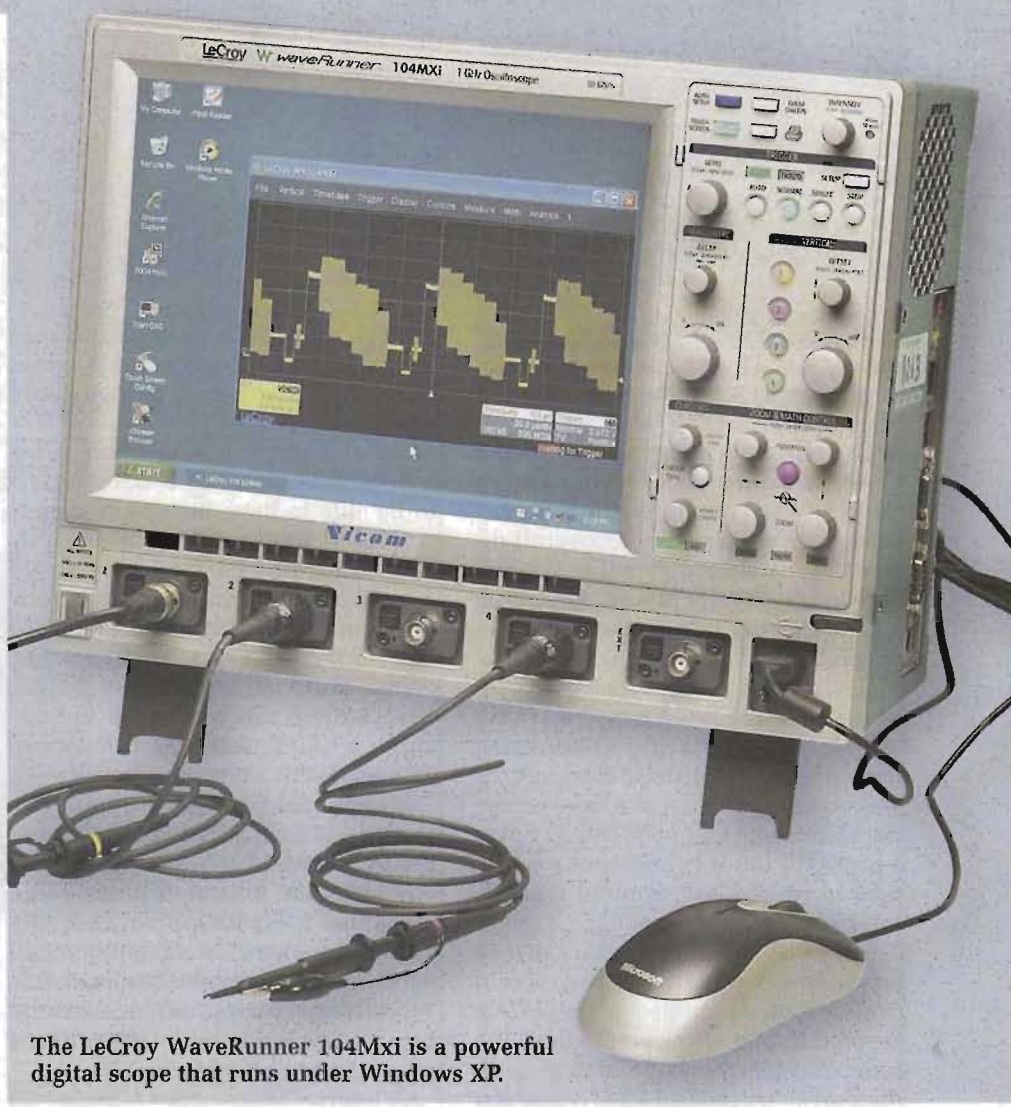
trigger source. All the inputs have probe sensing and active probes may be used. Also on the front panel is the already-mentioned USB socket which can be used to connect a mouse.

To the right of the screen is an array of knobs and buttons which let you select and adjust basic features of the scope, eg, vertical sensitivity and offset for each of the four input channels and timebase speed and delay. Each time you press a button or change a knob setting, it brings up a panel on the lower half of the screen which lets you access detailed settings.

In many ways, this works better than typical digital scopes which have "soft" buttons and multi-layered menus which can be quite hard to navigate, particularly if you don't use the scope frequently.

On the righthand side of the scope is a comprehensive input panel for connection of peripherals. There are mini DIN sockets for an external mouse and keyboard, four USB sockets, an Ethernet port (RJ-45), an RS-232 port, a VGA port for connecting an external monitor (as already mentioned), LeCroy's L-bus connector and line-in and speaker outputs for the sound card interface.

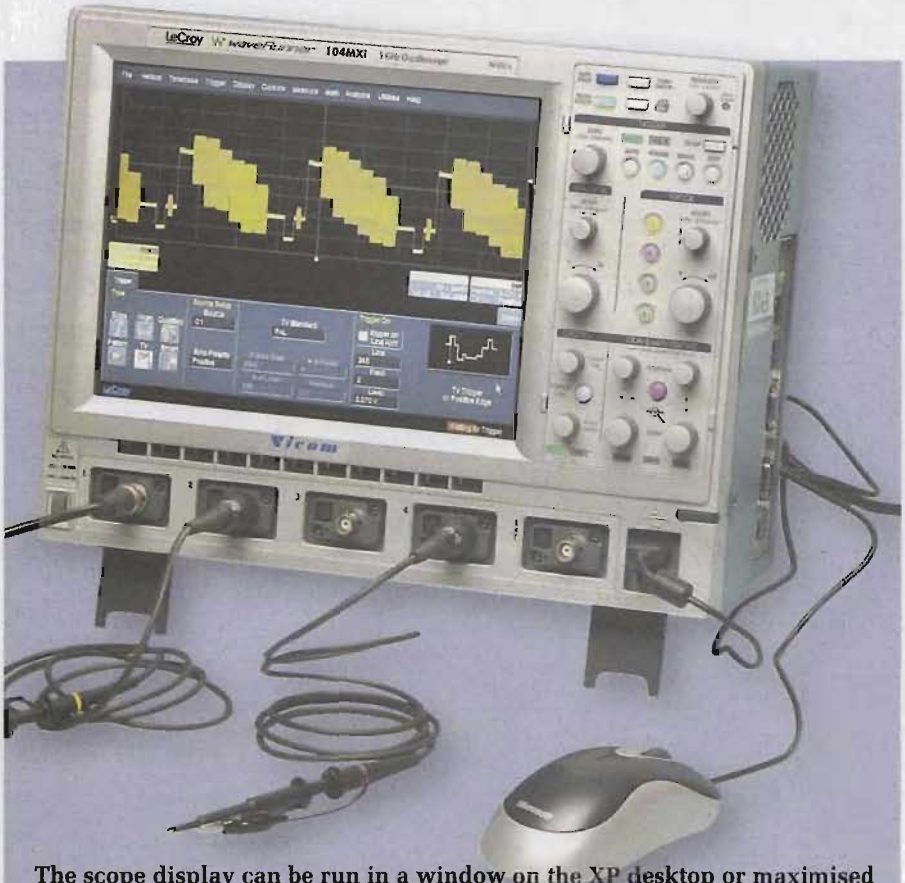
So essentially what we have is a laptop machine with a powerful digital scope built-in. In fact, there is nothing to stop you from using it as a conventional laptop. Just connect a full-size keyboard and USB printer (if you wish) and you're ready to go. Using Windows XP, it employs a 1.3GHz Celeron processor and 512MB of RAM.



The LeCroy WaveRunner 104Mxi is a powerful digital scope that runs under Windows XP.

And of course, you can connect it to a network if you desire. The internal hard drive is 33GB, partitioned into 10GB and 23GB, so there is no lack of capacity to store waveforms and set-ups and other software.

Normally, when you turn it, on it boots straight into Windows XP and



The scope display can be run in a window on the XP desktop or maximised to fill the screen as shown here.



The panel on the side of the machine includes an ethernet port, LeCroy's L-bus connector and I/O sockets for various peripherals & sound.

then loads the LeCroy DSO operating system. This can be windowed or minimised at any time to let you run other applications.

The 10.4-inch (diagonal) screen is a very good size, especially considering the relatively small amount of space taken up by the scope. Its overall dimensions are 340mm wide, 255mm high and 200mm deep, including knobs and the rear zippered pocket for probes and accessories.

Having said that, the ability to connect an external VGA monitor is very useful, particularly if you are using the scope to demonstrate to a group or classroom. Typically, in a large group, the VGA signal would be connected to a projector but it is here that a weakness in the LeCroy external monitor set-up becomes apparent.

Unlike the situation where you may be using a laptop for a PowerPoint presentation on a projector, the LeCroy scope does not allow you to have the same screen display on the scope as on the projector; you can have one or the other, not both. This makes it difficult to operate the scope when using the external display because nothing can be controlled by its touch screen – you have to use the mouse on the external screen. That could be very awkward if you are using a projector. It seems likely that a software change could easily remedy this.

On the other hand, when using the external monitor, it is very good to be able to have the scope operate on the external screen while you do other functions on the scope screen such as saving screen grabs or any other software function. In fact, if I had connected a full keyboard and loaded Word onto the LeCroy, I could have written this review on the machine while I tested its capabilities as a scope.

Unfortunately, time constraints prevented us from fully evaluating the LeCroy 104Mxi but it quickly becomes obvious that it is a fully featured 4-channel 1GHz 10Gs/s machine with very comprehensive waveform measurements. The full specifications of the WaveRunner scopes are available at **http://www.lecroy.com/tm/products/scopes/specs.asp?mseries=32**

A unique feature allows you to do separate measurements on each trace, something that is just not available on competing scopes. Importantly, the range of vertical input sensitivity is from 2mV to 10V/div in the usual 1-2-5 sequence. You need the maximum figure of 10V so that you can measure 240VAC waveforms with a 10:1 probe. That gives you 100V/div on screen. If your scope is limited to 5V/div, you need a 100:1 probe to enable you do the same thing; a small point perhaps but most labs do not have more than one 100:1 probe and this can be a hassle if you want to measure more than one 240VAC waveform at a time.

The timebase can be switched from 200 picoseconds to 10s/div in real time and up to 1000s/div in roll mode. Very comprehensive triggering is available, including TV (PAL, NTSC, SECAM and non-standard video modes up to 1500 lines), ORed-qualified, Pattern (logic combinations), Dropout, glitches and pulse widths, runt, slew rate and so on.

So how do summarise a scope like this? It certainly has a very wide range of high-performance features but the fact that it is operated under Windows probably means that it is easier to drive than if it relied on a multi-level menu system operated by soft keys – we liked it a lot.

For further information regarding price and availability of the full range of LeCroy digital oscilloscopes, contact the Australian distributors, Vicom Australia Pty Ltd, 1064 Centre Road, Oakleigh South, Vic 3167. Phone (03) 9563 7844; fax (03) 9579 7255; website **www.vicom.com.au** SC

PRODUCT SHOWCASE



New Tektronix MSO2000 and DPO2000 Digital Phosphor Oscilloscopes

Tektronix claim their new MSO2000 and DPO2000 Series of Digital Phosphor Oscilloscopes are the first entry-level oscilloscopes with feature-rich tools to simplify mixed-signal designs.

The DPO2000 series consists of three models ranging from 100MHz to 200MHz, with two or four analog channels, with the familiar Tektronix front panel layout, serial triggering, protocol decoding, USB plug and play PC connectivity, a 7-inch widescreen TFT display and a three year warranty.

The MSO2000 models also include 16 digital channels, providing up to 20 time correlated channels for analysing both digital and analog data.

All models have the deepest memory depth of any oscilloscope its class at a full 1M point per channel with 1GS/s sampling rate, which ensures at lease five times oversampling of the signal.

Key points which set the DPO2000 and MSO2000 apart as the new benchmark entry-level oscilloscopes are:

- 16 logic channels (MSO2000 models only)
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Looking for Inductive Touch-Sensing Solutions?



Touch sensing continues to gain popularity as an alternative to traditional push-button user interfaces, improving reliability and lowering total system costs. Touch sensing also enables a completely sealed and modern-looking design.

Inductive touch sensing works through a front panel such as plastic, stainless steel or aluminum and also through gloves and on surfaces that contain liquids.

With the new mTouch Inductive Touch-Sensing Technology, Microchip enables designers to integrate inductive touch-sensing functionality with their existing application code in a single standard 8-, 16- or 32-bit PIC microcontroller (MCU) or 16-bit dsPIC Digital Signal Controller (DSC), thus reducing total system costs.

Major applications for inductive touch-sensing user interfaces include those in the appliance market because of the possibility of a stainless steel front panel; the industrial market because of the technology's robustness and the automotive market because of the technology's aesthetics and ability to reduce accidental touch triggers.

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End of the road for the Hard Disk Drive?

Two press releases from industry leader Sandisk received as we were going to press arguably presage the end of the mechanical hard disk drive.

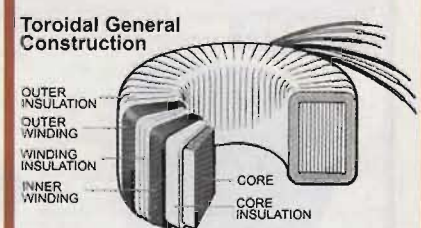
The first was for drop-in flash disk hard drive replacements for notebooks, laptops, etc. Initial members in the SanDisk G3 family are SSD C25-G3 (2.5") and SSD C18-G3 (1.8"), each available with a SATA-II interface. Available in capacities of 60, 120 and 240GB, the unit MSRPs are $US149, $US249 and $US499, respectively.

The second was the announcement of 2TB (two terabyte, or two trillion byte!) Memory Sticks, developed in conjunction with Sony.

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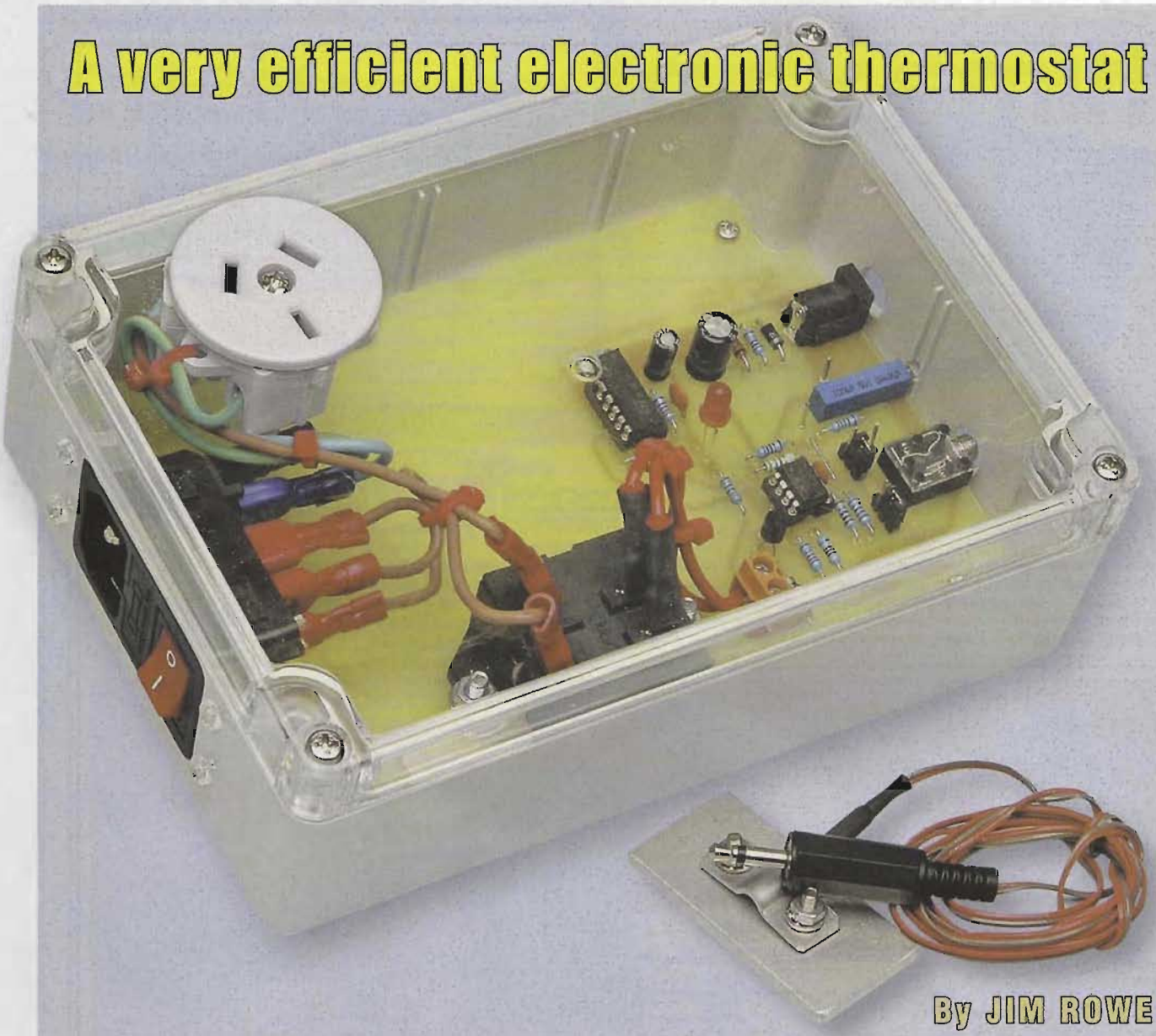
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A very efficient electronic thermostat



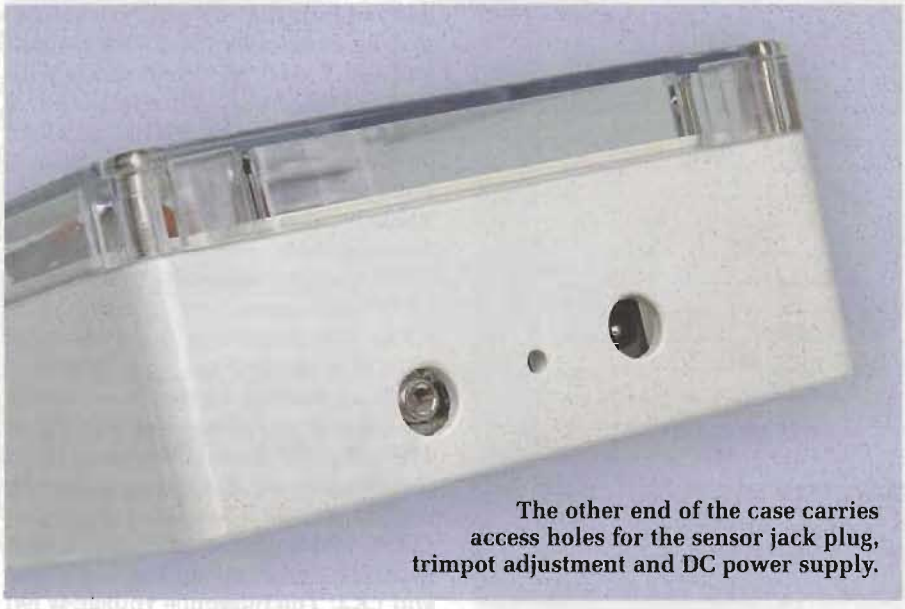
By JIM ROWE

TEMPMASTER MK.2

Want to convert an old chest-type freezer into an energy-efficient fridge? Or convert a spare standard fridge into an excellent wine cooler? These are just two of the jobs this low-cost and easy-to-build electronic thermostat has been designed to do. It can also be used to control 12V fridges or freezers, as well as heaters in hatcheries and fish tanks. It controls the fridge/freezer or heater directly via their power cables, so there's no need to modify their internal wiring.



The switched IEC connector is snap-fitted to an aluminium plate and this assembly is then secured to one end of the case using Nylon screws & nuts.



The other end of the case carries access holes for the sensor jack plug, trimpot adjustment and DC power supply.

BACK IN THE JUNE 2005 issue of SILICON CHIP, we described an electronic thermostat intended mainly for converting an old fridge into a wine cooler or a chest-type freezer into an energy-efficient fridge. Dubbed the "Coolmaster", it turned out to be a very popular project, especially with people wanting to reduce their power bill and reduce their "carbon footprint".

Converting a chest freezer into a "chest fridge" results in much lower energy consumption than a normal "vertical" fridge of the same internal capacity, because cold air doesn't fall out every time you open the door and chest freezers tend to be better insulated anyway.

The project became even more popular when the people in Jaycar's kit department came out with a slightly modified version which could be used to control heating elements as well as fridges and freezers. This modified version was called the "Tempmaster", to describe its expanded capabilities.

Unfortunately, some constructors did experience problems with the project. In most cases, this seems to have been due to spurious triggering of the control Triac due to inductive spikes fed back from the motor in the compressor of the fridge/freezer, causing noisy and/or hesitant switch-on or switch-off. This problem was solved in most cases by fitting a mains filter circuit between the Tempmaster and the motor but it did point to one shortcoming in the project's use of a Triac for power control of motors.

Of course, a Triac can only be used for controlling AC in any case, and this meant that the first Tempmaster could not be used to control fridges, freezers or heaters which run from 12V DC – shortcoming number two.

We also received criticism from energy conservationist Dr Tom Chalko, who complained that the Coolmaster/Tempmaster was mediocre in terms of energy efficiency. This was because of its own quiescent energy consumption and it would pose problems for those using electronic inverters to produce 240VAC from a solar or wind generating system, by preventing the inverters from ever being able to switch into "sleep" mode.

Dr Chalko claimed that our Tempmaster had a continuous quiescent energy consumption of 60 watt-hours per day, equating to a power consumption of 2.5W. I'm not sure how he arrived at this figure, because my calculations gave a figure of only 0.25W or 6Wh/day with a 90% efficient plugpack supply, or perhaps 10Wh/day with a plugpack which was only 50% efficient.

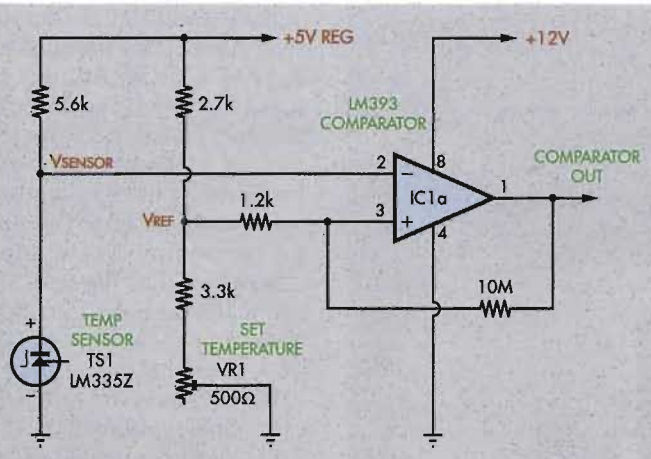
Added to the other shortcomings of the original Coolmaster/Tempmaster, though, Dr Chalko's criticism did prompt us to produce a new and improved Mk.2 version of the project. So that's the story behind the new version described here.

There are two main differences between this new Tempmaster and the original. First, it now uses a 240VAC-rated relay to switch the load power instead of a Triac. This has three main advantages: no problems with noise triggering, the ability to switch DC just as easily as AC and lower quiescent energy consumption because there is now no snubber circuit or bias filter circuitry associated the Triac.

The second main difference is that we have used a more efficient voltage regulator circuit, an LM723, to power the thermostat's control circuitry. This has lowered the quiescent power consumption to below 48mW (0.048W) – equating to just 1.15Wh/day.

How it works

There's very little in the thermostat



COMPARATOR CONFIGURATION – COOLING CONTROL

Fig.1: the circuit is based on remote temperature sensor TS1. It's output is fed to the inverting input of comparator IC1a where it is compared with a preset reference voltage (V_{REF}) derived from a regulated +5V rail.

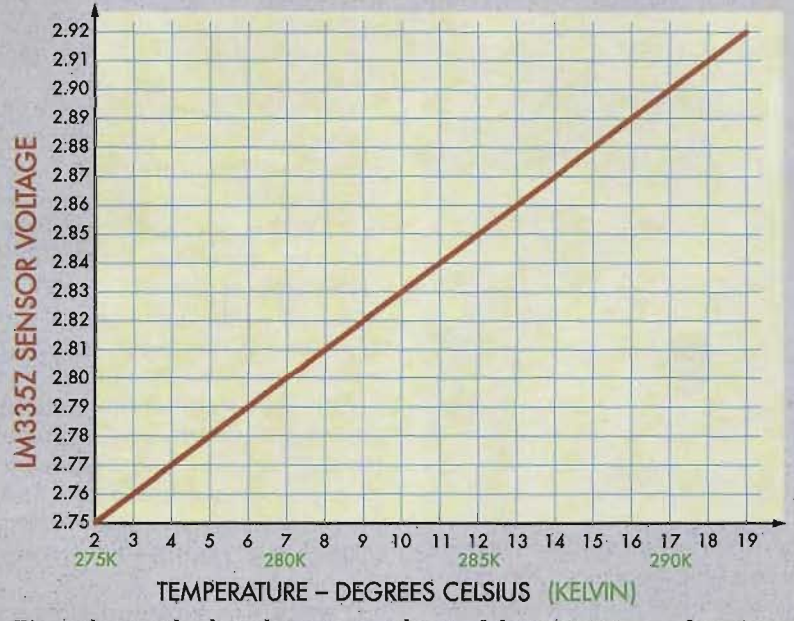


Fig.2: the graph plots the output voltage of the LM335Z as a function of temperature. It rises linearly by 10mV for every 1°C increase.

circuit and its operation is straightforward. Fig.1 shows the basic details.

The heart of the circuit is the remote temperature sensor TS1, which is an LM335Z device specifically designed for temperature sensing. The LM335Z acts like a special kind of zener diode, in which its voltage drop is not fixed but varies linearly and quite accurately with its temperature. In fact, its voltage drop is directly proportional to absolute temperature, having a value of 0V at 0 Kelvin (-273°C) and rising linearly by 10mV for every Kelvin (or °C) rise in temperature.

This is shown in the graph of Fig.2. At a temperature of 2°C (275K), the voltage drop of the LM335Z is very close to 2.75V. Similarly, at 19°C (292K), it rises to 2.92V. It's this change in voltage that we use to control the temperature of our fridge/freezer or heater, by comparing the sensor's voltage with a preset reference voltage.

The actual comparison is made by IC1a, one section of an LM393 dual comparator (the other section is not used). Sensor TS1 connects to the inverting input (pin 2) of IC1a which compares it with a reference voltage at its non-inverting input (pin 3).

Now remember that the lower the temperature being measured by sensor TS1, the lower will be its output voltage. So when the sensor voltage is below the reference voltage, the output of the comparator will be high and this means that nothing will be switched on by it.

When the voltage from the sensor rises, corresponding to an increase in measured temperature, at some point it will go above the reference voltage at pin 3. This will cause the output of the comparator to go low and it will then switch on transistor Q1 and the relay which we will come to later on.

Fig.1 also shows the sensor connection details and the means of deriving the reference voltage from the +5V supply. As can be seen, sensor TS1 is connected to the +5V rail via a 5.6kΩ resistor, which is used to provide the sensor with a small bias current.

The reference voltage at pin 3 is derived from the +5V rail via a voltage divider formed by the 2.7kΩ resistor and the 3.3kΩ resistor in series with VR1, a 500Ω multi-turn trimpot.

As a result, when VR1 is adjusted over its range this varies the reference voltage between 2.75V and 2.92V. These happen to be the LM335Z sensor voltages at 2°C and 19°C respectively. VR1 therefore becomes the thermostat's "set temperature" control.

OK, the foregoing description of IC1a applies to when the Tempmaster is in cooling mode. Now have a look at the complete circuit of Fig.3. This shows IC1a connected so that it can provide either heating or cooling control. Sensor TS1 plugs into socket CON2 which in turn connects to test point TP2 and one end of links LK1 and LK2. The reference voltage is fed to test point TP1 as well as the two other pins of LK1 and LK2.

The two inputs of IC1a are connected to the centre pins of LK1 and LK2. This allows us to set the Tempmaster for either cooling or heating control, simply by moving the jumpers on LK1 and LK2 from one end to the other.

For example, when LK1 connects IC1a's pin 3 to the reference voltage (TP1) and LK2 connects pin 2 to TP2 and temperature sensor TS1, this configures the Tempmaster for cooling control (ie, control of a fridge or freezer). Conversely when LK1 connects pin 3 to TP2 and TS1, and LK2 connects pin 2 to TP1 and the reference voltage, this configures the Tempmaster for heating control. The

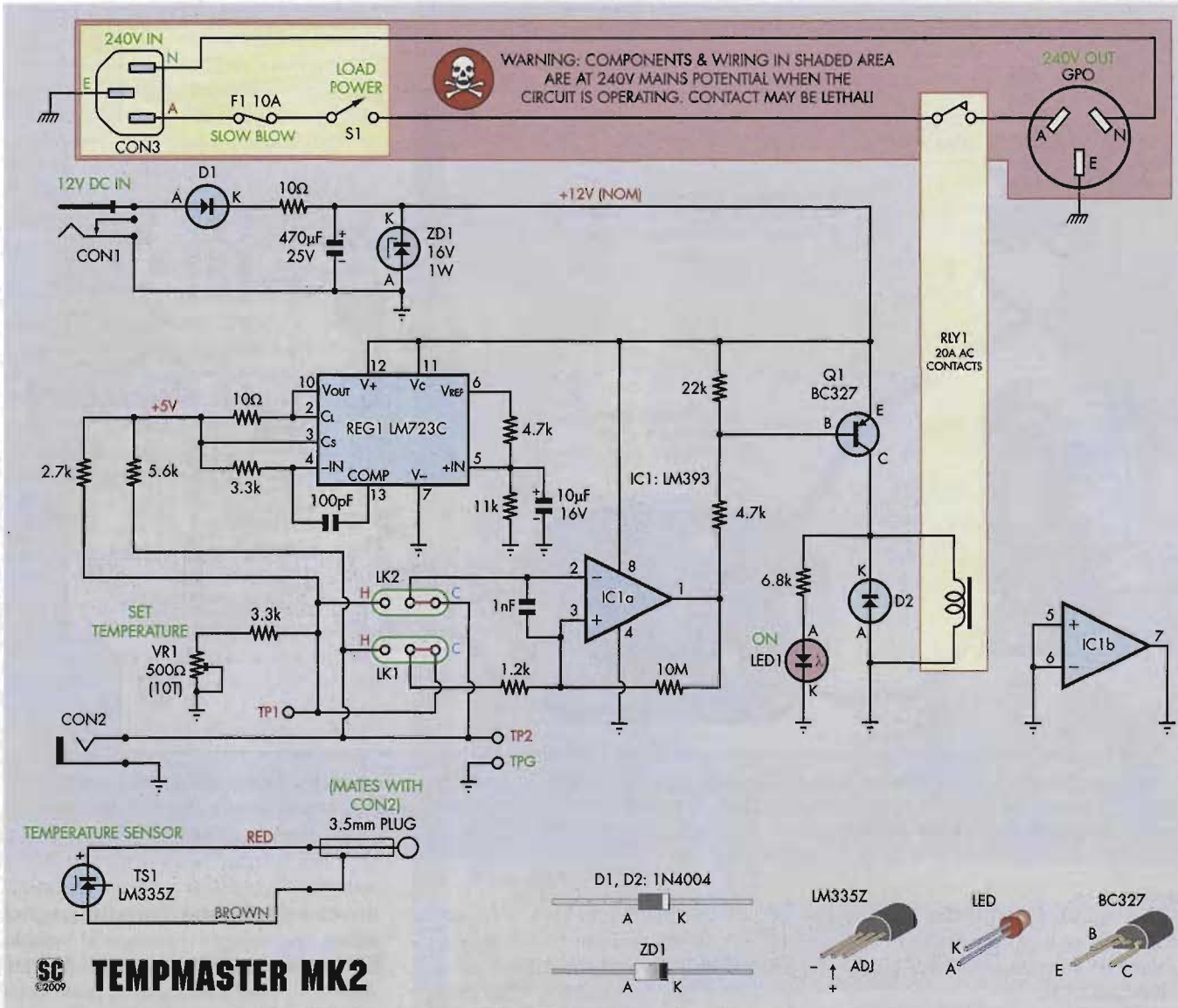


Fig.3: the complete circuit of the Tempmaster Mk.2. Links LK1 & LK2 allow comparator IC1a to be connected so that it can provide either heating or cooling control. IC1a drives transistor Q1 which in turn controls relay RLY1 to switch power through to the GPO.

"C" and "H" at each end of LK1 and LK2 indicate this.

Cooling control

Now consider that LK1 and LK2 are set for cooling mode, as shown by the two red links on the circuit diagram (Fig.3). This means that while ever the temperature of TS1 inside the fridge or freezer remains lower than the set temperature level, the voltage drop across TS1 (applied to input pin 2 of IC1a) will be lower than the reference voltage applied to pin 3 via LK1 and the 1.2kΩ resistor.

As a result, the open-collector output at pin 1 will not draw any current from the +12V rail and transistor Q1 will not be able to conduct to turn on LED1 or relay RLY1. So no output power will be delivered to the GPO.

On the other hand, if the temperature inside the fridge/freezer rises to just above the reference voltage (set temperature) level, the voltage drop across TS1 (fed to pin 2 of IC1) will just rise above the reference voltage on pin 3. The comparator output will switch low to pull current through the 4.7kΩ resistor and hence turn on Q1. This will operate LED1 and energise the relay coil. This will provide power to the compressor in the fridge/freezer, causing it to cool things down again.

Of course when the fridge/freezer temperature drops below the set level again, the voltage from TS1 will drop below the voltage on pin 3 of the comparator and the comparator will switch back off again, turning off Q1, the LED and the relay once again. It runs the compressor only long enough to bring the temperature just below the set level.

Heating control

If links LK1 and LK2 are swapped to their "H" ends, this reverses the way the comparator controls the power fed to the Tempmaster's GPO in response to changes in TS1's voltage. Since TS1's voltage is now fed to pin 3 of IC1a and the reference voltage to pin 2, the comparator's output will remain high and not draw any current while ever TS1's voltage is higher than the reference voltage.

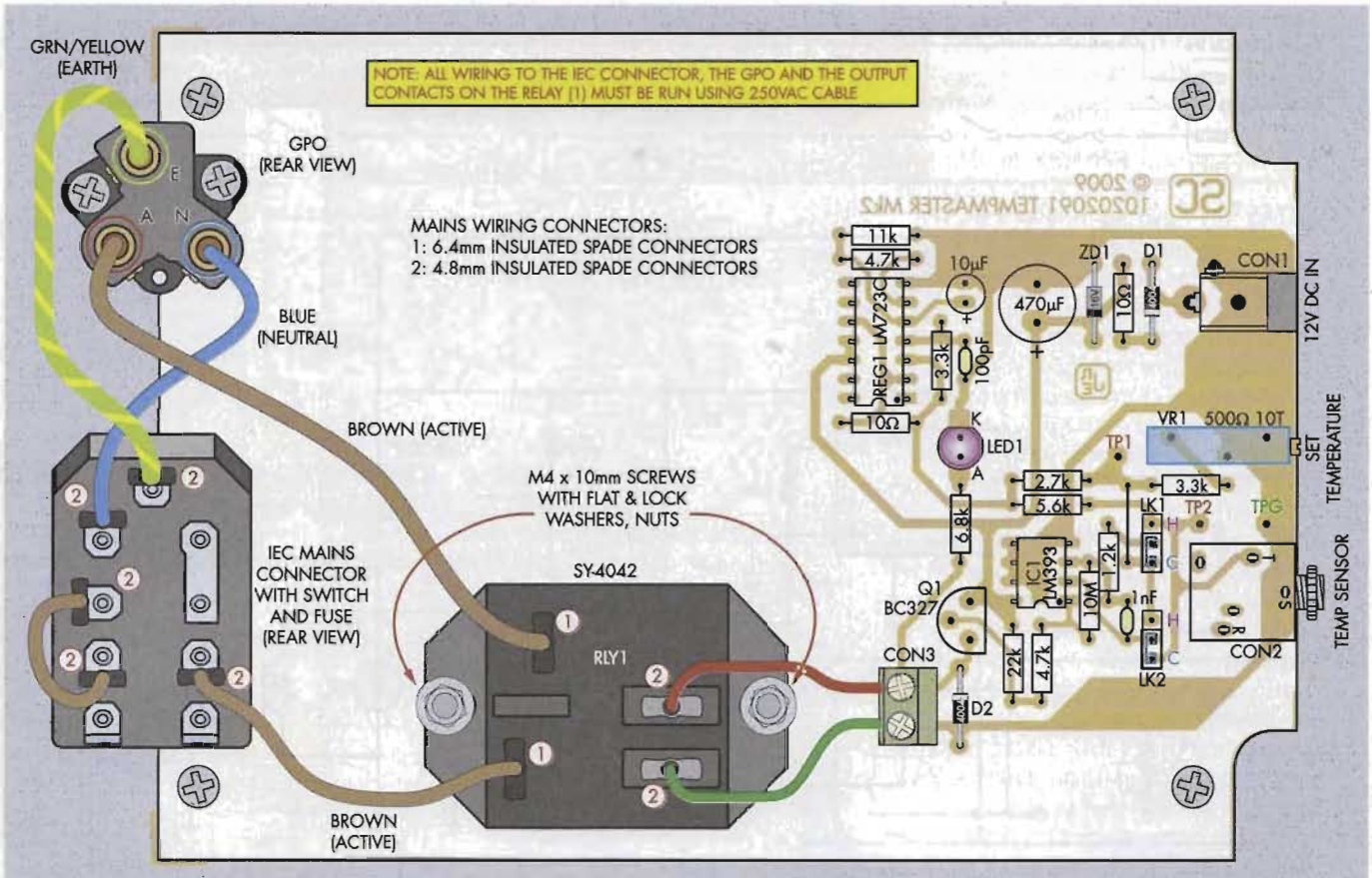


Fig.4: install the parts on the PC board and complete the wiring as shown here. Note that all connections to the GPO, the IEC connector and the relay contacts (1) must be run using mains-rated cable. Be sure to secure this wiring using cable ties, as shown in the photos.

As a result, Q1 and the relay will remain off and no power will be fed to the GPO or any heating element connected to it.

However, if the temperature inside the hothouse or fish tank falls just below the set temperature, TS1's voltage will drop below the reference voltage. The comparator's output will thus switch low, drawing current and turning on Q1 and LED1 and energising relay RLY1.

As a result, power will be switched through to the heating element to warm things up again. Then when the temperature rises above the set level again, TS1's voltage will rise above the reference voltage and the comparator's output will switch high again. This will turn off Q1, LED1 and the relay, removing power from the heater.

Positive feedback

Regardless of whether the circuit is working in cooling or heating modes, we need to prevent the comparator from oscillating back and forth (or hunting) by applying a small amount of positive feedback. This is arranged by the 10MΩ resistor between pins 1 and 3 of IC1a and the 1.2kΩ resistor connecting pin 3 to LK1. This lowers the voltage at pin 3 slightly when the comparator is switched "on" (pin 1 low and Q1 energising RLY1) and raises it slightly when the comparator is "off".

In cooling mode, this means that in the input voltage from TS1 at pin 2 must drop down to a level at pin 3 that is slightly lower than the reference voltage, before the comparator will turn off again. Conversely, it must rise to a level slightly higher than the reference voltage before the comparator will turn on. In other words, we give the comparator a small amount of hysteresis.

Low power drain

All the low-voltage part of the circuit operates from a nominal 12V DC supply, which is derived from an external DC plugpack or battery via CON1 and protection diode D1. The 470µF capacitor provides a reservoir for the additional current needed when the relay is energised, while the 10Ω resistor and zener diode ZD1 provide protection against over voltage damage.

The regulated +5V supply needed for TS1 and the reference voltage divider is derived from the nominal +12V rail via REG1, an LM723C regulator. We have used the LM723C here because it has a very low quiescent current. As a result, the maximum total quiescent current drawn from the 12V supply (via CON1) is less than 3.8mA. This is when the relay is not energised, of course. When the relay is energised, the current rises to about 79mA.

So in a typical freezer-to-fridge conversion application where the relay will be off for most of the time, the Tempmaster's average power consumption will be only around 50mW and its energy consumption around 1.2 watt-hours per day.

Construction

Most of the components used in the Tempmaster circuit are mounted on a

PC board measuring 151 x 109mm and coded 10202091. The board has rounded cut-outs at one end so it mounts inside a sealed polycarbonate enclosure measuring 171 x 121 x 55mm, sitting on the tapped pillars moulded into the bottom of the enclosure.

Relay RLY1 is mounted on the board at lower centre, as shown in the internal photos. The connectors for the 12V DC input and remote temperature sensor TS1 are mounted on the right-hand end of the board, being accessed via matching holes at that end of the enclosure. The "set temperature" trimpot VR1 is mounted centrally at the same end of the board and is accessed via a small hole in one end of the enclosure.

The only components not mounted on the PC board in the Tempmaster itself are the fused and switched IEC mains input connector and the 3-pin mains outlet or GPO. The latter is mounted in a cut-out at upper left on the enclosure's lid, while the former mounts on the lefthand end of the enclosure.

Since the IEC connector is a snap-in type that's suitable for panels with a maximum wall thickness of 1mm (much thinner than the enclosure walls), it's first fitted to a small metal plate of 1mm-thick sheet steel or aluminium. The resulting assembly is then fastened inside the enclosure behind the connector's cut-out, using four M3 x 10mm Nylon screws and eight M3 Nylon hex nuts (two on each screw, for safety).

This arrangement gives maximum safety combined with neatness, as the front surface of the IEC connector is virtually flush with the outside of the enclosure wall.

Wiring up the board and in fact the



Inside the completed Tempmaster Mk.2 – note how the mains wiring is firmly secured using cable ties, so that it's impossible for the leads to come adrift and contact low-voltage wiring.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10MΩ	brown black blue brown	brown black black green brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	1	11kΩ	brown brown orange brown	brown brown black red brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	1	5.6kΩ	green blue red brown	green blue black brown brown
❑	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	1	2.7kΩ	red violet red brown	red violet black brown brown
❑	1	1.2kΩ	brown red red brown	brown red black brown brown
❑	2	10Ω	brown black black brown	brown black black gold brown

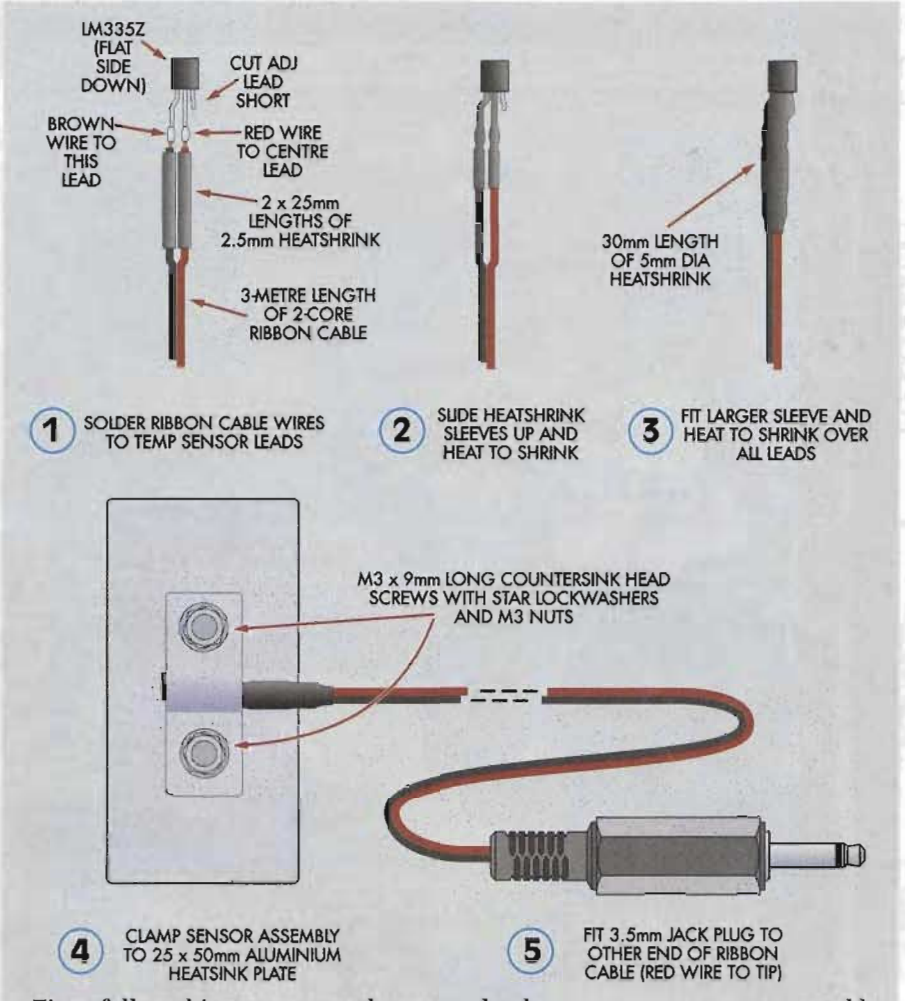


Fig.5: follow this 5-step procedure to make the temperature sensor assembly. As shown, the sensor is clamped to a 25 x 50mm aluminium heatsink plate.



This view shows the completed temperature sensor unit. It connects to the main Tempmaster circuit via a 3.5mm mono jack plug.

thermostat as a whole should be very easy if you follow the internal photos and the wiring/overlay diagram carefully.

Begin wiring up the PC board by fitting the three terminal pins (used to provide test points). These go at centre right on the board. Follow these with DC input connector CON1, the temperature sensor socket CON2 and the two-way terminal block CON3.

If you are using sockets for IC1 and REG1 these can now be fitted as well. You can also fit the two 3-way SIL headers for LK1 and LK2, which are located just to the left of CON2. It's also a good idea to now fit the wire link which goes just to the left of the LK1 header.

Next, fit the various resistors, making sure you fit each one in its correct position. Table 1 shows the resistor colour codes but it's also a good idea to check each one with a DMM just before it's fitted to the board. Once they are in, fit trimpot VR1 – this goes at centre right, between CON1 and CON2.

The two non-polarised ceramic capacitors can be fitted next, followed by the two electrolytics. Take special care with the latter as they are polarised. Make sure you follow the diagram carefully for their orientation or you'll strike trouble later.

Take the same care with the semiconductors. These can be fitted now, starting with diodes D1 and D2 and zener diode ZD1. Follow these with transistor Q1 and LED1. The latter should be mounted vertically, with the bottom of its body about 12mm above the board. Make sure the LED is orientated with its flat (cathode) side as shown, then fit IC1 and REG1, soldering these into place if you're not using IC sockets.

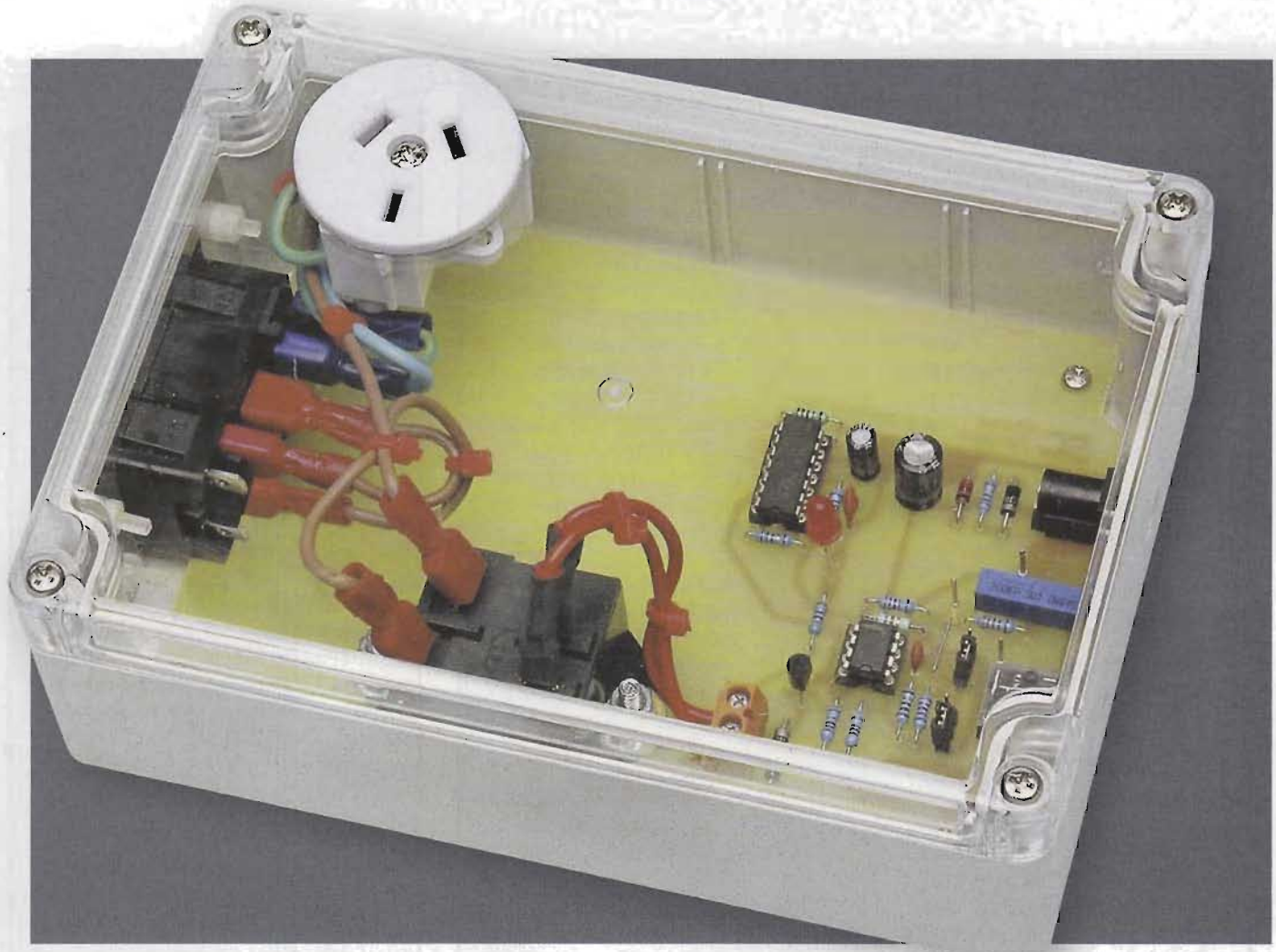
Now you can bolt relay RLY1 to the board at lower centre. It's attached to the board using two M4 x 10mm machine screws, flat washers, lockwashers and hex nuts. **Make sure that you mount the relay with its coil connection spade connectors to the right and its contact connectors to the left, as shown in the wiring diagram and photos.** Also make sure that you fit the relay mounting screws with their heads under the board, and their nuts and washers above the relay mounting flanges.

Preparing the enclosure

Your board assembly should now be complete and you can place it aside while you drill and cut the various holes needed in the enclosure and its lid (note: you probably won't have to do this if you're building it from a kit, as it will very likely come with the enclosure and lid fully prepared for you). Use the enclosure cutting diagram shown in Fig.6 as a guide to the size and location of all holes.

Fig.6 also shows the details for the metal mounting plate for the IEC connector.

Once the enclosure has been prepared, slip the PC board assembly down into it and screw it into place using the four M3 x 6mm machine screws, which mate with the metal nuts moulded into the standoffs in the bottom of the enclosure. That done, clip the IEC mains connector into its metal mounting plate and fit this



assembly into the matching cut-out in the lefthand end of the enclosure, from the inside.

You'll find that the flange of the IEC connector slips snugly inside the cut-out and the mounting plate is flush against the inside of the enclosure wall. You can then fasten the assembly in place using four M3 x 10mm Nylon screws and nuts. It's a good idea to then install an additional Nylon nut on each mounting screw. These will firmly lock the first nuts into position and ensure that the assembly can not come loose.

Next, mount the mains outlet socket in its matching lid cut-out. This is done by undoing the screw in the centre of the socket to separate the front and rear sections, then screwing them back together with the lid sandwiched between the two sections.

Fitting the mains leads

After the outlet socket is fitted you can then prepare the various mains connection wires which link it to the IEC mains connector and the contacts of RLY1 – see Fig.4. **Note that these leads must all be rated at 250VAC.**

The blue (Neutral) and green/yellow (Earth) leads from the outlet socket each have a 4.8mm insulated spade connector crimped firmly to their far ends. By contrast, the brown (Active) wire from the GPO is fitted with a 6.4mm insulated spade connector to connect to one of the relay contact terminals. The brown (Active) lead between the IEC connector and the relay is fitted with a 4.8mm insulated spade connector at one end and a 6.4mm connector at the other.

Finally, the lead that's used to link two terminals on the IEC connector has 4.8mm insulated spade connectors at both ends.

Fig.4 shows what type of spade connector to fit to each wire. These spade connectors must all be fully insulated. **If you are unable to obtain fully insulated 4.8mm connectors, then use non-insulated connectors but be sure to fully insulate them using 6mm-diameter heatshrink tubing after the leads are crimped.**

Points To Check

(1) Be sure to use the specified ABS plastic case & note that Nylon screws must be used to secure the IEC connector plate to ensure safety.

(2) Use mains-rated cable for all connections to the IEC socket, the GPO and the relay contacts. Secure this wiring using cable ties – see photos.

(3) Use fully-insulated spade connectors to terminate the leads to the IEC connector and to the relay contacts. A ratchet-driven crimping tool is necessary to fit the spade connectors.

(4) Do not touch any part of the 230VAC wiring while this device is plugged into the mains. Do NOT attempt to build this device unless you know what you are doing and are familiar with high-voltage wiring.

Make sure you attach all of these space connectors very firmly using a ratchet-type crimp connector, so they will give reliable long-term connections.

Two short wires are used to con-

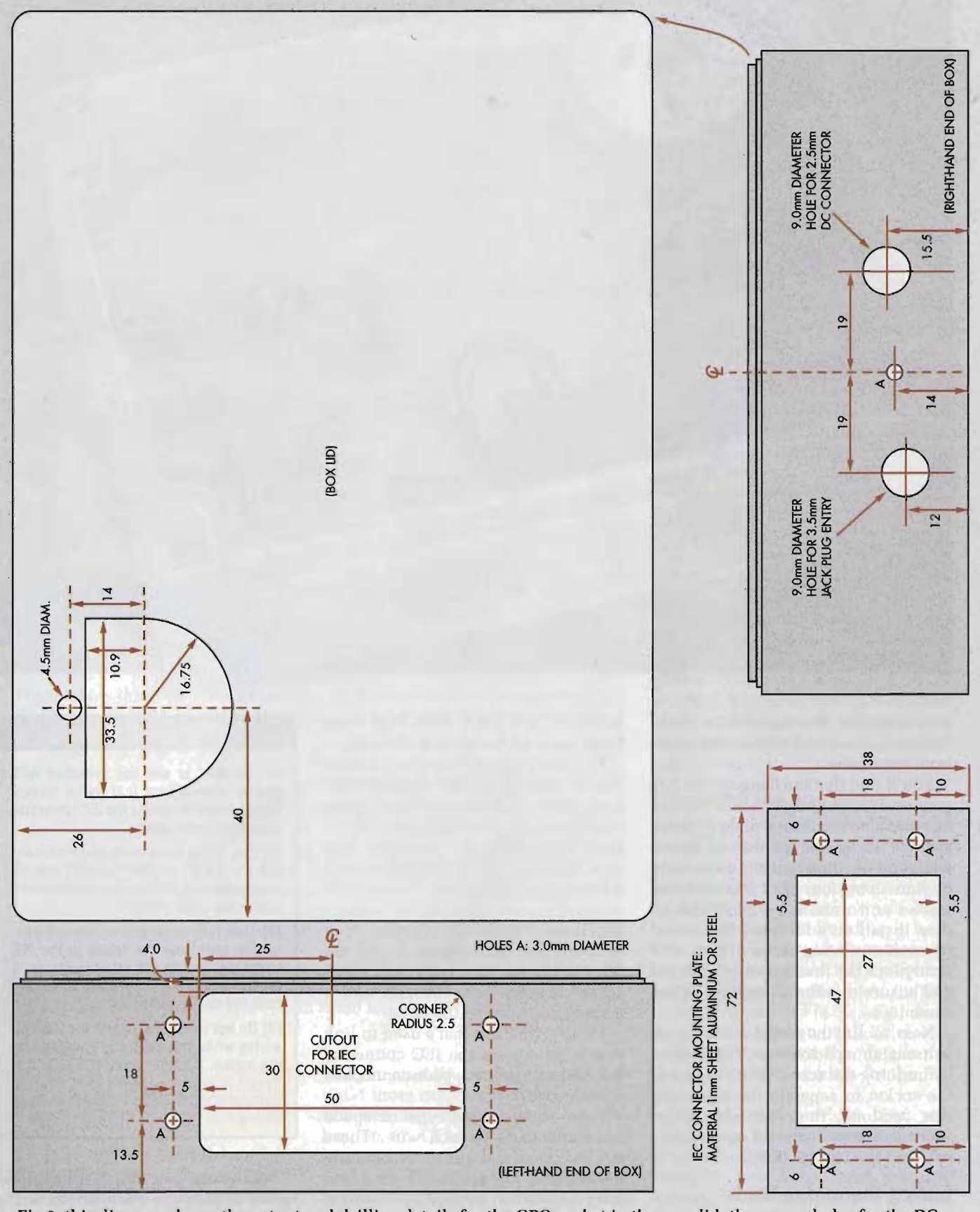


Fig.6: this diagram shows the cutout and drilling details for the GPO socket in the case lid, the access holes for the DC socket, the temperature sensor socket and the trimpot (righthand end), the IEC connector (lefthand end) and the metal mounting plate for the IEC connector. A large cutout can be made by drilling a series of small holes around the inside perimeter, then knocking out the centre piece and carefully filing the job to a smooth finish.



Non-insulated 4.8mm spade connectors can be used, provided they are fully insulated with 6mm heatshrink sleeving as shown here.

nect the coil of RLY1 to terminal block CON3. These can be made up from medium-duty insulated hookup wire, with each one having a 4.8mm insulated spade connector crimped to one end.

That completes the wiring of the Tempmaster but before you screw on the lid of the enclosure to finish it, fit plastic cable ties to the mains wiring as shown in the internal photos. **These will ensure that the spade connectors cannot come loose and make it impossible for a mains lead to make contact with any of the low-voltage wiring.** You can also fit one or two cable ties around the wires from the relay coil to CON3, to make sure these will also hold each other in place.

Installing the jumper shunts

Another job to do at this stage is to fit the jumper shunts to the two 3-way header strips on the top of the Tempmaster PC board, to provide links LK1 and LK2. Whichever positions you use for these two jumpers will depend on whether you're going to be using the Tempmaster to control cooling or heating. They go in the lower "C" positions for cooling or the upper "H" positions for heating.

Finally, fit the rubber sealing strip around the groove in the underside of the enclosure lid, and then screw the lid to the enclosure using the four screws provided. You should now be ready to make up the Tempmaster's remote temperature sensor.

Parts List

1 PC board, code 10202091, 151 x 109mm
1 IP65 ABS sealed polycarbonate enclosure with clear lid, 171 x 121 x 55mm (Jaycar HB-6248 or equivalent)
1 2.5mm DC input socket, PC board mounting (CON1)
1 3.5mm jack socket, PC board mounting (CON2)
1 2-way terminal block, PC board mounting (CON3)
1 3.5mm stereo jack plug
1 10A flush mounting mains outlet socket with side wire entry
1 snap-fit fused male IEC connector with switch
1 chassis-mount 12V coil SPDT relay with 20A contacts (Jaycar SY-4042)
1 10A M205 slow blow fuse
3 PC board pins, 1mm diameter
1 14-pin machined IC socket
1 8-pin machined IC socket
1 300mm length of 10A brown mains wire
1 100mm length of 10A blue mains wire
1 100mm length of 10A green/yellow mains wire
2 50mm lengths of medium duty insulated hookup wire
6 plastic cable ties
1 72 x 38 x 1mm sheet steel or aluminium (for IEC connector mounting plate)
2 3-pin SIL headers
2 jumper shunts
1 25 x 50 x 3mm aluminium sheet
1 30 x 10 x 1mm aluminium sheet
2 6.4mm insulated spade connectors for 1mm^2 wire
7 4.8mm insulated spade connectors for 1mm^2 wire
1 2m length of 2-conductor ribbon cable
2 25mm lengths of 2.5mm heatshrink sleeving
1 150mm length of 6mm heatshrink sleeving
4 M3 x 10mm Nylon screws, pan head
8 M3 Nylon hex nuts
2 M3 x 10mm machine screws, countersunk head
2 M3 hex nuts & star lockwashers
4 M3 x 6mm machine screws
2 M4 x 10mm machine screws
2 M4 hex nuts
2 M4 flat washers
2 M4 lockwashers
1 500Ω multi-turn cermet trimpot, horizontal adjust (VR1)
1 30mm-length tinned copper wire (for link)

Semiconductors
1 LM335Z temperature sensor (TS1)
1 LM393 dual op amp (IC1)
1 LM723C regulator (REG1)
1 BC327 or BC328 transistor (Q1)
1 16V 1W zener diode (ZD1)
1 5mm red LED (LED1)
2 1N4004 1A diodes (D1,D2)

Capacitors
1 470µF 25V RB electrolytic
1 10µF 16V RB electrolytic
1 1nF disc ceramic
1 100pF disc ceramic

Resistors (0.25W, 1%)

1 10MΩ	2 4.7kΩ
1 22kΩ	2 3.3kΩ
1 11kΩ	1 2.7kΩ
1 6.8kΩ	1 1.2kΩ
1 5.6kΩ	2 10Ω

Making the remote sensor

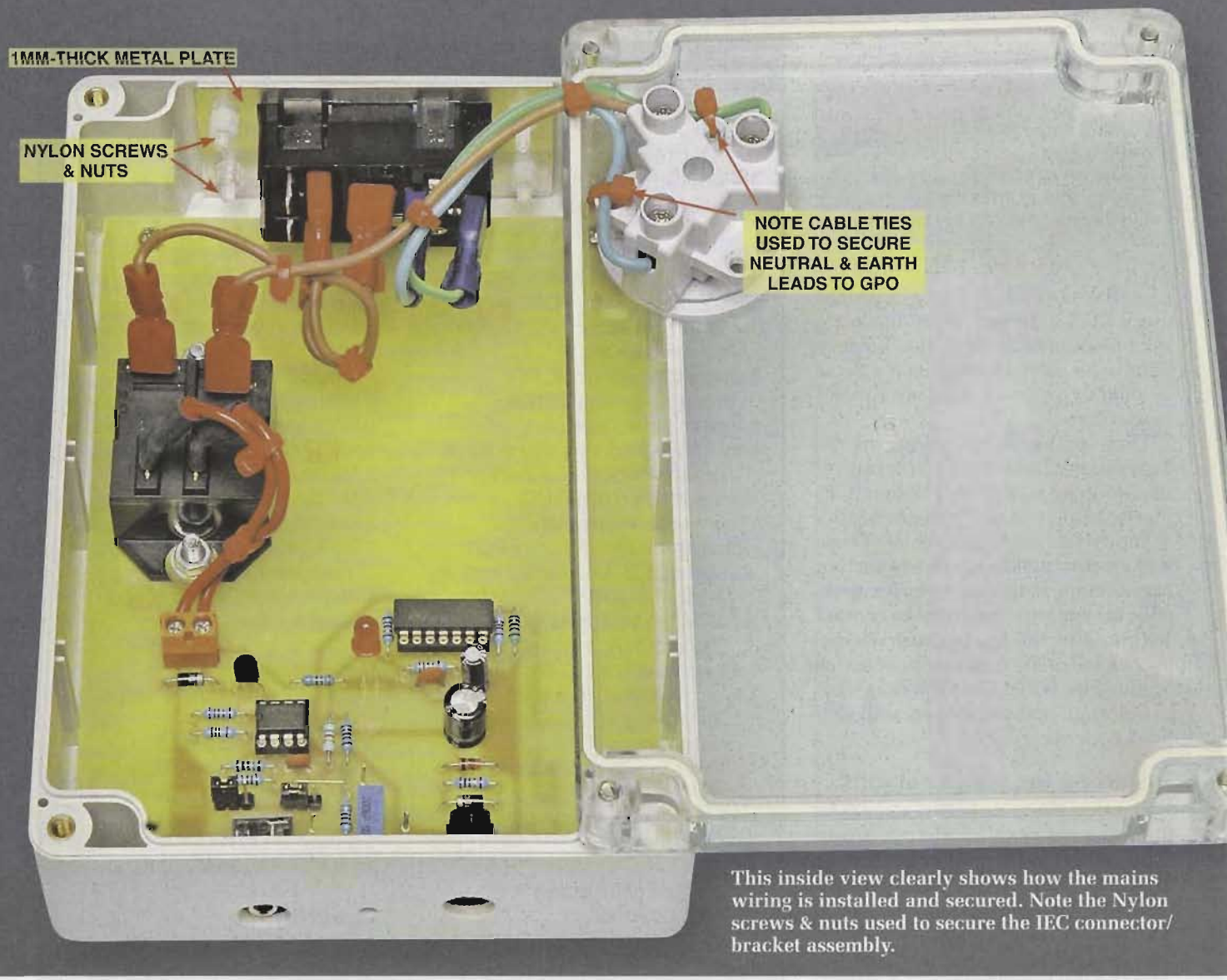
Follow the step-by-step diagram shown in Fig.5 as a guide. The first step is to clip short the unwanted third lead off the LM335Z sensor and then solder the ends of the 2-core ribbon cable wires to the other two leads after slipping 25mm lengths of 2.5mm diameter heatshrink sleeving over each one.

After the solder cools and you are happy that both joints are good, the sleeves are then moved up until they butt hard against the body of the LM335Z, after which they are heated to shrink them in place (step 2). Then a 30mm-length of 5mm diameter heatshrink sleeving is slipped along the cable and over the other sleeves, and heated in turn to shrink it in place as well (step 3).

Next, prepare the sensor's heatsink assembly by drilling two 3.5mm diameter holes on the centre line of the 50 x 25mm aluminium plate, 18mm apart. Both holes should be countersunk to accept countersink-head screws installed from underneath.

Next make the 30 x 10mm piece of 1mm aluminium into a clamp piece, by bending its central 8mm section into a half-round shape to fit snugly over the LM335Z's body. After this, drill 3.5mm holes in the flat ends of this clamp piece, 18mm apart again to match the holes in the larger plate.

You should then be able to assemble the probe with the LM335Z clamped to the top of the plate flat side down and



This inside view clearly shows how the mains wiring is installed and secured. Note the Nylon screws & nuts used to secure the IEC connector/ bracket assembly.

the screws tightened down using M3 nuts and star lockwashers (step 4).

Complete the sensor assembly by fitting the 3.5mm mono jack plug to the other end of the 2-core ribbon cable, connecting the red wire to the "tip" lug and the brown wire to the "sleeve" lug (step 5).

Initial checks

Before doing anything else, use your multimeter (set to a low ohms range) to check between the earth pin of the IEC connector and the Earth outlet of the GPO. You should get a reading of zero ohms here (this checks the integrity of the earth connection).

Having verified the earth connection, fit the 10A fuse to the fuseholder in the IEC socket. Note that this fuse should be a slow-blow type.

Note also that we strongly advise against connecting this unit to mains power without the lid in place, to eliminate the risk of electric shock.

Setting it up

This is mainly a matter of adjusting trimpot VR1 to produce the reference voltage level at test point TP1 that corresponds to the average temperature you want the Tempmaster to maintain. This can be done by trial and error once the project is finished and working but if you have a DMM it can also be done before the case is closed up (but before the IEC mains connector is connected to the power, of course).

If you want to do this, first plug the 12V DC cable from your plugpack or battery supply into CON1 at the righthand end of the box. Now connect the leads of your DMM (set to a low DC voltage range) to TP1 and TPG. Read the voltage, which should be somewhere between 2.75V and 2.92V. Now all you have to do is look up the voltage level for the temperature you want from Fig.1 and adjust VR1 until the DMM reading changes to this value. The enclosure can then be closed up again.

All that remains now is to mount the remote sensor inside the fridge or freezer cabinet, or inside the hothouse, fishtank or seed germinating cabinet, attaching the sensor's heatsink plate to the side of the cabinet using two short lengths of gaffer tape. Then you can run its ribbon cable outside, holding it down with further strips of gaffer tape so it will pass neatly under the rubber door seal when the door is closed.

If you mount the Tempmaster on the wall just behind the fridge/freezer or heater, the plug on the end of the ribbon cable can be plugged into CON2 on the righthand end of the enclosure to complete the job.

Connection Options For The Tempmaster

There are at least three different ways that the Tempmaster Mk.2 can be connected up to control the temperature of a fridge, freezer or heater set-up. Which one you use will depend on whether your fridge/freezer/heater operates from 240V AC or 12V DC and also whether you will be running it from the AC mains or from a battery supply.

The three main options are shown for your guidance in the diagram at right.

Option A

Option A shows the simplest arrangement, where a 240V fridge/freezer or heater is to be operated directly from the 240V AC mains supply. The 12V DC needed by the Tempmaster itself can be supplied either by a small plugpack DC supply or from a 12V SLA battery which is kept "topped up" by a suitable charger.

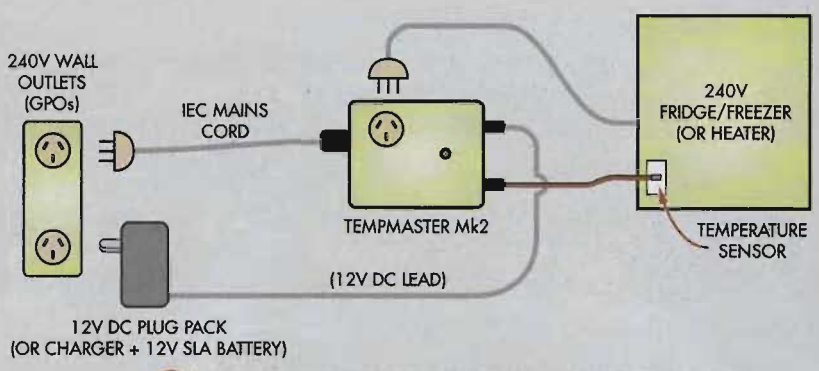
Option B

The next option (B) shows how a 240V fridge/freezer or heater can be connected to a 12V/240V power inverter, in a home or building which relies on solar panels or wind-generated power. As you can see, the Tempmaster itself can be powered from the main battery, along with the power inverter used to operate the fridge/freezer/heater.

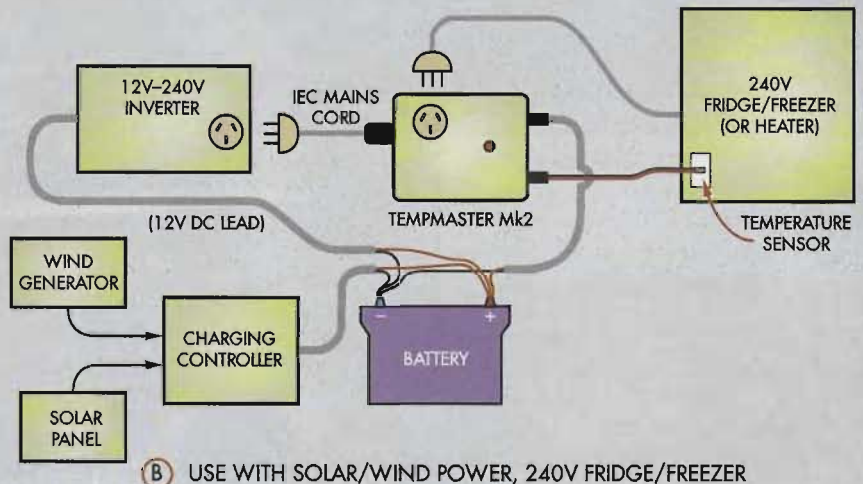
Because there is no current whatsoever drawn from the Tempmaster's IEC mains input socket when the Tempmaster has switched off the power to the fridge/freezer/heater, the inverter should drop back to "sleep" mode at these times.

Option C

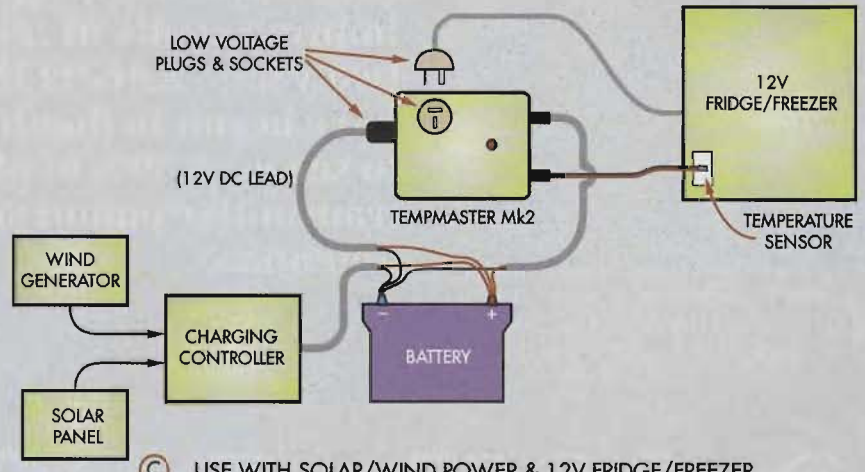
Option (C) shows how to connect things up when the Tempmaster is to be used with a 12V fridge/freezer and a solar power system. Here the configuration is quite straightforward **but you MUST replace both of the Tempmaster's "mains" connectors with suitable low-voltage plugs and sockets – to make sure that they can't be accidentally connected to 240V.**



(A) USE WITH 240V FRIDGE/FREEZER, MAINS POWER



(B) USE WITH SOLAR/WIND POWER, 240V FRIDGE/FREEZER

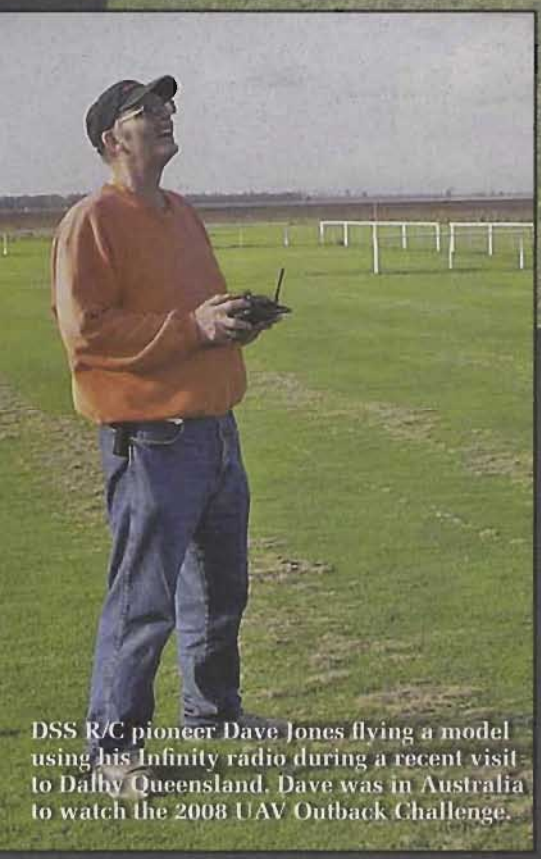


(C) USE WITH SOLAR/WIND POWER & 12V FRIDGE/FREEZER

Now you can unplug the power cord of the fridge/freezer/heating cabinet from its original GPO and plug it instead into the GPO on the top of the Tempmaster. Then when you connect the Tempmaster's own IEC mains connector to the original GPO via a suitable IEC mains cable, the complete system will begin working.

If you want to make sure that the thermostat is holding the fridge/freezer/heater to the temperature you want, this can be done quite easily using a thermometer placed inside the cabinet for a while. You can see when the Tempmaster is switching power to the compressor or heater simply by watching LED1.

If you need to adjust the average temperature up or down, this is done quite easily by adjusting trimpot VR1 using a small screwdriver, through the small central hole in the righthand end of the enclosure. **SC**



DSS R/C pioneer Dave Jones flying a model using his Infinity radio during a recent visit to Dalby Queensland. Dave was in Australia to watch the 2008 UAV Outback Challenge.

There is a revolution sweeping across the R/C model scene which will bring great improvements in reliability. In a little over two years, 2.4GHz DSS radio control systems have begun to dominate. It is now common to see over 50% of all transmitters in the transmitter pound sporting those little black antennas.

By BOB YOUNG

2.4GHz DSS radio control systems



This Silvertone Flamingo UAV has a 4-metre wingspan, can fly at 95 knots and is fitted with 2.4GHz DSS system.

DSS STANDS FOR "Digital Spread Spectrum", a highly robust radio system that was initially confined to exotic defence communications. Spread spectrum was primarily used by the military in the 1940s and 1950s for communication systems to send and receive secure data. It has only been since about 1985 that it's been available for use by the general public. Now it has come to radio control for model aircraft and it is revolutionising the scene.

The idea for spread spectrum communications originally came from the film actress Hedy Lamarr who conceived and patented a frequency hopping system using something akin to piano rolls. The technology originally could not support this system and the idea lay dormant for many years but was eventually picked up and developed into the modern spread spectrum system.

You can read more about Hedy Lamarr's patent and a lot of other interesting information at **http://www.inventions.org/culture/female/lamarr.html**

As near as I can ascertain, the pioneer of spread spectrum R/C systems was Dave Jones of AUAV, based in Florida, USA. In 2000, Dave began experimenting with Digital Spread Spectrum R/C systems for use in his UAVs (Unmanned Aerial Vehicles). He chose Digital Spread Spectrum (DSS) for its tight security and outstanding ability to reject intentional or unintentional radio frequency interference.

Dave Jones was looking to conduct a flight of a 3-metre UAV to an altitude of 30,000 feet. As you can imagine, one of the biggest concerns was how to ensure rock solid, reliable control of the aircraft. They had planned to conduct most of the flight under autonomous control but still wanted to have the ability to take over manually or make changes in the flight profile should the need arise.

The main concern was that while the aircraft was at those extreme altitudes it could be subject to higher levels of natural or man-made radio frequency interference. Without some form of protection, it would be very easy to lose control of the aircraft, with devastating results.

A likely scenario was that a 72MHz hobby R/C transmitter (72MHz being the legal R/C aircraft band in the USA) could be transmitting on the same frequency in the same locality as the UAV. This could have serious consequences if the autopilot activation switch was turned off due to interference.

AUAV's first approach was a Dual Redundancy R/C system with one link on 900MHz and one on 2.4GHz, with auto transfer from one to the other, if interference or failure occurred on one link. However, after much research, AUAV finally decided to use Digital Spread Spectrum and started developing the forerunner of the DSS R/C systems now being produced and sold to hobbyists the world over.

During the testing phase, a solid-state A/B switching system was used to transfer control of the test aircraft from the experimental DSS system over to a standard 72MHz system; a very sound approach from a safety aspect.

Following AUAV's early success, other manufacturers looked at DSS R/C systems with great interest. Thus 2.4GHz DSS was soon picked up by Spectrum (JR) and others, with low range, lightweight park flyers. After a very successful and relatively short period of introduction, the manufacturers began to produce sets aimed at small R/C sport models and then gradually the size restrictions fell away as manufacturers and R/C modellers alike began to have greater confidence in this new technology.

In fact, in November 2008, the author test flew the new Silvertone Mk.2 Flamingo UAV, using a commercial 2.4GHz direct-sequence DSS R/C system.

One of the really nice features of operating on 2.4GHz is that all of the annoying old bugbears such as servo electrical noise, long lead problems and electric motor interference, etc have all been minimised or completely eliminated. This is by virtue of the fact that the 2.4GHz frequency is far above the noise frequencies and the elaborate encoding/decoding simply obliterates whatever does get through. Hence R/C operation has become virtually problem-free.

How DSS works

Direct sequence spread spectrum, also known as "direct sequence code

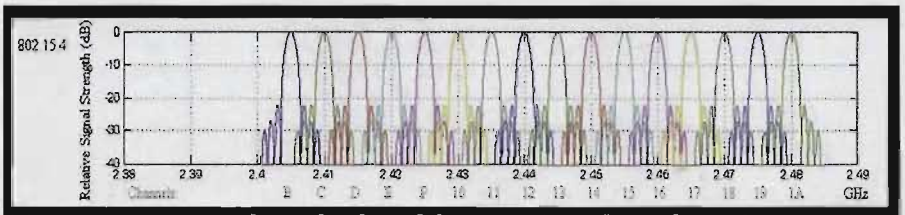
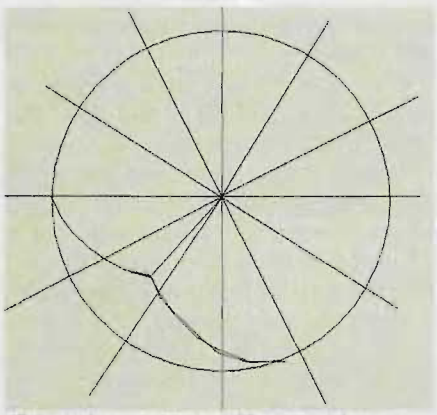


Fig.1: a spectrum analyser display of the 16 2.4GHz channels used in America. The Australian band allocation is a little different.

division multiple access" (DS-CDMA) or DSSS, is the basis for CDMA cellphones and 802.11 wireless transmissions. It multiplies the data bits by a very fast pseudo-random bit pattern (PN sequence) that "spreads" the data into a large coded stream that takes the full bandwidth of the channel.

DSSS is one of two approaches to spread spectrum modulation for digital signal transmission over the airwaves. A data signal at the point of transmission is combined with a higher data-rate bit sequence (also known as a chipping code) that divides the data according to a spreading ratio. The redundant chipping code helps the signal resist interference and also enables the original data to be recovered if data bits are damaged during transmission.

Direct sequence contrasts with the other spread spectrum process, known as frequency hopping spread spectrum or frequency hopping code division multiple access (FH-CDMA), in which a broad slice of the bandwidth spectrum is divided into many possible broadcast frequencies. In general, frequency-hopping devices use less power and are cheaper but the performance of DS-CDMA systems is usually better and more reliable.



This polar response diagram shows two complete orbits of the model – an ideal pass with a perfectly circular response and a slightly heart-shaped response indicating some form of receiver antenna shading in the model.

Frequency Hopping Spread Spectrum (FHSS) continuously changes the centre frequency of a conventional carrier several times per second according to a pseudo-random set of channels, while chirp spread spectrum changes the carrier frequency. Because a fixed frequency is not used, illegal monitoring of spread spectrum signals is extremely difficult, if not impossible, depending on the particular method.

Essentially, spread spectrum is a system in which the data is transmitted across a wide portion of the band or transmitted on a range of frequencies so that interference on one or more frequencies will not degrade the overall system performance to any great extent. This method can be used to make transmissions more secure, reduce interference and improve bandwidth sharing.

DSS systems used in the R/C industry can be divided into two categories: Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS).

R/C modellers are allowed to use a portion of the 2.4GHz band known as the ISM band (Industrial, Scientific and Medical), along with a myriad of other applications such as WiFi, video transmitters and portable telephones. The allocated ISM band may be divided up arbitrarily by each manufacturer in order to suit their own purposes and it is this fact that makes describing the typical DSS system so difficult.

Advantages of FHSS

There are five main advantages of FHSS:

(1) 2.4GHz band: this frequency is 68 times higher than the 36MHz radios currently used to fly model aircraft in Australia. This in turn allows the use of much smaller antennas on the receiver and higher gain antennas on the transmitter. The high frequency insures that we will not have interference from a 36MHz model radio control transmitter that may be near or on the flying site.

(2) Frequency Hopping: the transmitter and receiver are constantly changing channels by a predetermined pseudo-random sequence, through up to 75 channels to avoid interference from natural or man-made radio frequency interference. For example, if channel 12 has interference on it, the system would only be on that channel for such a short time that the pilot would not even notice a glitch of the controls.

(3) Unique Spread Code: if a second FHSS transmitter is transmitting on the same 2.4GHz band and even using the exact same set of frequencies, the spread code (hopping sequence) would have to be identical as well as time sequence matched to the first system in order to cause interference.

(4) Unique Addressing: each DSS transmitter and receiver pair use unique addressing that is assigned to only that transmitter and any receiver that is bound to it.

(5) Digital Data Format: the control data that is sent over this type of system is true digital data and is for all practical purposes immune to outside interference (in the manner that we use this system). Even if a second FHSS transmitter was transmitting on the same 2.4GHz band with the same hopping sequence, the servo decoder board would still have to receive the exact same digital data in the correct format before any of the servos would move.

Provided the hopping speed is relatively high, the FHSS system offers a very high level of protection and has proven quite successful out on the model fields.

Direct Sequence Spread Spectrum

Depending on the manufacturer's specifications, DSSS divides the allocated 2.4GHz band into a number of discrete channels. It then selects one of these discrete channels and spreads the data across that individual channel. This channel selection may be a fixed selection set by the manufacturer or a dynamic selection after a band search, depending upon the design of the system.

The Zigbee 2.4GHz RF module used in Dave Jones' Infinity radio uses 12 channels. Each channel is identified with its own unique ID number. Each of the direct sequence channels has 65,534 unique network addresses

available called the Personal Area Network (PAN ID or chipping code), represented in hex code as 0000 - FFFF. Address FFFF is set aside as a unique address for use during the binding process. This address will never be used in a system for flying – it is only used for the binding process.

In the binding process, it is necessary to set the transmitter and receiver to a common RF channel and a common set of codes. These codes consist of the channel ID number, PAN Address Number, Receiver Destination Address, Transmitter Source Address and the Transmitter's Serial Number.

This makes it possible for an unmatched Tx/Rx pair to communicate during the binding process. This process sets both the transmitter and the receiver to a particular RF channel, PAN address and pre-determined destination and source addresses. It also sets the receiver to the transmitter's serial number to get them comminicating.

After communication is established on the set-up channel, the transmitter then transmits to the receiver its own configuration codes that are factory preset. From this point on the Tx/Rx pair are bound via a unique set of codes and will no longer accept data from any other source.

As an illustration of just how secure this system is, let's say that there are12 RF channels that we can use and that each of the four addresses is 16-bit. A 16-bit number can be represented as 0000-FFFF in hex or 0-65,535 in decimal. If we set aside one address from each of the four address blocks for binding, as stated earlier in this article, then we have four unique addresses that will range from 0000-FFFE in hex or 0-65,534 decimal. From here we can do the maths and determine just how many unique combinations of address and RF channels we can have, ie:

RF Channel x PAN x Destination Address x Source Address x Tx Serial Number = 12 x 65,534 x 65,534 x 65,534 x 65,534 = 221,333,908,523,675,812,032.

In operation, the receiver is constantly looking for data assigned only to its destination address. To be valid, this data must contain the PAN ID, the Destination Address the Source Address and the correct Serial Number of the transmitter that the receiver has been bound to. Thus, it is immediately obvious that this is a very secure system indeed.



This view shows the Xtreme Link receiver installed in an autopilot housing. Note the tidy lead arrangement.



The Silvertone autopilot unit with the Xtreme Link receiver.

However, that is not the full story. The magical aspect of DSSS is that when noise is received by the receiver along with the transmitted data, it gets compressed out of existence when the data is decoded and recovered. Because the noise is in real time and the data is expanded across the spectrum, when the data is compressed back to normal the noise simply disappears. Thus, a DSSS system can pull signal out from below the noise floor. It is here that the DSSS system outshines the FHSS system.

Operating 2.4GHz R/C systems

While 2.4GHz DSS R/C systems are great, they do have some new problems and pitfalls. The very high operating frequency has the most far-reaching ramifications. At this frequency, any metal object close to the 26.1mm long antenna can be a hazard. Any relatively large mass of metal or carbon fibre will act as a shield, reflector, director or absorbing element at these frequencies. Even the paint used on the model can function as an antenna shield and so some receivers allow the antenna to be mounted outside the fuselage of the model.

Some manufacturers of R/C equipment also combat this problem with dual-diversity reception, as is now common in WiFi equipment. A diversity set-up allows antennas to be positioned at various locations around the fuselage (providing space diversity) and at different polarisation orientations. In this way, at least one



The Futaba 9C transmitter with the Xtreme Link 2.4GHz DSSS module in place of the 36MHz module. Note the small rubber duck antenna.

receiver can clearly decode data from the transmitter at any time. If using a non-diversity set-up (ie, single receiver), the placement of any conductive objects around the antenna becomes far more critical.

The author recently came across a photo of a 2.4GHz DSS dual diversity installation with figures quoted for the "circular walk-around" (polar diagram) that were very poor. They varied from 86 metres on the lefthand side of the model to 140 metres on the right handside, top 118 metres and bottom 137 metres, giving an overall range variation of up to 61% worst case.

A glance at the installation immediately showed why the results were so poor. The installation featured long metal pushrods passing over the receiver, a badly placed switch harness with long unsecured leads and an antenna coax that ran in parallel to the servo and battery leads.

To cap it all off, the receiver was stuck to the floor of the model with double-sided sticky tape! In a power model, this is one way that's certain to destroy your receiver. Engine vibration is a killer and even surface-mount components will eventually succumb if the vibration level is high enough.

Other measures

2.4GHz signals are also seriously affected by water in all of its forms so be aware that conditions on flying fields will vary from day to day and hour by hour. Wet trees will kill the signal, so do not fly behind trees even for a brief instant.

When installing the receiver in the model keep any metal, carbon fibre or water at least 50mm away from the receiver antenna. Water ballast tanks in gliders, for example, would pose a real threat if near the receiver's antenna.

Any aileron or flap leads dropping into the aircraft's radio compartment present a particular problem, so take special care that any such leads do not move close to the antenna during flight. All leads must be kept well away from the receiver's antenna but the aileron and flap leads on high-wing models pose a particular threat. These are difficult to secure in such a way that the leads remain in place while fitting or removing the wing. Thus, they can move close to the receiver's antenna when securing the wing onto the model and this can go unnoticed.

While on the issue of metal near 2.4GHz antennas, the author also removes the carrying handle from the transmitter as well as the original 36MHz telescopic antenna. The Assan manual, for example, states that it is not necessary to remove the 36MHz antenna but it is a little contradictory to state that metal should not be placed near the receiver's antenna whilst completely ignoring large masses of metal near the transmitter's antenna. In contrast, Extreme Link does recommend removing the 36MHz transmitter antenna.

The rest of the installation follows normal model aircraft procedure but it is recommended that all leads be lashed down to the receiver case with a cable tie or insulation tape to prevent any leads straying close to the receiver's antenna.

Range testing

Once installation is complete, it is time for a range test with the transmitter antenna completely removed.

In keeping with all radio receivers, the higher the receiver antenna is off the ground, the greater the range that will be achieved. Thus, it is important that the receiver's antenna should be set at a constant height from the ground during all range tests. Placing the model on a table, for example, delivers good range and also more repeatability in range testing from week to week as it isolates the antenna from ground moisture that will vary with weather conditions. With the Assan receiver in a small 1.5m high wing model sitting on the ground, a ground range of approximately 60-75 paces is typical.

Then comes the most important test of all – a "circular walk-around" the model. This test is to verify that there are no weak spots in the radiation pattern of the system and in particular, that there are no metal masses blocking the signal path inside the model.

First, place the model on the ground or table and with the transmitter on (in low-power mode, if available) and with the transmitter's antenna removed, walk to the nose of the model. That done, face the model with the transmitter held at waist height and the antenna stub pointing towards the model.

Now walk backwards from the model while operating the controls. Continue to walk out from the model until the servos start to move in a jerky manner, indicating a loss of data packets due to a weak signal. Move in towards the model until solid control is resumed and note the distance.

Now walk around the model in a circle with the antenna stub always pointing towards the model and at the same distance from the model. Note any weak points in the circle where it is necessary to move closer in to maintain solid control. Ideally, you should get a perfectly circular polar pattern.

If the pass is not circular, then rearrange the receiver installation, paying particular attention to the points listed above. Continue to retest until a circular pattern is obtained.

Considering the very low output power of the average 2.4GHz DSS system, the range obtained is excellent. For example, when range testing the Assan system with the transmitter antenna fitted, range was measured at 1.3km on the ground at Waikerie (in South Australia) with the receiver on a small cardboard box 300mm high and fitted with a 6V battery pack. It was not possible to take the transmitter out further due to limitations imposed by the terrain, so range was not tested beyond this point. The green valid data LED was solid green at this range, indicating good signal lock.

Battery packs

Even when operating 36MHz sets,

battery packs are the main source of failures. With 2.4GHz DSS systems, battery packs are even more important.

In the early days, DSS systems suffered badly from voltage fold-back due to the cut-off voltage on the front end being set too high by the manufacturers. This has largely been overcome by dropping the voltage cut-off point down to 2.8V or thereabouts. However even now there are still mysteries surrounding the voltage supply to DSS receivers.

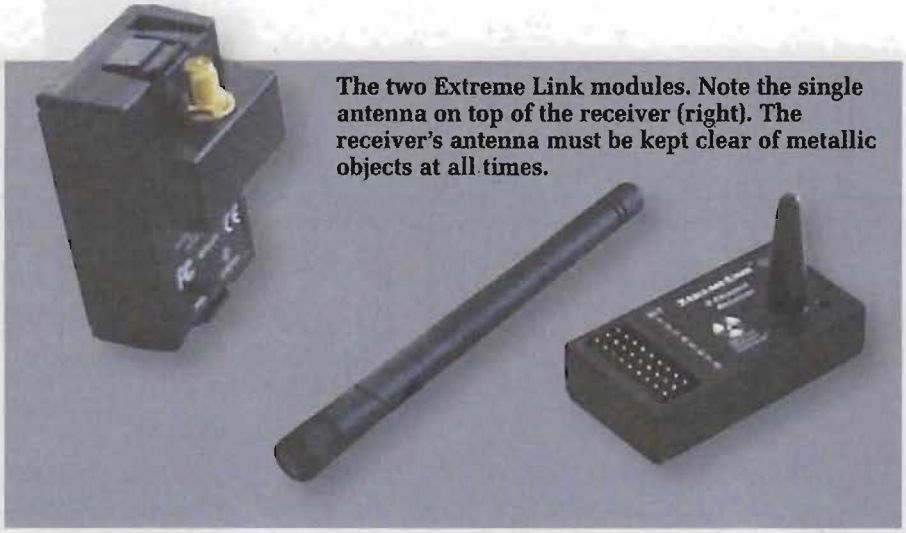
Tests were conducted on an Assan link receiver using a variable voltage power supply with adjustable current limiting. This receiver is interesting in that the manufacturer provides a large electrolytic capacitor fitted with a servo plug and it is recommended that this capacitor be plugged into a spare channel on the receiver.

In a series of tests, seven servos of various types, including one digital, were fitted to an Assan X8R receiver. Servo channel eight was kept clear for the electrolytic capacitor. This was not fitted for the first test. With the servos cycling on at least four channels constantly, the supply voltage was dropped gradually until the receiver stopped working at 2.4V.

The test was then repeated leaving the voltage set at 5V while the current limit was gradually reduced to simulate a battery that could not supply the necessary current. While there was no apparent (or noticeable) variation in the voltmeter, the servos started to slow down and behave erratically. The current limit was then further reduced until the receiver lost lock and the LED started flashing red/green. This test was then repeated but this time with the capacitor fitted to channel 8. This time the receiver did not lose lock even though some of the servos stopped working. The effect of the capacitor was very beneficial in stopping receiver lock out.

The above tests indicate that the internal impedance of the battery is an important factor in receiver operation and a series of antenna-off range checks were carried out with the same receiver to verify this observation.

The range was found to faithfully track the battery capacity, with the higher capacity battery packs delivering a better result. In other words, performance is more in line with battery capacity than battery voltage.



The two Extreme Link modules. Note the single antenna on top of the receiver (right). The receiver's antenna must be kept clear of metallic objects at all times.



The east-west static display line at the Dalby "fly in" (Queensland).

Considering that the Assan receiver works down to 2.7V, it is better to use a larger capacity 4.8V battery than a smaller 6V battery.

Flying experience

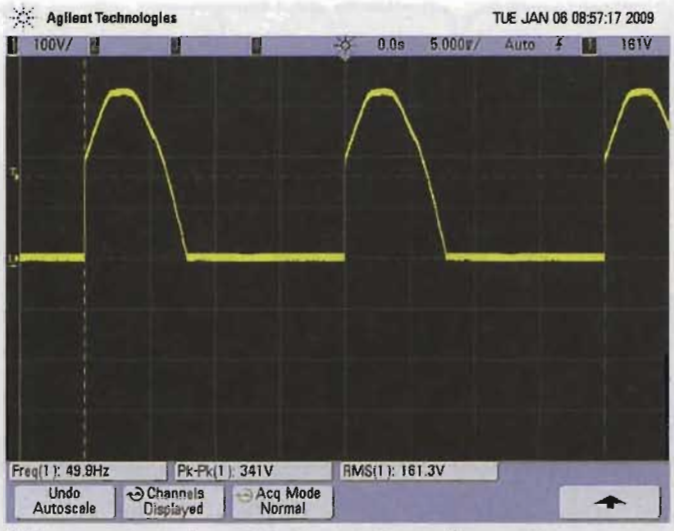
Non-diversity systems have been flown extensively in several locations in the USA, NSW and, on several occasions, in Dalby, Queensland. One system was also tested in Waikerie, South Australia. During these tests, the systems behaved flawlessly with absolutely no adverse events of any kind.

The Dalby tests included two days of flying with a very large gathering of models at the official opening of the new Dalby Club field. Aerial off range tests were carried out throughout the day with up to seven 2.4GHz systems operating at the same time. No reductions in range, glitching or interference were noted. Flights with many 2.4GHz systems of various brands operating simultaneously were again free of any interference, glitching or any untoward event.

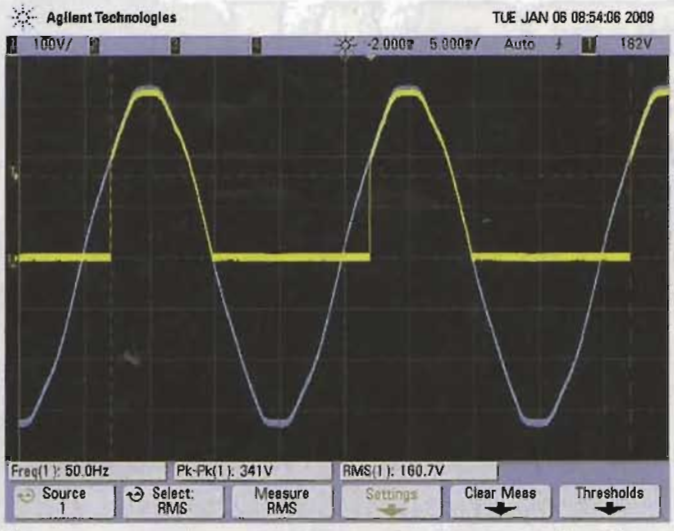
Never at any time has a single non-diversity receiver – whether Assan, Xtreme or Infinity – ever shown any tendency to glitch or behave erratically when fitted into five different models, on many busy club and display days.

From the tests, it is clear that the causes of many of the failures of 2.4GHz systems of all brands revolve around receiver installation, antenna shading and battery problems. I can only say that I am most impressed with the DSS system and look forward to some very interesting times in the future with who knows what equipment.

Acknowledgement: my thanks to Dave Jones for his invaluable input in explaining DSSS systems. SC



This waveform shows the Speed Controller set for maximum output when driving a 1kW resistive load. Note that the waveform is essentially a half-wave rectified sinewave with an RMS value of 161V (70% of 230V) and a peak value of 341V.



The same waveform superimposed on the 230VAC 50Hz input (blue). Notice that there is a small voltage loss across the Triac. The "flat-topping of both waveforms is due to fluorescent and gas discharge lamps and switchmode power supplies.

such as that shown in Fig.1.

It is based around an SCR (Silicon Controller Rectifier). When conducting, an SCR is just like a diode; current can flow in one direction but not the other. The difference between an SCR and a diode is that the SCR will block current in both directions unless driven into conduction with a gate signal.

Once it starts conducting, current will flow from anode (A) to cathode (K) and it will stay conducting until the load current drops to zero. The circuit must be used with AC voltage or half-wave pulsed DC for the SCR to be switched off. If the gate is triggered then the SCR will again conduct on the next voltage cycle. Without the gate triggered the SCR will remain off.

Because the SCR is a switching device, it can be used as a very efficient power controller, carrying large amounts of current while itself dissipating relatively little power.

The circuit of Fig.1 controls the AC power to the motor by triggering the SCR into conduction at some point in each positive half-cycle of the 230VAC waveform. The SCR does not conduct at all during the negative AC half cycles.

If the SCR is turned on early in each AC half cycle, the power fed to the motor will be relatively high. Conversely, if the SCR is turned on late in each AC half cycle the power fed to the motor will be relatively low and hence the motor will run slowly.

The trigger voltage for the SCR comes from VR1, a 2kΩ potentiometer connected in series with a 10kΩ resistor and diode D1. The potentiometer is fed with half-wave rectified AC that is partly smoothed by the 4.7µF capacitor across it. The resulting ramp voltage from the wiper is fed to the gate of the SCR via diode D2.

Speed regulation

Now you might be thinking we should use a Triac. This is similar to an SCR except that it conducts for both positive and negative cycles of the AC waveform. This would provide the full range in speed control.

In fact, we are using a Triac in our revised circuit but it still only provides conduction during one half cycle. The reason why we do not provide full-wave control (ie, conduction on both positive and negative half cycles) is that speed regulation would be lost.

The simple SCR circuit (and our revised version) gives speed regulation by monitoring the back-EMF from the motor. Back-EMF is the voltage developed by a motor that opposes the current through it. It is directly proportional to speed, so at high motor speeds the back- EMF will be higher.

This circuit monitors the back-EMF in the following way. One side of the motor is connected directly to the SCR's cathode while the other side is connected to the cathode of diode D1 and to the mains Neutral wire.

This means that the gate-to-cathode voltage applied to the SCR is the difference between the wiper voltage from VR1 and the back-EMF generated by the motor, if we

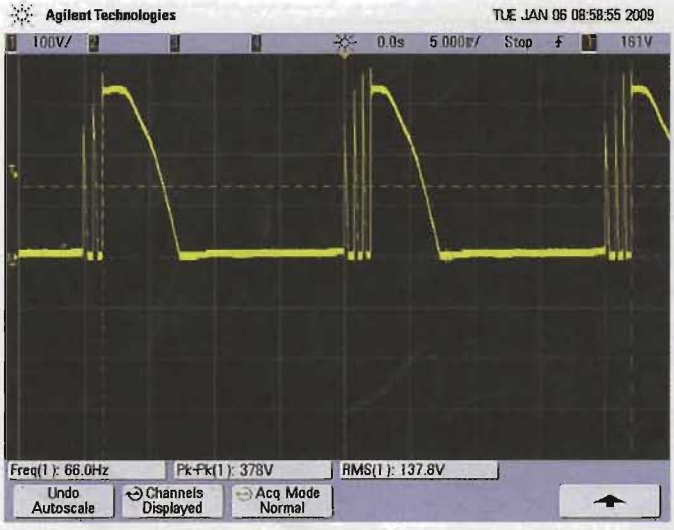
What motors can be controlled?

Virtually all mains operated power tools and small appliances use "universal" motors. These are "series wound" motors with a commutator and brushes. The "series wound" term refers to the fact that the motor armature and field windings are connected in series and this allows the motor to be run from AC or DC, hence the term "universal".

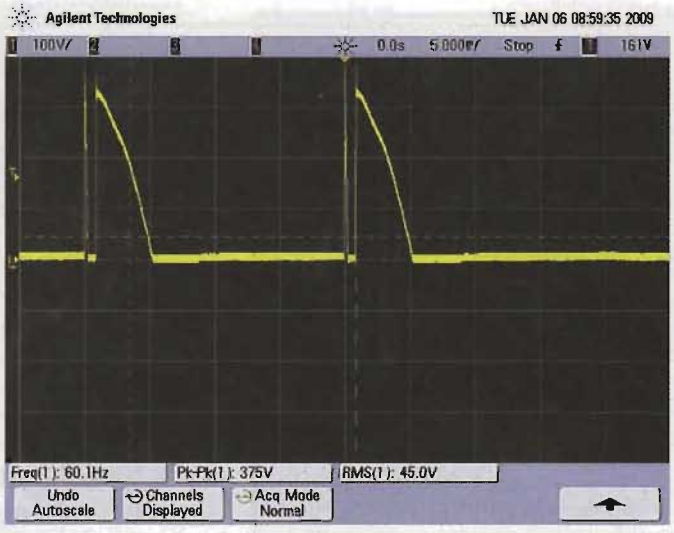
Induction motors must not be used with this speed controller. So how do you make sure that your appliance is a universal motor and not an induction motor?

In many power tools you can easily determine that the motor has brushes and a commutator – you can see sparks 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.

So how do you identify an induction motor? Most induction motors used in domestic appliances (eg, washing machines, fridges, water blasters, swimming pool pumps) will be 2-pole or 4-pole and always operate at a fixed speed. Typically this is 2850 RPM for a 2-pole unit or 1440 RPM for a 4-pole unit. Bench grinders typically use 2-pole induction motors.



This waveform shows the Speed Controller set for maximum output when driving an electric drill. Notice that there is considerable hash at the beginning of each positive half-cycle, caused by interaction between the drill's commutator and the Triac.



Now set for a lower speed from the electric drill, the Triac is on for a shorter time and the RMS value of the waveform is considerably reduced to 45V. Note the frequency error which is caused by hash on the waveform and the fact that the Triac triggering is more erratic.

ignore the voltage drop across diode D2.

Actually, in so-called universal motors (AC/DC series motors with commutators and brushes), there are two back-EMFs.

The first is a function of motor speed and the remanent magnetism of the field coils. It is generated during the time when the SCR is not conducting, ie, during the negative half cycles of the AC waveform and during the first portion of the positive half cycles before the SCR conducts.

The second back-EMF is generated during the time when the SCR is conducting and there will now be current flowing in the field coils (and also in the armature). This back-EMF will be higher than the first.

We are only concerned with the back-EMF generated while the SCR is not conducting since it is this voltage which determines how late or early in each positive half cycle that the SCR begins conduction.

In our circuit, the back-EMF from the motor applies negative feedback to the gate of the SCR. Say a particular motor speed is set by VR1and then the motor speed tends to drop because of an increase in loading.

This reduces the motor back-EMF and therefore increases the voltage at the gate the SCR. More correctly, it means that the trigger voltage for the SCR gate will exceed the voltage at the SCR cathode earlier in the positive half-cycle and hence more power will be applied to the motor. This will tend to correct the drop in motor speed. Speed regulation is not perfect but it's better than having no speed regulation at all.

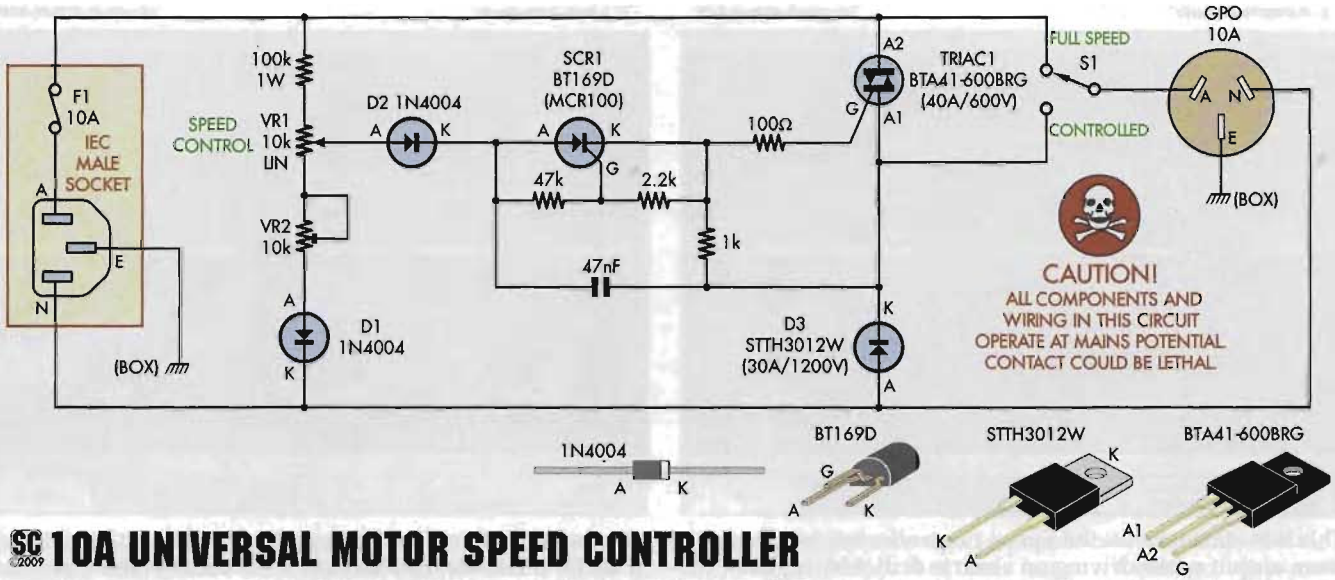
Better circuit

The basic circuit of Fig.1 has a number of drawbacks. First, the total power dissipation through the 10kΩ resistor is about 2W which means that it gets rather hot. Second, even though the current through the 10kΩ resistor and VR1 is relatively high, it is not sufficient for reliable triggering of higher power SCRs. And third, the circuit is not particularly good at very low speed settings.

A much better circuit is shown in Fig.2 which was published in SILICON CHIP in September 1992. Instead of



End-shots of the Speed Controller case showing the fused IEC mains input connector (left), while the shot at right shows the output socket and the controlled/full speed switch. Case and lid drilling details are shown on page 48.



SC 2009 10A UNIVERSAL MOTOR SPEED CONTROLLER

Fig.3: here's our new Universal Motor Speed Controller which has good low-end speed performance and speed regulation but is based on components that are easy to obtain. As a bonus, its rating has doubled to a nameplate rating of 10A.

an SCR, it uses a Triac and instead of feeding the gate directly from VR1 we have used a trigger circuit consisting of a silicon bilateral switch (SBS1) and a 47nF capacitor.

As mentioned above, while the Triac is capable of conducting on both positive and negative half-cycles of the 230V AC 50Hz waveform, this circuit only enables it to trigger on positive half cycles, because of the rectifier action of diode Dl.

The SBS is a voltage break-over device and at voltages below its break-over point it is essentially open circuit but once the break-over voltage is reached, it conducts. The 47nF capacitor charges up from VR1 via diode D2 until it reaches the break-over voltage of about 8V.

At this point the SBS dumps the capacitor's charge into the Triac's gate to trigger it into conduction and the cycle repeats for the next positive half cycle of the mains AC waveform.

The energy stored in the capacitor is quite enough to trigger even insensitive Triacs; hence we were able to use a high power 40A device in this circuit. In this circuit, the motor back-EMF acts to reduce the charging voltage to the 47nF capacitor rather than reducing the SCR gate voltage as in Fig.1.

Although the circuit arrangement is a little different, the speed regulation is just as good as Fig.1. The circuit efficiency is improved as well, with only 200mW being dissipated in the 150kΩ resistor that feeds VR1. This resistor has a rating of 1W to ensure that it has an adequate voltage rating to withstand the full 230VAC.

The functions of the three diodes in the circuit need to be explained. Diode D1 is there to reduce the power dissipation of the series resistor string and to ensure half-wave operation of the circuit. D2 is there to protect the gate of the Triac when it is in the conducting state – terminal A1 can be above the potential of the gate.

Diode D3 has been included as a flyback diode to quench the large inductive spike generated by the motor at the end of each positive half cycle. While the voltage spike does not cause any damage to the circuit, it does have the effect of disrupting the back-EMF monitoring system described above. Trimpot VR2, connected in series with VR1, is there to provide a minimum speed setting for the circuit.

One question we have not answered so far is why we specified a high current Triac instead of an equivalently rated SCR. The reason is quite simple. The Triac is half the price of an equivalent SCR.

The 600V 40A rating is so that it can withstand the "locked rotor" current of any power tool with a nameplate rating of up to 10A. Note that a "locked rotor" condition – eg, when a drill or power saw jams or stalls in the work – will probably blow the 10A fuse but the 40A Triac should not be damaged.

Another reason for using the 600V 40A Triac is that it is an isolated tab device. This means that it can be attached directly to the metal case without any need for a mica washer or other means of insulation.

Revised circuit

The circuit of our new 10A Speed Controller is shown in Fig.3. As already mentioned, this is a revised version of the design we featured in the September & November 1992 issues and later in the October 2002 issue.

Our new circuit replaces the SBS with a sensitive-gate SCR (SCR1) and this provides the same capacitor dump function as the SBS. The SCR was chosen instead of the SBS because the SBS is now difficult to obtain.

The 47kΩ and 2.2kΩ resistors form a voltage divider between the anode and cathode of the SCR, with the divided voltage applied to the gate. The SCR conducts when the gate voltage reaches 0.6V and is triggered by a mere 200μA of gate current.

Because of the resistive divider, the voltage across SCR1 must rise to some 13.4V before the gate reaches the 0.6V sufficient to trigger the SCR. When the SCR fires, the charge on the 47nF capacitor is dumped, via the 100Ω resistor, into the gate of the Triac to fire it.

Switch S1 bypasses the Triac so that the motor gets the full 230V AC applied to it. Note that the switch must be a changeover type to select either Active or the Triac A1 output rather than just using a single switch across the Triac. In the latter case, there would be a short circuit when diode

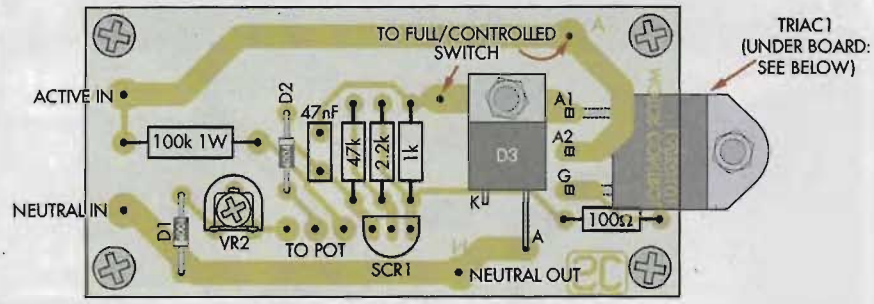


Fig.4 (top): the PC board component overlay. Note that the Triac mounts under the board, flat side down, with its legs bent up 90° through the board.

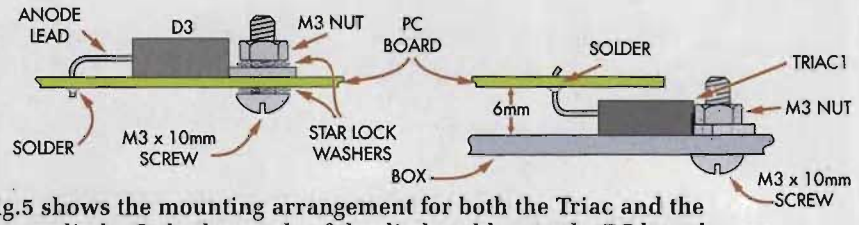


Fig.5 shows the mounting arrangement for both the Triac and the power diode. Only the anode of the diode solders to the PC board.

D3 conducts on negative half-cycles of the 240V AC mains.

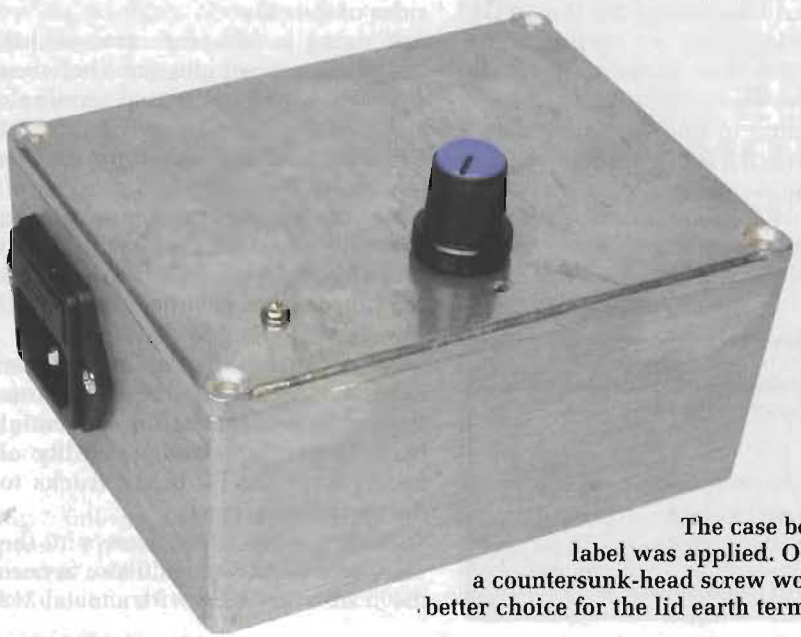
Construction

All the components of the 10A Speed Controller are mounted on a PC board coded 10102091 and measuring 79 x 38mm. It is housed in a diecast box measuring 120 x 92 x 57mm.

Begin the construction of the 10A Speed Controller by checking the PC board against the published pattern. There should not be any shorts or breaks between tracks. If there are, repair these as necessary. Use the overlay diagram of Fig.4 as a guide when assembling the PC board and Fig. 5 to complete the wiring inside the case.

Start assembly by soldering in the PC stakes to the external wiring connection points on the PC board (shown as black dots on the overlay). Then insert the resistors, using the table on P47 as a guide to the values. It's always a good idea to also check their values with a digital multimeter as some colour bands, particularly oranges, browns and reds, can sometimes be mistaken for each other. The 47nF capacitor can be installed next.

Neither the resistors nor capacitor are polarised but the diodes certainly are, so when inserting them, take care with their orientation. D1 and D2 mount in the conventional way but D3 is a larger (TO-220 case) type which is mounted quite differently.



The case before the label was applied. Obviously a countersunk-head screw would be a better choice for the lid earth termination.

Parts List - 10A Universal Motor Speed Controller

1 PC board coded 10102091, 79 x 38mm
1 diecast box, 115 x 90 x 57mm (Jaycar HB-5064 or equivalent)
1 panel label, 119 x 56mm
1 flush-mount mains socket (Jaycar PS-4090 or equivalent)
1 IEC male input socket with integral 10A M205 fast blow fuse
1 IEC mains lead (moulded 3-pin plug to IEC socket)
1 DPDT 10A 250V rocker switch (S1) (Jaycar SK-0981 or equivalent)
1 10kΩ linear 24mm potentiometer, 250VAC rated (VR1)
1 knob for potentiometer
2 crimp eyelets or solder lugs for earth connection
4 6mm Nylon spacers
2 M3 x 15mm screws
1 M3 x 10mm screw
1 M3 x 10mm csk head screw
8 M3 x 6mm screws
4 3mm star washers
3 M3 nuts
4 stick-on rubber feet
1 200mm length of blue 10A 250VAC wire
1 200mm length of brown 10A 250VAC wire
7 100mm long cable ties
1 120mm length of 5mm heatshrink tubing
1 40mm length of 8mm heatshrink tubing
7 PC stakes

Semiconductors
1 BTA41-600BRG Triac (TRIAC1)
1 BT169D or MCR100 sensitive gate SCR (SCR1)
2 1N4004 1A 400V diodes (D1,D2)
1 STTH1512D 15A 1200V diode (D3)

Capacitors
1 47nF 63V MKT polyester (code 473 or 47n)

Resistors (0.25W 1%)
1 100kΩ 1W 5% 1 47kΩ
1 2.2kΩ 1 1kΩ 1 100Ω
1 10kΩ horizontal 5mm trimpot (code 103) (VR2) (Jaycar RT-4360 or equivalent)

Only the anode (A) lead solders to the PC board; the cathode connection is made using the metal tab to physically connect to the PC board track using a screw, nut and star washer as shown in Fig.5. In fact, you should cut off the cathode (K) lead on the left of the package before mounting it.

Make sure you insert SCR1 into the PC board correctly, otherwise the circuit won't work. Note that in a kit you may be supplied with a BT169D or MCR100 – pinouts and mounting are the same. VR2 can also be installed at this stage.

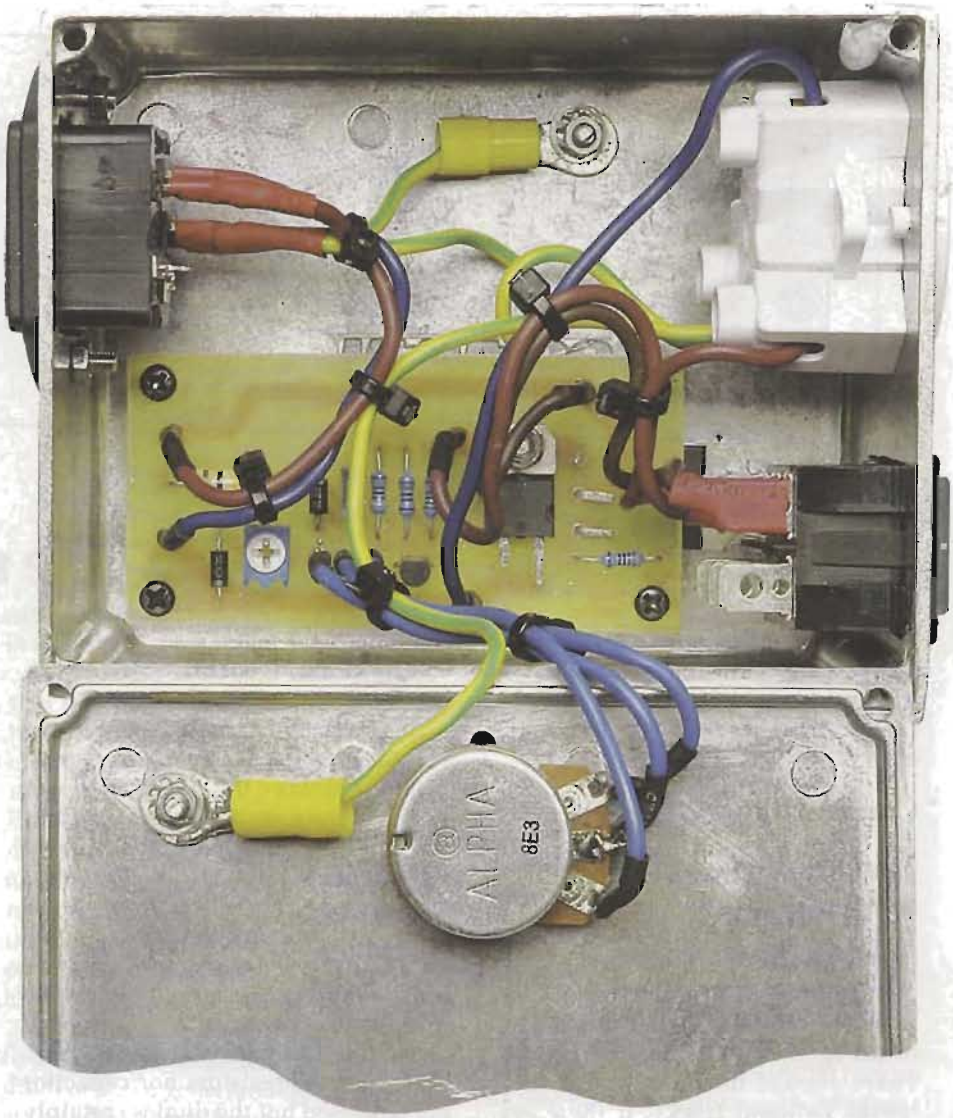
The Triac is mounted on the underside of the PC board with its leads protruding up through the holes in the PC board. Bend the leads up 90° so that the copper side of the PC board is 6mm away from the back of the Triac body, as shown in Fig.5. Short (~3mm) lengths of Triac leads should emerge from the top of the PC board. Bend these back down flat onto the PC board.

Putting it together

Temporarily place the PC board into the case and mark out the positions for the mounting holes for the four standoffs and for the Triac and the earth lug screw. Check these against Fig.8 – this diagram shows the hole positions for both the PC board and Triac.

Because the positioning of the Triac could easily be a couple of millimetres different to our prototype, it is probably best to mark and drill out the four corner holes for the PC board first. Then position the PC board within the box and mark out the hole position for the Triac. The hole for the Triac must be de-burred with a larger drill or countersinking bit before it is secured in place.

Fig.8 also shows the holes and locations for the fused IEC socket, mains output socket (GPO) and DPDT switch on the ends of the case and for the lid-mounted components. These must be cut out accurately to avoid any "slop" in these components. This is particularly important for the DPDT switch (S1), which is a snap-in type.



This photo matches the component overlay at right. Follow the photo and diagram exactly – especially the earth wiring, heatshrink tubing and cable ties. These are all very important for your safety.

Only one side, or pole, of switch S1 is used. This is simply because we were unable to find a suitably-rated SPDT switch. Don't be tempted to substitute a lower-rated switch for S1 because it has to be able to switch mains voltages at a high current.

All hole locations have been positioned so as to ensure adequate clearance between the wire connections and component terminals and to the sides of the case.

If using a different case, ensure you allow a 6mm clearance between any two Active or Neutral terminals and between the case and a PC board terminal and the case and switch terminals.

For the same reason, you should carefully check the solder (copper) side of the PC board to ensure that all component leads have been clipped off very close to their solder joins.

Attach the PC board to the case using Nylon standoffs and M3 x 15mm screws. **Nylon standoffs are essential here, to preclude the possibility of arcing from the PC board tracks to the mounting screws.**

Be sure to use metal screws for the Triac and earth connections. Secure the Triac to the case with a metal M3

RESISTOR COLOUR CODES

No.	Value	4-Band Code (1%)	5-Band Code (1%)
1	100kΩ	brown black yellow gold (5%)	
1	47kΩ	yellow violet orange brown	yellow violet black red brown
1	2.2kΩ	red red red brown	red red black brown brown
1	1kΩ	brown black red brown	brown black black brown brown
1	100Ω	brown black brown brown	brown black black black brown

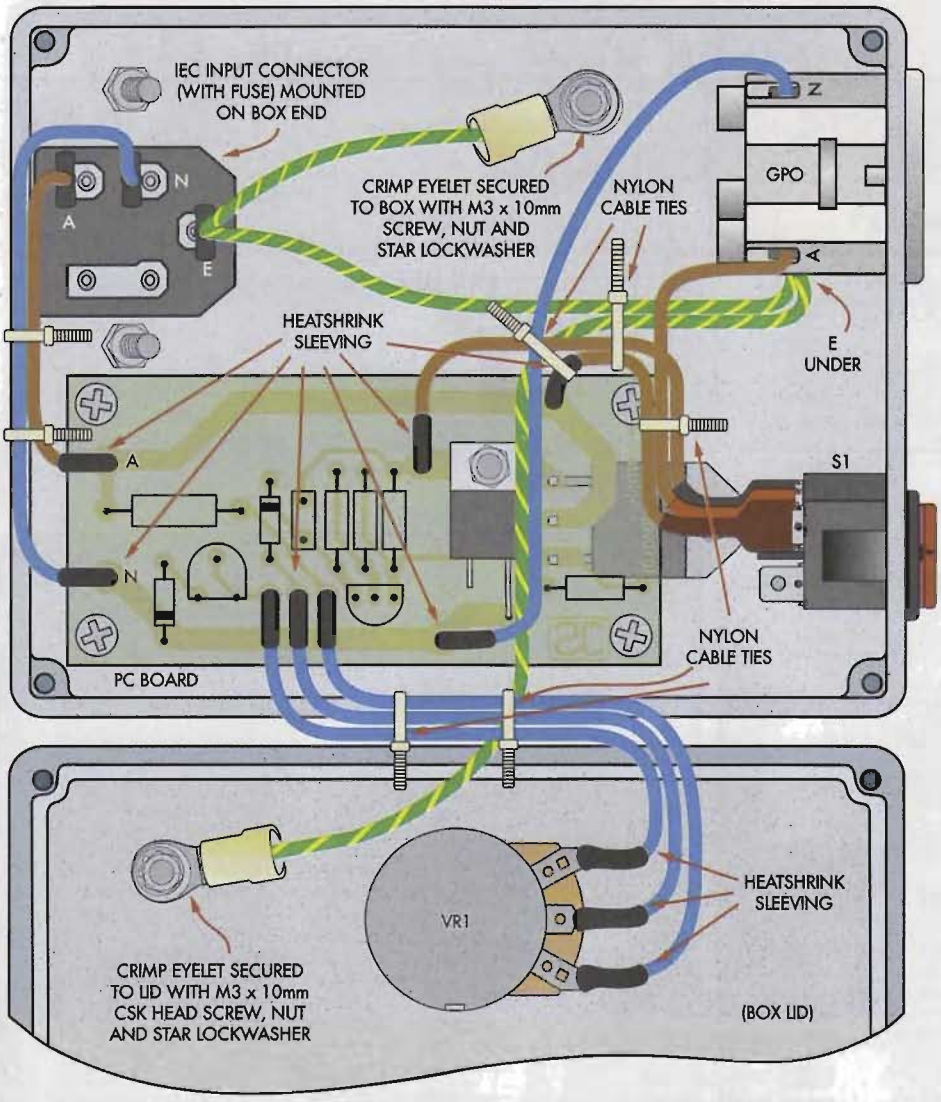


Fig.6: the wiring diagram shows all components in place. While the IEC socket is shown here "flat" for clarity, it is mounted vertically on the box end.

x 10mm screw and nut after applying a smear of heatsink compound on the mating surfaces. Note that the specified Triac is an insulated tab device and does not require an insulating washer.

If you are using a different Triac – **and we do *not* recommend that you do** – check that the metal tab is isolated from the A1, A2 and gate pins. In addition check the data sheet for that Triac to ensure it is an isolated tab device.

Using a photocopy of the front panel label as a guide to the positions, mark out and drill the front panel for the speed control pot (VR1) and earth screw. Note that it is important to drill the 3mm hole for the locking tab on the potentiometer to prevent it rotating inside the case should the pot nut work loose over time.

Attach the mains input (IEC) and output (GPO) sockets. Attach the front panel label and solder the wiring between the PC board and the pot, leaving enough length to enable the lid to "fold back" for convenience. **Wiring must be done using 10A, 250V AC-rated wire and heatshrink tubing should be used over all PC stake connections, the switch terminations and the IEC input socket.**

The earth connections are made using green/yellow mains wire. It is important to follow the diagram of Fig.6 and the photo alongside for your safety.

You will note that two wires connect to the earth terminal on both the IEC input socket and the output socket. From the IEC input socket, one goes directly to the metal case and the other to the earth terminal of the output socket. The second wire from the output socket goes to the case lid.

The earth wires which connect to the case and lid are crimped to eyelet lugs and are secured to the case using a metal screw, nut and star washer as shown in Fig.8.

Even though it is unlikely that any of the wiring can break off or move inside the closed box, tie the wires together with cable ties to prevent them breaking from their terminations.



Fig.7: full-size artwork for the front panel. A photocopy of this can also be used as a drilling template for VR1 – but don't forget the 3mm locating hole.

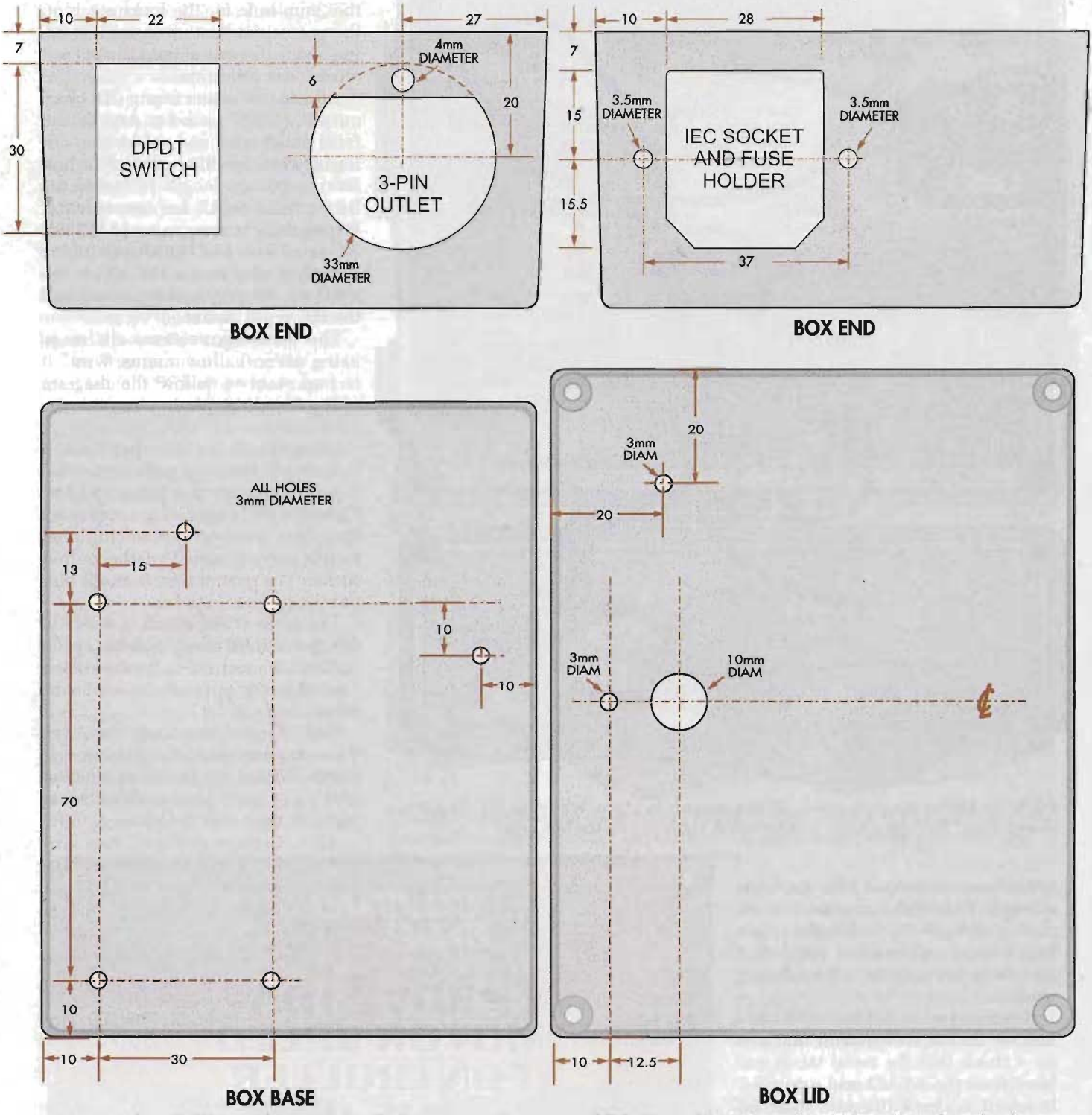


Fig.8: complete drilling and cutting details for the specified box and lid. These dimensions should be adhered to closely.

Finally, attach rubber feet to the base of the case.

Testing

Note that all of the circuit is connected to the 230V AC mains supply and is potentially lethal. **Do not touch any part of the circuit when it is plugged into a mains outlet. Always remove the plug from the mains before touching the circuit. In particular this applies to when making adjustments to trimpot VR2, which you may need to do to set the minimum speed.**

Screw the lid onto the case and plug in your favourite power tool. Switch to the "O" (controlled) position and note how it runs at the minimum setting of VR1. If it runs well (ie, no cogging) then VR2 could be set to make the motor run slower. **Disconnect the mains power first before making an adjustment to VR2** and then try the motor again when the lid has been replaced.

You may then want to try other power tools to get a compromise setting for the trimpot. SC

IMPORTANT: Do not operate the circuit with the lid off the case.

SERVICEMAN'S LOG

Oh Goody! A CRT Set To Fix

I used to get a steady stream of CRT TV sets into the workshop but that stream is now a mere trickle. Most people can not be bothered to get a CRT set fixed and, in fact, perfectly good sets are now being discarded in ever increasing numbers to make way for plasmas and LCDs.

Items Covered This Month

- Loewe Planus 4781ZW Q110 chassis
- Panasonic TH-42PA40A 106cm plasma TV set
- Resurrecting a Windows 3.11 computer
- The scams people try

A Loewe Planus 4781ZW TV was brought into the workshop. Oh goody, I thought, a heavy CRT set! At least there was a chance I might be able to fix it to component level.

This set employs a Q110 chassis and was reportedly DOA (dead on arrival). However, when I got it onto the workbench, it turned out that this rumour was somewhat exaggerated. As I quickly discovered, the set would click on and then click off again as a protection circuit cut in.

I began by checking the B+ rail and this was correct at +150V. However, there was no EHT and there were no short circuits on this rail. From there, it didn't take long to confirm that there was no horizontal drive coming from the signal board.

Before investigating this large assembly, I checked the remaining voltage rails. This was a good move because the 12V, 9V and 8V rails were all missing in action. I then checked FET Q663 BUZ71A (and changed it for good measure as these do give trouble) but it was F661, a 3.15A IC fuse that had failed.

I soldered in a new fuse and switched on. The set clicked, gave out an acrid smell and then immediately died. I should have known it wasn't going to be that easy.

Now before I had replaced the fuse, I had checked for shorts on the 12V rail (by measuring across C668) and everything had been OK. Now, however, it was measuring just 4Ω between this rail and ground, so there was a short somewhere in the works.

I unplugged the main signal board and found that the short immediately disappeared. I then removed and carefully examined this board but there were no shorts to be found so I replaced the fuse again. The supply rails now came up OK when the set was switched on with the main signal board still disconnected.

Next, I checked the main signal board for solder dags and bent pins but could find nothing that might be causing the intermittent short circuit. As a result, I reinstalled the board and checked it out again before switching on. Damn! – the short was back.

This time, I left the meter connected while I disassembled it yet again. It wasn't until I got to W1201, a 3-pin lead to the rotation coil on the CRT, that the short disappeared. Now I really had something to work on.

I closely inspected the coil and noticed that it had a small, sealed assembly in the middle. However, I could find no reference to this on the circuit diagram and eventually, feeling somewhat exasperated, I phoned Loewe technical support. It turned out that there are two versions of this set and guess what – my circuit was the wrong one for this set.

The good news was that this is a well-known fault and whatever it is inside the concealed lump, it does go short circuit, causing the fuse to blow. Fortunately, the set works quite well without this assembly connected (it is designed to straighten the picture to compensate for geomagnetic forces).

No milk or cookies

I'm writing this back in mid-December and the holiday season is almost upon us. And as usual, some customers are flying into a panic as to whether "it" will be fixed before Santa arrives.

Not only are we expected to have done our duty at half the usual price, no matter how late the call, but we don't even get milk and cookies, let alone a red coat and a team of reindeer.

My first such call was from an anxious mum, complaining that their beloved telly had been blown up by her 6-year old boy playing his X-Box. I really couldn't see how an X-Box could kill the TV without an awful lot of jiggery-pokery but hey, I'm just the TV technician. Prancer's stable boy would know more than I do!

Anyway, I asked what the brand and model number was, plus a definition of what was meant by "dead". She told me it was a Panasonic Viera and I was thinking LCD TV but it wasn't until I got the model number (TH-42PA40A) that I realised that it was a 2006 plasma set. She also insisted that she was right about the set being dead – there were no lights or LEDs coming on and yes, power was being fed to the set and it had been switched on.

The next hurdle involved getting her to take a few reality pills. The biggest and most painful to swallow was that it was unlikely to be fixed by Christmas. "But surely it is just the fuse?", came the reply.

This is always a hard one as it is difficult to explain that the prime



WE PROMISE OUR KIDS **SO** MUCH THESE DAYS & SOMETIMES IT REALLY DOESN'T HURT FOR THEM TO LEARN TO ACCEPT DISAPPOINTMENT!

function of a fuse is to fail in order to prevent all the smoke pouring out of the rest of the blown components.

Years ago, I worked for a TV rental company with a tyrannical boss who had a long hyphenated, unpronounceable foreign surname. So when things went wrong, as they inevitably did sometimes, we always used his name as the description for the parts that had failed – ie, they were badly put together and always blowing up. It was just luck that a customer never twigged and reported it back to the boss.

But I digress. As my caller was quickly getting impatient with me, I suggested she try calling Panasonic themselves. Good idea, she thought, and hung up. I was quite relieved but knew inside that this wasn't going to last. Sure enough, she was back within the hour, a little more contrite, so I agreed to call around and collect the set.

Now I should point out that although I used the word "I" here, I really meant "we". If it had been an LCD, it might have been just "I" but a 106cm plasma is too big and too heavy for just one bloke. You also need something a bit bigger than a Barina to stick it into.

When I arrived, it turned out that my customer was really quite charming but was being hassled by a mob of kids. However, they too were nowhere near as precocious as on first impressions. The little 6-year old was extremely proud of his X-Box and it was imperative that the set be fixed before Christmas so that he could make full use of it.

Eager to cooperate, he showed me what he was doing when the set died. However, this didn't really reveal much, the only possibility being that he might have caused the set's demise by repeatedly pushing the main power switch. In fact, this switch now felt as though it wasn't properly latching.

The set was wall-mounted in a slight recess with an expensive, highly-polished sideboard immediately in front of it. Not wanting to risk damage to such an expensive piece of furniture, I hijacked some pillows from the lounge and put them on the sideboard. I then unplugged the various leads, after which we were able to lift the plasma out and carefully lower it onto the pillows.

After that we had to negotiate a lot of stairs and a long path to the service van.

Being the softie that I am, I had reluctantly promised I would look at it as soon as possible. I could only sympathise with the mother – TV is a great "minder" and I would not want those kids on my back over Christmas without a TV to entertain them occasionally.

Back at the workshop, my first job was to create sufficient floor space for the job. Having done that, I carefully placed two milk crates covered with thick foam in position and then carefully laid the plasma face down on them so that the weight was only on the frame (not on the screen itself).

Next, I undid the compulsory 50 or so screws and removed the back. I then checked all the fuses but they were OK. The power switch was also OK – it is simply a momentary contact type and not a latching type as I had earlier assumed it to be.

As this stage, I applied power but the set was completely dead, just as the customer said it was. Power was going in but nothing was coming out of the power supply board (P TNPA3570 4).

As luck would have it, a colleague who works for a Panasonic agency was able to lend me a power supply that still had a buzzing noise problem he had been unable to economically solve. This would at least allow me to confirm whether or not it was the



Issues Getting Dog-Eared?

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power supply itself that was at fault.

As it turned out, the cause of the problem revealed itself when I removed the old board. Underneath, I found a large cockroach wedged onto the board where he had been electrocuted by the applied 240V from the mains. Not only that, but one of his antenna had been etched onto the board, creating a carbon track onto a small control signal track which in turn had melted.

The reason the fuses hadn't blown was that the series 1Ω 5W surge resistors (R411 & R413) had blown instead, while FET Q431 (2SK3265) had gone short circuit from source to drain. In addition, the fine control track ran to an unmarked surface-mounted transistor (Q440) which had gone open circuit.

From the good power supply board, I quickly deduced that Q440 was an NPN type. This was done using an analog multimeter (placing the black lead on the base and the red on either the emitter or collector gave a reading on the x1 ohms range).

Q440 was a 2SD1819A which I didn't have. As a result, I drilled holes through its PC board pads and mounted a BC547B general purpose transistor in its place.

Unfortunately, as these sets are only meant to be repaired to board level, none of these parts has even got a part number (or so I've been told). Worse still, there is no equivalent for a 2SK3265 and none of my suppliers have one. The good news is that Panasonic will be issuing a part number soon – probably B1DEG000001. The replacement board is about $400 trade but the final outcome on this set will have to wait until the Christmas break is over.

In view of this, I offered to deliver a loan set so that the 6-year old could use his X-Box during the Christmas period. However, his mother was juggling various commitments and I was unable to arrange a delivery time.

Still, it won't be the end of the earth for her son. We promise our kids so much these days and sometimes it really doesn't hurt for them to learn to accept disappointment!

Remember Windows 3.11

Remember MSDOS6.22 and Windows 3.11 for Workgroups? Not many of us really want to but this was the cutting edge of software in the early 90s (at least, for the PC), when a 66MHz 486DX2 with 4MB of RAM was the fast lane. At the time, small home PCs had only been in the existence for six or seven years and developments were coming thick and fast.



~REMEMBER MSDOS6.22 & WINDOWS 3.11 FOR WORKGROUPS?

I remember it all too well, especially configuring the system for maximum available conventional memory on boot up. This involved modifying and tweaking the *config.sys* and *autoexec.bat* files, either by hand or by using the DOS *memmaker.exe* utility. If you were left with more than 611KB of so-called conventional memory out of 640KB, you were doing well.

DOS was one thing and Windows 3.11 quite another. Now you also had *system.ini* and *win.ini* to tweak to get everything to work under Windows. You also had a swapfile – a defragmented area on the hard drive dedicated to short term memory for the exclusive use of Windows.

That was also back in the days before plug and play hardware. In those days, it was up to the system builder to avoid hardware conflicts by manually assigning IRQs and memory addresses to the various plug-in cards. Depending on the device, this was done using either on-board jumper links or (in later devices) by running a set-up utility from an accompanying floppy disk.

In short, it could be a nightmare and a generation of PC technicians tore their hair out trying to get recalcitrant hardware items to play nicely with each other. Some sound cards could be right proper so-and-so's to get going.

Well, I didn't really want to remember any of this until an old friend of mine from the country brought in his Pentium 90 computer. He used it specifically for his old DOS and Windows 3.11 games (which, for some reason or other, he was very fond of) but it was becoming more and more troublesome.

Foolishly, in the spirit of the season, I agreed to see what I could do to help. After all, it might be fun to go back in time and tangle with an old Windows 3.11 system.

When I switched his computer on, the first error message I got was that the CMOS battery was low and that the BIOS and clock needed resetting. In fact, it was so bad that it wouldn't even save any BIOS settings.

As luck would have it, the battery is embedded in a 24-pin lump of black plastic along with the computer's clock



THE SCAMS PEOPLE TRY

crystal (ie, a real-time clock, or RTC). This had to be solder-sucked off the multi-layer motherboard.

That done, I "googled" for a replacement part and the only supplier I could find was in the US who wanted US$20 for the part plus – get this! – $US50 to courier it to me. The whole computer wasn't worth that much. In the end, I persuaded them to post it via the US postal service to a friend of a friend who runs a large shipping service in the States. They ship engines, differentials and other heavy bits around the world and my package could ride along with one of their shipments to Australia.

Well, that was the plan bit it didn't quite work out. They are not used to handling small padded post bags and so, almost inevitably, it got lost and was eventually returned to the supplier. We repeated the exercise and this time it was successful. The part arrived and I wasted no time soldering it to the motherboard.

Unfortunately, somewhere along the line, probably when I unsoldered the original part, one of the tiny PC tracks had broken. As a result, the old-fashioned 5-pin DIN socket for the keyboard was no longer fully connected, thus preventing changes to the BIOS.

At this point, I was about to abandon the project when a friend offered to give me a similar old Pentium computer (in this case, a Pentium 200). He was about to chuck it out and I told him to chuck it in my direction which he was only too happy to do.

Of course, he couldn't let it go without having a bit of a dig at me. In short, he also told me that I was a masochist for wanting to fiddle with a Windows 3.11 system and said that I was a brave man.

Anyway, it was a relatively simple task to swap the hard drive, the CD ROM and all the internal cards over to this "new" computer. The drivers were already there on the hard disk – it was just a matter of fine tuning those four files I mentioned earlier.

Initially, everything went pretty well with no error messages and plenty of base RAM. All the DOS programs worked well and Norton Utilities v. 8.00 reported that everything was working correctly.

Windows 3.11 was also running well – almost! The problem was that sometimes there was sound and sometimes there wasn't. The sound card used an ESS688 chip set with the IRQ and memory addresses set by software at DOS level. The problem was that they were intermittently clashing with something else and causing an exception error.

I mucked around with these IRQs and memory addresses over and over again but couldn't find a combination that fixed the problem. I then managed to procure some more ESS sound cards but without the original installation floppy discs so I hunted down some drivers off the internet. The result was the same – sometimes there was sound and sometimes it was AWOL.

In the end I abandoned the project. My friend was right – I must be a masochist to want to go back and fool about with this stuff. Self-flagellation would be less painful.

In retrospect, I suspect that the sound card was probably conflicting with the video card. In fact, altering the video card settings may have been the way to go but I had already wasted enough time on this project.

The scams people try

You've really got to cover yourself in this business because, quite bluntly, some customers are less than honest. Personally, I've seen every scam in the book over the years.

Although not common, one such scam involves customers who have two identical TV sets, usually purchased at the same time. They both break down and one is brought in for service. Then, when that set is subsequently returned, they immediately bring the other one in – often with a completely different fault – and claim that the first one wasn't fixed properly.

Unfortunately for the customer, we're not that gullible. We carefully record both the chassis number and serial number of every set we service, along with the details of any work done, so we can spot a "ring-in" a kilometre away. A small service sticker is also attached to the set, along with the date of service.

It's amazing how quiet most customers become when confronted with the facts although some do try to bluster their way through it. "Aww, gee – I thought it was the same set", is one common excuse. Yeah, right!

In fact, they don't even have to be the same model set for some customers to try that particular scam. I even had one idiot who brought in two different brands, the second just a fortnight later! Apparently, he figured that my memory was only good for a couple of weeks.

Another scam involves bringing in a set that's completely dead and claiming that it was in perfect working order up until the time it died. Then, when you subsequently get the set going again, all sorts of other faults become evident, eg, incorrect picture height or a washed-out picture because the picture tube is on its last legs.

When these extra problems are pointed out, the customer then vehemently denies that they existed. I've even struck a couple of customers who demanded a replacement set, the implication being that I had caused the problems while servicing the set.

A friend who services power tools frequently encounters similar prob-

lems, the most common being the duplicate tool trick. Again, they are not that gullible, with the serial number of each tool serviced recorded on the job tickets, along with the work done.

Sometimes, problems arise not because the customer is being dishonest but because they lack understanding or even plain common sense. One such area that causes confusion is warranty.

For example, a customer buys a cheap tool (eg, a cordless power drill) at a large hardware store. The tool then fails (usually due to the customer's abuse) and so what to they do? – they go to the specialist high-end tool store where my friend works and demand their money back, despite the fact that they didn't buy the tool there in the first place!

Why do they do this? Because the specialist tool store happens to be a warranty service agent for that particular brand of tool. They can do warranty work but it's a bit rich expecting them to give refunds for tools that weren't purchased there in the first place.

But try explaining that to some customers!

One guy did take them for a ride, however. This particular character brought in an expensive power drill which wasn't working and he wanted it fixed.

The fault turned out to be a burnt-out armature – a fault normally caused by the user leaning so heavily on the drill that the motor stalls (and the armature current shoots up). When informed of the problem and the likely cost, the customer immediately blew a fuse and argued that this could not possibly occur in such an expensive drill, especially as it wasn't all that old.

Faced with that sort of attitude and the all-too-obvious insinuation that they were trying to pull a fast one, the service manager's patience quickly ran out. In the end, he bluntly told the customer to take the drill away and get it fixed elsewhere. And so it was reassembled with the faulty armature in place and returned.

What this guy did next was to get a mate who knew just enough to be dangerous to pull the drill apart. They then deliberately cut some leads in the armature and then went to consumer affairs, claiming that this damage had deliberately been done at the tool company as a scam and demanding compensation.

You can imagine how time-consuming dealing with this complaint became for the tool company. And although it really went against the grain, my friend's boss eventually decided that the easiest way out was to simply replace the armature at no cost. Time was money and he couldn't spare the time to attend the hearings to fight it.

But he had the last word. The boss was a pretty fiery character and when the scammer came back he copped a gobfull. He was bluntly told that customers like him were not needed and that if he ever set foot in the store again he would be thrown out on his ear!

According to my friend, the scammer took his drill, slunk out and never came back. He'd got his drill fixed for nothing but had suffered the indignity of being roundly abused and told where to go when he collected it. Some victory.

Having had my share of those sorts of scams, I can sympathise with the boss. It's one of those cases where "the customer is not always right". SC

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Into special effects photography? Or want to be? Try this

TIME DELAY PHOTOFLASH TRIGGER

by Jim Rowe



Want to try your hand at 'stop motion' photography, where dynamic events such as a match bursting into flame, a drop splashing into a container of liquid or a projectile passing through a light globe, are captured at a crucial moment?

Here's a project designed specifically for this kind of work. It lets you trigger your electronic flash at the precise moment for a great picture.



Who let the smoke out? 30ms after we smashed the light globe by hitting it with a metal weight (that's it on the right) the filament is only now starting to realise it's lost half of its bulb and is starting to burn up, with flame and smoke. This is a combined time exposure (hence the warm glow from the lamp) and flash shot using the delayed trigger (hence the white pieces of glass). Believe it or not, this was the first shot we took – and a dozen light globes later, we decided it was the best!

Have you been intrigued by those impressive photos capturing the crown-shaped splash when a drop falls into a dish of milk or the tip of a chameleon's tongue when it's attaching itself to a flying insect? Or a light bulb shattering as a bullet enters it? These are the kinds of shots which can be achieved using 'stop motion' photography.

You don't need much gear to take these shots. The main requirement is a camera with a very fast shutter speed or an electronic flash.

Either way you need an electronic triggering unit to either open the camera shutter release, or fire the flash automatically in response to a reference event – such as a sound (like a 'bang' or 'click') or a contact closure (like the contacts in a PIR motion sensor).

The electronic triggering unit must have an accurately adjustable delay time. This allows you to set the camera or flash triggering to occur not just automatically in response to the reference event, but a known period of time after it.

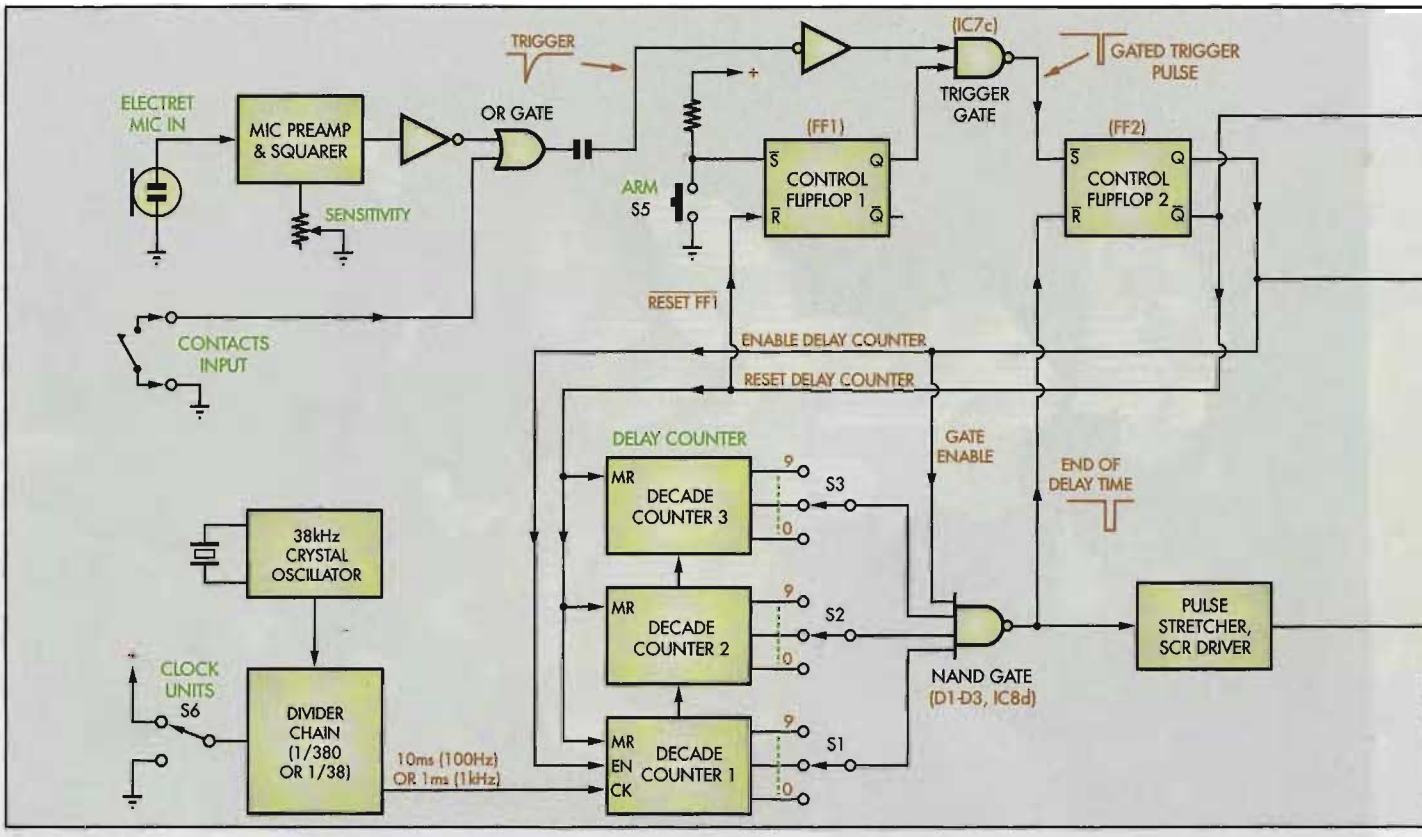
So if you predict that the crucial event you want to capture occurs about 40ms (milliseconds) after the reference event (eg, the bang or click, or contact closure), you can set the triggering delay to 40ms and see if this gets the shot. If it then turns out that the shot was a little early or late, you can either reduce or increase the delay to get the precise result.

So that's the rationale behind this project. It's an automatic electronic shutter release/flash trigger unit with a delay time which can be adjusted in 1ms steps from 0 to 999ms or alternatively, in 10ms steps from 0 to 9.99 seconds.

Triggering can be from an electret microphone (to pick up sound 'events') or other devices like a PIR (passive infrared) motion sensor, light-beam interrupter system, or custom sensor switches such as microswitches attached to machinery.

It is housed in plastic case which on the front panel (lid of case) has three rotary switches to set the time delay, a sensitivity control for the microphone/preamp, an "arm" button, toggle switches to turn on power and to select the time delay, a red LED to show that the unit has been triggered and a green LED to show that the flash or shutter has been fired.

Specifications	
Trigger inputs:	electret microphone or external trigger (via PIR sensor etc)
Delay time:	0 to 999ms in 1ms increments or 0 to 9.99 seconds in 10ms increments
Timing Accuracy:	1ms or 10ms
Outputs:	(1) Non-delayed triggering for external shutter release (2) Delayed triggering for electronic flash
Power:	9V alkaline battery
Consumption:	16mA (standby); 30mA when triggered.



Along the top side of the case are four sockets which connect an electret microphone, an external trigger (eg, PIR sensor), the electronic flash and, if required, the electronic camera shutter.

How it works

The block diagram of Fig.1 shows how it works. It has four states: the 'waiting' state – powered on; the 'armed' state where the unit is waiting for a triggering input; the 'triggered' state where the time delay is counting through and finally the 'fired' or 'ready' state where the time has elapsed and the unit has fired the electronic flash or electronic shutter.

When FF2 is in its reset state (Q-bar high) the circuit is in the 'ready' state but when the flipflop is triggered and switches to its set state (Q high) this swings the circuit into its 'triggered' state.

When the circuit is first turned on, FF2 is reset and so the circuit is in the 'waiting' state. The flipflop's Q-bar output is high , the Q output is low and as a result LED1 is turned on to show that the circuit is 'ready' for action.

A logic high is also applied to the MR (master reset) inputs of decade counters 1-3, forcing them all to reset with their '0' outputs high.

At the same time because FF2's Q output is low, the EN (enable) input of counter 1 is held low, preventing the counters from operating. The only other part of the circuit which operates in this 'ready' state is the 38kHz crystal oscillator and divider chain which runs all the time because it's used to generate the delay timing pulses. The divider chain is programmed by a switch (S6) to divide the crystal frequency by either 380 times or 38 times, to give timing pulses of either 100Hz (10ms) or 1kHz (1ms) respectively.

These pulses are fed to the CK (clock) input of counter 1 but while the circuit is in the ready state the counters can't respond.

Trigger gating

When a sound is picked up by the plug-in electret microphone, the mic signal is amplified and 'squared up' in the preamp/squarer section, then inverted and fed to one input of the OR gate.

The output of the OR gate is then fed via a differentiator circuit and an inverter to one input of a NAND gate – trigger gate IC7c. The other input of this gate is connected to the Q output of control flipflop 1 (FF1), which is used to ensure that only one trigger pulse can get through to trigger FF2.

The trigger gate is only 'open' when FF1 is set, by briefly pulling its S-bar input low using the 'ARM' pushbutton S5. The Q output then switches high, bringing the second input of the trigger gate high and thus allowing a trigger pulse to pass through and reach the S-bar input of FF2. This flipflop is therefore triggered, switching to the set state – with the Q output switching high and the Q-bar output switching low. So the circuit now swings into its 'triggered' state.

But notice that as soon as the Q-bar output of FF2 switches low, this immediately pulls down the R-bar (reset) input of FF1, resetting this again and causing its Q output to switch low. This closes the trigger gate, 'disarming' the circuit to prevent any further triggering until S5 is pressed again, to re-arm it.

Note that this triggering action can also be produced by the closing of a set of contacts connected to the circuit's EXT TRIG input, instead of a sound being picked up by the electret microphone.

The second input connects directly to the lower input of the OR gate, so the logic low produced by the contact closure is again able to pass through the gating and trigger FF2.

A number of other things happen

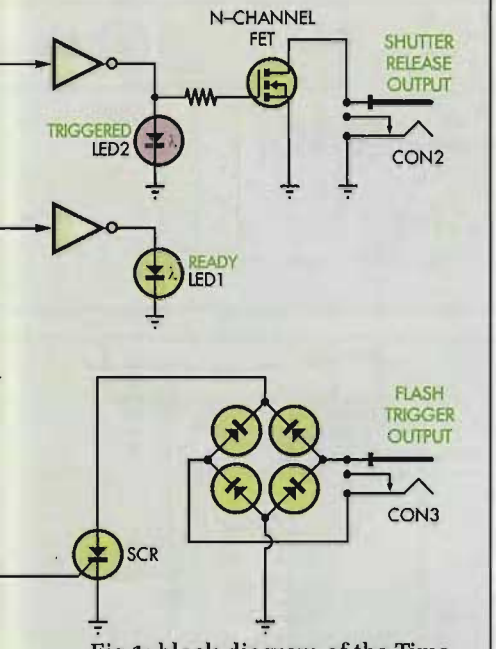


Fig.1: block diagram of the Time-Delay Photoflash Trigger breaks the circuit down into its various functions. Compare this with the circuit diagram overleaf.

once the circuit switches into its 'triggered' state. For a start, when the Q-bar output of FF2 switches low this causes triggered LED2 to be turned on via an inverter, to indicate that the circuit has switched into its 'triggered' state.

At the same time the N-channel FET is turned on, to produce a very low resistance across the 'shutter release' output connector (CON2).

So if your camera has the facility for remote control of the shutter, it can be automatically opened.

At the same time because FF2's Q output has switched high, LED1 is turned off to show that the 'ready' state has ended.

The reversal of FF2's outputs in the triggered state has another important effect, because it means not only that the logic high is removed from the MR inputs of the three decade counters, so they are no longer held reset, but also that a logic high is now applied to the EN input of counter 1, so it can begin counting the timing pulses.

Counting starts immediately, with the outputs of counter 1 going high in sequence for each timing pulse (ie, the 'units'), and then the outputs of counters 2 and 3 going high in sequence for each 10 pulses ('tens') and each 100 pulses ('hundreds').

This counting operation continues until the counter 1 output selected by S1, the counter 2 output selected by S2 and the counter 3 output selected by S3 are all high at the same time.

Because the three switches are connected to the inputs of a NAND gate, it's only when they are all high together that the output of this gate switches low.

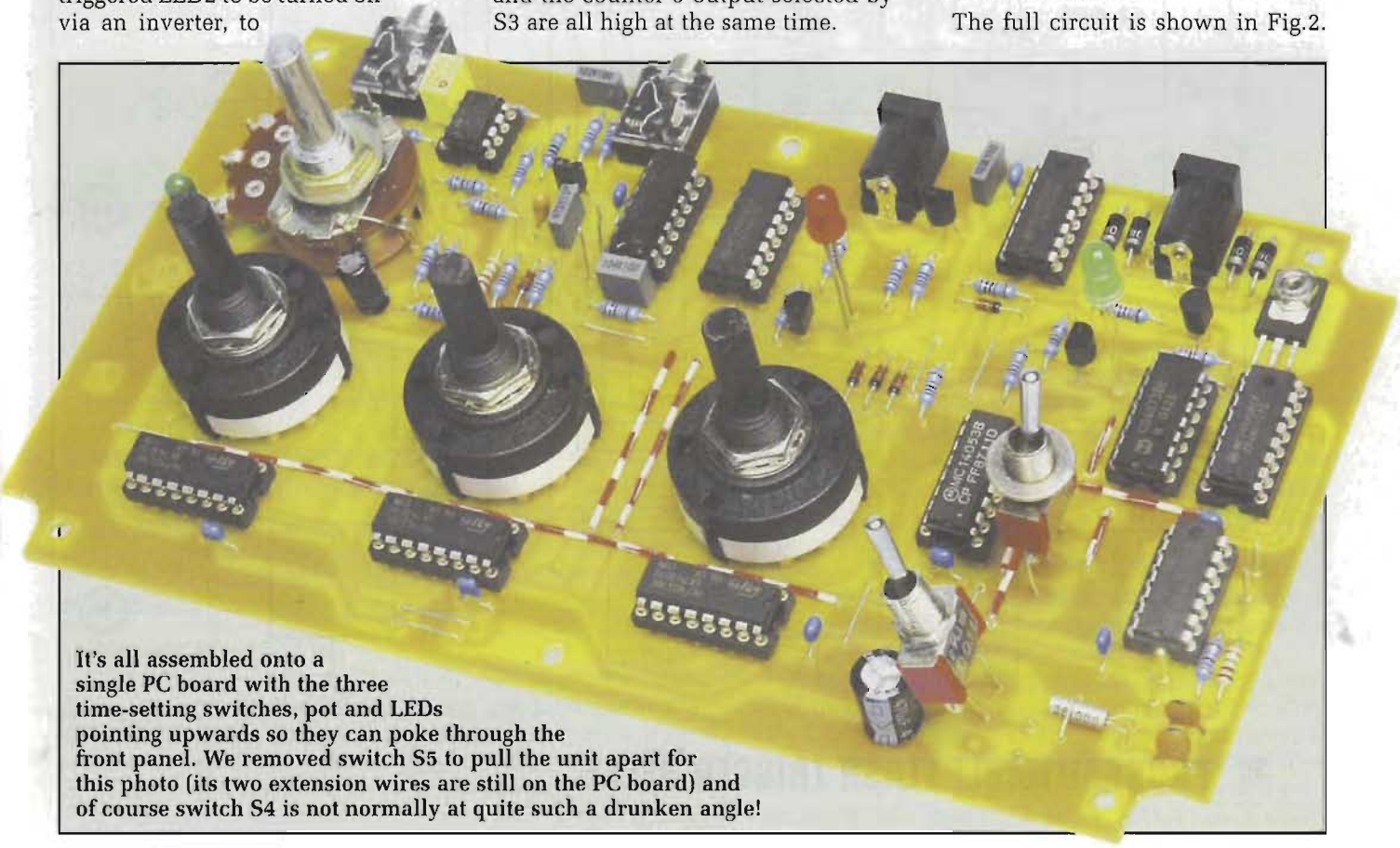
When this occurs, the resulting negative-going pulse is fed back to the R-bar (reset) input of FF2, causing it to be immediately reset. The decade counters are now disabled and held in their reset state, so counting stops and the circuit is switched back to its 'ready' state.

At the same time, the negative-going pulse from the NAND gate is fed through a pulse stretcher and driver to turn on the SCR (silicon controlled rectifier). The SCR conducts, and triggers your electronic flash unit via the diode bridge and trigger output socket (CON3).

To sum up, the settings of switches S1, S2 and S3 allow you to directly program the time delay between input triggering and output flash triggering. This means that if you set S3 for zero hundreds, S2 for two tens and S1 for five units, the flash triggering will be delayed by 25ms (using 1ms timing pulses) or 250ms (using 10ms pulses).

Circuit details

The full circuit is shown in Fig.2.



It's all assembled onto a single PC board with the three time-setting switches, pot and LEDs pointing upwards so they can poke through the front panel. We removed switch S5 to pull the unit apart for this photo (its two extension wires are still on the PC board) and of course switch S4 is not normally at quite such a drunken angle!

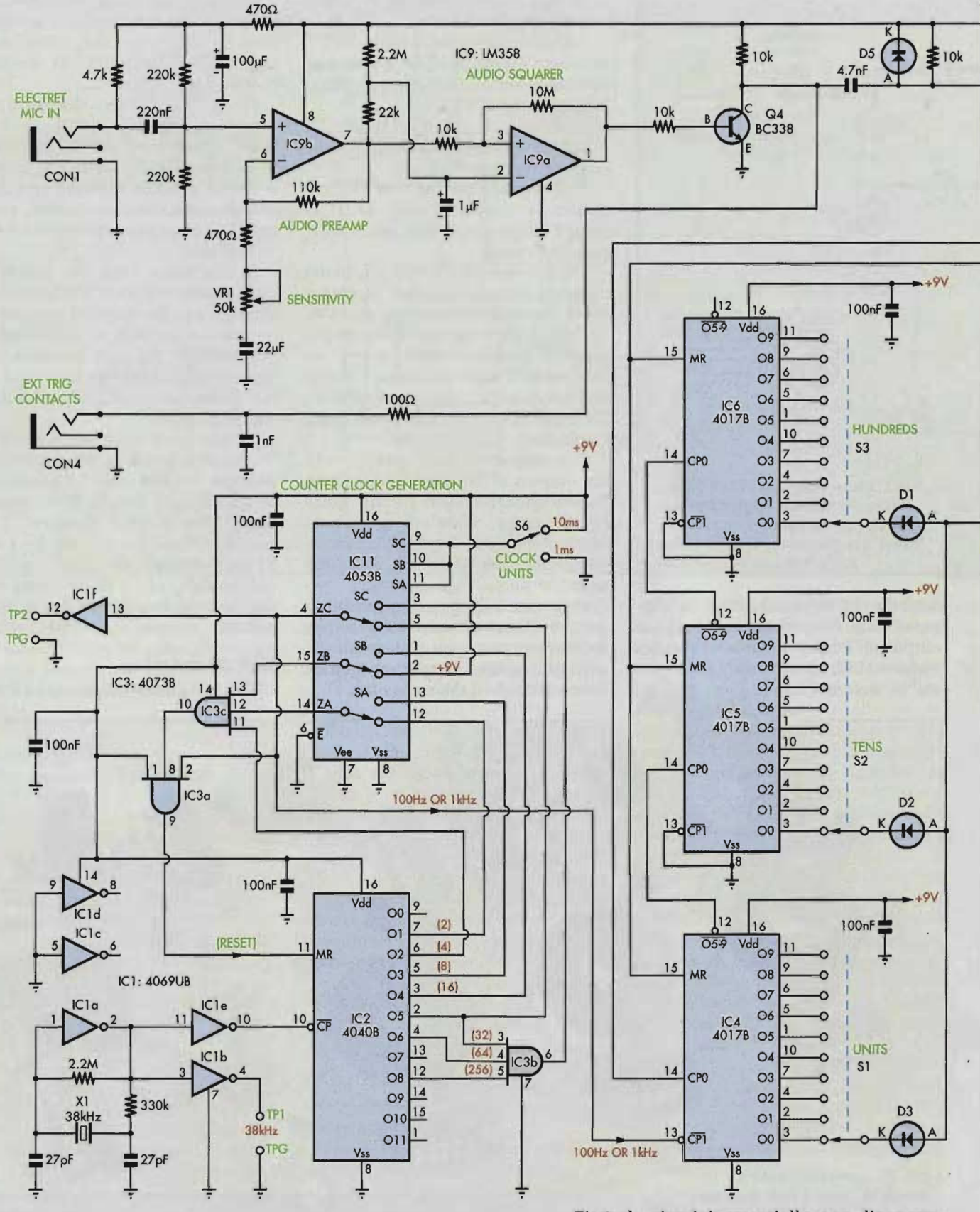
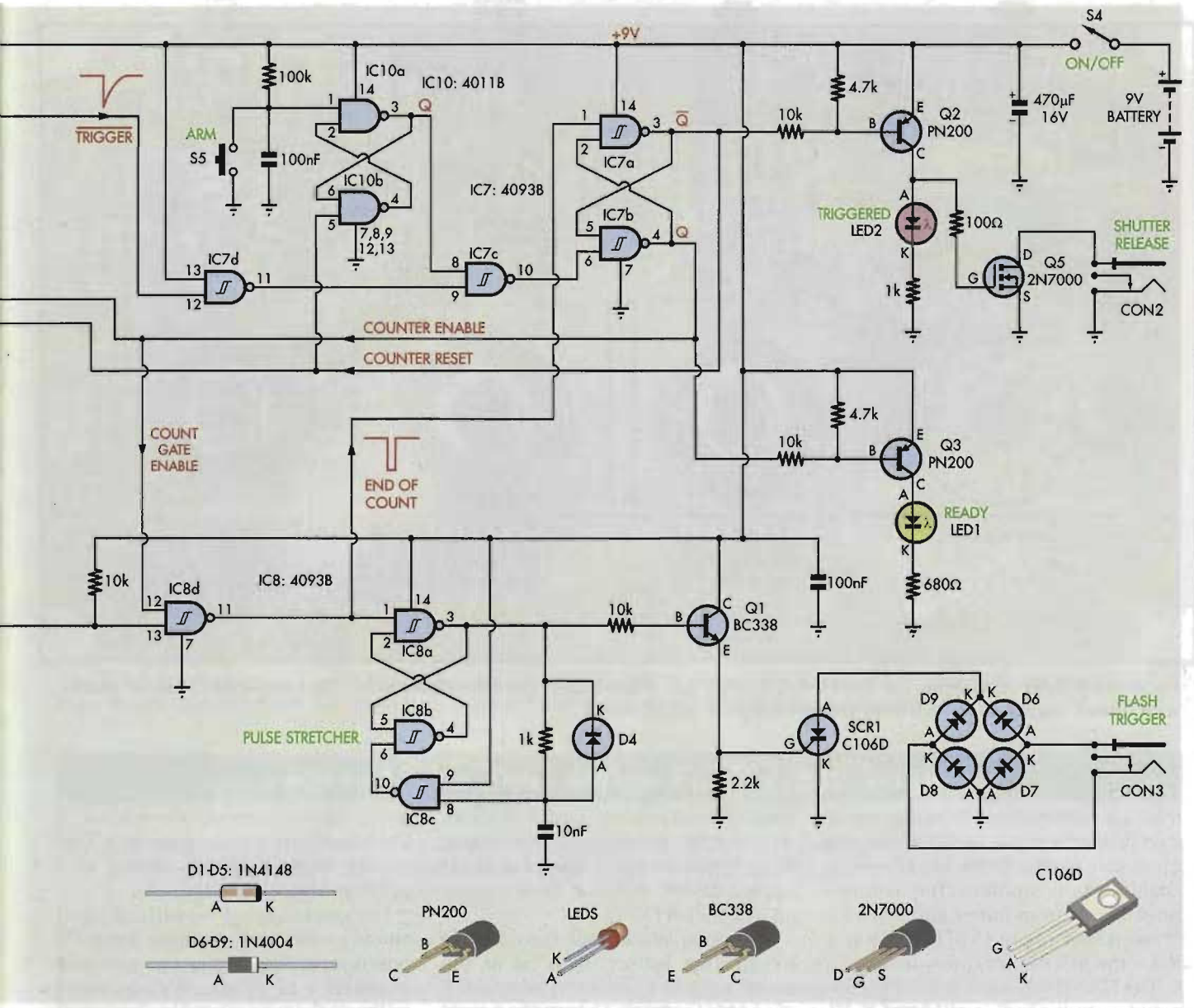


Fig.2: the circuit is essentially an audio preamp and shaper plus a counter which controls either a flash trigger and/or (if available) a camera shutter after a user-set time delay.

SC 2009 PROGRAMMABLE FLASH TRIGGER DELAY



The 38kHz crystal oscillator is based on inverter IC1a, whose output is buffered by IC1e to drive IC2, the 4040 counter and IC1b which makes 38kHz pulses available at test point TP1.

Gates IC3b, IC3c and IC3a together with triple CMOS switch IC11 (a 4053B) are used to configure IC2 for division by either 380 or 38 times, to provide the option of timing pulses with a frequency of either 100Hz (38,000/380) or 1kHz (38,000/38). The division ratio is determined by switch S6, which controls the state of SA/SB/SC inside IC11.

The resulting timing pulses are then sent to pin 13 of IC4 (which corresponds to decade counter 1 in Fig.1), and also made available at test point TP2 via buffer IC1f.

In the section of the circuit at upper left, you'll see the electret mic input socket CON1 plus the mic preamp and squarer circuitry based around op amps IC9b and IC9a, the LM358. Op amp IC9b is an inverting amplifier stage with negative feedback adjusted via pot VR1, so that its gain can be varied between 11.5 and 235 times to set the input sensitivity.

The preamp output is then fed directly to IC9a, which is configured as a comparator to 'square up' the audio signal and convert it into a train of pulses.

The output of IC9a is then used to switch on transistor Q4, so that its collector voltage drops quickly to near-zero after the arrival of the audio signal. The collector of Q4 is connected via the 4.7nF coupling/differentiating capacitor to pin 12 of gate IC7d, which is the inverter feeding trigger gate IC7c.

External trigger input

The EXT TRIG input comes in via CON4, which connects directly to the collector of Q4 via a 100Ω series resistor (the 1nF shunt capacitor across CON4 is used for noise filtering, to prevent spurious triggering). Hence the collector circuit of Q4 effectively forms a 'wired OR' gate, as either Q4 or the external contacts can pull it down to ground and hence begin the triggering process.

Cross-coupled gates IC10a and IC10b form control flipflop FF1, while gates IC7a and IC7b form control flopflop FF2. So pins 3 and 6 of IC10 is FF1's Q output, controlling trigger gate IC7c, while pins 4 and 2 of IC7

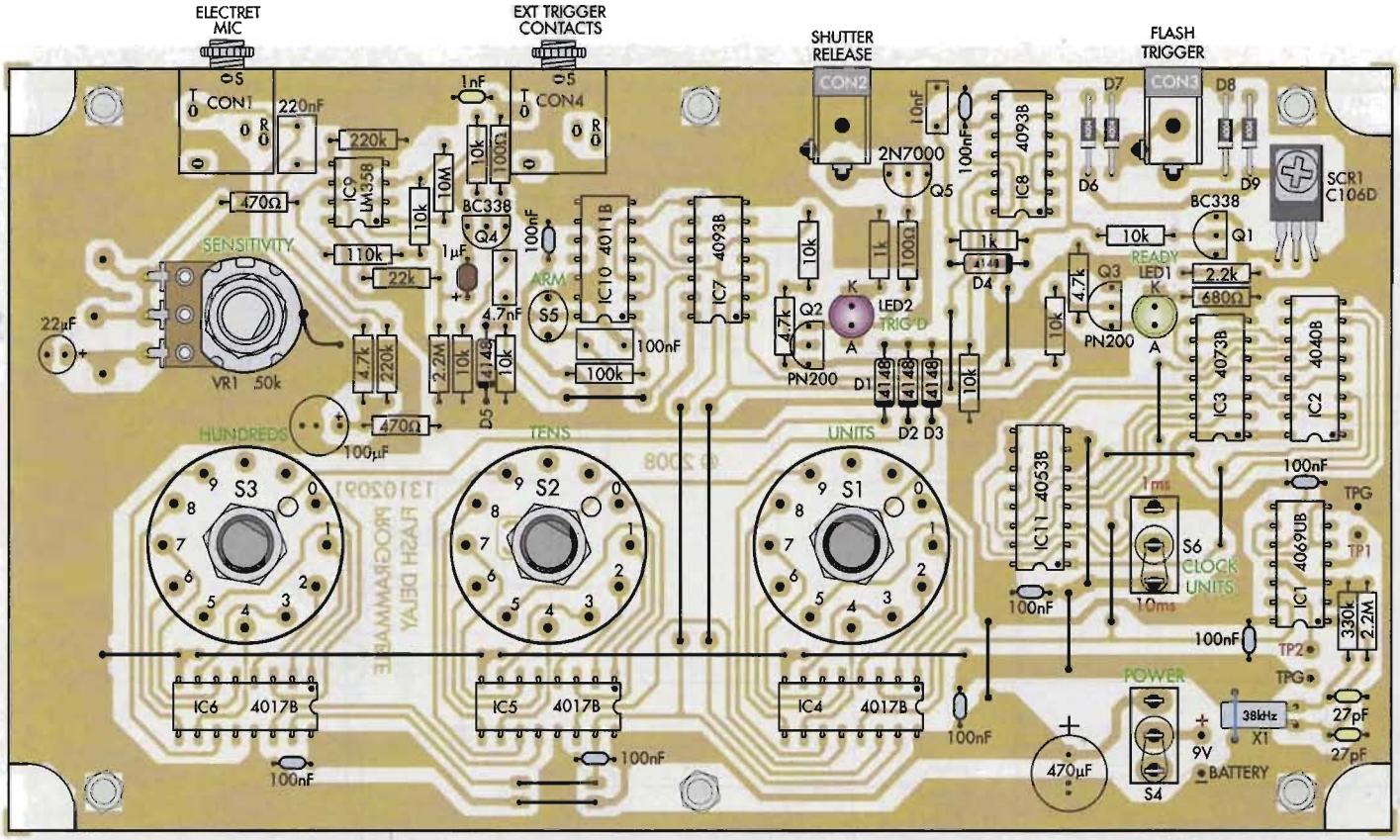


Fig.3: component overlay for the Time Delay PhotoFlash Trigger, from the component side. The longest links can be made with tinned copper wire – we used insulated type to avoid shorts.

are the Q output of FF2 and pins 3 and 5 are its Q-bar output. That's why the 'counter enable' signal from pins 4 and 2 is taken back to pin 14 of IC4 (counter 1), as this is effectively the counter's enable input. Similarly the 'counter reset' signal from pins 3 and 5 of FF2 is taken back to pin 15 of IC4, IC5 and IC6 – the MR pin for these devices.

The NAND gate used to combine the count outputs from switches S1, S2 and S3 is formed by diodes D1-D3 plus IC8d (connected as an inverter) and the 10kΩ resistor connected between its pin 13 input and the +9V rail.

This input of IC8d can therefore only rise to logic 'high' level when the cathodes of diodes D1, D2 and D3 are all high. This only occurs when the counter outputs selected by S1, S2 and S3 are all high at the same time. IC8d's output at pin 11 then goes low. This pin is connected back to pin 13 of IC7d, which is the control flipflop's R-bar input.

The remaining circuitry at lower right of Fig.2 forms the pulse stretching and SCR driver block. Gates IC8a, IC8b and IC8c, together with diode D4 and the 1kΩ resistor/10nF capacitor combination form a one-shot monostable to stretch the very narrow 'end of count' pulse from IC8d. Transistor Q1 functions as a buffer to apply the stretched pulse to the gate of SCR1, to switch it on. When SCR1 conducts it triggers the electronic flash via diode bridge D6-D9 and the flash trigger output socket CON3.

The complete circuit runs from a 9V alkaline battery, with S4 as the on/off switch. Unless you take a LOT of photos (or forget to turn the power switch off!), battery life should be very long indeed – probably approaching shelf life.

Construction

Virtually all of the circuitry and components used in the flash delay unit are mounted on a single PC board, coded 13102091 and measuring 185 x 102mm. The board has rounded cutouts in each corner so that it fits snugly inside a standard UB2 size jiffy box, measuring 197 x 113 x 63mm.

The shafts of switches S1-S3 protrude through the box lid (which becomes the front panel) along with the power switch S4 and the two indicator LEDs. The battery fits inside the box underneath the PC board assembly, while all four input/output connectors are accessed via holes in the upper rear of the box itself.

A small hole top left of the front panel allows screwdriver access to the sensitivity pot underneath. This should rarely need adjustment after the first time.

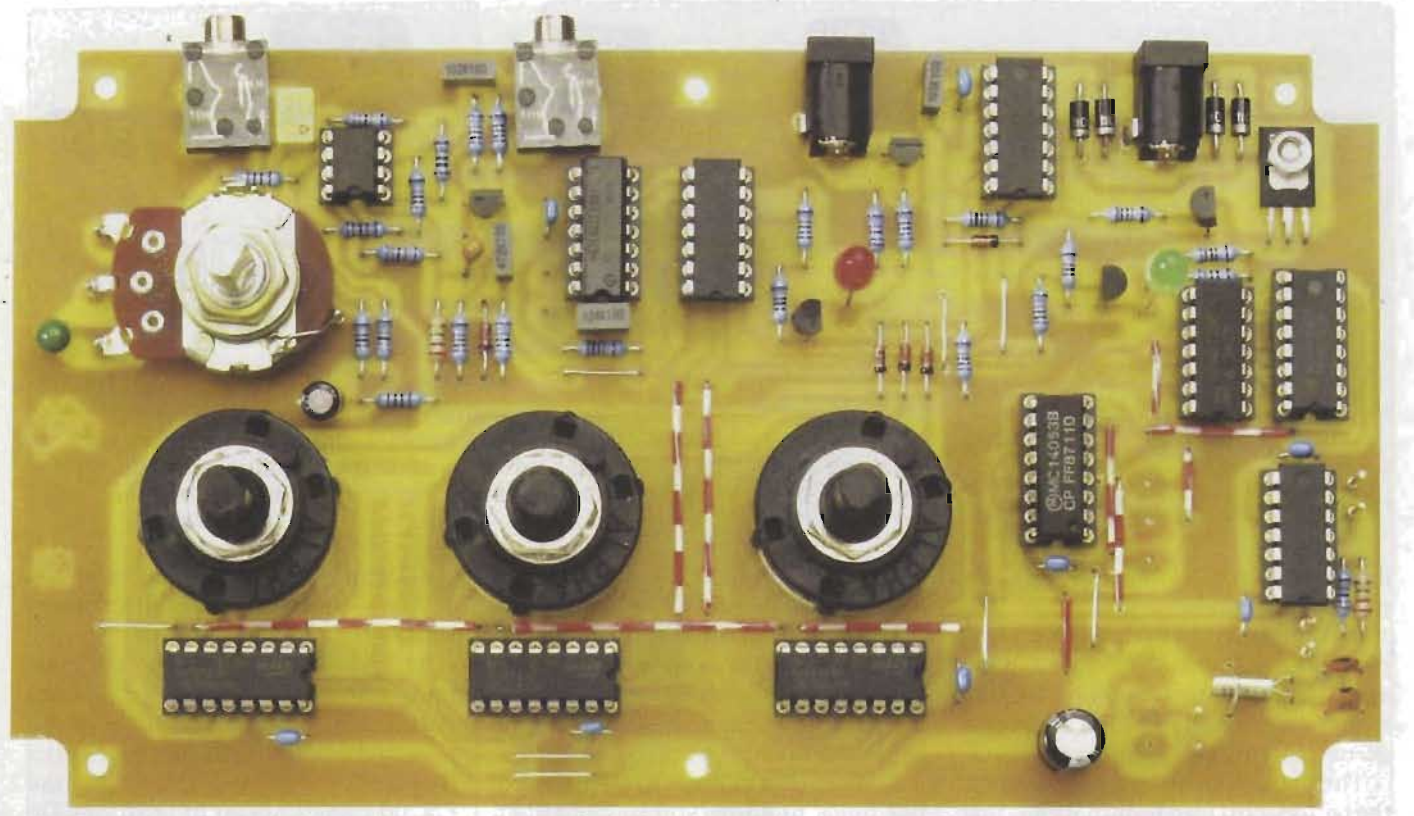
Incidentally, we specify 3.5mm stereo sockets only because mono PC board-mounting types are virtually impossible to obtain. We obviously only use them as mono (ie, the "ring" terminal is left unconnected). Mono line plugs can of course be used – these *are* commonly available.

The PC board overlay diagram of Fig.3 shows where all of the components are placed. Follow this diagram and the internal photo carefully, to build up the project without any problems.

Here is the suggested order for assembling the board:

1. Fit the four input/output connectors along the rear edge of the board.

2. Then fit the various wire links. There are 13 of these in all, eight of which are 0.4 inches long and can easily be made from resistor lead offcuts. The remaining five are somewhat longer, and will need to be made from lengths of tinned copper wire (pulled straight so there is no risk of



The matching photograph (to the component overlay) also shows all component placement. We used DIL sockets for the ICs – they're cheap enough and make both assembly and any later troubleshooting much simpler!

Parts List – Time Delay PhotoFlash Trigger

1 PC board, code 13102091, 186 x 102mm
1 UB2 size jiffy box (197 x 113 x 63mm)
3 1 pole 12 position rotary switches (S1-S3)
2 Mini SPDT toggle switches (S4,S6)
1 Mini pushbutton switch, momentary NO (S5)
1 38kHz quartz 'watch' crystal (X1)
2 3.5mm stereo sockets, PC board mtg (CON1,CON4)
2 2.5mm concentric DC connectors (CON2,CON3)
5 14-pin DIL sockets, PC board mtg
5 16-pin DIL sockets, PC board mtg
1 8-pin DIL socket, PC board mtg
9 1mm PC board terminal pins
1 9V battery clip lead
6 25mm long M3 tapped spacers
6 6mm long M3 screws, countersink head
7 6mm long M3 screws, pan head
1 M3 hex nut

Semiconductors

1 4069UB hex inverter (IC1)
1 4040B binary counter (IC2)
1 4073B triple AND gate(IC3)
3 4017B decade counter (IC4-IC6)
2 4093B quad Schmitt NAND (IC7,IC8)
1 LM358 dual op amp (IC9)
1 4011B quad NAND (IC10)
1 4053B triple SPDT switch (IC11)
2 BC338 (Q1,Q4)
2 PN200 (Q2,Q3)
1 2N7000 (Q5)
1 C106D SCR (SCR1)
1 5mm LED, green (LED1)
1 5mm LED, red (LED2)
5 1N4148 diodes(D1-D5)
4 1N4004 power diodes (D6-D9)

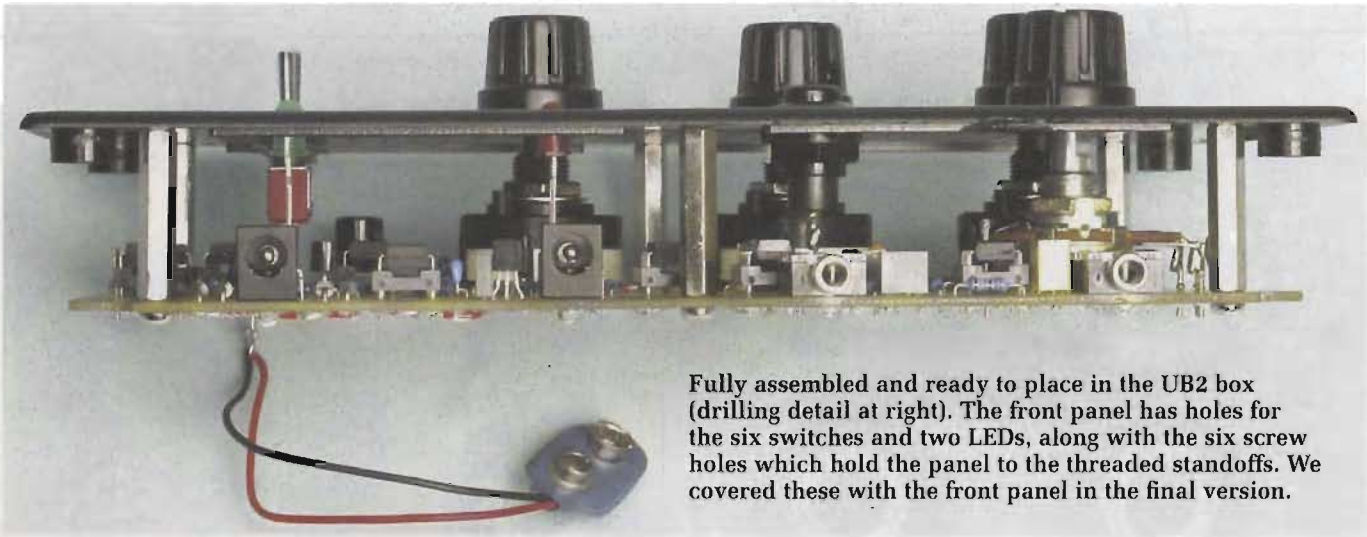
Capacitors

1 470µF 16V RB electrolytic
1 100µF 16V RB electrolytic
1 22µF 25V tag tantalum
1 1µF 35V tag tantalum
1 220nF MKT metallised polyester
1 100nF MKT metallised polyester
8 100nF multilayer monolithic
1 10nF MKT metallised polyester
1 4.7nF MKT metallised polyester
1 1nF MKT metallised polyester
2 27pF NPO disc ceramic

Resistors (0.25W 1% unless specified)

1 10MΩ	2 2.2MΩ	1 330kΩ	2 220kΩ
1 110k	1 100k	8 10kΩ	3 4.7kΩ
2 2.2kΩ	2 1kΩ	1 680Ω	1 470Ω
1 100Ω			

1 50kΩ potentiometer (VR1)



Fully assembled and ready to place in the UB2 box (drilling detail at right). The front panel has holes for the six switches and two LEDs, along with the six screw holes which hold the panel to the threaded standoffs. We covered these with the front panel in the final version.

them touching another link or component).

3. After the links fit the six terminal pins. Four of these are mounted in the usual from-the-top fashion, for the two test points (TP1, TP2) and their accompanying ground pins.

The remaining two pins are used for the battery clip lead terminations, just to the right of the mounting position for S4 (at lower right). These pins are mounted from under the board, so there is plenty of pin left under the board for soldering the ends of the clip lead wires.

4. Now fit the IC sockets, making sure that you fit each one with the orientation shown in the overlay diagram so they guide you later in plugging in the ICs correctly. Note that a socket is not used for RLY1, because this is best soldered directly into the board.

5. Next fit the four three-pin SIL headers used for LK1-LK3.

6. After these fit all of the fixed resistors. These are not polarised, but make sure you fit each one in its correct position using the overlay diagram as a guide. If necessary use your multimeter/DMM to confirm the values before soldering them in position.

7. Next fit trimpot VR1. The board has holes to allow you to use either standard size of horizontal trimpot, so whichever kind you use there shouldn't be a problem.

8. Now fit the smaller disc ceramic and multilayer monolithic ceramic capacitors, which are again not polarised.

9. Follow these with the electrolytic caps. There are only three of these (counting the 22µF tantalum unit), but they are polarised so watch their orientation.

10. Now you can fit the diodes, which are again all polarised. Take care here also to fit the 1N4148 'signal' diodes in positions D1-D4, and the 1N4004 'power' diodes in positions D5-D9.

11. After the diodes fit the four transistors, again watching their orientation but in this case also making sure that you fit the BC338 transistors in positions Q1 and Q4, while the PN200 transistors go in positions Q2 and Q3.

12. Now fit the 38kHz crystal X1. This is very small, so handle it carefully to avoid damaging it. Both of its leads are cranked outwards slightly and bent down by 90° about 3mm from the case, so that the crystal can lay on the top of the board with its leads passing down through the matching board holes.

When the leads are soldered to their pads underneath, bend a resistor lead offcut into a 'U' shape and slip it down over the crystal case, with its ends passing down through the two

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10MΩ	brown black blue brown	brown black black green brown
❑	2	2.2MΩ	red red green brown	red red black yellow brown
❑	1	330kΩ	orange orange yellow brown	orange orange black orange brown
❑	2	220kΩ	red red yellow brown	red red black orange brown
❑	1	110kΩ	brown brown yellow brown	brown brown black orange brown
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	8	10kΩ	brown black orange brown	brown black black red brown
❑	3	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	680Ω	red red brown brown	red red black black brown
❑	1	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown

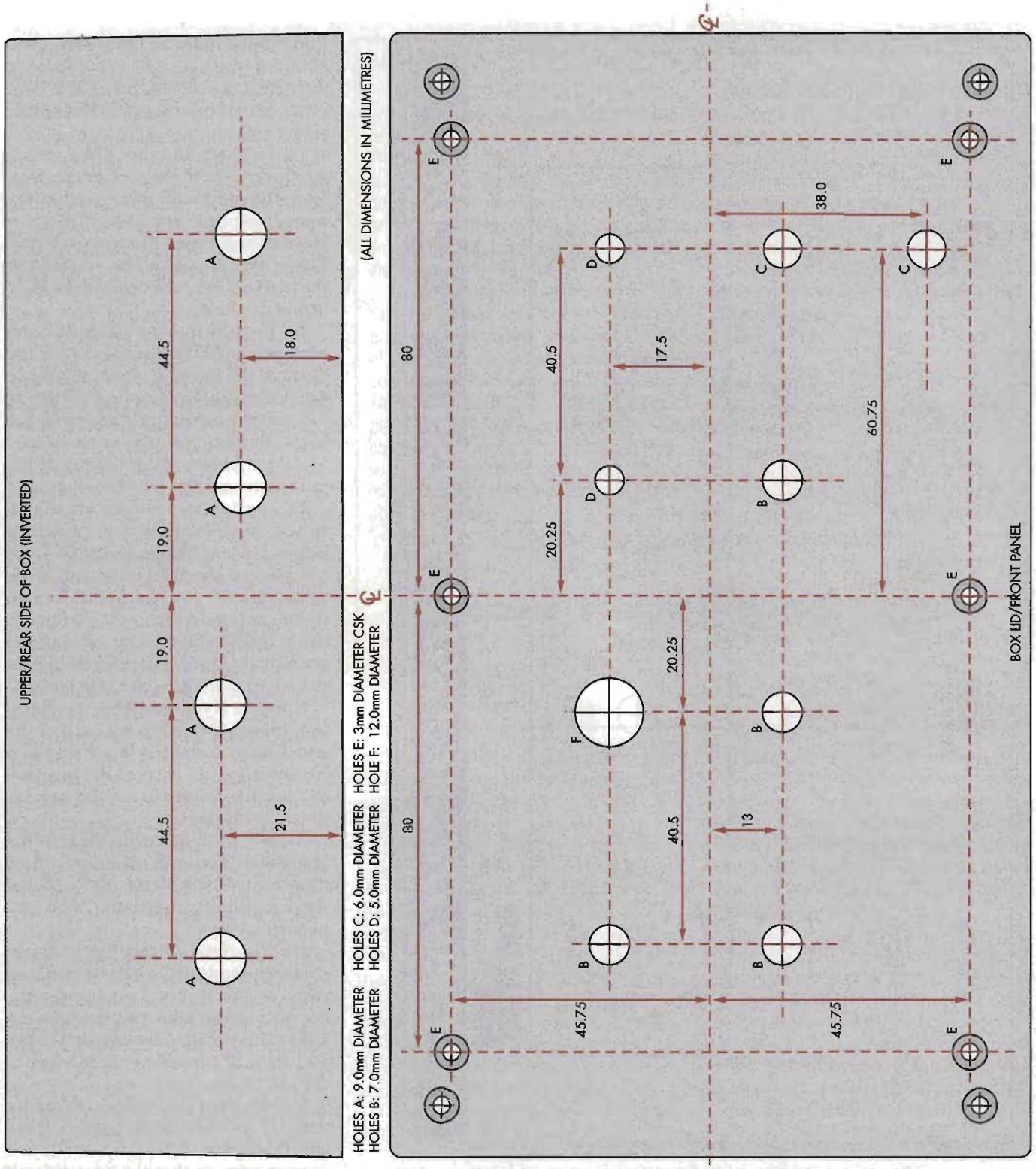


Fig.4: drilling detail for the UB2 Jiffy Box which houses the unit.

Capacitor Codes

Value	µF Code	IEC Code	EIA Code
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
4.7nF	.0047µF	4n7	472
1nF	.001µF	1n0	102
27pF	NA	27p	27

additional holes. The ends can then be soldered to the copper underneath so that the wire 'U' will act as a hold-down.

13. Next fit the three rotary switches S1-S3, after cutting each of their spindles to a length of 18mm and smoothing off any burrs with a small file.

These switches fit directly into the board but will only fit in with one orientation. This is where the single rotor pin is in the 'three o'clock' position.

Note that when you have fitted the switches and soldered all of their pins to the pads underneath, it's a good idea to program each switch to have a range of 10 positions. To do this, unscrew the nut from the threaded ferrule and then remove both the star lockwasher and the indexing stop washer. Then

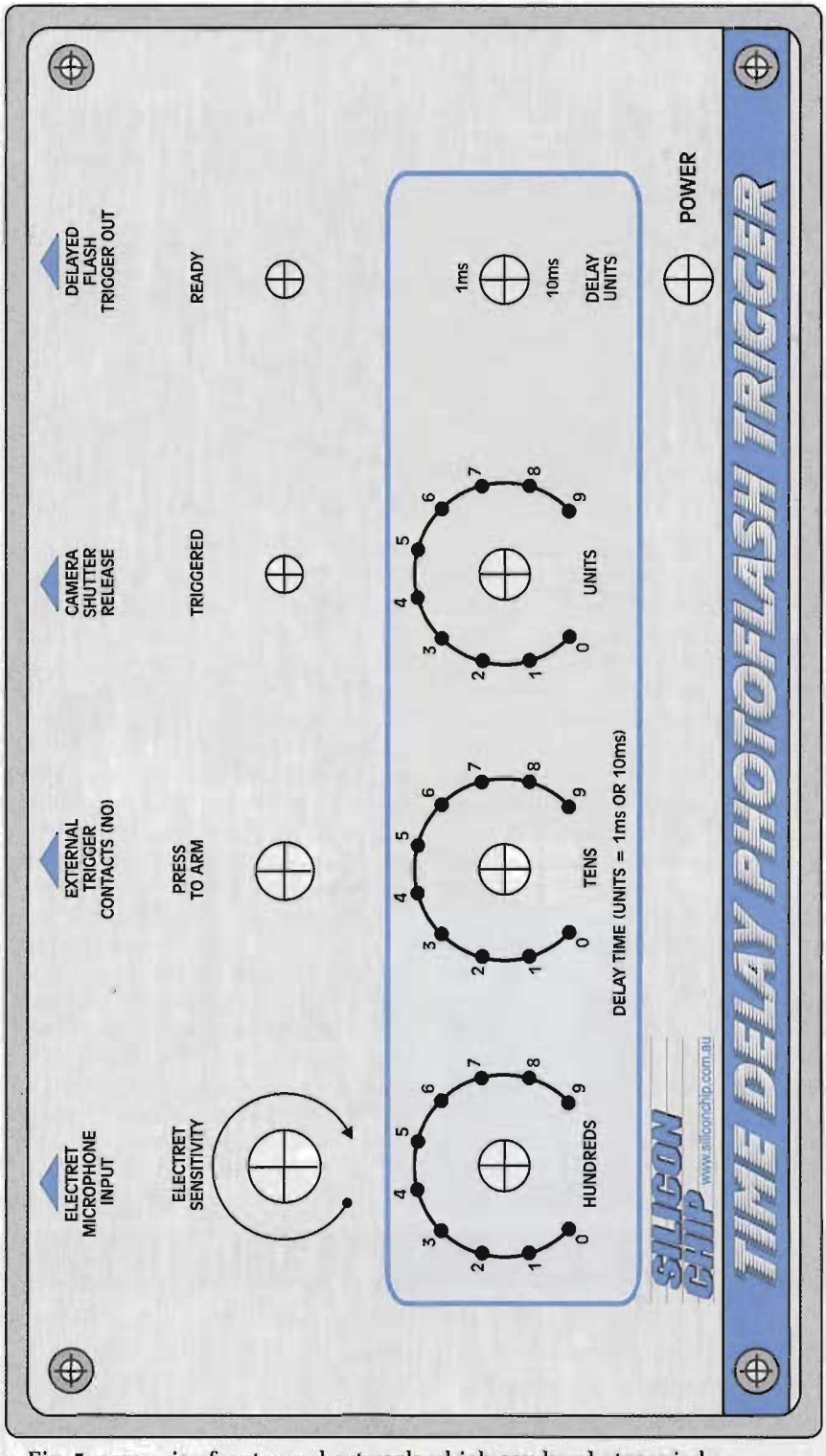


Fig. 5: same-size front panel artwork which can be photocopied or downloaded from siliconchip.com.au.

after turning the spindle anticlockwise as far as it will go, replace the stop washer with its cranked indexing pin passing down into the rectangular hole between the numbers '10' and '11' moulded into the plastic.

After this, place the lockwasher over the indexing washer, and finally screw on the nut again to hold it all together. You'll find that once this is done each switch will have only 10 positions.

14. Now fit the SCR, which mounts flat against the top of the board with its 'metal plate' side uppermost. The three leads of the device are bent down by 90° 6mm away from body and the outer leads cranked slightly outwards, so all three will pass easily down through the holes in the board. Then after the leads have been soldered to the pads underneath, the SCR is held down to the board using an M3 x 6mm screw and nut.

15. Fit the reed relay RLY1, orientated as shown in the overlay diagram. Note that although the relay has the same 'footprint' as a 14-pin DIL IC, it has only eight pins – four at each end. These pins should all be soldered to the pads underneath, to hold the relay firmly in place.

16. Next fit the two LEDs, remembering that LED1 is the green LED and LED2 is the red LED. Both should be fitted with their cathode ('flat') side towards the top of the board, with the leads left straight and measuring about 18-19mm between the bottom of the LED body and the top of the board.

17. The next step is to decide whether you want the project to provide a delay programmable in 10ms steps (i.e., 0-9.99 seconds) or in 1ms steps (0-999ms). If you want the former, there's no need to fit any of the jumper shunt links to LK1-LK4 because there are already four small copper links in the board pattern to suit this option.

However if you want the '1ms steps' option, you'll need to cut each of the small links under the board and fit a jumper shunt to each of the headers, at the ends indicated on the overlay diagram as '1ms'.

(If you want to swing back to the '10ms step' option in the future, this is done quite easily by simply changing the four shunts over to the other end of each header.)

18. The final wiring steps are to solder the ends of the battery clip lead wires to the terminal pins under the board (making sure you connect the red positive lead to the upper '+' pin), and then fit power switch S4 just to the left of these pins.

Note that this switch does not mount directly on the board, but via three short lengths of hookup or tinned copper wire so that the switch itself can be mounted to the box lid/front panel. For the moment though, just solder the three wires to the lugs on the rear of the switch, and solder the ends of the wires to the pads under the board. The wires should each be about 12mm long.

19. Your board assembly should now be complete, apart from plugging the various ICs into their sockets. So do this now, making sure that you plug

each one into its correct position and with the correct orientation.

Checkout time

Your flash delay unit board should now be ready for a quick functional checkout. To do this, first connect switches S4, S5 and S6 to the board using short lengths (say 25mm) of hookup wire. Then set clock switch S6 to the 10ms position, set the three rotary switches S3-S2-S1 to a setting of say '500' and connect the clip lead to a suitable 9V alkaline battery . Then turn on power switch S4. You should find that the red 'triggered' LED glows briefly but then goes dark and the green 'ready' LED1 begins glowing.

If you have access to an oscilloscope or a frequency counter, you can check that the board's clock oscillator is working correctly by checking the signal at test point TP1. You should find a 38kHz square wave of around 9V peak-to-peak. You can also check the timing pulses at TP2, which should have a frequency of 100Hz if you have switched S6 to the '10ms delay steps' option. If you switch S6 to the '1ms steps' option the frequency should change to 1kHz.

If all seems well so far, try plugging a 3.5mm jack plug into CON4 and then shorting its 'tip' and 'sleeve' connection lugs together with a short length of wire. You should find that nothing happens when you first do this, because the control circuit has not been 'armed'.

But if you now press S5 briefly and try again, this time LED1 should turn off and LED2 turn on, indicating that the circuit has been triggered. And it should remain in this state for five seconds, if you have set S3-S1 for '500' and S6 for 10ms (500 x 10ms = 5000ms or 5s). At the end of this time it should switch itself back to the 'ready' state, with LED2 dark and LED1 glowing again.

Assuming this is what you find, your delay unit is almost certainly working correctly. So switch off the power, because you should now be ready for the final assembly step: fitting the board assembly into the box.

Final assembly

Before you can fit the unit into its box, you may need to drill the various holes in the box first – unless you are building it from a kit with a pre-punched box and lid.

Making a custom microphone

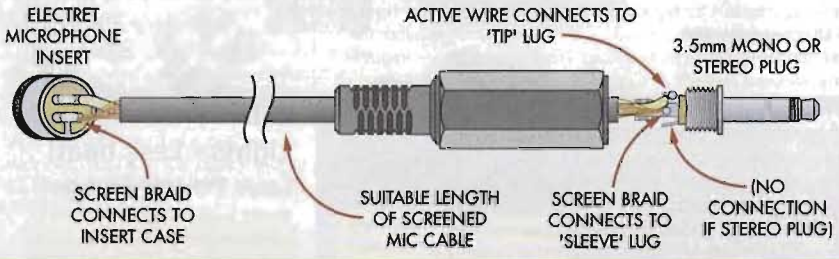
If you want to make use of the delay unit's sound triggering option, you'll need to make up a custom microphone lead. This is very straightforward, as you can see from the diagram below. The only components involved are a 3.5mm mono or stereo plug, a suitable length of screened single-core microphone cable and a small electret microphone insert.

At the microphone insert end of the cable, just make sure that the screening braid connects to the 'earthy' pin or pad of the insert – i.e., the one which is clearly connected to the metal case of the insert. The cable's inner wire connects to the other pin or pad. At the other end, the centre wire connects to the plug's 'tip' connection lug, while the screening braid connects to the 'sleeve' lug (the one which connects to the body of the plug).

Needless to say making up a cable for the delay unit's 'contact closure' input is even simpler. Here all you need is a 3.5mm mono or stereo plug plus a suitable length of screened cable, connected to the plug in exactly the same way as with the microphone. At the other end the inner wire and screening braid are simply connected to the two contacts (normally open) of the sensor unit you're using to provide your 'triggering event'.

Parts required

1 miniature electret microphone insert
1 3.5mm mono or stereo line plug
Suitable length shielded microphone cable



There are not many holes to drill as you can see from the drilling diagram, so preparing the box and its lid won't take very long.

If you are building the unit up 'from scratch' rather than from a kit, you may also want to fit the lid with a copy of the front panel artwork. This can be photocopied onto an A4 size adhesive label, and then cut to size before peeling off the backing and sticking it to the lid. To protect it from dirt and 'finger grease' you can then cover it with some clear adhesive film or, as we often do, laminate it (A4 laminators and sleeves are now ridiculously cheap!).

The board assembly mounts on the underside of the box lid via six M3 x 25mm tapped spacers, using countersink-head M3 screws to attach the spacers to the lid and pan-head screws to attach the board to the spacers.

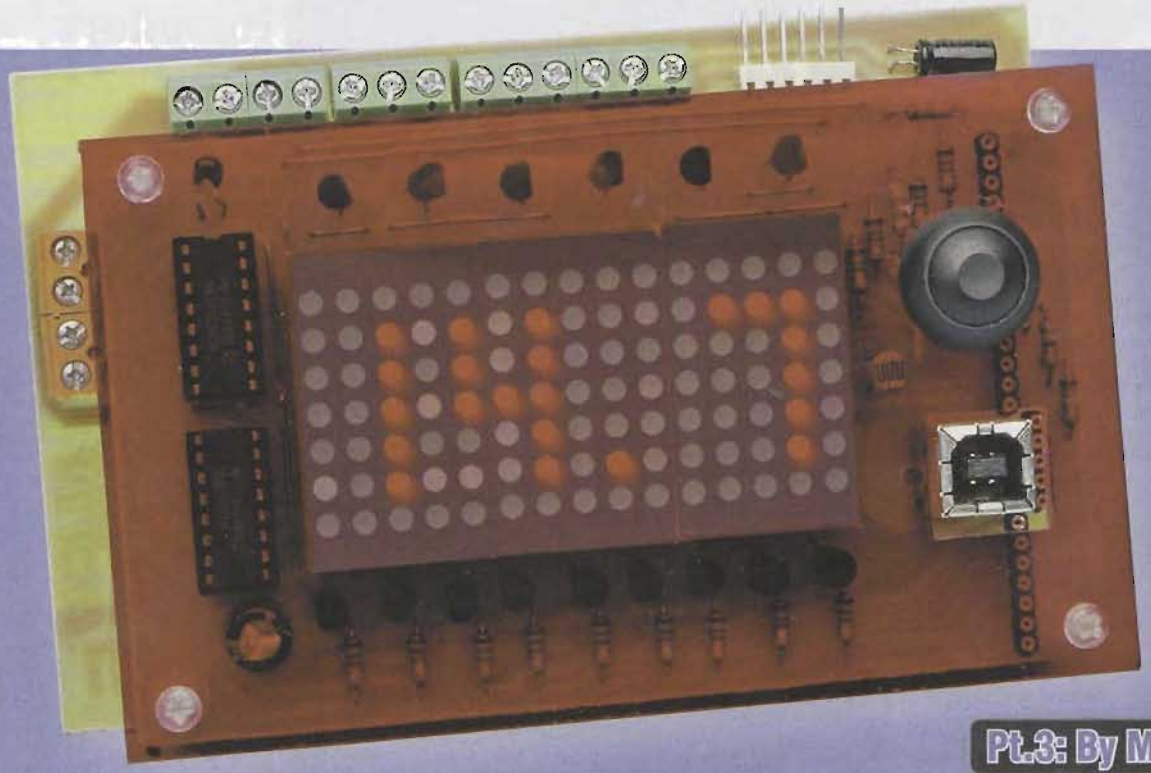
Just before you screw everything together, though, you need to mount switches S4, S5 and S6 in their respective positions on the lid/front panel, and also fit the lugs of each switch with a 25mm length of tinned copper wire. These will pass down through the matching holes in the board when it's brought up to the spacers, and are soldered to the pads underneath.

Note that pushbutton switch S5 (the "arm" switch mounts through the front panel from above, secured by a nut underneath the panel, while S4 and S6 mount through the panel from below and are secured with nuts from above.

When you are attaching the board to the lid/front panel via the spacers, take care to ensure that the tops of the two LEDs protrude through their matching holes, as do the rotary switch and pot spindles through their own holes. Needless to say you also have to ensure that the wires from the lid-mounted switches pass down through their own holes in the board. This is a bit fiddly but not difficult if you take it slowly.

All four of the input/output connectors CON1-CON4 are accessed through holes in the rear side of the box itself, with identification labels along the top of the front panel.

As noted before, the unit's battery simply sits in the bottom of the box, held in place by either a small bracket fashioned from sheet aluminium or even secured with a length of 'gaffer' tape. SC



Pt.3: By Mauro Grassi

Multi-Purpose Car Scrolling Display

User Software Instructions & Features Descriptions

In Pt.3 this month, we describe how the Multi-Purpose Car Scrolling Display is connected to the car and used. It's driven using a simple command-line program.

WHEN YOU HAVE built and tested the PC boards and installed the driver and software as explained in last month's article, you will then need to use the host program for calibration, to change preferences and to set up the features of the display.

This is done using a PC (a laptop is preferable if the device is already installed in a car), a USB cable and the command line program for Windows: **cardisplay.exe** (downloadable from the SILICON CHIP website at **www.siliconchip.com.au**).

There are many user-changeable settings but the software is organised into multiple-choice menus which should make it clear to use. We should point out that in most cases, the default values will not need changing – you can use them as they are.

Aside from the main features described in the December 2008 issue of SILICON CHIP, there are several other features. These are battery protection (if using a car's battery as the power source), dependent variables and limit condition messages. The latter are messages that, in the two scrolling display modes, will alert you when a variable is too low or too high. As previously mentioned, in **Static Display** mode, flashing and reversed modes indicate the limit conditions.

With dependent variables, you can display temperature in both degrees Celsius and Fahrenheit. More generally, you can display the same reading in different units, or show a corrected speed reading, for example.

When using the display in a car, with the car's battery supplying power, you can enable battery protection to switch off the display when the battery level drops below a set minimum. The display will then go into standby mode with a current drain typically around 10mA.

This mode is also recommended if

you want to use running totals that persist over many on/off cycles.

Connecting Sensors

The Car Scrolling Display can monitor up to six different sensors. For a Voltage/Resistance sensor, connect the output of the sensor to one of the four input channels on CON3 (referred to as AN0-AN3). For a sensor with a varying voltage (eg, oxygen sensor), you should connect its ground reference to pin 6 of CON3. For a sensor with a varying resistance (eg, thermistors), you should connect its other end to pin 1 of CON3 (+5V rail).

For a Frequency/Duty Cycle sensor, connect the output of the sensor to one of the two input channels on CON2 (referred to as FQ0-FQ1). You should also connect the ground reference to pin 1 of CON2. If you want to measure fuel injector duty cycle, for example, connect the fuel injector signal to one of the input pins of CON2 – see Table 1.

Connecting Relays & Buzzers

If you plan on using at least one of the two digital output channels for switching a relay or buzzer on a limit condition (a reading that is too high or too low), you should connect the relay or buzzer to CON4.

Note that if you are powering the Car Scrolling Display solely from USB power (+5V) then neither relays nor buzzers will work on the output channels, because they take their positive supply from pin 4 of CON1 (the power supply input pin). Using USB power only does allow you to do everything else though, including data logging and powering the display.

There are two relay/buzzer outputs, referred to here as Output 0 and Output 1. Output 0 corresponds to pins 1 (-) and 2 (+) of CON4 while Output 1 corresponds to pins 3 (+) and 4 (-) of CON4. For relays, which are not polarised, the coil is connected across pins 1 & 2 or across pins 3 & 4. You should connect buzzers with the correct polarity, however.

Connecting The Supply

There are two options when connecting power. One way is to connect the ignition-switched +12V supply from your car's battery to pin 4 of CON1 while connecting the negative terminal of the battery to either pin 2 or 3 of CON1 (it is immaterial which).

Physical Channel	Physical Input Pin	Measurement Type
0 (AN0)	Pin 5 of CON3	Voltage/Resistance
1 (AN1)	Pin 4 of CON3	Voltage/Resistance
2 (AN2)	Pin 3 of CON3	Voltage/Resistance
3 (AN3)	Pin 2 of CON3	Voltage/Resistance
4 (FQ0)	Pin 2 of CON2	Frequency/Duty Cycle
5 (FQ1)	Pin 3 of CON2	Frequency/Duty Cycle

Table.1: this table shows the pin-outs of the six channels. You connect the output of your sensor to either CON2 or CON3, depending on whether it is a voltage/resistance sensor or a frequency/duty cycle sensor – see text.

You then connect the positive battery terminal to pin 1 of CON1 (for battery level measurements).

With this configuration, the "off" state current drain (the current drain when the Car Scrolling Display has shut down) is very small and is essentially determined by the 66kΩ loading on the battery sense input (the input impedance of the ADC input, which is very high, is in parallel with the 10kΩ resistor). It works out to be roughly 200μA.

Unfortunately, with this power supply connection, three features of the Car Scrolling Display will not be available: battery protection, automatic shutdown and wake-up, and persistent running totals (see below for explanations of these features).

For cars that are driven frequently, say at least once a week, and to ensure all features of the Car Scrolling Display will function correctly, you should reverse the positive supply connections. In other words, connect the (unswitched) +12V battery line to pin 4 of CON1 and the ignition-switched +12V to pin 1 of CON1.

The only penalty is that when the Car Scrolling Display shuts down (for example, when you switch off the ignition), the display will still draw standby current – around 10mA. If that is a problem, you will need to connect the display to the car's battery in the alternative way described above.

Connecting A Computer

The next thing to do is to connect the Car Scrolling Display to a computer running Windows, using a USB cable. You can do this at any time to change settings, calibrate the sensors and to do real-time data-logging.

In last month's article, we guided you through the installation of the Windows Driver, and the PC host program. You may want to create a shortcut to the command window to go on your Windows Desktop. The guggested settings are shown in Fig.1. Change these by right clicking on the shortcut icon and going to "Properties".

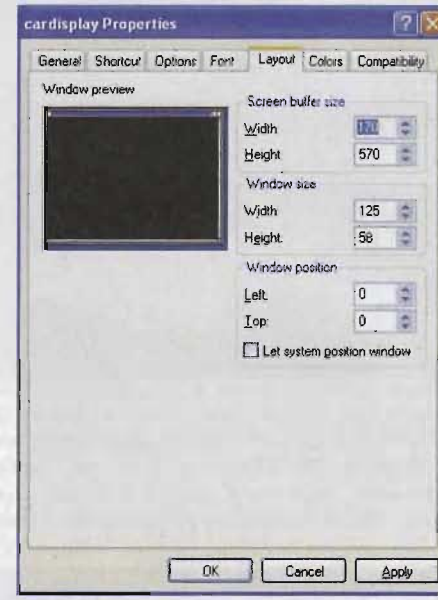


Fig.1: this screen grab from Windows XP shows the properties of the command prompt shortcut used with the program *cardisplay.exe*. We suggest you use size 16 Lucida Console font, while the window width should be 125 and the height 58.

The line width should be at least 120 characters, as the program can output some very long lines, which will otherwise wrap around and be difficult to read.

When **cardisplay.exe** is run without command line options, it will display the help message listing the available options. The full list of command line options is shown in Table.2.

Setting Name & Unit Strings

Each of the four values of each variable has an associated name and unit string. The default name strings are of the form VarD(N) where D is the

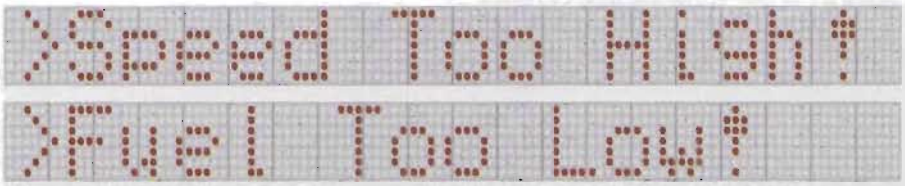


Fig.2: typical limit condition messages in the two scrolling modes. When a reading is below the minimum or above the maximum, you will periodically be warned about this. You set the minimum and maximum values by running the command *cardisplay -v* and choosing the "Change the Minimum & Maximum Values & Hysteresis" option.

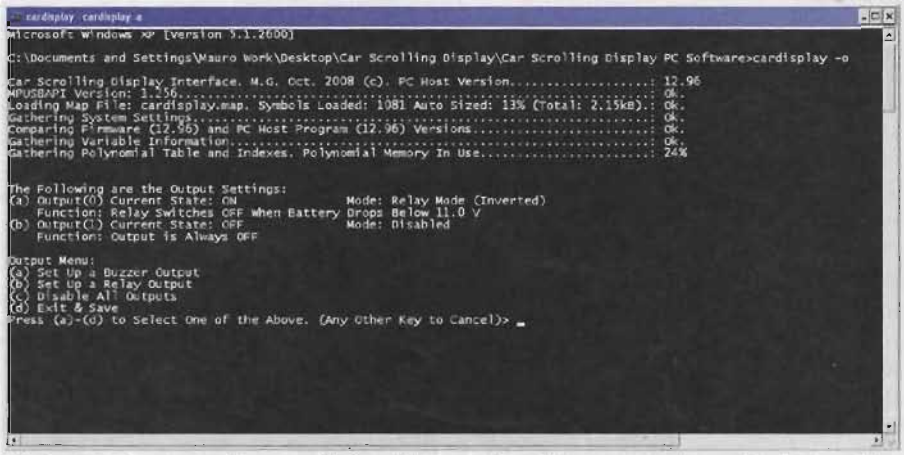


Fig.3: this screen grab was obtained by running the command *cardisplay -o*. It shows the output configuration menu and this is used to set up the two digital outputs to drive buzzers or relays, depending on limit conditions. In this example, the second output is disabled, while the first output controls a relay that will switch off when the battery voltage drops below 11.0V.

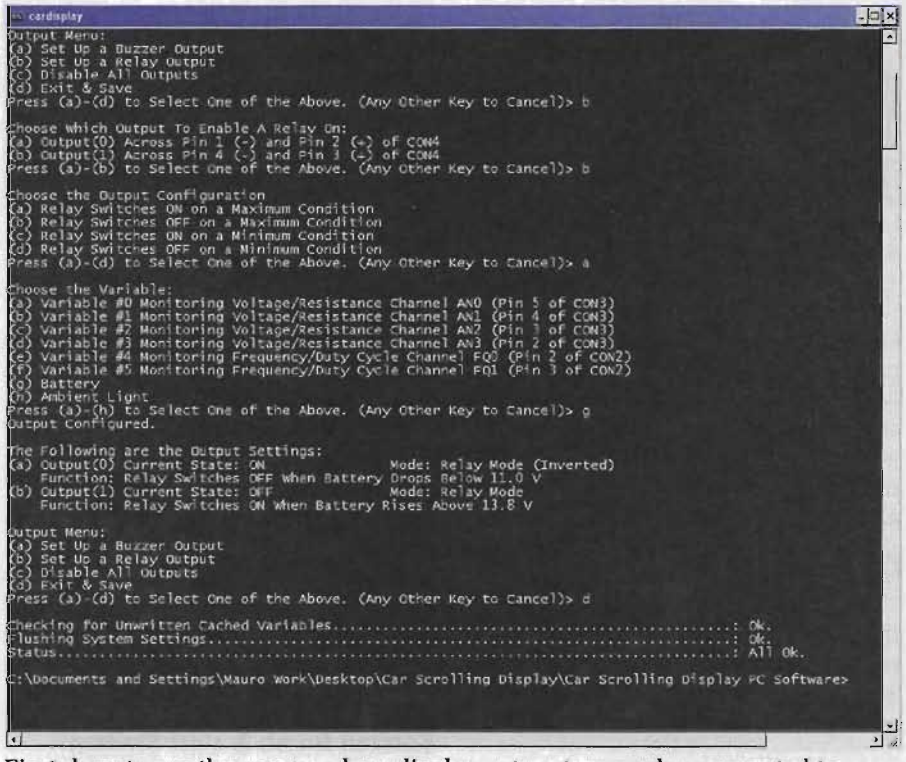


Fig.4: how to use the command *cardisplay -o* to set up a relay connected to Output 1. In this example, we have followed the prompts to set up the relay to switch on when the battery voltage exceeds the set maximum value of 13.8V. The choices are made at each step by pressing the appropriate key (we've selected options b, b, a, g & d here). Choose "Exit & Save" for the changes to take effect.

variable number (0-5) and N is the value number (0-3). For example, the default name of reading 2 of variable 3 is Var3(2). The default unit strings are similarly of the form UnitD(N).

For example, if you are measuring engine RPM, you could choose the name "Engine Revs" and the unit "RPM". To do this, run the command: **cardisplay -v** and choose the "Change the Name and Unit of the Variable". Once you've chosen the variable name and its units, select the "Exit and Save" option and they will be saved to non-volatile memory.

Remember that you will also need to add the reading to the display queue as explained in the section titled "Changing The Displayed Readings & Their Order" (see below), for it to be displayed.

Setting Minimum & Maximum Values

Next, you can also set the minimum and maximum values for the reading, by running the command **cardisplay -v** and choosing the "Change the Minimum and Maximum Values & Hysteresis" option.

Visible cues depend on the minimum and maximum values you enter. Recall from the first part of the article, that in the **Static Display** mode, the readings will flash when below the minimum and flash reversed when above the maximum.

In the other two scrolling display modes, there will be periodic warning messages as shown in Fig.2. If you are also planning to use one of the two digital outputs to monitor a reading and have a relay switch on or off or a buzzer sound on the extremes, these are also the values that determine the on/off switching of the relay or buzzer.

For example, for a 12V car battery, a typical minimum value would be 11V and a typical maximum would be 13.8V. For cabin temperature, you might choose 16°C for the minimum and 32°C as a maximum.

If you would like to monitor a reading and have a relay switch on or off on a limit condition, or have a buzzer beep, you should configure one of the two digital outputs as follows.

Setting Up A Relay

Setting up a relay to switch on or off on a limit condition is easy. Run the command **cardisplay -o** to enter the output configuration menu as

Command	Function	Example	Result
cardisplay or **cardisplay –h**	Show all available command line options (help).	**cardisplay**	The available command line options will be shown.
cardisplay –x:N or **cardisplay –q:N**	View real time information from variable number N, where N is in the range 0-5. The –x option is useful for troubleshooting	**cardisplay -q:0**	Shows information on variable 0 including all real time readings.
cardisplay –v ('v' is for variable)	Go to the variable setup menu.	**cardisplay –v**	You can change all variable settings, like minimum and maximum values, enable or disable averaging mode, change the name and unit strings for the variable, among others.
cardisplay –d ('d' is for display)	Go to the display menu.	**cardisplay –d**	You can change which readings are displayed and in what order, among other things. The menu options are listed in Fig.6.
cardisplay –i ('i' is for information)	Display Information about the Car Scrolling Display, including system settings	**cardisplay –i**	Displays the current values of the settings, including system settings.
cardisplay –e ('e' is for extended)	Display extended information about the Car Scrolling Display.	**cardisplay –e**	Displays extended information including internal settings useful for troubleshooting, if needed.
cardisplay –c ('c' is for calibration)	Go to the calibration menu.	**cardisplay –c**	Follow the on screen prompts.
cardisplay –o ('o' is for outputs)	Go to the output configuration menu.	**cardisplay –o**	Allows you to configure the two digital outputs for connecting relays or buzzers. The menu options are listed in Fig.4.
cardisplay –u:N	Start real-time data logging up to N samples or until interrupted by the user.	**cardisplay –u:100**	Capture 100 samples in real time at the set logging frequency and dump the data to a .csv file – see Fig.9.
cardisplay –l:N:<filename>	Start real-time data logging up to N samples and store as file <filename> in .csv format.	**Cardisplay "–l:2000:my Data Log"**	Capture 2000 samples in real time at the set logging frequency and dump the data to a file.
cardisplay –s ('s' is for system)	Go to the system settings menu.	**cardisplay –s**	Change any system settings. The menu options are shown in Fig.5.
cardisplay –w:<filename>	Write all settings to a file for later recall.	**cardisplay "-w:mySettings"**	Saves all settings to the file mySettings.
cardisplay –r:<filename>	Read all settings from a previously created file.	**cardisplay "-r:mySettings"**	Restores all settings from the file mySettings.
cardisplay –r	Reset the Car Scrolling Display and restore all default values.	**cardisplay –r**	Resets the car scrolling display and restores all default values.

Table.2: this table shows the command line options for the PC program "cardisplay.exe" running on your Windows OS. You can use a laptop to connect to the Car Scrolling Display if it is already installed in your car. You will need a USB cable and the PC host program will allow you to log your car's signals in real time.

shown in Fig.3. Note that the current settings of the two digital outputs will be shown.

Choose the "Set Up a Relay" option. Then choose the digital output connected to the relay you wish to control. You then select one of the four operating modes:

(a) Relay switches on at a maximum condition.
(b) Relay switches off at a maximum condition.
(c) Relay switches on at a minimum condition.
(d) Relay switches off at a minimum condition.

You then choose the variable to monitor and the relay output will be set up. A complete procedure is shown in the screen grab of Fig.4.

Note that each variable has its own hysteresis value (shown as a percentage) which is settable by running the command **cardisplay -v** and choosing the "Change the Minimum and Maximum values & Hysteresis" option. A typical value will be 10%. This affects how a relay connected to one of the two digital outputs is switched on or off.

Suppose for example, that the minimum and maximum values for the battery voltage are set at 11.0V and 13.8V respectively, with the hysteresis at 5%.

If the relay is set to switch on at a maximum condition, then the relay will switch on whenever the battery voltage is above 13.8V and switch off whenever the battery voltage is below 95% of the maximum value, ie, below 13.1V.

Setting Up A Buzzer

Again, run the command **cardisplay -o**. This time, select the "Set Up a Buzzer" option, then choose one of the two digital outputs and the variable the buzzer applies to. Remember that the buzzer will emit two short beeps when the reading is below the minimum and one long beep when the reading is above the maximum. Recall also that beeping is only enabled in the **Static Display** mode.

Changing System Settings

There are a few system settings which can be set by running the command **cardisplay -s**. You will be given

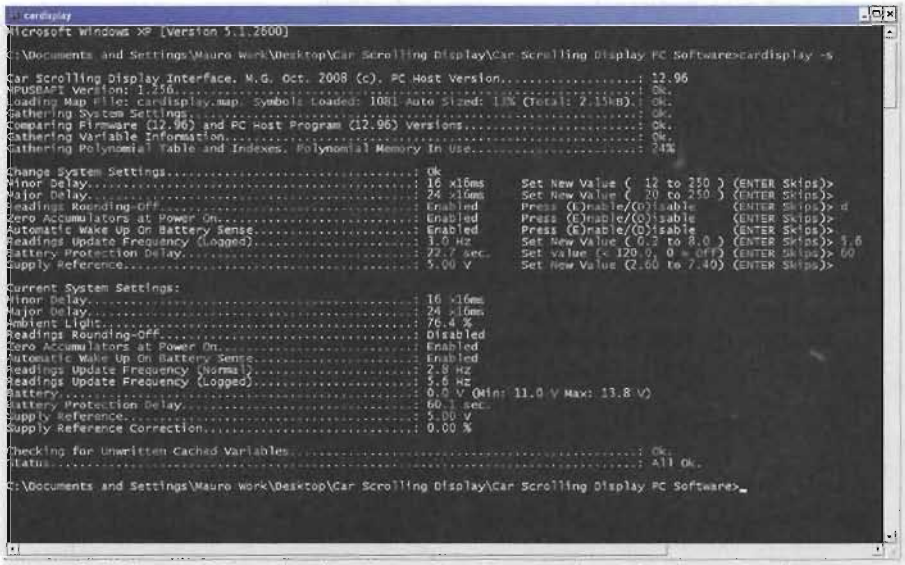


Fig.5: this shows the result of running the command *cardisplay -s* to change system settings. The value of the setting is shown and you are prompted to enter a new value. In each case, pressing ENTER retains the old value. For the Enable/Disable settings, you press either *e* (for Enable) or *d* (for Disable). When the settings have been entered, the new settings are displayed.

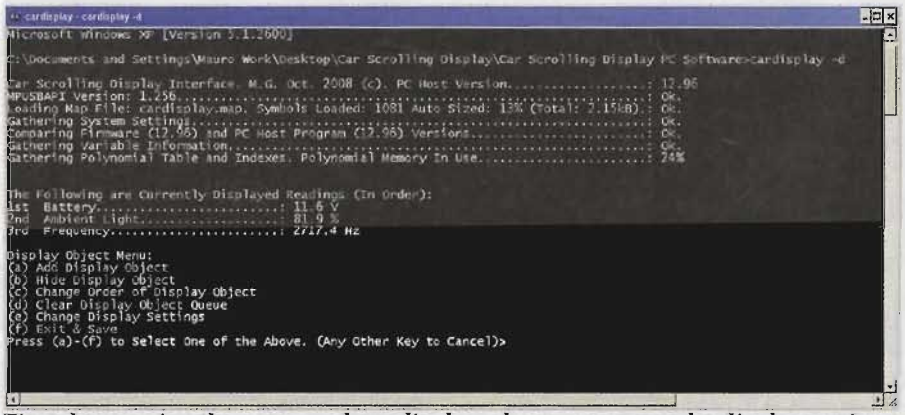


Fig.6: by running the command *cardisplay -d*, you can enter the display settings menu. Here you can add readings you want to show or hide readings you no longer want to display. You can also change the order of the displayed readings, the scrolling speed of the display and the minimum and maximum brightness levels.

the current value of each system setting and prompted to enter a new value. In all cases, pressing ENTER retains the current value. Again, in most cases, the default system settings probably will not need to be changed.

A typical screen grab is shown in Fig.5. Note that some are Enable/Disable settings and you simply type 'e' or 'd' to enable or disable respectively.

The system settings are:

(a) Minor delay: this is a number in multiples of 16ms that sets the delay for flashing and reverse flashing in **Static Display** mode. The smaller the number, the shorter the time that the readings will be off (if flashing to indicate minimum condition) or reversed (if flashing in reverse to indicate a maximum condition).

(b) Major delay: this is a number in multiples of 16ms that sets the time that the actual reading is displayed in **Static Display** mode when a limit condition occurs. The smaller the number, the shorter the time that the reading will be seen.

(c) Readings Rounding Off Mode: you can enable or disable rounding off of readings. If enabled, rounding will be applied to all readings, depending on how many digits after the decimal point are set for that variable.

For example, if a variable is set to show two digits after the decimal point and the reading is 123.5565, the display will show 123.56 (with rounding enabled) rather than 123.55 (with rounding disabled).

(d) Zero Accumulators at Power On: you can enable or disable setting all accumulators to 0.0 when the display is powered on. Disabling is useful if you want persistent running totals, ie, totals that retain their value when you switch off the ignition.

(e) Automatic Wake-Up On Battery Sense: enable this to have the display turn on automatically when power is detected at the battery sense input.

(f) Readings' Update Frequency (Logged): you can set the readings' update frequency for data logging from 0.2Hz to 8Hz. Note that the readings' update frequency for normal display mode is always half of this value.

Display Settings Menu

Once you've set up a variable, you can select which readings to display using the display settings menu. You can also select the order in which the readings are displayed, the minimum and maximum display brightness and the scrolling speed.

Ambient Light Level Response

The ambient light level is used to automatically dim the display when the light level drops. This can be overridden by setting the minimum and maximum brightness levels. The higher the number, the brighter is the display. If you set the minimum to be equal to the maximum, then the brightness will be fixed.

If, for example, you set the minimum to 100 and the maximum to 250, the brightness will vary between these extremes, depending on the ambient light level. It is usually desirable to have a dimmer display when the am-

Fig.7: this is the message that will scroll when the battery level drops below the set minimum. The Car Scrolling Display will protect the battery by shutting down to standby mode.

You Build It

bient level drops. It will also result in lower current drain.

The scrolling speed (applicable to the two scrolling display modes) can be varied. The lower the scrolling delay (measured in milliseconds), the faster the scrolling will be.

To set the minimum and maximum brightness as well as the scrolling speed, run the command **cardisplay -d** and choose the "Change Display Settings" option.

Changing the Displayed Readings & Their Order

The display menu also allows you to select up to 10 readings to display and choose the order in which they appear. Note that the first reading cannot be hidden, so there will always be at least one reading to display. The accumulator of each variable can also be displayed.

When the accumulator is displayed in any of the two scrolling modes, the name string will be that of the value which it is summing with a '(+)' suffixed to indicate that the accumulator rather than the value is being displayed.

To change which readings are displayed and in what order, or to hide or add a reading, run the command **cardisplay -d** and choose the appropriate options as shown in the screen grab in Fig.6. For example, choose "Change Order of Display Object" and select an object from the list of currently displayed readings. Then use the arrow keys to move the reading up or down in order.

Battery Protection, Automatic Wake-Up On Battery Sense

With the correct power supply connection, you can enable automatic wake-up on battery sense and battery protection. Recall that the Car Scrolling Display will go into standby mode (drawing only very small currents) when it detects that the battery voltage has dropped below the minimum (it will, however, not go into standby mode if USB power is available).

The delay from detecting the low battery condition to the Car Scrolling Display shutting down (with a message as shown in Fig.7) can be set by running the command **cardisplay -s**. The setting to change is the "Battery Protection Delay". This delay is useful, for example, if you are running a cooling pump from a relay on the digital outputs and you want it to operate for a while after the ignition key has been switched off.

When you enable automatic wake-up on battery sense, the Car Scrolling Display will turn on when it detects that the battery level is above the minimum. You can enable or disable this by running the command **cardisplay -s**. The setting to change is "Automatic Wake Up on Battery Sense".

Note that when you see the message in Fig.7 and the Car Scrolling Display goes into standby mode, you can manually force the display to wake up by pressing the pushbutton on the front panel. Keep it pressed for 10 seconds or so and the display will turn on.

System Messages

From time to time, you will see a number of messages scroll by on the display which are generated by the firmware in response to a number of events. These are shown in Fig.8.

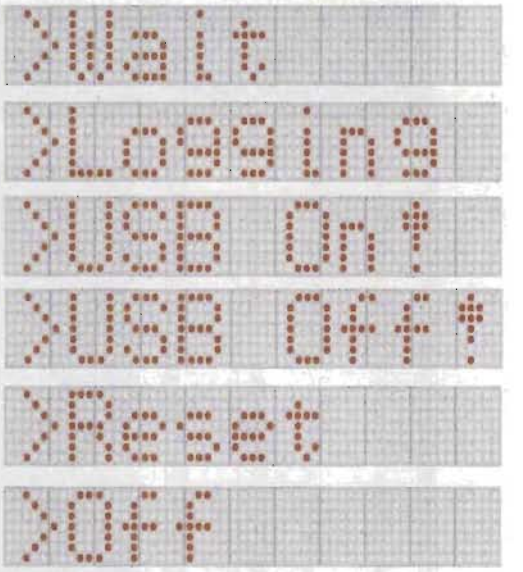


Fig.8: these are some system messages, which begin with a ">" character. "Wait" appears when the display is busy; "Logging" when entering data logging mode; "USB On!" when a USB cable is connected; "USB Off!" when a USB cable is disconnected; and "Reset" when a reset has occurred. "Off" indicates that you have scrolled past the last reading and that the display is about to turn off (but not go into standby mode yet).

Real Time Data Logging

For data logging, run the command: **cardisplay -u:<N>** or **cardisplay -l:<N>:<filename>**, where <N> is the number of samples and <filename> is the name of the file to save the data to. Fig.9 shows an example screen grab.

Note that when specifying a command line option with spaces, you use double quotes to enclose the argument. For example, to collect 2000 samples and store the result to a file called "My Output Log" you would type at the command prompt **cardisplay "-l:2000:my Output Log"**, enclosing the argument in double quotes.

The produced file will be a .csv (comma separated values) file which can be opened with any spreadsheet. Only values which have been made loggable will be logged at the set logging frequency.

To change the loggable values of a variable, run the command: **cardisplay -v** and choose the "Set the Logging Parameters For the Variable". You

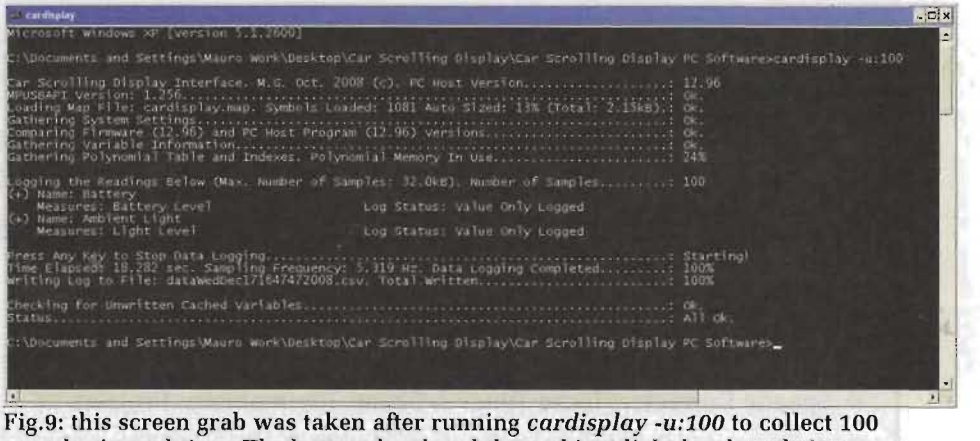


Fig.9: this screen grab was taken after running *cardisplay -u:100* to collect 100 samples in real time. The battery level and the ambient light level are being logged at the logging frequency of 5.6Hz. When using the *-u* option rather than the *-l* option, the filename is generated automatically from the PC's date and time. In this case, the log was saved to *dataWedDec171647472008.csv*.

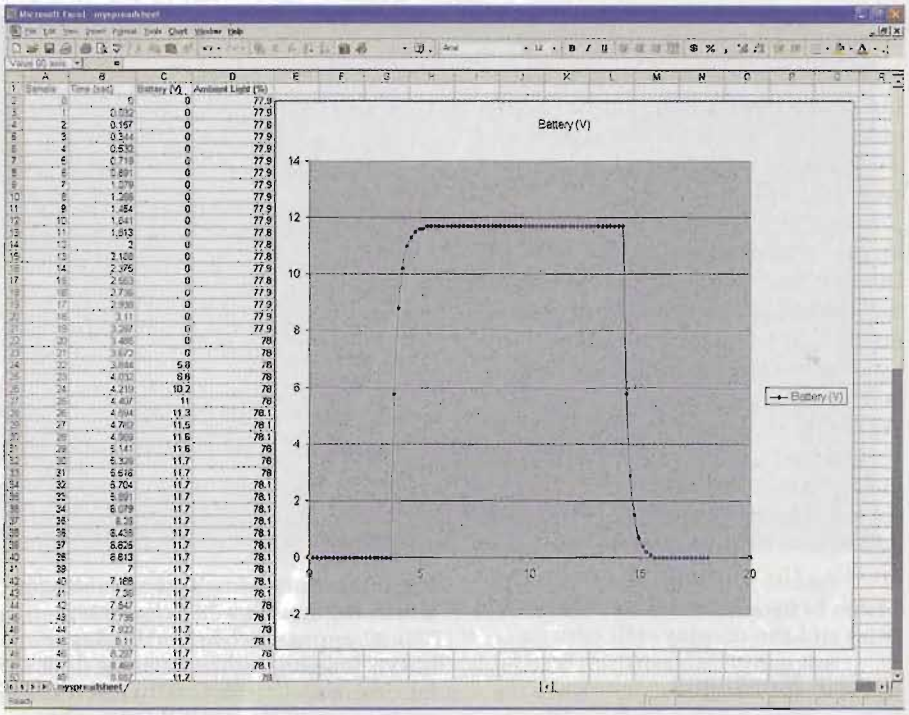


Fig.10: this shows the result of importing the log file into the spreadsheet application Microsoft Excel. We've also created a graph of the battery voltage level. This shows that the battery voltage was switched on around 4s after the start of logging and switched off again at about the 15s mark.

can choose to toggle whether each of the four values of the variable will be logged. If at least one value is made loggable, you can further choose to log the accumulator for the variable and to log the limit conditions.

A screen shot showing a log file that has been imported into Microsoft Excel is shown in Fig.10. Here, the battery level has been logged and a graph has also been created.

Out Of Range Values

In **Static Display** Mode, out of range values will be shown as four "+" signs. When a displayed value comes from a variable that has not been updated since being last displayed, the value will appear as "N/A" in the two scrolling modes and as four "–" signs in the **Static Display** mode (see Fig.11).

Changing The Welcome Message

When the Car Scrolling Display first powers on, a welcome message is shown. The default welcome message includes the firmware version. You can change the welcome message by running the command: **cardisplay -v** and choosing the "Change Welcome Message" option.

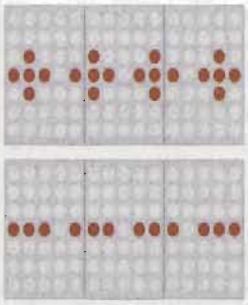


Fig.13: In the Static Display Mode, overflow is indicated by 4 '+' signs, while 4 '-' signs indicate that the reading is not ready to be displayed. In the scrolling modes, the value will appear as 'N/A' when the reading is not ready to be displayed.

Saving & Restoring Settings To A File

To write settings to a file for later restoring, run the command **cardisplay -w:<filename>**. You can restore settings by running the command **cardisplay -r:<filename>**.

Restoring Default Values

To restore all default values, as well as clearing all strings, you run the command **cardisplay -r**.

That completes our presentation of this project in the magazine. To obtain more detailed information about the operation of the software and the calibration procedure, as well as how to change the variables' settings, you can access a PDF file entitled "Car Scrolling Display User Guide" on our website. **SC**

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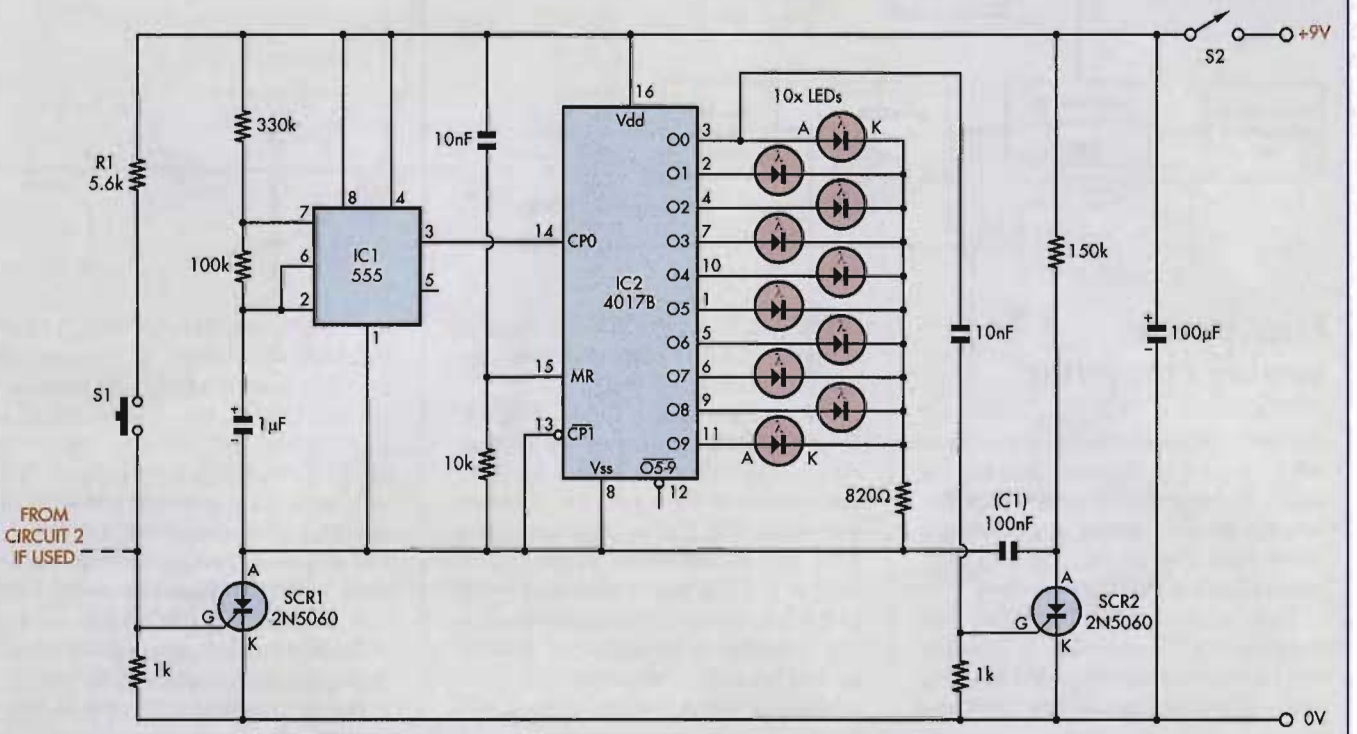


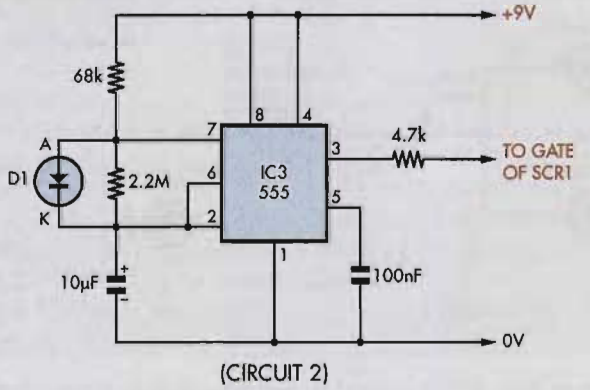
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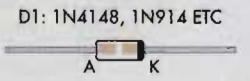
CIRCUIT NOTEBOOK

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.





(CIRCUIT 2)







Tricks with a 4017 chaser

This circuit uses two SCRs in conjunction with a 4017 decade counter/divider so that its 10-LED output cycles only once after each press of a button. This could be useful for door chimes, an eye-catching LED signal, a countdown timer or a time-out signal for a quiz game.

Initially, both SCRs are off and the circuit does not operate. On pressing switch S1, SCR1 is turned on to apply power to the circuit comprising 555 timer IC1 and a 4017 counter (IC2). The 555 timer sends pulses to the 4017 counter which turns on each of its 10 LEDs in turn. The auto reset components connected to pin 15 of IC2 ensure that its output 0 (pin 3) goes high first.

After a pulse has sent output 9 (pin 11) high, then next pulse sends pin 3 of IC2 high and this sends a trigger pulse to the gate of SCR2 via a 10nF capacitor. SCR2 turns on and commutates SCR1 off, by removing voltage from its anode which stops the entire circuit.

The first press of S1 does not trigger SCR2 because pin 3 of IC2 is already high (by virtue of the auto reset) and therefore no trigger pulse can be delivered (to SCR2).

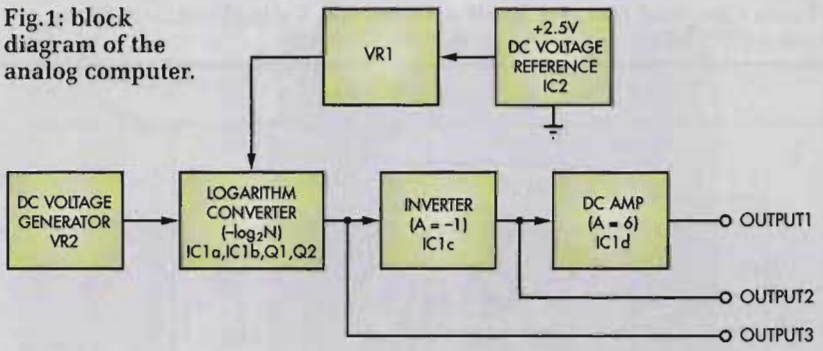
Pressing switch S1 will then restart the cycle. If you want to alter the speed of operation, just increase or reduce the 1µF at pin 2 of IC1.

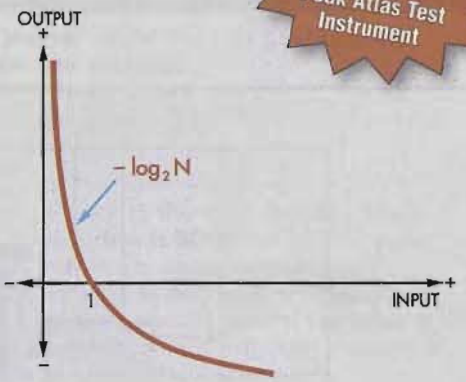
To provide repetition of the 10-LED display just connect Circuit 2 to the gate of SCR1. This is another 555 astable timer (IC3) which triggers SCR1 at intervals determined by the timing components connected to pins 7, 6 & 2 of IC3.

A. J. Lowe,
Bardon, Qld. ($40)

Malcolm Sharp is this month's winner of a Peak Atlas Test Instrument

Fig.1: block diagram of the analog computer.





Low-power analog computer

These days, digital computers are ubiquitous but there was a time when analog computers were more commonplace and they still have an advantage for certain applications. They also do not require any programming (as in written code).

This circuit will compute the logarithm of a number (N) using the base 2 system. To convert it to base "e" (2.718), use the function $1.4427\log_e N$, where N is the number entered. It will also compute the similar function $20\log_{10} N$.

As shown in the block diagram (Fig.1), the circuit can be broken down into four sections: a logarithm converter & inverter, DC voltage reference IC2, DC voltage generator VR2 and DC amplifier IC1d.

The heart of the circuit (see Fig.2) is the logarithmic converter involving op amps IC1a-IC1c and transistors Q1 & Q2. It works on the principle that the collector current in a transistor doubles for every 18mV increase in voltage at its base (at 20.3°C). The 56kΩ & 1kΩ feedback resistors from the output of IC1b give the required voltage attenuation of .018 needed for this effect. The output of IC1a provides bias to the emitters of transistors Q1 & Q2.

IC2 generates a +2.5V DC reference voltage. Together with VR1, this voltage and the 200kΩ resistor generates a reference current for the logarithmic converter to act on.

Potentiometer VR2 provides a

Loud repeater for traffic indicators

Many older drivers cannot hear the clicking of the traffic indicator lamps and so may forget to cancel off the indication after changing lanes. These add-on circuits use a 12V piezo buzzer to give a much louder indication.

The simple circuit of Fig.1 uses two diodes to sense the presence of +12V across the left or right turn indicator lamps. The commoned signal is fed via potentiometer VR1 which acts a volume control for the piezo buzzer. The 4.7V zener diode reduces the overall signal voltage, otherwise it would be far too loud.

The drawback of this circuit is that its indication becomes rather too insistent after a period, especially if there are passengers with keen hearing. The solution is to add a 555 timer to the circuit – see Fig.2.

Here, the diodes are now used to derive the power for the circuit, as they feed a 3300µF 25V capacitor. The 555 is configured as a standard timer and trimpot VR1 is set to sound the buzzer for every two to six flashes of the turn indicator lamps.

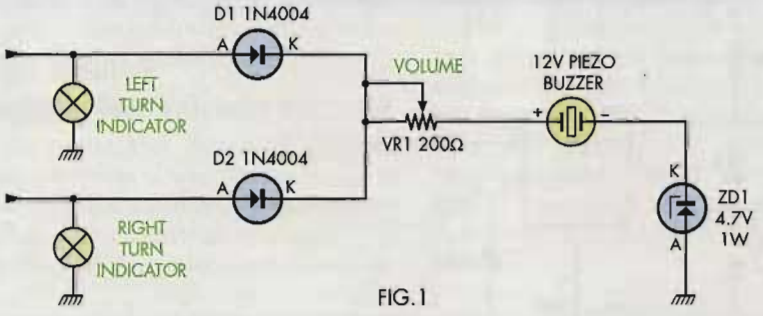


FIG.1

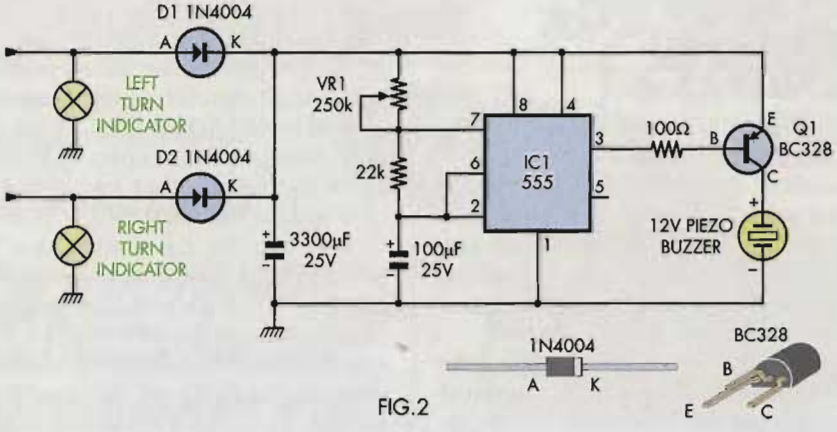


FIG.2

This has the advantage that when the turn indicators are cancelled, the sound from the piezo decays in a chime effect.

The 12V piezo buzzer is available from Jaycar – Cat. AB-3459.

Robert Baker,
Miranda, NSW. ($40)

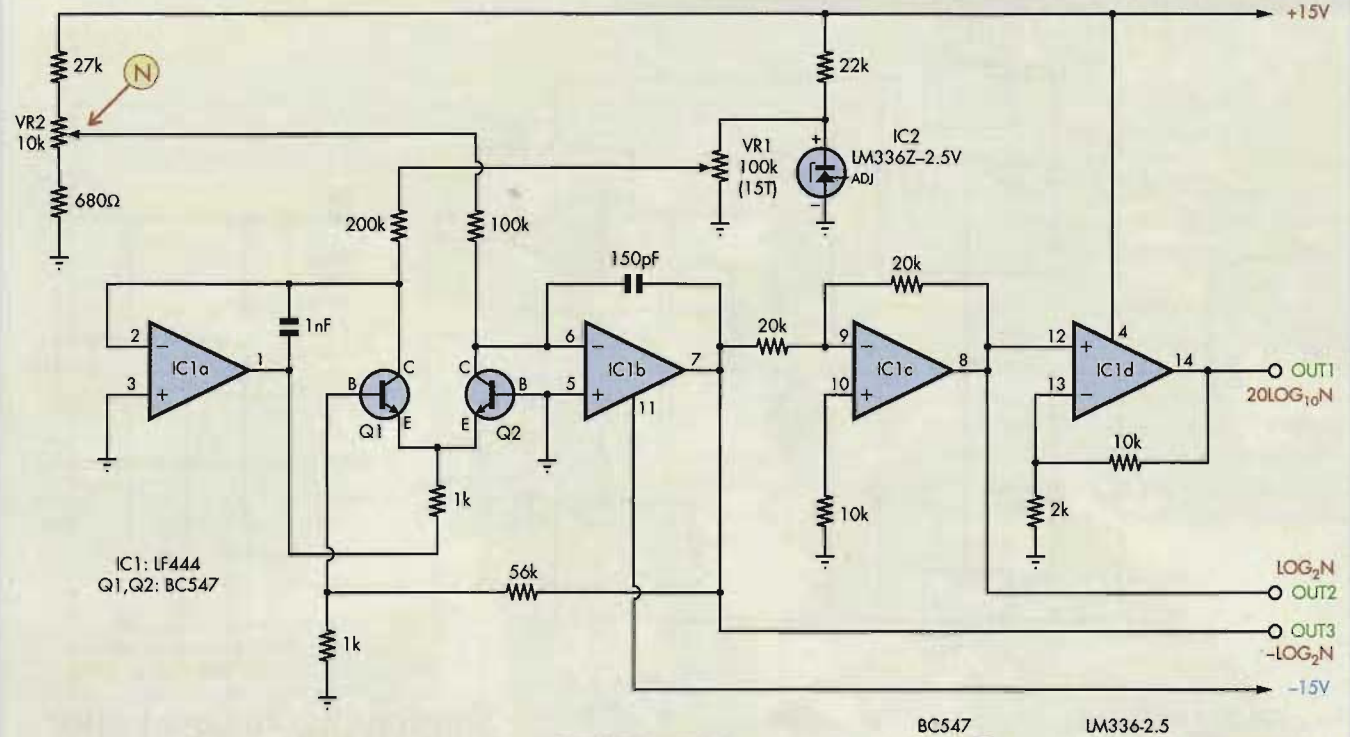




Fig.2: the complete circuit. It's based on a logarithmic converter involving op amps IC1a-IC1c and transistors Q1 & Q2.

variable DC voltage source to generate the number (N) entered into the logarithm converter, ie, the voltage on the wiper of VR2 represents the number, N, to be computed.

The output at pin 7 of IC1b is $-\log_2 N$ while op amp IC1c multiplies this result by -1 (ie, inverts the signal) to give the function $+\log_2 N$ at its output.

Finally, op amp IC1d is used to multiply the function on the output of IC1c by +6 to give the overall function $+20\log_{10} N$ at its output.

Calibration is as follows: adjust VR2 until +1.00V is on its wiper and then adjust VR1 until the output of IC1b reads 0.0V. Once calibration is done, you simply dial in your number via VR2 and let the circuit compute the logarithm; no need for a calculator!

Because the entire circuit is a DC amplifier, temperature changes can play havoc with it. The LF444 quad op amp minimises this problem to some extent. The accuracy of the circuit can be within 2% for a temperature range of 18-22°C.

There is one more interesting feature this circuit possesses. By feeding in a sinusoidal waveform superimposed on +2V DC in place of VR2, the output of IC1b (or for that matter IC1d) resembles a parabolic wave. The point of inflexion in this wave can be moved by increasing the amplitude of the sinewave, a similar effect to integrating a sawtooth waveform.

Malcolm Sharp,
Berala, NSW.

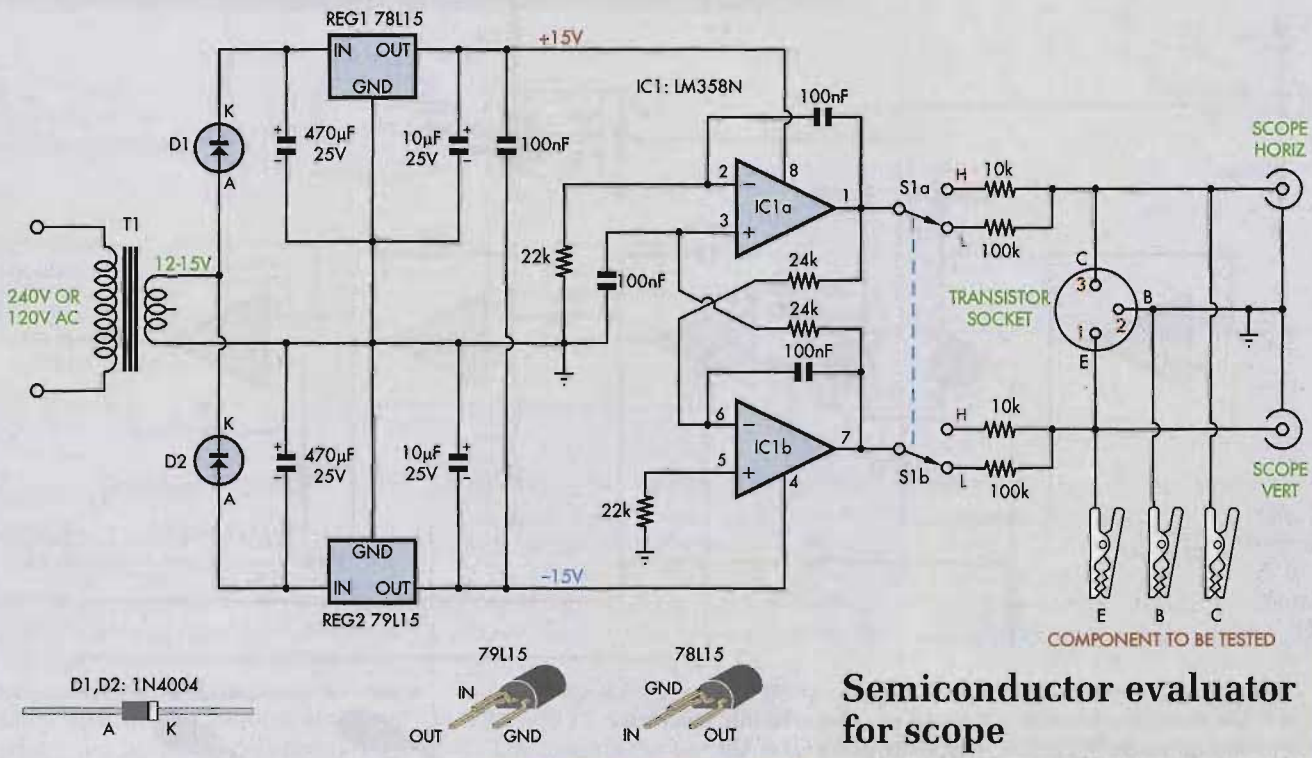
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STATUS	PNP	NPN	SCR	UJT	DIODE	BASING
GOOD						PNP OR NPN: 2 B, E 1, C 3
B–C SHORT OR E–B2 SHORT						
B–E SHORT OR E–B1 SHORT						
E–C SHORT OR B1–B2 SHORT						SCR: 2 G, K 1, A 3
B–C LEAKAGE OR E–B2 LEAKAGE						
B–E LEAKAGE OR E–B1 LEAKAGE						UJT: 1 E, B2 3, B1 2
E–C LEAKAGE OR B1–B2 LEAKAGE						
E OPEN OR G OPEN						DIODE: 1, 3, A, K
C OPEN OR B2 OPEN						
B OPEN OR B1 OPEN						

Semiconductor evaluator for scope

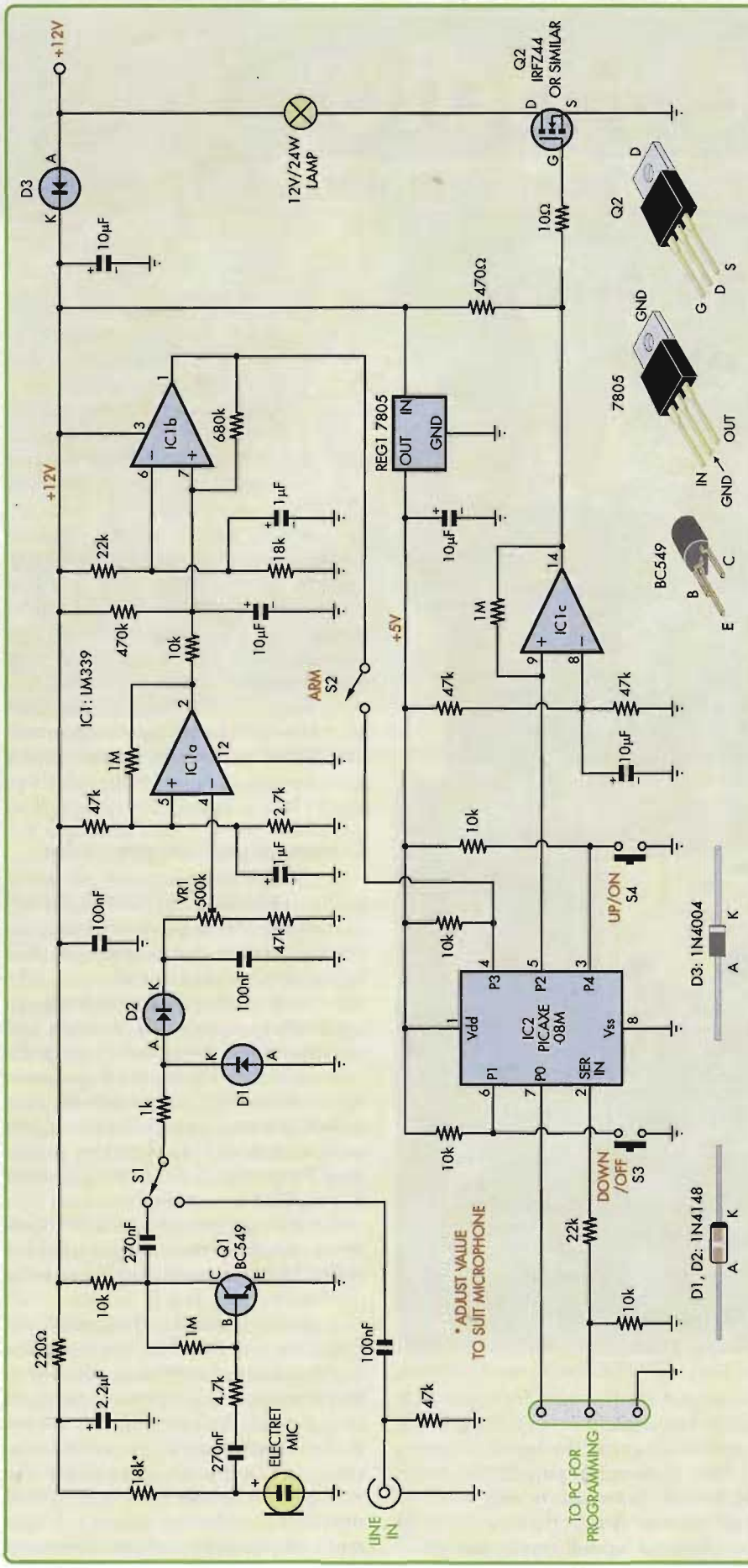
If you have an oscilloscope that can be operated in X-Y mode (ie, with horizontal timebase turned off), this circuit can be the basis of a useful semiconductor evaluator. It can help identify unknown semiconductors where you can no longer read the labelling. For example, it will distinguish between a diode and a zener diode, between NPN and PNP transistors and also identify SCRs and unijunction transistors (UJTs).

The circuit comprises two interconnected op amps (IC1a & IC1b) which generate sinewave signals which are 90° out of phase. These signals are then applied via the two sections of switch S1 to the horizontal and vertical inputs of the oscilloscope and to the socket for the component to be tested. The switch selects 10kΩ or 100kΩ resistors, depending on whether the component is a small signal device or power device.

Depending on the type of device being tested and whether or not it is faulty, the circuit will produce characteristic waveforms which are shown in the accompanying panel. Note that these waveforms are not definitive and will vary with the particular component being tested.

Note that when no component is connected, the oscilloscope controls should be adjusted to give a circular pattern.

Craig Kendrick Sellen,
Carbondale,
Philadelphia, USA. ($45)



Bedside lamp controller

Do you hate the bright glare as you switch on your bedside light when the alarm goes off? This circuit uses an electret microphone to pick up the sound of your alarm. It then slowly brings up the brightness of a bedside lamp made from a 12V 24W automotive tail/stop lamp. The result is that you wake to a much more pleasant situation.

When you stop the alarm, the lamp remains at the current brightness level. If you press the snooze button on the alarm, the lamp will become brighter next time the alarm sounds.

You can turn the lamp off whenever you wish by pressing the DOWN/OFF button. The system can also be disarmed if you don't want the system to control the lamp. The lamp can also be manually dimmed up and down using the UP/DOWN buttons.

The electret microphone signal is fed to BC549 transistor Q1. The amplified signal from Q1 is then rectified by a charge pump consisting of diodes D1 & D2 and a 100nF capacitor. The resulting DC is fed to trimpot VR1 which acts as a sensitivity control for the following comparator stages using IC1a & IC1b.

When the DC level at pin 4 is above the reference level at pin 5, IC1a quickly discharges the 10µF capacitor at pin 7 of IC1b and this causes the output of IC1b (pin 1) to go low. This low is sensed at pin 4 of the PICAXE microprocessor (IC2). As a result, IC2 now starts to turn on the lamp via comparator IC1c and Mosfet Q2.

The PWM signal from pin 5 is 5V peak but the Mosfet needs around 10-12V on its gate to fully turn on. Because the comparator outputs are "open collector", IC1c is able to perform signal level translation to convert this 5V signal to a 12V signal. The 470Ω resistor pulls the gate to +12V whenever the PWM signal goes high.

The software listing (BLC_4.bas) will be available on the SILICON CHIP website and is fully commented to make it easy to understand.

Jeff Monegal,
North Maclean, Qld. ($40)

Vintage Radio



By RODNEY CHAMPNESS, VK3UG

The Australian Army Signals Museum



This photo shows the WW2-era WS122 portable HF radio transceiver at top (without its power supply) while below it is a WS22 transceiver. The latter was a low-power (1.5W) HF unit covering 2-18MHz over two bands.

This month, we take a look at an interesting museum that's dedicated to the display of ex-Australian Army radio equipment. It's not often that you get the chance to see a collection of military communications gear.

TECHNICAL MUSEUMS have always interested me and I endeavour to visit them whenever the opportunity arises. Recently, an opportunity to visit the "Royal Australian Army Corps of Signals Museum" at Macleod in north-east Melbourne presented itself. I was fortunate that Major Jim Gordon was able to give me a personal tour of the facility.

This museum is part of the Army Museums Network, which itself is part of the Army History Unit. It commenced operation in the early 1950s at Balcombe where members of the School of Signals initially set up displays of equipment that was being phased out of use by the army. The museum was subsequently moved to its present location in Macleod in 1970, where it was housed a redundant satellite monitoring facility from the Cold War era.

It probably seems ironic that a museum is housed in a building previously used for the very "high-tech" satellite-monitoring task. In fact, the redundant monitoring station equipment still occupies some 60% of the floor space, which means the museum cannot display all of its stored equipment until the redundant equipment is removed. Two 600kVA emergency power plants are also still installed, although these are no longer operating.

Communications pre-radio

Although our interest in army communications is predominately concerned with radio, it is interesting to consider how armies communicated before radio was invented.

In very early times and even up until relatively recently, runners and couriers were often used to keep the commanders informed of progress on the battlefield and to deliver their orders. Horse-mounted dispatch riders were commonly used before giving way to motorcycle dispatch riders during WW2.

Courier pigeons were also commonly used by many armies up until WW2. In fact, they were still in use by the Swiss Army as late as 1994.

A variety of sound and visual signalling methods were also used over the centuries. Most were labour intensive and messages usually took quite some time to reach their intended recipient. However, some methods proved relatively fast in transferring signals. For example, the heliograph was an optical device that reflected strong sunlight and had quite a long range when used



Australian diggers pre-WW2 with a WT Set C Mk.2 "Cork Set". It took no less than nine soldiers to support and operate this equipment which was used by the Australian Army during the 1930s.

from hilltop to hilltop.

It was used from around the 1850s and even saw limited use in WW2.

Radio communications

With the invention of Morse code and the telegraph, communications from fixed locations became quite speedy. Insulated single and twin cables were often laid underground for fixed locations and on the surface for much more temporary installations.

Some readers will be familiar with the D-series (commonly called Don 5 by the layman) twin-insulated cable. This had one green and one black wire and was commonly available in disposals stores after WW2. This cable could be run out from a hand spool or more commonly from a cable-laying trailer.

Wired communications developed at a pace during WW1 and a variety of systems were used. Some using a single wire with an earth return proved not to provide secure communications. After all, one side of a conflict did not want to have the other side reading their messages.

To overcome this, the D-series cable and other similar twin cables were introduced. At around the same time, a telephone system using equipment called a "Fullerphone" provided much more secure communications than some other methods of the same era. The history and use of wired communications in the army and civil life is in itself quite an extensive and interesting story.



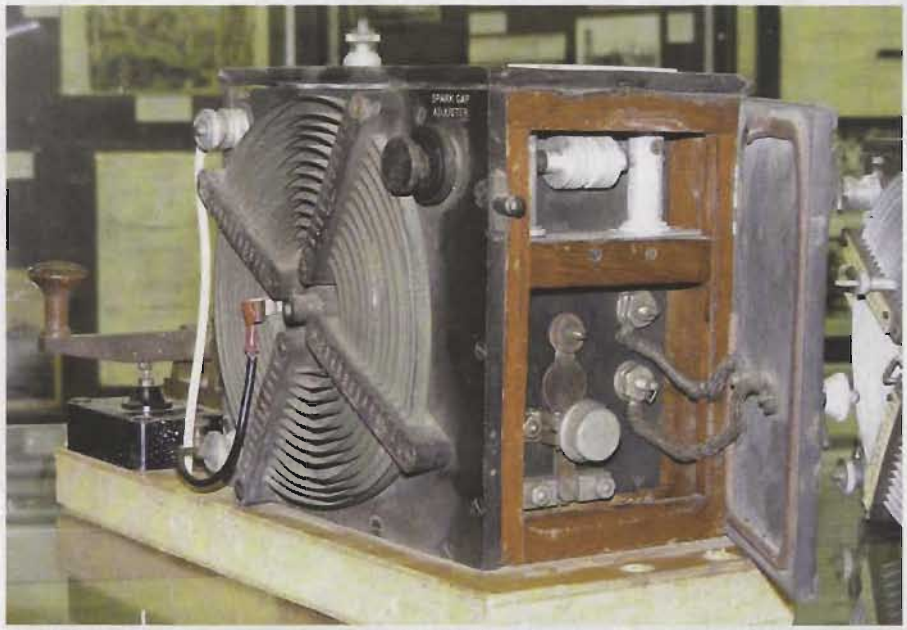
Designated the Model 94 Mk.6, this portable radio was used by the Japanese army during WW2. It operated over the 24-47MHz frequency band and could be powered from external 3V and 135V batteries or from a hand generator.

Wireless in WW1

Wireless communications were first



The WS208 was one of the first low-power sets to be used by commando units during WW2. This CW-only 6-valve set was carried in a back-pack and had an operating frequency range from 2.5-3.5MHz.



Made by an English War Department Wireless Factory during WW1, the WT1 transmitter was fitted to reconnaissance aircraft from 1916. The pilot's task was to transmit enemy troop deployments back to HQ and to artillery batteries.

used by armies during WW1. Wireless had been around in its fledgling form since the turn of the century and was now sufficiently advanced enough for use by the military.

However, it was not enthusiastically endorsed by all sections of the military because it was still relatively undeveloped. The main problems included the bulk and weight of the equipment, its unreliability and a lack of competent radio technicians to handle the gear.

At that stage, wired telephone and telegraph systems were well developed and worked well. However, the amount of wiring needed between each communications site had grown enormously and the system was inflexible due to the rapidly changing nature of the conflict.

It didn't take long for many forward-thinking military leaders to realise that "wireless" was the way to go if communications with the front line were to be effective and timely. It was just a matter of waiting for suitable equipment to be developed.

The first wireless sets in WW1 were Marconi pack sets. These required four horses to carry each pack set plus five or six men to set up a station, which took around 10 minutes! It then required two soldiers to operate it.

The range was claimed to be around 50km.

In 1915, another set called the BF was introduced, which had a range of around 17km. This meant that "portable" battery-operated spark transmitters with valve receivers were starting to be used at the front line. However, in 1915, "portable" meant that the set could be carried with difficulty by several soldiers.

Most of the sets worked on quite low frequencies which meant that their antennas were inefficient if made too small. For example, the Wilson spark transmitter worked on three wavelengths – 350 metres, 450 metres and 550 metres. However, some small spark transmitters operated on 65 and 80 metres.

By this stage, some aircraft were also being equipped with transmitters to report conditions back to headquarters from behind the front lines and to adjust the fall of artillery. The WT1 transmitter from 1916 was one of the sets used for this task and is shown in one of the photographs.

For the troops in the front line, progress in radio communications was slow but steady during WW1. During this time, low frequencies were still thought to be the most useful for long-distance communications. It was not until the 1920s that amateur experimenters proved that shortwave (high-frequency) communications were much more effective.

Perhaps the most successful "trench wireless" during WW1 was a unit developed by the British in 1917. This had a range of around 70km but if it had used shortwave frequencies, it would have been well ahead for its era. However, it was still a good performer and despite its limitations, it remained in service until the 1930s.

The post WW1 era

Developments in radio communications for both military and commercial use picked up speed during the 1920s and 1930s. In the early 1930s, the C Mk.2 "Cork Set" was being used by the Australian Army. It required no less than nine soldiers to look after it and is shown in one of the photos. Subsequently, by the time WW2 arrived, equipment like the No.11 set, the 101 and the FS6 were in use (an article on the FS6 appeared in the May 2002 issue).

During WW2, other more advanced transceivers, transmitters and receivers were developed to cater for the needs of the military. This equipment included the No.19, which was used in tanks, and the 22/122. Both were semi-portable transceivers that could be back-packed into remote areas and were good performers for their era (the 122 was featured in an article in October 2002).

Another well-known set was the AT5/AR8. Developed by AWA for the RAAF, this 50W MF/HF transmitter/receiver combination was also often used for low-power base station work and in shipboard installations.

Yet another interesting set is the 108. This was one of the first backpack or "walkie-talkie" sets and it's closely-related sibling, the 208, was one of the first low-power sets to be used by commandos. The 108 was described in the November 2006 issue.

Following WW2, the 62 replaced the 122 and the 108 was replaced by a much superior back-pack set designated the 128.

Radio communications equipment



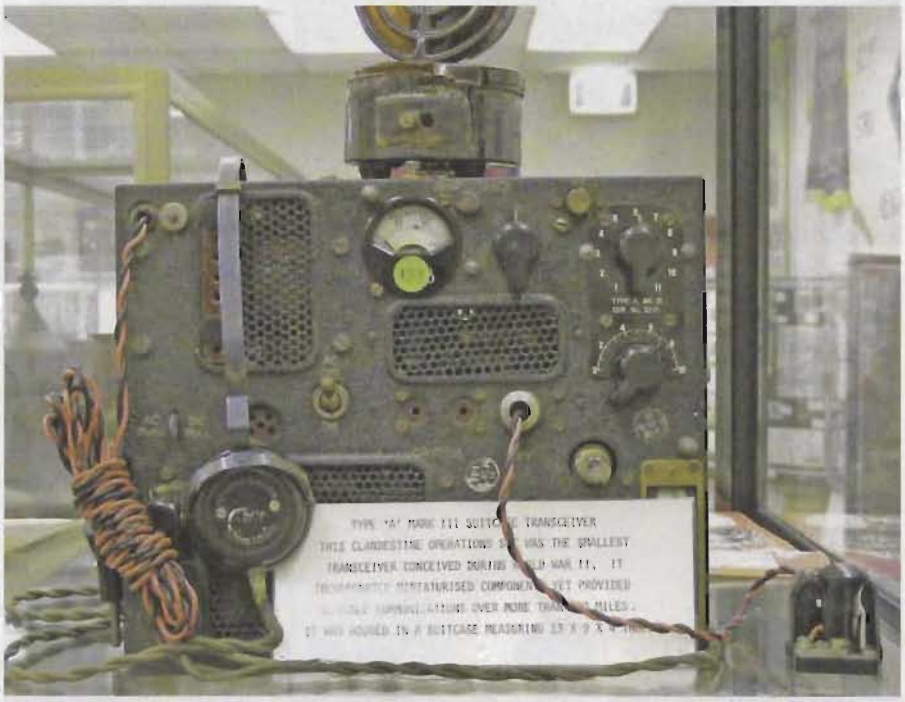
Major Jim Gordon, the Officer In Command of the museum, with a WW2 101 military transceiver.



A close-up view of the WT Set C Mk.2 used by the Australian Army during the 1930s. It required lots of support equipment.



The 62 portable transceiver (left) and the 128 back-pack transceiver (right) replaced the 122 and the 108 transceivers in the years following WW2.



The type "A" Mk.3 "suitcase" set was the smallest transceiver to be developed during WW2 and was commonly used by resistance groups and for clandestine operations in Europe. It used miniaturised parts and had a range of over 160km.

played an important role behind enemy lines during WW2. Sets such as the Type 3 Mk.2 and the Type A Mk.3 transceivers, plus the MRC-1 receiver, were commonly used in Europe by various resistance movements. The Type 3 Mk.2 and the Type A Mk.3 were described in the October 1998 issue.

Of course, much larger and more powerful transmitters were used to ensure reliable long distance communications. A good example is the AT20 which had an output power of 500W.

WW2 receivers

A number of communications receivers and amenities receivers were also produced during WW2. These included sets such as the AMR300, the HRO and AR7 communications receivers, along with the No.4 general entertainment (amenities) receiver.

General overview

From this short story, it can be seen that this museum caters for well over 100 years of military communications. It really is fascinating to see how things were done over the years and the explanations given by Major Jim Gordon helped me to understand why things were done the way they were. It is rare to have the opportunity to learn the rationale behind communications developments.

Most radio collectors concentrate on domestic radios and as such tend to shun military equipment. The reasons aren't hard to find – it is generally visually unappealing and quite complex technically. However, I think that all radio enthusiasts should consider having at least one piece of our military radio communications history in their collection. We think that our domestic radios are complex (and some are) but it was the military equipment that lead the way in technical innovation.

By the way, although most of the museum's display is indoors, there were also a few large items undergoing restoration in the compound. Many of these are post WW2 semi-mobile, high-technology communications and surveillance units that were mounted in trailers and vehicles.

My favourite gear

One highly-innovative piece of equipment from WW2 is the 122 high-frequency AM/CW transceiver. It's one of my favourites bits of gear and it used aluminium extensively to keep its weight down.

It also featured a semi-break-in Morse code facility, a press to talk (PTT) dynamic microphone and a metering system that allowed reading of all vital operational indicators. It was also well-sealed against moisture ingress. In fact, it could probably survive an accidental dunking in water with no ill effects.



This photo shows an AT5/AR8 MF/HF transmitter/receiver combination. It was commonly used as a low-power (50W) base station and was extensively used in RAAF aircraft and in shipboard installations during WW2.

The set ran from 12V and had quite a low current drain – about the same as many transistorised car radios, in fact. I could rave on about it for some time but the point I want to make here is that a large number of its facilities and innovations were not incorporated into domestic sets and communications receivers until 10-20 years later.

Summary

Like most good museums, this museum is still a work in progress. However, Jim would like to have more volunteers to assist in restoring equipment, setting up displays and guiding visitors around the museum.

Currently, due to staff shortages, the museum is usually open between 10am and 3.30pm on Tuesdays only. The entrance fee is just $2 and the museum is located in the Simpson Barracks. The entrance is from Greensborough Road, just south of Yallambie Road.

If you feel that you can assist as a volunteer or have some redundant military equipment which could be of value to the museum, please contact Major Jim Gordon on 0407 264 961 or contact him via e-mail at **jim.gordon@vicsig.net** SC



The WW2-era 108 back-pack transceiver was designed for use by infantrymen at battalion or company level. The Mk.2 version (1941) tuned from 6-9MHz, while the Mk.3 (1943/4) tuned from 2.5-3.5MHz and included CW as well.

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SLA battery charger

I have a few questions regarding an old SLA charger (Powakaddy 1999) and I hope you can help me to sort out some problems. First, there is no voltage across the alligator clips (with no load and just the voltmeter) and the regulator measured 24V. Is it true some chargers register 0V until connected to a battery?

The black negative output lead consists of three wires and is sort of terminated as one single wire before it's soldered to the alligator clip. I think the two wires incorporate a thermistor measuring the temperature near the battery. Would it be an NTC type? What is a typical value? 500Ω?

Unfortunately, I replaced the leads and have had no luck surfing for a schematic of the charger. (E. W., via email).

- It is possible that your charger does not deliver an output unless a battery is connected. Try connecting a large electrolytic capacitor (say 1000µF) across the output leads together with a shunt resistor of 100Ω or so. This will simulate a battery but depending on the complexity of the charger, even this may not work when you make a measurement.

The thermistor would be a NTC (negative temperature coefficient) type but you need to know the specified value as there is little point in making blind guesses.

Frequency indicator query

Could you tell me if any circuit modifications or misprints are associated with the "Frequency Indicator For Generating Equipment" featured in the Circuit Notebook pages of your May 2008 issue? I have built the unit, checked the circuit, connections and components several times. I can only get the LEDs running continually through a decade count and no variation on adjustment of VR1.

I am testing it with transformer T1, plugged directly into the mains. I know these are contributors' circuits and not yours. (R. C., via email).

- If the LEDs just run as a chaser, it suggests that Q1 is on permanently. You need to carefully check the connections around ICIc, IC1d & Q1.

Time To Get A Bigger Battery

I am working on a project that will turn on several different incandescent 12V lights using relays powered by a small 1.3Ah SLA battery. What I have found is that the battery voltage drops quite a lot when the lights are turned on, due to the large load, but what I am concerned about is that if this voltage drops too much it could reset the microcontroller that is being used to switch the lights on.

The light ratings are:

Relay 1: 3 x 6W
Relay 2: 1 x 18-21W
Relay 3: 1 x 18-21W
Relay 4: 2 x 18-21W

No more than two relays will be on at the same time. Is there any way of reducing this drop in the battery? If I added largish capacitors on the output of the 5V regulator, would they be able to provide a short supply of power until the lights are switched off, as they are only turned on briefly, for less than two seconds? Or should large capacitors be added across the input to the regulator?

Can you provide any ideas? (B. W., via email).

- By the sound of it, the battery is not big enough. You have to consider that an incandescent lamp will pull surge currents of 10-15 times its normal rating at the instant after switch-on. With a 21W unit, its surge rating can be anywhere between 17.5A (10 times rating) to 26.5A. The battery certainly cannot supply this current without drooping.

The solution is to use a bigger battery or use high-brightness LEDs instead of incandescent lamps.

Interference from High Energy Ignition

I get radio interference from the High Energy Ignition kit. I added a power line filter and also an aerial filter as the noise only comes through when the radio is playing – no noise comes through when the CD is playing.

I have tried placing the HEI as far away from the aerial and radio as possible. I even converted the ignition back to the standard Chrysler electronic ignition and have no interference at all. So it's obviously being generated by the HEI. Any suggestions, please? (W. S., via email).

- The causes of interference from the High Energy Ignition (HEI) could be a poor earth between the diecast case of the HEI and the vehicle chassis. Alternatively, a suppression capacitor may be required between the coil output from the HEI and chassis. Use a 220nF 240VAC class X2 capacitor or use a suppression capacitor available from automotive shops suitable for ignition coil suppression.

GPS clock power supply

I have recently purchased a Trimble Thunderbolt GPS-disciplined Clock (**http://trl.trimble.com/docushare/dsweb/Get/Document-10001/ThunderBoltBook2003.pdf**), without a power supply. The unit comprises a GPS receiver and ovenised quartz crystal oscillator and provides 10MHz sine-wave and 1 PPS square-wave outputs with high precision and accuracy.

The unit requires ±12V, +5V DC, with 750mA on +12V, 10mA on -12V, and 400mA on +5V. Note that I have it on good authority (**http://www.leapsecond.com/pages/tbolt/power.htm**)

Deep-Cycle Batteries Must Not Be Heavily Discharged

With reference to the letter titled "Incompatibility Between Smart Charger & and Digital Inverter Generator" in Ask SILICON CHIP for October 2008, I thought I might relate some of my experiences with an off-grid power setup.

We have a pair of 100Ah batteries, a 1500W pure sinewave inverter, a 300W windmill and two generators (petrol 6.5kW and diesel 900W). The system is set-up to run the 24V inverter so the windmill is also 24V and the batteries are in series.

The first thing that raised its ugly head was the fact that although the batteries are 100Ah, a warning written on the second one I bought said not to take it below half charge or this would compromise its life.

So instead of having 24V and 100Ah capacity I effectively had only 50Ah available. It is worse than that though, as in practice I can get only about 600W stored in the batteries.

That aside, the generators pose some interesting questions. They are both self-exciting generators out of China and are generic brands. The basic operating principle is that the rotor has a winding with what looks like big zener diodes to limit the voltage in the winding. A small magnet is buried in the rotor to start the magnetic field, once the rotor is turning. The stator has the main winding for the output and another winding which is tuned by a capacitor to be resonant at the output frequency.

Set up correctly, this gives a reasonably stable output voltage with varying loads. The output from both these generators is more a square wave than a sinewave and it contains a high level of a higher frequency components (around 300Hz from my scope and frequency meter). This high-frequency component plays havoc with our washing machine which will not even switch on when plugged into the 6.5kW generator but runs faultlessly on the inverter.

We also use a couple of 12V switchmode battery chargers to charge the batteries when the generators are running. They work perfectly on the 6.5kW generator but on the smaller 900W generator one of the chargers gets upset and its charging current (which is a 3-stage automatic system) drops off way below the voltage it is supposed to. The other charger performs normally.

My batteries are now difficult to charge, coming up to the limiting voltage (14.2-14.5V) in less than two hours at a 12A charge rate and thus have a capacity of maybe only 20Ah. Do you have any suggestions on how to improve the batteries' capacity?

Also, is there any way of filtering or modifying the generators to get a better waveform out of them so they can run switchmode power supply devices more successfully? (K. C., Tauranga, NZ).

● It may seem like a paradox but you cannot heavily discharge deep-cycle batteries repeatedly. It sounds as though your batteries may have become sulphated. You might want to try out our Battery Zapper project to recover their capacity. This project was in our May 2006 issue.

that after the initial oven warm-up, the unit only consumes about 160mA on the +12V rail and 260mA on the +5V rail.

Would the October 2005 Studio Series Preamplifier Power Supply be appropriate for this application? I plan to replace the 100Ω resistors between the Output and Adj pins of the LM317 and 337 regulators with 130Ω. My calculations show that this would give me ±11.83V (11.88V if you include the 55µA ADJ current).

Would the heatsinking arrangement be sufficient? Should I choose a transformer with 12V/12V rather than 15V/15V? If I choose a 12V/12V transformer, would I have to adjust the value of the 5W dropping resistor on the input of the 7805 regulator? Is the measured current draw on the -12V rail (3mA) sufficient to maintain regulation of this output? (S. M., Mawson Lakes, SA).

● The suggested power supply should be ideal for your application, with the change to make it 12V. Without knowing your local mains voltage, we would be inclined to stick with the specified 15V/15V transformer.

Bigger charge controller wanted

I read the project article on the "Charge Controller For 12V Lead-Acid Or SLA Batteries" (April 2008) and I am wondering whether it's possible to upgrade the capacity of the design to handle 20, 40 or even 60A charging.

There seem to be a lot of commercially available units from the USA (especially Xantrex) and a lot of cheaper ones coming out of Asia but they all seem to be focused on solar and wind systems. I feel that your design is not only simpler (less problems in future) but also better suited to my needs. What do you suggest? (D. B., via email).

● The circuit can be used for higher charge currents if the fuse and Mosfet are placed off board and the wiring and components are upgraded. The terminals for the negative supply would need to connect at the same point rather than via the short PC track.

The Mosfet would need to be suitably rated and mounted on a heatsink. The 20A rating could use the specified Mosfet but with a 20A fuse and fuseholder and heavier duty wire. For a 60A rating, a Mini-bloc SOT-227B package for the Mosfet is ideal as it has screw terminals rather than small diameter leads. The IXFN200N07 (Farnell Cat. 490-5659) is rated at 70V and 200A – www.farnellinone.com.au

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Cures For Battery Zapper Problems

Sometime ago, I started assembling the Deluxe Lead-Acid Battery Zapper Kit (SILICON CHIP, May 2006) and recently, I finally finished it! However, I noticed a variety of problems. In particular, I noticed that all the battery condition LEDs are lit when the battery voltage is at about 6V. This seems to be due to the supply voltage on the LM3914 (IC5) being no higher than the voltages at pins 5 & 6.

This situation arises because of the voltage drop across D5 and the 100Ω 5W resistor. To make matters worse, even more voltage is dropped as the LEDs draw twice the current at the transition between comparator levels because the LED drive terminals are paired up.

I recommend two actions: (1) add one 330Ω resistor in series with all the LEDs to limit their current drain; and (2) fit a fast recovery or Schottky diode between the 6V terminal on rotary switch S2c (ie, at the 1kΩ resistor to LED7) and the cathode of zener diode ZD4, thus bypassing the 100Ω resistor & D5 when operating at 6V. This will raise the supply voltage to the LM3914. This worked in my unit though the voltages on the LM3914 are still near critical.

I also noticed that the battery-condition-check function didn't operate consistently. This was due to the 4093 oscillator section running far too fast – 250Hz when it should have been 66Hz. Replacing the original 4093 brought that down to 145Hz and certainly helped the situation.

The 10µF capacitor at pin 5 on IC5 now had 7ms charging time but not the 15ms mentioned in the article. In my case (ie, mostly 12V operation), increasing the 82kΩ resistor at pin 8 of the 4093 to 150kΩ or so should correct that, though obviously 4093 ICs can vary quite a lot. (M. M., Dunedin, NZ).

- Thanks for those suggestions.

The fuse and its holder would also need a rating to suit your current requirements.

ULN2003 Darlington array query

I am looking to use the ULN2003 to drive a number of relays, using outputs from a PIC16F88 micro. In some articles, I have seen a resistor between the PIC output port and the input to the ULN2003 and in other cases, there is none.

The current through the relay coil isn't very large (35mA), so when would I need to use this resistor and is there something on either the PIC or ULN2003s data sheet to indicate if I need it? (B. W., via email).

- There is no need for a base resistor because there is already a 2.7kΩ series base resistor for each transistor in the ULN2003. Base current with a 5V output from the PIC would be about 1.4mA.

If you want to reduce the current used by your circuit, you can use a 7.5kΩ resistor at each ULN2003 input, to reduce current to 372µA. The collector drive current for the ULN2003 with 372µA base current is 200mA for a 1.3V (typical) collector emitter saturation voltage.

DC-DC converter causes radio interference

This is an old design by Peter Smith in SILICON CHIP, March 2004, and subsequently also published in the UK magazine EPE for June 2007.

I built one from a kit by Altronics and it works fine at producing the 9V, as designed. I thought it would be a great idea for use with an old restored Australian Kriesler radio that used a 2362 battery, as I could not fit six AA or AAA cells in the space available.

Unfortunately, the device puts out a terrible whine that seems impossible to overcome, even by wrapping the whole thing in aluminium and grounding it to the chassis. I twisted and shortened the input battery leads and the output leads to no avail.

It would be a perfect solution for this application if I could suppress the whine. Any ideas or suggestions? (R. G., via email).

- There are two specific reasons why your radio is picking up the whine. The first is direct radiation from the inductor and the input and output leads to the PC board. The other is the residual high-frequency switching ripple which will be superimposed on the 9V output.

We would expect the ripple to be pretty low so that leaves direct radiation. The best way to suppress this is to keep the inductor away from the radio's antenna and second, mount the whole device in a steel box.

Modern TVs don't have enough analog inputs

I just managed to get an 81cm LCD TV. The set works just fine but the problem is that it has three remote-selectable HDMI input sockets and only one analog A/V input. There must be thousands of others like me who have a HDD video recorder and a DVD player with only analog outputs but have a new TV with (mainly) HDMI inputs.

There must be a market for a video converter with a minimum of two analog A/V inputs and corresponding HDMI outputs. I was offered amplifiers with video processing starting at around $1000, well out of my price range. Has SILICON CHIP ever published or considered such a project? (M. H., via email).

- Yours is a common problem but I don't think we could justify the resources we would need to apply to produce an A/V to HDMI adapter. The only other way around it is to use an A/V switcher.

Knock sensor for after-market ECU

I have an enquiry about the " Knock Detector For The Programmable Ignition" in the June 2007 issue of SILICON CHIP. How does this unit connect or interface to an ignition system?

I have an aftermarket ECU which controls fuel and ignition and I have the ability to use an auxiliary input on my ECU to retard timing. To trigger this, I must supply +12V to the auxiliary input wire.

Can this knock detector deliver +12V or ground signal when it detects knock? Also, I imagine the trimpot on the circuit board is used to adjust sensitivity of the knock sensor? (R. M., Kingsgrove, NSW).

- The knock detector was designed

specifically for the Programmable Ignition system featured in the March, April & May 2007 issues of SILICON CHIP. However, it does deliver a +12V signal when knock is occurring so it could suit the same purpose with your ECU.

Give it a try but we cannot guarantee that it will work with your setup.

Courtesy light delay confusion

My original "Car Courtesy Light Delay" kit stopped working after five years. I bought the new "improved" model from Jaycar – Cat. KC5392.

It seems this kit does not cater for a single-earth at the door like the old kit did. The new instructions assume that the single wire is positive, ie, "if there's only a single wire running to the switch, this will be positive". Thinking this cannot be correct, I installed the new light delay kit in the same way as the old kit I previously built and installed. The new kit did not work. In fact, I sizzled the circuit.

Can someone please inform me if I can still buy the older kit or make the new kit cater for a single-earth wire switch? (J. H., Ermington, NSW).

- The Courtesy Light Switch-off Timer as published in October 1993 and the Courtesy Light Delay from June 2004 (Jaycar KC5392) are completely different projects with opposite functions. The first switches off the courtesy lights if the door is left open or not fully closed for a period. This design intercepts the positive 12V supply to the lamps and switches off the lamps.

The second circuit (June 2004) switches off the lamps after a delay period when the door is closed so you can still see for a time after the door closes; hence the term "courtesy". So they have completely different functions. The confusion probably comes about because the earlier circuit is misnamed. It should have referred to cabin or interior lights rather than courtesy.

You should be able to repair your switch-off timer from October 1993. Possibly the BD650 transistor has failed.

DIY radio control project

About 30 years ago, I built a radio control project that was serialised in "Electronics Australia" or possibly an English publication. It was quite a successful project with 10 channels that I think you could configure for an analog or digital output depending on the control board used on the transmitter and receiver.

One thing I do remember is that it used individual input and output boards for each channel.

Do you think it may be time for an updated version of this project as this may offer an alternative to commercial equipment with fixed and or limited outputs? (M. R., via email).

- We published a complete RC system in a series of articles between December 1994 and October 1996, by Bob Young, the designer of the system in "Electronics Australia". We would not do it again as a DIY R/C controller is now much more expensive than one you can buy. SC

Setting the Programmable Ignition Oscillator

I recently built the Programmable Ignition System from SILICON CHIP, March, April & May 2007.

Initially, at power up, the internal oscillator was always off (as designed). But now, it is always on, regardless of what state it was in when powered down. Would reprogramming the PIC IC cure this? Or would clearing the EEPROM be a better option?

This fault occurred while I was battling to get the timing light to work on the secondary coil. (W. D., via email).

- You can reset the internal oscillator by switching on power, selecting Settings and then switching off the oscillator manually. Then change the trigger edge from the current setting to the alternative setting and then return to the original setting. Switch off power and check that the oscillator is off at power up.

Notes & Errata

Car Scrolling Display, November 2008: on the schematic published on pages 32-33 of the December 2008 issue, the ground connections to pins 15, 18 and 19 of CON6 have not been shown. These connect to the ground rail of the display board via CON7.

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

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. Devices or circuits described in SILICON CHIP may be covered by patents. SILICON CHIP disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. SILICON CHIP also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

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