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- Milling PC Boards
- New "X2" Picaxes
- GPS Clock Update

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Publisher's Letter

High-speed broadband in Australia will be an expensive farce



Back in May 2009 I wrote about the federal government's proposed fibre-optic broadband network and how it would probably be a white elephant. I also asked the question whether it was likely to use above-ground cable, like the present Optus cable network. Well, already my misgivings are being confirmed. The rollout of the new broadband network has begun in Tasmania, in a $700 million program under the auspices of Digital Tasmania. They informed a recent Senate select committee that 96% of the proposed network would be via overhead cable. Aurora Energy, the state-owned power retailer, will string the fibre optic cable along its network of overhead power lines.

Well, what an absolute joke. Is this what the rest of Australia will get for a $43 billion investment? Talk about a third-world solution! Haven't we learnt anything from the rollout of the Optus cable TV network in the 1990s? Those eyesore cables are still there and no doubt they will still be there for decades to come!

At least, the trial BPL (broadband over power lines) experiment seems to have been discredited (or has it?).

You don't have to be a genius to see the drawbacks of overhead cables. Apart from being an eyesore, they are subject to breakage and interruption of service every time a power pole is knocked over by a car or by trees in storms – this happens very frequently in Tasmania. The quoted reason, by Digital Tasmania, is that overhead cables can be rolled out much more quickly than if they were to be buried in trenches. Well, that may be true but it is a half-baked solution. If cable is to be run, it should be underground.

I suppose the next part of this farce is that we will find that the vaunted network speeds will not be nearly so fast as promised. Or maybe the upload speed will be crippled as it presently is by Telstra and all the other networks. Unless the speeds are a great deal faster than is presently available from ADSL2, there is little point in providing yet another cable network, whether or not it is based on optical fibres. By the way, does anyone know what speeds have been promised?

In any case, we have to ask why the rollout in Tasmania will be so incredibly expensive at $700 million. That's $1400 for every inhabitant of this little island or about $3500 for every Tasmanian household. Just how expensive is this optical fibre cable anyway?

Thinking about it another way, this might be one of the reasons why the federal government wants to dismember Telstra. Do they want to get cheap access to Telstra's underground ducts? Why not just give $10 billion or so to Telstra and they can put in the broadband network they originally proposed (at a somewhat cheaper price)? After all, the government will need access to the ducts in all those suburbs and towns where all cables are presently underground.

And where cables are above ground, why should we have yet another cable strung along the power poles? In my own suburb of Collaroy for example, we have Optus and Telstra cables, the phone cable and the power cables – it is pretty unsightly.

This is yet another bungle by the federal government. Don't they have anyone in the Labor Party or in the bureaucracy who has any sort of understanding of finance or business who can perform a rigorous cost/benefit analysis? Apparently, they have very little technical expertise but this is tragic.

Leo Simpson

MAILBAG



Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask SILICON CHIP" and "Circuit Notebook".

LCD panel meter reads to 30V

In the "Ask SILICON CHIP" pages of the August 2009 issue P. W. was enquiring about an LCD panel meter that could read to 30V. Jaycar have a clock/voltmeter which is supposed to handle 24V systems. It is on all the time with switchable backlight and battery condition lights. The Jaycar part number is XC0118.

I am using one in my car to monitor the condition of my second battery.

Ray Saegenschnitter, VK3UCB, Huntly, Vic.

School zone speed monitoring is not necessary

I have some comments about school speed zones and kids. I've been doing bus supervision for 34 years now and I have seen countless accidents. Unfortunately I have seen kids hit by cars. One died getting off the bus (ran out from front of bus into car passing bus, while trying to get to mum parked on the other side). The other was hit on the pedestrian crossing. Both cars were going slowly.

The causes of nearly all of the accidents I have seen have been observational and parking violations NOT speed. They include drivers double parking, parking in no stopping zones, in the middle of the street even, pushing in, blocking bus lanes and turning circles, opening doors, making U-turns, reversing and general stupidity.

The point of my letter is that it would be more effective, in terms of safety, to focus the RTA cameras at the school bus, no stopping, no standing and drop off only zones, and nearby parking spaces, rather than using the technology just to monitor the through traffic.

Random sampling of scanned and recorded sites would be an effective and efficient method of monitoring the process and could yield thousands of dollars in revenue a week from many schools.

On a completely unrelated subject, please be advised that the NSW Board of Studies has reclassified the subject of Industrial Technology, at the HSC level, as a category A subject. It is now on par with the sciences and maths in terms of subject status and due recognition by universities. This includes the focus area of electronics technologies of course.

Well done to the many teachers who have been pushing for such accreditation over the past years.

Dave Kennedy, Collaroy, NSW.

Comment: that's good news about the upgrade of Industrial Technology.

DAB+ reception solution

A keen cricket fan, my spouse was offended when the recent Ashes series was interrupted on ABC local radio by the football. "They say it's on Digital – get one", was the demand!

We live in the country, about 80km SE of Adelaide (on Lake Alexandrina) with a clear line-of-sight to the Mt Lofty transmitters. Borrowing a city friend's DAB+ radio, I checked that indeed there was a good strong signal, so long as I was outside the house! Inside, there was nothing, the result of the thick limestone walls.

Attempts to find a Digital Radio with any sort of antenna socket were fruitless, so it looked like a lash-up to the whip antenna on a portable was in order. Presuming a high impedance at the whip, I set up an old 75:300Ω balun on the end of the cable from our amplifier/splitter, clipped one side of the balanced output to the whip and the other to a length of hookup wire wound around the body of the radio, at the other end to the whip.

Perfect! This arrangement gave at least 4 out of 6 signal strength bars all the time, sometimes more. There was great sound, no football and a happy spouse! However, you should encourage the ABC to remember to listen to it - there are times when the transmissions disappear, repeat small bits for hours, have the wrong program and never ever believe the scrolling text display!

John Yelland, Milang, SA.

Temperature sensing battery charger circuit error

I have a comment on the "Temperature Sensing Battery Charger Cut-Out" circuit on page 45 of the Circuit Notebook section in the September 2009 issue.

It probably doesn't matter too much in a circuit like this but the 1kΩ resistors feeding the LM335s are too low in value. The approximate 10mA current through the sensors, apart from being near the maximum recommended forward current for the devices, will cause considerable self-heating, particularly TS1, giving incorrect or less reliable readings, even if trimmed out with the 10kΩ pots.

A value of about 8.2kΩ, giving a current of about 1mA, would give more accurate operation of the circuit by reducing the self-heating. The higher resistor value would also provide more of a "constant current" source, improving performance by reducing the change in current through the sensors as the voltage across them changes with temperature.

The circuit obviously works fine in this application where the actual temperatures are not critical but would under-perform in a more critical ap-

PEBBLE on Macintosh

Many thanks to Ray Wilson and Wayne Geary for producing PEBBLE (SILICON CHIP, September 2009). I downloaded the off-line version and installed it in two laptops: an XP box running Firefox and a MacBook running Safari.

PEBBLE runs without any issues in Safari, performing identically to Firefox except that it loads considerably faster than in Firefox. Safari has no problems with ZIP files and PEBBLE uncompresses automatically into Downloads – it should then be moved to Applications. You can make an alias and place that on the Desktop; PEBBLE will run from the alias. Depending on how your mouse is set up, both left and right click work without problems (the Mac mouse allows you to click in five different places).

The "Clear All" and "Save/Load" buttons work as expected. Cut and paste the text file to TextEdit and save as text (not RTF). On the other hand, the "Print Srcn" button prints a very poor image. Instead use Grab and select an area of the screen. You can then store this to an image manipulation application or else print straight from the Grab window. Even a cheap inkjet printer produces an excellent image.

PEBBLE will be very useful for students at both secondary and tertiary level as well as hobbyists, but some professionals find that they are often asked to develop one-offs that do not justify making a PCB, as they do not use SMDs or else do not run at RF so a prototype board is satisfactory. PEBBLE allows you to play around with component positioning and keep an electronic record.

For the record, I used Safari 4.0.3 running on OSX 10.4.11. If you are looking for a PC board layout editor that works in Linux, OSX and Windows, try Eagle at www.cadsoft.de – the freeware version is suitable for students and hobbyists.

John Faulkner,
Hurstville, NSW.

plication. I am also not sure of the purpose of the 1MΩ resistors.

Brian Playne,
Toowoomba, Qld.

Flat panel TVs don't bend

How many people have bought their kids a new Nintendo Wii Games console who then forget their wrist-strap, only to send their controller on a collision course with the giant new-newfangled LCD TV?

The good news is that the Wii handset can usually survive this unharmed but the LCD TV is usually rendered beyond feasible repair. It will then eventually be left on the nature strip for the "council clean-up". There it will be fed into a compactor so that the mercury from its back lights will be dispersed liberally into the environment.

LCD panels have also been broken with a gentle tap from the back-swing of a vacuum cleaner, teenage kids bouncing a "super-ball" or kids knocking them over

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Mailbag: continued

Useful article on scope probes

I found Doug Ford's October 2009 article on CRO probes very interesting, especially his investigations into their bandwidth and rise time. Having been fortunate enough to have owned two Tektronix oscilloscopes, a 535 and currently a 2213, I am familiar with the earlier Tek probes.

The manual for the 535 included information on the Tek 6000 - 6005 series probes. The probes came with a 3.5, 6, 9 or 12-foot cable and were available in 1:1, 10:1 and 100:1 ratios. I don't have any data apart from input capacitance and the -1.2dB bandwidth. But I do have details of the 6006, 6007, 6015 & 6018 probes.

The 6006 probe had the compensating capacitor in the tip as a cylindrical capacitor [like the Philip's beehive type] which went over the 9MΩ resistor. Adjustment is by screwing the probe tip in or out, to alter the overlap with a smaller diameter sleeve which is connected to the inner of the coax. The 9MΩ resistor has a 4-pronged sliding contact which connects to the inside of the smaller sleeve. I recall when repairing one many years ago that the inner conductor was very difficult to solder; the original connections are crimped.

There is a small-value resistor connecting the inner sleeve to the inner of the coax; the value depends on the length of the cable. The resistor is 360Ω for the 3.5-foot, 180Ω for the 6-foot, 430Ω for the 9-foot and 360Ω for the 12-foot cables. There is a small inductor added at the BNC end for the 9-foot cable according to the probe manual but I suspect is also there for the 12-foot cable.

The quoted rise-time for the 6006 probes without connection to a CRO is approximately 5ns for 3.5-foot; 7ns for 6-foot and 9-foot and 14ns for the 12-foot cable. Plugged into a type-K plug-in (20pF input capacitance) in a 540 series CRO (12ns), rise-time is 13, 14, 14 & 18ns, respectively. The quoted -3dB bandwidth is 25MHz for the 6-foot and 9-foot and 12MHz for the 12-foot cable.

Rodger Bean,
Watson, ACT.

when generally romping. For these reasons, I have started the Facebook Group "I'm Going To Watch My Tube TV For 20 More Years With A Digital Set Top Box". Many older TVs have the potential for many more years of use and should not be discarded to landfill.

Tony Backhouse,
Narraweena, NSW.

Using a PC as a DC reference

In the May 2009 edition of SILICON CHIP, I read your excellent article "Precision 10V DC Reference For Checking DMMs" and thought it was time to calibrate my multimeters. Just as I was hypothetically reaching for the soldering iron to construct the project, I suddenly halted with the thought "Wait a minute – don't I already have access to a reasonable precision source?"

To cut a short story shorter, I dropped into the BIOS on my IBM-type Desktop PC to check the voltages it displays. It listed four voltages, two of which are VERY accessible: the +5V and +12V motherboard rails. These were showing readouts of +5.229 V and +12.196 V respectively and were relatively stable. Whether or not they are precise to the third decimal place or just the second is virtually irrelevant to the layman.

Even if only reasonably accurate to the first decimal point, that would suffice for the vast majority of requirements. It would also allow direct comparison of several medium-accuracy multimeters (tested simultaneously), at two voltage levels (since they should all read exactly the same value).

Most technicians needing good-accuracy multimeters would most likely already own a PC of some flavour and would know how to access the internal, standard 4-pin power plugs. For others (with desktop-type PCs), you simply unplug the PC's mains power, remove the PC's cover, locate a free

How to provide a remote control translator

On page 99 of the August 2009 issue, a reader asked for a remote control translator project and you gave a largely negative response. In fact, the range of Logitech Harmony remotes can be easily programmed to carry out this function. They are programmed via a web-based service to turn on several devices and select the correct input for each device.

This is an activity-based remote. For example, with a one-button push you can choose to watch a DVD. This will turn on your TV, DVD player and amplifier, select AV1 on your TV, select the DVD input on your amp and select play on the DVD player.

If you want to watch TV after the movie is finished, you then press the "Watch TV" activity button. The TV will then switch back to its own tuner and the DVD player and amplifier will turn off.

Using the software, you can set up many different devices in many different configurations. For example, you could have two different activities to watch TV; one using the sound from your TV and another using the sound through an amplifier. In the first activity, the volume control will work the TV volume and in the second activity it will work the amplifier's volume control. In both examples, the channel selection on the remote will change channels on the TV.

I have set up Harmony remotes for many families and in each case they have found them very easy to use. The remote can be reprogrammed many times and can be reprogrammed with only a few mouse clicks. There are thousands of different equipment devices already available on their website.

If your device is not available, it can be easily programmed using your original remote. The cheaper Harmony remotes can usually be purchased for under $100 from electronic retailers or on-line. The dearer remotes like the 785 can sometimes be found for under $150.

You can also download the software from the Logitech website and take it for a trial run without purchasing a remote.

Peter Harland,
Shepparton, Vic.

4-pin power plug and carefully insert the multimeter prongs – ie, black prong to either of the plug's black leads, red prong to either the yellow (+12V) plug lead or to the red (+5V) lead. Be careful not to let the prongs short when power is applied!

Switch on and quickly drop into BIOS (usually by tapping the ESC, F2 or F10 key), then navigate to the voltage displays, which you can then compare to your multimeter readings. If you consider the multimeter needs adjusting, carefully disconnect it, remove its cover, reconnect it and adjust the trimpot on its PC board to comply with the voltages shown in the BIOS.

Don't try probing the USB ports on a laptop though – that's too risky.

Being a retired technician, I thoroughly enjoy reading SILICON CHIP, especially the superb Serviceman's Log – surely one of the best-written, entertaining and informative series EVER printed anywhere in the world.

M. Dowson,
Stanwell Tops, NSW.

Comment: your suggestion for using the BIOS and the on-board monitoring in a desktop PC to function as a reference voltage is initially very attractive, especially since the monitored voltages are quoted with such apparent precision. However, the accuracy is actually illusory since on-board monitoring chips such as the LM80 typically have an accuracy of 1% (max. voltage error) with only 10mV resolution (least significant bit) at 2.56V. Hence, readings such as 5.229V are misleading.

In any case, the supply rails in computers are quite noisy and whether they should be used a reference to check multimeter accuracy is a moot point.

The readings quoted by your computer's BIOS should, at best, be rounded to 5.2V and 12.2V, as you have implied. Having said that, the BIOS still provides a useful reference where someone needs to do a quick check on the DC accuracy of a multimeter. Remember though, that any





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Mailbag: continued

Effect of the water vapour from combustion of hydrocarbon fuels on climate

I am a loyal and enthusiastic reader of SILICON CHIP. I have purchased every issue since its inception and I have learned much about electronics from it.

I have followed the discussion on climate change in the letters pages with some interest and increasing dismay at the Editor's stance on the question of the contribution of atmospheric carbon dioxide to climate change. In commenting on Morgan Sandercock's letter (Sept. 09) the Editor raises points that are at best specious and which must raise doubt about the validity of the Editor's other statements that are less easily tested.

Specifically, in his comment to Sandercock, the Editor states that *"water vapour is a greenhouse gas produced by the combustion of all fossil fuels yet it is never mentioned in the emotive discussion about carbon pollution"*. (Strictly it is not correct to say that all fossil fuels produce water vapour when burnt because coal is mostly carbon so its combustion products would contain little water. It is hydrocarbon fuels that produce water when burnt but this is nitpicking semantics.)

On the substantive issue, there is a very good reason why water of combustion is not mentioned in the climate change discussion and that is because the quantity of water produced from combustion of hydrocarbon fuels is insignificant relative to the natural turnover of water through the atmosphere. On average, the water content of the atmosphere is the equivalent of about 25mm over the entire global surface, which equates to 1.3×10^{13} tonnes. The average residence time of the water in the atmosphere is about nine days so the water is turned over around 40 times a year, which gives a throughput of 5.2×10^{14} tonnes/year. The global consumption of oil and gas is respectively 6.0×10^9 and 2.1×10^9 tonnes/year.

Assuming that all of it is burnt and that in respect to the carbon/hydrogen ratio, the oil is equivalent to octane and the gas is methane, the combustion of these amounts yields respectively 8.55×10^9 and 4.63×10^9 tonnes of water, which is a total of 13.2×10^9 tonnes of water/year. Thus the water from combustion represents as a fraction, just $(13.2 \times 10^9)/(5.1 \times 10^{14})$ or 0.0026%, of the turnover of water from natural causes.

Thus the contribution of water from combustion to atmospheric water is minuscule. The situation in clear simple terms. This is an excellent example of one of the reasons why you are a world-class journal for the technically-minded enthusiast.

Whilst I probably won't end up building this project (though tempted) I look forward to the second article which no doubt will be as equally lucid.

Gary Johnston,
Managing Director,
Jaycar Electronics,
Rydalmere, NSW.

such BIOS voltage readings are only accurate to within 1% (worst case). So a BIOS reading of 5.2V will actually be somewhere in the range from 5.148V to 5.252V.

If you want a precision reference, the AD588 10.000V circuit described in the May 2009 issue is the ideal solution.

Wideband O2 sensor project lauded

I want to congratulate John Clarke and the editors of SILICON CHIP on the writing, layout and overall construction of Pt.1 of this article, in the September 2009 issue. You may not realise it but you have done an extraordinary job of presenting a complex subject in

Piston motion is not sinusoidal

On page 97 of the October 2009 issue, you advised a reader that "maximum piston speed in an engine

respect to carbon dioxide is vastly different in large part because the residence time for that gas in the atmosphere is measured in millennia. Whatever amount we put in will stay there for a very long time. It took tens of millions of years to lay down the coal deposits. Given that we have burned a substantial proportion of that coal in just 200 years or so, we should not be surprised that it will boost the amount of carbon dioxide in the atmosphere.

On a second point, the Editor states in his comment that *"as far as we know, the IPCC models do not take into account the effect of increasing cloud cover"*. If the reader cares to refer to chapter 8 of the IPCC report *Climate Change 2007: the Physical Science Basis* they will find many references to consideration of clouds in the climate modelling **(http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter8.pdf)**

Indeed, because of the importance of cloud to the Earth's albedo (average reflectance), any global climate modelling that did not take account of cloud cover would be complete nonsense.

I do have some sympathy for the Editor's annoyance with the term carbon pollution that is now in common use in the media. Carbon dioxide is not toxic to air breathers at the proportions ever likely to be present in the atmosphere. Consequently it is not really a pollutant or contaminant in that sense. However, due to acidification of the oceans by increased dissolved carbon dioxide, the affected marine life might well see it as pollution.

I respectfully suggest that the Editor should better research and test his comments on this subject, lest they diminish the standing and respect for his fine publication. Given the considerable influence that the Editor can wield, I would expect that if the he wants to venture comments on this important subject, they should be researched and accurate.

Nigel Beal,
Chapel Hill, Qld.

Comment: while it is true that some coals such as Anthracite are almost pure carbon, most of the coal burnt in power stations or used for steel-making, is referred to as "bituminous" and has a carbon content of 60-80%. Before natural gas was discovered and exploited, all domestic gas supplies were produced by the pyrolysis of coal, to produce so-called "coal gas".

So coal does normally have a significant content of hydrocarbons.

As far as the amount of carbon dioxide produced by man is concerned, refer to the comments last month by Professor Ian Plimer – it is also insignificant, compared to that produced by volcanoes. And while carbon dioxide is increasing, there is little evidence of resulting global warming for the last 10 years.

always occurs at half stroke, regardless of conrod length" and that the piston moves in a sinusoidal manner. In fact, the movement is only sinusoidal for a conrod of infinite length.

For any normal conrod length, the maximum piston speed occurs just before and again just after 90° away from top dead centre. That is to say, at two closely spaced points on the down stroke and the same again on the upstroke. This is because the lateral component of movement of the big end modulates the movement of the piston.

Think of it as a rightangle triangle with fixed length hypotenuse and variable length base. Notice that the height varies as you change the length of the base? At the 3 o'clock and 9 o'clock rotation point of the crank there is no lateral movement of the big end, only vertical and consequently, the piston slows a little.

This is one reason why a balancer shaft, as used in some engines, cannot completely counterbalance engine vibrations, because of the remaining harmonics of piston vertical movement, ie, non-sinusoidal motion.

As an example, consider an engine that has a 3-inch stroke and a 6-inch centre to centre conrod. When the crank has rotated 90° from top dead centre around to the 3 o'clock position, the big end bearing journal centre line will be 1.5 inches to one side of the crank centre-line. This causes the conrod to lean 14.47° from vertical and

te Tech Edge

Alternative DIY Wideband Controller and Display

Tech Edge designs wideband DIY (and pre-built) controllers. We have sold thousands worldwide since 2002. Our latest DIY design is the 2Y1. We also sell a 4 digit DIY display (the LD02) designed to team up with the 2Y1. We sell Bosch LSU (wideband) sensors suitable for the 2Y1 and other wideband units.



The 2Y1 has superior speed and accuracy compared to other DIY designs, and performance exceeds that of many commercial units costing up to several thousand dollars. The 2Y1 also has an inbuilt logger with 6 analog voltage inputs and an RPM and pulse input. An optional 1 Mbyte logger module is also available for storage when a laptop is inconvenient to use.



The LD02 display is digitally connected (not via analog voltages!) for superior accuracy and can double as a monitor for analog voltages, collected from the 2Y1, or locally. LD02 can even be used with other wideband controllers that provide an analog voltage output. It can be used as a stand-alone display.



2Y1 DIY kit from	**$99.00 + GST**
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Both the 2Y1 and LD02 come as professional kits with double sided PCBs and some prebuilt and pretested SMD components. An online user forum as well as local telephone support is also available. Full construction details and further information from our website:

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Mailbag: continued

Critical review of Ian Plimer's book

To balance the letter that you published from mining geology Professor Ian Plimer in the October 2009 issue, you really need to publish Michael Ashley's review of Professor Pilmer's book on the climate warming debate. This was published in the May 2009 edition of *The Australian* newspaper.

In that article, professor of astrophysics Michael Ashley says: "Plimer has done an enormous disservice to science, and the dedicated scientists who are trying to understand climate and the influence of humans, by publishing this book. It is not "merely" atmospheric scientists that would have to be wrong for Plimer to be right. It would require a rewriting of biology, geology, physics, oceanography, astronomy and statistics. Plimer's book deserves to languish on the shelves along with similar pseudo-science such as the writings of Immanuel Velikovsky and Erich von Daniken".

Bruce Withey,
Mylneford, NSW.

Comment: so nothing written by Professor Ian Plimer has any validity?

so the effective "height" of the conrod is not 6 inches but 5.81 inches.

This causes the piston to be not 1.5 inches (half-way) down the stroke but 1.69 inches down. Because the piston is more than halfway down even though the crank is at the 3 o'clock position, it follows that the piston movement is not truly sinusoidal. By contrast, a Scotch yoke engine does have sinusoidal piston motion – see **http://en.wikipedia.org/wiki/Scotch_yoke**

So piston motion resembles a sine-wave with second harmonic distortion, ie, blunt at the bottom and pointy at the top. The shorter the conrod, the more pronounced the effect. A rather more mathematical explanation can be found at **http://ftlracing.com/tech/engine/rsratio.html**

Graham Pratt,
Hampton Park, Vic.

Link to review of Professor Ian Plimer's book

Having greatly enjoyed SILICON CHIP (and its predecessors ETI, EA, R,TV&H and R&H) for many years, I've been somewhat bemused on several occasions to find its editorial voice used in the service of climate change denial.

Since you've just given Ian Plimer two pages to expound his personal views and promote his book "Heaven and Earth", I'd like to draw your attention, and that of your readers, to Prof. Barry Brook's review of that book at: **http://bravenewclimate.com/2009/04/23/ian-plimer-heaven-and-earth/** and also available via **http://plimer.notlong.com**

Stephen Thomas,
Bruthen, Vic.

Comment: while the so-called denialists may one day be proved wrong (or right), we wonder if any global warming believer entertains even the slightest possibility that global warming might be non-existent or possibly, not due to anything done by man.

*Perhaps you might like to have a look at another opposing view at **http://www.oism.org/pproject/GWReview_OISM300.pdf***

Oscilloscope probes

That was a great article on probes in the October 2009 issue.

My university physics department's first Tektronix 551 scope was in 1959. From 1962 on we bought one a year, until about 1970. About 1963 the 6000 series probes arrived. Those probes had the thin, crimped centre conductor. I recall a reference in a Tek publication that Zo was 800Ω or so. The crucial difference is that, at the transmission-line-dominated high frequencies, the X10 probes give an 8kΩ load the tip. Perhaps the computer simulation could run that scenario.

The mention of John Kobbe led to an interesting hour on the internet. Thanks for your magazine, long may it prosper.

Tom Berg, VK6ZAF,
Bicton, WA.

Solution to switch-on surge problem?

I wish to comment on your response in the item entitled "Multiple CFLs Can Cause Switch-On Problems" in the "Ask Silicon Chip" section of the September 2009 issue.

While you gave details of the cause of this problem, you did NOT help the questioner by offering any help in overcoming the problem, except by suggesting increasing the circuit breaker rating.

Since the problem is the "surge" currents into 10 capacitors, one obvious solution is the rewiring of the fitting into two groups of five lamps each and providing an additional switch and associated wiring, so that the fitting is switched on by two switches.

Secondly, while these lamps are not "dimmable", it would also be possible to wire the fitting via a "dimmer", as long as the circuit was always switched on with the "dimmer" in its minimum position - so that the "dimmer" is used as a "brightener". Using a "dimmer" in this fashion with CFLs results in no lighting for about 25% of the "brightener's" action, followed by almost full brightness and then up to full brightness for the remaining 75%. Unfortunately, if the "dimmer" is left at its maximum position, when the circuit is switched on, the circuit breaker will operate.

This leads to a solution to this problem. What is required is an automatically acting "brightening" device, such as a "soft-start" control circuit in series with the load.

While "soft-start" circuits are usually employed in association with motor controls they can also be used to control the surge into capacitors, as in this case. Unfortunately, I have not been able to locate a commercially-made and approved unit of this nature, although it should be little more difficult to manufacture than currently available "dimmers". Perhaps a manufacturer could be encouraged to produce such a unit.

In the absence of a commercially available unit, a small amount of research on the internet has led me to a "Design Idea" entitled "Soft-Start Controller Is Gentle On Loads" at http://www.edn.com/article/CA181906.html

The PDF file with diagram is at http://www.edn.com/contents/images/112201di.pdf

Firstly, as the original circuit was designed for 115V operation, to provide approximately the same operational current (10mA) from the Australian 230V supply, the two parallel 22kΩ 1W resistors at the input to the bridge rectifier MUST be replaced by five parallel 120kΩ 1W resistors. This will give a total dissipation of 2.4W when the circuit is in operation.

Since a motor is not involved, T1, IC1 and most of the associated components in this circuit may be eliminated. R8, C4, Q6, D5 and the 24kΩ resistor should be retained, with C3 and R7 in series and junctioning with D5 reversed, with C3 connected to the 12V supply and R7 connected to "earth". Thus, Q4 will delay the circuit from operating until both C1 and C3 have been charged.

The MOV, capacitor and resistor across the output Triac could also be eliminated. I realise that use of this circuit would require it to be built in a suitable box and installed as part of the permanent wiring of the building which you may not wish to advocate.

Peter B. Taylor,
Box Hill North, Vic.

Comment: you are quite right in pointing out that we did not offer a solution. Our feeling was that there was no easy solution. However, an electrician has written in to point out that the solution is to fit a circuit breaker with a longer response time – a type D. His letter was featured in the October 2009 issue.

We don't think your suggested solution will work since it is based on a Triac. Triacs do not "like" capacitive loads and they can be damaged by large repetitive switch-on currents. Furthermore, CFLs tend to flicker with Triac dimmer circuits even though some CFLs are specifically designed to be dimmed. SC

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Quantumdata 780 HDMI tester

Now that HDMI sockets are standard on a wide range of LCD and plasma TV sets, set top boxes, DVD players and many computers, there is a need for a standard HDMI test source that can test this equipment. The Quantumdata 780 Handheld Test Instrument is a comprehensive solution which also provides digital audio test signals for DACs and Home Theatre receivers.

Review by Leo Simpson

Here at SILICON CHIP we have been following the development of HDMI interfaces on TV sets and other equipment and wondering just how to test this equipment without having a very expensive line-up of test equipment.

For example, on the internet you will see lots of claims about maximum length of HDMI cables for reliable operation. Some suppliers say the limit is 10 metres while others make considerably longer cables.

And there are cables and cables – some long cables just don't perform well.

Nor is it simply a matter of hooking up a DVD player to an HDMI-enabled TV or projector and seeing if it works. There is the question of which level of HDMI is being used and what is the bit rate applied to the colour signals.

Now, with the Quantum Data HDMI tester, a lot of those questions can be answered. And it is also possible to directly compare picture quality using defined video test patterns with HDMI, VGA and component video (YPbPr) cables.

You cannot do this with any degree of certainty with a signal from a DVD player – even if it is stationary.

So that is the background – now to Quantum Data.

It is quite a compact instrument, measuring 250mm x 68mm x 163mm (W x H x D). It is battery-powered with nickel metal hydride cells to give about four hours of operation. It can also be run from an AC adaptor which will charge the batteries overnight.

There are no controls as such, since all modes are controlled by the colour LCD touch screen, which measures 99 x 58mm.

On the rear panel there are sockets for HDMI input and output and VGA, for testing of projects, TV sets etc, as well as TOSLINK (optical) and SPDIF coax outputs for testing the digital outputs of sources such as DVD players and set-top boxes.

In addition, there is a USB socket and the DC input socket while on the







These three pictures shows some of the audio test screens which control digital signals delivered via the TOSLINK (optical), SPDIF (coaxial) or HDMI outputs.



All functions of the Quantum Data tester and selected and controlled via the touch screen. The unit can test all products which use HDMI connectors.

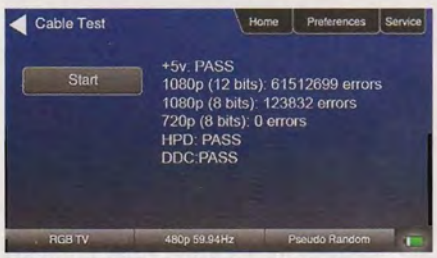
opposite panel is a socket for an SD card.

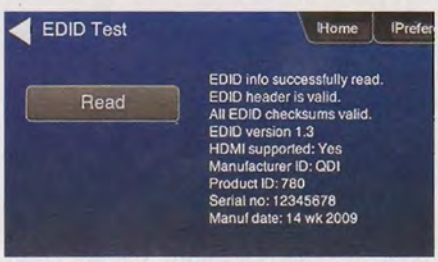
When you first turn it on, the Quantum Data tester displays a home screen which gives four small patterns depicting video or audio patterns, Test Sink (TV, projector) and Test Source (DVD player or STB).

If you are testing an LCD TV for example, you would touch the Video Pattern and it comes up with another screen of 15 patterns. These include colour bars, ramp/stair, raster, needles (white needle/black background etc), decoder adjust, convergence, pluge (black & white) and so on.

Another screen gives a choice of checkerboard, zone plate, and master test patterns at 720 x 480, 1280 x 720 and 1920 x 1080 pixels, in progressive or interlace mode.

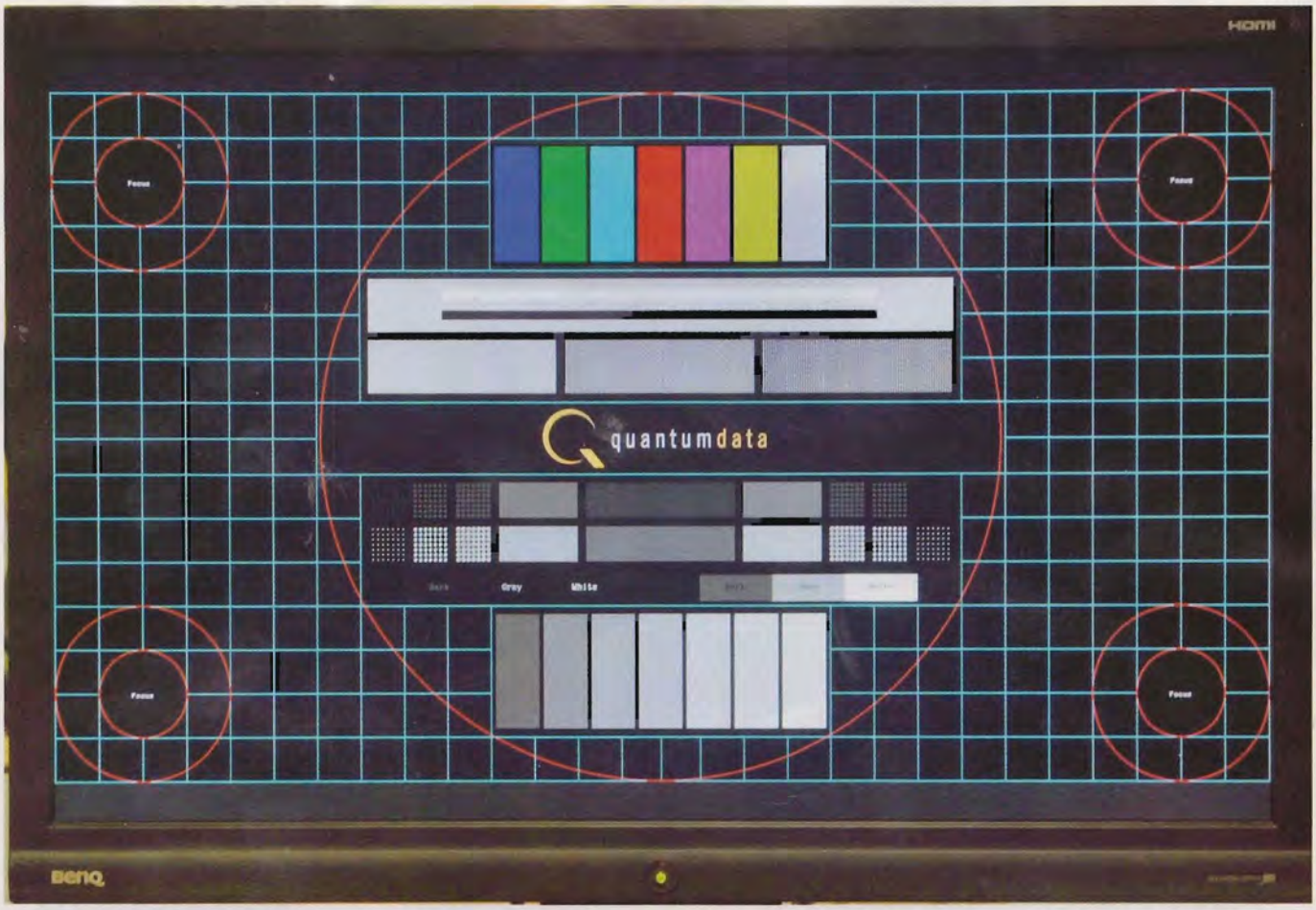
In addition, quite a few of the pattern selections have a plus symbol in them. Double-tapping these brings up







HDMI cables can be tested to the V1.3 standard at 8 bits and 12 bits. To the right is a report on a HD monitor tested via the HDMI output.



Our photo and the printing process do not show the extreme resolution demonstrated by the 1920 x 1080 pixel test pattern. This standard BENQ monitor came through with flying colours.

another screen which enables you to change the pattern parameters.

For example, on the colour bar patterns, you can set colour saturation, you can have vertical or horizontal bars, change the number of bars (7 or 8), and so on. For the raster pattern you have can have Red, Green, Blue, Cyan, Magenta, Yellow or white, with or without an IRE label, you can set the IRE level and you can have a full raster or a window. Similarly, for the master test patterns, you can select HDMI or DVI, VGA (analog) outputs and for VGA you can have RGB or component video.

DVI equipment must be tested with a HDMI to DVI adaptor (not supplied) while LCD monitors with component video inputs can be tested with a VGA to three RCA plug adaptor (which is supplied).

Cable test

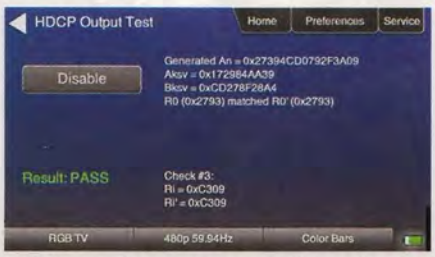
For HDMI cable testing, you plug the cable into the HDMI input and output sockets and press the start button. It runs the test and then displays the results as:

+5V: pass
1080p (12 bits) 0 errors
1080p (8 bits) 0 errors
720p (8 bits) 0 errors
Hot plug: PASS
DDC: PASS.

We ran the tests for a number of cables, including a 15m cable, and they all passed.

Source tests

For testing a DVD player or set top box, you plug the HDMI cable from the player into the input socket on the Quantum Data, tap the "Test Source" screen on the home screen and then tap the "Analyser" screen button. It then displays a comprehensive report of the signal output such as the signal format (eg, 730 x 576), frame rate, progressive scan enabled, color space (YcbCr 4:4:4) and so on. You can also







Left is another test screen from the Quantum Data 780 tester. The centre pic is one of the screens for selecting video test patterns, while at right is he home selection screen on the Quantum Data 780.



Front and rear photos of the Quantum Data. The analog output enables testing of monitors with RGB or component video inputs.

run the Audio Analyser and it will give a comprehensive report on the digital data.

Sink tests

To test HDMI monitors, you tap the "Test Sink" screen and you are presented with a choice of three buttons; EDID test, HDCP test and CEC test. Tapping the EDID button gives you another three screen buttons: Read, Copy to Rx and Reset Rx. Tapping the Read button runs a test which includes identifying the make and product ID of the monitor (TV, projector etc), its serial number, date of manufacture, and native timing, eg, 1920 x 1200 59.95Hz. Incredible, although not all this info agreed with that printed on the nameplate. The data can then be copied to the receiver port and downloaded to a PC via the USB port.

Audio tests

For audio tests, such as testing a DAC (such as the high quality DAC project in the current issues of SILICON CHIP) or a Home Theatre receiver, you connect an optical, SPDIF or HDMI cable and then select the Audio Pattern screen. You then tap the optical, SPDIF or HDMI button and the Signal Type: Dolby 5.1, Dolby 7.1, DTS-ES 6.1, DTS-HD HRA or PCM Sine Wave. You then go into the next menu level to set up the tests. We ran the SILICON CHIP DAC through the PCM Sine Wave tests and could select the sample, the bits per sample (16, 20 or 24), the output channel, sinewave frequency, amplitude (level) and so on.

Clearly, this is a very complex and capable instrument and in the few days that we had it we were just not able to come to grips with its full capabilities and nor did we have the necessary detailed information on all the test parameters. For example, we did not know what to expect in the qualitative results of the digital audio tests. Nor did we have sufficient info to interpret the high definition test patterns. Overall though, we were most impressed.

For further information on price and availability of the Quantum Data 780 Handheld Test Instrument, contact Tekmark Australia Pty Lt, Suite 302, Level 3, 18-20 Orion Road, Lane Cove, NSW 2066. Phone 1300 811 355; website www.tekmark.net.au SC

What is HDMI?



HDMI stands for **High-Definition Multimedia Interface**.

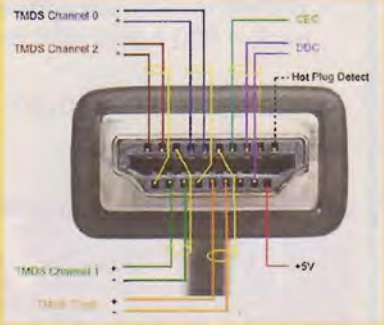
It is essentially a standard which provides, in a single cable, an uncompressed, all-digital audio/video interface between any HDMI-equipped audio/video source, such as a set-top box, DVD player or A/V receiver and an audio and/or video monitor, such as a digital television (DTV), video projector, etc.

HDMI has also started to earn wide acceptance as the interface between personal computers and A/V systems, particularly in home theatre.

Because HDMI is digital, it offers the best video quality, as there are no lossy analog-to-digital conversions as are required for all analog connections (such as component or S-video). The difference is especially noticeable at higher resolutions such as 1080p. Digital video eliminates the softness and ghosting sometimes found with component video. Small, high contrast details such as text bring this difference out the most.

HDMI supports standard, enhanced or high-definition video, plus multi-channel digital audio on a single cable. It transmits all ATSC HDTV standards and supports 8-channel, 192kHz, uncompressed digital audio and all currently-available compressed formats (such as Dolby Digital and DTS).

HDMI has become the defacto standard digital interface for HD and the consumer electronics market. More than 700 companies have become adopters, with a forecast of nearly one billion HDMI devices installed by 2010. HDMI is the only interface enabling connections to both HDTVs and digital PC monitors implementing the DVI and HDMI standards.



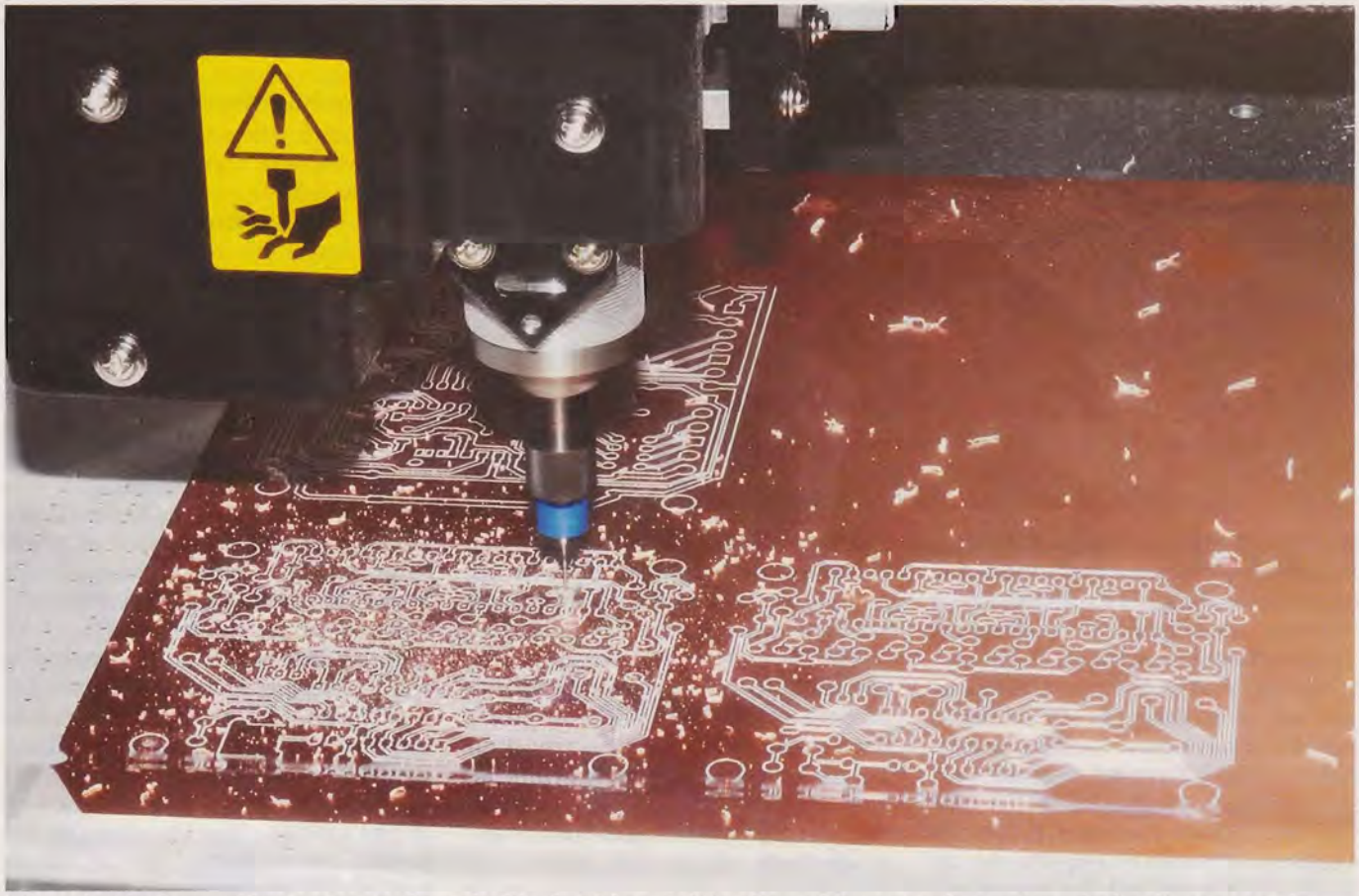
The HDMI standard. For more information, visit www.HDMI.org

Milling Prototype PC Boards with Roland's EGX-350 Desktop Engraver

Review by Mauro Grassi

We take Roland's EGX-350 CNC milling machine on a test run making fast prototype PC boards. We found it surprisingly good – it can route, drill and cut out a complete PC board quickly, without using chemicals. It lets you move from concept to working prototype in a matter of hours.





When that high-speed bit starts attacking the blank PC board, bits of swarf fly everywhere. Not only for this reason, the Roland has interlocks on the cover to make sure it stays closed – and you stay protected.

There are several options when it comes to making prototype PC boards, whether at professional designer level or in a school, college – or even an advanced hobbyist.

One is to send the artwork to a specialist PC board prototyping house and pay for it to be done. While relatively expensive, for many that's a completely viable option (and one we've used here at SILICON CHIP), even though the turnaround will normally be at least 3-5 days.

A big advantage of this method is that the board will (usually) be returned to you with all holes drilled, perhaps with a "conformal" protective coating on the copper and solder mask; sometimes even with a silk-screen component overlay.

Another option is to etch your own PC boards, using perhaps a photoresist pre-sensitised board and a UV light exposure box.

The results can be good but you have to use chemicals and drill the holes manually, neither of which is particularly pleasant. The chemicals are somewhat hazardous and must be disposed of properly. However, the quickest, most hassle free method, is to use a CNC (Computer Numerically Controlled) milling machine.

A CNC machine's head can be controlled precisely using a computer. It functions very much like a plotter but has a spinning head containing either a milling (or engraving) "bit" or a drill.

How does it do it?

Blank PC board consists of a non-conductive base layer, usually of fibreglass or a resin-bonded paper, onto which is laminated a very thin sheet of copper.

In the normal "etched" board, the pads and tracks are protected by "resist" while the areas between them are chemically dissolved away, leaving the tracks electrically isolated from each other.

Milling a PC board achieves a similar result but instead of etching, the areas between the tracks are mechanically milled or engraved away, down to the base layer, under the control of a computer. In fact, the software used to create the PC board pattern is usually able to produce the file which can control the CNC milling machine.

The CNC milling machine can also drill the holes and cut out the board, even in arbitrary patterns: non-rectangular boards with shaped edges and cut-outs can be made in this way. In this case, it is simply a matter of instructing the bit to cut deeper, right through both the copper and the base layers.

The Roland EGX-350

Although normally marketed as a general engraving CNC machine for making signs, panels and the like (which it does well), the Roland EGX-350 is adept at making fast prototype PC boards. It is also one of the most affordable CNC milling machines on the market.

However, to produce PC boards you will need special software, as the supplied Roland "Engrave Studio" is geared towards general engraving tasks and not PC board manufacture.

Although there are cheaper CNC machines on the market, few are suitable for milling PC boards. To be suitable,

Specifications at a glance:

Table (work) size:..... 305(W) x 230(D) mm
XYZ-axes travels: ..... 305(X) x 230(Y) x 40(Z) mm
XYZ-axes drive system:..... Stepping motor – 3-axis simultaneous control
Operating speed:
X and Y axes: ..... 0.1 to 60mm/second
Z axis: ..... 0.1 to 30mm/second
Software resolution:..... 0.01mm/step or 0.025 mm/step
Mechanical resolution:
X and Y axes: ..... 0.0025 mm/step
Z axis: ..... 0.00125 mm/step
Spindle motor:..... Brushless DC motor - maximum 50W
Spindle speed:..... 5000 to 20000 RPM
Dimensions:..... 616(W) x 591(D) x 393(H) mm
Weight: 34kg

a milling machine with good Z-depth control, mechanical resolution and repeatability is required. Repeatability refers to how accurate the positioning is over many movements.

To some extent, contactless laser cutters overcome the problem of having to have good Z-depth regulation – though these are prohibitively expensive.

Z-depth control is critical if the milling bit does not have a square section head – if it is conical, for example, a thin track may be cut too much and disappear altogether.

Resolution and Backlash

The resolution of a CNC machine refers to smallest step the head can move in each of its axes.

Good resolutions – of a fraction of a millimetre – can be obtained by using stepper motors, mechanical gears and linear screws (the screw assemblies that convert the rotational motion from a motor into linear motion, such as lead screws or ball screws).

As you can see in the specifications panel, the Roland EGX-350 has impressive resolution figures for its price.

The repeatability can be adversely affected by backlash. Backlash refers to the unwanted movement in response to a reversal in direction along an axis – it leads to inaccuracies in the head position and can be a problem where high precision is required, as when milling PC boards. This machine uses a proprietary anti-backlash mechanism developed by Roland.

Plated-through holes

Although it is possible, given some care with placement, to mill double-sided PC boards there is still the problem of how to connect the two layers together. Naturally, producing plated-through-holes, or "vias", cannot be achieved by a milling machine.

The simplest way around this is to use small (conductive) pins soldered on both sides. This is relatively easy but labour intensive, because each pin needs to be soldered individually. It is therefore more suitable for PC boards with relatively few inter-layer connections.

Work area

At 393 x 616 x 591mm, the Roland EGX-350 does not take up too much space on a desk.

When it comes to making PC boards with a milling machine, you are restricted by the size of the area over which the cutting head runs. In this case, the work area is 305mm by 230mm, which represents quite a substantial PC board. In any case, you can sometimes overcome this problem by breaking up a big design into separate PC board modules.

Connections

The connections to the Roland EGX-350 are accessible at the back, on two sides. Mains power connection is via an IEC socket on the right hand side. The serial, USB and hand controller connections are on the left hand side. The serial or USB connections can be used to connect the Roland EGX-350 to your PC.

The hand controller

The Roland EGX-350 can be controlled manually using the supplied hand controller.

This has a 16 x 2 line LCD display that shows the X, Y and Z coordinates in machine units, as well as a simple menu system. You select a menu and use the arrow keys to navigate through different sub menus. There is also a digital click wheel that can be used to vary the spindle speed between 5000 and 20000 RPM.

Every detail seems to have been well thought out in the design of this machine – for example, the hand controller contains no gaps between buttons, so no dust can fall into it.

Safety features

The Roland EGX-350 has a number of welcome safety features that make it a particularly good choice.

The work area is completely enclosed by a durable transparent cover, with microswitches which detect when the cover opens and automatically cut power to the motors.

It is possible to manually override the switches with the cover open; for this reason, where required for certain applications (eg schools), the machine can be delivered with tamper-proof micro-switches.

The machine also incorporates internal over-current protection which activates if the motors lock up (for example, if you drill into some hard material and the bit becomes stuck).

In that case, the current through the motor will rise steeply, which is detected by the driving electronics and the supply to the motor is stopped. You will get a failure message on the hand controller and the only way to proceed is to then reset the machine by turning the power off.

The other safety feature is the red kill switch – pressing it immediately cuts all mains power to the machine. This can be used in an emergency to stop the machine instantly. Apart from those features, any running job can be either paused or cancelled using the hand controller.

Setting up a job

For general engraving work, the machine comes with the Roland Engraving Studio software but as we mentioned earlier, for making PC boards you will need additional PC software – the one we tried is called CopperCAM from Intellecta (see www.galaad.net/coppercam).

This Windows software is normally an option but Intellecta will be including it with any Roland EGX-350 purchased from them as a result of this

review (make sure you tell them you saw it in SILICON CHIP!)

Producing Gerber plots

Gerber plots have been traditionally used to control plotters – they are almost universally accepted by PC-board-making houses. For that reason, most PC board design software such as Protel, Altium and Eagle have the facility to produce these and other CAM files. You will need Gerber plots (for each layer) as well as the Excellon drill file.

CopperCAM

Using CopperCAM, you can import the Gerber plots and the Excellon drill file. You select the layer and compute the contour paths.

The drilling coordinates are aligned to the copper tracks by selecting a reference pad on both. You then select 'adjust to reference pad' to align the two 'layers'.

Tools

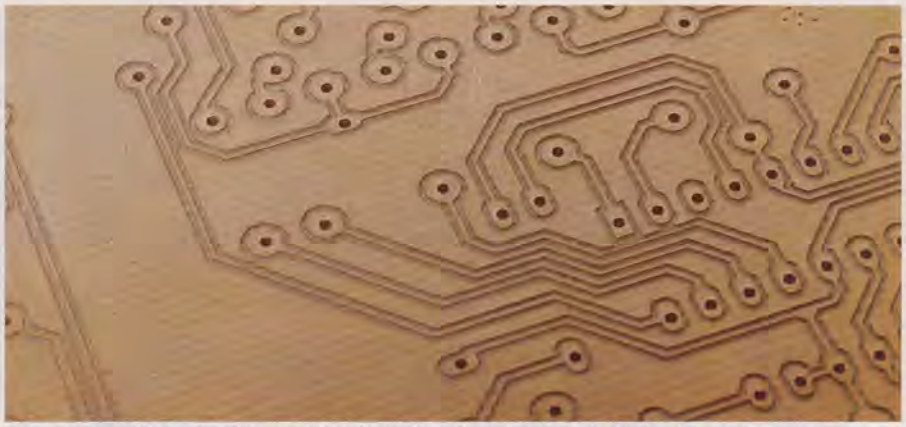
You can maintain a tool library for the different tools under CopperCAM. As a minimum, you will need an engraving bit and a drill bit. Each tool will have its own plunge speed and depth.

The top speed of the machine is quite fast (see the specifications). But the milling speed affects the quality of the cut: too fast and there will be noticeable burring of the edges along the cut and you may also damage the tool bit. Too slow a speed may well mean a slowly-made board.

Different materials and tools have natural milling speeds that are adequate for that application. For making PC boards, Intellecta recommended using paper phenolic PC boards, as these are softer than the typical fibreglass board, and therefore more forgiving on the engraving bit.

The engraving bit is made from tungsten carbide, which is a very hard composite but is expensive. The tools will wear out over time and they should be reasonably sharp to obtain a clean cut – especially if many thin tracks, of the order of 15 thou, are on the PC board.

It is also possible for the tool bit to break in the middle of an engraving job – the costs of tool replacement can quickly accumulate but experience to some extent circumvents this. The guaranteed life of the tool bit is measured in metres, and therefore it depends on the complexity of the PC boards being milled as to how many such boards can be made with the same tool bit.



Part of a PC board milled with the Roland EGX-350 CNC Desktop Engraver – one of many boards we produced. It looks a little different to conventionally etched PC boards because the cuts between tracks actually go a few thou into the base.

Setting the Z depth

Setting the reference Z depth is particularly important for milling PC boards. The reference Z depth will affect how deep the cut is made into the copper, because the depth set in CopperCAM is relative to the reference depth (which is the point of contact between tool bit and board).

The uniformity of the Z depth is especially important for those boards with fine tracks of the order of 15 thou or so (this was the smallest track we were able to route consistently in our testing).

You can purchase accessories for this machine including a vacuum table and a T-slot table that may help in achieving this uniformity. But we found that we could get quite good results simply by attaching the board to the supplied base using double-sided tape.

Tool Changes

Unlike more expensive milling machines with automatic tool changers, tool (bit) change is manual. While automatic changers are convenient, they add substantial cost and are not strictly necessary, especially for prototyping PC boards.

CopperCAM allows you to mill each layer separately, then the engraving bit can be changed to a drill bit and the holes drilled.

Drilling the Holes

Drilling is particularly easy, with various options in CopperCAM. You can select one drill bit for all holes – irrespective of the hole sizes embedded in the drill file. This is a good option to minimise the number of tool changes, which is time consuming and delicate, as the Z depth needs to be set every time a tool is changed.

If you do not wish to use different tool bits for differently sized holes, CopperCAM also has an option to use a single drill bit to make different hole sizes by circular boring. This is where the machine makes the hole by moving the head around the centre of the hole.

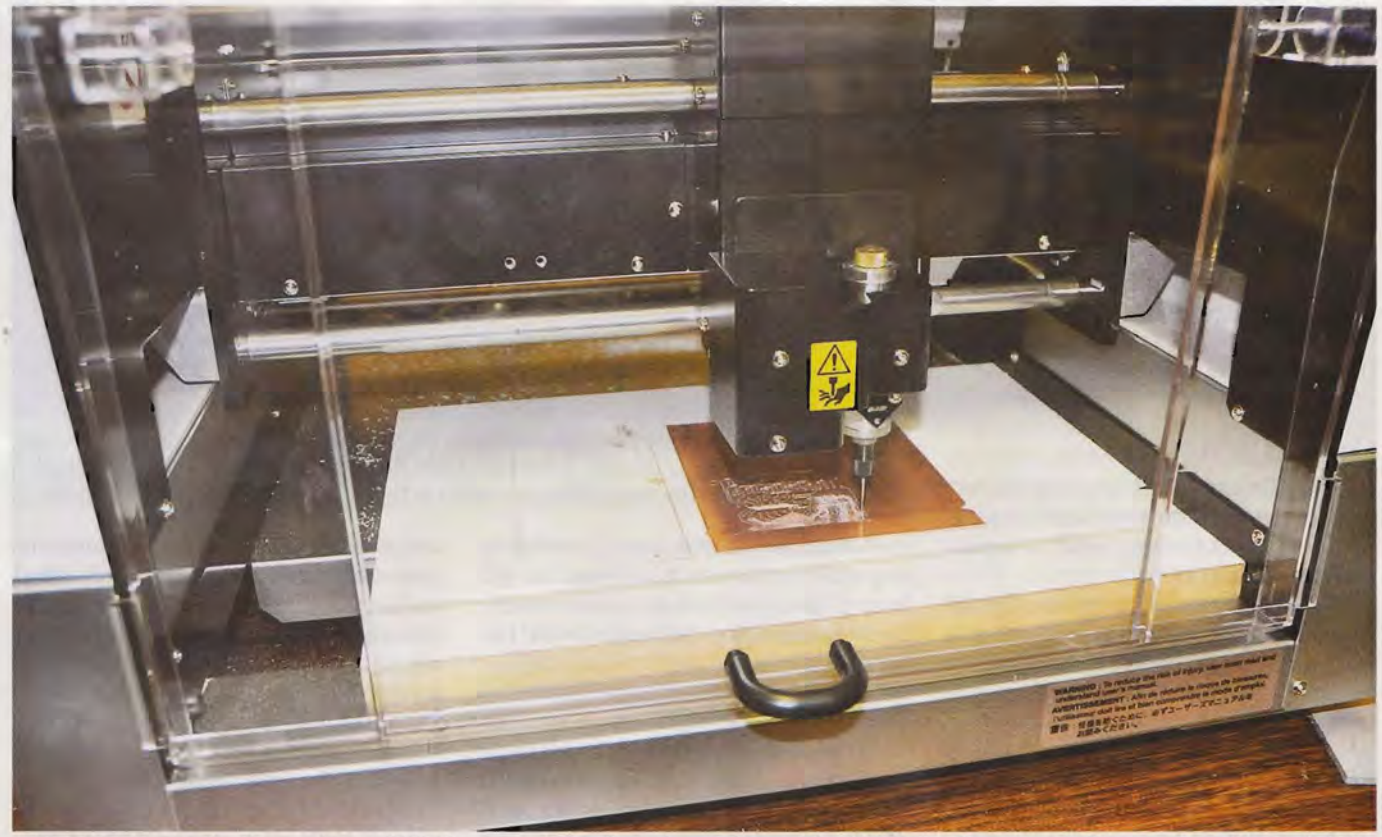
However, this can lead to many broken drill bits if not set up properly and is obviously harsher on the drill bits. In any case, for many PC boards, the best way is to use a single drill bit for all holes and enlarge the holes manually as the need arises.

This is the method we preferred, using a single 0.7mm drill bit. Most standard components such as resistors, capacitors, transistors, diodes and integrated circuits will usually fit through this size hole. Larger hole sizes, like those for TO-220 packages can then be drilled manually using a drill press.

Isolation Rub-outs

The quickest way to engrave the PC board is if the software creates a minimum isolation path around tracks – in other words, it leaves as much "dead copper" (copper which is not connected to the circuit) on the board as possible.

There may be legitimate reasons for removing the 'dead' copper, however, such as electrical considerations, ground planes, inter-track capacitance or perhaps simply to make assembly easier.



This shot shows the large piece of MDF we used as a base (complete with drill holes from an earlier produced board). It's very important that the blank PC board is flat and level due to the tight tolerances used in milling and drilling.

It is not hard to get solder bridges between a pad and an adjacent area when the only isolation is a single thin strip of missing copper.

Rub outs, although more time consuming and causing greater wear on the tool bits, help reduce the chances of solder bridges.

Conclusion

We tried this machine over a period of days. In that time we were able to manufacture a number of PC boards with consistently good results.

We were able to go from the electronic concept conceived in the morning to having a finished and working PC board by late afternoon – this involved not only designing the PC board on computer but also writing firmware, as the designs used a microcontroller.

Using a milling machine to manufacture PC boards, especially single-sided PC boards, is by far the most convenient and quickest method of production.

However, convenience costs: milling machines are not cheap.

This one, however, should certainly be affordable for designers but also fit within the budgets of educational institutions and perhaps even for advanced hobby use – especially when you consider that it can do much more than produce PC boards.

Admittedly, the outlay involved in purchasing a machine such as this could buy you many PC boards from your local board maker.

However, it is the convenience of a very short turnaround, coupled with the ability to test concepts on-the-go that make a milling machine attractive for situations that may require several iterations of boards.

Of course, apart from the initial capital outlay to purchase the machine, there is the ongoing cost of consumables.

This includes the tungsten carbide engraving tool bits, the collets, the drilling bits and the blank copper board. The bits wear out over time and will need regular replacement. They sometimes break too!

But if you chose the alternative photo-etching route, you'd also be up for the cost of pre-sensitised PC board, the chemicals required, drills and so on. And you'd certainly take a lot longer coming up with a finished board.

Simply put, we believe the Roland EGX-350 is one of the best CNC machines for making PC boards in its price range.

Price

The Roland EGX-350 costs $8795 (inc. GST) and can be purchased direct from Intellecta Technologies.

Intellecta Technologies supply the engraving tools for PC boards as well as drill bits, collets and services of interest to the education sector, specifically relating to PC board prototyping, including the CopperCAM software.

Acknowledgement

Our thanks to Dr Tony Pugatschew from Intellecta Technologies and Roland DG Australia for their technical assistance in this review.

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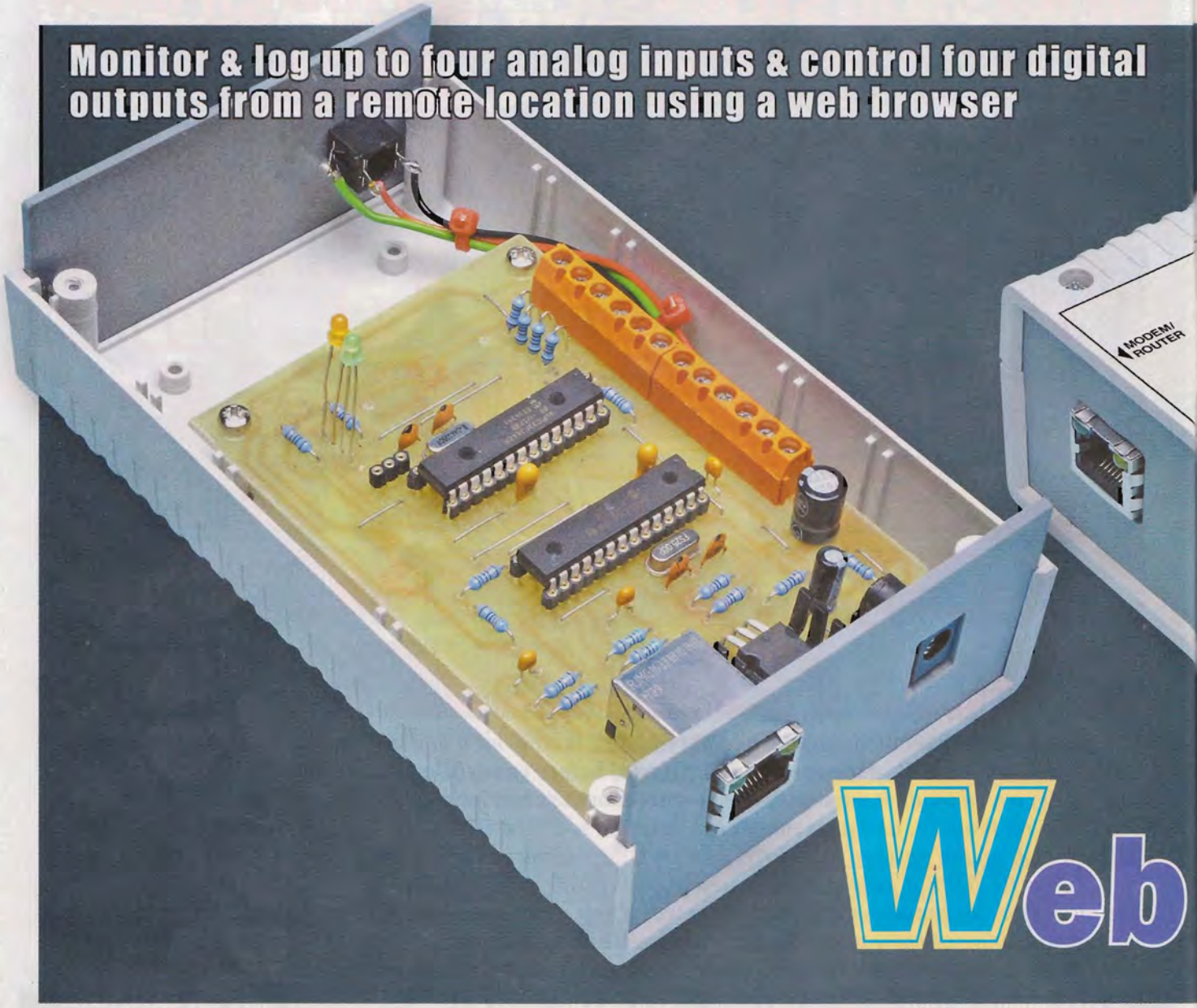
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Monitor & log up to four analog inputs & control four digital outputs from a remote location using a web browser



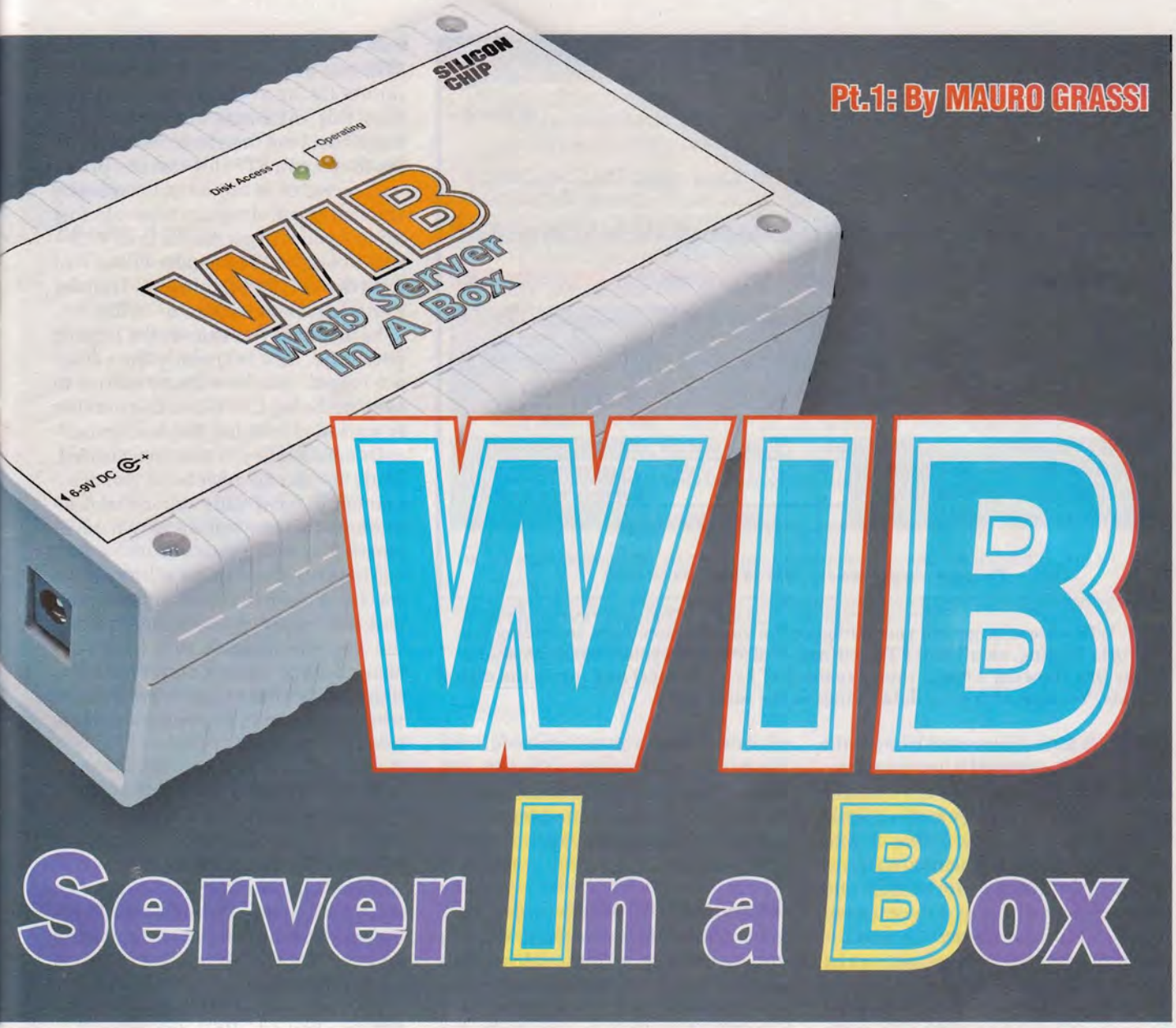
Web

We're very excited about this project. It will let you house your own website with possibly hundreds or even thousands of pages, all in a little box connected to the internet via your modem/router. You don't need a computer to operate and house a website – this little box does it for you and it can be accessed from anywhere around the world, at any time, even from a mobile phone which has a web browser. In fact, it is a complete web server in a box – so we've called it WIB (*W*eb server *I*n a *B*ox).

EVERYONE KNOWS THAT web servers normally involve big, expensive, powerful computers with large memory, large hard disks and exotic software, don't they? Well, that is the normal approach but now it doesn't have to be. In fact, you don't even need a computer!

WIB can do it all. Even better, it does not have a hard disk, uses practically no power and costs not much at all. WIB is just a small PC board (single-sided, no less) with a microcontroller, an SD/MMC card reader and not much else. In fact, it involves a total of just three ICs and a 3-terminal regulator.

Why have a memory card? This is the "Eureka!" feature: SD/MMC cards are used in the majority of digital cameras and they can pack a huge amount of memory for very little cash; we've



WIB Server In a Box

Pt.1: By MAURO GRASSI

seen them for as little as $8 for four gigs and going down all the time! So for not a lot more money WIB can use an SD/MMC memory card which can be 16 or even 32 gigabytes and that means it can store many thousands of pages of data, pictures or whatever and all of these can be accessed as a website via the internet.

Want to change the content? Well you could upload new data remotely via the internet or you could simply whip out the SD card, plug it into your computer and away you go. Or you could have several such SD cards, all with different web formats, presentations or whatever.

Maybe you would like to have a large picture library or whatever, accessible via the internet. Of course, you could take the conventional web server approach, as outlined above. Or you could do it with our WIB.

In fact, the applications are unlimited. Think of an application involving a website and WIB can probably do it. For example, do you have a small business, perhaps selling goods via the Internet? Maybe WIB could house your website. We're sure there a lots of applications that have just been waiting for this simple hardware solution.

It only requires a modem or a modem/router to connect it to the internet. And while it and the modem will need to be hooked up permanently, its energy use rates as flea power compared to a desktop computer or even a laptop when permanently powered up.

Furthermore, WIB can monitor the temperature or any other parameter (just connect a suitable sensor) and it can also be used to control four digital outputs and an RS232 serial port.

Down to earth

OK, we'll come clean. While we are very excited about this project, it didn't start out with such ambitious targets. The original intention was to produce a simple project which could monitor temperature or any other parameter in a home or remote location and display the resultant data on a website. At the same time it could control a few outputs – perhaps switch on a heater or air-conditioner or a few other prosaic functions.

But then we had the idea of using

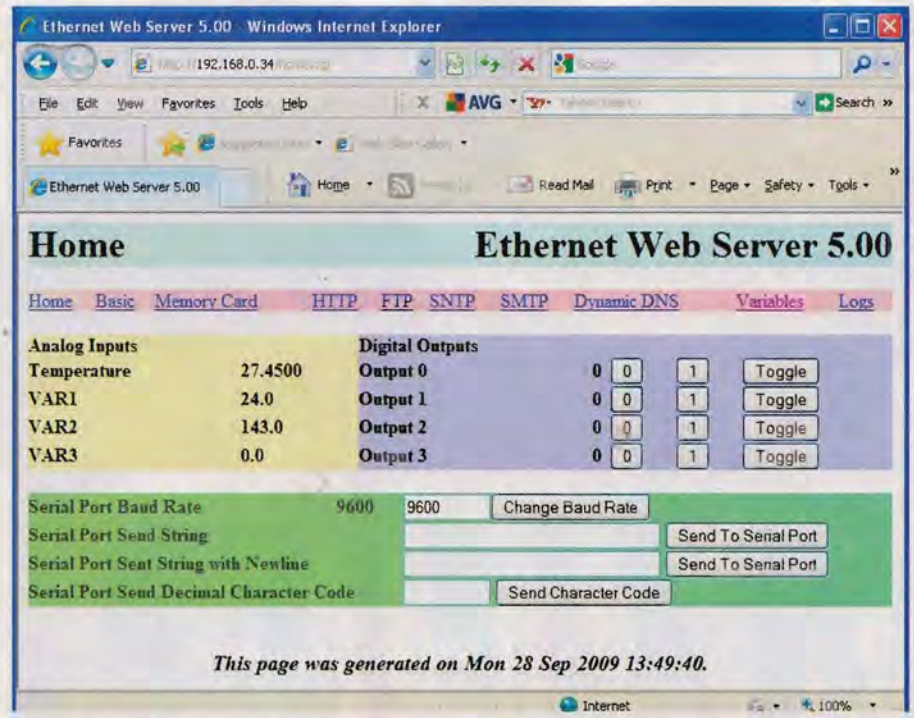


Fig.1: WIB's home page lets you configure the various functions, including the network, logging, email and FTP settings. It also allows you to read the analog inputs (it's showing a temperature reading of 27.45°C here) and toggle the digital outputs. You can also send data strings to the serial port.

an SD/MMC memory card to store the data and website. And it just grew from there. Having thought of the memory card as the bulk memory for the project and realising just how cheap it was, the potential uses seemed to grow enormously. We are sure readers will come up with a host of different uses.

Let's also be realistic. We need to describe how this WIB project works, how it connects to the internet and all the necessary know-how that this requires. There is a lot of jargon to be digested and understood but when we have finished describing WIB in considerable detail, we are sure that you will see the potential.

WIB presents a great learning opportunity for anyone interested in creating a personal website – it will be great for schools, too. For example, it could possibly be teamed up with our popular Seismograph project (SILICON CHIP, September 2005) or a weather station. Students would be able to access it at any time via a mobile phone with a web browser.

WIB is not the complete server solution – it lacks some features like server side scripting and encryption, for example, althought for most applications, this won't be a problem.

Its main advantage is that it is considerably simpler, cheaper and easier to set-up than a more powerful web server. In fact, if you have already gone through the set-up procedure for connecting a broadband modem to your computer, this project should not be any more challenging.

Remote monitoring

In most basic applications, WIB lets you monitor up to four analog inputs and control up to four digital outputs, as well as an RS-232 serial port.

WIB not only features an inbuilt web server but includes inbuilt FTP and an email (SMTP) client as well. We will explain these terms as we go through.

The email client is used by the WIB to send emails to a nominated email address via an email server. Most ISPs (Internet Service Providers) provide an outgoing email server that the WIB can connect to, in order to send email.

The FTP (file transfer protocol) server allows you to store and retrieve files from a remote location and also allows you to manage your website remotely. In addition, you can use it to back-up files off-site or transfer files (both text and images) to a remote location (eg, from the office to home).

The memory card can actually be an MMC, SD or SDHC card (up to 32GB). The website can include dynamic content that's constantly updated with data from the four analog inputs and WIB can perform data logging of the inputs (as in a weather station) and save this information to a file. The logged data can then be accessed either via the inbuilt FTP (file transfer protocol) server or it can be automatically emailed to you at regular intervals. Just think – you will get emails from WIB – mind-boggling! The emails will be sent from the SMTP (Simple Mail Transfer Protocol) client within the WIB.

In practice, you can set the logging period (ie, how frequently the values are logged) and how many entries to keep in the log file. When this number is exceeded, the log file is automatically emailed to you and then cleared, ready for the next cycle. In this way, you could have daily reports of fluctuations in temperature or whatever emailed to your inbox.

The WIB also allows a limit to be set on a variable being monitored and can notify you via email when the variable exceeds this limit. For example, you can set it to email you if the temperature rises above a preset level, so that you immediately know there is a problem.

Digital outputs

As stated earlier, you can also control four digital outputs and the serial RS-232 port using your browser (eg, Internet Explorer, Mozilla Firefox, Opera, Safari, Google Chrome, etc). These outputs can then be used to control external devices, either directly or via an interface board.

It's just a matter of toggling the digital outputs high or low by clicking on the "Toggle" buttons – see Fig.1.

Network time

Another feature of WIB is an SNTP (Simple Network Time Protocol) client, which allows the correct time to be gathered automatically from the Internet. This time is used for logging purposes and can also be displayed in a dynamic web page.

A dynamic DNS (Domain Name System) client is also included. Domain Name refers to any website name (such as **siliconchip.com.au**). DNS enables the unit to keep track of its public IP (Internet Protocol) address and notify a DDNS (Dynamic Domain Name System) service if this address changes. By using this service, you can log into the web server using a domain name rather than its IP address (an IP address is

numerical and all devices connected to the internet, such as your modem, have an IP address).

This is necessary as the public IP address can change if your modem is turned off for some time, so you might not always know what it is.

Earlier design

This is not the first web server project to be published in SILICON CHIP. An earlier project, the PICAXE Net Server, was published in the October 2006 issue and was based on a common Realtek ethernet controller chip and a PIC microcontroller. It came as a pre-built module and stored its web pages in an onboard EEPROM chip.

Because the data was stored in an EEPROM, the website was limited to 64 kilobytes. Even so, it did allow you to monitor several analog inputs remotely using dynamic web pages and had configurable I/O pins, including a PWM (pulse width modulation) output.

By contrast, our new design can store much more complex web pages.

Another advantage of the new design is that it implements simple file permissions through HTTP (Hypertext Transfer Protocol) authentication. This means that you can set a user name and password to access the whole website or just certain pages. You can also restrict access to certain files, based on the file extensions. The earlier design lacked a method of restricting access to its web pages and so its onboard website was completely open to the public.

Finally, the WIB is highly configurable and can be set up to work with almost any ethernet network. Did we mention ethernet? This refers to the ethernet cable and connectors on the back of your modem. Ethernet is a standard which is used to transmit data over a local network (eg, in an office) or to the internet via a modem.

We will also be providing the source code for a website so that you can easily modify the web server's settings if necessary, to suit your requirements.

Circuit details

Refer now to Fig.2 for the complete circuit details of the WIB. It's based on a dsPIC33FJ64GP802 microcontroller (IC1) and an ENC28J60 ethernet controller (IC2), both from Microchip.

The ethernet controller (IC2) provides the ethernet link, including MAC (Media Access Control) and the 10BaseT PHY (this means it runs at 10Mbits/second). It has 8KB transmit and receive dual port RAM buffers, hardware assisted CRC (Cyclic Redundancy Check – for error checking), automatic retransmit on collision (in case messages "collide") and programmable packet (blocks of data) filtering.

Although Microchip makes microcontrollers with in-built ethernet controllers, these are only available as surface-mount devices (SMDs). We wanted to avoid SMDs as far as possible so we have specified an external controller (IC2) which comes in a conventional DIL package, as does the specified PIC microcontroller (IC1).

The only SMD chip used in the whole project is the 8-pin MAC address chip (IC3) which comes in an SOIC package. And while IC2 does include Media Access Control (MAC), we still need IC3 for providing the unique MAC address; more on this below.

In operation, the microcontroller (IC1) communicates with the ethernet controller via an SPI (Serial Peripheral Interface) bus. This SPI bus is also shared with the MAC address chip (IC3) and the memory card, which is accessed in SPI mode.

SPI communication requires four lines and these are: CS-bar (chip select – active low), SO (serial data output), SI (serial data input) and SCK (serial clock). You can share the bus among multiple devices by having multiple CS-bar lines and ensuring that only one of these lines is active at any one time.

In this case, we use three CS-bar lines: one for the ethernet controller (RB8 of IC1), one for the memory card (RB2 of IC1) and one for the MAC address chip (RB6 of IC1). These are all controlled by the SPI master (IC1).

MAC address chip

The 25AA02E48 MAC address chip is a 256-byte EEPROM with an SPI interface. It's main feature is that its last six bytes (bytes with addresses 0xFA to 0xFF) contain a unique, licensed MAC (Media Access Control) address.

An ethernet device must have a unique MAC address in order to communicate in a network. By using this chip, we are ensuring that the MAC address for the web server is globally unique. These chips are intended for use in designs with small production runs and save on the cost of licensing a range of MAC addresses from the relevant authority (IEEE).

Note that it is quite possible to overwrite the pre-programmed MAC

Main Features

- **Highly customisable.** Most settings including IP address, port numbers and servers can be arbitrarily set.
- **MMC/SD/SDHC memory card** for storage of web pages and other files (FAT/FAT32 file system).
- **HTTP (web) server** with changeable file permissions, dynamic pages, modified CGI commands and HTTP basic authentication.
- **SMTP (email) client** for automatic email notifications with dynamic content.
- **FTP (file transfer protocol) server** for uploading web site.
- **Dynamic DNS client (DDNS)** to allow server to be contacted using a hostname.
- **Network time (SNTP) client** to gather Internet time for logging, etc.
- **Four analog inputs.** These can be: (a) monitored remotely using a web browser; (b) logged with periodic log files automatically emailed to a chosen email address; (c) assigned set limits, with automatic email notification when limits are exceeded.
- **Four digital outputs** for controlling devices over the Internet.
- **12 user defined file extensions,** file permissions and file content for the HTTP server.
- **A serial port output** that's controllable via the Internet.
- **System logging** of special events.

Reading & Writing Data To The Memory Card



TO TRANSFER files from a PC to the memory card, you may need a low-cost SD/SDHC/MMC-card reader. The one shown at left is available from Jaycar for less than $10 (Cat No: XC-4756), while the unit at right reads all sorts of memory cards and is also available from Jaycar (Cat. XC-4849). They are simply connected to a PC via a USB port.

Suitable memory card readers are also available from Altronics.

address (it is an EEPROM chip after all). However, the chip has a write protect feature that can be enabled on a 64-byte block basis and the last such block, which contains the MAC address, is protected by default.

In any case, the current version of the firmware does not write to the EEPROM and only reads from it. Pin 3 (WP-bar) is the write protect pin and this prevents writing to the EEPROM when low. In our case, however, it has been tied high to allow it to be written to if there is a future firmware upgrade.

Pin 7 (HLD-bar) is the hold pin and this pauses the SPI interface logic inside IC3 if it is low. This feature is used in SPI bus sharing situations but has been disabled here by tying pin 7 high. Instead, we rely on the firmware in IC1 to provide proper arbitration between the three SPI devices.

Ethernet controller

The ethernet controller chip (IC2) provides the physical and data link layer of the network. As already mentioned, it is a 10BaseT PHY (physical layer) running at 10Mbits/s and the data is transmitted on twisted-pair copper cables terminated in an RJ45 connector (the ethernet socket).

PIC microcontroller IC1 writes to the ethernet controller's registers via the SPI bus which runs at 8MHz. Ethernet transmissions occur by Manchester encoding on the T+ (pin 17) and T- (pin 16) pins of IC2 via two 51Ω resistors. The resistor values are chosen to be close enough to match the characteristic impedance of the 10BaseT (ethernet) cable, which is 100Ω. Similarly, reception occurs on the R+ (pin 13) and R- (pin 12) pins of IC2.

The ethernet controller (IC2) requires some passive components to complete the physical ethernet link (ie, to transmit and receive data), including two transformers. These transformers plus, four 75Ω resistors and a 1nF capacitor, are all part of RJ45 connector CON2 and provide electrical isolation from the network. In addition, the RJ45 connector contains two LEDs, one green and the other yellow.

According to the datasheet for the ENC28J60 (IC2), a 2.32kΩ resistor from pin 14 (R_{BIAS}) to ground is required to set the signal amplitude on the transmitting pair. This is made up using series 2kΩ and 330Ω resistors to give 2.33kΩ, which is near enough. IC2 also requires a 25MHz crystal to operate correctly and this, together with its two 33pF loading capacitors, is connected to pins 23 & 24.

Outputs LEDA and LEDB of IC2 drive the two LEDs in the RJ45 connector. These outputs can be configured (using the registers in IC2) to light the connector LEDs under various conditions. In this case, we have chosen to drive the LEDs to conform to the usual convention, with the green LED indicating a valid ethernet link and the yellow LED indicating data activity.

The remaining line to IC2 is the RST-bar line (pin 10). This is the reset line and is driven by the RB7 (pin 16) output of the microcontroller. It simply resets the internal logic of the ethernet controller (IC2) when required.

Note that there are two other lines on IC2 which are unused: CKO and INT-bar.

CKO (pin 3) is a clock out line and this delivers a square-wave whose frequency is related to IC2's system clock (in turn derived from the 25MHz crystal). This frequency can be configured via IC2's registers (it can be used to provide the clock for a microcontroller for example) but is not used here as IC1 has its own crystal (X1). This was done to allow the microcontroller to run at its highest rated clock frequency.

The other unused line (pin 4) is the interrupt line. This can be used to interrupt the microcontroller under certain circumstances but again is not used here.

Memory card

As mentioned above, the memory card is accessed in SPI mode and this is done via the SD card socket (CON4). This allows microcontroller IC1 to read from and write to the memory card.

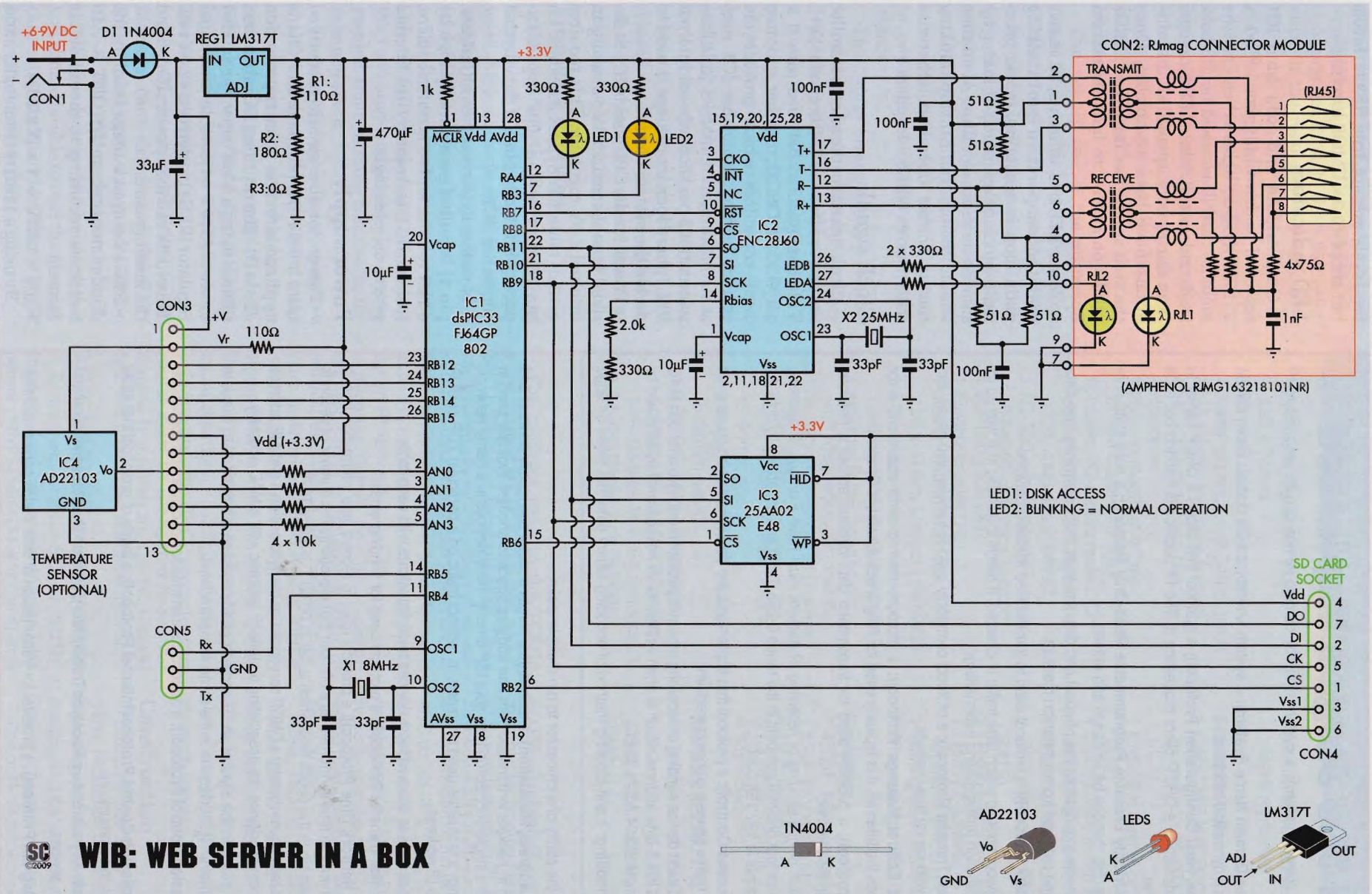
MMC/SD/SDHC cards can be accessed either in native mode or in SPI mode. The advantage of the SPI mode is that any off-the-shelf microcontroller that has an SPI peripheral can be used, making the hardware layer easy to implement. The interface with SPI is also simpler but the penalty is slower transfer speeds. However, SPI speeds are quite adequate for serving web pages.

Inputs & outputs

Connector CON3 provides access to the analog inputs and the digital outputs. The four analog inputs are AN0-AN3 of IC1 (pins 2-5) and these inputs are all protected using 10kΩ current-limiting resistors. An AD22103 temperature sensor IC (IC4) is shown connected to AN0 on Fig.2 but other types of sensors with a linear 0-3.3V output (or less) can also be used on the analog inputs.

The digital outputs are at RB12-RB15 (pins 23-26) of IC1 and toggle between 0V and 3.3V.

CON5 allows optional access to the serial (UART) port of IC1. Note that



WIB: WEB SERVER IN A BOX

Fig.2: the circuit is based on a PIC microcontroller (IC1), an ENC28J60 ethernet controller (IC2), a 25AA02E40 MAC address chip (IC3) and an external memory card. The PIC microcontroller interfaces to the memory card, reads the analog inputs and controls the digital outputs at RB12-RB15. It also drives the ethernet controller (IC2) which in turn interfaces to the external network via an RJ45 connector. IC4 is an optional temperature sensor (AD22103) and is connected to one of the analog inputs (AN0 in this case). Power comes from a 6-12V DC regulated plugpack supply.

All The Jargon Explained

DNS (Domain Name System): a system whereby domain names can be resolved to IP addresses.

DDNS (Dynamic Domain Name System): a system whereby a fixed domain name can be associated with a dynamic IP address.

DHCP (Dynamic Host Configuration Protocol): a protocol that allows a DHCP server to assign an IP address to a DHCP client requesting it. The IP address is handed out on a limited time lease.

EEPROM (Electrically Erasable Programmable Read-Only Memory): a solid-state non-volatile memory chip that can be written to and erased.

Ethernet: a network standard for the physical and data link layer that determines how data is transmitted and received from a common medium.

FTP (File Transfer Protocol): a protocol used to transfer files across a network.

Gateway: a network node to which data traffic is directed. It relays this traffic in a way so as to reach its destination (using routing information).

HTTP (Hypertext Transfer Protocol): a protocol commonly used to transfer web pages and content from a web server to a browser.

ICMP (Internet Control Message Protocol): a protocol used to send status and error messages across the Internet. It is typically used for Ping (Packet Internet Groper).

IP (Internet Protocol): a protocol used for transmitting data packets across a network, primarily used in the Internet.

IP Address: each device sending or receiving IP packets must have a unique IP address, typically written as four decimal numbers in the range 0-255 (8-bit) and separated by dots. An example IP address is 192.168.0.34.

MAC (Media Access Control): a protocol that implements the data link layer on an ethernet network where nodes share a common medium.

MAC Address: each device sending or receiving ethernet packets must have a unique MAC address. This is is a 6-byte address which is often written as six hexadecimal bytes joined by colons, for example: 00:04:A3:21:09:6C.

Manchester encoding: a self-clocking method of encoding binary data that relies on edge transistions.

Multi-tasking: the ability of a processor to run multiple tasks.

NAT (Network Address Translation): a technique whereby a router can modify address and port information in packets to translate from one address space to another. Typically used in routers to share a single connection from your ISP among many devices in a home network.

Port Forwarding: a technique used by routers to redirect traffic on a particular TCP or UDP port to a private IP address.

Protocol: a set of rules to allow network devices to communicate with each other.

SMTP (Simple Mail Transfer Protocol): a protocol used for sending email.

SNTP (Simple Network Time Protocol): a protocol used to receive time information from a remote time server. The time is returned as a number that represents the number of seconds that have elapsed since the epoch time which is set at 00:00 1 January 1970.

Static DHCP: a technique whereby a DHCP server can be made to assign a static IP address to a particular network device (by associating a static IP address with a MAC address).

Subnet Mask: this is in the style of an IP address and is used as a bitwise AND mask to determine whether an IP address is in the same network subnet.

TCP (Transmission Control Protocol): a protocol for transmission of data that is connection oriented.

TCP/IP (Transmission Control Protocol/Internet Protocol): a family of protocols that allow network devices to communicate.

UART (Universal Asynchronous Receiver/Transmitter): a circuit used for serial communication between devices.

UDP (User Datagram Protocol): a protocol for transmission of data that is packet oriented.

the levels are not true RS232 levels but simply 3.3V CMOS levels.

LED indicators

Outputs RA4 and RB3 from IC1 are used to drive indicator LEDs1 & 2. LED1 (green) lights when ever the memory card is accessed (ie, for both reads and writes), while LED2 (orange) is on during boot up until all initialisations have been completed. Once the web server has initialised, LED2 blinks on and off to indicate normal operation.

When LED2 is blinking, it shows that the cooperative multitasking main loop is executing, ie, no process is blocking operation or taking up inordinate processor time. At no time should the orange LED stop blinking during normal operation, otherwise data packets will be dropped.

Clock signals

Clock signals for the microcontroller are derived from an 8MHz crystal (X1). This is connected between pins 9 & 10 (OSC1 & OSC2), together with two 33pF capacitors which provide the correct loading. Note that IC1 runs at its maximum of 40MIPS (millions instructions per second) – an internal PLL (phase lock loop) stage is used to derive the system clock.

Power for the CPU inside IC1 is derived from the main 3.3V rail using an internal 2.5V regulator. This requires a 10µF tantalum bypass capacitor on pin 20. Similarly, a 10µF bypass capacitor is fitted to pin 1 of the ethernet controller (IC2).

Note that IC1's reset pin (MCLR-bar, pin 1) is pulled permanently high by a 1kΩ resistor and so is not used here. Instead, IC1 is reset by its internal power-on reset logic.

Power supply

Power for the circuit is derived from a 6-9V DC plugpack and this is applied via reverse polarity protection diode D1. The resulting DC rail is then filtered using a 33µF capacitor and fed to an LM317T adjustable 3-terminal regulator (REG1) to derive a +3.3V rail. This +3.3V rail then powers ICs1-3 and the memory card.

REG1's output voltage is set by the divider network on its OUT & ADJ terminals according to the following formula:

$$V_{OUT} = 1.25V \times (1 + (R2/R1))$$

By using a 110Ω resistor for R1 and a

180Ω resistor for R2, we get an output voltage that's very close to 3.3V.

In practice though, the 1.25V reference in the regulator can vary anywhere between 1.2V and 1.3V, due to manufacturing tolerances. For this reason, provision is made on the PC board for an additional resistor (R3) in series with R2 so that you can adjust the output voltage if necessary. In most cases, you won't need to do this and a wire link is used for R3 instead (more on this later).

The supply rail at the output of diode D1 is also fed to a terminal on CON1, so that it can be used to power external devices if necessary. In addition, the +3.3V rail is fed to two other terminals on CON3, in one case via a 110Ω current-limiting resistor. The current-limited +3.3V rail (Vr) is used to power the AD22103 temperature sensor (IC4).

The 110Ω current-limiting resistor is necessary because the temperature sensor is connected to the circuit via a stereo jack socket. In operation, it prevents the supply rail from being shorted to ground each time the stereo jack is plugged into its socket (the jack's tip touches the socket's ring as it is inserted). The 110Ω resistor protects against short circuits and doesn't interfere with the operation of the temperature sensor itself, as the latter's current draw is negligible.

Ethernet Web Server Parts List

1 PC board, code 07111091, 123 x 74mm
2 28-pin 0.3-inch IC sockets
1 3-way pin socket, 2.54mm pitch
8 M3 x 6mm machine screws
4 M3 x 15mm tapped Nylon spacers
1 250mm-length of 0.7mm tinned copper for links
1 2.5mm PC-mount male DC power connector (Jaycar PS-0520, Altronics P-0621A)
1 TO-220 mini heatsink (Jaycar HH-8502, Altronics H-0630)
1 8MHz crystal (X1)
1 25MHz crystal (X2)
1 plastic instrument case, 95 x 158 x 47mm (Jaycar HB-5922)
1 SD surface-mount memory card socket (Jaycar PS-0024)
1 ethernet RJ45 Connector with Magnetics, Amphenol RJMG163218101NR (Farnell 135-7435)
3 3-way screw terminal blocks (5.04mm pitch)
2 2-way screw terminal blocks (5.04mm pitch)
1 6-9V DC 300mA plugpack (Jaycar MP-3145 or Altronics M-9208 plus M-9191 connector)
1 3.5mm stereo jack (optional)
1 3.5mm stereo socket, chassis mount (optional)

Semiconductors
1 dsPIC33FJ64GP802-I/SP programmed with 0711109A.hex (IC1)
1 ENC28J60 ethernet controller (IC2)
1 25AA02E48 serial EEPROM with MAC address (IC3)
1 AD22103 temperature sensor (IC4) (optional) (Farnell 143-8415)
1 1N4004 silicon diode (D1)
1 LM317T adjustable 3-terminal regulator (REG1)
1 3mm green LED (LED1)
1 3mm orange LED (LED2)

Capacitors
1 470µF 16V electrolytic
1 33µF 16V electrolytic
2 10µF tantalum
3 100nF monolithic
4 33pF ceramic

Resistors (0.25W, 1%)
4 10kΩ
1 2kΩ
1 1kΩ
5 330Ω
1 180Ω
2 110Ω
4 51Ω

Firmware overview

OK, so that's the hardware side of things and it's all fairly straightforward. Most of the features are implemented in the firmware, so let's now take a closer look at this.

The firmware uses the freely available TCP/IP stack from Microchip. We've customised it and also implemented some missing features in the minimal stack.

The stack is based on a cooperative multi-tasking model (ie, a lot of tasks run concurrently) and this has been retained. The main program is an infinite loop, with finite state machines used to keep track of stack processes that need attention.

The other major addition is the memory card driver and the FAT/FAT32 file system that resides on top of that. The WIB recognises the FAT/FAT32 file system which means that you should be able to read the memory card using any Windows, Mac or Linux box (and a card reader).

The modules used in the TCP/IP stack include HTTP, FTP, ICMP, SNTP, SMTP, DNS and Dynamic DNS. Only the limited amount of program memory on the microcontroller prevented us from including further modules such as a DHCP client to automatically pick up an IP address.

Because there's no DHCP client, the web server is assigned a static IP address and this is also necessary for port forwarding. However, a DHCP client working in conjunction with static DHCP could have been useful for incorporating the web server into an automatically configured network.

In any case, the DHCP server in your router must be configured to reserve a static IP address for the WIB. We'll tell you how to do that next month.

MMC/SD/SDHC memory cards

Either an MMC, SD or SDHC memory card can be used in the web server. MMC (MultiMedia Card) and SD (Secure Digital) cards use FLASH memory technology and are available in capacities up to 2GB. SDHC cards are essentially high-capacity SD cards and are available in sizes ranging from 4GB to 32GB.

All three types of card can be used in this project. Note that while all three types look alike, MMC cards have only seven metal contacts whereas SD cards have nine.

MiniSD and MicroSD cards can also be used. These are essentially SD cards but are smaller. You will need an external adaptor in order to plug them into the SD card socket used in the web server.

Construction

Building the WIB is easy with all parts mounted on a single-sided PC board coded 07111091. This board measures 123 x 74mm and is housed inside a plastic utility case.

The only slightly tricky bit is the sur-

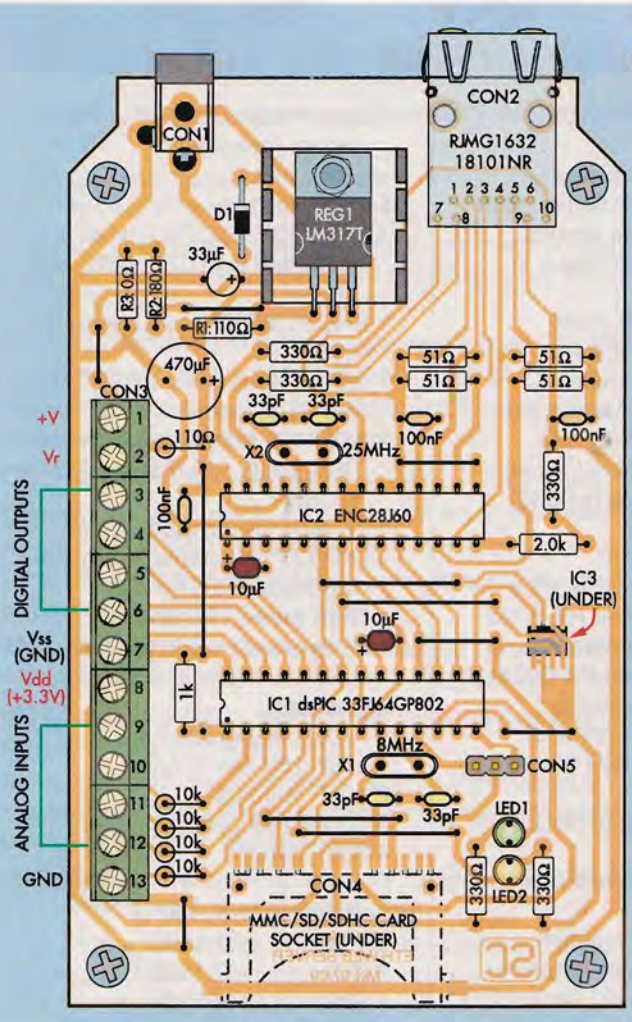
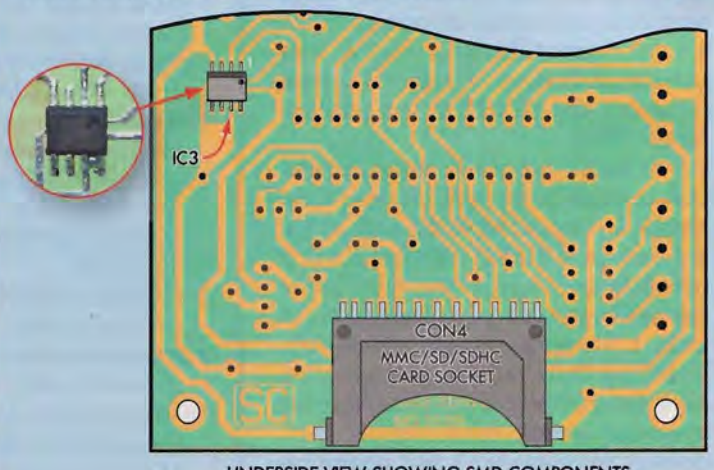


Fig.3: install the parts on the PC board as shown on this layout diagram. Make sure all polarised parts are correctly oriented and leave IC1 & IC2 out until after the power supply has been checked – see text.



Fig.4 (below): this diagram and the accompanying photos show how IC3 and the SD memory card socket are installed on the track side of the PC board. Note the orientation of the IC and don't forget to solder the two tabs of the memory card socket adjacent to the edge of the board.



UNDERSIDE VIEW SHOWING SMD COMPONENTS

face-mount IC (IC3) which is mounted on the copper side of the PC board. However, this SOIC device has only eight pins and the pin spacing is around 1.27mm, so it's not difficult to hand solder.

Figs.3 & 4 show the parts layout on the PC board. However, before beginning the assembly, it's a good idea to carefully inspect the board for etching defects (eg, shorted tracks and hairline cracks). Such faults are rare but checking now can save a lot a hassle later on.

Check also that corner cutouts have been made at the CON1 & CON2 end of the board, so that it will later clear the mounting posts inside the case. If not, you will have to make the cutouts yourself using a fine-toothed hacksaw and a small, flat file.

Having done that, the first job is to install the 11 wire links – see Fig.3. These can be cut from a length of 0.7mm tinned copper wire. If necessary, you can first straighten the link wire by clamping one end in a vise and then stretching it slightly by pulling on the other end using a pair of pliers.

Once the links are in, the next step is to install the resistors. These can go in either way and some are mounted end-on to save board space. Table 1 shows the resistor colour codes but you should also check each one with a DMM before installing it.

You can either use a zero-ohm resistor for R3 or you can install a wire link.

Diode D1 and crystals X1 & X2 are next on the list. Note the orientation of D1 and don't get the two crystals mixed up. The 8MHz crystal is used for X1, while the 25MHz crystal is X2.

Now for the LM317T regulator (REG1). This mounts horizontally on the board and is fitted with a mini heatsink for cooling. It's installed by first bending its leads down by 90° about 5mm from its body. It's then secured in place, along with its heatsink, using an M3 x 6mm machine screw, flat washer and nut and its leads soldered.

Note: do not solder REG1's leads before bolting it down. If you do, the PC tracks could crack as the assembly is tightened down.

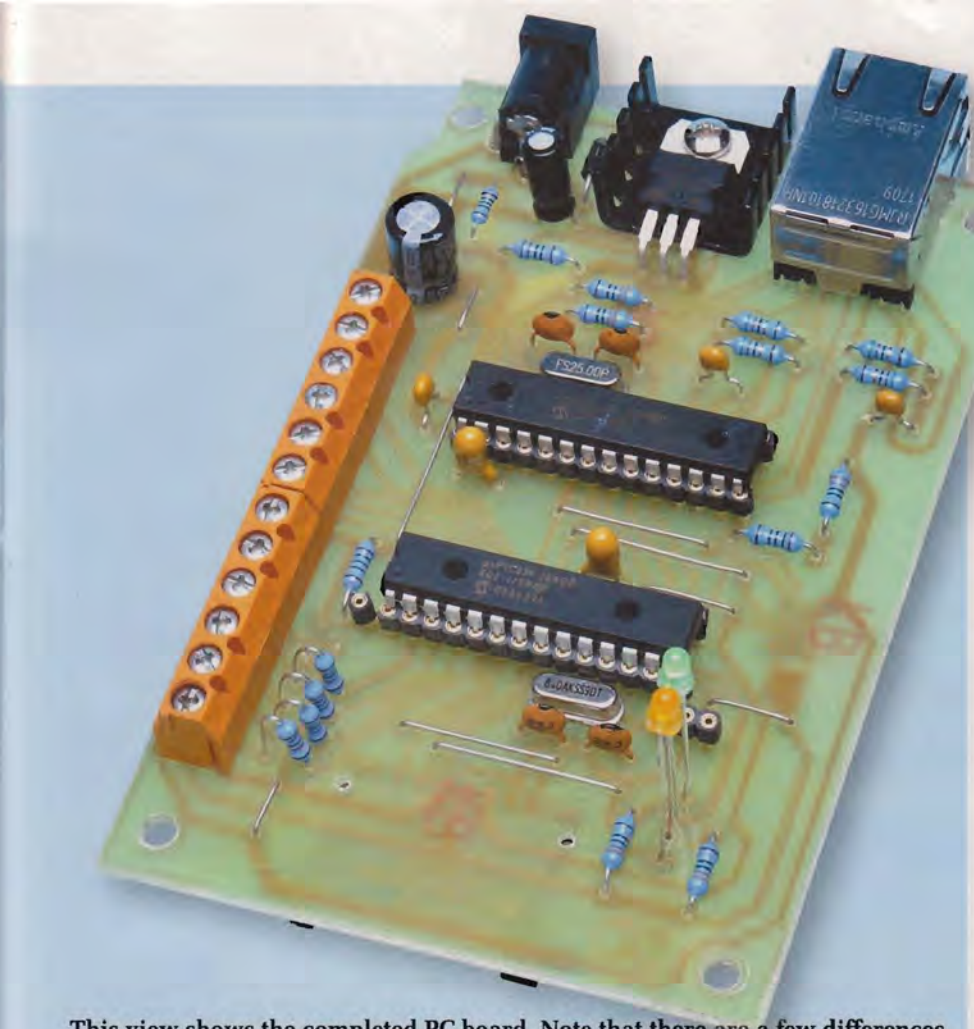
The two 28-pin machine IC sockets can now be installed. Be sure to orientate these with their notched ends as shown on Fig.3. If you are unable to obtain 28-pin 0.3-inch sockets, you can use pin header strips instead. Alternatively you can cut 28-pin 0.6-inch sockets in half or you can use two 14-pin sockets mounted end-to-end.

Do not install the two ICs in their sockets yet. That step comes later.

Follow these parts with the capacitors, starting with the 33pF ceramic and 100nF monolithic types. The two 10µF tantalum capacitors can then be installed, followed by the 33µF and 470µF electrolytics. Note that the tantalum and electrolytic capacitors are all polarised, so make sure they go in the right way around – see Fig.3.

Connectors

The DC socket (CON1), the RJ45



This view shows the completed PC board. Note that there are a few differences between this prototype board and the final version shown in Fig.3, especially around CON1, CON2 and REG1.

connector (CON2) and the 3-way pin socket (CON5) can now go in. Make sure that these parts are sitting flush against the PC board before soldering their pins. In addition, take care when soldering the RJ45 connector as some of its pins are quite close together and it's easy to get solder shorts. **Don't forget to solder the two pins near the edge of the PC board, as these help secure the socket in position.**

The 13-way screw terminal block (CON3) is made up using three 3-way blocks and two 2-way blocks. These should all be dovetailed together and mounted as a single unit, with the access holes facing the edge of the board.

The board assembly (minus the three ICs and the SD card socket) can now be completed by soldering in the two LEDs. These should both be mounted at full lead length, with their bodies 25mm above the board so that they will later protrude through the lid of the case. Use the green LED for LED1 and the orange LED for LED2 and make sure they are oriented correctly.

A 25mm-high cardboard spacer can be used to set their height. Just slide this spacer between each LED's leads and push the LED down onto it before soldering it in place.

Initial tests

You will need a 6-9V DC 300mA (or greater) regulated plugpack fitted with a 2.5mm connector to power this project. Suitable plugpacks include the Jaycar MP-3145 and the Altronics M-9208. Note, however, that the latter requires swapping the supplied 2.1mm connector for a 2.5mm connector (Altronics M-9191).

With the three ICs out of the circuit, apply power and use a DMM to measure the voltage between the OUT terminal of REG1 and GND. It should measure close to 3.3V and this same voltage should also appear at the Vdd (3.3V) terminal of CON3.

If you don't get the correct reading, switch off immediately and check for wiring errors. In particular, check the resistor values on the OUT and ADJ terminals of REG1 if the reading is high or low. Alternatively, if you don't get any voltage at all, check the supply polarity and D1's orientation.

Trimming the 3.3V rail

The accuracy of the +3.3V rail is important because some MMC/SD/SDHC cards operate over quite a narrow voltage range. The firmware checks that the inserted card operates at 3.3V and so it is crucial that REG1's output be close to +3.3V.

If the 3.3V rail is more than 3.4V or less than 3.2V, you will need to change one or both of the values for R2 and R3. For example, if the voltage is around +3.17V, you will need to install a 10Ω resistor for R3 and this should increase the rail so that it is close to +3.3V.

Alternatively, if the output voltage is +3.41V, you should change the value

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	4	330Ω	orange orange brown brown	orange orange black black brown
❑	1	180Ω	brown grey brown brown	brown grey black black brown
❑	2	110Ω	brown brown brown brown	brown brown black black brown
❑	4	51Ω	green brown black brown	green brown black gold brown

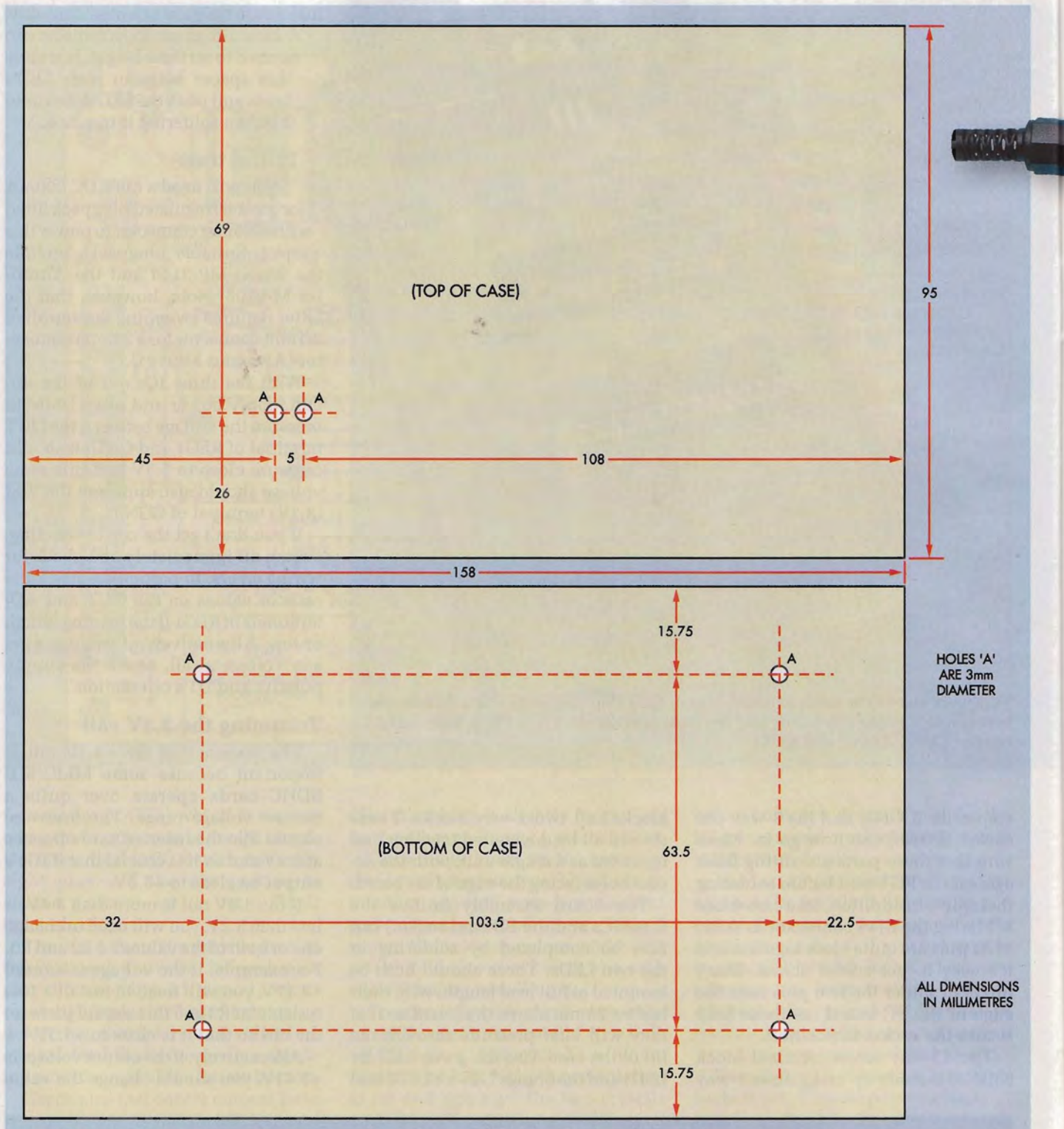


Fig.5: here are the drilling details for the top and bottom case sections. All the holes are drilled to 3mm diameter.

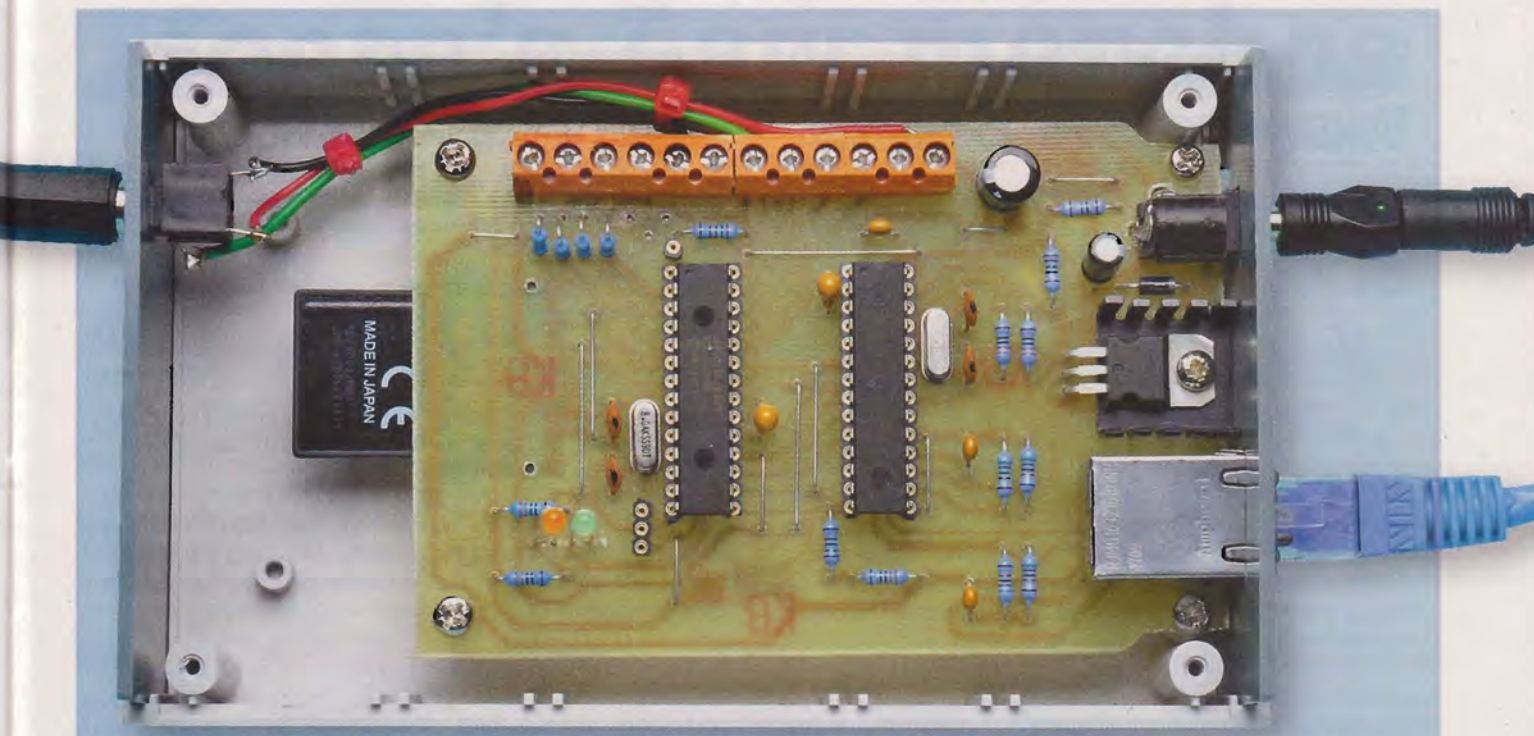
of R2 to 160Ω and R3 to 10Ω (giving a total value for R2 + R3 = 170Ω), or you could use 150Ω for R2 and 22Ω for R3. Again, this should bring the voltage from REG1 pretty close to +3.3V.

Once the supply voltage is correct, switch off and install IC1 & IC2 into their sockets. Make sure they are oriented correctly (see Fig.3) and don't get them mixed up.

Installing the SMD parts

The SMD parts (ie, IC3 and SD card socket CON4) mount on the copper side of the board as shown in Fig.4. You will need a fine-tipped soldering iron, some fine solder, some solder wick and (preferably) a magnifying lamp.

Begin by carefully aligning the IC with it solder pads, making sure that



The PC board fits neatly inside a standard plastic utility case (note: the final board is longer than the version shown here). The memory card can be removed or installed by sliding the adjacent end panel out of its slot.

it is oriented as shown (ie, pin 1 at upper right, as indicated by the dot in its body). If you like, you can hold it in position using self-closing tweezers.

That done, lightly tack solder pin 1, then remove the tweezers and inspect the IC under a magnifying glass to make sure it is in the correct position. The remaining pins can then be soldered, starting with the diagonally opposite pin (pin 5). Don't forget to add a little more solder to pin 1 if necessary to complete the job.

Do this job quickly, so as not to overheat and damage the tracks on the PC board. Once you have finished, inspect the job under a magnifying glass again. If any of the pins are shorted by solder (other than pins 7 & 8), then you can remove the excess solder using the solder wick.

Memory card socket

While you are on the copper side of the PC board, you can solder in the memory card socket as well. It is an SMD socket so you must place it over its pads and solder in one of the pins first to anchor it in position. Once that is done, check that it is correctly aligned before soldering the remaining pins.

Note that there are two mounting pads towards the front of the socket that also have to be soldered.

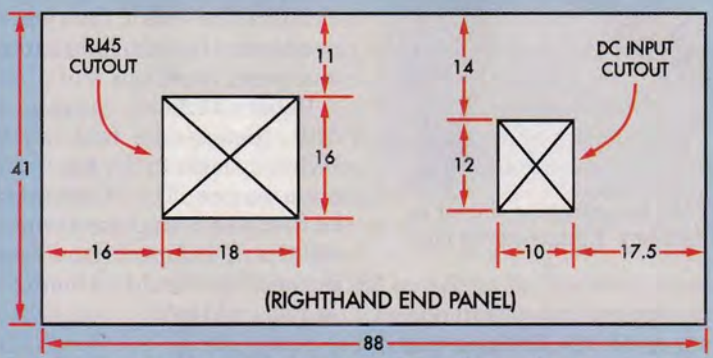


Fig.6: here's how to make the cutouts in the righthand end panel for the RJ45 socket and the DC power socket.

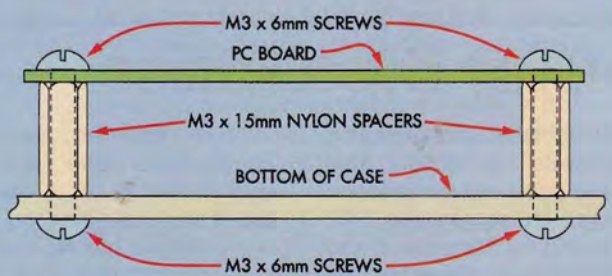


Fig.7: the PC board is mounted in the case on four M3 x 15mm tapped Nylon spacers and secured using M3 x 6mm screws.

Final assembly

The prototype was housed in a plastic instrument case measuring 95 x 158 x 47mm (Jaycar HB-5922). This is marked out and drilled as shown in Figs.5 & 6. As shown, you need to drill two 3mm holes in the lid for the LEDs and four 3mm mounting holes in the base (Fig.5). In addition, you have

Installing The Temperature Sensor

The optional AD22103 ratiometric temperature sensor (IC4) is installed by mounting it inside a 3.5mm stereo plug – see Fig.8. Its +Vs lead is connected to the ring terminal of the stereo plug, its Vo lead to the sleeve and its GND lead to the tip.

This then plugs into a matching stereo jack socket mounted on the end of the case and this is wired back to CON3 on the PC board.

As shown in Fig.8, the +Vs supply lead connects to the +Vr terminal (terminal 2) of CON3, the GND lead connects to terminal 7 of CON3, and the Vo (sensor voltage output) lead connects to one of the four analog inputs of CON3 (either terminal 9, 10, 11 or 12).

The temperature sensor is mounted outside the case to ensure that it is unaffected by the heat generated by other parts. This heat comes mainly from the LM317T voltage regulator but the ICs also contribute. Mounting the sensor outside the case ensures an accurate measurement of the room temperature.

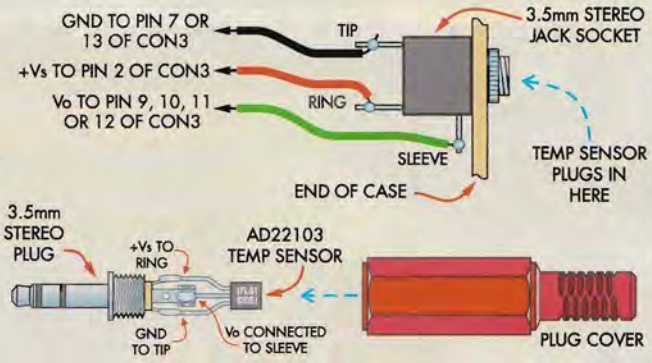


Fig.8: connect the AD22103 temperature sensor to the 3.5mm stereo plug as shown here. You can use a DMM to identify the tip and ring terminals.



The AD22103 temperature sensor is mounted inside a 3.5mm stereo jack – see Fig.8.

to make two square cut-outs in one of the end panels for the DC socket and RJ45 connector (Fig.6).

Each of these cut-outs can be made by drilling a series of small holes around the inside perimeter, then knocking out the centre piece and cleaning up the edges with a flat file.

If you are installing the specified temperature sensor, then you will also need to drill a 6mm hole in the second end panel (see Fig.8 and photos).

Deburr all holes using an oversize drill, then secure four M3 x 15mm Nylon spacers to the base using M3 x 6mm screws. The PC board can then be dropped into place along with the righthand end panel and secured using another four M3 x 6mm screws as shown in Fig.7.

Installing the memory card

You will need a suitable MMC, SD or SDHC memory card to use with the WIB. This should be formatted with a FAT/FAT32 file system before plugging it into the memory card socket (see photo). With the ICs installed and power applied, the orange LED should blink on and off approximately twice a second.

That completes the construction of the WIB. However, before using the device, you need to copy the necessary files to the memory card and interface the server to your network. This will involve entering a few settings like the Gateway address, IP Address and Subnet mask, turning on port forwarding in your router and activating a dynamic DNS (DDNS) service.

We'll explain how that's all done in Pt.2 in next month's issue. SC

Security Disclaimer

THIS SERVER relies on a username and password for security. This username and password combination must be used to access the FTP server (to modify the file system) and to access private web pages through HTTP (ie, using a web browser).

This is the main security mechanism to prevent unauthorised access from a remote location over the Internet. All settings should also be protected by the username/password combination and this is the approach taken in the sample website we are providing for download from the SILICON CHIP website.

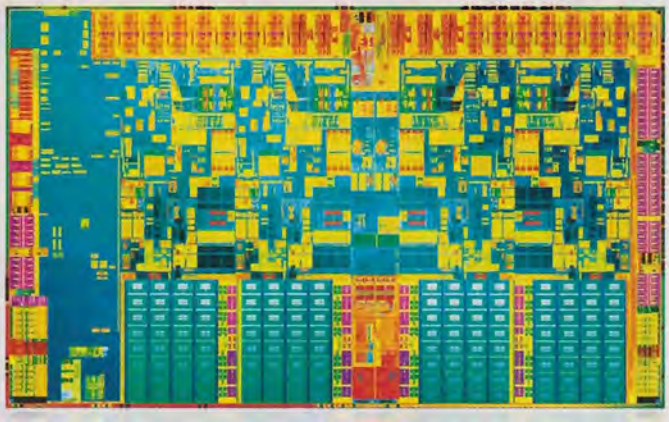
Note, however, that given the correct username and password combination, a user could log into the server and change all the settings by accessing the file system on the memory card through an FTP client. In addition, they could change the password and username combination to lock others out of the system.

If that ever happens, the remedy is to write to the card using a PC and a memory card reader and define a new username/password pair. Of course, this assumes you have physical access to the memory card.

This web server cannot be considered highly secure because it is prone to DoS (denial of service) attacks, as are most web servers. On a positive note, HTTP authentication occurs server side and therefore no transmission of a coded version of the username and password occurs (although it is possible to intercept the HTTP headers that contain the correct username and password – they are not encrypted but encoded using base64).

There are also a limited number of commands, no server side script execution and the microcontroller uses a (modified) Harvard architecture, making the server somewhat more secure than most.

Moore's Law marches on at Intel



Already in the market with 45nm technology CPUs (more than 200 million since 2007) and 32nm planned for a 2010 release, chip manufacturer Intel have displayed a silicon wafer containing the world's first working chips built on 22nm process technology. The 22nm test circuits include both SRAM memory as well as logic circuits to be used in future Intel microprocessors.

At the recent Intel Developer Forum in San Francisco, Intel President and CEO Paul Otellini said "Moore's Law is alive and thriving. We've begun production of the world's first 32nm microprocessor, which is also the first high-performance processor to integrate graphics with the CPU. At the same time, we're already moving ahead with development of our 22nm manufacturing technology and have built working chips that will pave the way for production of still more powerful and more capable processors."

2.9 billion transistors

The 22nm wafer displayed by Otellini is made up of individual die containing 364 million bits of SRAM memory and has more than 2.9 billion transistors packed into an area the size of a fingernail.

The chips contain the smallest SRAM cell used in working circuits ever reported at .092 square microns. The devices rely on a third-generation high-k metal gate transistor technology for improved performance and lower leakage power.

Intel's 32nm process is now certified and processor wafers are moving through the factory in support of planned fourth quarter 2009 production.

Following the move to 32nm Intel will subsequently introduce Sandy Bridge, Intel's next new microarchitecture. Sandy Bridge will feature a sixth-generation graphics core on the same die as the processor core and includes AVX instructions for floating point, media, and processor intensive software.

By continuing to drive the pace of innovation Intel is addressing the needs of entirely new market segments including netbooks, handhelds, consumer electronics and embedded applications.

"Intel Core and Atom-based processors have generated unprecedented excitement and opportunities in our key growth areas," Otellini said. "To build on this momentum, we're working on ways to create a seamless Internet experience for people across all their computing devices. We're announcing a program to encourage development of software applications that can be written once but run on Windows and Moblin devices – expanding their reach to more devices and consumers."

The Intel Atom Developer Program provides a framework for independent software vendors (ISVs) and software developers to create and sell applications for netbooks and other Intel Atom processor-based products.

To broaden application availability across platforms, the program will support multiple operating systems and run-time environments. Run-time environments enable developers to use a single code base to support various device platforms without massive reprogramming, reducing cost and time to market. Intel is working with partners, such as netbook OEMs ACER and Asus, to create application storefronts in which validated software applications will be sold.

In the embedded market segment, the Atom processor is driving advanced technology into new areas from hospital patient monitoring to avionics applications to audio systems. The company currently has 460 embedded Atom design wins including Harman International Industries. The provider of a wide range of audio and infotainment products for vehicles, Harman International has announced new in-car devices based on the Atom core that will enable full Internet access, 3-D navigation, brilliant graphics and high-speed wireless connectivity. SC

Intel's CPU technology: the story so far . . .

- Intel has shipped >200 million 45nm CPUs using HK+MG transistors since Nov 2007.
- Intel's 32nm process is certified and Westmere CPU wafers are moving through the factory in support of planned Q4 revenue production. 32nm second-generation high-k metal gate transistors have the highest-reported density (which means more transistors in a given area of silicon for increased functionality and better performance (as measured by drive current) than any other 32nm or 28nm technology
- NMOS transistors have 19 percent performance improvement over their 45nm counterparts while PMOS transistors have a 28 percent performance improvement over their 45nm counterparts
- Transistor gate pitch (a density measurement which indicates how tightly transistors can be packed in a given area), is 112.5nm.
- For the first time, Intel has developed a full-featured SoC process technology to complement the CPU-specific technology.
- Some special features of this process are ultra low power transistors with second-generation high-k + metal gate for low standby/always-on circuit applications; and high voltage I/O transistors.
- This process also includes new high-precision and high-quality passive components specifically needed for SoCs, such as resistors, capacitors and inductors.

Twin Engine SpeedMatch Indicator



By JOHN CLARKE





Avoid unnecessary noise and vibration in twin-engine boats by using this Twin Engine SpeedMatch Indicator. It comprises a meter that is centred when both motors are running at the same speed. When the motors are not matched in revs, the meter shows which motor is running faster and by how much.

MOST POWER BOATS over eight metres long have two engines, typically in-line 4-stroke diesels or petrol V8s, each driving its own propellor via a shaft or stern drive. Normally both motors should run at exactly the same speed unless the boat is manoeuvring up to a jetty or mooring, in which case the propellers may run at differing speeds and direction.

All boat-owners know how important it is to have the motors running at exactly the same speed. If the motors don't run at the same speed, there can be excessive noise and vibration and the motors will be far less efficient as one prop tries to pull the boat harder and the other produces more drag. At the same time, having the motors running at slightly different speeds means that you have to provide correction with the rudder to maintain a straight course and that causes further drag.

In fact, a speed difference between motors of as little as 15 RPM can cause lots of vibration that can radiate through the whole boat – most unpleasant.

To explain further, with V8 motors a difference of 15 RPM will cause a beat note of 1Hz. This is because V8s have four firing strokes per revolution so 15 RPM is equivalent to 60 pulses per minute or 1Hz. Apart from being most unpleasant to those on board, such low frequency vibration also causes lots of wear in the engines, gearboxes and shafts. So synchronisation of motors is highly desirable.

In fact, late model up-market boats often do have a facility for synchronisation while there are also electromechanical synchronisers available for older boats although these can be difficult and expensive to fit.

So most boat owners equalise the motor speeds as well as possible by watching the tacho readings and listening for the beat frequency. Trouble is, most boat tachos are not very accurate (typically ±3% or worse at mid scale) and they can also be subject to wavering readings. Furthermore, if you are driving the boat from the fly-

bridge in bad weather, it can be very difficult to clearly hear the engine exhausts, meaning that it is even more difficult to listen for "beat" notes.

And if your hearing is not the best (very common with older drivers), the difficulty is compounded.

Clearly, an electronic beat indicator is required. In setting out to produce a suitable design, we thought about an indicator based on a LED bargraph. When it was centred, the motors would be in sync. However, trying to see LEDs on a bright sunny day when driving on the flybridge is next to impossible and that goes for almost any electronic indicator. That is why most boats have conventional analog meters – they are easy to see!

Hence we decided to base our design on a good old-fashioned analog meter movement. When the motors are running at the same speed, the meter will be centred and if not, it will show the difference at up to 200 RPM (or whatever you decide to set). It is then easy to adjust the throttles so that the meter is centred.

The basic set-up of the Twin Engine SpeedMatch Indicator is shown in Fig.1. It compares the tachometer signals from each motor and the difference in RPM is shown on the panel meter. The panel meter needle is centred when the motor speeds are identical. If the port (left) motor is running faster than the starboard (right) motor, then the needle will move left.

Similarly, if the starboard motor is running faster, the needle will move to the right.

The meter shows only the difference in RPM and it does not matter if the engines are running at full speed or at idle.

The tacho signals will usually be a low-voltage signal from a Hall Effect sensor or reluctor, or they can be obtained from the ignition coils or from another source such as a low-voltage tachometer signal from a sensor. Where these are not available, such as in a diesel motor, a signal from the alternator can be used instead.

Fig.2 shows how the two tacho signals are compared. Each tacho signal is fed to a frequency-to-voltage converter (IC1 & IC2). The resulting voltage outputs are then buffered and compared in a differential amplifier, IC3d. This is offset using trimpot VR3 and then buffered by IC3a.

The offset voltage centres the meter (ie, to half scale) when the tachometer signals are the same frequency.

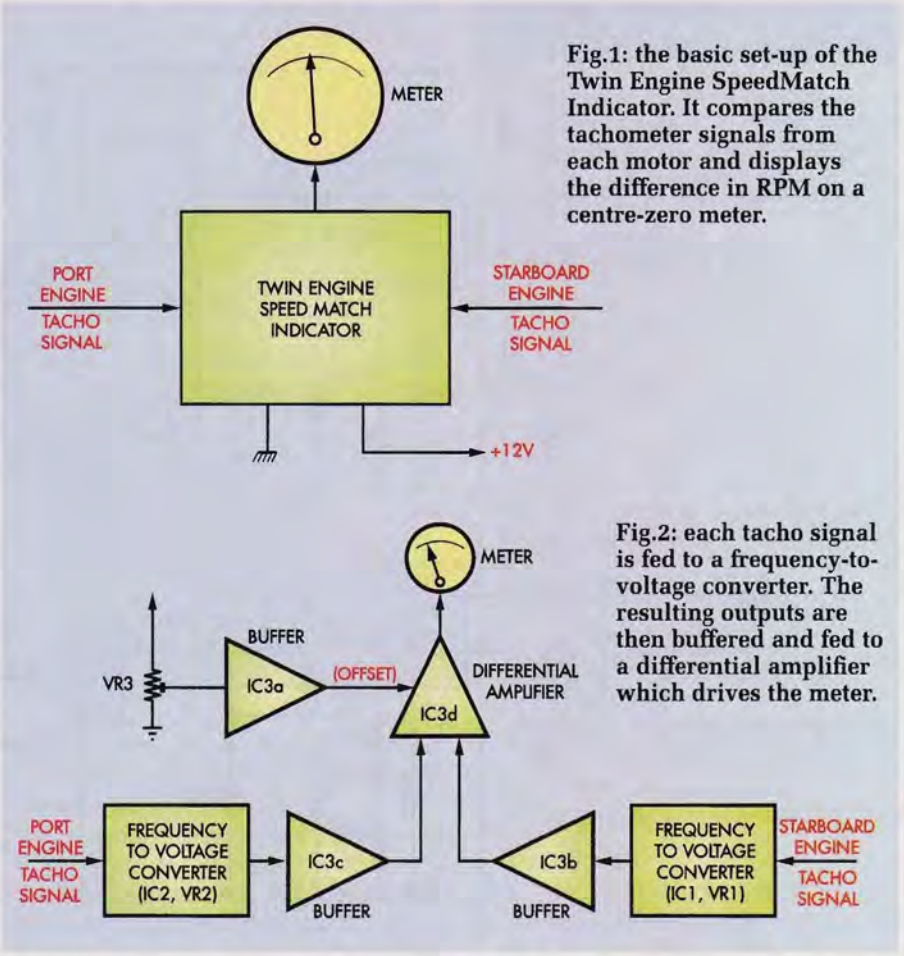


Fig.1: the basic set-up of the Twin Engine SpeedMatch Indicator. It compares the tachometer signals from each motor and displays the difference in RPM on a centre-zero meter.

Fig.2: each tacho signal is fed to a frequency-to-voltage converter. The resulting outputs are then buffered and fed to a differential amplifier which drives the meter.

Circuit description

The full circuit is shown in Fig.3. It comprises two LM2917 frequency-to-voltage converters, a quad op amp package plus associated resistors, capacitors and diodes.

Each tacho signal is applied to a filter network consisting of a 10kΩ resistor and 22nF capacitor. This is followed by a 22V zener diode and a 20kΩ resistor to ground. This filtered signal is fed to the non-inverting input of a Schmitt trigger at pin 1 of the LM2917 (IC1 & IC2).

The Schmitt trigger threshold (pin 11) is set at about +0.55V by the 10kΩ and 1kΩ voltage divider connected across the 6V supply. The output from the Schmitt trigger drives an internal charge pump which involves capacitors C1 & C2 (see Fig.4). C2 is discharged using the series 100kΩ resistor and a 1MΩ trimpot (VR1 and VR2 for IC1 and IC2, respectively).

The LM2917 is a special-purpose chip which has a number of refinements to ensure that the frequency-to-voltage conversion is linear. First, capacitor C1 is charged via a current source to a voltage that is ¾ the main supply to the IC. This charge current is duplicated (using a current mirror) for capacitor C2. During discharge, C1 is discharged to ¼ the main supply at a constant current. The specified upper and lower voltage thresholds ensure that the current source and discharge current circuitry operate within their designed voltage range.

In addition, charging and discharging is at a rate that is twice the frequency of the tachometer input. This doubling of input frequency reduces

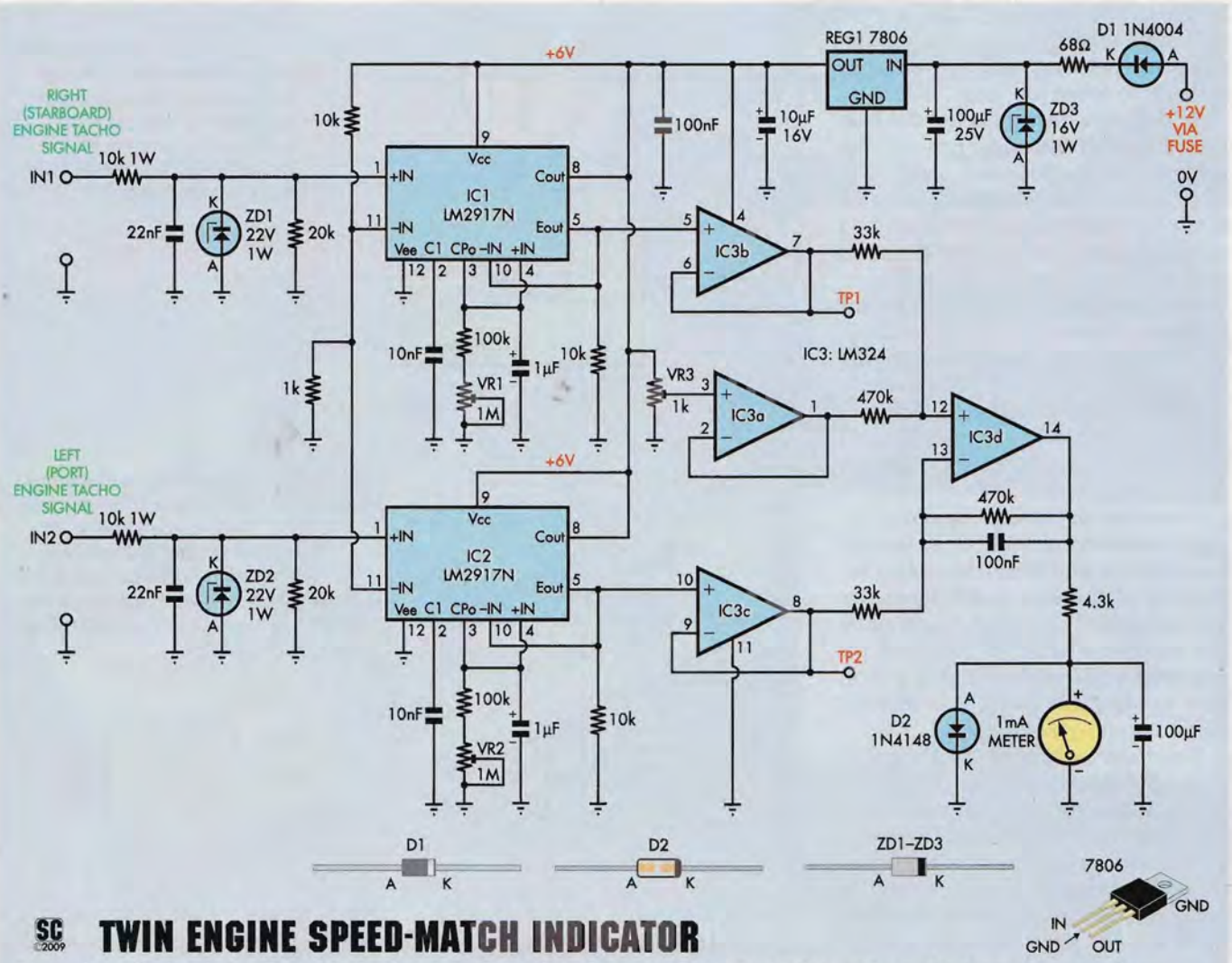
Specifications

Power Consumption: 12V at 20mA

Tacho Input Range: 0-6000 RPM

Display Range: typically set to ±200 RPM

Tacho Input voltage: 0.83V to 350VAC



TWIN ENGINE SPEED-MATCH INDICATOR

Fig.3: the full circuit for the Twin Engine SpeedMatch Indicator. IC1 & IC2 (LM2917N) are the frequency-to-voltage converters, op amps IC3b & IC3c are the buffer stages and IC3d is the differential amplifier. VR3 & IC3a provide an offset voltage for IC3d to centre the meter.

the ripple across C2. Fig.4 shows the internal schematic of the LM2917.

The charge pump voltage at pin 3 is applied to the non-inverting input of the amplifier internal to the LM2917. The inverting input to this amplifier at pin 10 is connected to the emitter output at pin 5 and this sets the amplifier as a unity gain buffer. A 10kΩ pull down resistor provides the emitter load.

Op amps IC3b & IC3c are connected as unity gain amplifiers to buffer the pin 5 outputs of IC1 & IC2. The buffered outputs are then fed to op amp IC3d which functions as the differential amplifier.

IC3d works as follows: the output from IC3c is amplified with a gain of -14, as determined by the 470kΩ resistor between pins 13 & 14 and the 33kΩ input resistor. The output from IC3b is first attenuated by the 33kΩ and 470kΩ voltage divider at pin 12 of IC3d (non-inverting input). The signal at pin 12 is therefore only 14/15 of the output from IC3b.

The overall gain for signal at pin 12 is 1+ (470kΩ/33kΩ) or 15. Therefore, the overall gain for the signal from IC3b is 15 x 14/15 or 14, ie, the same gain as for the signal from IC3c except that it is positive (instead of negative).

Note that we are using the LM324 right on the limits of its specifications in this circuit. This is because the LM324 op amp only has a 50µA sink current for output voltages less than +0.5V. This is why the resistor values in the circuit are relatively high. However, considering the DC outputs from the LM2917 frequency-to-voltage converters are generally above 0.5V when the engines are idling and more at higher RPMs, this is not really a problem for this application.

If you are using this circuit for a different purpose and require a better result especially at low outputs from the frequency-to-voltage converters, we would recommend using an LMC6484AIN CMOS rail-to-rail quad op amp in place of the LM324.

Meter offset

Op amp IC3a buffers the voltage from VR3 and provides the offset voltage for IC3d. IC3d is offset so the meter sits at half-scale (ie, centred) when there is no difference between the two input frequencies. For this half-scale condition for the 1mA meter, 500µA needs to flow and so VR3 is set for this condition, ie, close to +2.25V.

The meter movement is damped with a 100µF capacitor across it. Nor-

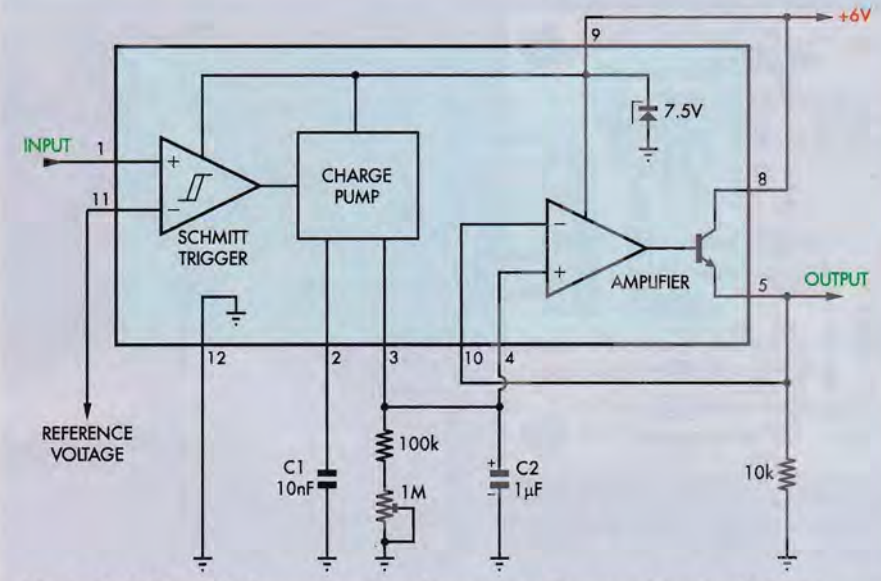


Fig.4: the LM2917N frequency-to-voltage converter consists of a Schmitt trigger, a charge pump and an amplifier wired here as a unity gain buffer.

mal full scale deflection of the meter will occur with +4.5V from IC3d. Note that while a gross difference in engine speeds can result in more than full scale deflection of the meter, the resultant overload is quite modest since IC3d's output can only go slightly above +4.5V with a 6V supply.

We have also included diode D2 across the meter. If a circuit fault applies excessive voltage to the meter, the diode will conduct at about 0.6V restricting the meter current to 0.6V/200Ω or 3mA.

Power for the circuit comes from the boat's 12V battery (ie, one of the engine batteries) via a fuse (ie, a switched accessory supply rail) and is applied through diode D1 for reverse polarity protection. The 68Ω resistor and 16V zener ZD3 protect against transient voltages, while a 100µF capacitor provides supply decoupling. Regulator REG1 then provides the 6V supply and its output is bypassed with a 10µF capacitor. A 100nF capacitor is also connected across the supply near IC1.

Construction

The Twin Engine SpeedMatch Indicator is constructed on a PC board coded 04111091 and measuring 105 x 63mm. This can clip into the integral mounting clips within a UB3 plastic case if required. Alternatively, four corner mounting points are provided for mounting in a different box or inside the dashboard of the boat. Note that if you have two helm positions in the boat, you will need two Speed-Match Indicators.

The component layout for the PC board is shown in Fig.5.

Begin construction by checking the PC board for breaks in the tracks or shorts between tracks and pads. Repair if necessary. Check that the hole sizes are correct for each component to fit neatly. The screw terminal holes are 1.25mm in diameter compared to the 0.9mm holes for the IC, resistors and diodes. The four corner mounting holes should be 3mm in diameter.

Begin by inserting the links, PC pins, diodes and resistors. We used 0Ω resistors in place of wire links but the latter could also be used. The diodes must be mounted with the orientation as shown. When inserting the resistors, use the resistor colour code table to help in reading the resistor values. A digital multimeter should also be used to measure each value.

Sockets are used for all three ICs and these must all be oriented in the same direction, with the notches as shown. Once they're in, fit the 3-terminal regulator (REG1) and the three trimpots, all of which mount with the screw adjustment oriented as shown.

The terminal blocks consist of two 2-way sections which are locked together before the are inserted and soldered into the PC board.

The capacitors can be mounted next, ensuring that the electrolytics are oriented correctly. Finally, the three ICs can be mounted in their sockets, again ensuring each is oriented correctly.

Parts List

1 PC board, code 04111091, 105 x 63mm
1 1mA MU45 moving coil meter (Jaycar QP-5010; Altronics Q-0500A) – see text
4 2-way PC-mount screw terminal blocks (5.08mm pin spacing)
3 DIP14 IC sockets
2 solder eyelet lugs
2 PC stakes
2 1MΩ multiturn top-adjust trimpots (code 105) (VR1, VR2)
1 1kΩ multiturn top-adjust trimpot (code 102) (VR3)
1 75mm length of 0.7mm tinned copper wire (for links)

Semiconductors
2 LM2917N frequency-to-voltage converters (IC1,IC2)
1 LM324 quad op amp (IC3)
1 7806 6V regulator (REG1)
2 22V 1W zener diodes (ZD1, ZD2)
1 16V 1W zener diode (ZD3)
1 1N4004 1A diode (D1)
1 1N4148 switching diode (D2)

Capacitors
2 100µF 16V electrolytic
1 10µF 16V electrolytic
2 1µF 16V electrolytic
2 100nF MKT polyester
2 22nF MKT polyester
2 10nF MKT polyester

Resistors (0.25W 1%)
2 470kΩ
2 100kΩ
2 33kΩ
2 20kΩ
3 10kΩ
2 10kΩ 1W
1 4.3kΩ
1 1kΩ
1 68Ω

Miscellaneous
Silicone sealant, hook-up wire

Testing

The Twin Engine SpeedMatch Indicator requires a 12V DC supply or anything from 8-16V DC at about 20mA. Apply power and check that there is +6V between pins 9 & 12 of both IC1 and IC2 and between pins 4 & 11 of IC3.

If there is no voltage, check for +6V at the output of REG1. Note that +6V is a nominal value and could range from +5.85 to +6.15V, depending on

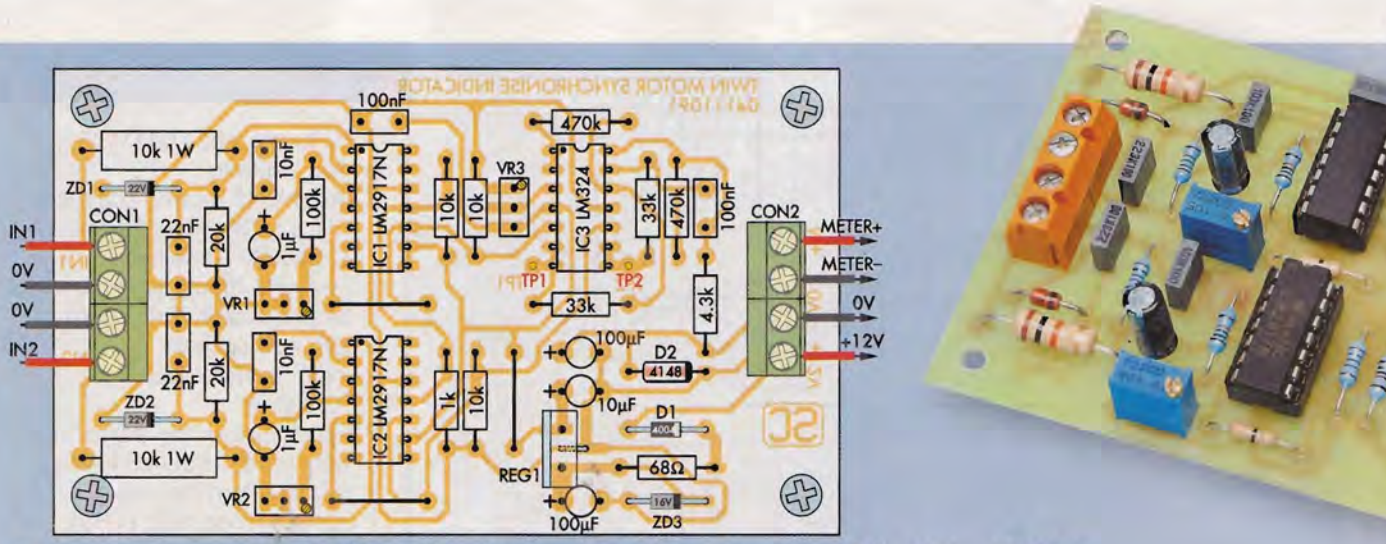


Fig.5: install the parts on the PC board as shown on this wiring diagram and the photo at right. In particular, make sure that all polarised parts are correctly installed and that trimpots VR1-VR3 have their screw adjustments positioned as shown.

the particular regulator. If there is no voltage from the regulator, D1 may be reversed or there may be a short circuit between the +6V rail and 0V on the PC board.

Marine meter movement

The meter shown in this article is a standard 1mA FSD (full scale deflection) analog movement which can be obtained from Jaycar or Altronics. However, depending on your application, this may or may not be suitable. For example, it may be OK if used on the helm dashboard inside the cabin. However, it almost certainly won't be suitable if used on the helm dashboard on the flybridge where it will be exposed to the elements.

Most boat owners may want the meter to match the other meters on their dashboard and this approach will no doubt be far more expensive – as is everything associated with boats. On the other hand, taking this approach will mean that the meter will probably include illumination, will be sealed against moisture ingress and condensation and incorporate a lens (eg, in VDO gauges).

If you are going to use a matching meter, it will probably need to be adapted from a voltmeter. In that case, you will need to pull the meter apart to change the scale. You will also need to remove the internal series resistor (voltage multiplier).

For the purpose of this article, we made up a replacement scale for the specified 1mA meter movement. If you use this particular meter, you can change the scale by carefully prising the plastic cover off the meter, undoing the two securing screws for the original 1mA scale and then attaching the replacement panel.

Fig.6 shows our replacement scale, which has maximum readings of ±200 RPM, or rather PORT +200 0 STBD +200. Note that this is a relative indication only and cannot be relied on as having great accuracy. All analog meter movements have their best accuracy at full-scale deflection of the meter and minimum accuracy at close to zero deflection.

In fact, since the SpeedMatch Indicator will be set up by you, it will be quite accurate for the centre speed match indication.

Setting Up

Connect the unit to the meter's M+ and M- terminals using leads terminated in solder eyelets. These eyelets are sandwiched between the nuts supplied with the meter. Ensure the meter polarity is correct. That done, apply power to the PC board and adjust trimpot VR3 so that the meter is centred.

Further setting up requires either a

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
22nF	0.22µF	22n	223
10nF	0.01µF	10n	103

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	33kΩ	orange orange orange brown	orange orange black red brown
❑	2	20kΩ	red black orange brown	red black black red brown
❑	3	10kΩ	brown black orange brown	brown black black red brown
❑	2	10kΩ	brown black orange brown	NA
❑	1	4.3kΩ	yellow orange red brown	yellow orange black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	68Ω	blue grey black brown	blue grey black gold brown



signal generator that can produce at least 1V output or by connecting the unit to the boat motor itself.

Tachometer signal

As mentioned, the inputs for the Twin Engine SpeedMatch Indicator can come from the ignition coil or from low-voltage tachometer signals. Where these are not available, such as in a diesel motor, signal from a separate sensor or the AC from the alternator can be used instead. The Twin Engine SpeedMatch Indicator will operate without any changes using either the ignition coil or low-voltage signal.

If the alternator has to be used then this may provide a higher frequency than from the other tachometer sources. The signal from the alternator is an AC signal and may be marked as AC, AUX, S, R or TACH. An idea of how many pulses from the alternator per engine rotation can be gauged by measuring the diameter of the crankshaft pulley and dividing this by the alternator pulley diameter. The number of poles in the alternator is multiplied by this pulley ratio. The number of poles is usually 4, 6, 8, 10 or 12.

The Twin Engine SpeedMatch Indicator was designed for between two and four pulses per engine rotation. If the alternator signal is higher than this, then the 10nF capacitors at pin 2 of IC1 and IC2 will need changing to a different value. The 10nF value is reduced by the ratio of 3/number of alternator pulses per engine revolution. So if the alternator produces 36 pulses per engine revolution, then the capacitor



Fig.6: this full-size meter scale can be cut out or downloaded from the SILICON CHIP website.

will need to be 10nF x 3/36 or 820pF, using the nearest capacitor value.

For a separate tachometer sensor, this may also deliver a higher number of pulses per revolution. The 10nF value is reduced by the ratio of 3/number of sensor pulses per engine revolution. In addition, for this sensor, there may be two leads – one for the signal and one at 0V. The 0V connection is provided on the PC board for this purpose if it is needed.

Now connect the tachometer signal from one motor to both IN1 and IN2. Connect a digital multimeter, set to a DC volts range, between test-point TP1 and 0V on the PC board. With the motor running, adjust trimpot VR1 for a reading of 0.8V per 1000 RPM, eg, 1.6V at 2000 RPM. This sets the meter scale to ±200 RPM. If the voltage cannot be set within the range of the trimpot adjustment, then the 10nF capacitor at pin 2 will need changing. If the voltage is too high, use a lower value capacitor and if the voltage is too low, use a larger value. As a guide, reducing the capacitor value by a factor of two will reduce the voltage by the same amount.

Having adjusted VR1 so that TP1 is at 1.6V at 2000 RPM, set trimpot VR2 so that the 1mA meter is centred. That is all the set-up requires.

Now connect the IN1 and IN2 inputs to the separate motor tachometer signals and test the operation. Note that it is quite possible that you will find that when the SpeedMatch is indicating that the motors are synchronised, the tacho readings may not be exactly the same.

This is to be expected with most analog tachometers since they are not particularly accurate, especially those with 270° movements (ie, most tachos). For example, a tachometer with a mid-scale accuracy of ±4% will have an error in the range of ±100 RPM at an engine speed of 2500 RPM. So it is quite possible that the port engine tacho might indicate 2400 RPM while the starboard engine tacho indicates 2600 RPM when the engines are actually doing the same speed.

At low engine speeds, the tachos may be much more inaccurate. For example, at 1000 RPM, the accuracy may only be ±10%, which means, again, that the readings can be off by ±100 RPM.

Why are analog tachos so bad? It is because their basic accuracy of, say, ±2% only applies at full deflection. So if the tacho reads to 6000 RPM, its reading is actually 6000 RPM ±120 RPM. It does not get any better at lower readings and in fact, the linearity at small deflections for all analog meters is generally not good.

Unfortunately, where the tacho signal is derived from the alternator, as in the case of some diesels, the tacho signal itself can be inaccurate because of variable slip in the drive belt. The only cure for this is to install a Hall Effect sensor and an accompanying magnet on the harmonic balancer, flywheel or the prop shaft.

Installation

The Twin Engine SpeedMatch Indicator is presented as a bare PC board and separate meter. For installation we recommend you seal the meter top cover to the body with silicone sealant. The meter can be mounted in the boat dashboard using a suitable bracket. Standard boat gauges tend to fit into a $3^3/_8$-inch (85.73mm) diameter hole and the meter would need to be mounted onto a metal plate.

The PC board can mount inside the boat dashboard. If you want to mount it in a box, it will fit into a UB3 box measuring 130 x 68 x 44mm. **The +12V supply connection should be run to a fused accessory supply line that's switched by the ignition, while the wiring to the ignition coil should use mains-rated (230VAC rated) cable.**

For moisture protection use cable glands for wire entry and seal the box with silicone sealant after calibration.

24V operation

Some boats may have 24V batteries. For 24V operation, the 16V zener diode ZD3 should be changed to 33V 1W and the 100µF 16V capacitor at the input to the 3-terminal regulator REG1 should be increased in voltage rating to 35V or 50V. In addition, REG1 should be fitted with a small heatsink such as Jaycar HH-8504 or HH-8502. SC

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March 1997: 175W PA Amplifier; Signalling & Lighting For Model Railways; Jumbo LED Clock; Cathode Ray Oscilloscopes, Pt.7.

April 1997: Simple Timer With No ICs; Digital Voltmeter For Cars; Loudspeaker Protector For Stereo Amplifiers; Model Train Controller; A Look At Signal Tracing; Pt.1; Cathode Ray Oscilloscopes, Pt.8.

May 1997: Neon Tube Modulator For Light Systems; Traffic Lights For A Model Intersection; The Spacewriter – It Writes Messages In Thin Air; A Look At Signal Tracing; Pt.2; Cathode Ray Oscilloscopes, Pt.9.

June 1997: PC-Controlled Thermometer/Thermostat; TV Pattern Generator, Pt.1; Audio/RF Signal Tracer; High-Current Speed Controller For 12V/24V Motors; Manual Control Circuit For Stepper Motors.

July 1997: Infrared Remote Volume Control; A Flexible Interface Card For PCs; Points Controller For Model Railways; Colour TV Pattern Generator, Pt.2; An In-Line Mixer For Radio Control Receivers.

October 1997: 5-Digit Tachometer; Central Locking For Your Car; PC-Controlled 6-Channel Voltmeter; 500W Audio Power Amplifier, Pt.3.

November 1997: Heavy Duty 10A 240VAC Motor Speed Controller; Easy-To-Use Cable & Wiring Tester; Build A Musical Doorbell; Replacing Foam Speaker Surrounds: Understanding Electric Lighting Pt.1.

December 1997: Speed Alarm For Cars; 2-Axis Robot With Gripper; Stepper Motor Driver With Onboard Buffer; Power Supply For Stepper Motor Cards; Understanding Electric Lighting Pt.2; Index To Vol.10.

January 1998: 4-Channel 12VDC or 12VAC Lightshow, Pt.1; Command Control For Model Railways, Pt.1; Pan Controller For CCD Cameras.

February 1998: Telephone Exchange Simulator For Testing; Command Control For Model Railways, Pt.2; 4-Channel Lightshow, Pt.2.

April 1998: Automatic Garage Door Opener, Pt.1; 40V 8A Adjustable Power Supply, Pt.1; PC-Controlled 0-30kHz Sinewave Generator; Understanding Electric Lighting; Pt.6.

May 1998: 3-LED Logic Probe; Garage Door Opener, Pt.2; Command Control System, Pt.4; 40V 8A Adjustable Power Supply, Pt.2.

June 1998: Troubleshooting Your PC, Pt.2; Universal High Energy Ignition System; The Roadies' Friend Cable Tester; Universal Stepper Motor Controller; Command Control For Model Railways, Pt.5.

July 1998: Troubleshooting Your PC, Pt.3; 15W/Ch Class-A Audio Amplifier, Pt.1; Simple Charger For 6V & 12V SLA Batteries; Automatic Semiconductor Analyser; Understanding Electric Lighting, Pt.8.

August 1998: Troubleshooting Your PC, Pt.4; I/O Card With Data Logging; Beat Triggered Strobe; 15W/Ch Class-A Stereo Amplifier, Pt.2.

September 1998: Troubleshooting Your PC, Pt.5; A Blocked Air-Filter Alarm; Waa-Waa Pedal For Guitars; Jacob's Ladder; Gear Change Indicator For Cars; Capacity Indicator For Rechargeable Batteries.

October 1998: AC Millivoltmeter, Pt.1; PC-Controlled Stress-O-Meter; Versatile Electronic Guitar Limiter; 12V Trickle Charger For Float Conditions; Adding An External Battery Pack To Your Flashgun.

November 1998: The Christmas Star; A Turbo Timer For Cars; Build A Poker Machine, Pt.1; FM Transmitter For Musicians; Lab Quality AC Millivoltmeter, Pt.2; Improving AM Radio Reception, Pt.1.

December 1998: Engine Immobiliser Mk.2; Thermocouple Adaptor For DMMs; Regulated 12V DC Plugpack; Build A Poker Machine, Pt.2; Improving AM Radio Reception, Pt.2; Mixer Module For F3B Gliders.

January 1999: High-Voltage Megohm Tester; A Look At The BASIC Stamp; Bargraph Ammeter For Cars; Keypad Engine Immobiliser.

March 1999: Build A Digital Anemometer; DIY PIC Programmer; Build An Audio Compressor; Low-Distortion Audio Signal Generator, Pt.2.

April 1999: Getting Started With Linux; Pt.2; High-Power Electric Fence Controller; Bass Cube Subwoofer; Programmable Thermostat/Thermometer; Build An Infrared Sentry; Rev Limiter For Cars.

May 1999: The Line Dancer Robot; An X-Y Table With Stepper Motor Control, Pt.1; Three Electric Fence Testers; Carbon Monoxide Alarm.

June 1999: FM Radio Tuner Card For PCs; X-Y Table With Stepper Motor Control, Pt.2; Programmable Ignition Timing Module For Cars, Pt.1.

July 1999: Build A Dog Silencer; 10µH to 19.99mH Inductance Meter; Audio-Video Transmitter; Programmable Ignition Timing Module For Cars, Pt.2; XYZ Table With Stepper Motor Control, Pt.3.

August 1999: Remote Modem Controller; Daytime Running Lights For Cars; Build A PC Monitor Checker; Switching Temperature Controller; XYZ Table With Stepper Motor Control, Pt.4; Electric Lighting, Pt.14.

September 1999: Autonomouse The Robot, Pt.1; Voice Direct Speech Recognition Module; Digital Electrolytic Capacitance Meter; XYZ Table With Stepper Motor Control, Pt.5; Peltier-Powered Can Cooler.

October 1999: Build The Railpower Model Train Controller, Pt.1; Semiconductor Curve Tracer; Autonomouse The Robot, Pt.2; XYZ Table With Stepper Motor Control, Pt.6; Introducing Home Theatre.

November 1999: Setting Up An Email Server; Speed Alarm For Cars, Pt.1; LED Christmas Tree; Intercom Station Expander; Foldback Loudspeaker System; Railpower Model Train Controller, Pt.2.

December 1999: Solar Panel Regulator; PC Powerhouse (gives +12V, +9V, +6V & +5V rails); Fortune Finder Metal Locator; Speed Alarm For Cars, Pt.2; Railpower Model Train Controller, Pt.3; Index To Vol.12.

January 2000: Spring Reverberation Module; An Audio-Video Test Generator; Parallel Port Interface Card; Telephone Off-Hook Indicator.

February 2000: Multi-Sector Sprinkler Controller; A Digital Voltmeter For Your Car; Safety Switch Checker; Sine/Square Wave Oscillator.

March 2000: 100W Amplifier Module, Pt.1; Electronic Wind Vane With 16-LED Display; Build A Glowplug Driver.

May 2000: Ultra-LD Stereo Amplifier, Pt.2; LED Dice (With PIC Microcontroller); 50A Motor Speed Controller For Models.

June 2000: Automatic Rain Gauge; Parallel Port VHF FM Receiver; Switchmode Power Supply (1.23V to 40V) Pt.1; CD Compressor.

July 2000: Moving Message Display; Compact Fluorescent Lamp Driver; Musicians' Lead Tester; Switchmode Power Supply, Pt.2.

August 2000: Theremin; Spinner (writes messages in "thin-air"); Proximity Switch; Structured Cabling For Computer Networks.

September 2000: Swimming Pool Alarm; 8-Channel PC Relay Board; Fuel Mixture Display For Cars, Pt.1; Protoboards – The Easy Way Into Electronics, Pt.1; Cybug The Solar Fly.

October 2000: Guitar Jammer; Breath Tester; Wand-Mounted Inspection Camera; Subwoofer For Cars; Fuel Mixture Display, Pt.2.

November 2000: Santa & Rudolf Chrissie Display; 2-Channel Guitar Preamplifier, Pt.1; Message Bank & Missed Call Alert; Protoboards – The Easy Way Into Electronics, Pt.3.

December 2000: Home Networking For Shared Internet Access; White LED Torch; 2-Channel Guitar Preamplifier, Pt.2 (Digital Reverb); Driving An LCD From The Parallel Port; Index To Vol.13.

January 2001: How To Transfer LPs & Tapes To CD; The LP Doctor – Clean Up Clicks & Pops, Pt.1; Arbitrary Waveform Generator; 2-Channel Guitar Preamplifier, Pt.3; PIC Programmer & TestBed.

February 2001: An Easy Way To Make PC Boards; L'il Pulser Train Controller; A MIDI Interface For PCs; Build The Bass Blazer; 2-Metre Groundplane Antenna; LP Doctor – Clean Up Clicks & Pops, Pt.2.

March 2001: Making Photo Resist PC Boards; Big-Digit 12/24 Hour Clock; Parallel Port PIC Programmer & Checkerboard; Protoboards – The Easy Way Into Electronics, Pt.5; A Simple MIDI Expansion Box.

April 2001: A GPS Module For Your PC; Dr Video – An Easy-To-Build Video Stabiliser; Tremolo Unit For Musicians; Minimitter FM Stereo Transmitter; Intelligent Nicad Battery Charger.

May 2001: 12V Mini Stereo Amplifier; Two White-LED Torches To Build; PowerPak – A Multi-Voltage Power Supply; Using Linux To Share An Internet Connection, Pt.1; Tweaking Windows With TweakUI.

June 2001: Universal Battery Charger, Pt.1; Phonome – Call, Listen In & Switch Devices On & Off; Low-Cost Automatic Camera Switcher; Using Linux To Share An Internet Connection, Pt.2.

July 2001: The HeartMate Heart Rate Monitor; Do Not Disturb Telephone Timer; Pic-Toc – A Simple Alarm Clock; Fast Universal Battery Charger, Pt.2; Backing Up Your Email.

August 2001: DI Box For Musicians; 200W Mosfet Amplifier Module; Headlight Reminder; 40MHz 6-Digit Frequency Counter Module; Using Linux To Share An Internet Connection, Pt.3.

September 2001: Making MP3s; Build An MP3 Jukebox, Pt.1; PC-Controlled Mains Switch; Personal Noise Source For Tinnitus; Directional Microphone; Using Linux To Share An Internet Connection, Pt.4.

November 2001: Ultra-LD 100W/Channel Stereo Amplifier, Pt.1; Neon Tube Modulator For Cars; Audio/Video Distribution Amplifier; Build A Short Message Recorder Player; Useful Tips For Your PC.

January 2002: Touch And/Or Remote-Controlled Light Dimmer, Pt.1; A Cheap 'n'Easy Motorbike Alarm; 100W /Channel Stereo Amplifier, Pt.3; Build A Raucous Alarm; FAQs On The MP3 Jukebox.

February 2002: 10-Channel IR Remote Control Receiver; 2.4GHz High-Power Audio-Video Link; Touch And/Or Remote-Controlled Light Dimmer, Pt.2; Booting A PC Without A Keyboard; 4-Way Event Timer.

March 2002: Mighty Midget Audio Amplifier Module; 6-Channel IR Remote Volume Control, Pt.1; RIAA Pre-Amplifier For Magnetic Cartridges; 12/24V Intelligent Solar Power Battery Charger.

April 2002: Automatic Single-Channel Light Dimmer; Pt.1; Water Level Indicator; Multiple-Output Bench Power Supply; Versatile Multi-Mode Timer; 6-Channel IR Remote Volume Control, Pt.2.

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May 2002: 32-LED Knightrider; The Battery Guardian (Cuts Power When the Battery Voltage Drops); Stereo Headphone Amplifier; Automatic Single-Channel Light Dimmer; Pt.2: Stepper Motor Controller.

August 2002: Digital Instrumentation Software For PCs; Digital Storage Logic Probe; Digital Therm./Thermostat; Sound Card Interface For PC Test Instruments; Direct Conversion Receiver For Radio Amateurs.

September 2002: 12V Fluorescent Lamp Inverter; 8-Channel Infrared Remote Control; 50-Watt DC Electronic Load; Spyware – An Update.

October 2002: Speed Controller For Universal Motors; PC Parallel Port Wizard; Cable Tracer; AVR ISP Serial Programmer; 3D TV.

November 2002: SuperCharger For NiCd/NiMH Batteries, Pt.1; Windows-Based EPROM Programmer, Pt.1; 4-Digit Crystal-Controlled Timing Module.

December 2002: Receiving TV From Satellites; Pt.1; The Micromitter Stereo FM Transmitter; Windows-Based EPROM Programmer, Pt.2; SuperCharger For NiCd/NiMH Batteries; Pt.2; Simple VHF FM/AM Radio.

January 2003: Receiving TV From Satellites, Pt 2; SC480 50W RMS Amplifier Module, Pt.1; Gear Indicator For Cars; Active 3-Way Crossover For Speakers.

February 2003: PortaPal PA System, Pt.1; SC480 50W RMS Amplifier Module, Pt.2; Windows-Based EPROM Programmer, Pt.3; Fun With The PICAXE, Pt.1.

March 2003: LED Lighting For Your Car; Peltier-Effect Tinnie Cooler; PortaPal PA System, Pt.2; 12V SLA Battery Float Charger; Little Dynamite Subwoofer; Fun With The PICAXE, Pt.2 (Shop Door Minder).

April 2003: Video-Audio Booster For Home Theatre Systems; Telephone Dialler For Burglar Alarms; Three PIC Programmer Kits; PICAXE, Pt.3 (Heartbeat Simulator); Electric Shutter Release For Cameras.

May 2003: Widgybox Guitar Distortion Effects Unit; 10MHz Big Blaster Subwoofer; Printer Port Simulator; PICAXE, Pt.4 (Motor Controller).

June 2003: PICAXE-Controlled Telephone Intercom; Sunset Switch For Security & Garden Lighting; Digital Reaction Timer; Adjustable DC-DC Converter For Cars; Long-Range 4-Channel UHF Remote Control.

July 2003: Smart Card Reader & Programmer; Power-Up Auto Mains Switch; A "Smart" Slave Flash Trigger; Programmable Continuity Tester; Updating The PIC Programmer & Checkerboard.

August 2003: PC Infrared Remote Receiver (Play DVDs & MP3s On Your PC Via Remote Control); Digital Instrument Display For Cars, Pt.1; Home-Brew Weatherproof 2.4GHz WiFi Antennas; PICAXE Pt.7.

September 2003: Robot Wars; Krypton Bike Light; PIC Programmer; Current Clamp Meter Adapter For DMMs; PICAXE Pt.8 – A Data Logger; Digital Instrument Display For Cars, Pt.2.

October 2003: PC Board Design, Pt.1; JV80 Loudspeaker System; A Dirt Cheap, High-Current Power Supply; Low-Cost 50MHz Frequency Meter; Long-Range 16-Channel Remote Control System.

November 2003: PC Board Design, Pt.2; 12AX7 Valve Audio Preamplifier; Our Best Ever LED Torch; Smart Radio Modem For Microcontrollers; PICAXE Pt.9; Programmable PIC-Powered Timer.

December 2003: PC Board Design, Pt.3; VHF Receiver For Weather Satellites; Linear Supply For Luxeon 1W Star LEDs; 5V Meter Calibration Standard; PIC-Based Car Battery Monitor; PICAXE Pt.10.

January 2004: Studio 350W Power Amplifier Module, Pt.1; High-Efficiency Power Supply For 1W Star LEDs; Antenna & RF Preamp For Weather Satellites; Lapel Microphone Adaptor For PA Systems; PICAXE-18X 4-Channel Datalogger, Pt.1; 2.4GHZ Audio/Video Link.

February 2004: PC Board Design, Pt.1; Supply Rail Monitor For PCs; Studio 350W Power Amplifier Module, Pt.2; Shorted Turns Tester For Line Output Transformers; PICAXE-18X 4-Channel Datalogger, Pt.2.

March 2004: PC Board Design, Pt.2; Build The QuickBrake For Increased Driving Safety; 3V-9V (or more) DC-DC Converter; ESR Meter Mk.2, Pt.1; PICAXE-18X 4-Channel Datalogger, Pt.3.

April 2004: PC Board Design, Pt.3; Loudspeaker Level Meter For Home Theatre Systems; Dog Silencer; Mixture Display For Cars; ESR Meter Mk.2, Pt.2; PC/PICAXE Interface For UHF Remote Control.

May 2004: Amplifier Testing Without High-Tech Gear; Component Video To RGB Converter; Starpower Switching Supply For Luxeon Star LEDs; Wireless Parallel Port; Poor Man's Metal Locator.

June 2004: Build An RFID Security Module; Simple Fridge-Door Alarm; Courtesy Light Delay For Cars; Automating PC Power-Up; Upgraded Software For The EPROM Programmer.

July 2004: Silencing A Noisy PC; Versatile Battery Protector; Appliance Energy Meter, Pt.1; A Poor Man's Q Meter; Regulated High-Voltage Supply For Valve Amplifiers; Remote Control For A Model Train Layout.

August 2004: Video Formats: Why Bother?; VAF's New DC-X Generation IV Loudspeakers; Video Enhancer & Y/C Separator; Balanced Microphone Preamp; Appliance Energy Meter, Pt.2; 3-State Logic Probe.

September 2004: Voice Over IP (VoIP) For Beginners; WiFry – Cooking Up 2.4GHz Antennas; Bed Wetting Alert; Build a Programmable Robot; Another CFL Inverter.

October 2004: The Humble "Trannie" Turns 50; SMS Controller, Pt.1; RGB To Component Video Converter; USB Power Injector; Remote Controller For Garage Doors & Gates.

November 2004: 42V Car Electrical Systems; USB-Controlled Power Switch (Errata Dec. 2004); Charger For Deep-Cycle 12V Batteries, Pt.1; Driveway Sentry; SMS Controller, Pt.2; PICAXE IR Remote Control.

December 2004: Build A Windmill Generator, Pt.1; 20W Amplifier Module; Charger For Deep-Cycle 12V Batteries, Pt.2; Solar-Powered Wireless Weather Station; Bidirectional Motor Speed Controller.

January 2005: Windmill Generator, Pt.2; Build A V8 Doorbell; IR Remote Control Checker; 4-Minute Shower Timer; The Prawnlite; Sinom Says Game; VAF DC-7 Generation 4 Kit Speakers.

February 2005: Windmill Generator, Pt.3; USB-Controlled Electrocardiograph; TwinTen Stereo Amplifier; Inductance & Q-Factor Meter, Pt.1; A Yagi Antenna For UHF CB; $2 Battery Charger.

March 2005: Windmill Generator, Pt.4; Sports Scoreboard, Pt.1; Inductance & Q-Factor Meter, Pt.2; Shielded Loop Antenna For AM; Sending Picaxe Data Over 477MHz UHF CB; $10 Lathe & Drill Press Tachometer.

April 2005: Install Your Own In-Car Video (Reversing Monitor); Build A MIDI Theremin, Pt.1; Bass Extender For Hifi Systems; Sports Scoreboard, Pt.2; SMS Controller Add-Ons; A $5 Variable Power Supply.

May 2005: Getting Into Wi-Fi, Pt.1; Build A 45-Second Voice Recorder; Wireless Microphone/Audio Link; MIDI Theremin, Pt.2; Sports Scoreboard, Pt.3; Automatic Stopwatch Timer.

June 2005: Wi-Fi, Pt.2; The Mesmeriser LED Clock; Coolmaster Fridge/Freezer Temperature Controller; Alternative Power Regular; PICAXE Colour Recognition System; AVR200 Single Board Computer, Pt.1.

July 2005: Wi-Fi, Pt.3; Remote-Controlled Automatic Lamp Dimmer; Serial Stepper Motor Controller; Salvaging & Using Thermostats; Unwired Modems & External Antennas.

August 2005: Mudlark A205 Valve Stereo Amplifier, Pt.1; Programmable Flexitimer; Carbon Monoxide Alert; Serial LCD Driver; Enhanced Sports Scoreboard; Salvaging Washing Maching Pressure Switches.

September 2005: Build Your Own Seismograph; Bilge Sniffer For Boats; VoIP Analog Phone Adaptor; Mudlark A205 Valve Stereo Amplifier, Pt.2; PICAXE in Schools, Pt.4.

October 2005: A Look At Google Earth; Dead Simple USB Breakout Box; Studio Series Stereo Preamplifier, Pt.1; Video Reading Aid For Vision Impaired People; Simple Alcohol Level Meter; Ceiling Fan Timer.

November 2005: Good Quality Car Sound On The Cheap: Pt.1; PICAXE In Schools, Pt.5; Studio Series Stereo Headphone Amplifier; Build A MIDI Drum Kit, Pt.1; Serial I/O Controller & Analog Sampler.

December 2005: Good Quality Car Sound On The Cheap; Pt.2; Building The Ultimate Jukebox, Pt.1; Universal High-Energy Ignition System, Pt.1; MIDI Drum Kit, Pt.2; 433MHz Wireless Data Communication.

January 2006: Pocket TENS Unit For Pain Relief; "Little Jim" AM Radio Transmitter; Universal High-Energy Ignition System, Pt.2; Building The Ultimate Jukebox, Pt.2; MIDI Drum Kit, Pt.3; Picaxe-Based 433MHz Wireless Thermometer; A Human-Powered LED Torch.

February 2006: PC-Controlled Burglar Alarm, Pt.1; A Charger For iPods & MP3 Players; Picaxe-Powered Thermostat & Temperature Display; Build A MIDI Drum Kit, Pt.4; Building The Ultimate Jukebox, Pt.3.

March 2006: The Electronic Camera, Pt.1; PC-Controlled Burglar Alarm System, Pt.2; Low-Cost Intercooler Water Spray Controller; AVR ISP SocketBoard; Build A Low-Cost Large Display Anemometer.

April 2006: The Electronic Camera, Pt.2; Studio Series Remote Control Module (For A Stereo Preamplifier); 4-Channel Audio/Video Selector; Universal High-Energy LED Lighting System, Pt.1; Picaxe Goes Wireless, Pt.1 (Using the 2.4GHz XBee Modules).

May 2006: Lead-Acid Battery Zapper; Universal High-Energy LED Lighting System, Pt.2; Passive Direct Injection (DI) Box For Musicians; Picaxe Goes Wireless, Pt.2; Boost Your XBee's Range Using Simple Antennas.

June 2006: Pocket A/V Test Pattern Generator; Two-Way SPDIF-to-Toslink Digital Audio Converter; Build A 2.4GHz Wireless A/V Link; A High-Current Battery Charger For Almost Nothing.

July 2006: Mini Theremin Mk.2, Pt.1; Programmable Analog On-Off Controller; Studio Series Stereo Preamplifier; Stop Those Zaps From Double-Insulated Equipment.

August 2006: Picaxe-Based LED Chaser Clock; Magnetic Cartridge Preamplifier; An Ultrasonic Eavesdropper; Mini Theremin Mk.2, Pt.2.

September 2006: Transferring Your LPs To CDs & MP3s; Turn an Old Xbox Into A $200 Multimedia Player; Build The Galactic Voice; Aquarium Temperature Alarm; S-Video To Composite Video Converter.

October 2006: LED Tachometer With Dual Displays, Pt.1; UHF Prescaler For Frequency Counters; Infrared Remote Control Extender; Easy-To-Build 12V Digital Timer Module; Build A Super Bicycle Light Alternator.

November 2006: Radar Speed Gun, Pt.1; Build Your Own Compact Bass Reflex Loudspeakers; Programmable Christmas Star; DC Relay Switch; LED Tachometer With Dual Displays, Pt.2; Picaxe Net Server, Pt.3.

December 2006: Bringing A Dead Cordless Drill Back To Life; Cordless Power Tool Charger Controller; Build A Radar Speed Gun, Pt.2; Super Speedo Corrector; 12/24V Auxiliary Battery Controller.

January 2007: Versatile Temperature Switch; Intelligent Car Air-Conditioning Controller; Remote Telltale For Garage Doors; Intelligent 12V Charger For SLA & Lead-Acid Batteries.

February 2007: Remote Volume Control & Preamplifier Module, Pt.1; Simple Variable Boost Control For Turbo Cars; Fuel Cut Defeater For The Boost Control; Low-Cost 50MHz Frequency Meter, Mk.2.

March 2007: Programmable Ignition System For Cars, Pt.1; Remote Volume Control & Preamplifier Module, Pt.2; GPS-Based Frequency Reference, Pt.1; Simple Ammeter & Voltmeter.

April 2007: High-Power Reversible DC Motor Speed Controller; Build A Jacob's Ladder; GPS-Based Frequency Reference, Pt.2; Programmable Ignition System, Pt.2; Dual PICAXE Infrared Data Communication.

May 2007: 20W Class-A Amplifier Module, Pt.1; Adjustable 1.3-22V Regulated Power Supply; VU/Peak Meter With LCD Bargraphs; Programmable Ignition System For Cars, Pt.3; GPS-Based Frequency Reference Modifications; Throttle Interface For The DC Motor Speed Controller.

June 2007: 20W Class-A Amplifier Module, Pt.2; Knock Detector For The Programmable Ignition; 4-Input Mixer With Tone Controls; Frequency-Activated Switch For Cars; Simple Panel Meters Revisited.

July 2007: How To Cut Your Greenhouse Emissions, Pt.1; 6-Digit Nixie Clock, Pt.1; Tank Water Level Indicator; A PID Temperature Controller; 20W Class-A Stereo Amplifier; Pt.3; Making Panels For Projects.

August 2007: How To Cut Your Greenhouse Emissions, Pt.2; 20W Class-A Stereo Amplifier; Pt.4; Adaptive Turbo Timer; Subwoofer Controller; 6-Digit Nixie Clock, Pt.2.

September 2007: The Art Of Long-Distance WiFi; Fast Charger For NiMH & Nicad Batteries; Simple Data-Logging Weather Station, Pt.1; 20W Class-A Stereo Amplifier; Pt.5.

October 2007: DVD Players – How Good Are They For HiFi Audio?; PICProbe Logic Probe; Rolling Code Security System, Pt.1; Simple Data-Logging Weather Station, Pt.2; AM Loop Antenna & Amplifier.

November 2007: Your Own Home Recording Studio; PIC-Based Water Tank Level Meter, Pt.1: Playback Adaptor For CD-ROM Drives, Pt.1; Rolling Code Security System, Pt.2; Build A UV Light Box For Making PC Boards.

December 2007: Signature Series Kit Loudspeakers; IR Audio Headphone Link; Enhanced 45s Voice Recorder Module; PIC-Based Water-Tank Level Meter; Pt.2; Playback Adaptor For CD-ROM Drives; Pt.2.

January 2008: PIC-Controlled Swimming Pool Alarm; Emergency 12V Lighting Controller; Build The "Aussie-3" Valve AM Radio; The Minispot 455kHz Modulated Oscillator; Water Tank Level Meter, Pt.3 – The Base Station; Improving The Water Tank Level Meter Pressure Sensor.

February 2008: UHF Remote-Controlled Mains Switch; UHF Remote Mains Switch Transmitter; A PIR-Triggered Mains Switch; Shift Indicator & Rev Limiter For Cars; Mini Solar Battery Charger.

March 2008: How To Get Into Digital TV, Pt.1; The I^2C Bus – A Quick Primer; 12V-24V High-Current DC Motor Speed Controller, Pt.1; A Digital VFO with LCD Graphics Display; A Low-Cost PC-to-I^2C Interface For Debugging; One-Pulse-Per Second Driver For Quartz Clocks.

April 2008: How To Get Into Digital TV, Pt.2; Charge Controller For 12V Lead-Acid Or SLA Batteries; Safe Flash Trigger For Digital Cameras; 12V-24V High-Current DC Motor Speed Controller, Pt.2; Two-Way Stereo Headphone Adaptor.

May 2008: Replacement CDI Module For Small Petrol Motors; High-Accuracy Digital LC Meter; Low-Cost dsPIC/PIC Programmer; High-Current Adjustable Voltage Regulator.

June 2008: DSP Musicolour Light Show, Pt.1; PIC-Based Flexitimer Mk.4; USB Power Injector For External Hard Drives; Balanced/Unbalanced Converter For Audio Signals; A Quick'n'Easy Digital Slide Scanner.

July 2008: DSP Musicolour Light Show, Pt.2; A PIC-Based Musical Tuning Aid; Balanced Mic Preamp For PCs & MP3 Players; Bridge Adaptor For Stereo Power Amplifiers.

August 2008: Ultra-LD Mk.2 200W Power Amplifier Module, Pt.1; Planet Jupiter Receiver; LED Strobe & Contactless Tachometer, Pt.1; DSP Musicolour Light Show, Pt.3; Printing In The Third Dimension.

September 2008: Railpower Model Train Controller, Pt.1; LED/Lamp Flasher; Ultra-LD Mk.2 200W Power Amplifier Module, Pt.2; DSP Musicolour Light Show, Pt.4; LED Strobe & Contactless Tachometer, Pt.2.

October 2008: USB Clock With LCD Readout, Pt.1; Digital RF Level & Power Meter; Multi-Purpose Timer; Railpower Model Train Controller, Pt.2; Picaxe-08M 433Mhz Data Transceiver.

November 2008: 12V Speed Controller/Lamp Dimmer; USB Clock With LCD Readout, Pt.2; Wideband Air-Fuel Mixture Display Unit; IrDA Interface Board For The DSP Musicolour; The AirNav RadarBox.

December 2008: Versatile Car Scrolling Display, Pt.1; Test The salt Content Of Your Swimming Pool; Build A Brownout Detector; Simple Voltage Switch For Car Sensors.

January 2009: Dual Booting With Two Hard Disk Drives; USB-Sensing Mains Power Switch; Remote Mains Relay Mk.2; AM Broadcast Band Loop Antenna; Car Scrolling Display, Pt.2; 433MHz UHF Remote Switch.

February 2009: Digital Radio Is Coming, Pt.1; Tempmaster Electronic Thermostat Mk.2; 10A Universal Motor Speed Controller Mk.2; Programmable Time Delay Flash Trigger; Car Scrolling Display, Pt.3.

March 2009: Reviving Old Laptops With Puppy Linux; Digital Radio Is Coming, Pt.2; A GPS-Synchronised Clock; Theremin Mk.2; Build A Digital Audio Millivoltmeter; Learning about Picaxe Microcontrollers.

April 2009: Digital Radio Is Coming, Pt.3; Wireless Networking With Ubuntu & Puppy Linux; Remote-Controlled Lamp Dimmer; School Zone Speed Alert; USB Printer Share Switch; Microcurrent DMM Adaptor.

May 2009: A 6-Digit GPS-Locked Clock, Pt.1; 230VAC 10A Full-Wave Motor Speed Controller; Precision 10V DC Reference For Checking DMMs; UHF Remote 2-Channel 230VAC Power Switch; Input Attenuator For The Digital Audio Millivoltmeter; Drawing Circuits in Protel Autotrax.

June 2009: Mal's Electric Vehicle Conversion; High-Current, High-Voltage Battery Capacity Meter, Pt.1; GPS Driver Module For The 6-Digit Clock; A Beam-Break Flash Trigger; Hand-Held Digital Audio Oscillator.

July 2009: The Magic Of Water Desalination; Lead-Acid Battery Zapper & Desulphator; Hand-Held Metal Locator; Multi-Function Active Filter Module; High-Current, high-Voltage Battery Capacity Meter, Pt.2.

August 2009: Converting A Uniden Scanner To Pick Up AIS Signals; An SD Card Music & Speech Recorder/Player; Lead-Acid/SLA Battery Condition Checker; 3-Channel UHF Rolling-Code Remote Control, Pt.1.

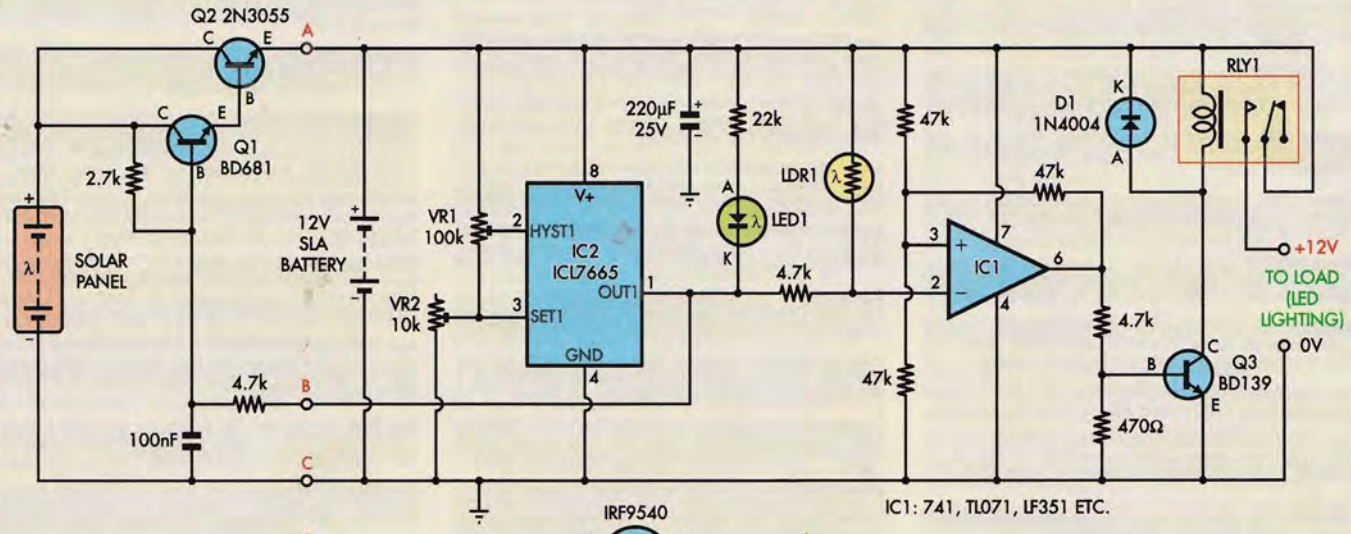
September 2009: High-Quality Stereo Digital-To-Analog Converter, Pt.1; WideBand O_2 Sensor Controller For Cars, Pt.1; Autodim Add-On For The GPS Clock; 3-Channel UHF Rolling-Code Remote Control, Pt.2.

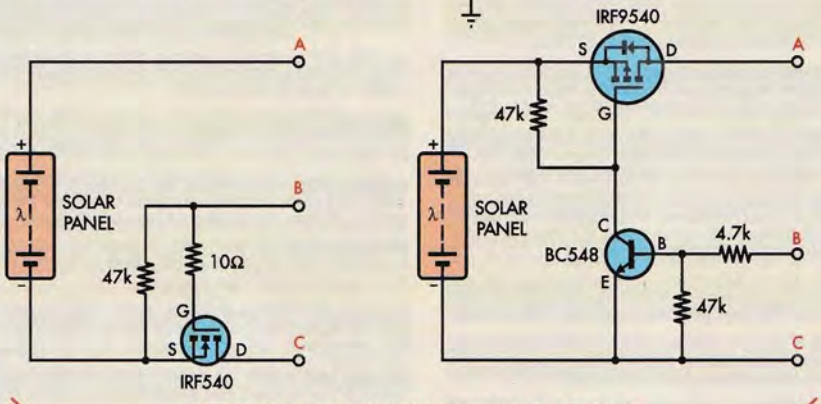
October 2009: The Secret World Of Scope Probes; How To Hand-Solder Very Small SMD ICs; Universal I/O Board With USB Interface; High-Quality Stereo Digital-To-Analog Converter, Pt.2; Digital Megohm & Leakage Current Meter; WideBand O_2 Sensor Controller For Cars, Pt.2.

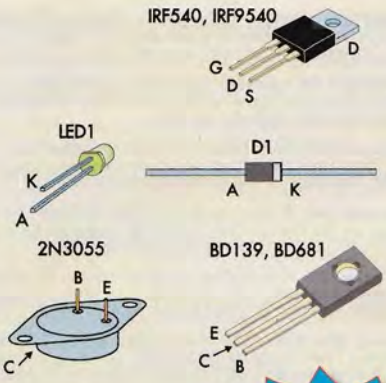
NOTE: issues not listed have sold out. We can supply photostat copies of articles from sold-out issues for $A9.50 each within Australia or $A13.00 each overseas (prices include p&p). When supplying photostat articles or back copies, we automatically supply any relevant notes & errata at no extra charge. A complete index to all articles published can be downloaded from **www.siliconchip.com.au**

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.







Solar powered automatic garden lighting system

This circuit is based on a 10W solar panel and 12V SLA battery which powers an array of LED lamps for a pergola. It uses the ICL7665 over/under voltage detector to prevent overcharge and over-discharge of the battery and to provide control of the supply to the LEDs.

Individual solar lights sold these days for garden applications don't seem to last too long before deteriorating and the light output can be low to unusable. The downside of this circuit is that the lamps/LEDs all have to be hard-wired to a common supply. On the upside, all contacts are soldered for reliability and only one battery is required.

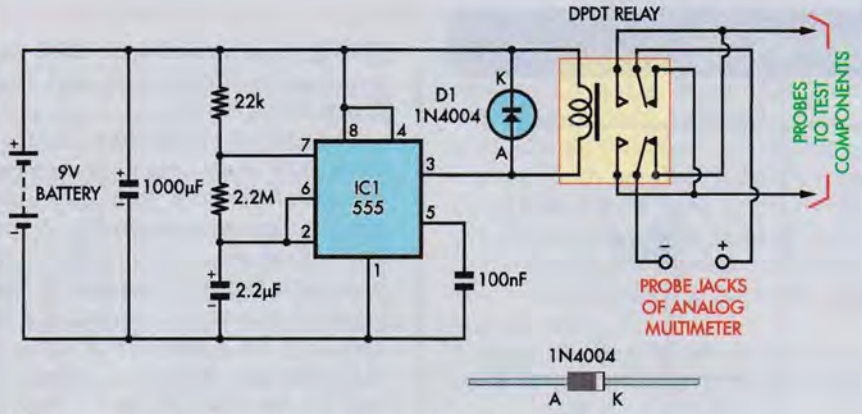
During daylight hours, the diode-protected monocrystalline solar panel delivers about 550mA at up to 21V, with peak power efficiency at around 17V. Only one half of IC2, an ICL7665, is used. It is preset to detect 14.1V and 10.8V via 10-turn trimpots VR1 and VR2. This is accomplished by detecting the nominal trigger voltage at SET1 (pin 3) of 1.35V and using the chip's internal hysteresis at HYST1 (pin 2).

To begin, assume that the Darlington-connected emitter-follower transistors Q1 & Q2 are conducting. As the battery charges up, the voltage eventually rises to 14.1V, whereupon pin 1 of IC2 switches from high to low. This turns on LED1 and switches off Q1 & Q2 (biased via the 4.7kΩ resistor to pin 1). This effectively disconnects the solar panel input to the SLA battery, thereby preventing overcharging.

Colin O'Donnell is this month's winner of a Peak Atlas Test Instrument

Pin 1 of IC2 also attempts to pull pin 2 of IC1 low via the 4.7kΩ resistor. However, LDR1's low daylight resistance, in the order of a couple of hundred ohms, ensures the voltage on pin 2 remains high.

IC1 is connected as a comparator with pin 3 held at approximately $1/2V_{CC}$ by two 47kΩ resistors. As dusk approaches, LDR1's resistance slowly rises to the megohm range and the voltage on pin 2 slowly falls to below the level at pin 3, where-



Relay switcher for easy testing of diodes & transistors

This simple circuit was designed to facilitate the testing of PN junctions in transistors and diodes.

To test a diode using an analog multimeter, you switch the meter to the x10 Resistance range and place the positive probe on the cathode (because the polarity of the probes is reversed) and the negative probe on the anode of the diode. You should read a low resistance. Then reversing the multimeter probes should give a high resistance reading.

If the resistance remains the same when you swap the probes around, the diode is most likely faulty.

For in-circuit testing, the reading may be prejudiced by any associated resistors or inductors. The procedure for testing transistor base-emitter and collector emitter junctions is the same.

This circuit automatically swaps the meter probe polarity every three seconds, so that testing diode junctions is made quickly, ie, it automatically changes polarity for you so you just monitor the readout to watch for the needle deflection.

LEDs can be checked in a similar way and provided the test current is sufficient, the LED will flash in sympathy as the DPDT relay changes state.

It can also be used as a crude method of testing electrolytic capacitors above about 1µF. Each time there is a polarity transition (which can be heard as the relay changes state) there should be a positive meter deflection before the capacitor discharges.

If there is no pointer deflection, the capacitor may be faulty.

The circuit itself is simply a 555 timer set to switch the relay on and off every three seconds. If you want to increase the speed of switching, reduce the 2.2µF at pin 2 of the 555.

John Malnar,
Banks, ACT. ($30)

upon IC1's output at pin 6 switches from low to high. This turns on Q3, energising the relay and connecting the positive supply to the load.

The battery slowly discharges through the load until one of two events occurs. When dawn arrives, LDR1's resistance drops as the ambient light increases, IC1's output switches low and Q3 switches off the relay. This also reconnects the solar panel via Q1 & Q2 to recharge the battery.

Alternatively, some time during the night the battery will discharge to IC2's detection point of 10.8V whereupon IC2's pin1 switches high, switching off LED1 and toggling IC1 so that Q3 switches off and de-energises the relay. The discharged battery voltage then floats up to around 12.6V and as Q1 & Q2 have also been switched on again, the unit then waits for the charging cycle from the solar panel the next day.

A point to note is that the battery must fully discharge, with IC2's output triggering high (LED1 off), before recharging through Q2 can commence. So it is important not to set the discharge voltage detection point too low, ie, no lower than 10.8V. More information on battery discharge/charge parameters can be found in the article entitled *Micropower Battery Protector* in the July 2004 issue of SILICON CHIP.

LED1 should be a high-brightness type so that the modest current allowed by the 22kΩ limiting resistor (about 750µA) will give adequate indication. The circuit is quite efficient, drawing only about 3-5mA in the off/ready state and about 35mA is required to activate the standard DPDT relay

Colin O'Donnell,
Glenside, SA.


into MICROS OR PICS?

There's a reference to suit every microcontroller maestro in the SILICON CHIP reference bookshop: see the bookshop pages in this issue


Microcontroller Projects in C – by Dogan Ibrahim
NEW LOW PRICE! was $81
Graded projects introduce microelectronics, the 8051 and programming in C.
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An in-depth look at the clever little 2.4GHz wireless ZigBee chip that's now being found in a wide range of equipment from consumer to industrial.
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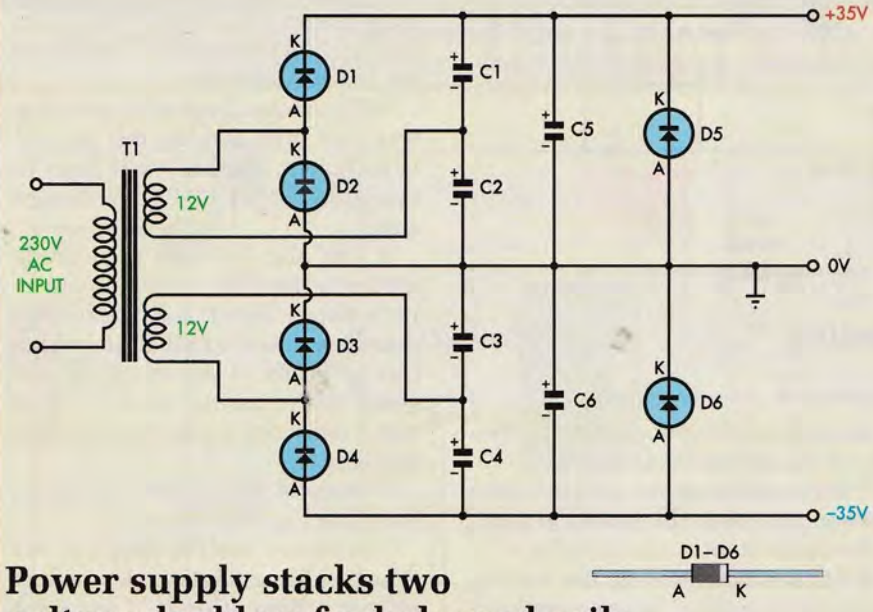

PIC Microcontrollers – know it all (Newnes)
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Programming 16-Bit Microcontrollers in C – by Luci Di Jasio
Learning to fly the PIC24. Includes a CD ROM with source code in C, Microchip C30 complier and MPLAB SIM.
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Power supply stacks two voltage doublers for balanced rails

The standard bridge rectifier/capacitor filter power supply used in most amplifiers results in a DC output voltage roughly 1.4 times that of the AC input voltage. So, for example, a 50VAC centre-tapped transformer (25-0-25) results in DC power rails of approximately ±35V (25 x 1.4).

Sometimes it is desirable to get a higher DC voltage supply from a transformer. For example, if you want ±35V it is difficult to purchase a suitable 300VA toroidal transformer. While such transformers with 12V-0-12V, 18V-0-18V, 40V-0-40V and 50V-0-50V secondary windings are available, there is no 300VA transformer with 25-0-25V secondaries (or at least, not from Jaycar Electronics).

The circuit shows how to use a 12V-0-12V transformer. It uses two separate full-wave voltage doubler circuits for each secondary winding. You can use two bridge rectifiers with the AC terminals joined together in place of diodes D1 & D2 and D3 & D4 if you like or else use high-current discrete diodes. C1 and C2 are charged up to roughly 17V each, for a total of nearly 35V on each rail. They in turn charge C5 and C6 which act as the primary energy storage.

D5 & D6 help protect the driven circuitry from reversed supply voltage as the capacitors discharge when the device is switched off. You can also put resistors across C1-C4 (eg, 10kΩ) which will act as bleeder resistors to discharge them after power off and will also help ensure that they share charge evenly. It's a good idea, especially while you're working on the circuit, but they aren't strictly required.

Note that unlike the standard bridge rectifier supply, none of the transformer secondary connections are earthed. Rather, earth is connected to the point at which the

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two full-wave voltage doublers are joined. As a result, the junction of C1 & C2 tends to sit half way between the 0V and +35V rails and similarly, the junction of C3 and C4 sits halfway between 0 and -35V.

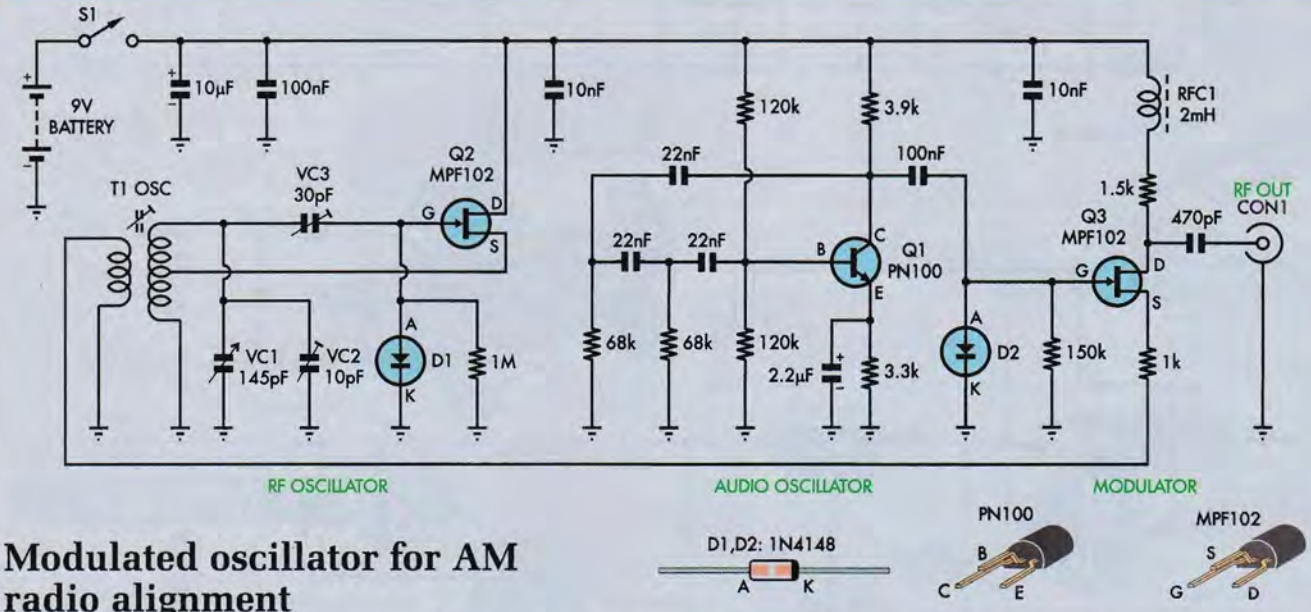
Note that all other things being equal, this circuit will have worse voltage regulation than a standard bridge rectifier circuit. Also, the current drawn from the secondary of the transformer will be twice as high.

You can compensate for this by making C5 & C6 larger than you otherwise would. Generally, these will actually consist of multiple capacitors in parallel. Also keep in mind that C1-C4 need to have ripple current ratings at least as high as the maximum amount of current you will be drawing from the DC supply rails.

Most medium/large electrolytic capacitors can supply around 1.5-2A each but you can increase this by parallelling multiple capacitors. The values used in the prototype power supply were 2 x 2200µF 35V for C1-C4 and 2 x 4700µF 50V for C5 and C6.

For the 12V-0-12V transformer shown, C1-C4 should have ratings of 25VDC and C5-C6 should have ratings of 50VDC.

Nicholas Vinen,
Randwick, NSW. ($40)



Modulated oscillator for AM radio alignment

If you are interested in restoring vintage AM radios, you are going to need a modulated oscillator to align the intermediate frequency (IF) stages. This is typically 450kHz for modern radios, 455kHz for radios produced prior to the 1980s and can be at lower frequencies for radios produced prior to the 1930s.

You will also need to align the RF input stages and for that you need an oscillator to cover the AM broadcast band.

This circuit provides this ability. Transistor Q1 is connected as a simple phase shift oscillator which produces an audio modulation tone at about 400Hz. The three 22nF capacitors and associated resistors form a 180° phase shift network while Q1 acts as an inverting amplifier to provide sufficient gain to sustain oscillation.

FET Q2, an MPF102, is connected as a Hartley oscillator. T1 is a commonly available local oscillator coil for AM radio – the red coil of the miniature IF/OSC coil packs (Jaycar LF1050). VC1 is a miniature tuning capacitor commonly used in transistor radios (Jaycar RV5728). Only one gang of the tuning capacitor is used (terminals A & G).

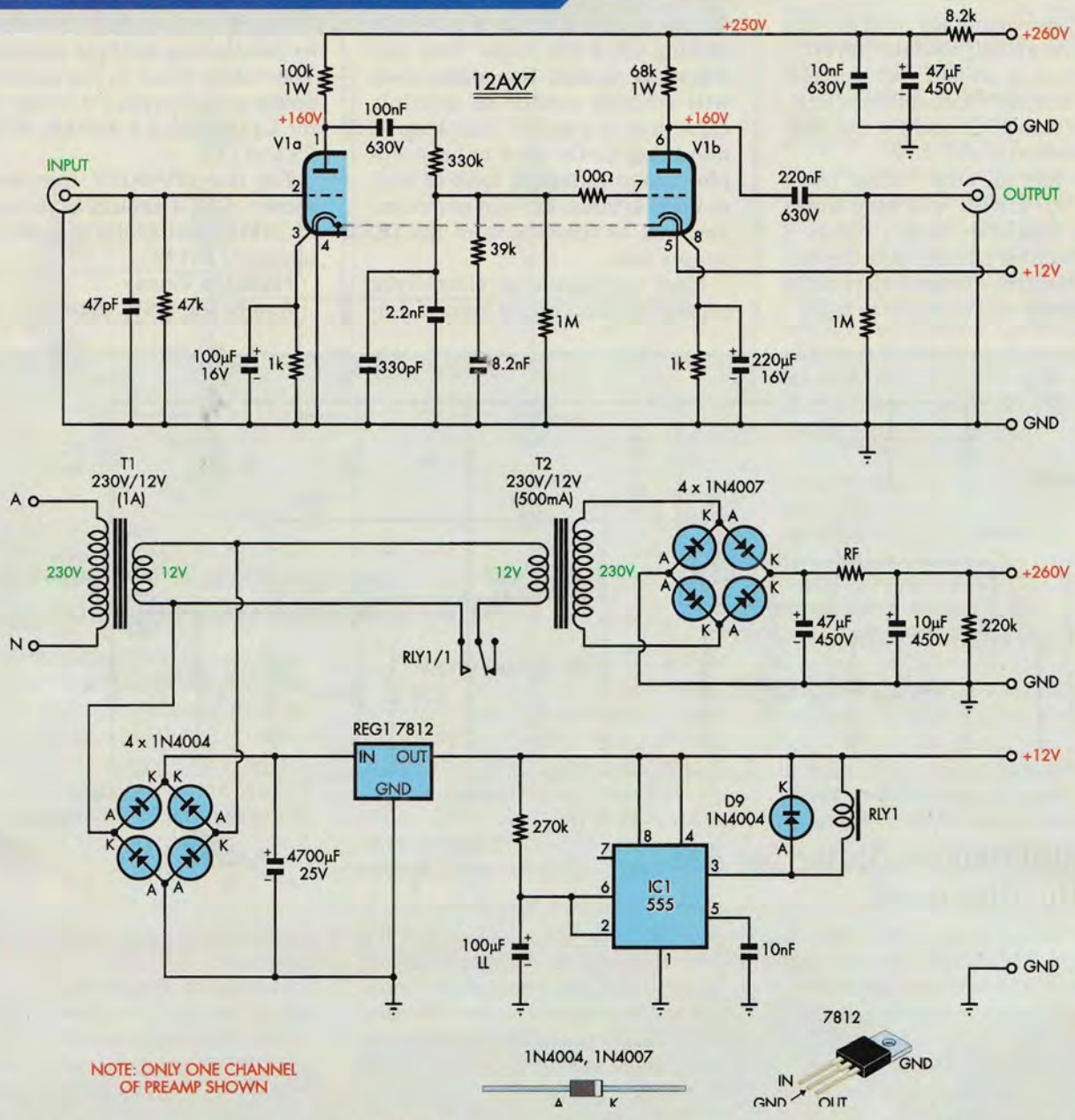
VC2 is the inbuilt trimmer capacitor in parallel with VC1. The tuning capacitor has a nominal maximum capacitance of 160pF. A tuning range of 550-1700kHz therefore requires an inductance of 523µH and a minimum capacitance of 16.75pF. In practice, a smaller inductance will be required because of stray capacitances and the self-capacitance of the coil. Trimmer VC3 limits the current in the tank circuit.

Transistor Q3 acts as a mixer for the audio and RF signals to produce an amplitude modulated RF signal. The RF signal is fed in by virtue of T1's secondary being connected in series with the source resistor of Q3, while the audio tone is capacitively coupled to the gate of Q3 via a 100nF capacitor.

Ideally, a frequency counter should be used to calibrate this oscillator. Failing that, you can use an AM/FM tuner (or car radio) with a digital readout. To set the oscillator, adjust both VC1 & VC2 for minimum capacitance and then adjust the slug of coil T1 for an output frequency of 1700kHz (or the top of the AM band if using a tuner).

You will find that with this adjustment, setting VC1 to maximum capacitance will only get down to around 600kHz. To go lower, add a 150pF capacitor in parallel with the tuning capacitor via a switch and this should get the low frequency end to about 400kHz. To set a frequency of 455kHz from the oscillator, set your radio to receive 900kHz. This will pick up the second harmonic of the signal.

Alex Sum,
Eastwood, NSW. ($45)



Passive RIAA valve preamplifier

This preamplifier is based on the 12AX7 twin-triode circuit featured in the November 2003 issue of SILICON CHIP. That particular design had an overall gain of 67 and had considerable negative feedback applied from the plate of the second triode to the cathode of the first. This gave quite reasonable harmonic distortion performance, relative to designs without overall feedback.

However, a lot more gain is required for a preamplifier providing RIAA equalisation for a magnetic cartridge. Hence, this circuit has both triodes connected as voltage amplifier stages but with no overall feedback. The RIAA equalisation is passive, with RC filter networks connected to the plates of both triode stages. Because the gain of both stages is around 60 times, Miller Effect capacitance needs to be taken into account when selecting the capacitor values.

This explains why the various RC time constants do not appear to follow the standard RIAA values which give 6dB/octave slopes beyond turnover frequencies of 50Hz, 500Hz and 2120Hz. When the preamp is terminated with a 100kΩ load, the resultant equalisation is within ±0.5dB of the RIAA characteristic. Overall gain is 180 times (+45dB).

The switchmode power supply used in the November 2003 design was judged to be too noisy for a magnetic cartridge preamplifier and so a conventional power supply with two back-to-back 12V transformers was used instead, with the valve heaters being supplied with regulated 12V DC from REG1.

A 555 timer (IC1) and relay is used to delay connection of the 260V DC supply to the valve plates until the heaters have come up to temperature.

Dean Brookes,
St Ives, NSW. ($60)

PICAXE UPDATE



Many SILICON CHIP readers enjoy using the PICAXE range of microcontrollers within their projects because of their low cost and ease of use. Clive Seager, Revolution Education's Technical Director, takes us through the recent PICAXE updates and new releases, including the eagerly anticipated new PICAXE-20X2.

AXE027 PICAXE USB download cable

When the PICAXE system was first developed over ten years ago the '9 way serial port' was the conventional way of connecting the computer to external devices, such as digital cameras.

The now-familiar PICAXE '3.5mm jack plug/socket' connection was selected as (1) it is robust and (2) many early digital cameras used exactly the same serial download cable, meaning the cables were a low-cost mass produced item!



USB has now taken over this role and most modern laptops now only have USB-style connectors.

Unfortunately, the USB protocol is far more complex than the serial RS232 protocol; in fact it is not possible to implement the USB protocol on low-cost, limited-memory devices like 8 and 14-pin PICAXE microcontrollers. There simply isn't enough memory space to implement both the USB protocol and the PICAXE firmware!

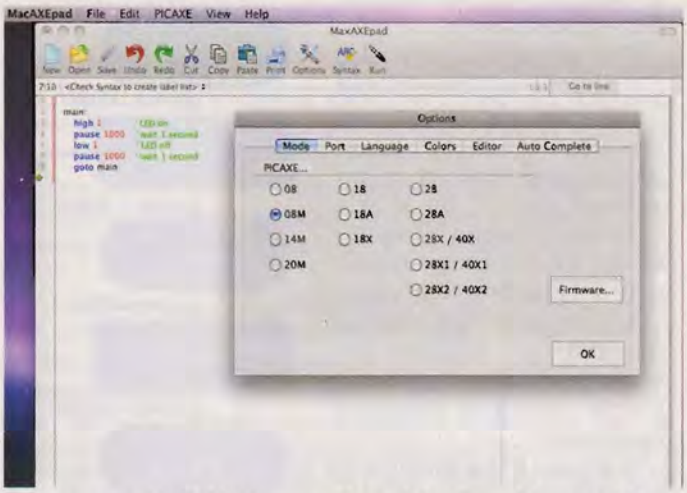
Therefore an alternate approach is required and that is to use a separate 'intelligent' USB cable with an embedded USB-to-serial converter chip, such as those made by FTDI. This gives the best of both worlds – a USB connection to the computer and a serial connection to the PICAXE chip itself.



As you can see, the AXE027 download cable contains a complete miniature circuit moulded into the USB connector.

This allows the cable to work via USB on all Windows, Linux and Mac computers.

AXEpad software



To support PICAXE users who wish to use Linux or Mac computers to develop their PICAXE BASIC programs the new cross-platform AXEpad software is now available (Windows users should still use the Programming Editor software).

When combined with the AXE027 USB download cable AXEpad provides a complete development system for Linux and Mac users.

AXEpad has been deliberately designed with a small footprint and so will also work well on low-cost flash drive Linux 'netbook' computers such as the eeePC.

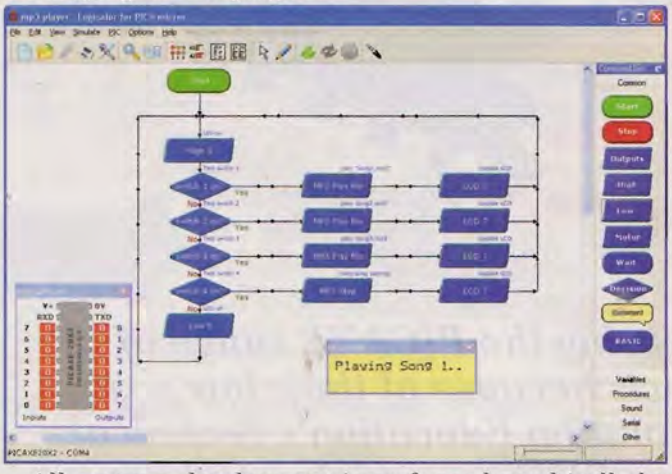
As you would expect AXEpad supports all the common PICAXE features such as colour highlighting of BASIC programs and in-built testing features such as the 'Debug' and 'Terminal' functions.

AXEpad is completely free of charge and will operate with:

- Linux – any modern x386 distribution with GTK2.8+
- Mac – OSX (10.3 or later) on PowerPC or Intel machines

Logicator flowcharting software

Logicator is a flowcharting application widely used within UK schools and colleges for over twenty years for developing control programs.



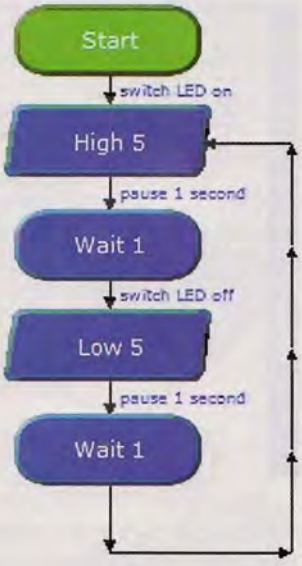
All program development is performed graphically by joining flowchart shapes together, and so is simpler for younger students to use than BASIC style 'textual' programming languages.

Recently Revolution took over the Logicator product and have spent the last 12 months bringing it up to date to support all the current PICAXE chips.

The software is now also distributed as unrestricted 'shareware' and so anyone can download it from www.picaxe.co.uk and try it out without charge. So if you have always been a bit daunted by BASIC programming why not give flowcharts a go!

Logicator is very easy to use and also supports on-screen simulation that allows simple testing of flowchart operation.

If desired the flowcharts can also be automatically converted into BASIC program listings.



Current PICAXE chip lineup

Over the years PIC microcontroller technology has vastly improved, resulting in more memory capacity and features. This has enabled the PICAXE chips to be enhanced with additional commands, more RAM variables and additional memory capacity, all at a lower cost!

The full PICAXE lineup is shown below:

Current PICAXE range		
Entry (100-200 lines)	Intermediate (600-2000 lines)	Enhanced (2000-3000 lines)
08M		
14M		
18M	18X	
20M		20X2
	28X1	28X2
	40X1	40X2

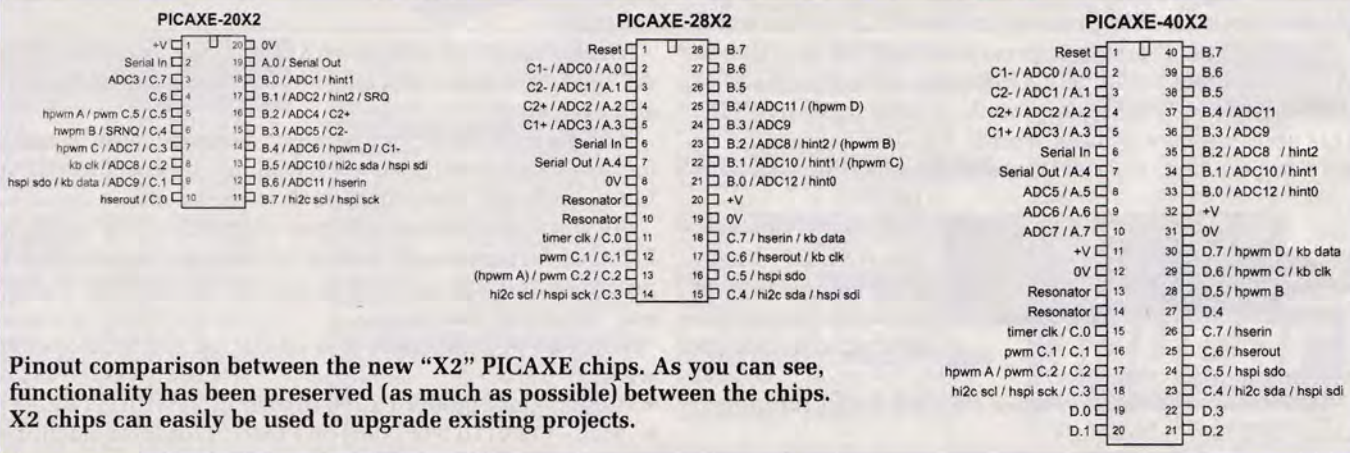
New X2 range

The new PICAXE X2 range (20X2, 28X2 and 40X2) is a complete new generation of the PICAXE chip, making use of the advanced features and architecture of the newly released PIC18F series of microcontrollers.

The entire PICAXE core has been completely rewritten to provide a more flexible and higher specification tool for more advanced projects. Although the features and memory capacity have greatly increased, prices have not – for instance the new 20X2 is the same price as the older 18X part!

X2 Enhancement Summary:

- Each pin can now be individually configured as input or output
- Up to 12 internal ADC channels available
- Up to 256 general purpose RAM bytes
- Up to 1024 additional bytes in the RAM scratchpad
- Indirect RAM access to support easier use of arrays
- Clock speed ups to 64MHz, 16x faster than 4MHz!
- Wider operating voltage range (1.8 - 5.5V), ideal for 3V systems
- Up to 4 internal program slots – allowing up to 10,000 lines of code with 1000 sub-procedures!
- Also supports up to 32 more program slots stored in external EEPROM chips
- Support for UNI/O brand EEPROM chips using a single i/o line
- New hardware interrupt pins
- New comparator functions to compare 2 ADC channels



Pinout comparison between the new "X2" PICAXE chips. As you can see, functionality has been preserved (as much as possible) between the chips. X2 chips can easily be used to upgrade existing projects.

X2 Enhancements

- **I/O Pin Flexibility**

One of the key new features of the X2 series is that almost every pin is configurable as input or output. This creates much more flexibility with circuit design as you are not fixed to a pre-defined ratio of inputs to outputs on any chip size. Naturally the pins can also be configured to the 'traditional' PICAXE layout if desired.

- **Analog Inputs**

Many more ADC channels, up to 12, are now available on a number of the i/o pins. This again provides greater flexibility with circuit design. New comparator features also allow two analog channels to be compared, so that an interrupt can occur if one analog value exceeds another.

- **Greater Processing Speeds**

The 20X2 can operate at up to 64MHz via it's internal resonator. This is a vast speed improvement – for instance a program that took 2 minutes to process on an 18X at 4MHz will now take less than 8 seconds! This is ideal for systems that need rapid response times, such as persistence-of-vision LED display systems.

- **Increased Voltage Operating Range**

The 20X2 will function from 1.8V all the way up to 5.5V, making the single part ideal for both 3 and 5V systems. This large voltage range is quite a technical breakthrough, and is achieved via a new innovative design – a 3V silicon core combined with an internal integrated low dropout regulator. This means that the 3V core, which would normally only tolerate 1.8V to 3.3V, can be used all the way up to 5.5V because the internal regulator 'kicks-in' when required and constantly maintains the internal core voltage at 3V.

- **Hardware Interrupt Pins**

The X2 range has up to 3 pins that can be configured as hardware interrupt pins. When configured, these pins continuously background scan for an edge based trigger, even during sleep. When this trigger occurs a flag is set which can be used to trigger a special 'interrupt' section of BASIC code.

- **RAM**

The X2 parts have a much greater RAM capacity, 256 bytes on the 20X2 and 1280 bytes on the 28X2/40X2. This increased memory capacity allows much more complex calculations and programs. X2 parts also accept indirect memory access via pointers (@ptr, @ptrinc, @ptrdec), which is ideal for building arrays of data.

- **Program Slots**

The 20X2 has 1 program slot, the 28X2/40X2 have 4 internal program slots. Each X2 program slot can contain approximately 2000-3000 lines of BASIC code. When the microcontroller is reset the program in slot 0 automatically starts running. The other programs can then be started by using a 'run' command.

- **External Slots**

As well as the internal memory slots, 4 additional slots can be used by connecting an external I^2C EEPROM chip. As up to 8 different I^2C chips could be used on the same I2C bus, this gives a theoretical 32 additional program slots with over 64,000 lines of BASIC code!

- **UNI/O Support**

The X2 support communication with external Microchip UNI/O EEPROM memory chips. The advantage of uni/o memory is that it only requires 1 microcontroller pin, as opposed to I2C which requires 2 and SPI which requires 3.

Summary

As you can see 2009 has been a very busy year for us at Revolution Education and we hope you enjoy using the new PICAXE software and parts. As ever, if you have any feedback or new feature requests please do not hesitate to contact us via www.picaxe.co.uk – almost all new PICAXE features are the direct result of PICAXE community feedback!

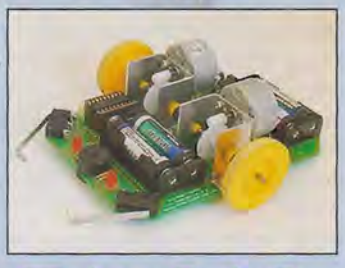
All software described in this article can be downloaded free of charge from www.picaxe.co.uk, while PICAXE cables and chips are available in Australia from www.microzed.com.au and in New Zealand from www.sicom.co.nz. They are also available from several electronics stores. SC

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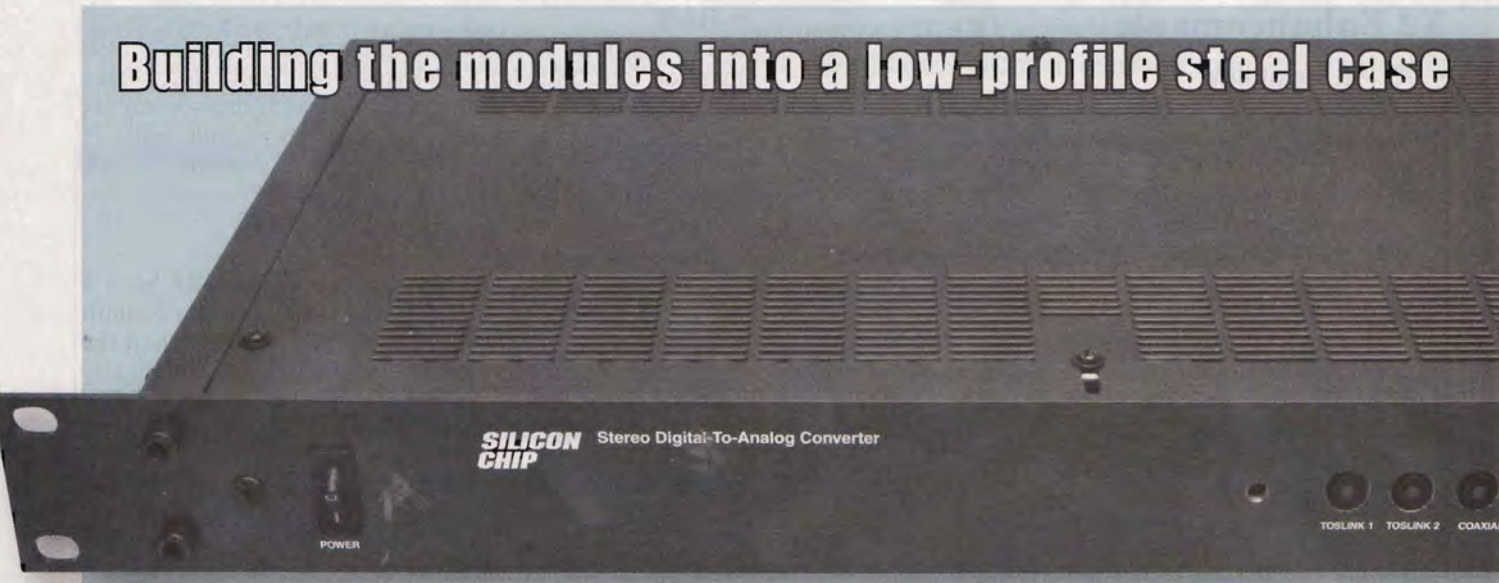


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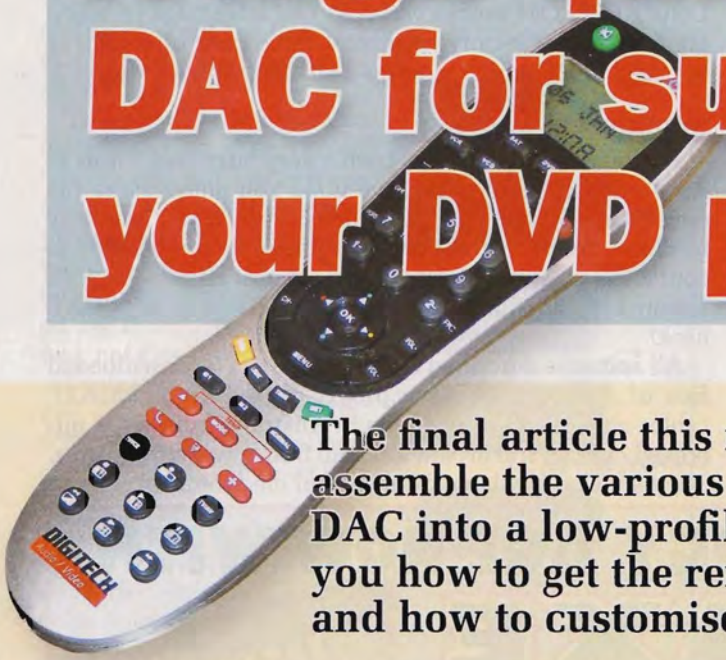
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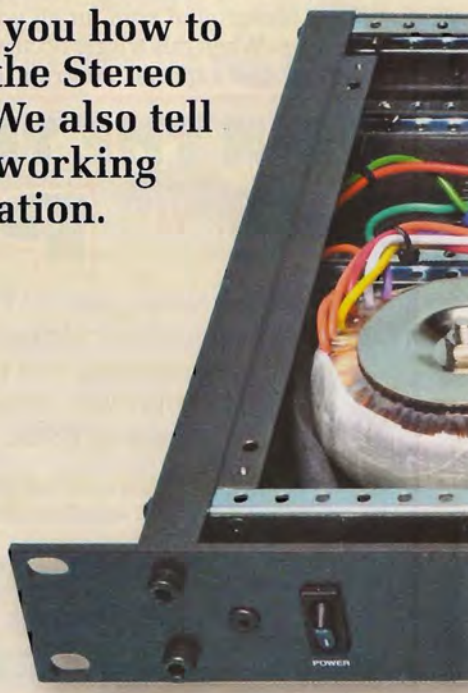
The final article this month shows you how to assemble the various modules for the Stereo DAC into a low-profile steel case. We also tell you how to get the remote control working and how to customise the configuration.

FOR THE PURPOSES of this article, we'll generally assume that you're building the unit from a kit and that the case comes with all the holes pre-drilled. If not, then you will have to drill the holes yourself using the photographs and the layout shown in Fig.12 to guide you.

As previously stated, if you have to buy a case separately, then we recommend the Altronics H-5035 rack case.

Basically, you will have to drill/cut holes in the front panel for the mains switch, the earth point (4mm), the three pushbutton switches (10mm) and the two LEDs (5mm). You will also need a 5mm hole for the IR receiver plus four 3mm mounting holes for the Switch Board. **Note that the Switch Board is directly attached to the front panel and not mounted on a sub-panel as in the prototype.**

Make sure that the cut-out for the mains switch is the correct size, so that it snaps securely into place and is retained by its plastic locking tabs. This involves drilling a series of holes inside the marked cut-out and then





By NICHOLAS VINEN

from

carefully (and tediously) filing it to shape. Alternatively, you can use a toggle switch that requires a round mounting hole but make sure that the switch is mains rated.

On the rear panel, you will need clearance holes for the various input and output sockets, holes for the fuseholder and rear-panel earth point (4mm) and a cut-out for the IEC socket. An alternative here is to use an IEC socket with an integral fuse, in which case the external fuseholder is no longer necessary.

Drilling the bottom of the case is straightforward. First, use the PC boards as templates to mark out their mounting holes. **Note that the Input and DAC boards sit right at the rear of the chassis and their sockets must be correctly aligned with their rear panel holes to avoid shorts.** Drill these holes to 3mm, then drill two 4mm holes for the earth points plus a mounting hole for the transformer. Having done that, fit four feet to the bottom of the case if it doesn't already have them. These can be either a self-adhesive type or you can use bolt-on feet in which case you will have to drill the necessary holes.

Mains wiring

Once the case is ready, the first step is to install the transformer, power switch and the 230VAC wiring.

As shown in Fig.12, all the mains wiring is located in a partitioned-off area in the lefthand side of the case. However, this steel partition will only be present if you purchase a custom case as part of a kit (ie, from Altronics). If you buy a standard rack case, then you can purchase a length of angle-aluminium from a hardware store and fit it yourself by bolting it to the base (make sure it is well earthed by scraping away the powder coating on the chassis around the mounting bolts).

Before fitting the mains transformer, scrape away the powder coating around its mounting hole on the bottom of the chassis. This is done so that the flat metal washer under the head of the bolt contacts bare metal, so that the bolt is correctly earthed.

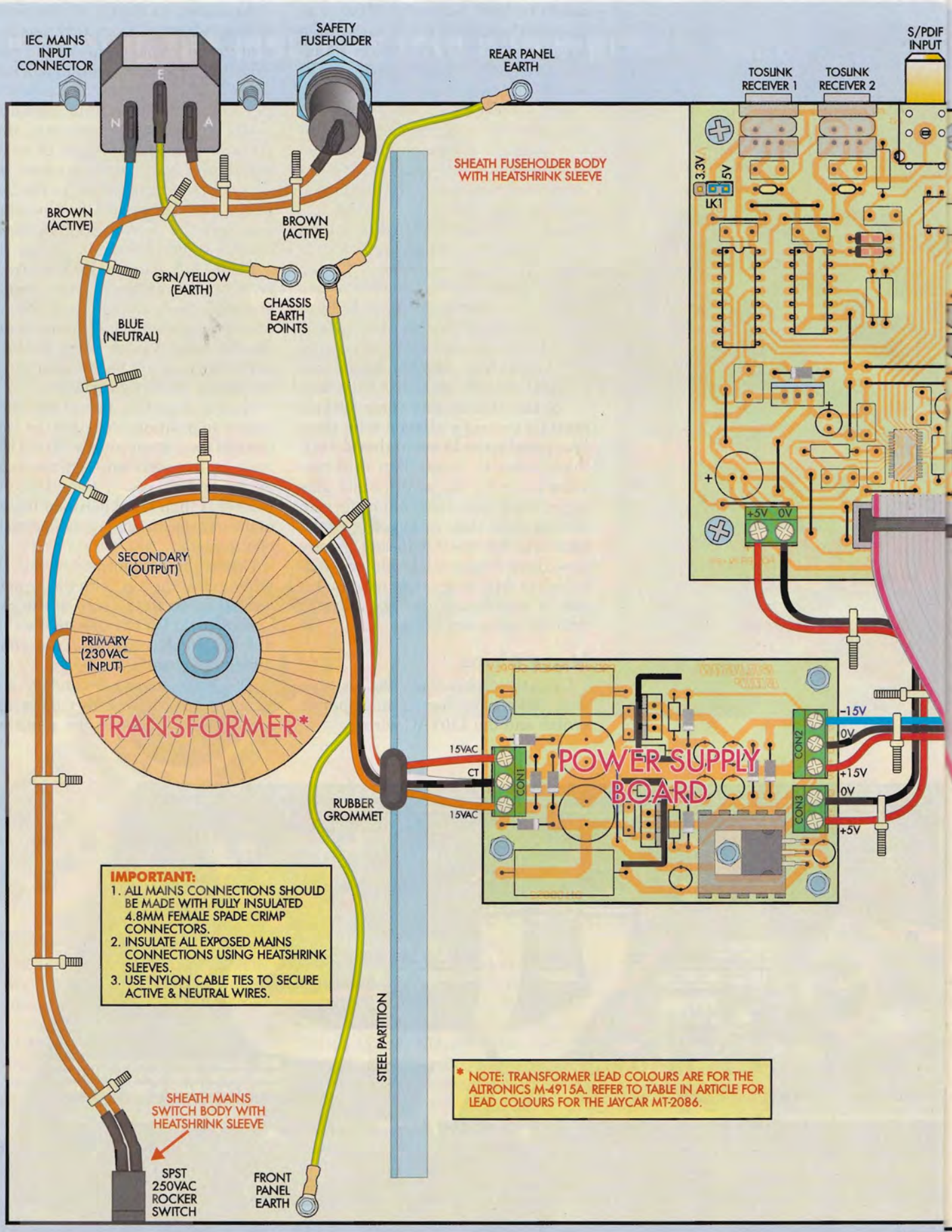
Having done this, mount the transformer in position. Note that the large flexible washer supplied with the unit must be installed between the transformer and chassis. A second flexible washer is then fitted between the top of the transformer and its dished metal clamp plate.

Orient the transformer so that the wires exit at the top, with the primary wires nearest to the side of the case – see Fig.12. Do not over-tighten the mounting bolt, otherwise you could distort the chassis.

The transformer's secondary side terminations can now be fed through a grommetted hole in the partition,



NOTE: THE SUPPLY LEADS TO THE FINAL VERSION OF THE INPUT BOARD ARE REVERSED AT THE TERMINAL BLOCK COMPARED TO THOSE SHOWN HERE.


IEC MAINS INPUT CONNECTOR
SAFETY FUSEHOLDER
REAR PANEL EARTH
S/PDIF INPUT
TOSLINK RECEIVER 1
TOSLINK RECEIVER 2
SHEATH FUSEHOLDER BODY WITH HEATSHRINK SLEEVE
3.3V
5V
LK1
BROWN (ACTIVE)
BROWN (ACTIVE)
GRN/YELLOW (EARTH)
CHASSIS EARTH POINTS
BLUE (NEUTRAL)
+5V 0V
SECONDARY (OUTPUT)
PRIMARY (230VAC INPUT)
TRANSFORMER*
15VAC
CT
15VAC
CON1
POWER SUPPLY BOARD
CON2
CON3
-15V
0V
+15V
0V
+5V
RUBBER GROMMET
IMPORTANT:
1. ALL MAINS CONNECTIONS SHOULD BE MADE WITH FULLY INSULATED 4.8MM FEMALE SPADE CRIMP CONNECTORS.
2. INSULATE ALL EXPOSED MAINS CONNECTIONS USING HEATSHRINK SLEEVES.
3. USE NYLON CABLE TIES TO SECURE ACTIVE & NEUTRAL WIRES.
STEEL PARTITION
* NOTE: TRANSFORMER LEAD COLOURS ARE FOR THE ALTRONICS M-4915A. REFER TO TABLE IN ARTICLE FOR LEAD COLOURS FOR THE JAYCAR MT-2086.
SHEATH MAINS SWITCH BODY WITH HEATSHRINK SLEEVE
SPST 250VAC ROCKER SWITCH
FRONT PANEL EARTH

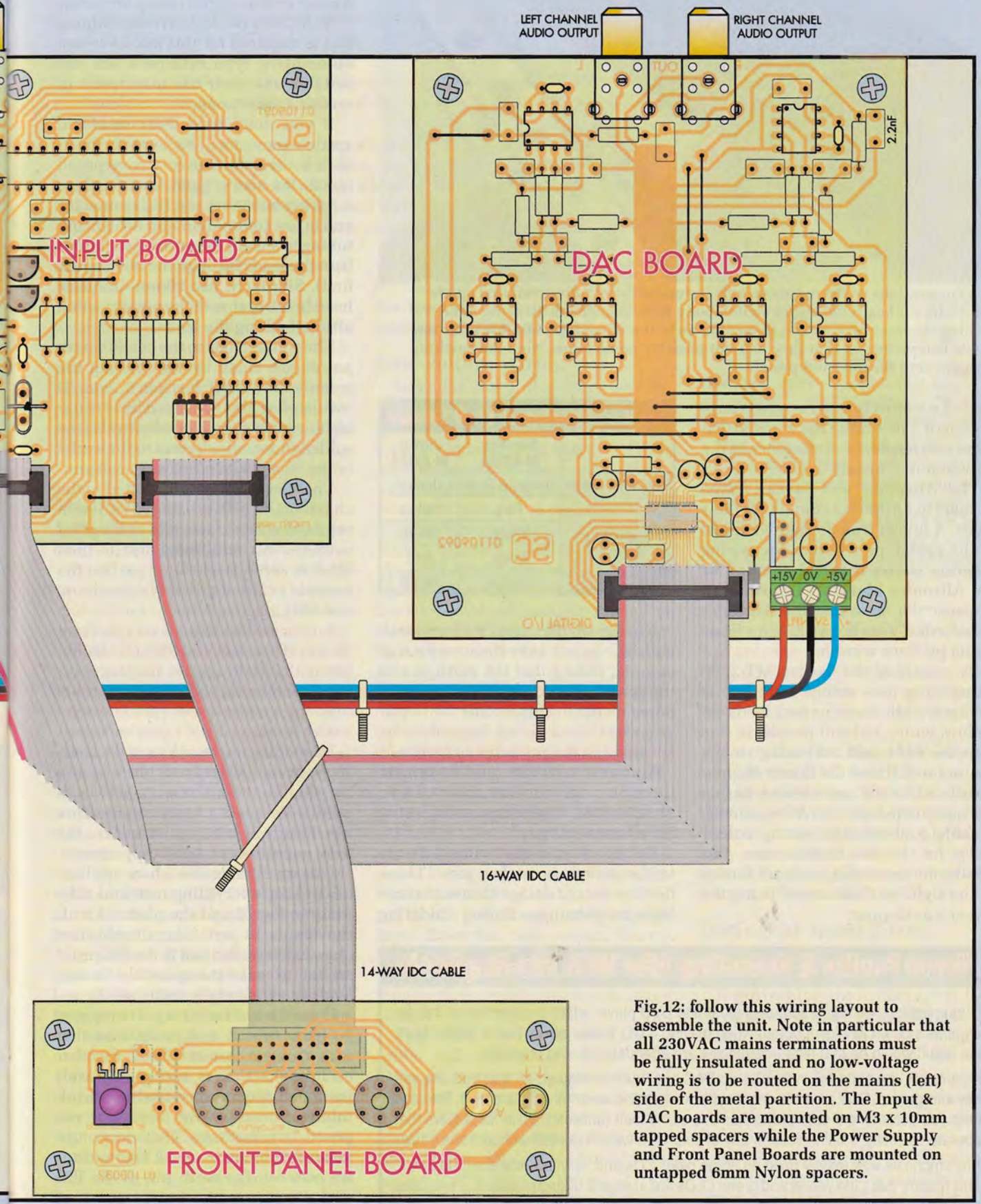


Fig.12: follow this wiring layout to assemble the unit. Note in particular that all 230VAC mains terminations must be fully insulated and no low-voltage wiring is to be routed on the mains (left) side of the metal partition. The Input & DAC boards are mounted on M3 x 10mm tapped spacers while the Power Supply and Front Panel Boards are mounted on untapped 6mm Nylon spacers.



The connections to the mains switch are made using fully-insulated spade connectors. Sheath the entire switch body with heatshrink sleeving after making the connections and fit a cable tie to the wires immediately after the spade connectors so that they can not possibly come loose. Note the earthing arrangement for the front panel.

ready for connection to the power supply board. Position all the wires so that there will be plenty of clearance to the lid when it is installed later.

The Altronics and Jaycar transformers use different colours for their leads. A Jaycar transformer was used in the prototype whereas the wiring diagram shows the lead colours for the Altronics M-4915A transformer. In particular, note that the Altronics transformer uses brown & blue leads for its primary winding.

By contrast, the Jaycar MT-2086 transformer uses orange leads for its primary, while its secondary leads are yellow, white, red and purple. In this case, the white and red leads go to the centre tap (CT) on the Power Supply Board, while the yellow and purple leads go to the outer 15VAC terminals.

Table 5 shows the wiring colour codes for the two transformers. Just use the corresponding colours shown in the righthand column if using the Jaycar transformer.

Table 5: Transformer Lead Colours

	Altronics M-4915A	Jaycar M-4915A
Primary Colours	Brown & Blue	Orange
Secondary Colours	Red	Yellow
	White	White
	Black	Red
	Orange	Purple

Next, push the mains rocker switch and IEC socket into their respective cutouts, noting that the earth pin of the socket goes towards the top. That done, install the fuseholder. **Note that you must use a safety fuseholder as specified in the parts list in Pt.1.**

You can now run and terminate the mains wiring. Use only 7.5A or 10A/250VAC mains-approved cable for all connections.

Do not solder the wires directly to the switch or socket pins! These devices are not designed to withstand high temperatures during soldering and may be damaged. Instead, terminate each wire end in a fully insulated 4.8mm female spade crimp terminal.

Note that a ratchet-driven crimping tool is required for this job. Low-cost automotive type crimpers are not suitable and their use may result in unsafe connections.

If you don't have fully-insulated spade connectors, be sure fit heatshrink insulation over any exposed metal. **It's also a good idea to place a rubber boot over the IEC connector and to use 16mm-diameter heatshrink tubing to sheath the entire fuseholder (run the leads through the heatshrink first). Similarly, use 20mm-diameter heatshrink to sheath the power switch after attaching the leads.**

The connections to the chassis earth points are made by terminating the green/yellow earth leads in 5.3mm ID insulated crimp eyelets. After crimping the wires, it's a good idea to also the solder wire ends adjacent to the eyelet holes, as a "belts'n'braces" measure.

These eyelets are then bolted to the chassis earth points using M4 x 10mm machine screws, nuts and shakeproof washers. An additional nut is then fitted to serve as a locknut, so that the assembly cannot possibly come loose – see Fig.13.

Important: be sure to scrape away the paint from around the holes before fitting the earth screws (ie, you must have good metal-to-metal contact between the chassis and the earth eyelets). This step is vital to ensure safety.

Depending on the colour of the chassis, you might want to use black screws for the front and rear panel earth points. We used a black countersink hex head M4 x 12mm screw on the front panel to ensure good appearance.

Use small cable ties where applicable to keep everything neat and tidy. Refer to Fig.12 and the photos for all the details. In particular, fit cable ties close to the switch and to the IEC input socket, to make it impossible for any leads to accidentally come adrift.

Once the mains wiring is complete, go back over it and make sure that everything is correct. Check also that each connection is secure and well insulated. If necessary, use heatshrink tubing to completely cover any exposed terminations. That done, use your multimeter to check for continuity between the earth pin of the IEC socket and any convenient point on the chassis that is devoid of paint,

Player Faults & Detecting CDs With Pre-Emphasis

During testing, we came across at least one DVD player which incorrectly set the de-emphasis bit on its digital output when playing a CD. If your player has a similar fault, the result would be that high frequencies are attenuated during playback.

As a result, the software in the Stereo DAC has been configured so that both the yellow and green LEDs are lit during playback when the de-emphasis is active. This can help you determine if your player has this same fault (unlikely), while for players that operate correctly, it will indicate if any of your CDs were recorded with pre-emphasis.

Pre-emphasis was mainly used on some older CDs and very few modern CDs use it. This means that if the yellow and green LEDs are always lit during playback, it indicates a fault with the player.

Where To Buy Kits For The Stereo DAC

Both Jaycar and Altronics will be supplying kits for this project and both companies will be supplying the Input and DAC Boards with the surface-mount ICs (IC3 & IC6) already soldered in place.

The Jaycar kit will be in short form only and will consist of the Input, DAC and Front Panel Boards plus all on-board parts. A kit for the Power Supply Board is available separately (Cat. KC-5418).

The Altronics kit will be complete and will include all the modules, the power supply components (including the transformer) and a laser-cut custom steel case with screened lettering. The modules will not be available separately except for the Power Supply Board (Cat. K-5501) and the remote control is not included.

such as the countersunk screws in the side panels.

This test must be repeated later when the top panel of the case is fitted. At that time, use your meter to check that the top and both side panels are earthed. If not, carefully remove the paint from beneath the heads of the retaining screws to ensure a reliable connection – see panel titled "Making Sure The Case Is Securely Earthed".

Mounting the modules

The four PC board modules can now be installed in the case – see Fig.12.

Both the Input and DAC Boards are mounted on M3 x 10mm tapped spacers and secured using M3 x 6mm machine screws from either side. By contrast, the Power Supply Board is mounted atop 6mm untapped Nylon spacers and secured using M3 x 15mm screws, shakeproof washers and nuts.

Similarly, the Switch Board is secured to the rear of the front panel using 6mm untapped Nylon spacers and M3 x 15mm screws, shakeproof washers and nuts. Make sure that the switches and LEDs just protrude through the front panel holes and that the switches operate correctly, without jamming. The IR receiver LED must also be correctly aligned with its front-panel hole.

Important: if the infrared receiver includes an external metal shield (see photo), then steps must be taken to ensure that it is insulated from the chassis. We suggest a short strip of ordinary insulation tape on the inside of the front panel, with a hole cut out to match the hole in the panel. Do not rely on the paintwork or powder coating to provide insulation!

Note that in the prototype (Jaycar rack case), the Front Panel Switch Board was fitted with spacers at the back and mounted on the sub-panel – see photos. **However, for the Altronics case, the spacers must be fitted on the front of the board and directly attached to the front panel.**

Low-voltage wiring

Now for the low-voltage wiring. First, trim the secondary leads of the transformer to the right length, then scrape the insulating enamel off the wire ends and tin them with solder. You should have about 5mm of tinned wire protruding from the insulation.

That done, solder the correct two leads together to form the centre tap. This will either be the white and black leads for the Altronics transformer or the white and red leads for the Jaycar transformer. The secondary leads can then all be connected the power supply module's AC input (CON1).

Before connecting anything to the output of the supply, apply power (don't forget the mains fuse) and measure the three rails at the supply outputs (CON2 & CON3). Assuming all is well, the +15V, -15V and +5V rails should all be within ±5% of the nominal values. Now switch the power off and physically disconnect the 230VAC mains lead to prevent accidents while working under the hood!

The +5V and 0V supply leads for the Input Board can now be run. Heavy-duty hook-up wire should be used for this job and you should begin by stripping about 8mm of insulation from the ends of each wire.

That done, tin the bare ends with solder and trim them to about 5mm before connecting them to the terminal blocks on the Input & Power Supply Boards. It's a good idea to twist the two supply leads together to reduce noise and improve appearance but be careful not to get them mixed up. Screw the terminals down tightly to ensure reliable connections.



If your infrared receiver module has a metal shield like this one, then be sure to insulate it from the front panel as described in the text.

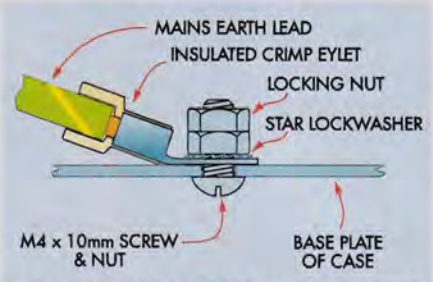


Fig.13: the earth terminals are all secured to the case as shown here. The top nut serves as a locknut, so that the assembly cannot possibly come loose. Make sure that the crimp eyelet makes a good electrical contact with the base.

Important: note that the supply leads to Input Board used in the prototype are reversed at the terminal block compared to those for the final version of this board. The wiring diagram (Fig.12) is correct (ie, the positive lead goes to the left).

Note also that the ±15V supply leads to the DAC Board are not installed at this stage. That's done later, after you've tested the Input Board.

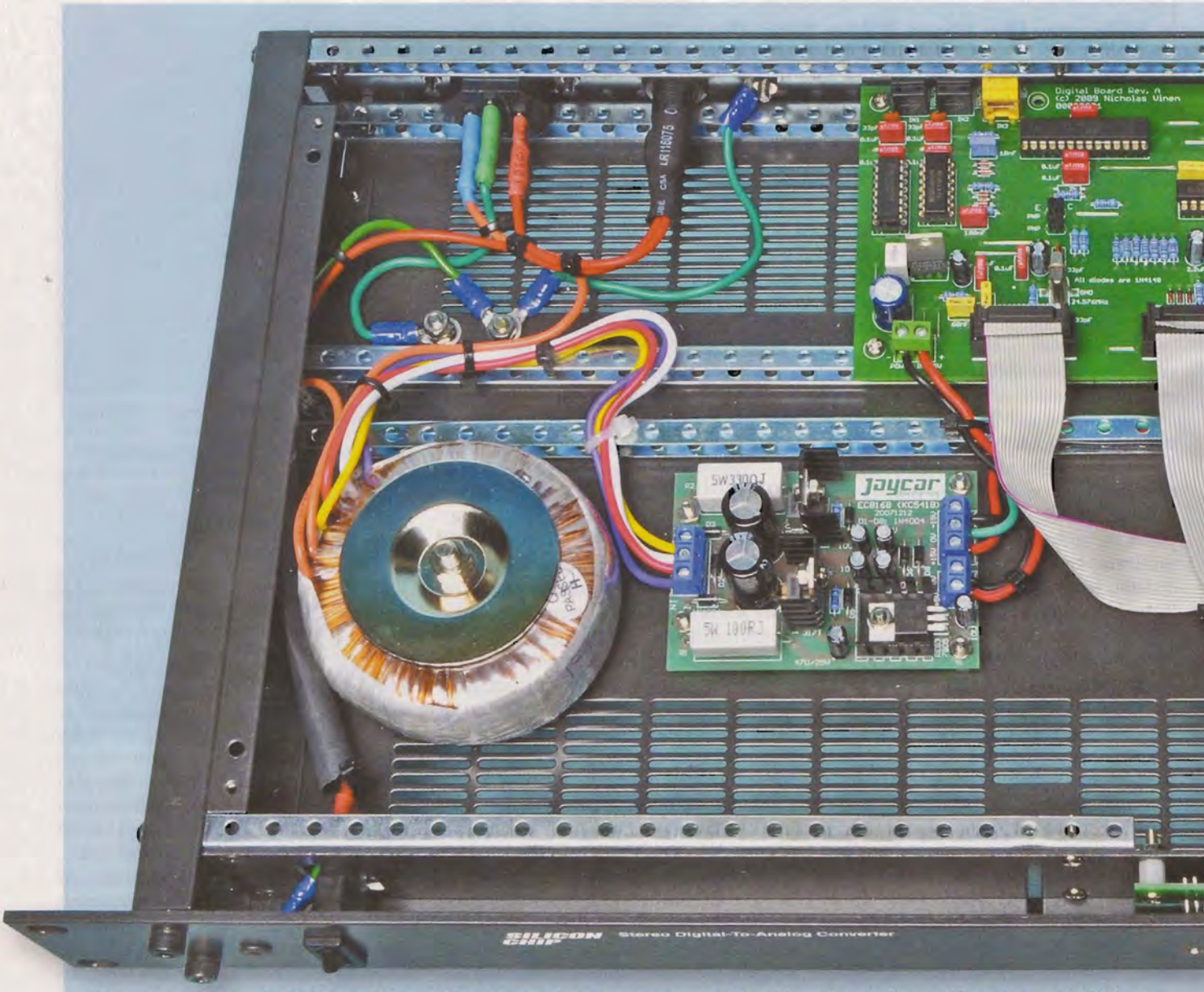
Secure the +5V & 0V supply leads with cable ties as shown in Fig.12, so that they can not come adrift and contact other parts of the circuit.

Testing the Input Board

You are now ready to do some initial tests, starting with the Input Board.

Begin by plugging in the 14-way IDC cable between this board and the Front Panel Switch Board, then connect a multimeter in series with the +5V supply. You will have to temporarily disconnect the +5V supply lead at one end (eg, at the Power Supply Module) to do this.

Set the multimeter to the amps range, then apply power and check the current reading. It should be around 0.1A and certainly not more than 0.2A.



The prototype was built into a Jaycar 1U rack case but we recommend the Altronics rack case if you're not building from a kit. If you do use the Jaycar case, fit covers over the ventilation slots above and below the mains wiring.

What To Do IF There's No Audio Output From The Stereo DAC

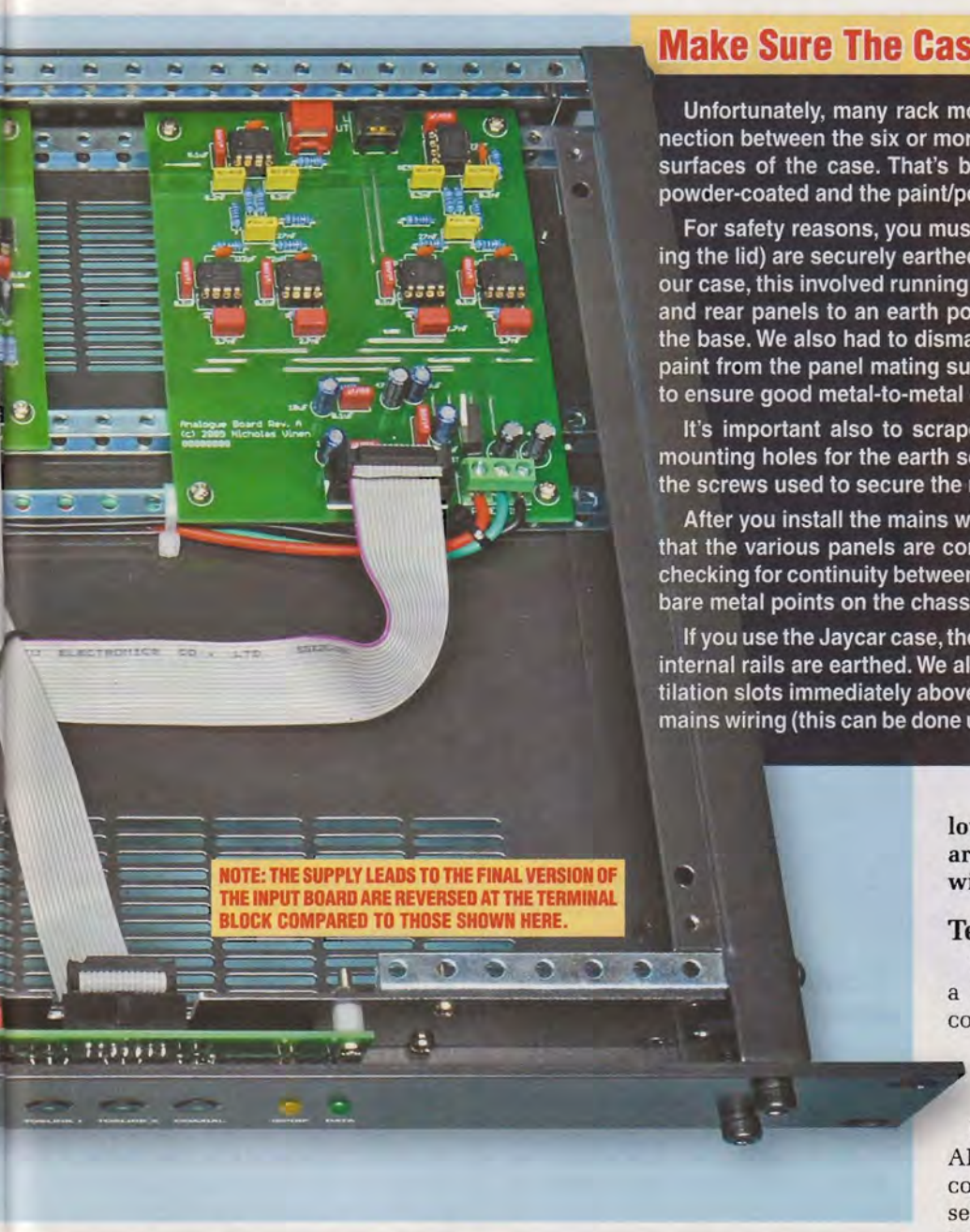
In order for the Stereo DAC to work correctly, it must be fed with LPCM (linear pulse code modulation) data from the DVD player (ie, uncompressed audio). If there's no audio output and the green and yellow LEDs on the Stereo DAC front panel are flickering rapidly, this indicates that the output from the DVD player is set to AC3/Dolby Digital. In that case, you will have to step through the menus of the DVD player and set the audio output to stereo LPCM.

Note that on one recent Pioneer DVD player we tested, it was impossible to change the audio output format with an HDMI cable hooked up. The trick was to disconnect the HDMI output and use either component video or a composite video connection instead. This then allowed the AC3/Dolby Digital output to be changed to stereo LPCM, after which the HDMI connection could be re-instated. Other DVD players may require a similar procedure.

If you see a reading of 0.2A or higher, switch off immediately, disconnect the power cord and check the Input Board for short circuits and incorrect parts placement.

If that doesn't solve the problem, disconnect the 14-way IDC cable and quickly re-apply power in order to rule out a fault with the cable or Front Panel Switch Board.

If the current is in the acceptable range, check that the blue LED on the front panel nearest the IR receiver is lit. No other LEDs should be lit initially but after about 10 seconds, the unit should enter scanning mode whereby each LED briefly lights in sequence. If that checks out, switch off, remove the



Make Sure The Case Is Securely Earthed

Unfortunately, many rack mount cases have no electrical connection between the six or more panels that make up the external surfaces of the case. That's because they are either painted or powder-coated and the paint/powder coating acts as an insulator.

For safety reasons, you must make sure that all panels (including the lid) are securely earthed when the case goes together. For our case, this involved running separate earth leads from the front and rear panels to an earth point adjacent to the mains earth on the base. We also had to dismantle the case and scrape away the paint from the panel mating surfaces and under the screw heads, to ensure good metal-to-metal contact when it all goes together.

It's important also to scrape away the paint from around the mounting holes for the earth screws, the transformer bolt and for the screws used to secure the rubber mounting feet.

After you install the mains wiring, use your multimeter to check that the various panels are correctly earthed. You can do that by checking for continuity between the earth pin of the IEC socket and bare metal points on the chassis panels.

If you use the Jaycar case, then you must also make sure that the internal rails are earthed. We also suggest that you cover the ventilation slots immediately above and below the IEC socket and any mains wiring (this can be done using black plastic or metal panels).

multimeter and reconnect the +5V lead to the terminal block.

The next step is to feed a signal into one of the inputs (ideally you should test all three inputs). If your DVD player (or CD player) has a TOSLINK output, connect it to the TOSLINK1 input on the Stereo DAC using an optical cable. The player needs to be switched on for this initial test but not playing anything.

Now power the unit back up. The TOSLINK1 blue LED should be lit along with the S/PDIF yellow LED. If the either LED fails to light, switch off immediately and check for faults on the Input and Front Panel Switch Boards. One of the most common causes of LEDs not lighting up is cable crimping problems, so check this out carefully. Other possible faults include shorts between adjacent pads, missing links, missed solder joints and incorrect parts placement or orientation.

Assuming all is well, you can now test the other two inputs. Press each button in turn and make sure that its corresponding blue LED lights. The yellow LED will go out if there's no signal input for that channel. If that checks out, connect the DVD player to the TOSLINK 2 and COAXIAL inputs in turn and check that the yellow S/PDIF LED lights when the corresponding input is selected.

Note that these tests (and the following tests with the remote control) are all done without the ±15V supply wiring in place.

Testing the remote control

This unit can be controlled using a Philips RC5-compatible remote control. That includes just about any universal remote.

You will need to program the remote to control a Philips TV. For example, if you have a Jaycar AR-1726 remote, you need to set its code to 103 with the TV control mode selected. Similarly, if you have an Altronics Aifa A-1009, set its code to 026.

Having done that, point the remote at the Stereo DAC's front panel and press some buttons. The yellow LED should flash each time a button is pressed. If so, you should then be able to select each input in turn using the 1, 2 & 3 buttons on the remote or by pressing the CH+ and CH- buttons.

If you don't wish to use the Philips TV code (eg, if you have a Philips TV), you can set the unit up to recognise a different RC5 code (see Programming The Remote Control Codes).

Final testing

You are now ready to test the complete unit. To do this, first switch off, disconnect the DVD player and

Programming The Remote Control Codes & Customising The Configuration

It isn't necessary to configure the Stereo Digital-To-Analog Converter before use. Most constructors will be happy to settle for the default settings in the firmware but some people may wish to customise it to suit their individual needs. Basically, you can change the remote control codes, the scanning behaviour and the initial input selection (TOSLINK1 is the default) when the Stereo DAC is switched on.



Virtually any universal IR remote control can be used, including the Digitech unit from Jaycar (Cat. AR-1726) and the Aifa RA7 unit from Altronics (Cat. A-1009). Set the Digitech unit to code 103 and the Aifa unit to code 026.

If you are using a universal remote, the simplest solution is to set it to control a Philips TV. This will allow the CH+ and CH- buttons to select the inputs. And if your remote has numeric buttons, you can also use buttons 1, 2 and 3 to select a particular input.

In addition, the Mute button should toggle mute on and off. While muted, all three blue LEDs should flash in unison to indicate this condition. Finally, the VOL+ and VOL- buttons should control the Stereo DAC's volume. Check that these functions all work.

Remote control reprogramming

The yellow LED should flash whenever a button on the remote is pressed. If you can get it to flash but not all the functions work or if you don't want to use the Philips TV codes (eg, if you have a Philips TV), then you can reprogram the unit to accept different codes.

To do this, hold down all three buttons on the front panel at once, then release them. Be sure not to release any until all three have been pressed or you may get into the wrong mode (if you do, just turn the unit off and then on again).

When the buttons are released, the lefthand blue LED will be flashing. Point your remote control at the IR receiver and press the button that you want to assign to select TOSLINK1. Hold it down for a few seconds until you see both the yellow and green LEDs flash. The first blue LED should then stop flashing and the second should start, at which point you should release the button on the remote.

If the yellow and green LEDs don't flash, make sure that the remote control is transmitting an RC5 code. Provided that you choose a Philips code, you will be OK but that might not apply to the codes for other manufacturers. Check also that the remote's batteries are OK.

If the first blue LED is still flashing, stop for a few seconds and try again. The Stereo DAC waits until it receives 10 identical codes in a row before programming that code. This is done to avoid the possibility of a transmission error programming in the wrong code.

If you don't want to assign that function to a button on your remote control, press any of the front panel buttons on the Stereo DAC to skip it.

You now repeat the above procedure for the following functions in this order: Select TOSLINK2, Select COAXIAL, Select Next Input, Select Previous Input, Mute Output, Volume Up and Volume Down. Each time you program a code, the flashing blue LED should cycle to the next button, wrapping around from the third to the first.

Once all the codes have been pro-

disconnect the mains lead. Now install the +15V, 0V and -15V leads between the Power Supply Board and the DAC Board. As before, use heavy-duty hook-up wire and twist the wires together to minimise noise pick-up. Secure the leads using cable ties as shown and tighten the terminal block screws down firmly to ensure good connections.

Finally, check that these supply leads are correctly wired at both ends.

The next step is to fit the 16-way IDC cable. **Note: do not apply power to the DAC board unless it is connected to the Input Board via the 16-way cable.**

Once everything is in place, apply power and check the ±15V supply rails at the input to the DAC board. If these are OK, check the +5V rail at the output of REG5 on the DAC Board. Switch off immediately and check for errors if any of these voltages are incorrect.

If all is well, the front panel LEDs should light as before. It's now just a matter of checking that the unit works.

Connect your DVD player to the TOSLINK1 input (or to the COAXIAL input if there's no TOSLINK output) and check that the yellow S/PDIF LED lights when that input is selected. In fact, the unit should automatically select that input if it was scanning. Now start playing a CD or DVD – the S/PDIF LED should immediately turn off and the green DATA LED should come on.

If that doesn't happen, there may be a problem with the DAC (IC6), the 16-way cable or one of the parts associated

Table 6: Selecting The Programming Function

Function	First Button	Second Button
Auto-Scan Delay, No Signal Present	1	2
Auto-Scan Delay, No Audio Present	1	3
Auto-Scan Delay, No Signal Present After Manual Input Change	2	1
Auto-Scan Delay, No Audio Present After Manual Input Change	2	3
Default Input At Switch-On	3	1
Input Scanning At Switch-On	3	2

Table 7: Setting The Multiplier

Value	Button
10ms	1
Seconds	2
Minutes	3

grammed, the LEDs will stop flashing and the Stereo DAC will revert to its normal mode. You can then check that the remote control codes have been properly assigned. If not, start again.

Scanning delays/default input

The scanning delays and the initial default input can also be reprogrammed. This is done by holding down one button on the front panel, then pressing a second button and releasing both together.

The buttons pressed and their order determines which function you are configuring, as set out in Table 6.

After pressing one of these combinations, the lefthand blue LED will flash. Each additional button press after that will cause the flashing LED to cycle to the next step until the configuration is complete.

To set any of the auto-scan delays after selecting the configuration mode, you first press one of the buttons to get a multiplier value – Table 7. It's then simply a matter of making two further button presses to set the delay value as shown in Table 8.

Table 8: Setting The Delay Value

Value	First Button	Second Button
1	1	1
2	1	2
3	1	3
5	2	1
10	2	2
20	2	3
30	3	1
40	3	2
50	3	3

As an example, if you wanted to set the delay to five minutes, you'd press and release button 3 (Table 7), then button 2 and finally button 1 (Table 8). The default auto-scan delay values are (in the order shown in Table 6) 10 seconds, one minute, five minutes and never.

By the way, the sequence 1, 1, 1 is a special sequence which is interpreted as "never" and thus disables that scanning mode.

Default input

There are two choices when it comes to programming the default input: (1) you can either have the unit remember the last channel it was set to and restore that channel at switch on or (2) you can program the unit to always select one of the inputs.

If you want it to remember the last channel, select the "Default Input At Switch-On" function by pressing the buttons shown in Table 6, then press button 1. Alternatively, to always select a certain input, select the function, then press button 2 and then the button for the input that you want selected.

The default state is for TOSLINK1 (Input 1) to be selected at switch on and most readers will probably leave it at that. However, you might want to change it to Input 3 (COAXIAL) if you are only using the COAXIAL input.

Scanning behaviour

There are three options for input scanning behaviour on start up:
(1) to configure the unit to immediately begin auto-scanning, select the "Input Scanning At Switch-On" function from Table 6 and press button 1 (left);
(2) to configure it to begin scanning after the usual auto-scanning delay (the default behaviour), press button 2 (centre); and
(3) to make it act as if the default channel has been manually selected at switch on, press button 3 (right).

Wait – there's more!

There's one other feature we haven't mentioned. Even if you have auto-scanning enabled, there may be times when you don't want it to happen.

In that case, all you need to do is switch to the input that you want to lock and then press the selector button a second time, holding it in for about a second. The LED will come on but blink off occasionally to indicate this "input lock" mode has been enabled.

In this mode, auto-scanning is disabled. However, the next time you manually change the input, or when you turn the Stereo DAC off, it will reset to the default mode.

with the DAC chip. You should also check the two BC327 PNP transistors on the Input Board and their associated resistors.

Assuming that it all works so far, switch off and connect the Stereo DAC's outputs to an amplifier, turn the volume down and reapply power. Now play some content and slowly turn the volume on the amplifier up. You should hear clean, undistorted sound.

Once you have verified that this works, test the other two inputs. Check also that you can adjust the volume from the Stereo DAC up and down using the VOL+ and VOL- buttons on the remote control. However, as explained in Pt.1, it's best to set the volume from the Stereo DAC to maximum if you want the best performance and use the volume control on the amplifier instead.

Enjoy the sound

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Balanced Outputs

In response to a number of requests for balanced outputs, we have produced a balanced output board with XLR connectors. This will be presented in the December issue.

SERVICEMAN'S LOG

Unforeseen consequences for e-waste charges

There is a famous line in the "Yes Minister" series where Sir Humphrey is attempting to block the minister's latest scheme. "But minister", he vehemently protests, "I foresee all sorts of unforeseen consequences".

Actually, it's a bit like that with the recent decision by some local councils in my area to start charging hefty fees for electronic waste disposal. We all know that e-waste is a problem and we all want to deal with it responsibly. But the decision by our local council to charge $40 an item from January to dump e-waste into landfill is going to have unforeseen consequences.

First, by charging such a high fee, it's certain that the amount of dumping of e-waste by the roadside and in pristine places like national parks will become an epidemic. Imagine the cost of cleaning up sets that are dumped in this manner.

Instead of charging at the end of a product's life, a better approach would be a prepaid disposal tax when the item is purchased new. You would then get a rebate if you do the right thing when it comes to that product's eventual disposal, somewhat similar to the recycling of soft-drink bottles in South Australia.

The second problem is that repairers will be less likely to take on equipment for repair. Having an electronic item repaired slows down the process to landfill, so repairers should have dispensation in disposing of e-waste. In our case, it will force us to insist on an up-front fee for a quote. That way, we are at least compensated for the disposal fee if the set is subsequently dumped on us if the quote isn't accepted.

In fact, it's quite common for customers to simply dump a set on the repairer in this way.

We also often get calls from people trying to sell us late-model LCDs with smashed screens for spare parts. We would be prepared to do this if it wasn't for the fact that the lifespan of a particular model is very short. Having a good stock of modules is fraught with difficulty unless you specialise in a particular brand and model.

Unless the government acts fast, many independent service centres will simply cease operation and many people will refuse to dispose of e-waste responsibly.



...SERVICEMAN'S CHOOKS COMING HOME TO ROOST

Another Porsche CDI

As repairs to TV sets dry up to a mere trickle, we have had to turn our hand to repairing other types of electronic equipment. And as often as not, that now involves repairs to car electronics.

Back in May, I described how I repaired a Bosch CDI for a Porsche. At the time, I cursed at having to trace out the circuit diagram from the PC board – a task that took far too long to make the job profitable.

Well, fortunately for me, the chooks came home to roost in a really good way, because I got another identical unit in for repair. It didn't matter that someone had had a fiddle with it because it was just a matter of comparing the photographs of the previous CDI with the latest one to see immediately what had been done.

As I quickly discovered, both diode D6 and zener diode ZD1 had been reinstalled with reversed polarity. I corrected D6 and then replaced all eight capacitors on the board plus the zener diode for good measure. What did throw me, however, was that someone had also removed the transformer and replaced it 180° around the other way in the Eddystone diecast box. Trying to get my head around this wasn't easy but I eventually got it sorted out.

I then had to borrow an old dizzy and a coil to test it and it worked fine, so I actually made some money out of this job. In fact, if I get more of these in to repair it will be worth making my own jig to test them.

Incidentally, Frank Zabkar wrote in to inform me that the RCA power transistor used in these CDIs is actually a 61019 (H8146 being the date code, ie, year 1981 week 46) and that an NTE130 might be a suitable equivalent.

OK, here are some more car electronics faults from my friend in the automotive trade. I'll let him tell them in his own words.

A tricky ABS fault

Most repairs to automotive electronics involve diagnosing faulty compo-

Items Covered This Month

- Ill-thought e-waste legislation
- Another Porsche CDI
- Faulty Holden VP ABS sensor
- Shorted HT rotor
- Automotive LED lighting



nents that have failed over time, either due to wear and tear or an accident of some sort. By contrast, it's not often that we get to diagnose a design or manufacturing defect, especially when the vehicle is several years old and well out of its new car warranty period.

A case in point was a 1992 VP Commodore wagon we had in the workshop recently. The issue at hand was that the ABS (anti-lock braking system) fault lamp was permanently lit, despite numerous attempts by others to diagnose the problem.

While talking with the owner, it transpired that he had only owned the car for a few months. It was a one-owner car that he had recently acquired through a used-car dealership. In fact, that probably now makes this a "three-owner" car but I've digressed.

After purchasing the car, he had it inspected at his local repairer and, among other things, they discovered that the ABS warning lamp did not come on at any time. That was news to the owner who had purchased the car without knowing that it actually had ABS at all. A list of repair items was then presented to the selling dealer for his attention, under the statutory warranty.

The listed items were quickly remedied to the owner's satisfaction, except for the ABS lamp problem. The dealer was very coy (read evasive) when this issue was raised, so the owner decided to take the car back to his repairer for a second opinion.

Upon investigation, it was found that there was actually no globe fitted to the ABS lamp socket in the instrument panel. As a result, a new globe was fitted but it immediately lit up during a brief test drive. The repairer then went through the usual rigmarole of data fault code readings and diagnostics but after many hours of measuring voltages, swapping components and pulling of hair, the repairer eventually threw in the towel.

A fault code for the righthand rear wheel sensor circuit was the issue. And no matter what was replaced or substituted, the same fault code was logged. This job was now costing the repairer time and money, not to mention his sanity, and so he decided to seek our assistance.

As a result, the car was presented to us with the ABS fault as described. So where does one begin? These cars are now quite old and ABS was a rare option in the VP and even rarer on V6 Executive wagons. In those days, ABS was usually only seen on top-line Caprice or Calais models or as an option on other models fitted with the then new IRS (independent rear suspension) but not generally on wagons with "live" rear axles.

That being the case, secondhand units for testing purposes are hard to come by. After checking the necessary voltages and waveforms, it became clear that the ABS module itself could be the culprit. Testing for an intermittent sensor was relatively simple in this case, because we could swap the two rear sensors. We tried this but the same fault code remained.

Even though we were assured that an ABS module from another car had already been substituted, we just had to give it a go with another module, no matter how difficult they were to procure. After many years of bitter experience, we have learnt not to rely on another technician's word.

Anyway, you guessed it, another

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unit was located and fitted but to no avail – the ABS lamp remained on and the same fault code persisted.

At this stage, we fired up the scope and took a close look at the waveforms coming into the ABS module. This revealed that while signals were present for all four wheel sensors, the peak voltage output of the sensor in question was slightly lower than from the other three. Apart from that, the waveform itself was correct but at last we had some sort of a clue.

But how could this be? We'd substituted both the sensor and the control module and had checked the wiring between them, so what could possibly be causing the lower output. The sensors themselves are a simple inductive pick-up type and are one of the more reliable types available.

In practice, they are placed in close proximity to a rotating toothed cog, which is fixed to the axle, rotor or hub of the wheel concerned. The pick-up produces a pulse, the voltage (and pulse-frequency) being proportional to the road speed.

If a wheel locks up or appears to be rotating at a much lower speed than the other wheels while braking, the ABS system modulates (pulses) the brake pressure to that wheel. This reduces the braking effort to that wheel and therefore avoids dangerous brake lock-up and skidding.

Normally, the ABS control module "sees" that each wheel is rotating at the same speed, because the output of each sensor is similar. But in this case, the righthand wheel's sensor output was lower than the other three even before any braking took place, so the fault code was logged.

So what was wrong? It had to be somewhere in the pick-up itself. The toothed cog in the pick-up was intact and was exactly the same size (and had the same number of teeth) as the one on the lefthand side. And in any case, the sensors had already been swapped.

What about the air gap between the sensor and cog? On some vehicles this is adjustable but not on this one. The gap is critical and should be around 0.5-1mm (20-40 thou. for the non-metric).

This car, being a wagon, retained the old-style live rear axle, so the cog wheel was pressed onto the axle shaft near the bearing retainer and the sensor was located in a small flanged, tubular fitting welded to the axle housing. The axle centre is fixed, the bearing has no lateral movement and so the sensor position is fixed. In other words, it hasn't altered since the car was built 17 years ago.

Despite this, we just had to measure the gap and compare it to the other side. Eureka! The gap measured over 2.5mm, yet the lefthand sensor's gap was just 0.8mm. So what had caused this to change (if that is what happened) and what's more, how do you fix the problem?

Well, it hadn't moved. Instead, it turned out that the flange and tube had been incorrectly welded at the time of assembly in the factory jig. The only possible fix was to carefully grind 1.7mm of metal off the sensor's mounting flange, to bring the face of the sensor closer to the toothed cog.

And that fixed the problem immediately. The peak voltage from this sensor was now the same as the from the other three sensors. This cleared the fault code and allowed the ABS fault lamp to switch off.

As an aside, it's worth noting that electronic braking systems are much more reliable nowadays than the system described above. Current systems have digital inputs, meaning peak-to-peak voltages are much less critical. The older analog type inputs (such as in the VP Commodore) were very sensitive to the sensor voltage whereas the newer digital systems actually count the pulses from the sensor.

This means that the actual voltage itself is far less important and a digital system probably would not have generated a fault code, as in the above example.

A look into this car's history would be good if it were possible, because the only likely scenario is that this fault has been with the car since manufacture. You can just picture the boys in the new car warranty workshop, back in 1992: "Oh no, here's that damned VP again, with the ABS lamp that won't go out. We've replaced everything in the car except the wiring loom. Let's just pull the !@#$%^ dash indicator globe out, that'll fix it".

So the first owner no longer had a problem with the ABS fault lamp coming on after the warranty "fix". But of course, it wasn't a real fix because the ABS braking system that he'd paid his hard-earned cash for simply didn't work. What happens is that when the ABS controller sees a fault (and activates the lamp), the system shuts down and the braking system reverts to "normal" (non-ABS) mode.

It wasn't until the new owner had a lamp fitted to the socket that the problem was rediscovered – some 17 years later. I wonder how many other cars with strange electronic problems like this are on our roads today.

Intermittent Mazda 323

A common misconception among many car owners is that all electrical problems generate fault codes in the ECU and are thus easily diagnosed. However, that's far from the truth.

A case in point was a Mazda 323 which was recently towed into the shop. It was a mid-90s model that still


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utilised a standalone distributor rather than the now more commonplace individual ECU-driven "pencil" coils.

The owner's complaint was that after driving for a certain distance, the engine would stall at idle and then not restart until left for some time, perhaps for it to cool down. As a result, we began by checking the cooling system to establish that the primary cause was not one of overheating. This was given a clean bill of health, so our trusty scanner was then plugged in to interrogate the engine control unit.

This showed that no fault codes were present but the client then mentioned that several other workshops had recently "had a go" at attempting to find the fault.

The problem here is that, each time a technician plugs in a scanner to read and erase any fault codes, any long-term history is then lost. Of course, this is better than the opposite situation where in attempting a repair, the amateur home mechanic disconnects just about every sensor in the system, the ECU then recording every fault code it is possible to log. In these cases, the technician has no choice but to erase the fault history and start over again.

Anyway back to the car. As is often the case with intermittent faults, the fault failed to materialise for us. All manner of extended test-driving failed to produce any sign of a breakdown but the customer insisted that it had now got to the point where it was a choice of having the fault found or sell the car. In fact, he mumbled about it having something to do with his marriage or his sanity, or perhaps both.

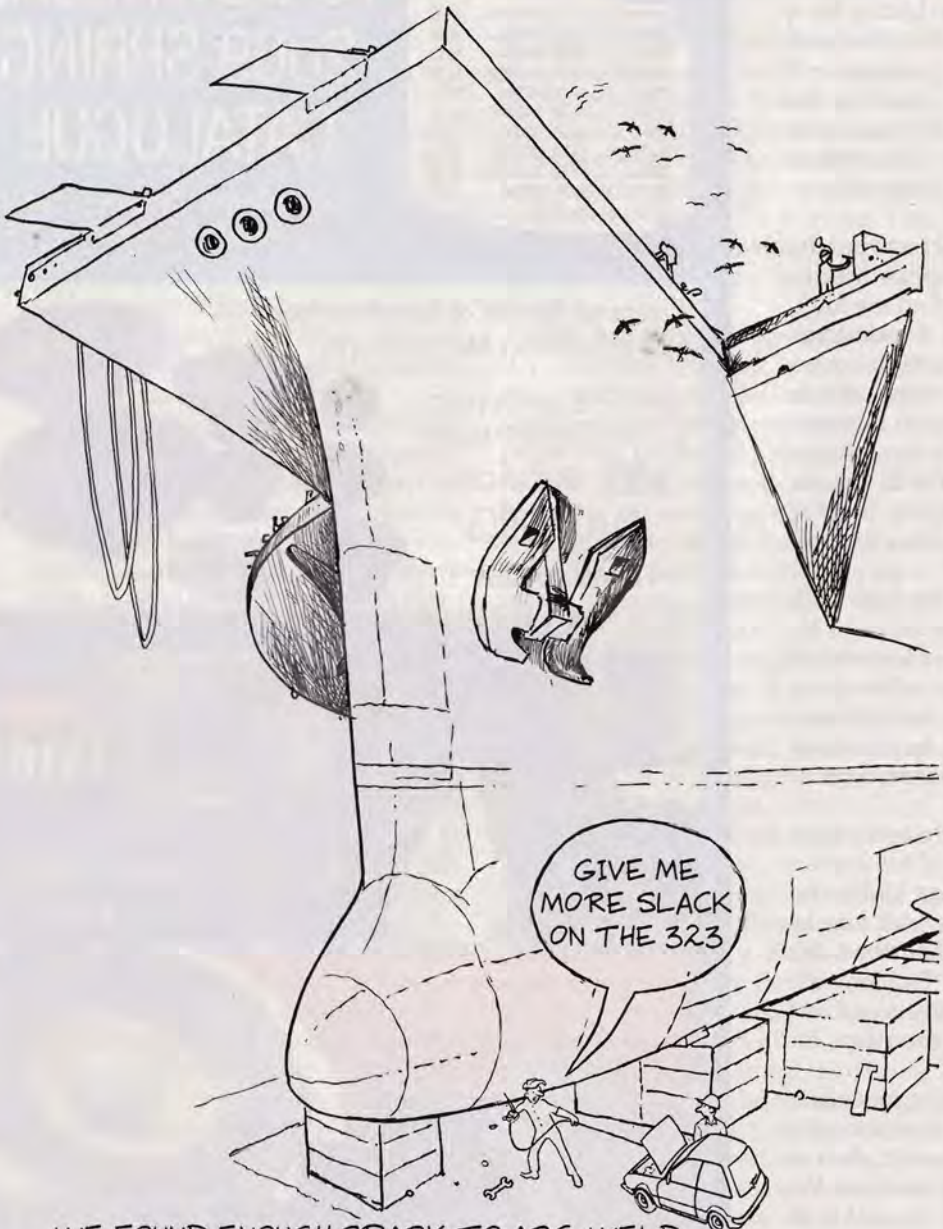
He also mentioned that he had already had an exchange distributor fitted because at one of his numerous roadside breakdowns, the NRMA man had found a lack of spark and had suggested that the fault may be in the distributor or something else further down the line. Anyway, because of the customer's "fix it or we'll have to sell it" attitude, it got the better of me and so I suggested he leave the car with us for several days for further investigation.

At the end of the second day, our senior mechanic used the car for a quick jaunt to the corner shop for some afternoon tea and as luck would have it, the car stalled just as he pulled into the workshop entrance. We checked for the presence of all the vitals as quickly as we could and found that the NRMA man had been right on the scent – there was no spark at the spark plugs.

We quickly removed the distributor cap to check the coil output and found enough spark to arc-weld the hull of the USS Enterprise. The leads checked OK for continuity and the cap looked like new, yet we had spark at the coil but not at the spark plugs. We then refitted the cap and the leads, only to have the engine spring into life yet again. This really was the worse kind of intermittent fault!

We let it idle for some time, hoping for the fault to return which it did several minutes later. And it was the same thing all over again – good spark at the coil but not at the plugs. On this occasion, the fault remained for a little more time, enabling us to determine that the rotor was shorting (internally) to the distributor shaft. Could it really be this simple and didn't the customer say that he had an exchange distributor fitted?





WE FOUND ENOUGH SPARK TO ARC-WELD THE HULL OF THE USS ENTERPRISE...

Well, yes, he did but as a convention in the motor trade, exchange distributors do not come complete with a new cap and rotor. They do get a full overhaul, including new bearing, seals, sensors, modules and whatever else needs servicing but no new cap or rotor. They are supplied less these two items and you just inspect and reuse the existing parts if they are OK.

In this case, while the rotor looked OK, it was obviously cracked and shorting internally. How frustrating – not only was the fault often only present for very short periods of time but the cause was not even visible.

A rotor generally gives years of trouble-free service, especially with the modern plastics now in use. However, we forget about the stress these little jiggers live under. Around 50kV of applied voltage and high underbonnet temperatures are a lot to ask of a small insulator less than 2mm thick.

It only takes an incident like this to remind us how a simple and cheap component can let the side down.

LED lighting

One trend in automotive electrics in recent years has been the increased use of LED lighting. This technology has been appearing from all quarters, not only in new vehicles from the factory but also in aftermarket assemblies for trailers and the like, as well as replacement LED globes to substitute for existing incandescent globes.

From memory, my first experience with automotive LEDs was a repair job on a spoiler-mounted brake light many years ago. A slimline row of LEDs were neatly moulded into the trailing edge of the car's boot spoiler but the owner had discovered that it had suddenly stopped working.

It was quickly established that 12V was present at the boot-lid wiring when the brake pedal was pressed, so the fault was inside the moulded LED assembly. Luckily the assembly was easy to remove and it was discovered that the fault was caused by several cracks in the circuit board on which the LEDs were mounted. Sitting out in the hot sun and vibrating away in a vehicle's boot-lid spoiler is really not the ideal environment for delicate circuit boards or equally delicate solder joints and the gradual ingress of moisture doesn't help either.

The fix was to either obtain a replacement circuit board or attempt to repair the existing item. We then established that the supplier of both the spoiler and, of course, the circuit board was no longer in business, making repair the only option.

As a result, we cleaned away all the corrosion and then fully resoldered every joint on the board. This meant 20 LEDs x 2 legs per LED (= 40 joints) plus a few extra for the wiring. We then repaired the cracks in the board material with epoxy and reinforced it in the appropriate areas. The assembly was then resealed and fitted to the spoiler and there were smiles all around when it lit up like a Christmas tree.

Substituting LED globes

We are also seeing more and more owners fitting LED globes as substitutes for failed exterior lights, or perhaps to brighten up or modernise their vehicle. The big problem here, especially for tail, brake and blinker lights where compliance for roadworthiness is necessary, is that LED globes do not necessarily suit the reflectors designed for incandescent globes.

The simple explanation for this is that an incandescent globe is omni-

directional, enabling the parabolic reflector to fully illuminate the sometimes-large lenses at the rear of the car. If a single LED is substituted, no matter how powerful, its unidirectional beam merely produces a bright "dot" of light at the centre of the lens. This is both dangerous and unroadworthy.

To overcome this, some suppliers now market multi-LED globes, with the individual LEDs arranged porcupine-style in an effort to make proper use of the reflector. However, while these offer improved light spread, I've yet to see any that would satisfy ADR compliance.

Another problem with LED lights that we've had through the workshop is that of polarity. Put simply, a LED is a diode and will only light when wired in the correct direction. This is not an issue if the globe and socket have an obvious orientation but what about the plain wedge globes that can be fitted in either direction.

This latter problem often occurs with parking light globes, which are fitted inside the headlight reflector. Parking lights in the past generally used BA9s bayonet-style globes whereas many nowadays use T-10 wedge-type globes instead. The problem is, many owners of modern cars dislike the appearance of a comparatively yellow-coloured parking light alongside the bright white or even "blueish" halogen headlight globes and so LED parking light globes emitting either white or blue light are substituted to match.

If you install the globe in the socket the wrong way around (the odds are 50% here), it will not illuminate. I wonder how many owners have returned their "faulty" LED globes to the spare parts counter after falling for this one. I'll put my hand up here to say that I have but only once!

In my opinion, the best use of LED lighting in the aftermarket is for the rear of trailer and commercial vehicle bodies. The fact that they are usually fully weatherproof, shockproof and have a brightness level that is not voltage dependent gives them a big advantage over conventional globes.

By using these, semi-trailers with rows of clearance lights down each side will no longer need constant attention due to the failure of the notoriously unreliable festoon and mini-bayonet globes and sockets. Low current draw and lack of voltage dependence make long wiring runs both more practical and more reliable.

How many boat trailers do you see with all their rear lights functional? With the advent of aftermarket LED assemblies, this situation can only improve with time. SC





GPS SYNCHRONISATION FOR CLOCKS WITH SWEEP HANDS



The GPS Synchronised Clock described in the March 2009 issue only worked with crystal clocks that ticked once a second. The more upmarket clocks have silent sweep hands, which are much more acceptable in a quiet lounge room situation. Now, with just a few simple modifications, you can upgrade to one of these.

There has been a lot of interest in the GPS Synchronised Clock published in the March 2009 issue of SILICON CHIP. It introduced a completely new way of driving the humble analog wall clock and turned it into an amazingly accurate timekeeper.

However, it was only capable of driving clocks that stepped once per second and that stepping mechanism can be very annoying to some people – especially in the dead of night and even more especially when sleep eludes them! Tick. . . tick. . . tick. . . tick. . .

They crave the silent, continuous sweep hand on the old-style electric clocks.

The good news is that some of the more expensive crystal clocks, such as those from Seiko and Citizen, now have a sweep second hand that continuously and *silently* glides around the dial.

By GEOFF GRAHAM

You do not have to part with a lot of cash to get this new silent treatment. K-mart sell a reasonably cheap clock with a continuous sweep second hand while replacement movements with a continuous sweep hand are available on the internet for $10 to $15 (Google "clock movement continuous sweep"). Note that some suppliers use the term

"sweep second hand" when referring to the old stepping movement, so look for the words "continuous sweep" or "silent".

We had already had emails from readers who wanted to upgrade these improved crystal clocks to GPS accuracy and so we thought it worth revisiting the GPS Synchronised Clock design to see if it could be modified to drive the new sweep hand movements. The answer was yes, although with an important caveat.

A standard crystal clock movement uses a coil with a soft iron core and a small bar magnet (the rotor) positioned in the magnetic field. An alternating current flows through the coil which causes an alternating magnetic field and the rotor rotates to follow this field. It is this rotation that, via gears, drives the clock's hands.

Fig.1 shows the driving waveform for a clock with continuous sweep hands. It consists of a positive pulse, an idle period, a negative pulse and another idle period. This repeats eight times a second. The rotor in the clock's movement has a certain amount of momentum which keeps it spinning while driven by this pulse train, so it never stops. This is different to the stepping clock movement where the voltage pulse on the coil pulls the rotor around and then stops it dead – once every second – thereby creating that tick sound.

The driving waveform is created by holding one wire of the coil at 0V volts, while pulling the other wire to the battery voltage, +1.5V. For the next pulse the coil wires are reversed causing a negative pulse compared to the first. Both types of clock essentially work in the same way; they use a series of alternating pulses to drive the clock. The only difference is in the speed of the pulse train, one pulse per second for the stepping clocks compared to 16 pulses per second for the swept-hand variety.



Fig.1: the waveform used to drive the coil of a sweep hands clock. The clock pulses alternate with a positive pulse, an idle period and a negative pulse. This is repeated at 16 pulses per second to drive the clock's hands around the dial.

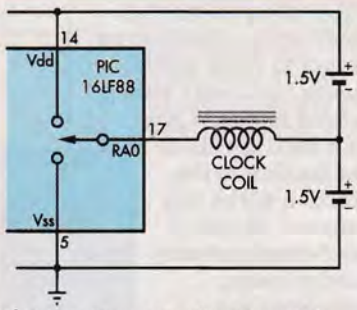


Fig.2: this is how the clock's coil is driven in the modified circuit. The micro can take pin 17 high for a positive pulse on the coil, low for a negative pulse, or open circuit (represented as a centre-off position) for the idle period between pulses.

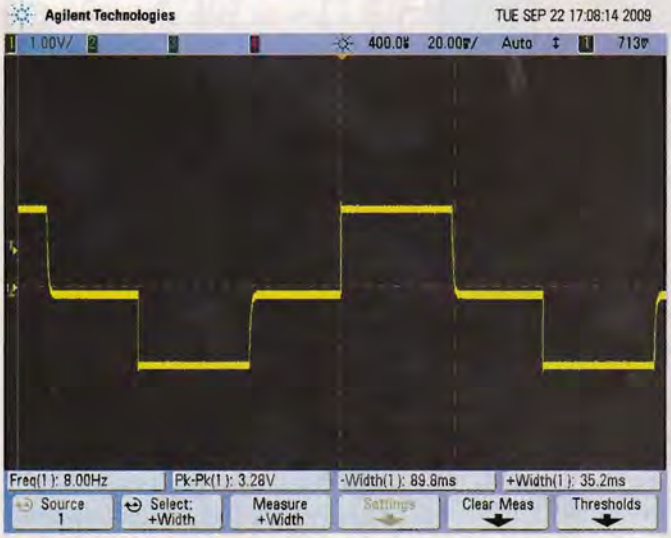
Driving the clock

So, it seems that all we need to do is modify the firmware for the GPS-Synchronised Clock to generate a faster pulse train. That should be easy, shouldn't it?

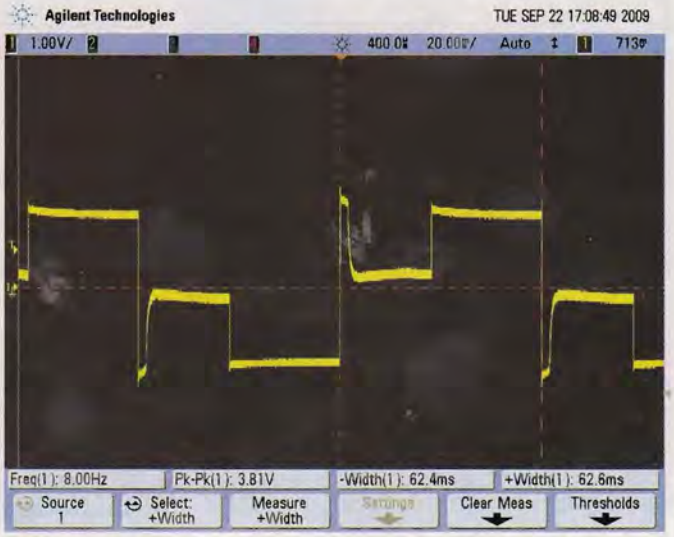
Even better, the pulse width required is exactly one 32nd of a second and it can be created by dividing the 32.768kHz crystal frequency by 1024, a neat binary number. The way the timer in the PIC microcontroller works it is easy to generate these precise binary divisions; this is why you could only change the pulse width in the original firmware in steps of 8ms.

A wrinkle!

At this point the first difficulty became obvious. The waveform in Fig.1 has a 50% duty cycle compared to the stepping clocks that have a duty cycle of just 4%. The current drawn by the coil in a sweep hand clock is lower but it is still about 1.25mA during each pulse. With a 50% duty cycle this results in an average current drain of



This scope screen grab shows the output signal from pin 17 of the microcontroller (IC1), with no load connected and is measured with the centrepoint of the batteries as the ground reference.



This shows the signal from pin 17 of IC1 when the clock movement is connected. The voltage spikes are created by the clock movement's inductance, each time the drive current is reduced to zero. The spikes are effectively clipped by the Schottky diodes, D3 & D4.

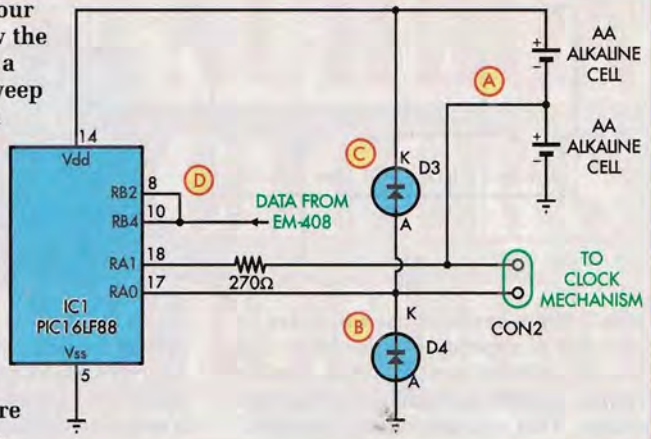


Fig.3: these are the four modications to allow the circuit to work with a quartz clock with sweep second hands. A is a link from the clock mechanism to the junction of the two batteries. B and C are Schottky diodes used to clamp voltage spikes created by the clock's coil. D links the GPS data to pin 8, the hardware UART built into IC1.

0.625mA and dividing that into the capacity of an alkaline AA cell gives a life of less than six months; not good and that does not include the small drain of the microcontroller and the specified EM-408 GPS module.

So how does the electronics in a normal sweep hands clock manage to deliver a reasonable battery life? In the main they achieve it by continuing to operate at very low battery voltages, down to 0.7V or so from the single cell. This option is not open to us as we need at least 2V (1V per cell) to power the microcontroller.

Incidentally, most clocks of this type can only start with fresh batteries. If you remove and replace half-used batteries they will not have enough energy to get the hands moving again.

It is this requirement to provide at least 2V to the microcontroller that is the problem for us. The clock coil only needs to be driven by one battery and in the original design, we wasted half our battery power in the 270Ω resistor used to reduce the microcontroller's output to the voltage equivalent of one cell.

Ultimately, there is always a novel solution, isn't there? This is illustrated in Fig 2. One wire of the clock's coil is taken to the mid-point between the two batteries, nominally at 1.5V. The other is driven by an output of the microcontroller. The chip has the capability of driving the output to the positive rail, driving it to the negative rail and thirdly, making it high impedance and not driving anything. This is depicted in Fig.2 as a centre-off switch.

So now, during each clock pulse, we take the microcontroller's output high or low as required and during the idle period we make it high impedance. The clock's coil will see positive and negative pulses of 1.5V, with nothing during the idle periods. This alternates the current consumption between the two batteries and in one stroke almost doubles the battery life!

As you might suspect though, it was not quite as easy as that. Didn't

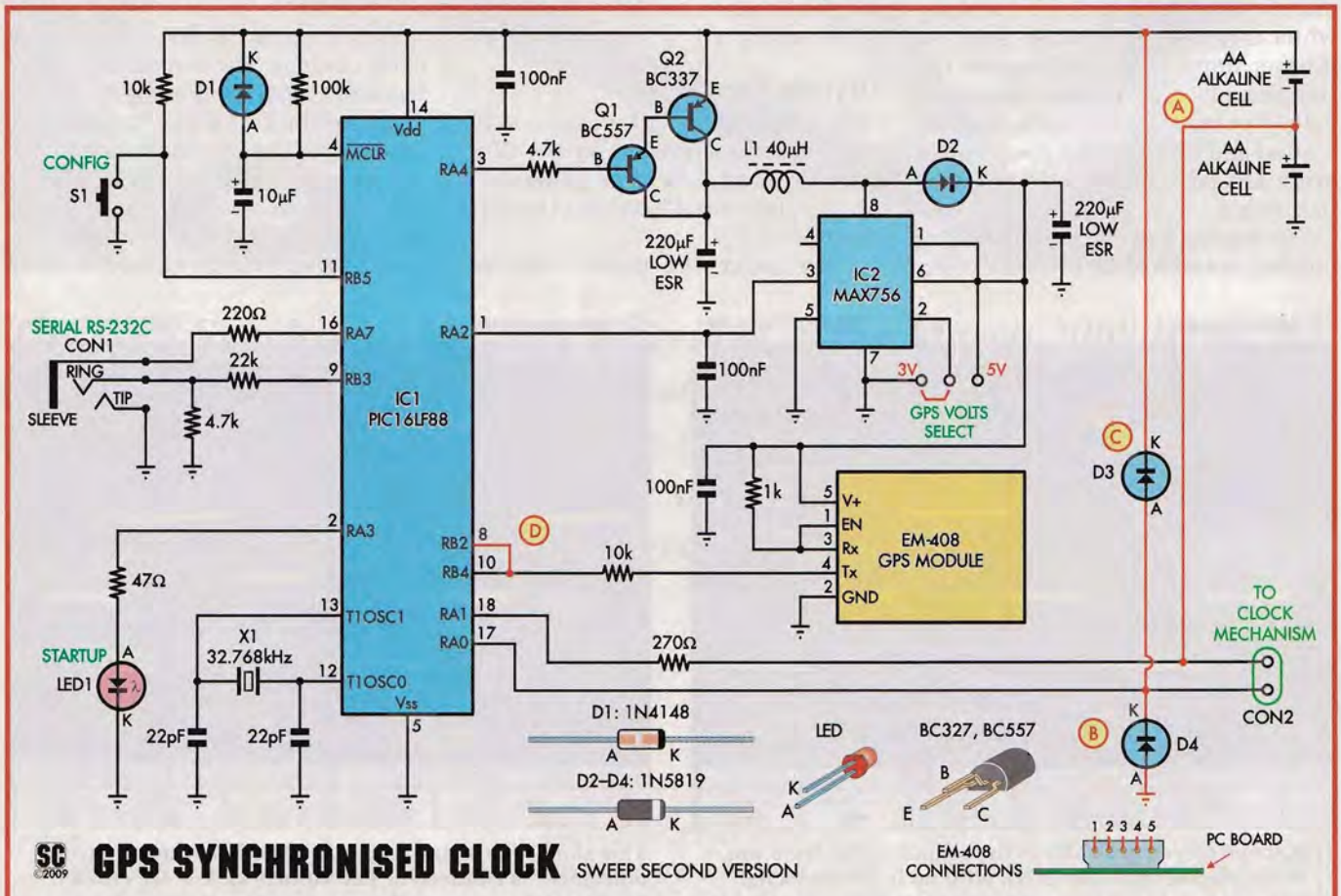


Fig.4: just in case you're starting from scratch, here's the complete circuit diagram, reprinted from the March 2009 issue, with the four modifications referred to above. The wiring to CON1 has also been corrected in this diagram.

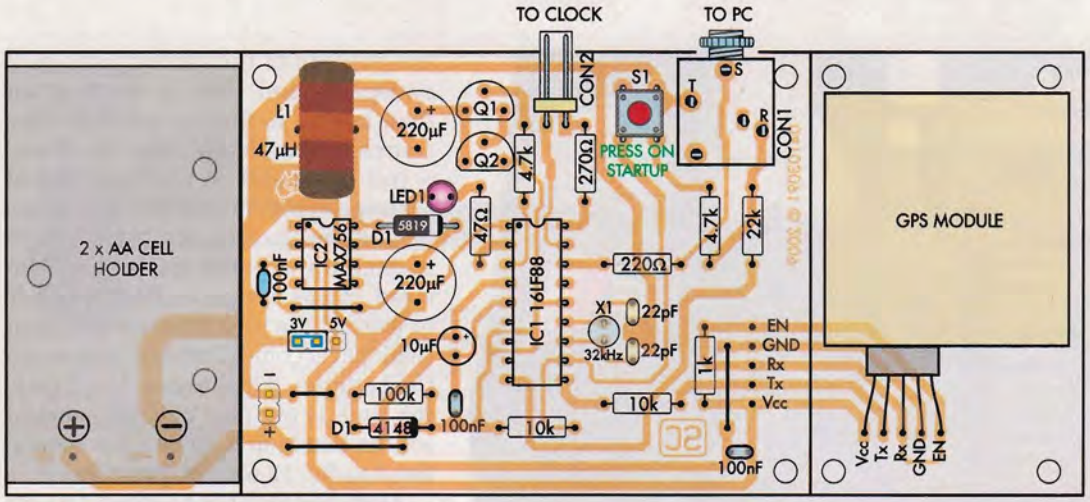
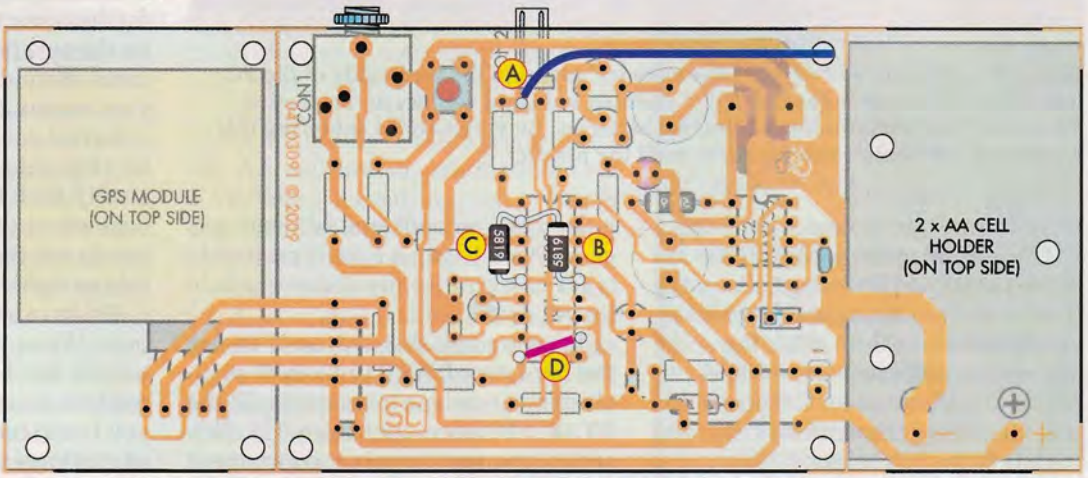


Fig.5: again reprinted from the March 2009 issue, this is the original component overlay for the GPS Clock Driver.



(BOARD VIEWED ON COPPER SIDE)

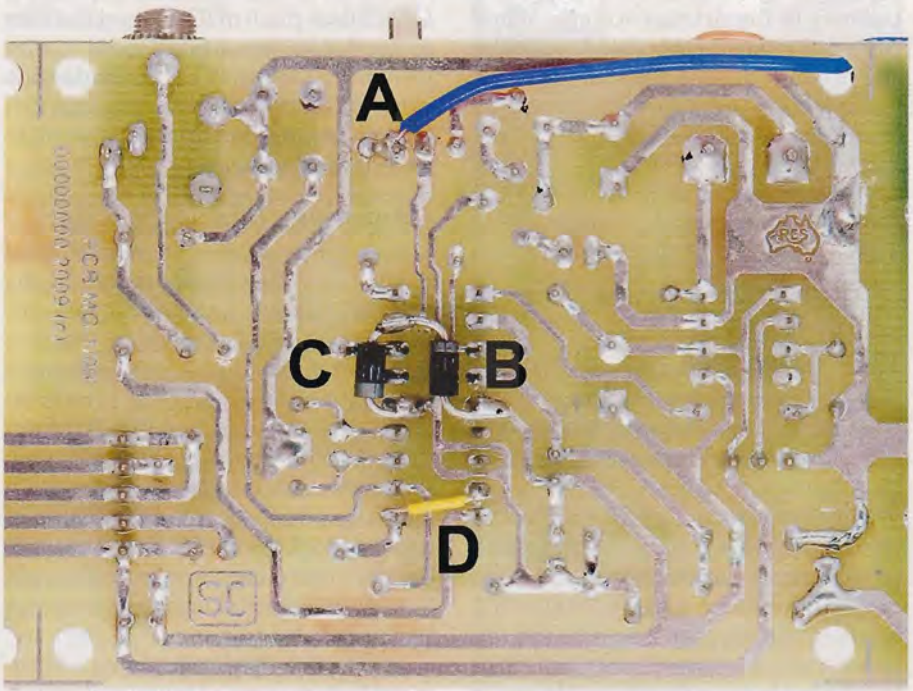
Fig.6: and here is the opposite (copper) side of the same PC board showing the four modifications – also labelled A, B, C and D to agree with those on the circuit diagram. No cuts are required to copper tracks, just the addition of two diodes, a wire link between the pins of the microcontroller and a new wire connecting to the junction of the two AA batteries in their holder.

someone once say "life wasn't meant to be easy?" The clock's coil has a significant inductance and when the microcontroller switches its output to high impedance the magnetic field in that coil collapses, generating a large spike voltage across its windings. In the normal circuitry both sides of the coil will be held at ground during the idle period and the coil will be effectively shorted out.

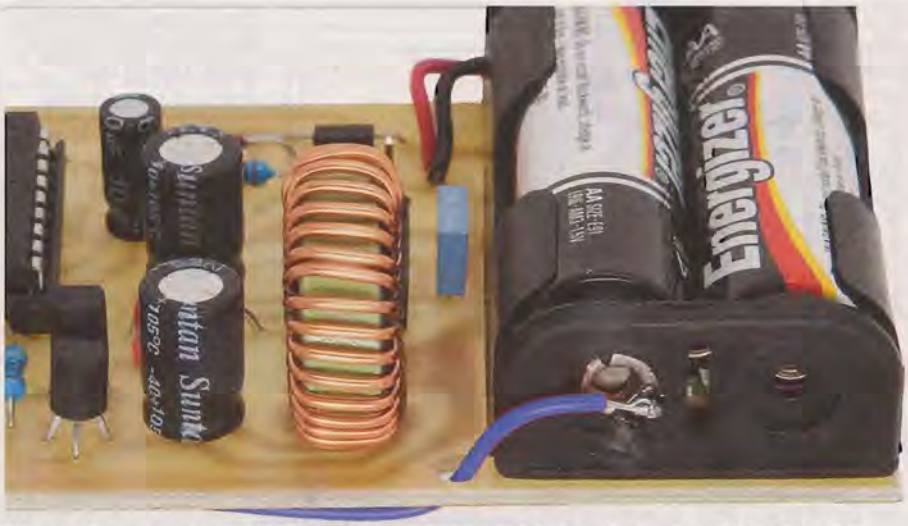
In our case the coil was free to generate a sizeable spike which was caught by the protective diodes in the microcontroller but this created all sorts of mayhem within the chip. The solution was to place Schottky diodes from the output pin on the PIC micro to the positive and negative battery rails.

Before we get too far with describing the modifications, have a look at the circuit of Fig.5.

This is similar to that for the original GPS Synchronised Clock, as published in the March 2009 issue of SILICON CHIP but shows the necessary mods to work with crystal clocks with sweep second hands. It also corrects an error in the wiring to CON1 where the tip and ring



The four modifications can clearly be seen in this under-board photo. Make sure you use insulated wire (or a length of insulation spaghetti slid over a wire) for the link (D) as it crosses over another track underneath the microcontroller. Similarly, ensure that the leads for the two Schottky diodes do not come even close to the tracks underneath, just to be safe!



Here's the opposite end of that blue wire we added to the underside of the PC board (Fig. 6) – it emerges through a suitable hole and solders to the riveted "common" connector between the two batteries. Be very careful soldering this connector – it doesn't take much to melt the plastic!

were shown transposed.

The additional Schottky diodes are shown as D3 and D4 in Fig.5. Schottky diodes are fast-acting and have a low voltage drop, so they catch the spike before the diodes inside the microcontroller are subjected to it. The result is that the energy is harmlessly dumped back into the AA cells.

The pulse generated by the collapsing magnetic field is of opposite polarity to the driving voltage. When the resulting voltage pulse is caught by the diode it acts as a slight brake on the spinning rotor and we found that the pulse width needed to be a little longer to compensate.

As pointed out earlier, the original pulse width was easy to create. Now a major rewrite of the firmware was required to allow a finer degree of control over the pulse width.

UART required

But when the new firmware was tested it became obvious that the microcontroller could not reliably receive data from the EM-408 GPS module.

The firmware in the microcontroller used a software timing loop to clock in the bits of data transmitted by the GPS module and it seems that when an interrupt was generated by the microcontroller's timer it interfered with the timing loop and caused a character to be lost.

The original design worked fine when there were only two interrupts in each second but now that we are generating 32 a second (to make 16 pulses per second) one of them was guaranteed to zap a byte. And it only takes one error to invalidate a whole line of data.

To overcome this we need to use the hardware UART (universal asynchronous receiver/transmitter) in the PIC16LF88 microcontroller, IC1. This serial transmit/receive component works independently of the firmware and is not affected by interrupts. The UART uses pin 8 of IC1. To get the data to the UART we simply need a wire link pin 10 to pin 8, on the underside of the PC board. Inevitably though, this change entailed yet another rewrite to part of the firmware.

Operation

The firmware for the sweep hand clock is similar in operation to the original version but with a few differences, the main one being that it is impossible to implement automatic daylight saving adjustment. This is because of the physics involved in spinning the rotor in the clock movement. It is balanced to operate at a certain speed and while the new firmware can run the clock 6% fast or slow, which is fine for correcting a few seconds error, it is no good for skipping forward or backwards by an hour.

Losing the daylight saving adjustment feature is not as tragic as it seems. The microcontroller will keep driving the second hand with perfect accuracy, so all you need do is wind the hands back or forward an hour and ensure that the minute hand agrees with the position of the second hand as it sweeps around. This is much better than having to find an accurate time source to completely reset the clock.

Not being able to run the clock at high speed also means that we cannot just set the clock to 12 o'clock and let it catch up with the correct time. Instead, in this design, you set the hands to exactly the next hour or half hour (whichever comes first) and then insert the batteries. This means that if (say) the time is ten past one, you should set the hands to 1:30 and the second hand to the 12 o'clock position.

After the clock has checked the GPS for the correct time, it will sit and wait for the next precise hour or half hour to come around and then automatically start running.

So that you do not fret while waiting for this to happen, the firmware will slowly flash the startup LED at about once every three seconds – just to let you know that it is alive and waiting for the right time to start.

We have a small Catch-22 situation here. When you purchase a clock the second hand will be pointing at some random position on the dial and when you insert the batteries the clock will sit motionless until it is time to start.

As the time adjustment on most clocks does not affect the second hand you will not have an opportunity to set the second hand to 12 o'clock before the clock starts – and then it is too late.

Because of this we have added a new feature. While the clock is sitting, waiting for the correct starting time to arrive (slow flashes on the LED), you can press the setup button and while you hold this button down the clock will run, causing the second hand to move around the dial.

When the second hand reaches the exact 12 o'clock position you can release the button and use the normal time setting facility of the clock to adjust the hour and minute hands to the correct position.

Other features are the same as before. The LED will flash to indicate the controller's progress as it starts up. One flash indicates that the microcontroller (PIC16LF88) is operating, two flashes means that the DC to DC converter (MAX756) is operating, three flashes mean that the GPS module is working and four means that the GPS module has got a lock on enough satellites.

As before, you enter the configuration menu by holding down the startup



Fig.7: construction of the cable that connects the clock controller to a standard PC serial port. You will need this if you want to change the settings. Note this is different to the one originally published in March 2009 – use this one!

button when you insert the batteries. You also need to connect the clock to your PC using the cable shown in Fig.7 and run a terminal emulation program on your PC set to 4800 baud. Because we do not need to set the time zone or daylight saving, the menu is much simpler – see the screen grab of Fig.8.

The firmware will also check for a flat battery and halt at exactly the hour or half-hour position if the cells are below par. Before you replace the battery you need to set the hands to the next hour or half hour but hopefully you will not have to mess with the second hand because it should have stopped at the exact 12 o'clock position.

If, after the clock has started, the signal level drops to a point that is too low for the GPS module to get a lock on enough satellites, the clock will stop at exactly five minutes before the hour/half hour. Similarly, if the GPS module stops running altogether the clock will stop at 10 minutes before. These indications make it easy to differentiate between a low battery and something more serious.

In either event the firmware will retry 10 times with a 4-hour delay between each attempt before it gives up. This gives the GPS module plenty of opportunities to come good.

Internally the firmware measures time in eighths of a second. This allows for much finer tracking of errors and control of where the clock's hands are pointing. Theoretically it will mean a higher degree of accuracy although this is offset to some extent by the fact that most clocks with sweep hands will lose a fraction of a second when they start up. This is something that the firmware is not aware of and cannot correct for.

Assembling and modifying the PC board

While many readers will have seen the original article in the March 2009 issue, we are repeating the constructional procedure here, along with the mods required to make the project work with sweep second hand movements.

All of the components for the GPS Clock, including the GPS module and the AA cell holder, are mounted on a PC board measuring 140 x 57mm and coded 04203091. The component overlay is shown in Fig.6.

Check the board carefully for etching defects, shorted tracks or undrilled holes. Then install the four wire links on the board and continue with the low profile components, moving up to the transistors and capacitors.

When mounting the battery holder, use double-sided adhesive tape or put a dab of glue on its underside before soldering it in. This will hold it securely when you remove or replace the batteries.

IC2 must be directly soldered to the printed circuit board. Do not use an IC socket as the switching current through L1 is quite high and the voltage drop through the socket contacts will prevent IC2 from working correctly at low battery voltages.

On the other hand, you should use a socket for IC1 so that you can remove it for reprogramming. The PIC16LF88 (IC1) must be programmed with the file 0420309A.hex which will be available from the SILICON CHIP website.

The GPS module comes with a connector cable with identical connectors at each end. We only need one, so cut the cable in the centre. This will give you two separate cables, each with a connector.

On one of these cables you should bare the cut ends and solder them to the PC board, ready for the GPS module.

Solder in the 3-pin header for LK1. Then install the jumper to select 3V for the GPS module. This must be

Parts List – GPS Synchronised Clock

1 PC board code 04203091, 140mm x 57mm
1 GlobalSat Technology EM-408 GPS module *
1 32.768kHz crystal (X1)
1 47µH high saturation inductor (Jaycar LF1274 or Altronics L6517)
1 3.5mm stereo phono socket (Altronics P0096 or equivalent)
1 momentary pushbutton switch (Altronics SP0601 or equivalent.)
1 dual AA battery holder (Altronics S5027 or equivalent)
1 18-pin IC socket
1 2-way header plug, 2.54mm pitch
1 2-way header socket, 2.54mm pitch, PC-mount, 90° pins
2 AA alkaline cells

Semiconductors
1 PIC16LF88-I/P microcontroller programmed with GPS Clock (0420309A).hex (IC1)
1 MAX756CPA DC-DC Converter (IC2) Available from www.futurlec.com
1 BC557 PNP transistor (Q1)
1 BC327 PNP transistor (Q2)
1 1N4148 diode (D1)
1 1N5819 Schottky diode (D2)
1 3mm red LED (LED1)

Capacitors
2 220µF 25V low ESR electrolytic (Jaycar RE6324 or Altronics R6144)
1 10µF 16V electrolytic
3 100nF monolithic
2 22pF ceramic

Resistors (0.25W 5%)
1 100kΩ 1 22kΩ 2 10kΩ 2 4.7kΩ
1 1kΩ 1 270Ω 1 220Ω 1 47Ω

Additional components required for Sweep version:
2 1N5819 Schottky diodes (D3, D4)
2 insulated wire links (see text)

* The EM-408 GPS module specified suits the PC board pattern and also has an integral antenna.
It is available from www.sparkfun.com (part number GPS-08234) , or www.starlite-intl.com or www.coolcomponents.co.uk and other suppliers).
Other modules may have different spacing and require an external antenna.



This is a replacement movement we purchased from China via the Internet. If you search on the Internet you will find many suppliers of clock movements with continuous sweep hands. They are generally hobby or craft shops catering for people who are making their own clocks. At right is the interior of a modified movement. The integrated circuit that normally drives the clock is bonded directly to the circuit board and hidden under the black blob. You can see our connection to the coil and if you look closely between the soldered connections you can see where we cut the copper track to disconnect the clock's internal circuitry.

done before the board is powered up. If you don't do this, pin 2 of IC2 will float and might cause the IC to deliver a lethal voltage to your GPS module.

With the PC board completed, you now need to make four changes to it, labelled A, B, C and D on the circuit diagram and (revised) component overlay.

Note that all changes are made on the copper side of the PC board.

A: Add an insulated wire from where the 270Ω resistor joins one pin of the clock connector socket (CON2) on the underside of the board. This is illustrated as point A in Fig.6 and we used a short length of blue light-duty hookup wire. The other end of the wire goes to the centre connection of the two batteries in the holder.

B: Solder a 1N5819 Schottky diode (D4) between pins 17 and 5 of the microcontroller with the cathode (banded end) on pin 17.

C: Solder a second 1N5819 diode (D3) between pins 17 and 14 of the microcontroller with the cathode (banded end) on pin 14.

D: Solder a link between pins 10 and 8 of the microcontroller on the underside of the board. This connects the UART, as described above. You should use a short length of insulated wire to avoid shorting the track that runs under the link.

Be very careful when soldering to the battery connector – the plastic will instantly melt with just a little too much heat. Use a knife to clean a patch of metal on the connector and use flux-cored solder to tin it first. Apply the soldering iron sparingly, half a second at a time. You should then be able to quickly solder your tinned wire to this patch.

Even though the 270Ω resistor looks superfluous it should be left in place as the firmware will set pin 18 of the microcontroller to high impedance and this resistor will prevent the voltage on this pin from floating, which is not a good thing for CMOS ICs.

Check all your changes with a high power magnifier, particularly looking for solder bridges between adjacent pins on the microcontroller. If you do have some of these use desoldering braid to pickup the excess solder.

All you need to do now is reprogram your PIC16F88 (or 16LF88) with "0420309A.hex" which is available on the SILICON CHIP website. When it is reprogrammed, place IC1 back in its socket.

Testing

The original article provided a number of hints to help get the clock running and they apply equally to the modified GPS Controller.

This firmware also has a new function in the setup menu that should help with testing. It will run the clock for an exact number of minutes and

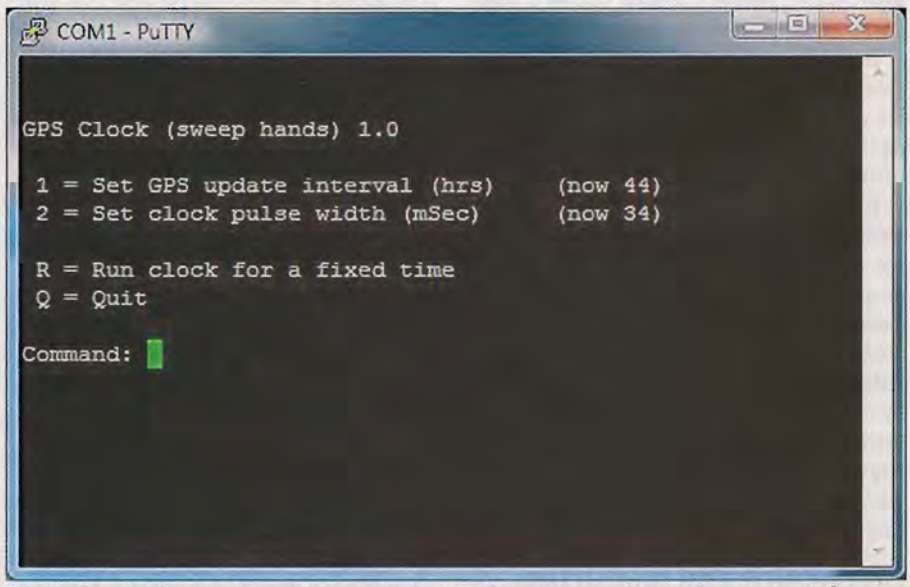


Fig.8: the configuration menu is much simpler now we do not have to set the daylight saving parameters. The Run command is new and makes it easy to test the clock movement for reliability.

then stop.

A good test is for 60 minutes and the idea is that the minute and second hands should return to exactly the same spot as they started from. Any error, even by half a second, will indicate a problem.

If you have a variable power supply you can use this function to test the clock's operation at various voltages. To simulate the half voltage point between the two batteries you should connect two 47Ω resistors in series across the output of the power supply.

The most important test is with the power supply set to below 2V, the minimum operating voltage, as it is here that problems will surface if they are going to.

If the clock does lose some time you can experiment by increasing the pulse width in the setup menu. This allows the pulse width to be varied in steps of one millisecond with increasing values delivering more energy to the clock's motor at the cost of battery life.

Note that you need to start the test at a normal voltage (about 3V) because the serial interface will not work at low voltages and the clock will not start running at low voltages. Once the test has started running you can reduce the supply voltage.

A second point to note is that you **must** sit the clock upright in its normal position while testing. The clock's motor has very little power and, if it is going to misbehave, it will occur while the clock is trying to push the second hand up against gravity.

Source code

The new firmware for sweep hands clocks is written in the C language and can be compiled with either the CCS C compiler or the Hi-Tech C compiler Lite for the PIC 10/12/16 microcontrollers.

The good thing about the latter is that it is totally free, so if you want to get into the C language and mess around with the code, this is one way to do it.

You can download the "Lite" compiler (the free version) from www.htsoft.com

Before you install this you should also download and install the MPLAB development environment from Microchip (www.microchip.com) – also totally free.

Stepping clocks

Readers who have a clock that steps once a second and are happy with the tock sound, may wonder if they can benefit from the remarkable improvement in the battery life described earlier. The answer is yes.

You can download a new version (ver 2.0) of the firmware for stepping clocks from the SILICON CHIP website ("GPS Clock – Stepping.hex). If you have modified your board as described it will automatically detect the change and use it to deliver a greatly improved battery life.

If you have not made these modifications you can still use the new version as it will work fine with the original circuit.

Because this version includes some bug fixes and improvements over the original firmware it is recommended that you download and install it anyway, even if you do not plan to modify your board.

The author has set up a web site to provide up to date errata, notes and new firmware for the GPS Synchronised Clock. You can check it out at http://geoffg.net/GPS_Synchronised_Clock.html SC



Decided to take the plunge and get into digital TV? For most people, it's simple – just plug the new TV or set-top-box into your existing antenna. But for many, the old TV antenna and cable just won't be up to it. Here's a new kit from Oatley Electronics which could solve your digital woes . . .

DEAD SIMPLE MASTHEAD AMPLIFER



Design by Branko Justic*

Article by Ross Tester

About now, with new HD Digital "Freeview" channels starting up, many people are investing in digital TV technology.

Whether that means a new, you-beaut flat-screen TV with all the bells and whistles or perhaps a digital TV set-top-box used in conjunction with your old faithful telly sitting in the corner, you should be getting a host of ***new*** TV channels, right?

Umm, no. At the time of writing there are only ABC2, SBS2 and One-Sport even worth mentioning. One or two more are imminent.

But the Freeview ads promised what, 20+ new channels? That *may* happen in the future but so far, the other (commercial) networks digital offerings are nearly identical to their analog offerings. And as we all know, that isn't much of an offering.

Incidentally, Freeview have recently been ordered to change their "misleading" advertisements . . .

Programming aside, many viewers have found another *slight* problem with digital TV: they can't view it!

This is usually limited to areas where the analog TV signals have been marginal anyway but the problem certainly manifests itself more with digital. With analog, your picture might be noisy or snowy but at least it's there and sort-of watchable.

With digital, the dreaded "digital cliff" means your signal is either there or it isn't. Unlike analog, with digital there's virtually no "grey area".

Just as importantly, the digital cliff can also rear its ugly head when the signal levels are *too strong*.

We've all heard the stories about people living close to the transmitters who didn't even need any antenna to receive TV signals . . . well, many of these are in for an unpleasant surprise when they try to install digital.

The digital cliff is more like a digital plateau: there is not enough signal, so you get nothing; there is enough signal, so you get reception; and there is too much signal, so you get nothing. It's relatively simple to attenuate the signal if you get too much, so we're more concerned with not enough.

Do you need a *digital* antenna?

There is another reason why TV signals might be inadequate for digital: the antenna.

With few exceptions, the antennas we have used for years have been designed to suit the (analog) channels being transmitted in your area.

Unless you were affected, you probably don't remember the problems when the 0-10 Network started – but a raft of viewers at the time complained bitterly that their TV picture, if it existed, was way down in quality compared to the other channels.

That's because their existing antennas were never designed for the higher (channel 10) or lower (channel 0) frequencies. TV antenna design has always been a compromise between performance and bandwidth.

Sydney and Melbourne VHF-only antennas, for example, were originally designed to cover specific and limited frequency bands: Channel 2 (about 65MHz), Channel 7 (about 185MHz) and Channel 9 (about 200MHz). Then along came these new channels up to 20MHz outside the band and the antennas had to cope as best they could. In some cases, they couldn't!

That problem has become significantly worse now that Digital TV has arrived. Of course, most modern antennas are cut to cover Channel 10 (Channel 0 has long since gone by the wayside).

But now we have digital channels "slotted in" between (and above) the existing analog channels – frequencies most of the antennas were, once again, never designed to cover.

UHF TV

So far, we've concentrated our discussion on VHF TV – the more recent advent of UHF TV of course demands a completely new antenna system.

Even many of the popular early VHF/UHF "combo" antennas tend to struggle somewhat as their UHF sections were only ever intended to cover UHF Band 4 (eg, SBS TV on channel 28 – about 530MHz).

With many of the UHF TV translators spread around the country up in the very high sections of UHF Band V (for example channel 69, at 820MHz, nudges the mobile phone frequencies) so any antenna to be used for these frequencies has to be designed to receive these frequencies.

Incidentally, we covered the subject of digital TV and its pitfalls in much more detail in the March and April 2008 editions of SILICON CHIP.

Having said all that, in the majority of cases, most older VHF antennas WILL receive digital VHF TV channels

AUSTRALIAN TELEVISION CHANNEL FREQUENCIES

Channel Number	Video Carrier (MHz)	Audio Carrier (MHz)
0	46.25	51.75
1	57.25	62.75
2	64.25	69.75
3	86.25	91.75
4	95.25	100.75
5	102.25	107.75
5A	138.25	143.75
6	175.25	180.75
7	182.25	187.75
8	189.25	194.75
9	196.25	201.75
10	209.25	214.75
11	216.25	221.75
28	527.25	532.75
29	534.25	539.75
30	541.25	546.75
31	548.25	553.75
32	555.25	560.75
33	562.25	567.75
34	569.25	574.75
35	576.25	581.75
39	604.25	609.75
40	611.25	616.75
41	618.25	623.75
42	625.25	630.75
43	632.25	637.75
44	639.25	644.75
45	646.25	651.75
46	653.25	658.75
47	660.25	665.75
48	667.25	672.75
49	674.25	679.75
50	681.25	686.75
51	688.25	693.75
52	695.25	700.75
53	702.25	707.75
54	709.25	714.75
55	716.25	721.75
56	723.25	728.75
57	730.25	735.75
58	737.25	742.75
59	744.25	749.75
60	751.25	756.75
61	758.25	763.75
62	765.25	770.75
63	772.25	777.75
64	779.25	784.75
65	786.25	791.75
66	793.25	798.75
67	800.25	805.75
68	807.25	812.75
69	814.25	819.75

quite happily – maybe more by good luck than good measurement (actually, it's more a factor of plenty of signal level in the first place!).

But if they don't, something needs to be done. It's either a new digital-band TV antenna, or . . .

Enter the masthead amplifier

The role of the masthead amplifier is often misunderstood. Most imagine it is some form of miracle worker which can find TV signals which aren't there in the first place. That is simply not so. If an antenna cannot receive signals, no amount of amplifying is going to fix that!

Its job is not so much to increase the level of a received signal but more so that other losses in the system (eg, the coax cable downlead, splitters, etc) are compensated for.

For instance, if you're in a relatively low signal area, the amount of signal received *at the antenna* may be barely adequate.

In fact, if you hook up a TV set right at the antenna you might get a relatively good or even quite good picture. But by the time the signal gets to the receiver you might have lost a significant proportion over the length of cable – and it may be completely inadequate for the TV to tune, process and produce a picture.

The masthead amplifier's job is to overcome this by keeping the signal level up at the bottom of the cable.

The situation is worse at UHF than at VHF and indeed is much worse for high UHF channels than low, simply because cables become progressively more lossy as frequency increases.

There are cables... and cables

There are many types of 75Ω "TV Coax" ranging from very cheap (and usually very nasty and high loss!) through to some very esoteric (quite expensive!) types offering much better performance.

For example, the (unfortunately) popular 3C2V coax cable used extensively for imported pre-assembled patch cords, etc, has a whopping 31dB attenuation per 100m at 700MHz (~ channel 52).

So if you have, say, a run of 10m from your antenna to your TV set (quite a common length) you're going to lose over 3dB – more than half of any signal your antenna has been able to sniff out. And that's before any losses from plugs and sockets, splitters or anything else.

Many people in poor signal areas have a TV antenna mounted very high, maybe on a mast on a high point some tens (or even more) of metres from the home.

I'm speaking from experience here: while my home is only 15km from the Sydney TV transmitters at Artarmon/Gore Hill, it is nicely shielded by a 50m-high cliff about 100m away.

Back in the VHF-only days, to get any reception at all, I had to mount my antenna nearly 30m off the ground (with, of course, a masthead amplifier). Even then, reception was ho-hum. If the antenna was lowered by even a metre, the picture deteriorated to virtually nothing.

Today, with UHF translators on the NSW Central Coast, I still need about 10m of height to get a decent picture.

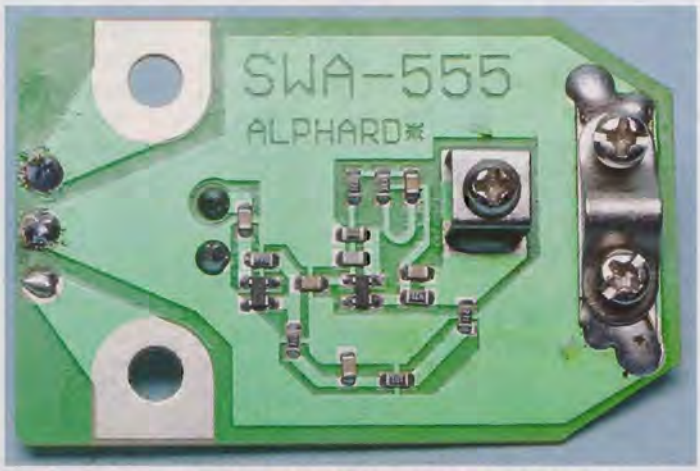
That brings us to another use for a "masthead" amplifier – maintaining levels for signal distribution. We've already mentioned signal splitters – a typical two-way splitter can lose anywhere from 3-6dB; a three or four-way double that and more.

If your signal is marginal to begin with, this can easily mean the difference between picture and no picture with digital. A masthead amp can help a lot.

The other application is for long-distance coax paths. You may want to send TV signals to the opposite end of the home or maybe down to the back shed! (We know someone who sends TV from his house way down to his boatshed on the river – probably 100m or more away).

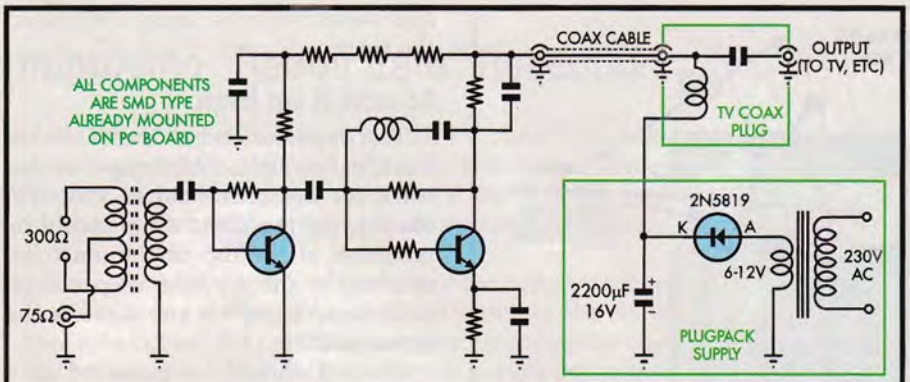
Even using the very best grade of commercial coax, signal losses can be intolerable. In all these cases, a masthead amplifier can be used to overcome cable losses in the system. In fact, the gentleman with the boatshed uses *exactly* the system we are describing here.

But keep in mind that one problem with a masthead amplifier is that it amplifies everything it receives – wanted signal as well as noise – so it's very





The two sides of Oatley's K-274 Masthead amplifier. One end contains the input terminals – it suits 300 ribbon or 75Ω coax – while at the opposite end is the cable clamp to suit 75Ω coax output (to the TV set). The photo at right shows the balun transformer mounted on the upper side of the PC board which allows the two different types of cable to be used. The board is fully populated and soldered with SMD devices.



The circuit diagram of the complete masthead amp. You only have to wire the power supply and connect the TV coax plug (shown here in green boxes).

important that it introduces as little of its own noise as possible.

Ready to build?

This amplifier, from Oatley Electronics, covers both the VHF and UHF bands – in fact, significantly more than the TV band. Actual range is from 50MHz to more than 1000MHz (1GHz). It doesn't discriminate between analog and digital signals – if they are there, they will be amplified.

The performance of this amplifier *is* something to write home about. Based on a couple of low-noise BFP67 transistors, the two-stage preamp has the excellent noise figure of just 1.75dB.

This compares very well indeed to most "out-of-the-box" commercial masthead amplifiers. It wasn't so long ago that manufacturers used to be delighted with a noise figure of 3dB. The better ones got into the 2-3dB range but this one does even better.

The gain is also more than adequate. Over the whole VHF/UHF bands, from TV channels 1-68, it's no worse than 26dB and is as high as 33dB. Again, these are very good figures – much less and you don't have enough gain; too much more and you risk not having an amplifier but an oscillator!

Pre-assembled PC board

You might have noticed from the photographs that the PC board is populated with surface-mount devices (SMDs).

Don't panic: the good news is that the PC board comes ready built and tested – all you need do is supply suitable power (10-15V DC) and connect coax for your antenna and output.

The PC board can be fed from a 300Ω or 75Ω TV antenna (most these days use 75Ω coax cable) or even from a distribution amplifier or other source of RF signal.

We won't mention other signal sources which could benefit from a masthead amp – or in this case a distribution amp – because they might not like you connecting an amplifier to their box (we're too FOXy for that). Besides, you would have to fit an F-type socket on the amplifier.

Bunny ears

It is obvious that the original design of the PC board was to act as an amplifier for "rabbit ear" antennas and you could do the same. Performance is often so good that you can get away without connecting an outside antenna. (See how we modified a rabbit ears antenna overleaf).

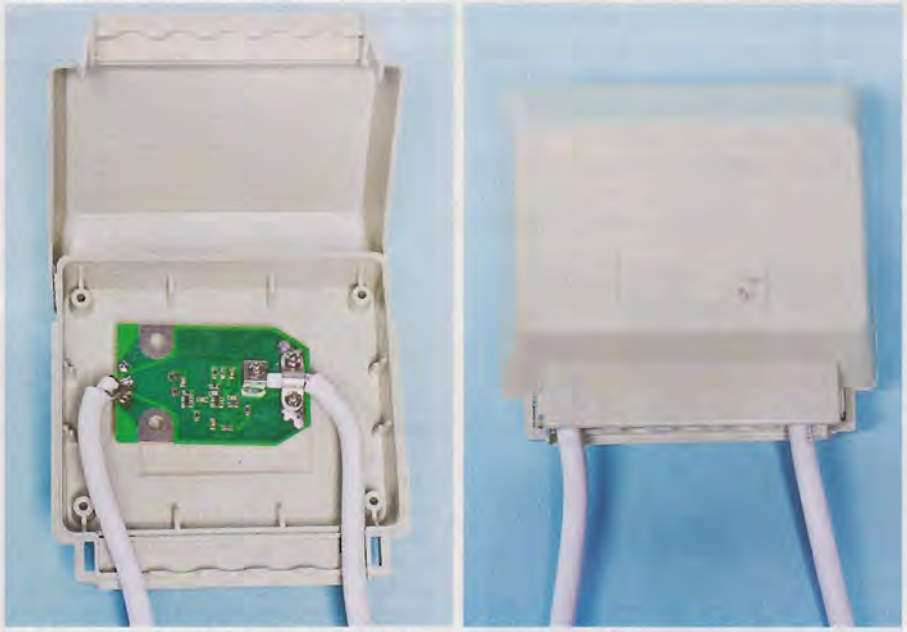
Once again that depends on your location – topography and distance from the transmitter play a major role



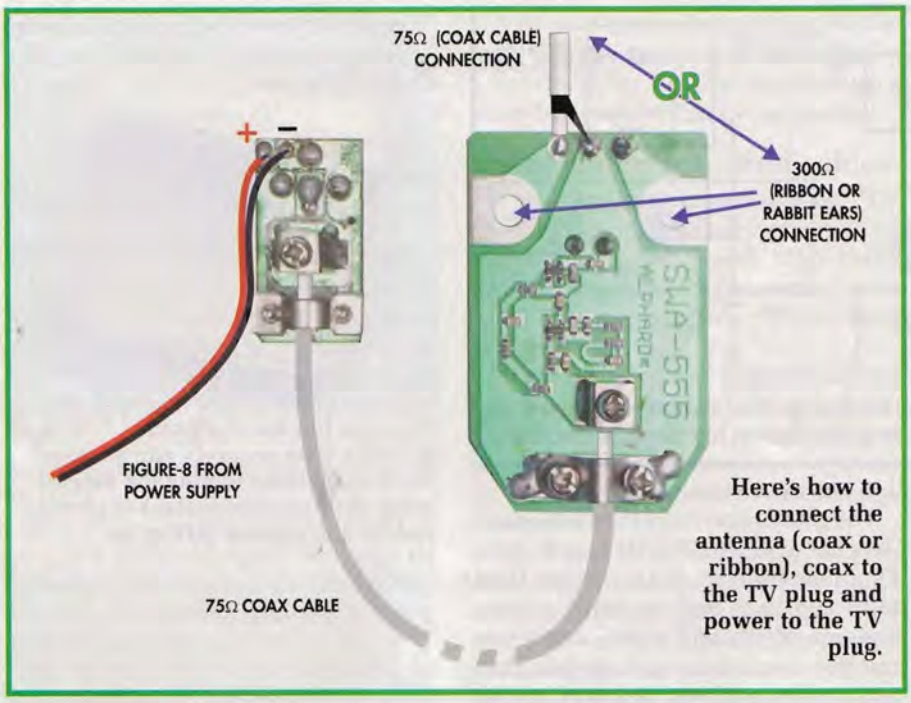
The case has four half-moon "clamps" to hold cables securely when closed. We'd be inclined to plug the unused holes with silicone sealant to prevent insects and spiders getting in.



A worm-drive hose clamp fits nicely into the mouldings on the back of the case to hold it firmly to a mast. A large cable tie could also be used.



The masthead amp mounted inside one of Oatley's HB4 cases which were obviously intended to be used for . . . masthead amps!



Here's how to connect the antenna (coax or ribbon), coax to the TV plug and power to the TV plug.

in determining whether you'll have enough signal.

There are two large holes in the PC board which are intended for the mounting screws for a pair of rabbits hears. If you are in a strong signal area (eg, <10km or so from the transmitter and no intermediate hills or buildings to block signal) try rabbit's ears – you could be surprised.

Remember that rabbit ears are simply a dipole antenna and, as such, require broadside-on orientation to the transmitter direction and horizontal or vertical polarisation to suit the polarisation of the local transmitter.

The other thing to keep in mind is that as frequency increases the length of the dipole decreases – theoretically, at the highest TV channel frequencies the telescopic dipoles should be pretty-much collapsed. Experimentation is the key here.

And if you cannot easily obtain telescopic rabbit ears?

Simple: use a pair of stiff wires – even the proverbial Aussie fencing wire will do fine or maybe that special "cotanger" wire which every wardrobe is full of . . .

Of course rigid wire won't be quite as adjustable as rabbit ears but replacement wire is pretty cheap!

So what's left to do?

Not much! If you want to use it as a true masthead amplifier, you need to connect the amplifier to your antenna. Provision is made for both 300Ω twinlead and 75Ω coax cables with a balun transformer already mounted on the PC board.

Unless you have very good reason for not doing so (eg, you own a twinlead factory), we would strongly recommend you use coax rather than twinlead.

While it has higher attenuation, coax offers several other advantages – eg, it doesn't break down so easily in the weather; it offers better protection from ghosting and interference (twinlead has no shield so often picks up unwanted signals along its length) and finally, the best reason – twinlead is becoming a lot harder to obtain!

The PC board is not clearly marked but follow our diagrams and you won't go wrong. One warning: make sure you use 75Ω coax, not 50Ω!

A cheapie might save a few bob now but it could give you grief later on, especially if you start adding splitters and second/third or more TVs down the track.



Mount it up high

The opposite end of the PC board has a traditional cable clamp arrangement for the coax feed to your TV. Ideally, the masthead amp should be mounted at the top of the mast (ie, as close to the antenna as possible) so it doesn't amplify any noise in the downlead.

If so, it should be mounted in a weatherproof box of some description. Oatley Electronics have available a suitable box (Cat HB4, $4.00) which was designed for masthead and distribution amplifiers. The box is self-locking and, as you do so, it clamps both the input and output coax in place. So you don't even have to mount the PC board – it can simply sit inside the box.

No mounting hardware is supplied with the box but a large cable tie or (preferably) a worm-drive hose clamp can pass through the bracket at the back of the case and secure it firmly to the TV antenna mast.

Once the box is mounted with the coax cables coming out the bottom, it is relatively weatherproof – but we'd be inclined to run some silicone sealant into the three other coax access holes to prevent moisture getting in and also to deter spiders and other small insects calling your masthead amplifier home.

There may be situations where you cannot mount the masthead amp at the masthead. Don't be concerned, it should still work "down low" (ie, close



This was how Oatley Electronics showed the power supply construction, with the rectifier diode and capacitor glued to the outside of the plugpack case. We are not enthusiastic about this method: we'd much rather open up the case and place the components inside, as described in the text.

Improving "Rabbit Ears" Reception

We mentioned in the article that the PC board appeared to be designed for direct use with a 300Ω antenna. Having recently seen first hand how patchy the performance was from a set of Rabbit Ear antennas (with a relative in hospital), we thought "why not?"

The Rabbit Ears antenna shown here are typical of those available from a variety of sources for $10 or less. We show how we modified this particular antenna; obviously the one you get may be different but we imagine in most cases, the principles will be the same.

We opened our antenna (four screws in the base underneath the four rubber bumper feet) and found quite a deal of empty space inside.

Apart from a baluin (which we don't need as there is one on the amplifier PC board), there is also a large lead weight, as shown below (which keeps the unit stable).

There was plenty of room to mount the PC board sideways but we wanted to mount it end-on, so that the coax cable could emerge from the original place.

Only a minor modification was required to the case to achieve this – there is a moulded plastic pillar right in the middle which was obviously intended to support some type of board (it doesn't support the existing balun PC board). After unsoldering the balun PC board and discarding it, we clipped the pillar off and smoothed the plastic out with a hot soldering iron.

To mount the PC board, we needed to shorten it. We did this by moving the balun back a little, drilling three new holes in the same pads/tracks and soldering it back in place.

We then cut the PC board across the large antenna holes, as shown in the centre photo below. A small amount of pad must be left to allow soldering.

The board, with coax cable attached, then fits nicely with the coax emerging in the right place.

Two short lengths of tinned copper wire connect the original solder lugs to what remain of the antenna mounting pads.

We ran some hot-melt glue over the end of the PC board not so much to hold it in place (even though it does to some degree) but more provide insulation between the board and the lead weight which mounts above the board. While the weight sits on pillars giving clearance, we thought it better to be sure, to be sure. . .



And that's it! Where we had a fairly watchable picture in the past, it's now a rock-solid picture much less prone to interference and flutter as people walk past.

One aside: the black loop in the picture above originally contained a single length of wire connected to the same terminals. Now we might be breaking some unwritten law of advanced Rabbit Ear technology but we couldn't see any sensible reason for this loop. So when we re-assembled our antenna, we left it out. Trust us: it works without it!



Opening the case (four screws) reveals a balun and a lead weight. We don't need this balun so we discarded it.



We shortened the masthead amp board a little to help it fit better, drilling new holes for the three balun wires.



Short lengths of wire connect the two "ears" to what's left of the 300Ω terminals – and that's about it!



When you "crack" open the plugpack as described in the text, you'll find there is plenty of room for the diode and electrolytic capacitor. That 0.68Ω resistor is a bit of a mystery – we removed it from our rebuilt supply. After testing, make sure you re-glue the two halves of the plugpack together and change the label to indicate it is now a 10V DC supply!

to your TV set) but performance might not be quite as good; adequate, perhaps even an unnoticeable difference – but theoretically, not as good.

Power supply

Finally, we need to add a power supply. In the Oatley kit, a small 6V AC plugpack is included along with a Schottky rectifier diode and a small electrolytic for a simple half-wave rectified supply.

Given the poor regulation of small plugpacks and the low voltage drop across the Schottky diode, this gives around 9.5V DC on light loads (which the masthead amp is – just 25mA) so will power the masthead amplifier.

The specifications say 10-15V DC so if you want to run a higher supply voltage you would possibly end up with slightly better noise figures and perhaps more gain. A half-wave-rectified 10V AC supply would result in about 14V DC.

Oatley's method of power supply construction is, shall we say, unique: they hot-melt glued both the diode and electrolytic to the power supply case and soldered the leads on.

We would much prefer a method we've used in the past, when there is room, and that is to put the rectifier components inside the plugpack.

When the plastic welds on the power supply case are squeezed in a vyce and tapped until the weld breaks, you can separate both halves of the case.

There is plenty of room for both the diode and capacitor at the top of the case and all the "bitey" bits are safely covered by the transformer and Presspahn insulation.

When we opened the supplied plugpack in this way we were surprised to find a 0.68Ω 1W resistor in series with the secondary. No, we don't know why either – so we removed it.

Fortunately, its mounting lug provided a perfect position for soldering the diode in series with the secondary (anode to the secondary). The electrolytic capacitor connects between the diode cathode and the other end of the secondary. A short extension to the positive wire from the capacitor was necessary to do so.

If you use this method, when you've checked it out and it works, simply glue the case lid back on (super glue, contact adhesive, etc) while clamping the two halves together. Don't forget to change the label to read 9V DC instead of 6V AC (a thin-pointed spirit marker is ideal).

Whether you choose Oatley's easy way or our harder but more professional way, you need to end up with a DC supply around 9-10V or so, connected with the polarity shown in the diagram earlier.

Connecting the supply

Also included in the kit is a special PAL-type TV antenna socket (male plug) connector which has a coax cable clamp inside.

DC power is also connected via this plug, which has the blocking components to make sure power doesn't get back into the TV set but allows power to reach the masthead amplifier via the coax cable. Therefore it is important to use this plug and not simply substitute a standard TV antenna plug.

Use the diagram and accompanying photo to show you where the DC power is connected relative to the coax connector.

So that's it: nice and simple and capable of excellent performance. SC

Where from, how much?

The K274 Masthead Amplifier kit is available from Oatley Electronics (www.oatleyelectronics.com) for $14.90. This includes the pre-assembled amplifier board, power supply components and TV antenna plug.

The masthead/distribution case sells for $4.00 (cat HB4).



This coax TV plug, supplied with the kit, doesn't simply connect your amplifier to the TV set. It also contains the components which allow you to send DC power back up the coax cable (seen here in grey) while stopping the power getting into the TV set. Don't be tempted to substitute a standard coax connector – your TV set might object to it. You also need to connect DC power (from the modified plugpack) – the positive wire goes to the arrowed (+) side. You might also need to cut a small notch in the back of the plug (alongside the coax cable cutout) to accommodate the power wires.

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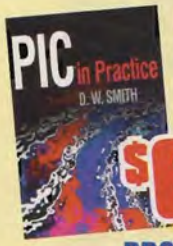


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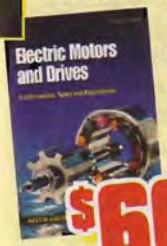
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Vintage Radio

By RODNEY CHAMPNESS, VK3UG



The development of AC mains power supplies, Pt.2



Last month, we looked at the development of AC mains power supplies for domestic radios and the all-important power transformer. In Pt.2 this month, we look at some of the other aspects of power supplies that a restorer needs to understand.

UNDERSTANDING THE power supplies in valve receivers is an important aspect of restoration. It's important that you know what you are doing when restoring such equipment, as incorrect servicing can cause a fire or even result in electrocution.

The power supply circuits used in valve radio receivers are usually relatively simple. They typically consist of a transformer, a rectifier like a 5Y3GT, two 16µF electrolytic capacitors and a 12 Henry choke between them. This was almost an industry standard for many years. Later sets used rectifiers such as the 6X4 and a resistor in place of the choke – see Fig.1.

Replacing like for like components with the same ratings is usually quite reasonable when restoring such circuits. However, because the circuits are relatively simple, many people are often lulled into thinking that any odd-value component can be used to replace a faulty part.

A typical power supply

Fig.1 shows the circuit of a typical power supply as used in many late-model valve mantel receivers. Let's take a look at the design requirements necessary to ensure reliability for this type of supply, starting with the power transformer.

Generally, the power transformers used in valve receivers are conservatively rated and it is rare to hear of them burning out. Most (but not all) power transformers have a tapped primary winding that (depending on the connections) can accommodate mains input voltages ranging from around 200V AC up to about 250V AC at 50Hz. However, some transformers were designed to work safely on 40Hz mains, as used in Perth many years ago.

Because they are conservatively rated, most transformers in valve receivers will withstand somewhat higher currents than originally intended. This may be brought about, for example, by substituting a valve that draws greater heater and HT currents than the valve originally specified. However, although they may withstand moderate overloads in the short term without too much fuss (but run warmer in the process), this is not recommended long term.

In any case, the transformer should not run hot in normal use.

Voltage regulation

The voltage drop across a valve rectifier varies significantly between low load and its maximum specified load. The figures provided as examples in the following paragraphs depend on the resistance of the transformer's primary and secondary windings, the type of rectifier used and the value of the first filter capacitor. These values are typically set down in valve data books.

For example, a 6V4 rectifier connected to a 600V centre-tapped transformer secondary winding will have a DC voltage of 424V on its cathode with no current being drawn. This slumps to approximately 300V at its maximum rated current output of 90mA.

A directly-heated GZ32 (with the

same input voltage) will have 424V on its filament at no load and this will drop to 320-360V at its full-load rating of 300mA. By contrast, the output from a 5Y3GT with the same voltages applied will drop to as low as 330V with a 60mA load and to 280V at 125mA.

If a field coil speaker is used in the HT line, then the HT line will typically be reduced a further 100V if a 6V4 or GZ32 rectifier is used. Alternatively, for a 5Y3GT, the voltage drop can be as high as 190V at 60mA.

Often, 5Y3GT valves were used with transformers with a 770V centre-tapped (ie, 385V per side) HT secondary winding. The no current voltage on the output of the 5Y3GT for a few seconds will thus be 385V x 1.414 = 544V DC peak and this voltage is applied to all valves and components connected between the HT line and the chassis. The transformer winding resistances, magnetic losses, field coil resistance and the voltage drop across the rectifier at full load will subsequently reduce this HT voltage to 250-300V DC after filtering.

For this reason, sets using a 5Y3GT or similar directly-heated valve rectifier must use components (particularly electrolytic capacitors) capable of withstanding the high peak voltage. That is why old sets had either 450V working (VW), 525V peak (VP) or 500VW/600VP electrolytic capacitors.

In later receivers, such as the Kriesler 11-99, silicon diodes were used as power rectifiers. In fact, I have a solid-state version of a valve rectifier power supply. It is a 100mA power supply with a 600V (300V per side) centre-tapped secondary transformer winding and the output voltage at no load is 425V DC. This drops to 368V at full load at the cathodes of the diodes and 355V immediately following the filter choke.

In short, silicon diodes are more efficient than valve rectifiers. The peak voltage and the full-load voltage are much closer together when using silicon diodes. This means that the secondary HT winding voltages can be much less than in a valve rectifier circuit for the same output.

In fact, a secondary HT winding of around 225V would be adequate for a HT voltage of 250V DC in a late-model valve receiver.

Rectifier rating limitations

Valve power rectifiers have a number of ratings that need to be observed to ensure a long life. In the preceding section, the 6V4 was described as having a maximum continuous current output of 90mA. However, in practice, the rectifier only supplies current for a fraction of a complete cycle (see Fig3.3-6), during which it charges the filter capacitor at its cathode.

The peak current specified for the 6V4 is 270mA per plate and the size of the filter capacitor is limited to 50µF. To limit the peak current to a safe value, the minimum effective plate supply impedance (ie, per plate) varies from 125-300Ω, depending on the output voltage of the supply. This impedance consists mainly of the primary and secondary winding resistances of the power transformer. However, you will sometimes see a low-value resistor in series with each plate lead to increase this resistance to the minimum recommended.

A scope shot of the peak current through the 6V4 rectifier of this power supply shows that the current is supplied to the filter network in pulses. The traces show both the ripple voltage and the peak capacitor charging current, which occur at the same time as each other.

Using a 16µF electrolytic as the first filter capacitor, the peak current through the rectifier is 0.4A (400mA) and the ripple voltage on the capacitor is 50V p-p with a 100mA load. Note that the 0V line is not shown on the power supply ripple trace (the upper trace).

Note also that the voltage across the 16µF capacitor (upper trace) begins to rise as soon as the charging current from the rectifier diodes (lower trace) commences.

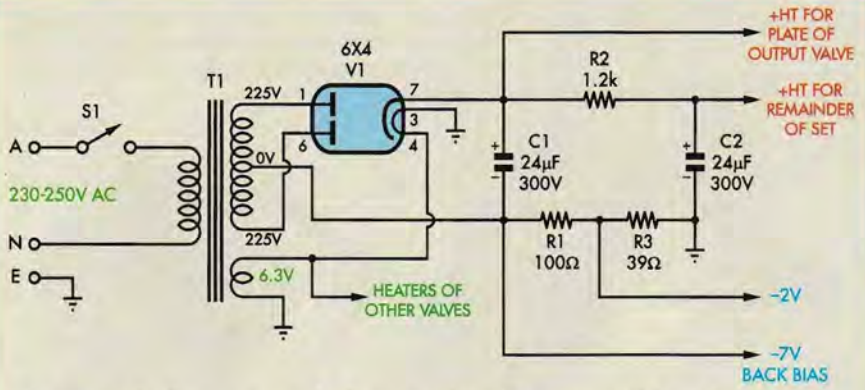


Fig.1: a typical power supply for a receiver that uses a 6M5 as its audio output valve. Note the method used to derive the two back bias voltages.

The horizontal line on the lower trace is zero current and the rectifier diodes only conduct when their anodes are more positive than their cathodes.

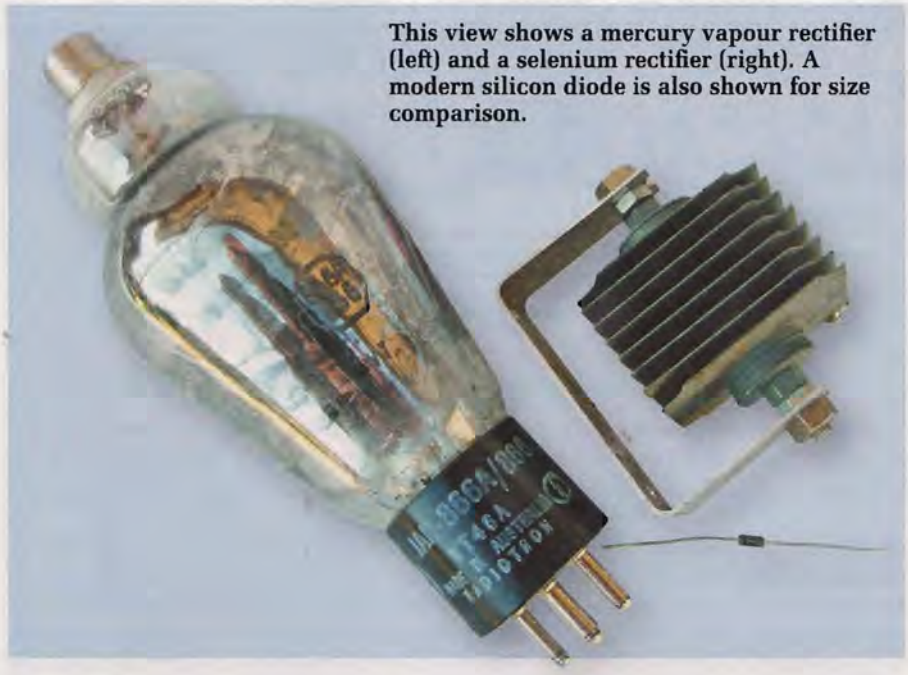
In the case of the 5Y3GT, the filter capacitor should not normally exceed 20µF, depending on the output voltage and the transformer winding resistances. The 5Y3GT is intended for vertical mounting but it can be laid on its side if pins 2 and 8 are in the horizontal plane. The filament sags as it heats up and under some circumstances the valve could flash over if this precaution is not observed.

Peak inverse voltage

Another rating rarely thought about is the peak inverse voltage (PIV) rating of each diode section when it is not conducting. If you measure the voltage across each half of the HT secondary transformer winding and it is around 285V (a common value), the output voltage following the rectifier will be around 400V with no load.

A common mistake made by radio restorers is to fit 1N4004 diodes (400V PIV rating) in place of a 5Y3GT rectifier valve or similar. Unfortunately, a 400V PIV diode is not adequate in a power supply that's delivering 400V and as some have found out to their sorrow, the power transformer can quickly become a charred, smelly mess.

To understand how this happens, assume initially that the no-load output voltage is +400V on the diode's cathode. What happens then is that the voltage on the winding reverses and this then results in -400V (peak) on the diode's anode. That means that the total voltage across the diode is 800V when it is not conducting, a figure which greatly exceeds its PIV rating.



This view shows a mercury vapour rectifier (left) and a selenium rectifier (right). A modern silicon diode is also shown for size comparison.

Rather than go into great detail, as a rough rule of thumb it's a good idea to allow three times the winding voltage as the PIV required for a rectifier. This is necessary to also allow for mains surges and spikes.

In greater detail, in the example above, the PIV rating of the diode should be at least 2.828 (2 x peak winding voltage) x 285 = 806V (NOT 400V). This means that a 1N4007 1000V PIV diode (or similar 1000V diode) would be necessary in this particular circuit.

If the calculated PIV is greater than 1000V, then two or more diodes can be connected in series to give the required PIV. However, it is necessary to put a resistor and a capacitor across each diode to compensate for unequal leakage currents and capacitances at the diode junctions. The ballpark requirements for a 1000V PIV diode are two 1W 150kΩ resistors in series across the diode and a parallel 1nF 1kV or higher-rated ceramic capacitor.

Solid-state diodes are relatively cheap and may be the only alternative in some restoration projects where the original rectifier type is no longer available. However, when substituting solid-state diodes for a valve rectifier, it is also necessary to install a resistor in series with their cathodes, before the first electrolytic filter capacitor.

This is necessary to reduce the output voltage to the normal value when the power supply is on load.

The value of this resistor is likely to be around 300Ω but the wattage rating needs to be around double the calculated value for pure DC, as the peak current through the resistor will be quite high.

Of course, the thermionic diodes in rectifier valves also have PIV ratings. The venerable 5Y3GT has a PIV of 1400V, the 6V4 1000V and the 6X4 1250V. You exceed these ratings at your peril.

In addition, indirectly-heated valve rectifiers have another rating that many are not aware of – the heater-to-cathode insulation rating. To explain, the heater and cathode are insulated from each other in indirectly-heated valves and for most power valves, the insulation rating is 100-200V. For rectifiers, however, it has to be much higher and in the case of the 6V4, it is 500V and for the 6X4 450V in a conventional power supply.

One rectifier that is prone to breaking down between the heater and cathode if it is overloaded is the 6X5GT.

Back bias & hum reduction

Fig.1 shows a typical power supply for a receiver that has a 6M5 as its audio output valve. Note that instead of the centre tap of the HT secondary winding going to chassis, it is wired to a common point along with the negative side of capacitor C1, one side of resistor R1 and a lead for the -7V bias line.

This arrangement is necessary to minimise hum loops.

Earlier power supplies earthed both the centre tap and the negative of the first capacitor to the chassis at the same spot if possible. If they are not connected to the chassis at the same spot, the peak currents flowing through the chassis due to rectifier action will develop an alternating voltage between the two earth points and this can cause hum in the output of the receiver.

As shown in Fig.1, the bias for the 6M5 and the earlier valves can be taken from particular points across resistors R2 and R3. The bias to the 6M5 in particular has ripple impressed on it due to the operation of the rectifier and filtering components. This ripple can be used to "buck" (or nullify) the effect of the ripple on the plate circuit of the output valve.

When the rectifier is conducting,

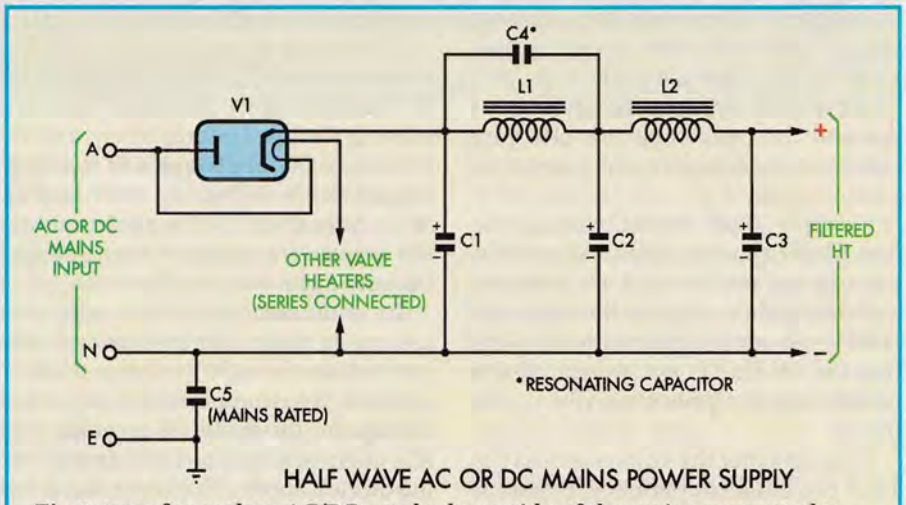


Fig.2: transformerless AC/DC sets had one side of the mains connected to the plate of the rectifier, while all the valve heaters were in series with the mains. Such sets are extremely dangerous to work on – see text.

the positive voltage at pin 7 rises and so the output valve will tend to draw slightly more current, as mentioned earlier. At the same time, the -7V bias will also go further negative and this will largely nullify any rise in the plate current, thus reducing the hum.

The -2V line supplies bias for the front-end valves and for delayed AGC (automatic gain control). So this simple supply performs several jobs using relatively few parts. Note that in some sets, the ratio of the bias variation to the plate voltage variation doesn't match and so additional filtering of the back-bias line is required.

Power supplies for AC/DC sets

The transformerless half-wave power supplies used in AC/DC receivers are extremely dangerous, so don't mess with them unless you are an expert, have lots of experience and understand exactly what you are doing. Do the wrong thing with one of these and you could get electrocuted.

In fact, depending on which way around the mains Active and Neutral are connected, the chassis could be at mains potential! In other words, one side of the mains was connected directly to chassis in some sets.

For this reason, it's vital to use an isolation transformer when working on such receivers. But we repeat the above warning – DO NOT touch such sets unless you are an expert.

Fig.2 shows a typical power supply as used in many AC/DC receivers. As the rectifier is only conducting for less than half the time, adequate filtering of the pulsating DC is harder to achieve than with full-wave rectification.

The values of the first and second filter capacitors were the largest that could be used with the rectifier (usually 8µF or 16µF each), while an iron-cored choke of around 12 Henry was used to achieve reasonable filtering. Even then, AC/DC receivers always tended to have more hum than those that derived their power via a mains transformer.

The Kriesler 11-90 and 11-99 sets, while they are not AC/DC sets, use a 6V4 and silicon power diode respectively in half-wave rectifying circuits. The first filter capacitor is 40µF to filter the pulsating DC output from the rectifier as much as possible.

Resonant tuning

In some power supplies, particularly in earlier times, the filter choke was tuned to resonance by a capacitor wired across it. A 10H choke resonates with a 1µF capacitor at 50Hz and by resonating the choke, the filtering efficiency was increased. If you have a set that has come from America, the value of this resonating capacitor should be increased by 20%, so that it will work better at the Australian 50Hz mains frequency.

Heater supply in AC/DC sets

By necessity, the heaters in AC/DC sets are wired in series across the mains (we said such sets can be dangerous). In fact, a whole series of valves was developed that had heaters rated at either 0.3A or 0.15A and even as low as 0.05A. The voltage across the individual valves varied according to the purpose they served. For example, a 35L6 output valve has a 35V 0.15A heater, while a 12SK7 RF valve has a 12.6V heater that draws 0.15A.

Because the valves on the set do not heat up at the same rate when power is applied, some valves will have excessive voltage across their heaters for a short time and this can ultimately reduce their working life. Several simple techniques were used to reduce this problem, the easiest being to install a resistor in series with the heaters. This resistor introduced an additional voltage drop to make up the difference between the mains voltage and the correct voltage drop across all the heaters.

Another common method was to wire a "Barretter" in series with the valve series heater string. Barretters are designed to stabilise the current through them to some predetermined value for a range of input voltages. For example, the 1941 barretter is rated to provide 0.3A over a voltage input range of 80-200V, while a 161 is rated for 0.16A over a voltage range of 100-200V.

A third method that I like is to use negative temperature coefficient (NTC) thermistors. When cold, they have relatively high resistance and as they warm up their resistance drops dramatically. By wiring them in series with the heaters, the valves will gradually have the correct current applied to them. However, they do take a while to drop in resistance as they warm up and sets using them take quite some time to start working.

Dial lamps can be a problem if wired



Fig.3: this scope shot shows the ripple (top) and the peak current from a typical full-wave rectifier when using a 16µF first filter capacitor. The ripple voltage is 50V peak-to-peak at 100mA.

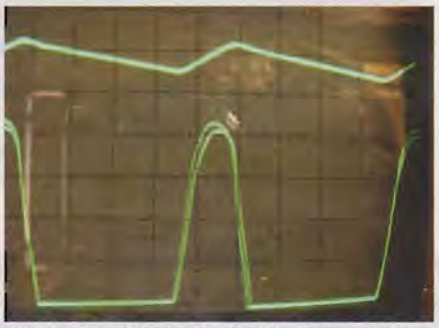


Fig.4: the effect of substituting a 64µF first filter capacitor. The peak current remains nearly the same and the ripple reduces to 15V peak-to-peak.



Fig.5: the waveforms for a half-wave rectifier and 16µF first filter capacitor. The HT voltage reduces from 350V to 305V, the peak current increases to 0.65A and the ripple voltage increases to 120V peak-to-peak.



Fig.6: using a 64µF capacitor in the half-wave circuit reduces the ripple from 120V to 30V.



The 6V4, 6X4 and 6CA4 "miniature" rectifiers were commonly used in radio sets towards the end of the valve era. Be careful when changing from one rectifier type to another, to ensure maximum ratings are not exceeded.

in series with the valve heater string. That's because if they blow, the set will be inoperative. However, it is common for the dial lamps in such sets to be run at reduced current so that they are unlikely to fail.

Unavailable valve rectifiers

If a rectifier is no longer available (eg, the 25Z6 which is used in AC/DC receivers), then it is possible to substitute solid-state diodes. For example, if the valve heater is intact but its emission is low, a 1000V 1A diode such as a 1N4007 can be wired directly across the valve's socket.

However, because the voltage drop under load is much lower with a 1N4007, it's advisable to install a resistor in series with one of its leads to drop the on-load voltage to that normally obtained with a good valve rectifier. The value of this resistor will be around 300Ω.

If no rectifier is fitted to the set and none is available, a 10W resistor with the same heater resistance as the original rectifier can be fitted. This is simply wired across the valve socket to the heater pins. For example, the 25Z6 has a 25V heater that draws 0.3A. The formula for calculating the value of the resistance is V/I = R, where V = volts, I = amps and R = resistance. Therefore 25/0.3 = 83Ω. The preferred value of 82Ω will be close enough.

If an indirectly-heated rectifier is replaced with a silicon diode(s), it is necessary to ensure that the electrolytic capacitors (and other components) can withstand the high voltage that appears across the supply line until the valves draw current. A series resistor in the supply line of around 300Ω before the first filter capacitor will usually be necessary.

In some cases, it is possible to substitute another type of indirectly heated rectifier. However, if this has a higher heater current than the original valve, make sure that the power transformer can withstand the increased load. PIV and maximum current ratings need to be observed too.

Electrolytic capacitors

After long periods of time, it's common for electrolytic capacitors to lose their capacitance and become electrically "leaky". For this reason, if a set has not been used or serviced for many years, it's essential to check the electrolytic capacitors to make sure they are still in good working order.

The first thing to do is to check that there are no shorts or near shorts between the HT line and the chassis. If there are, it is necessary to disconnect various components and sections of the receiver to determine where the fault lies. A multimeter can then be used to locate most shorts.

Occasionally an electrolytic capacitor will be found to be defective. What happens is that the dielectric in an electrolytic can lose its insulating properties. As a result, it can become be quite "leaky" electrically and draw many milliamps of current when a voltage is applied.

Any capacitors that are "leaky" either need to be replaced or "reformed". In the latter case, this is achieved by applying a voltage that's close to the working voltage of the capacitor through a current limiting resistor.

A current of 20mA is a reasonable limit when it comes to reforming the electrolytic capacitors found in vintage radios. In practice, it may take several minutes for the dielectric to reform, by which time the leakage current should be just a milliamp or two, depending on the capacitance. If the capacitor is defective, then the voltage across it after a few minutes of "reforming" will still be quite low compared to the voltage source.

If the reforming process appears to have been successful, the next step is to try the set out. However, if the capacitor has lost its capacitance, hum will be quite evident in the output from the speaker. Before condemning the capacitor to the scrap bin though, connect another one across it. If the hum is reduced, replace the faulty unit. If not, there is another fault somewhere in the set.

For more information on electrolytic capacitors and on reforming them, refer to the Vintage Radio column in the October 2006 issue of SILICON CHIP.

Summary

The power supplies used in old valve radios appear to be relatively simple. However, to achieve long-term reliability, particularly when major changes are made to a supply, you have to consider all the points raised in this article and in Pt.1 last month.

From personal experience, many vintage radio restorers are unaware of just how important some power supply design factors really are. Factors such as rectifier peak inverse voltage (PIV) ratings, current ratings, heater cathode insulation ratings and electrolytic capacitor values and voltages must all be considered.

This particularly applies when a switch is made from one type of rectifier to another, regardless as to whether you are simply substituting a different valve or changing from a valve rectifier to a solid state rectifier.

Finally, remember to stay well away from transformerless AC-DC sets. They are a death trap for the uninformed and the unwary. SC

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Changes to Tempmaster

I have just completed building the Tempmaster Mk2 (SILICON CHIP, February 2009), a very efficient design as I previously had an incubator that had a Triac and ramp generator problem with the IC; it was a UK design. My question is, can the temperature range be up to 40°C, as I need 37.5°C for incubating chickens? Currently it can only run up to 19°C. What components need changing? (G. F., via email).

The temperature range of the Tempmaster Mk2 can be extended up to a maximum of about 40°C by making the following changes:

(1). Reduce the value of the resistor from pin 3 of REG1 and test point TP1 from 2.7kΩ to 2.4kΩ.

(2). Increase the value of the resistor from TP1 to the trimpot VR1 from 3.3kΩ to 3.6kΩ.

With these values changed, use VR1 to set the voltage at TP1 to 3.105V to achieve a temperature threshold of 37.5°C.

Increasing hysteresis in the Tempmaster

I have recently built the Tempmaster Mk2 and while it basically worked as described, one or two problems have arisen. When constructed and initially tested it was incapable of achieving the temperature ranges described in the original SILICON CHIP article. My unit was only capable of reading between 4°C and approximately 15°C as built from the kit.

I've pondered the problem and after doing the arithmetic I ultimately replaced the 500Ω 10-turn potentiometer (VR1) with a 1kΩ unit, this certainly cured the temperature range problem. My intention was to run the unit in the heating mode and temperatures beyond 19°C were required and with that change the unit worked well up to a temperature over 22° C.

My next problem occurred with the unit being unable to switch cleanly and a given temperature setting. It appears to me that the rate of change of temperature/voltage in the LM335Z, is too slow to enable precise switching of the relay, resulting in a constant chattering as the sensor reacts to very small temperature changes. Can you suggest alternate values for the positive feedback resistors (10MΩ and 1.2kΩ) that would be suitable to create a sufficient differential between the reference voltage and the comparator? (W. G., Dunedin, NZ).

● Replacing the 500Ω trimpot with one of 1kΩ is one of a number of acceptable ways to increase the temperature range, so you chose well.

To provide the comparator with a larger hysteresis band in order to reduce 'chattering', simply increase the value of the resistor between pin 3 of the comparator and LK1, from 1.2kΩ up to 1.5kΩ, 1.8kΩ or even 2.2kΩ.

Collision deterrent for Skippy

Greetings from the paradise that is Kangaroo Island here in South Australia. We are blessed with a vast and fascinating range of marsupials but unfortunately we also have a large range and number of cars on the island and the two are not a good mix. I have been tasked with the challenge of seeing if there is an electronic high frequency sound that will harmlessly scare the kangaroos, possums and wallabies. I need to purchase or make a device that will work with kangaroos without affecting say, sheep or dogs! Any ideas please? (G. H., via email).

● We have not produced a circuit to scare kangaroos from oncoming cars. It would need to be very powerful to give the kangaroos sufficient time to react and escape. And if kangaroos and other marsupials can hear it, it will be equally audible to sheep and dogs.

Trickery with a projector

I was just wondering if you guys have been able to come up with a home made 3G signal booster (repeater) for use in homes that do not have the best 3G signal coverage.

Also, is there a way to make an inexpensive replacement projector lamp with LED lights instead of those hot lamps they currently use, or is there a way to make the projector think that the old lamp (reached its 2000 hours limit) is brand new and just keep using it till it dies hard? (M. P., via email).

● We are unlikely to produce such a project since mobile phone boosters are banned in Australia. However, they are available from overseas via the internet. You might find that you can improve reception sufficiently if you just use a 3G antenna - also available via eBay etc.

There is no easy way to produce a LED substitute for a HID projector lamp. However, it is possible to reset the "lamp hours" on your projector to trick it into thinking the lamp is new; you have to reset the "lamp hours" when you install a new lamp. However, be aware that when your projector lamp does ultimately fail, there is the slight possibility that it may fail catastrophically and may do damage to your projector.

Query on AC-coupling

I have a technical query about your "Infrared audio headphone link for TV" project (SILICON CHIP, December 2007). What is the purpose of the 100nF capacitor placed between the NAND gate buffer and the integrator in the transmitter circuit. I understand

that this capacitor AC-couples the output from the buffer to the integrator but would it cause a problem if the buffer was DC-coupled to the integrator, ie, no capacitor there?

Surely, in correct operation, this capacitor will be discharged as there is no DC to block therefore acting as if it were not there anyway. I think I understand that the output from the buffer must be very symmetrical otherwise the integrator output will gradually drift one way or the other. Has the capacitor got something to do with this? (C. H., via email).

- You are quite correct in suggesting that the capacitor is present to prevent the integrator from drifting one way or the other as a result of changes in symmetry of the 'square wave' output from the buffer. We did in fact try a direct connection initially but found that changes in symmetry (due mainly to the mark-space ratio of the IC2b clock oscillator) caused the distortion level to rise. Adding the capacitor kept this from happening.

Question on non-polarised capacitors

I notice that you have used non-polarised capacitors in a number of projects (Ultra-LD Mk2, speaker protection board, etc) but the non-polarised capacitors are quite a bit more expensive than polarised types, enough so that buying two polarised capacitors of twice the capacity can be cheaper. This is especially true when I buy capacitors that are on sale, it's much more common to find polarised electros on sale and I can get a bargain on them, while cheap non-polarised capacitors are much harder to find. I can quite easily get 47µF 50V caps for 5c each in quantity, whereas 22µF 50V non-polarised capacitors are nearly a dollar each.

Is the sound quality going to be worse if I use two polarised capacitors in inverse-series for AC coupling of inputs? Obviously the fact I have to install two capacitors rather than one is a disadvantage but they actually end up taking less board space since the polarised capacitors are so much smaller.

Also, for some reason most non-polarised capacitors are rated for 50V, whereas when AC-coupling on inputs it's unusual for there to be more than a few volts across the capacitor, so I end up having to buy a higher rated capacitor than seems strictly necessary – or am I missing something and 50V capacitors are necessary in such an application? This also contributes to the expense of using non-polarised capacitors.

Construction-wise as I understand it the non-polarised capacitors effectively are two polarised capacitors back-to-back except because they are monolithic they can share a common foil layer. So the two solutions aren't identical but it seems to me they will be pretty similar. (N. V., via email).

- In theory, there should no practical difference in terms of performance. However, in practice you would need to measure the performance differences between NP caps and two electros back to back. There might be a difference because of the possibly higher power factor of the two separate electrolytic capacitors in series. One other point to consider, is that if, for example, a 10µF NP capacitor is specified, you would need to replace it with two 20µF (or 22µF) polarised capacitors back to back, as the effective capacitance of two identical capacitors in series is halved.

Circuit Notebook questions & answers

In regard to the "12V Regulated Inverter Supply" in the May 2009 Circuit Notebook pages, I want to generate 24V DC 1A from a 12V DC supply with this unit and I was wondering if you could answer a few of questions, both specific to my required output voltage but also in general.

(1) What frequency would the transformer be running at?
(2) What controls the frequency?
(3) What does the actual output waveform look like?
(4) How does it start to oscillate? Why would both transistors not turn on together so that it stalls and never oscillates?
(5) It uses six turns and four turns. Why not 60 turns and 40 turns or some other value but the same ratio?
(6) Any idea on how to calculate the turns for 24V DC?
(7) Would BD139 be OK or do I need bigger? (N. W., via email).

- The answers to your questions are as follow:

(1) About 50kHz to 100kHz.
(2) The inductance of the windings, L1 and L2.
(3) A "squared off" sine wave when both windings are added at the cathodes of D4 and D5.
(4) One transistor will always switch on before another because of differences between them. The "switched-on" transistor ensures the other does not switch on at the same time due to the polarity of L1 & L2.
(5) Because the transformer would not provide the required output power.
(6) For 24V DC, use twice the number of turns (8 turns for L3 and L4)
(7) The BD139 is not rated for the primary current; use the TIP41C instead.

While the kettle boils . . .

I was making a cuppa one night and it occurred to me that when we boil a kettle, the water boils for around five seconds before the kettle switches off. So, how about a kit to turn off the kettle as soon as the water boils? Think about it, everyone has an automatic kettle. If every kettle in every home and office stays on for that additional five seconds after the water is boiling, how much power is being wasted everyday?

The other idea I had was prompted by your flash slave and beam break trigger project (SILICON CHIP, February 2009). My old Olympus had a shutter setting that held the shutter open as long as the shutter release was held down. This was a useful feature when I photographed lightning storms. I would set up the camera and tripod on my roof and then, with the remote release, point the camera at the storm

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Bogus warning against PICAXE in cars

I thought you may be interested in this article I copied from a website at **http://www.picaxeforum.co.uk/showthread.php?t=2940**

"How do I use a PICAXE in an Automobile?

Answer: Do not attempt to connect a PICAXE into an automobile's electrical system. Only use a PICAXE in an automobile when it is not connected to the vehicle electronics or power supply in any way.

Incorrectly fitted electronics could easily lead to damage to your vehicle and may even lead to your own death or that of others. It is highly likely that any electronics you add to an automobile will invalidate your insurance and make the vehicle illegal for use. The consequences could be that you may personally face huge legal bills should you be involved in an incident or accident (even if it is not your fault).

You may be prosecuted, and face a prison sentence or large fine, if such electronics are found to be fitted by the police or other authorities.

If you are considering fitting a PICAXE to a vehicle which will not be used on the public highway, you will face numerous difficulties in making the PICAXE safe for use and in connecting the PICAXE to the vehicle electronics.

You will need to run the PICAXE from a regulated power supply, and will need to design your circuit to work with the voltages used within the automobile.

Most automobiles are so-called "12V Negative Earth", which means that the chassis of the car is at 0V and all power is +12V relative to the chassis.

The actual voltage is however nominally 13.8V, but the voltage may often exceed this by a huge amount – hundreds of volts – for brief periods, and may also drop well below that.

The extremely high voltages, low voltages, brown-outs, and general 'noise' and interference which can be found on an automobile's power supply can make it extremely difficult to connect any electronics into a vehicle. The power supply needs to be protected from the massive input voltages which can destroy the power supply and other electronics, and drops in voltage may cause the electronics to reset or latch-up.

On top of that, any electronics you fit to an automobile may cause problems to other electronic systems within the vehicle and may render safety and other necessary equipment ineffective. Any flaws in your electronic design or faults in assembly may lead to consequences which are not acceptable; fire and even death.

Do not attempt to connect a PICAXE into an automobile's electrical system or interface it to any other vehicle electronics." (G. F., Masterton, NZ).

● This is typical of the mass of misinformation available on the internet.

It is true that any badly designed electronics device may cause a hazard when connected to a car's electrical system. There is huge range of after-market products which are available for connection in cars. Some of them might be dodgy but there are no warnings about particular devices. A blanket warning against PICAXEs or any other micro is just silly.

You might be interested to know that all the instrumentation systems in the Holden EFIJY concept car (SILICON CHIP, January 2006) were based on PICAXE circuits.

and hold the shutter open until a lightening strike occurred. Then release, wind on the film and press the shutter release again.

I understand that most digital cameras do not have any form of remote release but mine does. It is very similar to a flash trigger except that the 2.5mm mono socket simply closes the shutter release circuit through a momentary push switch. With that in mind, how about a light triggered remote release which will trigger the camera when a predetermined light level is reached, such as with a lightning strike? (D. S., Maryborough, Qld).

● We think you would find that if the kettle cut off sooner, not all the water would be as close to boiling point. The boiling before switch off undoubtedly helps in mixing the hotter and cooler regions of the kettle. In any case, if you consider that your kettle is boiled 12 times a day, that amounts to about 11kWh per annum for a 1.8kW kettle. At 15 cents per kilowatt-hour, that would cost less than $2 per annum. So developing an electronic device for earlier cut-off would not be viable.

Many digital SLRs do offer some form of remote control but as they all differ (most depend on a specific infrared code), interfacing a light-triggered switch to the camera electronics could be a problem and may well void the warranty. You would probably be better off triggering the infrared remote control for your specific camera.

Questions on the Railpower circuit

I have constructed the Railpower IV train controller (SILICON CHIP, September & October 2008). Unfortunately it does not operate as it should. Most of the indications are OK except that the speed and feedback bars show full scale, irrespective of the VR1 setting in LOCAL mode. The VR1 voltage on pin 1 of IC1 does vary from 0-5V as VR1 is operated.

I have checked voltages and the component locations. All are OK except there is no output from pin 9 of IC1. If I place 5V on pin 10 or 12 of IC2, the train operates. As IC2's input is a NAND gate this seems to be normal.

My next point to check was if the oscillator was operating. Looking at the circuit, I see that the two 27pF caps go to earth. The data sheet on the IC shows this to be the normal configuation for the oscillator. But on the PC board, these caps are connected to the 5V line, not earth. This has been confirmed with a meter. Looking at the PC board artwork on the PDF download from SILICON CHIP, this is also the case, ie, to the 5V rail.

Can you please confirm to me the correct configuration for these caps before I reroute the bottom end of the caps to earth? (K. M., Bunya, Qld).

● It is not a good idea to apply 5V to pin 10 or 12 of IC2 as these pins also connect to the pin 9 PWM output of IC1 and could damage this output.

The oscillator configuration is OK with the capacitors effectively coupled to the 0V rail via the 5V decoupling capacitors. In effect, the capacitors are still connected to an AC signal ground, even if they physically connect to the +5V rail. Your oscillator is operating because the display is being driven to show the speed and feedback

bars. However, if the percentage and direction buttons are not shown then perhaps the LCD is just showing the bars fully to the right of the display. In this case the contrast is set too high.

Check that pin 1 of IC1 also varies between 0 and 5V when VR1 is rotated. Perhaps IC1 may have a faulty pin 9 output.

Measuring impedances of the TDA1519A

I have a Phillips TDA1519A amplifier kit from Jaycar. I tried to work out the input and output impedance but was unable to. Do you happen to know what it is and how to measure it? One other question, this chip is supposed to work in Class B, so how does it avoid crossover distortion? (A. D., via email).

● The TDA1519A has an input impedance of 50kΩ in stereo mode and 25kΩ in bridge mode. You can check this by connecting a resistor in series with the input. The input impedance is the value of resistance added to reduce the output signal by half compared to when no resistance is added.

The overall input impedance will be less if measured before a volume potentiometer. The output impedance will be very low, of the order of milliohms because of the feedback control of the amplifier.

Class B operation in all amplifiers usually does have some bias current in the output transistors to reduce crossover distortion to reasonable levels.

Correct antenna for the Jupiter receiver

I am currently building a Jupiter Receiver (SILICON CHIP, August 2008) for use by Perth Modern School (WA's premier public high school). The school is spending a significant sum on the structural erection of the antenna. At this stage I have two questions.

First, in order to provide strain relief on the antenna balun, would it be OK to put a half-knot in the antenna wire inside the jiffy box on each side, before the antenna wire exits through the 3mm holes?

Secondly, in the original JPL / NASA Radio Jove "Antenna Manual Supplement" (January 2006), the length of the dipole is shown as 23ft 3in or 7087mm. In contrast, in the SILICON CHIP article, the dipole is specified as 6960mm. Which is correct? (G. B., via email).

● Yes, it would be a good idea to put a half-knot in each half of the antenna just inside the box, as strain relief.

With regard to the exact length of the antenna dipole, there is no "correct" figure because the signals from Jupiter (like those from the Sun) are essentially noise which is spread over a range covering a number of megahertz, with its lower end below 20MHz. So the exact frequency at which the antenna resonates is not critical, especially since the "Q" of the antenna is likely to be quite low.

Our figure of 6960mm should give a resonant frequency of about 20.5MHz (allowing for "end effect"), while the NASA figure of 7087mm would give a

... continued on page 111

Notes & Errata

Over-voltage protection for DC loads, Circuit Notebook, May 2009: In Fig.2, the 3.6MΩ resistor should be 1.2MΩ, to ensure the correct degree of hysteresis.

SD card Music/Speech Recorder/ Player, August 2009: The two 2.2kΩ resistors shown dividing the output of IRD1 on page 34 of the circuit should be 27kΩ. They are also incorrectly shown on the component overlay diagram on page 38 of the same issue.

Wideband Controller, September & October 2009: There are several mismatches between the circuit in the September issue and the component overlay diagram in the October issue.

1. The 100nF capacitor shown on the circuit connecting between pin 8 and ground is incorrect. It should be shown connecting between pins 8 and 4. The PC board is correct.
2. The 100µF capacitor shown at the anode of D3 and D4 on the circuit should also be 100uF on the overlay and not 10uF.
3. TP GND is not shown on the circuit. It connects to GND1 near pin 5 of IC1.
4. The 220nF capacitor at pin 5 of IC4b is shown connecting to GND1 on the circuit. It should be shown connecting to Vs/Ip, to match the PC board connection.
5. The 100µF bypass capacitor at the collector of Q3 should be shown on the circuit connecting to the GND2 rail.
6. The 10µF capacitor connecting to the emitters of Q1 and Q2 is shown with the incorrect (reversed) polarity on the overlay. The capacitor is correctly shown on the circuit.

WARNING!

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Ask SILICON CHIP – continued

Maximum gain for PreChamp circuit

In the circuit notes for the PreChamp unit (SILICON CHIP, July 1994) it indicates that the gain can be up to 100 times. Does this mean that the resistor across the 1n5 capacitor can be as high as about 9.9kΩ or can it in fact be somewhat higher than this? I have actually tried a 22kΩ resistor, with an electret microphone, and there doesn't appear to be any noticeable distortion. How high can this resistor go before the circuit either distorts or go into self oscillation etc?

- The amount of gain required depends on the input signal. A gain of 100 would require a 10kΩ resistor in place of the 2.2kΩ resistor. The 22kΩ resistor you used would provide a gain of 220 and this is OK to use if there is no distortion.

Ideally the .0015µF (1.5nF) capacitor should be replaced with a 150pF value to maintain the same frequency response.

Maximum gain depends on the transistors and is available when the feedback resistor in the 2.2kΩ is removed. There may be instability with this maximum gain and it could be around 10000.

resonant frequency of about 20.2MHz. As you can see there isn't a great deal of difference.

Secret Farter relay control

With reference to your articles on conversion of Jaycar's "Secret Farter" to the "Bed Wetting Alert" (SILICON CHIP, September 2004) and "Making a Door bell", is it possible to do a conversion for a remote controlled relay? I noticed with your Doorbell conversion you added an audio controller to drive a speaker using a 7555. Is it possible to use the pin 3 output to drive a 6V relay? (K. W., Hamilton, NZ).

- The collector of Q1 from the doorbell sounder might be used to drive a low coil current relay such as a 5V reed relay type. A diode would be required across the relay coil (1N4004 with anode to the collector of Q1).

Alternatively, use the Bed wetting alert sounder circuit and the collector of Q4 to drive a relay. The 10µF capacitor at Q1's collector would be replaced with a link.

The components for IC1c & IC1d, Q2 & Q3 and the speaker parts are not required. Again, use a diode across the coil; anode to the collector, cathode (striped end) to +V.

Speed Alert pulse requirement

I recently purchased a Speed Alert\ Speedometer kit from Jaycar to install into my old Datsun 260Z. I'm currently running an in-line electronic speedo sensor which is hooked up to a homemade digital tripmeter, and I was hoping to use that same input for the Speed Alert kit. I haven't measured the pulses from the sender, though I'm sure they are a 12V square wave. I notice in the kit that the input from the coil sensor is 300mV RMS floating, and as such won't work with my current sensor (already tried). Is there a way of modifying the circuit to suit? (T. B., via email).

- The square wave signal is applied to the 1kΩ input resistor. The shielded wire connection is not used. So the Speed Alert will work with a square wave signal of 3V peak-peak minimum referenced to 0V. SC

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