

SILICON CHIP

MARCH 2009

ISSN 1030-2662



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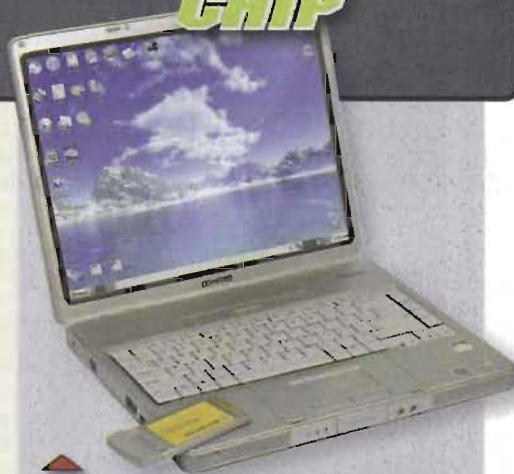
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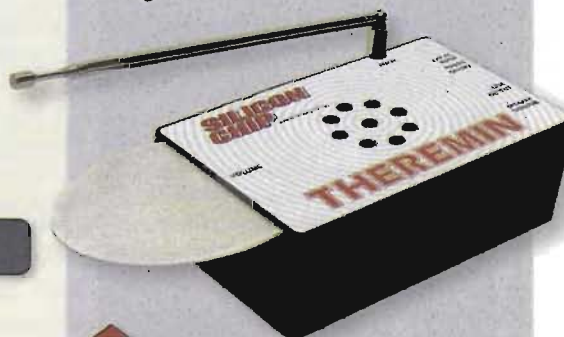
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Printing: Hannanprint, Noble Park, Victoria.

Distribution: Network Distribution Company.

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

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ISSN 1030-2662

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Publisher's Letter

Carbon trading may not be needed in Australia after all

I am writing this Publisher's Letter as Australia starts to come to grips with the aftermath of the dreadful bushfires in Victoria. Already, some green fanatics are trumpeting this as evidence of climate change, neglecting the fact that Australia has had many dreadful bushfire episodes in the past, long before climate change was thought of.

As always, the period just before the bushfires was one of very hot dry weather, creating just the right conditions. This was made much worse by pyromaniacs, another factor which has nothing to do with climate change.

One factor which did become abundantly clear during the weeks of hot weather before the bushfires was that much of Victoria's electricity grid and generating capacity cannot cope with very hot weather. Even the BassLink HVDC connector between Tasmania & Victoria failed during the hot weather, apparently unable to operate when the temperature exceeds 35°C. If this is the case, one has to ask: "Why?" It seems inconceivable that any piece of infrastructure in Australia would not be designed and maintained to cope with temperatures well in excess of 40°C. After all, such temperatures have always occurred during Australian summers, in all states including Tasmania.

The lack of generating capacity to cope with air-conditioning loads in summer is more serious and points to the fact that Australia urgently needs to build a lot more generating capacity, right now. But where are the plans to do so? Right now, we are mired in panic over the introduction of a carbon trading scheme, something which makes any new coal-fired power station an unlikely proposition. Nor is there any political will to consider nuclear power stations. Unless this changes and very soon, we can look forward to serious power shortages in the near future.

In fact, it is clear that many states are facing up to the fact that they will need to increase electricity tariffs quite drastically over the next few years, in order to cope with the need for increased maintenance and upgrading of their distribution networks. Just how drastic might these increases be? Western Australia is considering increases in household electricity tariffs by 78% over the next three years! And that is in a state that is not as badly affected as the eastern states.

This neatly dovetails with the Federal Government's plan to subsidise the installation of ceiling insulation in homes that do not already have some form of insulation. No doubt the Federal Government knows about the potential increases and is seeking to soften the impact. However, as with much Government reaction, it is probably the wrong move.

In fact, they would be better off subsidising the installation of double-glazing with low-E glass in all Australian homes. While this would be a much bigger budget measure, it would greatly reduce summer-time air-conditioning loads and winter heating loads. To support this idea, a recent industry report by Dr Peter Lyons in Glass Australia magazine (September 2008) demonstrated the very large power savings that could be obtained by upgrading the windows of all Victorian houses – equivalent to at least one or two very large coal-fired power stations. Not only would this reduce carbon diode emissions, it would also lead more comfortable home living conditions.

Surely, Australia should be adopting measures such as these, to reduce electricity demand, to stimulate the domestic economy and not adopt financially risky schemes involving carbon trading.



Leo Simpson

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Clarification on miniature tuning capacitors

The listing of the miniature variable tuning capacitors (eg, Jaycar RV-5728) as having a range of 60-160pF may be confusing to some constructors. The capacitance range in practice of the oscillator stage is usually about 9-65pF and the aerial stage is about 9-146pF.

When connected in parallel, the total range is usually about 18-216pF, as measured with a Lutron LCR-9073 meter.

**Matthew Weatherley, VK4TMW,
Highfields, Qld.**

Reliability of electrolytic capacitors

I have been servicing commercial lighting and communications products for several years and have noticed a dramatic increase in failure of electrolytic capacitors in the power supply

stages and other parts of the circuits.

In the past decade, capacitor failures were due largely to manufacturers' use of "cheap brand" units or the use of lower temperature capacitors than required. However, in recent years, where they are using known-quality Japanese high-temperature capacitors, they are still failing after only one or two years (just out of warranty). Previously we would get typically 6-10 years service life before the capacitors were failing.

I am starting to suspect that the capacitors now coming out of China and the cost-cutting demands have led to the supply of a poor-quality product with the same brand names across the range. It used to be that you could rely on certain brands as being a quality part but not anymore.

I was just wondering if other service companies are noticing a marked

increase in electrolytic capacitor failure.

**Peter Bates
Hillcrest, Qld.**

Comment: there does appear to be a downward trend in reliability of electronics products, especially where high-power switchmode circuitry is employed. The high-frequency ripple and switching currents in these devices, combined with the high-density of components on PC boards and insufficient ventilation, are all significant factors.

However, we cannot comment on the basic reliability of electrolytic capacitors. They are probably still being made to high standards but they are now subject to higher stresses.

USB-Sensing Mains Power Switch is too complicated

I have some questions and comments about the "USB Sensing Mains Power Switch" in the January 2009 issue. I think the design philosophy taken with this project has unnecessarily complicated what should be a very simple arrangement.

Have you considered using a Solid State Relay (SSR) in lieu the electro-mechanical relay and powering it from the PC's (switched) internal power supply?

I have for some time used an SSR (eg, Jaycar SY-4084, 240VAC, 40A) for switching power to PC peripherals. It operates with DC control voltages of 4V to 32V. At 5V it draws only 7.6mA, so it's quite suitable for operating from a laptop PC's USB power rail.

On a desktop PC it can be powered from one port of an added USB card, whose power then turns on and off with the PC's power supply or a DC socket internally connected to the power supply can be mounted on a spare backplane plate.

Backplane plates with power sockets are in fact commercially available. AC Ryan manufacture a range – under the name "Backy" – which are avail-

Relay ratings for USB switch

I am commenting on the USB-Sensing Mains Power Switch article in the January 2009 issue of SILICON CHIP. The article mentioned the 20A relay used was already overkill if someone wished to use the higher 30A-rated Jaycar relay.

While either relay should be fine, I would not recommend using a relay under 20A as most computer equipment with switchmode power supplies have a capacitor across the mains input to comply with RF radiation rules.

This capacitor draws negligible power from the mains when the unit is plugged in normally but when the power is initially connected (even when the power switch is off in most cases) there is a brief very high current surge. This surge is so brief that if the power is connected while the AC is at its zero-crossing point there will be no high current surge (as the capacitor will charge up slower with

the rising AC waveform). However, connecting at that very moment is unlikely so the usual thing is a surge as the capacitor must charge from zero to whatever the AC voltage is at that instant.

I have destroyed a few master switches on power boards as most have the small 10A-rated toggle switch (like the one used on this project) and can not handle the brief but very high current surge. One power board only lasted two uses and it was not a cheap one either.

In fact, this problem has been known about since the early days of computers; remember the huge 20A switches on computers of old?

This project solves the surge problem nicely but do not use a relay with less capacity. Do not use the mains switch while devices are plugged in; it essentially is there for emergency use only.

**Philip Chugg,
Launceston, Tas.**

able from Australian PC-modding suppliers for around \$A10. Using one of these makes it very easy to have the PC's power supply accessible for external use.

Yes, the SSR is quite a deal more expensive than an electromechanical relay but this cost difference is more than offset by: (1) eliminating the additional power supply, PC board and electronics which your design uses; (2) requiring a smaller enclosure; and (3) the overall simplification.

If in fact my suggested arrangements have been considered and rejected in favour of the January 2009 design, I'd be interested to know the reasons.

Bob Martindale,

Mill Park, Vic.

Comment: we did consider an SSR but rejected it. In fact, we have used an SSR (Jaycar SY-4080) in one of our past projects (Subwoofer Controller, August 2007) but in practice, it simply has not been as reliable as an equivalent relay. We are not sure why but we think that the snubber network across the Triac in the SSR cannot be ideal for the large range of inductive loads with which it is likely to be used.

We also used the equivalent of an SSR (and your design) in the previous USB-Up Switch which was published in the November 2004 issue. It had problems in that the USB ports on most desktop PCs now are still live when the machine is nominally turned

Digital Radio

I read with interest your article on Digital Radio in the February 2009 issue. Whilst my main interest is Digital Radio Mondiale (DRM), I have known about the many other standards for some years, including the IBOC (In Band On Channel) system employed in North America which wasn't mentioned.

I regularly hear Radio New Zealand International using DRM. My shortwave receiver's 455kHz IF output is fed to a down-converter circuit. The resulting 12kHz signal is then fed to my PC's soundcard where software decodes it into FM quality sound.

Of course, this is the radio enthusiast's way of doing things during this pioneering stage. Actual standalone receivers are thin on the ground, especially in this part of the world, as are broadcasts that target the region. One may, with a reasonable antenna, hear other countries but it's too "hit and miss" right now when they aren't pointing their transmitters in our direction.

A "chicken and egg" situation ensues where receiver manufacturers won't make radios unless there

is enough digital broadcasting but broadcasters won't adopt a system for which no receivers exist.

Another issue is the cost involved which, in the mind of the average consumer, may not offer significant benefits over conventional analog services to warrant the expensive upgrade. Plus, chipsets in these units have thus far been power hungry, limiting battery use.

Although many broadcasters have abandoned traditional methods and gone to an online presence (particularly those who occupied shortwave), I can't see there ever being no radio broadcasting. After all, there's no limit to the number of receivers that can tune in at the same time. There is always a limit online.

In the end, I hope all players involved are able to come to some agreement whereby receivers will be compatible with DRM, DAB etc, all in the same unit. That way, regardless of the standard any given country chooses to adopt, a receiver will work anywhere in the world, and that's just the way it should be.

Luke Biddle,

Currumbin Waters, Qld.

off. In that design, we also found the Triac switching was not a reliable as the rugged relay. We now regard our

November 2004 design as obsolete.

We also did not want to have a system which relied on modifications to

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Mailbag: continued

the computer, such as your addition of a USB card. We wanted a system which could be made to work with ANY PC that had a USB port.

The relay switching is well proven and is also used in our Brownout Protector (December 2008) and the Tempmaster Mk2 (February 2009).

Model track cleaner an inspiration

I was most interested to see the Model Railway Track Cleaner in the Circuit Notebook section of the January 2009 issue. I was already working on a project to remotely control a train, powered by on-board batteries. This was not for use as a track cleaner but as an alternative to conventional control via the track.

My project is based on a transmitter/receiver out of a very cheap model car, using the left or right turn signal to latch/unlatch a relay for direction of the train and the forward and reverse signal to increase or decrease speed. In my prototype, I had the battery pack, receiver and controller in a closed van wired to a separate locomotive in front. The batteries are charged via the wheels by parking the train on a live section of track set aside for the purpose.

But, unfortunately, my project had stalled, as I could not get the speed control I had designed to function to my satisfaction. Having read the article, I now have some alternative ideas and renewed enthusiasm for the project. Thanks for a great magazine.

**Steve Oppermann,
Mowbray, Tas.**

Relays are back in vogue

I would like to make an observation and then make a suggestion which some might find useful.

I have observed that SILICON CHIP has in recent times found out how useful relays are – a sort of relay renaissance. In Jim Rowe's Tempmaster article in February 2009, in the introduction, Jim explains how replacing the Triac of an earlier design with a relay has bought certain benefits.

In general among "electrical types"

I have noticed over many years an almost religious zeal of trying to eliminate elements with so-called moving parts. Moving parts were seen as things that wear out and were a source of weakness affecting reliability. Factors used to calculate Mean Time to Failure are dominated by contributions from switches and plugs and things that were not electrical. There was and still is a kind of pecking order in some people's minds with electrical things at the top and all other things reduced to a lower plane.

Yet I have often looked at a clock that came from my great grandfather that has ticked and tocked for the past 140 years with an occasional oil and clean every 50 or so years and thought of the electrical products that have come and gone as their electrolytic capacitors and more have crumble into worthless objects during those functional 140 years of this clock.

Relays were once ubiquitous but were progressively relegated as old technology as so-called superior alternative solid-state devices made them obsolete. Yet an appraisal of the offerings in modern catalogs reveals there are now more offerings of relays than ever before.

There are many features of relays that make them useful. First, they are 4-wire devices and provide full isolation. They are also less affected by spurious electrical spikes than more delicate solid-state devices and their time characteristics can in some instances be useful instead of a limitation. They can also have a wider operational temperature range than some solid-state devices. Relays are in fact quite common in many consumer items now.

Having believed in relays over many years I have often used a very simple design feature to vastly reduce their "on state" power consumption which I would like to share.

The voltage to hold a relay on is often as little as 1/10th of the nominal voltage. The power consumed at 1/10th the voltage is 1/100th of the power used at the nominal voltage. In many circuits, this feature can be exploited by using a dropping resistor

Australian mains voltage is 230VAC

Where has the "230 volt" in the Universal Speed Controller article (SILICON CHIP, February 2009) come from, when the nominal mains voltage in Australia is supposed to be 240V $\pm 6\%$?

All Australian States except BHP mine sites and Tasmania are 240VAC. In 1983 Australian Standards in their great wisdom decided to adopt a 20-year plan to alter Australian standard mains voltage to comply with the European Standard IEC38, to assist with compliance with our "major trading partners". Europe is NOT our major trading partner and the standard remains 240VAC apart from the exceptions above.

The fiction of dropping mains voltage to reduce carbon pollution is being also promoted. The actual voltage used as a standard is immaterial as long as appliances are efficiently designed. In fact, with some switchmode power supplies, supplying lower mains voltage other than the median design can cause excessive current to be drawn through the switching devices and in turn cause inefficiency through heating and possibly premature failure.

Supplying low mains in the belief of saving power can also cause some strobing effects in gas discharge lamps designed for higher voltages if loading causes the mains to go too low.

The low limit of -6% is a wishful thought, especially in the world of state governments opting out of the responsibility of electricity supply to "private" suppliers. A lower limit of 10-15% or more can occur in newer under-supplied housing/industrial development sites.

Please don't bow to a feely-goody namby-pamby approach which unfortunately the magazine seems to be doing. After years of following Electronics Australia and SILICON CHIP, the articles are now less well-informed and authoritative. The articles and projects seem more aimed at the "funway kit" generation.

Jim Hickey,
Luxfield Communications,
Bundaberg, Qld.

Comment: 230VAC is now the Australian standard and has been since the year 2000. The relevant standard is AS60038. It states that the "Point of Supply" voltage should be nominal 230V $+10\%/-6\%$, ie, the maximum voltage can be as high as 253V and the minimum 216V.

In fact, our mains voltage in the SILICON CHIP offices normally sits around 230VAC. You might think this is namby-pamby but it is reality.

We did not agree with this decision and, in fact, the Publisher's Letter in the April 1994 issue, 15 years ago, was very critical and covered most of the points you raise in objection.

While we are aware that there can be large variations in the mains supply throughout Australia, the fact is that the standard is no longer 240VAC but 230VAC. Hence, from now on SILICON CHIP magazine will reflect this fact and label our circuit diagrams accordingly.

A dispassionate assessment of the projects and technical content in current issues of SILICON CHIP will surely demonstrate that our standards have not dropped. For example, just consider the other projects in the same issue you refer to: the Universal Speed Controller, Tempmaster, Programmable Flash Delay and Car Scrolling Display. Are they trivial? And what about the feature articles: Digital Radio, LeCroy WaveRunner review and 2.4GHz DSS radio control? Hardly lightweight articles, are they?

in series with the supply side of relay coil. Putting a suitable capacitor that charges through the series resistor up to the supply voltage when the relay is in the off state provides the full voltage necessary to close the relay when the

circuit from the capacitor to the relay coil is closed.

For example, in Jim Rowe's Tempmaster circuit by putting a resistor of, maybe 1.2k Ω , between the emitter of Q1 and the +12V rail and a capacitor

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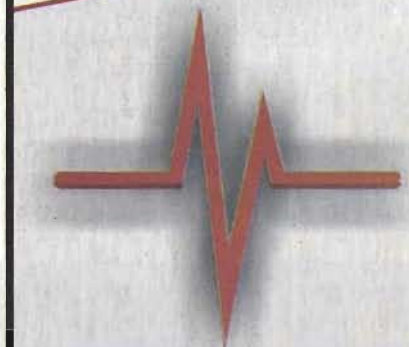
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Mailbag: continued

from the emitter to the ground side of the relay coil, then the on current of the relay would have gone from 75mA to 9mA and the total current of the circuit from 79mA to 13mA. You need to check that this works in each instance but I would guess that it would with this relay.

Not just relays can make use of this idea. I have controlled an irrigation type water solenoid for the past 30 years like this. It is still working. If I remember correctly the solenoid holds on with less than 1V DC on a 24V AC coil.

**Ken Moxham,
Urrbrae, SA.**

Comment: it is true that relays are enjoying something of a renaissance. However, while a relay's "holding current" can be substantially less than the operating current (ie, current to close the contacts), it is certainly is not as little as one-tenth. More typically, it is possible to reduce the operating current by about half once the relay is closed. However, any reduction in current must not jeopardise the contact rating, especially in high current relays.

Reducing standby power for home theatre equipment

I was happy to see your project for the "USB-Sensing Mains Power Switch". As many of your readers would know, standby power usage accounts for a significant percent of our energy usage. In my house it can be up to 10% of my energy usage if I leave everything on in standby mode.

A large number of my standby devices are part of my home stereo system. Luckily, my amplifier has a 12V DC output so I was able to build a mains relay with a soft starter to turn off all my stereo equipment with one device. This has significantly reduced my standby power usage. By the way, I also use a manually-switched power board to control my PC peripherals.

Unfortunately, most stereos or TVs don't have a switched DC output to make a project like this viable. This brings me back to the "USB-Sensing Mains Power Switch". I was wondering if there is a way to sense activity

on a video signal (sync signal?) line, or digital audio line? In my experience analog audio detection is too unreliable.

This way, you could choose a master device, say a set-top box or the TV, and plug the video or digital audio from this device into the mains-controlled switch. The remote for the master would then control power to the remaining devices. Similarly to the computer peripherals, the remaining stereo components would be powered by a power board from this switch.

Of course, you could make the switch itself remote-controlled (eg, the UHF Controlled Mains Switch) but this means another remote control to add to the collection.

**Chris Lister,
Carseldine, Qld.**

Comment: you raise some valid points about standby power etc. However, we have already produced a project which fits your application. Have a look at the Power-Up described in the July 2003 issue.

Low-power solar lighting works well

In August, I installed the Powertech 12V solar kit featured in the November 2008 issue to illuminate pathways in the garden. I decided on the kit because self-charging solar lamps did not operate on account of overhanging trees.

The 5W CFL was installed in a waterproof exterior Crompton fitting (Carlton Bunker X7200) attached to a fence post, while the two 1W LED lamps were installed in HPM glass and stainless steel garden lights (Capri Pathlights). The latter had to be adapted to accept the LED lamps, the lamps being soldered to the supply wires, as there was no room to accommodate sockets.

A pack of four bollard glass and stainless steel lamps ("Havana" by Magic Garden) completed the installation. These lamps are 12V 0.25W each. I used medium duty low-voltage garden cable for connecting the components of the solar kit.

The Havana set came with nine metres of cable and a transformer. I dispensed with the transformer and

wired in the lamps. They did not require modification for DC. A twilight switch (Keno M122) automatically turns on all the lamps at dusk. The twilight switch and its connections are housed in a watertight junction box having a transparent plastic lid.

All exterior connections are soldered, as clamped connections invariably corrode. The total load of this installation is 8W plus 0.42W for the twilight switch.

I was very surprised and pleased with the brightness of the lamps, including the 0.24W bollards. The lights come on at dusk and remain on until after 11pm on a sunny day when the 10W kit shuts off the battery. The lights go off earlier in winter, as the battery receives less charge, owing to tall trees that completely surround the property.

I encountered similar difficulties to Stan Swan in that the Edison screw sockets were defective and would not hold a lamp (Jaycar recently mailed me replacements – a different brand) and that polarities were not given for

the wiring. The undocumented LED at the rear of the solar panel seems to indicate when light falls on the panel (ie, is charging or is not charging).

The Compton, HPM, and Magic Garden fittings were obtained from Bunnings, while the twilight switch was obtained from Jaycar (Cat AA-0272).

**"Sydney Insider",
Lane Cove, NSW.**

Index for Radio & Hobbies

I have put together an index over the past few years from articles in Radio & Hobbies, Radio Television & Hobbies & Electronics Australia magazines. I set the index out in topics that were of interest to me at the beginning but as it grew I included most of the technical content from the magazines, eg, receivers, shortwave, antennas, power supplies, etc. I still have approximately 130 copies to read through and add to the list, so it should be finished in the next few months.

I always had an interest in electronics, making crystal sets while still at

school and when I commenced work in 1957 with the PMG, I started reading Radio Television & Hobbies magazines. From then on I have purchased most of them, making many projects along the way. After retirement I realised I had most of the magazines and set about collecting the whole set.

I then started reading through them again and copied down items of interest to me as I had just joined the Historical Radio Society of Australia and as a hobby, started restoring old valve radio sets. The magazines had many items that related to this and as I also had just obtained my amateur radio licence I included topics on this hobby as well; then I just kept adding topics.

As a lot of the topics in the magazines are of benefit to members of the HRSA they have put the index on their website, Maybe readers of SILICON CHIP will also find it useful. The HRSA web address is www.hrsa.asn.au and the index is listed under projects.

**Ray Tampion,
Mandurang, Vic.**

SC

NEW

MORNSUN

HIGH-PERFORMANCE HIGH RELIABILITY DC-DC/AC-DC converter

DC-DC Fixed Input Isolation Regulated

Ultra thin IF_RN/RT-1W



- 1W min: ultra thin
- Input: 5VDC
- Output: 5VDC
- Isolation voltage: 3000VDC

SIZE: 19.5x6.6x4.5(mm)

DC-DC Wide Input Isolation Regulated

Ultra Miniature WRA/B_LT-3W



- Wide(2:1) Input Range
- Input: 12VDC/24VDC/48VDC
- Output: WRA:±5VDC/±12VDC/±15VDC
WRB: 3.3VDC/5VDC/12VDC/15VDC
- Isolation voltage: 1500VDC

SIZE: 23.8x13.7x7.5(mm)

AC-DC Converter

LI24



- Universal input voltage:
90~264VAC, 50/60Hz/120~370VDC
- Output: 5VDC/12VDC/24VDC
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- Products include AC-DC、DC-DC、LED Driver、IGBT Driver、Isolated Amplifier、Isolated Safety Barrier
- Power range : 0.1W - 60W
- Isolation voltage: 1000VDC - 12000VDC / 2500VAC-4000VAC
- Input range: ±10% - Ultra-wide(4:1) input range
- Power density up to 8.5W/cm³
- Package style: SIP、DIP、SMD、DIN Rail







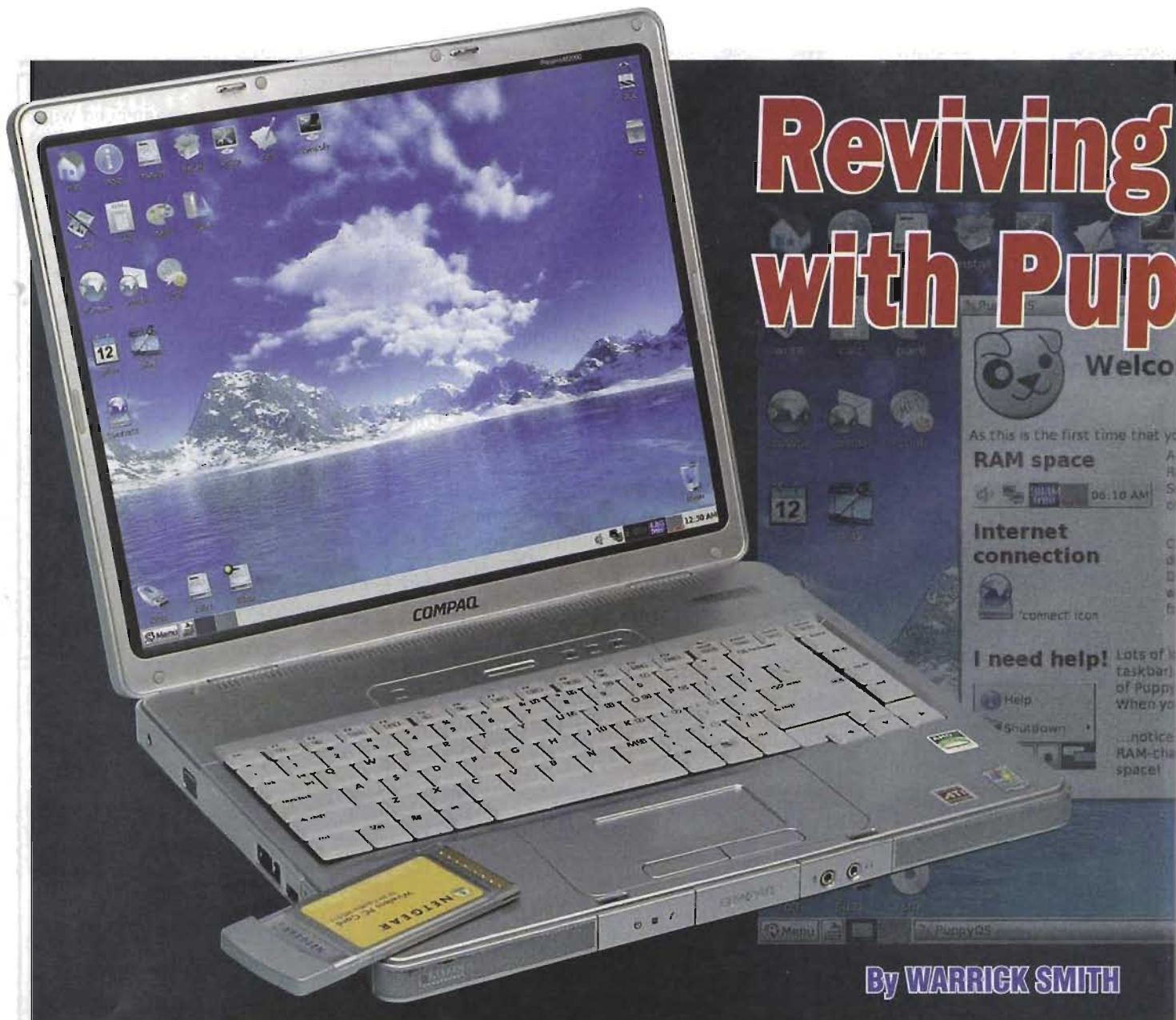


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By **WARRICK SMITH**

Laptop getting a bit long in the tooth? Does it now run like an old dog under Windows? You need a puppy – Puppy Linux, that is. Puppy runs like a scalded cat, even on old hardware (well, almost).

THIS PROJECT started about six months ago when I asked the computer technician at my school if he had any old hardware for my students to pull apart. I teach technology subjects and I'm always on the lookout for old or dead electronics, motors, lawnmowers, cars, etc. The kids either have a go at repairing them or use the parts in other projects.

A few days later, the computer

technician turned up with a heap of dead power supplies, hard drives, a VCR, various other bits and pieces and four dead laptops. I asked about the laptops and the response was "dead hard drives, they're not worth fixing, let the kids pull 'em' apart."

Dead hard drives

A computer with a dead or dying hard drive can have a number of

symptoms. Often, the computer appears to start OK but then the drive makes whirring or clicking sounds and the machine freezes or crashes. Alternatively, it may simply give an error message like "IDE Error" or "Operating System Not Found".

Often, an old laptop with a dead hard drive is usually not worth spending any money on. Many of the older models also struggle to run Windows XP at a decent pace, especially if they have only 256MB of RAM and a modest processor.

Puppy is the answer

I was starting to think that maybe I had run into a dead-end with these otherwise working laptops when I stumbled across the Puppy Linux web-

old laptops Puppy Linux

me, woof, woof!



Fig.1: Puppy runs fast on old hardware, is easy to drive and boasts a wide range of applications. The desktop shown in the photo at left is the default.

site at www.puppylinux.org. Puppy is basically a lean version of Linux that runs well on modest (read older) hardware. In fact, this operating system is so small it doesn't need a hard disk drive at all. When booted, it runs entirely in RAM (less than 93MB), so it's quite fast in operation.

As with other versions of Linux (and unlike Windows), Puppy Linux can be installed on a compact flash (CF) card, an SD card or a USB drive – you don't have to install it on a hard disk. This is a real advantage if the hard drive in your old laptop has died and you cannot get a replacement (or you don't want to spend the money).

Of course, if you do choose to install on a USB drive, then you must set the computer's BIOS to boot from this.

This may not be possible on really old machines but you should have no problems with laptops up to seven or eight years old.

Alternatively, you can create a live CD of Puppy Linux and boot from that. Your data plus any critical settings (eg, email accounts, network settings, etc) are then be stored on an external drive (USB, CF or conventional). These settings are then read back each time Puppy is loaded from the live CD.

Not only is Puppy fast on older hardware but it is also incredibly easy to install and use. It comes with a wide range of applications including wordprocessors, web applications (web browser, email, messaging and FTP client), multimedia applications and image editors.

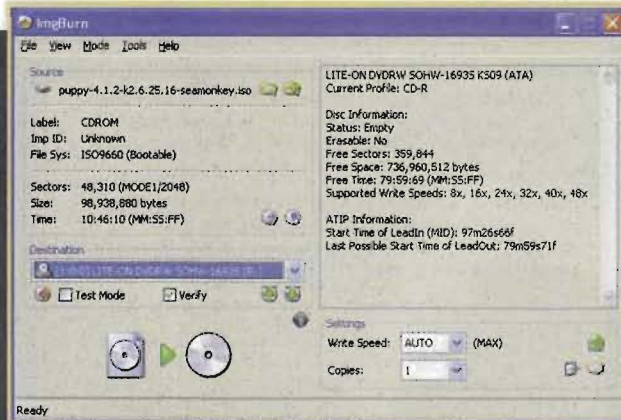


Fig.2: to install Puppy, you first have to download the image file & burn it to a CD. Imgburn from www.imgburn.com is a good freeware disk burner.

What's more, Puppy automatically detects your hardware and loads the correct drivers, so you don't have to worry about installing drivers yourself.

In short, Puppy is the perfect solution for getting old laptops going again, especially those that would struggle with Windows XP. You don't have to confine it to laptops either – it can also be used on to rejuvenate otherwise obsolescent PCs.

Making a Puppy boot CD

First, you need to get Puppy and make a boot CD. To do that, go to the Puppy website at www.puppylinux.org and download the latest release (version 4.1.2 at the time of writing). This will be an image (.iso) file which you then have to burn to a CD (or you can use a DVD if your laptop has a DVD player).

Note that it's important to burn the image file to the CD so that the file structure is recreated. It's not simply a matter of copying across the image file to the CD. What you should finish up with is a CD that contains a number of different files (typically seven). If your CD contains just the image (.iso) file, then you've done the wrong thing and you will have to start all over again.

In order to burn an image file, you can use a commercial disk burning program such as Nero or you can download a freeware program such as Imgburn from www.imgburn.com or CDBurnerXP from www.cdburnerxp.se. This is necessary because Windows by itself is unable to burn an image file to disk – it can only copy files to a CD.

We'll assume here that you're going

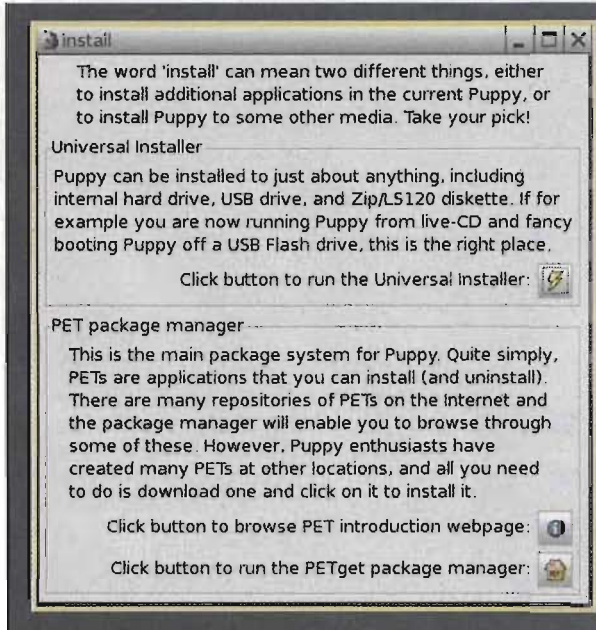


Fig.3: you can install Puppy on both internal & external disk drives. It can even go on a compact flash (CF) card that's fitted to an IDE adaptor and substituted for the hard disk drive.

to use Imgburn. Just download and install it, then click on the "Write Image File To Disc" icon. That done, browse for the source image file and select it. Finally, insert a blank CD and hit the burn icon at bottom left – see Fig.2.

When it's finished, check the CD to ensure that individual files have been recorded (not the .iso file). If that's the case, then you have successfully created a Puppy Linux boot disk (or "live" CD).

Boot disk priority

Once you have your boot disc, in-

sert it into the laptop and check that it boots correctly. If Windows starts instead (ie, if the HDD is still functioning), then you will have to get into the system BIOS and change the disk boot priority order.

This can be a bit of a pain if you've never done it before. And on some laptops, the splash screen that tells you which key to press to get into the system BIOS disappears before you've had a chance to read it. Often, it's the "Del" (or delete) key but it can also be one of the function keys or a special button on the machine.

Once into the BIOS set-up, it's just a matter of navigating to the boot priority menu (it's usually under "Advanced") and changing the boot order to suit (the instructions will be on the bottom of the screen). You will need to move the CD-ROM drive to the top of the list. That done, save the changes and exit the BIOS set-up utility.

Starting Puppy from the CD

All going well, Puppy should now start loading from the CD. During this process, you will be prompted to answer a few simple questions.

First, you will be asked to confirm what type of mouse you have (eg, USB, PS2 or serial). Puppy invariably gets this right, so it's usually just a matter of accepting the default. Next, you will be asked to confirm the keyboard type and then asked whether you want to use "xorg" or "xvesa" for the video. It defaults to xorg and this always works for me.

Next, the Puppy Video Wizard asks you to select the screen resolution and colour depth. Again, it invariably gets the screen resolution correct (eg, 1024 x 768) but it also usually allows you to select between a colour depth of 16 or 24 bits (ie, 65,536 or 16,777,216 colours). You can also test the selected mode, to confirm that it works OK.

Note that it defaults to the 16-bit setting but you can generally select a 24-bit colour depth, depending on your hardware.

Once you've done that, the boot procedure will quickly complete and

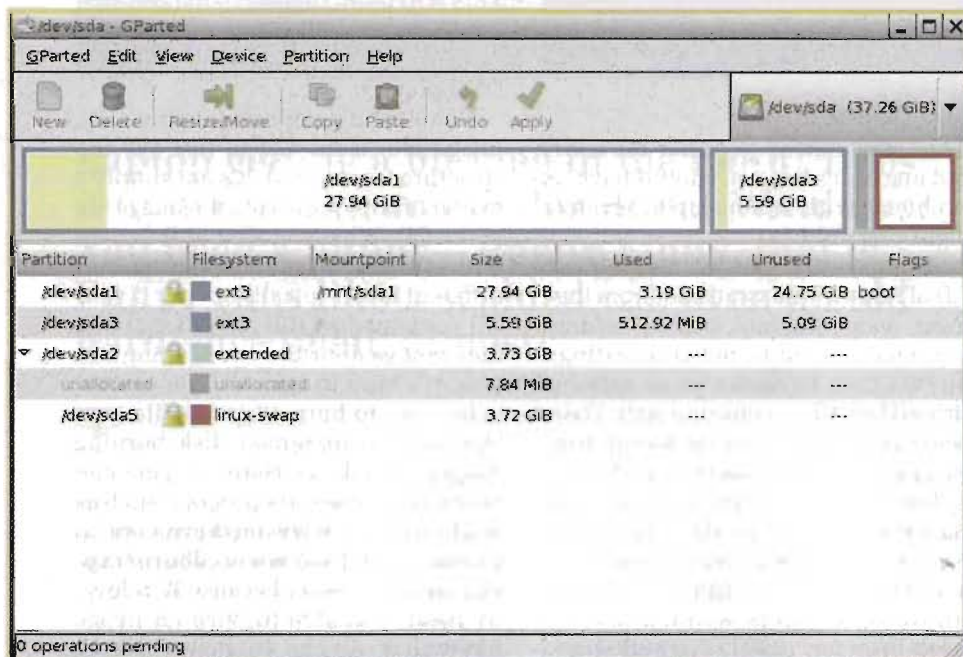


Fig.4: Puppy comes with the Gparted Partition Manager which can be used to partition and format disk drives, including during installation.

Playing With Puppy

In my case, Puppy successfully resuscitated all four of my old laptops and turned them into useful working computers able to browse the Internet, send and receive email, do wordprocessing and perform a host of other useful applications. As a result, these otherwise obsolescent laptops will stay out of landfill for quite some time yet. And that's good for the environment.

Best of all, Puppy Linux is simple to use. As in Windows, you just click on the icons and the menus to find your way around and to launch applications. The only difference is that just one click is used to launch applications from Puppy's desktop icons.

Another difference is that the drives are given names like sda1, sdb1 and so on. It's easy to follow: sda1 simply refers to the first partition on the first drive, while sdb1 refers to the first partition on the second drive. Similarly, sda3 is the third partition on the first hard drive. Get the picture?

When you install a USB drive, Puppy automatically places the drive icon on the desktop (along with any existing drives). You can then mount the drive and browse its contents simply by clicking on its icon. If you want to remove the drive, you first have to "unmount" it. That's done by right-clicking the drive and clicking the unmount option from the resulting menu list.

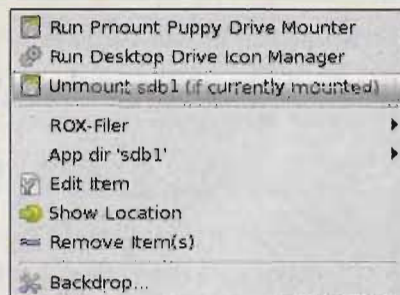


Fig.5: external drives must always be "unmounted" before removing them from the machine.

you'll be presented with Puppy's graphical desktop – see Fig.1. Woof woof – you're set to start exploring. It might be a bit slow to start from the CD drive but once it's loaded, you'll find Puppy is quite fast, even on old hardware.

Installing to other media

Unless you're a masochist, you won't want to load Puppy from a slow CD drive every time you want to start it. That's easily fixed. On the Puppy desktop you'll find an icon labelled "install". By clicking on it, you will be able to run the "Universal Installer" to install Puppy onto some other media.

This could be an internal hard disk drive (HDD), a USB flash drive, an SD card or a CompactFlash (CF) card.

My personal favourite is to install Puppy onto either an SD or CF card that's been substituted for the original hard disk drive. This is easily done using an SD (or CF) to IDE adaptor. Just plug the card into the IDE adaptor and then substitute this assembly for the existing hard disk in the laptop.

Of course, if the existing HDD is still OK, then you can install Puppy there. However, a CF or SD card is a great idea if the existing drive is faulty. As a bonus, a CF (or SD) card is completely silent and will draw far less power than a hard disk drive, so the laptop will run for longer on battery power alone.

An IDE adaptor to suit your CF or SD card can be obtained from www.siliconchip.com.au

Consider Using Ubuntu Linux



IF YOUR LAPTOP has a bit of firepower and at least 512MB of RAM, then consider using Ubuntu Linux as the OS. Basically, if the machine is capable of running Windows XP at a fair clip, then it's capable of running Ubuntu – you can even install a dual-boot system. Ubuntu is basically a "full-strength" Linux distribution. It's easy to install and drive and unlike Puppy, it will automatically connect to your wireless network each time it starts up.

darkwire.com.au. Alternatively, you will have to order one in from your local computer store.

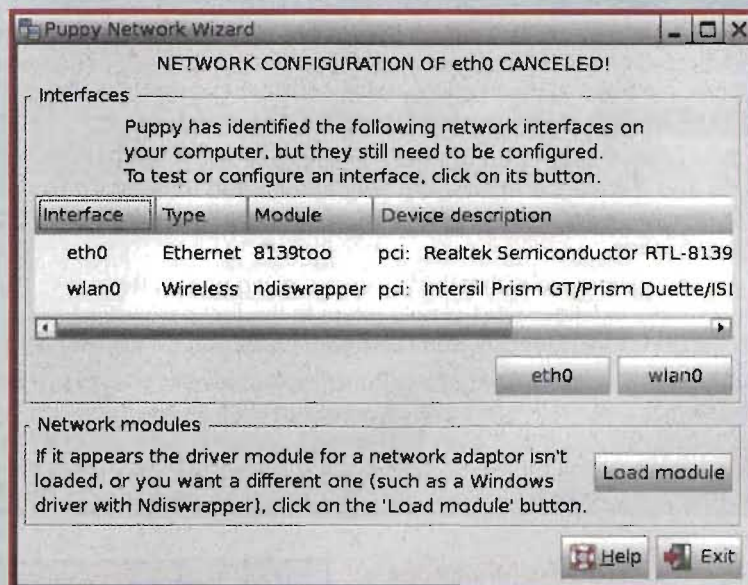
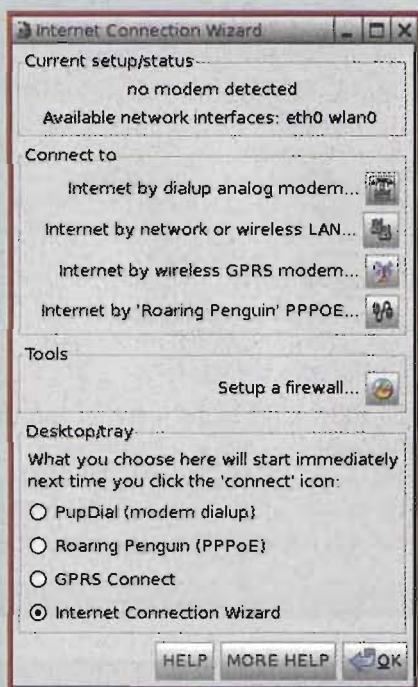
Saving files

You don't need a big CF or SD card to install Puppy – a 512MB or even

a 256MB card will do the job but a 1-4GB drive gives you a bit more elbow room to save files and store data. Alternatively, you can save files to an external USB flash drive.

In practice, a 1GB or larger card is more convenient. That's because if you

Connecting Puppy To The Internet



If you've got a wired broadband connection (USB or ethernet), then Puppy is incredibly easy to hook up to the Internet. You just click the "Connect" icon on the desktop and follow the bouncing ball. You can either click the "Auto DHCP" button in a subsequent dialog box to be automatically assigned an IP address or you can set up a static IP address.

Once connected, you simply click the "Browse" button to launch the web browser. Puppy uses the "Sea Monkey" browser and you will be impressed with its speed, even on older machines. Imagine being able to play YouTube videos on a laptop that was made in 2000!

Depending on your wireless card (or wireless chipset), wireless networking can be equally as simple. In many cases though, it will be more problematic but we've got that covered in a separate article in next month's issue.

Solving Problems

Any problems that I have encountered with Puppy have all been due to faulty (or inadequate) hardware. For example, on one laptop, Puppy would get stuck during boot up and stop loading.

The problem turned out to be quite simple – this particular machine had no hard disk drive and there just wasn't enough RAM to load Puppy. Another RAM chip got it going.

When it comes to troubleshooting, Puppy can be useful for recovering files if the hard drive is a bit dodgy and the existing Windows OS won't boot. By booting from the Puppy CD, you may be able to retrieve any important files and save them to a USB drive. In addition, Puppy comes with the Gparted Partition Manager (click Menu -> System -> Gparted Partition Manager) which can be used to partition and format disk drives.

Puppy can be installed onto a wide range of media, including USB memory sticks and CompactFlash (CF) cards. Want an internal solid-state drive? – just get an IDE adaptor for your CF card and substitute it for the hard drive.



do a "frugal" install, Puppy saves any subsequent system settings (to be read next time Puppy is booted) to a file called "pup_save.2fs" and this file is typically around the 500-600MB mark. If you install onto a memory card that's less than 1GB, then this file will have to be saved onto some other external media (eg, a USB flash drive or to a CD

if you have a CD burner).

Similarly, a full install will typically occupy some 500-600MB of disk space, so you will need at least a 1GB drive or, preferably, 2GB (see the panel for further information).

That's it. You're ready play with Puppy. He really is a good dog and you will have lots of fun. **SC**

Digital Radio

Part 2: AAC+ encoders & dec

Digital Radio broadcasts will use Advanced Audio Coding (AAC+) of the signals. AAC+ is a complex compression process which greatly reduces RF bandwidth and transmission power necessary to broadcast a high quality signal.

When we introduced Digital Radio last month, we explained how this completely new technology will commence in Australia in just a few weeks.

The panel below summarises what is required to broadcast high quality audio signals. Analog hifi systems and uncompressed digital systems (eg, compact disc) aim to produce a close replica of the original sound but this uses wide bandwidth and can require high transmission power.

The AAC+ compression process

aims to transmit what your ears and brain perceive but employs much reduced bandwidth and transmission power.

Digital Radio – The System

In an AAC+ encoder, the following information is sent to the receiver:

- A loudness signal
- Pitch/timbre signal
- Spectral Band Replication signal
- Parametric Stereo signal.

Let's take a general view of how these signals are produced and then

we will have a more detailed look at the AAC+ encoder.

At the bottom of the diagram (Fig.1) at right is an 88-key music keyboard but with grey "extensions" added at either end. The grey keys do not exist but match frequencies of sound if the keys did exist. So in music all frequencies above 4kHz are harmonics of the key used. The power of these frequencies is used to control the SBR signal.

You will also notice that the frequency difference between keys at the low frequencies is much less than at high frequencies. This follows the brain's ability to detect a change in pitch. AAC uses a "comb" filter and the bandwidth of each of the "teeth" (ie, individual filters) is not equal – it is much wider at the higher frequencies.

Loudness Signal

The average ear is most sensitive at about 4kHz and least sensitive at the extremes of the audio band. So to measure the loudness of the sound the comb filter characteristic in Fig.1 is used.

The sound power entering the microphone can vary from just audible to the threshold of pain. This is a dynamic range of 1:1,000,000,000,000 or 120dB.

It is accepted that if the sound is twice as loud, the measured power increase is +10dB or 10 times the original power. It is also true that if the sound is half as loud the power is one tenth of the original or -10dB.

The human ear has a logarithmic response to sound power. This allows us to hear sounds from the faint rus-



Your ear measures – at the ear drum

1. Total acoustic power (volume)
2. Fundamental frequency
3. The power of each harmonic frequency
4. The sound in this ear is less powerful at high frequencies than the other ear
5. The sound in this ear is delayed compared to the other ear at lower frequencies
6. Reverberation or echo delay

Analog systems and uncompressed digital systems aim to produce an exact replica of the original sound. Uses large bandwidth and can require high power.

Your brain hears –

1. Loudness: soft or loud
2. Pitch: low or high (the note played)
3. Timbre: which instrument is being played
4. Sound direction: left, centre, right, above, below, in front or behind
5. Distance of the sound source: close or distant

AAC and AAC+ systems transmit what your brain hears and then recreates the sound it needs to produce the same result in your brain. Much reduced bandwidth and lower transmission power are required.

by
Alan Hughes

coders

the digital audio
the amount of
quality signal.

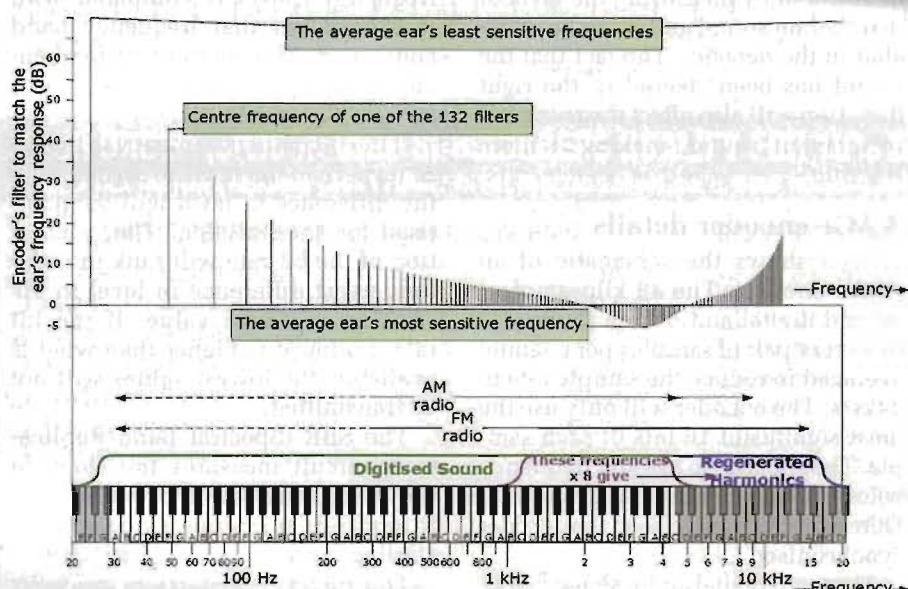


Fig.1: the comb filter in an AAC+ encoder has 132 centre frequencies and these are used to generate the pitch/timbre information.

ting of leaves to the roar of jet engines. The digital audio signal is handled the same way, ie, logarithmically. The end result is the loudness signal which is called the scaling factor.

Pitch/Timbre Signal

Another characteristic of our hearing is "masking. This is where a strong single frequency is heard but softer frequencies in a frequency band either side of this single frequency cannot be heard.

The comb filtering effect is created by taking samples of the signal at the centre frequency of the "teeth". This sampling will cause additional alias signals to be generated.

To use this effect the digital signal is

analysed by a Fast Fourier Transform (FFT). It converts a waveshape into the frequencies used to create this shape. The difference in level between the FFT signal and the level from the comb filter is calculated.

This difference is measured and sent to the decoder. Any signals where the output of the FFT is less than the comb filter output will not be sent, ie, they are discarded on the assumption that they will be masked and could not be heard.

The resulting quantised filter samples are then sent to the encoder.

Spectral Band Replication (SBR)

The frequency range above 11kHz has less effect on the perceived quality of the sound and requires a lot of data

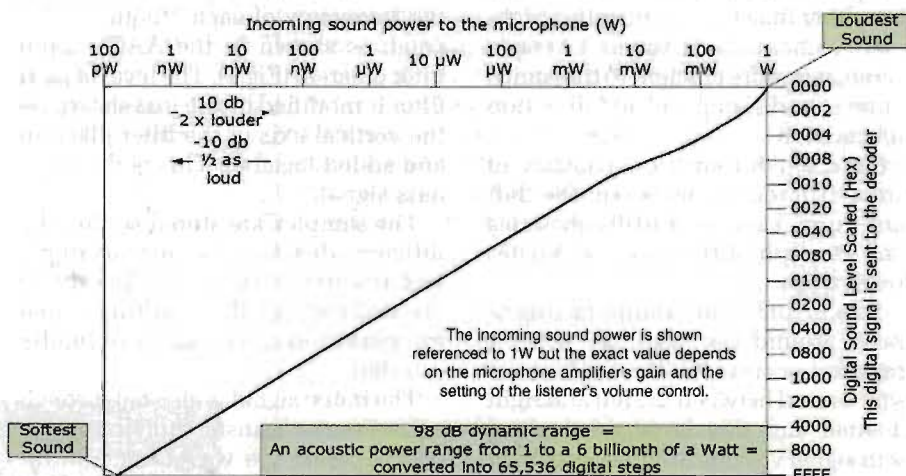
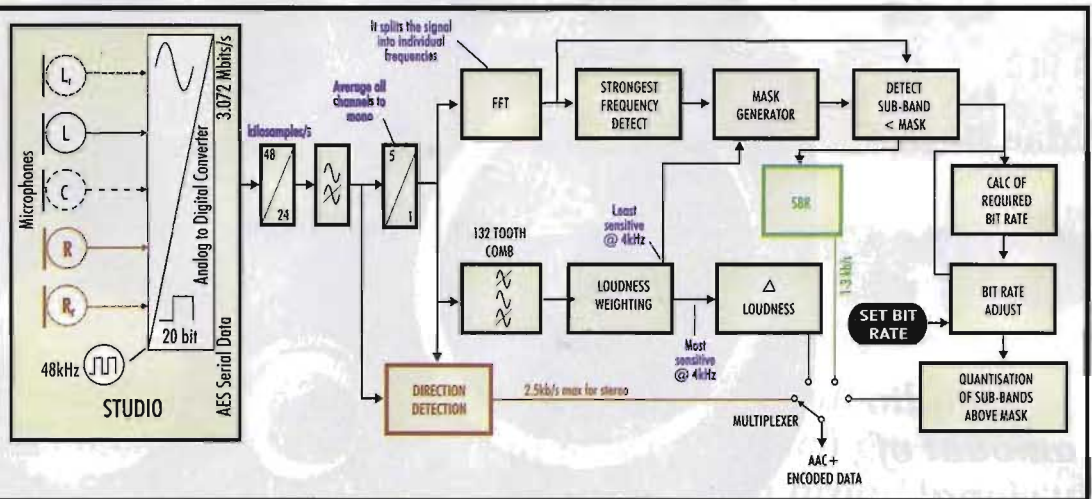


Fig.2: the huge dynamic range of audio signals must be compressed before being transmitted. The compression information becomes the loudness signal or scaling factor produced by the AAC+ decoder.

Fig.3: an AAC+ encoder takes 48kHz sampled data from the studio, averages it to 24ks/s, removes info below 10Hz, averages it to mono, passes it to an FFT and generates masking info and SBR info. The comb filter produces the loudness weighting info. Also added is direction info for stereo and parametric 5.1 info.



to reproduce. As a result the sample rate has been halved to 24kilosamples/second. This is done by averaging every pair of 48kHz samples. This will reduce the maximum frequency to 11.3kHz. The missing harmonics in the sound will be simulated in the decoder.

Unless the sound is a pure tone, the frequencies above 11kHz are harmonics of lower frequencies. The encoder measures and sends the level of the sound frequencies above 11kHz. This level is sent (within the SBR signal) to the decoder to control the level of the regenerated harmonics above 11kHz. If the sound is random, then random high frequencies will be used instead of harmonics.

Parametric Stereo

Most people prefer stereo sound of reasonable quality to mono sound. At high rates of compression the addition of direction greatly improves the perceived quality of the sound. But rather than transmitting two high-quality channels of sound to create stereo, it is more efficient to transmit a mono sound signal and add direction information.

Direction information consists of time differences between the left and right ears at mid-frequencies and strength differences at higher frequencies.

This is due to the sound having to travel around the head. So when a transient occurs, the time difference is measured between the left and right channel and this is encoded along with signal volume differences at high frequencies.

Normally only the strongest signals are transmitted and as a result, the

subtle sound reflections which cause reverberation are removed. These can be restored by measuring the level of reverberant sound and it can be recreated in the decoder. The fact that the sound has been steered in the right direction will also affect the recreated reverberant sound, making it more realistic.

AAC+ encoder details

Fig.3 shows the schematic of an AAC+ encoder. The 48 kilosamples/second digital audio from the studio has every pair of samples per channel averaged to reduce the sample rate to 24ks/s. The encoder will only use the most significant 16 bits of each sample. The signal also has any frequency below 10Hz, including DC, removed. Otherwise it's hard to keep the decoder synchronised.

The main digital audio signal has all time-coincident samples averaged to produce a monophonic signal.

A comb filter samples the audio at the frequency of each "tooth" of the comb as shown in the AAC+ comb filter diagram (Fig.1). The level of each filter is modified by the loss shown on the vertical axis of the filter diagram and added together. This is the loudness signal.

The samples are stored so that the difference between the current sample and the previous sample is sent to the decoder. So the resulting signal for transmission says makes it louder or softer.

The mono signal is also fed through a Fast Fourier Transfer function which will separate the waveform into individual frequencies. The strongest frequency is used to increase the sensitivity to the surrounding frequen-

cies. This characteristic is added to the loudness weighting. Now each frequency's level is compared with that signal in that frequency band concerned. The component frequencies are compared with the respective masked signal level.

If the incoming frequency is higher in level than the masked signal, then the difference in level will be quantised for transmission. The calculation of the bit rate will rank in order the largest difference in level to the smallest non-zero value. If the bit rate produced is higher than what is available, the lowest values will not be transmitted.

The SBR (Spectral Band Replication) circuit measures the slope of the decreasing levels of harmonics. It transmits this slope value and the starting level.

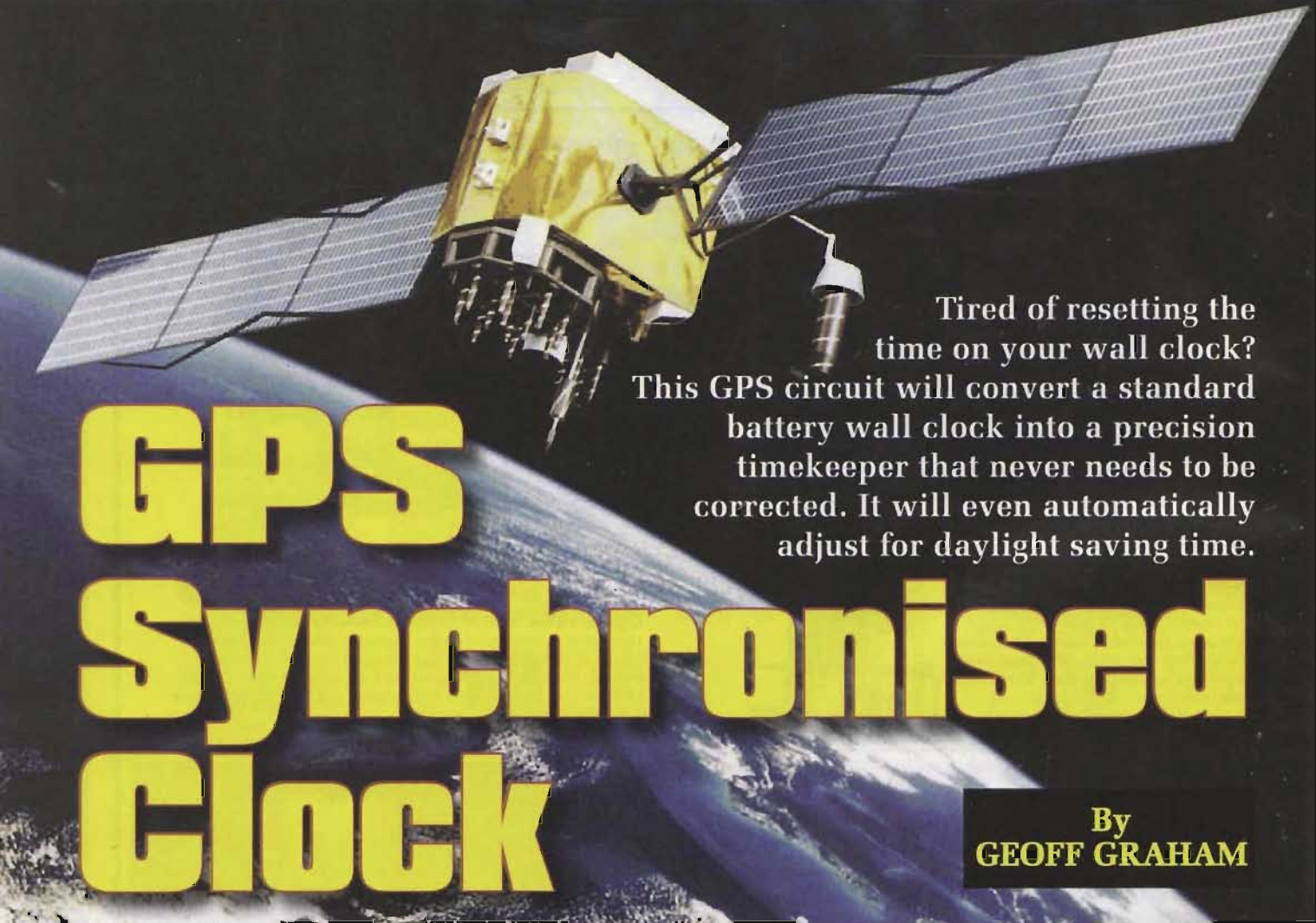
The direction detection measures the level difference between the input channels and the mono signal for frequencies above 2.5kHz. The same applies to the phase differences for signals between 250Hz and 2.5kHz.

Lastly, the time difference of signal transients in each channel is compared to the mono channel. A multiplexer will select the output signals in the pattern required by the standard.

So in conclusion, the following information is sent to the decoder (via the encoder and transmission):

- Loudness (Dynamic Range Control or Scaling Factor signal)
- Pitch/timbre (Quantised filter output signals & SBR signal)
- Direction (Parametric Stereo/5.1 signal).

Next month we will look at digital radio transmission and the subsequent program decoding in the receiver. **SC**



GPS Synchronised Clock

Tired of resetting the time on your wall clock? This GPS circuit will convert a standard battery wall clock into a precision timekeeper that never needs to be corrected. It will even automatically adjust for daylight saving time.

By
GEOFF GRAHAM

Battery-powered quartz crystal clocks are very common and they keep good time, with a typical accuracy of two seconds per day. However, that couple of seconds can add up. After a month it could be a minute out and after a few months, you are up on a chair again to reset it to the correct time.

Wouldn't it be nice if you never, ever had to do that again?

This design replaces the electronics in a standard quartz wall clock with a controller that synchronises itself via the GPS (Global Positioning Satellite) system. It uses a relatively inexpensive (US\$70) GPS module to get the precise time and a microcontroller to control the hands of the clock. It will run for about a year on two alkaline AA batteries and over that period will keep the time accurate to within a few seconds.

Even better, it understands the rules of daylight saving (DST) and will automatically adjust by skipping forward an hour at the legislated time and date when daylight saving starts. When

daylight saving stops, the clock will stop for exactly an hour at 3.00AM, – and start again when the indicated time is correct.

It is also easy to use. All you need do is set the hands of the clock (including the seconds hand) to the 12 o'clock position and then insert the battery. The controller will use the GPS to get the current time and then step the clock hands at double speed around the dial until it has reached the correct time. It will then drop back into normal time-keeping mode with the time derived from a crystal oscillator.

To conserve the battery, the GPS module is only used to synchronise the clock every 44 hours and following synchronisation, the clock will either skip seconds or double-step to reach the correct time. After synchronisation the microcontroller is also able to calculate the inherent inaccuracy of its crystal oscillator and will compensate by occasionally skipping or double-stepping a second. This process can also compensate for aging of the crystal and will keep the clock accurate

between synchronisations.

The controller also monitors the battery voltage and when it has dropped below 2V, the microcontroller will stop the clock at exactly 12 o'clock. You then replace the battery and it will repeat the start-up process by stepping to the correct time.

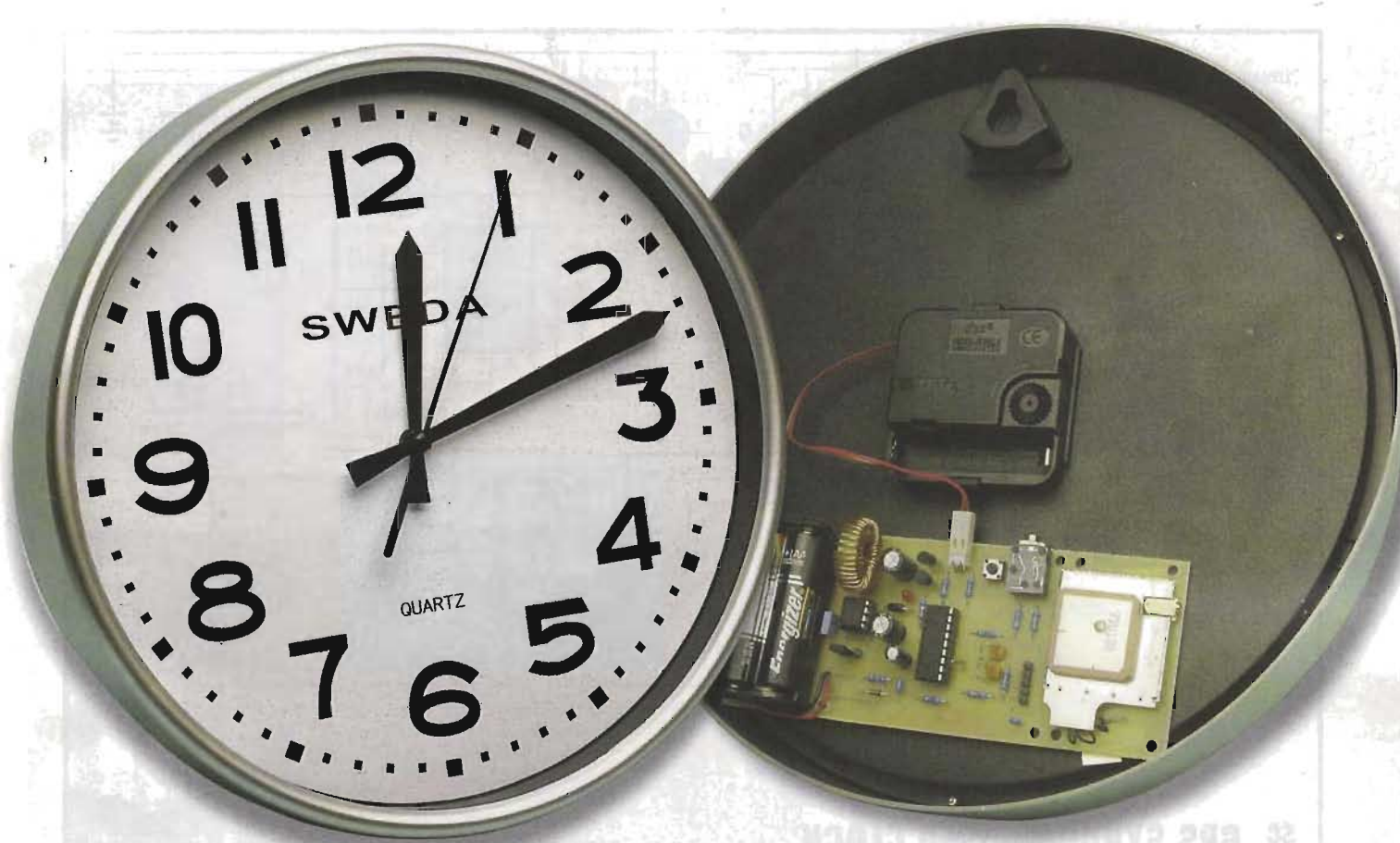
In short, you never have to set the time.

How it works

First of all, let's look at a standard battery-operated wall clock. It uses a crystal oscillator and a divider to generate a pulse every second to drive a simple stepper motor and, via gears, the hands of the clock. The crystal oscillator is normally quite accurate, especially when the clock is new – but it's affected by age, by temperature, by battery voltage... all of which can add up to seconds a week.

Our circuit replaces the clock's electronics and generates compatible pulses to drive the stepper motor.

The heart of our controller is a PIC16LF88 microcontroller which



It looks just like a bog-standard battery-powered wall clock and in fact, it started out life as such. But it's only when you turn it over . . .

You can see it has something that's not bog standard – a GPS module, microprocessor and driver. And no, we haven't forgotten to put the clock movement battery in!

uses a 32.768kHz watch crystal to drive a timer within the chip. This timer generates an interrupt which is used by the software running on the microcontroller to keep time. The software is where all the hard work is done and it is quite complex. As an illustration of this complexity, drafting the circuit of the GPS Clock took just a few hours, while the software took many weeks to develop.

A normal clock cycle starts at the beginning of a new second. The timer will generate an interrupt which causes the processor (CPU) in the microcontroller to wake up and execute the interrupt code. The program will perform some calculations (more on this later) and then raise the voltage on one of the clock lines. It then sets the timer to generate another interrupt exactly 40ms after the first interrupt (you can change this) and promptly puts itself back to sleep.

After 40ms, the timer will wake the CPU again and the program will lower the voltage on the clock line, terminating the pulse to the clock's stepper

motor. The program then will set the timer to 960ms and go back to sleep. This repeats, second after second.

During the sleep period, everything except the crystal oscillator and the timer is shut down, resulting in a current drain of only a few microamps drawn by the microcontroller. In addition, the CPU in the microcontroller will run at full speed for only 60µs to 100µs while processing an interrupt, so the total current drawn by the microcontroller is negligible. Most of the current, in fact, is drawn by the clock stepper motor – which is the case with a “standard” battery-operated clock (see the box: Calculating Battery Life).

At the start of a new second the program compares where the clock hands are actually positioned and where we would like them to be. The software does this with two variables, which hold the current position of the clock's hands in seconds and the desired position. Depending on the result of this comparison, the program will bring the clock's hands closer in agree-

ment to the correct time by skipping a pulse to the clock's stepper motor or by generating a double step.

Normally the variable representing the desired position is simply incremented every second but the beauty of this arrangement is that we can control the position of the clock's hands just by changing this variable. The code within the interrupt routine will automatically bring the hands of the clock into agreement. This is useful when, for example, daylight saving starts – we simply add 3600 seconds (one hour) to the desired position and the clock will fast forward until it is an hour ahead.

When it is time to synchronise, the program will keep running after an interrupt (ie, it will not return to sleep). It then applies power to the GPS module and waits for the GPS to return an accurate time reading. With this reading the microcontroller has some hard work to do – it must convert it into an internal representation (seconds since 1st January 2000), apply the time zone offset, calculate if daylight



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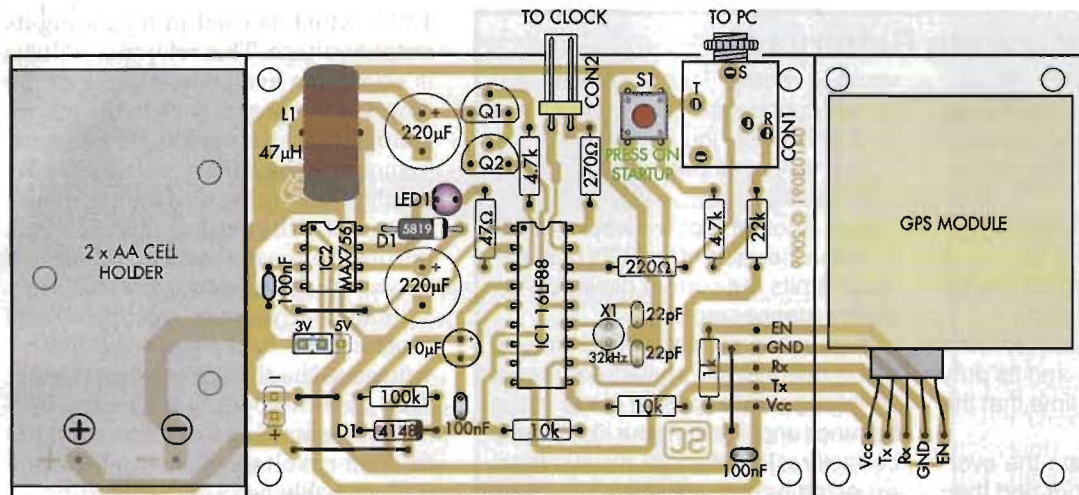
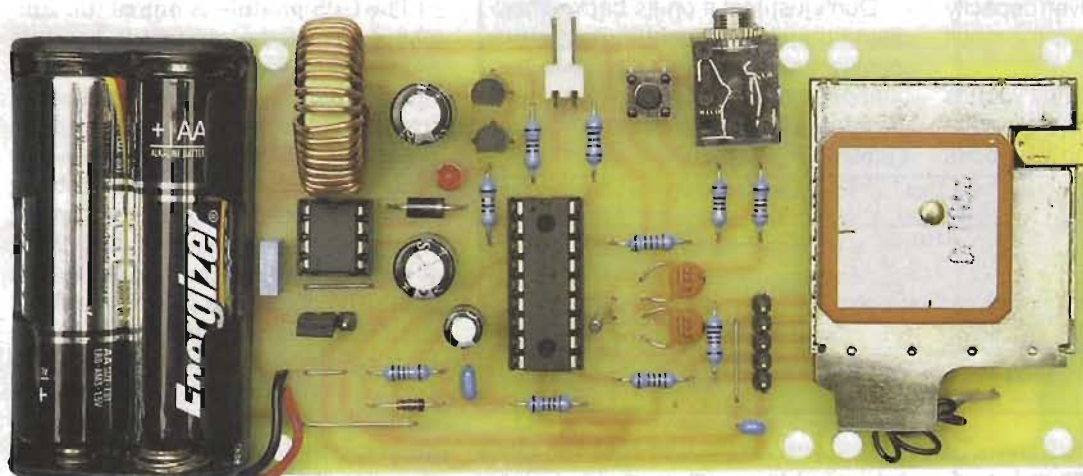


Fig.2: the component overlay for the GPS Synchronised Clock controller board, along with matching photograph below. Not shown here but mentioned in the text is the fact that an IC socket should be used for the microcontroller (IC1) but should NOT be used for IC2 due to the currents involved. The two AA cells on the left side of the PC board should last for at least a year in this application.



interprets the output of the module.

The specified chip (with LF in the middle) is the wide voltage version of this common microcontroller and is guaranteed to operate down to 2V, whereas the standard chip (PIC16F88) is only guaranteed to 4V.

Having said that, you will probably find that a standard PIC16F88 will operate without fault to below 2V. So, if you have a PIC16F88 in your parts box, give it a go before hunting for the LF version.

The 100kΩ resistor and 10µF capacitor connected to pin 4 of IC1 serve to hold the microcontroller in reset for about a second after the batteries have been inserted. This provides enough time for you to properly seat the batteries in the battery holder before the microcontroller starts executing its program. Diode D1 prevents the capacitor from discharging into the microcontroller when the batteries are removed.

The serial interface connector CON1 is linked to the microcontroller via a few protective resistors. This design

relies on the fact that nearly all modern serial RS232 interfaces use a threshold of about 1.5V between a high and low signal. This is not what the full RS232 standard specifies but we use this fact to provide a simple interface to a personal computer for configuring the clock.

Crystal X1 provides a stable time-base for the clock with the two 22pF capacitors providing the correct loading. Normally the accuracy of the clock between GPS synchronisations would be dependent on trimming these capacitors to achieve a frequency of exactly 32.768kHz but as the software automatically corrects for any errors, this is not required.

The microcontroller applies power to the GPS module by pulling its pin 3 low. This turns on the Darlington transistor pair of Q1 and Q2, resulting in about 2.7V (with fresh AA cells) appearing at the collector of Q2. This voltage is stepped up by IC2, a MAX756 DC-DC converter. IC2 operates by drawing a current through inductor L1 and then suddenly cutting

it off. The collapsing magnetic field causes a positive voltage spike across the inductor that is dumped via diode D2 into the 220µF capacitor.

IC2 can operate with a low supply voltage and still deliver a closely regulated output of 3.3V or 5.0V. The actual output voltage is controlled by pin 2 and this can be configured on the PC board to suit the GPS module in use.

L1 must have a saturation current rating of 1A or greater. This means that it should be wound with heavy gauge wire on a powdered iron core; an RF choke will not work. The parts list provides two alternatives. Also, both the 220µF capacitors must have a low ESR (equivalent series resistance). Diode D2 is a 1N5819 Schottky type specified for its low voltage drop. Don't be tempted to substitute an ordinary silicon diode as its higher voltage drop will lower the efficiency of the DC-DC converter and limit its operation at low battery voltages.

Note that with a minimum battery voltage of 2V and a 0.7V drop through

Calculating Battery Life

With an application such as this, battery life is important. After all, what is the point of a clock that does not need adjustment if you are forever changing the batteries?

To calculate the battery consumption, we need to divide the activity of the circuit into phases according to the current drawn from the battery.

Then, for each phase, we determine the current consumption and its duty cycle (the percentage of time that the current is drawn).

Finally, we can calculate the average current drawn per hour and then the battery lifetime for a given capacity of battery. The table below is the result for our prototype.

This table clearly indicates what is the major power user and this is the current drawn while driving the clock's

stepper motor. This is where you should concentrate your efforts if you wish to improve the battery life.

One way to do this is to reduce the width of the pulse using the set-up menu. Another option would be to increase the value of the 270Ω resistor which limits the current drawn by the clock's stepper motor.

If you experiment with either of these options you should connect a variable power supply in place of the batteries and test that your clock steps correctly at less than 2V, the minimum expected battery voltage.

Don't just test it on its back either; stand the clock upright in its normal position as you might find that the stepper motor does not have enough power to lift the second hand against gravity.

Function	Current Draw (mA)	On Time (seconds)	Total Time (seconds)	Duty Cycle	Consumption (mA hour)
PIC in sleep	0.004	158355	158400	99.97%	0.004
Clock step pulse	6	0.04	1	4.00%	0.240
During GPS synch	80	45	158400	0.03%	0.023
Battery self discharge*	0.009	1	1	100.00%	0.009
TOTAL DRAIN (mA hours)					0.276

Lifetime for alkaline AA cells (capacity of 2400 mA hours*) in months

12.1

* source: Energiser Alkaline Handbook Alk1.1

Q2, the voltage delivered to IC2 can be as low as 1.3V. The MAX756 has a typical minimum start-up voltage of 1.1V, so normally it should be OK. However, the specs for the MAX756 say that this might be as high as 1.8V on some devices. So, if you get one of these

chips, you might find that the clock will shutdown (stop at 12 o'clock) before the battery drops to 2V. This is unlikely but the only solution is to try a few different chips. All our samples worked without fault.

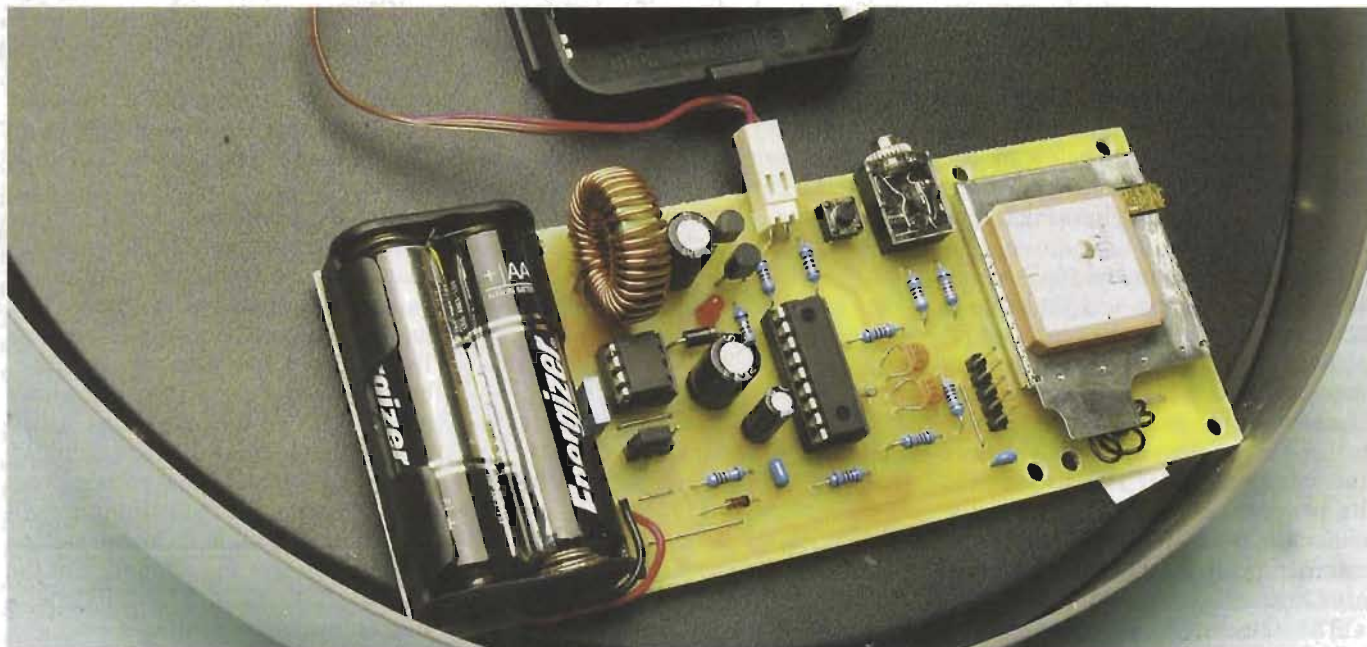
IC2 generates a reference voltage of

1.25V which is used in regulating its output voltage. This reference voltage is also made available at pin 3 of the chip and we pass it back to the microcontroller which uses it as a reference to measure the battery voltage. By accurately measuring the battery voltage, we can stop the clock at the 12 o'clock position before the batteries get too low to operate the microcontroller.

Incidentally, the microcontroller is programmed to measure the battery voltage at the time of greatest current draw (about 160mA) when the GPS module is starting up. If you measure the battery voltage without a load, you will probably get a higher reading.

The GPS module is one of the simpler parts of the circuit. It has two connections for power, two for communications to the microcontroller (transmit and receive data) and an enable signal. We pull the enable line high with a 1kΩ resistor so that the module is always enabled when power is applied. As we do not send anything to the GPS module (the manufacturer's default configuration suits us just fine), the receive data line is also pulled high by the same 1kΩ resistor. The 10kΩ resistor on pin 10 of the microcontroller limits the current into the microcontroller when the GPS module operates at a higher voltage.

The microcontroller drives the clock stepper motor from pins 17 and 18. The 270Ω resistor limits the current so that the coil of the stepper motor sees about 1.5V, which is the normal supply for



There is usually plenty of room (assuming the clock is large enough!) to fit the PC board, which includes the 2x "AA" battery holder and the GPS module. It can be held in place with some double-sided adhesive foam pads.

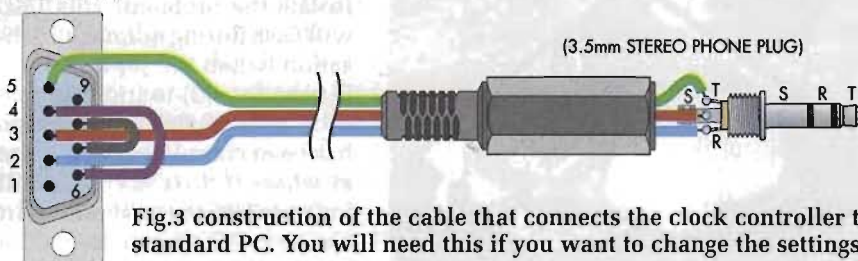


Fig.3 construction of the cable that connects the clock controller to a standard PC. You will need this if you want to change the settings.

this type of clock. The clock pulses alternate so that the first clock pulse is delivered by momentarily raising pin 17 high while pin 18 is held low – this will step the clock's hands by one second. For the next second this is reversed and pin 18 is taken high while pin 17 is held low. This cycle is repeated to drive the clock's hands around the dial.

Construction

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.2.

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 GPS Clock (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. The other cable can be used if you need to unplug the GPS module from the board and test with your computer (see box: Experimenting With 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 done before the board is powered up.

GPS Clock firmware 1.1

```

1 = Set timezone (hrs)                (now +10.0)
2 = Set daylight saving off            (now on)

3 = Set start daylight saving month    (now 10)
4 = Set start daylight saving Sunday   (now 1)
5 = Set end daylight saving month      (now 4)
6 = Set end daylight saving Sunday     (now 1)

7 = Set clock pulse (msec)             (now 40)
8 = Set GPS update (hrs)                (now 44)

Q = Quit

```

Command:

The setup menu is self-explanatory and provides prompts to help you. With it, you can set the clock to operate anywhere in the world.

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 | |

* 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.

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.

Powering up

Before you plug in the GPS module, you need to make some tests. With IC1 plugged into its socket, insert two fresh batteries in the battery holder. After a second you should see one flash from the Startup LED, followed by a further two flashes another second or so later. These indicate that the microcontroller and the DC-DC converter, respectively, are working. If you do not get these indications you should refer to the section on troubleshooting.

After the double flash, the microcontroller will wait for two minutes, expecting some data from the GPS module before shutting down the DC-DC converter. In this time, you need to measure the voltage at the connector to the GPS module. It should be between 3.2V and 3.5V, which is the safe range for the module. To reliably measure the voltage you need a load for the DC-DC converter, so connect a resistor of about 330Ω across your multimeter leads.

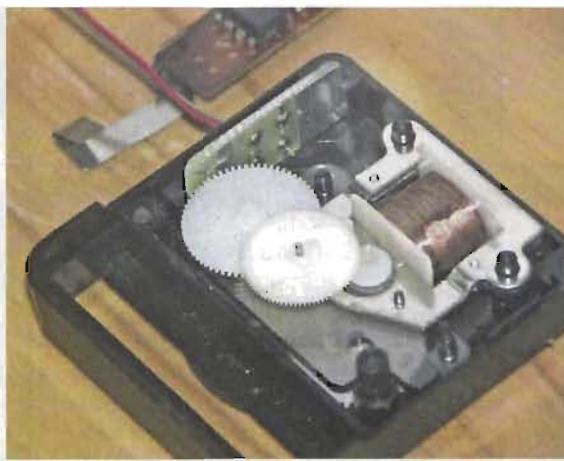
Now that you have confirmed that you will not blow up your GPS module you can remove the batteries and plug in the GPS module. The module should be attached to the PC board using double-sided adhesive tape.

Finally, replace the batteries and the controller should go through the whole startup sequence as described in the section on troubleshooting.

Modifying the clock mechanism

Jim Rowe's article in the March 2008 issue of SILICON CHIP provided a good description of the modifications required to access a clock's stepper motor. You will have to remove the cover from the clock mechanism, identify the leads to the stepper motor coil, cut and terminate these somewhere, and finally connect them to a lead terminated with a 2-way header plug. The stepper motor coil should be easily identified, as it will be a large coil of enamelled copper wire. Every clock is different so you will be on a journey of discovery here.

You can check your modification



The insides of a typical quartz clock mechanism showing the modifications we made to terminate the connecting leads to the stepper motor coil.

by using a 1.5V battery. Just connect the battery to the wires leading to the stepper motor coil, then reverse the battery and repeat. On each connection, the clock's second hand should step by one second.

The method of attaching the PC board to your clock will also vary but in the simplest case, you can use double-sided adhesive tape to hold it onto the back of the clock. The board has been designed so that you can cut off the area holding the batteries or the area holding the GPS module, or both. This might come in useful if you need to squeeze it into a small space.

Note that this design will only work with the standard type of quartz clock that "ticks" every second. Some modern clocks with a sweep second hand employ a different drive mechanism and will not work with this controller.

Troubleshooting

Hopefully your clock will work

first time but if it does not, you can use the Startup LED to help isolate the problem. This LED will flash during normal initialisation (when the set-up button is not pressed) to indicate that each step of the initialisation has been completed. The point at where it does not flash will indicate where you should start hunting. When you insert the batteries you should see the following signals in sequence:

One Flash: the microcontroller has started up. If you do not get this then something is fundamentally wrong with the microcontroller or the batteries.

Two Flashes: the MAX756 DC-DC converter has started up (determined by measuring a voltage on pin 3 of IC2). If you fail to get this signal you should check IC2 and its associated components. Check for approx 2.7V (with fresh batteries) on the collector of Q2 and between 1.23V and 1.27V on pin 3 of IC2.

Three Flashes: the GPS module is working and has transmitted its startup message. If you do not get this then check the wiring to the module. The GPS module is very sensitive to its power supply. Check that this is between 3.2V and 3.5V. If you have an oscilloscope, check that there is less than 150mV peak-to-peak noise superimposed on the supply rail to the GPS module.

Four Flashes: the GPS module has locked on to sufficient satellites and has responded with an accurate time signal. This can take up to 90 seconds or more, so be patient. Immediately following the GPS lock



You will need a PC terminal emulation program to change the clock controller's settings. Many free programs are available for download on the Internet.

(four flashes) the clock should double step around the dial to reach the correct time. If this does not happen, it means that the crystal oscillator (X1) is not working or the clock's stepper motor is not correctly wired to the controller. In particular, check that you have isolated the clock's electronic module and soldered your wires properly to the stepper motor coil.

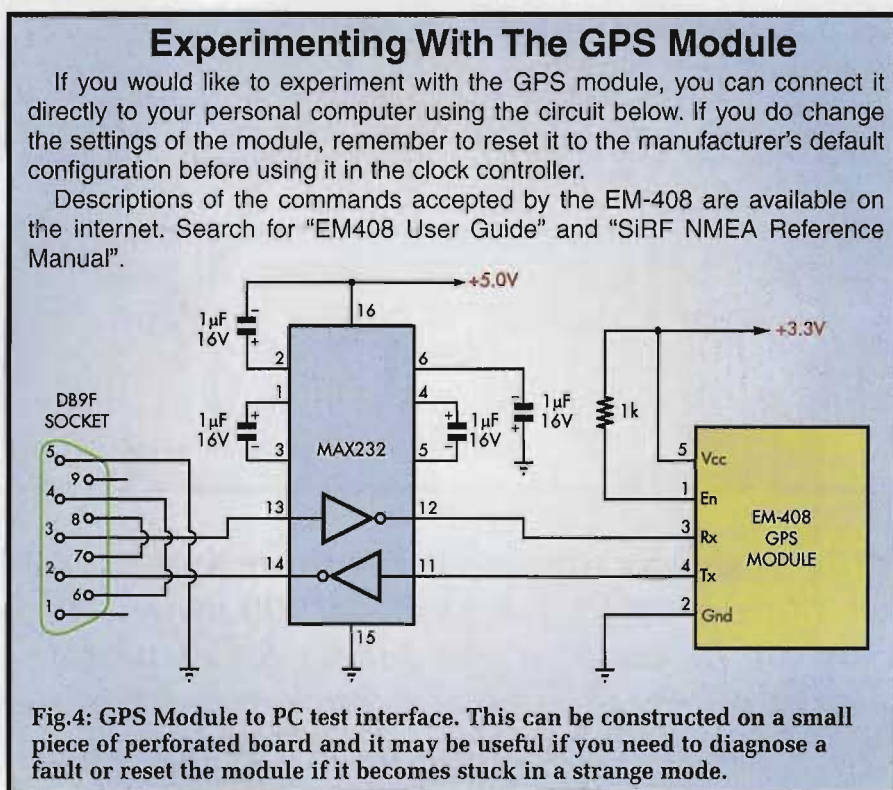
Incidentally, to save the clock from having to double-step for hours to reach the correct time, it makes sense to power up the clock shortly after 12 o'clock (ie, your local time). In that way, it will only take about ten minutes or so for the clock to finish double stepping and revert to normal accurate time keeping.

Set-up

By default, the controller is configured for the NSW, Victorian and Tasmanian time zone and daylight saving rules. If you live in these states and the government has not changed the daylight saving rules (unlikely), then you do not need to do anything.

If you live in another state, you will need to change the settings by connecting the GPS Clock to a serial RS232 port on a personal computer. If your computer does not have a "legacy" serial port then a USB to RS232 converter cable will do fine.

The cable from the clock controller to the PC is the same as the serial download cable used by Revolution Education Ltd for their PICAXE experimenter board, so if you have been programming PICAXEs, you can get double use from it! It is terminated at one end with a stereo phono connector and a 9-pin D connector at the other



end – see Fig.3 for details. These cables are available from Microzed (www.microzed.com).

You will also need a serial terminal emulation program running on your computer configured for 4800 baud, 8 data bits, no parity and one stop bit. Many free programs are available on the Internet including PuTTY, RealTerm or Hercules Terminal Emulator. Use Google to search for one or more of these names.

To enter set-up mode, hold down the Set-up button while you install fresh batteries and continue to hold it down until you see the menu. The

Startup LED will also flash when the microcontroller transmits a character to your computer, and this may help in diagnosing communication problems.

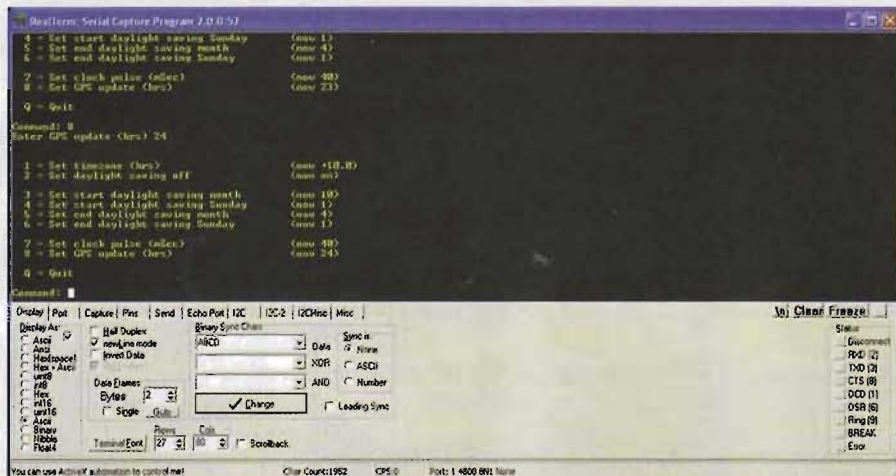
If you are observing daylight saving you can select any month for the end or start. You can also set the day for the event (1st, 2nd, 3rd or last Sunday in the month). The time of the day that daylight saving starts (2AM) is fixed in the program, as is the end time (3AM).

The clock pulse width can be changed in steps of 8ms and this setting might need to be adjusted to suit your clock. Most clocks work with the default 40ms but some may need 48ms or even 56ms to reliably step with a low battery voltage. Finally, to gain a little extra accuracy or improve battery life you can change the interval between GPS synchronisations.

All changes are saved in non-volatile memory and therefore will be retained, even when you remove the battery.

Well, that's it. With your clock properly set up you can hang it on the wall and be assured that at least one clock in the house is accurate.

Incidentally, you can also check the clock's accuracy at any time if you have internet time enabled on your desktop computer.



It is easy to reconfigure the clock for different time zones and clock mechanisms. When you change a setting you are prompted to enter the correct data.

NEW, IMPROVED THEREMIN

This design is an upgrade of our most popular Theremin which was featured in the August 2000 issue. We have added a voicing control, incorporated a larger loudspeaker and increased the power output. We've also changed the power supply to avoid problems with switchmode DC plugpacks.

By JOHN CLARKE

If you are not familiar with the Theremin, we should give a brief rundown on this most unusual instrument. It is an electronic musical instrument that can be altered in pitch and volume using proximity effects.

To play the instrument the right hand is moved horizontally toward the antenna to increase the pitch and away from the antenna to reduce the pitch. Left hand movements over the horizontal plate provide volume control. The volume is reduced as you move your hand closer to the plate.

In operation, the pitch change afforded by the antenna is infinitely variable over several octaves. In some ways this is similar to playing a trombone whereby the slide is moved back and forth to vary the pitch. Although most people can play the instrument at first attempt, an ear for pitch and fine hand control are essential requirements to become proficient at playing the Theremin.

Several fine performances by Peter Pringle using a Theremin are presented at www.peterpringle.com/thereminmp3s.html. These demonstrate only a fraction of what can be accomplished with a Theremin in the hands of a skilled musician. The same website has links to YouTube performances, some of which are quite remarkable.

The fascination with the instrument, when it was first invented by Leon Theremin in 1919, was that it represented a revolutionary change in thinking about how music could be produced. It challenged traditional stringed, brass and percussion musical instruments. Its design eventually led to the development of the Moog Synthesiser

and electronically synthesised music in general. Even today that fascination with producing sounds electronically is still prevalent. If you are interested in the history of the Theremin there is more information in the section headed "Theremin Origins".

The Theremin invention was not only instrumental in the development of electronic music; it also had an impact on a free-form style of playing music. The free-gesture hand control afforded by the Theremin was the harbinger of the modern Sensor Chair synthesiser controller where the whole body becomes a part of the musical generation process.

Before this, Jimi Hendrix was creating new sounds by generating feedback between his guitar and the amplified sound and then moving his body to modulate the amplitude. It freed him from the restriction of generating music solely by plucking the guitar strings.

In recent times there has been quite a renewal of interest in the Theremin and there is a lot of information on the Internet. However, none of it is really helpful if you want to build your own Theremin.

This is where the SILICON CHIP Theremin comes into the picture. It uses just three low cost ICs and a handful of other components. Our Theremin is considerably smaller than the original design too, although you could build it into a larger timber box if you prefer.

As noted above, this design is an upgraded version of our very popular Theremin that was published in August 2000. Interest in that

Specifications

Power requirements.....12VAC at 250mA minimum or 12V DC at 250mA
Current draw:30mA with no sound from loudspeaker,
up to 200mA at full volume.
Output frequency rangeGreater than five octaves, from 50Hz to >2kHz
Volume control range.....>60dB
Audio output level.....600mV RMS

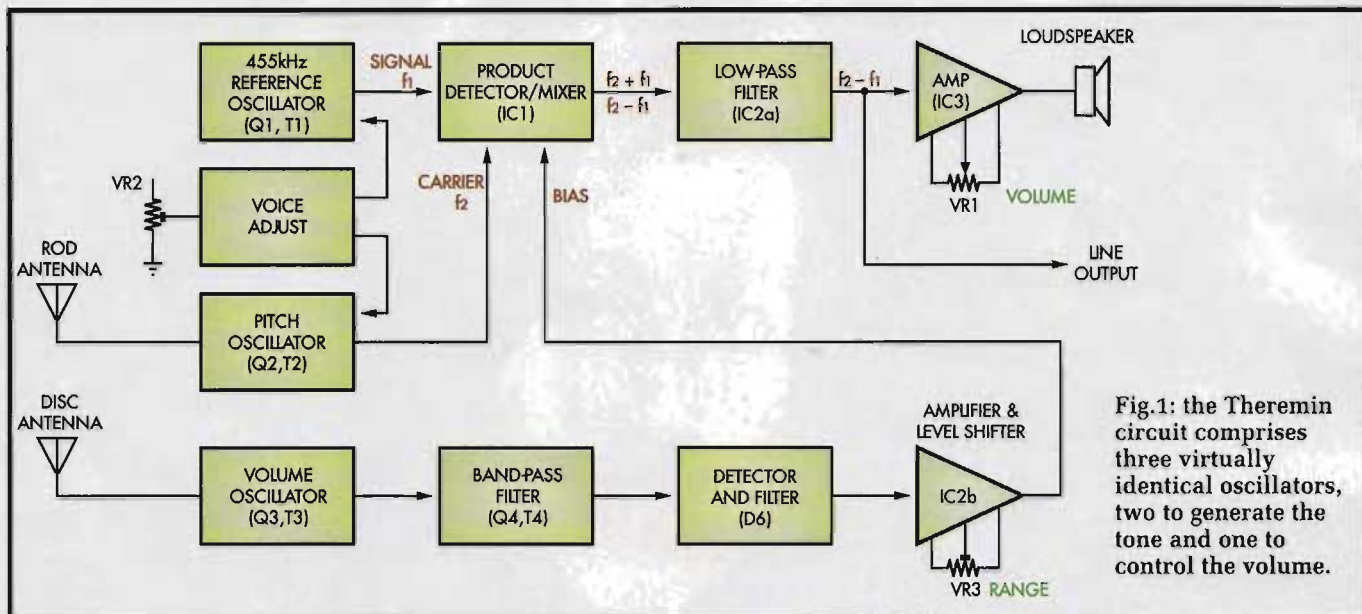


Fig.1: the Theremin circuit comprises three virtually identical oscillators, two to generate the tone and one to control the volume.

project far exceeded expectations and kits are still being built in Australia and around the world in large numbers. Compared to the August 2000 design, this latest Theremin is easier to construct, with minimal wiring, and it also includes a larger internal loudspeaker.

Our new Theremin is built into a medium-sized plastic box with the antenna and volume plate mounted at opposite ends. The internal loudspeaker is for practice sessions and a line output is included for connection to a sound system. The only manual controls are an On/Off switch and Volume control for the loudspeaker. A 12VAC adaptor powers the Theremin.

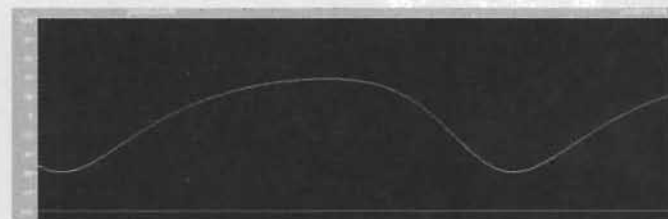
Our original Theremin (August 2000) was designed to run from a 9VDC plugpack. However, DC plugpacks now being sold are switchmode types and these do not work well with a Theremin. They can produce extraneous pitch changes, because a Theremin relies on very small capacitance changes with respect to earth (ground) to alter the pitch of the tone.

Switchmode plugpacks effectively ground capacitance either at the switching rate and/or the mains frequency (50 or 60Hz). This will cause a Theremin to misbehave unless the power supply earth is fully grounded.

The way around this dilemma is to change the supply to use a plugpack with an AC output. In this case, there is no internal switchmode circuitry and therefore no extraneous pitch changes.

Voicing

Our August 2000 design produced a fairly pure sine-



This shows the Theremin output at 100Hz with the minimum setting for the voice. The sound is relatively pure and similar to the original August 2000 Theremin.

wave tone that was not fully characteristic of a Theremin, which should have a richer harmonic content. Hence, the new design includes a voicing control. This varies the tone from a pure sinewave to something akin to a cello sound at low frequencies, extending to soprano voice at the higher frequencies.

Below and on the facing page, we have included a number of screenshots from Nero Wave Editor (see separate panel to see how we did it!) to show the typical waveforms available from our new design.

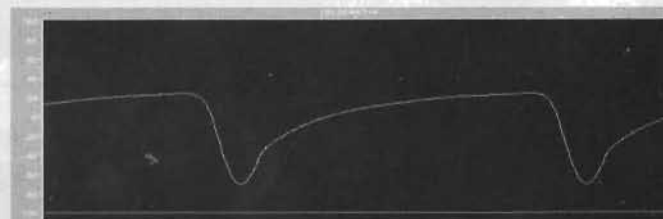
How it works

The block diagram of Fig.1 shows the basic arrangement of the Theremin circuit. It comprises three oscillators that all operate at about 455kHz. A beat signal is generated by mixing the reference and pitch oscillators together to produce an audible tone. The volume oscillator is then used to change the level of the tone output.

The reference oscillator operates at a fixed frequency and is mixed with the pitch oscillator in the product detector (IC1). The pitch oscillator changes in frequency depending upon the amount of capacitance to earth presented by your hand near the antenna.

The product detector essentially mixes the reference oscillator (f_1) with the pitch oscillator (f_2) to produce sum ($f_1 + f_2$) and difference ($f_2 - f_1$) frequencies.

The sum ($f_1 + f_2$) signal is around 900kHz and is removed with a low-pass filter. After filtering we are left with the difference signal of $f_2 - f_1$. This normally comprises audio frequencies from 2kHz down to below 10Hz.



Now the same 100Hz frequency but with the voicing adjusted to maximum. The sound produced by this waveform is more reminiscent of a cello.

So if the pitch oscillator frequency is 456kHz and the reference oscillator is at 455kHz, we will obtain a 1kHz audio output from the low-pass filter. If both the pitch and the reference oscillators are at the same frequency, then there will be no audio output.

Varying the coupling between the pitch and reference oscillators provides for voicing. When the pitch oscillator frequency differs from the reference oscillator we obtain an output tone and the difference in frequency between the two oscillators tends to “pull” or distort the f_2 - f_1 wave shape so that it is not a sinewave. Potentiometer VR2 allows adjustment of the coupling and its consequent waveform distortion or voicing.

Audio output from the low-pass filter is applied to a power amplifier to drive a loudspeaker. The overall volume from the amplifier is set by the volume control VR1.

The sensor plate or disc controls the volume oscillator. As you bring your hand closer to the loop, the frequency of the volume oscillator decreases. This is fed to a bandpass filter that has a centre frequency (f_c) that is higher than the volume oscillator frequency.

As the frequency of the volume oscillator increases, the level from the bandpass filter will also increase as it approaches the centre frequency. Similarly, as the frequency of the volume oscillator decreases, the level from the bandpass filter will also decrease. Fig.2 shows the output of the bandpass filter in response to the change in volume oscillator frequency.

This signal level is detected using a diode and filtered to produce a DC voltage. Amplifier IC2b increases the DC voltage and the level shifter sets the voltage so that it can control the product detector output level over a suitable range via its bias input. Changing the biasing of IC1 alters the gain of this product detector.

Circuit details

The full circuit of the Theremin is shown in Fig.3. It comprises three JFETs (Junction Field Effect Transistors), four pre-wound IF (Intermediate Frequency) transformers, three ICs, several diodes, a 3-terminal 9V regulator and associated resistors and capacitors.

All three oscillators are essentially identical. Each oscillator comprises a JFET and a standard IF transformer. These IF transformers are commonly used in low-cost AM radio receivers. Each IF transformer comprises a tapped main winding and a parallel connected capacitor to form a tuned circuit. The secondary winding couples the oscillator signal to the following circuitry.

Each JFET drives a portion of the primary winding (ie, between the tapped connection at pin 2 and ground) while the signal across the full winding is applied back to the gate via a 68pF capacitor. This provides the positive feedback

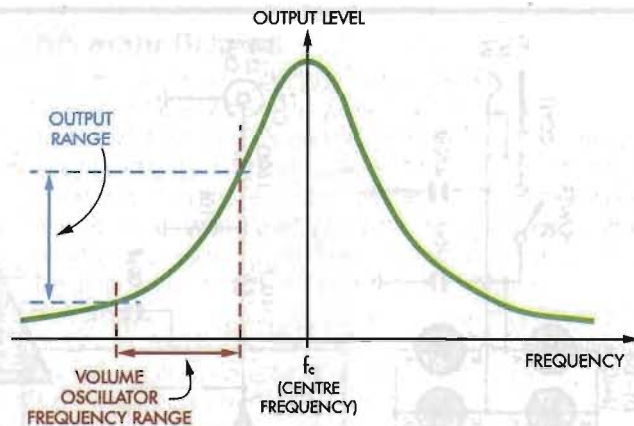


Fig.2: the output of the bandpass filter in response to the change in volume oscillator frequency. As the frequency of the volume oscillator increases, the level from the bandpass filter will also increase as it approaches the centre frequency of the filter. Similarly as the frequency of the volume oscillator decreases, the level from the bandpass filter will also decrease.

to ensure oscillation.

To make them controllable by hand capacitance, the Pitch and Volume oscillators have the pitch antenna and volume disc attached to the top (ie, active end) of the tuned coils, where they will have the most effect.

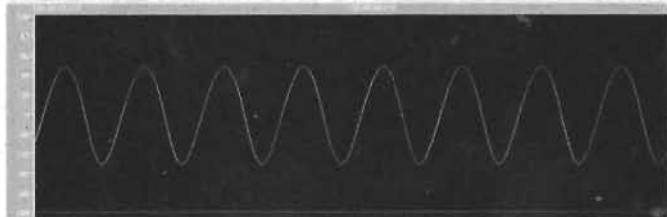
Diode coupling

Diode D5 connects the signal from pin 2 of transformer T1 (reference oscillator) to pin 2 of transformer T2 (pitch oscillator) via 10nF capacitors. The diode is used as part of a capacitive divider with the 10nF capacitors whereby its junction capacitance varies with the applied reverse voltage across it. This reverse voltage is provided by trimpot VR1 and can be adjusted between 0 and 9V. The diode anode (A) connects to ground (0V) via a 100kΩ resistor while the cathode (K) connects to the wiper of VR2 via another 100kΩ resistor.

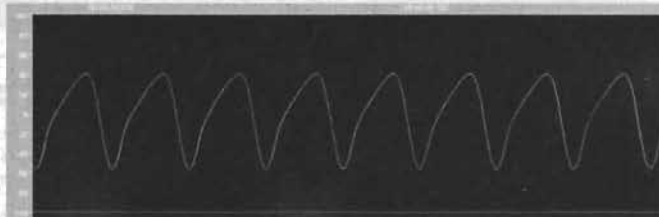
With VR2 wound fully up to the 0V supply, there is no reverse voltage across D2 and this provides the maximum capacitance across the diode and therefore maximum coupling between the two oscillators.

When VR2 is wound fully toward the positive 9V supply the diode is reverse biased and provides minimal capacitance. Maximum capacitance of the diode is very small, at around 4pF, but this is sufficient to produce the coupling action required.

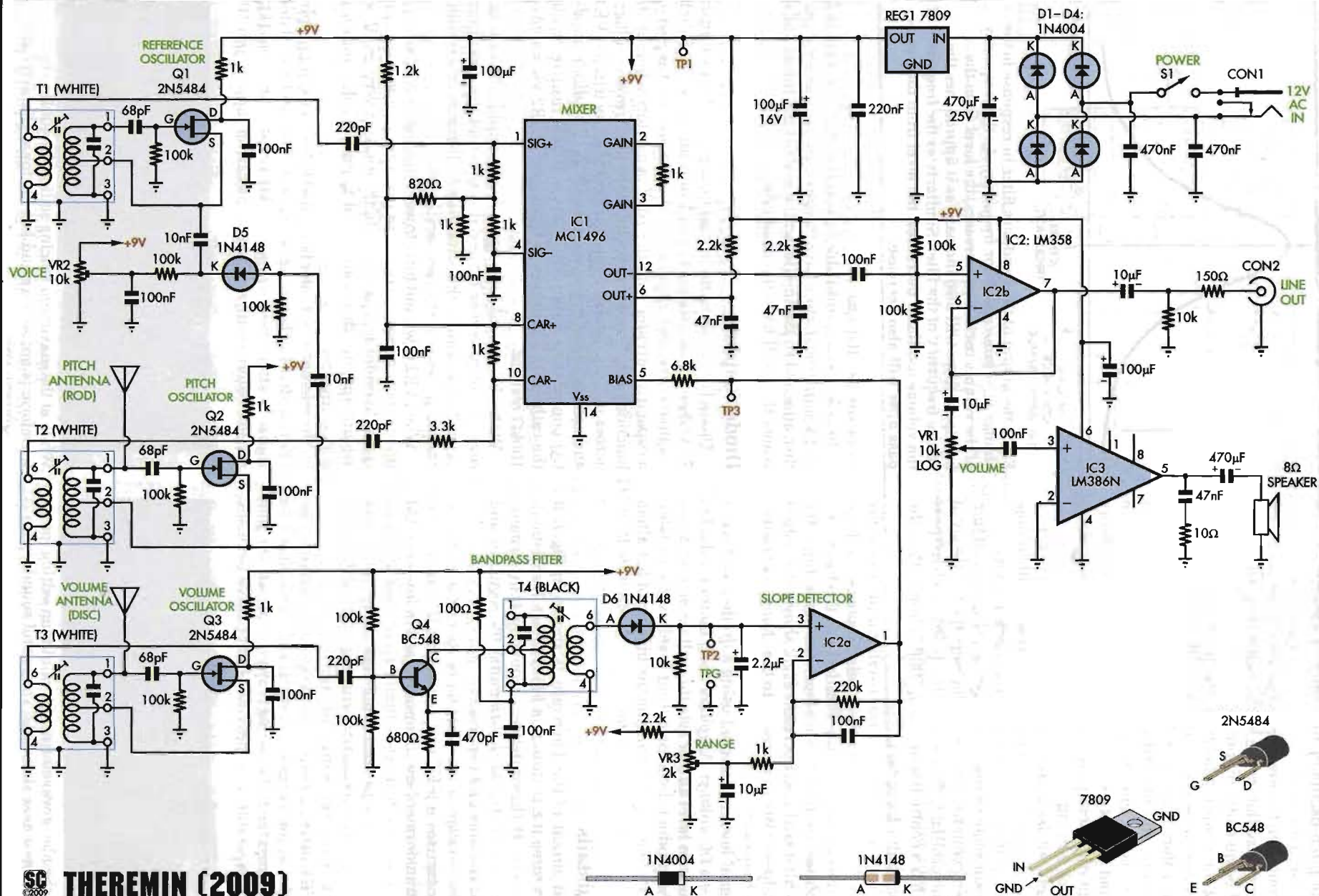
The reference oscillator is applied to the signal input (pin 1) of an MC1496 balanced mixer, IC1. The pitch oscillator signal is attenuated using a 3.3kΩ resistor and the 1kΩ resistor before being applied to the carrier input at pin 10.



At 400Hz the above waveform with minimum setting for the voicing has a near sinusoidal shape and sounds 'pure' in tone.



While at the maximum voicing setting for 400Hz, the waveform is not so pure and has the tonal characteristic of a soprano voice.



This reduction in signal level is to prevent overloading the mixer stages of IC1. Resistors between the +9V supply and ground set the bias voltages for the inputs of the balanced mixer, while the 1k Ω resistor between pins 2 & 3 sets the gain of the circuit.

IC1 provides a balanced output with signals at pins 6 and 12. These complementary outputs are filtered with a 2.2k Ω pullup resistor and 47nF capacitor to produce a rolloff above about 1.5kHz. This rolloff heavily attenuates frequencies at 455kHz.

The output from pin 12 is AC-coupled to op amp IC2b. IC2b is biased at half-supply using the two 100k Ω voltage divider resistors across the 9V supply.

This biasing allows the op amp to produce an output of 600mV (~850mV peak) above and below 4.5V without clipping. IC2b's output signal also goes to the line output terminal.

IC3 is an LM386 1W amplifier that drives the loudspeaker via a 470 μ F electrolytic capacitor. The 47nF capacitor and series 10 Ω resistor form a Zobel network to prevent spurious oscillation from the amplifier.

Volume oscillator

Output from the volume oscillator at the secondary winding of T3 is AC-coupled to the base of transistor Q4. This is connected as a common emitter amplifier with the collector load being a parallel-tuned circuit comprising an IF coil with internal capacitor.

T4 and the associated capacitor are tuned to a frequency just above the maximum available from the volume oscillator. The emitter resistor is bypassed with a 470pF capacitor to provide a rolloff below about 500kHz.

The output level from transformer T4 will vary in proportion to the frequency from the volume oscillator. This is because the filter provides a sharp rolloff below its tuning frequency and small changes in frequency below the centre frequency will cause large changes in the filter response. The action of this circuit is a simple frequency modulation (FM) detector.

High frequency signal from T4 is rectified by diode D6 and filtered to provide a DC signal which is amplified by op amp IC2a.

Amplification can be up to about 220 times with VR3 set at 0 Ω . Typically, the gain is about 100 since VR3 is set so that IC2a's output sits at about 7V with the hand away from the volume plate or disc. IC2a's output is then fed via a 6.8k Ω current limiting resistor to the bias input of IC1 at pin 5 to vary the level of the audio signal.

Power supply

As mentioned above, power for the circuit comes from an AC plugpack. Alternatively the Theremin could be powered from a 12V battery or an earthed DC power supply. As already noted, a 12V DC switchmode plugpack supply is not suitable. Most "plugpack"-type supplies sold these days are switchmode types, so be careful with this one!

Switch S1 applies power to the circuit. The 470nF capacitors on each side of the input supply ground the AC connections to swamp any capacitance effects of the plugpack to ground. This ensures there are no spurious sounds from the Theremin due to the plugpack.

Diodes D1-D4 rectify the 12VAC voltage and this is then filtered with a 470 μ F capacitor to provide a relatively

Theremin Origins

In 1919, a Russian physicist named Lev Termen (or Leon Theremin as he is called in the western world) invented an electronic musical instrument called the "Theremin". At that time, the Theremin was innovative and unique in the musical world and was essentially the first electronic instrument of its kind. Playing it relied solely on hand movements in the vicinity of two antennas to control two electronic oscillators – one antenna to vary the pitch of the sound and the other to change the volume.

In operation, the pitch change afforded by the antenna is infinitely adjustable over several octaves, with the frequency increasing as the hand is brought closer to the antenna. An ear for pitch and fine hand control are essential requirements to become proficient at playing the Theremin.

To a large extent, the Theremin was made famous by recitalist Clara Rockmore. Born in Lithuania in 1911, she was an accomplished violinist by 5-years old. She began to learn to play the Theremin after meeting Leon Theremin in 1927 and ultimately developed a unique technique for playing the instrument. This technique involved minute finger movements to capture and modulate the tone of the note and enabled her to play the instrument with great precision.

The Theremin was subsequently further developed and manufactured by the Radio Corporation of America (RCA) around 1929. This design consisted of a large box with an attached antenna and wire loop. The antenna provided the control for the pitch while the loop enabled the volume to be adjusted.

In practice, the pitch control antenna was mounted vertically while the volume loop sat horizontally, to minimise interaction between them. And of course, the circuit used valves.

General Electric (GE) and Westinghouse also made Theremins in the 1920s. However, the number of units produced was quite modest, with only about 500 being made.

Today, the Theremin is hailed as the forerunner to modern synthesised music and was instrumental in the development of the famous Moog synthesisers. Because of its unique sound, it has been popular with music producers for both film and live performances. The sound is ideal for background setting the scene for supernatural events and for close encounters with extraterrestrial beings in science fiction movies.

Famously, a Theremin was used to produce background music in the feature film "The Ten Commandments" by Cecil B de Mille. Its eerie sounds have also made it ideal for science fiction movies, including the 1951 and the 2008 versions of "The Day the Earth Stood Still" and "It Came From Outer Space", and in thriller movies such as "Spellbound" and "Lost Weekend".

In addition, Bands such as the Bonzo Dog Band and Led Zeppelin have embraced the Theremin. The Beach Boys used an instrument similar to the Theremin – called an Electro-Theremin (also named a Tannerin) – in their famous "Good Vibrations" hit from the 1960s. The Electro-Theremin differs from the Theremin in that it incorporates a mechanical controller to adjust the pitch rather than hand movements relative to an antenna. The sound, however, is very similar to the Theremin.

Many commercial Theremins are available on the market today, including the Etherwave series from Moog Music Inc, PaiA's Theremax and Wavefront's Classic and Travel-Case Theremins. Silicon Chip has also been prolific with three previous designs for home construction – a basic Theremin in August 2000, a MIDI Theremin in April and May 2005 and the Mini Theremin in July and August 2006.

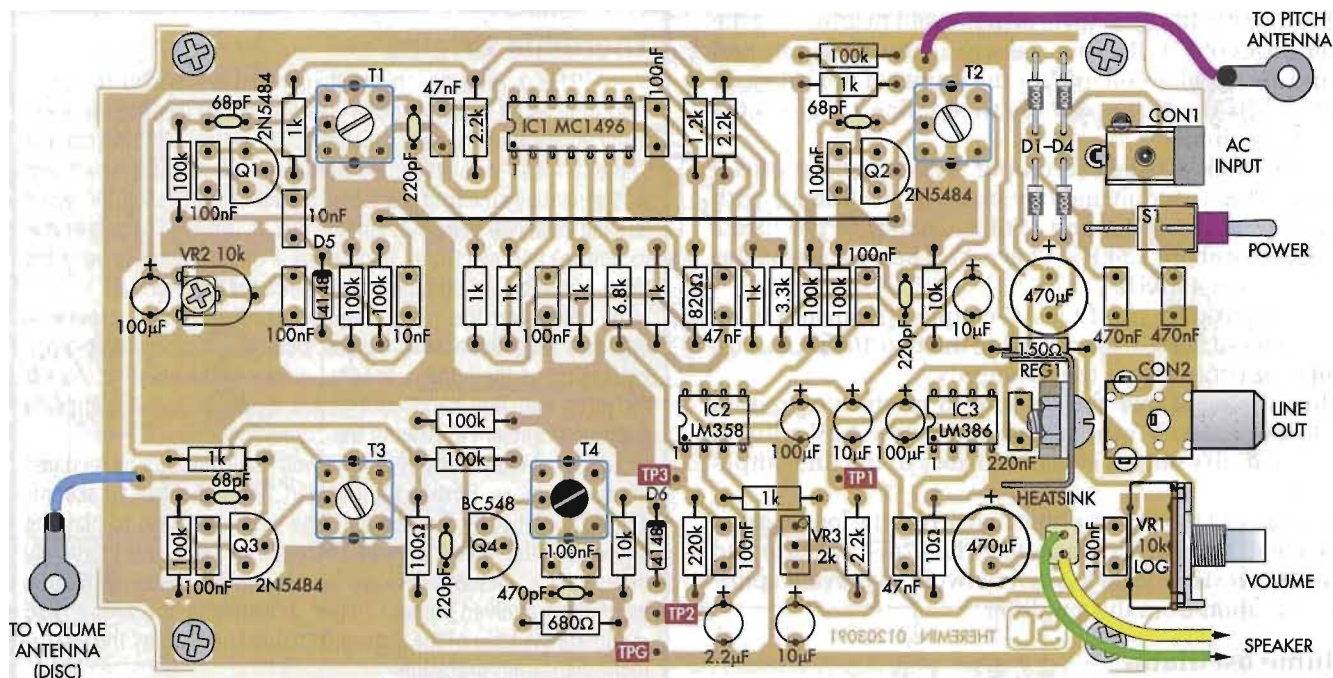
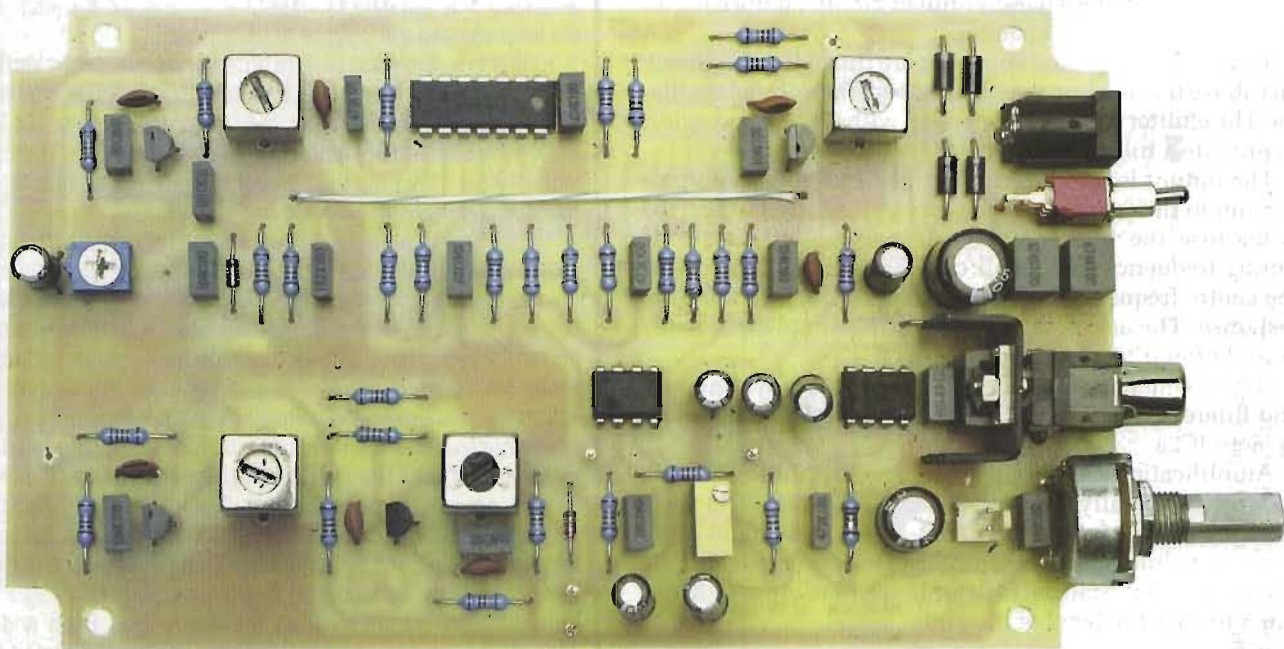


Fig.4 (above): everything except the speaker, volume plate and pitch antenna mount on a single PC board, so construction and wiring should be quite easy. Note the differences in the transformers: three have white cores while one has a black core. This is very easy to see in the matching photo below – so don't mix them up!



smooth 16VDC supply for REG1. REG1 is a 7809 3-terminal regulator that delivers 9V to the circuit. A 220 μ F capacitor close to the regulator output ensures stability and several 100 μ F capacitors decouple the supply at positions further away on the PC board.

Construction

Most of the parts for the Theremin are assembled onto a PC board, coded 01203091 and measuring 147 x 85mm. This is housed in a plastic utility box measuring 158 x 95 x 53mm.

While our assembly description revolves around the plastic case with its small speaker, there is no reason why

you couldn't build it into a much larger case in keeping with a traditional musical instrument. An external power amplifier and loudspeaker would also make a considerable improvement to the overall sound quality.

Indeed, fitting it into a large box may also improve the operation – the “playability” if you like – of the Theremin. Separating the pitch (antenna) and volume (plate) controls may give you more control over both. Note that we haven't tried this idea out but there is nothing to stop you doing it if you want.

You can begin construction by checking the PC board for any defects such as shorts between tracks, breaks in the copper tracks and incorrectly drilled holes. Check the



The control end of the Theremin – from left to right the volume control, line output socket, power switch and 12V AC power input.

hole sizes for the IF transformers (T1-T4), the PC mount components including the power socket, the RCA socket and potentiometer VR1. Four corner mounting holes should be drilled to 3mm. Holes for the PC stakes should be sized to suit their diameter; they should be a tight fit.

Check that the PC board fits into the plastic case and that it has clearance for the corner pillars. The PC board should have its corners shaped to provide this clearance. If this has not been done, a rat-tail file can be used to shape each corner to the outline shown on the PC board pattern. Before proceeding further, mark out the hole positions for the four corner mounting points for the PC board on the base of the case and drill these out to 3mm.

The component overlay for the PC board and the wiring details are shown in Fig.4. The long link on the PC board is made using a 80mm length of hookup wire. It is cut and the end stripped so that it is held straight between the two PC pads on the PC board. You can now insert the resistors. Use the resistor table as a guide to selecting each value. In addition, use a digital multimeter to check each resistor value before it is soldered in.

The three ICs can be mounted next, taking care with their orientation. Make sure that IC2 & IC3 are placed in their correct positions. Next, the capacitors can be mounted, noting that the electrolytic types are polarised and must



Here's how the pitch antenna mounts: a small cutout in the case lid allows it to be mounted to the side of the case via the screw clearly visible in this photo.

Parts List – Theremin 2009

- 1 PC board, code 01203091, 147 x 85mm
- 1 plastic utility box, 158 x 95 x 53mm
- 1 front panel label, 155 x 92mm
- 1 12VAC 500mA plugpack (do not use a switchmode 12VDC plugpack)
- 1 telescopic antenna, 6.5mm largest diameter (875mm fully extended) (pitch antenna)
- 1 80 x 95mm aluminium plate, 1mm thick (for volume)
- 1 PC-mount DC socket (2.5mm diameter pin)
- 1 panel-mount RCA socket
- 1 SPDT miniature PC-mount toggle switch (S1)
- 1 75mm 8Ω loudspeaker
- 3 2nd IF coils (white) (T1- T3)
- 1 3rd IF coil (black) (T4)
- 1 mini TO-220 heatsink, 19 x 19 x 9.5mm
- 1 knob to suit potentiometer with 2 nuts
- 2 solder lug eyelets
- 1 2-way pin header plug
- 1 2-way pin header socket
- 12 M3 x 10mm screws
- 3 M3 nuts
- 4 9mm tapped Nylon standoffs
- 4 stick-on rubber feet
- 1 260mm length of medium-duty hookup wire
- 1 80mm length of light duty hookup wire (wire link)
- 1 100mm cable tie
- 7 PC stakes

Semiconductors

- 1 MC1496P balanced modulator (IC1)
- 1 LM358 dual op amp (IC2)
- 1 LM386N-1 1W audio amplifier (IC3)
- 1 7809 3-terminal regulator (REG1)
- 3 2N5484 or 2N5485 N-channel JFETs (Q1-Q3)
- 1 BC548 NPN transistor (Q4)
- 4 1N4004 1A diodes (D1-D4)
- 2 1N4148 signal diodes (D5,D6)

Capacitors

- 1 470μF 25V PC electrolytic
- 1 470μF 16V PC electrolytic
- 3 100μF 16V PC electrolytic
- 3 10μF 16V PC electrolytic
- 1 2.2μF 16V PC electrolytic
- 2 470nF MKT polyester
- 1 220nF MKT polyester
- 8 100nF MKT polyester
- 3 47nF MKT polyester
- 2 10nF MKT polyester
- 1 470pF ceramic
- 3 220pF ceramic
- 3 68pF ceramic

Resistors (0.25W, 1%)

- | | | | | |
|-------------------|--------------------------|---------|--------|---------|
| 1 330kΩ | 1 220kΩ | 8 100kΩ | 2 10kΩ | 1 6.8kΩ |
| 1 3.3kΩ | 3 2.2kΩ | 1 1.2kΩ | 9 1kΩ | 1 820Ω |
| 1 680Ω | 1 150Ω | 1 100Ω | 1 10Ω | |
| 1 10kΩ log | 16mm potentiometer (VR1) | | | |
| 1 10kΩ horizontal | trimpot (VR2) | | | |
| 1 2kΩ multi-turn | top trim trimpot (VR3) | | | |

Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
□ 1	330k Ω	orange orange yellow brown	orange orange black orange brown
□ 1	220k Ω	red red yellow brown	red red black orange brown
□ 8	100k Ω	brown black yellow brown	brown black black orange brown
□ 2	10k Ω	brown black orange brown	brown black black red brown
□ 1	6.8k Ω	blue grey red brown	blue grey black brown brown
□ 1	3.3k Ω	orange orange red brown	orange orange black brown brown
□ 3	2.2k Ω	red red red brown	red red black brown brown
□ 1	1.2k Ω	brown red red brown	brown red black brown brown
□ 9	1k Ω	brown black red brown	brown black black brown brown
□ 1	820 Ω	grey red brown brown	grey red black black brown
□ 1	680 Ω	blue grey brown brown	blue grey black black brown
□ 1	150 Ω	brown green brown brown	brown green black black brown
□ 1	100 Ω	brown black brown brown	brown black black black brown
□ 1	10 Ω	brown black black brown	brown black black gold brown

be oriented with the correct polarity, as shown in Fig.4. The MKT and ceramic types are coded and you can cross-check these codes against the values shown in the table opposite.

PC stakes are used for the antenna and volume disc connections, for the test points TP1-TP3 & TP GND and for securing VR1 to the PC board. These can be inserted and soldered in now. In addition, the 2-way pin header for the loudspeaker connection can be inserted now.

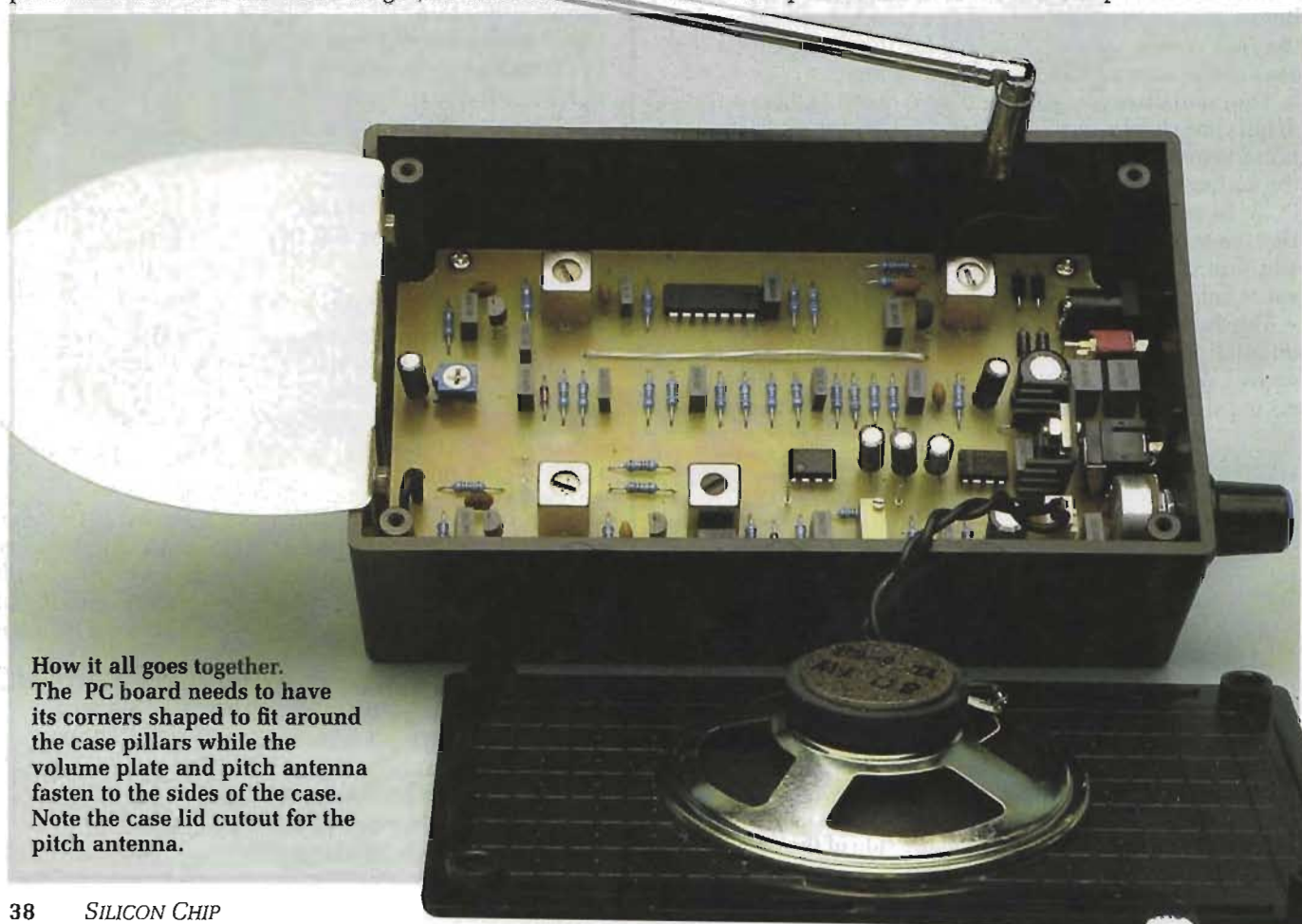
Transformers T1-T4 are mounted as shown. Be sure to place the ones with the white slugs (the threaded ferrite

core) in the T1-T3 positions and the coil with the black slug in the T4 position.

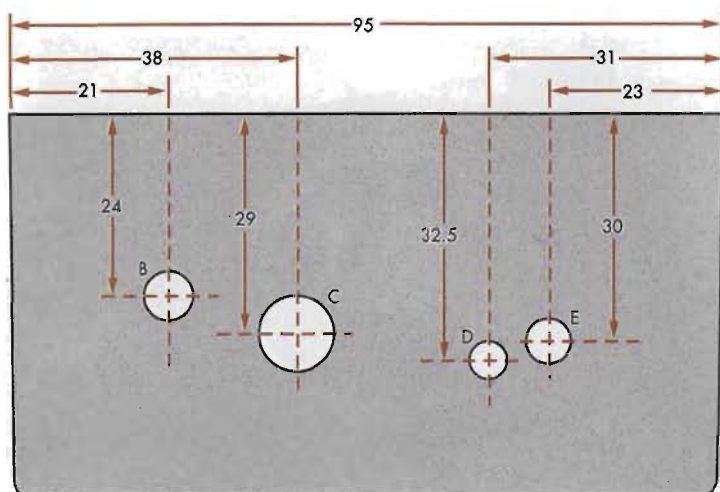
Now mount JFETs Q1-Q3 (2N5484), transistor Q4 (BC548) and the 7809 3-terminal regulator, REG1. 1N4004 diodes D1-D4 and the 1N4148 types for D5 and D6 can be mounted next, taking care with their orientation.

REG1 can be installed after the heatsink is attached to the metal tab, using an M3 x 10mm screw and nut.

Trimpots VR2 and VR3 can be mounted now. Potentiometer VR1 may require the shaft to be cut to length to suit the knob. The potentiometer is mounted in position as shown



How it all goes together.
The PC board needs to have its corners shaped to fit around the case pillars while the volume plate and pitch antenna fasten to the sides of the case. Note the case lid cutout for the pitch antenna.



HOLE B: 6.5mm DIAMETER
HOLE C: 10mm DIAMETER

HOLE D: 5mm DIAMETER
HOLE E: 6mm DIAMETER

END OF UB1 BOX CUTOUTS

Fig.5: the "Controls" end of the box showing the cutouts required. Hole B is for the volume pot, C the line out, D is for the power switch and E 12V AC power in.

and is supported using two PC stakes just behind the potentiometer body. Scrape or file off the passivated coating on the potentiometer body just at the positions where the PC stakes make contact. This will allow the PC stakes to be soldered to the potentiometer body. The soldering holds the potentiometer secure and the lower PC stake earths the potentiometer body to the circuit ground. Attach a nut to the pot securing thread. This is used as a spacer between the box and pot.

Next, the power socket, switch (S1) and the RCA socket can be inserted and soldered in place.

With the PC board complete, you are ready to work on the case. You will need to drill holes in the sides of the box for the DC panel socket, the RCA socket and for the antenna securing screw.

Volume plate

The volume plate is made from 1mm gauge aluminium, shaped as shown in Fig.6. One end is bent over at right angles so it can be secured to the side of the box using M3 screws and nuts. Mark out and drill the holes required in the side of the box. The aluminium disc is connected via a lead and solder lug to the PC board.

The antenna is attached to the side of the case with a



Looking inside the open case, this photo shows how the volume plate is secured.

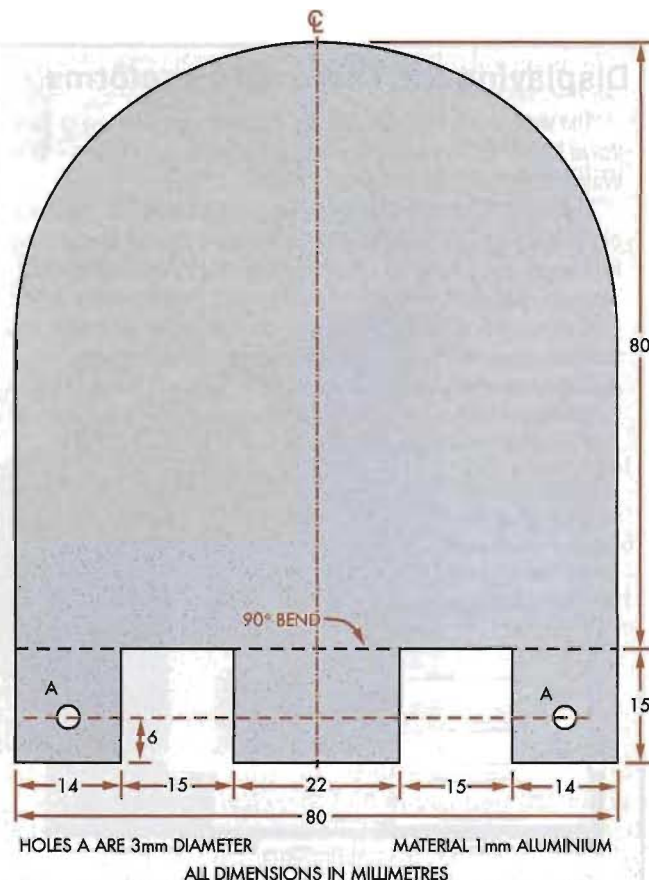


Fig.6: the 1mm thick aluminium volume plate. Both these diagrams are reproduced same size.

10mm long M3 screw that screws into the tapped base of the antenna. Mark and drill the hole in the side of the box. An eyelet is clamped between the box and antenna to make the wire connection to the PC board. Note that the lid of the box will require a half-circle cutout out to accommodate the antenna.

Mark and drill out the holes in the end of the box for the potentiometer, RCA socket, power switch and power socket as shown in Fig.5. Mount the PC board onto four 9mm tapped spacers using four 10mm M3 screws. Slide the PC board into the box so that the PC-mount components enter the holes and then push the opposite edge of the PC board down into the box.

Secure the PC board to the box with four M3 x 10mm screws into the 9mm standoffs from beneath the box. Attach the four rubber stick-on feet.

Attach the volume disc using two M3 x 10mm screws

Capacitor Codes

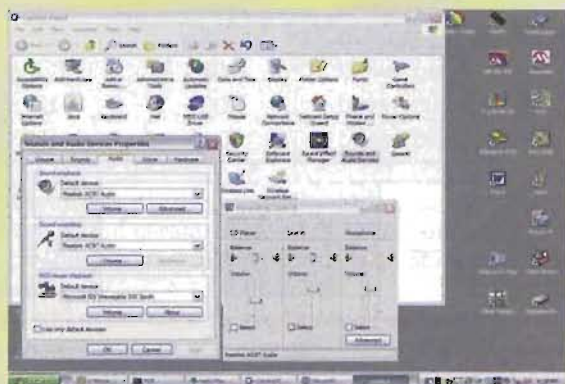
Value	μF value	IEC Code	EIA Code
470nF	0.47 μF	470n	474
220nF	0.22 μF	220n	224
100nF	0.1 μF	100n	104
47nF	.047 μF	47n	473
10nF	.01 μF	10n	103
470pF	NA	470p	471
220pF	NA	220p	221
68pF	NA	68p	68

Displaying the Theremin waveforms

The waveforms on pages 32 and 33 were recorded using Nero Wave Editor. Similar waveforms can be displayed using the NCH Wavepad or Audacity software or similar.

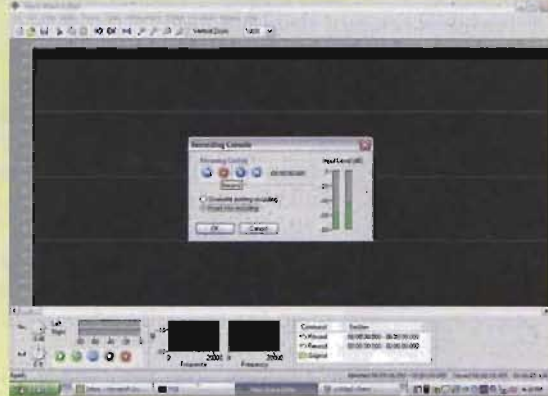
The signal from the Theremin was connected to the line input of the computer. An adaptor lead (RCA plug to 3.5mm stereo jack) is required to connect the Theremin output to the computer input. The recording will be in either the left or right channel as the single RCA output will only connect to one channel or the other.

In Windows XP, the signal levels are set to prevent clipping of the signal, by selecting <Control Panel>, <Sounds and Audio Devices Properties>, <Sound Recording Volume> and then adjusting the Line In slider.

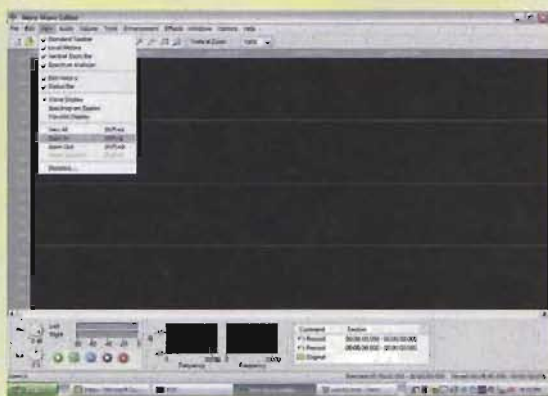


The level meter on the Nero Wave Editor Recording Console shows the signal reading and the volume is set for signal level below the 0dB maximum.

Signal is then recorded using a 16-bit 44.1kHz sample rate.



The recorded signal can then be expanded out to see the waveform in detail using the zoom in feature.



The internal speaker is secured to the lid with silicone sealant or other suitable adhesive.

and nuts and with the eyelet for the volume disc wire clamped under a nut.

The loudspeaker is centrally mounted on the lid which has a pattern of holes to let the sound out. We used 9 x 6.35mm holes with one in the centre and eight spaced evenly on a 16mm radius. The loudspeaker is attached to the lid of the case using contact or other suitable adhesive. Before affixing it, make sure that when the lid is placed in position, the speaker terminals face towards the 2-way connector on the PC board.

The loudspeaker is wired to the 2-way header socket on the PC board using two 70mm lengths of hookup wire. A cable tie wrapped around the wire and under the steel speaker frame at the loudspeaker connector will help prevent the wires breaking away from the connector.

Setting up

When your Theremin is complete, check your work carefully. Apply power and check that there is 9V between TP1 and TP GND (the voltage could range from between 8.75 and 9.25V).

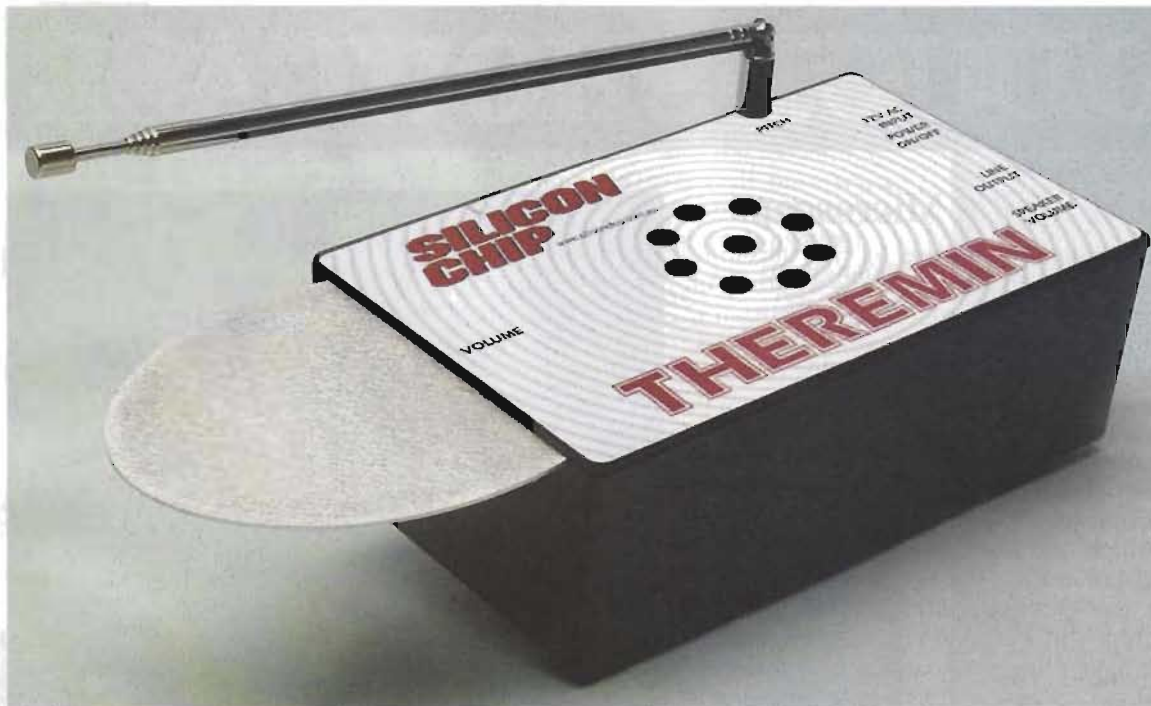
Using a suitable alignment tool, wind the slug for T2 clockwise until there is resistance to movement (do not force it). Then count the number of turns to wind it out anticlockwise completely. Set the slug half way between the two extremes.

Volume alignment

You must carry out the volume and pitch adjustments away from the effects of metallic objects, otherwise the Theremin will require retuning when removed from these grounding sources.

Wind the slug for T3 fully anticlockwise and then out again, counting the number of turns. That done, set T3 about 30% of turns anticlockwise. This will set the frequency of the volume oscillator (T3) to below the frequency of the pitch oscillator (T2) to prevent extraneous sounds that can be emitted if the two oscillators are close in frequency.

Now adjust T4's slug (with your hand and any multi-meter wires away from the volume disc) so that there is 2.5V between TP GND and TP2. Move your hand close to the volume disc and the voltage should drop in value. If



This photo of the completed Theremin clearly shows the volume control "plate" on the left side, the pitch antenna at the back (which really is a telescopic whip antenna!) in this case folded down 90° and almost fully contracted, along with the holes drilled in the case top and panel for the sound to get out.

the voltage goes up, readjust T4's slug anticlockwise with your hand away from the disc. Adjust it until the voltage increases and then drops back to 2.5V. Measure the voltage between TP3 and TP GND and set VR3 so that there is 7V, with your hand away from the volume disc.

Check that the voltage falls to 0V for a reasonable range of hand movement over the plate. You can change the range of volume control by adjusting the setting of the slug in T4.

Setting T4 so there is more than 2.5V at TP2 with your hand away from the plate will reduce the overall volume range while setting the TP2 voltage to less than 2.5V will increase the overall range. Note that the TP3 voltage will have to be set to 7V again using VR3 (with your hand away from the disc) after setting T4's slug to give a new value at TP2.

Pitch Alignment

Now you are ready to align the pitch control. Set the volume potentiometer (VR1) slightly away from minimum setting. Set the telescopic antenna so that just the two larger sections are extended.

Using a suitable alignment tool, rotate the slug in transformer T1 slowly until a tone is heard in the loudspeaker. Then adjust it to obtain a good frequency range when your hand is brought near to the extended antenna. The note should be at its highest when your hand is close to the antenna and should fall to a very low frequency (just a growl) when your hand is taken away.

If the effect is the reverse of this (lower frequency as your hand is brought close to the antenna) then readjust the slug until the effect is correct.

Adjust VR2 so you obtain the required sound from your Theremin. Note that adjustment at the fully clockwise setting will cause the pitch to lock to the reference oscillator for some movement of the hand before it snaps into sound. You can now adjust the tuning of the Theremin by carefully adjusting the antenna length from its normal length of two fully extended largest sections.

Placing the loudspeaker and lid in position will change the tuning slightly, although adjusting the antenna length should be sufficient to retune correctly. If hand control over volume is affected, then readjust this tuning.

Note that if you connect the Theremin to an amplifier, the extra grounding will affect the tuning but adjustment of the antenna length should correct this.

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PRODUCT SHOWCASE

Tiny Handheld Digital Microscope

SciNet are the Australian distributors for this versatile, easy-to-use handheld microscope which suits a variety of applications in the workplace or home, such as electronics, sciences, engineering, assembly, quality control, education, hobbies & collecting (coin, stamp, watch, jewelry, etc) and law enforcement (counterfeit ID, crime lab, etc).

There are more than 30 models available, suiting installation on PCs or Macs, or direct to TV screen. They come in both plastic and alloy housings. A mini stand is included and a range of accessories is available from a network of resellers.

The 90g, 100mm-high unit features high resolution (1.3 megapixels), magnification from 10x to 200x, has measurement function and uses a simple control dial to focus.

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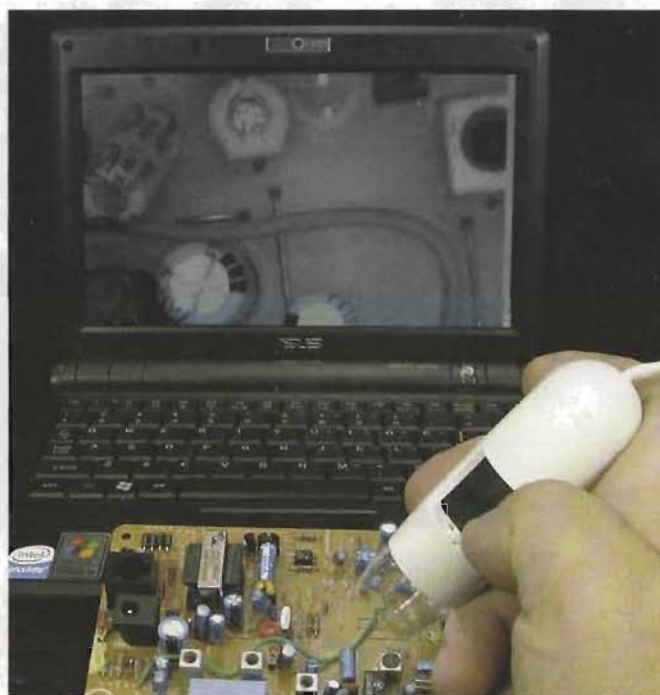
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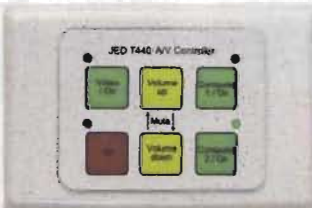
JED TE440 Classroom/Theatre AV Controller

Half of JED Microprocessors' business is the supply and installation of A-V control equipment.

Their latest offering is the JED T440 projector controller (and optional T461 audio

controller) which offers a convenient method of controlling video and data projectors from a lectern, bench or wall near a speaker's location in a hall or lecture theatre, classroom, church or conference room.

Alternatively, the controller and front assembly can be mounted on a black or white Clipsal 2000 base block and can be wall mounted near the operator's position. The T440 has an attractive white, or black, smooth escutcheon surrounding it, to give an overall size of 110mm by 70mm. This covers the screw holes and can be mounted



into a lectern or desk at a convenient point for the speaker to control video and data projector operations. As an option, just the adhesive backed keyboard and electronics board can be supplied

without a Clipsal plate, to allow installers to mount the system on their own panel to match the decor of media control desks or wall plates in boardrooms, etc.

It is wired to the LCD projector via an RS232 data cable, needing only three wires (TX, RX and Ground).

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World's smallest true AVR USB ISP

New from Inex Robotics is the PX4000, the world's smallest true AVR USB ISP.

It operates with the AVR Program software, which is included in AVR Studio and can be found in the tools menu and works with the Avr-OspII software as well.

The ISP connects to the host computer's USB ports and allows you to program the AVR microcontroller via

the ISP connector. Supporting read, write, erase and protection functions, it is suitable for a large variety of AT, AT-mega and AT-tiny microcontrollers (the complete list is available at www.inexglobal.com/products.php?type=micro&cat=AVR&model=px4000).

The kit includes the programmer box with cable and CD-ROM.

Contact:

Innovative Experiment Co Ltd

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Website: www.inexglobal.com

Bluetooth GPS receiver with logging

The latest addition to the MicroGram GPS range can be used as a Bluetooth GPS receiver for use with mobile phones & PDAs etc and will also function as a USB GPS receiver for use with laptops & mobile PCs. It has built in memory to store up to 130000 way-points that can be logged either automatically or by press button. The GPS can be configured to automatically log when certain speeds or altitudes are reached. Once plugged



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2009 Test Instruments Catalog from Emona

Emona Instruments, the specialist supplier of electrical and electronic test instruments and equipment, have released their 2009 Emona Test Instruments Catalog.

The 72 pages cover instrumentation and equipment for the electronics industry, industrial service and plant maintenance, industrial electrical and electrical contracting, and science and life sciences laboratories. The Emona Catalog is Australia's leading dedicated instrumentation catalog and is an invaluable reference for all engineers, technicians, scientists contractors and educators.

You can browse the 2009 catalog or request a hard copy on-line.

Contact:

Emona Instruments Pty Ltd

PO Box 15, Camperdown, NSW 1450

Tel: (02) 9519 3933 Fax: (02) 9550 1378

Website: www.emona.com.au

More Features for Fluke 8845/6 DMMs

Fluke Corporation has announced a user-downloadable free firmware upgrade for the Fluke 8845A/8846A Precision Digital Multimeters that delivers even more functionality and value from these powerful instruments.

The Fluke 8845A and 8846A 6.5 Digit Precision Multimeters have the precision and versatility to handle the most demanding measurements, on the bench or in a system. These meters are high performance, feature rich and remarkably easy to use.

Users can get even more value from their 8845A and 8846A Precision Digital Multimeters by downloading and installing the newest Fluke firmware upgrade, which delivers measurement enhancements and new features and functions.

More information is at <http://au.fluke.com/benchmarkfirmware>.

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How do you *safely* discharge high energy, high voltage capacitors?

It's a problem faced by electronics technicians and service personnel every day. The energy stored in a capacitor often remains for quite long periods, ready to bite the hand that's touching it, to distort an old proverb.

And if that capacitor involves high voltages, it's more than capable of causing death – in fact, there are such recorded accidents and fatalities.

So what's the answer?

Seaward Electronic Ltd, represented in Australia by Emona Instruments, has introduced the first instrument of its type for the safe discharge of stored energy in large capacitors and electrically charged equipment.

The SD300 has been specifically designed to enable engineers to safely discharge high power capacitors used for power factor correction and energy storage applications in the power generation, petrochemical, oil and gas, processing and motor drive control industries.

No official or recognised means of safely discharging large capacitors in these applications exists and the SD300 unit incorporates a number of special features to counter the common but unauthorised and highly dangerous practice of discharging high power capacitors with wires or screwdrivers.

The portable new SD300 is a self-contained safe discharge device that has been designed to protect the operator or test engineer from danger and the equipment under test from potential damage.

Seaward's SD300 is a long-life battery-powered tester that has been designed for use in situations with a maximum voltage of 1000V DC and maximum capacitance of 1200 μ F. The failsafe design of the SD300 incorporates a two-handed pushbutton operation to initiate and maintain the energy discharge, ensuring that the operator cannot come into contact with the live circuit. In addition, the operator is totally isolated from the discharged energy by a fully insulated and robust instrument case rated at IP66.

The self-contained instrument comes complete with fully shrouded fused test leads and includes an inbuilt test lead and fuse proving facility. Other safety features include an automatic pre-use self test, protection against prolonged connection to live operating circuits and monitoring of critical component temperatures with automatic cut-off.

Once activated, the stored energy is discharged in 30 seconds or less and both analog meters and LEDs provide a visual indication of the state of the stored energy. If the SD300 senses AC voltage at the probes it illuminates the AC warning LEDs to inform the user that the supply has not



been correctly isolated. The discharge buttons are disabled while AC is present and discharge is inhibited until the AC voltage is removed.

The DC LEDs indicate the polarity of the voltage present at the probes; ie, if the voltage on the red probe is positive with respect to say the yellow probe then the +DC LED by the red meter will illuminate along with the -DC LED next to the yellow meter.

As the first instrument of its type, the SD300 provides an innovative and highly effective solution for the safe discharge of electrically charged equipment.

The only major drawback that we can see is that the SD300 unfortunately cannot cover what is potentially one of the most dangerous – and very common – “charged capacitor” situation faced every day by service technicians: the microwave oven capacitor. These potentially lethal devices usually involve charges at least a couple of thousand volts higher than the maximum rating of the SD300.

More details: www.emona.com.au

SC

SERVICEMAN'S LOG

Anyone got a good recipe for crow?

It only takes a couple of minor blunders to turn what should be a quick job into a real time-waster. Unfortunately, in this business, it goes with the territory.

Things have been very quiet in the TV repair game since Christmas. Everyone, it seems, now has a new widescreen LCD or plasma set and few people want to spend money getting a faulty CRT set repaired.

Of course, the so-called global economic crisis isn't helping matters but I have this incurable disease called eating and besides, I'm much too poor (and young) to consider retiring! So lately I have been servicing a slowly increasing stream of computers.

As well as computers, I'm also prepared to take on related problems and that includes looking at Internet connection problems.

Recently, I was called out by Barbara to take a look at an ADSL2+ connection that had ceased working. Apparently, the DSL LED on the modem was con-

stantly blinking on and off (instead of remaining on), indicating that it was not correctly acquiring the DSL line.

When I got there, I found that the symptoms were pretty much as described. However, I also noticed that the modem was sometimes acquiring the DSL line for a brief period, only to quickly lose it again. Usually, it would only hold the line for no more than 5-10 seconds but occasionally it would acquire it for several minutes before losing it and repeating its hissy fits all over again.

Barbara's Toshiba laptop was connected to the modem via an ethernet cable and I tried browsing the net during the brief periods that the DSL LED remained lit. It worked but was painfully slow, indicating a noisy connection.

This was going to be a snack I thought. It just had to be a faulty telephone cable between the modem and the ADSL filter. Other possibilities included a fault between the filter and the telephone wall socket, corroded contacts in the wall socket and a faulty ADSL filter.

Initially, I tried swapping the telephone cable to the modem over but it made no difference. I then swapped the ADSL filter but this made no difference either so I checked out the wall socket. It too was OK so I tried disconnecting the telephones and bypassing the ADSL

Items Covered This Month

- Troubleshooting an ADSL connection
- Cleaning malware off a laptop computer
- Fixing a faulty iPod

filter, again without result.

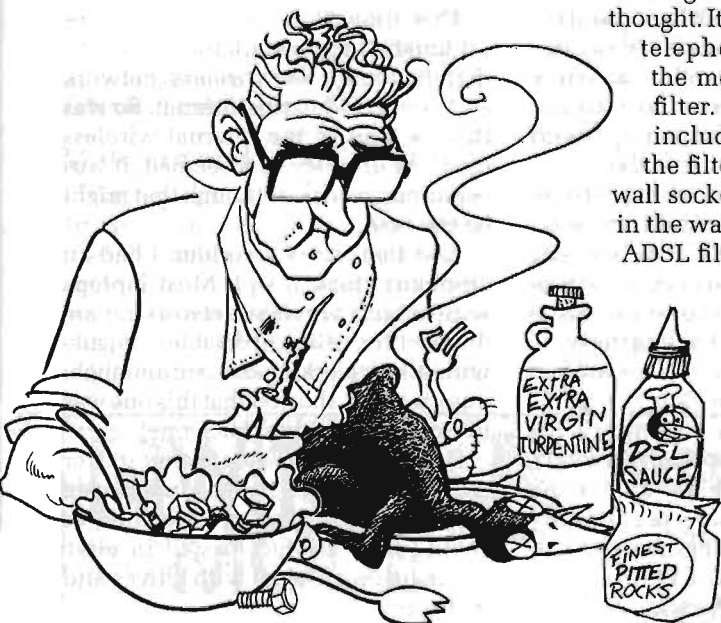
So much for my snap diagnosis that it was a faulty connection. Instead, it was beginning to look as though the modem itself was at fault, although an exchange fault was also possible. To test this, I swapped the ADSL2+ modem over for one that I had brought with me. It quickly acquired and held the DSL line, so it looked like it was the modem that was at fault.

The modem was an iConnect 622 and was only about 18 months old. These things are so cheap these days that even simple faults are not worth fixing. In any case, Barbara wanted to replace it with a new ADSL2+ wireless modem/router. That way, her laptop would no longer have to be tethered to the modem via an ethernet cable.

And so, acting on her instructions, I returned a couple of days later with a new Netgear DG834GV ADSL2+ Modem/Wireless Router. It also quickly acquired and held the DSL line but then I blundered when I went to do the set-up.

You set these things up using a web-browser and because I'm inherently lazy, I stupidly chose the automatic set-up option instead of the manual option when the opening menu appeared. And that's where things went pear-shaped. Despite the fact that it had acquired the DSL line, the unit couldn't automatically identify the DSL configuration and refused to go any further.

No problem I thought - I'll just switch off, restart the modem and this time choose the manual procedure. Unfortunately, that didn't work out



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Spotting the problem in Barbara's iConnect 622 ADSL modem wasn't all that difficult. Note the bulging tops on the two 330 μ F electrolytic capacitors towards the rear of the unit.

either because as soon as I logged onto the modem, it bypassed the opening menu and went straight into the automatic detect mode. I repeated the procedure and it did exactly the same thing.

Aaaaaghhhh! This was becoming frustrating – my piece of cake was transforming into crow.

Resetting the modem back to the factory defaults finally did the trick. I was then able to go through the manual set-up procedure, after which it immediately connected to the Internet.

So the unit was up and running, or at least it was for a wired network connection between the laptop and the modem. However, because of my earlier blunder, I had literally run out of time and had to leave for my next job. The wireless networking set-up would have to wait until the next day.

The next day I returned, logged onto the modem and entered all the wireless networking details. This basically involves entering a network identification name and the assigned username and password, before locking the wireless network down to stop freeloaders from using the connection.

That done, I then entered all the matching details into the Windows Wireless Networking set-up on the laptop. But guess what – despite only being a couple of metres away, it couldn't find the local wireless network, or any other wireless network for that matter.

Well, to cut a long story short, I mucked about with it for about an hour

without result. Barbara's laptop has an internal wireless card and Device Manager showed that the driver was installed and that the hardware was working correctly. But despite that, it stubbornly refused to find the wireless network, even when I got rid of all the security settings and left the network completely open.

Feeling utterly bamboozled by now, I tried fitting a Netgear wireless PC card that I'd brought along to Barbara's laptop. I then downloaded and installed the relevant software (including the driver) and repeated the set-up procedure.

This time, it worked. As soon as I'd finished the installation, it immediately found the wireless network and connected to the Internet. So was there a fault in the internal wireless card? As unlikely as it seemed, it was beginning to look as though that might be the case.

And then all of a sudden I had an epiphany (look it up). Most laptops with inbuilt wireless networking are fitted with a switch to disable or enable wireless networking and, sure enough, a quick check showed that this one was in the OFF position. Nice one!

Does anyone have a good recipe for crow? Should it be roasted in the oven with onions and baked vegetables or should it be stuffed, basted in olive oil, lightly garnished with chives and barbecued on a spit?

Setting the switch to the ON position made all the difference (to state the obvious) and I was then able to

reconfigure the system to work with the internal card and reinstate the security settings. This last step is most important. At the very least, you should change the log-on name and password for the modem from the factory default, turn off the broadcast ESSID and use WPA or WPA2 encryption. It also helps to enable MAC address filtering.

Now that it was all running correctly, I volunteered to take Barbara's old modem away to see if it could be fixed. After all, it might be something as simple as a bad solder joint on the telephone socket and I was suffering from a bad case of "the curiosities".

Back at the workshop, I quickly disassembled it when I had a spare moment and took a close look at all the solder joints under a magnifying glass. They all appeared to be OK, so I took a look at the component side of the PC board.

And that's when I spotted the likely fault – two 330µF 10V electrolytic capacitors near the microcontroller with tell-tale bulging tops. I whipped them out, replaced them with 16V-rated units and reassembled the modem in its case.

I tested it on my own ADSL line and the DSL LED remained lit, so it looked like the problem was licked. And that's how it turned out when I dropped into Barbara's place a week or so later. It now worked perfectly and so I left it with her to keep as a spare.

Of course, I couldn't charge for all the time I had spent on this job or even for fixing the old modem. If I blunder, then I just have to wear it.

Now about that crow . . .

Malware makes me sick!

I'm not sure which computer users are worse these days – kids who download anything and everything from the net (especially if it's free) or adults who really don't understand the dangers of doing so and let the kids do it!

Mr Phillips brought in his laptop

computer saying it was doing "funny things". Pressed further, he told me that when he logged on to his browsers (he had three installed – IE, Mozilla and Google Chrome) and did a search for something, a completely different site loaded.

These sorts of browser hijacks are never funny. Personally, I'd love to shoot some of the cretins who have to show the world how clever they are by writing malicious code. If they're that clever, why don't they write something that makes them some real money. Like Bill Gates.

Anyway, he asked me if I had wifi, which of course I did. I logged on to it using his computer and he demonstrated the problem. And yes, it was just as described. Then, to make matters worse, he showed me what happened when he logged on to the SILICON CHIP website. Up came a banner advert at the top telling him how he could add inches (or should that be centimetres?) to his anatomy.

Now I was 110% sure that SILICON CHIP would not have such ads on their site, so I logged on with my own computer. Sure enough, there was a banner advert but this one was legitimate and had nothing to do with extending anything.

And so here we had two computers, side by side and operating via the same router but showing different content on the same page. Just to prove the point, I rang the SILICON CHIP editor and he confirmed that the problem was definitely in the customer's computer and that mine wasn't simply being prudish (I can still hear his laughter).



~I WAS GIVEN AN OPPORTUNITY
BY MRS SERVICEMAN TO REPAIR
HER SISTER'S BROKEN IPOD

Having seen these symptoms before, I was pretty sure I knew what the problem was and that it would be fairly easy to solve. However, it does take some time and so I told Mr Phillips he'd have to leave the laptop with me for a day. I also asked him if he wanted me to improve its performance at the same time. He looked at me strangely for a moment (as if thinking "who is this genius?") and then gave me the nod.

Browser hijacking

The problem with his laptop is known as browser hijacking and occurs when "malware" is downloaded with something else, usually completely unknown to you. It's also known as a "Trojan horse" after the famous historical attack on Troy by the Greeks. Up to 30 soldiers hid inside the large horse and attacked the city when the curious Trojans wheeled it inside.

When it comes to computers, a

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This is the view inside the 30GB iPod. The screen, motherboard and battery all needed replacing.

Trojan horse might be disguised as software which does something useful but at the same time it installs software which can (a) do real damage to the computer's operating system, (b) replicate itself and spread, ie, a virus, and/or (c) change the operation of the computer, such as hijack the browser(s), as was the case with Mr Phillips' laptop.

Cleaning up

There are quite a few utilities around which are designed to clean up your computer. I have found over the years that most of them work most of the time but to be absolutely sure, I tend to run at least three.

Naturally, I'm pretty careful about what I download and install, for the reasons given above. However, there are a few programs which have earned a solid reputation for not only doing what they do well, but are free of Trojans or other nasties.

Three in particular I'd recommend. The first of these we've talked about before: Grisoft's Ad-Aware (www.grisoft.com).

It's been around a long time but they keep on updating it so it is still valid.

The second is CCleaner (www.ccleaner.com) which is more of a system optimisation tool which cleans unused items from your computer. But it's important to do that regularly, too.

The last (and arguably the most important when it comes to malware), is Malwarebytes (www.malwarebytes.org). It not only scans and removes (with your OK) malware, it then operates in the background to let you know if someone is trying to get back into your system! I saw a quote once which I loved: "using Malwarebytes is like bringing an M4 to a knife fight!"

I believe every computer owner should run these, or similar programs, periodically – and I don't mean every month! For mission-critical computers (ie, you earn your living using it!) I would even be inclined to say every day – or because of the time some scans take for large hard disk drives, every night.

Back to the subject at hand: Mr Phillips' laptop. It took me the best part of a day to run these tools on his machine (naturally, I had other things to do in the meantime) but when I'd finished, I was happy to be able to call him and get him to pick his machine up.

He came in next morning and before leaving, again logged on to my wifi and tried out his multiple-browsers. His smile got bigger and bigger as he no longer had to worry about pop-up ads for you know what or for a bigger bustline (which he definitely didn't want). He was even more impressed at how much faster his computer ran after I removed a lot of the never-used stuff that was running in the background.

Exit one happy customer.

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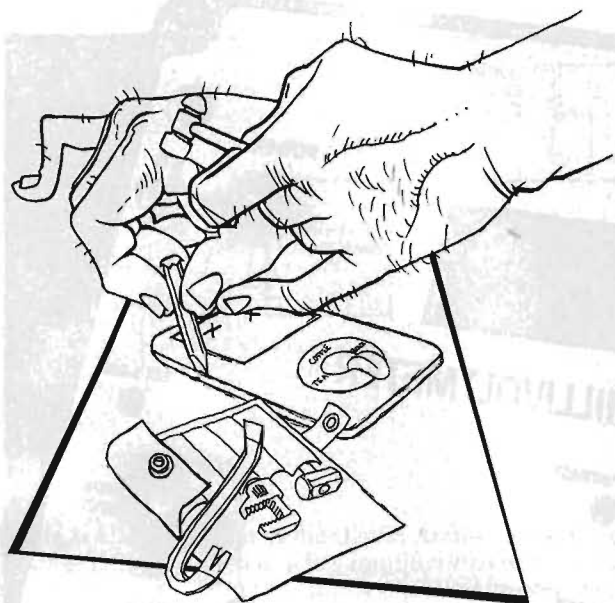
Recently, I was given a once-in-lifetime opportunity by Mrs Serviceman to repair her sister's broken iPod. It was a fifth generation 30GB video model and she (the sister) had dropped it on the kitchen floor, shattering the screen in the process. I was also told that it could still be used as a hard drive, which indicated that the USB connection was still working (this later proved to be the case).

The first thing I did was to order a new screen. These can be purchased cheaply on websites like eBay. That done, I decided to disassemble the unit to see if there was any more damage inside it.

The iPod opens by pulling the cover off and you need a fine instrument to pry the body from the aluminium casing. It was interesting to see the insides. It's all quite modular, with the battery, the hard drive and the screen all connecting to a small motherboard that accommodates a few VLSI chips.

A few brief checks quickly revealed that the internal battery was no longer powering the iPod. It wasn't hard to discover why – the battery is connected to the motherboard using flex type connectors and one of these had broken. As a result, I ordered a new battery too and waited for both it and the screen to arrive.

By the way, flex connectors can sometimes carry components too. I have seen entire ICs embedded in flex connectors going to OLED display modules. In this case, the IC is



~AND YOU NEED A FINE INSTRUMENT TO PRY THE BODY FROM THE ALUMINIUM CASING...

the driver chip and the flex connectors are suited to carrying many links in a compact space, especially for displays. Even when multiplexed, LCD and OLED displays require a great number of column and row connections.

It's worth noting that some electronic gadgets are built entirely on flexible boards and lack a PC board as well. Unfortunately, flex connectors often need to be replaced and are almost impossible to repair.

By now, it appeared that the repair would be straightforward. In fact, it would be more a matter of "replacing" rather than "repairing". But there was one further surprise in store for me.

When the new screen and battery arrived, I immediately installed them. However, when I applied USB power to charge the battery, a service screen came up, informing me that the iPod needed to be "restored" using iTunes. So far so good, I thought, it was now simply a matter of transferring all the material on the hard drive to my PC, restoring the iPod and then reinstating my sister-in-law's files.

Something's getting hot

Unfortunately, while copying the 22GB or so of music on the iPod's hard drive, I noticed that the front touch wheel was getting excessively hot. I quickly disassembled it again and found that the bottom righthand corner of the board was uncomfortable to the touch. It had become so hot that a small, surface-mount inductor in that area had desoldered itself and was now loose!

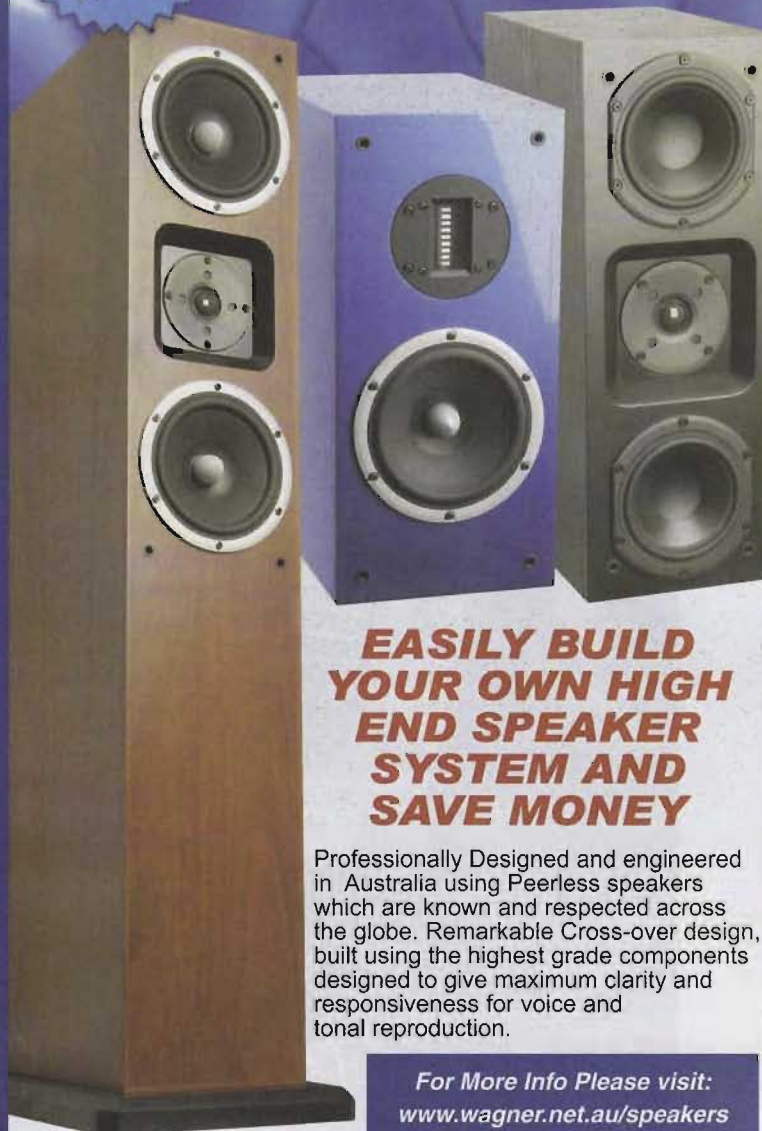
There was nothing for it but to order a new motherboard as well, pushing the total parts cost out to around \$100. That's still far cheaper than buying a replacement unit, however.

Anyway, after installing the new motherboard, restoring the iPod using iTunes, and copying his material again, my sister-in-law's iPod is fully functional again.

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By JIM ROWE

Low-Cost Digital Audio Millivoltmeter

Versatile unit indicates signal levels in mV, dBV & dbm

Want to measure small signals at audio frequencies? Here's a low-cost digital audio millivoltmeter which will allow you to measure audio signals from below 5Hz to above 100kHz. As well as indicating the level in both millivolts and dBV, it also shows the corresponding dBm level into 600 ohms.

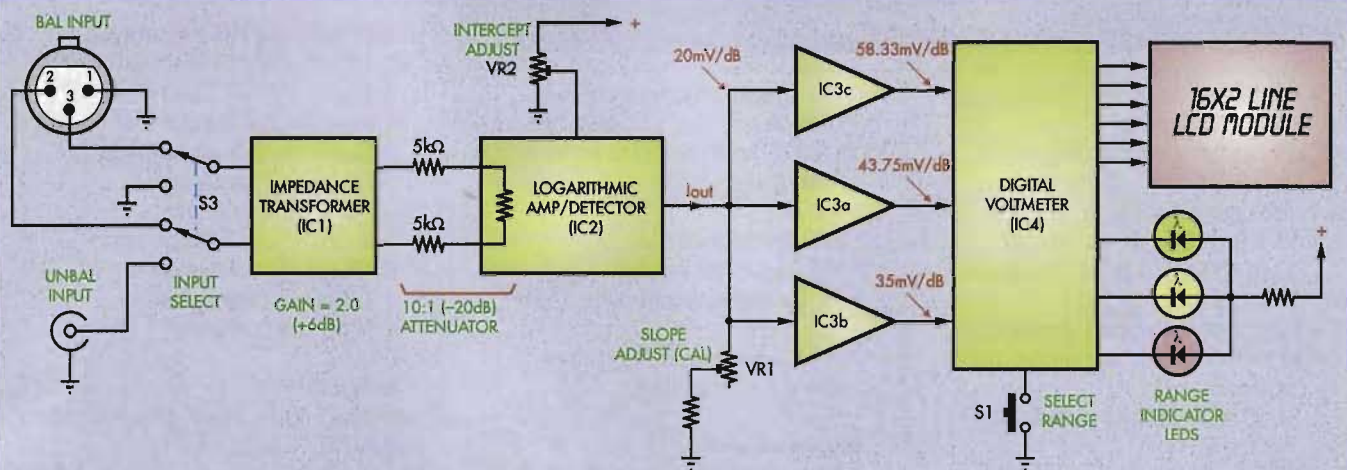


Fig.1: block diagram of the Digital Audio Millivoltmeter. The audio signal is first fed to an impedance transformer stage (IC1) and then to a log amplifier/detector via a resistive attenuator. Its output is then fed to three different DC amplifiers which in turn feed a digital voltmeter stage based on PIC microcontroller IC4 and an LCD module.

THIS NEW AUDIO millivoltmeter design is an adaptation of the RF Level & Power Meter described in the October 2008 issue of SILICON CHIP. Like that design, it makes use of a logarithmic amplifier/detector IC (an AD8307) to provide a very sensitive detector. This has a DC output which is closely proportional to the logarithm of the audio input voltage.

We have combined one of these Analog Devices AD8307 chips with an instrumentation amplifier to provide it with a high input impedance and also added an "intelligent" metering circuit based on a PIC microcontroller. In operation, the PIC processes the detector's logarithmic DC output voltage to indicate signal level and the equivalent dBV and dBm levels.

The PIC micro uses some fairly fancy maths routines to work out the signal level, which is then displayed on a standard 2-line LCD display. All the circuitry is on a single PC board and fits in a compact diecast aluminium case. The whole set-up works from an external 12V battery or plugpack, drawing less than 200mA (most of which is drawn by the backlighting in the LCD module).

How it works

The block diagram of Fig.1 shows how the new meter works. At far left are the two input sockets, one for a balanced input and the other for an unbalanced input. Switch S3 allows one of these inputs to be selected, with the desired input fed to an impedance transformer stage. This uses an AD623

instrumentation amplifier (IC1) to provide a relatively high input impedance of 100kΩ and operates with a gain of two (+6dB).

The output of the impedance transformer stage is then fed to the AD8307 log amplifier/detector (IC2) via a 10:1 resistive attenuator. This attenuator is formed by the 5kΩ resistors in series with each input and the AD8307's own input resistance of 1100Ω.

The output of the log amp/detector is essentially a DC voltage, with a value closely proportional to the logarithm of the AC input voltage. In fact, the slope of the detector's output is very close to 25mV per decibel rise or fall in the input. By adjusting the log detector's load resistance via trimpot VR1, we can set the slope to 20mV/dB (for calibration).

Trimpot VR2 is used to adjust the DC voltage levels inside IC2 to adjust its effective zero-input setting. The

output from the log detector is then fed to three DC amplifiers using IC3a, IC3c & IC3b. These are configured to provide three levels of voltage gain, to provide three measuring ranges.

IC3b provides a gain of 1.75, scaling the detector output slope to 35mV/dB (for the <0dBV range), while IC3a and IC3c provide gains of 2.1875 and 2.9165 respectively, giving output slopes of 43.75mV/dB and 58.33mV/dB for the <-20dBV and <-40dBV ranges.

Each of these scaled detector voltages is fed to a different analog input of the digital voltmeter, which uses a PIC16F88-I/P microcontroller (IC4). Switch S1 allows the user to select which of the three analog inputs is connected to IC4's 10-bit ADC (analog-to-digital converter). The firmware running in IC4 then directs the ADC to measure the scaled detector output, performs the necessary calculations to

Specifications

- **Main Features:** a low-cost audio millivoltmeter based on a logarithmic amplifier/detector coupled to a digital metering circuit using a programmed PIC microcontroller and an LCD readout.
- **Input Impedance:** 100kΩ (balanced input can be changed to 600Ω)
- **Measuring Frequency Range:** from below 5Hz to above 100kHz
- **Maximum Input Signal Level:** 1.4V RMS (+3.0dBV, +5.2dBm/600Ω)
- **Minimum Input Signal Level:** 160μV RMS (-76dBV, -73.8dBm/600Ω)
- **Measurement Linearity:** approximately ±0.3dB
- **Measurement Accuracy:** approximately ±3%
- **Power requirements:** 12-15V DC at <200mA with backlit LCD

Parts List

1 PC board, code 04103091,
160 x 111mm
1 diecast aluminium box, 171 x
121 x 55mm
1 front panel label
1 16 x 2 LCD module, Jaycar
Cat. QP-5516 or Altronics Cat.
Z-7012
4 M3 x 25mm tapped spacers
4 M3 x 15mm tapped Nylon
spacers
1 SPST momentary pushbutton
switch (S1)
1 SPDT mini toggle switch (S2)
1 DPDT mini toggle switch (S3)
1 panel-mount XLR type
balanced audio plug (CON1)
1 panel-mount BNC socket
(CON2)
1 PC mount 2.5mm concentric
DC socket (CON3)
1 7 x 2 length of DIL socket
strip OR 14 x 1 length of SIL
socket strip (half of 28-pin IC
socket)
1 7 x 2 length of DIL terminal
strip OR 14-way length of SIL
terminal strip
1 18-pin IC socket
1 14-pin IC socket
2 8-pin IC sockets

4 M3 x 6mm machine screws,
csk head
13 M3 x 6mm machine screws,
pan head
1 M3 nut
1 M3 star lockwasher
1 M3 Nylon flat washer
8 PC board terminal pins, 1mm
diameter
1 1.2-metre length of 0.8mm-dia.
tinned copper wire

Semiconductors

1 AD623AN instrumentation
amplifier (IC1)
1 AD8307AN log amplifier/
detector (IC2)
1 LM324 quad op amp (IC3)
1 PIC16F88-I/P microcontroller
(IC4) programmed with
0410309A.hex firmware
1 LM317T adjustable regulator
(REG1)
1 12V 1W zener diode (ZD1)
1 1N4004 1A diode (D1)
1 3mm green LED (LED1)
1 3mm orange LED (LED2)
1 3mm red LED (LED3)

Capacitors

1 470 μ F 16V RB electrolytic

1 220 μ F 16V RB electrolytic
1 100 μ F 16V RB electrolytic
1 22 μ F 16V RB electrolytic
2 10 μ F 16V tantalum
1 10 μ F 16V RB electrolytic
2 2.2 μ F 35V tantalum
2 1 μ F 25V tantalum
1 220nF monolithic ceramic
5 100nF monolithic ceramic
1 100pF disc ceramic
1 10pF disc ceramic

Trimpots

2 50k Ω linear horiz. trimpot (VR1,
VR2) – code 503
1 200 Ω linear horiz. trimpot (VR3)
– code 201
1 10k Ω linear horiz. trimpot (VR4)
– code 103

Resistors (0.25W, 1%)

2 220k Ω	1 2.4k Ω
3 100k Ω	1 2.2k Ω
1 68k Ω	3 2.0k Ω
1 51k Ω	1 1.5k Ω
1 33k Ω	2 470 Ω
5 10k Ω	2 330 Ω
1 6.8k Ω	1 200 Ω
2 4.7k Ω	1 120 Ω
1 3.9k Ω	1 100 Ω
1 3.0k Ω	2 10 Ω
1 18 Ω 0.5W – R _{BL}	(used with Altronics LCD module only)

work out the equivalent AC input voltage and dB levels and then displays these on a 16-character by 2-line LCD module.

Circuit details

Fig.2 shows the complete circuit of the Audio Millivoltmeter. The 100k Ω resistors connected between the inputs (pins 2 & 3) of IC1 and the +5V half-supply rail provide a biasing path and also set the instrument's input resistance. The 2.2 μ F input coupling capacitors set the instrument's low-frequency limit to below 5Hz.

On the other hand, the 470 Ω resistors in series with each input, together with the 10pF capacitor across the inputs, form a low-pass filter which rolls off RF signals which could disturb the operation of both IC1 & IC2. The 100k Ω resistor connected between pins 1 & 8 of IC1 sets its gain to 2.0.

The pin 6 output of IC1 is fed to the inputs of IC2 via a 10:1 attenuator formed by four 10k Ω resistors and the input resistance of IC2. The output

coupling capacitors have a value of 10 μ F, to maintain the low frequency response, while the 100pF capacitor across the inputs of IC2 provides a further measure of RF rejection.

PIC microcontroller

The rest of the circuit is straightforward, with most of the real work done by the firmware running inside PIC micro IC4. The PIC16F88-I/P device is well-suited to this application, because it includes an ADC module with 10-bit measuring resolution. The ADC is also flexible in terms of its operating mode, with a choice of positive and negative reference voltages and a 7-channel input multiplexer.

We take advantage of these features by using our own positive reference voltage of 3.50V (fed into pin 2) and also by using three of the ADC input channels to allow firmware selection of the measuring range via pin 1 (AN2), pin 18 (AN1) & pin 17 (AN0).

We select the ranges inside the PIC simply by selecting the appropriate

ADC input channel (AN2, AN1 or AN0). The firmware does this input selection by stepping from one range to the next each time you press S1, the range select button. To indicate which range is currently selected, the firmware switches on LED1, LED2 or LED3. The firmware automatically changes the scaling factor used for each range, so that the displayed values are correct.

Finally, the LCD module is driven directly by the PIC in standard "4-bit interface" fashion.

Power supply

Most of the circuit runs from 5V DC, derived from either a nominal 12V battery or a 12-15V plugpack supply. The only part of the circuit which runs directly from the 12V input voltage is IC1, which needs the higher voltage to handle the full input signal levels.

The +5V rail is obtained using an LM317T adjustable regulator. This allows us to adjust the supply rail to accurately set the +3.50V reference

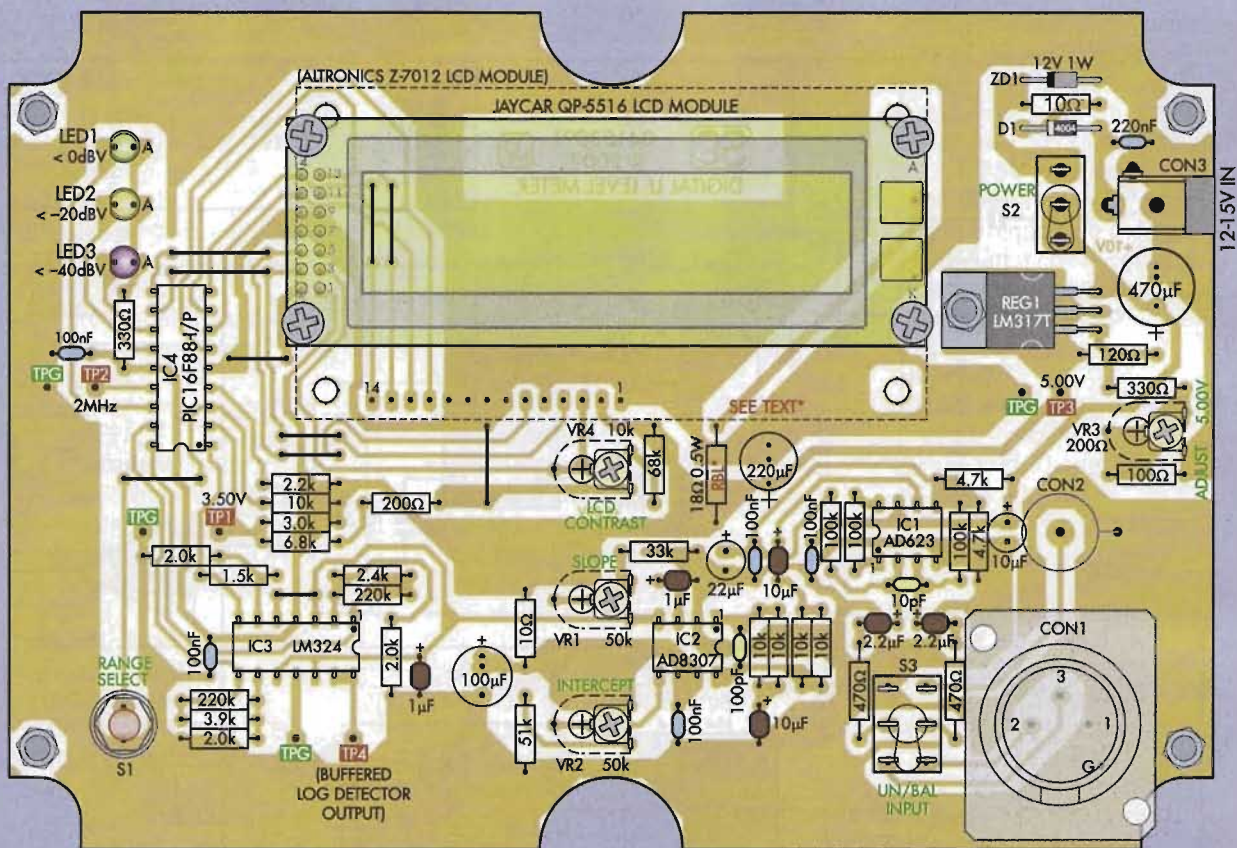


Fig.3: follow this layout diagram to assemble the unit. Note that neither connectors CON1 & CON2 nor switches S1-S3 are mounted directly on the board. Instead, they are first mounted on the case lid and fitted with tinned copper wire "extension leads". The leads then pass through the relevant board holes when the board is mounted on the lid.

voltage for the PIC's ADC. This +3.50V reference is derived directly from the +5V rail via a resistive voltage divider consisting of 3.0k Ω , 6.8k Ω & 200 Ω resistors. This reference voltage for the ADC is fed into pin 2 of the PIC, which is configured as the Vref+ input.

Notice that there are a number of test points provided on the PC board, to allow more convenient set-up and calibration. TP1 allows you to measure the ADC reference voltage, so you can adjust trimpot VR3 to achieve exactly +3.50V at pin 2 of the PIC. TP3 also allows you to measure the +5.00V rail directly, if you wish, while TP2 allows you to check the PIC's internal clock oscillator.

In this project, we run the oscillator at 8MHz, which means that the signal available at TP2 should be very close to 2MHz ($F_c/4$). So if the PIC is running correctly, you will find a 2MHz square wave of 5V peak-to-peak at TP2.

The fourth test point TP4 is provided to allow monitoring of the log detector's DC output voltage with an external DMM. Op amp IC3d is

configured as a unity gain voltage follower, making the voltage at IC2's pin 4 output available at TP4 without any significant loading and disturbance to circuit operation.

Construction

As noted earlier, virtually all of the circuitry in the project is mounted on a single PC board which mounts inside a diecast aluminium case (171 x 121 x 55mm) for shielding. The PC board measures 160 x 111mm and is coded 04103091.

As shown in the photos, the LCD module (Jaycar QP-5516 or Altronics Z-7011) mounts above the main board in the upper centre, while the complete assembly mounts behind the lid of the case on 25mm spacers. The switches and input connectors mount directly on the lid, which therefore forms the instrument's front panel.

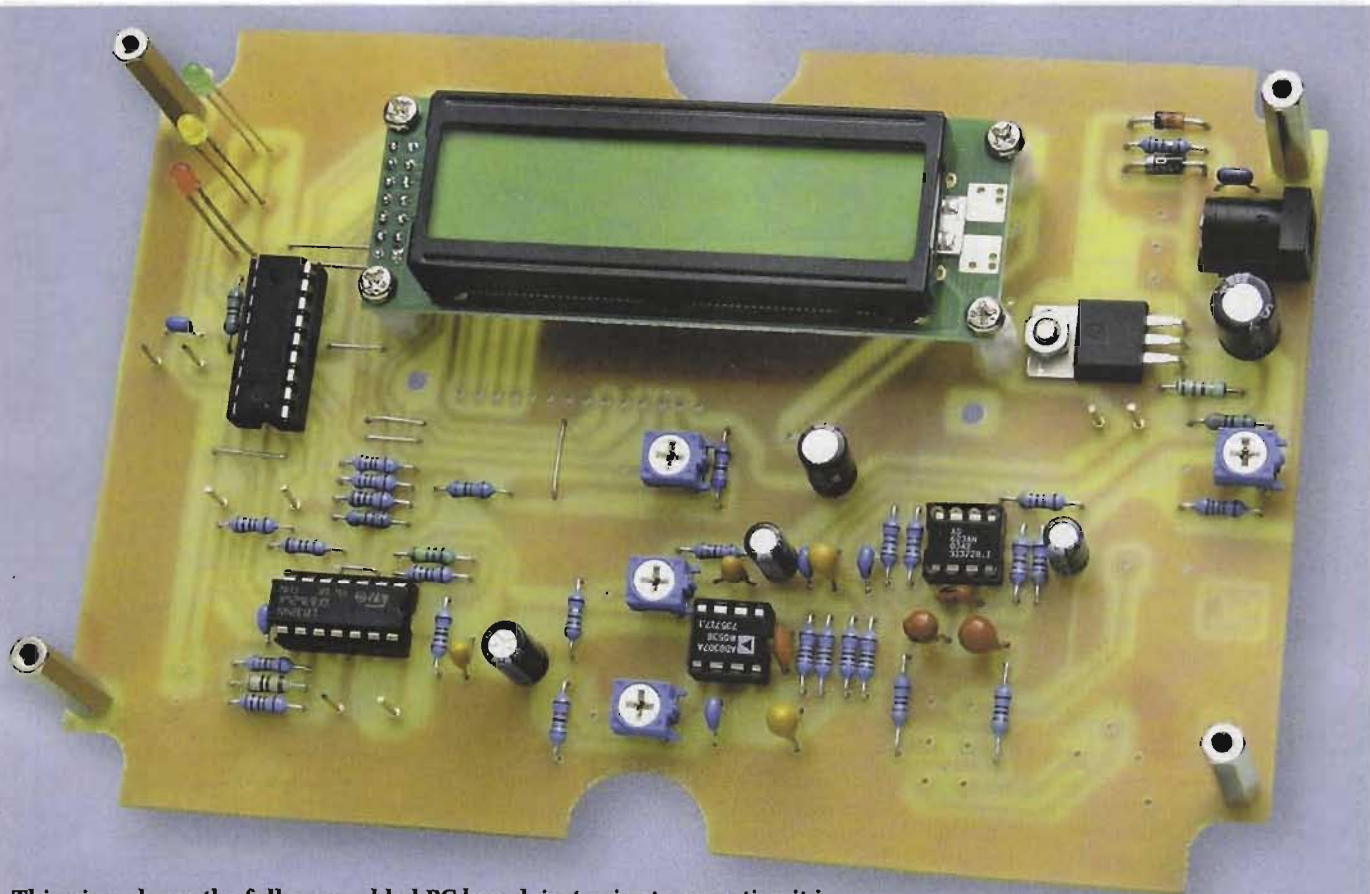
Fig.3 shows the parts layout on the PC board. Note that DC input connector CON3 is the only connector mounted directly on the board. The three range indicator LEDs are also

mounted directly on the board, with the underside of their bodies spaced up by about 24mm so that they just protrude through matching holes in the lid when the board is mounted behind it. Sockets are used for all four ICs, rather than soldering them directly to the board.

There are 10 wire links on the board and it's a good idea to fit these before any of the components, so they're not forgotten. Note that two of the links are fitted under the footprint of the LCD module, at upper left. These two links are only required if you use the Altronics Z-7011 module, however.

The test point terminal pins can also be fitted at this early stage, along with the IC sockets. Make sure you mount the latter with their orientation as shown in Fig.3, so they'll guide you in plugging in the ICs later.

Next fit DC input connector CON3, which goes in at upper right. It's then a good idea to fit the connector for the LCD module you're using. If you're using the Jaycar LCD module, this means that a 7 x 2 piece of DIL socket



This view shows the fully-assembled PC board, just prior to mounting it in position on the case lid. Make sure that all polarised parts (including the three ICs) are correctly orientated and note that IC1 & IC2 face in opposite directions.

strip must be fitted with a north-south orientation at the lefthand end of the module's footprint – see Fig.3.

Alternatively, if you're using the Altronics module, this needs a 14 x 1 section of SIL socket strip (made from one side of a 28-pin IC socket). This strip is fitted with an east-west orientation at lower left within the module's footprint (just above the position for trimpot VR4).

Follow this by fitting the four trim pots (VR1-VR4). These are all horizontal mounting types and the board allows either the small open type or the even smaller sealed type. Note that the two 50k Ω trimpots go in the VR1 and VR2 positions, while the 200 Ω trimpot is used for VR3. A 10k Ω trimpot is used for VR4 and is the LCD module's contrast adjustment.

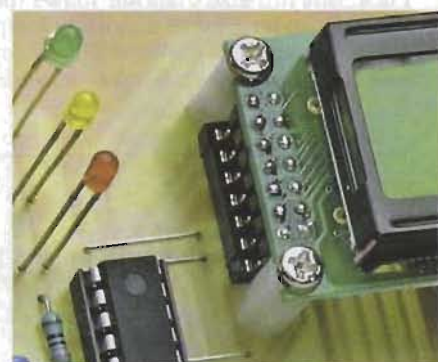
Once all four trim pots are fitted you can fit the resistors, making sure that you fit each one in its correction position as shown in Fig.3. **Note that the resistor labelled "R_{BL}" (18 Ω 0.5W) is the current-setting resistor for the Altronics LCD module's back lighting.**

It's not needed if you use the Jaycar module.

The disc ceramic and monolithic capacitors should be fitted next. These are then followed by the tantalum and electrolytic capacitors which are polarised – so take care to fit them with the orientation shown in Fig.3.

Now fit diode D1 and zener diode ZD1, followed by regulator REG1. Note that the latter is a TO-220 device and is mounted with its body flat against the top of the board. To do this, you will first have to bend its three leads down by 90° about 6mm from its body. That done, secure it to the board using an M3 x 6mm machine screw and nut before soldering its leads.

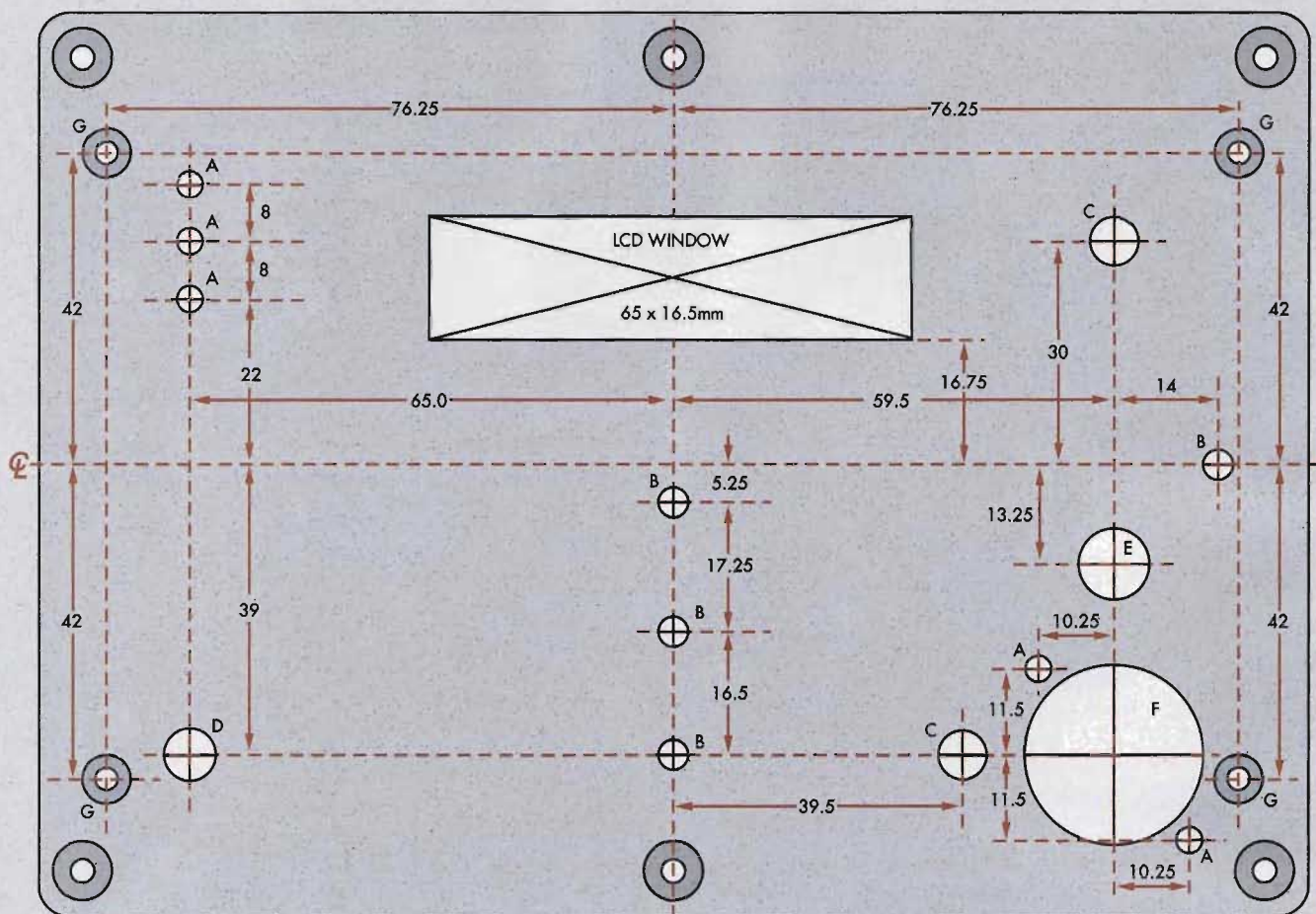
The LCD module can now be prepared for mounting on the main board, by fitting it with either a 7 x 2 DIL pin header in the case of the Jaycar module or a 14 x 1 SIL pin header in the case of the Altronics module. In both cases, the header pins are passed up through the matching connection holes in the module from below, until the upper ends of their pins are just protruding



The LCD module is fitted with header pins and plugged into a matching socket on the PC board – see text. This photo shows the arrangement for the Jaycar module (7 x 2 DIL header).

from the top of the LCD module board. All 14 pins are then carefully soldered to the pads on the top of the board using a fine-tipped iron and just enough solder to make a good joint.

The next step is to mount four M3 x 12mm tapped Nylon spacers on the main board to support the LCD module. These spacers must go in the correct positions to match the module



ALL DIMENSIONS IN MILLIMETRES

Fig.4: this full-size diagram shows the drilling details for the case lid and can be used as a drilling template. The large cutouts can be made by drilling a series of holes around the inside perimeter, then knocking out the centre piece and filing the job to a smooth finish.

HOLES A: 3.0mm DIAMETER
HOLES B: 4.0mm DIAMETER
HOLES C: 6.5mm DIAMETER
HOLE D: 7.0mm DIAMETER
HOLE E: 9.5mm DIAMETER
HOLE F: 24.0mm DIAMETER
HOLES G: 3.0mm DIAMETER (COUNTERSUNK)

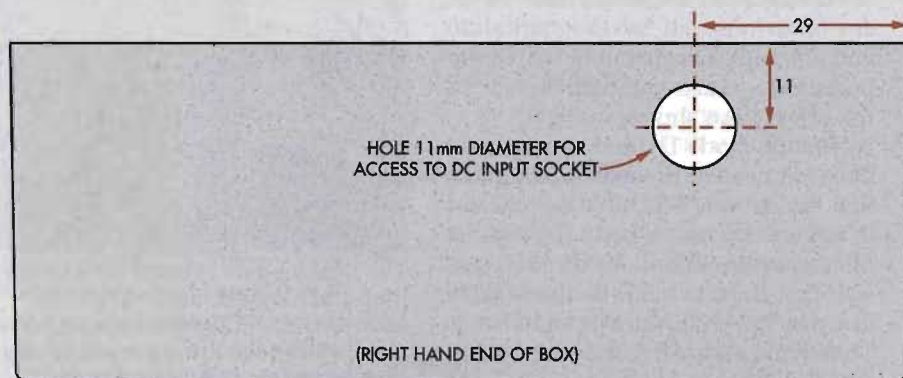


Fig.5: an 11mm-dia. hole is required in the righthand end of the case to provide access to the DC power socket on the PC board.

you are using and are attached using four M3 x 6mm machine screws. The LCD module is then mounted on top of these spacers, with its 14-pin "plug" mating with the matching socket on the main board. Four more M3 x 6mm screws are then used to hold the LCD module in place.

Note that if you are using the Al-

tronics Z-7012 LCD module, you will also have to connect its "A" & "K" terminals (for the backlight LEDs) to the corresponding pads immediately below on the PC board. This can be done using short lengths of tinned copper wire. These connections are not necessary for the Jaycar QP-5516 module.

The last components to mount on the board are the three range indicator LEDs. These all mount vertically with their longer anode leads to the right, towards the LCD module. The leads are all left at their full lengths, so the bottom of each LED's body is very close to 24mm above the board.

Note that the green LED goes in the

Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
□	2	220kΩ	red red yellow brown	red red black orange brown
□	3	100kΩ	brown black yellow brown	brown black black orange brown
□	1	68kΩ	blue grey orange brown	blue grey black red brown
□	1	51kΩ	green brown orange brown	green brown black red brown
□	1	33kΩ	orange orange orange brown	orange orange black red brown
□	5	10kΩ	brown black orange brown	brown black black red brown
□	1	6.8kΩ	blue grey red brown	blue grey black brown brown
□	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
□	1	3.9kΩ	orange white red brown	orange white black brown brown
□	1	3.0kΩ	orange black red brown	orange black black brown brown
□	1	2.4kΩ	red yellow red brown	red yellow black brown brown
□	1	2.2kΩ	red red red brown	red red black brown brown
□	3	2.0kΩ	red black red brown	red black black brown brown
□	1	1.5kΩ	brown green red brown	brown green black brown brown
□	2	470Ω	yellow violet brown brown	yellow violet black black brown
□	2	330Ω	orange orange brown brown	orange orange black black brown
□	1	200Ω	red black brown brown	red black black black brown
□	1	120Ω	brown red brown brown	brown red black black brown
□	1	100Ω	brown black brown brown	brown black black black brown
□	2	10Ω	brown black black brown	brown black black gold brown

uppermost position as LED1, with the orange LED in the centre (LED2) and the red LED at the bottom (LED3).

After the LEDs have been mounted, it's time to plug the four ICs into their sockets. Take special care to orientate each IC correctly, as shown in Fig.3. In addition, take care to ensure that all the pins go into the sockets and that none go down the outside of the socket or are folded back under the IC.

Take your time here – the AD623 and AD8307 devices are fairly pricey and PIC micro isn't exactly cheap either.

Preparing the case

Your board assembly will now be complete and can be placed aside while you prepare the meter's front panel. This involves drilling and cutting quite a few holes in the case lid as shown in Fig.4. Most are easily drilled, the two exceptions being the rectangular cutout for the LCD viewing window and the 24mm main hole for the XLR balanced input connector.

These are best cut by drilling many 3mm holes around the inside of the cutout outline and then using a small needle file to join the holes and allow the centre piece to be removed. A small file is then used to smooth the inside of the cutouts. It's tedious but if you take your time, this method gives a good result.

You also have to drill a single hole

in the righthand end of the box itself, to give access to the DC input socket. The location and diameter of this hole is shown in Fig.5.

Once all of the holes have been cut in the lid, de-burred and countersunk where appropriate (eg, holes "G" in Fig.4), you're ready to apply the front panel label. This can be made by photocopying the artwork shown in Fig.7 onto an adhesive-backed A4 sheet label, then applying a protective film (such as "Contac"). It's then just a matter of cutting it to shape before peeling off the backing and applying it to the carefully cleaned lid. Then when it has been smoothed down, you can cut out the holes in the label using a sharp hobby knife.

With the front panel now complete, you can mount switches S1, S2 & S3 in position, followed by input connectors CON1 and CON2. Note that connector CON 1 mounts with its flange on the underside of the lid (see photo). It may be necessary to file away one corner of the flange in order to do this.

Extension wires

You now have to fit each of the connection lugs on the rear of these switches and connectors with short "extension leads", long enough to pass through their matching holes in the PC board when it's mounted behind the panel.

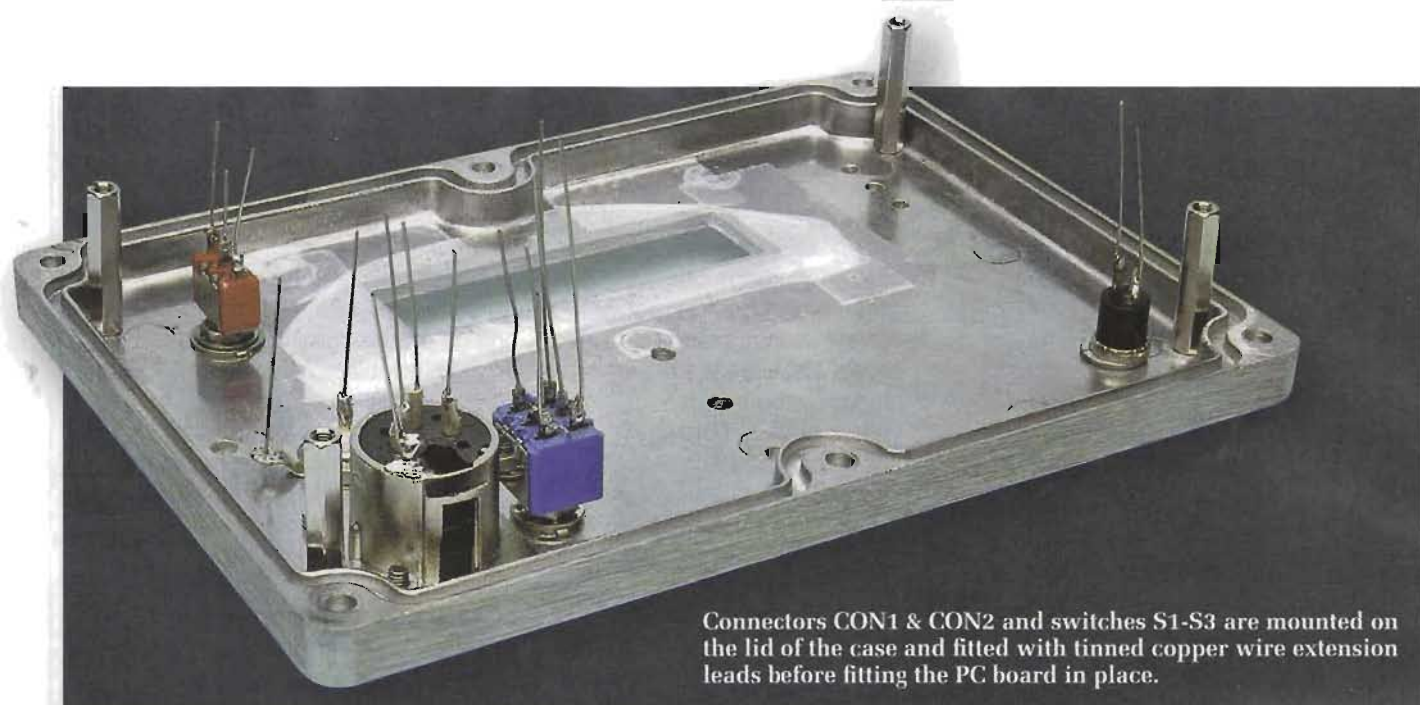
Table 2: Capacitor Codes

Value	μF Code	IEC Code	EIA Code
220nF	0.22μF	220n	224
100nF	0.1μF	100n	104
100pF	NA	100p	100
10pF	NA	10p	10

The best approach here is to use 40-60mm lengths of tinned copper wire for these extensions. Each of these is soldered at one end of a switch or connector contact lug and orientated vertically, ready to be passed through the board holes. **Make each extension wire a different length, as this will make it easier to get them through the board holes.**

Note that you will also have to shorten the existing earth lug on the 3-pin XLR socket before fitting its extension lead, to prevent it later fouling the PC board.

Now you should be ready to mount the board to the rear of the front panel. To do this, first attach four M3 x 25mm tapped spacers to the front panel, using four M3 x 6mm countersunk-head screws to secure them (these pass through "G" in Fig.5). That done, carefully offer up the PC board assembly to the rear of the front panel, taking care to ensure that the wire extension leads from the switches and input connectors all pass through their matching



Connectors CON1 & CON2 and switches S1-S3 are mounted on the lid of the case and fitted with tinned copper wire extension leads before fitting the PC board in place.

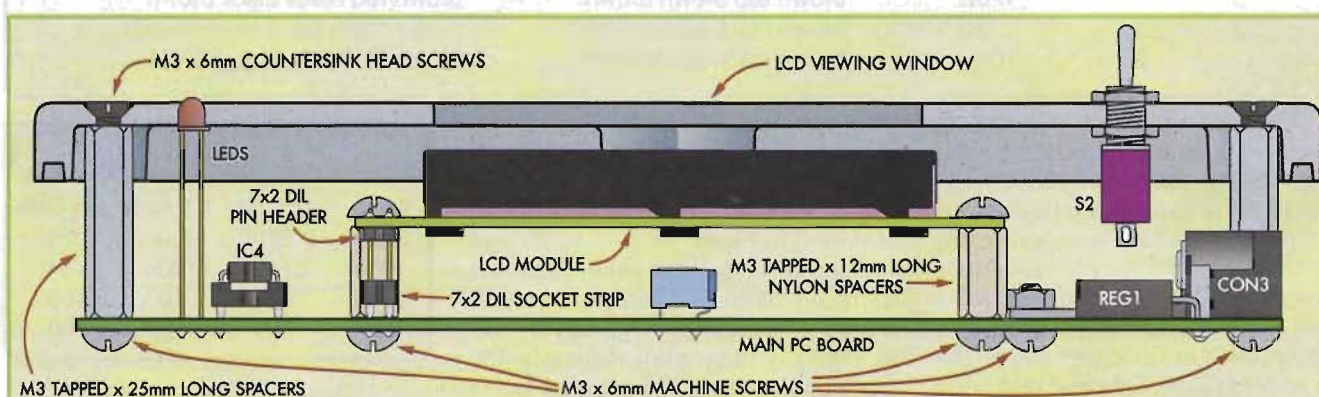


Fig.6: the PC board is attached to the lid of the case via four M3 x 25mm tapped spacers as shown here. Four M3 x 6mm countersink-head screws secure the lid to the spacers, while four M3 x 6mm pan-head secure the PC board.



This photo shows how the tinned copper wire extension leads soldered to the switches and connectors pass down through the PC board. Use a pair of long-nose pliers to guide each lead through its hole as the board is placed in position.

holes in the board.

At the same time, you also need to ensure that LEDs 1-3 each pass through their respective holes in the upper left of the panel.

Once the board is in position against

the spacers, secure it in place using four M3 x 6mm pan-head screws – see Fig.6. Note that it's a good idea to place a star lockwasher under the head of the screw nearest to CON1, to ensure a good connection between the board's

input earth copper and the metal of the case lid.

Having secured the board in place, the assembly can be upended and all the switch and input connector extension wires soldered to their cor-

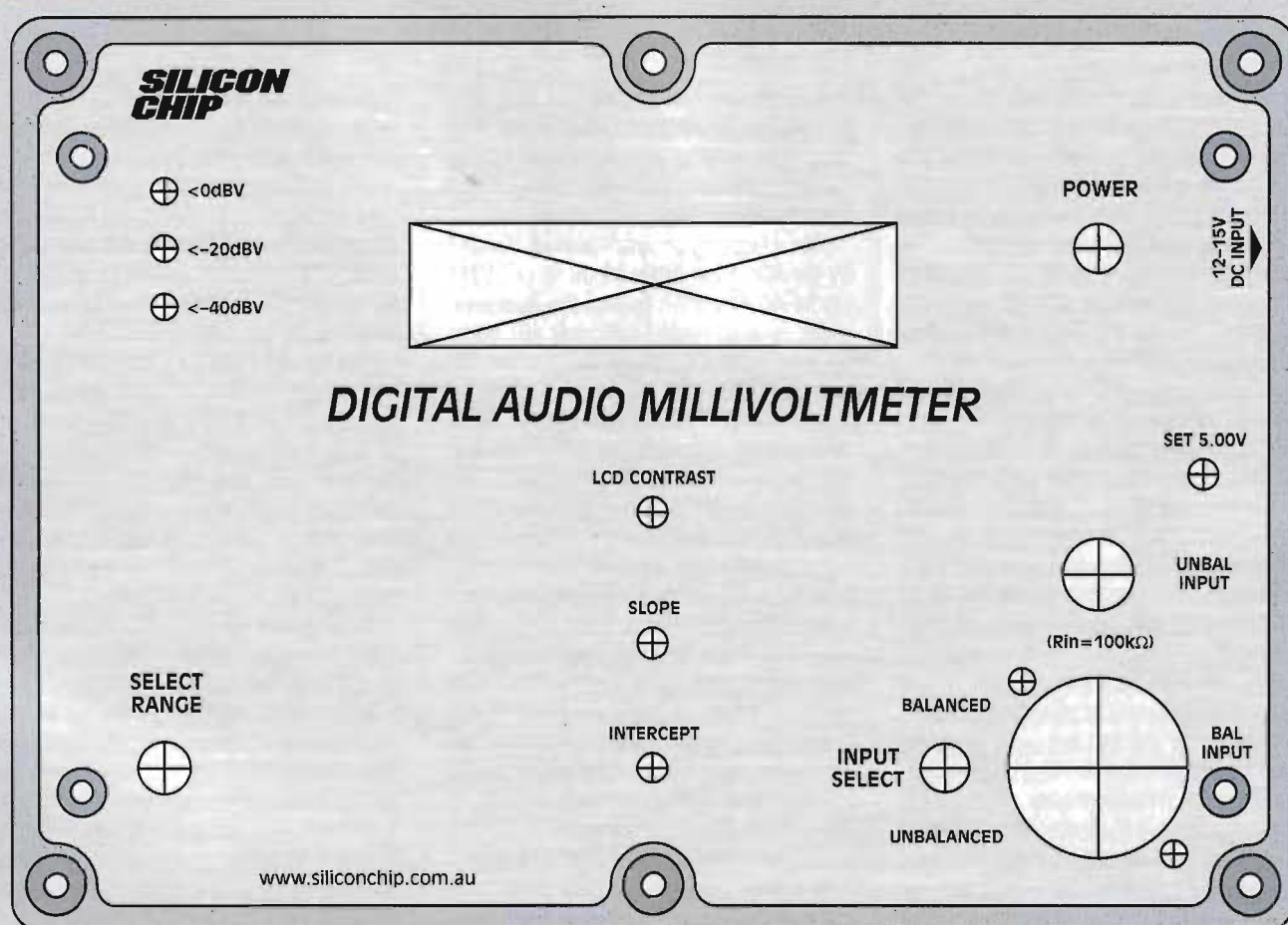


Fig.7: this full-size artwork can be copied and used to make the front panel. Alternatively, it can be downloaded from the SILICON CHIP website and printed out. Cover it with a protective film before attaching it to the case lid.

responding board pads. The board and front panel assembly will now be complete and ready for its initial checkout.

Initial checkout

Your Digital Audio Millivoltmeter should now be given a preliminary functional checkout, as this is best done before the front panel/board assembly is attached to the case.

To begin, use a small screwdriver or alignment tool (passing down through holes "B" in the front panel) to set trimpots VR1-VR4 to their centre positions. After this, use a suitable DC cable to connect CON3 to a suitable source of 12-15V DC, which can be either a 12V battery or a nominal 12V DC plugpack.

Next, apply power and check that LED1 lights. There should also be an announcement message reading "Silicon Chip AF Millivoltmeter" on the LCD, although you may have to adjust trimpot VR4 before this message

is displayed with good contrast.

Note that this greeting message only lasts for a few seconds, after which it is replaced by the meter's normal display of readings.

If all is well so far, now is the time to set the voltage regulator so that the PIC's ADC reference voltage sits at exactly +3.50V. This is easy to do: just connect your DMM to TP1 and to its nearby TPG pin and adjust trimpot VR3 until you get a reading as close as possible to 3.500V. Use your most accurate DMM for this, because to a large extent the accuracy of this setting will determine the accuracy of your millivoltmeter.

That basically completes the initial set-up, although if you have access to a scope or a frequency counter you may want to check the PIC's clock signal at TP2. You should find a 5V peak-to-peak squarewave with a frequency very close to 2MHz.

After this initial checkout, you are ready to mount the front panel/board

assembly in the case. Secure it using the six M4 countersink-head screws supplied. Note that although a length of neoprene rubber is supplied for use as a seal between the case and its lid, there's no need to use this seal here. In fact, the box will provide better shielding if the seal is left out.

Final adjustment

Your Digital Audio Millivoltmeter is now ready for the final step, which is adjustment and calibration. To do this, you'll need an audio signal generator of some kind, able to supply an audio sinewave signal of known level.

If you don't have access to a calibrated generator, an alternative is to use an uncalibrated oscillator with another audio measuring instrument of some kind, so that you can adjust its output to a convenient level (eg, 1.0V or 100mV RMS).

The calibration process is straightforward. Here's the step-by-step procedure:

What The Meter's PIC Firmware Does

As we explain in the main text, the AD8307 chip in the Digital Audio Millivoltmeter detects the incoming audio signals and converts them into a DC voltage according to a logarithmic conversion scale. It is this log-scale DC voltage which the PIC micro then measures and converts into the equivalent voltage and dB readings, under the control of the author's firmware program "0410309A.hex".

As you can imagine, the program directs the PIC to perform a number of maths calculations. To do this, it makes use of a suite of maths routines made available to PIC programmers by Microchip Technology Inc, the manufacturers of the PIC family of micros. These routines are used to perform 24-bit and 32-bit floating point (FP) addition, subtraction, multiplication and division, base-10 exponentiation, fixed-point multiplication and division, and floating-point to ASCII conversion.

In essence, the PIC firmware program works through the following sequence in making each measurement:

First, it directs the PIC's 10-bit analog-to-digital converter (ADC) module to take a measurement of the DC output voltage from the AD8307 chip. It then takes that

measurement and converts it into 24-bit floating point form, after which it is multiplied with a pre-calculated scaling factor (24-bit also) for the currently chosen measurement range.

The resulting product is then divided by the ADC's full-scale 10-bit value of 3FF (in 24-bit FP form), to give the measurement value in what I call "raw dB" form. This is essentially a 24-bit number varying between 0 and 100.

This raw dB value is then used to calculate the equivalent dBV value, by subtracting decimal 96.4782 (in 24-bit FP form), and also the equivalent dBm value (for a 600 Ω impedance level) by subtracting decimal 94.2602 (again in 24-bit form). These values are then saved for display.

The dBV value is also used to calculate the actual voltage level. This is done by first dividing it by decimal 20 (in 24-bit FP form) and then raising decimal 10 to that power using "EXP1024", Microchip's 24-bit floating point base-10 exponentiation routine. This is equivalent to calculating the antilogarithm, so we end up with the equivalent voltage value in 24-bit FP form. This is then saved for display.

Once the three parameters have been

calculated, the final steps of the measurement sequence involve taking each 24-bit parameter and processing it for display on the LCD module. For the dBV and dBm figures, this means working out the correct polarity indication (+ or -) and then using a Microchip routine called "Float_ASCII" to convert the numbers themselves into ASCII digits for display.

Things are a little more complicated for the voltage value, because this must first have its 24-bit binary exponent analysed to work out the scaling, the position of the decimal point and the most convenient multiplier to give it (eg, volts or millivolts). After this is done, it is again converted into the equivalent ASCII digits using Float_ASCII.

As you can see, there's a bit of mathematical jiggery-pokery involved but most of this is performed by Microchip's fancy maths routines. By the way, the full source code for the firmware will be available on the SILICON CHIP website, along with the source code for the floating point maths routines it uses (in a file called "FPRF24.TXT"). The assembled hex code of the complete firmware will also be available, ready to burn into a PIC.

All About Volts, dBV and dBm

The Audio Millivoltmeter described in this article gives three indications for every measurement: the audio input level in volts or millivolts and the corresponding values in dBV and dBm. The voltage level needs no explanation but we should explain the significance of the two decibel figures.

For many years, electronics engineers have found it convenient to describe signal amplitude in decibels, because of the very wide ranges involved – from microvolts (μ V) to kilovolts (kV). Because decibel scales are logarithmic, they make it easier to work with signals varying over such wide ranges.

For example, to describe the voltage gain of an audio amplifier in decibels, we take the base-10 logarithm of the voltage gain (V_{out}/V_{in}) and multiply this figure by 20. So a voltage gain of 10 corresponds to +20dB, a gain of 100 corresponds to +40dB, a gain of 1000 corresponds to +60dB and so on.

Similarly an attenuator which reduces

the voltage level by a factor of 10:1 can be described as having a "gain" of -20dB.

DBV & dBm

But what's the difference between the "dBV" and "dBm" figures? These are both decibel scales but they are used to compare a specific voltage level with a known reference value, rather than to compare two specific values. So the contractions dBV and dBm indicate that the figures they accompany are absolute, rather than relative.

A reading in "dBV" is a voltage expressed in decibels with reference to 1.0V. So +6dBV means a voltage that is 6dB greater than 1.0V (ie, 2.00V), while -20dBV means a voltage that is 20dB smaller than 1.0V (ie, 100mV) and so on.

Similarly, "dBm" means that a signal level is being expressed in decibels with reference to a specific power level of 1mW (milliwatt) – in other words, on a decibel scale where 1mW corresponds to

0dB. So +10dBm corresponds to 10mW, +20dBm to 100mW and -30dBm to 1 μ W (microwatt).

Since the dBV and dBm scales are "absolute", can they be related to each other? Yes they can but to work this out you need to know the impedance level, because this is what relates voltage and power in any circuit.

In traditional audio work, the impedance level is 600 Ω . At this level, a voltage of 1V corresponds to a power level of 1.667mW ($1^2/600$), so 0dBV equals +2.118dBm. So at this impedance level, there's a fixed 2.2dB difference between dBm and dBV.

Older audio level meters often indicated in just dBm or perhaps in dBV as well. If the user wanted to know the actual voltage level, they had to refer to a chart or grab a calculator and work it out.

This could be pretty tedious and that's why we've given this new Digital Audio Millivoltmeter the ability to calculate and display not just dBV and dBm (for 600 Ω circuits) but the equivalent voltage level as well, for every measurement.

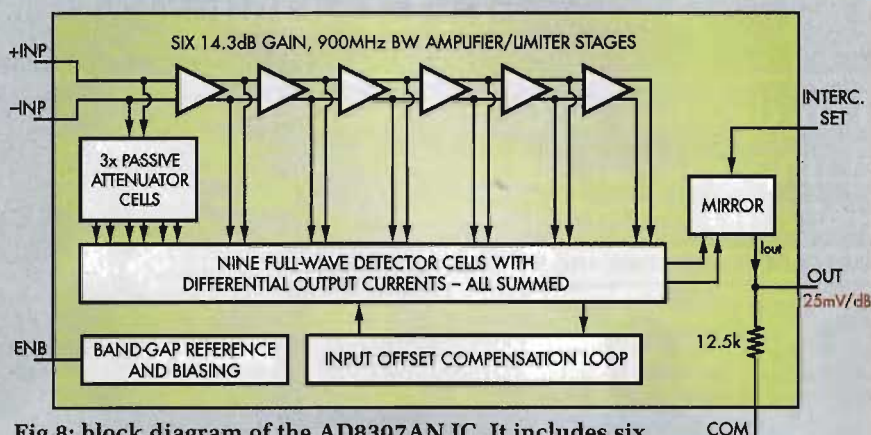


Fig.8: block diagram of the AD8307AN IC. It includes six cascaded amplifier/limiter stages with a total gain of 86dB.

The AD8307 Log Amplifier/Detector

You may not be too familiar with logarithmic amplifier/detector ICs because they are fairly specialised devices. But you can get an idea of how they work from Fig.8, which gives a simplified view of what's inside the AD8307AN device.

The incoming AC signals are passed through six cascaded wideband differential amplifier/limiter stages, each of which has a gain of 14.3dB (about 5.2 times) before it

enters limiting. This gives a total amplifier gain of about 86dB or about 20,000 times. The outputs of each amplifier/limiter stage are then fed to a series of nine full-wave detector cells, along with similar outputs from three cascaded passive 14.3dB attenuator cells connected to the input of the first amplifier/limiter.

The differential current-mode outputs of all nine detector cells are added together and

fed to a "current mirror" output stage, which effectively converts them into a single-sided DC output current. And because of the combination of cascaded gain and limiting in the amplifiers (plus an internal offset compensation loop), the amplitude of this output current turns out to be quite closely proportional to the logarithm of the AC input voltage, over an input range of just on 100dB – ie, from about -93dBV (22.4μV) up to +7.0dBV (2.24V).

In fact, this "logarithmic law" relationship is linear to within ± 0.3 dB over most of the range. The output current I_{out} increases at a slope of very close to $2\mu A$ per dB increase in AC input level and when this current passes through a 12.5kΩ load resistor inside the chip, this results in a DC output voltage which increases at the rate of 25mV/dB. This slope can be fine-tuned using an adjustable external resistor in parallel with the internal 12.5kΩ resistor.

The "intercept set" input allows us to adjust the DC offset in the output current mirror, which adjusts the effective "zero level" point of the chip's output current and voltage – ie, the "origin" from which the output slope rises. You can think of it as setting the detector's zero point.

Step 1: set switch S3 to select unbalanced input connector CON2, then fit a 50Ω termination load plug to CON2 so that the meter has a nominal audio input of "zero".

Step 2: apply power and monitor the LCD readout after the greeting message has been replaced by the normal readings. In particular, look at the dBV reading, because initially you'll probably find that it shows a figure rather higher than it should.

Step 3: leave it for a few minutes to allow the circuit to stabilise, then adjust the "Intercept" trimpot (VR2) carefully using a small screwdriver or alignment tool to reduce the reading down to the lowest figure you can – ideally -76dBV or less, corresponding to about 0.160mV (160μV) and -73.8dBm.

Step 4: remove the 50Ω termination plug from CON2 and instead connect the output of your audio generator. The latter should be set to some convenient frequency (say 1kHz) and to a known audio level – say 1.00V.

Step 5: adjust the "Slope" trimpot (VR1) until you get a reading of +00.0dBV on the LCD.

Step 6: reduce the generator output

to 10mV and check the dBV reading on the LCD again. It should now read -40dBV and if you press the unit's Range Select button (S1) so that the micro switches down to the <-20dBV range (ie, orange LED glowing), this reading should remain very close to -40dBV.

In fact, if you press S1 again to switch down to the <-40dBV range (red LED glowing), the reading should still remain very close to -40dBV. If it changes up or down by a significant amount, you should try adjusting either the Intercept or Slope trimpots (or both) very carefully to bring it back to the correct reading.

Step 7: to make sure that you have found the correct settings for the two trimpots, try changing the generator output back to 1.00V and also press S1 again to switch the meter back to its top range (<0dBV, green LED glowing). The LCD reading should again be 0.00dBV but if it has changed slightly you'll need to tweak VR1 and/or VR2 again to bring it back.

The basic idea is to repeat this process a few times until the millivoltmeter is giving the correct readings for both

Silicon Chip AF
Millivoltmeter

097.3mV=-20.2dBV
=-18.0dBm (600Ω)

Fig.9: the display at top shows the message that appears on the LCD when the unit is switched on, while directly above is a typical readout.

of the known audio levels: 00.0dBV for 1.00V input and -40.0dBV for 10.0mV input. Once this is done, your Digital Audio Millivoltmeter is calibrated and ready for use.

By the way, the maximum audio level that the Audio Millivoltmeter can measure by itself is 1.4V RMS, corresponding to +3.0dBV or +5.2dBm. To use it to make measurements of higher audio voltages, you'll need to connect an audio attenuator/divider ahead of its input.

If there's enough interest, we'll describe such an add-on divider in a future edition of SILICON CHIP. **SC**

CIRCUIT NOTEBOOK

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

Modification to Yaesu FRG7 SW receiver

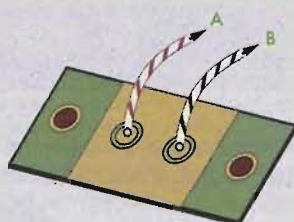
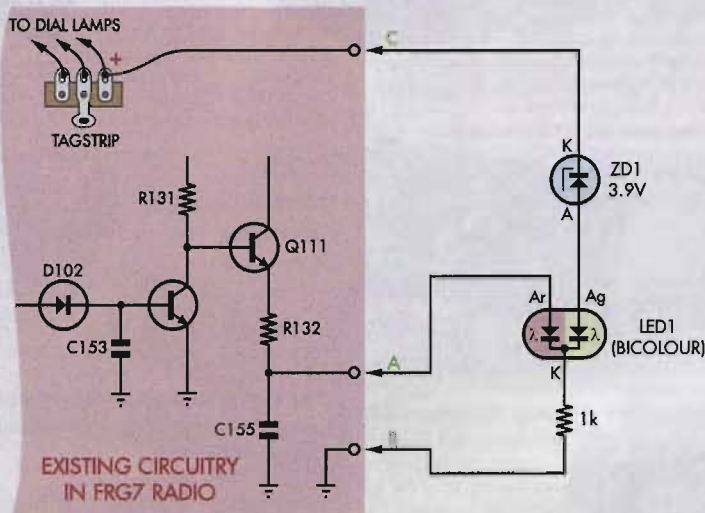
The Yaesu FRG7 shortwave receiver remains a popular choice with many listeners and this modification improves its ergonomics. As originally presented, the red LED "lock" indicator is designed to light up to signify that the Wadley loop is not tuned correctly and remains dark when all is well. This can be confusing for many operators not used to this tuning "quirk".

A common circuit to fix this (as published on the internet) requires a small circuit board, two transistors and several resistors to do the job. By contrast, this circuit requires just three components, including a bi-colour replacement LED. It can be simply constructed on the existing LED-mounting panel.

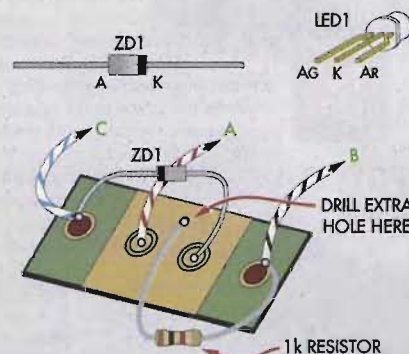
One extra hole needs to be drilled in this PC board, for the third lead of the LED – see diagram. This also shows how the 3.9V zener diode (ZD1) and the additional 1kΩ resistor are wired to the LED board.

Now, when the loop is unlocked, the red LED section of the bi-colour led is switched on, indicating the mistuned condition (as designed). In this condition, the voltage appearing at the common cathode junction of the LEDs rises above the 3.9V at the anode of the green LED, thus turning it off.

When the lock condition is achieved,



EXISTING LED BOARD



MODIFIED LED BOARD

ed, the green LED lights, indicating all is well. The green LED only is supplied from the dial lights, to conserve power when batteries are used.

The circuit is also useful anywhere a 2-LED indication is required

and only one switching voltage, without its inverted counterpart, is available. There is no reason why separate LEDs cannot be used, if that is preferred.

Dayle Edwards,
Taylorville, NZ. (\$40)

Contribute And Choose Your Prize

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

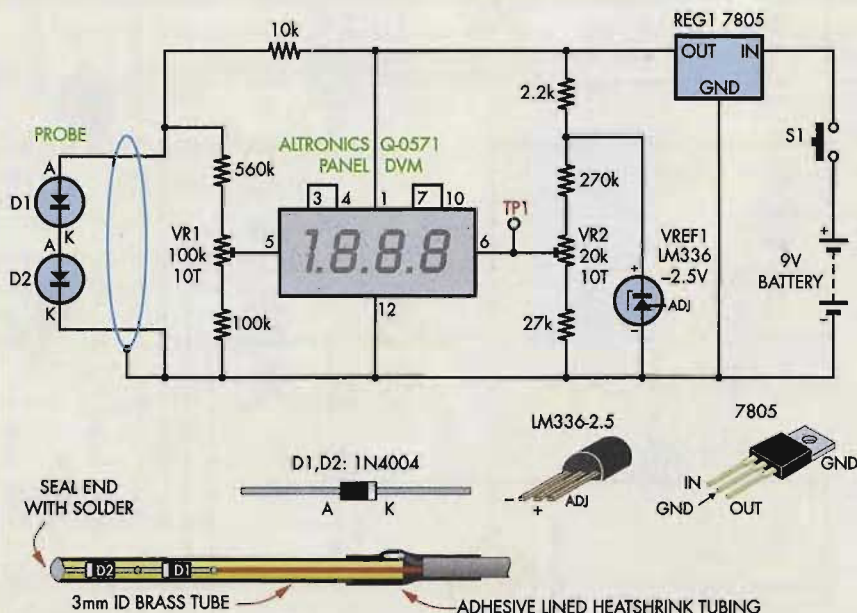
Each month, the best contribution published will entitle the author to choose the prize: an LCR40 LCR meter, a DCA55 Semiconductor Component Analyser, an ESR60 Equivalent Series Resistance Analyser or an SCR100



Thyristor & Triac Analyser, with the compliments of Peak Electronic Design Ltd – see www.peakelec.co.uk

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

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



Simple circuit measures the temperature of your hot water system

Most solar hot water systems are sold with an electric booster but if you leave this thermostatically-controlled heating element switched on permanently, what you end up with is more of an electric hot water system with solar boosting. Connecting it through a timer switch is a good idea but if you really want to save power and take command of the hot water production, you need to monitor the temperature in the tank. Because most solar systems are roof-mounted, this means a remote temperature sensor.

In my case, the distance from the HWS to a convenient mounting spot for the display (the hallway directly below) is six metres. Most commercially available digital probes have lead lengths of about 1.5 metres at best and won't read above 50°C but on a hot day, the tank temperature can reach 80°C or more.

The solution is to make your own hot water probe. You can then check the tank temperature at any time and if needed, switch on the electric booster.

This unit is based on the fact that the voltage drop across a forward-biased silicon diode varies linearly

with temperature over a wide range, at about -2.3mV per °C. This circuit uses two silicon diodes in series and a portion of the voltage across the two diodes is monitored by a 3.5-digit panel meter.

Precision voltage source

An LM336 precision voltage source is used for a stable zero reference and the constant current required by the two diodes is supplied via a 10kΩ resistor from the 7805 5V 3-terminal regulator, REG1.

The diode voltage is fed into the negative input of the digital panel meter and the zero reference into the positive. Pins 3 & 4 of the panel meter must be shorted to set it to read 200mV maximum and connecting pin 10 to pin 7 sets the display to one decimal place. In fact, this will give a maximum readout of 199.9mV.

We want the temperature range from 0-100°C to correspond to a voltage range of 0-100mV so the display will read directly in °C. This involves adjusting VR1 & VR2.

The first step is to read the voltage across the two diodes with the probe in boiling water to find the voltage

that corresponds to 100°C and then the same with melting ice to get the reading for 0°C. Don't fully immerse the probe in the boiling water – just dip the tip.

Typically, the 100°C value might be 0.715V while the 0°C value might be 1.18V. The difference (1.18 - 0.715) is 465mV. This range needs to be scaled down to get a range of 100mV.

To obtain the scaling factor, divide 100mV by the difference voltage in millivolts, ie, 465mV. The result is 0.215. This is the scaling factor. Multiply the zero voltage reading by this value (ie, 1.18 x 0.215 = 253.7mV). That is your set-point for zero. Monitor the voltage at TP1 with your most accurate digital multimeter and adjust it to 253.7mV with 10-turn pot VR1.

To set the span, simply put the probe tip back into boiling water and adjust VR2 to give a reading on the digital display of 100.

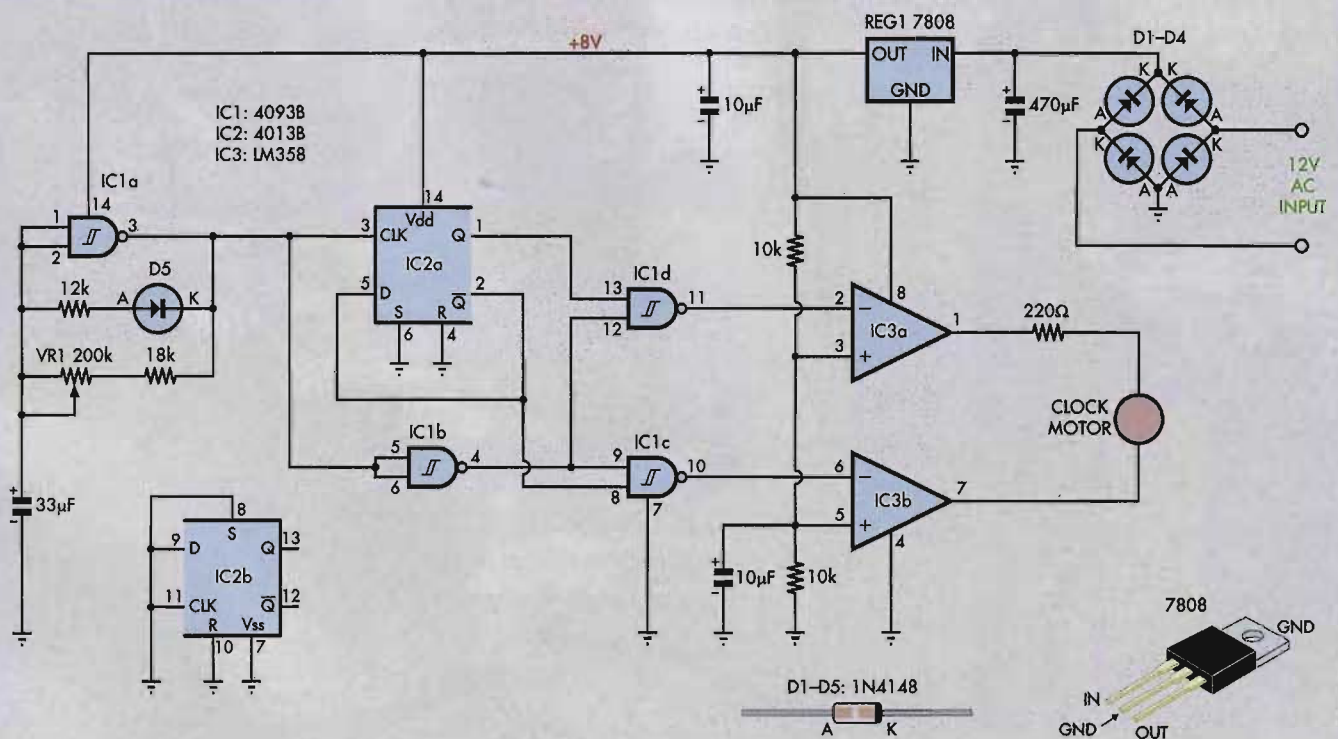
Making the probe

The probe must be waterproof, both for ease of calibration and survival in the hot and humid environment of the HWS. I housed mine in a section of thin-wall brass tubing scavenged from a broken transistor radio telescopic aerial.

I also used twin-shielded microphone cable for the probe although lightweight coax would do as well. The cathode end of the "bottom" diode is soldered through the end of the brass tube to give better thermal conductance. Make sure that this end is completely sealed. Heatshrink tubing (the type with internal hot melt glue) is fine for sealing the cable entry.

The probe needs to be in close contact with the metal tank and at the top, where the temperature will be the highest. Most tanks have polyurethane or polystyrene insulation under the exterior metal skin. After drilling a small hole through the outer skin (don't drill into the tank itself!), the probe can be simply pushed through the insulation and into contact with the tank. Be sure to keep the probe cable well away from all 230VAC wiring.

Roy Mercer,
Denmark, WA. (\$40)



Fast clock driver for a model railway layout

Because model railways “compress” large areas into a small area, with much shorter track lengths than real railways, it is common to use a “fast clock” for running schedules. Typically, the clock might run six to 12 times faster than normal so that a 24-hour schedule can be compressed into a few hours. So what is needed is a circuit to pulse the coil of a crystal clock mechanism at six or 12 pulses a second rather than the nor-

mal 1PPS rate. The pulse waveform needs to be bipolar, driving current through the coil in one direction for one tick and then in the other direction for the next tick.

The existing circuit board from the clock is removed and this substitute circuit drives the coil directly with pulses of alternating polarity.

Schmitt trigger IC1a is a variable frequency pulse generator which clocks IC2a, one half of a 4013 dual D flipflop. IC2b is not used. IC1 gates the Q and Q-bar outputs of IC2a, through to the dual op amps

IC3a & IC3b. The op amps drive the clock coil with pulses of about 4V peak, necessary to ensure reliable operation with the shorter pulses and higher pulse speeds of 10Hz or more.

The 220Ω resistor prevents overdriving the clock coil, while the clock's speed is set by VR1.

**Geoff Monegal,
North Maclean, Qld. (\$40)**

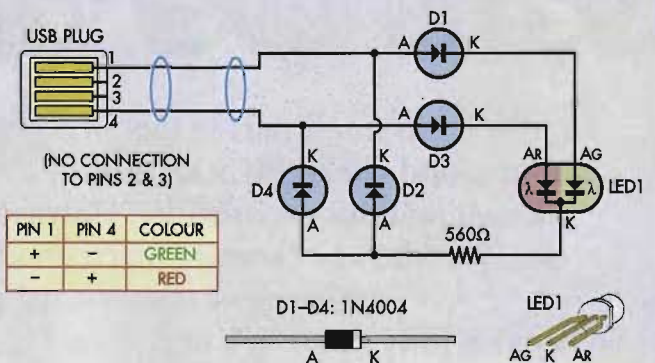
Editor's note: a Fast Clock circuit running on 3V (two AA cells) was published in the December 1996 issue of SILICON CHIP.

USB polarity tester is worthwhile insurance

If you need to wire up USB sockets for any reason, whether in a prototype USB interface or merely when making connections from a motherboard to a front panel socket on a PC, it is essential that you get the voltage polarity right. If you don't and you plug in a flash drive or some other item of hardware, you are likely to destroy it.

This simple circuit uses a bridge rectifier or four individual diodes and a red-green LED. It is wired to a lead with a USB socket. If the polarity is correct, current flows from pin 1 to pin 4 of the USB plug via diodes D1 & D4 and the green LED. As a result, the green LED lights.

Conversely, if the polarity is wrong, current flows via



diodes D2 & D3 and so the red LED lights. So green is good and red is bad.

**Steven Anthony,
Dalwallinu, WA. (\$30)**



Microcontrollers can be a SNAP!

Thanks in no small part to the SILICON CHIP promotion over the last five years, popular and cheap PICAXE micros are widely now considered the *best value* educational microcontroller. However, motivated pre-teens and fuzzy-eyed seniors who are “keen to learn about micros” may find PICAXE PC board soldering or breadboard circuit assembly too fiddly. So here’s a nifty approach that fits a PICAXE-08M micro-controller into the gutted sound module from a colourful “Snap Connector” electronic kitset.

by The Mad Scientist
(aka Stan Swan)

Snap Connector kits are globally sold under a variety of names but here in New Zealand they're known as "Electronic Brain Boxes". The simplest "80 Experiments" kit costs around \$20 from Dick Smith Electronics (NZ). They're also available from the NSW CSIRO shop (www.csiroshop.com).

Pre-teen kids thrive on them and classroom management is easy, since no tools are needed. That's right teachers – **no tools needed!**

Although this PICAXE conversion is designed around the most basic kit, the approach shows great promise for easing the electronics learner's transition from toys to tools. The modification still allows full PICAXE programming (~80 lines of high level code) but only three of the normal five I/Os are now available. That's normally quite enough for intro work. Some PICAXE-08M channels are limited normally anyway, with channel 0 output only and channel 3 input only.

Even with just three I/Os applications abound, with sounds, LED flashing, sensor reading, timers, data loggers,

simple reaction games, code sending, traffic light simulations and much more – even two-wire serial data communications to other units/PCs are possible.

Thousands of PICAXE programs have been written over the last five years and many will readily adapt to use here. Aside from youngsters, even sprightly seniors can now handle the setup – you're never too old to learn about micros!

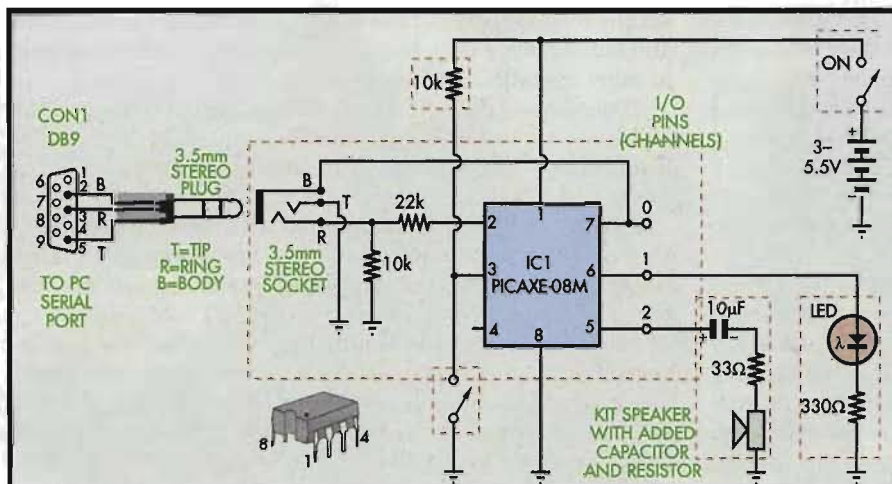
Basic electrical circuits included with the snap kits themselves of course can still be used, although (hooray!) those relating to the mindless, noise-making sound module can be now (thankfully) ignored.

Most electronics old timers can well recall the frustrations that blighted their early circuitry and many of today's electronics newcomers sadly experience the agony of defeat with wire stripping, tool use, soldering and component handling. Sure – just like laying bricks – it's easy when you know how!

The confidence boost gained from assembling **circuits that work** is immense. I've used a swag of 30 "Snap Kits" as part of my educational "mad scientist" work and have had

Components in the supplied kits quickly snap together to assemble colourful circuits. Lamps, LEDs, switches, series and parallel connections, motors and even sound and alarm circuitry can be quickly and reliably made by the simplest versions.





SC "PICAXED" ELECTRONIC BRAIN BOX

The schematic shows conversion parts and other minor kit modifications inside dashed red lines. A normal Rev.Ed PICAXE serial D9 programming cable, terminating in a grounded tip 3.5mm stereo plug, neatly matches the socket now fitted to the modified sound module.

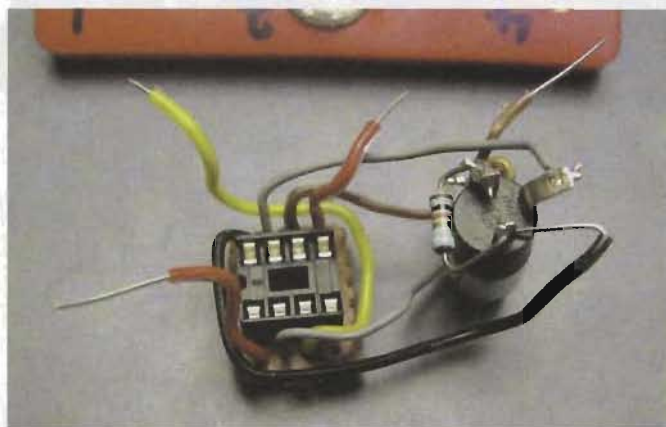
thousands of kids tinker with them in the past 18 months.

Even the simplest "80" kit keeps a "Friday afternoon on a hot day" class focused for ~45 minutes, with the small motor driven fan especially popular. Amazingly, however, most are still intact and *almost none of the parts have been lost!*

The design of the kits in fact cultivates compulsive tidying up – complete sets have been re-boxed in as little as three minutes! Youngsters (some even preschool) absolutely love them. As the colourful instructions are very graphical, users don't even have to be able to read – this could perhaps further appeal for those with poor English skills.

Even the larger kit versions may however only provide a few hours of out-of-the-box fun for most kids and an enhanced challenge is really needed to stimulate curiosity. Motivated teachers and parents could of course make up their own experiments and task worksheets – eg, Ohms law, series/parallel loads, switches etc.

The larger kits in fact even have radio and metering op-



Here's an assembled conversion, with the 9-pin DIL socket wired to a piece of Veroboard for convenience. It's ready for soldering to the five now-vacated contact tags in the Snap Connector kit. If significant numbers of these kits are being converted, as in a classroom, simple wiring templates and jigs will speed assembly.

tions, suitable for mid-level secondary school and innovative Science Fair projects based around these have been noted.

PICAXE persuasion!

But instead of such zeal with simple components, here's a low-cost end-user-oriented approach based around – *gasp* – a microcontroller. Read on!

Although the basic kit circuits are highly educational, both kids and (especially!) adults may soon tire of siren and machine gun noises from the sound module. Compared with the rest of the kit, the five connections to this C-O-B (Chip On Board) sound device are not lucid anyway – it's little more than a mindless "red box".

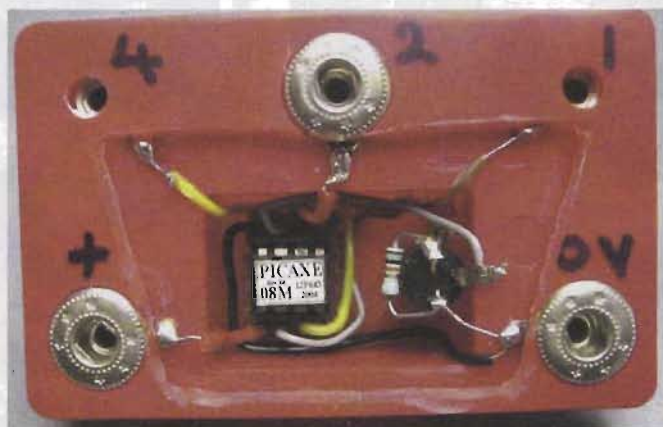
Hence, removing this module from its housing and replacing it with a far more versatile PICAXE-08M micro tempts instead. An alternative would be to make your own add-on module from a plastic project box but it naturally wouldn't

look as professional, and suitable snap connectors have also been elusive, at least here in NZ.

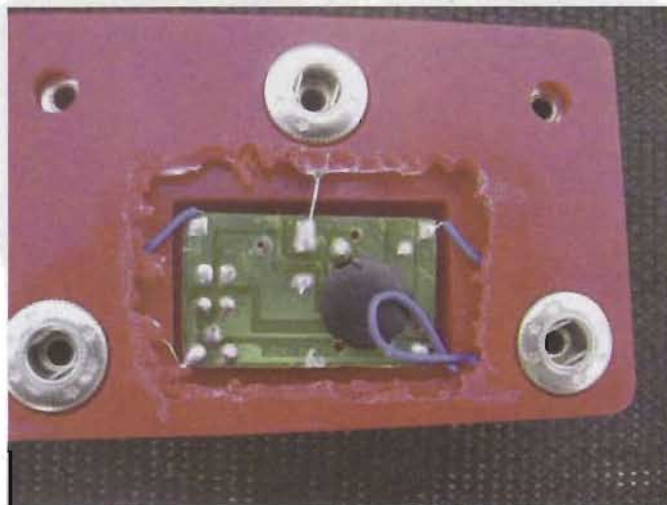
Initial case cutting with a Dremel readily exposes the innards but a larger trapezoidal cutout, as far back as the solder tag contacts, is preferred since the existing wires are rather too flimsy. A small piece of Veroboard (perhaps 4 hole x 6 hole) makes for the neatest assembly, although a "rats nest" ugly layout can be used.

It's recommended that colour-coded wires (Brown=1, Red=2, Yellow=4 etc) are used to identify the connections, with a DIP-8 socket for the PICAXE. Ensure the Veroboard copper tracks under the socket are completely cut, perhaps using a sharp drill bit. For those who've just come in, the PICAXE I/O "PIN" channels are NOT the same as the usual IC pins and an unusual supply pinout also exists. The IC pin 1 is positive, with pin 8 0V (ground).

The retrofitting modification is a tad fiddly but the wiring



Voila! Ready for programming. Tightening the ring on the 3.5mm programming socket nicely secures the circuitry – a clear plastic trapezoidal panel could be perhaps also fitted to suit display of the conversion while preventing tampering. Ensure the PICAXE is correctly inserted into the DIP-8 socket, with the positive supply on pin 1.



Here's the innards of the kit's supplied sound module. The noisy output arises from the (unknown) IC under the black blob – cut the five linking wires and remove the module from the holder.

is not really critical. Aside from the five links to the gutted module's connectors, two resistors (10k Ω and 25k Ω) and a 3.5mm 3-terminal socket are also fitted to allow PICAXE programming.

The pain of tight clearance soldering can be eased with a "helping hands" support. Use every trick in the book for such fiddly work! If quite a few conversions are being done, set up a simple spacing template to streamline assembly and wire lengths etc.

Subsequent programming, using the usual PICAXE 3-wire serial lead connected to an editing PC, can be readily done via the fitted (three terminal) socket. Download the free editor from the Revolution Education site => www.picaxe.com.

The editing PC doesn't have to be the latest (or networked), as even an old Win 95/98 standalone laptop – preferably one with serial ports – can still handle the task.

Extra circuitry (LEDs, 10kohm pullup resistors etc) can be made simply made by modifying spare two-contact "snap" strips. The speaker should now have a 10 μ F electrolytic and 33 Ω resistor fitted too. Extra LEDs will need a dropping



The completed "PICAXEd" circuitry, laid out to suit diverse PICAXE program applications. Parts in the simplest "80 Circuit" Snap Connector kit exactly cover this arrangement, and a 10k Ω resistor fitted to a spare 2-connector strip allows a useful READADC voltage divider.



Parts needed for the PICAXE modification can be readily mounted on both the 3.5mm stereo programming socket and a small Vero off cut. Use a Dremel to neatly enlarge the cutout for better access to the five snap contact tags.

resistor (~330 Ω). The PICAXE-08M itself runs on any supply from 3-5.5V, so the use of a dummy cell allows either 3 x fresh AA cells or 4 x 1.2 V NiCd/NiMH to be used in a 4xAA holder.

This dummy cell, shown here as a shorting screw for effect, can be more elegantly made using a nail inserted inside a suitable length and width of bamboo or plastic tube offcut. As the PICAXE itself only draws a few milliamps, the batteries may last months under light loads.

When they're nearly flat, the dummy can be replaced with another near-flat AA, squeezing a few more useful Joules out of the batteries in an environmentally (and tight budget!) friendly manner.

Just make sure you don't exceed that 5.5V PICAXE limit!

Applications

Layout trials lead to the suggested version that suits a versatile 3 I/O channel use. The "PICAXEd" sound module looks right at home amongst the colourful parts, although a simple neat label showing the I/Os and supply positions could be fitted (see the sample below).

Aside from easy LEDWINK: HIGH 1: WAIT 1: LOW 1: WAIT 1: SOUND 2,(100,10):GOTO LEDWINK style programs, this suggested setup in fact perfectly suits a simple PICAXE response timer game (REACTIONBB.BAS) originally devised in 2003.

Competitive kids who've tried this game have declared it "pretty cool" – you can't ask for better praise than that! **SC**

It's essential to suitably re-label the original sound module. Here is a suggested 30mm x 20mm label, with punch-out for the 3.5mm socket, can be covered with clear contact or laminated and then suitably glued on top.



Further ideas, including an Instructable, PICAXE links and downloadable programs are hosted at => www.picaxe.orconhosting.net.nz/snap.htm

Vintage Radio

By RODNEY CHAMPNESS, VK3UG



The deadly & the difficult – when to say no to a restoration



The "Pilot Little Maestro" is a 5-valve medium-wave (MW) and long-wave (LW) receiver made in 1939. It's potentially deadly, as revealed in the text.

Deadly equipment and difficult faults can present real challenges when restoring vintage radio gear. Sometimes, you just have to say "no" to a set that's just too dangerous to use unless it's correctly modified.

GENERALLY, we expect a vintage radio to be intrinsically safe due to its inherent design and as a result of either careful restoration or proper maintenance throughout its life.

Of course, if we are restoring an old set to working order, then nothing can be taken for granted. In fact, it is only to be expected that some faults may have developed in the set, particularly

if it has been stored for many years in a garage or shed in less than perfect conditions.

In particular, equipment that's been attacked by rodents and various creepy crawlies will need careful attention to ensure a successful (and safe) restoration. This same goes if the set has been subjected to damp, dusty and hot/cold conditions.

I have seen pictures of receivers that have been restored from absolute wrecks to pristine condition by dedicated enthusiasts. However, when the ravages of time and storage inadequacies have taken their toll, it is time to sit down and determine whether restoration really is worth the effort.

Of course, an extremely rare piece of equipment will be well worth it, provided it isn't like grandad's axe. You've probably heard the saying – it's had five new handles and three new heads but it's still grandad's original axe!

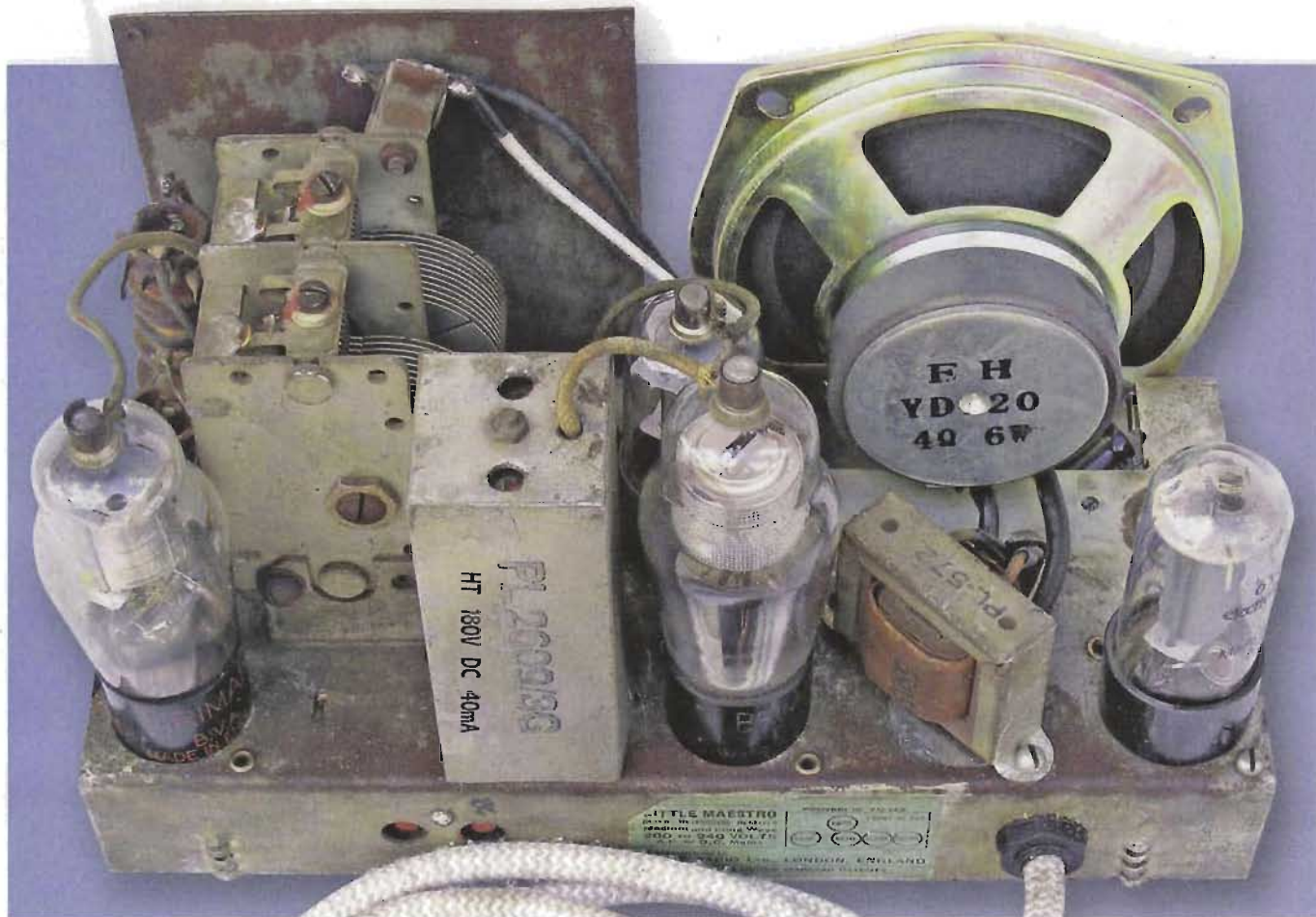
Well hardly and the same applies to rare vintage radios if the parts aren't original or, at least, the correct replacements.

If only a few parts of a set are recoverable, will it really be a genuine restoration or just a replica that happens to use some original parts? Not that there's really anything wrong with replicas. They are sometimes the only way of showing us how technology achieved things in times gone by.

Making the assessment

Assuming that the power cord itself is OK, the first thing to do when assessing whether an AC-powered radio is worth restoring is to check the power transformer. There are a couple of tests that will quickly reveal whether a power transformer has withstood the ravages of time. But first, if the set has been stored in a damp location, it's worthwhile heating the chassis with the transformer still attached in a kitchen oven at around 50-60°C for a few hours.

This will help to dry out any moisture in the transformer and make the



An above-chassis view of the Pilot Little Maestro. As originally designed, it was a AC/DC set with one side of the mains connected to chassis but this particular unit has been modified to run from an external power supply for safe operation.

following tests more realistic.

The next step to test the insulation between transformer's primary winding and the frame and also between the primary and secondary windings. The secondary high-tension (HT) winding also needs to be checked to ensure that it has no shorts to frame. This will usually involve lifting the centre tap of this winding from the chassis (or lifting the low-value resistor in series with it).

I do this insulation test at 1000V using a high-voltage, high-impedance tester. Mine was obtained as a kit from Altronics several years ago (Cat K-2555). If this test shows the insulation resistance to be greater than around 200MΩ between the various sections, the next test can be carried out.

This involves removing the rectifier valve, then connecting power to the transformer and running it for about 30 minutes. If, at the end of this period, the transformer is only slightly warm, it is fairly safe to say that it is in good order, provided there is continuity in each of the windings.

By the way, don't leave the equip-

ment unattended during this test. If there is a fault in the transformer (eg, shorted turns) it will quickly over-heat and will need to be turned off promptly.

From my experience, faulty power transformers are quite rare even after several decades in storage, often in less than ideal conditions. I have, however, come across a number of transformers which have perished leads emerging from the windings. Left as they are, disaster is just around the corner in the form of short circuits and a burnt-out transformer.

Depending on how the transformer is made, I have in some cases taken off the cover plates and installed new lead-out wires. Alternatively, if that is not possible, I have carefully removed the old insulation from the various leads and replaced it with fresh insulation.

Usually, the insulation has become hard and it can be cracked off using a pair of pliers. I then slip on new spaghetti insulation over the bare wires to make the transformer safe to use. I also often tie some of the leads together with plastic spaghetti

and also use some clear nail polish to hold the sleeves in position where they emerge from the windings on the transformer.

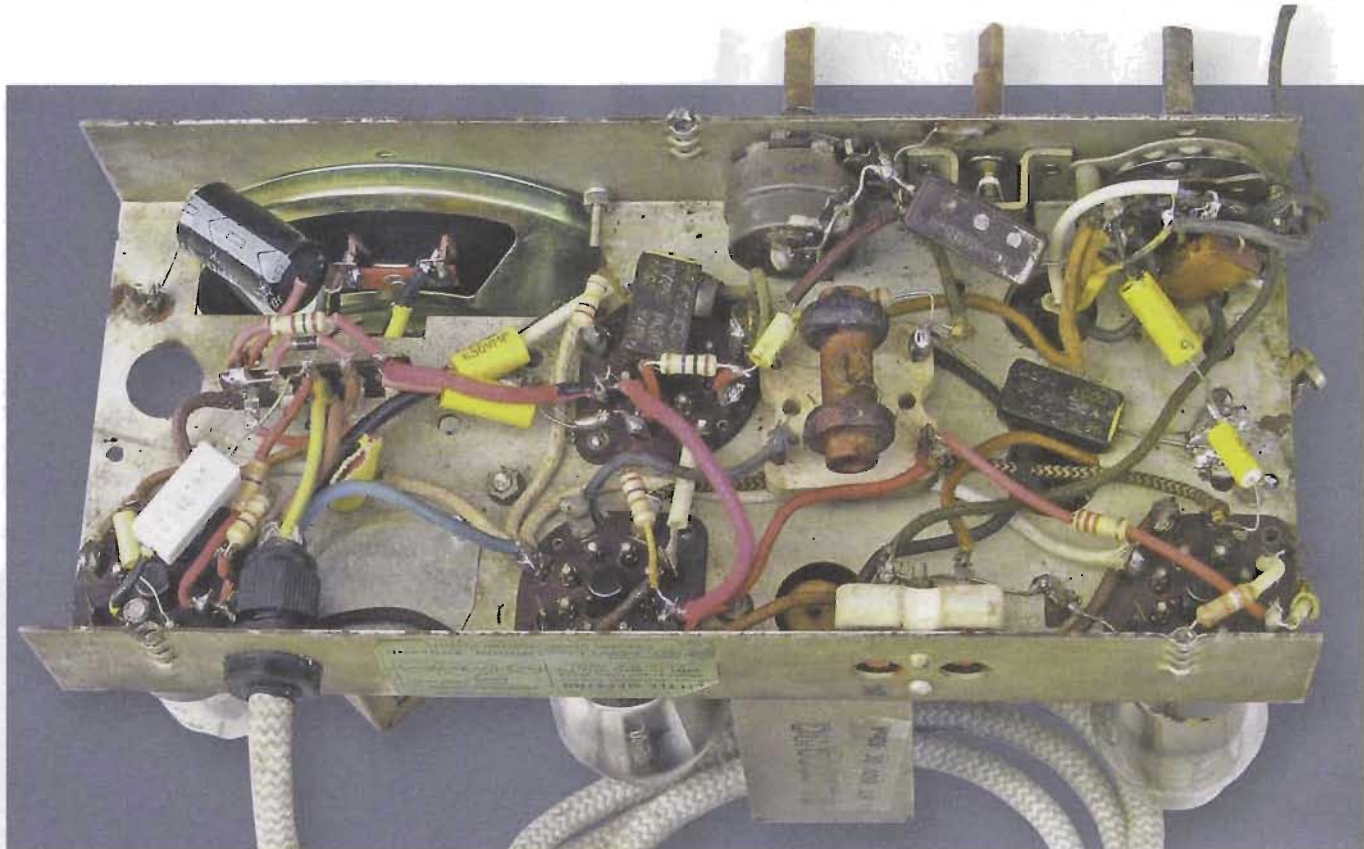
If the power transformer is faulty, it may mean that restoring the receiver is not an economic proposition. Alternatively, it may be impossible to restore if a suitable replacement isn't available. However, substituting a transformer from another set is often practical, providing it has a similar rating and fits the available chassis space.

Dial scale

The value of a receiver drops dramatically if the dial scale is broken or missing. To get around this problem, some restorers have become quite skilled at using computers to make new dial scales.

In some cases, they lay the broken pieces out in position and then scan the dial into a computer. Then, using a drawing program, they use this as a template to make another scale which can be printed out onto plastic film and fitted to a glass backing.

Some restorers even provide a service to others by supplying dial glasses



This below-chassis view shows the Pilot Little Maestro after it had been restored and modified. It's basically close to original except for the power supply wiring. Note the long metal control shafts. They protruded through the front of the wooden cabinet and, with the original power supply arrangement, could deliver a potentially lethal shock to an unsuspecting user if one of the push-fit knobs came off.

for a whole range of sets.

Most other items in a receiver can either be repaired or replacement parts salvaged from other wrecked sets. Of course, the closer those parts are in appearance to the originals, the better.

Cabinet restoration is often a big problem for many people, myself included (although I can do minor repairs successfully). The fact is, major cabinet restoration work is a craftsman's skill. It's a skill that some have thought and I've seen some magnificently restored cabinets over the years.

It's important to consider all of the above factors before taking on a major restoration job. But that's not all you have to consider. You also have to think about safety, especially when it comes to AC/DC sets (ie, sets without a mains transformer).

A deadly receiver

We come now to vintage radios which, due to their design, are inherently dangerous or, in fact, even deadly.

Not that long ago, I was looking at a couple of sets that belonged to a fellow restorer. I was rather keen to write them up for SILICON CHIP, as they both

looked quite interesting. One was a Philco AC/DC mantel receiver and this was featured in the January 2009 issue. The other was a "Pilot Little Maestro", a 5-valve medium-wave (MW) and long-wave (LW) receiver made in 1939. We only used LW for a short time in Australia but LW had been used in Europe for quite some time before the war.

This set is a British 240V AC/DC unit and was apparently adapted from an American design that ran on 110V AC/DC. As with nearly all AC/DC sets, the valves heaters are all in series.

The valve line-up included a 6A8G, a 6K7G, a 6Q7G, a 25AG5 and a 25Z6G. These valves all used 0.3A heaters and the total voltage drop across these heaters was around 69V. This meant that a further 171V needed to be dropped across a resistor in series with the heaters, so that the latter would not draw more than 0.3A from the mains.

By contrast, the high tension (HT) current would have been around 50mA, so the total power drawn from the mains would have been about 85W, of which 51W would have been lost across the heater series resistor. In practice, this resistor was actually formed into the mains power cord

and care would have been necessary to ensure it had adequate ventilation and that it wasn't placed near flammable material.

In this set, one side of the mains is connected directly to the chassis via the on/off switch. That's par for the course with AC/DC sets but in this case, the controls protrude through the front of the wooden cabinet. This means that if one of the push-fit control knobs were to come off, the exposed shaft could well be sitting at 240V!

In addition, the cabinet back is held in place using just four wood screws. There are no warnings on the back of the set about the possibility of electric shock, if the back is removed.

In short, I consider it to be a very dangerous set.

Modifications

A close inspection revealed that this particular set had been considerably modified by a previous owner. First, the 25V valves had been removed. A 6BW6 had then been substituted for the 25A6G, while a silicon diode replaced the 25Z6G rectifier. The filament supply was provided by a 6.3V filament transformer.

The set still had the mains con-

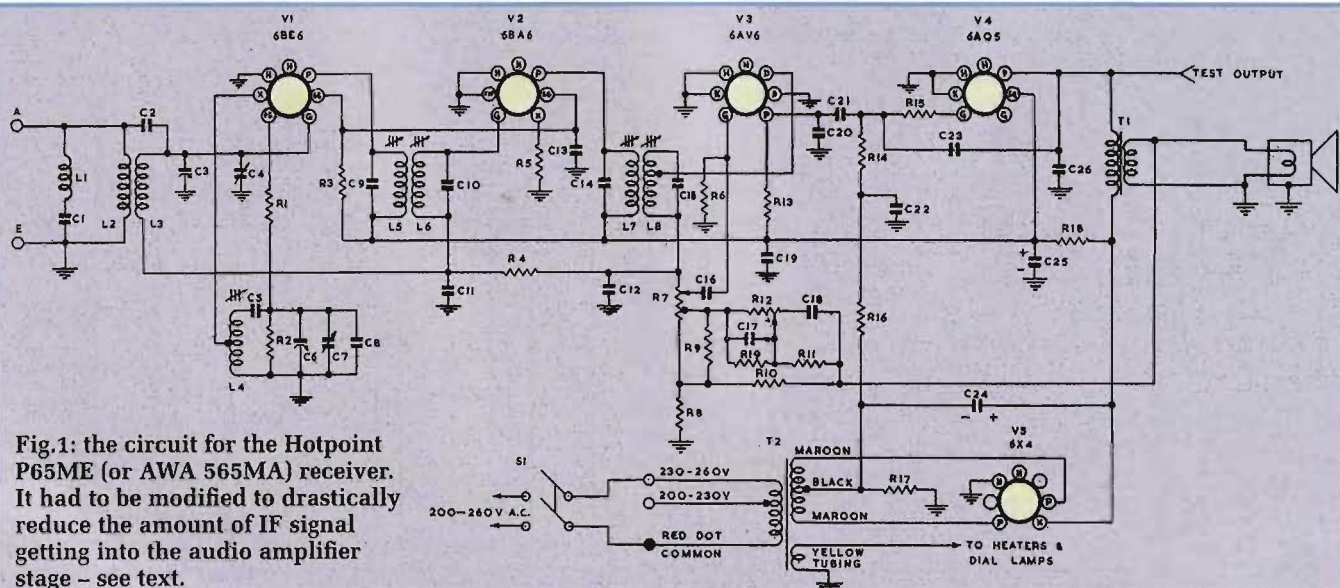


Fig.1: the circuit for the Hotpoint P65ME (or AWA 565MA) receiver. It had to be modified to drastically reduce the amount of IF signal getting into the audio amplifier stage – see text.

nected to the chassis and the HT was produced by using the silicon diode to rectify the incoming 240VAC. But that wasn't all – the standard of the revised wiring was atrocious.

In view of this, I refused to work on the set as I didn't think I could make it safe without spending a lot of time on it. However, a fellow vintage radio buff (Marcus) did have the time to make the set both safe and usable. He agreed that it was a death trap as it was and so decided to convert the set to AC operation only by using an external power supply. That way, the mains could be completely isolated from the chassis.

To cut a long story short, after quite a bit of effort restoring the set and making up an external power supply, the set is now working satisfactorily. It might not be completely authentic but the main part of the set is close to original condition with only the power supply wiring altered extensively.

This conversion is stage one, as Marcus has suggested to the set's owner that he obtain a power transformer from a defunct set that will fit the chassis. That way, they can eventually do away with the external supply.

The performance of the set as modified is good and it also works quite well on long-wave. It's just a pity that this AC/DC set could well have caused a fatality in its original condition.

Difficult faults

Most vintage radio restorations follow a fairly routine path. The cabinet is easily assessed and the work on that

is relatively straightforward for those with reasonable woodworking skills.

Next, a careful examination of the chassis will soon reveal any mechanical items that need attention, while many component faults will also be quite obvious. These faults include capacitors with cracks, bulges or extruded melted wax and resistors that show obvious signs of overheating.

A close inspection will also soon reveal perished wiring, shorts, poor soldered joints and any damage due to rodents and insects.

Of course, capacitors and resistors also need to be electrically checked to make sure they are in good order. Old paper capacitors, for example, are usually leaky and many will need replacement. Valves are more reliable than many people believe and I find that I only have to replace them occasionally.

Once all the faults have been fixed, some sets will also require alignment – especially where a previous owner has had a bit of a fiddle.

However, while most restorations are routine, occasionally a particularly difficult fault will be encountered. These can cause a range of symptoms including instability, distortion, tuning and alignment difficulties and other weird faults. Let's look at a couple of examples that I've had to deal with.

Hotpoint P65ME/AWA 565MA

A friend of mine (Richard) had been having problems with a couple of his sets. Both were unstable, with multiple

whistles across the band and generally just sounded unpleasant. They were also experiencing interference problems on the shortwave band.

The first set we tackled was a Hotpoint P65ME. This is quite a nice looking set and a good job had been done on its restoration.

If there is instability and it appears to be due to feedback in the intermediate frequency (IF) amplifier, the first step is to make sure that little or no IF energy is getting into the audio amplifier stage. Amplification of the IF signal by the audio stages can easily generate sufficient positive feedback to make a set unstable.

Fortunately, I'd had previous experience in solving what is basically a design shortcoming in this set. This involves several simple circuit modifications. Fig.1 shows the relevant circuit details of the set.

The first thing I did was to cut the connection between the bottom of L8 and the top of resistor R7. A 47kΩ resistor was then fitted between these two points and a 100pF mica capacitor added between the bottom of L8 and the chassis to provide additional IF filtering (see Fig.3).

In addition, a 47pF capacitor was connected between the grid of the 6AQ5 and the chassis (Fig.4).

Together, these modifications drastically reduced the IF signal on the grid of the 6AQ5. The set was now much more stable but a whistle could still be heard when tuning across the band.

Next, I removed the 6BA6 IF amplifier and checked the AGC (automatic

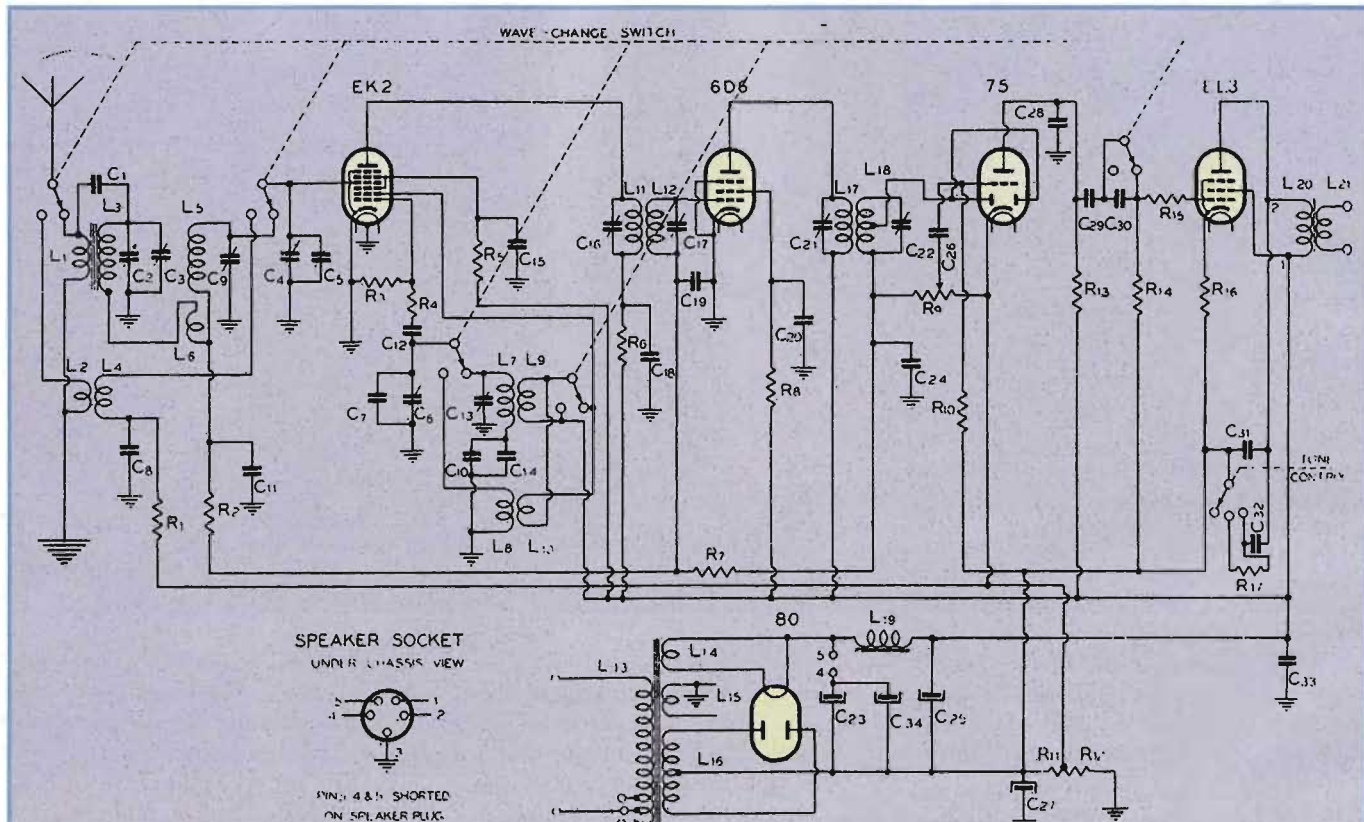


Fig.2: this Philips 1252 circuit also required several modifications to make it stable. This involved decoupling the HT line to the early stages and fitting a screen-stopper resistor to the EL3NG audio output valve – see Fig.4.

gain control) voltage. This measured 0V so I reinstalled the 6BA6 and removed the 6BE6. The set now had several volts of AGC bias when there should have been none.

Simply touching the 6BA6 or placing a finger on its grid altered the AGC voltage level, so the IF amplifier was obviously going into oscillation. This signal was being detected by the diodes in the 6AV6 which in turn provided the AGC voltage.

We substituted another 6BA6 and that completely fixed the problem. So a new 6BA6 and the added IF filtering

made the set better than ever.

I later suggested to Richard that he try refitting the old 6BA6 in the set, along with an earthed metal shield for this valve. My reasoning here was that the 6BA6 has an internal shield that is wired to pin 2 of its base. If a weld had broken in the set's original valve, the shield would not be functional and so the valve would oscillate.

However, when Richard plugged the old 6BA6 back into the set, the instability was absent. There are two possibilities here: (1) the valve has an intermittent break in the shield line;

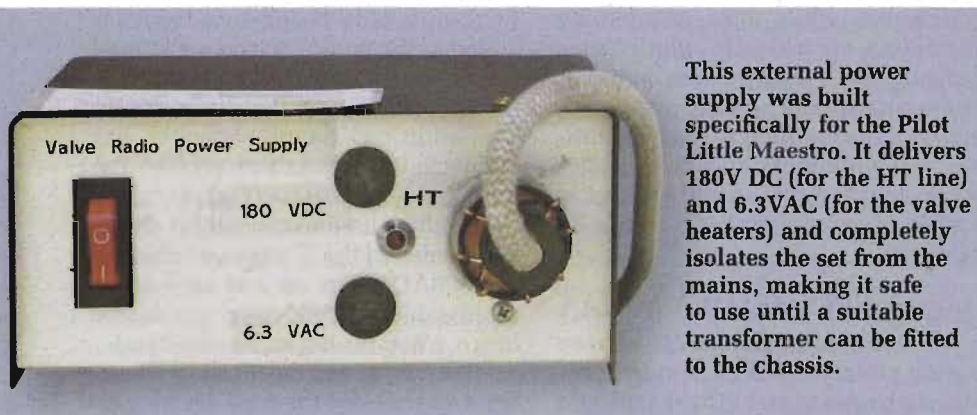
or (2) the socket itself might have had some contact resistance which reduced the efficiency of the shielding.

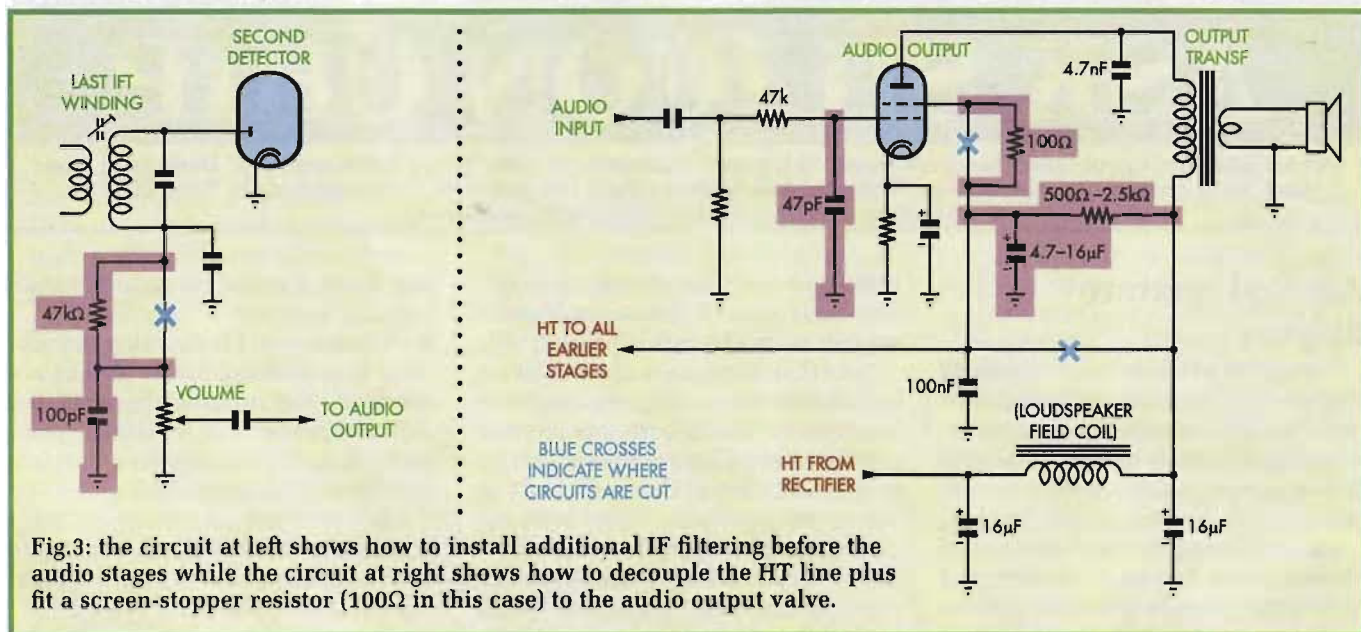
Philips 1252

Richard's Philips 1252 is a very attractive console set but its performance was also woeful. In particular, the IF coils could not be peaked without the IF amplifier going into oscillation, the tuning had many nasty unstable signals right across the shortwave band (7-22MHz) and the audio quality had a harsh edge to it.

Once again, Richard's restoration looked good. And as with his Hot-point receiver, it appeared that the instability in the IF stage was due to excessive IF signal levels finding their way into the audio amplifier stages. As before, the cure was to add additional IF filtering.

Fig.2 shows the circuit details. In this case the line going downwards on the circuit from the bottom of L18 was broken and a 47kΩ resistor inserted into the break. A 100pF mica capacitor was then wired from the bottom of L18 to the chassis. Finally, a 47pF mica capacitor was wired from the





grid of the EL3 (EL3NG in this set) to the chassis.

This simple modification drastically curtailed the amount of IF signal being fed to the audio amplifier but that didn't cure all the set's ills.

Many sets using field coils (as in this set) have very little decoupling of the HT line after the field coil. As a result, any variation in current drain by the output valve plate circuit will slightly vary the HT in the early stages of the receiver. And this in turn can cause instability.

The answer here is to increase the decoupling of the HT line. This involves decoupling the HT line to both those early stages and to the screen of the output valve using a 1kΩ series resistor and an electrolytic capacitor (typically 16μF) – see Fig.3.

I fully expected this modification to finally cure all the set's problems but we got a rude shock. On the positive side, the IF could now be tuned to a peak without the set spilling over into oscillation. However, the nasty "birdies" on the shortwave band were still there and the audio was still harsh.

Acting on a hunch, I touched the body of the resistor that's used to decouple the front-end and the audio output stage and this caused the nasty sounds to alter. This indicated that the audio output stage was still bursting into supersonic oscillation despite the extra filtering that had been added. This was confirmed when we found that placing a hand near the EL3NG output valve had a similar effect.

Photo Gallery: Healing Golden Voice Console Radio

THE CONSOLE radios of the 1930s and 40s were typically fine examples of the furniture-maker's art. A good number of them shared exactly the same chassis as a large mantel radio from the same manufacturer or were only slightly modified.

Consoles had a number of advantages, including a large cabinet which had plenty of space to mount both the chassis and a large speaker, the latter delivering better sound and volume than the smaller unit found in its mantel counterpart.

The valve lineup in this radio is 6J8G, 6U7G, 6B6G, 6V6G, 5Y3G. Photo by Kevin Poulter for The Historical Radio Society of Australia (HRSA). Phone (03) 9539 1117. www.hrsa.net.au



Richard had a spare EL3NG and substituting this gave a noticeable improvement but the set was still a little "edgy" in its audio quality. As a result, I decided to try fitting a screen-stopper resistor, as some valves will oscillate at all sorts of supersonic frequencies if a screen-stopper is absent.

In this case, a 100Ω screen-stopper resistor was added directly between

the screen and the output of the HT decoupling network that had been fitted earlier. Fig.4 shows the details.

Once this had been done, the audio sounded clean with either valve inserted into the audio output socket. In addition, the "birdies" (whistles) on shortwave also disappeared.

In short, the manufacturers didn't always get it right. **SC**

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Air/fuel mixture display

I found the article on the "Wideband Engine Air-Fuel Mixture Sensor Display" in the November 2008 fantastic, as well as the article on how an oxygen sensor works on page 27 of the same issue.

My question is this: is there a stand-alone kit that can be used to tune a carburettor on a motorbike? If there is, do you know where it can be purchased or could you do an article? The unit could also be used for go-karts, motor mowers, whipper snippers, garden blowers, etc. I have seen units for sale around the \$500 mark which isn't cost-effective for a DIY'er.

Looking at your kit, my guess would be to add in an oxygen sensor that attached to the end of the exhaust pipe? Keep up the good work. (V. P. Attwood, Vic).

- You could use a narrow-band oxygen sensor in conjunction with the Oxygen Sensor display (set to the narrow-band "S" curve setting) to enable mixture tuning at stoichiometric. For accurate tuning beyond the stoichiometric point you need to use a wideband sensor in conjunction with a

wideband controller. An article on this is coming up in a future issue as we are still working on this project.

Note that an oxygen sensor must not be inserted into a tail pipe. It must be mounted so that the sensor is screwed into the tail pipe (or a temporary extension piece) so that the main body of the sensor is external to the pipe and only the sensor tip end is exposed to the exhaust. This is so the sensor can compare the oxygen content of the air against the exhaust gases.

Note also that the sensor must be mounted so that it sits more than 10° above horizontal, to allow water to run out of it.

Amplifier overheats with 4-ohm speakers

I have run into problems with the output on the 20-Watt Class-A Amplifier described in SILICON CHIP during 2007. I use a pair of homebuilt "Kappelmeister" speakers which have 4-ohm drivers fitted.

The amplifier overheats after one hour. Can I manipulate or change the circuit so I can use the 4-ohm speakers without sacrificing the sound quality? The sound reproduction is unbeliev-

ably clear; it's the best amplifier ever. (A. H., via email).

- While 4-ohm loudspeakers are not ideal for this amplifier, it should not overheat. Try running the amplifier without speakers and see if it still overheats. If it does, it may be a problem with the initial set-up. Make sure that the DC voltage at the output terminals is less than 50mV. Alternatively, you may not have enough ventilation around the amplifier.

Video Reading Aid processor explanation

Can someone please explain this in an in-depth way but using elementary electronics: how does the last IC2d bilateral switch *invert* the signal? That is, pin 12 has the "Digital Positive" video signal. If this positive signal switches pin 11 to ground pin 10, doesn't that mean that the DEG NEG output is shorted to ground, ie, ZERO signal output? (C. V., via email).

- In this circuit, bilateral switch IC2d does act as an inverter for the digitised ("squared up") active video signals from the camera, even though it does not produce a signal that goes negative with respect to ground. It simply inverts the video sense of the signals, in that white and black levels are reversed – black becomes white and white becomes black.

This is possible because the digitised video only has these two levels. In the "positive" signal on pin 12 of IC2d, white level is positive (about 5V) and black level is 0V. But as you suggest, these levels are reversed at pin 11 of IC2d; white is changed to 0V (ie, black level), while black is changed to about 5V (ie, white level).

Since the signal at the pin 12 input of IC2d is either high or low, it can be used to switch the gate fully on or off. What happens is that when the gate is switched by a high signal, its pin 11 is pulled low (ie, the gate is on and becomes a short-circuit). Similarly, if the signal to pin 12 is low, the gate will off (ie, open circuit) and the voltage at

50MHz Frequency Meter Troubleshooting

I have purchased the kit for the 50MHz Frequency Meter Mk.2 (SILICON CHIP, February 2007) from Jaycar Electronics and assembled it up to the testing stage. I found the voltages on the ICs correct and after fitting the LCD module, found the various displays appeared as indicated. I applied a signal to the coaxial cable at the input but nothing was registered.

Tracing the signal with an oscilloscope, it appeared on pins 2, 3, 13, 14, 15, 10, 9 & 7 but not on 5, 12 or 6. The fact that it appeared on pin 2 but not on pin 12 seemed odd, so I checked the 100Ω resistor out of

circuit but found it to be OK.

Could you possibly advise on what could be done further to discover why the signal does not appear on the LCD? If the MC10116N is faulty, is it possible to purchase a replacement? (R. S., Inverness, UK).

- There would not be signal at pin 5 as this has a DC bias voltage. Pin 12 may not have signal if the wire link connecting pin 12 to the two 100Ω resistors is not on the PC board. Alternatively, pin 12 may be shorted to pin 11 at the IC pins with a solder bridge.

It is unlikely that the MC10116 is faulty.

Amplifier Has Dry Solder Joints

I am a complete novice and know nothing about electronics. Back in 2004, I purchased a Playmaster Pro Series 3 amplifier kit and managed to fluke its completion by following the instructions. However, there appear to be a few problems with it now and I am wondering whether you can either give me advice or refer me to somebody who can fix it.

The amplifier worked fine for about three years, being used to drive one 15-inch precision response sub-woofer per channel for a home theatre system (at relatively low load, never clipped). Recently though, it has developed two problems. First, it began to exhibit a low-frequency hum (my guess would be about 80Hz). The volume of this hum is not amplified under load.

I recently opened it up to tighten the RCA input plugs and speaker terminals. However, prior to closing it back up, I noticed that the solder

had failed on one of the filter capacitors (negative for the right channel I think, closest to the 230V input power socket on the rear panel). In addition, the red and white wire from the toroidal transformer had become detached. I re-soldered these and closed it back up. I turned the power on and all of the smoke seemed to stay inside it.

I turned it off, attached my speakers and turned it back on. When I began to feed the amplifier (again, low current) the woofer drivers seemed to move to full extension, then both fuses in the amplifier blew.

When I opened it back up, I found that the orange wire (hanging out of the middle of the rear toroidal) was not contacting the bridge rectifier on the righthand side properly. This was re-soldered. Also, when I was tightening the terminals on the rear panel, I made sure there was no contact between the wire shielding and

any other contacts for the inputs.

What I hope is that there is either a stupid error (apart from building the thing without understanding what I was doing) that is easily fixed. Alternatively, is there someone in my neighbourhood who can undertake the necessary extensive repairs at my expense to get my amplifier working again? (T. U., Penrith, NSW).

● It seems as though you could have problems with the solder joints in your amplifier. Short of going through and resoldering every suspect joint and then re-doing all the initial set-up in the amplifier, we suggest you contact Keith Rippon at 0409 662 794. He is in Sydney and may be able to take the job on for you.

Failing that, you could try your local electronics repairman – you would have to give him all the articles on the project. This could be expensive, though.

pin 11 will be high. Hence, the voltage across the 2.7kΩ resistor to pin 11 is always inverted with respect to that at pin 12.

Amplifier causes radio interference

I have recently completed building 20W Class-A Amplifier and I am very impressed with what I am hearing, despite my advancing years! However, I do have some comments and questions regarding its design.

(1) What protection is there against short-circuited outputs? I understood that most audio power amplifier designs incorporate some form of SOAR drive limiting to the output devices?

(2) Would there be any advantage in using the newer "ThermalTrak" power BJTs as featured in the Ultra-LD Mk.2 Class AB amplifier?

(3) When the Class-A amplifier is running it is generating interference on the AM radio band. Would you recommend capacitor filters on the bridge and/or at the mains input? (N. H., via email).

● The only protection against short circuits is via the fuses and the fact that the very rugged output transis-

tors can withstand a short until the fuses blow.

In fact, relatively few amplifiers incorporate SOAR (Safe Operating Area Rating) protection as this has a tendency to cause distortion even before there is any hint of overload. Worse still, the very nature of SOAR protection means that when driving an inductive load (as all loudspeakers are), the protection will rapidly switch on and off as the power output rises to the critical level. This causes very loud shrieks from the loudspeakers and these can be at such a level that it is potentially damaging for tweeters.

So SOAR protection is generally more of a problem than having no protection at all.

There would be no benefit in using the ThermalTrak power transistors. Stick to the transistors specified.

There should be little or no interference to AM radio unless you are in a very weak signal area. We assume that the interference you are referring to is 100Hz "rectifier buzz" due to the heavy currents flowing in the rectifier circuit being radiated in the power cord.

The solution to this problem is to keep all mains wiring away from the antenna of your tuner. Check also that

the amplifier chassis has been properly earthed.

Relay switching board controller

I am looking for a PC board-based relay controller. I need to control 12 external 24V relays via momentary operate pushbuttons (low-level switching). Can you help please? (K. C., via email).

● Our DC Relay Switch from November 2006 may be of use. The relay would be activated with the switch closure (can be configured for low-

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Fancy Fuse Tester Wanted

I have an idea for a circuit someone may be interested in developing – a fuse checker.

Over the years I have gathered hundreds of fuses – all good. But I cannot read the ratings on them. Effectively they are a wasted resource to me. I know someone else too who has accumulated hundreds of fuses the same way I did. And I think it is a conspiracy as to how unreadable the ends of fuses are.

How about a project which would display the fuse value so they could be sorted accordingly and reused (the original reason for scavenging)? As for fast-blow fuses, I think I am right in saying a “low ohms meter” would reveal the value; these circuits aren’t exactly scarce.

If you wanted to be elaborate, you could go for slow-blow fuses – same principle but different values (I think). Imagine, slipping a good fuse into a tester and a LED lights, telling you it is 1.5A FB. If that could be done for slow blow fuses as well, it would be fantastic.

You would select the fuse “speed” and a LED or even a meter movement would diagnose the fuse. I would (almost) kill to know whether a fuse was 1.5ASB or 2ASB. I think the whole idea comes back to a low ohms meter – and then analysing past that point. What do you think? (B. A., via email).

- We agree that fuses are very hard to read. The only way that most

people can read them is to use a magnifying glass in good light.

However, we think designing a device to measure a whole range of fuses is not feasible. For example, we tried measuring a 1A 3AG fast-blow fuse with a Tektronix TX3 DMM which has the facility for nulling out the resistance of the test leads. The fuse had chrome-plated brass ends.

Repeated measurements showed no consistency, with the readings varying from 80mΩ to 160mΩ. If you maintain the measurement for more than a few seconds, it also shows signs of thermal drift. Measuring an identical 1A fuse then gave values of 160mΩ to 200mΩ. And so it went from there; we could not get any consistency of readings.

The situation is much worse with M205 fuses. Here we could not distinguish between 2A, 5A & 10A fuses as they all tended to give readings in the region of 50mΩ or less. Clearly, varying contact resistance is a big problem.

Even if you could get consistent readings, we do not think such a tester would be sufficiently discriminating to detect the differences between fast-blow and slow-blow fuses of the same nominal value. It would depend on the resistance wire used, the method of terminating the wires to the end caps and the material of the end caps themselves (plated steel or brass, etc).

level switching) and re-open when the switch is open. There is a small delay if required. For 24V use, the relay and a few other components can be changed, as detailed in a separate panel within the article.

Trouble with a track detector

I had been looking for a photo-interrupter circuit for quite awhile and then I stumbled upon your “Using A Photo-Interrupter As A Train Detector” at http://www.siliconchip.com.au/cms/A_102632/article.html

I was very excited after Googling for days so I went straight to Jaycar

and bought all the components in the circuit and carefully soldered it all and then it didn’t work. I was so sure I had done something wrong that I went back to Jaycar, bought all new components, resoldered them all in and again it didn’t work.

Is there something wrong with the circuit schematic or is there anything you could recommend me to try? Or is there another similar circuit I could try? (D. J., via email).

- There is really very little in this circuit so it should be easy to troubleshoot. Troubleshooting is most easily done before you cut the interrupter in half (to straddle the track).

With the circuit powered up and

nothing in the gap of the interrupter, the internal phototransistor should be conducting to pull pins 1 & 2 of the 4093 chip high (ie, close to +12V). This should cause pin 3 to be low (ie, close to 0V) which means that transistor Q1 will be off and so will the relay.

Now place something in the interrupter’s gap, to prevent light passing through to the inbuilt phototransistor. This should cause pins 1 & 2 of the 4093 to go low and its pin 3 to go high. This should turn on the transistor and you should hear an audible click from the relay as it operates.

Incidentally, the 4093 is a quad NAND gate and if you are not using the other gates (say, to control three other track detectors), the unused gate inputs (ie, pins 5, 6, 9, 10, 12 & 13) should all be tied to the +12V line.

Accurate DC reference wanted

Now we are entering the era of domestic green power generation and storage, one of the problems I have is accurate battery voltage measurement. I have two multimeters that are generally 2.5% different over the low-voltage ranges, and every other multimeter I have borrowed to check is different as well.

I cannot locate an accurate battery voltage reference anywhere in Adelaide. Would you be able to design for us all a cheap, reliable, reproducible and temperature insensitive voltage reference, accurate to two (or more!) decimal points in the 12/24V SLA battery range please? (C. O., via email).

- Thanks for the suggestion. However, the best approach is to use an accurate digital multimeter. Even many basic DMMs now have a basic DC voltage accuracy of better than $\pm 0.5\% \pm 1$ digit and the better ones can be $\pm 0.1\%$ or better.

It would be difficult to design a voltage reference with higher accuracy than that.

How to connect the Champ amplifier

I have married up your preamp kit (featured in SILICON CHIP July 1994, Jaycar Cat KC5166) and the CHAMP kit (SILICON CHIP, February 1994, Jaycar Cat. KC-5152) and I’m not getting any sound out of the speaker. When I disconnect the preamp, I get some

Speedo Corrector For Old Ford

I am keen to purchase a Super Speedo Corrector kit but would appreciate your advice as to whether it is suitable for my requirements or if it could be easily modified to suit. I have an old Ford (1955 Crown Victoria) and we have put in an EFI engine with an EEC-IV ECU and automatic transmission computer.

The car that the engine, transmission and electronics came from had a purely electronic speedo but we needed one with a mechanical cable to drive the old-style speedo on the dash and an electrical signal to feed the ECU for shifting gears in the electronically controlled transmission.

I believe the original speedo sen-

sor was a Hall Effect type which has three wires. The replacement speedo sensor that we have put on the transmission has only two wires which I believe are for an inductive sensor. A custom box was fitted to convert the speedo signal which is labelled "Inductive in, Hall out" but it has nothing to indicate whether it is working and it is not possible to adjust the speed reading sent to the ECU. Everything was OK but recently we have run into some issues.

I would like to replace the custom signal conversion box with the Super Speedo Corrector (SILICON CHIP, December 2006). Do you think it will suit my needs and how should

the different links be connected to achieve the desired outcome?

I purchased issue 219 online for the full Super Speedo Corrector article and near the end it says "Table 4 shows the output configurations achievable by the different link positions" but there seems to be no Table 4 in the article. (D. M., via email).

● The Corrector is suitable for converting an inductive sensor to Hall Effect output. Table 4 is for the output setting and for Hall effect output would be link 1 in and probably link 3 as well. If this does not work, use link 4 instead of link 3.

The input should automatically set up for the AC (inductive pickup) when run in the "Autoset" mode.

output from the speaker (on the amp) and humming when I touch the inputs to the amplifier.

I have set up a microphone (lapel mike) to the preamp with 9V, ground and output and with another ground connected to the amplifier's input and ground respectively.

I have attached a speaker to the speaker+ and speaker- connections and another 9V battery to the + and - connections. (J. O., via email).

● It seems likely that there is nothing wrong with your circuit boards. However, you mention that you have connected a lapel mike. This probably has an electret insert which requires a DC voltage for it to work correctly. This is provided by the 10kΩ resistor at the input to the preamplifier.

Do you have this resistor in place?

If not, install it and the whole system should work.

We also note that you do not appear to have used shielded cable for any of

the signal leads in your set-up. This needs to be done otherwise you will have a lot of unwanted hum and noise in the sound.

SC

Notes & Errata

433MHz UHF Remote Switch, January 2009: RCS Radio Pty Ltd has produced a relay PC board to allow use of board-mounting relays with the 433MHz Remote Switch receiver. You can use the Jaycar SY-6066 3A SPDT relay for low-voltage use and the Jaycar SY 4080 for 250VAC use.

The PC board is coded 15101093 (with provision for two SY-4066 relays and one SY-4080 relay) or 15101094 (with provision for one SY-4066 and one SY-4080 relay). Contact www.rcsradio.com.au

Universal Speed Control, February 2009: the circuit shows the fast recovery diode as STTH3012W (30A/1200V) whereas the parts list shows it as STTH1512W (15A/1200V). The STTH1512W (15A/1200V) is the required device. The 30A diode is in a larger TOP-3 package and so is unsuitable.

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine.

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