SILICON CHIP

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DESALINATION: How it works

BATTERY ZAPPER & DESULPHATOR

WE LOOK AT CHEAP DVD RECORDERS

How do they perform?

Contents

SILICON CHIP

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Features

Projects To Build

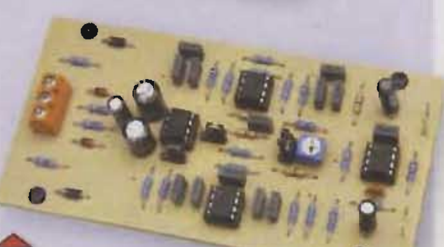
Special Columns

Departments

The Magic Of Water Desalination – Page 12.

Lead-Acid Battery Zapper & Desulphator Mk.3 – Page 26.

Hand-Held Metal Locator – Page 38



Multi-Function Active Filter Module – Page 58.

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Publisher's Letter

Natural gas means geosequestration is unnecessary

My "Publisher's Letter" last month poured scorn on "carbon pollution" and geosequestration, which is now known as "Carbon Capture & Storage Technology". As you might expect, there has been significant criticism of that viewpoint but considerable support as well.

Coincidentally, David Knox, CEO of Santos, has put the case for using natural gas to fire Australia's thermal power stations, some 80% of which are currently coal-fired.

As he points out, "if we are serious about confronting climate change, and if we are to deliver the Government's target of a 60 percent reduction in carbon emission by 2050, we need to reduce the carbon intensity of Australia's baseload power generation". He goes on to state "that gas fired power technology (known as combined cycle or CCGT) emits only 40 percent of the carbon emissions of the existing" average coal-fired power station. In fact, it already delivers 80 percent of the carbon reduction hoped for from geosequestration.

Now David Knox could be dismissed as simply selling his wares but he is nonetheless correct. He also highlights the peak load ability (as well as base load) of gas-fired stations and their greatly reduced use of water compared to coal-fired stations. In fact, a gas-fired power station only uses 1% of the water required for a coal-fired station. I am not referring to the water required for cooling but to the water required for coal scrubbing.

He could have added that the extraction of natural gas causes none of the problems of damage to water resources by coal mining. Nor does it cause subsidence as in the case of long-wall mining or have the need for extremely costly landscape remediation, as in the case of open-cut mining.

Nor does a gas-fired station produce huge quantities of ash which must also be disposed of. The more you think about it, using Australia's massive gas deposits for electricity generation is a very good idea.

You can read the full text of the Santos submission to the Australian Government's energy white paper process on the Santos website at **http://www.santos.com/Archive/NewsDetail.aspx?p=121&id=1145**

Not only is using natural gas for power stations more environmentally friendly, it is thermodynamically much more efficient, particularly when employed in "combined cycle". This is where the hot exhaust from the gas turbines is used to generate steam and run a turbo-alternator. The net result is that gas-fired power stations not only emit less carbon dioxide than coal-fired stations, they produce far less emissions than would be produced with a coal-fired power station which was using some sort of (yet to be proven) carbon capture and storage system.

So rather than introducing an elaborate and expensive emissions trading scheme (ETS), the government should be seriously contemplating converting Australia's existing coal-fired power stations to gas. And if it cannot do it for the black coal stations, it should certainly do it for the brown coal power stations in Victoria. Admittedly the conversion process will be expensive but it will be much cheaper and easier to implement than the proposed ETS. Furthermore, it could be done easily over the next 10 years or so.

Leo Simpson

MAILBAG

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

Earthing for TV distribution system

We recently had a room added to the house which then required a TV outlet. This and the purchase of an HD LCD TV prompted me to replace the motley collection of cable and splitters in my distribution system, which over the years had grown from the original single point to five. I rewired in RG6 cable with F connectors and cast alloy splitters. The improvement in reception is amazing.

One of the old splitters had failed on one output and the 5-year old Akai TV in that room had used a "rabbits ears" antenna. When I connected this to the new system, we had 50Hz hum on all radios in the house. When I unplugged the fly lead from the wall socket I felt a tingle when I touched the shroud.

I measured the voltage to earth with my Fluke DMM and it was 110VAC. As it could supply no current, the source was obviously high impedance. I have not had time the look at the TV yet to find the cause but it made me think about the lack of any earthing on the antenna system.

In the days before live chassis, switchmode supplies and 2-pin mains plugs, the shield on the antenna cable was earthed by its connection to the earthed chassis. Now the whole system floats above earth so that if a fault connects it to a dangerous voltage, there is no path to cause a protective device, fuse, circuit breaker etc, to operate.

I am planning to connect the metal housing of one of the splitters to my house protective earth, so as to provide this path.

Phil Andrews,
Adelaide, SA.

Comment: you would be better off earthing the whole system where the cable connects to the antenna. Earth the antenna as well. A separate grounding stake is desirable. This will also improve noise immunity on digital TV reception.

Electronic anti-fouling

I am the owner of a yacht which needs anti-fouling to be applied each year to take care of growth on the hull, as does every other pleasure craft. This is expensive but importantly, anti-fouling compounds pollute the marine environment.

Recently, a system has been developed which employs one or two ultrasonic transducers attached to the inside of the hull. This system effectively prevents growth from attaching to the hull. This can save boat owners annual bills of over $2000.

Now here is the rub: the marketers charge over $5000 for the kit to do my yacht, justifying the price by how much it could save me over time. I have no doubt you could design such a unit at a fraction of the cost if you put your minds to it.

This could be of interest to many boat owners who are also into electronics. These units are not yet mass-produced in China and so prices are not reduced accordingly, allowing the "merchants" to employ demand-driven pricing and so make super profits at the expense of "early adopters".

This is where SILICON CHIP comes in. Could you run this as a project in your magazine?

Anthony Willis,
Koolewong, NSW.

Comment: we are very interested in the electronic anti-fouling concept. In the meantime, we are publishing your letter to see if we can get reader feedback on whether it really works.

Possible flaw in GPS-Synchronised Clock

With regard to the GPS-Synchronised Clock in the March 2009 issue, surely the fatal flaw is that the GPS receiver won't be able to pick up satellites anywhere indoors. My relatively modern GPS receivers (a Garmin hand-held and Garmin car unit) don't have a hope of getting satellite signal anywhere in my house where I would want a clock. Am I missing something?

Mark Stephens,
Brisbane, Qld.

Comment: the recommended EM-408 GPS module is extremely sensitive. It works fine in our building which has a steel roof. Even better, it continues to work when placed in a steel filing cabinet!

GPS synchronised clock is delayed

I refer to the new "Dead-Accurate 6-Digit GPS-Locked Clock" in the May 2009 issue. Knowing that the NMEA 0183 data stream arrives about 250ms after its appropriate PPS and that the clock is not referenced to the PPS, I'm curious as to what the clock is actually referenced to.

I believe the update of the display will be around 250ms late. This is hardly "dead accurate".

Trevor Dalziell,
Calwell, ACT.

Comment: you are quite correct: there will be a fixed delay of about 250ms between the updated time and "actual" GPS time. There is nothing that can be done about this and anyone building either of our GPS-synchronised clocks will need to resign themselves to being forever 250ms behind real time.

GPS-Synchronised Clock web page

I have been getting a lot of email on the GPS-Synchronised Clock project so I built a web page with hints and notes to help constructors. It also contains a new version of the firmware which corrected one issue and added some additional features. You can find the page at **http://geoffg.net/GPS_Synchronised_Clock.html**

I thought that you could point people to it if they need help.

Geoffrey R. Graham,
Perth, WA.

EV conversion was a beauty

I would like to compliment SILICON CHIP on presenting its readers with such a delightful smorgasbord of articles and projects as we have seen these last couple of months. If I had to single out one article that I found particularly enjoyable, it would have to be the one describing Malcolm Faed's conversion of a Hilux ute to all-electric drive (June 2009). Without question Malcolm deserves to be congratulated for his splendid efforts. How nice it is to see such initiative displayed in an Oz setting.

I also liked the article on the battery monitor project in the same issue. There really has been a need for such a project for quite some time. I haven't as yet had time to fully digest all the good features but from a quick overview this monitor is definitely the sort of thing that every critical battery-operated appliance should be teamed with.

As the article points out, batteries are expensive. If I may add to that statement, usually by far the most expensive single component in battery-operated equipment is the battery. Not only do high-capacity batteries contribute a significant part of the initial cost of new equipment, they can represent a very high proportion of the maintenance costs, particularly if the battery charge and discharge cycles are not properly monitored (and controlled), resulting in shortened battery life.

On odd occasions, I have been asked to repair vari-

Mailbag: continued

More water vapour than carbon dioxide

Your recent Global Warming essay (Publisher's Letter, June 2009) is interesting but you will need to revise your basic stoichiometry if you are to pass this year's HSC Chemistry exam.

You did correctly balance your equation but if you burn two moles (228 grams) of octane with 25 moles (800 grams) of oxygen and "calculate the molecular weights" as you were taught in your chemistry class you would have correctly shown that 704 grams of CO_2 and 324 grams H_2O would be produced.

The reaction does make more moles of water vapour than CO_2 and so the gas volume of water vapour is greater than the gas volume of the CO_2 but you cannot really say that "there is more water produced than carbon dioxide".

Leo will need to work on biology revision as well. Yes, CO_2 is needed for photosynthesis and in a greenhouse increasing the concentration of CO_2 will allow the "plants to grow more vigorously". What you don't mention is that in most natural ecosystems, particularly in Australia, it is water availability that acts as the limiting factor for photosynthesis, not the CO_2 level. Even in aquatic ecosystems where there is high water availability, the extra CO_2 from burning fossil fuels will probably do more damage than good, as it lowers the pH when it dissolves in water. This pH change will reduce the efficiency of enzymes important in photosynthesis and other reactions.

Leo correctly argues that geosequestration is an expensive and energy-inefficient fantasy designed to allow us to keep mining and exporting coal.

We do not "really know if global warming is wholly or partially caused by human activity" but we must do everything possible, just in case. I am sure that you would not consider buying a car without seatbelts and airbags just because no one had proved that you were going to have an accident.

Dave Dobeson,
Berowra Heights, NSW.

Comment: the Publisher's Letter should have alluded to the fact that the volume of water vapour produced is more – not the mass.

However, the main purpose was to point out that it is not carbon pollution that is the problem and that water vapour is a major combustion product of the burning of fossil fuels. Carbon dioxide may be a problem but we still don't know whether human activity is the main cause of the current warming cycle or if indeed, the warming cycle has actually ended.

ous kinds of electronically-operated equipment for a non-profit community project that provides low-cost scooters for the elderly and disabled. Far too often have I seen what should have been perfectly good batteries ruined by improper charging (either too much or not enough) or by the batteries being run to their limits before they are recharged.

I lay at least part of the blame on the design of the scooters in certain cases, particularly in the case of older machines, which allows the machines to continue running even when the batteries are on the point of exhaustion. Another nag is that some designs employ what users might easily be misled to believe are state-of-charge displays but are in fact nothing more than glorified voltmeters.

Of course, when batteries, particularly of the lead-acid kind, are fully charged they usually give a significantly higher terminal voltage than when partially or fully discharged. Such displays can be used as rough and ready guides to the state of battery charge provided that the batteries are not heavily loaded. But as you know, every battery, together with any connecting cables, presents a resistance in series with a load.

So if you put a voltmeter across the load or even directly across the battery, in an attempt to measure the state of charge of the battery you would be very much disappointed, because the increased voltage drop across load (or battery terminals) due to the series resistance causes the apparent state-of-charge indication to be less than the true state of charge of the battery.

An obvious solution is to replace the voltmeter type display with an intelligent one that, in addition to battery voltage, also monitors the charge put into and drawn from a battery and, in addition, compensates for the voltage drop across any series resistance, to give a more reliable indication of state of charge.

As a passing thought, some constructors might like to see a scaled-down version of the project; one with, say, just the PC board plus essential on-board components and maybe a bit of extra software programmability (if necessary) to make it easy for someone to integrate the monitor into existing equipment.

Another article that I would like to mention is the 10A Motor Speed Controller featured in the May 2009 issue. I particularly liked the idea of sensing the motor current, rather than back-EMF, to control the speed (I wish I had thought of it). There are a couple of questions I would like to ask regarding this controller:

(1) Would it be possible to adapt the speed controller, without too much modification, to enable variable torque limiting?

(2) Would the speed controller work with the load on the AC side of the bridge rectifier rather than on the DC side as it is now?

Herman Nacinovich,
Gulgong, NSW.

Comment: with regards to your questions concerning the 230V/10A controller, it may well be possible to use the circuit as a torque controller for a particular motor but operating the load on the AC side of the bridge rectifier is problematic as the MOSFET loading arrangements would need to be changed.

Response to Publishers' Letter on global warming

With reference to your editorial on global warming in the June 2009 issue, a more correct term is climate change as it actually reflects what is happening.

You focused on carbon dioxide as one of the so-called greenhouse gases but the two primary gases are methane and water vapour. These are very important as they help keep the temperature of the surface of the earth within a liveable (for life as we know it) range.

As long as there is a balance between the creation and absorption and destruction of these gases, then the amount of energy radiated from the Earth matches the amount received from the Sun. If this balance changes, the result will be climate change.

The concept that this will be a general warming is very simplistic. What is actually happening is there is more energy being input into the atmosphere. You mentioned that the concept was just chemistry. No, this is physics, specifically atmospheric physics which is based on thermodynamics.

The adding of more energy into the atmosphere does

Mailbag: continued

not mean a general warming. An example is the lighting of a fire in a fireplace in a house. The immediate area is warmed but the rest of the house will cool down as cold air is drawn in to replace the air drawn up the chimney, so if you average out the whole temperature in the house it may actually show a drop.

The additional energy in the atmosphere will show as an increase in the frequency and severity of weather events such as cyclones; it will also cause a shift in weather patterns such as the monsoon, El Nino and La Nina, which in turn can cause excessive precipitation in one area and drought in another.

It will be interesting to see over the next few years how the Caribbean & Gulf of Mexico hurricane seasons shape up; will there be an increase in the number of category 5 storms? Will this be matched with a similar increase in the Bay of Bengal?

As you mentioned, CO_2 is absorbed by plants. The problem we have is not only are we emitting more, we are also clearing the forests that would be active in the absorption process.

The concept that the excess CO_2 can be dissolved in the ocean might work but this would slightly increase its acidity, which has the potential to affect anything that uses calcium carbonate as a shell or skeleton.

It is very easy to deny climate change but by the time it becomes totally obvious it will be too late. How many 1-in-100 year events will it take to prove it exists? The first sign will probably be from the insurance industry, as they will be watching the increased number of claims.

Laurens Meyer,
Richmond, Vic.

Leo Simpson comments: you have drawn conclusions from my editorial which are not justified. Carbon dioxide and "carbon pollution" is what politicians and environmentalists are focussing on. They are essentially ignoring methane and water vapour although the proposed Australian Emissions Trading Scheme will penalise graziers because their sheep and cattle emit methane. This is insane!

I was focussing on the burning of fossil fuels, not the existence or causes of methane.

If you want more authoritative information on whether climate change is caused by human activity, you need to read Ian Plimer's book entitled "Heaven & Earth; The Missing Science". He does not deny climate change and nor do I. I just don't think that humans have anything to do with it. The energy produced and used by humans may seem incredibly large but it is vanishingly small when compared to the total energy input from the Sun.

Even a very slight variation in solar output will completely overwhelm anything that humans do. The Sun's output does vary significantly and does have a major effect. Consider the Mediaeval Warming and the Little Ice

Age and other major global climate variations which have occurred in the last 2000 years and right back to the beginning. Man's presence has had no effect.

Disputing the Publisher's Letter

At the risk of seeming "hysterical", Leo Simpson's Publisher's Letter in the June 2009 issue cannot go without comment. Leo attempts to give us a simple chemistry lesson and then to use that to berate those ignorant "greenies".

The first problem is his lesson is wrong. The equation in his letter ($2C_8H_{18} + 25O_2 \Rightarrow 16CO_2 + 18H_2O$) means that by mass (ie, calculating the weights as asked) 16 * (12 +(16*2)) = 704 grams of CO_2 are emitted vs 18 * (1*2 + 16) = 324 grams of water (I've rounded the numbers).

Leo then makes the false and irrelevant comment that the mass of water being released from combustion is more than the mass of CO_2 and that therefore CO_2 is not a problem. This is equivalent to saying we only need to know one property of electrical components when deciding their importance OR function.

Water is the most significant greenhouse gas in the atmosphere. Those greenies called atmospheric scientists are well aware of this. But the global atmospheric water balance is largely unaffected by direct human action and is dominated by the dynamic equilibrium between solar-driven evaporation-transpiration and precipitation. The average lifetime of a water molecule in the atmosphere, where the bulk of the water is below the stratosphere, is eight days. Carbon dioxide has an atmospheric lifetime of decades.

I shouldn't need to point out that CO_2 and H_2O, being different molecules, unsurprisingly have different infrared spectra (**http://en.wikipedia.org/wiki/File:Atmospheric_Transmission.png**). We use this property in instruments to measure one in the presence of the other and it is this same property (in conjunction with the mass and lifetime) that is important when we determine the relative greenhouse effect of the two. In the link above we

Reaction to Puppy Linux

I'm an old IT buff, pretty up to speed on Windows but I was very attracted to try your Puppy Linux installation in the March 2009 issue.

I have a Sony Vaio PCG-R600 which was my main laptop for a few years, since replaced by a much faster Toshiba. Everything in the Sony was working but WinXP had slowed down incredibly, in spite of all the tweaks and scrubs of several maintenance programs.

So I followed your instructions to the letter. I downloaded the latest version of Puppy on my BIG desktop, burned the CD with your recommended ISO file burner and tried to boot the Sony with the CD.

Nothing! After searching for hours I finally found a clue: install hangs with SATA CD drives, not with IDE CD drives. I then used an outboard CD drive, which got me further down the track. However the install still hung. There is a work-around by putting the three vital Linux files on a thumb drive and completing the boot from there.

So, very elated in spite of the huge frustrations with the SATA drive, I decided to install the HD boot option and chose "Frugal" install. All went well until I got to GUMP. Making the changes to the GUMP execute text file felt like changing something in WIN registry, so I checked and double-checked before hitting "return" at each input.

My Linux partition was sda5 so I was careful to input the correct drive and partition details. Everything completed and I re-booted the PC from the HD.

Boom, end of story, the "Kernel / puppy400/vmlinuz pmedia=idehd psubdir=puppy400" hung with "file not found". I went back and changed every possible parameter (pmedia=satahd, idecd, sata cd, you name it) but no luck.

And I'm STUCK in GUMP – no way to go back to the BIOS program, no way to get back into Puppy, I am GUMPED for life! I searched for further hours and hours on the posts, Puppy search etc. Nothing!

So I'm afraid that my experience has been a complete waste of two days' time. Next move? Wipe the HD and do an XP reinstall. And forget about Linux (again – I tried a couple of years ago with similar results).

Mate, if it installs without hiccups, it's brilliant but once you get into the Linux coding side, it isn't for the faint-hearted!

John Nixon,
Optical Network Engineering,
Auckland, NZ.

Mailbag: continued

see that the spectra for CO_2 fills in some absorption gaps for water.

Leo also made the true but irrelevant comment that water and carbon dioxide are both essential to life; the implication being that they are therefore harmless. This is like saying that since voltage and current are essential for the functioning of a circuit, we can ignore the danger imposed by 1kV @ 1A, as we all know that 1V @ 10mA is "harmless". The dose makes the poison. Another element that is essential to life is selenium but only at trace amounts: swallow a gram or two and you will suffer.

The argument is frequently put that more CO_2 means plants grow better. This may be true in a greenhouse but in the real world it means more than that. Photosynthesis comes in several flavours and different plants have different mechanisms (C3, C4 & CAM) for taking up CO_2 – the initial step. Thus some plant species may be favoured over others. But, the so-called CO_2 fertilisation effect also depends on temperature, nutrients and water.

Increases in temperature can remove any benefit from the increased CO_2 concentrations. Climate zones can move but soils do not. If climate zones do move, will they fortuitously align with regions of high soil fertility? And what of water – a question very pertinent to Australia?

Moving on to the statement "Nor do we really know if global warming is wholly or partially caused by human activity". This is the Plimer argument. If the increase in CO_2 concentration was the only evidence at hand, one could argue for other sources of that CO_2. But we also have the isotopic signatures of carbon that comes from volcanoes, carbon that comes from fossil fuels and the carbon in the atmosphere. On top of that, we also have measurements of the O_2 concentrations – which are falling in line with the carbon increases thus suggesting combustion. How do volcanic emissions of CO_2 reduce O_2 levels? The evidence is clear. It's "us wot done it".

Even if you dispute that increased levels of CO_2 don't automatically mean the temperature will increase like Svante Arrhenius (a notable chemist and apparently a greenie before his time) suggested, another issue is the decrease in the oceanic pH that increased levels of CO_2 are causing! A mixed blessing. For while the oceans continue to absorb CO_2 it slows the rate of increase in the atmosphere – but at the expense of the ability of shell fish and corals to create their shells.

One day the oceans will no longer absorb as much CO_2 and then the trouble really starts – that's not being hysterical, it's a statement of chemical fact. We know the constants that describe oceanic equilibria.

While I agree with Leo's scepticism of Carbon Capture and Storage (it's a sop to the coal mining industry), articles and letters like this devalue the magazine. I suggest either consultation with real experts in the field or the purchase of an excellent reference like "Earth System Science: From Biogeochemical Cycles to Global Change". Anything by frustrated mining geologists near retirement should be returned to the remaindered bin. Am I hysterical?

Shane Perryman,
Margate, Tasmania.

Comment: if you have a look at the volumes of gases released in the combustion of octane, there is more water vapour than carbon dioxide. In any case, carbon pollution is not the problem. Maybe we do have a problem with carbon dioxide but that is still unknown. Doubling the "dose" of carbon dioxide probably won't have catastrophic effects.

You cannot simply reject an argument because it has been put forward by Ian Plimer (and others). He could well be correct or he might be wrong – we don't know at this stage. Do you dispute the previous warming cycles when man had nothing to with it?

Confusion over Freeview digital TV

I've been listening to media publicity on the introduction of digital TV but the information given raises more confusion; for example, "look for the Government sticker on set top boxes." Presumably, that means the designated boxes are compatible with whatever. Anything else is incompatible?

I made an enquiry to the "Digital TV Task Force" regarding a new SD set-top box which I purchased in haste some time ago - now residing in a cupboard, unused. The purchase was made just prior to connecting to Foxtel cable TV, of course with their own box. But when digital TV arrives, why not connect this SD box to our old CRT TV set, forgoing the wonders of HD (which I may have trouble in distinguishing anyway, because of deteriorating eyesight)?

I am getting little sense out of the "Digital TV Task Force" and have suggested to them that they should prepare advisory information to cover the sort of (dumb?) enquiry I made. I would guess there would be millions of Australians who are equally confused. This information should be the subject of a national letterbox drop, prior to introduction of the new TV format.

However, to be more practical, it occurs to me that perhaps SILICON CHIP is preparing an article to do exactly what I had suggested to the Task Force. This material should be valuable help for many.

While all of this wonderful technology is advancing on us, I've built my own (invisible!) home cinema in my living room, with a video projector and a large pull-down screen. This is very simply coupled to my video source (DVD/VCR player, cable TV, free-to air or whatever) and (prior to 5.1 surround sound) a simple stereo sound system, simply using yellow (video) red (R audio) and white (L audio) RCA connections into a simple video switch.

All of this involved some nifty installation techniques, such as housing the projector in a wall cavity with the lens aperture normally masked by a framed print which slides across on a track. The projected image might be standard definition and I could worry about HDMI leads and the like but I am enormously impressed with the quality of the picture on this large 2.5-metre screen and the sound is great too!

Brian Graham,
via email.

Comment: right now there are only three extra digital channels with different programming to the existing SD (and analog) channels: ABC2, SBS2 and Ten's One HD. Most programs on ABC2 are repeats of shows on ABC1 but there are some worthwhile additional programs to be seen. SBS2 has only just started broadcasting and will have a mixture of sport and other programming. One HD is great if you like lots of sport.

Later on, there will be a children's TV channel called ABC3. Some time later there might be a couple of others. There certainly will not be 15 extra channels although there is a selection of data channels which carry low-resolution video.

You need a HD set top box if you want to watch HD channels on your analog TV. Unless you have a large HD TV or a HD projector and very keen eyesight, you are unlikely to notice any difference between HD and SD broadcasts. Both HD and SD broadcasts do have a big advantage in that they eliminate noise and ghosting in the picture.

We agree with your comments about projectors and large screens. For overall impact, a video projector cannot be beaten.

AWA 893P portable transistor radio

I suppose you have already been notified but just in case, the radio featured in this month's Vintage article (June 2009) is definitely an AWA 893P not a 693P. The number can be plainly seen in the interior pictures. I have two of these and I am very pleased with them.

See my website at http://transistor.bigpondhosting.com/awa_893p.html

Ian Malcolm,
Scoresby, Vic.

SC

The Magic of

What do Perth, Saudi Arabia and cruise ships have in common? They all rely on desalination for fresh water. And the Gold Coast, Sydney and Adelaide are about to join the club!

by Geoff Graham

Turning salty water into fresh, drinkable water is not new. In the early Australian gold rush days large areas of woodlands were stripped to feed "condensers" that boiled salty water and trapped the condensation for sale to thirsty miners.

These days a large cruise ship will generate over a million litres of water a day from the sea using either flash evaporators or reverse osmosis, while Middle East countries such as Saudi Arabia produce over 70% of their drinking water using various forms of desalination.

Australia is not left out. The advent of a drying climate has triggered a flurry of desalination plants either planned or under construction with the first in Perth, Western Australia, running since 2006.

There are a number of technologies used for desalination but most modern large scale plants are based on reverse osmosis.

These plants are expensive to build but, in the longer term, cheaper to run. This technology is quite recent – it only got its start in the 1970s and 1980s when efficient reverse osmosis membranes were first manufactured in quantity.

In Australia

Small desalination plants have been operating across Australia for many years, providing drinking water for towns such as Penneshaw, Coober Pedy and Marion Bay in South Australia.

The new plants on the drawing boards are on a much larger scale and represent a major infrastructure investment. In total six plants are running or currently planned. All are destined

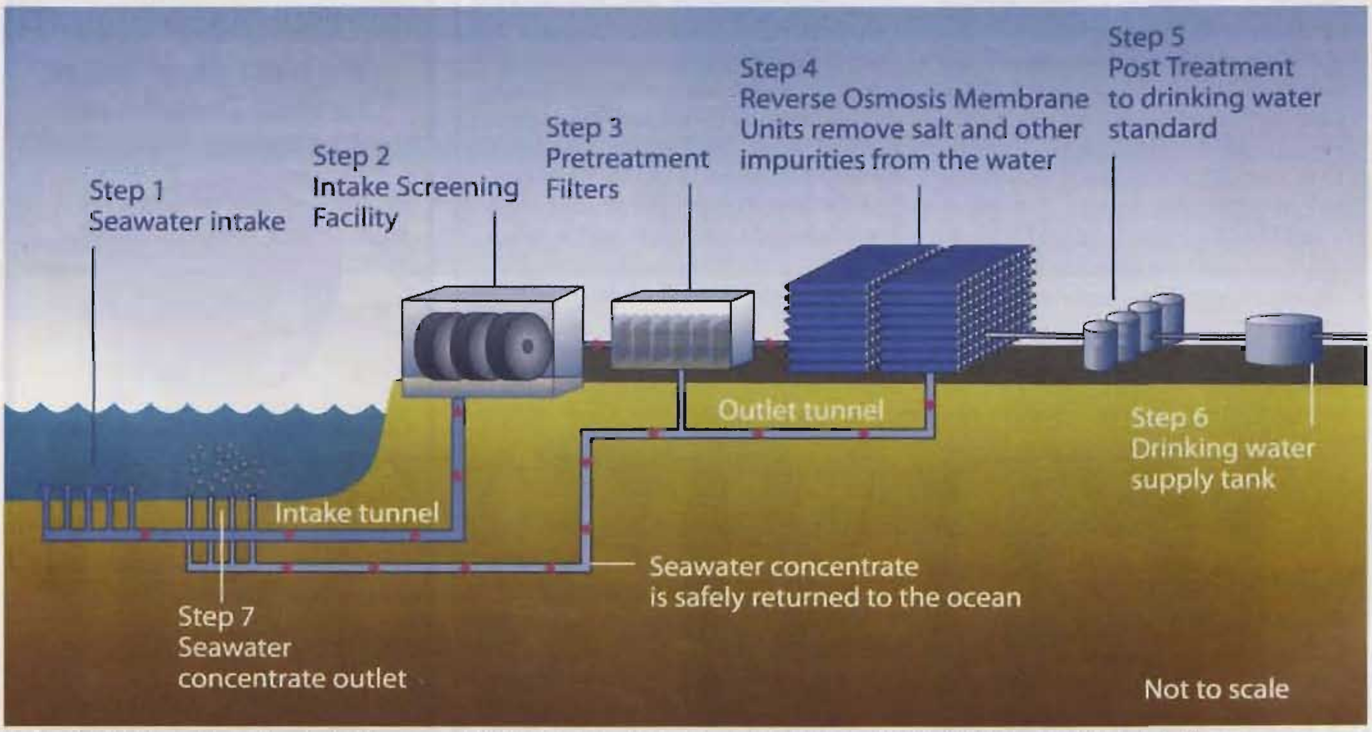
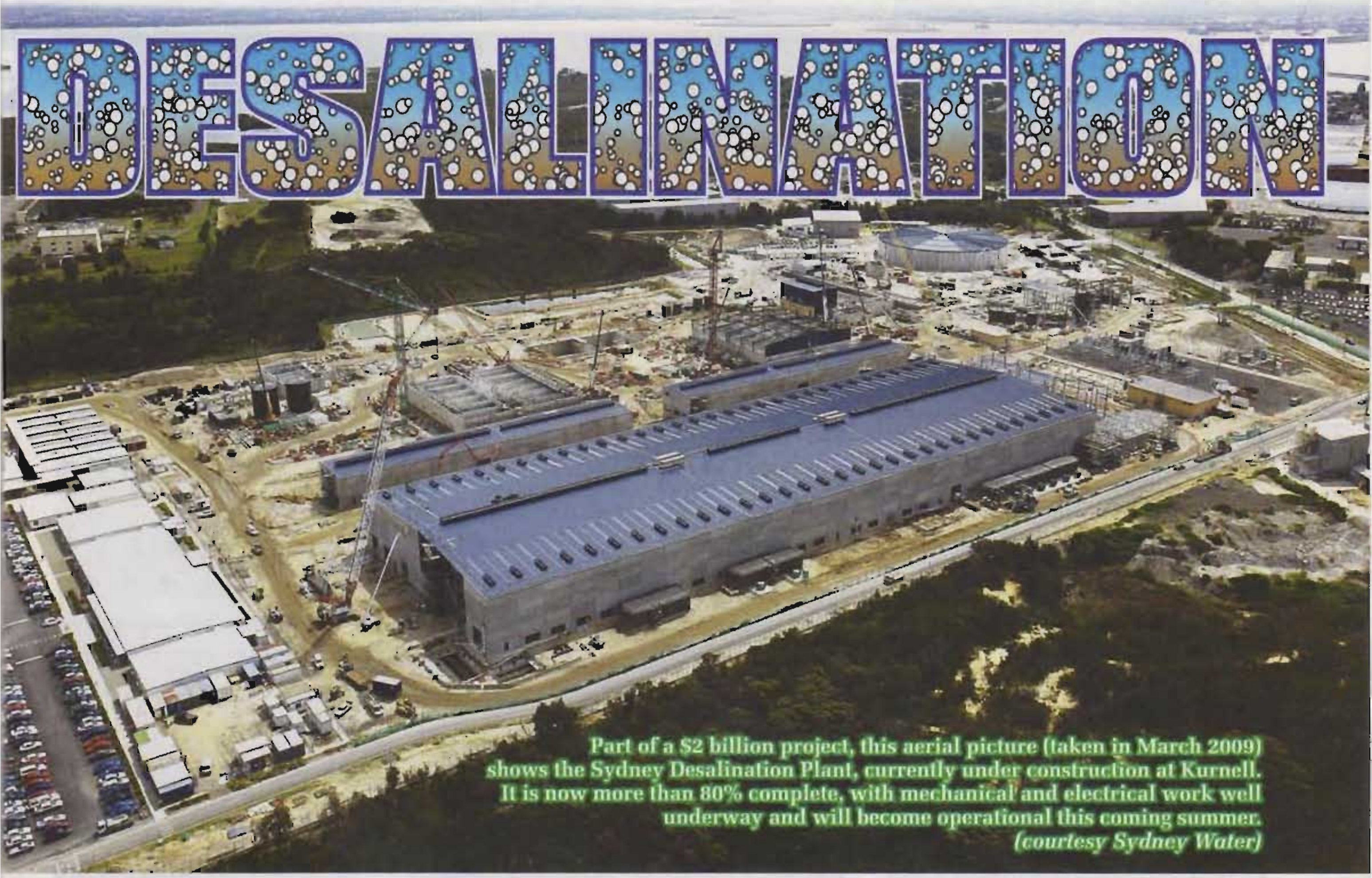


Fig.1: the layout of a typical desalination plant. It looks simple – salt water is filtered and passed through the reverse osmosis process. However, as with most things, the reality is more complex with the magic happening in the reverse osmosis section. *(courtesy Sydney Water)*

DESALINATION



Part of a $2 billion project, this aerial picture (taken in March 2009) shows the Sydney Desalination Plant, currently under construction at Kurnell. It is now more than 80% complete, with mechanical and electrical work well underway and will become operational this coming summer. *(courtesy Sydney Water)*

to serve major population centres and will supply a significant amount of our water needs.

The first was a plant at Kwinana, south of Perth, built three years ago for the WA government by a French consortium. A similar plant, built by another French consortium, has just been completed on the Gold Coast.

Sydney is not far behind with a monster plant nearing completion at Kurnell that is planned to supply 15% of the city's water requirements.

Others preparing for construction include a second plant for Perth and the first plant for Adelaide, at Pt Stanvac, both of which will be built by separate Spanish consortiums.

Finally, Victoria is in the early planning stage for an installation on the Bass Coast near Wonthaggi.

Desalination is not cheap. The Perth plant cost $387 million to build in 2006 while the Sydney plant is expected to cost almost $2 billion, including the connecting pipeline.

The amount of water produced is large by any measure. The Perth plant produces 130 million litres a day while Sydney is projected to produce 250 million litres of water each day.

A typical plant

On paper a desalination plant looks relatively simple. You suck seawater in, filter it to remove sand etc and then pass it through reverse osmosis membranes to obtain your clean water. As always, the complications lie in the details.

The inlet system is where the process starts. Typically a plant will suck in 20 million litres of water an hour through large concrete intakes on the seabed. This is an enormous amount of water and you might think that it could also suck in fish and other ocean life, even including someone who was enjoying a cooling dip.

This cannot happen because the inlets have grates across them and are designed with a very large intake area to keep the flow to less than 0.1 metre per second. At this rate the flow is less than a typical ocean current and does not affect marine life which can swim around the inlets as normal.

The water then goes through screen-

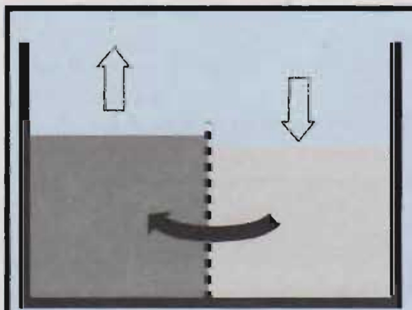


Fig.2: osmosis occurs when water migrates through a permeable membrane towards the more salty solution. The level on the less salty side will then decrease.

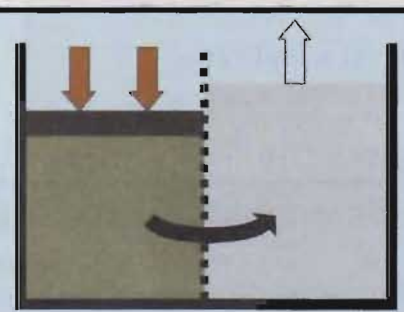


Fig.3: reverse osmosis occurs when pressure is applied to the salty solution forcing the water through the membrane to the less salty side.

ing and filtration stages to remove sand, algae and similar impurities. The technology varies but typically, as in the case of the Perth desalination plant, sand filters are used. These are a similar technique to the sand filter used in a home swimming pool.

All this is normal technology but the water then enters the high-tech reverse osmosis section where the magic begins.

Reverse osmosis

Reverse osmosis can be best explained by looking at the phenomenon of osmosis first, then explaining the reverse part.

Osmosis is the ability of water to migrate through a permeable membrane while leaving dissolved components behind. This can be observed with two solutions, one saline and the other not, separated by a suitable membrane. By osmosis the water will move slowly through the membrane from the less saline solution to the more salty solution.

Contrary to what you might first assume, this action will raise the level of the salty water above the level of the less salty solution (see Fig.2). Membranes are common in nature; your skin is a membrane and water will move through it via osmosis while you are sitting in the bath.

Reverse osmosis, as implied in its name, is the reverse of osmosis and occurs when you force the water through the membrane in the opposite direction as shown in Fig 3.

The pressure applied to the salty side must first overcome the tendency of the water to move via osmosis to the salty side. Then, with increasing pressure, the water will reverse direction towards the less saline side leaving the salt behind in the increasingly saline solution.

Special membrane

This process requires a special type of membrane that is permeable to water but not dissolved salts. It is tempting to think of the membrane as a fine filter which traps larger particles (salt) while letting water through - but that is not correct.

The osmosis mechanism is not fully understood but one explanation is that the water works its way through the membrane by packing into an ice-like structure (at room temperature) and "melting" away on the other side.

The ions from the salt cannot fit into the ice-like matrix and get left behind. Unlike a filter, in osmosis it is not the membrane pore size or the particle size that matters.

Osmosis itself was first observed

Reverse Osmosis pressure vessels. Each contains seven reverse osmosis membranes tightly wound in coils. The pressure used to force the water through the membranes is vey high, up to 1000 psi. At this pressure salt water is very corrosive so high quality stainless steel is used (courtesy Water Corporation WA).

A Serendipitous Discovery

In 1959 Sidney Loeb was researching for his master's thesis with Srinivasa Sourirajan when together they discovered the first practical membrane for reverse osmosis. That discovery is credited with being the foundation of modern desalination technology.

While working on membranes in their laboratory they hit upon a formula which was an unexpected success in that it allowed a practical flow of water while stopping most salt.

But a second test (from the same sheet of membrane) did not work. Subsequent tests were either good or bad "as if flipping a coin" according to Dr Loeb.

Finally they figured out that the membrane was anisotropic (directionally dependent). The side facing the air when the membrane was cast on a glass plate had to be installed in contact with the saline solution to work correctly.

In Dr Loeb's words, "I sometimes wonder if I would have continued testing that membrane sheet if the first test had been a failure."

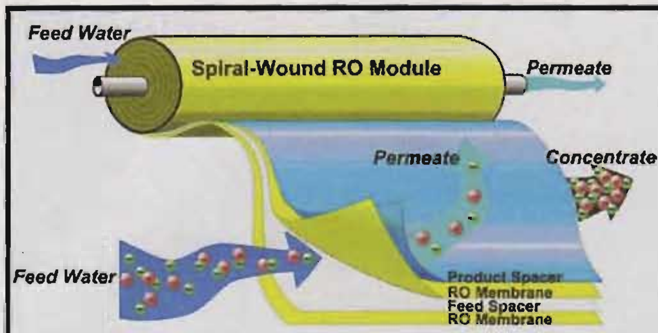


Fig.4: the construction of a reverse osmosis module. The clean water permeates through the membrane and collects in the centre while the water that does not pass through (the concentrate) carries away the salt and other impurities. ***(courtesy Water Corporation WA)***

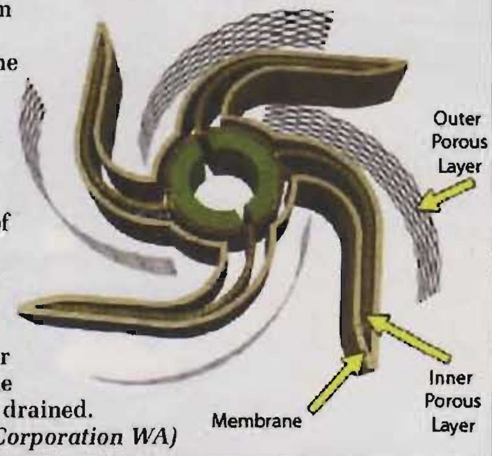


Fig.5: this diagram better shows the flow of water to the centre of the membrane coil. The outer porous layer allows the salt water to flow over the surface of the membrane. Water that passes through the membrane then flows via the inner porous layer to the centre where it is drained. ***(courtesy Water Corporation WA)***

250 years ago and since then researchers experimented with reverse osmosis.

Despite these efforts, reverse osmosis remained a curiosity because the water flow through the membrane was so low that the process was impractical for large scale use. The breakthrough came in 1959 when Sidney Loeb and Srinivasa Sourirajan in the USA discovered a membrane that was much more efficient (see the sidebar A Serendipitous Discovery).

The modern membrane used in reverse osmosis is a wonder of materials science and is normally a thin-film, composite membrane consisting of a thin polymer barrier layer formed on one or more porous support layers. Membranes have different characteristics and it is common for desalination plants to need two stages of reverse osmosis to remove everything. For example, the first stage will remove salt while the second targets boron or in some cases, bromide.

The pressure vessel

The membranes sheets are wound into large rolls held inside pressure vessels. These vessels are the long (generally white) tubes that you see in a photo of a typical desalination plant.

Inside a pressure vessel the sheets of membrane are rolled up (see Fig.4) with the desalinated water (permeate) collecting in the central spine. At least half of the intake water does not go through the membrane but instead runs out and is eventually discharged back into the sea. It is this flow of discarded water across the membranes that keeps them clean and prevents them from clogging up as a sieve would.

As shown in Fig.5, the membrane spiral is separated by a porous material that allows the seawater to contact every part of the membrane with an inner porous layer allowing the clean water (permeate) to flow to the centre.

A pressure vessel would hold a number of these rolled membrane sheets and a typical plant would use almost 20,000 membranes at a cost of about $1,000 each. Nothing in desalination is cheap.

A sea water intake. A desalination plant can suck up to 20 million litres per hour but the design of the intakes ensures that the flow into the intake is mild enough to have little effect on marine life (including divers!). ***(courtesy Water Corporation WA)***

Long Term Trend

You would have to be a hermit or living overseas, if you did not know that Australia is in a prolonged period of drought. Falling rainfall levels and rising water consumption across Australia have reduced the level of water in our dams and forced our politicians into making some expensive decisions.

The trend is most apparent in Western Australia where the inflow of water to Perth's dams has been steadily falling over the past 50 years to one third of the previously typical levels. To make it worse, demand has increased by three times during this same period.

Perth introduced its first water restrictions in 1960 and tapped into other sources such as groundwater but the trend has been inexorable. Three years ago the state government built Australia's first desalination plant, the largest of its kind in the southern hemisphere and now a second plant for Perth is about to start construction.

Sydney and Melbourne felt the effects of the big dry later but their dam levels have also been steadily falling since 1998. With traditional sources of water such as new dams being ruled out for environmental and other reasons planners across the country are turning to desalination.

This installation uses six high pressure centrifugal pumps drawing 2600kW each and pumping 1144 cubic metres/hour. They are made from super duplex stainless steel and need to be very well balanced during installation. Manufacturer was Clyde Pumps in Scotland. ***(courtesy Water Corporation)***

Recycle Instead?

Another approach to the crisis is to recycle water. The technology used in recycling is similar to desalination – you filter the water to remove the big stuff and then use reverse osmosis to remove everything else.

In planning for the Sydney desalination plant Sydney Water made a detailed comparison of the two systems and the differences are instructive. The cost of building identical capacity plants was about 50% higher for the recycling plant with the running costs also more expensive.

This makes sense if you think about it. Both desalination and recycling take in dirty water and clean it but recycled water is dirtier and needs more cleaning. Also, salty water is easier to get; you just suck it in from the ocean, whereas water for recycling must be piped from the sewage plants.

Apart from the cost, it is difficult to sell the notion of recycled water to the public, so it is no wonder that the planners chose desalination.

Due to the spiral construction the membrane does not rupture under pressure but rather is slowly compressed. It is this compression which limits the life of a membrane which is about five to seven years. During its lifetime the performance of each membrane is monitored by measuring the flow rate and testing the quality of the desalinated water. Membranes are also cleaned two to three times a year using caustic, acid and detergent solutions.

Practical issues

The principle of reverse osmosis works well, but implementing it in a plant that must produce millions of litres a day is not easy.

To force water through the membrane enormous pressures are required. In the Perth desalination plant there are six large centrifugal pumps which move millions of litres an hour at pressures up to 70 bar or in layman's terms, about 1000 psi.

These are made from super duplex stainless steel and must be very well balanced during installation to cope with the high speeds involved. Each consumes 2600kW, enough electricity to power hundreds of homes (see the sidebar Where Does the Electricity Come From?).

The energy used to drive the pumps is a large part of the cost of running a plant, and for this reason a lot of attention is paid to energy efficiency. The water that passes through the membranes loses its pressure on the way through. However, the salty water destined for discharge retains the high input pressure and rather than let that energy go to waste, a modern desalination plant tries to recover as much as it can.

The technique used in many plants is called isobaric or "pressure-equalising" energy recovery. This technology works by allowing the high pressure water to directly contact and push against the incoming water in pressure equalising or "isobaric" chambers. These chambers are inside spinning rotors that limit the contact time to avoid mixing; the result is a stream of high speed hammer blows against the incoming stream that transfer most of

Isobaric or "pressure-equalising" energy recovery devices. These transfer the energy contained in the discharge water to the incoming water and can reduce energy consumption by up to 96%. Inside each cylinder is a high speed spinning rotor made from tough ceramic that allows the outgoing water to hammer against the incoming water and thereby transfer the energy. *(courtesy Water Corporation)*

the energy held in the outgoing stream.

The energy recovery can be as high as 96% although in practice the actual percentage is rather lower. Regardless, this efficiency makes a huge difference in the amount of electricity required to drive the high pressure pumps and therefore the plant's running costs.

Another issue in plant design is corrosion. As anyone with a boat knows, sea water is very corrosive and at the high pressures used for reverse osmosis, it is positively destructive. As a result high grade stainless steel and ceramics are used in many places and this is part of the high price tag of a desalination plant.

Starting and stopping a plant can take some time (up to a day) and the membranes need special preservation arrangements to prevent damage when not being used. Accordingly, the engineers like to keep the plant running continuously at full capacity.

The only time it will be stopped is for maintenance and environmental reasons (for example, the salty outflow is not dispersing). Even in these circumstances the plant maintains a small output by continuously rotating a small production through each bank of membranes to prevent a full shutdown being forced on them.

Discharge

The water discharged from the plant is about double the normal salinity of sea water and this could be a problem for marine life if it was simply dumped back into the sea. Some sites, such as the Gold Coast and Sydney, can rely on strong ocean currents to help disperse the salty water but other locations are not so convenient.

For example, the Perth plant discharges into Cockburn Sound which does not have strong currents. Because of this the outlets were designed to

Where Does the Electricity Come From?

Former NSW Premier, Bob Carr, once famously dismissed the whole idea of desalination as "bottled electricity". Desalination can be thought of as:

salt water + electricity = drinking water

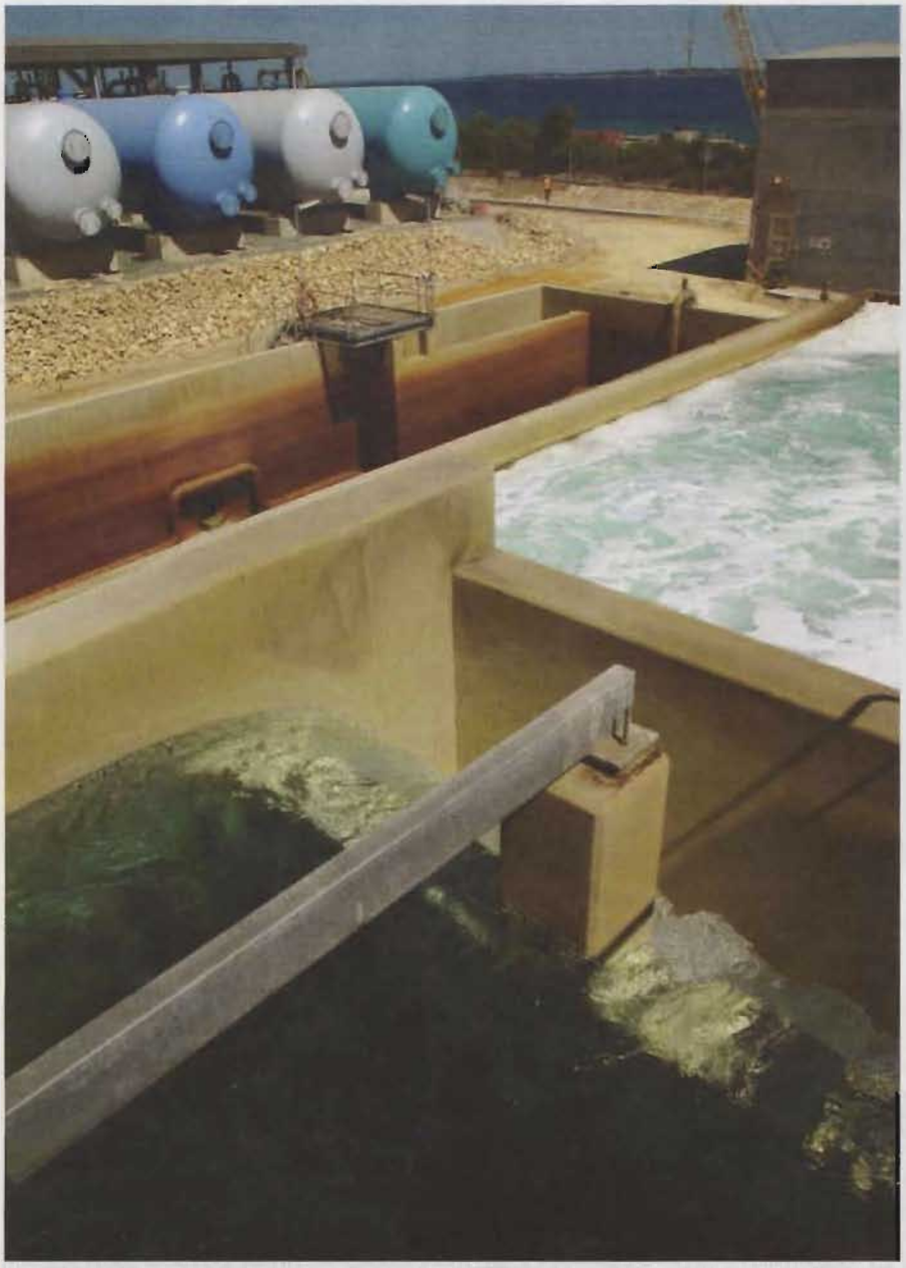
On average it takes about 5kWh of electricity to produce one thousand litres of fresh water. For plants producing millions of litres this adds up to a lot of electricity.

As we do not want to compound the environmental effects that are blamed on burning fossil fuels, renewable energy is a popular source for the electricity. Consequently Perth, Sydney and others have decided to go with wind farms.

As with the renewable electricity that you can purchase at home, the electricity for desalination is drawn from the general power grid. However, it is purchased at a higher than normal price, even if the wind farm is becalmed at that time. The extra money is then paid to the wind farm when they do generate some electricity and feed it into the grid, as that means that less power is required to be generated from fossil fuel. The result is the same as transmitting the power directly to the desalination plant but avoids the cost of building a duplicate transmission system.

The Perth desalination plant has a continuous power draw of 24MW and this is nominally supplied by the Emu Down Wind Farm located 100km north of the city. This facility cost $180 million to build and has 48 wind turbines capable of generating a peak 80MW of power. 40MW of that is reserved for the desalination plant which, given the variability of wind power, means that the desalination plant will end up paying for the equivalent of 24MW of continuous renewable energy.

For the Sydney desalination plant a wind farm will be built at Bungendore (near Canberra), with a capacity of 140MW. The second desalination plant for Perth will go one step further with 20% of its power to come from what is called "speculative energy sources". This covers technologies such as geothermal, wave power and other experimental sources and accordingly an even higher price will be paid for this electricity.



The salty discharge water on its way back to the ocean. The salt level is double normal levels but it quickly disperses in the ocean. In the background you can see the sand filters that are used to clean the incoming sea water by removing large particles such as sediment and algae. ***(courtesy Water Corporation)***

shoot the outflow upwards from the sea bed to encourage mixing. Before construction this design was tested by the University of NSW in a large swimming pool.

Overall, the designers aim to mix the outflow to such an extent that the salinity of the water reaches normal levels at 50 to 75 metres from the outlets.

Drinkable water

The water produced by reverse osmosis technology is essentially pure but still needs processing. So a desalination plant must include a post treatment stage which adds components such as fluoride that we expect in out drinking water.

This stage also adds alkalinity to the soft processed water. A similar treatment stage is used for soft dam waters as this prevents corrosion in the distribution system. In keeping with other treatment methods, chlorine is also added for cleansing and maintenance of the distribution system.

Finally the water is fed into the municipal water reticulation system. Because the plant is run continuously the engineers will throttle back other sources of water (such as dams) on days of light water consumption to favour water from the desalination plant. In extreme cases they will even pump the desalinated water into dams for storage.

As the overall aim of the desalination plant is to conserve the water in our dams this arrangement will even out in the long term.

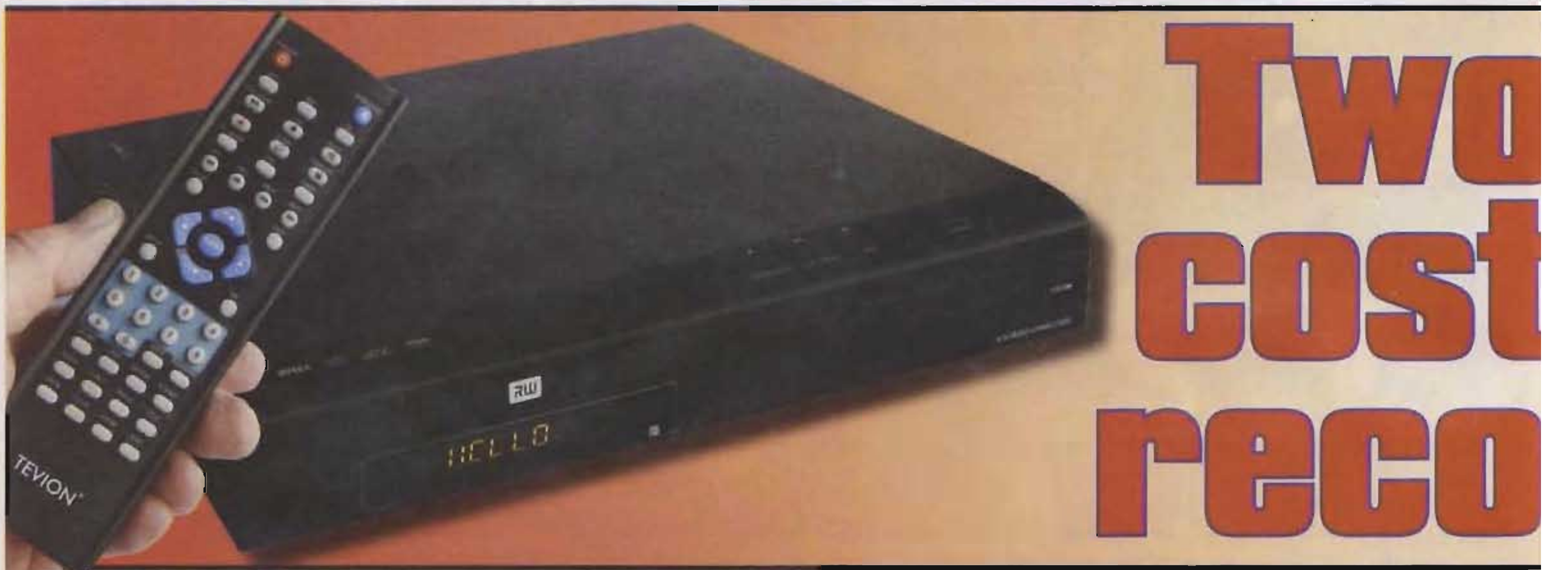
In the unlikely event that the dams approach overflow the desalination plant would then be shut down, probably for a long time.

The overall cost of desalinated water can vary considerably, depending on many factors, but it is still affordable. When constructed the Perth plant had running costs of about $20 million per year and the cost of water produced was close to $1.20 per kilolitre.

This can be compared to the cost of water from traditional sources at the time of 80c to 90c per kilolitre. Other plants currently under construction have projected production costs that range from $1 to $3 per kilolitre. If you are in a serious situation like Adelaide, even that price is a bargain.

With so much effort going into producing the water in your tap, you should appreciate a glass of water even more. SC

Monitoring buoys are used to monitor salt concentration, dissolved oxygen and many other parameters. If these exceed safe levels the desalination plant will be shut down until the ocean currents can return the sea water to acceptable levels.
(courtesy Water Corporation)



He's held onto a large library of VHS tapes for decades so Barrie Smith thought he could make good use of the Easter break by engaging with DVD recording. Here are his reactions to a Tevion DD1018 and an AWA DR711 DVD recorder.

It was very much due to our Prime Minister's urging to 'spend, spend, spend' that I fell upon the ALDI catalog with gusto: a DVD recorder for $99!

Zipping down to the local ALDI on Easter Saturday, I laid down the plastic and helped the economies of three countries in one swoop: China as the makers, Germany (who own the retailer ALDI) and hopefully, a band of Australian staffers working for the latter.

Before getting on to the main topic, I've noticed that something funny has been going on in the retailing of disc recorders: there are heaps of DVD recorders with 80/160/250 Gigabyte hard drives as their primary storage and selling for $400-500, with a solitary model at $299.

Parallel to this you can get your hands on a couple of Blu-Ray recorders from Panasonic, with prices starting at around $1600. So I felt the arrival of the low-cost Tevion DD1018 was a significant event.

Looks and Feel

The unit is a neat package in black with external controls placed on the upper edge. A drop-down front panel gives access to composite audio and video inputs, along with a camcorder DV input.

Round the back we face a whole complex of in/outputs: RF in/output loop; composite audio/video in/outputs along with an S-Video output; component Y, Cb/Pb, Cr/Pr inputs are there as well as a pile of audio ports for Dolby 5.1 channel outputs.

The remote control does a sterling job by expanding the options via 50 buttons (of which ten are channel numbers) with choices of front or rear composite inputs plus RF, audio volume up/down buttons, all the usual DVD navigation tools, channel selection via the internal analog tuner as well as a timer to record time shifted programs ... the Tevion can also 'one touch' record at any time.

The on-screen menus are well set out and copious in variety. However, due to the nature of DVD and its multiple skills and requirements, you do need a fair amount of study to get it going.

This is how I and my teenage son spent Easter Sunday; logging the channels into the menu, assigning program positions and making many test recordings. Little did I know at this stage that this exercise would need to be repeated twice more.

Single Layer

The Tevion replays DVDs containing NTSC/PAL programming and CD-R/RWs with AIFF and MP3 tracks. Discs with JPEG images are OK as well as Picture CD material, Video CDs, Super VCDs, HDCD and MPEG4. It will also record SD video to Single Layer DVD+/-RW and DVD+/-R media.

It will not record to Dual Layer DVDs ... but that's OK I guess, because the recording options are wide.

The recording quality choices are shown in the table below, with the highest quality (and shortest time) at the top.

QUALITY	LEVEL	RECORD TIME (hours)	MBPS	RESOLUTION (MPEG2)	ENCODING
HQ	High Quality	1	9.716	D1	CBR
SP	Standard Play	2	5.037	–	CBR + VBR
LP	Long Play	3	3.382	LP	–
EP	Extended Play	4	2.537	–	–
SLP	Super Long Play	6	1.691	SLP	–

Review by BARRIE SMITH

Early on, I had difficulty in reading the washed-out on screen menu but did eventually work my way through the options.

The timer menu was an easy one and compared to VHS machines, offered far more elegant ways to time shift than Ye Olde tape machine. After you choose channel number, date and time of recording commencement you then have only to select the length of recording in hours and minutes taking care to choose the recording quality that will comfortably encompass the record time.

Of course, the Muggins way is to select SLP, which gives six hours of recording but at the lowest quality. Thinking users will naturally juggle record time and quality level in their decision-making.

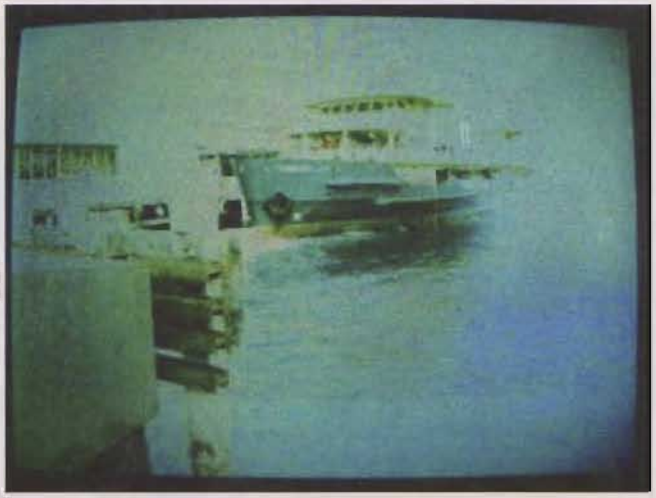
Post recording, you must finalise the DVD, with both DVD-R and DVD-RW discs. Doing so enables the disc to be played on any other compatible machine, just like a commercial DVD. But doing this changes the disc format so that you can no longer record to it, turning it into a 'play only' disc; this makes a DVD-R no longer writeable.

By using a DVD-RW platter you can still finalise the disc for replaying in another player, then return it to the Tevion, 'unfinalise' it, remove the existing programming and accumulate extra recordings, much in the way of Ye Olde VHS but with the attractive advantage of replay access in a random fashion, via on screen icons indicating the programs on offer. It's a great way to travel!

I didn't get into DVD+R/RW discs; for one thing they are far more expensive than DVD-R/RWs and don't seem to offer any advantages.

Back to recording: after you've committed pictures and sound to a disc, and before finalising, there is an option to rename the text that accompanies the program icon: you get only 11 characters but I found this is more than enough for an ID. There is

The Tevion DVD recorder is styled in black with external controls on the upper edge. A drop-down door reveals the standard yellow (video) and red/white (stereo audio) inputs along with its DV input. The Tevion's rear hookup panel has a host of inputs and outputs, including a duplication of the video and audio inputs from the front panel. As you can see, it also features antenna in and out, S-video and more.



Tevion's on screen display of a JPEG still image. Ignore the digital camera interference lines – this is seriously under-saturated. And this was the better of the two Tevions I tried – I'd taken the first one back already!

Compare this off-screen shot of the same Manly ferry image, as displayed by the AWA DR711 recorder. Note how much more saturated the image is and as a result, how much more detail there is. Oh bliss, oh joy!

also an option to select a frame of the program as a visual ID.

Another nicety is that the Tevion can insert chapter markers into the program; these will be automatically spaced five, ten and fifteen minutes apart during the recording.

By now you're probably thinking this piece of hardware is a whizzer; well, not quite.

The first warning should have sounded when I found the on-screen menu a bit washed out but the penny didn't drop until I made a recording, and then replayed it.

Show me the colour!

Where's all the colour, I cried out? It didn't matter whether I tweaked the Tevion's colour saturation/contrast/brightness, adjusted the TV, darkened the room, pulled the curtains – the colour depth was just not there.

Taking the disc to other DVD players (I've got three – don't ask why!) revealed full-bodied colour.

A phone call to Tevion tech support elicited the advice to swap the unit at ALDI for another. Which I did. Took it home, re-installed it. This was better; at least now I could read the menus more easily. But the replay was still noticeably desaturated.

At this point I decided to run a colour chart past the Tevion, showing the primaries: red, green, blue as well as the complementary hues: cyan, magenta and yellow.

It was apparent that the primaries were fine on the Tevion but the system was not delivering magenta (mix of blue and red) or yellow (mix of red and green), whereas the other players were delivering all primaries and complementaries. Not happy, Jan!

AWA to the rescue

By this time matters had become a little more complex as Big W announced the sale of their entry, a nicely satin-chromed model AWA DR711, with cosmetic differences but with a near-identical feature list and specs. Same factory in China? Possibly. Price? $148.

Being a canny shopper I managed to snaffle one just two days before the price dropped to an on-sale special of $128! But the good news was that at last I could see the on-screen menu clearly and matters only got better as I viewed on-air broadcasts and then ran some tests.

What a difference! Colours were now fully on while the brightness and contrast range were good.

The AWA unit is identical in features and operating modes to the Tevion, while the remote control differs slightly. It is obviously the one to go for. I'm now very happy with my purchase and plan to retire the home VCRs for day-to-day recording. Disc is in.

But you're probably wondering why I bought a DVD recorder with an analog tuner instead of considering a more expensive unit with an inbuilt digital tuner.

My attitude is that analog TV transmissions have some years to run before they cease to be broadcast and even after that, I will be able to couple A/V signals from my set-top box to the DVD recorder.

In the meantime, I have the use of a DVD recorder at a bargain price.

The Tevion screen display of an RGB/CMY chart. The primary colours appear OK on the Tevion but the system does not correctly deliver magenta (mix of blue and red) nor yellow (mix of red and green). It wasn't an isolated dud: this is the better of the two Tevions I tried before giving up on them and going to AWA.

AWA DR711 Specifications

Power Supply:	AC 100V-240V/50Hz-60Hz, 35W.
Signal Modulation:	PAL/NTSC.
Radium Laser:	Wavelength 650nm, 780nm.
Frequency Response:	DVD audio: 4Hz-22kHz (48kHz sample frequency). 4Hz-44kHz (96kHz sample frequency).
	CD audio: 4Hz-20kHz.
S/N:	>90dB.
Dynamic Range:	>90dB.
Operating temperature:	0-40° C.
Video out:	1.0V (P-P).
S-Video out:	(Y) 1.0V (P-P) 75Ω ; (C) 0.286V (P-P), 75Ω
Audio output:	2.0V (RMS maximum).
Receiving Modulation:	PAL I, PAL D/K, PAL B/G, SECAM, L SECAM D/K SECAM B/G.

Last Thoughts

As we all know, the majority of consumer electronic products is manufactured in China, either under an international monicker like Sony, Panasonic etc or a truckload of generic labels, like Tevion, AWA and many others. With the major brands you can presume the companies keep a strict eye on the products before they reach the market.

With generic brands, sold through retail outlets, one can only presume that a similar degree of surveillance is applied before the items are placed on shop shelves before sale.

From my experience with these two ostensibly identical DVD recorders it would appear that, in the case of one retailer, this degree of quality control was not maintained. SC

While cosmetically different to the Tevion, the AWA has similar specs and operating modes. The rear panel also reveals S- Video input as well as output along with optical audio (Toslink) and coaxial output. Apart from more versatile, it significantly out-performs the Tevion in the colour department.

Mk.3 Lead-Acid Battery ZAPPER and DESULPHATOR

Here is a revised version of the popular Lead-Acid Battery Zapper featured in the May 2006 issue of SILICON CHIP. It is now separate from the Battery Condition Checker and much easier to build. At the same time it has been revamped for more reliable long-period operation with 6V, 12V & 24V batteries.

By JIM ROWE

THE LEAD-ACID Battery Zapper & Condition Checker published in the May 2006 issue has been a very popular project but since it was published a few shortcomings have become apparent. The metering circuit on the Battery Condition Checker sometimes had a tendency to "lock up" on the 6V range and the current pulse loading circuit was sometimes unstable with 24V batteries, if the power switching MOSFETs were at the high end of their transconductance range.

In addition, the test current pulse amplitude was fixed at about 30A; OK for car batteries but too high for batteries used in motorbikes and for sealed lead acid (SLA) batteries.

Many readers also found the combination of the Battery Zapper & Condition Checker fairly tricky to assemble and disassemble because it was a bit of a shoe-horn job into the plastic case. In view of this, we recently decided to develop improved versions of both the Checker and the Zapper but to feature them as separate projects, to make them easier to build and use. The revised Battery Condition Checker is planned for publication next month.

What the Zapper does

First of all, let's have a quick recap about zapping and what it's all about. Lead-acid batteries have been used to store electrical energy for over 170 years – ever since Gaston Plante built the first one back in 1834. But lead-acid batteries are not without their faults. Probably their main drawback is that they tend to have a relatively short working life, typically no more than about three years although with care, they can last much longer than that.

So why such a short life? Well, every time energy is drawn from a lead-acid battery, lead and sulphate ions from the electrolyte combine and are deposited on the plates in the form of soft lead-sulphate crystals. Then when the battery is recharged, these crystals dissolve again in the sulphuric acid electrolyte.

At least MOST of them redissolve – but not all. Even if the battery is never over-discharged and always recharged promptly after it has been discharged, a small proportion of the lead sulphate crystals tend to remain on the plates,

Disclaimer!

Not all batteries can be rejuvenated by zapping. They may be too heavily sulphated or may have an open-circuit cell connection. Nor can the zapper restore a battery which is worn out; ie, one in which the active material on the plates has been severely degraded.

Depending on the battery, it is also possible that any rejuvenation effect may only be temporary.

where they harden into crystals of a much less soluble and less conductive "hard" lead sulphate.

The formation of these hard lead sulphate crystals gradually reduces the energy storage capacity of the battery, both by masking the active areas on the plates and also by reducing the concentration of lead and sulphate ions in the electrolyte.

This "sulphation" effect has been known about for many years. It's also well known that the effect happens much faster if a battery is over-discharged, left in a discharged state for long periods, or frequently under-charged. Batteries mistreated in these ways tend to have a particularly short working life.

For a long time, sulphation was regarded as non-reversible and batteries that had lost too much of their capacity from it were simply junked. This was not only wasteful but caused an environmental problem, because

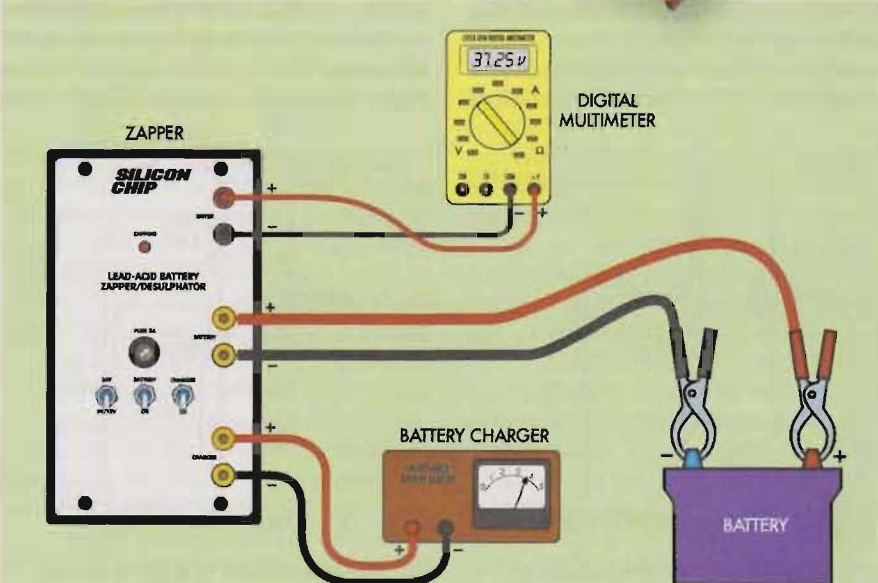


Fig.1: here's how the Battery Zapper is connected to a battery and charger. The multimeter monitors the zapping pulses and should be set to a range of 100V DC or more. In addition, make sure that the Battery Voltage switch (S1) is set in the correct position for the battery you're going to be zapping.

Parts List

1 ABS Jiffy box, UB2 size (197 x 113 x 83mm)
1 PC board, code 04107091, 185 x 100mm
3 SPDT mini toggle switches (S1-S3)
2 speaker box binding posts, red (Jaycar PP-0434 or equivalent)
2 speaker box binding posts, black (Jaycar PP-0435 or equivalent)
1 Premium binding post, red (Jaycar PT-0460 or equivalent)
1 Premium binding post, black (Jaycar PT-0461)
1 M205 LV panel-mounting fuseholder
1 3A slow blow M205 fuse cartridge (F1)
2 6073B type TO-200 heatsinks (HS1, HS2)
1 8-pin DIL IC socket
1 220µH air-cored inductor (L1)
2 1mH air-cored inductors (L2, L3)
3 Nylon cable ties, 250-300mm
4 M3 x 25mm tapped spacers
6 M3 x 6mm machine screws, pan head
4 M3 x 6mm machine screws, countersunk head
8 M3 flat washers
2 M3 hex nuts
1 400mm length 1mm tinned copper wire
1 300mm length 0.7mm tinned copper wire

Semiconductors
1 555 timer (IC1)
1 BC327 PNP transistor (Q1)
1 IRF540N MOSFET (Q2)
2 6.8V 1W zener diodes (ZD1,ZD2)
1 30V 1W zener diode (ZD3)
1 27V 1W zener diode (ZD4)
1 5mm red LED (LED1)
2 1N4148 diodes (D1,D2)
1 BT229-200 fast recovery diode (D3)
2 UF4003 ultra-fast diodes (D4,D5)

Capacitors
1 470µF 63V low ESR RB electrolytic
1 470µF 16V low ESR RB electrolytic
1 470nF 100V MKT polyester
1 100nF 100V MKT polyester
1 22nF 100V MKT polyester
3 10nF 100V MKT polyester
1 4.7nF 100V MKT polyester

Resistors (0.25W, 1%)
1 1MΩ
1 270kΩ
1 27kΩ
1 15kΩ
1 6.8kΩ
1 470Ω 5W wirewound
1 150Ω
1 100Ω
1 15Ω 5W wirewound

both lead and sulphuric acid are highly toxic materials.

Around the middle of last century though, farmers in rural areas discovered that they seemed to be able to resuscitate sulphated batteries and extend their life by zapping them with the high-voltage pulses from their electric fence controllers. They didn't quite know how this method worked but kept using it simply because it did.

Then in 1976, the US Patent Office granted a patent to William H. Clark of Salt Lake City, Utah, for a method of charging lead-acid batteries by means of narrow high current pulses – claimed to dissolve the lead sulphate crystals and hence prolong battery life. Since then, a number of designs for pulse-type battery rejuvenators or "zappers" have appeared in electronics magazines around the world.

We should point out that there is still argument and controversy about whether or not the sulphation of flooded lead-acid batteries can be reversed. That in turn means there is still argument about the effectiveness of zapper-type pulse rejuvenators. However, many people have reported achieving a useful amount of rejuvenation on badly sulphated batteries, using zappers – including our earlier designs. That's why we're describing this new version.

At the same time, we should also point out that this zapping process does not appear to work with sealed lead acid (SLA) batteries with a "gel" electrolyte. So we don't recommend building the Battery Zapper to try rejuvenating this type of battery.

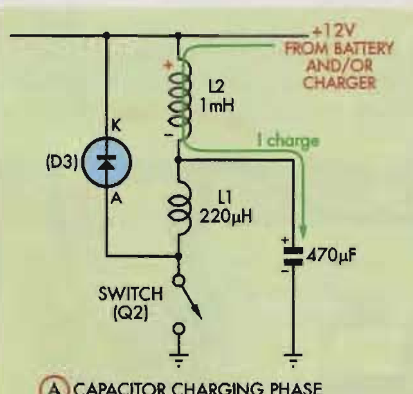


Fig.2(a): during the first phase of the circuit's operation, current flows from the battery (and/or battery charger) and charges a 470µF electrolytic capacitor via 1mH inductor L2.

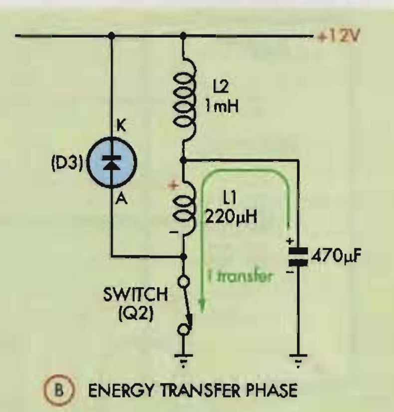


Fig.2(b): next, switch Q2 is closed for 50µs, and current flows from the capacitor into L1. As a result, the energy stored in the capacitor is transferred to the inductor's magnetic field.

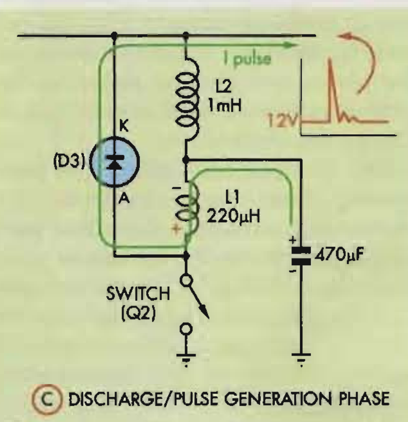
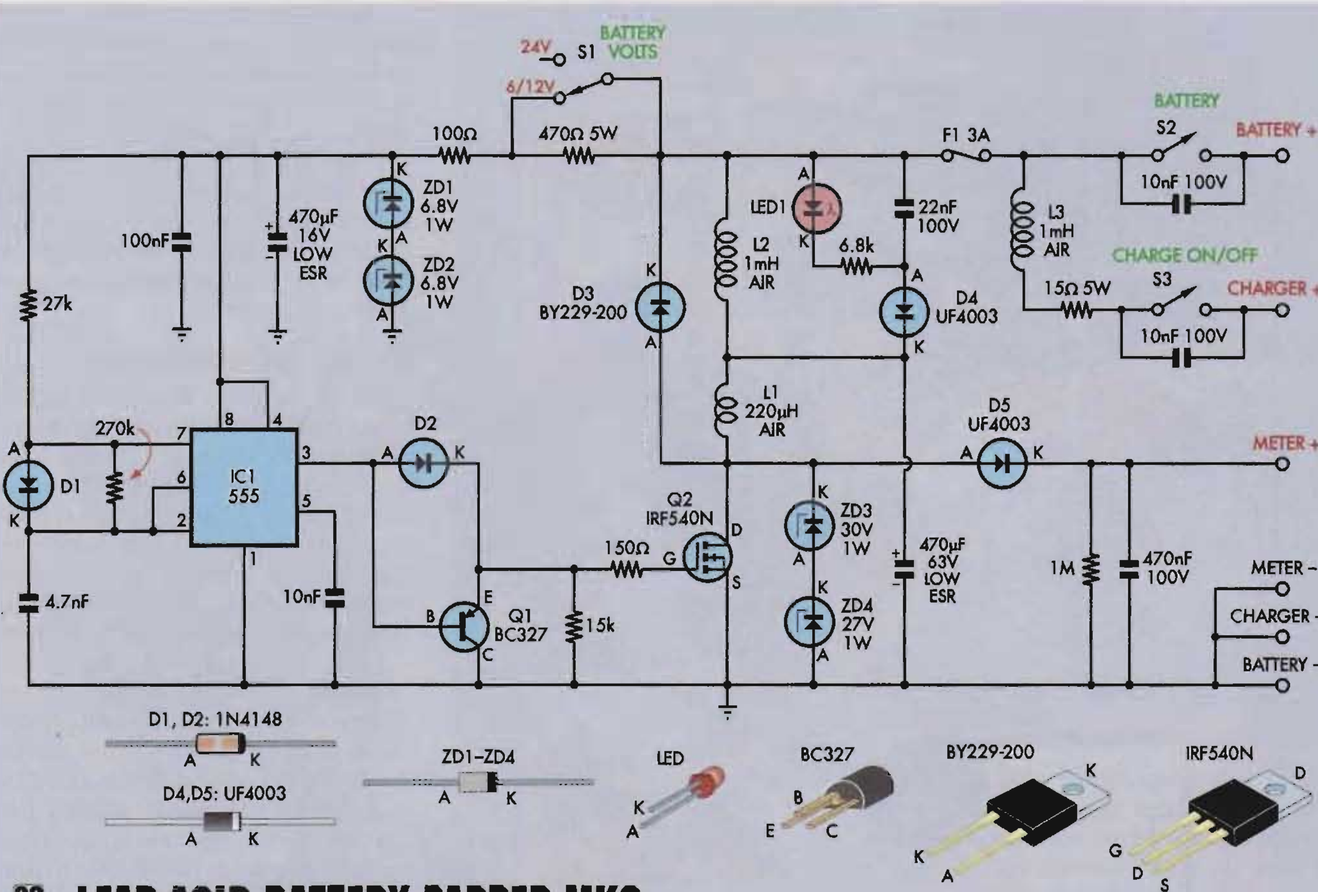


Fig.2(c): finally, switch Q2 opens again, interrupting the inductor current and causing a high-voltage pulse across the inductor with the polarity shown. The green arrow shows the discharge current path.



LEAD-ACID BATTERY ZAPPER MK3

Fig.3: the circuit uses 555 timer IC1 to turn MOSFET Q2 on for 50µs every 1ms (ie, at a 1kHz rate). Transistor Q1 turns on and shorts Q2's gate to ground each time IC1's pin 3 output switches low to ensure a fast turn off, while zener diodes ZD3 and ZD4 form an over-voltage protection circuit for Q2, which has a maximum voltage rating of 100V.

It's also worth noting that even on flooded lead-acid batteries, pulse desulphation is not quick. **It can involve tens or even hundreds of hours to achieve a significant amount of rejuvenation.**

How it works

As with our earlier units, the new Battery Zapper converts some of the energy from the battery itself (usually aided by a battery charger) into narrow high-voltage pulses which are fed back to the battery. This is done using the basic circuit configuration shown in Fig.2, which also shows its three operating phases.

In the first phase (A), current flows from the battery and/or charger through 1mH inductor L2 and charges a 470µF capacitor connected between the inductor's lower end and earth (battery negative). This phase lasts for about 950µs – long enough for the capacitor to charge up to the battery voltage.

At the end of this charging phase, switch Q2 (a power MOSFET) is closed for about 50µs (B), shorting the lower end of 220µH inductor L1 to ground and effectively connecting it right across the charged 470µF capacitor. As a result most of the energy stored in the capacitor is transferred into the inductor's magnetic field. Hence this second phase is known as the energy transfer phase.

The third phase (C) begins when switch Q2 is opened again. This breaks the inductor's transfer current, which causes a high voltage back-EMF pulse to be generated across L1 with the polarity shown. Fast recovery diode D3 then feeds this high voltage pulse back to the battery, as shown in Fig.1(c).

The third phase is therefore known as the discharge/pulse generation phase.

Circuit details

Refer now to Fig.3 for the full circuit details of our new Lead Acid Battery Zapper. You should now be able to identify this basic pulse generation circuit in the centre of the diagram. The discharging switch Q2 is now shown in its true form as an IRF540N power MOSFET, which we're using here as a fast electronic switch. Virtually all of the circuitry to the left of Q2 is used to switch it on and off repeatedly, so that the pulse generating circuit produces a stream of zapping pulses.

The pulses used to switch Q2 on and off are generated by IC1, a 555 timer. This is configured as an astable oscillator running at about 1kHz but with an output consisting of narrow positive pulses about 50µs wide, with spaces of about 950µs between them (ie, a 1:19 mark-space ratio). Each of these narrow pulses is used to turn on Q2, with diode D2 and transistor Q1 used to ensure that Q2 is switched both on and off as rapidly as possible.

So Q2 is turned on for 50µs, then off for 950µs and so on. The 150Ω resistor in series with Q2's gate is included to

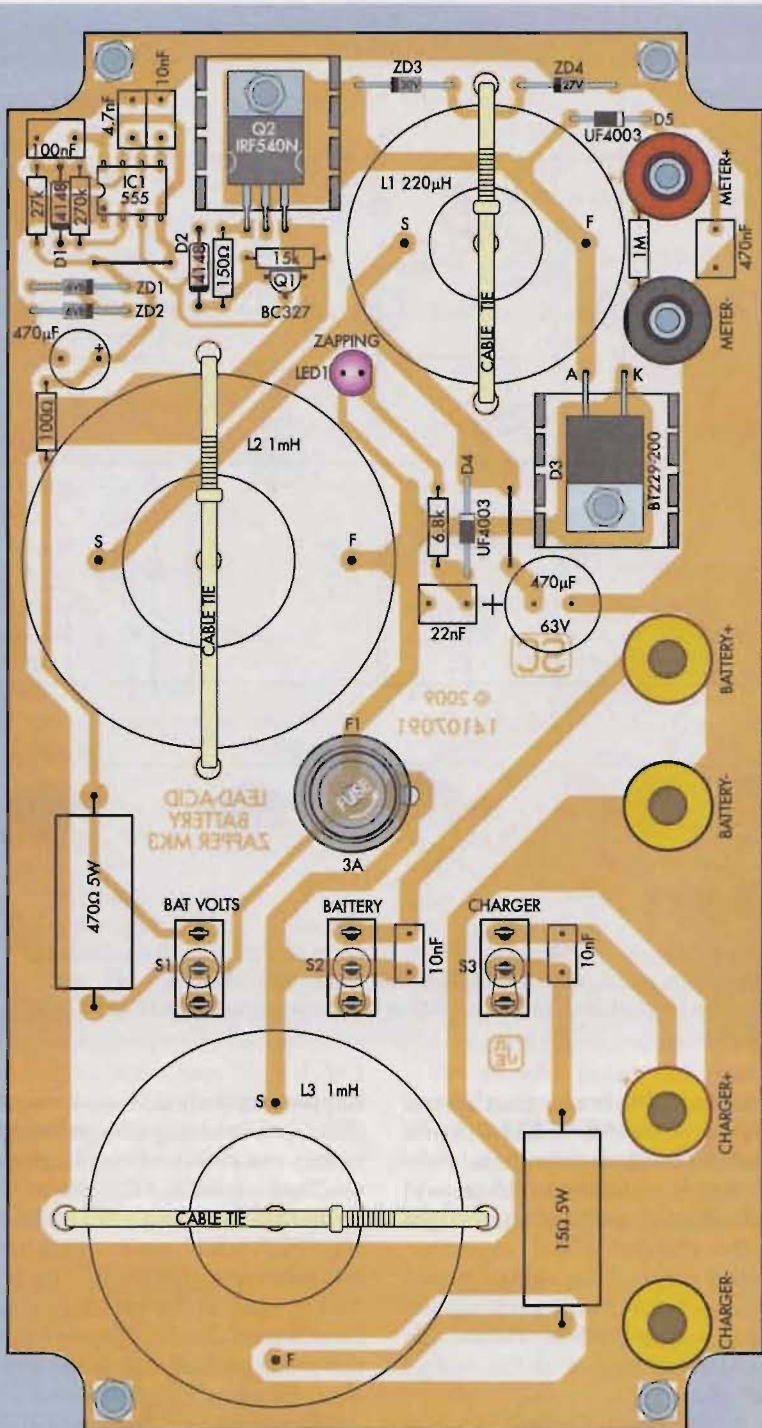


Fig.4: follow this parts layout diagram to assemble the PC board and make sure that all polarised parts are orientated as shown. The large inductors (L1-L3) are secured to the board using plastic cable ties which pass through holes on either side.

suppress any tendency for it to oscillate during the switching transitions.

That's all there is in the basic zapping circuit. Now let's look at the refinements.

Zener diodes ZD1 and ZD2 are included to prevent the supply voltage for IC1 from rising above 13.6V, especially when the Battery Zapper is being used with a 24V battery. They do not conduct any significant current when 6V batteries are being zapped and for 12V batteries they only serve as a limiter for any zapping pulses which find their way back from the cathode of D3, via the 100Ω series resistor.

Note that switch S1 inserts a 470Ω 5W resistor in series with the 100Ω resistor when the unit is being used with a 24V battery, to limit the dissipation in ZD1 and ZD2.

Zener diodes ZD3 and ZD4 form an over-voltage protection circuit for Q2, which has a maximum voltage rating of 100V. These zener diodes limit the maximum pulse voltage to about 70V under all conditions.

Pulse level monitoring

D5 is an ultra-fast diode which forms part of a simple half-wave rectifier circuit with the 1MΩ resistor and 470nF reservoir capacitor. These provide a DC voltage proportional to the maximum pulse amplitude between the "Meter" terminals, to allow monitoring the pulse level with a standard (high-impedance) digital multimeter.

LED1 indicates when the Battery Zapper is generating pulses and also gives a rough idea of their amplitude. Because the pulses are quite narrow, diode D4 is used to charge the 22nF capacitor to their full voltage (less the battery voltage across the 470µF capacitor) and the LED is able to draw a steady current from the capacitor via the 6.8kΩ resistor. This allows LED1 to glow fairly brightly, without taking too much of the energy in the zapping pulses.

Fuse F1 is provided mainly to protect inductors L2 and L1 against damage in the event of Q2 developing a short circuit or being switched on continuously due to a fault in IC1 and its associated components. The circuitry at upper right is to allow safe connection and disconnection of the unit to a battery (via switch S2) and also to allow safe connection or disconnection of a standard battery charger to the battery at any time, via switch S3.

Inductor L3 acts as a choke for the zapping pulses, preventing the charger from absorbing them and possibly being damaged, while the 10nF capacitors across both S2 and S3 are spark suppressors. The 15Ω 5W resistor between L3 and S3 is there to limit the current that can be drawn from the charger, preventing damage should the battery develop a short circuit during zapping.

Construction

To make the new Battery Zapper as easy as possible to build, virtually all the components are mounted on a PC

This view shows the fully assembled PC board. Note that the three toggle switches would not normally be mounted on the board at this stage but are instead fitted with extension leads and mounted on the lid of the case – see text.

board coded 14107091 and measuring 185 x 100mm. This PC board has rounded cut-outs in each corner so it will fit snugly inside a standard UB2-size ABS utility (Jiffy) box.

The only components which don't mount directly on the PC board are switches S1-S3, the fuseholder for fuse F1 and the various input terminals.

All of these off-board components mount on the box lid (which becomes the front panel) and are connected to the board beneath via short lengths of tinned copper wire, as you can see from the parts layout diagram of Fig.4 and the cross-section diagram of Fig.6.

Begin assembly of the PC board by fitting the wire links. There are only two of these and they're both only 10mm long (horizontal section), so they are easily made from resistor lead off-cuts. After the links, fit the

Warning!

(1) This circuit generates high-voltage pulses which could easily damage the electronics in a vehicle. Do not connect it to a car battery installed in a vehicle.

(2) Hydrogen gas (which is explosive) is generated by lead-acid batteries during charging. For this reason, be sure to always charge batteries in a well-ventilated area.

(3) Never connect high-current loads directly to a battery's terminals. This can lead to arcing at the terminals and could even cause the battery to explode! Note too that the electrolyte inside lead-acid batteries is corrosive, so wearing safety glasses is always a good idea.

(4) This unit is not suitable for use with SLA batteries.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	1MΩ	brown black green brown	brown black black yellow brown
❑	1	270kΩ	red violet yellow brown	red violet black orange brown
❑	1	27kΩ	red violet orange brown	red violet black red brown
❑	1	15kΩ	brown green orange brown	brown green black red brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	1	470Ω 5W	not applicable	not applicable
❑	1	150Ω	brown green brown brown	brown green black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	15Ω 5W	not applicable	not applicable

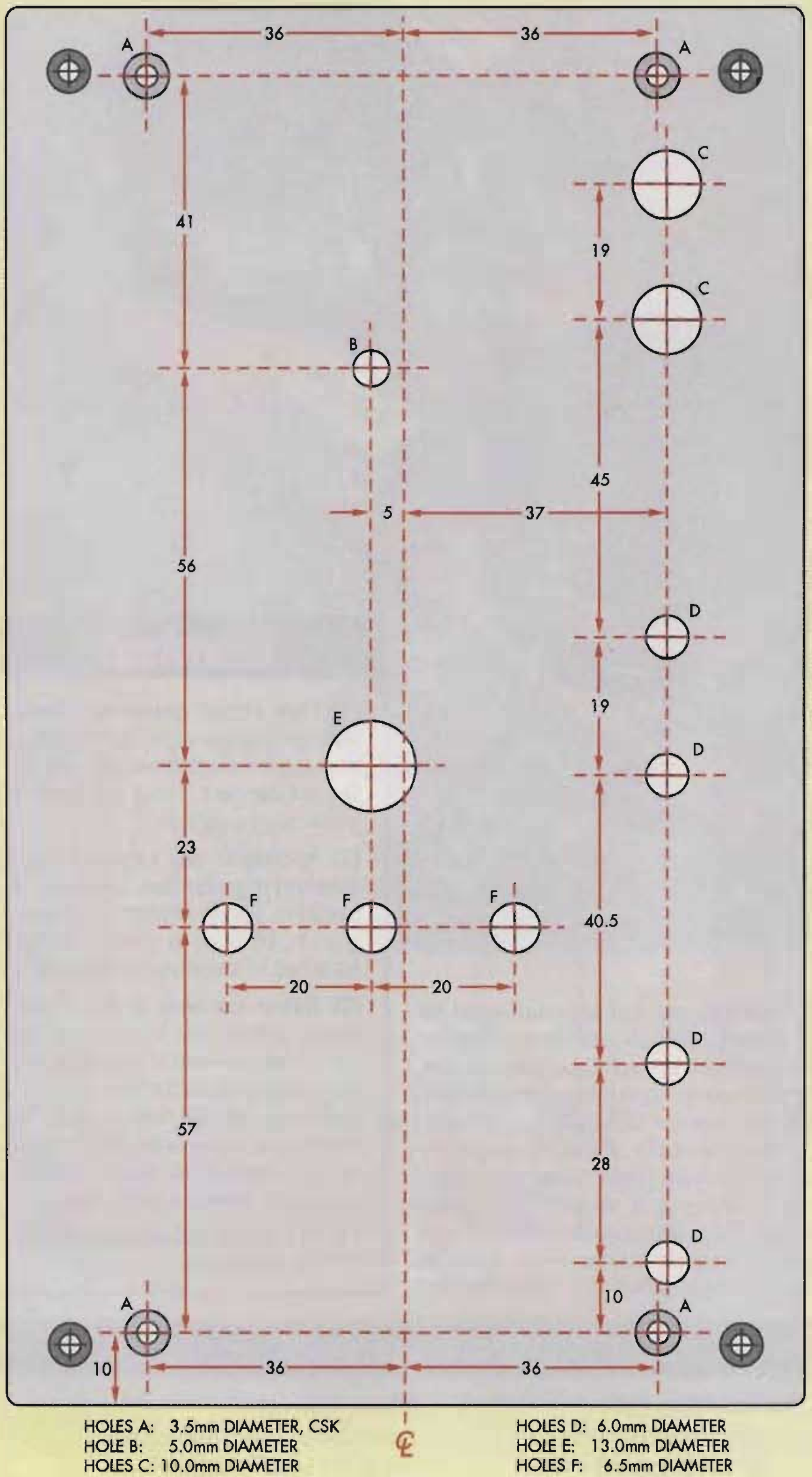


Fig.5: the drilling template for the front panel (ie, the lid of the case). Drill small pilot holes first & use a tapered reamer to make the larger holes.

8-pin socket for IC1, making sure you orientate it with the notch end to the left so it will guide you later when plugging in IC1.

Next, fit the smaller resistors, then fit the two larger 5W resistors which are in ceramic block packages. It's a good idea to fit these about 1mm above the board rather than flat down on it. This will provide them with a small amount of ventilation and also protect the board from damage if they should become overheated.

Follow these parts with the capacitors, starting with the smaller non-polarised MKT parts and then moving to the electrolytics. There are only two of the latter but be sure to fit them in the correct places and with the correct orientation, otherwise you'll strike trouble later.

Now you can fit the semiconductor parts, starting with diodes D1, D2, D4 & D5 and then zener diodes ZD1-ZD4 and transistor Q1. Once they're in, fit diode D3 and power MOSFET Q2. These are both in TO-220 packages and are mounted flat on the top of the PC board along with small 6073B-type heatsinks. In both cases, their leads must be bent down by 90° about 6mm away from the bodies, so they'll pass down through the matching holes in the PC board.

The tabs of both devices are then secured down against the heatsink using an M3 x 6mm machine screw and M3 nut. Then when the screws are nuts are tightened, the board is upended and the device leads soldered to the pads underneath. Don't solder the leads before bolting them down, otherwise you could crack the copper tracks as the screws are tightened.

Once D3 and Q2 are in place you can fit LED1. This mounts vertically in the upper centre of the board, with its leads straight and with the underside of its body spaced about 24mm above the board so that it will later just protrude through its matching hole in the front panel.

With LED1 in place, now is the time to fit the largest components which mount on the board: the three air-cored inductors. During this process, it's important to dress each inductor's leads carefully so they're straight and at 90° to the side cheeks of the inductor bobbin. This will allow the leads to be fed through their matching board holes without strain as each inductor is lowered into position.

Be sure to orientate each inductor so that its "start" lead (near the centre of the bobbin) passes through the matching "S" hole on the board, while its "finish" lead (on the outside) passes through the hole marked "F".

When each inductor is sitting flat down against the top of the board,

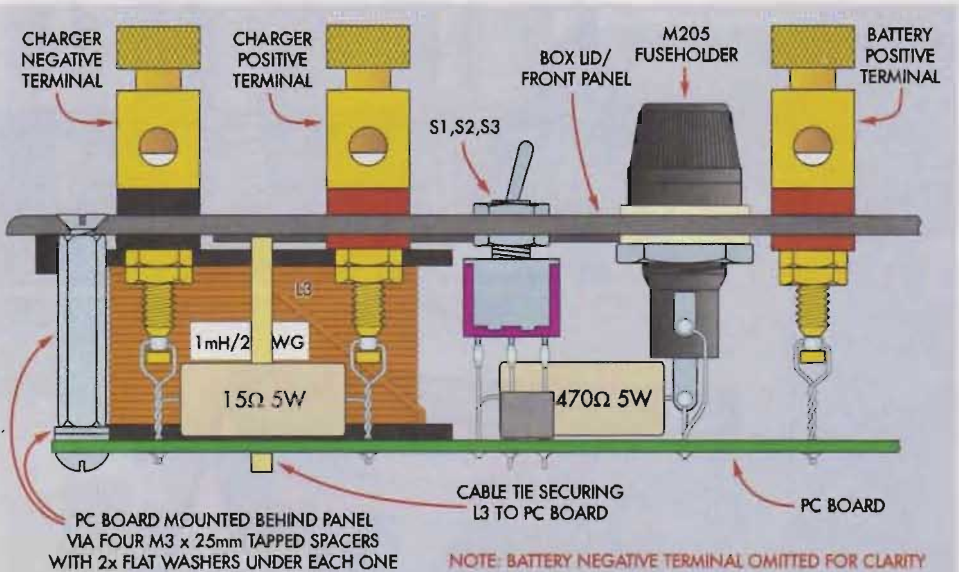
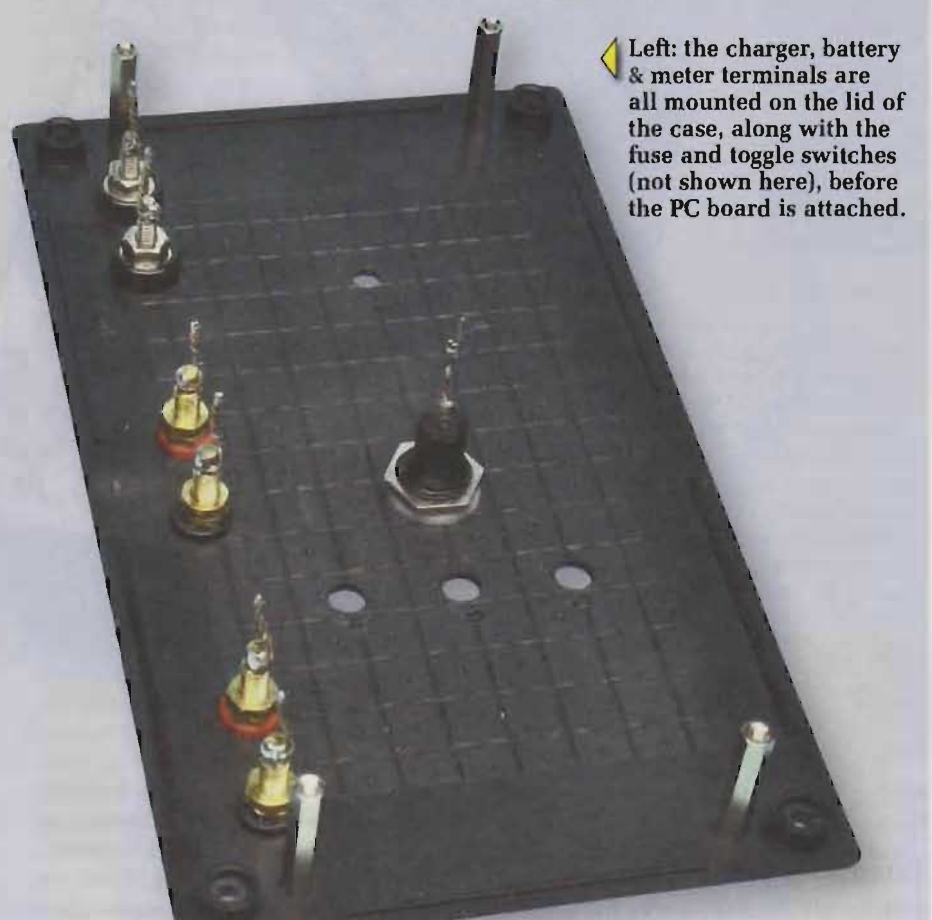


Fig.6: this end-elevation diagram shows how the PC board is mounted on the back of the lid on M3 x 25mm tapped spacers & washers. The front panel parts are connected to the PC board via "extension" wires.



Left: the charger, battery & meter terminals are all mounted on the lid of the case, along with the fuse and toggle switches (not shown here), before the PC board is attached.

you can solder its leads to the pads underneath and trim off any excess. A 250mm-long Nylon cable tie is then used to hold the inductor in place. As shown, this tie passes down through one of the edge holes provided in the board and up through the other. Tighten the ties quite firmly to secure each inductor in place.

Finally, cut off the excess ends of the cable ties, leaving only about 4mm.

Once all three inductors have been fitted to the board, it is almost complete. All that remains is to plug IC1 into its socket, taking care to fit it with the correct orientation. The board assembly can then be placed aside while you prepare the box lid/front panel.

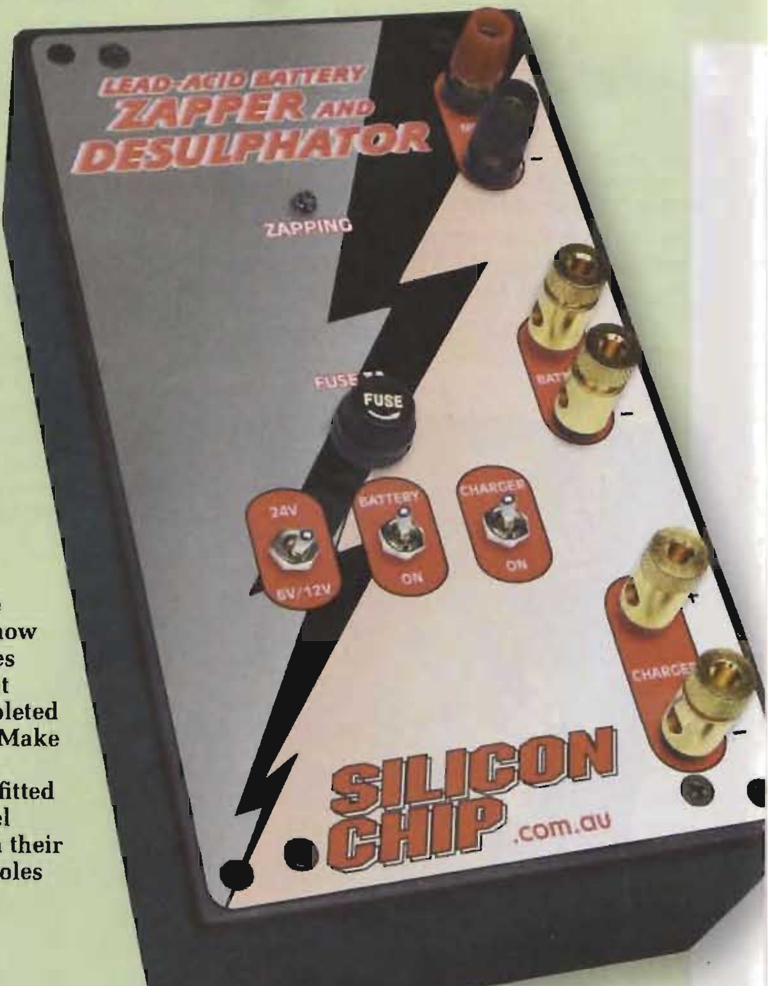
Drilling the front panel

Preparing the front panel requires 15 holes to be drilled and reamed. Their sizes and positions are shown in Fig.5, which is also shown actual size so you can use a photocopy as a drilling template if you wish.

After all of the holes have been drilled and de-burred, you may want to fit the lid/panel with a stick-on escutcheon to give it a more professional finish. To make this step easier, we have produced an artwork for the front panel – see Fig.7.

The easiest way to make a front panel is to photocopy the artwork onto an adhesive-backed A4 label sheet, over which is then applied a sheet of protective clear self-adhesive film (like "Contact" or "Duraseal"). Then the artwork can be cut to size and its backing sheet peeled off, allowing it to be placed carefully on the top of the box lid.

Another option is to download the



The views above left & top show how the assembly goes together, while at right is the completed Battery Zapper. Make sure that all the extension wires fitted to the front-panel items go through their corresponding holes in the PC board.

artwork from the SILICON CHIP website and print it out.

Once the label is in place you can then cut out the various holes in the escutcheon using a sharp hobby knife, guided by the holes already drilled in the lid.

Fuseholder & switches

The next stage is fitting the fuseholder, toggle switches and binding posts to the front panel. Don't use excessive force to tighten the nut on the fuseholder, as you might strip the plastic thread. The three toggle switches are identical, so they can go in any of the three positions. After these fit the red and black plastic binding posts, which are used for the "Meter" terminals.

The other two pairs of binding posts are gold-plated speaker terminals and they probably seem too good for this application. However, they have the advantage that they are readily available and will take heavier cables. They also have a top section which can be unscrewed completely to allow connections via crocodile clips. The binding posts with the red mounting bushes are used for the two positive terminals.

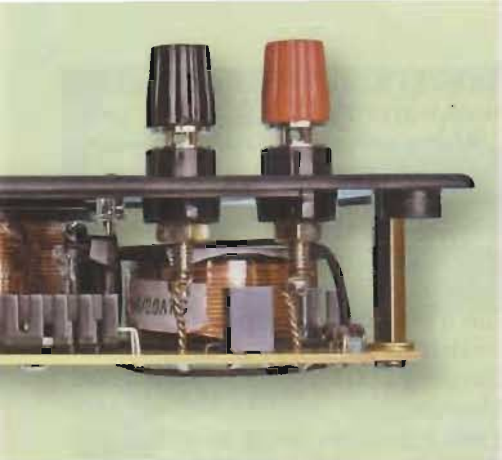
Extension wires

Once all of these items have been fitted to the front panel, it can be turned over and their connection lugs or spigots fitted with "extension" wires made from short lengths of tinned copper wire. This is necessary to extend the leads down through the matching holes in the PC board when the latter is mounted up behind the panel.

The extension wires for S1, S2 and S3 need only be about 25mm long but with one end bent into a tiny hook so that it can be attached firmly to the switch lug before soldering. The wires used for the fuseholder extensions should be about 15mm and 30mm long respectively, with the longer wire used for the holder's side connection.

As before, these wires should both be attached to the fuseholder lugs by forming them into a small hook before soldering.

The extension wires used for the binding posts should be cut from



longer lengths of 1mm diameter tinned copper wire – about 60mm long. The centre of each wire is then wound tightly once around the notch near the lower end of each binding post's spigot, before soldering. The two ends are then bent down along the axis of the post and finally twisted together to form a stout extension wire to pass down through the board.

All of these extension wire details are shown clearly in the diagram of Fig.6.

When all of these extension wires have been fitted the next step is to attach the PC board to the panel. This is done by first mounting an M3 x 25mm tapped spacer to the rear of the panel near each corner, with M3 x 6mm countersink head screws passing down through matching holes 'A' in Fig.5. Tighten these screws firmly to ensure that they don't work loose later.

Now offer up the PC board assembly underneath the panel, making sure both that the various extension wires pass through their matching holes in the board and that LED1 also passes up through its matching hole in the panel. Then once the board has moved up to almost touch the spacers (it won't quite reach them because of the cable ties around the inductors), up-end everything to allow you to fit two M3 flat washers between the board and each spacer. Secure the assembly using M3 x 6mm machine screws (pan head).

Finally, solder the ends of all of the extension wires to the copper pads on the board and clip off any excess wire.

It might all sound complicated but it's easier to do than to describe in words. Fig.6 shows the details.

Your new Battery Zapper should now be fully wired up and you should be able to lower the complete front panel/PC board assembly down onto the box. The assembly can then be fastened to the box using the self-tapping screws provided. Don't forget to fit the small plastic bungs over each screw recess, to finish the job.

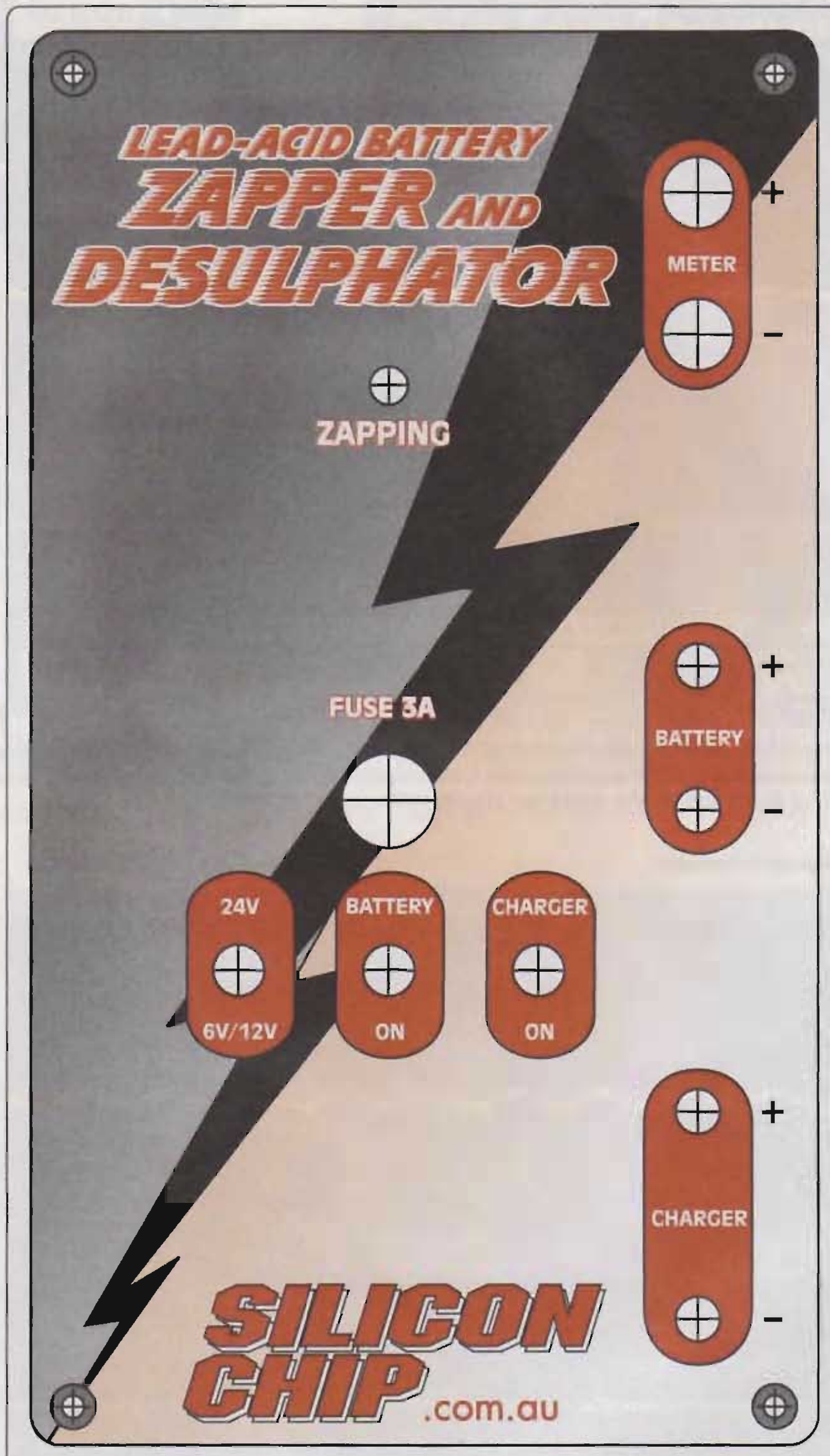


Fig.7: this full-size front-panel artwork can be photocopied and used direct or you can download a PDF of the artwork from the SILICON CHIP website and print it out on a colour printer – see text.

Putting it to use

It's very easy to connect the Battery Zapper Mk.3 to a battery, charger and optional DMM – just follow the connection diagram of Fig.1. Before you start, make sure that the Battery Voltage switch (S1) is set in the correct position for the battery you're going to be zapping. Switches S2 and S3 should both be in their upper "Off" positions.

The other main thing to watch is that

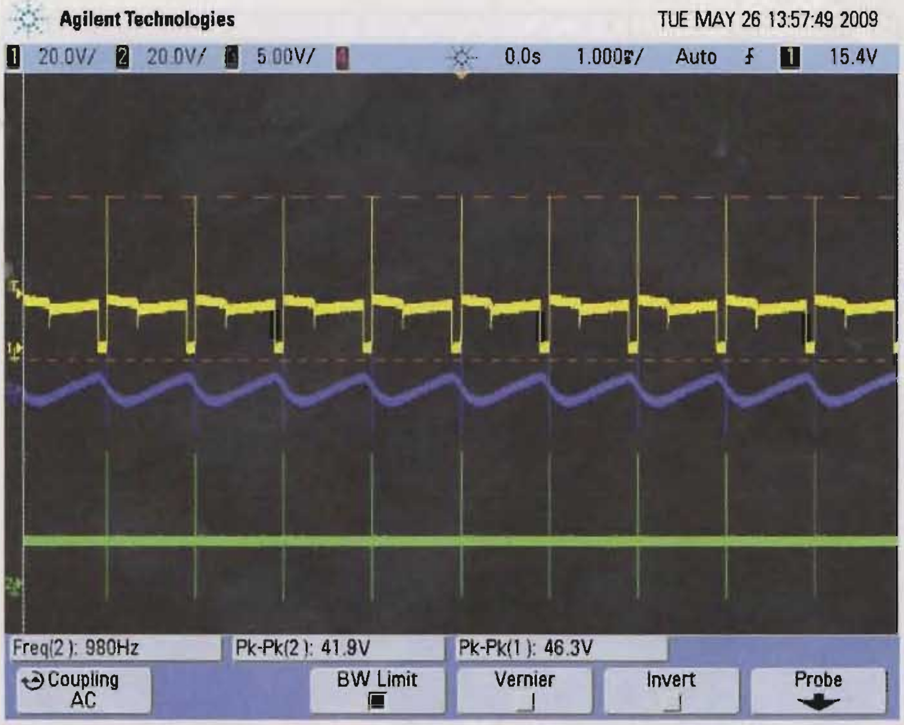


Fig.8: this scope shot shows the unit working with a 12V battery. The yellow trace is the voltage waveform seen at the drain of MOSFET Q2, while the green trace shows the resulting spike waveform impressed across the battery itself. The blue trace shows the resulting ripple voltage across the 470μF capacitor.

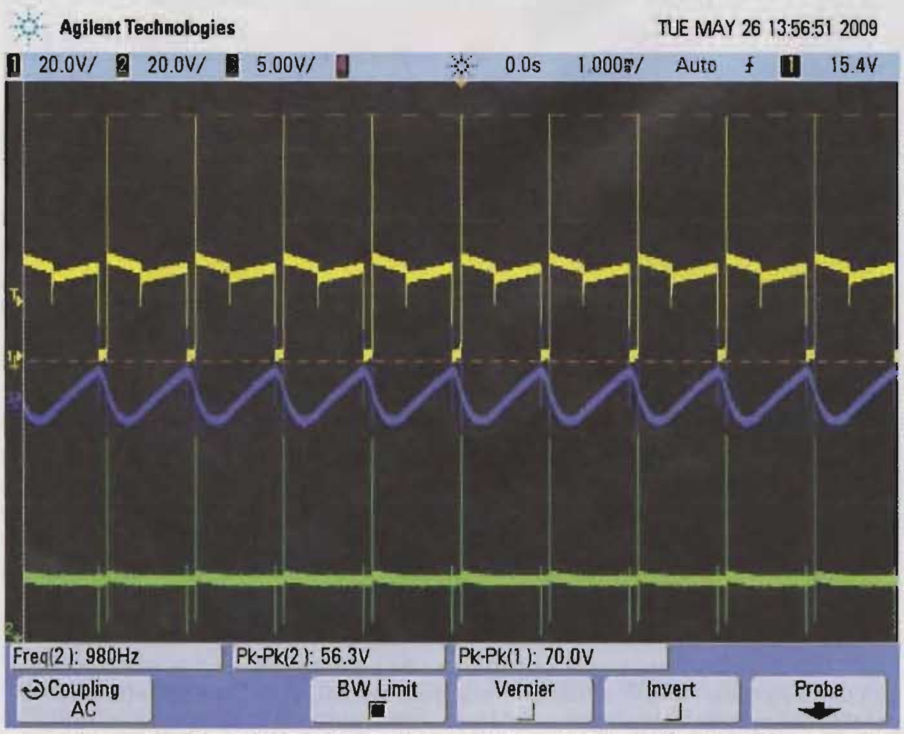


Fig.9: this scope shot shows the Battery Zapper working with a 24V battery. The yellow trace at top is the voltage waveform seen at the drain of MOSFET Q2 and is shown at 70V peak-peak. The spike waveform impressed across the battery (green trace) is 56V peak-to-peak, indicating a battery in need of zapping.

the unit's battery and charger terminals are connected to the battery and the charger respectively with the correct polarity, ie, positive-to-positive and negative-to-negative. **If you connect the battery with incorrect polarity, you will blow the 3A fuse and the chances are that you will blow the MOSFET (Q2) as well. There, you have been warned!**

If you are using a DMM to monitor the zapping pulses, it is connected to the Battery Zapper's meter jacks as shown. The DMM should be set for a DC voltage range of 0-100V or more.

To begin zapping a battery which has a reasonable charge, all you do is switch S2 to its lower ON position. Zapping LED1 should begin to glow, showing that the high-voltage zapping pulses are being generated and applied to the battery. If you have a DMM connected, it should be giving a reading of more than the battery's nominal voltage – up to about 70V DC, depending on the amount of sulphating in the battery.

If you are in a quiet location, you may also hear a faint 1kHz whistle from the inductors – further evidence that the circuit is working.

If Zapping LED1 doesn't light and the DMM simply reads the battery's nominal voltage (or less), this means that the battery doesn't have enough charge at present even to operate the Zapper. In that case, apply power to the charger and turn on the Zapper's charger switch S3, to allow the charger to provide enough current to support the zapping process. Zapping should then begin, unless the battery is beyond redemption.

As the zapping progresses, LED1 will tend to glow less brightly, as the lead sulphate crystals in the battery are gradually dissolved and the amplitude of the zapping pulses slowly drops. But be aware that this may take a considerable time. At the same time the reading on the DMM should slowly drop as well, eventually returning to the battery's normal "under charge" terminal voltage.

By the way if you do need to use a battery charger to allow the zapping process to proceed, the 15Ω resistor inside the Battery Zapper will limit the charging current to less than 1A, mainly to prevent the battery from being damaged by over-charging if zapping needs to continue over several days. This means that after the zapping process has been completed, the battery may still need further charging.

Note that, depending on the charge in the battery, the Battery Zapper circuit will draw up to 300mA. This means that you must connect a battery charger, otherwise the battery will end up fully discharged. **SC**

Ideal for finding steel frames and studs, steel bracing and nails in plaster walls, this Metal Locator can also show the length of the tang in knife handles, screwdrivers and other tools. As well, it can discriminate between ferrous and non-ferrous metals.

By JOHN CLARKE

Metal Locator

If you want to hang pictures, shelving or mirrors on a plaster wall in a steel-framed building it is useful to find where the metal studs are.

You may wish to secure your screws to the stud or alternatively, you may wish to avoid the stud and attach directly to the plaster wall using suitable fasteners. There are also other hidden items within the wall that should be located before drilling, such as metal bracing straps, screws and nails.

With the Metal Locator you can find the metal stud positions as well as any steel bracing, screw heads and nails. That is, provided the metal is no deeper than 25mm inside the wall. For small nails in wooden studs, the Metal Locator can detect them provided that the heads are within 10mm of the wall surface. Naturally, this device does not locate the timber studs themselves, nor can it find steel frames in walls that have a cladding thicker than 25mm (a very unusual wall, especially inside!). Nor can it detect power cables inside walls.

The Metal Locator can also distinguish between ferrous and non-ferrous metals. Ferrous metals include mild steel, stainless steel (both magnetic and non-magnetic), wrought iron, high tensile steel, galvanised iron, tin plated

Specifications

Detection range:...up to 25mm from the underside of the case
Current drain:...... <20mA with LED fully lit

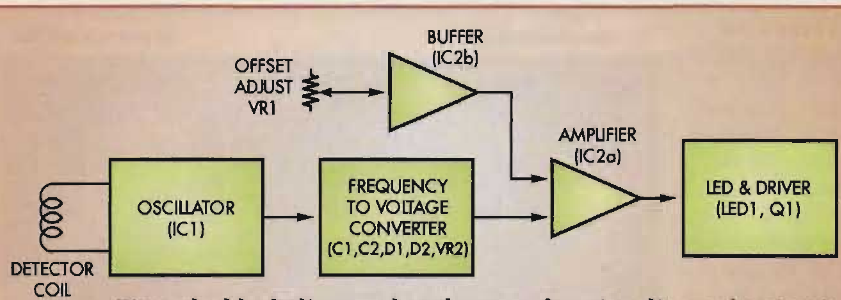


Fig.1: the block diagram has the same functionality as the circuit below.

steel (steel cans or tinplate), passivated steels and cast iron. Non-ferrous metals include copper, brass, zinc, aluminium, gold, silver, lead and tin.

In the presence of ferrous metals, the LED on the Metal Locator dims. Conversely, the LED brightens in the presence of non-ferrous metal. For ferrous metals, the sensitivity knob is adjusted so that the LED is reasonably bright in the absence of the metal. The LED then dims in the presence of ferrous metal. To detect non-ferrous metals, the sensitivity is adjusted so that the LED is dim in the absence of the metal. The LED will then brighten in the presence of the non-ferrous metal. Greater sensitivity can be had with the LED just glowing in the absence of metal for detection of either metal type.

The Metal Locator is housed in a compact plastic case that includes a 9V battery compartment. On the lid are the on/off switch, sensitivity control and the indicating LED.

How it works

Fig.1 shows the block diagram of the Metal Locator. It is based on an astable oscillator controlled by the detector coil, L1. The oscillation frequency changes with the presence of metal. For ferrous metals, the frequency decreases while for non-ferrous metals the frequency increases.

The oscillator's output is fed to a frequency to voltage converter. Small frequency changes are then detected as voltage changes that can easily be amplified before driving the LED. The LED brightness varies with a change in frequency from the oscillator. An offset adjustment using VR1 allows the LED brightness to be set at a very low level to brighten with non-ferrous metals. The LED can be set at a higher level to detect ferrous metals where the LED begins to dim.

The buffer stage (IC2b) between the offset control and the amplifier is there to ensure there is no gain change with adjustment of VR1.

Circuit details

The circuit in Fig.2 is based on just two ICs. One is a CMOS version of the 555 timer (IC1) and the other is a general-purpose LM358 dual op amp (IC2a and IC2b).

IC1 operates as an unconventional astable oscillator. To explain how it works, we will compare it to a conventional 555 astable oscillator, as shown in Fig.3. This has resistor R1 between its output at pin 3 and both the trigger and threshold inputs at pins 2 and 6. Capacitor Cx is connected between pins 2 & 6 and ground.

Initially, when power is first applied, the capacitor is discharged and the trig-

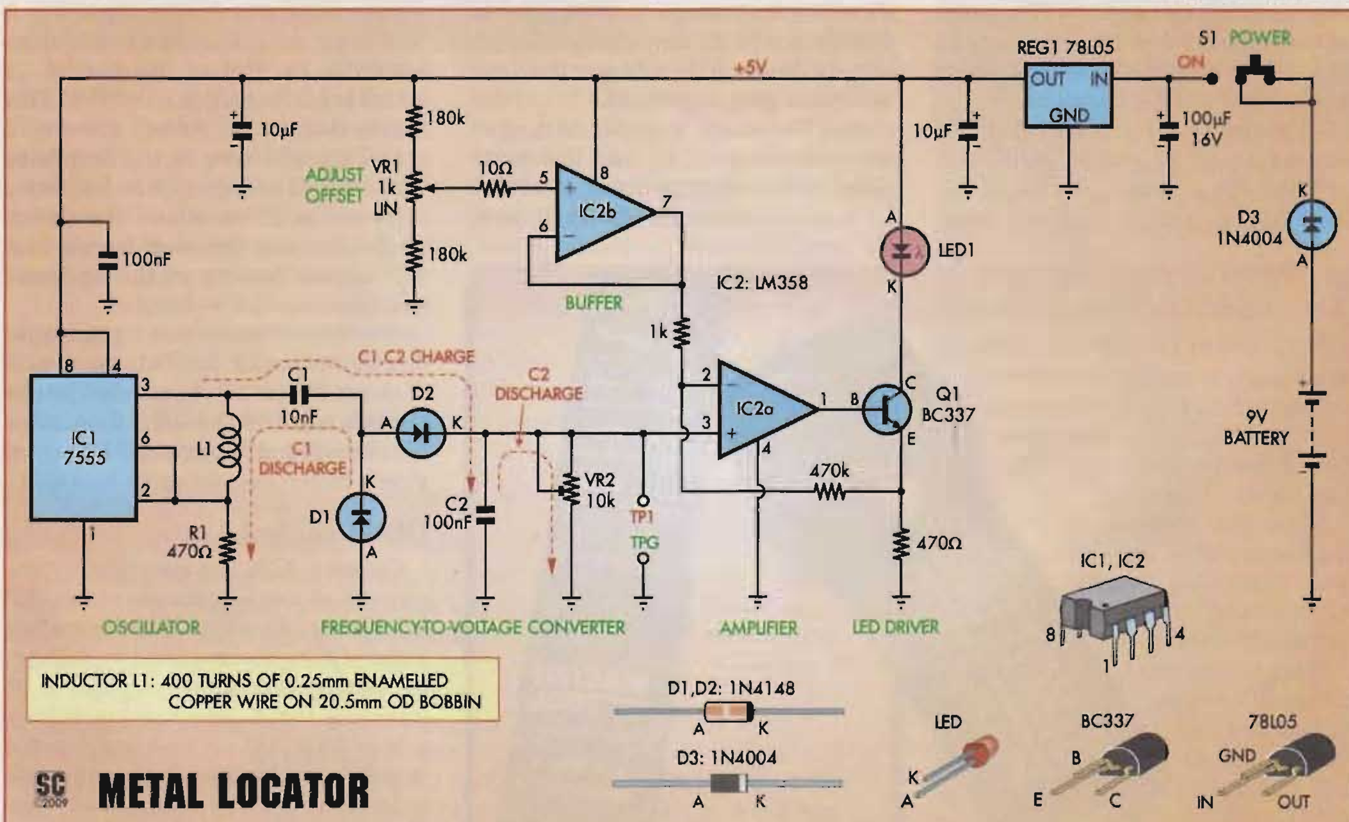


Fig.2: the Metal Locator circuit is based on two low-cost ICs and a handful of other cheap components.

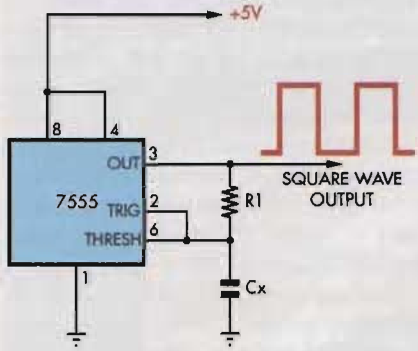
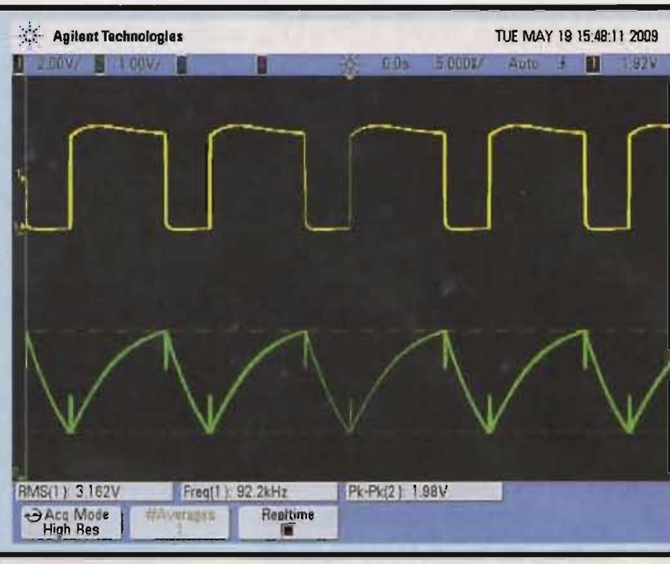


Fig.3: here's a "traditional" 555 oscillator circuit with the frequency determined by R_1 and C_X. But as you can see in Fig.2, it's possible to substitute an inductor and resistor to make it oscillate.

And here's the proof! The top trace is the waveform at pin 3 while the green trace shows the waveform at pin 6. The waveform at pin 6 is the voltage across R1 and this shows that the current through R1 does not reverse; it merely varies between about 3.5mA and 7mA. Note the spikes generated each time the 555 changes state.



ger input at pin 2 is at 0V. At this stage the timer is triggered and the output at pin 3 goes high to equal the positive supply rail voltage.

The capacitor now charges via R1. When the capacitor charges to the pin 6 threshold voltage (2/3 supply), the pin 3 output goes low (to 0V) and the capacitor now discharges via R1. When the capacitor voltage discharges to the trigger level voltage at pin 2 at 1/3 the supply, the pin 3 output goes high again to recharge the Cx capacitor. The process continues and so pin 3 produces a square wave output with the frequency determined by R1 and Cx.

In the circuit of Fig.2, we substitute inductor L1 for R1 and R1 (470Ω) for capacitor Cx. It now operates as follows. At the instant of power being applied, inductor L1 is effectively a high impedance and resistor R1 pulls the pin 2 input below the 1/3 supply threshold to trigger the pin 3 output to go high.

Current then begins to flow through L1 and R1. As the current rises, the voltage across R1 increases until it reaches the 2/3 supply voltage threshold. This changes the state of the oscillator so that pin 3 goes low. The current through L1 does not change direction but ramps down until the voltage across R1 drops below the 1/3 supply threshold to retrigger the timer and pin 3 goes high again.

The frequency is dependent upon the inductance of L1 and the resistance of R1 (which is fixed at 470Ω). L1 is an air-cored coil of wire. If metal comes close to this coil its inductance will change and this will alter the frequency of oscillation. For ferrous metals the inductance will increase and the frequency of oscillation will fall. For non-ferrous metal, the inductance will decrease and the oscillation frequency will increase. The frequency is around 94kHz and changes by up to 2kHz with metal near the coil.

The output from IC1 is fed to a diode pump comprising capacitors C1 & C2, resistor VR2 and diodes D1 & D2. It functions as a frequency-to-voltage converter by dint of the size of C1 which is fairly small at only 10nF. This means that the DC voltage developed across C2 will vary as the frequency varies; it will be higher as the frequency increases and this allows the circuit to discriminate between ferrous and non-ferrous metals as the apparent inductance of L1 is changed.

The DC voltage across C2 is amplified by op amp IC2a. This has a gain of about 470 (471 to be precise), set by the 1kΩ and 470kΩ feedback resistors. IC2a is buffered by transistor Q1 to provide a higher current drive for LED1.

Offset control

Op amp IC2a has an offset adjustment to enable adjustment of the LED brightness. In effect, the operating point of IC2a can be shifted up or down by varying the voltage applied to its inverting input. The varying voltage comes from IC2b, a unity-gain buffer which is fed by the wiper of the 1kΩ potentiometer VR1. Combined with the 180kΩ divider resistors, the range amounts to about 14mV.

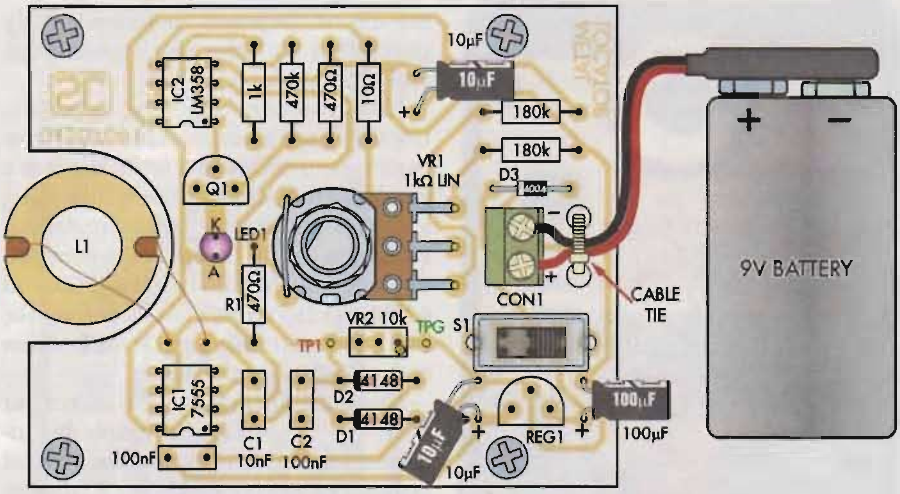
The buffer stage of IC2b ensures the

Why not use a Stud Finder?

Most readers know that stud finders are cheaply available from hardware outlets such as Bunnings and even from bargain stores. They often have three functions: stud, nail and power.

While they are cheap and readily available, they can give misleading results when looking for screws or metal studs in walls.

Nor can they discriminate between ferrous and non-ferrous metals and their sensitivity cannot be adjusted.



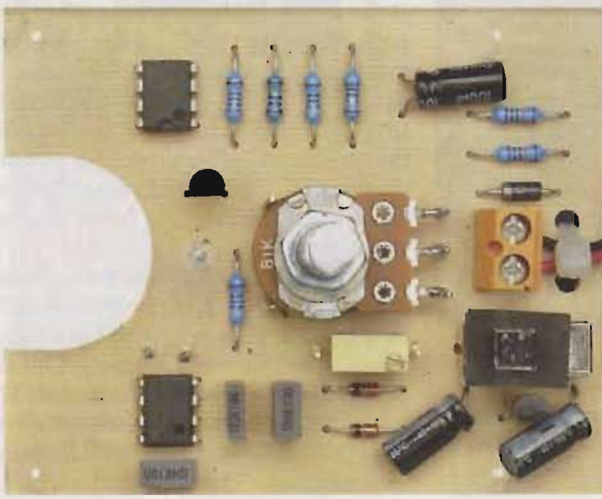


Fig.4 (top) shows the component layout for the Metal Locator, with the same-size photo prior to mounting in the case at left. Note the electrolytic capacitors need to be mounted folded over so they are flat on the PC board.

gain of IC2a is kept at 471 and is not affected by the resistance at the wiper of VR1. Any voltage change in VR1 is amplified in IC2a by 471, so the 14mV variation allows the IC2a output to be shifted over its full output range, from very close to 0V up to about 3.5V.

This adjustment allows the LED to be set at the required brightness for metal detection. In effect, VR1 operates as a sensitivity control for the circuit.

Trimpot VR2 provides a further range of adjustment. For optimum operation of VR1, VR2 is adjusted so the voltage at TP1 is at about half supply or +2.5V. This matches the nominal 2.5V available from the wiper of VR1 at its centre position.

The circuit is powered from 5V, derived from a 9V battery and a 5V regulator (REG1). Diode D3 prevents damage to the 100µF capacitor and the 5V regulator if the battery is connected the wrong way around. The 5V supply is decoupled with a 10µF capacitor at REG1's output and another 10µF ca-

How safe is that kitchen knife?

The handles on some kitchen knives are unsafe because they have a very short tang. The Metal Locator can show just how long the metal tang goes into the handle of a kitchen knife or screwdriver. Many professional knives have the tang extending the whole length of the handles and this tang can be seen running in between the two handle sections that are riveted to the outside of the tang.

But some low cost knives only have a tang that enters part way into a plastic moulded handle. They can even have imitation rivets along the handle length to give the impression that the tang runs along the whole handle length. A short tang means that a large amount of stress is applied to the handle when using the knife and it is liable to break. This can be dangerous, especially when doing heavy work such as cutting up pumpkins. Make sure you use a knife that is safe for the job.

Parts List – Metal Locator

- 1 PC board, code 04207091, 78 x 64mm
- 1 remote control case 135 x 70 x 24mm (Jaycar HB 5610 or equivalent)
- 1 front panel label 50 x 115mm
- 1 9V battery
- 1 9V battery snap
- 1 DPDT PC mount slider switch (Jaycar SS-0823 or equivalent; S1)
- 1 coil bobbin 20.5mm OD x 13mm ID x 10.5mm high
- 1 13m length of 0.25mm enamelled copper wire
- 1 knob to suit potentiometer
- 1 2-way screw terminals with 5.08mm pin spacing
- 4 TO-220 insulating bushes (used as spacers)
- 4 M3 x 4mm screws
- 1 20mm diameter x 12mm heatshrink tubing
- 1 100mm cable tie
- 9 PC stakes

Semiconductors
- 1 7555, LMC555CN CMOS timer (IC1)
- 1 LM358 dual op amp (IC2)
- 1 78L05 three terminal 5V low-power regulator (REG1)
- 1 BC337 NPN transistor (Q1)
- 1 1N4004 1A diode (D1)
- 2 1N4148 signal diodes (D2,D3)
- 1 3mm high brightness red LED (LED1)

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

Resistors (1% 0.25W)
- 1 470kΩ 2 180kΩ 1 1kΩ
- 2 470Ω 1 10Ω
- 1 1kΩ linear 16mm potentiometer (VR1)
- 1 10kΩ 25-turn top-adjust trimpot (3296W type) (Code 103) (VR2)

Here's the completed PC board screwed into the pastic "remote control" case. The coil is not attached to the PC board – it is glued in place to the case in the cutout provided in the PC board.

pacitor at the supply rails for IC2. IC1 has a 100nF supply bypass capacitor.

Construction

Construction involves mounting all parts, except coil L1, on a single PC board. This is coded 04207091 and measures 78 x 64mm and is housed in a remote control case measuring 135 x 70 x 24mm.

Fig.4 shows the overlay diagram. Begin by checking the PC board for shorted tracks or breaks in the copper. Check the hole sizes as well. The corner mounting holes should be 3.5mm (9/64") in diameter, as can the two holes to anchor the battery snap leads with the cable tie. Power switch S1 also mounts on the board - before assembly check that its holes are large enough and if not, enlarge slightly.

Now you can begin the assembly. Install the seven resistors first. We show their colour codes in a table but it is a good idea to also check the values using a digital multimeter before installing each onto the PC board. Make sure you don't mix up the side-by-side 470Ω and 470kΩ. Doing so may not let any smoke out but it certainly won't work when completed, either!

Next, install the five PC stakes for VR1, the two stakes to terminate inductor L1 and the two stakes for test points TP1 and TP GND. Install diodes D1 to D3 and take care to orient these correctly. IC1 and IC2 can be installed, making sure that the 7555 timer is placed in the IC1 position and LM358 in IC2. Each IC must be oriented with the notch as shown on the overlay diagram. You might find some ICs don't have a notch but will have a small dimple marking pin 1.

Q1 and REG1 can then be installed but make sure each is placed correctly, as they look very similar to each other.

LED1 can be installed, again taking care to get the orientation correct. The top of the LED should be 15mm above the PC board. Next, the capacitors can be installed. The three electrolytic types need to be oriented with the polarity shown but they also need to lie down to provide clearance in the box. A capacitor code table is provided to help identify the 100nF and 10nF capacitors.

Trimpot VR2 can be installed either way around. Switch S1 is mounted as high as possible on the PC board but with about 1mm of pin length under the PC board to allow soldering. CON1 can now be installed.

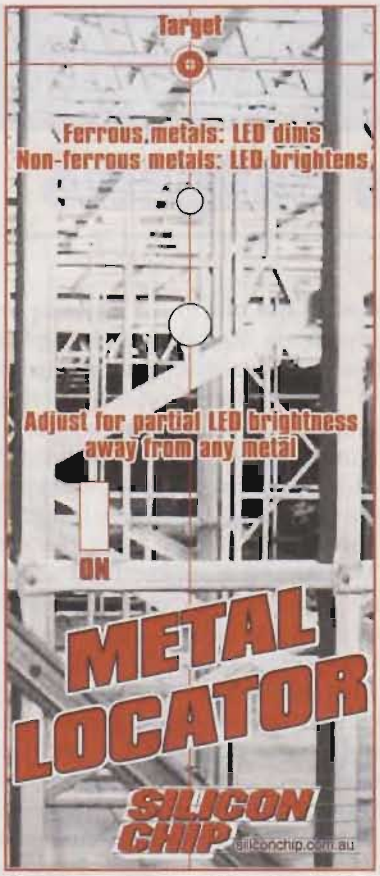
Cut the shaft of the 1kΩ potentiometer (VR1) to a length of 12mm. VR1 sits vertically with its back on the PC board surface and is secured in place by soldering the potentiometer case to the associated PC stakes. So that solder will adhere to the surface the passivated coating on the pot case must be removed by scraping with a knife or file where the PC stakes are positioned. The potentiometer terminals are soldered to the remaining three PC stakes.

The 9V battery leads pass through one of the battery compartment holes in the plastic case before inserting them into the screw terminals. A cable tie secures the wires in position.

The PC board is raised by about 1mm

RESISTOR COLOUR CODES

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
☐	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
☐	2	180kΩ	brown grey yellow brown	brown grey black orange brown
☐	1	1kΩ	brown black red brown	brown black black brown brown
☐	2	470Ω	yellow violet brown brown	yellow violet black black brown
☐	1	10Ω	brown black black brown	brown black black gold brown



Same-size front panel artwork. This glues into the recess on the top of the remoted control case.

by placing a TO-220 bush into each mounting hole from the underside of the PC board. This raises the PC board sufficiently so the switch slider is above the top of the case lid.

Secure the PC board to the case with four M3 screws that screw into the integral support bushes of the case.

Winding the inductor

Inductor L1 is wound with 400 turns of 0.25mm enamelled copper wire on a plastic bobbin. The windings are jumble wound. This means windings do not have to be placed neatly side-by-side, layer-by-layer.

The winding is held in place with a 12mm length of 20mm heatshrink tubing over the outside of the bobbin. There is no need to shrink the tubing down.

CAPACITOR CODES

Value	µF	IEC Code	EIA Code
100nF	0.1µF	100n	104
10nF	.001µF	10n	103

The bobbin is secured to the base of the case in the cut-out area reserved for it at the front of the PC board. We used silicone sealant to glue the bobbin in place.

Scrape off the enamel coating on each wire end with some fine grade abrasive paper and then solder them to the two PC stake terminals – it doesn't matter which way around.

A close-up of the coil (L1). It's about 400 turns of wire on a plastic bobbin.

Test & set-up

Apply power and check that there is 5V between TP GND and pin 4 & 8 of IC1 and 5V between TP GND and pin 8 of IC2. Depending on the regulator, the voltage could be anywhere between 4.85 and 5.15V.

Connect your multimeter between TP GND and TP1 and adjust trimpot VR2 for a reading of about 2.5V. Now set VR1 to its centre position and adjust VR2 until the LED just lights.

Using it

When the Metal Locator is first switched on and the LED is adjusted so that it glows dimly, there is a start up drift over about 10 seconds. During this period the adjustment will have to be altered to track the change in LED brightness. It is best to wait for the warm up period before using the Metal Locator.

As mentioned the sensitive area is directly under the target printed on the top side of the case (which of course lines up with the middle of coil L1). So for detecting metal in a plaster wall, the case is slid over the wall to detect a change in the LED brightness.

The adjust knob will need to be set to show some LED brightness in the absence of metal objects. The sensitivity to metal is dependent on this adjustment.

If the LED brightness is set too high then there will not be a noticeable change in brightness with the unit in proximity to a metallic object.

The LED will dim for ferrous and brighten for non-ferrous metals. SC

SERVICEMAN'S LOG

Car Electronics: A Whole New Ballgame

As a change this month, a colleague of mine is going to talk about the confusion electronic systems in cars can cause. After all, when it comes to cars, everyone's an expert (or has a mate who thinks he is). I'll let him tell the story in his own words.

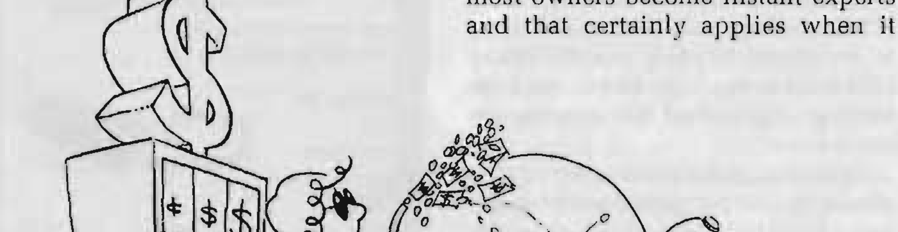
This month, the regular Serviceman has deputised me to fill in for him. He is taking a well-earned break, away from the soldering flux fumes, the blinding oscilloscope screens and his multimeter readouts.

Having had a good grounding in domestic electronics and 2-way communications, I have now owned and managed an automotive repair workshop for over 30 years. We specialise in electronics in cars in general and EFI in particular and my earlier training gives me a head-start over other mechanics when it comes to diagnosing problems in these areas. As a result, I tend to get all the "too hard" jobs that other workshops have attempted but have been unable to resolve, often after many hours of work.

One of the most annoying things about clients in the auto repair game is trying to diagnose faults based on the information given by the said client. If you go to your local GP for any health issue, you don't tell him which procedure you would like performed on your body. You certainly wouldn't consider telling the doctor that you wanted your appendix removed, just because you had pain in that area, or having your knee cartilage scraped because your mate told you it needed to be done.

However, when it comes to cars, most owners become instant experts and that certainly applies when it comes to the electronic systems and components. Many clients bring their car in and ask us to clean the injectors or to "tune" the engine, without telling us what the actual problem is. Another common request is to have the ABS (anti-lock braking system) diagnosed and overhauled. I have also lost count of those who simply want the car's ECU diagnostic codes read and/or printed out, without mentioning why they need this information.

Life for the automotive technician (a 21st century car mechanic) would be much easier if customers would simply come in and tell us, in plain English, what the real problem is, instead of muttering about ECU codes and other mumbo-jumbo that they don't really understand. Why not just say "the car is running roughly", or "it's using too much fuel" or "the engine stalls in traffic", or "the car shakes when the brakes are applied". The technician could then check that section of the car concerned, diagnose the problem and quote on a repair based on his skill and experience, rather than on the "gut feel" of the owner or the "expertise" of his mate.



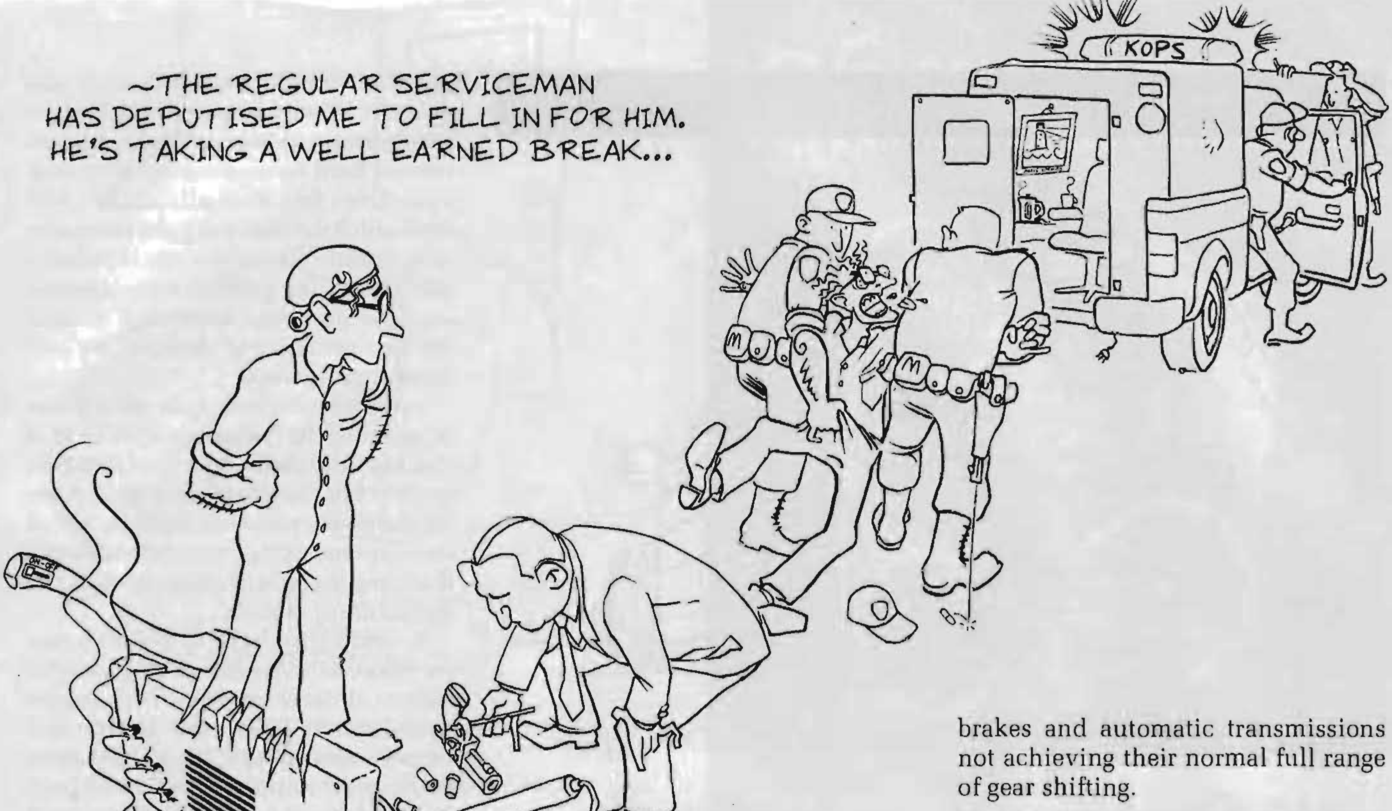
~IT'S INVARIABLY THE DOLLAR CONSUMPTION THAT INCREASES

Blaming the injectors

Perhaps because their operation is relatively easy to understand, the poor old EFI fuel injectors cop the blame for all sorts of problems – everything from excessive fuel consumption, to engine misfiring when hot, to intermittent no-start situations. The simple facts are, they cannot affect any of these.

The "excess fuel usage" problem is a myth originating from the days of diesel injectors wearing out, in the process causing the emission of black exhaust smoke and heavy fuel consumption. By contrast, EFI injectors do not "wear"; instead they actually clog up with deposits. This in turn restricts the fuel flow which means that they actually go "lean", not "rich".

Partially clogged injectors only really cause issues when cold, a lean misfire being the most common. These



problems all but disappear once the engine is up to operating temperature.

Excess fuel usage has so many causes that one could write a book about it. However, if it is suspected, the first thing that needs to be established is what that actual consumption figure is. An interesting anomaly is that such complaints increase markedly as the price of petrol increases. In fact, it is invariably just the dollar consumption that increases, not the litres consumption.

That aside, if increased fuel usage is a problem, the first step is to establish how many litres the vehicle is consuming for every 100km kilometres travelled (l/100km). To cut a long story short, any electronic causes of excess fuel usage that don't also cause other driveability issues are usually limited to the failure of the oxygen sensor (or sensors in some cars).

ECU failure, wiring issues and failures in other sensors are relatively rare on properly serviced cars that have done less than 250,000-300,000km. However, oxygen sensors are similar to spark plugs in that they have a finite life. Most have outlived their serviceable life by 150,000km.

Even so, the most common causes of heavy fuel consumption are more mundane and include things such as spark plugs, leads, coils, fuel pressure regulators and driver behaviour. Other causes include mechanical issues such as low tyre pressures, dragging brakes and automatic transmissions not achieving their normal full range of gear shifting.

Fixing a Camry

We had a 1998 Toyota Camry 4-cylinder come in recently, its owner complaining that he had already spent his last two weeks pay having the injectors removed and cleaned, the ECU bench tested and numerous parts replaced, including various filters, the air-flow meter, the coolant temperature sensor, the fuel pump and the spark plugs.

This work had all been done by a local mechanic at his insistence, in an effort to reduce the mysterious disappearance of extra litres of the precious petroleum liquid. Fortunately, he revealed all this to us before work commenced and he was actually asking us for advice rather than relying on his own skills.

Checking the basics quickly revealed a non-responsive oxygen sensor and tyres that were running very low inflation pressures. Low tyre pressures cause problems in two ways: (1) by increasing the rolling resistance (drag); and (2) by lowering of the overall gear

AN ENGINE IS OFTEN NOT "EARTHED" VERY WELL...

ratio (not to be underestimated). Some complimentary fresh air, a new oxygen sensor and an invoice for $297 put a happy customer back on the road in quick time.

Look for the obvious

A similar scenario was played a few months ago on a 10-year old VT Commodore Executive. A colleague from the northern suburbs who wasn't "full-bottle" on ABS electronics recommended the owner to us. The symptoms were violent vibrations through the steering wheel under heavy braking. In our colleague's defence, he hadn't driven the car and was only asked to diagnose the problem after the owner had already spent his hard-earned dollars elsewhere, to no avail. He didn't have the time (or perhaps the inclination) to attempt the job, so he passed it on to us.

The original repairer had replaced the entire ABS actuator and module assembly, along with all four wheel-sensors (at a 4-figure sum). They had then pressure-bled the entire system after a cursory examination of the brakes themselves. However, there was no indication (using diagnostic scanners or otherwise) that there were any ABS issues at all. The repairer should have had a closer look at the badly cracked, undersize and discoloured front disc rotors before assuming the worst.

A new pair of front rotors and better quality pads solved his hideous brake issues and saw the owner on his way.

Common sensor problems

Simply measuring in-circuit voltages or looking at sensor output waveforms are the easiest and best forms of diagnosis for many electronic problems in cars. However, many technicians depend heavily on reading built-in diagnostic fault codes and measuring individual sensors out of circuit, without checking the basics first.

One of the most common sensor "failures" is that of an open circuit in the coolant temperature circuit. It is always assumed that the poor old sensor is the culprit and so it is often just replaced as a matter of course, without measuring any voltages.

Some of the more "clever" technicians first unplug the "offending" sensor and measure its internal resistance. The technician is then mystified. If the sensor is OK, why does the ECU throw up a code for a faulty sensor? Well, the ECU hasn't actually condemned the coolant sensor; all the dumb processor knows is that the voltage in that loop is abnormally high and therefore the circuit appears to be open.

The most common single fault in these instances is simply a corroded or loose connector plug at the sensor. The various plugs and connectors in the engine bay live in a very hostile environment, with oil, water, excess heat and vibration present year in and year out. When compared to those that live in static, domestic surroundings, it's not hard to understand why they sometimes fail. Virtually all EFI systems since the year dot have an engine temperature sensor of some type (usually measuring coolant temperature), so these problems have been around for two generations and yet are still wrongly diagnosed.

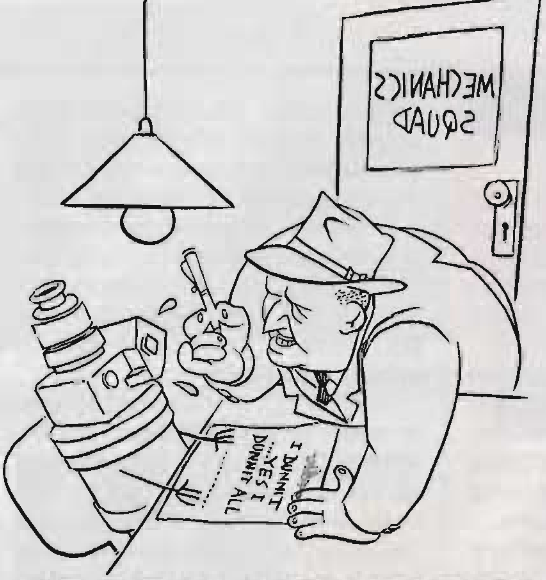
Another common cause of electronic maladies in the automotive field is that of faulty earth circuits. An engine is often not "earthed" very well. After all, the power plant is usually mounted on neoprene rubber mounts with some fairly ordinary earth links back to the body and/or chassis.

In years gone by, this wasn't a major issue, as there weren't many vital electrical items involved with engine operation. As long as the ignition system saw around 12V, the starter motor had a good supply of heavy current for starting and the alternator kept the battery charged, no dramas were generally seen.

These days, with EFI, ABS, traction control, electronically-controlled automatic transmissions, drive-by-wire throttle control and modules controlling just about everything in the car, those missing millivolts are of the utmost importance. Whether the cause is deterioration due to wear and tear or poor wiring design, bad earth circuits are more common than many technicians realise. Once again, they often chase their own backs by using diagnostic fault codes as the main line of defence, rather than checking a few basics first.

If I'm looking for a weird fault in an automotive electronic system, the items I always check first are: loose/corroded battery terminals, any wayward voltage between engine and body earth, the alternator charge rate and the operation of all warning lights on the instrument panel. With oxygen sensors oscillating either side of 500mV at a few hertz, a floating earth can negate its operation completely, yet not illuminate the "check engine light" or throw up any fault codes. The same applies to thermistor type sensors.

In cars with boot-mounted batteries, ECU-controlled alternator regulators and serial-BUS or CAN-BUS communication between the various control modules, these up-front basic checks are essential.



THE POOR OLD EFI INJECTORS COP THE BLAME FOR ALL SORTS OF PROBLEMS

A few of these BUS systems can have problems of their own. A commonly seen Bosch ABS system (version 5.3) fitted to many makes of car (everything from Toyotas, Holdens and Fords to Saabs, VWs and Audis) has an issue whereby open-circuit internal links not only cause ABS and traction control problems but also affect all other ECUs on that BUS line. We've had cars towed into the shop because this "small" ABS drama has locked the automatic transmission into third gear only (limp-home mode), switched the engine cooling fans to full speed and played havoc with all instrument warning lights and gauges.

In addition, it affects engine ECU operation and disables the air-conditioning system, making the car all but undriveable. This problem is now so common that these ABS modules are available as off-the-shelf re-manufactured exchange units. Fortunately, the cause was eliminated in later versions of this ABS system and so it doesn't occur in late-model cars.

ECU failure is rare

Engine or transmission ECU failure is a rare event for the most part but there are exceptions. There are a handful of popular cars where ECU problems are to be expected in the medium term, regardless of the kilometres travelled. For example, some Mitsubishis manufactured in the 90s have issues with electrolytic capacitors leaking over the PC board. The leakage permeates the protective lacquer and usually shorts out copper tracks on the board's surface. The 12V rail can short to anything close by and this can be to an earth track, causing severe charring of the board and all components in that area.

Alternatively, it can short to a 5V rail, often destroying any semiconductors or processors in the vicinity. Many of these items are custom-designed for the purpose and therefore unobtainable through normal channels, deeming the whole ECU an irreparable write-off. In other cars, the ECUs can suffer from good old dry joint issues or worse, corrosion from water entry due to a leaking windscreen or heater core. However, most EFI electronic

A Strange Problem

Actually, I did manage to sneak one story in this month, although I must confess that it's one that was held over from the previous issue. It's one of the strangest problems I have ever had to deal with and it involved a set belonging to a young lady with severe peripheral vision. In fact, her condition was so bad that she was classified as legally blind.

Her problem was that she was having a great deal of difficulty operating her JVC AV-21BS26 CRT TV. This is a silver TV with silver-coloured controls, which made them difficult for her to recognise. Apart from the flush-fitting power switch, these controls (Menu, Channel & Volume) are all hidden underneath an adjacent flap, which only added to her difficulties. In addition, the remote control is all grey, so it too was difficult for her to operate.

Adding to her woes, the reception in the Housing Commission village where she lived was quite poor. As I later discovered, this was due to the ancient Concordia coaxial cable used to distribute the antenna signal. This cable was also acting like an antenna and picking up signal, the end result being leading-edge ghost images.

Finally, every time she changed any of the control settings on the TV, the command was accompanied by two deafening beeps that could be heard by her neighbours. So that also had to be solved.

I decided to start with the extremely annoying loud beep. I couldn't find a reference to it in the set's instruction book, nor could I initially find it in any of the OSD menus. However, after some searching, I eventually found it in the install menu after scrolling down to reveal two extra items at the bottom. The first of these items is the blue screen mute option and the last one lets you turn off the beep.

There was no easy fix for the aerial system, except to use a Digital Set-Top Box (DSTB). Unfortunately, her JVC TV had a sloping back, so the DSTB couldn't sit on top, which was rather inconvenient.

Another problem was that in order to select the TV's AV input with the remote, you had to cycle through all the options until you got to AV1. Unfortunately, her set did not have last-state memory, so she would have to go through that exercise every time she switched the set on. However, that just wasn't practical, because it was difficult for her to see which input had been selected each time the mode button was pressed.

In the end, I swapped her JVC set for a rather nice Sony KVG-21S1 which I happened to have in the workshop. This Sony set has a flat top to rest the DSTB on and can also start and stop in the AV mode so she doesn't have to select it each time. In short, it was much more convenient for her to operate.

The DSTB fixed her reception problems too and I skipped all the channels she didn't want with the exception of Ch4 which is an orange digital program guide. This gave her a reference point she could actually see clearly and from which she could count sequentially to the program she wanted.

I contemplated covering the remote buttons other than on/off, channel up and down and volume up and down buttons so that she couldn't inadvertently press the wrong one. However, this wasn't practical and in any case wasn't necessary as the customer sits so close to the set that a remote control isn't necessary.

Instead, she came up with her own simple solution: orange dot stickers on the Volume and Channel buttons on the TV, so that the black buttons could be seen against the black cabinet.

problems are usually seen under the bonnet and not in the ECU itself.

Automotive design and their associated electronic systems have advanced so quickly in the last two decades that, in my humble opinion, it's time for a moratorium on further development to allow the service and parts industry to catch up. I know from personal experience that the same issues exist in the domestic electronics industry, where service technicians are forever playing catch-up obtaining the necessary equipment, literature and knowledge to service the latest gear. **SC**

PRODUCT SHOWCASE

Waterproof ABS case from Jaycar

You *could* buy a cheaper case for your compact camera, test gear, medical equipment, etc, at the local bargain store – but *would* you? It certainly won't offer your gear much in the way of protection, especially if it gets wet.

This new 260 x 94 x 159mm (external) case from Jaycar is made from tough ABS and is ideal for transporting sensitive equipment. It will protect valuable items from transit damage, dust and water ingress. The clam-shell style box has a soft "pluck" foam insert with precut squares that can be removed to snugly fit the item you want to protect. Its lid is also lined with egg shell foam, and is secured with strong 'snap closed' fasteners with a gasket seal that is waterproof and dustproof when closed. The case has a carry handle and two moulded anchor points that can be used for attaching tamper seals or padlocks. It will also float in case you're unfortunate enough to drop your gear in the drink.

It also comes in any colour you want, as long as it's black. Ideal for cameras, test and measurement equipment, medical equipment etc, the usable internal dimensions are 239 x 94 x 159mm (w x h x d).

You will be hard pressed to find a better case, even at twice the price – which, incidentally is $49.95 (rrp).

Contact:
Jaycar Electronics (all stores)
PO Box 107, Rydalmere NSW 2116
Order Tel: 1800 022 888 **Fax:** (02) 8832 3188
Website: www.jaycar.com.au

Cutter's IP modem replaces analog and ISDN modems

The SSV IGW/920-IPM from Cutter Electronics offers the ability to replace conventional modems with an IP-based intranet or Internet connection. The 10/100 Mbps LAN interface of the IGW/920-IPM is used for the connection to the IP network.

The serial RS232 interface of the IGW/920-IPM emulates an AT command interpreter. The IP address of the other IP modem in each case serves as the phone number for the connection setup. Alternatively, a DNS name or phonebook entry (quick dialing via match table) can be used.

The IGW/920-IPM is easy to set up using the integrated browser interface. For this an Ethernet LANbased connection to a PC with web browser will be established.

Contact:
Cutter Electronics Pty Ltd
Unit 12, 137-145 Rooks Rd, Vermont, Vic 3131
Tel: (03) 9873 5088 **Fax:** (03) 9873 5099
Website: www.cutter.com.au

Another PA labour-saver from Altronics

Here's one to bring a gleam to the eye of anyone who's had to install a lot of PA or fire warning ceiling speakers: Altronic Distributors new Redback One-Shot, a ceiling-mounted speaker complete with its own mounting kit and grille.

Instead of the usual four fixing screws, four cap covers and a lot of labour, this requires no fixings, fits in around four seconds and looks superb.

Simply cut the hole in the 10-13mm thick ceiling (Altronics have the right size holesaw!), connect the speaker wires to the integral terminal block then push in the spring-loaded catches. The job is done!

The model shown is a C-2146C 100V 5W PA speaker which retails for $31.10 inc GST; 8Ω 15W and Fire Evac models are also available.

Contact:
Altronic Distributors Pty Ltd
PO Box 8350, Perth Busn Centre, WA 6849
Tel: 1300 780 999 **Fax:** 1300 790 999
Website: www.altronics.com.au

Farnell's new online technical training service

In recognition of the increasing complexity of electronic solutions, Farnell has launched TechCast, a new online technical training service.

It provides assistance and answers to customers seeking to understand the latest technology and obtain guidance in the selection of the most appropriate components for their designs.

Techcast modules provide detailed information about a wide and diverse range of electronics technologies in a single, easy-to-use location.

Accessed by a single click from the Farnell website homepage, TechCast online training modules are adopted from suppliers and placed in standard format to ease familiarity.

Constantly added to, the library currently contains over 100 modules from 31 suppliers, such as Cree, Freescale, Molex and Murata Power Solutions, providing information on devices and products ranging from FPGAs and Microprocessors, to LEDs, connectors and front-end power supplies.

An alphabetical search feature helps to speed up locating the required training module and users can select either narrated or silent formats.

Adjacent to each training module indexed in the library is a 'Parts List' button which provides direct access to full technical and purchasing details for products referred to, or relevant to, that specific TechCast module.

With a single click customers can then purchase products for same-day despatch across Australia and New Zealand with no minimum order sizes.

TechCast complements other service initiatives recently introduced by Farnell, aimed at providing industry-leading support to design engineers across the globe.

These include the i-Buy free eprocurement management system and Live Technical Chat. SC

Contact:
Farnell
72 Ferndell St, Chester Hill NSW 2162
Tel: 1300 361 005 **Fax:** 1300 361 225
Website: www.farnell.com.au

Multi-Function Active Filter Module

Versatile design can be configured as a low-pass, high-pass or bandpass filter just by moving a few jumper links

By JOHN CLARKE

This versatile Active Filter is ideal for use as an active crossover in loudspeaker systems but has lots of other uses as well. It can be configured as a low-pass filter (for driving sub-woofer amplifiers), as a high-pass filter or as a bandpass filter, simply by moving a few on-board jumper links.

ACTIVE FILTERS ARE used in many analog circuits to tailor the frequency response. For example, an active filter could be used to prevent signals below 20Hz from passing through to the next stage (eg, to an amplifier). In this case, the filter allows the higher audio frequencies to pass through but blocks the sub-audio signals (including DC).

This type of filter is called a "high-pass" (HP) filter. If a HP filter is incorporated into an audio amplifier, it will prevent the woofer in a loudspeaker system from being driven at very low frequencies. In fact, it could be used as a turntable rumble filter to follow a magnetic cartridge preamplifier.

Preventing a loudspeaker from being driven at very low frequencies is important because such frequencies would cause audible distortion in the sound due to excessive cone movement. In addition, excessive cone movement at or below the loudspeaker's resonance frequency could damage the loudspeaker.

Similarly, an active filter could also be used to limit signals above 20kHz. This will prevent supersonic signals from driving the loudspeaker and protect the tweeter(s) from damage. This type of filter is called a low-pass (LP) filter; it allows frequencies below a certain frequency to pass through but blocks higher frequencies.

Bandpass filter

Cascading a high-pass filter and a low-pass filter produces a bandpass filter. So if a 20Hz high-pass filter and a 20kHz low-pass filter are cascaded, we end up with a bandpass ranging from 20Hz to 20kHz. This means that the signal is attenuated both below 20Hz and above 20kHz, while those frequencies between 20Hz and 20kHz are basically left un-attenuated.

However, some attenuation (or reduction) in level does occur as the signal frequency approaches 20Hz

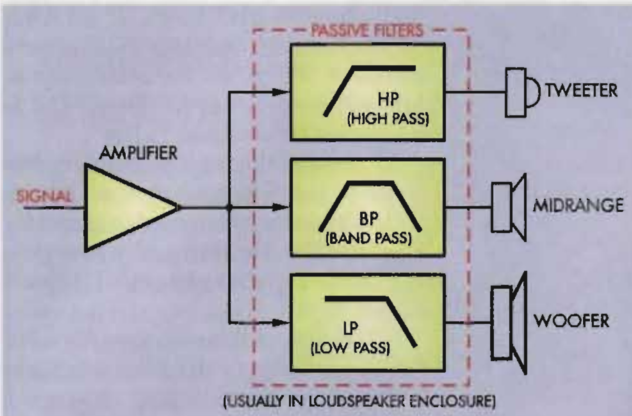


Fig.1: a single power amplifier is usually used to drive a passive crossover network in a loudspeaker box.

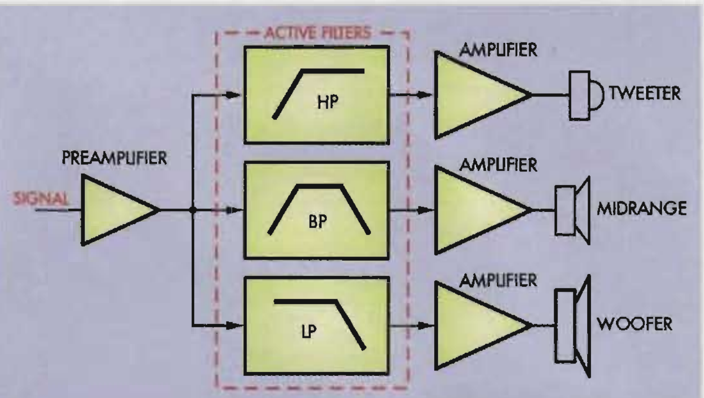


Fig.2: the arrangement for an active crossover filter system. The filters go before the power amplifiers and a separate amplifier is required for each loudspeaker driver.

and 20kHz, ie, the so-called corner or "roll-off" frequencies.

Additional filters can also be used to split the 20Hz-20kHz audio frequency range into separate frequency ranges or bands. This might be done to produce a 2-way or 3-way active crossover for two or three drivers in a loudspeaker system.

In greater detail, many loudspeaker systems include woofer, mid-range and tweeter drivers in the same box – see Fig.1. This is called a 3-way system, while a 2-way system includes just a woofer and a tweeter.

The separate drivers are used because no single driver can faithfully reproduce the whole audible range from 20Hz to 20kHz. So the audio band of frequencies is divided up and each driver is fed with its own "ideal" range of frequencies. In a 3-way system, for example, the woofer could be provided with signals ranging from 20Hz to say 150Hz, while the midrange would handle signals ranging from 150Hz to 2kHz. The tweeter would then cover the remainder of the audio range, ie, from 2-20kHz.

Passive crossovers

In most loudspeaker systems, the incoming audio signal is divided into separate frequency bands using passive filters. These "crossover filters" are located inside the loudspeaker box itself and are made up using inductors, capacitors and resistors.

Basically, a well-designed crossover network gives outputs to match the particular drivers used. This ensures that each driver (ie, woofer, mid-range and tweeter) is fed only with a frequency band it can effectively reproduce.

In addition, the design must cater for drivers that have different sensitivities and set the signal levels to achieve an overall flat frequency response.

For example, the woofer is often less sensitive than the midrange driver and tweeter and so the signals to the latter drivers must be reduced so that the output levels from the three drivers are well matched. This does waste amplifier power, however.

Another problem to contend with is non-linearity in the driver impedances and so extra components are often used in the crossover network to correct this, so that the filter appears to drive a purely resistive load. As a result, the crossover networks in high-performance speaker systems are often complex and can be difficult to design and optimise.

They also interpose a complex RLC network between the amplifier and the speakers which can mean a loss of damping factor. That particularly affects the lower frequencies where a high damping factor is most needed to achieve tight, clean bass and midrange reproduction.

As shown in Fig.1, a single power amplifier usually drives the passive crossover network in a loudspeaker system. However, some loudspeaker systems provide additional connections so that each driver can either be driven independently by its own amplifier (via its passive filter) or by a single amplifier but with separate wiring to each passive filter section.

Active crossovers

Active crossovers are an alternative to passive filtering. However, for this to work, a separate amplifier is required for each driver – see Fig.2. For a stereo system, that means six power amplifiers (or three stereo amplifiers) to drive 3-way loudspeakers or four amplifiers for 2-way loudspeakers.

As shown in Fig.2, the crossover filtering is now placed ahead of each amplifier to set the frequency band

Specifications

Voltage Gain: adjustable from 0-2; typically set at 1

Frequency Response: filter dependent

Filter Attenuation slope: 24dB/octave or 80dB/decade

Total Harmonic Distortion: typically .003% at 1V RMS

Signal-to-Noise Ratio: >100dB with respect to 1V input and 22Hz to 22kHz unweighted

Input Impedance: 47kΩ

Supply Voltage: ±15V to ± 60V DC dual rail supply or +12-30V DC single rail supply or 11-43VAC

Current Consumption: 40mA maximum

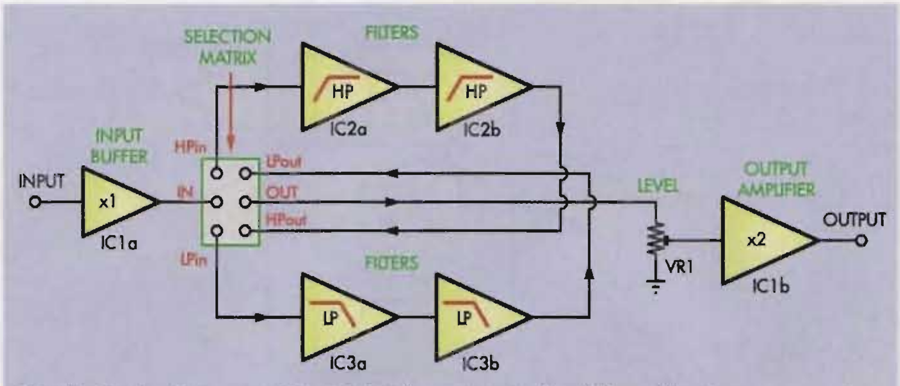


Fig.3: block diagram of the Multi-Function Active Filter. The low-pass and high-pass filter stages each consist of two cascaded op amps and the unit is configured by installing jumper links on the pins of the "selection matrix".

applied to its driver. There are two advantages to this scheme: (1) better control of the driver and (2) the inductive load presented by the driver does not affect the filter response (as it does in a passive system).

So our Multi-Function Active Filter module is designed to be used ahead of each amplifier. Basically, you need to build and configure one module for each driver (and amplifier) in the system. For a woofer, the module would be configured as a low-pass (LP) filter, while a bandpass (BP) filter would be used ahead of the mid-range amplifier. The tweeter driver amplifier would have a high-pass (HP) filter ahead of it.

Supply options

In operation, the Multi-Function Active Filter would typically be powered from the supply rails of the amplifier. Options are available to power the module from supply rails ranging from ±60V down to ±15V or from an 11-43V AC source.

The Multi-Function Active Filter can also be powered from a single supply rail, such as +25V, +15V or +12V. The 12V option enables it to be used in cars.

On-board jumper links are used to configure the module for LP, BP or HP operation. The roll-off frequencies are set by selecting the appropriate resistor and capacitor values in the filter feedback networks. These filter component calculations are made easy by using freely available software from the Internet.

Block diagram

Fig.3 shows the block diagram of the Multi-Function Active Filter (minus the power supply). It uses an input buffer stage (IC1a), four op amps to form the filter stages (IC2a,b & IC3a,b) and an output amplifier stage (IC1b)

IC1a is configured with a gain of one and can be connected to drive either the HP or LP filter stages, depending on the jumper options on the "Selection Matrix" block. If we want a HP filter, then terminal "IN" is connected to "HPin" on the matrix block. Alternatively, for an LP filter, "IN" is connected to terminal "LPin".

As shown, the high-pass filter uses two 2-pole HP filters based on IC2a & IC2b. These are connected in series (or "cascaded"). Similarly, the low-pass filter stage consists of 2-pole LP filters IC3a & IC3b.

Fig.4a shows the response for a HP filter and the way the filter response is described. As indicated, the region where frequencies pass through unattenuated is called the passband. Below the cutoff frequency, the response begins to rolloff (or is reduced) in level. This rolloff region is called the stopband.

An LP filter is similar except that it allows low-frequency signals to pass through and blocks signals above the cutoff point (Fig.4b). Finally, the bandpass filter rolls off both the low and high-frequency signals and the pass band is between the high-pass and low-pass cutoff frequencies (Fig.4c).

Rolloff slope

Note that the signal is not fully attenuated at the cutoff points but instead gradually decreases at a rate determined by the rolloff slope. In this case, each 2-pole filter stage has a rolloff of 40dB per decade or 12dB per octave. However, because the filter stages are cascaded, this rolloff increases to 80dB per decade or 24dB per octave and the signal level is actually 6dB down at the cutoff (crossover) points.

For a high-pass filter, the output from IC2b is fed through to level con-

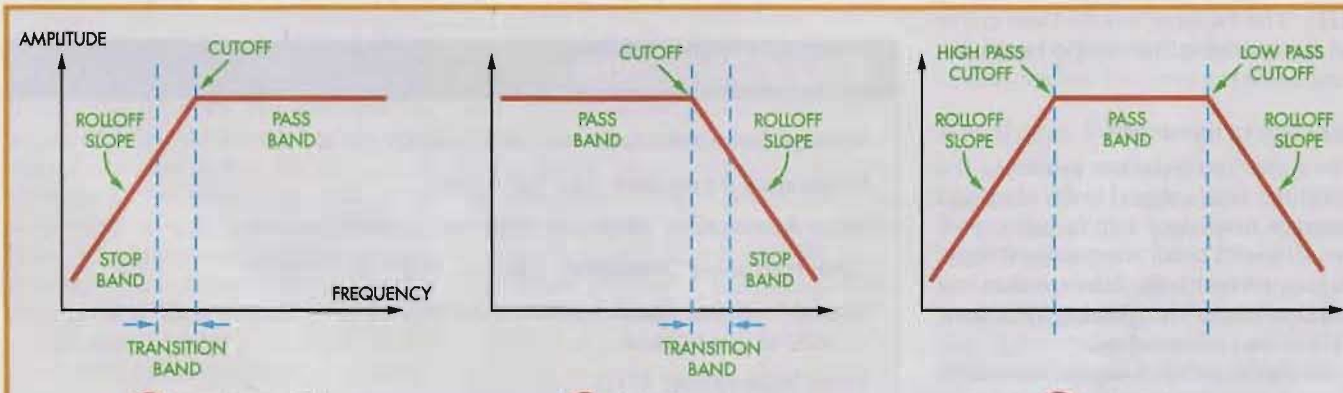


Fig.4: the high-pass filter (A), low-pass filter (B) and bandpass filter (C) response characteristics. Because the op amp filter stages are cascaded, the rolloff slope in each case is 24dB per octave and the signal is actually 6dB down at the cutoff (crossover) points.

Amplifiers For Active Crossover Systems

THE AUDIO AMPLIFIER requirements for active crossover loudspeaker systems depend on the power handling rating for each loudspeaker. Typically, a woofer (or subwoofer) amplifier should have twice the power of the midrange and treble amplifiers. For example, a 100W power amplifier could be used for the woofer, and 50W amplifiers used for the midrange and treble drivers.

One problem is that the output from a preamplifier will only have a single RCA output for each left and right channel. However, you will need to connect the preamp signal to two or three active filters, depending on how many drivers are in the loudspeaker.

This problem is easily overcome by using an **RCA Plug to 2 x RCA Socket** such as the Jaycar Cat. PA-3560. Two such adaptors will be required for each channel if you want to drive three active filter modules (ie, if you have a 3-way loudspeaker system).

Alternatively, you could use **RCA plug-to-plug leads with piggyback RCA sockets** (eg, Jaycar WA-7090/1/2/3 or Altronics P-7260) or you could make up your own 2-way or 3-way RCA socket panels.

trol VR1 by connecting point "HPout" to "OUT" in the selection matrix. Alternatively, for a low-pass filter, the output of IC3b at "LPout" is connected to the "OUT" terminal.

Bandpass filter connections

Bandpass filtering is achieved by cascading the high-pass and low-pass filter stages, ie, by connecting the output of the high-pass stages to the input of the low-pass stages or vice versa. However, it is normal to feed the signal to a HP filter first and then use this to drive the LP filter, rather than placing the LP filter first. This will result in less noise due to the final low-pass filtering.

However, you can connect the LP filters first if that's what you want to do.

Normally, to configure a bandpass filter, the signal is first fed to HP filter stage IC2a by linking "IN" to "HPin". The output from IC2b is then fed to the input of low-pass stage IC3a by connecting "HPout" to "LPin" in the Selection Matrix. The resulting bandpass filtered signal at the output of IC3b is then fed to VR1 by connecting "LPout" to "OUT".

Level control

The signal on VR1's wiper is fed to IC1b. This is configured as a non-inverting amplifier with a gain of two. As a result, VR1 can be adjusted to vary the signal at its output between zero and x2. This level adjustment allow the sound levels from the woofer, midrange and tweeter drivers to be adjusted when multiple filter modules are used.

By the way, the recommended design for each 2-pole stage is for a Butterworth response. When connected in series, the result of cascading two Butterworth filters is a Linkwitz-Riley (L-R) response.

This is ideal because at the crossover region, where one filter takes over from another, the overall L-R frequency response is flat. Note that the HP and LP filters must be set for same crossover frequency for this to happen.

Parts List

1 UB3 plastic utility case 130 x 68 x 44mm (optional)
1 PC board, code 01107091, 123 x 63mm
1 3-way PC-mount screw terminal block with 5.08mm pin spacing (CON1)
4 DIP8 IC sockets
1 3-way DIL pin header with 2.54mm pin spacings
2 3-way SIL pin header with 2.54mm pin spacings
5 jumper plugs to suit pin headers
1 100mm length of 0.8mm tinned copper wire or four 0Ω links
4 PC stakes

Semiconductors
3 LM833 dual op amps (IC1-IC3)
1 TL071, LF351 single op amp (IC4)
2 1N4744 15V 1W zener diodes (ZD1,ZD2)
2 1N4004 1A 400V diodes (D1,D2)

Capacitors
2 470μF 16V PC electrolytic
1 100μF 16V PC electrolytic
2 4.7μF non-polarised (NP) electrolytic
2 100nF MKT polyester
1 10nF MKT polyester
1 220pF ceramic
C1,C2,C3 to suit application (use MKT polyester) (see text & tables)

Resistors (0.25W, 1%)

1 47kΩ	2 150Ω
4 10kΩ	3 10Ω

Ra, Rb, R1, R2 & R3 to suit power supply & filter type (use 1% 0.25W for R1, R2 & R3) (see text & tables)

As indicated previously, the Multi-Function Active Filter board can only produce a single LP, HP or BP filter output. **This means that it can only provide signal to one loudspeaker driver – it is not designed to provide for two (or more) outputs.**

This in turn means that if you want separate LP, BP and HP filter outputs, then three Multi-Function Active Filter modules must be built (or six for a stereo system). Basically, a different filter is required for each amplifier and it can be installed inside its associated amplifier's case.

Fig.5: this screen grab shows the frequency response for the low-pass filter configuration with a nominal corner frequency of 1kHz. The attenuation slope is 24dB per octave.

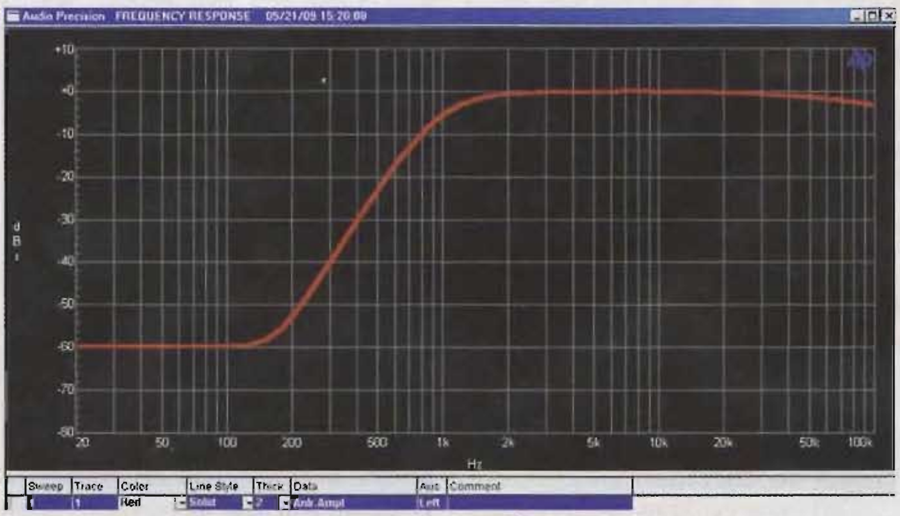


Fig.6: the frequency response for a high-pass filter configuration with a nominal corner frequency of 1kHz. Once again, the attenuation slope is 24dB per octave.

The inputs of the various active filter modules are then all driven in parallel by the preamplifier.

Circuit details

OK, let's now take a look at the full circuit details – see Fig.7. It comprises three dual op amps (IC1-IC3) plus a single op amp (IC4) in the power supply section.

The first thing to note here is that the designations for the op amps used in the input buffer, filter and output stages match those shown on the block diagram of Fig.3. So if you've followed the description for Fig.3, understanding how the full circuit works should be a snack.

As shown, the incoming audio signal is applied to unity gain buffer stage IC1a via a 4.7µF non-polarised capacitor and a 10Ω stopper resistor. The capacitor is there to block any DC voltage, while the stopper resistor blocks any stray RF signals that may have been picked up by the leads.

IC1a is biased to Earth 2 via the associated 47kΩ resistor. This earth is at 0V for plus and minus supply rails and at half-supply (0.5Vcc) for a single supply.

IC1a's output is fed to either HP filter IC2a or to LP filter IC3a, depending on the input jumper location in the Selection Matrix. This works exactly as indicated previously in the description for the block diagram (Fig.3).

Both the high-pass and low-pass filter stages (IC2a, IC2b, IC3a & IC3b) use a multiple feedback (MFB) 2-pole arrangement. This was used in preference to the unity gain Sallen-Key style of filter because the MFB response is less affected by component value variations due to manufacturing tolerances.

Note that 10Ω stopper resistors are included in series with the HP filter inputs. This is done in each case to prevent instability (oscillation) in the preceding stage. IC2a's output is fed to the second HP filter stage IC2b (ie, the stages are cascaded), while IC3a drives the second LP filter stage IC3b.

For a HP filter, IC2b's output is fed to level potentiometer VR1 by linking "HPout" to "OUT" in the Selection Matrix. Alternatively, for a LP filter, the output from IC3b is connected to level potentiometer VR1 using a jumper to link "LPout" to "OUT". Again, this functions exactly as described for block diagram Fig.3.

Finally, for a bandpass arrangement, HP filter IC2b's output is fed to LP filter IC3a via a jumper link between "HPout" and "LPin". IC3b's output is then fed to VR1 level via a jumper link between "LPout" and "Out".

Minimising noise

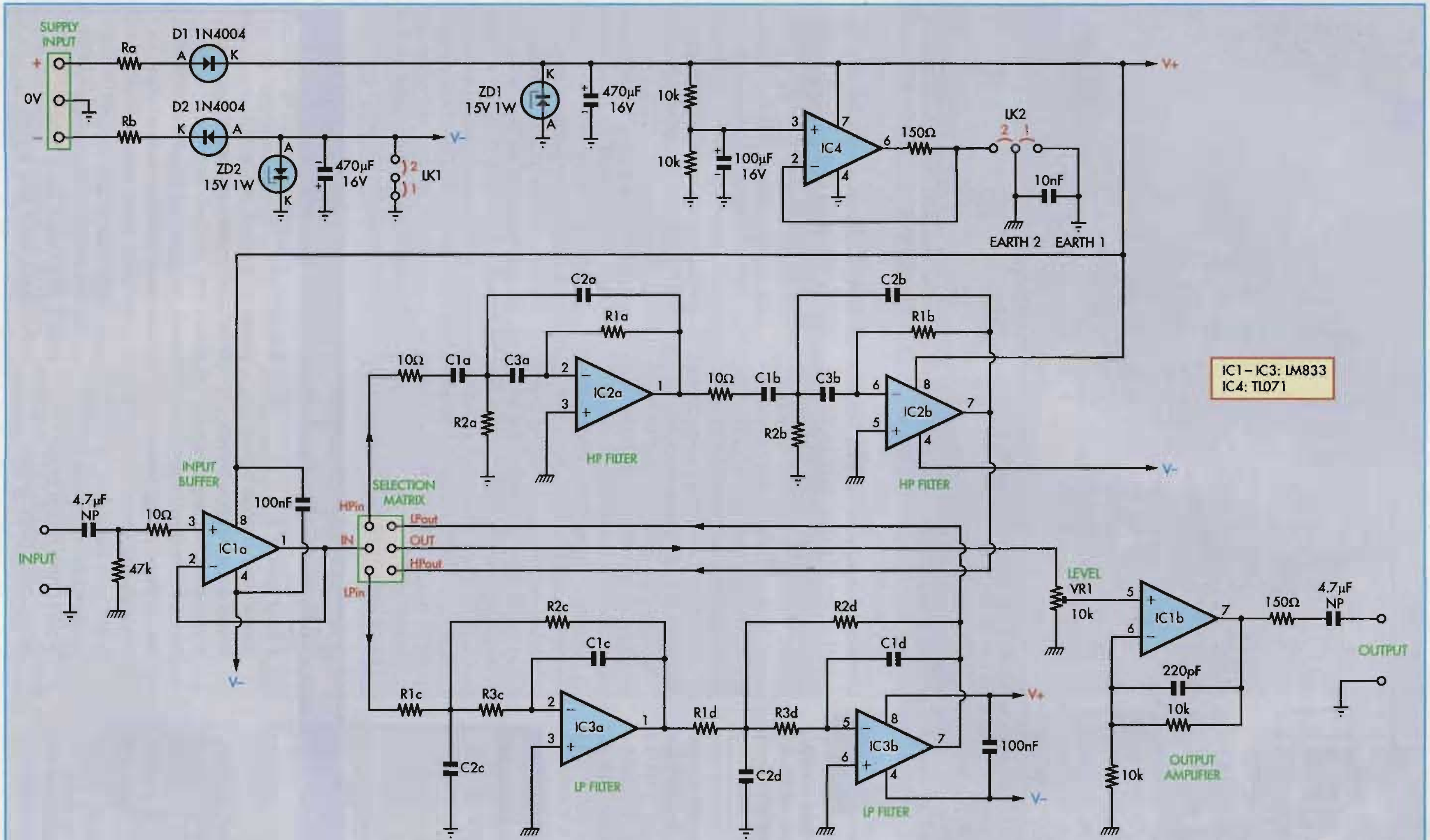
As stated earlier, the signal from IC1a is normally fed to the HP filter stages first ("IN" linked to "HPin"), so that the LP filter stages can then minimise noise. Alternatively, the LP stages can be placed first by linking "IN" to "LPin", "LPout" to "HPin" and "HPout" to "OUT".

The resulting audio signal on VR1's wiper is fed directly to the non-inverting input (pin 5) of IC1b. As previously stated, this amplifier has a gain of 2 but this gain reduces to 1 for frequencies above 72kHz due to the 220pF capacitor across the feedback resistor. IC1b's output appears at pin 7 and is coupled to the output terminals via a 150Ω isolating resistor and a 4.7µF NP (non-polarised) capacitor and 150Ω isolating resistor.

Power Supply

In operation, the Multi-Function Active Filter would typically be powered from the supply rails of the amplifier. As stated previously, options are available to power the module from dual DC supply rails or from an AC source.

The unit can also be powered from a single supply rail, such as +25V, +15V or +12V. The 12V option enables it to be used in a car.



MULTI-FUNCTION ACTIVE FILTER

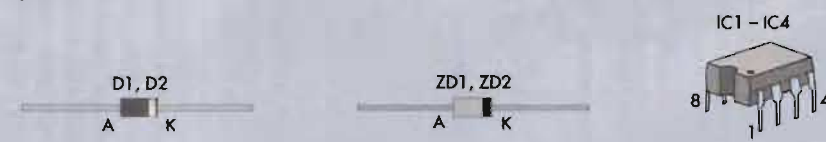


Fig.7: the complete circuit for the Multi-Function Active Filter. IC1a serves as an input buffer stage while op amp IC1b is the output amplifier. Cascaded op amp stages IC2a & IC2b together form the high-pass filter, while IC3a & IC3b make up the low pass filter. IC4 is used to provide a half-supply reference if the unit is powered from a single-rail power supply.

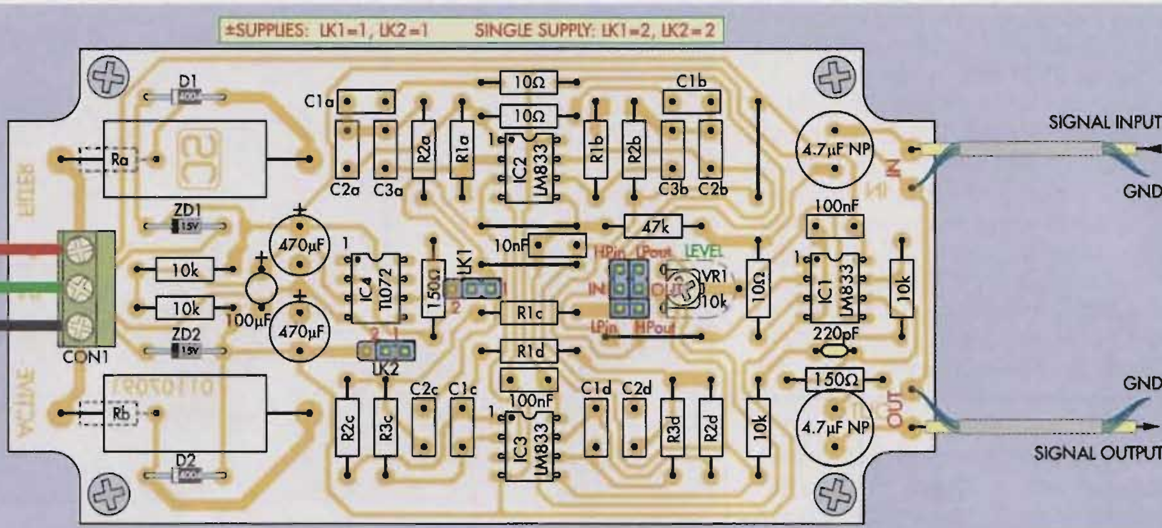


Fig.8: follow this parts layout diagram to build the PC board. The various tables show the values for resistors Ra & Rb and for the filter components (R1-R3 & C1-C2), while the linking options for the selection matrix are shown at right. Links LK1 & LK2 go in position 1 for a dual-rail supply (or for an AC supply) but must be moved to position 2 for a single-rail supply.

In summary, the three options for powering the module are as follows:
(1) A dual-rail (plus & minus) supply of between ±15V and ±60V (this connects to the "+" and "-' supply inputs of the terminal block);
(2) A single DC supply rail ranging from 12-60V (this connects between the "+" and "0V" supply inputs); and
(3) An AC supply ranging from 12-43VAC (in this case, the "+" and "-" inputs are tied together and the AC supply is connected between these commoned inputs and the 0V input).

In the case of a dual supply, diodes D1 and D2 (1N4004) protect the circuit against reverse polarity connection. Zener diodes ZD1 and ZD2 then regulate the supply to provide ±15V rails which are then used to power op amps IC1-IC3. Two two 470µF capacitors decouple the ±15V supply rails.

Resistors Ra & Rb are used to limit the current into ZD1 and ZD2. The values of these two resistors depend on the input voltage (see Table 4 for the required values).

In addition, for a dual supply, Earth 1 and Earth 2 are connected together by installing jumper link LK2 in position 1 (LK1 must also be in position 1 or left out). With no signal, this sets op amps IC1, IC2 & IC3 so that their outputs sit at 0V.

For a single supply, ICs1-3 need to be biased at half-supply so that the signal can swing symmetrically without clipping. This half-supply rail is provided by op amp IC4. As shown, a half-supply voltage is derived using two 10kΩ resistors in series across the positive supply rail. This is decoupled by a 100µF capacitor and then buffered by IC4 to drive Earth 2 when LK2 is in the "2" position.

In addition, for a single supply, the negative supply pins for ICs1-3 are connected to the 0V supply rail by placing link LK1 in position 2.

Note that when LK2 is in position 2, the half-supply output from IC4 is bypassed to earth (0V) via a 10nF capacitor. This prevents oscillation in the filter op amps. The 150Ω resistor at pin 6 of IC4 isolates the op amp's output from the capacitance in the shielded output leads.

Table 1: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
10nF	0.001µF	10n	103
220pF	NA	220p	221

Table 2: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	15kΩ	brown green orange brown	brown green black red brown
❑	1	13kΩ	brown orange orange brown	brown orange black red brown
❑	1	12kΩ	brown red orange brown	brown red black red brown
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	2	6.2kΩ	blue red red brown	blue red black brown brown
❑	2	5.6kΩ	green blue red brown	green blue black brown brown
❑	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	150Ω	brown green brown brown	brown green black black brown
❑	3	10Ω	brown black black brown	brown black black gold brown

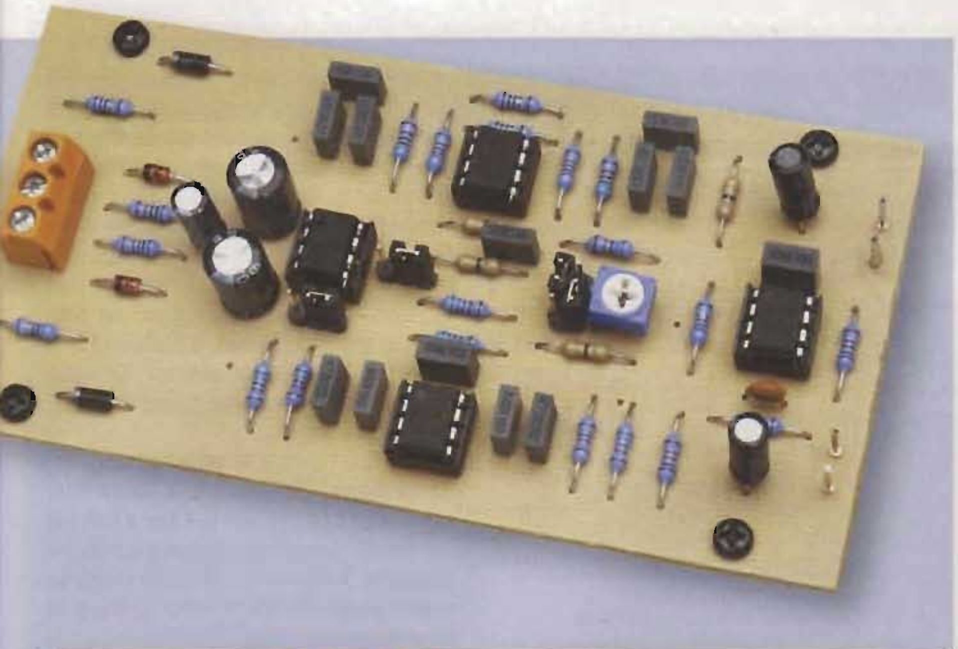


Table 3: Filter Type Configuration		
Low-Pass Filter	**High-Pass Filter**	**Bandpass Filter**
Link **IN** to **LPin**; Link **LPout** to **OUT**	Link **IN** to **HPin**; Link **HPout** to **OUT**	Link **IN** to **HPin**; Link **HPout** to **LPin**; Link **LPout** to **OUT**

Table 4: Power Supply Configuration			
Input Voltage	**Ra**	**Rb**	**Links**
±60VDC, 43VAC	1.2kΩ 5W	1.2kΩ 5W	LK1 position 1, LK2 position 1
±55VDC, 40VAC	1kΩ 5W	1kΩ 5W	LK1 position 1, LK2 position 1
±50VDC, 35VAC	820Ω 5W	820Ω 5W	LK1 position 1, LK2 position 1
±45VDC, 30VAC	680Ω 5W	680Ω 5W	LK1 position 1, LK2 position 1
±40VDC, 28VAC	560Ω 5W	560Ω 5W	LK1 position 1, LK2 position 1
±35VDC, 25VAC	470Ω 5W	470Ω 5W	LK1 position 1, LK2 position 1
±30VDC, 20VAC	390Ω 5W	390Ω 5W	LK1 position 1, LK2 position 1
±25VDC, 18VAC	270Ω 5W	270Ω 5W	LK1 position 1, LK2 position 1
±20VDC, 15VAC	120Ω 1W	120Ω 1W	LK1 position 1, LK2 position 1
±15VDC, 11VAC	10Ω 0.5W	10Ω 0.5W	LK1 position 1, LK2 position 1
+30V	390Ω 5W	NA	LK1 position 2, LK2 position 2
+25V	270Ω 5W	NA	LK1 position 2, LK2 position 2
+20V	120Ω 1W	NA	LK1 position 2, LK2 position 2
+15V	10Ω 1/2W	NA	LK1 position 2, LK2 position 2
+12V	10Ω 1/2W	NA	LK1 position 2, LK2 position 2

Finally, for an AC supply, D1 & D2 function as half-wave rectifiers to derive positive and negative supply rails. The circuit then functions exactly the same as for a dual-rail DC supply.

Construction

All parts for the Multi-Function Active Filter are mounted on a PC board coded 01107091 and measuring 123 x 63mm. This can either be housed inside a UB3 plastic utility case measuring 130 x 68 x 44mm or installed within an amplifier case.

Note that corner cutouts will be required if mounting the board in a utility case, to clear the integral mounting posts.

Fig.8 shows the parts layout on the PC board. However, before starting the assembly, you have to decide on the power supply to be used, the type of filter arrangement and the cutoff frequency.

Table 4 shows the resistors (Ra & Rb) required for various power supply voltages, plus the LK1 & LK2 linking options. The filter component values

Using The FilterPro Software From TI

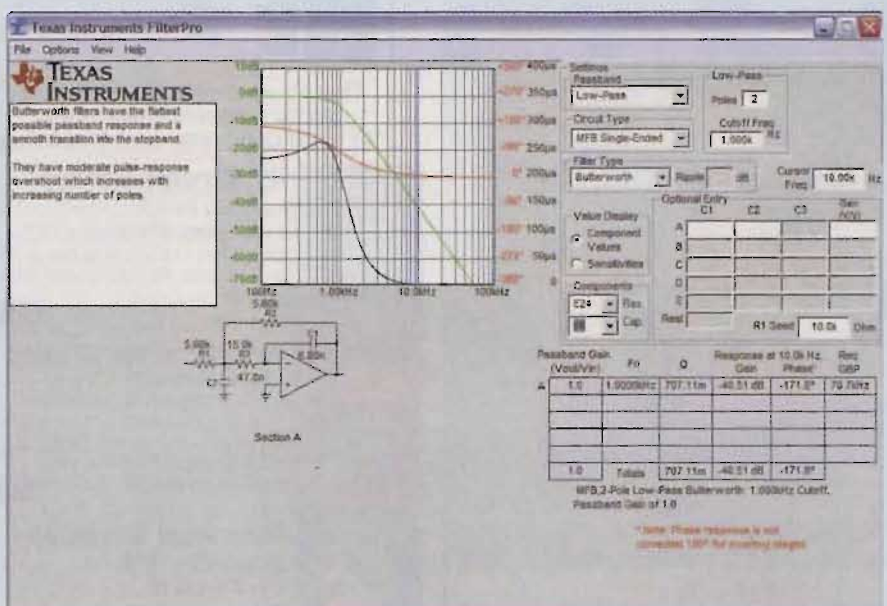


Fig.9: this is how FilterPro should look when set up to calculate values for a low-pass 2-pole Butterworth filter.

The first step here is to download the 2.848MB zipped file (available from **http://focus.ti.com/docs/toolsw/folders/print/filterpro.html**) and run the **FilterProSetup.exe** file. That done, navigate to *C:\ProgramFiles\Ti Analog Design Centre\Filterpro* and create a shortcut on your desktop for **FilterPro.exe**.

When you launch FilterPro, the program will show a screen with a graph, the filter circuit and various settings (see Fig.9). The graph shows the frequency response of the filter using an amplitude versus frequency plot. The actual rolloff can be seen as well as any excursions in the response across the passband or at the cutoff frequency.

Two other responses are also shown on the graph: the phase response and the group delay. The phase response plots the phase variations in the filter output as a function of frequency. By contrast, the group delay shows the slope (or rate of change) in the phase response and is ideal for displaying the filter response to a pulse signal.

Several different filter types can also be selected – ie, Bessel, Butterworth and Chebychev. Each has a different "Q" value and so the filter response differs from one to the other.

Each filter type has its own advantages and disadvantages. For example, a Bessel filter has a Q of 0.577 ($1/\sqrt{3}$) and has a smooth but drooping amplitude response across the passband. It has very little pulse response overshoot and its rolloff is not as steep as for a Butterworth filter.

Butterworth filters have a "Q" of 0.7071 ($1/\sqrt{2}$) and have the flattest possible (maximally flat) amplitude response in the passband and a moderate pulse response rise (or overshoot) at the cutoff frequency.

A Chebychev filter has a higher Q again. This filter has ripple in the passband, a steeper cutoff rate and higher pulse response overshoot compared to the two lower Q filters. The Q value depends on the amount of ripple that can be tolerated and is 0.956 for a 1dB passband ripple and 0.863 for a 0.5dB passband ripple.

A filter with a "Q" of 0.5 is critically damped and shows no pulse response overshoot. The Bessel, Butterworth and Chebychev filters are all under-damped and so each show some degree of overshoot in its response. An over-damped filter would have a "Q" of less than 0.5.

Butterworth filters

For audio work, the best compromise filter type is the Butterworth, especially when two filters are cascaded as in our Multi-Function Active Filter. So in FilterPro, select "Butter-

Calculating The Filter Component Values

CHOOSING THE CROSSOVER FREQUENCIES for loudspeaker drivers requires careful consideration. You will need the data sheet for each driver in order to make a decision as to where the crossover frequency should lie. Ideally, the crossover frequency should be well away from the driver's resonance frequency and the adjacent drivers should be a good match to ensure a smooth frequency response across the audio band.

Many books have been written on the subject and a good reference is **"The Loudspeaker Speaker Design Cookbook"** by Vance Dickason. This is available from Jaycar, Cat. BA-1400.

Once you have decided on the crossover frequencies, the filter component values can be calculated. Tables 5 and 6 show the recommended values for a range of common frequencies.

For other frequencies, you can download software off the net to make the calculations easier. Our recommendation is to use "Filter Pro" from Texas Instruments. You can download it from **http://focus.ti.com/docs/toolsw/folders/print/filterpro.html**

If this site becomes unavailable, do a search for "Ti filter software" or for "FilterPro". Information on how to use FilterPro and other useful information on filters is available at **http://focus.ti.com/lit/an/sbfa001a/sbfa001a.pdf**

An alternative on-line program is also available from Okawa Electric – see the section entitled "Using the FilterPro Software From TI".

are selected from Tables 5 & 6 (see also the panel titled "Calculating The Filter Component Values").

Note that for the single supply option, Rb, D2, ZD2 & C5 can be omitted. However, it does not matter if they are installed. Alternatively, for a dual rail supply option, IC4, R4, R5 & C6 are not required. Note also that either 5W or 0.5W resistors can be used for Ra & Rb, as the PC board accepts both types.

For a LP filter only, there is no need to install the HP components. These

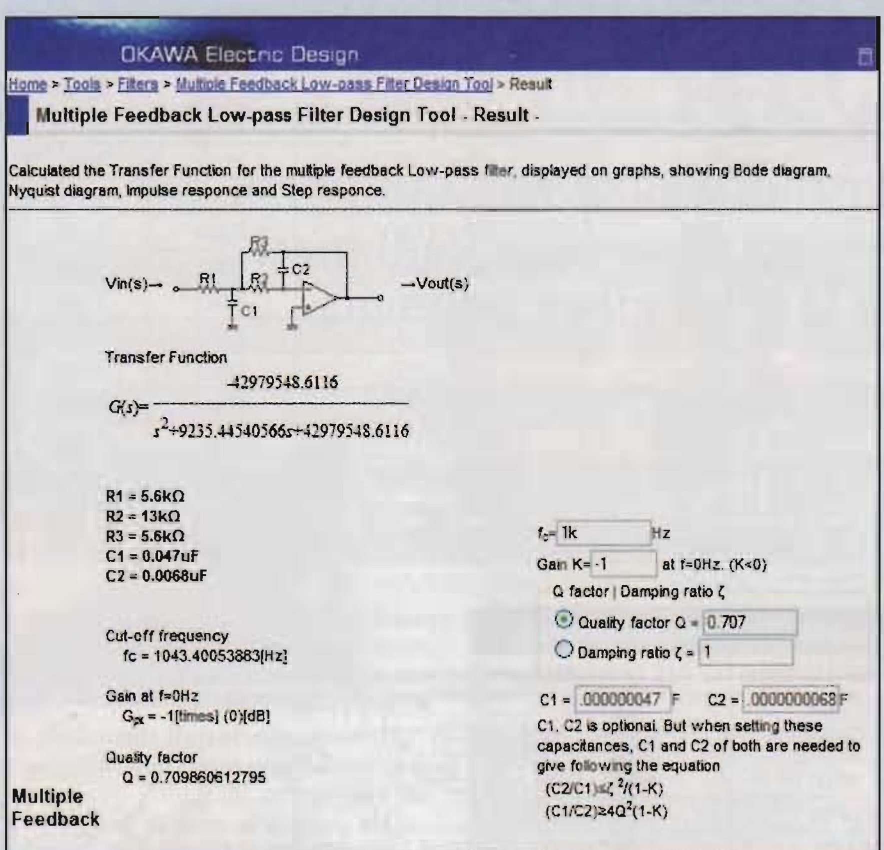


Fig.10: the low-pass filter design software from Okawa Electric shows the circuit values and filter responses in a similar way to FilterPro. A high-pass filter design tool is also available from Okawa Electric – see text.

worth" as the filter type and select "2" for the number of poles. The circuit type should be set to "MFB single ended" and the set display value should be "component values".

For components, select "E24" series for the resistors and either "E6" or "E12" for the capacitors (these "E" series values select the number of values available in a decade range). The relevant resistor and capacitor values will then be calculated based on readily available components.

Note: some component suppliers may not have the full E12 capacitor series. In that case, a recalculation may have to be made using the E6 series instead if using the E12 series gives components values that are unavailable.

The next step is to enter the cutoff frequency, select either LP or HP and then click on an unused section of the screen to start calculating the values.

Note that the circuit for the multiple feedback 2-pole filter shows the values for a single 2-pole filter section. These same values are also used in the second 2-pole filter stage of the Multi-Function Active Filter.

FilterPro provides values for the resistors and capacitors using R1, R2 & R3 and C1, C2 & C3 component designations. These are easily equated with the component designations on the circuit diagram (Fig.7) and parts layout diagram (Fig.7). Note: the a, b, c & d designations on Fig.7 are there simply to distinguish one filter circuit from another.

Bandpass filter

A bandpass filter is made by designing two separate cascaded HP and LP circuits. For example, if you want a bandpass filter with rolloffs at 500Hz and 2kHz, you simply use FilterPro to design independent 500Hz high-pass and 2kHz low-pass stages.

Do not select a bandpass design in FilterPro – the calculations are not applicable to the Multi-Function Active Filter module described here.

Alternative software

If you want to use an alternative program to FilterPro or if you want to check the predicted response of your filter using the values given by FilterPro, a good on-line program is one from Okawa Electric. For the low-pass filter, go to http://sim.okawa-denshi.jp/en/OPtazyuLowkeisan.htm For the high-pass filter navigate to http://sim.okawa-denshi.jp/en/OPtazyuHikeisan.htm

These sites not only allow you to calculate filter components but also allow you to input component values. The program will then show the actual cutoff frequency, filter Q and other features. These calculations can sometimes give a better result (ie, closer to the required Q and cutoff frequency) than FilterPro.

Note, however, that the R1, R2, R3, C1, C2 & C3 labelling is a little different to that of the FilterPro and our circuit, so make sure you transpose the labelling correctly. Also, do not forget to tick the Q value field at 0.707 rather than using the ticked damping ratio field of 1 for the calculation.

include IC2, R1a, R2a, C1a, C2a, C3a, R1b, R2b, C1b, C2b & C3b. The two 10Ω stopper resistors can also be left out (but not the one on pin 3 of IC1a).

Similarly, for a HP filter, you can leave out LP components IC3, R1c, R2c, R3c, C1c, C2c, R1d, R2d, R3d, C1d & C2d.

Start the assembly by carefully inspecting the board for any defects, then install the four wire links. Alternatively, 0Ω resistors can be used instead of the wire links. These look similar to a 0.25W resistor but have just one single black band around the centre of the body.

Next, install four PC stakes at the input and output positions, then install the resistors and trimpot VR1. Table 2 shows the resistor colour codes but a digital multimeter should also be used to check values, just to make sure.

Follow these with the diodes, zener diodes and the ICs. These parts must all be installed with the correct orientation. Note that IC4 is a different type to IC1, IC2 & IC3, so don't get it mixed up. We used IC sockets for the ICs and these sockets also have an orientation notch at one end – see Fig.8.

The electrolytic capacitors are next on the list and these must also be oriented correctly. The only exceptions here are the two 4.7μF NP (non-polarised) types which can go in either way around.

Once these parts are in, install the two 3-way SIL (Single In-Line) headers for links LK1 & LK2. The two jumpers

Table 5: High-Pass Filter Component Values (Butterworth Response)					
Frequency	C1 (IEC Code) (EIA Code)	C2 (IEC Code) (EIA Code)	C3 (IEC Code) (EIA Code)	R1	R2
50Hz	330nF (334)	330nF (334)	330nF (334)	20kΩ	4.3kΩ
100Hz	150nF (154)	150nF (154)	150nF (154)	22kΩ	5.1kΩ
120Hz	150nF (154)	150nF (154)	100nF (104)	24kΩ	4.7kΩ
150Hz	100nF (104)	100nF (104)	100nF (104)	22kΩ	5.1kΩ
200Hz	68nF (683)	68nF (683)	100nF (104)	20kΩ	4.7kΩ
300Hz	47nF (473)	47nF (473)	68nF (683)	20kΩ	4.7kΩ
500Hz	33nF (333)	33nF (333)	33nF (333)	20kΩ	4.3kΩ
1kHz	15nF (153)	15nF (153)	15nF (153)	22kΩ	5.1kΩ
1.5kHz	10nF (103)	10nF (103)	10nF (103)	22kΩ	5.1kΩ
2kHz	6.8nF (6n8) (682)	6.8nF (6n8) (682)	10nF (103)	20kΩ	4.7kΩ
3kHz	6.8nF (6n8) (682)	6.8nF (6n8) (682)	6.8nF (6n8) (682)	20kΩ	4.7kΩ
5kHz	3.3nF (3n3) (332)	3.3nF (3n3) (332)	3.3nF (3n3) (332)	20kΩ	4.3kΩ
10kHz	1.5nF (1n5) (152)	1.5nF (1n5) (152)	1.5nF (1n5) (152)	22kΩ	5.1kΩ
20kHz	680pF (681)	680pF (681)	1nF (102)	20kΩ	4.7kΩ

Table 6: Low-Pass Filter Component Values (Butterworth Response)					
Frequency	R1	R2	R3	C1 (IEC Code) (EIA Code)	C2 (IEC Code) (EIA Code)
50Hz	5.6kΩ	5.6kΩ	12kΩ	150n (154)	1μF (105)
100Hz	5.6kΩ	5.6kΩ	15kΩ	68nF (683)	470nF (474)
120Hz	4.7kΩ	4.7kΩ	12kΩ	68nF (683)	470nF (474)
150Hz	5.6kΩ	5.6kΩ	13kΩ	47nF (473)	330nF (334)
200Hz	6.2kΩ	6.2kΩ	15kΩ	33nF (33)	220nF (224)
300Hz	6.2kΩ	6.2kΩ	13kΩ	22nF (223)	150nF (154)
500Hz	5.6kΩ	5.6kΩ	12kΩ	15n (153)	100nF (104)
1kHz	5.6kΩ	5.6kΩ	15kΩ	6.8nF (6n8) (682)	47nF (473)
1.5kHz	5.6kΩ	5.6kΩ	13kΩ	4.7nF (4n7) (472)	33nF (333)
2kHz	6.2kΩ	6.2kΩ	15kΩ	3.3nF (3n3) (332)	22nF (223)
3kHz	6.2kΩ	6.2kΩ	13kΩ	2.2nF (2n2) (222)	15nF (153)
5kHz	5.6kΩ	5.6kΩ	12kΩ	1.5n (1n5) (152)	10nF (103)
10kHz	5.6kΩ	5.6kΩ	15kΩ	680pF (681)	4.7nF (4n7) (472)
20kHz	6.2kΩ	6.2kΩ	15kΩ	330pF (331)	2.2nF (2n2) (222)

Be sure to choose the correct filter component values when building the PC board – see Tables 5 & 6. In this case, the board has been configured as a high-pass filter and is set up to accept dual supply rails.

can then be fitted to these headers. They both go in position 1 for a dual-rail supply (or if you are using an AC supply) – see Table 4.

Alternatively, install them both in position 2 if you intend using a single rail supply.

The selection matrix requires a 3-way DIL (Dual In-Line) pin header and this should now be installed – it goes in just to the left of trimpot VR1. Once it's in, install the jumpers on this header to select your filter type (ie, LP, HP or bandpass).

The assembly can now be completed by installing the 3-way screw terminal block.

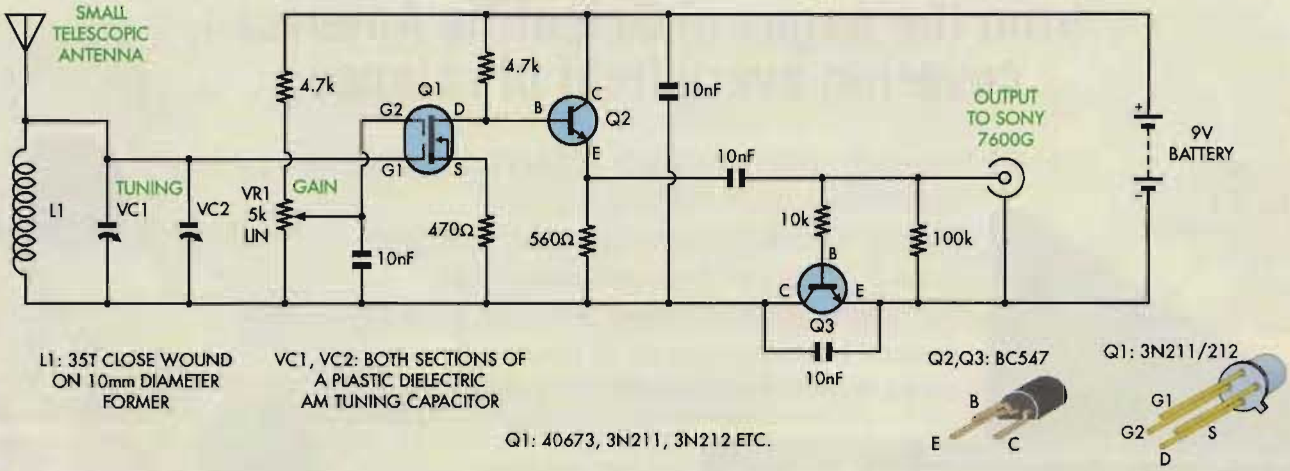
Power supply checks

Before applying power, check that the supply link options are correct (see Table 4) and that the correct values have been installed for resistors Ra & Rb. Check also that you've installed the correct link options for the filter type.

Next, connect one probe of your DMM to the 0V supply input, apply power and use the other probe to measure the supply voltages on the ICs. For a dual (±) or AC supply arrangement, check that there is +15V on pin 8 of ICs1-4. Similarly, there should be -15V on pin 4 of ICs1-3, while pin 4 of IC4 (if installed) should be at 0V.

For the single supply arrangement, check for +15V on pin 8 of ICs1-3 and on pin 7 of IC4 (if installed). Note that the measured voltage will be lower if the supply voltage is less than 15V. Pin 6 of IC4 should be at half-supply (eg, 7.5V for a 15V supply). SC

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.



RF preamplifier for world-band receivers

Synthesised world-band receivers are very popular but they do suffer generally from poor reception with the standard telescopic aerial. The radios are very sensitive by themselves but the aerial is far too short on the lower shortwave bands to supply any reasonable signal for good reception, the result being hiss and noise.

Wideband RF stages do not lend themselves to being connected to large antennas and usually suffer from overloading and cross modulation problems. The circuit described here combines modest gain with a tuned RF stage to help reduce out-of-band signals.

Inductor L1 and plastic dielectric variable capacitor VC1 comprise a tuned circuit, resonant to the band of interest. Dual-gate MOSFET Q1 then buffers the high impedance of the tuned circuit and also provides some gain which is limited by its unbypassed 470Ω source resistor. Transistor Q2 functions as an emitter follower to buffer the drain output of the MOSFET before it is fed into the antenna input of the radio.

Q3 functions as a switch, automatically turning the preamplifier on when the radio is activated. The Sony ICF7600GR, the radio for which this circuit was developed, has approximately 3.5V present at the external antenna input when switched on. This voltage will turn Q3 fully on via its 10kΩ bias resistor, thereby connecting the 9V internal supply of the preamp.

The overall gain is adjusted by VR1, allowing approximately +6dB gain when wound fully clockwise. When rotated fully anticlockwise, VR1 will attenuate the signal by around the same amount, which is very useful with strong signals.

Other world-band radios may not have this external antenna voltage present, in which case Q3 can be omitted and a normal switch used instead. The current drain is around 10mA and a small 9V battery will provide many hours of operation.

Inductor L1 is wound using 35 turns of enamelled wire (scrounged from a small transformer) on part of a ballpoint pen case. The tuning capacitor can be recycled from a defunct transistor radio, as can the gain control pot and telescopic aerial. The circuit can be constructed on a scrap of copper circuit board and housed in a small zippy box. A short cable is made to connect to the radio's external antenna input.

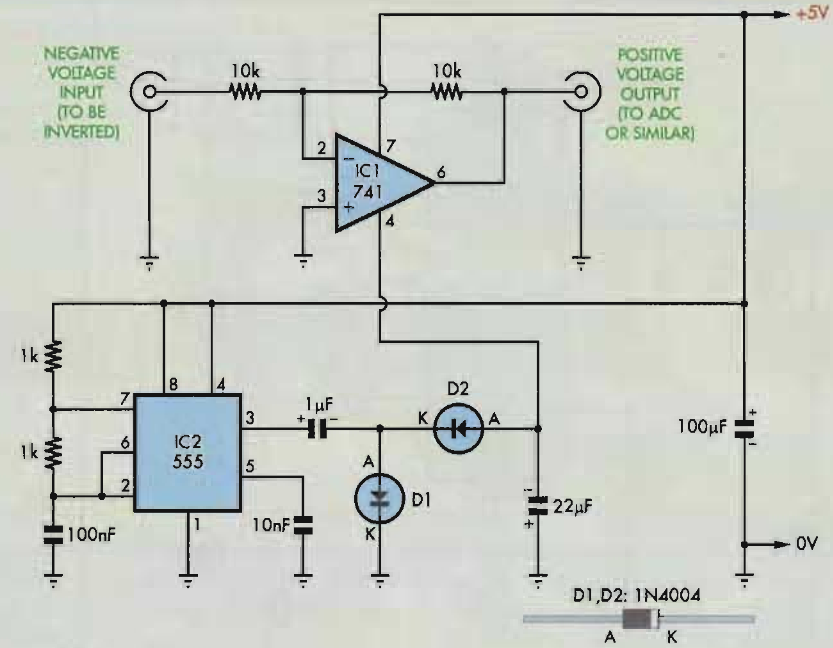
Dayle Edwards,
Westland, New Zealand. ($45)

Signal inverter runs from a 5V rail

This circuit is designed to be a basic signal inverter. It takes a negative or positive-going voltage signal and inverts it.

The circuit consists of a 741 op amp (IC1) and a 555 timer (IC2). IC2 runs as an astable multivibrator which drives a diode pump circuit consisting of diodes D1 & D2 and the 1µF & 22µF capacitors. This generates the negative supply rail for the 741 op amp which otherwise could not deliver a negative polarity signal.

Hence IC1 has positive and negative supply rails, as needed for normal operation. It is connected as an inverting amplifier stage with unity gain, as determined by the 10kΩ input and feedback resistors.



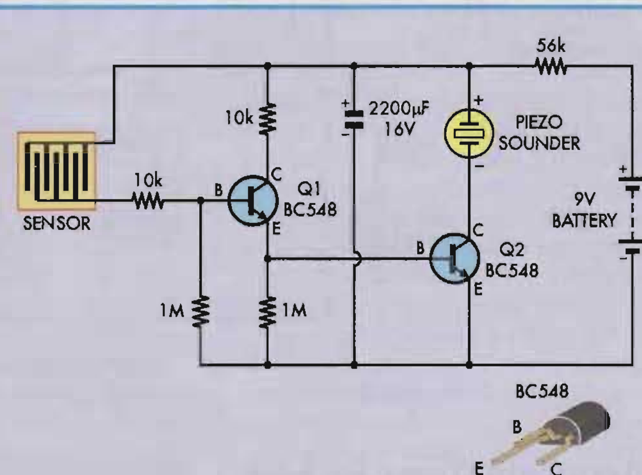
Note that there are no signal coupling capacitors in the circuit, necessary to ensure that the op amp can deliver DC output signals. With no input signal applied, there will be a slight DC offset error at the output of the op amp.

The original use for this circuit was to invert the signal from an AD-595 thermocouple decoder, which delivers negative voltages for negative temperatures but there are many other applications.

Reuben Posthuma,
Christchurch, New Zealand. ($35)

Simple water spillage alarm

Twin-tub washing machines are economical in water usage but do have drawbacks. Having to manually fill the spin side with water for final rinse requires continual monitoring otherwise there is the risk of water overflowing onto the floor. The resultant slippery floor can be a hazard unless it is mopped up immediately.



This circuit was designed to detect moisture on the laundry floor, with the sensor placed directly under the washing machine.

In essence, the circuit uses two NPN transistors in a Darlington configuration. The base of the first transistor, Q1, is fed via the moisture sensor and a 10kΩ resistor. If there is no moisture present, the transistor is held off by the 1MΩ resistor connected from the base to the 0V line.

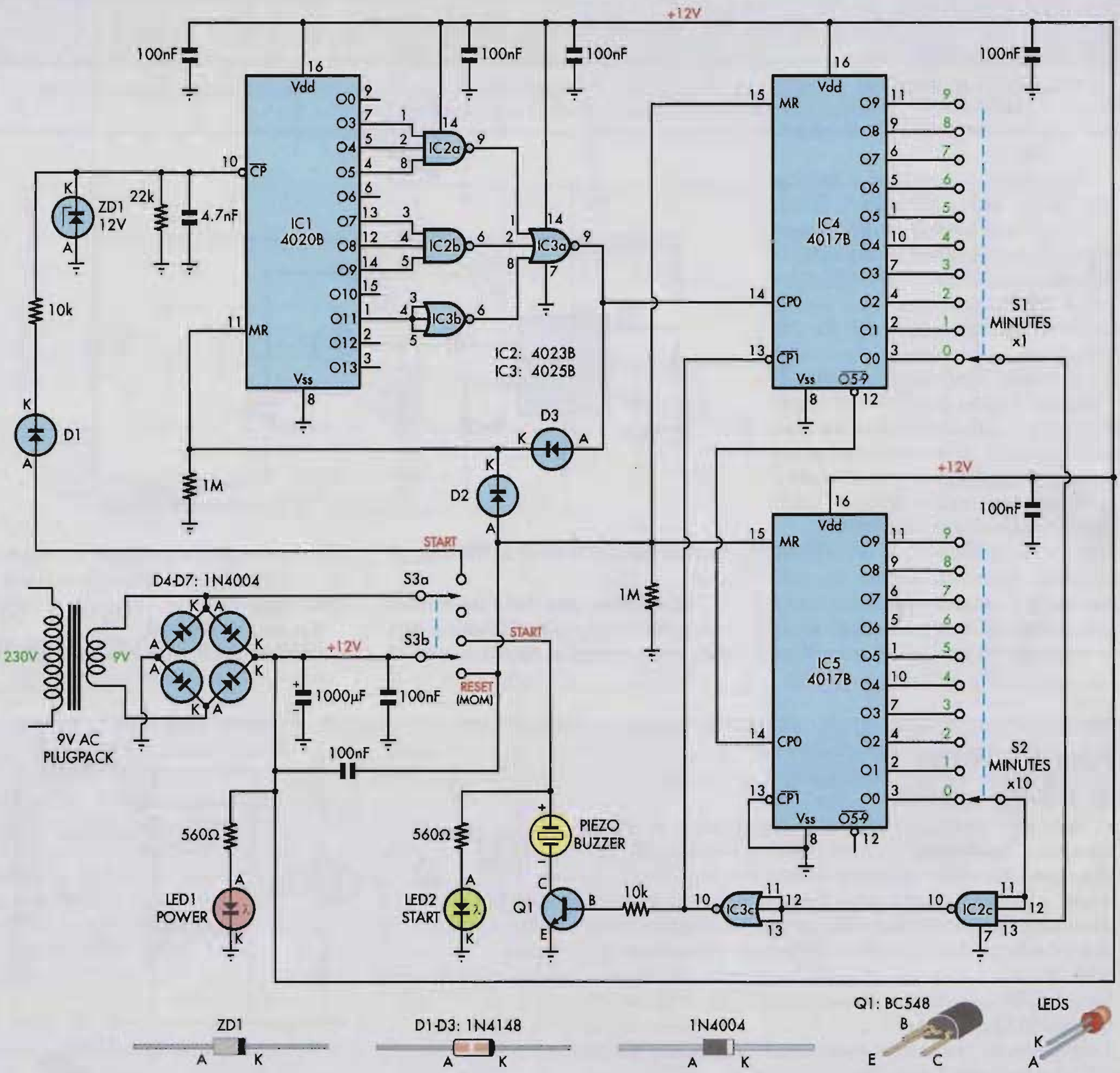
Once the resistance of the moisture sensor falls below about 4MΩ, Q1 will turn on as will Q2 and this powers the piezo alarm. It will continue to beep for about 15 seconds until the 2200µF supply capacitor is discharged. The 2200µF capacitor is charged by the 56kΩ resistor from the 9V battery supply. When the sensor has been dried out completely, the circuit can be used again and recharging of the 2200µF capacitor will take about five minutes.

When the moisture sensor is open-circuit (ie, no moisture is present), the standby current is almost solely dependent on the leakage of the electrolytic capacitor. For a good capacitor, this should only be a few microamps so battery life should be very long.

Any general-purpose small-signal silicon NPN transistors can be used. The alarm sounder is a Jaycar AB-3456 with the yellow and black leads connected for pulse (beep) operation. The red lead is not connected.

The sensor is made up from a strip of Veroboard, with alternate tracks bridged together and 1mm copper wire strips soldered along the tracks to keep the board slightly raised off the floor. The sensor is then lacquered and the wire strips slightly sanded for exposure to floor contact. The circuit, 9V battery and sounder were fitted into a small plastic utility box (UB5) with a circular cut-out for the alarm.

Warwick Talbot,
Toowoomba, Qld. ($40)



Accurate timer locked to 50Hz mains supply

This timer is very accurate, has long-term stability and requires no calibration. It does not use a crystal-controlled oscillator or a PIC with an internal resonator. Instead, it uses the 50Hz mains to derive its clock pulses. In the form presented here it is a kitchen minute timer but the design can be extended to include seconds or hours as required.

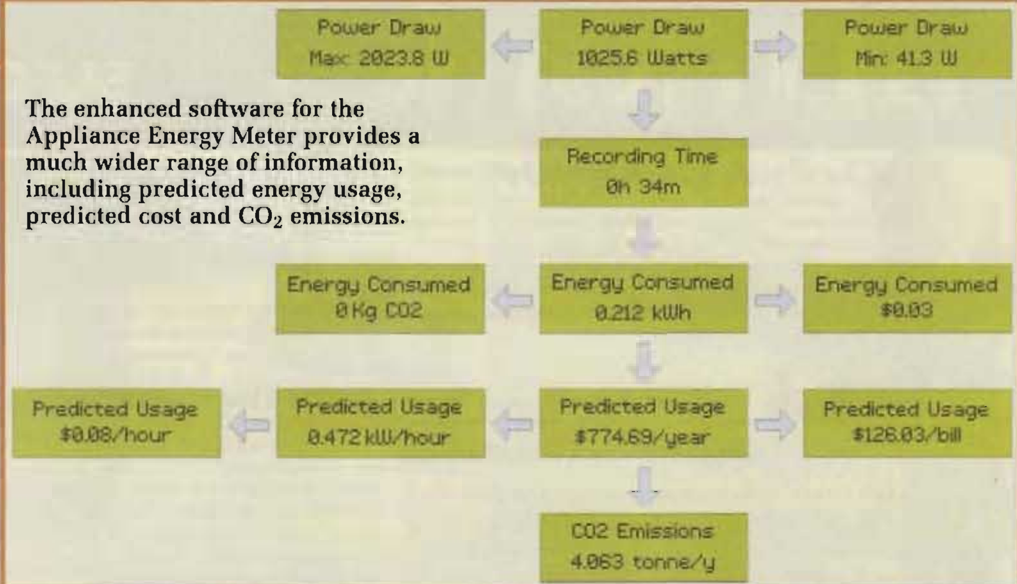
Power is provided by a 9V AC plugpack which is rectified to supply a DC voltage of between 12V & 13V. When power is first applied, all counters are automatically reset.

Switch S1 is a DPDT (double-pole, double-throw) type with a centre-off position. One side is a momentary contact which is used to reset the timer. The other side of S1 provides power to the alarm which will sound at the end of the timing period. It also provides half-wave rectified 50Hz pulses via diode D1 to IC1, a 4020 14-bit binary counter. The centre-off position will turn off the alarm which will sound continuously until attended to.

The 50Hz pulses are fed to the clock input (pin 10) of IC1 after signal conditioning by an RC filter (22kΩ & 4.7nF) and clipping by zener diode ZD1. Since we are interested in obtaining a 1-minute interval, IC1 is used to count 3000 of the 20ms pulses from D1. A count of 3000 in binary is 101110111000 so we need to detect when outputs Q4, Q5, Q6, Q8, Q9, Q10 & Q12 are simultaneously high. This is achieved using NAND gates IC2a & IC2b and NOR gates IC3b & IC3a. The output of IC3a supplies a reset pulse to IC1 and clocks decade counter IC4, a 4017.

IC4 counts single minutes and on reaching a count of 10, resets itself and advances the count on IC5 which counts 10s of minutes.

Geoffrey Graham is this month's winner of a Peak Atlas Test Instrument



The enhanced software for the Appliance Energy Meter provides a much wider range of information, including predicted energy usage, predicted cost and CO_2 emissions.

Enhanced software for the Appliance Energy Meter

The Appliance Energy Meter described in the July & August 2004 issues has been popular and is still available in kit form from Altronics (Cat. K4600). The original firmware was written in assembler and could only display a limited number of measurements (watts, accumulated kWh and cost).

This replacement firmware is written in the C language and uses 32-bit floating point routines to provide a much wider range of information, including predictions of the energy cost over time and CO_2 emissions. The above diagram shows all the readings that you can call up.

To install the new firmware you need to replace the original PIC-16F628 microcontroller with a PIC-16F88-I/P. The 16F88 is pin-for-pin compatible with the original microcontroller but has double the program memory and this is used to implement the new functions.

The only function of the original design that the new firmware does not cater for is brownout detection. As compensation, you get a much faster update rate (every second) compared to the original design (every 11 seconds).

To install the new firmware, simply download the HEX file from the SILICON CHIP website, program it into a PIC16F88-I/P microcontroller and install it in the Appliance Energy Meter. No other modifications are required.

To reset the meter and start accumulating a new set of readings you press the CLEAR button. The FUNCTION button will step you down through the five "layers" of readings as shown in the diagram. The UP and DOWN buttons will step you right or left on a horizontal line.

To set up the meter you hold down the CLEAR button for five or more seconds and the display will change to the calibration settings. To adjust a setting, use the UP and DOWN buttons as required. To step to the next setting, press the FUNCTION button. When you have run through all the calibration settings the display will revert to normal measurement.

In total, there are five calibration settings: cost of electricity, number of days between electricity bills, the rate of CO_2 emissions per kWH (your electricity supplier can tell you this – check their website), zero setting and calibration factor. If you wrote down the settings for the last two in the original firmware, you can re-enter the numbers here. Alternatively, refer to the original article for details on setting them.

The firmware predicts energy usage by averaging the readings over time. For something that draws constant power, the prediction is accurate after a few seconds but for an appliance that varies its power (like a fridge) you will need to leave it connected for a few days until the predictions settle to a constant value.

You can use this technique to measure the real cost of running many appliances, including your computer, water pump and even your electric kettle. For example, you can connect this to your "power hungry" plasma TV and after a while it will have averaged the on/off times dictated by your viewing habits.

You can then display how much it will cost you per bill, per year and even how much it will contribute to global warming.

Geoffrey Graham,
Perth, W.A.

Note: all parts in the Appliance Energy Meter (including the display) operate at 230VAC. Be sure to disconnect it from the mains before opening the lid.

The timer is consequently capable of timing intervals up to 99 minutes. The time interval is set by switches S2 & S3 which select the appropriate outputs of IC4 and IC5.

When the selected outputs are both high, this condition is detected by NAND gate IC2c and inverted by IC3c. The resulting high input is applied to pin 13 of IC4, inhibiting further counting. The high also turns on BC548 transistor Q1 which sounds the buzzer.

The buzzer continues to sound until power is removed from the buzzer circuit by returning switch S1 to its centre-OFF position.

As output 10 of IC2c is high throughout the timing period, it could be used to control a relay which would switch a device on for the timing period.

Jack Holliday,
Nathan, Qld. ($55)

A quick look at Australia's largest IT show . . .

CeBIT 2009

by Ross Tester

To stand out from the crowd (and believe me, it can be very crowded at CeBIT) you need something different. Whether that is a "wow!" stand (and there were a few of those) or a "gee whiz!" product, you needed something to stop the passers-by passing by . . .

At the very least you need something to make visitors remember you, your stand, your products or at least your name.

Bags displaying a name or logo (or both) are very popular, if only to carry home all the brochures before they're put in the recycling bin. Last year, I recall one of the stands handing out monster-sized yellow bags. Everywhere you looked, you saw those bags. The smaller bags that everyone else handed out were stuffed inside the big bags! I also recall talking to the stand staff and their philosophy was simple: the guys with the biggest bags win. Yep, they won at least as far as exposure was concerned.

While there was none of that this year (an edict from the organisers, maybe?), the NSW Government stand certainly took the prize for the best-bag-at-show. None of your Woolies and Coles bio-degradable politically correct bags here: your taxes went into a you-beaut, zippered (waterproof?) bag complete with compartments for your mobile phone and business cards. (And there were a lot of those bags with similar-sized bags crammed into them so I guess they won this year!).

But of course, CeBIT is much more than bags. It's about getting your message out to those who are interested (or might become interested if you're a good talker) into buying your product or service.

To be frank, I find it hard to comprehend the number of stands at shows like CeBIT all trying to flog the same type of products. There were countless companies selling countless software applications – it would appear that anything that started with an "e" was available: emarketing, ecommerce, elearning, etracking, epayments, ehr (how you can have e human resources is a bit beyond me) and so much more – even egovernment, courtesy of Kevin's sales team.

I noticed a lot more companies specialising in wireless – long range wifi figured prominently once again, as did several companies specialising in the "nuts and bolts" of wireless LANs and WANs, everything from the electronics right down to the connectors.

And there were the ubiquitous "sign up now special CeBIT deals" for all manner of goods and services. Not the least was "only while show lasts" broadband special offers. I'm not convinced those people going to CeBIT would fit the demographic of wanting to switch ISPs etc but given the number of them and the fact that they come back year after year, they must figure it's worth it.

If you look closely, you might notice the new "Shuttle X50" all-in-one PC... it's due to go on sale at the same time as this issue of SILICON CHIP.

One such company I spoke to (who must, of course, remain nameless) said that they were definitely questioning their CeBIT attendance next year. They had already reduced the size of their stand to a quarter what it used to be, mainly because the number of leads had been steadily decreasing over the past three years. They had over 500 the first year and were even happy with the 350 the following year. Last year it was down to 250 and when I talked to them late on the second day, their follow-up book had just over a hundred entries in it.

That's a pretty expensive form of advertising, even if – and it's a big if – those hundred are quality leads. It's not just the floor space (expensive!) but building and fitting out the stand (expensive!) staffing it for the four days (expensive!) . . . you get the picture.

CeBIT, held from May 10-12, occupied three halls at Sydney Convention and Exhibition Centre so it's no small show! It's broken down into quite a number of areas which specialise in certain fields – for example, VOIP, networking, wireless, telecoms, smart cards, RFID, POS, navigation, IT security, business software (almost a whole hall), data centres, IT hardware, financial services and so on.

Then there were the various Government stalls (Australian, state and overseas) which, given their large budgets, mostly had the largest areas.

Many of the big players in the IT game were present but many were conspicuous by their absence. One of the big boys that was there, raising my eyebrows at least, was Google. When a company name has entered the lexicon as a noun and verb in its own right (you don't search on line any more, you Google!), one wonders which market they were addressing at CeBIT!

Newsprout, an ISP based on the north coast of NSW, had an interesting gimmick: handing out tiny plants (Vibirnum, a very hardy, easily grown shrub in any sunny or partly shaded position with moist well-drained soil, if you were wondering!) – in keeping with their name. A lot of their push was "green" but they also claimed to be able to keep up with the big boys when it came to service and speed. (www.newsprout.com.au).

One of the most popular stands, at least at the time I was there, was Altech Computers. They had quite a variety of "new and unusual" products but the one that took my eye was the very new "Shuttle" X50 all-in-one PC. It's a 15.6-inch LCD touchscreen with the PC built in. No keyboard, no mouse. It suits a wide range of applications including digital signage, kiosks, etc. It was so new at the time they only had one in the country – the one on display – but they expected stock to arrive around now (www.altech.com.au)

The CSIRO had a rather interesting stand, not only because of the variety of applications displayed but also because of the experts they had on the stand to explain the applications and what the CSIRO is doing. Of particular interest was one of the Government's big "pushes" at the moment, broadband to the bush: the CSIRO has developed a wireless system which uses existing infrastructure to deliver 12 megabit/s internet access up to 100km from the antenna. An upgraded system will deliver over 50 megabits/s. (www.csiro.au).

One tiny stand (the smallest available!) had a real show-stopper, at least if the show crowds stopping were any guide. Scinet are the Australian distributors for Dino-Lite handheld microscopes, which plug into a USB port. I was impressed with the very-close-up display of PC board soldering. They had two models on display, both priced under $500 and they seemed to give a very good account of themselves. (www.scinet.com.au)

They reckoned this notebook case was rugged enough to go onto building sites and be walked on, even driven over!

IT security, both data and hardware, was featured heavily. With laptop/notebook sales now far exceeding desktop machines, Trace Technologies were proudly showing off their "Laptop Cop" system which not only lets you find out where your stolen laptop is (they claim to within 15m via cell triangulation!) but lets you control it when the crook uses it on the 'net for the first time – without the thief's knowledge. So you can remotely delete or retrieve important or sensitive files, then get it back (and hopefully apprehend the thief). (www.tracetechnologies.com.au)

Another "felon"-related application was the Federal Government's "CrimTrac" system – the award-winning crime-fighting tool. CrimTrac was established to allow police forces across Australia to share information, to solve crimes and catch criminals.

It's now evolved into a national automated fingerprint ID system, a national criminal investigation DNA database, a national Child Sex Offender register and a national Police Reference System providing rapid access to operational policing data. CrimTrac's record is already very impressive and we hope to provide more insight into this system in the future. (www.crimtrac.gov.au)

Data recovery was also a feature – and we plan to look at this area in significantly more detail in the future. One company was demonstrating its approach to the subject with a number of open, spinning hard drives. I don't think Xyber Data Recovery expects them to ever work again but they looked impressive. As well as hard disks, they also extract data from bent flash, tape, RAID and so on. (www.xyber.com.au)

Away from the halls was another part of CeBIT, the virtually continuous seminars and presentations by and for industry luminaries. We didn't have the time to attend any of these but if the number of press releases they generated is any guide, they were well received. There were also numerous

Scinet's Dino-lite handheld (or in this case stand-held) USB microscopes.

anyone-can-attend seminars held inside the CeBIT display halls, of particular note those of telecoms guru Paul Budde. We did manage to poke our head into one of these, if only for a few minutes. When deadlines loom, seminars are an unaffordable luxury.

Overall?

One of the main reasons we look at shows like CeBIT (and let's face it, CeBIT is the largest such show in Australia) is to see where the IT industry is up to and to keep abreast of the latest and greatest products.

From that point of view, CeBIT was, with some exceptions, disappointing this year. Sure, there was lots of razamatazz but there wasn't all that much in the way of innovation.

But as we said earlier, we go to keep abreast of the "IT" times and from that point of view, quite worthwhile. SC

We spotted these earphones (?) on the Korean Business stand. They don't go in the ear but on the ear, allowing you to still hear ambient sound (eg, sirens). They sounded good, too!

Calibrating, Setting the Battery Capacit

Last month we presented the full description, operation and construction details of our new Battery Capacity Meter. This month we guide you through the once-only setup and calibration. We also explain in detail how to use it!

Part 2 – by Mauro Grassi

Assuming you have completed the Battery Capacity Meter and installed it in its case, now it's time to calibrate it and set it up, ready for use.

We've also shown the various LCD readouts and what they mean – sorry the type is so tiny but we had to get a lot of information in!

After use, most of these screen messages and sub-menus will become very much self-explanatory and common sense. And you can always refer back to this article if you need to!

One Time Calibration

To calibrate the meter, you will need to follow these steps:

(1) Measure the voltage between pin 2 (GND) and pin 1 (+5V Rail) of CON4 using a DMM. Note this voltage and enter it in the **CALIBRATION>Set +5V Rail** SubMenu;

(2) Measure the voltage between pin 2 (GND) and pin 5 (Low Battery Voltage) of CON4 using a DMM. Note this voltage and enter it in the **CALIBRATION>Calibrate Lo. Divider** SubMenu;

(3) Measure the voltage between pin 2 (GND) and pin 6 (High Battery Voltage) of CON4 using a DMM. Note this voltage and enter it in the **CALIBRATION>Calibrate Hi. Divider** SubMenu;

(4) Enter the value of your shunt resistance (in mΩ) in the

```
Standby
```

STANDBY Mode: This flashes periodically when the meter is in standby mode. It goes into Standby mode when the load & charge currents are below the set threshold. USB must be disconnected for this to occur. In Standby mode, the meter consumes minimal power, turning the LCD backlight off. Use S1to bring the meter out of standby.

```
Voltage Too Low
Shutting Down...
```

SHUTDOWN Mode: This message appears briefly before the meter shuts down due to the battery voltage being lower than the shutdown voltage. This is a fail-safe way of protecting the battery. For example, a 12V SLA battery, it should not be discharged below 11V.

```
USB is Connected
Cannot Shut Down
```

TURN METER OFF SubMenu Message: This message appears briefly if you've requested to turn off the meter manually by going to the 'Turn Meter Off' submenu and confirmed the action but the USB is connected. Since power is delivered through the USB, the meter cannot perform the requested action.

```
<1:Battery Menu>
<2:Calibration >
```

This shows the typical view of a menu. A Submenu is enclosed in '<' and '>' brackets. Here the top two entries of the Main Menu are shown. You can press 'A' and 'B' to go up and down the menu and the corresponding number to enter the SubMenu. For example, pressing 1 here takes you to the Battery SubMenu. The strings scroll from right to left to show the entire name of the SubMenu.

```
[1:Beeper Statu]
[2:Average Samp]

[1:eper Status:]
[2:erage Sample]

[1:er Status: O]
[2:age Samples:]

[1: Status: On ]
[2:e Samples: 3]

[1:tatus: On   ]
[2:Samples: 30.]

[1:tus: On     ]
[2:mples: 30.0 ]
```

The typical view of a SubMenu as a sequence of snapshots from top to bottom. A submenu item that has no other SubMenus is enclosed in '[' and ']' brackets.

Top two entries of the System SubMenu are shown. Press 'A' and 'B' to go up and down the SubMenu and the corresponding number to enter the SubMenu – eg, pressing 1 takes you to the Beeper Status SubMenu to enable or disable the beep.

The strings scroll from right to left to show the entire name of the SubMenu, as well as any values of the relevant settings. This sequence shows how the SubMenu items scroll from right to left and how the value of the setting is shown in the scrolling string. The top line contains the string 'Beeper Status: On' indicating that the beeper system is enabled. You can change it by pressing 1. The bottom line contains the string 'Average Samples: 30.0' indicating that presently, 30 readings are averaged at a time. You can change the number of readings that are averaged by pressing 2. If you changed the number of average samples to 120, then on returning to this SubMenu, the bottom string would read 'Average Samples: 120.0' instead.

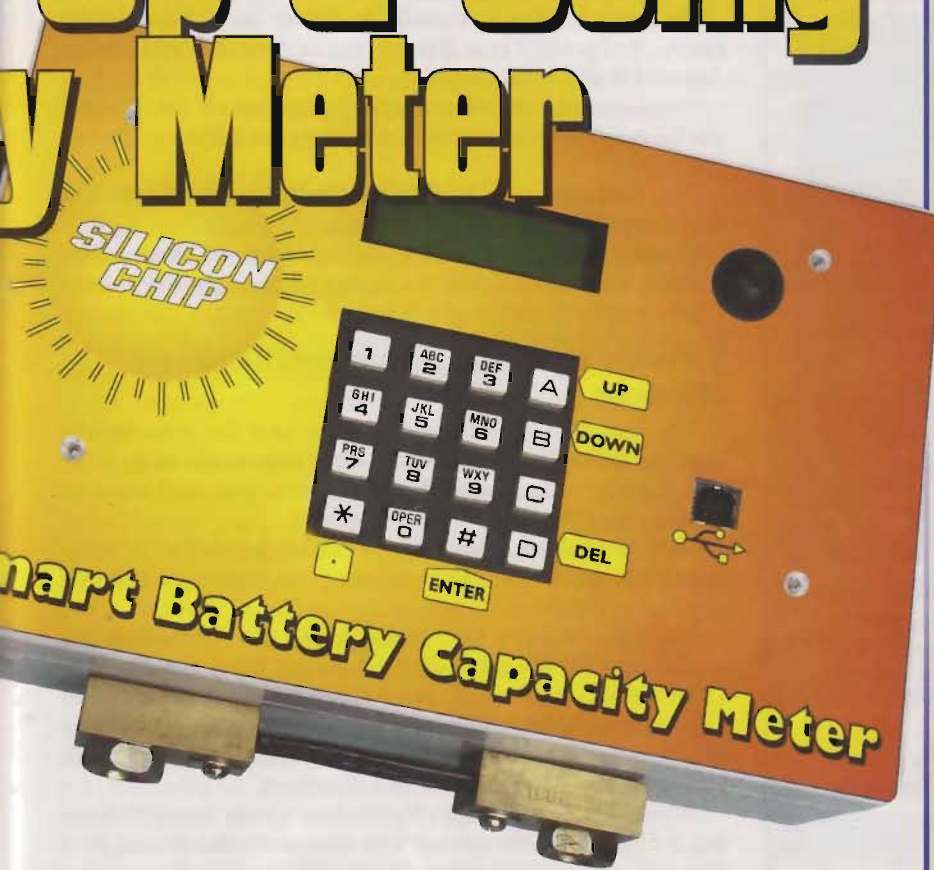
For numerical settings, enter the new value by using the number keys, the key '*' is for a decimal point & the key 'D' is used as backspace if you make a mistake in typing ('D' is for Delete). When you are satisfied with the entered value, press the '#' key to enter the value. If no input is entered but you then press the '#' key to exit, the current value of the setting is retained.

For values which are not numerical, you use the 'A' and 'B' keys to vary the value up and down, respectively, and use the '#' key to exit the SubMenu.

Most settings are numerical, where the range is also shown and you must enter a number in the valid range for the new value to be accepted.

Here are the various system messages and their meanings. Also shown is a sequence of screens depicting how the SubMenus appear on the LCD readout.

Up & Using y Meter



CALIBRATION>Shunt Resistance SubMenu;

(5) Enter the **CALIBRATION> Calibrate Current** SubMenu. Apply a small load of say a few amps to the LOAD terminal through a DMM. Note the current registered on the DMM and enter it;

(6) Enter the value of the gain of the load amplifier (usually 60.0 for the MAX4080SASA) in the **CALIBRATION>Load Amp. Gain** SubMenu;

(7) Enter the value of the gain of the charge amplifier (usually 60.0 for the MAX4080SASA) in the **CALIBRATION>Charge Amp. Gain** SubMenu;

(8) Enter the value of your sense resistance (usually 10Ω) in the **CALIBRATION>Sense Resistance** SubMenu;

(9) Enter the **CALIBRATION>Detect Sense Resistance** SubMenu. Connect the DMM in series between the GND terminal of the meter and the negative battery terminal. Note the instantaneous circuit current and enter it (in mA);

That completes the calibration.

One-time user setup

After the calibration is performed, you should run through the following checklist to set up your preferences:

(1) Go to the **BATTERY** SubMenu;

(2) Enter the full capacity of your battery in the **Battery Capacity** SubMenu;

(3) Enter Peukert's constant in the **Peukert's Constant** SubMenu if you are using a Lead Acid battery;

(4) Enter the cell chemistry in the **Cell Chemistry** SubMenu;

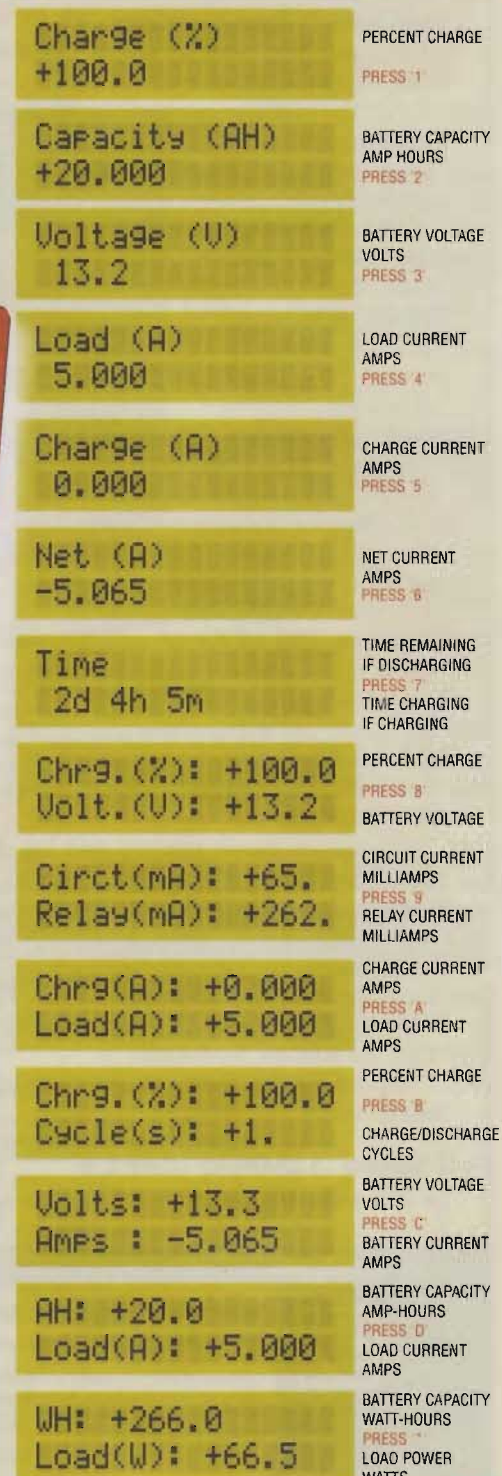
(5) Enter the charging efficiency in the **Charging Efficiency** SubMenu;

(6) Enter the cycle threshold in the **Cycle Threshold** SubMenu;

(7) Exit the **BATTERY** SubMenu;

(8) Go to the **DISPLAY** SubMenu and set up the display backlight preferences like brightness and time out period;

(9) Go to the **DETECTION** SubMenu;



PRESS '0' TO SEE ALL READINGS, IN SCROLLING MODE. PRESS '#' TO ENTER THE MENU SYSTEM AND CHANGE SETTINGS.

This shows all the available readings. Each is chosen by a single digit press on the alphanumeric keypad. For example, if you wish to display the battery voltage, type '3'. Or if you wish to see the battery capacity in Watt Hours and the load in Watts, press '*'. Notice that from here, you may press '#' to enter the extensive menu system. The remaining panels illustrate in detail the various submenus.

(10) Enter the voltage below which to shut down in the **ShutDown Voltage** SubMenu;
(11) Enter the low capacity alarm threshold in the **Capacity Alarm** SubMenu;
(12) Enter the standby current threshold in the **Standby Threshold** SubMenu;
(13) Enter the trickle current threshold in the **Trickle Current** SubMenu;
(14) Enter the minimum voltage of your battery in the **Min. Voltage** SubMenu;
(15) Enter the maximum voltage of your battery in the **Max. Voltage** SubMenu;
(16) Enter the Detection Period and number of detection points in the **Detection Period** and **Detection Points** SubMenus;
(17) Exit the **Detection** SubMenu;
(18) Enter the **SYSTEM** SubMenu;
(19) Choose whether to enable or disable the audible alarm in the **Beeper Status** SubMenu;
(20) Choose the number of samples to average in the **Average Samples** SubMenu;
(21) Exit the **SYSTEM** SubMenu;
(22) Enter the **RELAY** SubMenu;
(23) Choose whether you will use an external relay in the **Relay System** SubMenu;
(24) If you are not using a relay, go to step 29; otherwise continue.
(25) Enter the relay coil resistance in the **Relay Coil Resistance** SubMenu;
(26) Enter the overload current and its duration in the **Max. Load Current** and **Max. Current Duration** SubMenus;
(27) Enter the relay off voltage in the **Relay Off Voltage** SubMenu;
(28) Enter the relay hysteresis value in the **Relay Hysteresis** SubMenu;
(29) Exit the **RELAY** SubMenu;
(30) If required, set up the logging options in the **LOGGING** SubMenu.

Full Speed (12Mbps) USB 2.0

The firmware implements a USB 2.0 full speed bulk transfer bidirectional endpoint (EP1) with packet size set to 112 Bytes. This is used to communicate with the host program on the PC (battcap.exe) through the custom Microchip driver (MCHPUSB).

We explain how to install the driver on Windows OSs below. Endpoint 0 is implemented as well, as that is mandatory for any USB device.

A transaction between the host program on the PC and the battery meter consists in sending a 112-Byte packet to the meter.

The firmware will decode the packet, according to the sent command, and update itself accordingly.

The meter can also send logging data to the PC. Remember that the USB driver must be installed correctly for this to work. Instructions are given below.

Software setup and driver installation for Windows

The meter's USB device interface uses the generic Microchip driver for Windows. Before communicating with the display using the PC host program, you will need to install this driver.

This section explains how to install the driver in Windows XP, although other versions of Windows will be similar.

You should have first downloaded the Microchip installer (*MCHPFSUSB_Setup_v1.3.exe*) from the SILICON CHIP website and ran it. Note that you must use version 1.3. Older or Newer Versions may not be compatible. This will (normally) install the driver in the *C:\MCHPFUSB\Pc\MCHPUSB Driver\Release* directory.

When you first connect the meter to your computer using a USB cable, Windows will recognize the device as a "Meter" and a "Microchip Custom USB device".

The 'Found New Hardware' Window appears as shown in Fig.8 and you should select the "No, not this time" option and click "Next". You will be presented with the next screen as shown in Fig.9. Select "Install from a list or specific location" and click "Next" again.

The final screen is as shown in Fig.10. Select "Search for the best driver in these locations" and enable the "Include this location in the search" box as shown. Now click the

Fig.8: this Window appears when the meter is connected to a PC for the first time, using the USB interface.

Fig.9: use the "install from a list or specific location" option to select the correct driver to install.

"Browse" button. In the "Locate File" window that appears, navigate to where the MCHPUSB files were installed. Normally it will be *C:\MCHPFUSB\Pc\MCHPUSB Driver\Release*. Choose the file "mchpusb.inf". Select that file, and then click "Next".

Windows should install the driver.

If the driver is installed correctly you should be able to see the meter in device manager (under Control Panel>System (Hardware Tab)), as shown in Fig.11.

Using the PC host software

To install the PC host program, first download the compressed file **battcap.zip** from the SILICON CHIP website www.siliconchip.com.au (go to the downloads section under July 2009).

Extract the files in the zipped file to a directory on your hard drive. There should be these files:

(1) **battcap.exe**: this is the executable command line program.

(2) **battcap.map**: this is an internal file, needed for the host program to work properly. As long as it is copied to the same directory as battcap.exe the program will recognise it.

This file is produced by the C compiler of the firmware. It contains memory mapping information for the firmware produced by the linker. When and if the firmware is updated, the map file will change.

Using the software

Battcap.exe is a command line program () with three options. The -i option is used to get system settings ('i' stands for information). A screen grab is shown in Fig.12. So you would type at the command prompt: battcap -i.

The -x option is used to get the current readings which will update continuously every second or so (a screen grab is shown in Fig.13).

Finally, the -l option is used for data logging. You will be asked to confirm whether you wish to transfer the data to your PC (as this will empty the local buffer). If you choose 'Yes', you will be prompted for a file name (it should have a .csv extension). The default file name will contain the local time and date.

The data dumped to that file will be in Comma Separated

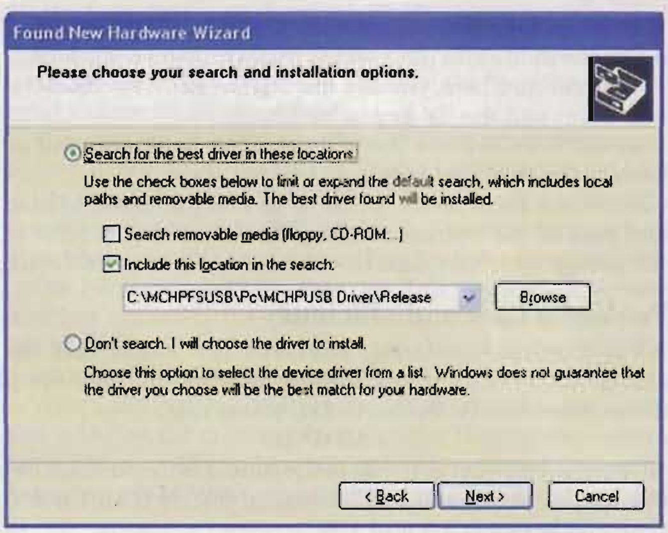


Fig.10: selecting the path to the driver previously downloaded from the SILICON CHIP website.

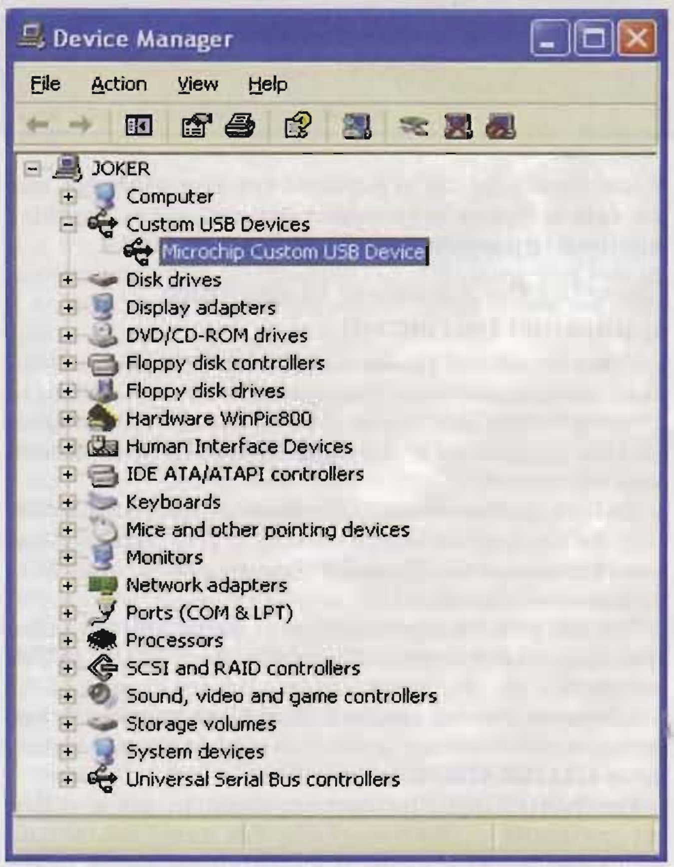


Fig.11: a view of Device Manager when the driver has been correctly installed and the meter is connected via the USB.

BATTERY SUBMENUS

```
Proceed?
*: Yes    #: No
```

DECLARE FULL NOW SubMenu: Use this menu to declare that the battery is now full. Press '*' to confirm the action and '#' to cancel it.

```
Capacity (AH)?
 0.0   - 999999.0
```

BATTERY CAPACITY SubMenu: enter the capacity of the battery in Amp-Hours from 0 to 999999 AH.

```
Peukert's?
 1.000- 2.000
```

PEUKERT'S CONSTANT SubMenu: enter the value of Peukert's constant for your battery. Allowed input is from 1.0 to 2.0. Typically 1.1. This only applies to Lead-Acid batteries.

```
Chemistry?
1: Lead Acid
```

CHEMISTRY SubMenu: sets the Chemistry. Use 'A' and 'B' to change the value and '#' to finish. Allowed values are Nickel or Lead-Acid. Note that Nickel includes both NiMH and NiCad.

```
Efficiency (%)?
 0.1   - 100.0
```

EFFICIENCY SubMenu: sets the charging efficiency of your charger/battery combination. It is a percentage between 0.1 and 100. Typically 80%.

```
Cycle Thr. (%)?
 10.0 - 40.0
```

CYCLE THRESHOLD SubMenu: sets the cycle detection threshold. It is a percentage between 10 and 40. Typically 25%. This also clears the cycle count.

DISPLAY SUBMENUS

```
Brightness (%)?
[██████████]+100.
```

BRIGHTNESS SubMenu: sets the brightness of the LCD Backlight. Use the 'A' and 'B' buttons to change and '#' to set. The value is a percentage of full brightness.

```
Timeout (sec)?
 0.    - 86400.
```

TIMEOUT SubMenu: sets the backlight timeout period in seconds. Typically 15 seconds.

CALIBRATION SUBMENUS

```
+5V Rail (V)?
 4.00 - 6.00
```

SET 5V RAIL SubMenu: calibrates the ADC system by entering the voltage of the 5V rail.

```
Lo. Voltage Now?
 0.00 - 60.00
```

CALIBRATE LO DIVIDER SubMenu: calibrates the low voltage divider. Enter the voltage at the Low Battery terminal, pin 5 of the calibration connector.

```
Hi. Voltage Now?
 0.00 - 60.00
```

CALIBRATE HI DIVIDER SubMenu: calibrates the high voltage divider. Enter the voltage at the High Battery terminal, pin 6 of the calibration connector.

```
Shunt Res.(mΩ)?
 0.100- 9999.000
```

SHUNT RESISTANCE SubMenu: sets the value of the shunt resistance in milliohms. This value can be further automatically calibrated by using the CALIBRATE CURRENT SubMenu below.

```
Load Now (A)?
 0.000- 1000.000
```

CALIBRATE CURRENT SubMenu: calibrate the value of the shunt resistance automatically. This is calculated from the entered instantanenous value of the load current.

```
Load Amp. Gain?
 1.00 - 1000.00
```

LOAD AMP GAIN SubMenu: sets the value of the load amplifier gain. Typically, this is 60 for the MAX4080-SASA. For the MAX4080TASA it is 20.

```
Chrg. Amp. Gain?
 1.00 - 1000.00
```

CHARGE AMP GAIN SubMenu: sets the value of the charge amplifier gain. Typically this is 60 for the MAX4080-SASA. It is independent of the load amplifier.

```
Sense Res.(Ω)?
 0.1   - 100.0
```

SENSE RESISTANCE SubMenu: sets the value of the sense resistor in Ohms. Typically this is 10. This can also be automatically set by using the DETECT SENSE RESISTANCE SubMenu below.

```
Circt. Now (mA)?
 0.000- 1000.000
```

DETECT SENSE RES. SubMenu: automatically calibrates the value of the sense resistor by entering the value of the instantaneous circuit current.

Values format and can be imported into a spreadsheet. Once the data is in your spreadsheet you can use its graphing functions to produce a graph, as shown in Fig.14.

Changing the hardware to suit your application (advanced)

There are several hardware values which can modified to suit your application. The sense resistor can be changed from the default of 10Ω (you should enter the correct value for your application in the **CALIBRATION>Sense Resistance** SubMenu).

You can choose to use a different version of the MAX4080 chip for the load or charge sensing if your charging currents are always much smaller than your load currents (to increase the resolution).

You can then change the value of the gain in the corresponding submenu (hint: they are in the **CALIBRATION** SubMenu).

Moreover, you can choose different resistors for the two voltage dividers as long as you then calibrate them by going to the **CALIBRATION** SubMenu.

You can change the current shunt to get a different maximum current range. In this case, you should both enter the new value of the shunt resistance in the **CALIBRATION>Shunt Resistance** SubMenu and then go to the **CALIBRATION>Calibrate Current** SubMenu and follow the prompts.

To turn power on, press S1. To see a particular reading, press the corresponding key on the keypad, according to the readings panel shown on p81. For example, to see the battery voltage you press '3'. To enter the menu system, press '#'.

Once in the menu system, use 'A' and 'B' to move up and down the menu and the number digits to enter a SubMenu.

To enter numbers, you use the digits, the '*' for the decimal point and the 'D' key as backspace.

In all cases you use the '#' to exit the SubMenu and go back to the previous menu.

From the main menu, press '#' to exit the menu system and restore the current reading. You should also refer to the panels which explain the menu system in more detail.

Peukert's Law and efficiency

For lead-acid batteries, Peukert's law states that the change in capacity is not a linear function of the current drain. Specifically, Peukert's law states that:

$$\Delta C = I^k \Delta t$$

where ΔC is the capacity, Δt is the time, I is the instantaneous current drain and k is a constant higher than 1.0 and typically between 1.1 and 1.3.

The meter will take into account Peukert's law when computing the capacity of the battery. The value of the

DETECTION SUBMENUS

Shutdown Volt.? 0.0 - 60.0	**SHUTDOWN VOLTAGE** SubMenu: sets the voltage below which the meter will shut down to protect the battery -- eg. 11V for a SLA Battery.
Alarm (%)? [████]+0.	**CAPACITY ALARM** SubMenu: sets the capacity below which the meter will emit an audible alarm. Use the 'A' and 'B' buttons to change and '#' to set. Typically 0%. It ranges from -60% to 100%.
Threshold (A)? 0.000- 99.000	**STANDBY THRESHOLD** SubMenu: sets the current threshold. When the load and charge currents are below this, the meter enters Standby mode. Typically 0.05A.
Trickle (A)? 0.000- 99.000	**TRICKLE CURRENT** SubMenu: sets the trickle current. When the charging current is below this the meter considers the battery to be trickle charging. Typically 1/100th of the AH capacity.
Min. Volt.(V)? 0.0 - 60.0	**MIN. VOLTAGE** SubMenu: sets the minimum voltage of the battery - eg, for a SLA this may be typically 11.5V, whereas for a NiMH battery this could be typically 1.1V per cell.
Max. Volt.(V)? 0.0 - 60.0	**MAX. VOLTAGE** SubMenu: sets the maximum voltage of the battery - eg, for a SLA this may be typically 13.8V, whereas for a NiMH battery this could be typically 1.2V per cell.
Check Prd.(sec)? 5. - 86400.	**DETECTION PERIOD** SubMenu: sets the detection period in seconds for synchronising the battery capacity. Typically 30 seconds.
Detection Pnts.? 1. - 16.	**DETECTION POINTS** SubMenu: sets the number of intervals in the detection period. Used only for Nickel batteries. Typically 4 points.
Last Sync. (ago) 0d 0h 1m	**LAST SYNC.** SubMenu: shows the time elapsed since the last time the battery capacity was synchronised. A value of N/A indicates the capacity has not been recently synchronised.

SYSTEM SUBMENUS

Beeper? 1: On	**BEEPER STATUS** SubMenu: enables or disables the beeper function using the 'A' and 'B' buttons. Use the '#' button to exit.
Average Samples? 0. - 120.	**AVERAGE SAMPLES** SubMenu: sets the number of samples that will be averaged for all readings. Typically this is 30.
Version 7.20	**FIRMWARE VERSION** SubMenu: shows the firmware version. Useful for debugging or reporting bugs or errors.
USB Connected Yes (6)	**USB CONNECTED** SubMenu: indicates whether the meter is connected to a PC via the USB. The number in brackets is the state of the USB enumeration - eg 0=DETACHED, 6=CONFIGURED.
Last Sync. (ago) 0d 0h 1m	**LAST SYNC.** SubMenu: shows the time elapsed since the last time the battery capacity was synchronised. A value of N/A indicates the capacity has not been recently synchronised.
Last Sample(ago) 0d 0h 0m	**LAST LOG SAMPLE** SubMenu: shows how much time has elapsed since the last log sample was captured.
Log Total Time 0d 0h 20m	**TOTAL LOG TIME** SubMenu: shows how much time has been logged in total. It indicates that this period of time has been logged.
Proceed? *: Yes #: No	**RESTORE DEFAULTS** SubMenu: restores default values for most settings. Note that hardware-dependent settings such as the sense resistance aren't changed.
Proceed? *: Yes #: No	**TURN METER OFF** SubMenu: turns the meter off. Note that USB power must be absent for this. The meter will turn off if the choice is confirmed by pressing '*'.

constant k will vary for different batteries and you must set this in the **BATTERY>Peukert's Constant** SubMenu.

There is no easy way to compute the correct k value for your system. It is there as a way of adjusting the meter if you have enough experience with the meter and wish to tune it.

Cell chemistry and synchronisation

By synchronisation, we mean that when certain conditions are met, the meter sets the capacity to either full or empty capacity automatically.

You can see at any time when the last synchronisation occurred by going to the **DETECTION>Last Sync.** SubMenu.

For example, when the meter detects the end of charge, it sets the capacity to full capacity. The synchronisation algorithms are different depending on the cell chemistry.

For Nickel-based batteries, the full capacity synchronisation occurs if the meter detects a trickle charge and the battery voltage is above the maximum voltage for the duration of the detection period.

When the battery voltage is detected to be dropping and is below the minimum voltage (for the duration of the detection period and is monotonically decreasing at each detection point) then the battery capacity is synchronised to zero.

This is because a Nickel battery's voltage will, once it has been discharged beyond a point, drop dramatically and quickly.

For a Lead Acid battery, the end of charge is detected if a trickle current and the battery voltage is above the maximum voltage for the duration of the detection period.

In this case, the battery capacity is set to full capacity again.

Note that there is no empty capacity synchronisation for Lead Acid batteries. However, you should note that Lead Acid batteries should never be discharged beyond a certain point or they will be damaged.

Set the detection period by going to the **DETECTION>Detection Period** SubMenu. A typical value is 30 seconds.

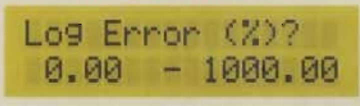
You should also set the number of detection points (only relevant for Nickel batteries). This is set at 4 by default.

The trickle current threshold can be set by going to the **DETECTION>Trickle Current** SubMenu. This is typically C/100 or so of the full battery capacity. So for a 20Ah battery this would be close to 200mA. It really depends on your charger, however.

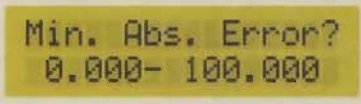
Set the Standby current (the current below which the meter will go into standby), by going to the **DETECTION>Standby Current** SubMenu. A typical value will be 50mA.

The meter considers any current higher than the standby current and lower than the trickle threshold to be a trickle current for the purpose of synchronisation.

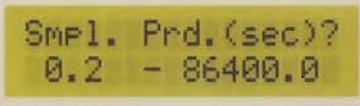
LOGGING SUBMENUS



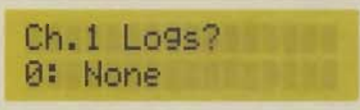
LOGGING ERROR SubMenu: sets the relative percentage error for logging RLE compression. The lower the error, the more resolution the data will exhibit. Typically 20%.



MIN. ABSOLUTE ERROR SubMenu: sets the minimum absolute error for logging RLE compression. The lower the error the more resolution the data will exhibit. Typically 0.1.

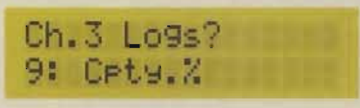


SAMPLE PERIOD SubMenu: sets the sampling period in seconds. Samples are taken at a frequency equal to the reciprocal of this period. The range is from 200ms-1day.

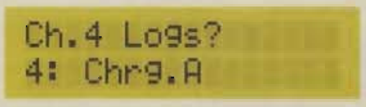


Ch. 1 LOGS SubMenu: sets what reading channel 1 logs. Use the buttons 'A' or 'B' to change and '#' to set. Here channel 1 is disabled.

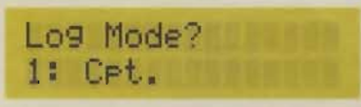
Ch. 2 LOGS SubMenu: sets what reading channel 2 logs. Use the buttons 'A' or 'B' to change and '#' to set. Here it is set to log the battery voltage.



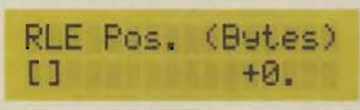
Ch. 3 LOGS SubMenu: sets what reading channel 3 logs. Use the buttons 'A' or 'B' to change and '#' to set. Here it is set to log the capacity percentage of full charge.



Ch. 4 LOGS SubMenu: sets what reading channel 4 logs. Use the buttons 'A' or 'B' to change and '#' to set. Here it is set to log the charging current.

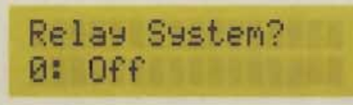


LOG MODE SubMenu: sets either CAPTURE mode (Cpt.) or OVERWRITE mode (Ovr.) for the RLE Buffer. Use the buttons 'A' or 'B' to change and '#' to set.

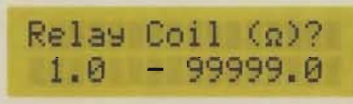


RLE BUFFER POSITION SubMenu: shows the state of the RLE Buffer. The brackets indicate the start and end of the buffer and its position. The number of bytes in the buffer is also shown.

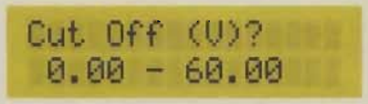
RELAY SUBMENUS



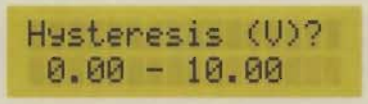
RELAY SYSTEM SubMenu: enables or disables the relay system using buttons 'A' and 'B'. Use '#' to exit. When the relay system is off, the relay remains off. Turn off if you are not using an external relay.



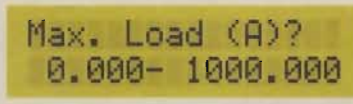
RELAY COIL RESISTANCE SubMenu: sets the resistance of the coil of the external relay (optional). If you are using a dropping resistor in series with the coil, enter the total (ie, sum) of the coil & resistor. If you are not using a relay, disable it in the RELAY SYSTEM SubMenu below.



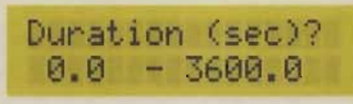
RELAY OFF VOLTAGE SubMenu: sets the voltage below which the relay switches off. Typically this is slightly higher than the minimum battery voltage.



RELAY HYSTERESIS SubMenu: sets the voltage hysteresis added to the cut-off voltage. The relay will switch back on when the voltage exceeds this sum.



MAX. LOAD CURRENT SubMenu: sets the maximum load current for overload protection. If the load current exceeds this current for the duration set below, the relay switches off. A soft-fuse then trips. It is reset by pressing S1.



MAX. CURRENT DURATION SubMenu: sets the maximum load current duration in seconds. The relay will switch off if the load current exceeds the max load current setting above for this time.

OVERLOAD FUSE STATUS SubMenu: shows the state of the overload fuse. The fuse trips if there is an overcurrent condition. The only way to reset the fuse is to press S1. 'Short' means that the fuse allows current, 'Open' that it has blown.

This panel and the ones on previous pages show the various SubMenus – Detection, System, Logging, Relay, Battery, Display, Calibration – in more detail and how to access their parameters. Each of the submenus has a number of options and these are displayed in the LCD readout as you step through.

Low capacity alarm

An alarm will be heard when the capacity of the meter falls below the set level (as a percentage). Go to the **DETECTION>Capacity Alarm** SubMenu to set the minimum capacity.

The minimum capacity ranges from –60% to 100%. The capacity of the battery will go negative if it is discharged beyond the zero point.

If you wish, you can disable the audible beeping by going to the **SYSTEM>Beeper Status** SubMenu and setting it to OFF.

Overload and under-voltage protection

An optional external relay can be connected to switch the load on and off. The charger can be left connected at all times, however, as shown in Fig.4 last month.

The relay energises to connect the load to the load terminal of the shunt, so the shunt terminal can connect to the relay common and the load can connect to the relay's NO (normally open) terminal.

Once the relay is installed, the microcontroller will control it.

If you decide to use a relay, make sure it is able to switch the required current.

For an 80A system we recommend a 150A relay (eg, Jaycar SY-4073). If you are using lower currents there are several 60A automotive relays available, eg, Jaycar SY-4074 or Altronics S-4339.

Note that these relays run from 12V. If your battery system is higher than 12V, a dropping resistor (in series with the relay coil) will be needed. Its value needs to be calculated from Ohm's law, taking into account the coil resistance of the relay.

For example, if your relay coil resistance is 180Ω and yours is a 24V system, a 180Ω 5W resistor would be used.

Similarly, for a 48V system you would need a 560Ω 5W resistor (actually 540Ω but 560Ω is the closest standard value).

A 1N4004 (or similar) power diode must be connected across the relay coil to quench any back-EMF when the relay switches off. See Fig.4 from last month.

Enter the value of the coil (or coil and series resistor) in the **RELAY>Relay Coil Resistance** SubMenu, as well as enabling the Relay System by going to the **RELAY>Relay System** SubMenu.

On an under-voltage condition the relay will turn off, switching off the load and thereby saving the battery from possible (and irrepairable) damage.

Note that the relay "off" voltage is usually slightly higher than the shut down voltage (the latter, typically, should not ever be reached and is only a fail-safe measure as detailed shortly).

The relay will only turn back on when the battery voltage rises above the sum of the relay off voltage and the relay hysteresis (both measured in Volts). This adds a measure of hysteresis avoiding 'hunting'. The trip point and hysteresis are set by going to the **RELAY>Relay Off Volt-**

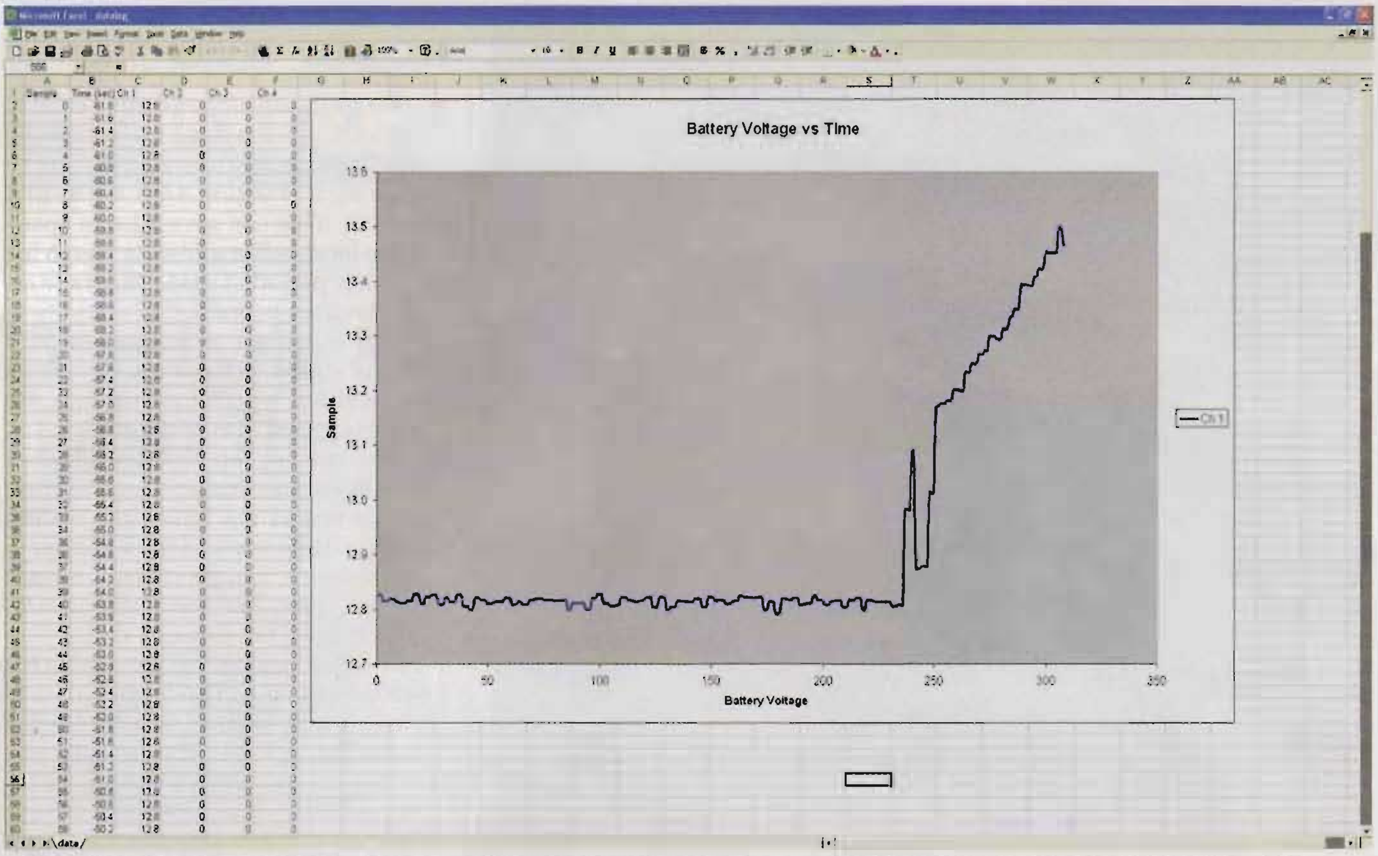


Fig.14: this screen grab is from the Microsoft Excel spreadsheet program. We have imported the CSV file obtained by running the command "battcap.exe -l" and graphed the battery voltage as a function of time.

age & **RELAY>Relay Hysteresis** SubMenus.

For an over-current condition, you set the maximum current and its duration before the relay switches off and trips a software fuse.

The relay (and hence the load) will remain off indefinitely after the fuse trips.

The only way to reset this software fuse is to press S1. The battery voltage should bounce back up once the load is disconnected.

Note that the relay will only turn back on once the voltage is above the sum of the relay off voltage and the hysteresis voltage.

The relay system should be switched off (**RELAY>Relay System**) if not used.

Fail-safe shutdown

When the voltage of the battery drops below the level set in the **DETECTION>ShutDown Voltage** SubMenu, the circuit (as well as the relay) will turn off.

This is a fail-safe measure and in normal operation should never occur. It is there to protect the battery in the last resort. After power is lost, the meter is turned on again by pressing S1. If the voltage is still too low, the meter will again shut down but not before you have a chance to access the menu system by pressing '#'.

This allows you to change any settings if needs be, before the meter shuts down (so you are never 'locked out' completely).

Note that when the meter has lost power and starts again, the capacity reading will revert to 50% and may not be accurate until the next synchronisation, or until you manually declare the battery at full capacity by going to the **BATTERY>Declare Full Now** SubMenu.

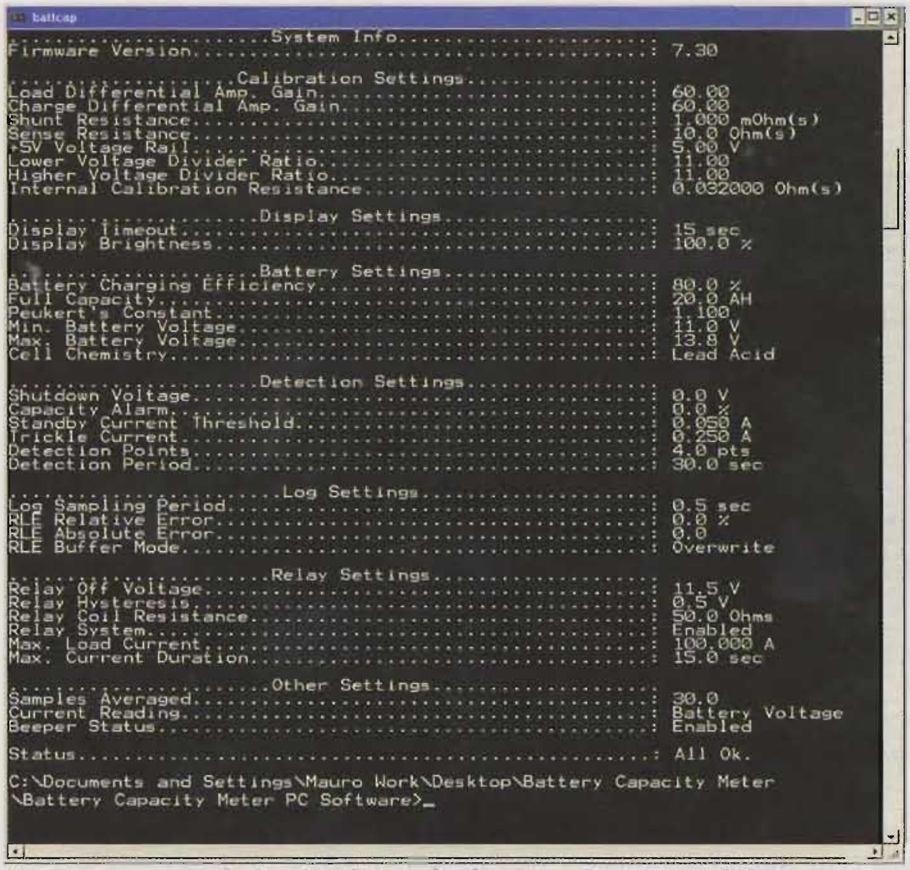
RLE compression

RLE (Run Length Encoding) Compression is used for data logging using an internal buffer.

Run-length encoding works by substituting a consecutive run of similar readings by a single reading and a multiplicity. For example, the sequence 1.0, 1.0, 1.0, 1.0, 1.0 would be encoded as (1.0, 5) to save space.

Depending on the set RLE Relative Error and the RLE Absolute Error, the compression is lossy or lossless.

It is lossless if both the errors are


battcap

```
....................System Info....................
Firmware Version..................................: 7.30

....................Calibration Settings....................
Load Differential Amp. Gain.......................: 60.00
Charge Differential Amp. Gain.....................: 60.00
Shunt Resistance..................................: 1.000 mOhm(s)
Sense Resistance..................................: 10.0 Ohm(s)
+5V Voltage Rail..................................: 5.00 V
Lower Voltage Divider Ratio.......................: 11.00
Higher Voltage Divider Ratio......................: 11.00
Internal Calibration Resistance...................: 0.032000 Ohm(s)

....................Display Settings....................
Display Timeout...................................: 15 sec
Display Brightness................................: 100.0 %

....................Battery Settings....................
Battery Charging Efficiency.......................: 80.0 %
Full Capacity.....................................: 20.0 AH
Peukert's Constant................................: 1.100
Min. Battery Voltage..............................: 11.0 V
Max. Battery Voltage..............................: 13.8 V
Cell Chemistry....................................: Lead Acid

....................Detection Settings....................
Shutdown Voltage..................................: 0.0 V
Capacity Alarm....................................: 0.0 %
Standby Current Threshold.........................: 0.050 A
Trickle Current...................................: 0.250 A
Detection Points..................................: 4.0 pts
Detection Period..................................: 30.0 sec

....................Log Settings....................
Log Sampling Period...............................: 0.5 sec
RLE Relative Error................................: 0.0 %
RLE Absolute Error................................: 0.0
RLE Buffer Mode...................................: Overwrite

....................Relay Settings....................
Relay Off Voltage.................................: 11.5 V
Relay Hysteresis..................................: 0.5 V
Relay Coil Resistance.............................: 50.0 Ohms
Relay System......................................: Enabled
Max. Load Current.................................: 100.000 A
Max. Current Duration.............................: 15.0 sec

....................Other Settings....................
Samples Averaged..................................: 30.0
Current Reading...................................: Battery Voltage
Beeper Status.....................................: Enabled

Status............................................: All Ok.

C:\Documents and Settings\Mauro Work\Desktop\Battery Capacity Meter
\Battery Capacity Meter PC Software>_
```

Fig. 12: a screen grab showing the result of running the command "battcap.exe -i" to get information on the current settings.


battcap

```
Battery Voltage...................................: 13.1 V
Battery Capacity..................................: 50.0 %
Relay Current.....................................: 262 mA
Circuit Current...................................: 38 mA
Load Current......................................: 0.000 A
Charge Current....................................: 0.000 A
Net Current.......................................: -0.300 A
Time..............................................: 1d 13h 34m
Battery Capacity..................................: 9.999 AH
Battery Power Capacity............................: 131.2 WH
Load Power........................................: 0.0 W
Cycles............................................: 1

Press Any Key to Stop.

Battery Voltage...................................: 13.1 V
Battery Capacity..................................: 50.0 %
Relay Current.....................................: 262 mA
Circuit Current...................................: 37 mA
Load Current......................................: 0.000 A
Charge Current....................................: 0.000 A
Net Current.......................................: -0.299 A
Time..............................................: 1d 13h 42m
Battery Capacity..................................: 9.999 AH
Battery Power Capacity............................: 131.1 WH
Load Power........................................: 0.0 W
Cycles............................................: 1

Press Any Key to Stop.

Battery Voltage...................................: 13.1 V
Battery Capacity..................................: 50.0 %
Relay Current.....................................: 262 mA
Circuit Current...................................: 38 mA
Load Current......................................: 0.000 A
Charge Current....................................: 0.000 A
Net Current.......................................: -0.301 A
Time..............................................: 1d 13h 30m
Battery Capacity..................................: 9.999 AH
Battery Power Capacity............................: 131.2 WH
Load Power........................................: 0.0 W
Cycles............................................: 1

Press Any Key to Stop.
```

Fig.13: this shows the result of running the command line "battcap.exe -x" – the real-time readings are displayed every second.

set to 0. If not, the compression will be lossy and can achieve a good compression ratio.

For example, if the relative error is set to 5%, the readings 1.0, 1.02, 1.03, 0.98, 0.99 will be encoded as (1.0, 5) since each is within ±5% of the first reading. This can save a lot of space in the local buffer allowing you to log a greater period of time. The trade off is of course accuracy.

RLE is simple to implement and ideally suited to this type of logging application, where the readings are changing slowly over time.

You can log up to four different readings at any time and each reading can be one of the following: battery Voltage, time remaining or charging, load current, charge current, circuit current, relay current, net current, capacity (AH) or capacity (%).

To set up logging, you go to the **LOGGING** SubMenu. The logging data is stored locally and can be downloaded to a PC using the USB interface.

Over time, this can become a useful set of data in monitoring the state of batteries to allow you to not only get peak performance but longest life.

Conclusion

As you can see, the battery capacity Meter has comprehensive features that will allow you to monitor the health of your battery and charger system.

It is not difficult to build and can be easily calibrated using a DMM. **SC**

Where to get the parts . . .

At least one supplier will be making a kit available for the Smart Battery Capacity Meter. It is possible there will be others but Altronics have indicated that their stores and mail/web order will have a kit soon (Cat K1700) for $175.00. www.altronics.com.au

If you wish to put together your own kit most parts are commonly available and you should have no problem obtaining them. One exception is the PC board, which (as with all SILICON CHIP boards) will be available in due course from RCS Radio, 41 Arlewis St, Chester Hill NSW 2162 (Ph 02 9738 0330).

The other component you may have problems with is the programmed PIC18F2550 micro. This is available direct from **SILICON CHIP** for $25.00 including P&P. See Page 37 in this issue for an order form and contact details.

Vintage Radio

By RODNEY CHAMPNESS, VK3UG

The Lyric 8-Valve Console From The 1920s

This view shows the rear of the chassis, with the valve cover for the RF stages removed. All the valves were still in working order.

Featuring no less than eight valves, the Lyric Model 70 broadcast-band receiver is an upmarket American-made set from the late 1920s. It's a tuned RF design with single-knob tuning and a number of interesting design techniques.

EXPERIMENTERS in the early days of radio produced some very ordinary looking receivers, mainly because they were forever changing things to improve the performance of their sets. Sometimes they were successful but mostly they just thought their set was definitely superior to their mate's set.

Those early sets were built on wooden boards and these were commonly referred to as "breadboards". In fact, some were built on a real breadboards, pirated from the kitchen!

The breadboard-style layout was a very convenient method of construction during the early days of radio, as it made it very easy to continually change a set's circuit or layout. As a result, experimenters' sets used this style of construction for many years and even today the term "breadboarding" is used when building makeshift circuits.

Breadboarding led directly to the so-called "coffin style" radios when companies began manufacturing domestic receivers in the early 1920s. In reality, these were breadboard sets with a nice wooden cabinet built around them, with a hinged lid on top that allowed ready access to the set's internals. This also made it easy to occasionally tweak the circuit for better performance.

Receivers in the 1920s were attractive pieces of lounge-room furniture and that certainly applied to many coffin-style receivers. However, as the 1920s progressed, most manufacturers quickly developed new methods for constructing their receivers. For a start, the top-of-the-line receivers needed to be more elegant in appearance. They also had to perform better and be easier to operate than the early 1920s sets.

In particular, those early receivers commonly used several single-gang tuning capacitors, a regeneration control and a filament control (for volume), which made them difficult to tune and adjust. What was wanted by the average user was a receiver with just one tuning control and a volume control that had no time delay (as occurred with filament rheostats). They also wanted sets that didn't whistle when the volume was increased above a certain level and they also needed to be more sensitive than the earlier 1920s models.

In short, ease of use was the aim and people were prepared to pay more for sets that met that aim.

Breadboard-style construction had reached its zenith during the 1920s. It was not easy to build relatively high-gain receivers with multiple radio frequency (RF) stages without shielding between the stages. What's more, these stages had to be close together in the later sets because people wanted single-knob tuning.

Initially, single-knob tuning was achieved by mechanically coupling single-gang tuning capacitors via metal bands. These were then coupled

The unit features a 4-gang tuning capacitor, a large drum-type dial and a plug-in capacitor box.

to a single tuning control. However, with the advent of multi-gang tuning capacitors, shielding became critical.

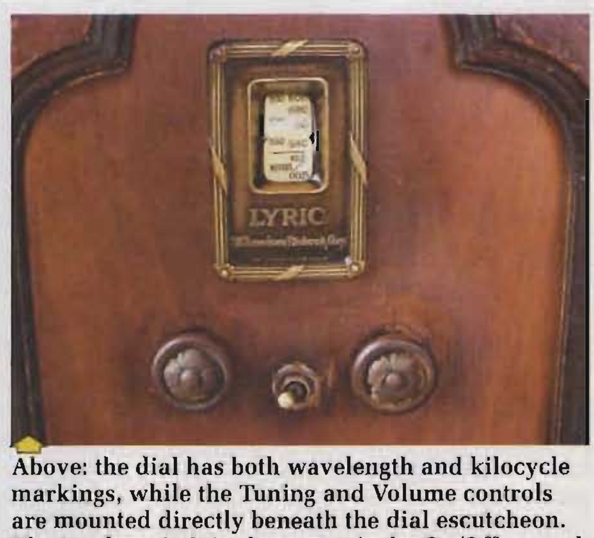
To overcome this problem, manufacturers hit on the idea of using a metal chassis – basically a "cake tin" turned upside down. A metal chassis had several advantages over the traditional breadboard: (1) it was possible to produce a layout that worked well with no feedback; (2) the shields for the RF coils were effectively earthed to the chassis, which made them more effective; (3) cut-outs in the chassis could be standardised so that assembly was easier to manufacture (and therefore less costly); and (4) more components could be used as they could be fitted both above and below the chassis while still retaining accessibility.

The downside was that many servicemen initially didn't like the idea of working on both sides of the chassis because the concept was foreign to them. The same sort of attitude initially greeted PC boards during the 1960s.

The Lyric Model 70

The Wurlitzer Company made many magnificent organs over many years but what is not so well known is that the company also dabbled in radio manufacture during the 1920s and early 1930s. In particular, the radios were made by the All-American Mohawk Corporation which Wurlitzer controlled.

Once such unit was the Lyric Model 70, which is a very interesting set from the 1920s era. The unit featured here is owned by Mark and has been overhauled by Marcus, both fellow enthusiasts in our local vintage radio club. In fact, the chassis was



Above: the dial has both wavelength and kilocycle markings, while the Tuning and Volume controls are mounted directly beneath the dial escutcheon. The toggle switch in the centre is the On/Off control.

Left: the iron-cored chokes, the speaker transformer and the electrodynamic speaker are all attached to each other to form a single assembly. This assembly is connected via a cable and plug to the chassis.

Another view from the rear of the chassis, this time with the perforated valve steel cover (for the RF valves) in place. The boxes at the back house the interstage audio transformers.

regularly brought to club meetings as the restoration progressed, to discuss any problems that had occurred along the way.

The set was originally imported from America and has been operating via a 240V to 110V isolation transformer for most of its life. In fact, the person who originally owned it must have been quite wealthy, as a set of this calibre was a top-shelf model in its day.

The set has also obviously been well looked after because its cabinet is still in very good condition. It was initially cleaned and then the inside brushed out with linseed oil thinned with mineral turps. A commercial furniture restorer was then applied to the outside using a soft rag.

The views from both the front and back show that the manufacturer took pride in the appearance of this set. The dial escutcheon is of similar style to the better sets of the era and has both wavelength and kilocycle markings. The ornate Tuning and Volume control knobs are mounted directly under the escutcheon, while the toggle switch in the centre is the On/Off control.

The cabinet is solid and the finish on the timber is good, with no short cuts in the making of this cabinet. It is definitely a 2-man job to shift, as the cabinet and chassis combined are quite heavy. In fact the speaker assembly and the chassis weigh in at 6kg and 12.5kg respectively, which the cabinet adding to that.

Circuit details

The Lyric Model 70 is an 8-valve TRF (tuned radio frequency) receiver, designed to be powered from 110V AC. It has a number of features that were quite cutting edge for the era plus a few other features that, while interesting innovations, were really not practical in the long term.

Fig.1 shows the circuit details. As can be seen, the antenna connects to the primary of the first RF tuned circuit. It also connects to a 12kΩ rheostat (R9) that gradually shorts out the antenna as it is rotated and forms part of the volume control network.

Following the antenna, the signal is fed to the first tuned circuit where it is amplified by a 226 triode. The resulting signal on the plate of this valve is then fed via a second tuned circuit to another 226 triode where it is further amplified. A third tuned circuit and RF amplifier stage, again based on a 226 triode, follow.

From there, the signal is fed via a fourth tuned circuit to a 227 triode detector stage. This has an audio transformer connected to its plate circuit (approximate step up ratio: 1:3) and the secondary of this is connected to a second 227 audio stage. The output of this stage is then fed through another audio step-up transformer to the grid of a 250 audio output stage.

Finally, the audio output stage drives the loudspeaker via a speaker transformer.

Interesting points

There are a number of interesting features in the RF amplifier stages. First, each RF triode stage is neutralised using neutralisation capacitors that are mounted on the 4-gang tuning capacitor – see photo. These are adjusted during manufacture (via three screws along the bottom edge) so that the receiver is stable under all conditions with the volume control set at maximum.

Another unusual feature of the 4-gang tuning capacitor is the method used to achieve tracking across the

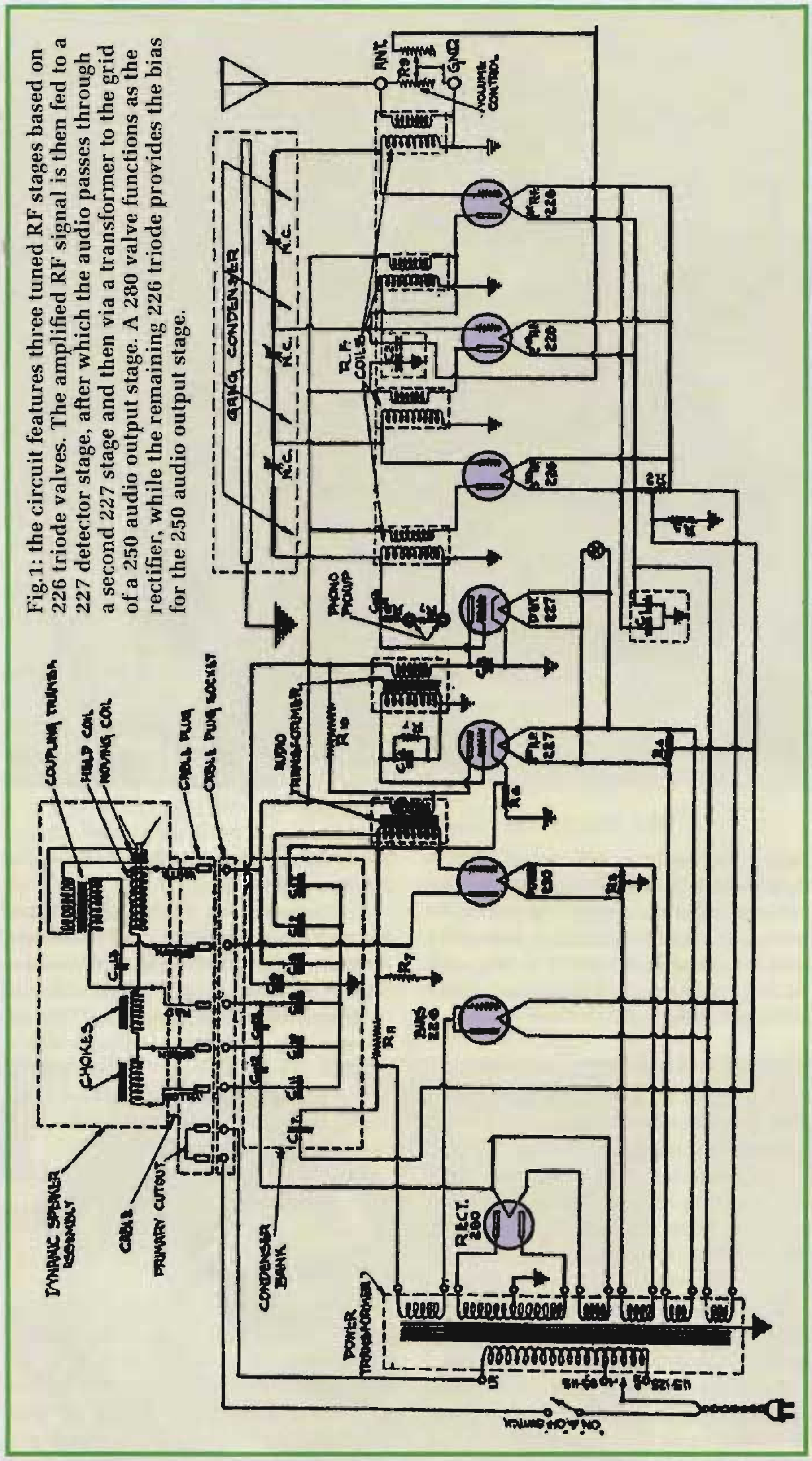


Fig.1: the circuit features three tuned RF stages based on 226 triode valves. The amplified RF signal is then fed to a 227 detector stage, after which the audio passes through a second 227 stage and then via a transformer to the grid of a 250 audio output stage. A 280 valve functions as the rectifier, while the remaining 226 triode provides the bias for the 250 audio output stage.

broadcast band. As shown in the photo, there are another six adjustment screws positioned on the edge of the frame, three between the four gangs at the front and three more at the back. These screws are adjusted to shift a plate between each gang section, to alter the capacitance between the fixed plates and earth so that the tuned circuits could be adjusted to track correctly. There are no cores in any of the RF coils, so getting the circuits to track would have been quite a task and certainly not one for the faint-hearted to attempt.

As mentioned above, rheostat R9 progressively shorts the antenna signal and functions as the volume control. This control also has a second section which is connected to capacitor C2 in the plate circuit of the first RF stage. In operation, R9 and C2 progressively detune and partially short out the signal in the plate circuit to increase the effectiveness of the volume control.

Another interesting feature is the filament supply arrangement. The first three stages have their filaments fed from a 1.5V line and they have a centre-tap resistor (R2) wired across the filament line. This was known as a "humdinger" and its function was to reduce any hum that may be induced from the filaments into the signal path. A resistor from the centre tap of this "humdinger" to the chassis provides bias for these stages.

The detector and the first audio stage also have a "humdinger" (R4) across their 2.5V heater line to null out hum that could affect the audio signal. These are the only two indirectly heated valves in the receiver. The centre tap of this "humdinger" goes to the same bias resistor used for the 226 valves.

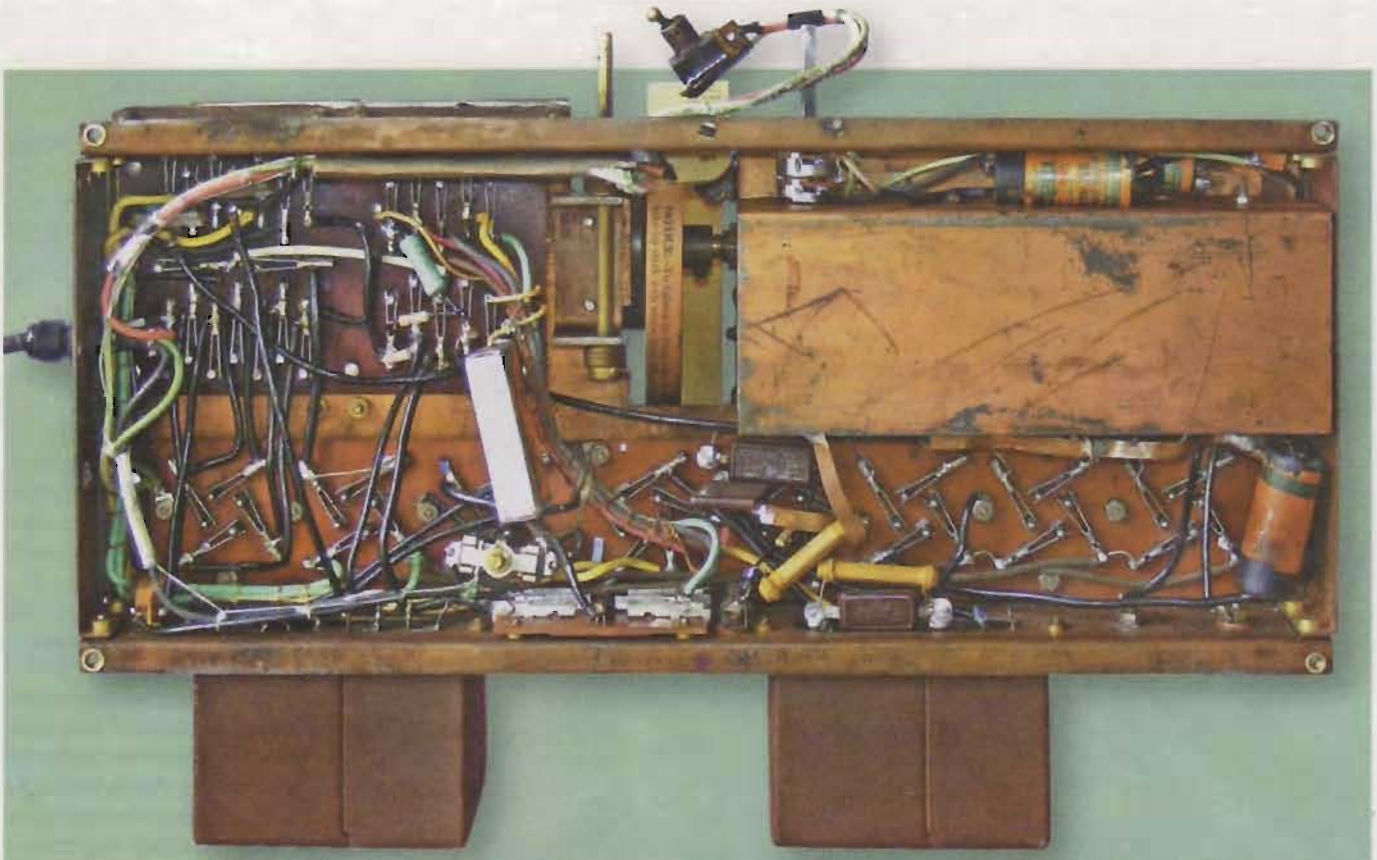
The audio output stage uses the rather large 250 valve. It is fed from its own 7.4V filament line, and once again it has a "humdinger" across the filament line to chassis. The 250 is a low-gain valve with a gain of less than four. It also requires quite a high bias voltage, which can be as high as -84V. However, in this receiver a bias of only -52V to -56V is required.

The bias for this stage is derived from a separate bias supply. This consists of a separate winding on the power transformer which is connected to a 226 valve wired as a diode, with a 0.5μF filter capacitor. This filtered is then fed through a resistive divider and the secondary of the driver transformer to the grid of the 250.

HT supply

The HT supply is conventional with a full-wave 280 rectifier supplying the HT to all stages of the receiver. The line is filtered by two 13-Henry iron-cored filter chokes plus five capacitors.

This receiver was built before electrolytic capacitors were available, so large paper capacitors of 2μF and 3μF



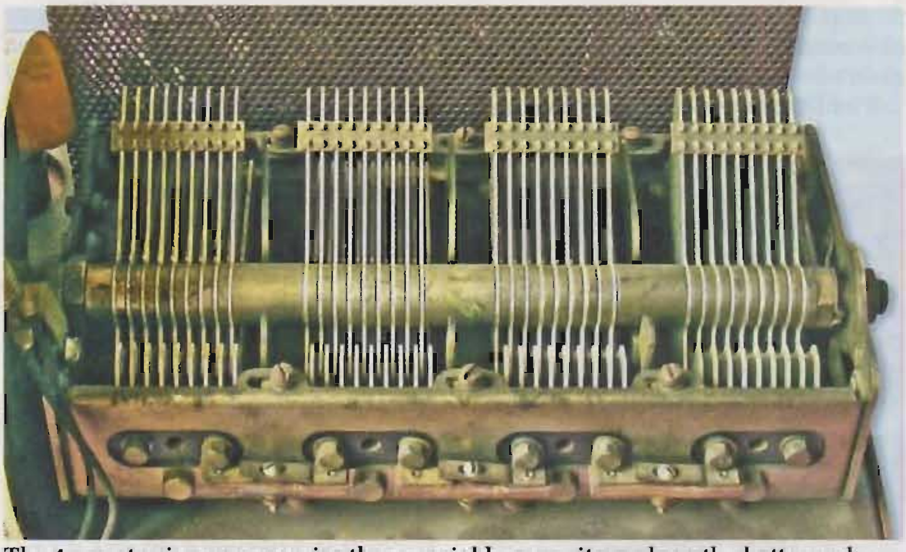
This under-chassis view shows the unit after restoration had been completed. The various plug-in modules have both advantages and disadvantages when it comes to servicing.

were used instead. However, from the circuit, it's apparent that the 280 rectifier is running close to its limits, with around 400V on the filament on load and a total HT current drain of around 70-80mA.

Record player input

The receiver has provision for a record player input but it's doubtful that it would work. As shown on the circuit, the audio from the record player appears to be connected across the secondary winding of the RF tuned circuit feeding the detector. As a result, the audio signal would be effectively shorted out by this RF coil winding.

Finally, the valve types used lost their prefix around 1930 and became known simply as the 26, 27, 50 & 80.



The 4-way tuning gang carries three variable capacitors along the bottom edge and these are used to neutralise each of the RF stages. In addition, there are six adjustment screws between the four gangs (three at the front and three at the back) and these are adjusted to ensure correct tracking across the band.

Plug-in modules

As shown in one of the photos, the iron-cored chokes, the speaker transformer and the electrodynamic speaker are attached to each other to form a single assembly. This assembly is connected via a cable and plug to the chassis.

The plug is wired so that when it is disconnected, the power is automatically disconnected from the primary of the power transformer. This prevents the power supply from generating excessive voltage on the output of the rectifier when the assembly is unplugged. It also helps to protect a careless serviceman from electrocution. However, C11 is part of this assembly and is normally connected directly to the output of the rectifier. As a result, it would stay charged and could deliver a lethal shock if touched.

The next plug-in module is the capacitor bank, consisting of 10 capacitors housed in a metal box (see photo). This was designed to be replaced as a single unit, meaning that if one became faulty the whole lot had to be replaced. This would have been expensive and

The chassis sits on a horizontal shelf in the top half of the cabinet, while the loudspeaker assembly is mounted in the bottom half and is connected via a cable and plug. Note the 240V to 110V step-down transformer at bottom right.

as a result, plug-in modules like this didn't find general favour at that time.

Finally, the power transformer and the two interstage audio transformers are also plugged into sockets. Each of these is then secured to the chassis using four bolts.

In short, this set had a number of modules that could easily be replaced if necessary, making it straightforward to service.

The plug-in capacitor box contained a large number of faulty paper capacitors, which meant that a complete new assembly had to be made up.

Restoration

When the set first arrived on Marcus's bench it was in a remarkably good condition considering its age. The cabinet and chassis only required a dust-out to make it easy to work on. However, he had no circuit diagram at that stage and this made things difficult. It is a complex set and it's not easy to figure out what exactly is inside the plug-in capacitor and choke boxes.

Despite having no circuit, Marcus immediately began restoring the set. His first task was to replace some poor-quality wiring, a legacy of some previous servicing. By contrast, the original wiring was found to be quite neatly done, even if it wasn't always easy to follow.

As mentioned previously, because it was designed for 110VAC, the set was powered via a 240V to 110V isolation transformer (not an autotransfomer). In the interests of safety, the original mains wiring was replaced to Australian standards.

Next, the valves were removed and tested and all were found to be in good working order. That was fortunate as replacements would not be cheap and in any case, would be difficult to source. The only electrolytic capacitor in the set, which proved to be a ring-in, had dried out and was replaced.

A Faraday shield had originally been fitted over the RF valves but this was now missing. As a result, a perforated metal shield was made up and painted the same colour as the chassis before fitting it into place.

The capacitors were the next on the list. After examining the chassis, Marcus concluded that any leaky capacitors in the capacitor box were unlikely to cause problems with the valves, as transformers are used for the interstage coupling. Further checks also indicated that there were no shorts to earth or excess leakage to earth, so it would be safe to run the set for a short time in order to check voltages in the various stages.

Well, it worked but it didn't work very well. A heat-sensitive intermittent fault soon became apparent and there was also a fault with the volume control.

Fortunately, a circuit diagram became available at about this time and this made troubleshooting so much easier, as it revealed the contents of the two "boxes".

First, the speaker/filter choke box was opened up and paper capacitor C12 across the speaker transformer primary replaced. All the other components in this box were in good order but the capacitors in the capacitor box were a different story.

Removing the capacitors from this box was a difficult job as they had been set in pitch. In the end, a heat gun was used to soften the pitch, after which a carving knife was used to separate the capacitor assembly from the case. In short, it was a time-consuming and messy job.

As expected, the 10 paper capacitors were all leaky and so had to be replaced. This was done by mounting much smaller replacement capacitors on two pieces of fibreboard (see photo). In particular, the 2μF and 3μF capacitors were replaced with mains-rated motor-start capacitors and the rest

The new capacitor bank was made up by mounting the parts on a couple of pieces of fibreboard and connecting them via flying leads. This assembly was then housed in the original box. The original capacitor bank is visible at top left.

with mains-rated MKT and polyester types. The value of each capacitor was marked next to it on the fibreboard, to aid future servicing.

As shown in the photo, the various leads were then soldered to the appropriate pins on the capacitor box plug, after which the box was plugged back into the set.

By the way, the two capacitors marked C12 are used to tune the filter chokes for maximum filtering effect. However, the originals were meant to resonate on 120Hz ripple, not the 100Hz ripple with Australian mains. As a result, it was unnecessary to increase the values of the two C12 capacitors to achieve resonance in the filter network. The mica capacitors were tested and found to be in good order.

Tracking down the intermittent

It was now time to find the thermally-sensitive intermittent fault. The volume of the set would vary at a slow rate, indicating a problem with either a valve filament, a socket or some other part of the filament supply line.

Careful testing revealed that the filament voltage on the lines to the 226 valves was varying and was low at around 0.9V AC. This problem was traced to the two "humdinger" centre-tap resistors on the filament lines to the 226s and 227s. These had riveted terminals which were making poor contact. They were cleaned and then soldered so that there was no discontinuity between the rivets and the riveted metalwork.

When this was done, the filament voltage to the 226s was restored to the correct 1.5V AC. This markedly improved the set's performance and it was now obvious that it would be worthwhile spending the money to get the speaker re-coned. This was subsequently done and it now has a high-quality foam-suspension cone which complements the quality of the rest of the receiver.

The defective volume control was the next item on the list. This item is quite different in construction to conventional pots and is basically a dual rheostat rather than a potentiometer. It only has one gang but two separate tracks, which in this circuit are earthed via the wiper.

The markings on the control, although appearing to relate to the resistance of the sections, are probably type numbers. It all confused Marcus before he obtained the circuit which revealed that each track has a resistance of 12kΩ. The unit was replaced with a dual-gang 10kΩ potentiometer.

Finally, all the resistors were checked and five out-of-tolerance component replaced.

Testing

It was now time to see what the receiver was capable of. There was no apparent instability in the RF sections so the neutralisation adjustments were left alone. The tuning coils and tracking adjustments were also left as they were, as the performance was very good and no adjustments were deemed necessary. The bias on the 250 audio output triode was checked and found to be in the design range of -52-56V.

In operation, the receiver proved to have quite good selectivity and each station appeared in only one spot on the dial. It certainly had no trouble selecting stations that were relatively close in frequency to the local broadcasting stations.

In summary, its performance is quite good for a set of its age and style and it would have been the focal point of any lounge-room it graced during the late 1920s and early 1930s. However, it would have become obsolete, at least in a design sense, by around 1935 due to rapid advances in technology and the increasing popularity of superhet receivers.

That said, it still would have been a great set to have in the home and even today its performance is quite credible. It's a set well-worth having in a collection, particularly as it is in such good working condition. **SC**

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Write to: Ask Silicon Chip, PO Box 139, Collaroy Beach, NSW 2097 or send an email to silicon@siliconchip.com.au

Faulty LED indication in Speed Alert

I built the Speed Alert project as published in the November and December 1999 issues of SILICON CHIP. The kit was a dream to build and functions well except that LED1 (visual alarm) stays on permanently.

I have checked all solder joints etc and cannot find any faults. It seems that there is ground potential on pin 6 of the PIC all the time. The audible alarm works every 10s (as it should) but is quite faint. (R. B., via email).

• The alarm LED (LED1) is driven via the 5V dimmed supply at the emitter of Q4 through the 560Ω resistor and to pin 2 of IC1. If pin 2 is low then LED1 will light.

Normally pin 2 is at 5V unless the alarm is on. The only way LED1 could be alight continuously is if there is a short to ground for pin 2 (or a low resistance to ground). Alternatively, check that LED1 is oriented correctly.

9V to 27V DC converter wanted

I am interested in your DC-DC Converter, as published in the June 2003 issue. Its maximum output is 20V.

My requirement is for a DC-DC converter which has a 9V input and a 27V output. Do you have a suitable circuit? (R. R., Rowville, Vic).

• The DC-DC Converter can be altered to deliver 27V by changing the 1.2kΩ resistor in series with trimpot VR1 to 470Ω. Note that the output current would be limited to about 450mA.

Help with old EA ignition circuit

I have been using a design for a transistor ignition published in EA in February 1983. It has been installed on numerous vehicles and recently on a 1985 model Toyota Hilux. This circuit has been extremely reliable and has given no problems in the vehicles it has run. Recently, I had the main switching transistor fail (short circuit).

Looking at the alternatives you have published over the years led me back to my original one as being easier to fix. But can I replace the BUX80, 2N6547 transistor originally used with one of the newer MJ10012 or MJH10012 Darlington transistors without any mods to the original circuit? If not, can you suggest any modifications to make it work? (C. L., via email).

• The MJ10012 or MJH10012 can be used to replace the BUX80 but the old "Electronics Australia" Transistor Assisted Ignition circuit is not ideal for the MJ(H)1012 transistor as it draws more current than is necessary to drive the latter Darlington transistor.

The 10Ω resistor at transistor Q4's base should be a 1W type due to the higher voltage drop from base to emitter for the Darlington MJ(H)10012. Two of the 2.7Ω resistors driving Q4's base could be removed since there is no need for the high base current with the Darlington.

Concern over Nixie tubes in digital clock

I refer to the Retro Nixie Clock in the July & August 2007 issues of SILICON CHIP. With the clock running permanently, what would be the predicted life of the Nixie tubes? Do they, after a period of time, simply "give up the ghost"? Would the clock's "normal" life be 3, 4 or 10 years? (K. J., via email).

• The life of a Nixie tube depends on the manufacturing quality, the way the tube is driven and the care with which they are handled. There is no definitive answer as to their life.

We expect a good Nixie tube to last many years in the digital clock. We cannot give a precise estimate. If you are concerned, it would be wise to get some spares before the availability of these becomes scarce.

Sourcing coils for the Theremin

I have read the article on the Theremin (SILICON CHIP, August 2000) and I need information to get the variable coils. I have visited the websites for Mitsumi and Toko but I cannot select suitable coils for the Theremin. Can you help? (C. T., Santiago, Chile).

• Mitsumi or Toko do not make the specified coils. You can obtain the correct coils from Jaycar Electronics (Cat. LF-1050). You would require three (3) of the LF-1050 coil packs to get the correct number of white-slugged cores. Contact **www.jaycar.com.au**

Note that a revised version of this Theremin circuit was published in the March 2009 issue of SILICON CHIP.

Power Supply For Multimedia PC Amplifier

I built the Multimedia PC Amplifier and Speakers (SILICON CHIP, October & November 1996) some years ago for use on an old 486 computer with ISA sockets. Recently I found a use for it again, using the line input from a set-top box and volume control via the STB remote in a TV set-up using a spare monitor I have.

The set-up works well but the old 486 computer is noisy and really all I need is an appropriate power unit for the 12-0-12V supply and a suitable enclosure. I note the computer 12V supply is 6A and 0.6A – and my son has advised me that there is a much larger current required on the positive rail of the amplifier. Apart from using the computer, have you any suggestions as to a suitable power supply. (G. C., via email).

• Your son is correct. The positive 12V supply rail will need to supply more than 4A peak when the amplifiers are running at full power. A computer power supply is still the best answer. These days they tend to be a lot quieter.

External DAC For A CD Or DVD Player

I cannot find any reference to DACs (Digital-to-Analog Converters) as used for hifi CD data conversion. These are available from hifi dealers but it's a project that SILICON CHIP could consider. I have already built several hifi-based projects published by SILICON CHIP and a top-quality DAC would be great.

Do you have any plans for such a project? (R. P, Horley, UK).

• As we see it, there are only two reasons why you would use a separate DAC with an existing CD player: (1) the existing DAC in your CD player is audibly inferior or (2) you want to avoid any problems with hum induction or earth loops by using the digital output of your CD player.

Neither of these issues are significant for the vast majority of users and in any case, in spite of all the subjective rubbish written in UK hifi magazines, most people would be unable to hear any difference between the DAC output of a typical good-quality CD player from Sony, Yamaha, Marantz, Denon etc and any external DAC, no matter how pricey it may be.

However, if you are using a DVD player to play your CDs, even a good-quality brand may be notably inferior to the abovementioned CD players. In fact, in our experience, all DVD players have significant problems when used in conjunction with a good-quality home hifi system.

This is firstly because they all use double-insulated switchmode power supplies. These can inject significant hum into a hifi system as well as high-frequency frizzle, in some cases.

Secondly, the DAC and audio output stages used in the majority of DVD players typically give inferior or even poor audio quality.

Ultimately, an external DAC with SPDIF or TOSLINK connection is the way to go if you want hifi audio from a DVD player. In fact, the TOSLINK connection is the best because it eliminates all problems with hum induction or hum loops.

With this in mind, we plan to publish a high-quality DAC with SPDIF and TOSLINK inputs, starting with the August or September issue.

How to make front panels

Have you ever described the process and materials used to produce the front panel labels of your projects. Alternatively, is there a website that you can point me to for information on the process that you use? (R. S., Burrill Lake, NSW).

• We have published several articles on making front panels:
(1) *Making Front Panels For Your Projects* (February 1999);
(2) *At Last – An Easy Way To Make Pro Panels* (April 2002);
(3) *Restoring Old Dials, Front Panels And Labels* (July 2004); and
(4) *Making Panels For Projects* (July 2007).

Incidentally, by far the easiest way to make a high-quality front panel these days is to produce it using any of the PC drawing/graphics packages (we use CorelDraw), print it out on good quality paper and then laminate it. A4 laminators are now very cheap – we've seen them for as low as $29.95!

No real need to vary speed control frequency

I have built four of the 12-24V high current motor controllers for use in work platforms in temperature-controlled, horticultural tunnel houses. The units drive a 24V DC motor/gearbox. The units all work well. My question is why do I need to alter the frequency? (B. B., via email).

• For most applications there will be no need to alter the frequency of the speed control. In fact, for most applications you can leave all the standard (default) settings unchanged.

However, if you have a motor or gearbox which is noisy at a particular frequency, then you have the option to change. Also, depending on the motor's inductance, you may find that it responds better to a higher or lower drive frequency.

Running a caravan from solar power

I have bought a new caravan with a 12V system and in-house battery. I use an electric razor and when on 12VDC will use a 12V-to-230V AC inverter.

I also thought the inverter would come in handy for charging a video camera and a still camera battery. The two chargers involved are both switchmode units and I have been told that this type of charger should only be connected to a sinewave supply; never to a modified square wave supply. Do you have any thoughts on this?

I have a 50W solar cell which has an output of a little over 3A, which I would like to use (if off mains supply) to top up the battery (a 95A.h deep-cycle type). Do I really need a charge controller on a system as small as this? If so, why? I don't think it would overcharge the battery at a maximum of 3A, do you? Has SILICON CHIP ever published a construction article for a charge controller? If so, would you tell me which edition it was in?

To lessen the load on the battery, I have constructed and fitted a number of LED lights in parallel to the fluorescent/incandescent lights already fitted, with a total battery drain of only 1A compared to about 10A! What with solid-state hard drives and LED lighting, the electrical and electronics scene sure is changing. (N. W., via email).

• We doubt whether you would need a controller. We would be inclined to just hook it up and then monitor the battery over a period to see how it goes.

Misconceptions About Ions In Salt Solution

I was just reading your article entitled "Test The Salt Content Of Your Swimming Pool" (SILICON CHIP, December 2008) and thought about using your technique at home. I was investigating further when I found a couple of articles stating that using an ohmmeter for testing will cause a molecular change within the salt solution due to the test current being DC, thus making the test invalid. I include a link to of one of the articles I read concerning this: **http://blea.ch/wiki/index.php/PPM_Meter**

I am now quite confused about the whole situation. (G. F., Kurralta Park, SA).

• The quote you are referring to is as follows: *"Because they pass DC current thru the probes and you cannot measure conductivity of salts with DC current because it will rip the molecules apart, and since the molecules are what conducts the electricity you get a constantly changing reading that is useless. Overcome this by using an AC signal. If the frequency is high enough (>1kHz it seems) the molecules don't have time to move apart before they are pulled in the opposite direction. Sort of like how high DC current will throw a person off of it, where as AC forces them to hold on and get shocked to death or something."*

As with so much stuff on the internet, this is utter nonsense and indicative of the high level of ignorance of all things technical by most people. In fact, when you dissolve salt into solution, the molecules of salt become sodium ($Na+$) and chloride ($Cl-$) ions and it is precisely because of these ions that electric current can pass through the solution. This is just basic chemistry.

However, the designer of this PPM circuit is on the right track in advocating the use of AC rather than DC to make the measurement. But it is has nothing to do with "ripping molecules apart".

The reason for using AC rather than DC is to avoid electrolysis of the measuring electrodes. In effect, the electrodes would be eaten away over a long period of time. That is why commercial TDS/PPM meters generally use carbon electrodes and an AC test voltage. If DC was used with carbon electrodes, it would lead to electrode polarisation and high resistance readings.

In fact, meters which purport to measure TDS (total dissolved solids) are a bit of a joke anyway because they can only measure those solids which dissolve to form an ionic solution. For example, they cannot measure the amount of sugar in a solution because sugar does not break up into ions.

And while the designer stresses the importance of a nice clean sinewave for the test waveform, that is not strictly necessary. All you need is an AC waveform with a 50% duty cycle and no DC component. In other words, a square or sawtooth waveform would do just as well.

In fact, the simple method we described in the December 2008 issue is quite valid. However, as pointed out by a correspondent in the Mailbag pages of the February 2009 issue, using measuring spoons for a quantity of salt can be inaccurate and you are better off using digital kitchen scales for making the solution.

If you do want to build a controller have a look at the December 1999, March 2002 and February 2008 issues. We have also published a lot of solar-related items in Circuit Notebook.

Your chargers should be OK running from a modified square-wave inverter.

Pressure switch wanted for pool pump circuit

I have a query regarding the pressure switch used for the Smart Pool Pump Control circuit featured in the Circuit Notebook pages of the October 2008 issue. Would you have any suggestions as to who would stock them?

Thanks for producing such a high-quality magazine every month with excellent projects and interesting articles. (P. B., Richmond, NSW).

• Farnell (**www.farnell.com.au**) sell pressure sensors (eg, Cat. 723-0461) but these are expensive. You may be able to obtain a suitable pressure sensor from **www.baccara.com.au/pressure-switches.shtml**

This Australian supplier has various switches available. You would probably need to set the sensor to about 5 psi.

Infrared remote extender query

I built the Remote Control Extender (SILICON CHIP, October 2006) and it works well with all my TVs & VCRs but it won't work on my Panasonic DMR-XW300 DVD recorder. I've used various IR receivers out of modern VCRs and it will only work intermittently.

Can you tell me where to source the TSOP4136 IR receiver? Altronics and Jaycar don't know if theirs is a TSOP4136 (Jaycar ZD-1952). Also Altronics supplied TLC555 for the 7555 timers. Are these OK? (E. L., via email).

• The IR receiver supplied with the kits from both Jaycar and Altronics for this project is the TSOP4136. The Jaycar ZD-1952, however, is not a TSOP4136 and is not suitable for use with the extender as it will not work with the Foxtel digital decoders. The standard IR receiver sold by Altronics also is not the TSOP4136.

Farnell (**www.farnellinone.com.au**) do sell the TSOP4136 and other types of IR receivers. Either the TSOP-4138 which operates at 38kHz or the TSOP1133 which operates at 33kHz may be more suited to your DVD recorder.

The Texas instruments TLC555 is equivalent to the Intersil 7555 timer. Both are the CMOS types and are suitable. The LMC555CN from National Semiconductor is also suitable.

Secondhand batteries are a risky proposition

After reading an article in your magazine that stated it is better to plan ahead when purchasing batteries for solar systems, I have spent quite a lot of time looking on eBay for some large batteries. I have run into some 12V 150Ah SLA batteries and I wonder what you think. They are secondhand, eight years old, with a design life of 15 years. Do you think they are worth buying for a DIY solar system, considering the price? (C. G., via email).

• You have no way of knowing what you are getting when you buy second-hand batteries, from eBay or any other source. Unless you could borrow them and do some careful capacity tests over several charge/discharge cycles you could simply be buying some very heavy garbage. The vendor may be quite genuine but you have no way of knowing that.

In any case, the vendor himself may have no way of knowing or measuring the performance of his batteries.

Notes & Errata

6-Digit GPS Clock, May 2009: a 100μF 16V capacitor has been omitted from the circuit on page 22. It is shown on the PC board overlay and is adjacent to transistor Q14.

10A/230V Motor Speed Controller, May 2009: the references to IC1a & IC1b and to IC3a & IC3b in the text should be swapped to agree with the block diagram on page 39 and circuit diagram on page 40 (the references to IC3a & IC3b for the current monitoring circuit description are correct).

Preamplifier for Speed Controller, Circuit Notebook, May 2009, page 35: the fourth paragraph in the right-hand column makes reference to Q1 & Q2 forming a simple 2-transistor amplifier. This should refer to Q1 & Q3.

2-Channel UHF Mains Switch, May 2009: on page 82, the +12V rail supplying the junctions of the 47Ω resistors and LED1 via Rs# should come from the cathode of diode D1, not the cathode of D2.

RF loop explanation

I was wondering if someone might be able to help me. When I look at advertisements for SD and HD-STBs, they sometimes refer to "RF-In" and "RF Loop Out".

What does "RF Loop Out" mean? Is it just passing through the unprocessed input signal to the output? Why don't any of the current breed of STB take the digital RF input and then provide, along with the other output formats, an analog RF output signal? The lack of such a signal means that another device (ie, RCA-to-analog RF modulator) is required. (P. M., Karabar, NSW).

• The RF loop is exactly the same as that on VCRs and DVD recorders, where you have an "Antenna in" and "Antenna out" socket to feed your TV.

One reason why STBs do not have an analog RF output is that it would defeat the purpose of the STB itself. The picture quality available via the composite video, component video or HDMI outputs is much better than can be provided via a modulated RF output.

Tank water level display

I recently built the Tank Water Level Display (SILICON CHIP, November & December 2007) and the base station to go with it. My problem is that they refuse to talk to each other.

I have replaced both transmitters and receivers and tested the new ones that I put in (both were good). Now if I connect a 4-ohm speaker to the data and earth pins on the transmitter and press the check button, the speaker emits a healthy blurt, so it appears to have a signal going to it.

I don't get any noise if I connect the speaker to the base station receiver data and earth pins. Now bear in mind that to test the transmitter and receiver I just connected 5V to the "Ve" and "Data" pins of the transmitter module and then monitored whether any signal came out of the data pin on the receiver module. I got a reading of 4.5V.

The only thing I can think of is that the transmitter module might not be getting any voltage before the data is sent to it but I have no way of testing this.

If you have any ideas, it would be greatly appreciated. (B. W., via email).

• For the base station to receive data from a tank meter, the base station must be set to receive data from that tank. For example, for tank 1 data, the base station needs to be set to receive tank 1. Setting up for this is described in the base station article.

Similarly, the encode setting must be the same for both the tank meter and the base station in order to receive and display the detected data.

Note that if the transmitter and receiver are too close when testing the units (less than about two metres apart), the receiver will not detect the data correctly. Note also that the transmitter and receiver both require an antenna as described to obtain adequate transmission range. SC