SILICON CHIP

OCTOBER 2016
ISSN 1030-2662
10
9 771030 266001
PP255003/01272
$9.95* INC GST NZ$12.90 INC GST

Make your own ZIKA VIRUS MOZZIE TRAP

Cheap & easy to build . . .

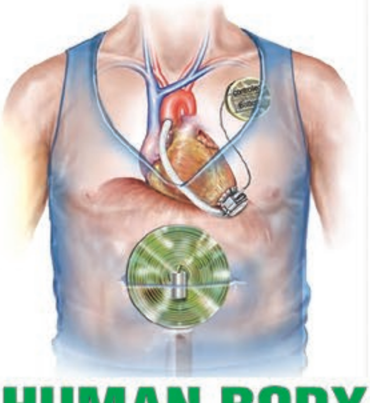
Adapts to other mozzie types too

Don't let a BITE spoil your BARBIE!

They're EVERYWHERE!

ARDUINO GADGETS: Really, really cheap!

FEATURE:



HUMAN BODY IMPLANTS

Jaycar Electronics
Better, More Technical

duinotech PROJECT OF THE MONTH

Our very own specialist's are developing fun and challenging Arduino®-compatible projects for you to build every month, with special prices exclusive to Nerd Perks Club Members.

DUINOTECH PROJECT OF THE MONTH

ULTRASONIC THEREMIN PROJECT

This project is ideal for the musically inclined. Just like a traditional Etherwave-Theremin, this theramin plays back samples and modulates them depending on the distance of your hand to the sensor. This simple project doesn't need many parts to get its sound because it uses a few of the special hardware features of the ATMEGA 328p chip in the Uno to do most of the work.

There is some soldering needed in this project.

Go on, build this project, create your own tunes and sounds and have some fun.

SEE STEP-BY-STEP INSTRUCTIONS AT jaycar.com.au/diy-ultrasonic-theremin

DIY | MORE INFO ONLINE


Finished project

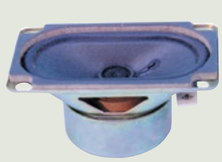
NERD PERKS CLUB OFFER
BUY ALL FOR $52
SAVE OVER 20%

WHAT YOU WILL NEED: VALUED AT $65.30

UNO MAIN BOARD	XC-4410	$29.95
PROTOTYPING SHIELD	XC-4482	$15.95
ULTRASONIC SENSOR MODULE	XC-4442	$7.95
MONO AMPLIFIER MODULE	AA-0373	$7.95
40MM SPEAKER	AS-3004	$3.50

EXPAND YOUR PROJECT AND MAKE IT LOUDER!

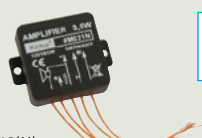
RECTANGULAR ALL PURPOSE REPLACEMENT SPEAKER AS-3025



- 8 ohm
- 5 Watt
- Magnetically screened
- 50 X 90MM

$6.95

UNIVERSAL AMPLIFIER MODULE
AA-0223



Ideal as a bench-test amplifier for audio, or as a mono headphone amplifier. Use two for stereo.

- 3.5 W (max)
- 4.5-12 V
- 4-16 ohm
- < 80 mV
- 40Hz - 20kHz
- 39(L) x 39(W) x 12(H)mm

$24.95

NERD PERKS CLUB MEMBERS RECEIVE:
10% OFF SPEAKER CABLES*
IN ROLLS OR BY THE METRE FORMAT
*Applies only to cables listed on page 7 of the Jaycar Sight and Sound October 2016 flyer

WHY NOT ADD SOME POWER!

$9.95

USB 2.0 A TO B CABLE 1.8M WC-7700
USB 4 Pin (A) Male to USB 4 Pin (B) Male.

$69.95

PORTABLE RECHARGEABLE POWER BANK MB-3726
- 10,200mAh
- 133(L) x 66(W) x 17.5(D)mm

$19.95

MAINS USB MINI POWER ADAPTOR - 2.1A MP-3449
- USB Socket A
- 100-240VAC, 50/60Hz
- 40(Dia.) x 27(L)mm

EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE* & BE REWARDED WITH A $25 JAYCOINS GIFT CARD ONCE YOU REACH 500 POINTS!
*Conditions apply. See website for T&Cs

REGISTER ONLINE TODAY BY VISITING: www.jaycar.com.au/nerdperks

Catalogue Sale 24 September - 23 October, 2016

To order phone 1800 022 888 or visit www.jaycar.com.au

Contents

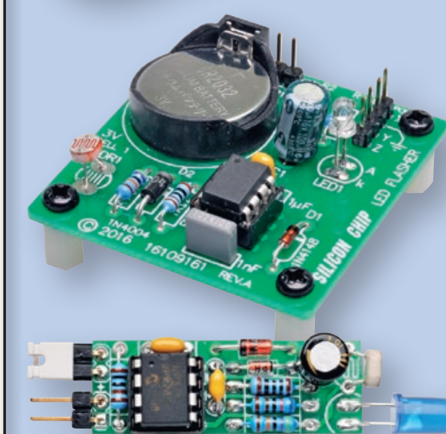
SILICON CHIP

Vol.29, No.10; October 2016 www.siliconchip.com.au

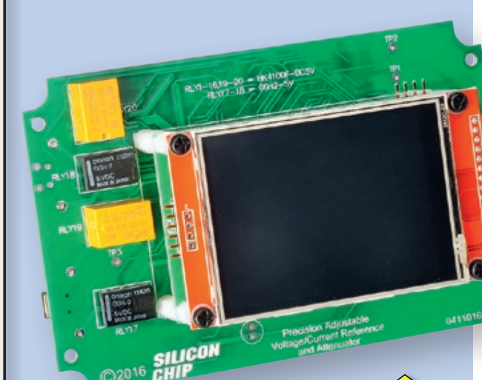
An Audio Lure For Lovelorn Male Mozzies – Page 36.

Features

Projects To Build

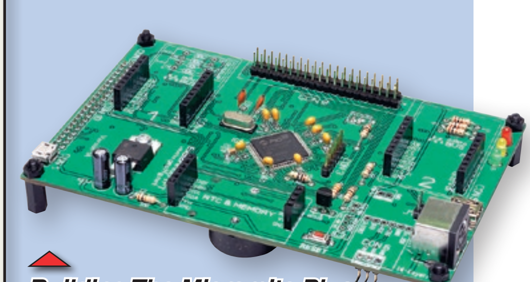


Two Micropower LED Flasher Modules – Page 62.



Touchscreen-Controlled Voltage & Current Reference, Pt.1 – Page 72.

Special Columns



Building The Micromite Plus Explore 100 Module – Page 80.

Departments

SILICON CHIP
www.siliconchip.com.au

Publisher & Editor-in-Chief
Leo Simpson, B.Bus., FAICD

Production Manager
Greg Swain, B.Sc. (Hons.)

Technical Editor
John Clarke, B.E.(Elec.)

Technical Staff
Ross Tester
Jim Rowe, B.A., B.Sc
Nicholas Vinen
Bao Smith, B.Sc

Photography
Ross Tester

Reader Services
Ann Morris

Advertising Enquiries
Glyn Smith
Phone (02) 9939 3295
Mobile 0431 792 293
glyn@siliconchip.com.au

Regular Contributors
Brendan Akhurst
David Maddison B.App.Sc. (Hons 1), PhD, Grad.Dip.Entr.Innov.
Kevin Poulter
Dave Thompson

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

Printing: Offset Alpine, Lidcombe, NSW.

Distribution: Network Distribution Company.

Subscription rates: $105.00 per year in Australia. For overseas rates, see our website or the subscriptions page in this issue.

Editorial office:
Unit 1, 234 Harbord Rd, Brookvale, NSW 2100.

Postal address: PO Box 139, Collaroy Beach, NSW 2097.

Phone (02) 9939 3295.

E-mail: silicon@siliconchip.com.au

ISSN 1030-2662

Recommended & maximum price only.

Publisher's Letter

El cheapo electronic modules – the new standard components

Many people who are electronic enthusiasts probably regard surface mount components as the biggest and most challenging change to their hobby. Surface mount components are quite a bit smaller than equivalent components with leads and they can be a lot more tricky to handle and solder into place. But most enthusiasts are adapting to and even embracing the change, as it allows much more compact PCBs than would ever have been possible in the past.

But there is another change which is a direct result of the huge range of surface mount components that are now available – tiny and very cheap modules. So even if you don't like surface mount components, you are likely to be using some of these modules in your future projects.

Arduino computing has been the main catalyst for the sudden appearance of these modules and the vast majority of them are marketed as Arduino-compatible modules or "shields". Now calling them "Arduino-compatible" is all very well but it tends to disguise the fact that they usually have much wider applications than in Arduino projects.

For example, they can be used with most other microcontrollers – you just have to know how to drive and control them. As evidence of this fact, SILICON CHIP has published five projects based on Geoff Graham's Micromite and all of these used a so-called Arduino-compatible module. Those used were a USB-to-serial converter (Micromite Touchscreen BackPack, February 2016), ultrasonic distance sensor (Parking Assistant, March 2016), GPS module (Touchscreen Boat Computer, April 2016), GPS or RTC module (Micromite-based Super Clock, July 2016), RTC and USB serial port (Appliance Energy Meter, August to October 2016).

But a lot of these Arduino-compatible modules don't need any sort of controller at all. They can be used in ordinary analog circuits with perhaps simple logic control using a few CMOS chips. For example, the ultrasonic sensor module listed above looks just like two piezoelectric transducers and a 40kHz resonator mounted on tiny a PCB with a 4-pin socket – nothing too complicated about that. Well, not quite. The underside of the PCB has three surface mount ICs and quite a few passive components to provide the "smarts" for the module. The net result is that it is feasible to control it with a microprocessor or some simpler CMOS logic.

There must be hundreds of Arduino modules available around the world and you can see a range of them listed on the Jaycar Electronics website at www.jaycar.com.au Some of these are quite simple while others are really powerful devices in their own right: UHF data transmitter and receiver modules, DDS signal generators, OLED/LCD modules, touch-screen TFT/LCD modules, temperature/humidity sensor modules, micro-SD card interfaces and many more.

The important point to be aware of is that these modules are a wonderful resource: compact, easy to accommodate on a larger PCB, and most importantly, really cheap. However, information on what they do and how they work is often hard to come by. So this month we have the first of a series of articles describing these modules. It covers the DS3231 real time clock & calendar module.

It took a while for electronics engineers to start using integrated circuits back in the early 1970s but we think these tiny modules will similarly become just standard components. In this case, it will happen in a very short time. In fact, it already is happening.

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", "Circuit Notebook" and "Serviceman".

Some 2.4GHz devices may not be legal to operate

I enjoyed reading your review of the 2.4GHz AV senders in the July 2016 issue. I was glad to see that the approximate power output of these devices is only -23dBm.

Many readers may be unaware, but the General User Radio License (GURL) for Short Range Devices (SRDs) in New Zealand has special condition 13 applied to devices in the 2.4GHz band. This states that devices with an EIRPS of 0dBm or greater must use frequency hopping or digital modulation techniques. Therefore, if the generic model you reviewed were to include a power amplifier of not much higher power, it would become illegal to operate in New Zealand, simply because of its fixed frequency. Thankfully, this model does not.

I suspect that perhaps the same cannot be said of some other models that can be imported online and as always, the buyer should beware.

For more details, see: https://gazette.govt.nz/notice/id/2016-go446

Pete Mundy,
Nelson, NZ.

Using CANBUS for home automation

Can the motor vehicle CANbus standard work for home automation systems? Here is an interesting slide-show presentation explaining how CAN and LIN are used in vehicles: www.elektor.com/Uploads/Files/CANbus.pdf

Here's an article describing one hobbyist's work on a home automation system using CANbus: http://hackaday.com/2012/03/07/can-bus-for-home-automation/

Many home automation systems use wireless, but wireless channel saturation can happen in big cities. There are also security implications. The "internet of things" may fail or be hacked, as commonly happens with WiFi networks.

Also, WiFi itself is becoming band-saturated. How many WiFi networks can you have in one building, especially if that building is a large apartment block?

In my opinion, what we need for a better home automation system is a system like CANbus that works over the power lines in a building but with good encryption and resistance to interference from other similar systems on the same set of power lines. It should be possible to design this to avoid AM radio interference and to avoid unauthorised access.

The power usage of hard-wired home automation systems and plug-in household appliances should be kept to a minimum. A hard-wired switch must look and work as a manual switch but with remote control. So in my opinion, a new building code or building CANbus standard for hard-wired home automation systems is needed. This system must be modular and logic programmable.

Such a system would let your electrician plug a laptop into a power point and then program each and every electrical fitting. Just as the internet has IP addresses, so a building CANbus needs addresses for each node and the ability to set authorisation codes so that only the owner can control the devices.

Multi-channel HD video and network audio also need a twisted-pair cable standard, to avoid interference in large apartment buildings. Maybe SILICON CHIP can suggest a standard that will work and maybe the Chinese will copy a standard if it works. Or it could be manufactured under an Australian licence agreement.

John Crowhurst,
Mitchell Park, SA.

Cheap power meters can be misleading

I've been waiting for someone to say something about those cheap power consumption meters which were mentioned in the first article on the new Touchscreen Appliance Energy Meter, featured in the August 2016 issue. I bought one about 12 months ago. As well as the screen being impossibly small to read, its accuracy was questionable, particularly with non-resistive loads.

If this thing was to be believed, my new flat-screen TV, which the manual says uses 1W on standby, actually used 12W. In addition, according to the meter, my 7W fluorescent desk lamp used 21W and my electric blanket, which gets quite hot, did so without using any power whatsoever. That's right, zero!

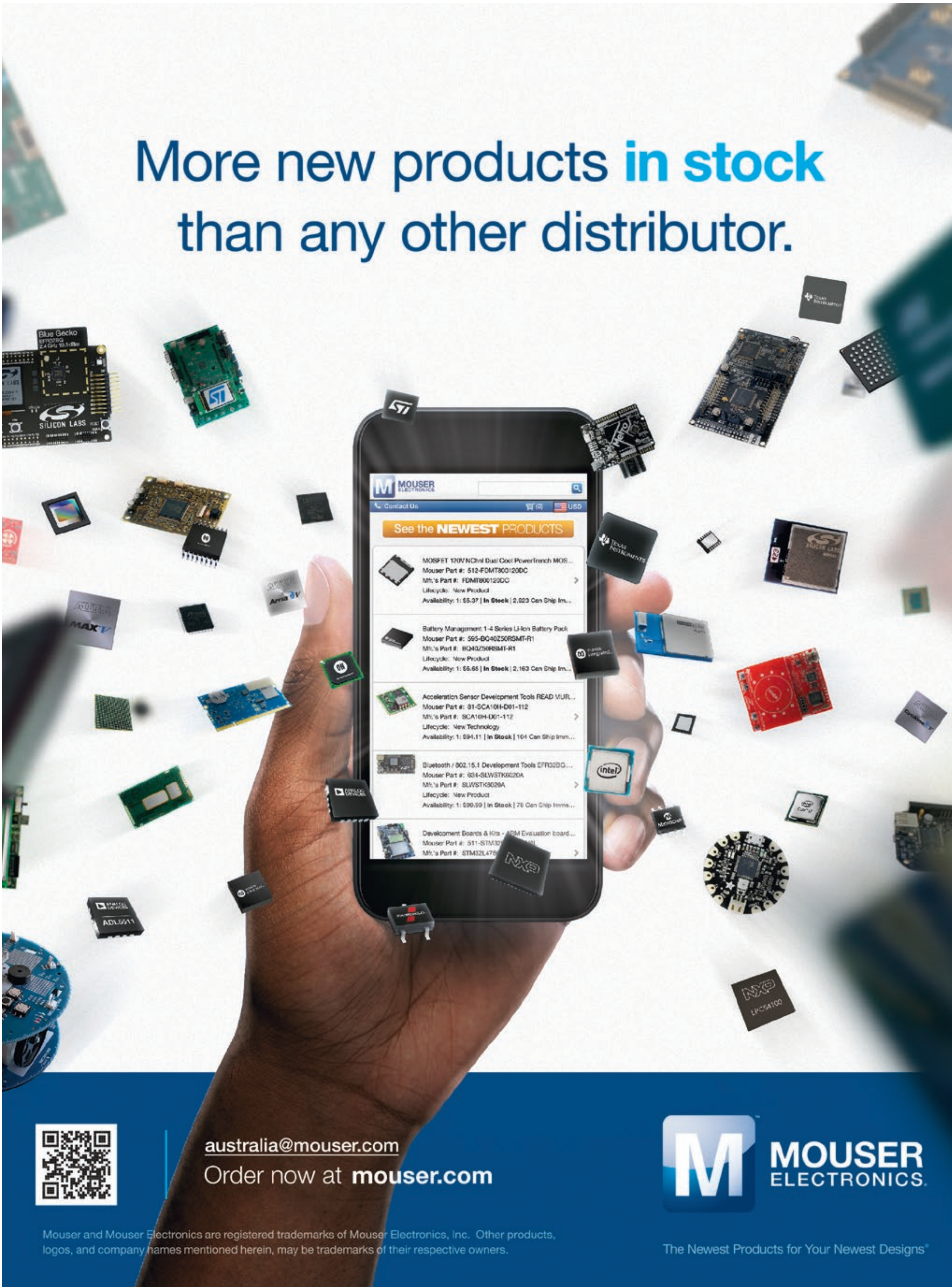
I have since discovered that the reading of zero watts on my electric blanket was due to the fact that the blanket draws pulses of current; the longer the pulse, the hotter the blanket. I had to use an analog meter to find this out. The device was soon consigned to the rubbish bin.

Graham Hunt,
Mt Martha, Vic.

Comment: Some of these meters are definitely dodgy. Some cheap meters also don't perform well with pulsed current loads, as you have discovered. However we have two examples from Aldi (branded Vivid) which have a good LCD and appear to be quite accurate.

NBN set-up did not go smoothly

Your serviceman Dave Thompson is not the only one with a less-than-satisfactory ISP. We were informed by mail that our area is now NBN-ready using FTTN (fibre-to-the-node) and to organise the new service through my selected ISP. The offer on the website of our existing ISP was competitive so I filled in the online form.



More new products in stock than any other distributor.
See the NEWEST PRODUCTS
australia@mouser.com
Order now at mouser.com
MOUSER ELECTRONICS
Mouser and Mouser Electronics are registered trademarks of Mouser Electronics, Inc. Other products, logos, and company names mentioned herein, may be trademarks of their respective owners.
The Newest Products for Your Newest Designs®

Mailbag: continued

Long URLs in articles are a problem

Thanks for a great magazine; it's very informative. My only gripe concerns the use of URLs in articles. Having long (and therefore descriptive) URLs on a website is fine as one can simply click on them. Having them in print is infuriating; it's very easy to get one digit or underscore wrong and end up with a 404 Page Not Found error.

May I suggest you use the services of a URL shortener such as bit.ly? This would make it far easier for your readers to follow a link. If you are worried about your readers not knowing where you are sending them, you could always put the name of the website in parentheses after the link.

I have opposing views to the Publisher in regards to carbon dioxide emissions and global warming. However, as a result, your Mailbag pages have carried some good debate about the feasibility of solar and wind power from which I have learned much. Please don't be tempted to ever shorten the Mailbag section as Silicon Chip has some very clever readers and even if I disagree with some of them, it is refreshing and educating to read their viewpoints.

The Mailbag section and Dave Thompson's Serviceman's Log are the two sections I enjoy the most.

One request for a project would be a small (10W or so) quality 2.1 amplifier. I have a lovely set of Cambridge Soundworks speakers whose amplifier is beyond economic repair. There are many small amplifier plans out there but none that incorporate a subwoofer. I have purchased an inexpensive Lepai 2.1 amplifier from China that sounds OK but has a high noise floor; enough to sometimes be intrusive at the levels I usually listen.

Keep up the great work.

Matt Agnew,
Christchurch, NZ.

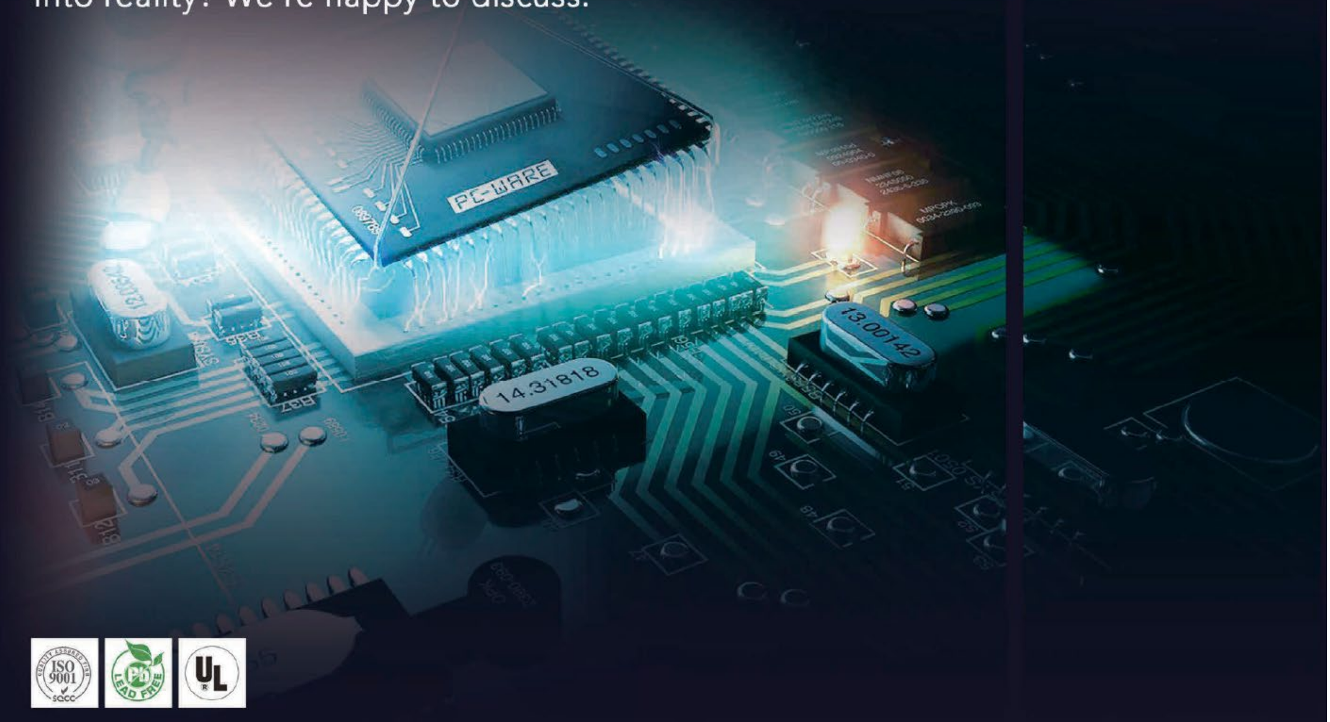
Publisher's note: thanks for your good feedback. We agree that the long links are a problem but shortened ones such as via TinyURL rely on the continued existence of the hosting service and thus may not last forever. On that basis, we prefer to use the long links. However, like you I am hopeless at typing in long links. The way around it is to pay a little extra for a combined print/digital subscription to give access to the full on-line edition. In that you will find that all links are live – you just click on them to take you to the site.

I know that lots of people probably don't agree with my views (ravings) but I think it is important for many issues to be debated. I really do think we are a long way from a full understanding of how climate works – the science is definitely not "settled".

As far as a good quality low-power amplifier is concerned, have a look at the Mini-D one-chip 2 x 5W amplifier module in the November 2014 issue. It is not extreme hifi but it is quite good. Click on this link(!) www.siliconchip.com.au/Issue/2014/November/One-Chip+2+x+5W+Mini+Stereo+Amplifier *to see a free 2-page preview.*

After a week I didn't have any response, so I raised a complaint in their online help desk system. I received the usual "your request has been received and you will be contacted within 24 hours" email but after several days there was still no response. I decided to fill in the online form again; the system responded that it duplicated an existing request. Fair enough, but why was there no response?

Also, their problem tracking system would not allow me to see the status of the complaint. So I raised another complaint, asking what was being done about the NBN connection and why I couldn't track my complaints. This elicited an SMS after midnight telling me how to reset my modem to re-establish my ADSL connection (which was running fine). The next day there was an email detailing how to access the tracking system, with exactly the steps I had used previously, which


PC-WARE
14.31818
13.00142

Mailbag: continued

Another Holden with an intermittent fault

I read the Serviceman's Log column by Dr Hugo Holden in the September 2016 issue with keen interest, regarding the intermittent problem in his Holden Berlina. It reminded me of a similar problem I had some years back.

At the time I owned a VL Holden Commodore which I purchased new in 1986. This was no doubt the best vehicle I ever owned, having a Nissan motor. Around the year 2000, it started to play up. I would be driving along and the car would just cut out without warning. This was quite nerve-racking as it also cut the power steering and with it, my control of the vehicle. Then a few minutes or sometimes up to an hour later, it would start again.

I had the NRMA check out the car on two occasions when it stopped. They couldn't find the fault. The dealer also couldn't find the fault. Another time the car just stopped right at the traffic lights which nearly caused a rear-end accident. I again had the NRMA look at it. Once again, no fault was found.

Being an electronics constructor, I decided to check things out myself. First, I just checked out the obvious like the cables, plugs and sockets. but I was really stabbing in the dark. I don't know what guided me to this next stage but I decided to pull apart the electronic distributor and started jiggling some wires. Almost straight away, I found a solder pad with a single wire sitting just a few millimetres above the copper circuit board.

This was an earth wire and as it heated up it caused the intermittent fault, but somehow was able to make some sort of connection whilst cold. I re-soldered the wire back on to the circuit board using more solder than required and bingo, it fixed the problem. I must admit that I can see how difficult it would be to fix an intermittent problem like this but I expected the dealer with their diagnostic systems to have picked it up.

Based on Dr Holden's experience, not much has changed. What a great idea the Automotive Fault Detector is.

Val Starr,
Canberra, ACT.

mysteriously now worked.

Then I received a phone call from a lady who said she had read an email that I wanted to connect to the NBN, and could she help. I explained that I had entered all the details in their online form. She was unable to find the data, although clearly their system had it somewhere; why else would it tell me that I couldn't enter it again? So we walked through the whole process over the phone.

The lady clearly didn't understand that setting up an FTTN connection involved cutting off the phone, as she insisted I retain the phone until the number could be ported to VoIP. "How long will that take?" "A couple of weeks maybe." Not satisfactory but no way around it. We discussed when the NBN switchover would occur, and I stressed it should not be in a week when we were away.

The Friday before we were leaving, after close of business, I received an email saying the work would be done the following Wednesday, when we were away. Fortunately, I was able to get this deferred but had I not read the email, my services would have gone down until I returned.

Things got a little easier after that but it wasn't all plain sailing. I received a VDSL modem from the ISP and three different emails telling me how to set it up. I was able to figure which one was likely to be right and set up the modem, ready to go. I was assured I would be contacted on the day of the cut-over before the line was cut. I was sitting at the computer waiting for the call and the internet connection cut out – fortunately not in the middle of anything important. The phone was also dead so I assumed it was an unannounced cut-over.

I swapped the modems and less than 30 minutes later the VDSL modem es-

Mailbag: continued

tablished a connection to the internet. Two hours later I received an SMS explaining how to set up the modem, except the instructions were for a FTTP connection, not FTTN. Four hours after that, I received an SMS advising the service was ready to use.

Just to add a little frustration, I have a VoIP service that uses a standalone ATA (Analog Telephone Adaptor), so I ordered a modem that didn't have built-in VoIP. At first try, the VoIP wouldn't work properly, even though it appeared nothing had changed. But further research revealed that VoIP was not designed to work through NAT and modems implement various workarounds that don't always work. And it seems my previous modem worked and the new one didn't. Fortunately, the ATA also had a workaround and enabling that fixed the problem.

The final straw was that the ISP charged me for the ADSL service for the month after the service was discontinued and also charged me for an email account despite the NBN service coming with free email accounts. I am assured this will be refunded but we shall see. On the bright side, our old landline number was ported to VoIP in two days rather than two weeks and the service has run without a glitch ever since the connection was first established.

I feel for less technically savvy people who have to go through this. Everyone who has access to FTTN will need to do so in the next 18 months if they want "landline" internet or phone. One hopes the ISPs are learning, and the process gets smoother.

Alan Cashin,
Islington, NSW.

TPG NBN gets the thumbs-up

Regarding Julian James' letter on the NBN (Mailbag, September 2016, page 16), I switched from a Telstra landline to the NBN about 18 months ago. I chose TPG and they were quite confident that all the phone line connected devices I had would work once plugged into their modem box.

They were 100% right! They have an extensive section about this on their website and they even adopted some suggestions of mine as to how some things could be worded better.

I found the information about the dialgizmo interesting, although I don't know if I want to spend $39.95 just to get my old phone working . . .

Keith Walters,
Bligh Park, NSW.

Cramming software into the Micromite

I found the panel in the Appliance Energy Meter article on fitting the software into the Micromite (page 94, September 2016) quite interesting. Thanks for the tips. I've a rather large program running on my Colour Maximite which was crashing with an "Out of Memory" error when doing a string manipulation after I added more code. The MEMORY command showed about 10% free. I also had about 100 variables of one sort or another. I had done some culling of string variables and other things previously.

I took the plunge and converted as many variables as possible that weren't in arrays into arrays, reduced name lengths, converted flags to bits etc. The results when I eventually got the program up and running again was a 50% reduction in variables, giving 29% free memory. I've now been able to add more features without any problems and there's now plenty of room for more expansion.

By the way, there was a comment by Geoff about the Colour Maximite and bulky VGA screens in the "Explore 100" article. The CMM may be long in the tooth but it still can serve a purpose when you want to display something large, so that it can be read across a room.


KCS TraceME
hello! TraceME LoRa™ Technology
VEHICLE TRACKING
PERSONAL TRACKING
premium
high-end
mid-range
budget
budget
mid-range
mid-range
budget
TM186/R9A10
TM201/R9U10
TMR9B3/R9A10
TM178/R9H7
TM203/R9F4
TM189/R9P4
TM179/R9Q1
TM206/R9D5
and goodbye GPS?
OBJECT TRACKING
high-end
mid-range
mid-range
budget
budget
budget
OEM
OEM
OEM
OEM
TM202/R9C7
TM202F/R9C5
TM230/R9M1
TM202B/R9C5
TM900/N1C1
TM901/N1C2
www.Trace.ME
All trademarks mentioned herein belong to their respective owners.

Mailbag: continued

Is the NBN capable of extended power outages or system failures?

After talking to a senior NBN consultant as to how our community would be serviced by the "microwave" solution I was alarmed by just how fragile their system was to equipment failures and power outages. As I understand it, the network starts after the optical fibre connection and is fed via a 3GHz network that interlinks the towers and provides the last connection to the premises via panels that can support up to 296 customers on each tower.

There is no redundant optical fibre in case of failure, there is no equipment diversity on the interlinked towers, and no apparent power backup in the form of batteries or alternative power. If we lose the fibre, the network goes down. If we lose power anywhere, including customer's power, no network again.

"No problem", says the NBN man, "we can fix it quickly to meet customer guarantee obligations". But I live in a very high fire probability area and the first problem that arises during a fire is when the power goes out. I am currently served by a Telstra RIM for both ADSL and phone and that is only good for, say, 12 hours of no power. When the power was out some time ago for 24 hours, the RIM didn't come back and it took seven days to fix a flat battery fault, even after a high level of complaints.

It would seem that FTTN (fibre-to-the-node) is also reliant on mains power at the cabinet. With an NBN final cost which is unknown, why are we being offered such a unreliable solution?

Brian Andrews,
Steels Creek, Vic.

Regarding software tutorials, one of my main problems is working out the syntax of commands, eg, when I am supposed to use "quotes" in a command. I spent about three hours the other week trying to read and write data to a file on another directory on the SD card. I could read data from the COM1 port OK. I eventually got the process up and running; quite simple really, once you know what you are doing.

If Geoff Graham wrote examples for each command or function in the manual, that would be great but I know that would put a bigger workload on him and make the manuals that much larger. So I say the more hints, tips and code snippets, the better. The information given on The Backshed Forum is also great (www.thebackshed.com) but a lot of that is over my head which is understandable as the forum covers a diverse range of members and followers (like me) with varied interests.

Brian Playne,
Toowoomba, Qld.

Modern cars already log a lot of data

On the "Motorway Patrol" program on New Zealand TV recently, after a car accident, the investigators pulled out the "Air Bag Initiator"; an alloy box about 125mm square and about 35-50mm high. From this, they found that the car was doing 161km/h in an 80km/h zone. This device holds the previous five minutes of the vehicle's travel!

I believe in the USA there was a legal stoush as to whether this information should be available to police or insurance companies.

Ray Trewartha,
New Zealand.

Terrible ISP support service

Your Serviceman story in the August 2016 issue reminded me of my last move to a country town when I tried to take my internet service with me. I was presented with bills for services left connected in Melbourne, as well as my new local accounts. Their service descriptions were so vague that I didn't know what I was supposed to be paying for, so I refused until things were clarified.

It was finally sorted but ongoing service problems with the ISP saw me switch to their opposition. As I repair computers, I have seen many of these issues happen with the poor users confused, disconnected, reconnected and billed for services which were never authorised.

In Melbourne, they used plastic bags to seal vital copper connections, as the other sealants became brittle after some time and failed to do their job. As a result, Melbourne was colloquially called "Bag dad" by the technicians.

I am not surprised by the moronic behaviour of support teams but hasten to say a lot of things have improved with the ACCC and Telecommunications Industry Ombudsman making a fast meal out of ISPs who don't toe the expected line.

I would suggest anyone having these sort of problems get in touch with them.

John Vance,
Wangaratta, Vic.

Article on the MEN system wanted

I am trying to locate a copy of an article written by the late, great Neville Williams in *Electronics Australia* magazine. As you can imagine, it would be quite old by now, however it was a very good article regarding why the mains power system is earthed. If I remember correctly, it was in either the Forum section or the Mailbag section of EA.

EA projects are listed on your website but not features. It really was a good article and I really would like to get a copy. Is there any way that such an article can be found?

David Haddock,
Bethania, Qld.

Leo replies: the article was published in the Forum pages of the June 1980 issue of EA and can be purchased via the SILICON CHIP website. However, we don't think that it goes far enough in explaining the need for earthing.

Back in August 2014, I unleashed a host of correspondence about the MEN (Multiple Earth Neutral) system, in an article entitled "Your House Water Pipes Could Kill You" (see the subsequent Publisher's Letter and letters in the September 2014 issue and in following issues). I think that this material would give a much better overview of the MEN system.

Sourcing parts for Vintage Radio restoration

I noticed a reader asking for a source of high-voltage axial capacitors in the "Ask SILICON CHIP" section in the August issue. The Australian Vintage Radio Society carries a full range of polyester, electrolytic and mica types along with valves and data to assist members with their restorations.

Components are listed under "AVRS Parts Service" on the righthand side of the home page. The link is: www.avrs.org.au/valves&components.htm

For further information, the AVRS can be contacted at www.avrs.org.au

Warwick Woods,
President, Australian Vintage Radio Society Inc.

SC

SILICON CHIP ONLINESHOP

PCBs and other hard-to-get components now available direct from the SILICON CHIP ONLINESHOP

NOTE: PCBs from past ~12 months projects only shown here but the SILICON CHIP ONLINESHOP has boards going back to 2001 and beyond. For a complete list of available PCBs, back issues, etc, go to siliconchip.com.au/shop Prices are PCBs only, NOT COMPLETE KITS!

ULTRA-LD MK4 200W AMPLIFIER MODULE	SEP 2015	01107151	$15.00
9-CHANNEL REMOTE CONTROL RECEIVER	SEP 2015	15108151	$15.00
MINI USB SWITCHMODE REGULATOR MK2	SEP 2015	18107152	$2.50
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	SEP 2015	01205141	$20.00
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	OCT 2015	01205141	$20.00
ULTRA LD AMPLIFIER POWER SUPPLY	OCT 2015	01109111	$15.00
ARDUINO USB ELECTROCARDIOGRAPH	OCT 2015	07108151	$7.50
FINGERPRINT SCANNER – SET OF TWO PCBS	NOV 2015	03109151/2	$15.00
LOUDSPEAKER PROTECTOR	NOV 2015	01110151	$10.00
LED CLOCK	DEC 2015	19110151	$15.00
SPEECH TIMER	DEC 2015	19111151	$15.00
TURNTABLE STROBE PCB	DEC 2015	04101161	$5.00
CALIBRATED TURNTABLE STROBOSCOPE ETCHED DISC	DEC 2015	04101162	$10.00
VALVE STEREO PREAMPLIFIER – PCB	JAN 2016	01101161	$15.00
VALVE STEREO PREAMPLIFIER – CASE PARTS	JAN 2016	01101162	$20.00
QUICKBRAKE BRAKE LIGHT SPEEDUP	JAN 2016	05102161	$15.00
SOLAR MPPT CHARGER & LIGHTING CONTROLLER	FEB/MAR 2016	16101161	$15.00
MICROMITE LCD BACKPACK, 2.4-INCH VERSION	FEB/MAR 2016	07102121	$7.50
MICROMITE LCD BACKPACK, 2.8-INCH VERSION	FEB/MAR 2016	07102122	$7.50
BATTERY CELL BALANCER	MAR 2016	11111151	$6.00
DELTA THROTTLE TIMER	MAR 2016	05102161	$15.00
MICROWAVE LEAKAGE DETECTOR	APR 2016	04103161	$5.00
FRIDGE/FREEZER ALARM	APR 2016	0310416	$5.00
ARDUINO MULTIFUNCTION MEASUREMENT	APR 2016	04116011/2	$15.00
PRECISION 50/60HZ TURNTABLE DRIVER	MAY 2016	04104161	$15.00
RASPBERRY PI TEMP SENSOR EXPANSION	MAY 2016	24104161	$5.00
100DB STEREO AUDIO LEVEL/VU METER	JUN 2016	01104161	$15.00
HOTEL SAFE ALARM	JUN 2016	03106161	$5.00
UNIVERSAL TEMPERATURE ALARM	JULY 2016	03105161	$5.00
BROWNOUT PROTECTOR	JULY 2016	10107161	$10.00
8-DIGIT FREQUENCY METER	AUG 2015	04105161	$10.00
APPLIANCE ENERGY METER	AUG 2015	04116061	$15.00
MICROMITE PLUS EXPLORE 64	AUG 2015	07108161	$5.00
CYCLIC PUMP/MAINS TIMER	SEPT 2016	10108161/2	$10.00/pair
MICROMITE PLUS EXPLORE 100 (4 layer)	SEPT 2016	07109161	$20.00
AUTOMOTIVE FAULT DETECTOR	SEPT 2016	05109161	$10.00

NEW THIS MONTH

MOSQUITO LURE	OCT 2016	25110161	$5.00
MICROPOWER LED FLASHER	OCT 2016	16109161	$5.00
MINI MICROPOWER LED FLASHER	OCT 2016	16109162	$2.50

Prices above are for the Printed Circuit Board ONLY – NO COMPONENTS OR INSTRUCTIONS ETC ARE INCLUDED! P&P for PCBS (within Australia): $10 per order (ie, any number)

PRE-PROGRAMMED MICROS

Price for any of these micros is just $15.00 each + $10 p&p per order#

As a service to readers, *SILICON CHIP ONLINESHOP* stocks microcontrollers and microprocessors used in new projects (from 2012 on) and some selected older projects – pre-programmed and ready to fly!

Some micros from copyrighted and/or contributed projects may not be available.

PIC12F675-I/P	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10), Cricket/Frog (Jun12) Do Not Disturb (May13) IR-to-UHF Converter (Jul13), UHF-to-IR Converter (Jul13) PC Birdies *2 chips – $15 pair* (Aug13). Driveway Monitor Receiver (July15) Hotel Safe Alarm (Jun16) **Mosquito Lure (Oct16) LED Flasher (Oct16)**
PIC16F1507-I/P	Wideband Oxygen Sensor (Jun-Jul12)
PIC16F88-E/P	Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13), Auto Headlight Controller (Oct13) 10A 230V Motor Speed Controller (Feb14)
PIC16F88-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Quizzical (Oct11) Ultra LD Preamp (Nov11), 10-Channel Remote Control Receiver (Jun13), Revised 10-Channel Remote Control Receiver (Jul13), Nicad/NiMH Burp Charger (Mar14) Remote Mains Timer (Nov14), Driveway Monitor Transmitter (July15) Fingerprint Scanner (Nov15) MPPT Lighting Charge Controller (Feb16) 50/60Hz Turntable Driver (May16) 8-Digit Frequency Meter (Aug16)
PIC16LF88-I/P	Garbage Reminder (Jan13), Bellbird (Dec13)
PIC16LF88-I/SO	LED Ladybird (Apr13)
PIC16LF1709-I/SO	Battery Cell Balancer (Mar16)
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semtest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F45K80	USB Power Monitor (Dec12)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12), Touchscreen Audio Recorder (Jun/Jul 14)
PIC32MX170F256B-50I/SP	Micromite Mk2 (Jan15) – *also includes **FREE** 47µF tantalum capacitor* Micromite LCD Backpack [either version] (Feb16) GPS Boat Computer (Apr16) Micromite Super Clock (Jul16)
PIC32MX170F256B-I/SP	Low Frequency Distortion Analyser (Apr15)
PIC32MX170F256D-501P/T	44-pin Micromite Mk2 (Now with Mk2 Firmware at no extra cost)
PIC32MX250F128B-I/SP	GPS Tracker (Nov13) Micromite ASCII Video Terminal (Jul14)
PIC32MX470F512H-I/PT	Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb14), Digital Effects Unit (Oct14)
PIC32MX470F512H-120/PT	Micromite Plus Explore 64 (Aug16)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)
dsPIC33FJ64MC802-E/P	Induction Motor Speed Controller (revised) (Aug13)
dsPIC33FJ128GP306-I/PT	CLASSiC DAC (Feb-May 13)
ATTiny861	VVA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)
ATTiny2313	Remote-Controlled Timer (Aug10)

When ordering, be sure to nominate BOTH the micro required AND the project for which it must be programmed.

SPECIALISED COMPONENTS

P&P: FLAT RATE $10.00 PER ORDER#
PCBs, COMPONENTS ETC MAY BE COMBINED (in one order) FOR $10-PER-ORDER P&P RATE

NEW-THIS-MONTH:

MOSQUITO LURE – TPA2005 Class-D amplifier IC plus SMD micro-USB socket	*(Oct16)*	**$7.50**

MICROMITE EXPLORE PLUS 64 – complete kit including PCB and all on-board parts	*(Aug16)*	**$30.00**
APPLIANCE ENERGY METER – BackPack kit programmed to suit project, ***no lid***	*(Aug16)*	**$60.00**
8-DIGIT FREQUENCY METER – matte black laser-cut lid for UB3 jiffy box	*(Aug16)*	**$5.00**
APPLIANCE ENERGY METER – matte black laser-cut lid for UB1 jiffy box	*(Aug16)*	**$10.00**
DS3231-BASED REAL TIME CLOCK MODULE with two 10mm M2 spacers & four 6mm M2 Nylon screws	*(Jul16)*	**$5.00**
100dB STEREO AUDIO LEVEL/VU METER All SMD parts except programmed micro and LEDs (both available separately)	*(Jun16)*	**$20.00**
RASPBERRY PI TEMPERATURE SENSOR EXPANSION Two BSO150N03 dual N-channel Mosfets plus 4.7kΩ SMD resistor:	*(May16)*	**$5.00**
MICROWAVE LEAKAGE DETECTOR - all SMD parts:	*(Apr16)*	**$10.00**
BOAT COMPUTER - **(REQUIRES MICROMITE LCD BACKPACK – $65.00 [see below])**	*(Apr16)*	
BOAT COMPUTER - VK2828U7G5LF TTL GPS/GLONASS/GALILEO module with antenna & cable:		**$25.00**
BOAT COMPUTER - VK16E TTL GPS module with antenna & cable:	*(Apr16)*	**$20.00**
ULTRASONIC PARKING ASSISTANT (REQUIRES MICROMITE LCD BACKPACK – $65.00 [see below] Ultrasonic Range Sensor PLUS clear lid with cutout to suit UB5 Jiffy Box	*(Mar 16)*	**$7.50**
BATTERY CELL BALANCER ALL SMD PARTS, including programmed micro	*(Mar 16)*	**$50.00**
MICROMITE LCD BACKPACK *** COMPLETE KIT ***** ** includes PCB, micro and 2.8-inch touchscreen **AND NOW INCLUDES LID** *(specify clear or black lid)*	*(Feb 16)*	***$65.00**
VALVE STEREO PREAMPLIFIER - 100µH SMD inductor, 3x low-profile 400V capacitors & 0.33Ω resistor	*(Jan 16)*	**$30.00**
MINI USB SWITCHMODE REGULATOR Mk II all SMD components	*(Sept15)*	**$15.00**
ARDUINO-BASED ECG SHIELD - all SMD components	*(Oct 15)*	**$25.00**
ULTRA LD Mk 4 - plastic sewing machine bobbin for L2 – pack 2	*(Oct 15)*	**$2.00**
VOLTAGE/CURRENT/RESISTANCE REFERENCE - all SMD components# # includes precision resistor. Specify either 1.8V or 2.5V	*(Aug 15)*	**$12.50**
MINI USB SWITCHMODE REGULATOR all SMD components	*(July 15)*	**$10.00**
BAD VIBES INFRASOUND SNOOPER - TDA1543 16-bit Stereo DAC IC	*(Jun 15)*	**$2.50**
BALANCED INPUT ATTENUATOR - all SMD components inc.12 NE5532D ICs, 8 SMD diodes, SMD caps, polypropylene caps plus all 0.1% resistors (SMD & through-hole)	*(May 15)*	**$65.00**
APPLIANCE INSULATION TESTER - 600V logic-level Mosfet. 5 x HV resistors:	*(Apr15)*	**$10.00**
ISOLATED HIGH VOLTAGE PROBE - Hard-to-get parts pack: all ICs, 1N5711 diodes, LED, high-voltage capacitors & resistors:	*(Jan15)*	**$40.00**
CDI – Hard-to-get parts pack: Transformer components (excluding wire), all ICs, Mosfets, UF4007 diodes, 1µF X2 capacitor:	*(Dec 14)*	**$40.00**
CURRAWONG AMPLIFIER Hard-to-get parts pack: LM1084IT-ADJ, KCS5603D, 3 x STX0560, 5 x blue 3mm LEDs, 5 x 39µF 400V low profile capacitors	*(Dec 14)*	**$50.00**

All items subject to availability. Prices valid for month of magazine issue only. All prices in Australian dollars and included GST where applicable. **# P&P prices are within Australia. O'seas? Please email for a quote**

To Place Your Order:

INTERNET (24/7)	PAYPAL (24/7)	eMAIL (24/7)	MAIL (24/7)	PHONE - (9-4, Mon-Fri)
siliconchip.com.au/Shop	Use your PayPal account silicon@siliconchip.com.au	silicon@siliconchip.com.au with order & credit card details	Your order to PO Box 139 Collaroy NSW 2097	Call (02) 9939 3295 with with order & credit card details

You can also order and pay by cheque/money order (Orders by mail only). ^Make cheques payable to Silicon Chip Publications.

10/16

FAST: Scanning

As we go to press, the world's largest single-dish radio telescope has started "listening" into signals from further out in space than has ever been possible. The 1.5 billion yuan, Five-hundred-metre Aperture Spherical Radio Telescope (FAST) in Guizhou Province, China has an Australian connection: its receiver was designed and built by the CSIRO at their Marsfield laboratory in Sydney.

by ROSS TESTER

Five hundred metres in diameter, the FAST Radio Telescope dwarfs the old leader, the Arecibo Observatory in Puerto Rico, by 200 metres, or 164% larger.

It was built by the Chinese National Astronomical Observatory in a natural karst basin at Dawodang, Pintang County in south-western China.

Apart from the topography and geology of the area suiting the dish construction (only limited earthworks were required), it was chosen because there are no cities or even major towns within 8km of the site, making it electrically very "quiet".

This is essential for a radio telescope seeking the unbelievably faint signals from the far reaches of space.

A small village directly at the FAST site was relocated to make room and almost 10,000 people who lived within a 5km radius of the site were each paid CN¥12000 (equivalent to about $AU2500) to relocate. To put this in persective, CN¥12000 represents about a year's income!

Natural sink holes for drainage in the karst basin (and arguably the reason *for* the basin) also influenced the location. It is surrounded by elevated areas – ridges and small mountains – which also lent themselves nicely to the towers which support not only the dish but the receiver platform – more on this shortly.

First proposed in 1994, it was approved and funded in 2007. Construction commenced in 2011 (much of the intervening period was taken up in finding a suitable site) and it was completed in July this year.

The dish, or reflector, consists of 4450 triangular panels made from perforated aluminium. They're 11m on each side and are connected together to form an inverted geodesic dome.

Originally budgeted for CN¥700 million (approx. $AU140 million), the final cost was more than double this at CN¥1.5 billion.

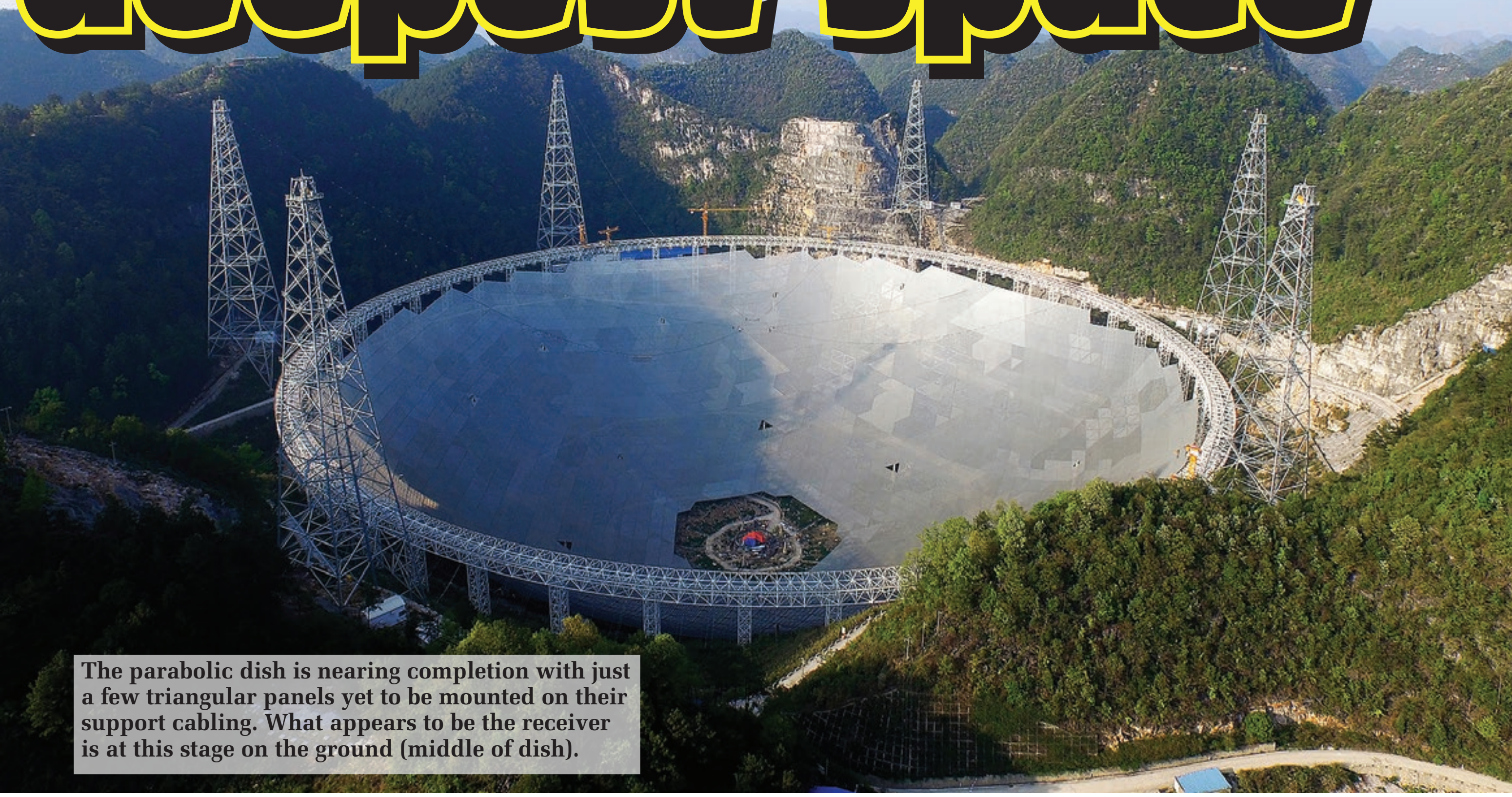
Its acronym, "FAST" is not entirely correct. Firstly, the "F" (standing for 500m) – not all of the 500m diameter can be used (in fact, only about 300m can be used at any one time) and the "S" (Spherical) – while the dish construction is spherical, the usable section is actually a parabola.

While the overall inverted dome is fixed in one place, it can be (and must be) somewhat movable to be of any use (otherwise it would be limited to how much sky it could view!).

Main specifications of FAST telescope

Item	Specification
Spherical reflector	Radius 300m, Aperture 500m
Opening angle	110-120°
Illuminated aperture	D_{illu} =300m
Focal ratio	f/D=0.4665
Sky coverage	zenith angle ±40°
Frequency	70-3000MHz
Multi-beam(L-band)	19, beam number of future FPA >100
Slewing	<10min
Pointing accuracy	8" (200mm)

deepest space



The parabolic dish is nearing completion with just a few triangular panels yet to be mounted on their support cabling. What appears to be the receiver is at this stage on the ground (middle of dish).

The supporting structure is made from aluminium to keep the weight to a minimum, but flexible steel cables underneath the panels can push or pull on the panel joins, thus moving them into a parabolic dish and aiming it at the area of the sky of interest. Maximum deviation between the ideal and the parabola thus formed is less than 0.67m across the illuminated area.

The receiver platform

Suspended above the dish on six cables, connected to the towers around its edge, is a light-weight feed cabin, mounted on a Stewart Platform (a platform which itself has integrated hydraulic/servo position setting) which gives very fine positional adjustment.

This is moved into position by servo mechanisms mounted on each of the six towers into the focus of the parabola. These not only provide the precision of the dish – eight arcseconds – it also compensates for disturbances such as wind motion and temperature variations. Design positional accuracy is less than ±10mm.

By the way, an arcsecond (abbreviated arcsec or asec) is 1/1,296,000 of a full 360° turn – or one sixtieth of one sixtieth of one degree.

That precision is absolutely required for meaningful reception. When looking for signals thousands of light years out in space, even that tiny error can mean it's millions of kilometres off!

Underneath the feed cabin is the nine-channel receiver, with the 1.23GHz-1.53GHz band around the hydrogen line

The hydrogen line

Radio astronomers are very interested in one particular frequency, 1420.405751786MHz.

This is the so-called "hydrogen line" (or H I line) and refers to the electromagnetic radiation spectral line that is created by a change in the energy state of neutral hydrogen atoms. Hydrogen is the lightest element and is believed to be one of the most widely spread elements in the universe.

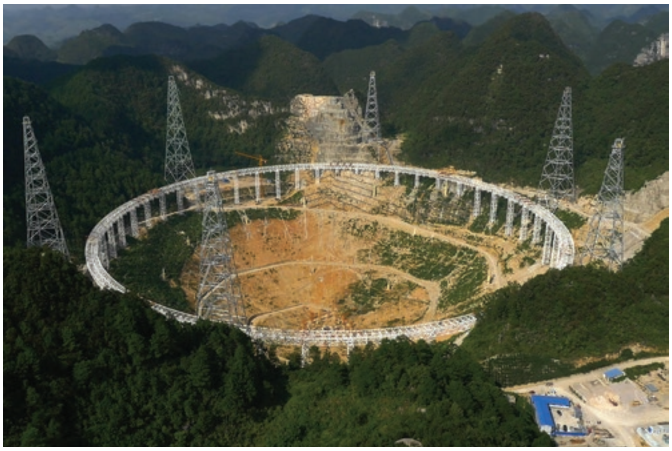
The microwaves of the hydrogen line come from the atomic transition of an electron between the two hyperfine levels of the hydrogen 1s ground state that have an energy difference of 5.87433μeV.

Electromagnetic energy of this frequency passes very easily through Earth's atmosphere and is one of the more promising pieces of evidence of extra-terrestrial "life"

It's also one of the most favoured frequencies used by SETI in their search for the elusive radio signals of space which may be an indication of inter-stellar communication. It was during such a search in October 1977 that a signal, believed to come from the Saggitarius constellation, was received by SETI radio-astronomers from Ohio State University (USA) that was of such significance that it earned the sobriquet of the "WOW!" signal (See https://en.wikipedia.org/wiki/Wow!_signal).

It has never been detected since.

With the significant increase in sensitivity of the FAST Radio Telescope, researchers are hoping that similar discoveries might become easier and/or more common.



Stages in the construction of the FAST Radio Astronony observatory in Guizhou Province, China. The site was chosen because it is a natural karst basin (karst being the dissolution of soluble rocks).

(see panel P17) using a 19-beam receiver designed and built by Australia's CSIRO as part of the Australian-China Consortium for Astrophysical Research (ACAMAR). Nineteen beams means that signals from different areas of space can be received at the same time.

The working frequency range is 70MHz – 3GHz and FAST is capable of pointing anywhere within ±40º of its zenith. However, vignetting (reduction in sensitivity towards the edges) reduces the effective aperture to about 30º.

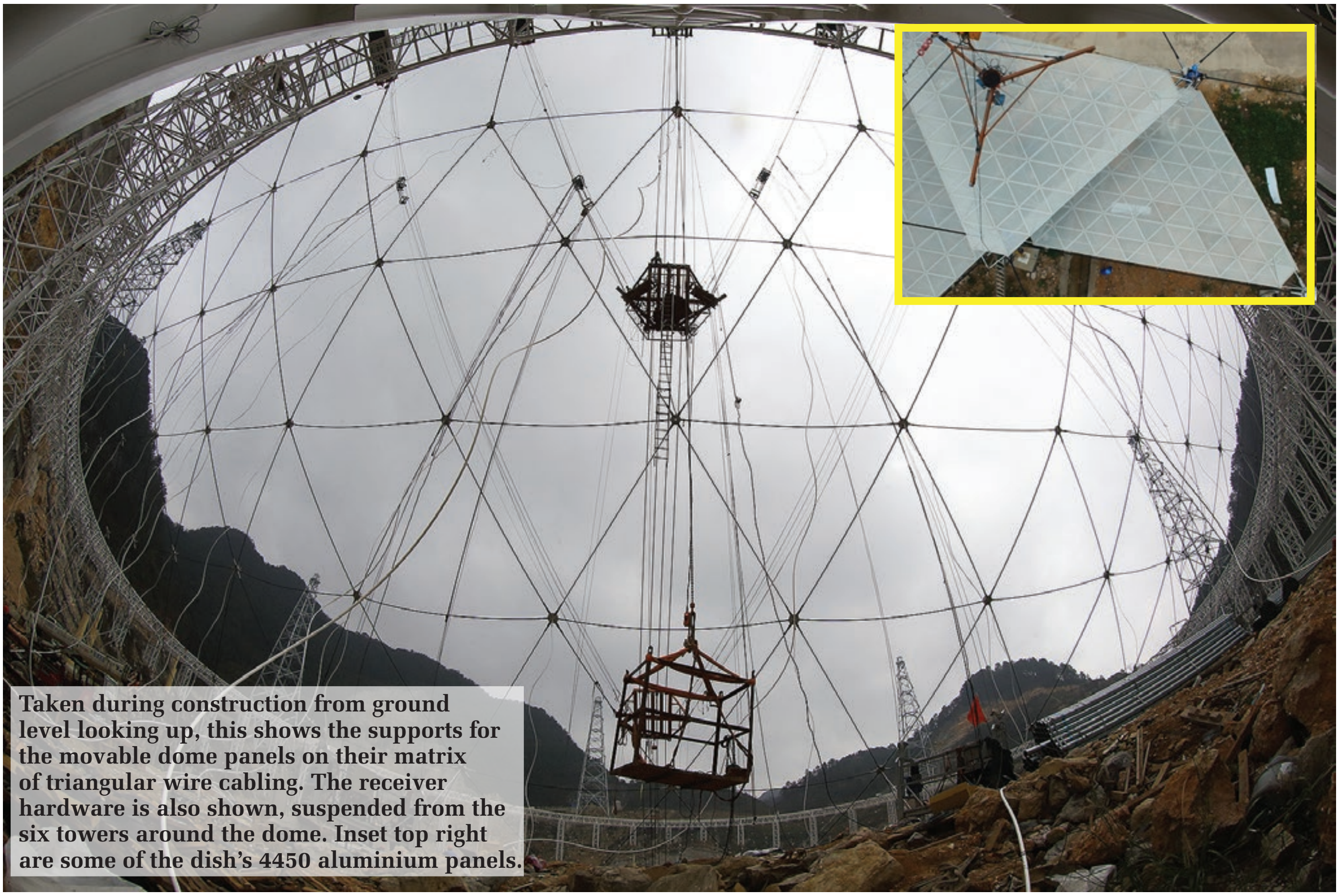
What's it looking for?

Like virtually all radio telescopes, FAST is looking for a number of phenomena in the far reaches of space . . . except it is doing so with considerably increased (and unprecedented) sensitivity.

Primarily, its targets include:

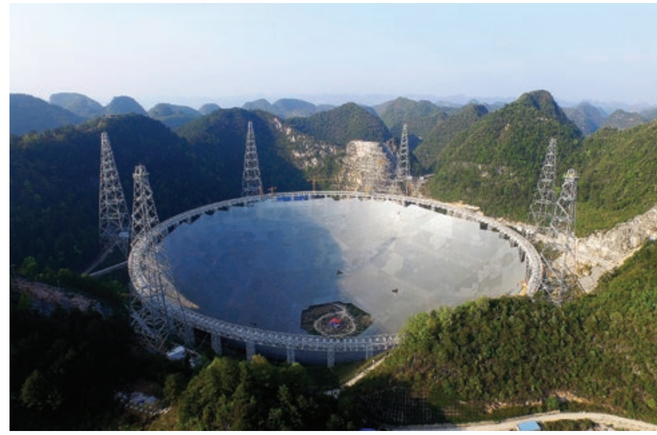
Masers – a naturally occuring source of stimulated spectral line emission associated with stars and active galactic nuclei. These can sometimes allow distance measurement by trigonometry (not to be confused with terrestrial masers, the microwave equivalent of a laser).

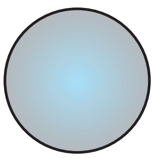
Pulsars – the rotating remnant of a collapsed star. The interesting thing about these is that they can form cosmic "clocks" providing ultra-stable periodic pulses (some of these are even better than the most stable atomic clocks on Earth!). Pulsars may provide detection



Taken during construction from ground level looking up, this shows the supports for the movable dome panels on their matrix of triangular wire cabling. The receiver hardware is also shown, suspended from the six towers around the dome. Inset top right are some of the dish's 4450 aluminium panels.

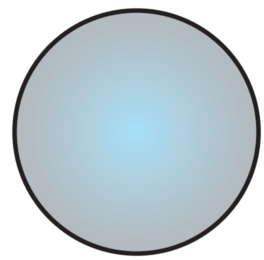
Comparison between Arecibo and FAST





Arecibo Observatory
Location: Puerto Rico
Built: 1963
(upgraded 1977)
Diameter: 305m
Dish: fixed

Postscript: Arecibo observatory was damaged by a 6.4 magnitude earthquake on Jauary 13, 2014 but is now back in full operation.



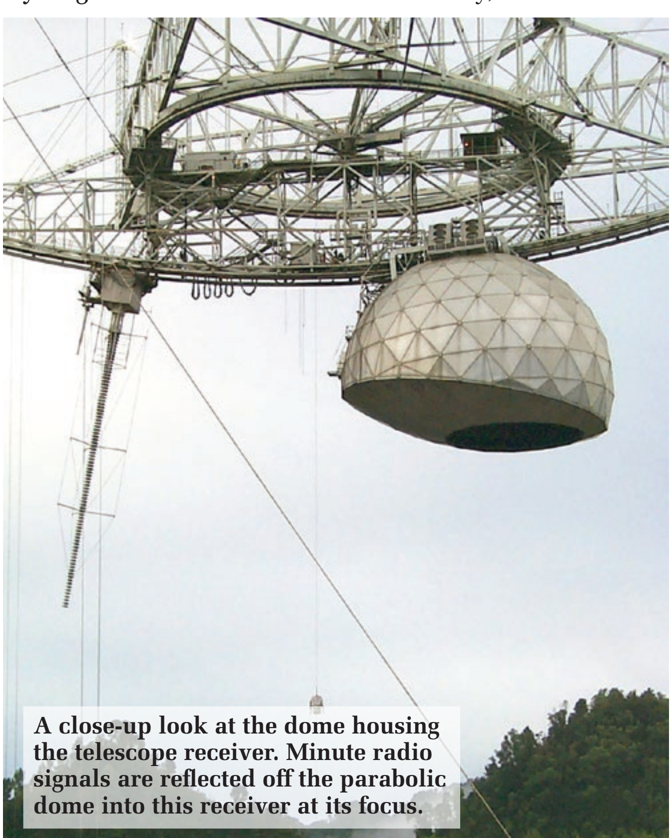
FAST Radio Telescope
Location: SW China
Built: 2011-2016
Diameter: 500m
Dish: variable

of gravitational waves (see SILICON CHIP, April 2016).

FAST is sensitive enough to look beyond our galaxy and possibly detect the first radio pulsar in another galaxy.

Exoplanets – planets orbiting other stars. Some of these have at least the possibility of supporting life, so FAST may well detect radio emissions from extra-terrestrial intelligence.

Hydrogen clouds – due to their sensitivity, FAST's receivers will allow examination of neutral hydrogen clouds in the Milky Way.



A close-up look at the dome housing the telescope receiver. Minute radio signals are reflected off the parabolic dome into this receiver at its focus.

New galaxies – similarly, FAST may discover tens of thousands of new galaxies, up to six billion light years away (a distance covering about half the age of the universe).

A VLBI element? Due to its own large collecting area and geographical location, FAST may be used to complement the existing international very-long-baseline interferometry (VLBI) network (see SILICON CHIP, May 2005). FAST would increase the baseline detection sensitivity by an order of magnitude.

Ground station for space missions – FAST might also be called into play for future long-distance space missions. The large collecting area would enable the downlink data rate to increase by orders of magnitude over other dishes.

SETI – The Search for Extra-Terrestrial Intelligence – is a world-wide search program using unused time by computer users trying to find evidence of, well, ET! Some of the radio-telescopes which have occasional down-time feed data into SETI and it is to be hoped that FAST may be one of those.

Comparison between FAST and Arecibo

The basic design of FAST is very similar to the Arecibo Observatory radio telescope in Puerto Rico. Both are fixed primary reflectors installed in natural hollows, made of perforated aluminum panels with a movable receiver suspended above.

There are, however, three significant differences in addition to the size. First, Arecibo's dish is fixed in a spherical shape. Although it is also suspended from steel cables with supports underneath for fine-tuning the shape, they are manually operated and adjusted only for maintenance. It has two additional reflectors suspended above to correct for the resultant spherical aberration.

Second, Arecibo's receiver platform is fixed in place. To

Early in the construction, this photo shows the infrastructure partially completed – but more importantly, the cosmos FAST will be searching.

support the greater weight of the additional reflectors, the primary support cables are static, with the only motorized portion being three hold-down winches which compensate for thermal expansion. The antennas are mounted on a rotating arm below the platform.

This smaller range of motion limits it to viewing objects within 19.7° of the zenith.

Third, the FAST dish is significantly deeper, contributing to a wider field of view. Although 64% larger in diameter, FAST's radius of curvature is 300m, barely larger than Arecibo's 270m, so it forms a 113° arc (vs. 70° for Arecibo.) While Arecibo's full aperture of 305m can be used when observing objects at the zenith, the effective aperture for more typical inclined observations is 221m.

Acknowledgement: most photographs in this feature courtesy CSIRO and/or Chinese National Astronomical Observatory SC

The Arecibo Message

To mark the recomissioning of the Arecibo radio telescope in November 1974, a digital message was transmitted into space which was designed to (hopefully!) show anyone who received it a little about who sent it and where they (we!) came from.

Dr Frank Drake, then of Cornell University and colleagues wrote a three-minute message consisting of 1679 binary digits (approximately 210 bytes) and was transmitted with a power of 1MW, on a frequency of 2380MHz. To mark the difference between "0" and "1", the frequency was shifted up by 10Hz.

1679 has its own significance: it's a semiprime number (ie, the product of two prime numbers – 73 and 23 – arranged retangularly as 73 rows by 23 columns).

The message, was aimed at a cluster of stars some 25,000 light years away – so if it is received and decoded, any answer will not be detected for some 50,000 years (about 500,000,000,000,000,000km round trip, give or take!).

What does it mean?

There were seven parts to the message, shown in the colour graphic at right for clarity (the actual message was in mono).

The top lines (white) show the numerals 1 to 10.

The second set (purple) show the atomic numbers of hydrogen, carbon, nitrogen, oxygen and phosphorous. These elements make up deoxyribonucleic acid (DNA).

The third set (green) show the formulas for the sugars and bases in the nucleotides of DNA.

The next, white and blue, show the number of nucleotides in DNA amd a graphic of the double helix structure.

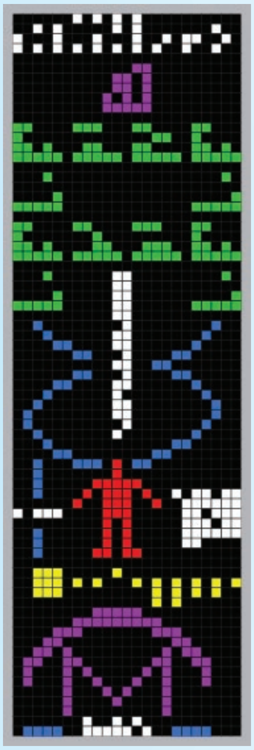
Following this in red is, obviously, a man (red) including his average dimension (blue/white) and the human population of Earth (white).

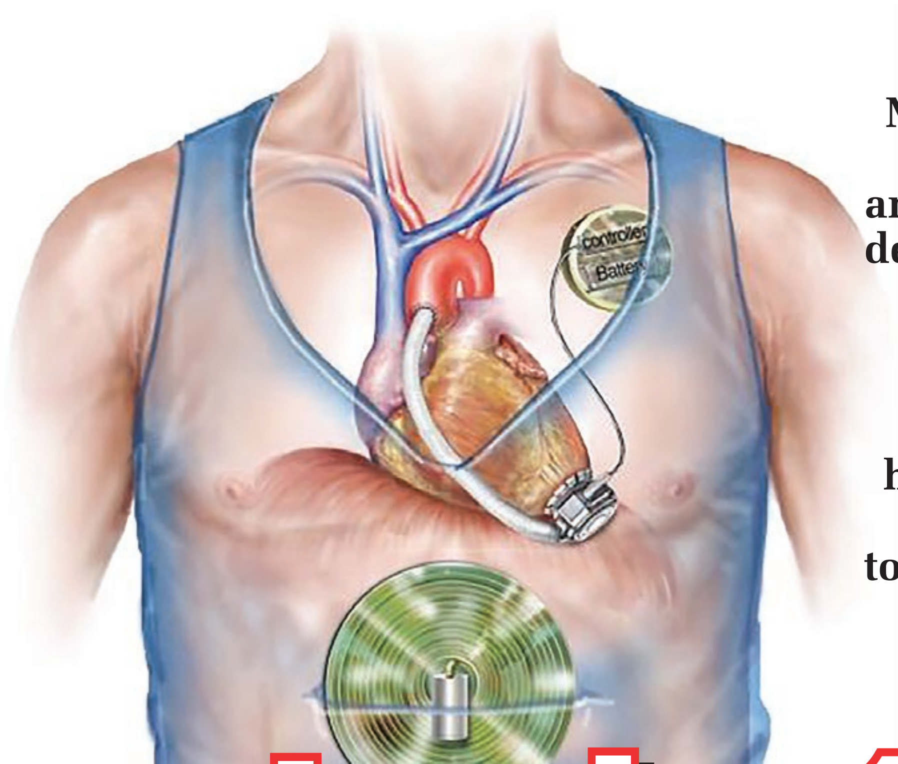
The yellow row is a graphic of our solar system, unfortunately not to scale because that was impossible to do – but the size of the nine planets is somewhat relative.

The third planet from the left is deliberately offset to mark the planet from which the signal was sent.

Finally, there is a graphic (purple) of the Arecibo radio telescope and the dimension of the transsmitting antenna dish (blue and white).

Incidentally, there hasn't *yet* been any reply to the Arecibo message!





More and more implantable electronic medical devices are being developed to correct deficiencies in bodily function due to disease, accident or simply wear'n'tear. They can range from pacemakers to devices to help bowel function, control epileptic seizures, to block back pain and a wide range of other uses.

By
Dr David Maddison

Implantable Medical Devices

There are hundreds, if not thousands, of implants available. Most people would be familiar with artificial hips and knees, heart pacemakers, coronary stents and eye lenses (for cataract surgery), along with a wide variety of screws and plates used in orthopaedic repairs.

But in this article we will focus on devices that embody some form of electronics rather than those of a purely mechanical nature.

One of the most simple (in principle) implantable electronic devices is the cardiac pacemaker.

The heart is a specialised muscle that is controlled by electricity within its tissues that flows in waves controlled by its natural pacemaker, causing the heart tissue to contract in a certain sequence and then repeat itself.

If this flow is disrupted due to disease, an artificial pacemaker may be required to restore normal function.

The artificial cardiac pacemaker was the first implantable electronic prosthesis and Australia played a significant role in its development in the late 1960s (see later panel on Telectronics).

In its most simple prototypical implementation, the cardiac pacemaker is a simple pulse generator and typical values might be a 5V, 0.5ms pulse, 70 times a minute.

In modern pacemakers, these basic values can be varied according to the requirements of the patient and physical activity.

A related type of implanted prosthesis is a cardioverter for patients whose heart is prone to dangerously fast rhythms. This device detects potentially lethal heart conditions and delivers a shock to reset the heart to a natural rhythm.

The cardioverter may also be combined with a cardiac pacemaker as a single device.

In this article, we will discuss the above and a variety of other implanted electronic devices. We won't be looking at retinal implants as they were covered in the "The Bionic Eye" articles in the June & July 2015 issues.

Nor will we discuss electro-cortical arrays to interface with the brain as these were covered in "Interfacing to the Brain" in January 2015.

A number of other implanted electronic devices, some of them amateur built, were also discussed in the "Biohacking" article of August 2015. Previews of these features can be viewed at siliconchip.com.au – click on the "Articles" or "Browse" tab.

Cochlear implants

The cochlear implant was also developed in Australia, to give people who are profoundly deaf a useful sense of hearing which can dramatically improve their quality of life.

In a normal ear, specialised hair cells in the cochlea respond to sound waves and cause the cochlear nerve to send signals to the brain. If these cells are damaged, hearing is affected.

In this case, an electrode array is placed within the spiral cavity of the cochlea to stimulate the cochlear nerve when sounds are present. The cochlear implant provides useful hearing although it is not as good as natural hearing, as would be expected.

The implant consists of an electrode array which, in a particular cochlear model, contains 24 electrodes, a wireless receiver and an earth wire.

Externally, there is a microphone, an audio processor that optimises speech signals for transmission and a wireless transmitter that couples to the implanted wireless receiver coil.

As improved audio processors and software are developed, the external part of the device can be easily upgraded.

For patients who have cochleas that are so damaged that they are not suitable for a conventional cochlea implant or other conditions, Cochlear have developed a brain stem implant described below.

Auditory brain stem implants

An auditory brain stem implant is designed for patients who are unsuitable for a cochlea implant.

For example, they might have damage to both auditory nerves (more correctly the vestibulocochlear nerve), damage to the cochlea due to tumours, or a congenital absence of the cochlea.

The implant is used to electrically stimulate part of the brain stem which is responsible for receiving information from the auditory nerve and relaying it to the rest of the brain, the cochlear nucleus.

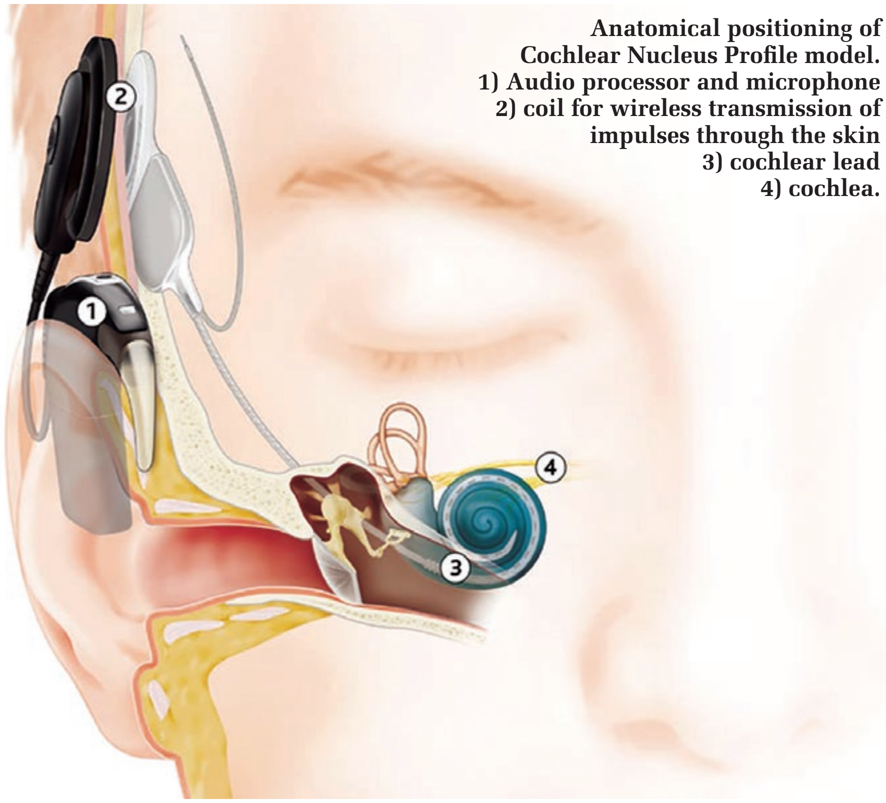
The brain stem implant contains 21 electrodes in an 8 x 3mm array. At the time of implant, each electrode is tested to see which causes auditory stimulation, as opposed to non-auditory stimulation.

Those electrodes that don't provide auditory stimulation are turned off. These 21 electrodes replace the 30,000 fibres of the auditory nerve.

The hearing that results from having an auditory brain stem implant is not as good as that of a cochlear implant. It provides more an indication of the presence or absence of sound and it becomes an aid to lip reading.

However users do report being able to distinguish more and more sounds as they and their brains adjust to it, with continued improvement over years.

See https://youtu.be/G3KOEEHSkPk "*What is a brainstem implant?*"



Anatomical positioning of Cochlear Nucleus Profile model. 1) Audio processor and microphone 2) coil for wireless transmission of impulses through the skin 3) cochlear lead 4) cochlea.

Bone growth stimulators

It has long been known that bioelectricity has a crucial role in bone growth. When a bone fracture does not heal naturally, it can be artificially stimulated to do so.

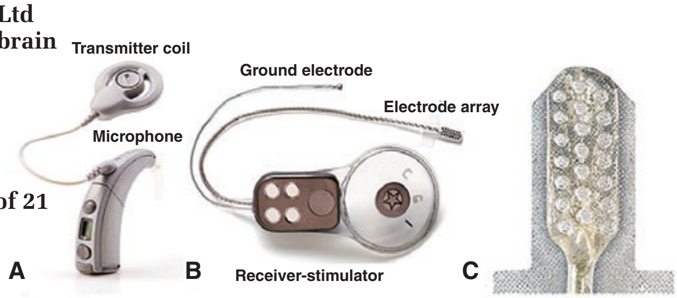
This is done by the application of a small DC current, of the order of 20µA, across the fracture site.

A cathode wire is placed at the fracture site and connected to a power supply implanted just beneath the skin. The metal case of the supply provides the anode connection and hopefully causes bone growth at the fracture.

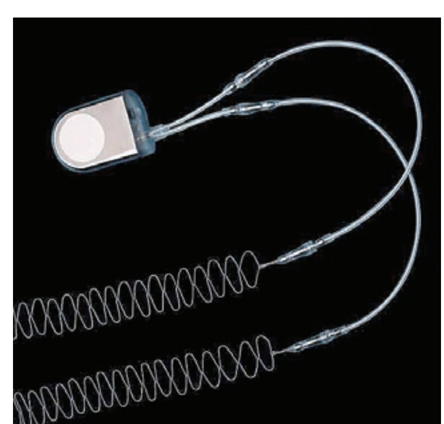
After healing, the power supply is removed but the cathode wire is left as it usually becomes incorporated into the bone and cannot easily be removed.

In one variant of the device, where spinal fusion is required, two cathode electrodes are fitted. One such model is the Biomet SpF. Its battery and electronics are contained within a titanium case, with a platinum coating in the region of the anode.

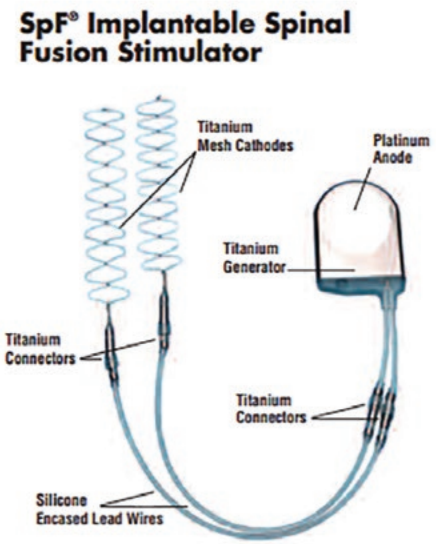
Its lithium manganese dioxide battery lasts at least six months and the leads that go to the cathode are silicone-insulated, with brazed stranded stainless steel wires. The cathode electrodes are made of titanium and connected to the power supply via titanium connectors.



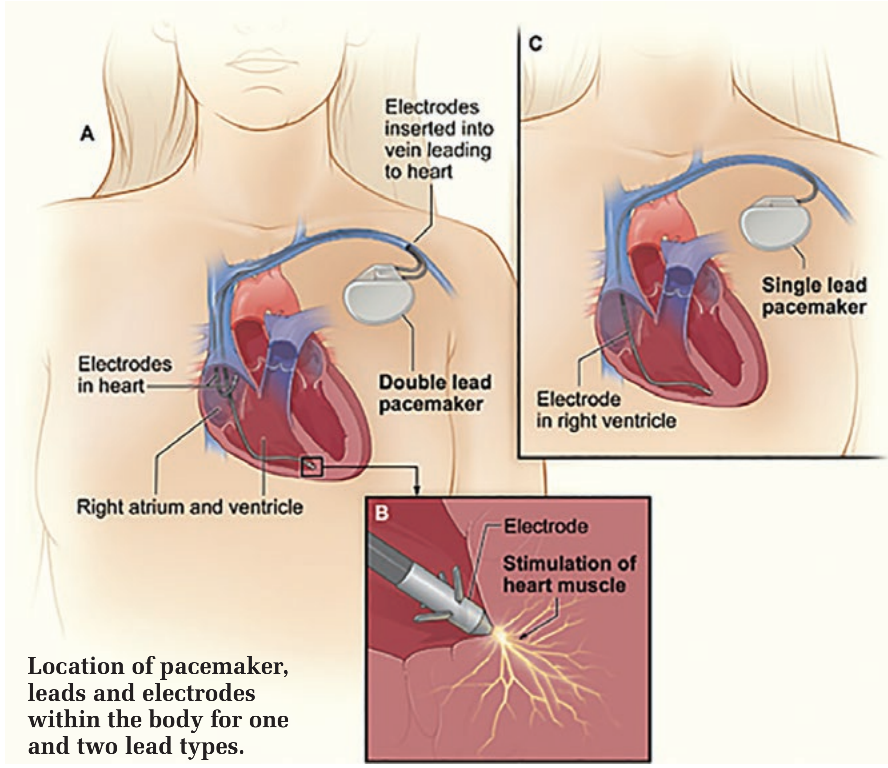
Australian Cochlear Ltd Nucleus 24 auditory brain stem implant. A) The external part of the device worn by the patient. B) The implanted part of the device. C) Detail of 21 electrode array that is implanted into the brain stem.



Biomet OsteoGen implantable bone growth stimulator.



Biomet SpF bone growth stimulator for spinal fusion applications.



Location of pacemaker, leads and electrodes within the body for one and two lead types.

Cardiac Pacemakers

As mentioned above, the heart contains a natural pacemaker which regulates it but this natural pacemaker has some redundancy.

The primary pacemaker of the heart is contained within the sinoatrial (SA) node and typically leads to a heart rate of 60 to 100 beats per minute.

If the SA node fails, such as through disease, there is a secondary pacemaker contained within the atrioventricular (AV) node. In the event of a non-functional SA node these cells cause the heart to beat at 40 to 60 beats per minute and will allow a person to live, although their physical activity may be restricted and they will likely need to have an artificial pacemaker fitted.

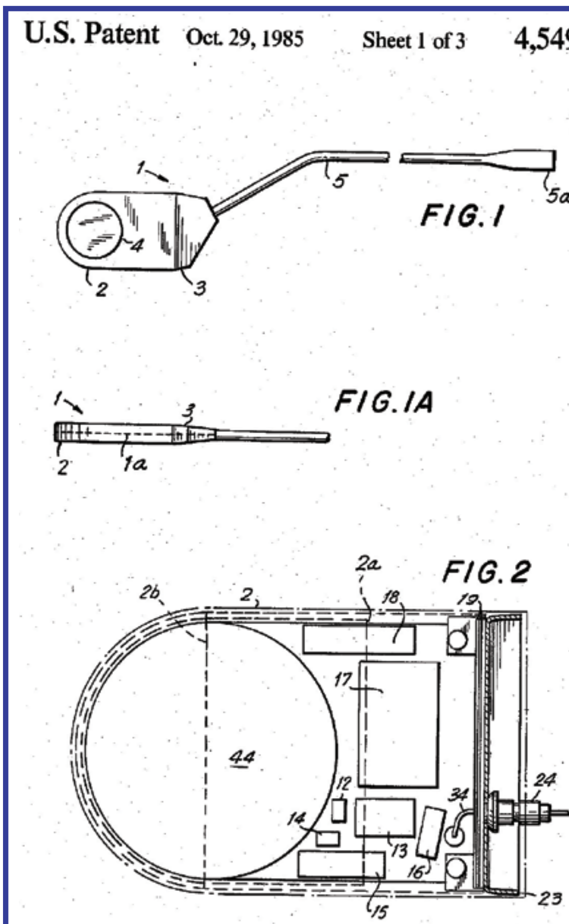


Image from Australian company Telectronics' 1985 US patent for bone growth stimulator with titanium case. Fig.1 shows the electronics package and power source on the left and the cathode lead on the right. Item 5a is a socket into which is plugged a lead connected to the fracture site. Fig. 1A is an elevation view of the device and Fig.2 is a cutaway view of the device showing battery (44), printed circuit board and electrical feed through arrangement.

The artificial pacemaker delivers electrical pulses to the heart in one or more locations, via leads inserted into the heart or, in the latest technology, with a leadless pacemaker.

In the leaded pacemaker, a pulse generator is implanted beneath the skin and leads are inserted into the heart via the subclavian vein.

The leadless pacemaker is implanted within the heart or on its external surface.

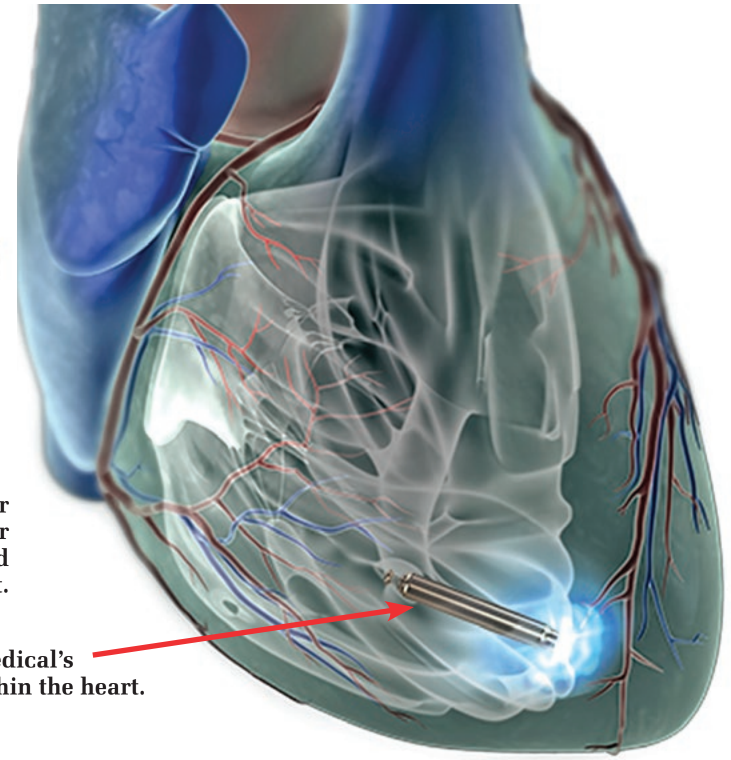
Modern pacemakers are all wirelessly programmable, while some earlier models were programmed by stroking a bar magnet across the surface of the device to open and close a reed switch.

Like many modern electronic systems, modern pacemakers have an event logging system to record changes in cardiac rhythms and other system events.

In one case in Melbourne, reported in the Journal of Pacing and Clinical Electrophysiology in 2002, a pacemaker record was instrumental in solving a murder case.

Two days after a man was murdered, his pacemaker was analysed and it

(Above): Nanostim leadless pacemaker from St. Jude Medical. It is smaller than a AAA battery and does not need a lead as it is implanted directly within the heart.



(Right): the location of St. Jude Medical's leadless Nanostim pacemaker within the heart.

was used to determine the time the man awoke, the time he spent walking around, his attack by an intruder and the time he was finally killed.

A total of 37 hours of data was retrieved from the pacemaker of which 1 hour and 13 minutes was intensively examined to determine the sequence of events and the exact time of the man's death.

For more information on conventional cardiac pacemakers see **https://youtu.be/lSdl2jVfpxs** "*Permanent Cardiac Pacemaker - NIK NIKAM, MD*".

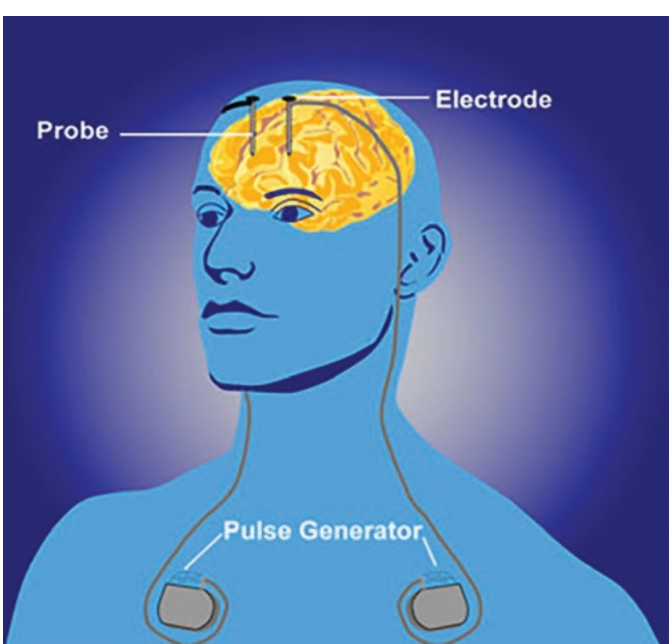
For a video of the implant of the leadless pacemaker see **https://youtu.be/tUtg5p64Y-A** "*Leadless Cardiac Pacemaker.*"

For a video of an amateur tear-down of an old pacemaker which shows construction techniques and componentry see **https://youtu.be/kUsP23pBRXk** "*Pacemaker teardown*".

The first development of an external cardiac pacemaker in the world was done by University of Sydney physics tutor Edgar Booth for Dr Mark Lidwell and was first used to revive a stillborn infant in 1926 at the Crown Street Women's Hospital in Sydney.

Deep brain stimulator

Deep brain stimulation (DBS) involves providing electrical stimulation to selected parts of the brain to treat a number of conditions, such as chronic pain, dystonia, essential tremor, major depression, obsessive-compulsive disorder and Parkinson's disease.



(Left): diagram showing location of pulse generators, leads and electrodes for deep brain stimulation. (At right): St. Jude Medical Infinity deep brain stimulator pulse generator unit and section of lead. The lead electrodes don't go all the way around the circumference of the lead but are only on certain sections, giving some directionality to the electric field. The device can be programmed with an iPhone.

Partial cutaway view of Boston Scientific Dynagen implantable cardioverter defibrillator, which features an extended battery life of up to nearly 12 years. The leads are not shown. This device is wirelessly programmable. This model also acts as a rate responsive pacemaker and has an accelerometer to detect levels of patient activity. Its dimensions are 54 x 78 x 10mm and it weighs around 70g. It can deliver a shock energy of up to 35 joules. The long life is enabled by the Li/MnO2 battery chemistry with a usable capacity of 1.9Ahr.

See the video https://youtu.be/abHuHFt_izI "*Deep Brain Stimulation .... How does DBS work*"

Doctor in a cell

A "doctor in a cell" is a biomolecular DNA-based computer concept conceived by Professor Ehud Shapiro of the Weizmann Institute of Science in Israel.

The long term vision is to produce nano-scale biological computers programmed with medical knowledge that would be injected into a person and roam within the body, detecting and treating disease with the targeted delivery of a specific drug molecule.

Small steps toward this ambitious goal have already been demonstrated in the test tube, such as

1) molecular based automatons controlled by DNA "software";
2) an automaton using DNA as "fuel";
3) a molecular automaton which can follow rules and
4) implementing input and output mechanisms such as detecting a cancer cell (input) and delivering a drug molecule to target the cancer cell (output).

In 2009 Shapiro and a student demonstrated an "autonomous programmable molecular system" based on DNA which was capable of performing logical deductions, using a simple programming language.

The team has also developed a compiler to translate between high level code and the specific DNA sequences to implement that code.

In 2012 Shapiro developed a "genetic device" that can be placed in a bacterium, which can search for specific abnormalities and mount a response. A possible response might be to cause cell death in the event abnormalities are detected.

Implantable cardioverter defibrillator (ICD)

An ICD is a cardiac pacemaker that continuously monitors a person's heart rhythm and when it detects an abnormal pattern such as a dangerously high heart rate, it delivers an electric shock to the heart muscle to "reset" it to a normal rhythm.

The specific conditions that cause rapid abnormal heart beat are ventricular fibrillation – uncoordinated contraction of the ventricles of the heart and ventricular tachycardia – an abnormal rapid heart beat originating in the ventricles. These conditions are usually fatal if not treated as soon as they occur.

ICDs can perform several functions: in anti-tachycardia pacing, a series of small electrical pulses are delivered to a heart that is beating too fast, in order to restore normal rhythm. Typically, tachycardia is considered to be a resting heart rate of over 100 beats per minut in an adult.

In cardioversion, a low energy electrical shock is applied to the heart at a certain point in the cardiac cycle, to restore normal rhythm.

By contrast, defibrillation applies a high energy electrical shock at a random moment in the cardiac cycle, to a dangerously fast-beating heart to restore normal rhythm. This is similar to the function of defibrillators used by ambulance personnel, in hospital emergency rooms and now becoming commonplace in most sporting clubs, schools, offices and factories (See "Defibrillators Save Lives", SILICON CHIP February 2016).

Finally, bradycardia pacing, as in a normal pacemaker, speeds up a heart that is beating too slowly.

ICDs are available in two types, those in which leads are inserted into

MRI and other sources of interference

Because of the possible presence of magnetic materials, certain implants are incompatible with MRI scans due to the strong magnetic fields generated. The high magnetic fields can also interfere with device electronics.

Increasingly, however, manufacturers are designing devices that are compatible with MRI machines, although some still require a reduction in the magnetic field strength used in the scan.

Interference with device electronics may also occur due to medical equipment used in operations such as use of an external defibrillator, RF catheter ablation, electrocautery, radiation from radiotherapy, lithotripsy (shock wave breakup of kidney stones, for example) and mobile phones.

All these sources of interference must be taken into account when implantable devices are designed.

the heart or a type which is installed beneath the skin (subcutaneously) with a wire placed above the rib cage.

To see an animation of the implant procedure for the subcutaneous device, go to https://youtu.be/VgHf0lRwMnw "*New ICD implanted subcutaneously*".

The production of these devices has only been possible due to the development of very small, high energy capacitors that have enabled the units to be miniaturised.

There is an amateur video of a tear-down of an old ICD (purchased on ebay!) which will reveal some of the construction and componentry at https://youtu.be/Gzw6c3Bi4TU "*Implantable defibrillator teardown*".

Note the triggering of the critical malfunction alarm during the teardown process.

Implantable loop recorder

The implantable loop recorder is a device that stores episodes of abnormal heart activity in a memory "loop", ie, the memory is filled and the oldest data is erased to make way for new data.

Abnormal cardiac episodes can be either recorded automatically or by patient activation of the device by a remote control.

The device is used when a patient's abnormal heart activity is not revealed by normal short-term clinical tests and extended monitoring is required to reveal evidence of the condition.

One particular model of device is the Medtronic Reveal LINQ Insertable Cardiac Monitoring System. It is tiny – with a volume of about 1cc or about a third that of an AAA battery – and it has a battery life of about 3 years. It is able to store 30 minutes of patient activated episodes or 27 minutes of

Medtronic Reveal LINQ superimposed on a recorded ECG waveform. It is around the length of a AAA battery but one third the volume, smaller than a typical USB flash drive.

Telectronics – Australian pioneers in pacemakers

Telectronics was started by Australian medical device pioneer Noel Gray in 1963 to manufacture a variety of medical electronic equipment including the implanted cardiac pacemaker.

Telectronics came up with many innovations, including the hermetically sealed welded titanium case in 1969, to replace the standard epoxy encapsulation at the time that was prone to moisture ingress along the lead ports. An important part of the titanium case was the electrical lead-throughs. These involved ceramic bushes which were hermetically sealed to the titanium by a process of metal-ceramic bonding. This process was developed by Taylor Ceramic Engineering in Mortdale, Sydney.

Titanium encapsulation is now the basis of many of the implantable devices described in this article. A process to sinter tiny platinum beads together for one type of pacing lead tip was also developed by Taylor.

Another innovation by Noel Gray was the determination that the pacing pulse could be reduced to 0.5ms from the standard 2ms pulse, as well as reducing the voltage from a nominal 7V to 5V. This improved battery life and also ensured more efficient pacing.

Noel Gray also established the cause of problems with mercury cells used in pacemakers before the development of lithium cells. These were prone to premature failure. It was found that when the batteries were sent via air from the US to Australia they were transported in the unpressurised cargo hold of an aircraft and the low pressure caused damage to the cells.

Thereafter pilots were asked to carry a briefcase containing the batteries on board the aircraft where they would be kept warm and at normal cabin pressure. When they arrived in Australia they were X-rayed to ensure quality.

According to the recollection of former colleagues, Noel Gray also made an experimental pacemaker when he worked at Kriesler in 1956, although this device was not implanted.

Among his visionary ideas was the leadless pacemaker and his belief that the usual location of attaching the pacing leads in the ventricle of the heart was not optimal. It was subsequently proven in 2004 by Dr Tim Lasky of Medtronic that this supposition was correct and the ideal site for pacing leads was the left ventricular apex.

The leadless pacemaker was to be implanted on the outside of the heart not the interior, as per the commercially available device described elsewhere in this article. Noel Gray's patent for the leadless pacemaker, which was proposed to be encased in either plastic or a ceramic material, can be see at https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/pdfs/US5674259.pdf

The custom-made integrated circuits used in later models of Telectronics pacemakers were made by AWA in Sydney to rugged military specifications.

In addition to pacemakers, Telectronics also made bone growth stimulators for a time and a patent in this area is mentioned elsewhere in this article.

An early 1974 Telectronics titanium case pacemaker can be seen at http://from.ph/55591 and a model of a Telectronics "Guardian" implantable defibrillator can be see at http://from.ph/82663

Telectronics was taken over by Pacific Dunlop in 1994, who then sold the assets to the American St. Jude Medical Inc. in 1996. There are no longer any pacemaker production facilities in Australia.

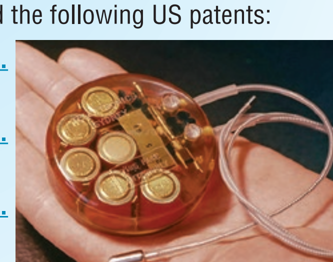
For those interested in more details, a history of Telectronics was published in 1993 by Christopher and Noel Gray called "Telectronics, the early years", ISBN 0646151347.

The Author once worked at Telectronics at Lane Cove, NSW, in 1984. In that time he was involved in lead development and obtained the following US patents:

https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/pdfs/US4798206.pdf

https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/pdfs/US5330520.pdf

https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/-pdfs/US5554176.pdf



An early pacemaker model P4 by Telectronics. Photo courtesy Christoper Gray, son of Telectronics founder Noel Gray.

automatically detected episodes.

The data can be wirelessly downloaded for analysis by a patient at home and automatically transferred to the medical specialist.

The device is inserted beneath the skin with an insertion tool into a small cut in the chest.

Implantable gastric electrical stimulator

There is a condition known as gastroparesis which involves partial paralysis of the stomach and results in an inability to properly move food out of it and into the small intestine.

Normally, the muscles of the stomach would contract to push food onward (peristalsis). These contractions can be affected if the vagus nerve becomes damaged – by diabetes mellitus, for example.

Symptoms of gastroparesis include chronic nausea, vomiting and a feeling of fullness after just a few mouthfuls of food.

The condition can be treated with alterations to the diet or drugs but if these don't provide a satisfactory result, a gastric stimulator implant is considered.

The device is implanted beneath the skin of the abdomen and two leads run through the abdominal wall and then attached to the exterior of the stomach. The leads are connected by a keyhole surgery.

The natural contractual rhythm of the stomach is about three contractions per minute but the rate provided by the gastric stimulator is about 12 contractions per minute.

To give an idea of the type of electrical stimulation provided by the Medtronic device, it can provide electrical pulses up to 10.5V in amplitude with a pulse width of between 60 and 450µs at between 2 and 130Hz.

In its default setting it remains on for 0.1 second and then turns off for 5 seconds. Its power source is a hybrid cathode silver vanadium oxide cell with a capacity of 4.5Ah.

Implanted insulin pump

Implanted insulin pumps contain a reservoir of insulin and control electronics for controlled delivery of the insulin into the body.

This is periodically refilled by injecting a new supply through the skin into the chamber of the device.

However, these devices remain relatively rare, mainly due to unpopularity with patients as they cause a large bulge in the skin at the implant site and there are many technical and other problems.

Medtronic Synchromed II intrathecal pump for drug delivery. It can hold either 20cc or 40cc of drug product and has a battery life of 4 to 7 years. The drug delivery schedule is wirelessly programmable. Drug replacement is typically made through the skin every one to two months.

Targeted drug delivery pump

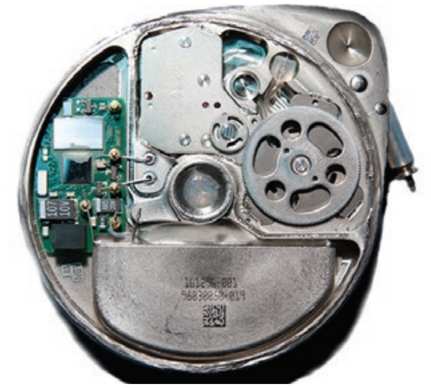
A targeted drug delivery pump delivers pain or spasticity-relieving medication directly into the fluid around the spine (also known as the intrathecal space).

Hence these devices are also referred to as intrathecal pumps. The pump and catheter are implanted beneath the skin; the end of the catheter goes into the intrathecal space.

See https://youtu.be/IFzrjOctQC8

Medtronic Enterra II gastric electrical stimulator. The device is shown without the leads that are attached to the stomach and without the external programming unit. Note the similarity of construction to the cardiac pacemaker. This device is 55mm tall, 60mm in length and weighs 45g.

X-ray showing position of gastric stimulator unit and leads going to stomach. Within the gastric stimulator can be seen the battery on the right and the control electronics on the left.



Cutaway view of Medtronic Synchromed II showing battery at bottom, electronics package on left, mechanical pump at top right and self-sealing silicone plug into which replacement drugs are injected at centre.

(Above): VeriTeQ human implantable RFID chip. The small coil visible in the device is the antenna.

(Right): method of reading the VeriTeQ RFID device.

"*Intrathecal Pump Implantation*".

MedRadio & MICS/MEDS

The Medical Device Radicommunications Service (MedRadio) and MICS/MEDS (Medical Implant Communications Service and Medical Data Service) are almost identical US and European specifications, which operate at frequencies in the 400MHz and 2360-2400MHz bands specifically for communication between an implanted medical device and an external device.

In the 400MHz band, transmit power from the internal device is set at 25μW.

The higher frequency band is for use in the Medical Body Area Network or MBAN which is used by implanted, surface-mounted and wearable devices to communicate with each other.

It is not clear from the ACMA (Australian Communications and Media Authority) website whether this protocol has been implemented in Australia but there are several letters on the site (dated 2009 and 2010) from medical device manufactures requesting that they do so.

RFID implants

VeriTeQ make an RFID (radio frequency identification) chip specifically approved for human implant; it is similar to those used in animals. The chip is about the size of a grain of rice and is inserted beneath the skin by injection. The chip is encoded with a unique 16-digit number which can be used to access a person's medical record from a password-protected database.

The chip does not allow the person possessing it to be tracked, a common concern of users. The only way this could be done would be by the installation of millions of readers everywhere people might go. The device communicates at between 30 and 500 kHz; the manufacturer does not specify the precise frequency.

As with typical RFIDs, the device is passive, with no internal battery and is powered from the radio signal received from the reader. It can be read at a distance of between 30cm and 3m. Thousands of people have had the device implanted.

VeriTeQ is also developing elements of this technology to be incorporated into other implanted medical devices, in order to be able to accurately identify them with a unique number.

The company has also developed an implanted temperature sensor chip that can be used to monitor tissue temperatures during radiation treatment.

This same chip can also be implanted in pets that may otherwise be resistant to having their temperature taken by the conventional method. An owner or vet could simply interrogate the chip to determine the animal's temperature to see whether treatment is required.

Incidentally, there are now many low-cost tiny devices, externally-worn (eg, around the neck) which *can* be used to track people, such as children, those suffering from dementia and even pets. They can be used in conjunction with a mobile phone to locate a person very accurately (Search for "trackr" on ebay, for example).

Neurostimulation for epilepsy

Around 40% of patients with focal epilepsy have seizures that are resistant to drugs. According to one 2014 study, using a neurostimulation device can reduce these seizures by 53% after two years and 66% after five years.

The location of the seizures is first determined by monitoring brainwaves

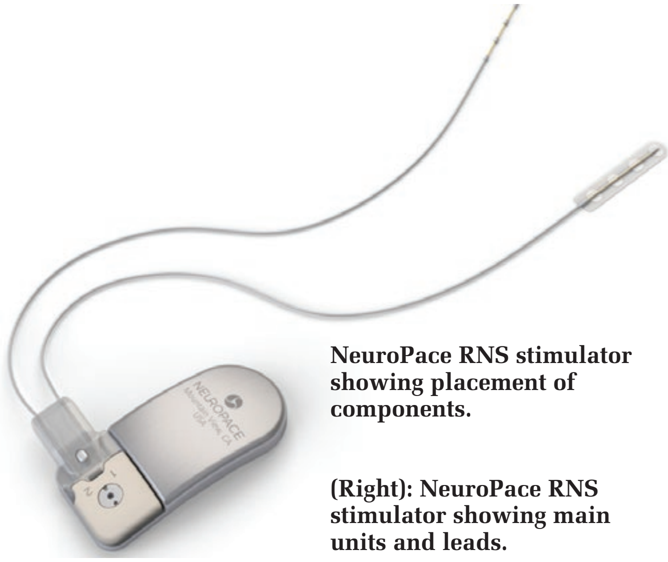
Security of implanted devices against hackers

With the wireless programming capability of many devices – and this feature being incorporated into more devices all the time, the security against a malicious individual taking control of the devices has become a serious concern.

A vulnerability in an implanted insulin pump was demonstrated in 2011 by Barnaby Jack whereby control of the device was demonstrated to be possible from 100 metres away; similarly in 2012 Barnaby Jack demonstrated that a laptop could be used to control an implantable defibrillator from 10-15 metres away.

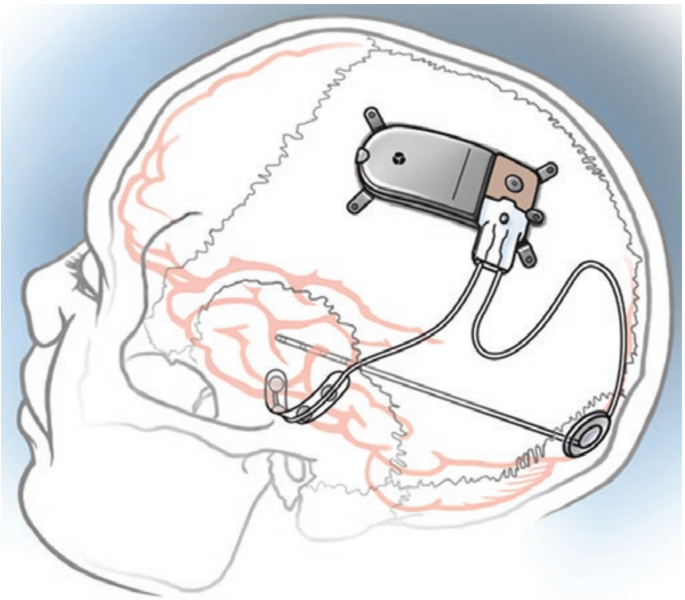
The concern with hackers taking control of devices was real and US Vice President Dick Cheney even had the wireless functionality of his implantable defibrillator disabledwhen it was installed in 2007 before Barnaby Jack demonstrated that taking control of such a device was possible.

Dick Cheney's comments on the issue along with a fictitious scene from the TV series "Homeland" where such an assassination attempt is portrayed can be seen at https://youtu.be/N-2iyUpnUwY "*Dick Cheney Worried About Remote Assassination Attempt Via Pacemaker*"



NeuroPace RNS stimulator showing placement of components.

(Right): NeuroPace RNS stimulator showing main units and leads.



by means of electroencephalography during a seizure.

When the seizure site (or sites) has been located, electrodes are implanted and connected to the neurostimulator device.

The neurostimulator constantly monitors brainwaves and when abnormal activity is detected, an appropriate series of electrical pulses is delivered. In this way, abnormal activity might be detected and corrected, even before a patient is aware of anything being amiss.

In the NeuroPace RNS system, neurological data can be wirelessly collected at home and transmitted to the treating doctor, who is then able to make adjustments to the device if necessary.

Sacral nerve stimulator

The sacral nerves S2-S4 control functions within the pelvic floor area such as those for the bladder and the bowel. If there is a disorder causing a lack of effective communication between the brain and the sacral nerves, incontinence can result.

Stimulation of the sacral nerves to replace the missing or defective signal from the brain can help restore continence.

The Medtronic InterStim II sacral nerve stimulator is an example of one such stimulator device The nerves are stimulated by a lead that is implanted adjacent to them, near the base of the spine. Typical stimulation parameters are a pulse width of 180-240µs at a rate 10-14Hz, an amplitude of up to 8.5V and off/on cycle of 8 to 16 seconds. There are four electrodes in a single lead. The battery has a capacity of 1.3Ah, giving a device life of between 2.9 and 5.4 years, depending on stimulation parameters. As well, the device can be wirelessly programmed.

A lumbar anterior root stimulator is a similar type of device but as the name suggests, it stimulates the lumbar nerves.

See https://youtu.be/ONaa8d96m8Q "*Overview of Sacral Nerve Stimulation for Urinary Control*".

Spinal cord stimulator to block pain

A spinal cord stimulator delivers electrical impulses to the spinal cord in order to block the transmission of pain signals. It does not eliminate the actual cause of the pain.

Electrodes are placed within the spinal canal in the epidural space and these are connected to a pacemaker-like pulse generator implanted subcutaneously within the lower abdominal or gluteal region (buttocks).

The pulse generator is wirelessly programmable and in addition, the patient is also able to control some of the device's settings.

Many different types of electrical stimulation patterns are possible, including constant current, constant voltage or variable current and voltage as well as different waveform patterns. A typical pulse for stimulation is 100 to 400µs with a frequency from 20 to 120Hz.

See https://youtu.be/ctTSivqcgoY "*Spinal Cord Stimulation Overview*".

Vagus nerve stimulator

A vagus nerve stimulator provides an electrical pulse to the vagus nerve of about 30 seconds duration every 3-5 minutes. It is used to treat certain forms of epilepsy and treatment-resistant depression. See https://youtu.be/rphsTyMdA2A "*Cyberonics / VNS / The VNS Therapy System*".

Wireless power transmission and artificial hearts

Lithium batteries might be adequate for many years' operation of devices such as pacemakers but cannot supply nearly enough power for an implant

The NeuroPace device monitors brainwaves for abnormal activity and when it is detected it delivers appropriate electrical pulses to normalise the activity.

such as an artificial heart or left ventricular assist device (LVAD).

An LVAD does not replace a heart but is designed to provide assistance to improve the function of a diseased heart.

Conventional approaches to artificial hearts or LVADs involve the use of either electrical or pneumatic leads that pass through the skin to an external power source.

Any permanent penetration of the skin is problematic because of the high risk of infection. An alternative way to deliver electric power into the body is via wireless transmission, similar to what you would find in consumer devices such as electric toothbrushes.

Traditional approaches to wireless power transmission such as inductive coupling through the skin require very accurate alignment of a pair of transmission and receive coils and it works only over distances of a few millimetres.

Overheating of flesh is also a potential problem, so this approach is not suitable for delivering power into the human body subject to constant movement.

The Free-range Resonant Electrical Energy Delivery (FREE-D) wireless power system is designed to provide wireless power to an LVAD over metre distances.

There is a receive resonator coil implanted in a patient's body and there are external power transmission coils which may be installed in a vest worn by the patient.

Alternatively, in a home environment power transmission coils might be installed in specific rooms, or even throughout the house, enabling the patient to not wear the vest.

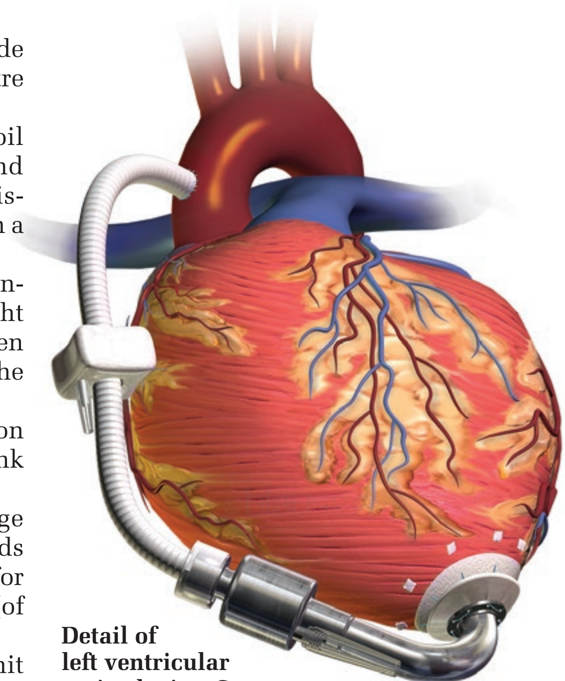
The FREE-D system is based on the Wireless Resonant Energy Link (WREL).

This system can transmit large amounts of power (up to hundreds of watts, far more than is required for a LVAD) at reasonable distances (of around one metre).

It works even when the transmit and receive resonators are in poor misalignment and maintains high power transmission even as the range and load varies, as it uses adaptive tuning techniques.

Uniquely, there is a certain "magic" regime, as the inventors call it, where efficiency does not fall with distance.

For more information see the videos at https://youtu.be/AMgnQ-NHOZk "*Wireless Power Transfer (WREL) - Auto-tuning and relay resonators*" and the first 28 minutes 40 seconds of https://youtu.be/6UfVLSYz33g "*Cutting the Cord: Wireless Power for Implantable Devices*". SC



Detail of left ventricular assist device. See illustration on page 22 which shows location of reserve battery and electronics pack and wireless power transmission coil for this device.

Nuclear powered hearts and pacemakers

There were serious efforts to build an atomic-powered artificial heart in the US in the 1960s.

This shows how small a nuclear power supply can be made and how useful it could be. The device was to be powered by a radioisotope thermoelectric generator which produces electricity from heat derived from the radioactive decay of plutonium-238. This is the same type of nuclear power generator used in all of NASA's nuclear powered spacecraft.

A nuclear powered heart would possibly be viable, assuming any radiation shielding, mechanical aspects of the heart design and biocompatibility issues were resolved. However the project did not go ahead as there were concerns with radiation levels in patients.

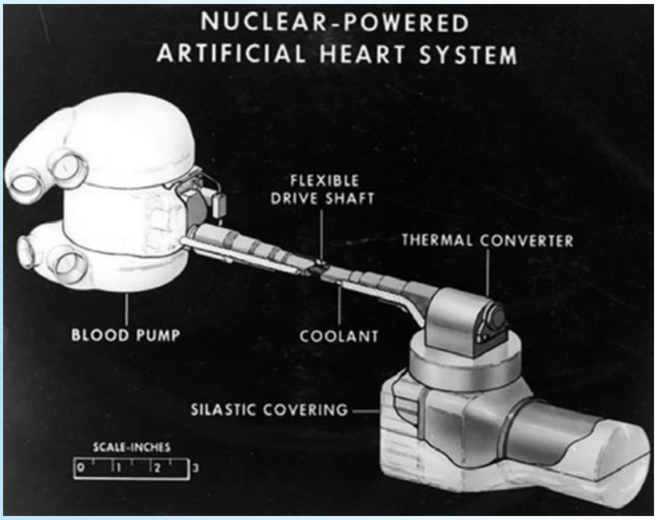
It was also thought that terrorists might kidnap people with atomic-powered hearts, remove them and use the nuclear material as a weapon to spread radioactive contamination, for example.

The plutonium-238 could not be used to make a nuclear explosive device however, as it is too unstable and generates too much heat.

While the atomic heart did not go ahead, a nuclear powered pacemaker did, which was first experimentally implanted in a dog in 1969 before being approved for human use. There are still people alive today who have nuclear powered plutonium-238 pacemakers.

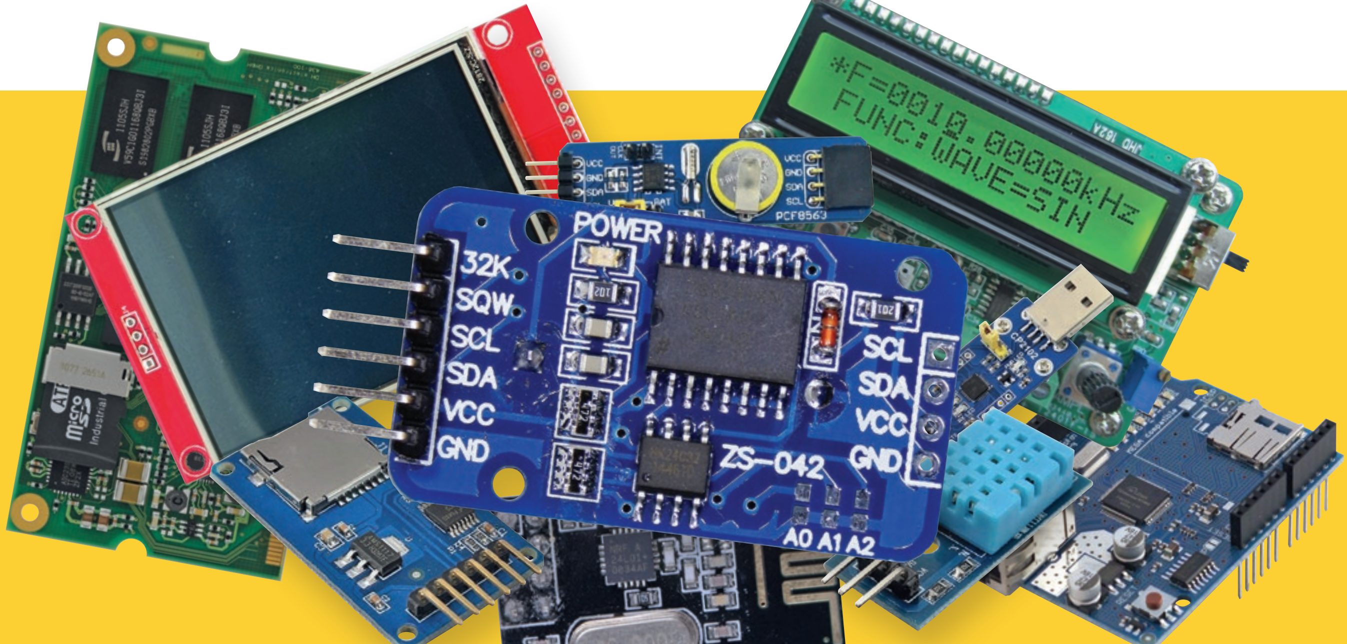
The devices will still operate after 88 years when half the original plutonium has decayed, compared to a modern lithium battery powered devices which lasts 10-15 years.

The nuclear pacemakers were designed to withstand gunshots and cremation. You can see some pictures of these devices along with instructions at http://osrp.lanl.gov/Documents/Pacemaker%20Fact%20Sheet.pdf "*What to do if you find a nuclear-powered cardiac pacemaker*"



Another type of nuclear-powered pacemaker that was used is based on the decay of promethium-147 which emits electrons and these interact with a specially designed p-n junction to produce electricity in much the same way as when photons strike a solar cell.

You can visit http://www.prutchi.com/pdf/implantable/nuclear_pacemakers.pdf for more information on these devices.



Low Cost Asian Electronic Modules
Now they are just standard components!

This is the first of a series of small articles which will help you take full advantage of the wide range of handy pre-built electronic modules that are now available from Asia. In this article, we review the DS3231 real time clock (RTC) module.

Pt.1: By JIM ROWE

IF YOU'VE been reading SILICON CHIP for a while now, you'll have noticed that small electronic modules have been creeping into our projects and the reader circuits published in Circuit Notebook.

These are not just Micromite, Arduino or Raspberry Pi boards either but really small and low cost modules including real time clocks/calendars (RTC), USB-to-UART serial "bridges", UHF data transmitters and receivers, DDS signal generators, OLED/LCD panels, touch-screen TFT LCDs, temperature/humidity sensors, microSD card interfaces and many more. They seem to be breeding like rabbits!

Many of these modules have sprung into life initially as "peripherals" for baby micros like the Arduino (ie, shields) and Raspberry Pi. But most of them have a lot of other applications in circuits and designs using standard TTL or CMOS ICs, and even in designs using olde-worlde discrete transistors.

But the really big advantage of this new generation of pre-built modules is that most of them are surprisingly low in cost. In fact, with many of them, you'll find that the cost of a complete module is much less than the price you'd pay for the main IC chip used in them.

A prime example is the popular real time clock/calendar module using Maxim's very accurate DS3231 RTC chip — plus a 24C32 4KB EEPROM, in most cases. Although the module is usually advertised as intended to be used with an Arduino, it has a standard I^2C ("Inter-IC") interface and can actually be used with most other micros (we used it with the Micromite in our Touchscreen Super Clock and Appliance Energy Meter projects, for example), as well as in a host of other designs.

So that's the rationale behind this series of articles on the new "el cheapo" modules. They're readily available, often have many applications and they're usually much cheaper than building up the same circuits for yourself. As a result, they've now reached the status of being just standard circuit components. The Electronic Modules As Components or "EMAC" revolution has begun!

Let's start the ball rolling by taking a look at real time clock/calendar modules.

RTC modules

Probably the first low-cost RTC modules to appear were those based on the Philips/NXP PCF8563 chip, a low-power 8-pin CMOS device which has an I^2C interface but needs an external 32.768kHz crystal. Modules based on the PCF8563 are still available at low cost from eBay or AliExpress, but they tend to be less popular than modules based on one of two newer Maxim chips: either the DS1307 or the DS3231.

Like the PCF8563, the DS1307 needs an external 32kHz crystal. However, it does have a built-in power sense circuit which switches to a backup battery when it detects a power failure. It also has 56 bytes of internal non-volatile SRAM and a standard I^2C interface, making it compatible with just about every type of microcontroller module such as the Arduino or the Micromite.

It does have one shortcoming, though: the time-keeping accuracy is inclined to drift a little with temperature and so it can vary by a few minutes a month.

Clock/calendar modules using the DS1307 tend to cost more than those using the PCF8563, but they often include extras like a DS18B20 temperature sensor and a 24C32 serial EEPROM (32Kbits = 4KB). This makes them quite attractive for applications where extreme accuracy isn't too critical.

But modules based on the DS3231 chip are currently the most popular, partly because the DS3231 has an on-chip temperature-compensated crystal oscillator and crystal.

It also includes an internal temperature-compensated voltage reference and comparator, both to maintain its own supply voltage and to automatically switch to a backup supply when necessary.

These features allow it to provide significantly higher timekeeping accuracy: better than ±2ppm between 0 and 40°C, or ±2 minutes per year for a temperature range of -40°C to +85°C. Its single shortcoming compared with the DS1307 is that it lacks the internal non-volatile SRAM.

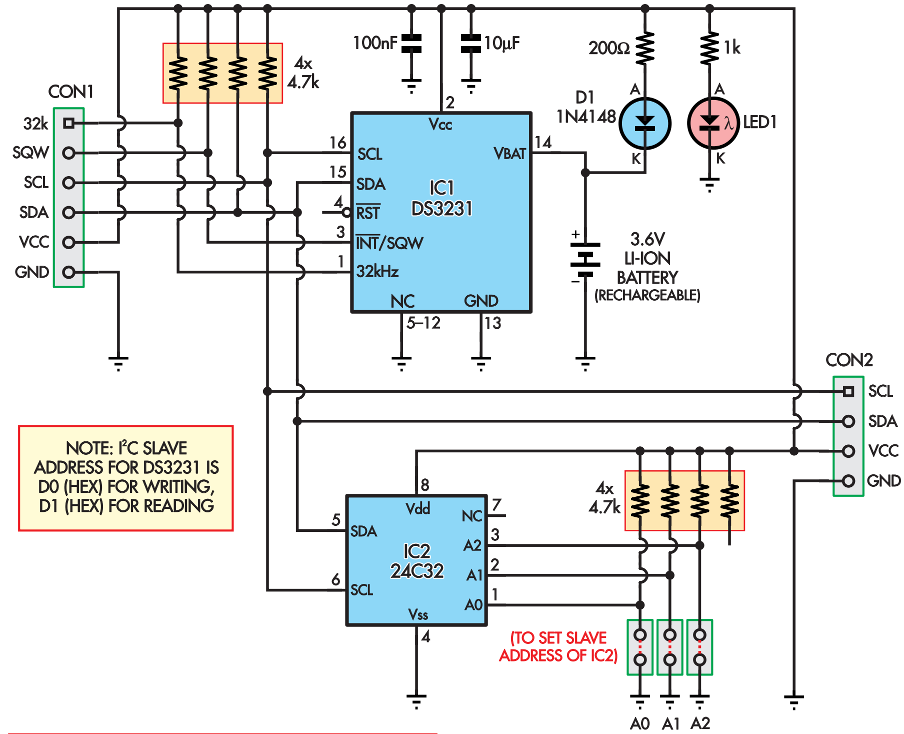
Despite the advantages offered by the DS3231, modules using it tend to cost no more than those based on the DS1307 or the PCF8563. And this applies for modules like the one shown in the pictures, which also includes a 24C32 serial EEPROM.

As mentioned earlier, this is the RTC module that has been used in a number of recent projects like the Touchscreen Super Clock, the Appliance Energy Meter and the Micromite Explore 100, so it's the one we'll now concentrate on.

DS3231 RTC

As shown in the circuit diagram of Fig.1, there isn't a great deal in this module apart from the DS3231 chip itself (IC1), its 3.6V backup battery and the 24C32 serial EEPROM (IC2). We'll discuss the rest of the components and circuitry shortly after we've looked at what's inside the DS3231.

Its compact 16-pin small outline (SO) SMD package contains an I²C data bus interface, address decoding for the 18 internal time, date and control registers, a temperature sensor and a power control circuit which can swing over to the backup battery when the supply voltage (V_{CC}) fails. Its block diagram is shown in Fig.2.



I²C SLAVE ADDRESSES (HEX) FOR 24C32 EEPROM					
MSD (FIXED)	A2	A1	A0	WRITE	READ
A	1	1	1	AE	AF
A	1	1	0	AC	AD
A	1	0	1	AA	AB
A	1	0	0	A8	A9
A	0	1	1	A6	A7
A	0	1	0	A4	A5
A	0	0	1	A2	A3
A	0	0	0	A0	A1

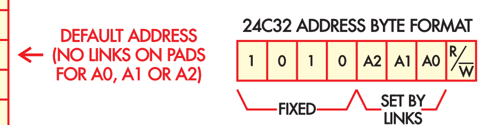


Fig.1: complete circuit for the DS3231-based RTC module. Both CON1 and CON2 provide serial bus and power connections, allowing extra devices to be connected. Note that the I²C bus should have only one set of pull-up resistors.

Then there's a complete temperature-compensated 32.768kHz crystal oscillator (TCXO), followed by a frequency divider chain and all of the time (seconds/minutes/hours), date (day of week, day of month, month and year), alarm, status and control registers. Finally, there's reset circuitry plus output buffers for both the 32kHz TCXO oscillator and the square wave output when it's enabled.

Note that since the module tracks the date as well as the time, it is more correctly described as a real time clock & calendar (RTCC) module but we'll stick with the more common RTC term.

As well as the time and date registers, the DS3231 also provides two time-of-day alarm functions which are programmable via two sets of dedicated registers. These can generate an interrupt output signal via pin 3 (INT-bar/SQW), for feeding directly back to a micro.

When pin 3 is not being used to provide this alarm interrupt function, it can be used to provide square wave timing signals derived from the 32kHz TCXO. The square waves can be programmed for one of four frequencies: 1Hz, 1.024kHz, 4.096kHz or 8.192kHz. These are in addition to the 32.768kHz signal made available at pin 1.

All of the DS3231's function settings, along with the initial time and date, can be programmed using the I²C bus to write into the appropriate internal registers. Then the time, date and status can be subsequently obtained by using the I²C bus to read from the same registers.

Pins 15 & 16 of the device are used for the I²C bus connections: pin 15 for the SDA serial data line and pin 16 for the SCL serial clock line. On the module shown, these are both

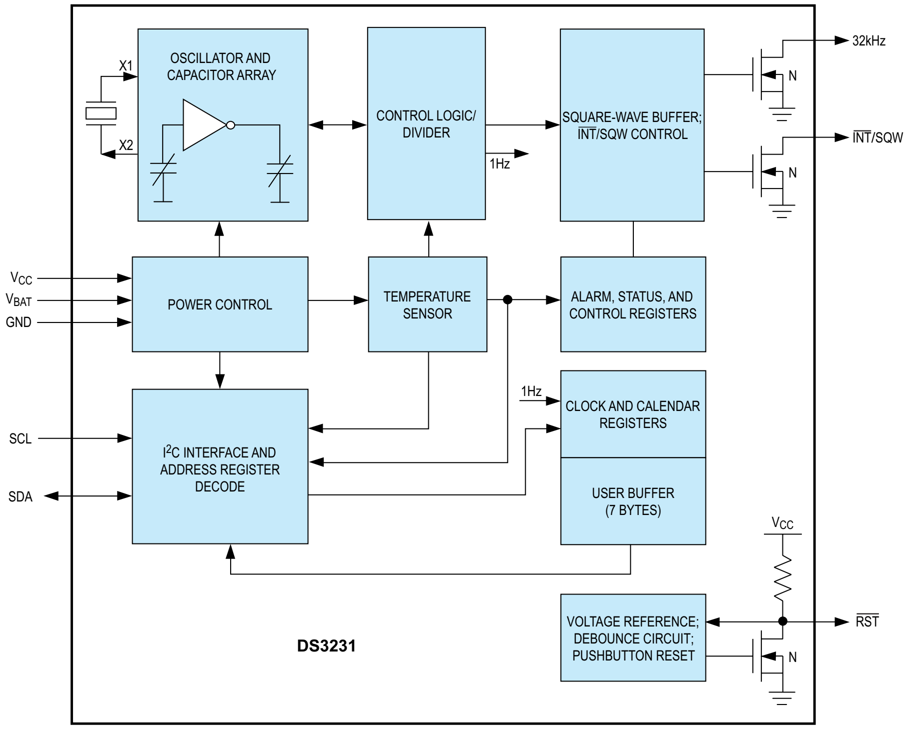


Fig.2: block diagram for the DS3231. A comparator monitors both V_{CC} and V_{BAT} and the DS3231 is powered from whichever is higher. The oscillator is automatically temperature-compensated for accuracy.

provided with surface-mount 4.7kΩ pull-up resistors to V_{CC}, as are pin 1, the 32.768kHz output and pin 3, the INT-bar/squarewave output. (The latter two pins are open-drain outputs, so they need the external pull-up resistors.)

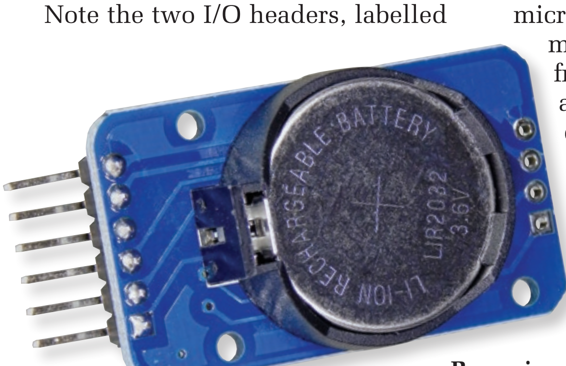
That's probably about all you need to know about the DS3231 itself, apart from the way that pin 14 (V_{BAT}) is used for the connection to the 3.6V lithium-ion rechargeable backup battery. In the module shown here, diode D1 and its series 200Ω resistor are used to maintain the battery charge when V_{CC} is connected to the module. LED1 and its series 1kΩ resistor are used to provide a power-on indicator. We'll have more to say about battery options later.

Note the two I/O headers, labelled in Fig.1 as CON1 and CON2. CON1 provides pins for both the 32kHz and SQW/INT-bar outputs as well as the SCL/SDA/V_{CC}/GND bus connections, while CON2 provides only the latter four connections, essentially to allow daisy-chaining further devices to the I²C bus - additional memory chips, for example.

Now let's look at IC2, the 24C32 serial EEPROM chip which is something of a bonus. The 24C32 is a 4KB (32Kb) device, with a standard I²C serial interface. In this module, the SDA line (pin 5) and SCL line (pin 6) are connected in parallel with those for IC1, to the module's SDA and SCL lines at both CON1 and CON2.

To allow IC2 to be addressed by the micro without conflicting with commands or data sent to or received from IC1, it has a different slave address on the I²C bus. In fact, it can have any of eight different slave addresses, as set by the voltage levels of pins 1, 2 and 3 (labelled A0, A1 and A2).

As shown in Fig.1, the module pulls all three pins up to V_{CC} via the 4.7kΩ resistors by default, which gives IC2 a slave address of AE/AF hex (AEh for writing, AFh for reading). But it also provides three pairs of pads on the PCB so that any of the three address pins can be pulled low (to ground) by soldering across the A0, A1 or A2 pads. This allows the slave address of IC2 to be set to any of the eight possible values, as shown.



Rear view of the DS3231 module showing the 3.6V Li-ion backup battery (pin 14) which powers the real time clock when the supply voltage (V_{CC}) fails.

So since the slave address of IC1 (the DS3231) is fixed at D0/1 hex (D0 for writing, D1 for reading), there is no conflict. In fact, the main reason for changing the slave address of IC2 via the wire links would be to avoid a conflict with any other devices that may be attached to the I²C bus.

How it's used

Since both the DS3231 and 24C32 devices on the module are intended for use via the I²C bus, this makes it easy to use with any micro or other system provided with at least one I²C interface. (Even if you don't have such an interface, you can use two GPIO pins in "bit banging" mode, but that's outside the scope of this article.)

For example, to use it with an Arduino Uno or similar all you need to do is connect the SCL line on the module to the AD5/SCL pin on the Arduino, the SDA line to the AD4/SDA pin, the V_{CC} pin to the +5V pin and the GND pin to one of the Arduino's GND pins.

It's just as easy with the Micromite. In this case, the SCL pin connects to pin 17 on the Micromite's main I/O pin strip, while the SDA pin connects to pin 18 next to it. Then the V_{CC} and GND pins connect to the +5V pin and GND pins on the same pin strip.

Programming either chip on the module should also be fairly straightforward, because of the I²C interfacing. The main thing to remember is that I²C transactions always begin with a control byte sent by the master (the micro), specifying the address of the slave device it wishes to communicate with and whether it wants to write to or read from the device.

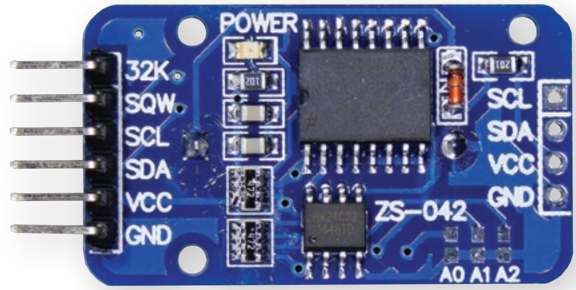
So, for example, the control byte to initiate a write operation to one of the registers in the DS3231 would be D0h, while the control byte to read from one of the addresses in the 24C32 would be AFh (assuming it's at the default address on your module).

After the slave device sends back an "ACK" or acknowledge indication (to show that it's present and ready for a transaction), the micro then sends the address of the register or memory location in the device that it wants to write data to or read it from. Then when this has been acknowledged, the actual write or read transactions can take place.

If this sounds a bit complicated, you'll be relieved to hear that if you're using one of the popular micros like the Arduino or Micromite, you probably don't need to worry about this yourself. That's because this has usually been taken care of in small code libraries, with functions specifically written for I^2C data communications. In the case of the Micromite, in fact, I^2C communication is handled by the MMBASIC interpreter.

For example, if are using an Arduino, the Arduino IDE application already includes a "Wire" library, providing about nine different functions for passing data between the micro and an I^2C device.

Similarly, if you're using a Micromite, you'll find that Geoff Graham's MMBASIC already includes functions like RTC SETTIME, RTC GETTIME, RTC SETREG and RTC GETREG specifically for talking to the DS1307 or DS3231 RTC devices. And there are other functions like I2C OPEN, I2C WRITE, I2C READ and I2C CLOSE for data transactions with other I^2C devices (like the 24C32 EEPROM chip in the current module).



Finally, there's also an automatic variable called MM.I2C, which can be read after any I^2C transaction to find out the result status.

So all in all, the RTC module shown with its DS3231 clock/calendar chip (and bonus 24C32 EEPROM chip) is relatively easy to use, and exceptional value for money.

Below is a link to a useful web tutorial by John Boxall of tronixlabs, explaining how to use either the DS1307 or DS3231 RTC modules with an Arduino:

http://tronixlabs.com.au/news/tutorial-using-ds1307-and-ds3231-realtime-clock-modules-with-arduino

SILICON CHIP has two versions of the DS3231 RTC module available via our on-line shop. Both come with mounting hardware; four 6mm M2 Nylon screws and two 10mm M2 tapped spacers, and one comes with an LIR2032 rechargeable cell already installed. You can view them at www.siliconchip.com.au/Shop/7

Note 1: the version supplied with no cell is designed to use a rechargeable cell. You can use a CR2032 (or similar) lithium button cell **but in this case, you MUST remove the on-board SMD diode to prevent the battery from being charged**. See the Super Clock article in the July 2016 issue for more details.

Note 2: as this module has onboard pull-up resistors for the I^2C bus, you may need to remove them, or avoid fitting pull-up resistors on the master, for it to share a bus with other peripherals. SC

A lure for lovelorn male MOZZIES!

By JOHN CLARKE

There has been a lot of recent news about the Zika mosquito-borne virus but the carrier, the Aedes aegypti mosquito, is a nasty little beast that also carries dengue and yellow fever. Now you can reduce the chances of these mosquitoes breeding in your locality by building this audio lure for the male mosquitoes.

kill 'em before they have any fun!

It's not fair, really! Female mosquitoes do the biting while the males are just there to make up the numbers. Well, they're just for breeding; male mozzies don't bite people.

And now along comes this electronic gizmo from SILICON CHIP with the potential to kill the males before they have any fun!

This project was produced in response to a recent news bulletin where two Australian Institute of Tropical Health and Medicine researchers (Brian Johnson and Scot Ritchie) discovered that a 484Hz tone attracted male mosquitoes of the Aedes aegypti species in large numbers.

The Aedes aegypti is the main species which carries and spreads the Zika virus (other species that can carry it are the Aedes albopictus [in the USA] and Asian Tiger types).

But why, you may ask, is that frequency of 484Hz important? Well, it so happens that the female Aedes aegypti flaps her wings at precisely this rate – so any . . . ahem . . . virile male Aedes aegypti hearing this immediately thinks he's on a sure thing.

Just in case you were wondering, this is a real, live, pregnant, female Aedes aegypti mosquito, busily biting a victim to get blood for her eggs.

Male mosquitoes only live for about a week or so, so he's got to get his jollies while he can, so to speak.

See **www.abc.net.au/news/2016-01-19/scientists-discover-frequency-traps-male-yellow-fever-mosquitoes/7084434**

So this little project produces a 484Hz tone to attract the sex-crazed males. Because it's so loud compared to a single female, it attracts them from a wide area.

And if you don't live in an area where the Aedes aegypti mosquito

Specifications

Supply: USB standard of 4.75V to 5.6V

Current: (@5V supply) 220mA at 911mW output power, 120mA @ 500mW, 70mA @ 250mW

Standby current: 6.8μA during night

Output power: 911mW maximum into 8Ω with 5V supply

Frequency: 484Hz sinewave (accurate to within 50ppm)

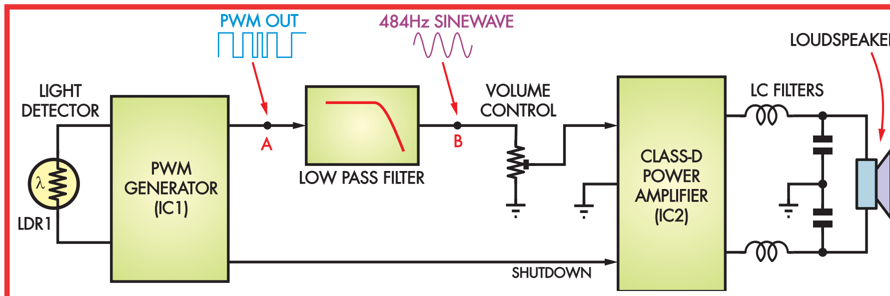


Fig.1: block diagram of our Mozzie Lure. The width of the 15.488kHz pulses is varied at exactly 484Hz. The low-pass filter removes the 15.488kHz to provide a 484Hz sinewave which is amplified and fed to the speaker.

is present, you can build a version to work with other mozzies instead.

Our lure comprises a mosquito trap with a sound generator inside. Once the male mosquito is lured into the trap, it finds it difficult to escape (in fact, it doesn't want to – he is still searching for the elusive, albeit noisy female!) and eventually drowns in beer, insecticide or is immobilised using sticky fly paper strips.

If you use beer, at least he will die happy!

The good thing to know about this lure is that if you can stop the males doing their thing, the females will not be fertilised.

And if they are not fertilised, they have no reason to bite us humans (pregnant females are the only ones which bite, to gain sustenance for their fertilised eggs). Win-win for us, never mind the mozzies!

(More seriously, a Zika-infected Aedes mosquito can pass the virus to its eggs so the possibility of spreading the virus is very strong).

The Aedes aegypti mosquito is most active during the day, so we have designed the lure to only run in daylight.

At night, the sound generator is switched off (it would drive you mad in the dead of night) and the circuit draws minimal current.

What's in it?

The Silicon Chip Mozzie Lure circuit comprises a microprocessor tone generator to produce the 484Hz tone, along with a tiny class-D amplifier which drives a small loudspeaker. It can be powered from any 5V source, such as a USB output on a computer or even a power bank for mobile phones.

Block diagram

The Mozzie Lure block diagram is shown in Fig.1. Microcontroller IC1 uses a light dependent resistor (LDR1) to monitor the ambient light. If daylight is detected, IC1 runs as a pulse generator at 15.488kHz.

Its pulse width is varied at 484Hz, producing a waveform which has an average value that varies between 0V and 5V at 484Hz. We then feed that pulse-width-modulated waveform to a low pass filter. This removes the 15.488kHz and what remains is a smooth 484Hz sinewave. The scope waveforms in Scope1 and Fig.4 show the general operation.

The yellow trace at the top shows the PWM signal generated at pin 6 of IC1 while the green trace shows the signal after filtering, at the input to trimpot VR1. The resulting 484Hz sinewave is delayed with respect to the PWM signal by the 2-stage filter network

We feed the 484Hz sinewave to a tiny class-D (ie, switching) amplifier which is normally used in mobile (cell) phones so it is designed to be highly efficient. It drives the small loudspeaker in bridge mode, to maximise the power output from the limited 5V DC supply.

Its operation is demonstrated in Scope2, showing the 484Hz sine waveform across the 8Ω loudspeaker. The amplifier is delivering 911mW into 8Ω.

Circuit details

The full circuit is shown in Fig.2.

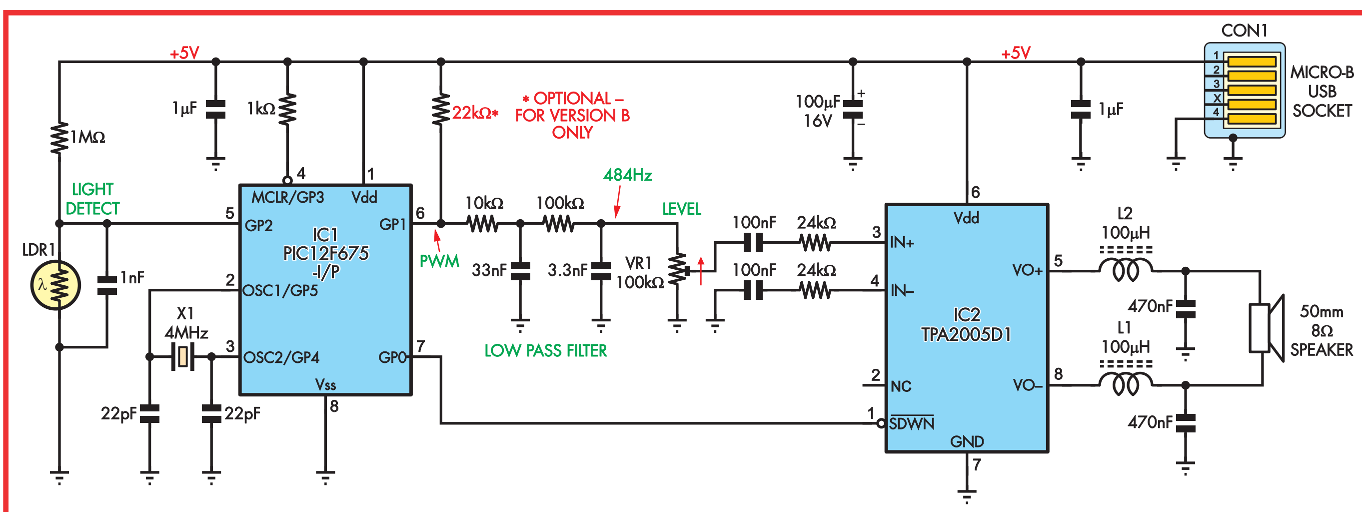
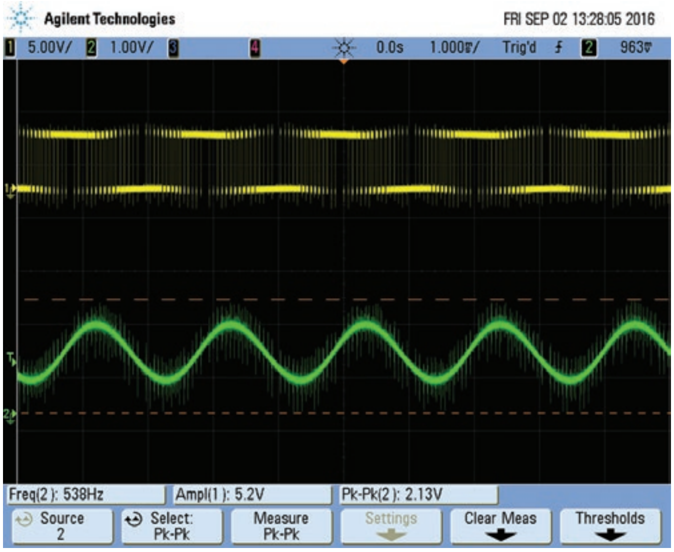
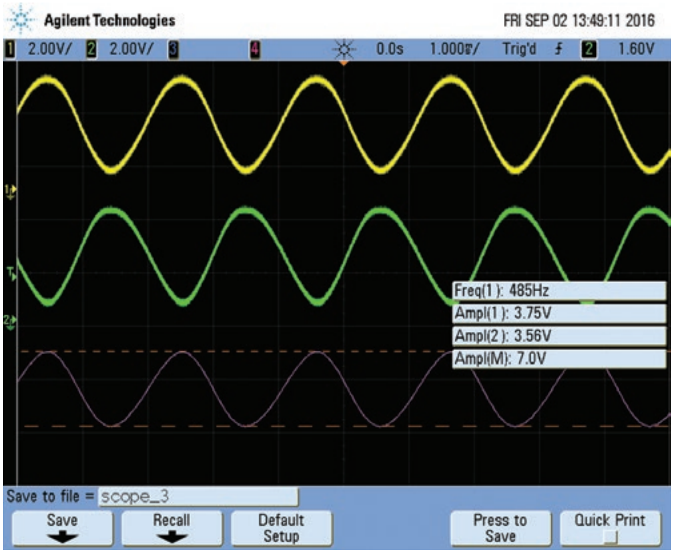


Fig.2: compare this circuit diagram with the block diagram above. Power can be provided by any USB (5V) source.



Scope1: the yellow trace shows the pulse-width-modulated 15.488kHz signal and the green trace shows the 484Hz sinewave, which remains after filtering.



Scope2: the top two traces show the anti-phase signals fed to the loudspeaker in bridge mode. The pink trace shows the summed waveform across the speaker.

Power is applied via an SMD micro USB connector and is bypassed with a 1µF capacitor. The PIC12F675 microcontroller, IC1, has its master clear input, pin 4, tied to the 5V supply rail via a 1kΩ resistor to provide a power up reset function.

The light dependent resistor LDR1 is monitored by the GP2 input of IC1, at pin 5. This is connected via a 1MΩ resistor to the +5V supply.

When the LDR is high resistance (in darkness), GP2 is pulled high toward 5V and IC1 detects this and stays mute. When exposed to light, the LDR's low resistance pulls the GP2 input low, so IC1 produces the PWM signal from its GP1 output, at pin 6.

IC1 uses a 4MHz crystal to ensure the generated 484Hz is precise. The PWM signal is then fed the 2-stage RC filter. The first stage comprises a 10kΩ resistor and 33nF capacitor to give a -3dB rolloff at 484Hz. The second stage has the same -3dB rolloff but uses a 100kΩ resistor with a 3.3nF capacitor.

These components give an impedance which is 10 times the impedance of the first stage filter and minimises any loading effect of the second stage on the first.

The filtered output signal is fed to trimpot VR1 and then to the non-inverting input, pin 3 of amplifier IC2 via a 100nF capacitor.

IC2 is a TPA2005D1 class-D (ie, switching) amplifier in a tiny SMD package, measuring only 3 x 5mm. It is specifically designed for use in mobile (cell) phones where its high efficiency is crucial.

We show the block diagram of the TPA2005D1 in Fig.3. As can be seen, it has differential inputs to an internal amplifier which drives the PWM section which has a switching frequency of 250kHz, set by the internal oscillator. The PWM section then drives an H-bridge circuit which drives an external loudspeaker.

We should note that the datasheet for the TAP2005 highlights two interesting points. Its high CMRR (common mode rejection ratio) is supposed to eliminate input coupling capacitors and it is supposed to be able to run without an output filter (to remove the 250kHz switching signal), if the output leads are short. So do we need those two 100nF input capacitors and the output filter components?

The high CMRR only applies if the amplifier is used in balanced mode, with both inputs at the same DC level.

But in our circuit we are using it in unbalanced mode, with the inverting input grounded (via the 100nF capacitor) and so we end up having to use two input capacitors.

The 24kΩ resistor for the non-inverting input, in conjunction with the internal 150kΩ feedback resistor, sets amplifier gain at about 6.25 times. Since the amplifier is a bridge type, the overall gain is double that at 12.5 times.

And as far as eliminating the output filter is concerned, that is really only

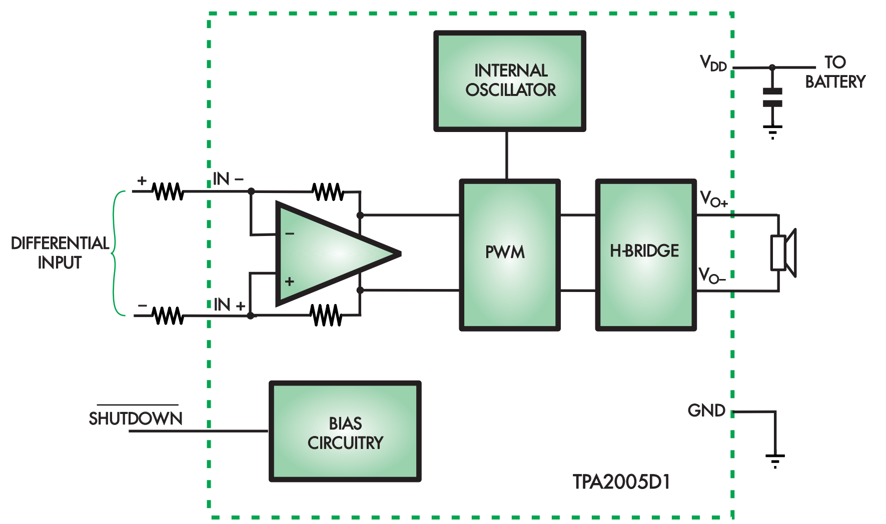


Fig.3: the internal workings of the TPA2005D1, taken from its data sheet.

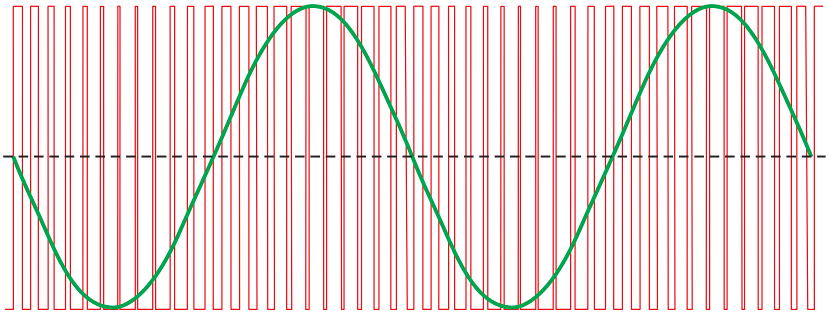


Fig.4: the red waveform represents the PWM output from the microprocessor, IC1, while the green waveform shows its average value which happens to be a sinewave. The green wave also shows the signal that actually appears after the low pass filter has removed all of the higher frequencies. Note that the PWM signal is a representation only, because it is not shown here as 32 times the sinewave frequency.

At right is the Mozzie Lure fitted inside the bottom third of a two-litre PET juice bottle, photographed against a dark background to show detail. The top third is cut off and inverted and slips inside the main body to make it difficult for mozzies to find their way out again.

possible if the output leads to the loudspeaker are very short, implying that radiated electromagnetic interference won't be a problems.

Even then, the datasheet makes a number of output filter suggestions, involving two ferrite beads and two 1µF capacitors at the simplest.

Our PCB has provision for a 3.5mm output jack socket which means that the circuit could be used with a remote speaker, connected via long leads.

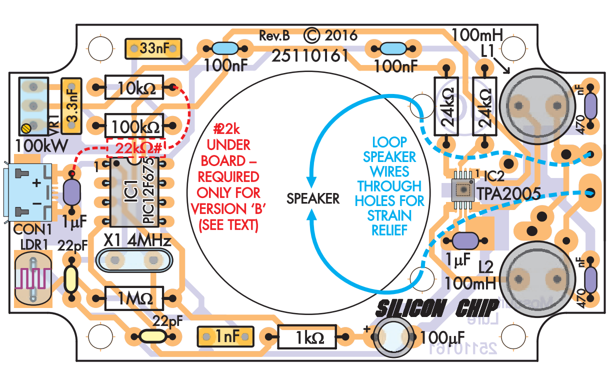
Accordingly, our circuit has an output filter using two 100µH inductors and two 470nF capacitors.

Construction

The Mozzie Lure itself is constructed on a double-sided, plated-through PCB, coded 25110161 and measuring 79 x 44.5mm. It is housed in a semi-transparent UB5 case, 83 x 54 x 31mm. This box is then mounted inside a mosquito trap that can be made using a PET bottle.

The first step in assembly is to position the PCB in the plastic case and mark out the position for each of the four mounting points on the bottom of the case. The board is a tight fit inside the corner pillars so the holes are very much determined for you – but marking with a fine felt-tipped pen now is easier than doing it later.

Now we move onto the PCB itself. Fig.5 shows the PCB component overlay. Begin construction by install-



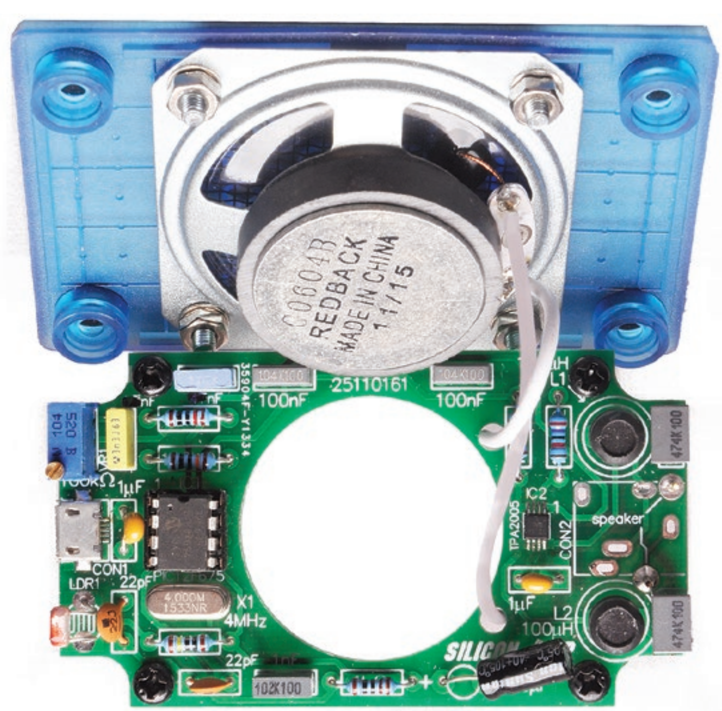
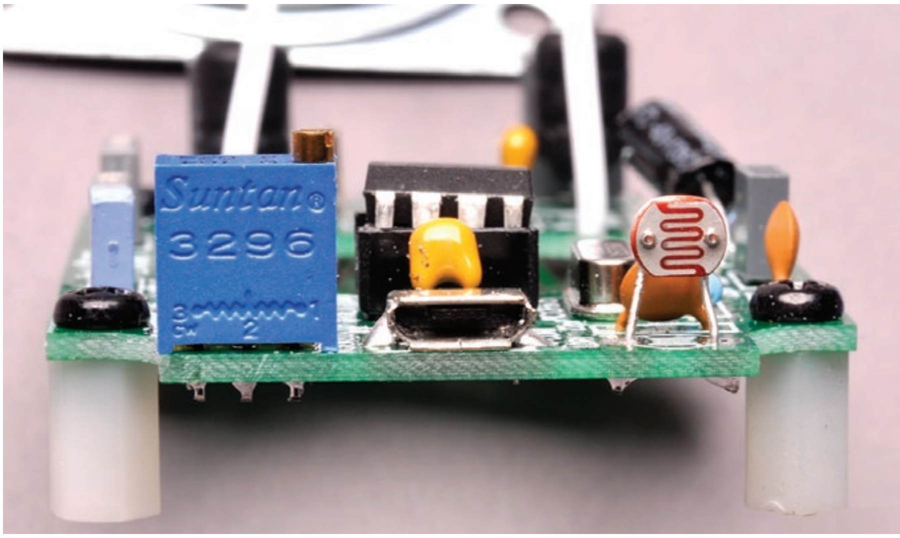


Fig.5: here's the component layout of the PCB. The 22kΩ resistor shown in red above is required for the alternative "B" version which has a slightly lower frequency and should attract different types of mozzies.



An extra close-up of the end of the PCB, mainly to show the location of the micro-USB socket (centre) and the LDR (right side, mounted at a right angle). Note our comments in the text regarding the use of any box which is not at least semi-transparent. The LDR needs to "see" daylight/darkness to work.

ing the SMD class-D amplifier, IC2. It requires a very fine soldering iron and, ideally, a lit gooseneck or desktop magnifier (a good LED headband magnifier also works well).

Position IC2 carefully then tack-solder pin 4 to its pad. (Many hobbyists find a wooden clothes peg handy to keep it in place while soldering).

Before proceeding, carefully check that the IC is still aligned to the IC pads on the PCB – remelt the solder if required. If all is OK, solder the remaining corner pins and then pins 2, 3, 6 and 7.

Use solder wick to remove any solder that bridges between the IC pins.

IC2 also has a ground pad that needs to be soldered to the PCB. This can be done by feeding solder through from the underside of the PCB through the hole positioned central to the underside of the IC. Use minimal solder to prevent the solder spreading out and shorting to the IC leads.

The USB connector can be installed now. It too must be carefully aligned in position and the side wing locating tabs are soldered to the PCB, making sure the tabs are heated sufficiently for the solder to adhere. Solder one tab and check alignment of the five connecting pins to the PCB pads before soldering the other tab and then the pins. Again, reheat the solder and realign the connector if it is not quite right.

Now install the resistors, using a multimeter and the resistor colour code table to check the value of each before inserting into the PCB, followed by the capacitors (note that the 100µF electrolytic must be laid over as shown in the photo).

We used a socket for IC1 – just in case we ever want to remove it for reprogramming, etc. Take care to orient the socket correctly (notch AWAY from the crystal).

Next is the LDR. We mounted ours with the wires bent over 90°, so that when the PCB is installed in the semi-transparent box, the LDR faces to the side. If you use anything but a semi-transparent box, you will need to drill a hole in the box so that the LDR "sees" daylight. Enough light passes

Parts List – Mozzie Lure

1 PCB, coded 25110161, 79 x 44.5mm
1 UB5 transparent box 83 x 54 x 31mm
1 panel label, 75 x 47mm
1 50mm 8Ω Mylar cone loudspeaker (Altronics C0604B)
1 SMD micro-USB connector (Jaycar PS0922, Altronics P1309) [CON1]
1 4MHz crystal [X1]
2 100µH inductors (Jaycar LF1102, Altronics L6222) [L1,L2]
1 LDR 10kΩ light dependent resistor [LDR1] (Altronics Z1621, Jaycar RD-3480)
1 DIL8 IC socket
1 50mm x 50mm square of flyscreen wire
4 M3 tapped x 9mm spacers
8 M3 x 6mm machine screws
4 M3 x 10mm machine screws
4 3mm shake proof washers
4 M3 nuts
2 PC stakes *(not used if CON2 is installed)*
1 200mm length of light duty hookup wire (or 100mm figure-8)

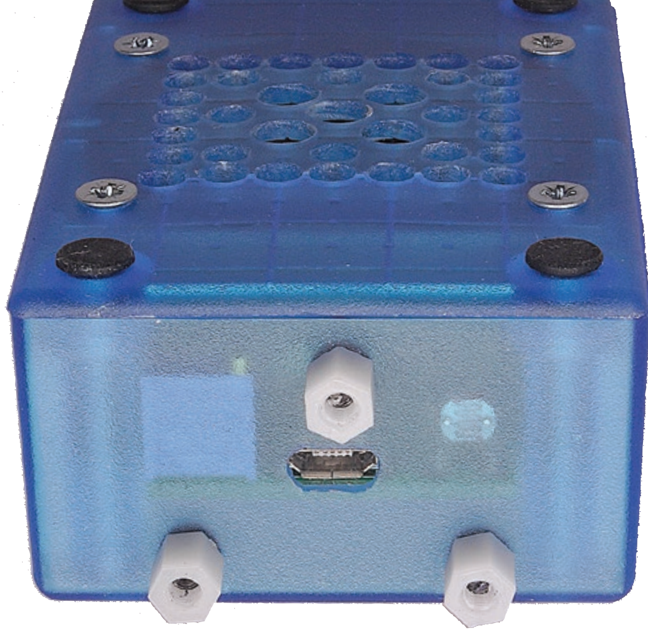
Optional parts for wiring a remote speaker
1 3.5mm PCB mount stereo jack socket [CON2] (Jaycar PS0133, Altronics P0092)
1 3.5mm mono jack plug
1 suitable length of light duty figure-8 wire *(for wiring remote speaker to jack plug)*

Semiconductors
1 PIC12F675-I/P programmed with 2511016A.hex [IC1]
1 TPA2005D1DGN mono class D amplifier [IC2] (Silicon Chip; www.siliconchip.com.au/shop)

Capacitors
1 100µF 16V PC electrolytic
2 1µF monolithic ceramic (Code 105 or 1u0)
2 470nF MKT or ceramic (Code 474 or 470n)
2 100nF MKT or ceramic (Code 104 or 100n)
1 33nF 63V or 100V MKT polyester (Code 333 or 33n)
1 3.3nF 63V or 100V MKT polyester (Code 333 or 3n3)
1 1nF 63V or 100V MKT polyester (Code 102 or 1n0)
2 22pF ceramic (code 22p or 22)

Resistors (0.25W, 1%)
1 1MΩ 1 100kΩ 2 24kΩ 1 10kΩ 1 1kΩ
1 100kΩ multiturn top adjust trimpot [VR1]

Mosquito trap parts
1 commercially available flytrap (ensure it has enough space to mount the Mozzie Lure box) ***or***
1 2-litre PET juice drink bottle (nominally 90 x 90mm square but with rounded corners)
3 M3 tapped x 6mm Nylon standoffs
3 Nylon washers
6 M3 x 5mm Nylon screws



This clearly shows the three threaded standoffs on the end of the box used for mounting, along with the cutouts for the micro-USB socket (on end) and the multiple hole cutouts for the speaker.

through the semi-transparent box to activate the LDR.

Note that if you do not want the circuit to switch off in the night (you must be a ***real*** heavy sleeper!), then use a wire link instead of LDR1. Neither the 1MΩ resistor nor 1nF capacitor are required in this case.

You may notice that provision is made on the PCB for a 3.5mm jack socket. This is if you wish to have the loudspeaker located remotely from the Mozzie Lure (eg, outside the case). Otherwise, install the two PC stakes for later connection to the loudspeaker.

Connect two wires, about 80mm long, to the two PC stakes under the PCB, thence up through the strain relief holes (see photo) and out ready to solder to the miniature 8-ohm speaker.

(We actually used two wires stripped from a length of rainbow cable; mini figure-8 would also work well).

At this stage, don't plug in the PIC microprocessor (IC1) – we'll test the PCB first.

Incidentally, if you purchase your PIC12F675-I/P for this project from the Silicon Chip online store it will already have the firmware 2511016A.hex programmed. But if you wish to do this yourself, the file can be downloaded from the Silicon Chip website.

Housing

The PCB is mounted on four feet made up using 9mm tapped spacers at each corner of the PCB. Before mounting, however, attach the four spacers to the PCB using 5mm screws and place it in position in the box.

Now mark the position for the micro USB connector on one end – when the PCB is removed, this is drilled out and shaped using a very fine file. See the cutout diagram for more detail.

Drill out the four 3mm corner mounting holes in the base of the case where marked previously.

When mounting the loudspeaker in the same box, first place the loudspeaker on the underside of the box lid and centre it in position. Mark out the corner mounting holes and holes within the cone area. The grid on the box lid can be used to form a neat grid of holes (See Fig.8).

If your box does not have the grid, then the panel artwork, with a grid, can be downloaded from the Silicon Chip website. You can either make a 40mm diameter cut out for the loudspeaker cone or a series of smaller holes within the 40mm diameter area.

To stop the mozzies trying to attack the loudspeaker itself and possibly clogging it (who knows what frame of mind they're in with this loud 484Hz super female in there!), it is mounted behind a 50mm x 50mm square of flyscreen wire "sandwiched" between it and the back of the lid using four M3 x 10mm screws, 3mm shake proof washers and M3 nuts. Chamfer the corners of the flyscreen so it doesn't foul the speaker mounting screws.

Now solder the two wires from the PCB to the terminals on the loudspeaker.

If you are not installing the loudspeaker in the same box as the PCB wire the loudspeaker to a suitable length of figure-8 cable and solder the other end to the tip and sleeve of a 3.5mm mono jack plug.

This plugs into an installed 3.5mm jack socket on the PCB.

Testing

Connect a 5V supply to the micro USB connector using the USB supply from a PC, a 5V plugpack or 5V powerbank. Check there is about 5V between pins 1 and 8 of the IC1 socket.

If this is correct (remember that USB supplies can range from between 4.75V to 5.6V), disconnect power and insert the programmed IC1 in its socket, making sure it is oriented correctly (the notch matching the socket).

Reapply power and the speaker should start making a tone. If not make sure there is light on the LDR and that VR1 is adjusted at least partly clockwise. Adjust further clockwise for more sound.

The current drawn by the Mozzie Lure will depend on the sound level set with VR1 (see the specifications). If using a 2200mAh powerbank, the Mozzie Lure should run for 10 hours at full volume (near 1W) before recharging. How loud you set the sound level depends on you. The sound will travel further with more volume but there is the current drain to consider and battery life.

And, of course, you don't want to scare off any male mozzies in the neighbourhood, thinking that the high level of sound is coming from some Amazon of a female. Then again, because of the Zika Virus, maybe an Amazon is *exactly* what you want!

Making the lure

As you can see from our photos, we built a mosquito trap using a recycled PET fruit juice container, cutting the top off with a knife or scissors and inverting this top piece then inserting it into the base. This is shown in the diagram of Fig.6.

The Mozzie Lure is attached to the inside of the PET container about half-way up using screws and washers into 6mm tapped standoffs attached to the box.

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	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	24kΩ	red yellow orange brown	red yellow black red brown
❑	1	10kΩ	brown black orange brown	brown black red brown
❑	1	1kΩ	brown black red brown	brown black black brown brown

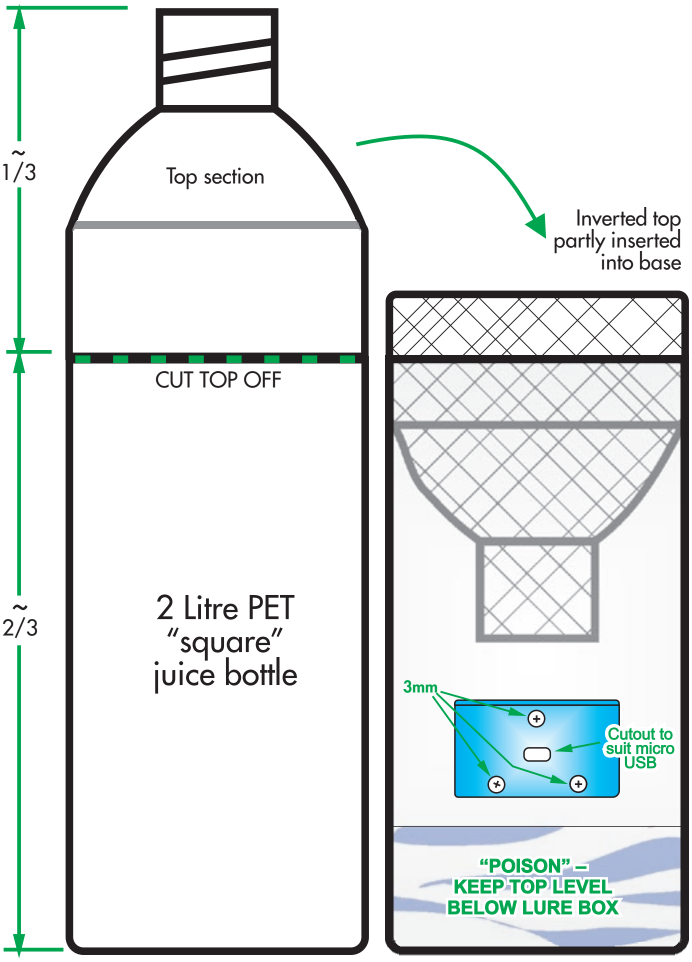


Fig.6: here's how to make a lure from an empty(!) PET juice bottle. Ours measured (roughly) 275 x 100 x 100mm and was cut with a sharp knife at about 90mm down from the top. After mounting the Mozzie Lure and putting some liquid in the bottom, we simply pushed the upside-down top part way into the bottom. Presto – one cheap lure!

Two of the 6mm long standoffs are located 4mm up from the outside bottom edge of the box. These are low enough in the box for the screw heads to clear the PCB when installed and in far enough to clear the internal pillars

The third standoff is 5mm down from the top edge of the box. None of these positions are critical, as long as they clear the PCB and pillars. Our photos show the positions we used.

Cut holes in the PET container for the screw mounts and USB plug matching the 6mm standoffs and USB cutout.

Note that the trap is not suitable for use out in the weather. It needs to be under cover (eg, under an eave) to prevent it becoming a rain gauge collecting water instead of mosquitoes!

What's your poison?

Many liquids have been tried – from plain water, to commercial pest killers, to soft drinks and even beer . . . and we've found that just about anything works!

Some things might attract mozzies better than others but we believe that the secret is more in the mozzies getting exhausted flying around trying to find the (very loud!) female and eventually falling into the liquid and drowning.

You could also try sticky fly traps instead of liquid – eg, an 8-pack of "Buzz Fly Paper Glue Trap" from Bunnings sells for $5.40

You can mount the trap on a pole or similar using cable ties. The power supply can also be attached using cable ties, or power can be run to the trap from an even more protected area (eg, inside!).

There are several commercial flytraps available and you could try one of these – they have the advantage of being easier than making your own and can normally be used out in the weather. The fly attractor supplied with the flytrap is not used and instead the Mozzie Lure box is fitted inside.

Of course, you need to ensure that any commercial flytrap you consider will do just that: fit the Mozzie Lure inside!

Wot about other mozzies?

If you don't live in Queensland (beautiful one day; perfect the next), you probably won't be too worried about the Aedes aegypti mosquito because it's more of a tropical pest.

But Australia has over 80 species of mozzie and most (not all) bite humans and most bite around or after dusk.

We haven't forgotten those little nasties and we have produced a version (B) which works at night.

The only modification required in order to build version B is to add a 22kΩ resistor between pin 1 & 6 of IC1. We show this on the circuit and PCB overlay in red – you can solder it to the underside of the PCB as shown in Fig.5.

The microcontroller has two software routines. If you build the Zika version (A), the circuit will only work in daylight and will produce a frequency of 484Hz to attract male Aedes mosquitos. If you build version (B), the micro will sense the presence of the 22kΩ resistor and will only work at night. In this case, it will produce a frequency of 400Hz to attract a range of mosquito species.

You could even try putting in a switch to vary between the two frequencies (ie, switching the resistor in and out) to perhaps rid your whole area of all of the little pests! Note that you will have to power off (ie, remove the USB plug) to switch to the different mode. SC

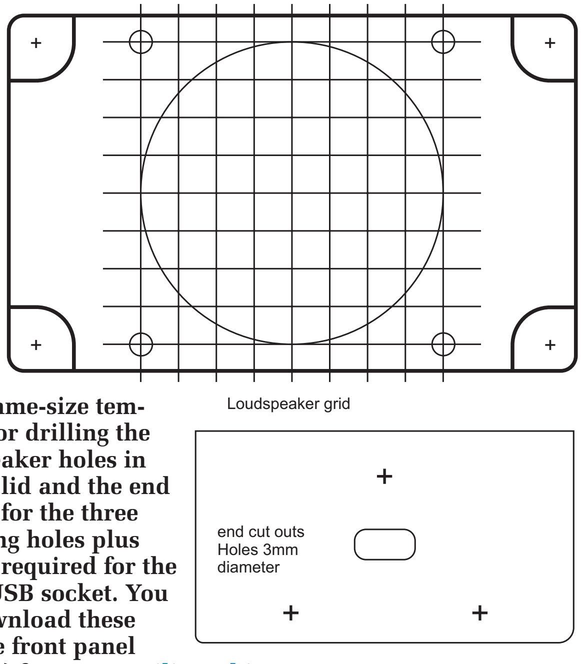


Fig.7: same-size templates for drilling the loudspeaker holes in the box lid and the end cutouts for the three mounting holes plus the slot required for the micro USB socket. You can download these (and the front panel artwork) from www.siliconchip.com.au

Subscribe to SILICON CHIP and you'll not only save money . . . but we GUARANTEE you'll get your copy!

When you subscribe to SILICON CHIP (printed edition) in Australia, we GUARANTEE that you will never miss an issue.

Subscription copies are despatched in bulk at the beginning of the on-sale week (due on sale the last THURSDAY of the previous month). It is unusual for copies to go astray in the post but when we're mailing many thousands of copies, it is inevitable that Murphy may strike once or twice (and occasionally three and four times!).

So we make this promise to you: if you haven't received your SILICON CHIP (anywhere in Australia) by the end of the first week of the month of issue (ie, issue datelined "June" by, say, 7th June), send us an email and we'll post you a replacment copy in our next mailing (we mail out thrice each week on Monday, Wednesday and Friday). Send your email to: missing_copy@siliconchip.com.au

- ✔ Remember, it's cheaper to subscribe anyway . . . do the maths and see the saving!
- ✔ Remember, we pick up the postage charge – so you $ave even more!
- ✔ Remember, you don't have to remember! It's there every month in your letter box!
- ✔ Remember, your newsagent might have sold out – and you'll miss out!
- ✔ Remember, there's also an on-line version you can subscribe to if you're travelling.

Convinced? We hope so. And we make it particularly easy to take out a subscription - for a trial 6-month, a standard 12-month or even a giant 24-month sub with extra savings.

Here's how: simply go to our website (siliconchip.com.au/subs) – enter your details and pay via Paypal or EFT/Direct Deposit. You can order by mail with a cheque/ money order, or we can accept either Visa or Mastercard (sorry, no Amex nor Diners').

If mailing, send to SILICON CHIP, PO Box 139, Collaroy NSW 2097, with your full details (don't forget your address and all credit card details including expiry!).

We're waiting to welcome you into the SILICON CHIP subscriber family!

Since the original Currawong amplifier was published in November & December 2014 and January 2015, it has created quite a deal of interest and those who have built it have been most enthusiastic. However it had a complicated power supply employing two transformers – so now we present a much simplified circuit using a single power transformer, which also saves on the overall cost.

By Leo Simpson

A New Power Transformer for The Currawong 2 x 10W Stereo Valve Amplifier

All electronic design work involves maximising performance from the cheapest, readily available components.

That certainly applied to the power and output transformers used in the Currawong stereo valve amplifier. The output transformer used in both channels were actually a 100V audio line transformer with the multi-tapped 100V windings being used to provide an (almost) ultra-linear connection to the plates and screens of the 6L6 beam tetrodes.

It works surprisingly well for a cheap transformer.

And while we would have preferred to use a single transformer in the power supply, the fact was that there simply wasn't a suitable unit available, at the time.

So we ended up using two toroidal power transformers, rated at 160VA and 80VA. We had their secondary windings connected to provide 114VAC for the HT supply and 12V for the series-connected tetrode heaters and the 12V regulated DC rail. This rail runs the heaters for the 12AX7 dual triodes, relay speaker switching and remote control circuitry.

The new 160VA transformer from Altronics. Note that this is a pre-production sample and lead colours in the stock item may be quite different.

New transformer

But the above 160VA transformer has since been discontinued, so we have now arranged with Altronics Distributors (who stock the Currawong amplifier kit) to source a new single transformer which will do the job by itself.

It is a 160VA toroidal unit (Altronics Cat MA5399) with two

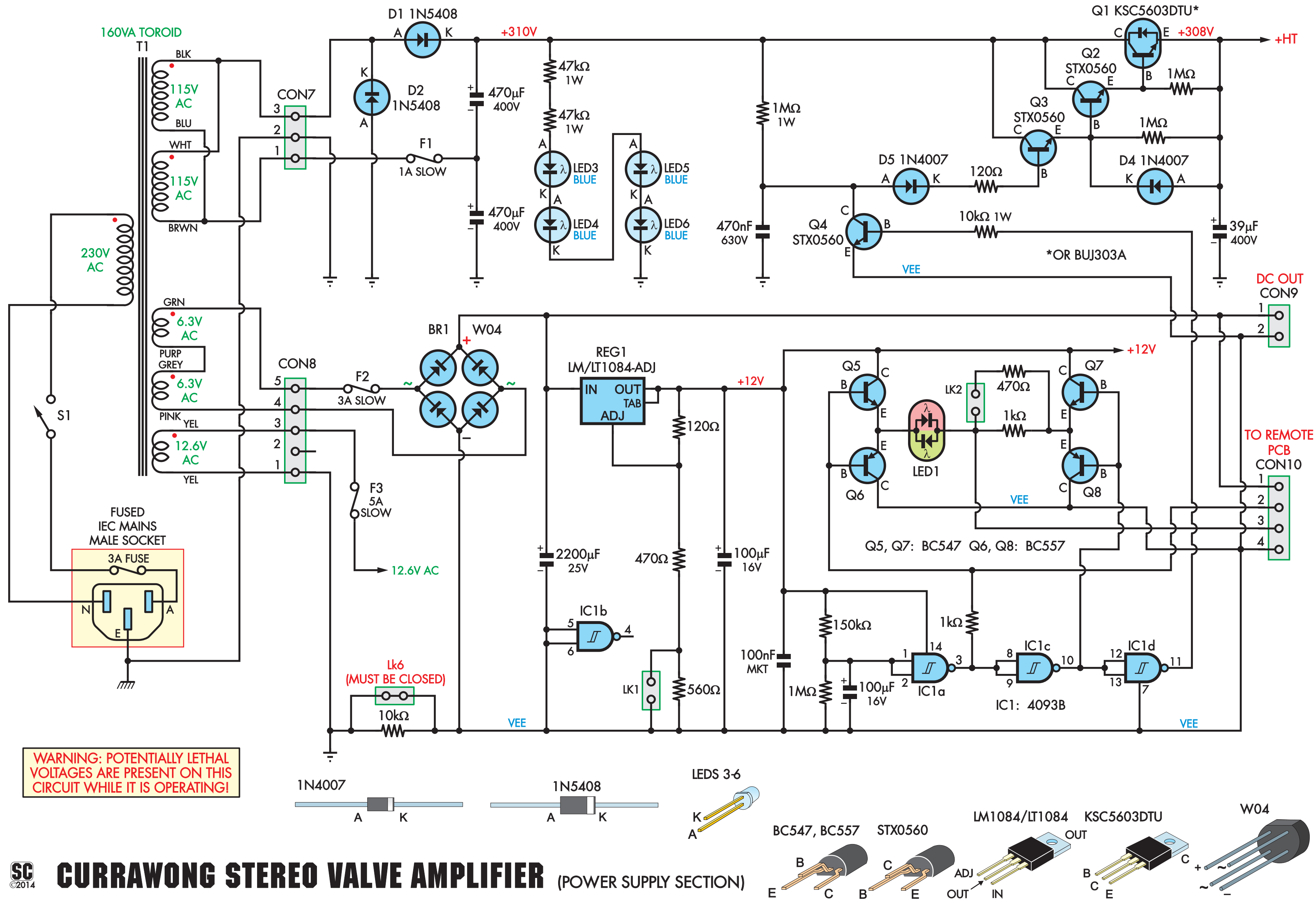


Fig.1: the 115VAC secondaries of transformer T1 are connected in parallel and rectified using a voltage doubler to produce a 310V HT rail. Most of the ripple is filtered out by a capacitance multiplier comprising high-voltage transistors Q1-Q3 and a 470nF polyester capacitor. T1's 12.6VAC secondary drives the 6L6 filaments directly in a series/parallel configuration. The two 6.3VAC windings are connected in series to drive bridge rectifier BR1, a 2200µF filter capacitor and linear regulator REG1 to produce a regulated 12V rail to run the 12AX7 filaments. IC1 provides an HT turn-on delay and soft start.

The new transformer mounted inside the same plinth as held the original two transformers. Again, ensure that any exposed mains wiring (for example, the IEC mains input socket) is properly covered, as shown here. NOTE: Altronics expect this transformer to be in stock from early to mid November.

115VAC 0.5A windings, two 6.3VAC 1A windings and a single 12.6VAC 2A winding. While that may seem like more windings than we actually need to run the Currawong, we have arranged it this way so that the transformer can be used in other applications, of which there are several (see panel).

However, the main game is to run it in the Currawong, as you can see from the power supply circuit shown in Fig.1.

Apart from the transformer connections and the connection for LK6, this circuit is identical the original version published in the November 2014 issue on page 32.

If you make comparisons between the two diagrams you will see that the connections for the new transformer are considerably simplified.

The two 115VAC windings are connected in parallel to pins 1 & 3 of CON7 and thence to the voltage doubler rectifier comprising diodes D1 & D2, together with the two 470µF 400V electrolytic capacitors.

The two 6.3VAC winding are connected in series and go to pins 4 & 5 of CON8 and then via a 3A slow blow fuse F2 to bridge rectifier BR1. The single 12.6VAC winding is connected to pins 1 & 3 of CON8 and then via slow blow fuse F3 to power the series-connected connected heaters of the 6L6 beam power tetrodes.

No change needs to be made to the componentry on the main PCB except for the fact that link LK6 must be fitted (the 10kΩ resistor that it shorts out can be omitted if you wish).

Wiring it up

Fig.2 shows the much simplified wiring inside the timber base of the Currawong and you should compare it with the photo on page 93 of the December 2014 issue, which shows the same details.

The transformer should be located as shown in the wiring diagram and in the photo. Leave enough room between the transformer and rear panel so that you can later reach behind the main PCB as it's being slid in and plug the various connectors into the underside (this requires more clearance than is available above the transformer).

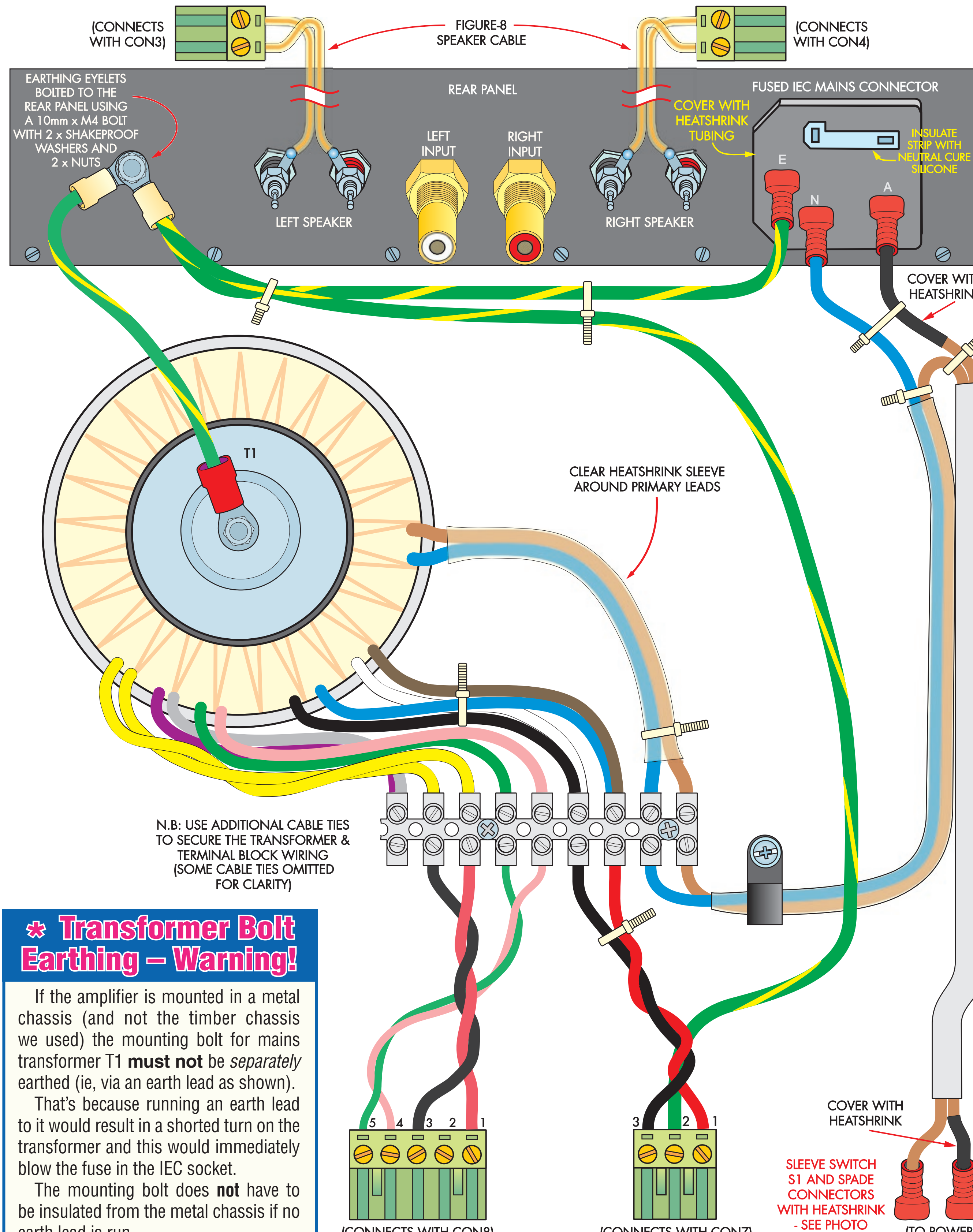
We suggest a gap of no less than 60mm between T1 and the rear of the case. In practice, this means positioning the transformer mounting bolt so that it is approximately 120mm from the back edge of the plinth (ie, about 100mm from the inside rear edge).

Mount the transformer using the supplied rubber mounting washers, metal plate and washers via a 6mm hole drilled in the bottom of the plinth but do not tighten nut at this stage.

Then position the 9-way terminal block, as shown in Fig.2. Use two 12mm self-tapping screws to hold it in place, as shown.

Wiring colours

It is important to note that the colours of the transformer connection wires shown in Fig.1 and Fig.2 are those on our pre-production trans-



* Transformer Bolt Earthing – Warning!

If the amplifier is mounted in a metal chassis (and not the timber chassis we used) the mounting bolt for mains transformer T1 **must not** be *separately* earthed (ie, via an earth lead as shown).

That's because running an earth lead to it would result in a shorted turn on the transformer and this would immediately blow the fuse in the IEC socket.

The mounting bolt does **not** have to be insulated from the metal chassis if no earth lead is run.

Fig.2: the Currawong wiring diagram with a single power transformer. Compare it closely with the transformer wiring in the circuit of Fig.1. Note that the IEC socket must be covered with heatshrink tubing (see photo). This diagram assumes a *timber* cabinet as per our prototype – see warning above re earthing if a metal chassis is used.

former. It is likely that these may change in the production transformers which will become available in the month of the November. So while we refer to particular colours in this article, to match those shown in the photo, it is important to look at the labelling of the supplied transformer to identify the particular winding colours.

For example, although our prototype transformer had two red wires for the 230VAC primary winding, it is likely (and preferable) that the production version will have blue and brown wires.

With that in mind, cut a length of 5mm diameter clear heatshrink tubing to cover the entire length of the primary winding wires, except for about 10mm at the ends. Then shrink the tubing down. Bend the wires so they run as shown on the wiring diagram and terminate them in the terminal block.

Now, twist the four 115VAC secondary wires together (black/blue and white/brown). This will help to minimise the radiated hum and buzz fields. Join the black and white wires together and connect them to one of the terminals of 9-way terminal block. Then do the same with the blue and white wires. Doing it in this way means that both 115V windings have the starts and finishes connected together. If you don't do this right, one winding will effectively short the other and the transformer would very rapidly overheat and (hopefully) blow the fuse.

On the other side of the 9-way terminal block, the 115VAC red & black wires are terminated at pins 1 & 3 of the green connector which mates with CON7 on the main PCB.

Now twist the four 6.3VAC wires (green, purple grey & pink) together in the same way and connect to the 9-way block. The green and pink wires provide 12.6VAC to pins 4 & 5 of the green connector which mates with CON8 on the main PCB. Then twist the yellow 12.6VAC wires together and connect to the 9-way block. These provide 12.6VAC to pins 1 & 3 on the same green connector.

Once all the wires are in place, measure the resistance between pins 1 & 3 on the CON7 connector.

You should get a reading of about 5Ω. There should be an infinite reading between pins 1 & 2 and pins 2 & 3.

Similarly, between pins 1 & 3 and pins 4 & 5 on the CON8 connector, you should get a very low value; less than 1Ω.

Any higher readings than these suggests at least one wire is not making good contact in the terminal block, so go over them again.

From this point on, you can follow the original wiring and assembly instructions which were featured in the December 2014 issue of SILICON CHIP.

However, before making connections to the main PCB via CON3, 4, 7 and 8, we suggest that you connect power to the transformer and check the voltages present at the green connectors for CON7 & CON8.

Remembering that the transformer has no load at this stage and assuming a mains input voltage of 230VAC, you should have about 127VAC at pins 1 & 3 of CON7 and 13.7VAC or thereabouts at pins 1 & 3 and 4 & 5 of CON8. SC

What else can you use this transformer for?

As described in the main article, the prime application of this new 160VA toroidal transformer is to power the Currawong valve amplifier. But it's quite a versatile transformer, offering a variety of other applications – nothing to do with the Currawong! Some of its possible uses include:

An Isolation Transformer

Fig.3(a) shows it with the two 115VAC windings connected in series so it can be used as a standard isolation transformer (ie, where you need to keep the device isolated from the mains supply) with a rating of about 150VA.

A Stepdown Transformer for 115V Equipment

Fig.3(b) shows it with the two 115VAC windings connected in parallel so it can be used as 230VAC to 115VAC transformer to run equipment rated up to about 150VA.

A Voltage Adjustment for High (or Low) Mains

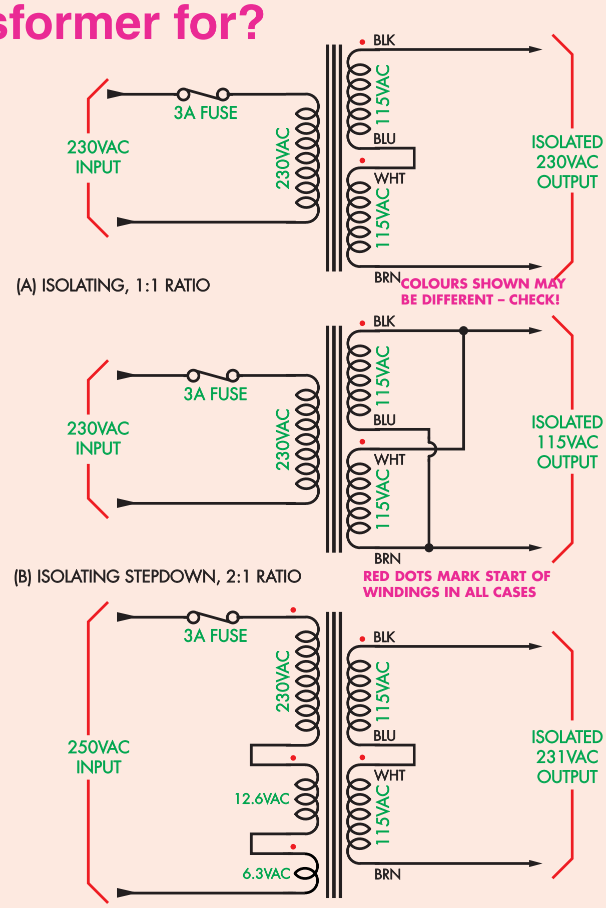
Fig.3(c) shows it with one 12.6VAC winding and one 6.3VAC winding connected in series across the incoming mains (primary) winding and with the two 115VAC windings connected in series.

You would use this connection if your mains voltage is very high at around 250VAC or more and you want to improve the reliability of connected equipment by running it at a much safer 230VAC, or thereabouts.

This arrangement can yield other voltages, eg, by using only one of the 12.5VAC or 6.3VAC windings in series with the primary (to yield a slightly higher output voltage than shown here) or connecting one or more of the low voltage windings in series with the 115VAC secondaries to step up the output voltage (eg, if you have a consistently low mains voltage).

However, you must ALWAYS check (carefully!) that you have the phasing of the windings correct – if the transformer gets hot or hums loudly, chances are they're wrong!

Above all, remember that you are dealing with lethal voltages!



As noted elsewhere, the Altronics catalog number is MA5399 and its recommended retail price is $79.95 including GST.


SIGHT & SOUND
GET READY TO ENTERTAIN
Jaycar Electronics
IMPROVE YOUR HOME ENTERTAINMENT AREA
NEW
$39.95
3 WAY TOSLINK SWITCH WITH IR AC-1594
Connect up to three Toslink sources to one Toslink input.
• 16Mbps, supports common audio formats
• 60(W) x 54(D) x 20(H)mm
NEW
$64.95
DIGITAL TO ANALOGUE AUDIO CONVERTER AC-1715
Converts your digital signal into analogue (RCA) stereo audio.
• Includes 5V 1A power supply
• 63(W) x 42(D) x 26(H)mm
ALSO AVAILABLE: ANALOGUE TO DIGITAL AUDIO CONVERTER AC-1716 $64.95
Due early October.
2 WAY DISPLAYPORT SPLITTER AC-1755
Allows for a DisplayPort signal to be split to two different devices.
• Supports a bit rate of 21.6 Gbps and includes 5V 1A power supply
• 71(L) x (61)W x 21(H)mm
ALSO AVAILABLE: 2 WAY DISPLAYPORT SWITCHER AC-1757 $99.95
NEW
$99.95
USB 3.0 TYPE-C TO SOCKET ADAPTOR PA-0935
Convert a standard USB 3.0 type A plug to type-C.
• Works for PCs or laptops
NEW
$11.95
3.5MM 4 POLE AUDIO SOCKET LEAD WA-7022
Connect headphones or earphones to a laptop with separate audio and microphone inputs.
• Length: 250mm
NEW
$6.95
BLUETOOTH® AUDIO DONGLE AA-2104
Enables a non-Bluetooth device to send or receive audio signals via Bluetooth®.
• 44(W) x 44(D) x 12(D)mm
NEW
$69.95
RECORD AND PLAYBACK MODULE ARDUINO® COMPATIBLE XC-4605
ISD1820 based. Includes an on-board microphone and can drive a small speaker directly.
• Records up to 10 seconds
• Can work in loop or single play mode
MORE ARDUINO® OVERLEAF
NEW
$9.95
PC MONITOR DESK BRACKETS
Trade in those boxes, old phone books or reams of paper stacked under your computer monitor for a PC Monitor Desk Bracket. You will maximise your workspace, stop straining or hunching over to see your screen and boost your productivity.
SINGLE CW-2874 $59.95
DUAL CW-2875 $79.95
STAND CW-2876 $79.95
ALSO AVAILABLE:
CABLE MANAGEMENT STRIP CW-2877 $19.95
• Aluminium 1m long
NEW
CW-2874
FROM $59.95
MOBILE TV ACCESSORIES
A range of products designed for running TV signals from an external antenna on a caravan, motorhome, boat or even a demountable to the inside without letting the rain and dust in.
ROOF MOUNT CABLE ENTRY COVER LT-3076
Run a cable through the roof or wall without introducing water leaks.
• 150(L) x 65(W) x 30(D)
$9.95
NEW
WEATHERPROOF TV/SATELLITE CONNECTION PANEL
Connections for satellite or TV. Supplied with 3m cables,crimp plugs and mounting hardware.
• 110(L) x 60(W) x 30(D)mm
DUAL F-TYPE CONNECTIONS LT-3074
F-TYPE & PAL CONNECTIONS LT-3072
NEW
$29.95 ea
ANTENNA MAST CLAMP SET LT-3208
Allows you to mount your TV antenna, adjust for the best reception, and to quickly remove it before travelling. Suits 25-30mm dia. antenna masts.
• Pack of 2
• 108(L) x 47(W) x 68(H)mm
NEW
$24.95 pr
DATA HOLD CATIII DIGITAL MULTIMETER WITH NON-CONTACT VOLTAGE SENSOR QM-1527
500V AC/DC, 2000 count. Diode test. 10A DC current. Backlight. Continuity beeper.
• 145(H) x 65(W) x 35(H)mm.
THIS METER INCLUDES QUALITY TEST LEADS
NEW
$19.95
WIN A WI-FI AUDIO STREAMING SPEAKER - SEE PAGE 5
Catalogue Sale 24 September - 23 October, 2016
To order phone 1800 022 888 or visit www.jaycar.com.au

THE ESSENTIALS FOR YOUR ARDUINO® PROJECT

$29.95

DUINOTECH CLASSIC (UNO)
XC-4410

The flagship of our duinotech family
- ATMega328P Microcontroller
- 32KB program memory
- 75(W) x 53(L) x 13(H)mm

$29.95

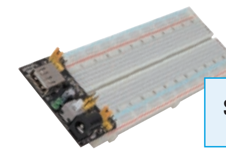
DUINOTECH LITE (LEONARDO)
XC-4430

Combines two chipsets in a single IC for more advance USB functions.
- ATMega32u4 Microcontroller
- 32KB program memory
- 75(W) x 53(L) x 13(H)mm

$49.95

DUINOTECH MEGA
XC-4420

Our most powerful Arduino™ compatible board.
- ATMega2560 Microcontroller
- 256KB program memory
- 108(W) x 53(L) x 15(H)mm



$19.95

SOLDERLESS BREADBOARD KIT
PB-8819

Ideal for circuit board prototyping and Arduino® projects. Kit includes solderless breadboard with 830 points, power supply module, 64 mixed jumper wires of different lengths and colours.

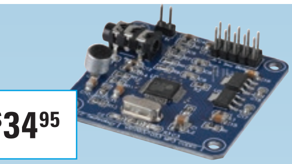
ADD SOME BELLS AND WHISTLES BY USING ARDUINO® COMPATIBLE MODULES & SHIELDS

$3.95

ACTIVE BUZZER MODULE
XC-4424
- Use the tone function with the buzzer module to give your project character
- Install the talkie library and give your robot an actual voice www.jaycar.com.au/diy-udcr
- 25(L) x 15(W) 10(H)mm

$4.95

AMPLIFIER MODULE
XC-4448
- Provides a 2 x 3W stereo audio amplifier
- 23(W) x 16(D) x 2(H)mm

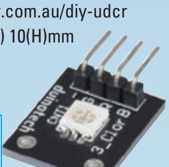


$34.95

MP3 RECORDING MODULE
XC-4516
- Record MP3s via the built in microphone
- Playback through the 3.5mm socket
- Includes a line in header
- 44(L) x 44(W) x 10(H)mm

$59.95

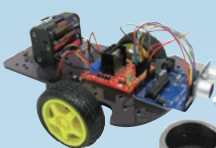
MUSIC SHIELD
XC-4544
- Music player and recorder
- Pins on Arduino® board can be assigned for music control
- 80.4(L) x 52.5(W) x 13.9(H)mm



$4.95

RGB LED MODULE
XC-4428

Plug it straight into your Arduino board to add a status indicator (green = good, red = bad)
- 25(L) x 15(W) x 2(H)mm

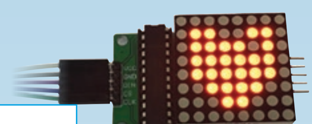


Robot not included.

$7.95

DUAL ULTRASONIC SENSOR MODULE
XC-4442

Give your next project eyes.
- Measure how full a tank is or build a reverse park sensor or door counter
- 45(W) x 20(D) x 13(H)mm



$7.95

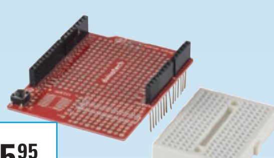
8 X 8 LED DOT MATRIX MODULE
XC-4499

Perfect for robot eyes or mouth, or even a beating heart!
- Able to show numbers or small graphs for status displays
- 62(W) x 32(H) x 14(D)mm

$10.95

3W 200 LUMEN LED MODULE
XC-4468

Includes a PWM input for brightness control.
- 6000K colour temperature
- 30(L) x 23(W) x 6(H)mm

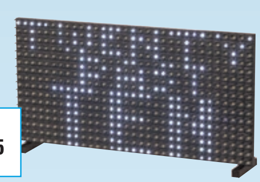


$15.95

PROTOTYPING SHIELD
XC-4482
- Includes reset button.
- SOIC-14 breakout, for surface mount ICs
- 68(L) x 53(W) x 12(H)mm

$16.95

8 X 8 DOT MATRIX DRIVER MODULE XC-4532
- Daisy-chainable.
- 74HC595 chipset
- 72(L) x 69(W) x 12(H)mm



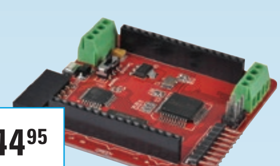
XC-4622

FROM $29.95

LED DOT MATRIX DISPLAY
Build your own clock or customisable information sign.

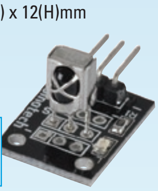
RED MATRIX XC-4621 **$29.95**

WHITE MATRIX XC-4622 **$39.95**



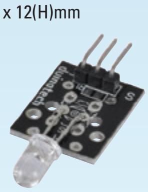
$44.95

8 X 8 RGB LED MATRIX DRIVER MODULE XC-4498
Driven by an ATMega328p, this module communicates with your project via I2C.
- 66(L) x 60(W) x 12(H)mm



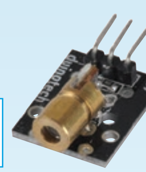
$3.95

INFRARED RECEIVER MODULE
XC-4427
- Receives data sent via infrared
- Pair with TX Module (XC-4426) to make a universal remote control
- 28(L) x 15(W) x 2(H)mm



$4.95

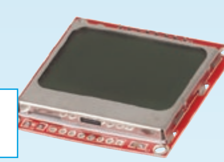
INFRARED TRANSMITTER MODULE
XC-4426
- Combine it with our RX module (XC-4427) and you have simple wireless communication



$4.95

RED LASER DIODE MODULE
XC-4490

Add a red laser light to your latest project.
- 45(W) x 23(D) x 10(H)mm



$19.95

84X48 DOT MATRIX LCD DISPLAY MODULE
XC-4616

Add a small black and white graphics display to your project.
- 44(W) x 44(D) x 13(H)mm

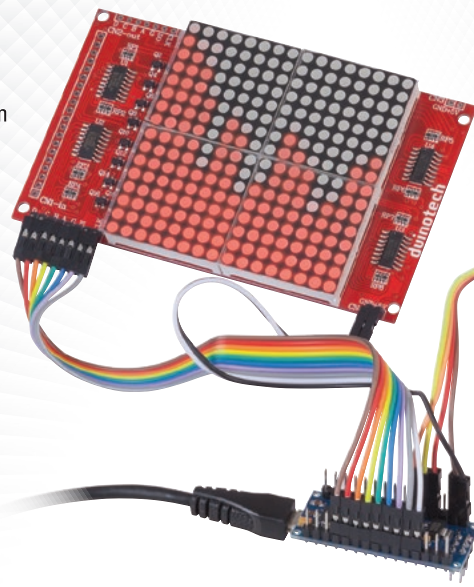
ARDUINO® PROJECT OF THE MONTH

BUILD YOUR OWN AUDIO MATRIX SPECTRUM

We have received many requests from Arduino hobbyists interested in projects involving an Audio Spectrum Analyzer/ Visualizer. So using our compact Matrix LED display (XC-4607), we have created a compact audio spectrum project that displays the audio waveform of your music. As well as an instantaneous level display, there is also a peak level 'waterfall' effect too. (Sit it on your desk, workbench or next to a speaker and add some life and colour to your music).

With this project no soldering is required, and it only uses a handful of parts making it a relatively simple and inexpensive exercise suitable for learners and keen Arduino hobbyists alike.

SEE STEP-BY-STEP INSTRUCTIONS AT www.jaycar.com.au/audio-matrix-spectrum



DIY

MORE INFO ONLINE

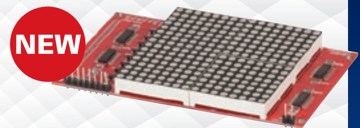
NERD PERKS CLUB OFFER

BUY ALL FOR $59

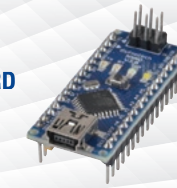
SAVE OVER 20%

ITEMS NEEDED:

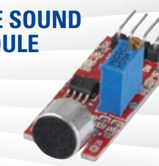
NEW



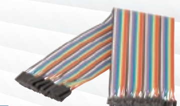
16X16 LED DOT MATRIX MODULE
XC-4607 **$29.95**



DUINOTECH NANO BOARD
XC-4414 **$29.95**

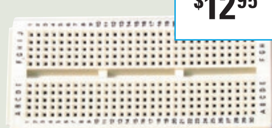


MICROPHONE SOUND SENSOR MODULE
XC-4438 **$7.95**



150MM SOCKET TO SOCKET JUMPER LEADS
40 PIECE WC-6026 **$5.95**

PROTOTYPE



$12.95 — NERD PERKS 2x POINTS

MINI BREADBOARD

PB-8832

- Total 300 holes
- 39(W) x 87(L)mm

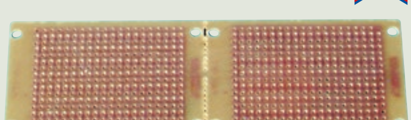
BREADBOARD JUMPER KIT

PB-8850

Includes 70 stripped pieces of single core sturdy wire.

- Supplied in a plastic box for easy storage

$13.50 — NERD PERKS 2x POINTS

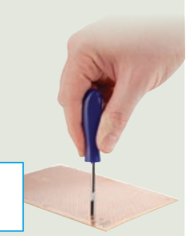


ULTRA MINI EXPERIMENTERS BOARD HP-9556

$4.95

Can be snapped apart to make two boards or one 130 x 45mm 0.3 wide x 0.1 pitch.

ALSO AVAILABLE:
IC EXPERIMENTERS BOARD HP-9558 **$6.95**



SPOT FACE CUTTER FOR STRIP BOARDS

TD-2461

Designed to neatly remove copper track on strip type prototyping boards.

- Total Length: 110mm

$8.95

PCDUINO & ACCESSORIES

pcDuino3 is a high performance, cost effective single board computer.

It runs operating systems such as Ubuntu Linux and Android and has HDMI interface to output to a monitor or TV.

It is also compatible with the popular Arduino ecosystem such as Arduino Shields.

PCDUINO V3.0 WITH WI-FI

XC-4350

- Built in Wi-Fi capability
- Supported digital audio via I2C
- 121(L) x 65(W) x 15(H)mm

$129

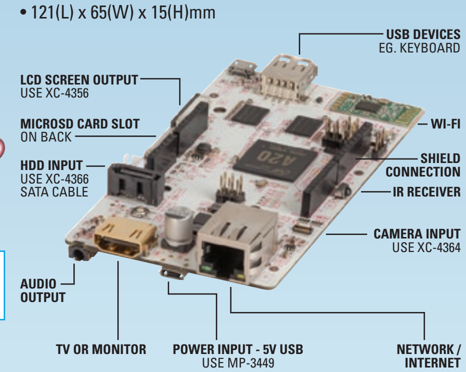
SATA CABLE

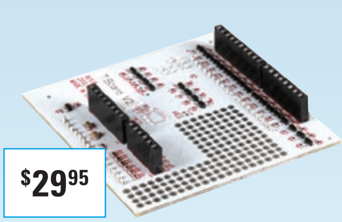
FOR PCDUINO XC-4366

Connects your pcDuino V3.0 to a hard drive or SSD.

- Length: approx. 15 cm

$9.95





$29.95

VOLTAGE CONVERTER MODULE

FOR XC4350/52 PCDUINO XC-4362

Safely marries 5V Arduino® shields with the 3.3V pcDuino and will stop damage caused by connecting a 5V shield to the pcDuino.

- 70(L) x 50(W) x 4(D)mm

$59.95

PCDUINO 5MP CAMERA

XC-4364

Connects directly to your pcDuino V3.0, and captures an active array video and images up to 2592 x 1944.

- 99mm ribbon
- 9(L) x 9(W) x 6(D)mm

TOOLS OF THE TRADE FOR SIGHT & SOUND PROJECTS

There has been an obvious resurgence in people getting back to the workbench and reviving skills involving manual dexterity. As you will see across the following pages, Jaycar has all the DIY tools you'll need to equip your workbench so you can create projects from the power of your brain and your hands.

1. MULTIFUNCTION ENVIRONMENT METER WITH DMM QM-1594 **WAS $129**
- Sound level meter
- Light level meter
- Indoor temperature and humidity measurement
- Non contact voltage

2. ROADIES CABLE TESTER AA-0405
- Instant go/no-go status of each conductor path in the cable.
- Requires 1 x 9V battery
- 190(L) x 98(W) x 35(H)mm

3. WATER RESISTANT INSPECTION CAMERA QC-3374
- Flexible 7m cable
- Hook, magnet and 45° mirror attachments
- 4 white LEDs (brightness adjustable)
- Resolution: 640x480
- Lens view angle: 54 degrees

4. AUTORANGING AC/DC DIGITAL CLAMP METER QM-1563

Easy one-hand operation perfect for the working installer or tradesman.
- 600V
- 4000 count
- 400A AC/DC
- Includes test leads & temperature probe

5. 35 PIECE MULTI-PURPOSE PRECISION TOOL KIT WITH VINYL CASE TD-2117
- Comprehensive tool set in a quality zipped storage case

6. MAGNIFYING LAMP WITH THIRD HAND TH-1989 **WAS $44.95**
- LED illuminated 3x magnifying glass, soldering iron stand, alligator clips, solder spool holder, cleaning sponge & ball
- 4 x AA batteries required (Available separately)
- 190x170mm base size

ESD SAFE PB FREE SOLDERING STATION

TS-1584
- CHT- Curie Heat Technology
- Power on demand
- Accurate temperature control
- No calibration requirement
- Includes free 0.5mm chisel tip

$359

THERMALTRONICS

TECH TIP

THE BENEFITS OF CURIE HEAT TECHNOLOGY (CHT) IN SOLDERING IRONS

With today's delicate and complex electronic assemblies, temperature accuracy is a consistent challenge. Component density, lead size and thermally sensitive components all combine to increase process control demands, criteria which many systems fail to meet.

CHT technology responds to the thermal demands of each solder joint by adjusting the power instantaneously, thereby meeting the exact requirements of the substrate component and solder material resulting in more accurate temperature control with no calibration required.

DURATECH SOLDER

60% Tin / 40%. Lead Resin cored.

1KG ROLLS

0.71MM NS-3002 **$74.95**
1.00MM NS-3015 **$74.95**

200G ROLLS

0.71MM NS-3005 **$15.95**
1.00MM NS-3010 **$15.95**

FROM $15.95

LEAD-FREE SOLDERS

500G ROLLS

0.71MM NS-3090 **$54.95**
1.00MM NS-3096 **$54.95**

200G ROLLS

0.71MM NS-3088 **$24.95**
1.00MM NS-3094 **$24.95**

FROM $24.95

NS-3090

SOLDER FLUX PASTE NS-3070

Reduce solder waste and produce high quality soldered joints.
- 56g

$15.95

SOLDER STAND

TS-1504
- Will hold our 1kg rolls
- Shaft diameter is 16mm
- 90(W) x 100(L) x 77(H)mm

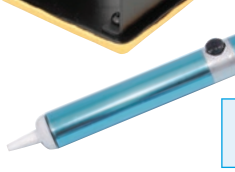
$19.95

NERD PERKS 2x POINTS

$12.95

SOLDERING IRON TIP CLEANER 15G TS-1512

Contains solder powder, and non corrosive flux. Cleans and tins your tip at the same time.



$16.95

METAL SOLDER TOOL

TH-1862

ABS plastic body with strong suction.
- Total length including tip 195mm

SPARE TIP TH-1863 **$4.95**

$69.95

SOLDER FUME EXTRACTOR

TS-1580

Designed to remove dangerous solder fumes from the work area.
- 260() x 200(W) x 170(D)mm

HAND-HELD TEST EQUIPMENT

Rechargeable test equipment for the workbench or toolbox.

10MHZ RECHARGEABLE HAND-HELD POCKET SCOPE QC-1914

Includes dozens of features found on full size digital oscilloscopes. Includes CRO probe.

- Full auto range operation
- 40MS/s real time sample rate
- 100Vp AC or DC
- 1mV to 20V per division in 14 steps

NERD PERKS
RRP $369
$339
SAVE $30

1MHZ FUNCTION GENERATOR

QT-2304

Produces accurate sine, square & triangle waveforms with adjustable frequency & amplitude.

- 8Vp-p max output voltage
- Linear or logarithmic, single or bidirectional

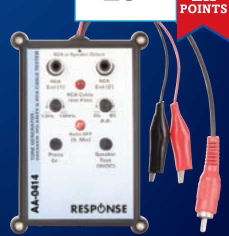
NERD PERKS
RRP $299
$279
SAVE $20

SPEAKER POLARITY TESTER WITH TONE GENERATOR

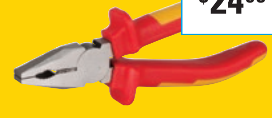
AA-0414

Ideal for troubleshooting and testing audio system and installation.

- Tone generator, speaker polarity and RCA cable tester
- 9V speaker popper
- RCA or alligator clips
- 9V Battery (Required)
- 100(H) x 65(W) x 23(D)mm



$29.95 NERD PERKS 2x POINTS



$24.95 NERD PERKS 2x POINTS

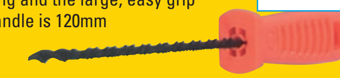
INSULATED BULL NOSE PLIERS

TH-1984

- 180mm

FILE SAW TH-2127

- The blade measures 175mm long and the large, easy grip handle is 120mm



$15.95 NERD PERKS 2x POINTS

WIRE STRIPPER TH-1824

Strips 0.2 to 6mm wire.

- Automatically adjusts to insulation diameter
- Spring return
- Colour may vary

$16.95 NERD PERKS 2x POINTS

FROM **$5.95** NERD PERKS 2x POINTS

TD-2235

PHILLIPS INSULATED SCREWDRIVERS TD-2235

Trade quality insulated screwdrivers.

- Ergonomic handles have a soft rubber coating for secure, comfortable grip
- All are TUV and GS approved and rated up to 1kV

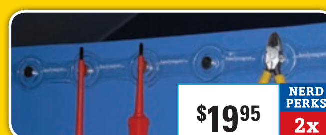
PHILLIPS #0 X 60MM TD-2235 **$5.95**
PHILLIPS #1 X 80MM TD-2236 **$6.95**
PHILLIPS #2 X 100MM TD-2237 **$7.95**

$49.95

HEAVY DUTY CRIMP TOOL

WITH QUICK INTERCHANGEABLE DIES TH-2000

Uses quick interchangeable dies (shown below), no screwdriver needed. Ratchet mechanism for maximum power and quick release.



$19.95 NERD PERKS 2x POINTS

HANDY MAGNET STRIP

LM-1624

It can be attached to walls, tables or other surfaces.

- 9 piece magnet, each holds up to 1kg
- 750(L) x 25(W)mm

TH-2005

DIES TO SUIT HEAVY DUTY CRIMP TOOL

NERD PERKS
3 DIES FOR
$40*
SAVE OVER $13

** See T&C's on page 8.*

6P6C RJ11/12 TH-2001 **$17.95**
BNC/TNC TH-2002 **$17.95**
INSULATED TERMINALS TH-2003 **$17.95**
BN/TNC RG58/59/62 TH-2004 **$17.95**
F CONNECTORS CATV RG6/59 TH-2005 **$17.95**
NON-INSULATED TERMINALS 26-18AWG TH-2006 **$17.95**
NON-INSULATED TERMINALS 20-10AWG TH-2007 **$17.95**
SMA/FIBRE OPTIC 1.09-6.48MM TH-2008 **$17.95**
SMA/FIBRE OPTIC 1.07-4.52MM TH-2009 **$17.95**

COMPACT DIGITAL SOUND LEVEL METER

QM-1589

GREAT FOR CAR AUDIO INSTALLERS, CLUBS AND PA.

- Frequency Range: 31.5 to 8,000Hz
- 9V (battery included)
- 210(L) x 55(W) x 32(D)mm

ALSO AVAILABLE:

MICRO SOUND LEVEL METER
QM-1591 **$49.95**

$129

PRO SOUND LEVEL METER WITH CALIBRATOR

QM-1592

IDEAL FOR VEHICLE, TRAFFIC OR ANY EVIDENCE-BASED NOISE TESTING.

- Suitable where accuracy, repeatability and/or validation is required
- Range: 30 to 130dB (±1.4dB)
- Frequency range: 31.5Hz - 8kHz
- 278(L) x 76(W) x 50(D)mm

$379

DIGITAL LIGHTMETER

QM-1587

IDEAL FOR PHOTOGRAPHY, LAB WORK, ARCHITECTURAL, ENGINEERING AND CONSTRUCTION APPLICATIONS.

- 4 ranges from 0.01 to 50,000 Lux
- Auto zeroing, data hold
- Separate Photo Detector
- 188(L) x 64(W) x 24.5(D)mm

$59.95

PROFESSIONAL DIGITAL LIGHT METER WITH COVER & CASE

QM-1584

SHOULD BE PART OF EVERY LIGHTING TECHNICIAN'S ARSENAL.

- Photopic spectral sensitivity
- Switch between LUX and FC
- Long-life silicon photo diode sensor
- Min & Max measurements

$169

START PROTOTYPING WITH 3D PRINTING

SINGLE FILAMENT 3D PRINTER KIT

TL-4100 **WAS $729**

Easy to assemble with clear instructions & online video. Controlled by built-in Arduino MEGA board.

- Print up to 250 x 140 x 140mm
- Heated Print Bed
- 800(H) x 300(W) x 265(D)mm

NOW
$699
SAVE $30

TL-4140

NEW

TL-4142

FROM **$19.95**

3D PRINTER FILAMENTS

- 1.75mm, 250g roll

WAX TL-4140 **$39.95** Soft rubbery finish, and prints down to around 100 degrees. Could also be used to print models for lost wax casting. Polish, machine or carve the printed object for desired results.

CONDUCTIVE TL-4142 **$19.95** Conducts electricity so you can print your own low-voltage circuits (not suited to power circuits). Could be used for signal circuits, touch sensor pads or even creating electrically shielded enclosures. Prints in a solid matt black. *Due early October*

WIN A WI-FI SPEAKER

SIMPLY SUBMIT A PHOTO OF THE TV OR SOUND SYSTEM SETUP THAT KEEPS YOU ENTERTAINED WHILE YOU'RE BUSY AT YOUR WORKBENCH AND YOU COULD WIN.

XC-5230

WORTH $139

iPhone® not included.

win.jaycar.com/workbench

Competition closes 23rd Oct. See website for the T&Cs

TECH TIP

THE BENEFITS OF LTE/4G FILTERS:

A consequence of the auctioning of broadcast TV channels to telecommunications companies is that older TV antennas are likely to be picking up signals (4G and LTE) other than digital TV with the potential to cause interference to TV reception - specifically the picture and/or sound may simply disappear. In such cases a special LTE/4G filter (such as the LT-3062) may be required to remove frequencies in the 720-1000MHz 4G LTE ("Long Term Evolution") band. For new installations LTE filters are now being routinely fitted.

FOR MORE DETAILS ABOUT TV BROADCASTING, VISIT:
www.jaycar.com.au/tv

STEP 1: SELECT YOUR ANTENNA AND HARDWARE

4G LTE FILTERING UHF ANTENNAS

Built-in filter for next-gen LTE/4G network signals.

91 ELEMENT UHF ANTENNA LT-3182
Suitable for medium or deep fringe signal reception.

43 ELEMENT UHF ANTENNA LT-3181
Suitable for medium signal reception areas.

$89.95 (LT-3182)
$44.95 (LT-3181)

ANTENNA BARGEBOARD MOUNT

LT-3200

Simply bolts onto bargeboard (below gutter) or other support. 1800mm long, galvanised steel construction.

- 215mm x 65mm mounting plate

ALSO AVAILABLE:

305MM EVE BRACKET
LT-3212 **$24.95**

U-CLAMP/V-BLOCK
LT-3235 **$4.50**

$39.95

ACCESSORIES

$14.95 NERD PERKS 2x POINTS

4G/LTE FILTER

FOR DIGITAL TV RECEPTION LT-3062

Blocks unwanted signals giving you uninterrupted TV reception.

- In-line coax connection
- Waterproof design
- Frequency pass range: 5-694MHz
- Insertion loss:<3dB
- LTE band rejection: 720-1000MHz, <40dB

$9.95 NERD PERKS 2x POINTS

VARIABLE ATTENUATOR LT-3050

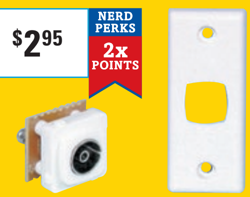
May reduce ghosting in some cases. In certain situations you can receive too much TV signal. This attenuator (signal reducer) goes in line and has a variable control. Supplied with two F sockets, maximum attenuation is 20dB.

$4.50 NERD PERKS 2x POINTS

INDOOR BALUN LT-3022

- 75 ohm socket for input and 300 ohm ribbon cable output
- Allows connection of any 75 ohm output (video, TV games etc) to a TV with an older style 300 ohm input

$2.95 NERD PERKS 2x POINTS



LT-3031 LT-3030

WALL PLATE - MINI LT-3030

Architrave type standard white wall plate with a cutout for the 75 ohm snap-in insert.

ALSO AVAILABLE: 75 OHM WALLPLATE INSERT LT-3031 **$3.50**

STEP 2: INSTALL WITH THE RIGHT GEAR

$119

KINGRAY AMPLIFIER MASTHEAD 35DB LT-3251

Provides a good VHF & UHF TV band gain, and user selectable filters for VHF bands 1&2, FM radio, fixed pagers, and the new 4G/LTE band.

$44.95

TV COAXIAL CABLE WB-2014

Great for domestic TV & Pay TV installations! 75 ohm RG6 quad shield in a handy 30m roll.

$19.95 NERD PERKS 2x POINTS

ROTARY COAX STRIPPER TH-1820

Strips the outside jacket and inner conductor in one operation. Simply rotate clockwise around the cable 3 to 6 times.

- Suitable for RG58/59/62/6 and 3C2V 75 ohm cable

$39.95

HEX RATCHET CRIMPING TOOL TH-1833

Crimps F, N, BNC, TNC, UHF, ST, SC & SMA connectors onto RG6 or RG58 coax cable. Four hex crimping dies: 1.72mm, 5.49mm, 8.23mm and 9.14mm.

$1.95

F-59 CRIMP PLUG FOR RG59 PP-0702

Foxtel Approved.

NEW

$2.95

F CONNECTOR SPANNER TH-1811

Handy tool for tightening and loosening F-type connectors.

$39.95

DIGITAL TV SIGNAL STRENGTH METER LT-3332

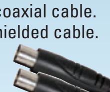
Connect the pocket sized DVB-T signal strength meter and adjust the angle of your digital TV antenna, the easy to read LED indicator lets you know when you've hit the right spot. Adapters included.

- Requires 1 x 9V battery
- 40-862MHz frequency range

STEP 3: IMPROVE YOUR RECEPTION

RG59 COAX LEAD - 1.5M WV-7350

RG- 59U coaxial cable. Double shielded cable.



$5.95

FLEXIBLE COAXIAL LEADS

Great for long cable runs. Flexible. Prevent tangling/kinking. F Plug to F Plug. Blue colour.

RG59 10M WV-7450 **$19.95**
RG59 20M WV-7452 **$29.95**
RG6 10M WV-7454 **$29.95**
RG6 20M WV-7456 **$39.95**

FROM $19.95

INDOOR TV AMPLIFIER / SPLITTERS

Boosts incoming signal, then splits it for use on multiple receivers. Mains powered, Australian made. F-type to PAL adaptors included.

2 WAY LT-3288 **WAS $44.95 NOW $34.95 SAVE $10**
4 WAY LT-3287 **WAS $89.95 NOW $79.95 SAVE $10**

FROM $34.95 SAVE $10

BRING YOUR OLD AND TIRED SPEAKERS BACK TO LIFE

PIEZO HORN TWEETER CT-1930

Does not require a crossover and is perfect for use for general PA applications where long throw is required.

- 100WRMS
- 8 Ohms

$12.95

25MM TITANIUM DOME TWEETER CT-2007

- Features a titanium dome with a phase shield
- Produces very crisp and clear high frequencies
- Power nominal: 50WRMS
- Nominal impedance: 8 ohms
- Frequency response: 2-20kHz

$19.95 NERD PERKS 2x POINTS

MIDRANGE PAPER CONE WOOFERS

Excellent for replacement or for new speaker design constructions.

4" 27WRMS CW-2190 **$24.95**
5" 50WRMS CW-2192 **$29.95**
6.5" 60WRMS CW-2194 **$34.95**

CW-2190

FROM $24.95

PAPER CONE WOOFERS

8" 90WRMS CW-2196 **$39.95**
10" 225WRMS CW-2198 **$64.95**
12" 225WRMS CW-2199 **$79.95**

CW-2198

FROM $39.95

FULL RANGE REPLACEMENT SPEAKERS

Full range speakers suitable for use in home theatre, surround, computer multimedia and portable speakers.

1" 1WRMS 8 OHM AS-3030 **$10.95**
2" 10WRMS 8 OHM AS-3032 **$16.95**
3" 15WRMS 8 OHM AS-3034 **$19.95**

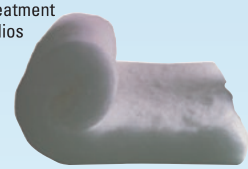
AS-3034

FROM $10.95

650GSM ACRYLIC SPEAKER DAMPENING MATERIAL AX-3694

- Ideal for speaker boxes
- Effective for acoustic treatment in sound rooms and studios
- 700(W) x 1000(L) mm

$12.50



FLARED SPEAKER BOX PORT

CX-2688

These ports are flared to minimise air turbulence.

- Inner Dia 58mm
- Length 120mm

$4.95

FROM $4.95

BLACK SPEAKER GRILLE CLOTH

CF-2752

Ideal for protecting expensive drivers.

- Supplied in a 1.5 x 1 metre pack
- Black in colour

$17.50

SPRAY-ON CONTACT ADHESIVE

NA-1504

- Bonds to almost any surface
- Great for speaker carpet in/on speaker cabinets

$16.95

SPEAKER WOOD SCREWS - PACK 20

Phillips Head self tappers ideal for mounting speakers

NO.6 X 15MM FOR TWEETERS HP-0620 **$4.95**
NO.10 X 30MM FOR WOOFERS HP-0624 **$5.95**

SPEAKER CABLES BY THE 30M ROLL

LIGHT DUTY 14/0.14MM
Grey with black trace. WB-1703 **$12.95**
HEAVY DUTY 24/.20MM
Clear with black trace. WB-1709 **$32.95**
EXTRA HEAVY DUTY 79/0.2MM
Clear with white trace.
WB-1713 **$74.95**

FROM $12.95

WB-1709

SPEAKER CABLES BY THE METRE

HEAVY DUTY WB-1708 **$1.20/m or $89 roll**
Suited for speaker systems up to 150 watts, 19 x 0.18mm. Black with white trace.
PRO AUDIO WB-1754 **$1.95/m or $165 roll**
Super flexible speaker cable. Separate colour-coded 18AWG red and black conductors in a single outer sheath.
JUMBO WB-1732 **$4.10/m or $340 roll**
For those who want top quality jumbo speaker cable. 259 259 x 0.12mm strands in each side.

WB-1708

FROM $1.20/m

RN-3460

FROM $2.95 NERD PERKS 2x POINTS

POLYSWITCHES PTC FUSES - SPEAKER PROTECTION

Low cost speaker protection. Polyswitches will protect against electrical (current) overload and will protect speakers in most situations. More specifications ensure accurate choice for better protection.

RXE075 1.5A RN-3460 **$2.95**
RXE250 0.5A RN-3470 **$4.50**

$4.95 ea NERD PERKS 2x POINTS

PP-0426

PP-0427

GOLD BANANA PLUGS

Designed for monster type speaker cable. They have a hole entry on the side, with a finger screw down action.- The hole will accept another banana plug or thick cable.

RED PP-0426 **$4.95**
BLACK PP-0427 **$4.95**

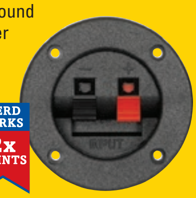
$11.95 NERD PERKS 2x POINTS

2 WAY GOLD TERMINALS ON A PLATE PT-3012

Top quality speaker terminal.

- Plate size 99 x 99mm.
- Hole cutout is round - 78mm diameter

$2.95 NERD PERKS 2x POINTS



LARGE ROUND SPEAKER TERMINAL PT-3004

Top quality speaker terminal.

- Up to 16 AWG cable
- Cutout 50mm

$7.95 NERD PERKS 2x POINTS

PLASTIC LOCKING CORNER PIECE PACK OF 8 HM-3829

- Ideal for stacking speaker boxes
- Has 4 x 4mm pan head fixing holes
- 84(H) x 50mm each side

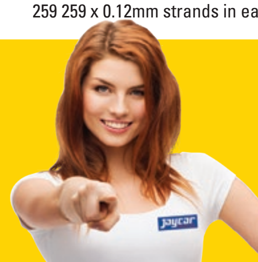
NERD PERKS CLUB MEMBERS RECEIVE:

10% OFF

SPEAKER CABLES*

IN ROLLS OR BY THE METRE FORMAT

*(*Applies only to cables listed on this page)*



EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE* & BE REWARDED WITH A $25 JAYCOINS GIFT CARD ONCE YOU REACH 500 POINTS!

**Conditions apply. See website for T&Cs*

REGISTER ONLINE TODAY BY VISITING: www.jaycar.com.au/nerdperks

Touchscreen Appliance Energy Meter

Part 3 – Calibrating and Using it!

By JIM ROWE & NICHOLAS VINEN

In the last two months, we've described how our new Touchscreen Appliance Energy Meter works and how to put it together. Having finished assembling the unit, all that's left to do is to calibrate it and start using it.

You will need to perform several calibration steps. These allow the unit to compensate for variations in the transformer and divider resistors used to monitor the mains voltage and the isolated current sensor used to measure the instantaneous current drawn by the load.

In a little more detail, as shown in Fig.2 on pages 30-31 of the August issue, the AC-coupled output of the transformer used to monitor the mains voltage is DC biased to around 2.5V by two 56kΩ resistors across the 5V supply rail.

However, the 5V rail from the AC/DC converter may not be exactly 5V and the resistors may not be exactly the same value, so we can't assume that the DC bias level is exactly 2.5V.

During the calibration procedure, the unit measures the average DC level of this signal and stores it so that it can be subtracted from future readings, to give a pure AC signal.

Note that while the mains waveform could have a slight DC offset due to asymmetrical current flow and improperly balanced phases, as we're measuring via a transformer, we have to ignore it.

Mains current calibration

The output of the ACS712 isolated current sensor (IC4) has its own separate half-supply DC bias, obtained from a voltage divider inside the chip. So, calibration is performed with no load to allow the unit to measure the zero-current voltage level. This too is stored and subtracted from subsequent readings.

This bias exists because current can flow in either direction through the sensor and thus its output can swing above or below the zero level, to indicate both the magnitude and polarity of the current.

This is important since we need to be able to distinguish in-phase current, which indicates power flowing from the mains into the load, and out-of-phase current, which indicates power flowing from the load back into the mains.

To calculate the true power drawn by the load, we subtract one from the other. Note that for purely reactive loads, such as capacitors connected across Active and Neutral, the result of this subtraction is zero, indicating that the power is purely reactive.

While measuring the current sensor's zero level voltage, the unit also determines its RMS noise output, so that it can subtract this from future readings. Otherwise, it would look like current was flowing even with no load.

Calibration procedure

First, power the

Firmware update required

We have discovered a few bugs in the original version of the firmware (v1.0) supplied. The most serious causes it to run out of memory if you try to change the time or date. Other bugs fixed include a factor-of-ten error in the cost computations, incorrect mains frequency readout and lost logging data while updating graphs.

As a result of these bug fixes, we recommend upgrading to v1.01 immediately. You can easily do this via the unit's USB port.

Essentially, all you need to do is download the new BASIC source code (available in a zip on our website) and load it into the PIC32 over the USB serial interface. This will wipe the unit's settings so it should ideally be done before doing any calibration or setting up.

The procedure was explained in the panel on page 91 of the September issue, although you can skip uploading the Library BASIC file into the chip if it has already been programmed. The library file hasn't changed.

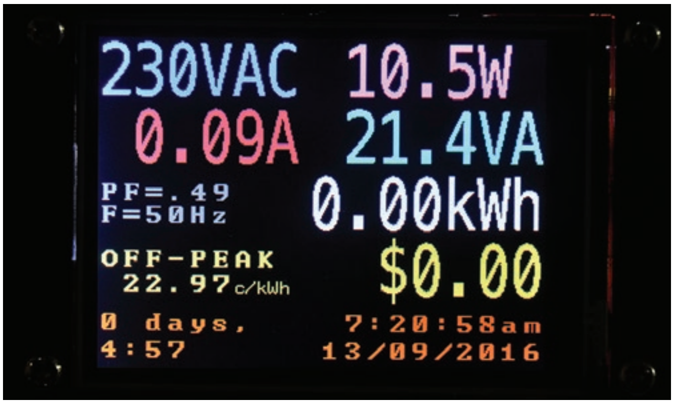


Fig.7: the main screen which has been improved slightly since the prototype was revealed in the August issue. The main differences are the addition of the frequency read-out below the power factor and support for fractional cents in the tariff, plus seconds display for the current time.

Fig.8: the logging status screen has also been improved since the first article. The same information is shown but there are now buttons to access the diagnostics screen and to perform automatic calibration. The button to dump logged data is not visible because you need to pause logging first.

unit up and wait at least 30 seconds for everything to settle (coupling capacitors to charge, etc).

You can judge this using the elapsed time in the lower-left corner of the device's display. Then touch this elapsed time display at the lower-left corner of the screen and you should see a "Calib" button appear at the bottom (centre) of the screen (see Fig.8).

Press this and the calibration screen will be displayed for a few seconds. It will then return to the main screen and after a second or two, the amps reading should drop to zero (power should be zero, too). This indicates that the unit has correctly calibrated the DC offset and base noise level from the current sensor.

Next, you need to manually adjust the voltage scale to give a correct mains voltage reading. All you need to do this is a mains-rated DMM.

Set it to AC volts mode and if it isn't auto-ranging, set it to a suitable range for measuring mains (eg, up to 260VAC). After ensuring that you have suitably rated leads, push its prongs into the Active and Neutral sockets of a mains outlet (GPO). Make sure that there's no exposed metal that you could touch and also check that the probes won't fall out.

Now touch the lower-left corner of the screen again (the elapsed time display) and this time press the "Diag" button. You should get voltage and current readings at the top of the screen, with + and – buttons to the right of each (see Fig.9).

Use these buttons to adjust the displayed voltage reading so that it matches the voltage on the DMM as closely as possible. You can now unplug the DMM from the GPO.

Current scale calibration

Now connect a device which will draw a small, fixed and easily determined amount of real power; for example, a small incandescent or halogen lamp. In a pinch, you could also use a desk fan or fluorescent lamp but make sure it has a power consumption figure printed on it so you know what to expect. If you already have an accurate mains power meter, that's even better – use it to measure the power so that you have a calibration target for the new unit.

Now connect your test load to the Energy Meter and switch it on, then let it stabilise (it may need to warm up etc) and check the power reading. It will probably be close to the rated power, but maybe a little off. As you did when adjusting the mains voltage, use the + and - buttons next to the current reading in the diagnostic screen to make small adjustments to the current reading, then go back to the main screen and check the power reading. Continue adjusting until the power reading is very close to what you would expect.

If you'd like, you can now disconnect your test load and connect another small load, and verify that you get a reasonably accurate reading. Note that loads which draw very little power (eg, under 5W) could have a quite substantial measurement error and some loads such as plugpacks may even read zero when they are in fact drawing a watt or two. This is down to the limited resolution of the ADC and current sensor and there isn't a lot we can do about it.

You may also get some slightly inaccurate readings from loads with very low power factors. But generally, the unit should be quite accurate, within 1% or so of the actual reading, plus or minus a couple of watts.

Setting up tariffs

That's all you need to do to measure power consumption but if you want to see how much an appliance is costing you to run, you will also need to program in your tariff(s) and if your home has a smart meter, the peak, off-peak and shoulder times. You will also need to set the current time and date. These all contribute to the unit being able to calculate the cost of power at any given time.

First, set the time and date by touching on the time/date display in the lower-right corner of the main screen. Type in the time, in 24-hour notation, with colons separating the hours, minutes and seconds. The seconds value is optional and the time will be set as soon as you press "OK", so once you have entered the time value, you can wait until your clock rolls over to the next minute and then press that button. The value entered will be red if it is invalid or incomplete, or black if it is valid and complete.

Having set the time, enter the date in the same manner, in DD/MM/YY format. You can just press OK if you just want to update the time and keep the current date.

Now that the time and date are set, press on the yellow tariff data to the left of the screen (initially, it will read

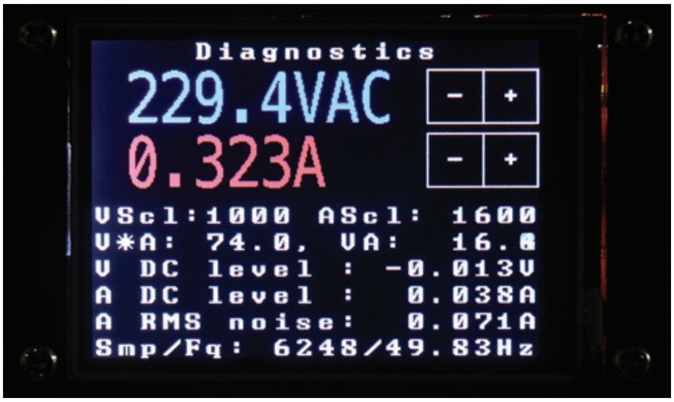


Fig.9: the diagnostic screen which shows the voltage and current readings with extra decimal places and allows fine adjustment of the scaling factors for both. It also displays the automatically calibrated calibration constants below, plus the sampling rate, measured frequency and pre-processing VA figures.

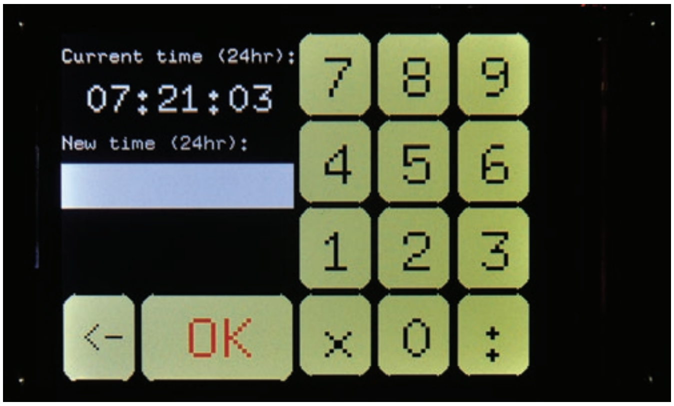


Fig.10: this keypad allows you to update the current time and date as well as set the tariffs and various other tariff-related settings. In this case we're setting the time and pressing OK without entering anything leaves it unchanged. The new time can be entered with or without seconds.

"OFF-PEAK 0.00c/kWh"). Now press on the "Off-peak" text towards the bottom of the screen, type in the cost of power, in cents per kilowatt-hour. You can use up to three decimal places. Press OK when finished, then press in the very upper-left corner to go back to the main screen.

If you don't have a smart meter, that is all you have to do because this tariff value is the default for situations where a conventional watt-hour meter is fitted. (Don't worry if you have an off-peak hotwater system as it is on a separate circuit in your house wiring).

Setting up time-of-day metering

Assuming you have a smart meter, you now need to set the peak and shoulder tariffs, using the same method. Then you will need to set the start and end times for the peak period during the week (ie, Monday through Friday). Refer to your electricity bill or electricity authority website if you don't have this information.

To set the peak times during the week, press on the text which says "Weekday: N/A", just under where the peak tariff is displayed, near the top of the screen. Then, enter the peak start time in 24-hour format, with the hours and minutes separated by a colon and press OK. You will immediately be prompted to enter the end time, in the same format.

The unit has support for two peak periods, however presently no Australian supplier has a separate morning and afternoon peak time. So you can simply press OK to go through the two following screens without entering any additional time values.

The peak time period should now be displayed below the peak tariff. If your supplier also has peak periods during the weekend, you can enter the start and end time by pressing on the line below which says "Weekend: N/A" and using the same procedure as above. Otherwise, move on to setting up the shoulder period.

Most suppliers which have a peak period also have a "shoulder" period before and after the peak period, where the cost of electricity is higher than it is off-peak but lower than during peak times. Assuming yours does too, you will need to set its start and end times just as you did for the peak period, but instead by pressing on the weekday and weekend lines below the Shoulder tariff.

Note that it's OK for the peak and shoulder periods to overlap; indeed, they should. The peak tariff will override the shoulder tariff during those times when they are both active.

That's it, you can now go back to the main screen. The tariff data is automatically stored in non-volatile flash memory and will survive a power outage (or simply unplugging and moving the unit).

Public holidays

While probably not critical, for the cost display to be truly accurate, we also need to take into account the fact that public holidays are charged the same as weekends. For the unit to take account of this, it must know the dates of public holidays and so you can program them in. If you don't, it won't normally make a big difference to cost calculations, so it's entirely up to you. But it only takes a few minutes.

To do this, acquire a list of the public holidays in your state for the next couple of years, then touch on the area at the bottom of the tariff settings screen. You can then press on each blank public holiday space and enter the date in dd/mm/yy format. Enter as many or as few as required. Whenever the date matches one of these days, weekend rates will be applied. Touch right at the top of the screen to go back to the main tariff settings display.

Accumulating & logging data

Logging and accumulation of energy usage and cost begin automatically when the unit is plugged in. However, you can pause or stop and reset this data at any time. To do this, press on the time elapsed in the lower-left corner of the screen. The logging screen displays the current logging status, such as how much memory has been used and the maximum time that logging can continue with the current interval, as well as some buttons to control it (see Fig.8).

Pressing the "pause" button will stop logging but retain all data so far. You can then resume or press the "stop" button to clear the cumulative energy usage, cost and voltage/current/power logs.

Note that you can log data for up to two hours and 40 minutes with a one-second interval, up to 24 hours with a ten-second interval and up to one week with a one-minute interval but you can only change the interval when logging is stopped (ie, no data is stored). To do so, simply press on the

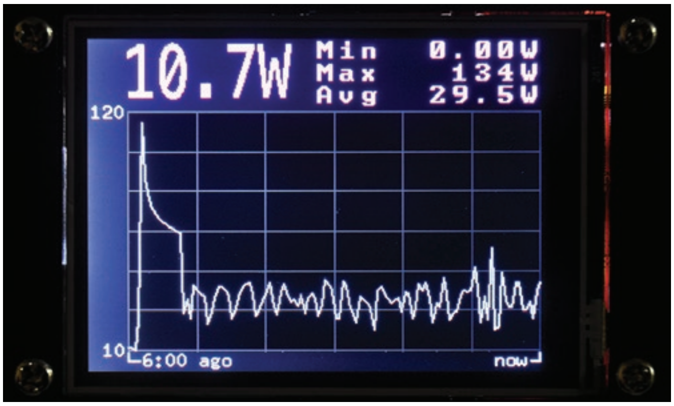


Fig.11: power usage plot for a soldering iron. The iron was switched on around five minutes ago and you can see the large power draw as it warms up initially, followed by the consumption jumping up and down as the element is switched on for brief periods to keep it warm.

Fig.12: plot of the mains voltage which shows how it varies over a one-hour period. Depending on the location and time of day, the voltage can vary far more dramatically than this. Even so, we can see it varying by more than 1% (2.3V) in a relatively short period of just 30 seconds or so.

"Interval:" line on the logging screen.

While paused, you also have the option to dump the logged data to your PC via the USB interface. This can be done with the mains still connected. In fact, if the unit loses power, this logged data will be lost, so you will need to keep the mains power plugged in, at least until you've connected the USB interface.

Once the USB serial port has been recognised by your PC, fire up a terminal program and open that port with the correct baud rate (normally 38,400). Next, set up the terminal program to capture data from that serial port to a file. You can then press the "Dump" button on the screen and the data will be output in CSV format, as follows:

```
SILICON CHIP Appliance Energy Meter log at 11:04:37 09/09/2016
num,seconds,time,v,a,va,power,pf
1,0,00:00,237,0.221,52.4,12.3,0.235
2,10,00:10,235,0.219,51.5,12.7,0.247
...
```

It may take some time to off-load all this data at 38kbaud, depending on how long you have been logging. This data can be saved in a CSV file and opened in a spreadsheet program. The columns are as follows:

1) record number, starting at one for the first row of data.

2) number of seconds since logging began. Starts with zero and increments by one, 10 or 60 depending on the logging interval.

3) time since logging began, in mm:ss or hh:mm format, depending on how long logging has been going.

4) average mains RMS voltage for the logged interval.

5) average mains RMS current for the logged interval.

6) product of #4 & #5, ie, average VA for the logged interval.

7) average real power for the logged interval.

8) average power factor for the logged interval (ie, #7 divided by #6).

When finished, press the "Back" button to return to the main screen.

Note that while logged data is lost if the unit's power is removed, the accumulated power usage and cost information, shown on the main screen, is stored in the EEPROM once per minute and the last saved data is restored at power-on. This data is only reset when logging is stopped.

Plotting data on the unit

The data stored in RAM which can be exported to a PC can also be used to produce various plots on the Meter's touchscreen. However, due to limited screen space (and program space), you can only plot one measurement at a time.

Simply touch on one of the following items on the main screen to draw a graph of the data collected so far: voltage, current, power, VA or power factor. Initially, a line graph will be drawn, showing the variation in that parameter over time. You can change the plot duration between one hour, one day and one week by touching on the duration legend below the graph. Note that if the unit has insufficient data to show the selected duration, it will simply show what it has so far.

The vertical axis of the graph is automatically scaled to fit the data collected so far. The horizontal axis has the latest measured value at right and the oldest data at far left. Note that depending on how long the unit has been running, it can take some time for it to average all the data required to plot the graph, so be patient.

The unit can also display the same data in a histogram. Simply press in the middle of the graph to switch to histogram mode. The data is automatically allocated to ten "bins" which span the range of data collected and their height indicates the proportion of values measured which fit into those "bins" (see Fig.13). Press on the middle of the graph again to go back to the main screen. (This is the only way to get out of the graph display.)

Extrapolating power consumption and cost

During logging, the total power consumption and accumulated cost on the main screen are continuously updated (once per second). They will continue to increase even if the logging RAM is full, indefinitely.

If you want to see how much an appliance is costing you on average, or its average power usage, connect it to the Meter and let it run for a sufficient period for it to experience representative power usage. In some cases (eg, a refrigerator or air conditioner), this may take one or two days.

At the end of this period, simply touch on the power consumption or cost figure on the main screen. The unit will divide the figure by the amount of time it has spent monitoring that load, then extrapolate the energy usage/cost out to the following periods: one hour,

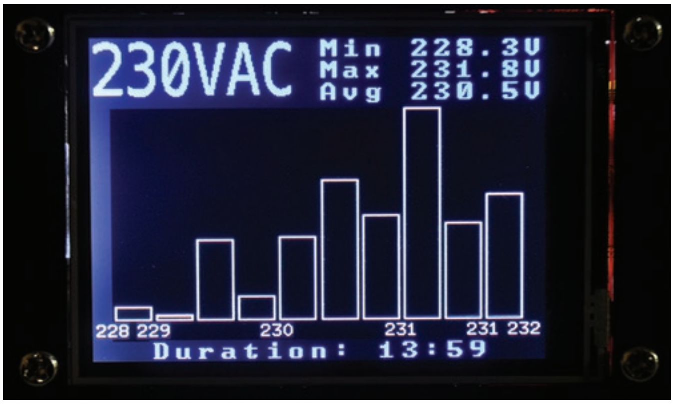


Fig.13: histogram plot of mains voltage. This gives you a good idea of which voltages the mains sits at most of the time relative to outliers. Note that the X-axis labels are rounded to the nearest volt while the data has sub-volt resolution.

Fig.14: extrapolated energy usage involved in running a temperature-controlled soldering iron, based on around eight minutes of data. You don't normally leave a soldering iron on all the time but if you did, this shows just how much power it would use.

one day, one week, one month and one year. This will tell you the energy usage/cost for running that appliance over those periods, assuming that the energy usage continues at the same rate (see Fig.14).

With something like an air conditioner, you will have to keep in mind that if you are measuring during summer or winter, the yearly usage will be overestimated (since you won't need the same amount of cooling or heating year-round). For heaters, the same is true in reverse. And refrigerator energy usage is likely to vary significantly with the season too.

Conclusion

The easiest way to become familiar with the functions of this device is probably to set it up and then "have a play".

For those constructors who may wish for features that we didn't have room for, feel free to download the BASIC source code and add your own features. However, keep in mind that you will probably need to remove some of the existing features to make room. SC

Developing the two critical CFUNCTIONs

While the GUI code is mostly written in BASIC, we had to write two sections of the program in C. The first is the part which queries the ADC and performs averaging, power calculations and zero crossing/frequency detection. This needed to be written in C both so that it was fast enough to be run thousands of times per second while still allowing enough free CPU resources to handle screen updates, and so that it could run constantly in the background to avoid missing any voltage, current or power samples.

The second is the part of the code which calculates the current tariff based on the time, date and configuration data. This was originally written in BASIC, however, it used too much RAM; this was especially problematic because the very inner-most function which reads and stores power data must call it in order to keep the running cost up to date (based on the current tariff). Re-writing this code in C caused it to use up more flash memory (due to the way CFUNCTIONs are stored) but significantly less RAM and solved a long-running problem with the unit crashing due to lack of memory. It's also a lot faster than the equivalent BASIC code.

Essentially, what this second function does is calculate the day of the week based on the date, then if it is a weekday, it checks to see if the date matches any of the public holidays programmed into the unit. Once it knows whether to use the weekday or weekend tariffs, it figures out the current tariff based on the time.

The other CFUNCTION is significantly more complex. While it's a single function, it performs multiple duties. The first one is to set up the hardware sampling timer (TIMER1) and the internal data structures used to keep track of the voltage, current, power, etc. As soon as TIMER1 is set up, the interrupt handler runs several thousand times per second and this alternately samples the voltage and current.

After each pair of samples has been completed, it then updates the internal RMS voltage, current, VA and power variables and checks to see if a zero crossing has occurred. If so, it increments the zero crossing count and transfers the accumulated data into a second area of RAM, so that all averages are performed on full multiples of half-cycles of data (to prevent readings from varying depending on which point in the half-cycle the data is read).

The BASIC software can then call the same CFUNCTION with a different set of parameters to read out these internal registers and get at the accumulated data. When this data is read, interrupts are disabled and it is cleared, so that the next ADC interrupt will start fresh, collecting the next set of data.

The number of zero crossings detected per time period are used to calculate the mains frequency along with the real time clock and the Micromite's internal millisecond timer.

Finally, this CFUNCTION also provides calibration functions, ie, the ability to read and write the registers which define the voltage and current DC offset levels as well as compute these levels when no load is connected. Once set, the calibration levels are used by the sampling code to improve the accuracy of the readings. Some calibration functions, specifically the relationship between measured voltage and actual mains voltage and current, as well as dealing with noise from the current sensor, are performed solely by the BASIC code.

Those who are curious can download both the BASIC and C source code from the Silicon Chip website and see the full details.

MICROPOWER LED FLASHER

We've used flashing LEDs for decades – but alas, the LM3909 Flashing LED IC is no longer available. What to do?

By JOHN CLARKE

Now we know that that there are lots of LED flashers available and that you can also obtain LEDs with inbuilt flashing. But we still get regular requests for a LED flasher, to provide similar functions to the now obsolete National Semiconductor LM3909 flasher/oscillator.

This new module provides similar functions to the LM3909 but also includes daylight detection with an LDR (light-dependent resistor). Since the LM3909 is no longer available, we have employed a low-cost microcontroller and it drives the LED in a similar way to the National Semiconductor device.

To be specific, it charges a capacitor, then "jacks it up" and dumps the charge through the LED to give a much brighter flash than would be possible with the otherwise limited supply voltage. In fact, you cannot normally drive a blue or white LED reliably with a 3V supply – you need to boost the voltage.

By the way, this module does not have to be battery powered. You can run it from any fixed supply from 3 to 5V, so you can eliminate the button cell and just connect it to any 5V USB source. Alternatively, you can run it from a much higher DC voltage if you connect a suitable resistor in series with the input.

Circuit details

The circuit is shown in Fig.1 and uses a PIC12F675 microcontroller, two diodes and several resistors and capacitors. It runs from a lithium button cell, or you could run it from two alkaline AAA cells or a 5V USB supply.

LDR1 is used to detect whether the LED Flasher is in daylight or in darkness. This is connected in series with a 470kΩ resistor. In darkness, the LDR resistance is typically well over 1MΩ. When the GP4 output is high (ie, at the positive supply voltage), the 470kΩ resistor pulls the GP2 input sufficiently high for IC1 to detect this as a high level. In daylight, the resistance of LDR1 is around 10kΩ and so GP2's input is held near to 0V. IC1 detects this as a low and then goes to sleep to conserve power.

If the GP2 input is high, indicating that the module is in darkness, the micro provides the LED flasher function, which we will come to in a moment. If the LDR is omitted, this input will always be high and so the flasher will run as long as it has power.

The micro has an internal "watchdog" timer and this is used to wake it up every 2.3 seconds so that it can check the voltage level at the GP2 input pin. If it is low, the microcontroller goes back into sleep mode. If it is high, LED flashing is enabled.

The Flasher section of the circuit comprises diode D1, capacitor C1, resistors R1 & R2 and LED1. We show its operation in Fig.2 which depicts the two modes of the circuit: charging the capacitor and then jacking it up while dumping its charge through the LED.

In the first part of the cycle, the GP5 output (pin 2) is taken high while the GP0 output (pin 7) is held low. In this state, capacitor C1 charges via R1 (6.2kΩ) and diode D1. The charge current path is shown in Fig.2 in green. No current flows through the LED and R2 because this process reverse-biases the LED, as its cathode terminal (labelled K) is held high while the capacitor is charging.

During this process, the voltage across C1 is monitored by input pin GP1 (pin 6). The software compensates for the fact that the voltage at this pin is higher than that at the capacitor's positive terminal due to the forward voltage drop of diode D1.

Once the capacitor has charged to the maximum possible level of about 2.2V, the comparator senses this and switches the GP5 output (pin 2) low

Features & Specifications

- Flashes any colour LED
- Flash rate set by resistor & capacitor values
- Optional LDR to disable flash with high ambient light
- Two PCB versions to suit different applications
- Small and easy to build
- Supply voltage range: 3-5.5V or higher with modifications (see text)
- Fixed flash time: 65ms
- Standby current: 10µA @ 5V, 2µA @ 3V
- Operating current: typically 0.7-1.6mA (0.5-2Hz) (see Table 1)

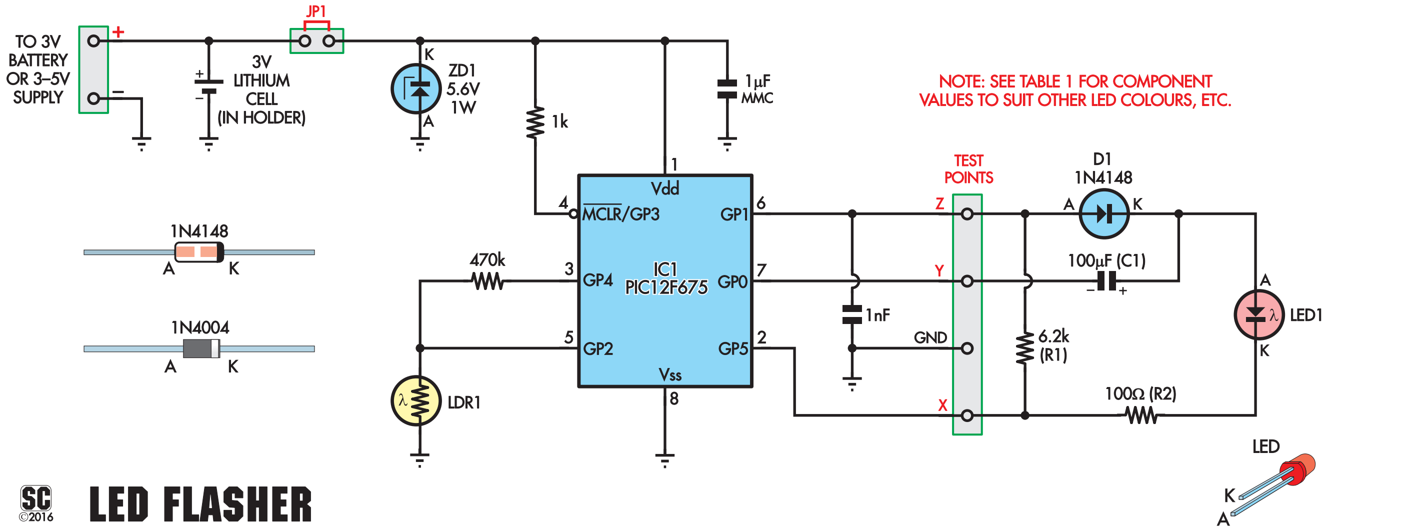


Fig.1: complete circuit for the LED Flasher. IC1 charges capacitor C1 via pins 2 and 7 and diode D1. C1 is then discharged through LED1 and R2, with a total flash voltage of about 5V when the circuit is powered from a 3V button cell. This is sufficient to allow blue or white LEDs to be used.

and the GP0 output (pin 7) high (up towards +3V). This has the effect of "jacking up" the negative side of the charged capacitor by about 2.6V or so, which means that the positive terminal will be at around 5V. This is fed to the LED to give a brief and very bright flash. The LED current path is shown in red in Fig.2.

The cycle then restarts, with GP5 and GP0 swapping polarity, so that capacitor C1 can charge up again.

Since the timing of this cycle is controlled by the component values, the flash rate is set mainly by the values of C1 and R1 but to a lesser extent, the type of LED and the supply voltage.

Table 1 shows typical flash rates and the corresponding component values required for various different LED types. Note that green LEDs require values which are somewhere between those specified for red and blue (depending on the exact construction).

To further demonstrate how this process works, see the scope grab, Fig.3, which shows four traces. The top blue trace is the voltage at GP0, pin 7, which is zero most of the time and switches high for about 65 milliseconds. The green trace below is the voltage at GP5, pin 2, which is high most of the time and then drops low during the same 65 millisecond period. The yellow trace shows the voltage at the positive side of capacitor C1.

As you can see, each time GP5 (green trace) goes high, the capacitor voltage starts to ramp up and after slightly less than one second, when GP5 goes low (stopping the charge) and GP0 flicks high, the capacitor voltage takes a sudden jump up. The capacitor voltage then drops over a period of 65ms as it discharges through the LED and the cycle repeats.

The mauve trace is the difference between the voltages at the positive terminal of the capacitor (yellow) and GP5 (green) and it shows a maximum value of 3.6V. This is the effective peak voltage applied to the LED and current limiting resistor R2.

Referring back to Table 1, note that the peak current is higher with a lower voltage drop LED (eg, red) compared to a higher voltage drop LED (blue or white). Also be aware that electrolytic capacitors typically have a wide tolerance range of -20% to +100%, so the flash rate may vary from the calcu-

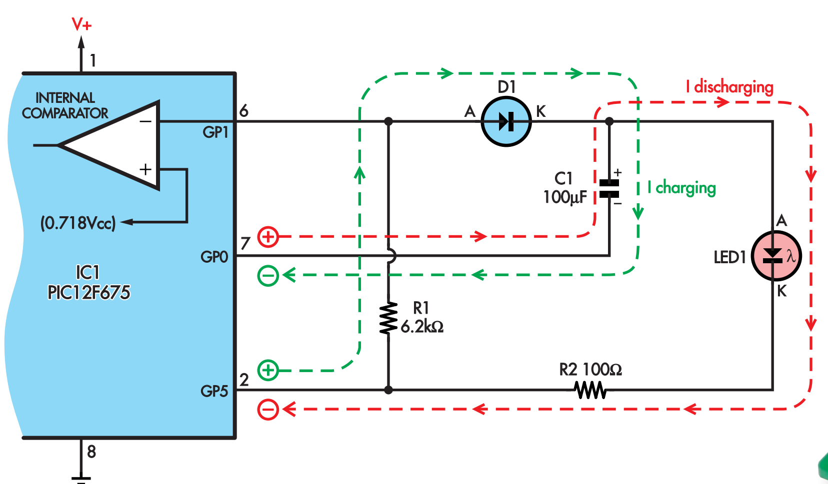


Fig.2: the charge and discharge currents for timing/boost capacitor C1. The charge current path is shown in green while the discharge current path is shown in red. Output pins 2 and 7 reverse polarity to switch current flow between the two paths while pin 6 monitors C1's charge status to determine when to switch between charging and discharging.

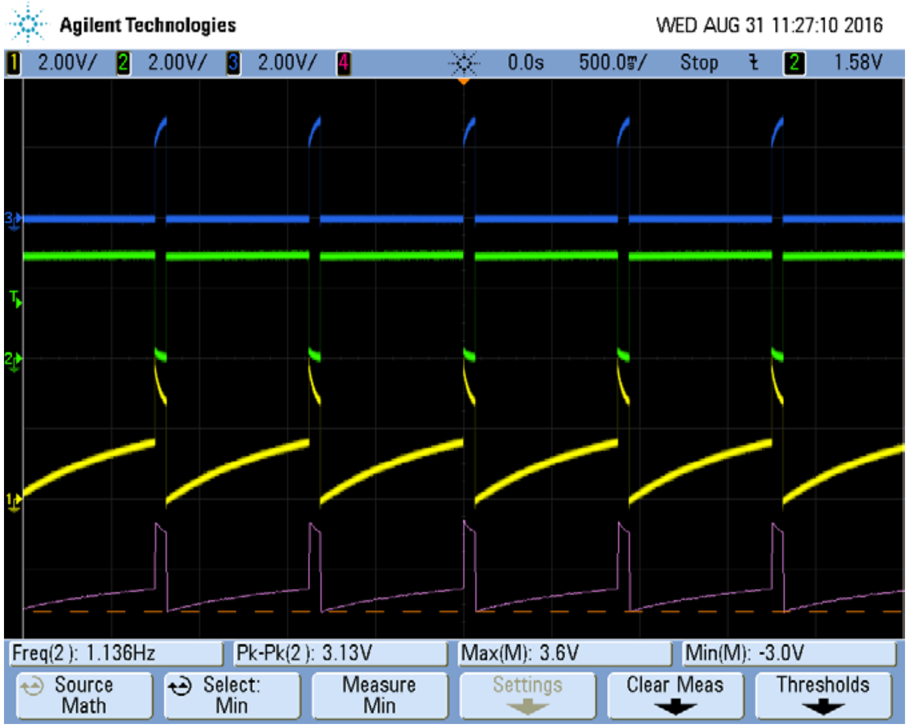


Fig.3: scope grab showing the critical voltages. The blue trace is pin 7 (GP0), green trace is pin 2 (GP5), yellow trace is the positive terminal of capacitor C1 while the mauve trace is the voltage across LED1 and R2. This shows a peak value of 3.6V, despite the 3V supply.

lated rate, depending on the actual capacitance.

Flash brightness can be increased by reducing the value of R2 or using a larger capacitor (up to 470µF) and scaling down R1's value proportionally. The minimum recommended value for R2 is 100Ω. For example, to flash a blue LED at 1Hz, you could increase C1 to 220µF and reduce R1 to 33kΩ and this will roughly double the LED current (as well as increasing the supply current drawn).

Note that the flash rate is inversely proportional to the supply voltage and is about 50% faster at 2V and 22% slower at 5V, compared to 3V.

Zener diode ZD1, across IC1's supply, protects IC1 from reverse supply polarity as it will be forward-biased under this condition. Its typical leakage current during normal operation with a 3V cell is around 10nA. JP1 functions as an off/switch.

ZD1 also provides protection against over-voltage to the microcontroller and it limits the supply to around 5.5V if you are using a much higher DC input voltage together with a series dropping resistor. In that case, the dropping resistor could be installed on the PCB in the place of JP1 (see "Higher supply voltages"). But we are getting a little ahead of ourselves.

PCB assembly

The LED Flasher is constructed on a PCB coded 16109161, measuring 45 x 47mm. If you wish, the PCB can be clipped into a small UB5 case (83 x 54 x 31mm), although most constructors probably will not bother.

Before you start assembling the PCB, you need to select the components required for R1, R2, C1 and the LED colour, eg, red, yellow, blue or white. Table 1 shows typical component values.

Fig.4 shows the PCB overlay. Begin construction by installing the resistors, using a multimeter to check the value of each before inserting it into the PCB.

Diodes D1 and ZD1 can now be installed, taking care to orient these correctly. The socket for IC1 is then fitted, with the notch towards the top of the board. Install the capacitors and if using a polarised electrolytic for C1, then this must be fitted with the shown polarity, ie, the longer lead inserted through the pad towards the top of the board.

Then solder in the 2-way pin header for JP1. The 4-way header is optional and it can provide convenient test points if you want to check the module's operation or display the various waveforms on a scope.

Install the cell holder, if using the 3V lithium cell as the supply. The positive side of the holder must be oriented as shown, to the top of the PCB.

If you are not going to use the cell holder, you can install two PC stakes for supply connections instead. Note that there are two 3mm diameter holes in the PCB located where the cell holder would otherwise sit. These are for looping the connecting wires through for stress relief. That's so the wires do not break off where they connect to the power PC stakes.

Alternatively, you can elect to install an SMD mini-USB type B socket on the underside of the PCB (ie, instead of installing the cell holder) for convenient connection to a USB source.

LED1 is mounted with the anode "A" oriented as shown and LDR1 can

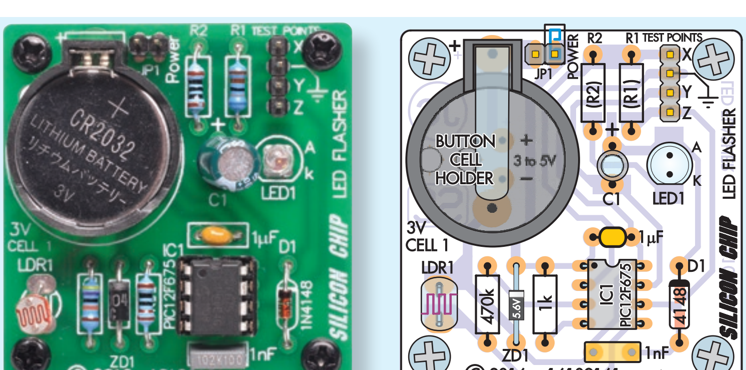


Fig.4 (left): the larger of the two flasher boards. Use this as a guide during assembly and take care with the polarity of IC1, C1, D1 and ZD1.

Fig.5 (right): fit the components to the smaller flasher board in this manner. Taller passive components such as C1 can be fitted to the bottom of the board and laid over to save space.

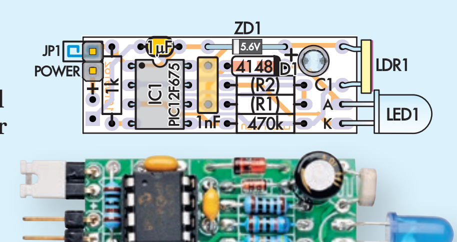


Table 1: LED Flasher Component Selection for 3V Supply

LED Colour	Supply Current @3V Supply	Peak LED Flash Current	C1	R1	R2	Flash Rate
Blue/white	680µA	3.6mA	100µF	15kΩ	330Ω	0.5Hz
Blue/white	760µA	3.6mA	100µF	10kΩ	330Ω	0.75Hz
Blue/white	830µA	3.6mA	100µF	7.5kΩ	330Ω	1Hz
Blue/white	1.0mA	6mA	100µF	7.5kΩ	100Ω	1Hz
Blue/white	1.1mA	3.6mA	100µF	3.9kΩ	330Ω	2Hz
Red/orange/yellow	750µA	6mA	100µF	12kΩ	330Ω	0.5Hz
Red/orange/yellow	860µA	6mA	100µF	8.2kΩ	330Ω	0.75Hz
Red/orange/yellow	950µA	6mA	100µF	6.2kΩ	330Ω	1Hz
Red/orange/yellow	1.1mA	10mA	100µF	6.2kΩ	100Ω	1Hz
Red/orange/yellow	1.6mA	6mA	100µF	2.7kΩ	330Ω	2Hz

be installed now as well. Note that if you do not want the circuit to switch off in the day, omit LDR1.

If required, the PCB can be used fitted with four 9mm tapped spacers at each corner of the PCB, attached with short M3 machine screws.

A pre-programmed PIC12F675-I/P can be purchased from our Online Shop. Alternatively, if you intend to program the PIC yourself, the firmware file (1610916A.HEX) can be downloaded from the SILICON CHIP website.

Powering it up

Insert IC1 into the socket, making sure it is oriented correctly. Watch out that you don't bend any pins under the IC. Now install the CR2032 cell in its holder (or apply 3-5V DC) and place the jumper link onto the 2-way header (JPI). If all is well, LED1 will begin to flash.

Version 2: a tiny PCB

For some applications where you want a tiny flasher module, the PCB with its on-board cell holder will be too large. For example, you might want to install the LED flasher inside an HO/OO model diesel locomotive or inside an HO/OO wagon at the end of a train as a BOG (battery operated guard).

For these other applications requiring a tiny module, we have produced an alternative PCB which measures only 36 x 13mm and this board is coded 16109162. We could have made it even smaller if we had designed it to use surface-mount devices, but we know that some readers, and particularly model railway enthusiasts, are not keen on soldering SMDs.

The same components are installed on the smaller PCB, except that it does not have provision for the button cell holder or optional 4-way pin header. Refer to Fig.5 when building this version. Note that some components could be installed laid over on their side on the bottom of the PCB, to reduce the overall size of the package (eg, C1).

Higher supply voltages

If you want to run the PCB from more than 5V, you will need to install a suitable dropping resistor across the input link, JP1. For a 12V supply, we suggest a value of 1kΩ with a rating of 1/4W.

If you want to run the tiny module in a model railway locomotive or freight wagon as an end-of-train device, you will need to take account of the track polarity. To do this, use a small bridge rectifier from the track (eg, type W01). Its two AC connections go to the track connections inside the loco or wagon and the DC wires go to the appropriate DC input wires on the PCB.

Furthermore, to provide for operation when the track is not energised, you could substitute a .047F or 1F 5.5V supercap for the 1µF MMC capacitor on the board. You will likely need to connect it via insulated flying leads. In this case, change ZD1 to a 5.1V type to ensure the supercapacitor can not be charged beyond its 5.5V rating. SC

Parts List

1 PCB coded 16109161 (45 x 47mm)
OR
1 PCB coded 16109162 (36 x 13mm)
1 20mm button cell holder**
(Jaycar PH-9238, Altronics S 5056)
1 CR2032 Lithium cell** (3V)
1 SMD mini-USB socket* (CON1)
1 10kΩ light-dependent resistor*
(Altronics Z 1621; Jaycar RD-3480)
(LDR1)
1 DIL8 IC socket*
4 M3 x 9mm spacers*
4 M3 x 6mm machine screws*
1 2-way pin header, 2.54mm pitch
(JP1)
1 jumper shunt for JP1
1 4-way pin header, 2.54mm pitch*
2 PC stakes*
** optional component*
*** not fitted to smaller PCB*

Semiconductors
1 PIC12F675-I/P programmed with
1610916A.HEX (IC1)
1 1N4148 diode (D1)
1 5.1V or 5.6V zener diode (ZD1)
(see text)
1 3mm or 5mm high-brightness LED
(LED1)

Capacitors
1 100µF 16V electrolytic capacitor^
(C1)
1 1µF multi-layer ceramic
1 1nF 63V or 100V MKT polyester

Resistors (0.25W, 1%)
1 470kΩ 1 1kΩ
1 6.2kΩ# 1 330Ω#
 # change values to vary flash rate and brightness; see text and Table 1

RESISTOR COLOUR CODES

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	1	1kΩ	brown black red brown	brown black black brown brown

CAPACITOR CODES

Value	µF Value	IEC Code	EIA Code
1µF	1µF	1u0	105
1nF	0.001µF	1n	102

SERVICEMAN'S LOG

How I got trapped inside my MG

Dave Thompson*

Items Covered This Month

- Dave's moving house saga
- Three switchmode power supplies
- Healing satellite TV box
- Exorcising the gremlins from a mains electricity supply

There are enough hassles when it comes to moving house without freezing because your car's driver-side power window is stuck half-way down. Even worse is getting trapped inside a car that's full of stuff and having to be rescued.

Things have been rather unsettled in the Serviceman's world recently. We've been moving house (and workshops) and it really is a wonder just how much (let's be frank) "rubbish" two people can accumulate during 15 years of living together in one place.

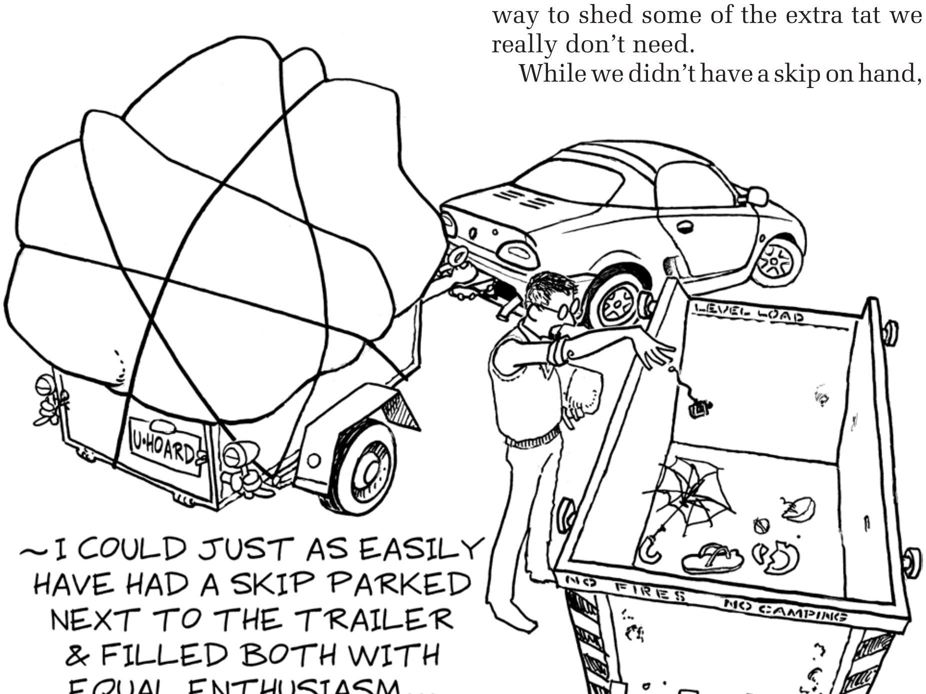
Like my electronics-enthusiast uncle in Melbourne and to a slightly lesser extent my Dad, I like to hold onto any stuff that comes my way, just in case I might need it one day. Some call this hoarding but I am a long way removed from those poor unfortunates who have to sleep standing up in a corner of their laundry, because every other room in the house has been stacked floor-to-ceiling with old tat and random salvage. I can certainly relate in some small way to those folks and my heart goes out to them. However, I do know where to draw the line, although my wife may disagree somewhat.

It's not hard to understand why. After making at least a dozen trips to our new house with cars and trailers packed full of stuff, the contents of our old house and workshop still looked to be untouched! That's not only terribly demoralising but also makes it impossible to deny that I/we have accumulated far too much junk.

It's at times like this that I could just as easily have had a skip parked next to the trailer and filled both with equal enthusiasm. I really need to ask myself: "do I really need this?" If the answer is "no", then out it goes. It's the only way to shed some of the extra tat we really don't need.

While we didn't have a skip on hand, a lot of stuff did actually make it to either the recycle station, the clothing bin or the refuse-collector's compactor. And to be honest, there's a lot more that can go yet, now that we've finished renovating the new house and can turn our now-jaded renovator's eyes towards the garage and workshop.

Shifting house is difficult enough at the best of times; renovating the house before moving into it should be classified as a form of madness. We kept postponing the actual moving-in date, much to the dismay of the friend who was moving into the house we were vacating, mainly because various tradies hadn't finished within their quoted time-frames. There was always some excuse as to why but if you take whatever time-frame they give you and double it, you'll generally be closer to the mark!



Power window problem

I was hoping that things would at least go smoothly during the move but then an unexpected problem cropped up. On one of the last trips over to the new place, my MG filled to the brim with whatever stuff I could cram into it, I pressed the button to lower the driver's-side window to let in a bit of air. Half-way down, the drive motor suddenly loaded up, let out a loud, nasty-sounding "bang" and stopped dead in its tracks.

"Oh great, just what I need", I thought. Fortunately, the weather was clear but it was very cold and the wind carried the freezing bite of snow falling somewhere to the south of us. I was on a high-speed ring road at the time and despite juggling the switch, it quickly became obvious that it was going to be open for the rest of the journey.

No worries, Kiwis are made of pretty tough stuff and a little cold never hurt anyone.

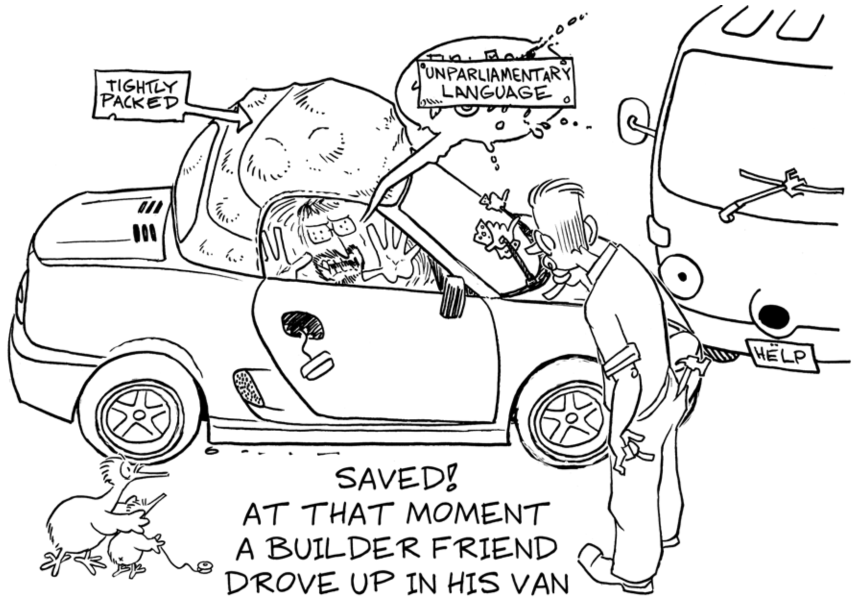
Once I got to our new place and had unloaded the stuff, I had a look at it to see if I could at least close the window, as the sky was threatening rain (or worse) and I didn't fancy driving back across town with it stuck down. First, I gave it a good heft and managed to move it in the track a little. I then pushed the switch and, with a bit of help from me, the motor strained and whirred away until the window eventually reached the top. I wasn't prepared to try opening it again and simply drove the car back to our old place, where I'd be spending another few nights before finally changing locations.

The next day, with the car once again piled high with more of our earthly possessions, I headed off to the new house. However, when I got there and went to open the door to get out, the handle felt unusually stiff. I pulled on it a little harder than usual and following a loud internal "thunk", the handle suddenly became very loose. Obviously, the cable that actuated the door latch had parted company with the handle mechanism somewhere.

With a sinking feeling, I recalled that the previous day, while helping the window into place, I'd felt (and heard) something "give" inside the door. At the time though, I assumed that it was something related to the window's scissor mechanism. Now it appeared to be more to do with the door opening mechanism!

Whatever it was, this presented me with a bit of a problem. I couldn't lower the window, I couldn't open the driver-side door and the passenger compartment was jammed full of bags and boxes. I can report that the air was turning bluer by the second!

At that moment, a builder friend who has been helping with the renovations drove up in his van. Saved! I shouted out the problem and he tried to open the door from the outside but without success. The exterior handle apparently wasn't attached to anything inside the door either. More blue air followed but no matter; he could at least unload the gear from the passenger side and I could clamber out that way.



And that's eventually how I extricated myself from my MG. It wasn't very elegant but at least I was out!

After dealing with the stuff I'd brought over, I set about looking at the door. Problem number one was how to open it. Neither handle worked, the window didn't want to move and I couldn't remove any panels from the inside of the door unless the door was open. This was turning into a real chicken-and-egg scenario.

My builder friend and I tried some of the more obscure methods of opening the door but nothing worked. We even tried the old hand-saw trick; something I'd seen done many years before and had actually pulled off once on a Nissan van I'd owned. However, while it might work for unlocking doors to retrieve locked-in keys, it certainly wasn't about to open this door! Still, we had a van that was loaded with tools and a temporary computer-servicing workshop that was also full of tools; surely we had something that would help us open this door!

The problem was that the mechanism to unlatch the door needed to be actuated, yet all approaches to it were obscured or simply not an option. By now feeling quite frustrated, I suggested cutting a hole in the internal door panel (I have a spare set) but my friend's calmer mind prevailed and after a lot of jiggery-pokery, we eventually managed to move the window down in its track. This involved him leaning on it different ways while I operated the switch and bit-by-bit we moved it, very choppily and noisily, most of the way down. Apart from everything else, something was also very wrong with this window mechanism!

With the window down, we now had access through the top of the door and could see the door-latch assembly a lot more clearly. All we had to do was figure out how it operated. Eventually, after a lot of poking and prodding, we discovered that the part that is actuated by a cable when either handle is toggled had popped out of its plastic housing. Usually, it was clipped securely in place but the Nylon bushing had come apart and so it wasn't holding onto anything at all.

All I had to do was get something onto that mechanism and actuate it to open the door but that was a lot easier said than done! Finally, I made up a tool from a 700mm length of thin aluminium tube I'd salvaged from a

Three switchmode power supplies

Faults in switchmode power supplies can sometimes be difficult to track down. R. L. of Oatley, NSW recently tackled completely different faults in three switchmode power supplies, each with complete success. Here's how he did it . . .

I retired some years ago after working as an electronics engineer in the aviation industry. However, friends still ask for my assistance and advice when their electronic gadgets, radios and toys, etc fail.

Recently, I was asked to look at three totally different devices that had failed: a docking station, a washing machine and a DVD/VCR machine.

The first item was a Phillips AJ7260D/79 clock/charging station which was completely dead. I removed the bottom cover and found a brown stain on the inside beneath the power supply. As there appeared to be no external spillage from the top, I guessed that something in the supply itself had failed.

On removing the supply, it was obvious that the main capacitor (EC1) had exploded. So was this due to something else failing or was this the only fault? I checked along the input path from the 230VAC connection and found that fuse F1 had gone open circuit and that thermistor RT1 had cracked from overheating.

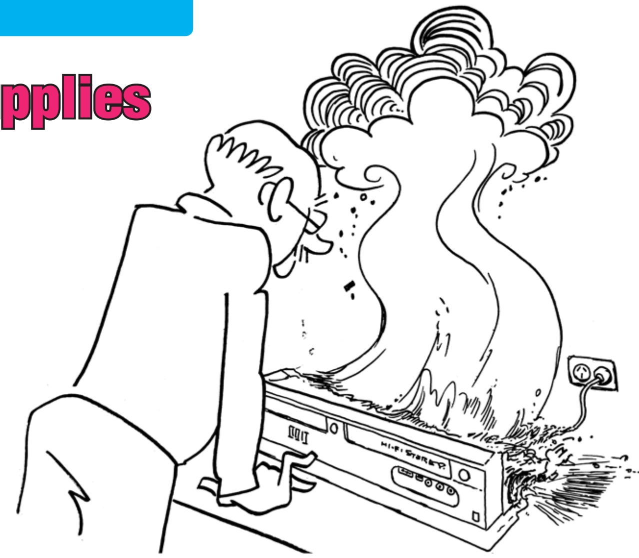
Further checking showed that the rectifier was OK and that switching transistor Q1 had no signs of heat stress. I obtained the replacement parts, reassembled the unit and powered it up. It functioned perfectly.

The second item, a Simpson EZISET 550 washing machine, was apparently working OK one day and dead the next.

After dismantling the top control panel, I checked that all the switches were functioning correctly and that power was getting to the control module, which it was, so it looked like the module itself was faulty. As a result, I removed the control module and took it back to the workshop.

After prising the circuit board out of its plastic cover, I discovered that the LNK306 power supply switching module (U1) had a crack in it and that the surrounding jelly-like coating had blackened. I checked all the other components between the 230VAC connections and U1 and they were OK.

I ordered a replacement LNK306 (U1) on-line and installed it as soon as it arrived. The machine then ran flawlessly.



THE THIRD ITEM, AN LG689D DVD/VCR, HAD SUFFERED A SUBSTANTIAL POWER SURGE

The third item, an LG RC689D DVD/VCR, had suffered a substantial power surge. I disassembled the unit and removed the power supply board. It was immediately obvious that there was some major damage.

I set about tracing out the circuit with the aid of an application circuit for the STR-W6200D switching IC that I'd found on the internet. The input diode bridge, the filter capacitor, the limiting resistor, two zener diodes and the switching IC (but not the input fuse) had all been destroyed, so I ordered the appropriate parts and waited.

Once these new parts had been installed, the unit powered up and everything worked fine, hopefully for many more years.

skip somewhere (see, I knew it would come in handy!) and an Allen wrench which was taped half inside one end. This was carefully eased through the window gap and then, bit by bit, a slight curve was formed in the tube until I got the Allen key onto the latch. Once it was in-place, it was almost an anti-climax as to just how easily the door popped open when I pressed on the mechanism. What a palaver!

With the door open, it was a simple matter of removing the door panel to reveal the goings-on inside. Straight away, I could see where the window's scissor mechanism had come apart. Two separate steel levers formed a stamped and spot-welded "X" section and this created a fixed-point around which the mechanism pivoted. I was going to need a new scissor mechanism but in the meantime, I fudged it back together by drilling a hole through both pieces and using a short bolt, nut and washer to secure them.

The window then worked, although not very well and not through its full travel. But at least I could open and close it a bit.

The handle mechanism problem was quite different. A right-angled piece of steel rod on the end of a short cable was supposed to hook into the door actuator assembly, with a Nylon clip preventing it from pulling away. However, this clip had broken. In fact, the assembly appeared to have been caught in the window scissor mechanism while I had been manhandling it the previous day. This had pulled the cable away from the latch and broken the clip.

The nylon clip obviously had to be replaced but in the meantime, I needed to be able to enter and exit the car without clambering through the passenger door! I tried putting the clip back together and gluing it with epoxy but it simply pulled apart when the handle was pulled. It was obvious that the clip wasn't going to hold together, so I scrounged through my parts boxes and found a nylock-style nut that was slightly smaller than the diameter of the steel rod on the end of the cable.

My aim was to thread the end of the rod and use the nut to hold it onto the latch, rather than rely on the plastic clip. To make things easier, I removed the latch mechanism from the door so I could work on it outside the car. Using a socket, I forced the nut onto the rod and with a drop of machine oil to lubricate it, used it as a crude die to cut a thread. Eventually, I managed to get it on far enough so that it was secured by the nylock section, so it wasn't going to come off in a hurry.

In the end, it worked so well that I don't think I'll bother trying to source a new clip for it. Besides, now that the end of the rod has been threaded, it would probably tear out the inside of a replacement plastic clip anyway.

Collateral damage

Another instance of collateral damage during the move involved my headphones. I usually have a reasonably good set of speakers connected to my computer but in the interests of domestic harmony, I also use a nice set of headphones when the situation requires it.

These aren't fancy, expensive headphones but they are good, cover-the-ear types that don't give me a headache. Many larger style headphones don't work well with people who wear glasses, such as myself, as they press on the arms and cause discomfort. However, these ones are just right and I was a bit annoyed when they started behaving badly after the move, with audible crackling and the audio cutting out on the righthand side.

I discovered that I could affect the sound by flexing the cable where it entered the left headphone cup, so it appeared something had come adrift inside. From memory, these headphones only cost about $12, so most people would just bin them and buy another set. However, as a serviceman, that goes against the grain and so it was out to the workshop with them.

After a rummage around to find the necessary tools to strip them down, I set about finding out what was going on. Most headphones come apart the same way; popping off the ear cushion reveals screws that hold the cup together. Once these have been removed, the ear plate comes away, usually with a speaker attached, and with trailing wires leading off to the rest of the set.

In this case, there was a small circuit board which was held on with a couple of screws at the base of the left ear-cup. Flying leads then ran from this board to the lefthand speaker and via the headband to the righthand speaker. What was rather odd was that a 3.5mm stereo socket was mounted on this PCB and the audio cable terminated into it via a standard 3.5mm stereo plug.

It's really a good idea, as it makes it easy to change the lead, should that be required. What wasn't such a good idea was the long, stripped speaker wires that were touching each other and other pads on the PCB. Flexing the cable where it entered the cup moved the PCB and wires slightly and this caused the audio interruptions.

The repair simply involved shortening the wires and re-terminating them with heatshrink insulation installed. The audio was then once again crackle-free and achieved without needlessly throwing away a perfectly good set of headphones.

Healing satellite TV box

N. G. of Gymea recently struck problems with a Healing satellite TV receiver that conked out each time he tried to point the motorised receiving dish in a new direction. Here's how he tracked the problem down . . .

I was a self-employed TV serviceman for most of my working life and still maintain a keen interest in hobby electronics, thanks largely to SILICON CHIP and its predecessors. My main lounge-room amplifier (still in daily use) is a Twin 17 Watt Ultra Linear Valve design, published by John Moyle

MANY LARGER STYLE HEADPHONES DON'T WORK WELL WITH PEOPLE WHO WEAR GLASSES AS THEY PRESS ON THE ARMS AND CAUSE DISCOMFORT...

in *Radio TV and Hobbies* and built while I was a student in 1959.

My wife and I were never able to find one that sounded better but I guess that's another story!

Several years ago, while heading for retirement and with more time to pursue the fun stuff in electronics, I decided to have a go at satellite technology. This was done with the help of Geoff, my first apprentice and still a good friend. He rounded up a secondhand dish and LNB (low-noise block)and suggested that to make full use of what was available, a dish motor would be a very worthwhile addition.

This has proved to be every bit the case, as the free-to-air stations available in Eastern Australia that are worth having are well and truly scattered across four different Ku-band satellite locations.

Of the hundreds of un-encrypted channels which can be viewed, I filter out 40 or so which are of some interest

Exercising the gremlins from a mains electricity supply

The gremlins really had fun with the electricity supply at A.L's home in Turramurra, NSW. At odd times, the power would switch off for no apparent reason and it took months to find the cause . . .

"There's no power dad – can you fix it?" That was the question from a family member some months back when our internet router went down, along with the dishwasher, the kettle and all sorts of sundry chargers, lamps and printers etc. It was just the usual family excess use of all the available power outlets.

"OK, that should be easy", was my answer (famous last words). I soon discovered that a circuit breaker (in combination with an RCD) in the fusebox had flicked off. However, before switching the power back on, I switched off all the chargers, desk-lamps and other items, including the kettle.

The power was then restored without incident and all was normal for about the next two weeks. And then one evening, the same thing happened again, just as the dishwasher was in the middle of a wash cycle but without much else on.

Aha! – now was the time to see which utensil was causing the problem! I removed everything, restored power and then plugged things in one-by-one to make it easy to establish the culprit. Wrong! Nothing seemed to trip the circuit breaker or RCD and even when I switched everything on, the power remained intact.

At that stage, I put it down to a possible surge from the mains because our voltage is relatively high. I measured it at 251V RMS at the time it cut out (off peak) and assumed (incorrectly) that any slight surge may be sufficient to flick the circuit breaker off.

All then went well for about two months and then it started to happen again, usually when the dishwasher was on. It got to the stage where my wife was insisting that everything be turned off (including the router) when she wanted to use the dishwasher and so I began checking the prices of new dishwashers, fearing that the one we had might "blow up" for good!

After a while though, nothing seemed to make sense, as the power seemed to cut out intermittently at any time of the day regardless of which appliances were being used. What's more, none of the appliances had any apparent faults!

I also checked the wiring with an RCD tester, fearing that there may be some kind of problem like a short circuit or leakage to earth. However, the system responded perfectly and only turned off at the specified 30mA and was OK at 10mA and 20mA. What's more, a static current measurement using a clamp ammeter showed no measurable residual leakage at all!

Then one day there was a "hallelujah moment" when my wife shouted "I've discovered the problem, it's the microwave oven!" She had switched it on at the power point and the circuit breaker had cut out at the exact instant. We quarantined the microwave oven but left it sitting on the kitchen bench while we celebrated our apparent victory.

Alas, two weeks later, while we were watching a movie, the power failed again! So it wasn't the microwave after all; it had just been coincidence.

I ventured out to the fusebox in the darkness and rain to switch the circuit breaker back on yet again but this time I noticed a distinct smell coming from it. It was also warm to the touch! "Wow", I thought, "there must be a lot of current through it to do that". Either that or perhaps there was a problem with the internal working components of the circuit breaker itself.

It was a 20-year-old unit (a Clipsal 4BE216/30) and it now became the main suspect in the mystery. I

and save them as favourites. There are many very useful programs that are not normally seen in Australia, even with pay TV. The satellite FTA choice seems to be definitely improving (perhaps being spurred on by all the free TV on the internet?).

The time shifting that is in effect provided by the ABC and SBS due to Australia's different time zones can also be very useful.

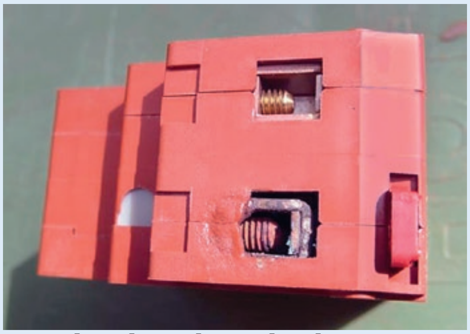
An FTA standard-definition (SD) satellite receiver was part of the original package (Strong SRT 4663X) and was good enough for a while. However, with increasing numbers of channels being only available in HD with MPEG-4, I eventually decided to buy a new Healing HHS242 satellite receiver.

This HD FTA receiver performs remarkably well for its size and price and incorporates Disec 1.2, giving full control of the dish motor (a Sadoun DG-280) via the single RG6 connecting cable. It all worked perfectly for the first 18 months or so, the motor drive always moving the dish to the exact location required in very little time.

At the end of this period, it suddenly ran into problems, with a "No Signal" message displayed on the TV screen. When I checked the problem out, I noticed that the dish was pointing much too far to the west. However, I was able to perform a motor reset to the north reference point and it then operated normally again – for a while!

This same problem was subsequently repeated several times, so I searched the internet for clues. This threw no light on my particular problem but I did discover that a firmware upgrade was available for the HHS242 receiver, mainly to deal with a sound issue. I held out a vague hope that installing this upgrade might improve things but no such luck; the problem was every bit as bad after the upgrade and, in fact, was becoming more frequent.

The problem subsequently progressed to the point where I was unable to even perform the motor reset, the dish remaining stuck pointing too far to the west. When I attempted to use the remote control to move towards the east, the notation on the screen was exactly as you would expect – a little flashing arrow indicating movement to the left but with no actual physical change in the direction of the motor itself.



This photo shows the obvious signs of the heat generated on the output terminal of the RCD due to a loose wire.

subsequently had it replaced and all returned to normal.

As it turned out, it was not really the fault of the Clipsal unit itself. If you look at the accompanying photo, you will see that one of the screw connectors had come loose, possibly because it had not been sufficiently tightened, and this had caused a hot spot as it was not making a good connection to the outgoing Active wire. And because it was on the bottom of the unit, the rising heat was causing the circuit breaker, which is tripped by heat, to turn off.

It's probable also that vibration caused by constantly opening and closing the fusebox and operating the switch exacerbated the loose connection. In fact, subsequent checks revealed that there was nothing wrong with the Clipsal device and except for a slightly burnt terminal, it still works as specified. It was replaced for good measure anyway.

I connected a meter to the receiver's LNB input socket and this gave readings of 13.5V DC when the receiver was tuned to vertically polarised transponders and 18.4V for horizontally polarised ones. This was exactly what you would expect and made me inclined to suspect the dish motor rather than the receiver. I then wired up a temporary RG6 adaptor lead which allowed me to measure the output voltages with the LNB and motor connected together. This time, the reading was 0.56V regardless as to where the receiver was tuned, so obviously the LNB and motor would be unable to function.

So was the dish motor placing an unduly heavy load on the receiver and causing it to effectively shut down? Or was it the LNB that was causing the problem? Or was the fault in the receiver?

I have learned over many years of involvement with electronics to be very careful about what I throw out (much to the annoyance of my wife). And fortunately, I'd had the good sense not to dispose of my old SD satellite receiver. This was now reconnected so that I could check the LNB and dish motor without the Healing HD receiver. I was a little surprised to find that the motor and LNB now operated perfectly; in fact all of the original satellite locations were still remembered!

When I reconnected the Healing receiver, I got another surprise. It was now doing a perfect job of receiving all of the usual channels on Optus C1/D3. I then realised that this just happened to be where the dish had been left pointing when I disconnected the SD box after testing. The receiver now appeared to be fully operational for C1/D3 but it shut down instantly when I tried to receive a channel from a different satellite.

Clearly, it was sheer luck that the HD receiver happened to be tuned to the C1/D3 channel when I first reconnected it, which coincided with the dish position. This indicated that most of the receiver was working normally but it would shut down each time I attempted to move the dish to a different location. The receiver was thus able to operate normally with DC power provided just for the LNB but was unable to provide the extra "grunt" necessary to turn the motor and drive the dish to a new location.

This indicated that the receiver's 13V and 18V supply rails were unable to cope with the dish motor when needed. On the other hand, these supply rails must still be present, otherwise it would not have been possible to receive any channels from the LNB. So how hard could a power supply problem be to track down? It was definitely worth a shot.

When I opened the box, I found a finely detailed double-sided PCB with numerous plated through connections. Unfortunately, the component labelling was sparse and there was no separate power supply board; everything was bundled together. Indeed, it appeared that this device was not made to be repaired.

I thought that the logical place to start was with the electrolytics, so I used my trusty Silicon Chip ESR tester to check all 11 of them. This didn't reveal anything unusual and after taking into account the young age of the unit, the fact that all the electros were 105° types and the plated-through connections, I decided to do a bit more checking before replacing any of them.

The distributor was unable to provide a circuit diagram, so I did an internet search for any technical details using the various letters and numbers on the PCB. This led to nothing of use so I then tried to make some sort of sense of what the circuit was doing.

The main power supply itself appeared to produce just two outputs, nominally 5V and 12V, both of which measured OK. So where did the 18.3V and 13.5V for the dish motor come from? There would have to be a switching voltage convertor of some kind involved near the LNB input side of things, so I decided to start with the electros in that area. Because replacement would not be easy (due to the plated through PCB holes), I initially tried bridging the electros in that area of the PCB but to no avail.

I then carried on bridging the electros in what looked like the main power supply area itself and that's when I struck pay dirt! Capacitor EC3, a 220µF 25V electrolytic across the 12V rail, was the culprit and bridging it with a similar value immediately restored the ability of the unit to rotate the dish motor without the receiver shutting down. When removed from the board and tested again, its ESR was certainly too high at 5.6Ω but when it was in-circuit, it was well under 1Ω.

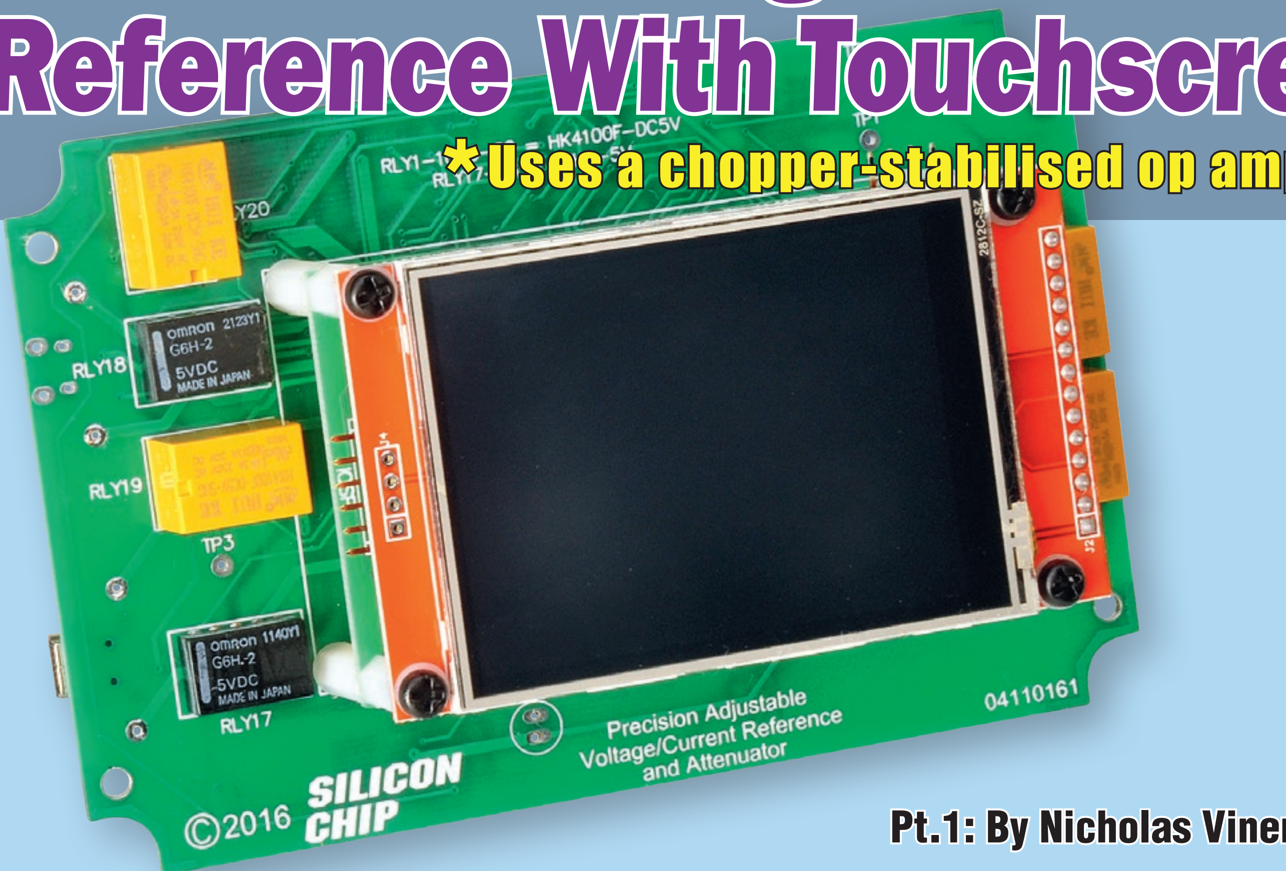
This would not be the first time that removing an electro was the only sure way of testing its ESR but I must say that the symptoms displayed by the unit were rather strange. It's several months now since the repair and there's been no hint of further trouble.

Finally, I can't help pondering what I would have done if the Healing HD receiver had been tuned to a different channel to the SD receiver when I reconnected it. In that case, it would have immediately tried to initiate dish movement and would have shut down, leaving me unaware that it was still capable of receiving channels.

And that may well have dampened my enthusiasm for proceeding further with this repair. So I was lucky – Murphy must have been on holiday at the time! **SC**

Precision Voltage & Curren
Reference With Touchscree

*Uses a chopper-stabilised op amp



Pt.1: By Nicholas Vinen

This new design lets you produce any voltage from 0-37V with 0.1% or better accuracy, with the convenience of a touchscreen interface. It can also act as a precision current source or sink from 1mA to several amps (with up to 2.5W continuous dissipation) and is largely self-calibrating. It can also be used as a precision AC signal or DC voltage attenuator/divider.

WE CAME UP with the idea for this project after selling hundreds of kits for the Accurate Voltage/Current/Resistance reference project described in the August 2015 issue. That project's popularity is no doubt due to its simplicity and low cost to build. But it's also quite limited, with just one reference voltage, one unbuffered current option and one resistance value.

So we decided to come up with a new project which would be a lot more useful, offering a huge range of reference voltages and currents without being too expensive, large or difficult to use. This unit is the result.

We decided to use the Micromite LCD BackPack as the user interface. This makes the user interface nice and simple, with no buttons or knobs – all settings are done via the touchscreen. You can simply punch in a voltage or current value or attenuator ratio. Or you can swipe to adjust the already set value. It also gives a nice clear read-out of the current state of the unit. We also decided it should be powered from a USB socket, due to the prevalence of suitable supplies, both mains-based and battery-based.

The PIC32 in the LCD BackPack does all the control work, so we just needed to add a precise voltage source, an accurate gain stage and programmable divider, a voltage-to-current converter, a boosted supply to provide a usefully wide voltage range and some switching to allow the user to easily switch between the various modes.

Design process

We immediately decided to use the same Maxim voltage reference IC as the earlier reference project. It has the advantage of being relatively cheap t

n Control

Features & Specifications

- Four modes: AC/DC attenuator/divider without buffering, AC/DC attenuator/ divider with buffering, voltage reference, current reference
- Interface: 320 x 240 pixel colour TFT touchscreen
- Power supply: 5V 1A USB supply (micro or mini connector)
- Protection features: over-voltage disconnect (buffered attenuator & voltage reference mode); over-voltage, over-current & over-heat disconnect (current sink/ source mode)

Unbuffered attenuator/divider mode

- Maximum input voltage: ±60V
- Input impedance: variable, displayed on screen; 3.5-114kΩ
- Output impedance: fixed; 2.4kΩ
- Attenuation steps: 65,535
- Attenuation accuracy: typically within ±0.01%

Buffered attenuator/divider mode

- Input voltage range: 0-38V
- Input impedance: variable, displayed on screen; 3.5-114kΩ
- Output impedance: effectively 0Ω
- Output current: 12mA source; 12mA sink above 1V, reducing to ~5mA @ 0V
- Bandwidth: >50kHz
- Attenuation steps: 65,535
- Attenuation accuracy: typically within ±0.01%

Voltage reference mode

- Output voltage range: 0-5V in 0.1mV steps; 5-10V in 0.5mV steps; 10-37V in 1mV steps
- Output current: 12mA source; 12mA sink above 1V, reducing to ~5mA @ 0V
- Uncalibrated accuracy: ±2mV 0-2.5V; ±3mV 2.5-5V; ±5mV 5-10V; ±10mV 10-20V; ±20mV 20-37V
- Typical output noise (1MHz BW): <200µV RMS 0-2.5V; <5mV RMS 2.5-37V
- Typical output noise (50kHz BW): <100µV RMS 0-2.5V; <500µV RMS 2.5-37V

Current reference mode

- Output current range: 0.5mA-5A in 0.5mA steps.
- Maximum applied voltage: 30V
- Calibrated current reference accuracy: typically better than ±0.1%
- Continuous sink/source current: up to 83mA
- Continuous dissipation: up to 2.5W
- Peak dissipation: 50W (10ms), 20W (100ms)

with a good basic accuracy of ±0.04% and low noise.

To attenuate its output, we considered using either a precision DAC or a discrete "R-2R" resistor ladder network switched by relays, like Jim Rowe used in his Lab-Standard 16-Bit Digital Potentiometer project, from the July 2010 issue.

You would think a single DAC IC would be the cheaper option but high-precision DACs are surprisingly expensive. We now have sources of suitable relays and high-precision SMD resistors that are cheap enough that the discrete option ends up being the same cost, or even lower.

Using a DAC IC would give us the ability to quickly vary its output, eg, for pulse testing purposes. However, that is not the primary intention for this project; it was envisioned more as a DC reference so that was not considered an important feature. Anyway, the relays do allow for output "bursts" as long as they are not too short.

The discrete ladder approach has further advantages which convinced us to stick with this approach. It allows the unit to be used as an attenuator for a wide range of external AC signals or DC voltages, including those which swing below ground. It also provides full isolation from the unit's own power supply in this mode.

Double-sided PCB

By producing a double-sided PCB which is stacked with the LCD Back-Pack PCB, we can easily fit the 16 relays and 50-odd resistors required for the precision attenuator into a standard jiffy box, with room for the other components required to provide the various extra modes.

Besides having more features, another important advantage of this design over the Lab-Standard Digital Potentiometer is the fact that our R-2R ladder uses resistors which are all the same value. This is made possible since precision SMD resistors are both smaller and cheaper than their through-hole equivalents, so we could simply create one value by combining two resistors.

We're using pairs of 12kΩ 0.1% resistors in parallel to form 6kΩ 0.1% resistances, so the R/2R ladder is in fact 6kΩ/12kΩ. This gives a divider impedance four times that of the earlier design, which used 1.5kΩ/3kΩ. This keeps the input impedance above 3kΩ at all times, making it easier to drive from an external source. The higher output impedance is partially solved by adding an optional buffer.

Using a single value gives us the benefit of the fact that resistors from the same batch are likely to be closer in value to each other than the tolerance would otherwise suggest. In addition, they should also have closely matched temperature coefficients, so the division ratio should not drift much with temperature.

Another advantage of this scheme is that the actual resistor value is not critical. If the 12kΩ resistors become difficult to acquire or expensive, constructors can simply substitute 10kΩ or another similar value. As a bonus, you can take advantage of the volume discounts often available when buying 50 or more resistors of the same value.

Chopper-stabilised op amp

As well as the precision divider and voltage reference, we have added an op amp to provide reference voltage gain, to expand the range of available output voltages. This op amp uses a boosted supply so that the 5V USB input isn't a limiting factor.

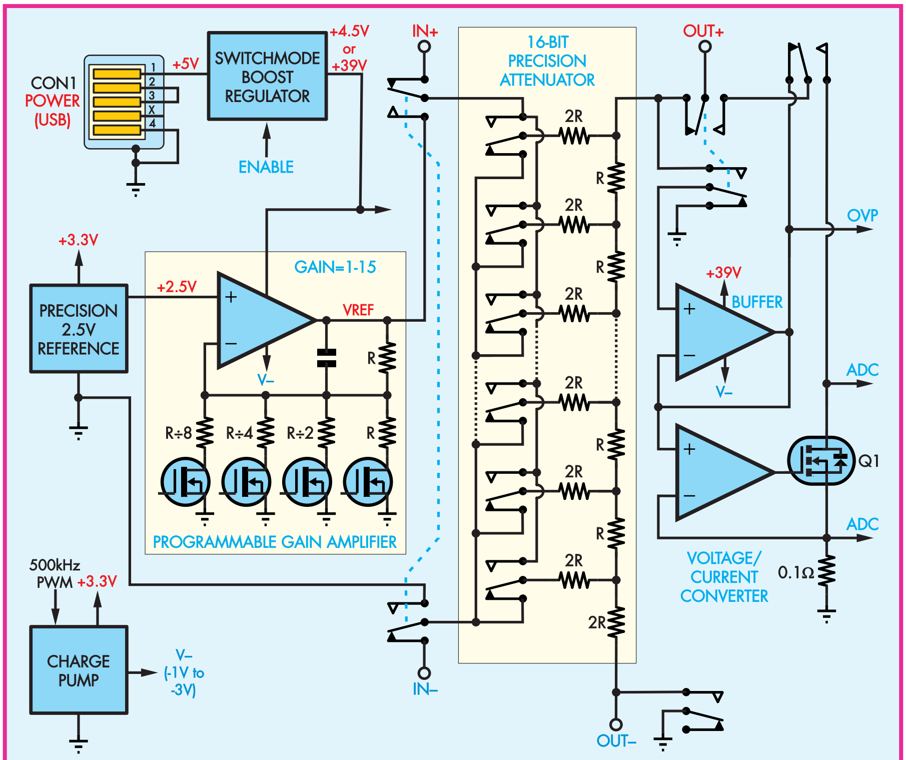


Fig.1: this diagram shows the basic concept of the Programmable Voltage & Current Reference. The output from a precision 2.5V reference is fed into a programmable gain amplifier (PGA) and the resulting reference voltage of 2.5-37.5V is then applied to a precision divider by a DPDT relay. The output of the divider can be accessed directly at the OUT+ terminal or optionally routed through either a buffer op amp or a voltage-to-current converter.

For this, we need an op amp with a very low input offset voltage, to avoid prejudicing the accuracy of the reference, along with low drift, low noise and a very low input bias current, to avoid errors due to the divider's output impedance (when acting as a buffer).

We originally planned to avoid chopper-stabilised op amps because, while they have a very low input offset voltage, they tend to have high noise due to the "chopping" (switching) action. However, in the end, the op amp we found that best suited our needs at reasonable cost is of this type, albeit one with very low noise.

It's the ADA4522-4ARZ from Analog Devices which has four op amps in one package, a maximum input offset of just 5µV, drift of just 2.5nV/°C, a low typical input bias current of 50pA (maximum 150pA @ 25°C) and very low noise at just 5.8nV/√(Hz). As a bonus, it will run off a supply voltage of up to 55V. We decided on 39V (since the boost regulator's internal Mosfet is rated at 40V peak), allowing reference voltages up to about 37.5V.

This quad op amp not only provides the gain stage but also drives a voltage-to-current buffer, allowing the unit to sink or source a programmable current between 0.5mA and 5A (within certain dissipation limits). Another of its stages is used as an optional output buffer.

Operating principle

Block diagram Fig.1 shows the basic operation of the device. We're ignoring the LCD BackPack and its control logic, for the moment. At its heart is a 16-bit precision attenuator with all the switching done by relays. With the control relays in their off (default) states, the positive and negative input voltages for the precision attenuator come from an external voltage source via the IN+ and IN- banana sockets. Similarly, the divided voltage, with the attenuation ratio set by the state of the 16 relays in the R-2R ladder network, appears across the OUT+ and OUT- terminals. Normally, OUT- and IN- are both connected externally to GND.

A DPDT relay can switch the IN+ and IN- terminals out of the circuit and connect the input side of the attenuator to the output of the programmable gain amplifier (PGA) instead. This is fed from the 2.5V precision reference. With the four PGA Mosfets off, the attenuator receives 2.5V and this can be divided into 65,536 discrete voltages at the OUT+ terminal; the OUT- terminal can be internally connected to ground via a relay, for convenience.

Should a voltage above 2.5V be required, the switchmode boost regulator can be enabled, raising the PGA op amp's supply voltage from USB 5V up to 39V. Its gain can then be increased to give a reference voltage from 5V to 37.5V, increasing the range of output voltages available from the divider.

A simple charge pump driven by the micro in the LCD BackPack provides a negative rail for the op amp that's typically 1-3V below ground, so that its outputs can reach 0V even when sinking several milliamps. This is a common issue with "rail-to-rail output" op amps; while in theory their outputs can swing to the supply rails, in practice they usually fall a bit short.

A DPDT relay at the OUT+ terminal can insert one of these high-precision op amps in series with the output, to buffer the voltage. The relay shown at upper right switches the buffered output from voltage mode to current mode. In this mode, current from the OUT+ terminal passes through Mosfet Q1 to the OUT- terminal. An op amp varies Q1's gate voltage so that it sinks the programmed current, by monitoring the voltage across the 0.1Ω shunt and comparing it to the reference voltage from the divider.

Finally, the micro in the BackPack uses its analog-to-digital converter (ADC) to monitor the dissipation in Q1 along with its drain voltage and current, and the voltage at the output of the buffer op amp. It can then disconnect the output terminal from this circuitry should any of these be driven outside their design ranges.

Circuit description

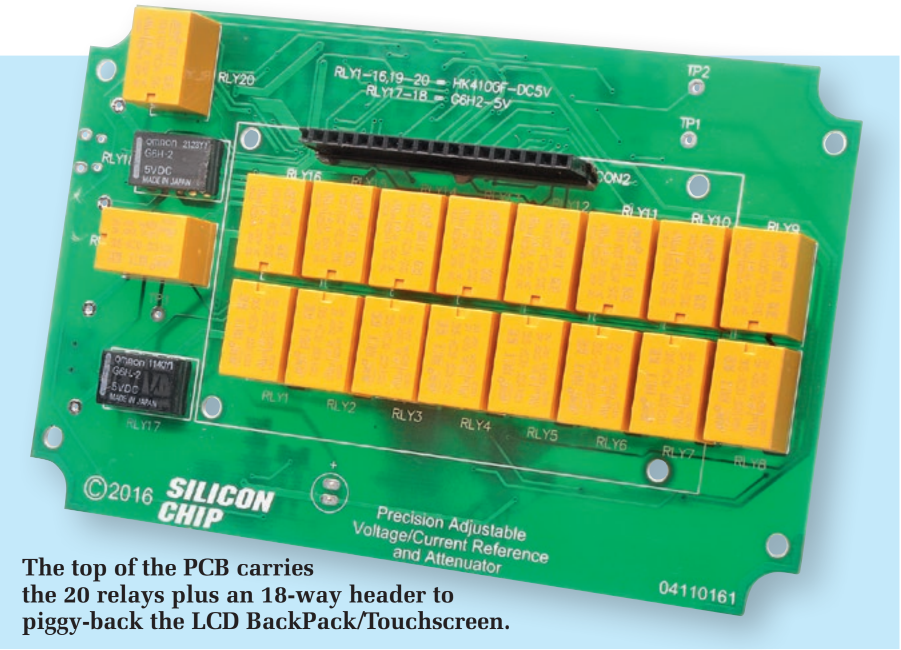
Fig.2 shows the full circuit diagram of the Precision Voltage & Current Reference. The main 2.5V reference is provided by REF1, a MAX6071-2.5 with an initial accuracy of ±0.04%. Its power supply is derived from the regulated 3.3V rail of the BackPack module via an RC low-pass filter (100Ω/4.7µF) in order to cut out switching hash from the microcontroller. We're using the 3.3V supply as it's likely to be less noisy than the unregulated 5V input.

The 2.5V output is fed to IC5a which forms the PGA. By default, with outputs O4-O7 of IC3 in their high impedance state, the op amp's feedback is via the 12kΩ resistor and parallel 100nF capacitor (for stability and noise reduction) and this gives unity gain, ie, V_{REF} = 2.5V.

However, if IC3's output O4 switches low, this forms a 1:1 divider (ie, 12kΩ/12kΩ) and so the op amp gain becomes two, giving V_{REF} = 5V. The 0.1%-tolerance resistors ensure this value is close to ideal but any error is automatically calibrated out, as explained later.

Similarly, if O5 switches low, the gain becomes four times and V_{REF} = 10V. Various combinations of O4-O7 can be switched to give a gain of 1-19, resulting in a V_{REF} between 2.5V and 37.5V.

When V_{REF} = 2.5V, IC5a runs from the 5V supply via Schottky diode D1 and inductor L2, resulting in around 4.5V. Before the PGA gain is set above unity, pin 12 of CON2 is brought low, enabling boost regulator REG1. This lifts IC5a's supply voltage up to 39V [1.276V x (22kΩ ÷ 750Ω + 1)]. The operation of REG1 will be explained later.



The top of the PCB carries the 20 relays plus an 18-way header to piggy-back the LCD BackPack/Touchscreen.

Voltage divider

When relay RLY18's coil is energised, V_{REF} is connected to the top end of the R-2R divider ladder while the bottom end is connected to GND. On the PCB, the GND connection is routed so that no additional current will flow along this path, ensuring accuracy; just that passing through the ladder.

The ladder itself consists of 47 12kΩ 0.1% tolerance resistors, chosen for the reasons explained earlier. Relays RLY1-16 connect various points in the R-2R ladder to either GND of V_{REF}. Depending on which combination of these relays are energised, the ladder output at TP3 ranges between GND and just a tiny bit below V_{REF}. For example, if RLY16 is energised and the other 15 are not, assuming all components are exactly the expected value, that will give V_{REF} x 32768 ÷ 65,535 or just slightly more than $V_{REF}/2$ at TP3.

When RLY17 is not energised, this voltage is available at the OUT+ terminal. Normally, RLY19 will be energised and so the OUT- terminal will be connected to GND.

Output buffering

When RLY17 is switched on, the voltage at TP3 is routed to the non-inverting input of op amp IC5c, another high-precision op amp. At the same time, this op amp's output is connected to the OUT+ terminal, via RLY20's normally-closed contact and a 47Ω resistor. This buffers the ladder output voltage, so that a few milliamps going into or out of the OUT+ terminal will have no effect on the voltage.

The 47Ω resistor prevents any capacitance at the OUT+ terminal from destabilising op amp IC5c. This would normally cause a voltage shift, however, this op amp stage actually has "zero DC output impedance" due to the 10kΩ resistor between the output end of the 47Ω resistor and the inverting input. In other words, DC feedback comes from the output end of the 47Ω resistor. But AC feedback comes from the other end, via a 47pF capacitor, so the op amp still benefits from the stability improvement provided by the 47Ω resistor.

Current sink & source

In current reference mode, RLY20 is energised. The OUT+ terminal is then connected to the drain of N-channel Mosfet Q1 and its source is connected to GND (and thence to OUT-) via a nominal 0.1Ω shunt. The voltage from this shunt is proportional to the current sunk by Q1 and this is fed back to the inverting input of IC5d, another precision op amp stage, via an RC filter.

The non-inverting input of this op amp, pin 12, is connected to the output of buffer stage IC5c via a 1kΩ resistor. So, as an example, let's say V_{REF} = 2.5V and the R-2R ladder is set up to divide this by 100, ie, with 25mV at TP3. This 25mV is applied to pin 12 of IC5d.

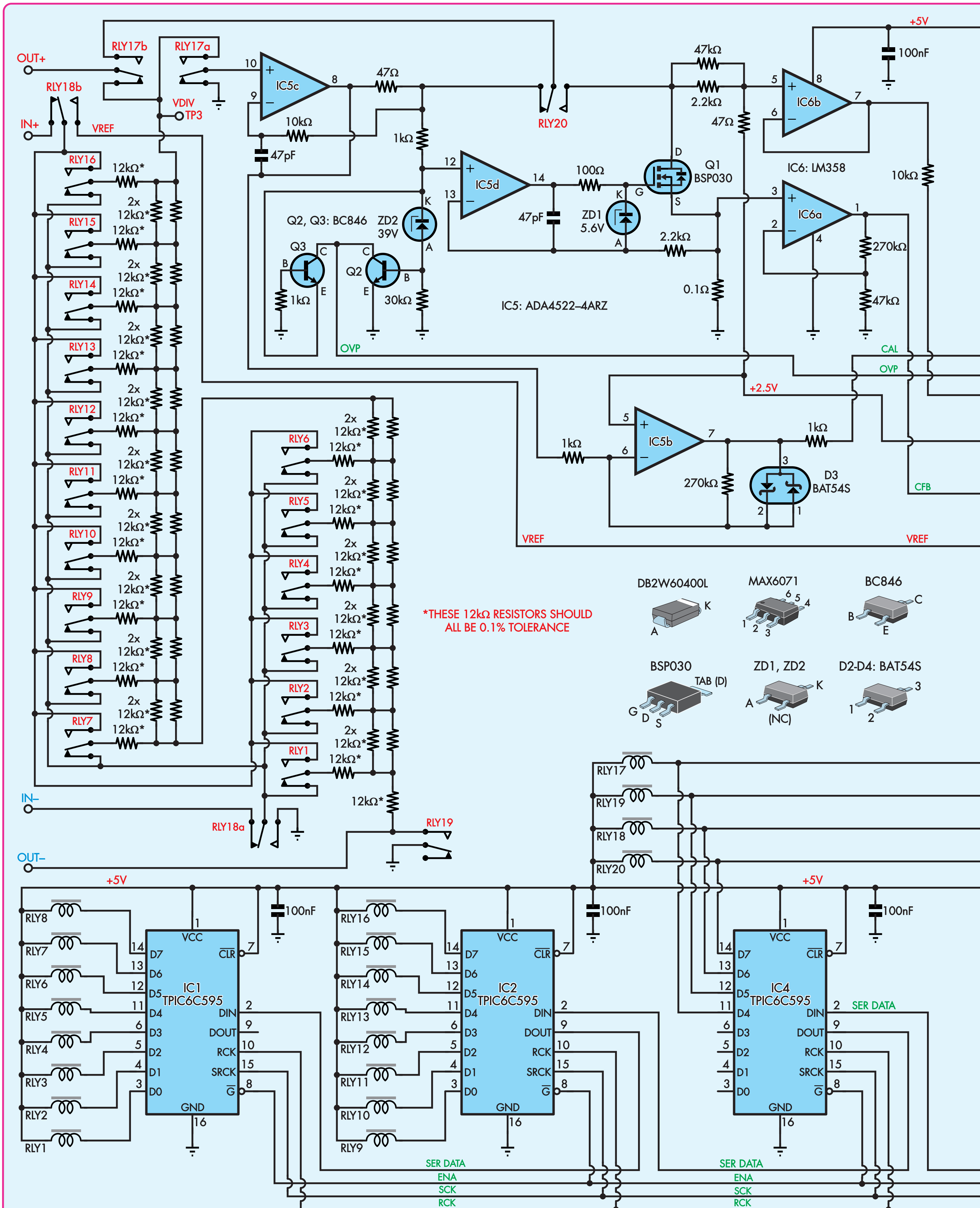
IC5d then controls the gate of Mosfet Q1 to sink enough current so that 25mV appears across the 0.1Ω shunt, ie, 250mA. Thus, the current through the shunt (in A) is equal to the voltage at TP3 (in V) multiplied by 10.

A series/parallel combination of three resistors between the 2.5V reference output and the drain of Q1 provides a minimum current flow. This prevents Q1 from being switched off fully when Q1's gate voltage drops, which could cause overshoot upon recovery.

Similarly, zener diode ZD1 keeps Q1 in linear operation during those times when Q1 can not sink the programmed current from the external voltage source. Once its gate voltage rises above 5.6V or so, Q1 is already switched on fully and ZD1 pulls its inverting input (pin 13) up to prevent any further rise in the output voltage at pin 14. This allows it to reduce Q1's conductance more quickly when current regulation resumes.

The 2.2kΩ/47pF filter in its feedback arrangement compensates for the phase shift due to Q1's gate capacitance and turn-on/turn-off time. Without these, the output at pin 14 would oscillate rather than reach a steady level to sink the required current. Essentially, the 47pF capacitor forms an AC feedback path between the pin 14 output and pin 13 inverting input, reducing gain to unity at high frequencies while leaving DC feedback high for precise current control.

Note that the 0.1Ω shunt resistor tolerance of ±1% means that the current reference will initially be much less precise than the voltage reference. But if the shunt's resistance can be accurately measured, this can be programmed into the unit and the er-



PROGRAMMABLE PRECISION VOLTAGE & CURRENT REFERENCE

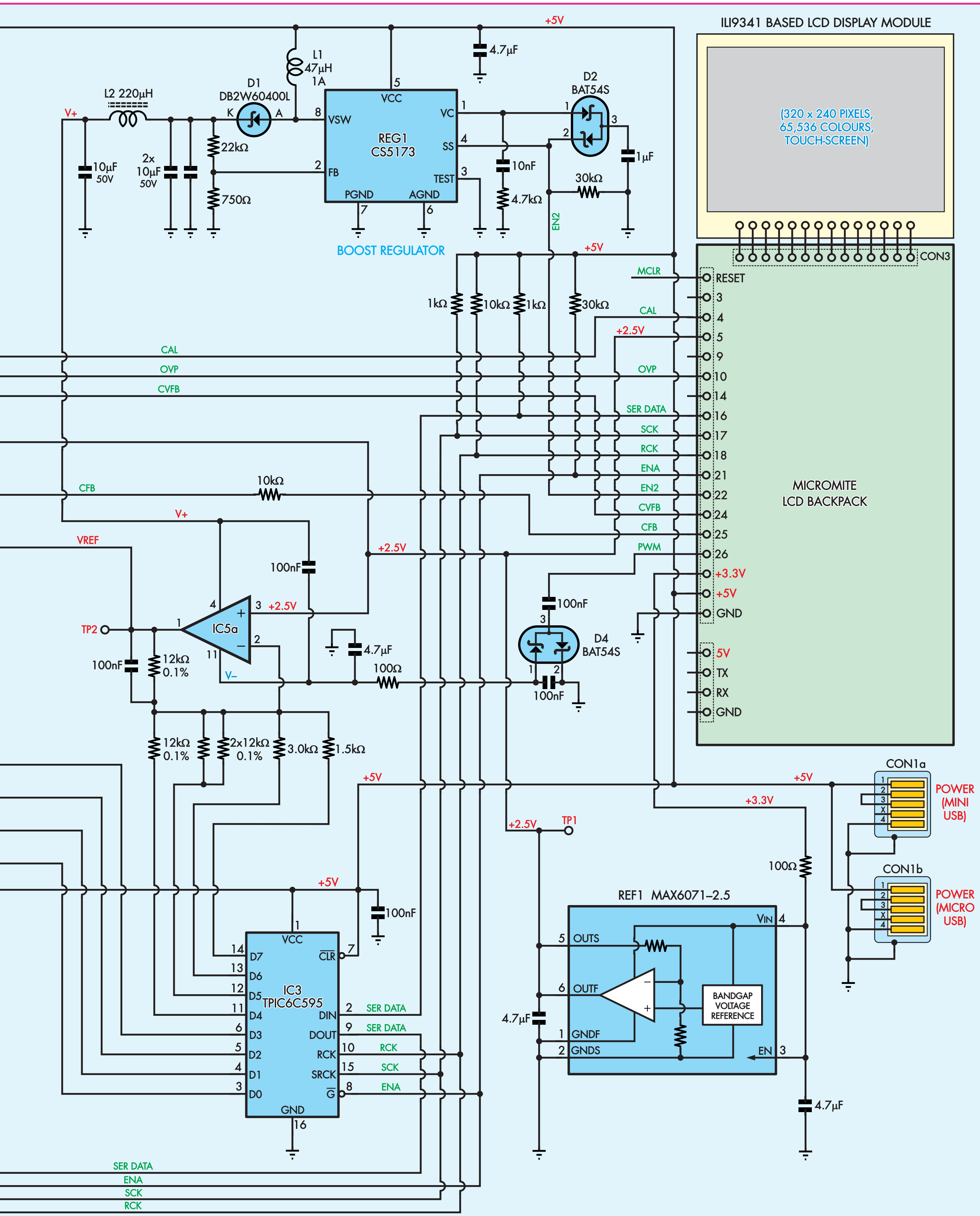
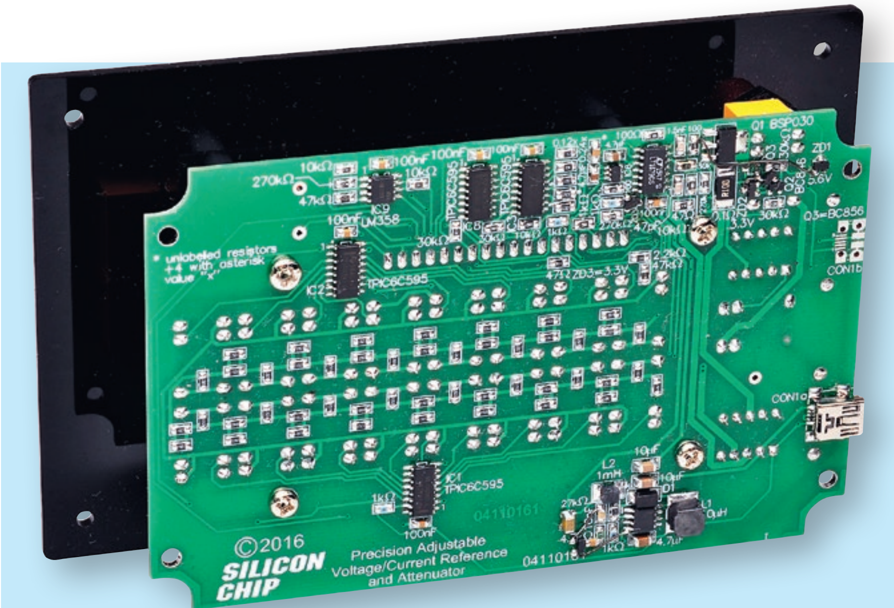


Fig.2: this is the complete circuit of the Programmable Reference, with the LCD BackPack and its associated PIC32 microcontroller shown in the upper-right corner. The precision attenuator (shown at left) is formed from 16 SPDT relays and 47 x 12kΩ ±0.1% resistors, with the control logic below. The switchmode boost converter, for reference voltages above 2.5V, is built around controller REG1 while the voltage reference is in the lower-right corner and the PGA above and to its left.



Most of the parts are mounted on the underside of the PCB (prototype board shown). Pt.2 next month has the assembly details.

ror calibrated out. More on how to do this later.

Note that while the circuit can only sink current, because the whole device is effectively floating (assuming the 5V supply is not earthed), it can just as easily be used as a current source, by connecting the OUT+ terminal to a positive voltage and then drawing current from the OUT- terminal. The circuit won't "know" the difference.

Boost regulator

Before configuring the PGA to give a V_{REF} of 5V or higher, the PIC32 in the Micromite LCD BackPack brings pin 12 of CON2 high. This is normally held low by a 30kΩ pull-down resistor. When high, REG1 is activated. At first, nothing happens since its internal current source at pin 1 must charge a 1µF capacitor via Schottky diode D2. But once the voltage at that pin rises sufficiently, it will begin to periodically sink current from pin 8, with a frequency of around 560kHz and a duty cycle that starts very low and steadily increases.

Each time REG1 brings pin 8 low, L1's magnetic field charges up. When it ceases sinking current from this pin, the voltage at pin 8 shoots up above the 5V supply, due to the magnetic field of L1 discharging. 2A, 60V Schottky diode D1 is forward-biased and the two parallel 10µF capacitors are charged up to a voltage which increases as the switching duty cycle builds.

Eventually, the voltage across these capacitors reaches 39V. The 22kΩ/750Ω divider across these capacitors results in a voltage of 1.276V at the feedback pin (pin 2) of REG1 for an output of 39V and when this is reached, REG1 dials back the duty cycle to keep the output voltage steady. The 10nF capacitor and series 4.7kΩ resistor provide frequency compensation, to avoid oscillation in this voltage.

The 39V supply is filtered by 220µH inductor L2 and another 10µF capacitor, to remove as much of the switching residual as possible. Note that L2 has a DC resistance of around 17Ω so it's effectively an RLC filter, ie, you can consider L2 as an ideal 220µH inductor with a 17Ω resistor in series. This 39V supply powers quad op amp IC5 only.

Relay control

In addition to the 16 relays which are used in the R-2R divider ladder, four relays switch between the various modes; RLY17 and RLY18 are DPDT types while RLY19 and RLY20 are the same SPDT types as used in the divider. All have 5V DC coils.

All 20 relay coils are driven directly from the 5V input supply rail and switched by one of three 8-way open drain serial-to-parallel latches (IC1, IC2 & IC4). These are similar to the 74HC595 but have open-drain outputs rated to 33V/100mA with diode clamps to allow direct switching of inductive loads.

Another identical IC, IC3, is used to switch the ground ends of the four PGA gain resistors. Note that while the coils of RLY17-20 are connected to outputs of both IC3 and IC4, only those outputs on IC4 are programmed to pull low by the software; the extra connections are simply for PCB routing convenience.

While we're only using 24 of the 32 available outputs, we need four ICs rather than three. That's because if the same IC was used to switch relay coils and the PGA gain resistors, the ground shift caused by the much larger relay coil currents would affect PGA gain accuracy.

IC1-IC4 are daisy-chained with a single 3-wire SPI serial bus. Serial data is fed to pin 2 (D_{IN}) of IC3 and is shifted out eight clock cycles later at pin 9 (D_{OUT}). This signal is fed to IC4's D_{IN} and thence on to IC2 and IC1 in a similar manner. Pin 15 of each IC is the data clock (SCK) and these are driven in parallel. Once 32 bits have been shifted through all four ICs, the parallel-connected RCK inputs (pin 10) are pulsed high, transferring that data to the output latches.

The fourth control line, G-bar (pin 8) is also connected in parallel between the four ICs and this is pulled high initially by a 30kΩ resistor from the 5V supply, disabling all 32 outputs by default. It isn't until data is loaded into the output latches that the micro pulls this line low, enabling the ICs.

Since IC1-IC4 run off 5V and their inputs are not compatible with 3.3V logic levels, as used by the PIC32 micro, all four of these lines are driven by 5V-tolerant open drain outputs on the micro and each line has a pull-up resistor from the 5V supply. The lines driving the D_{IN} and SCK inputs have a 1kΩ pull-up resistor as these need to be switched at a much higher frequency than the other control lines (ie, each toggled up to 32 times when the relay and PGA states are to be updated, compared to once).

Protection circuitry

Several protection features prevent damage in case the device's outputs are back-driven by excessive voltages or currents, especially in current reference mode. If this happens, the outputs are disconnected by RLY17.

The maximum continuous current for Q1 is 5A, as in this case, the 0.1Ω 3W shunt dissipating $5A^2 \times 0.1\Omega = 2.5W$. But the dissipation in Q1 itself depends on both the current and its drain voltage. While it can handle more than 2.5W for short periods, in the long term, it can overheat.

The software keeps track of the drain voltage by monitoring the output of IC6b, which buffers a voltage derived from Q1's collector. The divider resistors at its pin 5 non-inverting input have an effective ratio of around 45 times and bias the result by 2.5V, allowing it to sense voltages from well below 0V up to about 36V.

This is important since if the drain is pulled below ground, Q1's parasitic diode could conduct a lot of current, quickly overheating it. So if its drain goes below -0.5V or above its +30V rating, it's immediately disconnected.

The micro also monitors the current through Q1 via op amp IC6a which amplifies the shunt voltage by a factor of 6.75, giving 675mV/A, allowing measurement of up to 5A. Again, should this limit be exceeded, the output will immediately be disconnected.

While operating as a current reference, the micro subtracts the implied shunt voltage (ie, 0.1Ω times the measured current) from the drain voltage and then multiplies this by the current to obtain the instantaneous dissipation. This is then integrated over time, with a thermal model allowing for heat to be radiated and conducted away from Q1.

The micro therefore continuously estimates Q1's junction temperature and can disconnect the output should it approach a dangerous level (>125°C). This allows relatively high dissipation to be maintained in Q1, for higher reference currents, as long as they are only brief tests. The user can safely connect the test load and allow the unit to disconnect before Q1 overheats. The estimated junction temperature is displayed on the TFT display while using the current reference mode.

Additional protection features operate when the buffered output is enabled. If OUT+ is pulled above 39.5V, zener diode ZD2 conducts and switches on NPN transistor Q2, pulling pin 10 on the Micromite low. It then switches off RLY17 to protect IC5. Similarly, if OUT+ is driven negative, Q3 switches on and also pulls pin 10 low.

Self-calibration support

The 2.5V reference's initial accuracy is good and it does not require calibration. However, should you have the equipment to accurately measure its output, the software will allow you to enter the exact measured reference voltage for improved precision.

But the PGA gain is not necessarily as accurate as REF1; it should be within ±0.25% with a V_{REF} of 5V, 7.5V or 10V due to the use of 0.1% resistors but this is already worse than REF1's tolerance. At higher gains, the gain error could exceed 1%.

Fortunately, this can be automatically corrected by the software. It measures the actual PGA gain on each range the first time the unit is powered up and this can be repeated at any time, via the touchscreen user interface.

It works as follows. First, the PGA is set up for a gain of two, ie, V_{REF} = 5V. Then, relays RLY17, RLY18 & RLY19 are energised and the precision divider is set for a ratio as close to 2:1 as possible. In theory, this should result in a voltage very close to 2.5V at the output of IC5c, since the PGA's gain of two and the attenuator's gain of one-half should cancel out.

The difference in the output of IC5c and the output of REF1 is amplified by a factor of -271 by precision op amp IC5b and fed to pin 3 of CON2, which is connected to one of the Micromite's analog inputs. Pin 4 of CON2 is connected to the 2.5V reference rail. The micro measures the voltages at pins 3 and 4 and compares them.

If the PGA's gain is actually greater than two then the output of IC5c will be more than 2.5V and so the output of IC5b will be below 2.5V (it's an inverting stage). The gain factor of 271 means that even though the micro's ADC only has 10-bit precision, the micro can accurately measure the error. It can then adjust the precision divider's ratio and re-measure, repeating this until the output of IC5c is as close to 2.5V as possible.

Then, by using the attenuation setting and difference between the voltages at pins 3 and 4, the micro can calculate the exact voltage at V_{REF} when the PGA is set for a nominal gain of two. The software will then use this value to determine the correct divider ratio to get an accurate reference voltage between 2.5V and 5V.

This process is repeated for the other PGA gain settings, for example, PGA gain is set to three times (V_{REF} = 7.5V) and the attenuator is set to one-third; PGA gain is set to four times (V_{REF} = 10V) and the attenuator is set to one-fourth, and so on.

Note that this process takes a few seconds because the micro needs to wait for the output of the PGA to settle each time before performing measurements. The 100nF capacitor across its feedback resistor, required for stability and low noise operation, does take a little time to charge (~one second).

Once all the PGA gain measurements are made, the results are stored in flash memory for future use. They can be overwritten later if necessary. Similarly, if the user provides a more accurate measurement of REF1's output, this too is stored in flash.

Changing The R/2R Resistor Ladder Value

As mentioned in the text, the 12kΩ resistor value used in the divider ladder is not critical. If all the 12kΩ resistors are changed to another, similar value (eg, 10kΩ), you only need to change two additional components: the 3kΩ and 1.5kΩ resistors in the PGA. These should be as close as possible to 1/4 and 1/8 the ladder resistor value. For example, for 10kΩ ladder resistors, use 2.4kΩ and 1.2kΩ respectively.

Current mode calibration

The easiest way to calibrate the current sink is to use an accurate 4-wire resistance meter to measure the shunt's actual resistance and program this into the unit via the touchscreen. This is then stored in flash memory and used to compensate the control voltage.

The shunts included with our short-form kits will be supplied with a resistance reading made in this manner, using an accurate bench meter.

In theory, you could calibrate the unit by measuring the actual current sunk/sourced and adjusting the shunt value until it matches the set value. However, the average DMM only has a DC current measurement accuracy of ±1%, so that's a non-starter.

A more practical approach would be to purchase a 0.1% resistor of around 1kΩ. You would then check and possibly adjust your DMM's accuracy measuring 10V, using this unit. Next, set the unit to current mode and program it to sink 10mA, then apply 12V to OUT+ via the 1kΩ precision resistor. You can then adjust the unit's shunt value setting until you measure exactly 10V across this resistor (10mA x 1kΩ = 10V).

Coming next month

Next month, we'll describe how to assemble the PCB, attach the Micromite LCD BackPack, program it and mount it inside a box. We'll also show screen grabs and explain how to use it. SC

Micromite Plus Explore 100

Pt.2: By Geoff Graham

Last month, we introduced the Explore 100 module, described its features and gave the circuit details. Pt.2 this month gives the full assembly details, describes the display mounting and describes the setting-up, testing and fault-finding procedures. We also show you how to configure the touchscreen and configure the unit for use as a self-contained computer.

THE ASSEMBLY of the Explore 100 is straightforward, with all parts mounted on a 4-layer PCB coded 07109161 and measuring 135 x 85mm. This board mounts on the back of a 5-inch touchscreen LCD panel and plugs directly into a matching pin header on this panel.

Other LCD panels of various sizes can also be used but some of these have to be connected to the Explore 100 via a flat ribbon cable as described later.

Fig.2 shows the parts layout on the PCB. There are only four surface-mount parts: the Micromite Plus PIC32 microcontroller, its core filter capacitor, reverse polarity protection Mosfet Q1 and the USB socket(s). The remaining parts are all through-hole mounting types.

A complete kit (minus the LCD) is available from the SILICON CHIP Online Shop, as are various individual parts. You can purchase the PCB separately from the SILICON CHIP Shop or from Graeme Rixon (see parts list in Pt.1).

Graeme is also offering a kit with the four surface-mount parts already soldered in place and the microcontroller programmed with the latest version of MMBasic – see his website at: http://www.rictech.nz/micromite-products for details and prices. Note that his version of board does not include the microSD card socket or the optional micro-USB power socket.

The PIC32 chip has a pin spacing of 0.5mm and can be soldered with a standard soldering iron. The recommended soldering technique was described for the Explore 64 in the August issue, so we won't repeat it here. Just remember to use plenty of flux and keep only a very small amount of solder on the iron's tip.

Following the microcontroller, you should then solder the IRF9333 MOSFET (Q1), the mini USB connector (and micro USB connector, if you're using that) and the 10μF SMD capacitor. The recommended technique for all of these was also described in August.

If you aren't fitting Q1 then bridge the solder pads which would normally

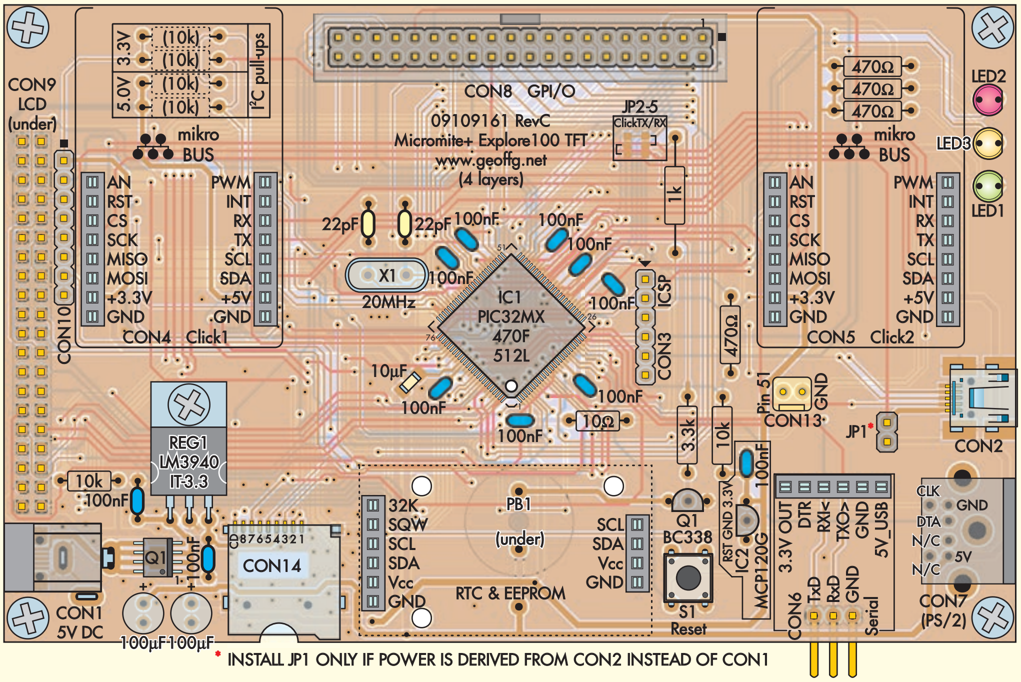
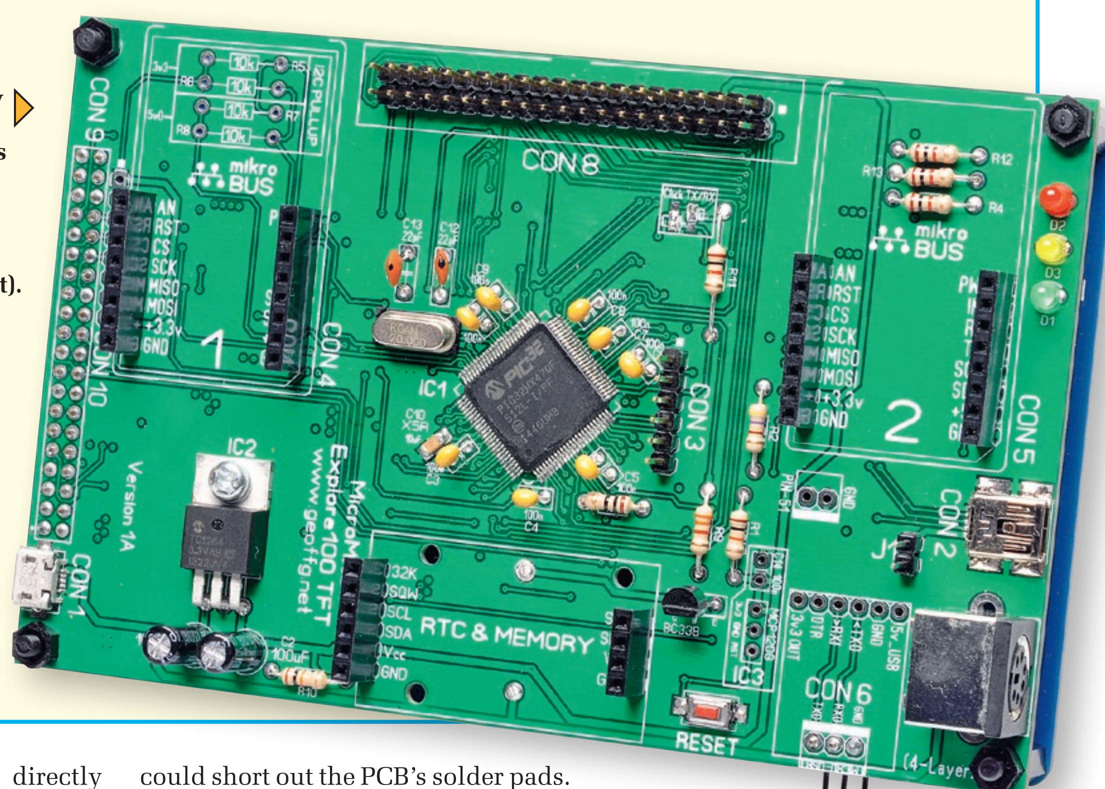


Fig.2: follow this parts layout diagram to build the PCB. The Explore 100 uses mostly through-hole components, with just five surface-mount parts (including the PIC32 micro). CON1 can be either a 2.1mm DC power connector or a micro-USB socket (the SILICON CHIP version of the PCB accepts both). Note that the SILICON CHIP PCB also includes a micro-SD card socket (CON14), whereas the original PCB simply includes a header for connecting the card socket (CON10).



This photo shows an early prototype version of the Explore 100. The PCB uses four copper layers and was designed by Graeme Rixon of Dunedin, NZ. Be sure to install the PIC32 microntroller first (see text).

be underneath it. This will directly connect the 5V input to the rest of the Explore 100.

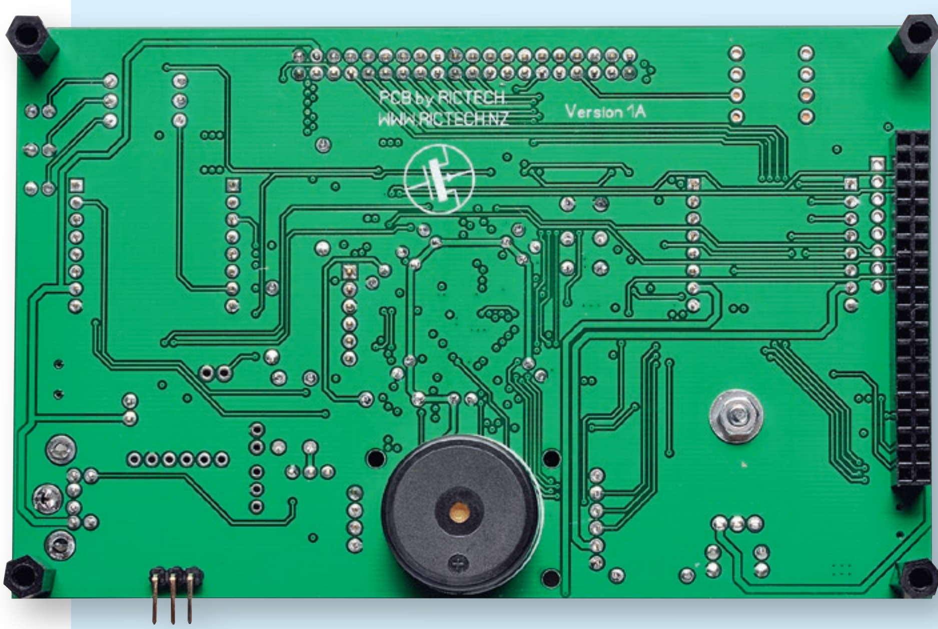
When fitting the remaining components, use the normal approach of inserting and soldering the low-profile components first (ie, starting with the resistors) and then working up to the taller items such as the header sockets.

When you come to crystal X1, unless you are using a PCB supplied by SILICON CHIP, you should mount it one or two millimetres off the PCB so that there is no danger that the metal case could short out the PCB's solder pads. Alternatively use a plastic mounting pad for the crystal as we did. The SILICON CHIP PCB has solder mask over the crystal's pads so this shouldn't be an issue and you can solder it flush.

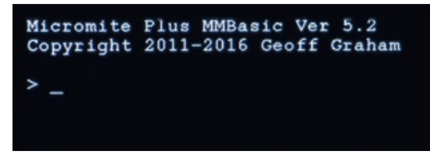
Regulator REG1 must be attached to the PCB using an M3 x 6mm machine screw and nut before soldering its leads. It should be in good contact with the PCB, so that the top copper layer acts as a heatsink.

There are a group of closely-spaced pads on the PCB marked "Click TX/RX" (JP2-5). These pads allow you to reverse the serial Tx and Rx lines for Click boards. **Normally though, you will want the two pairs of pads joined which are marked with brackets, so solder across these pads initially.**

The piezo buzzer mounts on the underside of the PCB. There is provision for two different types: a large 23mm buzzer for noisy locations and a smaller 14mm device for normal use.



The piezo buzzer and the 40-way connector for the LCD panel mount on the rear of the PCB. The connector plugs directly into a matching pin header on the back of the 5-inch LCD panel (see photos and page 71, August 2016).



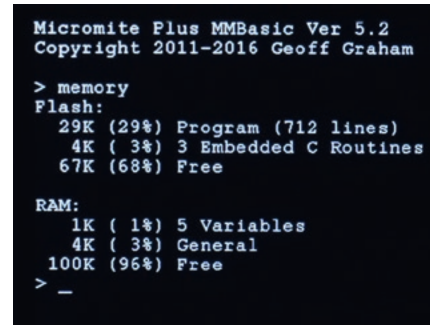
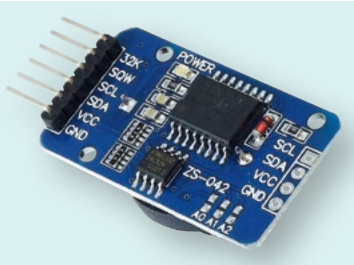


Fig.3: when you have configured the Explore 100 as a stand-alone computer (OPTION LCDPANEL CONSOLE) you should be rewarded with the command prompt on the LCD panel, as shown in the screen grab at top. Pressing the Reset button will then bring up the full MMBasic start-up banner (above).

There are seven 0.1-inch pitch female header sockets of various sizes on the board. They can be sourced individually but it is simpler to use the more readily available 50-pin single row header sockets and cut them to size. This can be done using a pair of side-cutters to cut the middle of one pin (thereby sacrificing that pin). The resultant jagged ends can be smoothed with a small hand file.



This is the RTC module that the Explore 100 is designed to use. It employs the Maxim/Dallas DS3231 which can keep the time to better than ±2ppm and its battery back-up facility will retain the time during power outages. Note that the existing pin header has to be removed and two straight pin headers soldered to the underside of the PCB at both ends of the module.

The Microchip MCP120 reset supervisor is only required as a protection against power supply issues so it and its associated 100nF capacitor are optional. The specified MCP120 is in a TO-92 package so be careful to not confuse it with the BC337/338 transistor which is also in a TO-92 package.

Real-time clock module

The Explore 100 has provision for a real time clock (RTC) module. This is optional but we strongly recommend it, since without it, the time setting of the Micromite Plus will be lost on power-up or reset.

Use a module that's based on the Maxim DS3231 IC as these are accurate and low in cost. They are available from the Silicon Chip Online Store or online from places like eBay, AliExpress and Banggood.com. Search for "DS3231". If you are purchasing online, make sure that the module matches our photograph so that it will fit the footprint on the PCB.

To prepare the module for the Explore 100, you need to solder a 4-pin header to the underside of the module at one end and a 6-pin header at the other end. Some modules come with a pin header soldered to the top of the module and that will need to be removed first. With the pin headers in place, it's then just a case of plugging the module into the socket and running the configuration commands listed later in this article.

Display mounting

If you are planning on using a 5-inch display, you should solder a 40-pin dual-row female header socket on the underside of the board at the position marked CON9 (see photo). Then, the Explore 100 can mount on the back of the panel using either four M3 x

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	2	10kΩ	brown black orange brown	brown black black red brown
❏	1	3.3kΩ	orange orange red brown	orange orange black brown brown
❏	1	1kΩ	brown black red brown	brown black black brown brown
❏	4	470Ω	yellow violet brown brown	yellow violet black black brown
❏	1	10Ω	brown black black brown	brown black black gold brown

12mm tapped spacers and eight M3 x 6mm machine screws, or four 12mm untapped spacers and four M3 x 16mm machine screws and nuts.

The Explore 100 will also plug directly into a 4.3-inch or 7-inch display but the mounting holes for the display will not line up. If you want to use one of these displays, a better solution would be to mount the display panel separately from the PCB and then use a 40-way ribbon cable fitted with IDC connectors to join them.

If you are using a ribbon cable, you will need to use a 40-pin male header plug for CON9. Incidentally, the required cable is the same as the old IDE hard disk cables used in old PCs, so you might already have a suitable cable ready to go. This cable should be as short as possible, ideally under 120mm. This is because the LCD panel can draw a lot of current (up to 750mA) and a large voltage drop in the ground wire can upset the logic levels seen by the LCD and the Micromite.

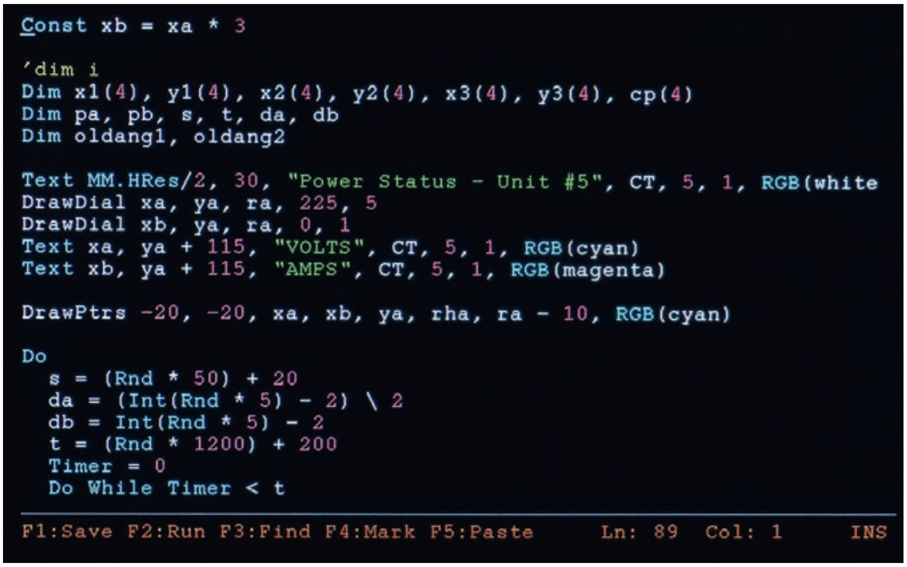


Fig.4: a nice feature of the Micromite Plus is the in-built program editor. This can edit a program in one session and its usage will be familiar to anyone who has used a standard editor (eg, Notepad in Windows). As shown, it colour-codes your program, with keywords in cyan, numbers in pink, comments in yellow and so on.

Testing & fault-finding

The test procedure described in the August 2016 issue for the Explore 64 also applies to the Explore 100, so we'll just summarise the steps required. First, if not already programmed, the microcontroller must be programmed with the Micromite Plus firmware using a PIC32 programmer such as the PICkit 3. You then connect a USB-to-serial converter to the console (see August issue) and check that you can get the MMBasic command prompt.

If you do not see this prompt, the fault could be with the Micromite or your connection to the console. First measure the current drawn by the Explore 100 without the display or any Click boards, etc attached. It should be 90-100mA after IC1 has been correctly programmed with the Micromite Plus firmware. Anything greatly more or less will indicate that you have a problem.

For example, a current drain of less than 15mA indicates that the MMBasic firmware has not been loaded or is not running.

In Pt.1, we went through the fault-finding steps in detail but essentially, you need to check that the correct power voltages are where you expect to see them, that the 10µF SMD capacitor (connected to pin 85) is present and correct, the crystal and its associated capacitors are correct and that all of IC1's pins have been correctly soldered. Also, make sure that you have properly programmed the firmware.

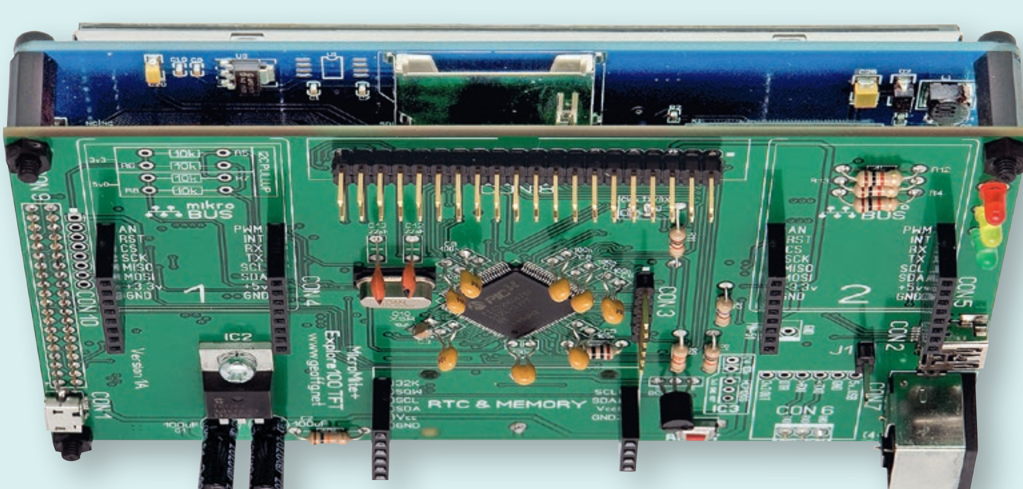
If the current drain is about right, then the fault is almost certainly with the USB-to-serial converter that you are using and its connections to the Explore 100. Again, refer to the August issue for the fault-finding procedure.

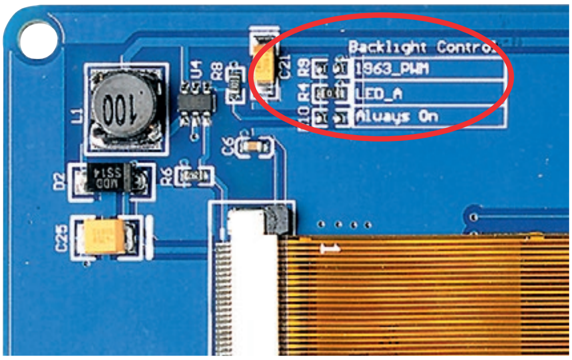
Configuring the touch-screen

Micromite Plus features can be enabled or disabled via OPTION commands which are saved in non-volatile memory inside the chip and automatically re-applied on start-up. These commands must be entered via the console (serial or USB).

With the command prompt dis-

The Explore 100 is designed to work with LCD panels that use the SSD1963 display controller which range in size from 4.3-inch (diagonal) to 8-inch. The mounting holes and physical dimensions of the PCB are designed to match the 5-inch version of this display. The PCB mounts onto the back of the display with four spacers, one at each corner, which creates a single rigid assembly.





As explained in the text, if you move the 0Ω resistor from position "LED_A" to "1963_PWM" you will be able to control the display's brightness in 1% steps. This photograph shows the back of a 5-inch display but the other display sizes each have a similar set of jumper positions.

played in the terminal emulator window, the first step is to configure the display. Enter the following command at the prompt:

```
OPTION LCDPANEL SSD1963_5,
LANDSCAPE, 48
```

This tells the Micromite that a 5-inch display is connected in landscape orientation and that pin 48 is used for backlight control. You have other options for the LCD panel size and orientation and these were listed in Pt.1.

You can now test the LCD panel by entering the command:

```
GUI TEST LCDPANEL
```

This will continuously draw a sequence of overlapping coloured circles. To terminate the test, press the space bar.

The next step is to configure the touch interface. Even if you are not going to use the touch facility in your programs, you will still need to set it up. That's because the touch controller will interfere with access to the SD card if it is physically present but not configured. To set this up, enter the following command:

```
OPTION TOUCH 1, 40, 39
```

This specifies that pin 1 is used for the touch controller's chip select line, that pin 40 is used for the IRQ (interrupt request) signal and that pin 39 controls the buzzer. The touch sensing then needs to be calibrated and this is done with the following command:

```
GUI CALIBRATE
```

The screen will display a target in the top left corner. Using a pointy but blunt stylus, press on the exact centre of the target. After a second, the display will blank and then present the next target on the top right. Work around all four corners in this manner to calibrate the display.

When you have finished, the Micromite should respond with "Done. No errors" or you might get a message indicating that the calibration was not accurate. You can ignore this if you wish but it would be better to redo the calibration, taking more care the second time.

You can test the touch feature with the command:

```
GUI TEST TOUCH
```

This will blank the LCD and when you touch it, the Micromite will draw a dot at the location that it has determined you touched. If your calibration was accurate, the dot should appear directly under the spot that you touched. Press the spacebar on the console's keyboard to return to the command prompt.

Configuring the SD card

The next step is to configure the Explore 100 to use the SD card socket that's mounted on the LCD panel. The required command is:

```
OPTION SDCARD 47
```

This specifies that pin 47 is connected to the chip select signal. **Alternatively, if you are using the on-board microSD card socket or the alternative SD card pin header (CON10), the chip select will be pin 52 instead.** The microSD card socket and CON10 have pin 53 connected to the Card Detect switch, so you can also specify this if desired. CON10 also provides a connection to pin 17 for the Write Protect/read-only (WP) pin, if used. Refer to the circuit and to the "Micromite Plus Addendum" at www.siliconchip.com.au/Shop/6/2907 for more details,

To test the SD card, use the FILES command which will list all the files and directories on the card. During testing, we discovered a strange issue where some SD cards would not respond and further, they disabled the touch controller on the LCD panel, requiring a power cycle to recover. It is not obvious if the issue is with the LCD panel, the SD card or the firmware but the solution is to use another SD card.

If we subsequently discover that this can be fixed with changes to the firmware, we will release an updated version so it would be worth checking the author's website (http://geoffg.net/micromite.html) from time to time if you run into this problem.

If you have installed a a real time clock (RTC), this also must be made known to MMBasic. The command to do this is:

```
OPTION RTC 67, 66
```

The command defines the I/O pins used by the RTC and instructs MMBasic to automatically get the correct time from the RTC on power-up or restart. You then need to set the time in the RTC, as follows:

```
RTC SETTIME year, month, day, hour,
min, sec
```

Note that the time must be in 24-hour notation.

Self-contained computer set-up

Before you can use the Micromite

Two Explore 100 PCB Versions

As noted last month, the Explore 100 PCB was designed by Graeme Rixon of Dunedin, NZ – see www.rictech.nz/micromite-products

The PCB sold by Silicon Chip is virtually identical to this board, the main difference being that we've added an on-board micro-SD card socket (CON14). It's linked directly to the original SD card header on the PCB (CON10).

The Silicon Chip PCB can also accept either a DC power socket or a micro-USB socket for CON1, whereas the alternative PCB now has provision for a DC socket only (in place of the original micro-USB socket).

Finally, note that the PCB shown in the photos is a prototype and the final version differs in a few respects. In particular, the earlier version did not include Mosfet Q1 in the supply line to provide protection against reversed supply polarity.

Plus as a self contained computer, you will need to run some more configuration commands. The first is to tell the Micromite Plus to echo all console output to the LCD panel. The command to do this is:

OPTION LCDPANEL CONSOLE

Following this command, you should see the command prompt (>) appear on the LCD panel. If you now try typing something on your terminal emulator, you will see that these keystrokes are echoed on the LCD screen.

Next, you need to tell the Micromite Plus that a PS/2 keyboard is connected using the following command:

OPTION KEYBOARD US

At this point you should be able to type something on the keyboard and see the result on the LCD screen. For example, try entering PRINT 1/7 and MMBasic should display 0.142857.

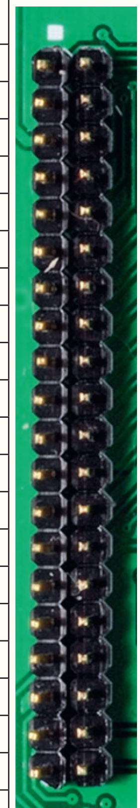
When you set up the keyboard, you also have the choice of a number of different keyboard layouts. The command above specifies the US layout which is common in Australia and New Zealand but other layouts that can be specified are United Kingdom (UK), French (FR), German (GR), Belgium (BE), Italian (IT) or Spanish (ES).

All these configurations are saved in non-volatile (flash) memory and will be automatically recalled on power-up or reset.

Now disconnect the serial console and cycle the power. The unit will start up and display the MMBasic banner and copyright notice on the LCD, followed by the command prompt.

You might wonder if the USB interface requires setting up but this is not necessary. The Micromite constantly monitors the USB socket and if it detects that it is connected to a host, it will automatically change its configuration to suit.

Fig.5: Explore 100 I/O Pin Allocations (CON8)



	Pin No.	Pin No.	
Ground		97	5V
5V Output		96	5V
3.3V Output (200mA max.)		95	5V
Count - Wakeup - IR - ANA	78	92	5V
ANA	77	91	5V
Count - ANA	76	90	5V
ANA	44	88	5V - COM1 Rx
COM1 Enable - ANA	43	81	5V - Count
ANA	41	80	5V
ANA	35	79	5V - PWM 1C
Count - ANA	34	74	5V - PWM 1A
ANA	33	72	5V – SPI OUT (MOSI)
ANA	32	71	5V – SPI IN (MISO)
COM3 Rx - ANA	26	70	5V – SPI Clock
COM3 Tx - ANA	25	68	5V – PWM 1B
COM1 Tx - ANA	24	67	5V - I^{2}C DATA
COM2 Rx - ANA	22	66	5V - I^{2}C CLOCK
ANA	21	61	5V
COM2 Tx - ANA	20	60	5V
ANA	14	59	5V

(1) Pin No. refers to the number used in MMBasic to identify an I/O pin.
(2) All pins are capable of digital input/output and can be used as an interrupt pin.
(3) ANA means that the pin can be used as an analog input.
(4) 5V means that the pin is 5V input tolerant.
(5) COUNT means that the pin can be used for counting or frequency/period measurement.

Further options

Some of the above configuration commands have additional options. These are not important but we list them here in case you want to experiment with them. The command for directing the console output to the LCD panel has four optional parameters. The full command is:

OPTION LCDPANEL CONSOLE font, fc, bc, blight

- "font" is the font to be used on power-up. The Micromite Plus has five suitable fonts built in and numbered 1 to 5, with the larger numbers designating a larger-sized font. If the font is not specified then it will use font number #2.
- "fc" and "bc" are the default foreground and background colours to be used on power-up. If you like yellow letters on a blue background (ugh), this is how you do it. Refer to the MMBasic user manual for details on the RGB() function that can be used to specify colours.
- "blight" is the LCD brightness setting to be used on power-up. By default, the Micromite Plus will set the LCD's backlight to full brightness but this can consume a lot of power (up to 500mA). Reducing it will only make a small difference to the perceived brightness but will considerably cut the display's power consumption.

The backlight's power requirement can be important if you are building a portable computer using the Micromite Plus. Setting the brightness to one third (ie, "blight" set to 33) will almost triple the battery life while still being bright enough for normal use.

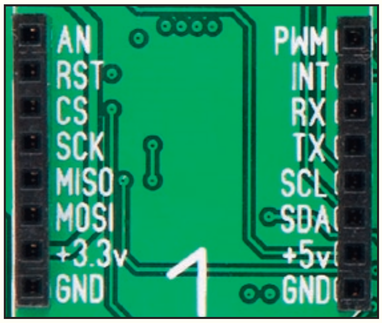
LCD backlight

The LCD panels used with the Explore 100 have two methods of regulating the backlight intensity. Both methods use a pulse width modulated (PWM) signal to rapidly switch the backlight on and off. The first requires the Micromite to generate this signal on the pin marked "LED_A" on the LCD's interface connector. The second requires the Micromite to send a command to the SSD1963 display controller, requesting it to generate the required PWM signal.

Either will work but the advantage of using the SSD1963 to do it is that it can vary the brightness with a finer degree of resolution (1% steps), whereas the Micromite-generated signal has a

Fig.6: Click Board Pin Assignments

Click Board 1 Socket

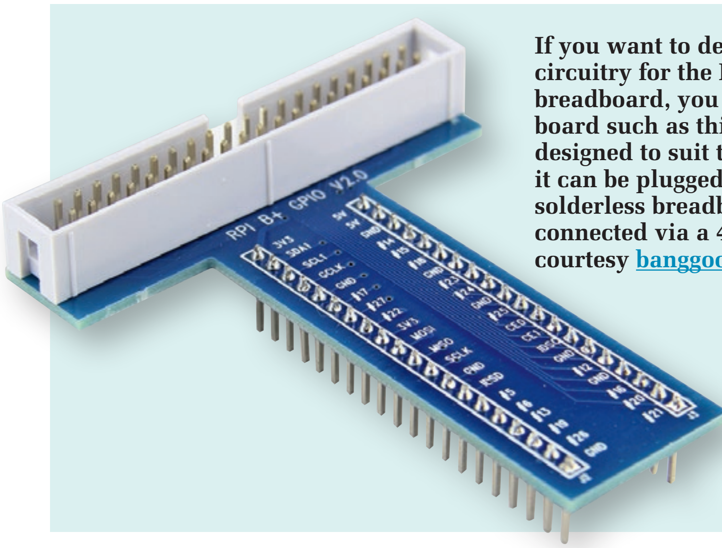


	Pin No.	Pin No.	
ANA	23	82	5V – PWM 2A
	29	8	5V
	28	26	COM3 Rx
SPI Clock – 5V	70	25	COM3 Tx
SPI In (MOSI) – 5V	71	66	5V – I²C Clock
SPI Out (MOSI) – 5V	72	67	5V – I²C Data
3.3V			5V
Ground			Ground

Click Board 2 Socket

	Pin No.	Pin No.	
ANA	27	9	5V – PWM 2B
	73	7	5V
5V	69	26	COM3 Rx
SPI Clock – 5V	70	25	COM3 Tx
SPI In (MOSI) – 5V	71	66	5V – I²C Clock
SPI Out (MOSI) – 5V	72	67	5V – I²C Data
3.3V			5V
Ground			Ground

(1) Pin No. refers to the number used in MMBasic to identify an I/O pin.
(2) All pins are capable of digital input/output and can be used as an interrupt pin.
(3) ANA means that the pin can be used as an analog input.
(4) 5V means that the pin is 5V input tolerant.
(5) COUNT means that the pin can be used for counting or frequency/period measurement.



If you want to develop additional circuitry for the Explore 100 on a breadboard, you can use an adapter board such as this unit. Originally designed to suit the Raspberry Pi, it can be plugged into a standard solderless breadboard and can be connected via a 40-way cable. Photo courtesy banggood.com

coarse control (5% steps). The difference is not normally noticeable but it can be important if you want to smoothly vary the brightness up or down for a special effect.

By default, the LCD panel will be configured for the Micromite control but you can change it with a soldering iron. As shown in one of the accompanying photos, the LCD panel will have an area on its PCB marked "Backlight Control". To use the SSD1963 for brightness control, the 0Ω resistor should be moved from the pair of solder pads marked "LED-A" to the pair marked "1963_PWM".

Programming the I/O pins

Fig.5 shows the pin allocations for CON8, the 40-pin I/O connector. Each pin can be independently set as an input or an output and any pin can generate an interrupt to the running program on a rising or falling signal, or on both. Note that the I²C, SPI and COM3 serial interfaces are shared with the Click boards, if one of these is installed.

The connection between a Click board and the Explore 100 is via two eight-pin headers which carry the three communications interfaces (I²C, SPI and serial), some general-purpose signals (analog, PWM, interrupt, etc) and 3.3V and 5V power. The Click boards require either a 3.3V or 5V power supply and the Explore 100 supplies both. In addition, the outputs from the Click boards connect to 5V-tolerant inputs on the PIC32 so you can use 3.3V or 5V click boards without concern.

Fig.6 shows the I/O pin allocations for the two Click board sockets. The I²C, SPI and serial buses are common between the two sockets while the other signals (analog, PWM, etc) are separate.

As previously mentioned, the PCB includes a set of solder pads which can be used to reverse the serial signals used for the Click boards. These are marked "Click TX/RX" and normally you should jumper the solder pads marked on the silk screened with brackets. However, there is a chance that some Click boards will have their transmit (Tx) and receive (Rx) signals swapped and you can accommodate these by moving the solder blob to the other solder pads.

When it comes to programming for the Click boards, it is normally a case of consulting the data sheets for the device on the board. MikroElektronika often offer one or more example programs written in their mikroBasic language and these can be converted to MMBasic for the Explore 100.

Another feature of the PCB is the two general-purpose indicator LEDs described earlier. The yellow LED (LED3) is controlled by the Micromite pin 38 and red LED2 by pin 58. Note that the BASIC program needs to set the output low to illuminate these LEDs. On power-up, these pins will be in a high impedance state so the LEDs will default to off. SC

SILICON CHIP .COM.AU

REACTANCE - INDUCTANCE - CAPACITANCE - FREQUENCY READY RECKONER

How good are you at remembering formulas? If you don't use them every day, you're going to forget them!

Things like inductive and capacitive reactance? Series and parallel L/C frequencies? High and low-pass filter frequencies?

This incredibly useful reactance, inductance, capacitance and frequency ready reckoner chart means you don't have to remember those formulas – simply project along the appropriate line until you come to the value required, then read off the answer on the next axis!

Here at SILICON CHIP, we find this the most incredibly useful chart ever – we use it all the time when designing or checking circuits.

In fact, it's so useful we decided our readers would love to get one, so we printed a small quantity – just for you!

And here it is: printed a whopping A2 size (that's 420mm wide and 594mm deep) on beautifully white photographic paper, ready to hang in your laboratory or workshop.

If you don't find it as useful as we do, we'll be amazed! In fact, we'll even give you a money-back guarantee if you don't!#

Order yours today – while stocks last. Your choice of: Supplied fold-free (mailed in a protective mailing tube); or folded to A4 size and sent in the normal post.

But hurry – you won't believe you have done without it!

#Must be returned post paid in original (ie, unmarked) condition.

Read the feature in January 2016 SILICON CHIP (or view online) to see just how useful this chart will be in your workshop or lab!

NOW AVAILABLE, DIRECT FROM www.siliconchip.com.au/shop:

Flat – (rolled) and posted in a secure mailing tube — **$20.00 ea** inc GST & P&P*

Folded – and posted in a heavy A4 envelope — **$10.00 ea** inc GST & P&P*

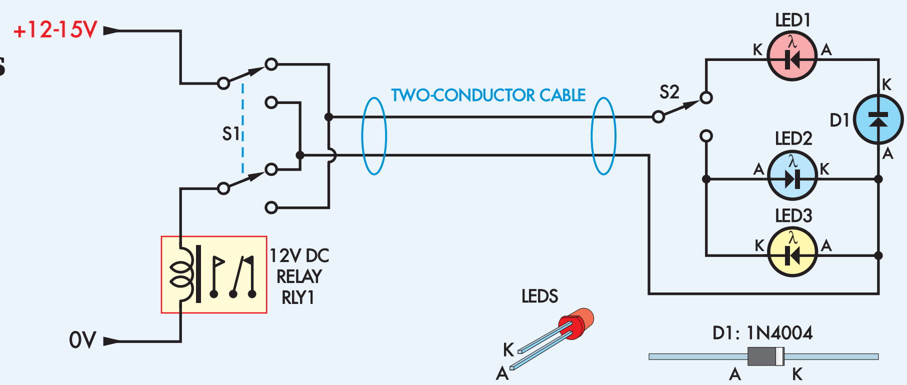
***READERS OUTSIDE AUSTRALIA:** Email us for a price mailed to your country (specify flat or folded).

ORDER YOURS TODAY – LIMITED QUANTITY AVAILABLE

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Dual-switch relay control logic using LEDs



This circuit uses LEDs both to indicate the status of two switches and the relay that they both control and to perform the logic needed to control that relay from both switches. It was designed to allow both indoor and outdoor switches to control a 12V LED lamp, illuminating the outdoor area.

The 12V DC coil relay was run off the same power supply. The LEDs and S2 were located indoors. All LEDs are rated for at least 50mA or 0.5W, as they must be able to pass the coil current for the relay, RLY1.

The outside 12V LED lamp is switched on via RLY1's COM & NO contacts.

With switches S1 & S2 in the positions shown, RLY1 is off and none of the LEDs are lit. If indoor switch S2 is toggled, blue LED2 lights and the relay coil is powered, switching on the outdoor light. In this mode, toggling outdoor switch S1 will not turn the light off but it will result in blue LED2 switching off and yellow LED3 switching on, to indicate that S1 is now overriding S2.

With indoor switch S2 off, outdoor switch S1 can be toggled to turn on the light. In this case, red LED1 lights up. Should the indoor switch be toggled off with S1 on, the relay will remain on and thus the outdoor light also stays on, preventing the person outside from being left in the dark. As explained above, yellow LED3 lights to indicate that both switches are in the on position.

Note that S1 effectively operates as a "changeover switch", ie, it swaps the connections to the 2-conductor cable when toggled.

Julian Sortland,
Hornsby, NSW. ($50)

Improvement to ducted home vacuum system

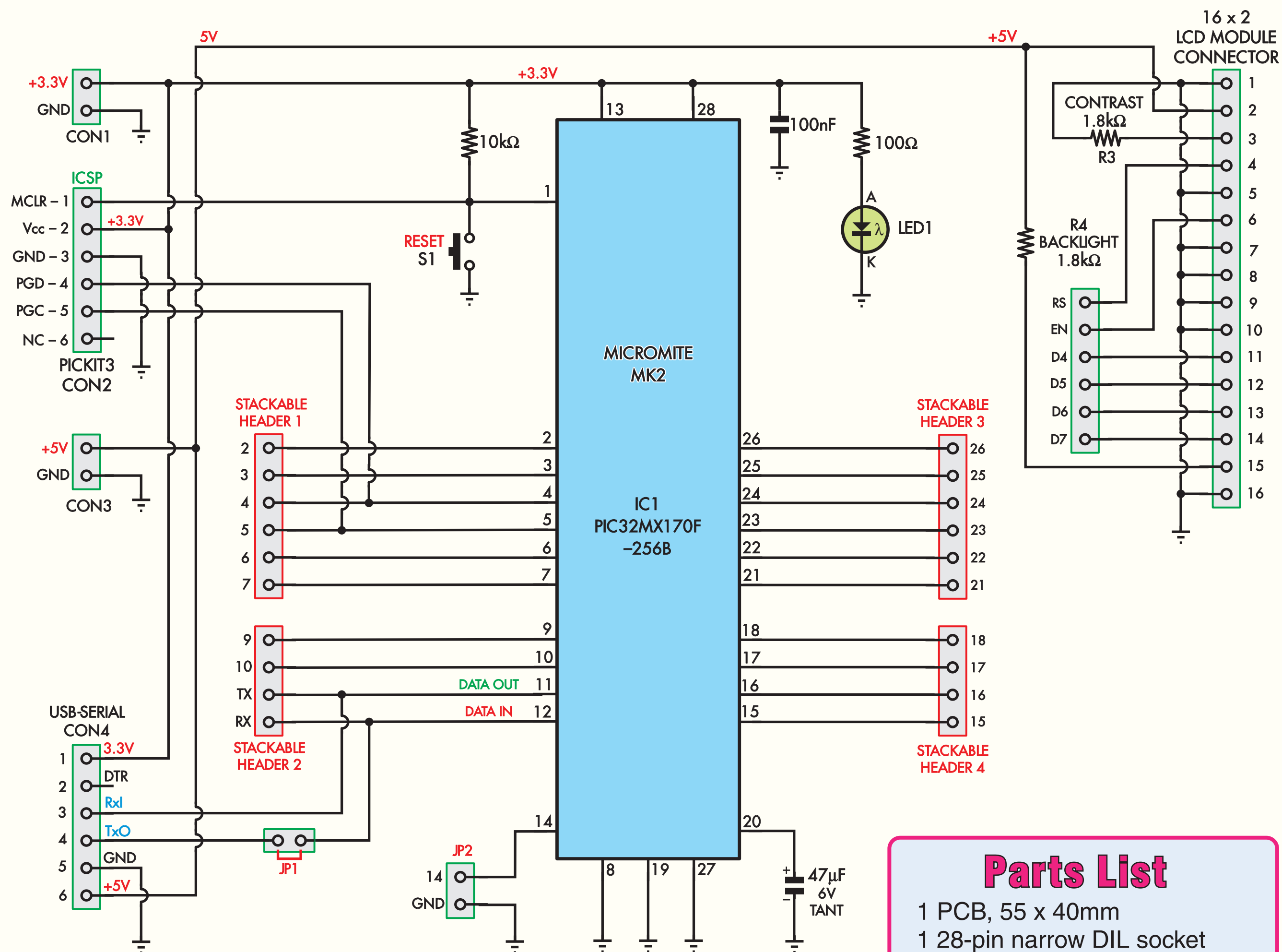
Ducted vacuum systems have a large vacuum unit with several hose inlets arranged around the home. The central vacuum unit starts automatically when the user connects the vacuum hose to an outlet. A simple switch mechanism in each of the outlets completes a low-voltage control circuit when the hose is connected.

The downside of this arrangement is that if you don't have a switchable hose, you find that you have to walk back to the inlet and unplug the hose a number of times during a typical cleaning session. You can upgrade to a switchable hose but they cost well over a hundred dollars.

A simple solution is to install a cheap wireless RF remote control switch near the central unit and clip the associated remote control fob to a cable tie on the end of the vacuum hose. These low-cost wireless RF Remote Control Switches are available on eBay or from KitStop (www.kitstop.com.au, as featured in the "Barking Dog Blaster Wireless Remote" article in the October 2012 issue). These typically have at least one set of relay terminals which are controlled remotely; the KitStop unit has two independent outputs.

You can power the relay/RF receiver from your vacuum unit if it uses a 12V DC control system. Mine uses 24VAC, so I used a small 12V plugpack instead. Wire the relay's NC (normally closed) contacts in series with the switches on the inlets. This means you can still use the vacuum system in case you misplace the remote control or its battery goes flat.

Roger Forsey,
Seaholme, Vic. ($40)



Micromite Mk2 Breadboard Adaptor

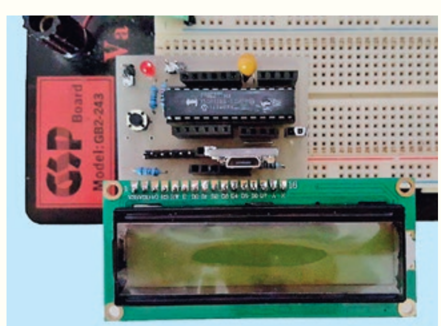
This simple design makes it easy to breadboard with the Micromite Mk2 without having to build the 44-pin module that uses the surface-mounting version of the chip. Essentially, it's a small (55 x 40mm) PCB with a 28-pin DIL socket on the top for the PIC32 chip, two rows of stackable pin headers to connect to the breadboard and optionally other points in the circuit, an on-board reset switch, power LED, bypass capacitors and a reset pull-up resistor.

The board also includes a number of extra sockets to make it easy to connect other modules to the Micromite. This includes a header socket for a 16 x 2 alphanumeric LCD, another socket for a USB/serial converter, an ICSP programming header for a PICkit 3 plus 3.3V and 5V power in/out headers. There's also provision for a jumper link between pin 14 (RB5) and ground. If you want to connect a USB/serial converter, use a CP2102-based module with a micro-USB socket and this should plug straight in. If you are using this module, its 5V USB power output will be routed to the LCD's power supply. Otherwise, you will need to feed 5V in separately via the 2-pin header provided.

The PCB is designed to allow the stackable headers, which connect to the breadboard, to be soldered on either a 0.6-inch or 0.7-inch pitch, depending on the type of breadboard you are using.

The PCB pattern and assembly overlay diagram (mmbreadboard.pdf) can be downloaded from the Silicon Chip website: siliconchip.com.au/Shop/10/3975 The parts required to build the module are listed above.

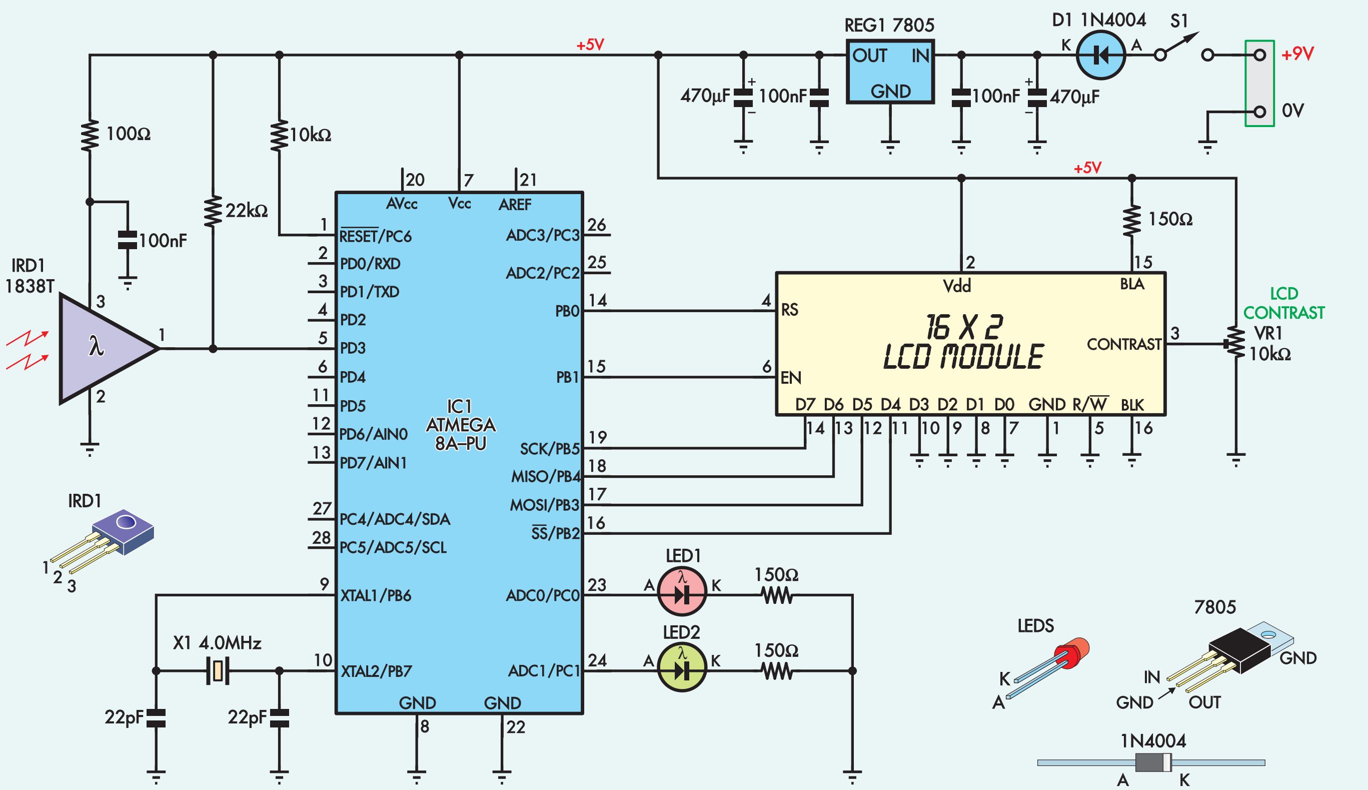
Gianni Pallotti,
North Rocks, NSW. ($50)



Parts List

- 1 PCB, 55 x 40mm
- 1 28-pin narrow DIL socket
- 1 47µF 6V Tantalum capacitor
- 1 3mm or 5mm LED
- 2 6-pin long pin stackable male/female headers
- 2 4-pin long pin stackable male/female headers
- 1 40-pin snappable male pin header
- 1 16-pin female header
- 1 6-pin female header
- 2 2-pin female headers
- 1 tactile switch

Resistors (0.25W 5%)
- 2 1.8kΩ (R3 & R4)
- 1 10kΩ 1 100Ω



Decoding Samsung & NEC remote control codes with BASCOM

Philips RC5 is the most common infrared protocol used with microcontroller projects, with NEC Pulse Distance Coding coming a distant second. This project shows how to decode those NEC transmissions, or those from a Samsung remote, using BASIC on an Atmel AVR processor. The received remote control codes are displayed on a 16x2 line alphanumeric LCD.

Both protocols transmit data using bursts of infrared light modulated at around 38kHz. With NEC's Pulse Distance Coding, each burst is 560µs long but the lengths of the pauses between the bursts depend on the value of the bit being transmitted. For logical 0, the pause is 560µs (1t) and for logical 1, it is 1680µs (3t).

Each data word transmitted has a start or leader code which is a pulse with a length of 9ms, followed by a 4.5ms pause. Eight bits of address data follow, and then the same eight bits but inverted. This is then followed by eight command bits and then the same eight bits inverted.

The data is transmitted twice for reliability. If each set of eight bits does not match the eight inverted bits, the data was corrupted and so can be ignored. In each case, the least significant bit (LSB) is transmitted first.

If a key is held down, after the first burst, the data will only consist of a 9ms leader code followed by a 2.25ms pause to signify the repeat and finally a 560µs burst to announce the end of transmission. This shortened data message is transmitted at 110ms intervals until the key is released. As a result, battery power use while a key is held down is reduced by about 65%.

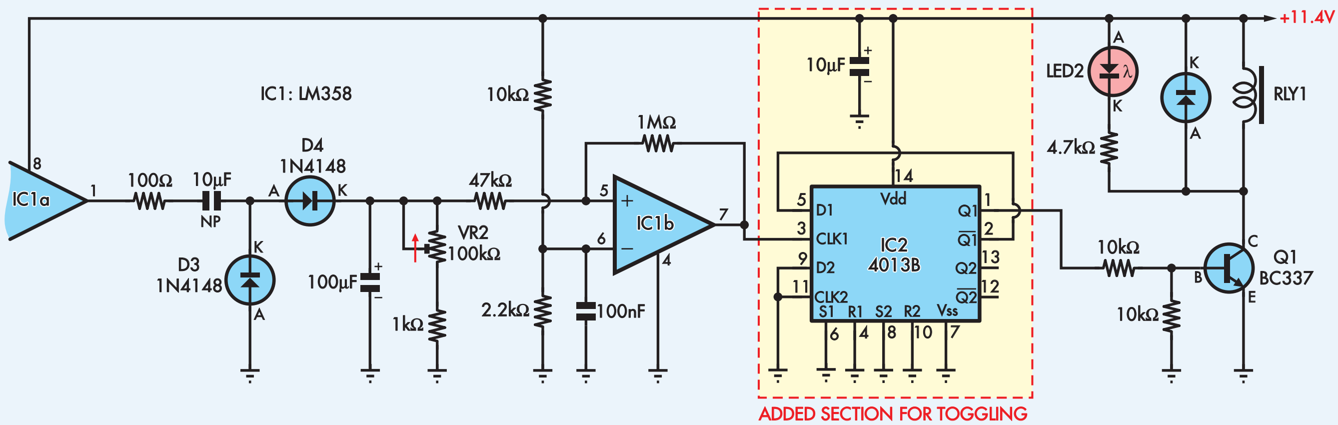
The decoder presented here was successfully tested with the following remote controls which use this encoding method: a Sanyo TV remote, Starsat Digital Satellite Receiver remote and Maxeeder Digital TV Receiver remote.

The Samsung protocol also uses Pulse Distance Coding with the same timings but the data encoding is different. In one version of the Samsung protocol used for the remote controls of LCD TVs, the address is 16 bits long while the command is just eight bits. In another version used for Samsung DVD players, the address is 16 bits and the command is also 16 bits long.

With the Samsung protocol, a button held down will cause the message to be repeated every 60ms. Some Samsung-compatible remotes (typically Samsung LCD TV remotes) use a 13.5ms leader pulse rather than 9ms as for the NEC protocol.

The address bits of remote controls are used to identify and limit the device to be controlled so that, for example, adjusting the volume of your TV will not affect the sound level of your DVD player. The command bits, in turn, serve to identify the individual key functions. For instance, one key is used to switch on the device, another one to change channels, etc.

As an example, my Samsung LCD TV remote control has 46 keys. Consequently there are 46 independent



Clap-on/clap-off switch

This addition to the Voice Activated Relay (VOX) circuit published in the July 2011 issue of SILICON CHIP changes it to operate as a "clap switch". Clap your hands and the relay turns on; clap again and the relay goes off.

The original VOX design switches the relay on for a set period after a certain signal threshold from the microphone is exceeded. This modification changes the relay to remain switched on until a second signal is detected from the microphone, at which time the relay is switched off.

The delay period of the VOX can then be used to control how quickly the relay is switched on and off with each signal.

The modification involves adding a flipflop between the Schmitt Trigger output (pin 7 of IC1b) and the drive to the transistor that powers the relay. This is a standard CMOS 4013B dual D flipflop with its data input connected to the Q1-bar output. This causes the Q1 output to transition from a high level to a low level upon receipt of the first clock pulse from the Schmitt trigger. Another high-going signal from the Schmitt trigger causes the Q1 output to switch low again.

The Q1-bar output is the inverse of the Q1 output, being high when the Q1 output is low and low when the Q1 output is high.

The reset and set inputs of the 4013B are tied low. The clock, data, reset and set inputs of the second D flipflop in the package are also tied low since this half of the IC is unused.

With this version of the circuit, it is recommended to set the VOX sensitivity so that it only responds to very loud noises close to the electret microphone (such as from a hand clap) to prevent nuisance triggering.

Barrie Davis,
Hope Valley, SA. ($50)

command numbers for these keys but only one address code is used for the device.

The circuit is based on an ATmega8 AVR microcontroller and 1838T infrared receiver module; virtually any standard IR receiver should be suitable. The protocol (NEC or Samsung) is displayed on the LCD when a command is received, along with the decoded address and command numbers. Reception of valid commands is indicated by LED2. To show a typical function use, two keys of the Samsung LCD TV remote control mentioned earlier will turn LED1 on or off.

The demodulated infrared signal is fed directly to the interrupt pin (PD3) of the micro. When the micro receives a signal, it initially checks whether it has a proper 9ms or 13.5ms leader pulse.

The micro then enters a loop to identify the bits of the address and the command on the basis of the lengths of pauses as described above. It then updates the display with the received data.

To check out the decoder, power it on, aim a remote control at it and momentarily press one key. LED2 should blink and the LCD will be updated with the protocol (NEC or Samsung) on the top line and the address and command/key number on the lower line.

The remote codes to switch LED1 are Address=224, Key=32 for on (Channel 1 button) and Key=160 for off (Channel 2 button). You can change the address and key code numbers in the do-loop of the software to suit your own remote control.

The software, "BASCOM NEC Samsung IR remote.bas" can be downloaded from the SILICON CHIP website (free for subscribers). It can be compiled into a hex file using the free demo version of BASCOM-AVR, available from: http://www.mcselec.com/index.php?option=com_docman&task=doc_download&gid=139

Mahmood Alimohammadi,
Tehran, Iran. ($60)

Circuit Ideas Wanted

Got an interesting original circuit that you have cleverly devised? We need it and will pay good money to feature it in the Circuit Notebook pages. We can pay you by electronic funds transfer, cheque (what are they?) or direct to your PayPal account. Or you can use the funds to purchase anything from the SILICON CHIP on-line shop, including PCBs and components, back issues, subscriptions or whatever. Email your circuit and descriptive text to editor@siliconchip.com.au

Vintage Radio

By Ian Batty

The Valve Mantel's Last Hurrah: Astor's DLP 2-Valve Receiver

Despite having just two valves, Astor's "cheap and cheerful" DLP mantel set still offers reasonable performance. It's a budget-priced set with some unusual design features and was designed to compete with early but still relatively expensive transistor portables.

SUPER-SIMPLE sets appeared quite early in the development of commercial receivers. Advanced sets were always more expensive compared to basic designs, so simpler sets attracted home constructors wanting their share of the "miracle" of radio.

Four and 5-valve superhet sets had become the design standard by 1940 but post-WW2 austerity led manufacturers to offer cut-down designs to keep prices low. Greater design complexity subsequently returned in the 1950s but a new challenge to valve radios emerged later in the decade with the introduction of the transistor.

Valve set manufacturers were stuck; they could survive either by offering high-end prestige designs or by offering "cheap and cheerful" sets aimed at undercutting the initial relatively high prices of transistor radios. The portability of transistor sets, for example, simply didn't justify their greater cost for those who simply wanted a kitchen mantel set that would sit on the fridge week after week.

The Astor DLP is one such cut-price kitchen mantel that was intended to compete with the early transistor portables. It uses just two valves but just how good is it?

First impressions

The Astor 3-valve DLP is built on a punched metal chassis with point-to-point wiring on tagstrips. Unusually, it sits at an angle within its moulded plastic case, as shown in one of the photos.

The controls are quite simple and consist of nothing more than a Volume/On-Off control and a large tuning dial with a 180°+ span. The dial directly drives variable-inductance coils to tune the aerial and local oscillator (LO) circuits (ie, this set uses permeability tuning rather than a variable tuning capacitor).

Circuit description

With three valve functions in just two "bottles", this must be the ultimate economy set, especially considering that it's a superhet design to boot. The cut-price features start with the tuned circuits – permeability tuning is cheaper to manufacture than a high-precision variable capacitor. In addition, permeability tuning systems are generally more robust than systems using conventional tuning gangs which are susceptible to corrosion, dust, dirt and mechanical wear.

As with other Astor sets, the original circuit diagram simply numbers the components in order. For example, the capacitors are numbered in order from largest non-electrolytic to smallest, with the electrolytics next and then the resistors (note: item #17 is not listed on the DLP's circuit).

It's an elegant method that aided assemblers during manufacture; they simply had to install numbered items

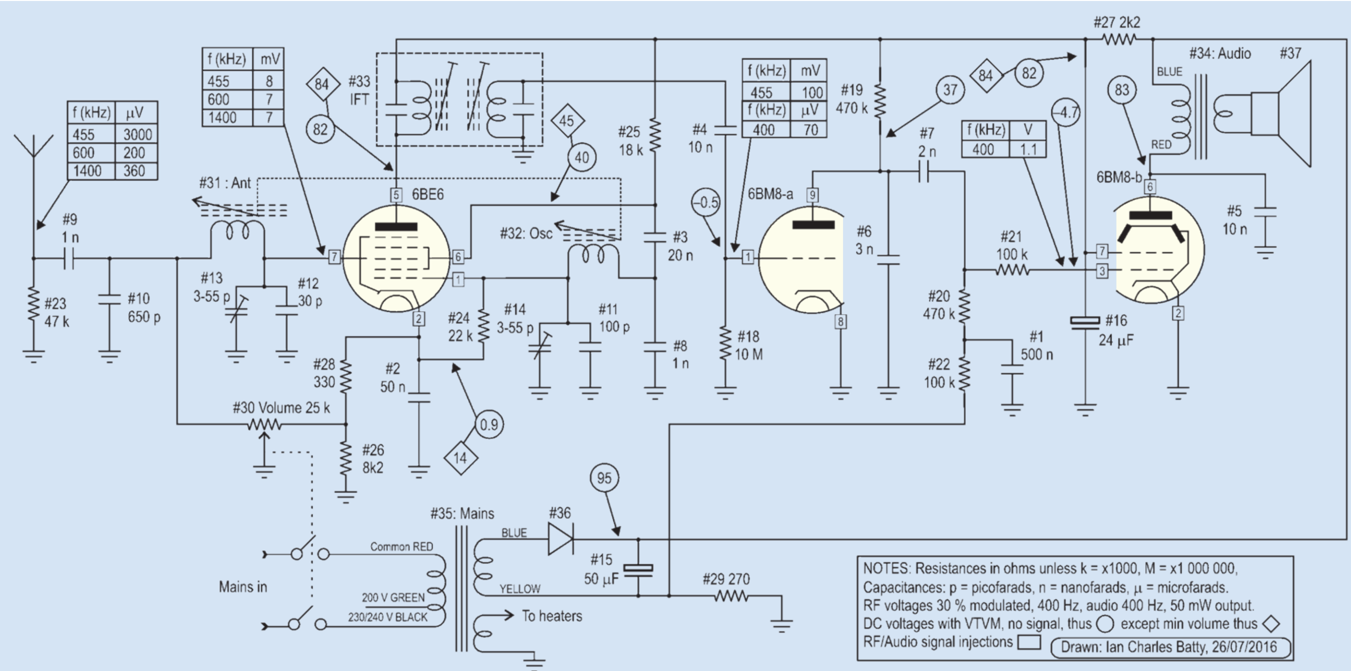


Fig.1: Astor's DLP mantel set is a superhet design using just two valves: a 6BE6 pentagrid converter stage and a 6BM8 triode-pentode which functions as a demodulator/audio preamplifier (6BM8a) and as an audio output stage (6BM8b). There's no IF amplifier stage, so the set's sensitivity is somewhat lacking compared to most other valve sets.

from bins in their appropriate locations in the chassis.

Fig.1 shows the circuit of the Astor DLP. It lacks of an IF amplifier stage and this, coupled with a low high-tension (HT) voltage (just over 80V), would seem to be a recipe for "radio deafness". If this cheap-and-cheerful set is to give any reasonable performance, Astor's designers must have pulled some magic tricks. But what were they?

The converter, a 6BE6 pentagrid, has a typical conversion conductance of some 450 microsiemens. In practice, a (high) IF primary impedance of 100kΩ would normally give a voltage gain of around 45, assuming plate and screen voltages of 100V.

This set, however, only applies some 40V to the screen and lowering the screen voltage causes a significant gain reduction in all screen-grid valves. So does the aerial circuit help compensate for the lack of gain in the converter stage?

Harking back to tuned circuit design in transmitters, capacitors #10, #12 & #13 in this set form a tuned circuit with variable inductor #31. As shown, the signal from the aerial is fed via capacitor #9 and appears across 650pF capacitor #10. This is paralleled by tuning inductor #31 and capacitors #12 and #13.

Basically, it's the classic Pi filter arrangement. In domestic radios, this configuration is commonly used as a power supply filter, to smooth the rectifier's pulsating DC output. Valve transmitters also commonly use a Pi filter to present a load of "a few" kilohms to the final power amplifier and to provide an impedance step-down to the antenna connection (usually 50 ohms). Conversely, transistor transmitters may use it to step impedances up, from a few ohms at the output stage collector to the 50-ohm antenna.

In the Astor DLP set, the capacitance ratio is roughly 650pF to some 40pF. This gives an input-output voltage ratio of around 1:15 by virtue of the capacitive reactance being inversely proportional to the capacitance. You can think of it as a step-up tuned circuit and we'll confirm its operation in the "How Good Is It?" section later on.

Another Pi filter is used in the local oscillator which is configured as a classic Colpitts circuit. Capacitor #3 (20nF) provides DC blocking in the feedback path from the converter's screen (LO plate) to its grid. The oscillator circuit is tuned by variable inductor #32 and capacitors #8, #11 and #14.

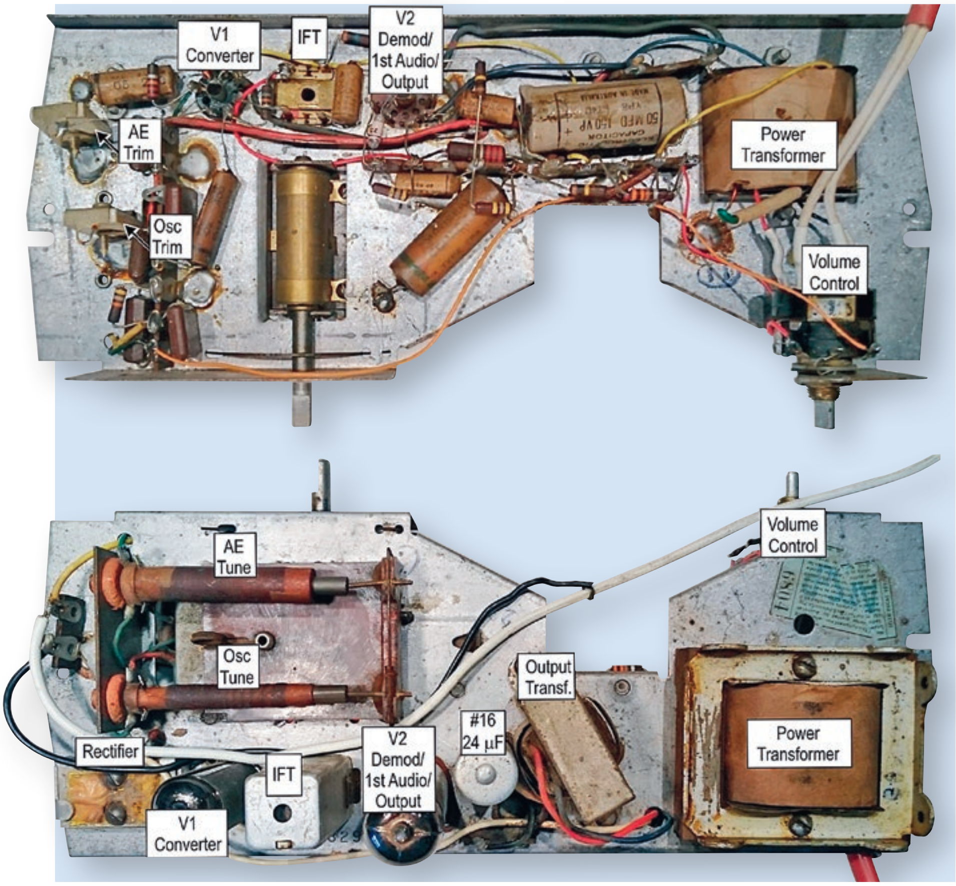
The capacitance ratio of capacitor #8 to capacitor #11 and trimmer capacitor #14 is approximately 10:1. This creates a step-up between the converter's screen (acting as a plate) and the oscillator's grid (grid 1) and ensure that the converter oscillates. Trimmer #14 sets the top of the LO's frequency span.

Potentiometer #30 (25kΩ) functions as the volume control. Its circuit arrangement is similar to sets of the 1930s that commonly used no AGC. As shown, one end of potentiometer #30 connects to the aerial input circuit, while the other end goes to the converter's cathode via resistor #28. Its wiper goes to ground.

When the volume pot is turned fully clockwise, its righthand end is connected to ground, leaving only the converter's 330Ω cathode resistor (#28) in the bias circuit. As a result, the converter's gain will be at maximum, while shunting of the aerial circuit will be at a minimum. The set's overall gain will thus be at maximum.

Conversely, when the pot is fully anticlockwise (ie, just before switching off), the pot's full resistance (shunted by 8.2kΩ resistor #26) will be in series with the 6BE6's cathode. As a result, the converter's gain will be at a minimum and the pot shunts the input signal from the aerial to ground.

A final wrinkle here is that the oscillator section is biased by the voltage across 22kΩ resistor #24 due to the grid current. However, it should be



The Astor DLP is built on a small, punched metal chassis with many of the parts mounted on tagstrips. The on/off switch is on the back of the volume control and as with all mains-powered sets, the condition of the mains wiring should be carefully checked before applying power.

noted that any change to the oscillator's bias will affect its operation and drag it off-frequency due to its input impedance (especially) changing with plate current. That in turn would mean that changing the volume would detune the set.

As a result, the bias must be undisturbed by other circuit changes and so the other end of resistor #24 is connected to the converter's cathode. This means that even though volume control pot #25 can raise the converter's cathode by some 12V above ground, the oscillator's bias conditions remain unaffected.

Audio stages

The two audio stages are based on a single 6BM8 triode-pentode valve. This valve combines a high-mu triode for audio preamplification with a power pentode capable of 3.5W output with a 200V HT supply.

So where's the demodulator? The answer is that the triode section uses 10MΩ grid resistor #18 to create "contact potential" bias. This method exploits the tendency of a valve's control grid to drift negative under the influence of the electron "cloud" (space charge) created by the heated cathode.

What this also does is reduce the valve's plate current to a low value. Applying a large IF signal to such a circuit will therefore bias the valve into cut-off on the negative peaks. It's the classic "grid leak" demodulator seen in early radios, either as a straight demodulator or with regeneration applied in Reinartz circuits.

Basically, this simple circuit combines demodulation with audio amplification, overcoming the attenuation that a conventional diode demodulator would create.

The output stage is back-biased by the voltage developed across resistor #29 (270Ω). This back-bias supply is filtered using 100kΩ resistor #22 and 500nF capacitor #1.

With only 90V HT available, the 6BM8's pentode bias is reduced from the more usual -16V to just -5V. As a result, this stage has a maximum audio output of just 300mW.

Power supply

The half-wave power supply uses selenium "flat pack" rectifier #36. Its output is filtered by 50µF capacitor #15 to produce the main HT rail, while resistor #27 and capacitor #16 (24µF) provide further filtering for the output stage screen and for the audio preamp and converter plate circuits.

The set's total current drain is only about 20mA, so rectifier #36 and power transformer #35 have an easy life.

Cleaning up

As it came to me, the set's plastic cabinet had badly faded, a common problem with economy designs. I was hoping that the fading was only "skin deep", so I initially hit it with some heavy-duty abrasive in an out-of-the-way place. This revealed that the fading was only some micrometres deep, so it will be possible to successfully restore the cabinet by simply polishing away the faded material.

This will need a day or so's work with suitable tools and materials but it's a practical alternative to spray painting.

The set also proved to be in non-working order. When I applied power, there was no audible output and while I

Identifying A Mystery Set

When I first obtained this set, it had no manufacturer's label and so its model number was a mystery. Fortunately, if you can't identify a set, you can always refer to Ernst Erb's Radiomuseum website (see "Further Reading" panel) which has an extensive listing of radios from around the world.

In this case, I knew that the set was a 2-valve Astor model. After bringing up the Radiomuseum website, I went to the Advanced Search pane, typed "Astor" for the manufacturer and hit "Go". This brought up almost 500 results but hitting the "Model Name" heading gave me a sorted list that I was easily able to scroll through. My 2-valve set (6BE6, 6BM8) turned out to be the DLP from around 1960.

After later cleaning the set, I eventually did discover a chassis stamping that also identified the set. Still, it's good to know that there are other ways of identifying a "mystery" set.

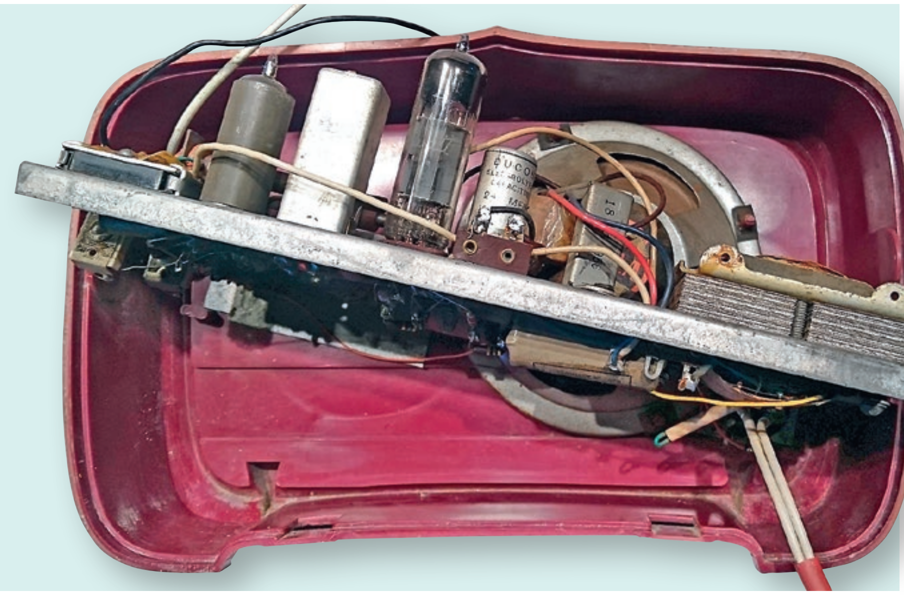
really didn't expect the usual between-station noise with a set this old before restoration, I did hope for something.

Applying several hundred millivolts of IF signal to the demodulator's grid did, however, result in useful output from the speaker and I also found that a strong IF signal would find its way through from the aerial terminal. This indicated that the converter stage wasn't working properly, probably due to an inoperative local oscillator (LO).

The 6BE6 converter valve came up as weak on my valve tester but popping a known good replacement into the socket didn't improve things. It was time for some good old-fashioned circuit analysis.

I began by checking the voltages around this stage and this showed that both the converter's plate and screen voltages were at 0V. When I looked under the chassis, I discovered that the lead that connected the +84V HT to the converter stage had been neatly cut off at both ends (and the wire completely removed). Restoring this connection gave me a working set.

A quick tweak of the IF transformer proved fruitful and adjusting the two trimmer capacitors completed the circuit restoration. But why had the HT lead to the converter been cut? Who knows? It's a real mystery!



The DLP's chassis sits at an angle inside the cabinet so that it fits in the allotted space. This view shows the set prior to restoration. The 2-core mains flex was later replaced with 3-core mains cable so that the chassis could be earthed.

How good is it?

So just how well does it perform? The answer is that with just a few metres of aerial lead, it's not too bad.

Astor's alignment guide mentions the use of a "25 foot antenna" and that's pretty much an admission of low sensitivity. However, although it can't match more complex designs, Astor's DLP has an audio output of 50mW output for a 200µV input signal at 600kHz and a 360µV signal at 1400kHz. Signal-to-noise ratios exceed 30dB in both cases.

The IF bandwidth is commendable for a set with single IF transformer, being ±2kHz at -3dB and ±73kHz at -60dB. However, the audio frequency response from antenna to speaker measured just 100Hz to 700Hz, which is really quite poor.

So what could be done about it? Checking the circuit indicated that the 3nF filter capacitor at the demodulator's plate (#6) was likely to be the main culprit. While the narrow IF bandwidth wasn't going to allow a top end much above 2kHz, that 3nF capacitor just had to go. I normally resist the temptation to "hot up" equipment but substituting a 220pF capacitor extended the audio frequency response out to 1.6 kHz and resulted in a much "brighter" sound.

Overall though, the audio performance is modest. The output is just 330mW at 10% distortion and 50mW at about 4.5% distortion.

By the way, grid leak demodulators can potentially respond to strong signals by increasing their DC grid bias voltage, thereby reducing the stage gain. This set did show some gain reduction but only when operating at full volume and with aerial signals exceeding many tens of millivolts. Effectively then, the Astor DLP lacks any type of AGC.

Tested in my kitchen with a few metres of aerial wire, the set pulls in the usual ABC Melbourne stations plus a few regional stations. So despite its modest performance, it's still a very useful little set.

More on the aerial network

I initially thought that the aerial tuned circuit based on #10, #31, #12 & #13 would give a voltage step-up of perhaps 15 times. Subsequent measurements at 600kHz revealed that an input signal voltage of some 200µV was required for 50mW out, while an injection of 7mV at the converter's grid was necessary to give the same output. That represents a gain from the aerial terminal to the converter's grid of some 35 times. It's a neat trick – transformer/tuned circuit gain is essentially noise-free.

This aerial circuit gain is multiplied by the converter's gain of some 14 times (ie, from its grid to the demodulator's grid). Overall, from the aerial terminal to the demodulator's grid, the "RF section" manages a gain of around 500, so "hats off" to the designers.

Special handling

The Astor DLP uses two steel clips on the underside to hold the front and rear case halves together. Unfortunately, this particular set had suffered a breakage in the clamped area, either due to being dropped or careless clip removal. So take care when undoing the clips.

Note also that the alignment is done with a 200pF capacitor in series between the signal generator and the aerial terminal. In addition, Astor states that you should not attempt to adjust the two moving ferrite cores. SC

Further Reading

(1) For complete service data and the circuit, refer to Kevin Chant's website at www.kevinchant.com/astor1.html and search for "Astor DLP".

(2) You can also refer to Ernst Erb's radio museum for photos and circuit – see www.radiomuseum.org/r/astor_dlp.html

PRODUCT SHOWCASE

Your old analog TV not receiving much these days?

Contact:
Altronics Distributors
(Head Office): 174 Roe St, Perth WA 6000
Tel: 1300 797 007
Web: www.altronics.com.au

Despite analog TV transmissions having progressively ceased right across Australia (the last in 2015), many people have "hung on" to their old analog TV sets – for a variety of reasons including the fact that their even older VCRs etc still worked.

Many others have them in a wall unit or display cabinet where a modern slim-line digital set might look completely out of place.

For these people (and it must be said for many other reasons) Altronics have released two high definition (HD) Digital Terrestrial Set Top Boxes from Dynalink. The "Digital" part means it receives all digital television channels; the "Terrestrial" bit means they're intended for land-based (as distinct from satellite) transmissions.

The first of the two, the Dynalink A 2809, is tiny at just 120 x 90 x 27mm. While a 12V DC plugpack is included, as it's powered by 12V DC it is obviously intended for a "mobile" market – caravanners, campers and mobile homers, the boating fraternity and the like.

Output is either HDMI or A/V (composite).

It has an infrared remote control (included) and despite its compact size, a full range of user controls including EPG, program selection including favourites and recording (via USB to an optional stick). It is compatible with DVB-T and MPEG-4 AVC/H.264 HP@L4. Recommended retail price is $79.95

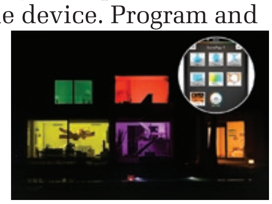
The secondset-top box is the Dynalink A 2856, which is mains powered. A little larger (220 x 160 x 40), this one is aimed at the home market, where the set-top box really can be on the top of the set! It has all the features of its little brother and a few more besides, such as coax and Cr/Pb and Cb/Pb connections along with stereo audio and video plus HDMI. Similarly, an infrared remote control is included and it too sports a USB port for recording. This one is slightly cheaper at $69.95.

They are available through all Altronics stores and resellers.

Five Smart Gadgets To Turn Your House Into A Smart Home

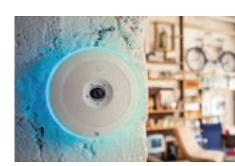
We've unearthed five interesting "appliances" guaranteed to turn your house into the smart home of the future. Some are so new they're not yet available in Australia but we believe they're not far away!

Philips Hue: On/off lighting just doesn't cut it any more – choose colour, tone intensity, create light recipes and much more! Control Hue with your mobile device. Program and save your favourite scenes! Starter set (remote, wifi connector and three lights) starts at around $US200.00 www.philips.co.uk/c-p/8718291547778/hue-personal-wireless-lighting

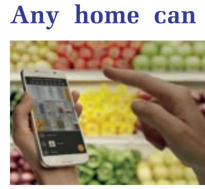


Tesla Powerwall: If you have solar panels, why not store that energy yourself instead of being paid a pittance for it? Capacity of 7 or 10kW, can be linked into other smart home devices. About $US3000, available in Australia now. www.tesla.com/de_DE/powerwall

BuddyGuard's Flare: The next big thing for home security. It's a complete home security system in a single device, powered by artificial intelligence. An HD camera and hi-tech sensors provide continuous coverage when you're not at home. It can distinguish between friend and foe and even recognise your pets! www.indiegogo.com/projects/flare-easy-and-intelligent-home-security--2#/updates

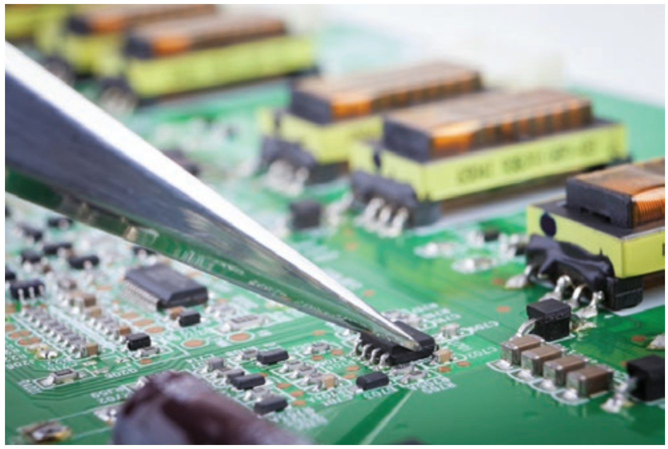


Any home can be a smart home: The SmartThings Starter Kit has everything you need to create and monitor your own smart home in no time. Once you've set up your Starter Kit, SmartThings lets you connect with hundreds of compatible smart devices for limitless possibilities. www.samsung.com/us/smart-home



1aim's SmartDoor: Brings a whole new meaning to "Open Sesame"! Automatically opens doors when the owner approaches with a Bluetooth smartphone, etc – or you can remotely open doors for visitors, even if you're not home! No more searching for keys! https://1aim.com/

Take advantage of PCBCart's value-added Prototyping PCB Assembly service



PCBCart offers full turnkey and consigned Prototyping PCB Assembly services.

Additionally, they follow the same strict procedures as full production PCB Assembly orders on Prototyping PCB Assembly orders so that customers can evaluate the project's function and performance.

Here are their specific procedures of their full turnkey PCB assembly service:

Step One: Give a custom quotation based on your PCB design file & BOM, then confirm with you about the price and rough build time.

Step Two: If you're OK with the quotation and lead time, they'll move forward to run a DFM check and review your PCB design file for possible issues that may affect manufacturability. As soon as any issue has been detected, they'll get in touch immediately to solve it with you.

Step Three: When those detected issues are fixed, they'll begin component procurement and PCB manufacturing procedures.

Step Four: Then, they'll start populating components on those boards exactly as you designed.

Additionally, X-ray inspection, 100% AOI test and X-ray test for BGA, IC programming, Components cost-down and Function test are all available as custom options.

They're now offering EXTREMELY low PCB assembly labor cost if you let them fabricate and assemble PCBs at the same time.

Have a project ready for prototyping?

Feel free to discuss with them by writing to sales@pcbcart.com, – they're always ready to serve you.

Contact:
PCBCart
Floor 3rd/4th, Building #1, NO.163
Wu Chang Road, Yu Hang District, Hangzhou, China 310023
Tel: +86 571 87013819 **Web:** www.pcbcart.com

Iris Recognition at 60cm away

New York-based EyeLock LLC has introduced new technology that authenticates identities at distances up to 600mm, even with glasses, contact lenses and daylight. The technology is intended for smartphones and mobile devices, as well as automotive, healthcare and other edge-of-network applications. EyeLock's technology represents a breakthrough in proprietary software, security, algorithms and optics and delivers the most secure, reliable and user-friendly capabilities available in the market today, outperforming all existing iris-recognition systems.

Uses are expected in financial services, healthcare, automotive, enterprise and government sectors, by delivering a solution to mitigate security threats while providing a more convenient way for consumers to interact.

Contact:
EyeLock LLC
Level 12, 355 Lexington Ave, New York, NY 10017
Tel: (0011 1) 855 393 5625
Web: www.eyelock.com

Solar Panel USB Charger/ 8000mAh Power Source

They reckon it's the handiest thing you can have when you don't have access to mains (or even vehicle) power!

This "solar battery charger" can charge or supply power to a range of small devices, such as mobile phones, tablets, MP3 players and so on. Its dual USB sockets means you can charge a couple of devices at the same time. You don't need any power source except the sun!

Along with an inbuilt LED torch, it features an 8000mAh capacity battery, is waterproof, durable, light weight and has both short circuit and over charge/ over temperature protection. A carabiner and micro USB charging cable are included.

Contact:
The Great MacHouse
2 12 Fraser St Glen Waverley VIC 3150
Tel: (03) 8692 0077
Web: www.machouse.com.au

Want a Microsoft HoloLens? Bad luck if you're not in the USA. Unless . . .

Microsoft's HoloLens has been getting some rave reviews in the US . . . even at $US3000, virtual reality enthusiasts (even in Australia) have been clamouring to get their hands on one!

But the HoloLens has been released only in the US – they won't sell one to an overseas address. So if you REALLY must have a HoloLens, the trick is to get your own US address!

It's not unusual to find geographic barriers placed by many manufacturers because they don't want to (or cannot) support their product outside the USA. But that doesn't stop Australian consumers wanting one!

That's where companies such as Big Apple Buddy, a New York City-based "shopping concierge", comes in.

You simply tell Big Apple Buddy what you want to buy and they search for it – then send it direct to your door via Fedex, UPS or DHL, meaning delivery to Australia can take as little as one week.

There's a minimum $US50 per order service fee to take into account the legwork required. They tell you the charges (including freight) up front, before proceeding to purchase the goods you require.

Conact Big Apple Buddy via their website, www.bigapplebuddy.com 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. Send your email to silicon@siliconchip.com.au

13.5V 25A transceiver power supply

I would like to build the 13.5V 25A transceiver power supply described in the May & June 1991 issues of SILICON CHIP. I have purchased the back copies but the two PCBs required are no longer available. Can you suggest how I can get them made and also tell me where I can purchase the key components? (D. X., via email).

● The PCB patterns are on pages 72 and 73 of the June 1991 issue, so one of the PCB manufacturers who advertise in Market Centre may be able to make them for you. As for the parts, you would need to contact Harbuch Electronics to see if the transformer and chokes are still available. You should be able to find the remaining components at the usual retailers although in some cases you will have to look for devices with equivalent specifications.

That power supply was quite an interesting design since it essentially employed a Triac regulator circuit which drove the primary winding of a large toroidal 18V power transformer. The output of this transformer was fed to a bridge rectifier and LC filter with a large bank of electrolytic capacitors and two iron-cored 25A chokes (inductors) with values of 50µH and 1mH.

This approach gave quite high efficiency without the hash and noise of a switchmode regulated supply. Lack of noise and hash is essential for radio transceivers. However, the cost of such a large project now would probably make it uneconomic and if we were to develop an equivalent project today, we would try to adapt a modern 3-stage 12V 40A switchmode battery charger or a high-power ATX computer power supply to the task.

This would be much cheaper but it would probably need a lot of filtering and shielding to get radiated and conducted hash levels down to a satisfactory level for transceiver use.

Acoustic wadding for Budget Senators

I am currently building the Budget Senator speakers. I am hoping you can confirm whether they require internal acoustic infill, how much and where it should be applied. Neither Allan-Linton Smith nor yourself addressed this matter. I am of the opinion that the speakers' performance will suffer if it is not used. (L. L., Somerville, Vic.)

● Oops, we forgot to mention the acoustic filling in the second article. However, it is required and is specified in the parts list on page 43.

Each cabinet should contain two 700 x 1000mm rolls of the wadding, as shown in the photos on page 38 of the September 2015 issue. Thanks for bringing this oversight to our attention.

Flexitimer for maintaining pool level

I am trying to work out if the Flexitimer will work in my application. I am maintaining the amount of water in a pool using a float valve with an integral reed switch controlling a 24VAC solenoid. The solenoid is the same as used in garden reticulation systems. When the water level is below the required level, the relay contact is closed and the solenoid is activated, filling the pool. Once the water level is appropriate, the relay opens and the solenoid shuts off.

I have the system set up to fill the pool in the early hours of the morning when there are no users (general activity in the pool causes the water level to vary dramatically, playing havoc with the float and solenoid). I do this by having the power supply to the solenoid on a timer, set to come on at 2am for one hour. Even at the height of summer, full operation of the solenoid will fill the pool to an acceptable level in 40 minutes.

The problem is that as the water level approaches the de-activation point of the reed relay, the float causes the

Using Multiple MPPT Chargers With One Battery

The Solar MPPT Charger and Lighting Controller project in the February 2016 issue raises a couple of questions. I travel extensively with 4WD groups and have seen many examples of people using solar panels to provide power when camping. There are various configurations of panels and batteries, although most systems seem to have almost all of the electrical load connected to one battery (often multiple fridges) and usually, all panels available are trying to replenish that one source. Most panel sets have an MPPT controller and many also have a multi-stage battery charger.

Is it viable to connect multiple panels to one battery in this way or will the controllers and chargers interfere with one another, producing sub-optimal results?

Is there an electronic device that can accept input from multiple MPPT (and perhaps PWM) controllers and then provide a charge management regime for a single battery, and would this be a better solution? (G. P., Canberra, ACT.)

● In general, while it is probably OK to connect identical panels in parallel to a single MPPT charger and then to a single battery, we would not recommend connecting the outputs of MPPT chargers in parallel to a single battery as they are likely to "fight" each other and give less than optimum results. We don't know any method whereby this could be safely done.

We do hope to publish a charger controller for quick battery charging on camp sites in the next few months although this is intended to be used with a generator.

solenoid to oscillate. The float valve sits in a section of 40mm pipe that is plumbed into the pool, well below the surface, some 15m from the pool. Even very small disturbances in the pool surface are induced into the "float-pipe", causing the float to "bobble" and subsequently activate/deactivate the solenoid rapidly. In practice, even a small amount of wind causes trouble with my system, especially as the float is approaching the point where it will open the reed relay.

My thought is to have the float trigger a device that will then activate my solenoid and ignore all further inputs coming from the float for a period of time, say 7-15 minutes (or longer as needed). At the end of that period, the device will shut off the solenoid, reset itself and then look at the float contacts again to see if they are active. If they are active, the solenoid will activate, allowing more water to fill the pool. The idea here is to get the water to go past the transition phase of the float operation, buffering the entire operation.

The Flexitimer looks like it *may* do the job but I can't find an in-depth article on the item to determine if it will do what I want. If you can provide a copy of the circuit description and kit arrangements, that would be most welcome. (P. D., Rockingham, WA.)

● A timer would work to delay the pump starting and switching off but will not prevent the pump cycling on and off with pool water movement. Damping of the pool water movement or damping the reed switch sensor would be far more effective.

There are many was to dampen the water movement. For example, you could use a thick sponge in the float pipe located below the float. This will slow down the water movement and effectively average out the water level. Other methods could involve the use of baffle plates or a baffled storage tank.

The electrical solution would be to filter the output of the reed switch so that the on and off switching is averaged out. A Schmitt trigger inverter could then be used to drive a relay that operates the pump. The Threshold Voltage Switch from July 2014 could do this job. That includes a Schmitt trigger. The input is filtered with a 1μF capacitor and 470kΩ resistor.

For your purposes, a 10μF or larger capacitor could be used and would remove the variation from the reed switch opening and closing more effectively. Note that the reed switch should be connected with one end to 0V and the other end to a pull-up resistor of around 10kΩ that connects to the positive supply. The junction of the reed switch and resistor then becomes the input to the Threshold Voltage Switch.

Altronics (**www.altronics.com.au**) in Western Australia sell a kit for the Threshold Voltage Switch designated K4005. The article is included in the kit. Alternatively, see **www.siliconchip.com.au/Issue/2014/July/Threshold+Voltage+Switch**

By the way, if you are still interested in the Flexitimer, a free 2-page preview can be seen at **www.siliconchip.com.au/Issue/2008/June/PIC-Based+Flexitimer+Mk.4** You can also order the full online or printed back-issue from our website via that link.

Mini-D Kit PCB Doesn't Match Diagram

I am building the Mini-D Class-D Audio Amplifier (September 2014) from a Jaycar kit, KC5530. I cannot find links 1, 2 or 3. I want to run it in mono mode and cannot see how to select mono or stereo. Also, if I do not wish to use the RCA inputs, can I solder the signal wires directly to the board? (D. K., Malak, NT.)

● We don't know if Jaycar might have modified the PCB design in their Mini-D kit but in the original design, LK1 and LK2 are near the output connectors and LK3 is in the middle at the bottom of the board.

If you don't have those links, you could run short lengths of wire between the pads of FB1/FB2 and FB3/FB4 but you would need to be sure to do it at the correct end, ie, the end that is not connected to CON4/CON5. That's the equivalent of fitting LK1 and LK2.

For LK3, you would need to connect pin 14 of IC1 to ground. There should be a 100kΩ pull-up resistor on this pin so if you can identify it, you can solder a length of wire from there to a ground point.

Note that if links LK1 and/or LK2 are fitted (or the equivalent), LK3 must be fitted or the stereo outputs will be effectively shorted.

Yes, you can solder wires directly to the pads of the RCA sockets. They are provided merely as a convenience. If the wires are more than a few centimetres long, you should probably use shielded cable to avoid picking up stray signals.

Running the Mini-D amplifier from 5V

I'm wondering if the wonderful little Mini-D Amplifier from the September 2014 issue will run from a 5V DC supply? I have built several of these running from 12-15V and one in bridge mode. I realise that the output with a 5V supply would be limited.

What a little beast this amplifier is for its size. Thanks for your great articles in the magazine. (P. H., Holland Park, Qld.)

● The TPA3113D2 IC has an under-voltage lockout function which will prevent it from running with a supply below 8V. Its specified operating voltage range is 8-26V.

However, you could change IC1 to a TPA3136D2 and it will then run from 5V. It is pin compatible. Links LK4 and LK5 would no longer have any effect.

Finally, the two 100kΩ resistors connected to pin 10 may or may not need to be changed in value (these affect maximum power; the values originally used may be OK but you'd have to try it to find out).

Auto-transformers have merits and drawbacks

I've seen a number of circuits in your fine magazine using an auto-transformer in step-down mode. My dear old Dad drilled it into me that this is potentially dangerous, as should the "bottom" end become disconnected then the load will see the full mains input. What is your view on this hairy matter? (D. H., via email).

● Auto-transformers do have their merits. They are typically smaller and cheaper but their main drawback when they are used in 230VAC mains circuits is that they they do not provide any isolation, as does a transformer with separate primary and secondary windings.

So for example, if you are using an auto-transformer to provide 110VAC to an American appliance and the Active

Problem Operating CLASSiC-D In Bridge Mode

Recently I built two high-power Class-D Amplifier modules and used both for a subwoofer application in bridge mode (CLASSiC-D, November-December 2012).

All of the relevant voltage readings for both amplifiers were in line with the article's suggested voltages before the 8-ohm speaker was connected. The suggested speaker protector was also used in the set-up and this worked in relation to the pre-test requirements. Both amplifiers performed well, in bridge mode, and provided adequate power levels during operation stages.

Now a problem has surfaced where amplifier #2 is causing the speaker protector to cut in and out when the volume is increased. Upon inspection, I found that this module's LK4 wire had disconnected itself from the speaker protector connection. This was re-connected and once again it performed correctly until the volume was increased. All wiring connections are correct and the modules have LK2 set for normal and phase inverted operation respectively.

A reading of the voltages was taken again, for both modules, and these are as expected. The resistance between TP1 and GND was set at 850Ω for module #1 and 853Ω for module #2. With the 8-ohm speaker load, module #1 has the 6mV reading whereas module #2 reads 1.57 V.

When I first powered up the unit for testing, no power-on or power-off noise was heard through the speaker. Now this is present in both modules. I'm of the opinion that the speaker protector unit may be causing the problem, even though it seems to be operating normally until the volume is increased. Module #1 does not show any operation problems; it is just module #2.

I would appreciate your thoughts as to what could be the problem as before this, the unit worked faultlessly and served my requirements. (D. W., Alexandra Hills, Qld.)

● It seems that the amplifier module #2 output offset is way too high at 1.57V and this is probably what's triggering the speaker protector; it's just doing its job and protecting the speaker. You could compare all voltages between each amplifier to see if there are any other discrepancies.

Try changing the invert link (LK2) so that the amplifier that is now inverting is changed to normal and the amplifier that was set for normal is set for invert. The problem may be with op amp IC2. The speaker protector will continue to cut out until the module #2 output offset is reduced to a more normal figure (well under 1V).

and Neutral inputs to the transformer have been transposed, the circuitry of the appliance will be operating at the full 230VAC. This could break down its insulation to chassis with disastrous results. It could be especially dangerous in a double-insulated 110VAC appliance which is not rated for 230VAC.

And while your scenario with the "bottom" end disconnected is also hazardous, at least the appliance is likely to stop operating, although it too may well break down, if it is only rated for 110VAC.

There is one situation where an autotransformer is quite useful and that is where you want to reduce the incoming mains voltage by a modest amount and a specific instance is you live in Western Australia or other parts of the country where the mains voltage can often be in excess of 250VAC. That is a particular problem if you are using imported appliances (eg, from Europe) which have been designed to run on 220VAC. At such an elevated mains voltage, their reliability is likely to be severely prejudiced.

With that idea in mind, we featured the Mains Moderator in the March 2011 issue. It is basically a 240VAC transformer with its 30VAC secondary wired in series, ie, as an auto-transformer. It should not have the safety issues mentioned above. Of course, if any high voltage wiring in a mains operated appliance does become disconnected, and if it is not anchored to stop it making contact with another part of the circuit, it will definitely present a hazard.

Finally, the only other auto-transformer that we would use is a Variac and we would only use that in a situation where we needed to operate an appliance outside its normal input voltage range for testing or repair purposes.

Optical trigger for the 8-Digit Frequency Meter

I am searching for a readout for my milling machine which is driven by your 3-phase Induction Motor Speed Controller (April-May 2012, August 2013). I want to monitor the RPM of the milling cutters.

I have built the LED Strobe & Contactless Tachometer (August-September 2008; Altronics K2510 kit). An optical trigger PCB coded SC04108083 came with it. I am using this instrument to monitor the RPM of small steam engine models via the strobe function and don't want to modify it.

Your Compact 8-Digit Frequency Meter project in the August 2016 issue (by John Clarke) seems a suitable alternative. Can I use the above mentioned optical trigger board with the frequency meter? I assume I would connect the "+" to the 9V line at V+. Will there be a kit for this project? (H. M., Bowral, NSW.)

● The Infrared Reflector Amplifier circuit (optical trigger board) can be used with the Compact 8-Digit Frequency Meter. And yes, it will run from the Frequency Meter's 9V supply.

There may be a kit but none are available yet. You can obtain the programmed PIC, the PCB, the front panel and the label artwork via the SILICON CHIP website.

CLASSiC-D running hotter than expected

I have just completed building four CLASSiC-D amplifier modules (November & December 2012), operating them in two bridged pairs as a 2-channel power amplifier for two subwoofers. They are performing well, however, they do seem to run hotter than I was expecting and one is hotter than the other three (about 20°C above ambient rather than 10°C or so, measured with no chassis lid). I have not cut down the heatsinks as I have plenty of chassis height.

Are these temperatures about normal for this design? I would appreciate some guidance on this. (J. M., Auckland, NZ.)

● The temperature differences could

be due to variations in the output Mosfet on-resistance between one amplifier and the other, or the oscillator frequency. It would be worth checking the hotter heatsink amplifier to make sure all components are the correct value, that circuit voltages are similar and that the oscillation frequency is within the normal range.

The hotter amplifier could be set to run at a lower frequency to reduce the operating temperature. Temperatures of 10-20°C above ambient seem normal. Note that you would expect when driving subwoofers that the amplifiers would run hotter than when used for amplification of normal program material of between 50Hz to 20kHz, due to a reduced dynamic range.

Automotive Power Supply For Dynaco Valve Amplifier

I built both SILICON CHIP 12AX7-based tube preamps (November 2003 and January 2016) and enjoyed them. It was great to see "real" tube designs for once that I could use in my car. Commercial models I've bought were poor and low-voltage, so I was fascinated to see and build these great little designs.

My goal is to build a "real" tube amplifier for car use from ~12V input. The problem I'm running into is the DC-DC switching supply. I plan to use the Dynaco ST-70 as a first revision amplifier design, as parts are common. However, I have not been able to find an off-the-shelf DC-DC high-voltage supply that can supply the +415V or so I need. The famous (and very expensive) Milbert BaM235 car amplifier uses a switching supply but is very rare and schematics are not available.

If a 70W-100W design is not feasible, I could also use two smaller supplies, one per channel if necessary. I was wondering if possibly I could utilise a 220V-6.3V transformer to produce the +415V as the ratio is close (ie, $415/12 \approx 220/6.3$) – perhaps something based on the 2016 tube preamp, using the MC34063 SMPS circuit?

Thanks for your time and I would appreciate any ideas you have or pointing me to a possible solution. Real tube amplifiers for car use have always been out of reach (excessively expensive) and I am determined to solve this challenge. I enjoy your great work at SILICON CHIP and the unique designs you all produce. (M. McL., Georgia, USA).

● In your country, the easiest way to power your proposed Dynaco amplifier would be to purchase a 12V to 115VAC sinewave inverter of, say, 300W rating. Then use it to power a conventional power transformer and rectifier set up. In fact, if you could obtain the original Dynaco spec power transformer, you could use the original GZ34 thermionic rectifier!

Trouble with Driveway Monitor

Can you please give me some help with my Driveway Monitor (July-August 2015), which I built from an Altronics kit? Presently, the transmitter unit is working correctly but there is no response from the receiver unit and I've run out of testing ideas.

I can't determine where the problem lies because there are a number of possibilities, from the UHF transmitter module in the transmitter to the receiver module and PIC12F675 in the receiver.

At the moment, I've programmed a new PIC16F88 and re-programmed the PIC12F675 and while the transmitter detects a metallic probe, the LEDs on the receiver still don't light.

I removed the PIC12F675 and checked that the LEDs and piezo buzzer worked, by feeding 5V into socket pins 6 & 7. When I checked the software in the PIC12F675, I found the chip was blank and presumed this was the cause of my problem. But while reprogramming the PIC12F675, I noticed that the software is "code protected" as supplied from SILICON CHIP and hence can not be read back.

I re-loaded the software without with CP bit set and it verified OK, though I may have changed the chip's clock calibration value in the process.

Examining the circuit schematics, I wonder if it's possible to feed the receiver with a simulated signal to test its function. Similarly, I assume I could fit another UHF receiver with a LED on its "data out" line to see if any data is being received.

One strange observation is the total lack of any activity from the receiver unit when power is applied. As you can tell I'm clutching at straws to fix the problem and I'd appreciate any help you can give. (R. T., Churchill, Vic.)

● You could test that both PICs are working by bypassing the UHF transmitter and receiver and making a direct connection between the units instead. To do this, remove the UHF receiver and connect a wire from the UHF transmitter's data input line to the location where the receiver's data output line was connected. Then join the grounds (0V lines) of the two boards.

Assuming the receiver then works, that points at one of the UHF modules being at fault. If it still doesn't work, the problem is likely with one of the PICs. Note that if you do not correctly program the PIC12F675 with its calibration value for the internal oscillator, the receiver is unlikely to work as the decode frequency will be incorrect.

Note also that the receiver will normally toggle its data output pin when the transmitter is quiescent as it will pick up RF noise. But you could still use a LED to check the data output, as long as you also connected a series current-limiting resistor (eg, 1kΩ).

Adapting PIC-TOC for a common cathode display

I am a model train enthusiast and run HO gauge. Recently, I came into possession of a number of super-miniature 7-segment displays designated VQB37. They look very much like a red bubble. These displays are common cathode and run on 1.6-2V at 3mA per segment.

The thought struck me that they would be nice in a model railway station, mounted in a wall with the PIC-TOC PCB (SILICON CHIP, July 2001) either inside the station or placed under the base board. The two could be connected with flying leads. I realise I would need a dropping resistor in the common return of each display, to reduce the voltage from 5V down to an appropriate level for the display.

My question is: can a modification be made to the PIC-TOC to allow me to use the common cathode displays with a circuit designed for common

Expanding the 4-Input Automotive Fault Detector

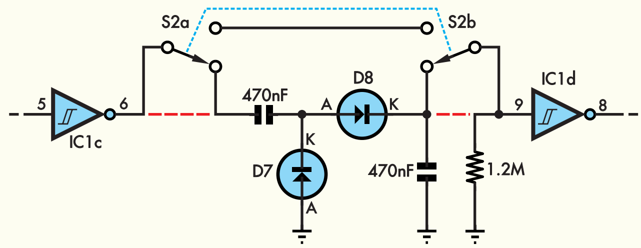
I am excited by the 4-Input Automotive Fault Detector project described in the September 2016 issue, being an electronics hobbyist and car enthusiast. But I think you've missed a huge opportunity with it because this doesn't need to be dedicated to the four inputs Dr Holden used but could be widened to a great diagnostic tool in general.

I'd have liked to see the inverter stage for negative switching designed into this circuit. It could be selected by DIP switches or jumpers for each input.

For inputs not being used at the time, a jumper or mini switch could provide the input with a constant 12V from its own supply, if the input cannot easily be isolated so that its particular LED won't light no matter what. That would leave only the connected inputs monitoring whatever the user has chosen to monitor.

It would be nice to see another two inputs such as Channel 1 & 2, giving four in total that can monitor for +12V or ground switching and still have the Channel 3 & 4 inputs as they are now for pulsing inputs. Or perhaps being able to select between a channel 1 & 2 front end and a channel 3 & 4 front end for each of four inputs?

I think the above would make this idea of Dr Holden's into a fantastically useful diagnostic tool for many purposes on anything with a 12V DC system – cars, boats, caravans, motorcycles and possibly more. Is there any chance you could quickly bring out the additions mentioned above as a follow up/expansion article as I would love to build and use it? Will any of the kitset suppliers produce it as a kit? (S. M., via email).



- Glad you like the concept of the project but the mods you are suggesting would require more circuitry and a larger PCB. In simple terms, to provide the extra facilities you want, you would need additional inverter stages (ie, another 74C14 plus diodes and input coupling components, plus DIP switching, as you suggest). However, we do think that the design we have presented will probably do 90% of the testing anyone might want to do, so we don't really want to change it, especially since we have only just published it.

You can easily modify the PCB to allow input channels 3 & 4 to be switched between the pulse detectors, as originally designed, and normally-low inputs suitable for use with negatively switched devices. We have produced a partial circuit (above) to show you how.

Four tracks would need to be cut and two DPDT switches inserted. When switched, they bypass the pulse detector charge pump and channels 3 & 4 operate like channels 1 & 2 but with an inverted sense.

If we did design a more comprehensive fault detector than the circuit already published, the logical approach would be to ditch the discrete CMOS logic ICs and use a micro instead. Each input could then be configured independently, depending on what it was to monitor.

At the time of writing this reply, none of the kitset suppliers have indicated that they will do a kit for the project. However, you can purchase the PCB from our online shop at www.siliconchip.com.au/Shop/8 and all the other parts are readily available from Altronics and Jaycar.

anode displays? If not (and I suspect that is what your answer will be), is there any design by SILICON CHIP that I could construct and use for this project, preferably with the simplicity of the PIC-TOC.

I think it would be really "cool" to have a working digital clock in the station. (K. J., Woodbine, NSW.)

- Yes, the PIC-TOC can be modified to suit common cathode displays. The outputs (both driving the common lines and individual segments) would all need to be inverted in the software. However, we are not in a position to make this modification and you may find that your displays will be very dim with the limited current available from the PIC pins, as they are not high-brightness types.

Alternatively, you could use an inverter on each 7-segment output of IC1 (pins 6-13) as well as on pins 1, 2, 17 & 18 to drive the common lines. Note that switches S1-S4 should connect directly to IC1's outputs, ie, pin 17 at one end and pins 6, 9, 11 & 12 at the other. The 1.1kΩ resistors should be moved to the inverter outputs which drive the individual segments.

A suitable inverter is the 4049 (six inverters per package, so use two). For the common lines, use inverters – either 4049 stages or alternatively, four BC337 NPN transistors (emitter to 0V, collector to the display common and base to IC1 via a 1kΩ resistor).

Yagi antenna boom wall thickness

I plan to construct the 5-element Yagi Antenna described in October 2015. I am seeking clarification on the material recommended for use as the boom.

The mechanical drawing on page 73 lists the boom material as 19mm square 1mm wall thickness aluminium tubing. However, the Bill of Materials on page 77 lists the boom material as 19mm square 1.8mm wall thickness aluminium tubing. Obviously the Boom will be stronger with the 1.8mm material but on the other hand, it will also be heavier.

I can easily obtain 19mm square 1.2mm wall aluminium tubing from Bunnings. Would this be adequate? (R. M., Melbourne, Vic.)

- Despite what was listed in the magazine, we actually used the same 1.2mm thick tubing from Bunnings.

Trying to cheat at Pokemon Go

Is it possible to create a GPS transmitter in some kind of Faraday cage

MARKET CENTRE

Cash in your surplus gear. Advertise it here in Silicon Chip

WANTED

WANTED: EARLY HIFIs, AMPLIFIERS, Speakers, Turntables, Valves, Books, Quad, Leak, Pye, Lowther, Ortofon, SME, Western Electric, Altec, Marantz, McIntosh, Tannoy, Goodmans, Wharfedale, radio and wireless. Collector/Hobbyist will pay cash. (07) 5471 1062. johnmurt@highprofile.com.au

FOR SALE

LEDs, BRAND NAME and generic LEDs. Heatsinks, fans, LED drivers, power supplies, LED ribbon, kits, components, hardware, EL wire. www.ledsales.com.au

tronixlabs.com - Australia's best value for hobbyist and enthusiast electronics from adafruit, DFRobot, Freetronics, Raspberry Pi, Genuino and more, with same-day shipping.

PCBs & Micros: Silicon Chip Publications can supply PCBs, programmed microcontrollers and other specialised parts for all recent projects and some not so recent projects. Visit our Online Shop at www.siliconchip.com.au for details.

ELECTRONIC & LED Business for Sale. Owner Going Overseas. Many SMD Parts and LED Parts. Contact Tony at tony@phoslighting.net or 61 417111500 or 86 1343556690.

PCBs MADE, ONE OR MANY. Any format, hobbyists welcome. Sesame Electronics Phone 0434 781 191. sesame@sesame.com.au www.sesame.com.au

PCB MANUFACTURE: single to multi-layer. Bare board tested. One-offs to any quantity. 48 hour service. Artwork design. Excellent prices. Check out our specials: www.ldelectronics.com.au

KIT ASSEMBLY & REPAIR

KEITH RIPPON KIT ASSEMBLY & REPAIR:

* Australia & New Zealand;
* Small production runs.

Phone Keith 0409 662 794. keith.rippon@gmail.com

VINTAGE RADIO REPAIRS: electrical mechanical fitter with 36 years experience and extensive knowledge of valve and transistor radios. Professional and reliable repairs. All workmanship guaranteed. $10 inspection fee plus charges for parts and labour as required. Labour fees $35 p/h. Pensioner discounts available on application. Contact Alan on 0425 122 415 or email bigalradioshack@gmail.com

DAVE THOMPSON (the Serviceman from Silicon Chip) is available to help you with kit assembly, project troubleshooting, general electronics and custom design work. No job too small. Based in Christchurch, NZ but service available Australia/NZ wide. Phone NZ (+64 3) 366 6588 or email dave@davethompson.co.nz

ADVERTISING IN MARKET CENTRE

Classified Ad Rates: $32.00 for up to 20 words plus 95 cents for each additional word. Display ads in Market Centre (minimum 2cm deep, maximum 10cm deep): $82.50 per column centimetre per insertion. All prices include GST.

Closing date: 5 weeks prior to month of sale. To book, email the text to silicon@siliconchip.com.au and include your name, address & credit card details, or phone Glyn (02) 9939 3295 or 0431 792 293.

Ask Silicon Chip

. . . continued from page 102

that can simulate sending specific coordinates to your mobile phone within that cage? This would allow me to go to any location to find Pokemons. Failing that do you know of any smart phones that allow you to write (hack) coordinates directly to the GPS receiver chip? (O. W., via email.)

- We think your proposition would be exceedingly difficult. As you may know, a GPS receiver computes its position and therefore its coordinates after receiving the time and position signals from a constellation of satellites. It needs to receive signal from at least three satellites to compute its 2-dimensional position and at least four to compute is 3D position (ie, including altitude).

Most modern receivers even look at the relative phase of the received signals for more precise positioning.

There are lots of websites which give a good explanation of how the Global Positioning System (GPS) works.

So to trick the GPS receiver in the way you suggest, you would need a generator which could produce four separate time and position signals. And then of course, you would need the phone and its "trick GPS signal generator" to be in a Faraday cage. Just as an aside, a microwave oven would be ideal for this task – just make sure

. . . continued on page 104

Notes & Errata

Stereo LED Audio Level/VU Meter, June & July 2016: in the circuit diagram on page 36 of the June 2016 issue and the overlay diagram on page 77 of the July 2016 issue, the 12kΩ and 1.5kΩ resistors associated with REG2 are swapped. This error has been carried over onto the PCB silkscreen as well.

Install these resistors in each other's marked positions to get the correct 11V output, otherwise the unit will not power up.

Touchscreen Appliance Energy Meter, August-October 2016: in the parts list on page 33 of the August 2016 issue, an incorrect part number was given for the Yunpen YF10T6 mains filter. It should be Jaycar Cat. MS4000.

Ask SILICON CHIP

. . . continued from page 103

that there is no risk of turning it on!

In fact, it might be easier to tap into the serial bus between the GPS receiver and processor and simulate the NMEA data from the GPS chip. It would probably be rash to state that it could not be done but if one was to indulge in such an exercise, we would want a somewhat more useful application than trying to find Pokemons.

Mind you, your suggestion would at least have the advantage of avoiding the situation whereby people wander across pedestrian crossings while totally fixated on the image on their smart phones, thereby risking death or serious injury.

Problem with SiDRADIO & CLASSiC DAC cases

I've ordered all the parts off your website to commence construction of the SiDRADIO Project (October/November 2013) and hence have already committed to spending nearly $100 on this project, only to discover this morning that the ABS instrument case no longer exists on the Jaycar website and a good Google search this morning on Altronics and RS Components and other search results reveals that there is no case that is 225 x 165 x 40mm available anywhere.

The closest I can find for a reasonable price is www.altronics.com.au/p/h0312a-ritec-220lx165wx60hmm-ip65-sealed-abs-enclosure/ but it is 220mm x 165mm x 60mm!

If you're going to advertise and promote this kit in the current edition of SILICON CHIP and continue to sell the kit on your website why then have you not made the case available to order from your website? Surely other people have experienced this problem to source the instrument case. (C. C., Mendooran, NSW.)

- The case is actually available from Altronics, Cat H0474 – see www.altronics.com.au/p/h0474-40x225x165mm-abs-grey-black-instrument-case/ The same case was also used in our CLASSiC DAC project from the February to May 2013 issues. SC

Next Issue

The November 2016 issue is due on sale in newsagents by Thursday 27th October. Expect postal delivery of subscription copies in Australia between 27th Octber and November 11th.

Advertising Index

Drop it. Douse it.

Up to 8x longer battery life than the competition.

Need a high performance, high resolution digital multimeter)DMM)? Need a durable, general purpose DMM? Either way, Keysight has you covered. Introducing the Keysight U1280 and U1240C Handheld DMM Series. Not only are they intuitive, functional and durable, they offer truly outstanding battery life - up to eight times longer than its competition.

	Keysight U1280	Keysight U1240C
Resolution	60,000 counts	10,000 counts
Battery life	800 hours	400 hours
Ruggedness	IP-67 certified for dust and water protection 3-meter (10ft.) drop test.	

Get your hands on the proof
www.keysight.com/find/U1280DMM

AUS: 1800 629 485 NZ: 0800 738 378

KEYSIGHT TECHNOLOGIES
Unlocking Measurement Insights

Agilent's Electronic Measurement Group is now **Keysight Technologies**