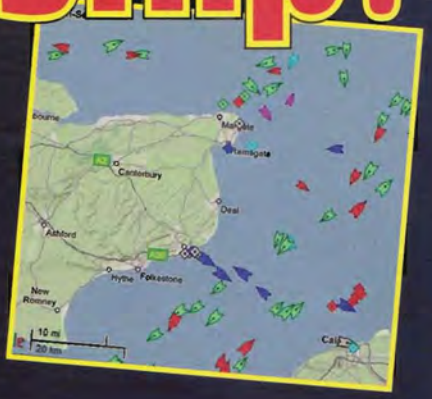
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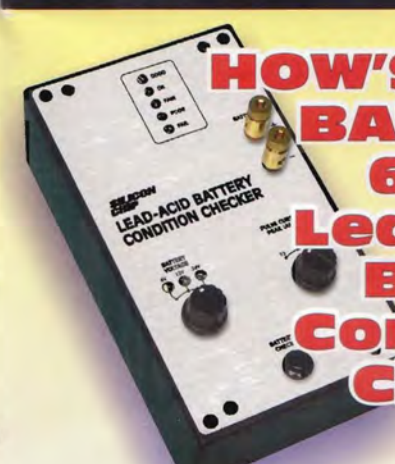
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Publisher's Letter

Tasers can be lethal



There has been a lot of concern in Australia recently over the use of Tasers by police. One person died in Queensland after allegedly being "Tasered" 28 times and there have been a number of cases where people were subdued by Tasers in situations where their use did not seem to be appropriate. Overseas, there have also allegedly been many deaths caused by Tasers.

On the one hand, police use of Tasers to subdue offenders is far more preferable than using guns. On the other hand, Tasers do inflict very severe electric shocks. How severe? Well, if I was confronted with the possibility that I was going to be hit with a Taser, I would immediately submit! I have had enough electric shocks in my lifetime to know that I don't want any more.

The truth is that very few people ever experience an electric shock of any kind unless it is the static discharge from filing cabinets in an office or from a car as you alight on a hot dry day. Such shocks are mere pin-pricks. More severe are those that some people might have experienced from electric fences on farm properties or perhaps from the high-energy ignition on modern cars – the latter can really give a severe shock. And some repair technicians could attest to getting severe shocks from the EHT supplies in colour TV sets or in other high-voltage circuitry. For the most part though, none of the shocks from these sources can compare with the severity of shock that could be delivered by a Taser.

The most severe shock that I can remember was when I was working in one of the laboratories at Ducon Condenser Company, way back in the 1960s. I was a cadet engineer and I was loading up racks of carbon resistors for testing at 500V AC. I had done this job before and it was pretty straightforward. Only this time I got things out of sequence and attempted to push a resistor onto the rack prongs while voltage was still applied. My involuntary screams stopped work on the entire floor as people rushed to see what was happening. In truth, it was a lucky escape as the voltage was applied right across my body. These days such test set-ups would have safety interlocks to prevent such a hazard.

It is difficult to describe the sensation of such a severe electric shock. Imagine having your entire body violently clamped and simultaneously vibrated. It is extremely painful! After a severe shock like that, you feel very weak. Your whole nervous system seems to have been "jangled", as indeed it has, and it can take quite a few hours to recover.

I have no doubt that a Taser would deliver a shock at least as severe. But it can also deliver the same severe shock to a person many times in quick succession. And that presents a real moral dilemma. Using a Taser to subdue a violent offender, even using it several times in succession, may be justified. But once that person is overcome, any further use constitutes torture, in my opinion.

I also know that police are sometimes placed in highly dangerous situations where their own lives are in jeopardy and a Taser can be the necessary deterrent to defuse such situations. However, I wonder if perhaps there is an inevitable temptation to be "trigger happy". I would like to think that where a Taser is brought into play, the potential victim is warned that it will be applied. In fact, apparently that did happen just recently in New Zealand and the person concerned immediately surrendered; a good result.

I do not know what is involved in police training for the use of Tasers but if they are going to be in general use, they should not be under any illusion – Tasers are a very powerful weapon. Depending on the victim's constitution and the circumstances of use, I have little doubt that a Taser could be lethal.

Leo Simpson

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Electric ute vibration is not good

The article in the June 2009 issue about Mal's electric ute was great. Mal has certainly taken on a huge project and done it well.

The article mentions significant vibration from the motor. If I may offer the following comment, the addition of rubber mounts for the motor will reduce a lot of the vibration. I'm surprised that Mal didn't try a pair of ordinary HiLux engine mounts up front.

The "cogging" effect described is symptomatic of propeller-shaft misalignment, which causes vibration and wastes a lot of power. The critical issue with this part of the drivetrain is to have the included angles of the front and rear universal joints equal to each other. Given the change to the length of the prop shaft and the new height of the electric motor, it seems to me that a readjustment of the prop shaft geometry is needed.

Apparently this work is something of a lost art but a good specialist workshop should be able to sort it out.

With good tailshaft angles and rubber mounts under the motor, the car can and should be vibration-free at any speed. Congratulations to Mal for a very neat result in a very complex project.

Warren Dickerson,
Berowra, NSW.

SMD technology is not too difficult for hobbyists

I wish to respond to Frederik Wentzel's comments in the May 2009 issue regarding SMD devices being too difficult for the average hobbyist to use.

I was of a similar mindset some time back and as I had no alternative but to use a particular SMD quoted in an article, I set forth and did some research into the matter. After having read a number of articles including your article in the March 2008 issue, I found that it was not some sort of magic as a lot people think but just an extension of what most hobbyists already know.

Possibly the single most important piece of equipment that is required is a temperature-controlled soldering iron with a fine tip, teamed with a fine pair of tweezers, a 100mm diameter magnifying glass and of course, some fine solder. Another essential item is a roll of 1.5mm solder braid. There are a number of other things available which may help but they are not essential.

I would like to encourage all hobbyists to try SMD technology. Do some experimenting with it and you will find that it opens up a whole new world of electronics; one you will love.

Alfred Hirzel,
Waitakere City, NZ.

High-speed broadband won't be a white elephant

In answer to the Publisher's Letter on the topic of the proposed high-speed broadband network in the May 2009 issue, it certainly isn't a white elephant! Surely this is the project Australia should be undertaking right now.

Somewhere around the turn of last century the nation rolled out overhead telephone lines all over the country as a response to new technology and a vision of the future. Fifty years on, more or less, it went underground as cable. We did what the rest of the developing world was doing despite the challenges peculiar to Australia.

Yes, we will find new ways of squeezing more out of this copper and we will do better with wireless but aren't we just inventing ways of pushing old technology and cramming an already stretched RF spectrum?

Today we have fibre with bandwidth that makes anything copper or wireless pale in comparison. Fibre-to-the-wall presents opportunities we can only speculate about. Let's bite the bullet and do it. I write this from rural Australia and we have no ADSL, mobile phone or vaguely decent Radio National coverage, yet there is a fibre optic cable passing my property not 100m from this farm office. Ironic, isn't it?

Hugh Paton,
Mitta Valley, Vic.

Global warming is a myth

On page 8 of the May 2009 issue Frederik Wentzel suggests that SILICON CHIP is being irresponsible about climate change (Publisher's Letter, SILICON CHIP, February 2009). Nothing could be further from the truth. SILICON CHIP is correct.

The facts are: from 2001-2008 the Earth did not warm; the Antarctic ice cap is growing (see **www.tinyurl.com/icecapgrowing**); recent ice core data shows that temperature rise preceded CO_2 rise by 800 years (**joannenova.com.au**).

The global warming myth is a fraud perpetuated by governments who have found something new to tax, along with thousands of "scientists" on the GW gravy train. Do not believe the mass media. Make your own enquiries to find the truth.

Geoff Allen,
Nowra, NSW.

Comment: thanks for your comments. However, it may be another 50 or 100 years before we know the truth about the current climate trend.

Cure for condensation in Tempmaster sensor

I have built the Tempmaster Mk.2 (SILICON CHIP, February 2009) and it is working perfectly on a Tuckerbox freezer. The set-up is used in a trial run at home and the planned use is

Electric vehicles are unnecessary

The article about Malcolm Faed's electric ute (SILICON CHIP, June 2009) prompted me to make a comment concerning electric vehicles. In the late 1970s, I built two electric cars and two electric motor cycles which competed in races sponsored by Lucas at the Boonah Show and the Kalbar Potato Festival. These were endurance races using a maximum battery size of 150Ah @ 12V and they taught me a lot about electric vehicles.

I even built a 5kW PWM controller using 2N3055s. Since then I have lost interest in electric vehicles and if a referendum were to be held to convert to all-electric vehicles, I would vote against it.

The reason is simple. We do not need electric vehicles of the size and capacity of current cars. When the demands of current living are examined, there are two distinct areas of demand for transport: city and country. I believe the best way to serve the country needs is to use current car technology with petrol, diesel, alcohol or a similar liquid fuel, with electric trains for passenger and heavy haulage.

When the city demands are examined, fixed-route electric buses and trains would be the best for mass transit. Small vehicles like the existing mobility scooters and golf buggies would better serve local personal transport and the situation would be even better if the majority of Australians worked within 5km of their homes. We have this silly situation where many people travel long distances to and from work each day and hence need vehicles with large endurance.

If they were to change to nearby jobs or the jobs move to them, then the electric buggy, scooter or bicycle becomes viable with existing technology and all the benefits would be available now. Instead we are locked into long-distance travel, relatively large vehicles and large costly highways.

George Ramsay,
Holland Park, Qld.

on a solar system in the bush.

Unfortunately, after 8-10 days running, it developed relay chatter when switching on. This was minor at first but after three weeks the relay chatter was bad enough to stop and start the compressor which was drawing three times the normal starting current.

The cause was found to be condensation across the sensor terminals in the fridge/freezer compartment, changing the sensor voltage. Sealing the sensor terminals with neutral-cure silicone sealant before replacing the outer heatshrink sleeve fixed the problem.

Friedrich (Fritz) Blahous,
Waterford, Qld.

Virtual machines for running DOS-based software

I read Rick Walters' article in the May 2009 issue with great interest, on giving our circuits a professional look. This article (and many others in previous issues) covers two of my main areas of interest – computers and electronics.

My situation today is that of a computer service and repair company owner and technology writer and this is in no small part due to reading and devouring the contents of magazines such as "Electronics Australia" and "Electronics Today International" and building as many projects as I could afford as a youngster back in the 1970s and 1980s. My fascination with all things electronic continues to this day and I look forward very much to the magazine in my postbox every month.

Regarding the article, Mr Walters mentions running an older DOS-based program on modern operating systems; specifically, the excellent Protel Autotrax software (which is not to be confused with the excellent but more modern Kovac Software AutoTRAX EDA). This is a big headache for many companies and individuals who rely on older software, be it for accounting, CAD, graphic design or indeed, circuit design. The great thing is that Microsoft acknowledges the problem and has made available everything we need to do the job.

I am talking about Microsoft Virtual Machine (MSVM). This is essentially

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Mailbag: continued

Gas-fired power stations should be big

In response to your Publisher's Letters in the June /July 2009 issues, I could not agree with you more. I have nearly 20 years in the power industry, covering all facets from power generation to distribution switchyards. However, I would like to add a few items of interest.

First, coal-fired thermal power stations could be made more effective if they were to be fired from the gas extracted from the coal. This process is already utilised in Germany. And why would it be of value to Australia? Simple – brown coal still needs another 20,000 years to mature into the sort of coal that is of the grade found in Europe and parts of North America. That's a little long to wait, don't you agree?

As it is, a boiler is designed around the calorific value of the fuel it is to burn. So converting to gas is not that difficult. As for the Closed Circuit Gas Turbine, the idea is also not new. But if you are going to invest in one it needs to be of suitable capacity. CCGTs are available up to 800MW or more and that's where the problem lies.

Governments don't want to spend money on them; not while they can wheel out diversions like carbon trading, carbon tax, alternative energy, etc. Western Australia recently installed two CCGTs at Kwinana Power House. They are supposed to have a capacity of 120MW each in total and will replace two existing 120MW coal-fired units. So where's the improvement? The urban energy grid for WA is already below capacity as it is. It's not technology which needs to change, rather the fact that "professional" organisations are still seemingly run by "amateurs".

Drew Merrit,
Perth, WA.

a way of running an operating system within another operating system and it works beautifully. For example, a client of ours runs a mixture of XP and Vista on their networked machines because of some modern software they use in their business.

Annoyingly, however, this set-up is not so good for the older-style, proprietary accounting/inventory package they have used for years (and paid many thousands of dollars for). No matter what we tried, we just couldn't get it to behave on these modern operating systems. By using MS Virtual Machine, however, our headaches disappeared.

It is a breeze to install and configure and in the example above, once installed, all I had to do was install Windows 98 and their old software package on the virtual machine. Whenever they want to use the DOS-based software, they just "boot" the 98 virtual machine by double-clicking an icon on their Vista/XP machine's desktop and once 98 has booted, they can run their software in either a window or full-screen mode, just like before.

Because the "virtual" Windows 98 system uses the Vista/XP hardware layer, there are no hardware compatibility issues and the DOS software has full networking and printing capability. It really is the answer to a lot of prayers.

If people do not like the Microsoft product (for some reason, many don't), there are other VM programs that do the same job. However, since MSVM is now free for anyone to use, there is no reason not to use it given that it should have the best compatibility with operating systems out of all VM programs.

The relevant links are:
(1) **www.microsoft.com/windows/downloads/virtualpc/default.mspx (Virtual PC download)**; and
(2) **http://www.ehow.com/how_2060126_install-operating-system-microsoft-virtual.html**

Dave Thompson,
PC Anytime Ltd,
Christchurch, NZ.

Tone generator and note analyser for singers and musicians

As a technician and a singer in a choir I would like to propose a kit-built tone generator and frequency analyser. During our choir rehearsal, we would find such a device invaluable and I am sure that musicians would find it equally useful.

I envisage the unit would be at least A4 size or larger, battery-powered and mounted on a microphone stand. This way, it could be among the choir, free of cords and easy to see when pitching notes during rehearsal. Nothing we have seen in the marketplace seems to come near meeting this need. Frequency analysers are generally very small and are intended more for use by musicians.

The analyser is the most needed feature but if it could be incorporated with a keyboard generator that would prove invaluable. We have found small "toy keyboards" that are frequency accurate, so presumably they could be



available for integration into a kit project.

In practice, a key could be struck and verified by the analyser. In turn, the singer could repeat the note and verify their accuracy.

If LEDs could be presented across the bass and treble clef, as shown, it would provide the ideal pictorial display of the frequency range for bass, tenor, contralti through to sopranos singers. If the appropriate LEDs could be dual or triple colour they could be used to denote the sharps and flats.

A volume control with off switch, a speaker and a microphone would complete the package.

We look forward to reading about it in a future edition of SILICON CHIP. Each member of the choir could have one at home for vocal training, so the market should be appreciable.

Nigel Davies,
Highgate, SA.

Comment: we have already published a PIC-based Tuning Aid which would probably meet at least part of your requirement. It was featured in the July 2008 issue.

Fast blow for a PIC micro

If there was a competition to blow a PIC in record time I think your "Multi-Function Remote Controlled Lamp Dimmer" would win the prize with pin 14 going to mains active and pin 5 going to ground.

The use of the ground symbol is unfortunate but I notice that the same convention was used in the diagram for the "Automatic Lamp Dimmer" July 2005. There are times when using the ground symbol simplifies a circuit diagram and should be used but when mains wiring is involved the ground symbol should defiantly not be used except when an actual connection to ground is indicated (as in your use of the chassis symbol in the July 2005 diagram).

David Dorling,
Buderim, Qld.

Fuel injector exerciser for Cordia

Your correspondent "C. C." in the "Ask SILICON CHIP" section for June 2009 requests assistance for a circuit to exercise fuel injectors as an aid to cleaning them. I have produced a similar circuit for the same task and I found a cleaning fluid made up of a 50/50 mix of toluene and acetone produced the best results.

Probability can produce strange results; the car for which I made the circuit is the same – a 1985 Cordia Turbo!

Aden Lindsay,
Darlington, WA.

Climate change comment

I read with interest your Publisher's Letter in the June 2009 issue, on the nonsense of Global Warming. I agree with you but you did not go far enough. Carbon dioxide is the source of the oxygen that we breathe. It's part of the carbon cycle.

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Mailbag: continued

The photosynthesis process is also a little more far-reaching than you quote. Carbon dioxide plus water in the presence of sunlight and green leaves produces sugars, cellulose, and some other plant material and oxygen. The reaction is endothermic (takes in heat). Forests are natural air-conditioners.

There is no shortage of carbon dioxide but clearly there is an increasing shortage worldwide of trees, particularly rainforests that are the best converters of carbon dioxide to oxygen.

The emphasis must shift from penalising "polluting CO_2 producers" to stopping the wilful destruction of the world's forests.

Alan Swales,
via email.

Inaccuracies are a problem

I am somewhat disturbed by the technical inaccuracies in your magazine. For example, in your editorial of the June edition, you state that petrol is mainly octane. In fact octane is certainly less than 12% in normal unleaded petrol (see **http://discovery.kcpc.usyd.edu.au/9.2.1/9.2.1_Unleaded.html**).

You go on to give the chemical reaction for the combustion of octane and state that of the two combustion products, there is more water produced than carbon dioxide. If, in your words, you calculate the molecular weights of the two combustion products, you will find that the molecular weight of water produced = 18 x (2 x 1 + 16) = 324, whilst the molecular weight of carbon dioxide is 16 x (12 + 2 x 16) = 704.

In other words, over two-thirds of the emissions, by mass, from burning octane is carbon dioxide. It is therefore quite false to say that there is more water produced than carbon dioxide.

Another extremely misleading piece of information in the magazine is your insistence that all incandescent lamps are being banned from sale. This is certainly not the case. The only incandescent lamps that are being banned are general lighting services types that do not comply with minimum luminous efficiency standards. Other types of incandescent lamps, such as special purpose lamps for refrigerators or ovens, indicator lamps, low voltage lamps (less than 220V) and lamps of over 150W are not affected.

Information on this can be obtained from the website of the Australian Government Department of the Environment, Water, Heritage and the Arts **www.energyrating.gov.au/incand-lamps2.html**

This website has a formula and graph for the minimum efficiency requirements and gives links to the legislation governing the importation of such lamps. There is also a link to the minimum efficiency and performance requirements for Compact Fluorescent Lamps, including life, luminous efficiency, colour and starting performance.

It would be of great service to your readers if you were to give them the correct facts about this.

Allan Tayler,
Ingleburn, NSW.

*Comment: maybe you are not aware of it but the government hopes to ban ALL incandescent lamps by 2015. See **http://www.environment.gov.au/settlements/energyefficiency/lighting/faq-phaseout.html***

As most readers can attest, trying to purchase any sort of incandescent lamp, apart from 12V halogens, is now quite difficult unless you go to a specialist lighting retailer.

As far as the combustion of octane is concerned, as noted last month, the Publisher's Letter should have referred to the fact that the volume of water vapour produced is more, not the mass.

In picking on octane, we possibly should have made it a more general discussion about hydrocarbons but most people associate octane with petrol, even if it is not the major component. In any case, the various aromatic components of petrol vary widely, depending on the refinery which may be local or overseas.

School zone legislation in SA is not so silly

Sometimes your great technical efforts get sidetracked by a silly comment. I refer to the comment made by the letters' editor in response to Ron

Colon therapy for 6-digit GPS clock



I thought you might be interested in my experiences with the 6-Digit GPS Clock featured in the May & June 2009 issues. I have added a 2-LED "colon" board produced by RCS Radio – it helps to finish the clock in my view. Although it may not be clear from the photo, the colon LEDs are a good match in brightness to the main displays.

In getting the clock going, I had one problem. When first fired up, it worked well except that every five seconds the seconds display was slow to update; the next second arrived when it should and then all would be well until the next five seconds were up.

The delays between seconds changes seemed like 1, 1, 1, 1.5, 0.5, 1, 1, 1, 1.5, 0.5, 1 etc. A little investigation showed that the GPS receiver was putting out a longer data stream every five seconds, which caught out the PIC processor.

After hooking up the GPS board to a PC, I was able to observe that every five seconds several GSV frames were being added to the normal three, hence the problem. I lashed up the full GPS Test Interface featured in Geoff Graham's March 2009 article, downloaded an appropriate program from the internet and was able to turn off the GSV frames.

After that, the GPS clock worked perfectly.

It's great just being able to turn it on and have accurate time display almost instantly.

Kevin Olds,
Latham, ACT.

Mills' note about the lack of need for the School Zone Speed Alert in South Australia.

As an ex-South Australian who was protected by the school speed zone rules and grew up to drive with them, I found them eminently sensible.

(a) The speed limit is constant and one that gives a driver a chance to react to unpredictable children (compared to the range of choices here in Victoria – 60km/h on major roads, 50km/h on some and 40km/h on others).

(b) The onus is clearly on the driver to watch for children, not a clock.

(c) When children come and go from school, flags are added to the signs in all the areas I drove in. Automated zebra crossings existed on busier roads, flashing 25. This means that there is generally a large set of clues that children are present.

(d) Senior school children were trained and given responsibility to monitor crossings and deal with the flags. This, coupled with serious police presence, meant the school zones were highly respected by the community.

So the fact that a clever School Zone Speed Alert is needed to deal with silly time-based rules does not mean alternative simple rules that rely on observant drivers are "stupid".

David Gates,
Notting Hill, Vic.

Comment: we reacted to Ron Mills' letter on the basis that the SA school speed limit had previously been 40km/h but had now been further reduced to 25km/h and now applies all the time, regardless of the time of day.

Hydrocarbon combustion by-products

I would like to set the matter straight regarding your comments about combustion emissions in your Publisher's Letter in the June 2009 issue; they are not as harmless as you state. You forgot nitrogen.

Prior to combustion, air is mixed with fuel and as we all know air consists of 20.95% oxygen, 78.08% nitrogen plus a few other gases making up the remainder. During the combustion process you were correct about

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how hydrocarbons (C_nH_{2n}) bond with oxygen (O_2) to produce carbon dioxide and water but in this combustion process nitrogen also bonds to the free oxygen to form NO_X (NO & NO_2) which is a highly reactive gas.

NO_X is the brown haze that is visible as smog pollution and it is also water-soluble, which creates nitrous and nitric acid, aka acid rain. Another pollutant of the combustion process which has to be mentioned is carbon monoxide (CO) which is quite toxic.

Carbon Geosequestration or CCS is not the answer. Taking into consideration that Australia has the majority of the world's uranium deposits, this is where we should be putting our resources.

Peter Ljaskevic,
Cheltenham, Vic.

Comment: it is true that nitrogen does enter the combustion process but only in a relatively small way. Carbon monoxide occurs only when cars are running rich and not when the mixture is stoichiometric. Any residual carbon monoxide will normally be converted to carbon dioxide in the catalytic converter.

Feedback on electric vehicle conversion

I just wanted to give a bit of feedback relating to the recent article on "Mal's Electric Ute Conversion" (SILICON CHIP, June 2009).

In this article you stated "As far as we know, it is the first such road-registered DIY conversion in Australia and it is probably one of the first in the world."

This is very wrong. There are a large number of conversions completed and road-registered in Australia and around the world. SILICON CHIP actually covered some of them which were featured at the latest Electric Vehicles Australia field day (SILICON CHIP, December 2008). There are also companies in the UK and US that do professional conversions of brand new cars and can provide you with a complete electric car.

John Williams,
Jane Brook, WA.

Comment: actually we said that it is the first road-registered conversion (that we know of) using a 3-phase induction motor. We are aware that there have been plenty of others using DC motors and indeed, as you point out, we covered some of them in our article on one of the AEVA field days.

It also appears that one of the universities may have done a van conversion using a 3-phase motor about 20 years ago but we have not been provided with details yet.

Electricity saver discredited

I happened to be browsing the website which used to advertise one of those fraudulent and useless Electricity Saver devices (see SILICON CHIP, May 2008) and the retailer now says they don't work and quotes SILICON

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Nixie tubes last a long time



I refer to a letter in the "Ask Silicon Chip" pages of the June 2009 issue where your correspondent questions the possible life span of Nixie tubes. The accompanying photo shows a clock I built four years ago using ZM-1020 Nixie tubes. These devices were removed from one of Tasmania's hydro power stations in a control upgrade and had been in non-stop use as lake-level indication for 33 years prior to their removal.

As you can see, they still perform like new. I have spare tubes but I believe they will remain just that, for at least my lifetime.

Terry Ives,
Gowrie Park, Tas.

CHIP as having proved the claims to be false; a victory for commonsense and consumer protection! – see http://electricitysaver.com.au/home/index.php/how-does-it-work

Graham Carter,
Canberra, ACT.

Comment on vacuum cleaner story

In the letter entitled "DIY Wiring Horror Story" (May 2009, page 9), there is mention of a vacuum cleaner being run from a phone line.

In your comment, it states that the phone line has an impedance of 600Ω. This is correct but would not have any bearing on the subject, as this is a characteristic impedance and alludes to the AC characteristics and not the DC characteristics, ie, the line resistance.

If the home was close to the telephone exchange it may have some small ability to operate a universal motor. I remember an event back in the 1960s, when they were still using electromechanical switching. The switches in the exchange were going berserk and to cut the story short, it was chased down to some idiot using the phone line to run his train set.

Peter Mallon,
Maitland, NSW.

Beam breaker trigger has other uses

I am writing about the Beam Breaker Trigger project in the June 2009 issue. This is a great project although its primary use, triggering a camera/flash, is probably not its best application.

For example, it could easily drive a piezo-type siren without any modifications which means it would be a good doorway monitor that sounds an alert when someone goes through the doorway. The receiver unit also makes a good infrared remote control tester whereby the green LED lights when it receives a signal from the remote, ie, point a remote control at the receiver instead of using its own beam generator.

I have some tips on setting it up. First, use a digital camera (either a movie or still camera is fine) to align the three infrared LEDs in the transmitter box. To do this, point the transmitter at a wall and look at the wall through the camera's LCD viewfinder; you should be able to see where the individual LEDs are shining. You can either align them to give a bigger beam or focus them into a point to get more range (you would need to focus them over the same distance of the intended use).

If you have no room to position the transmitter box away from the receiver, then use a mirror, have the transmitter and receiver next to one another and point them both at a mirror across the area needing to be monitored. The green alignment LED would make setting it up this way easy. The mirror could even be a bicycle reflector instead which makes it less critical to align.

Philip Chugg,
Launceston, Tas. SC

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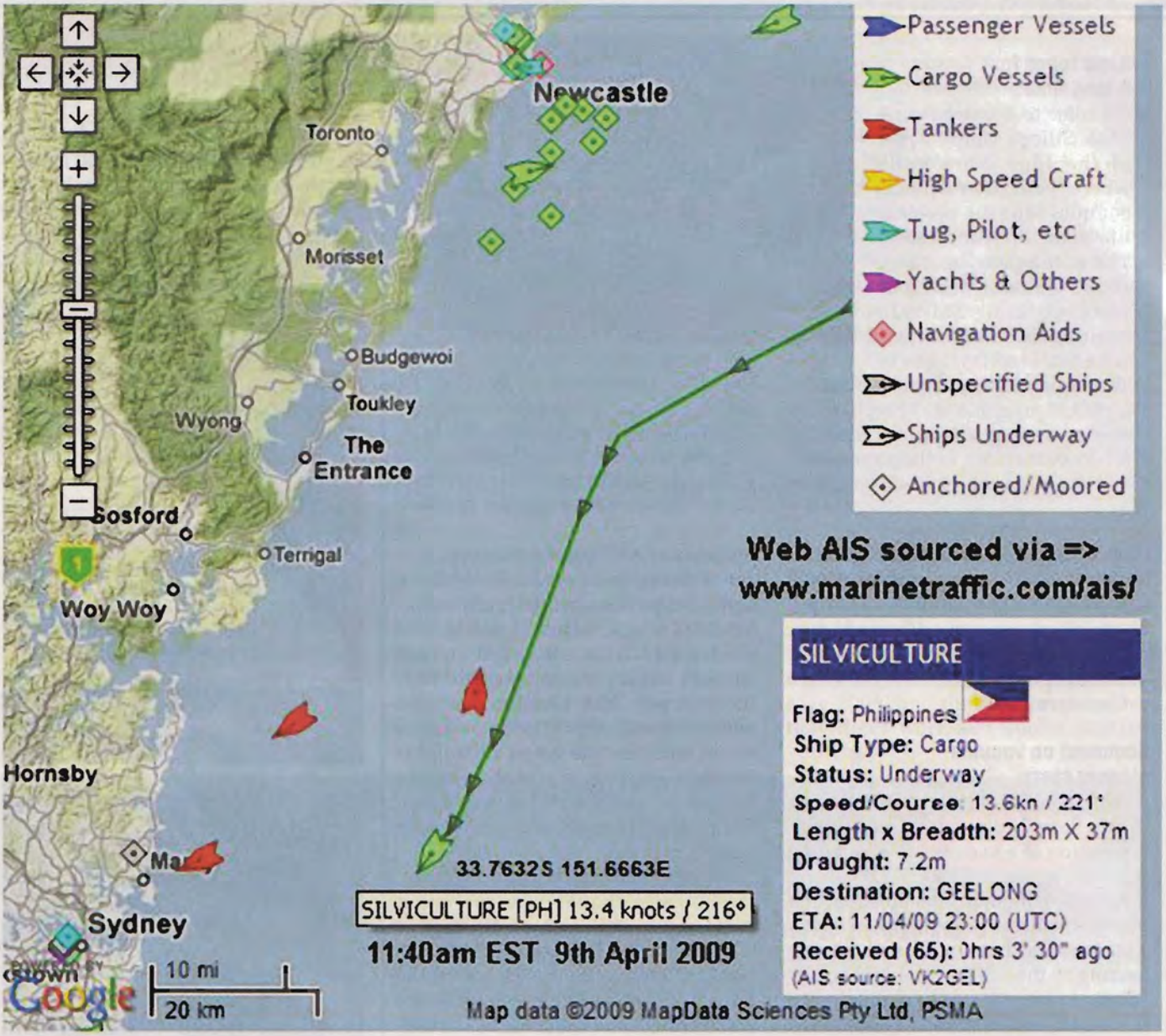


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What's that Ship?

or AIS for Landlubbers

by Stan Swan

What is that ship sailing past? Where's it heading? When is it due in port? What is its speed? How big is it? For all these questions – and many more – the answer is AIS: Automatic Identification System. You may even follow it, on line, on your own computer – from anywhere!

Readers may recall a few months ago we featured a means of identifying aircraft and following their progress using a hardware and web product called AirNav Radar Box (SILICON CHIP, November 2008).

Now you can do much the same thing with virtually all commercial shipping and even many of the larger pleasure craft you see off our coasts.

Somewhat akin to AirNav Radar Box, you have the choice of tracking in real time (using a VHF receiver or scanner) if you live close enough to the coast or alternatively, using the internet where details of that ship may well have been posted. But we are getting slightly ahead of ourselves!

Ship watching

Even viewed from the shore, ships often conjure up an exotic sense of far away places and tap an eternal human wanderlust.

Many a ship-watcher has idly gazed at passing vessels and pondered their destination and movements – particularly if one's vantage point is from a becalmed yacht in a busy sea lane!

Both at a romantic and utilitarian level, even a casual interest in shipping movements from a coastal location near sea lanes could mean an emerging VHF wireless technology called AIS – Automatic Identification System – may take your fancy.

Essentially a SOLAS (Safety of Life At Sea) collision avoidance system designed for professional seafarers, AIS shows immense potential even for landlubbers! It's a fascinating blend of software, radio, electronics and e-navigation, yet can be experienced on skinflint budgets.

Interested? But it sounds like digital sea-sickness? Gain your AIS sea legs instead (and to whet your appetite!) go to www.marinetraffic.com/ais/!

Just select a busy region (perhaps the Straits of Gibraltar) from the global map and zoom in to suit. Mouse-hovering over a coloured display symbol gives vessel details, while a right mouse click shows ship images and near-live vessel tracks.

The versatile real-time insights gained from this are quite astounding and should enthuse even hesitant landlubbers!

Collision avoidance

"Full speed astern!" Over past centuries of powered shipping, no doubt



Keeping track . . . of a sailing ship with AIS. The Spirit of New Zealand off the northeast coast of NZ. You can even see how the ship is tacking from the southeast before it makes its due-westerly run into Kawau Island. There's even a photo of the Spirit under canvas so you can see what she looks like!



The Channel is getting pretty crowded! This is just a tiny section with AIS showing cargo vessels, passenger vessels, tankers, ships under way, ships moored . . .

Commercial AIS equipment – at right the text-only SIMRAD A170, photographed on the bridge of the Norwegian coastal vessel MF Bastø II by Ulf Larsen. (Courtesy Wikipedia). Below is a Smart Radio SR161 AIS Receiver, an entry-leve single channel scanning receiver designed for both recreational and professional use. (Courtesy Milltech Marine).





this urgent command has been the last request handled by many engine-room telegraphs!

Radar (when fitted) has long helped identify possible shipping hazards but the returned radar trace requires skilled interpretation. As well, microwave signals may be masked by nearby terrain.

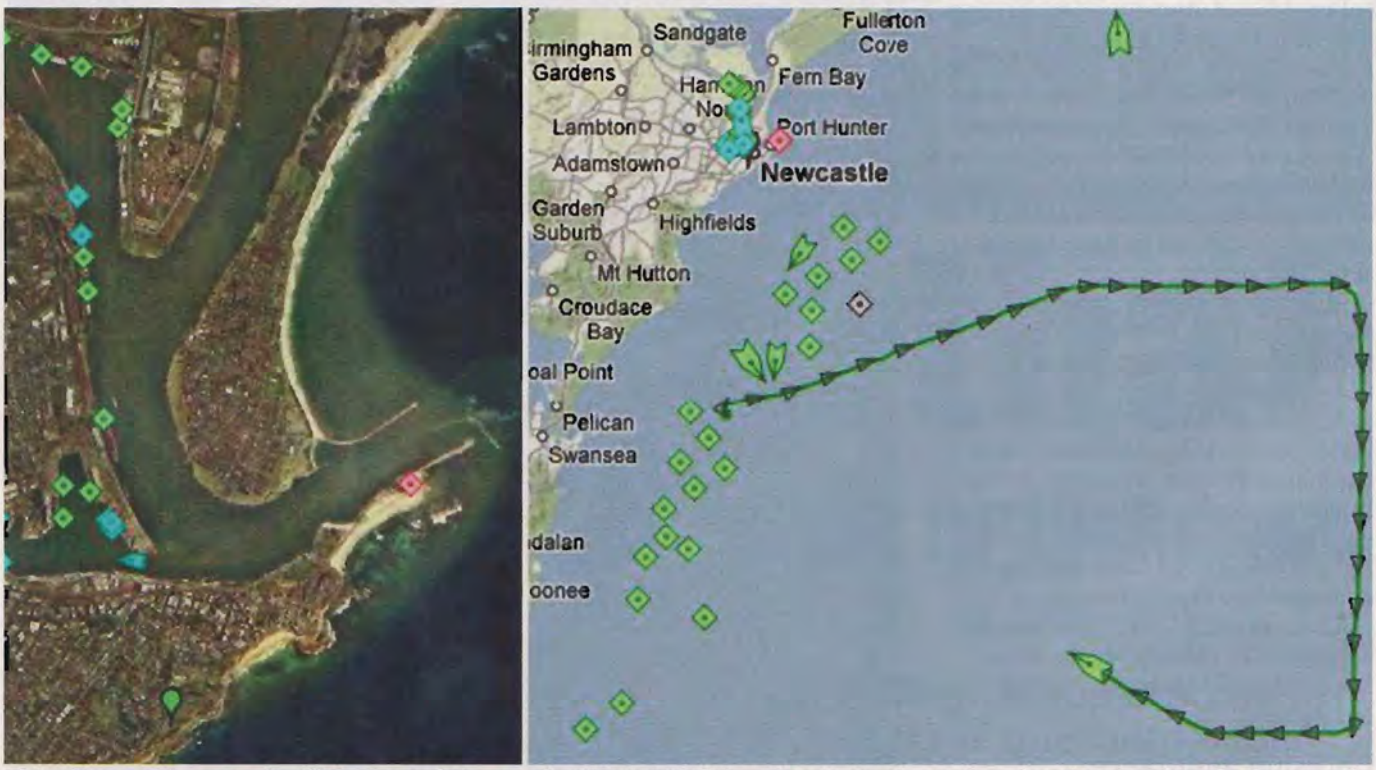
Thanks to GPS, *your* position may be accurately known but the intentions of the "tanker on my port bow!" (suddenly appearing around a headland or looming out of the fog) may be a mystery.

VHF voice communication may help clarify things but evasive action takes precious time – especially in congested waters.

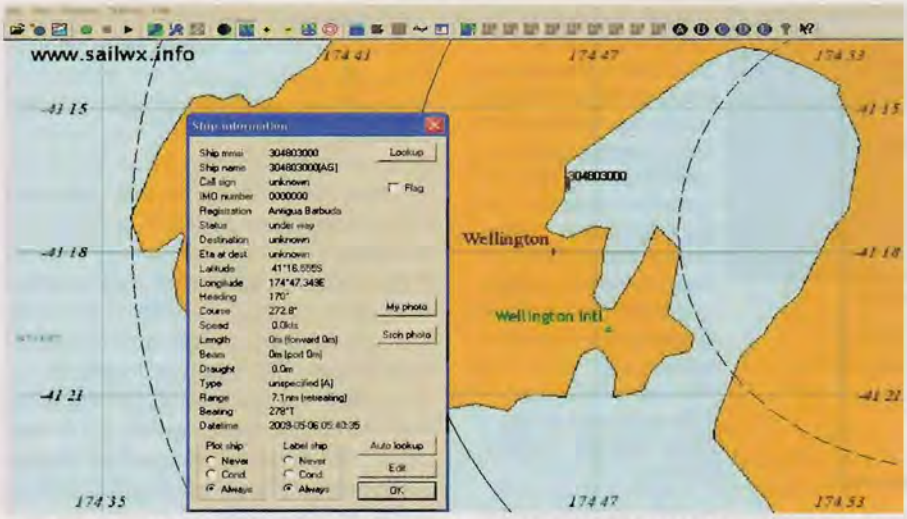
Aside from the ever-present dangers of weather, reefs and pirates, mariners have to increasingly contend with the possibility of accidentally colliding with each other.

The English Channel is so crowded with sea traffic that old salts swear white lines and traffic lights may soon be needed to prevent collisions!

When compared with aircraft, vessel speeds are orders of magnitudes slower. But aircraft have the third dimension available to climb or dive to avoid each other – ships naturally work in a more restrictive 2D environment and may also need several



This ship parking area is off the port of Newcastle, NSW. At left is a Google Earth overlay showing the ships lucky enough to have entered the Hunter River, while the queue at right shows those still waiting. Do you reckon the captain of one vessel might have got bored waiting and decided to do a hot lap to keep the crew busy?



On the left a "ShipPlotter" example shows single ship AIS details, plotted against a low resolution shoreline sourced from www.sailwx.info. Detailed marine charts can be costly, although the 1:250,000 global coastline extractions (freely available as "mapgen" downloads from http://rimmer.ngdc.noaa.gov/) may be satisfactory for shoreside users.

nautical miles to come to a stop, go astern or even to make an evasive turn.

Automatic Identification System (AIS)

An amateur radio APRS (Automatic Packet Reporting System) GPS-based technique has been in use since the 1980s and it's tempting to think such enthusiasts paved the way for commercial services again – much as amateurs did for "useless" shortwave broadcasting back in the 1920s.

ACARS (Aircraft Communications Addressing and Reporting System) began about 1990 and by the late 1990s an international shipboard based collision avoidance positioning system emerged.

This marine development has grown into perhaps the most significant navigational safety technology since the introduction of radar.

AIS is strictly called UAIS (Universal Automatic Identification System) but the "U" is often dropped to make it simpler. This wireless technology enables commercial vessels to "see" and clearly identify each other, whatever the conditions (night, fog, storms, congestion).

AIS does this by continuously transmitting a vessel's identity, position, speed and course to all other nearby AIS-equipped vessels or shore stations within VHF range (typically 20 nautical miles or ~ 30km).

These low-power and low-speed data signals are openly sent on VHF marine channels 87B (161.975MHz) and 88B (162.025MHz) as brief (~30ms) 9600 bps data bursts and can be readily received and decoded by others for textual or graphical display.

So-called Class "A" AIS transponders have been compulsory on vessels over 300 tonnes since 2004 but even smaller leisure craft are now fitting the less informative "Class B" version as part of their e-navigation tools.

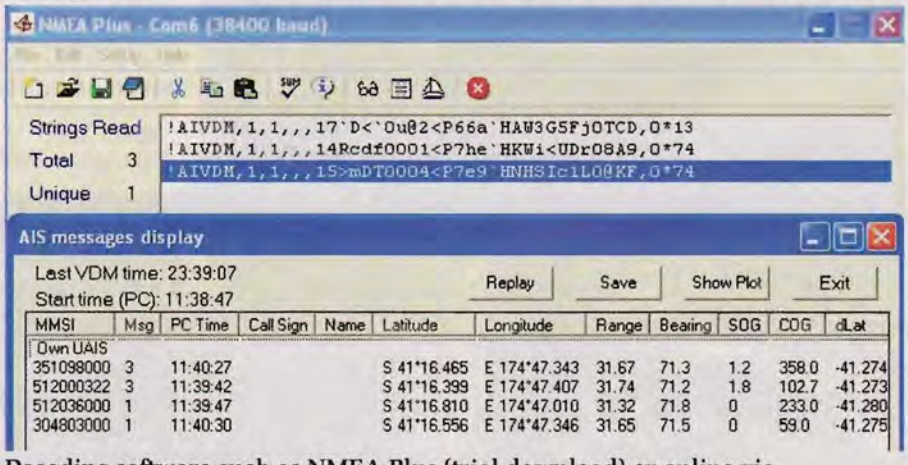
AIS acceptance and adoption has been very rapid and current worldwide usage is already (mid 2009) estimated at over 40,000 vessels.

AIS benefits

Although radar and GPS may be thought adequate instruments, there are seven major areas where AIS improves over them:

- Longer wavelength – AIS can "see" targets around islands and capes in coastal waters (as microwave radar doesn't penetrate hills etc)
- Ships identified – AIS "translates" radar echoes into ship names and types - useful when calling them on VHF!
- More information – AIS improves prediction of a target's intentions by taking into account its course and rate of turn (ROT).
- More range – at sea AIS receivers typically cover to the horizon.
- Two-way information – it alerts others to your vessel's nature and intentions.
- Low power – only small transmitters are needed– typically just 2-12 watts (radar is much higher power and has intricate moving parts).
- Inshore vessel information can be gained, perhaps globally via the web.

Typically the end result can be e-charted displays showing details of all AIS-enabled craft within VHF range, along with their course and speed and



Decoding software,such as NMEA Plus (trial download) or online via http://rl.se/aivdm, conveniently allows the cryptic AIS data messages to be shown as plain text. Although useful when first testing ones AIS receiving setup, graphical displays may be naturally more enlightening.



Rottnest Island, off Perth/Fremantle (WA), with the Swan River at right. This image comes from www.marinetraffic.com. Below is an extracted chart of the same area sourced via NOAA's free 1:250,000 global coastline resource (http://rimmer.nadc.noaa.gov/). "NavMonPc" can AIS-read and zoom these mapgen format charts.

even if they are at anchor or berthed.

Although essentially minimising the risk of collision, AIS allows harbour facilities to be productively managed and it's also useful for marine search and rescue operations (SAR aircraft now increasingly carry AIS), since it can identify and exactly pinpoint the position of an AIS-transmitting ship in distress.

AIS information details

At its most basic level, an AIS transmitter just continually sends the host vessel's call sign and GPS position, alerting others to its whereabouts.

An intricate method of time sharing the radio channel ensures that even with a large number of vessels nearby, blocking of individual transmissions is unlikely.

AIS ships typically automatically transmit dynamic voyage information at intervals of between 2 and 12 seconds (depending on speed and proximity to others), or every few minutes if at anchor.

Details include:

- MMSI number (Maritime Mobile Service Identity - a series of nine digits)
- Navigation status, eg, 'at anchor' or 'underway'
- Ground speed, from 0 to 102 knots in steps of 0.1 knots
- Rate of turn, 0 to 720 degrees per minute
- Position (GPS-sourced latitude and longitude)
- Heading and Course over Ground (COG)
- Time stamp.

Every six minutes vessel information is also transmitted, typically:

- Callsign
- Ship's name and unique ID number
- Type of ship
- Beam (width), length and draught
- Onboard GPS antenna location

Further voyage related information such as cargo, destination, ETA and route plan, short messages etc, is generally manually entered and updated by the bridge team.

Rusty English officers are prone to entering such amusing typos as Sidney instead of Sydney!

Nature of AIS data

Two-way ship-to-ship and ship-to-shore AIS is usually preferred by mariners, as it allows invaluable information to be automatically exchanged between all AIS-enabled craft, maritime traffic stations, coast-guard authorities and even buoys and lighthouses.

However, such equipment and its professional installation can run to several thousand dollars.

Dedicated AIS sets pick the 9600



You might expect to find a lot more ships in what Cook described as one of the world's great harbours . . . but ever since the NSW government's rather questionable decision to close Sydney Harbour as a working port, five vessels is about it!

bps GMSK (Gaussian Minimum Shift Keying) FM signal off the receiver's discriminator and process the entire 25kHz data bandwidth before later narrowing occurs.

GMSK (which is also most notably used in the GSM cellular system) enjoys the impulse noise immunity of FSK (Frequency Shift Keying) but the digital data stream is first filtered, thereby yielding high spectral efficiency.

If you live near a seaport and have a NBFM (narrow band FM) receiver covering the 161.975MHz and 162.025MHz AIS frequencies (either will do), the brief data bursts arising from nearby commercial ships, boats and ferries can usually be heard as scratchy "pops". Signals are often quite weak, so the receiver squelch may need to be opened.

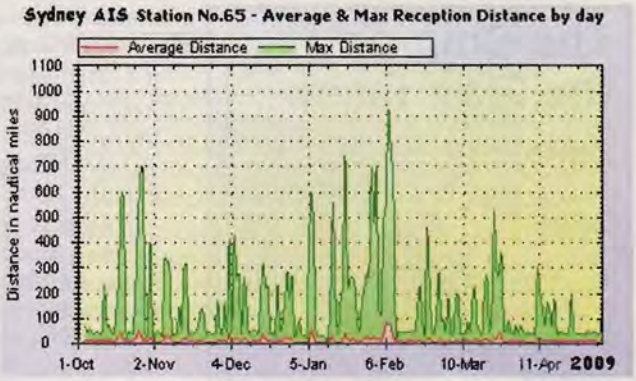
Unfortunately, in most scanners receiver filters and de-emphasis circuits trim off much of the incoming signal's intelligence, limiting raw audio decoding. However, it's feasible to modify even cheap VHF receivers and scanners to make them more acceptable for AIS service without compromising "normal" usage.

We show details on how to do this to a typical scanner shortly, with decoding via PC soundcard.

The conversion is straightforward on even older VHF scanners and a comprehensive resource site www.discriminator.nl/ details the technique for hundreds of different VHF sets.

Modern, more upmarket VHF receivers increasingly offer this "discriminator tap" output for direct soundcard input of the raw data.

Such direct access to raw data signals may be useful for other digital modes as well – soundcard data decoding is very well established!



Stats from a Sydney AIS station feeding into www.marinetraffic.com. Freakish AIS reception from far offshore usually relates to VHF tropospheric ducting – common in summer (and at night) when hot dry settled anticyclones overlay cooler, moist ocean air. NSW endured a heatwave early February 2009 !

NMEA

Just as modern aircraft are predominantly "fly-by-wire", modern ships have long enjoyed all-electronic "glass bridges". The National Marine Electronics Association (NMEA) has developed a specification to suit.

Specialised AIS receivers (such as the Smart Radio SR161) will probably include an NMEA port for direct interfacing to various pieces of marine electronic equipment, allowing information to be automatically sent between computers, GPS, radar, echo sounders, chart plotters and the like.

Although cryptic, for most purposes NMEA can be considered an RS232-compatible 4800 bps, 8 data bits, no parity and one stop bit (4800,8,N,1) protocol.

However AIS encoding assigns each ASCII character to 6 binary bits (unlike normal ASCII which uses 8 bits). Here are typical 64-bit plain text AIS data strings –

```
!AIVDM,1,1,,B,1INS<8@P001cnWFEdSmh00bT0000,0*38
!AIVDO,1,1,,A,100000002IP7NcvM@jupq79`0000,0*3A
```

It's certainly not easy to make sense of these!

An on line NMEA sentence decoder at http://rl.se/aivdm relates the first to an anchored ship near Athens (Greece) at latitude 37.91 N , longitude 23.56 E, while the second vessel travels through the English Channel at a heady 18 knots. (AIVDM = other vessels, while AIVDO means your own ship.)

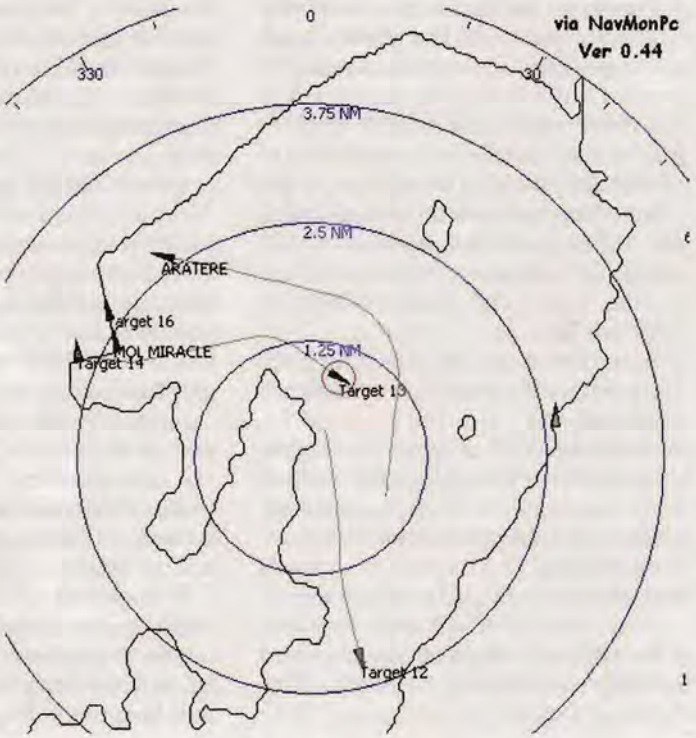
Fortunately there's no need to sweat the NMEA decoding! Convenient software is available, both for online and local use, that allows smooth PC decoding (and perhaps even plotting) of the shipping data contained in the cryptic NMEA AIS sentences.

Shore-side reception and decoding.

Let's imagine you're based near the busy seaport of Fremantle (WA) and are now interested in setting up a cost-effective AIS monitor.

As any "Freo" resident will confirm, even with a global downturn, dozens of ships continually ply the Swan River mouth between the mainland and offshore Rottnest Island.

What ARE they? Given the open and informative nature of AIS, such interest has soared amongst enthusiasts keen to monitor local shipping move-



Vessel tracks, which fade after selectable times on plotting programs, offer outstanding course insights. Although the AIS course data is near real time, it may be some minutes before ships transmit their name and voyage details. Google Earth pictures are all very pretty but a simple graphical screen, as seen here, is often far better to view ship details and paths without the clutter of buildings.

The Ship on the First Floor



When Stan Swan sent his draft and pictures over for this feature, we were intrigued to find a ship "at anchor" a little north-west of Manly, on Sydney's Northern Beaches.

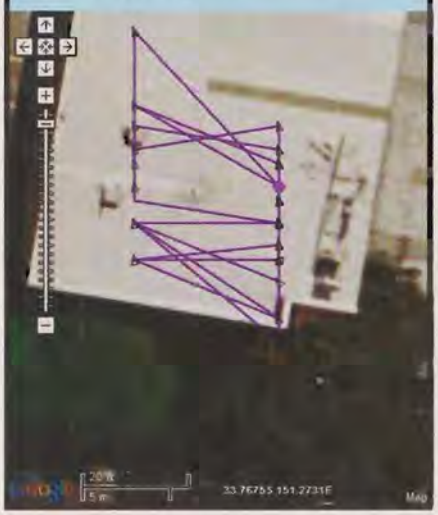
Those who know the area – as we do (very well!) – will know that there is a lagoon a little north-west of Manly but anything higher than about 30cm would not get through the pipe to the ocean.

There's also a dam in the hills above Manly – but we doubted any of small pleasure craft which sometimes use the dam would have AIS fitted.

On closer examination, we found that the "ship" was actually "anchored" in a street in Brookvale, only a couple of hundred metres from the SILICON CHIP offices.

Then Stan had another look at the data and found the "ship" was actually "under test" and appeared to be tacking back and forth on the first floor of an office building. In fact, he managed to print out the track of the ship, shown below. It certainly shows the accuracy of the GPS tracking signal which is part of AIS!

Umm . . . maybe the AIS transmitter should have been turned off or at least fed into a dummy load?



ments – both ashore and when afloat.

Before embarking on a full AIS quest it's first worthwhile experimenting with available VHF receivers (and perhaps simple antenna) to see if 161.975MHz/162.025MHz signals can even be heard locally.

As the two AIS channels are marine hi-band VHF ones, almost any VHF radio or old scanner will normally receive them.

Cheap US "Weather Band" receivers (~162.500MHz) are so near the AIS frequencies that retuning to suit may even be possible, as may tweaking older two metre (144-145MHz) ham band gear.

However, some older VHF receivers may be insensitive, subject to interference or prone to drifting, making full AIS decoding performance possibly frustrating.

Dedicated AIS commercial transponder and charting setups can cost many thousands of dollars and best suit the professional or well-heeled. Assuming signals have been detected, more cost effective approaches hence may tempt.

1. Purchase or construction. Aside from just buying a dedicated AIS receiver, making one's own complete receiver/decoder is not impossible. Several AIS-capable ICs are available (most notably CML's CMX7032 and CMX7042) to handle all the data massaging – with just a 162MHz RF front-end needed.

However such a constructional challenge best suits the real enthusiast, even then one with a reasonable level of skill. So both landlubber ship followers and small vessels keen to receive and decode AIS are advised to look at simpler (and cheaper) options.

2. Discriminator tap + soundcard. As outlined overleaf, basic local AIS reception really only requires the following, with most of the (Windows) software free:

- A sensitive, stable ~162MHz VHF receiver with discriminator output (see below)
- A suitable VHF antenna (the higher the better - refer "Slim JIM" below)
- An mono-to-stereo audio cable between your receiver and PC soundcard input
- A Windows PC with 16-bit soundcard – even older laptops will do fine.
- Soundcard demodulating and NMEA producing software (AIS-Mon 2.2.0)
- A virtual serial port program (VSPD XP5) to feed the decoding program
- Either decoding software to turn NMEA strings into plain text (NMEA Plus), or
- Simple graphical software to e-chart the NMEA output (NavMonPc)

Although increasingly considered a cartographic display norm, Google Earth-style charting of local shipping movements requires powerful software and perhaps local e-charts, both of which can be costly. Naturally a web connection may ease this but remote coastal sites or underway vessels may not enjoy this convenience.

The esteemed "ShipPlotter" (Portuguese; 21 day trial then around $50) provides acceptable displays, including linked satellite views and it directly handles the soundcard signal processing and NMEA feeds.

In spite of these processing needs, almost any PC will do, as the AIS data handling is relatively pedestrian – there's even a Win98 version.

Although there are numerous other tracking programs, ShipPlotter is presently considered the best value AIS package but it has near overwhelming features with a steep learning curve. Even the alternative (and free) "SeaClear" may take days to fine-tune soundcard settings and charts to your needs.

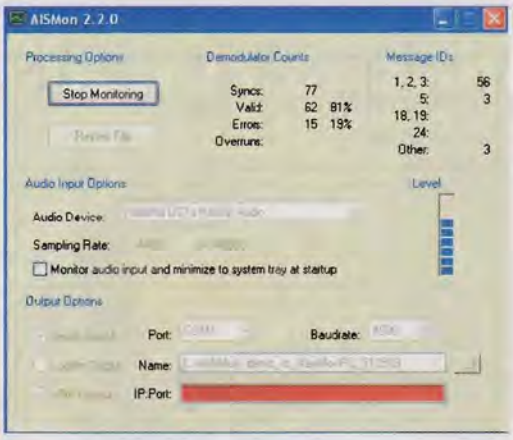
In contrast the simpler (but comprehensive, global and free) 1:250,000 coastline chart extractions used by NavMonPc may better suit. Remember that ships naturally are at sea and Google Earth terrestrial details may hence be incidental (most Google Earth satpics don't go very far out to sea).

3. Web Server and on line display Although this looks more ambitious, in fact setup is streamlined compared with the 2nd option, as such dedicated sites as www.marinetraffic.com (University of the Aegean, Greece) handle much of the final NMEA decoding and graphical display.

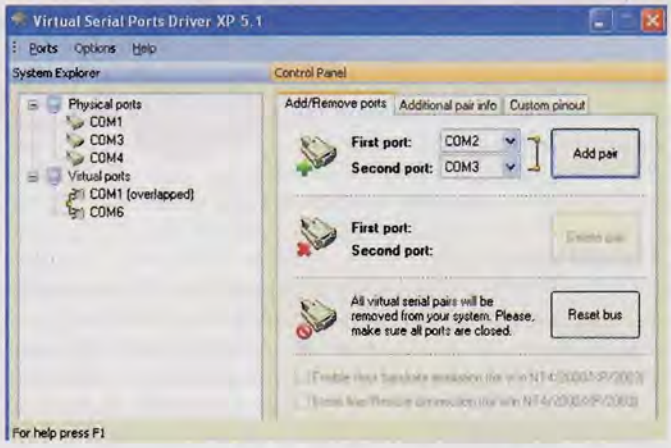
Naturally internet access is necessary. Both you and global ship watchers can monitor real-time marine traffic while half a world away (and miles from the ocean) in Alice Springs.

That's right – no receiver is needed!

Web-served AIS display viewing is highly recommended initially, as the nature and variety of zoomable graphical ship tracking in popular locations will be quickly experienced.







Getting your PC to work its soundcard decoding magic requires three linked programs – an NMEA decoder, com port emulator and AIS displayer. AISMon 2.2.0 has been found a robust initial NMEA decoder, with its blue signal input bar invaluable for audio level setting. Click a 48000 sample rate, 4800 baud rate and serial output on perhaps COM1.

Decoded NMEA file saving (and even an internet feed address) can be set from here too – this may be handy for examining the NMEA strings. Connect the discriminator tap to sound card input cable and click Start Monitoring – the level should show mid range blue bars. Sync's and Message ID numbers should soon appear, with Demodulator Counts (100% is best) often relating to soundcard overload, distant ships or poor local antenna. Once verified as working this program can be minimized.

VSPD – a Virtual Serial Port Driver (14 day trial however) next must be run to provide com port pairs. Com1 from the AisMon feed is simply paired to give a Com3 output. Numerous emulator offerings exist and programs such VSPE (free) may well suit.

NavMonPc, a comprehensive (but lean) e-navigation program completes the chain. Start this program, select File and set Serial Channel A as Com3 4800 baud. Clicking Done should finally display decoded NMEA messages as they arrive – recheck all earlier settings and connections if they don't. Options allows entering (as DD MM.mmm) your local latitude and longitude – just approximate values will initially do – with Use This Position. Clicking AIS then gives a circular display, with targets shown as triangles, although true vessel outlines can be selected at high zoom levels if the bridge crew have entered them correctly. Local NOAA charts can be obtained from http://rimmer.ngdc.noaa.gov/. Tweak your receiving locality details if need be. After all the hard work, spend some time enjoying the settings, tracks and zoom levels!

This may even be all you need, especially if living inland beyond marine VHF range.

You can help contribute data!

Our Fremantle example is one such area that web-based AIS info is lacking – at the time of writing, virtually none of the WA coast (including the very busy Pilbara) had web-based AIS coverage. This will no doubt change as more and more enthusiasts contribute their received AIS data to the world wide web.

Of course, not having web-based AIS doesn't stop you receiving it direct – and if you are at a fixed site with VHF AIS reception, you can become active in supplying YOUR soundcard-gathered AIS data to a global audience.

By altruistically providing your own local AIS web feed you can help extend the global AIS footprint.

All that's required is to enter the IP port address supplied by the hosting service and ensure a reliable upload feed.

A modest few megabytes per day of uploaded data seems typical of harbours such as Wellington and although essentially just a public service, beneficial educational and promotional spinoffs may result.

Serious ship watchers who are keen to provide coastal coverage in busy regions still not served may even manage a free professional AIS receiver from site hosts such as www.vesseltracker.com. Their motivation behind such largesse is no doubt commercial!

Web monitoring concerns

Although enthusiasm is globally very high (especially in Europe) for AIS adoption, both at the super-tanker and recreational boating level, concerns have been raised over web-based AIS data availability.

The International Maritime Organization (IMO) Safety Committee especially feels that web publication of freely-available AIS-generated ship data could be detrimental to the safety and security of ships and port facilities.

Given recent piracy, it's indeed feasible that criminals may be monitoring inshore ship movements with devious intent.

But ships in global trouble spots can, of course, simply turn off their AIS transmitter or remove sensitive voyage entries – or even spoof their true identity (eg, a cruise liner or oil tanker anywhere *near* the Somali coast appears on AIS to be a destroyer!).

Taken overall, public AIS information, both locally-monitored or web-based, seems so informative that beneficial aspects win the day.

Just being able to pop into an internet café and web-locate a moored dockland vessel may save the bacon of lost crew floundering around in the fog as sailing time approaches!

Web-published information is not, of course, intended to enhance safety at sea. Any internet-provided AIS data may be obsolete, in error or incomplete and best suits general shore-side informative purposes.

On-board seamanship and navigation aids are naturally still required.

Article links and AIS resources are hosted at www.manuka.orconhosting.net.nz/ais.htm

OVERLEAF:
How to modify a Uniden scanner (without affecting its normal usage!) to receive 160MHz AIS transmissions.

CONVERTING UNIDEN SCANNERS FOR AIS

These well-priced, wide-coverage and very popular hand held scanners further offer a valuable "close call" feature and have become well respected for general VHF/UHF work.

The discriminator tap access is straightforward and fitting an external socket should make for a neat and professional enhancement to the set. However, your scanner warranty may become invalid!

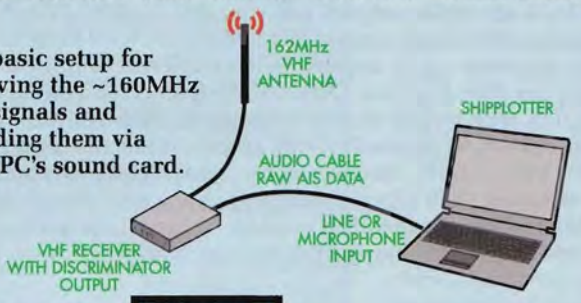
All variants of the UNIDEN UBC72/73 & 92/93 use the 24-pin TOKO TK10931 discriminator IC, with base- band audio output at pin 12 (LND7). This accesses the unfiltered audio. A resistor soldered to a convenient pad on the PC board provides the tap without otherwise affecting scanner operation. In most cases a 10kΩ resistor suffices but with some sound cards we've had to go as high as 220kΩ to avoid overload. You could also use a 220kΩ trimpot in series with a 10kΩ resistor to make adjustment easier.

The resistor's other end is wired to a 2.5mm mono chassis socket mounted on the back of the scanner. There is sufficient space between the stacked PCBs and case for this.

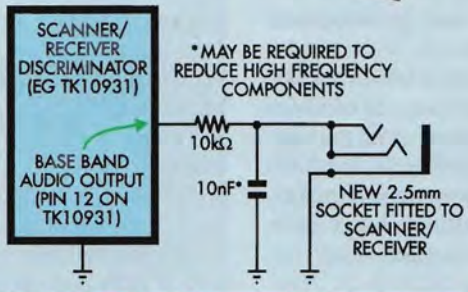
A short wire for the ground lead can be run to the antenna's ground terminal – a 10nF capacitor between the resistor's far end and ground may help remove residual higher frequency portions.

A 2-wire external lead then connects to a stereo 3.5mm plug to suit the PC soundcard's line-in or mic input socket. The scanner squelch must be wide open ("hissing") but the scanner's internal speaker volume can be turned right down.





The basic setup for receiving the ~160MHz AIS signals and decoding them via your PC's sound card.



Tapping into the receiver's unfiltered audio is quite simple. At right is the circuit diagram suiting the Uniden scanner.

The antenna

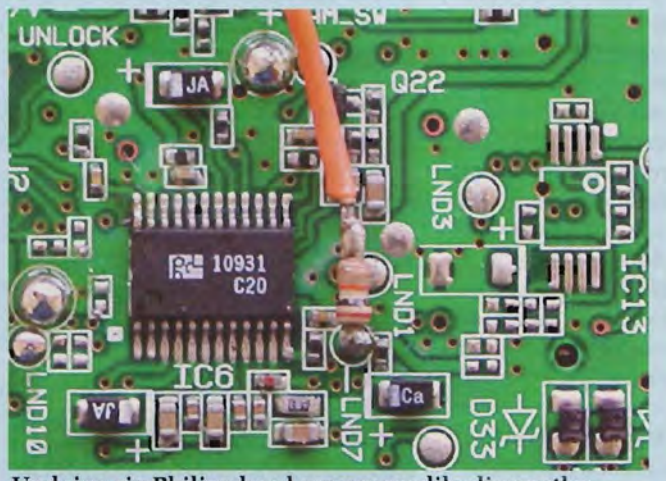
Unlike 2.4GHz WiFi, VHF marine signals are not *so* influenced by nearby obstructions but the best AIS reception will still be gained with clear line-of-sight (LOS) coverage.

The supplied "rubber ducky" whip antenna on most scanners should allow open-terrain AIS reception to perhaps 6nm (~10km) but either elevation or a better antenna (or both) will greatly assist – it really depends on your proximity to nearby shipping.

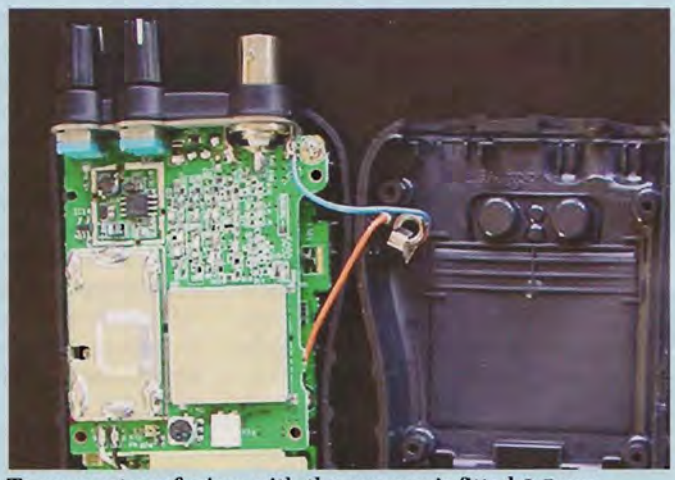
The BNC socket on most scanners readily allows modest coax runs to rooftop Yagi beams but a simpler and more portable antenna may be better – especially if AIS signals come from a wide arc.

A DIY "Slim JIM"

One of the most appealing antennas for such work is the so called "Slim Jim" (an acronym for "J-type Integrated



Undoing six Philips-head screws readily dismantles the Uniden scanner and the revealed circuit boards simply clip apart. Neatly solder the 10kΩ resistor and outlet wire at LND7, perhaps sliding fine heat shrink tubing over the wire joint to prevent circuit board shorts.



To prevent confusion with the scanner's fitted 3.5mm headphone socket, the output socket to the computer sound card should be an open-type 2.5mm mono socket (eg, Jaycar PS-0105), as modern enclosed types are slightly too long for the most suitable rear case hole position.

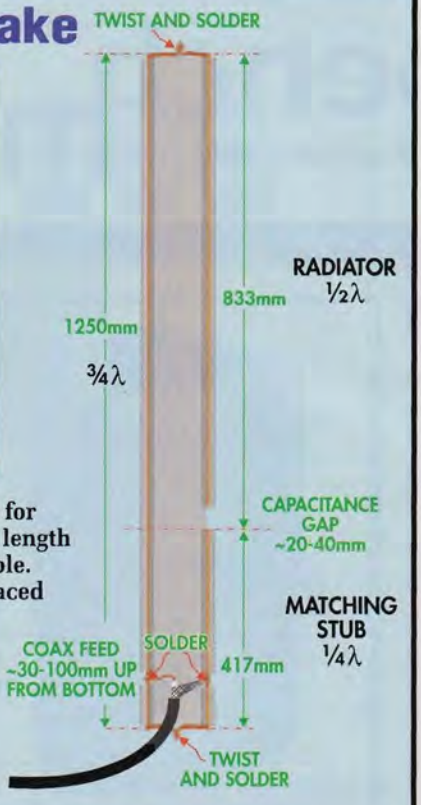
. . . and a cheap "Slim Jim" antenna to make

Match") – invented in 1978 by the late Fred Judd, G2BCX.

Any parallel conductors could be used (some diehards swear by HO-scale model train track!) but such an antenna can be quickly and cheaply made from a length of 300Ω impedance TV ribbon.

This is becoming rather difficult to get, having largely given way to 75Ω coaxial cable (which is, of course, entirely *unsuitable*!) but Dick Smith stores still stock it (Cat W2071).





A "Slim Jim" antenna for 162MHz made from a length of 300Ω TV ribbon cable. This would best be placed inside a length of plastic conduit and mounted outside, as high as possible and away from metal (such as a mast, roof, etc).

Although cheap, this ribbon rapidly deteriorates in the wind and sun if left unprotected, so housing inside a vertically supported plastic conduit (eg, mains conduit) is almost essential for outside use. Plastic conduit will not degrade performance at all.

Considerable variation on the basic design can be tolerated, as aspects such as the gap space, conductor spacing, velocity factor (VF) of the wire and even nearby metallic objects influence performance.

At 162MHz an open-space wavelength = speed/frequency = $3 \times 10^8 / 1.62 \times 10^8$ = 1850mm. However slower signals within the TV ribbon decrease this by ~0.9 (known as the Velocity Factor) giving a working AIS wavelength of 1665mm.

The Slim Jim is ¾-wavelength long (although only the upper half-wave portion receives), so a 1250mm antenna length should suffice. "Cut and try" experimentation is encouraged – cut slightly longer initially and trim to suit for best performance.

Almost any TV-grade (ie 75Ω) coax suits Slim Jim connection to the VHF receiver's BNC antenna socket and use of light-grade flexible coax makes a roll-up version feasible.

Unless you're making a very long run from antenna to receiver, losses should not be too much of a problem. Of course, if your run is long (ie, greater than, say 10m), go for one of the better (low-loss) cables.

To construct a Slim Jim, simply follow the diagram at right. You'll need a length of ribbon cable about 1280mm long, to allow the two ends to be stripped and shorted, as shown.

The wires at each end of the cable are bared, twisted together and soldered (don't ignore the last part, especially if you are going to erect the antenna outside). In fact, a short length (30mm or so?) of heatshrink tubing over each end will further protect the copper wire from corrosion.

The exact position for the coax feed connection is not all that important for a receiving antenna – between 30 and 100mm up from the bottom is the range. The centre wire of the coax is soldered to the 3/4 wavelength side (don't cut the wire, just remove the insulation) while the braid connects to the matching stub opposite the centre wire connection point.

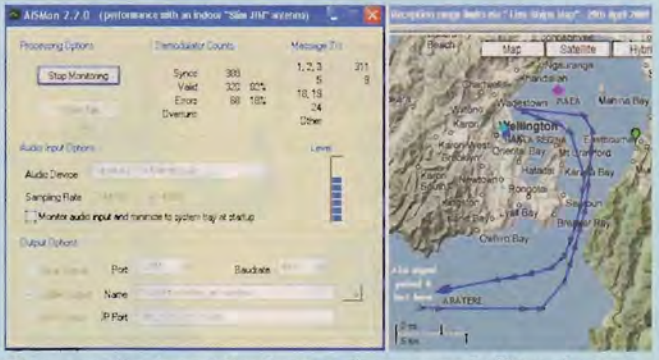
Again, the capacitance gap, on the "earthy" side only, can be anywhere from about 20 to 40mm. Don't simply cut the cable; the short length of wire needs to be removed.

Apart from putting it inside a suitable length of conduit (say 1.3m) with a plug on the top end (the bottom end could be filled with silicone sealant to stop insects and spiders calling the Slim Jim home), your antenna is now complete and ready for use.

Slim Jim low angle performance is legendary, as the design best handles signals received near parallel to the ground – forget it for near-overhead aircraft and satellites!

Unless you're tracking flying boats (or live on a hilltop), vessels are naturally going to be near-horizontal anyway. Slim Jim AIS reception out to 20nm (~30km) could be expected when the antenna is well elevated, perhaps by being hoisted up a tree (inside a conduit) with a nylon line.

At my harbourside location near Wellington (NZ), 162MHz reception performance with a Slim Jim was spectacularly improved over a scanner's whip! SC



Stan, monitoring at Eastbourne (green symbol) tracks two vessels using VHF radio AIS into and out of Wellington harbour. This gives a good idea of the type of performance to expect using the modified scanner and Slim Jim antenna described here and AISMon software running on your PC.

Digital Radio

Part 5: The Official Australian Start – 6th August 2009

Australia, currently the country with largest population to adopt DAB+, was instrumental in the adoption of the DAB+ as a world standard. Switzerland, Malta, Hungary, Poland and Singapore already have DAB+. It is to be launched in Germany and Italy this year and will be the standard in the Czech Republic, Israel, Malaysia, Indonesia, China, much of Scandinavia and other European and Asian markets.

by Alan Hughes

When FM radio was first being introduced, it wasn't particularly attractive for the AM broadcasters of the day.

For a start, there were *very* few radio receivers with an FM band, mainly because manufacturers didn't want to waste money fitting what amounted to a separate front-end for a band which had only a few "experimental" transmissions on it.

Second, AM broadcasters saw FM as a threat, something that might go away if ignored. Or that FM would not attract listeners from AM. Around that time, something happened which made them change their minds: imports of receivers with both AM and FM bands flooded in as the Australian radio manufacturing industry collapsed.

In more recent years, huge amounts of money have been paid for commercial FM licences; even low-power, restricted area licences have attracted enormous bids, making analysts wonder how on earth these stations can ever be a money-making proposition.

Today, the commercial stations have seen the error of their ways and have certainly not refused free DAB+ frequencies. In fact the broadcasting industry has been the main force in pushing government to allow DAB+ transmissions.

They did not want to be left behind (again!) in the digital race.

The advantages of DAB+ are irresistible; 15 – 25 audio services per DAB+ channel and better resistance to errors. There is one transmitter per DAB+ channel.

Many radio manufacturers are developing DAB+ sets which will be progressively marketed in the coming months. Commercial Radio Australia has been supplying manufacturers with disk copies of some transmissions. This is so they can test their designs on DAB+ to optimise the sound quality and to ensure the receivers at the edge of the coverage area mute quietly, unlike some DTV receivers.

Commercial Radio Australia has also been in negotiations to convince car makers to include digital radios in new models.

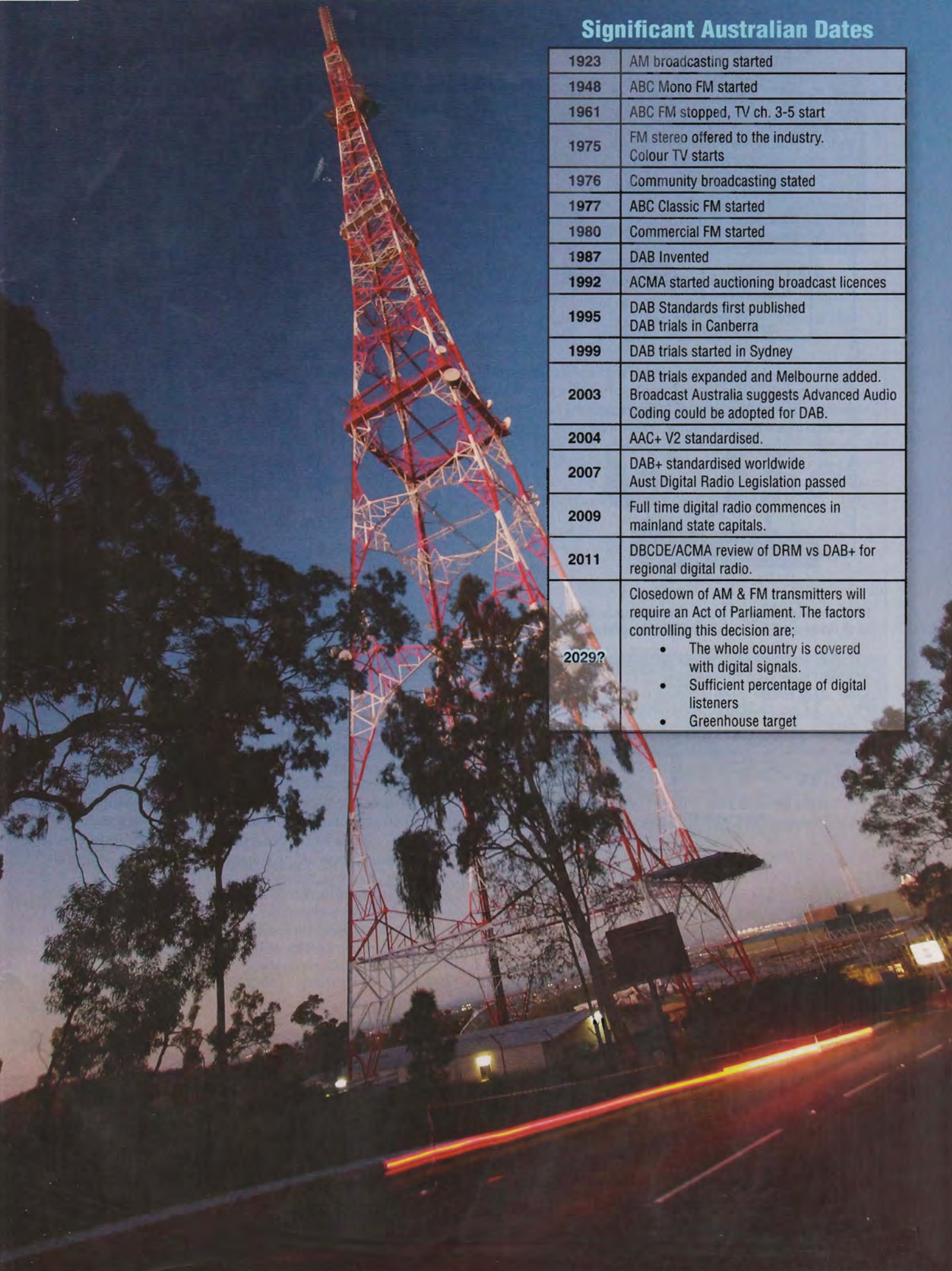
Existing car users can use a product like the "Pure Highway" as seen in "Digital Radio part 4".

Receiver Profiles

WorldDMB and the European Broadcasting Union have defind three basic receiver profiles. Profile 1 radios are available now; Profile 2 receivers should be available by the end of the year and Profile 3 some time in the future.

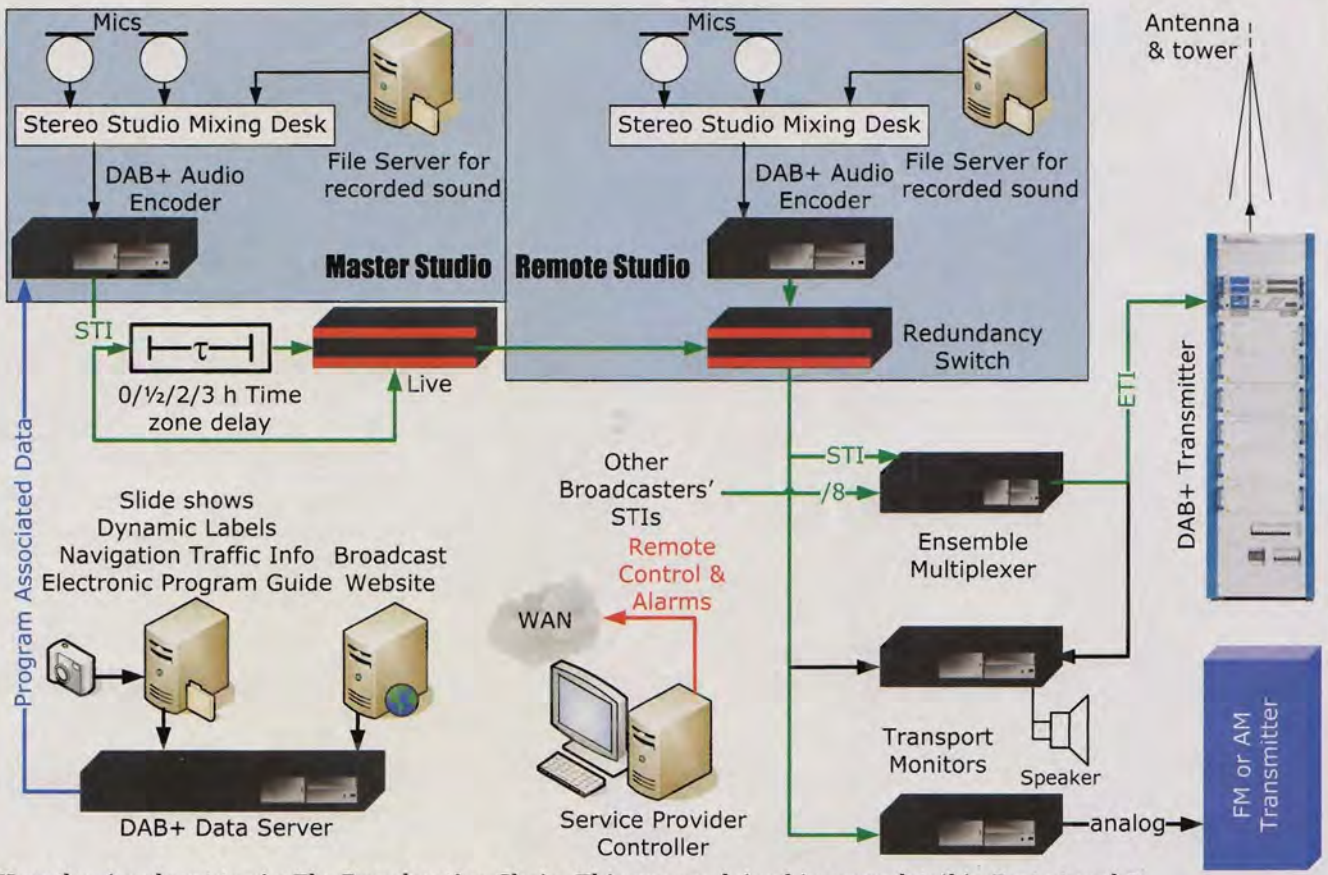
Profile 1. The simplest radios produce sound, scrolling text display for station name and limited messaging - characteristics present on some FM radios and entry-level DAB+ radios.

Profile 2. As profile 1 with the addition of a colour display to show slide shows of pictures, an electronic program guide and a broadcast website browser so that the user can select pages from the broadcasters' website. It is also possible that radio stations may allow you to download



Significant Australian Dates

1923	AM broadcasting started
1948	ABC Mono FM started
1961	ABC FM stopped, TV ch. 3-5 start
1975	FM stereo offered to the industry. Colour TV starts
1976	Community broadcasting stated
1977	ABC Classic FM started
1980	Commercial FM started
1987	DAB Invented
1992	ACMA started auctioning broadcast licences
1995	DAB Standards first published DAB trials in Canberra
1999	DAB trials started in Sydney
2003	DAB trials expanded and Melbourne added. Broadcast Australia suggests Advanced Audio Coding could be adopted for DAB.
2004	AAC+ V2 standardised.
2007	DAB+ standardised worldwide Aust Digital Radio Legislation passed
2009	Full time digital radio commences in mainland state capitals.
2011	DBCDE/ACMA review of DRM vs DAB+ for regional digital radio.
2029?	Closedown of AM & FM transmitters will require an Act of Parliament. The factors controlling this decision are; • The whole country is covered with digital signals. • Sufficient percentage of digital listeners • Greenhouse target



How the signals get to air: The Broadcasting Chain. This was explained in more detail in Parts 1 and 2 of this series (SILICON CHIP, February/March 2009).

a music selection for a price.

Profile 3. A DAB+ profile 2 radio with the addition of a Digital Mobile Broadcast (DMB) TV receiver. This system is in competition with DVB-Handheld system which has been trialled in Sydney on TV channel 29.

Mobile TV

You might be wondering why DAB+ would want to be used to transmit TV signals, After all, DAB+ is radio and TV is TV, right?

Not quite! The digital age means re-thinking many traditional boundaries between TV and radio when digital technology is being used.

One of those changes is mobile TV – or more correctly, TV reception on mobile devices. We've all seen the adverts (on TV, of course!) where (some) TV programs can be received by mobile phones and PDAs, etc. These use the 3G phone network, just one way to transmit TV to these devices.

Unfortunately 3G is also the most expensive method – and coverage is limited.

Another method is DVB-H which is a ruggedised version of our existing TV signal but with less-sharp images than SD TV.

It uses MPEG4 compression (as used by Foxtel HD, NZ terrestrial digital TV) so that a total of 20 programs can be transmitted by a single TV transmitter. Some of the programs are encrypted so you have to pay for them.

It doesn't use the phone system – a single 7MHz TV channel is used for this service.

Yet another development is DMB (Digital Multimedia Broadcasting) which uses band-3 VHF to transmit a single MPEG4-compressed TV program as above.

The receiver may be a specific radio with a screen or a mobile phone/PDA etc with a DMB digital radio receiver. The picture quality is similar to DVB-H. This system is used in Korea and in Norway.

The use of band 3 VHF makes the signal more reliable. All new DAB+ receivers can decode the sound but for the TV pictures you need a profile 3 digital radio. The idea is to be able to watch sport at the game or elsewhere while mobile.

Australia is not proposing the introduction of DMB at this point. It will need to wait until the analog TV switch off to make more band 3 channels available for radio.

The last method, as we alluded to above with Profile 3, is to use DAB+ with its many advantages.

Broadcast licence categories

There is one transmitter per DAB+ channel, hence one licence.

Category 1: Commercial broadcasters are allocated 896kbit/s, so that 7 broadcasters get 128kbit/s each. Wide-area community broadcasters have been allocated a total of 256kbit/s.

Category 2: A mixture of commercial, national and community broadcasters.

Category 3: All national broadcasters (ABC & SBS). The ABC has 768kbit/s and SBS 384kbit/s. The programs to be available initially will be all existing ABC services,

Dig music, Dig Jazz, Dig Country and SBS1 and SBS 2

Brisbane, Sydney & Melbourne have two Category 1 and one Category 3 licences each. Adelaide & Perth only have a Category 1 and a Category 3 licence each.

A licence is for 2.25 Mbit/s of which 1.152 Mbit/s is available for data. This gives commercial broadcasters 128kbit/s each.

How each broadcaster uses their allocation is up to them. For example some broadcasters will use it for two stereo sound programs at 64kbit/s each. Sport broadcasters may wish to transmit one stereo sound program, results service and a slideshow showing the finish of races.

A broadcaster in the future may wish to transmit a single 5.1 surround sound program of higher quality. The broadcaster can change their configuration at will.

Sound transmission characteristics

All broadcasters are likely to use Spectrum Bandwidth Replication (SBR).

We covered this in detail in part 2 but briefly, it is a method where high pitch sounds are not transmitted. They are recreated from the lower pitched sounds through the use of these sounds and a control signal which determines how much high pitched recreation to use.

SBR allows you to almost halve the amount of data required for transmission, which in turn allows more programs per radio channel.

For rates of 48kbit/s or less Parametric Stereo is a must. Sound bit rates are likely to vary from 48-96kbit/s depending on the broadcaster – although higher and lower rates are technically available if required. These rates can be dynamically configured. Some receivers display the bit rates.

Comparison of transmission systems

AM radio:

- Not available on most DAB+ receivers, portable audio devices & mobile phones.
- Sounds duller due to a lack of high frequencies due to inadequate design in virtually all AM tuners and radios.
- Limited dynamic range due to the presence of noise
- Higher distortion, again due to inadequate tuner design.
- Suffers from interference from lightning and electrical switching
- Fading at dawn and dusk near the edge of the coverage area.
- Co-channel and adjacent channel interference, especially at night
- 9kHz whistling (again due to adjacent channel interference).

FM radio:

- Most broadcasters process the sound to make it as loud as the other broadcasters. So there is little variation in volume and a lack of "sparkle" on loud sounds because of the pre-emphasis required in an FM transmitter.
- Hiss and a lack of sound direction, when signals are weak (weak signals mean the receiver switches to mono).
- Fuzzy sound with little spread of sound sources due to reflected FM signals (multipath distortion).

DAB+:

- Sound processing has to be used with care when combined with an AAC+ V2 encoder, which does its own processing.
- More variation of loudness is likely to liven up the programs.
- Sound quality is determined by the bit rate used for the

DAB+ Digital Radio Receiver
– now available from Av-Comm

ONLY $149.00 PLUS P&P

Av-Comm's Q4000 DAB+ receiver is the result of over 12 months product development and market research. Rather than releasing a non-compatible DAB receiver which could have been used during early on-air testing, the company chose to wait until the DAB+ standard was formalised.

Originally intended to combine the features of DAB+, FM with RDS and Internet radio, the results of Av-Comm's market research indicated that different demographics exist for DAB+ and Internet radio. The result is the Q4000 which is purely a DAB+ receiver.

It has a clock and alarm functions, with snooze, allowing it to be used as a bedside clock radio. Priced at just $149 (plus P&P), the receiver represents an affordable entry point into the world of Digital Radio. The unit is capable of running from 6 AA (internal) batteries but is supplied with a bonus 9V regulated DC power supply for mains operation.

For those technically minded, the important specs are:

RF Input Frequency Range:	174.928-239.2MHz
Sensitivity:	-100dBm
Power supply:	9V DC, 800mA
DAB+ channels:	5A,B,C,D, 6A,B,C,D, 7A,B,C,D, 8A,B,D,C, 9A,B,C,D, 10A,N,B,C,D, 11A,B,C,D, 12A,B,C,D, 13A,B,C,D,E,F.



BE ONE OF THE FIRST TO EXPERIENCE THE BRILLIANCE OF DAB+!

EXCLUSIVELY FROM: Av-Comm Pty Ltd
24/9 Powells Rd, Brookvale, NSW, Australia (PO Box 225 Brookvale, NSW 2100)
Phone: (02) 9939 4377 Fax: (02) 9939 4376 Website: www.avcomm.com.au

sound program channel. Noise in the transmission path is not audible; if it causes too many errors the receiver mutes itself.

- It is a typical digital system. It is either good quality, it breaks up or is non-existent.

Coverage area

The coverage area will be limited to the licence area designated by the ACMA. So for the mainland capitals it will be limited to the metropolitan areas.

This means that the coverage is designed to minimise spillover into the adjacent licence areas such as: Sunshine Coast, Gold Coast, Central Coast, Illawarra, Geelong, and Mandurah.

Once analog TV is switched off in the mainland capitals then these non-metro areas can get DAB+ local stations. All transmissions in a given licence area are radiated from a single antenna so all programs will have the same coverage area.

The terrain in Sydney and the skyscrapers in Sydney and Melbourne are producing some areas of poor reception. So a low-power TV transmitter will be used to repeat all DAB+ channels in these areas. This will produce a Single Frequency Network. SFNs are used in digital TV on some of the same sites.

How the signals get to air

This was covered in much more detail in parts 1 & 2 but for readers who missed those parts, a brief recap. Read this in conjunction with the diagram on page 26.

The microphones pick up the sound and/or uncompressed pre-recorded sound is fed into the mixing desk. The on-air studio desk output is AAC+ V2 compressed and the Program Associated Data is added. A sound program from other on-air studios or recorded content can be added in the same DAB+ encoder system.

The resulting signal is called "Service Transport Interface" (STI) and contains all the signals from a single broadcaster. If the transmitter is in the same city as the Master Studio then the STI signal is fed into a local Ensemble Multiplexer.

If the transmitter is in a remote city then the STI signal is delayed to match the time zone and is fed into a redundancy switch. The switch allows the remote studio to be out of the circuit when the program is coming from the master studio.

If a local program is being inserted then the redundancy switch is told to switch inputs. Another redundancy switch can be used to bypass the delay for live inserts. The remote studio is identical to the master studio including the data server.

The reason for using a Redundancy switch is that it will ensure the time stamp is correct and the switch occurs at the end of a super frame. If this is not done the receiver will have to re-synchronise which will cause silence for four seconds.

The Ensemble multiplexer continuously, sequentially switches through 32 audio/data streams and adds the synchronising signals, Fast Information Channel Data (Inputs not shown), generates and inserts all the error correction data as well as performing the data shuffling.

The transmitter contains the COFDM modulator, frequency up-converter to the transmission frequency and the power amplification. The signal is then fed to the antenna at the top of the tower.

Redundancy

The system shown on the diagram is duplicated so that in event of failures the worst that can happen is a small drop of power. This assumes that the transmitter building and/or tower are not destroyed. At strategic points in the chain after the DAB+ encoder, more redundancy switches are used to switch around faulty units.

Monitoring the system.

The Service Provider Controller computer on each "TXA" transmitter site collects the alarm status and data of the equipment on that site. The status is sent to Broadcast Australia's control centre in Sydney, via a wide area network. This control centre can also send commands to the redundancy switches and all other equipment on the site.

Transport monitor

This device will measure the error rates in the signal and check the error correction coding so that the SPC can report problems. It also contains a broadcast standard decoder, which can be used to feed analog signals to either an FM or an AM transmitter.

Signal distribution

If you wish to send your signals interstate you have two choices:

(A) An uncompressed signal such as 3.072Mbit/s for a single AES stereo audio and no programme associated data.

(B) A compressed signal, such as 128kbit/s for an STI signal containing one or two stereo programs and embedded program associated data. This reduces you link costs. The only warning is that you cannot encode/decode/encode again, hence the use of switching mentioned above.

Signal storage

1.3824TByte/hour for a single AES Stereo sound signal without embedded PAD (Program Associated Data).

57.6Mbyte/hour for an AAC+ V2 signal of 128kbit/s and containing embedded PAD data.

The advantage of embedded data is that it always matches the surrounding program and is appropriate to the time when the sound was sampled. The use of DAB+ signals in STI or ETI form for distribution drastically reduces the distribution costs and stereo sound is included.

Conclusion

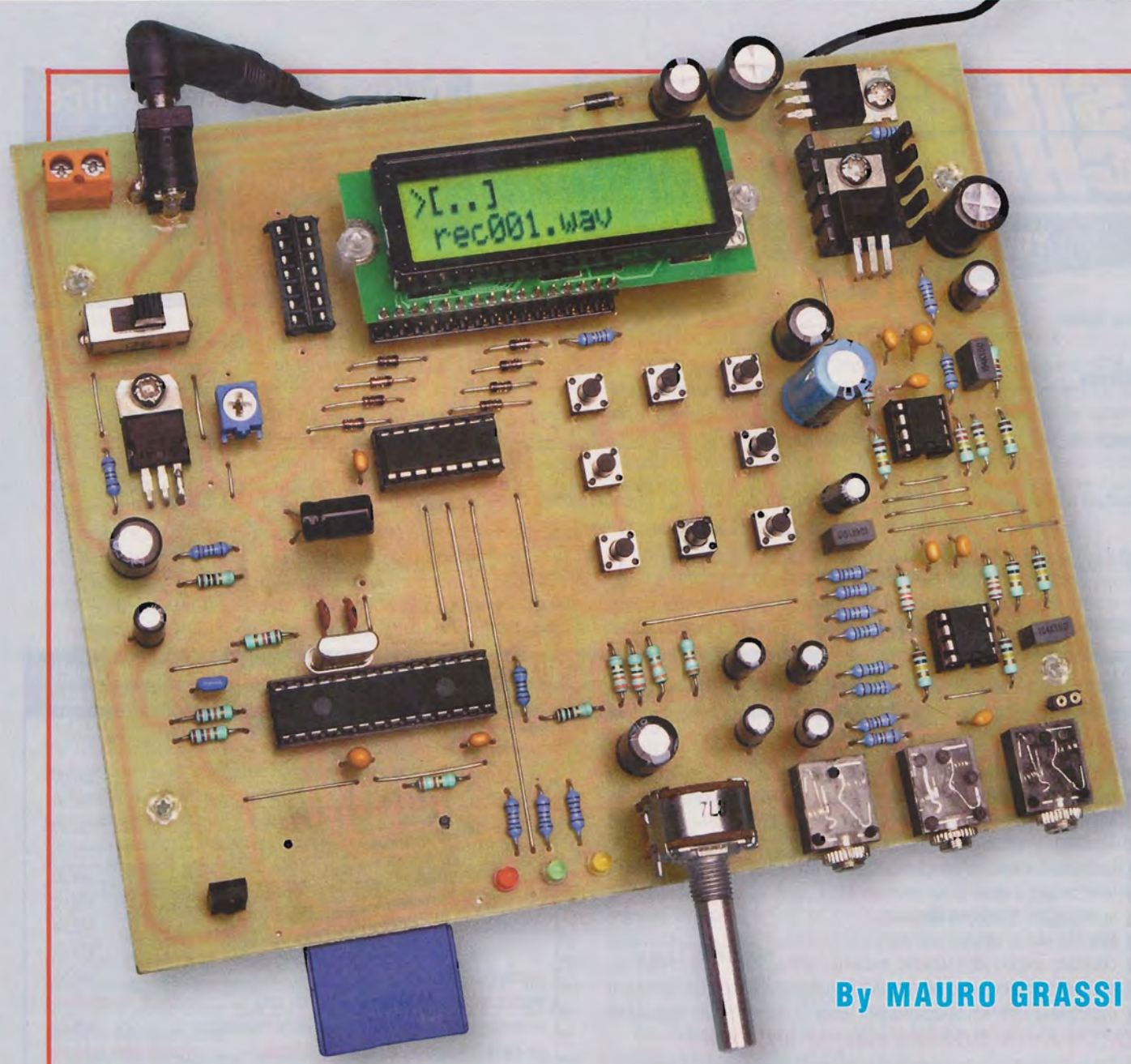
City listeners can now enjoy the benefits of digital radio. The next trial sites are likely be Hobart or Townsville.

As the analog TV shutdown will commence next year and be completed by the end of 2013 it is hoped that some rollout of DAB+ transmissions will be possible during this timetable in non-metro areas.

Remote area listeners may have to wait for the results of the DRM review sometime in 2011.

As the use of DAB+ and DRM expands worldwide (except in the USA), then the price of receivers should keep dropping after the development costs have been returned to the manufacturers.

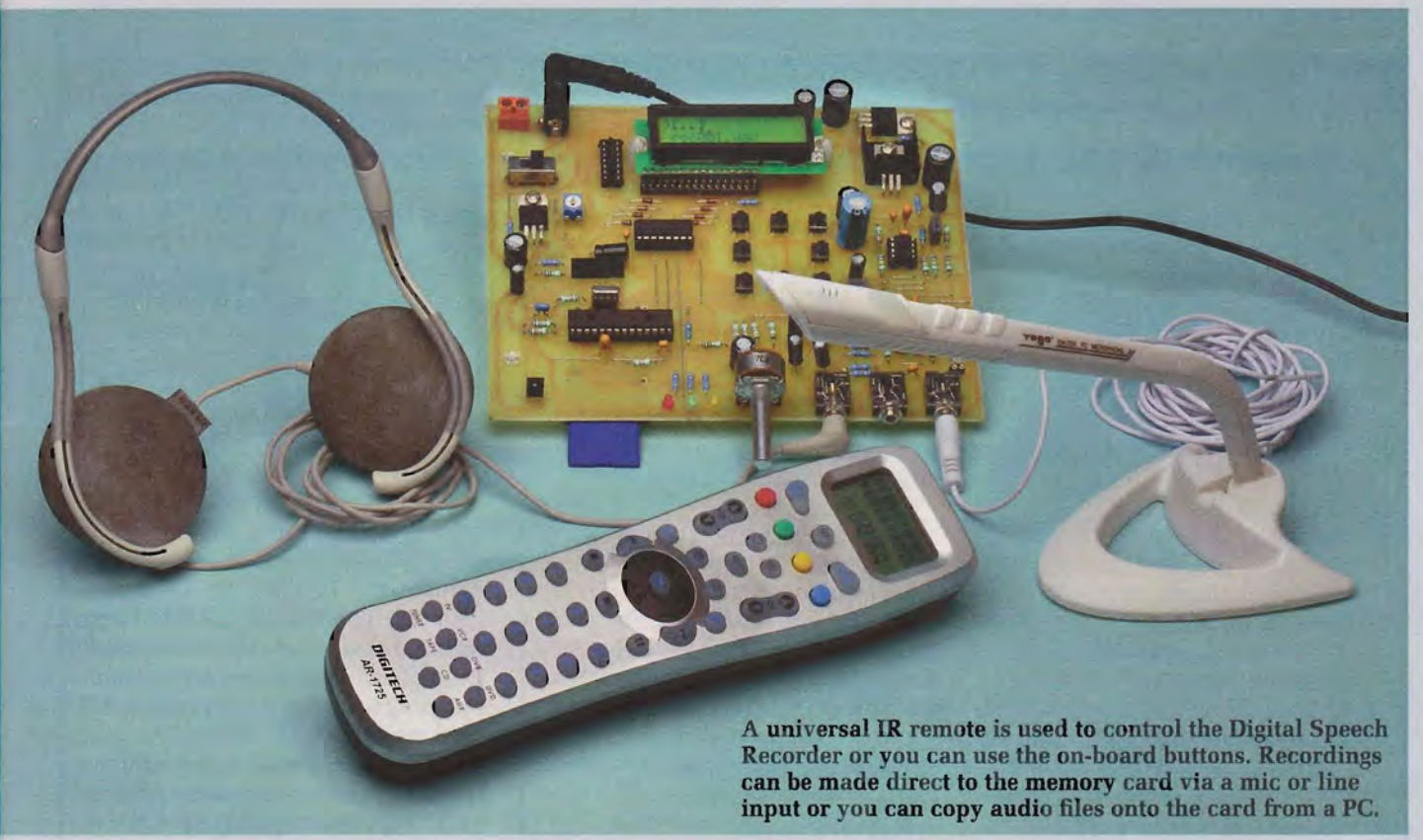
For up to date information on digital radio check www.digitalradio.com.au SC



By MAURO GRASSI

An SD Card Music & Speech Recorder/Play

This digital recorder stores WAV files on low-cost MMC/SD/SDHC cards. It can be used as a jukebox, a sound effects player or an expandable "dicta-phone". You can use it as a free-standing recorder or in conjunction with any Windows, Mac or Linux PC.



A universal IR remote is used to control the Digital Speech Recorder or you can use the on-board buttons. Recordings can be made direct to the memory card via a mic or line input or you can copy audio files onto the card from a PC.

IN MAY 2005 and December 2007 we published two very popular solid-state voice recorder projects. The 2007 design was an improved version of the original project, employing the same voice recorder chip. These allowed you to record a number of short messages (up to about one minute of speech) and play them back at the touch of a button. The messages were stored in "analog EEPROM" cells in an analog 8-bit format.

This project takes the message recorder concept to a whole new level and employs a common SD memory card or MMC (multimedia card) for message storage. Depending on the size of the card, you can store and play back many hours of audio. We've also added infrared remote control and it can be used to play back any WAV file that you have downloaded or recorded on your PC.

We are presenting this project in a very simple module format; it is just a PC board with an SD card socket, a 2-line LCD panel and eight pushbutton switches to select the audio files and other features. If you want to build the unit into a case, you can take the LCD panel off the board and separately mount it and the same goes for the switches and sockets.



The unit works with all commonly-available MMC, SD and SDHC memory cards. You can copy files from a PC onto these cards via an MMC/SD/SDHC card reader like the one shown at bottom right.

Compatible memory cards

The compatible cards to use with this project are MMC (MultiMedia Card), SD (Secure Digital) and SDHC (Secure Digital High Capacity) cards. SD cards come in capacities up to 2GB. Beyond that, you will find SDHC cards with capacities from 4GB to 32GB. The current version of the standard does not specify cards with capacities higher than 32GB, although these will become common in the future.

This project will work with most presently available cards. SD cards in particular have dropped in price dramatically and you can now pick up a 1GB SD card for less than $10.

In operation, the unit can be run from either a 12V battery or a DC plugpack supply. It can drive stereo headphones or an external amplifier and loudspeakers.

WAV file format

The WAV file format from Microsoft can carry both compressed and

Parts List

1 PC board, code 01108091, 164 x 136mm
1 16 x 2 LCD module (Jaycar QP-5515, Altronics Z-7013)
1 1kΩ horizontal-mount trimpot (VR1)
1 10kΩ log 16mm dual-gang pot (VR2)
8 SPST 6mm tactile switches (S1-S8) (Jaycar SP-0601, Altronics S-1124)
1 DPDT PC-mount slide switch (S9) (Jaycar SS-0823, Altronics S-2060)
1 2.5mm PC-mount male DC connector (Jaycar PS-0520, Altronics P-0621A)
1 TO-220 mini heatsink (Jaycar HH-8502, Altronics H-0630)
1 10MHz crystal (X1)
1 SD surface mount card socket (Jaycar PS-0024)
3 3.5mm PC-mount stereo jack sockets (Jaycar PS-0133, Altronics P-0092)
1 infrared receiver module (IRD1) (Jaycar ZD-1952, Altronics Z-1611)
1 40-pin IC socket (to be cut)
1 28-pin IC socket (0.3-inch)
1 16-pin IC socket
2 8-pin IC sockets
12 M3 x 12mm Nylon screws (some to be cut)
8 M3 x 9mm tapped Nylon spacers
1 500mm 0.8mm-dia. length tinned copper (for links)
1 32-way machined pin socket strip
1 40-pin header strip
1 electret microphone insert (optional – see text)

Semiconductors

1 dsPIC33FJ64GP802-I/SP microcontroller (IC1) programmed with 0110809A.hex (Altronics LCD) or 0110809J.hex (Jaycar LCD)
1 74HC595 8-bit shift register (IC2)
2 LM833N dual op amps (IC3-IC4)
8 1N4148 signal diodes (D1-D8)
1 1N4004 silicon diode (D9)
1 7809 3-terminal regulator (REG1)
1 7805 3-terminal regulator (REG2)
1 LM317T variable 3-terminal regulator (REG3)
1 3mm red LED (LED1)
1 3mm green LED (LED2)
1 3mm yellow LED (LED3)

Capacitors

1 1000μF 16V electrolytic
2 470μF 25V electrolytic
3 470μF 16V electrolytic
1 220μF 16V electrolytic
5 100μF 16V electrolytic
3 10μF electrolytic
1 10μF tantalum
1 4.7μF electrolytic
2 220nF MKT polyester
2 150nF MKT polyester
3 100nF MKT polyester
5 100nF monolithic
2 18pF ceramic

Resistors (0.25W, 1%)

1 220kΩ	3 1kΩ
7 100kΩ	1 180Ω (R2)
5 39kΩ	1 110Ω (R1)
5 22kΩ	7 100Ω
4 10kΩ	3 10Ω
4 2.2kΩ	1 0Ω (R3)

(Note: 10Ω & 160Ω resistors may be required to adjust REG3).

uncompressed audio but this speech recorder can only record and play back uncompressed WAV files. The samples are stored as 16-bit signed integers. The sampling rate of the encoded audio is stored in the WAV file header and is read by the recorder to vary the playback sampling speed.

Both stereo and mono files can be played. When playing mono files, both output channels (L & R) carry identical signals. A stereo WAV file contains information for the left and right channels interleaved, meaning every second sample is taken for each channel.

WAV files essentially store the PCM (Pulse Code Modulation) samples of the audio waveform. The sampling frequency is twice the highest reproducible frequency in the audio stream. Note that WAV files have a ".wav" file extension.

Firmware overview

The firmware is responsible for all the features of our new Digital Speech Recorder. When you play a file, the firmware reads the WAV header that stores the sampling rate of the audio file. It then sets up an interrupt to push data into the DACs (Digital-to-Analog Converters) in the microprocessor at the requested sampling rate from the memory card.

When recording, data from the micro's ADC (Analog-to-Digital Converter) is written to a WAV file on the memory card using double buffering. The audio buffer stores up to 10KB of audio samples and each sample is 16 bits.

FAT files

In this case, FAT does not stand for fat or obese! Instead, it stands for "File Allocation Table" and is a file management system that's commonly used for hard disk drives and memory cards.

This Digital Speech Recorder recognises the FAT/FAT32 file system, meaning you should be able to read the cards using any Windows, Mac or Linux box coupled to a card reader or by using a laptop PC with an inbuilt card reader.

If you want more information on the FAT file system, refer to **http://en.wikipedia.org/wiki/File_Allocation_Table** or to a host of other internet sites.

If your memory card has a different file system on it, you will need to format the memory card first using a FAT/FAT32 system. Be sure to back up whatever was on the card before you do this, because the formatting process will erase everything that may be on the card.

File sizes

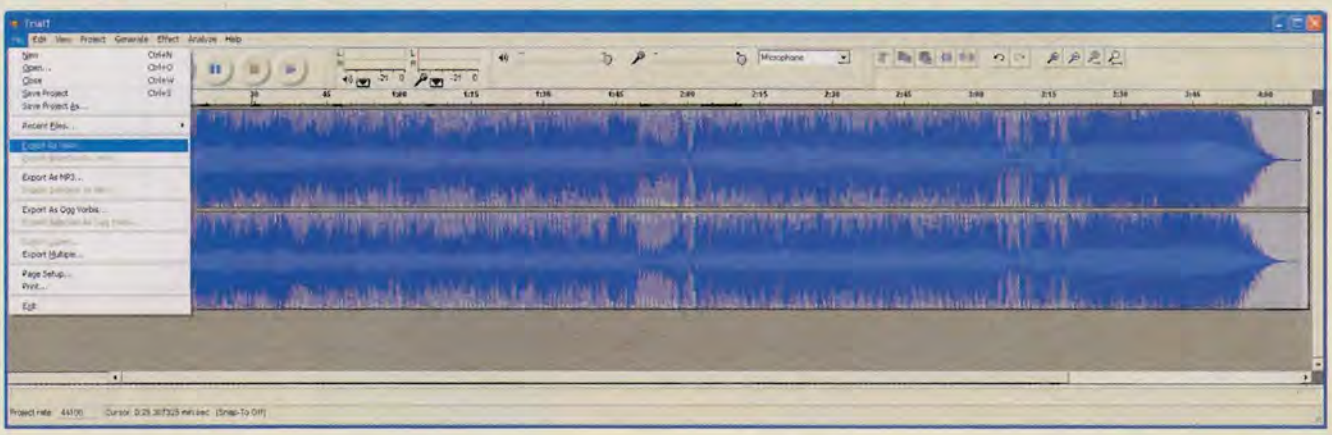
Because this project does not decode compressed audio files, the size of the WAV files used is rather large compared to common MP3 files or similar audio formats. A WAV file can be up to 10 times larger than an equivalent MP3 file at the 44.1kHz sampling rate. Unlike MP3, uncompressed WAV is a lossless encoding format. Using lower sampling rates can reduce file sizes but this will also reduce the audio quality and bandwidth.

Because we are using cheap and readily available SD or MMC cards, we are not too concerned about the size of the files. Even at 40MB per 4-minute audio track, you can still store around 25 songs (or 100 minutes) of audio on a $10 1GB SD card.

Circuit description

Refer now to Fig.1 for the circuit details. As shown, it's based around a powerful 16-bit DSP microcon-

Using Audacity To Convert MP3 Files To WAV Files



CONVERTING MP3 FILES (and other compressed audio formats) to WAV files suitable for the Speech Recorder is easy using a program called "Audacity". This excellent freeware program allows you to convert at different sampling rates and can also be used as a basic sound editor.

Audacity can be downloaded from **http://audacity.sourceforge.net/download/**. There are versions for Windows, Mac and Linux. Follow the on-screen prompts after executing the downloaded installation program.

As indicated, Audacity can open MP3 (and other compressed) files. You can then export them to WAV format and copy them to an MMC/SD/SDHC card for use with this unit.

The first step in the conversion is to select the required sampling rate. This is a compromise between audio quality and the size of the file. The higher the sampling rate selected, the higher the audio quality but the bigger the file size.

Having selected the sampling rate, it's then just a matter of clicking "File" and then selecting the "Export As WAV..." option.

There is no reason to choose a sampling rate higher than 44.1kHz, as this is high enough to encompass the whole of the audio spectrum (remember that the sampling rate will be double the highest reproducible frequency and that the audio spectrum reaches up to about 22kHz). Having converted the files to WAV files, it's then just a matter of copying them from the PC to the memory card via a card reader.

troller from Microchip, the dsPIC33FJ64GP802 (IC1).

The reasons for choosing this microcontroller are fourfold. First, it is one of the first microcontrollers from Microchip to have an integrated stereo DAC (Digital-to-Analog Converter). Second, it is very fast, running at 40MIPS (Millions of Instructions Per Second). You need such speed when you are reading from a memory card in real time and dumping audio data onto the DACs!

Third, it has enough on-board RAM and program memory to implement the features of this project and comes in a through-hole package which is easier to install than an SMD. And finally, it runs from a 3.3V supply which is compatible with the supply requirements for a typical memory card.

IC1's system clock is derived from a 10MHz crystal (X1) via a PLL (Phase Locked Loop) stage to derive a 40MHz instruction clock. The two accompanying ceramic 18pF capacitors provide the correct loading for the crystal.

In operation, the microcontroller is responsible for implementing the hardware layer to read and write sectors to the MMC/SD/SDHC card. This low-level layer is called by higher layers that implement a FAT/FAT32 file system. The result is that we can read and write files.

The SPI (Serial Peripheral Interface) outputs of the microcontroller connect to the SD card and to IC2, a 74HC595 8-bit shift register that's used to drive the LCD module. This shift register is used as a "port expander" because there are simply not enough output pins on the microcontroller.

The output of the shift register is also used to scan the eight on-board tactile switches, S1-S8. These are connected via diodes D1-D8 which effectively form a wired AND gate and they are active low. The microcontroller can detect a switch press by loading the shift register with the values 0xFE, 0xFD, 0xFB, 0xF7 and so on, up to 0x7F (one 0 bit).

Note that the E (enable) line to the LCD module is kept low during this scan, so as not to affect the contents of the display.

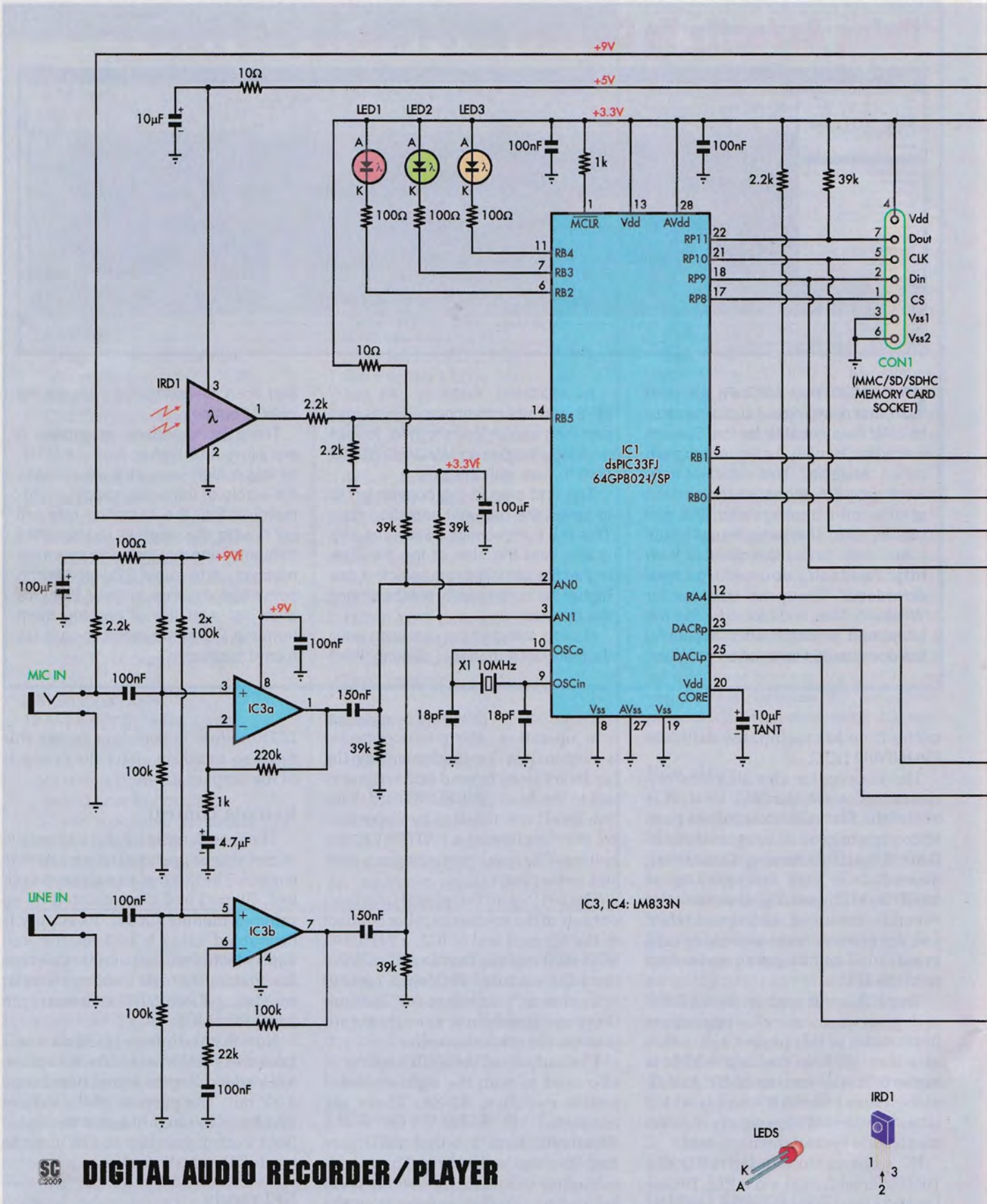
Remote control

The speech recorder and audio player can also be operated using a remote control. The infrared signals are amplified, filtered and demodulated by an infrared module (IRD1). Its supply is decoupled using a 10Ω resistor and 10µF electrolytic capacitor. The data line passes through a voltage divider consisting of two 2.2kΩ resistors to pin 14 (RB5) of IC1.

Note that the infrared module works from a +5V rail whereas the microcontroller decoding the signal runs from a 3.3V rail. The purpose of the voltage divider is to roughly halve the signal level from the module so that it can be used with a 3.3V device.

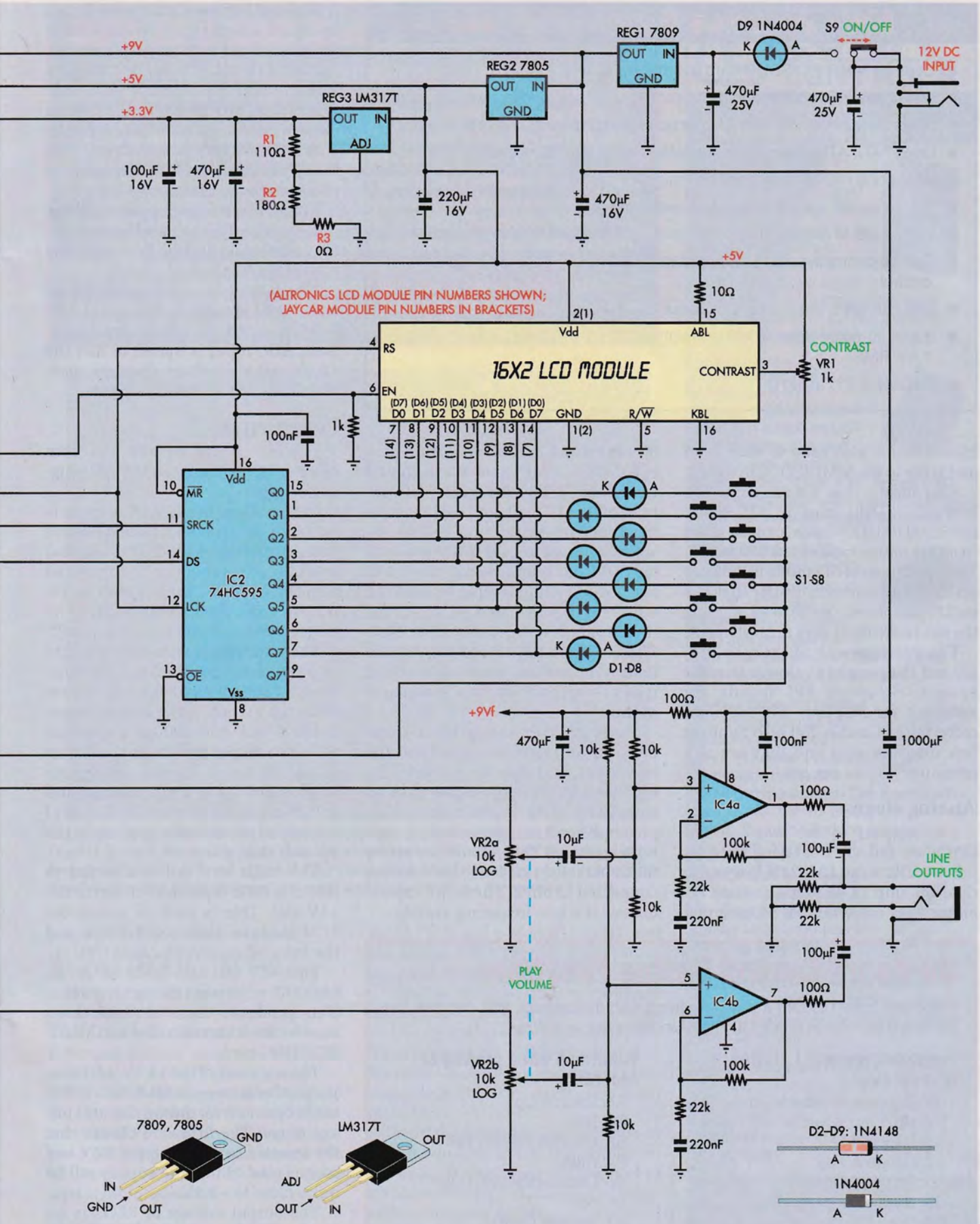
SPI mode

As noted above, the SPI peripheral on the microcontroller is used to drive the LCD and scan the tactile switches.



DIGITAL AUDIO RECORDER/PLAYER

Fig.1: the circuit is based on a dsPIC33-FJ64GP802 microcontroller and a 16 x 2 LCD module. The micro scans the switch inputs via shift register IC2, drives the memory card, decodes the signals from the infrared receiver module (IRD1), writes to the LCD module and performs the ADC conversions on the analog inputs.


+9V
+5V
+3.3V
REG1 7809
REG2 7805
REG3 LM317T
OUT IN GND
OUT IN ADJ
D9 1N4004
K A
S9 ON/OFF
12V DC INPUT
470µF 25V
470µF 25V
R1 110Ω
R2 180Ω
R3 0Ω
100µF 16V
470µF 16V
220µF 16V
470µF 16V
(ALTRONICS LCD MODULE PIN NUMBERS SHOWN; JAYCAR MODULE PIN NUMBERS IN BRACKETS)
10Ω
2(1) Vdd
15 ABL
16X2 LCD MODULE
4 RS
6 EN
CONTRAST
3 CONTRAST
VR1 1k
(D7) (D6) (D5) (D4) (D3) (D2) (D1) (D0)
D0 D1 D2 D3 D4 D5 D6 D7 GND R/W KBL
7 8 9 10 11 12 13 14 1(2) 5 16
(14) (13) (12) (11) (10) (9) (8) (7)
100nF
1k
IC2 74HC595
16 Vdd
10 MR
11 SRCK
14 DS
12 LCK
13 OE
Vss 8
Q0 15
Q1 1
Q2 2
Q3 3
Q4 4
Q5 5
Q6 6
Q7 7
Q7' 9
S1-S8
D1-D8
+9Vf
100Ω
470µF
10k
10k
100nF
1000µF
IC4a
IC4b
VR2a 10k LOG
VR2b 10k LOG
10µF
100k
22k
220nF
100µF
LINE OUTPUTS
PLAY VOLUME
7809, 7805
GND IN OUT
LM317T
ADJ OUT IN
D2–D9: 1N4148
1N4004
A K

Main Features & Specifications

- Uses an MMC/SD/SDHC card to store audio files
- Stores mono recordings as Microsoft WAV files at 16kHz sampling rate
- Plays back Microsoft WAV files at up to 44.1kHz sampling rate
- Uses FAT/FAT32 file system (transfer files to any PC operating system)
- Has mono microphone and line inputs for recording
- Stereo socket for line output or headphone use
- 2-line LCD to display file names, show volume and other settings
- Can be controlled using on-board switches or any RC5 universal remote control
- Unit can learn remote control codes
- Signal-to-noise ratio: -70dB unweighted (22Hz to 22kHz) with respect 1.6V RMS
- THD+N: 0.7% at 1kHz

However, it's also used to read from and write to the MMC/SD/SDHC card.

This means that we are using the MMC/SD/SDHC card in SPI mode (MMC/SD/SDHC cards can be used in either native mode or in SPI mode). The advantage of SPI mode is that any off-the-shelf microcontroller that has an SPI peripheral can be used, making the hardware layer easy to implement.

The interface with SPI may be simple but the penalty is slower transfer speeds. However, SPI speeds are adequate for real-time playing (and recording) of audio. SPI also requires less interface pins and they are at a premium, as you can see.

Analog stages

The outputs of the two internal DACs are fed via dual-gang potentiometer VR2 to an LM833N low-noise dual op amp (IC4a & IC4b). Both op amp stages are wired as AC-coupled non-inverting amplifiers with a gain of 5.5. The 220nF capacitor to ground from each feedback divider network rolls off the DC gain and sets the low-frequency response.

The outputs at pins 1 & 7 are each fed to the line output socket via a 100Ω resistor and a 100µF capacitor and can either drive stereo headphones or the line inputs of a stereo amplifier. Note that the LM833 is not really intended for driving low impedance loads but it is a low-cost solution for a headphone output.

There are two analog input channels, the microphone input and the line input, and they are provided by another LM833N low-noise dual op amp (IC3). IC3a is the microphone preamplifier. It is a non-inverting stage with a gain of 221 (+46dB), as set by the 220kΩ and 1kΩ feedback resistors connected to pin 2. The 4.7µF capacitor sets the low-frequency rolloff.

On-Board Control Button Functions

If you don't wish to use a remote control with this project, you can use the on-board buttons to control it. Their functions are as follows:

Functions while not playing or recording:

S1: Random Shuffle
S2: Up
S3: Record Mic
S4: Delete A File
S5: Record Line In
S6: Down
S7: N/A
S8: Play

Functions while playing or recording:

S1: Volume Up
S2: N/A
S3: Choose Display Up
S4: Stop
S5: Choose Display Down
S6: N/A
S7: Volume Down
S8: Pause

The microphone itself can be an on-board electret microphone insert or you can use a PC microphone (eg, Jaycar AM-4087) plugged into the 3.5mm stereo input jack – see photo. A 2.2kΩ resistor provides the biasing current for the electret microphone and its DC supply is decoupled from the +9Vf supply using a 100Ω resistor and 100µF capacitor.

IC3b is the line input preamplifier. It has a gain of 5.5 (+14.9dB), as set by the 100kΩ and 22kΩ feedback resistors connected to pin 6.

The outputs of both preamplifier stages are fed to the ADC inputs (AN0 & AN1) of IC1 via 150nF capacitors. Each ADC input is biased to half the +3.3V rail via voltage dividers, each consisting of two 39kΩ resistors.

Power supply

The circuit can be powered from either a 12V battery or a 12V DC plugpack supply.

In operation, the 12V DC supply is fed in via on-off switch S9 and reverse polarity protection diode D9. Note that a 470µF 25V capacitor is connected adjacent to the DC input socket and is not protected from reverse polarity by D9 (this reduced the hum the most).

There are three 3-terminal regulators to provide the required supply rails. First, a 7809 9V regulator (REG1) provides the 9V rail for the analog stages. It has 470µF and 1000µF capacitors across its output at different positions on the PC board. Further decoupling is provided by a 100Ω resistor and 470µF capacitor to provide the +9Vf rail which provides the biasing for the op amp stages.

The main +9V rail is also fed to REG2, a 7805 regulator, to derive the +5V rail. This is used to power the LCD module, shift register IC2 and the infrared receiver module (IRD1).

This +5V rail also feeds REG3, an LM317T adjustable voltage regulator. This produces the +3.3V rail that's used by the microcontroller and MMC/SD/SDHC card.

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

The output voltage of REG3 is set by the divider network between its output terminal and its ADJ terminal

MMC, SD & SDHC Memory Cards

Both MMC (MultiMedia Card) and SD (Secure Digital) cards are a type of non-volatile storage that uses FLASH memory technology. Similarly, SDHC (HC = high capacity) cards are a type of SD card with capacities between 4GB and 32GB.

All three types of cards can be used with this project. While they all look alike, MMC cards have only seven contacts, whereas SD cards have nine.

Note that miniSD and microSD cards can also be used as these are essentially SD cards with a smaller form factor. You will, however, need an external adaptor to convert them to standard size to connect to the Digital Speech Recorder.

MMC/SD/SDHC cards are commonly used in portable devices like mobile phones, computers, cameras and audio players, among others. They conveniently store a lot of data in a small form factor, consume little power and are light. Cards with increasingly larger storage capacity have been steadily appearing since their introduction in the late 1990s.

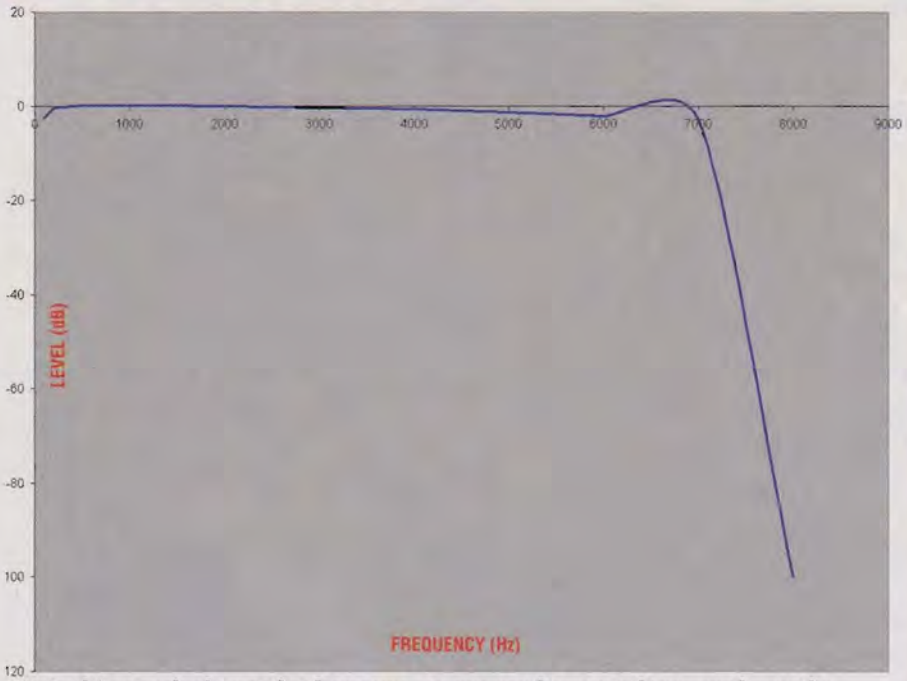


Fig.2: this graph shows the frequency response for recordings made on the Digital Speech Recorder. Note that the response is limited to half the sampling frequency which is fixed at 16kHz for recording. The frequency response can be much wider for files recorded on a PC and transferred to the memory card.

to ground. The output is set at:

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

With R2 = 180Ω and R1 = 110Ω, we get a supply of 3.29V (close enough to 3.3V). However, the 1.25V reference in the regulator can vary between 1.2V and 1.3V.

For this reason, provision is made on the PC board for an additional resistor (R3) to allow you to adjust the 3.3V supply rail if necessary. We will touch on this point later, in the setting-up procedure.

Construction

All parts are mounted on a single-sided PC board coded 01108091 and measuring 164 x 136mm. Fig.3 shows the parts layout on the board.

The first thing to do is to carefully inspect the board for hairline cracks and for shorts between adjacent tracks. It's rare that you will find a fault but it's easier to spot any problems at this stage than after the parts have been installed.

Begin the assembly by soldering in the 18 wire links. You can straighten the link wire by clamping one end in a vice and then pulling on the other end with a pair of pliers to stretch it slightly. Don't forget link LK1 under the LCD module.

OCEAN CONTROLS

Helping to put you in Control

Control Equipment

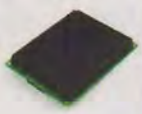
Digital Stepper Motor Drives We could not believe the speed and quietness of these new drives. Based on a DSP with advanced control algorithm. Software is provided to tune the performance resulting in faster, cooler and quieter stepper motors **From $99+GST**



Digital Servo Motor Drive This is a18-80VDC, 0-20A, 20-400W drive. It is based on DSP control technology and high smooth servo control algorithm. It has a PC based and handheld configuration tools, including Pro Tuner for easy tuning. **$229+GST**



Serial Graphic LCD The Serial Graphic LCD backpack is soldered to the 160x128 pixel (100x130mm) Graphic LCD and provides the user a simple serial interface to a full range of controls. **$99.95+GST**



Serial 7 Segment Display The display can be controlled in one of two ways: (1) serial TTL communication or (2) SPI serial communication. The display will give you full control of all digits, decimal points, the colon and the apostrophe. 50x15mm **$17.50+GST**



MyPCProbe Is a simple to use temperature or temperature and humidity sensor which connects to a PC via a USB port. It comes with an intuitive and easy-to-use Windows software which plots and records data, shows gauges, bargraphs and digital readouts. **From $149+GST**



Large 7 Segment Display. No really this display is 153mm tall and can be seen from 30 metres plus away. A controller is coming soon **$19.95+GST**



Contact Ocean Controls
Ph: 03 9782 5882
www.oceancontrols.com.au

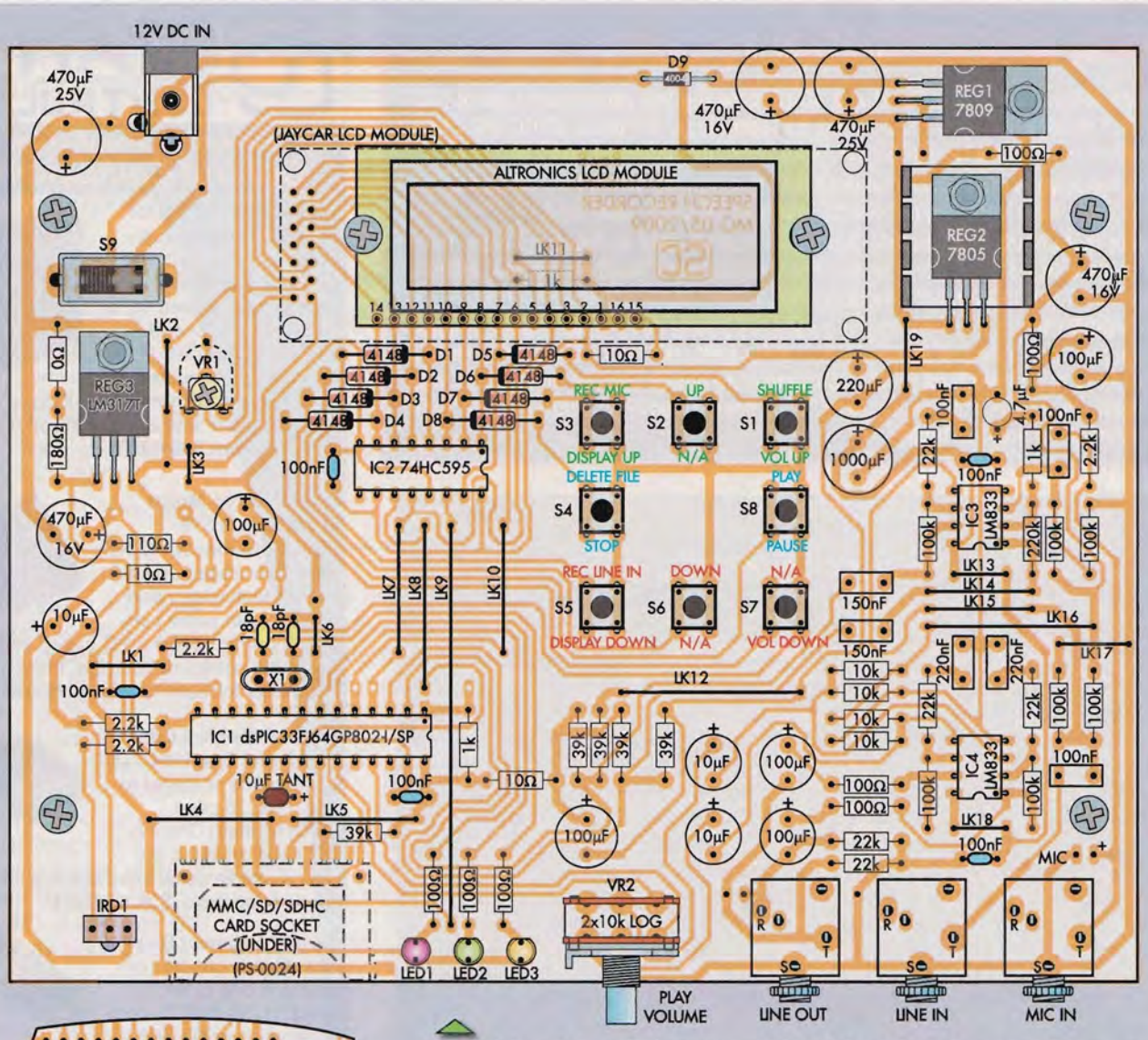


Fig.3 (above): install the parts on the PC board as shown on this parts layout diagram. Take care to ensure that all polarised parts are correctly oriented and leave the ICs and the LCD module off the board until after the initial power supply checks have been completed.

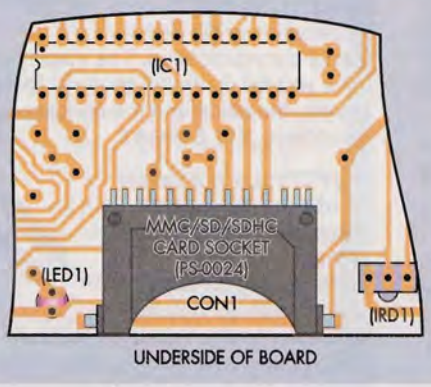


Fig.4 (left): the memory card socket (CON1) is a surface-mount device (SMD) and is installed on the underside of the PC board as shown here. Lightly solder tack one pin first, then check the socket's alignment before soldering the remaining pins.

The resistors are next on the list and again one of these is under the LCD module. Table 1 shows the resistor colour codes but you should also check each resistor using a DMM before soldering it to the board. Resistor R3 can be either a 0Ω resistor or you can simply install a wire link **(note: this 0Ω resistor may have to be changed later – see section on trimming the 3.3V rail).**

Follow these parts with the diodes and the infrared receiver (IRD1). Note that D9 is a 1N4004 type, while the remaining eight diodes (D1-D8) are all 1N4148 signal types. These diodes must all be installed with the correct orientation (the striped end is the cathode), while IRD1 must go in with its domed lens facing outwards.

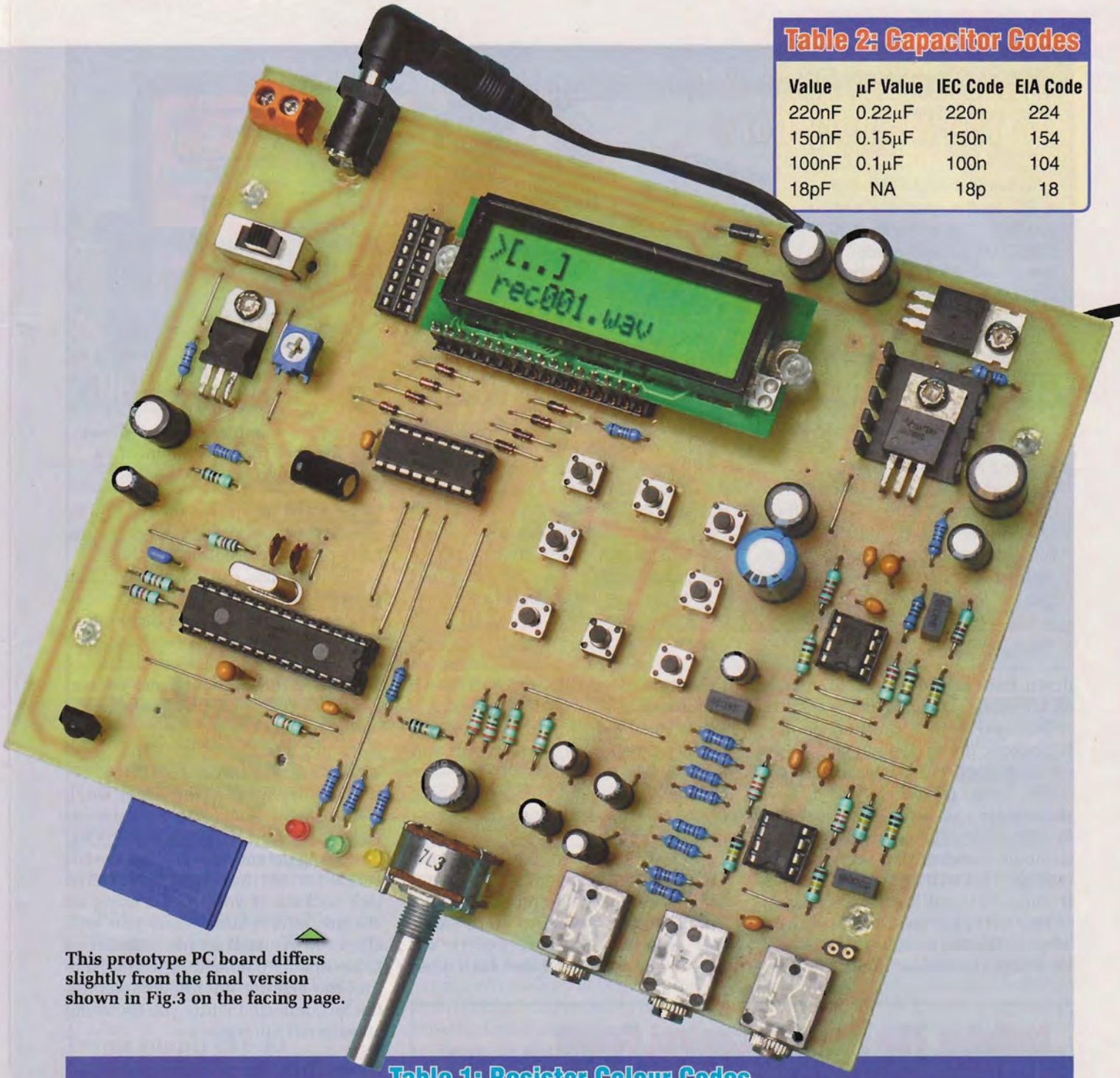
The three LEDs (LED1-3) can be installed at this stage as well. Make sure that these are oriented correctly and match the colours shown on Fig.3.

Installing the regulators

The three TO-220 regulators (REG1-REG3) can now go in. As shown, these are all mounted horizontally, with their leads bent down at right-angles about 6mm from their bodies. In addition, the 7805 regulator must be fitted with a mini heatsink before it is bolted

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
220nF	0.22µF	220n	224
150nF	0.15µF	150n	154
100nF	0.1µF	100n	104
18pF	NA	18p	18



This prototype PC board differs slightly from the final version shown in Fig.3 on the facing page.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	220kΩ	red red yellow brown	red red black orange brown
❑	7	100kΩ	brown black yellow brown	brown black black orange brown
❑	5	39kΩ	orange white orange brown	orange white black red brown
❑	5	22kΩ	red red orange brown	red red black red brown
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	4	2.2kΩ	red red red brown	red red black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	1	180Ω	brown grey brown brown	brown grey black black brown
❑	1	110Ω	brown brown brown brown	brown brown black black brown
❑	7	100Ω	brown black brown brown	brown black black black brown
❑	1	0Ω	black	black

Transferring Files & Recording To The Memory Card



To transfer audio files from a PC to the memory card, you will need a low-cost SD/SDHC/MMC-card reader. The one shown in the accompanying photo is available from Jaycar for less than $10 (Cat No: XC-4756).

Note that before copying the files (eg, music tracks) to the MMC/SD/SDHC card, they must first be converted to WAV format. This can be done using a freeware sound editor program called "Audacity" – see panel on page 33.

As indicated earlier, you can also directly record files to a memory card in the Digital Audio Recorder. Basically, you have two choices when making recordings: either use the microphone input or feed signals in via the recorder's line input. When using the microphone input, you can use either an onboard electret microphone (see photo) or you can plug an electret microphone into the MIC In socket. Suitable external electret microphones are available from Jaycar and Altronics. Be sure to disconnect the on-board microphone if you are using an external microphone.

Note that the microphone and line inputs differ in the gain of their respective preamplifier stages, so be sure also to choose the correct input.



This larger-than-life size view shows how the card reader is mounted on the copper side of the PC board.

down. Each regulator is secured using an M3 x 5mm machine screw and nut.

The next step is to install the four IC sockets. If you don't have a 28-pin 0.3-inch socket (or have a 0.6-inch socket instead), you can cut it down the middle and install the two strips for IC1. Orientate each socket so that its notch matches that shown on the overlay. This will make it easier when it comes to installing the ICs later on.

You will also need to cut down a 40-pin IC socket to make the connector for the LCD module. If you are using the Altronics module, you will need a single row of 16 pins. Alternatively, if you are using the Jaycar module, you will need two rows of seven pins and they must be installed with what were originally their outside edges touching in the middle, otherwise they won't fit in place.

Now move on to the capacitors. There are four different types: monolithic, ceramic, MKT and electrolytic. The first three types can go in either way around but the electrolytic capacitors are polarised and each must be oriented as shown on Fig.3. The negative terminal is marked on the body of each capacitor.

The switches can go in next. The power switch (S9) is a DPDT slide type, while the rest (S1-S8) are momentary pushbutton tactile types. Note that these tactile switches are not symmetrical in the horizontal and vertical directions, being slightly longer in the vertical direction.

It's just a matter of installing them with their terminals positioned as shown (they won't fit the wrong way).

The larger items can now be installed. These include trimpot VR1, dual-gang potentiometer VR2, the DC connector and the three 3.5mm stereo jack sockets. If you intend using an electret microphone, then you will also have to install a 2-pin socket strip to accept its connecting leads. Note that the electret microphone should not be connected while you are using an external microphone.

Installing the card socket

The memory card socket is mounted in the underside of the PC board – see Fig.4. This is an SMD device so you must carefully position it over its pads and solder one of the pins first to anchor it in position. Once that is done, you can solder the rest of the pins. Note that there are two mounting terminals on either side of the device that must also be soldered to matching pads near the front edge of the board (see Fig.4 and photo).

The initial assembly can now be completed by fitting four M3 x 12mm Nylon spacers to form the mounts for

Defining The Remote Control Codes

If you wish to use a remote control with this unit, you will need an RC5-compatible remote. RC5 is an infrared communications protocol that was initially developed by Philips and is used by many Philips appliances.

This means that if you have a universal remote, there's a good chance it will work if you set it to control a Philips appliance. For example, we tested the project with the Jaycar AR-1726 remote and can confirm that it works.

Setting up the remote is straightforward. You start by pressing the S2 & S6 (UP & DOWN) buttons together while booting the recorder, to enter the remote control programming menu. You are then prompted to press the key you want to define for that function.

For example, you may be prompted to "Press Play" and you then simply press the relevant button on the remote which is to be assigned that function.

A recommended set-up using the AR-1726 Remote from Jaycar is shown in Table 3. It should be set to the VCR 917 code which corresponds to the default programmed into the recorder's firmware.

Table 3: Recommended Key Assignments For Digitech AR-1726 Remote Control

Button	Function(s)	Recommended Key Definitions for the Digitech AR-1726 Remote
0	Unused	Press '0'
1	In Triggered mode, used to play file rec001.wav	Press '1'
2	In Triggered mode, used to play file rec002.wav	Press '2'
3	In Triggered mode, used to play file rec003.wav	Press '3'
4	In Triggered mode, used to play file rec004.wav	Press '4'
5	In Triggered mode, used to play file rec005.wav	Press '5'
6	In Triggered mode, used to play file rec006.wav	Press '6'
7	In Triggered mode, used to play file rec007.wav	Press '7'
8	In Triggered mode, used to play file rec008.wav	Press '8'
9	In Triggered mode, used to play file rec009.wav	Press '9'
VOL UP	In Normal mode, used to select a file to play. While playing, used to increase the volume	Press 'Vol Up'
VOL DOWN	In Normal mode, used to select a file to play. While playing, used to decrease the volume	Press 'Vol Down'
CH UP	While playing, used to select what is displayed in the second line on the LCD module	Press 'Ch Up'
CH DOWN	While playing, used to select what is displayed in the second line on the LCD module	Press 'Ch Down'
MENU	Used to delete the selected file; confirmation is requested	Press 'Menu'
STOP	Used to stop a playing file or a recording	Press 'Stop'
PLAY	Used to play the selected file	Press 'Play'
PAUSE	Used to pause a playing file or a recording	Press 'Pause'
FAST FWD	Used to start random shuffle	Press 'FF'
REWIND	Unused	Press 'Rewind'
RECORD	Used to initiate a recording from the microphone input	Press 'Rec'
OK	Unused	Press 'Ok'
EXIT	Unused	Press 'Exit'
LINE	Used to initiate a recording from the line input	Press '->'

the PC board. **DO NOT fit the ICs or the LCD panel at this stage. These parts are installed only after the supply rails have been checked and that step comes next.**

Power supply checks

You will need a 12V DC 300mA (or higher) regulated plugpack with a 2.5mm connector to power this project. Suitable plugpacks include the Jaycar MP-3147 and the Altronics M-9243. However, you will need to cut off the 2.1mm connector on the Altronics unit and replace it with a 2.5mm connector. Be sure to get the polarity correct – the centre pin is positive.

Before applying power, make sure that the LCD is unplugged and that no ICs have been fitted. That done, apply power and move S9 to its ON position (ie, to the right). Now, using a DMM, measure the voltage between the OUT and GND terminals of REG1 – you should get a reading of 9V. If not, switch off immediately and check for supply errors. If no voltage is present, then D9 may be reversed or the supply polarity could be incorrect.

Assuming all is OK, check the voltage on the OUT terminal of REG2. This time, you should get a reading of 5V.

Finally, check the voltage on the OUT terminal (ie, the centre terminal) of REG3. It should be close to 3.3V. If any of the above voltages is incorrect, disconnect power immediately and check your work.

Note: the OUT terminal of REG3 is the centre lead of the device. By contrast, the OUT terminal of both REG1 & REG2 is one of the outside leads – see Fig.1 for the pin-outs.

Trimming the 3.3V rail

If the 3.3V rail is more than 3.4V or less than 3.2V, you will need to change one or both of the values for R2 and R3. For example, if the voltage from REG3 is 3.17V, you will need to install a 10Ω resistor for R3 and this should bring it pretty close to 3.3V.

Alternatively, if the output voltage is 3.41V, you should change the value of R2 to 160Ω and R3 to 10Ω, giving a total value for R2 + R3 = 170Ω (or you could use 150Ω for R2 and 22Ω for R3). Again, this should bring the voltage from REG3 pretty close to 3.3V.

If all three supply voltages are now close to their nominal values, you can disconnect power and insert the four ICs in their sockets. These ICs should all be oriented correctly of course.

Installing the LCD module

The LCD module can now be installed. The Altronics module is secured to the board on two M3 x 9mm

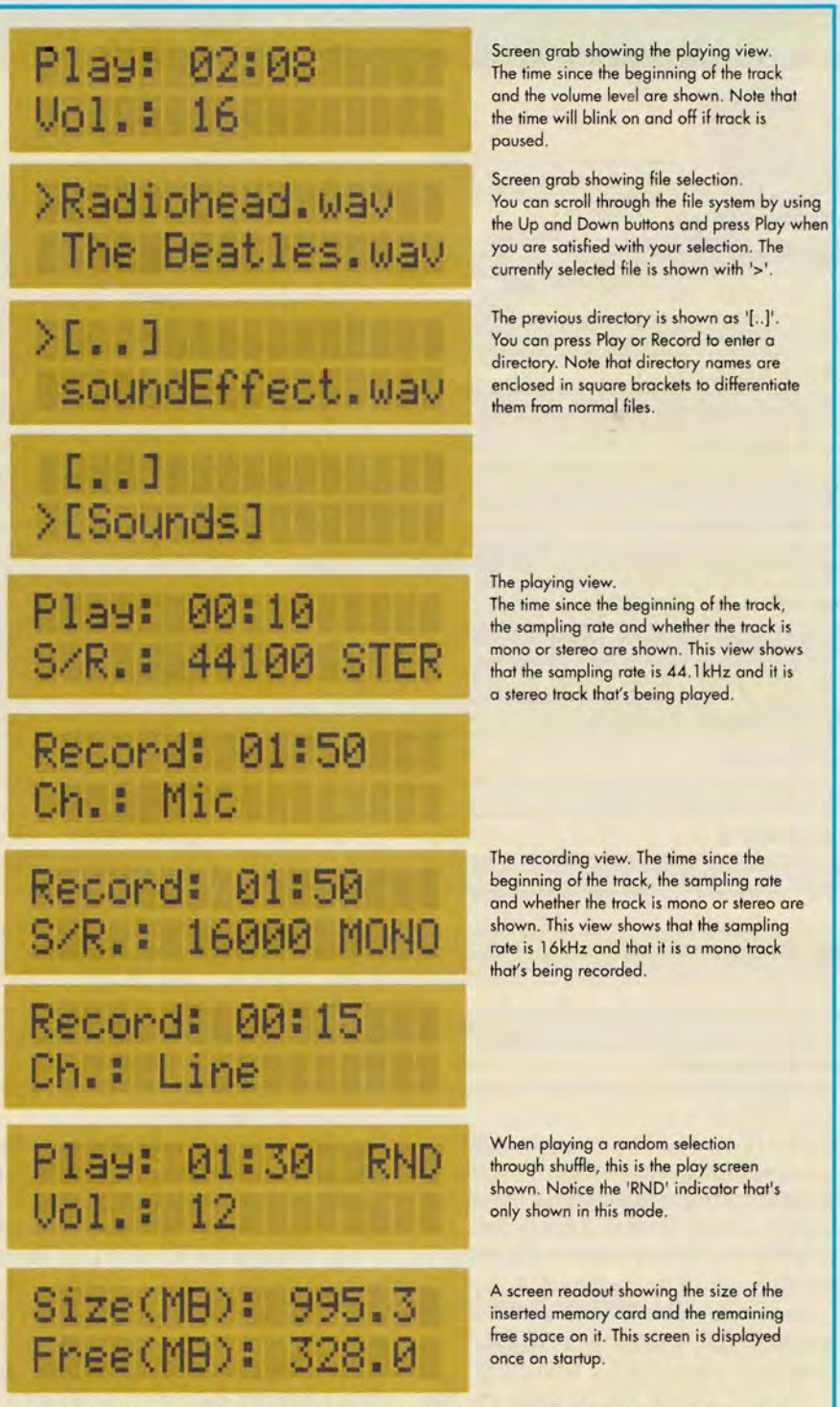


Fig.5: this diagram show some typical displays on the LCD, together with accompanying explanations. The unit shows file names, time elapsed while playing, the recording source, volume, sampling rate, card size, free space and other information.

tapped Nylon pillars as shown in Fig.3, while the alternative Jaycar module is secured using four M3 x 9mm tapped Nylon pillars, ie, one at each corner (all the necessary mounting holes are on the PC board).

Your Digital Speech Recorder & Audio Player is now completed and ready for use.

You should transfer the audio WAV files you wish to play to an MMC/SD/SDHC card using your PC or Mac, making sure the card is formatted with a FAT/FAT32 file system. Once the memory card has been inserted in its socket on the underside of the PC board, you can apply power. The firmware should display the version on the LCD panel and then compute the free size on the memory card. Your player is then fully operational.

Configuring the unit

The Digital Speech Recorder can be used in either of two modes: normal or triggered.

By default, the unit works in normal mode. However, if you wish to configure it for triggered operation, you simply create a file "trigger.txt" and place it in the root folder of the memory card you are using. You can do this using a card reader and a PC. The file need not contain anything – it just needs to be there (as an empty file).

The microcontroller will look for this file on boot up and switch the mode of operation to triggered if it is present. On the other hand, if this file is absent, the recorder boots for normal operation.

The differences between these two modes of operation are explained below.

Normal mode

In Normal operation, you begin by using the UP and DOWN buttons (S2 & S6) or the VOL UP and VOL DOWN buttons on the remote control to scroll through the file system on the card.

When you've selected the correct file, you simply press PLAY (S8) to play it. A screen grab showing a typical view of the filesystem is shown in Fig.5 (second from top). Of course, only two files are ever shown at any one time. A directory is indicated by its name being enclosed in square brackets. Press PLAY to enter a directory. The previous directory is shown as "[..]" – see Fig.5.

The delay in playing a new file is very small, of the order of a fraction of a second. This makes this project perfect for playing sound effects on demand.

Pressing SHUFFLE (S1) or FAST FF on the remote enters random shuffle mode. In this mode, there is an "RND" indicator on the display and a random selection of tracks (eg, songs) is continuously played from the root directory. You exit this random shuffle mode by pressing STOP (S4).

Pressing REC MIC (S3) or REC LINE-IN (S5) starts a recording from the microphone or line input respec-

Configuring The Software To Suit The LCD Module

If you look closely at the PC board for this project, you will notice that the Jaycar and Altronics LCD modules are wired with their data lines "transposed". Basically, the D0 line on the Altronics module is connected to the D7 line of the Jaycar module, while the D1 line on the Altronics module is connected to the D6 line of the Jaycar module and so on. This was done to simplify the PC board layout.

It means, however, that the firmware must drive these two LCD modules differently. As a result, the microcontroller must either be programmed with 0110809A.hex if you are using the Altronics LCD module or with 0110809J.hex if you are using the Jaycar LCD module.

You can also toggle either version to drive the alternative module. This is done by holding down buttons S4 & S8 together while applying power. Note that this needs only to be done once, as the new setting is stored in non-volatile memory.

If nothing appears on the LCD at initial switch-on, try adjusting the contrast (VR1). If that doesn't work, you may have the wrong software for your particular LCD module, so switch off and reapply power while holding down S4 & S8.

If you buy a kit, then the default will be correct for that kit supplier's LCD module.

tively. Alternatively, you can press the Record or Line buttons on the remote.

When recording a file, the filename will be of the form rec???.wav with ??? a string of three decimal digits. The filename recorded will be shown when the recording is ended using either the STOP button (S4) on the board or the STOP button on the remote.

In practice, it's more complicated "in the telling" than "in the doing". A few minutes spent pressing buttons will quickly reveal how it works.



This close-up view shows how an on-board electret microphone can be installed (it plugs into a 2-pin header near the external microphone socket but watch the polarity). Do NOT install this if you intend using an external mic.

Triggered Mode

In Triggered mode, you simply press one of the eight buttons to play the file "rec00?.wav" where "?" is a digit from 1-8. For example, pressing S3 will play the file "rec003.wav".

You can also press the corresponding digits on the remote control to play each of these eight files.

Basically, the Triggered mode is useful for quickly playing back one of eight tracks (or messages) once they have been recorded. After recording the messages (using Normal mode), it's just a matter of copying a file called "trigger.txt" to the root folder of the card as detailed above and restarting the Digtial Speech Recorder. SC

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The JTAGMaster: Boundary Scan Tester & In-System Programmer

By Mauro Grassi

The JTAGMaster is a boundary scan interface controller for your PC with ports for all IC manufacturers including Altera and Xilinx. As well as for in-circuit programming of FPGAs, CPLDs and selected microcontrollers, you can use it for training purposes and to create test flows for production PC boards. It will provide you with a thorough introduction to boundary scan technology.

JTAG stands for "Joint Test Action Group", a group of engineers from various companies like IBM, Texas Instruments and Philips that developed boundary scan technology.

It was originally called JETAG, where the E stood for *European* but that was dropped when it became misleading.

The group's task was to develop a system for automated testing of PC boards given that it was becoming more costly and difficult using traditional test methods.

There is an estimated ten-fold increase in the cost of repair as you move from component level faults to module level to board level and so on. For many electronic manufacturers, this economic cost was unacceptable and it became important to develop a more feasible method of testing PC boards. The result was boundary scan technology.

Theory of Boundary Scan

Boundary scan technology was developed in the 1980s and 1990s as a way of overcoming major problems with traditional test methods that were compounded by advances in SMT (Surface Mount Technology) and PC board making (especially multi-layer boards).

In fact, it only became an IEEE standard in 1991 and is now known as IEEE 1149.1: *"Standard Test Access Port and Boundary-Scan Architecture"*.

The traditional method of testing at the time involved a bed of nails fixture. This was literally a matrix of nails on which the device under test (DUT) was placed.

Connections to test points on the DUT were made via these nails that then allowed testing to be performed. The kind of defects which one could test for using a bed of nails fixture included shorts between adjacent tracks, open circuits, component orientation, dry solder joints and others.

As SMT progressed, device packages began to have many more pins than before and came in smaller and more physically constrained packages that made traditional testing near impossible.

Severe limitations were imposed by such SMD packages as BGA (Ball Grid Array) where the connections to the PC board are made using small balls of solder on the underside of the IC package.

Since these connections were not physically accessible on the PC board, it was impossible to perform a traditional bed of nails test on boards that contained BGA and other high density SMDs.

The standard way to test BGA components before boundary scan technology was using X-rays and visual inspections that were neither cheap nor effective.

At the expense of four or five extra pins on an IC's package, boundary scan technology overcomes the limitations imposed by having to have a mechanical connection to a test point on the PC board, allowing a test instrument to directly drive pins on the periphery of a JTAG compliant IC.

Under boundary scan technology, the traditional bed of nails fixture is moved inside the silicon chip and becomes

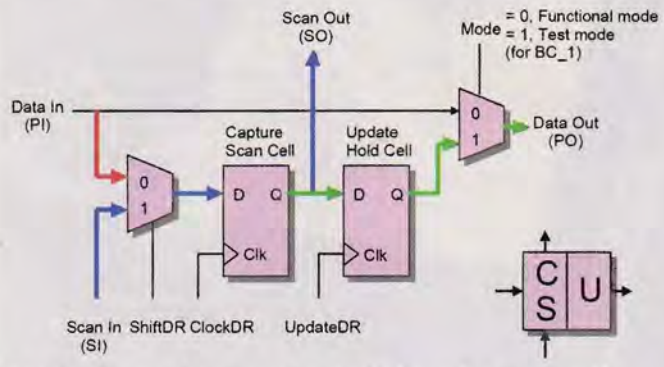


Fig.1: the basic structure of a single boundary scan cell. Each digital pin of a JTAG compliant device has an associated boundary scan cell (except power supply pins). This diagram shows the structure of the cell, which is logically equivalent but not necessarily illustrative of the implementation in silicon.

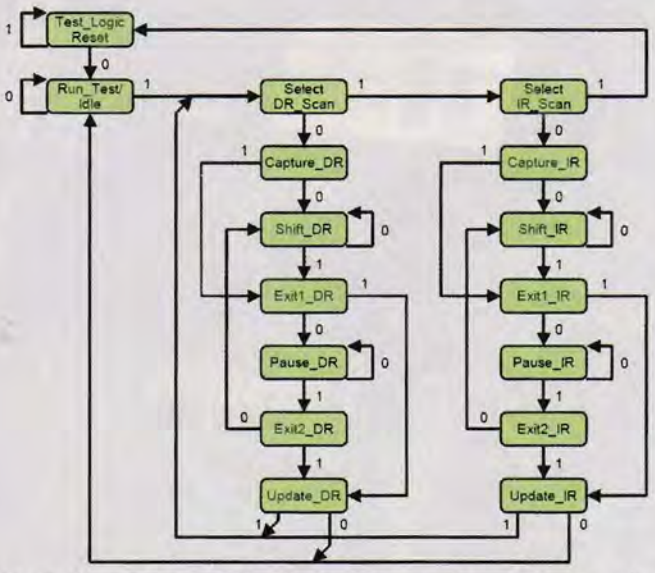


Fig.2: the TAP controller finite state machine diagram. The 16 states correspond to the boxes while there are exactly two transitions leading out of every state. One is labelled 0 (low) and the other is labelled 1 (high) corresponding to the two possible states of the TMS line. The transitions occur on a low to high transition on the TCK line.

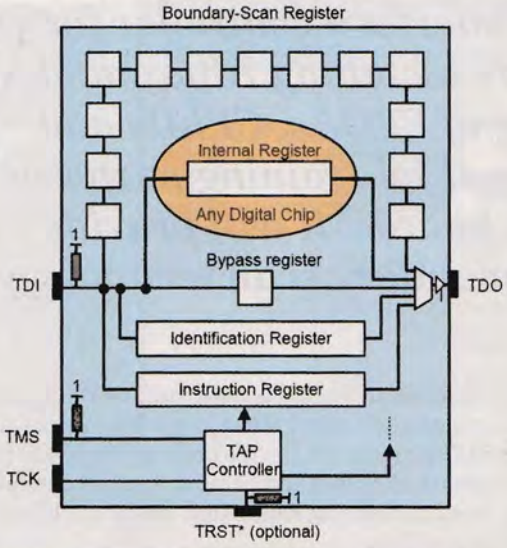


Fig.3: a representation of the JTAG boundary scan architecture, including the TAP controller and the chain of boundary scan cells. Notice that the standard specifies a minimum number of data registers and instructions but manufacturers can add proprietary instructions. As a result any internal register of the IC can end up between the TDI and TDO lines.

a virtual bed of nails.

Boundary scan technology has itself progressed to the point where today it is used not just for testing the connectivity of PC boards but also for programming and debugging FPGAs (Field Programmable Gate Arrays), CPLDs (Complex Programmable Logic Devices), microcontrollers and for in-circuit emulation (ICE).

Boundary Scan basics

Each pin on an IC accessible by JTAG testing has an associated circuit, called a boundary scan cell. The logically equivalent circuit for each boundary scan cell is shown in Fig.1. Note that this kind of testing is only possible on 'digital' devices where there are only two signal states.

For analog devices, similar schemes exist equivalent to JTAG in the limited, digital case, for example IEEE 1149.4. Such mixed signal schemes are substantially more complex than the digital case.

Each boundary scan cell can behave in one of four modes- capture, shift, update, or transparent.

In transparent mode, the parallel input is seen at the parallel output, effectively shorting out the boundary-scan cell logic. This is the normal mode for a functioning IC when it's performing its role in a wider circuit.

The other three modes pertain to JTAG debugging and have the following functions.

In update mode, the content of the update flip-flop is passed on to the parallel output. In shift mode, the serial input is shifted onto the serial output, while finally in capture mode, the parallel input is transferred to the capture flip-flop.

Boundary Scan signals

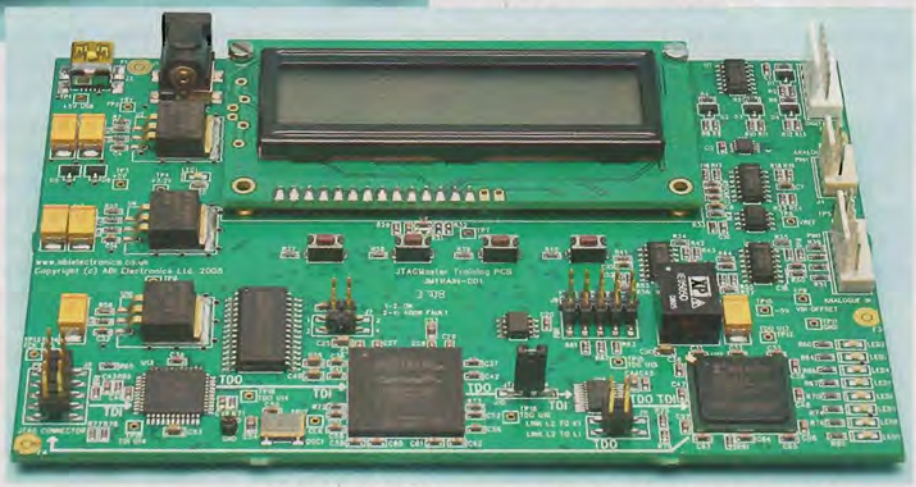
There are four mandatory JTAG signals and one is optional. The four mandatory signals are named TDI, TDO, TCK, and TMS. They have the following functions:

TI: serial data in



Shown here is the JTAGMaster kit and training PC board with interface cables and instructions. Not seen here is the AIM software CD.





At left is the JTAGMaster hardware. The two connectors are here configured for Xilinx and Altera hardware (connectors for other manufacturers are also available). Below is the training PC board incorporating four JTAG devices. The training board can be connected to the JTAGMaster to run more pre-loaded tests using the supplied AIM software. It's included for training purposes.

TO: serial data out
TCK: serial clock
TMS: control signal

The optional TRST is a reset signal and is active low, if it exists.

A number of JTAG compliant devices can be linked together on a PC board by connecting the TI line of one device with the TO line of another. The TCK and TMS lines are connected in parallel for all JTAG devices on a PC board. Thus linked, the JTAG compliant devices on a PC board become a scan *chain*.

The TMS line is used to control the state of the TAP controller within each JTAG device.

The TAP Controller

The TAP (Test Access Port) controller is a sixteen state finite state machine controlled by two digital lines, TCK and TMS. Each state has two transitions, one for when TMS is low and one for when TMS is high. The transition occurs on a low to high transition of the TCK signal.

From any state, with TMS high for five consecutive clock cycles, the TAP controller ends up in its reset state. From there, you can end up in any of the other 15 states by judiciously selecting a combination of states for the TMS line, while clocking the TCK line.

The TAP controller finite state machine is shown in Fig.2. There are two distinct sequences of instructions, a SHIFT-UPDATE sequence for the instruction register, and a SHIFT-UPDATE sequence for the data register (which can be one of many registers).

The BYPASS instruction, for example, places the bypass register between the TDI and TDO lines in the boundary scan chain. Doing so effectively shortens the chain by omitting the bypassed device.

The Instruction Register

Part of the IEEE1149.1 standard is a collection of registers, only one of which is ever connected between TDI and TDO, the serial input and output data lines respectively, as shown in the architecture diagram of Fig.3.

There is an instruction register, and among data registers, there is the Boundary Scan Register (BSR), a 1-bit Bypass Register and a 32-bit identification register. The latter can be

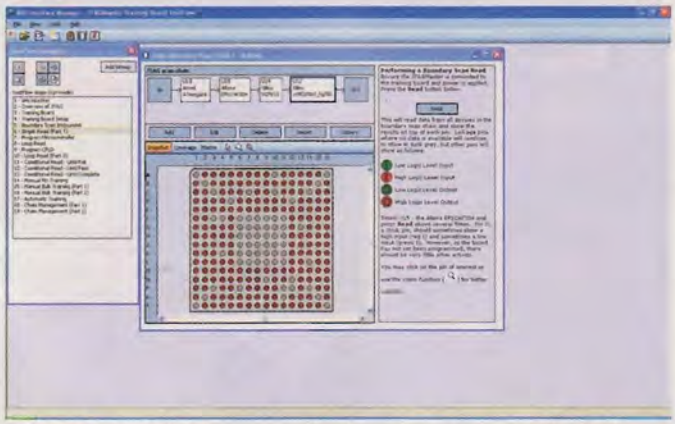


Fig.5: the result of reading the boundary scan cells of the Xilinx CPLD on the JTAG Master training board. The red pins indicate a high level- in this case the Xilinx CPLD has been erased. The grey pins are those for which there is no information and these are usually power supply pins which do not have associated boundary scan cells.

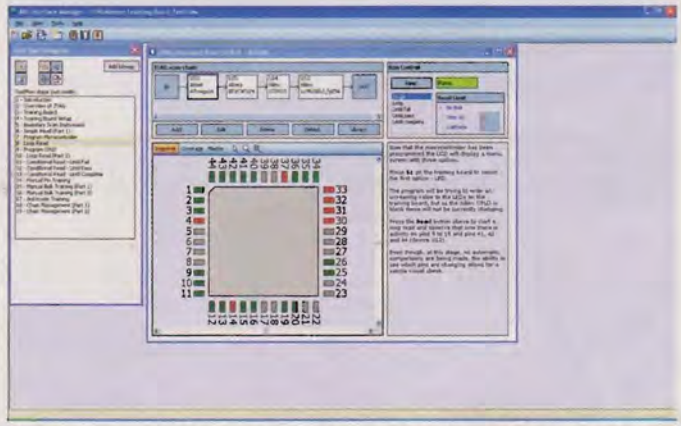


Fig.6: the result of capturing the state of the Atmel microcontroller pins using the AIM software connected to the JTAG Master. The green pins are logic low while the red are logic high. The grey pins are those for which there is no information – these are usually power supply pins. Also indicated is whether the pin is a digital input or an output.

used for identification, being unique to each JTAG device. The Bypass register is used to shorten the scan chain, as mentioned previously, and the boundary scan register is used to perform the actual testing of the PC board on which the JTAG device sits.

External and internal tests

One mandatory instruction is the external test, where the test path is between two different JTAG devices. In an external test instruction, the boundary scan cells have permission to write to their outputs. The result is then captured at the other end and shifted out of the cells serially.

The great thing about external testing is that passive components in the interconnect path can also be tested. Such testing of non-boundary scan devices is common using boundary scan technology.

Such an external test assesses the integrity of the entire connection path between the two pins, starting and ending with the path inside the two ICs between silicon and pad.

An internal test, on the other hand, tests the integrity of the signal between two pins of the same IC.

The JTAGMaster hardware

The JTAGMaster consists of two dual in line header ports (one is compatible with Xilinx, while the other is compatible with Altera hardware), a column of four LEDS, one green (PASS), one red (FAIL), and two yellow (POWER and TESTING) and a USB port for connection to a computer. The device fits inside the palm of your hand.

As you can imagine, every test ends with either the green or the red LED being lit to indicate respectively a pass or a fail response to the test.

The JTAGMaster can be used to diagnose complex PC boards with multiple JTAG compliant devices. The pins of each JTAG device in the scan chain can be monitored for their logic level. External and internal tests on tracks and joints on the PC board can be performed easily and repeatedly.

These may uncover manufacturing defects, incorrect logic levels at pins indicating a bad solder joint, a faulty device or other causes.

Note that it is very rare for an IC to show signs of damage in the centre and not in the periphery, near the boundary scan cell logic.

You can also program and verify microcontrollers, FPGAs and CPLDs using manufacturer provided standard files. The JTAGMaster is controlled using the supplied PC software.

Using the PC software

The JTAGMaster is supplied with the "ABI Interface Manager" (AIM) software suite. This allows you to create your own test flows and then run them. Each test is stored in a test flow file. This makes it easy for an operator to complete the testing, as there is a step-by-step sequence.

Pictures and text can be incorporated into the test flow to provide visual guidance to the test operator or for training purposes. The entire scan chain is represented graphically by a block diagram that can be edited and augmented with devices from an extensive manufacturer library.

The test operator follows the test flow to complete the test, with possibly multiple pass/fail responses of the testing. A pass result for the entire test is then equivalent to a pass response for every step of the test flow.

There is even a JTAG Master training PC board that has been specifically designed for training purposes. You can connect the JTAG Master to it and perform a sequence of tests using the AIM software. The training board comes with four JTAG devices, including an Atmel microcontroller, a Xilinx CPLD and an Altera FPGA.

Conclusion

We found the AIM software intuitive and easy to use. Performing tests is simple, in any one of a number of industry standard file formats supplied by device manufacturers and the test flows with integrated text and pictures are a nice feature.

The JTAGMaster consists of the JTAGMaster hardware, 10-way interface cable, 14-way interface cable, USB cable and AIM software on CD. The cost is $AU5800.00 plus GST. The JTAGMaster Training board, which costs $AU920.00 plus GST, also includes a USB cable.

For further information, contact TekMark Australia, Suite 302, 18 Orion Rd, Lane Cove NSW 2066. Phone 1300 811 355 or visit www.tekmark.net.au

SC

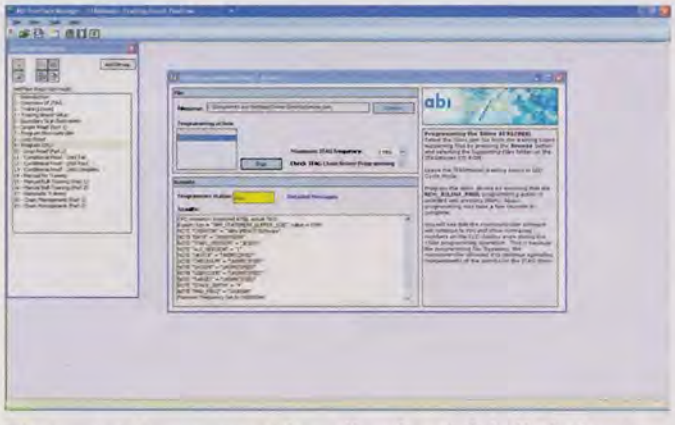


Fig.7: a test in progress. The yellow box is labelled 'Busy' while the test is being performed using the JTAG Master. The chosen file is an erase sequence 'erase.jam' for the Xilinx CPLD on the JTAG Master training board. The JTAG serial clock frequency has been selected to be 1MHz although the JTAG Master can operate at higher rates than that.

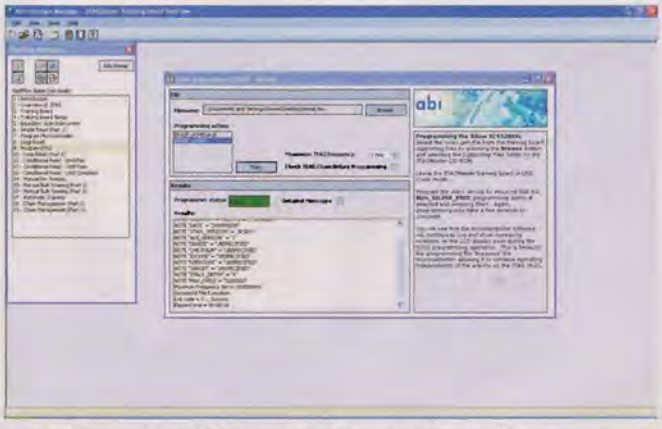


Fig.8: the result of the test is a Pass, indicated by a green box. The green LED on the JTAG Master will also light to indicate a pass response. The selected test was actually an erase sequence for the Xilinx CPLD in the form of the file 'erase.jam'. These are files in an industry standard format that the AIM software understands.

SERVICEMAN'S LOG

It's chaos theory to the rescue

I am eternally grateful for the discovery of chaos theory. It has made my life relevant and means that I don't have to worry any more about phenomena that simply don't make sense. Whoever invented it must have specifically had electronic servicing in mind.

Chaos theory, as I have discovered, works brilliantly when applied to my line of work. For example, I recently had not one but several Denon AVR-1604 AV tuner/sound theatre systems come in dead. In each case, only the standby LED would come on. And again in each case, I reset the microprocessor by pressing the speaker A and B buttons together while powering on and this completely fixed the problem. But why?



Well, why not? It's chaos theory to the rescue!

LG DVD recorder

On a similar theme, I was recently called out to an LG DVD Recorder/VCR (Model RC195), its owner complaining that he couldn't record sound. This is a hifi VCR and I quickly discovered that it not only couldn't record sound but couldn't erase previously recorded sound either.

I opened it up but could find nothing wrong with the mechanics. This machine was in an entertainment unit and the mains power lead was stretched to its maximum which meant it was very difficult for me to work on the unit. Eventually, the inevitable happened and the power cord was pulled out of its socket and when I replaced it, I found that the fault was "fixed". And no matter what I did, the unit now continued to work correctly.

That wasn't quite the end of the story though, as the same fault reoccurred again some three months later. Unplugging the unit from the power socket again fixed the fault and this time I advised the client to get a surge-protected power board to use with the unit. But "why?". Simple – its just chaos theory in action again.

Items Covered This Month

- Denon AVR-1604 AV Tuner
- LG RC195 DVD recorder/VCR combo unit
- Panasonic RAMSA WR-DA7 Mixer Console
- Vivax VX104-02 pipe locator
- Sanyo VHR-VK310A hifi VCR
- LG RH4820W DVD player/ recorder
- Philips 21PT1321 L7.1 TV set
- Apple PowerMac G5 PSU
- Toshiba 42WL58A LCD TV
- Rudeness doesn't pay

Panasonic mixer

We were recently asked to repair an expensive 10-year-old Panasonic RAMSA WR-DA7 professional mixer which had no LCD readout and no functions. This is not a domestic piece of electronics and would normally be serviced by Panasonic but I decided to take it on anyway, even though I didn't have a service manual.

By means of the internet, we managed to obtain the November 99 Service Kit CS-A003. This describes how to repair an "Impossible to Operate" fault symptom which also gives intermittent abnormal LED indicators and no LCD readout.

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FRIED MOUSE

dismantling instructions from the Apple website and these certainly came in handy.

When I eventually opened up the supply on the workshop bench, I could see that the mains fuses were blown. These comprise two 6.3A ceramic fuses (F1 & F2) in parallel, so it must have blown with a "helluva" bang!

I traced the short circuit to Q4, a 2SK2611 transistor. I also checked R39 and R101 in parallel and found that they had been "blown" open circuit. The next step was to determine their values. Now I know my colour codes pretty well but with some of the 5-band E24 range of resistors, it can get difficult.

One of the resistors was a 4-band resistor with Brown Grey Gold Gold bands which gives a value of 1.8Ω. The second one had Brown Grey Silver Gold Black bands and I had to first make sure that I was reading it the right direction. However, the order listed is correct which means it is a 0.18Ω resistor but what was the meaning of the last black band? It took a few minutes with Google to discover that the final black band means that it is fusible resistor.

Anyway, I replaced all these components along with many nearby electrolytic capacitors before powering it up on the bench. You can switch it on by linking the green lead to a black lead on the power harness plug but in this case not a lot happened. I could measure +335V on the main electros and on the FETs but could find no low tension rails anywhere – not even to start it up.

Subsequent investigation revealed that all the surface-mount transistors had blown on a small sub-module which is soldered vertically to the main power supply board. So for now I have had to put it aside until either I can get a circuit or buy a new one. Can anyone help with a circuit?

Toshiba LCD TV

A Toshiba 42WL58A LCD TV came in with no picture or sound. The power supply was not completely dead however, as the standby power supply was delivering +5.1V and +25V.

The rest of the power supply is quite involved, with three different switchmode power supply sections. The first power supply is the PFC which generates +370V and +22V rails. This too was working OK and could be switched on and off.

The Resonance Power supply was also OK. It produces +30V and +2V rails (and a +24V INV rail).

It was the RCC power supply which wasn't working, so we had no +32V, 20V or 12V outputs. And because this wasn't working properly, it activated the protect line which then closed down the other supplies.

I examined this circuit closely and could find no shorts in the secondary. And although the optocoupler and NJM431L circuit could have been faulty, I suspected the control IC in the primary (Q880, STR-W6765). My suspicions proved correct. Replacing this 7-pin IC fixed the fault and the set functioned correctly again in all modes.

Rudeness doesn't pay

To change pace, here are a couple of stories passed on to me by an antenna technician. I'll let him tell the stories in his own words.

In the first instance, a client called complaining of no digital reception in a block of units. An appointment was made and I duly called around.

I began by testing the signal strengths at his antenna socket (on digital) and these all came in at about 58db/μV. In addition, CSI (Channel Status Information) was between 20-25%, while BER (Bit Error Rate) was greater than -E7 as measured on a Promax digital signal strength meter/spectrum analyser (valued at $15,000).

Based on these readings, I informed the customer that everything was OK at that moment, before going on to explain the various factors and antenna faults that could cause intermittent reception. His response was a rather belligerent "I don't believe you, it never bl__dy works."

Somewhat taken aback, I replied "I can assure you it is working fine right now. I can even show you a picture on my analyser which has an inbuilt COFDM receiver".

He still wanted to argue. "I will show you then that I do not and have never had digital reception". He marched over to the set and attempted to turn it on but couldn't and was forced to get his wife to do it for him. Guess what – up it came with a perfect picture on all digital channels! I tried to control myself but my smirk must have been painful for him to see.

With that, I edged towards the door as he mumbled a series of excuses before asking what I was going to do about the problems he had been experiencing. My reply was that I would send in a written quote. I must say that I did him no favours with the quote but I still must have been cheaper than everyone else because I got the job anyway.

My second story began when I was called out to check the reception at a block of units during a particularly busy period. My secretary had previously booked the appointment for 9.30am and I duly arrived at 9.20am but no-one answered when I rang the doorbell. I then tried phoning the

customer but again there was no answer.

There was nothing further I could do. I was very busy, with lots of other calls to be made in that area, so I left at 9.25am for my next appointment.

I worked through my busy schedule surprisingly quickly and subsequently found myself in the vicinity of the first call at around 11am. It was then that I decided to call my office to see if there were any messages.

It turned out that my first client had just called and had got stuck into my secretary, complaining that he had been waiting for me since 9.30am that morning. She had told him that she would contact me and that I would be able to return within the hour as I was still in the general area.

When I returned for the second time and rang the doorbell, he wasn't there again, much to my frustration! However, on my way out of the building, I found him downstairs in the laundry. I told him that I had called earlier and he indignantly told me that he had "only popped out" for a newspaper and that he had been waiting for me since 9.30am.

Now this guy is about 70 and retired, so why did he choose to go out when he was expecting a tradesman to arrive? He had all day to get a newspaper and he could have waited until after our appointment.

I pointed out that although the call had been booked for 9.30am, it was impossible to guarantee a time of arrival to the exact second. His retort was "When I call a tradesman for 9.30, I don't expect him to be there at 9.29 or 9.31 but at 9.30 exactly".

He then began rubbishing my very reliable, efficient and experienced secretary of 10 years standing. According to his convoluted logic, it was all her fault. She should not have said 9.30am if she didn't mean it.

That was a big mistake on his part because by now, I had completely lost interest in this guy and his job. I just don't need hassles like this. In the end, I told him that I was extremely busy (which was true) and that as he was so unhappy with our service, he should find someone else to fix his antenna system.

The mouse that fried

Finally, I had an old microwave come in with the complaint that it was dead.

When I took the cover off the cause was immediately apparent, the body of an electrocuted mouse lying across some high-voltage circuitry – see photo below. Removing this mouse and repairing the oven wasn't exactly the most pleasant job I've had but that's life. SC



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An Improved Lead-Acid

BATTERY CONDITION CHECKER

In July 2009 we presented an improved version of the Battery Zapper & Desulphator. Here we present the companion Battery Condition Checker. It gives more stable readings for all three main battery voltages (6V, 12V & 24V) than our earlier model, as well as giving a choice of test current pulse levels to suit batteries of different capacities. As a result, it's now also suitable for testing sealed lead acid (SLA) batteries.

By JIM ROWE



The Battery Condition Checker circuit fits inside a standard UB2 plastic box and is suitable for checking 6V, 12V & 24V lead-acid & SLA batteries.

AS NOTED IN the July 2009 article, the May 2006 Lead-Acid Battery Zapper & Condition Checker has been a very popular project but since it was published a few shortcomings have become apparent. The metering circuit sometimes had a tendency to "lock up" on the 6V range and the current pulse loading circuit was sometimes unstable with 24V batteries, if the power switching MOSFETs were at the high end of their transconductance range.

Many readers also found the combination of the Battery Zapper & Condition Checker fairly tricky to assemble and disassemble because it was a bit of a shoe-horn job into the plastic case. In view of this, we recently decided to develop improved versions of both the Checker and the Zapper but to feature them as separate projects, to make them easier to build. As noted, the new Battery Zapper was presented in July and here we present the companion Battery Condition Checker.

How it works

The circuit of the new Battery Condition Checker is shown in Fig.1 and comprises two distinct parts: an upper section incorporating ICs1-3 and transistors Q1-Q7 and a lower section involving IC4, IC5 and LEDs 1-8. Essentially, the upper section is a pulsed current load which draws a sequence of three very short high-current pulses from the battery, after you press the CHECK pushbutton S1.

The lower section of the circuit is basically a sample-and-hold digital voltmeter which samples the battery voltage only during the last of the three current pulses and compares it with the battery's no-load voltage. This indicates the battery's condition by showing how much its terminal voltage droops under load. In effect, the heavy current pulses drawn from the battery enable us to measure its output impedance.

If the battery voltage doesn't droop much at all, blue LED8 will light, indicating GOOD; if it droops by only a small amount, green LED7 lights (OK); if it droops more but not too much, green LED6 glows (FAIR). If it droops even more than this, either yellow LED5 (POOR) or red LED4 (FAIL) will glow, giving you an idea of how urgently the battery should be replaced. This assumes that you have just charged the battery, of course.

If none of the LEDs light, your battery is dead or flat. If charging and zapping does not fix it, it is beyond redemption.

Current pulser

In more detail, the heart of the pulsed current load section is IC2, a 4017B decade counter. This can count clock pulses from gate IC1d, which is configured as a relaxation oscillator running at about 66Hz. This oscillator only runs when pin 12 is high and this is controlled by a "run flipflop" comprising gates IC1a & IC1b.

When battery power is first applied to the circuit, the flipflop immediately switches to its "stopped" state, with pins 3 & 5 low and pins 2 & 4 high. So IC1d is prevented from oscillating and at the same time IC2 is held in its reset state by the logic high applied to its MR pin (15). The only output of IC2 at logic high level is O0 (pin 3).

No further action takes place until you press the CHECK pushbutton S1, whereupon one side of the 22nF capacitor connected to pin 1 of IC1a is pulled down to ground, forcing it to charge via the 10kΩ resistor. Until it charges, pin 1 of IC1a is pulled low, causing pins 3 & 5 to swing high and pins 2 & 4 to swing low. Thus clock oscillator IC1d is enabled and at the same time the reset is removed from pin 15 of IC2.

IC2 now begins to count the pulses from IC1d and its outputs switch high in sequence: O1, O2, O3 and so on up

Parts List

1 plastic box, 197 x 113 x 83mm
1 PC board, code 04108091, 185 x 100mm
1 SPST momentary pushbutton switch (S1)
1 220µH choke (Jaycar LF-1104 or Altronics L6225)
2 3-pole rotary switches (S2,S3)
1 'Speaker box' binding post, red (Jaycar PP-0434 or equivalent)
1 'Speaker box' binding post, black (Jaycar PP-0435 or equivalent)
1 8-pin DIL IC socket
2 14-pin DIL IC sockets
1 16-pin DIL IC socket
1 18-pin DIL IC socket
4 M3 x 25mm tapped spacers
9 M3 x 6mm machine screws, pan head
4 M3 x 6mm machine screws, countersink head
5 M3 hex nuts
2 knobs, 20mm diameter
5 PC stakes
1 180mm length 0.8mm tinned copper wire

Semiconductors
1 4093B quad Schmitt NAND gate (IC1)
1 4017B decade counter (IC2)
1 MC34063 DC-DC converter (IC3)
1 4066B quad bilateral switch (IC4)
1 LM3914 dot/bar LED driver (IC5)
1 LM2940-5V regulator (REG1)
1 2N7000 N-channel FET (Q1)
2 BC338 NPN transistors (Q2,Q3)
4 IRF1405 55V/169A MOSFETs (Q4-Q7)
3 5mm green LEDs (LED1, LED6, LED7)
2 5mm yellow LEDs (LED2,LED5)
2 5mm red LEDs (LED3,LED4)
1 5mm blue LED (LED8)
7 1N4148 diodes (D1-D4,D6-D7, D10)
2 1N5819 40V/1A Schottky diodes (D5,D11)
2 6A1 100V/6A diodes (D8,D9)

Capacitors
1 470µF 35V RB electrolytic
2 220µF 16V low-ESR RB electrolytic
1 10µF 16V tag tantalum
1 2.2µF 16V tag tantalum
2 100nF MKT metallised polyester
4 100nF monolithic
1 22nF MKT metallised polyester
1 820pF disc ceramic

Resistors (0.25W, 1%)

1 10MΩ	2 1.2kΩ
1 270kΩ	1 680Ω
2 100kΩ	2 470Ω
1 22kΩ	8 220Ω
1 15kΩ	1 150Ω
2 10kΩ	4 100Ω
3 4.7kΩ	1 1.0Ω

4 0.22Ω 5W wirewound

to O9. Each counter output switches high for around 15ms (milliseconds), so the complete sequence takes 9 x 15 = 135ms. When output O9 finally drops low again at the end of the ninth clock period, the 100nF capacitor connected between this output and pin 6 of IC1b feeds a negative-going pulse back to IC1b, which resets the flipflop.

This stops the clock and activity again ceases until S1 is pressed again. So IC1a, IC1b, IC1d & IC2 form a simple digital sequencer which generates nine 15ms long pulses when pushbutton S1 is pressed.

Diodes D2, D3 & D4 are connected to the O9, O5 and O1 outputs of IC2 to form an OR gate feeding the commoned inputs of IC1c, which are normally pulled down to 0V via a 22kΩ resistor. When the sequencer runs and outputs O1, O5 and O9 switch high in turn (with 45ms gaps between them), the inputs of IC1c are also pulled high.

As a result, IC1c's output (pin 10) switches LOW during the three corresponding 15ms periods.

Because the output of IC1c is connected to the gate of FET Q1 via a 150Ω suppressor resistor, this transistor is normally turned on but is turned off during the three 15ms pulses. This means that during each pulse, the drain voltage of Q1 rises to about +12V, being pulled up by the 4.7kΩ drain load resistor.

When this happens transistor Q2 turns on, delivering about 11.3V to the top of the 470Ω emitter resistor connected to the collector of Q3 and the gates of our main switching MOSFETs Q4-Q7. So during each of the three 15ms pulses, Q4-Q7 are switched on to draw heavy pulses of current from the battery.

MOSFET gate supply

IC3, an MC34063 DC-DC converter, is used to generate a +12V supply rail purely for Q1 and Q2, from the +5V rail. This is done because MOSFETs Q4-Q7 need a gate drive voltage of at least +9-10V in order to switch on properly.

IC3 operates in switchmode at around 40kHz, storing energy in inductor L1 and then releasing it through diode D5 to charge the 220µF capacitor. The 10kΩ and 1.2kΩ resistors form a divider which feeds back a proportion of this output voltage to a comparator inside IC3, to allow it to maintain the output voltage at +12V.

So Q1 and Q2 are basically a level translating inverter which turns on Q4-Q7 whenever the output of IC1c switches low during each 15ms pulse from the sequencer.

MOSFETs Q4-Q7 are effectively in parallel, with their drains connected to battery positive via 6A polarity protection diodes D8 & D9 and their sources connected to battery negative via separate 0.22Ω 5W resistors. The MOSFET gates are each fitted with 100Ω suppressor resistors and are also pulled down to 0V via a 4.7kΩ resistor, so normally they are switched off and not conducting.

Pulse current limiting

The current pulses are limited by the circuit involving transistor Q3 and diodes D6 & D7 in series with its emitter. The base of Q3 is connected to the top of each source resistor via a 220Ω base current-limiting resistor, so that when the MOSFETs conduct and current flows in the 0.22Ω resistors, the resulting voltage drops provide forward bias for Q3.

If switch S2 is in the 40A position, diodes D6 & D7 are connected in series between the emitter of Q3 and 0V. As a result, Q3 doesn't conduct collector current to any significant extent until the voltage drop across the MOSFET source resistors rises above 2.1V, where it matches the forward voltage

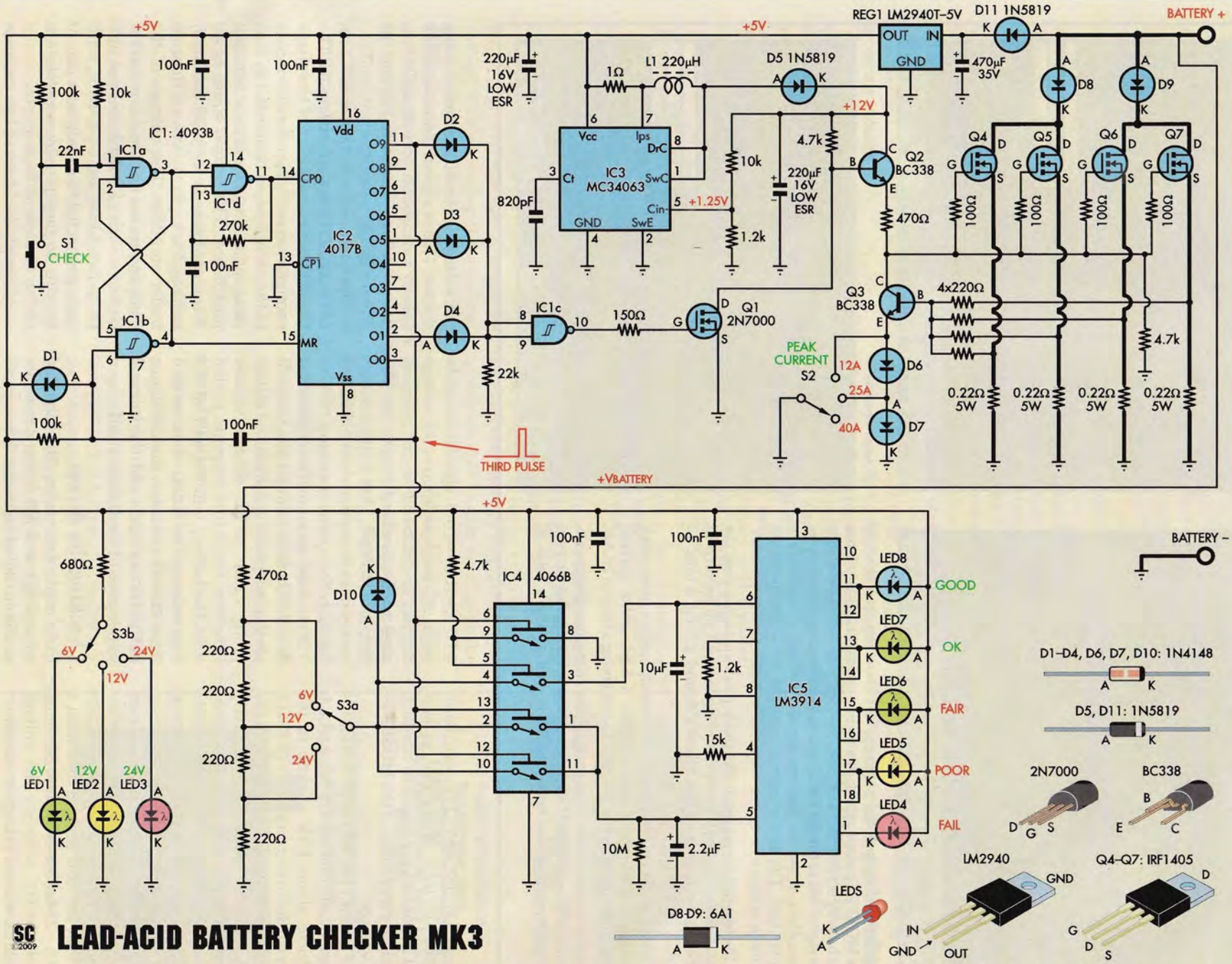


Fig.1: the circuit has two distinct sections. The top section consisting of ICs1-3 & transistors Q1-Q7 forms a pulsed current load which draws a sequence of three very short high-current pulses from the battery when the CHECK switch (S1) is pressed. The bottom section involving IC4, IC5 & LEDs 1-8 forms a sample-and-hold digital voltmeter which samples the battery voltage during the final current pulse and compares it with the battery's no-load voltage.

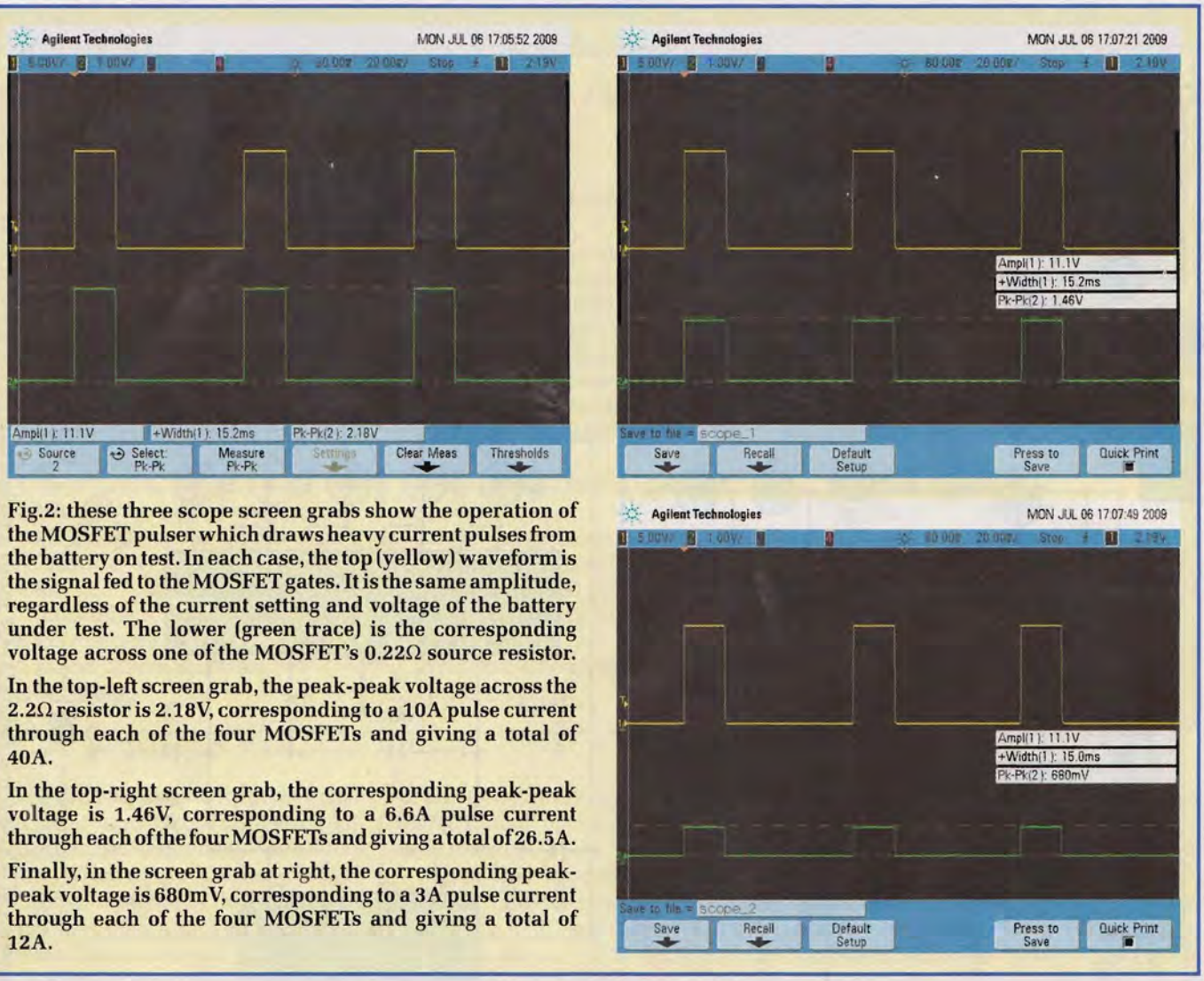


Fig.2: these three scope screen grabs show the operation of the MOSFET pulser which draws heavy current pulses from the battery on test. In each case, the top (yellow) waveform is the signal fed to the MOSFET gates. It is the same amplitude, regardless of the current setting and voltage of the battery under test. The lower (green trace) is the corresponding voltage across one of the MOSFET's 0.22Ω source resistor.

In the top-left screen grab, the peak-peak voltage across the 2.2Ω resistor is 2.18V, corresponding to a 10A pulse current through each of the four MOSFETs and giving a total of 40A.

In the top-right screen grab, the corresponding peak-peak voltage is 1.46V, corresponding to a 6.6A pulse current through each of the four MOSFETs and giving a total of 26.5A.

Finally, in the screen grab at right, the corresponding peak-peak voltage is 680mV, corresponding to a 3A pulse current through each of the four MOSFETs and giving a total of 12A.

drop of D6, D7 and Q3's own base-emitter junction. When that voltage level is reached, Q3 begins to conduct, shunting away some of the MOSFETs' gate voltage.

As a result the MOSFET current is automatically limited to a value which produces about 2.1V of drop in the source resistors: around 2.1V/0.22Ω = 9.5A. This is for each MOSFET, so the total current is around 38A, or pretty close to 40A. So when you press push-button S1, a sequence of three 15ms 40A pulses is drawn from the battery, each 45ms apart.

When switch S2 is set to its centre 25A position, exactly the same sequence of pulses takes place except that they are now limited to around 4 x 6.3A = 25A. This is because S2 shorts out diode D7, reducing the voltage threshold where Q3 begins to conduct from 2.1V down to 1.4V.

In the third position of S2, both D6 & D7 are shorted out. Q3 will therefore begin to conduct as soon as the voltage drop in the MOSFET source resistors rises to above about 0.65V, the Vbe drop of Q3 itself. This limits the current pulses to around 0.65V/0.22Ω = 3A each, for a total of around 12A.

If you have a look at the scope waveforms of these current pulses, you will see that our prototype produced pulses pretty close to the design values. However, the actual currents pulled from the battery will depend on the tolerances of the 0.22Ω resistors and other circuit variables, the resistance of the battery leads and the internal impedance of the battery itself.

Checking the droop

As explained earlier, the circuitry around IC4 and IC5 forms a sample-and-hold digital voltmeter. It compares the battery voltage during the last of the three 15ms current pulses against the voltage when no current is being drawn. This is a good indicator of the battery's condition and its ability to deliver a high discharge current, as when starting a motor.

The heart of the voltmeter is IC5 an LM3914 LED bargraph driver IC. The LM3914 is basically a set of 10 voltage comparators, with the reference inputs of the comparators connected to taps on an internal voltage divider between pins 6 & 4. The second input of all 10 comparators is fed with the input voltage from pin 5, via an internal buffer amplifier. The outputs of the comparators are used to drive current sinks for each LED driver output pin. Only five LEDs are used here, with each connected to an adjacent pair of outputs so they provide a resolution of five discrete voltage levels.

Although the LM3914 has an internal voltage reference, we're not using it here; the reference pin (pin 7) is simply

connected to 0V via the 1.2kΩ resistor, to set the LED current levels correctly.

So that we can use the circuit to compare the on-load battery voltage with its off-load value, we use the off-load battery voltage as the voltmeter's reference. Actually we use a proportion of the battery voltage selected by switch S3a, because the LM3914 input voltage range must be limited for linear operation.

So S3a selects a suitable proportion of the battery voltage, depending on whether a 6V, 12V or 24V battery is being tested. Diode D10 is used to prevent the voltage at the rotor of S3a from rising above the +5V supply line by more than 0.6V, to prevent damage to either IC4 or IC5 if S3 is set to the incorrect battery voltage.

The proportion of the battery's voltage selected by S3a is normally fed to the reference input of IC5 (pin 6), where it also charges the 10µF capacitor at all times EXCEPT during the third current pulse drawn from the battery by Q3-Q6. The end result is that the 10µF capacitor becomes charged up to a voltage proportional to the battery's off-load voltage.

When the Checker's sequencer is running and the third current pulse is being drawn from the battery, the voltage from S3a is switched to pin 5 of IC5, where it also charges up the 2.2µF capacitor. This means that the 2.2µF capacitor charges up to a voltage proportional to the battery's loaded voltage. This switching of the voltage from the rotor of S3a is performed by CMOS switch array IC4, under the control of the pulse voltage from output O9 (pin 11) of IC2.

When the voltage at IC2 pin 11 is low, which is most of the time, it turns off the uppermost switch element of IC4 (pins 9, 8 & 6) which is wired to function as a simple inverter. As a result, pin 9 of IC4 rises to +5V, pulled high via a 4.7kΩ resistor. This pulls pin 5 of IC4 high with it, turning on the second switch element (pins 3 & 4), which switches the voltage from S3a through to pin 6 of IC5.

On the other hand, when pin 11 of IC2 switches high during the crucial third current pulse, this switches on the inverter element in IC4, dropping the voltage at pin 9 down to 0V and hence switching off the second switch element. At the same time, it switches on the two remaining elements in IC4 (pins 1-2 and pins 10-11), directing the voltage from S3a through to pin 5 of IC5 and the 2.2µF capacitor.

So the reference input of IC5, pin 6, is fed with the "off load" battery voltage on the 10µF capacitor. Pin 4 of IC5 is not connected to 0V but via a 15kΩ resistor. This expands the range of the LM3914's comparator voltage divider to the upper 40% of the total reference voltage.

The LM3914 therefore compares the selected proportion of the battery's off-load voltage at pin 6 with the same proportion of its on-load voltage at pin 5. If the voltage drops very little, LED8 will light; if it drops a little more, LED7 will light and so on.

Note that if the on-load battery voltage drops below 60% of its no-load value, none of the LEDs will light – that's why a "no glow" indicates that the battery is either flat or completely dead. **Note too that regardless of which LED lights during the test to indicate battery condition, after a few seconds the glow will transfer down through the lower LEDs and then finally they'll all go dark again.** That's because the sampled on-load voltage stored by the 2.2µF capacitor is gradually leaked away by the parallel 10MΩ resistor, to ready the circuit for another test.

The second pole of switch S3 (S3b) is used to indicate which battery voltage has been selected, via LEDs1-3. This is mainly to remind you to set S3 for the correct battery voltage, because otherwise the Checker won't give the correct readings.

Note that except for Q1 & Q2 in the inverting level translator, all of the Checker's logic circuitry operates from a +5V supply rail, derived from the battery voltage via REG1, an LM2940-5 low-dropout regulator. As explained before, Q1 & Q2 operate from a +12V rail generated by IC3, while MOSFETs Q4-Q6 are connected to the battery via diodes D8 & D9.

Construction

Most of the parts are mounted on a single PC board coded 04108091 and measuring 185 x 100mm. This fits neatly into a standard UB2 sized jiffy box (197 x 113 x 83mm). The battery terminals and switch S1 mount on the box lid, being connected to the board via short lengths of tinned copper wire. The board is mounted under the lid via 25mm-long tapped spacers.

The component overlay diagram is



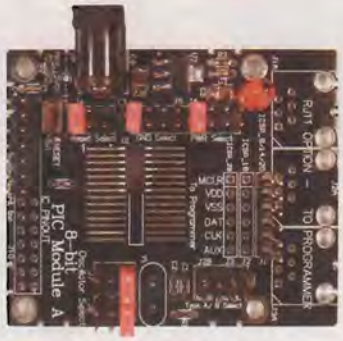
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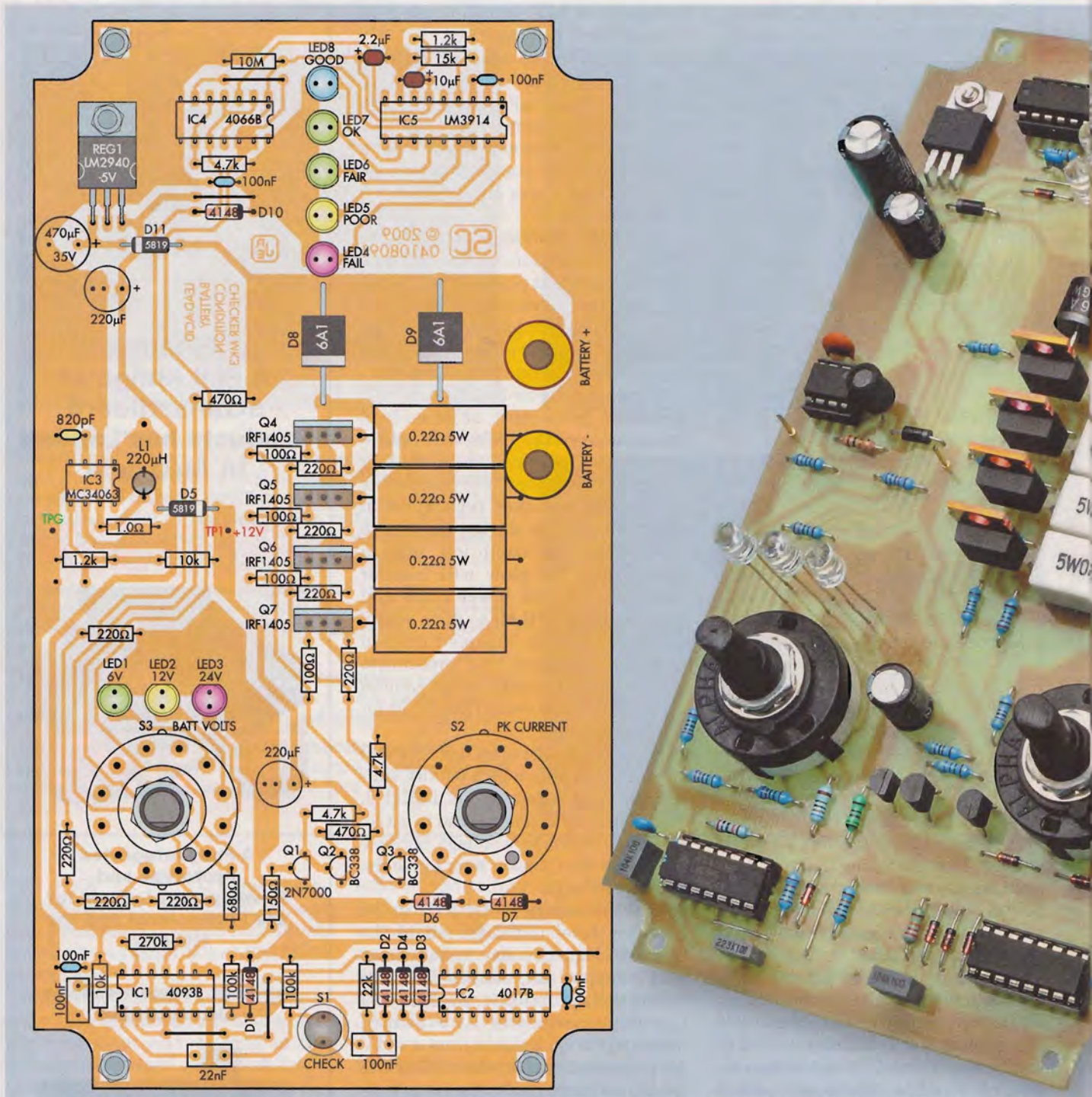


Fig.3: follow this diagram to install the parts on the board. Make sure that all polarised parts are correctly orientated and take care also with the orientation of rotary switches S2 & S3 (see text)

shown in Fig.3. Begin the assembly by fitting the five wire links, two near IC1 and D1, one just above IC2 and the remaining two at upper left near D10 and IC4. The links are all 10mm long (above the board) and can made from resistor lead off-cuts.

Next, add the five IC sockets. Be sure to orientate all five so their end notches are as shown on Fig.3. Then fit all of resistors, including the four 5W wirewound units. Follow these with the multilayer monolithic and MKT capacitors, then fit the five polarised capacitors (the 2.2µF and 10µF tantalums, plus the 470µF and the two 220µF electrolytics), taking care to orientate these as shown in Fig.3.

Fit the two rotary switches S2 and S3, although their spindles should first be cut to about 15mm long (from the threaded mounting sleeve). **As indicated in Fig.3, both switches mount with their orientation spigot at about 5-o'clock.**

After both switches are soldered in place, make sure they're both configured for three positions. Do this by turning their spindles anticlockwise as far as they'll go and then removing

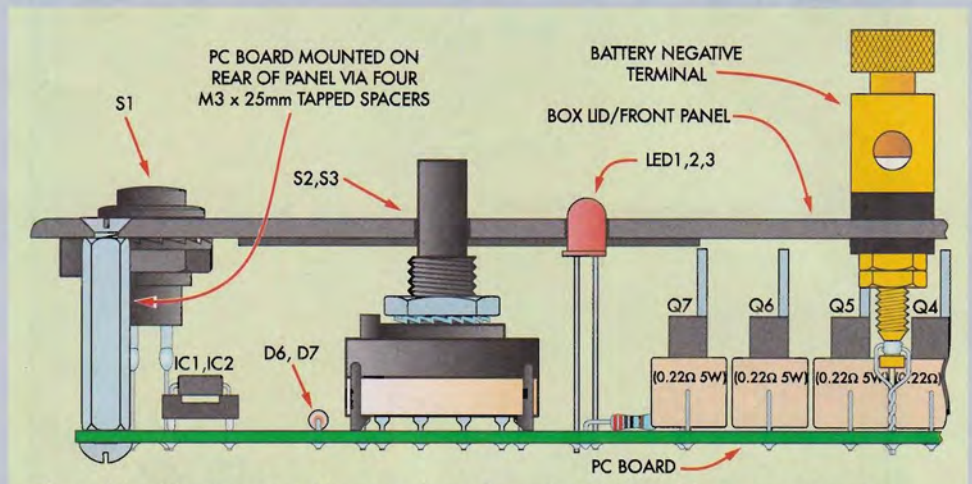
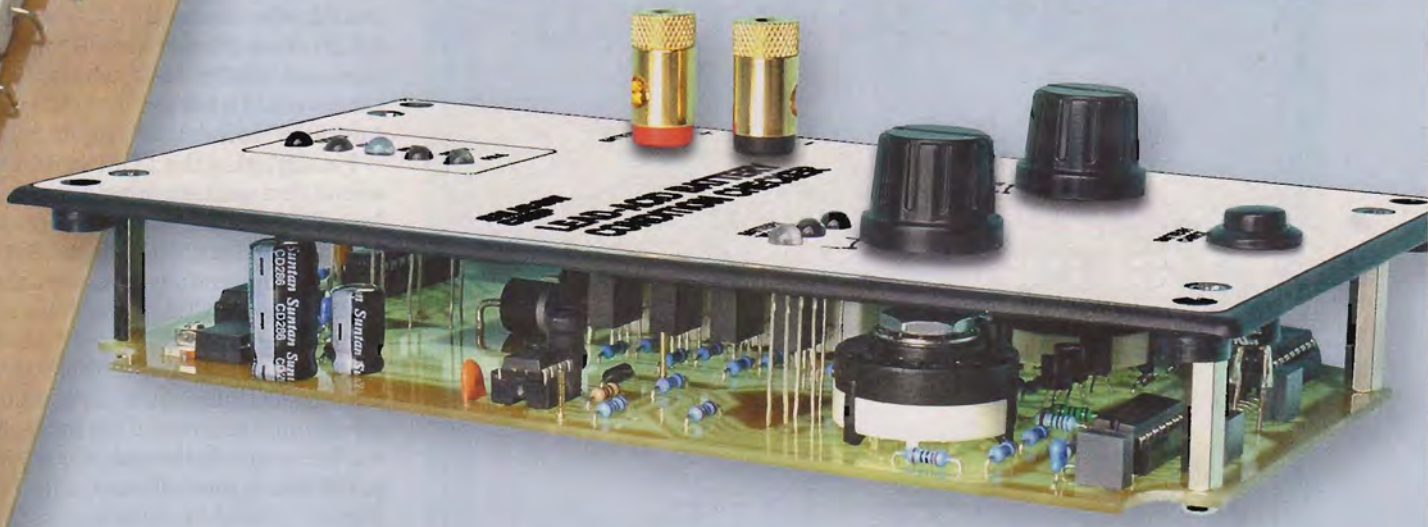


Fig.4: this side-elevation diagram shows how the PC board is mounted on the back of the lid on M3 x 25mm tapped spacers & washers. The battery terminals are connected to the PC board via "extension" wires, as is switch S1.





Left & above: these two photos show how it all goes together. The cutouts in the corners of the PC board are necessary to clear the four integral corner pillars inside the case.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10MΩ	brown black blue brown	brown black black green brown
❑	1	270kΩ	red violet yellow brown	red violet black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	1	15kΩ	brown green orange brown	brown green black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	3	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	1.2kΩ	brown red red brown	brown red black brown brown
❑	1	680Ω	blue grey brown brown	blue grey black black brown
❑	2	470Ω	yellow violet brown brown	yellow violet black black brown
❑	8	220Ω	red red brown brown	red red black black brown
❑	1	150Ω	brown green brown brown	brown green black black brown
❑	4	100Ω	brown black brown brown	brown black black black brown
❑	1	1Ω	brown black gold gold	brown black black silver brown
❑	4	0.22Ω 5W	not applicable	not applicable

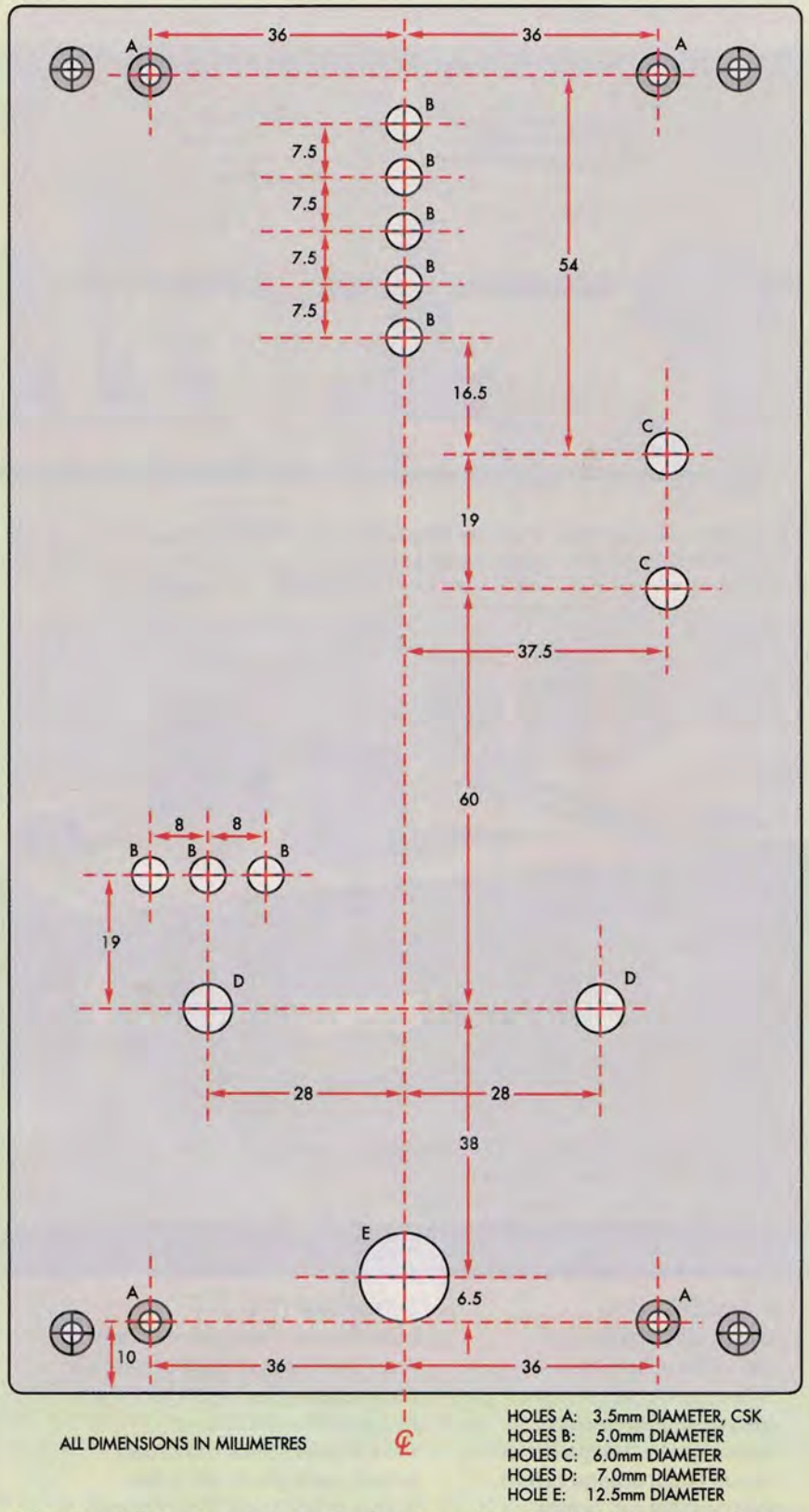


Fig.5: the drilling template for the front panel (ie, the lid of the case). Drill small pilot holes first & use a tapered reamer to make the larger holes.

their mounting nuts, lockwashers and stopwashers. That done, replace the stopwashers with their stop tabs passing down through the hole between the moulded "3" and "4" digits, and finally refit the lock washers and nuts to hold them down in this position.

The diodes can be fitted next, followed by FET Q1 and transistors Q2 & Q3, making sure you don't inadvertently swap them. Then fit regulator REG1 and MOSFETs Q4-Q7. These are all in TO-220 cases, with REG1 mounted flat against the PC board with its leads bent down by 90° about 6mm from its body. In contrast, the MOSFETs are all mounted vertically, with their leads pushed through the matching board holes as far as they'll go without strain.

The MOSFETs don't need any heatsinks as they are switched on too briefly for them to get hot.

Before soldering the leads of REG1, you should bolt its tab to the board using an M3 x 6mm machine screw and nut. This avoids stress on the soldered joints, as can occur if you bolt the tab down after soldering the leads.

The eight LEDs are mounted vertically above the board, with each LED's body about 23mm above the board so that it will just protrude through the lid after assembly. Note also that LEDs1-3 are orientated with their cathode lead "flat" sides towards the top, whereas LEDs4-8 are orientated with the "flats" towards the right.

Finally, plug the five ICs into their respective sockets, making sure you install each one with the correct orientation (see Fig.3). Notice that IC1 and IC2 have their notch ends towards the left, while IC3-IC5 have their notch ends towards the right.

With the PC board finished, you need to drill the box lid. Fig.5 shows the size and location of the holes. After the holes are drilled, attach the front panel using the full-sized artwork of Fig.6.

Next, fit pushbutton switch S1 to the 12.5mm hole near the bottom of the front panel, fastening it in place using the moulded nut that comes with it. Once it's in place, solder a 15-20mm length of tinned copper wire to each of its connection lugs, so that they are ready to make the connections to the PC board pads.

Now fit the two battery connection binding posts to the front panel, in the two 6mm holes on the upper right-hand side. The binding post with red mounting washers should go in the upper hole and the post with black mounting washers in the lower hole. Secure them in place with the nuts provided, tightening these to ensure that the binding posts don't become loose in the future.

Now take two 70mm lengths of 0.8mm diameter tinned copper wire and wind the centre section of each one around the "groove" at the rear

end of each binding post's mounting stud, before bending both ends down parallel with the stud's axis and finally twisting them together to form an extension, ready to pass through a matching hole in the PC board. Finally solder the loop in each extension to the binding post lug, to make a good connection between them.

The final step before attaching the PC board assembly to the rear of the front panel is to attach four M3 x 25mm tapped spacers to the rear of the front panel using four countersink head M3 screws (passing through the four 3mm countersunk holes marked "A" in Fig.5).

Now if you offer the PC board assembly up behind the front panel, you should be able to position it so that the bodies of the LEDs and the spindles of S2 and S3 all pass up through their matching holes in the panel. At the same time the wire extensions from S1 and the two binding posts should all pass down through their matching holes in the PC board, until the top of the board is resting on the four 25mm spacers. Then you can fasten both parts together using four M3 x 6mm machine screws, passing up through the board holes and threading into the spacers.

Once these screws are fitted and tightened, the complete assembly can then be up-ended and the extension wires from S1 and the binding posts soldered to their board pads. Fig.4 and the photos will clarify some of the foregoing assembly details.

Your Battery Condition Checker is now finished, apart from attaching the PC board/panel assembly to the box using the screws provided.

Using it

There are no internal setting up adjustments required, so you can use it immediately. First, set switch S3 to the nominal voltage (6V, 12V or 24V) and then set switch S2 to suit the battery's size/capacity. For larger car and truck batteries this will mean setting S2 for 40A, with the 25A position more appropriate for smaller car batteries and the 12A position for motorbike and SLA batteries.

Next, use a pair of clip leads to connect the unit to the battery. One of the LEDs associated with battery voltage switch S3 should immediately light, indicating that you have selected the correct range. Now briefly press Battery Check switch S1.



Fig.6: this full-size front-panel artwork can be photocopied and used direct or you can download a PDF of the artwork from the SILICON CHIP website.

If your battery is good, the blue and/or a green LED will immediately light and then fade as the lower LEDs light – this is the sampled voltage fading away. If your battery is only fair or worse, one of the other LEDs will light.

Basically, the blue or a green LED should light, indicating that your battery is fully up to scratch. If not, you might want to put the battery on charge again or connect it to our Battery Zapper, presented in the July 2009 issue.

What happens if only the "FAIL" LED lights or – even worse – none of the five condition LEDs lights at all? Well, this means that your battery is probably dead and ready for replacement. You might like to give it a few hours on the charger and the Zapper just to see if it can be rescued, before checking it again. There's nothing to lose by doing so but if you still get the same result afterwards, the battery is definitely due for replacement. SC

A Deluxe 3-channel Rolling Code Remot

This high-security 3-button UHF transmitter and receiver can be used for keyless entry into homes and commercial premises and for controlling garage doors and external lighting. Three separate outputs on the receiver can be used to activate various electrical devices such as a door strike, a motorised garage door and 230VAC lights. Up to 16 transmitters can be used with the one receiver so it's even suitable for a small business.

Maybe you have been thinking of building the low-cost UHF remote switch which was featured in the January 2009 issue of SILICON CHIP.

That was mainly intended as a cheap replacement for garage door controls and any application where security is not paramount – for example, when the garage does not have internal access to the home. This completely new design is for applications where you want high security and the ability to control more than one device.

For example, you may want to control a garage door (one or two) and your house lights to illuminate the driveway or entry. Or maybe you want to control the garage door, the driveway lights and have keyless entry into your home.

After all, you already have keyless entry into your car; why should you have to fumble with keys to open your front door? In fact, there are already commercial keyless entry systems for homes. Why shouldn't you have it too. . . and at lower cost?

Or how about this scenario? Say you have a 2-car garage in which the cars are tightly parked with not enough room for the passenger to get in before you drive out.

So you turn on the lights in the garage and outside, reverse your car out, the passenger gets in and you then use the 3-button transmitter to close the garage door, turn off the lights and you drive away. When you return, you can turn on all the lights, your passenger alights and you can drive into the garage; all very civilised and convenient. . .

And then you could also have keyless entry into the house itself!

Rolling code for high security

As with any type of lock, it is important that no one can gain access without the correct key.

For UHF remote control systems, the "key" is a specific code sent by the transmitter to the receiver. Usually, this code is a long sequence of on and off signals sent in a specific sequence and over a set period. The code must be correct in order for the receiver to allow access.

It's effective – but there's a problem. The coded signal is transmitted over a relatively wide area each time it is used to gain access. Intruders have, in the past, used a radio receiver and recorder to intercept the signal as the transmitter sends it. The intercepted signal could then be retransmitted to gain access.

Another method they've used is to continuously generate access codes with a computer and send them one after the other to the receiver. Eventually, the code is broken and access is possible.

Neither of these tampering methods will work with a "rolling code" or "code-hopping" system. In a rolling code system, the code transmitted is altered after each transmission.

So intercepting the signal and resending the signal will not enable access because the door lock is now expecting a different code. The code is based on an algorithm (calculation) that both the transmitter and receiver have in common.

Many cars now have rolling code keyless entry systems.

The code possibilities of a rolling code system usually run into the trillions. This renders any attempt to break the code totally unrealistic. The odds of picking a correct code at random for our rolling code transmitter, for example, is one in 2.8 trillion. Even then, the code needs to be sent correctly at the required data rate, with the correct start and stop bit codes and other transmission requirements.

As we said, rolling code is high security!

Features

Our UHF Rolling Code Security System has two parts: a keyfob-style transmitter and a separate receiver.

The keyfob has three pushbutton switches and an acknowledge LED that briefly lights up each time one of the switches is pressed. Up to 16 separate keyfob transmitters can be used with one receiver.

The receiver has three relays that can be switched independently using the three switches on the keyfob transmitter(s). Each relay can be set to toggle on or off, or remain energised for a set period. This can be adjusted from 0.26s to 4.4 minutes.

The relay outputs can switch up to 10A and 230VAC. For

UHF e Control

By JOHN CLARKE

Features

Transmitter

- Three function buttons
- Coding randomisation
- Rolling code UHF transmission
- Registering ability
- 16 identifications encoding
- 12V remote control battery operation
- Keyfob case
- Acknowledge LED indication

Receiver

- 12V DC plugpack operation
- For use with up to 16 separate transmitters
- 3 independent 230VAC rated relay contact outputs
- Door strike driver output
- Momentary or toggle operations for each output
- Momentary outputs adjustable in duration from 0.26 seconds to 4.4 minutes
- Acknowledge, power and output LED indicators
- Look-ahead feature for 100 codes when transmitter code is ahead of receiver code
- Lockout available for any registered transmitter
- Local control of outputs available





Specifications

Transmitter

Battery: ..... 12V 55mAH (A23 type)
Battery life: ..... >2.5 years expected with typical use
Standby current: ..... Typically 2.5µA with switches open (drawing 22mAH/ year from battery)
Code Transmit current: ..... 3mA average over 160ms (133nAH / transmission drawn from battery)
Register Transmit current:.. 3mA average over 2.75s
Randomisation current: 3.3mA
"Stuck switch" current: ..... 220µA (after transmission is ended if a switch is kept pressed)
Code transmission rate:..... 1.024ms/ bit (1k baud)
Encoding: ..... A high (or a 1 bit) is transmitted as a 512µs burst of 433MHz signal followed by 512µs of no transmission. A low (or 0 bit) is transmitted by a 512µs period of no transmission followed by a 512µs burst of 433MHz signal.
Rolling code: ..... Sends four start bits, an 8-bit identifier, the 48-bit code plus four stop bits. The start bits include a 16.4ms gap between the second start bit and the third start bit. Code scramble value is altered on each transmission.
Register code:..... Sent as two blocks. Block 1 sends four start bits, the 8-bit identifier, a 32-bit seed code and four stop bits. Block 2 sends four start bits, a 24-bit multiplier, the 8-bit increment and 8-bit scramble values, and four stop bits. The start bits include a 16.4ms gap between the second start bit and the third start bit.
Code randomisation: ..... Alters the multiplier values, the increment value, the scramble value and the seed code at a 40µs rate.
Transmission range: ..... 40m minimum

Receiver

Power: ..... 12VDC at 150mA. (If using an electric door strike up to 12VDC at 1A intermittent)
Standby current: .....14mA (168mW) with all relays off. 150mA (1.8W) with all 3-relays and indicator LEDs lit
Relay contact rating: .....10A @ 240VAC
Momentary period: ..... When set to momentary operation, each output is adjustable from 0.26s to 2s in 0.26s steps, then in 1s steps to 10s and in 15s steps to 4.4 minutes. See Table 2.

use with an electric door strike, the third output on the receiver can provide switched power directly rather than having to wire up through relay contacts and 12V power.

Facility to setup for momentary or toggle action for the three outputs is provided with three pushbutton switches, a small rotary switch and three trimpots.

Indicator LEDs are included for power indication, relay on or off and receive acknowledgement. The three pushbutton switches can also double up to function as local controls to switch the relays instead of using the UHF remote control.

Security & registration

Each keyfob transmitter must be allocated an identity number from 0 (zero) through to 15. This is set by coding links on the PC board. Then the initial rolling code needs to be randomised and the algorithm parameters set so that they are unique for each transmitter.

Finally, each transmitter is registered and this involves sending a synchronising code to the receiver from the transmitter when the receiver is set in its registration mode. As we said before, this can be done for 16 transmitters and each will operate independently with the receiver.

Also included is a facility to lock out a particular transmitter after it has been registered. This is useful if a transmitter has been lost and you do not wish it to be able to be used with the receiver. If the lost transmitter is found then it can be easily re-registered.

When the identity of the lost transmitter is not known, then all transmitters can be locked out and ones that are in use can be re-registered.

Another use for this lockout facility is where people hire a public hall for a function, are lent a keyfob transmitter to gain entry (via an electric lock) and turn off any alarm system. If the keyfob is not returned, it can be locked out to prevent future security breaches.

Transmitter circuit

Fig.1 shows the circuit for the 3-channel UHF Rolling Code Keyfob Transmitter. There is not a lot to the circuit with just a PIC16F88-I/P microcontroller (IC1), a 433MHz UHF transmitter module and 5V regulator (REG1) as the major parts.





The keyfob transmitter, shown above about life size, has three buttons, each of which control a relay in the receiver. At bottom left is a LED which briefly flashes when any button is pressed, telling you that the battery is still OK!
At right is an oversize view of the completed transmitter inside the open keyfob case. The green PC board is the 433MHZ UHF transmitter itself.

IC1 is normally kept in sleep mode with its internal oscillator stopped and most internal features switched off. In this state it draws a typical standby current of 0.6µA from the 5V supply (which in turn is derived from a miniature 12V battery).

Switches S1 to S3 and the jumper links LK1 and LK2 connect to the RB6, RB5, RB7, RB0 and RB4 inputs. Each input is normally held high by an internal pullup resistor to the 5V rail. A closed switch will bring the respective input low (0V). Similarly when LK1 is closed the RB0 input will be held low. RB4 is brought low only when LK2 is in and switch S3 is pressed. IC1 is programmed to wake up from its sleep condition when any one of the RB4 to RB7 inputs change in level or the RB0 input goes to 0V.

When IC1 wakes up it starts running its program. If RB0 is low, the routine to randomise the parameters is run. If RB4 is low, the registration codes are transmitted and if RB5, RB6 or RB7 are low, as when one of the keyfob buttons is pressed, it sends the normal rolling code.

The rolling code and registration codes are sent via the 433MHz transmitter module. This module is powered via the paralleled RA3 and RA4 outputs of IC1 which go high to provide a nominal 5V to the V_{CC} input of the module. The code signal is applied to the data input of the module from the RA2 output of IC1.

LED1 is driven via the RB3 output and is modulated at the code transmission rate of about 1kHz. The LED acts as a transmit indicator.

Inputs RA1, RA0, RA7 and RA6 inputs can be tied to 0V or to the 5V supply rail via links on the PC board. These select the identity of the transmitter. With all inputs connected to 0V, its identity is '0'. When all inputs are tied to 5V, the identity is '15'. Various combinations of high and low connections for these inputs select the other identities from 1 to 14.

When the selected software routine is completed, IC1 returns to sleep mode.

Firstly, if UHF transmission was involved, supply to the UHF transmitter module is removed by taking the RA3 and RA4 outputs and the data line at RA2 to 0V. LED1 is switched off with a low at RB3.

So IC1 returns to the sleep mode, when the RB0 and RB4 to RB7 inputs are high, with open links and switch connections.

Flea-power regulator

Putting the micro to sleep for most of the time is useful in keeping battery drain to the minimum but that still leaves the quiescent current of the regulator, because it needs to continuously provide 5V supply for IC1.

A standard low-power 78L05 regulator is out of the question as it typically draws 3mA quiescent current. Better still is the micropower LP2950 voltage regulator which has a 75µA quiescent current (typical).

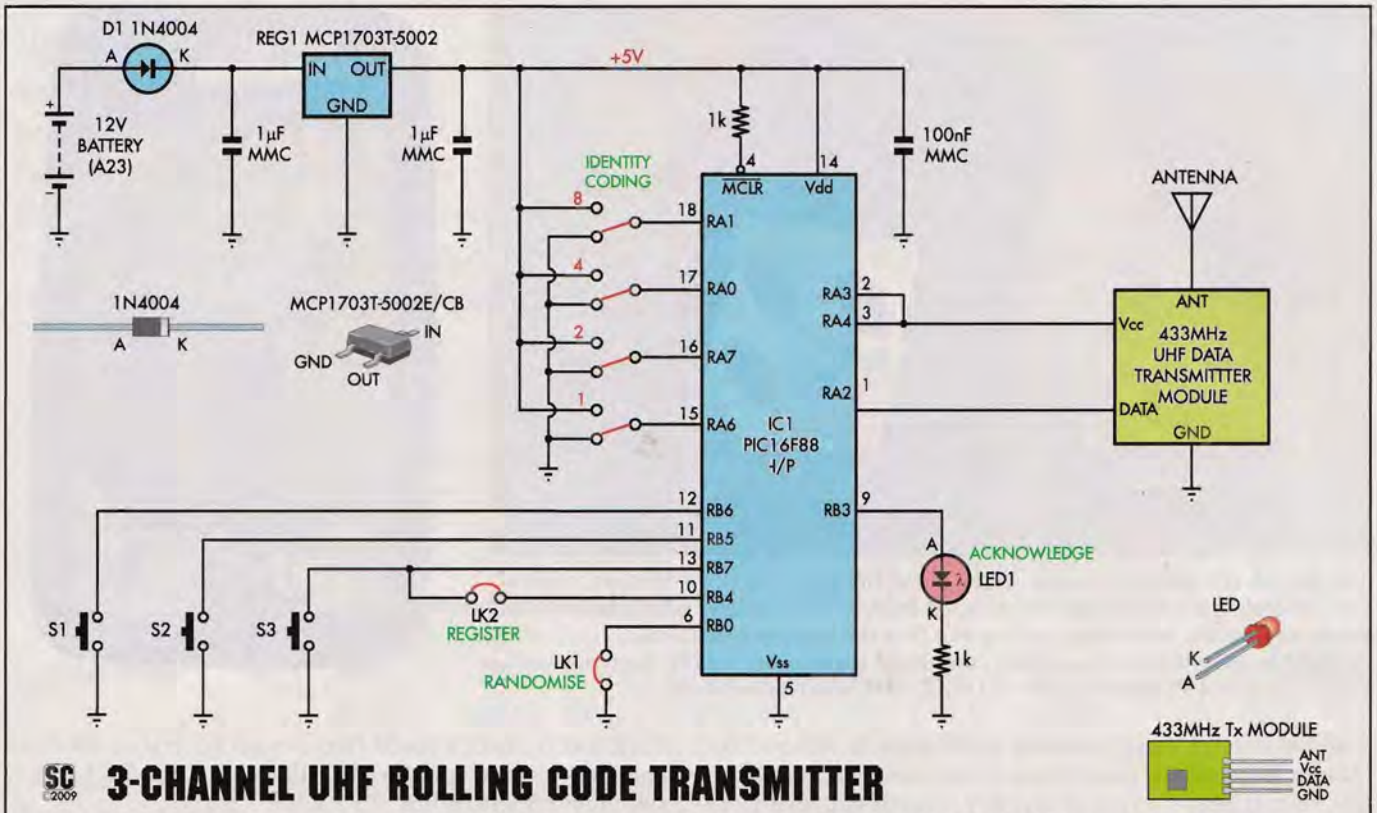
But even with 75µA quiescent current, the battery will be flat after only 733 hours or 30 days. The solution was to use Microchip Technology's MCP1703T-5002E/CB 3-terminal regulator which draws a mere 2µA. This regulator current, combined with the micro's quiescent current when it is asleep has the whole circuit drawing about 2.6µA.

We measured the standby current draw of our prototype circuit and found that it consumed 2.5µA of current from a fresh 12V battery. Measuring this current was easy. A 1kΩ resistor was temporarily placed in series with the battery supply and the voltage drop across this resistor was measured. As we measured 2.5mV, the current is then calculated as 2.5mV/1kΩ or 2.5µA.

During a transmission of a rolling code command, the current will briefly rise to about 3mA. If you hold one of the buttons down after the transmission is complete, the current will be about 220µA. This is due to current flow in the switch pullup resistor that connects from the 5V supply to 0V via the closed switch.

Battery life is expected to be more than 2.5 years, after which the 12V battery will have discharged down to 6V.

The transmitter circuit will continue to operate even at



SC 2009

3-CHANNEL UHF ROLLING CODE TRANSMITTER

Fig.1: the transmitter is based on a PIC16FBB-I/P chip and a commercial 433MHz UHF data transmitter. Don't substitute REG1 with a conventional 5V regulator – even the low-power devices will quickly flatten the battery.

this low voltage – and this takes into account the nominal 600mV drop across the reverse polarity protection diode D1. In fact, the regulator can operate down to 5.150V at its input and still maintain a 5V output.

The input and output of REG1 are decoupled with 1µF monolithic ceramic capacitors. The regulator is designed to be stable with between 1µF and 22µF of capacitance on its output.

The effective series resistance (ESR) of the capacitor can range from 0 to 2Ω and so ceramic, tantalum or electrolytic capacitors can be used. IC1's supply is also decoupled with a 100nF monolithic ceramic capacitor.

Receiver circuit

The receiver also uses a PIC16F88-I/P microcontroller (IC1) (see Fig.2). The UHF receiver module has a substantial on-board coiled wire antenna input to provide very good reception range.

When no signal is present, the receiver's output signal is random noise that is caused by the module's automatic gain control (AGC) being set at maximum. Upon reception of a 433MHz signal, the receiver gain is reduced for best reception without overload and the coded signal from the data output of the module is applied to the RA2 input of IC1.

LED4 indicates whenever a valid signal is received.

The RA4, RA6 & RA1 outputs of IC1 each drive a transistor and relay. When RA4 goes high, it turns on transistor Q1, which pulls in RELAY1 and LED1 lights up. Diode D1 clips spike voltages at the collector of Q1 when the relay switches off. The relay contacts are rated at 10A and 240VAC and can be used to control 230VAC lights if required.

Relay operation can be either momentary or toggle. Toggle operation means that the relay switches on with one press of switch S1 on the transmitter keyfob and switches off when S1 is pressed again. Momentary operation has the relay switch on for a short preset period of time.

For RELAY1, the momentary period is set using the trimpot VR1. The trimpot wiper can be adjusted from 0V through to 5V and this voltage is monitored at the AN3 input of IC1 to give the actual period which ranges from 0.26 seconds to 4 minutes 24 seconds.

The other two relays operate in a similar manner with LED2 and LED3 indicating when they are on. Similarly, VR2 and VR3 set the momentary periods for RELAY2 and RELAY3.

Note that transistor Q3, used to switch RELAY3 is a power Darlington. This allows it to drive an electric door strike (which may require 800mA or so) as well as the relay.

Dual function switches

Switches S1, S2 and S3 have different functions, depending on whether link LK1 is in or out of circuit. When LK1 is out of circuit, the RA5 input is held high via a 33kΩ resistor to the 5V supply and switches S1, S2 and S3 then can be used to operate the relays directly. Hence, S1 operates RELAY1, S2 operates RELAY2 and so on.

Whether each relay operates in toggle or momentary mode depends on how it has been previously set.

When LK1 is placed in circuit, S1, S2 and S3 perform a different function. S1 does the lockout function, S2 sets toggle or momentary operation and S3 does keyfob registration.

BCD rotary switch

The on-board BCD rotary switch (S4) has 16 positions,

labelled 0-9 and A-F. This switch is only applicable to the lockout and momentary/toggle selections; it plays no part in the keyfob transmitter registration.

The BCD switch has four outputs that connect to the RB3, RB1, RB2 and RB0 inputs of IC1. They are normally held high via internal pullup resistors in IC1 unless an input is held low via a closed contact in the switch. When the BCD switch is set at 0, all four inputs are held high. Position 1 on the switch has the '1' output at RB3 pulled low. Position 16 (or F) sets all switch outputs at 0V.

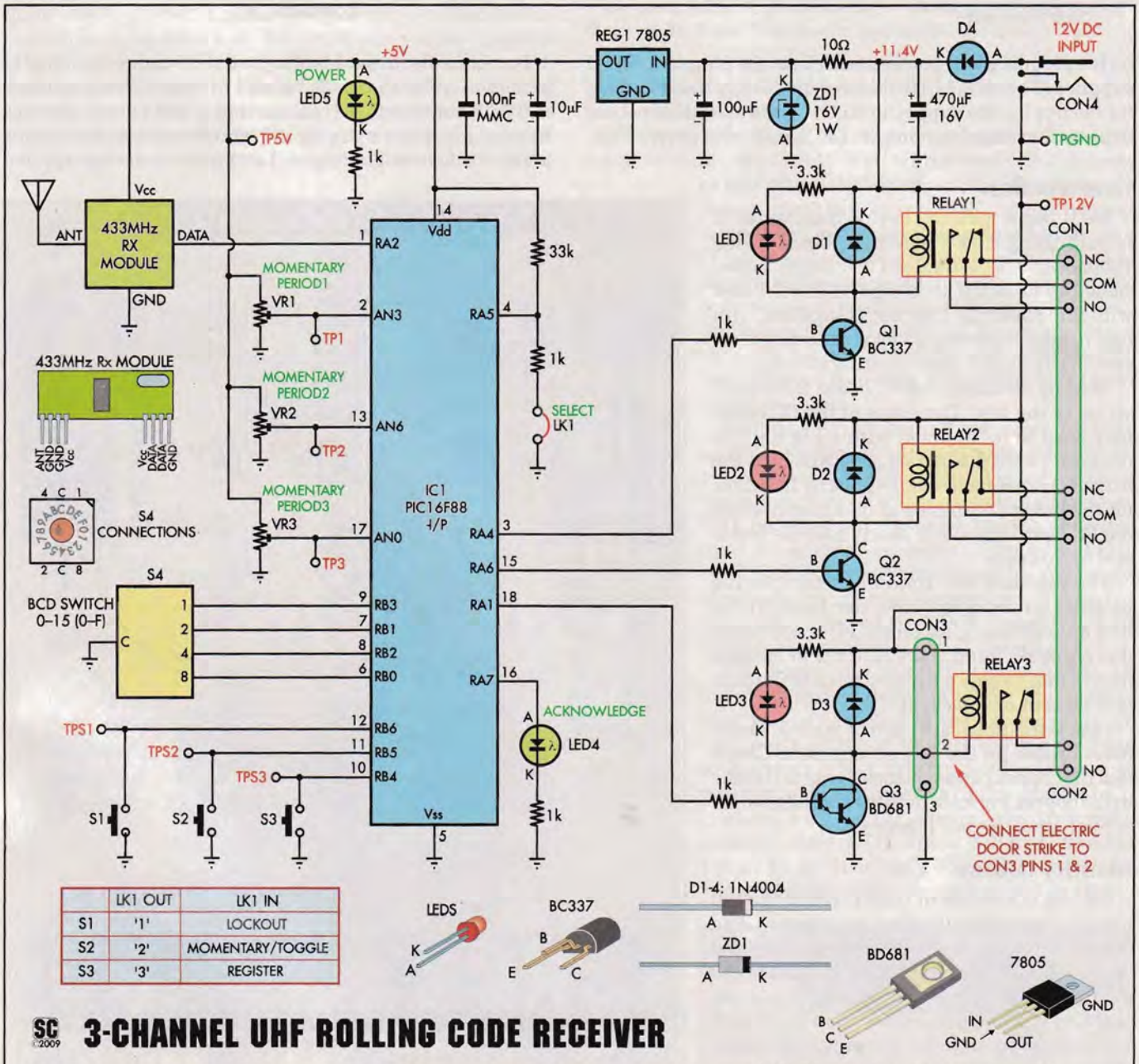
Also in the settings mode with LK1 in circuit, pressing S3 places the program in IC1 ready to accept the registration signal from a transmitter. S1 provides the lockout function.

Pressing S1 will prevent the transmitter from operating the receiver. The transmitter to be locked out is identified by the number selected with BCD1. Similarly for the momentary/ toggle function the position of BCD1 determines the output that will be changed from momentary to toggle or toggle to momentary when S2 is pressed. BCD1 position 1 changes output 1, position 2 changes output 2 and position 3 changes output 3.

Power

The circuit is powered by a 12V DC plugpack. Reverse-polarity protection is provided by diode D4 while the 7805 3-terminal 5V regulator, REG1, is protected against excessive input voltage by zener diode ZD1.

A nominal 12V rail supplies the three 12V relays. It is labelled as 11.4V on the circuit diagram (12V – 0.6V drop across D4) but the actual voltage could be higher depending



	LK1 OUT	LK1 IN
S1	'1'	LOCKOUT
S2	'2'	MOMENTARY/TOGGLE
S3	'3'	REGISTER

SC 2009 3-CHANNEL UHF ROLLING CODE RECEIVER

Fig.2: the receiver is not dissimilar to the transmitter, again based on the same PIC. The main difference is in the coding arrangement (S4) and the relays which can be used to switch just about anything, mains (up to 10A) or low voltage. If used to control a door strike, relay 3 isn't required – it can be switched directly via the Darlington (Q3).

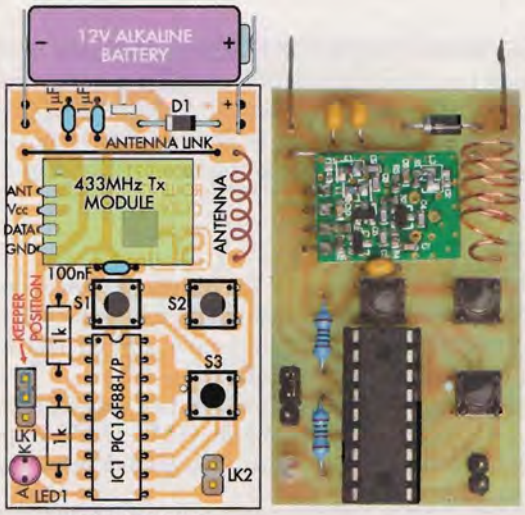
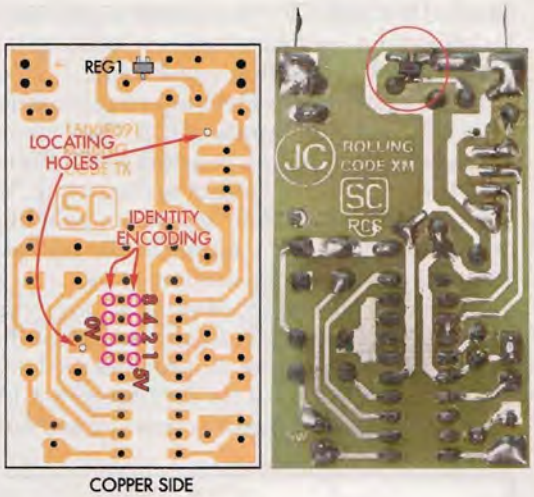


Fig.3 (left) shows the component side of the transmitter PC board. The UHF data module lies flat on the main PC boardwith its antenna, comprised of a short length of PC board track, a wire link and a wire coil.

At right (Fig.4) is the underside of the PC board, showing the identity coding links and the two locating holes. REG1, an SMD device, is also mounted on the copper side (highlighted in red).



on the plugpack and power drawn from the plugpack. REG1 supplies IC1 and the UHF receiver module. A 100µF capacitor decouples the supply to REG1 while a 10µF capacitor bypasses the regulator output. LED5 indicates power is on.

Construction

We'll begin with the keyfob transmitter. It is built using a 34 x 56mm PC board coded 15008091. The assembled PC board is designed to fit into a Teco type-11 keyfob case with three buttons. The case is supplied with two battery contacts, a key ring loop, three switch caps and a case securing screw.

Start by checking the PC board for correct sizing in the box. The edges of the PC board may need to be trimmed with a file if it has not been cut to the correct size. Note that the base of the case has a + and – polarity indicator for the battery terminals at its top end while the PC board should fit neatly into the lower end of this case.

The case has two 1mm-diameter locating protrusions moulded into the base. These line up with the holes on the PC board when it is correctly fitted. Take care not to damage them – don't apply excessive force or the pins will be bent or squashed.

Check the holes are correct with 1.25mm holes drilled for the battery terminals. Check that the copper pattern is intact with no breaks in the copper tracks or hairline shorts between copper areas. Repair if necessary.

Identity coding

On the underside of the PC board are the identity encoding linking selections. The default setting is set for identity 0 where the '8', '4', '2' and '1' connections are tied to the 0V track with narrow PC tracks. If you are building just one transmitter there is no need to change these settings; it is only when more than one transmitter is required to work with the receiver that each transmitter requires a different identity. To set a different identity, use table 1 as a guide to setting the linking.

For example, to set identity 1, the '1' connection has to be tied to 5V with the '2', '4' and '8' connections left tied to 0V. To connect the '1' connection to the 5V rail, the narrow track connecting to the 0V rail has to be broken with a hobby knife or engraving tool and a solder bridge applied

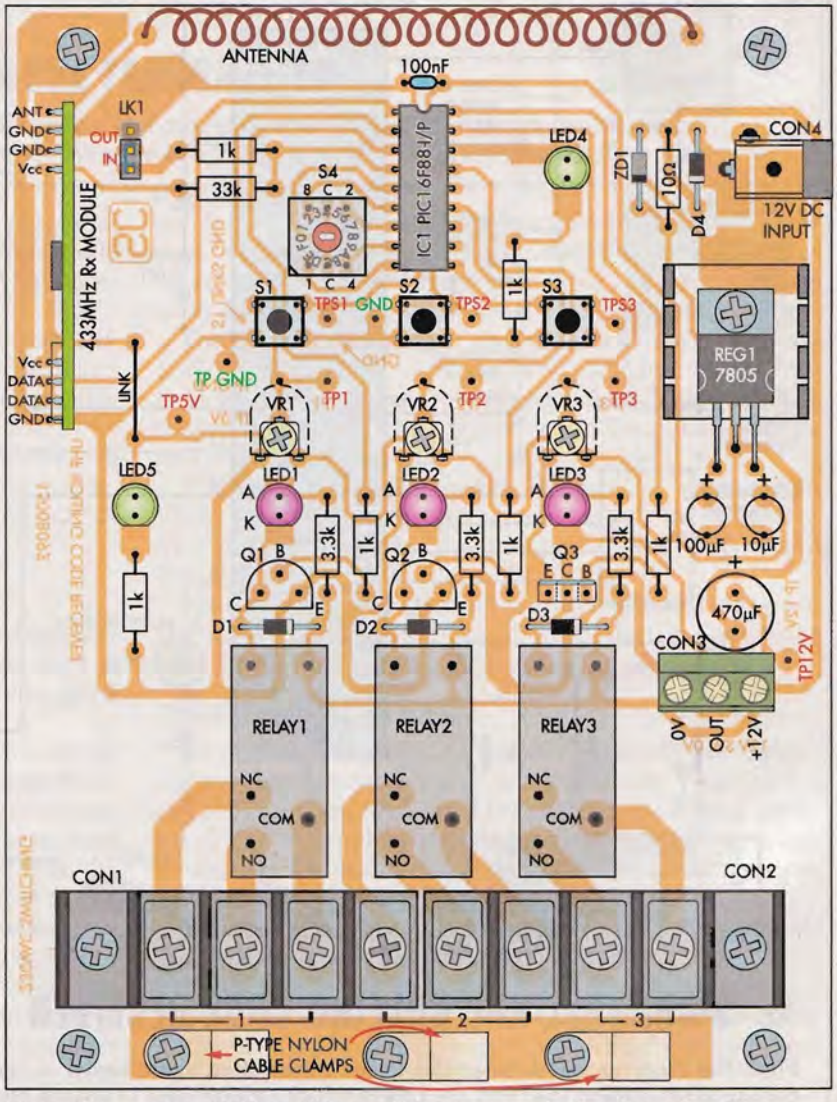


Fig.5: the receiver PC board. Everything is mounted on-board, with a similar coiled wire antenna at the top of the board.

between the terminal and the 5V rail track. Make sure the 0V and 5V supply are not shorted by connecting both these supply rails to the one connection.

Identities available are from identity 0 to identity 15. Identities 10 to 15 are the letters A to F respectively. We mention the A to F values because the lockout switch on the receiver is labelled with these hexadecimal numbers instead of decimal – to lockout a transmitter identity on the receiver you must match the switch setting with the identity value.

It is a good idea to write the actual identity of each transmitter on the rear of the keyfob case. This will make it easier to determine any lost transmitter identity so that it can be locked out.

REG1 mounts on the copper side of the PC board. This is a surface-mount device but it only has three leads, so is quite easy to solder in place. Position the device over the copper lands as shown on the underside overlay diagram (Fig.4) and solder just one of the leads to the PC board. Check the device is still located correctly before soldering the remaining pins. If you need to realign the device, it is much easier when only one pin is soldered! Use solder wick to help remove it – don't try prising it off while heating the pins as it is easy to damage either the pins or the copper lands underneath.



Con1 and Con2 are actually two 4-way barrier terminals, with one mounting hole cut off each end and the two halves glued together, as you can see here. Hot-melt glue holds them together while soldering and bolting in place (which takes most of the strain anyway). Note that these are actually panel-mounting types which we made fit – the right ones, with PC pins instead of solder tags, were out of stock at the time. You should use the PC-mounting type.

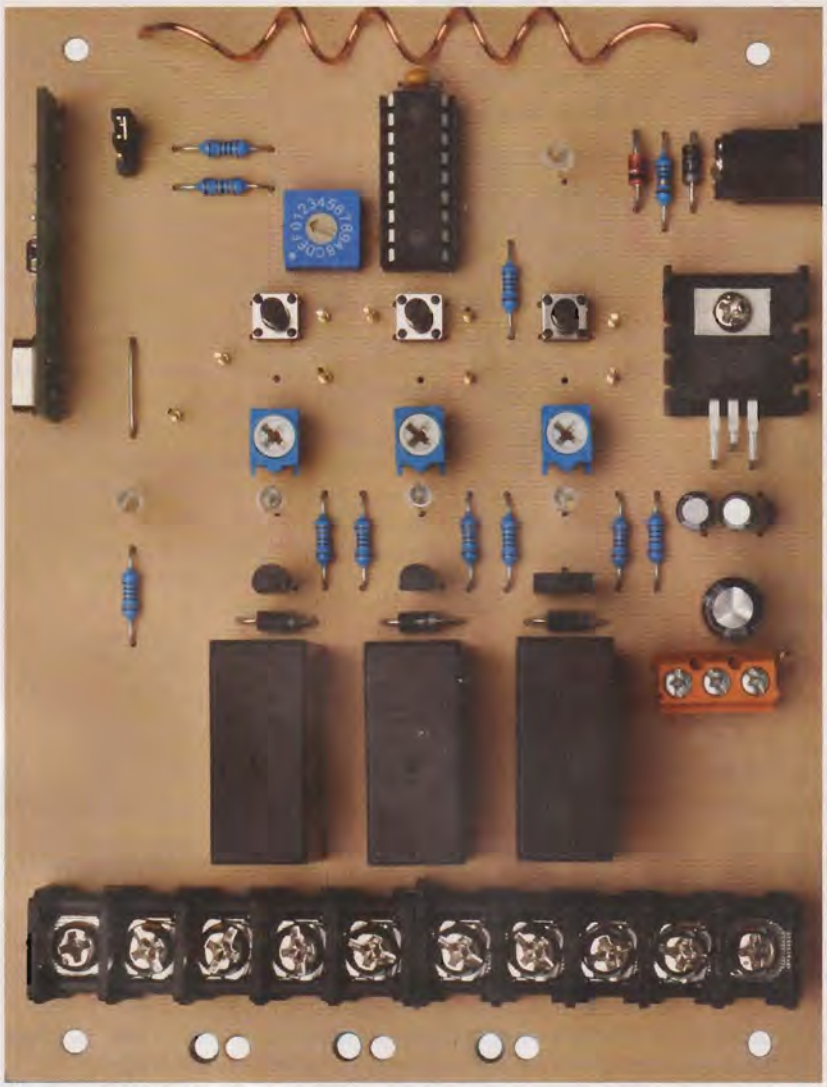
The topside of the PC board can now be assembled with the remaining components. Start with the wire link that acts as part of the UHF antenna. This is made from a 30mm length of 0.7mm tinned copper wire and is stretched as a straight wire between the two PC pads and soldered in position. We'll look at the remainder of the antenna (the coil) shortly.

Now insert the IC socket taking care to place the notched end toward S1 as shown. Make sure the socket is fully seated onto the PC board before soldering the pins. Don't insert the IC just yet.

Switches S1, S2 and S3 are mounted fully seated onto the PC board. When soldering, be sure the locator hole near to S3 is not soldered but is left clear of solder. Also install the two 1kΩ resistors and diode D1 (which of course must be oriented correctly). Similarly, LED1 must go in the right way around – so that its anode, the round edge/longer lead, is oriented toward the lower edge of the PC board. The LED mounts right down on the PC board.

The 2-way and 3-way pin headers can be mounted and soldered in place. The jumper plug can be installed in the keeper position. This position is just to store the jumper plug so that it is not lost. When placed in the keeper position, it does not make a connection for LK1.

There are two 1µF monolithic capacitors, mounted near REG1. These will be marked as 105 or 1µ on their body. The 100nF capacitor just above S1 will be marked as 104 or 100n.



Here's a matching photo to help get everything where it should be! In the receiver, the UHF module mounts at right angles to the board . . .



. . . as shown in this close-up photo. Make sure it goes in the right way around!

Parts List – Deluxe Rolling-Code UHF Remote Control

Transmitter

1 PC board coded 15008091, 34 x 56mm
1 keyfob case with 3-buttons (Teko type-11 No.11123.4) [supplied with battery contacts, key ring loop, 3-switch caps, LED diffuser and a securing screw]
1 433MHz UHF transmitter module (Jaycar ZW-3100 or equivalent)
1 12V alkaline remote control battery (Energizer A23 or equivalent)
1 DIP18 IC socket
3 SPST micro tactile switches vertical mount with 3.5mm actuator (S1-S3) (Jaycar SP-0602 or equivalent)
1 3-way 2.54mm spacing pin header
1 2-way 2.54mm spacing pin header
1 2.54mm jumper shunt
1 35mm length of 0.7mm tinned copper wire
1 138mm length of 0.63mm enamelled copper wire

Semiconductors

1 PIC16F88-I/P microcontroller programmed with 1500809A (IC1)
1 MCP1703T-5002E/CB (SOT-3 package) 5V regulator (REG1)
1 3mm green LED (LED1)
1 1N4004 1A diode (D1)

Capacitors

2 1µF monolithic ceramic
1 100nF monolithic ceramic

Resistors (0.25W 1%)

2 1kΩ

Receiver

1 PC board coded 15008092, 110 x 141mm
1 IP65 sealed polycarbonate box with clear lid 171 x 121 x 55mm
1 433MHz UHF receiver module (Jaycar ZW-3102 or equivalent)
1 0-F BCD rotary switch (BCD1) (Jaycar SR-1220, Altronics S 3000A or equivalent)
3 SPST micro tactile switches vertical mount with 6.0mm (or similar) actuator (S1-S3) (Jaycar SP-0603 or equivalent)
3 12V SPDT relays with 10A 240VAC contacts (RLY1-3) (Jaycar SY-4050, Altronics S 4170A or equivalent)
2 4-way PC mount terminal barriers with transparent cover and 9.5mm spacing (CON1) (Jaycar HM-3162 or equivalent)
1 3-way screw terminals with 5.08mm pin spacing (CON3)
1 3-way pin header with 2.54mm pin spacing
1 2.54mm jumper shunt
1 30mm length of 0.7mm tinned copper wire
1 157mm length of 1mm enamelled copper wire
3 P clamps for 5mm cable
3 Cable glands (3-6.5mm diameter cable)
1 18-pin DIL IC socket
1 mini heatsink 19 x 19 x 9.5mm
1 2.5mm PC mount DC socket (CON2)
10 PC stakes
2 M4 x 15mm screws
3 M4 x 10mm screws
5 M4 nuts
1 M3 x 10mm screw
4 M3 x 6mm screws
1 M3 nut
3 M4 washers
2 M3 washers

Semiconductors

1 PIC16F88-I/P programmed with 1500809B (IC1)
1 7805 5V regulator (REG1)
2 BC337 NPN transistors (Q1,Q2)
1 BD681 NPN Darlington transistor (Q3)
3 red 3mm LEDs (LED1-LED3)
2 green 3mm LEDs (LED4,LED5)
4 1N4004 1A diodes (D1-D4)
1 16V 1W zener diode (ZD1)

Capacitors

1 470µF 16V PC electrolytic
1 100µF 16VW PC electrolytic
1 10µF 16VW PC electrolytic
1 100nF monolithic ceramic

Resistors (0.25W 1%)

1 33kΩ 3 3.3kΩ 6 1kΩ 1 10Ω
3 10kΩ horizontal trim pots (coded 103) (VR1-VR3)

The 433MHz transmitter module mounts parallel with the PC board by bending the mounting pins down at right angles. Make sure the pins are bent in the correct direction so when installed the module has the antenna pin toward the top edge of the PC board. The module sits about 3mm above the PC board.

Battery clips are mounted with the dimples pointing inward to face each other. The larger dimpled clip is for the + end and this mates well with a dint in the battery + terminal.

The antenna is made up using the straight wire link soldered in earlier and a spiral section, made using a 138mm length of 0.63mm enamelled copper wire. The insulation on each end is scraped clean for about 1mm to allow the ends to be soldered in position. The wire is coiled by winding on about five turns on a 6.35mm (1/4") former – a drill bit is ideal. The coil winding should look something like our prototype (as shown in the photograph).

Before inserting the microcontroller, connect the battery and check that there is 5V between pins 5 and 14 on the IC1 socket. The voltage could range from 4.85V to 5.15V. Anything outside this means there is a problem. A 0V reading could mean the battery is in the wrong way or there is a short circuit across the 5V supply rail.

If it is correct, remove the battery and insert IC1, the notch on the IC matching the notch on the socket.

The quiescent current can be measured if a 1kΩ resistor is placed in series with the battery to one of the clips. This

is done by temporarily soldering one end of the resistor to the PC board at the + terminal. Connect your multimeter leads across the resistor and set the meter for reading millivolts. Then connect the "-" end of the battery to the minus terminal on the PC board and hold the unsoldered end of the resistor to the plus battery terminal. The voltage should be around 2.5mV to 3mV, representing 2.5µA to 3µA. The voltage will rise when one of the switches is pressed to about 3V but fall back to the quiescent value after the LED has flashed and the switch is released.

Receiver construction

The receiver uses a PC board coded 15008092, measuring 110 x 141mm. It is housed in a 171 x 121 x 55mm IP65 sealed polycarbonate box with clear lid.

As you did with the transmitter, check the PC board fits neatly into the box. The corner mounting holes should already be drilled out to accommodate M3 screws that are used to screw into the integral brass threads of the box. Holes for CON1 and CON2 are 2mm for the 4-way terminals and 4mm for the outside securing screws. The holes to secure the P-clamps are 4mm. Again, check the PC board for breaks in the copper tracks or for shorts between tracks and repair any faults, if necessary.

Begin assembly by installing the wire link and the resistors. The table below shows the resistor colour codes for each value but it's a good idea to also verify each value with a digital multimeter before soldering in position. PC stakes can go in next.

Install the diodes D1-D4 and ZD1 taking care to orient correctly. The IC socket can be installed again making sure the notched end is correctly oriented. S1-S3 can be installed now as well as the 3-way pin header for LK1. Install BCD1 ensuring the switch is oriented correctly, along with trimpots VR1 – VR3.

Transistors Q1 and Q2 are mounted with the orientation shown. Darlington transistor Q3 is not so immediately obvious: it is installed with its metal face towards LED3. Next install the four capacitors – the three electrolytic (polarised) types need to be oriented as shown. CON1, CON2, CON3 and CON4 can be installed.

Because barrier terminal strips only come in four and six-way (and we need seven-way!) we made our own by carefully cutting off the mounting holes from one end of two four-way types and gluing them together. Because they are soldered to the PC board and there is also a mounting point at each end, this should be more than adequate.

Before soldering in, the combined CON1 and CON2 block is secured to the PC board using two M4 x 15mm screws placed through the two outside holes and with two M4 nuts on the underside of the PC board.

We ended up using only one of the clear protective coverings – it adequately covers the eight live terminals while leaving the two mounting screws uncovered.

LEDs 1-5 are mounted about 15mm above the PC board.

Table 1: Transmitter Identity Coding

IDENTITY	'8'	'4'	'2'	'1'
0	0V	0V	0V	0V
1	0V	0V	0V	5V
2	0V	0V	5V	0V
3	0V	0V	5V	5V
4	0V	5V	0V	0V
5	0V	5V	0V	5V
6	0V	5V	5V	0V
7	0V	5V	5V	5V
8	5V	0V	0V	0V
9	5V	0V	0V	5V
10 (or A)	5V	0V	5V	0V
11 (or B)	5V	0V	5V	5V
12 (or C)	5V	5V	0V	0V
13 (or D)	5V	5V	0V	5V
14 (or E)	5V	5V	5V	0V
15 (or F)	5V	5V	5V	5V

The default setting is Identity 0 as set by narrow PC tracks that connect the '8, 4, 2 and 1' inputs to 0V. Other Identities are set by breaking the appropriate track that connects an input to 0V and soldering a bridge from the input to the 5V rail. For example to set Identity 1, break the 0V connection to the '1' terminal and solder to the 5V rail. For Identity 5, the '4' input would need to be tied to 5V as well as the '1' input.

with red LEDs used for LEDs 1-3 while LEDs 4-5 are green. Be sure to orient each correctly. The UHF receiver module can be installed next; again take care to orient correctly. The pin connections for the module are printed adjacent to each pin.

The three relays can be mounted now, followed by the 5V regulator. It mounts horizontal to the PC board on a small heatsink. The leads are bent down 90° to protrude through the holes in the PC board. Fasten the regulator and heatsink to the PC board (with an M3 x 10mm screw and nut) before soldering the leads in place underneath.

The antenna is made using 157mm of 1mm enamelled copper wire. The ends are stripped of enamel insulation for about 1mm using a sharp hobby knife to scrape it clean. Again, the wire is wound into a coil over a 6.35mm (1/4") former such as a drill bit. The coil is stretched out to reach the two connection points and soldered in position.

That completes the construction of the boards themseleves. Next month, we'll look at testing and setting them up to talk to each other and complete the project. We'll also look at some Frequently Asked Questions about rolling code and code scrambling.

Stay tuned!

SC

RESISTOR COLOUR CODES

No.	Value	4-Band Code (1%)	5-Band Code (1%)
1	33kΩ	orange orange orange brown	orange orange black red brown
3	3.3kΩ	orange orange red brown	orange orange black brown brown
8	1kΩ	brown black red brown	brown black black brown brown
1	10Ω	brown black black brown	brown black black gold brown

CAPACITOR CODES

Value	µF value	IEC Code	EIA Code
1µF	1µF	105	1u0
100nF	0.1uF	104	100n

CIRCUIT NOTEBOOK

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

Phase modulator vibrato for musical instruments

The term "vibrato" is often used mistakenly instead of "tremolo" which describes a regular variation in signal or loudness. Vibrato, on the other hand, is modulation of pitch or frequency

In this circuit, vibrato is achieved by using two cascaded phase shift networks. The two different phase shift networks are connected in parallel and are fed the same audio signal. The forward gains of the two networks are varied by two transconductance amplifiers which are controlled by a single low-frequency oscillator.

Following the transconductance amplifiers, the two separately phase-shifted signals are resistively mixed to obtain a vibrato output.

In essence, each phase shift stage is a low-pass filter with a different corner frequency, as marked. When signal has passed through the two paralleled phase shift networks, the two outputs are 90° out of phase. Dual op amps IC1, IC2 & IC3 provide the six phase shift stages. Op amp IC1a acts as a unity gain buffer. Its non-inverting input is connected to 0V via a 1MΩ resistor to provide a high impedance – important if an electric guitar is the signal source.

The two phase-shifted signals are applied to LM13700 transconductance amplifiers IC4a & IC4b. Their individual gains are controlled by the DC voltage fed to IC4's pins 1 & 16.

The slowly varying control voltage is generated by op amp IC1b which is configured as a low frequency sinewave oscillator. Its output at pin 7 is fed to a phase splitter stage comprising op amps IC2c & IC2d. IC2c is a unity gain inverter while IC2d is a unity gain non-inverting buffer. Hence the gain control signals applied to pins 1 & 16 of IC4 will be in anti-phase. Hence, IC4a will be at maximum gain when IC4b is at minimum and vice versa.

The net result of the common signal at the junction of the two 10kΩ resistors is that its amplitude is essentially constant while its phase is continually shifted back and forth over a 90° range. The overall gain of the entire circuit is unity.

The six phase-shift stages need to be calibrated one at a time and the easiest way to do this is with an oscilloscope connected in XY mode. For example, for IC2a, first connect your scope to the input and output of the phase shift stage and set your audio oscillator to 206Hz. You then adjust trimpot VR1 until a circle pattern appears on the scope screen.

You then do the same thing for IC3a at 1657Hz and so on until all stages have been adjusted.

Craig Sellen,
Carbondale,
Philadelphia, USA. ($65)

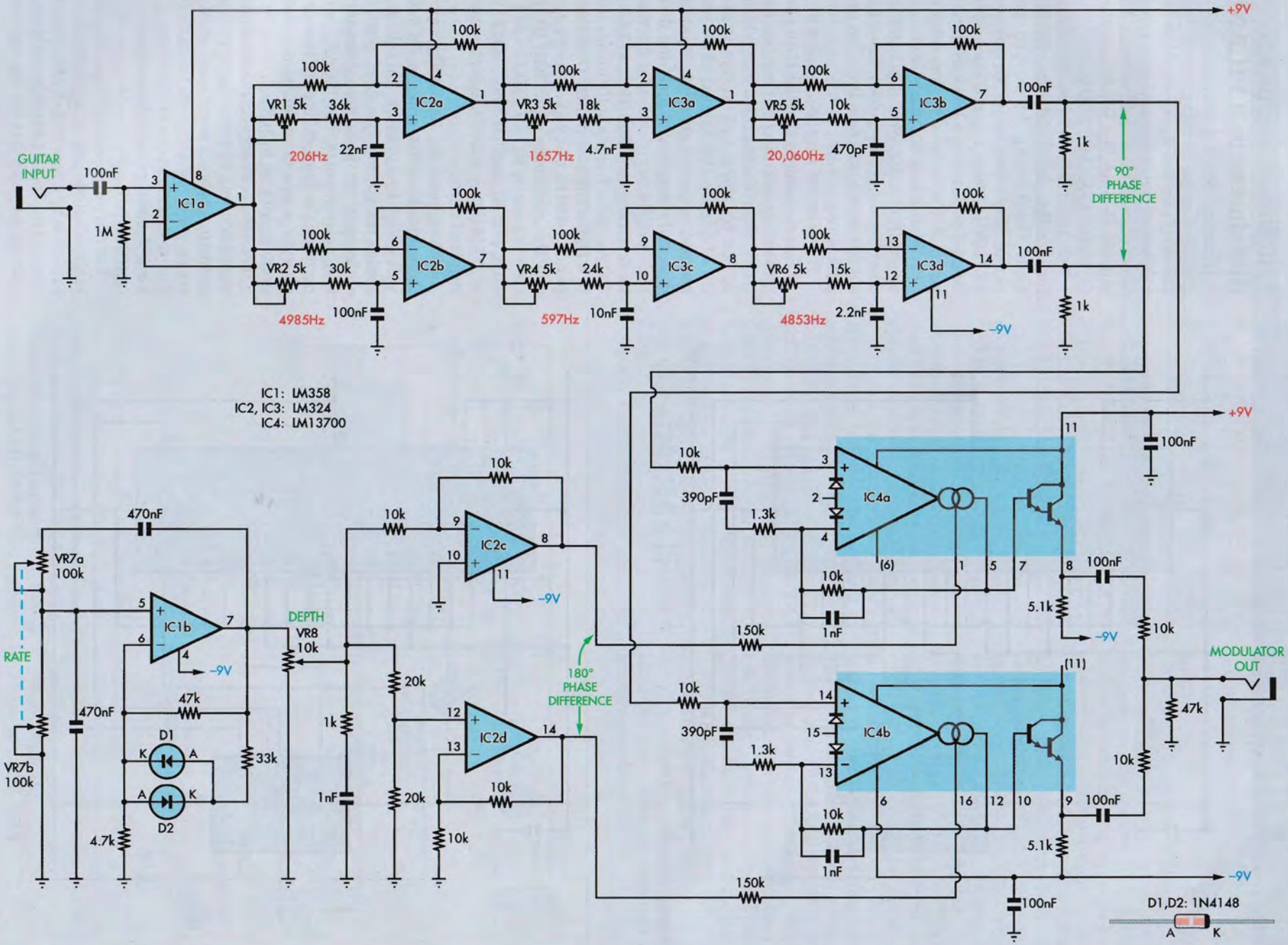
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+9V
GUITAR INPUT
100nF
1M
IC1a
100k
VR1 5k
36k
22nF
206Hz
IC2a
VR3 5k
18k
4.7nF
1657Hz
IC3a
VR5 5k
10k
470pF
20,060Hz
IC3b
1k
90° PHASE DIFFERENCE
VR2 5k
30k
100nF
4985Hz
IC2b
VR4 5k
24k
10nF
597Hz
IC3c
VR6 5k
15k
2.2nF
4853Hz
IC3d
-9V
IC1: LM358
IC2, IC3: LM324
IC4: LM13700
470nF
VR7a 100k
VR7b 100k
RATE
IC1b
47k
470nF
D1
D2
33k
4.7k
DEPTH VR8 10k
IC2c
IC2d
20k
1nF
180° PHASE DIFFERENCE
IC4a
IC4b
390pF
1.3k
150k
5.1k
MODULATOR OUT
D1,D2: 1N4148
A
K

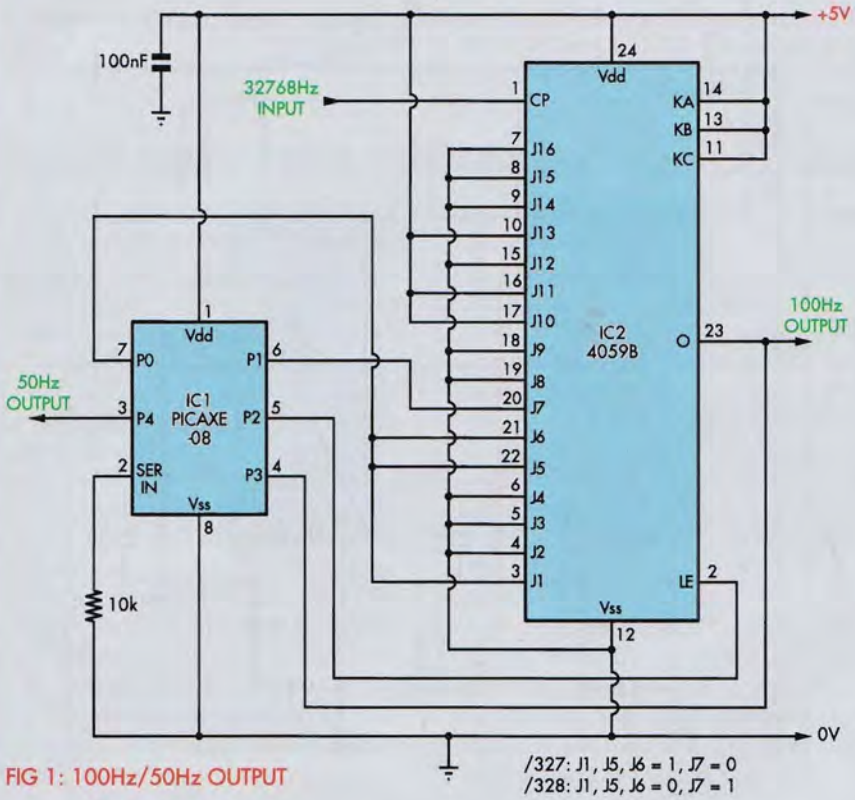


FIG 1: 100Hz/50Hz OUTPUT

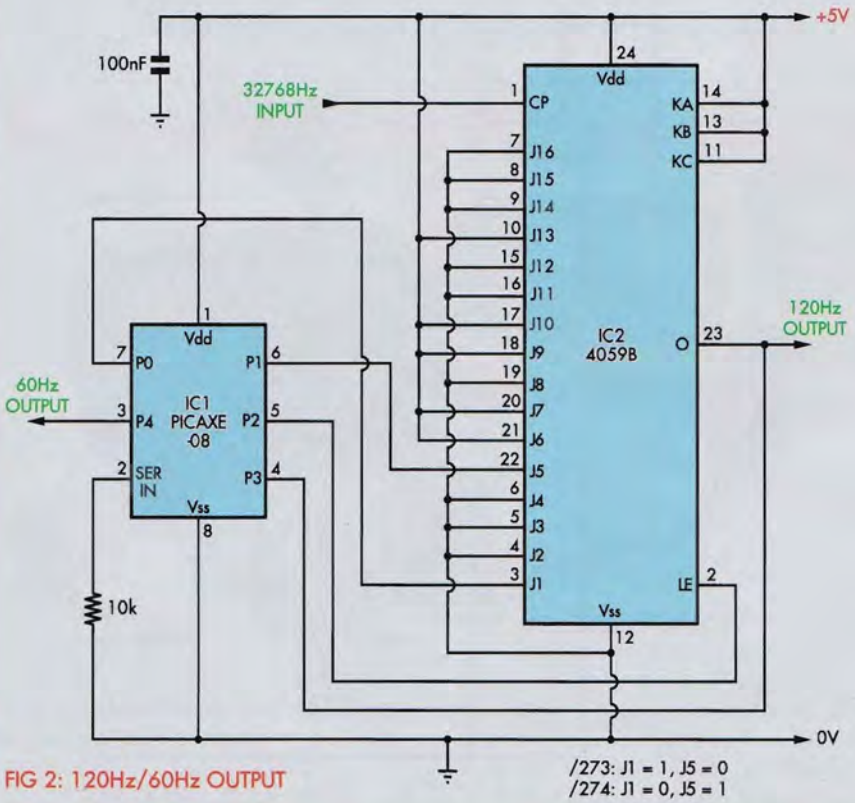


FIG 2: 120Hz/60Hz OUTPUT

Fractional frequency division with a PICAXE

Dividing down a frequency by a round number is easy; either off-the-shelf counter ICs or flipflops can achieve any ratio. Even oddball values like 37 can be implemented with presettable counters. But what if you want to divide down by a fraction?

This is not as far-fetched as it seems. Imagine that you have a line-synchronised timekeeping device that you would like to back up with a common 32.768kHz watch crystal. For a 50Hz device, performing a little arithmetic yields a fractional division ratio of 655.36 which is not achievable with a simple counter. And if you divide down by either 655 or 656, the resultant frequency will be a little fast or a little slow.

The solution involves using a PICAXE and a counter like the 4059 with presettable jam inputs. First, we calculate the required ratio by dividing 32,768 by 100 = 327.68 (the reason we divide by 100 instead of 50 will become apparent shortly). Now, by trial and error, figure out if the decimals can be expressed as a fraction. In this case, we find that 327.68 = $327^{17}/_{25}$, which essentially means that in a 25 period time frame, 17 of those periods will be divided down by 328, and the remaining eight will be divided down by 327.

Or put in another way: (328*17 + 327*8)/25 = 327.68, which is our required ratio.

In this circuit, the 4059 will perform the actual counting and the PICAXE will assist by counting periods and setting the appropriate jam inputs. In addition, since the output of the 4059 is a narrow pulse, the PICAXE will perform the final divide by two and provide a square wave with a duty cycle very close to 50%.

The 4059 is a very versatile programmable counter, however the steps necessary to set the different count modes are beyond the scope of this article. The instructions can be found at: **http://focus.ti.com/lit/ds/symlink/cd4059a.pdf**

For our purposes, suffice to say that in the ÷2 mode select, to preset a 4059 to divide by either 327 or 328, the setting in Jam Table 1 must be followed.

It can be seen that for the required

Jam Table 1

Jam In	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16
÷327	1	0	0	0	1	1	0	0	0	1	1	0	1	0	0	0
÷328	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0
Toggle?	Y	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N	N

Jam Table 2

Jam In	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16
÷ 273	1	0	0	0	0	1	1	0	1	1	0	0	1	0	0	0
÷ 274	0	0	0	0	1	1	1	0	1	1	0	0	1	0	0	0
Toggle?	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N

division ratios, only the jam inputs J1, J5, J6 & J7 toggle, while all others remain the same and may be hardwired to either +5V or 0V. Furthermore, of those four inputs, the first three have the same value and may be tied together and therefore, only two control lines are required. This allows a PICAXE 8M to handle the toggling requirements of these two bits.

The resultant schematic is shown in Fig.1. All the jam inputs are tied to +5V or 0V with the exception of the toggling inputs that are tied to PICAXE's OUT0 (P0) and OUT1 (P1) outputs. The divided output pulses from the counter are fed back to IN3, which interrupts the PICAXE in the low-to-high transition, and allows it to keep tabs of the proper counting periods.

Output OUT2 (P2) performs a vital function. Normally, the output pulses from the CD4059 are only one clock period wide, which means they are very narrow. Unfortunately, the PICAXE is not the quickest microcontroller around and it would not respond to an interrupt request fast enough and miss some pulses.

To prevent that situation, the PICAXE turns OUT2 (P2) high, which is used by the LE (latch enable) input to keep the output pulse latched high. It will remain in that state until the PICAXE acknowledges the interrupt and toggles OUT2 low, releasing the latch.

Finally, OUT4 (P4) produces a square wave output at 50Hz. The 100Hz output is also available, but the duty cycle is narrow.

Since this technique operates by speeding and slowing the counts, it will have a small amount of jitter. This is fine for timekeeping but may be a problem with some other applications.

If the desired frequency is 60Hz, we may follow the same approach described above and calculate the required ratio as $273^{1}/_{15}$. This means that in a 15-period time frame, 14 periods will divide by 273 and 1 by 274.

In other words: (273*14 + 274*1)/15 = 273.066666666666666667. In this case, the CD4059 must be preset as shown in Jam Table 2.

Only J1 and J5 toggle in this case. The resultant circuit is shown in Fig.2.

Finally, the PICAXE must be loaded with the correct software; ie, either *32kHz50Hz.bas* or *32kHz60Hz.bas* respectively. This can be downloaded from the SILICON CHIP website.

Fernando Garcia,
Brownsville, Texas USA.

Editor's note: the CD4059 may be obtained from www.futurlec.com or www.mouser.com

Fernando Garcia is this month's winner of a Peak Atlas Test Instrument

12V to 36V DC converter

Conventional solenoid valves used in agricultural irrigation systems typically operate from 24VAC. 12V DC is usually available from solar panels and batteries but this cannot supply the solenoids directly.

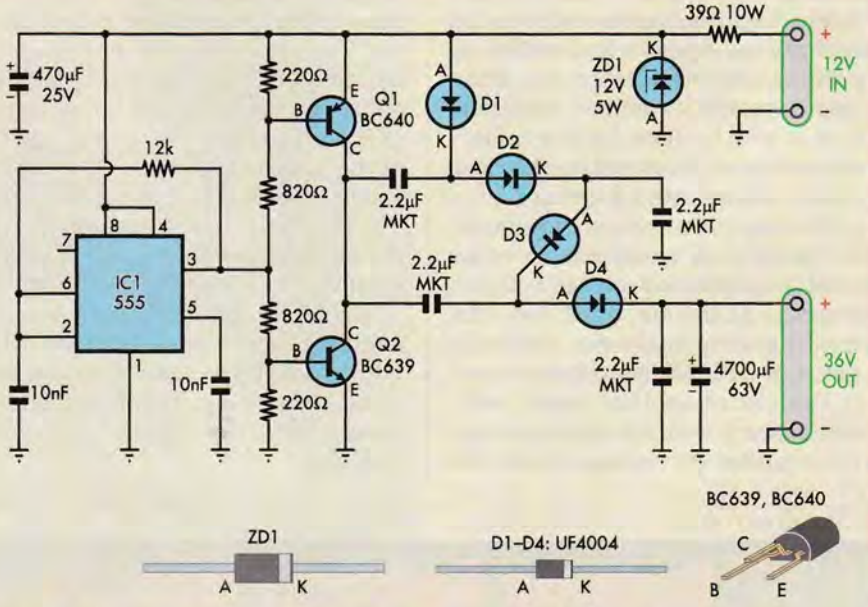
The solution is to use a DC-DC converter to boost the supply to about 36V DC. This will operate a 24VAC solenoid without problems.

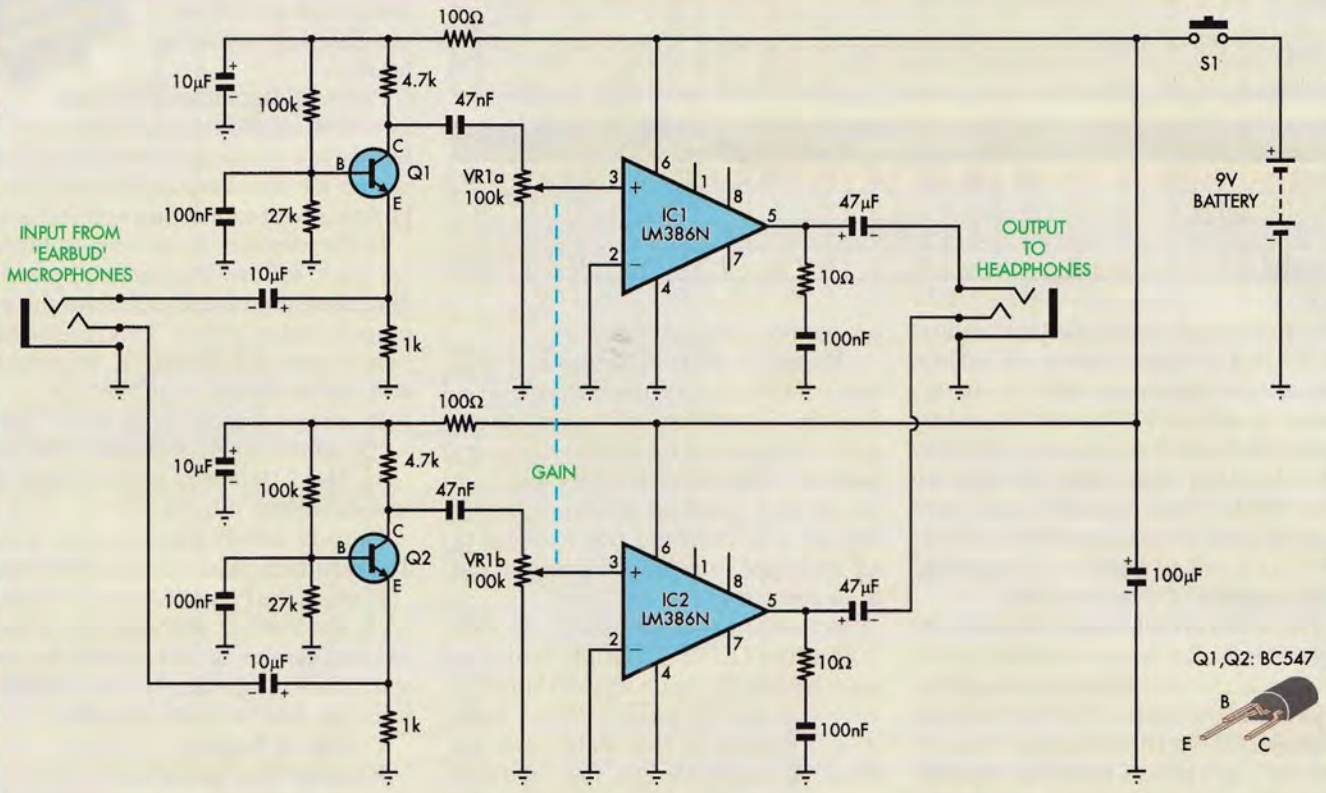
The circuit is based on a 555 timer (IC1) connected in astable mode to operate at about 5kHz. Its output at pin 3 is buffered by complementary transistors Q1 & Q2 which drive a voltage multiplier consisting of four fast recovery diodes (D1-D4) together with the associated 2.2µF capacitors. The DC output is stored in a 4700µF capacitor.

The energy to operate the selected solenoid comes from this capacitor and after it is discharged, the solenoid is held in by the current from the 39Ω 10W resistor which is fed via the four diodes (D1-D4). This resistor also provides current limiting for the associated 12V 5W zener diode which enables the circuit to be operated directly from a 12V solar panel without a battery.

The system takes about 30 seconds to recover after each solenoid operation.

Merv Thomas,
Mutarnee, Qld. ($45)





Stereo stethoscope for troubleshooting

This device was constructed to safely diagnose, isolate and identify odd noises, squeaks and rattles in rotating industrial machinery. It has also successfully helped find rodents in wall cavities, leaking underground water pipes and mechanical noises underneath a moving car.

The input transducers are nothing more than cheap earpieces as used for Walkman or MP3 music players. These are separated and rigidly secured to the machine with plasticine, BluTak or even duct tape.

The circuit itself is largely self-explanatory, with a single transistor preamplifier preceding an LM386 power amplifier in each channel.

Each preamplifier stage is unusual as it is a "grounded base" transistor circuit to match the very low impedance of the ear buds to the amplifiers. The gain of the preamplifier is determined by the ratio of the 4.7kΩ collector resistor to the impedance of the earpieces. The overall gain of the circuit is adjusted by a dual-ganged 100kΩ potentiometer (VR1). The coupling capacitors throughout the circuit have been kept small to limit the low-frequency response.

The circuit for the LM386 power amplifier stages is quite standard, with a Zobel network consisting of a 10Ω resistor and 100nF capacitor connected to the outputs to ensure stability.

It is important that the left channel directs its sound to the left ear and the right channel to the right ear, or confusing results will be obtained. It is also helpful if the headphones are tight close-fitting types, to filter out as much ambient noise as possible when testing.

With experience, the source of the noise can be identified very easily by arranging the ear buds in varied configurations, the eyes being drawn to the centre of the sound because of the "stereo" imaging effect.

A momentary pushbutton power switch is used to conserve battery power, as the device needs to be on for very short periods only.

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



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Vintage Radio



By RODNEY CHAMPNESS, VK3UG

The unnamed console – an orphan from the 1930s



Orphans have always been with us and that includes products with no identifiable manufacturer. This month, we take a look at a rather interesting 6-valve console receiver from the 1930s. It's a well-made set with no name but is one that any manufacturer would have been happy to claim.

THE ORPHAN RECEIVER described in this article is owned by Mark who restored it to full working condition with the help of fellow club member Marcus. Mark regularly browses secondhand and antique shops and he obtained this particular console a couple of years ago.

The job of tracing out the circuit fell to Marcus and some of the odd component values are those that were fitted when the set was obtained – see Fig.1. The purpose of some components has us mystified, while others have strange values so someone in the past had had a fiddle and got it very wrong. These errors have since all been corrected in the chassis, so the set now works quite well.

Circuit details

As shown in Fig.1, the first stage consists of a 58 valve (a 6U7G is identical electrically) which functions as a conventional RF amplifier. This then feeds an autodyne converter stage based on a 57 valve (6J7 equivalent) via a tuned circuit.

Autodyne frequency converters were used before good pentagrid and triode hexode type frequency converters came onto the scene. They can be critical to set up but a well-designed circuit will give few problems. As an aside, autodyne converters were also commonly used in solid-state receivers.

Following the converter stage, the signal is fed to the first IF transformer which is tuned to 175kHz and amplified in the following 58 valve. The amplified output from the 58 then goes through the next IF transformer and is detected using a 55. AGC is also generated in this stage and it is applied to the 55 and to the two preceding 58 valves. To me, this appears to be a significant mistake and the set would not work at all well if it were wired this way. That's certainly not the way the chassis is wired now.

After detection, the audio signal is

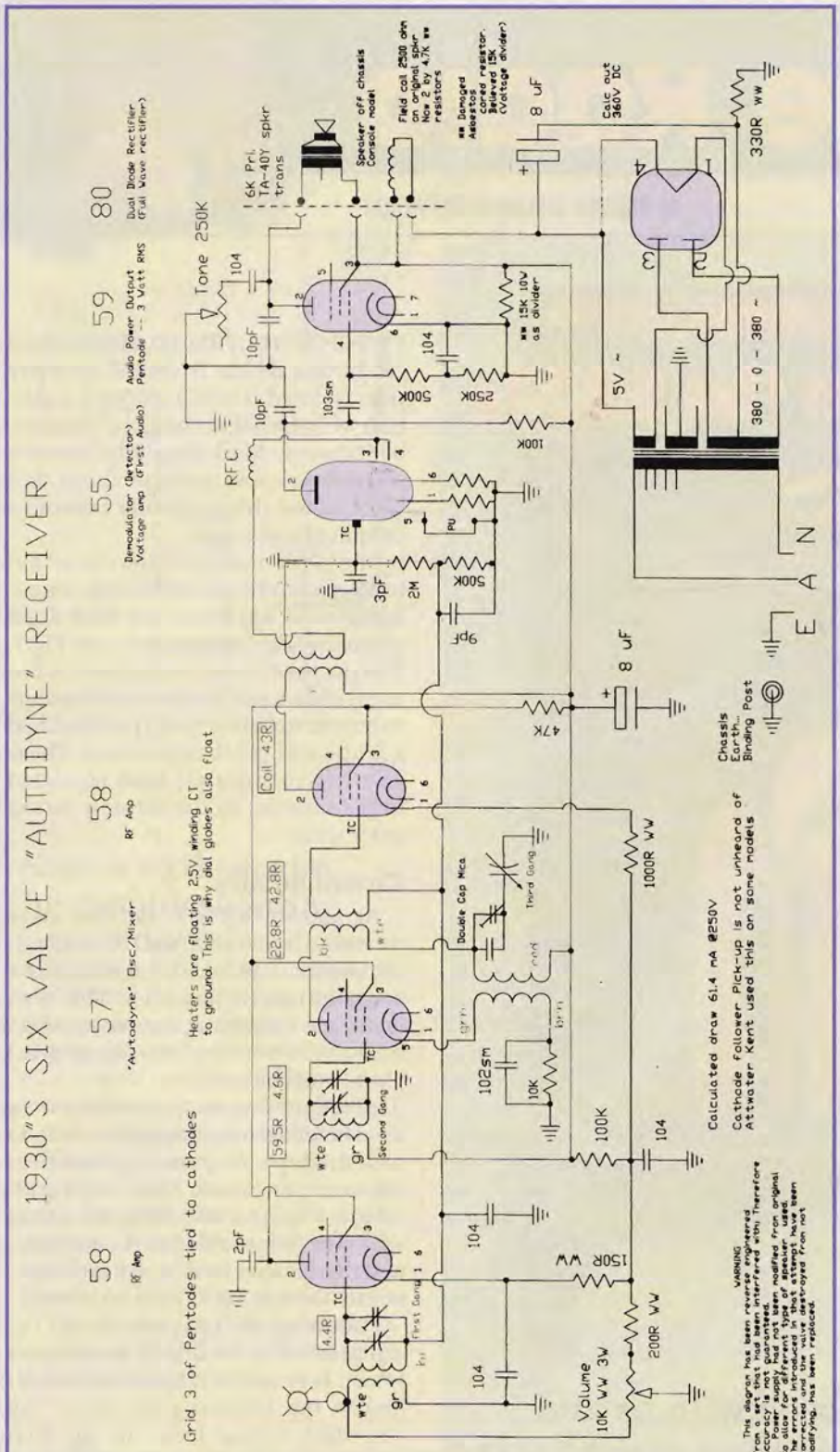


Fig.1: the circuit is a 6-valve superhet design with an autodyne converter (57) stage. The first stage (58) functions as an RF amplifier, while the second 58 functions as an IF amplifier. The 55 functions as the detector, the 59 is the audio output stage and the 80 is the rectifier.

applied to the triode section of the 55 and then fed to a 59 audio output stage. The 55 has only quite low amplification so the audio amplifier isn't the most sensitive in the world. The resulting audio output is fed through a speaker transformer to an 8-inch (200mm) speaker which is mounted on the substantial baffle board that forms part of the cabinet.

Other features of the circuit include a tone control which is wired between the plate of the 59 and earth, to provide a degree of high-frequency audio attenuation. In addition, the unit can be used to amplify the signal from a record player turntable. The 55 audio appears to be wired as a cathode-driven stage, with the grid supposedly grounded for audio signals. However, the circuit as drawn won't work, as the grid is not earthed for audio signals.

In practice, the chassis has since been modified so that it works as originally intended.

Power supply

The power supply is quite conventional, with an 80 used as a full-wave rectifier. Bias of around 20V is developed across the 330Ω resistor and this is fed to the grid of the 59 output valve.

Originally, the set had a 2500-ohm field coil following the first 8µF electrolytic capacitor but two parallel-wired 4.7kΩ resistors have replaced this. Following the resistors, another 8µF electrolytic capacitor completes the filtering of the power supply.

Cabinet restoration

The cabinet of the old console was in remarkably good condition and according to Mark, required very little to make it look almost like new. The controls on the front of the set are, from left to right: Tone, Tuning and Volume. However, like most sets of the era, it had no On-Off switch.

The speaker escutcheon is quite attractive and the dial, although only calibrated from 0-100, is quite easy to read and looks much better than the keyhole-sized dials used on many sets of the era.

The cabinet was first brushed out and then carefully cleaned using a damp cloth to remove any residual dust. A couple of joins in the cabinet were then re-glued but the rest was physically in good order.

Next, teak oil was applied to the outside of the cabinet using a soft cloth, while the inside of the cabinet was treated with linseed oil diluted with mineral turps. A fresh speaker cloth was then fitted as the original was in poor condition.

The end result is a cabinet that looks like new. Cabinet manufacturers, when console receivers were king of

the lounge room, really made some excellent pieces of furniture.

Cleaning the chassis

As can be imagined, the chassis was showing the ravages of time, with a number of minor rust patches showing through. A 15kΩ wirewound resistor had also been severely damaged and because it was covered with asbestos, it had to be dealt with safely.

Marcus used an industrial vacuum cleaner, gloves and a mask to clean the underside of the chassis and remove any asbestos fibres. Acetic acid (or cleaning vinegar) was then used to remove the small amount of rust on the chassis, after which the chassis was thoroughly cleaned using household kerosene and WD40.

It now looks quite good and a clean chassis is always much more pleasant to work on than a dirty one, especially when it comes to troubleshooting.

Circuit repairs

As obtained, the receiver wasn't in working order but that's hardly unusual (despite what the secondhand and antique shops sometimes claim).

One of the first things to do is to get hold of a circuit diagram if at all possible. Most domestic radio circuits from 1939-55 will be found in the Australian Official Radio Service Manuals (AORSM) but circuits for many earlier sets are not so easily found.

In this case, because the set was an orphan, it was not possible to find a circuit and so Marcus laboriously traced out the circuit as he found it. As indicated earlier, there were several mistakes in the circuit. Some may well have been there at the time of manufacture but others had obviously been introduced by a repairer many years ago. In fact, there were two serious mistakes which had caused some components to break down.

First, Marcus found that the original electromagnetic speaker had been replaced with a permanent-magnet "Amplion" speaker. There is nothing inherently wrong in changing the speaker type but in this case, the 2500-ohm speaker field coil resistance had not been taken into account and no resistance had been fitted to the HT line in place of the field coil.

The resistance of the field coil is indicated on the back of the chassis, so there was no excuse for a previous repairer to get it wrong. As a result, higher voltages were applied to various stages than the set had been designed for and this had caused the demise of the output valve and the 15kΩ asbestos-cored wirewound resistor mentioned above.



The parts on the top of the chassis are closely packed together, with the RF, converter and IF valves all fitted with metal shields. Despite its age, the chassis was still in good condition and cleaned up quite well.

Marcus replaced the 2500-ohm resistance of the field coil with two 4.7kΩ wire-wound resistors wired in parallel. Another wirewound resistor was used to replace the damaged 15kΩ asbestos-cored resistor.

Another problem was that the chassis-mounted electrolytic capacitors were missing. Dark discolourations on the chassis indicate that they may have disintegrated due to the errors made by the previous owner. The replacement 10µF 450V electrolytics are tiny in comparison with the original 8µF capacitors that would have been used.

In most sets, the switch-on voltage



The chassis sits on a shelf about half-way down the cabinet, while the speaker mounts on a baffle below it. The original electrodynamic speaker was defunct and was replaced with a more modern permanent-magnet unit.

at the output of the rectifier would rise to around 530V with a 2 x 380V HT secondary feeding the rectifier. In this case, however, this does not occur as the 15kΩ resistor loads the HT line sufficiently so that it does not rise above the 450V rating of the electrolytic capacitors.

Having replaced the electrolytics, Marcus then checked the carbon resistors. Most were out of tolerance and were replaced, as were all the paper capacitors. To keep the chassis looking authentic, the leads of these components were sleeved in fabric-style spaghetti similar to that used in the early 1930s.

Testing the power transformer

As a safety precaution, the power transformer was tested using a high-voltage insulation tester and found to be in good order. However, its leads were showing their age and so spaghetti sleeving was slid over them.

Even after 70 years, the varnish on the underside of the transformer looked like new but the top metal cover hadn't fared nearly as well and shows signs of corrosion. The original mains cord had also deteriorated and was replaced with a 3-core fabric-covered lead which was securely anchored to the chassis.

One potential problem was a mains socket on the rear of the chassis, presumably for a turntable motor. This had exposed (recessed) pins which presented a serious safety hazard. As a result, the mains leads to this socket were removed to render it inoperative and so it is now purely a cosmetic item to help maintain the original appearance.

Finally, the tone and volume controls were both faulty and were replaced with new items. Note that the volume control is a wirewound potentiometer which is wired into the cathode circuit of the RF and IF amplifier valves. One end of the potentiometer goes towards the valve cathodes, the other end is connected to the antenna terminal and the moving arm is connected to earth.

When the moving arm is at the 200Ω end of its travel, the volume is at maximum. Conversely, when the moving arm is at the other end of its travel, the antenna (and hence the incoming signal) is virtually shorted to earth. In addition, the self-bias on the RF and IF valves is increased significantly, which reduces their gain to quite a low level.

This type of volume control was quite common in the early to mid-1930s and is quite different to that used in later receivers.

Alignment

When power was initially applied, it was discovered that the 59 audio output valve was defunct, probably due to the previous owner's modifications. As soon as it was replaced, the set showed signs of life and the voltages were all nominally as expected. No overheating was evident and it was apparent that the restoration had been successful.

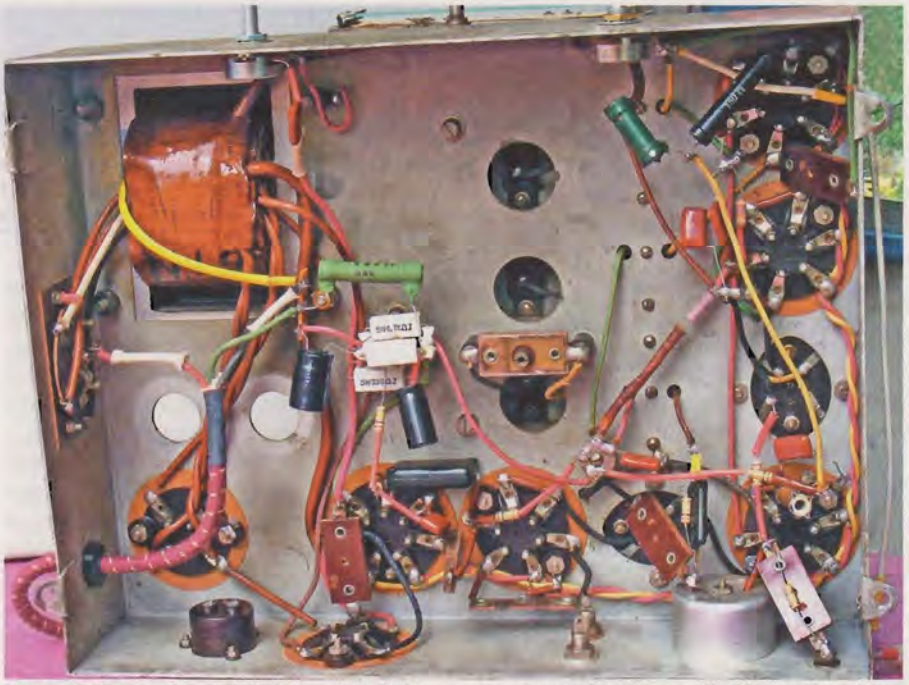
Having checked that the voltages were correct, it was time to align the receiver. I always start with the IF (intermediate frequency) amplifier but Marcus couldn't do that as this set has no tuning adjustments in the IF amplifier stage at all. Instead, it appears that the IF transformers were aligned during manufacture and then sealed.

This is rather strange as it means that if any components in the transformers drift in value with time, they cannot be re-aligned.

Marcus began the alignment by



This close up view shows the dial fitted to the receiver. There are no station markings. Instead, it's simply marked with a 0-100 scale.



Most of the carbon resistors and all the paper capacitors were faulty and had to be replaced, along with the electrolytic filter capacitors. The wiring to the mains output socket at bottom left was disconnected in the interests of safety.

connecting a signal generator to the grid of the 57 autodyne converter stage. By then sweeping the output frequency of the generator, he found that the maximum response occurred at between 175kHz and 180kHz, thus indicating the set's IF.

The next step was to tune the front-end. The tuning range of this receiver is from 550-1500kHz. The local commercial broadcast station at Wangaratta in North East Victoria is on 1566kHz but the tuning range of the set could not be adjusted so that this station could be received, although the set can tune 2AY on 1494kHz at Albury.

With the signal generator lightly coupled to the antenna and the gangs closed, the padder on the oscillator was adjusted so that the set tuned to 550kHz. Then, with the gangs fully open, the oscillator trimmer capacitor was adjusted so that 1500kHz was tuned. The tuning gangs were then closed again and the padder adjusted so that the receiver still tuned down to 550kHz before being opened again and the set retuned to 1500kHz at the top-end of the dial.

Finally, the set was turned to around 1400kHz and the trimmers on the RF and antenna sections of the 3-gang tuning capacitor peaked for best performance. The set was now performing quite well and had no trouble tuning numerous stations. In fact, it is better than many other sets in terms of selectivity – the local national 10kW station is just 8km away and appears only where it should on the dial, despite the high signal strength.

Summary

The circuit as traced out is not how the set was originally made. However, it gives a good indication of the set's basic configuration.

Personally, if I have any doubts about a circuit, I look at other circuits from the same era and alter the wiring if necessary. I also try to work out if the circuitry in doubt is original or if it's been modified by someone who didn't understand what they were doing.

In short, this is an interesting console from the early 1930s. It's quite an attractive set which performs well, so it's surprising that the manufacturer's name isn't on the set somewhere, as it is obviously a commercial product.

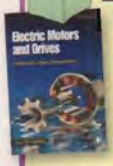
It's also surprising that the IF transformers have no adjustments. However, they appear to have kept their tuning over the 70 years or so since the set was manufactured.

Finally, we would like to be able to put a name to this set and discover its manufacturer. It has the figures "75-425" on the back of the chassis and Rickett and Thorp of Sydney made the cabinet. Can anyone help? SC



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Ignition system to suit bike

I need an ignition system to suit my bike. It has one pickup coil mounted at the crankshaft which I think is a Hall effect coil and it has only two wires going to it. The trigger plate is a half-moon shape and I think it triggers the IC igniter twice per revolution of the crankshaft.

The bike has two ignition coils firing four cylinders, so the igniter has to treat the coils as separate units to fire each one individually. The coils each have two plug leads so if cylinder number 2 is on the compression stroke, number 3 is on exhaust, so only number 2 is firing.

This system is a typical late-model 4-cylinder Japanese system for a motorbike. The trouble is I cannot adjust it because it is all sealed up. I need to build two of these systems as I have a race bike as well. (M. E., via email).

● If your bike uses a 12V battery for its original ignition, you could use the Programmable Ignition System described in the March, April and May 2007 issues. Two would be required, since you effectively have two ignition systems. The reluctor input version will operate on the magneto trigger.

If your bike does not use the battery for ignition but uses a high-voltage coil to generate power for a capacitor discharge unit, then you could use the replacement module featured in May 2008. Note that the trigger for your coil and magnet is most likely a magneto trigger and not a Hall effect sensor.

Oscillation problem in headphone amplifier

I have built four of your headphone amplifiers from the November 2005 issue, using Jaycar kits. These have all given excellent results but I would be interested in your comments on the following. While testing the latest of the amplifiers I happened to reduce the supply voltage and noticed that at about ±10V there was significant ringing on a 1kHz square-wave and then the amplifier broke into sustained oscillation at a slightly lower supply voltage.

This turned out to be due to using a 2kΩ resistor for R3 (and R6 in the other channel). Replacing the resistor with a shorting link completely removed the instability.

Retro testing of all the other amplifiers gave the same results. The 2kΩ value was used since the amplifier is connected via a 50kΩ volume pot and hence I followed your suggestion of trying to balance the input impedances. I realise the amplifier is designed to be used with ±15V regulated supplies and this is what I normally use. I have not seen any problems at this voltage.

However, given that the reduction in distortion through balancing is small (and probably inaudible) whereas the oscillation was very significant, is it not better to build the amplifier for unconditional stability rather than for a theoretical reduction in distortion?

I assume the above results are why

Quarter Second Pulser For GPS Clock

The GPS clock in the March issue looks like an interesting project but my clock seems to advance in quarter second intervals. Any chance of devising a simple circuit using a 555 timer say to deliver four pulses per second and still be kept in sync with the 1-second pulses from the project?

Another item I have been meaning to ask about concerns a distortionless AM demodulating process I read about in the 1960s. It was called the "synchrodyne". The process relied on mixing an unmodulated carrier wave of the same frequency as the RF carrier back into the AM RF signal.

Sum and difference beat frequencies would be produced and the key issue is that the difference frequencies are exactly the audio signal which can be separated out from the higher RF components with a simple LP filter.

The problem with such an approach back in the 1960s was to get the injected unmodulated carrier to be exactly the same frequency as the RF signal. This problem was a big stumbling block back then but these days, with readily available crystals and phase locked loops, it might be more practical. But I suppose with the advent of digital radio interest in AM is fading fast. Have you ever come across this type of AM detection?

● Regarding the GPS clock, it is not quite as simple as producing a four pulse/second circuit. We would also need to know the characteristics of the clock driver motor.

Even though digital radio is being introduced it will be many years before AM is phased out and it may not happen at all. The synchrodyne was an interesting technique but it was difficult to implement before modern ICs came along. However, it is probably true to say that an op amp configured as a precision rectifier was much simpler and gave lower distortion.

"Electronics Australia" produced a synchrodyne circuit in the June 1975 issue. EA also produced a high-quality AM tuner in four issues from December 1982 to March 1983. This design used an op amp precision rectifier.

Photocopies of "Electronics Australia" and ETI articles are available from Silicon Chip Publications for $A12 each including GST and P&P (Australia) or $A15.00 each including airmail outside Australia.

Severe Interference From Local AM Radio Station

It has been suggested that we write to see if you or any of your readers has the answer to a problem that is facing many residents in Perth suburbs which surround the ABC/6WF transmitting station in Hamersley and in particular, the suburbs of Balga, Westminster, Warwick and of course, Hamersley.

The ABC has a local radio/radio national/news radio transmitting station at the Hamersley site and the interference from the transmitting process has impacted on residents for many years, with ABC 6WF programs being heard in many non-mobile phones, answering machines, sound equipment and on AM radios, as well as interfering with internet access, etc.

It is also common for TV reception to be impacted upon with an angled moving grid pattern over ABC1 as well as unreliable digital TV reception on every channel except SBS, where the picture seems to break into blocks, and the sound goes on and off at most inconvenient times.

It would be appreciated if we can be given some practical advice in order to restore our sanity by having all these interferences resolved. (Alan Stafford, Balga Action Group Inc, Westminster, WA).

● Unfortunately there is no simple solution to the problems of AM radio breakthrough into electronic equipment in your community. You evidently have a very strong AM radio signal being radiated from a local transmitter tower.

However, a competent electronics technician or TV repairman, a TV antenna installer and a telephone technician should be able to remedy most problems between them. Some electronics businesses can provide all the services needed.

To begin with, audio and other electronic equipment should be connected to the 230VAC mains supply via filtered mains power boards which can be purchased from retailers such as Dick Smith Electronics, Jaycar & Altronics. Similarly, it should be possible to eliminate most interference to TV reception by the installation of suitable filters in the antenna leads – contact your local antenna installer or TV repairman.

Stopping breakthrough in telephones is more difficult but getting a telephone technician to install filter capacitors across the phone lines may help. This may also help with improved internet service but again, a competent technician needs to do the work so that the internet service is not compromised.

Unfortunately, none of the above will help the community at large. The interference problems can only be solved in each individual dwelling and will inevitably cost money.

Perhaps your group can liaise with a group of competent technicians in order to work out a common strategy for each household.

you stress that R3 and R6 MUST be 0Ω if the amplifier is fed with a low-impedance source. (D. A., via email).

● The OPA2134 op amp headphone circuits are designed to run on ±15V and with this supply, they do not oscillate with the specified resistance at the inverting input. Changing the conditions to ±10V would alter the operational amplifier's performance to the point that it may oscillate. Try connecting a capacitor of several picofarads between pin 2 and 3. This should fix the problem.

Flash trigger doesn't fire

I am building the Programmable Time Delay Flash Trigger (SILICON CHIP, February 2009) to delay the flash on a Canon camera but I cannot get any voltage reading out of CON3. The rest of the circuit seems to work fine. I can set delays and short the trigger input like you state in the testing section of the article. The LEDs switch from red to green and back again like they should but nothing comes out of CON3.

I find the circuit slightly too complex to follow exactly but I can still understand how the circuit functions. By looking at it, pin 3 of IC8 drives the base of Q1. But unfortunately, I can never get a voltage reading out from pin 3 of IC8 at any stage of the operation. Any ideas? I'm really confused now after trying to debug it for so long. (J. A., via email).

● You shouldn't be able to get any voltage reading from CON3 because no voltage is produced at this connector. The trigger circuit merely short-circuits this connector briefly to trigger your flash unit, instead of the usual shutter contacts.

So it sounds as if your unit is actually working correctly. You should be able to confirm this by connecting CON3 to the trigger socket of an electronic flash.

GPS module is very sensitive

Your article on the GPS Synchronised Clock in the March 2009 issue is cool but there is one catch. I live in a house with a tin roof and get no GPS signal inside the house.

I note there is a gold plug on the side of the GPS module and I assume that this is an antenna jack. Can I use any old length of wire or is there a special antenna I need to use? (C. A., Eleebana, NSW).

● You will be surprised how well that GPS module performs. It worked in our building which has a steel roof and we also tried it inside a steel filing cabinet and it worked. We admit that this is not a very scientific test but it does show the level of sensitivity that the chipset achieves.

The gold connector on the module is for an external antenna but you cannot just stick in a piece of wire. You will

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Exposure Times For Homemade PC Boards

On page 9 of the January 2009 issue of your magazine, there is an article from William Andrew, about UV Light boxes. In the last three paragraphs he mentions the exposure times for three different materials. The last material is 80 gsm paper but I am wondering why and how he is using paper and under what conditions.

Is he using the 80 gsm paper (whatever the 80 gsm actually means) to place between the photoresist board and the UV light source, to transfer the image to the board? Are you able to advise me on what he is doing with the 80 gsm paper?

On a completely different note, does SILICON CHIP know where I can obtain a digital panel meter, preferably LCD, that would measure from 0-30V DC and that uses a common ground for both the supply to the meter and the voltage being measured? (P. W., via email).

● William Andrew was indeed using 80 gsm paper. This is standard "bond" paper used in practically all "plain paper" photocopiers and printers. 80 gsm means that the paper weighs 80 grams per square metre but this is not important – simply use standard good-quality photocopier bond.

The PC board image is printed on the paper, preferably by a laser printer because they produce really good blacks, "back to front", so that when it is turned over with the image in intimate contact with the photo resist, the image comes out the right way. The technical term for this is right-reading, emulsion side down. UV light is shone through the paper so as to expose the photo resist underneath.

When working with "positive" photo resist, as with Kinsten emulsion, the blacks of the PC board image block the vast majority of the UV light, while the sections of the board exposed to UV light soften and can be developed away, leaving the PC board pattern on the copper, ready for etching.

Because the light must go through paper, the exposure times are significantly longer than if it only had to go through clear film, as William Andrew's times suggest.

We covered all of this, using Kinsten photoresist PC boards, in a step-by-step feature in March 2001.

Unfortunately, we do not know of an LCD panel meter which will meet your needs.

have to connect a proper active GPS antenna with an MMCX connector. There are quite a few to choose from; just Google for "GPS antenna MMCX".

A good example is SparkFun who also sell the GPS module. They have an antenna with a magnetic mount for US$15 (see **http://www.sparkfun.com**). This has an SMA connector so you will also need an MMCX to SMA interface cable for US$10. We have not tested any of these so you are on your own in that respect.

High pass filter for microphone preamp

I read the article on the "Microphone Preamp for PC & MP3 players" in the July 2008 issue and am wondering if at any stage a 100Hz high-pass filter with an 18dB/octave slope was considered, as that's what I'm looking for?

Most good mixers now have this function and the makers recommend that inputs using microphones should have the HP filter switched on. But my mixer doesn't. It's not only the handling noises but also the way my users talk; thud ,thud, thud. As there's plenty of room in your project box, I was hoping to add a 100Hz HP filter if I had the circuit. (B. S., via email).

● The microphone preamplifier does not have a 100Hz high pass filter as this would severely compromise the bass frequency response and the sound quality of the signal.

You could add high-pass filtering by reducing the two 22µF NP input capacitors to 68nF (the marking on the capacitor will be coded as 683 or 68n). These can be MKT polyester types. However, we think you will find that the microphone will sound very tiny with the 100Hz filter. A 220nF (224 or 220n) capacitor may give better results by rolling off at about 32Hz.

Using a better quality microphone will improve the handling and pop noises. Most good-quality microphones exhibit negligible handling and pop noises and do not require the savage 100Hz high-pass filtering you suggest.

Query on School Zone Speed Alert

I am writing in relation to the article "School Zone Speed Alert" (SILICON CHIP, April 2009). On page 37 under the heading "What It Does" it quotes the times during which the "School Zone" is effective as being 08:00 to 09:30 and 14:30 to 16:00.

This may be correct for some states but not all. The article seems to imply that these times are common throughout Australia. However, in the ACT, school zones operate ALL DAY. I live in Queanbeyan and have on occasion either worked in the ACT or had to cross the border to go shopping and from memory believe that their school zones operate from 08:00 to 16:00 with NO gap between 09:30 and 14:30.

Would the existing program handle this or would it need to be reprogrammed with a location (ie, state or territory in which it will be used), possibly based on a variant of the state's STD code, keeping in mind, for example, that the ACT and NSW share the 02 STD code and the same situation may also exist for Vic/Tas & SA/NT? An alternative code might be to simply assign 0 to ACT, 1 to NSW, 2 to Qld, etc.

● The School Zone Speed Alert is able to cope with a single 8-hour school zone simply by setting the start and finish times for one of the two zones provided to the appropriate times – say 08:00 and 16:00. The other time zone could be ignored (ie, left at its default settings) or could be set to the same start and finish times if you wish.

Another option would be to set the "AM" zone start and finish to 08:00 and 12:00, and the "PM" zone start and finish to 12:00 and 16:00 – so the two zones are contiguous.

No reprogramming of the PIC's firmware is required.

Remote control translator wanted

Many people have remote controls that come with devices such as DVDR/PVR/VCRs. These remotes often also have the ability to control a TV set. However, people who have a brand of TV not supported by the remote control for their other equipment have only two alternatives: use two remote controls or use a universal remote control to replace both remote controls. I am hoping that you can design a third and more acceptable solution.

What I am imagining is a little infrared receiver box that sits on top of the TV and recognises the codes from the DVDR/PVR/VCR and converts it into a code that the TV recognises and sends a signal out via an IR LED placed in front of the TV IR sensor.

In other words, it is a learning universal remote control that is slightly different to the usual universal remote controls – it learns two sets of codes. Code A is the code it is listens for and when it receives code A, it transmits code B. So we might call it an IR translator!

An extra feature that might be nice is the ability for it to see the power-on signal for one device and to transmit the power-on signal for multiple devices so you can turn on all your equipment with one button. (S. W., via email).

● Thanks for your suggestion. However, such a device would require a lot of software design and making it compatible with every device on the market is a huge requirement. We know from our previous work on remote control extenders that compatibility between brands is a big problem.

Nor is it practical to have it mounted on top of the TV or equipment set-up since that is exactly the worst place for it to be if it is to control equipment in the same pile. Nor do we like the necessity of an external IR LED to transmit the codes. Ideally, the "translator" would go on top of the coffee table in front of viewing position (if you have a coffee table). That means that it would need to be battery operated.

Large hard disk for CDs

Can you tell me if the CD-ROM Playback Adapter (SILICON CHIP, November & December 2007) can be adapted to take a IDE ATA HDD of about 100GB and play CD tracks off it (as ripped by Windows media player from my CDs)? I would like to put one in my car, hooked up to my Sony car stereo AUX input. (A. S., via email).

● Unfortunately, the CD-ROM Adapter cannot be adapted to connect to a hard drive and play music from it, as you describe.

The main reason is that there is no onboard codec to decode the music files and produce an audio signal. Unlike hard drives, CD-ROM drives have an audio signal output and hence no onboard codec is required for these drives.

Clarification on crystal frequency

I am gearing up to build the GPS Synchronised Clock from in the March 2009 issue. Could you please confirm that the crystal X1 is 3.2768MHz rather than 32.768kHz? If not, where can I buy it? (D. B, Artarmon, NSW).

● The crystal is 32.768kHz, as specified several times in the article. You can use the crystal out of the clock module, since you will be discarding its driver PC board.

Notes & Errata

Multi-Function Active Filter, July 2009: the LK1 and LK2 labelling on the overlay diagram (Fig.8) should be reversed. On the circuit (Fig.7), the numbers for pins 5 & 6 of IC3b are shown reversed. Pin 5 should be the non-inverting input and pin 6 the inverting input.

In addition, the 10kΩ resistor shown as connecting from pin 3 of IC4 to ground should connect to V- instead. The PC board is correct and requires no changes.

Huge clock problem

I have built the "Mesmeriser" LED Digital Clock (SILICON CHIP, June 2005). The difference is that I made it very big; three feet in diameter! I soldered wires from the LED mounting holes to 10mm LEDs on the clock face. However, I made a few mistakes along the way and to get the solder out of the LED holes I drilled the holes out with a 1mm drill.

Would drilling out these holes remove the plating in the holes? Only half of the clock works and I think this might be the problem. What do you think? (D. D., Blenheim, NZ)

● Wow, that must be an eye-blasting clock! Drilling out the holes would certainly remove the through-hole plating. The solution is to solder the affected components on both sides of the board. SC

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