SILICON CHIP

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DECEMBER 2007

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SILICON CHIP

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Publisher's Letter

Electric cars are viable right now



Peter Seligman's articles on "How to Cut Your Greenhouse Emissions" in the July, August & September issues certainly stirred up some controversy. One good thing about that is that it clearly demonstrated that the simplistic solutions often bandied about in the popular press are not workable. Making large cuts to greenhouse gases is neither easy nor simple.

Much of the controversy stirred by Peter Seligman's articles revolved around his conclusion that electric cars were not a useful approach when most of the power stations are coal-fired, as they are in Australia. Quite a few people disagreed but went on to quote figures drawn from overseas sources where the power generation mix is quite different to here. Even so, there have been disagreements about the estimated efficiency of electric vehicles. A representative letter in that vein is included in the Mailbag pages this month.

For our part, we are very attracted to the concept of electric vehicles and do believe that a modern electric car employing similar technology to the much vaunted Tesla Roadster would be quite successful. In fact, we think such cars should be on Australia's roads in large numbers right now, in spite of the fact that they would ultimately draw their electricity from mostly coal-fired power stations. In any case, it is unlikely that any new power stations in Australia will be coal-fired. They are far more likely to be gas-fired since they are much more efficient and put out considerably less greenhouse gases for the electricity they generate. So with future Australian electricity supplies likely to be much cleaner, we should be planning for electric vehicles.

In the meantime, consider the potential advantages of electric vehicles if they were in Australia right now. In heavy traffic or on the open road, they generate no pollution at all. They would not contribute to Australia's growing import bill for oil and petrol. When stopped, they are silent, apart from the possibility of a ventilation fan running. And when driving along the road, there is virtually no noise at all, apart from that generated by the tyres, suspension and any wind noise. That is a pretty attractive proposition. More importantly, such a car would require virtually no regular maintenance and very few visits to the local garage for costly service – no oil changes or engine service – just check the tyres and the water level for the windscreen washers. Now that is attractive.

Sure, batteries are an expensive component in an electric vehicle's first cost but if NiMH or Lithium-ion batteries are used, they should last for many years. In fact, wear in the motor should be very low, so electric vehicles could be very long-lived.

Sadly, there are only a handful of electric cars on the road in Australia and to our knowledge, virtually all of these have been built by enthusiasts. In fact, the Australian Electric Vehicle Association (AEVA) had a recent field day in Sydney and a number of such vehicles were on display. But sadly too, they were all far shy of what can be achieved with technology presently available in Australia. For example, they all used lead-acid batteries and DC motors (not brushless) without regeneration. Significantly too, most of them would be dicey in a major collision and none had air-conditioning.

By contrast, it would be possible to put together a consortium of Australian suppliers right now, to manufacture a world-class electric vehicle with good performance and range, able to accommodate four people and their luggage and with full crash safety. I wonder if any of our local car manufacturers is actually working on such a project right now. I hope so.

Leo Simpson

MAILBAG



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

Solar effectiveness is regional

A number of readers have commented that I appear to have condemned electric cars in my article "How to Reduce Your Greenhouse Gas Emissions, Pt.3" (Silicon Chip, September 2007). Electric cars are quite advantageous in countries or regions where the electricity produced generates less than about 0.9kg of CO_2 per kWh. Victoria averages about 1.4kg/kWh and the Australian average is about 1.0kg/kWh.

In the USA, the average is about 0.7kg/kWh, so electric cars would be better there than petrol. For Australia at present, gas-powered cars may be the best option since, apart from being relatively low in CO_2 emissions, they reduce our dependency on foreign oil.

In the case of solar hot water heating, there are several factors which determine whether a booster is required and what sort of booster is appropriate. To give some examples: if you live in Victoria, with high CO_2 per kWh and your solar system supplies only 60% of the energy, then a gas booster is appropriate. In Tasmania, most of the electricity is hydro and so even though the solar fraction is lower, electricity produces the lowest greenhouse gas emissions.

If you live in the sunnier areas of Australia, where the solar fraction can be very high or 100%, again electricity may be the best. So essentially the decision is based on solar insolation (how sunny your location is), your usage level and the "dirtiness" of the electricity supply you would use to heat the water.

Peter Seligman,
Essendon, Vic.

Electric cars are cleaner than petrol

I would like to dispute Peter Seligman's conclusions in his article on "How to Cut Your Greenhouse Emissions" on page 20 of the September 2007 edition. Peter claims that a mains-recharged electric car generates more CO_2 than a petrol car. His conclusion is only true if petrol car efficiency is better than 20%. I contend that petrol car efficiency is closer to 12% rather than the 25% that Peter claims.

In justification, a typical small car uses 7 litres/100km at 90km/h on highway cycle and 8.5 litres/100km on city cycle. On highway cycle, this motor uses 1 litre of petrol (10kWh) to generate 1.7kWh at the wheels; ie, 17% efficiency. On a city cycle, because of frequent braking, its efficiency is much lower at around 5-10%. Assuming 60% city and 40% highway usage, the average petrol efficiency is 12% so it only generates an average of 1.2kWh/litre of petrol used.

Using Peter's CO_2 equivalence figures of 2.6kg/l for petrol and 1.35kg/kWh for mains-generated electricity, let us now compare the amount of CO_2 generated by a petrol car per litre used and by an electric car generating the equivalent power of 1.2kWh.

In a petrol car, one litre of petrol

Australia on the right wavelength with digital radio

I wish to comment on the letter concerning DAB+ in the September 2007 issue of Silicon Chip. It's a shame a letter writer has attacked Australia's plans for digital radio without the facts and without being prepared to put their name to their opinion.

Commercial radio broadcasters have every confidence that Australia can successfully lead the way with digital radio. We have a long history of innovation that has seen radio adapt and flourish over the years despite the advent of technologies such as TV, CD players and the internet. The development of portable and in-car listening, the introduction of top 40 music formats, talkback radio, pioneering live news and sports reports from the scene, interactivity, streaming online and radio podcasts are examples of the way radio has continually evolved both its content and distribution over the years. Digital radio is the next step.

The decision to go with DAB+ was not driven by "bureaucracy" but by radio stations who understand what listeners want. DAB+ technology allows us to offer exciting new features and a multitude of content that just isn't possible with AM and FM.

We should be proud that Australia was the first country in the world to switch on a high power DAB+ test - but we are far from alone. Trials have been conducted in Italy, Czech Republic and France, while many other countries including Canada, Hungary, Israel, Kuwait, Malaysia, Malta, New Zealand and China are making preparations for trials and launches. DAB+ is our opportunity to move the industry forward and those who don't embrace this change will most likely be left behind. If our anonymous critic would like to come out from behind the cloak of anonymity then we can make sure he or she is acquainted with the facts of digital radio, both here and globally, and will thus be equipped to make, in the future, an informed comment.

Joan Warner,
Chief Executive Officer,
Commercial Radio Australia.

Updated Prawnlight

I thought you might be interested in my adaptation of the Prawnlight featured in the January 2005 issue.

This was one of those projects that I was going to do when a trip to the coast was looming. By the time that happened, Oatley Electronics were out of stock of the kit so I found an alternative. Fortunately, newer bright LEDs have become available and by using a cut-down trailer tail-light assembly, a similar Prawnlight soon took shape.



The new Prawnlight uses a cut-down trailer tail-light assembly and a LED auto lamp.

I tried this with just one of these Superbright LED lights for cars and it is very bright. They have a directional beam of 15° which is fine for a torch function. I also tried it as a replacement for overhead lights in a pop-top caravan but there's not enough side light which is a pity as they draw one-fifth the current of incandescent globes and remain cool.

As you can see, the unit is virtually the same as the January 2005 version with the exception of the bright LED assembly, which at around $20 is cheaper than the original kit. Care is needed when sawing/cutting off the excess portion of the trailer light housing.

One thing different is that the LED assembly is polarity-sensitive whereas the incandescent is not. I used a permanent marking pen to label each end.

Now all I need is a dark night and an outgoing tide. Roll on summer.

Murray Solomon,
Cheltenham. Vic.

generates 2.6kg of CO_2 and 1.2kWh of power at the wheels. With an electric car, assuming 90% efficiency of charger and 90% efficiency of control electronics combined with dynamic braking, if we recharge the batteries from the mains, then 1.2kWh at the wheels requires us to input 1.5kWh from the mains. So the electric car generates 1.35 x 1.5 = 2kg of CO_2 for 1.2kWh at the wheels.

This is completely the opposite conclusion to Peter Seligman's example whereby he claims "Less CO_2 is generated using a mains recharged electric car compared with a petrol car."

Peter Kay,
Dromana, Vic.

Best wishes for another 20 years

On behalf of all staff at Jaycar Electronics, Electus and Soanar, I would sincerely like to congratulate you and your staff on 20 years of "well done".

I am flattered that you mention Jaycar in your November editorial. It must be said, of course, that SILICON CHIP magazine has been a major factor in our group's prosperity.

Please accept our best wishes. We look forward to the same great relationship for the next 20 years.

Gary Johnston,
Silverwater, NSW.

Congratulations on 20 years

Congratulations on the 20th anniversary of SILICON CHIP. Its obvious success is a credit to you and for your foresight in launching the magazine originally.

I note that EPE magazine is now reproducing some of your construction articles and this is surely a compliment to you and your staff for your excellent projects.

Keep up the good work!

Garth F. Jenkinson,
Emerald, Vic.

Possible error in Variable Speed Drive circuit

I don't know if I have this analysis correct but I have gone through the Variable Speed Drive circuit on page 93 of the October 2007 issue and I am

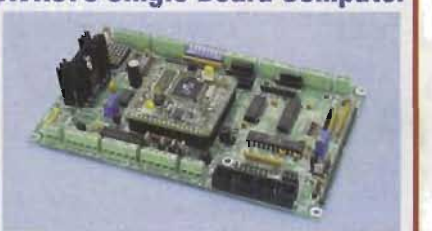
Atmel's AVR, from JED in Australia

JED has designed a range of single board computers and modules as a way of using the AVR without SMT board design



The AVR570 module (above) is a way of using an ATmega128 CPU on a user base board without having to lay out the intricate, surface-mounted surrounds of the CPU, and then having to manufacture your board on an SMT robot line. Instead you simply layout a square for four 0.1" spaced socket strips and plug in our pre-tested module. The module has the crystal, resetter, AVR-ISP programming header (and an optional JTAG ICE pad), as well as programming signal switching. For a little extra, we load a DS1305 RTC, crystal and Li battery underneath, which uses SPI and port G.
See JED's www site for a datasheet.

AVR573 Single Board Computer



This board uses the AVR570 module and adds 20 An./Dig. inputs, 12 FET outputs, LCD/Kbd, 2xRS232, 1xRS485, 1-Wire, power reg. etc. See www.jedmicro.com.au/avr.htm

$330 PC-PROM Programmer

This programmer plugs into a PC printer port and reads, writes and edits any 28 or 32-pin PROM. Comes with plug-pack, cable and software.



Also available is a multi-PROM UV eraser with timer, and a 32/32 PLCC converter.

JED Microprocessors Pty Ltd
173 Boronia Rd, Boronia, Victoria, 3155
Ph. 03 9762 3588, Fax 03 9762 5499
www.jedmicro.com.au

Movement timer wanted for PC addicts

I frequently spend hours surfing the web and only when I get up, I realise I'm a bit stiff and sore. Sometimes my legs are also a bit numb.

Bearing in mind the recommendation that PC users get up and walk around for a few minutes each hour, I thought a detector/timer/alarm for people seated at a computer may be a useful project. As the sensor, I thought a microswitch attached to a chair which detected flexing in the chair could be used or a thermistor embedded in the seat to detect body heat (OK unless you have a cold posterior!). Or perhaps a PIR sensor could be used.

The circuit would have to detect a seated person being there for some time and if there were no gaps (ie, not detected) for five minutes or more, activate the alarm after one hour. Because of their high-temperature coefficient, PIR sensors usually detect changes in radiation over a few seconds, so this may be a challenge.

Charles Tivendale,
via email.

Comment: this general concept is important; ie, people need to get up and move about rather than being frozen to one spot in front of the computer. However, we don't think a hardware project is the best or easiest solution. What is needed is a reminder which pops up on the screen to remind you to take an exercise break. There are any number of free diary packages which can be arranged to do this.

pretty certain there is an error.

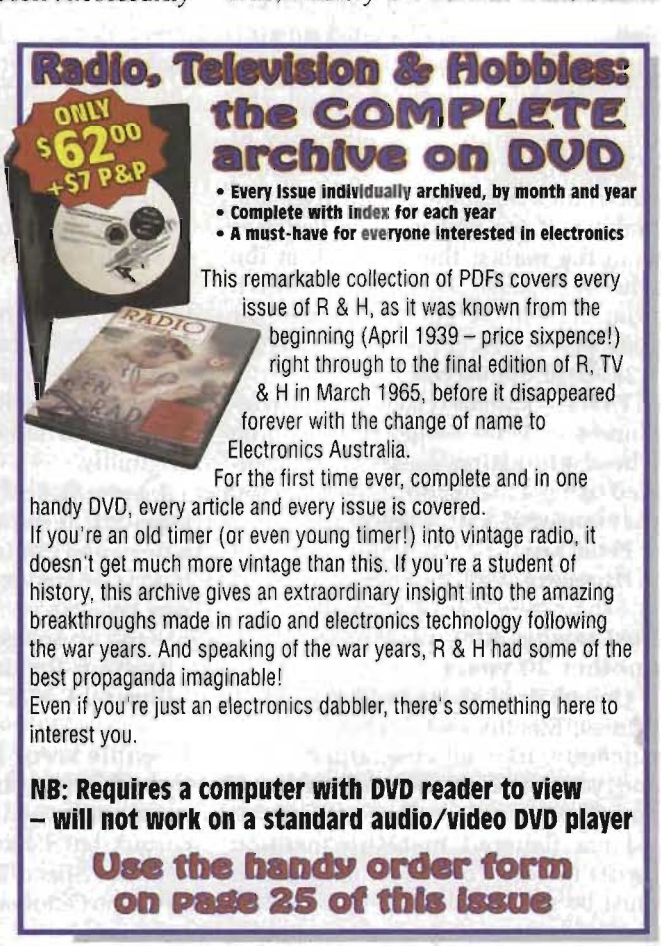
Going through the logic table, for example, when FWD command is high and the PWM is high, Q1 should be on, Q2 off, Q3 off, Q4 on, which is what should happen. My analysis shows that if one builds the circuit as shown, you will have a major problem, in that when FWD is high and PWM level is high, Q1 is off, Q2 is off, Q3 is on and Q4 is on. This condition would destroy the Mosfets. Please correct me if I am wrong.

Alan Mainwaring,
Koroit, Vic.

Comment: the circuit is correct, as far as we can tell. The point you may be missing is that two of the optocouplers are acting as inverters and the other two are not. In other words, when there is current flowing through the LEDs in the optocouplers, it doesn't necessarily mean that the corresponding Mosfet is turned on.

This is due to the way the optocouplers in this circuit work. As you can see from their schematic, when there is current flowing in the optocoupler's input LED, the top transistor in the output stage is on while the bottom one is off. When there is no current flowing through the input LED the reverse is true, namely the bottom transistor is





Is waveform sawtooth or triangular?

It may be a bit pedantic but I thought that a sawtooth waveform used to be a climbing ramp followed by a sudden return to zero (or vice versa). The drawing on page 28 of the April 2007 edition shows what is referred to as a sawtooth but it is drawn as a triangular waveform.

Is this an error or have definitions changed? Or has the younger generation grown up with the "Jack" saws which do have triangular teeth. Do they therefore describe a triangular wave as a "sawtooth"?

I noticed that page 15 of the April 2007 issue also shows a triangular waveform and calls it a sawtooth. This is from same author and he's not a youngster!

National Semiconductor differentiates between the two and I believe that they are an authority in the field. Their examples certainly are in accord with what I believe are the standard usages of the terms. In particular, see:

https://secure4.vivid-design.com.au/jaycar2005/images_uploaded/LM2900.PDF

Graham Goeby,
Greensborough, Vic.

Comment by the editor: I tend to think of the terms triangular and sawtooth as being interchangeable. In fact, I would go further than that and say that using the word triangular to describe a continuously repeating waveform is not quite logical; the sawtooth is more pictorially correct in the descriptive sense.

In any case, with a function generator, you can have a sawtooth waveform where you can vary the positive and negative slopes, so at what stage do you have a triangular waveform and when does it become sawtooth?

Having said, you will find other writers in SILICON CHIP describing such a waveform as triangular.

on while the top one is off. Now the voltage at pin 5 of OPTO1 is around 12V since there is a voltage divider formed by the 1kΩ, 47Ω and 1kΩ resistors across pins 8 & 5 of optocouplers 1 & 2 respectively.

Q1 & Q3 are P-channel Mosfets while Q2 and Q4 are N-channel Mosfets. When pin 8 of IC2 is high, it means that there is current flowing through the input LED of OPTO1. Hence, as mentioned before, the top transistor in the output stage of OPTO1 is turned on and hence pin 6 of OPTO1 is close to 24V, meaning that the corresponding Mosfet Q1 is off, not on.

In other words, OPTO1 and OPTO3 act as inverters while OPTO2 and OPTO4 act as buffers.

The demise of a discipline?

While SILICON CHIP is a commendable electronics and technology magazine endeavouring to cater for a wide variety of reader interests, an important topic and whole technical discipline largely conspicuous by its absence is that of RF and radio communications projects and articles. Projects in recent years seem excessively dominated by automotive electronic gadgets and engine control boxes, PIC-based microcontrollers with an endless succession of PICAXE projects, and audiophile amplifier and loudspeaker construction articles, etc.

Australia once had a vibrant abundance of amateur radio and radio/wireless communications focused publications that are all now defunct with the notable exception being the enduring WIA publication *Amateur Radio*.

Also conspicuous by their absence is the parallel disappearance from newsagent's and bookshop shelves throughout Australia of venerable international radio orientated magazines like *Practical Wireless*, *CQ*, and *QST*. In fact, SILICON CHIP seems to be the only remaining electronics journal left!

Bookshops have become a wasteland in respect of technical books, the classic *ARRL Handbook for Radio Amateurs* being impossible to find anywhere. Coincidentally, amateur radio equipment and associated components and hardware have all but vanished from the public consciousness.

This rather surprising demise and almost extinction of an important field of electronics no doubt mirrors the par-



Pulsed LEDs can cause strobing effects

As you are no doubt very well aware, the humble light emitting diode (LED) has advanced in leaps and bounds in the last decade and is now used in many applications which 10 years ago could be only dreamed about. The automotive field has benefited greatly both in use on cars and trucks and also on road fixtures such as signs and signals. But have readers noticed that while some of these bright LEDs are run on a continuous current, others are powered by a pulsed current source?

It is these pulsed ones which I find can be quite distracting, especially at night and when they are in my peripheral vision. I first noticed this when I was at an intersection one night and a semi-trailer went past on the intersecting road. The marker lights down the side of the trailer, instead of just being four or five small red lights were a flickering strip of what seemed to be a hundred jittering lights with a "tail" extending beyond the end of the trailer.

Where I live there are some electronic speed limit signs outside the schools that can be switched to show a lower speed limit during school arrival and departure times. I find these signs are very bright at night and if I blink as I drive past, the number showing (eg, 80) seems to dance in front of my eyes. I wonder if anyone else has noticed the strobing affects that these pulsed LEDs cause? Perhaps they are simply fed with a pulse frequency that is too low?

Ray Chapman,
Pakenham, Vic.

Comment: your observations about pulsed LEDs and strobing are right on the money. In fact, it is easy to observe these effects, if the light source is moving rapidly with respect to your position or by blinking. No doubt some of these effects could be much reduced if the multiplexing or switching was performed at a much higher frequency.

allel elimination of creditable training courses at the universities and technical colleges whereby motivated folks with the inclination and appropriate science and maths talent can gain a solid education and training.

Formal TAFE-based training for the traditional radio broadcast and television broadcast operators certificate of proficiency seems to have vanished off the planet, so where is the next generation of broadcast engineers and radio technicians going to receive their specialist training? Gone are the once-traditional training schools for electronics apprentices and technicians operated by our former PMG and Civil Aviation Departments, the ABC, Weapons Research Establishment/DSTO, etc. After the demise and restructuring of these once great institutions, this para-professional training was palmed off and handed over to the TAFE colleges but such electronics vocational courses are nowhere to be found today.

The dominant technical fields on offer in recent years are courses in IT and computers. Where will the future technical competencies to operate and maintain complex communications systems, radio transmitters and broadcasting equipment come from?

One is also hard-pressed to find good RF engineering and radio communications subjects in any university syllabus nowadays so where are the next generation of RF and radio communication engineers coming from? This serious problem should be a major concern for all high-technology and R&D companies in Australia as they struggle to address the skills shortage and compete for the dearth of adequately trained and experienced professionals.

All of the above afflictions seem symptomatic and commensurate with a general dumbing down of many technical fields of endeavour across all education levels. The dilemma undoubtedly also links back to a preoccupation and over emphasis on computers in the home and our schools, effectively displacing electronics and its many speciality fields as a hobby pursuit.

The ranks of amateur radio have in the past provided Australian industry a richly-skilled pool of hands-on and savvy technicians, engineers and scientists. Sadly these talented folks are quickly becoming a rarefied and almost extinct breed. There's a need for an urgent resurgence in young folks pursuing technical careers stemming from their passionate hobby interests.

Perhaps SILICON CHIP could take a proactive role in helping restore the lost balance in the radio and wireless technologies and RF/microwave communication fields by stimulating the young formative reader's interest in these important technical disciplines. It was heartening to see the simple "AM Loop Antenna & Amplifier" project in the October 2007 issue. It would indeed be nice if that kind of project was a taste of greater things to come in this neglected field of technical endeavour.

Leigh Turner VK5KLT,
Adelaide, SA.

MP3 sound effects

Readers interested in the use of MP3 players and similar devices to provide background sounds for model railways or other displays (see Circuit Notebook, page 42, May 2007) may find the following observations helpful.

Numerous sounds can be downloaded from the Internet, ripped from sound effects CDs or digitised from analog recordings. Audiograbber is a freebie that works well both as a CD ripper and as a Line In sampler. With Algorithmix's Easy Tools plug-in installed, clicks and other noises can be attenuated on the fly.

Once desired sounds have been captured as *wav* files, an audio editor can be used to manipulate the left and right tracks either as a stereo pair or independently of each other. Audacity, another freebie, can do some of this but GoldWave provides more features and better interfaces.

For operation in quiet environments it may well be satisfactory to retain the dynamics of the original record-

ings but in noisier situations like exhibitions there can be advantages in applying compression — as commercial radio stations, wedding DJs and hearing aid manufacturers well understand. Both Audacity and GoldWave have simple compressors built in and both accept plug-ins. Audiostocker is a simple-to-use free WinAmp plug-in that works in GoldWave but not in Audacity.

Slim Slow Slider's c3 multi-band compressor is a more versatile freebie that works with both Audacity and GoldWave, although Audacity unfortunately reduces its interface to a daunting stack of sliders. Kjaerhus's Classic VST Compressor is another simple freebie that works in GoldWave and which appears to be better engineered and therefore more reliable than Audiostocker or c3.

Ots Turntables' DJ software also includes compression facilities. Unfortunately, Ots's free edition doesn't allow audio files to be saved but audio recorders with Line In sampling facilities, such as Audiograbber or Nero Media Player, can capture the audio streaming from it.

Much more sophisticated software processors costing several hundreds of dollars are also available. iZotope's Ozone-3, for example, includes a 4-band dynamics processor (compressor/expander/limiter) as well as many other features designed to "sweeten" or otherwise modify sounds. The graphical interface is far more than mere eye-candy (skin) as it displays processor transfer functions, albeit for just one frequency band at a time, which can be invaluable when carrying out multiple operations simultaneously.

Ozone-3 is available as a DirectX plug-in (as well as other formats) and thus works in GoldWave but would probably be overkill for background sounds. A much simplified and cruder version is available as a WinAmp plug-in for $29 or for free if you don't mind being restricted to presets.

Three compressor/expander/limiter processors that feature transfer function displays and work in GoldWave are: Audioware's dB-D dynamics processor, Coyote's Compressor 1.1 and FASoft's Compressor 1.1. These cost between $US20 and $US40 but generally outperform the freebies.

In some cases it may be convenient to retain the original recording as the left track and to save a compressed version as the right track. A simple switch could then be used to select either one.

A hardware compressor inserted between the MP3 player and the speaker(s) allows for a variety of effects to be controlled in real time without the need for a computer. Designs for simple hardware compressors intended for home construction have been published in SILICON CHIP (June 2000) and elsewhere. The SILICON CHIP design is available as kitset KC5291 from Jaycar Electronics. If desired, this compressor could readily be repackaged and incorporated into a sound system such as that described in the May 2007 issue of SILICON CHIP.

More complex hardware compressors are available from music stores and recording studio and broadcasting suppliers. These range upwards in price from $US40 and are available in a myriad of models (one New York City store, BHphotovideo, sells around 100 different types).

Hugh T. Middleton, Lower Hutt, NZ. SC

TENROD

Small Colour TFT LCDs



Door Camera



3.5" Small TFT LCD



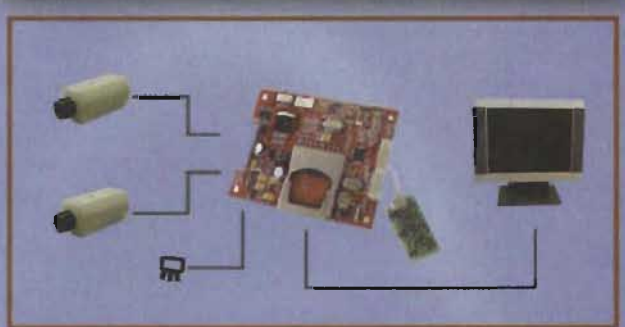
4.0" Small TFT LCD



5.6" Small TFT LCD

- Full Colour TFT LCD
- NTSC & PAL Compatible
- With Picture Quality Control
- DV 12V Operation
- Simple Wire Harness Connection

Digital Video Recorder Module

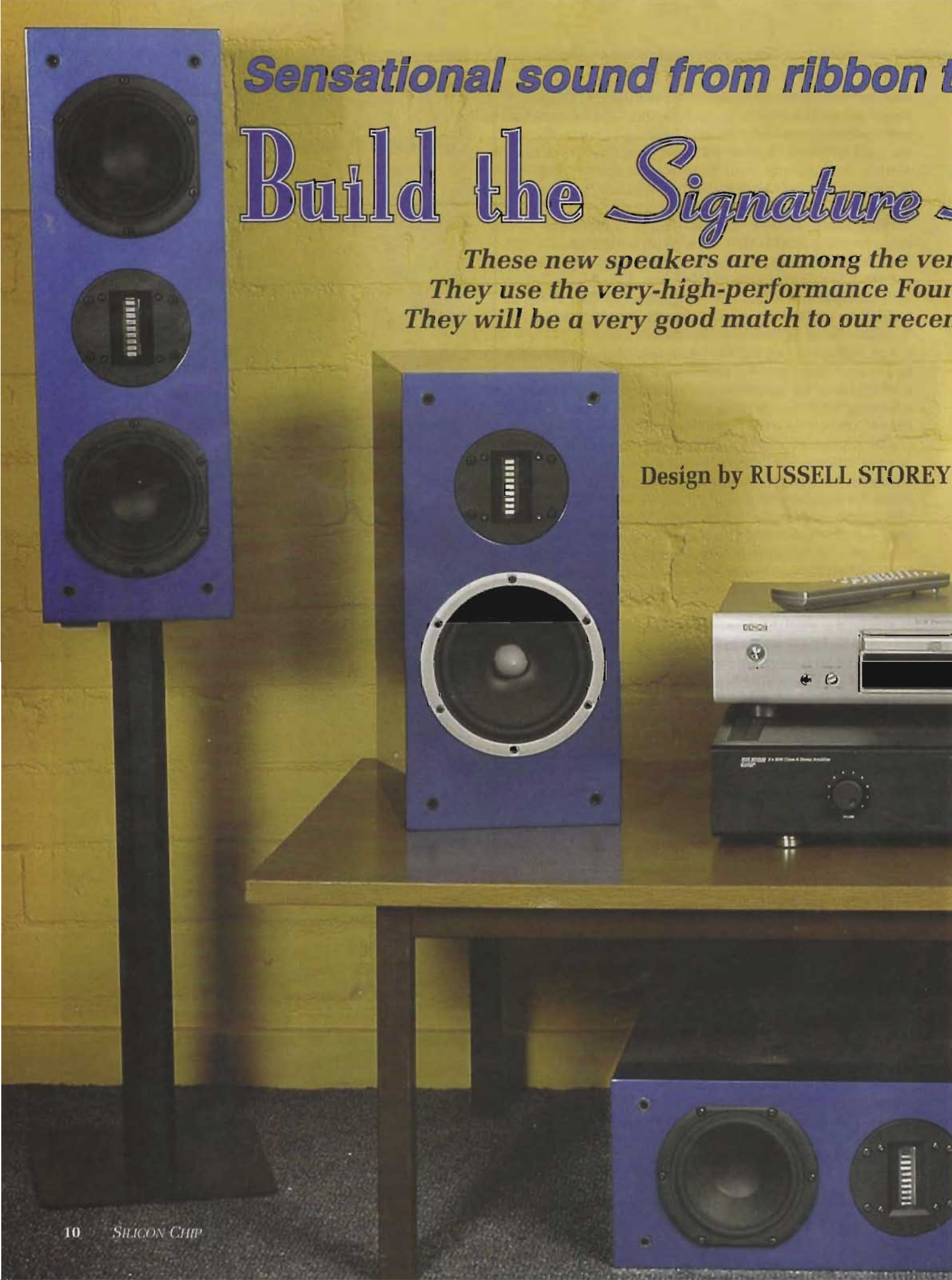


Video & Still Image Recording On Motion Detect

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Sensational sound from ribbon t

Build the Signature

These new speakers are among the ver
They use the very-high-performance Four
They will be a very good match to our recer

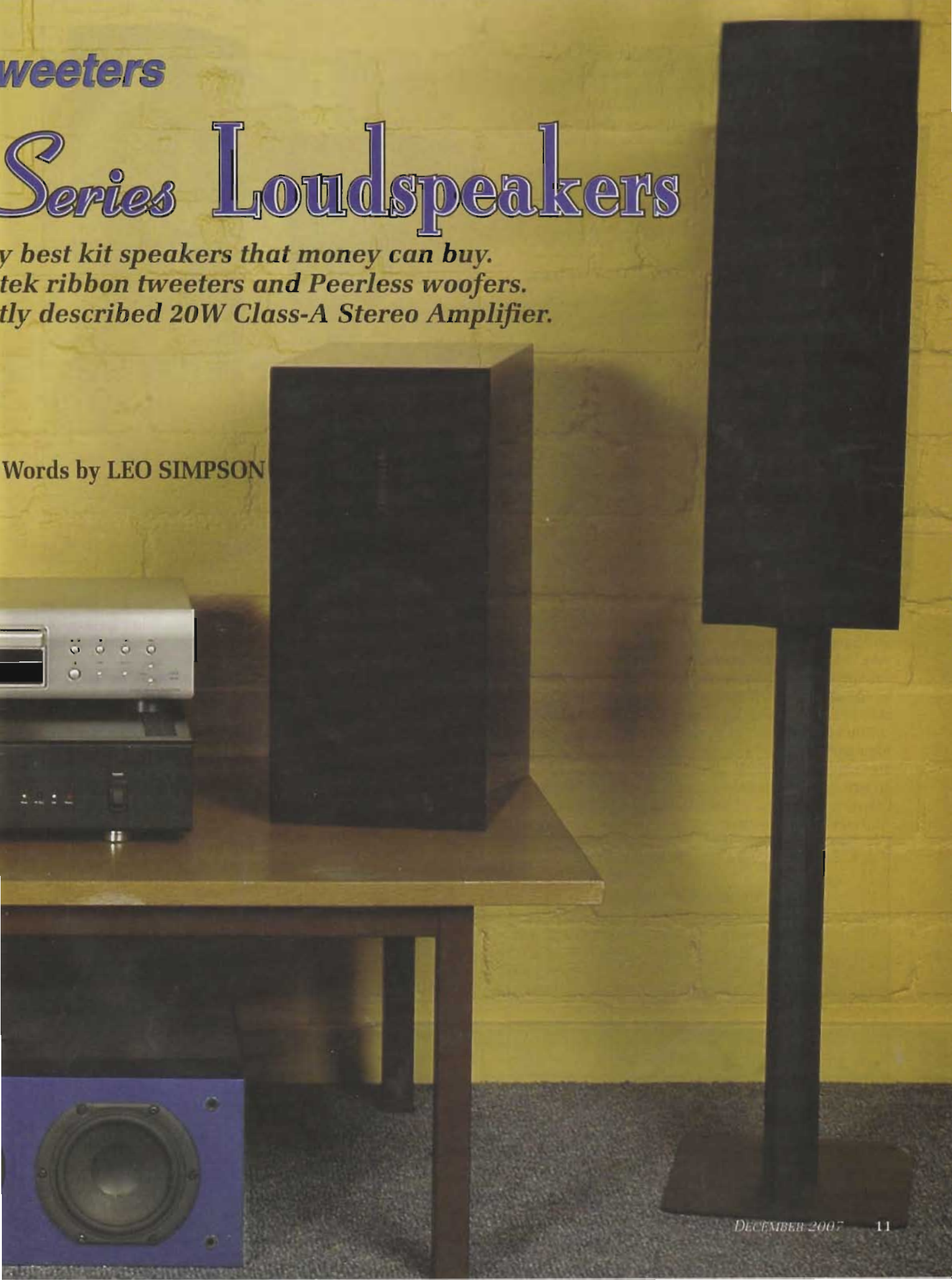
Design by RUSSELL STOREY

weeters

Series Loudspeakers

y best kit speakers that money can buy.
tek ribbon tweeters and Peerless woofers.
tly described 20W Class-A Stereo Amplifier.

Words by LEO SIMPSON





At far right is the 260 tower system and its dimensions while below is its centre channel variant, the 260C. The 360, at right, uses a 6.5-inch woofer. The pick of the two systems is the 260 because of its considerably higher efficiency: 92.5dB/1m/1W. Both systems produce commendably low harmonic distortion.

SINCE WE COMPLETED our description of the 20W Class-A Stereo Amplifier a few months ago, readers have been asking us for a kit speaker system to match its performance.

As it happens, the Signature Series have been in development for over a year now and we are very pleased to present a complete set of speakers which can be used in stereo or home theatre systems.

They provide excellent stereo sound stage and definition and have a very wide and smooth frequency response with very low harmonic distortion. And while they are eminently suitable for our Class-A amplifier, they can be matched up to any amplifier with a power output up to 120 watts per channel, when running normal program material.

The heart of each of these speaker systems is the very high performance Fountek ribbon tweeter. For those who are not familiar with ribbon tweeters, consider them as an extremely light filament of aluminium foil suspended between the poles of an extremely strong magnet. The audio signal from the amplifier is passed directly through the ribbon and the interaction of the current with the strong magnetic field deflects the ribbon back and forth to produce sound.

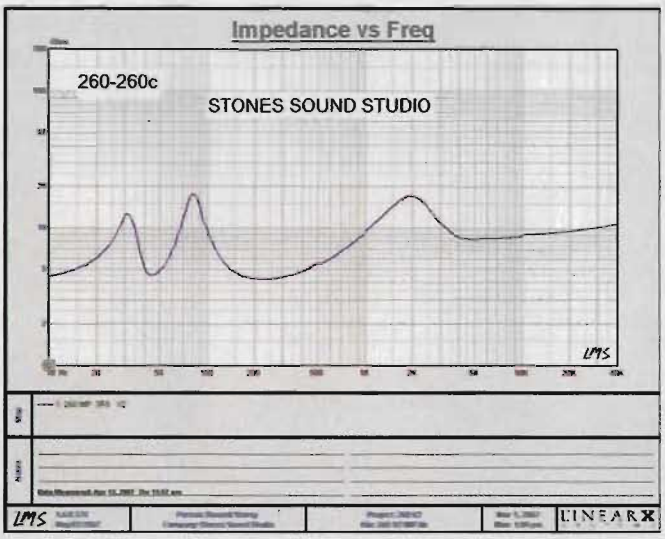
Incredibly, such an apparently flimsy system can produce deafening sound levels and with unsurpassed fidelity, transient response and so on.

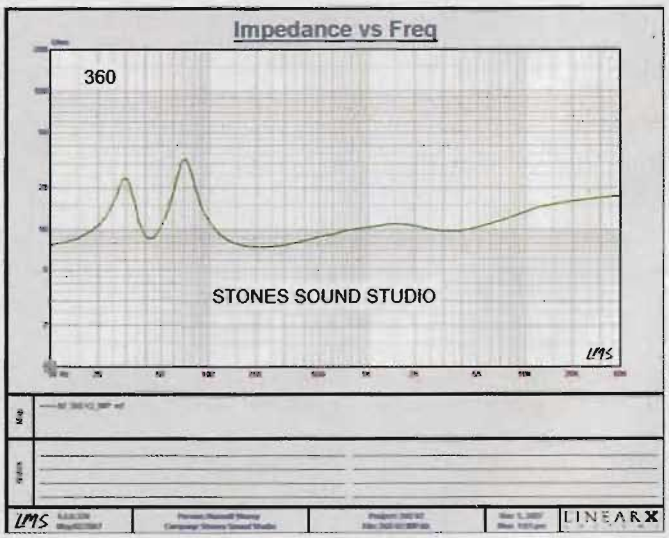
Ribbon tweeters have been around for a long time but until recently they have been largely confined to very expensive esoteric loudspeakers systems and their reliability and ruggedness was always a little suspect.

In the particular Fountek JP3.0 ribbon tweeters featured here, the aluminium ribbon weighs a mere 11 milligrams and is just 9 microns thick – much thinner than the proverbial human hair!

The aluminium ribbon is 66mm long and 8mm wide and suspended between the poles of a Neodymium magnet with a gap flux of 0.6 Tesla.

As you might expect, such a short piece of aluminium





The impedance curves for both the Signature Series speaker systems show the classic "double hump" at the bass end, due to the tuning provided by the bass reflex port.



This series of photos show the line-up of the drivers used in the Signature Series speaker systems. The woofers are made by Peerless and both have rugged diecast chassis. The ribbon tweeter is made by Fountek and incorporates a very high quality matching transformer. Note the fine mesh protecting the ribbon from curious fingers.

represents a very low resistance and it cannot be driven directly by any normal audio amplifier. Hence, the tweeter has an integral matching transformer with a frequency response to 120kHz. This results in a very flat tweeter impedance of 7Ω from 1kHz to 40kHz. The basic tweeter is also extremely efficient and in fact, is used with resistive attenuation to match the Peerless woofers used here.

Two separate stereo pairs of loudspeakers are presented, the Signature Series 260 and 360 systems. In addition, a centre channel variant of the 260, the 260C was designed to complement the 260 and 360 for high-end home theatre A/V systems.



The overall frequency response of the Signature Series 260 and 360 speakers is commendably flat to below 50Hz. This is the response of the 260.

Depending on your budget, you may decide to build either the 260s or 360s for a high-performance stereo system. Alternatively, for high-end home theatre A/V system, you may decide on a mix of the 260 (front) and 360 (rear), together with the 260C for the centre-front channel.

Whichever approach you take, you can be sure that you will be getting a sensational speaker system. Make no mistake, these ribbon units are the finest tweeters we have ever heard. They are so clean in their definition and their pin-point localisation of instruments in a stereo spread has to be heard to be believed.

On top of that, these speakers have very low distortion – measured at around 0.3% THD at 1kHz and 1 watt.

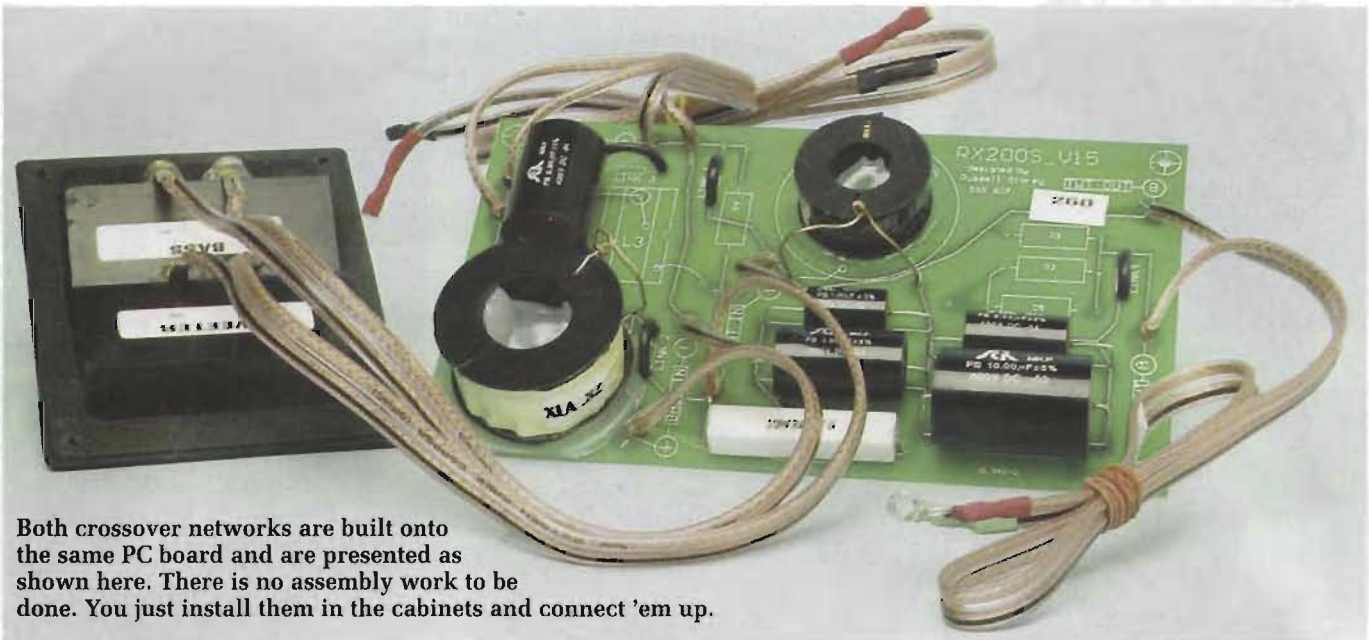
260 & 360

The 260 is a slimline speaker using the Fountek ribbon tweeter and two Peerless HDS 832873 5-inch mid/range woofers. This uses a Nomex paper cone, a very large ferrite magnet and neoprene rubber roll surround. The 260 system has exceptional efficiency of 92.5dB/1m/1W and will provide very good volume levels from the SILICON CHIP 20W Class-A Stereo Amplifier, even in large rooms.

The 260 is a MTM (midrange-tweeter-midrange) arrangement (also known as D'Appolito) with a rear bass reflex port. The 260C centre speaker is identical in every respect except that the tweeter is rotated through 90°, so that it will be vertical when the cabinet is laid on its side.

The smaller 360 bass reflex system uses the Fountek ribbon tweeter and a Peerless 830883 6.5-inch midrange woofer, also with a rear port. Its efficiency is somewhat lower but still quite respectable at 87.5dB/1m/1W.

Both speaker enclosures were developed using LEAP 5



Both crossover networks are built onto the same PC board and are presented as shown here. There is no assembly work to be done. You just install them in the cabinets and connect 'em up.

wave diffraction analyser and FFT vibration analysis software. The resulting enclosures have an EBS (extended bass shelf) low-pass filter response to ensure optimum bass and transient response.

While the enclosures are relatively small, they are very strong and rigid to ensure very low panel resonances. They are made from 18mm MDF (medium density fibreboard) while the baffle is made from two thicknesses (36mm), to allow the ribbon tweeter to be flush-mounted and still provide maximum rigidity.

In addition, the inside edges of the woofer holes are chamfered to prevent diffraction effects at midrange frequencies and all models have internal bracing of the large side and top panels.

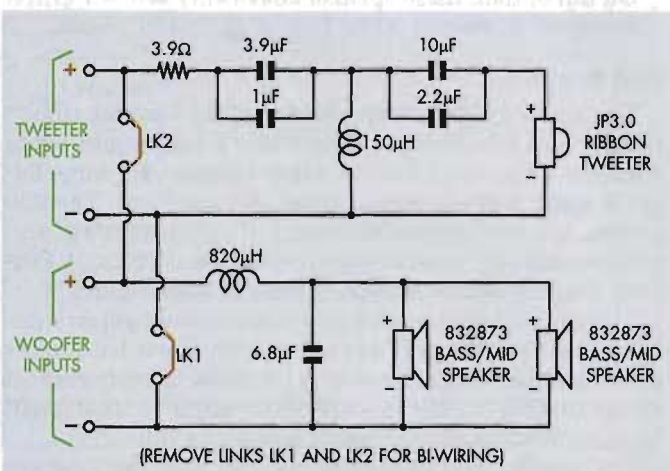
Rear bass port

Both enclosures employ a rear port to ensure a reduction of overall driver distortion and cross-modulation which can be generated by front ports. According to the designer, with a front port a form of speaker (low-frequency) distortion and cross modulation is generated by the compressed air exiting the port out of phase with the woofer, creating (modulation) interference of the woofer cone. This interference occurs at medium to high playback levels (port velocity) and is one of the factors reducing overall dynamic range or head-room of the transducers and speaker system.

The port itself is 63mm in diameter with small flared ends. All this is done to keep distortion at a minimum.

Crossover networks

Using the best drivers and a carefully designed cabinet would be a waste of time without an equal standard in the crossover networks. In the Signature Series, the crossover networks are quite complex (Linkwitz Riley with Bessel/Butterworth response). They were developed to enable good linear phase and minimum distortion through the passband and overlap regions of both the woofer and ribbon tweeter.



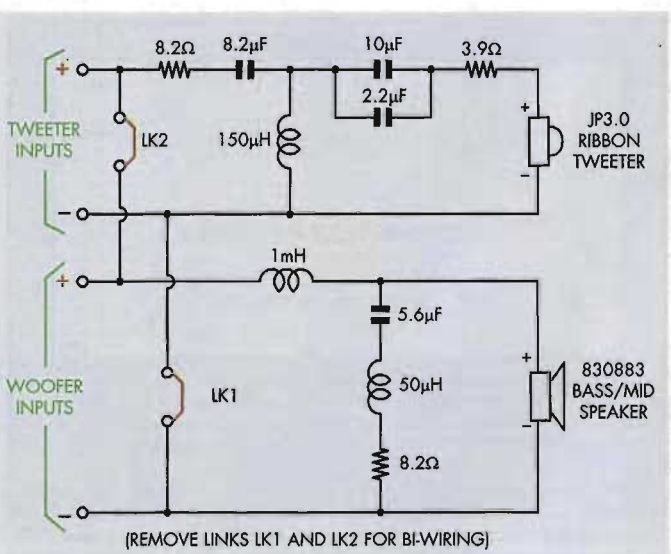


Fig.1: these are the crossover networks for the 260 (above) and the 360 (right). Both use an 18dB/octave rolloff below the crossover frequency to the tweeter and a 12dB/octave slope above the crossover frequency to the woofer.



This photo shows the crossover network installed in the base of the 360 enclosure.

They have been developed with bi-wiring in mind so the tweeter and woofer filter networks are essentially quite separate, as shown in the diagrams of Fig.1.

The tweeter is fed with a third-order high pass (18dB/octave) filter and the woofer is fed with a second-order (12dB/octave) low pass filter. In the case of the 260, the crossover frequency is 3.8kHz and 3.2kHz in the 360.

Both crossover networks are based on the same PC board but there are differences. Each crossover network employs air-cored inductors, non-inductive wirewound resistors and SCR 400V metallised polypropylene capacitors. High quality components are used throughout.

Building them

The designer of these Signature Series loudspeakers has been very particular in specifying how everything must go together, from the initial specification of the drivers, down to the very last detail of the cabinets, crossover components and even oxygen-free copper wiring. We don't think that last detail is really necessary but that is a story for another time.

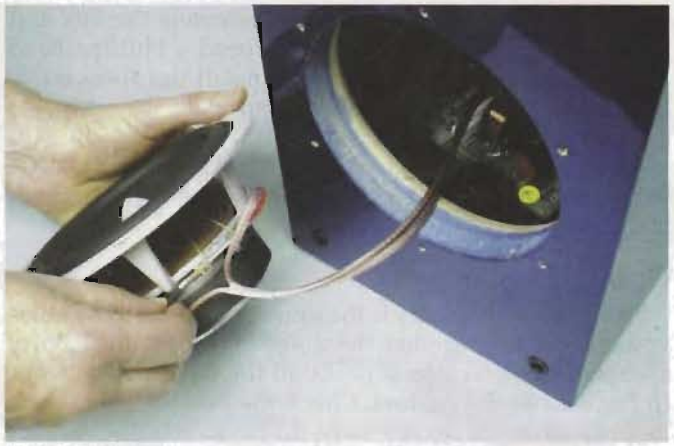
This very fine attention to detail on the part of the designer has made the task difficult for the kit supplier but it means that you, the ultimate kit-builder, will have an easy time putting them together.

The loudspeaker cabinets are supplied fully assembled in two forms, unfinished MDF or black vinyl. In the case of the unfinished MDF cabinets, it is up to you as to how you finish them.

The prototype cabinets featured in this article were spray-painted to a very high standard. If you have access to a high-pressure spray gun and spray booth, so much the better.

Alternatively, if you intend painting them, we recommend using a roller, to avoid leaving brush marks – it is amazing how brush marks can catch the light and become noticeable, especially if gloss paint is used.

Not only are the cabinets fully assembled but they also come fully lined with a grey felt, to damp internal reflections and they are also supplied with the fully finished grille cloth frames.



Making the connections to the woofer. The terminals are colour-coded and differently sized so that you cannot make a mistake.



Fit the woofer carefully and do not touch the cone at this point, otherwise you may damage it. It is secured to the baffle with six Allen screws.



Making the connections to the tweeter. Do it exactly as the photo depicts. Don't over-tighten the nuts on the tweeters – it would be a shame to damage such a magnificent performer.

No special tools are required to assemble the kits and no soldering is required. You will need a Phillips head screwdriver, a 3mm Allen key to install the speakers to the baffle and an adjustable wrench to attach the crossover connections to the terminals of the tweeters.

The fully assembled crossover networks even include the wiring to the speaker terminal panels – as we said, there is no soldering at all!

Order of assembly

The order of assembly is the same, regardless of whether you are putting together the 260s, 360s or 260C (centre speaker). The first step is to install the crossover network in the base of the cabinet. Check the back of the cabinet to make sure you do not have it upside down – the rectangular hole for the terminal panel should be below the circular bass port.

Fit six Velcro tabs to the underside of the crossover PC board and then pass it through the lower woofer hole and secure it to the felt on the base of the cabinet. Pass the terminal panel out through the rear of the cabinet, making sure that you do not disturb the felt which covers the rectangular hole. Then secure the panel with four countersunk MDF wood screws.

Bring out the wires for the woofer(s) through their respective holes in the front baffle. Fit the push-on connectors from the crossover speaker cables to the woofer(s). The wires are colour-coded (red for positive and black for negative) and differently sized so that you cannot make a mistake when you do the connections.

Carefully place the woofer into its hole in the front baffle and secure it with six Allen head screws using a 3mm Allen key. It is important that you do not over-tighten these screws otherwise you will strip the holes in the MDF panel.

Mounting the tweeter

Now is the time to mount the highly prized Fountek ribbon tweeters. Important: do not remove the protection label from the front of the tweeter until you have completed the assembly.

First, check that the felt cover is fitted behind tweeter cutout hole. That done, bring out the tweeter wires from the crossover. These are fitted with colour-coded (red for positive, green for negative) ring terminals to suit the threaded posts of the tweeter.

Make the connections and tighten them with a small adjustable wrench – do not over-tighten them! Hint: angle the connector lugs to allow enough room between the felt cover and back of the ribbon magnet when installing the tweeter.

Next, install the tweeter to the front baffle with four Allen head screws. Again – do not over-tighten them. You can then carefully remove the protection label from the tweeter faceplate.

Bi-wiring option

Just back-tracking for a moment – if you intend running these speakers bi-wired, then the installation procedure is slightly different. You need to cut links LK1 and LK2 on the crossover PC boards and then remove the gold plated links from the 4-terminal panels.

Keep the plated links – in fact, it's a good idea to put them in a small plastic bag and tape them to the rear of the cabinets, in case you ever want to run the speakers with conventional amplifier drive (ie, not bi-wired).

A final step is to connect a 1.5V battery across the terminals of the completed loudspeaker. With the battery positive to the red terminal, the woofer cone should move forward. If that's OK, you can fit the grille cloth frames.

You are now almost ready for a listening session. When positioning your speakers in the room, make sure that they are not in the room corners and are out from the walls by around a metre or so. Ideally, they should be placed on stands so that the tweeters are at your ear level, when you are seated.

Making your own enclosures

If you want to save some money by building your own enclosures, all the necessary dimensions and other information are accessible on the designer's website at **www.stonessoundstudio.com.au**.

If it was our choice, we would pick the complete kits rather than going to all the trouble to make the cabinets. Sure, you will save some money but there is a great deal of work involved. Consider that the front baffle needs to be laminated from two 18mm sections and you need to make the bass port with its carefully flared ends.

There are really no short cuts to making the cabinets and if you don't follow the diagrams very closely, you will prejudice the sound quality. The above site has all the information on these speakers so if you want to check any aspect of the design, you can readily do so. SC

Kit Availability

Fountek ribbon speakers, Peerless speakers and all of the kits for the Signature Series are exclusive to Wagner Electronics, 138 Liverpool Road, Ashfield, NSW 2131. Phone 02 9798 9233; fax 02 9798 0017.
Website: www.wagner.net.au

COMPLETE KITS
Include speakers, cross-overs, all hardware and cabinets. (Price per pair [except 260c] including GST).

260		
Plain MDF	KIT260-MDF	$1299.00
Black vinyl	KIT260-BV	$1399.00
260C (one unit only)		
Plain MDF	KIT260C-MDF	$649.00
Black vinyl	KIT260C-BV	$699.00
360		
Plain MDF	KIT360-MDF	$1159.00
Black vinyl	KIT360-BV	$1299.00

SPEAKER KITS (Without Cabinets)
Include speakers and crossovers but no cabinets and hardware. (Price per pair [except 260C] including GST).

260 kit	SPK260	$799.00
260C kit	SPK260C (one driver only)	$399.00
360 kit	SPK360	$699.00

Restoring a Vintage Telev

With Australia celebrating 50 years of television last year, I thought I should celebrate the occasion and restore a TV set that was around not long after it started. But like the hare in Mrs Beaton's cookbook, I first had to catch my set . . .

In my quest to find a television to restore, I had a particular one in mind – an AWA Model 229, from around 1958. My grandparents had owned one back then; in fact it was their very first television. They were the second house in the street to have a TV set and early on they had made many new friends thanks to that television!

Back then television was still magic and somewhat of a mystery to most people. Crowds used to gather on the footpaths outside retailers just to watch the TV sets in the window (often with no sound!).

I had an old black and white picture of the AWA, so knew what to look for. When one turned up on eBay, I just had to have it. One problem: I'm in Sydney and it was in Melbourne. So having won the auction, I arranged to have it freighted to Sydney. This cost nearly three times as much as the set.



This old, grainy photograph was the picture that started it all. I wanted one of these AWA Model 229s, just like my grandparents had back in 1958

What have I done?

The set duly arrived about a week later. It was as described on eBay and bearing that in mind, I knew it would take a fair amount of work before this would be a working clean example of a 1950s television.

The set, while all there, was dirty. The set had apparently been stored in a damp location as much of the

ision

By Timothy Stuart



This is how it arrived from Melbourne after the successful eBay bid. It looks to be in pretty good condition but notice the peeling veneer (lower right). And there was a fair bit of damage inside. This photo doesn't do justice to the legion of dead bugs between the screen and safety glass!

veneer on one side had lifted; some corrosion on the chassis was evident and other components had suffered, which I'll mention later. And not least were the many bugs that over the last few decades had taken their last breath between the screen and the safety glass.

Before starting any type of repair I like to clean the dust off the chassis, remove all the valves and check for anything that's obviously missing.

Having removed the chassis from the cabinet and then getting rid of the dust using some paint brushes, a vacuum cleaner and a damp cloth, I then washed all the valves, being careful not to rub off the delicate valve number markings.

One valve in the tuner (a 6U8) was obviously gassy (a white/grey look inside) and was replaced with a new one. I next turned my attention to its underside.

Lots of paper and wax

With all vintage televisions and radios that I restore, I tend to favour a complete replacement of the paper and electrolytic capacitors. While there is some argument from the purists about doing this (polyester capacitors weren't invented in the 1950s!), I find I end up with a much more reliable set and hopefully one I won't have to repair again for a long time.

I use tubular metallised polyester capacitors for the paper replacements which, while smaller than the originals, don't look too out of place under the chassis, as compared to the more common 'orange drop' type capacitors.

Following the paper caps, I replace all the electrolytics. Most high voltage electrolytics in vintage TVs are of the chassis-mount (can) type. I leave these in place on the chassis but disconnect them. This means there are no holes in the chassis, where there would have been had I removed them.

Modern electrolytics are very much smaller and can be easily wired in under the chassis, often using the terminals on the old capacitors as tie points.

Some restorers go to the trouble of removing the "innards" of the old can electros and mount a modern one inside the can. But not me!

Spending a few hours replacing these components is very worthwhile and often a TV will be brought back to life just by replacing all the capacitors.

Resistance is futile!

Following the capacitor replacement, I then turn my attention to the higher value resistors in the set. Experience has shown that replacing all resistors 100kΩ and over will also greatly enhance the chances of the

television working as it should when first switched on.

Many old resistors over this value 'go high' with age and cause strange effects on the picture and ineffective contrast, brightness, volume controls. Moreover, old high value resistors tend to go even higher in value as they warm up, causing all the settings to drift as the set warms up.

In undertaking the resistor replacement, I found a number to be burned out, no doubt due to increased current flow caused by the old paper capacitors being 'leaky'.

Check those fuses!

Another thing I always do is check that the correct fuse values are fitted. Many times I've found they've been replaced by a nail, paperclip or something like a 15A fuse where it should be a 1A.

Next comes the "smoke test" – powering up the old set for what could be the first time in decades.

Use a variac

To power a set up for the first time, I always use a variac. This allows me to detect anything wrong before it fails catastrophically and causes damage to other components.

I always power a set up in four stages. The first stage is with no valves installed, which checks that the power transformer is OK and that all secondary voltages are present and correct.

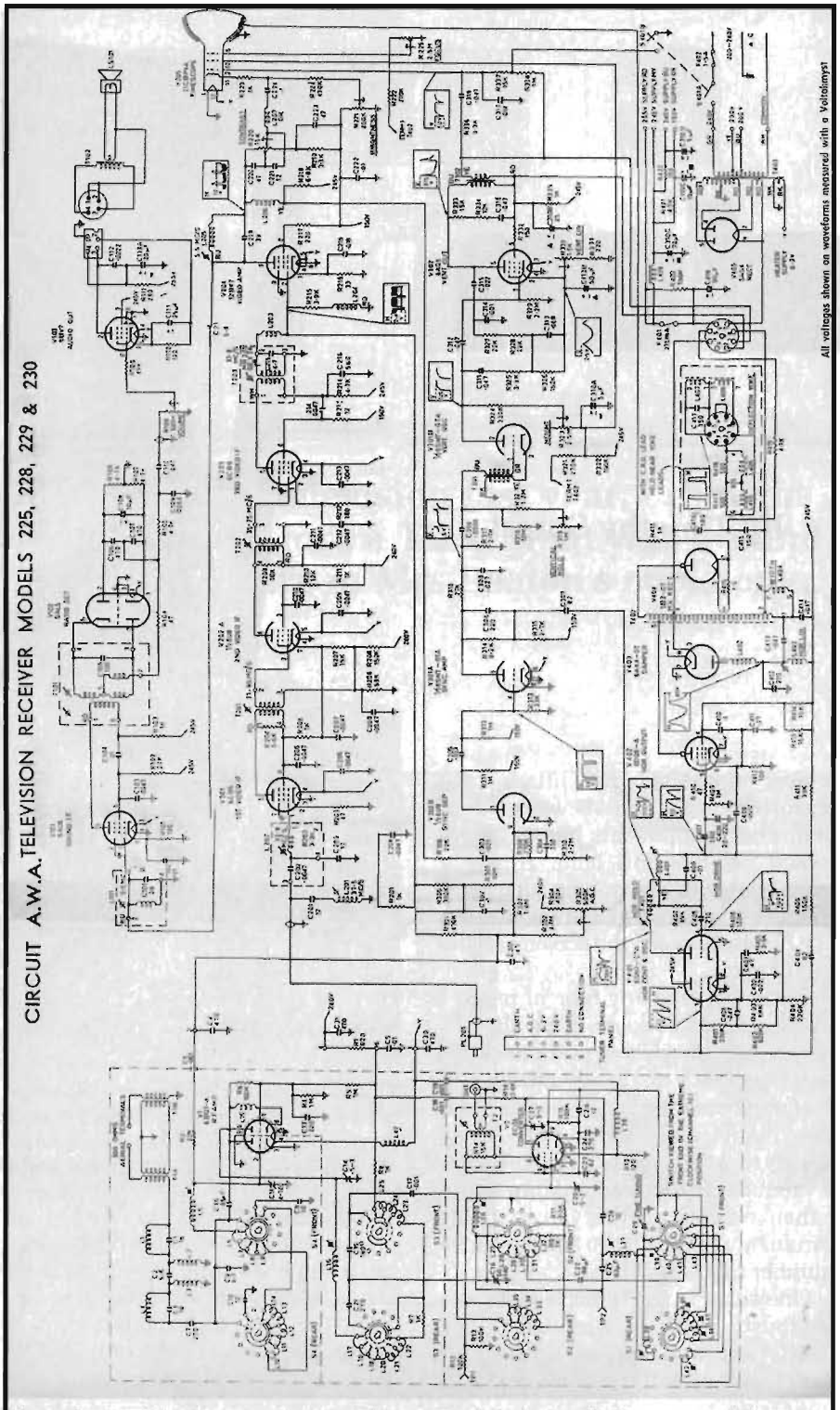
The second stage is to gradually increase the input voltage to 240V. In the case of the old AWA, having run the set for an hour the transformer was warm but showing no signs of distress.

Note also that old television sets usually had transformers with many input (primary) voltage taps. To increase the tube brightness, unscrupulous servicemen would often change the tap from 240V to 220V, increasing the secondary voltages in turn to levels far above the design voltage. So this is another thing to check before you power up the set.

Valves go back in

Stage 3: having passed the transformer test, it was time to plug in the valves. Initially, I start with just the rectifier valve(s). Slowly powering up the set again revealed nothing smoking or otherwise in distress. Measuring the rectified high tension (HT) voltages indicated that all appeared well.

Next check is with all valves installed with the exception of the high voltage rectifier, damper diode and horizontal output valve. Again, the set passed this test. Finally, with the remainder of the valves installed, the chassis returned to the cabinet and the picture tube and speakers connected, powering up yet again, resulted in a more or less completely working set.



I was lucky: I had a complete service manual and circuit diagram to help me.

It works!

With an antenna connected, I could now see a picture on the screen and had audio as well. However, there were a few problems still to resolve. The picture needed alignment, the



The accumulation of several decades of dust. The first step in restoring any old TV set is to get it as clean as possible without doing any (further?) damage. Contrast this photo with the cleaned (and restored) version overleaf.

vertical hold and volume pots were very noisy, there was a noisy crackle in the audio and one of the speakers wasn't working. I put most of these faults down to the television having been stored in a damp environment.

Fortunately I had an almost direct replacement in stock for the faulty speaker, so I attached the speaker transformer to the new one and it fitted nicely into the original mounting holes and speaker opening.

The vertical hold pot was replaced but the volume put was a different matter. Being a dual gang, concentric, switched type, replacements are almost impossible to find these days and so removal, taking apart and cleaning is the only option. So far this seems to have been very successful.

Snap, crackle, pop!

The last problem to fix was the loud crackle in the audio. The audio circuit in vintage televisions is usually relatively simple and I quite easily located the problem in a low value HT feed resistor. Replacing it with a new one completely removed the crackle from the audio.

After having done the picture alignment and centring, it was time to watch television, 1950s style.

The pretty parts

While I had been busy working on the electronics, a friend had been busy with the cabinet. It was in generally good condition, so I felt there was no need to do a full restoration. The veneer was re-glued and the interior of the cabinet vacuumed, brushed and wiped with a damp cloth.

An oiling inside and out makes the timber look like new and moisturises the dry wood at the same time.

The cleaned-up cabinet, although not brand new looking by any means, is very presentable and is still very original.

Polishing and cleaning

While the picture tube was out, the tube and safety glass were thoroughly cleaned and many expired bugs removed.

The screen mask was also carefully cleaned. In this set it was made of plastic so had to be treated very carefully. The difference this made to the look of the front of the set was amazing. It was starting to look nearly new again!



Some may argue the modern polyester capacitors (yellow) look out of place in a vintage set but you simply cannot trust the original paper capacitors. I make it a rule to replace them and high voltage electros and it has paid off every time.





Inside and outside the restored AWA. Above is the fully cleaned out and repaired (where necessary) chassis – though I was quite lucky with the relatively small amount of work necessary. You can't see the repaired veneer in the photo at right but looks every bit as good as the rest of the set.

The final touches

The final touches included cleaning all the front panel control knobs, the aluminium front panel and finding some suitable replacement screws and bolts to hold the chassis in properly and the back cover on.

What's on the box?

Finally it was all back together and I could settle back to watch TV 1950s style. This must have been a cosy family experience back then. With its small 17" screen, one has to sit relatively close for comfortable viewing.

Still, maybe that's not such a bad thing. Bring back 1958 I say!

The end (or is it the beginning?)

To conclude, although this restoration took place over a number of weeks and was somewhat time intensive, I'm very pleased with the final result.

I should also point out that I had access to a service manual and circuit diagram for this set, which made the restoration a lot easier.

Lastly, although I've heard many stories about hard-to-find parts like line output transformers for vintage televisions I must have been lucky.

Of all the televisions I've restored I'm yet to come across any with faulty transformers or picture tubes.

That has been very good for me, as restoring a set with such faulty parts would require another one to scavenge parts from. SC

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Infrared audio headphone link for TV



By JIM ROWE

Do you have trouble understanding what's being said on the TV? Do you need the volume cranked up too loud for everyone else? Do you have a hearing aid as well? If you said yes to any other these questions, here is your answer: an infrared transmitter and receiver to let you listen to the TV sound via headphones. That way, you can listen as loudly as you like, without disturbing anyone else.

IT HAPPENS all the time. One of the older members of the household is getting a bit deaf and needs the TV sound turned well up. But then it is too loud for everyone else. It's worse at night when people go to bed but one family member wants to watch the late-night movie – or whatever.

The problem can be even worse if you have a hearing aid because it also tends to pick up extraneous noises – coughs, heater fans, a radio in another room, toilets flushing, planes flying overhead, cars and trucks passing in the street and people washing up the dishes, to list just a few irritations.

The real answer is to listen via headphones – preferably good "surround your ears" muff-type headphones which not only deliver the wanted sounds directly to your ears and hearing aid(s) but also cut back the competing sounds at the same time. And if you pick the right kind of headphones with some acoustic damping in the earmuffs, they don't cause your hearing aid(s) to feed back and whistle either.

The result is comfortable listening at a volume level that's right for you, where you can hear and understand everything that's being said.

Headphone jack

Some TV sets do have earphone jacks, so you could simply fit a pair of stereo headphones with their own volume control (if necessary), plus a long cord and plug to mate with the jack on the TV. But many sets do not have a headphone jack and many that do have it wired so that when head-



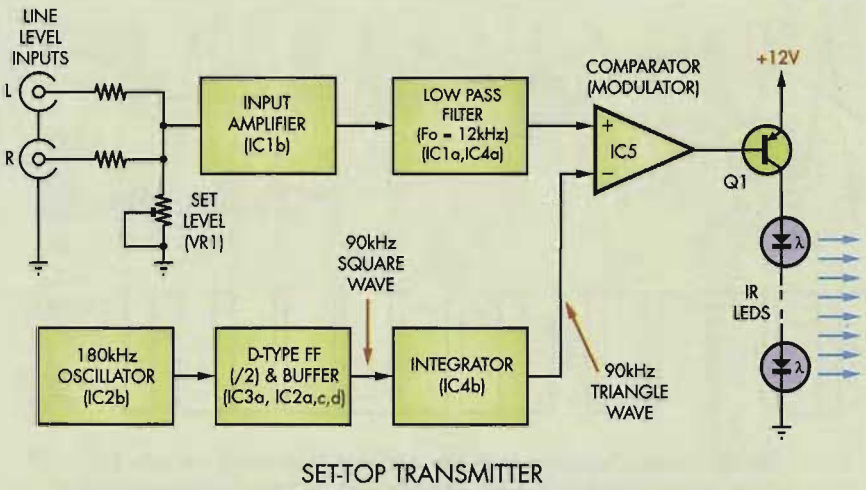


Fig.1(a): how the transmitter works. The left and right channel audio signals are converted to mono, amplified and fed to comparator stage IC5 where they are compared to a 90kHz triangle wave (the sampling signal). The resulting PWM signal then drives transistor Q1 to pulse a string of infrared (IR) LEDs.

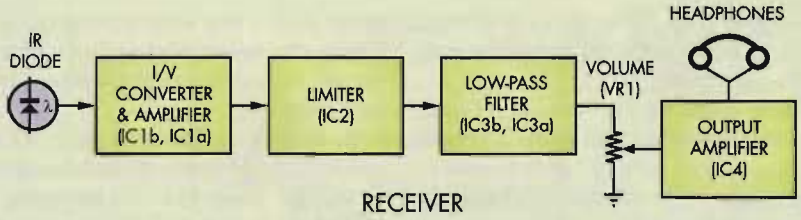


Fig.1(b): at the receiver, the transmitted signal is picked up by an IR diode and the resulting current pulses converted to voltage pulses (and amplified) by IC1b & IC1a. This amplified pulse waveform is then fed through a limiter and filtered to recover the audio waveform. This is then fed via volume control VR1 to an audio output amplifier (IC4).

phones are plugged in, the speakers are disabled.

That's fine for you but no good for everyone else. In any case, being hooked up to the TV via a long cable has its own problems: you can forget to take 'em off when you get up for a comfort break or someone else can trip on the cable when they move about the room.

Cordless headphones

A much better solution is to use "cordless" headphones, either via a UHF or infrared link. This means that you have a transmitter or sender unit that sits on the top of the TV, plus a small battery-operated receiver to drive the headphones at your end.

Of course, IR-linked cordless headphones are available commercially and these can give you some improvement. But there are drawbacks, the main one being that the receiver unit is built into the actual earphones and/or their headband, so it can't be used with any other headphones. That means you're stuck with the ones you get and in most cases, they are not the "surround-your-ears" muff type. Nor do they have any acoustic damping.

As a result, you not only have to throttle back your hearing aid to stop it from whistling but the headphones allow quite a lot of competing sounds to enter as well.

So that's the reasoning behind the development of this project – by building it, you get to choose the best type of headphones. However, there is one more feature – it works in mono only. This has been done deliberately because stereo sound is a real drawback to those who have trouble making out speech from the TV.

This applies particularly to those films, documentaries and sportcasts where there is a lot of background music or other sounds. By using a mix of the left and right channels, we cancel most of these extraneous sounds, making the speech much easier to discern. In addition, we have applied a small amount of treble boost to the audio signal which further improves intelligibility on speech – see Fig.6.

There's one more bonus with using mono sound – it also simplifies the circuit considerably.

How it works

The method of transmission is simple and effective. Basically, the signal is transmitted using pulse-width modulation (or PWM). This converts the audio signal directly into a pulse stream of constant frequency but with the pulse width varying with the instantaneous amplitude of the audio signal.

Fig.1(a) shows the method. First, the left and right stereo signals are mixed together to give a mono signal. This signal is then passed through an input amplifier stage (IC1b) and then via a

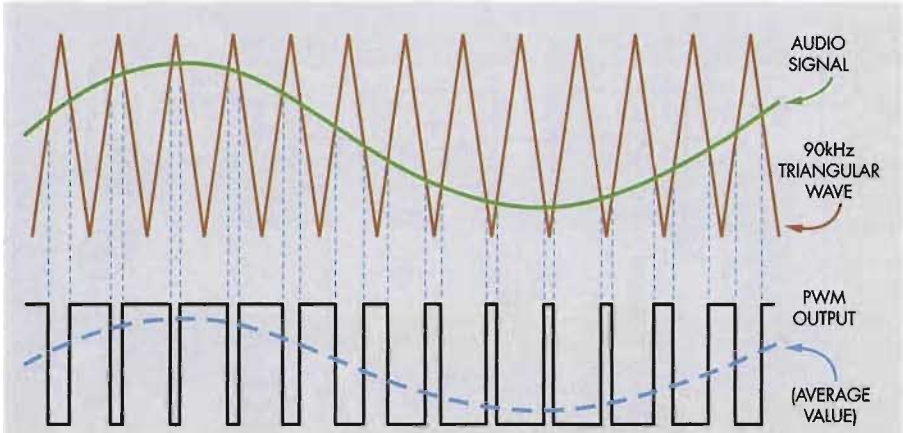


Fig.2: this diagram illustrates how the audio signal that's fed into the transmitter is compared to a 90kHz triangular waveform (the sampling signal) to produce the pulse width modulated (PWM signal). As shown, the PWM output is high when the audio signal level is higher than the sampling signal.

4-pole low-pass filter (IC1a & IC4a), which sharply rolls off the response just above 12kHz.

This is done for two reasons. First, if you are partially deaf, signals above 12kHz are not much use anyway. And second, it prevents any spurious "alias" signals from being generated during the digital modulation process – which is equivalent to digital sampling. We are using a fairly high sampling frequency of about 90kHz which tends to reduce aliasing but the low-pass filtering is also worthwhile because it ensures that virtually no signal frequencies above 15kHz are fed to the modulator.

90kHz sampling signal

Next, the audio is fed directly to the non-inverting input of a comparator (IC5) where it is compared with a 90kHz triangular wave "sampling" signal on the inverting input. This 90kHz triangular wave signal is generated by feeding a 180kHz clock signal into a D-type flipflop. This then produces a very symmetrical square-wave signal at half the clock frequency, or 90kHz. This 90kHz signal is buffered and fed through an active integrator stage which converts it into a linear and very symmetrical triangular wave.

But how does the comparator use this 90kHz triangular wave to convert the audio signal into a PWM stream? To see how this works, take a look at the waveforms of Fig.2. Here the green sinewave represents the audio signal fed to the positive input of the comparator, while the higher frequency red triangular wave shows the sampling signal fed to the comparator's negative input.

In operation, the comparator's output is high when the audio signal level is higher than the 90kHz sampling signal. Conversely, the comparator's output is low when the sampling signal's level is the higher of the two. A switching transition occurs when ever the two waveforms cross.

The resulting PWM output waveform from the comparator is shown as the lower black waveform.

Note that the comparator output is a stream of 90kHz pulses, with the pulse widths varying in direct proportion to the audio signal amplitude. The average value of the pulse stream is directly proportional to the instantaneous value of the incoming audio, as shown by the dark blue dashed curve.

Referring back to Fig.1, this PWM pulse stream is fed to a PNP switching transistor which drives a string of IR-emitting LEDs. As a result, the digitised audio is converted into a stream of IR light pulses, directed towards the receiver unit.

Receiver block diagram

The receiver is even simpler than the transmitter because of the fact that the average value of the PWM pulse stream varies in direct proportion to the audio modulation.

As shown in Fig.1(b), a silicon PIN photodiode is used to detect the IR pulse stream from the transmitter. Its output current is then through a current-to-voltage (I/V) converter and amplifier stage (IC1b & IC1a) to boost its level. The resulting pulse waveform is then fed through a limiter stage (IC2) to produce a stream of clean, rectangular pulses of constant amplitude.

Next, the pulses are fed through a multi-stage low-pass filter (IC3b & IC3a) to remove all traces of the 90kHz sampling/modulating signal. This simply leaves the audio signal which was carried in the average signal level of the pulses.

From there, the recovered audio passes to a volume control pot and finally to a small audio amplifier (IC4) to drive the headphones.

Power for the receiver circuit comes from four AA cells, which can be of either alkaline or NiMH rechargeables.

Circuit description

Refer now to the full circuit for the transmitter – see Fig.3. As shown, the incoming line level stereo signals are mixed together using two 47kΩ resistors, while trimpot VR1 sets the level. The resulting mono signal is then fed to op amp stage IC1b which operates with a gain of 23, as set by the 22kΩ and 1kΩ feedback resistors.

Next, the signal is passed through op amps IC1a and IC4a which form a 4-pole low-pass filter (or two 2-pole active filters in cascade, to be more precise). Together, these roll off the response above 12kHz. The filtered signal then emerges from pin 1 of IC4a and is fed directly to the non-inverting input of comparator IC5.

The 180kHz "twice sampling clock" signal is generated by IC2b, a 4093B CMOS Schmitt NAND gate wired as a simple relaxation oscillator. A 12kΩ resistor and 680pF capacitor set the operating frequency. This is not particularly critical, although for best performance it should be between 160kHz and 200kHz (corresponding to a sample frequency of 80-100kHz).

Flipflop stage IC3a is used to divide the clock pulses by two and generate the symmetrical 90kHz square wave. Its output at pin 1 is then passed through Schmitt NAND gates IC2a, IC2c & IC2d which are connected in parallel as a buffer. The buffer output is then coupled via a 100nF capacitor to op amp IC4b.

IC4b is configured as an active integrator to convert the 90kHz square-wave into a linear symmetrical trian-

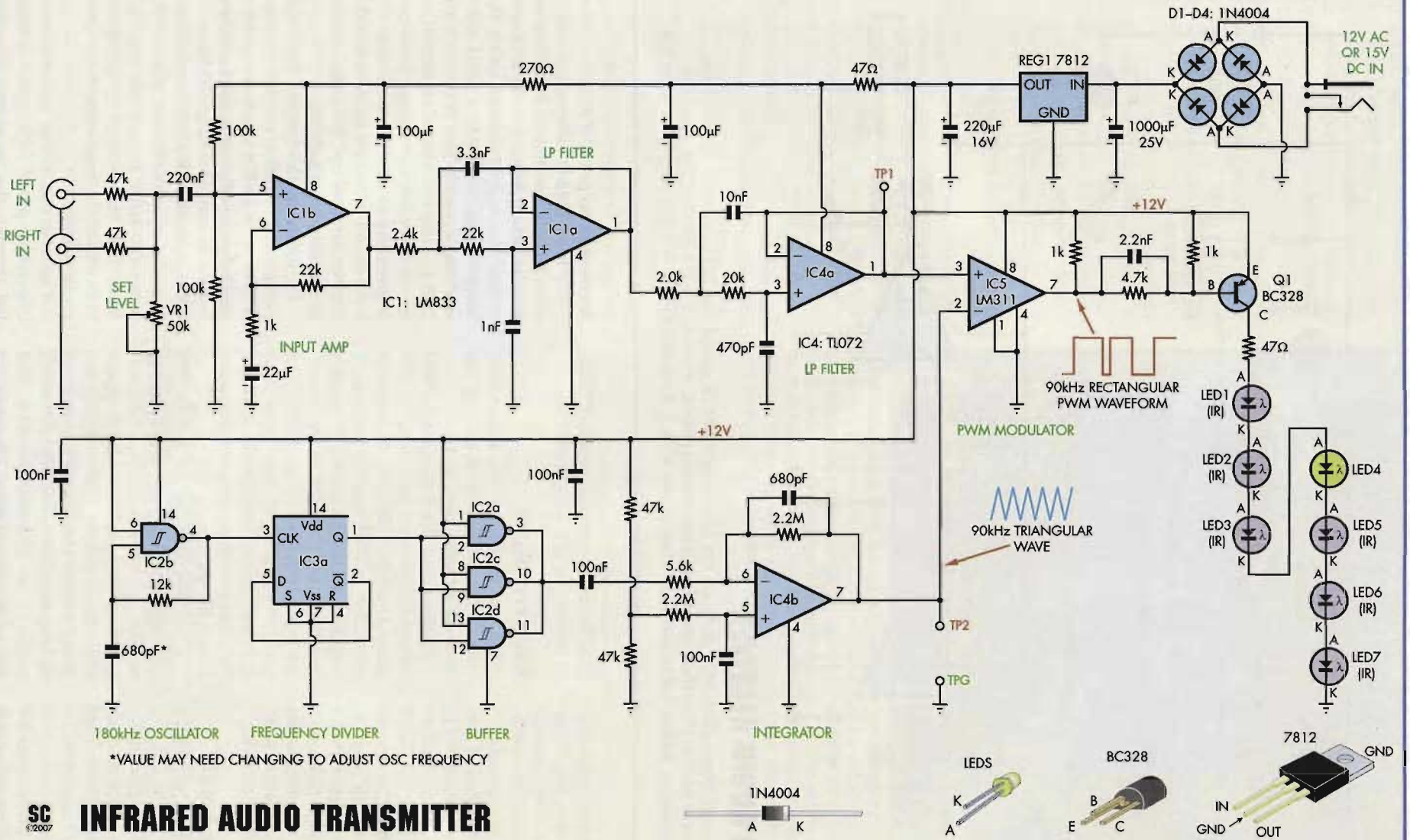
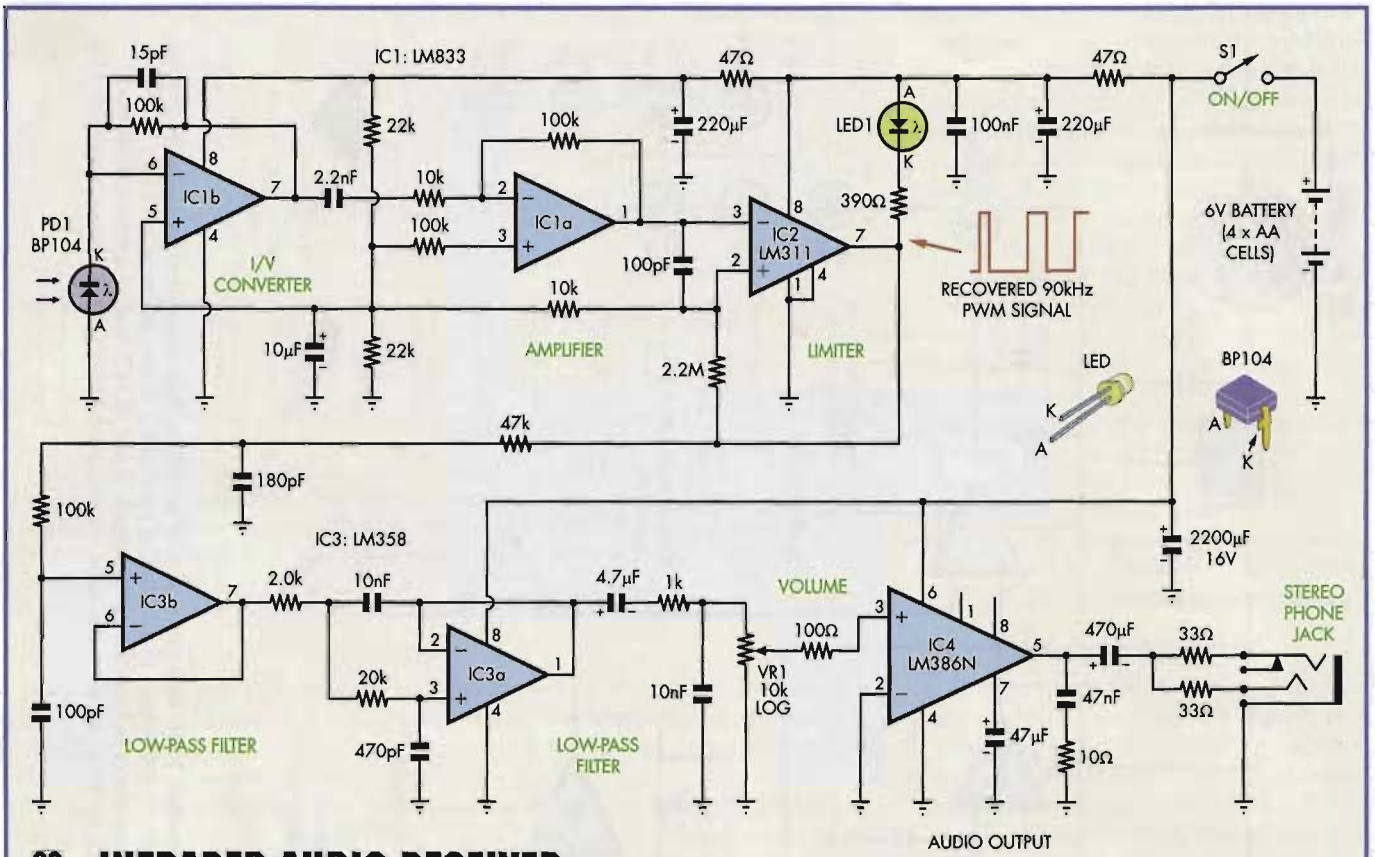


Fig.3: the circuit for the transmitter. The incoming stereo audio signals are first mixed together to form a mono signal which is then amplified by IC1b. IC1a and IC4a then filter this signal and drive pin 3 of comparator stage IC5. IC2b is the 180kHz clock. Its output is divided by two using IC3a, buffered by IC2a, IC2c& IC2d and fed to integrator stage IC4b to produce the 90kHz triangular waveform. This waveform is then fed to the other input of IC5 and compared with the audio waveform. The resulting PWM waveform from IC5 then drives transistor Q1 which in turn pulses a string of six infrared LEDs plus a power indicator LED.



INFRARED AUDIO RECEIVER

Fig.4: the receiver circuit. Photodiode PD1 picks up the incoming PWM IR signal and IC1b converts the resulting current pulses to voltage pulses. IC1a then amplifies these voltage pulses, while IC2 is the limiter. The resulting PWM signal from the limiter is then fed to low-pass filter stages IC3b & IC3a and finally to audio amplifier stage IC4.

gular waveform of the same frequency. This triangular wave is then fed directly to the inverting input of comparator IC5, to sample and convert the audio signal into the PWM pulse stream.

IC5's PWM output appears at pin 7 and is used to drive transistor Q1 (BC328). This in turn drives series-connected infrared LEDs (LEDs1-3 & LEDs5-7), along with LED4 (green) which serves as a "power on" indicator. The 47Ω resistor in series with the LED string limits the peak pulse current to around 45mA, resulting in an average current drain for the complete transmitter circuit of about 25mA.

Transmitter power supply

Power for the transmitter circuit is derived from a 12V AC or 15V DC plugpack. This feeds diode bridge D1-D4 which rectifies the output from an AC plugpack. Alternatively, the bridge rectifier allows a DC plugpack to be used with either polarity.

The output from the bridge rectifier is filtered using a 1000µF capacitor and then fed to 3-terminal regulator REG1 to produce a 12V DC supply rail.

Receiver circuit

OK, so much for the transmitter circuit. Let's take a look now at the receiver circuit – see Fig.4.

In operation, the transmitted PWM infrared signals are picked up by PIN photodiode PD1 (BP104). This device produces output current pulses in response to the incoming IR signals and these are then fed to the inverting input (pin 6) of op amp IC1b. The non-inverting input (pin 5) of IC1b is biased to half-supply (ie, 4.5V) by two 22kΩ resistors connected in series across the 9V supply rail.

IC1b operates as an active I/V (current-to-voltage) converter. In operation, it converts the input current pulses to voltage pulses which appear at its pin 7 output. These pulses are then coupled via a 2.2nF capacitor to op amp stage IC1a which operates with a gain of -10. The resulting amplified output pulses appear at pin 1 and are fed directly to pin 3 of IC2.

IC2 is an LM311 comparator and is used here as the limiter. Note that its non-inverting input (pin 2) is biased to half the supply voltage using the same voltage divider (2 x 22kΩ resistors) that's used to bias IC1a and IC1b. This ensures that the pulses from IC1a are compared with a voltage level corresponding to their own average DC level. And that in turn ensures that the limiter "squares up" the pulse stream in a symmetrical fashion.

In addition, the 2.2MΩ feedback resistor and the 10kΩ resistor in series with the bias for IC2 together provide a small amount of positive feedback hysteresis, to ensure clean switching.

Because the LM311's output (pin 7) is an open collector, it must be provided with a resistive pull-up load. This is provided by power-on indicator LED1, together with its 390Ω series resistor.

The restored PWM pulse stream appears at pin 7 of IC2 and is then fed through the receiver's low-pass

filter circuitry. This comprises passive 47kΩ/180pF and 100kΩ/100pF RC filter stages, voltage follower IC3b, active low-pass filter stage IC3a and finally, a 4.7µF coupling capacitor and a 1kΩ/10nF passive filter connecting to the top of volume control VR1.

As a result, the signal appearing across VR1 is a very clean replica of the original audio signal fed into the transmitter unit.

IC4 is the audio amplifier output stage and is based on an LM386N. It amplifies the signal from the volume control (VR1) and drives a stereo phone jack via a pair of 33Ω current limiting resistors (one to the tip and one to the ring).

Finally, the receiver is powered from a 6V battery consisting of four AA cells connected in series. These cells can be either standard alkaline primary cells or rechargeable NiMH (or Nicad) cells if you prefer. The average current drain is typically around 20mA, so even ordinary alkaline cells should give at least 80-100 hours of listening.

Construction

Building the SILICON CHIP Infrared Audio Link is straightforward, with all the parts mounted on two PC boards – one for the transmitter (code 01112071) and one for the receiver (code 01112072). The transmitter board fits inside a standard low-profile ABS instrument box measuring 140 x 110 x 35mm, while the receiver board goes inside a standard UB3-size jiffy box (130 x 68 x 44mm), along with its 4xAA cell battery pack.

Fig.7 shows the assembly details for the transmitter unit. Begin by installing the resistors and diodes D1-D4, taking care to ensure that the latter are all correctly oriented. An accompanying table shows the resistor colour codes but you should also check each resistor using a digital multimeter before installing it, just to make sure.

Next, install the small ceramic and monolithic capacitors, then install trimpot VR1, transistor Q1 and the electrolytic capacitors. Make sure that the electrolytics and transistors all go in the right way around.

Follow these parts with the five ICs. Be sure to use the correct IC type at each location and again check that they are all oriented correctly. IC sockets were used on the prototype but we suggest that you solder the ICs directly to the PC board.

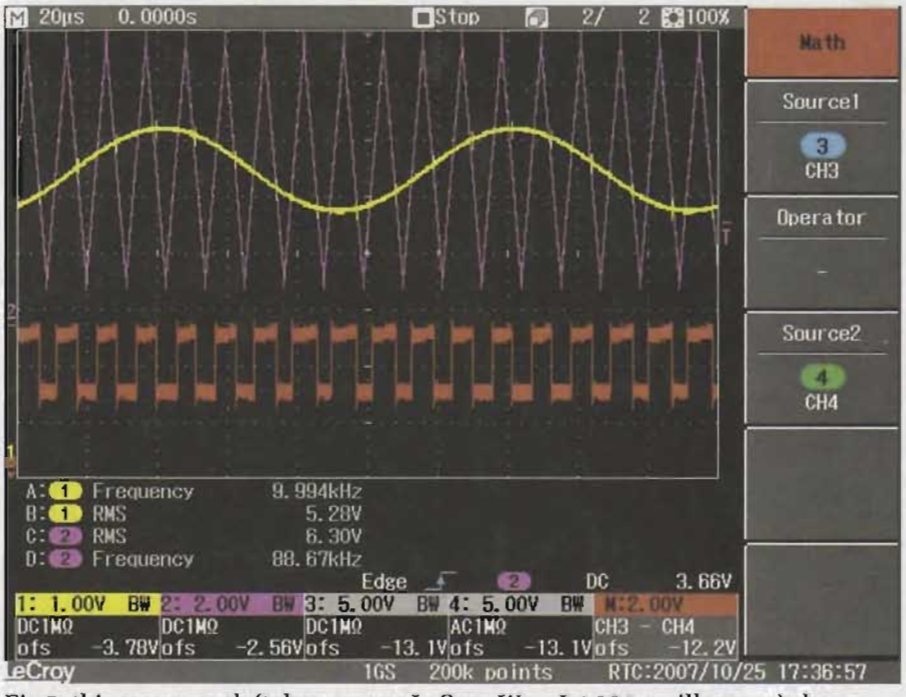


Fig.5: this screen grab (taken on our LeCroy WaveJet 324 oscilloscope) shows three waveforms. The purple trace at top is the 90kHz "sampling" triangular waveform (the carrier frequency), as measured at TP2. The yellow trace is the audio input to the transmitter, in this case a 10kHz sinewave (at TP1). And the red trace shows the signal across the 47Ω resistor at the emitter of Q1 (this signal is proportional to the current driving the transmitter's infrared LEDs). As can be seen, the pulse width of this waveform is modulated by the audio input.

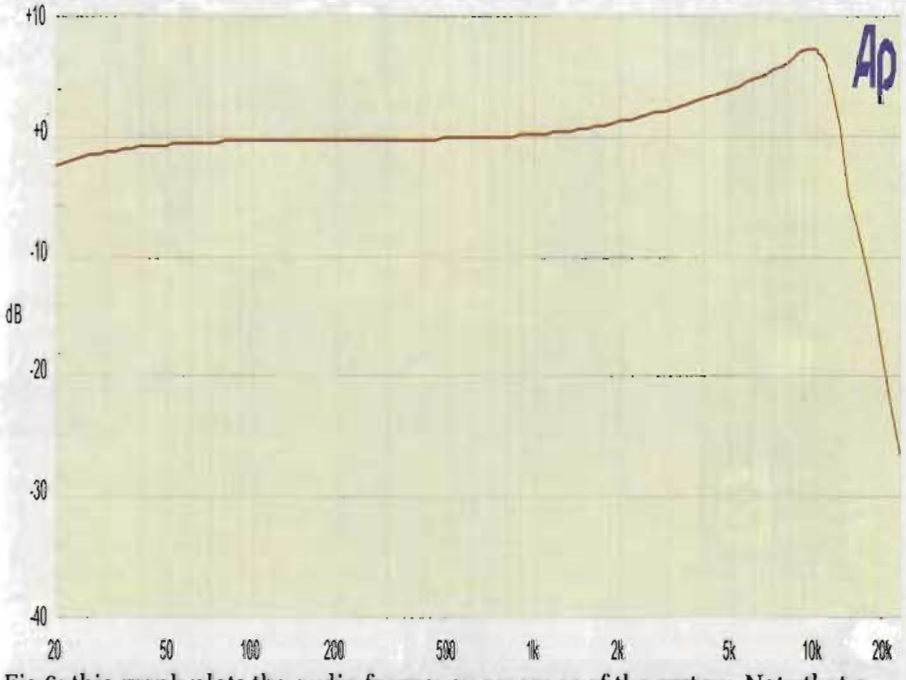


Fig.6: this graph plots the audio frequency response of the system. Note that a small amount of treble boost is applied from about 1kHz (rising to a maximum of 7dB at 8kHz) to improve intelligibility on speech.

Regulator REG1 is next on the list. As shown, this is fitted with a small U-shaped heatsink and mounted flat against the PC board.

The correct procedure here is to first bend the regulator's leads down by 90° about 5mm from the device body (use a pair of needle-nose pliers to grip the leads while you bend them). That done, the regulator and its heatsink

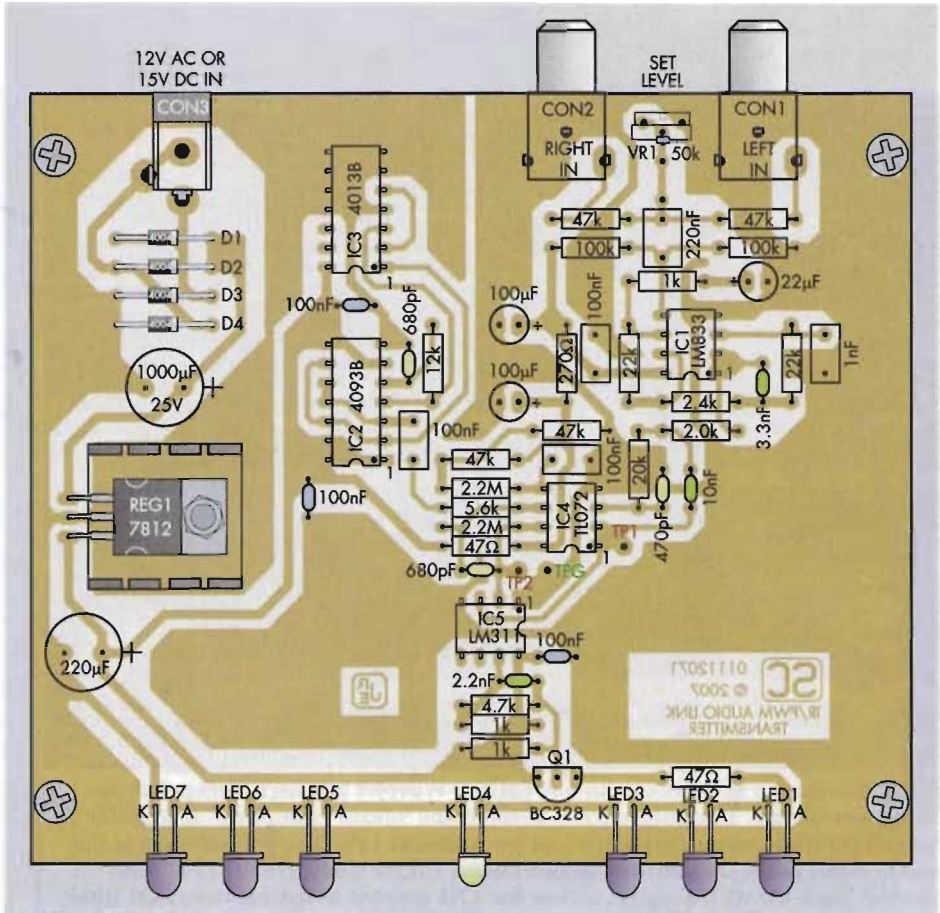
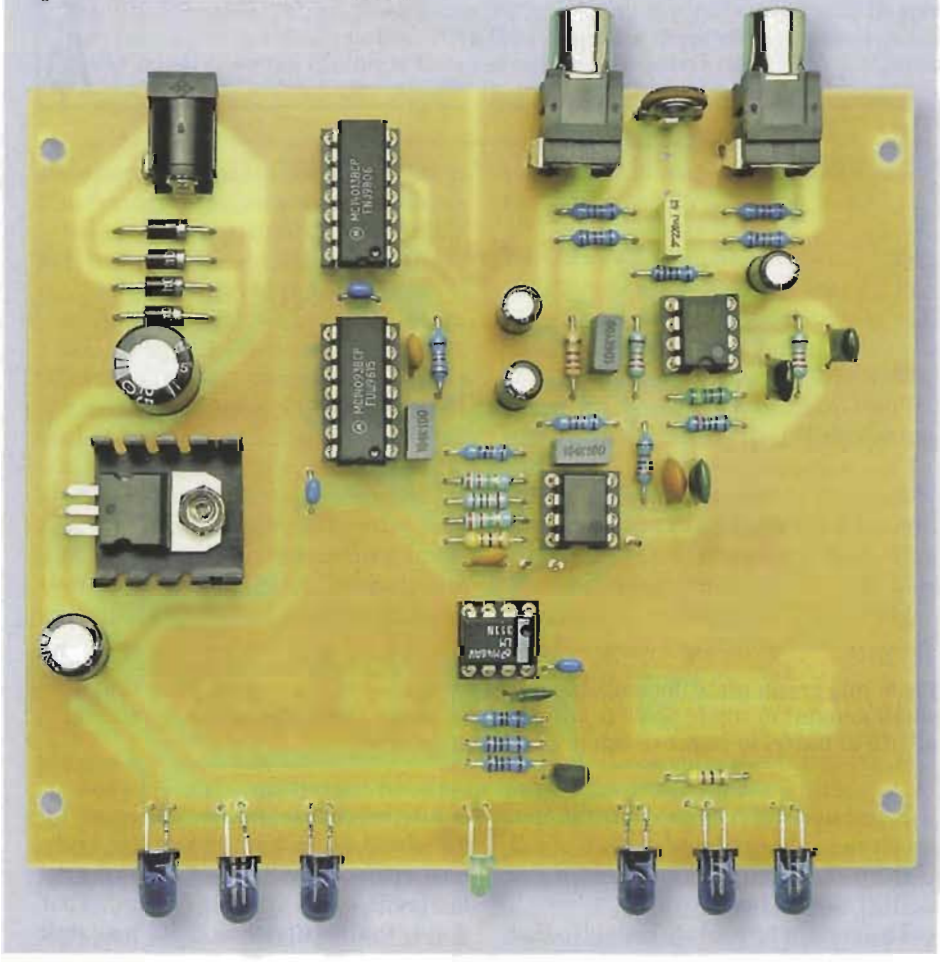


Fig.7: install the parts on the transmitter board as shown here, taking care to ensure that all polarised parts are correctly orientated. Below is a full-size photo of the assembled PC board.



Capacitor Codes (Trans.)

Value	µF Code	IEC Code	EIA Code
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
10nF	.01µF	10n	103
3.3nF	.0033µF	3n3	332
2.2nF	.0022µF	2n2	222
1nF	.001µF	1n0	102
680pF	NA	680p	681
470pF	NA	470p	471

are secured to the PC board using an M3 x 6mm machine screw, nut and lock washer.

Mounting the LEDs

As can be seen on Fig.7 and in the photos, LEDs1-7 are all mounted with their leads bent down through 90°. This is done so that the LED bodies later protrude through their matching holes in the front panel.

In each case, it's simply a matter of bending the leads down through 90° exactly 5mm from the LED's body, then installing the LED with its leads 8mm above the PC board (see photo). Make sure that each LED is correctly orientated – the anode lead is the longer of the two.

The easiest way to get the LED lead spacings correct is to cut two cardboard templates – one 5mm wide and the other 8mm wide. The 5mm template is then used as a lead bending guide, while the 8mm template is used to correctly space the LEDs off the board.

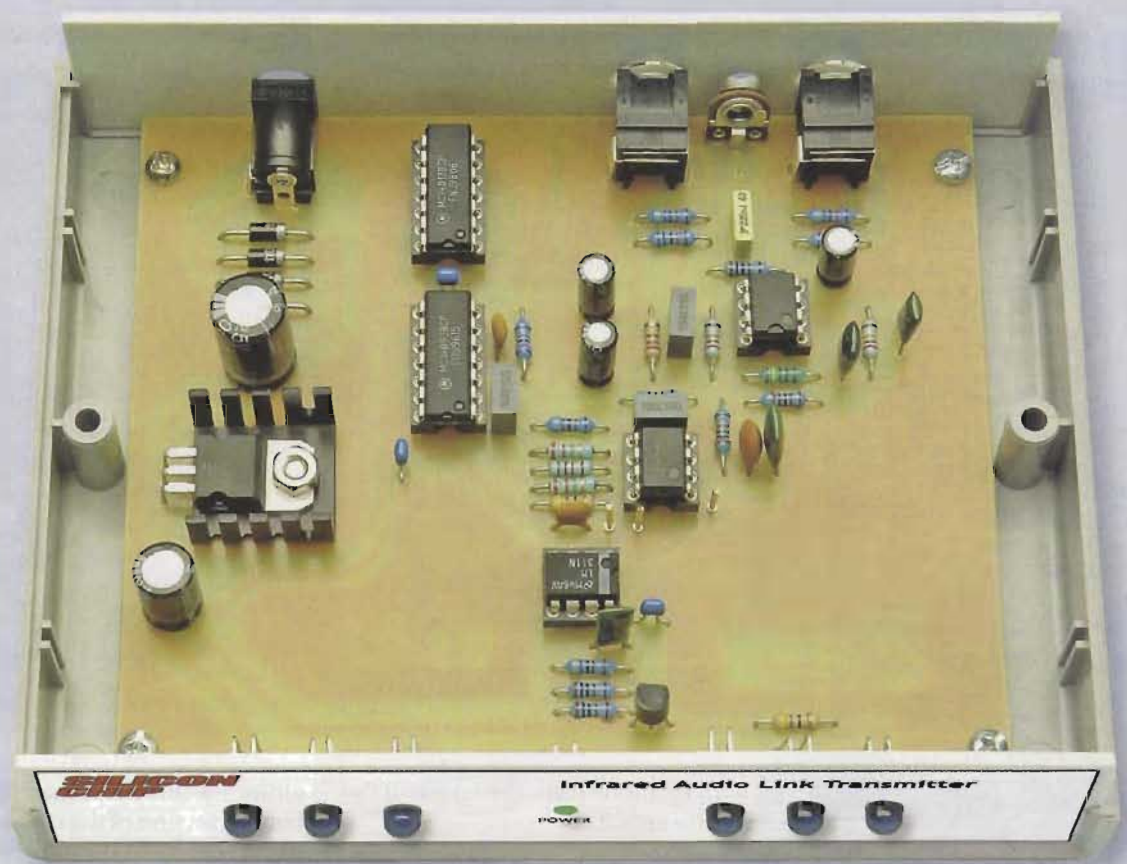
The transmitter board assembly can now be completed by installing the two RCA connectors (CON1 & CON2) and the DC power socket (CON3).

Receiver board assembly

Fig.8 shows the assembly details for the receiver board. Once again, begin by soldering in the resistors and the small non-polarised capacitors, then install the larger electrolytics and the ICs. Note that the large 2200µF electrolytic capacitor is mounted on its side, with its leads bent down through 90°.

Note also that the ICs are all different, so don't mix them up. Take care to ensure they are correctly orientated.

Once the ICs are in, install the volume pot (VR1), the headphone socket



The completed transmitter PC board is installed in a low-profile instrument case and secured using four self-tapping screws that go into integral mounting posts in the base. We used IC sockets for the prototype but you can solder the ICs directly to the PC board.

and power switch S1. Follow these by installing PC pins at the A & K positions for PD1 (the BP104 photodiode) and at the power supply inputs.

The BP104 photodiode can now be installed by soldering its leads to its PC pins (see side-view diagram in Fig.8). Be sure to install this part the right way around. Its cathode lead has a small tag, as shown on its pin-out diagram in Fig.4.

It's also vital to install this device with its sensitive front side facing out from the PC board.

Finally, LED1 can be mounted in position. This part must be mounted with 13mm lead lengths, so that it will later protrude through the lid of the case. A 13mm wide cardboard template makes a handy spacer when mounting this LED. Be sure to orientate

Resistor Colour Codes (Transmitter)

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	2.2MΩ	red red green brown	red red black yellow brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	4	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	2	22kΩ	red red orange brown	red red black red brown
❑	1	20kΩ	red black orange brown	red black black red brown
❑	1	12kΩ	brown red orange brown	brown red black red brown
❑	1	5.6kΩ	green blue red brown	green blue black brown brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	2.4kΩ	red yellow red brown	red yellow black brown brown
❑	1	2.0kΩ	red black red brown	red black black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	1	270Ω	red violet brown brown	red violet black black brown
❑	2	47Ω	yellow violet black brown	yellow violet black gold brown

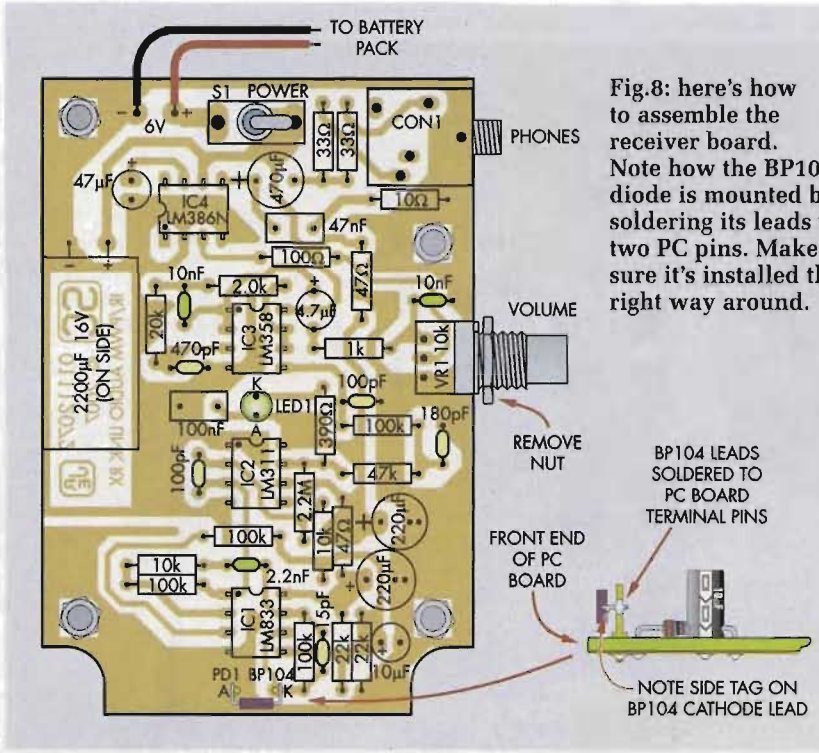
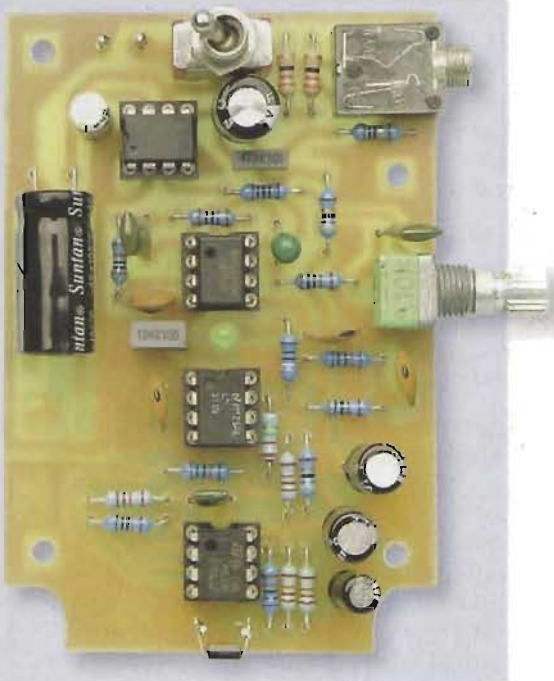


Fig.8: here's how to assemble the receiver board. Note how the BP104 diode is mounted by soldering its leads to two PC pins. Make sure it's installed the right way around.



it with its anode lead (the longer of the two) towards IC2.

Final assembly – transmitter

The final assembly involves little more than installing the PC boards inside their respective cases.

If you are building the unit from a kit, the transmitter's front and rear panels will be come pre-drilled (and with screen-printed lettering). In this case, it's just a matter of first slipping these panels over the LEDs and input sockets on the PC board. That done, the entire assembly is then slipped into the bottom section of the case and secured using four self-tapping screws that go through the PC board and into integral matching stand-offs in the base.

If you are not building from a kit, then you will have to drill these panels yourself. Fig.10 shows the drilling details. The best approach is to photostat these diagrams and then attach them to the panels so that they can be used as drilling templates. Note that hole "D" is the adjustment access hole for trimpot VR1.

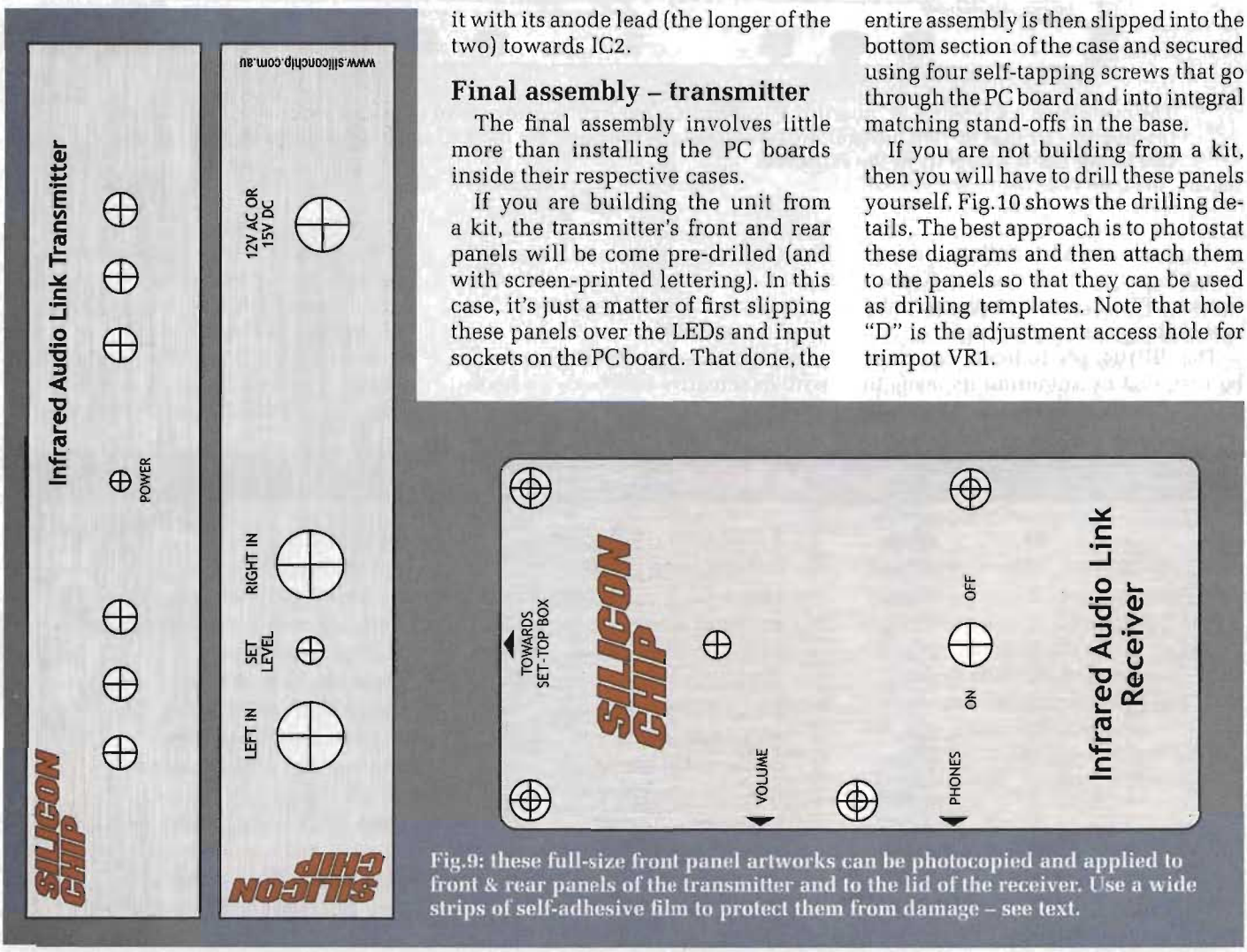
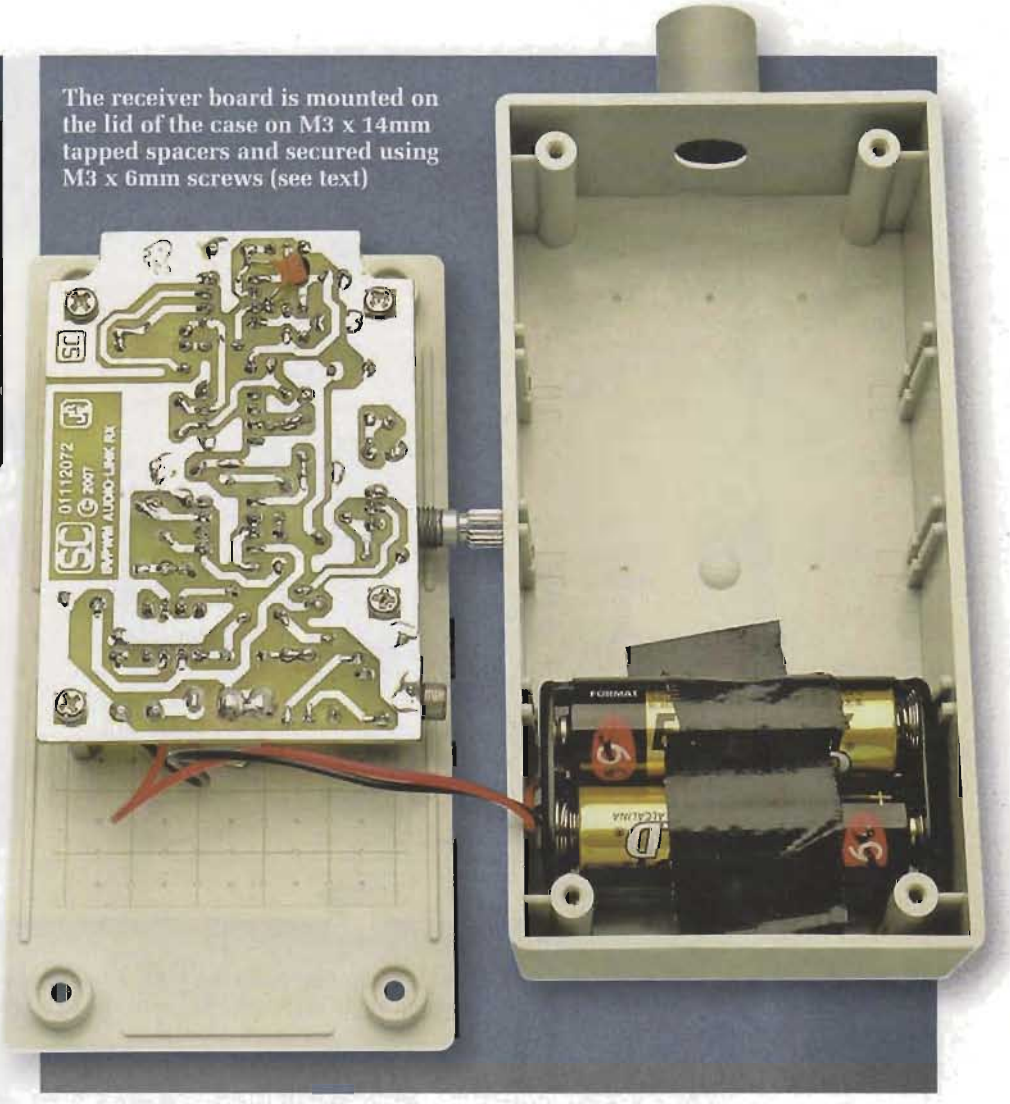


Fig.9: these full-size front panel artworks can be photocopied and applied to front & rear panels of the transmitter and to the lid of the receiver. Use a wide strips of self-adhesive film to protect them from damage – see text.

Capacitor Codes (Rec.)

Value	µF Code	IEC Code	EIA Code
100nF	0.1µF	100n	104
47nF	.047µF	47n	473
10nF	.01µF	10n	103
2.2nF	.0022µF	2n2	222
1nF	.001µF	1n0	102
470pF	NA	470p	471
180pF	NA	180p	181
100pF	NA	100p	101
15pF	NA	15p	15



The receiver board is mounted on the lid of the case on M3 x 14mm tapped spacers and secured using M3 x 6mm screws (see text)

Once the panels have been drilled, they can be dressed by attaching the relevant artworks (the files can be downloaded from the SILICON CHIP website and printed out on a colour printer). These artworks are attached using double-sided adhesive tape. Once they are attached, they can be protected by covering them with clear self-adhesive film (eg, wide sticky tape) and the holes cut out with a sharp utility knife.

Final assembly – receiver

Now for the final assembly of the receiver. Once again, kit versions will come with a case that's pre-drilled and screen printed. If you're not using a kit, use Fig.11 as a drilling template and attach the front panel artwork as described above.

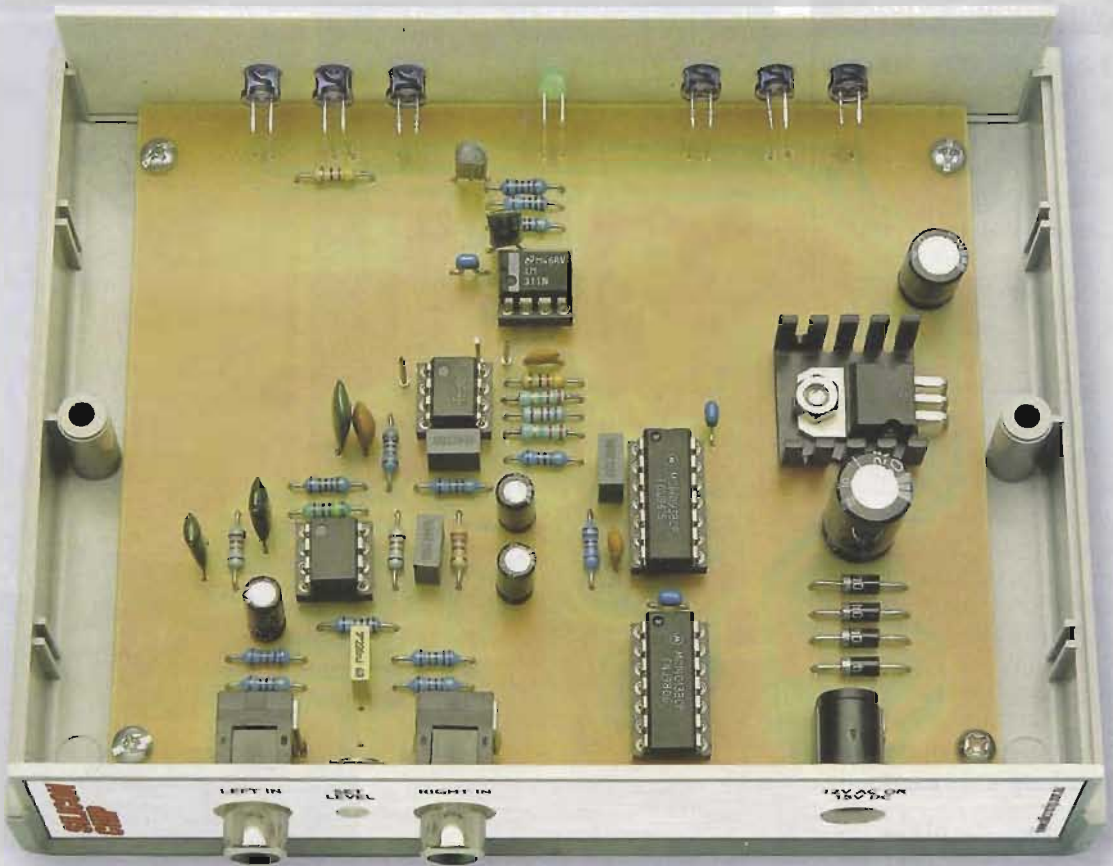
As shown in the photos, the PC board is mounted on the underside of the lid on four M3 x 15mm tapped spacers. Four M3 x 6mm countersink-head screws secure the spacers to the lid, while the PC board is secured using four M3 x 6mm pan-head screws.

The power LED (LED1) and toggle switch (S1) both protrude through matching holes in the lid. Once the PC board is in place, one of the switch nuts is fitted to the top of the threaded ferrule, to help hold everything securely together.

The two holes in the side of the box accept the shaft of the volume control (VR1) and the collar of the headphone

Resistor Colour Codes (Receiver)

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	2.2MΩ	red red green brown	red red black yellow brown
❑	4	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	2	22kΩ	red red orange brown	red red black red brown
❑	1	20kΩ	red black orange brown	red black black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.0kΩ	red black red brown	red black black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	390Ω	orange white brown brown	orange white black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	2	47Ω	yellow violet black brown	yellow violet black gold brown
❑	2	33Ω	orange orange black brown	orange orange black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown



Here's another view inside the completed transmitter. Note the lead dress on the infrared LEDs and the green indicator LED, so that they protrude through their matching holes in the front panel.



The rear panel of the receiver has clearance holes for the two RCA audio input sockets, plus access holes for the "Set Level" trimpot and the power socket. Power can come from a 12V AC or 15V DC (regulated) plugpack.

socket (CON1). Another hole at one end of the box provides the "window" for photodiode PD1.

As shown in the photos, a short length of PVC conduit was fitted around this hole, on the end of the box, to make a light shield "hood". Although not strictly necessary, it does improve the signal-to-noise ratio of the link when you are using it in a fairly large room that's lit with compact fluorescent lamps (CFLs) – ie, when there's a long link path. CFLs produce a significant amount of noise at IR wavelengths and the hood stops most of this noise from reaching PD1.

For the prototype, the hood was made using a 15mm length of 16mm OD PVC conduit. This was glued to the box end (concentric with the hole) using fast-setting epoxy cement.

The battery holder, with its 4 x AA cells, is mounted at the other end of the box. This can be held in place us-

Parts List

Transmitter Unit

1 low profile ABS instrument case, 140 x 110 x 35mm
1 PC board, code 01112071, 117 x 102mm
2 PC-mount RCA sockets (CON1, CON2)
1 2.5mm PC-mount DC socket (CON3)
1 19mm square heatsink, 6073 type
3 8-pin DIL IC sockets (optional)
2 14-pin DIL IC sockets (optional)
1 M3 x 6mm machine screw, pan head
1 M3 nut with star lockwasher
4 self-tapping screws, 4g x 6mm long
3 PC board terminal pins, 1mm diameter
1 50kΩ vertical trimpot, 5mm (VR1)

Semiconductors

1 LM833 low-noise op amp (IC1)
1 4093B quad CMOS Schmitt NAND (IC2)
1 4013B dual flipflop (IC3)
1 TL072 dual op amp (IC4)
1 LM311 comparator (IC5)
1 7812 +12V regulator (REG1)
1 BC328 PNP transistor (Q1)
6 5mm IR LEDs (LED1-LED3, LED5-LED7)
1 3mm green LED (LED4)
4 1N4004 1A diodes (D1-D4)

Capacitors

1 1000µF 25V RB electrolytic
1 220µF 16V RB electrolytic
2 100µF 16V RB electrolytic
1 22µF 16V RB electrolytic
1 220nF MKT metallised polyester
3 100nF MKT metallised polyester
3 100nF multilayer monolithic ceramic
1 10nF metallised polyester
1 3.3nF metallised polyester
1 2.2nF metallised polyester
1 1nF metallised polyester
2 680pF disc ceramic
1 470pF disc ceramic

Resistors (0.25W 1%)

2 2.2MΩ	1 4.7kΩ
2 100kΩ	1 2.4kΩ
4 47kΩ	1 2.0kΩ
2 22kΩ	3 1kΩ
1 20kΩ	1 270Ω
1 12kΩ	2 47Ω
1 5.6kΩ	

Receiver unit

1 UB3-size jiffy box, 130 x 68 x 44mm
1 PC board, code 01112072, 57 x 84mm
1 battery holder, 4 x AA cells (square)
1 SPDT mini toggle switch (S1)
1 PC-mount 3.5mm stereo jack socket (CON1)
4 8-pin DIL IC sockets (optional)
1 small knob, push-on (for VR1)
1 15mm length of 16mm OD PVC tubing (optional)
4 M3 x 6mm machine screws, CSK head
4 M3 x 6mm machine screws, pan head
4 M3 x15mm tapped spacers
4 PC board terminal pins, 1mm diameter
1 10kΩ log pot, 9mm square PC-mount (VR1)

Semiconductors

1 LM833 dual low noise op amp (IC1)
1 LM311 comparator (IC2)
1 LM358 dual low power op amp (IC3)
1 LM386N audio amplifier (IC4)
1 BP104 IR sensor diode (PD1)
1 3mm green LED (LED1)

Capacitors

1 2200µF 16V RB electrolytic
1 470µF 16V RB electrolytic
2 220µF 16V RB electrolytic
1 47µF 16V RB electrolytic
1 10µF 16V RB electrolytic
1 4.7µF 25V tag tantalum
1 100nF MKT metallised polyester
1 47nF MKT metallised polyester
2 10nF metallised polyester
1 2.2nF metallised polyester
1 470pF disc ceramic
1 180pF disc ceramic
2 100pF disc ceramic
1 15pF disc ceramic

Resistors (0.25W 1%)

1 2.2MΩ	1 1kΩ
4 100kΩ	1 390Ω
2 22kΩ	1 100Ω
1 20kΩ	2 47Ω
2 10kΩ	2 33Ω
1 2.0kΩ	1 10Ω

ing a strip of electrical insulation tape. It's then wedged firmly in position by the end of the PC board when the lid goes on.

Note that the lid assembly must be introduced into the box at an angle, so VR1's shaft and the headphone socket can enter their matching holes. It's then swung down and fastened to the box using the self-tapping screws supplied.

Set-up & adjustment

Getting the transmitter unit going is straightforward. Basically, it's just a matter of connecting the audio input leads and applying power. However, if you have an oscilloscope or a frequency counter, it's a good idea to check the frequency of the clock oscillator before you close up the case.

This is easiest done by checking the frequency of the triangular wave signal at test point TP2 (just behind IC5). The frequency here should be between 80kHz and 100kHz. If it's well outside this range, then you'll need to change the value of the 680pF oscillator capacitor to correct it.

The capacitor concerned is easy to find on the transmitter board – it's just to the right of IC2.

In practice, a value of 680pF (as shown on the circuit) should be suitable if a Motorola MC14093B device is used for IC2. However, if an ST Micro 4093B is used, this capacitor will probably have to be reduced to 470pF or 390pF. Conversely, for a Philips 4093B, the capacitor may need to be increased to 820pF or even 1nF.

The basic idea is that you increase the capacitor's value to lower the clock frequency, and reduce its value to increase the frequency.

If you don't have a frequency counter but have a modest uncalibrated oscilloscope, you can still check and

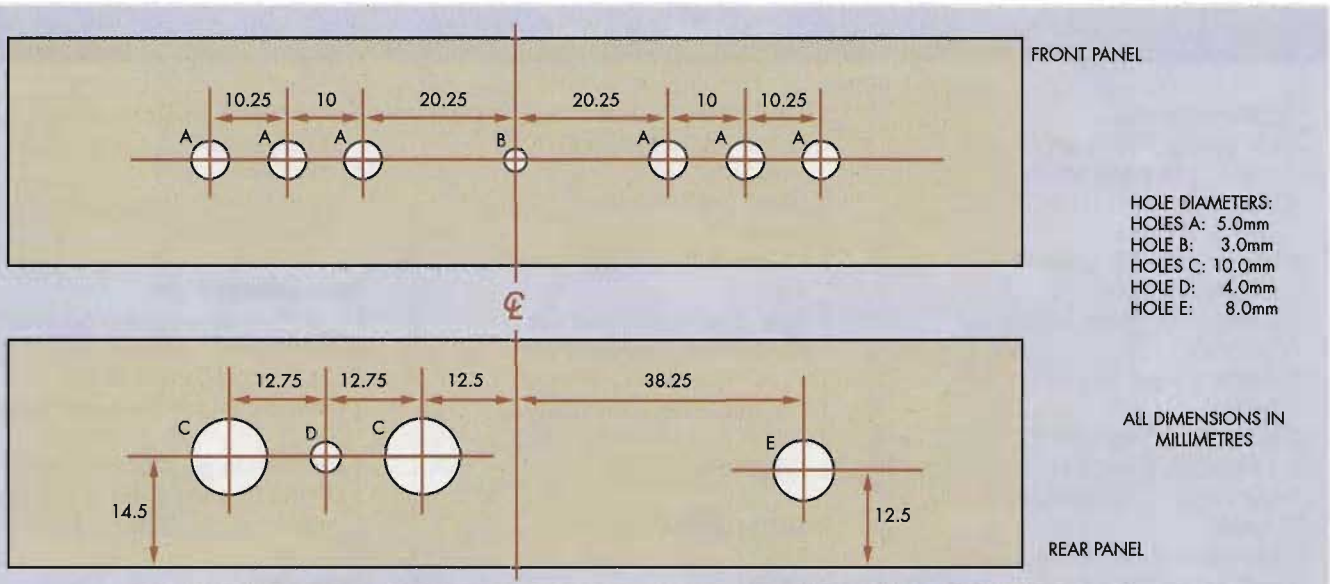


Fig.10 (above): these are the drilling diagrams for the front and rear panels of the transmitter case. They can be photostated or downloaded from our website and directly used as drilling templates if required.

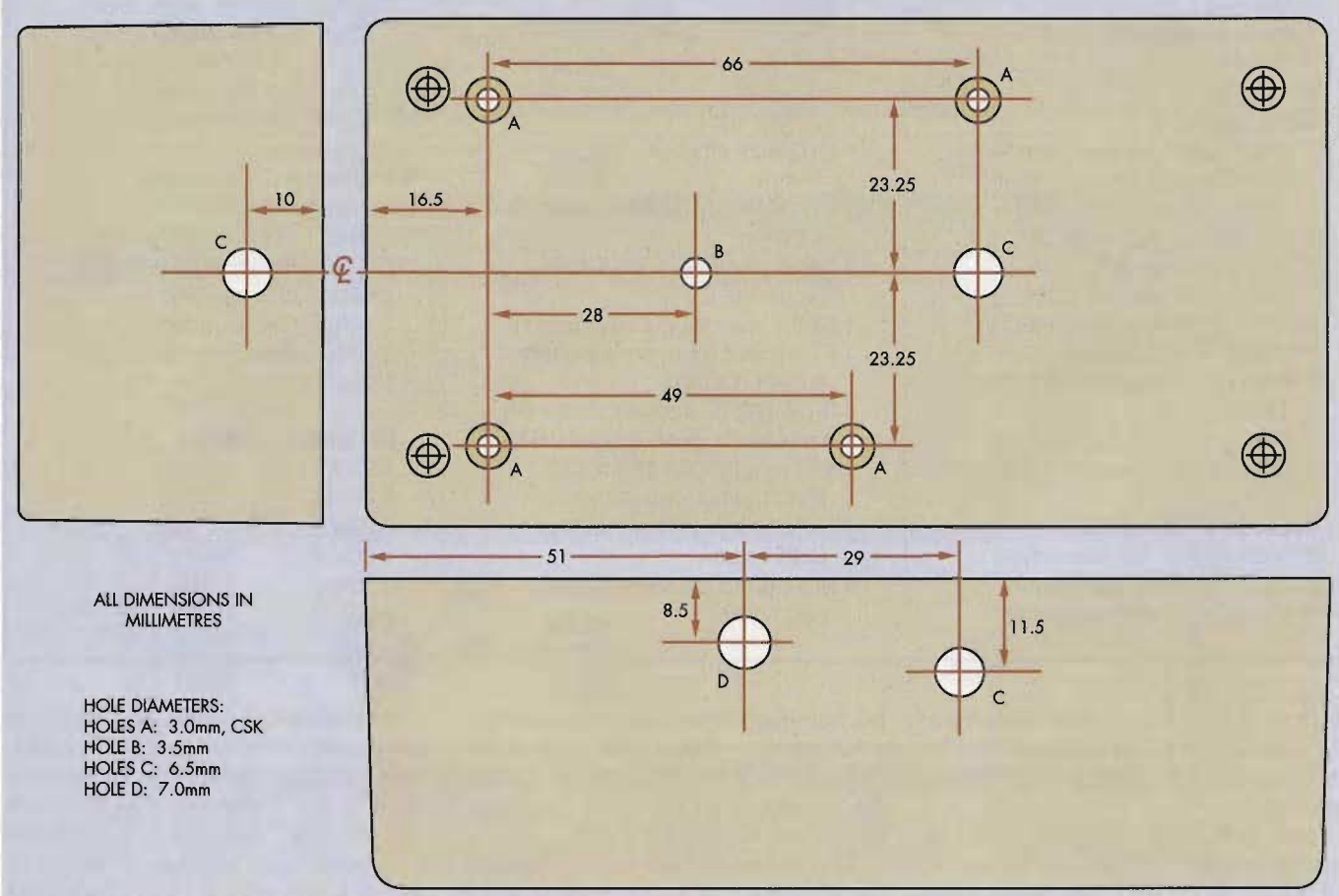


Fig.11: here are the drilling details for the receiver case. It's important to get all holes in their correct locations, so that everything lines up correctly when the receiver board is installed.

adjust the clock frequency fairly easily by using the waveform at TP2 as a guide. The waveform here should be a very linear and symmetrical sawtooth, with a peak-to-peak amplitude of about 10.5V and only a very tiny "pip" on each positive and negative peak.

If you find that the waveform is a clean sawtooth but much lower in amplitude than 10.5V p-p, this means that the clock oscillator's frequency is too high. To fix this, simply increase the value of the 680pF capacitor.

On the other hand, if the waveform does have an amplitude of 10.5V p-p

or more but is clipped or truncated rather than being a clean sawtooth, this means that your clock oscillator's frequency is too low. That's fixed by reducing the value of the 680pF capacitor.

If you don't have a counter or an oscilloscope, leave the capacitor's value at 680pF and wait to see if the link's performance is satisfactory. We'll discuss this option shortly.

The receiver unit needs no adjustments; all you have to do to get it going is to plug in your headphones, switch it on and point it towards the transmitter. The small green power LED should light and it's then simply a matter of adjusting the volume control for a comfortable listening level.

Testing the link

To test the link, first connect the left & right channel audio signal leads to the transmitter's inputs. These signals can come from the stereo line outputs on your TV. You can also use the line outputs on your VCR or DVD player but only if you are actually using this equipment.

Note that piggyback RCA socket leads may be required to make these connections if the audio outputs are already in use (eg, Jaycar WA-7090).

Next, use a small screwdriver to adjust the "Set Level" trimpot (VR1) at the rear of the transmitter to mid-position. That done, position the transmitter (eg, on top of the TV) so that it faces towards your viewing position and apply power. The transmitter's green centre LED should immediately light (assuming an audio signal is being applied) but the IR LEDs will remain dark to your eyes.

It's now just a matter of checking that the link actually works. To do this, initially set the receiver's volume control to minimum, then plug the headphones in and switch the receiver on. The receiver's green power LED should either blink briefly (if you're not pointing the receiver towards the transmitter) or light steadily if PD1 is able to "see" the infrared signal.

The idea now is to place the receiver in a convenient position so that it gets an unobstructed "view" of the transmitter. In most cases, it can simply be positioned on an armrest, an adjacent coffee table on even on the back of the sofa.

Now turn up the volume control and you should be able to clearly hear the TV sound. If so, your link is finished and ready for use.

If the sound is overly loud and distorted, even when the receiver's volume control is down near zero, it's probable that the audio input signals from the TV are overloading the transmitter. In that case, try adjusting trimpot VR1 anticlockwise using a small screwdriver, to lower the input level. This should allow you to remove any audible distortion and bring the volume down to a comfortable level.

If you find that distortion is still present even when the audio level is turned well down, this probably means that your clock frequency is either too high or too low. This can occur if you weren't able to previously check the transmitter's oscillator frequency – eg, if you don't have a counter or an oscilloscope.

In this case, try altering the 680pF capacitor's value one way or the other, to see if the distortion gets better or worse. If it gets worse, go back the other way. If it gets better, keep changing the value in that direction.

In practice, you shouldn't need to increase the capacitor value above 1nF or reduce it below 390pF in order to remove all audible distortion. SC

Specification

A cordless audio headphone link for the hard of hearing.

Provides a single channel audio link via infrared (IR) light, using pulse-width modulation (PWM).

Overall frequency response restricted to 20Hz – 12kHz, with a small amount of treble boost (maximum of 7dB at about 8kHz).

Signal-to-noise ratio approximately 50dB.

Transmitter Unit

Small set-top box accepts line level audio (either mono or stereo) from a TV receiver, VCR or DVD player, etc.

Input impedance: 47kΩ.

PWM output via six infrared LEDs

Range: about five metres.

Power supply: 12V AC or 15-18V DC, with an average current drain of approximately 25mA.

Receiver Unit

A small portable box which responds to the modulated IR light beam from the transmitter, demodulates the audio and drives a standard pair of stereo headphones (2 x 32Ω impedance).

Power supply: four AA cells (either alkaline or rechargeable NiMH).

Average current drain: approximately 20mA, giving a battery service life of 80-100 hours or more.

Controls: local volume control and a power on/off switch, plus a power/signal indicator LED.

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Rohde & Schwarz "Pigeon Pair": FS300 & SM300

Mauro Grassi takes an in-depth look at Rohde & Schwarz' new FM300 Spectrum Analyser and SM300 Signal Generator

The FS300 Spectrum Analyser can analyse the frequency domain from 9kHz to 3GHz and the matching SM300 Signal Generator can produce the same set of frequencies.

In fact, the FS300 and SM300 look almost identical face on. Both housed in robust cases; the only difference in the front panels is that the signal generator has an extra LF (low frequency) output.

Apart from that, both have a rotary knob, a numeric keypad, some soft buttons (meaning their use varies according to the selected sub menu) and some keys for navigating through their on-screen menus.

The screen is a quarter-VGA (320x200) TFT LCD. Both the Spectrum Analyser and Signal Generator will fit snugly side-by-side in a single 19inch rack.

At the rear of the units lie a host of connectors. From a monitor output, USB host port (for connecting a USB flash drive), USB device port (for connecting to a PC), a keyboard port (for attaching an external keyboard) and various BNC connectors for accepting an external trigger and reference signals.

Menus

Both the FS300 and SM300 have intuitive and easy-to-use on-screen menus. The layout of the menus is very similar in both units, making the interface rather uniform.

In the user screen there is a horizontal row of menu items, each of which has a vertical set of submenus. Thus it is easy to navigate through the menus by moving across horizontally to the desired menu and then selecting the

relevant vertical item with its dedicated "soft" button. Any further submenus appear on the vertical panel and are easy to navigate.

In both units, a number of automatic settings are provided which are adequate for most routine measurements, with a manual override available for custom measurements.

The FS300 Spectrum Analyser

Let's begin by looking at the FS300 Spectrum Analyser in more detail and what can be done with it.

The noise level is exceptional at better than -110dBm, so very weak signals – of the order of microvolts – can be detected. This is outstanding for a device in this price range. There are 16 digitally-selectable resolution bandwidths from 200Hz to 1MHz with an accuracy of 5%.

The frequency menu allows start and stop frequencies to be entered via the numeric keypad. These set the range of frequencies whose amplitudes will be displayed on the screen.

Alternatively, one may set the centre frequency and the span, with the range of resulting frequencies being the centre frequency minus half the span to the centre frequency plus half the span.

The amplitude menu allows the amplitude axis to be set for the relevant measurement. Either a relative or an absolute scale can be selected. In relative mode, a percentage scale is used while in absolute mode, the unit can be chosen from among dBM, dBmV, dBµV, mV or mW.

A Simple Radio Test

We connected an antenna (simply a random length of wire) to the input of the FS300 Spectrum analyser. We set the starting frequency at 88MHz and the end frequency at 108MHz. The result we obtained is shown in Fig.1.

The resulting spectrum shows the FM radio stations in Sydney with each peak corresponding to a radio station. Fig.2 shows what happens when we zoomed in on the interval between 104MHz and 107MHz, showing in more detail the peaks of RF detected, corresponding to the stations at 104.1MHz, 104.9MHz, 105.7MHz and 106.5MHz.

Signal Tracking

The FS300 Spectrum Analyser has an option called "Signal Tracking". When enabled, the effect is that the frequency with the greatest amplitude is set to be the centre frequency. This is useful for analysing passband filters, for example, where one very narrow range of frequencies is predominant.

Level Display Ranges

The vertical scale range can be adjusted from a choice of five ranges. Four ranges from 8dB to 80dB and a linear scale 0% to 100% are available.

In linear scale mode, 0% corresponds to a 0V or 0W reading, whereas 100% corresponds to the level offset. Moreover, up to 30000 sweeps can be averaged to reduce interference and obtain an overall impression of the amplitude of a frequency.

Markers

Markers can be used to measure the amplitude at a particular frequency. The reading of the marker is shown at the top of the display, and the marker can be varied by

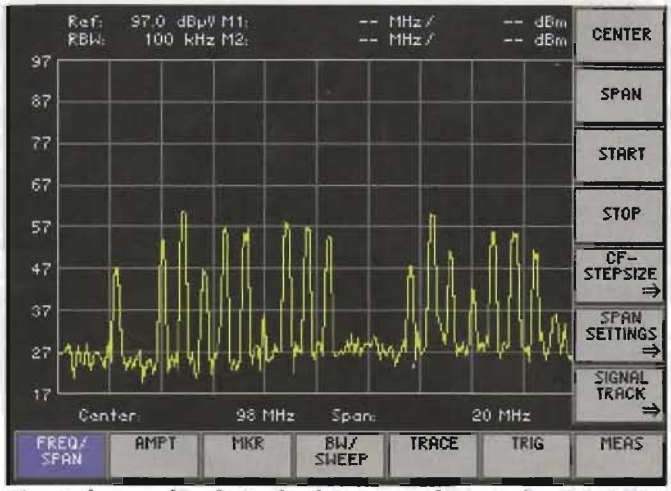


Fig. 1: the amplitude in the frequency domain from 88MHz-108MHz (the FM radio band) obtained with a makeshift aerial (a length of wire). The peaks correspond to the carrier frequency of radio stations in the Sydney area.

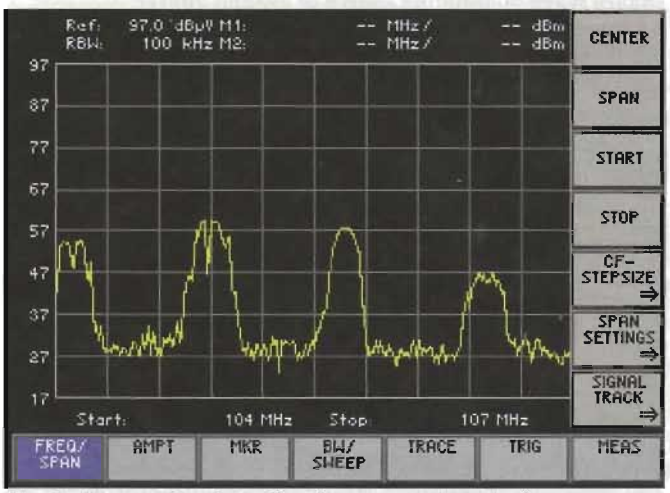


Fig. 2: the amplitude in the frequency domain from 104MHz to 107MHz (part of the upper FM radio band). The peaks (from left to right) correspond to the equally spaced FM radio stations transmitting at 104.1MHz, 104.9MHz, 105.7MHz and 106.5MHz.

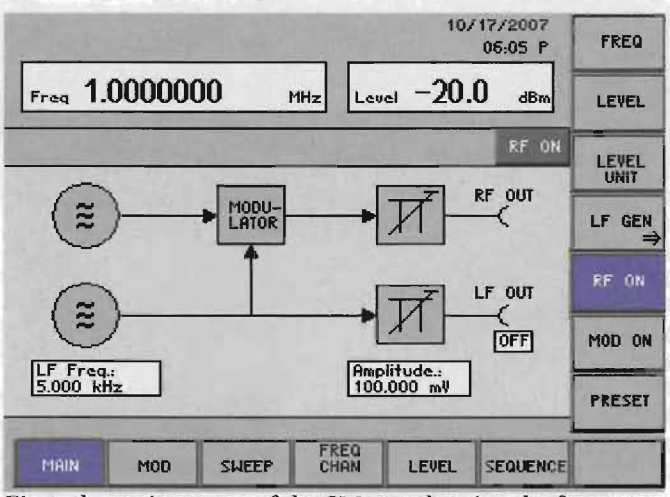


Fig.3: the main screen of the SM300, showing the frequency and amplitude of the "carrier" signal. The horizontal row of menus can be seen, with the vertical column of menu items corresponding to sub-menus of the selected horizontal menu item.

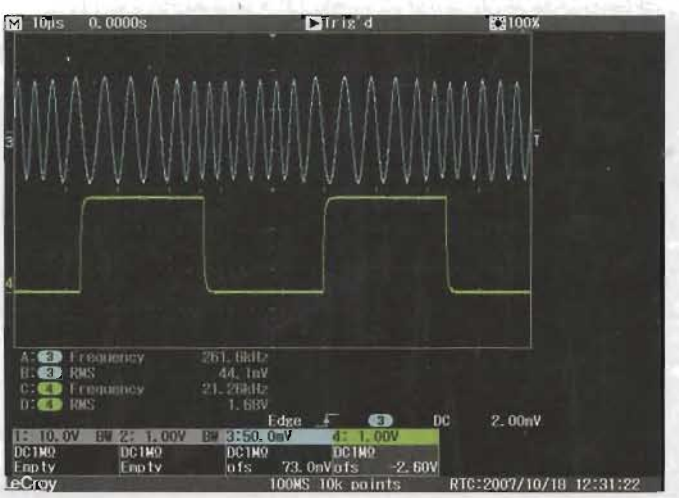


Fig.4: this shows the output of the SM300 signal generator in FM mode (blue). The carrier frequency is 200kHz. Notice the signal frequency measured by the oscilloscope is not exactly 200kHz, as expected. The green trace is the square wave modulating source of around 20kHz.

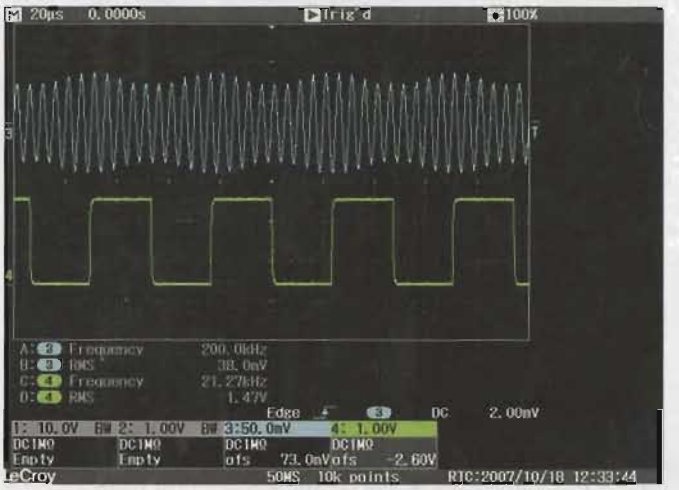


Fig.5: by contrast, the output in AM mode (blue). The carrier frequency is 200kHz. Notice the signal frequency measured by the oscilloscope is exactly 200kHz, as expected. The green trace is the square wave modulating source of around 20kHz.

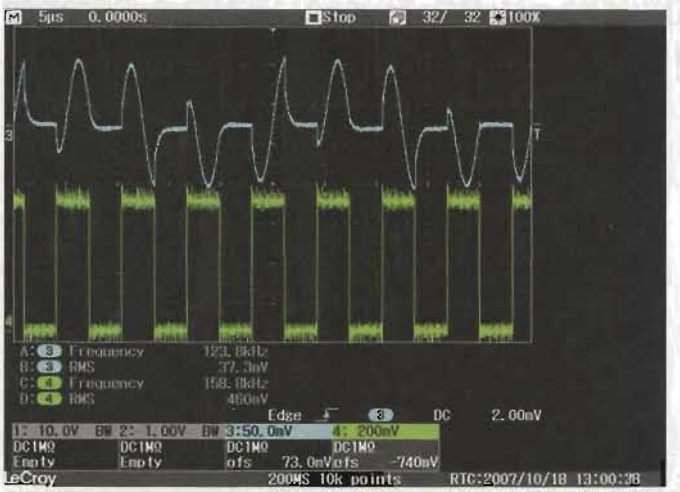


Fig.6: the signal output in IQ modulation mode. The blue trace is the signal output, which is IQ modulated with a carrier frequency around 200kHz. The green trace is the I component, a square wave at around 160kHz.

the rotary knob. Up to two markers are available on the screen at any one time.

Measuring the FM radio spectrum using the marker revealed that the signal at 104.1MHz (corresponding to 2DAY-FM radio station) was around 6nW (nanowatts). Two markers can operate in "delta" mode, where the value measured is the difference in level between the two markers.

A very useful feature allows the reference level (amplitude) and centre frequency to be set according to the *current value* of a marker.

Noise power density and signal bandwidth measurements

Using an on-screen marker and moving the rotary knob allows a particular frequency to be singled out. The FS300 can then measure the Noise Power density for that frequency. Moreover, by setting two markers the FS300 can measure the signal bandwidth. That is particularly useful when working with filters.

Display Lines

Activating a display line on the FS300 allows you to detect whether a particular frequency exceeds a certain level of amplitude. You simply change the display line with the rotary knob. The reading is displayed above the line. This feature can be considered a vertical cursor.

Frequency counter

A built-in 6-digit frequency counter allows exceptionally precise frequency measurements to be made, with resolution from 1kHz down to 1Hz.

All in all the FS300 is an impressive Spectrum Analyser with quite a fast response.

The SM300 Signal Generator

Let's now turn to the SM300 Signal generator. This is a robust and exceptionally precise signal generator with a range of modulation options. It can produce digitally modulated signals in the continuous spectrum between 9kHz and 3GHz.

Frequency, amplitude, phase, pulse and IQ modulations are possible. For IQ (in-phase/quadrature) modulation, the SM300 accepts the I and Q components from external BNC connectors on the back of the unit, meaning virtually any kind of modulation is possible.

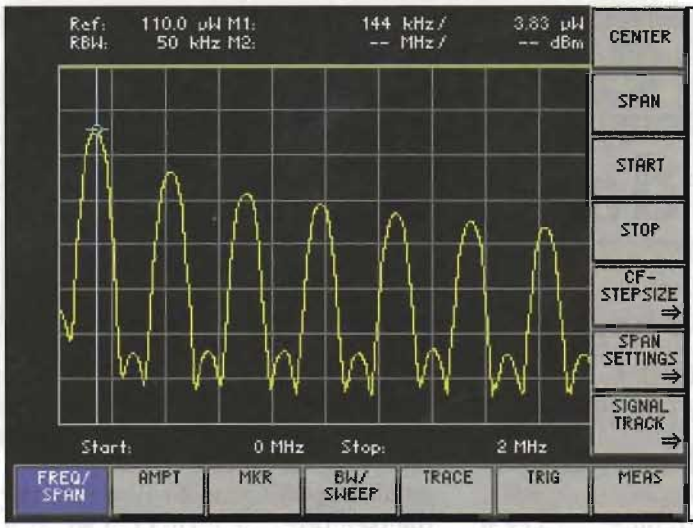
The SM300 can produce a stable source of test signals applicable to diverse areas such as mobile radio and video equipment. And its high IQ bandwidth allows it to be used for testing wifi and other wireless digital streams. A typical screen shot of the signal generator is shown in Fig.3.

Modulation

Either an internal LF (low frequency) generator or an external signal can be used as the modulation source. We connected a 20kHz square wave as the modulation source and set a carrier frequency of around 200kHz. We then tried in turn amplitude, frequency and IQ modulation and the resulting waveforms were captured using an oscilloscope.

Fig.4 shows the result of frequency modulation, Fig.5 amplitude modulation and Fig.6 IQ modulation.

We should clarify that the I component was a square wave at around 160kHz while the Q component was shorted out



UMT FS300

Rohde & Schwarz, Munich
Thu Oct 18 12:51:55 2007

Version 1.44
from 08.11.2004

CENTER	1.0000000 MHz
SPAN	2.0000000 MHz
START	0.0000000 MHz
STOP	2.0000000 MHz
CF-STEPSIZE	105.9200000 MHz
REF LEVEL	110.0 µW
REF LEVEL OFFSET	0.0 dB
RF ATTEN	0 dB /MAN
RBW	50 kHz /AUTO
VBW	200 kHz /AUTO
SWEEPTIME	50.0 ms /AUTO
TRACE 1	CL/WR
TRACE 2	BLANK
MARKER 1	ON
MARKER 2	OFF /DELTA
TRIGGER	FREE RUN

This shows the screen shot of the FS300 Spectrum Analyser displaying harmonics of a 145kHz square wave. On the right is the data recorded with the screen shot by the PC software – very handy for future reference.

with a 1kΩ resistor.

Frequency Sweeps

A powerful feature of the SM300 signal generator is its frequency sweep. The frequency can be varied gradually from a start to a stop frequency in user-selectable steps. The dwell time (ie, the time between steps) can be set from micro seconds to seconds.

This feature is useful for measuring the frequency response of a piece of equipment, including (for example) a filter.

The SM300 signal generator is exceptional and well suited to a vast range of testing applications.

PC connections

Both the FS300 and SM300 have standard USB device ports (rev 1.1) for connection to a PC. This allows screen shots and data to be acquired directly from the device. The device can also be controlled by the software. As well as this, an external keyboard and monitor can be connected.

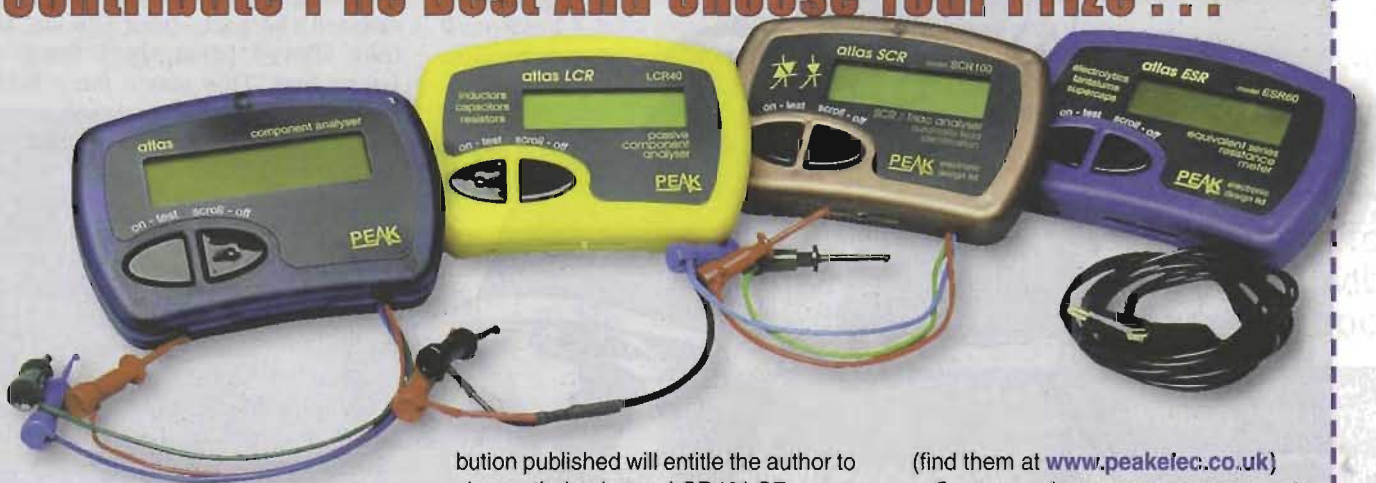
Conclusion

The FS300 and SM300 are a compatible, complete frequency domain solution for testing and d iagnostics.

For more information on pricing and availability, contact the Australian distributors:

Rohde & Schwarz Australia
Unit 2, 75 Epping Rd, North Ryde NSW 2113.
Tel (02) 8874 5100
Website: www.rohde-schwarz.com.au SC

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SERVICEMAN'S LOG

It's all in a day's work

This month, I've got rather a mixed bag, ranging all the way from a car stereo CD player to an Apple iMac monitor and on to widescreen plasma TV sets. It's all in a day's work.

A Mitsubishi Clarion PE 2527KA car stereo was brought in by a mechanic from my local garage. Its CD player wasn't working and although I don't usually do this sort of work. I agreed to have a look at it when I saw that he had gone to the trouble of bringing in the correct wiring harness (Aerpro 717011).

Anyway, I connected the red (pin 11) +12V ACC and yellow (pin 10) +12V Constant BAT leads together at my +12V supply and connected the chassis to the negative. I then switched the radio on and pressed the DISP button until the display showed "0000", after which I punched in the security code I had been given. This is done by pressing each successive preset button from 1-4 the prescribed number of times, according to the Security Code digit allocated to that button.

When I finally had the number fully displayed, I pressed the DISP button again to activate it.

I then put a CD in and you could hear it try to spin before quickly stopping with the display showing E_ _6. This meant that the laser was unable to read the TOC (table of contents).

Disassembling this radio requires the removal of a fair bit of hardware and also involves desoldering the PC board from the case. Having done that, I then propped the CD player up at an angle so that I could inspect the laser. I could now see the sled motor move as the spindle motor spun and also the laser beam lens trying to focus.

Next, I ejected the CD and cleaned the laser lens with a cotton bud before repeating the play function. It still wouldn't play and was still displaying the E6 error.

The upshot of all this was that either the laser was low emission and/or the spindle motor was worn out. In fact, I have been caught out too many times quoting for just the laser only to find out later on that the motor was on its way out too, so I tend to err on the side of caution here.

The problem was that the cost of a new mechanism plus the labour to install it was about the same as a new cheap generic car stereo (incidentally, the radio also needed a new set of 10 x 9V 6.5mA lamps). I thought that the client wouldn't go for it but the garage pointed out that fitting a new stereo meant a lot more labour on their part when it came to installing it, rather than just putting the old one back in. In addition, the original car stereo matched the rest of the car.

Having been given the go-ahead, I ordered the parts from Clarion and they arrived promptly. I fitted the lamps first. This was a fairly fiddly job and I managed to break one of the 22nF capacitors that looks like a resistor connected to the volume control switch. I had to choose a very thin replacement, as there is very little room for it.

Next, I fitted the CD servo to the new mechanism, taking care not to break the flexible cable to the laser. I then plugged it back into the main chassis, reassembled it all and switched on. To my frustration, the CD displayed exactly the same fault – an E6 error!

Now my excuses for being a dill are as follows: (1) I am a semi-senile TV technician; (2) I had had a hard week; and (3) I hate audio repairs. Clearly, I needed help.

It took an emergency help call to Clarion to find out what I had done



Items Covered This Month

- Mitsubishi Clarion PE 2527KA car stereo player
- Onkyo TXD5777 AV receiver
- Apple G5 iMac computer
- NEC PX42VP4G plasma TV
- Hitachi 52-inch plasma TV

wrong. With infinite patience the technical officer first politely asked whether I really was a technician and then went on to explain the cause! Apparently, nearly all laser assemblies are shipped with an anti-static solder short installed. I should have known this and removed it as a matter of course.

In mitigation, all the ones I have been sent by other companies in the past didn't have this solder short installed but then I only do about half a dozen such repairs a year. In fact, the Grundig stereos I repair use Sanyo lasers and these just have a plastic hood clipped over the lens. Anyway, removing the short finally fixed the CD player function.

I was a little disappointed with the six panel lights, as I couldn't quite see how those were meant to come on. With the orange DIM-IN lead disconnected, the three LCD backlights came on. The DIM-OUT lead to pin 9 wasn't connected to the wiring harness.

There was a complicated 3-transistor (Q607, Q615 & Q617) light dimming circuit but even applying a bias of 0.6V to Q617b didn't switch the front lights on, yet the transistor measured OK. However, it didn't come in for this fault and I had run right out of time, so I had to leave it as it was – at least the rest now worked correctly.

Onkyo AV receiver

To compound my bad week, an Onkyo TXD5777 AV receiver also came in with the complaint that it wouldn't turn on. When I tried it, I could hear the relay clicking but nothing else.

My initial diagnosis was that the electrolytic capacitors had gone leaky in the power supplies, especially on those rails feeding the 100-pin surface-mount microcontroller (Q8007) in the bowels of the amplifier. The relay is controlled by pin 63 and the power failure detection input is pin 20. If there isn't 5V on this pin, the microcontroller turns the relay off.

Unfortunately, I was wrong (again) because changing the electros made no difference and all the rails measured OK.

Next, I took a look at the 13V rail which is fed via 5.6V surface-mounted zener diode D8003 to the cathode of D8005. The anode is connected to pin 20 via R8002 (10kΩ), thus keeping it at +5V. The zener diode had failed so I fitted a new one but it still didn't fix the fault. However, by now, I was sure that this was the source of the problem, so I figured that the replacement was also faulty.

I changed the zener again and this time fitted a 5.1V type. The set now came on and stayed on. I then checked my first replacement zener diode by connecting it to a variable power supply and found that it was actually a 15V type. My parts supplier had put the wrong zener diodes in a bag they had clearly marked as "5.6V zener".

In the end, I tracked down a 5.6V zener diode and fitted that. None of this improved my temper because what I haven't told you is that access was rather difficult and this is not the sort of job you like to do repeatedly, especially when the component is surface mounted.

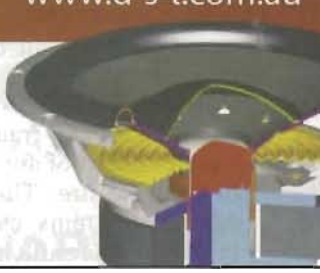
TV sets & fires

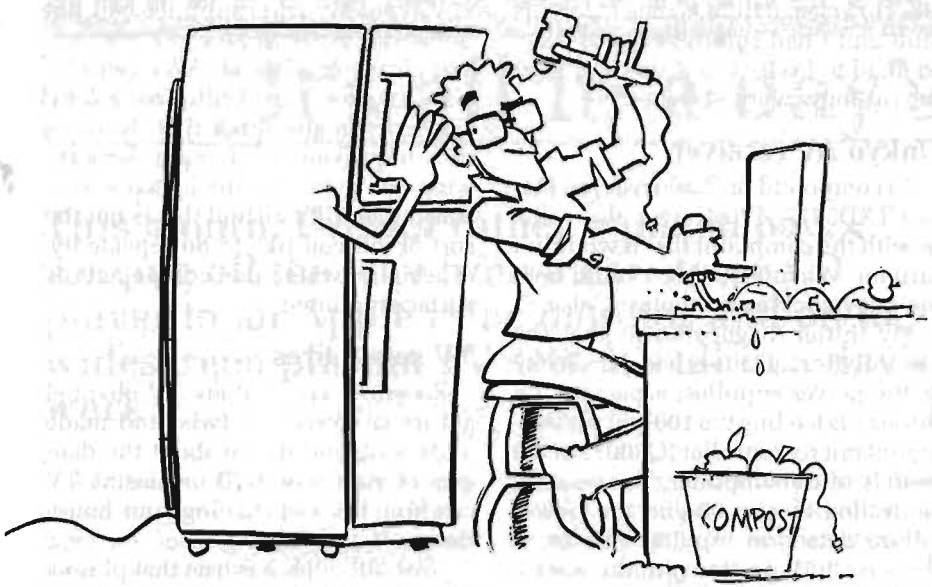
Recently, one Sydney TV channel got its knickers in a twist and made a big song and dance about the dangers of your new LCD or plasma TV catching fire and burning your house down.

Now although it is true that plasma TVs in particular consume a lot of power (and thus contribute to greenhouse gases), they do have their plus points. For example, because of the heat they radiate, they can double up as heaters in winter! Of course, the downside to this is that they contribute to the air-conditioning load in summer.

Plasma sets are still cheaper and perform better (in some respects) in the larger sizes (>101cm) than LCDs, although the latter are rapidly catching up and are better in the smaller sizes. Both are a problem for the planet when it comes to disposal because of the dangerous chemicals used in their construction.

When it comes to standby power


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consumption, the LCDs and plasmas are no worse than CRT TVs. The main problem with standby power supplies is that they are fitted into all sorts of appliances, all consuming power for 24 hours a day.

CRT TVs for the last 20 years or so have used plastic cabinets which incorporate fire retardants. In fact, these are made to various world standards. The result has been an extremely low incidence of fire due to TVs.

Of course, if there is a house fire, then the TV cabinet will be badly melted and the CRT will often implode. However, it is extremely rare for the TV itself to be the actual cause of the fire.

In fact, fires due to TV sets would be in the region of less than one per year for the whole country. Instead, fires caused by faulty plug packs and the improper use of power boards are much more common.

Ironically, one of the adverse effects of fire retardant in TV cabinets is that they tend to suffer from plastic cancer. After many years, they sometimes fracture and collapse of their own accord.

Plasma and LCD sets mainly use metal backs and frames and as yet, I haven't heard of any being the cause of a house fire. The only way that electronic items can catch fire is when there is sufficient heat to ignite surrounding components. However, plasmas and LCD sets use massive heatsinks on just about anything that gets warm on their PC boards.

The biggest danger is if a component (like a capacitor) fails in a spectacular fashion, in such away as to ignite neighbouring parts. That's unlikely in plasma and LCD sets though, since the circuits are generally designed to handle three or four times their average loads without failure. In addition, dry joints and poor plug and socket connections can sometimes melt plastic support brackets and cables in CRT sets but that doesn't seem to be a problem in plasmas and LCD sets which have solder joints as good as on computer boards. In fact, I have yet to see a dry joint in any of them.

The whole electronics industry works very hard to ensure that all components are fireproof or fire-retardant, and considering the huge quantities of electronic products out there, they have to be amongst the safest.

According to the National Coroners Information System (NCIS), there were 458 deaths due to house fires in Australia between 2001-2006, NSW having 169. Only two of those fires were attributed to TV sets over that 5-year period. Battery chargers pose a much greater risk of fire.

Of course, common sense is also necessary when it comes to TV sets. They should always be installed where there is plenty of ventilation and should not be covered with mats or other materials which can restrict airflow and which themselves are flammable.

My impoverished son

My son is an impoverished student studying medicine at university. He has a job in the evenings to make ends meet and even managed to save enough money to buy a beautiful 20-inch Apple G5 iMac computer which he uses for his studies.

Unfortunately, after using the computer for a couple of years, it developed an annoying habit of cutting off after a period of time. This period progressively became shorter and shorter, until it eventually got down to less than 10 minutes or so.

Getting it fixed by an Apple Authorised Service Agency was going to be expensive and this particular model didn't qualify for the repair extended warranty scheme being offered by Apple on the power supply. And so I volunteered to have a squiz at it for him.

The first thing to do was to identify the model. This is done by reading the EMC number which in our case was 2008, making it a Series 1 or first generation model. In addition, it carried a marketing number (M9250X/A), a model number (A1076) and, of course, the serial number.

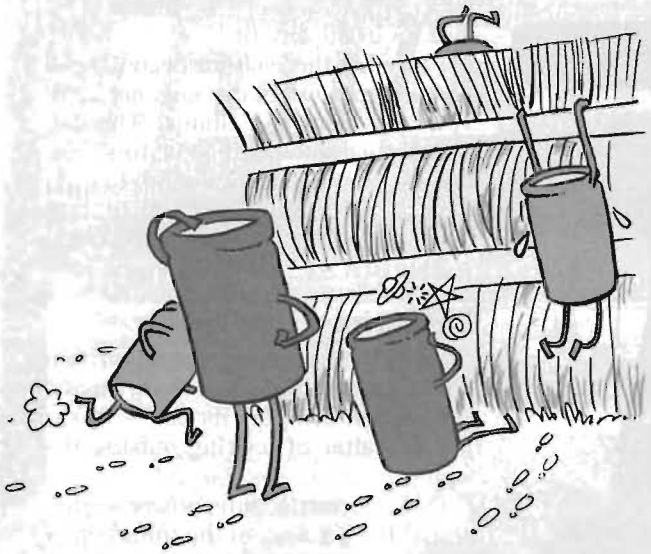
Access to the inside is very easy – just place the front down on top of two telephone books and loosen three screws along the bottom. The back and stand then swing up quite easily.

Situated in the middle of the main logic board are four diagnostic SMD LEDs, three of which glow when the computer is running. LED 4 is only on when the computer overheats, LED 3 only goes off in the sleep mode, LED 2 indicates full power and LED 1 shows that there is +5.1V standby voltage.

In our case though, all the LEDs would go out and after 10 minutes or so, LED 1 would come on again and the computer could be rebooted.

My first step was to check the power supply rails and all were correct with the exception of the +5.1V rail which feeds LED 1 (or LED 702) via R710 (330Ω) to LED 1. This started off as 5.1V but then gradually dropped until the computer died.

Unfortunately, the Chinese-made



power supply (Part No. 614-0279 or AP13 PC97) is not available as a consumer replaceable item from Apple. Instead, you have to take the computer into an Apple Authorised Service Provider (AASP) and pay a quote fee. They will then arrange for an exchange power supply which you then pay them to install.

Rather that take that route, I decided to persevere. Removing the power supply easy – it has three screws and a connector which you loosen off, after which it "folds" out towards you.

Inside is a high-density and rather complex switch-mode power supply with five ICs arranged on either side of the PC board. However, I thought I had a pretty good idea as to what was wrong from the symptoms.

First, I decided to replace all 13 electros until I came across my first big hurdle – size restraints. Many of the electros fitted had very small footprints. For example, the main B+ electros were two 82µF 450V 105°C types which had dimensions of just 31 x 18mm and obtaining exact replacements was impossible.

In the end, I managed to replace 10 of these capacitors. I then used extension leads to external electrolytic capacitors to confirm that the problem lay elsewhere and that the three remaining capacitors on the board could be left where they were.

Next, I hit the components inside the power supply with freezer and found that the most temperature-sensitive parts were around M6, a TNY267P IC. I replaced the IC and the symptoms improved immediately, though the computer would still close down after a period of time and the standby LED never went out.

It was now time for some voltage checks and this showed that the 5.1V rail was dropping to 4.45V, at which point the computer would crash. This meant that the problem was confined only to this power source.

The TNY267P is a 7-pin DIP-8B IC which is part of the TinySwitch-II family of Enhanced Low-Power



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This is a 1992 Kenwood KR-V8040 Dolby Pro Logic 100W AV Surround Sound Receiver which was caught up in a fire described in last month's Serviceman. Out of curiosity, I cleaned away the soot, removed the front panel (as the switches had all buckled and melted) and tested it. And would you believe it? – it still worked! Resistors R196 (100Ω) and R32 (47Ω) gave way a little later because I hadn't been thorough enough removing the caustic fire retardant but even then it was still working. Unfortunately, there are no parts available for it but I'm not proud. However, if there is anyone out there who has one of these that is being wrecked for whatever reason, I would be most appreciative if I can recycle the leftovers!

Off-line Switchers. It uses a power FET to do the switching and only four of its seven pins are actually used: Source, Drain, Bypass and Enable Under Voltage.

Unfortunately, the circuit isn't available to the general public and Apple's website mentions the problem but doesn't nominate the specific component that's responsible. However, I was determined to find the cause.

Though the TinySwitch-II is a simple circuit, this power supply had fully optioned it with additional features, making it far more complex. Basically, the 5.1V was fed back via SMD optocouplers M7 and M11 using shunt regulator ICs M8 and M5 (TL431). I replaced these parts, along with SCR1. The latter is an MCR100-3 but I substituted a BRY55-4.

It made no difference and the freezer told me that the more sensitive parts were the TNY267P, D18 (HER105G6), D10 (T2D44) and optocoupler TCLT1006. I managed to get replacements for just about everything except the diodes and that's where I ran into problems.

The HER diodes are high efficiency GPP types (whatever that means) and I couldn't find anything at all on T2D44. I reverted to the notes on the TinySwitch-II circuits and noted they were using 1N4005s for diodes in this location as a drain clamp.

The 1N4005 is just a normal standard-recovery diode. The trouble is, there are just too many different types of diodes with special functions to decide what sort to use for an equivalent in this particular circuit.

Disaster strikes

It was about now that disaster finally struck. When I removed diode D10 (T2D44) and measured it, I discovered that I had damaged it and it was now completely open circuit. And that meant I was snookered as there is absolutely no information available on the T2D44. I tried a UF4007, a 1N4007 and a BA159 as substitutes but the circuit refused to fire up and I am now left wondering whether it is a diode across the primary of the chopper transformer T2 that's the problem or whether I have blown something else up in the circuit.

I trawled the web for secondhand power supplies but can only get 110V versions from the States. The UK refurbished ones cost $374.40 so unless inspiration plays a hand, I might have to eat humble pie and finance the computer's trip to an AASP (Apple Authorised Service Agency).

Postscript

Well, the foregoing was all written about a month ago. And then, finally, inspiration did play its part – it was just a matter of looking outside the square.

D10 is situated in the power supply across the primary of the transformer with one end (A) going to the Drain and the other (K) to the main B+. Yet the notes on the TinySwitch-II applications do not show this. In fact, it shows a diode in *series* with a capacitor and resistor in parallel. So I tried a UF4007 diode in series with a 2.2nF 2kV capacitor and a 100kΩ resistor across the capacitor.

I switched it on and this time the PSU delivered 5.1V constantly and was running quietly, which it wasn't before. Now I haven't messed about with different values but I am pretty confident that this fixes the whole problem.

Now to track down the real part. If it isn't a diode what is it? That's when I found a German on-line forum with some bloke trying to get one for his LG plasma set! The only trouble is that he hasn't given the correct model number and I do not speak German. Anyway, I am still working on it.

Faulty power supplies

We had an NEC Plasma PX42VP4G come in that would work fine until a signal was fed into it and then the picture would go green and shut down. Until then, the OSD menu worked fine. The fault turned out to be the power supply.

This set was followed by a 3-year old 52-inch Hitachi plasma set that came in dead. We soon found that there was no standby 5V rail coming out of the extremely complex power supply.

This supply in fact consists of multiple switchmode power supplies and has enough feedback networks to choke a horse. A replacement power supply will cost around $900 fitted. The client is still recovering from a choking fit. SC

PRODUCT SHOWCASE

Got broadband? Want to set up a Hotspot?



Freenet Antennas, a leader in wireless networking (WiFi) solutions, has released the most cost effective WiFi Hotspot-in-a-box in Australia – the easyHotspot. It is designed as a plug-and-play way of adding controlled Internet access for motels, caravan parks, corporate networks, etc.

Most hotspot solutions work in much the same way as the easyHotspot. The user connects using the normal wireless interface in their laptop, open their browser and are redirected to a 'login' page. After entering their login/password, they have access to the Internet for web browsing, email, etc.

The features that make the easyHotspot standout are – Cost: from $200 including GST, it is the most cost-effective product on the market in Australia today. In addition, ongoing costs for the easyHotspot owner are minimised as the user tickets can be printed locally on any standard office printer.

Simplicity: the easyHotspot is designed to be a plug-and-play appliance. There is no user configuration. In most cases, where a site already has broadband Internet, the installation is a simple do-it-yourself process.

Customisable: the standard easyHotspot comes with a generic (unbranded) login page and generic ticket design. The easyHotspot can be customized with customer logos or other information. This is normally done before the unit is shipped.

Remotely upgradeable: an easyHotspot unit that has already been installed can be remotely customised/upgraded if needed.

Flexible ticket profiles: when a user logs in, he is then subject to zero or more limitations. Those limitations can be any mix of time – the user is logged off when his time limit expires; data volume – the user is logged off after he has downloaded a given number of bytes; and data rate – while the user is online, he has a maximum possible download speed.

Full product details are available at: http://store.freenet-antennas.com/product_info.php?products_id=250

Contact:
Freenet Antennas
3 Barker Place, Bicton, WA 6157
Ph: (08) 6262 3333 **Fax:** (08) 9319 3275
Website: www.freenet-antennas.com

eLabtronics ezCircuit Designer unlocks creative talents

ezCircuit Designer (ezCD) from eLabtronics enables students and professionals to rapidly design and program innovative microchip applications.

Released this month, ezCD Professional includes all the PIC chips in CoreChart Professional covering PIC10F, 12F, 16F and PIC18F families.

ezCD curriculum resources for high schools have been developed for systems engineering in Victoria and science studies in South Australia.

ezCircuit Designer has three major outputs: the documents, the hardware schematics and the CoreChart graphical Assembler program for the microcontroller.

Formatted documentation structures are given to help with specification, management and design documentation. Pin settings, parts lists and test procedures are automatically generated and updated, while an overall project summary shows all the project files currently contained in the project folder.

The final hardware diagrams can be exported to Proteus Lite schematics in a single step or graphic files of the circuit can be generated. Printing is flexible with tick options to print each section.

Each of the circuits comes with software drivers that are formatted into test microcontroller programs for the user.

Project templates are available to help with the design of microchip applications.

Hands-on example projects: Flash, Line Follower Robot, Reaction Game, Microswitch Counter, LCD Display, Fan/Globe Thermostat, Light Level Display and Relay control, Sounds, Music, Servo Motor control, Stepper Motors + more.

ezCircuit Designer (ezCD) Starter Pack includes:

eLab16m re-usable mini controller board with CD

Prebuilt Inputs and Outputs: Buzzer, 2 LEDs, Push Button, LDR, Thermistor, Fan, Microswitch, Relay, LCD Display

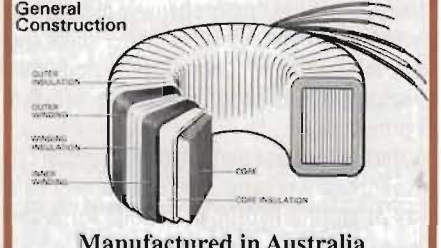


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Jaycar's solar-powered and rechargeable LED Christmas lights set

Just in time for Christmas comes this 5m string of LED lights. But this set from Jaycar are no ordinary Christmas lights: they are are solar-powered so (a) require no connection to any form of power and (b) can be safely used outdoors because there is no mains voltage involved!

All you do is put the solar cell in direct sunlight for a day or so and the unit's rechargeable batteries are automatically charged. Jaycar claim up to eight hours of lights per charge but sorry, Jaycar – we have to disagree: in our test we were able to achieve just a wee bit longer – a massive 52 hours straight (no recharging) before the LEDs gave up the ghost!

There are eight patterns to choose from and the LEDs automatically turn on at night and extinguish at sunrise. You can leave them on all night because they're not costing you even one cent in power!

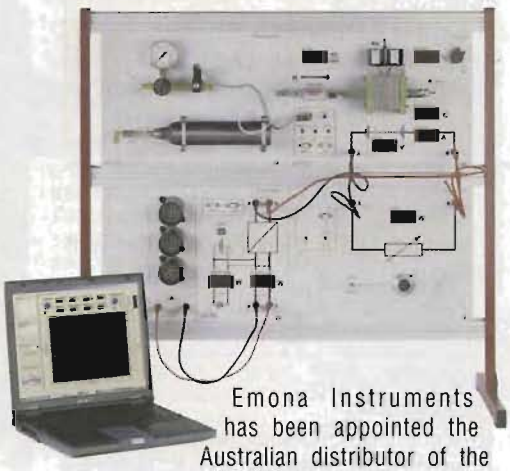
At $79.95 they are significantly more expensive than those bargain store Christmas lights – but just think: you will never have to track down that infernal blown globe again! (Cat SL-2828).





Contact:
Jaycar Electronics (all stores)
100 Silverwater Rd, Silverwater NSW 2128
Ph: (02) 9741 8555 Fax: (02) 9741 8500
Website: www.jaycar.com.au

Hydrogen Fuel Cells from Emona



Emona Instruments has been appointed the Australian distributor of the Berlin-based manufacturer of hydrogen fuel cell teaching and research equipment, Heliocentris.

Established in 1995, Heliocentris is the recognised world leader in hydrogen fuel cells for education and R & D markets having sold more than 35,000 fuel cells worldwide. Heliocentris has comprehensive curriculum and course materials which allow quick and easy integration of fuel cell technology into existing courses or for integration into R & D projects.

Heliocentris use metal hydride canisters to power their fuel cells. These are a very safe way of storing hydrogen in solid form and make the units independent of the hydrogen supply and safe to operate anywhere, i.e. laboratories, lesson theatres and perfect for mobile applications.

Metal hydride canisters can store up to 940 litres of hydrogen, but the pressure hardly exceeds 15 bar, 50 times lower than conventional pressurized bottles.

Products in the Heliocentris range include demonstration systems such as the "Professional" and the "Instructor". The "Professional" is an entry level unit for demonstrating all aspects of a single-cell fuel cell. It includes an electrolyser for hydrogen generation and comes complete with four comprehensive lesson volumes covering 25 experiments. The "Instructor" is ideal as a 2nd or 3rd undergraduate-year system with a range of auxilliary components that allows students to learn about integrating fuel cells into a system.

Finally, the "Nexa Integration Kit" is a system for electrical engineering students working to integrate a fuel cell stack into a variety of applications investigate how the stack interacts with auxilliary components. It is very popular for building into a fuel cell-powered motor vehicles in alternative energy projects and competitions, as well as commercial applications including stationary power supply systems, back-up power generators and other portable products.

The Nexa Power Module is licensed exclusively to Heliocentris for the education sector by Ballard Power Systems, the world's first volume producer of proton exchange membrane fuel cell technology.

Contact:
Emona Instruments Pty Ltd
PO Box 15, Camperdown NSW 1450
Ph: (02) 9519 3933 **Fax:** (02) 9550 1378
Website: www.emona.com.au

Legacy converters

Many new PCs and especially notebooks no longer come with connections for older devices, such as serial, parallel, or PS/2 (known as legacy devices). However, with a suitable converter, most of these can be run through a USB port, saving the user from buying new equipment.



USB is designed to accept all of the things that presently plug into serial and parallel and other (keyboard, for instance) ports and run them all from one interface usin only one IRQ and I/O range, no matter how many devices are connected (up to a maximum of 127). And if that's not enough, USB Hubs are available to multiply the number of ports.

MicroGram has a range of USB I/O converters to suit legacy devices, including USB to RS232 (serial) devices, USB to RS422/485 (industrial), USB to parallel and USB to PS/2

Contact:
Microgram Computers
PO Box 8202, Tumbi Umbi, NSW 2261
Ph: (02) 4389 8444 Fax: (02) 4389 8388
Website: www.microgram.com.au

Lightweight handsfree LED head torch from RS



This lightweight, water-resistant LED head torch has three brightness settings, maximum, optimum and economic and an intermittent mode.

Features of the Petzi Tikka Plus, now available from RS Components, include:

- Bright illumination along with lightweight, efficient and comfortable design
- Adjustable elastic headband giving stability and comfort
- LED produce flood beam lighting with a long burn time.
- The lighting level can be adjusted to help conserve battery life, batteries last up to 150 hours on regular settings and up to 400 hours on intermittent mode
- Lamp articulates with new tilt feature – The beam can be easily aimed where needed.
- Single compartment contains LED and batteries making this lightweight head torch only 78 g including batteries.

All Petzl headlamps are individually tested and guaranteed for three years. They are water resistant for all-weather use.

Contact:
RS Components Pty Ltd
25 Pavesi St, Smithfield NSW 2164
Ph: (02) 9681 8558 **Fax:** (02) 9681 8614
Website: www.rsaustralia.com

Altronics Classy Class-A Kit

Altronics have released their superb Class-A Amplifier kit which follows the series of articles earlier this year in SILICON CHIP.

The kit is true to the original design and includes remote volume control, speaker protection and muting, low noise power supply, transformer and all components required to construct a fully built up amplifier – with a professionally punched, screened and powder-coated steel chassis.

And what an amplifier! With 2x20W output at an almost unmeasurable 0.0006% THD, this is one for the true believers in state-of-the-art audio.

Retail price of the complete kit is $599.00. It's hard to compare this with commercial amplifiers because it's very hard to find any which compare – at any price!



Contact:
Altronics (Perth, Melbourne, Sydney)
PO Box 8350, Perth Busn. Centre WA 6849
Ph: 1300 797 007 Fax: 1300 789 777
Website: www.altronics.com.au

Are the days of cheap flash disks about to end?

SanDisk Corporation, the inventors of flash storage cards, is getting tough with companies that manufacture, sell and import into the USA, removable flash storage products including USB flash drives, CompactFlash cards, multimedia cards, MP3/media players and other variations on the theme.

They have filed three patent infringement actions against 25 companies. And there are some pretty well-known names included in those 25.

SanDisk said that the legal actions demonstrate their long-term commitment to enforcing its patents, both to protect their investment in research and development by obtaining a fair return on that investment and out of fairness to third-parties that participate in their patent licensing program

Their goal to resolve the matters by offering the opportunity to participate in the patent licensing program, otherwise they will be seeking damages, obtaining injunctive relief and banning the importation of infringing products.

Electronics Project Designer /Writer Wanted!

SILICON CHIP, Australia's only electronics magazine, is looking for a technical all-rounder to join the team in 2008.

You'll need good electronics design and prototyping skills – as a **SILICON CHIP** reader, you'll have seen (and almost certainly built!) the type of projects which appear in the magazine so you'll know what we are looking for.

But you'll also need to be able to write very well; to describe your projects in the **SILICON CHIP** style, ready for publication with minimal editing.

Of course, you'd be very computer literate, perhaps with some experience in web development and web software skills. A working knowledge of popular PC-based packages (eg, word processing, graphics, photo and desktop publishing) wouldn't go astray.

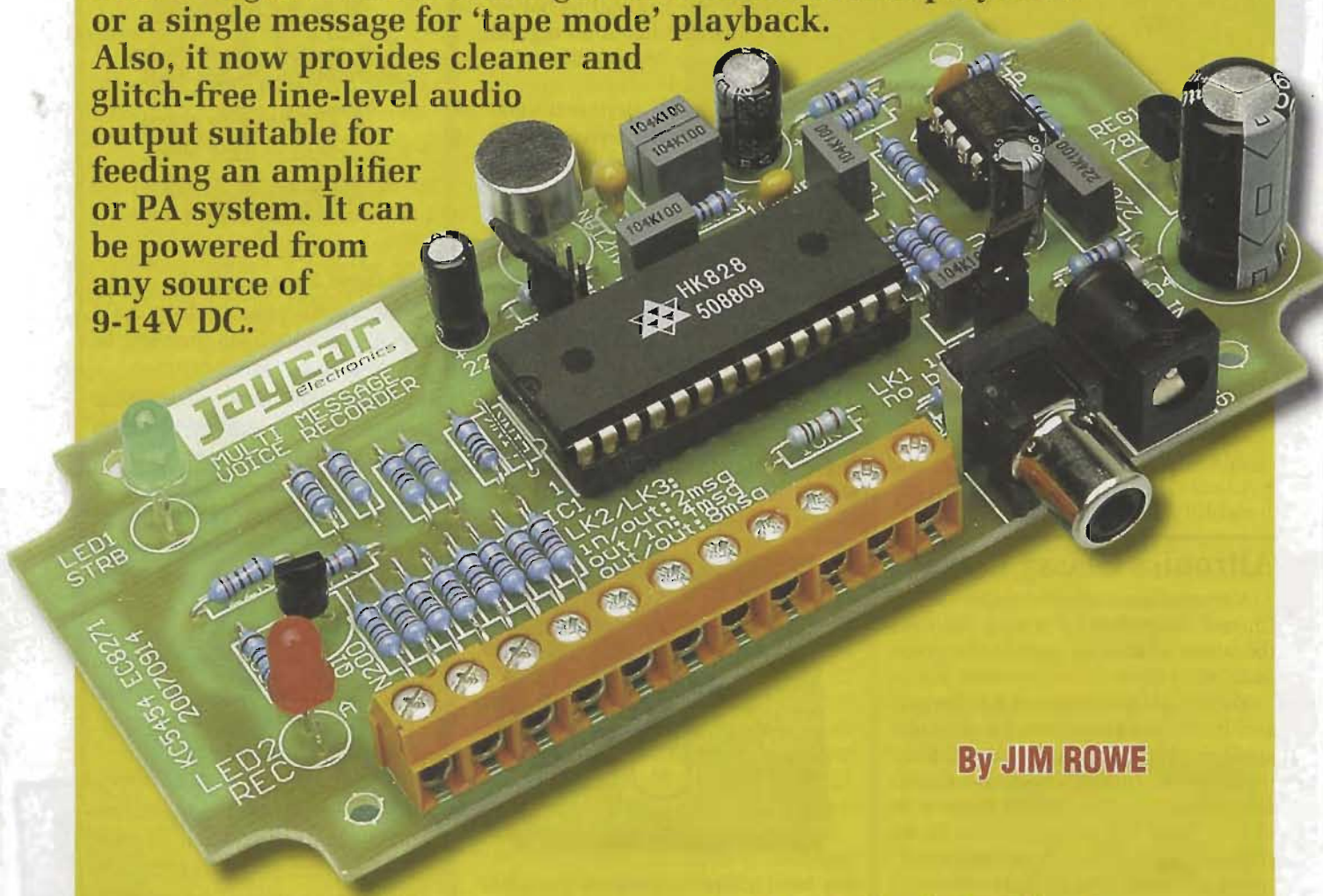
Sub-editing experience? That's a bonus too!

This is a full-time position, located at Brookvale on Sydney's Northern Beaches. For the right person, this position could lead to a future management role.

In first instance, email your resume (including detailed experience and references) to Leo Simpson, **SILICON CHIP** Editor/Publisher:

editor@siliconchip.com.au

Here's an improved version of the very popular voice recorder design we published in May 2005. It can now be set up easily to record two, four or eight different messages for random-access playback or a single message for 'tape mode' playback. Also, it now provides cleaner and glitch-free line-level audio output suitable for feeding an amplifier or PA system. It can be powered from any source of 9-14V DC.



By JIM ROWE

AN ENHANCED 45-SECOND VOICE RECORDER MODULE

The solid state voice recorder module published in the May 2005 issue of SILICON CHIP proved to be very popular. It has been used in all sorts of applications where messages or sounds needed to be recorded and played back reliably under either manual or micro control.

But it had limitations – one of which was that it could only be used to record and play back one long message or a number of short messages in sequential 'tape recorder' fashion.

This was despite the fact that the recorder chip we used was capable of recording and playing back up to eight messages in 'random access' mode. The module needed a fair bit of 'hacking' to make the chip work in this mode.

Another limitation was that the playback sound quality of the module was fairly noisy and each message played back was accompanied by an irritating 'click' at the start and finish. With the benefit of hindsight this was due to the way we had chosen to couple the output audio from only one side of the recorder chip's push-pull output.

Hindsight also revealed a third limitation: the 2005 module had been designed to operate from a 6V battery, whereas many people wanted to use it from a nominal 12V DC source.

It was with these limitations in mind that we decided to develop the new and improved sound recorder module described here.

It's based on the same HK828 chip used in the 2005 module but with the rest of the circuit designed to allow more flexibility in terms of message storage and to provide much cleaner and click-free playback audio. Finally, the new circuit can run from any source of DC between 9V and 14V.

The HK828 chip has the ability to store single or multiple messages with a total length of between 40 and 60 seconds, depending on the sampling rate and the voice quality you want.

In this new recorder module the chip is again teamed up with a low-cost electret microphone to allow easy message recording, plus an LM358 dual op amp IC which allows the recorded messages to be played back as a line level audio signal available for feeding an external amplifier and speaker.

A suitable small amplifier for use with the module would be "The Champ", as described in the February 1994 issue of SILICON CHIP. This is available at low cost ($5.95) from Jaycar Electronics as KC-5152.

We've given the new module a set of 'jumper links' so it can be easily configured to record and play back messages in any of four modes: either two, four or eight messages in random access mode or one or more messages in sequential access 'tape mode'. Another link allows the HK-828 chip's message start 'beeps' to be enabled or disabled, as you wish.

All message selection, record and play functions are controlled externally, by connections to a row of screw terminals along the side of the module. All functions are enabled by switches or logic signals. This makes it easy to record or play back messages using a set of pushbuttons and a switch or under the control of a PC, microcontroller or security system if you prefer.

By the way, since the HK828 voice recorder chip is only available from Jaycar Electronics in Australia and New Zealand, kits for the new recorder module will only be available from Jaycar and its dealers.

How it works

Because HK828 chip forms the functional heart of the recorder module, you need to have at least a rough idea of what goes on inside this chip in order to understand how the recorder works. Fig.1 shows the chip's basic architecture.

First, the chip includes a high-gain microphone preamp so that it can be driven directly by a low cost electret microphone insert. An automatic gain control (AGC) circuit follows the preamp, to ensure that good quality recordings can be made without any need for manual gain adjustment, despite input signal level variations.

The output of the AGC circuit is not connected directly to the chip's recording circuitry but is brought out to the 'Aout' pin instead. This is linked to the 'Ain' pin by the user, to record messages from the microphone. This arrangement allows the chip to be used to record from line level signals in other applications.

Since the main part of the HK828 records by a process of sampling the audio signals fed into it via the Ain

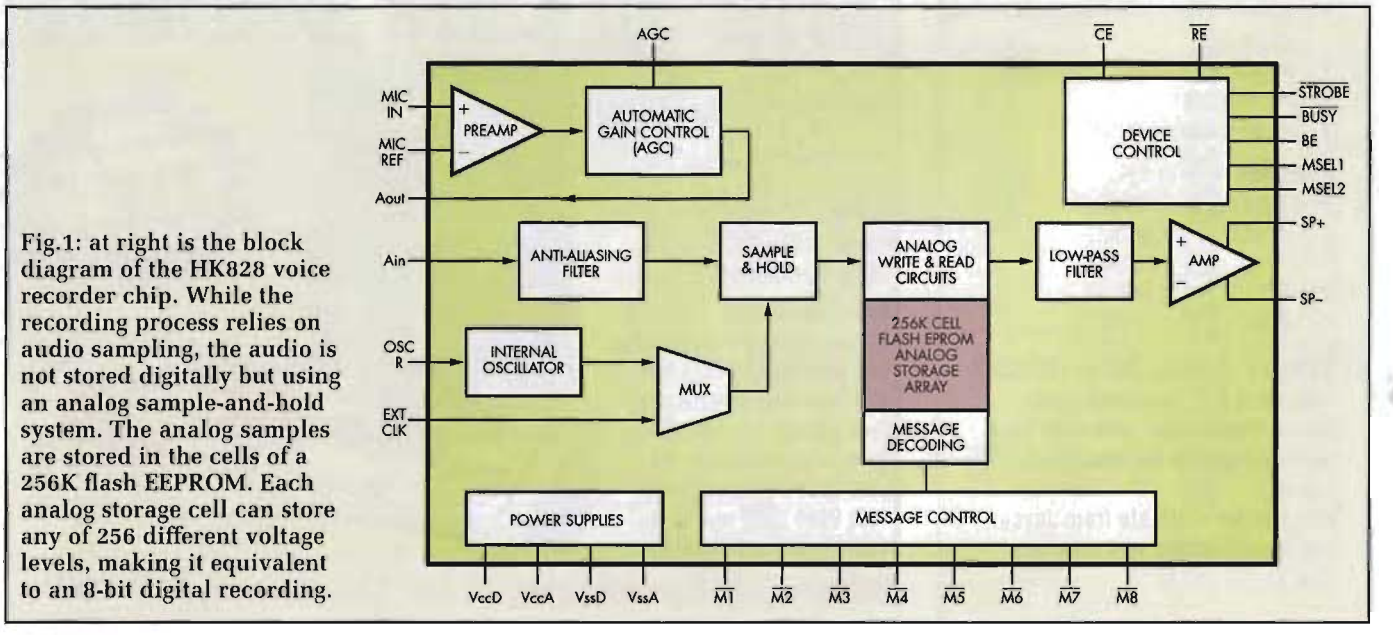


Fig.1: at right is the block diagram of the HK828 voice recorder chip. While the recording process relies on audio sampling, the audio is not stored digitally but using an analog sample-and-hold system. The analog samples are stored in the cells of a 256K flash EEPROM. Each analog storage cell can store any of 256 different voltage levels, making it equivalent to an 8-bit digital recording.

Parts List – Enhanced Voice Recorder

1 PC board, code EC8271, 119 x 57mm
1 electret microphone insert (AM-4011)
3 3-way terminal blocks, PC board mtg
1 2-way terminal block, PC board mtg
3 2-pin sections of SIL header strip
3 jumper shunts
1 28-pin DIL IC socket, 15.24mm spacing
1 8-pin DIL IC socket, 7.62mm spacing
1 2.5mm concentric DC power plug, PC board mtg (CON1)
1 RCA audio socket, PC board mtg (CON2)

Semiconductors

1 HK828 voice recorder IC (IC1)
1 LM358 dual op amp (IC2)
1 78L05 +5V regulator (REG1)
1 PN200 PNP transistor (Q1)
1 5mm green LED (LED1)
1 5mm red LED (LED2)
1 1N4004 1A diode (D1)

Capacitors

1 2200µF 16V RB electrolytic
1 220µF 16V RB electrolytic
1 22µF 16V RB electrolytic
1 10µF 16V RB electrolytic
1 4.7µF 25V tag tantalum
1 220nF 100V MKT metallised polyester
5 100nF 100V MKT metallised polyester
1 100nF multilayer monolithic ceramic
1 150pF disc ceramic

Resistors (0.25W 1%)

1 470kΩ	1 220kΩ
2 100kΩ	8 47kΩ
9 22kΩ	2 10kΩ
2 1kΩ	2 680Ω
1 100Ω	1 47Ω

Where from, how much?

This kit is only available from Jaycar Electronics, who also hold the copyright on the design and PC board.
Kits will be available from Jaycar Electronics stores and resellers (Cat no KC-5454).

pin, it needs to pass these signals through a low-pass filter before the sampling. This is done to prevent distortion caused by sampling aliases, hence the "anti aliasing" filter between the "Ain" input and the sample and hold circuit block.

Now although the audio is sampled inside the HK828, this is done using an analog sample-and-hold system rather than the more common digital sampling system. It stores the samples in an array of 262,144 (256K) Flash EEPROM analog storage cells, each of which can store any of 256 different voltage levels. This gives the equivalent of 8-bit digital recording.

The capacity of the storage array means that the HK828 can store a total of 256K samples. How long a recorded message this gives depends on the sampling rate that's used.

For example, if the sample rate is 8000 samples per second, 256K samples will correspond to a total message length of just over 32 seconds (262,144/8000). However if you sample at 4200 samples/second, the 256K samples will give a total message length of just over 62 seconds (262,144/4200).

The recording bandwidth or 'fidelity' is directly proportional to the sampling rate. So if you sample at 4200 samples/second, the recording bandwidth will be just over 2kHz, whereas sampling at 8000 samples/second gives a bandwidth of just on 4kHz.

Choosing the sampling rate is therefore of a compromise: the lower the sampling, rate the longer the recording time but the lower the audio bandwidth. Conversely, the higher the sampling rate the higher the bandwidth but the shorter the recording time.

The HK828 chip has an internal sampling rate clock oscillator, as well as an input for an optional external clock. Either clock signal can be fed to the sample and hold circuit via the multiplexer (MUX), to control the sampling.

The frequency of the internal oscillator is set by varying the value of an external resistor connected between the 'OscR' pin and ground. Our circuit uses a 47kΩ resistor, which sets the sampling rate to about 5800 samples/second. This gives a message recording time of about 45 seconds and a bandwidth of about 2.9kHz, for reasonable voice-quality recording.

As shown in Fig.1, the recording and playback of samples in the storage array is controlled by analog write and read circuits, along with the message control and message decoding circuits. When a message is being played back the signals pass through another low-pass filter to remove sampling noise, and are then fed to the inbuilt output amplifier.

The rest of the circuitry inside the HK828 chip is used for overall device control, mode switching and so on.

Circuit details

Fig.2 shows the complete circuit

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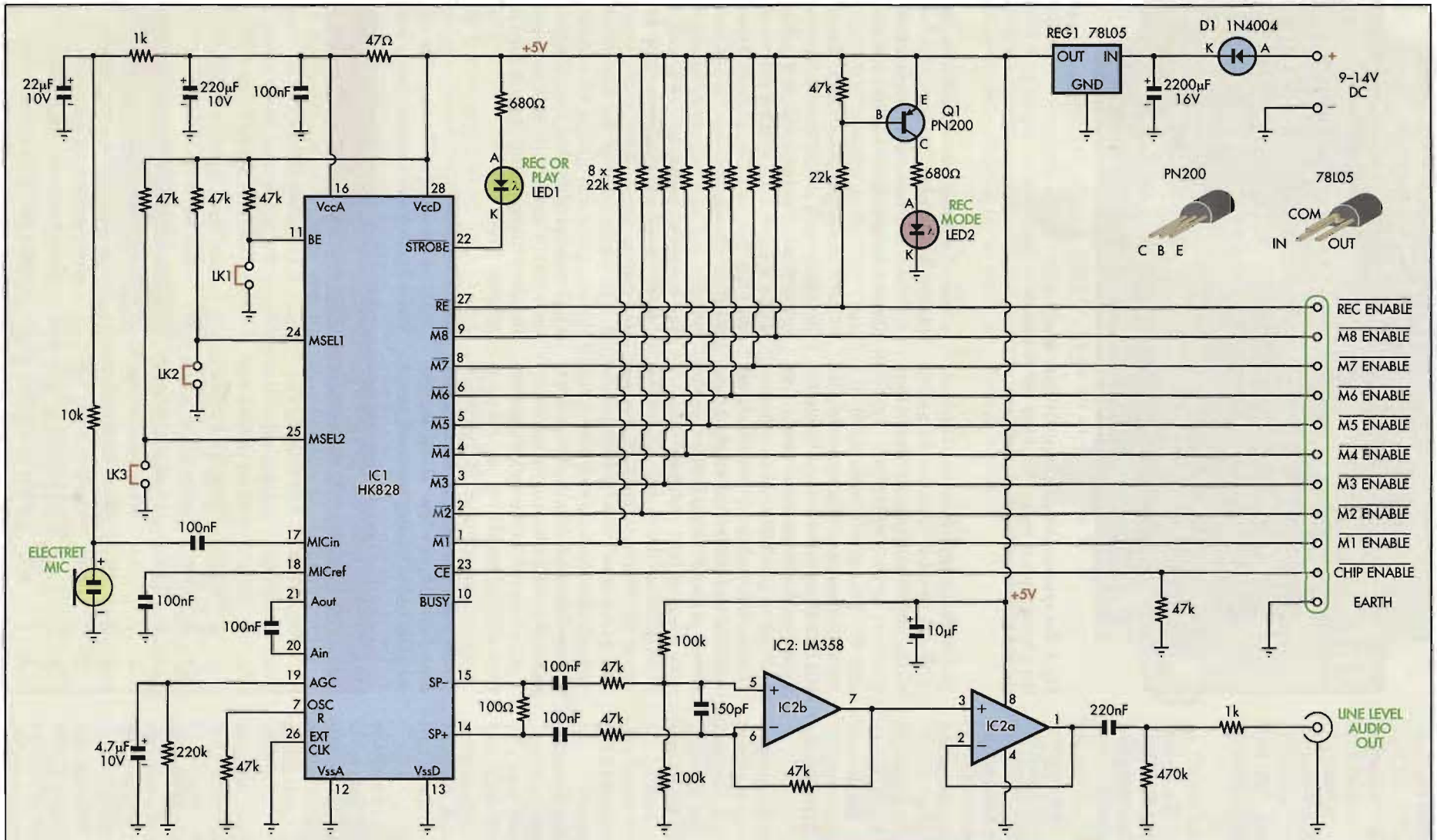
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LK2	LK3	OPERATING MODE
IN	OUT	2 MESSAGES, RANDOM ACCESS
OUT	IN	4 MESSAGES, RANDOM ACCESS
OUT	OUT	8 MESSAGES, RANDOM ACCESS
IN	IN	(TAPE MODE)

SC ©2007 MULTI-MESSAGE VOICE RECORDER

Fig.2: Most of the circuit action takes place in the HK828 voice storage chip. IC2, the LM358 dual op amp, performs a balanced-to-unbalanced conversion of the output from the HK828 and then provides a buffered output which can be fed to an audio amplifier and loudspeaker.

details for the new Multi-Message Voice Recorder.

As shown, signals from the electret microphone insert are coupled into the MicIn input of the HK828 (pin 17) via a 100nF coupling capacitor. Another 100nF capacitor is used to tie the preamp's second 'MicRef' input (pin 18) to ground, to provide maximum gain.

The 4.7µF capacitor and 220kΩ resistor connected between pin 19 and ground are used to optimise the chip's AGC attack and decay characteristics for speech. The amplified audio from the mic preamp and AGC circuit appears at pin 21 (Aout) which is coupled directly to pin 20 (Ain) via another 100nF capacitor.

As mentioned above, the internal sampling oscillator frequency is set to 5.8kHz by the 47kΩ resistor connected to ground from pin 7 (OscR).

Setting the HK828 into record or playback modes is achieved by an external switch or logic signal connected to the RecEnable-bar terminal, which connects to the chip's RE-bar pin (27).

The terminal is pulled to ground for record mode or allowed to rise to logic high level (+5V) for playback mode. Note that when the terminal is pulled down to ground for Record mode, this also allows transistor Q1 to draw base current and turn on – allowing current to flow through LED2, the Record Mode indicator.

Link LK1 is used to enable or disable the HK828's message starting 'beep', by changing the logic level at pin 11 ("Beep Enable"). Similarly LK2 and LK3 are used to set the desired message recording and playback mode, as shown in the small table on the circuit diagram.

To record a message in one of the random access modes, all that needs to be done is to pull down the RecEnable-bar line to force the chip into recording mode, and then pull down one of the message-select lines (M1Enable-bar, M2Enable-bar etc) using an external pushbutton or a logic signal from a PC or microcontroller.

The message select line must be held down for the duration of the message recording; recording ends when the line is allowed to rise high again.

To play the recorded message, the RecEnable-bar line is allowed to rise high again, and the message select line for the message you want to replay pulled down again for about 400ms.

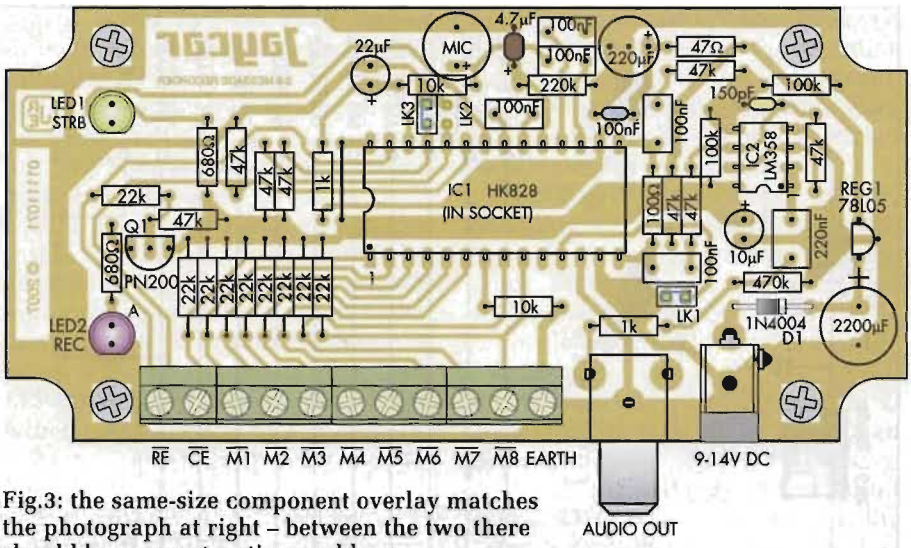


Fig.3: the same-size component overlay matches the photograph at right – between the two there should be no construction problems.

The playback audio emerges in push-pull (ie, anti-phase) fashion from pins 14 and 15 of the HK828, the SP+ and SP- pins and is connected to a 100Ω load resistor. The signals are fed via 100nF capacitors to a balanced-to-unbalanced matching stage using IC2b, one half of an LM358 dual op amp.

This effectively adds the two signals together, and cancels out the 'common mode pedestal' signal that appears with them on both outputs.

As a result the output audio signal at pin 7 of op amp IC2b is clean and 'glitch free'. This is then passed through op amp IC2a, connected as a voltage follower/buffer and then fed to the line-level audio output socket.

All of the part of the circuit operates from +5V DC from REG1, an LM78L05 regulator. We are able to use a low power regulator because the total current drain is quite low: about 4mA in standby mode, rising to about 45mA when a message is actually being played or recorded.

There's one remaining point which should be mentioned about the circuit.

You'll note that the HK828 chip is provided with a ChipEnable-bar pin (pin 23), which in this circuit is pulled down to earth via a 47kΩ resistor – so the chip is enabled by default. However the ChipEnable-bar line is also brought out to a terminal, to allow you to apply a logic high (+5V) to this line if you want to disable the chip for any reason.

You might want to do this if you have a microcontroller or PC controlling a number of the modules, in which case it will need to be able to select between them using their ChipEnable-bar lines.

Construction

All of the components used in the Voice Recorder module on a compact

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	470kΩ	yellow purple yellow brown	yellow purple black orange brown
❑	1	220kΩ	red red yellow brown	red red black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	8	47kΩ	yellow purple orange brown	yellow purple black red brown
❑	9	22kΩ	red red orange brown	red red black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	2	680Ω	blue grey brown brown	blue grey black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	47Ω	yellow purple black brown	yellow purple black gold brown



Team this little module with a small audio amplifier, to provide a great range of sound effects for a model railway layout, for example. It has the ability to store up to eight different "sound grabs" which could be switched to different parts of the layout as trains pass through stations.

PC board. This is coded EC8271, and measures 107 x 57mm. It can be mounted inside a standard UB3 size jiffy box. As all of the terminals and connectors are along one side the board, they will all be accessible via a slot or series of holes along that side of the box. Only three holes will be needed in the box lid: two 5mm holes for LED1 and LED2, and a larger hole to allow sound to reach the electret mic insert.

The location and orientation of all components on the board can be seen in the overlay diagram of Fig.3, and also in the matching photo of the module.

Start board assembly by fitting the four screw terminal blocks, then the DC input and audio output sockets. Follow these with the two IC sockets, the three 2-pin headers for LK1-LK3 and the short wire link which fits just near the end of the 28-pin IC socket. After this you can fit the resistors and smaller non-polarised capacitors.

Next come the 4.7µF tantalum and the electrolytic capacitors, which are all polarised, so make sure you fit them with their orientation as shown in the diagram.

Now you'll be ready to fit the semiconductor parts. These are again all polarised, so make sure you follow the diagram carefully as a guide to their orientation. Fit diode D1 first, then transistor Q1 and the two LEDs, followed by regulator REG1.

Then fit the electret mic insert. This has only two wire leads, but it is polarised, so make sure you check the back of the insert to make sure which lead connects to the metal body of the insert. This is the negative lead, which must be connected to the earthy outer pad under the board. The other lead is the positive lead.

Finally, plug the LM358 op amp IC2 into its 8-pin socket and the larger HK828 chip IC1 into its 28-pin socket. Make sure they're both orientated as shown in Fig.3. Your Multi-Message Voice Recorder should now be complete and ready to go.

Trying it out

To check that your recorder is working correctly, first decide on which message mode you want to use it in, and then place jumper shunts on link headers LK1, LK2 and LK3 to set the module for that mode of operation. (Use the table in Fig.2 as a guide.)

Then connect a small toggle switch and one pushbutton switch for each message you want to select to the appropriate screw terminals of the module, as shown in Fig.4. For the present switch the toggle switch off, which corresponds to message playback mode.

The audio output of the module can now be connected to the line input of any suitable audio amplifier. Then you can connect its DC power input to a source of 9-14V DC.

Capacitor Codes

Value	µF Code	IEC Code	EIA Code
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
150pF	n/a	150p	151

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At this stage neither of the LEDs should light but you may hear a small turn-on 'plop' from the speaker connected to the external amplifier. If you wish you can use a digital multimeter to confirm that the supply voltage at pin 8 of IC2 is very close to +5V, relative to the module's earth terminal.

Now switch the external toggle switch on, pulling the RecEnable-bar line down to earth potential. This should switch the module into Record mode, so LED2 should begin glowing. (If it doesn't begin glowing, you either have the DC power polarity reversed, or LED2 fitted to the board the wrong way around.)

Next, press one of the message select pushbuttons – say MSG1 in Fig.4. Holding it down, begin talking into the electret mic to record your test message.

As you speak, you'll notice that the green Strobe LED (LED1) is flashing. Keep talking until you reach the end of your message or until LED1 stops flashing (which indicates that recording has stopped automatically, because you have reached the end of that segment of the HK828's memory). Then release the pushbutton.

To replay the recorded message, turn the toggle switch off to swing the module into Play mode and briefly press the message pushbutton again, but this time only briefly because in Play mode, the message buttons only trigger the replay operation.

Your recorded message should then be replayed through the external amplifier and speaker. If it does, your Multi-Message Voice Recorder is working correctly and should now be ready for use.

Changing message length

As mentioned earlier, the total message length stored in the HK828 chip's memory is determined by the sampling rate which is set by the resistor connected from pin 7 of the chip (OscR) to ground.

The 47kΩ value shown for this resistor in the circuit and overlay diagram gives a sampling rate of 5800 samples/second, resulting in a total message length of 45 seconds and an audio bandwidth of about 2.9kHz.

We picked this as a reasonable compromise between message length and recording quality but you can experiment with the value of this resistor to try longer/shorter recording times and narrower/wider audio bandwidth.

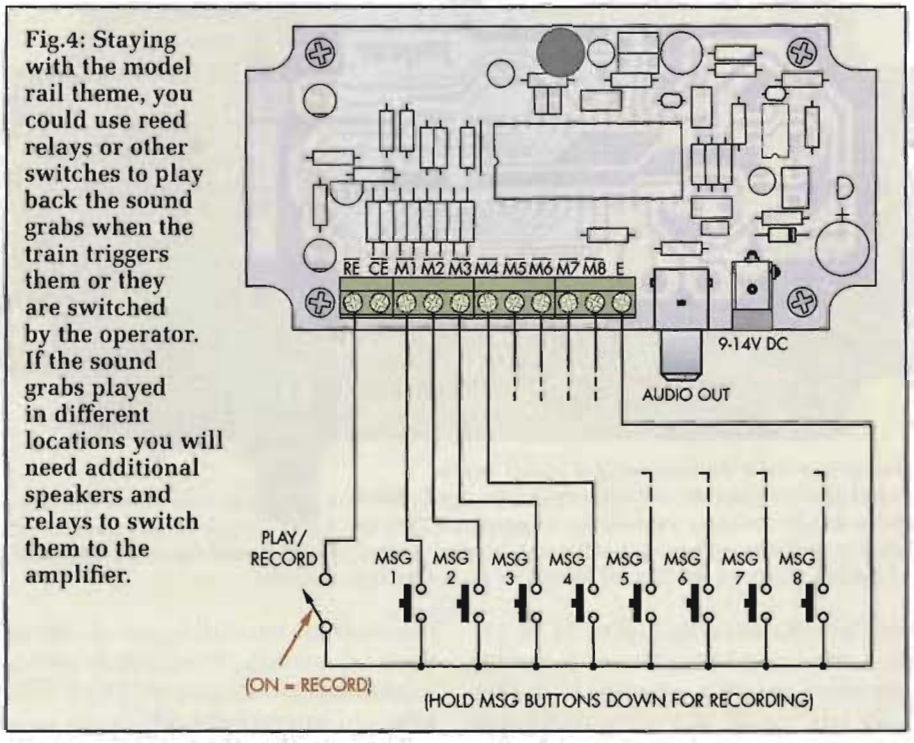


Fig.4: Staying with the model rail theme, you could use reed relays or other switches to play back the sound grabs when the train triggers them or they are switched by the operator. If the sound grabs played in different locations you will need additional speakers and relays to switch them to the amplifier.

For example, if you change the resistor value to 82kΩ, this will lower the sampling rate to about 4200 samples/second and give a total recording time of just on 60 seconds. However the audio bandwidth will also drop to around 2kHz, so the played-back message(s) will sound rather 'muffled' – a bit like talking through a wet sock!

On the other hand, if you lower the resistor value to 24kΩ, this will increase the sampling rate to about 8000 samples/second and drop the recording time to just on 32 seconds. But the recording quality will improve, as the audio bandwidth will increase to about 4kHz.

So experiment by all means, and settle on the resistor value you decide gives the best combination of total message length and acceptable audio quality for your application.

Changing message mode

As noted earlier, header links LK2 and LK3 on the board can be used to change the module's message access mode.

For example with a jumper shunt fitted to LK2 but removed from LK3, the module will be able to record and play two messages (each using half the HK828's memory space). You'll only need two external pushbuttons to select one of these messages: MSG1 and MSG2, along with the Record/Play toggle switch.

If you want to record and play four messages, remove the jumper shunt from LK2 and place one on LK3 instead. You'll now need four external pushbuttons as well as the Record/Play toggle switch: MSG1, MSG2, MSG3 and MSG4. Note that in this case each message will be able to use one quarter of the HK828's memory.

Leave the jumper shunts off both LK2 and LK3 if you want to record and play any of eight short messages (each using one eighth of the HK828's memory). You'll now need all eight external pushbuttons MSG1 - MSG8, along with the Record/Play toggle switch.

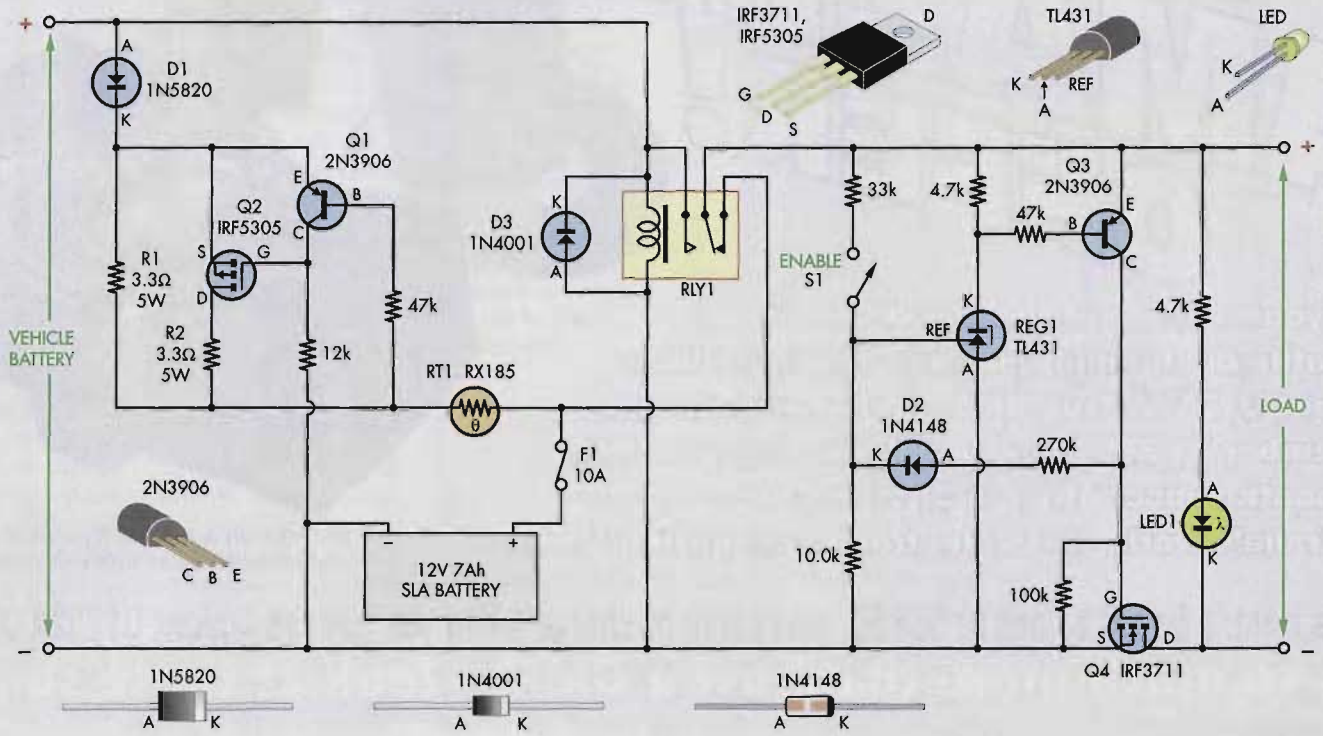
The last option is to fit jumper shunts to both LK2 and LK3, which sets the module for "tape mode" operation.

In this mode you normally only need one external pushbutton (MSG1), because the HK828 records and plays back either one message or a sequence of messages, using all of its memory space.

That's it then – an easy-to-build solid state Multi-Message Voice Recorder module that can be used for all kinds of applications, especially those involving sending pre-recorded messages over an amplifier or PA system under the control of a PC or microcontroller. SC

CIRCUIT NOTEBOOK

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



In-car charger & switcher for an SLA battery

This circuit was devised to switch power to a Peltier cooler in a vehicle. Power to the load from the vehicle's battery is switched by a SPDT relay while the ignition switch is turned on and from the SLA auxiliary battery when the ignition is off.

The SLA battery is charged from the vehicle's battery. When the engine is running, the voltage remains fairly constant, which greatly simplifies the charging circuit. If the SLA battery is fully charged, any further charging current from the vehicle battery is limited by a 3.3Ω 5W resistor (R1). If the SLA battery is deeply discharged, the voltage drop across this resistor will be enough to bias on PNP transistor Q1. This will turn on P-channel Mosfet Q2 and it will provide further charging current via R2, effectively becoming a 2-step charger.

Since the paralleled resistors (R1 & R2) have a lower combined voltage drop, Q1 will receive lower base bias, which in turn will cause Mosfet Q2 to fully saturate. This positive feedback creates a clean transition between the two states and prevents Q2 from over-dissipating by being partially on. The current then will ramp down until the battery is only receiving a trickle charge and the voltage drop across the paralleled resistors is only a few dozen millivolts. Schottky diode D1 prevents the SLA battery from discharging into the vehicle's accessory circuits when the engine is off.

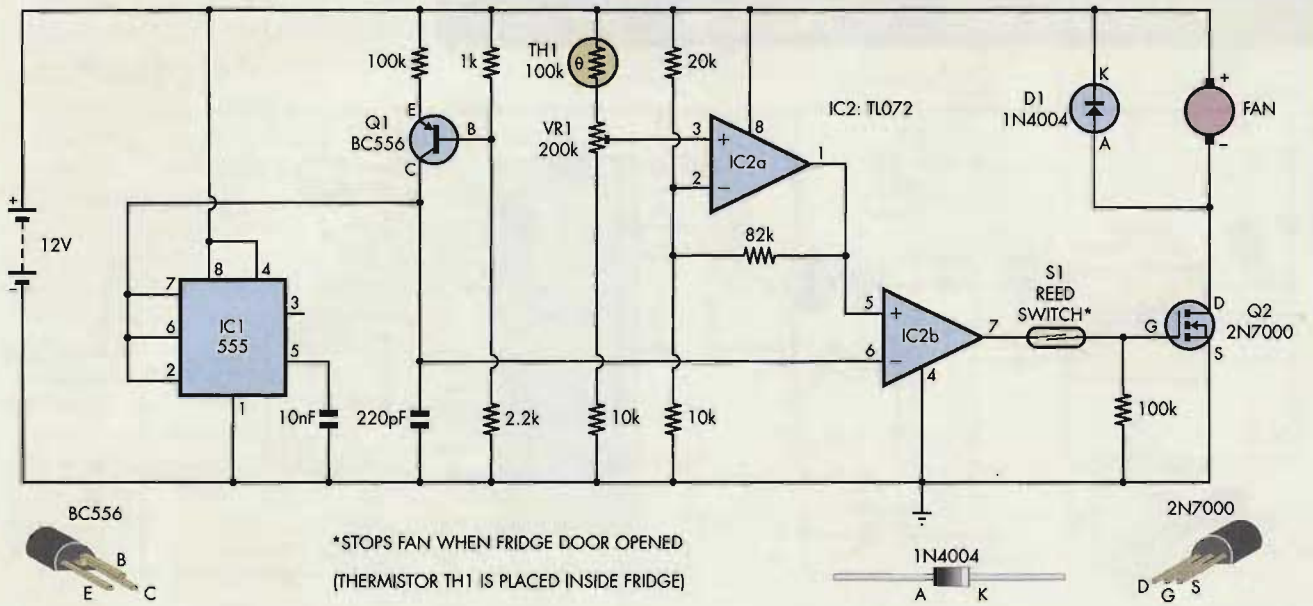
Two safety devices are included in the circuit, the first being in-line fuse F1 which will prevent serious damage in case of shorts. In addition, a PTC resettable thermistor (RT1) protects the battery from sustained overcurrents during the charging phase. It is a 1.85A hold, 3.70A trip device at 23°C. Since it has a positive temperature coefficient, at 70°C, these ratings decrease to 1A and 2A for hold and trip respectively, which can further protect the battery.

Lastly, to protect the SLA battery from deep discharge, a low voltage disconnect is included. This is centred around REG1, a voltage reference configured as a comparator. Its reference (REF) input is connected to a voltage divider, as long as "enable" switch S1 is closed.

Whenever the voltage at REG1's reference terminal exceeds 2.5V, its anode will be pulled low, biasing on PNP transistor Q3. Q3 provides positive feedback via the 270kΩ resistor and diode D2 to turn on N-channel Mosfet Q4, which allows the load to be powered up.

If the SLA battery voltage drops below 10V, the reference terminal will fall below 2.5V and the anode of REG1 will go high, thereby removing bias from Q3 and turning off Q4 to disconnect the load and prevent deep discharge. LED1 indicates when power is being applied to the load.

Fernando Garcia,
Brownsville, Texas, USA. ($45)



Temperature-controlled fridge fan

This circuit is intended to assist fridges that can't cope during hot days when the door is frequently opened and which then tend to freeze up at night! It is a temperature-controlled fan that speeds up as temperature increases, then slows down as the temperature decreases, helping to maintain a constant level of about 3°C or whatever you wish.

This worked well in a "moist cold" fridge that uses a large cold plate at the back. The extra fan converted it from an ice-covered veggie death trap to a constant 3°C or 4°C, with very quick recovery time from the door being opened. A single 12V 80mm computer fan is mounted towards the back on an angle to circulate the air.

The circuit uses a sawtooth waveform generator based on a 555 timer (IC1) which is fed to pin 6 of op amp IC2b set up as a comparator. Pin 5 of IC2b is driven by op amp IC2a which amplifies the voltage variations caused by thermistor TH1 which is placed inside the refrigerator.

Thermistor TH1 has a nominal value of 100kΩ and is connected in a voltage divider with trimpot VR1 and a 10kΩ resistor. The gain of op amp IC2a is set by the 82kΩ feedback resistor and it determines how quickly the fan speeds up with a rise in temperature. A lower feedback resistance will make it adjust to temperature more slowly. The pulse-width modulated output signal from IC2b drives the Mosfet and the fan. The Mosfet generates very little heat and doesn't need a heatsink.

The reed switch is included to stop the fan when the door is opened. It is positioned on the side of the fridge with a high-power magnet on the door. This prevents the fan from blowing out all the cold air when the door is opened.

Darren Kirkegard,
Runcorn, Qld. ($45)

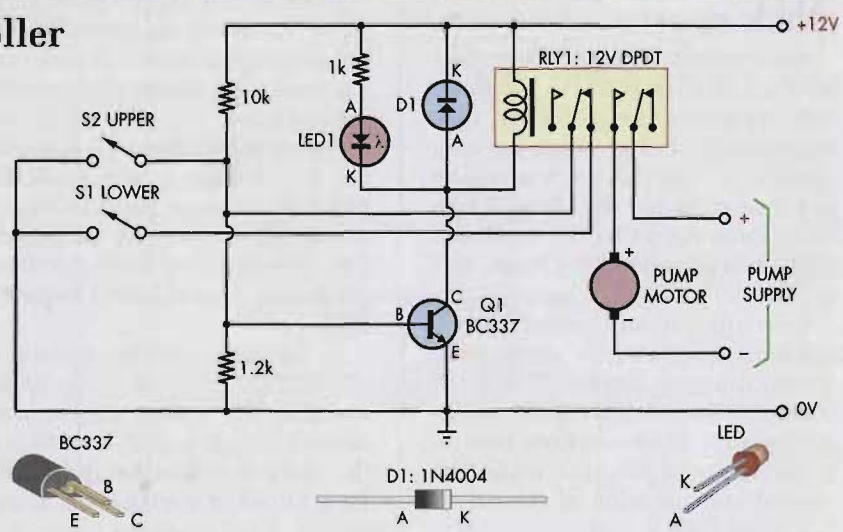
Simple water pump controller

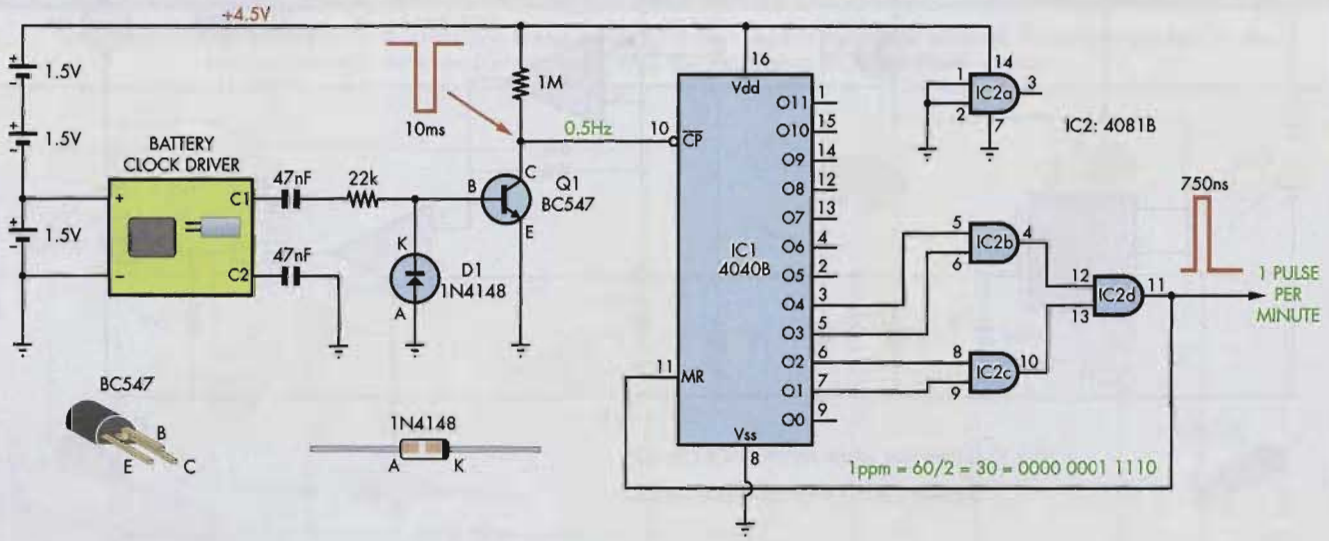
This simple circuit automatically switches a pump on and off to maintain the water level in a tank between two pre-defined levels.

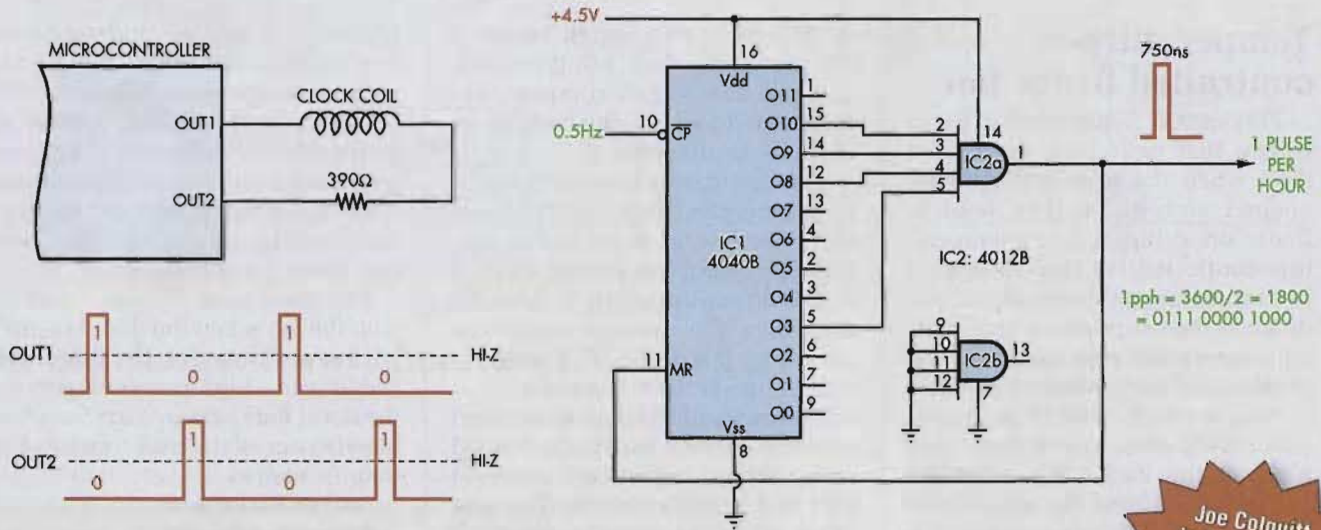
Two float sensors, S1 & S2, are used, each being an assembly of a plastic float, a reed switch and a small magnet. Assume the water level is below sensor S1. It closes to bias on transistor Q1 which energises the relay to run the pump.

When the water level subsequently rises to sensor S2, Q1 turns off and the relay opens, thereby shutting off the pump. The pump runs again after the water level goes below sensor S1.

T. A. Babu,
Chennai, India. ($40)







Low-current stable clock source

Although most microcontrollers have a-low power 32kHz oscillator that can be used as a timebase, they are generally not accurate for long periods. A 1Hz deviation amounts to a 3-seconds per day error. It also takes some power for the oscillator block to run, anywhere from 4µA to 10µA.

By using the coil driver from a standard quartz clock movement, the accuracy is increased and the current decreased. Even a reasonable-quality clock can keep time to a few minutes per year while the current consumption of the driver is around 100nA.

A clock driver has alternating outputs driving a coil. These outputs pulse on alternate seconds, each pulse reversing the coil field, turning a magnetic escapement to move the second hand.

A CMOS divider is used to count the 0.5Hz output and generate a pulse on a longer timebase; for example, 60 seconds or 60 minutes. The Q outputs are ANDed together, according to the binary value for each.

In the 60-second example, when Q1, Q2, Q3 and Q4 all go high (a count of 30), a short positive pulse results, which is both the Reset for the 4040 and a wake-up/interrupt for a micro or a trigger for another device. If a low-power micro like a nanowatt PIC is used, the quiescent current of the whole circuit can be very low. A 12F675, for instance, uses a miserly 10nA when asleep.

Joe Colquitt is this month's winner of a Peak Atlas Test Instrument

The only significant increase in consumption is for the brief time (10ms per 2s) the transistor turns on. It is possible to use the other output as well for a 1Hz timebase. Although 1000mAh AA cells will power even a 100µA circuit for a long time, lowering the circuit drain does give one the option of using smaller cells.

One other advantage is that the woken micro doesn't have to be using a slow clock. In fact, it can

Quiz adjudicator has no pushbuttons

This is a basic 4-station quiz adjudicator with a difference. Instead of the usual four pushbuttons which inevitably get a hammering from the contestants, this button has four holes in a panel. All the contestants have to do is hold a finger over their respective hole in the panel. Under each hole is a phototransistor about the size of a 3mm LED. Hence, the holes can be quite small.

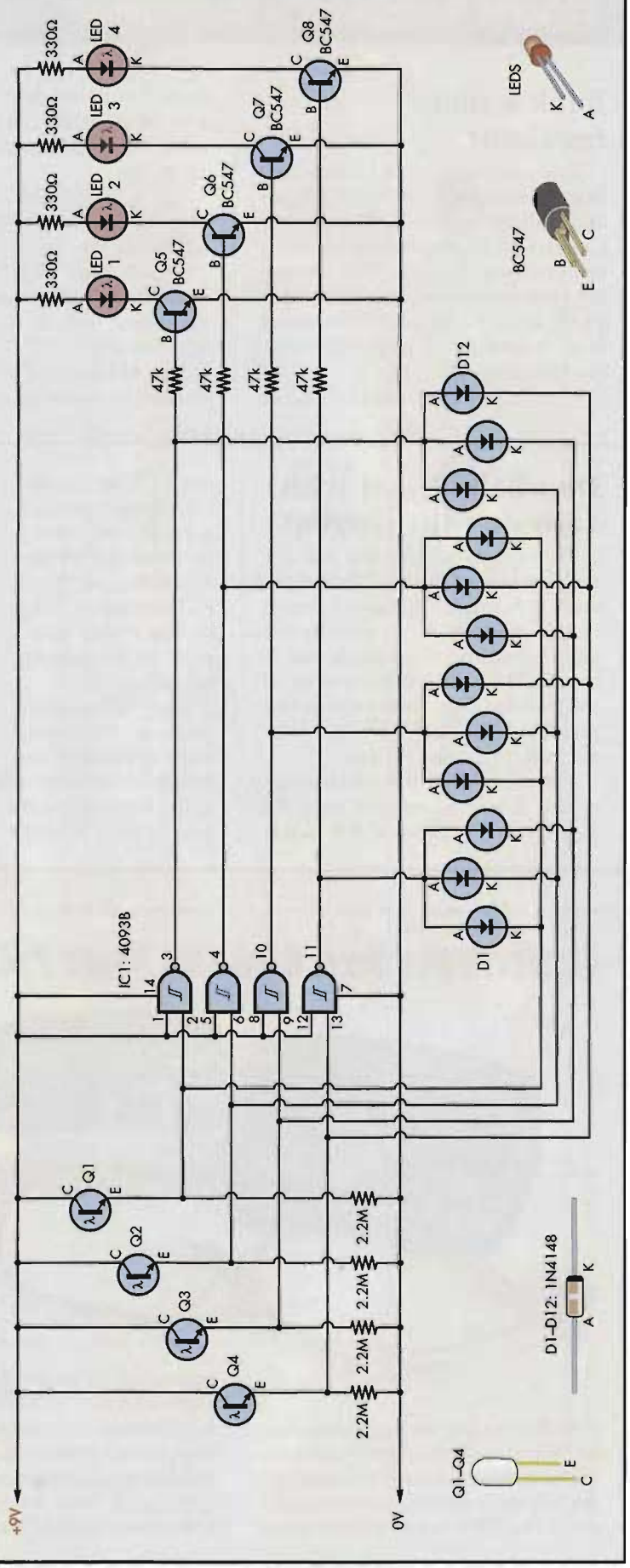
Possibly the contestants won't get the same adrenalin rush as when they bash a large pushbutton but at least there will be little chance of physical damage to the adjudicator. To make a bid, the contestant merely has to cover their hole in the panel, cutting off light to the phototransistor.

The circuit depends on a 4093 quad NAND Schmitt trigger package. Each Schmitt trigger gate monitors the emitter of one phototransistor. When all holes are uncovered, the outputs of all four gates are low and transistors Q5-Q8 are all off and their respective LEDs are off.

When a finger cuts off light to phototransistor Q1, the transistor stops conducting and pin 2 of IC1 is pulled low by the 2.2MΩ resistor. This sends pin 3 high to turn on transistor Q5 and lights LED1. At the same time, it forward biases three diodes (D1-D3) to hold pins 6, 9 & 13 high and thus prevent those gates from being triggered.

The other three gates work in exactly the same way, so that the first contestant to cover a hole in the panel wins and blocks the other contestants. The sensitivity of the circuit can be reduced if necessary, by reducing the 2.2MΩ resistors in value. The phototransistors were L-32PC from Prime Electronics.

A. J. Lowe,
Bardon, Qld. ($40)



be running at full speed. Calculations show that waking a fast micro for a short period uses less power than waking a slow micro for a longer period, given that the same number of instruction cycles is needed to perform the task it was woken for. Some tasks, like sending a burst of data, will be over much quicker with a fast micro and will therefore save more power over and above the instruction time savings.

The remains of the clock can also be re-used. After the driver PC board has been removed, the coil and gearbox can be driven by a micro, using two reciprocating outputs. One application might be for a big stopwatch.

Joe Colquitt,
New Lynn, Auckland, NZ.

Buck & boost regulator

This circuit accepts 12V or 24V from a vehicle's electrical system and delivers 13.8V to the load. It consists of step-up and step-down switchmode circuits. The change between the two modes is controlled by op amp IC1 which is connected as a comparator. Trimpot VR1 sets the changeover point.

The heart of the circuit is IC2, the switchmode regulator, and it drives Mosfet Q3 in the step-down mode while Mosfet Q4 is used in the step-up mode.

Q3 is held hard on during the step-up function while Q4 is held off during the step-down mode. The 74HC02 quad NOR gate controls both these Mosfets and directs the switching signals from the TL494 accordingly.

The MAX471, IC4, is a high-side current monitoring chip and provides a voltage at pin 8 for comparison with the reference at pin 15 of the TL494 for current limiting. The output current limit is set at 2.5A, mainly restricted by the maximum current through the MAX471. The zener diodes are placed to protect the circuit from voltage transients in the input electrical system. TO-220 flag heatsinks are sufficient for D1, Q3 and Q4.

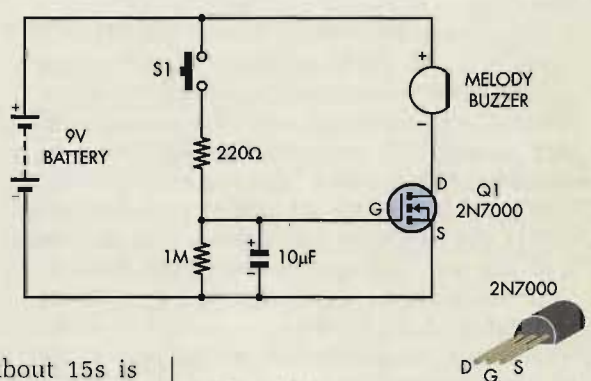
Gregory Freeman,
Mount Barker, SA. ($60)

Doorbell circuit with zero standby current

This circuit allows the use of a melody buzzer with a pushbutton switch. Normally, a melody buzzer is not suitable for a pushbutton switch because the switch has to be closed for the entire duration of the melody. This circuit solves that problem by using a FET with a delay network in its gate circuit.

Powered by a 9V battery, the circuit draws no current until the pushbutton is pressed for a moment. This charges a 10µF capacitor via a 220Ω resistor and the resultant voltage applied to the gate of FET Q1 turns it on so that power is applied to the melody buzzer.

The 1MΩ resistor gives a time-constant of 10s and the resultant on time of about 15s is sufficient to allow the melody to be played right through.



T. A. Babu,
Chennai, India. ($40)

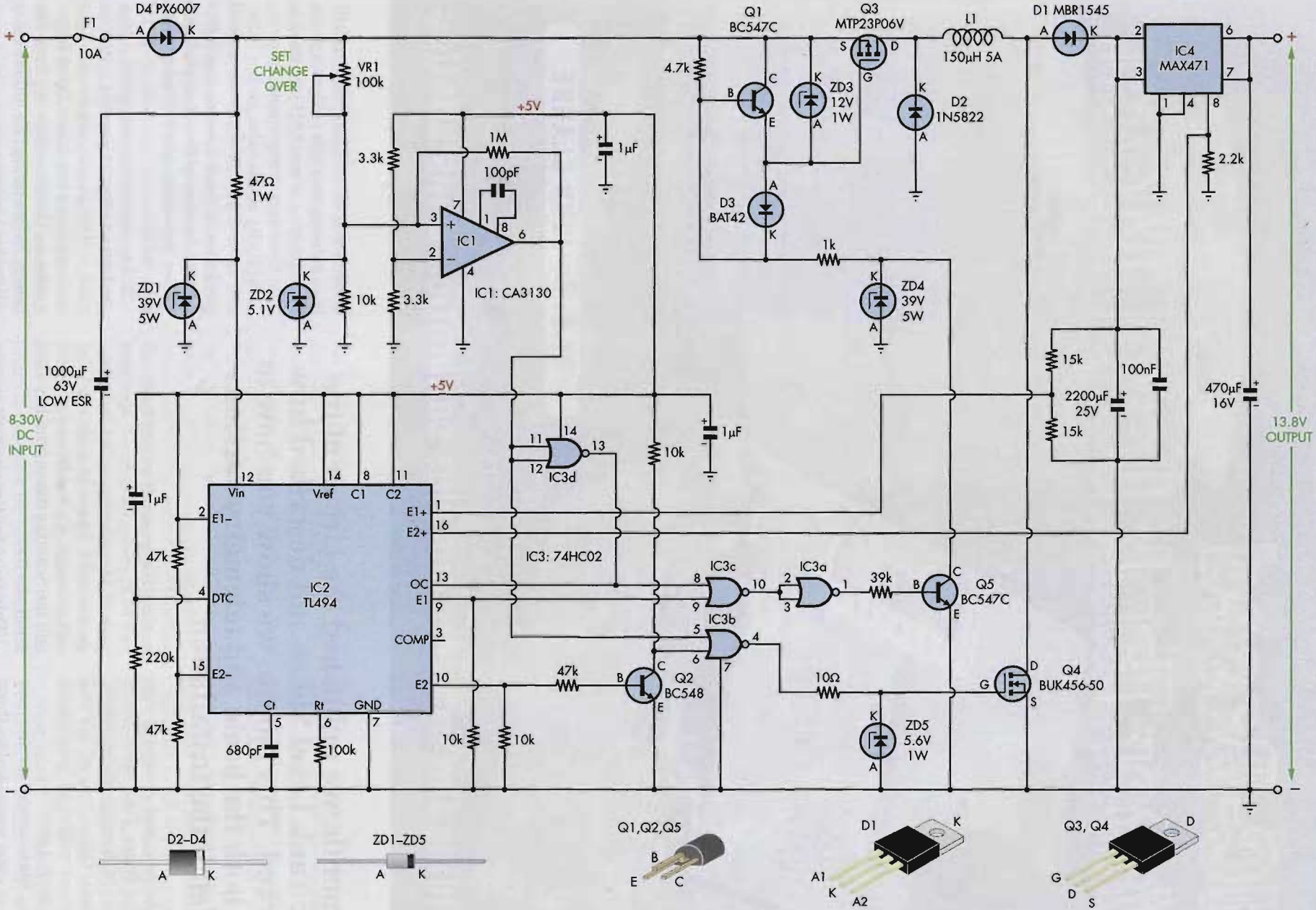
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As you can see, we pay good money for each of the "Circuit Notebook" items published in SILICON CHIP. But now there are four more reasons to send in your circuit idea. Each month, the best contribution published will entitle the author to choose the prize: an LCR40 LCR meter, a DCA55 Semiconductor Component Analyser, an ESR60 Equivalent Series Resistance Analyser or an SCR100 Thyristor & Triac Analyser, with the compliments of Peak Electronic Design Ltd **www.peakelec.co.uk**

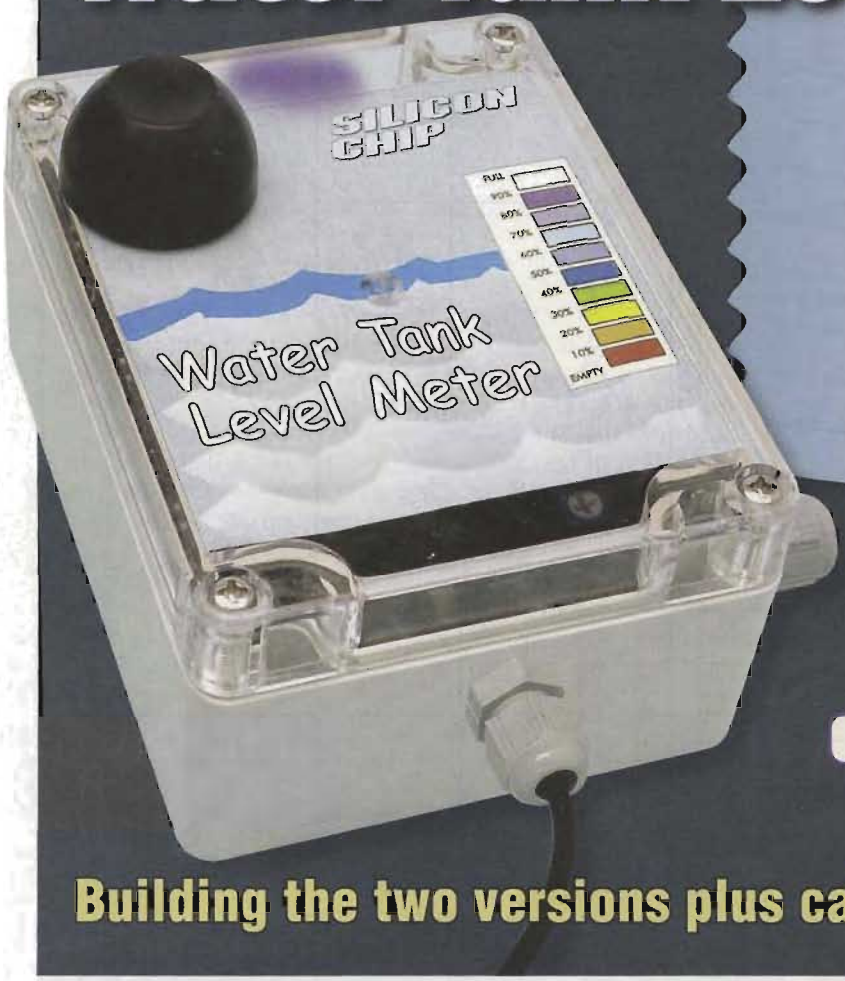
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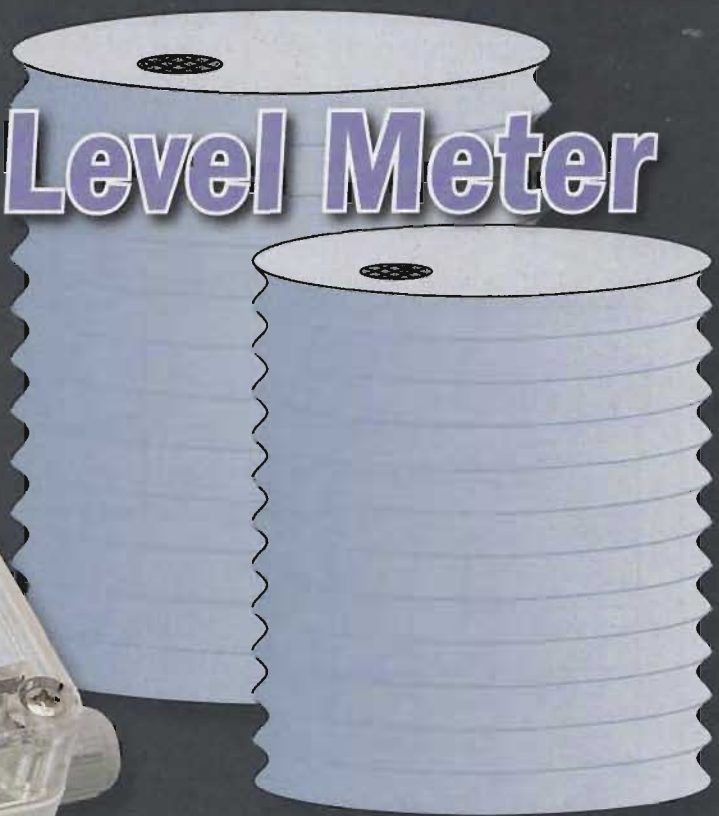
You can either email your idea to silicon@siliconchip.com.au or post it to PO Box 139, Collaroy, NSW 2097.



The circuit is based on switchmode regulator IC2. This device drives Mosfet Q3 in the step-down mode while Mosfet Q4 is used in the step-up mode. IC4 provides the current limiting function.

PIC-Based Water Tank Level Meter





Pt.2: By JOHN CLARKE

Building the two versions plus calibration & installation

Last month, we published the circuit of the Water Tank Level Meter and described how it worked. This month, we show you how to build both the basic and telemetry versions and detail the installation.

Both the basic and telemetry versions of the Water Tank Level Meter use the same PC board (code 04111071, 104 x 79mm). This is housed in a 115 x 90 x 55mm sealed polycarbonate enclosure with a clear lid.

Basically, the telemetry version uses a handful of extra parts, among them a 433MHz transmitter module and two BCD rotary switches. It also uses parts that are salvaged from a solar garden light. These include the solar cell, a single AA NiMH or NiCd cell and the Schottky diode which is used for diode D2.

This is by far the cheapest way to obtain the solar cell and you also will have some spare parts such as a white LED driver, a white LED and garden light hardware components.

Typically single solar garden lights cost around $10. Don't be tempted to get the multi-pack solar garden lights that sell for around $5 or less per light. These generally use lower quality solar cells.

Before removing the parts, it's a good idea to first charge the NiMH or NiCd cell by placing the garden light in the sun for a few hours. Don't forget to remove the insulation tab from the battery before doing this, otherwise it will never charge.

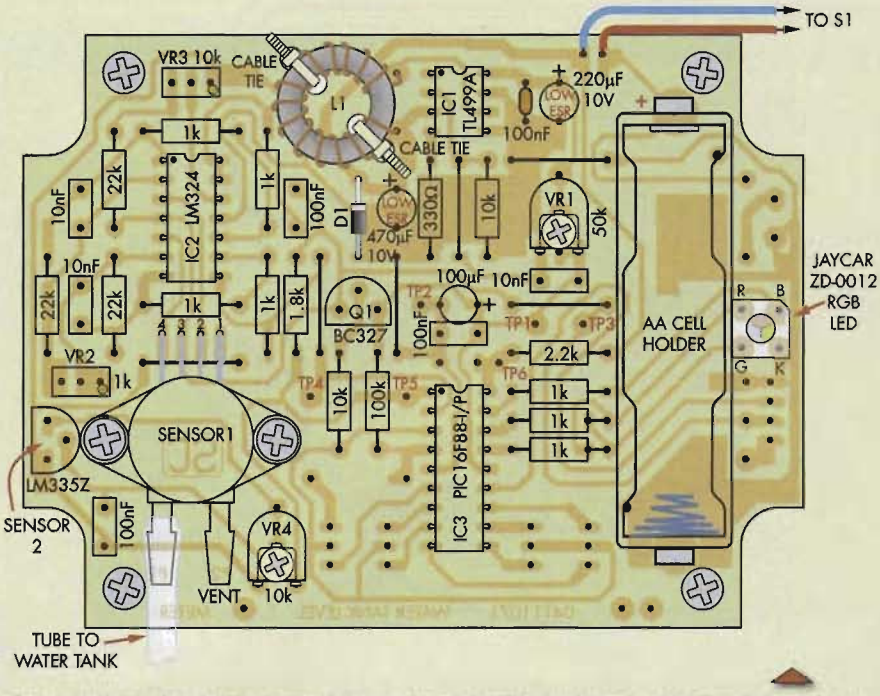


Fig.9: follow this parts layout diagram to build the basic version of the Water Level Meter. The pressure sensor is shown mounted on the board here but could also be in installed in a separate box that sits on the bottom of the tank.

Fig.10 (below): this diagram shows the board layout if you use an RGB LED with a different pin-out to the Jaycar ZD-0012. Note the changes to two of the 1kΩ resistors.

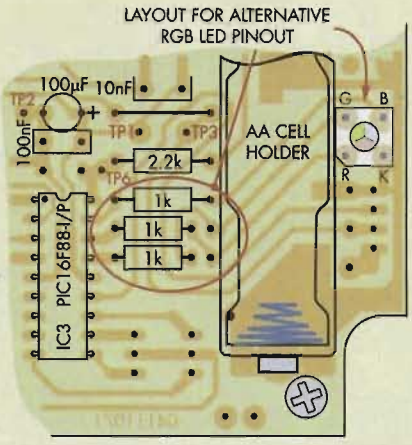


Table 2: Capacitor Codes

Value	µF Code	IEC Code	EIA Code
100nF	0.1µF	100n	104
10nF	.01µF	10n	103

Table 1: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
1	100kΩ	brown black yellow brown	brown black black orange brown
3	22kΩ	red red orange brown	red red black red brown
2	10kΩ	brown black orange brown	brown black black red brown
1	2.2kΩ	red red red brown	red red black brown brown
1	1.8kΩ	brown grey red brown	brown grey black brown brown
7	1kΩ	brown black red brown	brown black black brown brown
1	330Ω	orange orange brown brown	orange orange black black brown

Once that's done, you can remove the solar cell, the rechargeable AA cell and the 1N5819 Schottky diode (or equivalent).

Board assembly

Begin construction by checking the PC board for any defects such as shorted tracks or breaks in the tracks. It's rare to find such defects these days but it's always a good idea to make sure as it's usually easier to spot any defects before the parts are installed.

Check also that the hole sizes are correct. The four corner mounting holes should all be 3mm in diameter, as should the mounting holes for Sensor 1 and holes for the cable ties that are used to secure inductor L1. That done, check that the PC board is cut and shaped to size so that it fits into the box.

Fig.9 shows the parts layout diagram for the basic version, while Fig.11 shows the PC layout for the telemetry version. It's just a matter of following the diagram for the version you are building.

Note that if you build the basic version, this can later be upgraded to the telemetry version simply by adding the extra parts. The software for the PIC micro is the same for both versions.

Begin the board assembly by installing the six wire links, then install the resistors. Table 1 shows the resistor colour codes but you should also use a digital multimeter to check each resistor because the colours can sometimes be difficult to decipher.

Note that if you are using the Jaycar RGB LED, then the 1kΩ resistors immediately to the left of the cell holder are installed as shown in Figs.9 & 11. However, if you are using a different RGB LED that has the alternative pin-out, the resistors must be connected as shown in Fig.10.

Next, install PC stakes at test points TP1-TP6, at either end of the cell holder position and at the termination

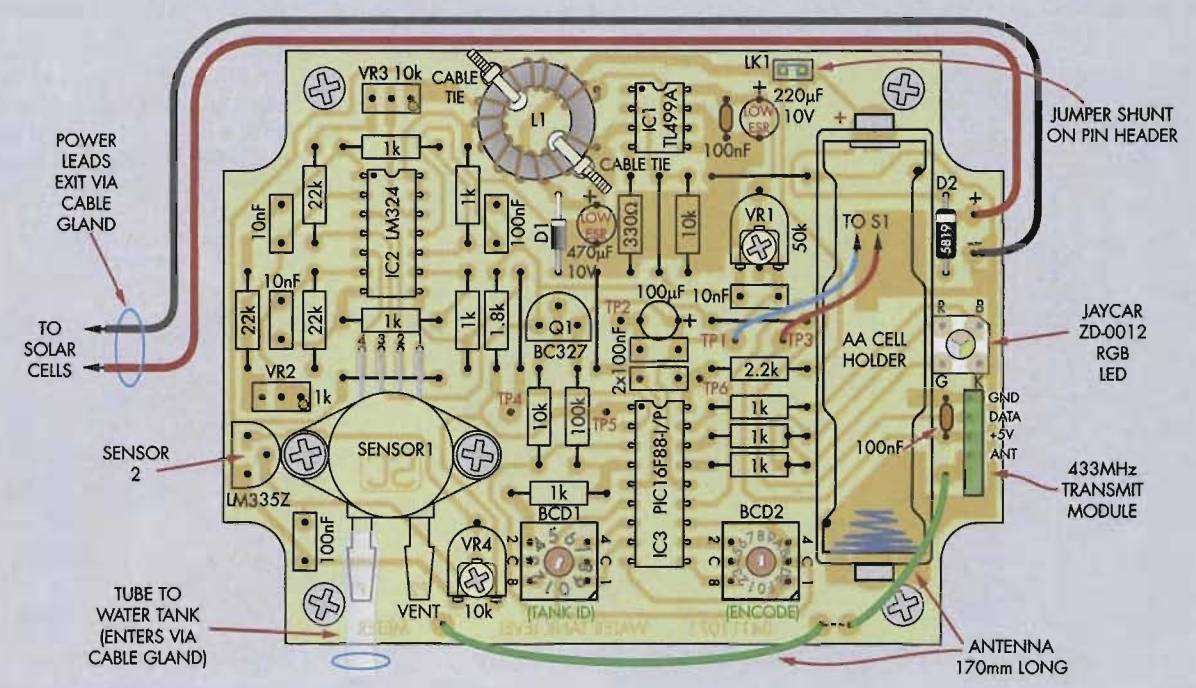
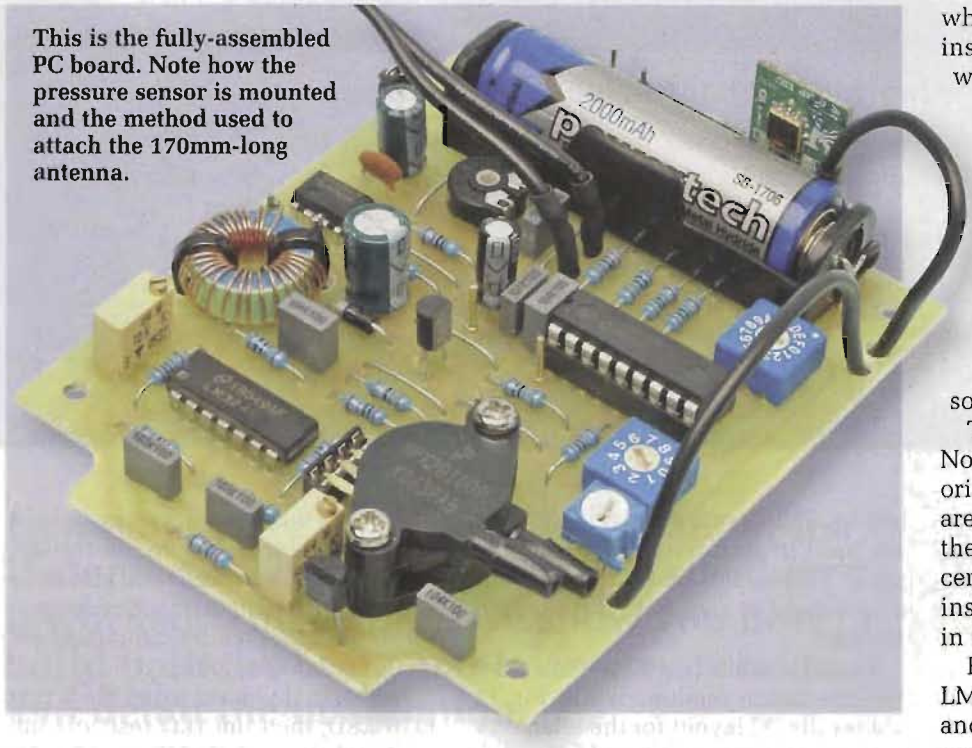


Fig.11: this is the parts layout for the telemetry version of the Water Level Meter. It basically adds the 433MHz transmitter module, two BCD switches, diode D2, jumper shunt LK1, a 1kΩ resistor and two 100nF capacitors



This is the fully-assembled PC board. Note how the pressure sensor is mounted and the method used to attach the 170mm-long antenna.

points for inductor L1. That done, install a couple of PC stakes at top right to terminate the leads for switch S1 (basic version only). Alternatively, fit a 2-way pin header to these PC stakes if you are building the telemetry version (see Fig.11).

If you are building the telemetry version, install an additional PC stake to terminate the antenna lead – this goes in immediately to the bottom left of the 433MHz transmitter module.

Follow these parts with diode D1 (and D2 for the telemetry version), then install the ICs. IC1 & IC2 can be directly soldered to the PC board, while IC3 (the PIC micro) should be installed using a socket. Take care with the orientation of each IC and the socket.

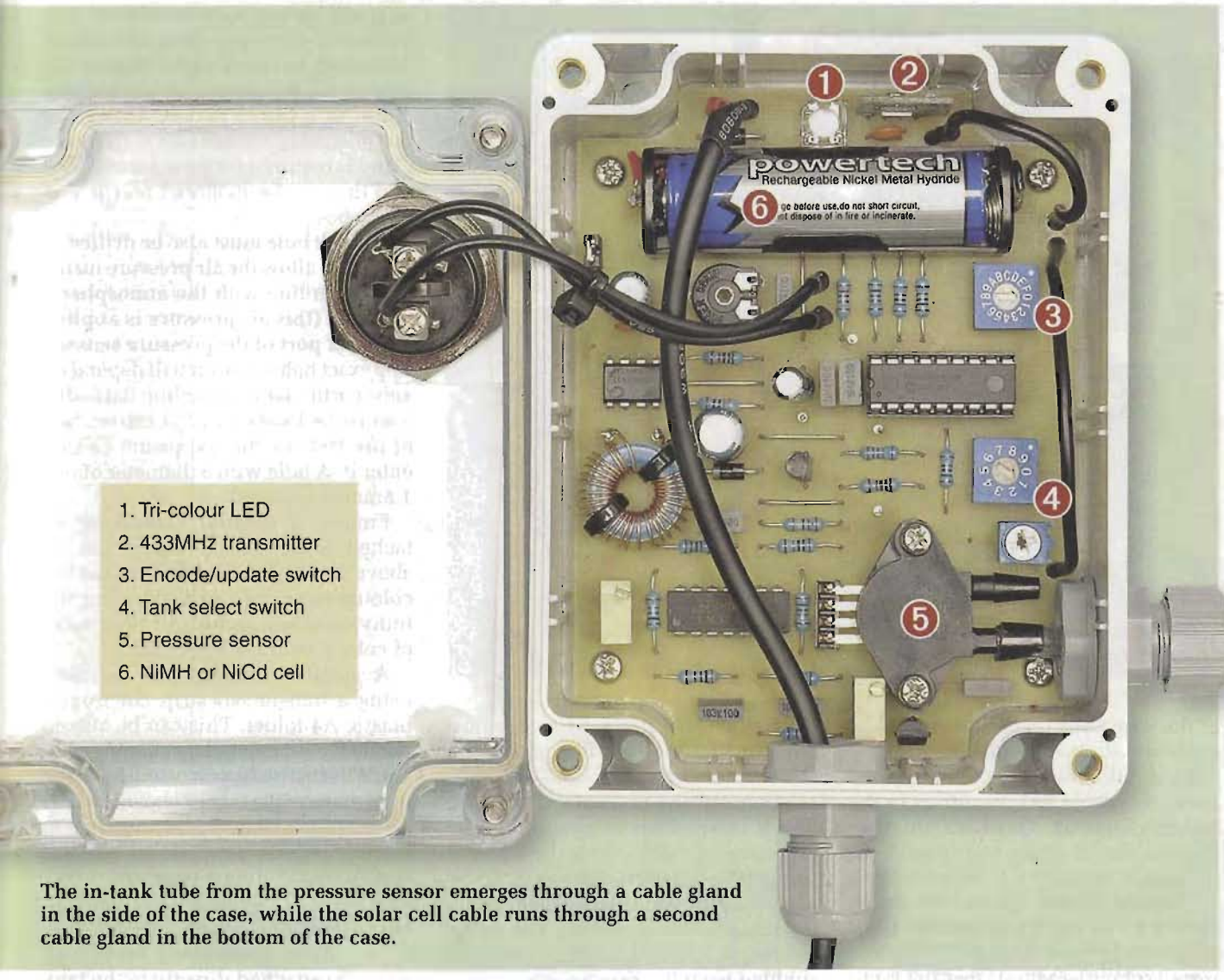
Don't plug IC3 onto its socket yet – that step comes later, after the power supply has been checked.

A 4-way single-in-line (SIL) socket is used for the pressure sensor connection. This can be made by cutting off one side of an 8-pin IC socket to obtain the 4-way socket strip.

The capacitors are next on the list. Note that the electrolytic types must be oriented as shown. Note also that there are two types of 100nF capacitors: the rectangular MKT types and the ceramic disc-shaped types. Be sure to install the 100nF ceramic capacitor(s) in the positions shown.

Follow these with transistor Q1, the LM335Z temperature sensor (Sensor 2) and trimpots VR1-VR4. Note that it's a good idea to orient the multi-turn trimpots as shown (ie, screw adjustments to the right) so that the sensor signal from IC2c increases as the adjustments (wipers) are turned clockwise.

Be sure to use the correct value trimpot in each position. Trimpots are usually marked with a code instead of the actual value. This means that



The in-tank tube from the pressure sensor emerges through a cable gland in the side of the case, while the solar cell cable runs through a second cable gland in the bottom of the case.

the 50kΩ trimpot (VR1) may have a "503" marking, the 10kΩ trimpots (VR3 & VR4) may be marked as "103" and the 1kΩ trimpot may be marked as "102".

Installing Sensor 1

Sensor 1 can either be installed directly on the PC board or it can be mounted in a separate box and submersed in the water tank (see Fig.14). In the latter case, it's connected back to the PC board via a 4-way cable.

If you elect to install it on the PC board, you first have to bend the leads down through 90° so that they can be inserted into the 4-way SIL socket strip. However, take care to orient the sensor correctly. It must be installed with its notched pin to the right and with the type markings for the sensor (MPX2010DP) visible on top.

Once the sensor is in position, it can be secured in place using two M3 x 15 screws and nuts.

The AA cell holder can be installed now. It's secured to the PC board using two No.4 self-tapping screws. That done, wire the cell holder's leads to the adjacent PC stakes.

Telemetry version parts

If you are building the telemetry version, the next step is to install the BCD switches. Note that these have an orientation dot that must be positioned as shown. In addition, be sure to install the 0-9 position switch in the BCD1 position and the 0-F switch in the BCD2 position.

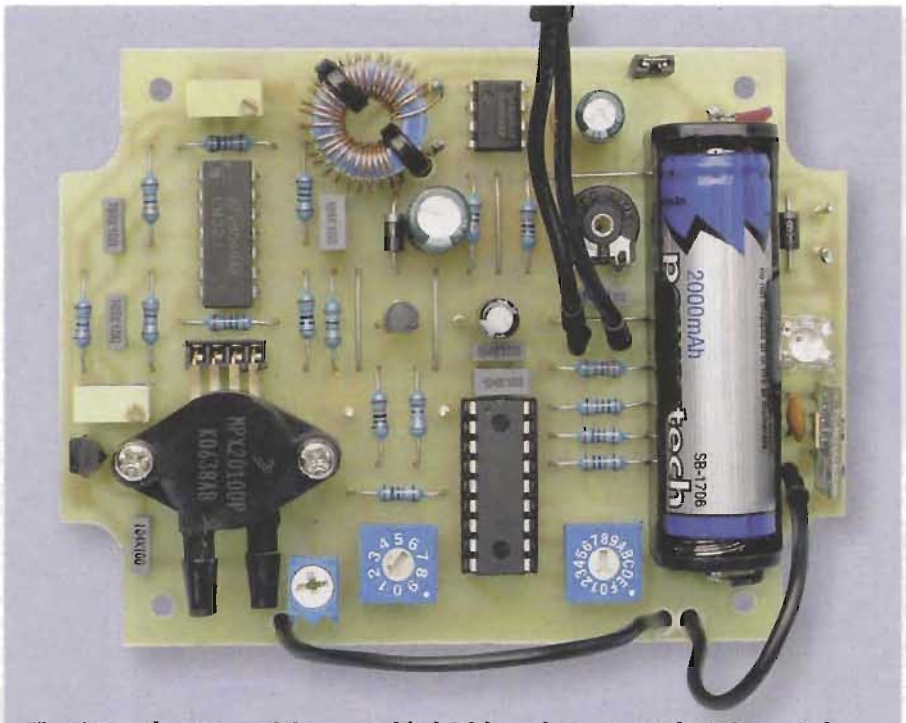
Once these parts are in, install the 433MHz transmitter module (it goes in just below the RGB LED). Make sure this part is correctly oriented – the pin designations are labelled on both the transmitter PC board and the main board, so be sure to match them up.

The antenna is made using a 170mm length of hookup wire which is soldered to the antenna PC stake (immediately to the left of the transmitter module). As shown, it's then fed through three holes in the PC board to hold it in position.

Alternatively, for long-range transmissions over 50m, the antenna should be made using a 170mm-long length of 1mm enamelled copper wire. This wire is stripped of insulation at one end and soldered to the antenna PC stake. It then protrudes through a small hole in the side of the box.

Finishing up

Inductor L1 is made by winding 27 turns of 0.5mm enamelled copper wire onto an iron-powdered toroid core. Wind the turns on evenly around the toroid, then scrape away the enamel



Here's another view of the assembled PC board. Don't get the BCD switches mixed up and be sure to orient them correctly.

at the wire ends using a sharp hobby knife and tin them with solder.

L1 should now be secured in place using two cable ties, as shown in the layout diagrams. Once it's in position, solder its leads to the adjacent PC stakes.

Next, for the basic version, connect switch S1 to the 2-pin header. Alternatively, for the telemetry version, install a jumper shunt over the 2-pin header and connect switch S1 between TP1 and TP3.

Testing

To test the unit, first insert a charged NiMH (or Nicad) or alkaline cell into the holder and connect a multimeter between test points TP1 and TP2. That done, set the multimeter to read volts and press switch S1 if you built the basic version (pressing S1 is not necessary for the telemetry version).

Now adjust trimpot VR1 for a reading of 5.0V. When that's correct, check that 5V is also present between pins 14 & 5 of IC3's socket.

You now need follow this step-by-step set-up procedure:

(1) Switch off and insert IC3 into socket (make sure it's oriented correctly).

(2) Connect a multimeter between test points TP2 & TP4.

(3) If you have the basic version, connect a link between TP1 and TP3.

(3) Switch on, press S1 and adjust trimpot VR3 for a reading of 1.0V on the multimeter.

(4) Connect the multimeter between TP2 & TP5 and adjust trimpot VR4 for a reading of 2.98V when the ambient temperature is 25°C degrees. You can also make this adjustment at any ambient temperature by setting VR4 so the reading is 2.73V plus the temperature divided by 100.

For example, if the ambient temperature is 15°C, the voltage should be adjusted to 2.73V plus 0.15V or 2.88V. Table 3 provides all the values, to save you doing the calculations yourself.

(5) Remove the cell and disconnect the short between TP1 & TP3 for the basic version.

(6) Install IC3 into its socket, making sure it is oriented correctly, then re-insert the cell.

(7) Check that the RGB LED now lights for two seconds when switch S1 is pressed with either version. If this does not happen, check that the RGB LED is oriented correctly.

Final assembly

If you buy a kit for this unit, then the box will be supplied with all the holes drilled. If not, you will have to drill the holes yourself. Fig.12 shows the drilling details.

Note that some of the internal ribbing will have to be removed where the nut for the pressure sensor cable gland is located, so it can sit flat against the side of the box. You can use a sharp chisel or a file to remove these. For the telemetry version, an extra cable gland is required for the solar cell lead and this can be mounted on the end of the box.

A small hole must also be drilled in the box to allow the air pressure inside to vary in line with the atmospheric pressure (this air pressure is applied to the P2 port of the pressure sensor). The exact hole position will depend on your particular installation. Basically, it must be located on the lowest face of the box, so that rainwater cannot enter it. A hole with a diameter of just 1.5mm is required.

Finally, a diffuser should be attached to the inside top of the lid above the RGB LED. This makes the colours more obvious by blending the individual red, green and blue spots of colour from the RGB LED.

A suitable diffuser can be made using a translucent strip cut from a plastic A4 folder. This can be affixed inside the lid using clear silicone sealant. Alternatively, you can diffuse the inside area of the lid just above the LED by using some fine-grade sandpaper to roughen up the transparent surface, thereby making it translucent.

Installation

The Water Tank Level Meter can either be attached directly to the tank or mounted on a nearby wall. Which ever method you choose, it must be mounted so that it is always out of the direct sun. This is necessary to prevent the temperature sensor reading excessively high and producing incorrect temperature compensation.

The positioning also depends on your tank and whether you have built the basic or the telemetry version. For the telemetry version, the unit also needs be positioned so that the base station can receive the transmitted signal. In this case, we suggest you build the Base Station to be described next month before deciding on a mounting position for the meter.

Note that the box has four mounting points that are effectively outside the box's sealed section but which are covered by the lid. It's simply a matter of removing the lid to access these mounting holes.

By the way, do not drill holes

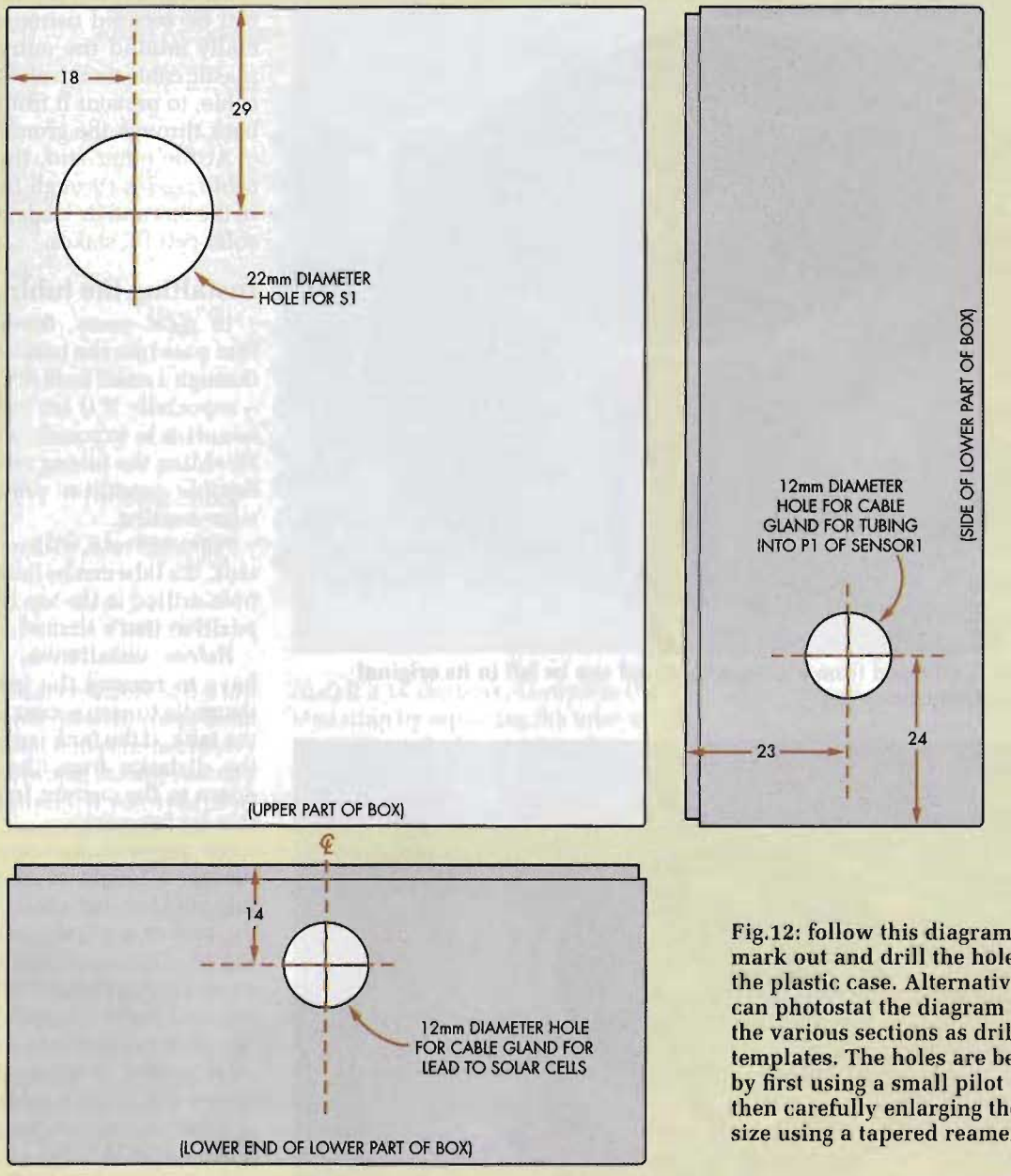


Fig.12: follow this diagram to mark out and drill the holes in the plastic case. Alternatively, you can photostat the diagram and use the various sections as drilling templates. The holes are best made by first using a small pilot drill and then carefully enlarging them to size using a tapered reamer.

anywhere in a concrete tank, as this can cause cracks that can leak. By contrast, plastic and steel tanks can have mounting holes drilled in the top cover but not the sides. Plastic tanks also generally have lifting attachment points and you can either drill into these sections or use the existing lifting hole for mounting.

If you want to mount the box on the side of the tank, the best approach is to first secure two 19 x 19 x 120mm hardwood batons to the tank using builders' adhesive or silicone sealant. These should be spaced to match the box's mounting holes. The box can then be attached using short wood screws into the timber (make sure that these screws are short, so that they cannot possibly go all the way through the timber and into the tank).

Solar cell mounting

In most cases, you can use the stainless steel surround supplied with the solar-powered garden light as its mounting bracket. A convenient mounting location is on top of the water tank itself, provided it receives adequate sunlight.

Alternatively, you can mount the solar cell on the house (or shed) roof, or even install it on the ground using the garden light fittings. Note that it should face north towards the midday sun, to ensure best performance.

In practice, this means tilting the cell away from the horizontal (in a northerly direction) by about your latitude plus 15°. The tilt angles for major Australian and NZ cities are as follows: 27° for Darwin, 42° for Brisbane, 46° for Perth, 49° for Sydney and Adelaide, 51° for Auckland, 52° for Melbourne, 56° for Wellington and 57° for Hobart.

The lead between the solar cell and the Water Level Meter should be run using single-core microphone cable. In most cases, you will have to drill a hole in the stainless steel housing to



The solar cell is salvaged from a garden light and can be left in its original housing to facilitate mounting.



The connections to the solar cell are coated with neutral-cure silicone sealant to make them waterproof and to anchor the leads in position (see text).

feed this lead through to the cell. A rubber grommet should then be fitted to this entry hole, to prevent damage to the cable.

Use the core wire for the positive connection to the cell and the shield for the negative connection but note that the connections to the solar cell are easily damaged, so take care here. In practice, it's best to use neutral-cure silicone sealant to first secure the leads that are already attached to the cell. The microphone cable is then soldered directly to these leads and the connections anchored and waterproofed using additional silicone.

Finally, the microphone cable itself can be secured using silicone, especially around the entry grommet. A plastic cable tie can also be fitted to the cable, to prevent it from being pulled back through the grommet.

At the other end, the microphone cable passes through the cable gland in the box and its leads soldered to the solar cell PC stakes.

Installing the tubing

In most cases, the plastic tubing that goes into the tank can be inserted through a small hole in the inlet screen – especially if it isn't exposed to the sun. If it is exposed, we recommend shielding the tubing with some white flexible conduit to prevent excessive solar heating.

Alternatively, with a steel or plastic tank, the tube can be inserted through a hole drilled in the top of the tank, in a position that's shaded from the sun.

Before installation, you will first have to remove the insect screen or manhole to gain access to the inside of the tank. If the tank isn't full, measure the distance from the full position down to the current level and record this for later use.

To support the pressure sensor tubing, a length of 25mm PVC tubing wedged between the base and the roof of the tank can be used – see Fig.13. The top of this pipe can later be secured to the roof of the tank using silicone sealant or builders' adhesive (ie, after calibration). As shown, the 3mm sensor tubing is attached to the 25mm PVC tubing using cable ties.

Alternatively, a weight could be attached to the end of the tubing to hold it down but don't use anything that will contaminate the water, such as lead. This weight needs to be about 150g per metre of tubing in the water. A 2.54cm (or larger) galvanised steel water-pipe end-stop is recommended.

The best way to attach this weight is to first drill a 6mm hole through the top, so that the tube can protrude a little way inside the end stop. This hole should be large enough to let water pass around the outside of the tube. The tube is then secured to the weight using cable ties on either side of the hole.

Whichever method you use, the assembly should be adjusted so that when it is later placed inside the tank, the end of the 3mm tube is level with the bottom of the tank's outlet pipe.

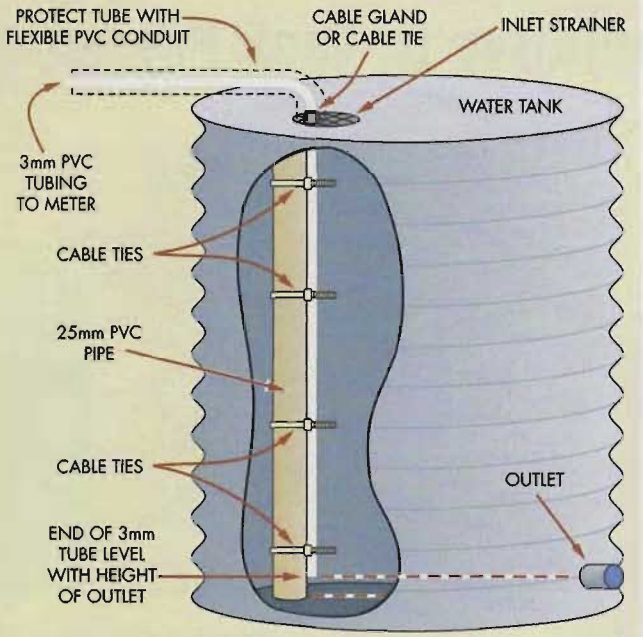


Fig.13: the 3mm PVC tubing that runs to the pressure sensor is installed as shown here. The 25mm PVC pipe is used to keep this tubing vertical in the tank. Note that the end of the 3mm tube should sit level with the base of the tank's outlet.

Note that if the access hole in the top of the tank is some distance away from the screened inlet, it may be necessary to pull the 3mm tubing through using a draw wire. Similarly, if you ever need to remove the assembly, then you may have to retrieve it using a pole with a hook.

As stated previously, it's important to route the tubing between the tank and the Level Meter so that it is not exposed to direct sunlight. If necessary, it can be protected from the sun by covering it in flexible PVC tubing.

At the Level Meter, the tubing runs through the cable gland in the side of the box and fits over the Port 1 nozzle of the pressure sensor. In most cases, you will have to gently heat the end the tube using a hot-air gun so that it will slide over the nozzle.

This should form an airtight connection but if you have any doubts, apply some silicone sealant around the connection behind the nozzle flange. Clamping the tube with a cable tie can also help prevent air leaks.

The rest of the tubing and its weight can now be lowered into the water tank until it sits in the correct position. That done, wait for at least an hour for the air temperature inside the tube to stabilise. This is necessary because the cooling effect of the tank water can affect calibration.

At the end of this 1-hour period, remove the tube from the tank, shake it so that all water runs out, then reinstall it in the tank. Complete the installation by replacing the inlet screen filter or manhole cover on the tank.

Note that it is always necessary to lower the tube assembly into the tank after connecting it to the pressure sensor. If this not done, the water will not pressurise the air inside the tube.

Calibration

Basically, it's simply a matter of calibrating the Level Meter to the current water level in the tank. If the tank is full, then the meter is calibrated to read 100%. Similarly, if it's half-full, the meter is set to read 50%.

Note, however, that to ensure accuracy, it's best to calibrate the meter when the tank is at least 25% full.

The step-by-step calibration procedure is as follows:

(1) Determine the water height that represents 100% full. This is done by measuring the vertical distance between the outlet hole at the bottom of the tank and the overflow pipe at the top. If there's no overflow pipe, then measure to the bottom of the inlet strainer.

(2) Measure the actual depth of the water (ie, the distance between the top of the water and the outlet pipe). You can easily calculate this depth by measuring the distance to the top of the water and then subtracting this from the full water height.

(3) Calculate the water level in the tank as a ratio of full capacity. This simply involves dividing the actual water height by the full water height.

(4) Use this ratio to calculate the calibration voltage. This is done by first multiplying the ratio value by 2 (this converts it to the 2V range that the meter uses for water level measurement) and then adding 1 (since the calibration voltage is 1V when the tank is empty).

For example, if the tank is half full, the full-height ratio is 0.5. This value is then doubled (0.5 x 2 = 1) and then 1 is added to give a result of 2V. Similarly, if the tank is two thirds full, the result is 0.66 x 2 + 1 = 2.32V. And if the tank is full, the result 1 x 2 + 1 = 3V.

(5) Calibrate the meter by adjusting trimpot VR2 so set the voltage at TP4 to the calculated calibration value. Note that switch S1 will have to be pressed while you do this.

Note also that for the basic version, power will only be applied to

continued on page 88

Table 3: TP5 Voltage vs Temperature

Temperature (°C)	TP5 Voltage
10	2.83
11	2.84
12	2.85
13	2.86
14	2.87
15	2.88
16	2.89
17	2.90
18	2.91
19	2.92
20	2.93
21	2.94
22	2.95
23	2.96
24	2.97
25	2.98
26	2.99
27	3.00
28	3.01
29	3.02
30	3.03
31	3.04
32	3.05
33	3.06
34	3.07
35	3.08
36	3.09
37	3.10
38	3.11
39	3.12
40	3.13

Building The Alternative In-Tank Pressure Sensor

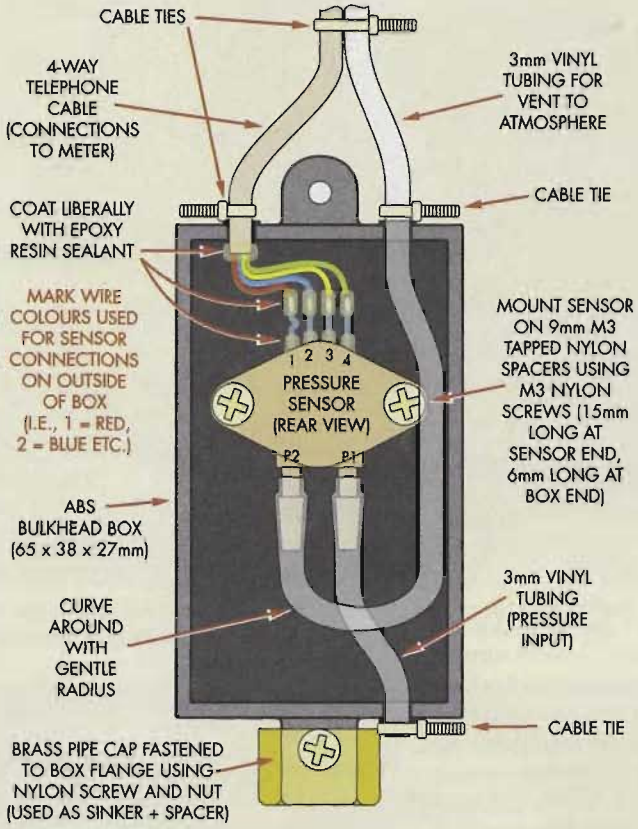


Fig.14: follow this diagram to build the in-tank pressure sensor. Make sure that all electrical connections are sealed with epoxy resin and that the box is filled with silicone sealant, as described in the text.

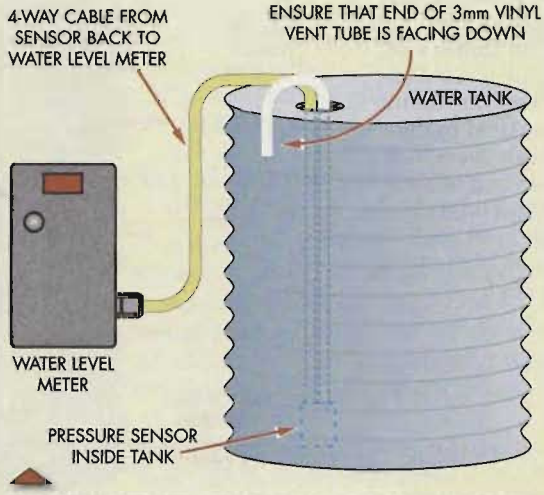


Fig.15: here's how the in-tank pressure sensor is installed and connected to the Water Level Meter. The end of the tube connected to port P1 should sit level with the bottom of the tank's outlet pipe.

AN ALTERNATIVE to mounting the pressure sensor on the PC board is to mount it in a separate small box and place this at the bottom of the tank. The sensor's leads are then connected back to the PC board via a 4-wire telephone cable fitted with a 4-way header plug.

The big advantage of this scheme is that the sensor now directly measures the water pressure. This eliminates the problems associated with air-pressure variations within the connecting tube due to temperature.

In practice, a short air-tube is fitted to prevent direct water contact to the sensor's element but this has little effect on the readings. That's because it is very short (just 40mm long) and because of the more stable temperatures inside the water tank.

Fig.14 shows the assembly details for the "bottom of the tank" sensor. As shown, the sensor is mounted on two M3 x 9mm tapped Nylon spacers and has a "snorkel" attached to its P2 port which vents to the atmosphere.

The short tube attached to the P1 port just exits from the bottom of the box. As stated, the air inside this tube isolates the water from the sensor. This air will remain in the tube unless the assembly is inverted in the water tank.

The snorkel tube has to be long enough to reach beyond the top of the tank. It can exit either via a hole in the insect screen or the tank's lid and must be positioned to keep out both rainwater and any run-off from the tank itself.

In practice, this means that the tube must be bent so that the end faces downwards after it exits from the tank – see Fig.15. This can be done by gluing the tube down the side of the tank (eg, using silicone). Make sure that the radius of the bend is large enough to prevent the tube from kinking.

When installing the wiring, be sure to make a note of the wire colour used for each sensor connection. This will make it easy when it comes to making the connections to the 4-way pin header that plugs into the sensor's socket on the Water Level Meter's PC board.

By the way, the pressure sensor in Fig.14 is depicted from the rear whereas Figs.9 & 11 show the sensor from the front. As a result, the pin designations run in different directions. Be sure to match the pins correctly.

Fortunately, if you do get the connections to the sensor reversed, it is unlikely to be damaged. That's because the sensor comprises piezo resistive elements that act just like resistors. However, it will not operate unless it is connected correctly.

Note that the 4-way header that plugs into the PC board will not fit through the cable gland. This means that the lead must be passed through the gland first, before making the final connection to the 4-way header.

The next step is to check that the unit is operating correctly by blowing gently into the short tube (ie, the one going to port P1). The RGB LED should immediately light up to a colour higher than red (depending on the pressure) when the LED display is activated (eg, by pressing switch S1).

If it doesn't, check the wiring connections and check that the sensor port connections are correct.

If it works OK, the connections are ready to be sealed. This involves coating all of the exposed wire and lead connections to the



Above: this view of the in-tank sensor assembly shows the inside the box before the epoxy resin and silicone was applied to waterproof the connections. Note that the pressure sensor is mounted upside down here compared to its orientation on the PC board (see Figs.9 & 11). The view at right shows the completed unit with the weight attached so that it sinks to the bottom of the tank.

sensor with epoxy resin and then filling the box with neutral-cure silicone sealant.

Note that the epoxy resin used must be suitable for use in wet conditions and must adhere to both PVC and thermosetting plastics; eg, J-B Weld (part No.8270) and Bostik Titan Bond Plus. It should be mixed according to the instructions and applied to totally cover the attachment points where each sensor lead enters the sensor body.

In addition, you should apply resin around the central seal between the two halves of the sensor. Note that you will need to temporarily remove the sensor from the box in order to access the whole underside section.

Next, use epoxy resin to cover the whole length of the lead connections up to where they enter the outer sheath and around the end of the sheath itself. You should also lightly coat the gland in the box where the cable exits, so that the cable will be affixed in position.

That done, remount the sensor and clamp the 4-way cable in place on its gland until the resin cures. Once it has cured, check the coating for any gaps and re-coat if necessary.

Filling the case with silicone

The inside of the box must now be filled with neutral-cure silicone (use a type that's suited to wet area use). This provides added protection and also prevents any lead movement that may cause the resin to crack.

First, apply the silicone so that it reaches to top of the box but do not overfill. That done, allow the silicone to cure without the lid in place. During this period, the tubing should be held in place at the exit points using cable ties or bulldog clips.

Be sure not to let any silicone get inside the short tube connected to port P1 during the above procedure.

It will take some 24-72 hours for the silicone to cure, depending on the type used. Once it has cured, apply additional silicone all around the edges of the box so that the lid can be sealed.

Note that the specified box has two outlet slots at one end and one outlet slot at the other, with matching flanges on the lid. Each slot can be held closed with a cable tie around the exposed flanges. These cable ties will crimp the tubes a little but not enough to close them.

Weighing it down

A weight must be attached to the bottom of the box, so that it sinks to the bottom of the tank.

As shown in Fig.14, you can use a 25mm ID brass pipe end-cap for this weight (or you can use galvanised steel). This can be secured to a mounting eyelet at the end of the specified box using a Nylon screw and nut.

Alternatively, the box can be attached to a length of 25mm PVC conduit tube, as before.

No temperature compensation

Another advantage of the in-tank sensor installation is that temperature compensation is not required (although temperature calibration is still carried out). This means that if the compensation has already been set (eg, if you are converting to the in-tank sensor set-up), then it will need to be adjusted to the no compensation setting (see main text).

Finally, the calibration procedure is the same as for the in-tube method – ie, the sensor is inserted into the tank and trimpot VR2 adjusted to set the calculated calibration voltage on TP4 (see main text). That done, the sensor is removed from the tank and VR3 is adjusted for a 1V reading at TP4. The sensor is then reinstalled and VR2 again re-adjusted to set the calibration voltage at TP4.

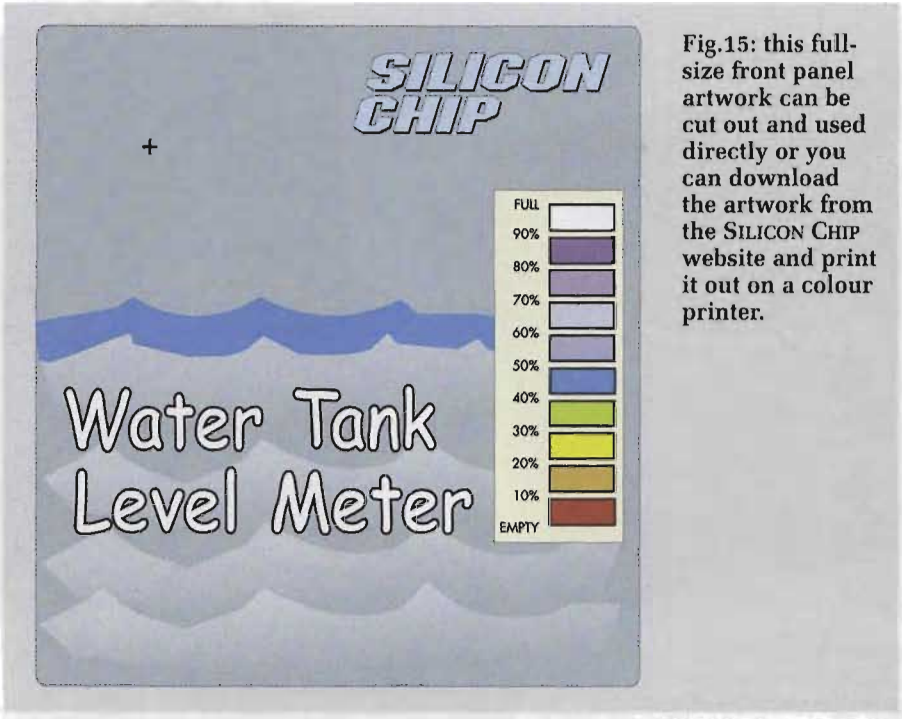


Fig.15: this full-size front panel artwork can be cut out and used directly or you can download the artwork from the SILICON CHIP website and print it out on a colour printer.

the sensor while the tri-colour LED is alight. This means that if the LED goes out and you need more time to adjust VR2, the switch will have to be pressed again.

(6) If practical, remove the tubing from the tank again and shake the water out. Adjust trimpot VR3 (offset) for a reading of 1V between TP4 and TP2.

(7) Reinstall the tube assembly in the tank and readjust VR2 to give the calibration voltage at TP4 (ie, between TP4 & TP2).

Calibration temperature

The next step involves setting the current calibration temperature, so that the readings can be corrected for any subsequent temperature changes. Note, however, that if you intend mounting the pressure sensor inside the tank, this procedure is not required.

Setting the calibration temperature is easy – simply connect a short jumper lead between test points TP2 and TP6. For the telemetry version, the RGB LED should immediately flash green three times. If it doesn't, try removing the jumper at LK1, then wait a few seconds and reconnect the jumper again. For the basic version, S1 must be pressed for the LED to flash when the jumper is connected.

Note that if the tank ever runs dry, then the air trapped in the tube when the water subsequently rises again may be at a different temperature to that set during the calibration. As a result, the calibration may be slightly in error.

Generally, this will not cause much of a variation in level readings. However, if you are using temperature compensation, you can correct the reading by momentarily linking TP6 to TP2 to set a new calibration temperature.

If running out of water is going to be a constant problem, you can install the pressure sensor inside the tank instead – see panel.

Temperature compensation

Having set the calibration temperature, check the water tank level readings over a wide temperature range during the day. You probably will not notice any variations with the basic version because the graduations are in 10% steps and so there is no need to apply temperature compensation. Conversely, when using the unit with the Base Station (to be described), any small variations will be seen and so compensation is worthwhile.

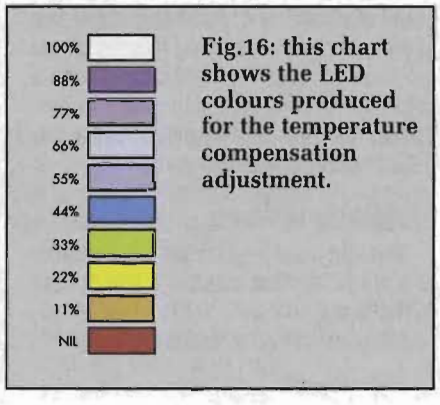


Fig.16: this chart shows the LED colours produced for the temperature compensation adjustment.

Basically, if the reading rises with higher ambient temperatures and falls with cooler temperatures, then temperature compensation can be applied to improve accuracy. Initially, no compensation is set but you can alter the compensation in 10 discrete steps.

The amount of compensation required will depend on the length of tubing exposed to the air outside the tank compared to the length inside the tank. To some extent, it also depends on the pressure sensor and its variation in output with temperature. This can be up to a 4% change over 85°C.

To change the temperature compensation value, you first need to connect a link between TP5 & TP2. If you have the basic version, you then simply press switch S1 to change the compensation. Similarly, for the telemetry version, you have to remove jumper LK1, wait for a few seconds and then re-attach the jumper (to apply power).

Each time you do this, the compensation will step to the next value and the LED display will light to indicate this. The indicated compensation level follows the same colour pattern as for water level, with red indicating zero temperature compensation and white indicating full compensation – see Fig.16.

Note that to reduce the compensation from the current setting, you will have to cycle through the colours to return to the wanted colour.

You will need to experiment to arrive at the best compensation setting. As a guide, full compensation gives a variation of about 10% for a 30°C range in temperature. Don't forget to remove the link between TP5 & TP2 after you are finished.

Finally, note that the solar cell will not recharge an NiMH (or Nicad) cell if the cell voltage drops below about 1.0V. That's because the step-up voltage converter circuit (based on IC1) draws excessive current from the rechargeable cell in an attempt to maintain a 5V output but the solar cell cannot match this current.

In that case, you can recharge the cell by removing jumper LK1, so that the cell is disconnected from the circuit while it charges.

That's all for now. Next month, we'll describe the LCD Base Station. SC



By MAURO GRASSI

Playback adaptor for CD-ROM drives; Pt.2

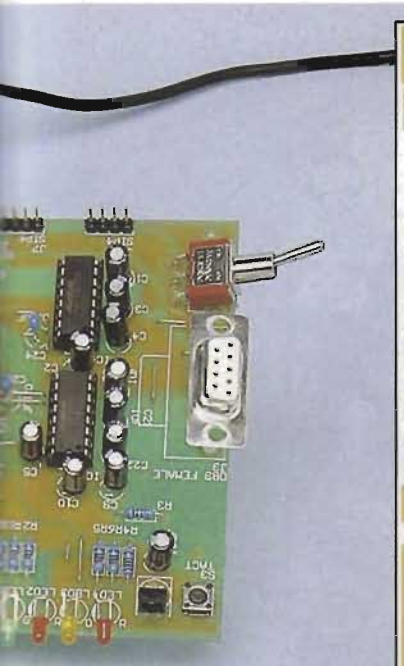
Last month, we published the circuit details of our new CD-ROM Player Adaptor and described its operation. This month, we show you how to build it.

TO KEEP COSTS DOWN, we've designed a single-sided PC board for this project. This board is coded 07112071 and measures 136 x 97mm. The complete board and the CD-ROM drives could optionally be encased in a plastic case or mini-tower computer case, along with the power supply.

Because it's single-sided, the PC board is somewhat larger than a double-sided board would be and there are quite a few wire links that have to be installed. Before installing any parts though, it's a good idea to inspect the PC board for hairline cracks in the tracks or shorts. Some of the tracks are very fine and quite close together, so check these carefully.

Installing the wire links

Fig.2 shows the locations of the wire links and these should all be installed first. Because some of these links are quite close together, it's essential that they be perfectly straight so that they



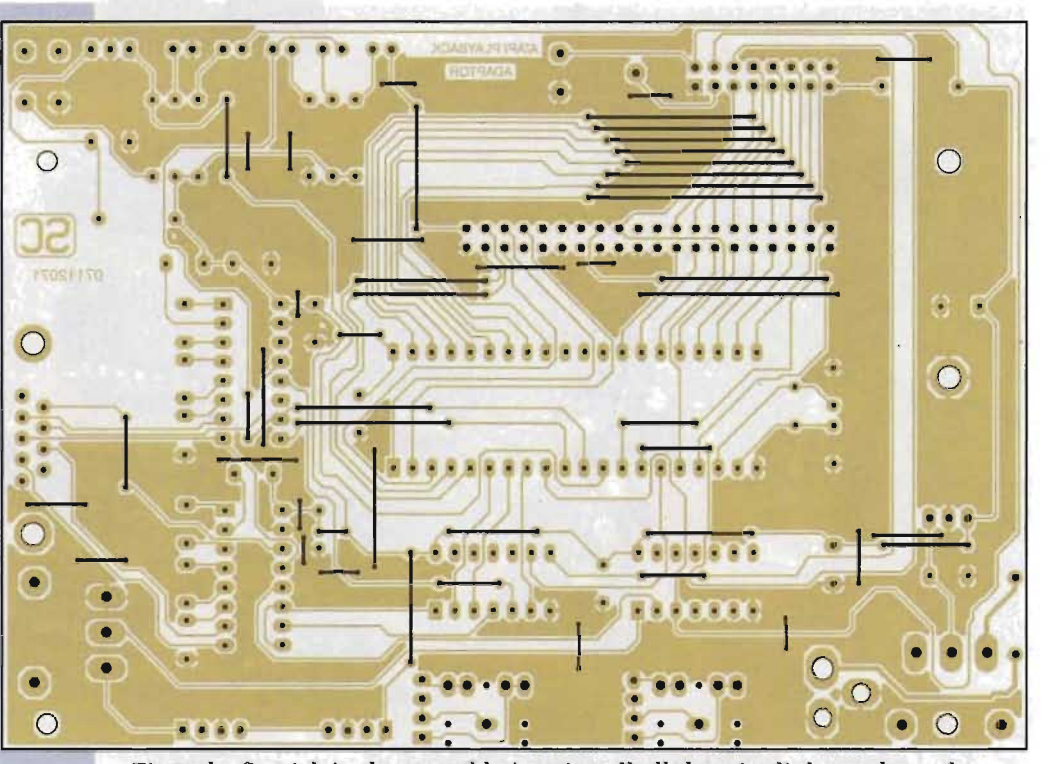


Fig.2: the first job in the assembly is to install all the wire links as shown here. Make sure that these links are straight, to prevent shorts – see text.



Programming The Microcontroller

IF YOU PURCHASE a kit, then the microcontroller will be supplied pre-programmed. If not, then you will have to program it yourself.

To do this, you will need to install both IC4 & IC5 (MAX232), as well as the other two logic ICs. You then load the hex file into Pony Prog 2000 and write to flash. If you don't already have this program, it is available as a free download from **www.lancos.com/ppwin95.html**.

You will need to first flick switch S1 and make sure the orange LED lights up. The micro is then ready to be programmed. We should also mention that if you are using Pony Prog 2000, you must change the setting under Setup -> Interface Setup and make sure that the only box that is ticked is the "Invert Reset" box. Then select the correct device by going to Device -> AVR -> Atmega8515.

Prior to programming, Pony Prog 2000 needs to be calibrated for correct timing. To do this, simply go to Setup -> Calibration. This only needs to be done the first time you run Pony Prog 2000 on a new computer.

Now choose File -> Open Program (FLASH) File and select your hex file. Go to Command -> Program (FLASH) and Pony Prog 2000 should start programming your micro. Once programming is complete, you should flick switch S1 so that the orange LED goes out and then the firmware should start running.

don't short together.

The best way to straighten the link wire is to stretch it slightly by clamping one end in a vice and pulling on the other end using a pair of pliers. Each wire link can then be cut to length and its ends bent down at right-angles using needle-nose pliers before mounting it on the PC board.

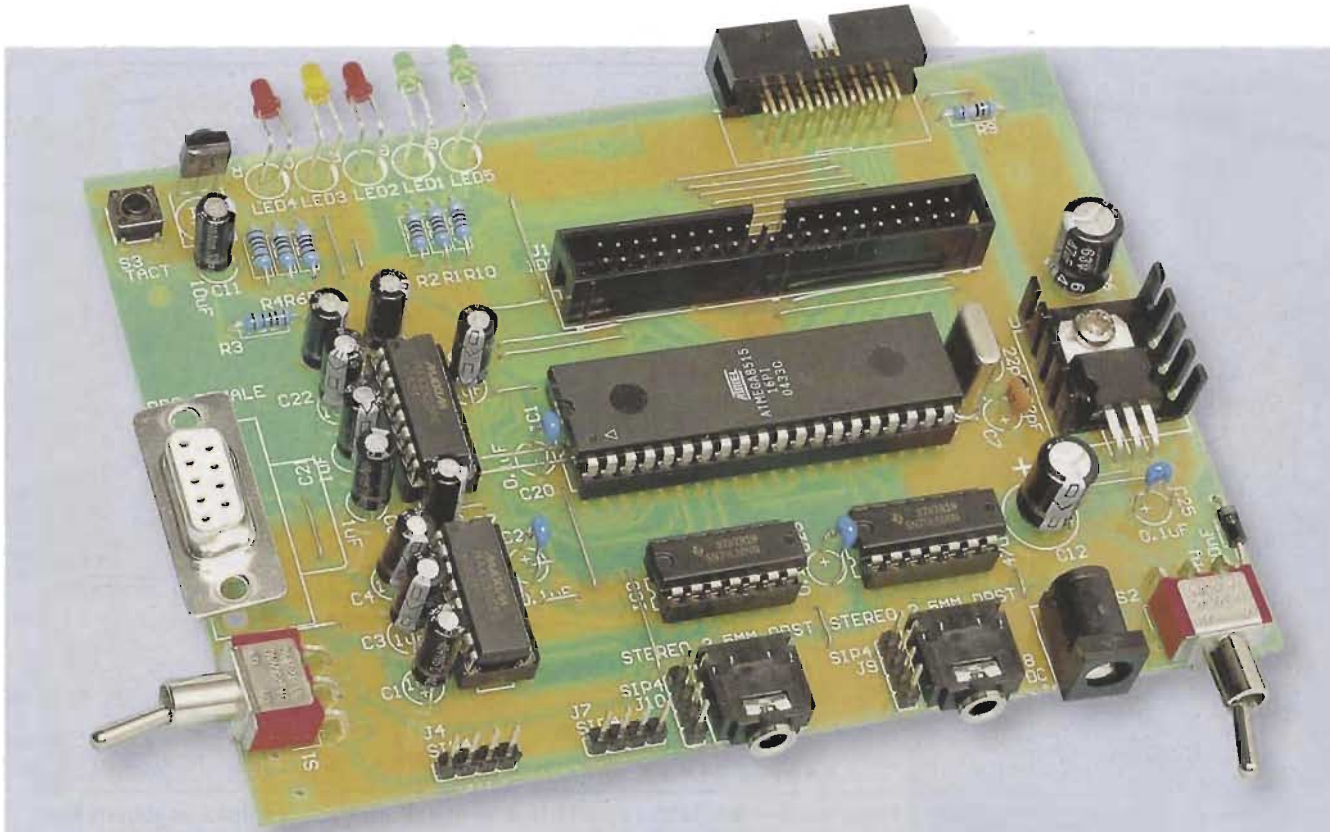
Once you've completed this task, you're ready to install the remaining parts. Fig.3 shows the parts layout on the board.

Start with the resistors, taking care to ensure that the correct value is used at each location. Table 1 shows the resistor colour codes but it's also a good idea to check each one using a digital multimeter before soldering it to the PC board.

Next, solder in protection diode D1, making sure that it is oriented correctly, then install the small tactile switch (S3). The latter only fits correctly if it is the right way around.

The next step is to solder in the 40-pin IC socket for the microcontroller, plus the two 14-pin and two 16-pin DIP sockets for the other ICs. Note that only IC1, IC2 and IC3 are required for normal operation, while IC4 and IC5 are required only if you are planning to program the micro via this board. Make sure that the sockets are all oriented correctly – ie, with their notched ends oriented as shown on Fig.3.

The TO-220 regulator is next on the list. As shown, this part is fitted with a small heatsink and is mounted horizontally on the PC board.



This view shows the fully assembled prototype PC board. Note that the two MAX232 ICs and the DB9 socket (CON3) are only necessary if you intend programming the microcontroller on the board. If you buy a kit, the microcontroller will be supplied pre-programmed. Note also that trimpot VR1 and several wire links were added to the board after this photo was taken.

The correct procedure here is to first bend the regulator's leads down though 90°, exactly 5mm from its body. That done, the device and its heatsink are fastened to the PC board using an M3 x 10mm screw and nut. The leads are then soldered.

Don't solder the leads before bolting the device to the PC board. If you do, you could stress and break the PC tracks as the device is tightened down on the board.

Trimpot VR1 can go in next, followed by the 2.5mm DC socket (CON6) and the electrolytic capacitors. The latter are polarised, so make sure they go in the right way around.

Now solder in the 100nF bypass capacitors. Take particular care with the 100nF capacitor immediately to the left of IC1. It straddles a couple of wire links and should be mounted proud of the board so that its leads don't short against these links.

The other 100nF capacitors can be pushed all the way down onto the board.

The five LEDs (LEDs1-5) and the infrared receiver module (IRD1) can now be installed. As shown in the photos, the LEDs all go in with their leads bent at right angles and are mounted about 5mm proud of the PC board. A cardboard spacer cut to 5mm makes a handy gauge when it comes to bending the LED leads and spacing them evenly off the board, so that they all line up.

Take care to ensure that the LEDs all go in the right way around. Just remember that the anode lead is always the longer of the two.

IRD1 can be mounted so that its lens lines up with the centres of the LEDs. It must be oriented so that its lens faces out from the PC board.

Installing the headers

The next job is to solder in the 16-

Table 2: Capacitor Codes

Value	µF Code	IEC Code	EIA Code
100nF	0.1µF	100n	104
22pF	NA	22p	22

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	5	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	51Ω	green brown black brown	green brown black gold brown

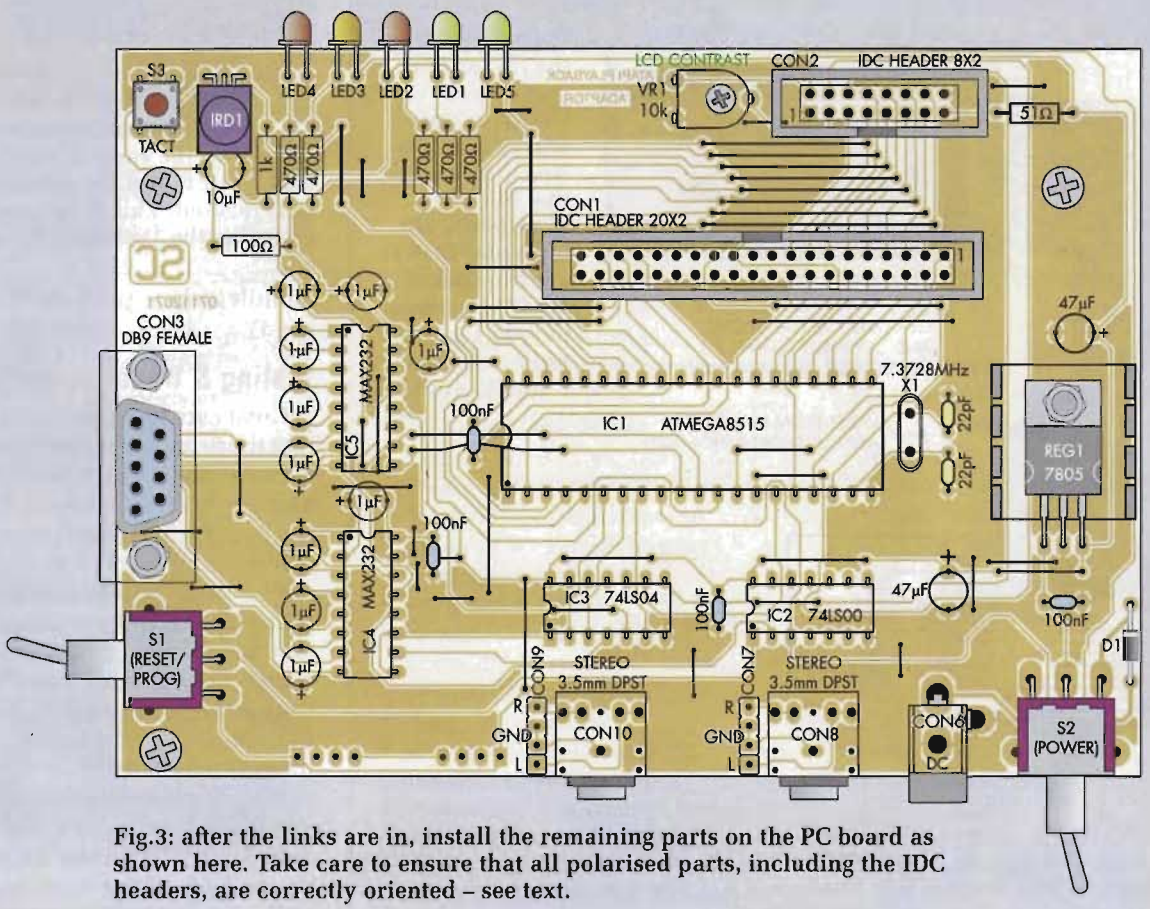


Fig.3: after the links are in, install the remaining parts on the PC board as shown here. Take care to ensure that all polarised parts, including the IDC headers, are correctly oriented – see text.

pin and 40-pin IDC headers. Pin 1 of each of these is indicated by an arrow on the side of the header and this corresponds to the square pad on the PC board. Be sure to get them the right way around.

In each case, it's a good idea to initially solder just two pins of the header and then check that it is sitting flat against the PC board. After that, it's a routine job to solder the rest of the pins.

Finally, complete the PC board assembly by installing the 7.3728MHz crystal (it can go in either way), the two 22pF capacitors, the DB9 serial port connector (CON3), the two stereo jack sockets (CON8 & CON10), the two 4-way SIL pin headers (CON7 & CON9) and the two toggle switches.

Connecting the LCD module

The LCD module to use must conform to the Hitachi HD44780 industry standard. This has an interface consisting of 16 or 14 lines, depending on how the LED backlight is connected.

A 16-way (or 14-way) ribbon cable is used to make the connection to the

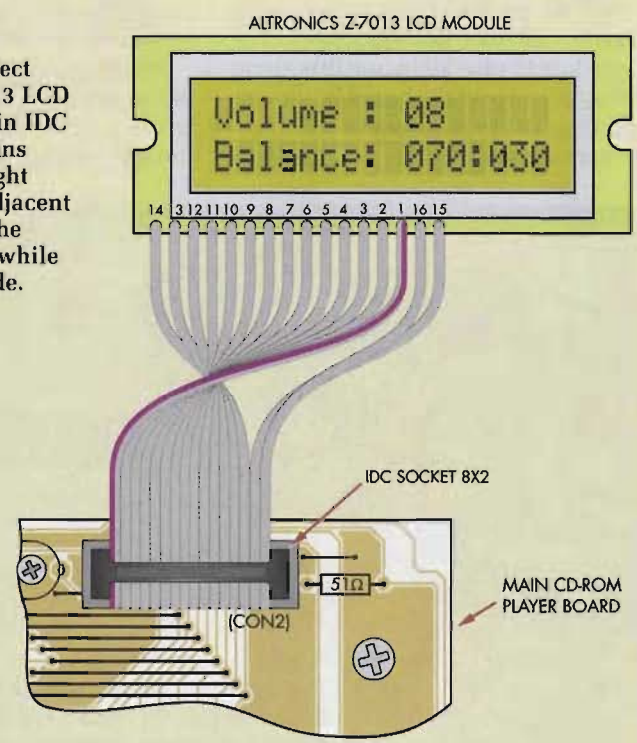


Fig.4: this diagram shows how to connect the Altronics Z-7013 LCD module to the 16-pin IDC socket. Note that pins 15 & 16 (the backlight connections) are adjacent to pin 1. Pin 15 is the anode connection, while pin 16 is the cathode.

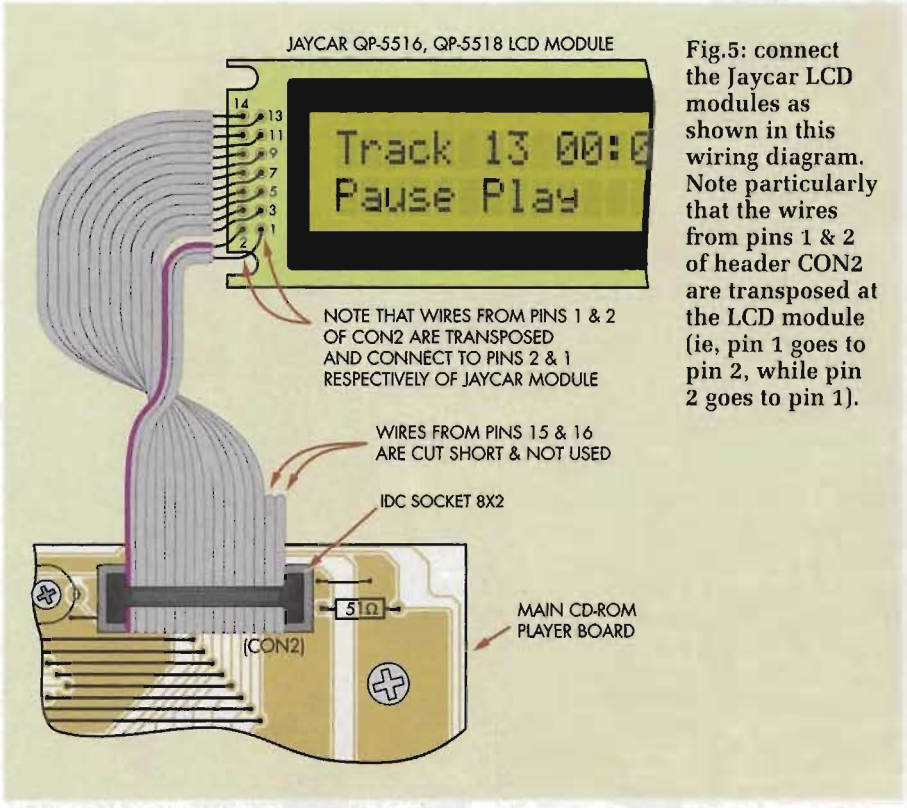


Fig.5: connect the Jaycar LCD modules as shown in this wiring diagram. Note particularly that the wires from pins 1 & 2 of header CON2 are transposed at the LCD module (ie, pin 1 goes to pin 2, while pin 2 goes to pin 1).

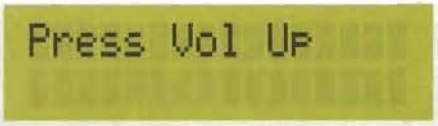


Fig.6: assigning the buttons on the remote for the various functions is easy – just follow the prompts on the LCD readout. This is the prompt for assigning the "Volume Up" button.

LCD module and this is terminated at the other end in a 16-way IDC line socket, with the red stripe on the cable going to pin 1. This end then plugs directly into the 16-way IDC header on the PC board.

Fig.4 shows the connections to the Altronics Z-7013 LCD module. This device has 16 pins all in one line along the bottom edge of the board (although pins 15 & 16 are adjacent to pin 1).

Alternatively, the Jaycar QP-5516 and QP-5518 LCD modules each have a 2 x 7-pin arrangement at one end; ie, there are only 14 connections. The backlight connections are made on the module itself, so pins 15 & 16 of CON2 are not connected in this case. Fig.5 shows the wiring connections for the specified Jaycar modules.

In particular, note that pin 1 on the Jaycar modules is the +5V connection, while pin 2 is the 0V connection. It's the other way around on the Altronics module, where pin 1 is 0V and pin 2 is +5V.

Testing & troubleshooting

Great care has been taken to ensure that the firmware is free from bugs but we cannot guarantee that it will work with every CD-ROM drive. We did test the board with six different CD-ROM drives and it worked well.

The only problem was that two of the drives did not respond to the volume change command. However, we are not sure that these two drives were actually functioning correctly all of the time, as they appeared to have intermittent faults.

Whichever drive you want to use for this project, make sure it is an ATAPI device (check that the IDC connector on the back of the drive has 40 pins, as opposed to 50 pins for a SCSI connector). Note also that the adaptor will not work with some smaller form factor CD-ROM drives which have 44-pin connectors (akin to the 2.5-inch notebook hard drives).

Before plugging in the micro (IC1), the first thing to do is to check the power supply rails. To do this, first connect a 9-12V DC plugpack to the DC socket (CON6) and switch on. That done, check that the OUT terminal of REG1 is at +5V with respect to ground. Similarly, you should be able to measure +5V on pin 40 of the 40-pin socket, while pin 20 should be at 0V.

If these checks are OK, switch off



The audio output at the back of a CD-ROM drives can be connected to CON7 or CON9 via a standard 4-way cable fitted with matching headers. These cables are readily available from computer stores or you can make your own.

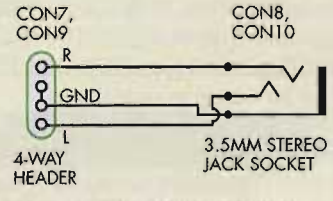


Fig.7: 4-way headers CON7 & CON9 are connected to the two 3.5mm stereo jack sockets. This makes it easy to connect to the CD-ROM drive audio outputs via a standard stereo jack plug.

Table 3: CON2 Pin Assignments		
Pin	Pin Name	Description
1	V_{SS}	Supply rail for module; typically GND
2	V_{DD}	Supply rail for module; typically +5V
3	V0	Set LCD contrast
4	RS	RS = 0 selects instruction; RS = 1 selects data
5	R/W	R/W = 0 selects write; R/W = 1 selects read
6	E	E = 1 selects the LCD module
7	D0	Data bus bit 0
8	D1	Data bus bit 1
9	D2	Data bus bit 2
10	D3	Data bus bit 3
11	D4	Data bus bit 4
12	D5	Data bus bit 5
13	D6	Data bus bit 6
14	D7	Data bus bit 7
15	A	LED backlight anode
16	K	LED backlight cathode

and plug in the micro. Make sure that this device is oriented correctly and that all its pins go into the socket. In particular, take care to ensure that none of the pins are folded back under the device.

That done, set trimpot VR1 to mid-range and switch on again. Check that the LCD module initialises correctly, then adjust VR1 for optimum display contrast.

Remote control functions

The firmware has an option that allows you to use any RC5 protocol remote control. That means that you can use virtually any universal remote control plus most of the remotes that are commonly used with TV sets, VCRs and DVD players

The first step is to assign the buttons that will control the various functions. To do this, you first need to press and hold the "Remote Program" button (S3) while the device resets. To get the device to reset, you toggle switch S1 so that the orange LED lights and then toggle it again to turn the LED off (ie, you hold S3 down while you toggle S1 twice).

This resets the micro and takes you to the "Setup Remote" screen. Here

Parts List: CD-ROM Controller

1 PC board, code 07112071, 136 x 97mm
1 16x2 backlit LCD module (Jaycar QP-5516 or QP-5518, Altronics Z-7013)
1 PC-mount 40-pin IDC header (CON1) (Jaycar PP-1114, Altronics P-5040)
1 PC-mount 90° 16-pin IDC header (CON2) (Jaycar PP-1122, Altronics P-5066)
1 PC-mount DB9 female RS-232 socket (CON3) (Altronics P-3050, Jaycar PS-0804) (optional for programming)
1 28-pin or 40-pin SIL header strip (Jaycar HM-3211, Altronics P-5430)
1 16-way IDC ribbon cable (to connect LCD module, length to suit) (Jaycar WM-4502, Altronics W-2616)
1 40-way IDE HDD cable (to connect CD-ROM drives)
1 16-way IDC line socket (Jaycar PS-0985, Altronics P-3516)
2 3.5mm stereo sockets, PC-mount (CON8,10) (Altronics P-0094)
1 2.5mm DC socket, PC-mount (CON6) (Jaycar PS-0520, Altronics P-0621A)
1 PC-mount micro tactile switch (S3) (Jaycar SP-0600, Altronics S-1120)
2 SPDT 90° PC-mount toggle switches (Altronics S-1325)
1 40-pin IC socket
2 16-pin IC sockets (optional for programming)
2 14-pin IC sockets
1 TO-220 mini heatsink (Jaycar HH-8502, Altronics H-0630)
1 7.3728MHz crystal (X1)
1 10kΩ horizontal trimpot (VR1)
1.5m tinned copper wire for links
1 M3 x 10mm machine screw
1 M3 nut

Semiconductors

1 ATMega 8515 microcontroller programmed with CDATA.hex (IC1)
1 74LS00 quad NAND gate (IC2)
1 74LS04 hex inverter (IC3)
2 MAX232 RS-232 transceivers (IC4,IC5) (optional for programming)
1 infrared receiver module (IRD1) (Jaycar ZD-1952, Altronics Z-1611)
1 7805 3-terminal regulator (REG1)
1 1N4004 silicon diode (D1)
2 3mm green LEDs (LED1,LED5)
2 3mm red LEDs (LED2,LED4)
1 3mm orange LED (LED3)

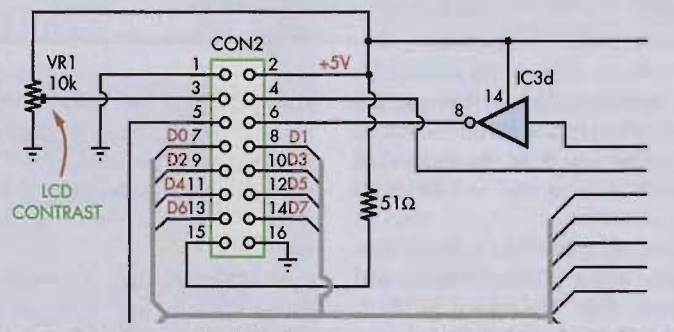
Capacitors

2 47µF 16V electrolytic
1 10µF 16V electrolytic
10 1µF 63V electrolytic (optional for programming)
4 100nF monolithic
2 22pF ceramic

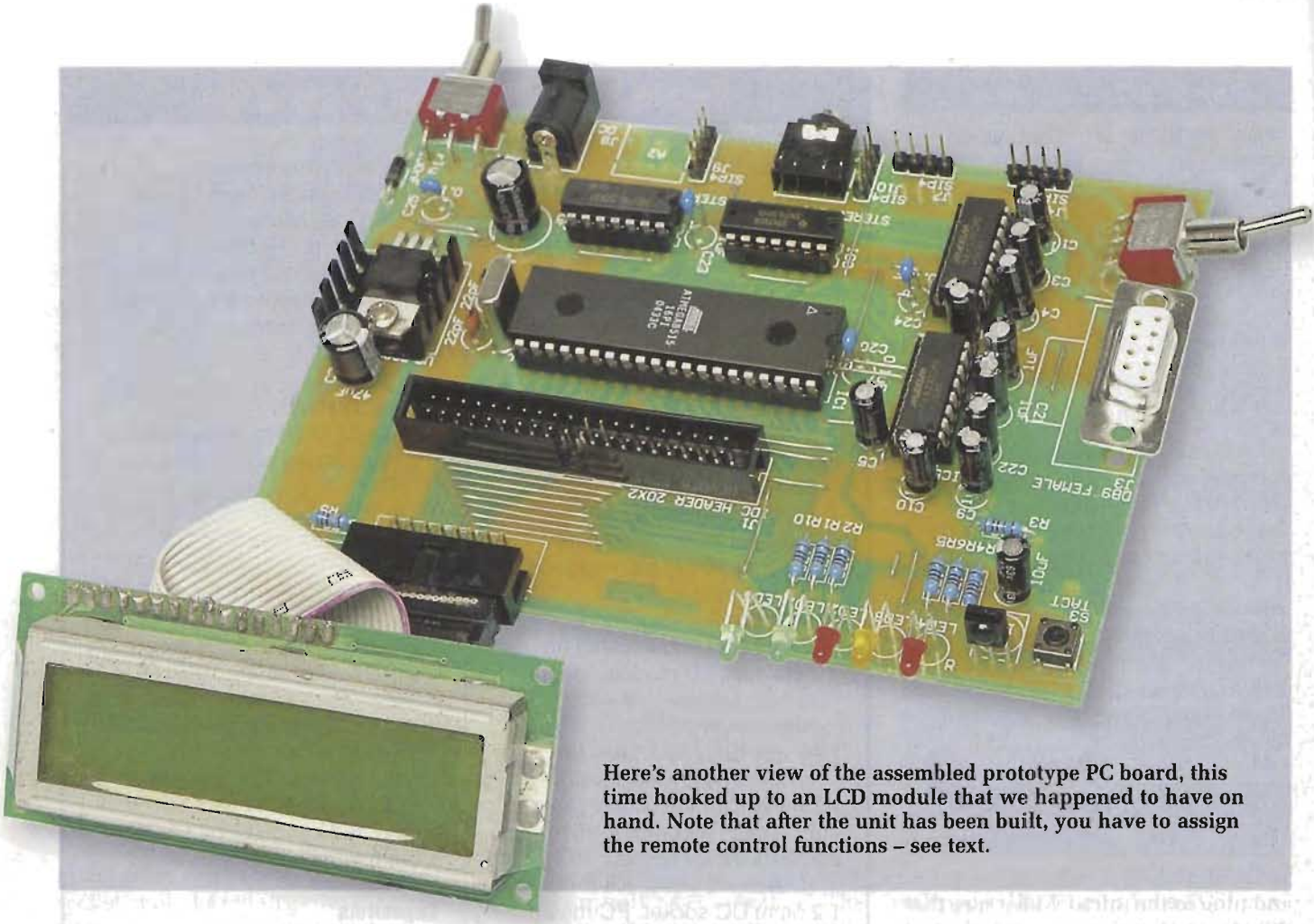
Resistors (0.25W, 1%)

1 1kΩ 1 100Ω
5 470Ω 1 51Ω

Correction To Circuit Diagram



Whoops! – we inadvertently left the contrast trimpot (VR1) off the circuit for the CD-ROM Player Adaptor (Fig.3, p42, Nov.07) and off our prototype PC board. This diagram shows the amended circuit section. Note also that there should be two 47uF capacitors across the output of REG1, not one as shown on the circuit (the PC board is correct).



Here's another view of the assembled prototype PC board, this time hooked up to an LCD module that we happened to have on hand. Note that after the unit has been built, you have to assign the remote control functions – see text.

Power Supply Options

LAST MONTH, we stated that one of the supply options for the board was to plug a computer power supply into either CON4 or CON5. We have since decided to scrap that option and now recommend that you stick to powering the board from a 9-12V DC plugpack.

The disk drives can be powered directly from a computer power supply. Alternatively, if you don't want the fan noise of a computer power supply, you can use a mains adaptor like the Jentec JTA0202Y. This unit supplies +12V and +5V rails at 2A each which is enough to power two drives and comes with the correct plug (you'll need a Y-splitter cable to power two drives).

At the moment, you will have to purchase this adaptor via eBay but it may be available from Altronics and Jaycar in the near future.

you can program the keys to be used for the project. The device will guide you through the set-up, and the keys that you define will be stored in EEPROM for later use.

For example, when the screen displays "Press Vol Up" (see Fig.6), you simply press the "Volume Up" button on your remote. It's just a matter of cycling through all the options until the button assignment has been completed.

This means that you can use any spare RC5 remote and define the keys as you see fit. The "Power" button is deliberately unused for this project and this lets you control the device with your TV remote control, for example.

In other words, because the "Power" button is unused, you can have your TV off and use its remote to control the CD-ROM Player Adaptor. Then, when you are finished with the adaptor, you can switch it off and use the remote to control your TV again.

Of course, you won't be able to play a CD and watch your TV simultaneously using the same remote but this feature can keep costs down. It means that you don't have to purchase a separate universal remote control, although you can if you wish.

Operation

The user interface has been kept quite simple. Occasionally, issuing a command will result in an error screen. This is perfectly OK as the firmware has been designed to be quite tolerant of errors. If it happens, simply try the command again but if the problem persists, it may indicate an incompatibility or fault with your drive.

The "Error" screen typically looks like that shown in Fig.2 last month but may have different numbers which are used for debugging purposes. The hexadecimal numbers give an indication of the state of the ATA registers and the state machine when the error occurred.

If the errors consistently re-occur, this information will help to diagnose the problem. SC

Vintage Radio

By RODNEY CHAMPNESS, VK3UG

Kriesler 11-59 5-Valve Dual-Wave Mantel Receiver

Like many manufacturers, Kriesler built numerous 5-valve, dual-wave receivers with quite good performance. The 11-59 receiver was aimed at the low-priced end of the market but its performance was still quite acceptable, with good reception on the shortwave stations.

Dual-wave and multi-band receivers were quite popular during the late 1930s through to the mid 1950s. These sets covered both the broadcast band and a selection of shortwave bands between 1.5MHz and 30MHz.

Initially, multi-band receivers covered just the medium-wave band of 550-1500kHz and the long-wave band of around 150-400kHz. In the early days of wireless, it was considered by "the powers that be" (ie, government authorities) that wavelengths shorter than 200 metres (1500kHz) were useless for long-range radio operation. As a result, they decided to allow amateur radio operators to use wavelengths shorter than 200 metres in the belief that they would be able to do no more than "get over the back fence".

In practice, the amateurs quickly demonstrated that shortwave was the best to use for long-range communications. That, in turn, soon led to the authorities (having wiped the egg from their faces) allowing various broadcasting stations to use the shortwave bands. These early shortwave broadcasts were mainly nationalistic programs loosely disguised as general entertainment.

Eventually, various segments of the shortwave bands were allocated by international agreement for these broadcasters. These bands became known as the 120, 90, 75, 60, 49, 41, 31, 25, 19, 16, 13 and 11-metre bands, with a 23-metre (13MHz) band added at a later date.

Like millions of others throughout the world, Australians grasped the opportunity to listen to shortwave radio broadcasts, particularly the direct test cricket broadcasts from England. There was nothing like listening through the static and fading while Bradman compiled another century!



The Kriesler 11-59 was a budget-priced dual-wave mantel receiver. It covered the broadcast band from 540-1650kHz and the 6-18MHz shortwave band.

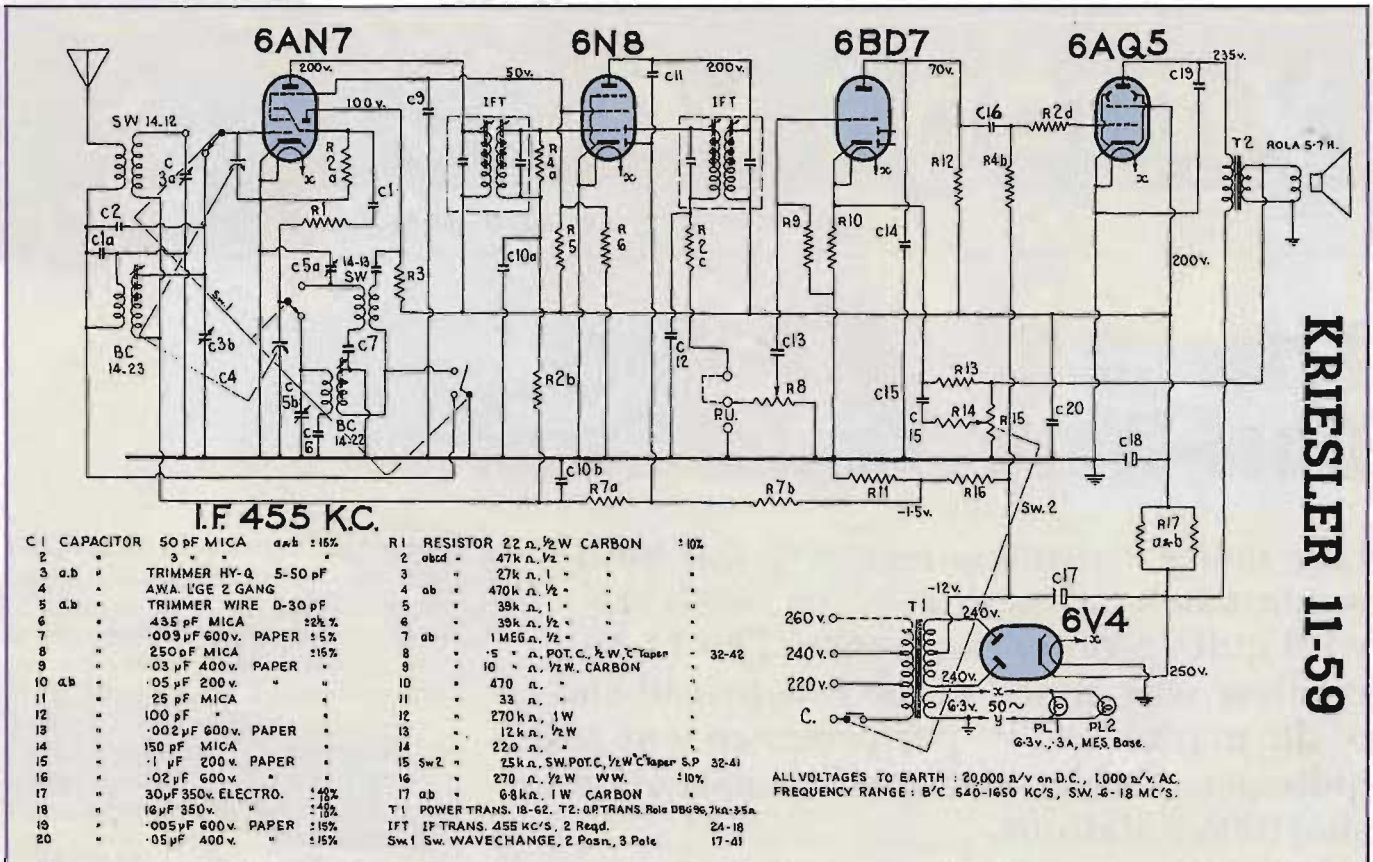
Multi-band receivers

Multi-band receivers, like the AWA 6-valve 7-banders (see March & April 2002) were used by many keen shortwave listeners during the late 1930s and into the 1950s. However, the cost of these radios was quite high due to the complexity of the switching that was necessary in order to tune the various bands.

For this reason, many manufacturers produced sets with just one shortwave band. The international broadcast bands of most interest were in the 6-18MHz range or the 7-22MHz range. By only tuning one or the other of these ranges, it was practical to have just one shortwave band plus the broadcast band installed in the set.

This drastically reduced the complexity and the price of the receiver and opened up a new market for such radios.

Up until the late 1940s and even into the 1950s, most dual-wave receivers



C1		CAPACITOR	50 pF MICA	a.b	±15%	R1	RESISTOR 22 Ω, ½W CARBON ±10%
2		"	3 " "		"	2	abcd - 47k Ω, ½ " " "
3	a.b	"	TRIMMER HY-Q 5-50 pF			3	" 27k Ω, 1 " " "
4		"	A.W.A. L'GE 2 GANG			4	ab " 470k Ω, ½ " " "
5	a.b	"	TRIMMER WIRE 0-30 pF			5	" 39k Ω, 1 " " "
6		"	435 pF MICA		±2½%	6	" 39k Ω, ½ " " "
7		"	·009 µF 600v. PAPER		±5%	7	ab " 1 MEG Ω, ½ " " "
8		"	250 pF MICA		±15%	8	" ·5 " Ω, POT. C., ½ W, 'C' Taper - 32-42
9		"	·03 µF 400v. PAPER		"	9	" 10 " Ω, ½W., CARBON "
10	a.b	"	·05 µF 200v. "		"	10	" 470 Ω, " "
11		"	25 pF MICA		"	11	" 33 Ω, " "
12		"	100 pF "		"	12	" 270 kΩ, 1W "
13		"	·002 µF 600v. PAPER		"	13	" 12 kΩ, ½W "
14		"	150 pF MICA		"	14	" 220 Ω, " "
15		"	·1 µF 200v. PAPER		"	15	Sw2 " 25 kΩ, SW. POT. C., ½W 'C' Taper S.P 32-41
16		"	·02 µF 600v. "		"	16	" 270 Ω, ½W WW. ±10%
17		"	30 µF 350v. ELECTRO.		+40% -10%	17	ab " 0·8 kΩ, 1W CARBON "
18		"	16 µF 350v. "		+40% -10%	T1	POWER TRANS. 18-62. T2: O.P. TRANS. Rola DBG96, 7kΩ-3·5Ω.
19		"	·005 µF 600v. PAPER		±15%	IFT	IF TRANS. 455 KC/S., 2 Reqd. 24-18
20		"	·05 µF 400v. "		±15%	Sw1	Sw. WAVECHANGE, 2 Posn., 3 Pole 17-41

Fig.1: the circuit of the Kriesler 11-59 dual-wave receiver. It's a fairly conventional 5-valve superhet receiver with a 6AN7 converter, a 6N8 IF amplifier and 6BD7 & 6AQ5 audio amplifier stages. A 6V4 is used as the rectifier.

with decent shortwave performance included a radio frequency (RF) stage. However, the introduction of valves such as the 6AN7, 6AE8, 6AJ8 and other triode-hexode valves for the converter stages made it possible to obtain good performance without an RF stage, thus further reducing receiver cost. These valves are low-noise converters, whereas valves like the 6BE6 and similar pentagrid converters are inherently noisy by comparison.

An additional feature of shortwave broadcasting during that period was that the transmitter powers were being increased, as were the antenna gains. Today, Radio Australia at Shepparton uses transmitters of 100kW output. These feed antennas with gains that give an effective radiated power in the favoured direction of up to 10MW. No wonder an RF stage is no longer needed!

In fact, I know of one listener in Rockhampton who can listen on 9MHz to Radio Australia (Shepparton) on a crystal set.

Some very good dual-wave receivers were manufactured but there were some duds too, such as the dual-wave 4-valve sets. The latter just didn't have enough gain to be useful on shortwave.

By the mid-1950s, most Australians were no longer interested in listening to shortwave. The average dual-wave set was probably tested on shortwave a few times during its life but generally, the wave-change switch was left in the broadcast position.

That said, there was a niche market for dual-wave receivers from the late 1940s right through to the early 1960s, due to Australia's expanding migrant population. Many were homesick and shortwave radio broadcasts gave them the opportunity to listen to news from home.

Kriesler 11-59

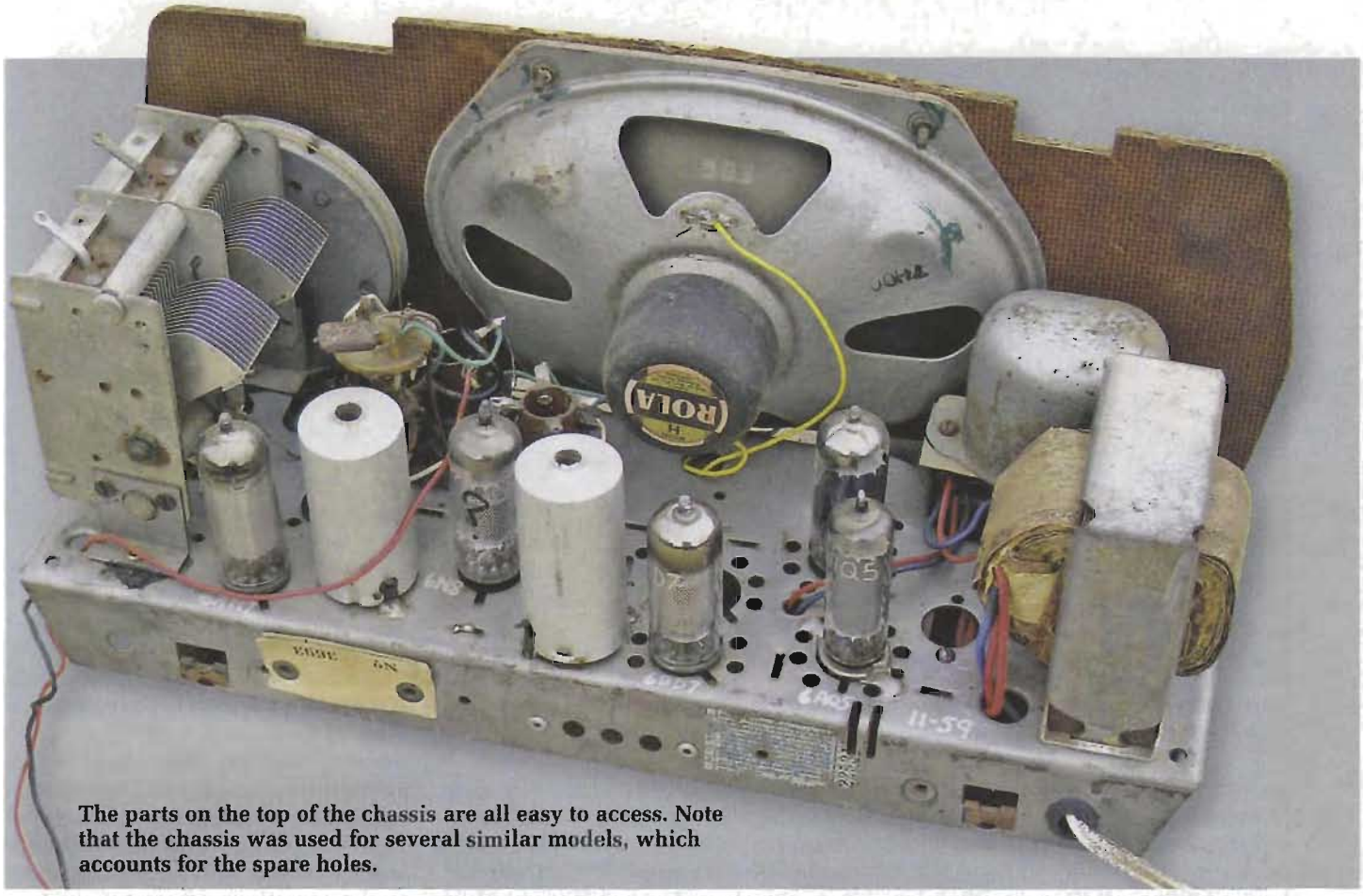
During the 1950s, Kriesler built a number of different mantel receiver models on a common chassis and mounted them in the same cabinet. The main difference in the appearance of these sets was the front escutcheon, which had provision for either two or four control knobs. The dial scales were also different, to suit particular models.

I obtained my Kriesler 11-59 dual-wave receiver back in 1992 as just a dirty, greasy chassis with no cabinet. I initially thought that I would scrap the set and use the parts as spares for other sets. However, when I looked at it more closely, it was plain that it was a dual-wave model, which I didn't have. As a result, I decided to clean it up, restore it to full working order and scrounge a cabinet from a similar broadcast-band only Kriesler set.

The clean-up

Most of the cleaning was done using rags and kitchen scouring pads soaked in household kerosene. To get into the awkward spots, I used a screwdriver to push a kerosene-soaked rag around. This proved effective and the majority of the muck was removed from the chassis and the components. It certainly wasn't pristine but it certainly looked a lot better than when I started.

Note that because kerosene is slightly oily, it also acts as a rust inhibitor.



The parts on the top of the chassis are all easy to access. Note that the chassis was used for several similar models, which accounts for the spare holes.

As a result, the set's metalwork hasn't shown any obvious increase in rust since it was obtained 1992.

I was fortunate to have a cabinet from another receiver that I could use for the set. It responded well to automotive cut and polish compound to get rid of some small scratches and the cabinet now looks quite presentable. I had three knobs that were in good order but the fourth was slightly damaged and I have so far been unable to get a suitable replacement.

The felt washers that go between the knobs and the front of the cabinet were missing so I had to cut some out. The felt sheet was obtained from a craft shop and two hollow hole punches were used to cut out the centre and the outer edge of each washer.

Another problem was that the paintwork on the front panel behind the dial escutcheon had faded. This was given a coat of gold-coloured spray paint and it came up looking quite good.

Circuit details

The circuit is similar to many other 5-valve dual-wave sets of the 1950s. It covered the broadcast band from 540-1650kHz and a shortwave band from 6-18MHz. Fig.1 shows the details.

As shown on Fig.1, a 6AN7(A) is used as the converter valve. This stage converts the incoming signal (either broadcast band or shortwave band) to the intermediate frequency (IF) of 455kHz.

A 3-pole, 2-position switch is used to switch the aerial and oscillator coils. The untuned windings on the coils are wired in series with one another in such a way that operation on either band is not compromised. This method of wiring saves using a bigger switch to achieve the band changes.

The converter's output is fed via an IF transformer to the pentode section of a 6N8 valve which acts as an IF amplifier stage. A diode inside the 6N8 acts as the detector, while a second diode is used to provide delayed AGC.

The gain of the IF amplifier is apparently high enough to cause the IF stage to be regenerative, so the secondary of the first IF transformer has a 470kΩ resistor across it to improve stability. The cathodes of both RF stages are earthed and -1.5V of bias is applied to these stages via a back bias arrangement consisting of resistors R11 and R16. This -1.5V also sets the delay for the AGC system, so a reasonable amount of output is obtained before any AGC is applied to the front-end of the receiver.

In addition, a bias voltage of -12V is derived for the 6AQ5 output valve

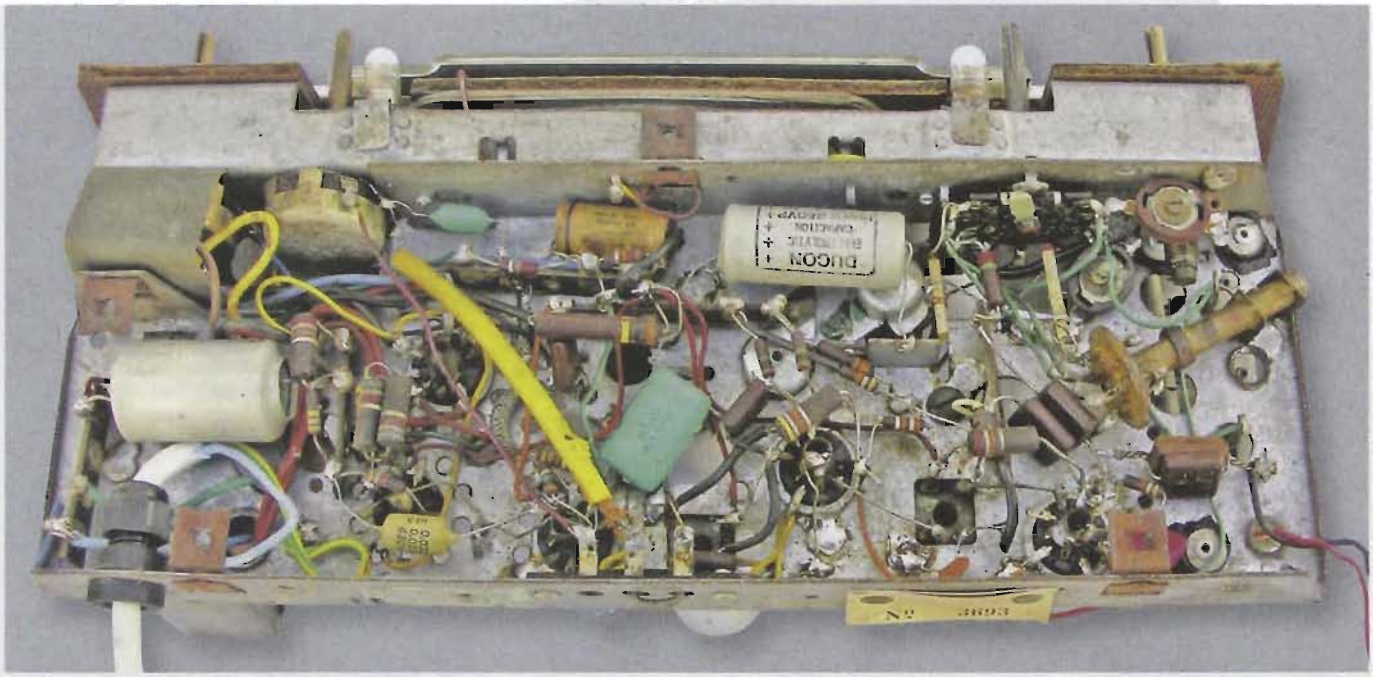


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This under-chassis view shows the rather untidy nature of the wiring. The original 2-core mains lead has been replaced by a 3-core lead, so that the chassis could be earthed for improved safety.

(ie, at the junction of R16 and the transformer's HT secondary centre tap). Note that 235V of HT is applied to the 6AQ5's plate, while 200V is applied to its screen and to the plate circuits of the two RF valves (6AN7 & 6N8). The 6BD7 has a plate voltage of just 70V.

Following the detector, the extracted audio signal is applied to a plug and socket arrangement on the back of the chassis. This allowed the set to be used as a normal radio receiver or simply as an audio power amplifier (mono) for a turntable. I'm not sure how often this facility was used in the real world but it was probably rarely used. Basically, it was a handy sales gimmick that didn't cost much to provide.

Two stages of audio amplification are provided, first by a 6BD7 and then by a 6AQ5 output stage. Note that feedback from the voice coil of the loudspeaker is applied to the cathode of the 6BD7 to lower distortion. This feedback network also acts as a tone control in conjunction with potentiometer R15. The audio quality from the Rola 5-7H loudspeaker is quite good.

Power supply

The power supply is quite conventional and is based on a 6V4 rectifier. This is driven by the centre-tapped secondary of the mains transformer and delivers a nominal 250VDC of HT. Capacitors C17 & C18 and resistor R18 provide the necessary filtering.

Overhauling the circuit

My first step in overhauling the circuit was to replace the paper capacitors with polyester types. The only one I didn't replace was the tone control capacitor (C15), as even quite high leakage here would have little effect on the operation of the set.

The electrolytic capacitors all proved to be in good order and reformed readily (the techniques used to reform electrolytic capacitors were discussed in the October 2006 issue). The resistors were then checked and were all found to be within tolerance, which is within around 10% of the marked value.

Next, the speaker transformer windings were checked for continuity, as was the power transformer. The power transformer was also tested using my 1000V insulation tester for any breakdown between the primary and the chassis. No discernible leakage

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resistance was detected so it was still in good order.

As can be seen from one of the photos, the wiring in the set is rather untidy with bits and pieces added here and there in any available space. This is probably due to the fact that the same chassis was also used for a variety of broadcast-band sets. That said, the set isn't difficult to work on.

Testing

Having determined that no obvious faults were present, the set was connected to the mains and switched on. Unfortunately, it wasn't working, there being no audible output.

Because the audio amplifier input is at the back of the chassis, it was easy for me to place my finger on the link. A healthy "blurt" immediately came from the speaker which meant that the audio amplifier stages (6BD7 & 6AQ5) were OK. The problem was therefore in the RF section of the set so I initially decided to try replacing the two valves in that section. Replacing the 6AN7 had no effect but when I replaced the 6N8, the set burst into life.

Alignment of the receiver was quite routine and was along the lines described in the December 2002 and January & February 2003 issues. The sensitivity of the receiver is quite good and shortwave stations are quite easily heard.

As with most dual-wave receivers of the era, tuning on shortwave is extremely touchy and care is needed to accurately tune stations in. Perhaps this is one of the reasons why these sets were not used to any great extent on shortwave. By contrast, sets that had bandspread shortwave bands were much easier to tune and were more popular.

Postscript

Having restored this receiver around 15 years ago and not using it since, I wondered how it would go after such a long period of inactivity. Initially, I once again reformed the electrolytic capacitors by turning the set on for around 30 seconds, then off for a short period and then repeating this procedure several times. No overheating or any other untoward things occurred but one dial lamp was not working and the set refused to operate correctly.

There was plenty of noise from the set on the broadcast band, which increased as lower frequencies were tuned. This indicated that the local oscillator wasn't working. I then operated the band-change switch and the set worked but with quite a bit of "crackling".

The cure was quite simple. First, the chassis was removed from the cabinet and the band-change switch sprayed with Inox to clean the contacts. That done, the non-operative dial lamp was tightened down in its socket (it had come slightly loose).

Once those simple steps had been completed, the set burst into life as soon as power was re-applied. It just goes to show that, having restored these old radios, they require little maintenance and will keep going with reasonable care.

Like most sets of the era, this set had a 2-core power lead, so the chassis wasn't earthed. That said, I have never encountered a faulty power transformer that had shorted between its primary and metal frame.

However, there's always a possibility of this occurring, with the danger that someone could be electrocuted. As a result, the 2-core lead was replaced with a 3-core lead so that the chassis could be earthed.

The best way of obtaining a 3-core lead is to buy a low-cost 3-metre extension cord. It's then just a matter of cutting the socket off and wiring the cable in to the equipment.

Summary

The 11-59 is a good performer, its main drawback being that the tuning on shortwave requires critical adjustment. There's no noticeable backlash in the tuning though and although a better tuning mechanism would have been nice, the set was designed for the low-cost end of the market.

Finally, the components are all run well within their ratings and this would contribute to a long operational life for the set. In summary, the 11-59 was a fine example of Kriesler's design and and manufacturing expertise. It's a set I am happy to have in my collection. SC

Photo Gallery: 1934 Emmco "Little Jewel"



PRODUCED BY THE ELECTRICITY METER MANUFACTURING CO., Waterloo, NSW, the "Little Jewel" was another example of a small wooden mantel set in a style that was popular at the time. The set is a 5-valve autodyne superhet and was manufactured in 1934.

The valve line-up was as follows: 57 autodyne mixer; 58 IF amplifier; 57 anode bend detector; 2A5 audio output and 80 rectifier. Photo: Historical Radio Society of Australia, Inc.

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Class-A power supply & 80V capacitors

I am excited about the SILICON CHIP 20W Stereo Class-A Amplifier but I have a quick question. I have two beautiful and new 33,000µF 80V electrolytic capacitors. Can I use them in the 20W Stereo Class-A Amplifier power supply or is the rating 80V rating too high for the capacitors to be effective? The capacitors have an ESR (equivalent series resistance) of 5 milliohms. (L. L., via email).

● You can certainly use your 80V capacitors. In general, having a higher than specified voltage rating is never a problem unless there is a limitation on physical size.

Vehicle speed sensor for a Valiant

I have fitted EFI (electronic fuel injection) to my 1962 Valiant. The Delco "808" ECU requires an input of two pulses/rev.

I have sourced a VSS (vehicle speed sensor) from another Chrysler which fits in-line in the speedo cable and produces eight pulses/rev, so I purchased a MkII speedo corrector (SILICON CHIP, December 2006) and fitted that to reduce the number of pulses.

All seemed well but the ECU is not sensing the correct number of pulses/rev. I set the rotary switches to -75% to get two pulses output from the 8-pulse input.

The ECU has a 200km/h default speed limit but is cutting in at about 100km/h. I tried lots of settings, even up to -99% which only increased the limit by about 30km/h.

Am I missing something? How can I easily measure the pulses, both input and output? I have a multimeter and a LED test light. Any suggestions? (M. T., via email).

● The Speedo Corrector does not provide for more than a 50% reduction, so setting it to -99% will reduce the speedometer pulses by a factor of almost 2. An 8-pulse/rev signal will therefore be only reduced to almost four pulses/rev.

This range of variation is more than adequate for correcting speedometers and so this is not the solution to your problem. Instead, you need a divide-by-4 circuit which could be built using two D-flip-flops (ie, a CD4013). The divider would also give the required phasing of the signal for EFI.

Huge DC power supply wanted

I would like to know if there is a DC-DC power supply (from an automotive battery) or kit that can be further modified to give me the following values approximately: 12V DC input (automotive battery supply) and output up to 48V-72V at up to 20A. (E. P., via email).

● We have not published such a huge supply. To obtain 72V at 20A would mean that the 12V battery would need to deliver more than 120A to the DC-DC converter. In fact, the actual current would probably be closer to 150A when efficiency is considered.

A standard automotive battery would be destroyed in a short time under these conditions. Even the vehicle's alternator could not deliver such a high output.

Powering the Loudspeaker Protector

I am building your Speaker Protector & Muting circuit featured in the July 2007 issue of SILICON CHIP. I am interested in it because it has anti-thump capabilities as well as muting and it operates directly from the amplifier power supply.

Some of your stereo amplifiers use just the one transformer whereas the SC480 uses a separate power transformer for each amplifier. May I point out just one small thing in using your Speaker Protector for use with two

Getting The SC480 To Drive 2-Ohm Loads

Is it possible to add high-current output devices to make the SC480 amplifier (SILICON CHIP, January & February 2003) stable into 2-ohm loads? The power supply is no issue as I am using a 50kHz switcher for a car amplifier.

I realise I would need to redo the PC board and make the high current tracks a bit thicker. Could it work with ±40V rails and with three pairs of MJL21193/4 (two less than the Studio 350) and something with more collector current than the MJE340/350s to drive them? I'd really like to see an article on how you draw the reactive load lines up when you design amplifiers.

I am currently using two of the April 1996 modules at home; they're great. (S. P., Carrum Downs, Vic).

● In fact, just changing the output pairs on the SC480 to MJL21193/4 should make it OK to drive 2-ohm loads. No other changes should be necessary although we would prefer to see heavier copper tracks for the main current paths.

You will also need to leave out the Polyswitch output protection devices. Instead, we would recommend the Loudspeaker Protector from the July 2007 issue.

For interest, you can plot the 2-ohm load line on the load-line graph for the April 1996 modules and then take an approximation of the equivalent 1.4 + j1.4-ohm reactive load line on the same graph to demonstrate that two pairs of MJL21193/94 transistors should comfortably handle a 2-ohm load.

SC480s. It appears to me that the Speaker Protector will be powered by just one of the amplifiers with its 0V return. Won't it be necessary for the two amplifiers to be joined together via a common 0V return for this Protector to operate effectively with both amplifiers? (G. K., via email).

● It is true that the Loudspeaker Protector will be powered from only one power amplifier in a separately powered stereo amplifier pair. However, since all such systems will already have a common earth reference via the stereo program source, that should not present any operational problems. However, it is also true that a power supply failure in one amplifier, would cause both speaker channels to be disabled by the Loudspeaker Protector. Again, that is not really a problem.

By the way, the power supply suggested for a single SC480, in the February 2003 issue, would be quite adequate for powering a stereo system in most situations. There is no real need for separate power supplies for each channel.

Simulator for ignition waveforms

I would like to simulate various car ignition waveforms on the bench so I can test various automotive kits and circuits before having to go to a vehicle. I would like an oscillator with independent frequency (revs), mark/space ratio (dwell angle) adjustments and amplitude (volts output).

I have made a PICAXE08 PWM with two control pots (revs and mark/space ratio) but the responsiveness to changes on the pots was not quick enough. Do I need to string a couple of 555 ICs together or something?

Are there existing solutions or can you provide any suggestions of a solution? (D. C., via email).

● A 555 timer would be ideal because the charge and discharge periods can be adjusted independently if a diode is used between pin 7 (discharge) and pins 2 & 6 (triggers) with anode to pin 7. This would mean that in the free-running astable configuration, the capacitor at pins 2 & 6 would charge via the resistor to the supply and discharge via the resistor between pins 7 and 2 & 6. These can be variable to adjust the frequency and "dwell".

A 555 can also be used to invert the signal if required.

A PICAXE would be too slow because it needs to read the pot and change the PWM and has to wait until the PWM counter resets before the new value for PWM starts.

How to specify relays

I am building a relay box and I need to know about the likely resistance of the relay coils, as it will run off a 12V computer power supply. Do I need a safe diode with the relay? (P. A., Wodonga, Vic).

● The resistance of a relay coil depends on several factors. Firstly, it depends on the coil voltage and how well it can operate at voltages that are lower than its specified voltage. Other factors are the contact current rating for the relay, with lower coil

Troubleshooting The Radar Speed Gun

I am having problems getting the Radar Speed Gun kit (SILICON CHIP, November & December 2006) running. The main board seems OK; it counts and displays OK and the oscilloscope measurements look OK.

I think the microwave head section is the problem. The DC voltages are low – about 6.8V into the board and about 1.65V at the emitter of Q1 (the oscillator). When using headphones I get a fairly severe hum on power up.

When I wave my hand near the antenna I get a series of very low frequency clicks – under 30Hz. When I move my hand it's more of a click, click, click sound then a buzz – but it does seem to vary according to how fast I move my hand. The board is very "tap" sensitive and it almost seems to act like a microphone as the taps are clearly reproduced in the headphones (this worries me.) I've been over the board checking for dry joints but nothing is obvious.

My RF circuit knowledge is very scant so I've been struggling to debug this kit with just a multimeter and a 40MHz oscilloscope. I replaced all of the SMD active devices on the board (Q1, IC1 & D1) in case I had smoked them and carefully monitored the voltages as each was added. IC1 was the device that seems to drop the voltage the most but it looks like a simple case of biasing it with the resistor (looked up the data sheet), but hard to determine if a low voltage would impact it.

I suspect the oscillator may be to blame. I don't understand this part of the circuit but I gather the 10nF caps and the micro-strip determine the frequency. My gut feeling is that it is not running at 2.6GHz. I don't get the buzzing sound that is mentioned in the article and there seems to be a lot of background hum.

Any suggestions would be gratefully received. (T. S., via email).

● The voltages on your Radar Gun's front-end board and microwave oscillator do seem a little low but not to a serious extent. The loud hum you get on power up may be due to the lighting on your workbench. This can produce quite a bit of 100Hz hum, especially if fluorescent tubes are being used.

From your description of the clicks you get when you wave your hand near the antenna, it does sound as if the microwave oscillator is working, especially if the click frequency increases when you increase the speed of hand movement towards or away from the antenna.

If the oscillator board seems very microphonic, we wonder if you have glued down the 1µF tantalum capacitors. If these are not glued down, they can vibrate in the air and this will produce microphony. This can also happen with the 10kΩ oscillator base bias resistor (the one that 'floats'), so you can also reduce microphony by gluing this down as well, with a dob of epoxy cement. Basically, any physical vibration inside the microwave oscillator box will produce microphony, because the vibration affects the standing wave pattern inside the box and hence produces its own Doppler signal.

Finally, apart from the microphony, your Radar Gun unit is probably working. Have you actually tried it or have you delayed doing this so you could get to the bottom of the microphony problem?

Possible Damage To Oxygen Sensor

I built two of the Car Fuel Mixture Display kits and have found that the LM3914 has a voltage of 0.6V on the signal input at pin 5. Of this, 0.3V is dropped across the 1MΩ resistor so therefore 0.3V is applied to the oxygen sensor. Because of this, it has damaged an old sensor and then a new one.

Oxygen sensors will be damaged if you try to apply a voltage to them and in fact, if you do your research on these sensors, they warn against using a multimeter set on "ohms" because the voltage used by the meter will damage the oxygen sensor.

If I am correct, then there may be people who have unknowingly damaged their oxygen sensors without realising it. I would be interested to hear your comments. (T. G., via email).

● We have produced several projects using the LM3914 to monitor the oxygen sensor and thousands of these have been built without causing problems. The specifications for the LM3914 indicate that the input current at pin 5 is typically 25nA but could be at a maximum of 100nA. This would mean that the voltage across the 1MΩ input resistor to pin 5 would be typically 0.025V (25mV) when connected to an oxygen sensor or to ground.

We are not sure why your LM3914 produces a 0.6V output at pin 5. It would suggest either a faulty IC or that there is severe leakage on the PC board. A multimeter set to read "ohms" produces a current that could damage an oxygen sensor. We do not say to measure an oxygen sensor resistance in any of our articles. The 25nA (100nA max) from the LM3914 will not cause damage to an oxygen sensor. In fact, the car's engine management computer would cause the same order of current to flow in the oxygen sensor.

resistances usually found with higher contact current relays of the same coil voltage rating (so that the contact will hold closed with more force).

If the relay has a normally-open (NO) and a normally-closed (NC) contact, the coil resistance may be lower than one that only has a normally-open contact. This is because the coil will be required to overcome the extra spring force applied to keep the normally-closed contact together when the relay coil is de-energised. Then there is the speed at which the relay contact closes and opens when the coil is energised or de-energised.

So there are many factors involved in deciding the final relay coil resistance. To choose a relay, first decide what type of contacts you require (ie, just a single contact normally-open type or one with normally-open and normally-closed contacts or a relay with many contacts). You then select the current rating and the coil voltage (and whether a DC or AC coil).

Note that for any relay and especially for heavy currents over 10A, it is best to choose one that has a contact rating well in excess of the current you expect to use. This is important if switching a light bulb or motor where start-up currents are higher than the normal running current. In addition, the voltage rating of the contact can be important because relay contacts for low voltages (<32V) are not suited to mains operation (240VAC). In addition, the contact ratings are different for AC currents compared to DC.

If you want a low coil current, then consider the solid-state relays that only require a small current to energise them. These tend to have just a normally-open contact.

A reverse-connected diode across the relay coil is usually required when a transistor is used to drive the coil. This diode protects the transistor from damage by clamping the back-EMF generated when the coil de-energises.

Solar tracker does not give full voltage

I am in the process of making the Solar Sun Tracker featured in the January 1995 issue. I would like to know why it says that the Mosfets only have a 7.5V output. Are they not fully turned on? I thought that with the Mosfets fully turned on you would have 12V available. Could you explain this please? (G. C., Rockhampton, Qld).

● The reason that the circuit cannot apply the full 12V is that the top Mosfets, Q2 and Q3, are acting as "source followers" and so they can never turn fully on. This is because their gate drive voltage cannot rise by 6V or more above their source electrodes.

Furthermore, their gate voltages are limited by the drive circuit to less than 10V and so the maximum that can be delivered from their source electrodes will be around 8V or less. Add in the small voltage loss across Q4 or Q5 (both of which can turn on fully) and

Auxiliary Battery Controller Not The Complete Answer

I have built the 12/24V auxiliary battery controller (SILICON CHIP, December in my car but it seems to me that the design of the circuit is around the wrong way.

Would it not be better for the circuit to work in the following way: when the voltage of the auxiliary battery drops below a preset level, the latching relay is triggered, completing the circuit and enabling charging of the auxiliary battery?

The challenge with this concept is to stop the auxiliary battery charging when it no longer requires it. You couldn't set it up so that when the auxiliary battery reaches a certain voltage the latching relay will switch off because the circuit will be continually turning on and off, I would think. I thought that using a 555 timer circuit could be a possible way of switching the latching relay off after a pre-determined length of time charging. (A. E., Knoxfield, Vic).

● Your comment is interesting but you would need two comparators in the circuit to do what you propose: one to monitor the main battery and one to monitor the auxiliary and then some logic to decide how to switch the relay.

the result is around 7.5V across the motor. This is not a problem with the specified 3V barbecue spit motor.

Increasing airflow for an oil heater

I have been trying to locate a variable frequency device to enable the variation of fan speed in a room oil heater. I would like a device or kit that would operate from 240VAC 50Hz input with a 240VAC output with a variable frequency or just the choice of 50Hz and 60Hz.

My aim is to be able to increase the airflow from the heater. I am aware these devices are available commercially for pumps, etc but I am looking for a simple low-output device (around 100W or so). (P. J., via email).

● To be frank, if you need to increase the airflow through your heater, you would probably be better off checking to see that the fan is actually operating properly. Typically, such fans are squirrel cage designs driven by a small shaded-pole motor and they are prone to being seriously clogged up with dust and fluff.

The motors are also prone to progressively seize, as they are used in a very hot environment. The solution: pull the entire oil heater out of its cabinet and take it outside where you can give all the air passages a thorough clean out.

Do the same for the squirrel cage fan, making sure that all the vanes are completely clean. The more thorough you are with this aspect, the longer the fan will stay unblocked. The whole procedure is a messy job which is why we suggest that you do it outside.

Next, pull down the motor and clean and oil the bearings. Make sure it will spin freely by hand after reassembly before attaching it to the fan. When you now apply power you should be greeted by a blast of air. These things really do push a lot of air. After all, you can be pretty sure that the heater was provided with a more than adequate fan when it was first manufactured.

Notes & Errata

Magnetic Cartridge Preamplifier, August 2006: for Table 5, R1 should be a link for the x1 gain position. Note also that the relative gain values should be x2, x11 and x 101 instead of x1, x10 & x100.

Lightbox Timer, November 2007: CON5, the plug and socket shown for 240VAC mains connection to the PC board, is not mains-rated and should be replaced by a 3-way mains terminal block (eg, Altronics P2037A). The published PC board pattern has been amended to reflect the wider pin spacing required.

Also the circuit description on p73, paragraph 4, righthand column, is wrong. It should read "When the timer has completed countdown, RB5 goes low, which turns off Q7 & Q5 and turns on Q6".

Subwoofer Controller, August 2007: a 47kΩ resistor in the input circuit to the Speaker position of the Source Select switch (S1) was not included on the PC board and is not necessary.

NiMH Battery Charger, September 2007: The 100µF capacitor shown on the overlay diagram of Fig.3 adjacent to VR6 should be 10µF, to be consistent with the parts list and circuit.

Sensor for Coolant Alarm

Do you know whether the later model Falcon coolant level sensors are suitable to use with the Coolant Alarm project from the June 1994 issue. The later model sensors use two wires, probably because the sensor is mounted in a plastic tank and therefore not possible to directly earth. (D. D., Kellyville, NSW).

● The sensor should be useable but you would need to test it by verifying its ability to detect the presence of water. It should have two small probes or metal plates that make contact with the coolant. When the sensor is dry it should show a high resistance in the megohm range. When immersed in water, it should be about 100kΩ – the exact value is not critical.

Source for potting compound

I need some potting resin for some projects I am working on. Is it only the normal resin used for fibreglass work, in which case it won't be hard to find, or is it a special type? If it is special, could you tell me where I could obtain some? (T. U., Georgica, NSW).

● Perhaps the easiest approach would be to use a clear neutral-cure silicone sealant such as Selleys Roof & Gutter sealant. SC

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Harmonic Distortion THD	±0.3% @ 1watt 2.83Vrms 1kHz
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(No Soldering required)	Wiring cable : Internal speaker cable high quality OFC 384 strand with push on connections Speaker terminals : 4mm twin gold plated binding post Filter : 2 way off set Bessel / Butterworth , linear phase Freq : 3.8kHz Order: 2nd Lp, 3rd Hp Components: High quality, Copper Air core inductors , SCR 400V metalized MKP capacitors Non Inductive resistors Bi-wiring: Option provided
Drivers	
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