

*You won't believe how good they sound...
and your friends won't believe you built them!*

"Tiny Tim" Horn Loaded Speaker System

This low-cost speaker system uses a single 4-inch driver to give surprisingly good bass and treble response. It is quite efficient and only needs a low power amplifier to give excellent sound levels.



This speaker system turns heads, not only because it looks quite different from the speaker systems you may be used to but more importantly because it sounds so impressive.

It does not use bulky and expensive eight, ten or twelve-inch drivers and there are no tweeters or crossovers.

Instead, the single driver in each box is a four-inch model, which costs

as little as \$25.00. Add some pieces cut from a sheet of plywood, which costs perhaps \$70, some glue and a few hours of construction time and you'll have a speaker system which easily competes with much-higher-priced commercial units on the market today. And yes we know that there are

**By Allan Linton-Smith
and Ross Tester**

quite a number of tower and mini-tower speakers on the market right now, many with multiple drivers and all sorts of claims. Quite simply, we believe these are better than anything we've heard recently at anything like the price!

The secret to such a high-performing speaker is in the design of the cabinet. Unlike the simple bass-reflex or other ported designs you're used to, these

are actually rear-loaded horns. They look difficult to build but providing you're accurate with your woodwork (or you use someone who is!) they are surprisingly simple to put together.

The drivers

You have a choice of 4-inch drivers for this design. The cabinets are perfectly matched to – and in fact were originally specifically designed for the high-performing Fostex FE103EN models.

But we tried a couple of locally-available drivers: the Altronic C0626 and Jaycar CS-2310 models, which are significantly cheaper than the Fostex. And while they might not perform *quite* to the level of the Fostex drivers, most people would be very happy with the cheaper approach.

Having said that, several of the SILICON CHIP staff commented that they thought enclosures fitted with the Altronic drivers actually sounded the best!

While the Fostex is a single cone driver, the Altronic C0626 is a twin-cone model and the Jaycar is a coaxial unit with separate miniature tweeter fed by a bipolar electrolytic capacitor.

The first two speakers have the advantage of simplicity and there is no problem with phase shift in a crossover network, albeit even the simple crossover capacitor of the Jaycar unit.

All three drivers have the advantage of using a single driver with its phase coherency over a wide range of frequencies. This helps in the realistic reproduction of voice, instruments or complex orchestration and in accurate sound staging or positioning of each instrument.

Just a note about the Jaycar CS-2310, it's intended as a car speaker and its nominal impedance is 4Ω so you will need to make sure your amplifier can handle this low impedance (fortunately these days, most can). The Fostex and Altronic drivers are both 8Ω.

So which to choose?

If you're looking for "most bang for your buck" the Altronic would be a good choice because they are the most efficient (95dB/W @ 1m) vs 89dB for the Fostex and 83dB for the Jaycar unit. Offsetting that lower efficiency is the fact that the Jaycar driver will actually receive twice as much power as the other two (because it has half the impedance) for a given volume setting

from the amplifier. This will mean that the difference in efficiency will be less apparent than the raw figures might indicate.

The Altronic and Jaycars are similarly priced, at about \$30 pair for the Altronic vs \$25 for the Jaycars but you'll pay much more for the Fostex drivers. You can compare the three drivers in the spec table below.

The cabinet design

The enclosure design for this speaker (which you can download at www.fostexinternational.com/docs/speaker_components/pdf/FE103En.pdf) can be regarded as a cross between a bass reflex vented enclosure and a horn-loaded enclosure. Horn-loading can be thought of as an efficient means of coupling between the relatively heavy mass of the speaker to the much lighter mass of air.

Horns have been used for a very long time. For example, they have been used for centuries in musical instruments and as megaphones – the very first horn speaker. And of course,

all the early wireless sets and gramophones used a horn-loaded speaker. In all of these early examples, efficiency was paramount.

The tower speaker we are using here uses the 4-inch driver as a direct radiator for the upper frequencies and a horn radiator for the lower frequencies. The internal construction of the tower is actually a folded horn with each section being longer and larger in cross-section, to approximate the exponential taper of an ideal horn.

While efficiency is a big advantage of a horn speaker system, they do not necessarily result in the smoothest bass response. However, in our case where we are using tiny drivers, we get a much more extended bass response than could normally be expected with their relatively high free-air cone resonances.

Anyone who is reasonably competent in woodworking and has a selection of suitable tools should be capable of putting these cabinets together.

In fact, we fully expect these speakers to become the "project of choice" for many students in their Higher

| MANUFACTURER'S SPECIFICATIONS | Fostex FE103En | Altronic C0626 | Jaycar CS-2310 |
|---|-------------------|-------------------|-------------------|
| Price per pair (\$ approx) | 150 | 34 | 25 |
| Voice coil dia (mm) | 20 | - | - |
| Impedance (ohms) | 8 | 8 | 4 |
| SPL (dB/W@1m) | 89 | 95 | 83 |
| Rated input (W) | 5 to 15 | 8 to 15 | 15 |
| Magnet | ferrite | ferrite | ferrite |
| Magnet wt (grams) | 193 | - | - |
| Net wt (grams) | 580 | - | - |
| Baffle hole dia (mm) | 93 | 93 | 93 |
| Cone area (sq m) | 0.005 | - | - |
| R _e (ohms) | 7.5 | - | - |
| Free air Resonance (Hz) | 83 | 120 | 122 |
| VC inductance (mH) | 0.0398 | - | - |
| Q _{ms} | 2.747 | - | 4.28 |
| Q _{es} | 0.377 | - | 1.88 |
| Q _{ts} | 0.33 | - | 1.31 |
| M _{ms} | 2.55g | - | - |
| V _{as} (Litres) | 5.95 | - | 3.31 |
| X _{max} mm | 0.6 | - | - |
| Frequency response | 83-22kHz | 120-20kHz | 90-18kHz |
| MEASURED RESPONSE | | | |
| Frequency response ±5dB | 60-15kHz | 70-15kHz | - |
| Distortion (THD+N) [1kHz 90dB] | 0.45% | 0.65% | - |
| Sound Pressure Level 1kHz 1watt/1m (dB) | 92.65 | 89.97 | - |

The enclosures are designed for the Fostex FE103En drivers but we've found the much-cheaper Altronic C0626 or Jaycar CS-2310 do an admirable job as well: in fact, some of our staff members commented they sound better!

School Certificate design and technology courses: do the cutting, assembly and finishing in the woodwork room, mount the speakers and wire them in the technology or electronics classes – and best of all they won't break the bank. And after they earn top marks, they'd have speakers Mum and Dad would be proud to put in the lounge room!

Plywood is a must!

The pieces for both boxes can be cut from one and a half sheets of 15mm plywood (1220 x 2440mm and 1220 x 1220mm). In fact, with care you'll get all bar one small piece (no.7) from one sheet. See Fig.1: it shows how the pieces are cut – the first cut needs to be made where shown.

The missing piece, (235 x 150mm), could even be cut from scrap as it is internal and won't be seen.

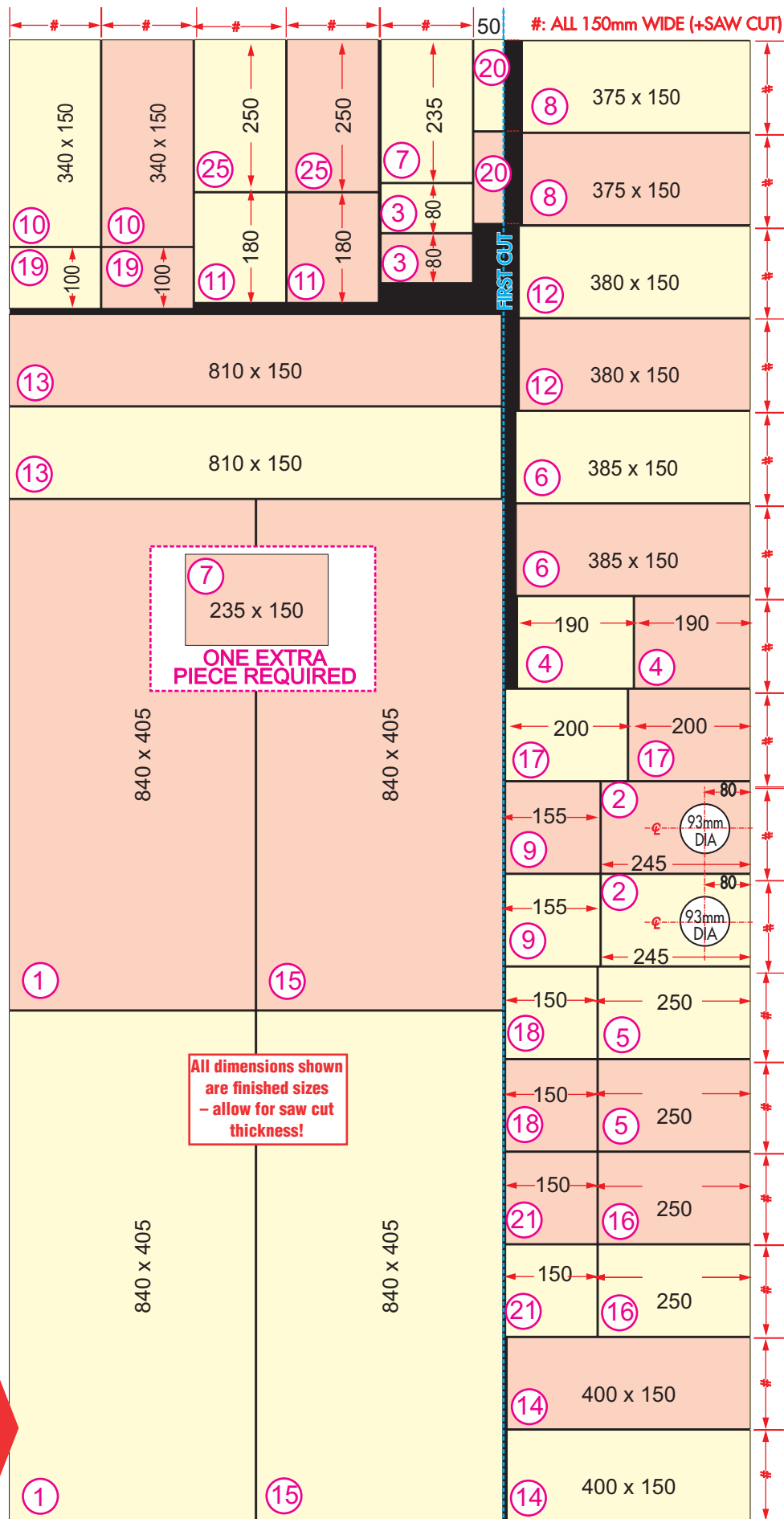
Note that this cutting diagram does assume an "imperial" size sheet; some suppliers have taken to making their sheets 2400 x 1200 – this size is not quite large enough as it cannot make allowance for the saw cuts. Your supplier should be able to advise you of the exact size of their sheets. If they are 2400 x 1200, you'll definitely need a second (half) sheet.

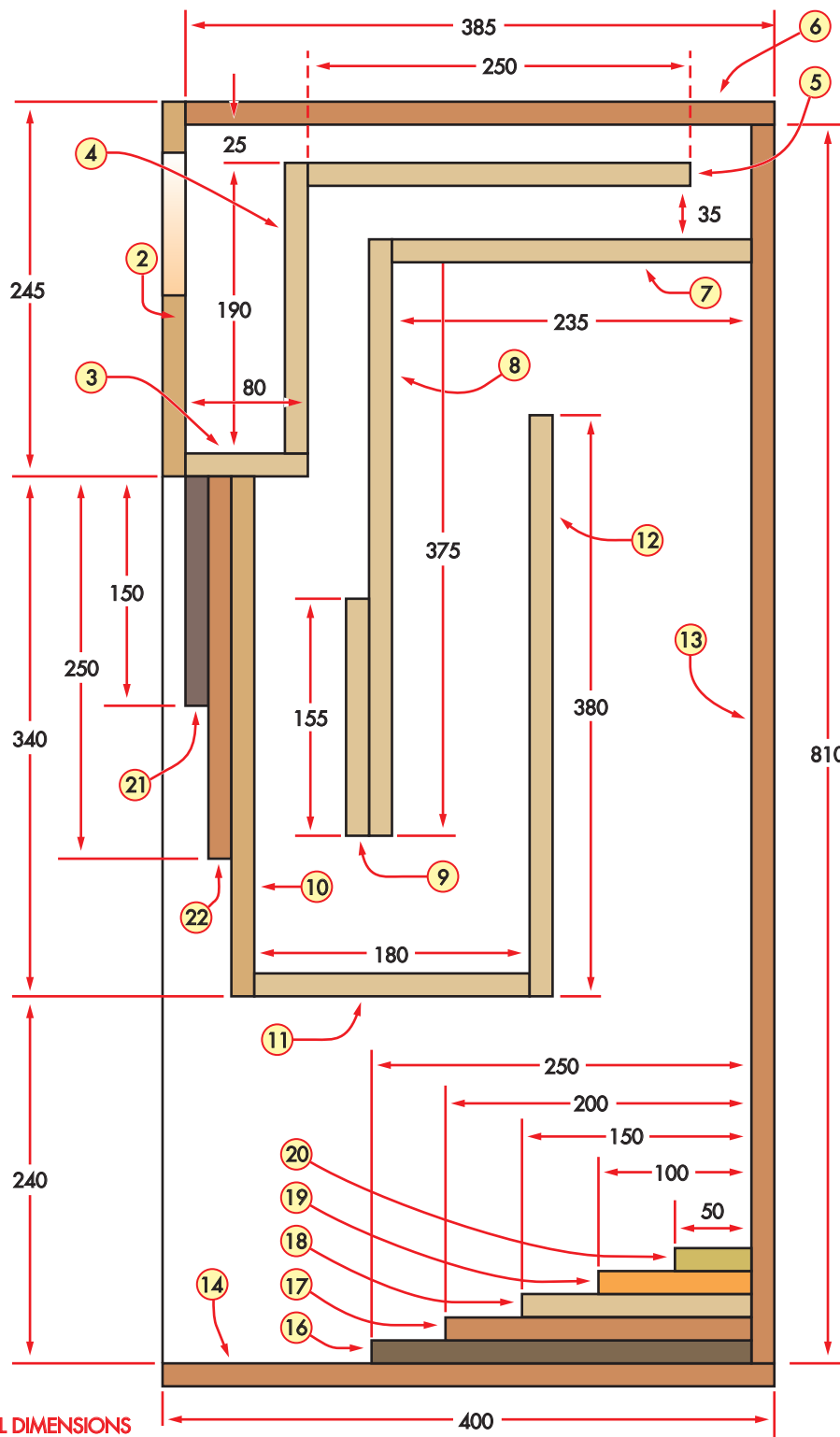
We used good quality Aspen Birch veneer because of its fine grain and appearance but you can choose the finish to match your décor. You *could* use plain plywood, sand it smooth and paint or stain it to your tastes.

Note that we **DO NOT** recommend the more commonly available MDF because it is 16mm thick – the extra 1mm will decrease the width of the "horn" by a cumulative 6mm and will drastically affect performance.

You will note from the photos and diagrams that the horns are built up by layers of plywood pieces. It is absolutely vital that these pieces are very accurately cut to size. If you don't have either the equipment or the skills to cut to close tolerances (to the millimetre!) we suggest you approach a local kitchen cabinet maker – most will do it for a reasonable cost; indeed, many will be

Fig.1: it's a tight fit but all except one piece (one of the '7s') can be cut from a sheet of 1220 x 2440 x 15mm ply. This assumes a saw cut thickness of 2.5mm, about normal for a kitchen cupboard maker. Note where the first and second cuts are made. The lemon coloured pieces are for box 1, pink for box 2.





(ALL DIMENSIONS
IN MILLIMETRES)

Fig.2: looking down on the right side, without the side panels, here's how all the pieces glue together to form the loaded horn. The photographs later in this article will help explain how it all goes together.

able to supply the veneered plywood as well. Just don't let them talk you into MDF (a lot of kitchen cabinets are made from the stuff these days!).

Incidentally, we investigated a major hardware chain offering a cutting service and found them unacceptable for two reasons: first, they guaranteed a

tolerance of no better than 5mm – useless as far as this project was concerned and second, they only had “construction grade” 15mm ply.

Now that would be OK if you only wanted a painted surface but even then, a fair amount of sanding and finishing would be required. Also, they

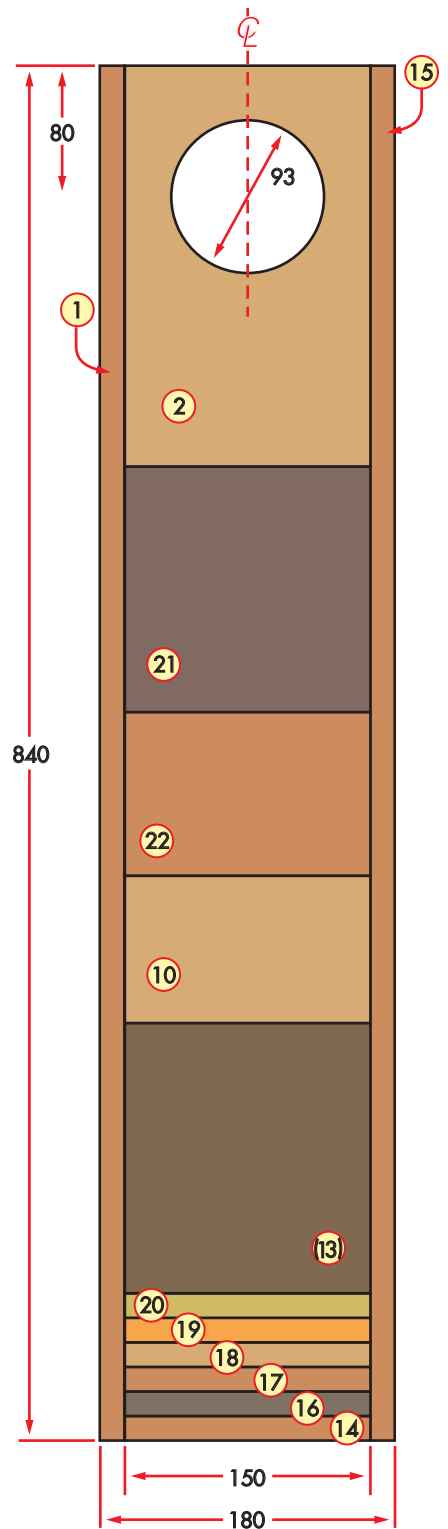


Fig.3: and here's the front-on view with the side panels fitted. Piece 13 is actually the rear panel.

only had full “metric” sheets (2400 x 1200mm) in stock and, as expected, they tried to talk us into MDF, which did come in half sheets!

It may be that in time, some of the kit suppliers will produce a full kit of parts – keep an eye on their advertisements in SILICON CHIP.

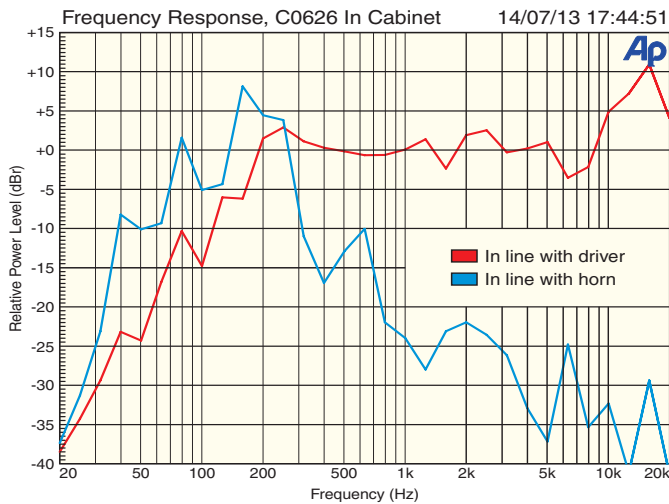


Fig.4: frequency response plots of the Altronic drivers in the horn-loaded cabinet. The red trace is the on-axis flat response and blue trace shows the output from the mouth of the horn section.

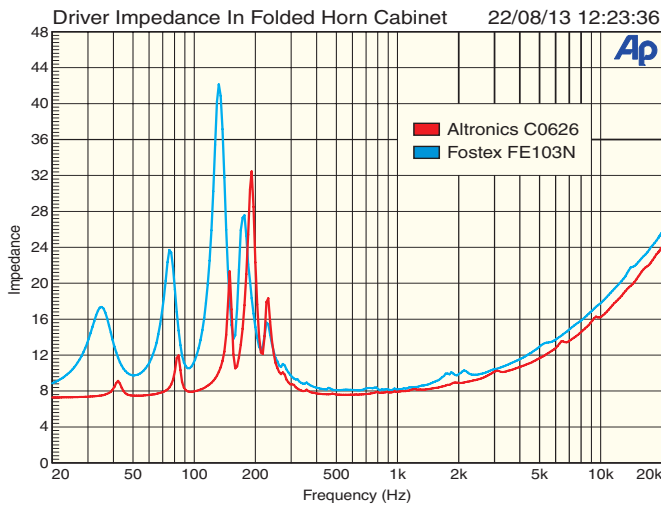


Fig.5: impedance curves of the Altronic and Fostex drivers, with multiple peaks resulting from the horn loading. This is partly a result of the much higher loading to the rear of the driver's cone.

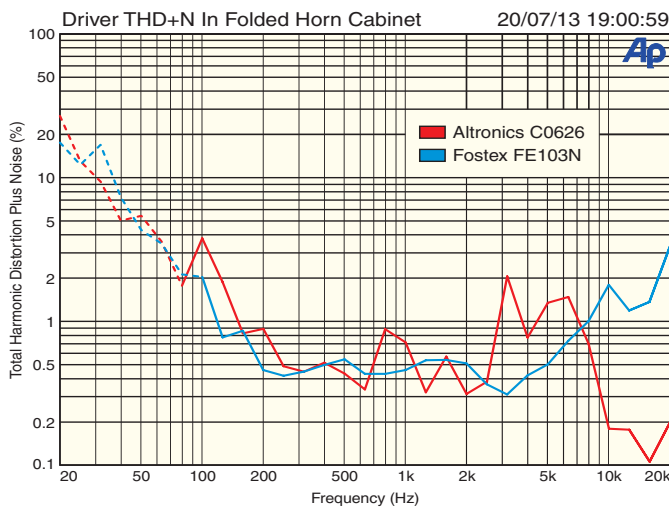


Fig.6: harmonic distortion of the Altronic and Fostex drivers. Note that the distortion of both drivers is quite low over much of the audible range but rises at the low end, partly as result of the horn loading.

The amplifier

Another feature of these speakers is their ability to handle a range of amplifiers. While they're ideally suited to lower-power amplifiers (again, that "schoolies" market springs to mind), they can handle more, with sound output to match. All three speaker drivers mentioned above are rated at 15W maximum input so you certainly *cannot* run them flat out from a high power amplifier.

We've run them from amplifiers as low as 5W output (eg, "The Champion" from January 2013) and we've run them (judiciously!) from the much higher power Ultra LD MK3 (July-September 2011).

However, even running from The Champion they certainly filled the large SILICON CHIP warehouse with sound!

Performance

We tried these with all three speaker drivers mentioned above. As you might expect, the Fostex drivers gave the best bass response – but you do pay for it! The others were surprisingly beefy!

Fig.4 shows two frequency response plots of the Altronic drivers in the horn-loaded cabinet. The red trace was taken with the microphone on axis and very close to the tweeter cone of the driver and it shows a reasonably flat response to 10kHz and rising to a peak at around 18kHz. The blue trace was taken with a microphone adjacent to the horn section and it measures the augmenting effect of the horn loading.

As you can see, the response is quite well maintained to below 60Hz (quite similar to the much more expensive Fostex drivers). Generally speaking, at distances of over 2m, the response will be a combination of the two curves.

Fig.5 shows the impedance curves of the Altronic and Fostex drivers. These are quite different to the equivalent curves you would see with the drivers in a bass reflex enclosure which normally shows two impedance peaks in the low frequency region. The horn loading results in multiple peaks and this is partly a result of the much higher loading to the rear of the driver's cone. It also results in better bass, as shown by Fig.4.

Fig.6 shows the harmonic distortion of the Altronic and Fostex drivers and again the cheaper Altronic driver gives a good account of itself. Note that the distortion is quite low over much of the audible range but rises at the low end, partly as result of the horn loading and also the fact that the fundamental output drops markedly at very low frequencies.

Building the speakers

We have simplified each step so you shouldn't have any problems. Build one speaker box at a time otherwise mistakes are much more likely; do not rush things and make sure you understand each step before diving in!

Again, we must emphasise the need for accuracy in cutting out the panels. Using a hand-held saw of any description will usually result in errors and out-of-square cuts which will inevitably lead to air leaks or malfitting panels. The panels are butt-glued so squareness is next to Godliness! To this end, wipe up any glue excess as you go.

And to ensure perfect alignment, the enclosures need to be assembled on a completely flat surface – a work bench is fine if it is flat and stable; otherwise a (say) concrete floor with some single newspaper sheets spread on it.

Putting them together

Step i: We are assuming you already have all your pieces accurately cut out. Number each piece as shown on the diagram – use “Post-It Notes” or similar to avoid leaving glue – in any case stick them to the “bad” side of the plywood (ie, not the face side).

Step ii: Using the diagram (Fig.2) as a guide, on one of the side panels (piece 1) use a pencil on the “bad” side to mark out where all the pieces are going to go.

Step iii: Take pieces 2 and 3 and first check their dimensions to make sure you have the right ones – we’re about to glue them together and once stuck, you won’t be able to get them apart. Use 2 or 3 small nails or panel pins to tack them together, then prise them apart without bending the nails and run a 3mm bead of glue* along the joint. Push the nails back into the holes and gently tap them with a hammer until you are happy with the fit. Wipe off any excess glue with a damp rag.

If for some reason they haven’t ended up where they should, light tapping with the hammer should get them right. You have about 10 minutes to move things around before the glue sets.

Clamps or a vice should be used to hold the pieces together to give a really good bond – the glued pieces should be ready to remove after about half an hour.

Take the completed pieces and place them on the side panel where they will go – but don’t glue them in place just yet.

* We used a caulking gun and “Parfix Maxi Nails Fast” water-based construction adhesive, which will bond wood to just about anything. It’s cheap (\$3.95 for a caulking gun tube at our local hardware store), it sets quickly (about 20 minutes) but gives up to 10 minutes or so of “fiddle time” before the glue gets too tacky. This glue (or several other bonding adhesives) are available from most hardware outlets. NOTE: PVA wood glue is not recommended.



Lay out all the pieces on a flat surface so you understand how they all go together. Note the identifying “post-it” notes.



Now we’ve glued all the pieces together and when dry, have then glued them in position on the left-side panel.

Step iv: Repeat step iii for pieces 4 and 5.

Step v: Glue pieces 2 & 3, and 4 & 5, together

Step vi: Glue pieces 21, 22 & 10 together, using a square to ensure that the end is perfectly flat. Allow them to set for an hour or then glue them to the pieces you made in step v. (They glue to piece 3).

Step vii: Now glue pieces 11 & 12 together, allow to set for an hour, then glue those to the pieces in step vi (they glue to piece 10)

Step viii: Glue pieces 7, 8 & 9 together and set aside to dry.

Step ix: Fit the input (banana) binding posts to piece 13 – drill two 3.5mm holes 50mm down from the top and 25mm apart.

Step x: Now glue pieces 16, 17, 18, 19 & 20 together.

Step xi: Glue pieces 6 & 13 together, using the side panel to keep them square while they set.

Step xii: Glue pieces 13 & 14 together, again using the side panel to keep them square while they set.

Step xiii: Now glue all the pieces together from step x, to pieces 13 and 14.

Step xiv: Once all of the glue has set, you now should have everything ready to be glued to the side panel. Place all pieces accurately in position on the side panel.



Use small panel pins and clamps to hold your speakers together while the glue is setting. Any blemishes can be smoothed over later.



Here's the completed speaker box once the glue has dried. All that remains is a bit of tidying up, finishing the veneer with your desired stain or paint and then fitting the 4-inch speaker.



And here it is with a clear polyurethane finish. This shot of the rear of the speaker (from the top) also shows the input terminals in place. You can see how the rear panel and top are inset 5mm from the rear edge of the side panels.

Step xv: Glue all those pieces in place. By now you should have a pretty good idea how much glue is used so you shouldn't have too much excess. If you do, don't waste time wiping it away - remember, you only have about 10-20 minutes before the glue sets so you need to work fairly fast.

Step xvi: When everything is in place, take the other side panel (piece 15) and without applying any glue, place it on top of the whole assembly with some weights on top. If you have worked fast enough, the glue should still be wet enough so that you can move any pieces that need to be adjusted so they are flush with the side panel. It's most important that the front of the cabinet is flush to the side because that's the part that you see. Adjust it first, then the back if you have time (you won't see the back!).

Step xvii: When the glue has dried, solder a 300mm length of figure-8 cable to the input terminals. Remember which is to the red and which is to the black (normally, stripe goes to - or black). Hang the other end of this wire out the front speaker hole.

Step xviii: It's time to complete the enclosure. Add a bead of glue to all the edges and place the side panel in place, adjusting it again so that the front is aligned to the sides. Put the weights back on and wait until it dries.

Hopefully, you will have done it all correctly. . . now you get to do it all again with the second enclosure!

Finishing off

You can now carefully sand off any rough edges or dags of glue then stain, coat or paint your enclosures as you desire. We simply applied a coat of clear polyurethane to the timber as the Aspen Birch veneer really shines with this treatment.

But remember that paint hides a multitude of sins if you have made any "oopses" along the way.

When the cabinets are completely dry, cut two 150mm x 245mm pieces of cellulose wool (often sold under the brand-name "Innerbond") and place them loosely behind the speaker area - but do not block the entry to the horn. We found that any packing in the horn reduced the bass by half (6dB) but the little packing behind the speaker had no effect on the bass. However, it did reduce the "hollow" sound at mid frequencies, caused by standing waves and reflections.

Fit the speaker drivers to the boxes, making sure you get the phasing (ie + and - connections) the same on both boxes. As a final check, briefly connect a 1.5V battery to the input terminals (+ to red, - to black) and watch the cone. Both speakers should move the same direction when connected the same way.

The drivers should have some form of gasket between them and the woodwork to ensure a seal. We wouldn't use silicone sealant - it works really well but makes the speaker incredibly difficult to remove intact if you have to remove it for any reason. A large "O" ring is ideal; at a pinch you could even use a large elastic band. Just make sure it seals all the way around as you tighten the four screws.-

If you use the Jaycar drivers, fit the grilles over the front of each speaker. Of course, you can buy grilles to fit the Altronics or Fostex speakers. Grilles are almost mandatory if you have young people with prying fingers around: that speaker height is just about perfect.

Training the speakers

What's this? Training speakers? Believe it or not, all speaker drivers "straight out of the box" are a little stiff and benefit from being "run in". We allowed about two hours of continual music at reasonable volume before we were satisfied that ours were nice and mellow. You will certainly note a significant improvement over time, particularly in the bass response. SC



PRODUCT SHOWCASE

“Value Instruments” range from Rohde & Schwarz



Rohde & Schwarz and its HAMEG Instruments subsidiary now market a range of favourably-priced test and measurement equipment bearing the new joint “Value Instruments by Rohde & Schwarz” label.

In addition to spectrum analysers and oscilloscopes, the Value Instruments portfolio includes EMC (electromagnetic compatibility) pre-compliance products as well as power supplies from Rohde & Schwarz and its HAMEG Instruments subsidiary.

The Value Instruments range is the premium provider’s way of addressing

those users from medium-sized companies who in the past found Rohde & Schwarz products too expensive.

The instruments are available through the existing direct sales network, authorised distributors as well as the R&S Surf-In webstore available in certain countries.

Contact:
Rohde & Schwarz Australia Pty Ltd
Unit 2, 75 Epping Rd, North Ryde NSW 2113
Tel: (02) 8874 5103 **Fax:** (02) 8874 5199
Website: www.rohde-schwarz.com.au

World’s thinnest Android Smartphone



It might not be a name you’d instantly recognise but online electronics specialists BecexTech have released what they claim is the thinnest Android smartphone in the world: the Oppo Find 5 Smartphone.

It also offers a full HD display – meaning text, pictures and videos are more vivid and lifelike – and a 13MP camera with a dedicated camera button. It can even hold up to 2GB of RAM which allows it to do more things at once.

One feature that differentiates Oppo from its competitors is its ability to play Adobe Flash. The multimedia and software program is supported with video and sound in the device’s browser.

Recommended retail price is \$699.00

Contact:
BecexTech Australia
PO Box 6297, Point Cook, Vic 3030
Tel/Fax: 1300 558 873
Website: www.becextech.com.au

New Thorens turntables



Made in Germany and based upon the award winning older brother TD309, the TD206 and TD209 turntables from Thorens are feature packed and stand out in the sub-\$2K price range.

The bespoke TP-90 tonearm uses the same ultra-low-friction, high-performance bearing and the innovative zero-stiction anti-bias system as the TP-92, along with a low noise electronically controlled DC motor. The two-part aluminium/acrylic platter is critically damped.

They’re available in gloss white, black and red.

Contact:
Speakerbits
Unit F51/63 Turner St, Port Melbourne 3207
Tel: (03) 9647 7000 **Fax:** (03) 9681 8207
Website: www.speakerbits.com

CadSoft EAGLE Webinars

Mostyn Enterprises and CadSoft USA are pleased to host on the Element 14 Community website www.element14.com/community, a series of three webinars providing application training for the award-winning CadSoft EAGLE schematic and PCB capture software package. The latest version of EAGLE also allows seamless interfacing with Linear Technology’s LTspice IV circuit simulation package.

The three 30-minute webinars will be presented by the CadSoft USA team, commencing at 10am Sydney local time, on October 19th and 26th, and November 2nd. The webinars will consist of 20 minutes instruction and 10 minutes Q&A.

The first webinar will cover an introduction to EAGLE and the Control Panel, Library description, and creating projects, new schematics and board files. The second webinar will consist of a review, making a circuit board module, creating a board from a schematic and auto-routing. The third webinar will cover a review, creating a new component library, and defining new schematic symbols and devices.

Details regarding webinar registration, and for purchasing the CadSoft EAGLE package, are available on the Mostyn Enterprises website. A free evaluation copy of the CadSoft EAGLE schematic and PCB capture software package is available from the CadSoft USA website www.cadsoftusa.com. Linear Technology’s free LTspice IV circuit simulation package is available from their website www.linear.com

Further webinars from Mostyn Enterprises are currently under development.

Contact:
Mostyn Enterprises (Technologies)
Tel: (02) 9834 1299
Website: www.mostyntent.com

WORKSHOP ESSENTIALS

Centre Drill Set

- No. 1, 2, 3, 4, 5
- HSS M2 bright finish
- Industrial quality

~~\$38.50~~
\$33

(D508)



GREAT VALUE



4 Piece Countersink Set

- HSS M2 Bright Finish
- Range: Ø2 - Ø20mm
- Angle 45°

~~\$66~~
\$59

(D1051)



GREAT VALUE

EDBD-13 Drill Sharpener

- 3-13mm or 1/8" - 1/2"
- Diamond wheel
- Split point
- 80W, 240V motor

~~\$99~~
\$89

(D070)



Cast Iron Bench Vices

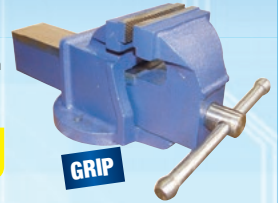
- Acme screw thread
- Fitted with serrated jaws
- Manufactured from cast iron

100mm
~~\$64.90~~
\$60

(V088)

127mm
~~\$103.40~~
\$100

(V089)



GRIP

Includes **FREE**

Magnetic Soft Jaws with V088



(V0534)

Includes **FREE**

Magnetic Soft Jaws with V089



(V0535)

Industrial Drill Sets

- Precision ground flutes
- HSS M2 bright finish

25 Piece Metric

- Range: 1-13mm
- 0.5mm increments

~~\$88~~
\$79

(D1271)

29 Piece Imperial

- Range: 1/16 - 1/2"
- 1/64" increments

~~\$90.20~~
\$79

(D1281)



Extra Long Hex Key Sets with Ball End

Imperial Set (H800)

- 9 piece
- 1/16" - 3/8"

Metric Set (H801)

- 9 piece
- 1.5 - 10mm

~~\$16.50~~
\$14 EACH



Metric & Imperial Drill Gauge

- Stainless steel
- 1 - 13mm
- 1/16 - 1/2"

~~\$16.50~~
\$14

(M988)



GAUGE

RP7834 Air Tool Kit

- 1/2" impact gun
- 1/4" die grinder
- 3/8" ratchet wrench
- Air hammer & chisel set

~~\$176~~
\$159

(A053)



COMPLETE

SBD-20B Bench Drill

- 16mm drill capacity
- 2MT, 16 spindle speeds
- Swivel & tilt table
- 1hp, 240V motor

~~\$349~~
\$309

(D138)



Includes **FREE**
Drill Press Vice
V124



Valued at **\$22.00**

WBS-5D Work Bench

- 1370 x 510 x 890mm
- Ball bearing slides
- Powder coated finish

~~\$352~~
\$329

(A383)

HEAVY DUTY



AR-P10 Air Hose Reel Retractable

- 15M x Ø9.5mm
- Polyurethane hose
- Wall or ceiling mount
- 232psi / 16 Bar pressure
- Includes dusting gun

~~\$143~~
\$129

(H045)



RAV2.75/36 Air Compressor

- 205 L/min pump
- 36 litre tank
- 100psi pressure
- 2.75hp, 240V motor

~~\$418~~
\$385

(C327)

MUST HAVE



WTC-1450 Tooling Cabinet Workstation

- 1170 x 580 x 1450mm
- 250kg bench capacity
- Key lockable drawers
- Includes drawer dividers

~~\$1,023~~
\$969

(T773)

MOBILE



AI-50GA Bench Lathe

- 230 x 500mm capacity
- 20mm spindle bore
- Quick change gearbox
- Speeds 100-1800rpm

~~\$1,155~~
\$1050

(L157)

HOBBY LATHE

SAVE \$105



HM-10 Mini Mill Drill

- Dovetail column
- 2 speed gearbox
- Head tilts ±45°
- 350W 240V motor
- Travels: (X) 225mm (Y) 100mm (Z) 190mm

~~\$969~~
\$829

(M150)

COMPACT



BECOME A MACHINERYHOUSE MATE

SIGN UP FOR MATES RATES
AT MACHINERYHOUSE.COM.AU/SIGNUP

- GAIN ACCESS TO:**
- ✓ ONLINE PROMOS
 - ✓ EXCLUSIVE OFFERS
 - ✓ TRACK ORDERS
 - ✓ NEWSLETTERS
 - ✓ LATEST RELEASES
 - ✓ COMPETITIONS

ORDER NOW!

USE PROMO CODE:
12VDIODE

TO RECEIVE THESE SPECIAL PRICES ONLINE OR INSTORE!
Valid until 29-10-13

Specifications & Prices are subject to change without notification. All prices include GST and valid until 29-10-13

HARE & FORBES
MACHINERYHOUSE

NSW
(02) 9890 9111
1/2 Windsor Rd,
Northmead

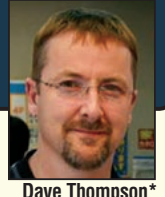
QLD
(07) 3274 4222
626 Boundary Rd,
Coopers Plains

VIC
(03) 9212 4422
1 Fowler Rd,
Dandenong

WA
(08) 9373 9999
41-43 Abernethy Rd,
Belmont

www.machineryhouse.com.au

SERVICEMAN'S LOG



Dave Thompson*

Servicemen watching other servicemen servicing

Sometimes, I have to swallow my pride and call in other servicemen to repair appliances in my home. And I must admit, being a serviceman, I like watching other servicemen servicing. I'm always curious and you never know what you might learn.

ONE ASPECT OF being a serviceman is my perspective of other service companies' procedures and performance. This isn't unusual; people in any given walk of life will take particular note of others doing similar work.

There is a downside to this though; I played live music professionally for many years and was also part of a team bringing together a daily live kids' variety show on national TV. These experiences have dampened my enthusiasm for going to see live bands and watching some TV shows, because knowing how it is done removes a lot of the gloss and glamour. It's the same as knowing how a magic trick or illusion is done; while you can appreciate how the magician is performing his act, knowing the technical secrets detracts from the entertainment value.

At the same time, being a serviceman takes the shine off getting other servicemen in to do jobs I (for whatever reason) don't want to tackle. For example, a while back my washing machine started delivering more water to the outside of the cabinet than to the inside. It turned out to be a relatively simple fix but several aspects of the job really irked me at the time, aside from the obvious "I could've done it myself if I'd known how" hindsight that all DIY'ers and many servicemen deal with at various times.

The first annoyance came when talking to the company I'd telephoned to do the job. I explained (or so I thought) the problem pretty clearly in terms I was familiar with. However, once the customer service representative

began asking his preliminary questions, I ended up feeling more and more stupid.

In my own business, I am keenly aware that my customers (and potential customers) have a diverse range of computer literacy. As a result, I take great pains to avoid leaving people feeling like they've been patronised and/or belittled during our customer contact.

My staff (when I actually had some in those golden pre-recession and pre-earthquakes days) were carefully trained in not only what to say but how to say it when dealing with customers. This ensured that customers didn't feel uncomfortable or in any way inadequate when describing the computer problems they were experiencing or what was going on with their machines. In fact, many people begin their accounts with "I'm hopeless with computers" or "I'm not very computer literate", as a kind of apology for the way they are about to describe the problem.

Our approach is to always try to put them at ease by telling them that everyone has their own way of describing computer hardware and how they work and to just to go for it, as we will understand what they mean. I also like to mention comparisons like "we don't have to be mechanics to drive a car" or "chefs to work the oven" either.

The absolute worst thing we (or any company) could do is make them feel like they are making a fool of themselves – which admittedly can sometimes be a challenge if their question or issue seems ludicrously simple. It

Items Covered This Month

- Watching servicemen while they service
- Fixing a spa bath
- Microwave oven repair

*Dave Thompson runs PC Anytime in Christchurch, NZ.

Website: www.pcanytime.co.nz

Email: dave@pcanytime.co.nz

sometimes isn't easy, yet much of our future business depends on how we deal with clients today and even more so on first contact.

Service call-outs

This approach extends to service call-outs as well. If a customer wants to book a call-out, I can tell them exactly when one of us is going to be at their home or place of work. If I say 10 o'clock, for example, we'll be there at 10 o'clock (or just before) unless something really drastic or unforeseen occurs. And in the rare case something does happen, I or one of my staff phone the client as soon as possible before the appointed time and explain what's happened. We then arrange for the technician to either arrive a little later or, if that's not convenient, make another appointment.

Unfortunately, the company I contacted to fix my washing machine was nowhere near as precise when it came to nominating a time for their technician to call. The best they could manage was to ask "morning or afternoon?". When I asked if it was possible to narrow the time-frame down a bit more, they said "no" because the technician had no way of knowing when he would finish his previous jobs.

That meant that I (or my wife) would have to take at least half a day off work just to be at home to meet the serviceman (because, of course, they don't work weekends). In my opinion, this is not really satisfactory but it's exactly

how things are done in many service industries. It's certainly a much more common approach than giving clients an accurate time as to when they will be on-site.

As a result, many customers are surprised when we offer a specific appointment time and they seem to appreciate the fact that we arrive on time. It might be more difficult managing such a schedule but I think we get a lot of repeat business because of the way we arrange and keep appointments.

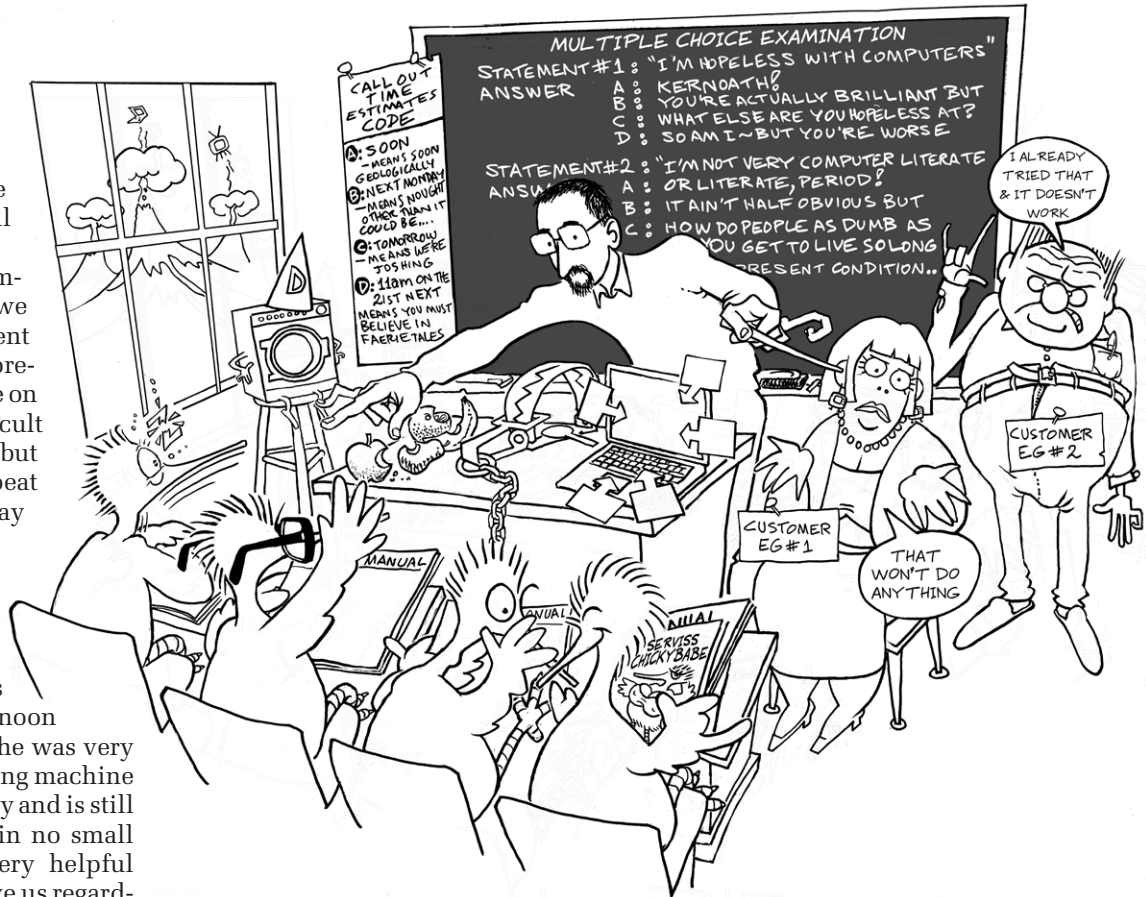
Still, at least when these guys agreed to an afternoon visit, the service guy did arrive as arranged. It was mid-afternoon when he showed up and he was very good at his job. The washing machine was fixed relatively quickly and is still going strong years later, in no small part because of some very helpful advice the serviceman gave us regarding quirks peculiar to our particular model.

That said though, he didn't seem overly keen for me to be standing around while he did the job, although to be fair, that applies to most serviceman. This may well be because they just want to get on with their work undisturbed or perhaps because they don't want to give away any trade secrets.

Watch but don't interrupt

Personally, I don't mind clients watching what I do as long as they don't constantly (and unproductively) interrupt or try to influence how I'm doing things. Most who take an interest will ask me if they can pull up a chair and watch and that's usually fine. However, nothing irks me more than statements by hovering clients along the lines of "I already tried that and it didn't work", or "that won't do anything" or "what does that have to do with fixing the problem?"

To those who ask such things I patiently explain that I have a troubleshooting process to go through and it may well be that something I do has already been done but this is the way I have to do it. This usually settles things down and while it hasn't yet come to the point where I've had to



~ MY STAFF WERE CAREFULLY TRAINED IN NOT ONLY WHAT TO SAY BUT HOW TO SAY IT WHEN DEALING WITH CUSTOMERS

ask someone to shut up and let me get on with it, I've been very close to this point on several occasions!

The truth is that nothing I do is top-secret and clients wanting to watch usually aren't interested in seeing what I do so that they can do it themselves next time. Instead, it's more about being interested in how I solve a problem they've likely Googled and had a go at fixing themselves anyway.

Even if the client is a pedantic type and wants a running commentary, I'm happy to provide it. After all, they are paying for the service and my time, so that's their prerogative.

In reality, most clients aren't interested in exactly what I'm doing and probably think (correctly) that the more they interject, the longer it will take and the more it will cost. Instead, they just want their machine fixed so that they can get back to work or go back to doing what they were doing.

I am keenly aware of all this when working on-site so I must admit to being rather put out when the washing-machine guy made it plain he didn't want to talk or explain what he was doing, or have me hovering around while he worked. Once I'd related the

symptoms to him, it was as if I didn't exist. I got the impression he thought I was trying to watch what he did so I wouldn't need to call him again.

That may have been the case to some extent but to be honest, it was more out of professional curiosity. Basically, it was more a case of wanting to see the innards of a modern washing machine than wanting to work on my own appliances.

It's the same with working on cars. In days gone by, I've pulled engines and gearboxes out, stripped them down and rebuilt them. I also once handled all my own automotive repairs but these days I just don't have the facilities (or the motivation) to do this. Instead, it's far easier to let a professional who knows all the tricks of his trade do the work.

To be fair, the washing machine guy did clearly explain what he'd done once the job was finished and that was good. I've learnt that most people want to at least know what the problem was and while some are happy with a brief description, others want a bit more detail. Knowing which "speech" to give is all part of keeping our clients happy and is yet another important aspect of

The dogs chewed on my spa bath

F. W. of Airport West, Victoria recently got roped into fixing his daughter's spa bath. It wasn't so much a case of the dog ate my homework but the dog chewed on something it "shouldn't oughta" chewed on. Here's what happened . . .

Being a retired licensed aircraft engineer and general handyman, I often get called on by my kids to fix various items. Just recently, I received a call from my daughter with the news that her spa bath had stopped working. As the spa is in a 20-year-old house they bought last year, she thought that it might be time to get a new one but suggested that perhaps I could take a look at it first.

I didn't know how a spa bath worked but with common sense and a multimeter, I figured that I would soon find out.

When I got there, I pushed the button on the spa bath edge and confirmed that it (the spa) didn't make any of the noises or bubbles it was supposed to. At the side of the house outside the bathroom, I found a large metal cover which I removed. Underneath was the spa pump and

its motor, with a 240VAC lead going to a wall-mounted GPO.

I soon confirmed that 240VAC was getting to the plug but not to the pump motor connectors. Closer inspection revealed that there was a microswitch on the top of the motor, with what looked like a small cylinder attached. A piece of plastic tubing ran from this cylinder and disappeared down through the cobwebs and through the brick wall into the underside of the spa bath.

I then realised that the pushbutton switch on the bath wasn't really a switch at all but was in fact an air master-cylinder. Obviously, you do not want electrics anywhere near the spa bath 'switch' with all that water and bubbles around. Basically, to operate the spa, you pushed the button on the bath and the air pressure in the tube would then move the small cylinder piston on top of the motor and operate the microswitch. This then switched on the motor.

So what was at fault? There were various possibilities: a faulty master cylinder, a faulty slave cylinder, or perhaps it was the microswitch. As



~THE DOGS ATE MY SPA

it turned out, it was none of these.

Clearing away the cobwebs revealed the problem. The plastic tubing between the small slave cylinder on top of the motor and the master cylinder had been severed, thereby preventing the slave cylinder from operating.

So how did that happen? My money is on two new Border Collie pups that had just recently joined the household and had become bored. Chewing on the tubing had relieved their boredom at the expense of the spa bath.

A small garden spray joiner was used to join the two ends of the plastic tubing and the spa bath immediately resumed normal operation. An old gate was then erected to prevent the four-legged miscreants from re-offending.

the serviceman's trade – especially if he wants to get more of the customer's business.

In this case, the service company didn't get my repeat business. When my oven subsequently went on the blink, I called someone else because while the technician was OK, I wasn't impressed with the rest of the way his service company did things.

This time around, I was given a time window of a few hours as to when the technician would arrive and this made planning things much easier. He also said he'd call me to confirm the exact time closer to the appointed hour. This was a much better start to our relationship and when he arrived exactly when he said he would, I felt good about giving them the job.

This serviceman was very friendly and chatty and was more than happy to have someone looking on while he did the job. He was forthcoming with what he thought the problem was with

the oven and what our possible options were likely to be, all while he was busy removing the oven's door and various access hatches.

The earthquakes did it

Our oven is one of those dual wall-mounted models, installed by the home's previous owner. And the problem with wall ovens is they rely on everything being square for everything to align, seal and work properly. The recent Christchurch earthquakes didn't do things much good in that respect and while the house is still basically square and level, the oven got knocked about quite a bit which resulted in the door no longer closing or sealing properly.

Most oven doors are designed to stay open once pulled past a certain point but ours wouldn't. And when closed, it was obviously out of square; not only could you see it didn't line up properly, when the oven was on you

could feel heat escaping from gaps to the extent you had to be careful you didn't get scorched.

So something had to be done. Being a bloke and a serviceman, I had an obligation to at least have a go at fixing it and so I did. I took the door off and removed all accessible panels and covers but to me everything looked a long way out of whack and no matter what (or where) I prised with my trusty jemmy bar, I couldn't get any significant movement.

After a period of static inspection (ie, standing and staring at it), I decided it was beyond my oven-repair skills and so I put it all back together. I did manage to rig up a door-latching system using a spring, a rubber band and a self-adhesive plastic hook and this at least kept the door closed and the majority of the heat inside the oven when it was operating.

However, after subsequently going through a few springs and hooks, we

eventually decided it was time to call in the professionals, which is why I was now standing and watching as the oven repair guy removed the door and panels. The big difference, of course, was that he knew what he was doing and it wasn't long before he said the whole frame of the oven had twisted beyond repair and the whole assembly would need to be replaced. We measured up the walls and found the wall and aperture for the oven were as square as they would ever be, but the oven frame had obviously been forced in several directions during the quakes and this had permanently bent it out of shape.

The bad news was that a new frame assembly for this particular model was going to cost many hundreds of dollars. However, we had well and truly fallen out of love with this particular appliance, so that was hundreds of dollars too much. The repair guy also told us that it wouldn't be a wise investment to spend that kind of money on something of this vintage and since he had no side-line business in new ovens, his advice was obviously unbiased and so a new unit was the best way forward.

Shopping is not one of my favourite pastimes, except when I'm looking for tools or something I'm personally interested in. Indeed, most guys will agree that appliance shopping is tough duty. Not only are there literally thousands to choose from, there is no possible way the one the man likes will be the one that ends up being installed at home. There's also the very real danger that you'll decide on one and pay for it only to find the exact same model advertised the very next day for considerably less money.

Anyway, we duly picked a nice unit out and a friend helped me mount it in the gap left by the old one and wire it in. In New Zealand, a home handyman can wire in a wall oven provided there is an isolation switch within a few metres. Job done!

Microwave oven repair

A. P. of Briar Hill, Victoria recently cured an unusual fault in a microwave oven. Here's his story . . .

Having retired not so long ago and now expected to take on additional home duties, I had the perfect excuse to replace our 30-year old Toshiba microwave oven with a brand new Sharp R-890N. As well as being a lot

more powerful, this new unit also came with top and bottom heating elements for grilling and convection oven cooking.

Admittedly, the price of the new unit was about four times that of an ordinary microwave oven but I figured that the ability to quickly and efficiently bake, roast and grill foods would more than make up for the expense.

Anyway, with the Sharp installed, it wasn't long before I was experimenting with cakes, crispy potato wedges and roast meats, all with impressive results. My only concern was an occasional intermittent mechanical "clunk" from inside the unit, followed by a momentary interruption to the turntable rotation.

It seemed to happen only when there was a particularly heavy load on the turntable. As everything else was working fine, I assumed that this clunk was probably the result of a clutch mechanism being activated, this being designed to prevent overloading of the turntable motor. In retrospect, I should have made a warranty claim but at the time, I dismissed the problem as a minor one and quite possibly normal behaviour although there was no mention of it in the owner's handbook.

The clunk gets worse

I didn't give it much further thought over the next 18 months but then I noticed that the clunk was gradually becoming more frequent. And it was also happening with lighter loads on the turntable.

The turntable itself is rather unusual. Because of the high operating temperatures, it is made from heavy pressed steel finished in vitreous enamel. And instead of the more usual captive rollers to support the turntable, this one has three small, axle-mounted wheels welded to its underside. I wondered if these wheels might have become sticky under load, thereby putting a greater strain on the motor.



A.P. OF BRIAR HILL, VIC.
RECENTLY CURED AN UNUSUAL
FAULT IN A MICROWAVE OVEN...

They seemed to be running freely enough but just to be sure, I carefully cleaned each one using degreaser and detergent.

Unfortunately, this gave no improvement and with continued use, it was clear that the problem was rapidly getting worse. By now, it was well outside the warranty period and I was kicking myself for not reporting the problem at an early stage to the manufacturer.

A few more weeks went by and I then noticed that there were occasions when the turntable had stopped altogether. This was annoying since with two cups of coffee inside, the one closest to the waveguide would boil over before the other had reached the desired temperature. Curiously, I noticed that by giving the turntable a gentle nudge back and forth, it would then always commence rotating as it was meant to when the door was closed and the microwave restarted.

So much for all my earlier theorising about a clutch mechanism! The unit was clearly faulty.

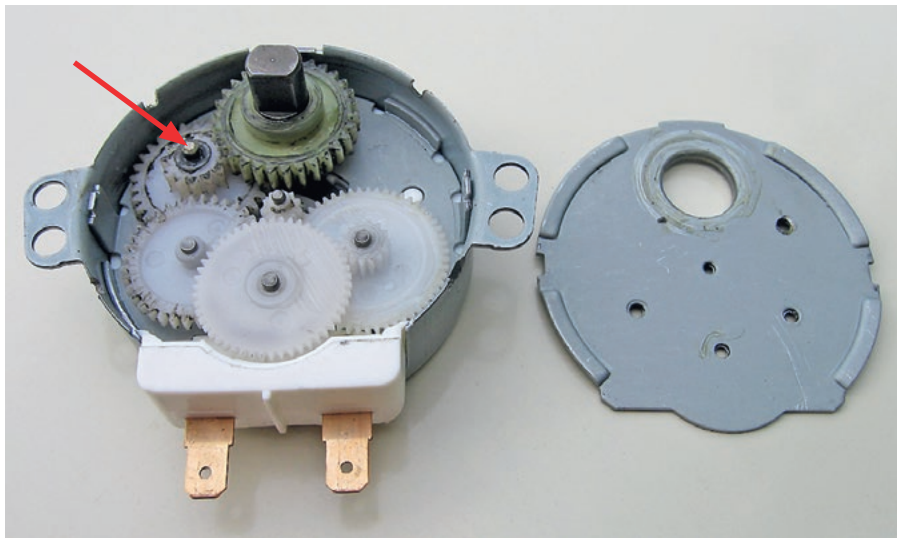
Deciding that the problem could be ignored no longer, I up-ended the unit, hoping that the motor might be accessible. My worst fear was that the motor had been the first item fitted during assembly and that the rest had been built around it! If it had, it would

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? It doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au
Please be sure to include your full name and address details.

Serviceman's Log – continued



This is the view inside the faulty microwave oven motor. The arrowed gear axle was jumping out of its seat in the cover plate at right.

have meant delving inside the unit and dealing with a high-voltage capacitor that can store a lethal charge, even after the power has been disconnected.

However, I was lucky. To my delight, there was a pre-punched inspection cover in the cabinet base, held only at the corners by slender metal bridges that could be easily cut through with side cutters. Better still, the cleverly designed hatch could be refitted by rotating it 180° and securing it with a single self-tapper.

The motor itself was held with a single screw and in less than five minutes it was in my hand. The drive was transferred to the turntable via a simple plastic coupler. It was now clear that if there was a clutch of any sort it would have to be inside the motor itself.

I then remembered I had a defunct LG microwave in the garage that was waiting to be scrapped. Could it have a similar motor? It too was easily accessible and at first glance it looked identical. Unfortunately though, it was a 21V motor whereas I needed a 240V one. What's more, the round drive shaft was longer, with a single flat instead of the two flats that the Sharp motor had.

A quick internet search showed that turntable motors can be purchased on ebay for anything from \$5 up to \$80, despite all being physically very similar. The main differences seem to be in the voltage, RPM, power and

type of drive shaft. The motor I needed was a 3.5W unit with a shaft speed of 3RPM. Most of those on sale had slightly lower power ratings and a higher RPM specification, some as high as 6RPM.

I figured that as I needed a motor with good torque, one with low RPM would be a better choice. Unfortunately, the most suitable ones were right at the upper end of the price range.

I now had to make a decision. Should I put the motor back temporarily and order a new one? Or should I dismantle the motor to see if the problem could be identified and perhaps solved? The risk with this latter option would be that the motor might not be repairable and I would then be without an oven until I could source a suitable replacement.

At that stage, I decided to get back on the internet and find out if others had reported the problem or found a fix. I soon discovered that others had experienced the same problem and that the suggested fix was a new motor.

Taking a chance

Being reluctant to buy a replacement motor without knowing what had caused the original problem, I decided to take a chance and grind away the turned-over tabs and remove the cover plate to expose the gears. When I did this, the fault was immediately apparent.

A synchronous motor in the centre

drives a series of gears to reduce the rotor speed down to the drive-shaft speed of 3RPM. And it was obvious that the last cog before the drive shaft had been disengaging. Basically, its axle shaft had been only shallowly seated in the cover plate. When the pressure was too much, the shaft simply popped out, allowing the cog to deflect sideways and skip a tooth. This created the clunk and momentary loss of rotation.

Once the pressure was relieved, the shaft would then pop back into place. However, over time, the shaft had worn an escape path in the cover plate to the point where sometimes it would not pop back into position. This explained why the turntable sometimes did not rotate at all.

The accompanying photo shows the motor with its internals exposed and the rogue axle arrowed. Beside it is the cover plate with its inside surface showing. If you look carefully, you can see the wear around the axle seat in the cover plate.

Replacing the axle

After some thought, the most practical solution seemed to be to replace the problem axle with one that was slightly longer and more securely seated. And that's what I did. After finding a suitable axle in my spare parts drawers, I spent some time cutting and grinding it to just the right length, with a slight taper at the end so that it would seat more securely. Once I had it right, I reassembled the motor gears, redistributed some of the excess lubricant to where it was more needed and fixed the cover plate in place with glue.

I couldn't crimp the cover plate in place the way the maker had but I didn't see that as a problem. Once the motor was mounted back in place, the cover plate couldn't move anyway, so there was no real need for it to be crimped.

It's now been several weeks since the motor was repaired and to my great satisfaction, the cure has been permanent. However, I'm going to be careful to avoid obstructing the free rotation of the turntable, otherwise the motor might stall or possibly strip the gears.

And if that happened, I would have no option but to buy an expensive replacement motor . . . or a new microwave.

SC

TECH FEST

OCTOBER EDITION



Prices valid until 23/10/2013

Online & in store

Wi-Fi Inspection Camera

A smart inspection camera that uses your Smartphone as the screen. Hold your Smartphone and point the camera where you please. Includes a bracket if you require the Smartphone to be fixed.

- IP67 rating (camera only)
- 1/8" Colour CMOS camera
- Flexible gooseneck length: 685mm
- Handle size: 180(L) x 45(W) x 50(D)mm

DUE EARLY OCTOBER



Note: iPhone® not included

NEW
\$149 00



Better, More Technical

Wind Speed Meter/Thermometer

Capable of measuring wind/airflow parameters at the same time as monitoring temperature.

- Metres/sec; km/hr; feet/min; miles-per-hour; knots
- Cubic metres/minute; cubic feet/minute
- Air temp, 0-50°C (0.1°C resolution)
- Vane impeller ball bearing mounted
- 1m vane probe lead



NEW
\$99 00

5-in-1 Jump Starter

Your personal roadside assistant! Includes heavy duty insulated jumper leads, a 400W inverter, LED work light, 12V power outlets, status gauges, and even a 260PSI air compressor! Powered from the built-in 18Ah SLA battery and comes with mains and 12V charging cables.

- Size: 220(L) x 215(W) x 295(H)mm

MB-3594 **WAS \$149.00**

\$119 00
SAVE \$30



Economy Network 4 Channel DVR

Price breakthrough! An affordable 4 channel DVR for home or office surveillance. Connect to a computer network to view video remotely from anywhere in the world using a web browser or Smartphone/iPhone® (via free installed app).

- 500GB of storage for up to 300 hours of continuous video recording
- Control across the network or by using the included mouse or remote control
- Manual, scheduled or movement activation
- Size: 300(L) x 210(W) x 50(H)mm

Cameras available in store **Bullet 600TV Lines Camera (QC-8632 \$99)**

NEW
\$249 00



In-Car FM Transmitter and Charger

A convenient way to playback music from your iPhone®5 Smartphone through the car's sound system. It features a Lightning connector to charge an iPhone®5 and a 3.5mm plug for audio streaming through the FM radio band.

- Up to 5m transmission range
- Built-in microphone
- USB port
- Size: 100(L) x 30(W) x 12(D)mm

AR-3127

NEW
\$29 95

DUE EARLY OCTOBER

Note: iPhone® not included



500W 240V Electric Drill

Suitable a variety of tasks around the house or on the job. Features a forward/reverse switch, lock setting, and moulded plastic grip. Will accommodate bits up to 10mm and includes a handy belt clip.

- Mains powered
- Cable length: 1.8m
- Size: 250(L) x 190(H) x 65(D)mm

TD-2493
DUE EARLY OCTOBER

NEW
\$19 95



60W Solder/ Desolder Rework Station

Complete solder/desolder station for production and service use. The temperature is easily adjusted in 1° increments with simple up/down buttons and the soldering/rework functions can be operated independently of each other.

- 60W ESD Safe
- Suitable for lead-free solder
- Celsius and Fahrenheit display
- Microprocessor controlled
- Size: 225(L) x 215(W) x 155(H)mm

TS-1574 **WAS \$369.00**

\$299 00
SAVE \$70



Automatic Headlights Kit for Cars

Ref: Silicon Chip October 2013

Like modern cars, this kit will turn your car headlights on automatically if you forget to turn the lights on when it gets dark. It can also turn the lights off when you park to avoid a flat battery. See website for full features.

- Kit supplied with double sided, solder-masked and screen-printed PCB, die-case cast, buzzer and electronic components.

Cabling not included.

KC-5524 **DUE LATE OCTOBER**



NEW
\$59 95

JAYCAR ROXBURGH PARK

NOW OPEN
Unit 4
195 Somerton Rd
Roxburgh Park,
VIC 3064
Ph: 03 8339 2042



6-Way Membrane Switch Panel with Relay Box

Your personal roadside assistant! Includes heavy duty insulated jumper leads, a 400W inverter, LED work light, 12V power outlets, status gauges, and even a 260PSI air compressor! Powered from the built-in 18Ah SLA battery and comes with mains and 12V charging cables.

- Size: 220(L) x 215(W) x 295(H)mm

MB-3594 **WAS \$149.00**

\$119 00
SAVE \$30

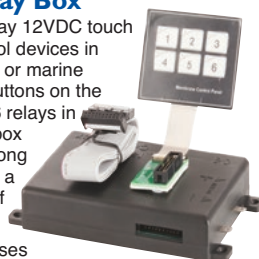


6-Way Membrane Switch Panel with Relay Box

An ultra compact 6-way 12VDC touch control panel to control devices in automotive, camping, or marine applications. The 6 buttons on the switch panel control 6 relays in the separate control box with an included 1m long ribbon cable resulting a completely waterproof (IP67) switch panel.

- Built-in resettable fuses
- Max current: 10A per channel, 35A total
- Touch Panel size: 70(L) x 63(W) x 1(H)mm
- Membrane Control Box size: 135(L) x 90(W) x 33(H)mm

SP-0900



NEW
\$99 95

12" Active Subwoofer

Explosions, car crashes, and other movie events that demand thumping bass vibrations will be drastically enhanced with this 12" active subwoofer. The amp is rated at 70WRMS with a 30Hz-250Hz frequency response. Great addition to a home theatre system.

- Matte black finish
- Size: 436(L) x 433(W) x 446(H)mm

CS-2429

NEW
\$199 00



To order call 1800 022 888

www.jaycar.com.au