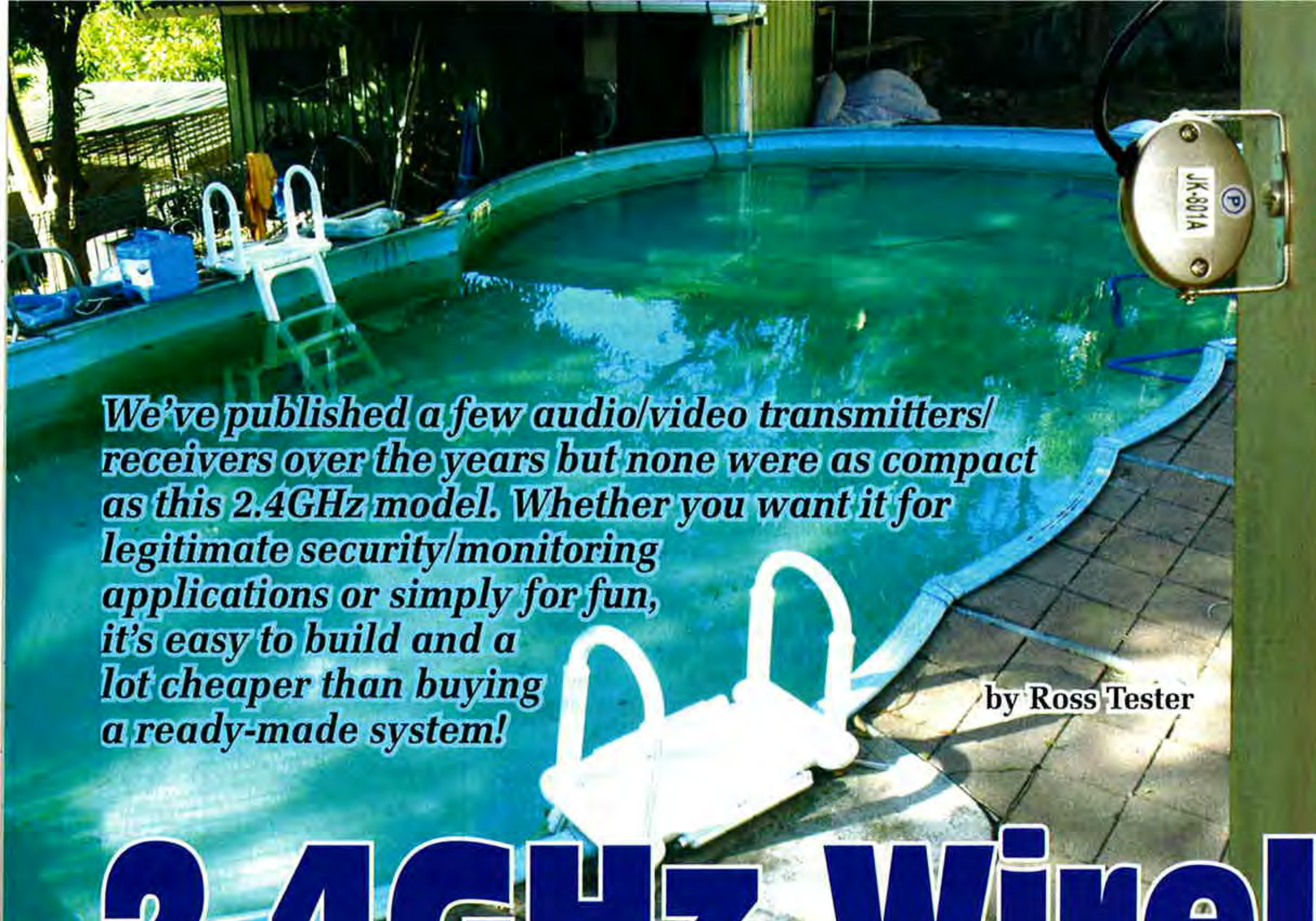


We've published a few audio/video transmitters/receivers over the years but none were as compact as this 2.4GHz model. Whether you want it for legitimate security/monitoring applications or simply for fun, it's easy to build and a lot cheaper than buying a ready-made system!

by Ross Tester

2.4GHz Wirel

This transmitter and receiver pair is delightfully simple to build because most of the hard yakka is already done for you.

The transmitter and receiver are both pre-assembled modules – all you have to do is solder them to a couple of PC boards, add some power supply components, a video source . . . and that's it!

The transmitter board is not much bigger than a postage stamp (actual size is 30mm square x 13mm high [not including antenna]), so if you wanted to, you could conceal this little board virtually anywhere (eg, for surveillance/security or even hazardous area monitoring applications) and have the receiver feeding a monitor some distance away.

The 2.4GHz band

Once upon a time, 27MHz was regarded as the "garbage band" – just about anything and everything was chucked in there, including model control, garage door controllers, industrial, scientific and medical equipment (that, in fact, was/is what the band was called) – and even the first CB radios and low-cost marine radio transceivers (which of course exist to this day).

In recent times, 2.4GHz has earned much the same reputation. You name it and it's in that frequency band – everything from microwave ovens to WiFi and Bluetooth, cordless phones and doorbells to almost limitless types of "wireless" links. And of course, all sorts of A/V equipment.

Which brings us to the reason for this interlude: there are three channels to choose from in the system presented here to hopefully allow you to avoid frequencies which are already in use (we'll go into setting channels later). You may need to experiment to find which one is right for you.

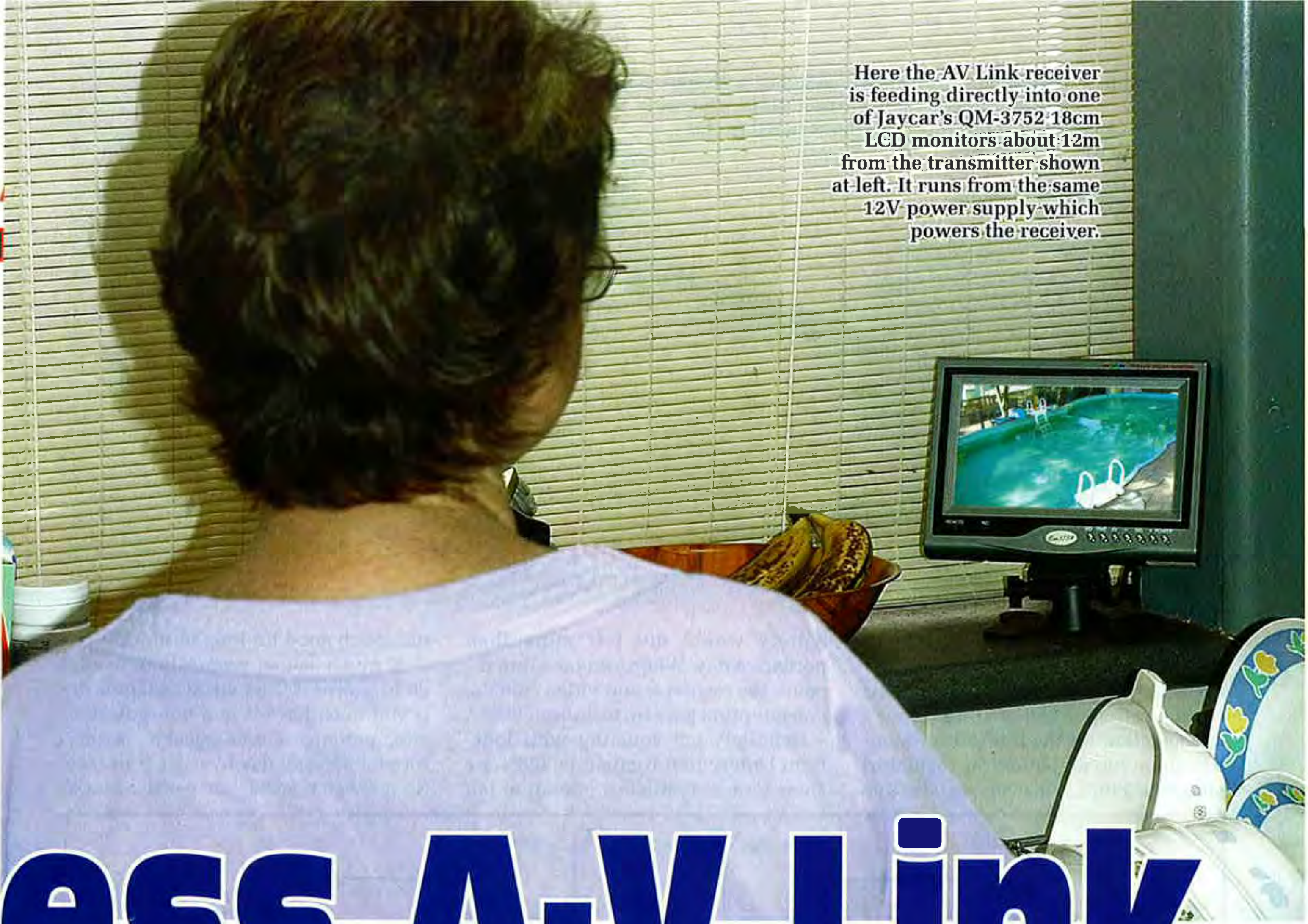
On the prototype, Channel 1 was initially used – which knocked my WiFi system off the air. The converse was also true – my WiFi system interfered severely with the reception, even with the transmitter and receiver at very close range.

It was akin to the interference, both vision and audio, which you get on your TV when a Vee-dub drives by (no, I'm not a VW hater!).

Fortunately, changing channels on the A-V link cured the problem (I didn't want to go to the trouble of changing channels on the WiFi – let sleeping dogs lie, and all that!).

The transmitter

There are three main parts to the transmitter: input, which we'll look at in just a moment; the transmitter module itself, which is pre-assembled, and lastly, the power supply components for the transmitter.



Here the AV Link receiver is feeding directly into one of Jaycar's QM-3752 18cm LCD monitors about 12m from the transmitter shown at left. It runs from the same 12V power supply which powers the receiver.

ess A-V Link

The last two parts are assembled on the one PC board and to save space, are mounted layer-fashion one on top of the other. Those components which will fit are mounted hard down on the PC board, with the transmitter module mounted above them via some header sockets (with a little surgery!). The larger components, specifically three electrolytic capacitors, mount along the edge of the board.

A 31mm length of stiff wire acts as an antenna. This is soldered directly to the RF output pin of the transmitter module. For extra range, an external 2.4GHz gain antenna could be connected to this point and earth via a short length of 50Ω coax cable but this would possibly mean the transmitter would no longer be legal.

The camera

The transmitter module will accept both composite video and stereo audio signals. These would normally be from a video camera and microphones or as in the case of the prototype, a combination unit with both.

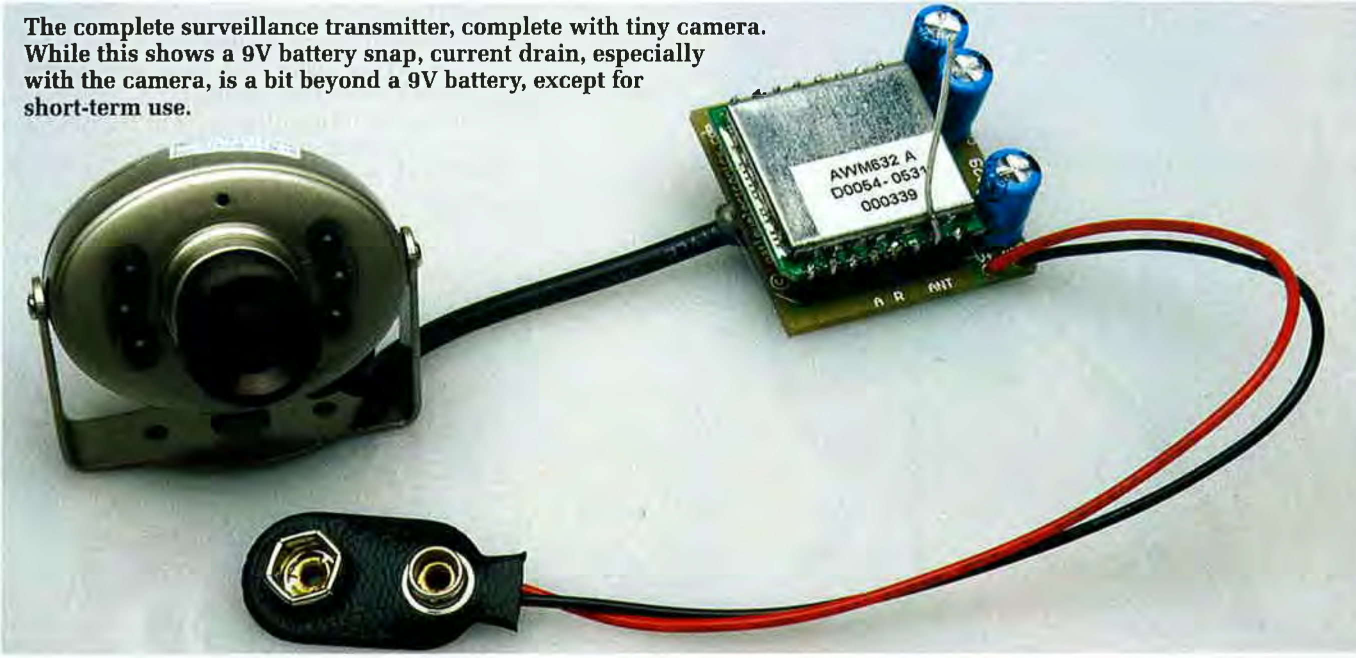
This 1/3-inch, CMOS camera operates in very low light conditions (down to just 3 lux) and is also from Oatley Electronics. It measures just 25 x 35 x 14mm with a swivel mount and appears to have six infrared LEDs mounted around the lens. We have been assured by Oatley that these are not actually IR LEDs – they're dummies!

While not supplied with the kits, this tiny colour camera from Oatley Electronics is an ideal partner. It has an inbuilt microphone but those aren't real IR LEDs!

The camera was hard-wired onto the PC board, with the lead glued to the back of the board via hot melt or epoxy to prevent it flexing and damaging the solder joints.

Input could also come from a zero-light camera (such as an infrared type) but could also come from any other device capable of producing composite video (PAL) signals, such as a video recorder, DVD player, etc – so the transmitter could form the basis of a video distribution system around your home, office, etc.

The transmitter module is designed to operate from a 3.3V supply. This could be derived from a 6V "lantern" battery (for long life) but the prototype



The complete surveillance transmitter, complete with tiny camera. While this shows a 9V battery snap, current drain, especially with the camera, is a bit beyond a 9V battery, except for short-term use.

was wired for a 9V battery (mainly for its small size). Note that we are not expecting a very long life from this configuration – the manufacturer's specification for the transmitter module alone (ie, no battery or regulator) suggests 55mA, so even an alkaline battery would not last more than perhaps a day. When you take into account the regulator and video camera, consumption goes up to around 90mA – definitely not equating with long-term battery life! It might be OK for a short-term surveillance operation but not much good for long-term use.

A much better proposition would be to power it from an AC adaptor or, if you must have it in a non-powered site, perhaps a rechargeable battery topped up each day by solar cells (see Stan Swan's article in April SILICON

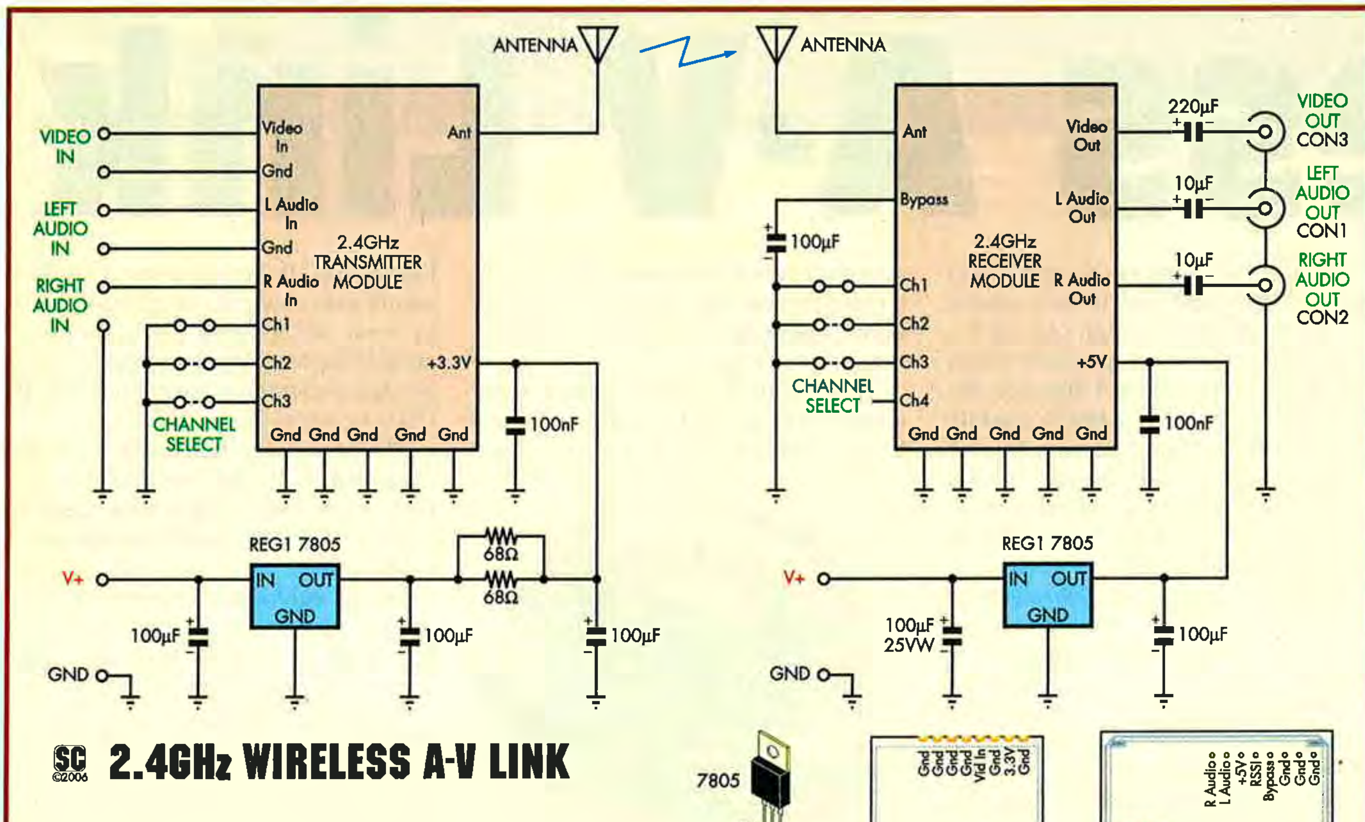
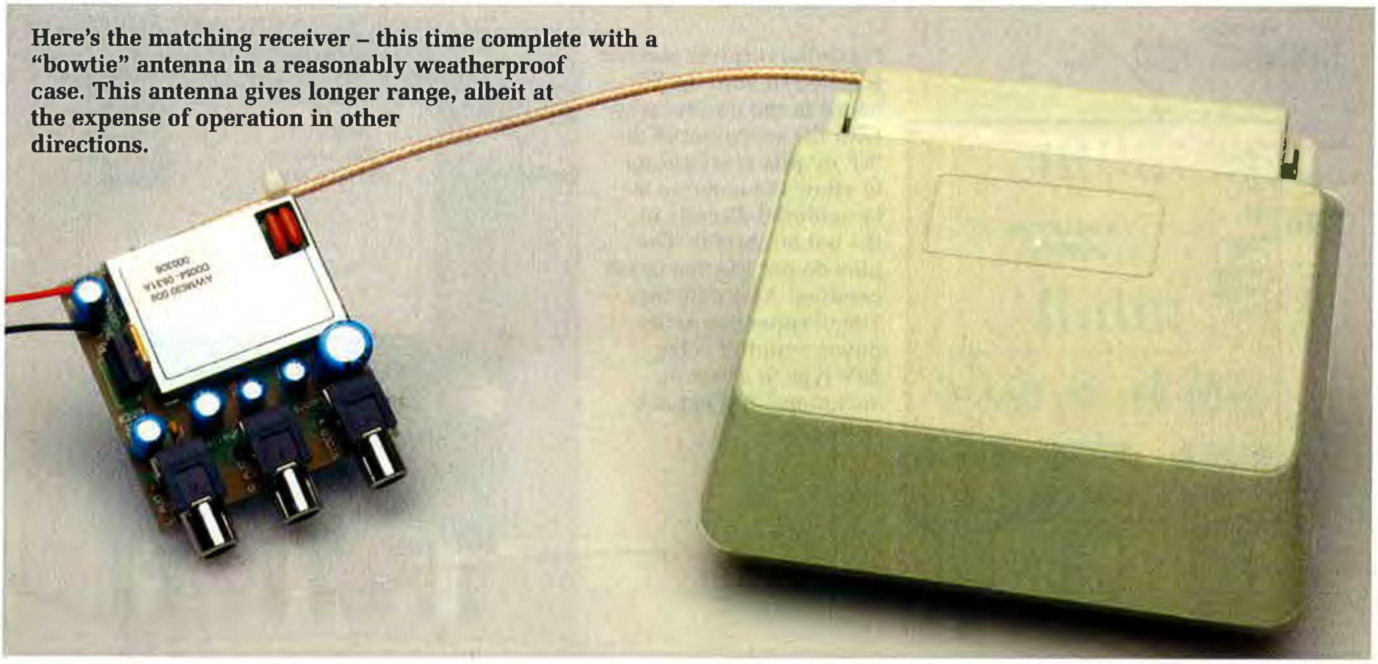


Fig.1: the circuit diagram for both the transmitter and receiver. Both are based on pre-built modules so all you have to do is add power supply components and input/output connections.



Here's the matching receiver – this time complete with a "bowtie" antenna in a reasonably weatherproof case. This antenna gives longer range, albeit at the expense of operation in other directions.

CHIP for some really neat, low-cost recycling ideas).

The receiver

At 17 x 50 x 62mm, this board is larger than the transmitter. Once again, it incorporates a prebuilt 2.4GHz module, a power supply (the receiver module requires 5V) and three "RCA" output sockets – one for video, two for stereo audio.

Unlike the transmitter, the receiver module is soldered directly to the PC board (ie, there's nothing underneath it). The only other components on the board are seven capacitors and a 5V regulator.

The power supply for the receiver could be just about any DC plugpack with a 9V to 12V output. Receiver current drain is less than 100mA so you won't find many plugpacks which can't handle this.

The receiving antenna can be the same as the transmitting antenna – a 31mm length of stiff wire, or for more range it can be a gain antenna without transgressing any laws (Oatley's K-198 bowtie antenna kit is ideal). Gain antennas simply concentrate signal to or from one direction at the expense of most other directions. Therefore they appear to offer higher performance than a "stick".

Construction

We'll start with the receiver because it's the simpler of the two.

Start by mounting the seven capacitors (six electrolytic and one monolithic) in their respective positions on the PC board. Solder in the monolithic first – it is not polarised.

Identification of the electrolytics shouldn't be difficult: the 220µF capacitor is the largest, the two 100µF are in between and the two 10µF are the smallest. In all cases, watch polarities: the '+' side of the electros all go the same way on the PC board.

Now solder in the 7805 regulator – its metal tab goes towards the middle of the PC board – followed by the three RCA sockets. They will only go in one way but make sure you don't bend the pins underneath them!

OK, the slightly more difficult part follows: you need to identify and bend out the RF input pin so you can connect an antenna to it. Turn the module over (pins up) and note the set of eight pins close to one corner.

The second pin down from the corner is the RF input pin. With a fine pair of (needle nose) pliers, bend this pin down so it points out from the edge of the board. Note that you can only do this once because if you try to straighten it or do it again, the pin will almost certainly break off. You have been warned!

With that pin bent out, push all of the other pins through their holes in the PC board (the module will only go one way) and solder the module in place.

Apart from power supply and antenna wires, the receiver module is now finished. Solder in the power supply wires (red and black hookup wire) to their appropriate places on the PC board.

You now need to make a decision as to the type of antenna you are going to use: wire or external.

If it's a wire, cut a 31mm length of tinned copper wire and solder its very end to the bent-out pin (pin 2) of the module, taking care not to short to adjacent pins or to the module case. In fact, it would be a good idea to slide a length of insulation over the antenna to make sure it doesn't get bent and short later on.

If you're going to use an external antenna, the inner wire of the coax solders to pin 2 (as above) with the shield soldering to the point directly underneath (on the bottom side of the PC board).

Again, make sure that you don't short anything out – and also make sure that you keep the length of the inner conductor to an absolute minimum.

To prevent the coax flexing, we used a tiny cable tie to secure it to the corner of the PC board at the opposite end of the edge to which it had been soldered.

Solder the opposite end of the coax to your external antenna (if it's the Oatley antenna, see the instructions which come with it).

Transmitter module

There's not much difference between the construction of the receiver and transmitter, except that the transmitter module solders onto two rows of header pins after first soldering

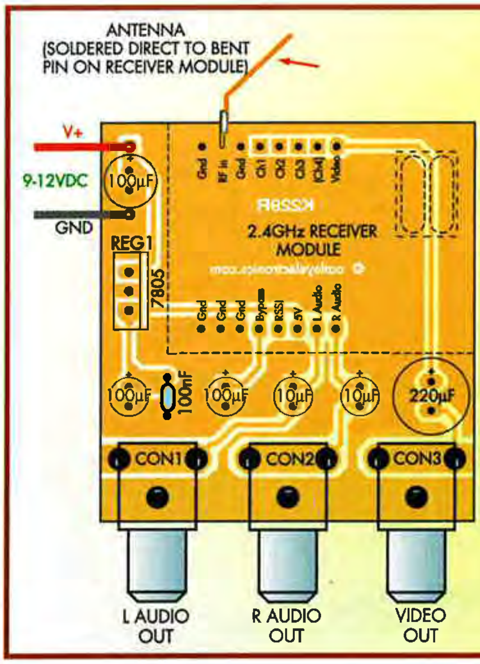
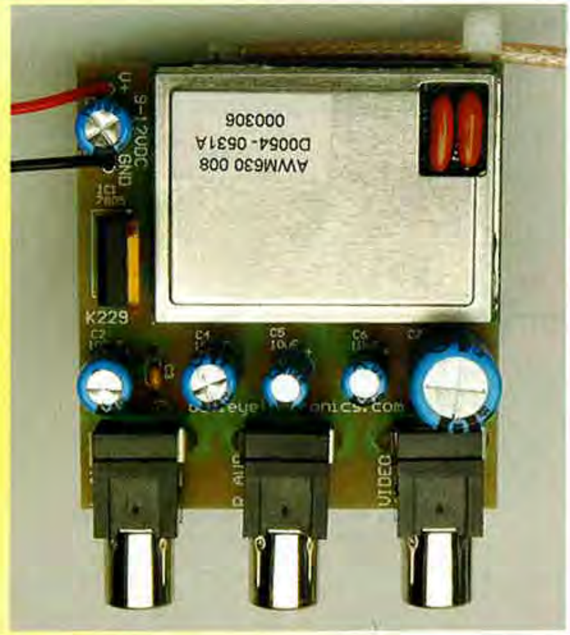


Fig.2: the receiver module is soldered onto the PC board in the normal way, with the exception of the 'RF in' pin. It is bent up to allow the antenna to be soldered directly to it – but be careful. The pins do not like too much bending! Also note the 100µF capacitor at the power input: it is the 25V type to allow for variations in plugpack voltages.



some components underneath.

Start with these components: the two 68Ω resistors, the 100nF monolithic capacitor and the 7805 regulator. In the latter case, you'll need to bend down the ends of the regulator's pins – say 5mm from the bottom – by 90° to allow them to pass through the PC board holes and allow the regulator to lie flat on the PC board.

Now solder the red and black 9V battery snap wires in place. Last to go in are the two rows of header pins.

You will note that the transmitter module doesn't have pins of its own; rather, it has half-holes along each edge into which the header pins sit (and are soldered). There is copper on the top side of the board so it's not too difficult to do.

But it's far easier to solder the header pins onto the board first, then solder the transmitter module to those, rather than try to solder the module to the pins then insert the assembly.

The header pin under the antenna (2nd from left) is not used – in fact, it must be removed because there is no hole in the PC board for it. So on the left of the PC board, from the bottom, you will have one header pin, then a gap, then six header pins. On the opposite side all eight pins are used.

Push the module down onto the header pins (the right way around!) and very carefully, solder each pin to the PC board with a fine soldering iron.

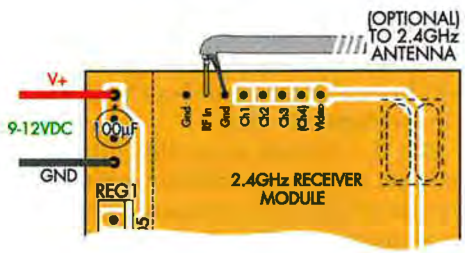


Fig.3: if you're using an external antenna, here's where to connect it. Keep the bared wires as short as possible.

Assuming you will be using a simple wire antenna (as distinct from a gain antenna) on the transmitter, cut and solder a 31mm length of stiff tinned copper wire to the antenna (RF out) pad. Ideally, the antenna should be 31mm from the module's PC board to the tip, so it might pay you to solder say, a 35mm length on, then carefully measure and snip it back to 31mm long.

You don't want any wire below the module's PC board because this would create an unbalanced dipole.

If you want to use a gain antenna (see the warning above), its 50Ω coax cable will solder to the antenna pin and to the square pad underneath the PC board as follows for the signal connections.

Detail of the RF output modifications on the receiver board – the pin is not soldered to the PC board but bent out so that the 31mm wire antenna can be soldered directly to it. At left is the underside of the module showning this bent-out pin.

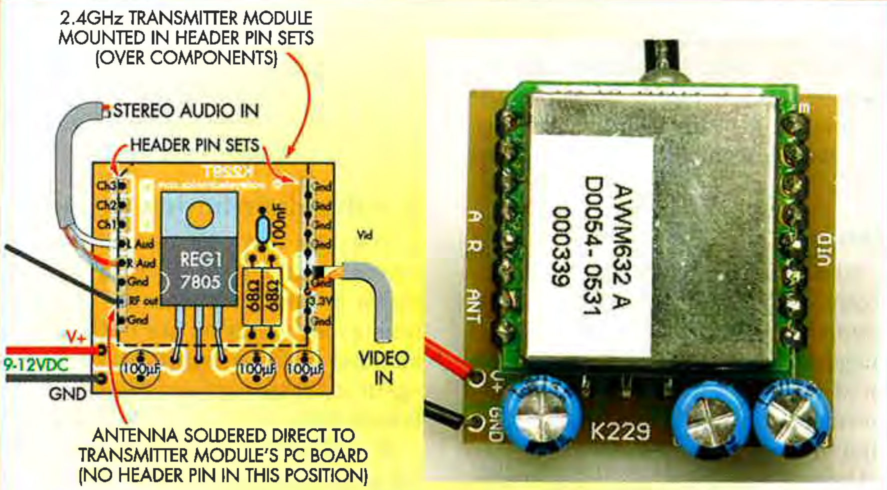


Fig.4: at left is the component overlay for the transmitter board, with the transmitter module shown dotted. The regulator, two 68Ω resistors and 100nF capacitor mount underneath the module which itself is then soldered onto the two rows of header pins . The antenna is soldered directly to the "ANT" position (it is end-on in the photo at right so is almost perfectly camouflaged!)

All of the signal connections (audio and video) can be made direct to the appropriate header pins on the edge of the PC board, or they can be made to the pads under the PC board if you wish to anchor (glue) the cable to the PC board for security. Our diagrams show these connections – they are made with the inner wires of the shielded cables.

You need to remove 1cm of outer insulation and bare back the shield wires/braids so that the inner conductor insulation is exposed. Remove 3mm of insulation from the inner conductor to allow you to solder it to the pin. The shields (earths) of each of the wires solder to the square pads immediately alongside the signal connection points.

If connecting an external antenna, the shielded cable must be the right type: 50Ω UHF (low-loss) coax and the length kept to a minimum. All coax cables are lossy at 2.4GHz and most are intolerable – the higher the frequency, the more lossy coax cables become. Many perfectly good cables at HF (high frequencies – up to 30MHz) are totally useless at UHF (300MHz–3GHz) and above.

Only a few cables will be made for use at UHF (coax cable supplied with the Oatley K198 kit is the right stuff).

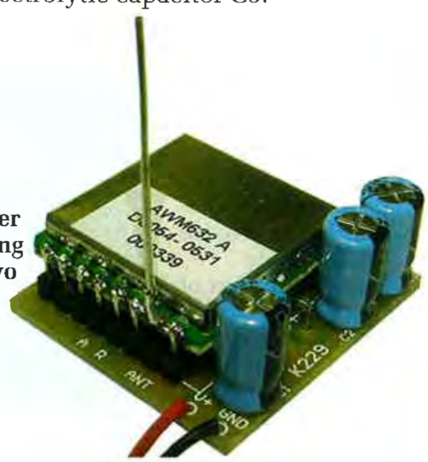
In any event, the length of inner conductor exposed from the shield must be kept to an absolute minimum (a few millimetres is OK, a few centimetres definitely not!). Just be careful that the shield doesn't short onto the inner conductor or the pin it is soldered to or, indeed, adjacent pins.

Selecting the frequency

As we mentioned earlier, there are three channels available for selection and the transmitter and receiver modules must both be selected to the same channel.

If you turn the transmitter board over, you'll see in the copper pattern three square pads with a shorting bar running alongside them – they're under the module, diagonally opposite electrolytic capacitor C3.

At left is the transmitter module, clearly showing the half pads along two edges to which the header pins solder. At right, the finished transmitter PC board – not far off life size.



Parts List – 2.4GHz A-V Link

Transmitter:

1 2.4GHz transmitter PC board, labelled K229T, 30 x 30mm
1 AWM632 2.4GHz transmitter module
1 7805 5V regulator

Capacitors
3 100µF 16V electrolytic
1 100nF monolithic (code 104 or 100n)

Resistors (0.25W, 1%)
2 68Ω (code blue-grey-black-brown or blue-grey-brown-gold-brown)

Miscellaneous
2 8-pin header pin sets
1 9V battery connector
1 50mm length tinned copper wire for antenna (see text for alternative)

[All above components are in the Oatley Electronics 2.4GHz transmitter kit, Cat K229TX].

Receiver:

1 2.4GHz receiver PC board, labelled K229R, 50 x 62mm
1 AWM630 2.4GHz receiver module
3 PC-mount RCA connectors
1 7805 5V regulator

Capacitors
1 220µF 16V electrolytic
1 100µF 25V electrolytic
2 100µF 16V electrolytic
1 10µF 16V electrolytic
1 100nF monolithic (code 104 or 100n)

Miscellaneous
1 length red hookup wire to suit (+ power)
1 length black hookup wire to suit (– power)
1 50mm length tinned copper wire for antenna (see text for alternative)

[All above components are in the Oatley Electronics 2.4GHz receiver kit, Cat K229RX].

Options (as photographed):

1 mini colour video camera, with inbuilt microphone (Oatley CAM9)
1 2.4GHz bowtie gain antenna, with case and coax cable (Oatley kit K198)

One (only) of these pads must be connected to the shorting bar – you'll probably find it easiest to solder a very short length of resistor pigtail offcut across the gap (it's often hard to get solder to flow over even a small gap when you want it to).

(This is the converse of one of the more famous of Murphy's corollaries: if you don't want solder bridging out two pads or tracks on a PC board, it will do so very easily . . .)

Similarly, on the receiver board, there are four pads and a shorting bar diagonally opposite capacitor C2. Hang on a sec – four pads? Yes, there are four – but the last one is not (and can not) be used. As we said before, the shorted pad must match on both transmitter and receiver.

Is it finished?

And that's just about it. Now it's time for a test. You'll need a TV set with an AV/TV switch (most do these days, even the cheapies!) and a 3-way RCA-RCA lead for connecting video and stereo audio channels (you can connect a single channel of audio if you wish).

Plug the receiver in and connect it to power – as we mentioned before, a 9-12V DC plugpack would be ideal. Just make sure you get the polarity right – check with your multimeter because many plugpacks are not the expected "centre positive"!

Assuming you're using a small video camera (with microphone) directly wired to the transmitter module as described before, connect a 9V battery to the transmitter and you should find a picture appears on the screen and sound comes from the TV speaker/s.

If not, you obviously have something wrong: the obvious errors are power supply connections, different channels selected on transmitter and receiver, shorted video, audio or antenna connections, etc.

If you are using a directional antenna on the receiver (and/or the transmitter) make sure it is/they are aligned with each other – a perpendicular line from the receiver's antenna PC board should point directly at the transmitter (and vice versa if you have it) for longest range.

Having said that, however, we found that it wasn't that critical – on our test setup (about 20m), a quite usable picture was obtained with the antenna completely off-axis but it was certainly best aligned as above.

This system will not work as an audio-only link: the audio doesn't work without video – ie, you must have video running to hear anything. However, you can have video without audio.

Range

While our test setup was limited to about 20m, Oatley Electronics have assured us that their tests over a much longer distance – 100m – were entirely satisfactory and in fact suggested that the range would be significantly longer than this.

Oatley's setup included the bowtie antenna on the receiver only; the transmitter had the wire antenna as described here. A bowtie antenna at the transmitter end as well might well mean dramatically longer range, though this has not been tested.

Other video sources

You might like to wire the transmitter with its own video and audio sockets (eg, RCA), to allow different signal sources. Just make sure that the cables are secured to the PC board so they don't place any strain on the board's copper pads – they don't like being stressed.

As a matter of fact, the mini video camera photographed with this kit originally came with RCA plugs – they were cut off when the camera was hard-wired to the PC board.

As we mentioned earlier, just about any composite video (PAL) source can be used, such as a VCR, DVD player, handycam or minicam, etc. Even digital camcorders usually have a video out socket (and it is usually yellow). Check with your manual to find which socket it is.

If the budget can't quite stretch (yet!) to a dedicated mini camera, any of these sources can be used to check that the system is working.

Note that you cannot use webcams or similar if they are fitted with USB connectors. These do not have the required output.

A video distribution system

You can use one transmitter and several receivers to distribute an AV signal around your home – again, as long as all receivers are on the same channel as the transmitter. And once again, aim the receiver antennas at the transmitter.

If you have cable or satellite TV, for example, you can use this system instead of paying a monthly rental for a second set-top box/receiver.

The main drawback, of course, is that you can only watch one channel at a time. And there are some set-top boxes which do not have video/audio out sockets.

Where do you get it?

This project was designed by Oatley Electronics, who hold the copyright on the PC board patterns.

The transmitter, receiver, gain antenna and video camera are all sold separately so you can make design your system to suit your needs.

The transmitter kit (Cat K229TX) sells for $17; the receiver kit (Cat K229RX) sells for $32; while the "bowtie" gain antenna (K198) sells for $7.00, complete with a suitable case.

The tiny video camera you see photographed with this kit is a standard Oatley stock line, Cat Cam9, selling for $39.00. It comes with the swivel bracket but does not have infrared LEDs which are seen in the photo.

Contact Oatley Electronics on (02) 9584 3563; by mail at PO Box 89, Oatley NSW 2223; or via their website, www.oatleyelectronics.com. SC

This Oatley Electronics K-198 2.4GHz bowtie antenna kit comes with the weatherproof case shown earlier and will extend the range of the 2.4GHz A-V link quite significantly. Best of all, it's really cheap! (For more information on this design, see SILICON CHIP, January 2004 issue).