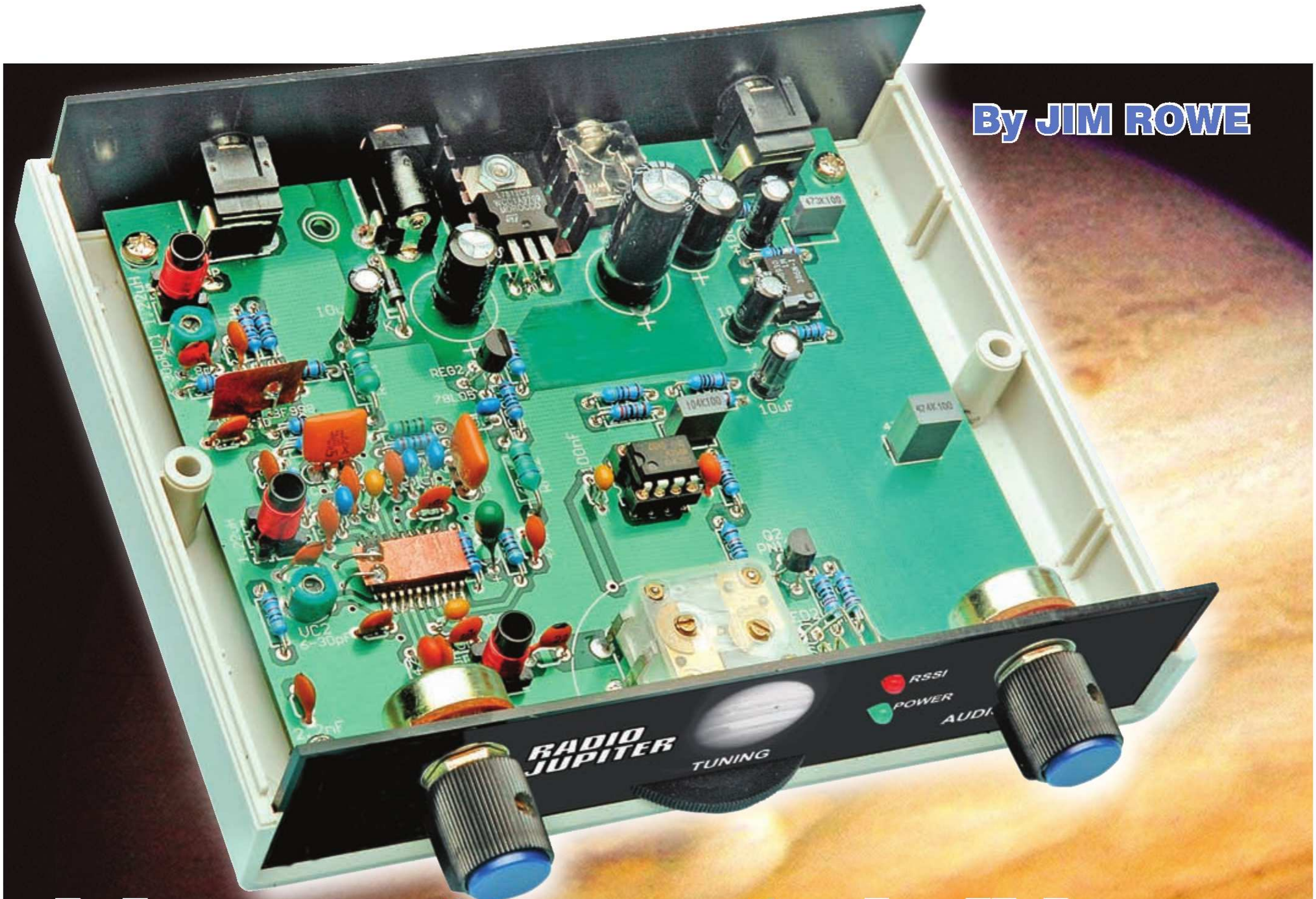


By JIM ROWE

A low-cost, easy-to-build
Planet Jupiter Receiver

How would you like to try some basic radio astronomy – listening to the bursts of noise originating from the planet Jupiter, or from the Sun? You don't need a lot of fancy equipment to do this, just the simple shortwave receiver described here. It's hooked up to a basic dipole antenna (which we describe as well) and to the sound card in your PC, so that you can print out 'chart recordings' of the noise signals.

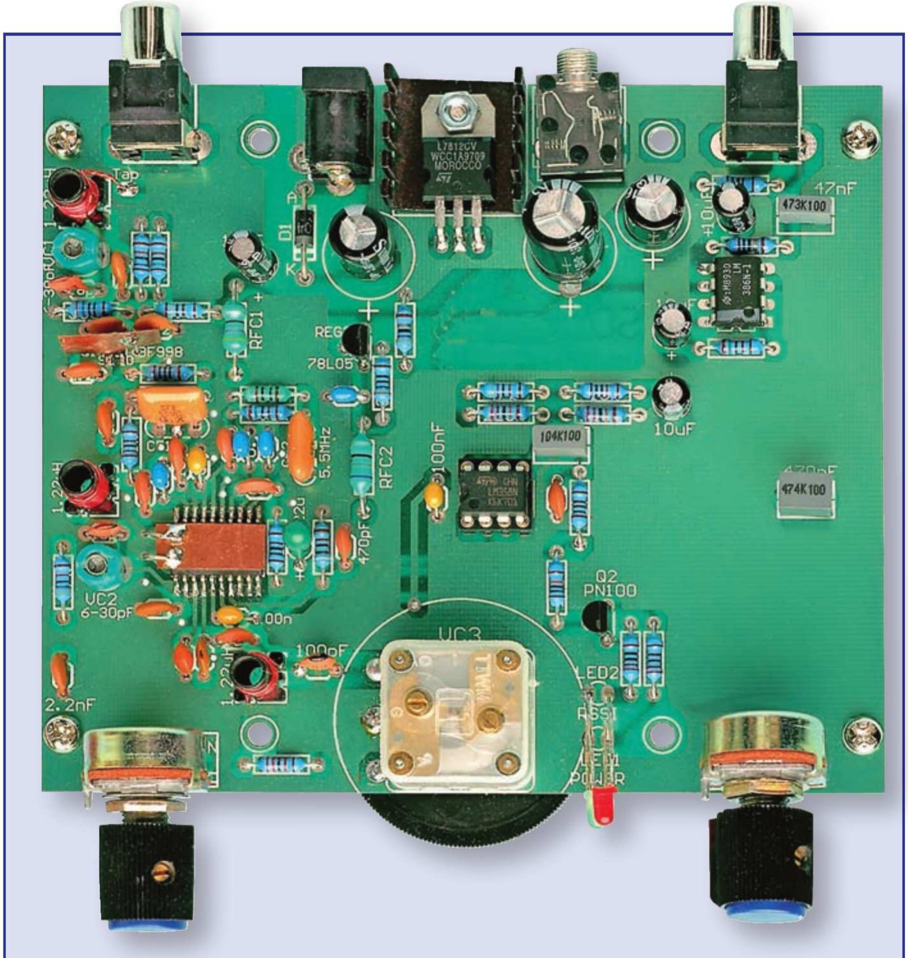
MENTION the term 'radio astronomy' to most people, and they'll either look completely blank or visualise huge steerable dishes – like the one at Jodrell Bank in Cheshire. While a lot of radio astronomy is done nowadays using huge 'valley sized' antennas like the one at Aricebo in Puerto Rico, or big arrays of smaller antennas, it's still possible to do interesting observations using much simpler antennas and equipment, at 'decametric' frequencies (8-30MHz) in the HF radio band.

In fact, a NASA-sponsored project called '*Radio Jove*' has been promoting this type of radio astronomy for the last 10 years as a science project for high-school students and interested hobbyists. Over 1000 simple receiver kits have been sold, for 20.1MHz reception of noise bursts from the planet Jupiter, the Sun and other objects in the Milky Way galaxy.

There's only one problem with the US-designed Radio Jove receiver as far as non-US students and hobbyists have been concerned: the receiver kits cost US$155 each, plus shipping from the States, so it will set you back quite a lot to have one sent to you. This has discouraged more than a handful of people from radio astronomy.

To encourage more students and hobbyists to have a go, we have developed our own low-cost receiver project. And that's the background to the new receiver described in this article. You'll find its basic specifications summarised in the 'Main Features' panel, but the bottom line is that it's quite suitable for basic radio astronomy at decametric frequencies around 21MHz. This makes it fine for receiving noise bursts from Jupiter, the Sun or other sources in the Milky Way.

We estimate that it will cost you around £50 for the basic receiver module, plus a 'fiver' if you decide to house it in an ABS instrument box. In other words, less than half the cost of the Radio Jove receiver. We also think it is a much better design, by the way.



The parts for the Jupiter Receiver are all mounted on a double-sided PC board. The top groundplane pattern is necessary to ensure stability.

How it works

The complete circuit for the receiver is shown in Fig.1. The heart of the circuit is IC1, an SA605D single-chip receiver IC that includes a local oscillator, an RF mixer, a high-gain IF amplifier and an IF limiting amplifier, plus a quadrature detector for FM signal demodulation.

We are not using the last of these sections here, because we're using the SA605 in a slightly unusual way – for AM signal demodulation. We do this by taking advantage of the chip's RSSI (received signal strength indicator) output from pin 7.

This works because associated with the high-gain IF amplifier and limiter stages inside the SA605 are a number of signal level detectors, whose outputs are combined to provide a DC output current from pin 7. This DC output current is logarithmically proportional to the incoming signal strength, so it is essentially an AM detector output. We convert it into a voltage signal by passing the current through a 91kΩ load resistor, shunted by a 470pF capacitor for low-pass filtering.

The centre intermediate frequency (IF) of the receiver is set at 5.5MHz using ceramic filters CF1 and CF2. These require no alignment. The local oscillator circuit inside IC1 is brought out to pins 3 and 4, to which we connect frequency-determining components L3 and VC3, together with 22pF and 39pF capacitors. Together, these components allow the local oscillator to be tuned manually over the range 25.75MHz to 28.0MHz, which is 5.5MHz above the input signal range of interest (20.25-22.5MHz).

The use of a 5.5MHz IF means that the receiver's image frequency will be 11MHz above the wanted frequency – giving a good image rejection ratio.

The input of IC1's mixer stage is tuned to the centre of the wanted frequency band (ie, about 21MHz) by

Main Features

The receiver is a single-conversion superhet design, tuning from about 20.25MHz to 22.5MHz, with a sensitivity of approximately 1μV for a 10dB signal-to-noise ratio. Only three controls are provided: RF gain, tuning and audio gain.

All components are mounted directly on a small PC board measuring only 117mm × 102mm, which can either be used 'naked' or housed in a standard low-profile ABS instrument case (140mm × 110mm × 35mm).

The receiver can be powered from either a 12V battery or a mains plugpack supply delivering between 15V to 18V DC. The current drain is typically between 55mA and 75mA.

There are two audio outputs from the receiver: 1) a line output suitable for connection to the line-level input of a PC sound card, and 2) a low-impedance output capable of driving external headphones or a small 8Ω speaker. Both outputs can be used at the same time.

Parts List – Planet Jupiter Receiver

1 double-sided PC board, code 771, available from the *EPE PCB Service*, size 117mm × 102mm
1 plastic case, 140mm × 110mm × 35mm (optional)
2 Murata 5.5MHz ceramic filters (CF1, CF2)
3 mini RF coil formers (Jaycar LF-1227 or similar) (L1 to L3)
1 300m length of 0.25mm enamelled copper wire
1 47μH RF choke (RFC1)
1 68μH RF choke (RFC2)
2 trimmer capacitors, 6.3pF to 30pF (green) (VC1, VC2)
1 10pF to 120pF miniature 'transistor radio' tuning capacitor, with edgewise knob (VC3) (Jaycar RV-5728)
1 50kΩ 16mm rotary PC-mount *linear* pot (VR1)
1 50kΩ 16mm rotary PC-mount *log* pot (VR2)
2 16mm-diameter control knobs
1 8-pin DIL socket (for IC2)
2 PC-mount RCA phono sockets (CON1, CON2)
1 3.5mm PC-mount stereo jack (CON3)
1 2.5mm PC-mount concentric DC power socket (CON4)
1 TO-220/6093B finned heatsink
4 M3 × 10mm tapped spacers
5 M3 × 6mm machine screws
5 M3 nuts (two used as spacers for VC1)
2 M2.5 × 5mm machine screws (for VC1)
1 15 × 7mm copper sheet or tinplate (for IC1 shield)
1 14 × 10mm copper sheet or tinplate (for Q1 shield)
1 3.5mm mono jack plug to 3.5mm mono jack plug audio cable

Semiconductors
1 SA605D surface-mount single-chip receiver IC (IC1)
1 LM358 dual op amp (IC2)
1 LM386 audio amplifier (IC3)
1 7812 +12V voltage reg.(REG1)
1 78L05 +5V voltage reg. (REG2)
1 BF998 dual-gate MOSFET (Q1)
1 PN100 *NPN* transistor (Q2)
1 3mm green LED (LED1)
1 3mm red LED (LED2)
1 1N4004 diode (D1)
1 16V 1W Zener diode (optional)

Capacitors
1 2200μF 16V radial electrolytic
1 470μF 25V radial electrolytic
1 330μF 16V radial electrolytic
1 22μF 16V tag tantalum
4 10μF 16V radial electrolytic
1 470nF MKT metallised polyester
8 100nF monolithic ceramic
1 47nF MKT metallised polyester
6 10nF monolithic ceramic
7 2.2nF disc ceramic
1 470pF disc ceramic
2 39pF NPO disc ceramic
1 22pF NPO disc ceramic
2 18pF NPO disc ceramic

Resistors (0.25W 1%)

2 220kΩ	2 1.5kΩ
1 150kΩ	5 1kΩ
1 110kΩ	1 820Ω
1 100kΩ	1 360Ω
1 91kΩ	1 300Ω
2 47kΩ	1 220Ω
1 22kΩ	1 100Ω
1 10kΩ	1 47Ω
1 2.2kΩ	2 10Ω
1 1.8kΩ	

Antenna Parts
1 UB5 plastic box, 83 × 54 × 31mm
1 35 × 21 × 13mm ferrite toroid (Jaycar LO-1238 or similar)
50-ohm coaxial cable plus RCA phono plug for downlead

means of inductor L2 and trimmer capacitor VC2. The 'Q' of this circuit is fairly low, so that the receiver's sensitivity is reasonably constant over the 2MHz-wide tuning band. As a result, tuning is achieved purely by adjusting the local oscillator frequency.

Although the SA605 IC does provide a great deal of gain in the IF amplifier and limiter sections, we have included an RF amplifier stage ahead of the IC to ensure that the receiver has adequate sensitivity. As you can see, this RF stage uses a BF998 dual-gate MOSFET (Q1), with the second gate (G2) voltage adjusted via VR1 to allow easy control of RF gain.

The RF input signal from the antenna enters the receiver via CON1, and is fed into the input tuned circuit (L1/VC1) via an impedance-matching tap on inductor L1. As before, the 'Q' of this circuit is kept relatively low, so once it's tuned to about 21MHz it does not need to be changed.

From the RSSI output of IC1, the demodulated audio signals are passed through op amp IC2a (half of an LM358) which is connected as a voltage follower for buffering. They then pass through a simple low-pass RC filter (the 1kΩ resistor and 10nF capacitor) before being fed to IC2b. This is the other half of the LM358 and is configured as an audio amplifier with a gain of ×5.7, as set by the 47kΩ and 10kΩ feedback resistors.

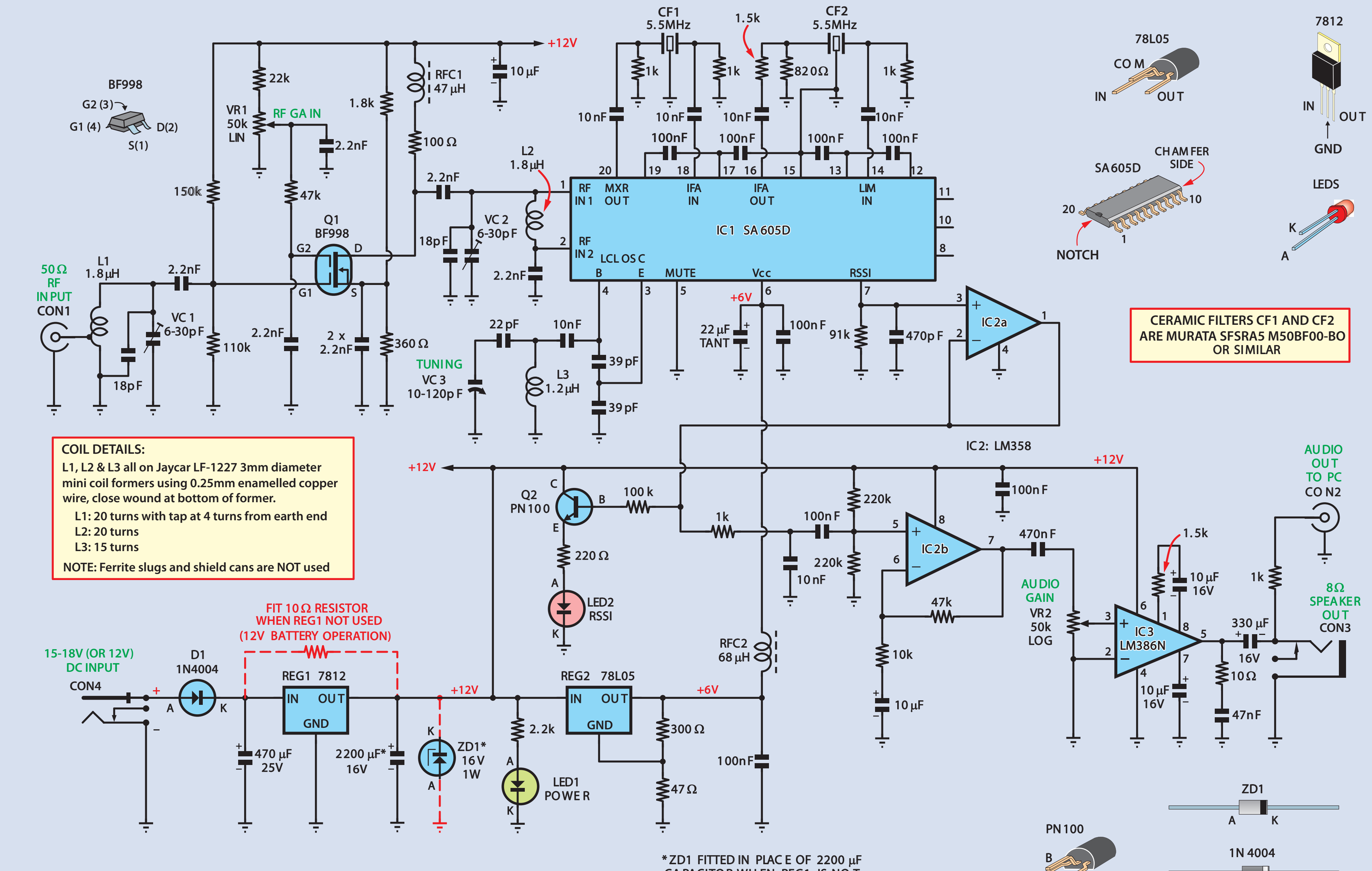
From IC2b, the signals pass through a 470nF coupling capacitor to VR2, the volume/audio gain control. They are then fed through IC3, an LM386N audio amplifier configured here to provide a gain of about ×40. The amplified audio signals are then coupled via a 330μF output capacitor to speaker output jack CON3, and also to line output socket CON2 via a 1kΩ isolating resistor.

Notice that the buffered RSSI signal from the output of IC2a is also fed to transistor Q2, which is used to drive LED2, the RSSI/overload indicator. Because Q2 does not conduct until the output voltage from IC2a reaches a level of around +2.65V, this means that LED1 really only lights when a very strong signal is being received – ie, when the receiver is tuned to a shortwave radio transmission or some other strong terrestrial signal source. So the main purpose of LED2 is to help you tune *away* from such signals, rather than *to* them.

Power supply

The receiver's power supply is very straightforward. Most of the circuitry operates from +12V, which can come directly from a battery if you wish. In this case regulator REG1 is not used, but is instead replaced by a 10Ω resistor. The 2200μF capacitor is also replaced by a 16V 1W Zener diode, to protect the circuit from damage in case of higher-voltage transients (when the battery is being charged, for example).

On the other hand, if you wish to operate the receiver from a 15V to 18V DC source such as a mains plugpack supply, then this is very easy to do. In this case, REG1 is fitted to regulate the supply down to +12V, while a 2200μF



21MHZ 'PLANET JUPITER' RECEIVER

Fig.1: the circuit is based on an SA605D surface-mount single-chip receiver IC (IC1), which includes a local oscillator, an RF mixer, a high-gain IF amplifier and an IF limiting amplifier, plus a quadrature detector for FM signal demodulation. The latter feature is not used here. Instead, the SA605 is used in a slightly unusual way to obtain AM signal demodulation.

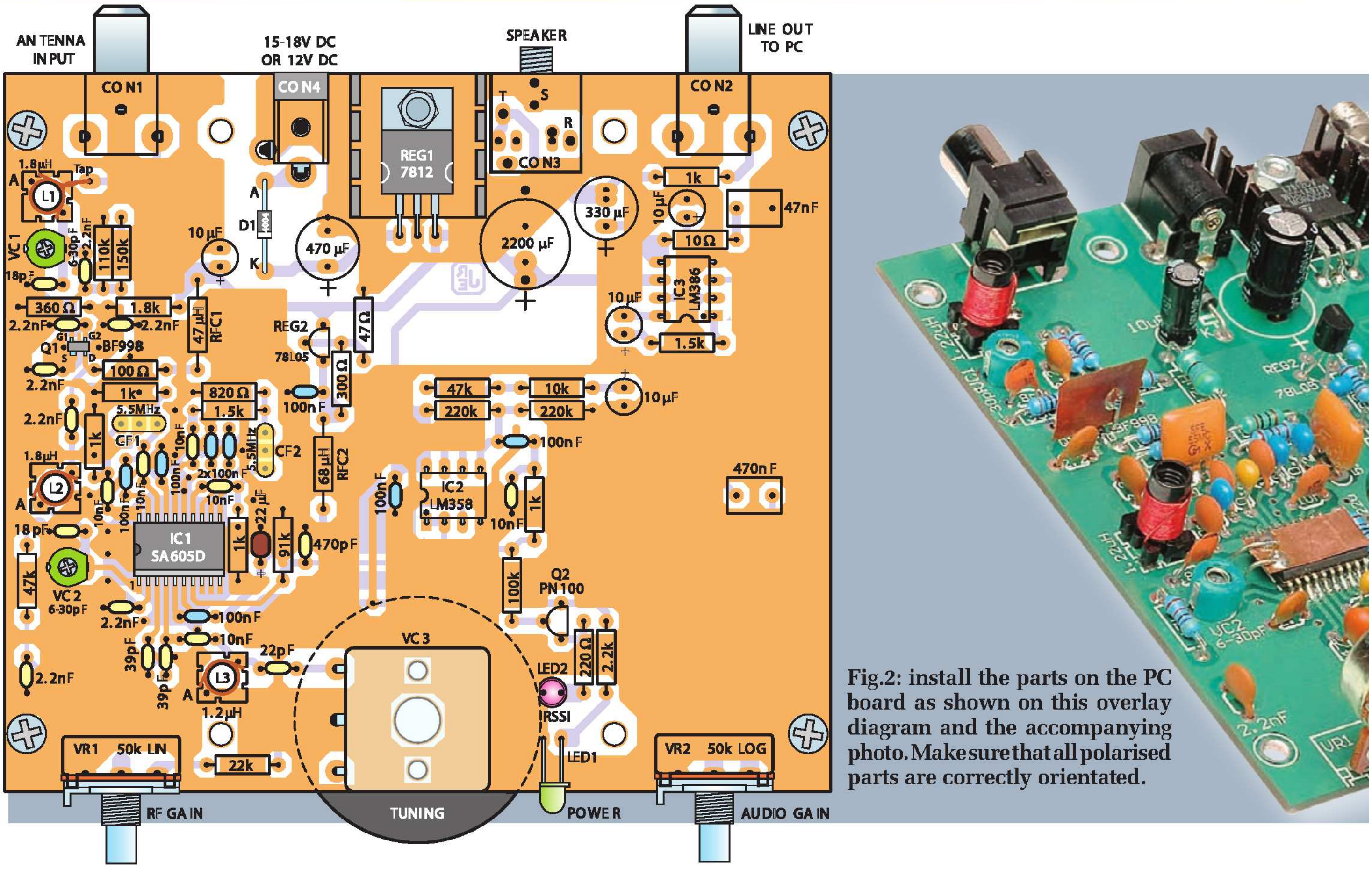


Fig.2: install the parts on the PC board as shown on this overlay diagram and the accompanying photo. Make sure that all polarised parts are correctly orientated.

capacitor is also fitted to provide the necessary filtering.

The only part of the receiver which does not operate directly from the +12V line is IC1, which needs a supply of +6V. This is provided by REG2, a low-power 5V regulator arranged here to provide an output of +6V by means of the 300Ω/47Ω resistive divider across its output.

LED1 is connected to the +12V supply via a 2.2kΩ series resistor to provide power indication, while diode D1 is in series with the DC input to protect against reverse-polarity damage.

Construction

As you can see from the photos, all of the receiver's parts are mounted on a small double-sided PC board measuring 117mm × 102mm and coded 771. This board is available from the *EPE PCB Service*. The printed circuit board component layout is shown in Fig.2.

As the double-sided PCB is not a plated through hole type, constructors will have to take extreme care when soldering components in position on the board – especially around IC1, a surface-mount device, where a sound 'earth plane' is essential for stability. Some components will need soldering on both sides.

The two black dots by the left side of IC1 are where its 'shield' leads are soldered to both sides of the board – see text. You will also need a vertical shield for MOSFET Q1. Other spare holes on the board need to be 'pinned' through to the underside tracks.

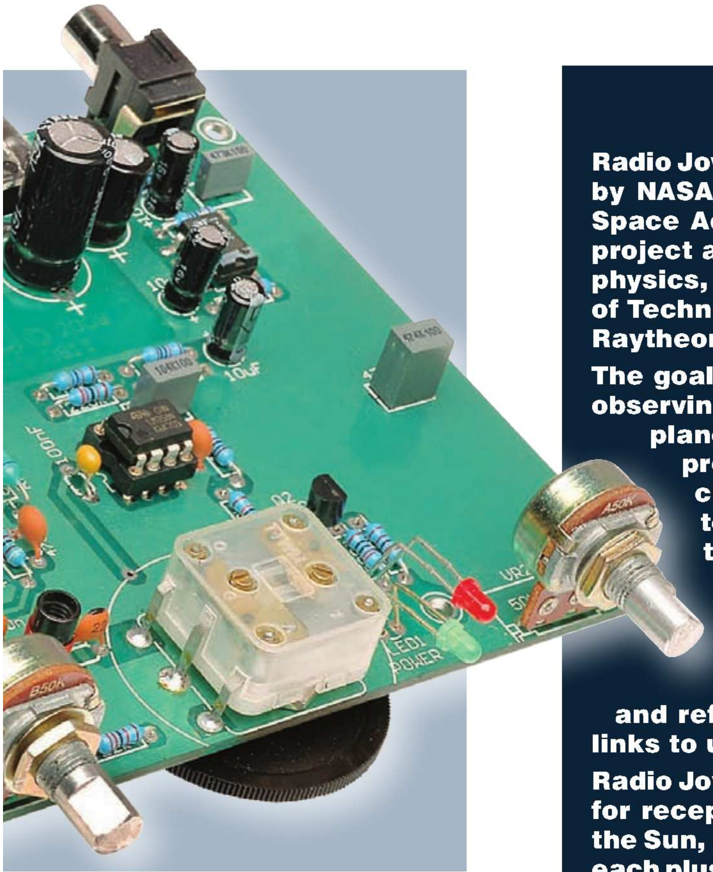
All the input-output connectors are mounted along the rear edge of the board, while the controls and two indicator LEDs are mounted along the front edge. Note that tuning capacitor VC3 (a standard mini 'transistor radio' tuning gang with only one section used) is mounted upside down on the top of the board, with its edgewise tuning knob fitted under the board.

Two 3mm nuts are used as standoffs between the tuning capacitor body and the top of the board, to bring the knob up closer to the board. **This is important if you want to fit the receiver into a low profile instrument case, because the knob will otherwise interfere with the bottom of the case.**

All the components mount on the top of the board, including IC1 and Q1, which are both SMDs (surface-mount devices).

Although you need to be especially careful when fitting IC1 and Q1, building the receiver should be quite straightforward if you work carefully and use the board overlay diagram (Fig.2) and the photos as a guide. Here is the suggested order of assembly:

1) Fit connectors CON1 to CON4 along the rear of the board.
2) Fit the resistors, taking care to fit the correct values in each position.
3) Fit the 8-pin socket for IC2, orientating it as shown to guide you in plugging in the IC later. Note that **a socket is not used for IC3**, as the LM386N is more stable when soldered directly into the board.
4) Now fit IC1 and Q1 to the board, taking the usual precautions with these SMDs. Use an earthed soldering iron with a fine chisel-shaped tip (very clean) and hold each device in position with a wooden toothpick or similar while you apply a tiny drop of solder (tack solder) to the diagonal end pins of the device, to hold it in position while you solder all of the remaining pins.



What Is Radio Jove?

Radio Jove is a radio astronomy education project sponsored by NASA – the US government's National Aeronautics and Space Administration. Other organisations involved in the project are the University of Florida's Department of Astrophysics, the University of Hawaii, Kochi National College of Technology, the INSPIRE Project and companies such as Raytheon, RF Associates and Radio-Sky Publishing.

The goal of Radio Jove is to promote science education by observing and analysing radio signals emanating from the planet Jupiter, the Sun and our Milky Way galaxy. The project is directed primarily at high-school science classes, both in the US and internationally, but interested hobbyists and radio amateurs are welcome to participate.

The Radio Jove project has an office at NASA's Goddard Space Flight Center and also has its own website at http://radiojove.gsfc.nasa.gov.

On this site there are a wide range of resources and reference materials, including observing guides and links to useful secondary sites.

Radio Jove also sells kits for a simple radio receiver suitable for reception of 'decametric' noise signals from Jupiter or the Sun, around 20.1MHz (14.915m). The kits cost US$155.00 each plus shipping (from Greenbelt in Maryland). An assembly manual for the receiver can be downloaded from the Radio Jove website.

The idea is to make each joint quickly and carefully, using a bare minimum of solder so you don't accidentally bridge between adjoining pins. Also make sure you orientate Q1 correctly; this 4-pin device is very tiny, but its source (S) pin is wider than the other three. **Orientate the device so that this pin is at lower left, and tack-solder this pin first if possible.**

5) Next, fit trimmer capacitors VC1 and VC2, making sure their flat sides face the centre of the board.
6) After these, fit all the smaller fixed capacitors. These are not polarised apart from the 22µF tantalum capacitor, which fits between the 1kΩ and 91kΩ resistors, just to the right of IC1. This capacitor is polarised, so make sure its positive lead is towards the front of the board.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	220kΩ	red red yellow brown	red red black orange brown
❑	1	150kΩ	brown green yellow brown	brown green black orange brown
❑	1	110kΩ	brown brown yellow brown	brown brown black orange brown
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	91kΩ	white brown orange brown	white brown black red brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	1	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
❑	2	1.5kΩ	brown green red brown	brown green black brown brown
❑	5	1kΩ	brown black red brown	brown black black brown brown
❑	1	820Ω	grey red brown brown	grey red black black brown
❑	1	360Ω	orange blue brown brown	orange blue black black brown
❑	1	300Ω	orange black brown brown	orange black black black brown
❑	1	220Ω	red red brown brown	red red black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	47Ω	yellow violet black brown	yellow violet black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown

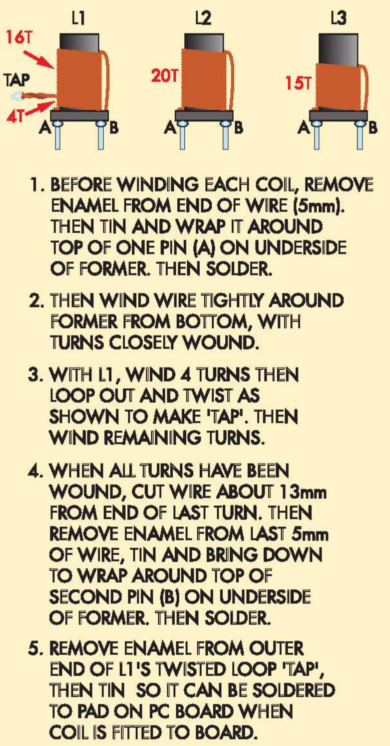


Fig.3: follow these instructions to wind coils L1 to L3.

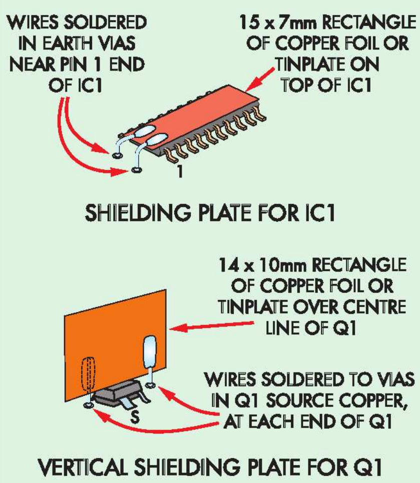
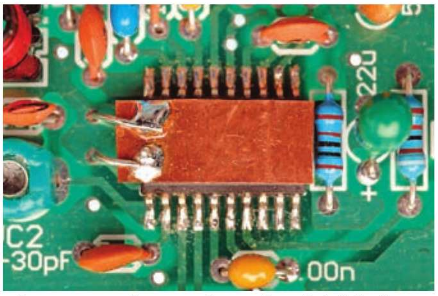


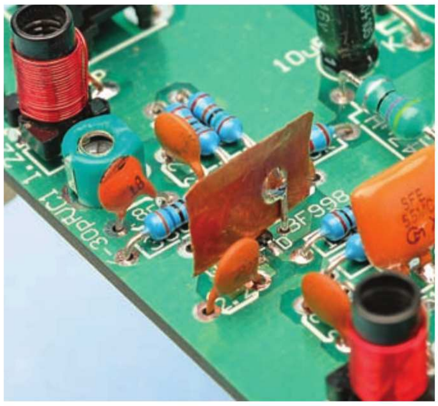
Fig.4: here's how to make and fit the shield plates for IC1 and Q1.

7) Now fit the remaining electrolytic capacitors, which are again all polarised. The correct orientation of each electrolytic capacitor is shown clearly in the overlay diagram.

8) Next, fit RF chokes RFC1 and RFC2, which should both be about 2mm above the PC board.

9) Now fit the two ceramic filters CF1 and CF2, which are not polarised.





These two photos show the shield plates for IC1 (above) and transistor Q1 (right). You can make the shield plates from either copper or tinplate.

10) Follow with transistor Q2, diode D1, REG2 and LED1 and LED2. Note that the green LED is used for LED1 and the red LED for LED2.

LED1 is fitted first, with its leads bent down by 90° about 8mm from the body. It's mounted with its body 6mm above the board surface. LED2 is then fitted with its leads bent down about 14mm from the body, so that it sits about 14mm above the PC board.

11) Fit REG1, if you are using it, noting that it is mounted on a small 6093B type finned heatsink. The regulator leads are bent down at 90° 6mm away from the device itself, so they can pass down through the matching board holes. The device and its heatsink are then fastened to the board using an M3 × 6mm screw and nut, after which the leads are soldered to the pads under the board.

12) Fit IC3 directly on the board, orientating it carefully as shown in the overlay diagram Fig.2.

13) Next, fit tuning capacitor VC3. As noted earlier, this fits upside down on the top of the board at centre front, with M3 nuts used as standoffs. The capacitor's tuning knob must be removed from the spindle before it is mounted, and only refitted once the capacitor's leads have been soldered under the board.

14) Fit VR1 and VR2 (the RF and audio gain rotary control pots). These should first have their spindles cut to 10mm long and any burrs removed with a small file. Then each pot is fitted to the board, making sure that you fit the linear (B50k) pot in the VR1 position, and the log (A50k) pot in the VR2 position. Pass their pins carefully through the board holes as far as they'll go comfortably (ie, without undue strain) and then solder them to the pads underneath. Then you can fit the control knobs to the pot spindles.

Tuning coils

15) Wind the three tuning coils L1 to L3. As you can see from the data box in Fig.1, all three coils are wound on 3mm diameter mini coil formers (Jaycar LF-1227, or similar), using 0.25mm enamelled copper wire. In each case, the coils are close-wound at the bottom of the former, as shown in the small diagram of Fig.3.

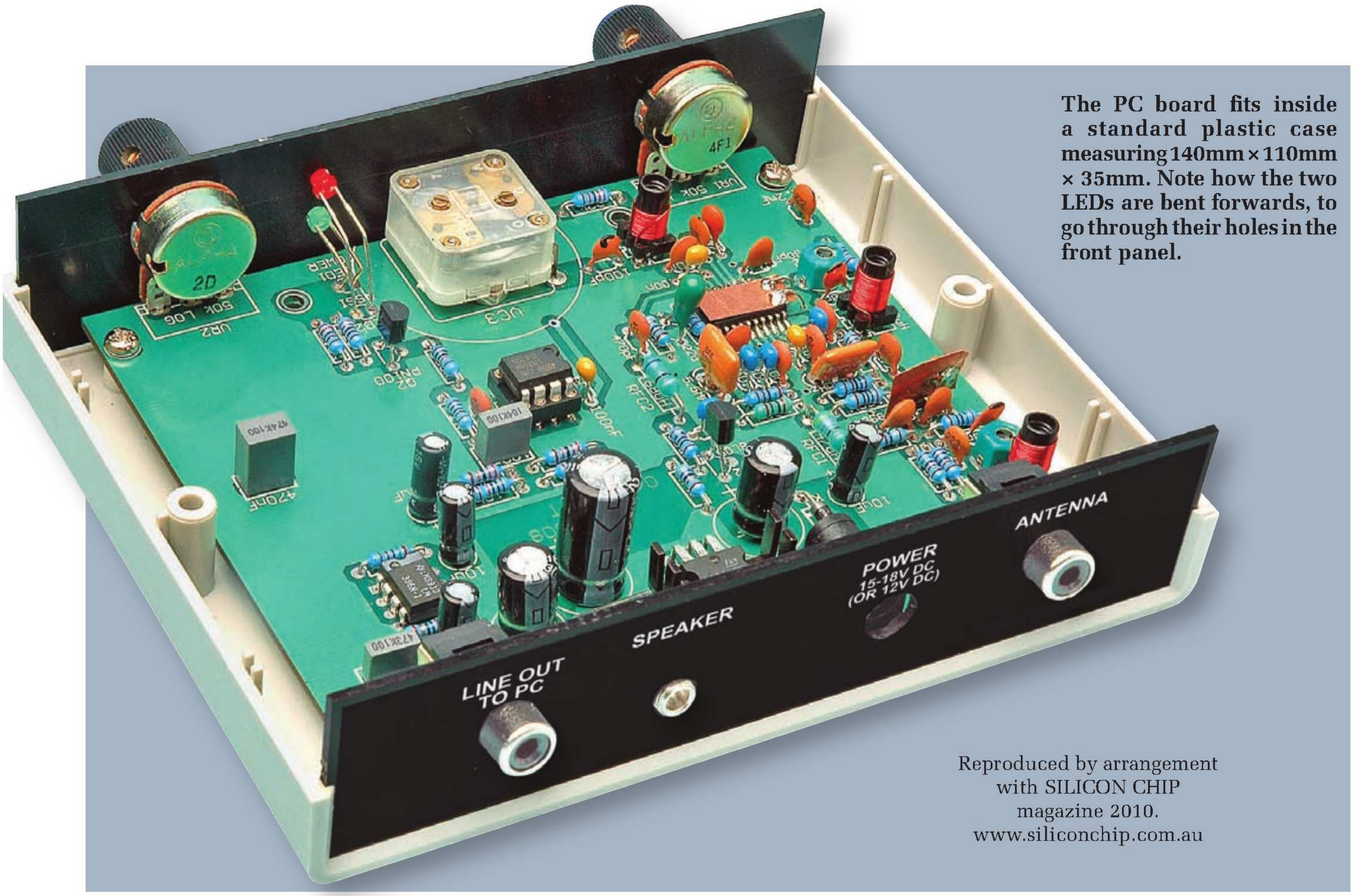
Oscillator coil L3 has 15 turns, while the other two have 20 turns each. The difference between L1 and L2 is that L1 has a 'tap' four turns from the bottom.

This tap is formed from a loop of the winding wire, twisted and tinned at the end so that it can be soldered to the appropriate pad on the PC board (just below CON1) when the coil is fitted. It's a good idea to apply a small amount of clear nail varnish to the upper part of each coil, to hold it in place.

16) When the three coils are completed, they can be fitted to the board. When doing so, make sure you orientate each coil so that its 'A' pin (connected to the bottom of the coil) mates with the earthy or 'colder' pad on the board. The board overlay diagram has a small 'A' next to each coil, to guide you in this regard.

Shield plates

17) Next, you need to make a couple of copper shield plates for IC1 and transistor Q1 to ensure stability.



The PC board fits inside a standard plastic case measuring 140mm × 110mm × 35mm. Note how the two LEDs are bent forwards, to go through their holes in the front panel.

Fig.4 and the photos show how these plates are made and fitted (note: if you are unable to obtain copper foil, you can use tinplate or a piece of blank PC board).

Both shields are attached using short pieces of tinned copper wire which go into adjacent holes in the PC board.

18) Last, plug IC2 (LM358) into its socket, the notched end nearer IC1.

Your Jupiter Receiver board should now be complete and ready for switch-on and set-up.

Setting up

Before applying DC power to the board via CON4, turn both VR1 and VR2 to their fully anticlockwise position. Then plug a small loudspeaker (8Ω) or a pair of stereo headphones into CON3, so you'll be able to monitor the receiver's operation audibly. When you then apply power, very little should happen initially, apart from LED1 beginning to glow.

If LED1 doesn't light, odds are that you've connected the DC supply to the board with the polarity reversed.

Now try turning VR2 (Audio Gain) clockwise slowly. You should begin to hear a gentle hissing sound in the speaker or one of the 'phones. If you have a DMM (digital multimeter), measure the voltage at pin 8 of IC2. It should measure very close to +12V if you're using REG1, or +11.4V if you are powering the receiver from a 12V battery. Now measure the voltage at the rear end of RFC2 (ie, the end nearer REG2) which should be very close to +6V.

Finally, measure the voltage at pin 1 of IC2; this should be quite low – a few tens of millivolts. If you then turn VR1 (RF Gain) clockwise, this voltage should steadily rise due to noise being amplified by Q1, as its gain is increased. The hissing sound in the speaker or 'phone should increase at the same time.

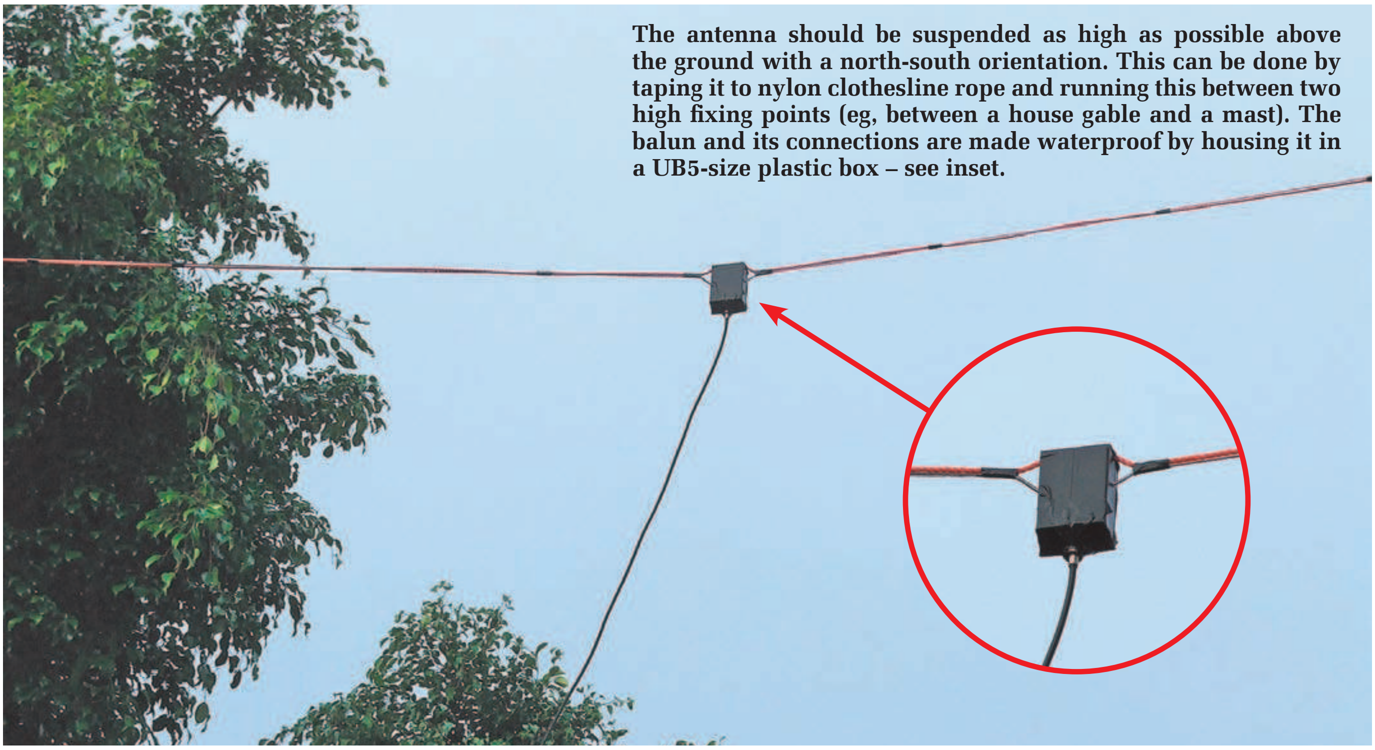
If all is well so far, your receiver is very likely to be working as it should and you'll be ready for setting it up. This mainly involves adjusting trimmer capacitors VC1 and VC2 so that the input and output circuits of the RF stage are tuned to around 21MHz.

The easiest way to do this is if you have access to an RF oscillator or signal generator, able to deliver an amplitude modulated RF signal of 21MHz to the receiver's input. The generator's output is set to a level of about 100mV at first. Then you should turn up both VR1 and VR2 to about the centre of their ranges ('12 o'clock'), after which you can slowly turn the knob of tuning capacitor VC3 up from its lowest setting, until you hear a 400Hz or 1kHz tone (the generator's modulation signal).

Now fine-tune VC3 carefully back and forth with your thumb, to achieve the loudest signal. If the sound becomes too loud or LED2 (the RSSI indicator) begins glowing, turn down VR2 and/or VR1 to reduce the gain. And if the signal is still too loud, try reducing the output level from the RF generator.

Once you are sure that the oscillator is correctly tuned for reception at 21MHz, the next step is to carefully adjust trimmer VC2 with a small alignment tool, to again find the correct position for maximum signal. You may again need to reduce the generator's output level, to prevent overload when you do achieve a peak.

Once the correct tuning position for VC2 has been found, the last step is



The antenna should be suspended as high as possible above the ground with a north-south orientation. This can be done by taping it to nylon clothesline rope and running this between two high fixing points (eg, between a house gable and a mast). The balun and its connections are made waterproof by housing it in a UB5-size plastic box – see inset.

to adjust VC1 in the same way. In this case, you will almost certainly have to reduce the output level from the generator to prevent overload.

In fact, by the time the tuning procedure is finished, the generator's output should be wound down to a mere 1μV or so.

No RF generator

If you don't have access to an RF generator, you'll have to delay this tuning operation until you have built the receiver's antenna, erected it outside in a suitable position and connected it to the receiver's input so that it can provide you with some sort of signal – either a shortwave broadcasting station somewhere in the 20.25MHz to 22.5MHz range, or just some atmospheric noise. More about this shortly, after we've talked about antennas.

Antennas for 21MHz

For reception of noise burst signals from Jupiter or the Sun in the northern hemisphere, the Radio Jove people recommend the use of a twin-dipole antenna array in which two half-wave dipoles are each aligned in an east-west direction and spaced about one half-wave apart, and with both suspended at least 3.6m above ground. The outputs of the two dipoles are combined using a phasing cable arrangement, to tilt the antenna's main receiving lobe towards the south – because currently, Jupiter's orbit is inclined somewhat south of the equator.

In fact, the 'declination' of its highest point ('transit') in moving over the sky varies, but it is currently (summer 2010) rising steadily, and will continue to do so for several years.

However, with our circuit it should be quite feasible to use a basic single-dipole antenna for reception of Jupiter's noise bursts. Accordingly, we have produced and tested the very simple antenna design shown in Fig.5. It consists of a single length of multi-strand copper wire (we used one side of a length of figure-8 speaker cable), cut to a length of 6960mm (6.96 metres) to make it resonant at very close to 21MHz.

This antenna should be suspended at least 3.6m above the ground and aligned as closely as possible to a north-south direction. I did this by taping it to a 6m length of nylon clothesline rope, which was then run between a high point on the gable of my house and the top of a 3m mast, attached to the side of a workshop in the backyard.

To couple signals from the antenna to a cable running back to the receiver's input, I made up a 1:1 balun (balanced to

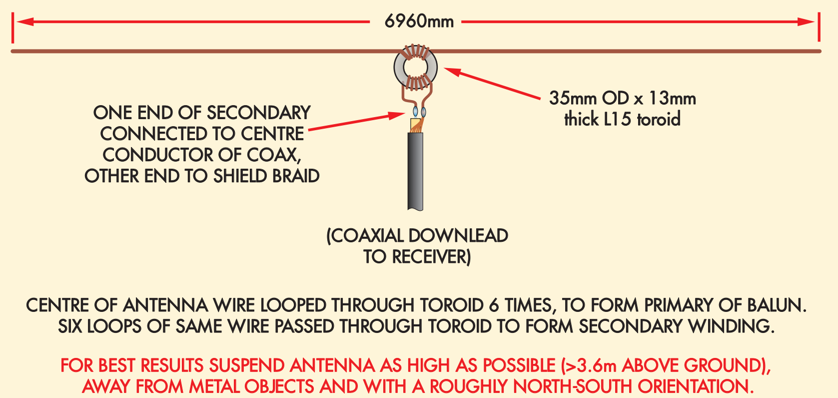


Fig.5: this simple single-dipole antenna can be used with the Jupiter Receiver to receive Jupiter's noise bursts. The dipole is cut to a length of 6960mm to make it resonant at close to 21MHz and is coupled to a coaxial downlead using a simple 1:1 balun made from a ferrite ring toroid.

unbalanced transformer) using a small ferrite toroid as shown. This toroid uses L15 material and is 35mm outside diameter, with a thickness of 13mm (Jaycar LO-1238 or similar). The centre of the antenna wire itself is looped through the toroid six times to form the primary winding of the balun, while a short length of the same type of wire is also looped through the toroid six times to form the secondary winding.

To make the balun weatherproof and secure, it was housed in a little UB5-size plastic box (83 × 54 × 31mm), with the two ends of the antenna wire brought out through a 3mm hole on each side near the top. A BNC socket was then fitted to the lower end of the box, with the ends of the balun secondary winding connected to the socket inside. The downlead cable was connected to the socket on the outside, after the box lid had been screwed on.

The whole thing was then hauled up on the nylon rope (it's very light in weight). I used short strips of gaffer tape to attach the antenna wire and balun to the rope, but nylon cable ties would also be suitable.

A twin dipole antenna?

So how do you choose between a single or twin dipole antenna? There is no question that the single dipole is easier to make and install; on the other hand, the twin is more sensitive. Taking everything into account, it is definitely worth starting off with a single dipole version as described here. However, if you are feeling ambitious, then the twin dipole makes a good addition to this project.

Rather than repeat NASA's Radio Jove material, readers interested in this superior but more complicated approach should go to: **http://radiojove.gsfc.nasa.gov/telescope/ant_manual.pdf** for a full account of the twin dipole design. It also provides useful material on how the declination of Jupiter varies for antennas placed in southern Britain (approx 50˚ N, and with a little interpolation it is not difficult to estimate it for the rest of Britain, up to approx 55˚ N.

No-generator tune-up

As mentioned earlier, if you don't have access to an RF oscillator or signal generator it's still possible to tune up the receiver reasonably well once you have an antenna to provide it with some signals in the vicinity of 21MHz.

The way to do this is to connect the antenna, apply power to the receiver and set both VR1 and VR2 to their mid-range (12 o'clock) positions, so you can hear a reasonable level of noise.

Now try adjusting tuning control VC3 very slowly, to see if you can find a shortwave broadcasting station. I found a Chinese station at about 21.68MHz, for example – about two-thirds of the way up the tuning range.

If you do find a station, leave VC3 set to the position for clearest reception and then try adjusting trimmer VC2 very slowly and carefully with a small alignment tool. You should find a position which gives a peak in the signal's reception, but you may need to turn down gain controls VR2 and/or VR1 to lower the volume and prevent overload, so you can accurately find this peak.

Once you are confident that VC2 has been set correctly, leave both VC2 and VC3 with their current settings and turn your attention to VC1, the input circuit trimmer. Again, it's a matter of adjusting this very slowly and carefully until you achieve a signal peak, turning down VR2 and VR1 if necessary to prevent overload and distortion.

What if you can't find a shortwave station to use in the tuning procedure? That needn't be a complete disaster, because if you have a DMM it's possible to use a similar procedure using just the decametric 'cosmic noise' being picked up by the antenna.

To do the tuning this way, set your DMM to a low DC voltage range (say 0V to 2V) and connect it to the receiver to monitor the voltage at pin 1 of IC2. Next, set tuning capacitor VC3 to the centre of its range and gain pots VR1

Decametric Radio Astronomy

BACK IN 1955, US radio astronomers Bernard Burke and Kenneth Franklin discovered that the planet Jupiter was a strong source of 'noise burst' radio signals in the frequency range between about 8MHz and 40MHz – where the radio wavelength is in tens of metres (hence the term 'decametric'). They were using a 'Mills Cross' antenna array, the design of which had been pioneered by Australian radio astronomer Bernard Mills of CSIRO's Division of Radiophysics. The first Mills Cross had been built at Fleurs (about 40km west-south-west of Sydney) the previous year.

It was soon discovered that the Sun itself is also a source of noise bursts during periods of sunspot activity and 'coronal mass ejections' (CMEs). These solar noise bursts extend from the decametric range up to around 80MHz.

The relative ease of receiving noise bursts from Jupiter and the Sun in the decametric frequency range using low-cost equipment seems to be why the Radio Jove project selected this range (rather than in the UHF or microwave regions). It should be noted though that because the signals are broadband in nature, the specific frequency used to receive the signals is not critical. The main requirement is to avoid frequencies occupied by international broadcasters and other terrestrial sources of radio signals.

Useful websites

A great deal of useful information on Jovian and Solar decametric radio astronomy – both theory and practice – can be found on the following websites:

http://radiojove.gsfc.nasa.gov/

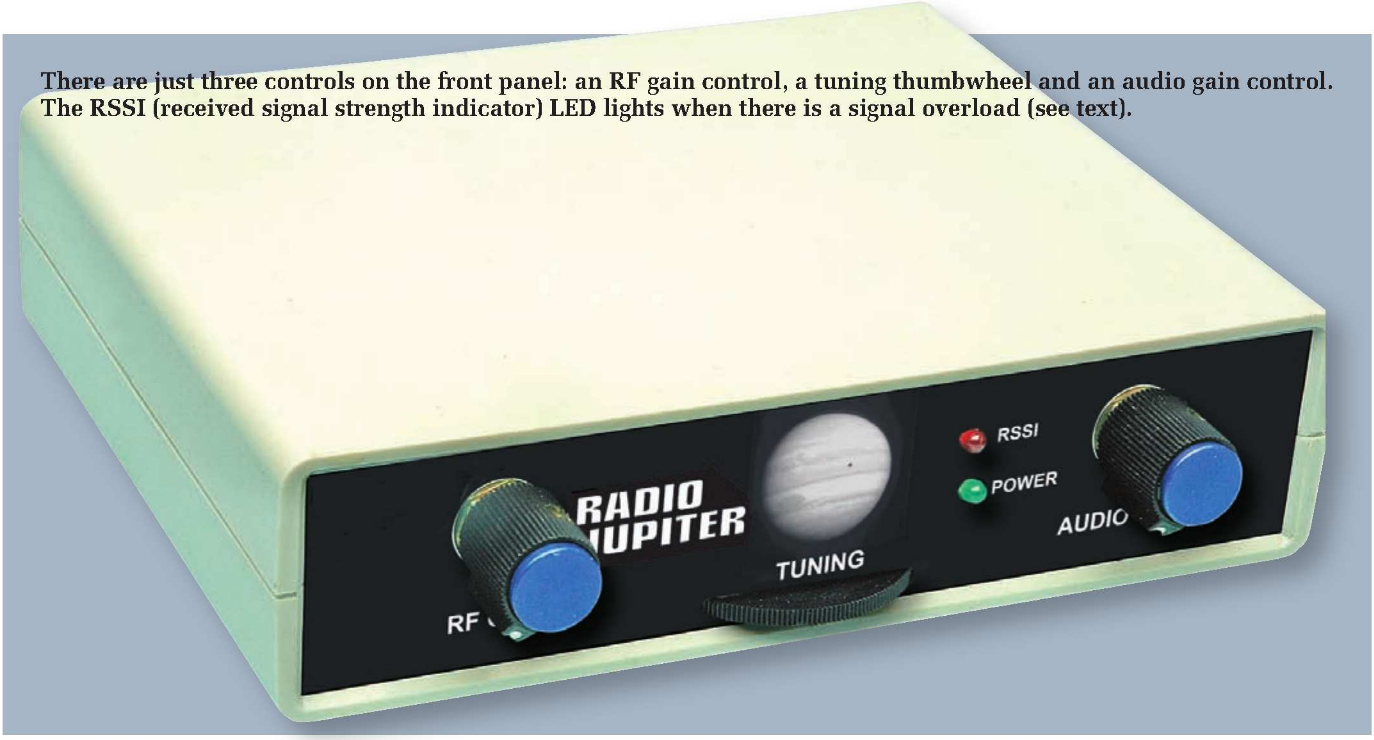
http://ufro1.astro.ufl.edu/dec-contents.htm

http://www.jupiterradio.com/

http://www.radiosky.com/

The last of these sites is the source of the Radio-Skypipe software, which runs on a Windows PC and allows you to record noise data from a Radio Jove or similar receiver and print out 'chart recordings' of them. There is a freeware version of the software that can be downloaded from this site.

A useful source of skycharts and information on the rising and setting times for Jupiter (as well as many other astronomical bodies) in any specific location is: **http://www.heavens-above.com.**



There are just three controls on the front panel: an RF gain control, a tuning thumbwheel and an audio gain control. The RSSI (received signal strength indicator) LED lights when there is a signal overload (see text).

and VR2 to the centre of their ranges as well. When you apply power to the receiver, you should get a reading of 100mV to 200mV or so on the DMM, as well as hearing the received noise in the speaker or 'phone.

Now try adjusting VC2 slowly, first in one direction and then the other, to see if you can increase the DMM reading. Keep turning slowly in that direction, until the meter reading reaches a peak and then begins to drop again. Now return to the position where the reading peaks and leave VC2 in that position.

If the DMM reading rises above about 800mV, lower the RF gain by turning potentiometer VR1 anticlockwise, to bring the reading down again to 200mV. This will make it easier to see the peak reading on the DMM as you adjust VC2.

After VC2 has been set to produce a peak in this way, leave it as before and follow the same procedure with VC1. Again turn down VR1 if necessary to prevent the DMM reading from rising above about 800mV.

Once VC2 and VC1 have been set, your Radio Jupiter receiver should be tuned up about as well as possible without access to a generator.

Fitting it to a case

The PC board is designed to fit inside a low-profile plastic instrument case measuring 140mm × 110mm × 35mm. First, you will have to drill holes in the front and rear panels. Fig.9 and Fig.10 show the front and rear panel artworks, and these can be photocopied and taped to the panels and used as drilling templates.

The board is secured to the two corner pillars at the back of the case using self-tapping screws, while the front of the board is secured to the front panel via the pot shafts and their nuts. **Note that the board sits slightly proud of the front pillars in the case. Don't attempt to screw the board down to these pillars (otherwise the board could crack).**

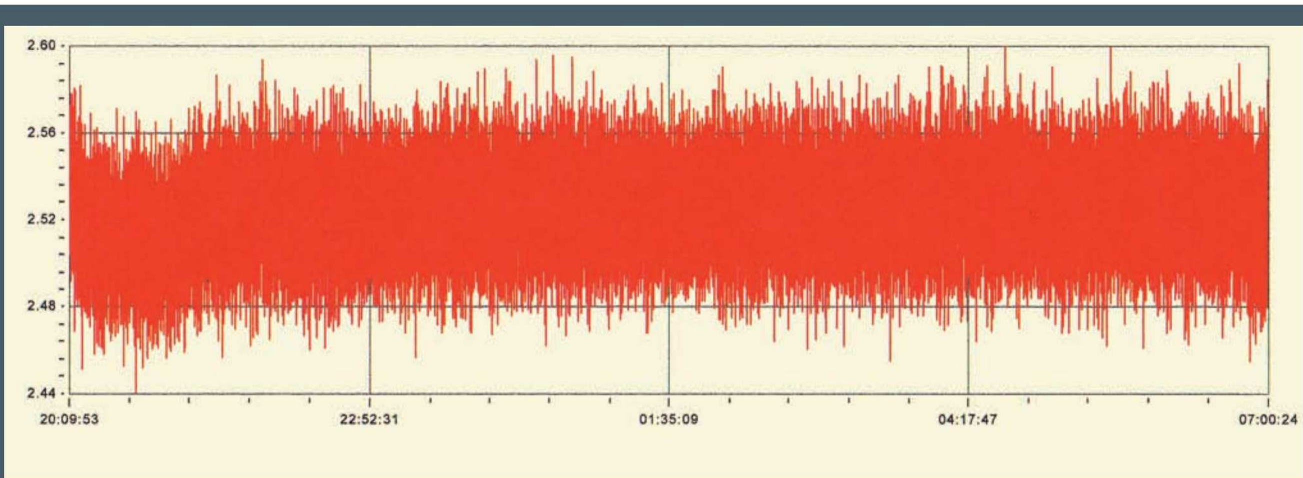
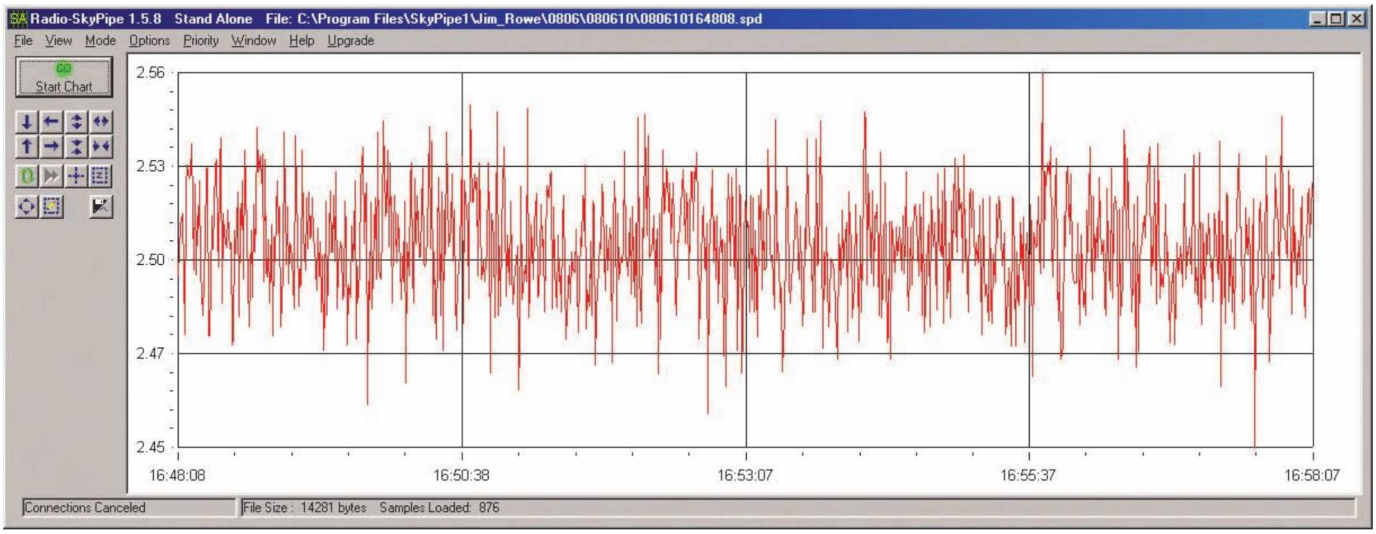


Fig.6: this recording chart covers almost the full period (about 11 hours) of Jupiter's pass on the night of 11 June 2008, but shows very little evidence of signal bursts from Jupiter. Things were quiet around Jupiter that night!



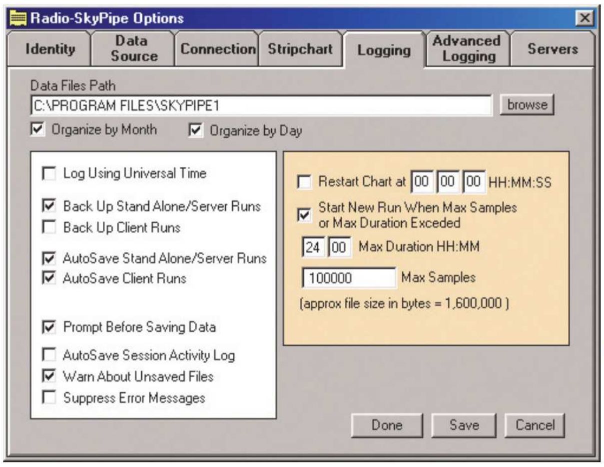


Fig.7 (above): this screen grab from the Radio-Skypipe software shows a recording chart of the 21MHz signal for a 10-minute period.

Fig.8 (left): the Radio-Skypipe software has lots of logging options, including start and logging duration times.

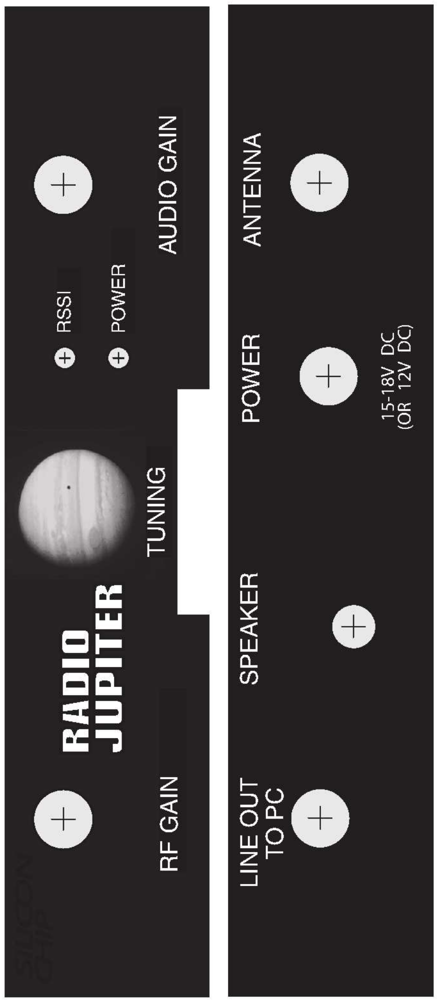


Fig.9: these artworks can be photocopied and used as drilling templates for the case panels.

Testing with Radio-Skypipe

To try out the new receiver and the basic home-brew dipole antenna described earlier, I decided to download a copy of the 'Radio-Skypipe' software, which is recommended by the Radio Jove people. This is a data-logging application which runs under Windows 95/98/NT/2000/XP and can be configured to log data signals via either the ADC (analogue-to-digital converter) in a standard 16-bit PC sound card or an external ADC.

There's a free-download version for non-commercial and non-government users and a Pro Edition with extra bells and whistles available for US$39.95, for commercial and serious users.

I had no trouble installing the Radio-Skypipe software on my old Win98 workshop PC and I was soon using it to take samples of the Jupiter Receiver's audio signal twice every second. It was then left running so that it would log a complete pass of Jupiter over the following night.

When I stopped the logging at 7.00am the next morning, I then saved the log file to the hard disk and was also able to print it out as a pseudo-strip chart recording – see Fig.6.

As you can see, the recording covers almost the full period of Jupiter's pass that night (June 11, 2008), because it rose at about 7pm, reached full transit at 2:07am and set again at around 9am the next morning. But the sky was very overcast that night, so perhaps that's why there's very little evidence of any bursts of signal from Jupiter. Either that, or things were pretty quiet around Jupiter that night.

Looking around for some more information, I discovered that there are two different kinds of decametric noise burst from Jupiter: 'L' or long bursts and 'S' or short bursts. Both seem to be controlled by various factors, including which side of Jupiter is facing our way at the time and also the orbital position of Jupiter's principal moon, Io.

Sunspot and storm activity on the Sun also seem to play a role. They affect the way the Sun sends out streams of charged particles which can spiral around in Jupiter's magnetic field.

So it seems that there probably wasn't much happening around Jupiter the night of my first logging run. The only way to find out is to keep trying, I guess. How about giving it a go yourself? ***EPE***

TechnoTalk

Silly Season

Mark Nelson

Summer is traditionally the silly season for the press, so it's only right that Mark should go with the flow. Not all of his stories are daft though, even if it sounds as if he's taking the proverbial mickey.

Regular readers of this column will know I have a weakness for alternative energy sources, from the serious to the sublime. A memorable example of the latter was the NoPoPo (no pollution power) Aqua battery, a reusable AAA or AA-size cell that you activate with beer, apple juice or human urine.

Now a less embarrassing, but equally personal product is the Power Welly. Wearing a pair of 'power wellies', your mobile phone will never die on you, thanks to power-generating soles that convert heat from your feet into electrical current for charging your cellphone tucked into a charging pocket on the thigh part of the boot; apparently.

Wellie-tricity

Twelve hours of aggressive walking is claimed to generate one hour of phone use. The more you exert your feet, the hotter they get, producing more energy. So, power wellies will be fine for farmers and dancers at music festivals, but less beneficial to leisure gardeners. The funny footwear is a product of the amusingly named renewable energy company GotWind (**www.gotwind.org**), where you can see these wacky wellies that were produced in association with mobile phone company Orange.

Andrew Pearcey, Orange UK's head of sponsorship is enthusiastic about this product, which he thought made an ideal fit with the green ethos of the Glastonbury music festival, declaring: 'The Orange Power Wellies use clean and renewable energy to create valuable electricity, ensuring festival goers can text and phone their mates for the duration of the weekend.' Festival-goer Rachel Stone from Southampton endorsed the product, saying: 'These new boots are exactly what I need – my phone never lasts four days.'

Cola-powered phone

An equally way-out British innovation, supported by mobile manufacturer Nokia, is the 'greenphone' designed by Daizi Zheng. Daizi, a graduate of Central St Martin's College in London developed the idea as her final year project: a mobile phone powered by Coca-Cola.

Liquid-infused batteries are by no means new, but this one is alleged to be more effective than previous versions. In fact, it is capable of lasting up to four times longer than a regular lithium-ion battery from a single charge of the drink that 'things' go better with. It generates electricity by using enzymes to catalyse sugar in the drink. It's certainly green in this respect, generating only water and oxygen over and above electricity, although heaven only knows what the environmental cost of producing cola drinks is. The battery itself is attached to the back of the handset, which is a bit awkward, and refilling it looks a bit of a hit and miss affair in the published photographs.

According to *Sky News*, Nokia now considers the phone charging system 'too advanced for immediate development' and has given up on the original idea of bringing out a product within the next two years. Nevertheless, within the next five years, bio-batteries may well be available on the market, as development continues around the world.

Pressure power

As I've said before, some of the most interesting stories get little coverage in the news. Putting this to rights, here's a remarkable tale of a pioneering power plant that in theory at least, is emission-free, renewable and works in all weather conditions (no sun or wind required). The prototype has been quietly in operation since last November and although it currently (no pun intended) generates only enough to heat a large electric kettle (4kW), the aim is to produce enough electricity to light and heat a small town within five years.

The Norwegian organisation that constructed this ultra-green generator is Stakraft, Europe's largest renewable energy company. The group develops and generates hydropower, wind power, gas power, solar power and district heating, and is a major player on the European power exchanges. Its innovative power plant is located at Tofte, outside Oslo, and exploits the commonplace natural mechanism known as 'osmosis'.

In osmosis, water passes through a semi-permeable membrane, which is how plants absorb moisture through their leaves – and prevent it from leaking out. When fresh water meets salt water (for instance where a river runs into the sea), enormous amounts of energy are released. This energy can be utilized for the generation of mechanical power through osmosis.

At the osmotic power plant in Tofte, fresh water and salt water are guided into separate chambers, divided by an artificial membrane. The salt molecules in the sea water pull the freshwater through the membrane, increasing the pressure on the sea water side. The pressure is equivalent to that of a 120 metre water column, or a significant waterfall, which can be used in a power generating turbine.

Research ahead

Statkraft CEO, Bård Mikkelsen declares: 'In an era of major climate change and an increasing need for clean energy, we are proud to be presenting a renewable energy source which has never been harnessed until now.'

Maybe we should be asking why it has not been exploited before and there is certainly plenty of research yet to be done. A major task is creating a membrane of exactly the right thickness, capable of withstanding huge pressures that does not constantly get clogged up with salt.

Right now, the efficiency of the trial set-up is less than $1W/m^2$, but they plan to install membranes that can deliver 2 to $3W/m^2$ after they have run the plant for a while and then reach $5W/m^2$. The prototype station will be in operation for 2 to 3 years. After this the capacity will be increased in stages until ultimately a full-scale osmotic power plant could be built in 2015. At this point, a plant the size of a football stadium could have a capacity of 25MW, enough to supply 30,000 European households.

Statkraft concedes the viability of this technology is unclear, so is osmosis the answer to a maiden's prayer (and everybody else's)? Possibly, the BBC notes that protagonists say the technology has almost unlimited potential, needing just a coastline. Detractors on the other hand claim osmotic power is likely to be prohibitively expensive and argue that tidal power is far more promising as a possible solution for the world's energy problems.

Finally

Going back to the introduction, some people called Michael occasionally take offence at the expression 'taking the mick' or 'taking the Michael', without realising the saying has an entirely different origin. According to the BBC website, and many other normally reliable sources, it's an abbreviation of 'taking the micturition'. Micturition is a medical word and you will probably not be very surprised when you look up its meaning in a dictionary.

Wikipedia has an alternative derivation, from Cockney rhyming slang, 'taking the Mickey Bliss'. The oddest thing is that the Oxford English Dictionary traces 'taking the mike' back to 1935, whereas the cruder 'taking the ****' does not appear in print until 1945. However, this may be simply because past generations (like me) were too polite to use four-letter words in print.