Add a video input to your TV set

Video amplifier for computers & VCRs

Bothered by smeary colours, signal beats and RF interference on your computer display? Throw away that cheap and nasty RF modulator and use a direct video connection instead. It's much better.

by JEFF SKEEN

Up until now, the most common method of obtaining a display from a computer (or VCR) has been to use an RF modulator to couple the signal into the TV antenna terminals. The main advantages of this approach are its simplicity and low cost. There is no need to spend hundreds of dollars on a separate display monitor and no need to delve into the "works" of a standard TV set to find a suitable entry point.

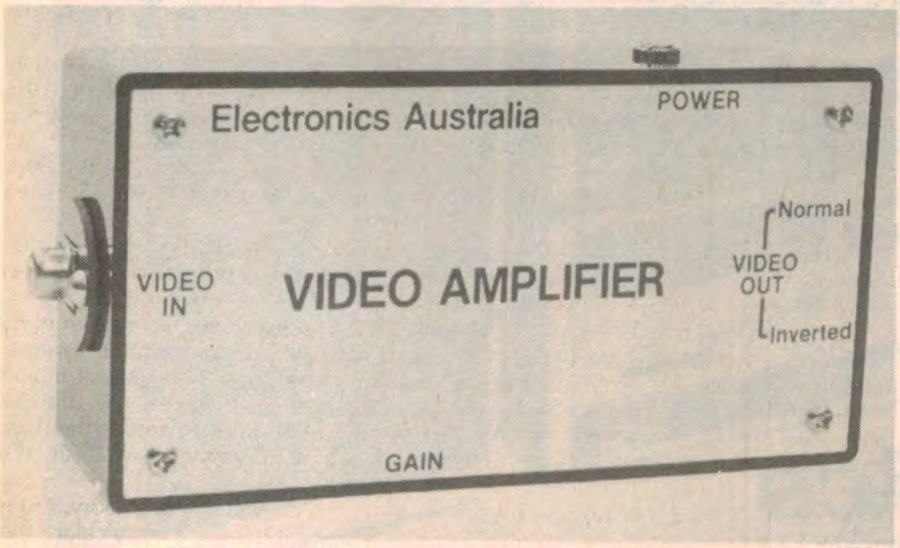
In fact, the enthusiast need know nothing at all about the TV set, its circuit, or its physical layout. All he has to do is hook up everything as indicated in the computer manual, select the appropriate unused channel, and fine tune for the best picture. Usually, the signal level out of the modulator will be equivelent to a strong local TV signal so the resulting display should be of reasonable quality.

At least that's the theory!

Unfortunately, as many users have come to realise, the RF modulator method has several significant drawbacks. Typical problems include interference patterns (particularly with some colour computers), images that waver, and text outlines that are not as sharp as they should be. Most of these problems are related to limited bandwidth and to RF radiation, both of which degrade picture quality.

In addition, an RF modulator can cause significant interference to other TV sets in the vicinity.

It's not surprising that the modulator approach has its limitations. First, the computer generated video has to be converted to an RF signal and this inevitably involves some losses. Add to this bandwidth limitations in the tuner and IF stages in the TV receiver and it's easy to understand why video modulators cause problems, particularly with high resolution computer graphics.



The Video Amplifier features adjustable gain and provides both normal and inverted outputs. Power is derived from a 12V DC plugpack supply.

Fortunately, there's a low-cost solution to these problems. The trick is to make a direct video connection to the TV set, thereby eliminating the troublesome RF modulator and bypassing the tuner and IF stages. Provided the job is done properly, the result will be a rock-steady picture with sharper images and no interference.

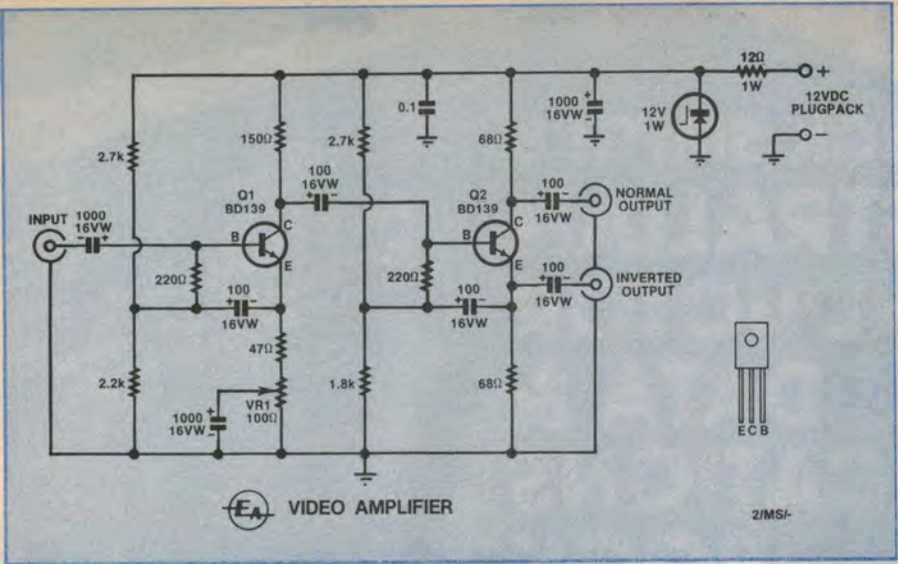
Finding an input

The input to the first video amplifier – ie, immediately following the video detector – is the most logical first choice to couple in a computer video signal (see Fig. 1). Provided that you have access to a circuit diagram, you should be able to find the appropriate spot in the circuit without too much difficulty. Ideally, the circuit will also show the amplitude and polarity of a composite sync/video waveform which is normally present at the input to the video amplifier stage, when signals are being received.

If you are lucky, the selected point will have the same signal polarity as that of the computer signal and will operate at a similar level. If this is the case, the computer signal can probably be AC-coupled directly to the video input via a 1000μF 25VW electrolytic capacitor. The polarity of the capacitor can be determined by measuring the DC voltage between the computer output and the TV input (don't forget to tie the two earths together).

In most cases, however, it may not be quite that simple. Often, the signal amplitude from the computer may be insufficient to drive the video amplifier, or the signal polarity may be the reverse of that required by the TV set. In the latter case, the result will be poor or incorrect picture sync and a negative (ie, reversed) picture.

Our Video Amplifier is designed to overcome these problems. It features an adjustable gain of between one and



The complete circuit diagram. Q1 provides a gain of between one and three times while Q2 acts as a buffer and phase splitter to produce the normal and inverted waveforms. Below is a view of the assembled PCB.

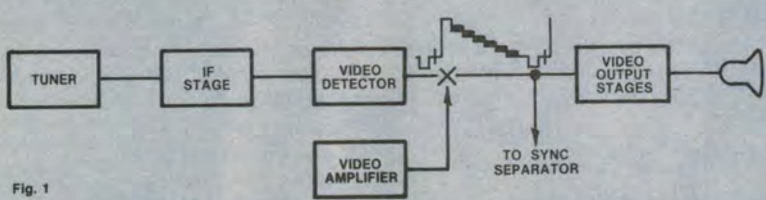


Fig. 1

three times so that you can match signal levels, and it provides both normal and inverted video outputs so that you can match waveform polarity. It uses just two low-cost transistors and can be used with most TV sets that employ mains isolation (see warning panel).

Apart from an interference-free display, the main advantage of using a direct video feed is the increase in available bandwidth. While this is not critical in the case of VCR signals, where the bandwidth seldom exceeds 3.5MHz, it can give a dramatic improvement to computer graphics and alphanumerics. In particular, it allows us to take full advantage of the video stage bandwidth which, in most TV sets, is likely to approximate 5.5MHz.

Of course, the bandwidth if the Video Amplifier must also be at least 5.5MHz. Our design easily exceeds this requirement. It has a bandwidth of 10MHz (−3dB point) at full gain, extending to 19.5MHz (−3dB) at unity gain.

By now some readers will be wondering whether the Video Amplifier can be used to provide a direct video feed from VCRs. The answer to this question is yes, although whether it's worth doing is another matter. Picture quality will probably be slightly improved but the drawback wil be the need to provide a separate sound circuit.

In some situations it may be possible to use the TV sound circuit while in others it will be easier to feed the audio signal from the VCR to your hifi system.

How it works

Refer now to the circuit diagram. The amplifier is a two-stage common emitter design with a gain adjustable between one and three and a maximum output of about 5V p-p from either output. This should be more than adequate to cope with the usual combinations of computer video output levels (which typically range from 1V p-p to 3V p-p) and TV video input requirements. All of the gain is produced by the first stage, while the second stage acts as a buffer and phase splitter to produce both normal and inverted output waveforms.

The video signal from the computer is AC-coupled into the base of Q1 via a 1000μF capacitor, while the 2.7kΩ and 2.2kΩ resistors set the base bias to slightly less than half supply. Althouth not strictly necessary, this first stage has been bootstrapped by connecting a 100μF capacitor and series 220Ω resistor from the emitter back to the base. This increases the input impedance so that loading on the computer video output is minimal.

We'll take a closer look at how bootstrapping works a little later on.

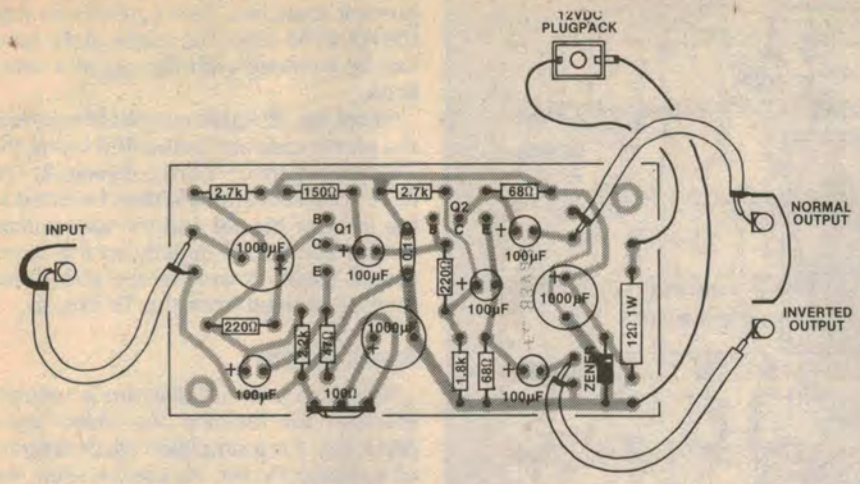
The AC gain of Q1 is set by the ratio of the collector load (150Ω) to the emitter load. Trimpot VR1 and its associated 1000μF capacitor vary this gain by bypassing part of the emitter resistance. Note that a large value bypass capacitor is necessary as the symmetrical nature of the video waveform can cause the voltage on smaller capacitors to fluctuate, resulting in a distorted display.

The signal output from the first stage is taken from the collector and AC-coupled into Q2 via a 100μF capacitor. Q2 is bootstrapped in a similar manner to Q1 and functions as a unity gain amplifier since the collector and emitter loads are the same. As already mentioned, Q2 also acts as a phase splitter, the normal output appearing at Q2's collector and the inverted ouput appearing at the emitter.

The 100μF capacitors on the outputs provide AC-coupling between the amplifier and the TV set. They allow the signal to be coupled to the TV set without upsetting the DC bias conditions on either the amplifier or the TV video input.

It is normal practice to make the output impedance of the video amplifier as low as possible to minimise loading effects. This requirement has been met by using 68Ω collector and emitter resistors. At the same time, Q2's collector and emitter must be biased to 9V and 3V respectively in order to ensure the maximum possible voltage swing at the outputs.

Now let's discuss a little theory. From the above criteria we can calculate the quiescent collector current for our output stage as 3/68 = 44mA. Assuming a



Only the RCA sockets and the power socket are not contained on the PCB.

minimum transistor beta of 40, Q2 requires a quiescent base current of around 1mA and thus a relatively low-resistance bias network.

And this is where we run into problems. Without the bootstrap circuit on Q2, the bias network is effectively across the signal input circuit (ie, 2.7kΩ in parallel with 1.8kΩ). Combine this with the low impedance offered by Q2 due to its low value emitter resistor, and the result is excessive loading on the Q1 output stage.

Hence the need for the bootstrapping circuit between the base and emitter of Q2. Its job is to increase the input impedance of this second stage, thus minimising loading effects on the output of Q1.

To understand how bootstrapping works, consider the fact that the signal voltage at Q2's emitter is almost identical to the base signal – ie, exactly in phase with it and only slightly lower in amplitude. By coupling the emitter signal back to the earthy end of the 220Ω resistor, we create a situation whereby the signal voltages at each end of the resistor are almost identical. As a result, very little signal current will flow in the 220Ω resistor and so it behaves as a high impedance, at least as far as signal voltages are concerned.

Bootstrapping thus effectively isolates the bias network so that it does not contribute to the loading on the previous stage. The input impedance of the second stage is now simply the transistor beta multiplied by the emitter resistance – ie, 40 x 68 = 2.72kΩ. This compares with an input impedance of around 770Ω without the bootstrap circuit, and reduces loading on the output of Q1.

Power for the circuit is derived from a 12V DC plugpack and is regulated by a 12V zener diode. The total current drain is around 85mA and, at this modest figure, a 12V plugpack will typically deliver 14V or more. The 1000μF and 0.1μF capacitors across the supply provide filtering and transient suppression.

Alternatively, many TV sets will have a well-regulated 12V supply rail which may be used in place of the plugpack supply. In this case, the 12Ω resistor and the zener diode should be deleted.

Construction

Construction is straightforward with nearly all the parts mounted on a small printed circuit board (PCB) coded 83va8 and measuring 94 × 48mm. Follow the layout diagram when installing the parts on the PCB and take particular care with polarised components. These include the transistors, diode and electrolytic capacitors.

The PCB is mounted in a small plastic zippy box measuring 130 × 67 × 42mm (L × W × H). A good idea of the general layout can be gained from the photographs. You will have to drill two mounting holes for the PCB, together with mounting holes for the RCA sockets and the plugpack socket.

A matching hole is also drilled opposite trimpot VR1 so that the gain can be externally adjusted using a screwdriver.

The wiring can now be completed according to the wiring diagram. Note that shielded cable must be used for the connections between the RCA sockets and the PCB. Don't forget the earth connection between the two output sockets.

The front panel label is made from Scotchcal material and gives the unit a

WARNING!

DO NOT USE WITH LIVE CHASSIS TV SETS

This project is suitable for use only with TV sets that have an earthed chassis and transformer isolation from the mains. **It is NOT suitable for use with sets that employ a live chassis.**

Before building this project, it will be necessary to determine which type of set you own. Generally speaking, sets that use a mains transformer or a switchmode power supply will be isolated from the mains and this can be confirmed by studying the circuit diagram or by direct inspection of the chassis. Most early Australian-made colour sets use a mains transformer, while many European designs favour the switchmode design approach.

Readers should note, however, that live chassis sets are increasing in popularity. This particularly applies to modern designs with screen sizes less than 48cm. Usually, if the set has a live chassis, a warning label will be attached to the rear panel. Do not, under any circumstances, attempt a direct video connection to this type of receiver.

If your set has a live chassis, then you will just have to use an RF modulator. Do not fool around with live chassis sets — unless you know exactly what you are doing they can be dangerous!

PARTS LIST

1 printed circuit board, code 83va8, 94 x 48mm
1 plastic zippy case, 130 x 68 x 42mm
1 3.5mm jack socket to suit plugpack supply
1 2-way panel-mounting RCA socket
1 panel-mounting RCA socket
1 Scotchcal label, 125 x 63mm
2 12mm PCB standoffs

SEMICONDUCTORS
2 BD139 NPN transistors
1 12V 1W zener diode

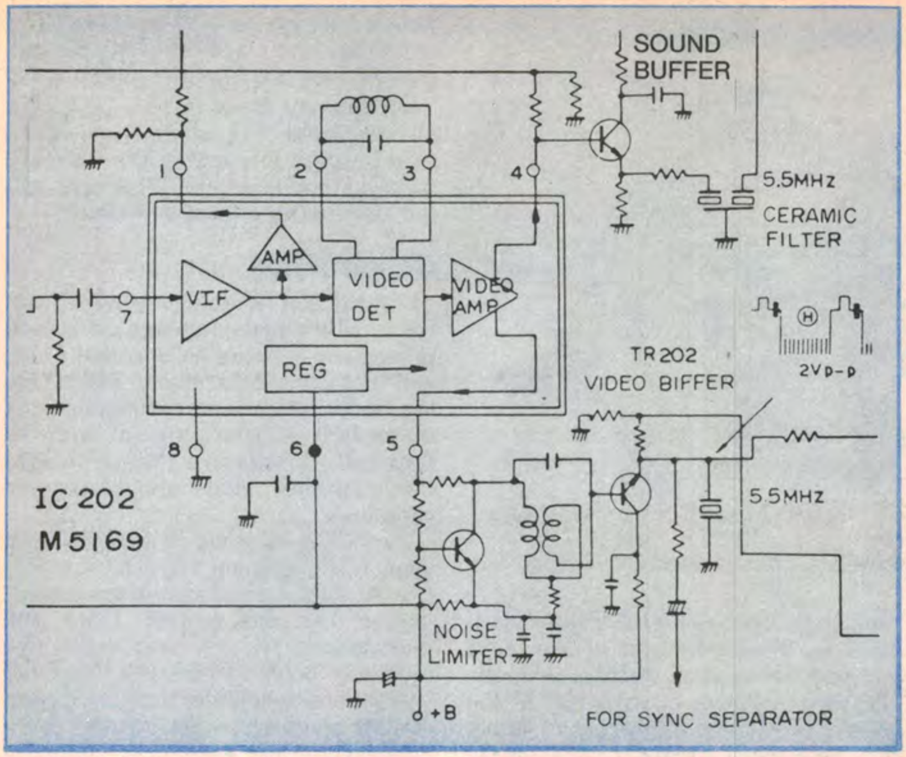
CAPACITORS
3 100μF 16VW electrolytic
5 100μF 16VW electrolytic
1 0.1μF ceramic

RESISTORS (¼W, 5% unless stated)
2 x 2.7kΩ, 1 x 2.2kΩ, 1 x 1.8kΩ, 2 x 220Ω, 1 x 150Ω, 2 x 68Ω, 1 x 47Ω, 1 x 12Ω 1W, 1 x 100Ω large vertical trimpot

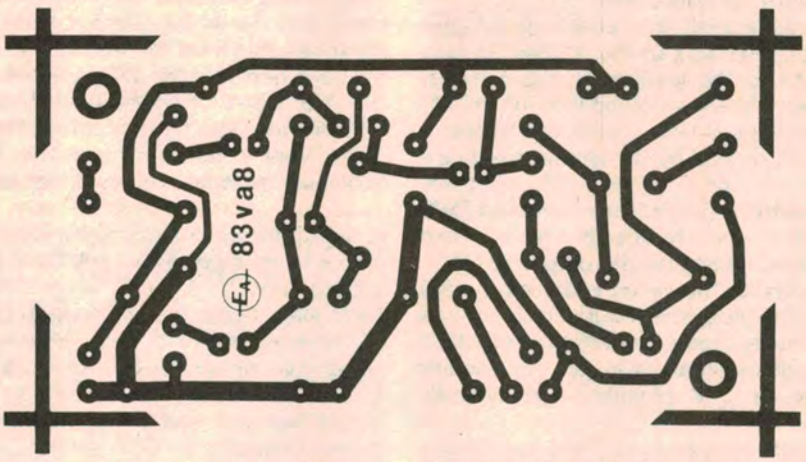
MISCELLANEOUS
Machine screws and nuts, shielded cable (15cm), hook-up wire, solder, etc.

professional finish. Spray the label with a hard-setting clear lacquer (eg, Estapol) to prevent scratches, then carefully fix it to the lid of the case. The edges of the label can be trimmed with the aid of a sharp knife.

Of course, it's quite permissible to omit the plastic case and fit the PCB inside the TV chassis if this is more convenient. The RCA input socket could then be fitted to the back of the set and the appropriate output connected directly to the video output stage. Power for the circuit can then be derived from the TV chassis.



The base of transistor TR202 provides a convenient video input for this early-model Rank Arena set. Note the take-off to the sync separator.



Above is an actual-size reproduction of the PCB artwork.

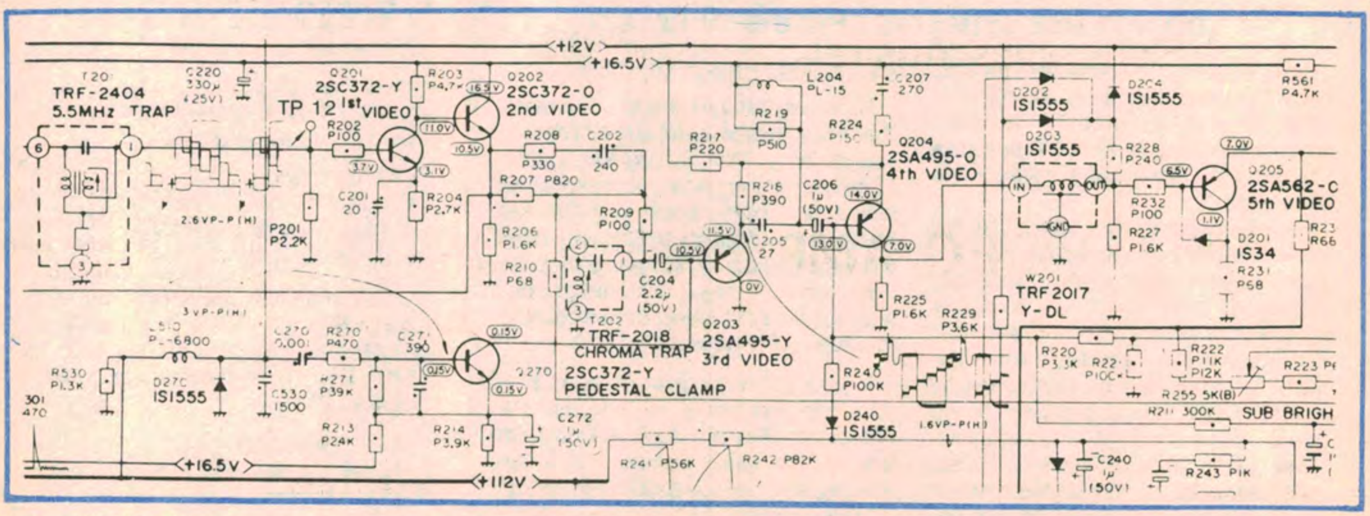
Installation

Access to a circuit diagram is virtually essential for locating the video input point. Fig. 1 is a simplified block diagram of a typical TV set. As can be seen, the output of the Video Amplifier is coupled into the video output stage, immediately following the video detector.

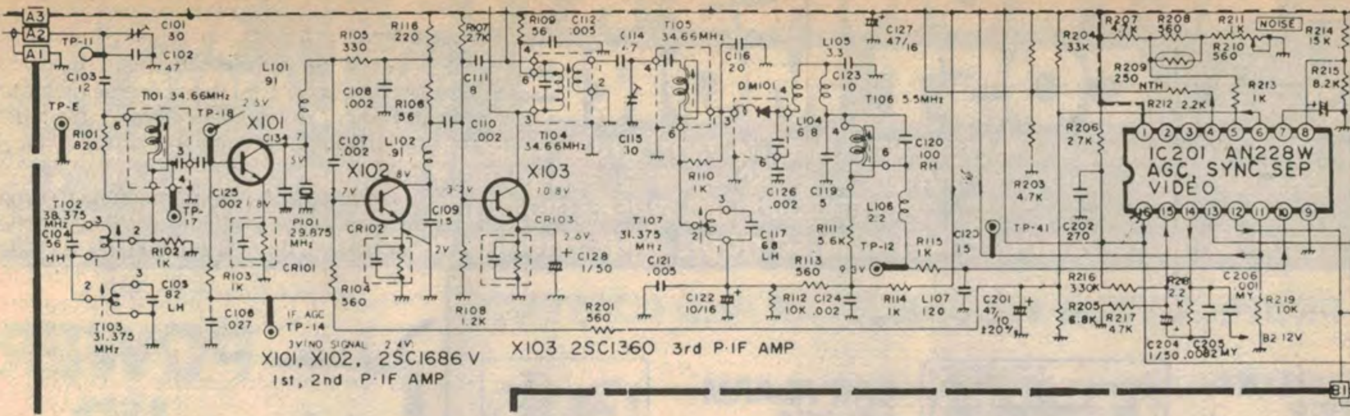
Also shown in Fig. 1 is a composite video waveform for a colour bar signal as it would emerge from the video detector. Quite often, a waveform of this type will be indicated at some point on the circuit diagram and this can serve as a useful guide. Note that, in some sets, this waveform may be shown inverted, in which case the inverted output of the Video Amplifier should be used.

It's also worth noting that some manufacturers provide a test terminal at the output of the video detector, and this can provide a convenient connection point. But whatever you do, make sure that you select an input ahead of the sync separator take-off point. If signals are fed in after this point there will be no sync pulses to lock the line and frame oscillators. The ideal connection point is the base of the first video amplifier stage.

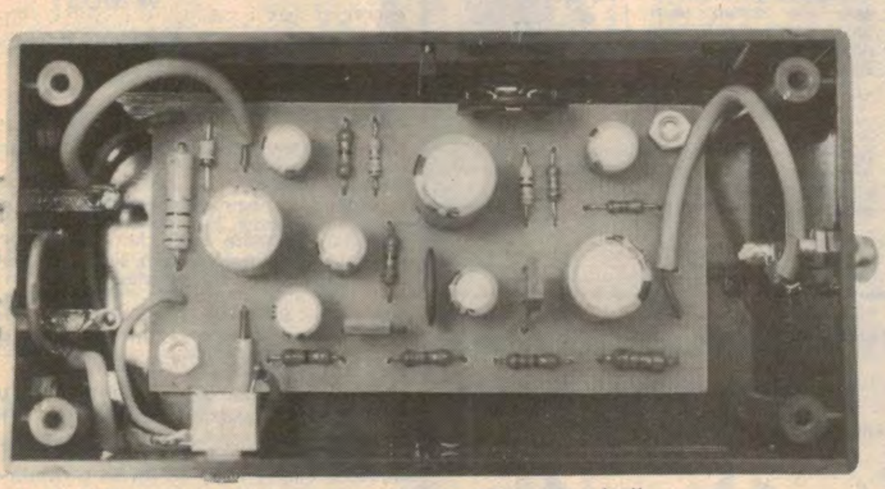
By connecting the signal to the base of the first video stage, any signal or noise from the preceding receiver circuitry will be swamped by the low output im-



Test point TP-12 (at transistor Q201) is the video input for this late-model Toshiba C-2021 receiver.



Test point TP-12 (immediately following the 5.5MHz sound trap) is the video input for this JVC receiver.



The PCB is mounted in the case using two 12mm stand-offs.

We estimate that the current cost of parts for this project is approximately

$15

This includes sales tax but not the plugpack supply.

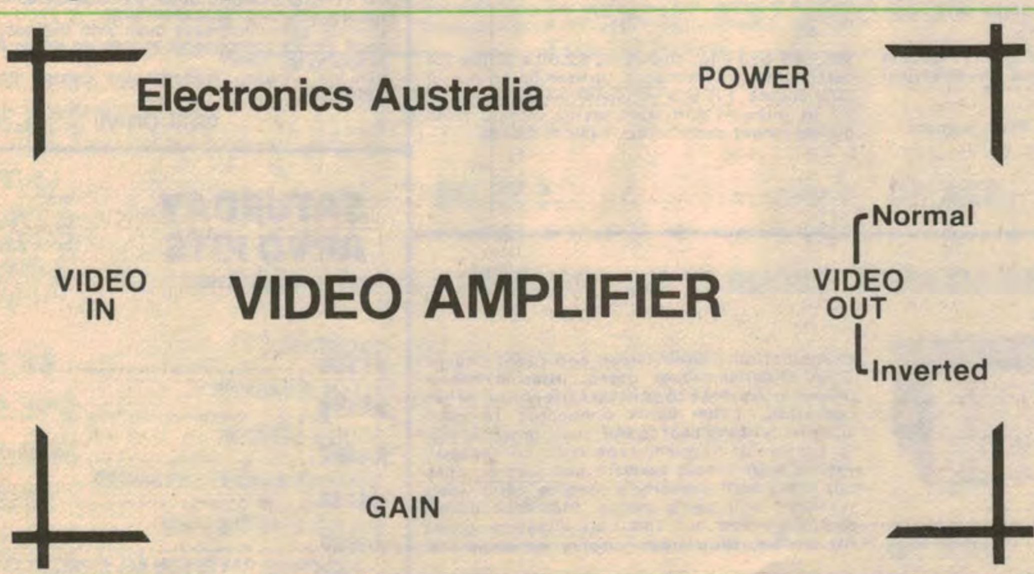
pedance of the external video amplifier.

In cases where a high impedance input cannot be found, it will be necessary to "kill" the front end noise by switching out the supply rail to the tuner.

Depending on the set design, it may also be necessary to reverse the output coupling capacitor. This can be checked by connecting everything up and then measuring the voltage across the capacitor. If the capacitor is reverse biased it will have to be removed and reinstalled the other way round. Alternatively, if you are able to obtain 100μF bipolar capacitors, this step will not be necessary.

Finally, if you propose to use an old valve set for which no circuit diagram is available, it is usually possible to identify the video amplifier relatively quickly. Just take note of the single lead from the picture tube socket (ie, the video output lead) and trace this back to the appropriate valve. From there is should be easy to identify the grid. This can be done by measuring voltages – the grid will usually be a few volts negative with respect to chassis.

The same approach would apply to solid state black and white sets. The video output transistor can be found by tracing the video output lead from the picture tube back to its source. From there it's a matter of identifying the base of the transistor and then feeding the signal in as before. In some cases, it may be necessary to move back one or two stages to ensure that the signal is fed in prior to the sync take-off point.



Shown at left is an actual size reproduction of the front panel artwork. Finished boards and panels are available from kit suppliers.