Constructional Project

PIC VIDEO CLEANER by MIKE DELANEY

Improve your PICture quality.

This project is the result of a visit by the author to a friend's home to see a video recorder and portable TV the friend had installed in his son's bedroom that was giving trouble. He was complaining that the picture was "flickering" and the brightness varying.

The brightness variation was particularly noticeable when watching at night with the light turned down low. Both of the units had been obtained from second-hand shop, and they did not want to know about any problems.

Using a known good tape and head cleaner etc., the system was duly checked out. After much experimentation it was discovered that the problem lay with the tape – a recently-purchased "Block Buster'' – because the good tape, along with his home-recorded tapes, all worked fine. You could see that the picture flickered and the brightness was indeed wavering, but this did not happen with the same movie on the main TV in the lounge.

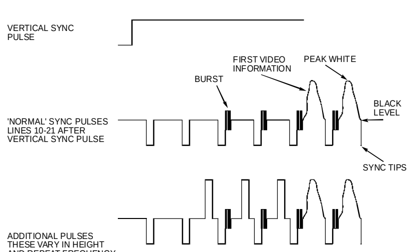


Fig.1. Sync pulse showing interference details.

Making further inquiries, from another friend who is in the TV trade, it transpired that the problem was caused by something called "Macrovision*", which is a VCR-to-VCR copy-prevention system. This purposely introduces interference pulses on the video tape. Not all sets are disturbed in this way, and it was suspected that the portable was simply over-sensitive. Searching on the Net, an article was discovered which described these pulses in detail.

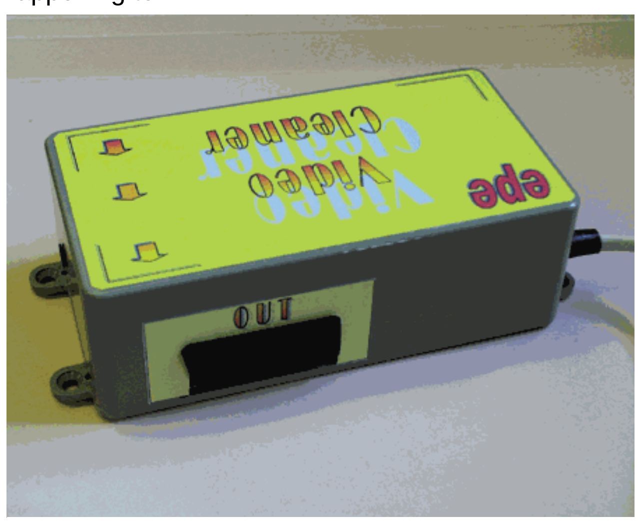
MAKING A START

"First identify the cause" seemed a good approach. This entailed using a video sync-separator IC, type LM1881 from National Semiconductor, to see exactly what was happening to the signal on an oscilloscope. The LM1881 has been around for a long time and all the application data that was needed came from National's web site.

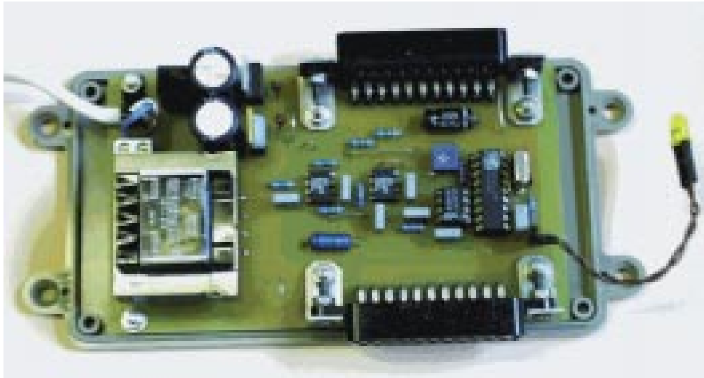
Breadboarding revealed some strange goings-on indeed! It was not surprising that the portable TV was having a struggle. The resulting sync pulse waveform, showing details of the introduced "interference", can be seen in Fig.1.

This simplified diagram shows the difference between a "clean" signal and the interference pulses added to prevent tape-to-tape copying. VCRs use the amplitude of the black level voltage immediately following the Line Sync pulse to set their AGC level. They also rely on incoming sync pulses on the video information, unlike TVs which have their own sync circuits built in. Because the added pulses are variable both in amplitude and repeat timing the brightness of the picture can vary and the line and frame stability can be affected to a point where it is almost unrecognizable.

These interference pulses



PIC Video Cleaner showing input SCART



are added between the end of the frame-sync pulse and the first video information. They repeat at intervals of about two seconds and are themselves in sync with the line-sync pulses. In this way they do not stop the average TV from working satisfactorily, but prevent copying (despite the fact that Copyright laws allow you to make a back-up copy of any legally purchased tape for your own use), and in my friend's case sometimes interfere with a sensitive TV.

ON THE LINE

Clearly it would be necessary to remove the interference pulses and replace them with an appropriate DC level, since the TV or VCR requires a reference voltage to set its brightness. The first twenty or so lines following the vertical sync pulse are not seen on a correctly set up TV, so it does not matter if they are lost.

However, it is necessary to allow the color burst and correct horizontal sync pulses through during this time, otherwise it would upset the operation of the TV. Therefore, it is not just a case of erasing all information up to the start of the video information.

There is occasionally more interference added for a period of about a dozen lines before the vertical sync pulse, and this must also be taken into account when designing any circuit.

DETAIL OF SYNC PULSE AND BURST

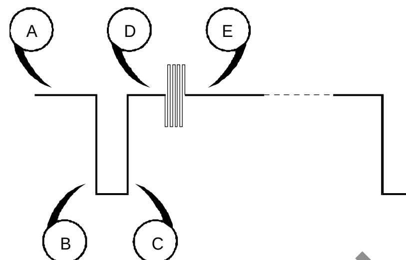


Fig.3. Sync timing of the PIC used to clean up the output from the video recorder. (A) Enable gating to check for falling edge of line (horizontal) sync pulse. (B) Line Sync detected. Turn on IC3 to allow video sync through. (C) Turn off IC3, turn on IC4 and allow black level through. (D) Turn off IC4, turn on IC3 to allow burst through from video. (E) Turn off IC3, turn on IC4 to allow black level voltage through. Wait for approximately 60us before looping back to (A).

BLOCK DIAGRAM

A simplified block schematic for the *PIC Video Cleaner* is shown in Fig.2.

The Sync Separator LM1881 splits the video sync signal into its constituent parts, two of which, Composite Sync and Frame Sync, are used by the PIC micrcontroller. The PIC synchronizes with these two inputs, and turns on either the

COMPONENTS

Resistors
R1 680k
R2, R7, R8 75 ohms (3 off)
R3, R4 750 ohms (2 off)
R5, R6, R9 1k (3 off)
All 0.6W 1% metal film

Potentiometer
VR1 2k cermet preset

Capacitors
C1, C2, C3, C7 to C10
100n polyester (7 off)
C4, C5 22p ceramic disk (2 off)
C6 6u8 axial electrolytic, 16V
C11 22u axial electrolytic, 16V
C12, C13 1000u radial electrolytic, 16V (2 off)
C14, C15 1u tantalum bead (2 off)

Semiconductors
D1 5mm red LED
REC1 1A 25V bridge rectifier
IC1 LM1881N video sync separator
IC2 PIC16F83-10P microcontroller preprogrammed (10MHz version)
IC3, IC4 AD810 low-power current-feedback video amp with disable (2 off)
IC5 7805 +5V 1A voltage regulator
IC6 7905 -5V 1A voltage regulator

Miscellaneous
X1 10MHz crystal
T1 3VA mains transformer with 0V-6V,0V-6V@0.25A secondary
SK1, SK2 21-pin right-angle SCART socket (2 off)
SK3 2-way PCB-mounting mains connecting block (10A 230V AC)

Printed circuit board available from the *EPE Online Store*, code 7000251 (**www.epemag.com**); plastic case, size 44mm x 146mm x 75mm internal; 8-pin DIL socket; 18-pin DIL socket; L-shaped support metal bracket (4 off); multistrand connecting wire; mains cable; 3mm nuts, bolts, and washers (6 off each); PCB spacer (6 off); rubber grommet; P-clip for mains lead; LED clip; sleeving, solder, etc.

See also the SHOP TALK Page!

Approx. Cost Guidance Only **$64**
(Excl. SCART skts & mains cable)

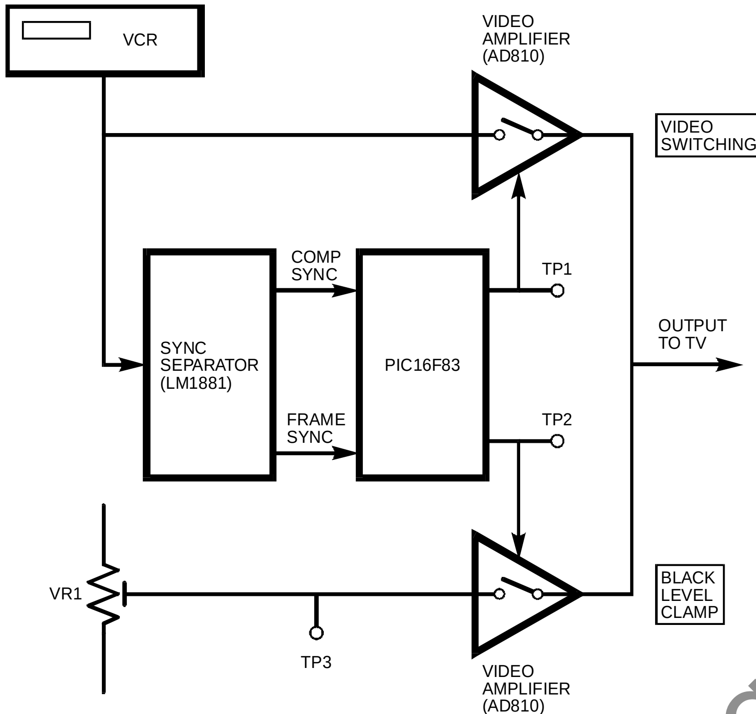


Fig.2. Video Cleaner block diagram showing video signal and control signal paths.

video switching IC (IC3) or the black level clamp IC (IC4).

FIRMWARE

Most of the work is done by the PIC microcontroller, and the sync timing waveform is shown in Fig.3. The cycle begins with the rising edge of the Frame Sync Pulse, following this the PIC waits for the next falling edge of the Line Sync Pulse (A). It is this which is used to start the cycle and subsequently determine which of the two AD810 multiplexers to turn on and which to turn off.

Each Line Sync pulse is detected and counted as it arrives. In this way the PIC remains in sync with the incoming video signal line-by-line.

After the first 25 or so lines following Frame Sync, all of the video information is allowed through. So for about the next 290 lines, C4 is turned off and IC3 is turned on and the PIC, IC2, simply counts in the Line Sync pulses.

After this period, more multiplexer switching is needed to eliminate the interference added just before Frame Sync goes low. The PIC then checks for Frame Sync and when this is detected the whole cycle repeats for the even field, and so on, *ad infinitum!*

CHOICE OF COMPONENTS

Initial tests using a 4MHz PIC microcontroller proved that it was too slow; the delay between detecting a sync pulse and responding to it was too great. Changing to a 10MHz device solved this problem. There is still some jitter, but this has no adverse effect on the observed image.

Video switching in the *Video Cleaner* is carried out by a pair of Analog Devices AD810 video amplifiers (Fig.4), which have a disable mode built in, thereby simplifying multiplexing. One is used for the video signal, while the other is merely for switching the black level voltage.

It was found in tests that the AD810s were very stable, not prone to bursting into oscillation, provided the PCB was carefully laid out.

The power supply is straightforward. The PIC requires +5V, which will suit the LM1881, and the AD810s need a split plus and minus 5V. Both of these are produced in the circuit by a split secondary transformer and two voltage regulators.

Note that the supplies to each IC are individually decoupled with 100nF capacitors. The regulators *MUST* be decoupled with *solid tantalum* capacitors placed very close to their pins. They have a far superior (less) leakage factor than electrolytic capacitors.

Standard right-angled PCB-mounting SCART connectors are used for signal input and output. If your VCR does not have SCART connectors, simply connect the video output to pin 20 of the SCART socket SK1, and take the output from pin 19 of SK2. It is not necessary to connect the sound through the circuit in this case.

CIRCUIT DETAILS

The sync separator, PIC microcontroller, and amplifier stages for the *PIC Video Cleaner* are shown in Fig.4. The regulated power supply circuit diagram is shown in Fig.5. ***(Note that this circuit is based on a UK 240V 50Hz mains power supply, and will have to be modified for other countries' power supplies. In***

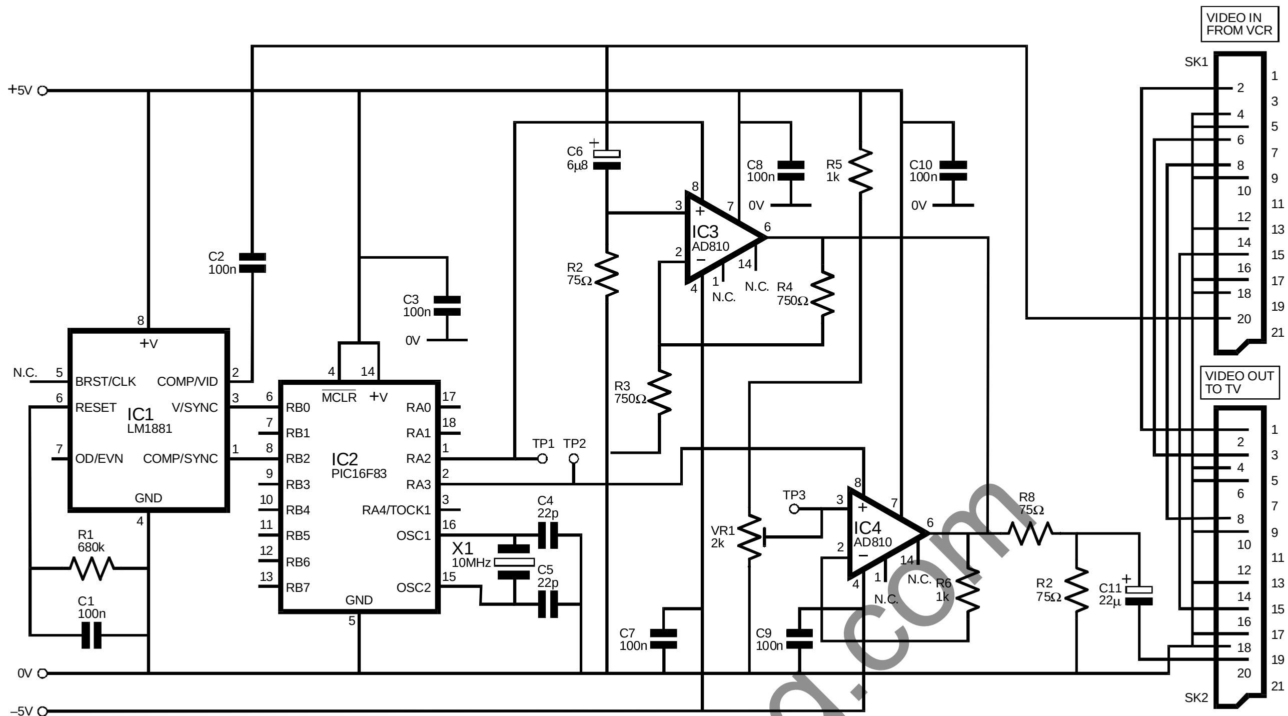


Fig.4. Main circuit diagram of the PIC Video Cleaner showing the sync separator, PIC microcontroller and input/output stages.

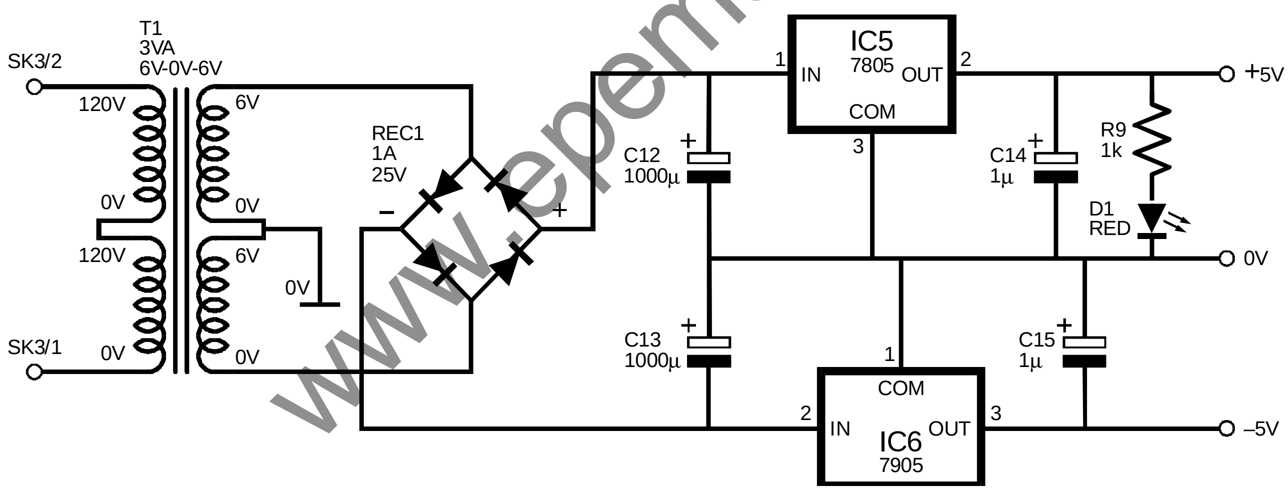


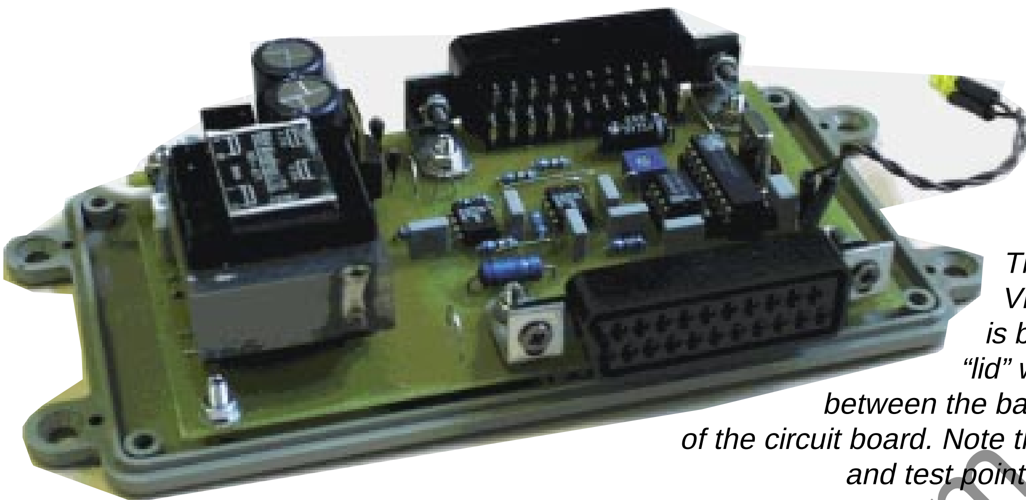
Fig.5. PIC Video Cleaner regulated power supply circuit diagram.

this case you should consult with a qualified electrician if you are in any way unsure as to what you are doing.)

The incoming video signal, from pin 20 of input socket SK1, is AC coupled into IC3, the video switching AD810, by capacitor C6 and terminated at 75 ohms by resistor R2. It is also AC coupled into the video sync separator IC1 by capacitor C2. The LM1881 (IC1) splits this into its constituent parts, two of which, *Vertical Sync* and *Composite Sync*, are fed to the PIC (IC2) at pin 6 (RB0) and pin 8 (RB2) respectively.

As IC2 receives the Line Sync pulses it counts them, and depending upon the line number sets the two lines to the DISABLE pins (8) of IC3 and IC4. When the disable line is low, the output of the relevant video amp (IC3 or IC4) goes high impedance so blocking the input signal, while logic 1 (+5V) turns the device on and its input signal is allowed to pass through.

Video amp IC3 is configured as a x2 amplifier and IC4 is used as a unity-gain buffer switching the DC black level obtained from the voltage



The completed PIC Video Cleaner PCB is bolted to the case "lid" with small spacers between the base and underside of the circuit board. Note the "looped" supply and test point links.

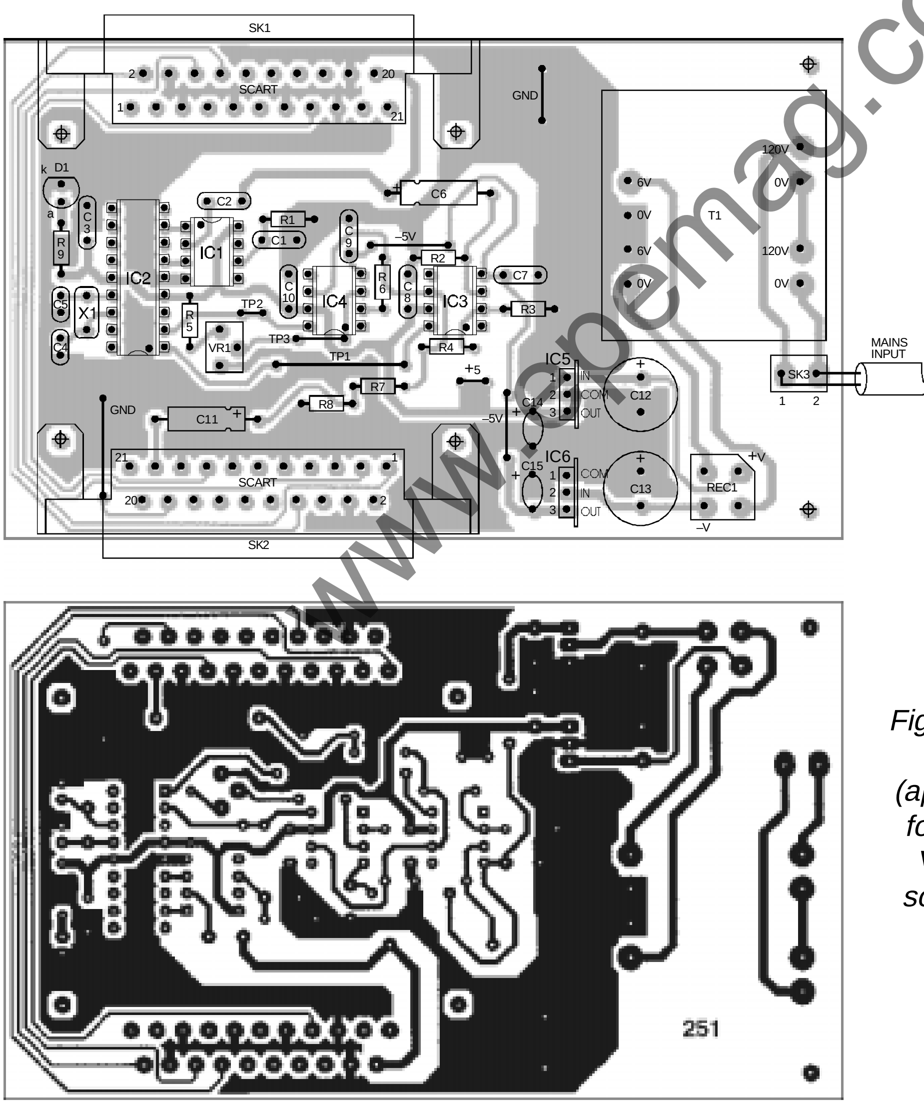


Fig.6. Printed circuit board component layout and (approximately) full-size copper foil master pattern for the PIC Video Cleaner. The SCART sockets are bolted to the PCB via small right-angle brackets.

divider network of resistor R5 and preset VR1.

Resistors R7 and R8 terminate the output of the AD810s at 75 ohms and capacitor C11 couples the output to the TV.

CONSTRUCTION

BE AWARE THAT RAW MAINS IS PRESENT ON THE BOARD. THIS MAY PROVE LETHAL IF TOUCHED!

Before undertaking any testing, take the precaution of placing insulating tape over the underside of the completed circuit board where the soldered connections protrude before handling the unit with the supply switched on.

Construction of the *PIC Video Cleaner* project is based on a single-sided printed circuit board (PCB). All the components, with the exception of the power-on light-emitting diode (LED) D1, are mounted directly on the PCB. D1 is mounted on one side of the case and short wires are soldered to it and its position on the PCB.

The printed circuit board component layout and (approximately) full-size copper foil master are shown in Fig.6. This board is available from the *EPE Online Store* (code 7000251) at **www.epemag.com**

Component placing should cause no problems. Check the orientation of the ICs and electrolytic capacitors before soldering them in place. There are a few jumper/test points and these should be left long enough to attach a 'scope or DVM. As is usual practice, start by mounting the lowest profile components first and the mains transformer last.

Do not use IC sockets for IC3 or IC4. Instead, these should be soldered *directly* to the board in order to avoid affecting the video signal due to parasitic capacitance – be as quick as possible when carrying out this operation.

The PIC IC2 and IC1 are both mounted in sockets. These sockets should be turned-pin types if possible for reliability.

The unit should be housed in a plastic case, with holes cut in it for the SCART sockets and LED. If the box suggested is used the SCART sockets will just protrude, making them easier to access when the box is assembled.

The SCART sockets are supported with metal L-shaped brackets. This helps to prevent the soldered connections failing due to stress when inserting or removing their plugs.

The circuit board is mounted with six 3mm bolts and spacers onto the bottom of the box. Using the unpopulated PCB as a drilling template will ensure correct alignment of the mounting holes.

TESTING AND SETTING UP

Having completed placing the components, check that the ICs and electrolytic capacitors are mounted correctly. Then check for short circuits on the 5V lines with a meter. If these check out apply mains to the circuit and confirm you have +5V and –5V supplies present, and nothing is getting hot.

There is only one preset, so setting up may be done "live", but you will need a second video recorder. It should not be necessary to record a tape in order to set up the *PIC Video Cleaner*. Select the video channel on the TV. Play back a good quality video tape through the video recorder and select the "AV" channel on the second recorder. This should give direct picture feed-through from SCART to SCART. Now vary VR1 until clean whites and a stable picture are obtained. This completes setting up.

Complete mounting the unit in its case, carefully pushing LED D1 into position as you close up the top and secure the mains cable.

FAULT FINDING.

If things do not work and the component placement checks out, carefully check the board for solder-whiskers or dry joints. Check that the 5V supplies are both present and correct to within ±100mV.

If these are both correct disconnect the power and remove the PIC. This allows the two disable lines to IC3 and IC4 to be connected to ground (0V) or +5V without damaging the PIC.

With IC2 removed first establish that a normal tape will play back through your TV by connecting test point TP1 to +5V and TP2 to ground (0V). Doing this turns the video signal ON, and disables the rest of the circuit.

If this works, reverse the leads and use a multimeter to check that the black level voltage is present at test point TP3 and is also enabled via IC4 on the junction of R7/R8/C11. This should vary from zero to 3·3V, as the preset is turned.

Assuming that this is correct, power down and replace IC2. If you have access to an oscilloscope check that the 10MHz clock is running on pins 15 and 16 of IC2, and that the MCLR line, pin 4, is at +5V. The sync pulses to the PIC should be clean and the 'scope should have no trouble locking on to the VSYNC line.

Should the sync pulses appear to be unstable, having a variable length and frequency then the playback VCR is suspect. This problem would be caused by dirty or worn heads. Try using a head cleaning tape first, and if this does not correct the problem the VCR should be swapped for another, newer, one.

SOFTWARE

The software for the *PIC Video Cleaner* may be downloaded *Free* from the *EPE Online Library* at **www.epemag.com**

A ready-programmed PIC chip is also available and full details, including the above options, can be found in the *Shoptalk* page in this issue.

IN THE FUTURE

This circuit should be fairly future-proof since all the work is done by the PIC. It should only be a matter of re-writing the firmware to overcome any changes, which may come along.

My friend's son? Quite happy!

Acknowledgments

Analog Devices AD810 datasheet. Antii Paarlahti at **www.cs.tut.fi** FAQ and details of line pulses. National Semiconductor's LM1881 datasheet. This datasheet is also a useful source of information on the composition of the video signal and sync pulses.

*Macrovision is a registered trademark of Macrovision Corporation, USA

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