S-VHS/CVBS-TO-RGB CONVERTER

PART 1: INTRODUCTION

Although the technical advantages of the Super-VHS video system are well proven, many owners of an S-VHS video recorder balk at the expense of a compatible monitor or TV set with separate luminance and chrominance inputs. This article describes an obvious missing link in the apparently ever-incompatible field of video equipment connections. An advanced circuit is discussed that converts S-VHS or CVBS (composite) video signals into RGB components. The upshot is that you can use your existing monitor with an RGB input (i.e., with a SCART or Euro-AV connection) to benefit from the improved picture resolution offered by an S-VHS video recorder. This month we discuss the basics of the video standards involved.

H. Reelsen

The compatibility issue has played a significant role in the development of both the NTSC and the PAL TV transmission systems. In both cases, there were two conflicting aspects: on the one hand, existing monochrome TV sets were not to be affected by colour transmissions; on the other hand, existing bandwidths of about 5 MHz for the luminance (brightness) signal were to be maintained.

The compatibility requirement automatically dictates that the black-and-white information (luminance or 'Y' signal) must also be conveyed in colour transmissions. The Y signal forms the sum of all basic colours, red (R), green (G) and blue (B), but only as far as their relative brightness is concerned. From perception experiments, the brightness appears to determine the overall sharpness of the picture. Hence, the luminance bandwidth must be as large as possible (up to 5 MHz) for monochrome as well as colour TV sets. However, this raises the problem of where to put the colour information.

Colour components and transmission

Any colour can be reproduced on a picture tube by actuating in the correct proportion the basic colours it is composed of. The final colour is obtained by controlling the intensity at which the RGB pixels at the inside of the picture tube light up. To the human eye, the three individual basic colours in a pixel group appear as one, composite, colour or hue at a particular saturation.

The need to convey R, G and B, is, therefore, obvious. Since the sum of the equivalent luminance values of all three is already contained in the Y signal, only two further signals, R–Y and B–Y, are generated by means of a differential operation with the Y signal. R–Y and B–Y are therefore referred to as the colour difference signals. Before these signals are transmitted, they are given relative brightness factors. The resulting chrominance signals may be written as

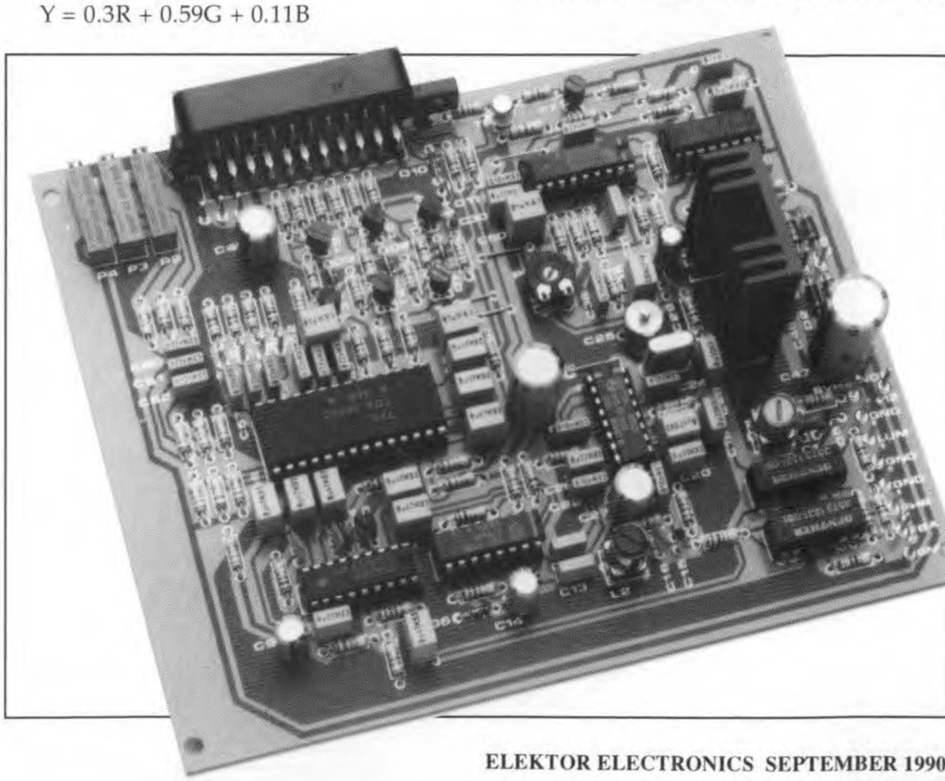
$$U = 0.49(B-Y)$$
$$V = 0.88(R-Y)$$

and the luminance, Y, as

$$Y = 0.3R + 0.59G + 0.11B$$

The RGB intensity information required to control the respective electron guns in the picture tube is obtained from the R–Y, B–Y and Y information with the aid of an addition operation in a matrix circuit.

A problem that remains to be solved is how to include the colour difference signal in the bandwidth already occupied by the Y signal, without causing interference on monochrome TV sets, or reducing the picture sharpness on colour sets. At this point, design engineers are in a position to profit from a characteristic of human eye, namely its reduced ability to resolve colour contours as compared to brightness values. This means that the colour infor-



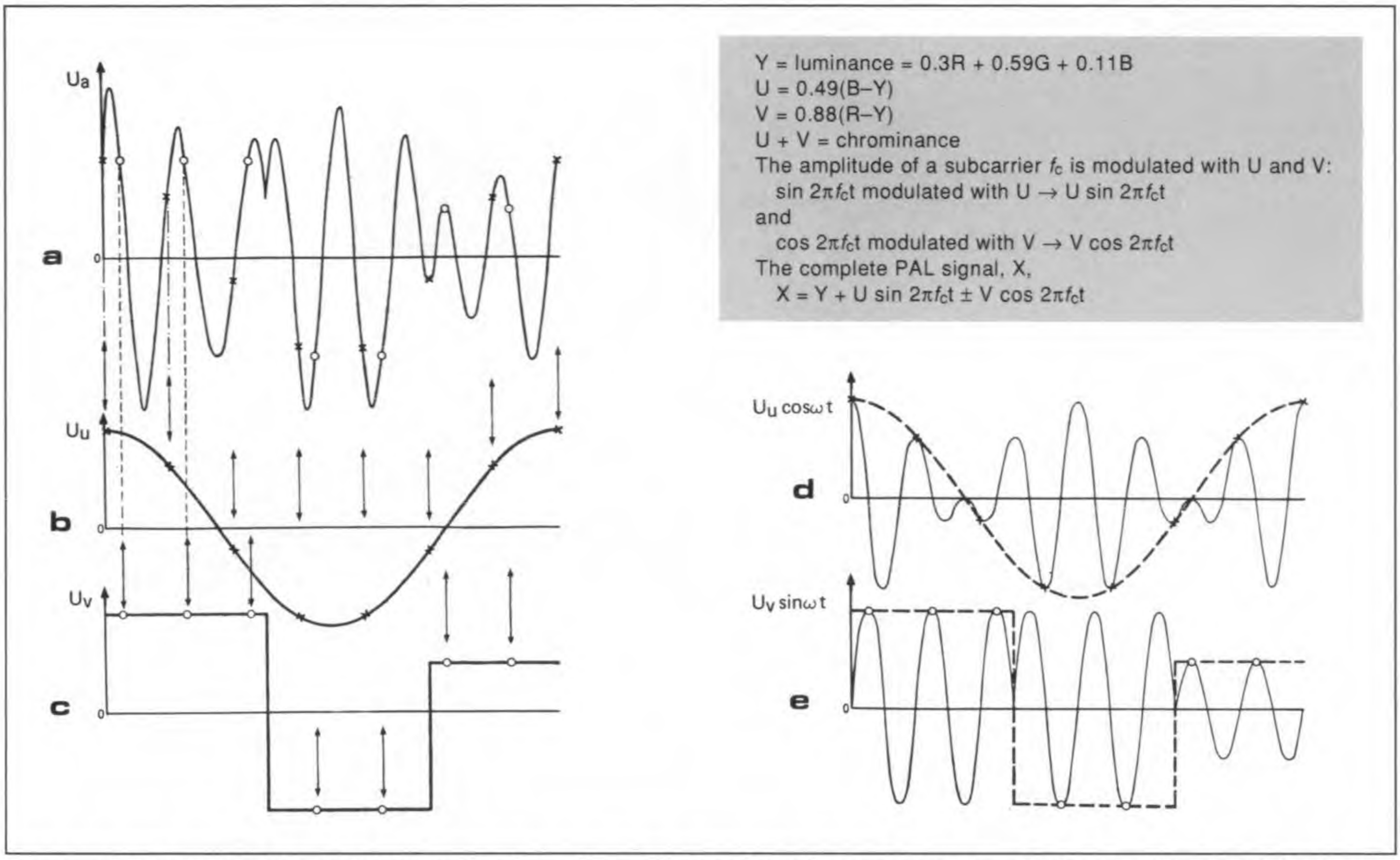


Fig. 1. Signal waveforms resulting from quadrature modulation of the colour difference signals U_u = 0.49(B–Y) and U_v = 0.88(R–Y). Drawing 'a' shows the quadrature-modulated signal U_a, while 'b' and 'c' show the modulation signals U_u and U_v, which for clarity's sake are formed by a sinusoidal waveform and a rectangular waveform respectively. Drawings 'd' and 'e' illustrate how these signals are modulated on to the 90-degrees shifted carriers. The waveform shown in drawing 'a' is the result of adding the signals in 'd' and 'e'.

mation may be transmitted at a relatively low bandwidth without significantly degrading the overall sharpness of the picture. In the PAL system, the colour (or chrominance) bandwidth is about 1 MHz.

The colour difference signals are readily embedded in the frequency spectrum of the Y signal by making use of the fact that the spectral lines of the Y signal occur at even multiples of the line frequency (15,625 Hz). Also, the amplitude of these spectral lines decreases with frequency.

The colour difference signals modulate a subcarrier of which the frequency, f_c, is an odd multiple of the line frequency divided by four, plus the picture refresh frequency (see Ref. 1):

$$f_c = 1135 \times (15{,}625/4) + 25 \quad \text{(Hz)}$$

This causes the spectral lines of the colour difference signal to be slotted in between those of the Y signal. The colour subcarrier frequency is set at 4.43361875 MHz, and the colour difference signals are quadrature-amplitude modulated (QAM). The B–Y and R–Y components modulate the amplitude of the colour subcarriers of 0 degrees and 90 degrees respectively (see Figs. 1d and 1e). The carrier itself is suppressed, so that it has an amplitude of nought in the absence of a colour difference signal. This is done to keep the picture free from interference caused by the otherwise continuously present subcarrier.

In order to eliminate the risk of phase shifts in the transmission path, the phase of the R–Y component is inverted every other picture line. Details of this operation peculiar to the PAL system may be found in Refs. 2 and 3.

The use of amplitude modulation with suppressed carrier requires a phase- and frequency-synchronized subcarrier at the receiver side. In a TV set, the modulated R–Y and B–Y components are recovered from the chrominance subcarrier with the aid of a 4.433-MHz quartz crystal oscillator whose phase and frequency are corrected every 64 μs by a 2-μs long burst signal slotted into the rear porch in the blanking period at the end of every picture. The burst consists of 8 to 11 cycles of the colour subcarrier frequency and follows the line sync pulse as shown in Fig. 2. A phase comparator is used to keep the crystal oscillator synchronized to the received burst, which also contains the PAL switch signal for the line-by-line R–Y phase reversal. This arrangement ensures that the R–Y signal in the receiver is inverted in synchronism with that at the transmitter side to ensure that the demodulation operation can work correctly.

Pitfalls...

In practice, the 'packaging' of the luminance and the chrominance information into a single CVBS (chrominance-video-blanking-synchronisation) signal is not without problems. Since the colour subcarrier falls in the spectrum of the luminance signal, it causes a finely patterned type of interference known as moiré. Luminance circuits in all modern TV sets are therefore fitted with a 'colour trap', which is a relatively simple filter that removes most of the moiré effects with the exception of those occurring at areas with sharp colour transitions. Here, large phase jumps give rise to subcarrier sidebands that fall outside the stop band of the 4.43-MHz colour trap. Unfortunately, Y signals in this stop band are also suppressed, which results in reduced picture resolution because some of the high-frequency components disappear. Incidentally, most monochrome sets also contain a colour trap to eliminate moiré.

The (possible) interference between chrominance and luminance also works the other way around: since the lumin-

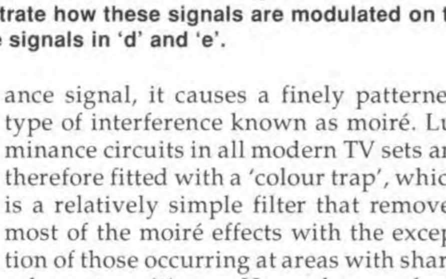


Fig. 2. Structure and timing of a composite video signal (PAL standard).

ance band includes the frequency range for the colour subcarrier, high-frequency Y signals can cause interference in the frequency range around 4.43 MHz. The result is a quasi-random type of patterning and colouring in and around picture areas of fine detail. Notorious examples of this happening can be seen virtually every evening in jackets, shirts or ties of people on television.

Standard VHS video recorders

Some 15 years ago, during the development of the VHS video system, a luminance bandwidth of 3 MHz was deemed satisfactory for VCRs considering the technical limitations imposed by the drum head speed and the tape consumption. In the original VHS system, the colour subcarrier is mixed down to 627 kHz to keep it well way from the lower end of the spectrum of the Y information, which is recorded as a frequency-modulated (FM) signal (see Fig. 3)

The FM recording improves the signal-to-noise ratio of the Y signal and makes it largely independent of amplitude variations of the tape signal. The frequency sweep ranges from 3.8 MHz to 4.8 MHz.

Returning to the colour information, this is recorded as an analogue signal in 'helical scan' mode (Ref. 3). The different frequencies used allow ready separation of the two signals. However, the bandwidth of the colour information is inevitably reduced to about 500 kHz. The result is noticed as 'smeared' colour transitions, to which the reduced (3-MHz) luminance bandwidth adds an impression that the picture is blurred.

These imperfections of the original VHS system were soon recognized by VCR manufacturers. Their answer, the HQ video recorder, was based on small improvements to the recording method and a better edge definition of the Y signal. The resultant picture quality improvement was marginal and not really a step forward. It was, however, the best that could be achieved given the need for continued compatibility. Clearly, real improvements to the picture quality offered by VCRs could be achieved only by changing some of the standards.

The Super-VHS system

The bandwidth of the recorded video signal was increased significantly (at the existing relative speed of 4.85 m/s between the tape and the head) by virtue of two technological developments. First, new metallurgic techniques allowed the size of the air gap of the video head to be reduced. Second, tapes with a very high magnetic particle density became available.

To maintain compatibility with older VHS recorders, the S-VHS system is based on the same method of colour recording (see Fig. 3). However, the frequency sweep of the Y signal is shifted up to a band from 5.4 MHz to 7.0 MHz to give a much higher noise margin. At the same time, the frequency of the FM subcarrier allows the luminance signal to be recorded at its full bandwidth of about 5 MHz.

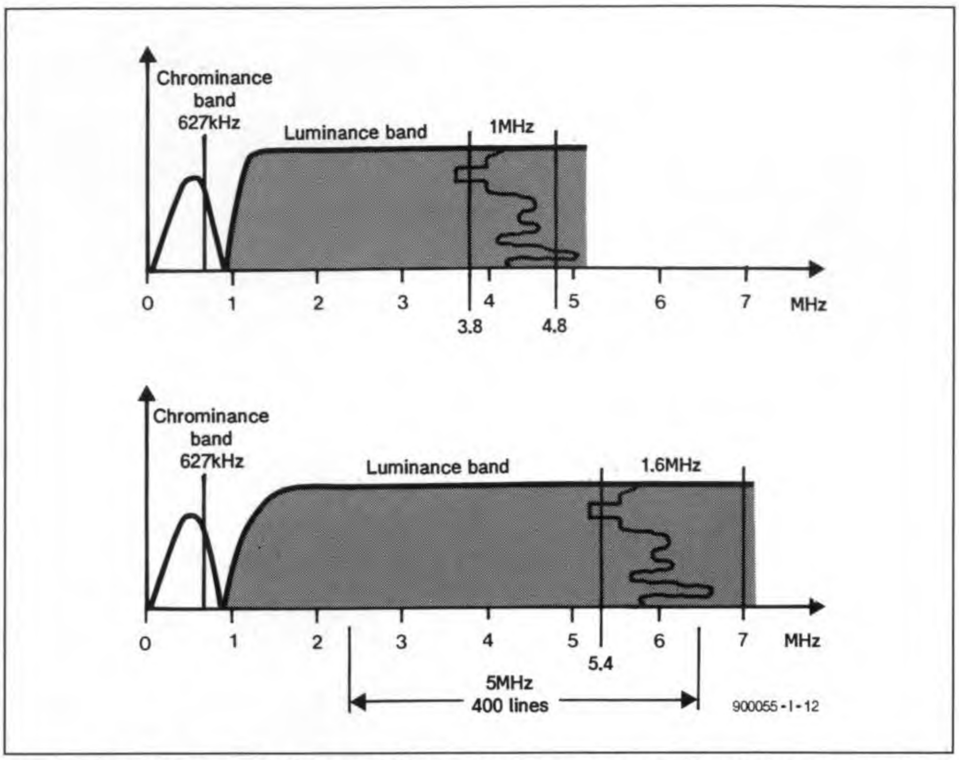


Fig. 3. Typical standard-VHS and S-VHS spectra. In both cases, the quadrature-modulated colour signal is recorded with the aid of a carrier which is mixed down to 627 kHz, while the luminance signal (Y) is recorded in FM. S-VHS recorders use a luminance carrier frequency of 5.4 MHz and a frequency sweep of 1.6 MHz. This offers a bandwidth of 5 MHz for the Y signal, as opposed to about 3 MHz for the standard-VHS video recorder.

In most standard VHS video recorders, the chrominance and luminance signals are processed separately until they are combined to give a CVBS signal with all the previously mentioned risks of running into trouble with interference.

By contrast, the S-VHS system is based on separate chrominance and luminance signals right up to the two associated outputs on the VCR. Evidently, this separation is not perfect when, for instance, a TV programme is recorded, since then the chrominance and luminance components must be extracted from the composite signal before they can be recorded, played back and fed separately to a monitor. The process of extracting the components has pitfalls as described before. Not so, however, with video sources that do supply the components separately. Examples include S-VHS cameras, some prerecorded S-VHS video tapes and MAC decoders.

Connection problems

So far, so good. A look at the rear panel of the TV set, however, reveals that there is at best a SCART connector, which does not allow luminance and chrominance signals to be taken in separately. The TV set is, therefore, not S-VHS compatible. This unfortunate discovery forces owners of S-VHS recorders to connect the monitor and the recorder via a CVBS link, forgoing most of the advantages of better picture reproduction offered by the new video system.

Considering the cost of an S-VHS compatible monitor, the only way to benefit from the separate chrominance and luminance signals supplied by S-VHS recorders and other video sources is to convert these to RGB signals that can be applied to the existing monitor or TV set via its SCART input. Next month's second instalment of this article discusses a circuit to accomplish this. In addition, the circuit provides a colour transition improvement (CTI) function, and is capable of converting CVBS to RGB.

From composite to RGB

Although most standard video recorders have a SCART socket, this rarely supplies RGB signals. Likewise, most set-top TV tuners and indoor units for satellite TV reception supply a CVBS (composite video) signal only. A problem arises when this equipment is to be connected to a high-resolution colour monitor with analogue RGB inputs, or a TV set with a SCART (Euro-AV) input. In both cases, the converter to be described next month can link this equipment and ensure optimum picture quality. ❑

References:

1. Chrominance-locked clock generator. *Elektor Electronics* July/August 1988.
2. Video line selector. *Elektor Electronics* April 1990.
3. *Video Handbook* (second edition). by R. van Wezel. Published by Heineman Newnes, ISBN 0 434 92189 0.

400-watt laboratory power supply

October 1989 and November 1990

A number of constructors of this popular project have brought the following problems to our attention.

1. The onset point of the current limit circuit lies at about 3 A, which is too low. Solve this problem by replacing T1 with a Type BC517 darlington transistor, and R20 with a 82kΩ resistor.

2. Depending on the current transfer ratio of the optocoupler used, the transformer produces ticking noises. This effect, which is caused by overshoot in the pre-regulation circuit, may be traced with the aid of an oscilloscope monitoring the voltage across C26 at a moderate load current. The capacitor must be charged at each cycle of the mains frequency, and not once every five cycles. The problem is best solved by reducing the amplification of the regulation circuit. Replace R17 with a 39 kΩ resistor, and create feedback by fitting it between the base and the collector of T3. Also add a resistor in series with the optocoupler. These two changes are illustrated in Figs. 1 and 2. Lower R16 to 10 kΩ, increase C24 to 10 µF, and increase R15 to 270 kΩ.

3. Excessive heating of the transformer is caused by a d.c. component in the primary winding. This is simple to remedy by fitting a capacitor of any value between 47 nF and 470 nF, and a voltage rating of 630 V, across the primary connections. This capacitor is conveniently mounted on to the PCB terminal block that connects the transformer to the mains.

4. One final point: when using LED DVMs for the voltage/current indication, their ground line must be connected to the **positive** terminal of C12.

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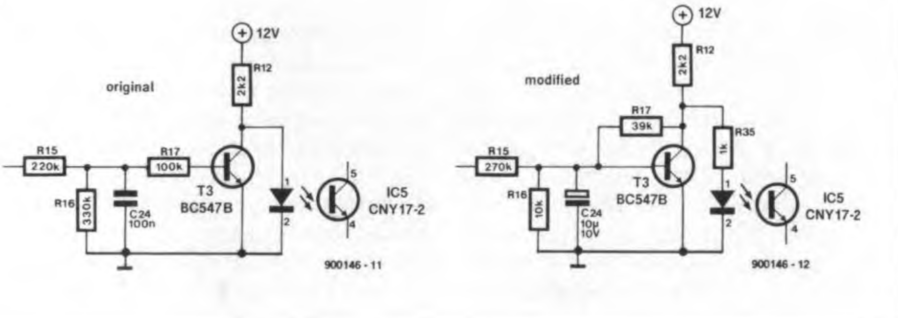

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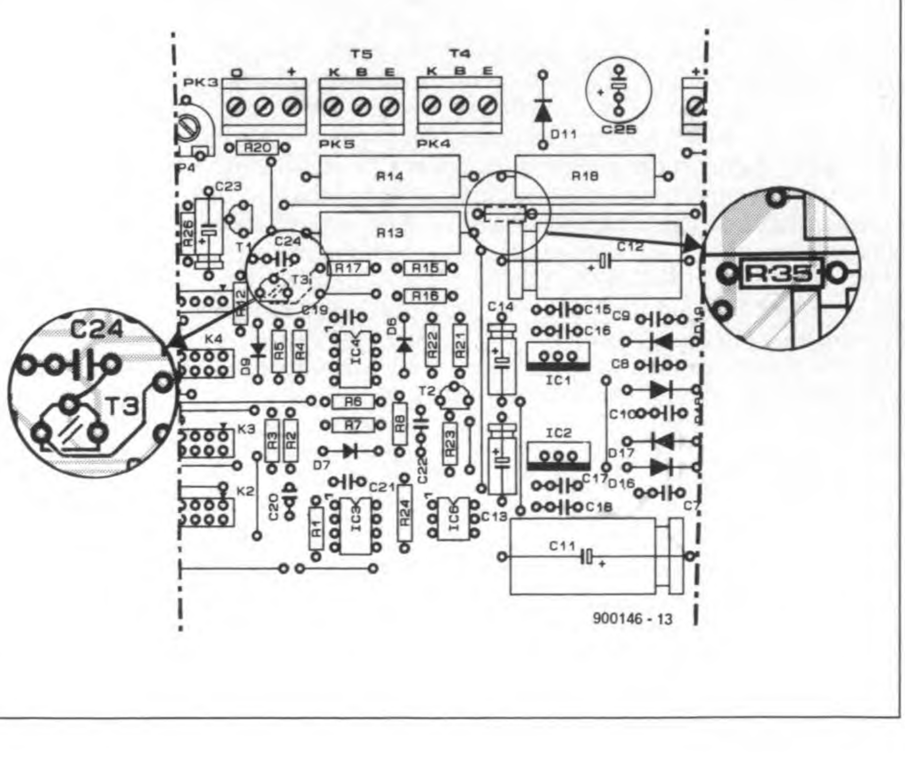

Hard disk monitor

December 1989

In some cases, the circuit will not reset properly because the CLEAR input of IC3A is erroneously connected to ground. Cut the ground track to pin 3 of IC3, and use a short wire to connect pin 3 to pin 16 (+5 V).

Microprocessor-controlled telephone exchange

October 1990

In some cases, the timing of the signals applied to IC17 causes a latch-up in the circuit, so that the exchange does not detect the state of the connected telephones properly. Solve this problem by cutting the track to pin 1 of IC17, and connecting pin 1 to ground (a suitable point is the lower terminal of C6).

The text on the fitting of wires on the BASIC computer board (page 19, towards the bottom of the right-hand column) should be modified to read: 'Finally, connect pin 6 of K2 to pin 7 of IC3 ($\overline{Y7}$ signal).'

S-VHS/CVBS-to-RGB converter (2)

October 1990

The capacitor marked 'C37', next to R21 on the component overlay (Fig. 7b and ready-made printed circuit board), should be marked 'C39'.

In case they are difficult to obtain locally, inductors type 119-LN-A3753 (L1) and 119-LN-A5783 (L2) may be replaced with the respective types 119-ANA-5874HM and 119-ANA-5871HM, also from Toko, Inc. Suggested suppliers are Cirkit Distribution Ltd., and C-I Electronics.

EPROM simulator

December 1989

Counters IC3 and IC4 may not function properly owing to a too low supply voltage. This problem may be solved by replacing IC12 with a 7806. Alternatively, use BAT85 diodes in positions D1 and D2.

Programmer for the 8751

November 1990

The ready-programmed 8751 for this project is available at £35.25 (plus VAT) under order number **ESS 7061**, not under order number ESS 5951 as stated on the Readers Services pages in the November and December 1990 issues.

CORRECTIONS

6-metre band converter

April 1991, p. 38-43

The components list and the inductor overview in the top left hand corner of the circuit diagram should be corrected to read:

L_1, L_2 = 301KN0800.

Capacitor C_{16} (4.7 pF) must not be fitted on the board.

Finally, a few constructional tips:

- Fit a 10 nF ceramic decoupling capacitor at junction L_7-R_{36}.
- Fit a 18 kΩ resistor between the base of T_3 and ground. This reduces the Q factor of L_2, and prevents too high signal levels at the base of T_3.
- For improved tuning, inductor L_9 may be replaced by a Toko Type 113KN2K1026HM.

Multifunction measurement card for PCs

January and February 1991

We understand that the 79L08 (IC_{17}) is no longer manufactured and, therefore, difficult to obtain. Here, the IC may be replaced by a 7908, which, although physically larger than the 79L08, is pin-compatible, and should fit on the PCB.

Dimmer for halogen lights

April 1991, p. 54-58

In the circuit diagram of the transmitter, Fig. 2, pin 14 of the MV500 should be shown connected to pin 13, not to junction R1-R_2-C_2. The relevant printed-circuit board (Fig. 6) is all right.

RDS decoder

February 1991, p. 59

Line A0 between the 80C32 control board and the LC display is not used to reset the display, but to select between registers and data.

We understand that the SAF7579T and the associated 4.332 MHz quartz crystal are difficult to obtain through Philips Components distributors. These parts are available from C-I Electronics, P.O. Box 22089, 6360 AB Nuth, Holland. For prices and ordering information see C-I's advertisement on page 6 of the May 1991 issue.

S-VHS-to-RGB converter

October 1990, p. 35-40

Relays Re_1 and Re_2 must be types with a coil voltage of 5 V, not 12 V as indicated in the components list. Constructors who have already used 12-V relays may connect the coils in parallel rather than in series.

Suitable 5-V relays for this project are the 3573-1231.051 from Günther, and the V23100-V4305-C000 from Siemens.

The components list should me modified to read:

6 33nF C57-C62