RGB-COMPOSITE CONVERTER

Got RGB? Need composite? Dan Ogilvie has this neat solution for you — and it's far from discrete.

Until fairly recently a discrete solution to colour encoding had to be used. Perhaps the most popular circuits used the LM1886. This National Semiconductor IC accepts a 3-bit digital code for each of the R, G and B inputs which limits the number of available colours to 512 ($2^{[3\times3]}$), although this is usually adequate. Some support chips are required; for example the half line frequency generator (7.8kHz) for the 90° PAL phase shifting.

Our design uses a Motorola IC, the MC1377P, accepts true analogue or digital inputs for encoding and provides a direct composite video output. It's a circuit taken more-or-less directly from the applications notes published by Motorola and may be useful for owners of QL, Spectrum+2, Commodore 128 and other computers with RGB but no composite output. Composite monitors are generally cheaper and easier to come by.

The IC

The 20-pin MC1377P (see Fig. 1) contains all that is necessary to perform good quality colour encoding to either PAL or NTSC standards (Fig. 2). The incoming RGB inputs are AC coupled into pins 3, 4 and 5 (Fig. 3). Each input requires 1V peak-to-peak to achieve colour saturation and gives an output with a luminance bandwidth of 8MHz, comfortably exceeding the broadcast TV standards.

The inputs are fed to the colour difference and luminance matrix which generates the luminance (brightness-Y) and the colour difference signals — (R-Y) and (B-Y) — according to the colour equation Y=0.3R+0.59B+0.11G.

The matrix outputs are clamped to the back porch (reference black) by sync driven clamp. The IC requires a negative going composite sync input. This must contain the correctly serrated sync pulses within the field pulse for proper operation of the internal PAL flip-flop (which generates the half line frequency). The sync input can be driven directly from TTL or CMOS. The IC also generates the burst gate pulse from the sync input.

The colour burst is obtained from a Colpitts oscillator on pins 17 and 18. Alternatively a burst may be lightly coupled in to lock the oscillator or it may be displayed completely and driven from an external source.

The oscillator output provides the reference to the B-Y modulator and is also fed to a voltage controlled 90° phase shifter which provides the reference for the R-Y modulator. By allowing the 90° phase shifter to be voltage controlled, fine tuning of the phase shift may be achieved by a pot on pin 19. Without this, the phase shift is guaranteed at ± 3°. This phase shift affects the hues of the picture.

The output of the R-Y modulator is fed to a 180° phase shifter which is switched in and out at the half line frequency. This is fed, together with the B-Y

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	15	Vdc
8.2 Vdc Regulator Output Current	I_{REG}	10	mAdc
Operating Temperature	T_{AMB}	0 to −70	°C
Storage Temperature	T_{stg}	−65 to −150	°C
Junction Temperature	$T_{J(max)}$	150	°C
Power Dissipation, package Derate above 25°C	P_D	1.25 10	W mW/°C

RECOMMENDED OPERATING CONDITIONS

Supply Voltage	12 = 2	Vdc
Sync Tip Level Sync, Blanking Level	−0.5 to −1.0 +1.7 to +8.2	Vdc
Red, Green, Blue Inputs (Saturated)	1.0	V_{p-p}

ELECTRICAL CHARACTERISTICS (V_{CC} = 12 Vdc, T_A = 25°C, Circuit Of Figure 1 Unless Otherwise Noted.)

Characteristic	Pin No.	Min	Typ	Max	Unit
Supply Current	14	—	32	—	mAdc
Oscillator Amplitude	17	—	0.5	—	$V_{(p-p)}$
External Subcarrier Input (Oscillator Components Removed)	18	—	0.25	—	V_{RMS}
Subcarrier Input: Resistance Capacitance	18	— —	5.0 2.0	— —	kΩ pF
Modulation Angle (R−Y) to (B−Y)	—	85	90	95	Degrees
(R−Y) Angle Adjustment	19	—	0.25	—	Deg/μA
R, G, B Input For 100% Color Saturation	3, 4, 5	0.95	1.0	1.05	$V_{(p-p)}$
R, G, B Input: Resistance Capacitance	3, 4, 5	— —	10 2.0	—	kΩ pF
Sync Threshold (See Figure 2e)	2	—	1.7	—	V
Sync Input Resistance (Input > 1.7 V)	2	—	10	—	kΩ
Chroma Output Level At 100% Saturation	13	—	1.0	—	$V_{(p-p)}$
Chroma Output Resistance	13	—	—	80	Ω
Chroma Input Level For 100% Saturation	10	—	0.7	—	$V_{(p-p)}$
Chroma Input: Resistance Capacitance	10	— —	10 2.0	— —	kΩ pF
Composite Output, 100% Saturation (See Figure 2d): Sync Luminance Chroma Burst	9	— — — —	0.6 1.4 1.7 0.6	— — — —	$V_{(p-p)}$
Output Impedance (See Note 1)	9	—	—	100	Ω
Luminance Bandwidth (3 dB), Less Delay Line	9	—	8.0	—	MHz
Subcarrier Leakage In Output	9	—	—	40	$mV_{(p-p)}$

Note 1: Output Impedance can be reduced to less than 10Ω by using a 150Ω output load from Pin 9 to ground. Power supply current will increase to about 60 mA.

Fig. 1 MC1377P data (Courtesy Motorola).

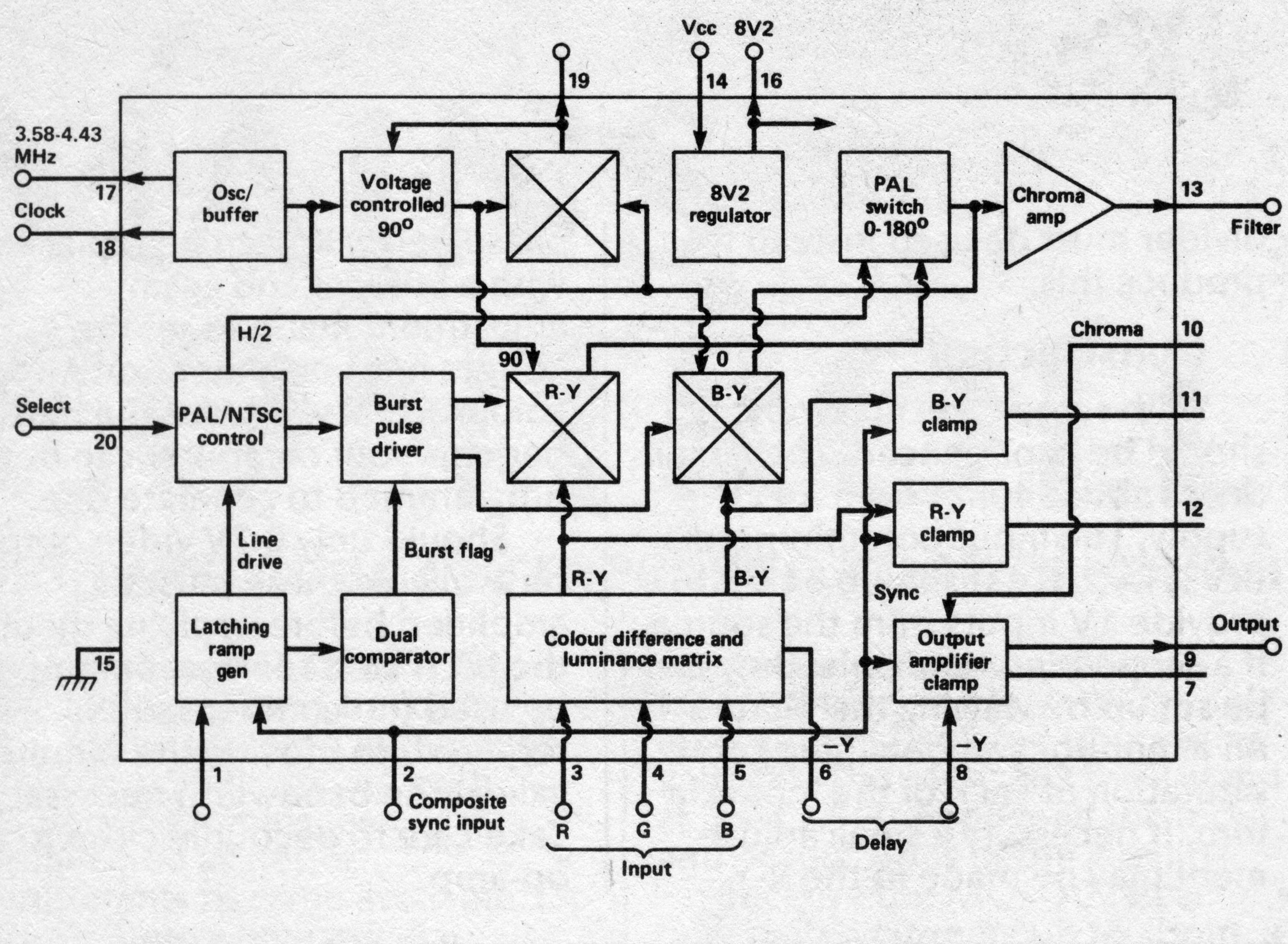

Fig. 2 Block diagram of the MC1377P encoder IC.

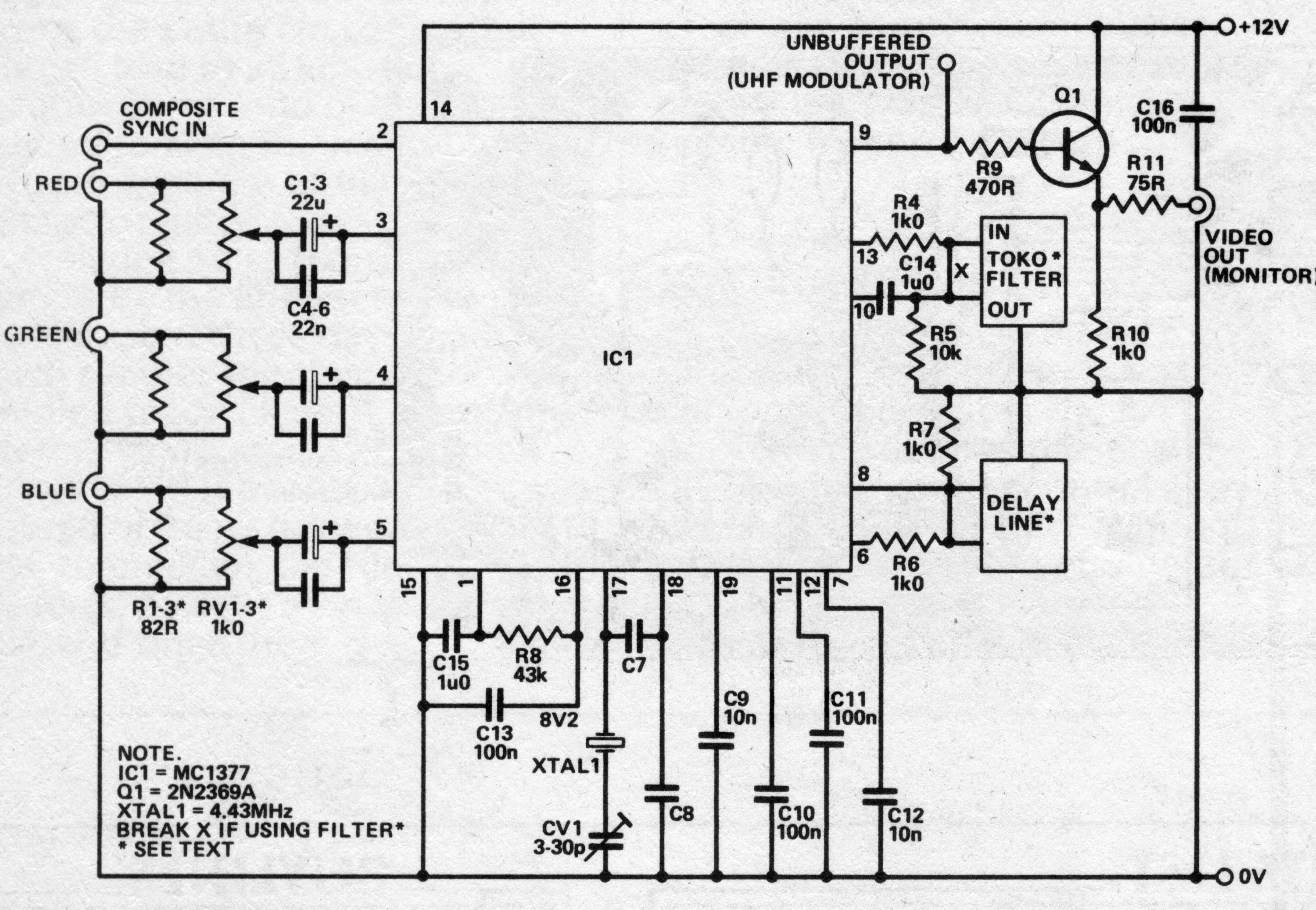

Fig. 3 Crcuit diagram of the converter.

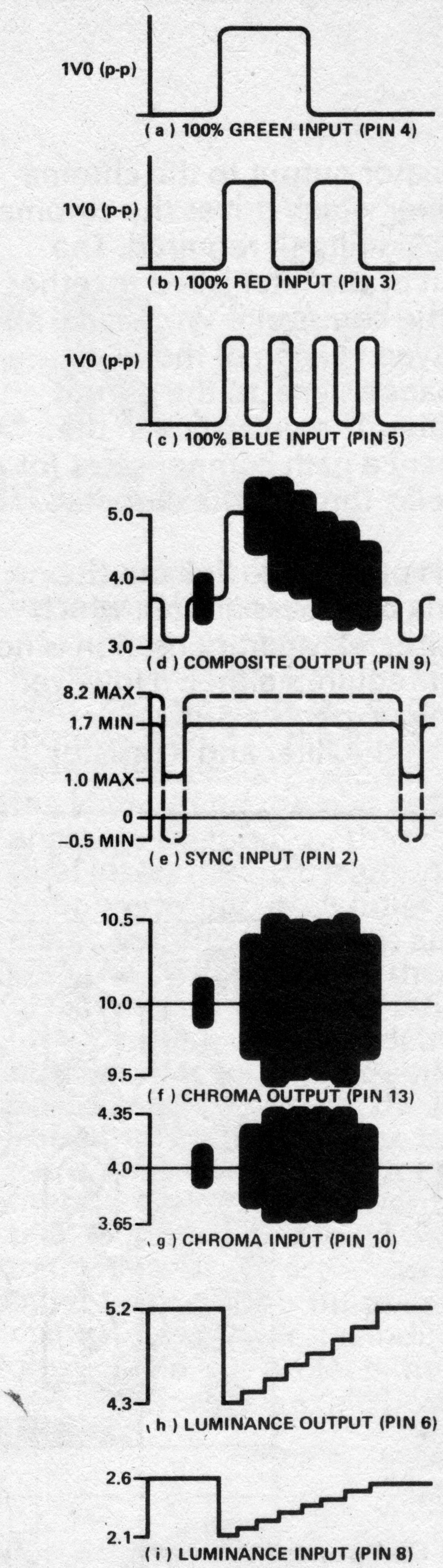

Fig. 4 The signals that should appear at the test points around the chip.

HOW IT WORKS

The incoming RGB inputs are terminated with resistors R1, R2 and R3 and potentiometers RV1, RV2 and RV3 (Fig. 3). These provide input impedances of approximately 75R. The presets should be adjusted to provide a maximum input of 1V p-p (for saturation) into the MC1377. If the inputs to the board cannot drive 75R (LSTTL, for example, can only provide a source current of 400μA) the 82R resistors should be removed and the pots replaced with 10k values. This will decrease the bandwidth of the system due to the filter formed by the potentiometer and the input capacitance of the MC1377. The inputs are AC coupled into the encoder — the large value of capacitor being required for the 50Hz field component.

The Colpitts oscillator for the colour burst is formed around pins 17 and 18. About 0.5V p-p should appear on pin 17 and 0.25 VRMS into pin 18 with the oscillator components removed.

The incoming composite sync signal (pin 2) should be negative going. The device will accept CMOS and TTL directly. The range of acceptable inputs is shown in Fig. 4. If it is necessary to AC couple the sync then a pull up to 8.2V is required (a regulated 8.2V is provided on pin 16).

From the composite sync input the MC1377 generates a ramp which it uses to provide the burst gate pulse. The slope of this ramp can be varied by a potentiometer on pin 1. However a preset value is usually sufficient (shown as 43k).

The chrominance filter should be fitted between pins 13 and 10. If the filter is not used, a compensatory potential divider should be fitted (both are shown in Fig. 3). We used a prealigned Toko bandpass filter centred on 4.43MHz. If the chroma filter *is* fitted, the delay through it (400ns) has to be compensated for by a luminance delay line between pins 6 and 8. This is shorted out if the filter is not fitted. The composite video output from the IC is buffered to provide a low impedance drive for a monitor or it can be applied directly to one of the common UHF modulators used in computers. Just follow the manufacturer's instructions for connecting this up.

modulator output to the chroma amplifier which drives the chroma bandpass filter if required. The output of the filter is fed together with the composite sync signal and a delayed version of the luminance signal to the output amplifier. The delay line in the luminance path compensates for the delay through the chroma filter.

It is possible to link out the chroma bandpass filter in which case the delay compensation is no longer required either. However the chip expects a 3dB loss through the filter and a resistor divider must be used instead to produce this.

Construction

With some care, no problems should be experienced. The circuit draws about 40mA from a 12V supply. The input potentiometers (RV1, RV2, RV3) should be set to provide 1V inputs from the source. If a scope is not available, they can be set up by viewing the picture on a monitor and obtaining good saturation of each of the inputs in turn. If necessary a small adjustment may be made to the R-Y phase delay. R8 can be replaced with a 50k pot and again adjustment made to set the correct hues on a monitor. A colour signal will be useful here, perhaps your computer can be programmed to generate one.

Should only 0.7V video outputs be available these must be amplified before applying them to the IC. A LM318N fast op-amp can be used (no compensation required) to provide the required gain at the bandwidth necessary. Take care to decouple close to the op-amp.

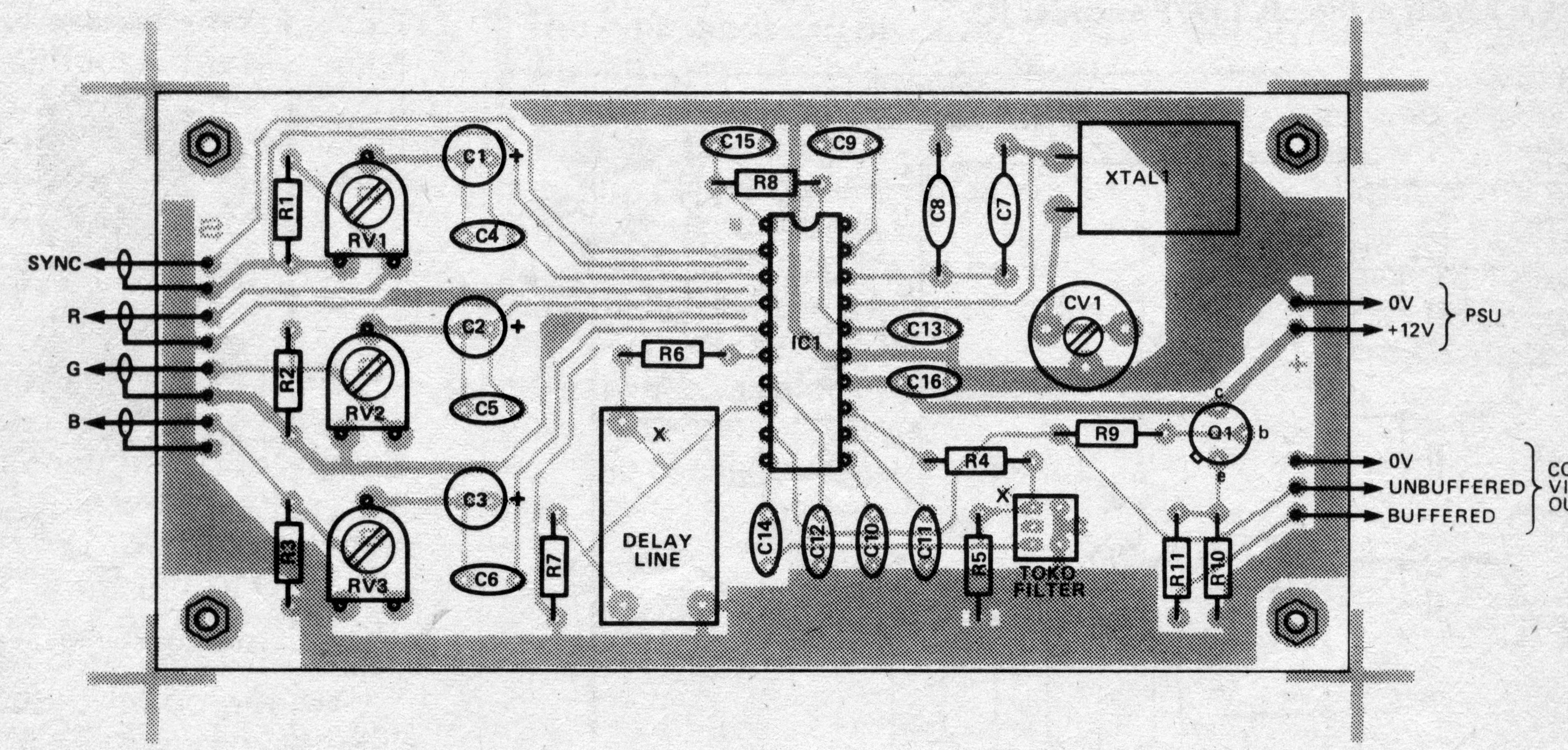

Fig. 5 Component overlay.

PARTS LIST

RESISTORS (All ¼W ±5%)	
R1, 2, 3	82R
R4	1k0 (2k2 without filter)
R5	10k (only fitted when filter isn't)
R6, 7, 10	1k0
R8	43k
R9	470R
R11	75R
RV1, 2, 3	1k0
CAPACITORS	
C1, 2, 3	22μ 16V radial electrolytic
C4, 5, 6	22n
C7, 8	22n
C7, 8	220p polystyrene
C9, 12	10n
C10, 11, 13, 16	100n
C14, 15	1n0
CV1	3-30p
SEMICONDUCTORS	
IC1	MC1377P
Q1	2n2369A

MISCELLANEOUS
Chroma filter - Toko VUS1054; 400ns delay line. 3-pin 1" 1" x 4" (HLW); XTAL1 — colour burst frequency. 4.433619MHz, HC18U can; PCB; suitable connector.

BUYLINES

The MC1377P is available from Macro-Marketing (telephone: 06286-4422). The Toko filter and variable capacitor are available from Cirkit, order numbers 18-01054 and 06-36001 respectively The delay line — a TDK T9006 has been recommended — may prove more problematic and we suggest trying TV repair shops for a second-hand luminance delay line from a colour TV chassis — Fergusson TX9 or TX10, for example. Manor Supplies of West End Lane, London NW11 (01 794 8751) may be able to help. The 43k resistor may be obtained from Electromail or a 50k preset will do — or use a 33k and a 10k resistor in series.

ETI