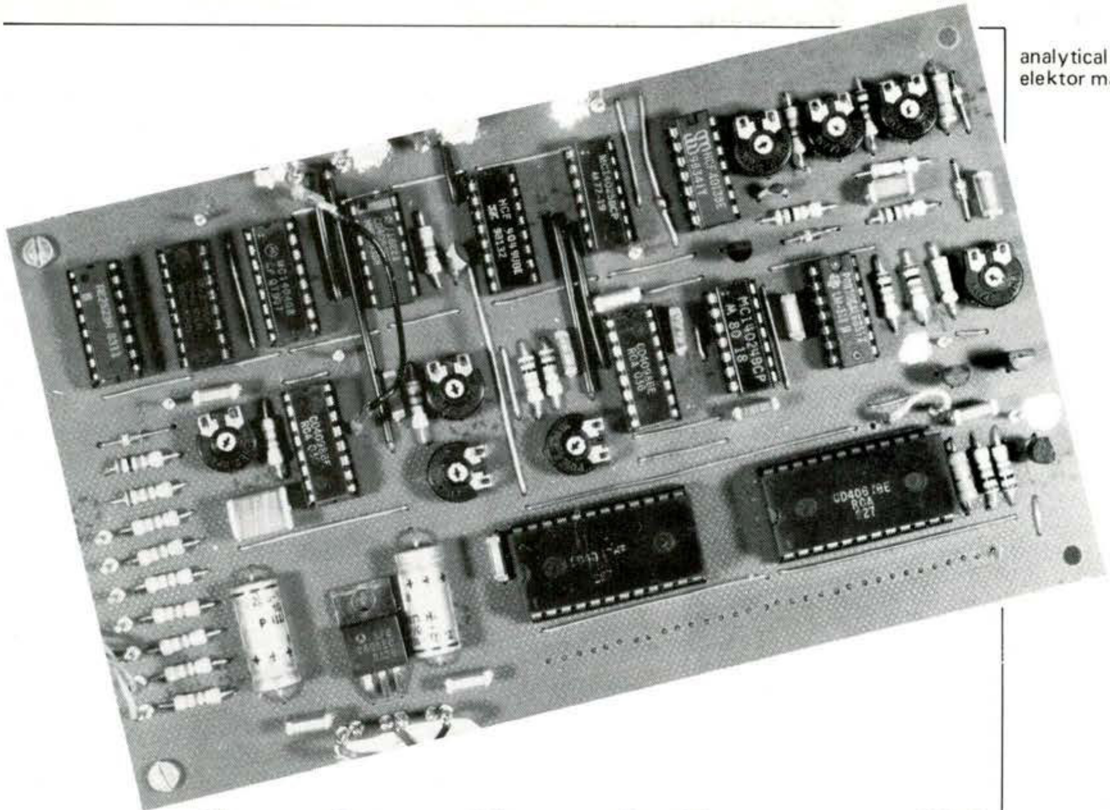


analytical video display

The third, and last, part of the real-time analyser is dealt with elsewhere in this issue. That project is now complete but it can be enhanced with the addition of this display which shows the output of the analyser in colour on a normal TV set or monitor. The bar for each output channel is sub-divided into 32 sections each of which represents a step of 1 dB. The colour of the bar changes per dB so that the value of each bar is easily read. This circuit is also extremely suitable for any application where it is useful to see a read-out in bars on a screen.

turns a TV set into a colourful bar-graph display with a full scale sensitivity of 1 V d.c.

The real-time analyser, which is now complete, provides its read-out on a LED display built up from 330 discrete LEDs. This is more than sufficient for 'personal' use. It can sometimes be useful to have a larger display for some applications, such as for demonstration purposes or to be able to see the result at a greater distance from the analyser. This circuit forms the output of the 30 rectifiers into a video signal so that the display can be shown on any monitor or TV set (via a modulator).
The LED display of the real-time analyser can simply be left connected, but it is also possible to leave out the LED display completely and build an analyser that has only this video display. As stated in the associated article, the complete display board and the 8 V supply on the base board are then no longer needed.
The analytical video display circuit can also be used for other applications, principally where d.c. voltages are to be displayed on a screen. In the basic version the circuit works with 30 (possibly 31) inputs but this number can be reduced even to one.

The block diagram

The drawing of figure 1 shows the block diagram for the circuit. A 32-channel analogue multiplexer combines all the input signals (the maximum number possible is 31) into one complex signal that must then be processed synchronously with the video signals. The signals needed for the synchronizing are provided by the video sync box published in the February 1984 issue of Elektor.
The output signal from the multiplexer is sent to a fast comparator (IC3) whose switch-over point is defined by the reference voltage applied to the inverting input. This voltage follows an exponential sawtooth characteristic, which is an easy way to achieve quite an accurate (± 1%) logarithmic division.
The sawtooth is synchronized to the raster frequency of the video signal (50 Hz) by the field display gate (FG) generated from the synchronization signal ($\overline{CS}$) and the blanking signal ($\overline{CBLK}$). The total period of the ramp is about 256 lines as this is the number of lines available vertically for

1

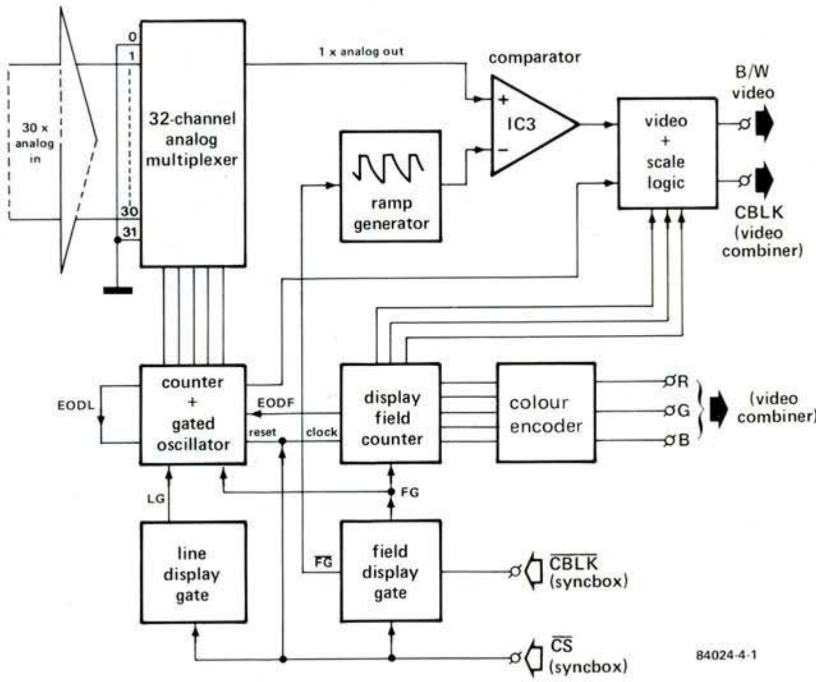


Figure 1. The functioning of the circuit can be readily seen from the block diagram here.

displaying the signal levels. The display field counter (DFC) ensures that information is only shown on the screen during these 256 lines. As soon as this number is reached the end of display field (EODF) signal stops the analogue multiplexer along with the circuits around it. The display field counter also provides the base signals for the scale logic and the colour encoder. Due to the fact that the DFC is clocked by the $\overline{CS}$ signal (line frequency) each line can be provided with colour information. Careful use of colour makes the display more attractive and the steps easier to read.
The input signals are multiplexed in the same way as was used in the LED display, namely by using a pair of 16-channel multiplexers connected 'in series'. Now, however, the switching frequency is much higher (about 666 kHz). Switching occurs synchronously with the line frequency so all thirty channels are run through in one line time. For one complete raster all 30 signal inputs must be examined 256 times. To ensure that this happens correctly the start moment counter and the gated oscillator must be controlled by the $\overline{CS}$ signal. The LG (line gate) and FG signals are taken from this $\overline{CS}$ signal. The oscillator is stopped by means of the EODF and EODL (end of display line) signals.

The circuit

The complete circuit for the video display is shown in figure 2. The layout of the multiplexer section has already been dealt with in the article on the LED display so we do not need to spend any time looking at IC1 and IC2. The next section shows a marked difference from the LED display as a single comparator (IC3) is made to do all the work in this case. This is possible because a varying reference voltage is used here along with a different sort of display (a TV screen).
The varying reference voltage is provided by the external synchronized exponential sawtooth generator. This generator, in fact, is no more than an RC circuit consisting of C10, R7, R8, P2 and P3. The discharging pulse for the sawtooth simultaneously synchronizes to the image window available. The pulse is taken from the composite sync and blanking signal.
If there is a raster blanking signal present this is noted by MMV1 (because no trigger pulse then arrives within 80 μs) and MMV2 is then triggered by the $\overline{CS}$ signal. This monostable therefore supplies one pulse per raster and this pulse not only synchronizes the sawtooth signal, $\overline{FG}$, but also defines the start of the field display gate (FG) as IC11 (the display field counter) can only start counting at the end of this pulse. The vertical image position can be set by changing the width of the FG pulse. The image height is fixed at 256 lines because after this number of $\overline{CS}$ pulses the gated oscillator (N13) is disabled via output Q8 of IC11 (EODF) and N1. At the same time N1 receives the FG signal so that the gated oscillator is only enabled during the (vertical) visible (not black in other words) part of the image. The build-up and colour of the scale division is entrusted to IC11, as we will see later when we come to describing the layout of the display.
The horizontal image division is handled in much the same way as the vertical. It is done by means of the $\overline{CS}$ signal, MMV3, MMV4, the gated oscillator (N13), and the address counter of the multiplexer (IC4).

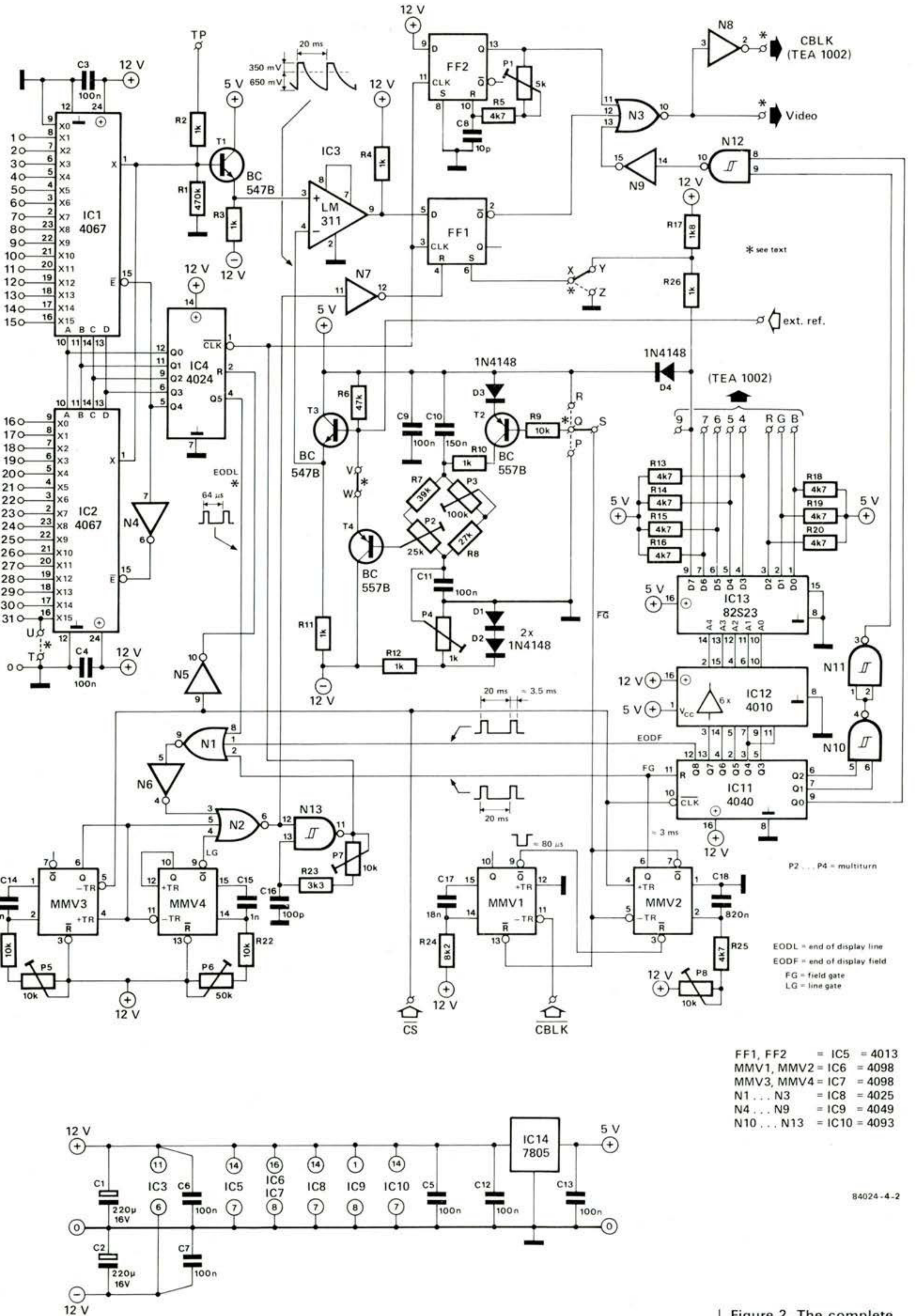


Figure 2. The complete circuit diagram, as shown here, relates very closely to the block diagram of figure 1.

3

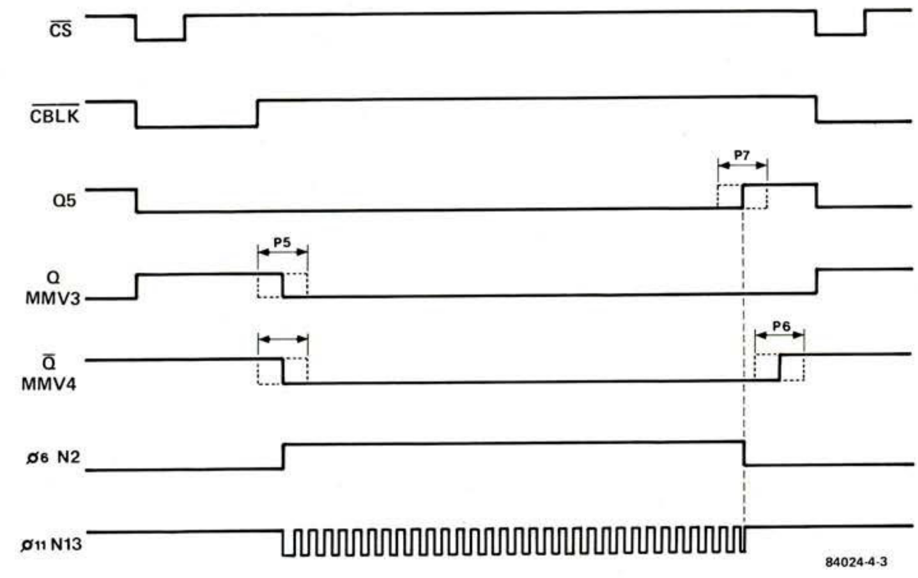


Figure 3. This timing diagram should help to clarify the operation of the circuitry responsible for the horizontal image window.

Table 1.

colour	RGB
black	0 0 0
blue	0 0 1
green	0 1 0
cyan	0 1 1
red	1 0 0
magenta	1 0 1
yellow	1 1 0
white	1 1 1

Table 1. The basic colours that can be displayed on the screen with the aid of this circuit are given in this table.

The operation of this section of the circuit is clarified by referring to the timing diagram of figure 3. The waveforms shown only apply when both FG and EODF signals are '0', which means during the vertical image window. The $\overline{CS}$ signal travels via inverter N5 to the reset input of IC4. After a reset Q5 (EODL) becomes '0'. At the same time MMV3 is triggered so that N13 is still disabled via N2 even though EODL, EODF, and FG are all zero. The falling edge of MMV3 triggers MMV4 and the pulse provided by this latter monostable (LG) defines the maximum width of the image window. The horizontal position can now be set by adjusting the left side of the image with P5 and then the position of the right side can be fixed with P6 depending on the setting of P7. The image can thus be centred by means of this P5/P6 combination. If the frequency of N13 set with P7 is so high that more than 32 periods occur within the LG pulse the position of the right side of the image will be defined by Q5. This is referred to again in the section on calibration.
The oscillator signal of N13 is fed to the clock input of IC4. The combination of signals shown in figure 3 ensures that the oscillator is always started at the same moment during each of the 256 lines. During each line the Q0 . . . Q4 outputs of the counter select each of the multiplexer inputs in chronological order. The falling edge of the oscillator signal clocks IC4. The next rising edge is used to load FF1 with the data supplied by IC3. This is done to give the comparator sufficient time to react to the input signal. Furthermore, the display width of each channel is exactly one clock cycle, with the exception of channels 1 and 31 which are never totally visible because of the starting and stopping of the oscillator. This is also the reason why channel 0 is tied to ground. Channel 31 could possibly be used to specify, for example, a certain reference level.

4

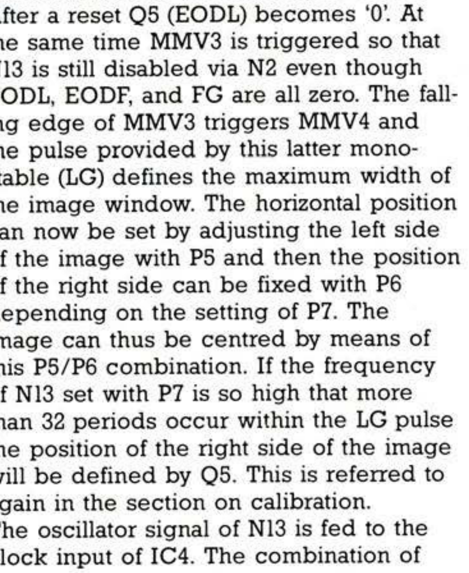


Figure 4. The display needs a couple of extra circuits in order to operate and this diagram shows how the video sync box and the video combiner are linked to the display.

The make-up of the display

Various ICs which we have ignored up to now are responsible for the scale division of the display. The levels cannot be given on the screen with letters and numbers so the alternative chosen was a number of 'fields' with different colours. Each channel is separated from its neighbours by means of a thin black line. Horizontal scale division is also indicated with black lines. The scale of each channel is visible up to the signal level present, and above this it is black ($\overline{Q}$ of FF1 is then '1').
The assembly point for measurement information and scale division data is formed by NOR gate N3. An inverter is included after N3 for colour transmissions, as we will see shortly. Both of these outputs are active high but there is a difference in the function of the signals. The *video* signal for monochrome displays (black and white) is provided by N3 whereas output N8 gives the *blanking* signal for the colour image.
For the time being we will confine ourselves to the blanking signal. It has

already been mentioned that a '1' at the $\overline{Q}$ output of FF1 gives a black image. This can also be seen as blanking. The lines separating the channels are generated by FF2. This flip-flop is connected as a MMV which supplies a pulse of 200 . . . 300 ns with each rising edge of the gated oscillator. Each pulse results in a short blanking period.
The horizontal lines for the scale division are generated from the count on the display field counter (IC11) with the aid of a few NAND gates. Working from the top of the image (or the measuring field) every eighth line is blanked. There is a total of 32 black lines resulting from the Q0 + Q1 + Q2 function realized with N9 . . . N12. The thirtysecond line is not visible as it is right at the bottom of the image.
The display now has a scale division but the readability is not all that good yet. A marked improvement can be made by adding colour.
One bit is taken for each of the primary colours, red, green, and blue, so that with three bits a maximum of seven colours can be made, as table 1 shows (black is not usable). The steps in the scale division, each consisting of eight lines, can also contain colour information. The colours chosen are given in table 2. The video display/real-time analyser combination uses a scale in which each of the steps represents 1 dB. Colour is used as follows: between —1 and 0 dB the display is white, above that the steps up to +6 dB are magenta and red, below the white and down to —6 dB the colours are green and yellow. The range from —6 dB to —26 dB (the lowest screen section) is cyan and blue.
The colour information is coded by means of a PROM (IC13) which is addressed by the display field counter. The PROM operates at TTL level (+5 V) so a level adapter (IC12) is needed between this and IC11. A number of resistors, R13 . . . R16 and R18 . . . R20, are included because IC13 has open collector outputs. The output signals are suitable for connecting to the video combiner published in the February 1984 issue of Elektor.
Four of the eight PROM outputs are not used but these could possibly be brought into service to make other colour patterns. Output D7 makes a base visible on the screen at the expense of 2 dB of measuring range. This is done by controlling a two-divisions high bar at the bottom of the display via the set input of FF1. This then gives an indication that the display is 'on' even when there are no signals at the input.
Data bits D3 . . . D6 in the PROM are programmed, as table 2 clearly shows. One or more RGB bits can be exchanged with the other data bits if desired. Also, because the outputs here have open collectors it is possible to connect a number of outputs in parallel. If one of the colour bits is exchanged for D6, for example, the display gives a scale with 6 dB steps.

Colour or black and white

The colour display can be shown on a colour monitor with TTL RGB inputs or a TV set or monitor with a PAL input, the latter possibly via a modulator (such as the one published in the March 1984 issue). We will concentrate, from now on, on the PAL system as this is the more common. Besides the video sync box already mentioned a video combiner is also needed to make a suitable signal. It is clear from figure 4 which connections are needed between the three boards in order to generate a PAL video signal.
A monochrome TV set requires the addition of the circuit shown in figure 5 but without colour the readability of the display suffers. The scale sections will

Table 2. The 'colour' information for the display is stored in an 82S23 PROM which is programmed according to this table.

Table 2.

level	PROM 82523 address	hex	D6	D6	D5	D4	D3	R D2	G D1	B D0	D hex	colour
+6	0 0 0 0 0	0 0	0	0	1	1	1	1	0	0	3 C	red
+5	0 0 0 0 1	0 1	0	1	1	1	0	1	0	1	7 5	magenta
+4	0 0 0 1 0	0 2	0	1	1	0	1	1	0	0	6 C	magenta
+3	0 0 0 1 1	0 3	0	1	1	0	0	1	0	1	6 5	magenta
+2	0 0 1 0 0	0 4	0	1	0	1	1	1	0	0	5 C	red
+1	0 0 1 0 1	0 5	0	1	0	1	0	1	0	1	5 5	magenta
0	0 0 1 1 0	0 6	0	0	0	0	1	1	1	1	0 F	white
-1	0 0 1 1 1	0 7	0	1	0	0	0	0	1	0	4 2	green
-2	0 1 0 0 0	0 8	0	1	1	1	1	1	1	0	7 E	green
-3	0 1 0 0 1	0 9	0	1	1	1	0	0	1	0	7 2	green
-4	0 1 0 1 0	0 A	0	1	1	0	1	1	1	0	6 E	yellow
-5	0 1 0 1 1	0 B	0	1	1	0	0	0	1	0	6 2	green
-6	0 1 1 0 0	0 C	0	0	0	1	1	0	1	1	1 B	cyan
-7	0 1 1 0 1	0 D	0	1	0	1	0	0	0	1	5 1	blue
-8	0 1 1 1 0	0 E	0	1	0	0	1	0	1	1	4 B	blue
-9	0 1 1 1 1	0 F	0	1	0	0	0	0	0	1	4 1	blue
-10	1 0 0 0 0	1 0	0	1	1	1	1	0	1	1	7 B	blue
-11	1 0 0 0 1	1 1	0	1	1	1	0	0	0	1	7 1	blue
-12	1 0 0 1 0	1 2	0	0	1	0	1	0	1	1	2 B	blue
-13	1 0 0 1 1	1 3	0	1	1	0	0	0	0	1	6 1	blue
-14	1 0 1 0 0	1 4	0	1	0	1	1	0	1	1	5 1	blue
-16	1 0 1 1 0	1 6	0	1	0	0	1	0	1	1	4 B	blue
-17	1 0 1 1 1	1 7	0	1	0	0	0	0	0	1	4 1	blue
-18	1 1 0 0 0	1 8	0	0	1	1	1	0	1	1	3 B	blue
-19	1 1 0 0 1	1 9	0	1	1	1	0	0	0	1	7 1	blue
-20	1 1 0 1 0	1 A	0	1	1	0	1	0	1	1	6 B	blue
-21	1 1 0 1 1	1 B	0	1	1	0	0	0	0	1	6 1	blue
-22	1 1 1 0 0	1 C	0	1	0	1	1	0	1	1	5 B	cyan
-23	1 1 1 0 1	1 D	0	1	0	1	0	0	0	1	5 1	blue
-24	1 1 1 1 0	1 E	1	0	0	0	1	0	1	1	8 B	cyan
-25	1 1 1 1 1	1 F	1	1	0	0	0	0	1	1	C 3	cyan

5

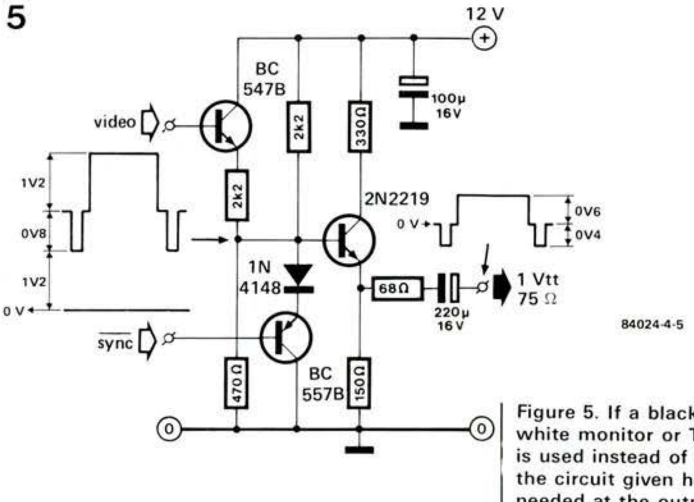


Figure 5. If a black and white monitor or TV set is used instead of colour the circuit given here is needed at the output of the display.

6

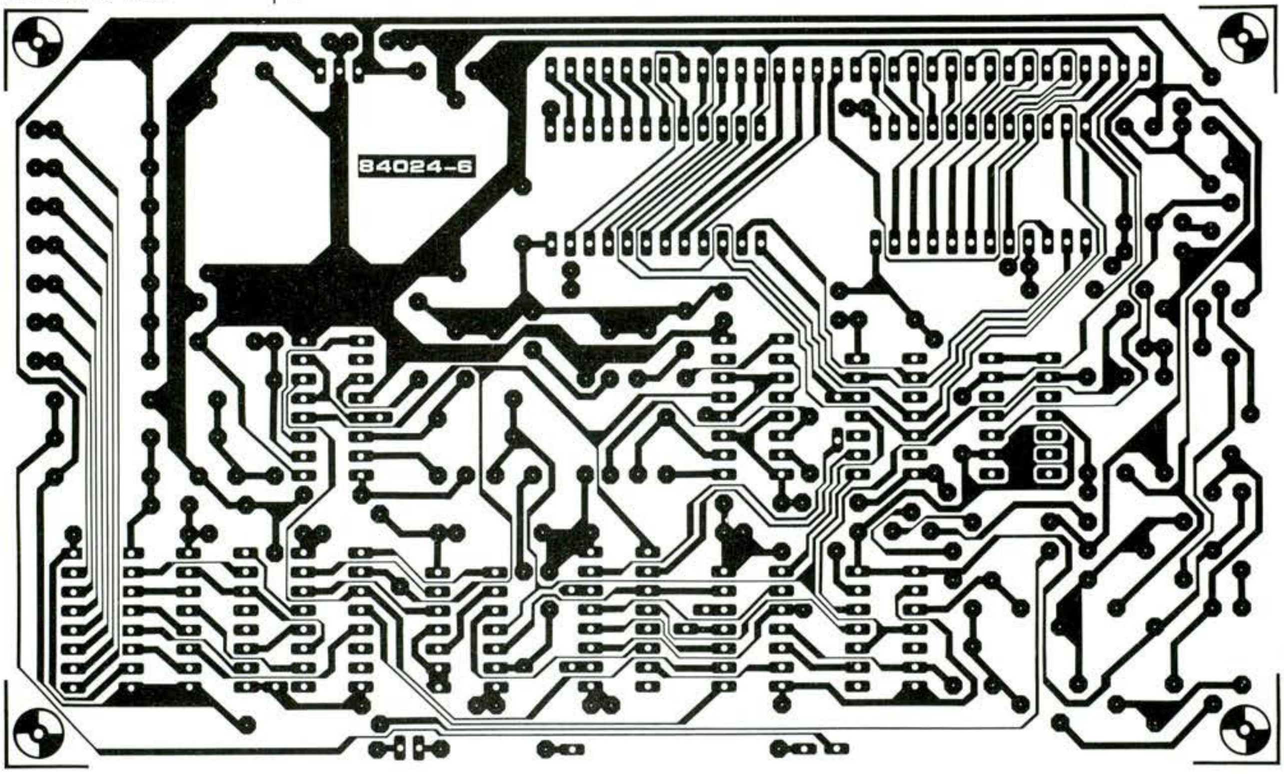


Figure 6. Constructing this project is greatly facilitated by using the printed circuit board whose layout is shown here.

then simply have to be counted or the colour signal could be displayed in black and white which would at least give a number of different shades of grey. The monochrome version also has one small plus point. If the base for the display is not considered important then IC12, IC13, R13 . . . R20, R26, and D4, as well as the video combiner in its entirety, can be left out. Now, instead of connecting X to Y, X must be connected to Z. The output of N3 (video) is connected to the video input of the circuit in figure 5, as is the $\overline{CS}$ signal. The output of this circuit then provides a good monochrome signal that can be connected directly to a TV set or monitor with a sensitivity of 1 V_{pp} at 75 Ω.

Construction

The whole circuit shown in figure 2 can be constructed on the printed circuit board shown in figure 6. Mounting the components is just a matter of following the parts list and component overlay. Two things to watch out for are that the PROM is programmed correctly (it is also available pre-programmed) and that no wire links are forgotten. Link T-U is inserted if output 31 is not used. To select colour or monochrome display either link X-Y is made (colour) or X is connected to Z (black and white). Points P, Q, R, and S remain open for the moment.

The connection points for the video sync box and video combiner are on one long side of the printed circuit board and the inputs are at the other side. Inputs 1 . . . 30 are connected to the filter outputs of the real-time analyser by means of a suitable length of ribbon cable. One short side of the board has the PROM outputs and normally these are only connected to the RGB inputs of the video combiner. A symmetrical + and —12 V supply is needed for the circuit, but if used with the real-time analyser the power can be tapped off the appropriate point on the input or base board. Otherwise a separate supply with two voltage regulators (7812 and 7912) must be built. The current consumption will not exceed about 300 mA.

Calibration

All presets are first centred. The screen should now show at least a part of the base bar (occupying two scale divisions across the screen) and probably also a few undefined vertical bars (for the channels).

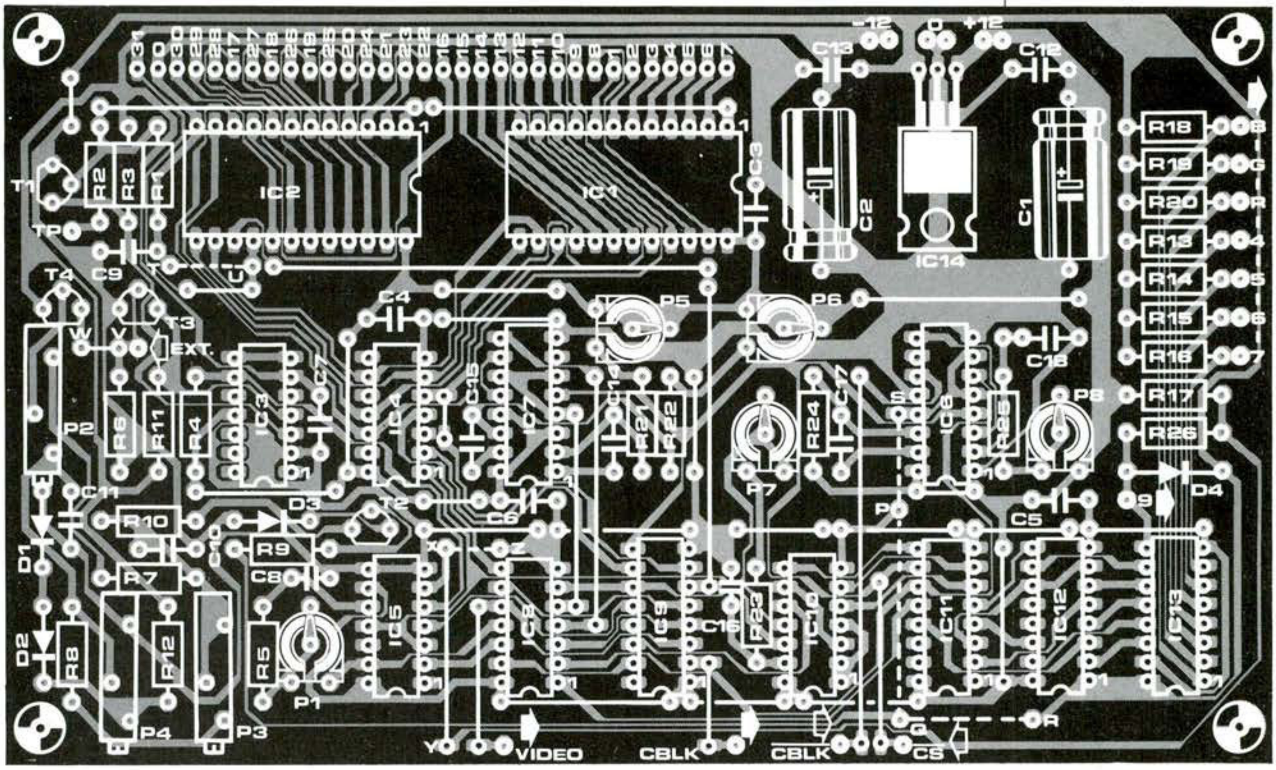
The screen format

Rotate preset P2 completely anti-clockwise and then turn P4 anti-clockwise until the 'bars' grow into a rectangular block that stretches the whole height of the screen. The image can now be correctly positioned vertically by means of P8. This preset must be set so that one complete line is visible at the top of the display. The monostable time of MMV2 is then such that the end of the FG signal is in the black part of the screen. The width of the image is decided with P6 by adjusting this preset anti-clockwise until the display fills the whole width of the screen. If this proves impossible the frequency of the oscillator based on N13 must be reduced by rotating P7 clockwise. Now the adjustment of the screen format is finished by setting the horizontal centering with

Parts list

Resistors:

R1 = 470 k
R2 . . . R4,R10 . . . R12,R26 = 1 k
R5,R13 . . . R16, R18 . . . R20,R25 = 4k7
R6 = 47 k
R7 = 39 k
R8 = 27 k
R9,R21,R22 = 10 k
R17 = 1k8
R23 = 3k3
R24 = 8k2
P1 = 5 k preset
P2 = 25 k ten turn preset
P3 = 100 k ten turn preset
P4 = 1 k ten turn preset
P5,P7,P8 = 10 k preset
P6 = 50 k preset



preset P5.
The screen is now set to display 30 (or 31) channels. A smaller number of channels may be selected by reducing the frequency of N13 with P7. In this way the number can be lowered to 25. A further reduction, to 15, for example, can be achieved by increasing the value of C16 to 180 pF. If only 15 or less channels are used IC2 is superfluous and can be removed.

The reference sawtooth

A few 'extra' links have been included on the board in order to enable the sawtooth waveform to be adjusted. These are the already mentioned P, Q, R, and S, with Q being the central point.
Connect Q to R (+5 V) and all the inputs of IC1 and IC2 to ground. As a result of this, capacitor C10 is completely charged and the zero level of the sawtooth can be set with P4. A millivolt meter must be connected from the emitter of T1 (—) to the emitter of T3 (+) and P4 is then adjusted until the meter shows a reading of zero millivolts. This will also be clearly visible on the screen. A negative voltage difference will fill the screen whereas with a positive voltage only the base bar will be visible. The correct setting is when the image is at the (unstable) switching point between full and empty screen.
Connect Q to P instead of to R. The voltage across C10 now drops to about 0.75 V. The millivolt meter remains connected to T1 and T3 but is switched to a range where it can measure up to 2 V. The reading on the meter is adjusted to +1 V by means of P2. A better alternative, actually, is to apply exactly 1 V to all the inputs and trim P2 so that the meter reads zero volts, but this requires two accurate meters. The upper limit of the measurement range is now set (+6 dB = 1 V).
On to the lower limit of the measuring range next. The (non-visible) absolute lowest limit is at —26 dB. The 0 dB level represents a voltage of 0.5 V d.c. so —26 dB corresponds to an input of 25 mV. For practical reasons the bottom of the display is not a very suitable adjustment point. A more usable point, which is also easier to locate on a colour display, is —6 dB (= 250 mV). This is the exact point on the screen where the blue/cyan section meets the green/yellow part (i.e. the black line between cyan and green). Taking this as an adjustment point has the added advantage that the error introduced by the fact that the reference voltage is not 100% accurately logarithmic is kept to a minimum. A very accurate millivolt meter is needed for this adjustment.
Apply 250 mV d.c. to all the inputs and connect Q to S (having first removed the Q-P link). Adjust preset P3 (sawtooth frequency) until all the bars come exactly to the cyan/green border. Then, if necessary, the sawtooth adjustment can be repeated. The width of the dividing lines between the channels can now be set with preset P1.
The adjustment of the real-time analyser is dealt with elsewhere in this issue and these two circuits will normally fit together without further ado. Any differences in level can be compensated by adjusting the value of resistor R12 on the input board of the analyser.

Capacitors:
C1,C2 = 220 μ/16 V
C3 . . . C7,C9,C11 . . . C13 = 100 n
C8 = 10 p
C10 = 150 n
C14,C15 = 1 n
C16 = 100 p
C17 = 18 n
C18 = 820 n

Semiconductors:
D1 . . . D4 = 1N4148
T1,T3 = BC 547B
T2,T4 = BC 557B
IC1,IC2 = 4067
IC3 = LM 311 (14 pin DIL)
IC4 = 4024
IC5 = 4013
IC6,IC7 = 4098/4528
IC8 = 4025
IC9 = 4049
IC10 = 4093
IC11 = 4040
IC12 = 4010
IC13 = 82S23*
IC14 = 7805

*IC13 programmed according to table 2.