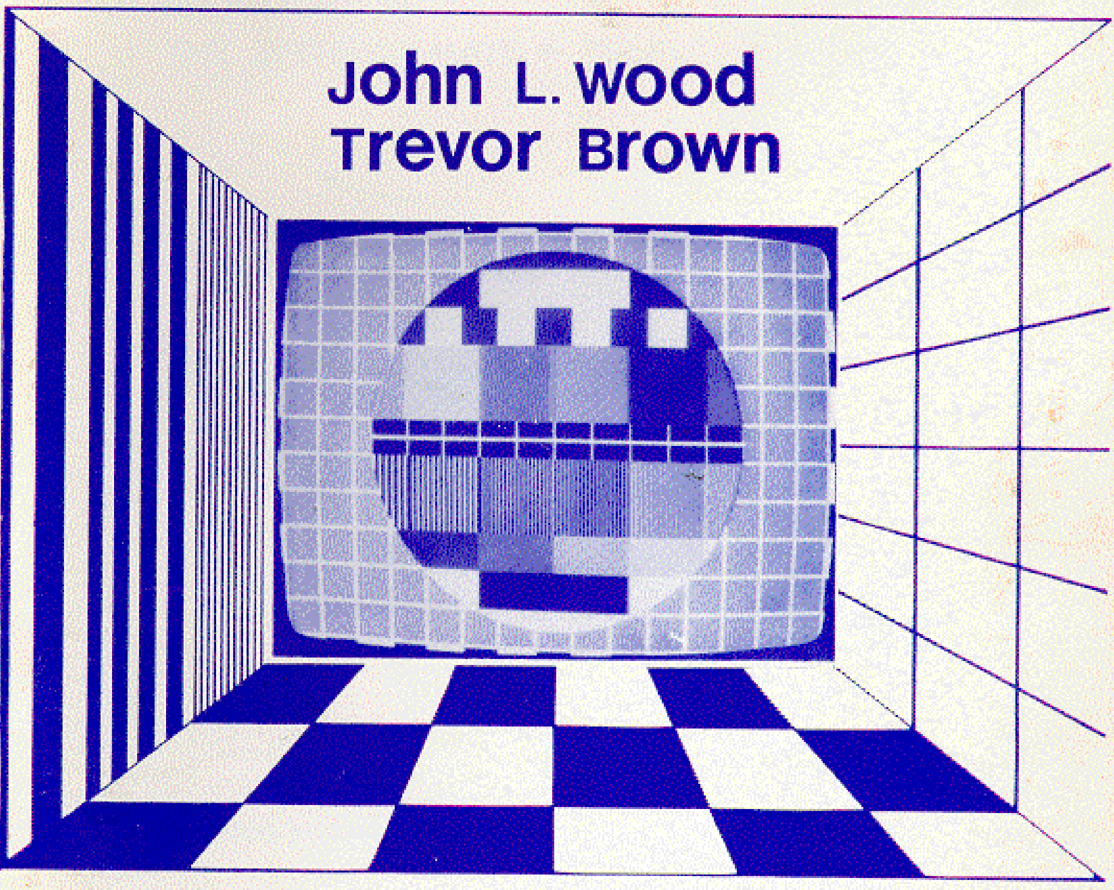
AMATEUR - TELEVISION HANDBOOK

John L. Wood
Trevor Brown



Amateur Television Handbook

By John L. Wood, G3YQC and Trevor Brown, G8CJS

Acknowledgements

The British Amateur Television Club expresses its gratitude to the following companies, societies and individuals who have provided material and assistance for this publication.

Blean Video Systems, Canterbury, Kent

Plessey Semiconductors Ltd., Swindon, Wiltshire

Radio Ref. Paris

Radio Society of Great Britain, Doughty Street, London

Wasco Electronics, Queens Street, Leicester

C. Browabridge		D.E.Jones	GW8PBX
M.Chamley	F3YX	J.Lawrence	GW3JGA
M. Crampton	G8DLX	T. Mitchell	G3LMX
C. G. Dixon	G8CGK	R. S. Roberts	G6NR
A.Emmerson	G8PTH	R.T.Russell	G4BAU
J. Goode		N. Walker	G8AYC
A.F.Wood	G3RDC		

Please note: The material in this book is dated and components may no longer be available, the PCBs are NOT, and modulation techniques are now normally FM rather than the AM covered in this book.

This special A4 sized edition edited by Ian Pawson, January 2000

Editor's note: This book was originally printed A5 size. This version has the same content, but has been rearranged to A4 size. The quality of some of the diagrams and pictures is not up to our usual standard as they have been scanned in from an original paper copy.

Contents

Preface

Amateur television is a large and complicated subject and to do justice to its many facets a book of several volumes would be required.

Amateur television handbooks in the past have tried to cover as many subjects as possible and consequently, due to size limitations, each subject has been treated in rather less detail that one could have wished. The original conception of this handbook was to deal in greater depth with the more complex, and in some cases less-well publicised, techniques used in the modern amateur television station. You will therefore find less information on basic principles, aerials, operating techniques, licensing requirements and even transmitters, all of which are adequately covered in books and frequently found in magazines. Instead, emphasis has been placed on subjects such as modern receiving systems, electronic video sources, vision-processing techniques and of course colour television. These subjects are particularly susceptible to changes in modern techniques and innovations and therefore the designs need to be periodically up-dated.

The newcomer to ATV has not been forgotten, however, and a chapter explaining such things as the composition of the modern TV signal and the organisation of an amateur station has been included. There is also guidance on aerials, feeders, simple receiving equipment and colour television principles and it is hoped that this information will adequately augment the large amount of already published data in other books and periodicals.

Almost all of the projects in this volume have never before been published and indeed some were designed especially for this book. Printed circuit boards will be made available to the constructor in order that the more complex circuitry may be successfully built by less experienced constructors. The video projects are all compatible with each other and the PC boards have been made to a standard size and use standard edge connectors that enable them to be installed in a card-frame cabinet system if required. This ensures complete flexibility and permits the use of only those units that are required.

The British Amateur Television Club is pleased to present this book in the hope that it will encourage and stimulate television amateurs throughout the world to strive for technical improvement and will help newcomers to enjoy this fascinating hobby.

Principles

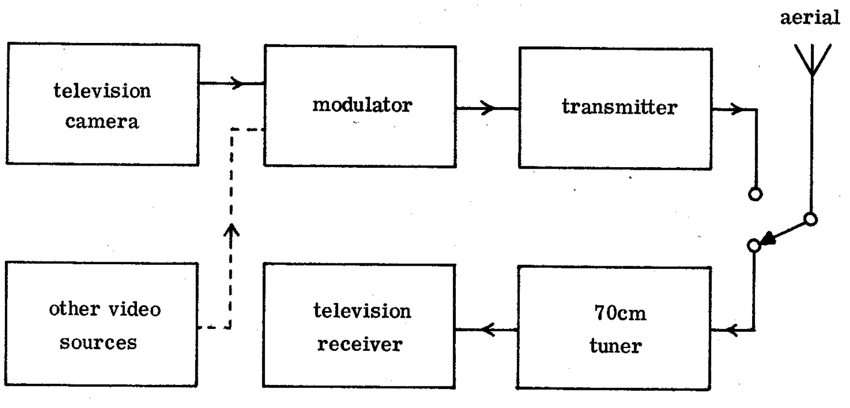


Fig 4. A simple amateur television station.

There are several methods of picture transmission; high and low definition television, slow scan television and facsimile (FAX) for still pictures, pictures built up using radio teletype, and so on. This book is mainly concerned with high definition television and sets out to describe the equipment necessary to build a modern amateur television station.

The broad principles involved in television transmission are well known, and this brief review is intended to highlight many of the important features of a modern system which are dealt with in full detail in the following chapters.

All forms of picture transmission and reception differ from normal 'seeing' with a human eye in one important respect, the human eye uses about 150 million simultaneous channels of visual communication, but an electronic system uses only one channel at any instant in time. Consequently, a process termed 'scanning' has to be used whereby the visual information to be transmitted and received is explored bit-by-bit and translated into electrical terms for modulation of a transmitter. The received signal is demodulated and used to build up a reconstituted picture on the screen of a cathode-ray tube.

Scanning

To simplify the explanation we will consider a picture made up of only eight lines and displaying a black square in the centre of the screen.

Scanning requires, firstly, that the

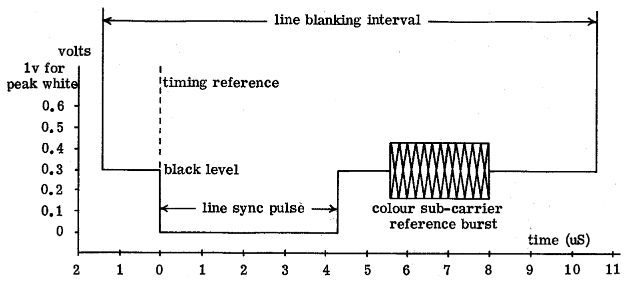


Fig. 2(d)

picture to be transmitted is framed in a field of view having an ‘aspect ratio’. The standard aspect ratio for television is 4 x 3 units, as shown in Fig 1(a). It is seen that the actual picture size is of no importance so long as the aspect ratio is correct.

Fig 1(a) shows a scanning spot that traverses the field line by line, (similar to the manner in which we read a book page), translating the variations of light and shade (and possibly colour) into voltage variations which are used to amplitude-modulate the transmitter. The camera, with its optics and electronics carries out this operation. At the receiver, a CRT beam is swept across the face of the tube in synchronism with the camera scan, and the demodulated signal is used to modulate the beam current, thus writing a reproduction of the picture scanned at the transmitter.

Fig 1(b) shows the voltage obtained by scanning (say) line four of the picture. Because electronic circuitry cannot respond instantly the changes from white to black and from black to white at the edges are not sharply defined. To improve resolution the spot is made smaller and the number of lines increased.

Television, in dealing with moving pictures, requires a complete scan of the field to be so fast that, compared with any movement taking place in the scene, each complete scan is of a virtually still picture. Standard broadcast television in the UK scans 25 pictures per second.

All broadcast television systems use a technique called ‘interlaced scanning’, this means that the screen is scanned and every other line is displayed onto the screen, during the next scan the in-between lines are displayed thus completing the picture. Referring to the eight line picture in Fig 1(a), interlaced scanning would require that the complete field would be scanned by lines 1, 3, 5 and 7 and then the gaps would be filled by re-scanning the field with lines 2,4, 6 and 8.

Television Standards

Picture quality is determined by the scanning spot size and, therefore, the number of lines required to fully scan the field. There are many reasons why amateur television should follow existing broadcast standards, not least of which is the availability of receivers. There are two UK broadcast standards, the original 405 line ‘black and white’ system A, and the later 625 line system I which includes colour. Both use an aspect ratio of 4 x 3, and both transmit 25 pictures per second. The highest modulation frequency generated during scanning in system A is about 3MHz, whilst 5 to 5.5MHz can be generated in system I.

Any TV system can include a sub-carrier with colour information; the normal 625 line system uses a colour sub-carrier frequency of 4.43MHz. A black and white system does not of course require a colour sub-carrier.

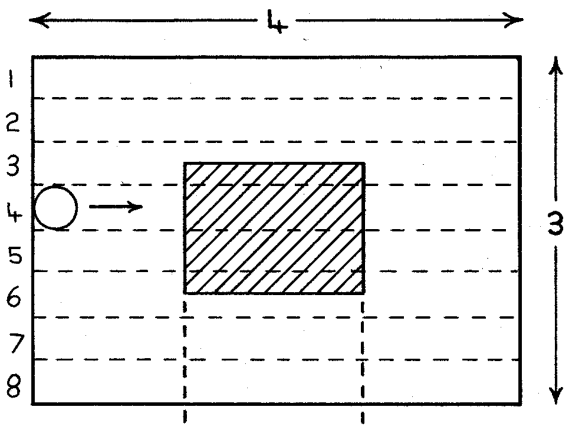


Fig. 1 (a)

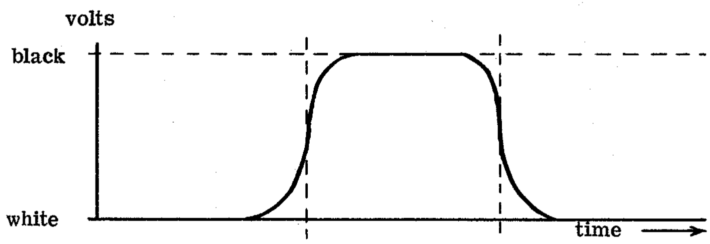


Fig. 1 (b)

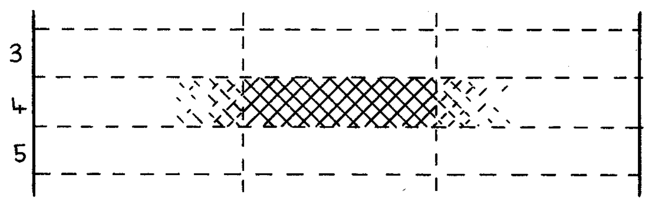


Fig. 1 (c)

The Modulating Waveform

The scanning system output will be used to amplitude-modulate the transmitter, and it is necessary for the receiver tube beam to be in the same two-dimensional position as the scanning beam in the transmitter camera. As stated earlier, a single communication channel can only handle one bit of information at any instant of time but, in addition to the video information, it is necessary for the transmitter to send synchronising information to the receiver indicating the precise position of the scanning spot in both horizontal and vertical planes.

Fig 2(a) shows the modulating waveform during a one-line scan. The video signal varies the transmitter output according to its amplitude. Time is taken from the complete video line scan by ‘blanking’ the video signal for a fraction of the total line period. During the blanking period a line-synchronising pulse is inserted which takes the transmitter output from 30% to near zero. This pulse is processed in the receiver to ‘tell’ the sweep circuits when to start the line scan across the CRT face. When the line scan reaches the bottom of the field, a field blanking pulse blanks several lines and a train of broad pulses are inserted during the blanking interval (Fig 2(b)). The receiver processes this train of pulses to return the CRT beam to the top of the display tube to retrace its vertical sweep.

Fig 2(a) shows what is termed ‘positive’ modulation as used in system A, in which peak white corresponds to maximum transmitter output. The 625-line system I uses the same principle but an inverted waveform ('negative' modulation) is used in which sync tips drive the transmitter to maximum output, and peak white is near zero.

For a black and white system, a complete picture requires two cycles of video and synchronising information, as shown in Fig 2(b). Colour requires, in addition, further information in the form of a 'burst' of about ten cycles of sub-carrier on the back porch. This burst experiences a phase change on every line and, although interlacing is completed in two scans, the complete cycle of blanking, pulses and colour-burst phase requires four fields, as shown in Fig 2(c). Fig 2(d) shows how the burst of colour sub-carrier (about ten cycles) is inserted on the back porch, together with the timing associated with the line blanking pulse.

Bandwidth and Channel Space

Television is characterised by the need to handle very high video frequencies throughout the system from the camera to the receiver, and this includes the aerial system Amplitude modulation of the transmitter would produce the normal double sidebands which, for system A, would require a channel space of about 6MHz, and up to 11MHz for system I. Including a sound channel to either system would increase the channel width by about another 1MHz.

It was realised very early in the history of broadcast television that the heavy demands for channel space would limit the number of available channels, and a new system for saving channel space was evolved and called 'vestigial sideband' (VSB), or 'asymmetric sideband' (ASB). Fig 3 shows the

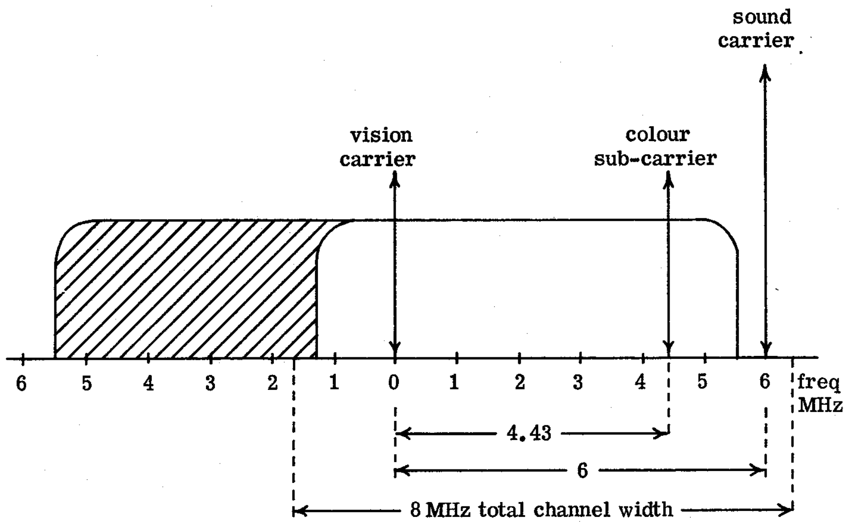
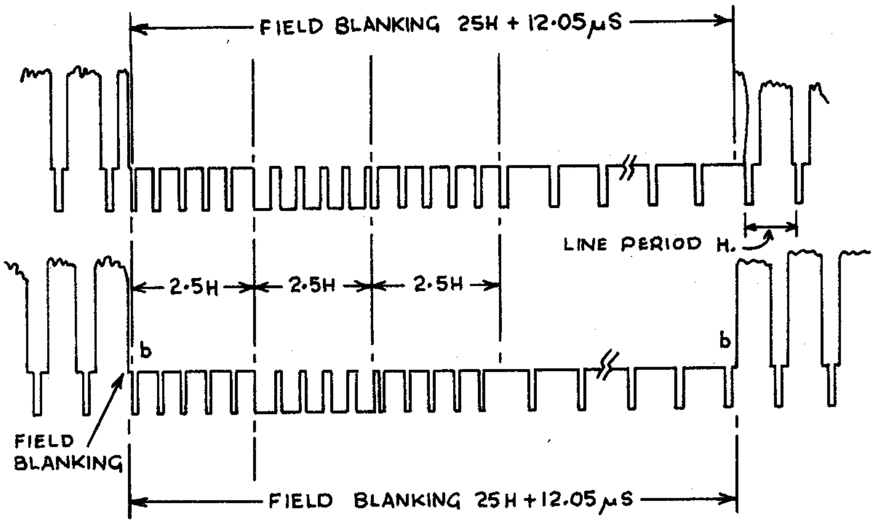


Fig. 3

FIG. 2b



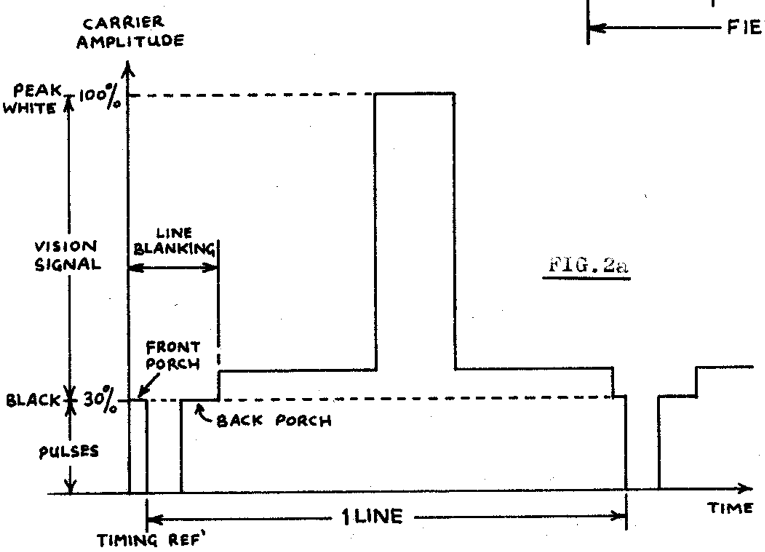


FIG. 2a

channel spectrum for one system I channel. VSB involves filtering off a large part of the lower sideband, leaving only about 1 MHz or so, and an overall channel width (with guard bands) of 8 MHz. With suitable tuning of the receiver IF circuits distortion of the vision signal by the loss of part of a sideband can be reduced to negligible proportions.

The bandwidth required for a single system I channel is 8 MHz. The 2-metre band is thus quite unsuitable for television transmissions. The 430 MHz band can only support one channel by the use of nearly the whole of the band. Higher carrier frequencies such as 10.5GHz are much easier to modulate than are low carrier frequencies and, of course, can provide the much-needed channel space. Another reason for using a band such as 10.5GHz is that risks of interfering with other users are minimised because the aerials used at both the transmitter and the receiver are highly directional and have a narrow beamwidth.

The Station

The modern amateur television station is neat, compact, usually solid-state and by no means complicated or difficult to construct and use. Gone are the days of 6ft racks of equipment, huge valved linear amplifiers and their associated lethal power supplies and large modulators. Gone also are the large valved ex-commercial cameras with their boxes of control equipment which took two strong men to lift.

A modern 10-Watt vision transmitter can be housed in a small neat cabinet often smaller than an H.F. bands transceiver. The tuner can also be incorporated in the same cabinet or tucked away inside the station TV set. If a camera is used it will typically be an ex-commercial surveillance type such as those seen in supermarkets and department stores.

The block diagram of a station is shown in Fig 4 and many amateurs use no more equipment than this.

It is often possible to modify an existing FM or SSB transmitter for video service without jeopardising its intended mode of operation. Solid-state linear transverters are usually quite suitable for vision use with fairly simple modifications. Custom-built transmitters are not difficult to construct using modern techniques.

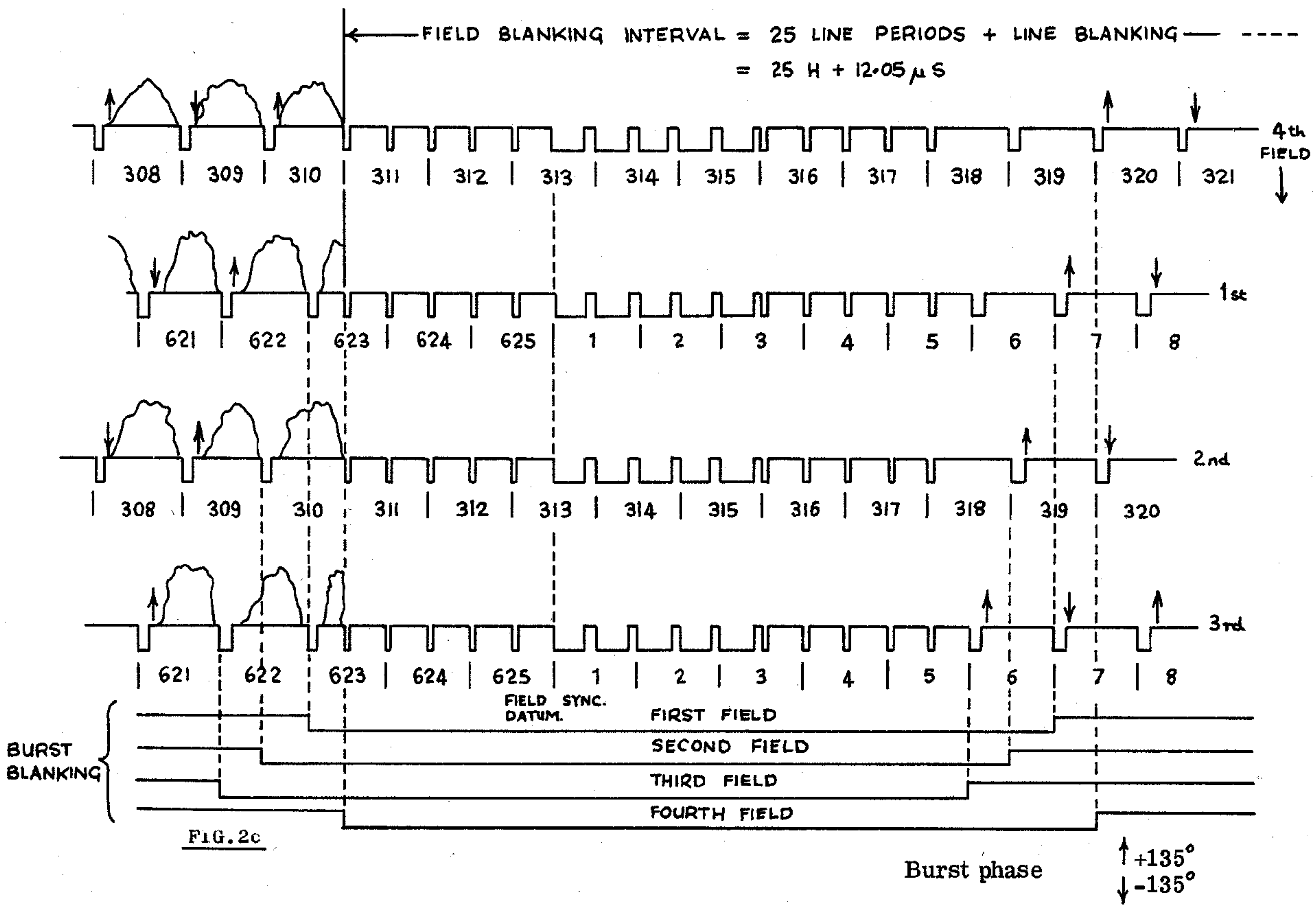


FIG. 2c

Aerials

Aerials suitable for amateur television are similar to those used for other modes of amateur radio, although the actual selection is limited by some specialised requirements. The two most important considerations in ATV work are gain and bandwidth. For anything other than local operation an aerial gain of 10dB should be considered to be the minimum requirement. Since television requires a stronger received signal for adequate results, care should be taken to obtain the maximum possible ERP from the aerial system over the whole of the 70cm band. Poor aerial design will degrade or lose colour sub-carrier and may cause you to miss foreign DX at the top end of the band.

Polarisation, though technically non-critical, should be horizontal since this is the standard used throughout Western Europe. Height and location of the aerial are prime factors and should be chosen carefully to ensure the shortest possible feeder length. The aerial should clear any local obstructions - including trees which absorb RF - and should have as clear a take-off as possible. Height gain increases usefully up to 50ft or so, above this the increase in gain due to height is offset by increased feeder losses, so ultra high aerial systems are often not ideal unless special arrangements are made to reduce losses.

In practice three types of aerials are in common use in the UK. The first is the eight-over-eight skeleton slot that has good forward gain (around 12dB) and adequate bandwidth for television work. It is small and light making it easy to handle and erect.

The second is the eighteen element Parabeam which has been around for many years. This aerial, although not so popular today, has a good performance in amateur television service. It exhibits high forward gain and a fairly good polar pattern together with sufficient bandwidth for modern colour transmissions.

Lastly there are the 'X' element types of aerial commonly known as 'Multi-beams'. The 48 element Multibeam achieves a gain of 15. 7dB and has a beamwidth of 26 degrees. It is 1.83 metres long. There is also an 88-element version that has a gain of 18.5dB. This is a very big aerial however, almost 4 metres long, and the beamwidth is so narrow (19 degrees) that it is easy to miss signals through incorrect beam alignment. The 48 element Multibeam is therefore considered by many as an ideal compromise and is one of the most popular ATV aerials presently in use. It has been noted by a number of amateurs however that the performance of Multibeams often falls off during wet weather, presumably due to the water on the element insulators shorting out the elements since these points are at high impedance.

Feeder Systems

Feeder cable should be 50ohms coaxial and should be low loss hard-line. Uniradio 67 is probably the minimum acceptable quality, anything flimsier or thinner will only be a disappointment. In particular beware of so called 'bargains' in 50ohm cable.

When choosing and installing coaxial cable try to ensure that the braiding is densely woven to provide adequate screening and preferably should be made from tinned copper strands since bare copper will oxidise in time and prevent good electrical contact between the individual strands. The inner dielectric should preferably be solid rather than semi-airspaced to try to minimise the ingress of moisture over the years.

When installing the cable avoid sharp bends and undue strain or pressure on any part of the feeder run and make sure that both ends of the feeder are properly sealed to stop moisture getting under the outer sheath and corroding the braiding. Finally, ensure that all connections to aerials, plugs and sockets are properly made, scrupulously clean and adequately protected against moisture.

The subject of RF connectors in VHF and UHF amateur stations is one that is often neglected but many would be surprised at the losses incurred by using poor quality or incorrectly chosen connectors. Ideally an RF connector will be transparent to the signal, i.e. it should appear like a continuous piece of coaxial cable.

There are many different types of connector available today and it is well worth establishing a standard throughout the station. Since large diameter coaxial cable is almost essential for effective 70cm work 'UHF' or 'N' types are to be preferred. 'UHF' (PL259, S0239) are adequate if correctly fitted but the 'N' type is undoubtedly superior and is used throughout the modern electronics industry. It is important that good quality plugs are obtained and fitted according to the manufacturers instructions, this is most important if the connector is to perform at its best.

'N' type and 'UHF' connectors however are rather bulky and it is good practice to use smaller connectors such as 50 ohm BNC and thinner cable for general purpose video and IF connections inside the shack. Do not use long runs of this coax at 70cm otherwise unacceptable losses will result.

Note that with 'N' type plugs and sockets 50 and 75-ohm types are NOT interchangeable because of different sized centre pins. If one decides to standardise with say 50 ohm 'N' type then it is strongly recommended that 75 ohm versions be completely excluded from the shack, junk box etc. to avoid costly mistakes.

The well known 'Belling Lee' type of plug and socket used commonly on broadcast television sets should never be used in an amateur station, the losses and un-reliability caused by these connectors make them totally unsuitable. In case you ask why, broadcast television signals are almost always very strong and therefore losses in poor quality cable and connectors are often insignificant.

Receivers

The most popular amateur television system in current use consists of a standard black and white 625 line TV, (the modern portable set sold in the high street is a popular choice) together with an external commercial tuner modified for 70cm.

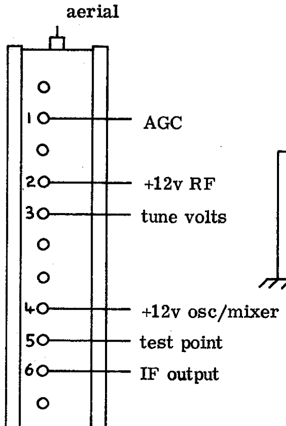


Fig.1

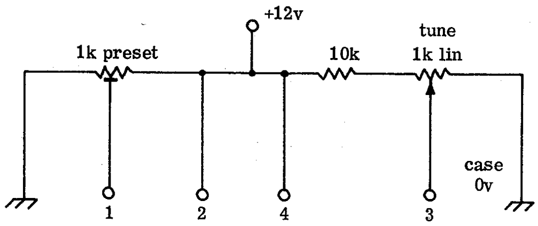


Fig.1(a)

A favourite tuner used extensively by amateurs is the Mullard ELC1043 and ELC1043/05. These are readily available and inexpensive; the later versions may not quite tune down as low as the 70cm band but by a simple modification can be made to do so. The tuners as purchased are quite sensitive and suitable for receiving local and semi-local amateur transmissions but the addition of a good pre-ainplifier improves the gain and sensitivity making the system suitable for longer distance working.

The IF output may be left tuned to the standard IF frequency and fed straight to the IF input of a domestic 625 line TV set; great care should be taken when using a mains operated set with a live chassis. If required a switch may be installed in the TV to change over from the internal to external tuner thus preserving the set for domestic use. Alternatively the IF may be set to channel 1 or 2 in band 1 and fed to the VHF tuner (if the set is dual standard), in this case though the timebase will need to be changed to 625 lines and the modulation sense should be correct for receiving negative modulation. The advantage of this system is that the gain of the VHF tuner is used as IF amplification giving perhaps a small advantage.

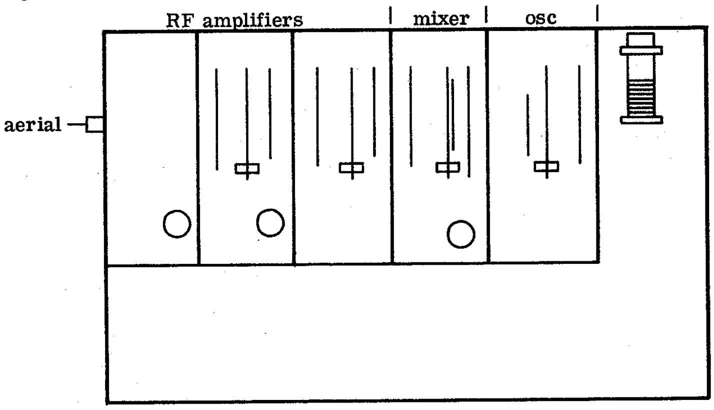


Fig.2

TOP VIEW

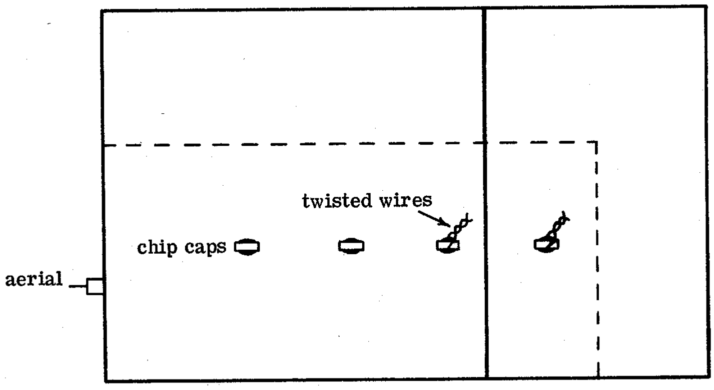


Fig.2(a)

BOTTOM VIEW

A slightly different converter makes use of the fact that only one 625 line television channel can occupy the band between 434 and 440 MHz at a time. The converter is adjusted such that it can only receive a television channel in this segment, thus there is no need for a tunable converter since this is the only place where television on 70cm is permitted.

This type of converter usually out-performs modified commercial tuners since it uses relatively high Q bandpass filters which considerably attenuates out of band signals and give a better overall noise performance. Low noise transistors are used in the RF and mixer stages and the mixer is usually more capable of handling strong interfering signals without causing intermodulation distortion.

Some domestic TV receivers-particularly it seems the Japanese sets-will tune directly to 70cm without modification, in this case all that is needed is the addition of a good low noise pre-amplifier to make a suitable amateur TV receiver.

The ELC1043 Series Tuners

Fig 1 shows an ELC1043 type tuner and gives the layout and pin connections. A circuit for wiring up the tuner is given in Fig 1(a) the 1K linear potentiometer is the main tuning control that should preferably be mounted onto a 10-1 ratio reduction drive.

The later model ELC1043 and ELC1043/05 may not tune low enough to cover the 70cm band and consequently will need slight

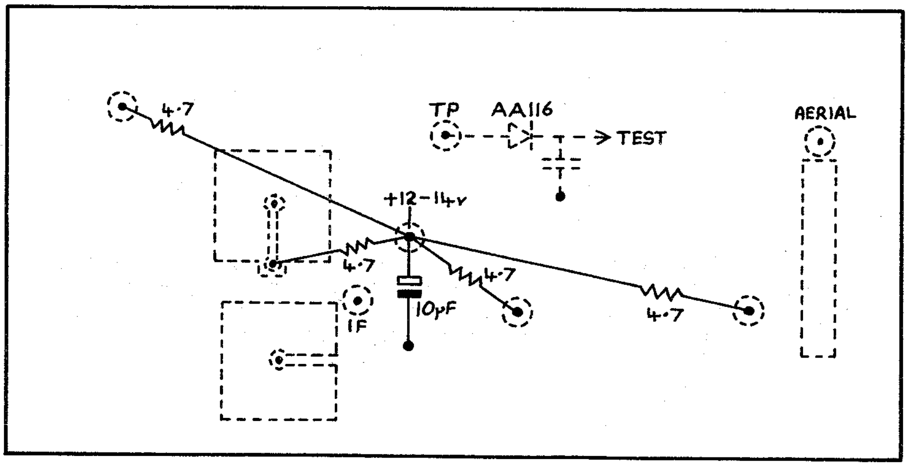


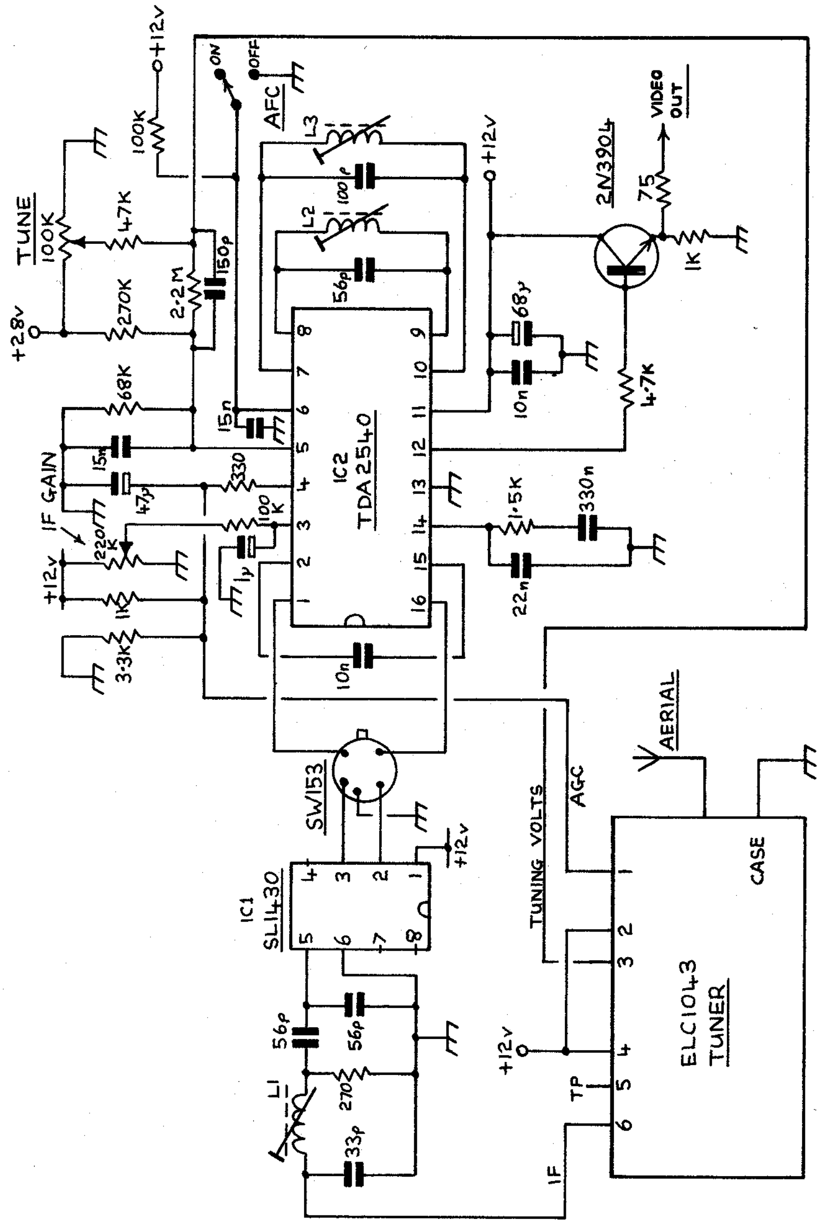
Fig. 5 EARTH PLANE SIDE.

modification to enable them to do so. Two modifications are described here and either or both may be used as required.

The first and most effective is simply to lengthen the tuned lines in the mixer and oscillator compartments, this is done by unsoldering the main lines (those connected to the varactor tuning diodes) and pulling the line out of the PC board as far as it will go whilst still leaving enough line protruding through the print side to enable it to be re-soldered properly, this will effectively lengthen the line by up to an eighth of an inch overall, this should be sufficient to allow the whole of the 70cm band to be tuned. The RF amplifier lines may be lengthened in a similar manner and the tuner re-aligned.

The second modification increases the capacitor values in the oscillator and mixer tuned circuits.

Refer to Figs 2 and 2(a) and locate the ceramic chip capacitors at the ends of the oscillator and mixer tuned lines, these protrude through the print side of the board. Take two pieces of thin hookup wire about 1 inch long and solder one to each side of the oscillator and mixer chip capacitors. Set the tuning voltage on pin 3 to about 0.3 volts and with the aid of a strong local 70cm signal twist together the oscillator wires a little at a time until the signal is tuned in. In a similar manner adjust the wires on the mixer for maximum signal. It is important to use as little extra capacitance as possible since too much may stop the oscillator. The remaining tuned circuits should then be re-aligned for maximum signal.



RECEIVER CIRCUIT DIAGRAM.

A High Performance Wideband Tuner

This converter is a high performance unit which receives amateur television transmissions on the 70cm band. It is fixed tuned and covers the range 434 to 440 MHz and therefore needs no tuning control. The converter has a sensitivity and immunity to cross modulation which considerably exceeds that found in most commercial tuners. The performance owes much to the correct adjustment of the tuned circuits to reduce out of band signals.

This project is intended for those with access to proper test equipment but may also be successfully built by those less fortunate but who are prepared to spend time on the alignment.

The overall gain is of the order of 30dB with a supply of 14 volts. The measured noise factor of several specimen converters was measured at between 1.8 and 3dB. The bandwidth is nominally 6 MHz but can be adjusted as required, the passband ripple is better than 0. 5dB between 434 and 438.5 MHz. Total power consumption is around 40mA at 14 volts.

Circuit Description

Two BFR9l low noise transistors provide RF amplification of the signal before it is applied to the 40673 MOSFET mixer. The local oscillator is a self-oscillating push-pull circuit.

The input signal is applied to a quarter wave line L1 which matches the impedance of the aerial system to the first RF amplifier and provides input selectivity. The first transistor is used in a common-emitter configuration with the emitter lead soldered directly to the earth plane, because of this a compensation network is provided in the collector circuit to provide bias for the transistor in the absence of an emitter resistor.

The signal is then applied to the second RF amplifier via a bandpass filter consisting of two over-coupled tuned circuits L2 and L3 and then to the mixer via L4. The IF output is fed to the transformer that has adjustable capacitive coupling. The secondary has an adjustable capacitive potential divider for correct matching to the IF unit and to control the damping on the output tuned circuit due to the output load.

The push-pull oscillator circuit uses printed inductors and has been found sufficiently stable for TV reception. Oscillator injection is applied to gate 2 of the mixer via a 9pF trimmer capacitor.

Construction

The tuner is built on a double sided printed circuit board, most of the components are mounted on the circuit side, the underside is used as an earth plane and for the point-to-point wiring of the 4.7 ohm decoupling resistors in the transistor output circuits.

The 47pF coupling capacitors must be low impedance disc ceramic or chip types, all decoupling capacitors should be good quality disc ceramics. The trimmer capacitors are not critical with the exception of that which tunes L1, this should be an air spaced type. The trimmers are placed flat on the PCB and the earth connection, where needed, is passed through the board and soldered onto the earth plane. The 4.7 ohm decoupling resistors should be mounted on small stand-off insulators on the earth plane side (see Fig. 5).

RF chokes CH1 and CH3 are made from 12 turns of 28swg enamelled copper wire close wound using a one eighth drill and made self supporting on SHORT leads. CH2 and CH4 have 10 turns on a 1K ¼W resistor.

The transistors should be mounted last, the BFR9l's are mounted on their edges with the emitter leads passing through the board and soldered to the earth plane in such a way that they are as short as practicable. Bend the leads of the oscillator and mixer transistors about half a millimetre from the case

to unplug the iron from its supply just before making the joints.

Screens are used to isolate the RF stages from each other, positioning is shown on the circuit diagram (Fig.3). The screens may be made from sheet brass, copper, tin or double-sided copper laminated board and fixed to pins pushed through the board and soldered through to the earth plane. Care should be taken to make cut-outs in the bottom of the screens to prevent fouling of components or shorting of the printed tracks. A long cut-out should be made in the screen separating the bandpass filter lines to enable the shorting link to be adjusted during alignment.

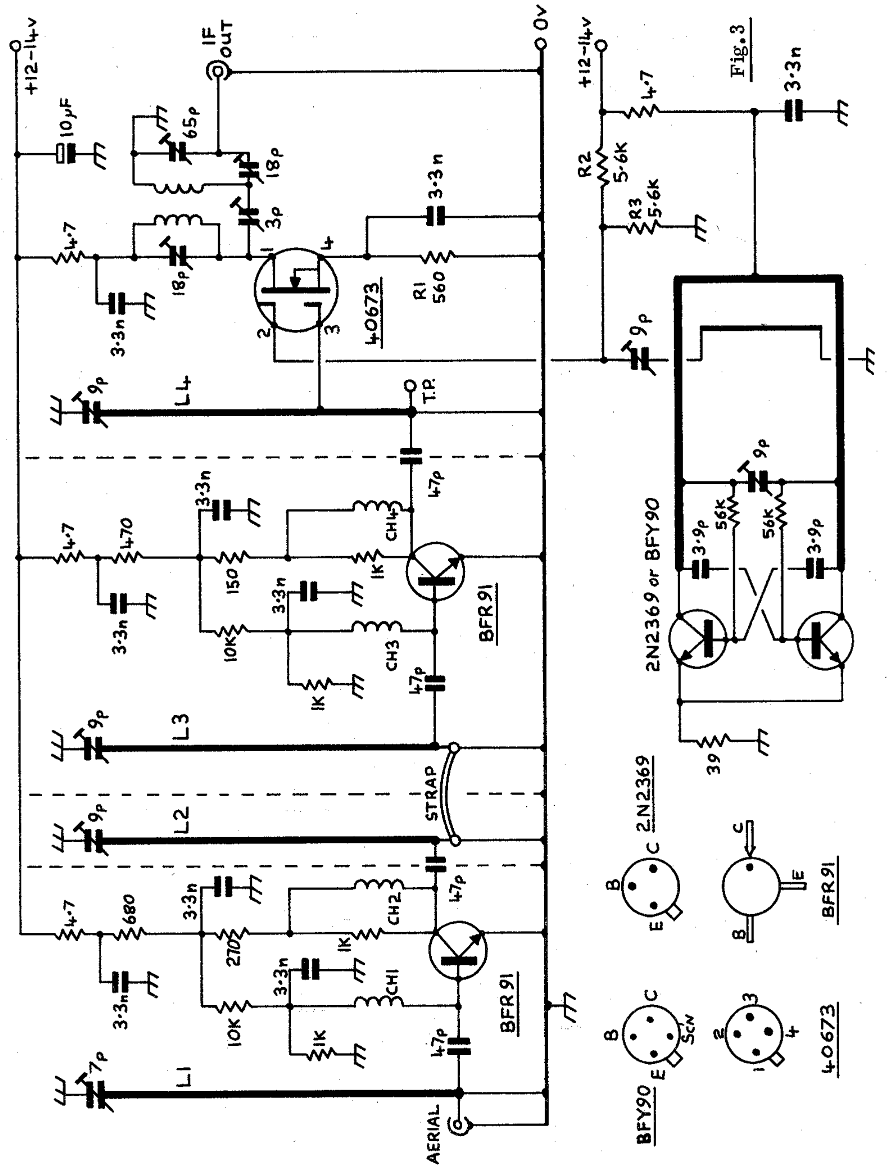
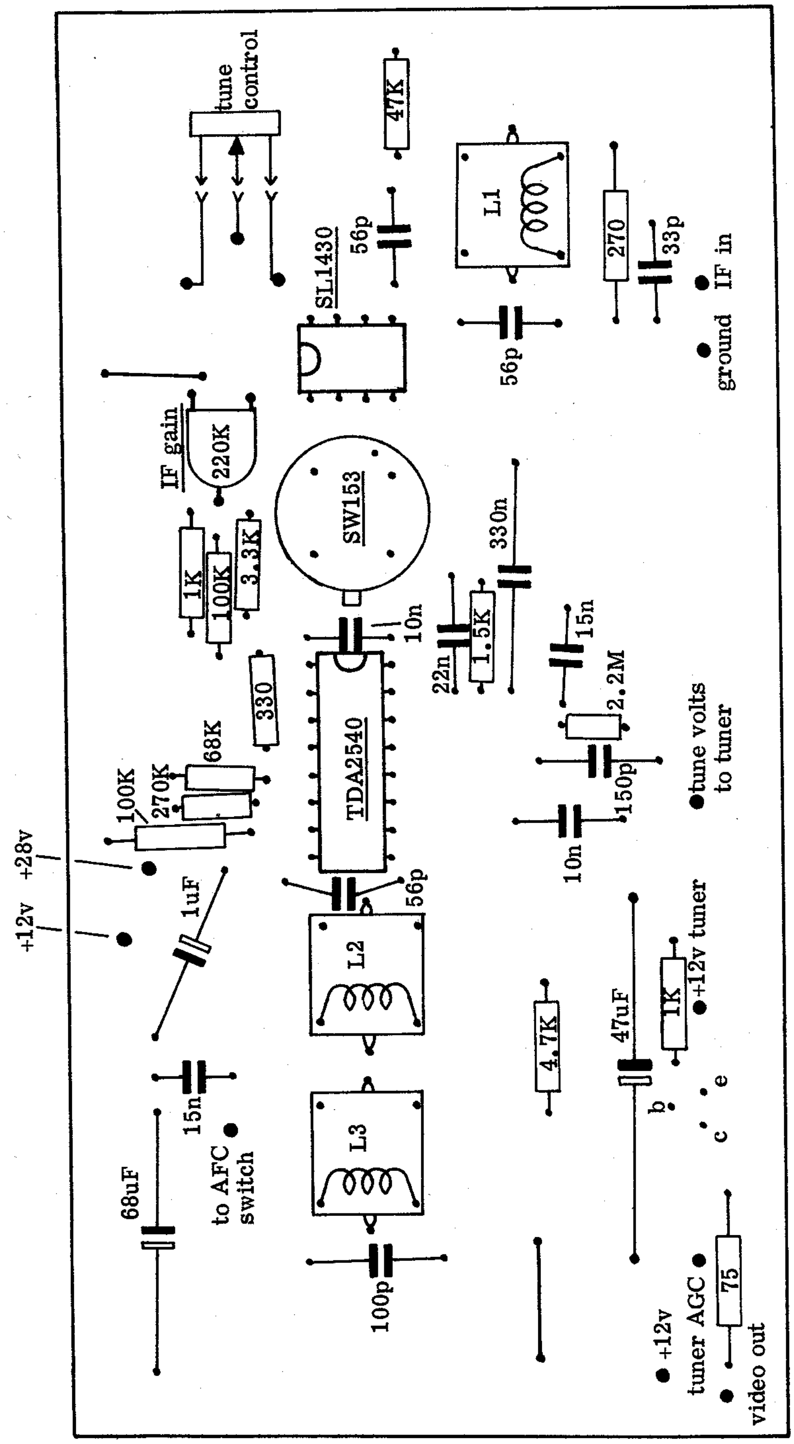


Fig.3

and solder them with a small iron keeping the leads as short as possible. Special care should be taken to ensure that the iron used to solder the FET is properly isolated. In practice it is wise

Adjustments

The converter is intended to have an IF frequency on a convenient channel in band 1 but can be modified for the standard TV IF frequency or any other



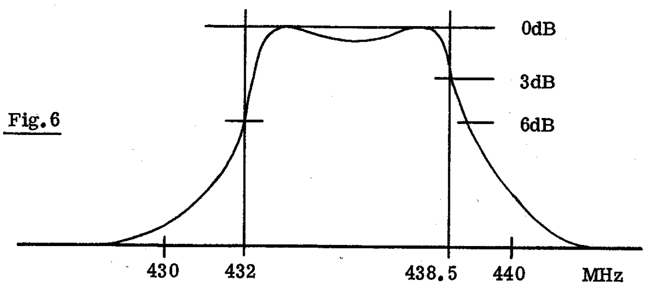
COMPONENT LOCATIONS.

suitable frequency up to about 250MHz.

Adjustments are best made in three stages with the aid of a sweep generator, detector and oscilloscope display (a Polyskop or similar RF analyser is ideal).

Connect the swept source to the aerial input and the detector probe to the test point on L4. Adjust the capacitors on L1, L2, L3 and L4 and the position of the shorting strap between L2 and L3 to obtain a passband curve having a band-width between 434 and 440MHz at the -1dB points.

Fig.6



RESPONSE CURVE.

Using a grid-dip oscillator, frequency counter or a receiver adjust the local oscillator frequency to that required for the chosen IF output.

The oscillator is positioned on the low side of the input and is calculated from:

F oscillator = F input - F if.

eg. for an IF frequency of 39. 5 MHz and taking the centre of the band as 437 MHz the oscillator frequency is:

F oscillator = 437MHz - 39.5MHz = 397.5MHz.

For final adjustments connect the swept source to the aerial input and the detector probe to the IF output socket. Adjust the four trimmers around the output transformer to achieve a curve similar to that shown in Fig. 6. Finally re-adjust the capacitor on L4 to peak in the middle of the band.

In the absence of proper test equipment the converter may be adjusted by trial and error using a strong local amateur TV signal. If a signal generator is available a probe can be made using a germanium diode and a decoupling capacitor the output of which is connected to a sensitive voltmeter, the probe should be connected to the points described earlier. By manually tuning the signal generator and plotting the response on a piece of graph paper it should be possible to obtain the correct curve.

If a high IF frequency is used it may be necessary to short circuit one or more turns of each output transformer winding and to increase the values of the oscillator injection and tuning capacitors.

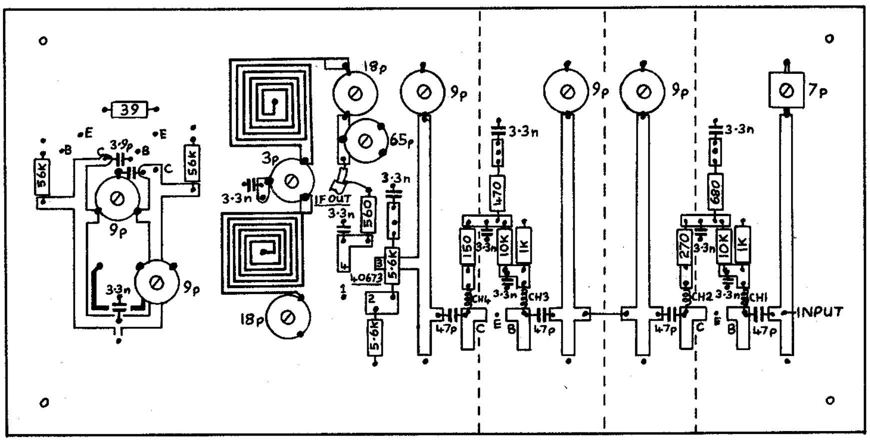
If the standard IF frequency of 39.5 MHz is chosen it will be necessary to increase the four trimmer capacitors around the output transformer to roughly twice their original values. This may best be done by selecting fixed capacitors and placing them in parallel with the existing trimmers. It may be necessary to change the 3pF coupling capacitor to around 10pF to achieve the correct response.

The completed converter should be housed in a screened box which can conveniently be made from sheet metal soldered together or from copper laminated printed circuit board.

A drilled and tinned printed circuit board is available for this converter, details of which may be found at the back of this book.

An Amateur Television Receiver

This receiver differs from the majority of systems used by television amateurs in that it includes IF selectivity, amplification, demodulation, AGC and AFC circuits and its output is 1 volt peak-to-peak video. Thus there is no need to use the RF circuits of a standard broadcast receiver, display being via a video monitor.



COMPONENT LAYOUT.

The tuner can be a modified ELC1043 commercial type, the broadband converter shown elsewhere in this chapter or any other tuner having an IF frequency of 39.5 MHz. The tuner IF output is matched to the IF pre-amplifier (IC1) with the tuned circuit L1/C1, R1 ensures correct broadband termination.

IC1 is a high gain IF amplifier and is needed to offset the large loss caused by the selectivity filter.

Selectivity is achieved using a surface acoustic wave filter (SAW). This filter is specifically designed for the UK 625 line broadcast television standard and is a significant advance on the multitude of tuned circuits previously required.

The differential output from the SAW is applied to IC2 which is an IF amplifier, video demodulator, AGC and AFC generator all on one integrated circuit. The tuned circuit L2/C2 is a critical part of the synchronous demodulator and must be of good quality and high Q. L3/C3 is part of the AFC generator, its adjustment is described later

The video signal from pin 12 of IC2 is applied to an emitter follower which matches the output to 75 ohms suitable for feeding a video monitor.

Construction

Component layout is not particularly critical providing care is taken to preserve symmetry around IC2, input and output circuits should be kept well separated and all leads should be as short as possible, particularly those on the bypass capacitors. Connections to the SAW filter should be made in such a way that the input and output leads are kept as short as possible and are kept away from each other otherwise the filter passband characteristic may be distorted.

The printed circuit board should be mounted on top of the tuner using 3/16 inch spacers. The two top corners and one of the bottom corners should be earthed to the tuner case.

If the whole of the broadcast band is not required the 28 volt tuning supply may be omitted and the 12 volt supply used instead. Band-spreading for 70cm may be obtained by fitting a series resistor between the tune control and the tuning volts rail, this resistor should be chosen to give a tuning volts range of between 0 and 1.5 volts.

Coil details

L1	12 turns
L2	6 turns
L3	4 turns

In each case using 26 s.w.g wire, close wound on a 4mm former with a ferrite core.

A drilled and tinned printed circuit board is available for this receiver, details of which may be found at the back of this book.

Alignment

Alignment is best carried out using a strong television signal such as one of the local broadcast transmitters.

Adjust the core of L1 to about half way and the IF gain control to mid-position, switch off the AFC.

With no aerial connected measure the dc voltage between video output and ground, adjust L2 and note the voltage reading at each end of the adjustment range, adjust the core for a voltage reading exactly mid way between the two.

Connect the aerial and tune in a strong signal. Switch on the AFC and adjust L3 until the signal is brought back on tune (this adjustment is fairly critical).

If an oscilloscope is available monitor the video output waveform and adjust the ‘scope to display one or two lines of video, check the adjustment of L2 and if necessary re-adjust slightly for minimum distortion of the video waveform.

Finally, adjust L1 and the tuner IF output coil for maximum signal.

Transmission

Video Modulators

Modern amateur television transmitters are usually low power and invariably have transistorised final amplifiers. It is often possible to vision modulate an existing FM or SSB “black box”. These will typically produce HF levels up to about 10 watts.

Vision modulation is quite straightforward and details are given here of two modulators suitable for transmitters up to about 2 watts or 10 watts respectively. The circuit of the low power modulator is given in Fig 4 and is very simple whilst that required for higher power is shown in Fig 5.

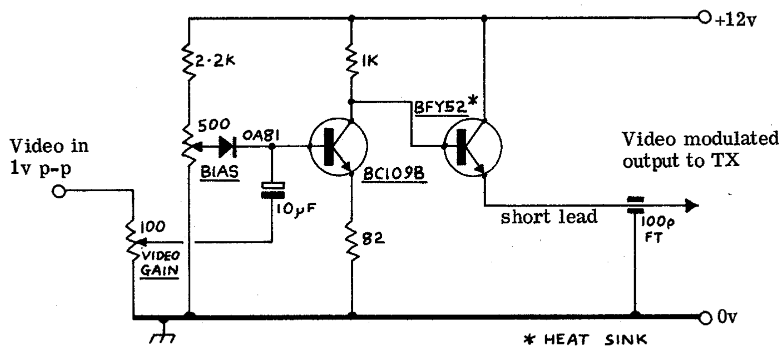
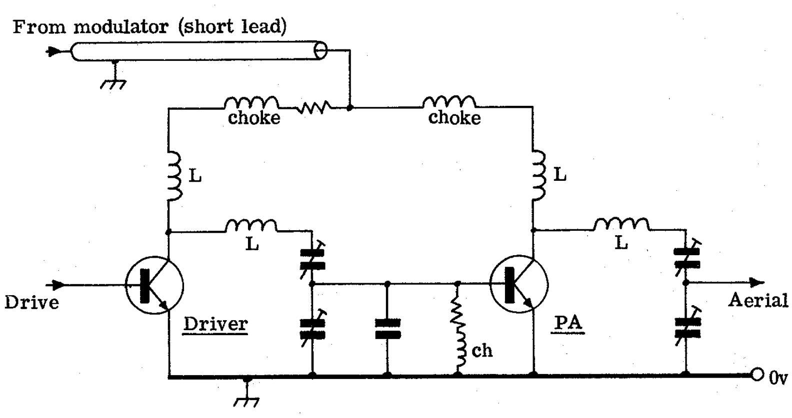


Fig 4 VIDEO MODULATOR FOR 2W TRANSMITTERS



Showing a typical driver/PA with video modulator connected.

“High level” modulation is used in both cases and on the low power version the bandwidth has been reduced to 3MHz so that the resulting signal comprising carrier and both sidebands can be contained within the limits of the 70cm band.

Both modulators are wired in series with the HT supply to the final amplifier of the transmitter. It is important that a very short lead is used and that all bypass capacitors which exist in the original transmitter HT circuit to the stages to be modulated are removed, otherwise the video information will be lost. A choke will prevent HF from entering the modulator. Bypassing may be accomplished with LOW value capacitors (100pF or less).

If possible both the final amplifier and its driver stage should be modulated to achieve a reasonable depth of modulation.

The bias control sets the black level and the video gain control sets the level of the picture signal. With the transmitter switched on and with no video input, adjust the bias control until about three-quarters of the transmitters output power is observed on a power meter, then connect a video signal when it will be seen that the power output will drop, this indicates modulation and it will be expected that the power will drop to about half which indicates a good depth of modulation. Final adjustments should be carried out by using a video HF probe and monitor or a local station receiving the signal.

The modulators should be built in well-screened boxes to exclude HF and should have adequate heat sinks for the output transistors.

A Modular Linear Amplifier

The Motorola MHW710 hybrid module an integrated circuit and transistor device which is encapsulated in blue epoxy and mounted on a heat sink flange. It was originally designed as a 15Watt class C amplifier for radio telephone use and has been used as the final amplifier in many 70cm amateur FM transmitters-principally in the US. When correctly biased and driven however it can be made to work as a linear amplifier though with reduced output power.

To achieve linear amplification suitable for television service an HF level of 80mW is sufficient to drive the output to 10Watts peak, care should be taken not to overdrive the module otherwise compression of the video and sync pulses will result. The power supply must be 13 volts plus or minus 1 volt and very well regulated, power leads should be as short as possible and certainly not longer that 18 inches. Supply levels greater than 15volts may destroy the module. The amplifier is otherwise virtually indestructible and will tolerate a high VSWR or even no load for short periods.

The following notes regarding amplifier adjustment and operation apply equally to other amplifiers used for television transmission.

Although this unit will deliver 10Watts peak to a 50 ohm load a power meter will show considerably less, typically half peak power. This is because with a negative modulation sense such as that used by most amateurs peak power will only be acheived on sync tips, black level will produce about 7Watts and the video information will drop the power towards zero - thus the power meter reading is proportional to the average power developed by the complex modulating signal.

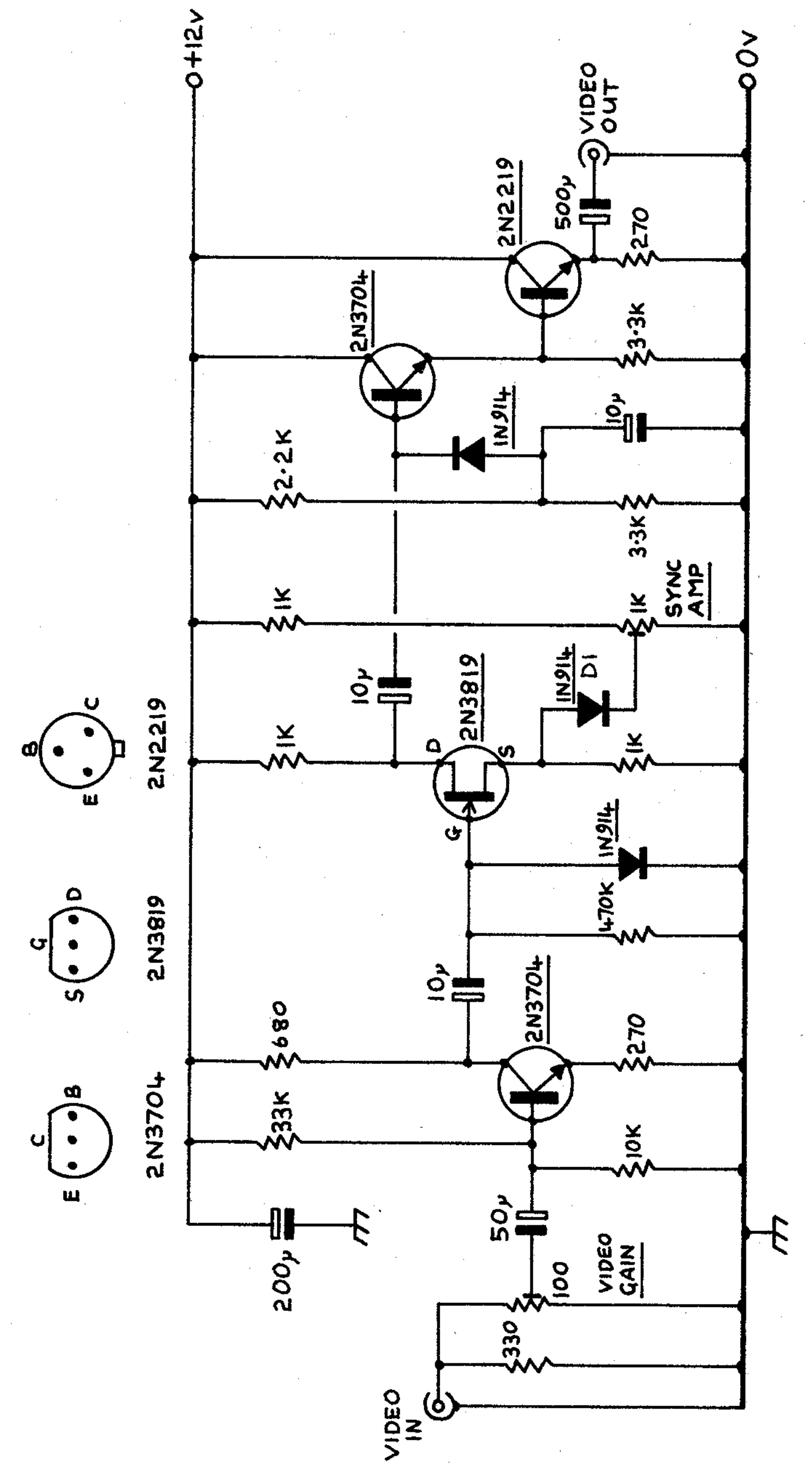


Fig. 2 Sync stretch amplifier.

A technique of 'pre-distortion' is often used to raise the average power generated by the video information whilst ensuring that the sync pulses are not crushed. A suitable sync-stretch pre-distortion circuit is shown in Fig. 2. Using this circuit the power amplifier can be driven into sync compression until the syncs are reduced to their proper size.

The video signal is amplified, inverted, DC restored and applied to the gate of an FET. DC restoration is necessary so that the amount of distortion is independent of the average signal level.

The gain of the FET stage is unity but during the sync period diode Dl switches on and effectively reduces the value of the source resistor thus increasing the gain. The amplitude of the syncs can be adjusted with the sync amp control. DC restoration is again applied to re-establish black level before the signal is passed to the emitter follower output stages.

The output signal of an amateur television station should always be monitored with an HF probe and an oscilloscope to check that an undistorted signal is being radiated. Fig. 3 shows a suitable probe.

A pickup wire is connected to a tuned circuit and the signal demodulated to produce a video signal which is fed to a two-stage emitter follower, the resulting output is suitable for display on a video monitor.

A 1mA meter is provided to give an indication proportional to the HF output power and is useful in tuning the transmitter since, because of the tuned circuit, it only responds to power at 70cm.

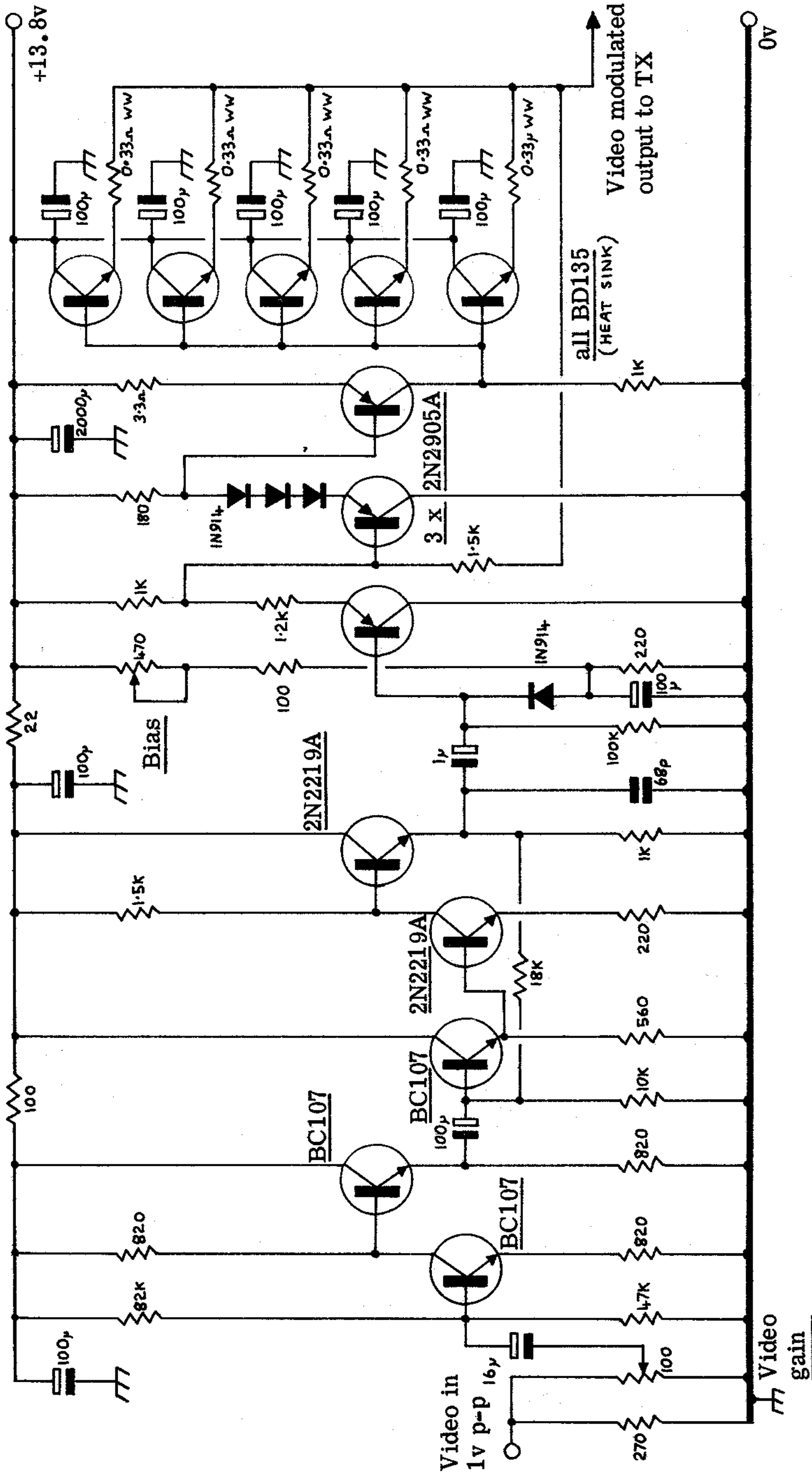
Construction.

Construction should preferably be on a printed circuit or plain copper laminate board which should be firmly secured to the aerial feeder. To insert the pickup wire cut out a small square of outer covering from the coax cable and push open the braiding, thread a thin piece of connecting wire under the braiding for a distance of about half an inch and connect the free end to the 4.7pF coupling capacitor using as short a lead as possible. The actual length of wire will vary according to the HF output power of the transmitter but will usually be between a quarter and half an inch.

Adjustment.

Connect the video output to an oscilloscope terminated with a 75 ohm resistor. Transmit a properly modulated television signal and adjust the input tuned circuit for maximum, adjust the length of the probe pickup wire until about 1 volts peak to peak is displayed on the oscilloscope. Set the meter adjustment control for a convenient reading, usually about two-thirds deflection.

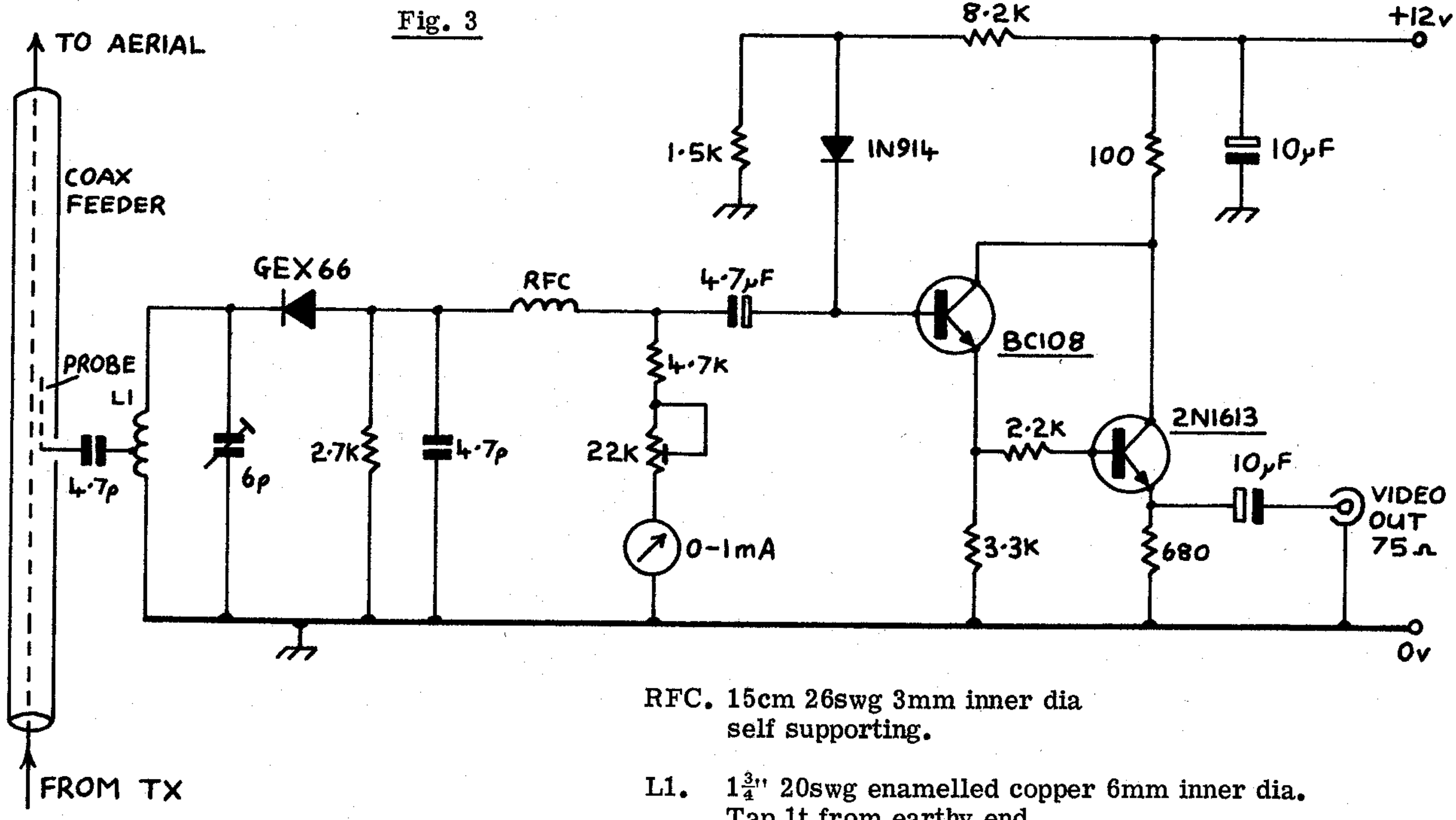
The MHW710 module is available in the UK mounted on a finned heatsink and wired as shown in Fig. 1 from Blean Video Systems, 4 Mount Pleasant, Blean Common, Canterbury, Kent, CT2 9EU



VIDEO MODULATOR FOR 10W TRANSMITTERS

Fig 5

Fig. 3



RFC. 15cm 26swg 3mm inner dia
self supporting.

L1. $1\frac{3}{4}$" 20swg enamelled copper 6mm inner dia.
Tap 1t from earthy end.

RF probe

An Electronic Character Generator

This character generator is designed to enable two lines of up to eight characters per line to be superimposed upon any existing composite video signal. Its most obvious applications are for callsign generation, CQ captions and so on. The characters can be varied in height and width and can be positioned anywhere on the screen.

The unit takes its sync information from the video signal upon which the superimposition is to be made.

The unit is based upon a read only memory character generator which generates the complete ASCII character set in a seven by five dot matrix. The use of the ASCII code could enable modifications for keyboard operation if required.

Characters are selected by a diode matrix on the main board but an edge connector has been made available to enable remote programming with various plug-in boards if required.

TTL logic devices are used in the timing circuits because of their availability, flexibility and low cost.

The character generator is designed for 825 line operation but can easily be modified for 405, 525 or even slow scan television standards. The generator works with colour as well as monochrome sources.

Circuit Description.

The 2513 character generator ROM (1C9) has nine inputs (Al to 9) and five outputs (1 to 5). For any combination of logic 0 or logic 1 on the input or address lines a given combination of logic 0 or logic 1 will appear on the output lines, the precise combination being set by the programme within the chip. This programme is set up by the manufacturer and cannot be changed by the user.

```
 1111          01111
1              10000
1              10000   ROWS
1              10000
1    11        10001
1     1        10011
  1111         01111

               COLUMS
 Fig.1         Fig.2
```

For example Fig.1 shows the letter 'G' as it appears on the screen. It is made up from the 7 x 5 dot matrix. To generate the letter 'G' address lines A4 to A9 must be preset with the following code: -

Input line	A4	A5	A6	A7	A8	A9
Logic state	1	1	1	0	0	0

Fig 3

This causes the five outputs to go to 0 0 0 0 0 (top row, Fig.2) which is applied to the serial-to-parallel converter. The converter can be considered like a rotary switch that is driven by a binary coded decimal (BCD) code supplied from the first (column) counter. Output 5 is first connected to the video combiner, then, on the next clock cycle, the counter is incremented and the BCD code is advanced by 1 to connect output 4 to the combiner and so on until 6 cycles of the clock have passed and all the columns of the first row have been clocked out.

To clock out the second row of the 'G' the column counter is reset and the second (row) counter is incremented, this counter supplies a BCD code to the ROM address lines A1, A2 and A3. Incrementing this counter causes the second row to be output from IC9.

ROW CODE			OUTPUTS (1C9)				
A3	**A2**	**A1**	**5**	**4**	**3**	**2**	**1**
0	0	0	0	0	0	0	0
0	0	1	0	1	1	1	1
0	1	0	1	0	0	0	0
0	1	1	1	0	0	0	0
1	0	0	1	0	0	0	0
1	0	1	1	0	0	1	1
1	1	0	1	0	0	0	1
1	1	1	0	1	1	1	1

Fig.4 **Fig.5**

As the parallel to serial converter is incremented the code 0 1 1 1 1 is obtained. The column counter is reset and the row counter is incremented yet again to clock the code 1 0 0 0 0 out of the parallel-to-serial converter. The column counter is reset and the row counter incremented again to clock out the third row and so on until all 7 rows have been clocked out of the serial-to-parallel converter.

In the video combiner a logic 1 causes the TV screen to be driven to peak white and the letter 'G' will be displayed. To display a different letter all that is required is a different code on the address lines A4 to A9 as listed on the programme chart.

The fast clock runs at about fifty times line speed and is stopped during line sync so as to make it synchronous, this clock drives a counter that controls the parallel to serial converter and the first output is the top row of the first character.

When this is complete the counter resets itself and advances the letter change counter which generates binary code driving a binary to hexadecimal converter IC10 which increments and changes the code on A4 to A9 to that of the second letter in the matrix. The parallel-to-serial converter now clocks out the top row of this letter and increments the matrix to the next letter, resets itself and so on until the top row of the top line of print has been displayed. The character code counter resets and the process is repeated, in all it does this on four lines or more of the screen depending upon the setting of the character size switch. The row counter is then incremented and repeats the exercise on the next four lines of the raster except that this time the second row of the top line of print will appear ie. 0 1 1 1 1 in our example 'G'. Row count is then incremented and row 3 is clocked out and so on until the top line of print is present on the screen.

After the first line of characters has been written a counter is incremented to provide a most significant bit into IC10 which has been working 0 to 8 so now it works 8 to 16, i.e. a different location in the matrix which is programmed with the second line of print. The above process is repeated and the second line of print appears. Finally a clock stop bus disables the fast clock and no further characters are generated until a frame pulse occurs which resets the counters and the whole process is repeated.

If the printed circuit board matrix is being used the inputs to 1C9 are brought out to a six bit address bus which runs along the top of the printed circuit board. The outputs from IC10 are brought out on links, the link at the end of the address bus, i.e. that furthest from IC9, corresponds to the first letter.

One final point on plug-in matrix boards, the ASCII address bus is already brought out to the edge connector because it is required to interconnect to the keyboard module so all that is required to remote the matrix so that plug-in programme modules are possible is that the programme links be wired to the edge connector. II you decide to do this you should use pins 7 through to 11 and 22 through to 32 with the link nearest the edge connector going to pin 7, this will keep all modules compatible with each other and not cause any problems later when adding the keyboard module.

SSTV Modifications

To make the character generator work on SSTV standards it is necessary to change the value of the components marked *

In Fig. 6 the 1nF capacitor on pin 9 of 1C3 is changed to 1nF and the 390ohm resistor between pins 8 and 9 is changed to a 470ohm with a 100ohm pot in series with it to adjust the character width.

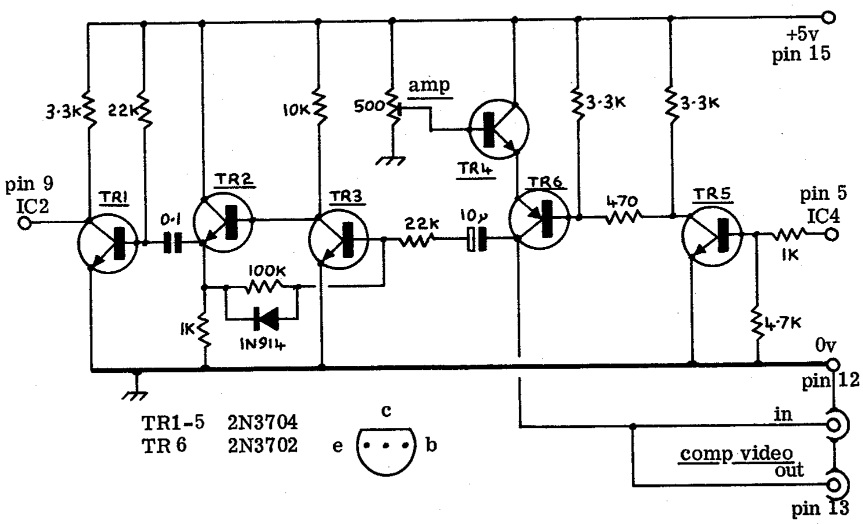


Fig.7 ANALOGUE DIAGRAM

Also included in the circuit are two monostable delays, one triggered from line and one from frame which are used to inhibit the clock, this is so that the display can be moved to different positions on the screen.

It is important to keep the print within the active area otherwise it can infringe on the blanking or sync pulses; this is because no mixed blanking is provided into the video combiner in order to keep the circuit as simple as possible.

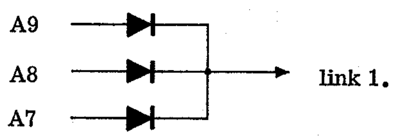
Programming.

To choose each individual character a simple diode array is required which will connect the A4 to A9 inputs of 1C9 to the binary-to-hexadecimal chip IC10. At the input of IC10 is a four-bit code that changes every time a different character is output. The output of IC10 has 16 pins each of which goes low in turn as a different character is required.

The inputs of IC9 are pulled high by the 100k pull-up resistors so that the code input to IC9 with no diodes in circuit is 1 111 1 1 and produces the **'?'** symbol. A diode between an IC9 input and an IC10 output will cause one of the logic 1 states to be replaced by a logic 0.

The programme chart shows the placing of diodes to create any character. In the case of 'G' for example there is an 'X' in the first three columns, 'X' mean that a diode is required so the A9, A8 and A7 inputs require diodes whilst A6, AS and A4 are left blank. The bus nearest the top edge of the printed circuit board is A9 and is represented by the first column in the programming chart.

The diodes are wired with the anode to the data bus and the cathode connected to the link corresponding to their position, i.e. if the first letter of the top line is the letter 'G' then diodes connect from A9, A8 and A7 to link 1.



If the character required is a blank space then five diodes are needed, this is a small problem when working with this kind of code but it does represent a considerable economy in diodes over the earlier X-Y matrix type of character generators.

PROGRAMMING CHART

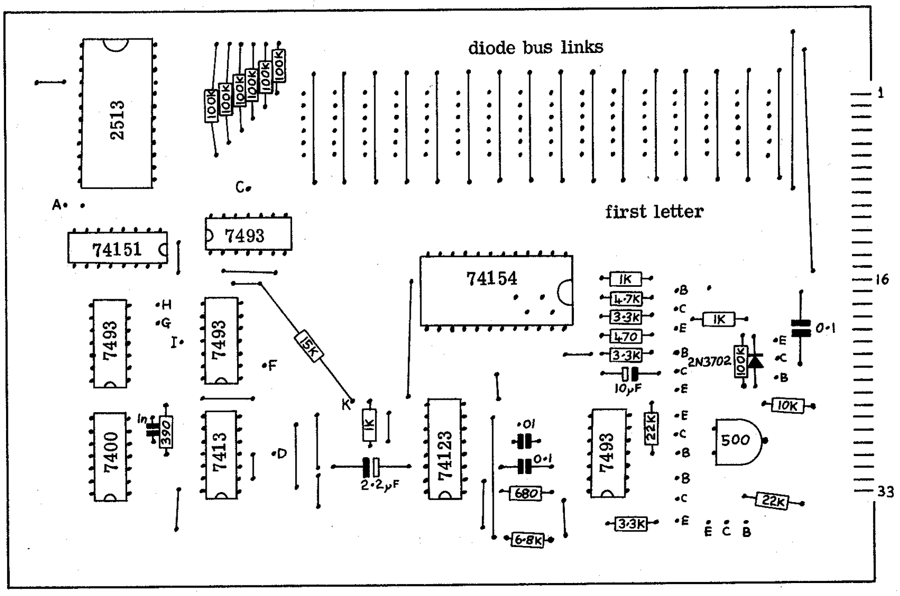
CHARACTER	A9	A8	A7	A6	A5	A4
A	X	X	X	X	X	
B	X	X	X	X		X
C	X	X	X	X		
D	X	X	X		X	X
E	X	X	X		X	
F	X	X	X			X
G	X	X	X			
H	X	X		X	X	X
I	X	X		X	X	
J	X	X		X		X
K	X	X		X		
L	X	X			X	X
M	X	X			X	
N	X	X				X
O	X	X				
P	X		X	X	X	X
Q	X		X	X	X	
R	X		X	X		X
S	X		X	X		
T	X		X		X	X
U	X		X		X	
V	X		X			X
W	X		X			
X	X			X	X	X
Y	X			X	X	
Z	X			X		X
BLANK		X	X	X	X	X
0			X	X	X	X
1			X	X	X	
2			X	X		X
3			X	X		
4			X		X	X
5			X		X	
6			X			X
7			X			
8				X	X	X
9				X	X	
-		X			X	
/		X				

'X' denotes that a diode is required.

On IC2 the 2.2μF capacitor between pins 14 and 15 is increased to 100μF.

The 0.01μF capacitor between pins 6 and 7 is also increased to 2. 2μF with the positive end wired to pin 6. The 5.6k resistor from pin 7 to the supply rail is changed to a 1.5k. The 680ohm resistor and the 0.luF capacitor on pins 1 and 9 are omitted.

The circuit of Fig.7 is not required for SSTV



COMPONENT LOCATIONS.

The unit now requires driving with field and line drive at pins 1 and 9 of IC2 and will produce TTL level characters at pin 5 of IC4.

Construction

Care should be taken when mounting the 2N3702 and 2N3704 transistors since some devices have non-standard lead configurations.

Provision for a diode matrix is made on the board but if the remote prog-ramming facility is required connections may be jumpered across to the edge connector.

When wiring the on-board matrix the links shown on the layout diagram should be made about a quarter of an inch high so that the diodes can be mounted vertically.

It is usually best to mount all integrated circuits using IC sockets; the real value of this becomes clear during fault finding. Sockets are particularly important on the two 24 pin devices.

External synchronisation may be applied if required by disconnecting the 10µF capacitor from TR5 collector and applying mixed syncs to the free end of the capacitor.

As an aid to troubleshooting removing 1C9 should cause the characters to be written as white blocks on the screen. Removing IC10 (but leaving 1C9 in place) will cause question marks to be written into all character positions, this will also occur if no diodes are present in the matrix.

A drilled and tinned printed circuit board is available for this character generator, details of which may be found at the back of this book.

A Processing unit

As previously described the character generator superimposes a white caption onto an existing composite video signal. The unit can however be used purely as a caption generator to produce white letters on a black background and synchronised to the station sync pulse generator, this makes it suitable for feeding a caption keyer etc.

The circuit shown in Fig 7(a) picks off the character video information and mixes it with syncs to produce a dedicated composite output.

The video information in the character generator appears at 1C4 pin 5, this should be connected to pin 14 of the edge connector. Mixed syncs (2v p-p) are applied to the composite video input socket of the character generator and to the mixed sync input of the processing unit.

The video information is fed to pin 1 of the open-collector quad 2 input NAND gate (SN7403). The sync signal is gated and fed to pin 2 of the IC to inhibit video during sync periods. The potential divider on the base of TR2 sets black level. When video is present the diode is switched on and the output goes to peak white. The composite video output is nominally 1V p-p across 75 ohms.

A Memory Unit for the Character Generator

This unit, which is intended to be an add-on accessory for the electronic character generator described earlier, enables character programming to be carried out with switches instead of a diode matrix and permits up to four different pages of text to be stored and recalled as required. A page consists of two lines of up to eight characters per line.

The memory unit works by storing the data set up on the switches in a 04 x 8 bit random access memory chip (IC11), the information being read out at the appropriate time to the character generator ROM (1C9) in the character generator unit.

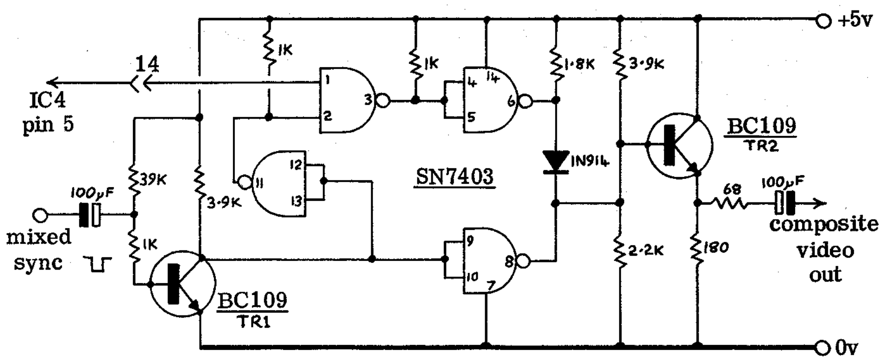
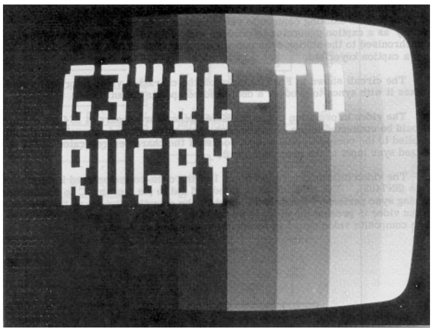


Fig 7 (a)

The character generator circuit diagram is shown in Fig. 6, a four-bit address code applied to pins 20 to 23 of IC10 is decoded and passed to the diode matrix, diode arrays generate a code for each character that is applied to 1C9. With the memory unit installed the four bit code is applied to the RAM address lines, the output (data) bus is connected to the character generator ROM 1C9, IC10 is disabled and the diode matrix is not required.



This photograph illustrates a caption superimposed over colour bars. The characters do not affect the colour.

Circuit Description.

To write data into the RAM the correct address must be set up on the address bus. 1C13 is a four-bit up/down counter that is manually incremented or decremented by the load/advance or backspace push buttons.

The four bit output is compared with the four bit code from the character generator unit in 1C12, when the same address is reached the gates driving the data bus are enabled and the character set up by the switches is displayed. To load this into RAM, press the load button and a write command will be presented to IC11 pin 6.

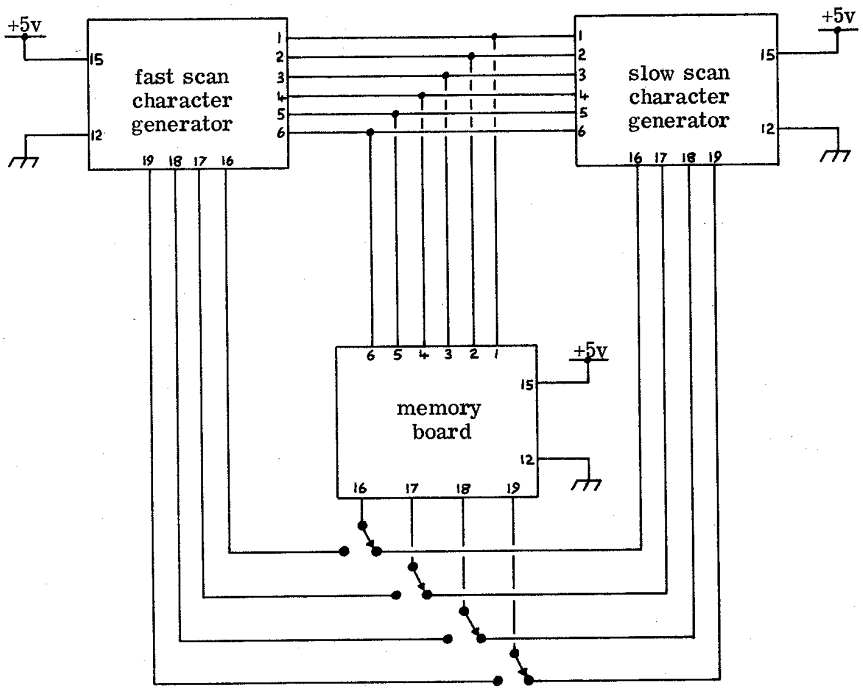


Fig. 9. INTER-BOARD WIRING FOR FAST/SLOW SCAN APPLICATIONS.

Installation.

To install the memory unit remove the ground connections from pins 18 and 19 of IC10 on the character generator unit, this returns its output to question marks and ignores the diode matrix.

Connect pins 20 to 23 inclusive on IC10 to the edge connector according to the following table.

Connect the two boards together via their edge connectors, as shown in the table. Note that not all edge connector pins are used.

The backspace and load/advance switches must be changeover push button types and must rest in the position shown on the circuit diagram.

SSTV Use

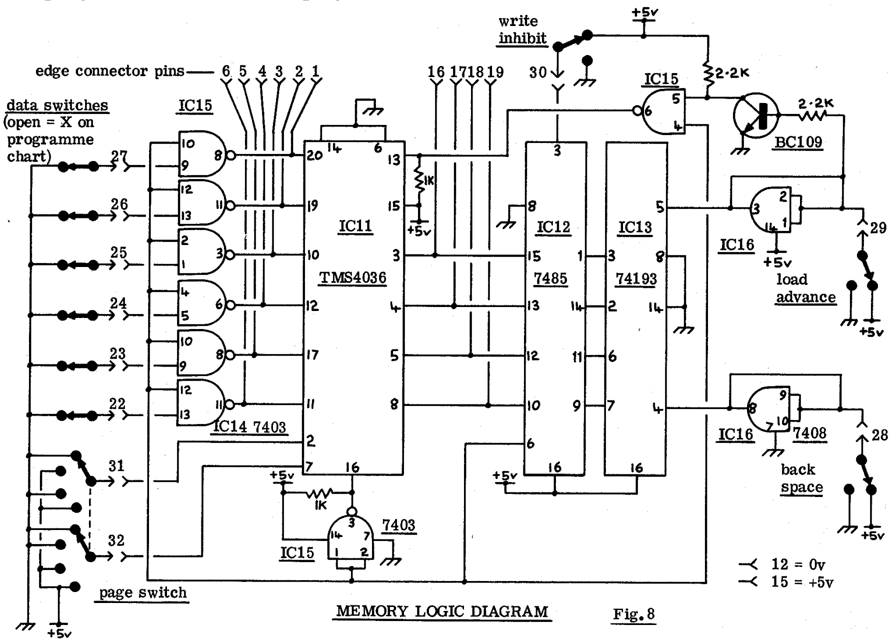
When using the memory unit with a slow scan version of the character generator the load button must be kept depressed until the character has been scanned. Alternatively the system shown in Fig. 9 may be used, this enables the messages to be set up on fast scan, stored into memory and read out at slow scan rate.

Keyboard

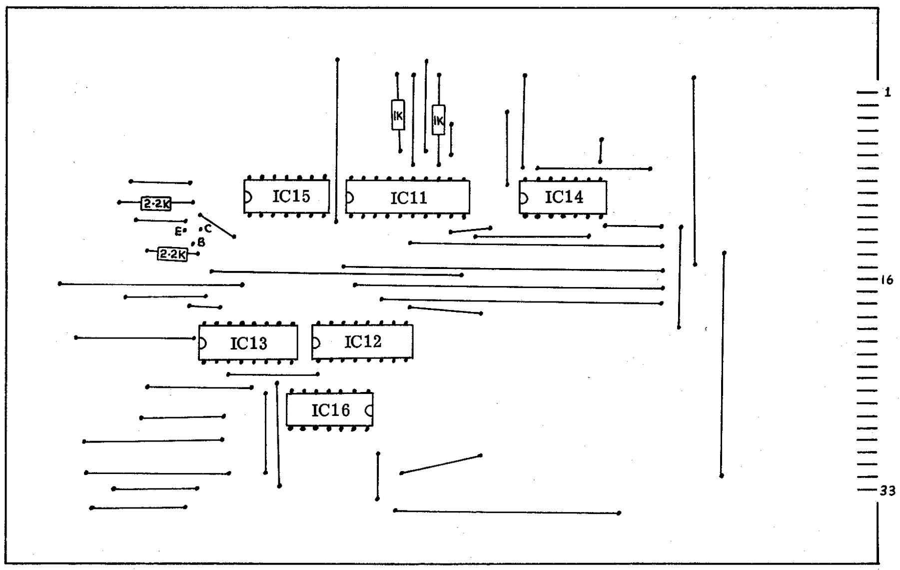
For those who may wish to use an ASCII keyboard instead of the data switches the following notes may be helpful.

The keyboard parallel data should be fed to the switch inputs on pins 22 to 27 after first being inverted, this is necessary because of the inversion that takes place in ICs 14 and 15. IC16 is no longer required and should be removed from the board. The keyboard strobe pulse should be connected to pin 29 of the edge connector, this may also need to be inverted depending on the type of keyboard used.

A drilled and tinned printed circuit board is available for this memory unit, details of which may be found at the back of this book.

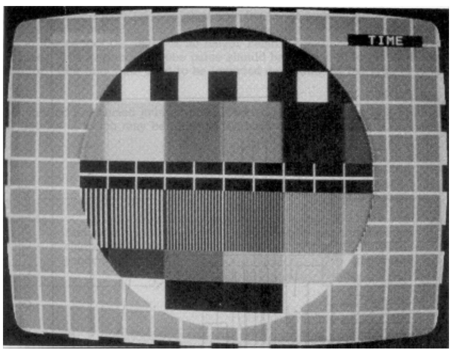


MEMORY LOGIC DIAGRAM Fig.8



COMPONENT LOCATIONS.

A Colour Test Card Generator



Introduction

This unit was designed to provide an electronically generated test pattern to replace the conventional test-card/camera combination. The concept is not, of course, original; the familiar Phillips PM5544 test card has been with us for some years now and many broadcasters have designed similar units for their own use. No particular merit for originality is claimed for this design except that it is simple and cheap enough for the average amateur to tackle.

Facilities

The generator requires an Input of standard mixed-sync and mixed-blanking pulses plus a 5volt power supply, and provides RGB outputs suitable for feeding to a colour coder. The general appearance of the test card can be seen from the photograph although it is reproduced here in black and white for reasons of economy.

It is not as comprehensive as its commercial counterparts but does Include the most important features needed for evaluation and adjustment of picture monitors, etc. These are as follows;

- CROSSHATCH for linearity and convergence tests including a special central pattern for static convergence.
- CASTELLATIONS for setting picture size.
- A CIRCLE for aspect ratio and linearity tests.
- GREY-SCALE and COLOUR BARS for video and coder adjustments.
- MULTIBURST for focus and high frequency response.
- LETTER BOX for low frequency response (smearing).
- RED/WHITE alternate bars for testing chromlnance/lumlnance delay.

In addition to the composite test card, individual full-screen waveforms can be selected by means of an optional decade thumbwheel switch.

These are:

- Field square-wave (50Hz).
- Multiburst (1.25 to 6.67MHz).
- Red/white bars.
- Grey scale.
- Colour bars (100%).
- Peak white.
- Black.
- Line square-wave (15.625Hz).
- Cross-hatch (white on black).

Note that because of the masking effect of the circle, the multiburst part of the composite testcard covers the frequency range 1.5 to 5MHz.

GENERAL DESCRIPTION

The unit is split up into three functional blocks, each of which occupies a standard sized printed circuit board.

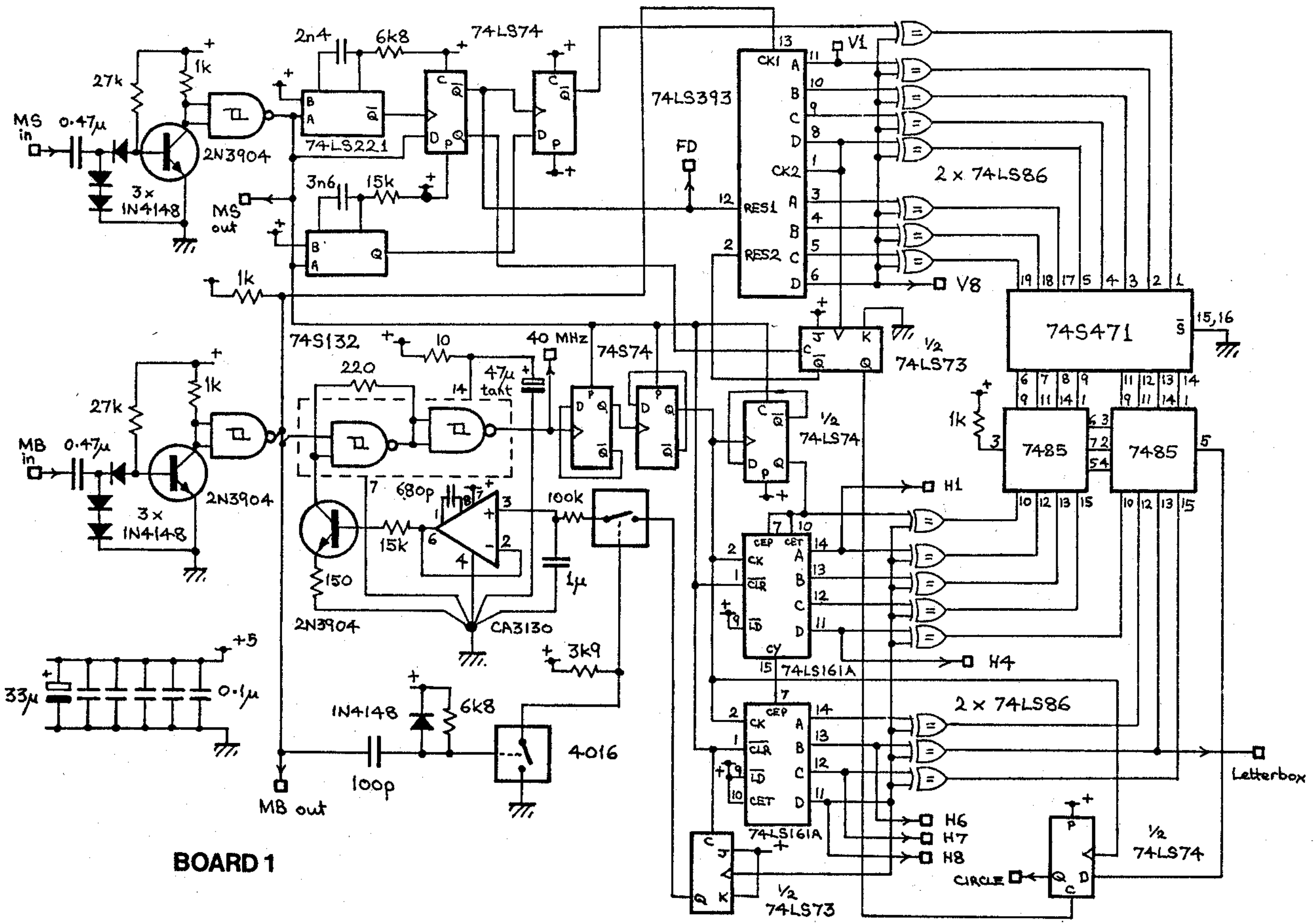
Board 1 is the timing generator which accepts mixed syncs and blanking and generates a line-locked clock at approximately 40MHz which is divided down to give various horizontal waveforms) and derives field and line drive pulses. This board also contains the circle generator that uses a PROM to store the circle shape information.

Board 2 generates the cross-hatch, multiburst and castellation waveforms by counting and gating together pulses from board 1; board 3 combines and selects the various signals from the other two boards so as to produce the required composite RGB output. It would be a simple matter to modify board 3 to adapt the final pattern to suit individual requirements, for example an electronic ally generated callsign could replace one of the patterns within the circle.

Circuit Description . Board 1

The mixed sync and blanking inputs (standard 2v p-p) are first converted to 'TTL levels by the transistor and diode input circuits. The arrangement adopted results in the input signals being 'sliced' at a level of approximately twice the voltage dropped across a diode from their positive excursion, this being about right for 2V p-p pulses. If a non-standard pulse amplitude is used some experimentation may be required; any disturbance or glitches in the TTL syncs and blanking waveforms can wreak havoc in the digital circuitry.

The TTL sync signal is fed to two monostables, one with a period of approximately 11µS and the other 37µS, the output of the latter being a line frequency square-wave with half-line information removed. The output of the first mono-stable clocks a D-type flip-flop that has syncs fed to its D input, the result being that the Q output is normally 1 but during broad pulses It changes to 0, in other words, the output



of the flip-flop is field drive. The field drive in turn clocks another D-type, which this time has the 37µS monostable output fed to its D input. Because on one field the first broad pulse occurs during the first half of a line, and on the other during the second half, the flip-flop output consists of a 25Hz picture rate square wave.

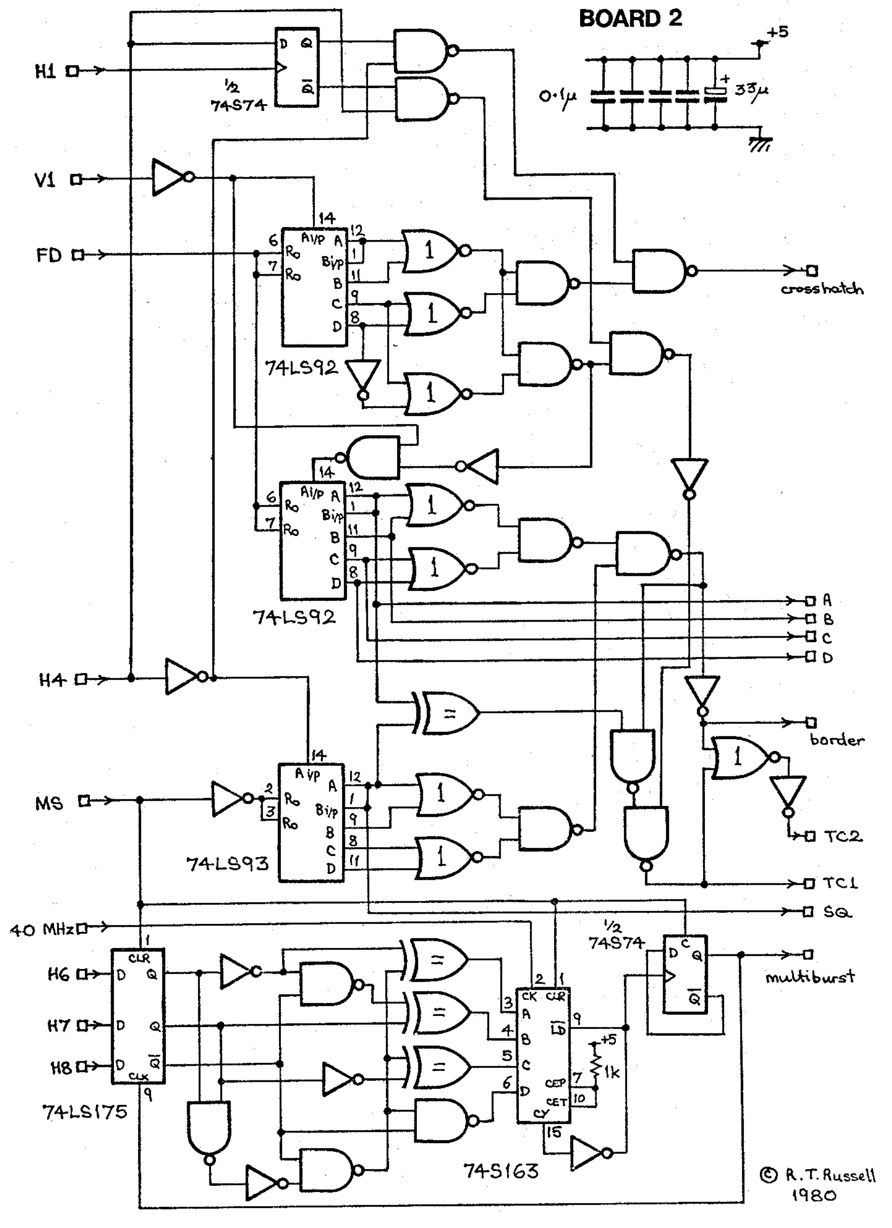
The TTL mixed blanking signal enables a 40 MHz oscillator consisting of a Schmitt-trigger gate with feedback from output to Input. A Schottky device must be used here because a standard speed gate will not oscillate at 40MHz. It will be noticed that the usual timing capacitor from the Schmitt input to ground is absent, and is replaced by a transistor! This transistor, along with stray capacitance, allows the oscillator frequency to be varied so as to maintain the period of the oscillator at exactly one 2048th of the active line period (approx 52µS). Line locked oscillators are notoriously troublesome in their somewhat conflicting requirements of accurate frequency stability and precise phasing with respect to syncs. The novel approach adopted here is to separate these requirements by using a hard-gated oscillator to ensure good phase stability plus a slow-acting frequency control loop to keep the period correct. Obviously this does result in an oscillator that is as sensitive to short term disturbance, as is a free running oscillator, so extreme care must be taken not to couple noise or transient signals into it. In practice single point earthing has been found desirable plus local decoupling of the oscillator supply as shown on the circuit. It may be necessary to add a small capacitor (up to 10µF) from ground to the Schmitt Input.

The 40MHz clock is divided by 4 in the 74874 to give a gated 10MHz clock (actually 9.86MHz) which feeds the horizontal counter. This consists of half of a dual D type flip-flop plus two 4-bit synchronous counters, giving nine bits in all. The counter outputs follow a binary sequence of 0 to 511 from left to right across the television line. The most significant bit (MSB) of this counter is used to clock a J-K flip-flop on its negative transition. If the oscillator frequency becomes slightly lower than it should be there will be less than 512 clocks to the 9-bit counter during the active line period and the most significant bit will never be clocked back to zero. If however the frequency becomes high then the MSB will be clocked to zero before the end of the line. In the first case, therefore, the 74LS73 flip-flop output will remain low whereas in the second case it will be clocked high near the end of the TV line. The state of this flip-flop is sampled just at the beginning of line blanking by means of the CMOS analogue switch (4016) and controls the charging/discharging of the 1µF capacitor The voltage across this capacitor is monitored by the CA3130 FET input op-amp and determines the oscillator frequency. In this way the frequency is stabilised at the correct value. Several copies of this circuit have been made and it has been found to be very reliable.

The mixed blanking signal is also used to clock the 8-bit vertical (line) counter 74LS393. By means of the other half of the 74LS73 dual flip-flop, the most significant four bits of this counter are held reset to zero until after the first sixteen lines following field blanking. As the number of active lines per field is 288 (which equals 256+32) this results in the vertical count of 0 to 255 being accurately centred in the picture. Because of the interlaced line structure, spatially adjacent lines are in fact in opposite fields. From a spatial point of view, therefore, the 25Hz picture square wave represents the least significant bit of the vertical screen address, and Is used as such. What we have then is a horizontal count and a vertical count, both running from 0 to 511, correctly centred in the active picture area. From these signals most of the waveforms needed for the test card can be derived.

The circle generator works on the principle of storing in a PROM the value of the horizontal coordinates of the edge of the circle for each TV line, that is it stores values for X=SQR(RxR-YxY), one form of the equation of a circle of radius R. From what has been said, it might be thought that we need a value in the range 0-511 for each of 512 lines. However PROMs do not come with 9 bit outputs so it is fortunate that we can reduce this to 8 bits by taking advantage of the symmetry of the circle. The procedure adopted is to feed the 8 least significant bits of both vertical and horizontal counts each into an exclusive . 0 gate. The other inputs of the 8 vertical XOR gates are commoned and fed to the most significant bit of the vertical count, and similarly the horizontal ones are connected to the most significant horizontal bit. In effect, we have arranged that counts 0 to 255 are unaffected (the XOR gates acting as non-inverting buff e whereas counts 256 to 511 now become 255 to 0 on the exclusive-OR outputs because the 8 bits are inverted. We now have vertical and horizontal address€ which accurately reflect the symmetry of the circle and the PROM need hold on one quadrant's worth of data (256 eight bit words).

The modified vertical address is fed to the address inputs of the PROM, whose outputs now give the correct horizontal coordinate for the edges of the circle (note that the aspect ratio has been taken into account when calculating the PROM contents). All we need to do to actually generate the circle signal Is to compare the PROM outputs with the modified (reflected) horizontal count; when the count exceeds the PROM data then we are inside the circle, otherwise we are outside To this end, two 7485's are wired as an 8-bit comparator whose output is then de-glitched by the remaining D-type flip-flop to provide a clean circle.



Board 2 . Crosshatch & Castellation

The waveforms generated on board 1 are not directly suitable for producing the crosshatch and castellation signals (which we will call the 'basic test-card') for two reasons; firstly, we want the test-card squares to be truly square:, Because of the aspect ratio, and the choice of horizontal clock frequency, a rectangle of, say, 16 lines by 16 clock pulses is not a square. With an aspect ratio of 4:3 we will get squares if we divide the screen into 16 (horizontal) x 12 (vertical) parts. We cannot easily derive the appropriate vertical waveform from the counter on board 1, so instead an additional divlde-by-12 counter on board 2 is used, clocked from the least significant output of the vertical counter on board 1 (shown as V1 on the circuit). This results in an overall division factor of 24 (12x24=288). The divide-by-16 horizontal waveform is already available on board 1 so what is the other problem? We want to produce an all-round castellation, but the size of the large squares is too great to do this by having a central area of 10 by 14 squares and a one-square thickness border all round. Rather, the Ideal Is to have a 15 by 11 central region with a half-thickness border. This is what the second 74LS92 and the 74LS93 achieve. The arrangement adopted results in the second 74LS92 having a zero count during the top and bottom borders and the 74LS93 having a zero count during the left and right borders. It is a simple matter to gate these outputs together to produce a composite 'border' signal. To make castellation, we must use this border signal to enable a 'chequerboard' pattern-this is easily generated by gating together suitable horizontal and vertical square waves in an exclusive-OR gate (centre of circuit).

All that is now needed are two crosshatch patterns. One to form the dividing lines between the test-card squares (the lines are white and the squares grey) and the other for the central static convergence pattern. It may not be obvious why two crosshatches are needed; for static convergence there must be a ‘cross’ at dead centre whereas the test-card one does not provide this – it is offset in both vertical and horizontal directions. The horizontal components of the two crosshatch patterns are derived by gating together the outputs of the first 74LS92, resulting in horizontals 4-lines (per picture) thick. The vertical components are obtained by means of the D-type flip-flop at the top of the board 2 circuit diagram and when combined with the horizontals give the required crosshatch signals. The crosshatch which forms part of the ‘basic test card’ is gated with the castellation and border signals to form the component signals of the test-card TC1 and TC2 on the circuit).

Board 2 – Multiburst

Feeding the main 40 MHz clock into a programmable divider whose division ratio is changed in eight steps across the active line derives the multiburst signal. A square-wave output is required so the division factors must all be even. The factors chosen are: -

32	1.25MHz
26	1.54MHz
20	2.00MHz
16	2.50MHz
12	3,33MHz
10	4.00MHz
8	5.00MHz
6	6.67MHz

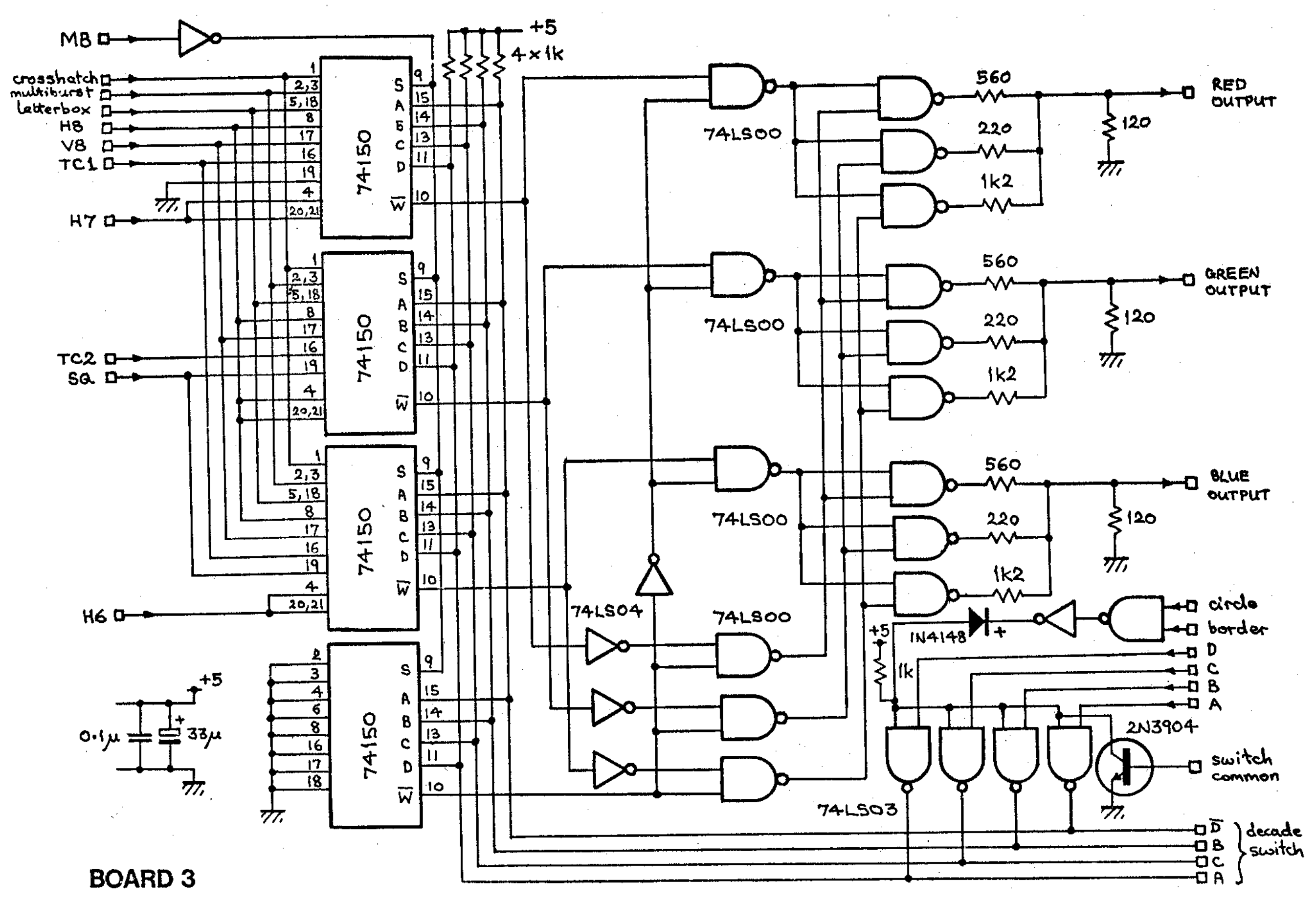
As mentioned earlier, the first and last are only available when the full-screen multiburst is selected. A 3-bit horizontal address (H6, H7i, H8) is taken from board 1 and latched by the 74LS175. It must then be converted into a four bit code which, when fed to the preset inputs of the 745163 divider, results in the required division ratios (in fact half the values given above as there is a subsequent divide-by-two stage). This is the function of the network of gates between the 74LS175 and the 74S163. If you care to work it out you should find that the correct code conversion is carried out, bearing in mind that the H8 output from the latch is inverted and that in fact the complement of the division ratio is required.

Board 3 – Pattern Selector & Output

This board has the simple job of selecting the required patterns to the correct parts of the screen, and of providing the RGB outputs. There are fourteen possible combinations of outputs – eight luminance values, from black through grey to white (R=G=B), plus the six saturated colours obtainable from the primaries (red, green, blue, yellow, cyan, magenta). The output stages consist of TTL signals resistively matrixed together so that each output, when terminated in 75 ohms, can take up a voltage between 0V and 0.7V in steps of 0.lV. The output circuitry is fed from four TTL lines; one selects monochrome or colour and the other three select either one of eight luminance values or one of the colours. Both black and white are obtainable either when ‘monochrome’ or ‘colour’ is selected, or advantage is taken of this to slightly simplify the selection circuitry.

The four bits controlling the output stages are fed from four 16 to 1 line multiplexers (74150), which have the various pattern signals from boards 1 and 2 fed to their inputs. When a full-screen pattern is selected the thumbwheel switch data is simply fed

R. T. Russell.



to the multiplexer address inputs. The circuit is arranged so that, using a decade thumbwheel having true and inverted outputs wired as shown, positions 0 through 7 and 9 select the nine patterns listed earlier. When the switch is in position 8, the common becomes open circuit and the 2N3904 turns off, thus allowing the A-D vertical select lines (from board 2) to control the multiplexers when the circle signal corresponds to 'inside'. When the circle signal is at 0 ('outside') the multiplexers receive an address of 1111 which selects the 'basic test card' to the outputs, the result being the full test-card display as shown in the photograph. By re-arranging the inputs to the 74150's many different effects can be achieved, but bear in mind that some inputs are used only in the test-card (e.g. letter-box) and others only for full-screen patterns (e.g. field square wave V8).

A useful tip is to temporarily disconnect one of the pattern inputs to board 3 and instead connect a flying lead to the 74150. If you select this Input with the 3witch, you have a ready made probe, which can be used to monitor signals within the generator on a TV screen. Mixed line and field rate signals, meaningless on an oscilloscope, are made instantly recognisable by this method.

The photograph shows a 'time' inset, which is not part of the test card generator but gives an example of the kind of additions that are possible.

Although at the time of writing, printed circuit boards for the test-card generator are in the design stage, it Is hoped to be able to offer these to con 5tructors shortly after publication. Details of the PC board set will be given in CQ-TV magazine.

0000	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
0010	F0	EA	E6	E2	DF	DB	D9	D6	D4	D1	CF	CD	CB	C9	C7	C6
0020	C4	C2	C1	BF	BE	BC	BB	B9	B8	B7	B5	B4	B3	B2	B0	AF
0030	AE	AD	AC	AB	AA	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	9F
0040	9E	9D	9C	9C	9B	9A	99	98	97	97	96	95	94	94	93	92
0050	92	91	90	8F	8F	8E	8D	8D	8C	8B	8B	8A	8A	89	88	88
0060	87	87	86	85	85	84	84	83	83	82	82	81	81	80	80	7F
0070	7F	7E	7E	7D	7D	7C	7C	7B	7B	7A	7A	79	79	79	78	78
0080	77	77	76	76	76	75	75	74	74	74	73	73	73	72	72	71
0090	71	71	70	70	70	6F	6F	6F	6E	6E	6E	6E	6D	6D	6D	6C
00A0	6C	6C	6C	6B	6B	6B	6A	6A	6A	6A	69	69	69	69	68	68
00B0	68	68	67	67	67	67	67	66	66	66	66	66	65	65	65	65
00C0	65	64	64	64	64	64	64	63	63	63	63	63	63	63	62	62
00D0	62	62	62	62	62	61	61	61	61	61	61	61	61	61	61	60
00E0	60	60	60	60	60	60	60	60	60	60	60	60	60	5F	5F	5F
00F0	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F

74S471 PROM for test card generator.
(Hexadecimal notation)

A pre-programmed PROM for this test card is available. Details of which are at the end of this book.

Construction & Testing

No serious problems should be encountered in getting the generator to work as long as good high-speed logic construction techniques are adopted throughout. Take particular care with decoupling and earthing. Trouble spots, if any, are likely to be the 40MHz oscillator on board 1 and the multiburst divider on board 2. Feeding a 40MHz TTL signal along more than an Inch or two of wire can be tricky, and you may find it helps to add a small series resistor at the sending end to absorb reflections.

Test Card Parts List

Board 1

2 off	7485
1 off	74LS73
2 off	74LS74
4 off	74LS86
2 off	74LS161A
1 off	74L5221
1 off	74LS393
1 off	74574
1 off	748132
1 off	748471
1 off	4016
1 off	CA3130
3 off	2N3904
7 off	1N4148
2 off	0.47uF polyester
1 off	1µF polyester
1 off	2n4 polystyrene
1 off	3n6 polystyrene
1 off	680pF polystyrene
1 off	100pF ceramic
5 off	100nF ceramic disc
1 off	33uF 6.3v electrolytic
1 off	47µF 6.3v tantalum
1 off	10 ohm
1 off	150 ohm
1 off	220 ohm
2 off	1k
1 off	3, 9k
2 off	6.8k
2 off	15k
2 off	27k
1 off	100k

Board 2

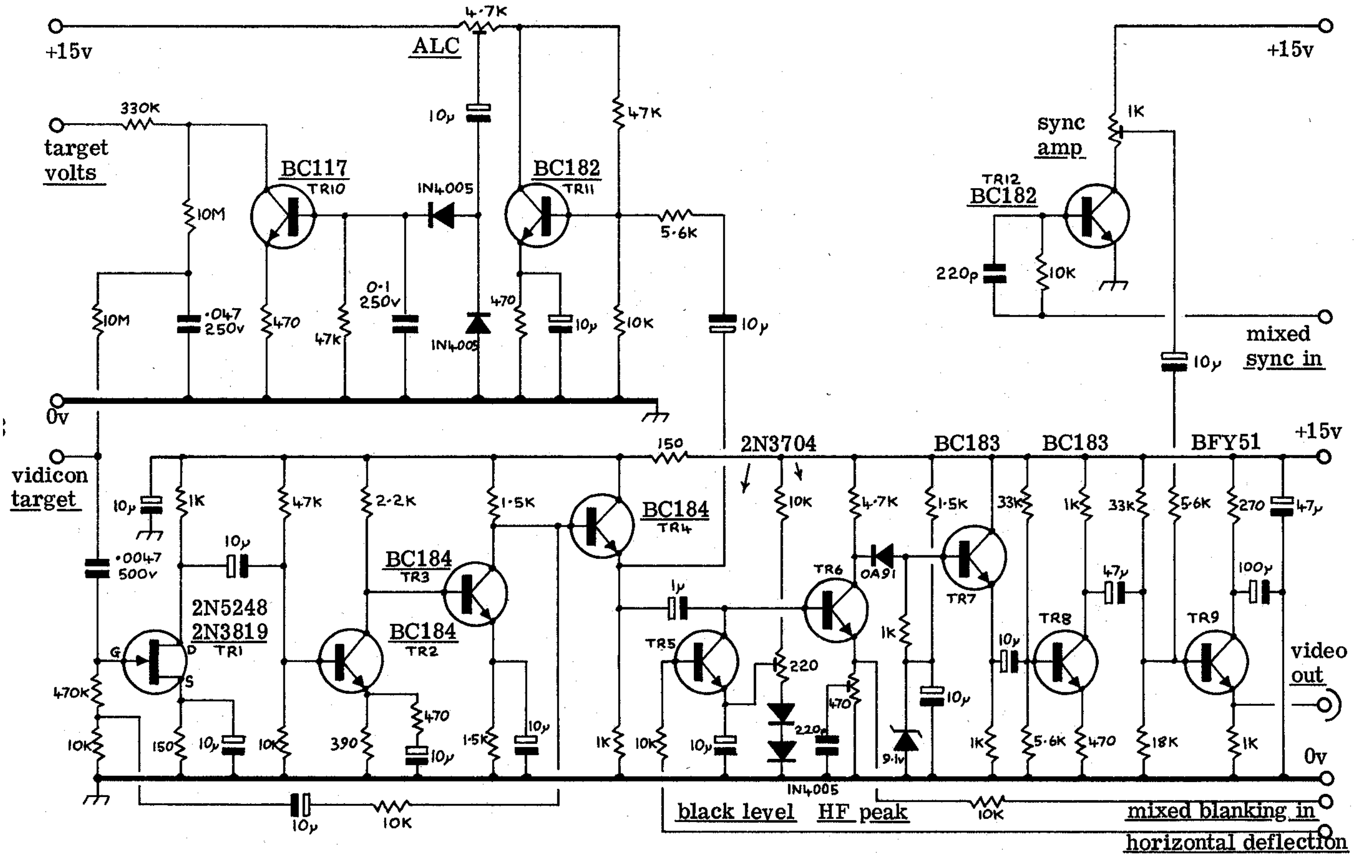
4 off	74LS00
2 off	74LS02
2 off	74LS04
1 off	74LS86
2 off	'14LS92
1 off	74LS93
1 off	74LS175
1 off	74S'14
1 off	74Sl63
4 off	100n ceramic disc
1 off	33uF 6.3v electrolytic
1 off	1k 1/4W

Board 3

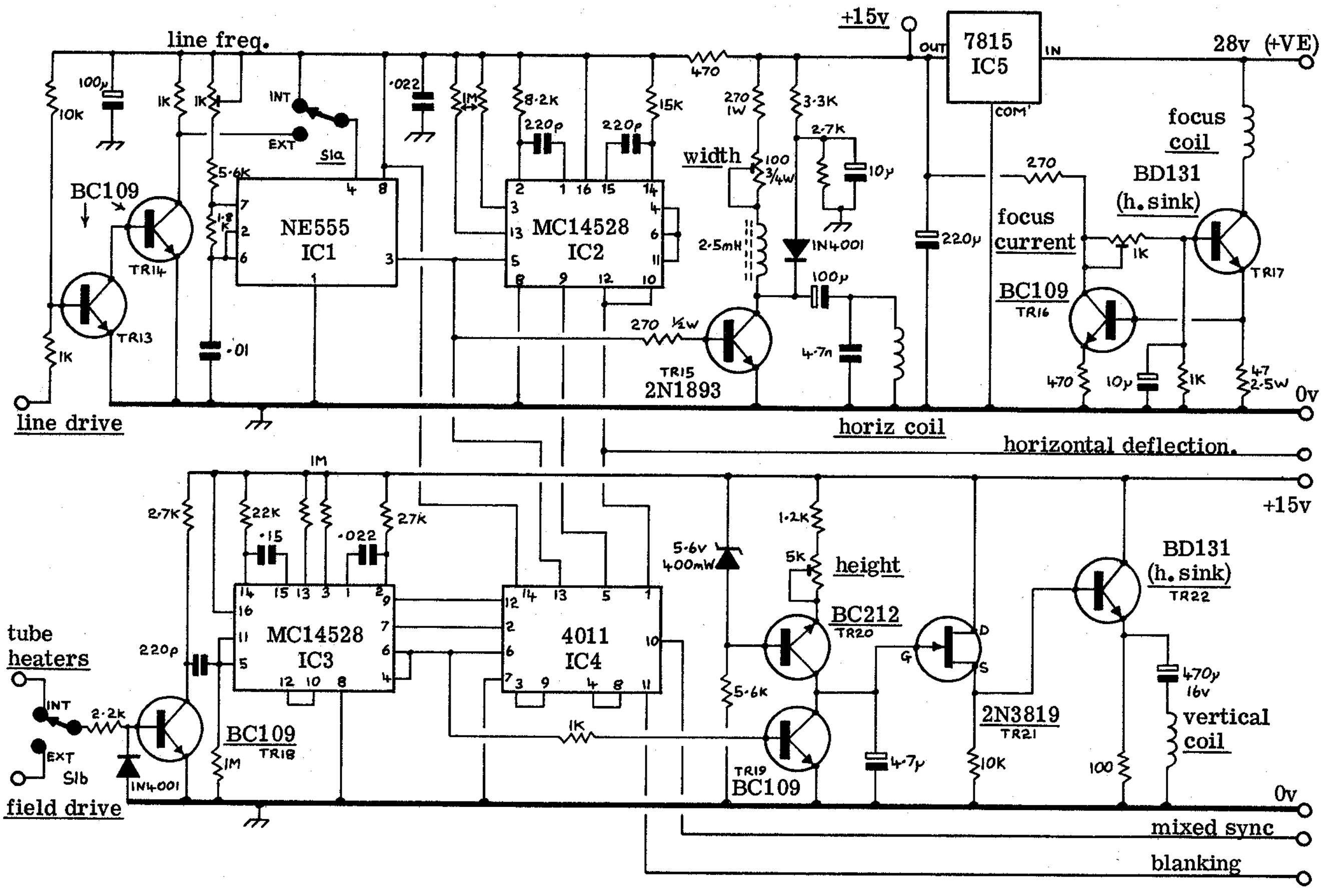
4 off	74LS00
1 off	74L503
1 off	74LS04
4 off	74150
1 off	2N3904
1 off	1N4148
1 off	100n ceramic disc
1 off	33µF 6.3v electrolytic
3 off	120 ohms
3 off	220 ohm
3 off	560 ohm
5off	1k
3 off	1.2k

all resistors 1/4w

A Television Camera



CAMERA VIDEO CIRCUITS



CAMERA TIMEBASE CIRCUITS

This high performance television camera uses up to date techniques and takes advantage of Integrated circuits where possible.

The camera uses a 2/3-inch vidicon tube and can be built into a very small space making it Ideal as a primary vision source in an amateur television station.

Power supplies and sync circuits are built-in so that the camera becomes as portable as possible but for fixed station use it may be locked to the station sync pulse generator.

Circuit Description

The video signal at the vidicon tube target electrode is applied to TR1, which is a low noise high gain FET head amplifier. TR2, TR3 and an emitter follower TR4 further amplify the video. Clamp pulses are applied via TR5 to ensure that the video signal is at black level during sync pulse intervals, a pre set resistor permits adjustment of the actual black level. Blanking is applied via TR6 and syncs are applied via TR9. The composite video output consists of a positive going video signal of 1 volt peak to peak into a nominal output impedance of around 75 ohms.

An automatic level control (ALC) circuit consisting of TR10 and 11 provides a dc voltage proportional to the amplitude of the video signal which reduces the video output from the vidicon, this ensures that the output level is kept substantially constant over a wide range of lighting conditions.

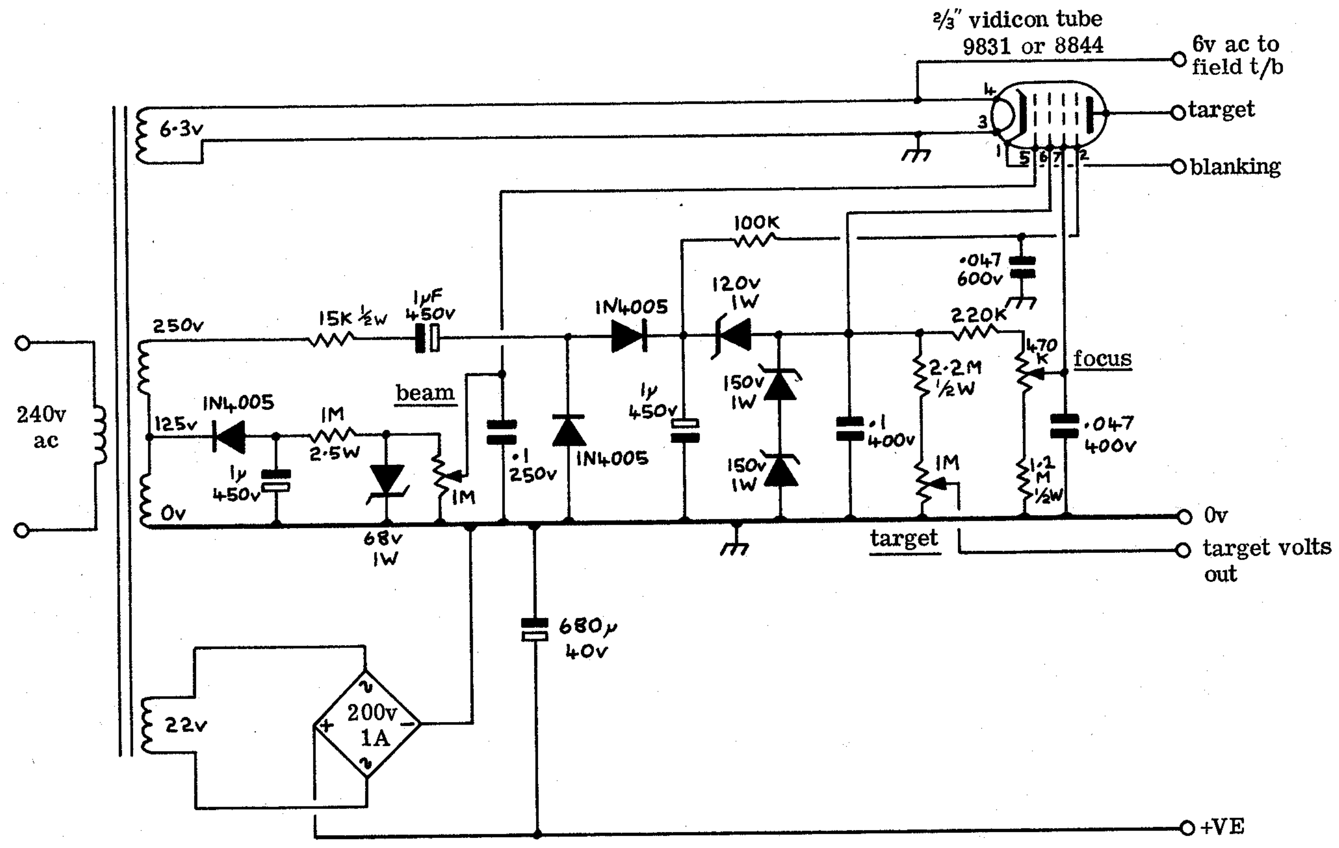
Frame sync and blanking pulses are generated by the dual monostable IC3; the pulses are normally locked to the 50Hz mains supply.

The timer circuit IC1 free runs at line frequency to produce line drive, the dual monostable IC2 generates line syncs and blanking pulses.

Line and field sync and blanking pulses are mixed together in a quad 2 Input NAND gate IC4 to produce composite syncs and blanking.

The line and frame timebase circuits are quite conventional and produce the required drive to the deflection coils.

This test card has been specially designed for use under weak signal conditions and is therefore an excellent aid to accurate reporting.



POWER SUPPLY AND TUBE CONTROLS.

The card is available from BATC club sales at 50p plus 20p p& p.

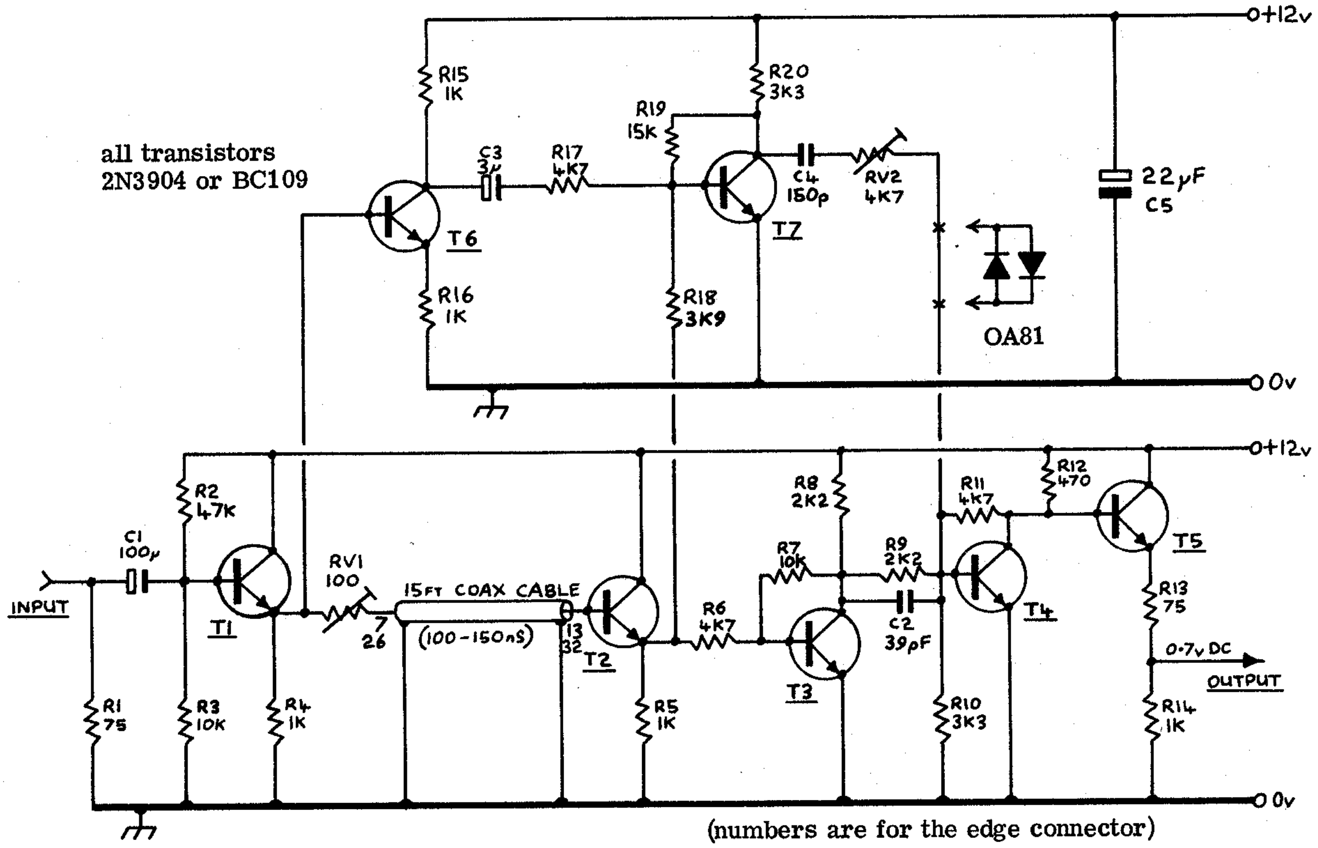
Construction

Component layout is not critical and construction can be carried out on two printed circuit or Vero boards.

Care should be taken to keep the vidicon target lead and head amplifier leads as short as possible since this circuit is at high impedance and is very sensitive to noise and stray magnetic fields. The power supply can conveniently be built on the same board as the timebase circuits but make sure that the mains transformer Is kept as far away from the vidicon tube as possible.

The MC 14528 (IC’s 2 and 3) may be replaced by their equivalents 4098BE.

Suitable vidicon tubes and scan coil assemblies are normally available from the club sales department.



HORIZONTAL APERTURE CORRECTOR

A Horizontal Aperture Corrector

An aperture corrector is a device used to automatically correct poor definition in a television camera; it has been used in broadcasting for some time in the form of a video aperture corrector (VAC) that provides compensation in both the horizontal and vertical planes. Vertical correction is not yet within the capabilities of most amateurs but a great improvement can be made by horizontal correction alone.

It is usual to process non-composite video (i.e. without syncs) and then to add syncs later, in this way the sync information is preserved unmodified. Amateur sync pulse generators however are not always as good as they might be and therefore it is considered acceptable to process the full composite video signal, this also results in a certain amount of simplification in the circuitry.

Circuit Description

To sharpen up a picture the transitions from black to white and white to black must be speeded up, to do this it is necessary to know what the signal level is (present), what the signal has just been (past) and what the signal is about to become (future), with this Information, available a deduction can

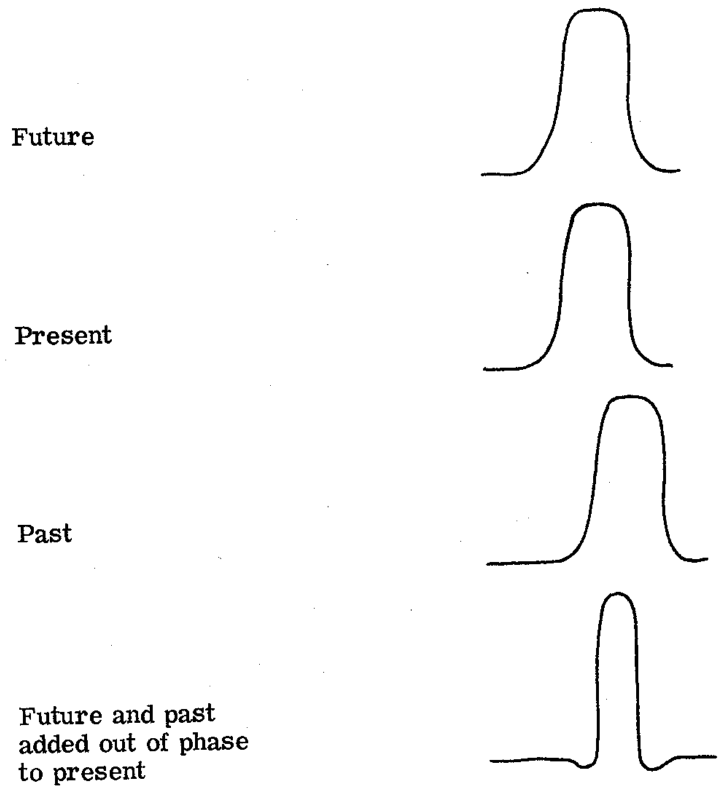
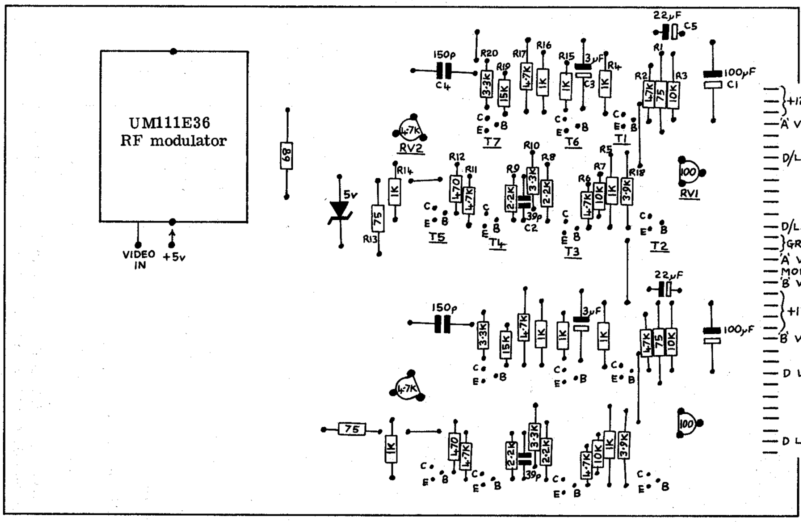


Fig 1.

be made as to whether the signal is about to change in such a way that requires correction or not. This information is obtained with the aid of a delay line.



COMPONENT LOCATIONS.

The input signal to the delay line represents the future since it is the signal that will appear later on (after being delayed). The output of the delay line represents the present and, because the delay line is not terminated and hence reflects the signal back to the input the reflected signal represents the past.

The future and past signals are amplified by T6 and applied to TI. The present signal is applied to T7 via T2, the three signals will add in TI and will cancel the present signal; T7 output is thus future and past. This signal is then applied to T4 via a level control RV2, the present signal is also passed to T4 via T3, the resulting corrected signal is output via an emitter follower T5 to match 75 ohm coax. Signal addition and cancellation is shown in Fig 1.

Construction and Use

The drilled and tinned printed circuit board which is available from BATC (details of which may be found at the back of this book) Includes circuitry for two identical aperture correctors so that they may be used with a two-camera set-up, Provision is also included for a ready built RF modulator unit (ASTEC UM1111 E36 or similar), if required.

RV1 is adjusted to the characteristic impedance of the delay line; a fixed resistor may be substituted if desired. The delay line is made from about l5ft of thin coaxial cable, which can be coiled up or otherwise stowed as convenience dictates. The 12-volt supply rail should be well regulated to avoid distortion of the signal. The input is standard 1-volt p-p 75-ohm composite video.

When the corrector is in use it may be noticed that noise signals are also sharpened, this undesirable effect may be reduced by inserting two back-to-back diodes (0A81) into the signal line after RV2 as shown in Fig 2, this will limit correction to large signals only and will leave noise un-processed.

When using the aperture corrector with colour signals It should be connected in the luminance path for a R-Y, 13-Y, Y drive to the coder or in the green path for a RGB feed system. In either case the corrector will delay the signal because of the delay line and so any signals that are not fed through the corrector, must be delayed by a similar amount.

Connections to the printed circuit board edge connector are given in the table below.

The HF modulator is intended for use with the complete card frame system and is included on this board as sufficient space was available.

PIN FUNCTION	PIN NU VAC-A	MBERS VAC-B
÷12 volts	1, 2, 3	19, 20, 21, 22
Video input	4	23
Delay line, between pins: -	7 and 13	26 and 32
Ground (0V)	14, 15	14, 15
Video output	16	18
Input to RF modulator	17	17

A Video Switching Unit

This unit permits the switching of up to six separate video sources, five of which may be routed to the station transmitter. Switching is carried out in such a way that there is no picture roll on switchover thus improving the presentation of television transmissions.

The switcher has two outputs: -

1) Transmitter bank output to pass the selected video source to the transmitter.

2) Preview bank output to permit previewing of any of the six Inputs.

Switching to the transmitter bank output only takes place during the frame sync period, this stops picture jump as previously mentioned, the technique is called inter-field cutting. Since the preview bank output is intended to drive only the station preview monitor inter-field cutting is not necessary. The unit will handle colour sources as well as monochrome.

Circuit Description.

Refer to Fig 2. Each of the six video sources are connected to the bases of a pair of cross-point switching transistors, one of the pair routes the video to the preview bank output whilst the other passes it to the transmitter bank output. Each switch is enabled by applying a logic zero (0V) to its emitter resistor. All ‘switching transistors in either bank share common load resistors (Rp in the preview and Ri in the transmitter banks) thus the video signal selected is always present across the load. The video from each bank is passed to a virtual-earth amplifier where it is inverted back to its original sense and then to an emitter follower that drives the 75-ohm impedance output lines.

points 'X' denote the presence of a switching transistor.

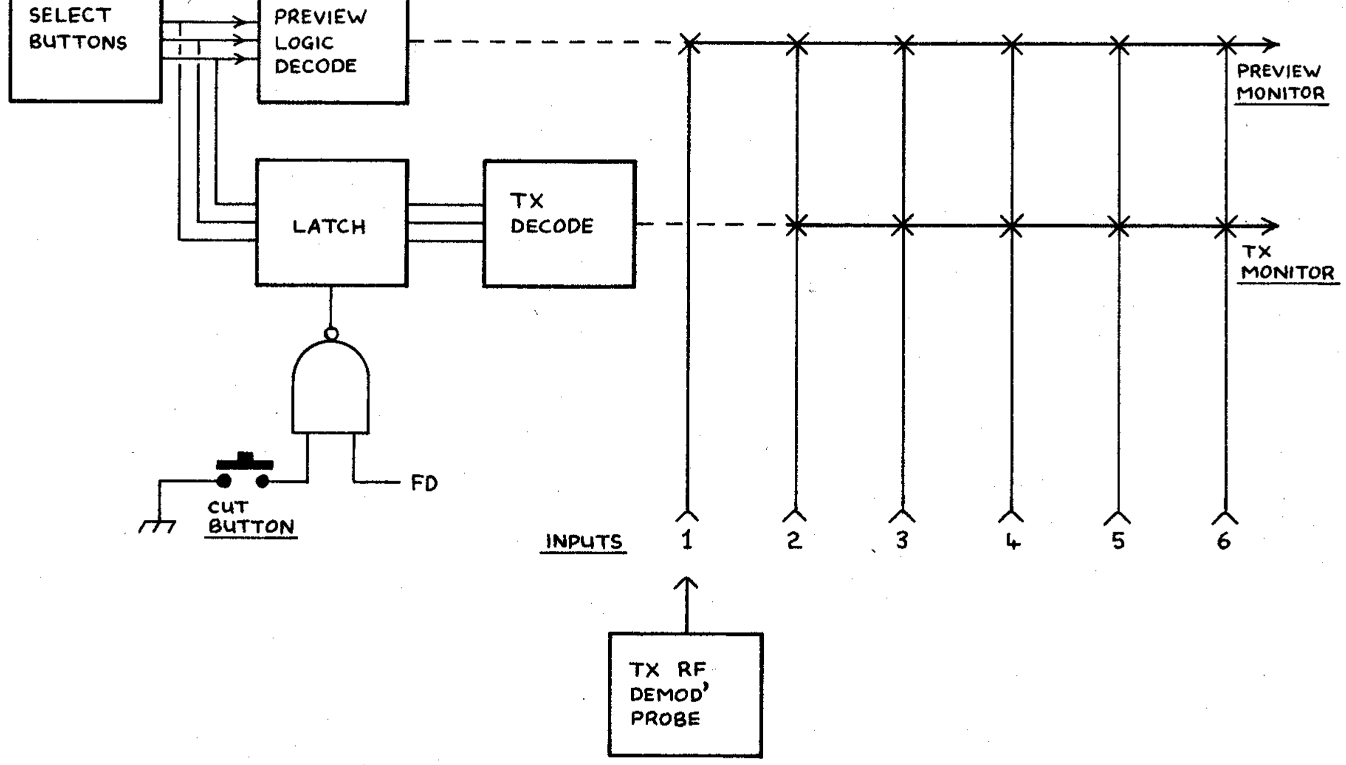


Fig 1. BLOCK DIAGRAM OF VIDEO SWITCHING UNIT.

Fig 3 shows the decoding logic. A three bit binary word generated by the push button unit is applied to IC3 where it is decoded and the outputs used to control the preview bank switching transistors. Similarly the push button data is applied to 1C4 where decoding takes place to control the transmit bank switching transistors, however in this case the data Is first applied to a quad latch (IC2) which will only make the data available to the decoder when the cut button is depressed and during a field sync period.

Note that it is not possible to switch Input 1 through to the transmit output line, this input channel Is reserved solely for the off air probe monitor signal so that the transmission may be monitored if desired, if this input were to be transmitted feedback would occur and the circuit would howl.

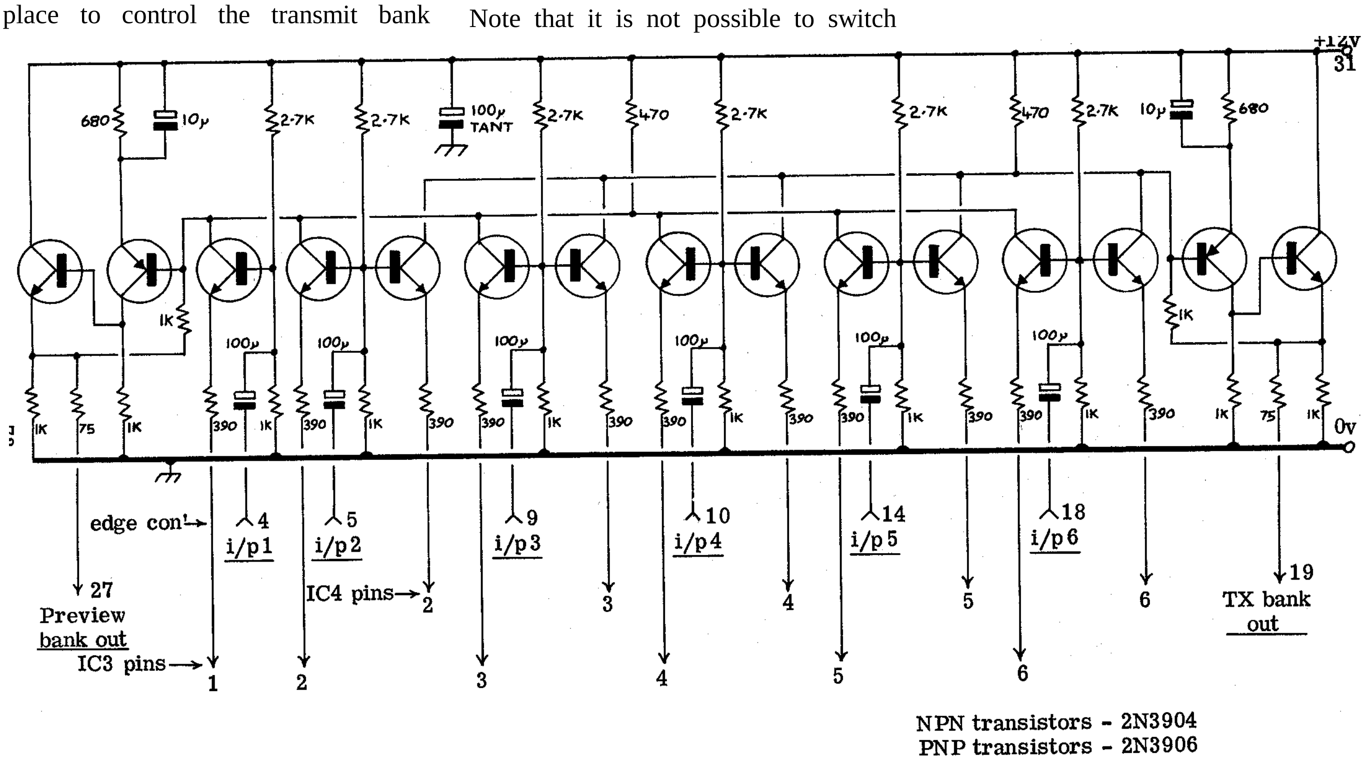


Fig 2. VIDEO SWITCHES

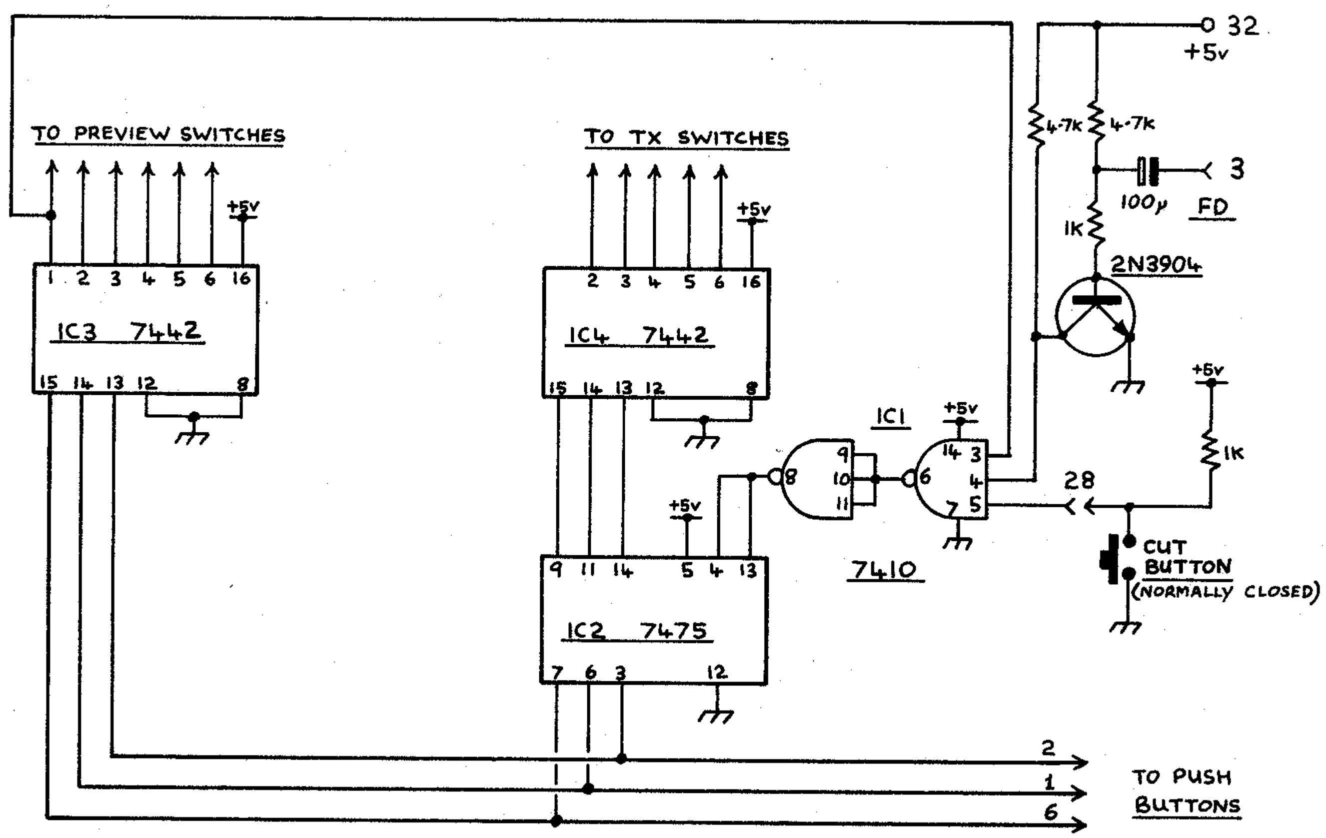


Fig 3. **SWITCHING LOGIC DIAGRAM.**

The six push buttons are of the mechanical latching type; this ensures that only one vision source is selected at any one time.

Fig 4 shows two methods of generating the push button binary data, which selects the appropriate input channel. Note that all switching is done using DC signals and only three wires and a common line is required, this makes remote operation easy and avoids complicated video coax connections.

Operation

In use the video switching unit will display any one of the six video Input channels on the preview monitor, it it is required to output this channel to the transmitter then the cut button is pressed momentarily, any other channel can now be selected and will be viewed on the preview monitor but the output to the transmitter will not be affected until the cut button is depressed again. If an attempt is made to cut to input 1 the command will be ignored and the previously selected channel will continue to be output to the transmitter.

The video switching unit will also control sources that are not locked to the station sync pulse generator, however there maybe picture roll present during cutting.

A drilled and tinned printed circuit board is available for this unit, details may be found at the back of this book.

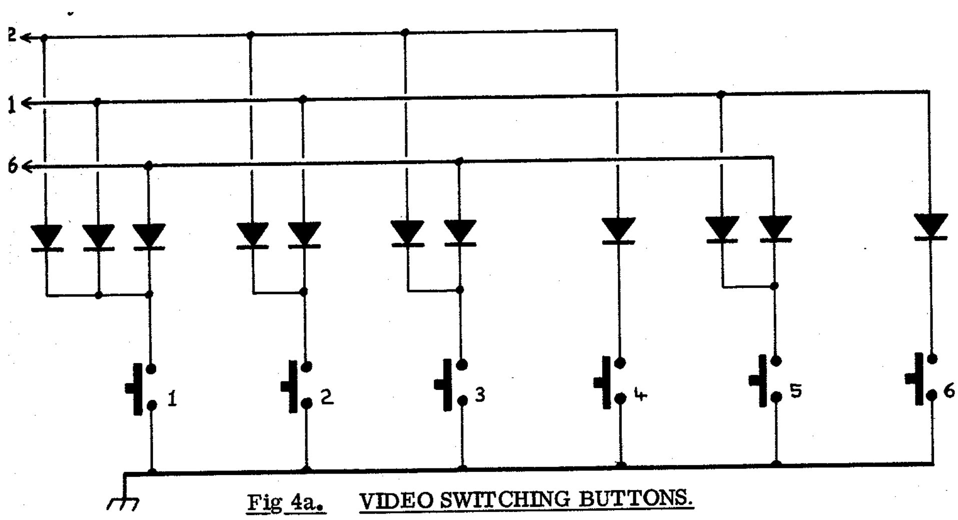


Fig 4a. **VIDEO SWITCHING BUTTONS.**

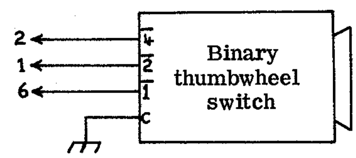
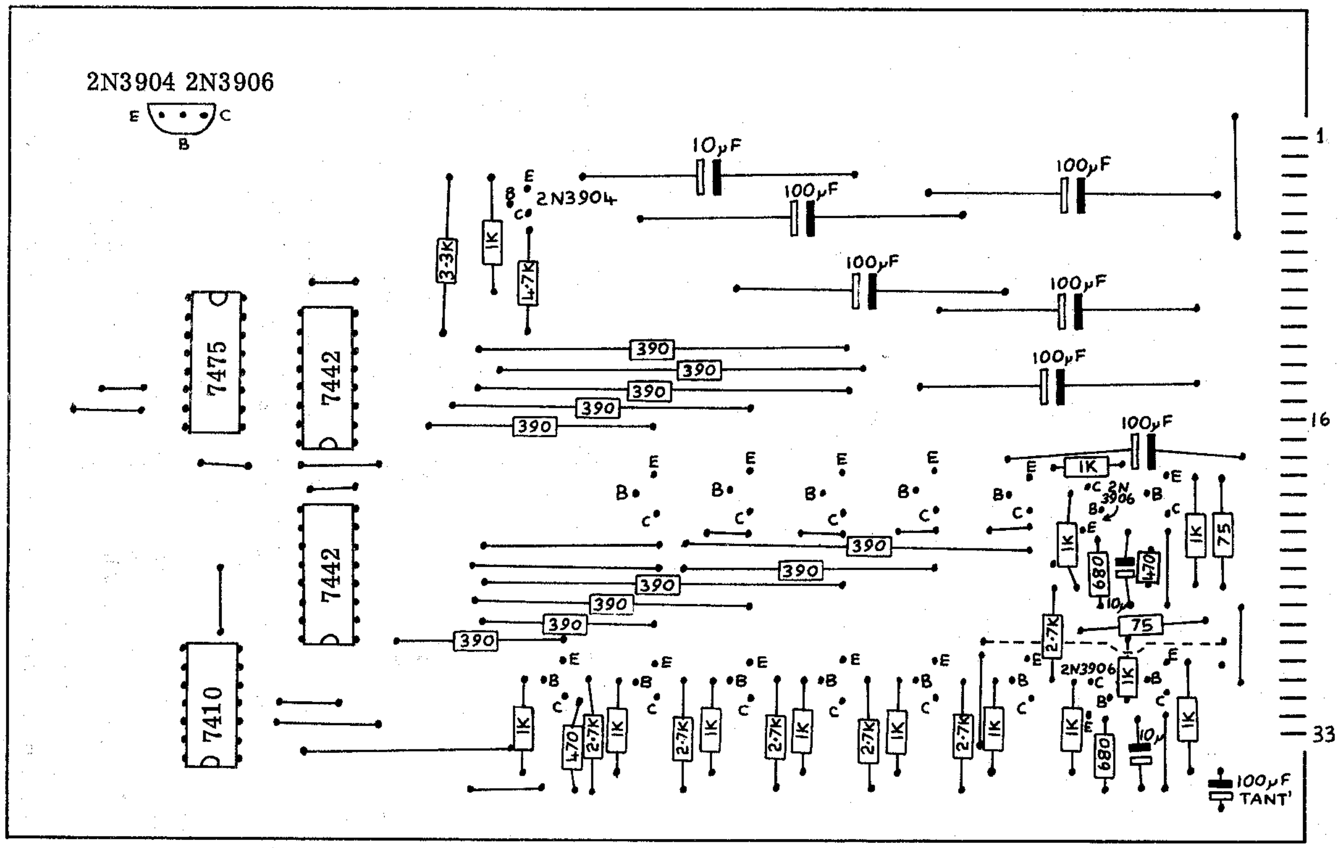


Fig 4b. **REPLACING THE PUSH BUTTONS WITH A BINARY SWITCH.**

When using a thumbwheel switch, source 1 is selected by position 0, source 2 by 1 and 3 by 2 etc.

- - - - - - - - denotes raised wire link.



COMPONENT LOCATIONS.

Colour Television

This chapter will describe the basic principles and techniques used in colour television systems, the constructional articles are for use with the UK standard colour system (PAL). It is not intended to give a deep theoretical study of colour television as this is adequately dealt with in a number of textbooks that are freely available.

Fig 1.

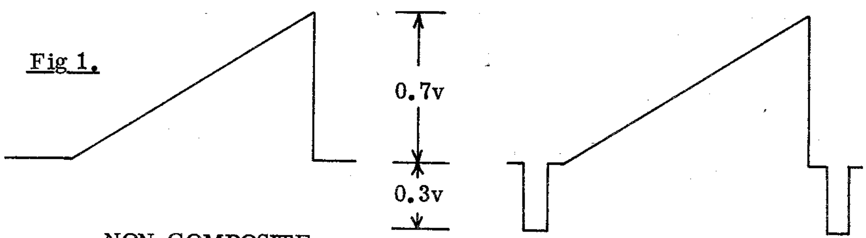


Fig 1 shows the waveforms of one line of a monochrome (black and white) signal, the diagrams show a ramp which will result in black, white and all intermediate shades of grey being displayed on the screen, the shades of grey being determined by the signal amplitude.

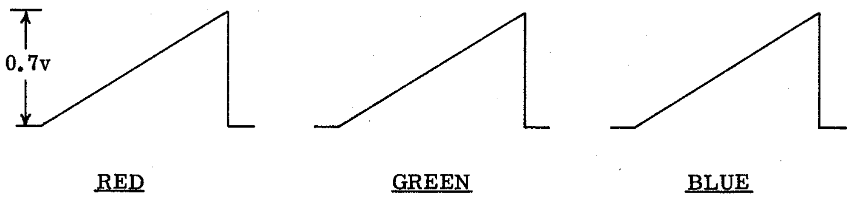
Now a colour signal can take two basic forms, the first consists of three non-composite signals. Each one of these signals looks exactly the same as the non-composite monochrome signal shown in Fig 1. One of these signals is allocated for red, one for green and the third for blue. By varying the amplitudes of these three signals it is possible to produce any colour that the TV system is capable of reproducing. For example, if a signal was present on the red channel only then a red picture is produced. If equal amplitudes of say, red and green were generated, a yellow picture would result. A peak white signal would be produced if the red, green and blue channels were all fed with their maximum amplitude (0.7V) signals. Furthermore, if the red, green and blue amplitudes were kept equal, it would be possible to display any amplitude of monochrome signal. i.e. If R = G = B then a monochrome signal will always be produced. Fig 2 shows the colour equivalent of the monochrome signal shown in Fig 1.

Note that the red, green and blue (RGB) form of colour signal is always non-composite, thus to feed a colour monitor four wires will be required, one each for red, green, blue and syncs.

Coding and Decoding

The colour signal in its RGB form differs little from a monochrome signal except that there are three of them instead of just one, this form is suitable for feeding a RGB monitor. Undoubtedly this is the best system, as the signals do not become distorted due to deficiencies in the coding-decoding circuits. If however the colour signal needs to be transmitted over the air or fed into a domestic receiver (via a modulator), or if there are several

Fig 2.



sources to be switched or mixed, then the EGB signal has to be coded. The process of coding produces a single composite signal, which provides all the information necessary to reconstitute the original RGB signal after decoding.

It is now necessary to briefly explain how the PAL system was developed since it will assist in the understanding of the operation of colour coders and decoders.

The 'Y' Signal

Use is made of the very important fact that the human eye cannot resolve fine colour detail, only detail in terms of brightness, regardless of colour. In a monochrome system there is already a signal that defines the brightness of a scene. This signal (the normal video output of a monochrome camera) is of sufficient bandwidth to define the fine detail of the scene. In colour terms, this signal (the black and white information) is called the luminance signal and is usually given the symbol 'Y'. To produce a compatible composite colour signal the colour information must somehow be added to the Y signal. The various colour systems, such as SECAM, NTSC and PAL all use some form of HF modulation of a carrier which is then superimposed on to the Y signal.

Now use is made of the fact that the colour part of the signal need not be of such a wide bandwidth as the Y signal. In practice, the Y signal bandwidth is of the order of 5.25MHz whereas the additional colour Information has a reduced bandwidth of 1.5MHz.

The question now is that given an RGB colour source, how can the Y signal and colour information be obtained from it? Each colour has its own brightness level, and the red, green and blue signals all contribute to the brightness levels of the scene. Therefore, by adding together defined proportions of the HG and B signals it is possible to obtain the Y signal. The actual relationship is: -

Y = 0.299R + 0.587G + 0.114B

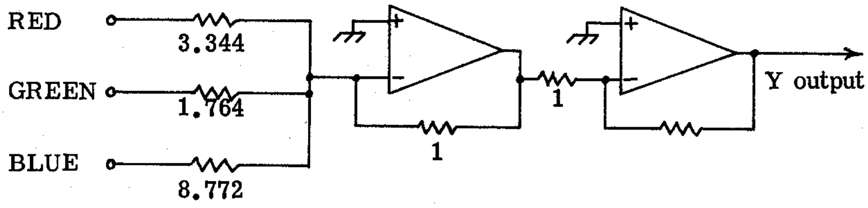


Fig 3. GENERATING Y FROM R,G AND B.

Fig 3 shows a circuit that will derive the Y signal from the RGB signal so that the monochrome component can be observed.

Colour Difference Signals

Having now obtained a luminance signal the colour information must be derived and somehow added to it. There Is no point in including the Y signal in the colour information therefore it Is subtracted from the RGB sources to provide signals containing only the colour information. The colour signals thus produced are R-Y, G-Y and B-Y. These are aptly called colour difference signals.

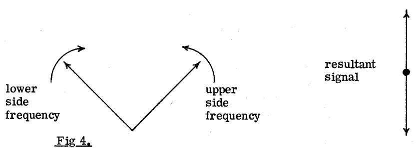


Fig 4.

A certain amount of study will show that it is only necessary to transmit two of these signals in addition to the Y signal and the necessary information will still be recovered. This is shown by the following relationships; suppose that the three signals Y, (R-Y) and (B-Y), then at the receiver R and B can be obtained by: R = (R-Y) + Y and B = (B-Y) + Y but Y = R + G + B. Thus the green signal can be obtained from the other three signals, le. G = Y – R - B.

Fig 5.

To sum up so far it is necessary to transmit two additional signals for colour, B - Y and R - Y each having a bandwidth of 1.5MHz. The PAL system is an adaptation of the NTSC system, so for the moment the NTSC system will be considered and then an explanation will be given to show how it has been modified to PAL to get over some of the initial problems.

To add the colour signals onto the Y signal they are modulated onto a carrier. To explain how this is done, first consider a double sideband suppressed carrier system modulated with a sine wave source. Fig 4 shows the vector diagrams of the modulator output. (These diagrams are rotating at the carrier frequency).

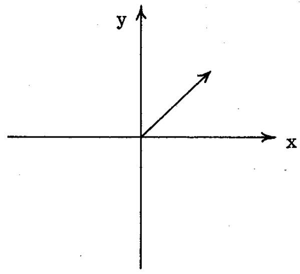


Fig 6.

The resultant signal is seen to have a phase that is either 0 or 180 degrees with respect to the carrier. The amplitude is a function of the modulating signal voltage and its phase is a function of the polarity of the modulating signal. A second DSB modulator fed with a different modulating signal and a carrier which is 90 degrees out of phase with the original producing a resultant vector as shown in Fig 5.

The outputs of the two modulators can now be added together, this produces a resultant signal of variable amplitude and phase. (Fig 6)

Since the two components x and y are in quadrature it is possible to demodulate them back into two independent signals, this is achieved with two synchronous demodulators working in quadrature (le. fed with 0 and 90 degrees sub carrier). In the

NTSC system the (B-Y) signal is modulated onto the x-axis and (H-Y) onto the y-axis. Fig 7 shows in block form how the colour signal is generated.

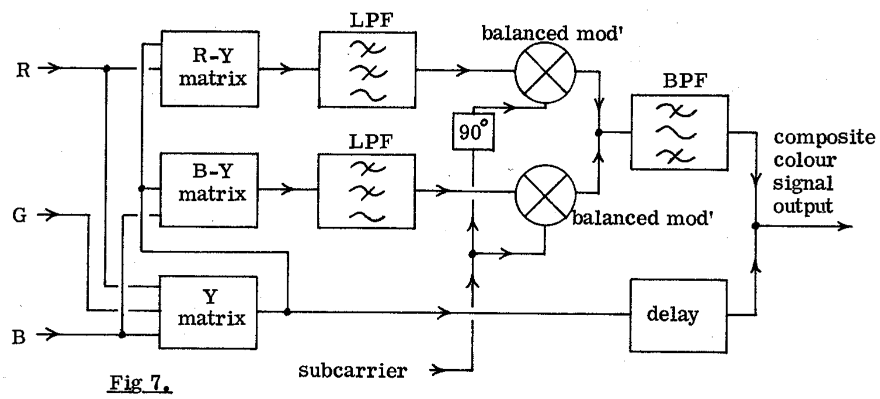


Fig 7.

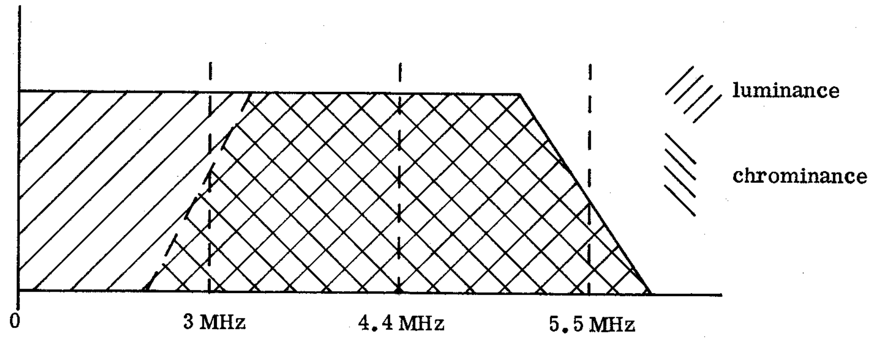


Fig 8. THE SPECTRUM OF AN ENCODED COLOUR SIGNAL.

A big advantage in using a suppressed carrier form of modulation is that the lower the colour content of the picture (saturation) the lower Is the amplitude of the sub carrier, and in fact, in the absence of colour, the sub carrier disappears completely and the signal reverts back to Its monochrome form. This fact is important as the sub carrier is within the video band and results in patterning on the television screen.

The spectrum of the colour signal is shown in Fig 8 and illustrates how the chrominance occupies the upper part of the luminance bandwidths.

Regenerating the Subcarrier

So far no mention has been made of how the subcarrier for the decoder synchronous demodulators is obtained. At the coder a 'burst' of subcarrier is added to the signal, as within the back porch period in NTSC the phase of this burst is constant and is on the -(B-Y) axis. At the decoder a phase locked loop is used comprising a varactor controlled crystal oscillator and a gated phase detector. The phase detector is arranged to compare the phase of local and received subcarrier only during the period of the burst, this is called the 'burst locked oscillator'. Fig 9 shows the arrangement for decoding the composite NTSC signal.

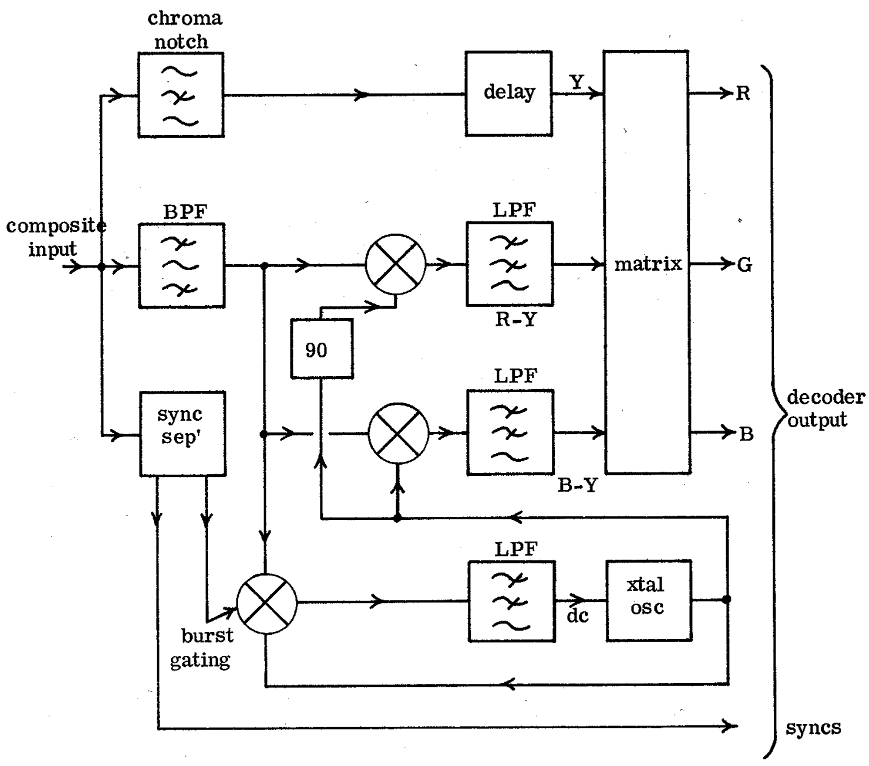


Fig 9. BLOCK DIAGRAM OF AN NTSC DECODER.

The PAL System

The parts of the NTSC system so far described are identical to PAL. The PAL system has however one distinct difference. In this system the R-Y axis is reversed in polarity on alternate lines at the coder. In the decoder, the subcarrier feed to the R-Y demodulator is reversed In phase in step with the coder. It can be seen that this arrangement produces exactly the same signals, as before, so what is the point? There is a distortion which a colour signal can suffer which is termed differential phase. This is the effect whereby the phase of the subcarrier component varies depending on the level of the luminance signal it Is sitting on. This means that a colour object in the picture could well have the 'wrong' phase with respect to the burst that is sitting at black level. In NTSC this error would result in an incorrect colour being reproduced. In PAL on a given line we have (assuming we have picked the right one out of the two) an identical situation as in NTSC where incorrect colour is reproduced. Observing the next line, the signal suffers the same phase error but, as the axis of R-Y has been reversed, the resulting colour error is in the opposite direction to the preceding line. This means taking the average of two consecutive lines results in the correct colour being reproduced. In a single system this averaging can be achieved

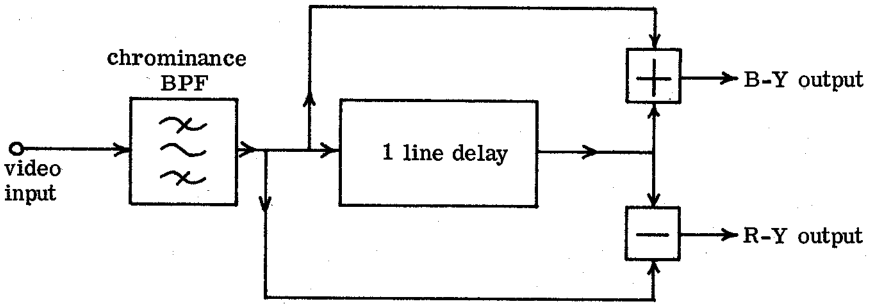


Fig 10. DELAY LINE ARRANGEMENT OF A PAL DECODER.

by observing the picture at a distance where two lines tend to merge and the eye does the averaging. LI the errors are too great, an effect called 'Hanover bars' results produced by large colour differences on alternate lines. To overcome this problem the signals on alternate lines are averaged electronically. This has the requirement that the signals from two lines be available at the same time, which means a one-line delay has to be used. Fig 10 shows how this is done. The arrangement shown also provides a rough separation of the signal into its R-Y and B-Y components prior to the synchronous demodulators.

Ident

The alternating subcarrier feed for the R-Y demodulator is derived from a balanced modulator that is switched by a 7.8 KHz (half line frequency) square wave. This is obtained by dividing separated line syncs by two in a flip-flop. With this arrangement there is a 50/50 chance that the flip-flop will start in the wrong phase, to prevent this from happening, the burst at the coder is made to swing + and - 45 degrees about the -(B-Y) axis. The decoder has circuits to detect the phase of the first and set the divide by two into the correct phase. The time constant of the burst locked oscillator loop is made sufficiently long to make the oscillator lock to the average phase of the burst, i.e. the -(B-Y) axis.

The other circuit usually built into a decoder consists of a 'colour killer' that switches off the chrominance circuits when no colour is present on the input. The colour killer usually detects the presence or absence of a signal in the ident circuitry. Additionally the burst signal is blanked, otherwise it would appear as an incorrect pulse at the output during the blanking period.

A PAL Colour Coder

This coder takes the basic red, green and blue colour signals and combines them with syncs and other necessary signals to produce a composite PAL video signal.

The unit has been made as simple as possible and features a single IC balanced modulator circuit, no complicated filter networks to adjust thus avoiding the need for a luminance delay, single PC board, simple adjustment, single power supply requirements and low cost. The simplicity means that the residual carrier balance is outside professional broadcast standards though this is of little consequence to the amateur and there is no bandwidth limiting of the chroma information, the harmonics of the colour sub-carrier frequency however have been reduced to acceptable levels with a simple filter.

Specification

Inputs

a. Standard 0.7V non-composite RGB into 75 ohms.

b. Colour sub-carrier (CSC), 0.5 – 1V p-p into 75 ohms, frequency 4.433MHz.

c. Mixed syncs, burst gate, PAL axis switch. All pulses 2V p-p across 75 ohms.

Output

1V p-p composite video across 75 ohms,

Power supply

10 – 12V dc stabilised.

Description

A block diagram of the PAL coder is shown in Fig 1. The coder uses a low-cost TV receiver decoder integrated circuit (IC1) in the 'reverse' direction to code B-Y and R-Y signals into PAL video. The coder is a linear as opposed to a digital device and may be used for coding normal video signals from a camera, flying-spot scanner etc. as well as those from digital sources.

Red, green and blue video input signals are matrixed along with a burst gate pulse to give B-Y, R-Y and luminance signals, also colour burst. Processing is done by TR1, 2 and 3 and associated resistor networks.

The B-Y and R-Y signals are a. c. coupled and need to be referred to a DC level before entering a balanced modulator IC1. Buffering and clamping, using mixed syncs, is carried out by TR4, 5, 6 and 7 for the B-Y signal channel and by TR8, 9, 10 and 11 for the R-Y signal channel.

IC1 accepts B-Y and R-Y signals, colour sub-carrier quadrature signals and axis switch (alternate line) signals. The output from IC1 consists of a full bandwidth PAL coded chrominance signal.

The last section of the coder adds the chrominance and luminance signals, together with the mixed sync signals to provide a composite PAL coded signal at standard level. Gain setting and output stage are provided by TR12, 13 and 14.

It should be noted that in the interests of simplicity the colour signals exist at full bandwidth. A simple low Q filter is included between the modulator and the output amplifier to reduce the harmonic content to an acceptable level.

The PAL coder has been tested on colour bars and colour signals from a studio colour camera and gives very acceptable results on a vectorscope and subjectively when compared with a professional coder costing several thousand pounds:

Construction

The coder is built on a single-sided PC board measuring 114mm x 203mm, with connections brought out on the

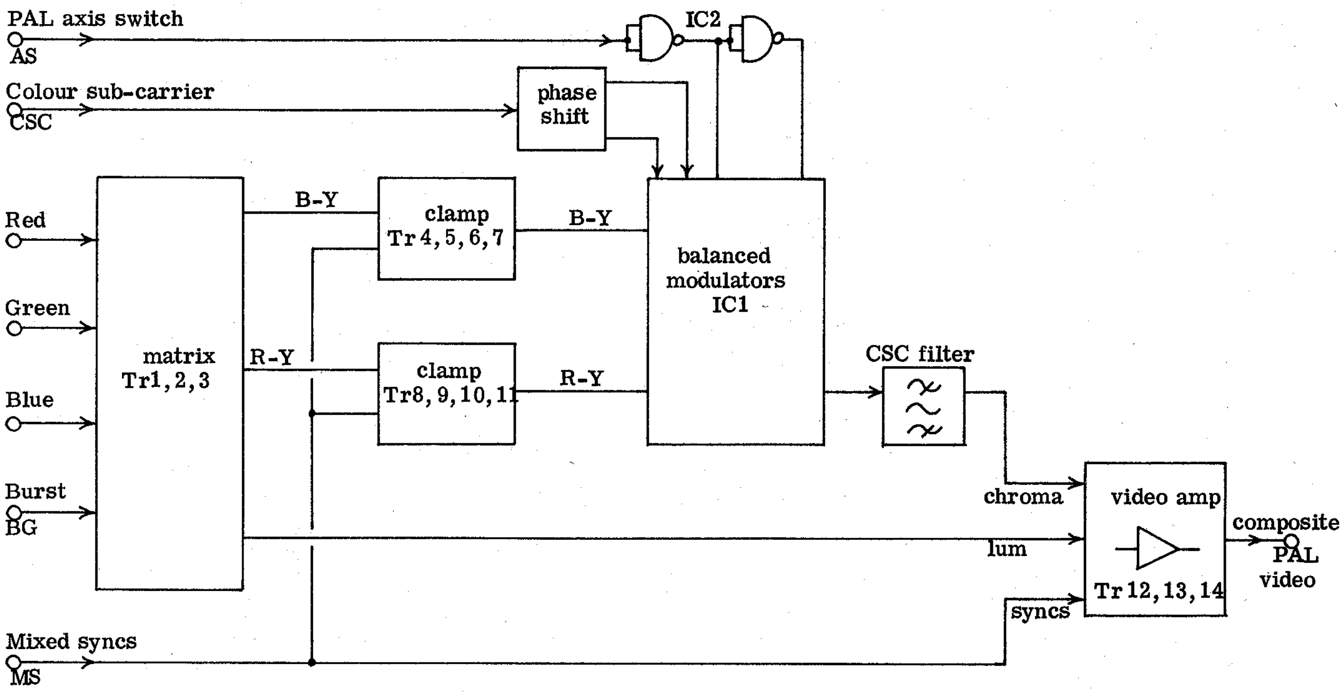


Fig 1. PAL CODER BLOCK DIAGRAM.

edge of the board suitable for plugging into a direct edge connector (0.1in spacing).

In its original form, the TBA52O (IC1) has physically 'staggered' pins. These should be carefully bent with pointed nosed pliers to convert it into a 'dual inline' device. DIL sockets are fitted for both IC1 and 1C2.

Setting-up Procedure

Setting up should preferably be done using an oscilloscope connected to the output although an alternative method using only a colour monitor is also given.

Since the carrier balance is voltage sensitive it should be set up with the power supply that will be used in the finished unit.

Procedure.

1. No input to R, G, B. Terminate output with a 75 ohm resistor. Scope. Adjust CARRIER BAL RV4 and RV5 for minimum colour sub-carrier. Mon/TV Increase COLOUR SATURATION on monitor, adjust RV4 for minimum blue/yellow tinting, adjust RV5 for minimum red/cyan tinting, repeat until neutral background is obtained.
2. Colour bars to H, G, B inputs.

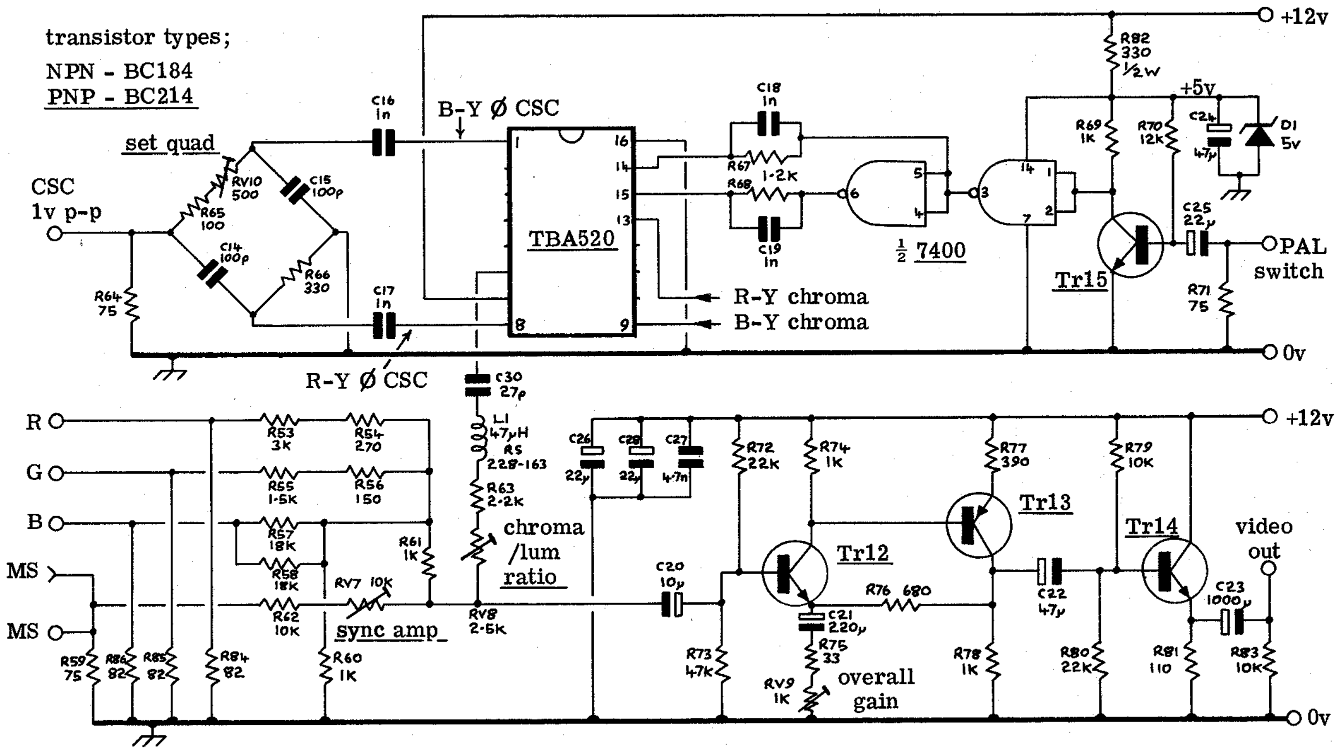


Fig 2. PAL CODER.

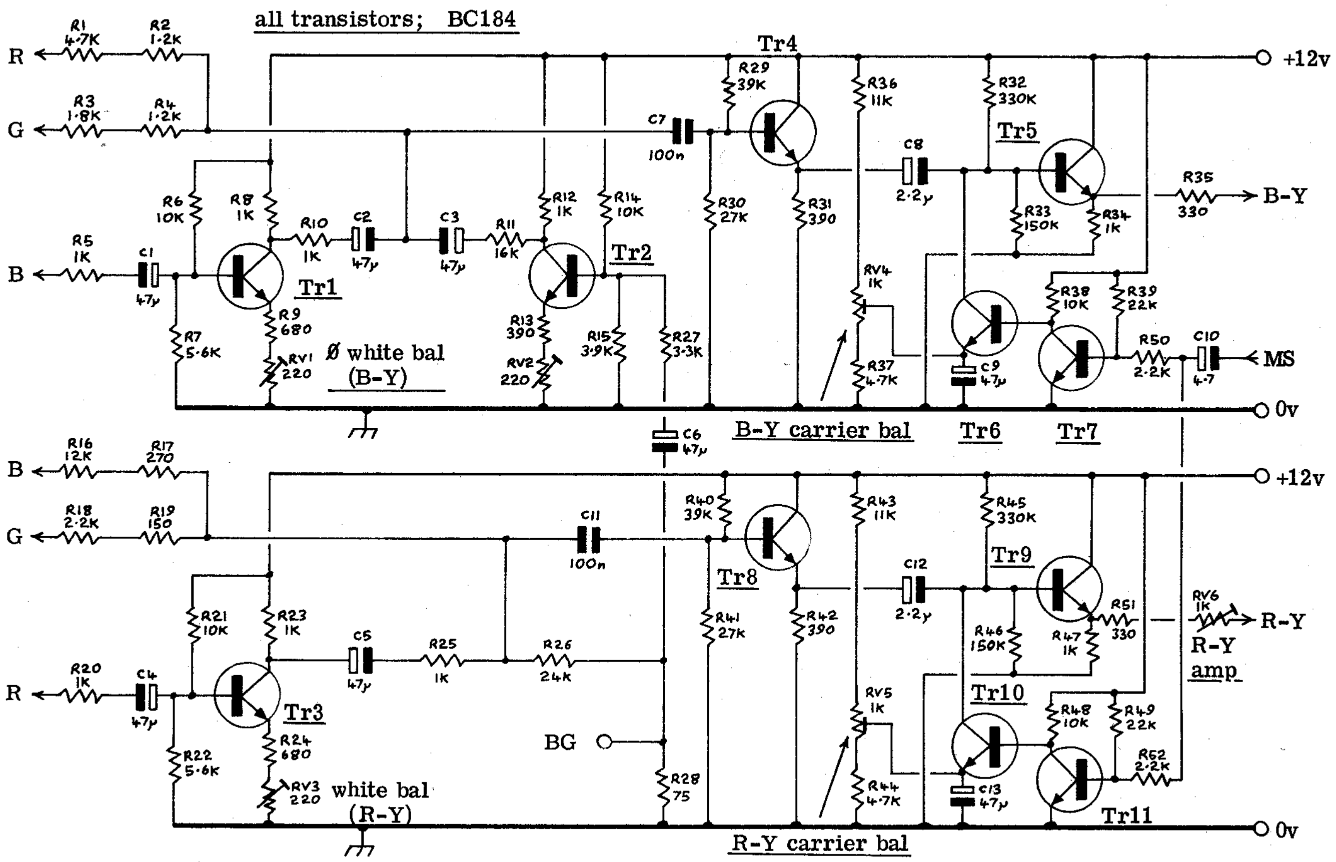


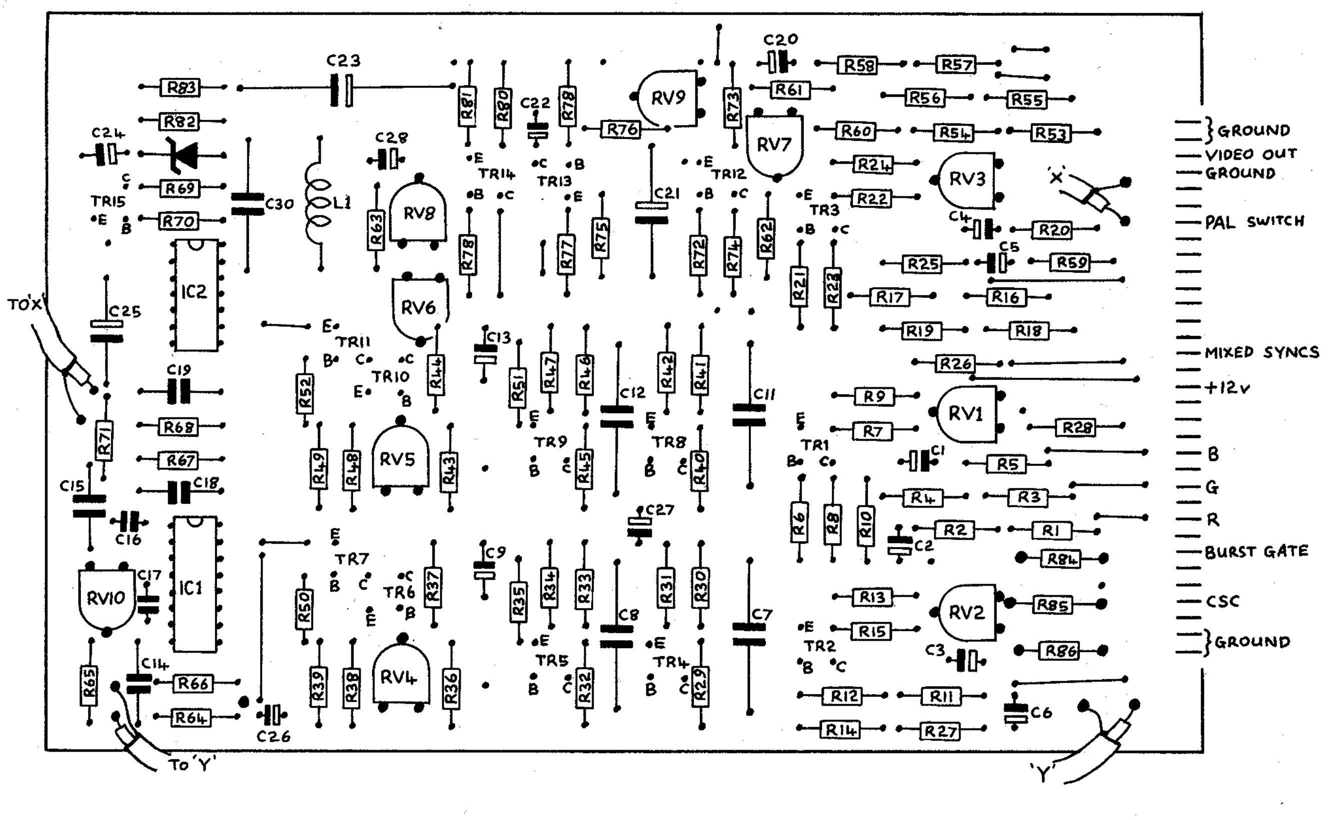
Fig 3. PAL CODER.

Short inputs together. Adjust WHITE BAL RV1 and RV3 for minimum CSC. Mon/TV Adjust WHITE BAL RV1 to minimise blue/yellow tint, adjust WHITE BAL RV3 to minimise red/cyan tint.

3. Remove R, G, B short.

a. Adjust QUAD RV10 for minimum ‘twitter’ on waveform when viewed at line rate with scope trigger control adjusted for ‘twitter’ effect between alternate lines.

b. Adjust QUAD RV10 for best



COMPONENT LOCATIONS.

saturation (look at red or blue bar).

4. Chrominance/luminance levels.

Scope.Adjust R-Y AMP RV6 for top of cyan bar envelope to equal top of yellow bar.

Adjust CHROMA/LUM RV8 for bottom of green bar envelope to sit at black level.

Switch off R and G guns of monitor; adjust CHROMA/LUM RV8 for equal brightness of blue In white bar and blue bar positions.

Switch off B gun; switch on R gun, Adjust R-Y AMP RV6 for equal red intensity in white bar and red bar positions. Return monitor to normal working.

TV. First adjust saturation using normal off-air pictures, preferably colour bars. (Bear in mind that there are 95% bars (BBC) or EBU bars (ITV)).

Adjust as for monitor.

5. Overall gain and sync amplitude.

Scope.Adjust SET OVERALL GAIN RV9 for 0.7v p-p video only, (ignoring sync amplitude).

Adjust SYNC AMP RV7 for 0. 3v p-p sync, giving 1V p-p composite video.

Mon/TV. Set SYNC AMP RV7 to mid-position; adjust SET OVERALL GAIN RV9 for maximum contrast consistent with no sign of clipping (colour changes in yellow bar).

6. Burst phase.

BURST PHASE RV2 is difficult to adjust without a vector scope, however the setting is not critical and could be set to mid-position.

Scope. Adjust BURST PHASE RV2 so that the burst ‘pulse’ in the R-Y chroma is the same amplitude (opposite polarity) as the burst ‘pulse’ in the B-Y chroma signal. Burst amplitude should then be 0.3V p-p, the same as the sync amplitude.

Mon/TV. Most domestic TVs will tolerate -50% to +200% variation in burst amplitude so the setting is not critical.

R26 in the R-Y matrix will alter burst amplitude and should this require changing in value to achieve correct operation then RV2 will require re-adjustment.

Whilst the input of the red, green and blue signals is matched to 75 ohms nominal that should prove to be sufficiently accurate an exact match may be obtained by selecting resistors R84, R85 and R86 if desired.

A Colour Sub-Carrier Oscillator

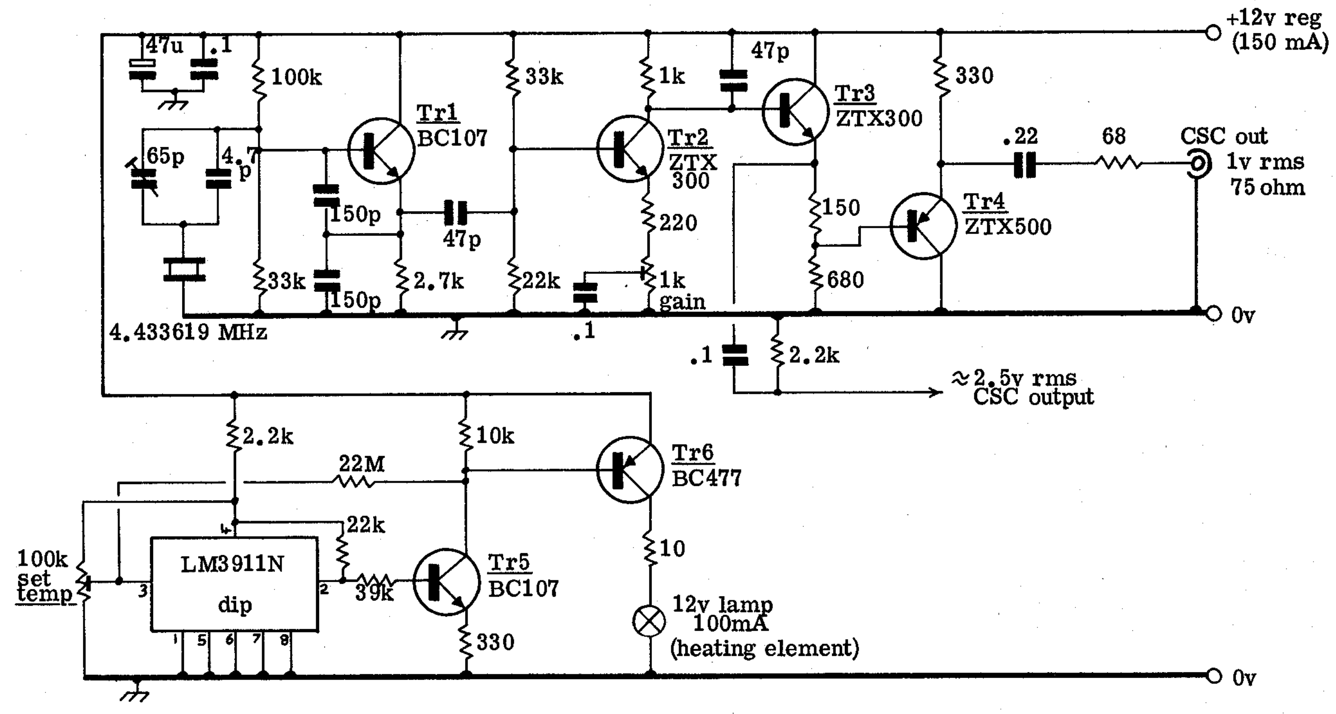
An oscillator suitable for providing a colour sub-carrier signal must be accurate and stable, this unit is crystal controlled and well buffered to provide isolation from the low impedance load and it is temperature controlled, to achieve high stability.

The whole unit is built into a diecast box (4½ x 2½ x 1¼) and a heating element is used to keep the temperature stable. There is no reason why a conventional crystal oven should not be used if desired.

Description,

Tr1 is a crystal oscillator and includes a trimmer capacitor to permit precise adjustment of frequency. Tr2, 3 and 4 make up the distribution amplifier that provides around 2.5V rms at medium impedance suitable for driving digital circuits such as those found in a colour sync pulse generator and 1V rms across 75 ohms which drives a PAL coder.

Temperature sensing and controlling is done with IC1, Tr5 and Tr6. Tr6 is the lamp driver. The integrated circuit is



COLOUR SUB-CARRIER OSCILLATOR CIRCUIT DIAGRAM.

mounted in close proximity to the crystal so that they are both at the same temperature. Any temperature variation will cause the heating element (a 12V bulb mounted inside the box) to light or dim and hence bring the temperature back to nominal.

The power supply should be well regulated to prevent drift due to supply variations.

The best type of crystal to use is the glass-cased type that has a much greater long-term stability than metal cased types.

Corrections to diagrams

The following are corrections to the text in this reprinted edition: -

Page

9 L1 = 12 turns, L2 = 6 turns, L3 = 4 turns. All 26swg, close-wound on 4mm former, with core.

10 The 100µF capacitor in the base circuit of the third BC107 is shown the wrong way round. The + should connect to the 820 Ohm resistor.

18 The 4.7k at the base of TR5 may be reduced to around 390 Ohms. This should assist where the characters are slightly streaky.

24 Pin 1 of the bottom 74150 should connect to ground.

28 The delay line is 15 yards long and not 15 feet as shown.

32 The 10µF capacitor shown at top centre should be 100uF.

36 The TBA520 pin ‘1’ should be pin 2, pin ‘6’ should be pin 5 and pin ‘7’ should be pin 6. The printed circuit board is correct.

37 RV2 should be labelled “burst phase”.

37 ‘R78’ next to RV8 should be labelled R79. C10 is fitted between the two spots below R74, + to the left. C8 and C12 are shown non-polarised, their + ends are at R31 and R42 respectively. C27 is non-polarised.

The BATC’s “P100” sync pulse generator will provide all the drive pulses required for use with projects in this book. Copies of the original articles may be obtained from BATC Publications. Printed circuit boards are available from Members Services.

Any correspondence concerning this book may be sent to; Mr. I Brown, G8CJS, 14 Stairfoot Close, Adel, Leeds. LS16 8JR. please enclose a S.A.E.

Advertisements