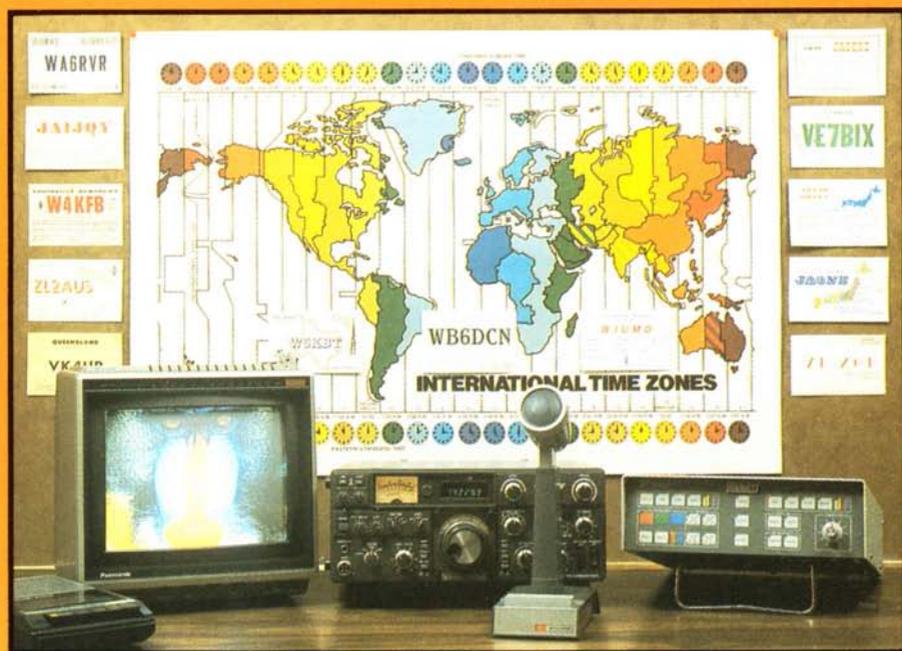


THE SLOW SCAN COMPANION

C Grant Dixon, G8CGK
John Wood, G3YQC
Mike Wooding, G6IQM



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THE SLOW-SCAN COMPANION

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This book is dedicated to Richard Thurlow, G3WW,
the world's most ardent slow-scanner.



ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the following for their major contributions to this book:

Damien Mannix, Robot (U.K.) Ltd. Robot Research Inc. Radio Society of Great Britain. Peter Asquith, G4ENA. Clive Asquith, G4ENB. B.A.Smith, G3WCY. John Hibbert, G3YCV. Trevor Brown, G8CJS.

Acknowledgement is also made to the following for their assistance.....

Jeremy Royle, G3NOX. Peter Delaney, G8KZG. Deryk Wills, G3XXK. C.Watkins, G3TTZ. Albert Corker, G4NJI. Richard Thurlow, G3WW. John Brown, G3LPB. J.C.Pennell, G3EFP. Ian Hollingsbee, G4NVC. Dick Hunter, G3LUI. M.Browne, G8UUL. Arthur Bevington, G5KS. Deryck Aldridge. John Pearson of Pearsons Computing. Grosvenor Software. J & P Electronics. Technical Software. Davtrend Ltd. Narrow Bandwidth Television Association. Roland Hall, G8KER.

...and also to the authors of works to which reference has been made and all those who have given advice and encouragement during the compilation of this book.

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Front cover picture courtesy of Robot Research Inc.

First edition

First printing January 1987

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FOREWORD

Having dabbled with field-sequential colour TV in the 1950's, my attention was captured by a report of a new type of TV using very slow scanning speeds and an afterglow type of cathode ray tube. It wasn't long before I had constructed an SSTV monitor which, as far as I can recall, was the second to be built in this country.....and I only had a 1200ft reel of tape recorded pictures to view!

Things have moved very far since 1959 and modern SSTV is a science in itself, so I was delighted when John Wood expressed a desire to produce a book on SSTV. I supplied him with my collection of reprints and photocopies which, together with a good deal of other material, has resulted in this volume. I am glad to be associated with John and Mike who have together done most of the work of editorship. I wish 'THE SLOW-SCAN COMPANION' every success and am left wondering what will happen to SSTV in the next 25 years.

C.Grant DIXON, G8CGK

Ross-on-Wye
December 1986

REFERENCES

In a book such as this it is impossible to cover all the practical aspects of SSTV. In order to help those wishing to obtain past published works on the various subjects, the authors have included a list of references at the end of some chapters. These references relate to articles which are particularly recommended although of course there are likely to be many others in existence.

Many of the references are followed by a code eg. GD82, this refers to a quite comprehensive collection of SSTV material - dating from the original Cop Macdonald articles - which have been collected over the years by Grant Dixon G8CGK. Grant has produced an index of all his reference codes with details of the articles to which they refer. The collection has formed the basis of the research material for this publication and now resides in the BATC library. Members wishing to borrow material from the library should contact the librarian, whose address may be found in the current issue of CQ-TV magazine, quoting the reference and/or GD code number.

John Wood, G3YQC

SSTV STANDARDS

The original idea behind slow scan TV was to find a method by which a wideband television picture could have its bandwidth reduced so as to allow its transmission over a single channel voice communication system. This meant that a typical 3MHz television signal had to be reduced to around 3KHz - a 1000 to 1 reduction in bandwidth!

DERIVATION OF SLOW SCAN STANDARDS

To reduce the bandwidth of a TV signal both the horizontal and vertical scanning rate must be reduced to as low a frequency as possible. At the outset it was decided that both line and frame frequencies could be conveniently derived from the domestic a.c. mains supply (50Hz in the U.K.). Table 1 lists the actual frequencies used as well as detailing the other parameters of the system. It can be seen that the line frequency of 16.6Hz is obtained by dividing the mains frequency by three (in countries with 50Hz), and the frame frequency of 1/7.2Hz by dividing 50Hz by 360. In countries using a 60Hz mains frequency different division ratios are used to arrive at approximately the same standards.

The above description relates to the 'original' slow scan specification, however in view of the fact that SSTV is increasingly using digital techniques, there is a tendency to increase the number of lines to 128 which is a convenient binary number. Most SSTV monitors and receivers will accept either standard, the only noticeable effect being a slightly larger picture on the screen.

In order to separate the spectrum of the sync pulse as much as possible, the line pulse length is made 5mS. Analysis shows that such a pulse width has a base video bandwidth of 200Hz. The frame sync pulse is made much wider than the line to make it easier to separate the two pulses in an integrating circuit. The frame pulse was made 30mS or about half a horizontal line.

Parameter	50Hz Mains	60Hz mains
Line speed	16.6Hz (60ms)	15Hz (66ms)
Lines per frame	120 or 128	120 or 128
Frame speed	7.2S or 7.68S	8S or 8.53S
Aspect ratio	1 to 1	1 to 1
Scanning direction	Horizontal left to right Vertical top to bottom	left to right top to bottom
Sync pulse duration	Horizontal 5ms Vertical 30ms	5ms 30ms
Subcarrier frequency	Sync 1,200Hz Black 1,500Hz White 2,300Hz	1,200Hz 1,500Hz 2,300Hz
Required transmission bandwidth	1.0 to 2.5KHz	1.0 to 2.5KHz

Table-1 SSTV STANDARDS

The aspect ratio of 1:1 is rather an inherited standard which was originally chosen to suit the ex-radar, long persistence cathode ray tubes originally used in display monitors. These tubes had round faces therefore a square rather than rectangular format was appropriate.

MODULATION

It has been shown that a video bandwidth of some 900Hz is adequate to reproduce the slow scan picture. Since the line and frame rates are very low in frequency, a high level of video energy is positioned near to zero frequency. This means that amplifiers and modulation devices must operate near the d.c. level. Of course this is impractical since phase shift and drift would cause a significant deterioration in the picture. The problem can be avoided if the video signal is modulated onto a subcarrier placed within the required 3KHz SSTV spectrum.

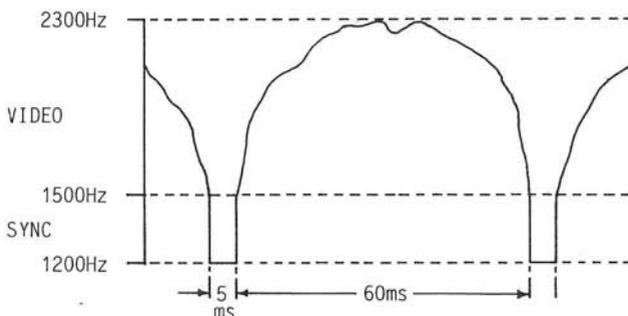
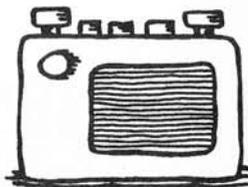


Fig.1 **FREQUENCY COMPOSITION OF A SINGLE SLOW SCAN TV LINE.**

The subcarrier is frequency modulated by both video and synchronising signals to the standards shown in Table 1. The basic video frequency at black level is 1,500Hz which rises to 2,300Hz at peak white. The sync frequency of 1,200Hz represents 'blacker-than-black' so that the visible raster is blanked out during retrace or flyback of the scanning beam. Fig.1 shows the frequency composition of a single slow scan line and illustrates the placement of the three key modulating frequencies, clearly showing that frequencies for the complete picture go no lower than 1,200Hz.

The above standards are those laid down by Copthorne Macdonald - the inventor of SSTV - and form the basis for all slow scan TV transmissions. The original system devised in fact used AM but 'on air' tests however showed this to be very susceptible to impulse interference and noise and the present FM system was adopted instead. Other standards and specifications do exist but these have been largely produced by equipment manufacturers, often for no better reason than to simplify their own designs. There are however several 'genuine' variations in standards such as high definition and colour and these are referred to in the appropriate chapters.

RECEIVING SSTV



SSTV pictures can be received using an ordinary communications receiver or transceiver covering the popular amateur bands. No modifications are required to the receiver although the internal I.F. filter should not be less than 2.5kHz wide - 3kHz for preference. The SSTV signal is extracted either from an audio line output or from a headphone jack.

Table 1 shows the amateur bands used for slow scan TV as well as the IARU recommended working frequencies and those frequencies which are perhaps most often used. The mode of transmission may be either SSB or FM.

BAND (MHz)	IARU Recommended frequency (MHz)	Popular frequencies (MHz)
3.5	3.735	3.730
7	7.040	7.040
14	14.230	14.230
21	21.340	21.340
28	28.680	28.680
144	144.500	144.500

Table 1. SSTV FREQUENCIES.

DISPLAY HARDWARE

Broadly speaking there are three methods by which a slow scan picture can be displayed:

- 1) A conventional monitor containing an integral long-persistence cathode ray tube together with signal processing and deflection circuits.
- 2) A digital scan converter whereby the received signal is digitised and stored in a memory. The memory is then scanned at fast-scan (625-line) rate for displaying on a conventional TV set or monitor.
- 3) A home computer which processes the picture either directly or via a hardware interface.

THE MONITOR

The basic principle of all SSTV monitors is the same. The audio signal from a receiver is a frequency modulated subcarrier, therefore FM detection is required. As with conventional FM receivers a good limiter is needed ahead of the discriminator to help eliminate AM noise etc. and to present a constant-amplitude signal to the demodulator.

The discriminator changes the FM signal to an AM one, however, it is important to realise that the waveform still consists of a subcarrier centred around 1,500Hz. The sync signal is recovered by using a tuned-circuit sync discriminator which can be adjusted to accentuate its amplitude in order that both vertical and horizontal pulses can be recovered by threshold detectors.

The AM subcarrier signals will need to be detected to recover the original baseband video and sync signals. Full-wave rectification is most often used because the design of the necessary post detection filter is eased.

The deflection circuits are controlled by the sync pulses to produce a raster on the screen in the same way as a conventional TV set, however in simpler designs no internal generator is provided to scan out a raster in the absence of received syncs. When using this type of monitor one must take care that a stationary scanning spot does not burn the CRT phosphor and, ideally some form of spot suppression should be employed.

The baseband video signal itself is filtered and used to bright up the CRT in the normal manner.

A block diagram of a slow scan monitor is shown in Fig.1 and designs may be found in ref's. 1 & 2.

It is possible to utilise an oscilloscope for viewing SSTV pictures and a practical system is described in ref.3.

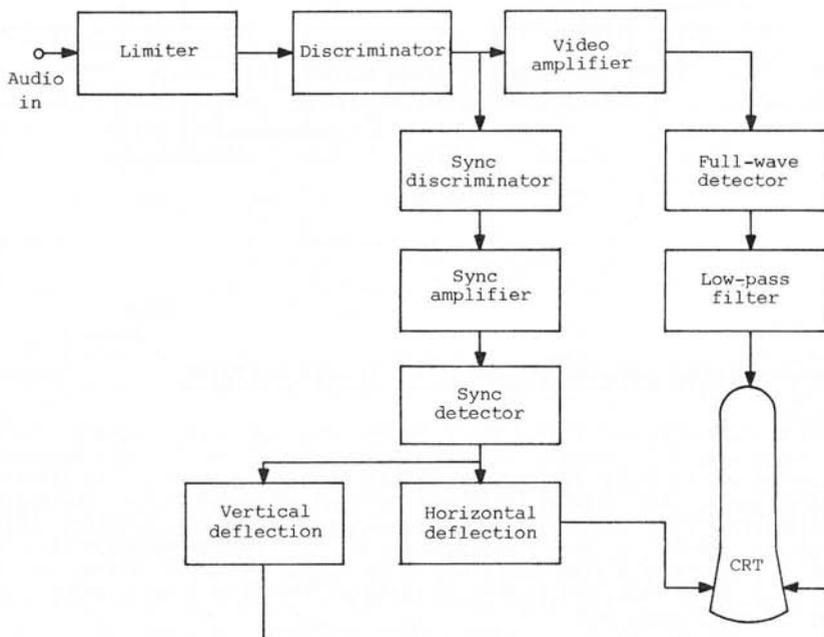


Fig.1

BLOCK DIAGRAM OF A SLOW SCAN TV MONITOR.

DIGITAL SCAN CONVERTER

It is only in recent years that digital techniques and devices, especially memories, have come within the reach of amateurs. The main reason for adopting this technique in a receiver is to enable a domestic TV set (or monitor) to display the slow scan picture. The benefits will be realised by those who have experienced conventional SSTV monitors. With these the picture would start to fade at the top of the frame as it was being traced out, and because it was not possible to easily increase the overall brightness and persistence of the image, it became necessary to view the pictures in subdued room lighting. Also the reception of colour transmissions was very difficult on such a monitor and necessitated several frames of each of the three primary colours, each viewed through an appropriate colour filter, and recorded on film to photographically build up the full colour picture.

Although there are several methods of accomplishing digital frame store and scan conversion, the method described here is typical. Shift registers are now considered obsolete, RAM is used nowadays, however, for ease of explanation shift registers are referred to. It should be noted that dynamic RAM addressed by a clock and address lines is not equivalent to a shift register.

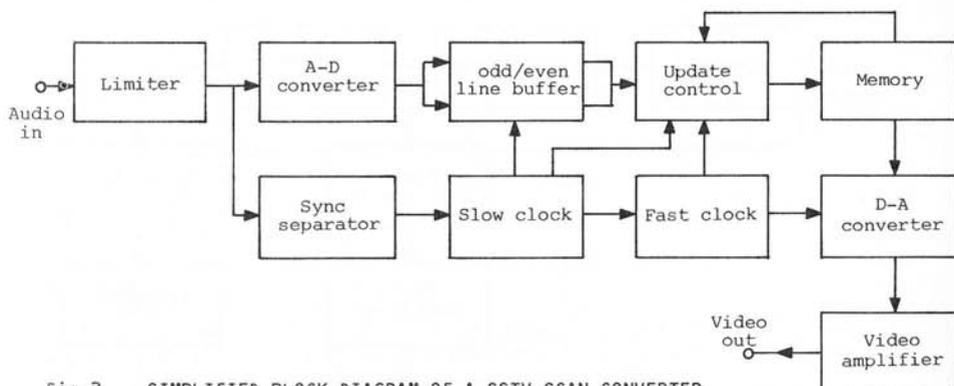


Fig.2 SIMPLIFIED BLOCK DIAGRAM OF A SSTV SCAN CONVERTER.

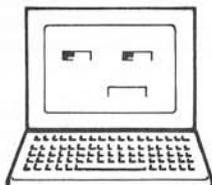
As with a conventional monitor the incoming audio signal is limited to provide a constant-amplitude signal. This is then passed to an Analogue-to-Digital converter whose purpose is to digitise each line of information into 128 4-bit binary words. Two 512-bit shift registers act as buffer stores, the digital information for the first slow scan line being stored in the odd-line buffer which is controlled by a slow-speed clock. The storage operation will take 60ms, the length of a slow scan line. The second line is stored in the even-line buffer but, whilst this is going on, the first line is being loaded into the main memory bank.

The main memory consists of a set of four shift registers, each of which handles one bit of the 4-bit word. Because the whole TV frame is made up of 128-lines, each containing 128 pixels, there will be a total of 16,384 4-bit words thus each shift register must have a capacity of 16k bits. The memory is continually scanned at fast scan rate and the information passed to a digital-to-Analogue converter to bring it to a baseband video signal. The video is mixed with fast scan syncs and either fed out to a monitor or used to

drive a UHF modulator so that it may be viewed on a domestic TV set. A continuous picture is displayed on the TV screen the beauty of which is that it will stay there until a new SSTV frame is received, this will slowly replace the first picture as it progresses down the screen. Of course any picture may be stored on the screen for as long as you wish by disabling the input to the scan converter.

Naturally there is a difference in aspect ratio between the two TV systems; SSTV having a 1:1 ratio whilst fast scan TV has 4:3. If this were left uncorrected it would result in distortion of the displayed picture, so arrangements are made within the scan converter to blank out the first and last eighths of each fast scan line, resulting in a square SSTV picture framed by a completely black border on either side. This does not detract from the presentation of the picture on the screen.

Apart from the design by G3WCY elsewhere in this book another popular system was described in ref.4.



COMPUTERISED SSTV

Most personal computers are capable of being employed as SSTV receivers and picture generators, perhaps the most popular being BBC, Sinclair Spectrum, CBM64 and Vic 20. With the exception of the Spectrum, computers generally require a simple interface in order to present the correct information to the computer's I/O port.

The BBC for example requires a PC board which (a) separates out the SSTV line and frame sync pulses and converts them to TTL levels ready for feeding into the I/O port, and (b) limits and rectifies the video signal before feeding to an Analogue-to-Digital converter whose output also connects to the computer's I/O port.

One of the main reasons for using a computer is to make use of the relatively large amount of memory available as well as taking advantage of the excellent display facilities. Of course once the information is in the computer's memory it is relatively simple to manipulate it in various ways to provide extra facilities and effects.

For example different timings can be set enabling experimental and colour SSTV transmissions to be received. Picture compression; this reduces the size of the picture on the screen giving the impression of greater definition. 'Fill' enables the spaces between SSTV lines to be filled in thus producing a picture more like a fast scan one. Picture width is controllable providing compensation for transmissions derived from different mains frequencies. Video invert provides a reversed image - useful for receiving captions - and of course the facility for dumping the SSTV picture to a graphics printer or plotter.

Commercial and build-it-yourself versions of computerised receive equipment are available, details of which may be found elsewhere in this book.

REFERENCES

- 1) W4TB Simplified electrostatic monitor (GD53) and W6MXV High performance magnetic deflection SSTV monitor (5FP7 tube) (GD54): 'Slow Scan Television Handbook' by W9NTP & WB8DQT published by 73 Magazine.
- 2) A basic solid-state slow scan television monitor by WB8DQT; 73 Magazine August 1973 (GD69).
- 3) Slow-scan TV viewing adaptor for oscilloscopes by W7ABW & W7FEN: QST Magazine June 1970 (GD57).
- 4) SSTV to fast-scan converter by WB9LVI; QST magazine March & May 1975 (GD100)

SSTV TUNING INDICATOR

This simple circuit is most useful as an aid to the correct tuning-in of a slow scan signal on a receiver. The unit provides a L.E.D. which flickers in sympathy with the received sync pulses, providing a visual indication of correct tuning.

A sync signal from the station SSTV monitor or other receive system is connected to the input where it is amplified and fed to a tuned circuit. This tuned circuit, formed by an 88mH toroidal inductor and a parallel capacitor ('C') resonates at 1200Hz (sync frequency) and the signal is rectified in a pair of switching diodes. From there the signal passes to a single transistor lamp driver which is switched on and off in sympathy with the signal presented to its base.

Sync input should be taken from the point of highest sync within the monitor or SSTV receiver; TTL level being ideal.

Capacitor 'C' is selected to resonate with L1 at 1200Hz and in practice will be around 0.2uF. This should ideally be set with the aid of an audio signal generator. Apply a 1200Hz sine-wave to the input and adjust 'C' for maximum voltage at the base of Tr2. Alternatively apply a SSTV signal to the input of the monitor and adjust 'C' for best flicker.

88mH toroids are widely used in RTTY equipment and can be supplied by the British Amateur Radio Teleprinter Group. They were also used in the recent past by British Telecom and may therefore be found in surplus telephone equipment.

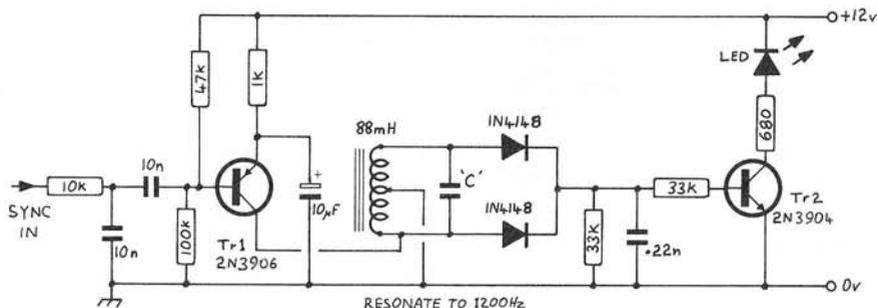


Fig.3

AN LED SSTV TUNING INDICATOR.

TRANSMITTING SSTV



Sending SSTV pictures over the air is quite straightforward. An ordinary HF or VHF transmitter or transceiver can be used and the combined SSTV signal is simply fed into the microphone socket. The band in which you are operating largely dictates the mode of emission and sideband convention, although both SSB and FM are used on VHF.

No modifications to the transmitter are necessary, however when using SSB there is one very important factor to be borne in mind: Transmitting ordinary speech with SSB means that maximum power output is only reached at speech peaks, therefore the duty cycle for the power amplifier is fairly low enabling it to be run harder whilst not overheating. An SSTV signal however, transmitted in the same way produces a 100% duty cycle due to the presence of the subcarrier. When transmitting slow scan via SSB therefore you must turn down the audio gain so that the transmitter output stages are operating within their recommended limits.

PICTURE SOURCES

Newcomers to SSTV, having equipped themselves with a receiver, are naturally keen to transmit some pictures as well. There are many ways of generating slow scan pictures but a newcomer may, in the first instance, enlist the help of a local slow scanner to record some pictures and captions onto an audio cassette tape. A standard cassette recorder therefore is all that is required as the slow scan source for the transmitter, and the receiving station may never know that the pictures are not live.

The most popular slow scan picture generators are: Home computer, Electronic pattern generators, Keyboard, Digital scan converter with fast scan camera, Slow scan camera, Sampling camera and Flying spot scanner. Let's look briefly at each one....

HOME COMPUTERS

The computer can be used to generate both graphic pictures and text and can save them out to tape or disc for future use. The computer can be programmed to output the screens at slow scan rate in which case external circuitry must be provided to convert the vision signal into analogue form, combine it with syncs and modulate it onto the subcarrier prior to transmission. The fast scan composite video output from the computer may also be used but will need digital scan conversion to SSTV before transmission (see below).

The use of computers in a slow scan environment is covered elsewhere in this book.

ELECTRONIC PATTERNS

It is quite easy to make small logic circuits to produce such patterns as Grey scale, Chequer board, Horizontal and vertical bars, grille etc. but in their simple form these patterns are only of limited use because personalisation cannot be easily added to them. Such patterns nevertheless do

have considerable value in providing standard test signals to help in aligning equipment. A pattern generator is described elsewhere in this book.

KEYBOARDS

The keyboard is an electronic typewriter on which you can type a message which will be output as a combined slow scan TV picture ready for transmission. These devices were very popular some years ago and are still quite widely used, however SSTV is a visual medium and it is generally considered bad form to conduct an entire QSO using keyboards. Keyboards though are an excellent way of titling and captioning within a QSO.

One of the first and most popular SSTV keyboards was designed and described by WOLMD (Ref.1).

DIGITAL SCAN CONVERTERS

The digital scan converter for transmission is similar in principle to the one described in the chapter on receiving SSTV. The transmitting system has to accept a fast scan TV signal, store it and then scan the memory at slow scan rate in order to provide a SSTV picture. In practice only samples of the fast scan signal are stored in memory, since to store all of it - in high resolution - would take a considerable amount of memory capacity which would be very wasteful. In use the scan converter 'snatches' a frame of video and stores it, then waits until the slow scan picture has been transmitted before snatching the next frame. Digital scan conversion is covered in depth elsewhere in this book.

A practical fast-to-slow scan converter may be found in ref.2.

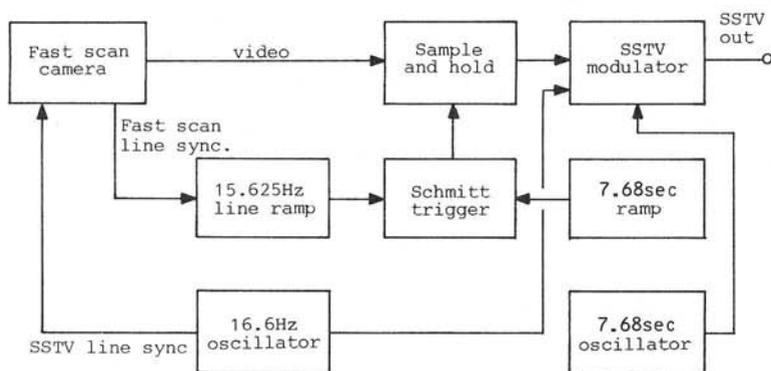


Fig.1 BLOCK DIAGRAM OF A SAMPLING CAMERA SYSTEM.

SLOW SCAN CAMERAS

Cameras which actually scan a vidicon tube at slow scan rates are not often used these days. The tube essentially stores a latent image so that a mechanical shutter may be used to 'freeze' the action at the beginning of a scanning period, with the image being read off during the remainder of the scan. A typical vidicon tube of this type is a 7290 and a practical camera design may be found in ref.3.

Perhaps a better method of achieving direct slow scan scanning of a tube is to use a Plumbicon. The Plumbicon is also an image storing device and will produce good slow scan pictures without the need for a mechanical shutter.

The tube is easy to obtain since they are used in modern broadcast three-tube colour TV cameras and are often available on the surplus market. An eye on the 'Market Place' section in CQ-TV magazine often produces Plumbicon tubes together with their rather complicated scanning yokes. A construction project for a plumbicon camera may also be found in ref.3.

SAMPLING CAMERAS

A sampling camera is essentially a conventional vidicon camera, operating in a near-conventional manner but having the actual video information sampled in order to produce a slow scan picture.

The normal (U.K.) fast scan standards call for a line frequency of 15.625kHz and a frame speed of 50Hz. If one turns the camera on to its right side then the 50Hz scan now becomes horizontal, dividing this rate by three results in the correct slow scan line speed. The modification required is normally to either drive the camera's frame sync circuit with external slow scan line syncs or, in the case of a camera with internal synchronisation, alter the timing circuit of the oscillator (usually by raising the capacitor value) to obtain the correct speed. The block diagram of a sampling camera is shown in Fig.1.

The fast scan line (now running along the vertical axis) is sampled many times during the slow scan frame period and the resulting video is used to produce the slow scan image. Of course since a part of every fast scan frame is sampled, it follows that in order to produce a complete slow scan picture the subject must remain stationary for the duration of the slow scan frame.

An excellent article containing practical details for modifying an existing camera may be found in ref.4.

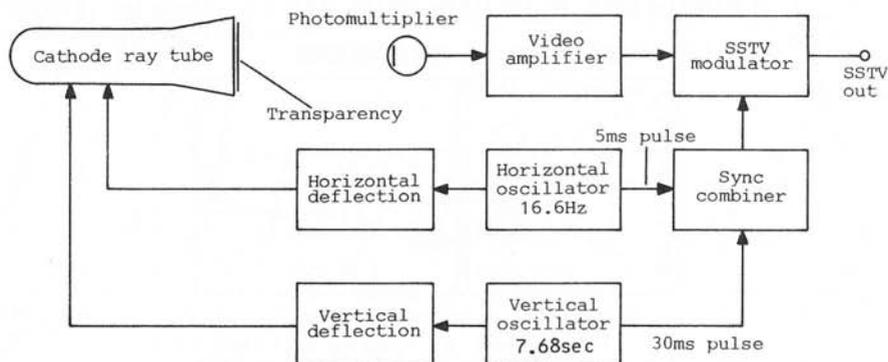


Fig.2

BLOCK DIAGRAM OF A FLYING SPOT SCANNER

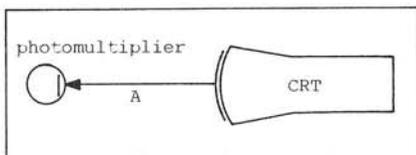
FLYING SPOT SCANNERS

It must be said that equipping oneself with a live slow scan camera is neither straightforward nor cheap. There is however one method of generating slow scan from photographs, slides or pictures which may appeal to the home constructor, this is the flying spot scanner.

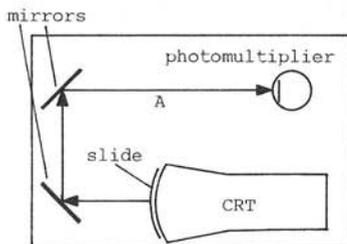
The principle of the flying spot scanner may be learned from Fig.2. With the aid of slow scan deflection circuitry a raster is produced on the face of a small magnetic or electrostatic cathode ray tube. The raster is actually a fast-moving spot of light which is used to scan the picture to be transmitted.

This can be accomplished by placing a photographic transparency onto the face of the tube allowing the light to shine through it and be picked up by a photomultiplier. Another method is to use a lens system to focus the raster spot onto a photograph or drawing and pick up the reflected light with a photomultiplier. In both methods the brightness of the light produced fluctuates depending upon the part of the picture being scanned.

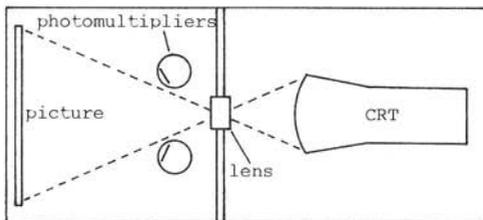
A sensitive photomultiplier tube, often a 931A, is used to pick up the light and convert it to a voltage which is proportional to the amount of light falling onto its sensor. A photomultiplier is generally used because it is so constructed that it provides a considerable amount of internal amplification, thus the following amplifying stages are kept to a minimum. It does however need a rather high voltage (up to 1000v) to operate and therefore many constructors prefer to use modern solid state image sensors. Fig.3 gives some examples of mechanical layouts for flying spot scanners including a two-tube version. (ref.3 & 5).



a) Direct light pick-up. The distance 'A' should not be less than about 6" to avoid impaired resolution caused by parallax errors.



b) A system of mirrors may be used to extend the length of A in order to shorten the box.



c) Indirect pick-up from an opaque picture. The lens focusses the scanning spot onto the picture. Note the directions in which the two photomultipliers are pointing.

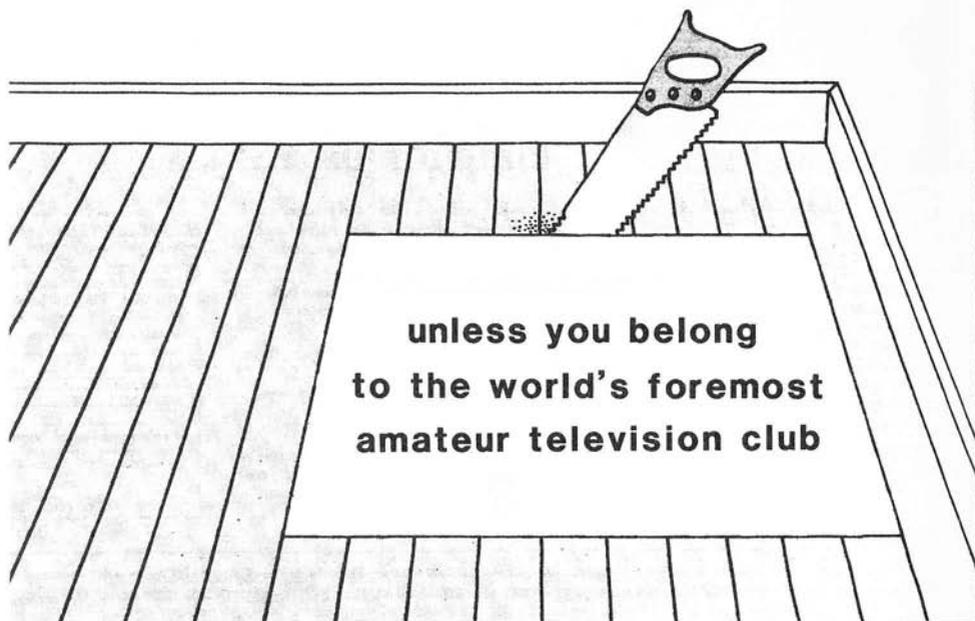
Fig.3

SUGGESTED MECHANICAL ARRANGEMENTS FOR A F.S. SCANNER.

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- 1) SSTV keyboard, WOLMD (GD66, GD101, GD101a).
- 2) SSTV scan converter by WOLMD; 73 magazine August 1974 (GD82 & GD82a).
- 3) 'Slow Scan Television Handbook' by Don C. Miller W9NTP and Ralph Taggart WB8DQT. Published by 73 magazine.
- 4) Conversion from fast-scan to slow-scan television by W3EFG and W3YZC. Ham Radio magazine July 1971 (GD32).
- 5) A simple solid-state flying spot scanner for SSTV by WB8DQT; 73 magazine July 1972 (GD43).

**Understanding television can be like having
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The BRITISH AMATEUR TELEVISION CLUB is for everybody interested in TV, be they slow-scanners, transmitting amateurs, video enthusiasts, constructors, satellite buffs or computer graphics whiz-kids. Membership brings you the quarterly magazine 'CQ-TV' which is packed with up-to-date practical information for beginners and old-hands alike, there is truly something for everyone and should not be missed!

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THE SSTV STUDIO

The final quality of an SSTV picture should be the most important consideration in any slow scan station, since it is by your transmissions that you are judged by others. Experienced SSTV'ers will no doubt have observed considerable variations in received picture quality from different stations, especially on camera shots. One of the main reasons for this is one of lighting or the correct illumination of the subject. Let us therefore examine this subject so that you may, hopefully, be able to ensure optimum performance from your slow scan equipment.

A camera is normally set up and used in a 'studio'. Now this may sound very grand, but in practice a studio may be no more than a corner of the shack or a few feet of bench space. Whatever you use as a studio it will certainly need a fixed and properly controlled lighting system. It is worth therefore taking a look at a suitable layout.

AN SSTV STUDIO

Fig.1 illustrates a basic studio. For effective SSTV pictures a fairly bold approach to subject matter and contrast levels is required. It is perhaps best to use a matt black background which could typically be made from a sheet of black poster card obtainable from your local stationers or art shop. The card can be about two feet square and should have some means, towards the bottom, of holding or standing caption cards and pictures. The lights are connected to a lamp dimmer (available from electrical shops) which allows the lighting level to be adjusted for different subjects.

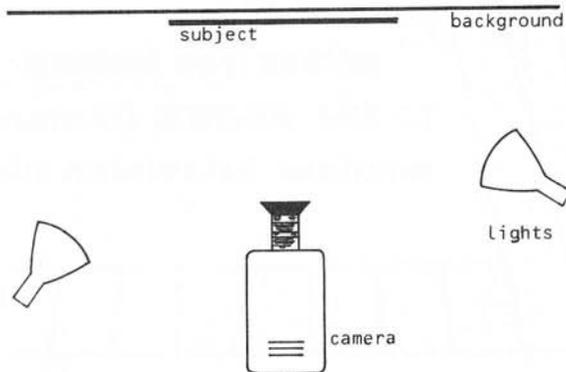


Fig. 1 Basic lighting arrangement

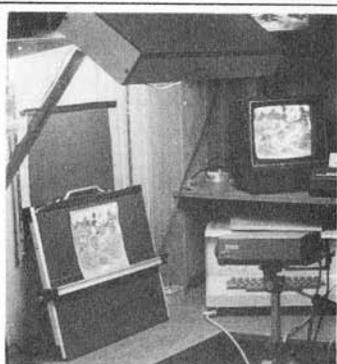
The use of a black background ensures that maximum light from the subject - not the background - is returned to the camera thus keeping contrast levels high. Having such a background also reduces the risk of light reflections feeding back to the camera. The lighting arrangement in Fig.1 is adequate for pictures and captions, but for three-dimensional objects a third light can be used to good effect, this is often placed behind the subject, or sometimes

overhead, its purpose being to provide back or top illumination to create roundness and depth and also produce interesting highlights. Try it for yourself and see how 'flat' a purely front-lit subject looks in comparison.

LIGHTING

The amount of light required on a given subject is of course that which produces the best quality image in terms of contrast and detail. Generally, looking after the contrast will ensure that the detail looks after itself. If too much light is used the camera will not reproduce detail from the lighter parts of the subject and these areas will tend to flare or 'white-out'. If too little light is used then the picture will be somewhat thin and of poor contrast.

Suitable lights for black and white SSTV can be almost any that produce a fairly white light and daylight is, of course, ideal. Photographic photoflood and spot lamps are very good but do tend to be somewhat expensive as well as running very hot. Also, as they age, the light tends to fall off towards the red end of the spectrum. The conventional 100W household lamp can produce good results and they are certainly a lot cheaper. Both photofloods and domestic bulbs may be controlled by the dimmer switch. The author has had good results from using an old slide projector as a light source. Some small household fluorescent tubes are OK for black and white but not for colour although the standard fittings using 'daylight' tubes seem to be very good indeed - even for colour. With any source it should be remembered that the further away the subject is from the light source the brighter it needs to be to produce a given picture quality. A further look at lighting for colour cameras may be found in the chapter on colour SSTV.



A suitable setup for captions and printed pictures. Simple strip lighting may be used here.

SETTING UP

Let's now go through a typical adjustment procedure for setting-up a studio for SSTV work. Firstly you should make sure that the video camera is set according to the manufacturer's recommendations. Since many shack cameras though are second-hand the following general instructions may be of assistance:

This sequence assumes that the camera is electrically adjusted, that is having one-volt peak-to-peak of video available at the output and that beam current, target volts and electrical focus are correct. Choose a subject with some black and some white content as well as in-between shades and adjust the camera lens to f8. Turn on the lights and focus the lens. If a fast-scan monitor is being used its contrast control should be set for an average picture - neither fully up or down - and the brilliance for a comfortable level. If the studio lights are turned up and down now you should be able to adjust them for best lighting. The black parts of the picture should be truly black and the whites (you guessed it!) truly white. Once the lighting level is right any correction needed for different subjects may be made using the aperture ring on the lens.



The caption holder has a black background and a means of supporting or fixing pictures.

If no fast-scan monitor is available and adjustments are made using a SSTV monitor then it is important that this be set up correctly using a good quality recording of an 8 or 16-step greyscale or a custom-built greyscale generator. When displayed on the monitor the brilliance and contrast controls are adjusted to produce an even graduation between white and black. It is important that ALL the tone steps be clearly seen on the screen. Once the monitor has been adjusted in this way DO NOT CHANGE THE SETTINGS FOR ANY REASON; this is now your standard against which everything else is set. The camera should now be set up in a similar way to that described above where a good slow scan picture should be produced.

You should now be in a position to make a number of test recordings. Use the monitor as your standard and, if the pictures look good, record them onto tape. These should be played back and checked on your monitor to confirm the quality. The various settings of lens aperture and light brilliance may be noted for later reference if required.



A good picture shows rich blacks, brilliant whites and good in-between shades of grey.



This was the first SSTV picture to be transmitted across the Atlantic ocean. It was sent by Copthorne Macdonald, WA2BCW, on December 20th 1959 and received in England by John Plowman, G3AST.

SSTV IN COLOUR



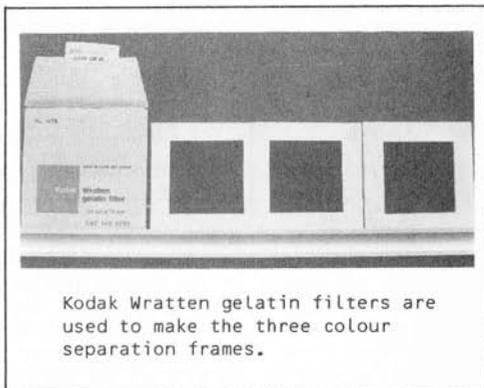
Colour SSTV is a very complex subject which is made worse by the number of different systems in use by amateurs. All have their merits and drawbacks although the particular system used by the individual is often dictated by the equipment available. Broadly speaking the common systems fall into 'camps' which are usually those adopted by various SSTV equipment manufacturers. Because of this diversity no attempt is made in this volume to describe or analyse the various systems, instead a description of the principles of colour SSTV is given together with a practical sequence using a black and white camera, and general guidance on the use of a colour camera in order to achieve best results from a modern digital scan converter.

PRINCIPLES

Colour SSTV consists of breaking the colour subject down into three black and white pictures which can be transmitted using a standard SSTV system. This process is called analysis. The three frames consist of the original colour picture viewed through three filters - a red, a green and a blue. It is a fact that three separate black and white frames, each taken through a different filter, contain all the colour information necessary to reassemble a complete colour picture at the receiving end thus making them suitable for use with all colour SSTV systems.

The filters commonly used are the Kodak Wratten type which are in gelatin form and should be available from most photographic shops. The filters required are: RED - No.25; GREEN - No.58 and BLUE - No.47B.

The various colour SSTV transmission systems are likely to be based on either Frame Sequential or Line Sequential techniques and these are briefly defined below. However there are other systems such as "Time Multiplexed Component Colour", used in some Robot equipment which take advantage of the latest in digital technology.



Kodak Wratten gelatin filters are used to make the three colour separation frames.

FRAME-SEQUENTIAL COLOUR:

This involves the use of three separate frames of the same picture each containing red, green and blue information. These frames are transmitted in sequence and may be repeated several times to ensure that at least one good frame is received, even over a difficult transmission path.

LINE-SEQUENTIAL COLOUR:

Alternating red, green and blue lines are transmitted and are synchronised by the vertical synchronisation pulse. The usual sequence is red - green - blue.

COLOUR SSTV WITH A BLACK-AND-WHITE CAMERA

Making a colour picture is quite straightforward: First you will need a scan-converter which is fitted with three memories that can be used for transmitting. The camera should be correctly adjusted as detailed in the "SSTV Studio" chapter as should the SSTV monitor. To set the colour monitor load each of the memories with a grey-scale and display all three memories together, adjusting contrast and brilliance for correct display of the B&W picture (good black, good white and each step clearly discernable). The setting is left alone from this point.

Now the scan converter brilliance and contrast settings should be set to produce the best picture, after which the settings remain un-touched. Put the memory switch to RED and place the red filter in front of the camera lens. Hold this position for two or three seconds to allow any automatic functions within the camera to settle, then load the picture into the red memory. The same procedure is adopted, WITHOUT MOVING THE CAMERA, for the green and blue frames after which your scan converter memory will contain the complete colour picture but in its separated form. Now switch the scan converter to 'display' and you should have a good colour picture on the screen.



Good contrast and tonal range is important in achieving the best colour pictures.

If the colours don't match the subject check the lighting and scan converter settings. After a few test pictures have been made and recorded play them back to see how they look after being passed through the memories a few times.

Of course, once you have the colour separations in store you can transmit the pictures at will using any of the colour systems available.

COLOUR SSTV WITH A COLOUR CAMERA

With the advent of the modern digital scan converter it is often possible to use a colour TV camera directly, the converter then 'snatches' a complete frame and automatically breaks it down into the three colour separations ready for transmission. Such a scan converter is the Robot 1200C, and the following section, providing guidance on the use of colour cameras in this application, is reproduced from the Robot 1200C instruction manual (appendix A) by kind permission of Robot Research Inc:

The use of a colour TV camera as a video source requires that we look at things somewhat differently than we do with a black and white camera. We are no longer able to think strictly in terms of "contrast" because we must now consider colour. In the world of composite colour the term usually used instead of "contrast" is COLOUR SATURATION. Colour saturation refers to the relative intensity of the colours in the image. An image with relatively subdued colours is said to have low colour saturation while a brightly coloured image is described as having high colour saturation.

Colour intensity, or saturation, is only one aspect of colour quality. Another factor, perhaps the most important in colour work, is HUE. Also referred to as TINT or PHASE, HUE is colour itself. Thus red, green, blue, orange, etc., are different HUES. The term is important because we need a way to describe the colour errors in a reproduced image. Such errors are called HUE errors. Green skies, blue faces and purple hair are the result of HUE errors.



Good lighting brings out some essential highlights.

Now that colour saturation and hue have been defined, let's consider the role that light plays in determining the quality of a composite colour video image. The amount of light used to illuminate a colour image in front of a TV camera affects colour saturation in the same way that it affects contrast in a black and white system. The more light falling on the subject, that is, the greater the illumination, the more saturated the colours in the video image will be. In practice, sufficient light must be provided for the camera to produce colour which is as saturated as the original. The problem of determining how much light is required when a modern colour video camera is used is a relatively simple one to solve. This is because most manufacturers of colour cameras

have gone the extra mile and designed very good video control circuitry into their products. Too much light is almost never a problem and, in general, the more light the better the colour reproduction. Lighting requirements vary, of course, depending on subject material and the nature of the video equipment used but the important point is DON'T SKIMP. (For a great example of how NOT to skimp on lighting try to arrange a visit around a broadcast TV studio).

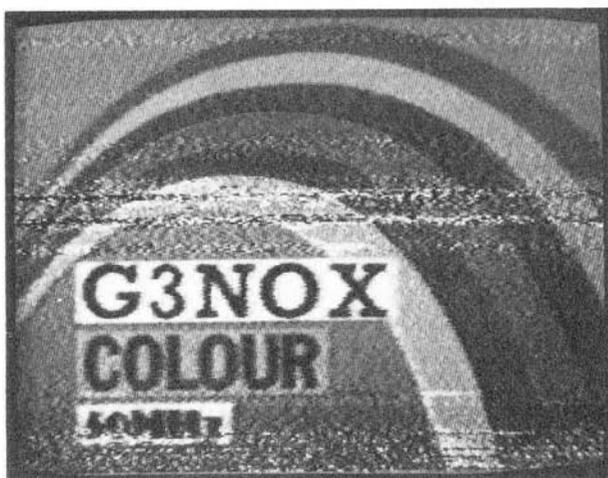
Having discussed the importance of providing sufficient light in colour video work we must now consider the quality of the light utilized. The character of the light falling on the subject before a camera is tied intimately to the quality of the colour it will produce. This is where HUE comes in, as you will see.

Truly white light is balanced, that is, it consists of equal portions of every visible colour. If this balance is disturbed the light will no longer be white, but will take on some characteristic overall colour or hue. The colour of anything which is illuminated by a source of unbalanced light will take on the same characteristic hue as the light itself. This fact applies to an illuminated subject in front of a TV camera. If the light source is not balanced the colour of the subject will be biased. Now, while a source of perfectly white light is difficult to find, we can come close rather easily. The important point is that what the camera "sees" is totally dependent on the colour of the illuminating light.

In practice there are many sources of fairly well balanced light. The most common, of course, is daylight. If you are forced into operating indoors there are a number of inexpensive lamps available which will suffice. The most familiar is the ordinary household tungsten lamp which emits a fairly white light when new. Tungsten lamps age and as they do their light becomes more red. A more sophisticated version of this type of lamp is the "photoflood". Generally, its light is very close to white but it shares the

same tendency towards red as it ages. Another source of light which has become rather common recently is the quartz halogen lamp. Quartz light is very well balanced and changes very little with time. Quartz lamps typically produce a great deal of light for their size but have a somewhat shorter lifetime than tungsten lamps. Generally good results can be obtained by utilizing a sufficient amount of light from any of the lamps just described. Colour "perfectionists", however, may wish to use the best quality illumination available. That's part of the fun.

There is one common source of home lighting which is not suitable for use with most cameras and that is fluorescent lamps. The light produced by fluorescent lamps is spectrally very narrow (that is many colours are missing altogether from its light). As a result it is very difficult to accurately reproduce colour subjects when ordinary fluorescent lamps are used for illumination.



Off screen photo of G3NOX colour SSTV received in Scotland by GM3W0J via meteor scatter.

The originals of these two photographs are in colour. It is regretted that circumstances prevent their full reproduction here.



Off screen photo taken direct from the space shuttle on 145.550MHz. photo G3NOX

COMMERCIAL EQUIPMENT

So far in this book we have been discussing mainly home-brew equipment and the use of computers for the reception and transmission of SSTV. However, there are of course many commercially built items of SSTV equipment available to the amateur. In this chapter then we shall take a look not only at currently available gear, but also at some of the earlier models so that readers may be aware of what to look out for on the second-hand market.

The principal manufacturers of SSTV equipment at present are; ROBOT RESEARCH INC, DAVTREND LTD and WRAASE ELEKTRONIK. Whilst Davtrend and Wraase equipment is quite popular in the U.K. and Europe, Robot products are used almost exclusively in the U.S.A. and the rest of the world and are fast catching up over here. Robot have been manufacturing SSTV equipment for the amateur market for many years and as a consequence have the largest range of models, therefore we shall start this chapter with a look at their equipment. All specifications have been taken from the manufacturer's original publications.

ROBOT RESEARCH INC. - Model 1200C

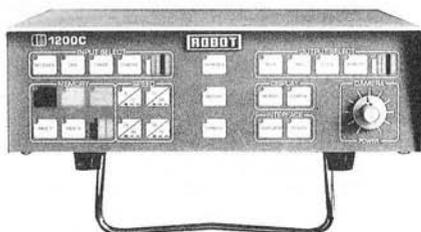
The most recent model to be described here is the 1200C Colour Scan Converter. This is a sophisticated microprocessor based high resolution colour video scan converter and image processor. The features displayed by this converter are very advanced, using state-of-the-art techniques such as 'Time Multiplexed Component Colour'. (An explanation of this technique is not within the scope of this book, but

suffice it to say that the results obtained can be more accurate and efficient than other SSTV transmission modes.) The converter is compatible with existing scan converters with a choice of four transmission formats. This choice, for black and white and colour operation, allows the operator to obtain the best pictures, optimising between speed and noise immunity.

A problem that can often be a source of irritation is the constant need to fine-tune some signals when receiving pictures, especially when tuning in SSB.

This problem is alleviated with the 1200C due to the software system developed for the microprocessor. This system automatically detects mistuning within +/- 150Hz and compensates accordingly. Hard copies of received colour pictures can be produced in colour if a suitable printer (eg. Seikosha GP-700A) is attached. When the converter is being used to transceive pictures with another Robot colour converter, an automatic mode of operation may be selected.

The fast-scan picture source for transmission can be 'snatched' from either a colour camera or a black and white camera equipped with colour filters. Alternatively a previously stored picture can be recalled from one of the six memories for transmission. There is also a built in colour bar generator which is useful as a test pattern for receiver adjustment. For ease of transmission the converter is equipped with a full width screen cursor indicating the line being transmitted.



Model 1200C

Another feature of this converter is the provision of two input/output ports for connection to a suitable computer. This facility allows for full remote control operation of the 1200C from the computer via the parallel port or an RS-232 serial port.



Rear view of 1200C

It can be seen therefore that this converter, utilising as it does the most modern ideas and circuitry, is a very sophisticated piece of equipment and will provide the user with state-of-the-art results.

Specifications for the 1200C include the following:

Transmit speeds selectable from: B&W - 120 lines @ 8 or 12 seconds, 240 lines @ 24 or 36 seconds, Colour - 120 lines @ 12 or 24 seconds, 240 lines @ 36 or 72 seconds.

Automatic speed following on receive to any of the standard SSTV formats.

Video display composed of 61,440 pixels in a 256 pixel by 240 line array when in the memory page 1 or 2 mode. An 18-bit digital 'word' for each picture element giving a possible 262,144 colours.

Standard camera input, 1v p/p into 75-ohm.

SSTV signal input 20mv to 1v. Minimum S/N ratio for clear picture 6dB.

Composite video output at 1v p/p into 75-ohm.

RGB video output with composite sync on each. Separate syncs available.

SSTV output 20mV to 1v for transmitter, adjustable by rear panel control.

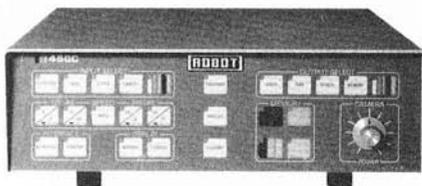
SSTV output 500mV (nominal) for tape recorder

Touch sensitive front panel controls with LED status indicators.

Other models previously manufactured by Robot include the 450C, 400, 300 and the 70. Many of these models, as well as their accessories, become available on the second-hand market from time to time. Of course the facilities available with each model vary according to the technology available at the time of their design. However, any of them will provide the operator with an SSTV station capable of receiving and transmitting excellent slow-scan pictures.

MODEL 450C

The 450C is basically the same as the 1200C but with less memory and as a consequence restricted operational modes. (It is also worth pointing out that this model may still be available new at the time of publication.) The main differences between the two models lie in their relative display capabilities and possible colour combinations. The 450C has a 128 pixel by 120 line display producing 15360 pixels, but still remains compatible with 240 line reception, and 4096 possible colour combinations. Apart from these differences the specifications and operation remain much the same.



Model 450C

MODEL 400

The first of the Robot models to incorporate digital techniques and solid-state memories, the 400 represented a major step forward at the time of its introduction and was possibly their most successful model. The most noticeable difference between using digital memories to the previously used display method of phosphor or silicon storage tubes, is the permanent retention of the received picture in the memory without fading after a few minutes (whilst the power remains switched on of course). Flicker-free received pictures with the slow downward scan of the replacing frame, and the ability to preview transmit pictures on the fast-scan receiver were also new experiences. The features exhibited by the model 400 are generally the expected norm for modern scan converters:



Model 400

Standard 8 second 128 line by 128 pixel transmit and receive, Black and white only with a 16 level grey scale.

Fast scan video input 1v p/p into 1k.

Fast scan video output 1.4v p/p into 75-ohm.

SSTV input 20mv to 1v into 10k. S/N ratio for noise free picture 6dB.

SSTV output 2v p/p maximum into 1k, adjustable by rear panel control.

Snatch controls for brightness and contrast to enable picture level to be set prior to transmission or storage.

Receive controls for adjusting contrast and brightness whilst viewing picture, or prior to memory storage.

'Hold' facility to allow retention of a received frame without it being updated by further incoming SSTV.

Width control to allow reception of pictures from countries using 50 or 60 Hz supplies.

Internal grey scale generator for receiver adjustment or transmission.

MODEL 400C

The 400C is actually an upgrade unit for the model 400 giving the added features of full colour transceive, automatic fine tuning of the received picture, three picture memories and the capability of interfacing to the model 800 for colour graphics.



Model 400C

The upgraded specification changes are:

Transmit speeds selectable from: 120 lines @ 8 or 12 seconds, or 240 lines @ 24 or 36 seconds B/W, 120 lines @ 12 or 24 seconds, or 240 lines @ 36 or 72 seconds colour.

Automatic speed tracking of the received picture, allowing reception of the standard SSTV formats without independent selection.

Automatic fine tuning within the range +/- 150Hz.

Three independently selectable memories for storing received or snatched pictures. The memories can be simultaneously selected to give a composite picture of all three.

MODEL 300

This model was produced using storage tube techniques and is believed to have been the first commercially available scan converter. Another first for this model was the ability to view the received picture on a fast-scan monitor.



Model 300

The incoming SSTV picture is processed and stored on a silicon target storage tube, it is then electrically read out and reprocessed into a fast-scan picture for viewing on a monitor. The transmit picture is snatched from a fast-scan source, processed and stored in the tube from where it is again electrically read and processed into the slow-scan picture for transmission. The facilities available with this unit are comparable with today's generation of converters, the only real differences being black and white working only and no internal picture storage. Storage is achieved by recording on magnetic tape or by photographing the screen. Once an SSTV picture is stored on tape it can be read back into the converter for transmission. It is worth remembering that the same applies to most of the digital converters available, their memories only store pictures whilst the power is connected, permanent storage must be on tape.

As previously mentioned any picture that is stored in the silicon tube will eventually fade out and after a few minutes will have to be refreshed or replaced. Also, even when new, these tubes, by nature of the manufacturing process, exhibit small blemishes on the target which are sometimes seen on the picture.

The specifications for the model 300 include:

Transmit and Receive speeds: 128 lines @ 2, 4 or 8 seconds, 256 lines @ 4, 8, 17 or 34 seconds - black and white only.

Video input 1v p/p into 75-ohm.

Video output 1.4v p/p into 75-ohm.

SSTV input 20mv to 1v into 10k. Minimum S/N ratio for clear picture is 6dB.

Transmit FM deviation controls set degree of FM swing and centre value of SSTV picture. Indicators show when limits of swing are reached (ie. 1200Hz for sync and 2300Hz for white).

Snatch controls to set the required depth of modulation of the picture from the camera or video source.

Normal or inverted video transmitted picture.

Tuning indicator activated by incoming SSTV sync pulses when correctly tuned.

Horizontal hold control to allow reception of pictures from countries using 50 or 60Hz supplies.

Span and balance controls to set depth of modulation and centre value of swing of incoming pictures.

'Hold' facility to freeze an incoming picture on the screen without updating to allow viewing or storage.

Transmit mode can be switched between SSTV mode and voice mode, the microphone being plugged into a socket on the rear panel.

MODEL 70

The model 70 monitor was the first commercially available slow scan unit in the world. The final version, the 70D, was quite sophisticated for a unit built around a P7 phosphor cathode ray tube. The 70 series are receive only monitors, but include in their circuitry power feeds for the 80 series slow-scan cameras to enable the operator to transmit as well.



Model 70A monitor

The received SSTV signal is processed and then fed to the CRT. The CRT is scanned by free-running timebases thus producing a raster at all times whether or not a picture is being received. Due to the persistence of the P7 phosphor tube (similar to those used in early radar equipment) the displayed picture remains on the screen for approximately 8 seconds, after which time it has to be refreshed because it fades out. The picture is best viewed in a darkened room, or by using a viewing hood to reduce the level of ambient light falling on the screen.

The models 70C and 70D were the last produced in this series and the facilities they offered make them useful even in today's shack. The specifications for these two models include:

Reception of 128 lines @ 8 seconds or 256 lines @ 34 seconds. Will also accept 2 and 4 second transmissions, the resulting pictures being quarter and half screen respectively.

Automatic sync threshold circuit accepts line sync pulses from 3 to 10ms and frame sync pulses from 30 to 90ms duration. This permits the monitor to receive pictures originating from tape storage, where the tape speed may vary causing frequency shift.

SSTV input 40mv to 10v into 1k. S/N ratio for a clear picture is 6dB.

SSTV output suitable for cassette tape recorder.

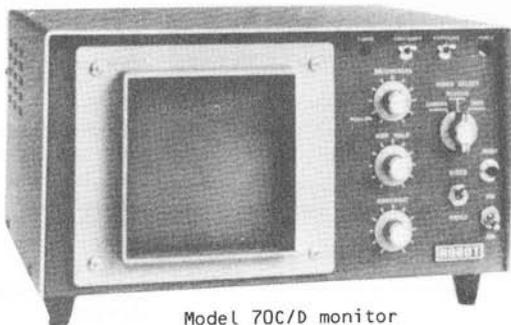
Horizontal hold control to allow reception of pictures from countries using 50 or 60Hz supplies.

Contrast control to vary the amplitude of the SSTV applied to the CRT.

Model 70D only:

Oscillator mode enabling accurate fine tuning of the incoming SSTV or for setting-up a slow-scan camera.

Viewfinder mode allowing the monitor to be used to preview the picture from the slow-scan camera, enabling rapid set-up of pictures for transmission.



Model 70C/D monitor

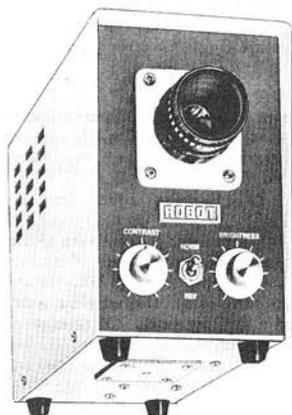
(The 80 series slow-scan cameras have a fast-scan output for feeding into the monitor for this purpose).

It is also worth noting that, not without some patience, 256 line 32 second pictures could be received on this unit. Although the picture will have started to fade by the time the scan is completed, enough remains on the screen to be viewed.

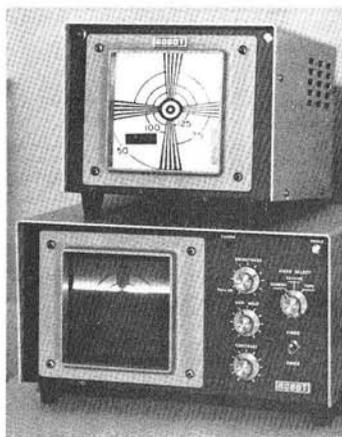
MODEL 70 ACCESSORIES

There are two main accessories used with 70 series monitors; a slow-scan camera for transmit and a viewfinder. As previously noted the model 70D monitor has a built-in viewfinder, so only a camera is required to transmit 'live' pictures.

The models 80 and 80A slow-scan cameras are powered from a 70 series monitor. They operate as sampling cameras, the picture initially being fast-scan generated from a standard vidicon tube. This fast-scan picture is sampled within the camera at slow-scan rates thus producing an SSTV picture. Both pictures are fed to their appropriate output sockets on the camera. The slow-scan picture produced is in the standard format of 8 second/128 lines. The audio FM output is variable to 2.5v p/p maximum into 1k. There are contrast and brightness controls to set the picture to the desired level and a beam control for optimum sharpness. On the model 80A quarter (2 second) and half (4 second) frame durations can also be selected. The fast-scan output is suitable for driving 60-series viewfinders or the model 70D monitor direct .



Model 80 video camera



Model 61 viewfinder on top of a 70A monitor

The models 60 and 61 viewfinders provide a convenient fast-scan display of the picture from the 80 series cameras. The picture viewed is an exact replica of the SSTV picture transmitted, therefore accurate setting of grey level etc. is possible. The model 60 has a 4 inch display whereas the 61 is 6.5 inch. The fast-scan rate of 3kHz used produces a 180 line display (200 lines @ 60Hz).

MODEL 800 KEYBOARD

The Robot 800 is a multimode keyboard terminal unit combining baudot, ASCII, Morse code and SSTV. The SSTV mode is transmit only and the unit is intended to be used in conjunction with model 400 and all later models to complete the transceiver station, whilst at the same time enhancing the transmit features of the 400. The unit operates as a character generator, allowing 6 lines of 6 alphanumeric characters, or 3 lines of 6



Model 800 SSTV keyboard

taller characters to be typed onto an SSTV format screen. The message being typed in is displayed on the fast-scan monitor connected to the unit, whilst at the same time it is generated as a slow-scan signal and sent to the transmitter. A line cursor moves down the screen at the slow-scan rate indicating which portion of the display is being transmitted. Complete on-screen cursor controls allow the operator to change any part of the text easily and immediately, there are also carriage return/line feed, delete character and clear screen commands. Further commands give the ability to transmit only certain lines of the text instead of the whole screen and also to reverse the display from the default mode of black characters on a white background to white on black. Also built into the terminal are a standard 6-bar grey-scale and a chequerboard pattern to assist in setting up equipment or for transmission.

MODEL 800C

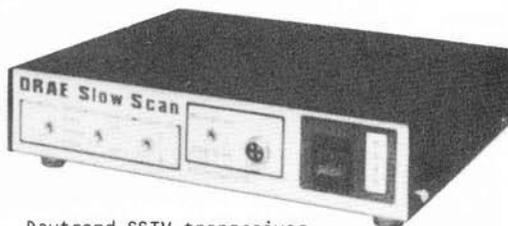
The model 800C is basically the same as the 800 but has some expanded features. The display becomes 6 lines of 8 or 3 lines of 8 characters allowing more text on the screen. A serial output is provided for colour graphics and special effects with Robot colour scan converters, with eight graphic memories and battery back-up.

This completes our look at the Robot range of equipment. They have been producing SSTV equipment since 1970 and as a result have made available more models in the U.K. than any other supplier, therefore it is more likely that any second-hand equipment found will be of their manufacture. Should any problems arise with any Robot equipment it is comforting to know that the company are only too willing to offer advice and assistance.

Robot (U.K.) Ltd, Building 33, East Midlands Airport, Castle Donington, Derby, DE7 2SA. Telephone: 0332 812446.

DAVTREND Ltd. Model DRAE SSTV Television Transceiver.

A more recent entry into the SSTV field by the U.K. company Davtrend has resulted in the manufacture of this SSTV scan converter. The unit was designed initially as a receive only converter, but provision has been made on the main circuit board for the installation of a transmit board. A certain amount of setting-up of the internal pre-set controls has to be carried out to achieve correct results, but the manufacturers point out clearly in their documentation which controls to adjust and which not to touch. The overall operation of the converter is quite acceptable and the quality of pictures received and transmitted are comparable with other units having similar facilities.



Davtrend SSTV transceiver

The manufacturer's specifications for the unit are:

- Receive and transmit 128 lines @ 8.5 seconds with 128 pixels per line.
- 16 level grey scale.
- SSTV input 100mV to 2V.
- Video input fast-scan 625 lines 1V peak-to-peak into 75-ohms.
- SSTV output FM modulation 1500Hz to 2300Hz. Sync pulse 1200Hz.
- Video output 1V peak-to-peak into 75-ohms.
- UHF output on channel 35 into 75-ohms.

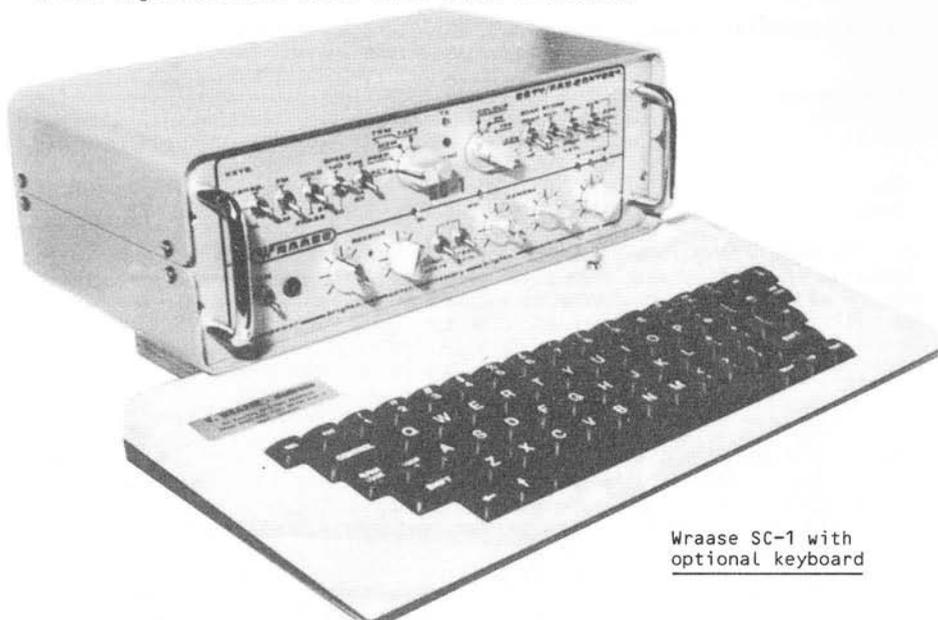
The converter also carries a microphone socket on the front panel which allows for phone operation without having to disconnect the unit from the transmitter. The input to the converter is switchable between the radio receiver, a tape recorder or a fast-scan camera to allow setting up focus etc. prior to transmission. The only transmit picture source input is for a fast-scan camera (or video recorder), from which the unit snatches a frame during each slow-scan frame pulse and transmits it as SSTV. A 'freeze frame' facility is also available which allows the received picture to be displayed on the screen without being overwritten by incoming video.

Davtrend Ltd, Sanderson Centre, Lees Lane, Gosport, Hampshire, PO12 3UL.
Telephone: 0705 520141.

WRAASE ELEKTRONIK Model SC-1

The SC-1 is the latest model Wraase converter to be described here. It is a portable dual-mode unit for SSTV and FAX. Also available as optional extras are a colour graphics keyboard, a video light pen, a computer printer interface and a colour camera interface to allow the 'snatching' of colour pictures from fast-scan. Later versions of the SC-1 (serial numbers above 1000) are equipped with a new line sequential colour sync system. A 1mS long 2300Hz pulse at the beginning of each RED line is used to synchronise the colour sequence, thus, even under strong received interference, the colour will not change during reception of a colour frame.

These later versions have a 'high resolution' colour mode in which both memory banks are switched together for 256 lines colour. Transmission or reception of one high-resolution colour frame takes 48-seconds.



Wraase SC-1 with optional keyboard

MANUFACTURER'S SPECIFICATIONS:

SC-1 SSTV/FAX STANDARDS

SSTV/FAX FM-MODULATION

SUBCARRIER FREQUENCIES

Sync:	1200Hz
Black	1500Hz
White	2300Hz
Horizontal Sync:	5mS
Vertical Sync:	50mS

	<u>SSTV 8s</u>	<u>SSTV 16s</u>	<u>SSTV 32s</u>	<u>COLOUR SSTV</u>	<u>FAX</u>
Scanning lines	128	128	256	256	256
Picture elements per line	128	256	256	256	256
Line rate (lines/sec.)	16	8	8	16	4
Scanning time per frame (secs.)	8	16	32	24	64/128

Picture format 1 : 1

COLOUR SSTV STANDARDS

Frame-sequential colour	RED, GREEN, BLUE manually switched 1, 2 or 3 frames each depending on propagation conditions.
Line-sequential colour	RED, GREEN and BLUE lines alternating, synchronised by the vertical sync pulse, starting with red. Sequence: R-G-B.

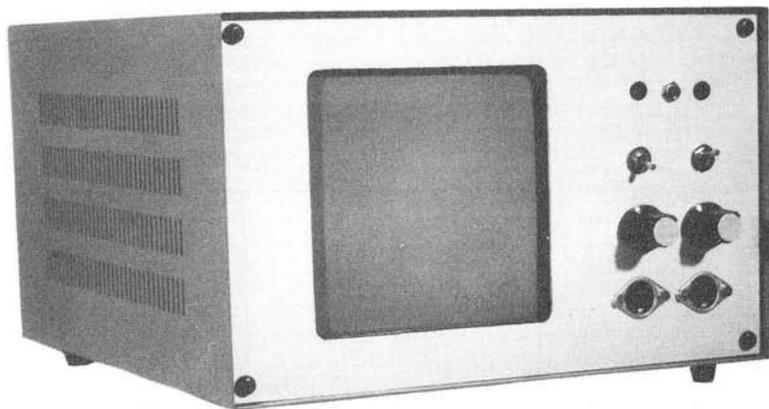
The U.K. agent for Wraase equipment is: Mr.A.Corker, 59 Foljambe Road, Eastwood, Rotherham, South Yorkshire, S65 2UA. Telephone: 0709 68098.

There have been one or two other notable SSTV products in the past which, although no longer made, may still be available on the second-hand market so it is worth taking a brief look at them here:

SPACEMARK SSM-1

This monitor is built around the 5FP7 long persistence phosphor CRT, giving a yellow or green picture which remains viewable for about 8 seconds before it fades. In this model the line and frame timebases are NOT free running, so nothing at all appears on the screen until a correctly locked SSTV signal is received. There is a built-in tuning indicator in the form of a LED that flashes in sympathy with the received SSTV signal. When the signal is correctly tuned the LED flashes at its most rapid and brightest, with long flashes indicating the frame pulses. Once correct tuning has been achieved the frame reset button is operated and the picture appears on the screen. Further tuning may then be necessary to obtain the best picture resolution.

This monitor is of the 'old school' type, being designed before the widespread use of digital techniques revolutionised slow-scan TV. The monitor was sold in kit form.



Spacemark SSM-1 monitor

The specifications for the SSM-1 include:

- Reception of 120 line/8 second format only.
- SSTV input 10mv to 20v into 3k.
- LED tuning indicator.
- Brilliance and contrast controls.
- Four position input selector.

Although very basic in its capabilities this monitor could still provide a cheap entry into SSTV and would no doubt be of interest to SSTV 'old timers' as well.

VENUS SS2

Venus were very proud of the fact that they produced the high voltage power supplies used in the television cameras on the Apollo space missions. To quote their original brochure 'Your Slo-Scan may not have to work on the moon...but it is reassuring to know that the same quality and reliability has been designed into it'. It is still possible to find the occasional Venus monitor on the second-hand market and they are worth looking out for.

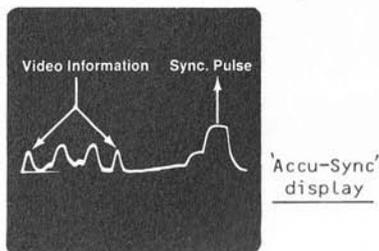


Venus SS2 monitor

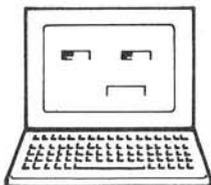
Again the monitor is only capable of receiving 120 line 8 second SSTV, but to be fair that was the only standard in use at the time of it's introduction. The display utilises a square P7 phosphor tube (not an ex-RADAR device), with the provision of a film camera adaptor on the facia to accomodate a Polaroid camera for directly photographing off-screen. This model features an oscilloscope mode which allows the operator, by selecting the 'Accu Sync' function, to accurately tune-in the incoming signal by watching the sync pulses appear on the display.

Features included are:

- Receive only 120 lines at 8 seconds.
- SSTV input 40mv to 10v into 1k.
- Oscilloscope mode tuning.
- Contrast and brightness controls.
- Four position input selector.



THE HOME MICRO



Now that home micro-computers with large memories are commonplace it is natural that we should want to use them in an SSTV environment. Unfortunately, most computers capable of analogue to digital conversion do not run fast enough to cope with a fast-scan TV signal. Likewise, the computer does not easily cope with the task of displaying a 128 x 128 pixel SSTV picture. If one's computer has a graphics capability for displaying a 128 x 128 square and it can make each element have a grey value from 0 to 15 units, then it is merely a question of writing a suitable SSTV program. Such a program should sense the SSTV frame and line sync pulses to effect the correct timing, recognise the grey level of each pixel and store the required data in the screen area of the memory map. As the time taken for one line of SSTV, including sync pulses, is of the order of 60ms, then quite a lot of computation can be carried out for each line and thus within each pixel time. However, this is only the case if machine code or assembler language is used, BASIC is far too slow.

Storing a fast-scan picture in computer memory is best done by converting the signal to SSTV and then arranging an interface which allows the digital information to be sampled at slow scan rate and stored by the computer. The circuit in Fig.1 would serve well for this purpose. The computer samples the 4-bit video, the line and frame sync at an input port; it can also deliver, via an output port, the 4-bit video stored in memory and a control line which is used to switch the two video sources. After the interface the scan converter does a digital to analogue conversion and this analogue signal modulates a VCO to give the usual FM SSTV signal.

An alternative method for storing all, or part, of a fast-scan picture is a sampling method. It does not require any modifications to the camera and relies on the fact that the computer's memory is truly random access. Therefore, although the picture is scanned vertically and stored in memory, the data can easily be read out as horizontal lines.

Once we have got the picture stored in memory what can we do with it? Here are a few suggestions:

- 1) Switch between the computer picture and the current picture to inlay a small picture.
- 2) Inlay text in either black, white or grey.
- 3) Invert the picture...left to right, top to bottom or black to white.
- 4) Use the computer to generate a test card.
- 5) Alter the grey scale to give a more contrasty or less contrasty picture.
- 6) Print the picture using a dot-matrix printer.

Once you have the facility for manipulating the elements of a picture then the sky is the limit and it is a great challenge to the imagination of the reader.

There are one or two facts in connection with the use of a computer in this way which need pointing out. The SSTV line and frame pulses are derived from the camera (or VCR) frame sync by division, and as the computer samples these pulses to determine whereabouts it is in the picture at any given time, then it is essential to have the camera running even if its picture is not being

used. The alternative is to write a program which generates SSTV sync pulses. With such a program the computer will be self contained and able to deliver a digital SSTV signal with sync pulses. If your computer has an internal timer, such as a 6522, then the problem is eased considerably. Alternatively, you could use interrupts to service routines for the line and sync pulse requirements from an external Sync Pulse Generator (SPG).

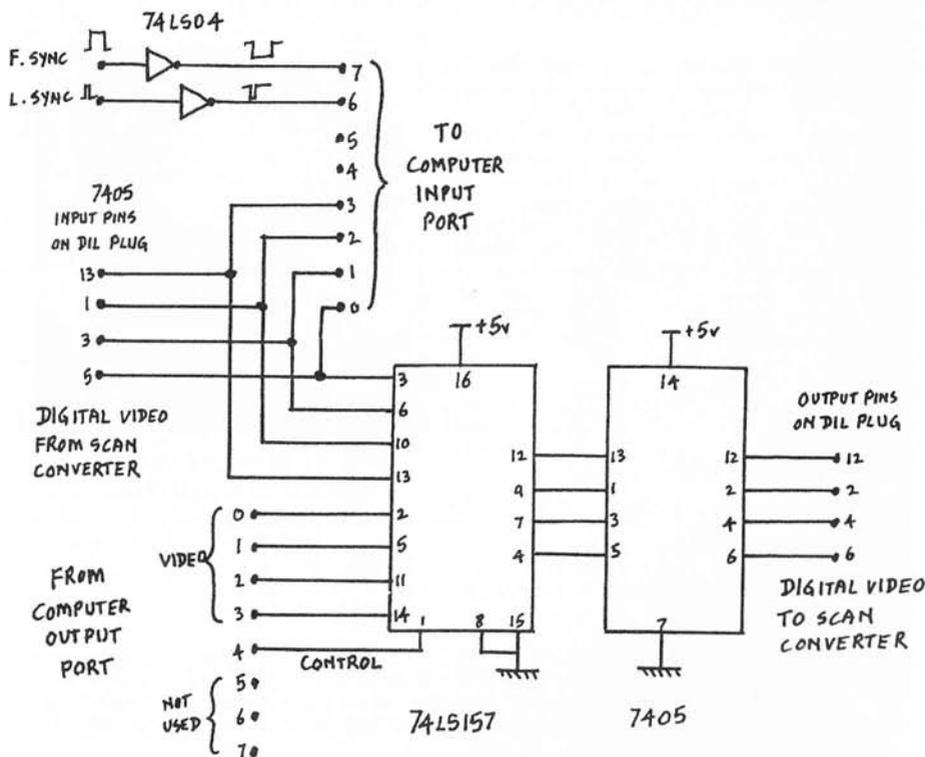


Fig.1 Computer interface for SSTV scan-converter

So far we have discussed methods of using a computer as part of an already existing SSTV transceiver. However, the more usual method of using a home computer is to actually employ it as either a receiver, or transceiver, in its own right. This entails, in some cases, a simple interface between the radio receiver and the computer and a sophisticated program. As will be discussed later not all computers require an interface, but the basic techniques of the software program are the same.

As we have already seen, a picture with at least 16 levels of grey is desired to produce an image with good depth and definition. The problem with many home computers is that such control of the grey scale is not possible at individual pixel level. However, quite a reasonable compromise can be reached by using varying pixel concentrations to represent the changing brightness of

the SSTV picture. (It may be pertinent here to define that a pixel is the smallest picture element that the computer can produce to make up a picture.) Many programs do not use this technique to its full advantage, in that they take each line of the picture as it comes and plot the pixels without regard to the pixels in adjacent lines. This can lead to a vertical streaking effect in the resultant picture. In reality every pixel should be considered along with the eight pixels surrounding it, or at least those above and to the left of it.

Another major problem for the software is maintaining linearity across each scan line. The program needs to know accurately where and when the next pixel is to be plotted, or the picture will slowly disintegrate as it reaches the right hand side of the screen. This problem can be overcome in two ways, either by using the on-board programmable counter and zeroing it with each line sync pulse, or, if your computer does not have one, by rigorous timing within the program and the maintenance of a software counter.

A computer based SSTV system is very flexible and can be made to perform equally as well as a hardware based one (ie. the G3WCY/G4ENA system described elsewhere in this volume). In some areas it may well be that a computer based system can provide better results. Such techniques as 'intelligent' noise rejection, false sync rejection and flywheel syncing are more easily achieved with a computer. Also the relationship between input frequency and displayed brightness can be varied much more easily with the software system.

Many of the available programs have facilities built into them that allow for an oscilloscope mode, where the SSTV video waveform is displayed along with the sync comparison value. Another feature that is available with some is an audio spectrum analyser which draws a graph of the relative occurrence of the various audio frequencies.

Thus it can be seen that a computer based SSTV system can provide results compatible with the more conventional methods of operating SSTV, with the advantage that the computer is not dedicated only to SSTV, as is a hardware system. Another advantage to be taken into account with a computer based system is the immediate ability to store a received picture, or a picture for transmission, on whatever type of filing system you are operating, ie: tape or disc. With the trend towards modern home computers having better and better graphics capabilities, computer based systems now provide excellent results and are rapidly taking prime position in the field of SSTV operating.



Pearsons computing

Vertical streaking can occur in a computerised picture.

SPECTRUM SSTV

The Spectrum, although rather limited in this application, can provide a simple and cost effective SSTV terminal, especially since it may not need any hardware interfacing between the computer and radio equipment.

G4ENB SPECTRUM SSTV SYSTEM - This system has been designed to be used in conjunction with an existing SSTV converter. It provides the facility to generate call-sign captions and other information itself so leaving the camera and converter available for actual pictures. However, the system can be used quite independently of an existing converter providing a full transceive SSTV terminal on its own.

In receive there has had to be a compromise due to the limitations of the Spectrum which does not allow more than two colours to be in any one character square at the same time. This means that the full eight grey levels with high resolution are not possible. To give some level of grey, noise is inserted where the normal grey areas would be. The level of this noise and the threshold between white and black can be adjusted for best contrasting on the picture. With any picture displayed on the screen it is possible to obtain a hard copy on the printer, also any received picture can be re-transmitted from the Spectrum. When receiving pictures which are not of the correct width the use of two of the arrow keys will adjust the horizontal scan rate to compensate. The software also allows for the reception of 24-second line-sequential colour pictures, one line in three is displayed giving one of the colour separations and each colour separation can be pre-selected as required (a colour picture can not be displayed). Some examples of pictures received using this system are shown in Fig.3.

To transmit SSTV from the Spectrum a programmable sound generator is used to generate the required frequencies. Using this method means that no calibration of the output is required since the frequency is defined in the software. The program allows for two different sizes of text; 3 lines of 5 characters per line or 4 lines of 8 characters per line. Each individual character colour can be defined and each line of text can have a different paper (background) colour. A full screen 8-level grey scale is available with an automatic grey scale at the bottom of each transmitted picture but not displayed. A Union flag with call-sign and rainbow patterns is held in memory with a further area reserved for another user defined caption. There is a cursor to show the transmission point and also a facility



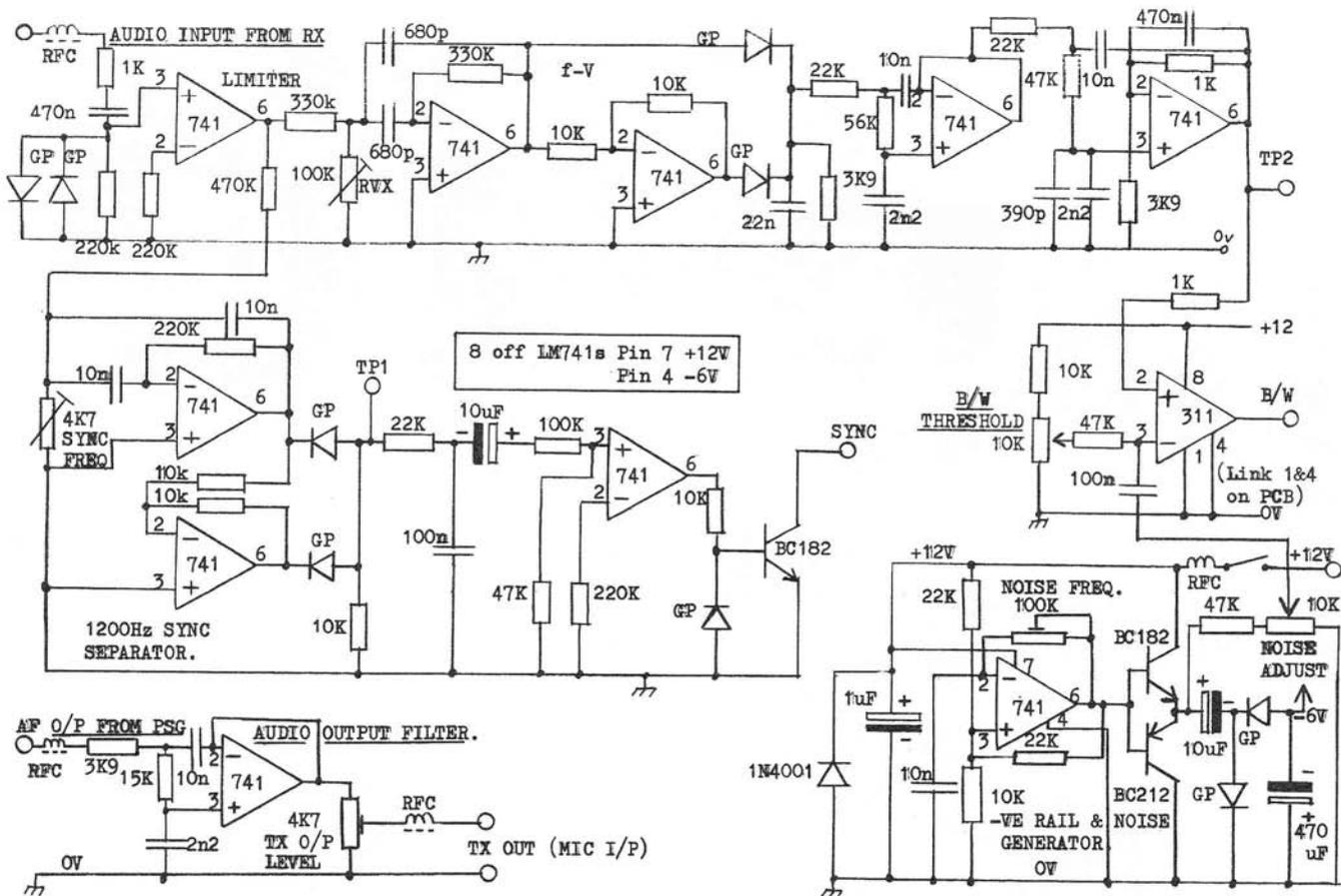


Fig.5

Spectrum analogue board

for character correction and half spacing. Character sizes can also be mixed. Monochrome transmission is achieved by the software converting each colour to its appropriate grey level. Colour transmissions can be in 8 second frame sequential or 24 second line sequential mode. Two examples of captions are shown in Fig.4.



Fig.4

Example captions

INTERFACE

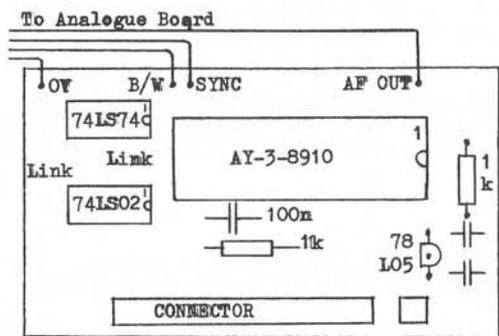
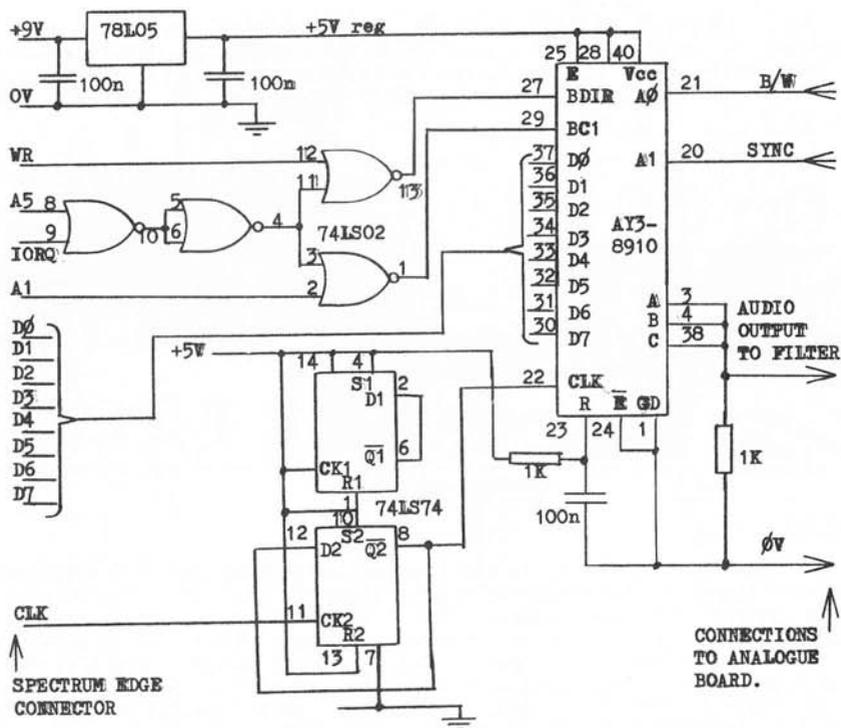
The interface circuitry is contained on two printed circuit boards; one handling analogue and the other the digital signals. All the frequency-to-voltage conversion and sync detection for receive is mounted on the Analogue board (Fig.5), as well as the transmit audio bandpass filter. Interfacing to the Spectrum is on the Digital board (Fig.6), which is plugged directly onto the user port. The programmable sound generator and address decoding are also on the digital interface board. A separate 5 volt regulator drops the +9 volts taken from the Spectrum to provide a +5v supply. The Analogue board requires +12 volts and -6 volts for the Op-Amps which is derived from an on-board oscillator that also provides the 'noise' input to simulate the grey level on receive.

The Analogue board is best mounted in a box so that the potentiometers, audio connections and switches are rigidly supported. The Digital board can be quite satisfactorily used unboxed and plugged directly into the Spectrum or printer.

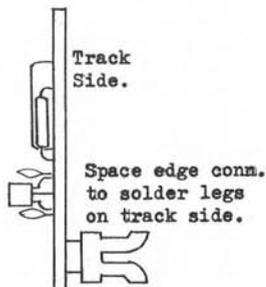
CALIBRATION

- a) - Connect TX OUT to RX INPUT. Set Tx output level to Maximum.
- b) - Load program, set paper colour to white and select 8 sec. black and white Tx.
- c) - Adjust the SYNC FREQ potentiometer to obtain the waveform shown in Fig.7a.
- d) - Press BREAK, press CAPSHIFT G for grey scale and select 8 sec black and white Tx. Monitor TP2 and adjust RVX to obtain the waveform shown in Fig.7b.
- e) - The 100k potentiometer in the noise generator circuit should be adjusted to give the best grey pattern on receive.

Connect the system to the radio transceiver and make final discrete adjustments on received pictures to your own requirements.



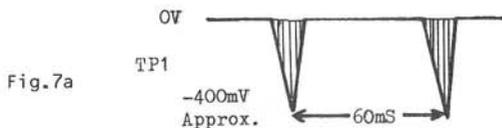
END VIEW



N.B. The 74LS74 must be an 'LS' device.
The length of the leads to the Analogue board is not critical.

Fig.6

Spectrum digital board



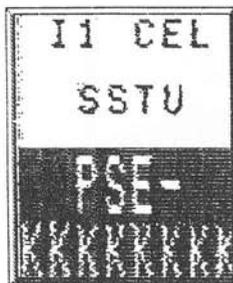
The software, full instructions and printed circuit boards can be obtained at a cost of £15 from Mr.C.A.Asquith G4ENB, 25 Wychwood Avenue, Luton, LU2 7HT.

COMMERCIAL SOFTWARE

There are many different home computers in popular use, many of which have SSTV software packages written for them, so let's look at a selection of the available software, and in some cases firm and hard ware, for the most popular machines:

SINCLAIR SPECTRUM

J.&P.ELECTRONICS SPECTRUM SLOW SCAN - This program is in three parts which are all loaded automatically by a single load command. Once loading has been completed the program self-starts presenting the menu on the screen. There is no interface required so the computer is connected directly to the receiver. The computer can also be connected to a cassette recorder if received pictures are to be stored on tape. A simplified oscilloscope mode is built into the program which allows correct tuning of the receiver by aligning the sync pulses with a reference line on the screen as the signal is tuned in. A rather useful noise cancelling routine is included to help overcome processor noise generated within the computer. A quick check to see if your machine suffers from this problem is to switch to the oscilloscope mode and remove the



input from the receiver. If a large amount of noise is present then it will show up on the screen and operation of the noise cancel mode should rectify it, although this will not be evident in the oscilloscope mode as it is rendered inoperative. The program can only receive 128 line, 8 second black and white pictures with the facility to store up to eight complete received frames in the memory.

To allow the reader to gain an idea of the various functions and facilities typically available in computer programs of this sort, the key functions for this package are listed below:

The following keys are active on the menu page:

R ----- Receive mode.
T ----- Tuning aid.
L ----- Loads picture from cassette.
I ----- Noise canceller on.
O ----- Noise canceller off.
U ----- Contrast level up.
D ----- Contrast level down.
5 & 8 ----- Move the \wedge on screen to select the background colour.

The following keys are active in receive mode:

SPACE ----- Dumps screen to printer.
N ----- Picture attributes to normal white.
B ----- Picture attributes to bright white.
3 ----- Normal video.
4 ----- Inverse video.
W ----- Contrast level up.
Q ----- Contrast level down.
CAPS SHIFT - Stops receive mode, on screen prompt for saving received picture to one of the eight memory stores or to the printer, before returning to menu.

The following keys are active once a picture has been loaded in from tape:

SPACE ----- Dumps picture to printer.
B ----- Picture attributes to bright white.
N ----- Picture attributes to normal.
4 ----- Inverse video. (To revert to normal video press N)
CAPS SHIFT - Return to menu.



In use the program appears to be quite responsive and produces pictures as good as the Spectrum will allow. The noise cancelling routine had quite a marked affect on the computer used in the test, but not all machines suffer internally generated noise to the same degree. The program comes supplied with full instructions and is available from: J.&P.Electronics, New Road Complex, Kidderminster, Worcestershire, DY10 1AL. Telephone 0562 753893.

NOTE: Another system available for the Spectrum is 'Technical Software's RX-4' program (without interface for this computer) which is described in the Commodore section.

BBC

The second computer to be looked at is the BBC. This machine is well suited to SSTV applications due to its superior graphics and screen handling.

G3LIV SSTV TERMINAL - This system for the BBC model-B requires an interface and comprises a printed circuit board and a program tape. The printed circuit board is well produced and the component overlay quite explicit. All the components can be easily obtained, the only specific item being a modular DC-to-DC converter which is available from Electromail (RS Components) although an external power supply can be used instead. Once assembled the unit is easily set-up using test signals supplied on the reverse side of the program tape and an oscilloscope. Fine tuning of the input filters and the balancing of the diode bridges (both easily accomplished with potentiometers) is recommended whilst receiving 'off-air' pictures, to achieve the best black to white balance and 'spotting' reduction.

The program runs immediately on loading although, unless the interface is connected, there is no visible sign on the screen that anything is happening. With the interface connected and the program loaded a scanning bar appears at the top of the screen, upon receipt of SSTV signals from the receiver (or tape) this scanning bar moves down the screen producing the picture line by line as it does so.

Facilities available:

- 7.2 second frame timing (128 line).
- 16 second frame timing (256 line).
- 32 second frame timing (256 line).
- Reduce picture width.
- Increase picture width.
- Fill in even lines. (this highlights captions and gives a more contrasty picture - 7.2sec only). Positive video.
- Negative video.
- Hard copy to printer (only if a 'Printmaster' ROM is fitted).
- Frame re-trigger.
- Clear screen.

The usual U.K. standard for SSTV is 7.2 seconds. If 7.2sec signals are being received 16sec frame timing can be selected to give reduced picture size and higher resolution.

All these facilities are keyboard selected and can be used at any time during receipt of pictures. In use the system produces very good results with a good range of grey scale and the software is very responsive to the keyboard commands. It appears to be quite immune to interference and noise when a reasonable level signal is being received. The program and circuit board are available from: Mr.J.Melvin, 2 Salters Court, Gosforth, Newcastle, Tyne and Wear, NE3 5BH. Telephone 091 284 3028.



Pearsons computing

NOTE: Another system available for the BBC is Technical Software's RX-4 program and interface which is described under the Commodore section.

COMMODORE VIC-20 & CBM64

Although one of the more powerful home computers, the CBM64 is somewhat lacking in commercial software for amateur use. This is in part due to the less straightforward manner in which it is programmed, making it less attractive to software writers

RX-4 MULTIMODE RECEIVE PROGRAM - This package, as its name implies, is divided into four sections: SSTV, RTTY, MORSE and AMTOR, and is also available for the Spectrum and BBC computers (when used with the Spectrum no interface is required). When used with the Commodore range (and the BBC) a simple interface is required which can be purchased either as a kit, or ready built and tested.

The CBM64 with its large area of user memory (32K) is well suited to this application and the program makes full use of the excellent screen handling capabilities of the computer.

Features of this package include a horizontal scan of either 128 pixels (60ms) or 256 pixels (120ms) and a vertical scan of either 128 or 256 lines shown on the screen display. Frame sequential colour pictures are displayed as a set of monochrome frames and line sequential colour pictures are displayed in colour. The grey scale can be adjusted from the keyboard as the picture is received. As with most SSTV programs, when a picture has been completely scanned the printing point is returned to the top of the screen to resume scanning. However, with this system when the next picture scan starts a different background colour is automatically selected, thus showing clearly where on the screen the scan has reached. As each new line is reached it is cleared of old text thus making the screen easier to read.

Received pictures can be stored in a separate area of memory and the various storage options are shown below:

CBM64	-	4 Pictures
VIC-20 + 8K	-	2 Pictures
VIC-20 + 16K	-	6 Pictures
VIC-20 + 24K	-	10 Pictures

Alternatively, a received picture can be stored in the same location as a previously stored one, thus avoiding filling up the RAM area with unwanted pictures. Received pictures can also be stored on disc or tape, or dumped to a printer for hard copy. A 'hold' facility freezes a completed picture on the screen for examination, storing or printing.

The program is available on either tape or disc and the interface can be obtained either in kit form or as a ready-built, boxed and tested unit. Technical Software, Upper Llandwrog, Caernarfon, Gwynedd, LL54 7RF. Telephone 0286 881886.

DRAGON 32/64 & TRS-80 COLOUR

G4BMK SSTV RECEIVE PROGRAM - This program enables standard SSTV pictures to be received and displayed through Dragon or TRS-80 computers, although the TRS-80 needs extended BASIC and 32k of RAM for tape and 16k or 32k for the cartridge version. No hardware interface is required, the audio signal from a receiver being fed directly to the cassette socket. An on-screen visual indicator enables accurate tuning of the received signal.

Pictures are produced with 4 levels of grey using the high resolution graphics mode. This means that a resolution of 128 lines of 256 pixels is produced, although an intelligent "fill-in" facility expands the picture vertically to 192 lines giving an enhanced presentation and the correct 1:1 aspect ratio.

A printer dump routine, enabling the production of hard copy printouts, is included in the package and most printers can be supported (state which when ordering). Principal commands for the software are as follows:

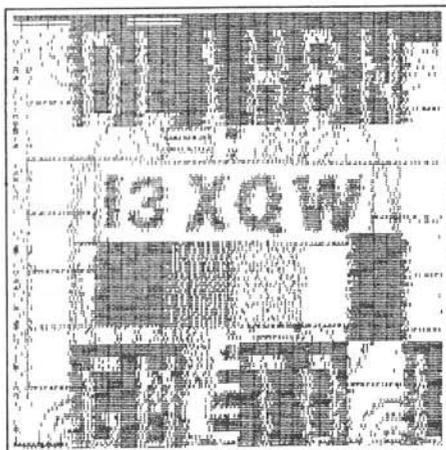
Receive (and cassette motor on).
Freeze picture at end of frame.
Scroll picture.
Adjust width.

Freeze picture immediately.
Black and white invert.
Fill-in - expand vertically.
Dump picture to printer.

The program is available on cassette tape or disc (Dragon DOS/Cumana 2.0) or cartridge and includes some demonstration pictures. Grosvenor Software (G4BMK), 2 Beacon Close, Seaford, East Sussex BN25 2JZ.

There are several other such programs and systems for the computers discussed, some of which unfortunately have not stood the test of time and are no longer available new. Also there are other makes of computer for which SSTV software is available, therefore the above information should be considered as typical, well tried examples of the type of package available for a computer orientated SSTV system.

It should be stated that the use of 'ordinary' 8-bit personal computers is somewhat restrictive and they cannot be expected to attain the standards reached by purpose-built scan converters. The increasing use of 16 and even 32-bit processors however could mean a great step forward in this respect and it is hoped that some more sophisticated systems will become available soon. Nevertheless, for an outlay of considerably less than that required for the purchase of an SSTV converter, one can set-up a useful and rewarding transceive station using an 8-bit micro.



A typical off-air frame taken on the G4BMK receive system. The picture shows some received noise.

SCAN CONVERSION TECHNIQUES

FAST TO SLOW

The first scan-converters used in SSTV were designed to allow a normal TV camera to be used for generating the SSTV signal. For this purpose there were two approaches; the line-sampling camera, and the line-store converter. In the former a normal TV camera was modified so that its frame timebase was scanning at the SSTV line rate (50/30Hz) and the camera was put on its side so that the picture was scanned vertically with 3 x 312 lines. The grey value was sampled, using an electronic switch, for a brief period on each line and this series of samples constituted one SSTV line. The process was then repeated at intervals down the picture thus producing the required 128 SSTV lines. The great disadvantages of this method were the need to modify a camera and the difficulty in monitoring a fast-scan picture.

The second form of scan-converter cleared up these problems. In the 'line-store' converter a single line of fast-scan picture is digitised and clocked into a quadruple shift register during the 60 μ s of the line. During the next three fast-scan frames (60ms) this data is clocked out of the shift register at the slow rate thus generating the SSTV signal. The digitising process can be done with a string of 711 dual comparator IC's. Devices known as 'Flash Digitisers' are now readily available which digitise to 64 levels (6 bits) at a rate of 15MHz, but their cost is still likely to be prohibitive. A string of 711 devices will digitise to 16 levels (4 bits) and this is quite adequate for most amateur requirements, the limitations only becoming apparent when large areas of the picture have only small changes in the grey level, causing the phenomenon of 'contouring'. This effect is less apparent where a picture has lots of detail and there are rapid transitions through several grey levels, or where the number of grey levels is much larger - 64 for example.

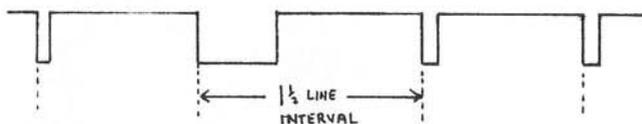


Fig.1a

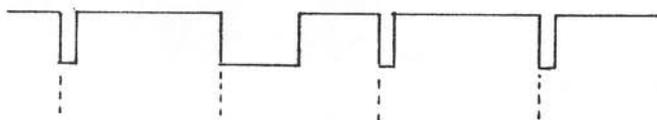


Fig.1b

EQUAL INTERVALS

The mention of quadruple shift registers above ties in with the 4 bits which the 711's produce; one shift register is allocated to each bit. If the fast clock is made to run a little too fast, then the first part of the fast-scan line disappears out of the end of the shift register and is lost. This is a good thing as it enables us to adjust the left-hand edge of the SSTV picture with relation to the fast-scan screen. Similarly, if the slow clock is too slow, it fails to deliver the last bit of the line and this can be used to control the right-hand edge of the SSTV display.

Shift registers are now going out of fashion as a means of storage and they are being replaced by random access memories (RAM), which are only limited by their access time. If they are used in a manner similar to the shift register then they should be capable of being clocked at about 5MHz, which means that the access time should be less than 200ns. Dynamic RAMs are readily available with access times of 150ns and these serve as very satisfactory picture stores. The main difficulty with using RAM is that each chip requires a large number of address lines and it is these addresses which must be clocked at the fast or slow rate; on the bonus side, however, is the fact that each picture element can be selected by using the correct address and one is not limited in the order in which they are selected.

There are two different ways of adding sync pulses to the SSTV video as shown in Figs.1a and b. In Fig.1a the frame sync pulse, which is of 30ms duration, starts at the end of the last picture line and continues until the first line of the next picture. As a result of this, if the line oscillator is free running, at the start of the picture the sync pulse is half a line period out of step with the oscillator and a 'hard lock' circuit is required to bring it rapidly back into step. In Fig.1b the frame pulse occurs during the first line and the rhythm of the line sync pulses is not interrupted. It can be seen therefore that the latter method of adding syncs is by far the more elegant, even at the expense of the first half of the first picture line.

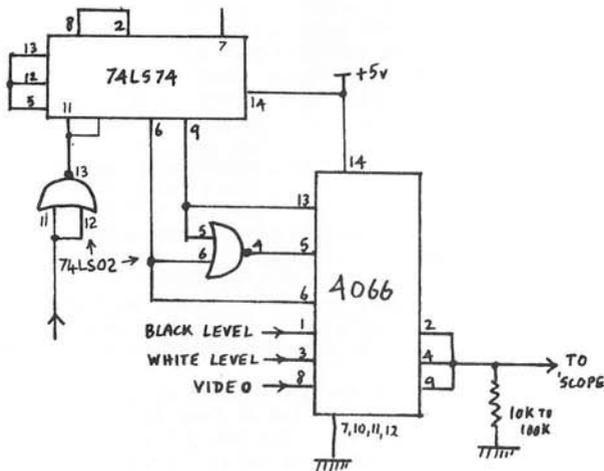


Fig.2

MONITOR CIRCUIT

When a fast-scan signal is digitised it is essential that some form of monitoring is used to check that all 16 grey levels are being used in the conversion. The circuit in Fig.2 can easily be added to a converter which uses a chain of 711's. The output of this circuit is fed to an oscilloscope which has its timebase set to display three fast-scan frames. The fast-scan line sync clocks a divide-by-3 circuit which closes three electronic switches in rapid succession. Thus, on the screen of the oscilloscope we see a sequence of 1 line of white level, 1 line of black level and 1 line of video, which is repeated across the screen. This gives the appearance of a steady line at the white level, a similar line at the black level and the varying video signal in between. The white and black level controls are then adjusted so that the video waveform lies between them. If the white level is too low or the black level is too high, then clipping will occur and this can be seen on the SSTV display as large areas of white, or black, with very little detail in them. Note that some digitisers use 'contrast' and 'brightness' controls rather than the white and black level controls referred to; the principle of setting the video between the two levels remains the same.

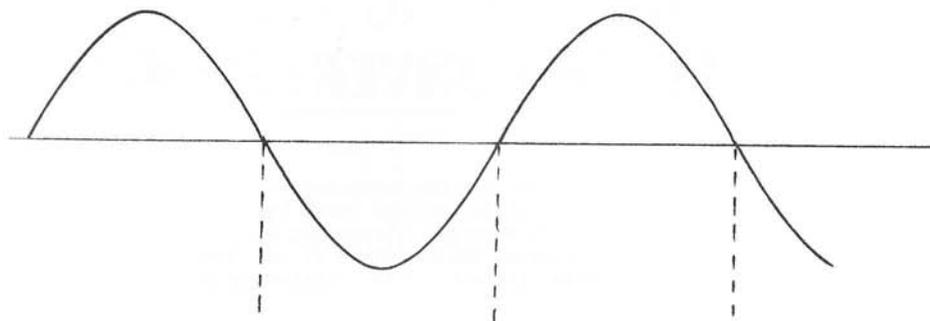
Whilst on the subject of picture quality, it is worth doing some trials with a series of different pictures, as it appears that some pictures are more suitable than others for the SSTV system. Experiment with a critical eye on the SSTV screen and you will soon find out the type of picture the system likes best.

SLOW TO FAST

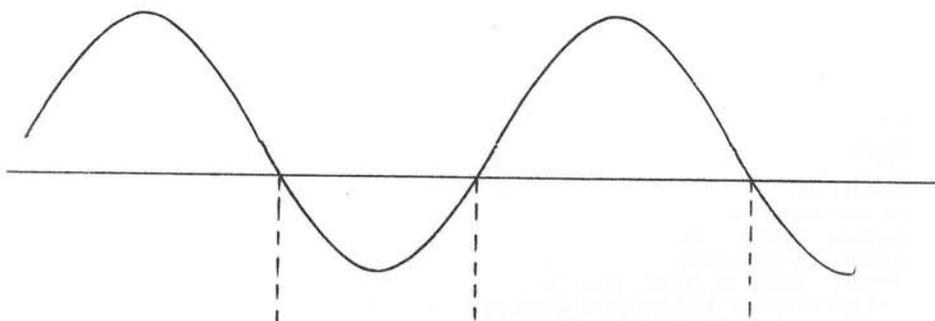
When we come to consider the use of a fast-scan monitor to display SSTV, it is easily seen that the required memory must be large enough to store a complete picture, as the fast-scan display must repeat its display many times in the course of a single SSTV frame. In computer terms we need $128 \times 128 \times 4 = 64k$ bits, or 8k bytes. As there are 8 bits in one byte we can store two 4-bit pixels (i.e. 2 nybbles) in one byte. Memory chips are being made with ever increasing capacity and this amount of memory could be built using four 4116 devices (16k by 1 bit) or even a single 4416 device, which is conveniently 16k by 4 bits. Note that although dynamic RAM's usually require refreshing, if we are using them in a rapid read-out cyclical manner then refreshing will occur automatically and there is no need to make special provision for it.

One of the earliest slow-to-fast converters, which was designed by WB9LVI, used four massive recirculating shift registers, with some clever circuitry involving a line buffer store which was switched into the path of the recirculating data to give a 'load-on-the-fly' arrangement. The advantage of having RAMs for memory is that one can load a complete picture in the fast-scan frame time of 20ms, which is within the SSTV frame sync pulse. Thus we can display successive frames of SSTV, taken as snapshots about 7.68 seconds apart. With the use of a line store the subject must remain still in front of the camera for the full 7.68 seconds - as for a Victorian photograph!

The resolution of a converted slow-to-fast picture using these methods leaves a little to be desired. At any given period of time during the picture the frequency determines the level of grey. Thus the period of half of a cycle is the smallest 'information packet' which is being transmitted and one can only make use of this half cycle if the waveform is symmetrical about the axis (Fig.3). When the waveform is asymmetric with respect to the axis then the two periods between the crossing points are different and would be interpreted as two different shades of grey.



EQUAL PERIODS



UNEQUAL PERIODS

Fig.2

Now for a black signal: $f = 1500\text{Hz}$ $t = 666\mu\text{s}$ $1/2t = 333\mu\text{s}$
 Line time = 60ms..less 5ms for sync gives 55ms
 Hence the possible elements per line = $55000/333 = 165$

For a white signal: $f = 2300\text{Hz}$ $t = 434\mu\text{s}$ $1/2t = 217\mu\text{s}$
 Hence possible white elements per line = $55000/217 = 253$
 Average number of elements per line is 209

From this we can see that the usual 128 x 128 pixel converter is not using the full potential of the system. What we need is a scan converter with a 128 x 256 memory, which would give better resolution in the horizontal direction!

REFERENCE:

- 1) SSTV to FSTV Converter. QST March/May/August 1975 (GD100).
 See also modifications (GD124)

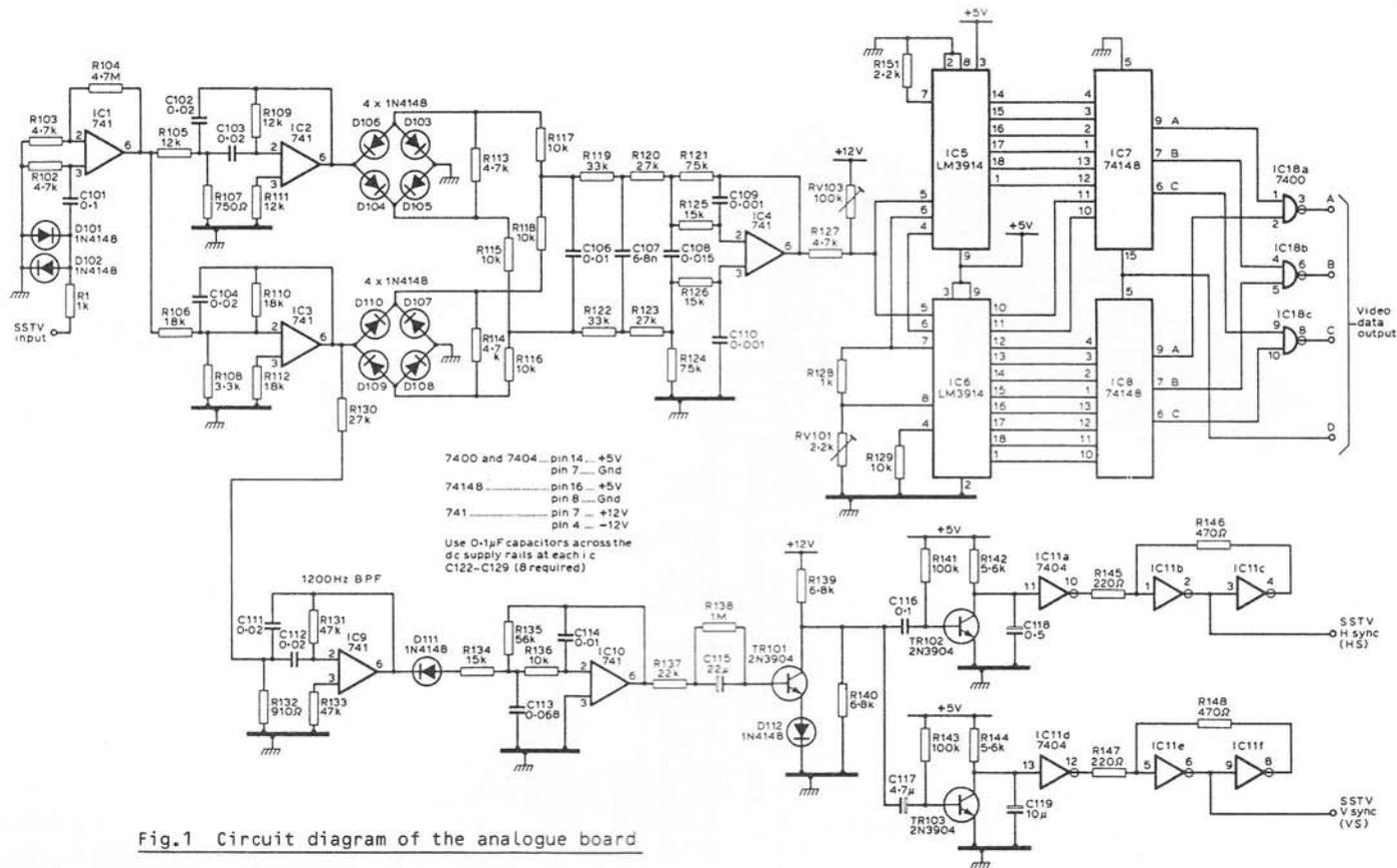


Fig.1 Circuit diagram of the analogue board

divide-by-two mode, producing an output of 15.625KHz for the fast-scan horizontal sync pulses, the remaining 7490 IC's are connected in the divide-by-five mode, providing division down to 50Hz for the fast-scan vertical sync pulses.

OPERATION OF THE DIGITAL MEMORY BOARD

The circuit of the board is shown in Fig.3. The memory section, IC37 to IC40, uses 16K RAM type 4116 selected to have an access time of 250nS or less, otherwise errors may occur in the write mode. The seven address lines A0 to A6 are driven by IC23 and IC31 which act as row and column address counters respectively. The write and read counters used are ordinary binary counters type 74LS393, IC27 is the Read-Row counter and IC28 is the Read-Column counter. The Write-Row and Write-Column counters are IC29 and IC30 respectively, whilst Write-Enable for the memories is fed from pin-1 of IC32. The alternate row and column counters are multiplexed from four 74LS153 dual 4-to-1 line multiplexers, IC33 to IC36.

The position of the horizontal picture is determined by IC24 which sets IC20. When this occurs oscillator IC19 starts up and IC27 then begins to count to 256 upon which IC20 resets and IC27 stops counting and waits for the next horizontal sync pulse. Parts b and c of IC21 produce a blanking pulse, the length of which is determined by R210 and C210. Vertical timing is achieved in a similar manner, the clock for the vertical counter is fed from the fast vertical sync pulse at the base of TR202.

To stop the write function the horizontal slow sync is halted by connecting pins 2 and 12 of IC29 to the +5V rail, with the effect of producing a freeze-frame function. This facility is very useful for picture study and storage, hence a small toggle-switch (S202) is brought to the front panel for convenience.

The digital video signal from data output of the 4116 memories (pin-14) is converted by IC41 (74LS175) into a binary code with the aid of the common R, 2R, 4R, 8R method using resistors R214 to R217 (use good quality 2% types here). Horizontal and vertical fast sync is re-introduced at this point by means of TR203 and TR204. At this stage video is ready for display at either of the output terminals (a) and (b). These two points give alternate outputs: (a) is for connecting to a normal TV via a suitable modulator, as used in computers or TV games; (b) goes via TR205, an emitter-follower, to provide the correct 75ohm output impedance for a monitor.

Feeding the video via a modulator to a TV is not recommended as rather poor picture quality and resolution is obtained. If a video monitor cannot be obtained a normal TV set can be easily modified to suit the purpose and act as a monitor, with no harm or change to the receiver's normal operation (not forgetting to observe the necessary safety precautions when opening a TV set).

The first essential is to obtain the circuit diagram or manual of the TV set in question. With this locate the cathode of the crt and trace back to the video driver stages, which in modern sets comprises two transistors in a series configuration. Cut the track at the base input of the first of the driver transistors and bring a pair of miniature 75ohm coaxial leads from either side of the cut track to a convenient point on the case. These leads (as short as possible) should be connected to a switch and socket arrangement, where the switch is wired to open and close the cut pcb track, thus restoring normal TV operation when required. When the switch is in the open position

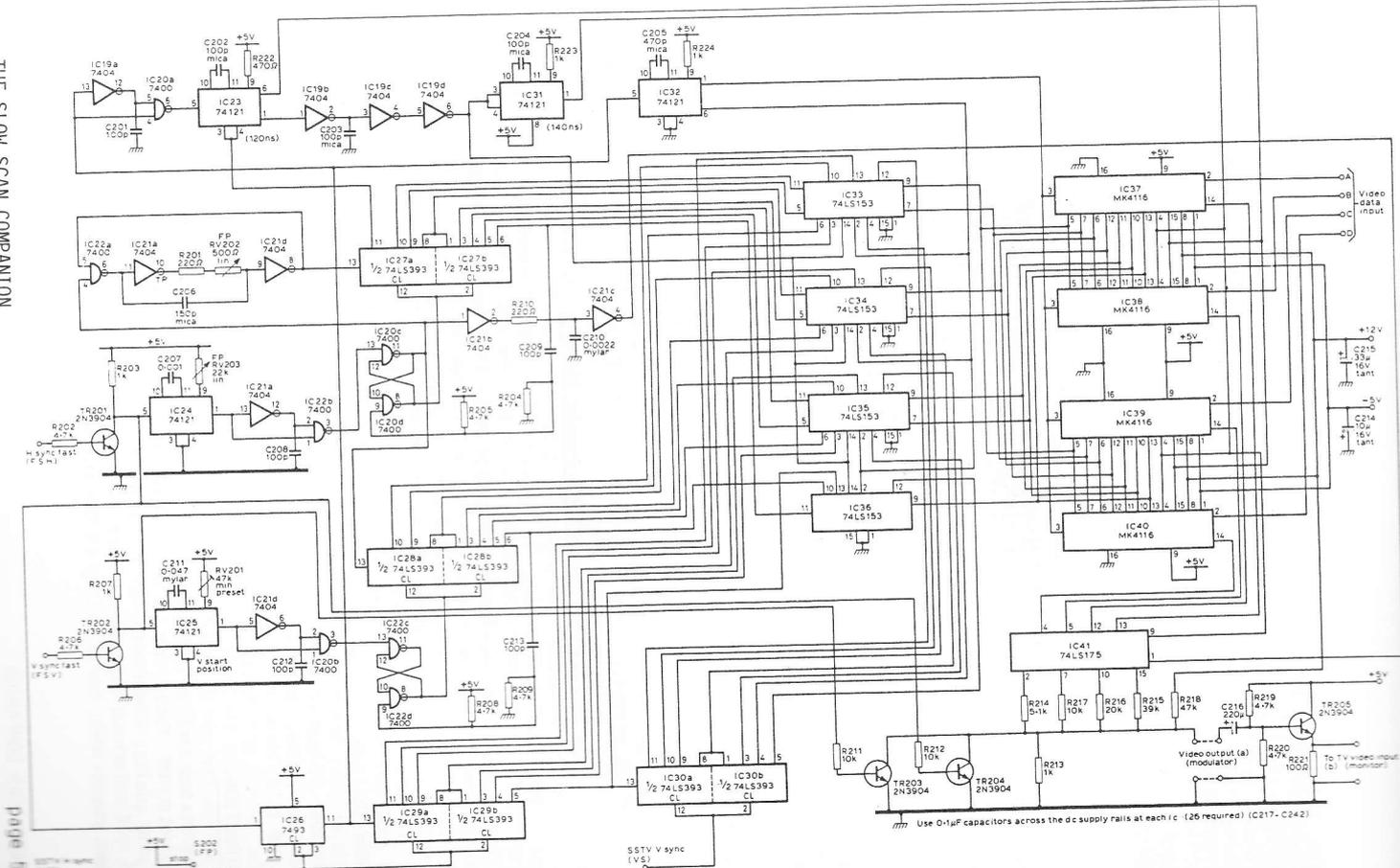


Fig.3 Circuit diagram of the digital memory board

the coaxial socket will be connected to the base of the driver transistor, therefore the SSTV video output from the converter can be plugged into this socket giving good quality and resolution. The ideal screen size for the SSTV format is 12-inches, any larger than this results in the pixels making up the picture appearing as large squares and the viewer would have to be 5ft or more from the screen to make the picture recognisable.

NOTE: When using a converted TV set in this manner an isolation transformer must be used if none exists in the television already.

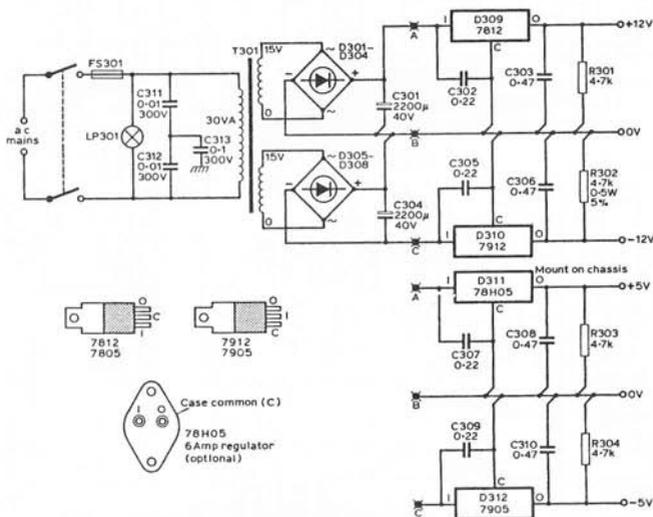


Fig.4 Power supply circuit

POWER SUPPLY

The power supply may be of any design or as that shown in Fig.4. In this a single 30VA transformer with two 15V secondaries is used for convenience, with the usual regulator configuration to provide plus and minus 12 and 5V. Current requirements are +5V @ 500mA, -5V @ 1mA, +12V @ 80mA and -12V @ 15mA; thus in most cases a common zener output could be used to cut costs. If a 7805 regulator is used for the +5V rail a good heat sink must be incorporated, a 78H05 (6A regulator) would of course allow plenty of scope for future memory expansion, say for colour where three memory boards are used. It may be found that these DC supply rails are noisy so it is advisable to fit a 100uF capacitor across all four even though bypass capacitors are fitted at almost all the IC's.

CONSTRUCTION

As stated earlier construction is quite straightforward with no difficult components to find, but a word of warning, this is not a junk box project. Use good quality components, 5% resistors (unless otherwise stated) and at least 10% tolerance capacitors. Use Mylar, metallised polyester or monolithic ceramic capacitors, particularly in the analogue filter circuitry.

It is suggested that IC socket strip or Soldercon sockets be used instead of conventional bases for the IC's, as there are a lot of links that run under the IC areas. When wiring the memory board fit the socket strips first and then the links, noting that there are six long links using insulated wire labelled LK1 to 6. All resistors are 0.25W types to keep size to a minimum, the only pre-set, RV201, is a miniature vertical type. Printed circuit boards for this converter may be obtained from BATC Members Services. Whatever type of cabinet or chassis is used provide plenty of ventilation to keep the temperature to a minimum.

SETTING-UP AND CALIBRATION

No special equipment is required just a good multimeter (or DVM) and an oscilloscope. The only difficulty is an SSTV source, which is essential, but this can be overcome by either asking a transmitting station to record a transmission on cassette for you, or by recording an off-air transmission yourself (making sure that the receiver is tuned-in correctly). A grey-scale pattern is an ideal source for setting up the converter.

Before connecting the source SSTV signal some preliminary adjustments have to be made, it is also advisable not to plug the IC's in yet. First check that the power supply is functioning correctly and verify that the correct voltages appear at the appropriate IC pins, switch off and plug in the IC's and again check the voltages. Initially the analogue board is set up on it's own without the memory board connected. Set all three potentiometers to mid-position and, with the aid of the oscilloscope, adjust RV102 to give a square output at pin-3 of IC12 at a frequency of 31.250KHz, thus giving a corresponding output at TP1 (FSV) of 50Hz and at TP2 (FSH) of 15.625KHz.

The following adjustments are carried out with a SSTV source connected to the input. Connect the oscilloscope to TP3 (HS) and observe narrow pulses approximately 5.8cm apart at a timebase speed of 10mS; likewise at TP4 (VS), pulses should be observed every 8 seconds, note however that these pulses appear very quickly and are not permanently present as are the HS pulses. As a reassuring check at TP3 and TP4, stop and start the cassette recorder, or connect and disconnect the SSTV source if not coming from tape, whilst monitoring the oscilloscope and the pulses should start and stop accordingly. Now connect the oscilloscope to the video data outputs A, B, C and D in turn (IC18), again with the SSTV source connected. Varying width data pulses should be seen which verify that analogue-to-digital conversion is taking place. Leave RV101 and RV103 undisturbed for the time being.

Connect the digital memory board to the analogue board not forgetting the two front panel potentiometers, RV202 and RV203, both of which should be set to mid-position. Leave the connection of S202 until later. Connect the output of the memory board to a video monitor, or TV if using a modulator, and with no SSTV input to the analogue board alternate black and white bands that move from top to bottom in approximately 8 seconds should be observed. Adjust RV202 and RV203 to produce a square and centralised format on the screen, with gaps at either side; this is normal for SSTV. Connect the SSTV source to the analogue board and a picture should appear, although it may not as yet be discernable. Adjust RV101 and 103 on the analogue board for the best shading and resolution, this is where a grey-scale source is advisable, there will be some interaction between the two potentiometers but patience will get it right. Potentiometer RV201 on the digital board is adjusted to centralise the picture vertically on the screen. Finally connect S202 to the memory board

and check the freeze-frame action when it is operated. Once all the adjustments have been completed all that remains to be done is to install the complete converter into the cabinet.

It may be found that some SSTV signals are more critical to tune-in than others. This is mainly because some stations use cassette tape-recorders for transmission of pre-recorded pictures which often results in poor sync pulses as these recordings become worn. Also, of course, the other problem that can arise from using tape-recorders is the variation of speed that can occur. It will be noticed that the best resolution and definition is observed in the grey areas of the pictures, not at the extremes of black and white.

If noise is experienced on the received picture, usually line jitter, then an additional link from the earthy end of C120 direct to the circuit board 0 volt connection will improve the frequency stability of IC12, the cause of the problem.

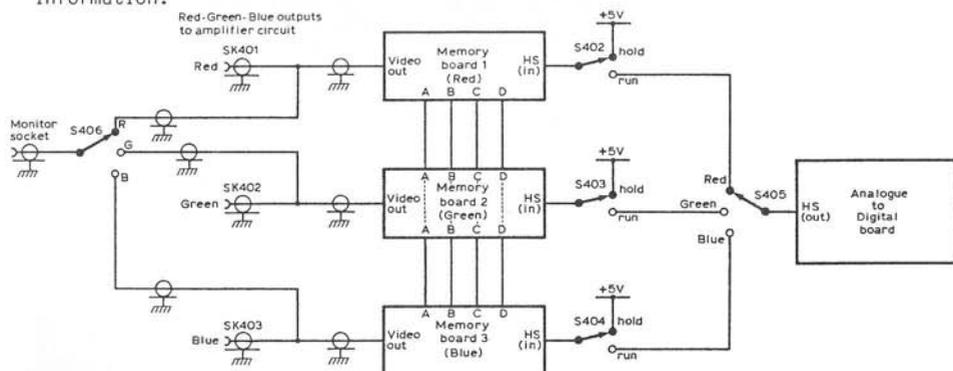
COLOUR SSTV RECEPTION

To use this converter system to receive colour pictures it is only necessary to add two extra memories to the digital circuits. This is achieved by 'piggy-backing' two extra memory boards over the top of the digital board, circuit boards and all instructions for this are available from BATC Members Services. This system with one memory for each colour (Red, Green and Blue) produces a perfectly registered, clear, picture on the screen.

COLOUR AMPLIFIER

There are three methods of getting your colour picture onto the screen: The first is to use a RGB colour monitor such as those used for home computers, the second is to use a colour modulator with a standard TV set, again with the loss of definition, the other is to build the colour amplifier described and feed the CRT of the colour TV or monitor directly.

The colour amplifier consists of three separate amplifiers, one for each colour, to drive the guns in the CRT, with the various controls for brightness, contrast and colour. It will also be necessary to feed mixed horizontal and vertical sync pulses from the converter, but minus the video information.



Colour memory switching

The circuit shown in Fig.5 is the sync mixer, the inputs to TR401 and TR402 are taken from the collectors of TR201 and TR202 on any of the memory boards. Using a common load resistor for TR401 and TR402 gives the required mixed sync which should be fed to the sync line of the TV. Components C401 and R405 ensure sufficient isolation when the TV is being used normally without the need to disconnect the external sync feed.

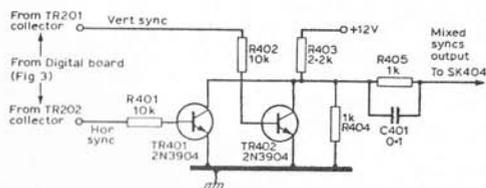


Fig.5 Sync mixer circuit

A suggested colour amplifier circuit is shown in Fig.6. This is very straightforward and can be built on a small piece of Vero-board and easily incorporated inside most TV sets. A small control panel can be made to house potentiometers RV401 to RV404, S401, BNC sockets for the colour inputs and a Phono socket for the sync (Fig.7). This control panel may then be mounted conveniently on the rear or side of the TV set. Alternatively build the unit into an external box with only the need to fit sockets 401 to 404 and the DC feeds from the TV to the rear panel of the set. The 115V and 12V DC supply lines should already be available within the TV on it's own video amplifier panel.

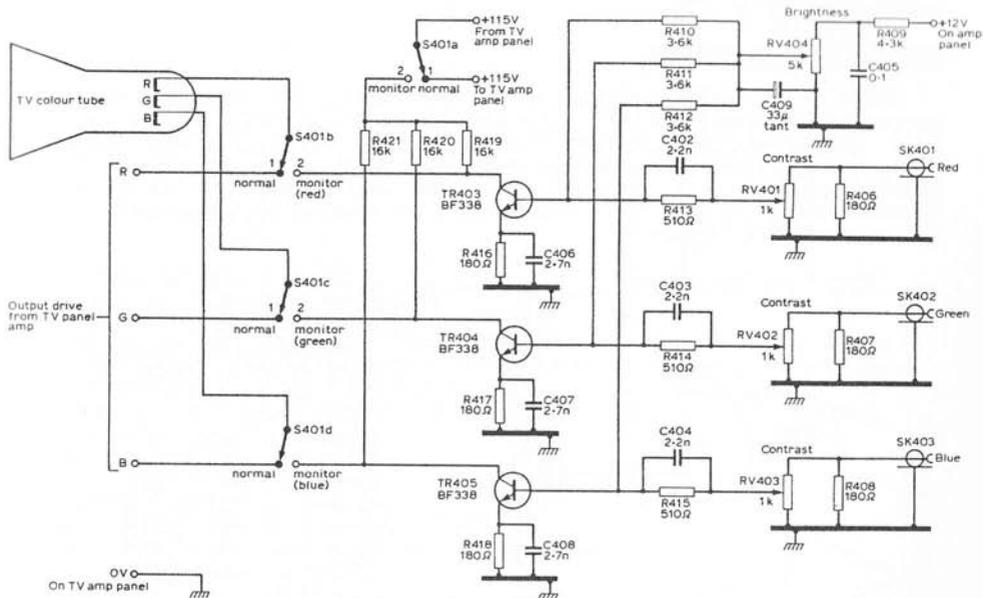


Fig.6

SSTV colour amplifier circuit

The purpose of S401, a rotary 4pole/2way, is to switch from monitor position (1) to normal operation (2). The only real modification to the set on the video amplifier board is to break the red, blue and green tracks, or leads, to guns of the crt and re-route via S401. A very important point to note is that this modification MUST NOT be carried out if the TV set does not have an isolating transformer. If the set is not isolated in this manner then a suitable transformer (1000VA) may be used externally.

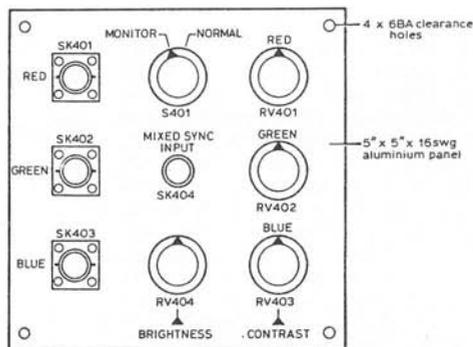


Fig.7 Colour control panel layout

Setting up the colour amplifier board requires a grey-scale picture source to achieve perfect results. Load each memory with the grey-scale and as each is transferred to the TV the picture is observed for pure black and white with no colour tinges. This balance is determined by the parameters of the colour tube and the colour amplifier circuit. If colour tinges do occur change resistors R410, R411 and R412 to 4.7k presets and adjust in turn to obtain a pure black and white picture. In the initial construction of the colour amplifier it may be convenient to mount resistors R410 to R412 on Vero-pins to facilitate easy conversion to presets if necessary. Also selection of close-matched transistors for TR403, TR404 and TR405 will help overcome this colouration.

MODIFICATIONS AND ADDITIONS

Since the original publication of the G3WCY converter system, several components have been found whose value and configuration required changing. These changes have been incorporated in the diagrams and explanations already given, however, there have also been other units built which complement the system, and these are described below. Any necessary modifications to the converter when it is used in conjunction with the transmit system are detailed in the appropriate chapter.

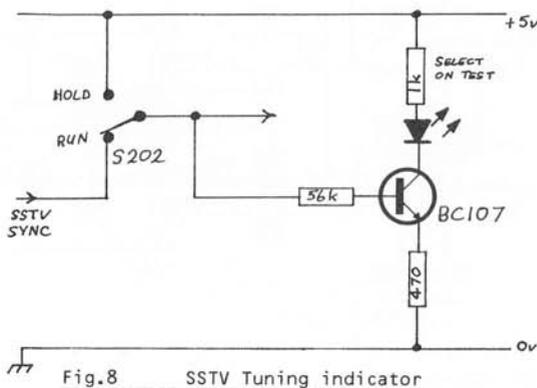


Fig.8 SSTV Tuning indicator

A simple tuning indicator is shown in Fig.8; this circuit can be built on a small piece of board and rounded directly onto switch S202, the LED is added to the front panel. As an SSTV signal is tuned in the LED flashes in sympathy with the received Line syncs, thus giving a guide to the correct tuning point at which the received picture should be taken, tune for best flicker.

Many stations have the facility to clear the screen, which is easily achieved by adding a switch in the input line from the radio receiver. On opening this switch the screen will be cleared as the slow-scan progresses. This switch could in fact be a multi-position one giving a choice of inputs as well as the clearing facility.

The circuit in Fig.9 can be incorporated to overcome the stripes displayed at the top and bottom of the slow-scan frame. These stripes are due to the short periods when the column counter isn't working. Upon reaching 128 the counter resets, thus displaying the top line of the picture as stripes. The 'clear' signal to IC28 (pin-12) is used to blank the display during the waiting periods created by the fast scan timing signals. The 470-ohm variable resistor controls the blanking voltage and must be set to the black level. The easiest method is to use an oscilloscope to monitor the video output signal whilst making the adjustment. If too low a blanking voltage is applied, then there will be sync problems.

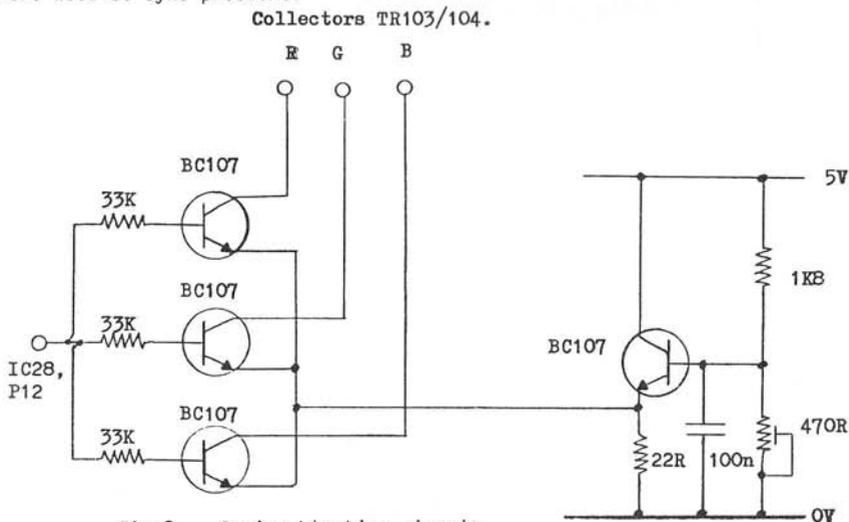


Fig.9 Stripe blanking circuit
(G4ENA)

Fig.10 shows another method of stripe blanking. This method involves a small modification to the Digital Memory Board; the connection to pin-1 of IC21 is broken, joining the cut tracks together with a wire link, leaving pin-1 isolated. The two diodes and the resistor may be easily wired to the back of the board.

The width control modification shown in Fig.11 permits the full memory map to be used when receiving as the existing design only utilises the complete memory when receiving 60Hz generated pictures.

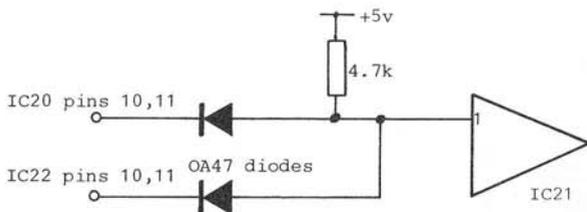


Fig.10 Stripe blanking circuit
(G8KZG)

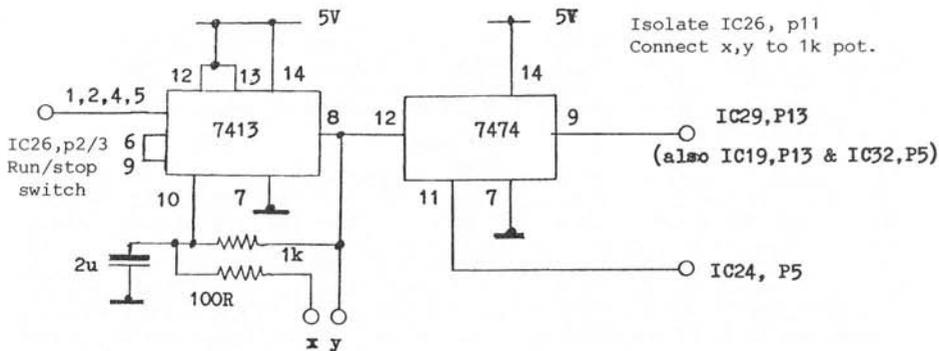


Fig.11 Width control

Line-sequential-colour is advantageous in a colour receive system as it allows for normal (normal for SSTV that is) colour reception. The circuit shown in Fig.12 selects each of the three memories in turn and loads the respective colour into it's memory, thereby taking 21 seconds to write the frame on the screen of the RGB monitor or TV conversion. A printed circuit board incorporating this modification and the width control is available from BAC Membership Services with full instructions.

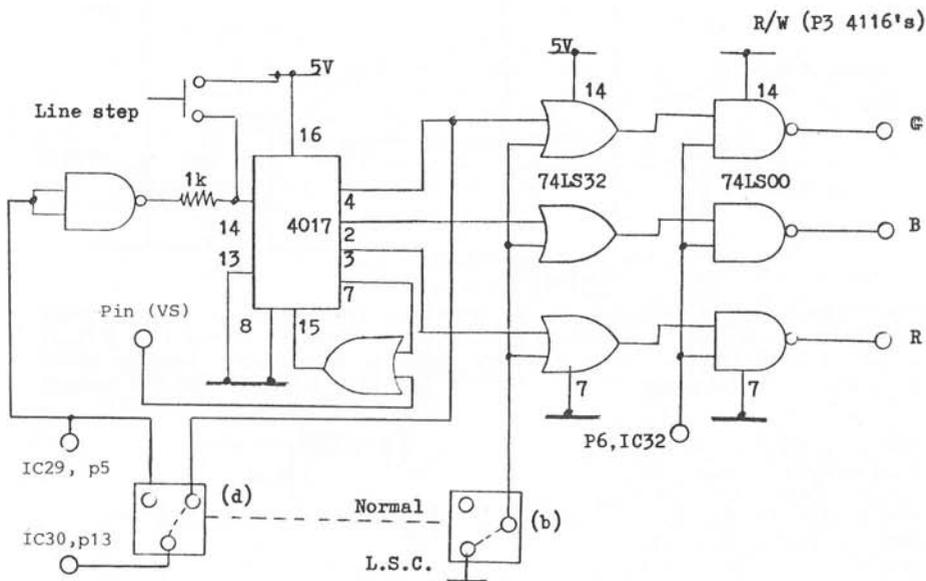
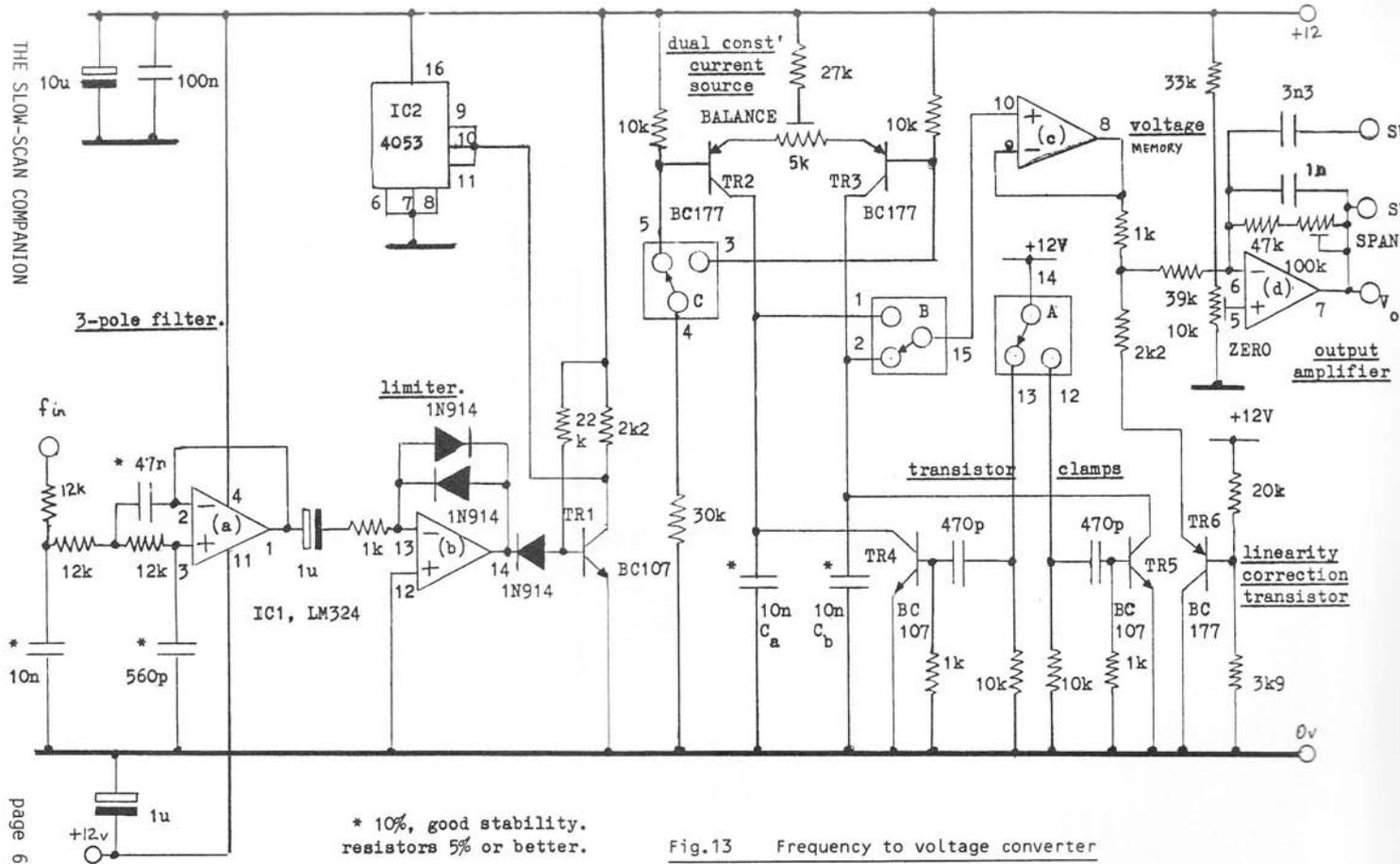


Fig.12 Line sequential colour



* 10%, good stability.
resistors 5% or better.

Fig.13 Frequency to voltage converter

Due to the design of the frequency-to-voltage conversion stage in the system, blurring of the picture has to be traded for ripple for a noise-free grey level be realised. The circuit shown in Fig.13 is a suggested way of overcoming this. IC1a is a 3-pole filter which removes unwanted noise above 2.3KHz. IC1b limits the sine-wave and, through TR1, generates the timing signal for the analogue switches (IC2). During the first half cycle of the incoming frequency, the voltage on Ca ramps up until the timing signal changes the state of the analogue switches. The voltage reached is stored, buffered by IC1c and fed to the output amplifier IC1d. During the next half cycle the process is repeated for Cb. Potentiometer RV1 adjusts the constant current charge to Ca and Cb and is set to give zero ripple for a steady input frequency, it is best set when receiving at 1.5KHz. The printed circuit board and instructions available from Members Services for this modification does not, however, incorporate the circuit in Fig.14, which is recommended for use at the input of this frequency-to-voltage unit in order to obtain a standard drive voltage for a varying input level. Also it is very important that the incoming signal is not distorted at all, due to overdriving the audio stages in the radio receiver, as any such asymmetrical distortion will cause an error in the period of the half cycle times and a resultant patterning effect on the screen.

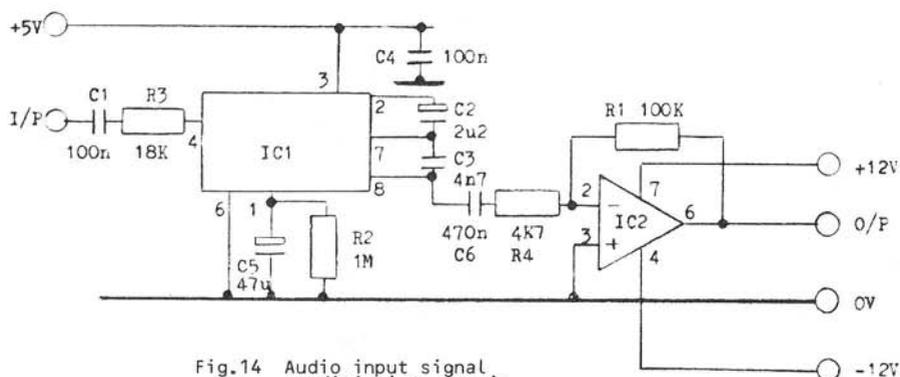


Fig.14 Audio input signal conditioning circuit

The editors wish to express their thanks to the Radio Society of Great Britain and the editor of 'Radio Communication' magazine for permission to reproduce parts of the original article 'A digital slow to fast converter for monochrome or colour', by B.A.Smith G3WCY which appeared in the February and March 1983 issues of the magazine.

TRANSMIT CONVERTER

The Transmit converter described in this section has been designed by G4ENA to be compatible with the G3WCY receive converter and a set of printed circuit boards is available from BATC Members Services.

The facilities offered by this design are:

- * Auto picture snatch of Fast-scan pictures.
- * 'Look through' memory for fast camera adjustment.
- * Receive digital board memory used to store transmit pictures - allows re-transmission of a received picture.
- * Positive and negative video control.
- * Width control and Line-sequential colour receive for the G3WCY converter, (as already described in that section).
- * 21-second Line-sequential colour Transmission, (3 memories required).
- * Audio output for direct connection to a microphone socket.

CIRCUIT DESCRIPTION

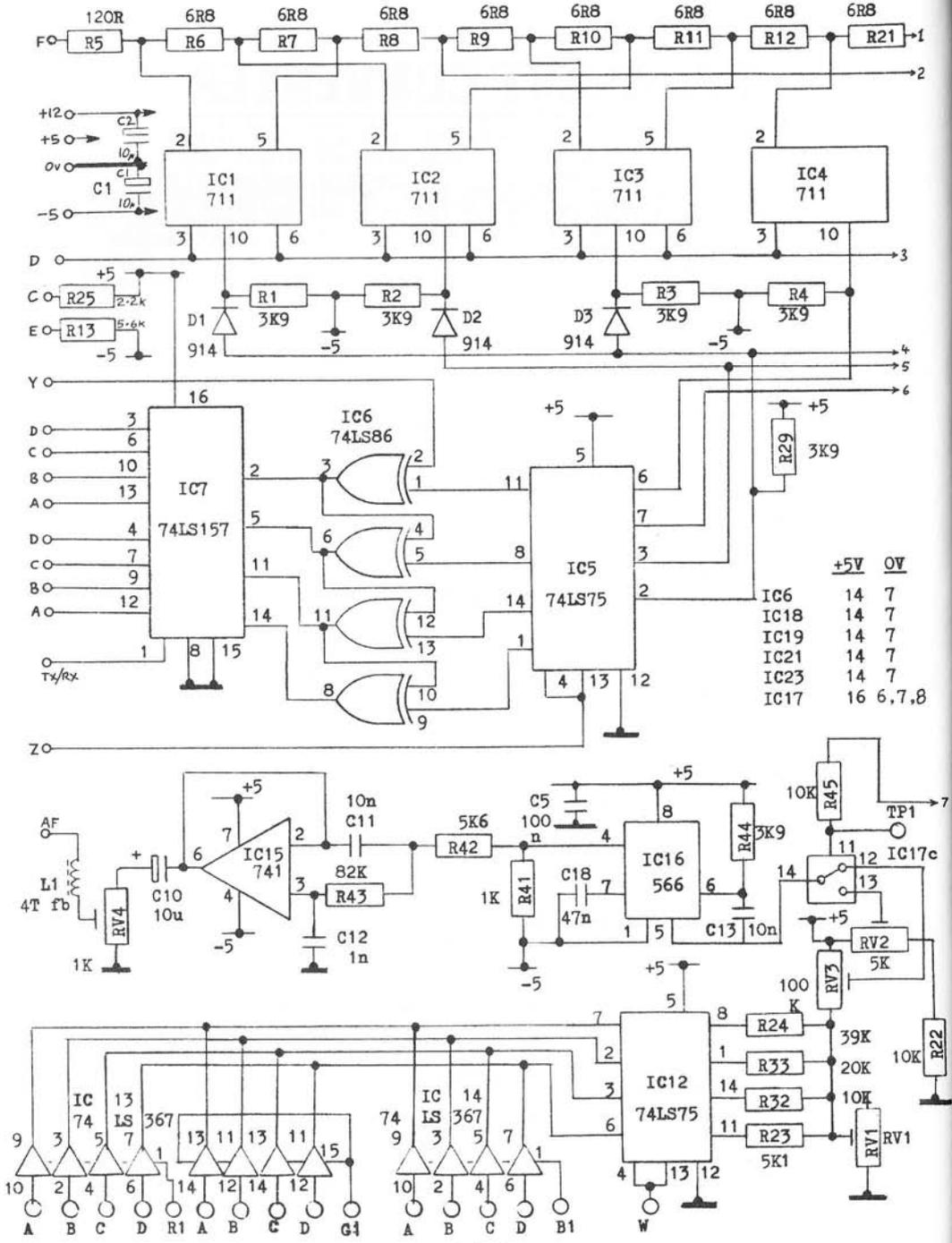
Reference should be made to the circuit diagram, Fig.1, and the switching/interconnection diagram, Fig.2.

The video signal selected by S13 is converted to a 4-bit gray code by the eight dual-comparators, IC1 to IC8. The video is latched by IC5 before each of the 128 pixels that make up a line are loaded into the memory. IC5 performs a gray-code to binary conversion and the video is then stored as a 4-bit binary picture in the receive converter memory. Selection of either fast-scan digital video, or slow-scan receive video, is carried out by IC7.

Selection of the fast-scan sync pulses is by S14. Transistors TR1, 2 and 3 form a sync separator circuit which extracts the external pulses for the memory board. If an independent sync source is used, rather than the composite video, then the thin piece of track connecting pins 'A' and 'B' should be cut.

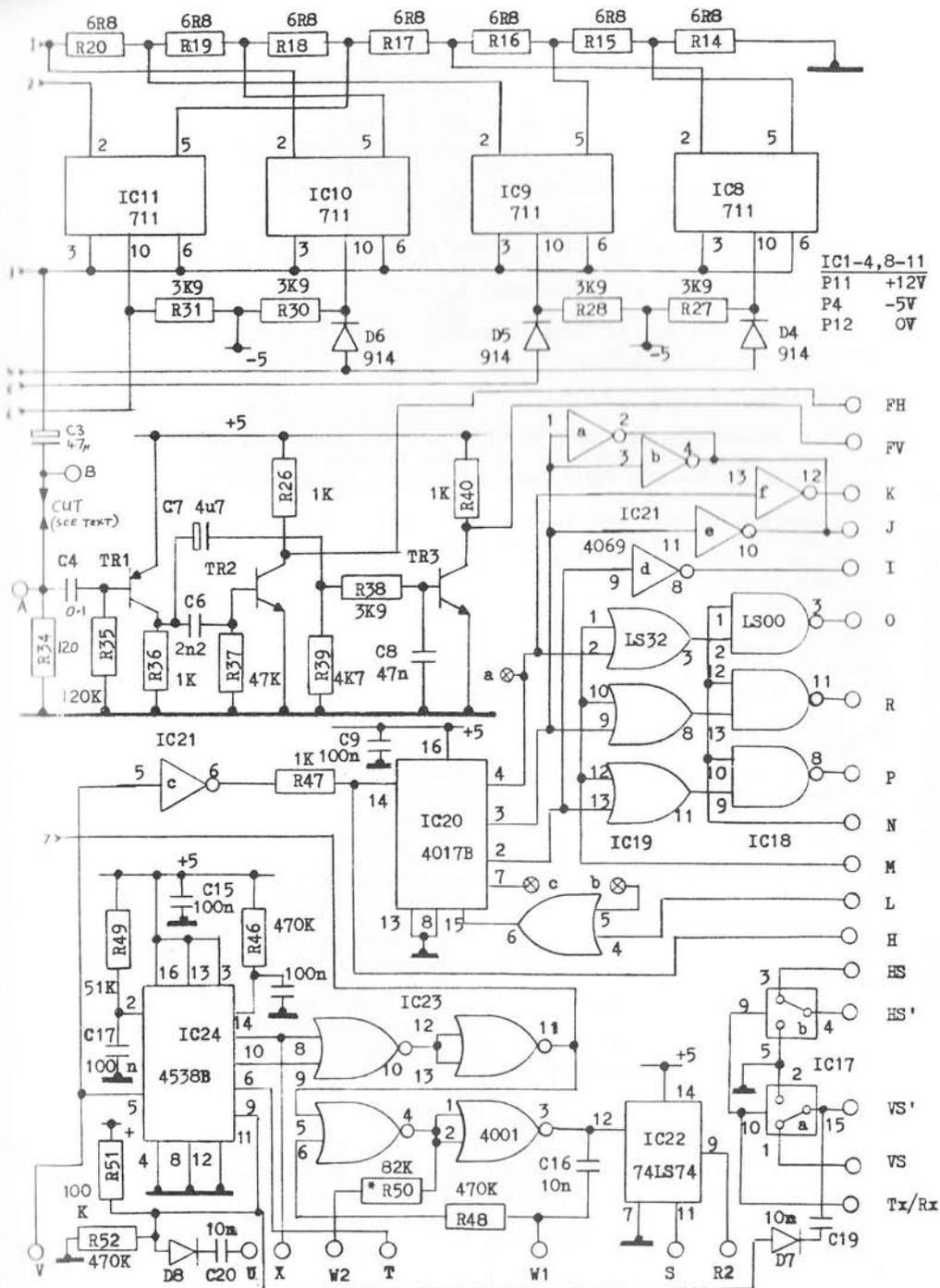
The video information to be transmitted is selected by S1 which controls the tri-state buffers IC13 and IC14, a logic 'low' enables the buffers. The video is latched at the slow-scan rate by IC12, before conversion to a scaled, 16 level analogue voltage by resistors R23, 24, 32 and 33. Potentiometers RV1 and RV3 set the black and white span of the picture.

The SSTV FM audio is generated by IC16 and to this is added the line and field sync pulses, by IC17c switching in the voltage from RV2. Any unwanted high frequency components of the FM audio are removed by IC15, which is configured as a 2-pole low-pass filter. Potentiometer RV4 adjusts the level of audio drive to the transmitter microphone input.



	+5V	0V
IC6	14	7
IC18	14	7
IC19	14	7
IC21	14	7
IC23	14	7
IC17	16	6,7,8

Fig.1



The dual monostable IC24 produces slow-scan line and field sync pulses from timing information derived from the receive converter memory board address counters. The slow-scan line oscillator IC23 is gated off during sync pulses which permits the maximum use of available memory for SSTV pictures. Width control potentiometer RV5 adjusts the oscillator frequency to cater for both 50Hz and 60Hz formats.

Line-sequential colour timing is controlled by IC's 18, 19 and 20. The link from 'b' to 'c' can be connected to 'a' and 'b'. This will load a 14-second, 256 line picture into the red and green memories.

Typical signals found at various points in the circuit are shown in the waveform diagrams of Fig.3.

CONSTRUCTION

It is recommended that the printed circuit boards are housed in a metal instrument case, with removable side panels allowing easy access for wiring. Full information for a suitable front panel layout may be found in Fig.4.

The transmit board uses the IC pins to connect top and bottom tracks, therefore it is not possible to use conventional IC sockets, however 'Molex' or 'Soldercon' socket strips may be used. It is advisable to solder the C-MOS components in last.

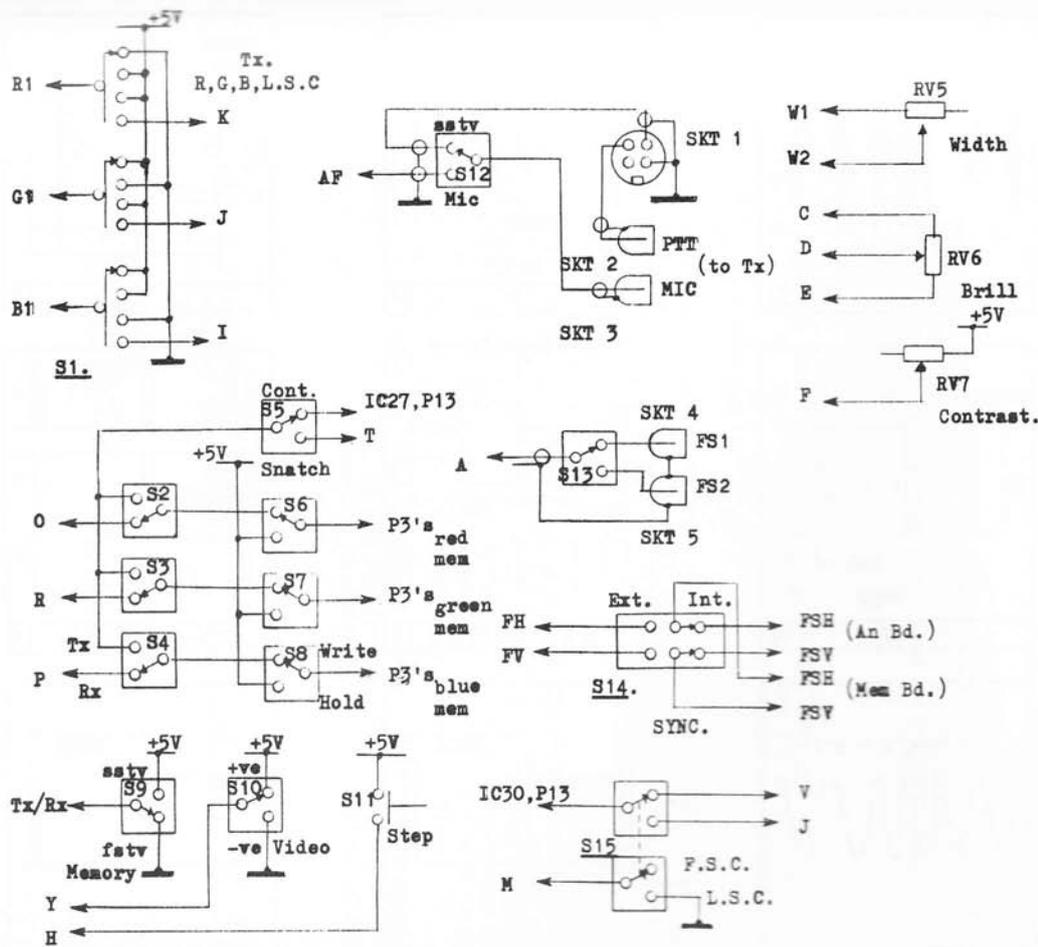
Careful checks should be made for shorts, solder splashes or IC pins only soldered on one side, where they should be soldered on both. When all visual checks prove satisfactory the boards may be installed and connected up, using screened cable for all video and audio signals.

CALIBRATION

The width oscillator is set using an oscilloscope to monitor the waveform at 'W2' (see waveform 8, Fig.3), whilst selecting a value for R50 (in the region of 20k) and adjust RV5 until the correct waveform is observed. To set the sync frequency, connect TP1 to +5v and, whilst monitoring the audio frequency output, adjust RV2 for a frequency of 1200Hz. The simplest way to set the black and white levels is to load a black and white picture into the memory and feed 'AF' back into the receive input, adjusting potentiometers RV1 and RV3 until peak black and white are achieved. It is most important that the receive converter has been correctly calibrated first if this method is used to set the black and white levels. An alternative method of setting black and white is to connect 'W2' to 0v, which will inhibit the line oscillator and prevent the generation of sync pulses. With a peak white video signal (adjust 'Brill' control) and S5 set to CONTinuous, adjust RV3 for a frequency of 2300Hz (measuring at 'AF'). Operate S10 (video invert switch) and adjust RV1 for a frequency of 1500Hz. Repeat until both black and white frequencies are correct.

MODIFICATIONS TO THE G3WCY CONVERTER

Analogue board: It is necessary to invert the polarity of the sync pulse 'VS'. To do this the printed circuit track from pins 6 and 9 of IC11 to the 'VS' output pin must be cut, ensuring that pins 6 and 9 remain connected. The 'VS' output is then taken from pin-8 of IC11.



Internal connections

From.	To.
G	N.C.
B	N.C.
N	IC32, P6
L	X
S	IC24, P5
R2	IC29, P13
U	IC30, P5
V	IC29, P5
W	IC32, P6
Z	IC23, P6
HS	HS (An Bd.)
HS'	S202 (Mem Bd.)
VS	VS (An Bd.)
VS'	VS (Mem Bd.)
J	S15
MEM A,B,C,D	A,B,C,D, (Mem Bd.)
SSTV A,B,C,D	A,B,C,D, (An Bd.)

A } B } C } D }	R	IC41, P13	Red Memory.
		IC41, P12	
		IC41, P5	
		IC41, P4	
A } B } C } D }	G	IC41, P13	Green Memory.
		IC41, P12	
		IC41, P5	
		IC41, P4	
A } B } C } D }	B	IC41, P13	Blue Memory
		IC41, P12	
		IC41, P5	
		IC41, P4	

Fig.2

SWITCHING AND INTERCONNECTION DIAGRAMS

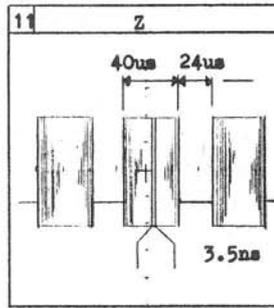
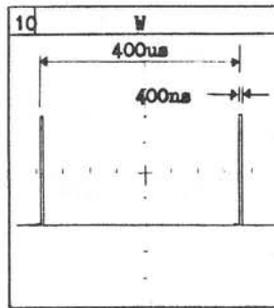
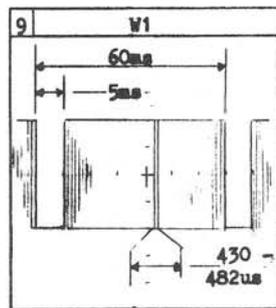
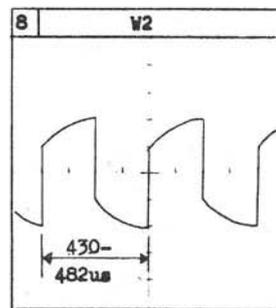
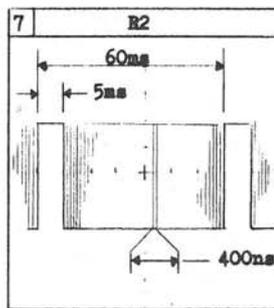
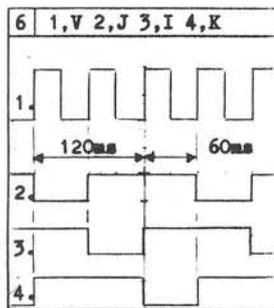
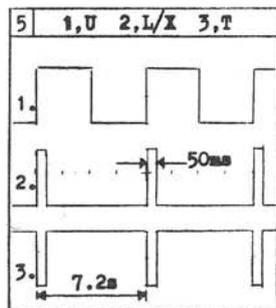
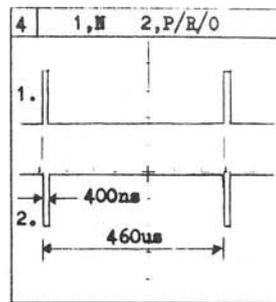
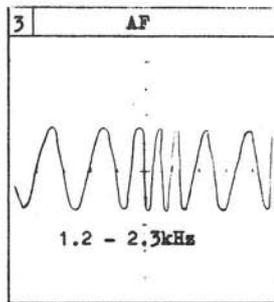
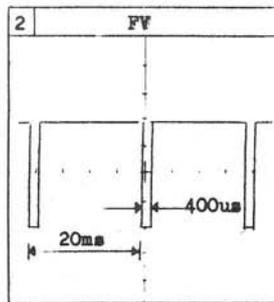
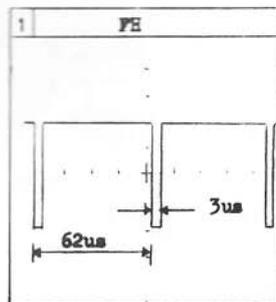


Fig.3

WAVEFORM DIAGRAMS

Digital board: IC32 must time out before IC31 to enable the SSTV picture to be sampled for transmission. This is effected by replacing C205 with a 220pF, or a select-on-test value close to this to achieve correct timing. As the memory's read/write lines are now controlled from the transmit board by switches S2 to S8, the track connecting IC32 pin-1 to pin-3's of IC37-40 must be cut on each memory board (ensure that the pin-3's of IC37-40 remain connected together). If the G4ENA memory boards have been fitted to the converter, then the CAS lines (pin-15 of the memory IC's), which are at present switched, must be reconnected to IC31 pin-1. Only the read/write lines (pin-3's) of each memory IC are independently controlled.

A small modification to the 'VS' circuitry also has to be carried out on the memory board. Cut the track from IC26 pin-11 to IC29 pin-13. Cut the track from IC29b pin-5 to IC30 pin-13. Connect 'VS' from the memory board to 'X' on the transmit board.

Constructors should note that if you have already built the line-sequential colour and width control circuits as additions to the G3WCY converter, they are accommodated on the transmit converter board supplied from BATC Membership Services.

OPERATION

To receive a picture into a memory, eg. RED, the switches are set in the following manner: S2 to RX, S6 to Write, S15 to F.S.C. and S14 to INT. Either INT or EXT syncs can be used if a camera is connected. Adjustment of RV5 will load the whole picture into memory.

To transmit a picture from a memory, eg. BLUE, the switches are set as follows: S4 to TX, S8 to Write, S10 to +, S5 to CONT and S14 to EXT. Adjust CONTRAST and BRILL to produce a picture which spans all the grey levels from peak white to peak black. To store the picture in memory set S8 to HOLD. To transmit the picture set S1 to B.

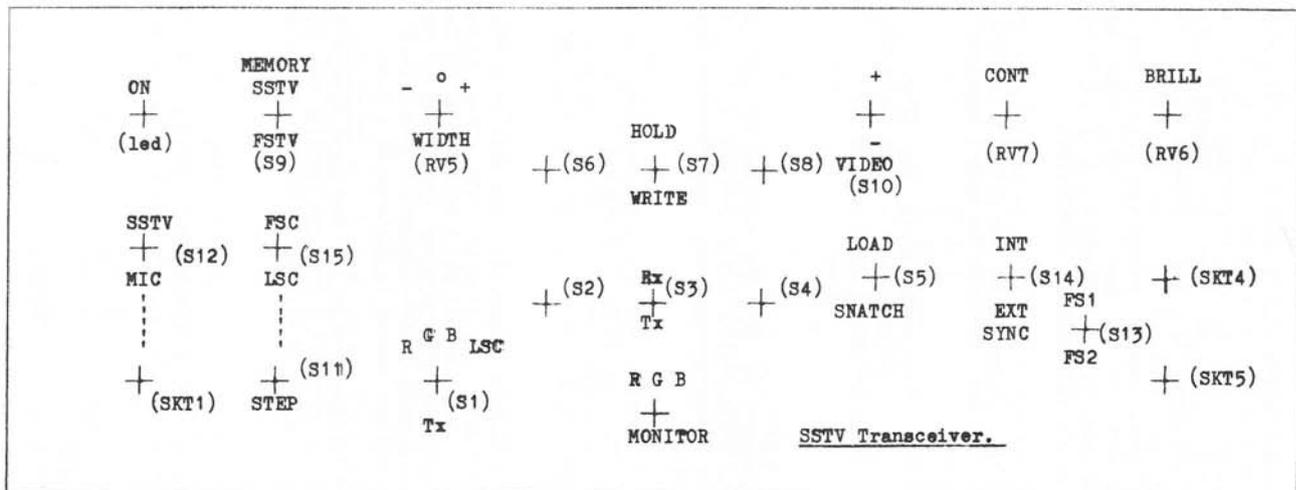
To receive a line-sequential picture all three memories must be enabled and S15 set to L.S.C. If a field sync pulse is missed and the wrong colour is being loaded into the wrong memory, then correction is possible using the STEP push-button S11. Re-transmission of the received colour is achieved by setting S1 to L.S.C. The 21-second mode of line-sequential colour could also be used to transmit three separate black and white pictures at a time.

It has been found on some units that unreliable 'VS' may cause some problems. If this is the case, then connect a 1M resistor from the junction of C20 and D8 to the +5v rail, likewise connect a 1M resistor from the junction of C19 and D7 to +5v.

TRANSMIT AUXILIARIES

A transmit auxiliary board is available from Members Services which has been designed to complement the transmit converter. On this board are three separate circuits (Fig.5):

- 1) Cursor
- 2) Colour picture snatch
- 3) Three video buffers and sync combiner.



Case type - $\frac{1}{2}$ W12,2U.

Instrument case supplied by :-

H.J.Morgan Smith
Sheet Metal Engineers
Egham House
36 Furlong Road
Bourne End
Bucks. SL8 5AA
Bourne End 20415

Fig.4

FRONT PANEL LAYOUT

1) CURSOR (IC1)

A 4-bit magnitude comparator compares the binary value of the fast-scan and slow-scan counters (IC's 28 and 30) and, when both are equal, the A = B output (pin-6) pulses high. This pulse appears as a bright strip and moves down the screen as the SSTV picture is transmitted. Tr2, controlled by TX/RX, clamps the pulse when receiving as tuning is difficult when it is present. (A cursor is unnecessary on receive). Pin C1 connects to any one input of the video buffers.

2) COLOUR PICTURE SNATCH

This facility allows the separate R,G and B frames of a colour picture to be loaded into memory during the SSTV frame pulse. This frame pulse has to be extended to at least 80mS to ensure that three complete frames can be sampled. To ensure that this pulse length is correct, change R46 on the transmit board to 750k. When in receive IC2 connects R2 (Aux board) across R46 (TX board) to shorten the pulse length again.

When IC3 is enabled it closes the R,G and B video switches in turn (IC4) and, at the same time, writes the respective video information into memory by electronically operating the write/hold switches (S6 - S8).

S11 is a three-position switch (DPDT, ON-OFF-momentary ON). With S11 in the OFF (centre) position, S5 controls CONTINUOUS and SNATCH sampling of the fast-scan colour video. CONT allows setting of the contrast and brilliance controls and SNATCH takes a new picture after the transmission of the existing one in memory.

S11 up-locks the colour picture in memory and SNATCH (step RX) instantly resets the frame, loads the next picture and commences transmission. This is the momentary switch position. Colour snatch is only possible when S9 is set to L.S.C. R17 provides a high impedance DC path to ensure that C8 is correctly charged before RGB sampling takes place.

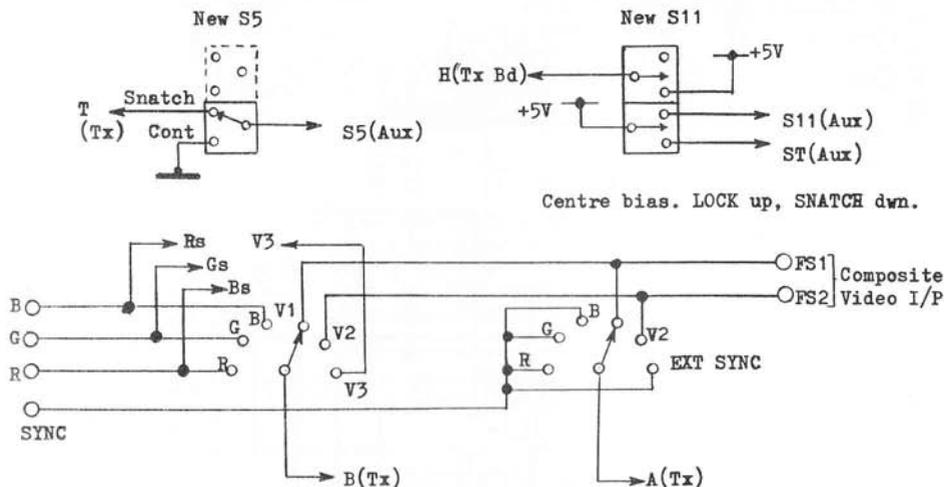
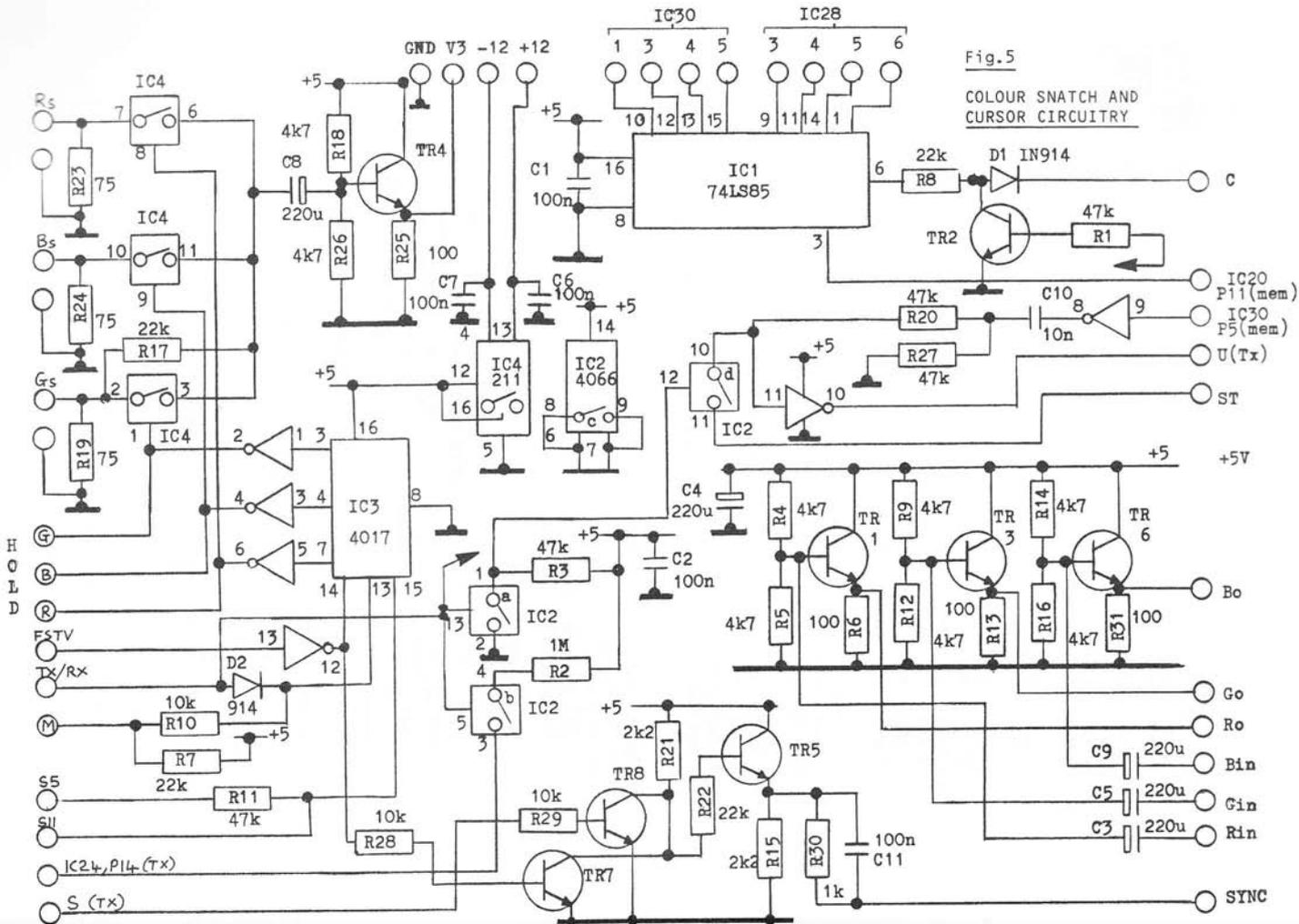


Fig.6 SUGGESTED SWITCHING ARRANGEMENT

Fig.5

COLOUR SNATCH AND CURSOR CIRCUITRY



No extra holes need be drilled in the front panel as the additional switching is achieved by increasing the poles of S5 and S11.

3) VIDEO BUFFERS AND SYNC COMBINER

It will be necessary to drive a colour monitor from the RGB memory outputs. Three buffers, the same as on the memory board, can be used for this purpose. Also mixed syncs are available from TR5.

The switching of video signals will vary according to individual requirements but an example is given below for guidance (Fig.6). It caters for two B/W cameras and one RGB source.



Picture by Grant Dixon, G8CGK

This is an SSTV picture printed from a computer screen. Each pixel was represented by a 4 x 2 dot matrix. The micro used for this experiment was a Microtan and the constraints of this display were 256 lines by 512 dots per line. A nearer representation to the usual 1:1 aspect ratio could be obtained using a 3 x 2 dot matrix.

4 x 2 matrix gives 9 levels of grey
3 x 2 matrix gives 7 levels of grey

This picture was produced from a tape by David Cawthorne, G6HQS, who put it onto a floppy disc. The picture was printed using a screen dump routine to an Epson MX80F/T III dot matrix printer.

The horizontal sweep driver in Fig.3 is virtually identical to the vertical except for a different value discharge capacitor at Tr4. The 16.6Hz sweep should show a linear sawtooth waveform on an oscilloscope and any clipping or crushing can be removed by adjusting the 'width' and 'position' controls.

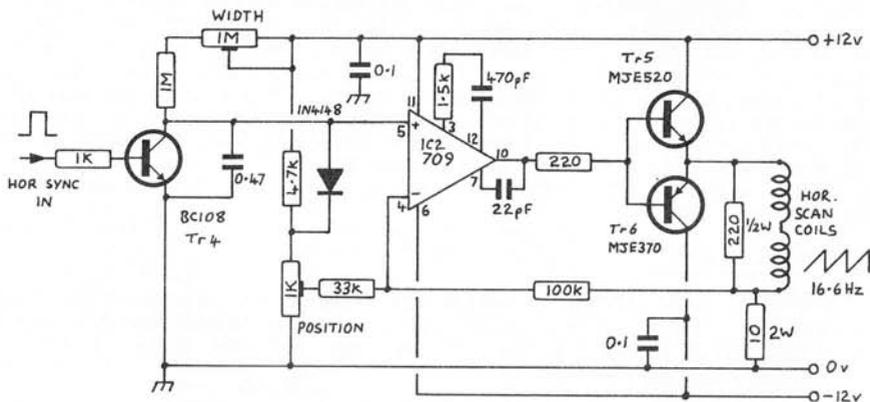


Fig.3 HORIZONTAL TIMEBASE - MAGNETIC DEFLECTION

DISPLAY TUBE & EHT

The circuitry for controlling the CRT is illustrated in Fig.4. For FSS use, only a brilliance control need be provided since the tube is only required to produce an even-brightness raster without modulation. This diagram also illustrates a winding to supply ac drive for the sync generator.

Fig.5 shows a simple EHT supply, the output of which is suitable for many types of cathode ray tube. The circuit is based on a modified domestic TV line output transformer which is described below.

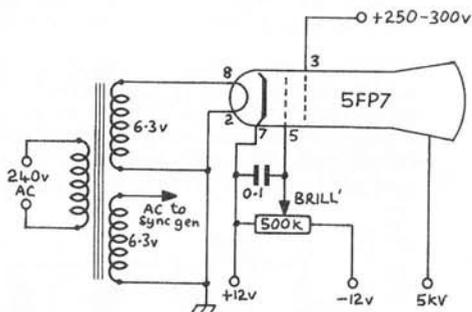


Fig.4 CRT CIRCUITRY

Tr1 is a simple oscillator whose frequency can be varied by the 'freq. adj' control. The necessary feedback comes from L1 and L2 which are both wound on the transformer ferrite. EHT is taken from the original overwind coil and multiplied by the D/C network. A separate winding is also provided to obtain the 250-300v required by the CRT.

TRANSFORMER

Most ordinary 'open' types of line output transformer as found in old TV sets may be used. The types which are sealed in resin cannot be dismantled and are therefore not suitable for this application. A typical transformer is illustrated in Fig.6.

Carefully dismantle the transformer into its component parts. Remove all the wire from the primary winding by cutting through it with a small saw. Re-assemble the core and overwind ensuring that there is a gap between the ferrite core ends where they go into the winding. A thin piece of paper should be sufficient.

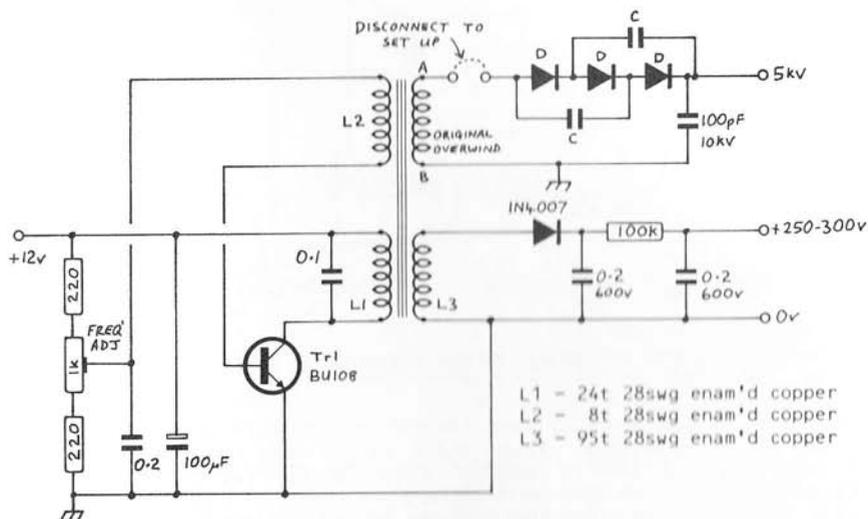


Fig.5 EHT POWER SUPPLY

On the other limb of the ferrite core wind on a couple of layers of electrical insulation tape, then wind L1 onto it to form the first part of the new secondary. Slip sleeving over the free connecting wires and trap part of each sleeve under a couple more turns of insulation tape which should cover the new winding. Repeat the process with L2 and then the same with L3. L3 will need to have several layers although each layer can be somewhat longer than L1. Each layer should be insulated from the previous one with adhesive tape.

The EHT diodes and capacitors were taken from the original EHT line output assembly but most EHT trays will serve as well. If too much EHT is generated then a diode and capacitor may be omitted. If such diodes are not available they may be purchased from many component shops. Ensure that each diode and capacitor has a working voltage of several kV. The capacitor values are not critical and can be around 100pF each.

ADJUSTMENT

Ensure that the EHT link is disconnected and apply +12v via a current meter. If the meter reads more than 1-amp then adjust the 'freq adj' control to try and reduce it. If the current is still greater than 1-amp reverse the connections to L2 and try again. The oscillator frequency should now be audible and the 'freq adj' control will set it for a smooth continuous ring. If the ringing is annoying to the ear try tightening the transformer clamps or else enclose the assembly in an insulated compartment.

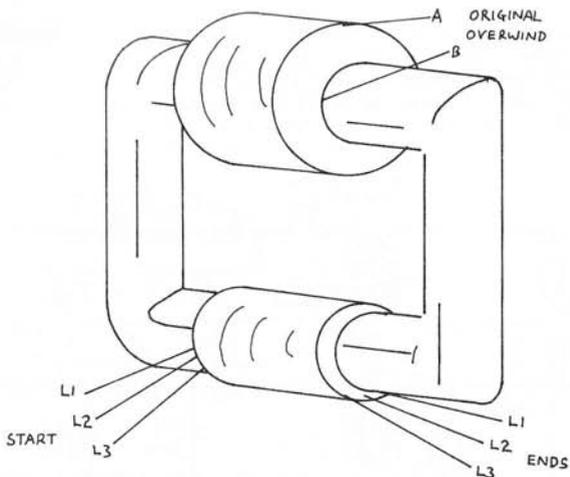


Fig.6 DETAIL OF EHT TRANSFORMER

Connect the link and carefully check the EHT voltage which may be adjusted by altering the supply voltage. Always start low and raise the voltage gradually until the required EHT is reached. BE CAREFUL WHAT YOU TOUCH. It is good practice when working on such units to keep one hand in your pocket, this reduces the risk of shorting high voltages to ground - via you! Also stand on a good insulated mat or floor covering such as rubber. Having said that, this form of EHT unit is considerably safer than those derived from mains transformers.

PHOTOMULTIPLIER

By far the most common type of photomultiplier tube available is the 931A and Fig.7 shows its base wiring and signal output to the video modulator. Fig.8 is the photomultiplier power supply circuit which provides around -700v.

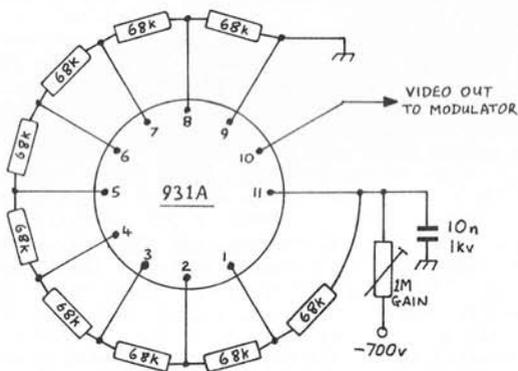


Fig.7 PHOTOMULTIPLIER WIRING

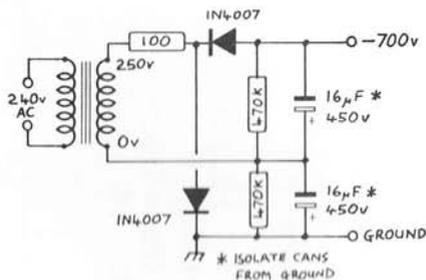


Fig.8

PHOTOMULTIPLIER POWER SUPPLY

VIDEO CIRCUITS

The video amplifier and modulator circuitry is shown in Fig.9.

Since photomultiplier tubes have an output in the absence of light (dark current) it is necessary to balance this by inserting some bias current into the inverting input of a 741 op-amp (IC1). In general the 'dark current' control is set to make IC1's output near to zero volts after the gain has been correctly set.

Amplifier IC2 has unity gain and the input is switched to provide a video inversion facility. A black frequency adjust control is included which provides an offset current into the inverting input of IC2. Positive-going sync pulses are applied to the inverting input which drives the output to near zero thus producing the correct VCO frequency.

Tr1 is a unijunction relaxation oscillator whose frequency is determined by the resistance in its gate circuit and the capacity to ground. The oscillator is set to run at twice the operating frequency (2400Hz) and this is divided by two in IC3 to produce the required 1200Hz squarewaves. These squarewaves are filtered in the active filter IC4 which produces near sine waves in the frequency range 1200 - 2300Hz.

The composite slow scan signal is available at the slider of the output gain control which sets the required amplitude to the transmitter.

CONSTRUCTION NOTES

Construction of the FSS cabinet is a matter for personal choice but is likely to be similar to one of the designs outlined in the chapter on transmitting SSTV. A wooden, lightproof cabinet is probably ideal and this should be painted matt black on the inside to prevent any light reflections.

The lens (if used) should be mounted centrally in a partition which is made adjustable between the picture and CRT face. Fig.10 shows the lens arrangement for a typical scanner and has some suggested measurements to act as a guide. The distances and geometry for a 50mm lens are detailed since this is the focal length of a standard 35mm camera lens and the most likely one to be used by amateurs.

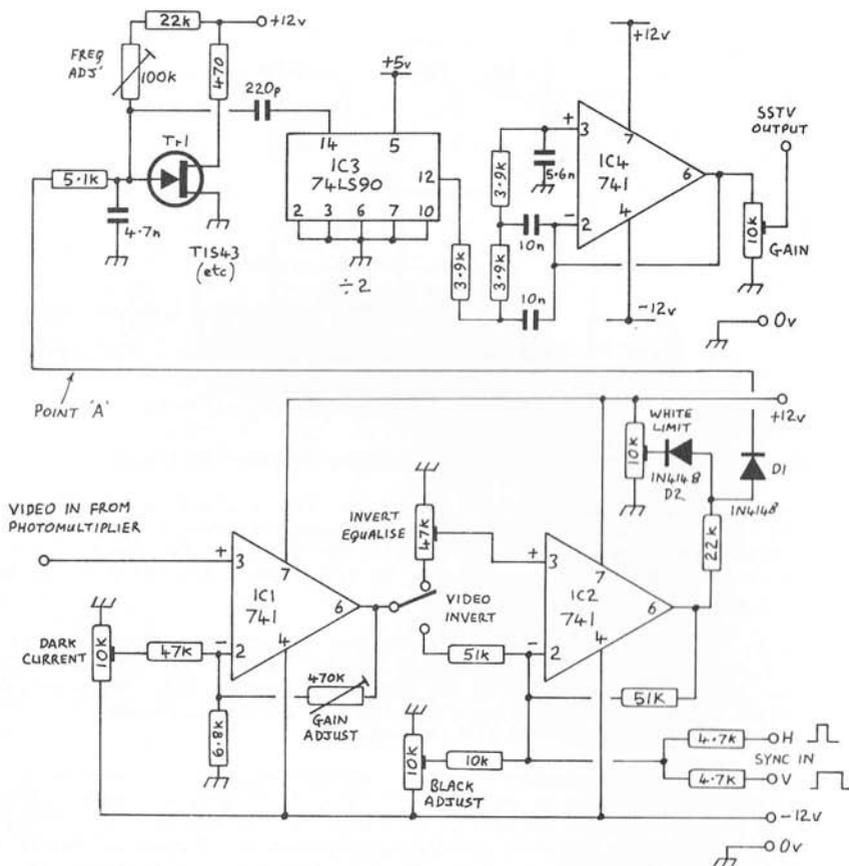


Fig.9

VIDEO CIRCUITS

It is quite possible to use two photomultipliers (as shown in Fig.10). Simply duplicate Fig.7 and connect the two video outputs together. In this application the 'gain' controls will also act as 'balance' controls to even out the sensitivity between the two.

Care should be taken if mains transformers are enclosed in the same cabinet since the 50Hz fields can easily introduce hum on the CRT raster causing scanning lines which are not straight. Placing the transformer directly behind the CRT and as far back as possible is usually the best choice, although a separate power supply (excluding the EHT generator) is probably best. A shrouded or toroidal transformer could also help.

The CRT scanning yoke is usually obtained from a very old TV tube neck (not the modern ones with the slim necks). Alternatively you will no doubt find a slow-scanner who has a spare yoke which was probably used on an early monitor and which he would be pleased to pass on to a good home. The yoke should be stripped of all capacitors and resistors and the four wires from the

horizontal and vertical deflection coils freed for use. The coils having the lower resistance are used as the horizontal ones. The resistor across the coils (Figs 2 and 3) is to prevent ringing on the sweep. It should be noted that some old yokes had high impedance frame coils, these should be avoided unless you are using valves to drive them.

A permanent magnet focus assembly may be obtained from the same source as the yoke and is slid onto the tube neck behind the scanning yoke. Focus is adjusted by moving one magnet relative to the other or by sliding them along the tube.

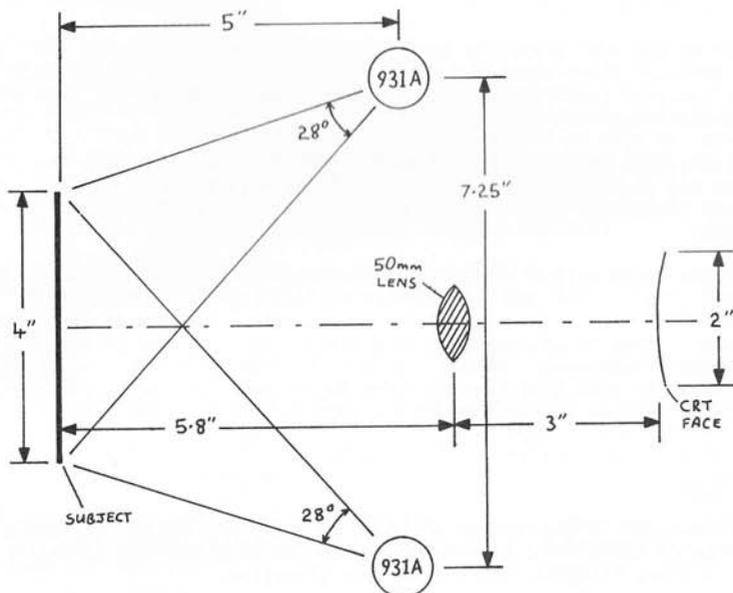


Fig.10

FLYING SPOT SCANNER OPTICS

ADJUSTMENTS

1. Set the photomultiplier 'gain' control to maximum resistance (Fig.7).
2. Set the 'gain adjust' pot (Fig.9) to mid range and break the connection from pin 6 of IC1 to the invert switch.
3. With the photomultiplier in total darkness adjust the voltage at pin 6 of IC1 to zero volts using the 'dark current' control.
4. Without re-connecting pin 6 apply a variable voltage to the common of the switch. Adjust this voltage to zero (ground). Move the slider of the 'white limit' control to the earthy end when the voltage at IC2 pin 6 should read zero. Adjust the input voltage to some positive potential (say +2v) and with the switch to 'invert' the output should read -2v. Now change the switch to normal and alter 'invert equalise' to produce +2v. Now re-connect IC1 pin 6 to the switch common.

5. The sync frequency of the VCO is set by grounding point 'A' and adjusting the 'freq adjust' control for an output of 1200Hz from IC4. Up-end the 5.1k resistor at the diode end and apply a variable voltage to it. Plot a frequency versus voltage curve measuring frequency at the output and voltage applied with a multimeter. The frequency should increase linearly from 1200 to 2300Hz. Note the voltage required to obtain 2300Hz.
6. Still with the photomultiplier in darkness turn the 'black adjust' control to produce 1500Hz at the SSTV output. With the aid of the 'white limit' control set the slider to read the same voltage as that noted in 5 which produced 2300Hz.
7. Connect the sync pulses to the timebase circuits and turn up the brightness, there should be a raster on the CRT face. Adjust focus for the clearest scanning lines (do not keep the brightness too high otherwise you may damage the CRT phosphor).
8. Place a high contrast picture in front of the lens and focus the raster onto the picture (do this in subdued light - it's easier to see). Now close the lid of the photomultiplier compartment to shut out all external light.
9. Set the 'gain adjust' control to drive the VCO up to white limiting level, this is most easily observed by 'scoping the cathode of D1. Now connect the output to a slow scan monitor and a picture of sorts should appear. Some re-adjustment to the various circuits may be required for optimum performance. If there is a lack of uniformity in the displayed picture this could be caused by the two photomultipliers being out of balance or they are not facing the subject at the correct angle.

FINAL NOTES

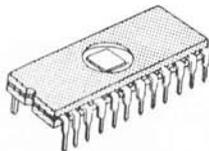
The use of a blue filter in front of the 5FP7 tube may eliminate (or at least reduce) the afterglow, although since the 931A photomultiplier is itself blue sensitive, filtering may not be very effective.

Constructors are reminded that this design simply brings together a number of separate circuits, therefore some adjustments and minor alterations may be required to gain optimum performance. The object of this article has been to illustrate how standard SSTV circuits may be used and to show one possible practical application to help constructors.

REFERENCES

A transistorised EHT unit, G3LPB - CQ-TV92.
A flying spot SSTV scanner, G3RHI - CQ-TV81.
Slow Scan Television Handbook, W9NTP & WB8DQT - A 73 publication.

A SSTV CHARACTER GENERATOR



Unless one is fortunate enough to have a SSTV typewriter or computer which can produce large characters, it is difficult for SSTV users to generate a bold, personalised identification caption. Of course a camera could be used but this would have to be set up, lights switched on and the correct card found each time you wanted to use your ident caption, not the best way to get on the air in a hurry!

This project is designed to electronically produce two lines of up to eight characters which you can customise to your own requirements. The large characters produced will stand out even when they are being received off air under weak signal or noisy conditions. The unit is quite versatile in that it allows you to change the vertical size of the characters as well as providing on-board switching, so that either the top line, bottom line, both lines together or no characters at all (blank raster) is produced. It is also possible to change the overall width and position of the display by selecting appropriate resistors, or even by providing variable controls.

A printed circuit board for this project is available from BATC Members Services, and some add-on units are also available to further enhance the project.

Since this is a practical design in a largely practical book the circuit operation will not be discussed in detail. Those wishing to do so however are referred to the BATC's 'Amateur Television Handbook' - volume-1, where the original article was described for fast-scan television. Unfortunately this publication is now out of print however photocopies are available from BATC Publications dept. (six A4 pages).

The circuit is built around a custom character generator chip the RO-3-2513UC. This chip produces upper case (capital) letters, however a lower case version is available suffixed LC.

PROGRAMMING

In the basic unit described here the character generator is programmed by connecting diodes in a matrix which programmes the ROM to produce the required characters. To choose each individual character diodes connect the A4 to A9 inputs to the binary-to-hexadecimal chip IC10. A four-bit code is presented to the input of IC10 which changes each time a new character is output. The output of IC10 has 16 pins, each of which goes low in turn as a different character is addressed.

IC9's inputs are held high by pullup resistors so that the code input to IC9, with no diodes in circuit, is 1 1 1 1 1 1 which produces the '?' character. A diode between an IC9 input and an IC10 output will cause one of the logic-1 states to be taken to logic 0.

On the board the inputs to IC9 comprise six address lines which run parallel towards one edge of the board. The outputs from IC10 are brought out on wire links, the link at the end of the address bus (nearest the edge of the board) representing the first letter.

The program 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' indicating that a diode is required, therefore the A9, A8 and A7 inputs require diodes whilst A6, A5 and A4 are left blank. The bus nearest the edge of the PCB is A9 and represents the first column on the programming chart.

The diodes are wired with the anode to the data bus and the cathode (marked end) soldered to the wire link corresponding to their position, eg. if the first letter of the top line is 'G' then diodes connect from A9, A8 and A7 to link-1 (see Fig.2). The wire links are formed by bending a piece of tinned copper wire into a wide 'U' shape and soldering this at each end to the board tracks. The diodes are then stood on end, one wire passing through the appropriate hole in the PCB and the other (marked end) connected to the link. In this way diodes can be easily re-arranged simply by disconnecting the link end, this saves the risk of damage to the PCB.

Use any ordinary silicon diodes.

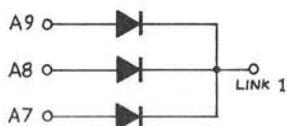


Fig.2 DIODES REQUIRED FOR A "G"

PROGRAMMING CHART													
Char'	A9	A8	A7	A6	A5	A4	Char'	A9	A8	A7	A6	A5	A4
A	x	x	x	x	x		V	x		x			x
B	x	x	x	x		x	W	x		x			
C	x	x	x	x			X	x			x	x	x
D	x	x	x		x	x	Y	x			x	x	
E	x	x	x		x		Z	x			x		x
F	x	x	x			x	blank		x	x	x	x	x
G	x	x	x				0			x	x	x	x
H	x	x		x	x	x	1			x	x	x	
I	x	x		x	x		2			x	x		x
J	x	x		x		x	3			x	x		
K	x	x		x			4			x		x	x
L	x	x			x	x	5			x		x	
M	x	x			x		6			x			x
N	x	x				x	7			x			
O	x	x					8				x	x	x
P	x		x	x	x	x	9				x	x	
Q	x		x	x	x		-		x			x	
R	x		x	x		x	/		x				
S	x		x	x			&		x	x			x
T	x		x		x	x	?						
U	x		x		x								

'x' indicates where a diode is required

ADDITIONAL CIRCUITRY

A sync pulse generator having the required TTL level output is described under the chapter detailing a flying spot scanner. If the output pulses are the wrong way up it will be necessary to invert the signals either in invert or two-input NAND gates. The video produced by this generator can be used to drive the modulator also detailed in the same chapter, however an alternative simple and rather novel circuit is shown in Fig.3.

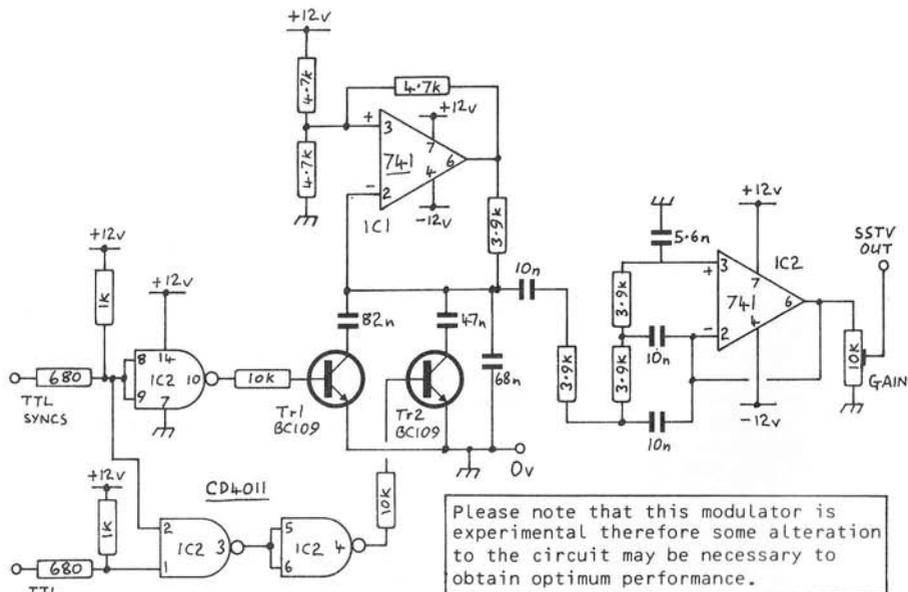


Fig.3

SSTV MODULATOR AND FILTER

IC1 is a voltage-controlled audio oscillator which is very stable and independent of supply fluctuations. The frequency is set by the 3.9k resistor at pin 6 together with a 68nF capacitor and whichever capacitor in Tr1 or Tr2's collector is switched in.

Inverted sync pulses fed to Tr1 ensure that it conducts during sync periods only. This causes the 82nF capacitor in its collector to be switched in parallel with the 68nF making IC1 oscillate at 1200Hz (SSTV sync frequency). The sync signal also blanks the video to stop interference during sync periods.

Peak white video from the character generator is represented by a logic zero and black level by logic one. During the line period Tr1 is switched off whilst a logic one will switch Tr2 on, making the oscillator time constant capacitors 68nF plus 47nF which will cause the oscillator to run at 1500Hz - SSTV black level. When characters are present in the video the input will be at logic zero which means that neither transistor will be switched on therefore the time constant is set by the single 68nF making the oscillator run at peak white (2300Hz).

Since the resulting SSTV is largely comprised of square waves, the combined signal is passed through a simple 3KHz active filter (IC2) which produces near sine waves in the 1200 - 2300Hz range. The output level to the transmitter is set by the 'gain' control.

An add-on memory board for this unit is described in the BATC's publication "Amateur Television Handbook - Vol.2". The article also describes the addition of an ASCII keyboard to replace the 'hard-wired' diode program.

A PATTERN GENERATOR

This design produces five different black and white test patterns, invaluable when setting up SSTV equipment. Also provided are the three standard test frequencies used in SSTV: 1200Hz, 1500Hz and 2300Hz. A printed circuit board for this unit is available from BATC Members Services and is supplied complete with a component layout diagram.

The standard frequency generator (Fig.1) provides the three standard frequencies from a single master oscillator, IC5, running at 276kHz. This oscillator is fed to a series of divider chains to produce the three frequencies, IC6 and 7 for 2300Hz, (peak white), IC8, 9 and 10 for 1500Hz (black level) and IC11 for 1200Hz (sync). The 1200Hz is then further divided by IC12, 13 and 14 to derive the line frequency of 16.3Hz for the UK and 15Hz for US standards, selectable by S1. Further division again by IC17 and 18 gives the frame frequency for 120 or 128 lines, selected by IC16 and S2.

The pattern generator (Fig.2) is based on a hex inverting buffer IC1 which is configured as a digital-to-analogue (D/A) converter. The digital 'word' is selected by means of a 4-pole 6-way rotary switch wired as shown in Fig.3. This digital 'word' is decoded by the D/A, which is also fed with line and frame sync from the frequency generator, and the resultant analogue signal is fed to an op-amp IC2, which feeds the corrected level to the voltage controlled oscillator (VCO) IC3. The VCO converts the analogue output from the D/A stage into a frequency corresponding to an SSTV signal. This signal is then fed to another op-amp, IC4, configured as a low-pass filter, whose output can then feed to a single pole 4-way rotary switch to select between either the pattern generator output or the standard frequencies.

The power supply circuitry is not catered for on the board but a simple regulated supply is all that is required. Power requirements are: +5V @ 220mA, +12V @ 20mA and -12V @ 20mA, although if some IC's are replaced (where appropriate) with 'LS' versions the current drawn from the +5v can be reduced.

CONSTRUCTION

The master oscillator capacitor is given as 5600pF, but this will depend on the tolerance of other components, so a second position on the PC board is provided where a capacitor may be placed in parallel with it. This will allow for the oscillator to be adjusted to its correct frequency at the mid-point of the potentiometer travel. All resistors should be 5% tolerance, with the exception of the summing resistors associated with the D/A, IC1, which should be 1% if possible. These summing resistors should be in the ratio 1:2:4:8, with 5.5k being the value of the first. Where resistors have an awkward value they may be built up by series/parallel combinations.

SETTING UP

- 1) Using a dual-beam oscilloscope monitor the line sync waveform at the output point on one channel and a 50Hz waveform on the other. Adjust the master oscillator until the sync pulses are stationary with respect to the 50Hz waveform. Alternatively, a single-beam oscilloscope may be used if it has the facility to trigger the input waveform from an external source. If this method is used then the line sync pulses should be stabilised against an external 50Hz trigger input.

- 2) Adjust the line sync pulse width to 5mS and the frame sync pulse width to 30mS.
- 3) Connect the output of the unit to an SSTV receiver and connect the oscilloscope to a point where the SSTV signal has been demodulated. Feed in 1200Hz from the frequency generator and note the position of the trace, the (oscilloscope has to be operated in the DC-coupled mode for these adjustments). Now feed the output from the pattern generator into the SSTV receiver and, with no pattern selected, adjust the 'SYNC' potentiometer to give the same trace position on the oscilloscope as with the 1200Hz. Repeat this process selecting Black and White patterns, adjusting the 'BLACK' and 'WHITE' potentiometers respectively to position the trace at the same position. These adjustments are somewhat interdependent so the whole process must be repeated to achieve perfect results.

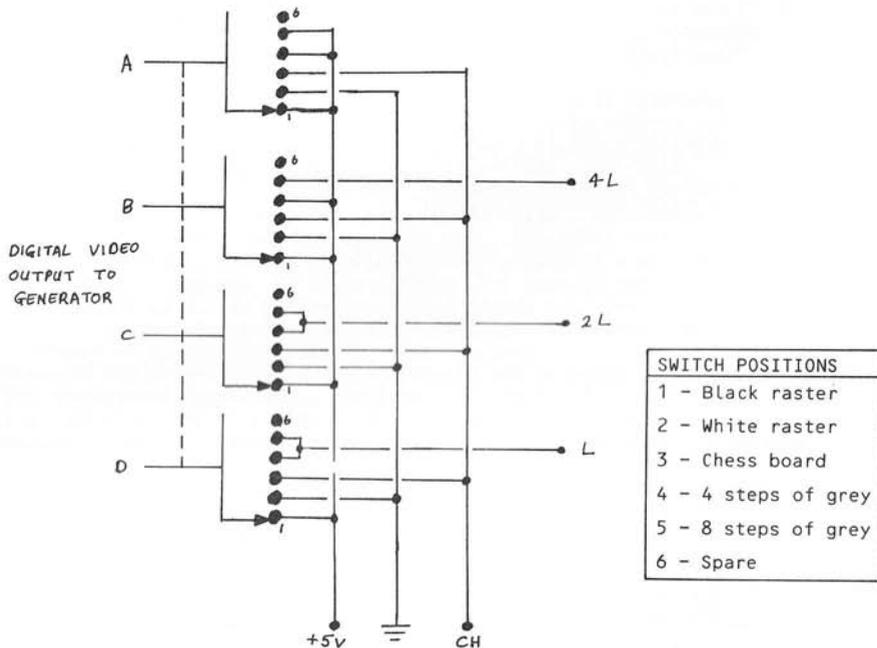


Fig.3

Pattern select switch

ALTERNATIVE MASTER OSCILLATOR

For those wishing to use a more stable master oscillator, fig.4 shows a suitable circuit using a standard colour TV subcarrier crystal at 4.433619MHz.

Although when this frequency is divided by sixteen the resulting frequency is 277.101KHz (instead of the required 276KHz), it is nevertheless within one percent of the standard and therefore perfectly suitable for general use. Provision for this oscillator is NOT provided on the pattern generator PC board.

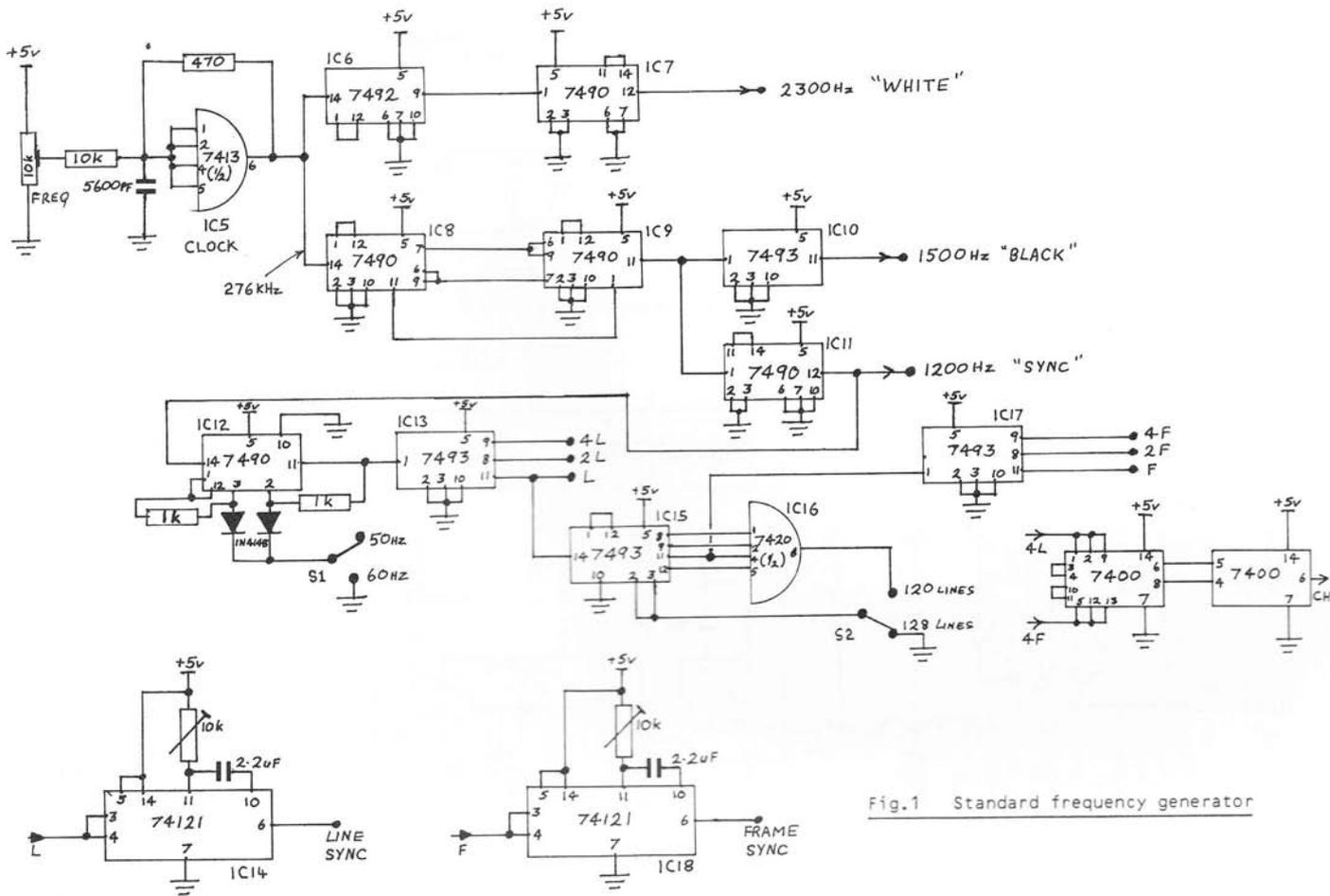
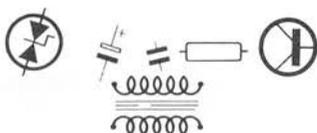


Fig.1 Standard frequency generator

SSTV CIRCUITS



The chapter entitled "A FLYING-SPOT SCANNER" introduces many useful circuits to the slow scan TV constructor. There are a wide variety of other circuits however and a selection of these is described in this chapter.

FILTERS

Audio filters are extensively used in SSTV equipment and, because of the almost universal use of operational amplifier ICs these days, such filters are invariably of the 'active' (rather than passive) kind. This means that filter designs can be more accurately reproduced and have a better overall performance than those using passive components.

INPUT FILTER

The first filter to be described is a low-pass design whose purpose is to reject all signals above about 2,500Hz (just above white frequency) and pass everything below. It is used right at the audio input to an SSTV receiver and effectively rejects unwanted co-channel interference.

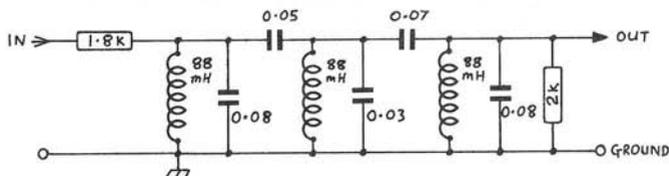


Fig.1 Passive low-pass filter

Fig.1 shows the circuit of a design which uses all passive components. It has a medium input/output impedance (around 2k) and is thus suitable for installing in an audio line. The 88mH toroidal inductors may sometimes be found lying around in the shack, especially by those whose interests also lie with RTTY, however if you have to buy them they are available from the British Amateur Radio Teleprinter Group at reasonable cost. The odd looking capacitor values may be made up by connecting two or more preferred values in parallel.

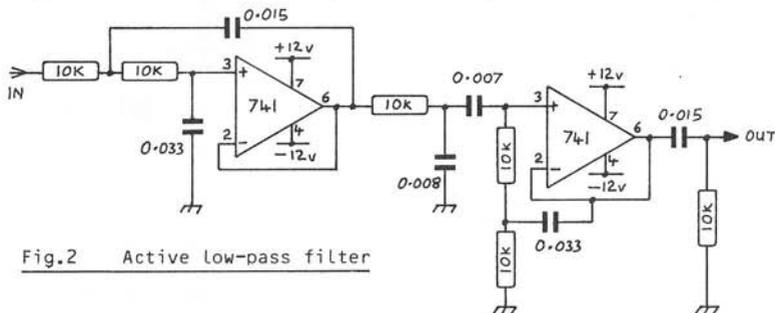


Fig.2 Active low-pass filter

The circuit in Fig.2 does the same job as the passive design but has a somewhat better response. It also uses easy to get components, has a medium input/output impedance and may be built quite easily on a small piece of

'Vero' board. Again the odd capacitor values should be made up from parallel capacitors. The circuit has approximately unity gain.

SYNC FILTERS

Once the SSTV audio signal is present in the receiver it is necessary to separate the synchronising pulses from the video (picture) information. The sync frequency is 1200Hz therefore a filter having a centre frequency of 1200Hz and a bandwidth of around 400Hz would be about right to extract the SSTV sync signals.

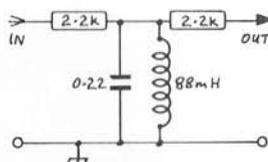


Fig.3 Passive sync bandpass filter

Fig.3 shows a simple passive sync extraction filter using an 88mH toroid. Although this circuit will perform quite well it does not exhibit the excellent performance of the active filter shown in Fig.4.

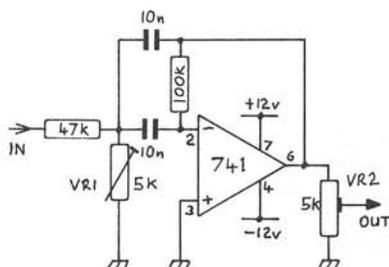


Fig.4 Active sync bandpass filter

The circuit in fig.4 is called a multiplier feedback active bandpass filter and, using this circuit it is possible to set the required gain as well as providing a good bandpass response. This design has a gain of around ten and VR1 is used to finely adjust the centre frequency.

To test the circuit an audio signal generator should be fed into the input and the output monitored on an oscilloscope. Set the generator to 1200Hz and adjust VR1 for maximum

indication on the 'scope. Now check the passband by varying the input frequency and plotting the output level on graph paper, in this way the passband response can be examined accurately. The output level is adjusted by VR2.

SYNC EXTRACTION

Most slow scan monitors rectify the 1200Hz sync burst in order to recover the video sync pulse. The easiest method is to use full-wave rectification and a suitable circuit is shown in Fig.5. This uses a miniature audio transformer and a pair of diodes to produce a positive-going sync pulse. An alternative, and much nicer and more versatile rectifier, is illustrated in Fig.6. Here a couple of op-amps are used to provide the correct clipping level as well as adjustment of rectifier balance. With a sync signal from the filter applied to the input and a 'scope to the output, RV1 is adjusted to achieve a correct rectifier balance (see waveforms inset). Fig.7 illustrates in 'a' the sync burst before rectification (note the very low level video signal either side of the sync burst) and in 'b' the rectified signal showing a positive-going sync pulse and a clipping level set well above the noise in order to produce a 'clean' sync pulse.

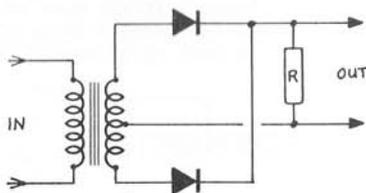


Fig.5 Full-wave sync rectifier

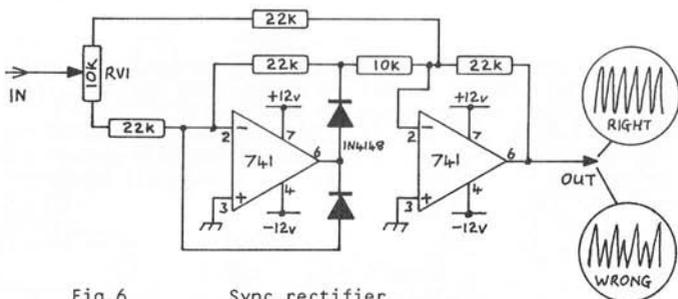


Fig.6 Sync rectifier

Fig.8 shows the circuit of a simple sync separator using discrete transistors. Available at the outputs are both line and frame pulses, both of which have adjustable clipping levels. The outputs are negative-going and are suitable for driving deflection coil assemblies.

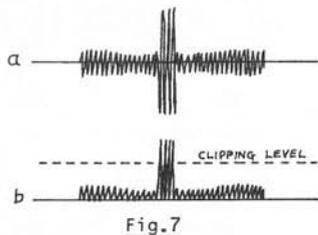


Fig.7

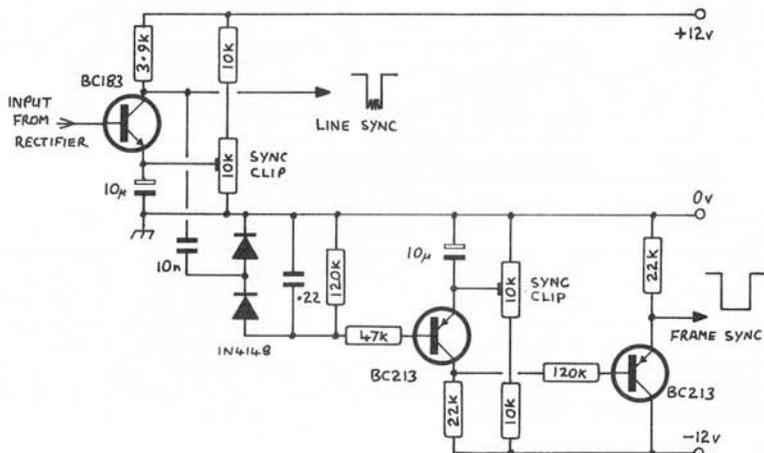


Fig.8 Discrete transistor sync separators

SSTV MODULATOR - DIGITAL INPUTS

SSTV modulators for analogue inputs are detailed elsewhere in this book, however with all the digital hardware around these days it is likely that a requirement for a suitable modulator will be high on the constructor's priority list. Such a circuit is shown in Fig.9.

IC1a accepts a TTL composite sync signal and presents the pulse to Tr1 which in turn passes it on to the video/sync mixer circuit. IC1b accepts a TTL video signal which is either passed directly to the mixer or it can be inverted in IC1b to produce a 'negative' picture effect. The two signals are

combined and the levels may be individually adjusted before being applied to a 741 amplifier. The combined signal is then used to modulate a voltage controlled oscillator (NE566) which has been suitably designed to produce the correct SSTV frequencies. A control is provided on this VCO for the accurate setting of the white frequency (2300Hz). The SSTV signal is then passed through an active filter in order to restrict its overall bandwidth prior to feeding a transmitter.

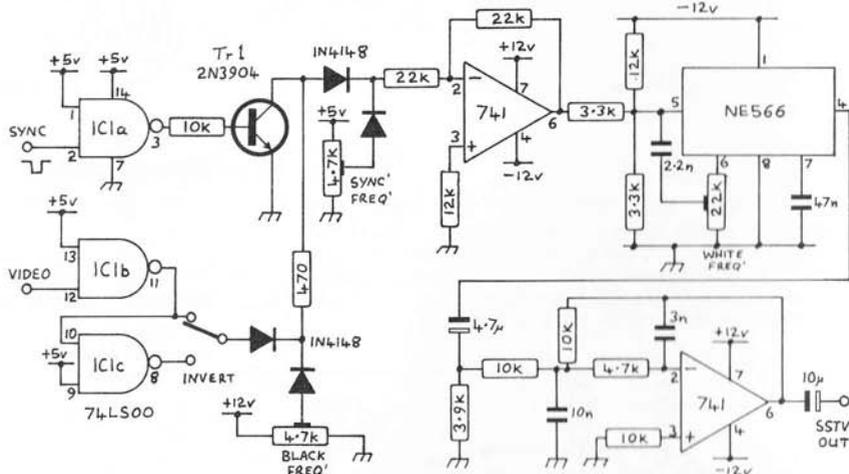


Fig.9 SSTV modulator with digital inputs

LIGHT DETECTION

Elsewhere in this volume a flying spot scanner is described. This unit employs one or two photomultiplier tubes to detect the relatively small amount of light reflected back from the picture, which produces the fluctuating video signal. The photomultiplier has been the mainstay of light detection for decades and is still widely used, nevertheless they are relatively large and expensive and, moreover, need a high voltage power supply as well. With all the modern optical sensors available it should be possible to dispense with photomultipliers for SSTV work.

Fig.10 shows the circuit of a video head amplifier which uses a solar cell as its detector. This circuit was in fact designed by Deryck Aldridge for use in a NBTV drum camera and thanks are expressed to the NBTVA for permission to reproduce the circuit here.

Tr1 and Tr2 are chosen for their low-noise characteristics. Tr1 is used as an emitter follower stage to allow the solar cell to be loaded with the preferred value for 'R'. Although 4.7k is used here other values may be needed to suit different cells. Tr2 is a straightforward amplifier with its gain controlled by RV1. Tr3 and 4 form a compensating amplifier which enables correction for the inherent capacity of the cell thus avoiding signal distortion. The stage allows for variable degrees of HF compensation and adjustments must be carried out on test to achieve best results. Ideally a LED should be driven from a square-wave oscillator and the light produced used to illuminate the solar

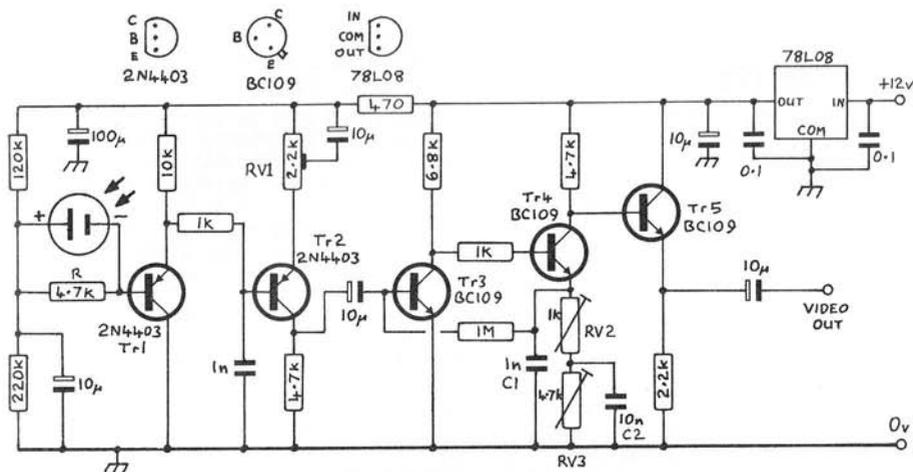


Fig.10 Solar cell video amplifier

cell (in the dark). The output from the amplifier is then fed into an oscilloscope and adjustments made to RV2 and RV3 until a good approximation of a square-wave is achieved. This may necessitate some adjustments to C1 and C2 (e.g. C2 may be increased to 0.02µF whilst C1 may be found completely unnecessary). Note that reducing both RV2 and 3 to zero at the same time will cut off the signal since bias to Tr3 would be removed. RV3 could be altered to 3k plus a fixed resistor of 1k to stop this happening.

The square-wave frequency is not important, anything from about 100 to 1,000Hz works OK with the higher frequency being better for checking the upper end of the spectrum. In the absence of an oscilloscope RV2 and 3 can be adjusted by viewing a test card pattern as the picture source.

Tr5 is simply an emitter follower stage whose output could be taken to a potentiometer (typically 22k lin.) which is then used as an overall video gain control for feeding into a SSTV modulator. The use of a simple voltage regulator isolates the head amplifier from variations in the power supply. The input/output decoupling capacitors should be fitted close to the regulator pins.

Most of the commonly available solar cells seem to work well with this amplifier, the only possible alteration being with the shunt resistor 'R'.

AUDIO ANALYSER

Slow-scan TV has three key frequencies which must be considered in signal analysis: 1200, 1500 and 2300Hz. It is important that these frequencies are correct so that precise carrier insertion is achieved, thus resulting in the correct reproduction of the sync frequency as well as maintaining the full video swing to ensure best received picture contrast. It is also desirable to know that the three frequencies are correct during transmission. The unit described here is an audio spectrum analyser which will give a visual display, in real time, of these three main frequencies using an ordinary oscilloscope.

THEORY OF OPERATION

The analyser measures the length of time needed for the positive going portion of each cycle in the signal being analysed. A positive going zero-crossing triggers a monostable which starts the 'scope timebase after a delay. The next zero-crossing, which is negative going, is used to generate a very narrow pulse which appears as a bright dot on the screen. The trace begins on the left side of the screen and moves to the right. The higher the frequency, the shorter is the time needed to complete the positive half of the cycle. Therefore the vertical spot generated from comparatively high frequencies will appear closer to the start of the trace on the left hand side of the screen, whilst lower frequencies, which require a longer time for completion, results in spots being displayed further toward the right side.

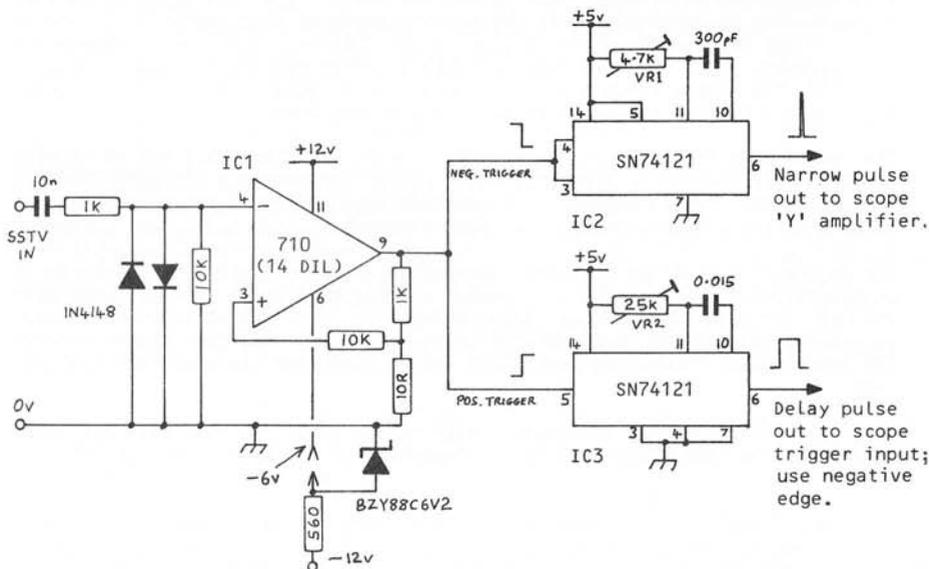


Fig.1 Circuit diagram

CIRCUIT DESCRIPTION

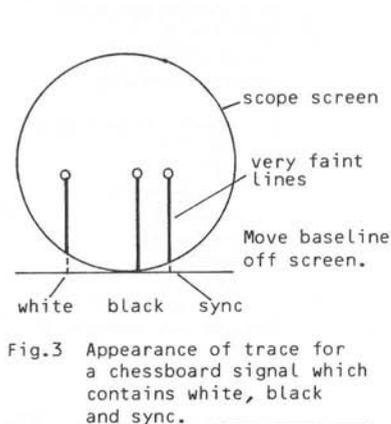
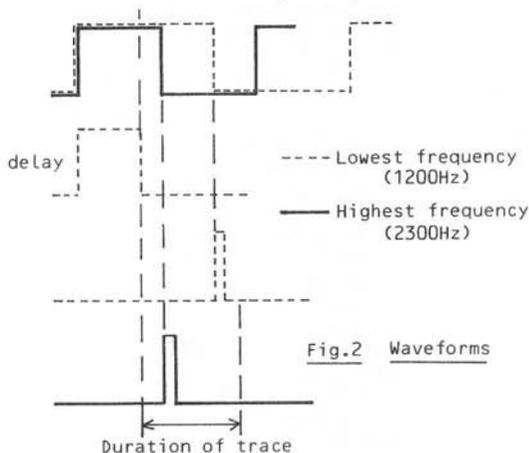
The SSTV signal is connected to a differential comparator (IC1) whose threshold is governed by the potential divider between output and zero volts, this gives some positive feedback to ensure a rapid transition.

The resulting output is fed to a monostable (IC2) which initiates a vertical pulse triggered from IC1 when the positive half of a cycle is complete. VR1 sets the size and clarity of the vertical pulse. The output of IC2 connects to the oscilloscope's 'Y' input. The positive-going portion of each incoming cycle triggers a delay monostable (IC3) which starts the sweep just before the beginning of the highest expected frequency (2300Hz). This delay eliminates the wasted scanning space which would result from triggering the sweep at the beginning of a positive pulse. VR2 adjusts the delay time and provides pulse positioning on the display. The output of IC3 connects to the oscilloscope's TRIGGER input. Fig.2 shows the various waveforms to further illustrate the principle of operation.

CONSTRUCTION AND ADJUSTMENT

The circuit shown in Fig.1 may be built on a printed circuit board or on a small piece of perforated stripboard. IC1 requires +12v and -6v supplies however, if only +/- 12v is available an extra resistor and zener diode may be used (as shown) to obtain -6.2v from the -12v line. +5v for the TTL circuits could similarly be derived from the +12v rail or a 3-terminal voltage regulator - 78L05 - could also be used.

Calibration of the analyser should be carried out with the aid of an accurate audio frequency generator. Set the 'scope to 2v/cm for the 'Y' amp., and 50uS/cm for the 'X' timebase. Apply a 1500Hz signal and adjust the 'scope to display a faint vertical line at the centre of its screen. Adjust VR1 for a suitable pulse amplitude. Set the audio generator to 2300Hz and adjust VR2 so that the pulse appears just inside the left-hand edge of the screen. Now adjust the generator for 1200Hz and make sure the new pulse is displayed towards the right-hand edge. Further adjustments to VR2 and the oscilloscope 'position' control may be needed to centre up the display and show all three frequencies at once. Now calibrate the oscilloscope screen by either marking with a felt tipped pen the precise positions of each pulse on the graticule, or make a note of the pulse positions for future reference.

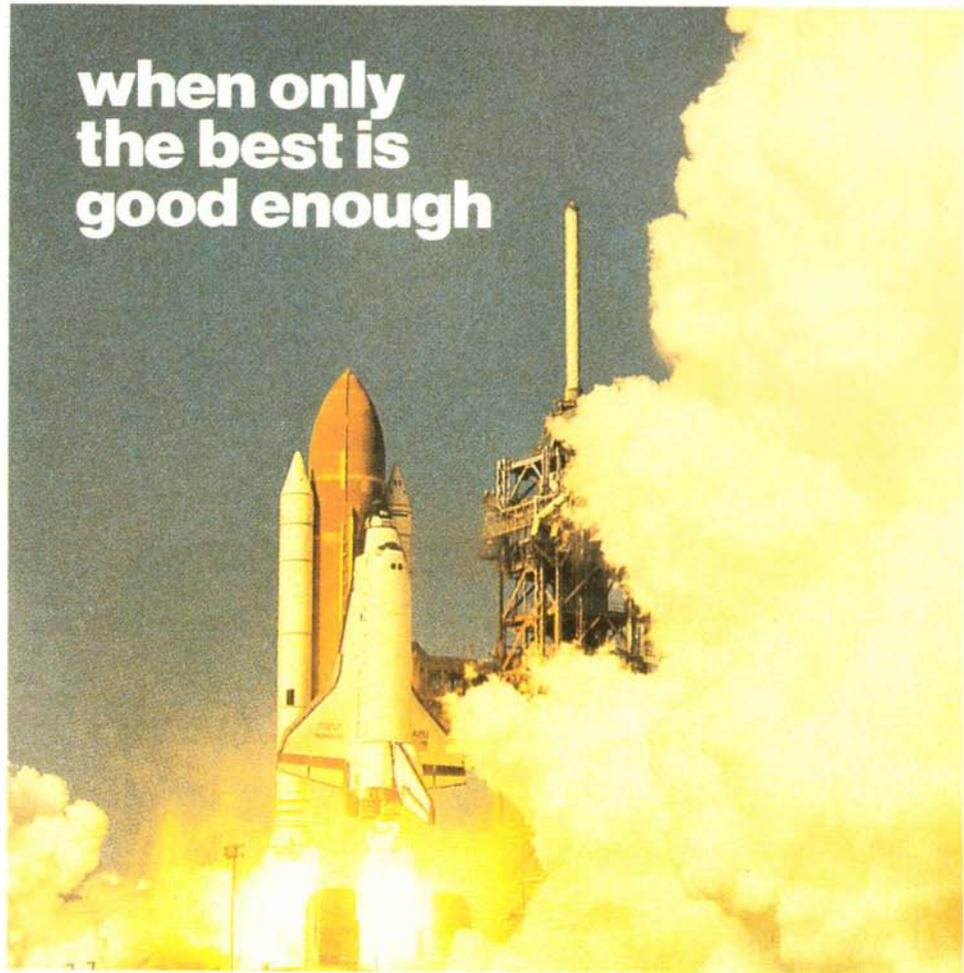


The baseline is usually moved to just off the bottom of the screen (see Fig.3) and because of the narrowness of the vertical pulse, it is likely that only the 'spot' at the top of each will actually appear on the scope.

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