SSTV in Colour

First 2-way color SSTV transmissions across the Atlantic! Technical details on the equipment used at the European end of the path are included here.

By Jeremy Royle,* G3NOX

After many years of experimenting with fast-scan amateur television in the 436-MHz band, I visited the slow-scan station of Richard Thurlow, G3WW, to see his Robot 400 in operation on the hf bands. I was immediately impressed with the picture quality, in particular the bright fast-scan display of received and transmitted pictures. At the time, the technique of standards conversion was completely new to me.

I decided to buy a Robot 400 and to link it with my full-size image orthicon fast-scan television camera. The results in terms of picture quality were so good I immediately realized that by using the frame-storage system it would be possible to produce color pictures by sequentially loading two or more memory stores with color-separation signals.

The first stage in converting to color was to see whether my Pye 2014 image orthicon camera would produce the red, green and blue color-separation signals necessary for a full-color system using Wratten no. 47B, 58 and 25 filters. The results were good in terms of sensitivity and colorimetry, so I decided to remove the neutral-density filters from the supplementary filter turret (used in this camera for outside broadcast applications) and to install the Wratten filters on a permanent basis. A motor was also fitted so that the filters could be selected from the operating position.

To obtain the best signal-to-noise ratio with each of the red, green and blue (RGB) filters I use a Thorn Artificial Daylight fluorescent tube to illuminate the objects being televised. This type of tube, in conjunction with the filters used and the spectral response of the image orthicon tube, results in a near-perfect amplitude balance between the RGB color separation signals. Having produced the RGB signals from the camera, it is of course possible to load them one by one into a single Robot 400 and to transmit

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On March 15, 1980, at 1430 UTC, Jeremy Royle, G3NOX, made the first transatlantic two-way SSTV contact with Don Miller, W9NTP, a pioneer of color SSTV. Signals consisted of electronically generated red-green-blue color separations from G3NOX, transmitted on 29.150 MHz using field-sequential emissions. W9NTP transmissions consisted of only two color separations, red and green. Shown here are the transmitted color picture as photographed directly from the monitor screen at G3NOX and the W9NTP picture as received.

The author uses a Thorn Artificial Daylight fluorescent tube to illuminate the objects being televised, not visible in this photo. The original rainbow test card is visible in front of the modified image orthicon camera, as is a BBC test card for use as a flesh-tone reference.

them in turn. However, in order to obtain a color-monitor display of incoming and outgoing pictures, it is necessary to be able to store all three colors simultaneously and to feed the outputs to a color monitor via an encoder. An alternative method is to feed separate RGB signals to a monitor having individual video inputs for each color.

At this stage I discussed the problem of synchronization with Martin Emmerson, G3OGD, who has built his own standards converter. He came up with a most elegant method of synchronizing the fast-scan clocks of the three Robot 400s. The method used is shown in Fig. 1.

Before carrying out the modifications to the Robot 400s, I gave considerable thought as to how the digital links could be made in such a way that things could be quickly returned to normal if necessary. The solution to this is to mount on the rear panel of the master 400 two DIN sockets, with a further one on each of the slave units. The result is neat and in my view does not detract in any way from the value of the 400! The internal connections can be made to the main Robot 400 circuit board via "header" plugs plugged in to the U48 and U10 sockets of each 400. These can be removed and the ICs plugged in again if it is desired to revert to normal. Any modifications can result in the warranty being affected and it is up to each Robot owner to make his own decision on this before carrying out the modifications!

It will be seen from Fig. 1 that one Robot 400 becomes in effect the master and through U48 controls the fast-scan synchronization of the remaining two units. For this reason it is not necessary for the crystal oscillators in the two slaves to function. In fact, to avoid possible beat patterns, I have removed the crystals in the two slave units.

In order to ensure black-level stability and constant color balance it is also necessary to install black-level clamps to the fast-scan video inputs of each Robot 400. This can be done by means of the circuit shown in Fig. 2. Existing pulses that are available on the Robot 400 board are used. Signals can be conveniently routed through spare pins on the main edge connector. The diodes and components can be mounted on the spare terminals of the board associated with the power supply. The black-level clamps make it possible to preset the "snatch" contrast and brightness controls, resulting in more consistent pictures in black and white, as well as being essential for color.

Monitoring

Having modified the Robot 400s as shown in the circuit diagrams, we come to the question of how to monitor the color picture produced by the synchronized Robot 400s. There are two approaches: (1) Use a standard color television set as a monitor, in which case it will be necessary to encode the RGB color signals and apply them to the color set via an rf modulator, or (2) use a professional RGB color monitor by feeding the output of each 400 as a separate signal to each input of the monitor.

Although the second method is expen-

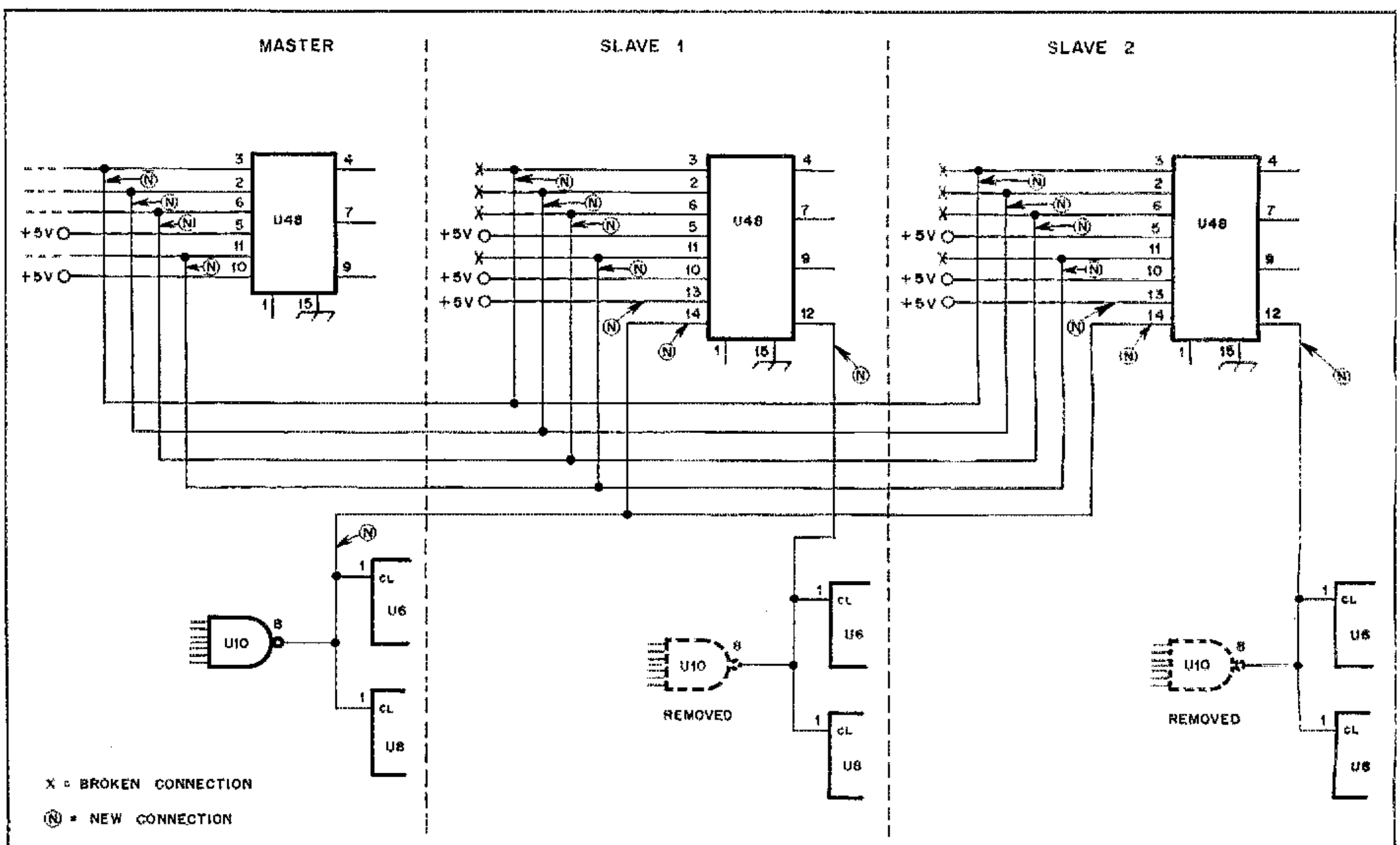

Fig. 1 — Circuit for synchronizing the fast-scan clocks of three Robot 400 scan converters. Two of the 400s thus became "slaves" to the "master." IC numbers are those of the manufacturer. See text regarding interconnections.

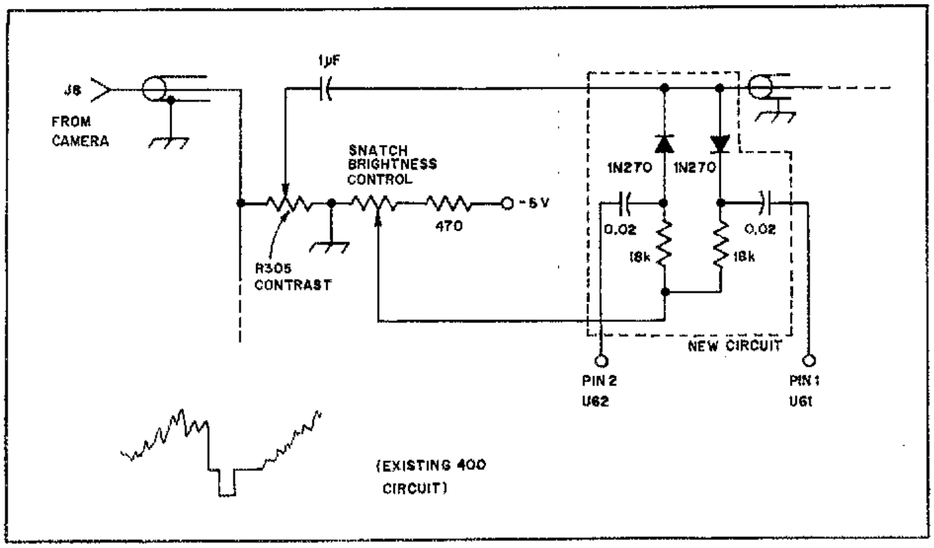

Fig. 2 — This circuit clamps the black level at the end of each scan line. Once they are adjusted, it is not necessary to readjust the controls. Only the camera iris need be set according to lighting conditions — a good procedure for black-and-white pictures, and essential for color!

G3NOX transmitted the first full-color SSTV signals on March 8, 1980, at 1145 UTC on 28.6 MHz. The color signal was received and tape recorded at K2RZ near New York, played back and received in color by G3NOX. The picture arrived at G3NOX with some interference, as shown here, after traveling a path distance of approximately 7000 miles.

The G3NOX color picture received at W9NTP on March 15, 1980. (*Photo courtesy of Don Miller, W9NTP*)

sive, the writer feels that this is really the best way, for it eliminates the problems of encoding and rf modulation, and gives the most accurate color.

Connecting the Complete System

To produce a color picture, the whole system is connected as shown in Fig. 3. The composite video and sync from the camera is fed to the video inputs of all three Robot 400s using BNC T connectors with a 75-ohm termination resistor on the last unit. Video outputs from the 400s are taken to the RGB monitor and to a 3-way switching unit which enables the black-and-white monitor to be switched to look at each of the three stored images — useful for normal black-and-white operation as well as for examining the RGB color separations.

The outputs from the transceiver, tape recorder, etc., are fed into the appropriate sockets on all three Robot 400s. In order to provide complete control of SSTV and microphone functions the three units are connected together as shown in Fig. 4. This also means that no extra switch boxes are needed to sequentially transmit the three color SSTV signals.

I have considered the possibility of making up a sequential switcher but experience with color SSTV on the hf bands has shown that at least two frames of each color are desirable to overcome QRM. This is most easily done with manual switching at both stations where human intervention can result in the best frames being held.

Setup and Color-Balancing Procedure — Transmission

Place the red filter on the camera. Adjust the iris, lighting and contrast control on the camera to give a good picture on a black-and-white monitor. If a scope is available, this should be connected to monitor the fast-scan video. This will assist in getting the correct video levels.

Next, cap the camera lens to give a black level. Switch all three Robots to the CAMERA DISPLAY' position and turn all three snatch brightness controls fully counterclockwise. Set all the snatch contrast controls at the 3 o'clock position.

Now select the Robot gray-scale position on the memory-input switch and press all three snatch buttons. The color monitor should now display a neutral gray scale with no color tinting. If a color bias is apparent, the color monitor bias and gain controls should be carefully adjusted to give a completely neutral gray scale.

Select the CAMERA position on the memory switch and CAMERA on the display switch, leaving the lens capped. Adjust the snatch brightness on the red channel so that a red tint is *just not visible*. Repeat for the green and blue. The color monitor should now show a *black* level. If not, the color monitor brightness should be adjusted for the correct black level.

Uncap the lens on the camera and adjust the snatch contrast controls on each Robot to give a neutral gray picture consistent with correct contrast. Do not limit whites by setting the contrast too high. After this stage has been reached it is worth capping the lens again and repeating the preceding paragraph to ensure accurate black-level tracking.

Snatching a Color Picture

Switch to the memory display on all three Robots. Select the red filter on the camera and press the red snatch button. Repeat for green and blue and you should have a color picture. Because of lighting, camera spectral response and other factors it will probably be necessary to carry out fine adjustments of the snatch contrast controls *only* to get a true gray balance when using a gray scale in front of the camera.

I know this sounds complicated, but it is a once-and-for-all process, as the Robots are very stable. All you will have to do normally is to snatch a color picture and carry out fine adjustments. Make sure your lighting and camera exposure are correct by monitoring the camera video level on your scope against a graticule.

Setup and Color-Balancing Procedure — Reception

In order to receive accurate color pictures it is necessary to align the receive

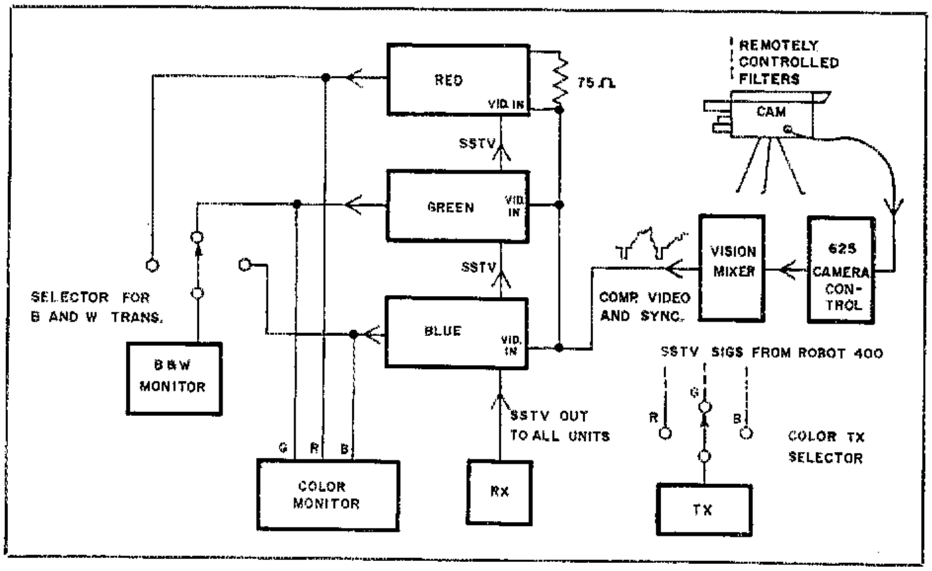

Fig. 3 — System interconnections for a complete color SSTV system using three Robot 400s.

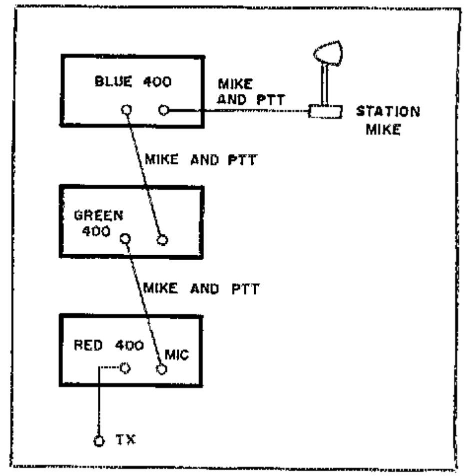

Fig. 4 — This system allows the switching of each Robot 400 to transmit in turn without making extra switching arrangements. Just use the normal Robot VOICE-VIDEO TRANSMIT switches on each unit.

brightness and receive contrast controls on each of the Robot 400s using the following procedure. Record about 5 minutes of gray scale from one of the Robot 400s after having previously checked the SSTV sync and black-and-white levels for the correct frequency, as laid down in the instruction manual.

Follow the procedure recommended for setting the receive brightness and contrast controls by comparing the taped gray scale with the local snatched gray scale. Repeat for each of the 400s. When this is done correctly, the *occasional* sampling error should be visible in the black and white ends of the scale. This indicates that no tones are being lost at either end by compression. Take your time with this setting as this is a once-and-for-all operation. *Do not* touch the receive contrast and brightness controls once this condition has been obtained.

Feed the tape-recorded gray scale into the red 400 and set the width control to just fill the screen. Adjust the width control on the green and blue 400s to obtain perfect registration of the gray scale on the color monitor.

To receive a color picture from another station switch all three Robot 400s to CONTINUE. Wait for the red frame to complete, switch to hold, wait for the green frame and switch to hold, and wait for blue frame and hold. If the transmitted signal was correct you should now have a color picture!

Operating Procedure

The standard color sequence of red, green and blue should be used for all transmissions and at least two frames of each color transmitted. This allows for a second chance at the receiving end if there is QRM or QSB. Caution: Color SSTV takes at least three times as long to transmit as black and white. Make sure you do not overheat your linear!

Avoid adjusting *any* of the controls on the 400 when using color. It is only necessary to adjust the video gain and lens aperture on the camera for correct levels.

The standard Robot Gray Scale will appear at the foot of all color pictures. This provides an excellent check on the overall alignment of the SSTV frequencies produced by the Robot 400s at the transmitting station. It also checks the correct adjustment of the receive contrast and brightness at the receiving station.

Providing that the incoming SSTV frequencies are correct, it should be possible to adjust your transceiver for "natural" speech and to receive the color SSTV picture without further adjustments. In any case the receiver tuning should not be altered during the reception of color frames or balance will be lost. If one of the color frames is lost because of QRM, it is possible to "repair" the picture by asking the sending station to send this color again.

The transmission of color SSTV is more complex than black and white. It is therefore necessary to reduce the number of operational controls to a minimum, and this has been achieved by treating all the Robot 400 controls as presets, using the procedures already detailed. On a well set-up system, all that is necessary is to set the camera iris, select the correct filter, and operate the snatch buttons.

Results

Some idea of the results that can be achieved with color SSTV are shown in the accompanying photos. However, it must be remembered that in these printed illustrations two *further* color-reproduction systems have been used — off-the-screen photography and the color printing process. The actual results on the monitor must be seen live to really appreciate the quality!

At the time of writing only about three stations in the world are known to be equipped for color SSTV. For this reason the writer has been sending color SSTV to stations equipped with audio tape recording and playback facilities connected to their transceivers and having them play back the color. The results have been very good, particularly when QRM and the Woodpecker[1] are absent!

Summary

The development of this field-sequential color SSTV system has involved some interesting problems of colorimetry, digital electronics and interfacing different types of equipment that were never intended for producing color pictures. Although this is a good example of the ham approach of using what is available to form a complete system, I appreciate that it is fairly costly — but then color in any medium usually is!

The thrill of seeing a full-color SSTV picture form on the monitor screen after its traveling many thousands of miles over a normal speech type circuit is a thrilling experience — certainly the most exciting thing the writer has done in Amateur Radio.

I would like to acknowledge the great assistance I have received on this project from Martin Emmerson, G3OQD, who developed the digital synchronization system and has given valuable advice to me.

[1]See "More Woodpecker Thoughts," *QST* Technical Correspondence, Jan. 1980.