Color Computer SSTV: Part II

Complete the picture by adding weather-satellite facsimile to your new color SSTV system.

Editor's note: Part I of this article, detailing a complete color SSTV interface, appeared in the November, 1984, issue of *73*.

Clayton W. Abrams K6AEP
1758 Comstock Lane
San Jose CA 95124

Dr. Ralph Taggart WB8DQT
602 Jefferson
Mason MI 48854

With the initial success of the K6AEP interface, SSTV software, and high-resolution display board, the next "new" application considered was facsimile. HF FAX operation has never had much of a following among amateurs but there is one area where amateur FAX techniques are booming—weather satellites.

Thousands of amateurs and non-amateurs alike track the many different kinds of weather satellites now in orbit, and what has been needed for years is a nice, simple, and versatile display system that would

Photo A. An infrared (IR) view of the NW quadrant of the earth as transmitted by the GOES E spacecraft using the WEFAX imaging format. A major frontal system can be seen wrapping around from the Gulf Coast up into New England. Broken frontal activity can also be seen in the Rockies and Plains states. Although some of the gridding of state borders and other features can be resolved, one of the higher-resolution formats (see photos) would be required to capture all the details in a picture of this type.

Photo B. Full-frame display of the NW quadrant of the earth as seen by GOES E in visible light. This image covers the same area as Photo A but visible-light imagery is rarely gridded. Even with the full-frame display the resolution achieved exceeds that of some small CRT display systems and is entirely adequate for most uses.

handle pictures from all of them! K6AEP was certain that the SSTV software could be modified for FAX display, and WB8DQT was equally certain that a multimode satellite interface could be designed to take advantage of the CoCo® as an image processor and display system.

With the two of us madly experimenting in our areas of expertise, we soon had a workable system up and running, and the results exceeded all of our expectations! With the satellite interface to be described this month (and with the high-resolution display board described in Part I) you can be scan-converting all types of US and Soviet weather-satellite pictures in no time at all! The mix of features available with the current software is mind-boggling compared to conventional techniques! Some of these features include:

- Full-frame display of imagery from all current operational satellites. These include both geostationary (US GOES, European METEOSAT, and Japanese GMS) and polar-orbiting spacecraft (US TIROS/NOAA and Soviet METEOR).
- The ability to capture extremely-high-resolution subsets of any images that exceed the theoretical resolving power of the image format.
- Computerized "zooms" on any portion of the image in memory.
- The ability to rotate images by 180 degrees, thus eliminating the upside-down pictures characteristic of south-to-north polar-orbiting passes.
- The capacity to enhance the contrast of the satellite picture—a real boon in the case of infrared polar-orbit imagery.
- Two different kinds of false-color display.
- The ability to generate hard copy using a graphics printer.

This is a mix of features you cannot find in any available display system, but there is even more! If you combine the SSTV interface (Part I) with the satellite interface to be described here, you obtain the following additional features:

- Complete HF FAX display capability for wirephotos and weather charts.
- The ability to record or transmit weather-satellite pictures in standard SSTV formats.

All of this may seem like quite a tall order but we can deliver—as we hope to demonstrate here. Let's get fired up and see how it's done!

The Satellites

The one thing we do not have the space for is a description of the various satellite systems and image products. Your best source of information in that area is the *New Weather Satellite Handbook,* available at your local library (out of print). This publication provides all of the information on the satellites, their video formats, tracking and antenna alignment, construction of receivers, antennas, test equipment, and a full range of construction projects for FAX and CRT image display. If you are into satellites, you probably have the book already and can move directly to the CoCo scan-converter project. If you are new to the game, you had better find a copy so that you are ready to go when your hardware is on-line.

Photo C. A NOAA 7 visible-light APT pass showing the east coast. Delaware, New Jersey, and Long Island show quite clearly in this full-frame display but much of New England is buried under a major cyclonic storm system in the process of moving out to sea. Lake Erie and Lake Ontario are visible at the top center of the display.

The Weather-Satellite Interface

At this point we will deal with how to condition and process the satellite signal for proper input to the CoCo. Satellite mode is relatively unimportant in the discussion which follows. Simply keep in mind that we are dealing with an amplitude-modulated 2400-Hz tone (black = minimum and white = maximum) with line rates of either 120 or 240 lpm (equivalent to either 2 or 4 Hz).

Each of the circuit descriptions to follow has several sections. The *Function* description tells what the circuit does; the *Operation* section describes how it works; the *Construction* section will describe any specifics that need be observed in laying out or wiring the circuit; the *Adjustment* section tells how to set up that part of the system. Actual operation of the complete interface will be described under "System Operation."

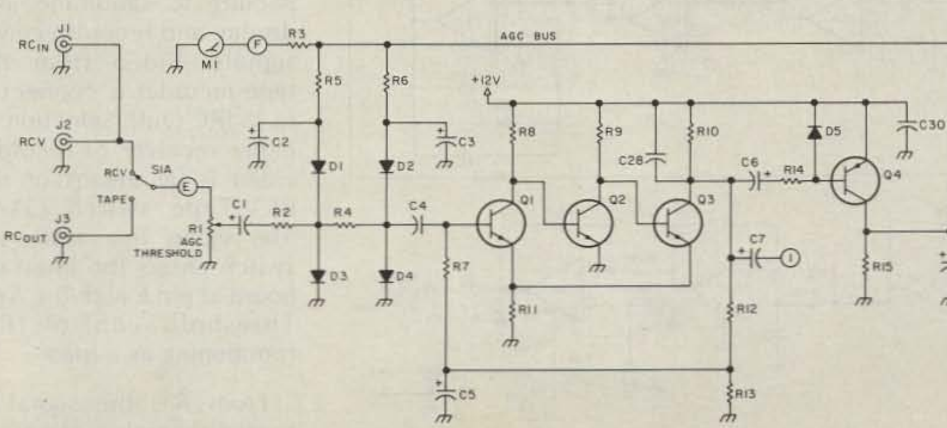


Fig. 1. Automatic gain control.

Main-Board Pinouts

Schematic Designation	I/O Function
A	Ground
B	+5 V (If regulator off board)
C	+12 V
D	−12 V
E	Video in from S1A
F	Agc meter
G	Contrast control
H	Contrast control
I	Video out to J7
J	Clock out to J4
K	Clock out to S1B
L	To Phase switch
M	To 120/240 lpm switch
N	Sync out to J6
O	To Reset switch

Front-Panel Controls and Indicators

- Power switch (if supply internal)
- Power lamp
- 120/240 lpm switch
- Phase switch
- Reset switch
- Agc meter
- Contrast control
- RCV/Tape switch

Rear-Apron Connections

Power	Ac or dc
RCV	From station receiver
RC Out	Right-channel tape output
RC In	Right-channel tape input
LC Out	Left-channel tape output
LC In	Left-channel tape input
Sync	To CoCo serial port
Video	CoCo right joystick port

Main-Board Controls and Indicators

Agc threshold	R1
Black level	R31
Clock freq.	C17
Vco lock	R42
Sync lock	D9 Indicator

Table 1. Packaging data.

One final note. It is assumed that the interface will be wired on a plug-in prototype card or on a PC board available from one of several vendors. The pinout designations in the following descriptions are arbitrary and the actual pinouts on your board will have to be related to these designations. Table 1 is provided to summarize the pinout designations used in the descriptions to follow. This information can be related to your board documentation or consulted as you work up your own layout. A list of vendors known to be supplying boards, kits, and wired-and-tested units is included in Part I of this article.

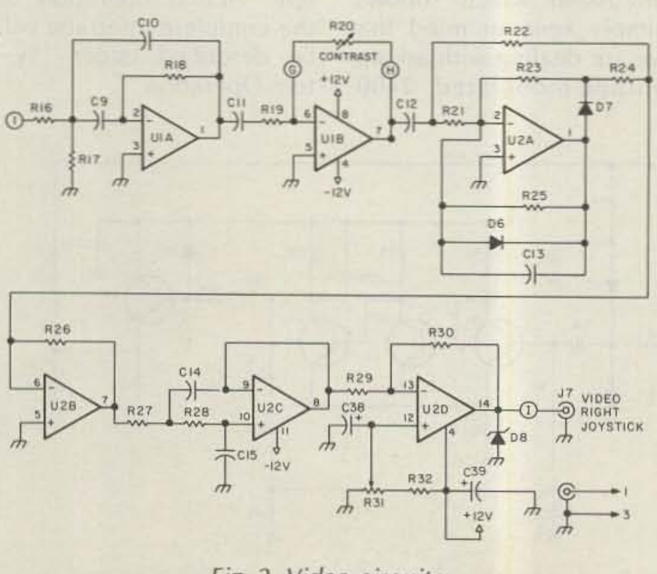


Fig. 2. Video circuits.

Automatic Gain Control (See Fig. 1)

Function. Since weather-satellite video involves amplitude modulation of an audio tone, the various video circuits are sensitive to peak subcarrier levels. With multiple satellite video sources, different receivers, tape systems, etc., constant readjustment of video-input levels would be required to maintain an acceptable gray-scale range. The automatic-gain-control (agc) circuits process signals of varying levels, delivering a signal of constant peak amplitude to the rest of the video processing circuits. Thus the video system functions with minimal adjustment over a wide range of input levels.

Operation. Video from the receiver is routed to J2 (Receiver) with J1 (RC In) in parallel to provide the capability to simultaneously display and record receiver signals. Video from the tape recorder is connected to J3 (RC Out). Selection of either receiver or recorder video is by means of the RCV/Tape switch (S1A). The video line from the switch enters the interface board at pin E with the Agc-Threshold control (R1) functioning as a load.

From R1, the signal is routed through a two-stage diode network (D1–D4) which provides attenuation as a linear function of the control voltage on the agc bus. From the attenuator, the signal is routed through a three-stage agc amplifier (Q1–Q3) with a fixed voltage gain of 100. Normally the output of this amplifier is about 2 V p-p. The amplifier drives the agc detector (Q4) which develops the agc control voltage on its collector. The attack time constant of the detector is a function of C6 and R14 while the decay time constant is determined by C8, R15, and the series resistance of R3 and the 50-microamp agc meter (M1).

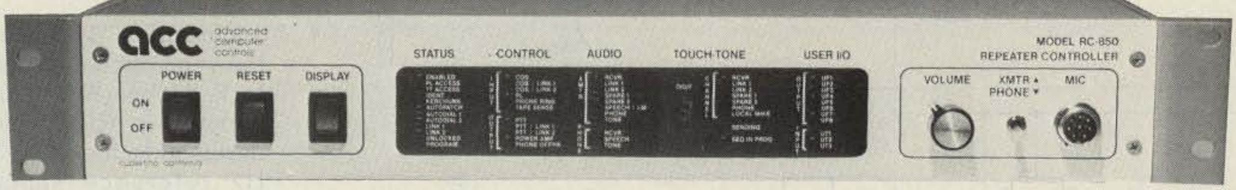
If the peak input signal should increase, the agc bus voltage will rise, increasing the attenuation in the diode network and lowering the output of the agc amplifier to its previous value. Similarly, should input peak level decrease, the agc bus voltage will drop, decreasing input attenuation and raising the output of the agc amplifier. The output of the agc amplifier chain, maintained at a relatively constant peak level, drives the remaining video circuits at point (1). The agc meter serves to indicate the agc control voltage and is used to ensure that input signals produce control voltages in the most linear portion of the agc response curve (1–2 V).

Construction. Note that Q4 is a PNP transistor and must be installed with its emitter on the 12-V bus. Also note the polarity of C6 which is oriented differently from all of the other tantalum coupling capacitors.

Adjustment. For best results, the output from the receiver should be tapped at the top of the volume control through a .1-μF coupling capacitor to provide a constant output level that is independent of the receiver volume-con-

Advanced Computer Control

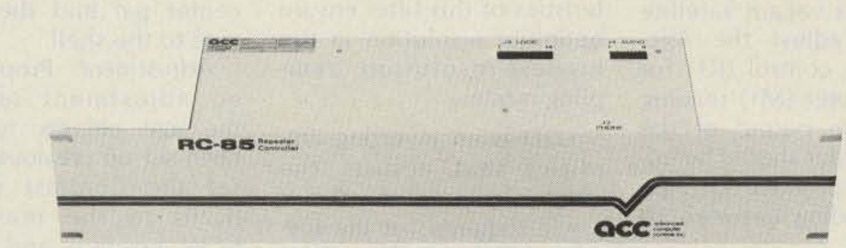
. . . for your repeater



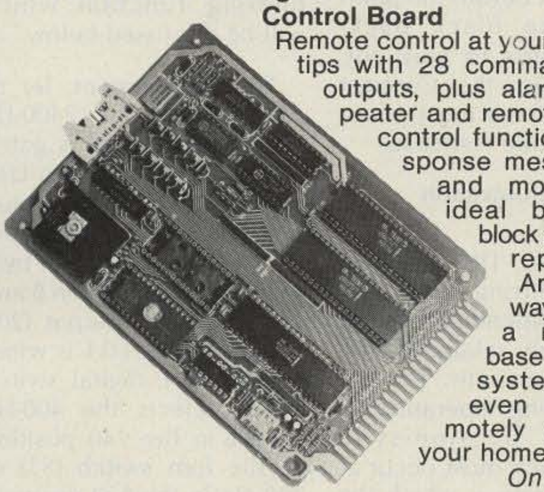
The RC–850 provides the most advanced technology available in repeater control. With "designed for the future" architecture that allows upgrade through software so that it will never be obsolete. Complete remote programmability with E^2PROM via Touch-Tone™ or your personal computer. Offering unique features including the highest quality synthesized speech and fully automatic scheduled operation. Plus voice response metering, synthesized remote base operation, paging, mailbox, and the most advanced autopatch available — anywhere! Designed for reliable, consistent, enjoyable operation in any system. Field proven in hundreds of commercial and amateur repeater installations. The RC–850 will **always** be the leader in high performance repeater control.

*Available from $1195***

The RC–85
Repeater Controller
The RC–850's "little brother"! Remotely programmable ID's, command codes, auto-dial numbers, timers, and more. The RC–85 controller includes many of the features pioneered by ACC such as synthesized speech, remote base, paging, and more. Now any repeater budget can afford the benefits of an ACC controller! *All just $895 (board) or $995 (rack mount).**



The ITC–32 Intelligent Touch-Tone Control Board



Remote control at your fingertips with 28 commandable outputs, plus alarms, repeater and remote base control functions, response messages, and more. An ideal building block for your repeater. An easy way to add a remote base to your system. Or even to remotely control your home.

Only $389

NEW PRODUCTS

DVR 128 • Digital Voice Recorder — Solid state voice storage and playback for remote recording of ID's and announcements, voice mail, and user diagnostics.

IVS 6/12 • Intelligent Voting System — Six or twelve channel voting with DTMF remote control. In-band signal quality evaluation, audio equalization, and activity logging.

ShackMaster™ — Remotely control your home station using Touch-Tone commands over the air or over the telephone. Patch yourself through your home equipment onto the HF bands, and to VHF and UHF frequencies.

*Includes a one year limited warranty
**Includes a two year limited warranty

✓127

Call us for more information on our complete line of amateur and commercial repeater control products.

10816 Northridge Square, Cupertino, CA 95014 (408) 749-8330

acc advanced computer controls, inc

✓ See List of Advertisers on page 80

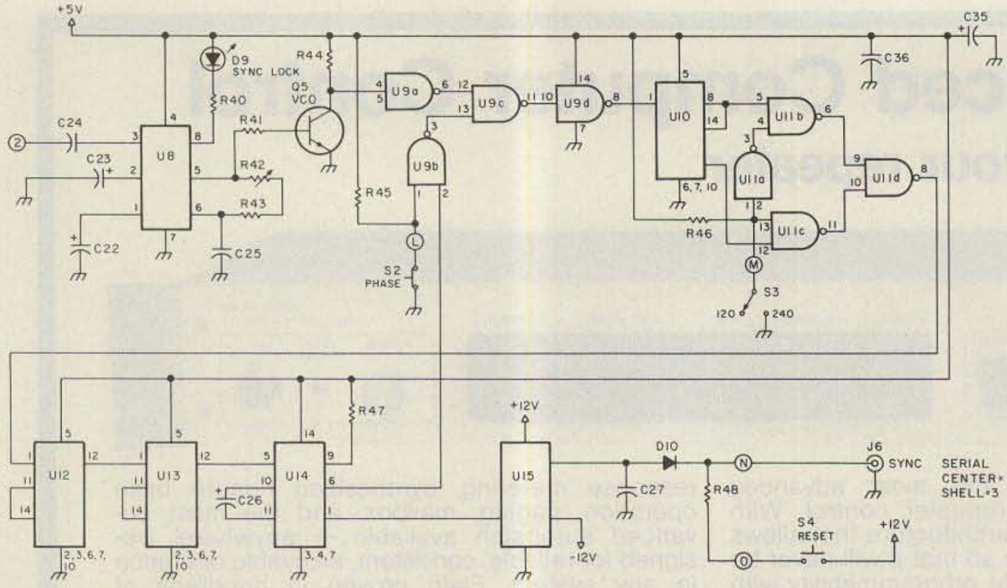


Fig. 3. Line synchronization.

trol setting. With noise output from a vacant satellite channel, adjust the Agc-Threshold control (R1) for an agc-meter (M1) reading of 15. The output of the tape recorder should be adjusted to produce an agc-meter reading between 10 and 20.

Video Circuits (See Fig. 2)

Function. The video circuits provide subcarrier filtering, detection, post-detection filtering, and gain adjustments to properly drive the joystick (A/D) input.

Operation. Video from the agc amplifier (point 1) is routed through an active bandpass filter (U1A) with a center frequency of 2400 Hz, a bandwidth of 1600 Hz, and unity gain. The filtered output drives a variable gain stage (U1B) with gain set by the front-panel Contrast control (R20).

U2A and U2B comprise a precision full-wave detector that generates a negative-going signal containing the modulation envelope superimposed on the post-detection 4800-Hz subcarrier component. U2C is an active low-pass filter with a nominal cutoff frequency slightly above 500 Hz. The roll-off characteristics of this filter ensure optimum resolution in the highest-resolution sampling modes.

U2D is an inverting amplifier that adjusts the video signal to the 0–5-V range required for the joystick A/D input. The offset is adjustable (R31) to set the desired black level while the Contrast control provides the drive adjustment that determines the maximum white level. D8 provides white-level clipping at 5.1 V. The detected waveform is routed off the main board at pin I and on to J7 (Video) on the rear apron. The center conductor of the mating jack for J7 is connected to pin 1 of the joystick plug while the shell (ground) is connected to pin 3 of the joystick plug.

Construction. The front-panel Contrast control should be wired so that minimum resistance corresponds to maximum CCW rotation of the control shaft. The joystick plug can be a hard item to obtain. The easiest approach is to disassemble a standard CoCo game joystick, since you get the plug with cable attached. The phono plug to J7 should be wired with the yellow lead to the center pin and the black wire to the shell.

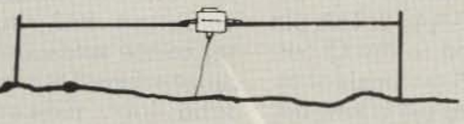
Adjustment. Proper video adjustment requires the agc circuits to have been set up previously. Preset the Contrast control (R20) to the maximum CCW position and preset R31 so that the wiper arm is at ground potential. With the program running and video at the input, adjust R31 to just before the point where the black background starts to gray out. Then adjust the Contrast control for the most pleasing gray-scale response.

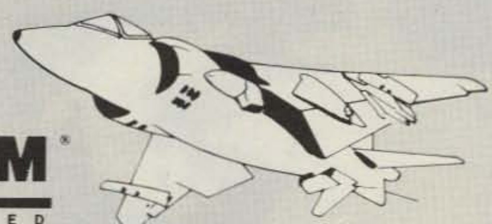
Line Synchronization (See Fig. 3)

Function. The business of transferring incoming video into memory must be very closely related to the satellite line rate. The actual loading operation is initiated by line-sync pulses which must occur at the same rate at which the satellite video is being transmitted and at the same time a line of satellite video begins. The line-synchronization circuits provide an accurate 2-Hz (120-lpm) or 4-Hz (240-lpm) trigger pulse to control the loading operation and also provide for proper phasing—the ability to shift the position of the line-loading pulse to ensure that it coincides with the beginning of satellite video lines. In addition, provisions are included to ensure the required timing accuracy for both live and tape-recorded imagery.

Operation. The heart of the sync circuit is a phase-locked-loop (PLL) tone-decoder chip (U8) which is designed to lock to a 2400-Hz reference signal at point (2). Sources for this reference tone are discussed under the heading of "Clock Circuits," below. With 2400 Hz applied at point (2), the internal voltage-controlled oscillator (vco) of U8 will lock to this signal since the vco adjustment control (R42) of U8 has been set to free-run near 2400 Hz. When U8 has locked to the tone at point (2), an internal-control transistor pulls low and lights an indicator LED (D9—Sync Lock) to show that lock has occurred. The 2400-Hz vco signal is buffered to TTL levels by Q5 and applied to a set of gates in U9. U9 controls the phasing function which will be discussed below.

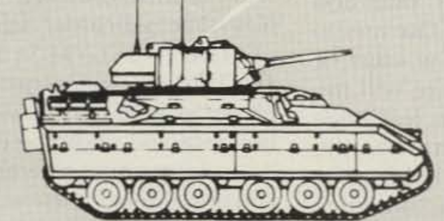
For the moment, let us assume that the 2400-Hz vco-derived signal is gated through U9 and on to U10—a divide-by-12 counter. Two outputs are available from U10—a divide-by-6 output (400 Hz) at pin 8 and a divide-by-12 output (200 Hz) at pin 12. U11 is wired as an SPDT digital switch which selects the 400-Hz output in the 240 position of the lpm switch (S3) or 200 Hz in the 120 position. The output of U11 is routed through two decade counters (U12 and U13), providing a total frequency division of 100. With the lpm switch in the 240 position, the output of U13 is a 4-Hz square wave, while in the 120 position it is a 2-Hz square wave. The output of U13 triggers a single-shot

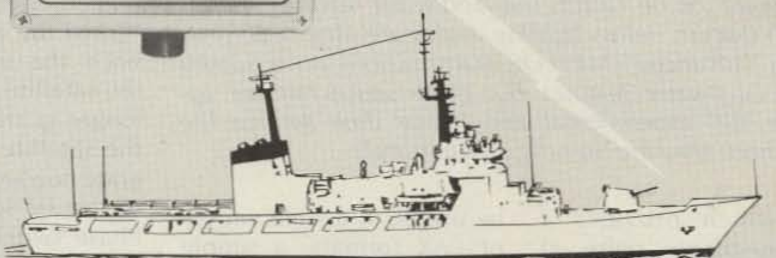




MAXCOM
INCORPORATED

AUTOMATIC ANTENNA MATCHER





ONE ANTENNA .3 TO 70 MHZ.
VSWR 1.5:1 OR LESS

UNEXCELLED FOR **"FREQUENCY HOPPING"**

* NO MOVING PARTS !
* 5 YEAR WARRANTY !
* INSTANT MATCHING !
* 50 OHM INPUT !
* LOW NOISE !
* DIPOLE !
* MARINE !
* AMATEUR !

* 100% SOLID STATE !
* NO CONTROL LEADS !
* LIGHT WEIGHT !
* HIGH EFFICIENCY !
* 200 TO 2KW. P.E.P. !
* LONG WIRE !
* MILITARY !
* AVIONICS !

* NOW IN USE ON THE FOLLOWING NAVY VESSELS *

* USS ENTERPRISE * USS HECTOR * USS SARATOGA * USS PHOENIX * USS PRAIRIE *
* USS LEXINGTON, AND US NAVY M.A.R.S. *

"NEW R.F. GROUNDLESS LONGWIRE MODELS NOW AVAILABLE"

CONTACT

MAGNUM DISTRIBUTORS INC.

1831 South Dixie Highway, Pompano Beach, Florida 33060
54 305-785-2002 • Telex 514365 (English FTL)

See List of Advertisers on page 80

Photo D. A full-frame display of a "standard" 120-lpm Soviet METEOR display. The 120-lpm METEOR imagery does a great job on clouds but land/water features are difficult to discern unless lighting angles are almost perfect. 240-lpm "advanced" METEOR transmissions do a superb job on land/water features but these spacecraft are apparently still experimental and hence their service life seems short; they are on only intermittently.

(U14) which provides a 5-ms line-trigger pulse at either a 4-Hz or a 2-Hz repetition rate. This pulse is buffered by U15 to RS-232 levels to drive the CoCo serial port via the Sync connector (J6) on the rear apron. The Reset switch—a normally-open push-button—is wired to provide +12 V to the RS-232 line for manual reset.

Although the PLL and digital dividers provide the proper line-trigger rate, they are not sufficient to ensure that triggering is in phase—a condition where the line-trigger pulse corresponds to the start of a line of satellite video. Since it is desirable that the interface be usable in a wide variety of FAX formats, a simple manual-phasing circuit is provided. U9A buffers the vco-derived 2400-Hz tone, which then is applied to one input (pin 12) of U9C. The other input (pin 13) is derived from the output of U9B. This input is normally high since one input of U9B (pin 1) is normally held low by the normally-closed Phase push-button switch (S2).

Thus the 2400-Hz reference signal is typically gated through U9C, through U9D (a simple buffer), and on to the divider chain. When the Phase switch is pressed, however, it will open, causing the pin-1 input of U9B to go high. The output of U9B is then controlled by the status of the other input—pin 2. This pin is connected to the Q output of the 5-ms single-shot. Normally this pin is low, but for 5 ms of each line, the SS-trigger interval, pin 2 of U9B is pushed high, causing the output of U9B to go low for the 5-ms trigger interval.

This prohibits the 2400-Hz reference signal from going through U9C for the 5-ms interval, causing a 5-ms counting error once each line pulse for as long as the Phase switch is depressed. This causes the trigger repetition rate to be slowed (by about 2%), and since the trigger rate and the satellite line rate are no longer in step, the edge of the satellite image will migrate toward the left edge of the TV screen when the Phase switch is held open. When the left picture edge is aligned with the left edge of the TV screen, indicating a properly phased display, the Phase switch is released, the output of U9B goes high, and the 2400-Hz signal is gated through U9 without interruption, thus restoring the proper trigger rate.

Construction. The only note here is not to confuse the Reset and Phase push-button switches. The Reset switch is a normally-open type while the Phase switch is normally closed.

Adjustment. With 2400 Hz applied at point (2), adjust the vco adjustment control on the board (R42) until the Sync-Lock indicator on the board (D9) comes on. R42 should be set to the midpoint of the range where D9 provides a solid lock indication. A logic probe on pin 6 of U14 will show a series of short, high pulses indicating the proper operation of the divider chain. The pulses should be noticeably faster in the 240 position of the lpm switch than they are in the 120 position.

Clock Circuits (See Fig. 4)

Function. The clock circuits are designed to provide a 2400-Hz reference signal for both real-time and recorded-image display. The subcarrier signals of the US GOES and TIROS/NOAA spacecraft are phase-locked to the video line rate and could be used as a frequency reference. Unfortunately, this is impractical for several reasons. In the case of the GOES spacecraft, occasional modulation anomalies will drop the subcarrier black level to 0%, causing the line-sync circuits to lose lock and hence synchronization.

In the case of the TIROS/NOAA spacecraft, signal fades resulting in high noise levels also can cause sync lock to be lost. In addition, the standard Soviet METEOR spacecraft have subcarriers that are not locked to the video line rate and hence cannot serve as a suitable frequency reference. HF FAX signals have a variable subcarrier frequency (subcarrier FM modulation identical to the video swing for SSTV) so that sync lock is not possible with these services.

In order to make the interface compatible with the greatest range of FAX services, a crystal-controlled 2400-Hz signal source is employed. The crystal sync source is used directly during live image

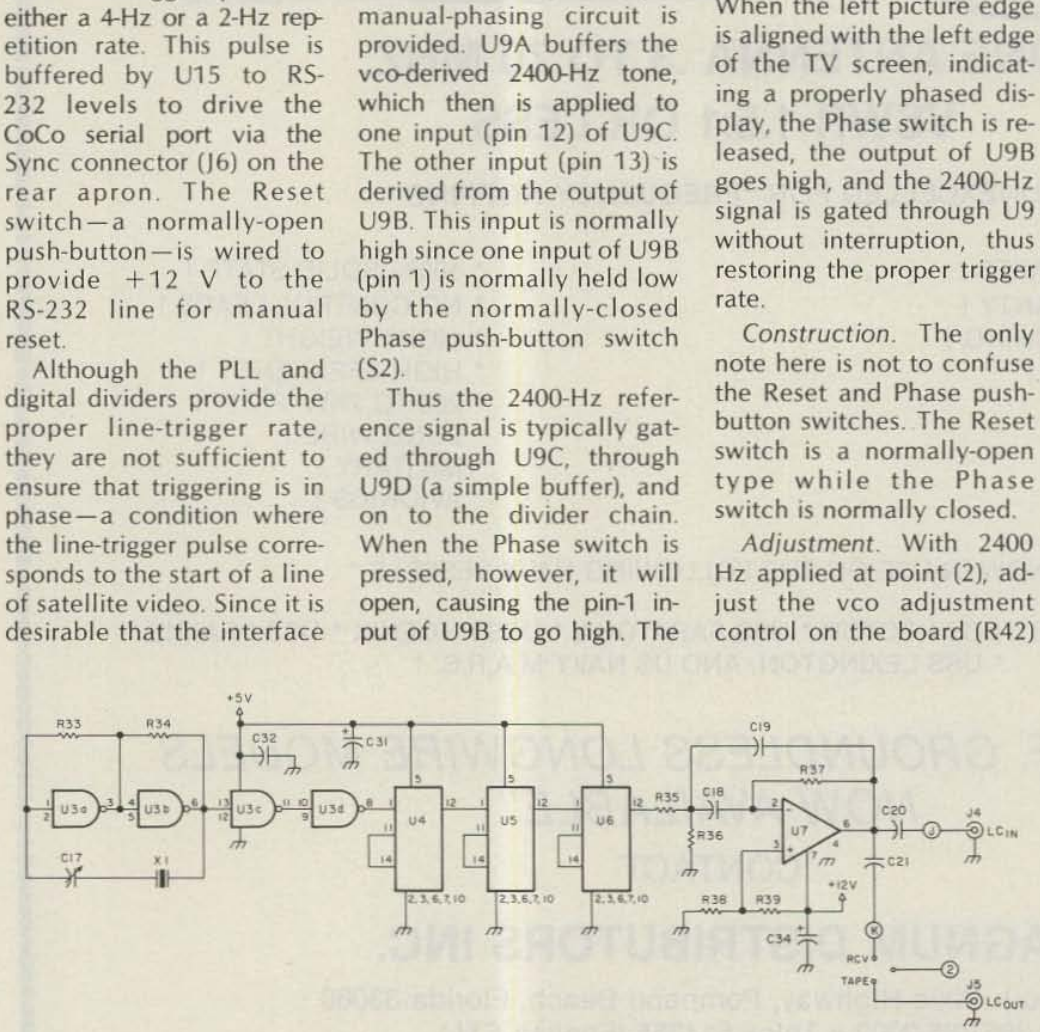


Fig. 4. Clock circuits.

Photo E. Example of High Resolution 1 sampling of an IR WEFAX frame such as in Photo A. It shows a frontal system extending down the central Dakotas into Nebraska.

Photo F. The area in Photo E six hours later. In the upper-left corner of the image you can see that the front has intensified and that the system has moved into eastern South Dakota with some low-altitude clouds (indicated by their darker-gray color) moving into western Iowa.

display and is also recorded on the left channel of a stereo tape system while the video subcarrier signal is simultaneously recorded on the right channel. During playback, the line-sync PLL is locked to the recorded tone on the left channel and will effectively track frequency variations caused by tape speed changes during recording and playback, thus maintaining line synchronization.

Operation. U3 functions as a crystal-controlled oscillator/buffer operating at 2.4 MHz with fine frequency adjustment provided by C17. The 2.4-MHz signal is divided by 1000 using three decade counters (U4, U5, and U6). The 2400-Hz square-wave output from U6 is passed through a 2400-Hz active filter stage (U7) to convert the square wave to a sine wave. When the RCV/Tape switch (S1B) is in the RCV position, the PLL tone detector in the line-sync circuit is driven directly by the 2400-Hz crystal reference. A sample of the 2400-Hz signal also is routed to the left channel input of the recorder (LC In) at J4. With the switch in the Tape position, the PLL is driven by the signal recorded on the left channel (LC Out) via J5.

Adjustment. The only operational adjustment is to set the oscillator output accurately to 2.4 MHz by adjusting C17. This can be accomplished in one of three ways:

(1) Connect a frequency counter to pin 8 of U3 and adjust C17 for a frequency of 2.4 MHz to the resolution limits of the counter.

(2) Calibrate a receiver using WWV and a crystal calibrator. Connect a short test lead to pin 8 of U3, loosely coupling the lead to the receiver input. Adjust C17 to obtain precise zero beat at 2.4, 4.8, or 7.2 MHz. The latter frequency is useful for ham-bands-only transceivers.

(3) Display live images using the interface and WEFAX software. If the picture margin drifts to the right as the image reads out, the oscillator frequency is high. If it drifts to the left, the frequency is low. Adjust C17 until the margins are precisely vertical.

Packaging and Power Supplies

There is an old saying in the home construction game that once you have the boards wired you may be almost half done! What kind of packaging you use is pretty much up to you. In the case of the WB8DQT prototype, the display board was placed in its own metal enclosure with a 5-V regulator chip to run the board off the station's +12-V bus. Display-board power drain was measured at 600 mA.

The interface board was dropped into its own cabinet along with a small receiver. The +5-V interface requirements were taken care of with a 5-V regulator chip on-card and the current drain on the +12-V bus was 280 mA. The −12-V drain was minimal—slightly less than 20 mA. Required front-panel controls and indicators include the 120/240 lpm switch, the RCV/Tape switch, the Phase and Reset push-button switches, the Contrast control, and the agc meter. If the power supply is internal, you will also need a power switch and a power-indicator lamp.

The rear apron tends to be a busy-looking place with lots of cables heading off to other gear. There are a total of five audio leads—RCV (receiver output), RC In and LC In (right- and left-channel tape-deck inputs), and the RC and LC Out jacks (tape-deck right- and left-channel outputs)—where you should use standard shielded audio cables (phono-plug terminations) for the interconnections. The Video cable runs from the rear apron to the right joystick port of the CoCo while the Sync cable runs from the interface rear apron to the CoCo serial port. Although not absolutely necessary, it is helpful if the output from the receiver has a constant level—if only to simplify maintaining constant recording levels. A shielded audio lead coupled to the top of the receiver volume control through a .1-uF capacitor should do the job nicely with most receivers.

Tape Equipment

Obviously, the minimal satellite installation consists of the interface, display board, 64K CoCo, and your satellite-receiving gear. In order to make the most of the program features, however, you really should include a good (by music standards) cassette or reel-to-reel stereo tape deck. Regular cleaning and pressure-pad maintenance will keep almost any recorder up to par if you use high-quality tape. Taped transmissions never have

Photo G. *A High Resolution 1 image obtained from a NOAA 7 visible-light APT pass showing the Great Lakes in considerable detail. A multitude of small lakes are clearly visible in southern Canada. For the ultimate in high resolution you can use the HR-2 format as shown in Photo H.*

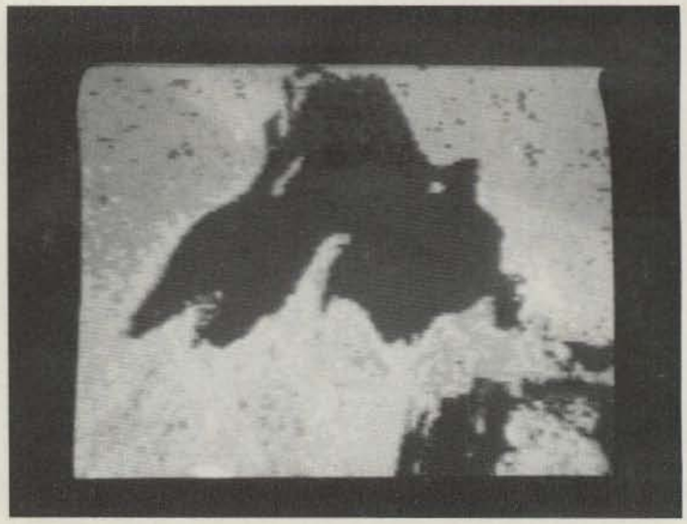


Photo H. The HR-2 format for Photo G. Lake Superior takes up much of the image area. The resolution of the HR-2 format equals the theoretical resolution limit for APT and WEFAX imagery and reveals details that are beyond the capacity of most systems.

quite the quality of "live" displays, but you will rarely notice the difference in practice. All of the photos used to illustrate this article are taken from tape, and the versatility of the program routines possible with tape makes it well worth the marginal loss in image quality.

In order to keep things simple, recordings should be made at constant input and output levels. The output level is easy—simply set it for maximum on both the left and right channels for most decks. Assuming the system has been set up as specified (video into the right channel, sync into the left), you should set the left-channel recording level for 0 VU with the interface running. With the receiver set to an empty channel (no satellite signal), set the right-channel recording level for a mid-range reading (−10 to −7 VU on most decks) using the noise output of the receiver as the signal source.

System Operation

What follows will be a very brief outline of the operation of the major routines in the present WEFAX Rev.3 program available from K6AEP. The software will certainly evolve with time, but most of the evolution will be "bells and whistles" in the sense of new routines. The basic image-display routines should remain fairly stable and you should have little trouble relating the instructions which follow to the extensive program documentation you will receive with your software.

As we discuss program features, we will have occasion to talk about two different displays—what we will call the "CoCo display" and the "image display." The CoCo display is simply the normal computer monitor where prompts, menus, and inputs are displayed. The image display is the monitor where the output of the display board is viewed.

Loading the Program. Insert the cassette and rewind if required. Preset the cassette volume level to about 5, set the cassette recorder to play, type CLOADM, and hit the <ENTER> key. The cassette machine will start to run and an S will flash in the upper-left corner of the CoCo display. The display board and interface should be powered up at this time, but pay no attention to the image display—expect garbage! When the WEFAX program is found, the flashing S will change to a flashing F and a short notice will print out to the effect that the WEFAX program is loading and will execute automatically when loaded. This magic event is easy to spot—you will suddenly get the main menu display (shown in Fig. 6) and the image display will show a random but static pattern based on the contents of the display RAM at power-up.

Virtually everything in the program starts with the main menu, and no matter where you are in the program you almost always can get back to this menu by hitting the <CLEAR> key on the CoCo keyboard. If you find the random-image display a bit disconcerting, you can get a gray-scale display (actually color bars) by typing I followed by G followed by <CLEAR>. If your monitor is like most, you will have considerable vertical overscan on the image display. We would suggest adjusting the monitor height control to compress the display slightly to minimize the loss of picture information at the top and bottom of the screen.

Notes on Contrast Settings. At this point we will assume that the interface has been checked out as noted in the *Adjustment* section of each circuit description. If not, this is the point at which to complete checkout. The only variable that remains to be considered is the proper Contrast setting for each class of satellite. The first time or two you display a given type of picture you can expect to jiggle the Contrast setting until you get the best image display for that mode. Once you have determined the optimum setting for each mode, you should mark it on the front panel. You probably will end up with distinctly different settings for WEFAX, APT Visible, APT IR, 120-lpm METEOR, and 240-lpm METEOR. Alternatively, you may wish to install a small rotary switch on the front panel to switch in a small PC pot for each mode. With the switch positions properly labeled, you need only optimize each pot in turn, after which you can use a switch setting appropriate to the mode you wish to display.

Primary Image Display

General Notes. The Interface RCV/Tape switch should be set to RCV for "live" display directly from the receiver or to Tape for recorded display. Early experiments are best done with tape as you can always rewind the tape if you make a mistake, or you can display a full frame followed by one of the high-resolution formats, etc.

All image displays will begin with the R option from the main menu. This will reset the image display and the incoming picture will begin to read out. At the same time, a secondary menu (Fig. 7) will appear on the CoCo display and will provide you with your display options following phasing. The image display can be "frozen" at any time by hitting the <CLEAR> key, and the CoCo display will return to the main menu.

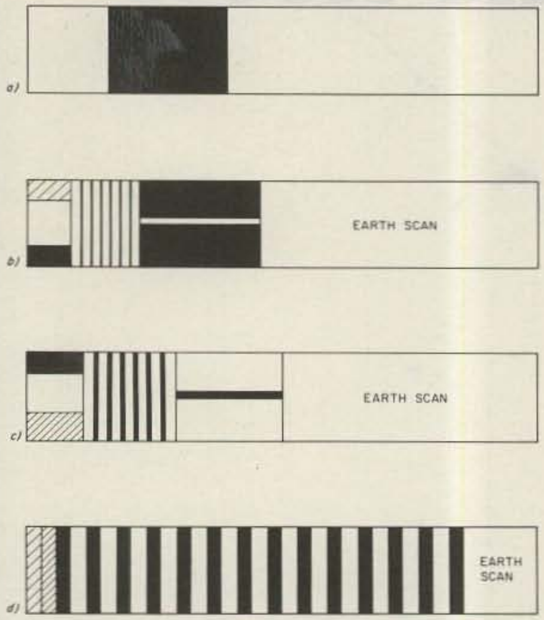


Fig. 5. Diagrams of line-sync pulses for the various satellite-video formats. Proper phasing of satellite pictures requires recognition of each kind of pulse. The Phase switch is pressed until the desired sync pulse moves across the screen and just off the left edge of the display. (a) shows the WEFAX line pulse—a simple black bar on a white background. It is transmitted during the phasing interval at the start of a GOES or METEOSAT frame transmission. (b) shows the sync pulse for NOAA visible-light APT imagery. It consists of seven cycles of 1040-Hz subcarrier modulation, followed by a black interval representing the scanner's view of space just prior to the start of the earth scan. Once each minute a white minute marker bar will interrupt the black space scan. The essential cues for the visible-light sync pulse are the black space scan and usually high-contrast video in the earth scan. Just to the left of the pulse train is a telemetry signal that is displayed as horizontal gray-scale data. (c) shows a typical infared (IR) line pulse in the NOAA APT format. This pulse is also seven cycles in length but it is seven cycles of 832-Hz modulation so it is somewhat wider than the visible-light pulse. The IR pulse is followed by a white interval (cold) representing the space scan. The earth scan is typically quite white and low in contrast. IR minute markers are black. To the left of the pulse is a telemetry gray-scale pattern similar to that of the visible-light pulse. (d) is the line-sync pulse for standard 120-lpm METEOR imagery—a long 13-cycle pulse that is very easy to recognize. The earth scan data is immediately to the right of the pulse while vertical gray-scale stripes are immediately to the left of the pulse. All of these pulses are enlarged illustrations—much as you might see with the HR-1 or HR-2 display formats. They are quite easy to recognize in full-frame display however, once you are familiar with their appearance.

WEFAX Display. Set the 120/240 lpm switch to 240. When you hear the characteristic 300-Hz "start" tone, simply hit R from the main menu and watch the display. You should see a white background with a vertical black bar somewhere in the image display area (shown in detail in Fig. 5(a). Press and hold the Phase switch and this bar should march step-wise toward the left edge of the image display area. Allow the bar to move off the display to the left and release the Phase switch. About 20 seconds after the end of the start tone you should hear some rough subcarrier modulation as the picture header begins to print out.

At this point, press key 1 and the WEFAX picture will begin to display from the top of the image display area. When the display reaches the bottom of the screen, press the <CLEAR> key to freeze the image and return you to the main memory. Note that with the US GOES spacecraft the picture starts about 20 seconds after the start tone. The European METEOSAT delays only five seconds, so you will have to hustle to complete the phasing operation.

Photo A shows a typical infrared (IR) WEFAX display, while Photo B is a visible-light example.

APT Display. Images from the TIROS/NOAA satellites are transmitted continuously in the APT format and display can begin whenever the signal rises out of the noise and can continue until the spacecraft begins to approach the opposite horizon. Preset the 120/240 lpm switch to 120 and hit R from the main menu to start display.

Phasing with APT is governed by which image, visible light or infrared, you wish to display. Daylight passes will have both formats available while night passes will have a black visible-light display and only IR data will be useful.

```
I — TEST INTERFACE
R — RECEIVE HIGH DENSITY FAX
L — RECEIVE LOW DENSITY FAX ON TRS80C
D — DISPLAY IMAGE IN MEMORY
Y — MEMORY CHANGE
C — DISPLAY COLOR IMAGE IN MEMORY
T — PRINT PICTURE ON SCREEN
S — SELECT PRINTER SPEED
E — CONTRAST ENHANCE PIX
UP DOWN ARROW PICT UP DOWN
```

Fig. 6. Main menu display, WEFAX program.

```
WHILE VIEWING A FAX PIX
KEY 1 = WEFAX, APT, ADV METEOR
KEY 2 = STND METEOR
KEY 3 = HIGH RES 1
KEY 4 = HIGH RES 2
KEY 5 = HF FAX FAST
KEY 6 = HF FAX SLOW
KEY R = ROTATE PICTURE
ANY OTHER KEY WILL END
```

Fig. 7. Secondary display menu, WEFAX program.

Photo I. Polar-orbit infrared (IR) imagery in low contrast.

Photo J. Once the display has been optimized using the Contrast control, the image in memory can be enhanced using the contrast enhancement routine. Unlike other routines, enhancement alters the image in memory.

The visible-light sync-pulse train is shown in Fig. 5(b) while the IR-sync-pulse sequence is shown in Fig. 5(c). To display visible-light imagery, simply press and hold the Phase switch until the visible-light sync pulse passes off the left edge of the display. If you want IR display, simply hold the Phase switch until the IR pulse has moved off the left edge of the image display area. With either visible or IR phasing complete, hit key 1 to restart the display from the top of the image display area.

With a simple omnidirectional antenna you can expect to receive at least 10 to 12 minutes of imagery on a good pass. If you keep the display going unattended, the image will automatically reset as it reaches the bottom of the screen. For the first look at a pass, you may wish simply to let it scroll in this fashion. Once you have an idea of the features of interest, you can run the tape again and when you get to the point where you want to display the material, simply hit either the interface Reset switch or key 1 on the keyboard. Once the display fills up, simply hit <CLEAR> and the image display will be frozen while the CoCo display returns to the main menu. Photo C shows a sample of visible-light imagery from a daylight APT pass.

METEOR Display. Soviet polar-orbiting METEOR spacecraft come in two varieties—the standard 120-lpm spacecraft and the rarer 240-lpm birds which are apparently still experimental. Both types of METEOR imagery are restricted to visible-light data from daylight passes. For 120-lpm METEOR display you should preset the 120/240 lpm switch to 120 and hit R from the main menu to start display. The 120-lpm "standard" METEOR sync pulse is shown in detail in Fig. 5(d). As the image reads out, press and hold the Phase switch until the sync-pulse train marches out of view to the left of the image display. Release the Phase switch and hit key 2.

Like the APT format, METEOR pictures are continuous and you can scroll through an entire pass or hit the Reset switch to reset the display whenever desired and the <CLEAR> key to freeze the image display and return to the main menu. Photo D illustrates the results from a typical "standard" METEOR pass.

240-lpm "advanced" METEOR operation is similar except that the 120/240 lpm switch should be in the 240 position and you should hit key 1 following phasing.

High-Resolution Display

In order to provide for the display of extremely-high-resolution data, two high-resolution formats, High Resolution 1 and High Resolution 2, are supported by the WEFAX program. In each we sample a progressively smaller subset of the image with the capability of resolving finer detail. Prior to using one of these formats, you should display the entire image of interest to determine what features you wish to emphasize. Once this has been done, note some easily-recognized feature a short distance above the feature you are interested in. This feature will be the "recognition" feature and will tell you when you should shift to the high-resolution mode.

High Resolution 1. This is an intermediate format that will exceed the resolution limits of most CRT systems and many FAX displays. Assuming you have located the picture-area of interest to you and a suitable recognition feature, begin display with the main-menu R option and proceed to phase the image. In this case, however, you should phase the image so that the feature of interest will read out on the left half of the image display area. Key either 1 or 2 (depending upon mode) and watch for the recognition feature. As it begins to read out, simply hit key 3 and the High Resolution 1 sampling will begin. When display is complete, hit <CLEAR> to freeze the display and return to the main menu. Examples of HR-1 images are provided in Photos E and G.

High Resolution 2. The resolving power of this format exceeds that of any of the satellite formats and you can expect to see details that almost no one else can resolve. Start with R and phase the display so that the feature of interest will read out just to the right of the left image display margin. Key either 1 or 2 and watch for the recognition feature. As it starts to read out, hit key 4 and your HR-2 image will load quickly. Press <CLEAR> to freeze the display and return to the main menu.

An example of the HR-2 format is provided in Photo

Photo K. A full-frame display from a NOAA polar-orbit pass. The Great Lakes region is buried under a huge compound frontal system shaped like an upside-down V. Now see Photos L and M.

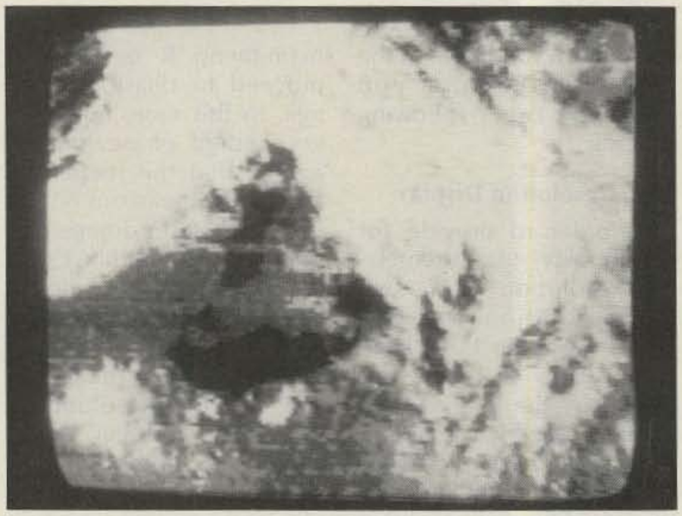


Photo L. An HR-1 display of the center of Photo K. The southern part of Lake Huron and all of Lake Erie can be seen between the open angle of the "V".

Photo M. An HR-2 view that reveals even greater detail, including a cloud "stringer" stretching across Lake Huron, a feature that is invisible in Photo K and barely resolvable in Photo L.

H. This is a demanding format due to the small area sampled but if you don't quite capture the area you want, simply run the tape back and try again. As you can see, the results are well worth the effort!

Display Options

Although most people would be quite happy just to be able to capture the full-frame or high-resolution formats, there is still quite a bit that can be done once the image is in memory! To access these functions, simply type D from the main memory and you will get a menu like that shown in Fig. 8(a). The functions you will use most often on this menu are summarized below. You can try these options in any order and as often as you like. Although the display will change with each option, the original picture will remain unaltered in the main memory.

(a)

DISPLAY PIX IN RAM
L = LOW DEN PIX
R = ROTATE PICTURE
T = TOP HALF
B = BOTTOM HALF
P = TOTAL PIX
1 TO 8 QTR FRAME

(b)

1	2
3	4
5	6
7	8

(c)

T
B

Fig. 8. (a) Display options menu. (b) and (c) Zoom formats.

Picture Rotation. South-to-north passes of polar orbiters will read out a picture in which south is at the top (start) and north at the bottom (finish); basically, the picture is upside down! If you type R from the display memory the image display will be rotated 180 degrees, and such inverted images will now be upright with north at the top. This neat software trick sure beats turning the monitor upside down or standing on your head to view the image!

Top and Bottom Image Subsets. Although the image in memory is stored in a 256 × 256 format, the standard display board format is 256 × 128, which means you lose some vertical resolution relative to the picture actually in memory. You can get all the resolution in memory by hitting either T or B, displaying the top or bottom half of the image in memory, using the entire image display area. Although this will distort the aspect ratio slightly—the pictures will appear "stretched" vertically—it is a quick way to look for fine detail that may be lacking in the full-frame format. The T and B formats are shown in Figs. 8(b) and 8(c).

Image Enhancement. IR imagery—particularly APT—can appear quite white and washed out, especially during the winter months, due to a lack of strong temperature differences between land and sea surface and overlying clouds. Careful adjustment of the Contrast control will help, but the pictures still will be pale compared to their visible-light counterparts. The E option from the main menu can help out in such cases. Once you have captured the picture you want, you can enhance contrast by a factor of 1.5 by typing E from the main menu.

When you do so, there will be a slight delay and then the E you have typed will disappear. If you type D followed by P, you can see your enhanced image. An example of a standard and an enhanced picture can be seen in Photos I and J. *Note that this routine should be used with care!* Unlike all the other routines discussed so far, it permanently changes the image in memory! If you don't like the results, you will have to reload the picture from tape to get the original version back on the screen. Also, although there is no limit to how many times you can run the E routine on a picture, the image will tend to degrade steadily after the first enhancement run. You can try additional passes through the routine if the first did not get you all that you expected, but don't say you weren't warned!

Hard Copy. One of the beauties of scan conversion is that you can view a large number of satellite pictures without piling up costs for photographic supplies or FAX paper. Obviously, however, there will be times where you would like to have a permanent copy of a particularly interesting picture. Photographing the TV display is one option, and you can use relatively economical roll film since you do not need the pictures immediately.

A second option is to use the T routine from the main menu. This will permit you to print the image being displayed using an Epson printer (MX-80 with the Graphtrax option, or the newer RX-80). An example of a full-frame printout is shown in Fig. 9. Full-frame printouts will have lower resolution than the image displayed but will be quite useful in most applications. The resolution of printouts from High Resolution 1 images is equal to that obtained with many CRT display systems. The advantage of the printer approach to hard copy is that the printer is useful in all other applications of your CoCo, so your hardware acquisition will have multiple uses.

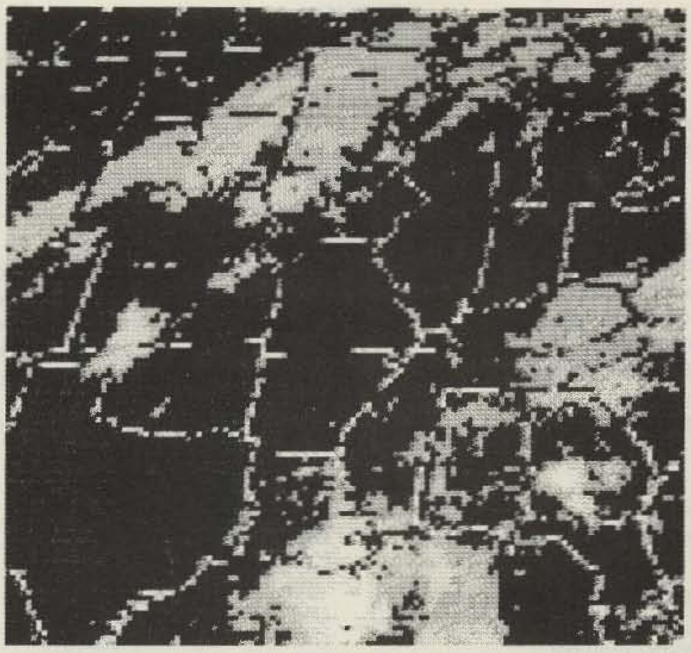


Fig. 9. An example of image printout using an Epson RX-80 printer. This is an HR-1 image from a GOES E infrared image of the United States (as in Photo A). This HR-1 view extends from Texas in the lower left to northern Florida in the lower right. Michigan is in the upper right and the US/Canadian border runs along the top. IR images display cold objects as white. The ground surface is warm and hence dark. Most of the cloud features in this view are mid-range gray, indicating relatively warm (and low) clouds. The white centers of the clouds in the Gulf of Mexico and southern Georgia indicate colder and higher cloud features.

Low-Density TRS-80C Display

Most of the remaining main menu functions that are available will not be discussed as they are more specialized and space is limited. The exception is the L routine which appears on the main menu and also on the display menu. This is a routine that will print a low-resolution, limited gray-scale version of a satellite picture directly on the TRS-80C display monitor without the use of the high-resolution display board. If you use a color monitor you should disable the color when using this option. The picture is quite crude and the routine is perhaps best used to check out the interface functions prior to getting the display board on line. This routine will not be supported with future program revisions and may eventually be dropped if other new routines have a higher priority.

High-Frequency FAX

Weather charts and almost any imaginable kind of picture material are transmitted regularly on HF (SSB) using various FAX formats. All of these have a video "swing" identical to that of SSTV—1500-Hz black to 2300-Hz white. Since HF video is identical to SSTV video, you can simply drive the CoCo joystick port with the output of the SSTV demodulator while driving the serial port with this month's interface to provide line sync. The only change in recording an HF FAX signal is to route the output of the HF receiver to the right-channel input with the right-channel output going to the input of the SSTV demodulator.

The single biggest problem with FAX is that the signal does not contain a 1200-Hz sync pulse, and since there are no intervening voice transmissions, the signal can be difficult to tune on SSB. One possibility is to wire up a pair of NE567 tone decoders with LED indicators, one tuned to 1500 Hz (black) and the other to 2300 Hz (white). The circuit values shown for U8 on the interface should do just fine for such decoders. Phasing on HF FAX usually uses one of two formats—white video with a black framing marker or black video with a white framing marker. In either case, if you tune so that both indicators flash during phasing, you will be right on frequency.

HF FAX uses several standard line rates—typically 120 but also 60 and 240 lpm. Begin by typing R from the main menu and phase the picture. You can then try keys 2, 1, 5, and 6 in sequence to see which gives the best display for the transmission in question. Once you have identified the proper key for a specific station, you should log the information for future use. Again, as in the case of satellite transmissions, recordings will let you experiment as long as desired to determine the optimum display format. Weather charts will tend to be disappointing due to the large amount of fine detail, but wirephoto transmissions yield excellent results. The press frequencies for this sort of thing are not widely publicized, but several books are available listing these and other "confidential" HF frequencies.

Parts List
(Weather-Satellite Interface)

Transistors	
Q1-3, 5	2N4401 (General purpose audio NPN)
Q4	2N4403 (General purpose audio PNP)
Integrated Circuits	
U1	LM1458 (Dual 741/Mini-DIP)
U2	LM324 (Quad op amp)
U3, 9, 11	SN7400N (Quad NAND gate)
U4-6, 12, 13	SN7490N (Decade counter)
U7	LM741CN (741 op amp/Mini-DIP)
U8	NE567 (PLL Tone decoder)
U10	SN7492N (Divide-by-12 counter)
U14	SN74121N (Single-shot)
U15	MC1488P (RS-232 Line driver)
Diodes	
D1-7, 10	1N4001
D8	5.1-V, 1-W zener
D9	Radial mounting LED (sync lock)

Resistors

All values in Ohms. Unspecified units are 1/4 W, 5% composition or metal film. PC indicates A 1/4- to 1/2-W printed-circuit pot. Panel mounting indicates a standard panel-mounted pot.

R1	10k PC (agc threshold)
R2, 4, 32, 47	4700
R3	47k
R5, 6, 16, 21, 22, 24, 26, 29, 30, 35, 38, 39, 41, 48	10k
R7, 12, 15	56k
R8, 14	120k
R9	22k
R10, 19, 44, 45, 46	1000
R11	1
R13	6800
R17, 36	2700
R18, 23, 37	20k
R20	10k Panel mounting (contrast)
R25	1 megohm
R27, 28	2200
R31	1000 PC (black level)
R33, 34	470
R40	150
R42	5000 PC (vco adj)
R43	1500

Capacitors

Unless otherwise noted, capacitors should have a working voltage of at least 16 V. T indicates a dipped tantalum electrolytic, A an aluminum electrolytic (radial leads), M a dipped mylar™/paper capacitor, D a disc ceramic capacitor, SM a silver-mica capacitor, and MT a mica compression trimmer. All capacitance values in uF unless noted.

C1, 6, 7, 16, 26, 39	1 T
C2, 3	22 T
C4, 9, 10, 18, 19, 28	0.01 M
C5, 38	10 T
C8	100 A
C11, 12, 20, 21, 24, 25	0.1 M
C13	27-pF SM
C14	0.22 M
C15	0.047 M
C17	40- or 60-pF MT
C22	2.2 T
C23, 31, 35	4.7 T
C27	120-pF SM
C29, 30, 34	0.1 D
C32, 33, 36, 37	0.01 D
Misc.	
X1	2.4 MHz at cut crystal/32-pF load/0.002%
M1	50-microamp panel meter (agc)
J1-7	Switchcraft 3501FR or other phono jack
S1	DPDT subminiature toggle (RCV/Tape)
S2	Normally-closed push-button (Phase)
S3	SPDT subminiature toggle (120/240 lpm)
S4	Normally-open push-button (Reset)
S5	SPST toggle (power if supply internal)
L1	12-14-V LED or other panel lamp (power)

The Future

The present CoCo FAX system offers extreme flexibility and excellent results. One of us (WB8DQT) has all kinds of CRT and FAX display systems but has used little but the CoCo since we got the system up and running. If new routines prove to be useful or if new FAX formats appear, they will be added to the software in an attempt to keep it as current and useful as possible. The guiding philosophy will be that inexpensive software upgrades are preferable to making extensive hardware modifications.

There is a hardware option, however, where you can expect to see developments—the display board. The basic high-resolution display board is limited to a 256 × 128 format since only 16K of static RAM is used. Despite this limitation, the FAX results are quite good as evidenced by the photos in this article—all of which were photographed from that standard display-board output. Some experimentation by K6AEP has shown that it is practical to load the display board with as much as 32K of static RAM—enough to provide a 256 × 256 display format!

By the time this article appears, Multimode and L. W. Interface will offer both versions. The 256 × 256 version is obviously a bit more expensive, but the display is capable of pushing the resolution limits of most monitors. The WEFAX Ver. 3 software has been modified (along with various SSTV options) to support either 256 × 128 or ×256 display. You can start with and stay with the first or later upgrade to the second and still use the same software.

Conclusion

Up to this point in time the differences in image formats and the equipment required for image processing have kept the various types of video experimenters separate and distinct. One of our goals has been to use the power of the 6809 microprocessor as a flexible image-processing system. With the power of a 64K CoCo, some hardware interfaces, and flexible software, the segregation of ATV, SSTV, FAX, and the weather-satellite crowd is a thing of the past—not to mention CW and RTTY! For about what you would pay for a dedicated system for any one of these modes, you can have it all!

If you stop to think that the same computer can calculate satellite orbits, keep your log, balance the checkbook, and teach the kids, we think you will agree that it will be a much easier job to sell the family on the "new" gear. Of course everything has its price. Once you are geared up you will have the terrible decision about which of all those modes you want to use when you fire up the rig! For that weighty question we can suggest only that you write a program to let the computer decide! ■