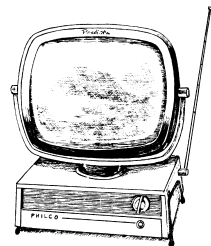


TELEVISION

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A Short History of SSTV (The Early Years)

While tuning my Ham radio around on a very quiet band the other day I came across several familiar signals. Their distinctive rhythmic warble took me back almost 40 years, when I was dabbling in the somewhat arcane aspect of the hobby called Slow Scan Television, or SSTV.

SSTV is not quite television as most of us know it. It's probably more correct to call it just picture transmission, since the images are still, and each one takes many seconds to receive. The slow speed allowed Amateurs to add pictures to their voice transmissions without modifying their transmitters or receivers. To do so required a reduction in bandwidth of about 1000:1 compared with regular television.

Though digital image compression now is commonplace, in 1957 when SSTV was proposed by college senior Copthorne Macdonald there were no such techniques. It was an analog world. To squeeze even a simple image into the 300-3000 Hz audio bandpass of typical Amateur gear something (or many somethings) had to give. Video bandwidth is approximately the product of the number of vertical and horizontal pixels multiplied by the number of frames per second, and then divided by two. So Macdonald had to reduce both the frame rate and scan lines of his system to fit video into an audio channel. He proposed a 120 line picture transmitted in six seconds.

There certainly was precedent for such a system. The early mechanical television methods made 24 to 60 line pictures, though they did move. RCA introduced its type 1847 "Experimenter's Iconoscope" in 1940, which made acceptable pictures using a 120 line 30 frames/sec raster, which might be termed "medium scan." In 1956 Bell Labs demonstrated an experimental "Picture-

phone" apparatus with a 60-line picture of 40 pixels per line transmitted in two seconds, which could be sent through normal telephone lines. It used a rotating analog drum memory and a special storage-type CRT (ITT "Iatron") to produce a still picture about 2" high, at considerable cost.

Much of Macdonald's 1957 system is still used today, though updated and extended. His first equipment, built for a college extra-credit paper, determined some of the system's characteristics. The view screen was a war-surplus radar display cathode ray tube, with a P7 phosphor. Those CRTs were cheap, often \$5 or so, and the long-persistence part of the P7 phosphor could make an image that would last up to a minute (when viewed in the dark). He figured that a 6-second image time would be comfortably visible. The round CRT faceplate made a square (1:1) aspect ratio a natural choice.

His "camera" was a flying spot scanner with a surplus 908-A CRT (3" diameter, short-persistence P5 phosphor) for raster into a 931-A photomultiplier. The 908-A shared electrostatic scan signals with the display CRT to simplify things further. A 2¼" square photographic negative was placed on the CRT face to be scanned, with video inverted in the following circuits. A 2 kHz subcarrier was then amplitude modulated by the slow-scan video and fed into the transmitter's microphone jack.

Off-air tests were done with a tape recorder. Coincidentally, 1957-59 were the first years of broadcast video tape as well. Even cassette recorders had sufficient audio bandwidth to reproduce the signals, and were widely used. Varying tape speed (wow and flutter) caused wavy or uneven scan lines in the images but didn't materially affect resolution.



Copthorne Macdonald as photographed on an SSTV monitor.

The FCC granted Macdonald's request for permission to transmit tests in 1959, and successful reception of his SSTV images in England was achieved in November of that year. British Amateur Television Club members were enthusiastic promoters of the new mode in Europe. The fading of the AM signal they experienced in long distance reception led to a major change in the original system; use of FM instead of AM for the audio subcarrier. The FM subcarrier placed sync at 1200 Hz, black at 1500 Hz and peak white at 2300 Hz, an arrangement borrowed from commercial facsimile services. Additionally, the scan was slowed further, to eight seconds, to allow increased horizontal resolution. Adopted as proposed in 1961, this standard is still used today, though many newer scan configurations have arisen.

Slow scan television was slow to gain adherents, in part because the FCC didn't authorize its use by U.S. Amateurs until 1968. A few enthusiasts continued to develop equipment to make it more convenient to use. In 1964, while working for Westinghouse, Macdonald created a slow scan camera using their WL-7290 vidicon. This special low dark current pickup tube could store an image for up to two minutes when kept in the dark after a short exposure (using a shutter, like a film camera). These tubes were hard to get and expensive, but several cameras were built using them, as

they were more versatile than the previous flying-spot picture generators. Others attempted cameras using ordinary vidicons (7735, 7038, etc) even though their dark current was an order of magnitude greater, washing out the pictures. They did meet with some success by eliminating the shutter and accepting the need for keeping the subject very still during the 8-second exposures. Second-hand Plumbicons (TV station discards), with their greater sensitivity and lower dark current were even better, but not yet common in the late '60s. The penultimate slow scan camera was the "sampling camera." This type operated at a faster scan rate than SSTV, though a little slower than standard television, making framing and focusing a picture much easier. Its output was gated pixel by pixel to form a correctly-timed slow scan waveform. This neat trick (first demonstrated by General Electric in 1957) first required the fast-scan camera to rotate its scan raster 90 degrees. The field rate was then changed to equal the line rate of the slow-scan system. Since the SSTV line rate of 15 Hz is $\frac{1}{4}$ of the standard US TV frame rate of 60 Hz, slowing the camera's frame rate could be achieved pretty easily without much alteration of the circuits. Then a sample-and-hold circuit was timed to develop a slow scan line from each frame of fast scan video. In eight seconds a complete SSTV picture was created.

This was the technique used by Robot Research in their 1970 introduction of the first commercial SSTV equipment—the Model 80 sampling camera, and the Model 70 slow scan decoder and monitor. The Model 80's vidicon operated at a sort of "medium scan" raster, with a line rate of 4 kHz and a 15 Hz frame rate—good enough for easy focusing using the Model 61 camera monitor. Sampling and conversion to the SSTV audio signal took place on the same single printed circuit (PC) board that created the vidicon scanning. Power was provided by the Model 70 monitor/receiver, which featured a modern rectangular CRT with a P7 phosphor. It was brighter and more compact than the old surplus



Robot model 70 receiver and model 80 camera (1970).

radar tubes, but of course the picture still faded away rapidly. Ham Operators compensated by transmitting the same picture several times so the image could be viewed longer.

The Robot model 70 and 80 pair, despite initially selling for almost \$1000 (about \$6800 now) made slow scan available to more than just technically inclined do-it-yourselfers. They were produced for several years, with regular improvements and price reductions. Robot also introduced a slight variation in the SSTV scan standard, adding eight lines of digitally-generated gray-scale video through its use of Resistor-Transistor Logic (RTL) logic integrated circuits. The slight increase in frame time was easily ab-

sorbed by contemporary analog circuits and the accurate gray steps made calibration easier. Though a small number of entrepreneurs had been making parts and PC boards for SSTV builders and experimenters from the beginning, Robot's entry prompted ready-to-play products from new companies. Venus Scientific and SBE Linear Systems joined the game in the early '70s with their versions, all with P7 monitors and sampling cameras, and promoted by full-page ads in Amateur Radio magazines.

The last real barrier to more universal acceptance of SSTV as a popular mode, besides cost, was the fading nature of the pictures on the P7 monitors. Storage type CRTs had been available since the late

DEVELOPMENT OF THE SSTV SCAN STANDARD

Parameter	Original 1957 1957 System	1961 Standard	"Robot 8" Standard (1970)
No. of lines	120	120	128
Aspect Ratio	1:1	1:1	1:1
Frame time	6 sec	8 sec	8.5 sec
Line rate	20 Hz	15 Hz	15 Hz
Modulation type	AM on 2000 Hz subcarrier; max at sync, min at white	FM; 1200 Hz sync, 1500 Hz black, 2300 Hz white	FM; 1200 Hz sync, 1500 Hz black, 2300 Hz white
Horizontal sync	5 mSec	5 mSec	5 mSec
Vertical sync	30 mSec	30 mSec	30 mSec



Robot model 300 analog SSTV scan converter (1975).

1950s from RCA, Hughes and ITT (remember the previously-mentioned “Iatron”.) While they could retain a bright image for 20-60 seconds, these CRTs were quite complicated, and their gray scale performance was limited. A few SSTV enthusiasts built monitors using them, but their cost was beyond the reach of most Hams.

In 1975, Robot introduced the model 300, which was the first product to provide a direct conversion between Amateur Radio slow scan and standard television equipment for both transmitting and receiving. The 300 could accept standard television video, store a “grabbed” frame, and convert it to slow scan, as well as receive slow scan audio and display the captured picture on an ordinary TV monitor. At the heart of the 300 was a Princeton Electronics “Lithocon.” This image-storage tube could be scanned at slow- or fast-scan rates to write an image onto its silicon target and then read it off non-destructively at a different speed. The image could be retained for months with power off. The model 300 was a wonderful device with a not-so-wonderful price of \$1300 (\$6300 today). It was the ultimate in SSTV convenience and performance for those who could afford it.

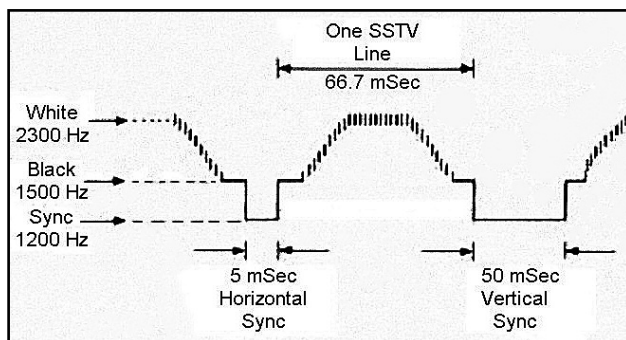
Yet only a year later Robot replaced the 300 with the model 400, which was about 25%

smaller and slightly over half the 300’s price (\$700). Digital memory had finally displaced analog for commercially built SSTV gear. Some of the more advanced experimenters had shown fast-to-slow scan converters as early as 1972, using selected factory-reject (and therefore

more affordable) MOS (metal oxide semiconductor) shift registers as data storage devices. As RAM chips started to become faster and less expensive, prototype slow-to-fast scan converters appeared in 1974. The Robot 400 put everything together in one more-affordable box and brought an end to the era of homebuilt analog SSTV, with its flying spot picture generators and P7 monitors.

The digital processing age has made SSTV even easier to use and experiment with. 8-second images have been joined on the air by perhaps 70 other formats including both sequential and simultaneous color and (relatively) high resolution. The signals I recognized recently on my Ham rig carry the legacy of the SSTV pioneers of 60+ years ago.

If you’ve enjoyed the Television column, or hated it, have a suggestion/correction or just want to talk old TVs, drop me an email: television@tv-boxes.com



Slow Scan TV video signal format (8 seconds/frame).