It's also possible to save your SWR plots for future comparison. Sweep your antenna system and save the curve(s) to disk. Come back in a few months or a year and sweep it again. Within seconds you can compare the curves and see how your system has changed over time.

In Figure 1 you'll see the results of three SWR-121 sweeps of my 20-meter dipole. Once all three plots were complete, I pressed the **PRINT SCREEN** key on my keyboard and printed the curves on my printer. This is convenient when you want to compile a log-book of your antenna activities, or when you want to show your friends what you've been up to.

Conclusion

It's fair to say that the SWR-121 is prob-

ably the ultimate antenna-measurement tool for Amateur Radio applications. There is a stiff price to be paid for this level of quality and convenience, though. If you're a ham who does a lot of antenna building and testing, you can probably justify the cost. An SWR-121 is also a good investment for clubs (make the SWR-121 available for members to use and keep it handy for Field Day). The average ham who toys with his or her antennas only a few times a year—if that much—may find the price of an SWR-121 a little hard to swallow.

Manufacturer's suggested retail price: SWR-121 (HF) $399; SWR-121 (VHF/UHF) $469; SWR.COM software $75. Manufacturer: Advanced Electronic Applications, PO Box C2160, Lynnwood, WA 98036-2160, tel 206-774-5554.

No More Guilt

All hams know that it's Very Bad Practice to swoosh a transmitter (or transceiver) across a band to find the point of minimum SWR (ie, the antenna's resonant frequency). But it's very tempting to do so, especially when adjusting mobile antennas. When you start adjusting the length of the tip on a new mobile whip, you have no idea where the antenna is resonant. Neither do you know how far in frequency the resonant point will move for a given adjustment of the tip length.

I must admit that I have sometimes been a frequency-swoosher, but only at times when propagation on the band I was using was shut down, and with the minimum power necessary to make the SWR meter read upscale (perhaps 1 W output). Even at that, I always felt guilty.

When Steve, WB8IMY, asked me if I wanted to try the AEA SWR-121 Antenna Analyst, I said I'd be glad to experiment with using it to adjust some of my mobile antennas. Wow! It works great!

I hooked the Analyst up to my motorcycle antenna—a Hustler with a two-band top and resonators for 40 and 20 meters. The Analyst was soon plotting *Handbook*-style dotted-line SWR tracings. As it turned out, my mobile antenna was resonant at two frequencies slightly removed from where I had originally tuned it, so it was indeed time to retune.

I retuned the 40-meter resonator to 7.030 MHz—short work with the Analyst—then the 20-meter resonator to 14.025 MHz. As usual, because of the interaction between the two resonators, the 40-meter resonant frequency moved a bit when the 20-meter resonator was adjusted. But a second adjustment to each of the two resonators brought them both right on the desired frequency.

Then I turned on the TS-140S and tuned it to 3.640 MHz to listen for the Analyst's little pulses. With no antenna on the TS-140S, which is about four feet from the mobile antenna, and its RF and AF gain controls set to maximum, I could just barely hear little bitty pulses quickly kerchunking in and out of the passband—sort of a Baby Woodpecker effect.

One minor problem with the Analyst is that the microprocessor can (and does) assign irrational values to the top tick mark on the SWR scale (the bottom tick mark is always 1.0). The two maximum values assigned in the examples of Figure 1 are SWR = 9.9 and 2.8. With the former, the intervals between tick marks is 1.48; with the latter, 0.3. Neither is especially good for easy interpolation, so it's difficult to read the SWR at a given frequency. If the microprocessor would assign a top value of either 4, 7 or 13, interpolation would be easier, with the tick marks then at intervals of 0.5, 1.0 or 2.0, respectively.

The bottom line: Mobile antenna adjustment with the SWR-121 was fast and accurate, the graphical display of antenna SWR gave me confidence in the results, and—perhaps best of all—I didn't feel guilty!—*Al Brogdon, K3KMO*

JPS SSTV-1 DSP Filter for Slow-Scan TV

Reviewed by Ralph E. Taggart, WB8DQT

HF slow-scan television (SSTV) operation is conducted in the same subbands used for voice. The 20-meter band is by far the most popular for SSTV communication, and there has been a major increase in the number of SSTV operators. This influx of new SSTV stations coincides with unusually crowded conditions on 20 meters as we approach the minimum in the 11-year solar cycle. While there has always been the potential for mutual interference between SSB and SSB/SSTV operators, the situation is probably now the worst since the FCC authorized HF SSTV operation in 1968.

Advances in digital signal processing (DSP) technology are currently revolutionizing how we process voice and data signals. DSP filter units can be remarkably effective in minimizing the impact of SSTV signals on voice transmissions, but stock units do not provide much reduction in the impact of SSB interference to SSTV transmissions.

The SSTV Signal Format

The SSTV signal consists of a mid-range audio tone or *subcarrier* whose frequency is varied to convey picture data. All SSTV modes (and fax modes as well), transmit

information on image brightness (in both monochrome and color formats) by varying the subcarrier frequency from 1500 Hz (black, or minimum brightness) to 2300 Hz (white, or maximum brightness). In addition, most modes (with the exception of the AVT SSTV modes and fax) also transmit synchronizing pulses to start the image and trigger each line. These synchronizing pulses are created by shifting the subcarrier frequency down to 1200 Hz for short intervals. As SSTV modes diversified during the last decade, another element, the vertical interval signal (VIS) code was added to new and existing SSTV signal formats. The VIS

code involves shifting the subcarrier between 1100 Hz and 1300 Hz in a simple serial data format (1200 Hz is used for start and stop bits). The short VIS data sequence, transmitted at the start of the frame, can be used to automatically set the receiving display equipment to the proper mode for the picture to follow.

Allowing for bandwidth considerations, the SSTV signal occupies a range of frequencies from slightly below 1100 Hz to just above 2300 Hz. In modern HF receivers and transceivers, a combination of RF and audio filtering is used to set the audio bandpass to a typical value of 300 to about 2600 Hz in SSB modes. DSP filtering can be used to sharpen the skirts of the audio bandpass but usually doesn't tighten it significantly (in normal SSB operation) because of the potential for the loss of speech intelligibility.

Thus, when SSTV signals are received, speech products or tones below the SSTV bandpass (between 300 and 1100 Hz) and above it (between 2300 and 2600 Hz or higher) are passed with no significant attenuation. Obviously signals that fall within the SSTV passband (1100 to 2300 Hz) can cause interference, but so can the signals above and below this range. The reason is simple. SSTV demodulators typically start with one or more audio limiter stages (or their equivalent in software) to remove the effects of signal fading and receiver AGC effects. If audio products outside of the SSTV video passband (but within the receivers SSB audio passband) are comparable in level or stronger than the desired SSTV signal, they can saturate or "capture" the audio limiter. The effect is quite similar to the "capture effect" when using FM on VHF or UHF. The end result is that the SSTV demodulator input is dominated by the interfering signals or tones and the desired picture data is degraded or completely obliterated.

The JPS SSTV-1 DSP Filter

Given the flexibility inherent in DSP technology and the rapid rise in the number of SSTV operators, it was inevitable that someone would implement a DSP filter tailored to the needs of SSTV operators. JPS Communications, which manufactures a diverse line of DSP accessories, has done just that with their model SSTV-1 DSP filter. This is a single-mode device targeted directly to the SSTV/fax market. Because it is a single-mode unit, the unit is attractively priced compared to multifunction models, which, despite their usefulness in other modes, are less than optimum for SSTV.

The SSTV-1 is housed in a small, heavy, thick-walled two-piece aluminum cabinet. The manual is small and sparse (18 pages) but entirely adequate given the simplicity of installation and use. A reasonably comprehensive troubleshooting guide is included, as well as a schematic. The details of the DSP processor and the A/D and D/A converters are not documented, but the circuit diagram does include all the analog and digital support circuits.
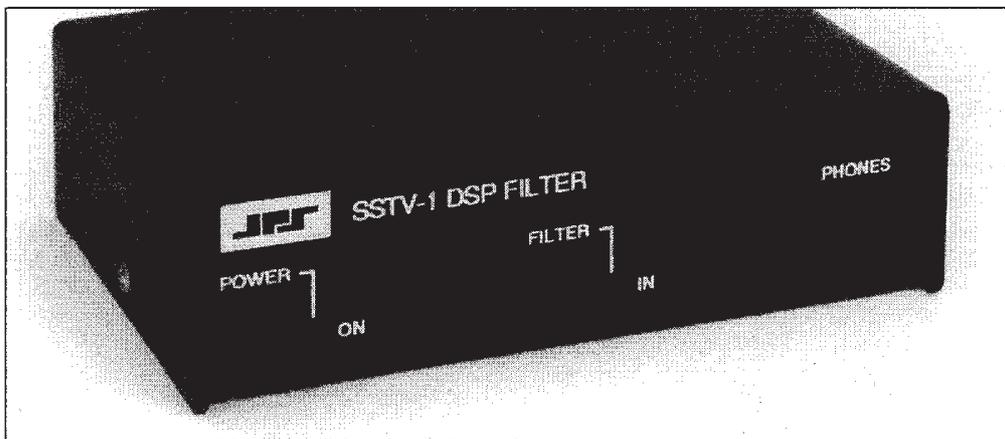
The unit must be powered from an external dc supply (11 to 16 V, not supplied) via a coaxial jack on the rear apron (mating plug supplied). The unit is protected against the application of reverse polarity.

The only other rear-apron items are a grounding lug and RCA phono jacks for **AUDIO INPUT** and **SPEAKER OUTPUT**. The audio input, with a nominal impedance of 22 Ω, can be connected to an accessory audio or data output jack on the HF equipment or paralleled with an external speaker using a **Y** connector. I used the phone-patch audio output on my venerable FT-101E with no loading problems. If all your audio output options are high impedance, clipping one resistor in the SSTV-1 circuit board (detailed in the manual), will convert the unit's input impedance to 47 kΩ.

Although the audio output jack is labeled **SPEAKER OUTPUT** and will drive a low-impedance load, I suggest that the output be connected directly to the input of your SSTV demodulator and that you rely on the internal or external speaker of your transceiver/receiver for normal voice reception.

The front panel is sparse, but there are relatively few operational options with a dedicated unit like the SSTV-1. There is a push-button **POWER** switch (with an LED indicator) for switching the unit on and off. A second **FILTER** switch, with a companion LED indicator, is used to select the filter options, which will be discussed in the next section. A ¼-inch **PHONES** jack for headphone use completes the front panel. Installed as I have suggested, there is little reason to use the **PHONES** jack unless you suspect a cabling problem when the unit is first placed in service.

Test Results

When the front-panel **POWER** switch is off, audio/SSTV signals are switched through the unit just as if the filter was not in place. With the **POWER** switch on, one of two possible filtering modes is selected via the **FILTER** switch, the only other control on the front panel.

With the filter switched out, the unit provides a fairly effective voice-bandwidth filter comparable to the SSB bandpass mode in many other DSP processors. The passband in this mode is flat to within 1 dB from about 200 to 2600 Hz. Signals are down almost 12 dB at 80 and 3000 Hz.

Pushing the **FILTER** switch in enables the SSTV-1's slow-scan filtering mode. JPS has implemented a dual bandpass filter, optimized to the SSTV signal format. The first bandpass filter has cut-offs at 1050 and 1350 Hz to pass the sync (1200 Hz) and VIS (1100 and 1300 Hz) signals. The sync/VIS passband is flat to within 0.5 dB from 1100 to 1300 Hz. At 1400 Hz, attenuation is almost 18 dB, providing useful rejection in the narrow audio "window" between the sync and

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Table 3
JPS SSTV-1 DSP filter, serial number 010156

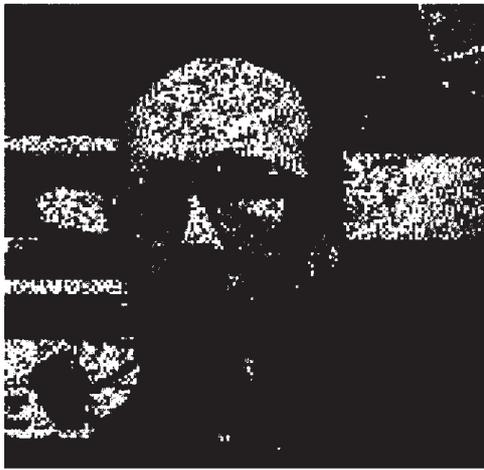| *Manufacturer's Claimed Specifications*	*Measured in ARRL Lab*
Power requirements: 11 to 16 V dc @ 500 mA peak.	170 mA at 12.7 V (with 2 V input signal).
Audio input: 22 Ω or 47 kΩ; 100 mV to 2 V RMS.	Not measured.
Input-to-output delay: 6 ms.	As specified.
Filter bandwidths: 1050 Hz to 1350 Hz and 1500 to 2300 Hz at –6 dB.	At –6 dB points: 1039 to 1370 and 1507 to 2303 Hz.
Ultimate attenuation: 60 dB.	As specified.
In-band ripple: <1 dB.	Approximately 0.5 dB maximum.
Audio output: <0.5% distortion at 0.5 W output; 2 W at 10% distortion into 8 Ω.	0.5% THD at 1.4 W; 10% THD at 2.3 W into 8 Ω.
Size (height, width, depth): 1.7×6×4.3 inches; weight, 2 lbs.	

Figure 2—This image is the result of mixing an S-7 FAX-480 image with an S-9 heterodyne with a frequency of 900 Hz. Image display was initiated with the filter in the circuit; otherwise, the image could not have been displayed. The filter was then switched out of the circuit, resulting in a black display, with no trace of image data, as a result of capture of the SSTV limiter by the offending 900-Hz tone. The filter was then switched back in for the remainder of the frame. Other than some minor noise-like artifacts (discussed in the text), the filter was completely effective in eliminating out-of-band interference that would normally have eliminated any chance of displaying the image.

video passbands. At the low-frequency end, attenuation rises to about 26 dB at 1050 Hz and exceeds 30 dB from about 950 down through 100 Hz.

The second bandpass window covers the video spectrum from 1500 to 2300 Hz. The actual passband in the unit tested was a bit tighter. Measured attenuation was 6.8 dB at 1500 Hz and under 0.5 dB between 1700 and 2200 Hz. At 2300 Hz attenuation rose to slightly over 5 dB. Given the dynamic range of most SSTV limiters, the modest attenuation at the black and white ends of the video range is not significant with moderate to strong SSTV signals. It can, however, create an anomaly when receiving comparatively weak SSTV signals. JPS recently introduced a version of the SSTV-1 with low attenuation between 1500 and 1700 Hz. If you need this feature, specify it when ordering.

Given the sharp filter response, accuracy in tuning the video signal is an important consideration. The LED indicator associated with the **FILTER** switch on the front panel set up to function as a 1200-Hz sync-tuning indicator and will flash when SSTV sync pulses are present. If you tune carefully for the brightest pulses, the incoming SSTV signal will be properly tuned. The AVT SSTV and conventional HF fax formats don't use 1200-Hz sync pulses, so the indicator will not function with such signals, although it may flash intermittently with noise or QRM.

On the Air

The unit was initially installed at the SSTV operating position and used for about a week. The unit was then transferred to the test bench. At this stage, one SSTV source (ViewPort VGA system) was used to modulate an extremely low-powered SSB exciter that was routed to the FT-101E receiver through a step attenuator. A Pasokon SSTV system was used to demodulate the SSTV signals from the receiver. This set-up permitted precision control of the received SSTV signal level and permitted the SSTV signal to be mixed with varying levels of real-world noise, heterodyne tones of varying frequency and amplitude, and actual samples on on-the-air SSB chatter and splatter. In short, the bench-testing phase permitted real-world simulation of a number of worst-case simulations under controlled conditions, compared with hit-and-miss and poorly controlled situations that occur when actually operating SSTV.

All DSP processors have a delay between signal input and signal output as a result of the processing overhead inherent in the hardware and the software algorithms. The measured delay in the unit tested was between 5 and 6 ms. If you begin display with the **FILTER** switch out and then push it in at some point in the picture, the output delay is clearly evident. It will create a one-line disruption in triggered SSTV modes (such as the various Robot color modes), but, in the more useful synchronous modes (Scottie, Martin, AVT, and FAX480), the offset persists as long as the filter is in the circuit, shifting the entire display to the left the equivalent of the width of the line sync pulse. The result is quite distracting. The only way to avoid the effect of output delay is to switch the filter in before the picture starts or to leave it on for the entire operating session. Leaving the unit on at all times is entirely practical.

One of the first tests I performed was to mix wideband noise with the video signal at the input of the SSTV demodulator. In this configuration, the filter was moderately effective in reducing the impact of noise on the image. In contrast, on-the-air testing failed to demonstrate any significant noise reduction, an observation confirmed in the bench-testing phase. The noise output from a modern HF receiver is *not* wideband noise, but rather is noise largely confined to the 300 to 2600-Hz signal passband established by the RF and audio filtering incorporated into the receiver. The filter does reduce the audio passband by approximately 50%, but that represents only a 3-dB reduction in the noise power spectrum. In terms of the peak noise voltage, the reduction is only 1.5 dB. Statistical analysis of image pixel brightness distribution confirmed that the filter was indeed doing its job, but the reduction in noise as perceived by the eye was to small to be significant. Noise reduction can be significant if the receiver does not provide SSB-bandwidth filtering.

The performance of the SSTV-1 in eliminating interference falling outside of the SSTV signal passband is quite spectacular, as shown by the accompanying photograph. A FAX-480 image was transmitted from the ViewPort VGA system and set to an S-7 signal level on the FT-101E. An S-9 heterodyne with a frequency of 900 Hz was then introduced. This frequency is well within the SSB passband and would not normally be attenuated by the receiver circuits or external DSP units in an SSB compatible modes. The heterodyne tone controlled the FT-101E's AGC and the SSTV signal was difficult to hear and highly distorted when monitored on the station speaker. Display was initiated with the filter in the circuit and then was switched out for several seconds before re-engaging the filter. With the filter out, the interfering tone completely captures the input limiter, reproducing as black with no trace of the image data. When the filter was switched in, a good-quality image was displayed. At both the black and white ends of the signal spectrum, there are extremely short signal drop-outs as a result of the finite dynamic range of the SSTV limiter circuit. These effects are hardly objectionable, compared to no image at all with the filter disengaged.

Repeated testing indicated that interference falling outside of the filter passband was essentially eliminated. The SSTV-1 has no capability to eliminate in-band interference. Some of the JPS literature suggests the elimination of in-band interference, probably as a result of the rejection of signals in the very narrow window between and sync and video passbands. While there is useful attenuation over this narrow frequency range, this does not justify claims for significant in-band signal rejection. The present state of the art provides no ready solution to interference falling within the SSTV sync/video passband. Fortunately, the vast majority of real-world interference problems involve signals that fall entirely or at least partially outside of the video/sync window; in such cases, the results with the SSTV-1 can range from useful to truly spectacular.

In summary, the JPS SSTV-1, moderately priced by current DSP filter standards, is an extremely useful accessory for serious SSTV and fax operations. There is still no substitute for courtesy and mutual consideration. Unfortunately, the crowded nature of our bands seems to promote less-than-courteous behavior by both SSB and SSTV operators, each toward the other. When that happens, a filter like the SSTV-1 can certainly help. Just keep in mind that problems that technology can't fix can often be resolved by a combination of patience and diplomacy!

Manufacturer's suggested retail price: $160. Manufacturer: JPS Communications, PO Box 97757, Raleigh, NC 27624; tel 919-790-1011, fax 919-790-1456.