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System One Newsletter

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FFT Analysis of Stereo Composite Signals

The FFT spectrum analysis capability of System One + DSP and System One Dual Domain permits examination of composite (baseband) stereo broadcast signals up to an 80 kHz bandwidth limit. This accomodates the main and sub-channels of FM stereo signals and of the NTSC (BTSC) TV aural stereo signal, and will also permit examination of the lower-frequency FM SCA signals.

FM Stereo Spectra

Figure 1 is a spectrum analysis of an FM stereo composite signal during 100% L+R modulation with a 1 kHz signal. The monaural signal is visible at 1 kHz and 0 dBr amplitude, where 0 dBr represents full modulation. The 19 kHz stereo pilot is at an amplitude of -20 dBr (10% modulation). The sub-channel carrier is visible at 38 kHz (twice the pilot frequency) and -92 dBr amplitude, with sidebands of about -78 dBr amplitude 1 kHz above and below. Figure 2 is a similar analysis, but with 100% L-R modulation. Now, the 1 kHz component amplitude is down 78 dB and the sub-channel sidebands 1 kHz above and below the 38 kHz signal are at -6 dBr. Figure 3 shows the spectrum with a 15 kHz 100% modulation signal. The L-R sidebands now fall at 23 kHz and 53 kHz (38 kHz ± 15 kHz) and are 62 dB below full modulation. Figure 4 shows the result of approximately 50% modulation with an L-R pink noise signal.

BTSC TV Stereo Spectra

Figure 5 shows the spectrum of a BTSC (U.S. standard TV aural stereo) composite signal with 100% L+R modulation from a 1 kHz signal. The harmonics (dominantly odd) from 2 kHz to approximately 10 kHz indicate that the clipper in the stereo generator was slightly mis-adjusted. The pilot frequency is 15.734 kHz, and about 14.5 dB down. The sub-

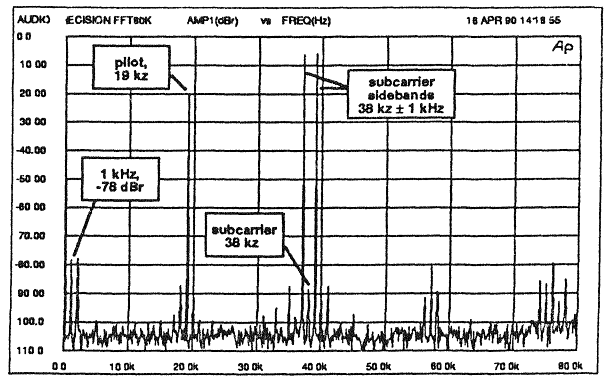

Figure 2 *FM Stereo Composite Signal, 1 kHz 100% L-R Modulation*

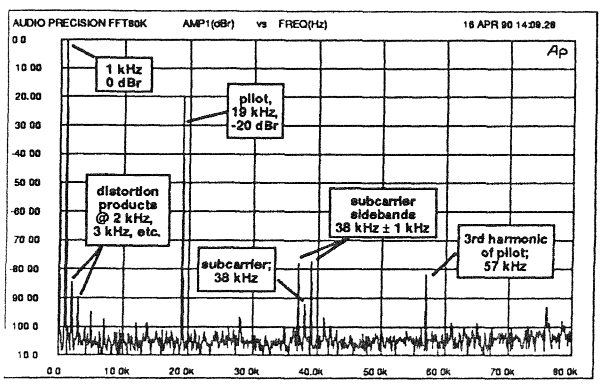

Figure 1 *FM Stereo Composite Signal, 1 kHz 100% L+R Modulation*

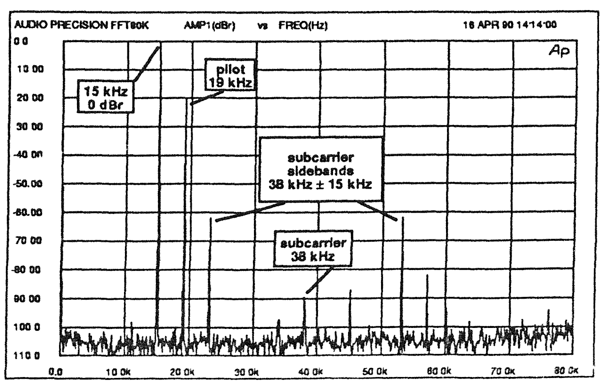

Figure 3 *FM Stereo Composite Signal, 15 kHz 100% L+R Modulation*

channel frequency is twice the pilot frequency, or 31.468 kHz. Above and below the sub-channel carrier the L-R sidebands can be seen, with the exciter residual input noise pre-emphasized and greatly amplified by the spectral companding inherent in the BTSC standard. Figure 6 is a BTSC spectrum with 100% L-R modulation at 1 kHz. Figure 7 shows 100% L+R modulation from a 14 kHz signal. The L-R sidebands fall at 17.468 kHz and 45.468 kHz, at about -17 dBr. Expansion of noise on the sub-carrier is much less with this high-level 14 kHz signal than with a 1 kHz signal (Figure 5). Figure 8 shows 50% modulation with an L+R pink noise signal; Figure 9 shows 50% modulation with an L-R signal. Note that the pre-emphasis slope of the subcarrier sidebands is different with the L-R pink noise signal (10 dB amplitude change across the audio spectrum), compared to the L+R pink noise signal (40 dB change).

System One's DSP modules permit spectrum analysis to 80 kHz with use of a 192 kHz sample rate. The maximum data length which can be transformed is 16k samples, resulting in 8k spectral lines (bins) evenly spaced from 0 Hz (dc) to half the sample rate, for a resolution of better than 12 Hz.

The graphs shown here were created as HPGL-compatible (.GL) files using PLOT.EXE, then imported into Ventura Publisher for incorporation into this newsletter. Printed resolution is limited by the 300 dots per inch resolution of the laser printer in use. A graph over 27 inches wide would be necessary to fully exploit the 8,192-line spectrum with a 300 dpi laser printer.

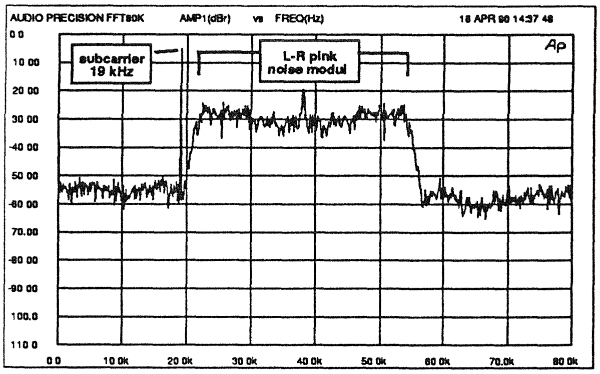

Figure 4 *FM Stereo Composite Signal, 50% Modulation with Pink Noise, L-R Modulation*

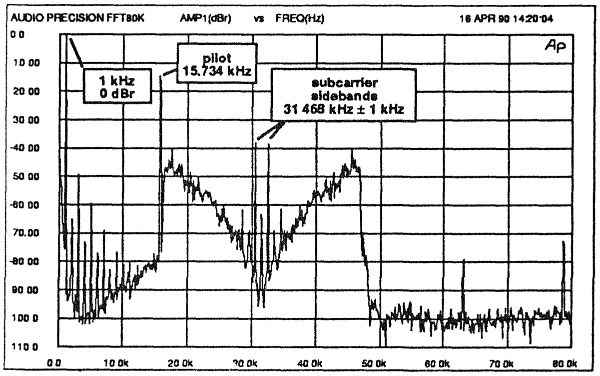

Figure 5 *BTSC Stereo Composite Signal, 1 kHz 100% L+R Modulation*

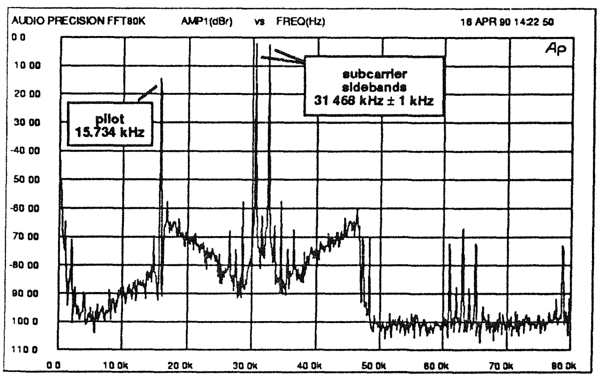

Figure 6 *BTSC Stereo Composite Signal, 1 kHz 100% L-R Modulation*

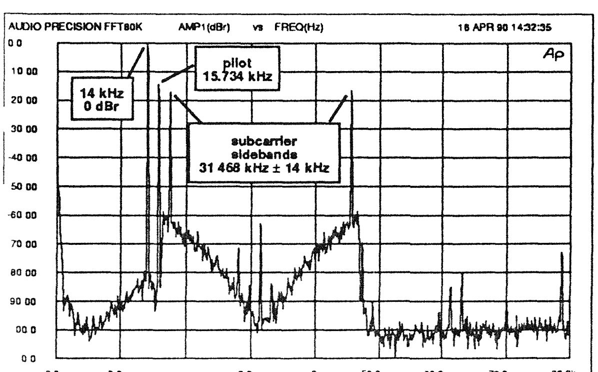

Figure 7 *BTSC Stereo Composite Signal, 14 kHz 100% L+R Modulation*

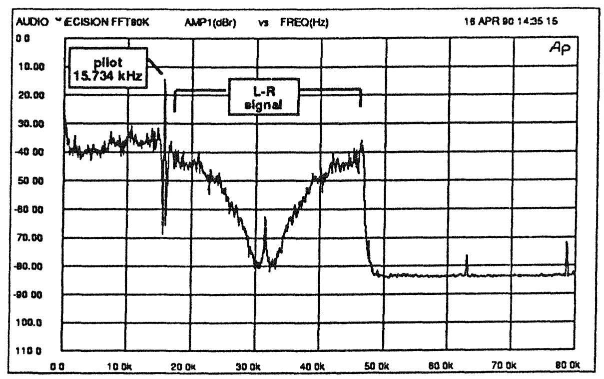

Figure 8 *BTSC Stereo Composite Signal, Pink Noise 50% L+R Modulation*

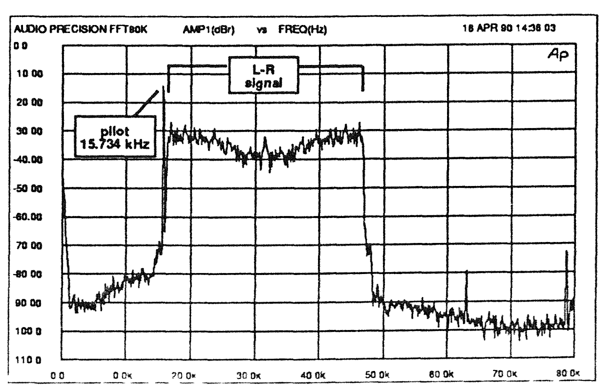

Figure 9 *BTSC Stereo Composite Signal, Pink Noise 50% L-R Modulation*

Compatibility of Old DOS and v2.00 S1.EXE

Compatibility problems may exist between S1.EXE and older DOS versions, such as DOS 2.11 used in some portable computers. The symptom is usually a total lock-up of the computer when S1.EXE is started. The Audio Precision logo never appears on screen, and the computer must be re-booted.

This problem is due to these older DOS versions not properly initializing the portion of memory which deals with the mouse. This is a problem even if no mouse is present. When S1.EXE v2.00 or v2.00a then attempts to load, the absence of a proper "mouse vector" causes S1.EXE to go to some non-functional memory address and never return.

A "fix" for this problem has been written and is available free from Audio Precision or your Audio Precision Distributor. This program is called NULMOUSE.COM. It must be copied onto your hard disk or system disk and run by your AUTOEXEC.BAT program each time the computer is started, before attempting to load S1.EXE. Future revisions of S1.EXE will add the necessary features internally, but NULMOUSE.COM will be necessary until then.

Running Procedures and Loading Files from Any Directory

Would you like to run commonly-used procedures from any directory on your hard disk, without needing to first copy them into the current directory or specially prepare the procedures and test files by using full path names? Would it be useful to load tests while in any directory without having to type in the full path name? Would you like to "NAME" (attach) a .DSP file, .EQ file, DELTA file, or .SWP file to a test in the current directory without first copying those files into the current directory? If you are using DOS version 3.10 or later, all this is easily possible by use of the DOS APPEND function.

APPEND.EXE is an "external" DOS command; it is actually a separate program supplied on diskette as part of DOS, rather than being always internally present (like DIR, for example) when DOS is loaded. APPEND.EXE is usually run as part of your AUTOEXEC.BAT file when the computer boots, and thus remains effective during all operating sessions. The APPEND command must be followed with a list of sub-directories containing non-executable files (usually data files) which you wish to access from any directory on the hard disk. Non-executable files are basically all types of files other than .EXE, .COM, or .BAT files. Thus, System One's .PRO, .TST, .EQ, .DSP, etc. are all non-executable files. Whenever you attempt to load a non-executable file and DOS cannot find it in the current sub-directory, DOS goes to the APPEND list of sub-directories and searches through them, in sequence, for a file of that name. If DOS finds the file, it loads and uses it as if it were in the current sub-directory. The APPEND function thus operates similarly for non-executable files to the way the PATH function works for executable files (.EXE, .COM, etc.). So, you can choose to keep all your commonly-used .PRO and .TST files, plus things like all .DSP program files (if you are a DSP owner), .EQ files, etc. in one or a few sub-directories. Then, list those "reference" sub-directories with the APPEND function, and you can load them from anywhere. The DOS APPEND function is not to be confused with S1.EXE's APPEND TEST and APPEND DATA commands, which are a totally different concept.

The form of the APPEND command is:

APPEND=c:\dirname1;c:\dirname2;

where dirname is the full path name of the sub-directory which you want to be automatically searched. Suppose, for example, that you wish to keep all .DSP programs in the c:\S1\DSP sub-directory and your commonly-used .EQ, .PRO, and .TST files in a c:\S1UTIL sub-directory. The command in your AUTOEXEC.BAT file would then read:

APPEND=c:\S1\DSP;c:\S1UTIL;

Note that use of the DOS APPEND will not make .TST, .PRO, etc. file names appear in other directories in response to a DIR command or S1.EXE's LOAD command. But, if you type in the .TST or .PRO file name at the LOAD prompt, the DOS APPEND command will load it if it is in one of the sub-directories specified in the APPEND command. And, since a procedure (.PRO) in effect types in every .TST file name and each .TST file may specify .EQ, .LIM, .DSP, and .SWP files, you only need remember the .PRO name to get it all.

Caution on File Erasure

Note that DOS commands such as DEL or ERASE operate only on the current sub-directory unless a full path name is specified for the file to be erased. This may lead to surprises in the common S1.EXE procedure case of attaching one error file name via the NAMES ERR-FILE command to every test in a procedure, in order to have a final summary at the end of the procedure. It is normal in this case to start the procedure with a

DOS ERASE errfilename.txt/R

line to erase the old error file (from the last time the procedure ran). Otherwise, new pass/fail data is appended at the end of the old error file and the error file keeps getting longer and longer. If such a procedure is run for the first time from another directory via the power of the APPEND function, the DOS ERASE command at the beginning will do nothing since no error file of that name exists yet in the new directory. When the first test runs, DOS looks in the current directory and finds no error file of the specified name to which to add data. However, the APPEND function will then find the old error file in the "reference" directory, add the new test data at the bottom, and re-save it in the "reference" directory. The most straight-forward solution to this problem is simply to be sure no old error file is stored in the "reference" directory along with the .PRO, .TST, and other necessary files.

Determining Equivalent Input Noise

Equivalent Input Noise (EIN) is the term used to describe noise present in the input circuitry of a device such as a microphone preamplifier or mixing console. It is not possible to measure equivalent input noise directly by connecting an audio analyzer across an input connector. Instead, equivalent input noise is determined by a combination of measurements and calculations. Both the measurements and calculations can be automated into a simple and rapid System One procedure. Evan Mater of Vark Audio in Cabin John, Maryland, developed such a procedure which is now shared with all System One users through this article.

Basically, determining equivalent input noise is a three-step process:

1. Determine the device gain.
2. Measure the device output noise.
3. Subtract the device gain from the measured output noise.

Gain Definition and Measurement

In order to have an accurate gain figure for subtraction from measured output noise, the gain must first be determined. Before we can determine gain, we must define what type of gain we should use. Two basic gain-measurement techniques are frequently called voltage gain and transducer gain.

Voltage gain is determined by dividing the measured output voltage of a device by the measured input (stimulus) voltage while the device is operating in a linear region. Even when the device output is properly loaded into a resistor equal to its normal load, this technique ignores the relationship between the device input impedance and the source impedance of the stimulus. A basic principle of electrical measurements is, while measuring, to reasonably emulate the working system environment of the device under test so that the measurements will represent the performance of that device when in its usual on-line working environment. A simple voltage gain measurement technique may accurately emulate performance of individual amplifier stages inside a piece of equipment, where output impedances are near zero Ohms and input impedances are tens or hundreds of kilohms. Most modern professional audio and broadcasting equipment has input impedances considered to "bridge" the normal source impedance. Bridging means having a high input impedance compared to the normal load. However, bridging input impedances are not infinitely high. A typical bridging input may be on the order of five to twenty times the source impedance. An input resistance five times the source resistance will load down the source to 0.833 times its open-circuit voltage (emf), or by 1.58 dB. An input ten times the source resistance still causes 0.83 dB loading (0.9090 times open-circuit voltage). Gain determined by simple terminal voltage ratios will thus be higher than the actual system gain with real-life (non-zero) source impedances. This erroneously-high gain, when subtracted from the measured output noise, will result in an erroneously-low computation of equivalent input noise.

A more generally correct gain determination technique is sometimes called transducer gain. In this technique [illegible] In stead, [illegible] impedance is the same as the output impedance of the device connected to this point during normal operation (the microphone, in this case). The open-ci[illegible]uit voltage of the generator is set to a convenient reference value within the linear range of the device. The output voltage of the device is measured while working into a load resistance which properly emulates its load during normal system operation. Then, gain is computed as the ratio of the measured (loaded) output voltage to the generator open-circuit voltage (emf). Any loading down of the generator output open-circuit voltage by the device input impedance emulates normal system operation, and simply appears as a reduction of gain compared to the (unrealistic) voltage gain.

Measuring Noise

Noise measurements are quite straight-forward with System One. Measurement bandwidth is a critical factor during measurement of noise or any other spectrally-distributed signal. System One's standard low and high pass filters may be set to produce the desired measurement bandwidth. If a weighted Equivalent Input Noise determination is desired, an optional weighting filter such as A-weighting or CCIR weighting may be added. The detector should be true RMS for all noise measurements except weighted noise per CCIR Recommendation 468, which calls for a quasi-peak detector.

Subtracting Gain From Noise

Subtraction can be done automatically in System One software via the COMPUTE DELTA command. COMPUTE DELTA subtracts the data value in any file specified by the NAMES DELTA command from the data presently in memory. Thus, the basic flow of an Equivalent Input Noise procedure is to determine gain, save this gain value to disk as a .TST file, measure noise, use NAMES DELTA to specify the just-determined gain file to be subtracted, and execute the COMPUTE DELTA command to do the subtraction.

Obtaining Gain as a Positive Value

The straight-forward way to determine transducer gain with S1.EXE software is to select GEN AMPL (generator amplitude) as DATA-1 in dBV units, use the REGULATION feature to cause generator a[illegible]plitude to be adjusted for an exact 0.0 dBV output from the device, and then use F9 to display as data the resulting value of generator programmed (open-circuit) amplitude. Assuming a typical microphone preamplifier with approximately 60 dB gain, the result will be a displayed DATA-1 value of GEN AMPL of -60.0 dBV. We must have a positive value of gain to subtract from the noise measurement, however. The COMPUTE INVERT command inverts data by "rotating" it around the 1.000 Volt (0.00 dBV) value. This is why we must do the regulation and gain determination in dBV units rather than dBu. The finally-determined value of Equivalent Input Noise can still be stated in dBu by a simple and automatic units change on the panel at the end of the procedure.

The Procedure

So, we now can describe the flow of a procedure to automate all these processes. It will look like this:

[illegible] REGULATION

[illegible] late device output to 0.00 dBV by varying [illegible]

```
GENERATOR          LOCAL     SWEEP (F9) DEFINITIONS        REGULATION
WAVEFORM   SINE  NORMAL     DATA-1      GEN     AMPL      ENABLE       SWEEP
  IN-FREQ  60.0000  Hz      GRAPH TOP   +20.00   dBV
FREQUENCY  1.00000 kHz        BOTTOM    -40.00   dBV      REGULATE     ANLR   RDNG
           FAST               # DIVS    0        LIN        TO         +0.00   dBV

AMPLITUDE  -60.00   dBV     DATA-2      ANLR    NONE      BY VARYING   GEN    AMPL
                            GRAPH TOP            OFF        HI BOUND   -20.00  dBV
OUTPUT     A        BAL       BOTTOM             OFF        LO BOUND   -90.00  dBV
           150Ω   FLOAT       # DIVS             LIN
                                                          OPERATION    LINEAR
BURST ON   1.000   CYCL     SOURCE-1    GEN     NONE      STEP SIZE    +3.01   dB
  INTERVAL 3.000   CYCL       START              OFF      ITERATIONS   30
  LOW LVL  -80.17   dB        STOP               OFF
                              # DIVS    0        LOG
AMPSTEP    0.010    +
FREQSTEP   1.260    *       # STEPS     0
                              TABLE     OFF
REFS Freq  1.00000 kHz
     dBr   387.3  mVrms     DISPLAY     MONO-GRAPH
     dBm/W 600.0    Ω

Ctrl-F3 SWEEP OFF                        To change setting, use SPACE bar.
Regulation Enable                        To return to menu, press the Esc key
```

Figure 1 *Key Setup Panels, REGULATE.TST to Determine Transducer Gain of Device*

generator amplitude with the LINEAR algorithm. A good starting point for amplitude on the generator panel is about -60.0 dBV. Generator output impedance must be 150 Ohms balanced for normal microphone inputs. DATA-1 is selected as GEN AMPL in dBV units. AMPL TOLERANCE on the SWEEP SETTLING panel should be about 0.3%. SOURCE-1 is GEN NONE for a single-point "sweep" with tabular display. The key panels of this test are shown in Figure 1.

2. Execute the regulation and test cycle via <F9>.

3. Use COMPUTE INVERT to change the algebraic sign of the generator amplitude from minus to plus, thus making it a gain value since the output voltage was exactly 0.0 dBV.

4. Save the result to disk with a name such as GAIN.TST, to be used as the DELTA file.

5. Load a test with AMPLITUDE measurement function. Select high-pass and low-pass filters for the appropriate noise measurement bandwidth. If A-weighted or CCIR-weighted noise measurements are required, select the proper optional filter and detector (Q-Pk for CCIR-weighted). Select ANLR RDNG as DATA-1, and the generator output OFF. The AMPL TOLERANCE on the SWEEP

```
GENERATOR          LOCAL     ANALYZER           LOCAL     SWEEP (F9) DEFINITIONS
WAVEFORM   SINE  NORMAL     MEASURE    A AMPLITUDE        DATA-1      ANLR    RDNG
  IN-FREQ  60.0000  Hz        RANGE               AUTO    GRAPH TOP   +20.00   dBV
FREQUENCY  1.00000 kHz      READING                V        BOTTOM    -40.00   dBV
           FAST             LEVEL                  V        # DIVS    0        LIN
                            FREQUENCY              Hz
AMPLITUDE  -60.00   dBV     PHASE                  OFF    DATA-2      ANLR    NONE
                                                          GRAPH TOP            OFF
OUTPUT     OFF      BAL     BP/BR FREQ             AUTO     BOTTOM             OFF
           150Ω   FLOAT     DETECTOR   AUTO        RMS      # DIVS             LIN
                            BANDWIDTH  22Hz      22kHz
BURST ON   1.000   CYCL     FILTER     OFF                SOURCE-1    GEN     NONE
  INTERVAL 3.000   CYCL                                     START              OFF
  LOW LVL  -80.17   dB      CHANNEL-A  INPUT     100kΩ      STOP               OFF
                              RANGE              AUTO       # DIVS    0        LOG
AMPSTEP    0.010    +       CHANNEL-B  INPUT     100kΩ
FREQSTEP   1.260    *         RANGE              AUTO     # STEPS     0
                                                            TABLE     OFF
REFS Freq  1.00000 kHz      REFS Freq  1.00000 kHz
     dBr   387.3  mVrms          dBr   387.3     mV       DISPLAY     MONO-GRAPH
     dBm/W 600 0    Ω            dBm/W 600.0     Ω

22kHz 30kHz 80kHz >500kHz                To change setting, use SPACE bar.
Anal zer L w ass filter                  To return to menu  press the Esc key
```

Figure 2 *Setup Pan... ...OISE.TST*

```
NOISE  19 APR 90  09:34:42
NONE(OFF)        AMPL(dBu)
     OFF    -117.58  dBu
```

Figure 3 *Results Display, Equivalent Input Noise Procedure*

SETTLING panel should be about 10% for the expected variations in noise level. Again, GEN NONE for SOURCE-1 will produce a single-point tabular display. The panels of this test are shown in Figure 2 for an unweighted RMS 22 kHz bandwidth noise measurement.

6. Prompt the operator via a screen message to disconnect the cable from System One's generator to the device input and replace it with a 150 Ohm terminator directly at the device input. Even though System One's output voltage is specified to be less than -140 dBV in the OFF condition, ground loops or imperfectly-shielded cables are almost certain to prevent accurate noise measurements through a high-gain microphone preamp unless a terminator is mounted directly at the input connector.

7. Measure noise via <F9>.

8. Specify the file to be subtracted via NAMES DELTA GAIN.TST.

9. Execute COMPUTE DELTA to do the subtraction.

10. Go to the panel and change the DATA-1 units from dBV to dBu as normally desired in professional audio and broadcasting.

11. Display the final result and pause via <F7><F10>. A typical result is shown in Figure 3.

An actual S1.EXE procedure to accomplish this sequence is listed below as Figure 4. Thanks again to Evan at Vark Audio for the concepts and many of the details of this procedure.

```
-----|-----1----||:-----2-----|-----3-----|-----4---
PROCEDUREv2.00
LOAD TEST REGULATE/R
/F9/E
COMPUTE INVERT
SAVE TEST GAIN/RY
LOAD TEST NOISE/R
UTIL PROMPT /R/R/R/R/R
    DISCONNECT CABLE FROM GENERATOR/R
    TO DEVICE INPUT.  CONNECT 150 OHM/R
    SHIELDED TERMINATOR DIRECTLY AT/R
    DEVICE INPUT./R/R
    PRESS <ENTER> TO CONTINUE./E
/F9/E
NAMES DELTA GAIN/R
COMPUTE DELTA /R
PANEL S1↓||/R
/F7/F10/E
UTIL END
```

Figure 4 *Procedure to Determine Equivalent Input*

Importing High-Resolution Graphs into Desktop Publishing Software

The PLOT.EXE and POST.EXE programs originally released permit sending high-resolution graphs to HPGL plotters, Postscript-compatible laser printers, or the HP LaserJet printer equipped with "Plotter in a Cartridge" (see story below regarding LaserJet III and LaserJet IIP). The resolution of such graphs is limited only by the number of points measured during the test, and by the resolution of the plotter or laser printer. Resolution of the computer display system is not a factor, since these are vector graphic representations rather than pixel representations.

In addition to directly driving a plotter or laser printer, PLOT.EXE and POST.EXE also can write a file to disk for later plotting or printing. Many desktop publishing programs, such as Xerox Ventura Publisher, have the ability to import vector-type graphic files. The files saved to disk by the first versions of PLOT.EXE and POST.EXE, unfortunately, were not compatible with Ventura Publisher. Thus, the only way until now to import graphics files into Ventura Publisher was as pixel-limited screen capture files such as the .PCX (PC Paintbrush) format. System One graph illustrations used in previous issues of AUDIO.TST and in User's Manuals have been imported in .PCX format.

Version 2.02 of PLOT.EXE has just been completed, making its .GL file output compatible with Ventura Publisher. All graphs in this issue of AUDIO.TST were obtained by the SAVE GRAPH command of S1.EXE, followed by use of the LOAD GRAPH and OUTPUT commands of PLOT.EXE.

POST.EXE has also been modified into a version 2.02 which can save Encapsulated PostScript (.EPS) files. These files can be imported into Ventura Publisher and printed only to PostScript-compatible laser printers. Note that .EPS files display on screen only as a large X in Ventura Publisher.

For a copy of versions 2.02 of PLOT.EXE and POST.EXE, contact Audio Precision or your Audio Precision Distributor.

LaserJet III Is Directly HPGL Compatible

The new Hewlett-Packard LaserJet III includes HPGL plotter emulation as a standard feature, with no accessory cartridge required. To print high-resolution graphs directly from PLOT.EXE, the LaserJet III requires 1 megabyte of optional memory to be added and must be placed in "Page Protect" mode via front panel menu keys. For System One users, the LaserJet III is the most attractive purchase of the H-P laser printer range. Contact Audio Precision or your Audio Precision distributor for a copy of version 2.02 of PLOT.EXE which supports the LaserJet III.

We understand from Pacific Data Products that a version of "Plotter in a Cartridge" is now available for the H-P LaserJet IIP. With this cartridge, the HP emulates an HPGL plotter and plots high-resolution graphs from PLOT.EXE.

System One Nominated for TEC Award

We were pleased to learn that System One + DSP has been nominated in the "Ancillary Equipment" category for a TEC award. MIX Magazine established these awards some years ago. MIX readers vote on the nominations; the winners are presented with awards at a banquet held in conjunction with the Audio Engineering Society convention in the autumn. If you read MIX Magazine, you may wish to look for the ballot which will accompany the July issue and vote for your favorite audio test equipment in the Ancillary Equipment category.

Quick Tip—Bold Text from PLOT.EXE

First, plot the graph as you normally would with your desired selections for line attributes and, if desired, wide lines. If you are using the LaserJet II with Plotter in a Cartridge, be sure to turn off Eject Page until completing the following actions.

Next, on the attributes panel, turn off all lines except the text by selecting Pen 0 for all other portions of the graph.

Then, on the position panel, adjust the scale of the plot by perhaps 0.1% larger and re-plot the text. Change the scale to perhaps 0.1% smaller and re-plot. Note that the scale field only displays resolution to the nearest 1%, but the field accepts numbers of greater resolution as can be seen by adjusting the scale and watching the calculated position coordinates. Repeat this process as many times as necessary with progressively larger and smaller plot scale, bracketing both above and below the original scale, to obtain the desired effect. The scale increments and number of increments will need to be determined experimentally to produce the desired effect, depending upon the plotter pen width or laser plotter line width. Once a satisfactory set of increments and repetitions has been selected, the setups can be saved as configuration files (.CFP). A batch file with the appropriate command line options can then automate the entire process on future graphs.

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