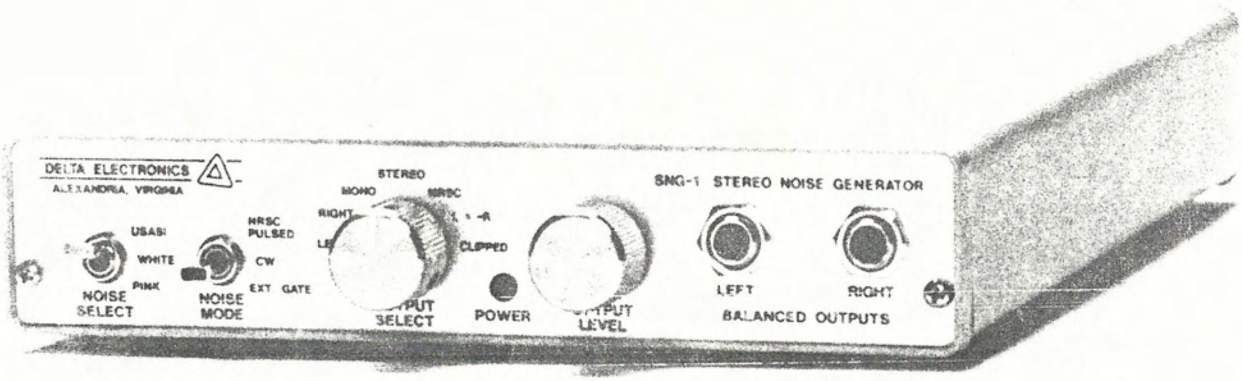
INSTRUCTION MANUAL
MODEL SNG-1
STEREO NOISE GENERATOR



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D93-414A

ISSUE DATE: 31 JANUARY 1990

SPECIFICATIONS

Model	SNG-1 Stereo Noise Generator		
Amplitude Distribution	Gaussian and Random		
Peak to RMS Ratio	Capable of ≥4:1 to full rated output		
Noise Weighting	White	20 Hz to 20 kHz:	±1 dB
		20 Hz to 50 kHz:	±3 dB
	Pink	−3 dB/Octave 20 Hz to 20 kHz:	±1 dB
	USASI	+6 dB/Octave 100 Hz high pass and −6 dB/Octave 320 Hz low pass:	±1 dB
Connectors	Rear panel dual XLR balanced outputs		
	Front panel dual stereo phone jack balanced outputs		
	BNC input for external amplitude control— continuously variable from 0V (off) to +5V (full output)		
	IEC Standard line cord receptacle		
	3AG Fuse holder (1/4 Amp standard-blow fuse)		
Output Selection	Stereo (independent left and right)		
	Mono (L=R)		
	Left only		
	Right only		
	NRSC (subchannel 3 dB below main channel)		
	Subchannel only (L=−R)		
	Clipped (L=−R with clipped peaks on L+ and R−)		
Output Level	Full output:		
		≥+10 dBm into 600 ohms balanced	
		≥0.5 Vrms into 50 ohms unbalanced	
		≤10 mV DC offset	
	Output level adjustable by front panel control		
Channel Tracking	0.5 dB between channels		
Turn On Time	8 seconds after application of power		
Output Impedance	Approximately 25 ohms balanced, 12 ohms unbalanced		
Pulse Output	NRSC:	2.5 Hz rate at 12.5% duty cycle with 20 dB peak to average ratio	
	External:	Amplitude controlled by external signal (EXT GATE)	
	Continuous:	Not pulsed (CW)	
Line Voltage	120/240 VAC ±10%, 47 to 63 Hz (line voltage selected by internal jumpers)		
Size	7.3 inches (185 mm) wide		
	2.6 inches (66 mm) high		
	9.9 inches (252 mm) deep		
Weight	3 lbs. 14 oz. (1.76 kg)		
Operating Temperature	0 to 50 °C ambient		

INSTRUCTION MANUAL
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INTRODUCTION

The Delta Electronics Model SNG-1 produces white, pink or USASI (United States of America Standards Institute) weighted, stereo noise. Seven different configurations of the left and right channel outputs are easily selected. A front panel potentiometer controls output noise amplitude, which can also be modulated by internal or external pulse sources.

Since the SNG-1 has three noise weightings and seven output modes, it is useful in a wide variety of studio processing and transmitter equipment measurements. Applications include tape head alignment, dynamic audio processor adjustment using pulsed noise, adjustment of stereo equalization filters, and tracking stereo phasing in an audio chain.

The SNG-1 meets the requirements of National Radio Systems Committee (NRSC) standards NRSC-1 (EIA-549-1988) and NRSC-2 for testing AM radio transmission facilities. These standards require a pulsed USASI weighted noise source to measure both the spectrum of the audio delivered to an AM transmitter and the RF spectrum of the transmitter output. The SNG-1 meets these requirements for both monophonic and stereophonic stations.

DESCRIPTION

Figure 1 shows detailed front and rear panel views of the Stereo Noise Generator, depicting the components described below.

Front Panel Components:

The NOISE SELECT switch selects white, pink or USASI weighted noise. The NOISE MODE switch selects continuous, internal pulsed or external pulsed noise. In the CW position, the noise is not pulsed and the OUTPUT LEVEL potentiometer controls the noise output level. In the two pulsed modes the OUTPUT LEVEL control sets the maximum output level. In the NRSC PULSED position, an internal circuit pulses the noise in accordance with NRSC standards. In the EXT GATE position, a voltage applied to the EXT GATE INPUT connector on the rear panel controls the noise level.

The seven position OUTPUT SELECT switch determines the left channel and right channel outputs. In the LEFT or RIGHT switch positions, only the left channel or only the right channel, respectively, is active. These positions are useful in wide bandwidth separation measurements where the level of intrusion of one channel into the other channel is measured. For example, the equalization filters of an AM stereo exciter may be quickly adjusted using left channel only or right channel only noise.

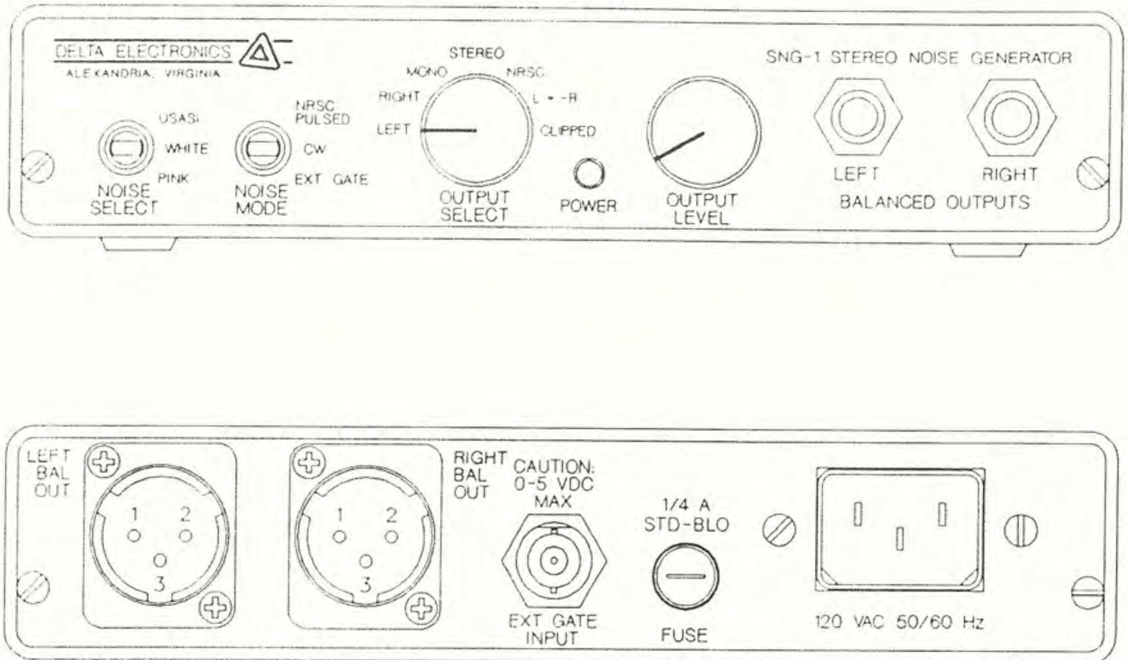

FIGURE 1
SNG-1 FRONT AND REAR PANELS

In the MONO position, the left and right channels are identical so that the main channel (L+R) exists and the subchannel (L−R) has no signal. Similarly, in the L=−R switch position, the subchannel exists with no main channel signal. These two outputs are useful in measuring the leakage of the main channel signal into the subchannel or vice versa for crosstalk measurements. The CLIPPED position produces only subchannel noise with the negative peaks of the right channel clipped and the positive peaks of the left channel clipped. This output is useful for detecting polarity and phasing errors in a chain of audio equipment.

The STEREO position produces independent left and right channels with the same output level. In the NRSC position, the left and right channels are partially blended so that the subchannel level is 3 dB below the main channel level. This approximates the ratio of main channel level to subchannel level in program material.

Two 1/4-inch stereo phone jacks allow easy access to the left channel and right channel balanced outputs. These jacks are compatible with ANSI/EIA Standard RS-453-78 stereo 1/4-inch phone plugs. The tip and ring are the positive and negative balanced outputs, respectively, with the sleeve as signal ground. With a plug inserted, the signal to the rear panel XLR connectors is broken to prevent inadvertent parallel connection of two devices to the SNG-1 output amplifiers. Do not use monophonic phone plugs – monophonic plugs short the ring to the sleeve, thereby shorting to ground the negative balanced output amplifier.

Note: Not all 1/4" phone plugs are the same! During the development of the Stereo Noise Generator significant differences between "standard" 1/4-inch phone plugs were observed. Excess plug length may result in intermittent tip connections, and insufficient tip diameter may not break the shunt connection to the rear panel XLR connectors.

Switchcraft 260-series and 290-series stereo phone plugs meet ANSI/EIA Standard dimensions accurately. These plugs are available from Delta, as well as most distributors. Please write or call for information.

Rear Panel Components:

AC power is supplied to a standard IEC line cord receptacle, which contains an integral EMI/RFI filter. A fuse holder meeting IEC shock-safe specifications holds a standard type 3AG 1/4 Amp fuse. The fuse is accessed with a flat-bladed screwdriver.

A line cord fitted with a standard North American male connector and an IEC female connector supplies main power. Standard color codes for the individual conductors are brown=line, blue=neutral, and green/yellow=ground. Alternate conductor codings are black=line, white=neutral, and green=ground.

The BNC connector labelled EXT GATE INPUT allows external control of the noise output level when the NOISE MODE switch is in the EXT GATE position. An input voltage between zero and positive five volts will vary the output level between off and full output, respectively. This allows the user to create noise pulses whose repetition rate, duty cycle, and attack and decay times are controlled entirely by an external function generator. This input is high impedance with an overload protection network.

The two XLR male connectors provide left and right channel balanced outputs. Pin 1 is signal ground, pin 2 is positive and pin 3 is negative. As explained above, these outputs are routed through the front panel phone jacks, so that whenever phone plugs are inserted, the signals to the XLR connectors are disconnected.

THEORY OF NOISE

White noise is random noise with a uniform spectral energy distribution. That is, the noise power is evenly distributed over any frequency band of interest. Any two segments of spectrum with equal bandwidths will measure equal RMS noise voltages. This fact makes white noise useful for frequency response measurements. White noise is random when its amplitude is not predictable except in a statistical fashion. The amplitude distribution of Gaussian white noise conforms to the familiar bell-shaped normal distribution curve, shown below in Figure 2. The horizontal axis shows noise amplitude in standard deviations (σ), where one standard deviation is equal to the RMS voltage of

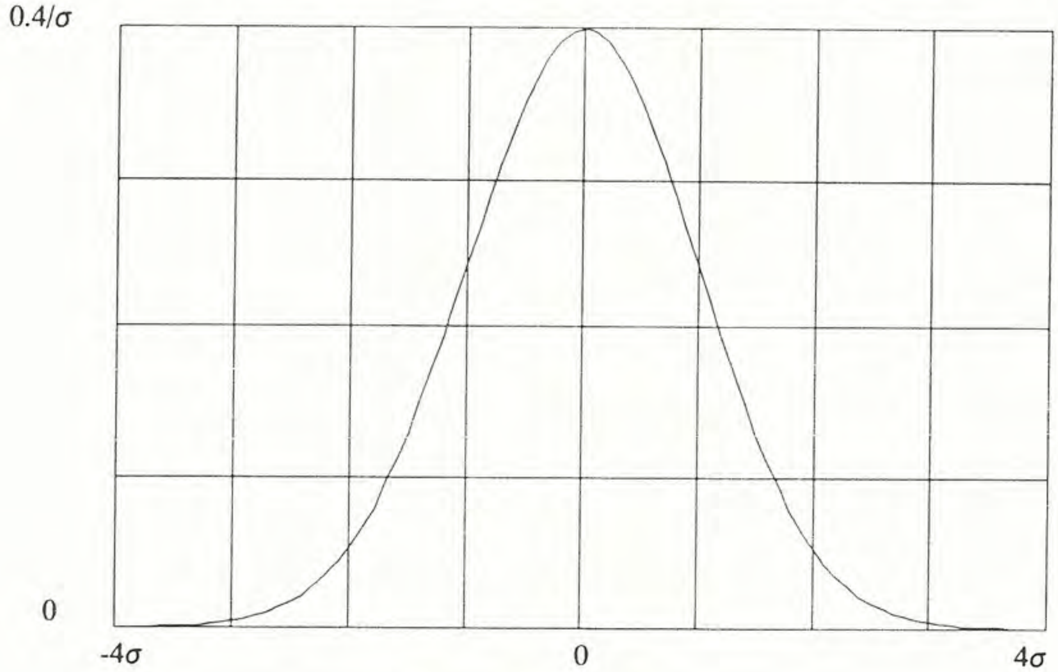

FIGURE 2
PROBABILITY DENSITY FUNCTION

the noise. For any voltage segment along the horizontal axis, the corresponding area under the distribution curve is the probability that the noise voltage will lie within that voltage segment at any instant and is equal to the fraction of the time that the noise voltage is in the voltage segment. The area under the curve from -4σ to $+4\sigma$ is very nearly 1. In other words, the instantaneous noise voltage almost never exceeds plus or minus four times the RMS voltage. A crest factor of four is therefore sufficient to pass Gaussian noise.

Figure 3 shows the response characteristics of the white, pink, and USASI networks used in the SNG-1[1]. The white noise is deliberately band-limited to provide a known noise bandwidth while maintaining flat response in the audio frequency range. The USASI curve has a high pass corner frequency at 100 Hz and a low pass corner frequency at 320 Hz. This response closely approximates the spectral content of music programming. The pink response has a lowpass function, rolling off at a slope of -3 dB/octave.

[1] Figure 3 shows the response of the pink and USASI filters relative to the white noise at their inputs. The pink and USASI outputs are then amplified to provide the same wideband RMS output level as the white noise.

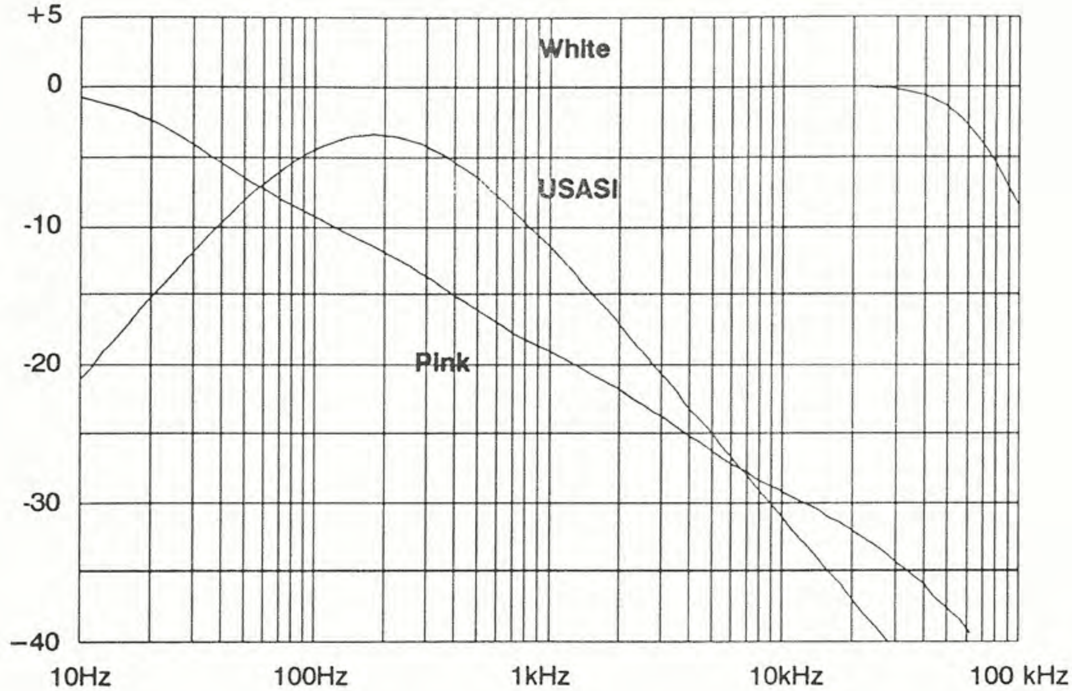

FIGURE 3
RESPONSE VS FREQUENCY

PRINCIPLES OF OPERATION

The SNG-1 produces true Gaussian white noise over its 20 Hz to 50 kHz bandwidth. Pink and USASI (United States of America Standards Institute) noise are derived by appropriate filtering. Figure 4 shows the complete schematic diagram of the SNG-1. The functional blocks of circuitry are described in the following paragraphs.

Noise Sources:

Special zener noise diodes, CR1 and CR2, operate in reverse breakdown producing low level, wide bandwidth, white noise. This noise is coupled through blocking capacitors C8 and C23 to inverting amplifiers U1B and U3B. Resistors R5 and R35 establish a nominal load for the noise diodes to produce optimal white noise characteristics. Trimpots R29 and R38 set the maximum output level for each channel at +10 dBm into 600 ohms. The two-pole low pass filters of U1A and U3A band-limit the noise outputs of U1B and U3B. These filters cut off at 63 kHz and are less than 1 dB down at 40 kHz. Resistors R9 and R41 bias the filter outputs to a small negative voltage to guarantee that C5 and C18 are correctly biased.

Weighting Networks:

The band-limited white noise connects to pink and USASI weighting networks. The circuitry of U2A and U4A are the pink weighting networks, with gain to restore noise power lost in weighting. Similarly, the circuitry of U2B and U4B are the USASI weighting networks. U5 is a dual four input analog multiplexer which selects white, pink or USASI noise according to NOISE SELECT switch S1.

Output Mode Select:

The front panel OUTPUT SELECT switch, S3, controls the independent analog switches in U8 and U9. When S3 is set to STEREO, analog switches U8A and U9A are on. Left channel noise currents from U6A flow through R21, R20, and U8A to the summing point of U7A. Similarly, right channel noise currents from U6B flow through R52, R53, and U9A to the summing point of U7B. Operational amplifiers U7A and U7B convert these currents into inverted voltage signals. When S3 is set to LEFT, only analog switch U8A is on and only left channel noise currents flow into the summing point of U7A. The output of U7A produces a left channel signal and U7B has no output. Similarly, if S3 is in the RIGHT position, only analog switch U9A is on and only right channel noise currents flow into the summing point of U7B. The output of U7B produces a right channel signal and U7A has no output. When S3 is set to NRSC, analog switches U8A, U9A and U9D are on and stereo is produced except that some of the left and right channel noise currents blend through R25, reducing the subchannel level by 3 dB.

When the OUTPUT SELECT switch, S3, is set to MONO, analog switches U8A and U9B are on and equal left channel noise currents from U6A flow to the summing points of both U7A and U7B. The outputs of U7A and U7B are identical. With S3 set to L=−R, analog switches U8A and U9C are on and left channel audio appears at the output of U7A. Left channel signal current flows through R27, R148 and U9C to the summing point of U7B producing an inverted left channel signal at the output of U7B.

Level Control:

The left and right channel signals from U7A and U7B go to the positive inputs of transconductance amplifiers U10B and U10A. The current from Q9, split by R161 and R162, determines the gain of the transconductance amplifiers. Negative 1.65 volts from the wiper of R113 produces maximum current from Q9 and a transconductance amplifier gain of one. Higher voltages from R113 reduce the current from Q9 and reduce the gain. Trimpots R58 and R71 are input offset adjustments that minimize control line feedthrough so that switching signal components do not appear in the noise outputs.

Output Stages:

The left and right channel noise outputs of U10B and U10A couple through DC blocking capacitors C34 and C32 to the inverting and non-inverting amplifiers of U11 and U12. These amplifiers are balanced driver stages for the four push-pull output amplifiers. Since the four output amps are identical, only the stage formed with Q1 and Q2 is described. The resistor chain of R93, R75, R74, and R90 along with light emitting diode CR18 form a bias network for Q1 and Q2 producing quiescent collector currents of about 10 ma. Light emitting diode CR18 is included for temperature compensation. The DC offset voltage at the output is maintained below 10 mV under all conditions by the DC servo feedback circuit of U11C, R154, C45, and R153. Resistors R94 and R89 current limit the output protecting Q1 and Q2. This circuit provides a low impedance output to the phone jack and XLR connector.

NRSC Pulse Circuit:

The circuitry of U17B, U17C and U17D form a 20 Hz gate oscillator which clocks the divide by 8 Johnson counter, U16. The Q0 output of this counter is a 2.5 Hz pulse train at 12.5% duty cycle as required by the NRSC standards. U17A and U17F buffer this pulse train providing a signal to the clamp circuit of U15. The clamp circuit prevents the low level of the pulse waveform from dropping below one diode drop less than the voltage at U15A's output. R140, R139, R137 and CR5 set the voltage at U15A's output so that pulsed USASI noise has the 20 dB peak to average ratio required by the NRSC standards. U15B buffers the clamped pulse.

When the NOISE MODE switch, S2, is set to NRSC PULSED, pulse signal currents flow through R138 and U14 to the summing input of U13B. U13B inverts the clamped pulse signal from U15B. The OUTPUT LEVEL control, R113, attenuates the signal. The circuit of U13A and Q9 converts this signal to level control current for the transconductance amplifier U10. Thermistor R136 temperature compensates for the temperature coefficients of the noise diodes and the rest of the circuit to provide constant output level over temperature.

External Input:

The rear panel BNC connector, J5, labelled EXT GATE receives the external level control signal. An input protection network consisting of R147, CR3, CR4 and C28 keeps the level control signal within one diode drop of its nominal 0 to +5 volt range and protects the input of U18B. U18B buffers the external level control signal. The 100k ohm resistor, R146, to ground at the input of U18B keeps the output of U18B at zero volts when no external level control signal is present. Zero volts corresponds to no noise output and +5 volts corresponds to full noise output.

When the NOISE MODE switch, S2, is set to EXT GATE, external level currents flow through R143 and U14 to the summing input of U13B. U13B inverts the external level signal from U18B. The OUTPUT LEVEL control, R113, attenuates the signal. The circuit of U13A and Q9 converts this signal level to control currents for transconductance amplifier U10.

Non-Pulsed (CW) Mode:

In the NRSC mode, the input of U17E is held high so that the clear input of U16 is low and U16 produces the desired NRSC pulses. When the NOISE MODE switch, S2, is set to CW, R122 pulls the input of U17E low thereby setting the clear input of U16 high. This sets the Q0 output of U16 always high resulting in +5 volts at the output of U15B. This +5 volts corresponds to full noise output.

When the NOISE MODE switch, S2, is set to CW, the +5 volts from U15B generates current through R138 and U14 to the summing input of U13B. U13B inverts the +5 volts from U18B. Thus, −1.65 volts at the top of the OUTPUT LEVEL control, R113, corresponds to full noise output. U13A and Q9 convert this voltage to control currents for U10.

MAINTENANCE PROCEDURES SIMPLIFIED USING STEREO NOISE

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Noise has long been considered an undesirable entity to be eliminated. However, many of the tests and measurements in a broadcast facility are more easily performed using stereo noise as a test signal. In addition, pulsed noise can be used to measure the dynamic response of audio processing equipment under real-world operating conditions. The Delta SNG-1 Stereo Noise Generator provides several noise weightings and output channel combinations that facilitate these tests. The NAB Test CD is an inexpensive alternative that provides some of these output capabilities.

This paper defines noise characteristics and describes how various noise test signals can be used to simplify and speed common broadcast tests and measurements.

INTRODUCTION

Noise can be used as a test signal containing all frequencies of interest simultaneously, eliminating the need to repeatedly adjust individual tones. Starting with the flat frequency response of white noise, weighting filters can provide many useful response curves, tailored to the specific measurements being made.

A special pulsed noise signal has been adopted by the NRSC as a standard test signal. Consisting of pulsed USASI noise with partial channel blending, this signal accurately simulates program audio and forms a dependable, repeatable baseline for broadcast measurements.

The Delta SNG-1 Stereo Noise Generator provides three basic noise weightings, and generates continuous or pulsed noise. In addition, seven left and right channel output configurations are selectable. Many routine test and measurement procedures can be performed more easily and quickly using different combinations of noise types and channel configurations. By selecting USASI noise in pulsed mode with NRSC channel blending, the special NRSC test signal is generated.

The NAB Test CD contains a number of useful test signals, including pink, white, and USASI noise, and also the NRSC test signal. Some of the tests and measurements below can be made using these signals.

DEFINITIONS OF NOISE

Several noise concepts should be defined before proceeding to specific applications. White noise is the basis from which noise generators form their various output weightings. True random white noise may be defined as having no periodic spectral components: Its future value cannot be predicted except in statistical terms.

A further measure of the quality of white noise is its statistical amplitude distribution. True random noise should conform to the Gaussian amplitude distribution. This is the familiar bell-shaped normal distribution curve shown in Figure 1. The horizontal axis shows noise amplitude in standard deviations (σ), where one standard deviation is equal to the RMS voltage of the noise. For any voltage segment along the horizontal axis, the corresponding area

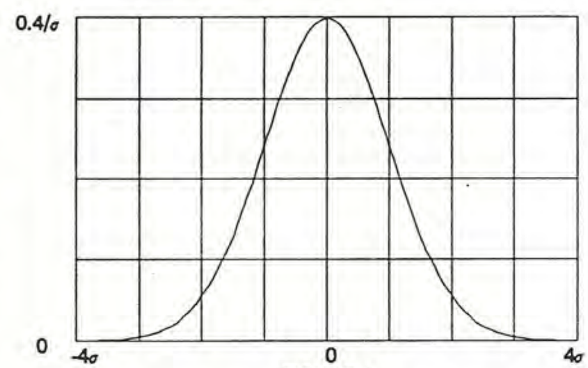

FIGURE 1
PROBABILITY DENSITY FUNCTION

under the distribution curve is the probability that the noise voltage will lie within that voltage segment at any instant and is equal to the fraction of the time that the noise voltage is in the voltage segment. The area under the curve from -4σ to $+4\sigma$ is very nearly 1. In other words, the instantaneous noise voltage almost never exceeds the value equal to plus or minus four times the RMS voltage. A crest factor of four is therefore sufficient to pass Gaussian noise.

Three noise weightings are most commonly used: White, Pink and USASI (United States of America Standards Institute). White noise contains equal spectral energy per unit of bandwidth, as evidenced by its flat response over frequency seen on a spectrum analyzer or constant bandwidth wave analyzer. Pink noise is formed by filtering white noise with a 3 dB per octave lowpass function. It contains equal spectral energy per octave of frequency. This provides a flat response when measured with an octave or third-octave real time analyzer (RTA). USASI noise is formed by band-limiting white noise at the low and high ends. The filters used are both first-order, 6 dB per octave. The highpass corner frequency is 100 Hz and the lowpass corner is 320 Hz. Figure 2 shows the spectrum curves of these three types of noise.

The NRSC-1 AM Broadcasting Standard, ANSI/EIA-549-1988, defines pulsed USASI-weighted noise as a standard test signal. The USASI weighting curve closely simulates the spectral distribution of typical program audio, having primarily midrange content with rolled-off highs and lows. Dynamic pulsing simulates the repetitive amplitude variations of music and speech. The pulsed noise is defined to have a 20 dB peak-to-average ratio, with the peaks occuring at a 2.5 Hz repetition rate, with a 1/8 duty cycle.

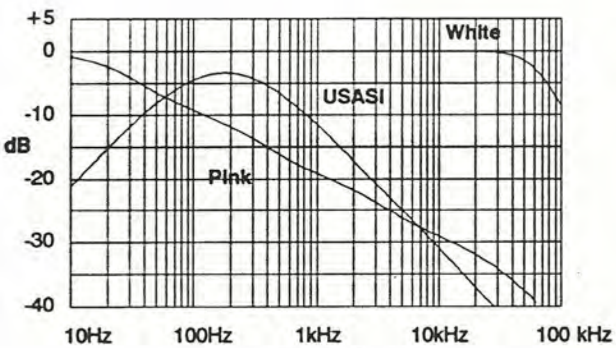

FIGURE 2
RESPONSE VS FREQUENCY

This test signal further simulates real-world program audio by partially blending the left and right channels. This creates a sub-channel signal (L-R) which is 3 dB below the main channel (L+R). A block diagram of the circuitry required to create this test signal is shown in Figure 3 below.

OPERATION OF THE STEREO NOISE GENERATOR

The Stereo Noise Generator has several front panel controls which select the variety of noise signals available. Figure 4 depicts the front panel with the components described below.

The NOISE SELECT switch selects white, pink or USASI weighted noise. The NOISE MODE switch selects continuous, internal pulsed or external pulsed noise. In the CW position, the noise is not pulsed and the OUTPUT LEVEL potentiometer controls the noise output level. In the two pulsed modes the OUTPUT LEVEL control sets the maximum output level. In the NRSC PULSED position, an internal circuit pulses the noise in accordance with the NRSC-1 standard. In the EXT GATE position, a voltage applied to the EXT GATE INPUT connector on the rear panel controls the noise level.

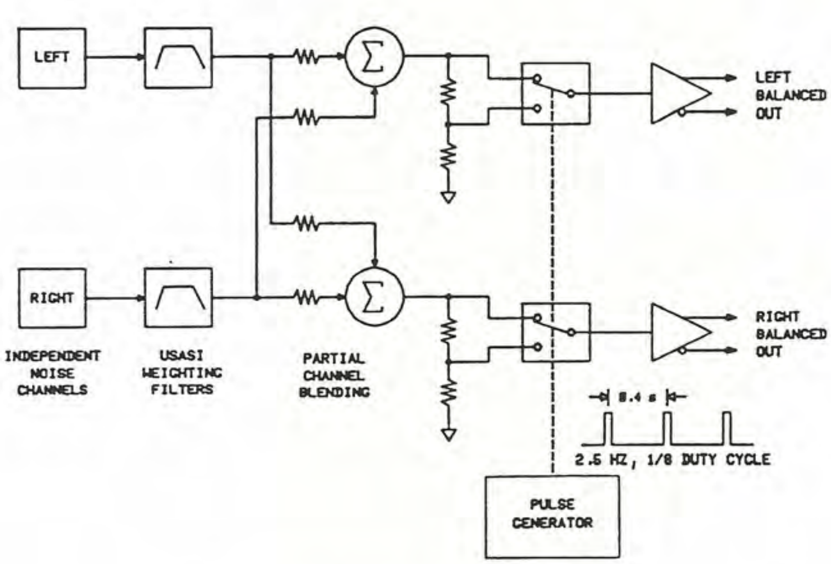

FIGURE 3: NRSC TEST SIGNAL BLOCK DIAGRAM

The seven position OUTPUT SELECT switch determines the left channel and right channel outputs. In the LEFT or RIGHT switch positions, only the left channel or right channel, respectively, is active.

In the MONO position, the left and right channels are identical so that the main channel (L+R) exists and the subchannel (L−R) has no signal. Similarly, in the L=−R switch position, the subchannel exists with no main channel signal. The CLIPPED position produces only subchannel noise with the negative peaks of the right channel clipped and the positive peaks of the left channel clipped.

The STEREO position produces independent left and right channels with the same output level. In the NRSC position, the left and right channels are partially blended so that the subchannel level is 3 dB below the main channel level. This approximates the ratio of main channel level to subchannel level in program material.

NOISE APPLICATIONS

Response Measurement

Frequency response measurements are probably the best-known use of noise. Noise is useful for measuring the response of consoles, amplifiers, studio-transmitter links, or even equalized phone lines. System response can be quickly ascertained by feeding the noise test signal into the input and monitoring the output with a real time analyzer (RTA) or spectrum analyzer. Pink noise provides a flat response when measured with a third-octave or octave RTA, whereas white noise is appropriate when using a spectrum analyzer or wave analyzer. Exercise care when using white noise to prevent loudspeaker damage from the strong high frequency content of this signal.

Tape Machine Head Alignment

Tape head azimuth adjustment using stereo noise makes a complicated process easier. First align the playback head using a standard pink noise alignment tape. Then connect MONO pink noise to the tape deck inputs, and monitor the output while recording. While adjusting the record head azimuth, the operator will clearly hear the increase in high frequency "hiss" when the head is optimally aligned. This measurement can also be monitored on an RTA or an oscilloscope.

After aligning your master cartridge recorder, generate a series of pink noise alignment tapes. These tapes can be used to phase-align all the recorders in the studio to the master recorder.

Filter Response and Alignment

Filters are employed in many broadcast products. They can often be aligned much faster using noise than audio tones. For example, to align the AM Stereo Exciter, start with all delay and EQ switches disabled. Apply LEFT-channel USASI noise and adjust the output level to reach a 50% indication on the modulation monitor left channel. Connect the mod monitor's left and right unbalanced outputs to an oscilloscope's A and B inputs, respectively, and set the scope to read in X-Y mode. The scope display will show a vertical line with horizontal noise extrusions. Now adjust the Left Bulk Delay to minimize the horizontal noise traces. Finally, adjust the Left Low Frequency EQ to produce a near-perfect straight line. Repeat the above steps with RIGHT-channel noise, observing a horizontal line on the scope display.

Separation and Crosstalk

Separation and crosstalk tests measure the level of signal intrusion from one channel into another. Separation refers to the discrete left and right channels; crosstalk refers to the main channel (L+R) and subchannel (L−R) signals. The SNG-1 output selections facilitate either of these measurements: Use the LEFT only and RIGHT only outputs for separation, and the MONO (main channel only) and L=−R (subchannel only) outputs for crosstalk.

White noise, with equal amplitudes over the audio bandwidth, can be used to measure the worst-case intrusion of full-level high frequencies from one channel into another. Use USASI noise for numbers that reflect the real-world separation and crosstalk levels that would be present during program audio.

The dynamic separation of an entire stereo transmission system can easily be measured by applying LEFT- or RIGHT-channel noise to the system input and reading the separation on the modulation monitor. This test will show the effects of every device in the system, and can be sobering.

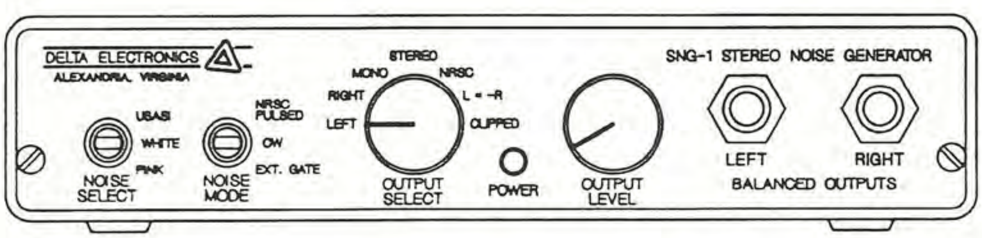

FIGURE 4: SNG-1 FRONT PANEL CONTROLS

Audio Processor Setup and Alignment
Adjustment and setup of audio processors using USASI noise will give very close correlation between the test adjustment and actual program material. The "quality" of the audio processing can be measured by comparing the peak-to-average ratios of the pulsed noise at the processor input and output. The difference in dB corresponds to the amount of compression taking place. An oscilloscope and an AC voltmeter with a long time constant can provide a rough measure of the peak and average levels. The Potomac Instruments QA-100 QuantAural™ is particularly well-suited to this type of measurement, with Peak and Average settings and four measurement bands that correspond to an "inverse-USASI" function.

The audio processor's frequency response *during active processing* (peak limiting, compression, etc) can be measured using pulsed pink noise and a real-time analyzer in peak-hold mode. This provides an accurate picture of "real-world" processor frequency response - which may not be as flat as response curves using steady-state tones or noise.

System Cabling and Polarity
The CLIPPED NOISE output is a unique feature of the SNG-1. In this mode, the positive peaks of the LEFT channel and the negative peaks of the RIGHT channel are clipped. When fed into stereo pair, and viewed using an oscilloscope, channel reversals (LEFT and RIGHT) and phasing errors can be quickly spotted. Switch the SNG-1 first to LEFT-only. Verify on the scope that only the LEFT wire has signal present. Then switch to the CLIPPED position to verify that channel phasing is correct. If the phasing on the left channel is reversed, the scope will show the negative peaks clipped, rather than the positive. The same procedure can then be repeated for the right channel. In facilities with long runs of wires, multiple runs through patch bays and daisy-chained audio processors, this method of channel verification speeds testing of the equipment wiring and quickly points out potential faults.

Amplifier Dynamic Range
A test signal with a high peak-to-RMS factor which limits the total RMS power is useful for this test. The peaks will test the dynamic range capability of an amplifier, while the lower RMS value won't work it too hard. This ratio is typical of program audio. Because the random noise of the SNG-1 is a symmetrical signal with a guaranteed crest factor of 4:1, it is useful for this purpose. The peaks of white noise occur often enough to be visible on an oscilloscope. The broadband signal insures that the amplifier will be tested throughout the audio frequency range.

Meter Measurements
Many level meters are polarity sensitive because they use internal half-wave rectification. Two of these meters which are wired across the same line but with opposite polarity will read differently and appear to have different ballistics, even though they read the same with line-up tones. This effect is especially pronounced on asymmetrical waveforms like the male human voice. The clipped noise output of the SNG-1 is inherently asymmetrical, and can be used to quickly pinpoint such meters.

The EXT GATE input allows the user to trigger noise bursts from a function generator, or simply from a switch wired to +5VDC and ground. Switching USASI noise on and off allows direct measurement of meter response ballistics.

Transmitter Tests
White noise is an excellent signal for making transmitter adjustments while monitoring the AM noise component of FM or TV transmitters. Since a broad band of frequencies is applied to the transmitter under test, the transmitter tuning and loading can be more accurately adjusted. Furthermore, when used in conjunction with a spectrum analyzer, the effect of tuning and loading adjustments on system bandwidth can be seen.

Pulsed noise can be used for checking the positive peak capability of AM transmitters without overworking them. It can also be used to verify that the lightning gap on the mast base won't flash over on peaks, without keeping the power there long enough to weld anything.

NRSC Compliance Measurements
The stereo noise generator provides a source for making repeatable compliance measurements to the new FCC emission standard. Because of the repeatability of the noise measurement signal, more accurate readings can be obtained than when using regular program material. Pulsed USASI noise combined with the NRSC channel blending simulates program audio very closely, yet offers a test that - though it is random in content - has the same distribution of frequencies in each burst.

These measurements can be made using either a spectrum analyzer or the less-expensive Delta Splatter Monitor. Delta offers a free FCC RF Mask Compliance Package which includes the charts and forms needed to make these required measurements.

CONCLUSION

Stereo noise is a useful test signal and an improvement over discrete tone testing in many applications. A stereo noise generator which can amplitude-modulate the noise, and which provides additional output capabilities discussed above such as MONO and L=−R, NRSC channel blending, and clipped noise provide the user with enough flexibility for a myriad of useful measurements.

THE AUTHOR

The author is a Design Engineer for Delta Electronics, Inc. in Alexandria, Virginia. While at Delta he has worked on the designs for the Splatter Monitor and the Stereo Noise Generator, in addition to numerous smaller projects. He graduated with a BSEE from University of Virginia in 1981, and worked for six years in avionics instrumentation and military aircraft radar signal processing before coming to Delta.

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Employ Some Noise.

A Noise Primer Using The SNG-1 Stereo Noise Generator.

The Above Standard
Industry Standard.

DELTA ELECTRONICS

EMPLOY SOME NOISE

A Noise Primer from Delta Electronics

INTRODUCTION

Employ noise? Most engineers spend their time trying to eliminate noise. In this Primer we will show you why noise - when used properly - can be a very useful test signal.

Noise originally meant simply any undesirable sound. In today's information-based society, the term "noise" has a multitude of meanings. Generally, noise now refers to any undesired portion of a signal that tends to obscure its intelligibility. In engineering, "noise" can refer to random noise, distortion, hum, crosstalk, and other unwanted signal components.

RANDOM NOISE

We must define random noise more precisely: It can not have any periodic components, and its future value can not be predicted absolutely. We measure and describe the amplitude of noise using statistical terms: The probability that the noise signal will be within X volts during Y percent of the time.

The white random noise spectrum is a continuous function of frequency. No discrete spectral line components (which indicate a periodic signal like a sine wave) can be present. On a spectrum analyzer with maximum video filtering, the ragged trace of a random noise signal smooths to a flat line. The Delta SNG-1 Stereo Noise Generator generates true random noise.

The amplitude distribution of this random noise follows the familiar "bell curve" called the Gaussian Distribution (see Figure 1). The horizontal axis shows noise amplitude in standard deviations (σ), where one standard deviation is equal to the RMS voltage of the noise. For any voltage segment along the horizontal axis, the corresponding area under the distribution curve is the probability that the noise voltage will lie within that voltage segment at any instant and is equal to the fraction of the time that the noise voltage is in the voltage segment. The area under the curve from -4σ to $+4\sigma$ is very nearly 1. In other words, the instantaneous noise voltage almost never exceeds plus or minus four times the RMS voltage.

The "peak-to-RMS ratio" measurement shows how well a noise signal approximates a true Gaussian amplitude distribution. Theoretically, a true Gaussian amplitude distribution has an infinite peak-to-RMS ratio. This means that the noise signal will show peaks of infinite amplitude during an infinitely small percentage of the time. Real-world noise generators must compromise between maximum RMS output capability and the headroom required to maintain the peak-to-RMS ratio specification. For example, an output level of 1 mV RMS could theoretically achieve 60 dB (1 V) peaks, but such a low average level wouldn't be very useful for broadcast testing. It can be shown mathematically that a peak-to-RMS ratio of 4:1 (or 12 dB) is within .0063% of a true theoretical Gaussian amplitude distribution. Since unprocessed audio exhibits peak-to-RMS ratios of 10 to 20 dB, random noise can closely approximate actual programming. The SNG-1 provides a peak-to-RMS ratio greater than 4:1 (without clipping) at full rated output level.

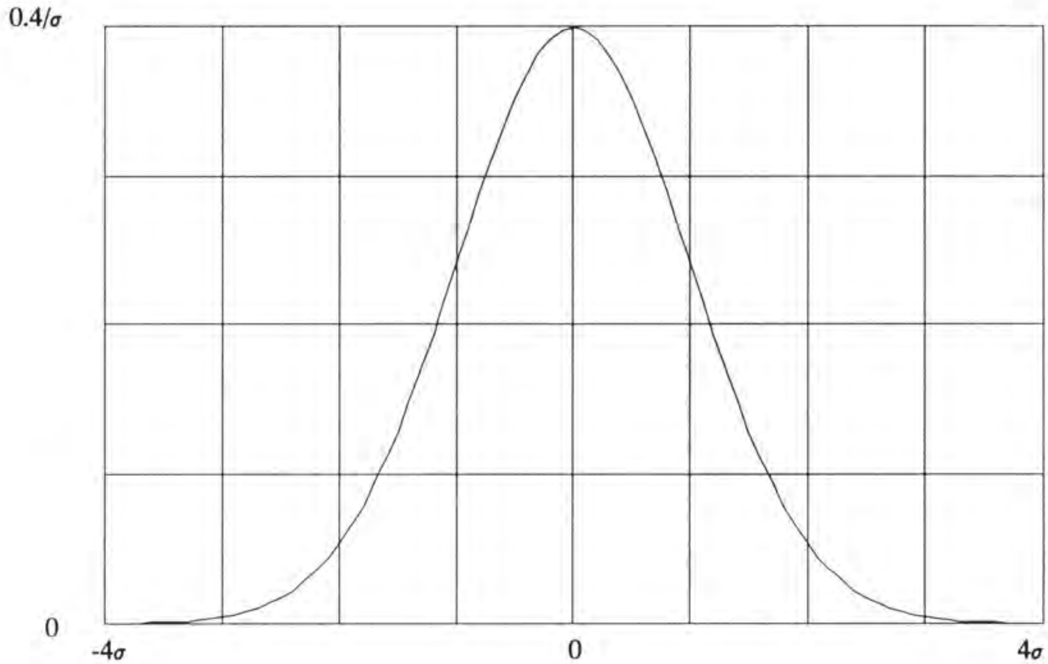

FIGURE 1
PROBABILITY DENSITY FUNCTION

TYPES OF NOISE

WHITE NOISE

White noise is analogous to white light in that its spectrum contains equal energy at all frequencies over the bandwidth of interest. White noise is useful for making frequency response measurements with a spectrum analyzer or wave analyzer, where the measurement bandwidth is constant at each frequency measured.

White noise exhibits "constant spectral power density." Any two segments of spectrum with equal bandwidths will measure equal RMS noise voltages. For example, if white noise is passed through a bandpass filter, a true RMS voltmeter will measure the same noise voltage at any filter center frequency - as long as the filter's bandwidth is kept constant. Doubling the bandwidth will double the noise spectral power in the passband. The RMS voltmeter will then read 3 dB or 1.414 times higher.

In the real world, white noise cannot contain equal energy at all frequencies simultaneously (the signal would contain infinite power). All noise generators roll off their outputs at some low and high corner frequencies, generating white noise which is flat within a certain bandwidth of interest. The noise diodes in the SNG-1 generate a spectrum which is flat to 5 MHz. This spectrum is then intentionally band-limited below 10 Hz and above 70 kHz, providing a usable bandwidth of 20 Hz to 20 kHz ±1 dB.

This constant output over frequency makes frequency response tests very easy. Unlike an audio generator, all frequencies are always present, and so do not require level adjustments. Simply feed the white noise spectrum into the device under test and measure the output with a spectrum analyzer or wave analyzer.

Other noise weightings are created by appropriately filtering the flat spectrum of white noise. Some commonly-used noise weightings include pink, USASI, CCIR, inverse RIAA, and A- and B-weightings. The SNG-1 generates pink and USASI outputs in addition to white noise. Figure 2 shows the spectrum curves of these three types of noise[1].

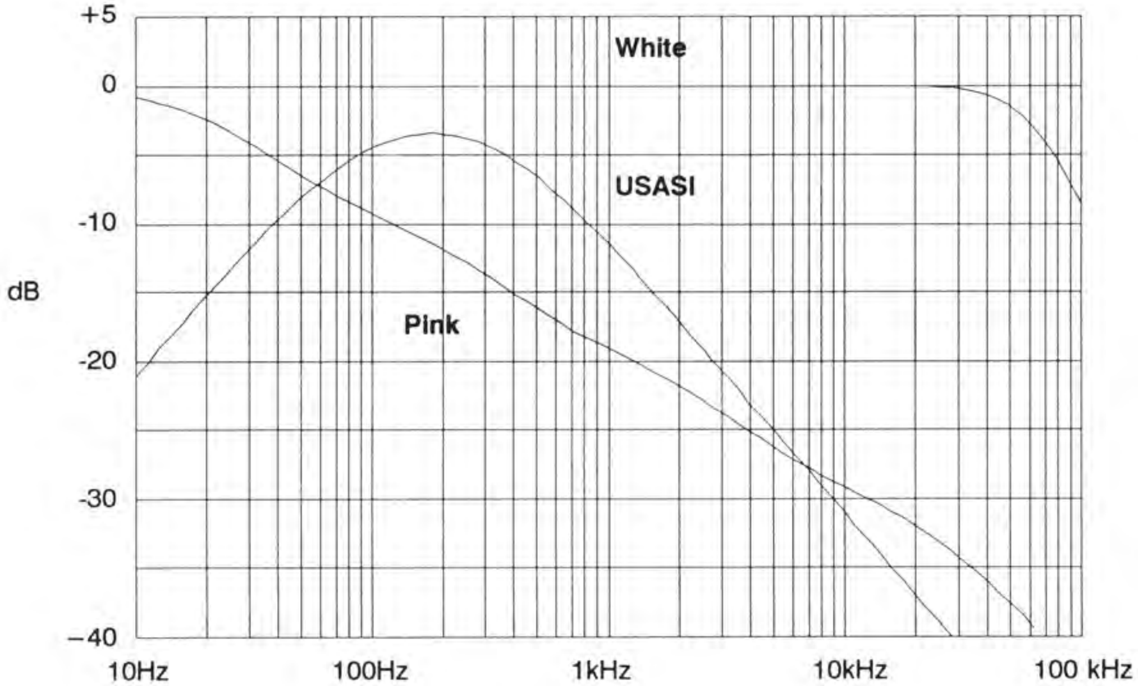

FIGURE 2
RESPONSE VS FREQUENCY

PINK NOISE

Pink noise is a very useful test signal for audio response measurements. It is created by filtering white noise with a lowpass function rolling off at a rate of three dB per octave[2]. The resulting signal contains equal spectral power density in each octave (a doubling in frequency), rather than in equal bandwidths as with white noise. For example, white noise contains the same spectral energy in any 10 Hz band: from 20-30 Hz, 200-210 Hz, or 2000-2010 Hz. Pink noise contains the same spectral energy in any two octaves: from 10-20 Hz, 20-40 Hz, 1000-2000 Hz, etc. Similarly, any two 1/3-octave bands would also contain the same spectral energy for pink noise. Pink noise is perfect for frequency response measurements using an octave or one-third octave real time analyzer (RTA). Because pink noise contains equal spectral energy per octave, a flat frequency response shows up as equal level readings in each band of the RTA. Accurate response measurements can thus be made using a high-quality pink noise source and an RTA, instead of using white noise and an audio spectrum analyzer.

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[1] Figure 2 shows the response of the pink and USASI filters relative to the white noise at their inputs. The pink and USASI outputs are then amplified to provide the same wideband RMS output level as the white noise.

[2] The pink filter characteristic requires a series of partially-canceling poles and zeroes, since the 3 dB/octave rolloff is less than the inherent rate of even a first-order filter.

The properties of pink noise make it very useful for loudspeaker testing and room response measurements. The rolled-off highs make loudspeaker measurements much safer than with white noise. White noise provides a spectrum with just as much spectral energy per Hz at 18 kHz as at 50 Hz, as discussed above. In other words, with white noise the same power levels seen by the woofer are seen by the tweeter. This high-frequency energy spectral density can easily destroy tweeters. Pink noise, like program audio, has very little energy at high frequencies. Octave-type RTA's with calibrated microphones provide an inexpensive system for accurate frequency response measurements.

USASI NOISE

USASI (United States of America Standards Institute) is the third type of noise weighting provided by the SNG-1. By rolling off the high and low frequencies and weighting the midrange more heavily, USASI noise closely simulates the spectral content of typical programming. The NRSC (National Radio Systems Committee) chose USASI as the basic test signal used to verify compliance to NRSC-1 and NRSC-2 AM Broadcasting standards.

The SNG-1 creates USASI noise by passing white noise through two first-order (6 dB/octave) filters. The high-pass filter has a corner frequency of 100 Hz and the low-pass filter has a corner frequency of 320 Hz.

CCIR NOISE

CCIR (International Radio Consultative Committee) is a noise weighting curve similar to USASI. It was developed for testing AM radio protection ratios. The SNG-1 does not provide CCIR weighting, since it is similar to USASI. Note, however, that CCIR (or any other desired noise weighting) can be created by passing white noise from the SNG-1 through the appropriate weighting network.

NOISE AS A TEST SIGNAL

USASI VS PINK NOISE

USASI and pink noise weightings each have advantages for making certain measurements. USASI is an excellent test signal for simulating actual program audio. It is not as well suited for response measurements because an "inverse USASI" measuring function is not easily obtained. Pink noise, while lacking the spectral characteristics of programming, can be easily measured on octave or 1/3 octave real time analyzers. RTA's inherently measure with an inverse pink response curve so that a flat frequency response results.

GATED NOISE

White, pink and USASI noise weightings provide useful frequency spectra for many kinds of tests. The SNG-1 provides another feature which makes these noise signals even more useful: the ability to modulate the noise amplitude.

Steady-state signals allow audio processor automatic gain control (AGC) circuits to reach equilibrium. A processor's frequency response is often much better at equilibrium than during peak compression or AGC action. An accurate test signal should provide not only spectral shaping but amplitude modulation to activate these processor circuits.

To simulate program dynamics, the SNG-1 has an internal pulse generator which modulates the noise amplitude. This internal generator pulses the noise at a 2.5 Hz rate with a 12.5% duty cycle. When pulsed USASI noise is selected, the output of the SNG-1 conforms to the recommended standard test signal of ANSI/EIA-549-1988 (NRSC-1). This signal provides a very accurate spectral and dynamic simulation of program audio. Processor adjustments can be quickly performed and accurately rechecked using this test signal.

The SNG-1 also provides an external amplitude modulation input. This input modulates the noise amplitude with any external waveform varying between 0V (full attenuation) to +5VDC (no attenuation). The front-panel LEVEL potentiometer controls the maximum output of the SNG-1 when in PULSED mode.

STEREO, MONO, AND MORE

To further simulate true program audio, the SNG-1 provides seven output channel functions: LEFT only, RIGHT only, MONO, STEREO, NRSC, LEFT=−RIGHT, and CLIPPED. In the LEFT or RIGHT only switch positions, only the left channel or only the right channel, respectively, is active. These positions are useful in wide bandwidth separation measurements where the level of intrusion of one channel into the other channel is measured. The STEREO position produces independent left and right channels with the same output level. In the MONO position, the left and right channels are identical so that the main channel (L+R) exists and the subchannel (L−R) has no signal. Similarly, in the L=−R switch position, the subchannel exists with no main channel signal. These two outputs are useful in measuring the leakage of the main channel signal into the subchannel or vice versa for crosstalk measurements. In the NRSC position, the left and right channels are partially blended so that the subchannel level is 3 dB below the main channel level. This approximates the ratio of main channel level to subchannel level in stereo program material. The CLIPPED position produces only subchannel noise with the negative peaks of the right channel clipped and the positive peaks of the left channel clipped. This output is useful for detecting polarity and phasing errors in a chain of audio equipment.

REPEATABILITY

A high-quality noise signal provides a constant, repeatable source for tests and measurements. Program audio changes constantly, making equipment adjustments frustrating and time-consuming. An audio processor alignment using pulsed USASI noise can be rechecked days or weeks later with confidence that the measurements can be accurately repeated.

APPLICATIONS OF NOISE

Though most engineers are more familiar with discrete tone testing, the dynamic, spectral, and amplitude characteristics of noise make it a superb test signal. The following examples are just a few of the many applications employing noise as the test source.

AUDIO PROCESSOR SETUP & ALIGNMENT

Adjustment and setup of processors using USASI noise will give very close correlation between the test adjustment and actual program material. You can gauge the "quality" of the audio processing by measuring the peak-to-average ratio of the pulsed noise at the processor input and then at the processor output. An oscilloscope and an AC voltmeter with a long time constant can provide a rough measure of the peak and average levels. The Potomac Instruments QA-100 QuantAural™ is particularly well-suited to this type of measurement, with Peak and Average settings and four measurement bands that correspond to an "inverse-USASI" function.

Pink noise is useful for response measurements with a third-octave real time analyzer. The audio processor's frequency response during processing action (peak limiting, compression, etc) can be measured using pulsed pink noise from the SNG-1 and the peak-hold function of the RTA.

RESPONSE MEASUREMENT

Noise is very useful for measuring the frequency response of consoles, amplifiers, STL's, or even equalized phone lines. The system response performance can be quickly ascertained by feeding the noise test signal into the input and monitoring the output with a real time analyzer or spectrum analyzer. As discussed above, pink noise will provide a flat response when using a third-octave or octave RTA, whereas white noise is appropriate when using a spectrum analyzer or wave analyzer. Exercise care when using white noise to prevent loudspeaker damage from the strong high frequency component of this signal.

TAPE MACHINE HEAD ALIGNMENT

Azimuth adjustment using pink noise makes a complicated process easier. First align the playback head using a standard pink noise alignment tape. The record head can then be quickly adjusted by recording MONO pink noise from the SNG-1 and monitoring the playback head output. When adjusting the head alignment back and forth, the operator will clearly hear the increase in high frequency "hiss" when the head is optimally aligned. This measurement can also be monitored on an RTA or an oscilloscope.

After aligning your master cartridge recorder, generate a series of pink noise alignment tapes. These tapes can be used to phase-align all the recorders in the studio to the master recorder.

FILTER RESPONSE/ALIGNMENT

In many broadcast products, filters are employed. The SNG-1 speeds alignment of these filters. For example, in the AM Stereo Exciter, the left and right equalization filters can be checked and quickly adjusted using the LEFT- and RIGHT-only channel noise.

SEPARATION AND CROSSTALK TESTS

Separation and crosstalk tests measure the level of signal intrusion from one channel into another. Separation refers to the discrete left and right channels; crosstalk refers to the main channel (L+R) and subchannel (L-R) signals. The SNG-1 output selections facilitate either of these measurements: use the LEFT- and RIGHT-only outputs for separation, and the MONO (main channel only) and L=-R (subchannel only) outputs for crosstalk. These tests can be made using white noise to measure the worst-case intrusion of full-level high frequencies from one channel into another. Use USASI noise for numbers that reflect the real-world separation and crosstalk figures that would be present during program audio.

The dynamic separation of an entire stereo transmission system can easily be measured by applying left- or right-only noise to the system input and reading the separation on the modulation monitor. This test will show the effects of every device in the system, and can be sobering. However, one SNG-1 user has reported measuring 50 dB of separation after carefully tuning an FM system.

ACOUSTIC MEASUREMENTS

Pink noise can be used to determine resonances or cancellations in a room or studio response. Long used by sound reinforcement companies, this same technique is now used by engineers designing studios. The acoustical noise spectral distribution is particularly useful in placing studio furniture, and determining both microphone and monitor locations in the studio. Random noise is also useful in measuring the transmission of sound through panels, walls, and floors, and sound attenuation in heating and air conditioning ducts.

SYSTEM CABLING AND POLARITY

The CLIPPED noise output is a unique feature of the SNG-1. In this mode, the RIGHT channel has only positive peaks and the LEFT channel has only negative peaks of noise. When fed into a stereo cable or chain of processors, and viewed using an oscilloscope, channel reversals (LEFT and RIGHT) and phasing errors can be quickly spotted. Switch the SNG-1 first to LEFT-only. Verify on the scope that only the left channel has signal present. Then switch to the CLIPPED position to verify that channel phasing is correct. If the phasing on the left channel is reversed, the scope will show the positive peaks present, rather than the negative peaks. The same procedure would then be repeated for the right channel. In facilities with long runs of wires, or multiple runs through patch bays or several pieces of processing equipment, this method of channel verification speeds testing of the equipment wiring and quickly points out potential faults.

AMPLIFIER DYNAMIC RANGE

A test signal with a high peak-to-RMS factor which limits the total RMS power is useful for this test. Because the random noise of the SNG-1 is a symmetrical signal with a guaranteed crest factor of 4:1, it is useful for this purpose. The peaks of white noise occur often enough to be visible. The overall performance of audio amplifiers can be verified using a broadband test signal like random noise. The broadband signal insures that the amplifier under test will be tested throughout its entire frequency range. Because of the similarities in spectra between speech, music and USASI noise, the USASI noise weighting is most desirable for such tests.

METER MEASUREMENTS

Many level meters are polarity sensitive, using internal half-wave rectification. Two of these meters which are wired across the same line but with opposite polarity will read differently and appear to have different ballistics, even though they read the same with line-up tones. This effect is especially pronounced on asymmetrical waveforms like the male human voice. The clipped noise output of the SNG-1 is inherently asymmetrical, and can quickly pinpoint such meters. Studio engineers have told us that they use the SNG-1 to sort out level meters on tape decks where they have been aware of discrepancies for years, but never quite been able to explain them.

The EXT GATE input allows the user to trigger noise bursts from a function generator, or simply from a switch wired to +5VDC and ground. Switching USASI noise on and off allows direct measurement of meter response ballistics.

AM TRANSMITTER TESTS

White noise is an excellent signal for making transmitter adjustments while monitoring the AM noise component of FM or TV transmitters. Since a broad band of frequencies are applied to the transmitter under test, the transmitter tuning and loading can be more accurately adjusted. Furthermore, when used in conjunction with a spectrum analyzer, the effect on system bandwidth versus tuning and loading adjustments can be seen.

Pulsed noise can be used for checking the positive peak capability of AM transmitters without damaging them. This can also check if the lightning gap on the mast base is going to flash over on peaks, without keeping the power there long enough to weld anything.

NRSC COMPLIANCE TESTS

The Stereo Noise Generator provides a source for making repeatable compliance measurements to the new FCC emission standard. Because of the repeatability of the noise measurement signal, more accurate readings can be obtained than when using regular program material. Pulsed USASI noise combined with the NRSC channel blending very closely simulates programming, yet offers a test that - though it is random in content - has the same distribution of frequencies in each burst.

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ACKNOWLEDGEMENTS

Employ Some Noise was prepared by Harry Gardner and John Bisset. The authors gratefully acknowledge the input and assistance of the following individuals:

Bud Aiello, EZ Communications
John Diamantis, Group W
John Innes, Broadcast Consultant
Chris Payne, Broadcast Consultant
Dan Ryson, Infinity Broadcasting
Stanley Salek, NAB
Milford Smith, Greater Media
Chris Wilk, Delta Electronics

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PP-4-90-2k