AUDIO PRECISION
SYSTEM TWO CASCADE

SPECIFICATIONS

(Effective with APWIN version 1.6 software)

Audio precision®

CE

This mark signifies that the product conforms to all applicable requirements of the European Community. A Declaration of Conformance is included with the user information that describes the specifications used to demonstrate conformity.

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Audio Precision, Inc.
PO Box 2209
Beaverton Oregon 97075-2209

US Toll Free: 1-800-231-7350 Tel: (503) 627-0832 Fax: (503) 641-8906
email: techsupport@audioprecision.com Web: www.audioprecision.com

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Analog Signal Outputs

All System Two Cascade configurations, except the SYS-2500, contain an analog signal generator consisting of an ultra-low distortion analog sinewave generator and two independent transformer coupled output stages that can be driven from both the analog sources and optional hardware signal generators. Option "BUR" adds analog generated sine burst, square wave, and noise signals. Option "IMD" adds analog-generated IMD test signals. SYS-2422 and SYS-2522 configurations also contain dual channel D/A-based signal generation capability. Unless otherwise noted, all specifications are valid for outputs ≥150 µVrms [420 µVpp].

Analog Signal Generator

Low Distortion Sine Wave

Frequency Range	10 Hz to 204 kHz
Frequency Accuracy	
High-accuracy mode	±0.03%
Fast mode	±0.5%
Frequency Resolution	
High-accuracy mode	0.005%
Fast mode	0.025 Hz, 10 Hz – 204.75 Hz; 0.25 Hz, 205 Hz – 2.0475 kHz; 2.5 Hz, 2.05 kHz – 20.475 kHz; 25 Hz, 20.5 kHz – 204 kHz
Amplitude Range[1]	
Balanced	<10 µV to 26.66 Vrms [+30.7 dBu]
Unbalanced	<10 µV to 13.33 Vrms [+24.7 dBu]
Amplitude Accuracy	±0.7% [±0.06 dB] at 1 kHz
Amplitude Resolution	
V_{out} ≥150 µVrms	0.003 dB
V_{out} <150 µVrms	0.05 µVrms
Flatness (1 kHz ref)	
10 Hz – 20 kHz	±0.008 dB (typically <0.003 dB)
20 kHz – 50 kHz	±0.03 dB
50 kHz – 120 kHz	±0.10 dB
120 kHz – 200 kHz	+0.2/-0.3 dB
Residual Distortion[2]	
20 Hz – 20 kHz	typically <0.0001% [-120 dBc];
at 1 kHz	typically <0.00003% [-130 dBc]

[1] *20 Hz-50 kHz only. Decrease maximum available output by a factor of 2 (-6.02 dB) for the full 10 Hz-204 kHz range.*

[2] *Relative amplitude of any individual harmonic ≤80 kHz measured with a passive notch filter and FFT analyzer. Not valid for outputs above 12 Vrms balanced, or 6 Vrms unbalanced.*

Residual THD+N[3]	
20 Hz – 20 kHz	≤(0.0004% + 1 μV), 22 kHz BW [-108 dB]
	≤(0.0006% + 2 μV), 80 kHz BW [-104 dB]
	≤(0.0015% + 6 μV), 500 kHz BW [-96.5 dB]
10 Hz – 100 kHz	≤(0.0040% + 6 μV), 500 kHz BW [-88 dB]

Intermodulation Distortion Related Signals

with option "IMD"

SMPTE (or DIN) Test Signals

LF Tone	40, 50, 60, 70, 100, 125, 250, or 500 Hz; all ±1.5%
HF Tone Range	2 kHz – 200 kHz
Mix Ratio	4:1 or 1:1 (LF:HF)
Amplitude Range[4]	
Balanced	30 μVpp to 75.4 Vpp
Unbalanced	30 μVpp to 37.7 Vpp
Amplitude Accuracy	±2.0% [±0.17 dB]
Residual IMD[5]	0.0015% [-96.5 dB], 60+7 kHz or 250+8 kHz

CCIF and DFD Test Signals

Difference Frequency	80, 100, 120, 140, 200, 250, 500 or 1 kHz; all ±1.5%
Center Frequency	4.5 kHz – 200 kHz
Amplitude Range[4]	
Balanced	30 μVpp to 75.4 Vpp
Unbalanced	30 μVpp to 37.7 Vpp
Amplitude Accuracy	±3.0% [±0.26 dB]
CCIF Residual IMD[5]	≤0.0004% [-108 dB], 14 kHz+15 kHz (odd order & spurious typ <0.05%)
DFD Residual IMD[5]	≤0.0002% [-114 dB], 14 kHz+15 kHz (odd order & spurious typ <0.025%)

DIM (or TIM) Test Signals

Squarewave Frequency	3.15 kHz (DIM-30 and DIM-100); 2.96 kHz (DIM-B); both ±1%
Sinewave Frequency	15 kHz (DIM-30 and DIM-100); 14 kHz (DIM-B)
Amplitude Range[4]	
Balanced	30 μVpp to 75.4 Vpp
Unbalanced	30 μVpp to 37.7 Vpp
Amplitude Accuracy	±2.0% [±0.17 dB]
Residual IMD[5]	≤0.0020% [-94 dB]

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[3] Measured with System Two analog analyzer (system specification).Derate 20-25 Hz THD to 0.002% for outputs >20 Vrms balanced, or >10 Vrms unbalanced.

[4] Calibration with other amplitude units is based upon an equivalent sinewave having the same Vpp amplitude.

[5] Measured with System Two analog analyzer (system specification).

Special Purpose Signals

with option "BUR"

Sine Burst

Frequency Range	20 Hz – 100 kHz
Frequency Accuracy	Same as Sinewave
ON Amplitude Range	Bal 30 μVpp to 37.7 Vpp Unbal 30 μVpp to 18.8 Vpp
Accuracy, Flatness	Same as Sinewave
OFF Ratio Range	0 dB to -80 dB
OFF Ratio Accuracy	±0.3 dB, 0 to -60 dB
ON Duration	1 – 65535 cycles, or externally gated
Interval Range	2 – 65536 cycles

Square Wave

Frequency Range	20 Hz – 20 kHz
Frequency Accuracy	Same as Sinewave
Amplitude Range[4]	
Balanced	30 μVpp to 37.7 Vpp
Unbalanced	30 μVpp to 18.8 Vpp
Amplitude Accuracy	±2.0% [±0.17 dB] at 400 Hz
Rise/fall time	Typically 2.0 μs

Noise Signals

White Noise	Bandwidth limited 10 Hz – 23 kHz
Pink Noise	Bandwidth limited 10 Hz – 200 kHz
Bandpass Noise	Approximately 1/3-octave (2-pole) filtered pink noise, continuously tunable from 20 Hz – 100 kHz
Generator	True random or Pseudo-random
Pseudo-Random Repeat Time	Typically 262 ms (synchronized to the analyzer 4/s reading rate)
Amplitude Range[4]	(Approximate calibration only)
Balanced	30 μVpp to 37.7 Vpp
Unbalanced	30 μVpp to 18.8 Vpp

D/A Generated Analog Signals

Available only in models SYS-2422 and SYS-2522. All D/A generated signals (except Arbitrary Waveform) may be selected simultaneously and independently with the concurrently available digital domain output signals. Unless otherwise stated, amplitude range, accuracy, and resolution are the same as for the analog sinewave signal.

Common Specifications

D/A Resolution	24-bit sigma-delta, stereo
Sample Rate (SR)	
Sine, IMD signals	fixed 65.536 ks/s or 131.072 ks/s
Other signals	7.2 ks/s to 108 ks/s variable; or fixed 65.536 ks/s or 131.072 ks/s
Frequency Accuracy	±0.0002% [2 PPM] internal reference, lockable to external reference

"SINE (D/A)" Signal Family

The Sine family includes "Normal," "Var Phase," "Stereo," "Dual," "Shaped Burst," and "EQ Sine." Normal and EQ Sine modes produce a monaural signal with the same frequency in both channels and provide the lowest residual THD+N performance. EQ Sine differs from Normal only by varying the amplitude in accordance with a selected EQ file. Var Phase mode produces the same sinewave in both channels but with settable phase offset. Stereo mode provides sinewaves of independently settable frequency in each channel (phase is random if both frequencies are set equal). Dual mode produces a monaural test signal containing a mixture of two sinewaves of independently settable frequency and amplitude ratio. Shaped Burst produces a monaural sine burst signal with a raised cosine amplitude envelope (see Figure 31).

Frequency Ranges	10 Hz to 30 kHz (65.536 ks/s), or 10 Hz to 60 kHz (131.072 ks/s)
Frequency Resolution	Sample Rate ÷ 2^{23} (typically 0.0078 Hz in the 30 kHz range)
Flatness (1 kHz ref)	
20 Hz – 20 kHz	±0.01 dB
10 Hz – 30 kHz	±0.03 dB
30 kHz – 50 kHz	±0.10 dB (typically -0.5 dB at 60 kHz)
THD+N[6] (20Hz-20kHz)	
30 kHz range	0.0007% [-103 dB]
60 kHz range	0.0010% [-100 dB]
Variable Phase Range	-180.0 to +179.9 deg
Dual-Sine Ratio Range	0 dB to -100 dB, usable to -138 dB
Shaped Burst Interval	2 – 65536 cycles
Shaped Burst On Time	1 to number of interval cycles minus 1

[6] *Measured with System Two analog analyzer, BW = 22 kHz.*

"IMD (D/A)" Signal Family

SMPTE/DIN Test Signal

LF Tone	40 Hz to 500 Hz (continuously settable)
HF Tone	2.00 kHz to >50 kHz
Mix Ratio	4:1 or 1:1 (LF:HF)
Residual IMD[7]	≤0.0010% [-100 dB], 60/7kHz or 250/8kHz

CCIF/DFD Test Signal

Difference Frequency	80 Hz to 2 kHz
Center Frequency	4.50 kHz to >50 kHz
Residual CCIF IMD[7]	≤0.0004% [-108 dB], 14kHz/15kHz pair
Residual DFD IMD[7]	≤0.0002% [-114 dB], 14kHz/15kHz pair
Odd order and spurious	Typically <0.0004% [-108 dB]

DIM Test Signal

Squarewave Frequency	3.15 kHz for DIM30 and DIM100; 2.96 kHz for DIMB
Sinewave Frequency	15.00 kHz for DIM30 and DIM100, 14.00 kHz for DIMB
Residual IMD[7]	≤0.0020% [-94 dB]

Other Signals

Arbitrary Waveform (and Multitone)

Signal	Determined by the associated file specified in the panel drop-down box.
Number of Tones	1 – 8191
Length	256 – 16384 points per channel, user specified waveform. Utility is provided to prepare a time record file from user specified frequency, amplitude, and phase data.
Frequency Range	20 Hz to 47% of sample rate
Frequency Resolution	Sample Rate ÷ length of arbitrary waveform size (typ 2.92 Hz at 48 ks/s)

Maximum Length Sequence (MLS)

Sequences	4 pink, 4 white
Sequence Length	"32k" (32767) or "128k" (131071)
Frequency Range	10 Hz to 47% of sample rate

Special Signals

Polarity	Asymmetric waveform for polarity testing. 15 kHz at 30 kHz bandwidth 20 Hz to 30 kHz at 60 kHz bandwidth
Pass Thru	Accepts signal at rear panel Reference Input with sample rate from 27 kHz to 54 kHz.

[7] *Measured with System Two analog analyzer.*

Squarewave

Frequency Range	20 Hz to 20.0 kHz
Risetime	Typically 2.0 µs

Noise Signal

True random white

Output Characteristics

Source Configuration	Selectable balanced, unbalanced, or CMTST (common mode test)
Source Impedances	
Balanced or CMTST	40 Ω (±1 Ω), 150 Ω[8] (±1 Ω), or 600 Ω (±3 Ω)
Unbalanced	20 Ω (±1 Ω) or 600 Ω (±3 Ω)
Max Floating Voltage	42 Vpk
Output Current Limit	Typically >80 mA
Max Output Power	
Balanced	+30.1 dBm into 600 Ω (Rs = 40 Ω)
Unbalanced	+24.4 dBm into 600 Ω (Rs = 20 Ω)
Output Related Crosstalk	
10 Hz – 20 kHz	≤-120 dB or 5 µV, whichever is greater
20 kHz – 100 kHz	≤-106 dB or 10µV, whichever is greater

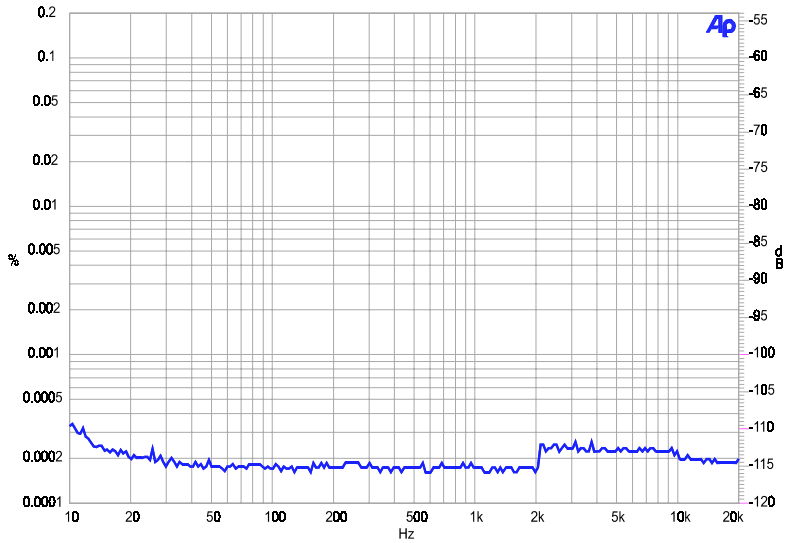

Figure 1. Typical total system THD+N versus Frequency using analog sinewave at 2Vrms

[8] *200 Ω with option "EURZ"*

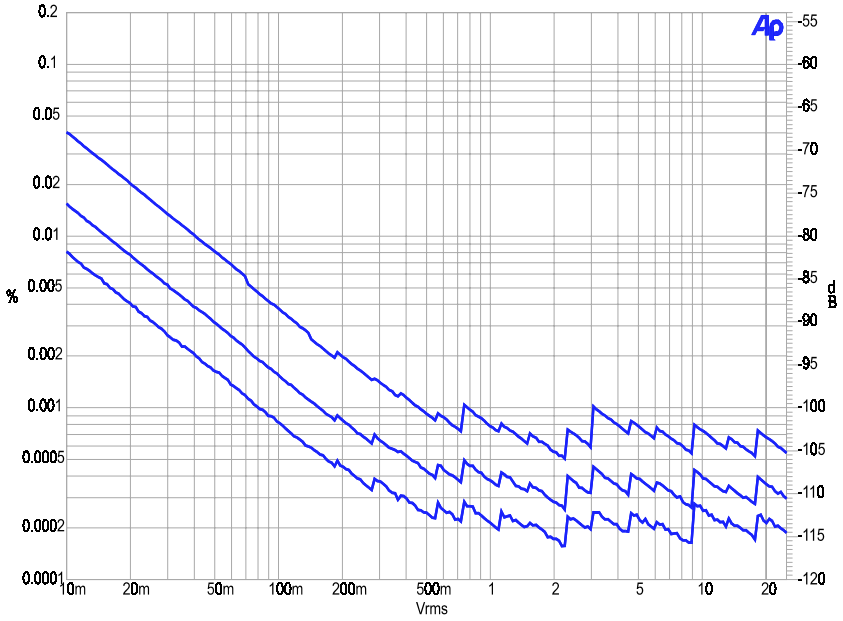

Figure 2. Typical THD+N versus Amplitude at 1 kHz for three different analog analyzer measurement bandwidths. Lower curve is with 22 kHz bandwidth limiting. Middle curve is with 80 kHz. Upper curve is with 500 kHz.

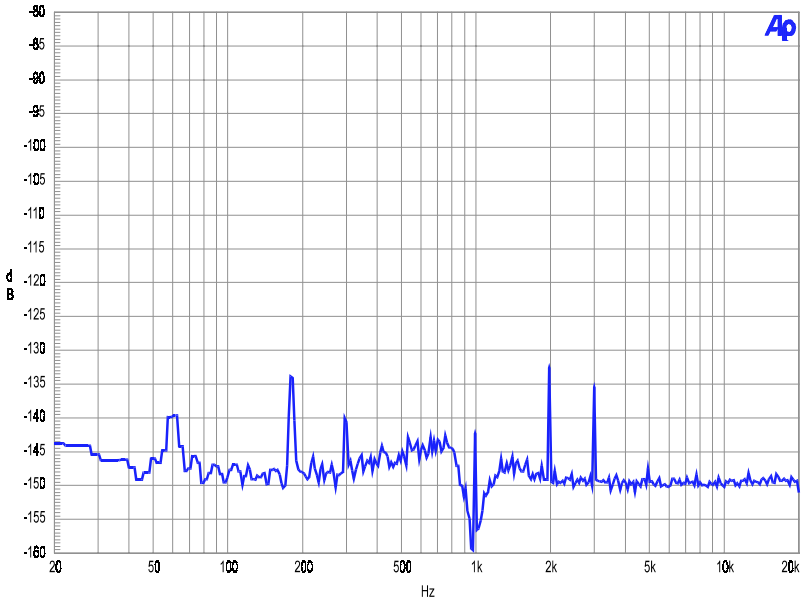

Figure 3. Typical analog generator residual THD+N spectrum at 1 kHz, 2 Vrms (16384 point FFT of notch filter output, Fs = 48 kHz, 16 averages)

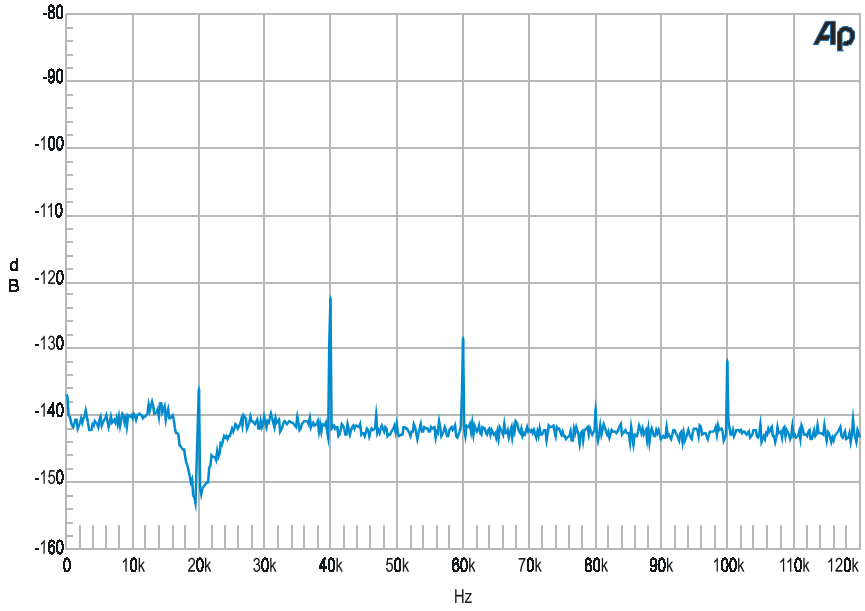

Figure 4. Typical analog generator residual THD+N spectrum at 20 kHz, 2 Vrms (16384 point FFT of notch filter output, Fs = 262 kHz, 16 averages)

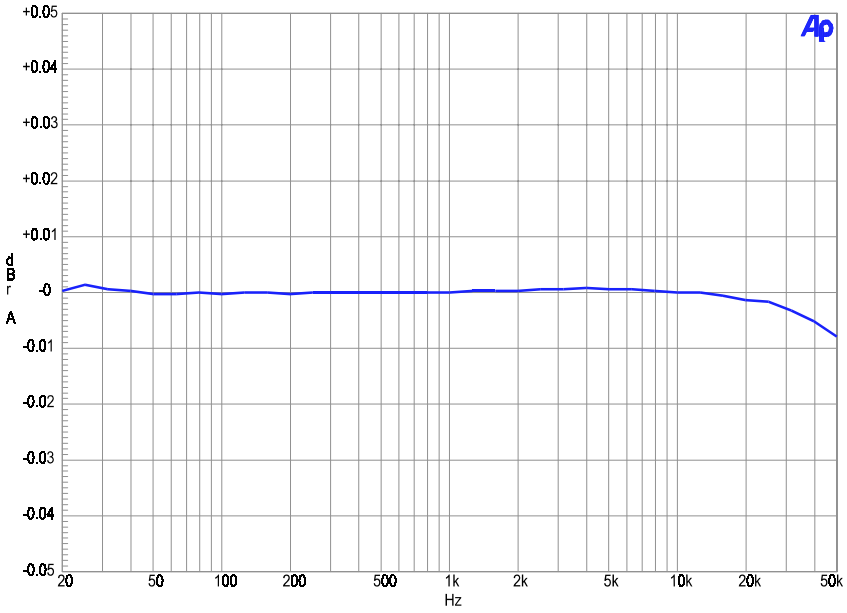

Figure 5. Typical analog system flatness at 2 Vrms signal level

Analog Analyzer

All System Two Cascade configurations, except SYS-2500, contain an analog analyzer consisting of an input module with two independent auto-ranging input stages, each having its own level (rms) and frequency meters; a phase meter connected between the channels; plus a single channel multi-function analyzer module providing additional signal processing and gain stages.

SYS-2422 and SYS-2522 configurations also include dual channel A/D converters for FFT and other special forms of analysis on the analog input and analyzer output signals. Unless otherwise noted, all specifications assume dc coupling and rms detection.

Standard analyzer functions include amplitude and noise (both wideband and selective), THD+N, and crosstalk. Option "IMD" adds intermodulation distortion (IMD) measurement capability. Option "W&F" adds wow and flutter measurement capability.

Analog Input Characteristics

Input Ranges	40 mV to 160 V in 6.02 dB steps
Maximum Rated Input	230 Vpk, 160 Vrms (dc to 20 kHz); overload protected in all ranges
Input Impedance	
Balanced (each side)	Nominally 100 kΩ // 185 pF (typ)
Unbalanced	Nominally 100 kΩ // 185 pF (typ)
Terminations	Selectable 600 Ω or 300 Ω, ±1%; 1 Watt [+30 dBm] maximum power
CMRR[9]	
40 mV – 2.5 V ranges	≥80 dB, 10 Hz – 20 kHz
5 V and 10 V ranges	≥65 dB, 10 Hz – 20 kHz
20 V – 160 V ranges	≥50 dB, 10 Hz – 1 kHz
Input Related Crosstalk	
10 Hz – 20 kHz	≤-140 dB or 1 μV, whichever is greater
20 kHz – 100 kHz	≤-126 dB or 2.5 μV, whichever is greater

[9] *Not valid below 50 Hz with ac coupling.*

Level Meter Related *(both channels)*

Measurement Range	5 mV to 160 V for specified accuracy and flatness, usable to <100 µV
Resolution (full scale)[10]	
4/s	1/40,000 [0.00022 dB]
8/s	1/40,000 [0.00022 dB]
16/s	1/20,000 [0.00043 dB]
32/s	1/10,000 [0.00087 dB]
64/s	1/5,000 [0.0017 dB]
128/s	1/2,500 [0.0035 dB]
Accuracy (1 kHz)	±0.5% [±0.05 dB]
Flatness (1 kHz ref)[11]	
20 Hz – 20 kHz	±0.008 dB (typically <0.003 dB)
15 Hz – 50 kHz	±0.03 dB
10 Hz – 120 kHz	±0.10 dB
120 kHz – 200 kHz	+0.2/-0.3 dB (typically <-0.5 dB at 500 kHz)

Frequency Meter Related *(both channels)*

Measurement Range	10 Hz – 500 kHz
Accuracy	±0.0006% [±6 PPM]
Resolution	6 digits + 0.000244 Hz
Minimum Input	5 mV

Phase Measurement Related

Measurement Ranges	±180, -90/+270, or 0/+360 deg
Accuracy[12]	
10 Hz – 5 kHz	±0.5 deg
5 kHz – 20 kHz	±1 deg
20 kHz – 50 kHz	±2 deg
Resolution	0.1 deg
Minimum Input	5 mV, both inputs

Wideband Amplitude/Noise Function

Measurement Range	<1 µV to 160 Vrms
Accuracy (1 kHz)	±1.0% [±0.09 dB]
Flatness (1 kHz ref)[11]	
20 Hz – 20 kHz	±0.02 dB
15 Hz – 50 kHz	±0.05 dB
50 kHz – 120 kHz	±0.15 dB
120 kHz – 200 kHz	+0.2 dB/-0.3 dB (typically < -3 dB at 500 kHz)

10 Resolution within a given range is equal to its full scale value multiplied by the fraction indicated for the selected reading rate. (Example: 40 mV input range reading resolution = 4 µV, using the 32/s reading rate). Numerical displays using a dB unit are rounded to the nearest 0.001 dB.

11 Derate flatness above 5 kHz by an additional ± 0.02 dB in the 20 V, 40 V, 80 V, and 160 V input ranges.

12 Both analyzer input channels must have same coupling (ac or dc) selection. Accuracy is valid for any input signal amplitude ratio up to ± 30 dB.

Bandwidth Limiting Filters	*see Figure 6*
LF -3 dB	<10 Hz, 22 Hz per CCIR Rec 468, 100 Hz ±5% (3-pole), or 400 Hz ±5% (3-pole)
HF -3 dB	22 kHz per CCIR Rec 468, 30 kHz ±5% (3-pole), 80 kHz ±5% (3-pole), or >500 kHz

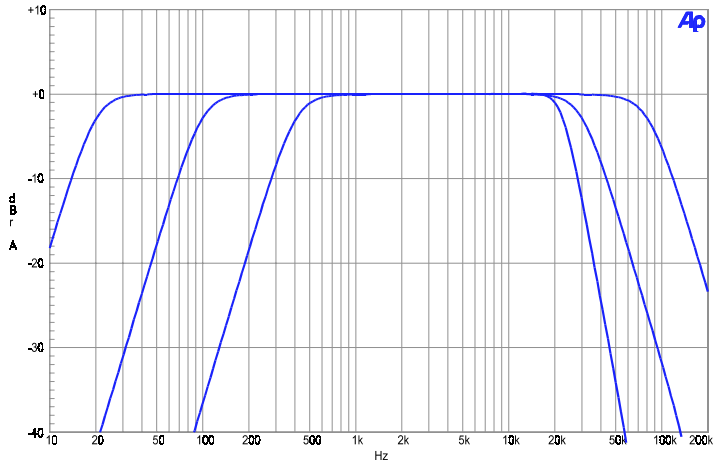

Figure 6. Standard Band-limiting filters included with every System Two Cascade: High pass selectable 22 Hz, 100 Hz, 400 Hz; Low pass selectable: 22 kHz, 30 kHz, 80 kHz

Optional Filters	up to 7
Detection	RMS (τ = 25 ms or 50 ms), AVG, QPk per CCIR Rec 468, Pk (pseudo-peak), or S-Pk (0.7071 x Pk reading)
Residual Noise	
22 Hz – 22 kHz BW	≤1.0 µV [-118 dBu]
80 kHz BW	≤2.0 µV [-112 dBu]
500 kHz BW	≤6.0 µV [-102 dBu]
A-weighted	≤0.5 µV [-124 dBu]
CCIR-QPk	≤2.5 µV [-110 dBu]

Bandpass Amplitude Function

Tuning Range (f_o)	10 Hz to 200 kHz
Tuning Accuracy	±2%
Bandpass Response	1/3-octave class II (4-pole); <-32 dB at 0.5 f_o and 2.0 f_o
Accuracy (at f_o)	±0.3 dB, 20 Hz – 120 kHz
Residual Noise	
10 Hz – 5 kHz	≤0.25 µV [-130 dBu]
5 kHz – 20 kHz	≤0.5 µV [-124 dBu]
20 kHz – 200 kHz	≤1.5 µV [-114 dBu]

Bandreject Amplitude Function

Tuning Range (f_o)	10 Hz to 200 kHz
Tuning Accuracy	±2%
Bandreject Response	typically -3 dB at 0.73 f_o & 1.37 f_o -20 dB at f_o ±10% -40 dB at f_o ±2.5%
Accuracy	±0.3 dB, 20 Hz – 120 kHz (excluding 0.5 f_o to 2.0 f_o)
Residual Noise	same as Amplitude Function

THD + N Function

Fundamental Range	10 Hz to 200 kHz
Measurement Range	0 – 100%
Accuracy	±0.3 dB, 20 Hz – 120 kHz harmonics
Measurement Bandwidth	
LF -3 dB	<10, 22, 100, or 400 Hz
HF -3 dB	22k, 30k, 80k, or >500 kHz; option filters are also functional
Residual THD+N[13]	
20 Hz – 20 kHz	≤(0.0004% + 1.0 μV), 22 kHz BW [-108 dB]
	≤(0.0006% + 2.0 μV), 80 kHz BW [-104 dB]
	≤(0.0015% + 6.0 μV), 500 kHz BW [-96.5 dB]
10 Hz – 100 kHz	≤(0.0040% + 6.0 μV), 500 kHz BW [-88 dB]
Minimum Input	5 mV for specified accuracy, usable to <100 μV with fixed notch tuning
Notch Tuning Modes	Counter Tuned, Sweep Track, AGen-Track (analog generator), DGen-Track (digital generator), or Fixed (set by direct entry)
Notch Tracking Range	±2.5% from fixed setting

Crosstalk Function

Frequency Range	10 Hz to 200 kHz
Accuracy[14]	±0.4 dB, 20 Hz – 120 kHz
Residual Crosstalk[14]	
10 Hz – 20 kHz	≤-140 dB or 1 μV
20 kHz – 100 kHz	≤-126 dB or 2.5 μV

13 *System specification including contribution from analog generator. Generator residual THD may limit system performance below 25 Hz if output is >20.0 Vrms balanced, or 10.0 Vrms unbalanced.*

14 *Uses the 1/3-octave bandpass filter to enhance the measured range in the presence of wideband noise. Alternate (interfering) channel input must be ≥ 5 mV.*

IMD Measurements

with option "IMD"

Option "IMD" adds the capability to measure intermodulation distortion (IMD) using three of the most popular techniques. The demodulated IMD signal can also be selected for FFT analysis in SYS-2422 and SYS-2522 configurations.

SMPTE (DIN) IMD Function

Test Signal Compatibility	Any combination of 40-250 Hz (LF) and 2 kHz-100 kHz (HF) tones, mixed in any ratio from 0:1 to 8:1 (LF:HF)
IMD Measured	Amplitude modulation products of the HF tone. -3 dB measurement bandwidth is typically 20 Hz – 750 Hz
Measurement Range	0 to 20%
Accuracy	±0.5 dB
Residual IMD[15]	≤0.0015%, 60 + 7 kHz or 250 + 8 kHz

CCIF and DFD IMD Functions

Test Signal Compatibility	Any combination of equal amplitude tones from 4 kHz to 100 kHz spaced 80 Hz to 1 kHz (difference frequency)
IMD Measured	
CCIF function	2^{nd} order difference frequency product relative to the amplitude of either test tone
DFD function	u_2 (2^{nd} order difference frequency product) per IEC 268-3 (1986)
Measurement Range	0 to 20%
Accuracy	±0.5 dB
Residual IMD[15]	CCIF ≤0.0004%, 14 kHz + 15 kHz [-108 dB], DFD ≤ 0.0002%, 14 kHz + 15 kHz [-114 dB]

DIM (TIM) IMD Function

Test Signal Compatibility	2.96 – 3.15 kHz squarewave mixed with 14 – 15 kHz sine probe tone
IMD Measured[16]	u_4 and u_5 per IEC 268-3 (1986)
Measurement Range	0 to 20%
Accuracy	±0.7 dB
Residual IMD[15]	≤0.0020%

15 System specification measured with the System Two analog generator. Valid for input levels ≥200 mVrms.

16 IEC 268-3 defines nine possible DIM products. The System Two IMD option analyzer is sensitive only to the u4 and u5 products using the simplified measurement technique proposed by Paul Skritek. DIM measurements using this technique will typically be 6-8 dB lower (better) than the results obtained using FFT-based techniques which sum all nine products.

Wow & Flutter Measurements *with option "W&F"*

Option "W&F" adds the capability to make both conventional wow & flutter and scrape flutter measurements (using the technique developed by Dale Manquen of Altair Electronics, Inc). The demodulated W&F signal can also be selected for FFT analysis in SYS-2422 and SYS-2522 configurations.

Test Signal Compatibility	
Normal	2.80 kHz – 3.35 kHz
"High-band"	11.5 kHz – 13.5 kHz
Measurement Range	0 to 1.2%
Accuracy (4 Hz)	±(5% of reading + 0.0005%)
Detection Modes	IEC/DIN (quasi-peak per IEC-386), NAB (average), JIS (per JIS 5551)
Response Selections	
Weighted	4 Hz bandpass per IEC/DIN/NAB
Unweighted	0.5 Hz – 200 Hz
Scrape[17]	200 Hz – 5 kHz
Wideband[17]	0.5 Hz – 5 kHz
Residual W+F	
Weighted	≤0.001%
Unweighted	≤0.002%
Scrape or Wideband	≤0.005%
Minimum Input	5 mV (20 mV for specified residual)
Settling Time	
IEC/DIN or NAB	Typically 3 to 6 seconds
JIS	Typically 15 to 20 seconds

[17] *Operational with high-band test signals (11.5 kHz-13.5 kHz) only. Upper -3 dB rolloff is typically 4.5 kHz using 12.5 kHz.*

Option Filters

Up to seven optional filters can be installed in the System Two Cascade analyzer for weighted noise or other special measurements. Option filters are selected one at a time and are cascaded with the standard bandwidth limiting filters.

The following tables list only the most popular types. Contact Audio Precision for a quotation regarding other possible designs. The maximum usable dynamic range will be limited to about 40 – 50 dB because system auto-ranging is based upon the peak value of the unfiltered wideband signal. Custom designs may be constructed on the FIL-USR blank card.

> ***Note:*** *The optional filters described here can be cascaded with the standard band-limiting filters.*

Weighted Noise Measurement

FIL-AWT	"A" weighting per IEC Rec 179	*see Figure 7*
FIL-CCR	Weighting per CCIR Rec 468 and DIN 45404 (Also for CCIR/ARM)	*see Figure 8*
FIL-CIT	Weighting per CCITT Rec P53	*see Figure 9*
FIL-CMS	"C-message" per BSTM 41004 and ANSI/IEEE Std 743-1984	*see Figure 10*
FIL-CWT	"C" weighting per IEC Rec 179	*see Figure 11*

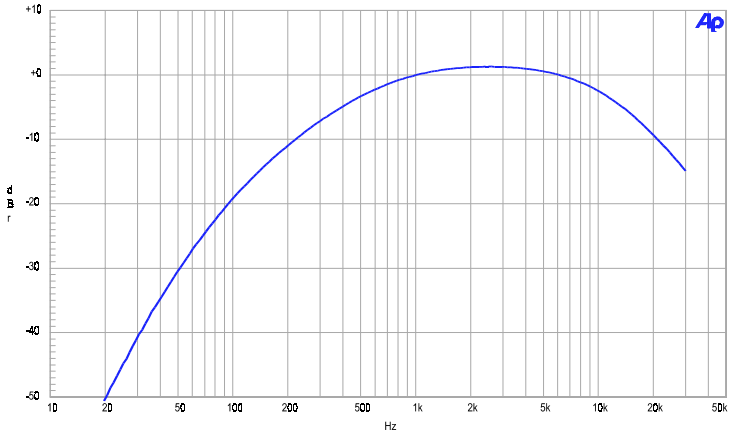

Figure 7. FIL-AWT ANSI-IEC "A" Weighting Filter

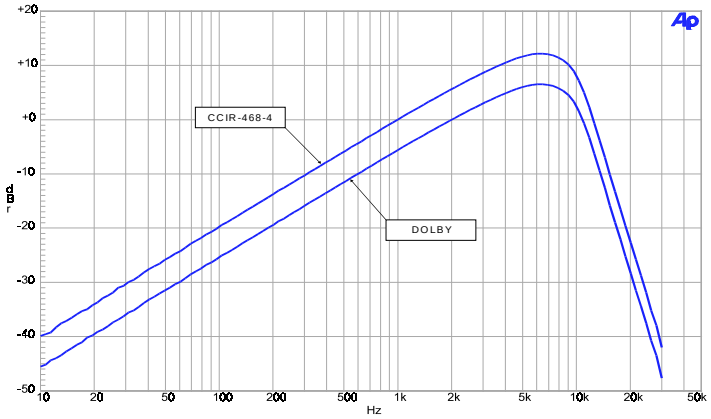

Figure 8. FIL-CCR CCIR-468 / DIN 45404 Noise Weighting Filter

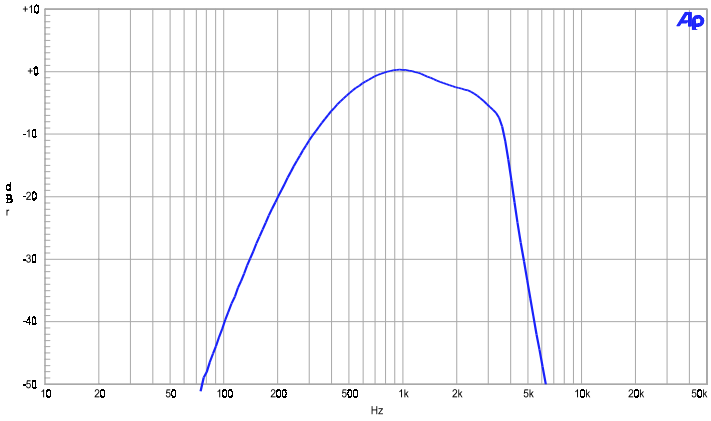

Figure 9. FIL-CIT CCITT P53 Noise Weighting Filter

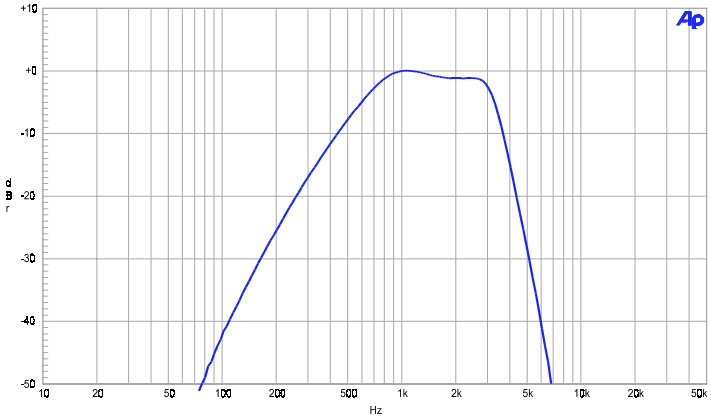

Figure 10. FIL-CMS C-Message Weighting Filter (ANSI/IEEE 743-1984)

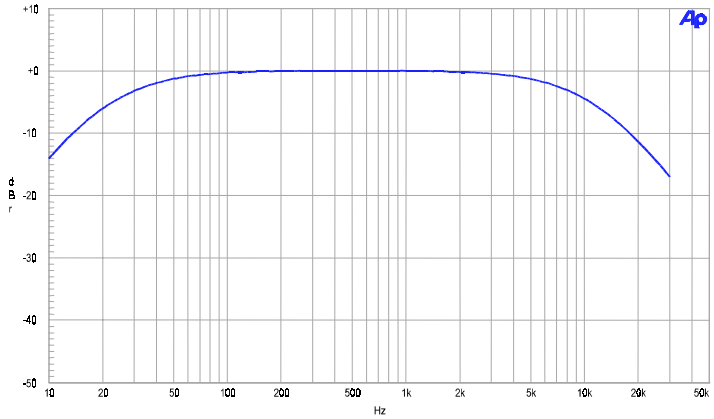

Figure 11. FIL-CWT "C" Weighting (IEC-179)

Precision De-emphasis Family

FIL-D50	50 µs ±1%	*see Figure 12*
FIL-D50E	50 µs ±1% + 15.625 kHz notch	
FIL-D50F	50 µs ±1% + 19.0 kHz notch	*see Figure 13*
FIL-D75	75 µs ±1%	*see Figure 14*
FIL-D75B	75 µs ±1% + 15.734 kHz notch	*see Figure 15*
FIL-D75F	75 µs ±1% + 19.0 kHz notch	*see Figure 16*

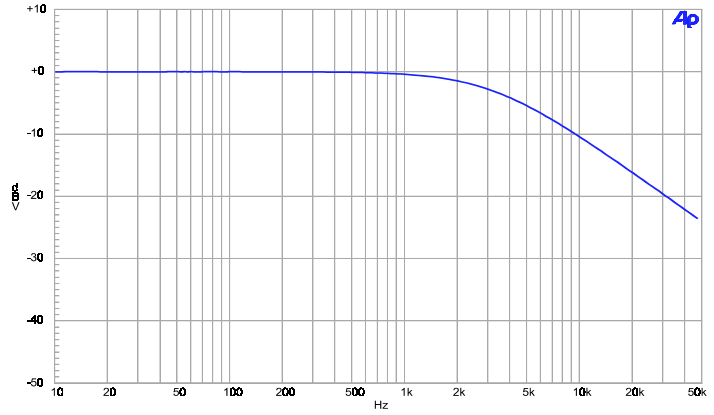

Figure 12. FIL-D50 50 µs De-emphasis Filter

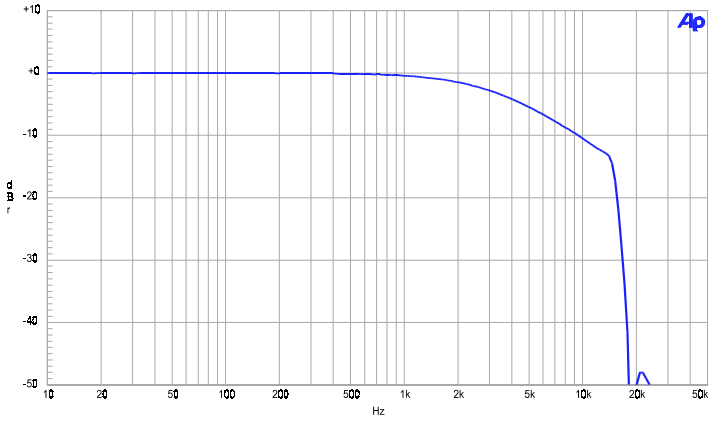

Figure 13. FIL-D50F 50 µs with 19 kHz (FM) notch De-emphasis Filter

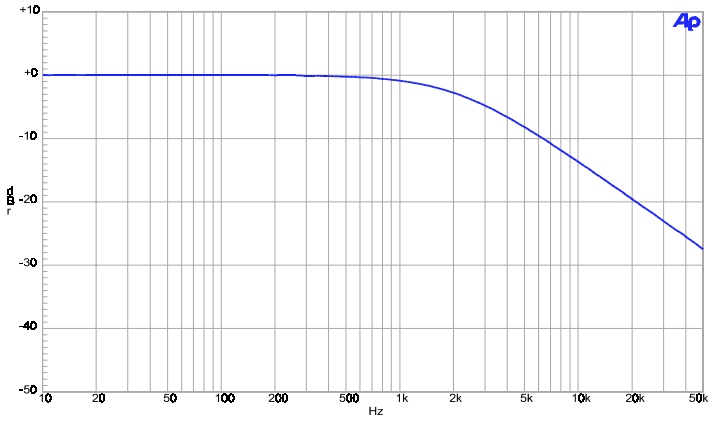

Figure 14. FIL-D75 75 µs De-emphasis Filter

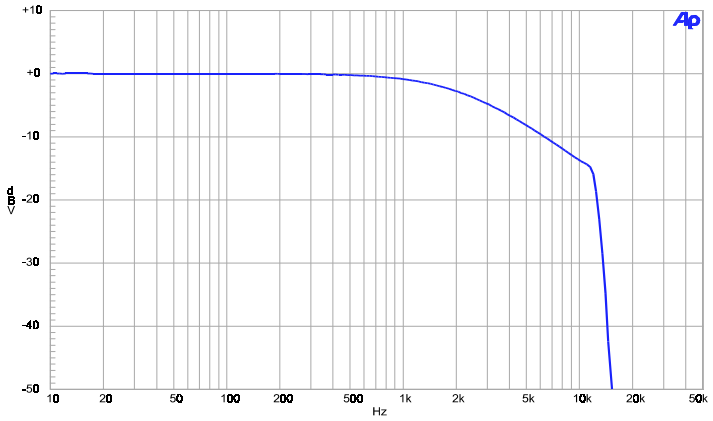

Figure 15. FIL-D75B 75 µs with 15.734 kHz (NTSC) notch De-emphasis Filter

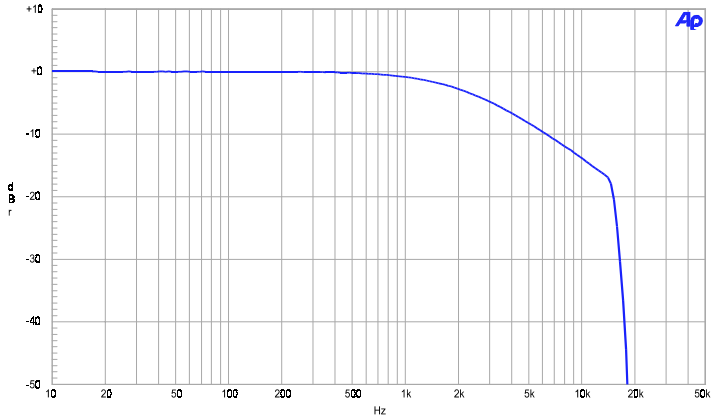

Figure 16. FIL-D75F 75 µs with 19 kHz (FM) notch De-emphasis Filter

Precision Sharp Cutoff Low-Pass Family

Family Response	-3 dB at f_c ±1.5%; ±0.2 dB to 0.5 f_c, ±0.4 dB to 0.8 f_c ; <-50 dB above 1.8 f_c	
FLP-10K	f_c = 10.0 kHz, quasi-elliptic	
FLP-15K	f_c = 15.0 kHz, quasi-elliptic	
FLP-18K	f_c = 18.0 kHz, quasi-elliptic	
FLP-19K	f_c = 19.0 kHz, quasi-elliptic	
FLP-20K	f_c = 20.0 kHz, quasi-elliptic	*see Figure 17*
See also FLP-A20K under Miscellaneous		*see Figure 26*

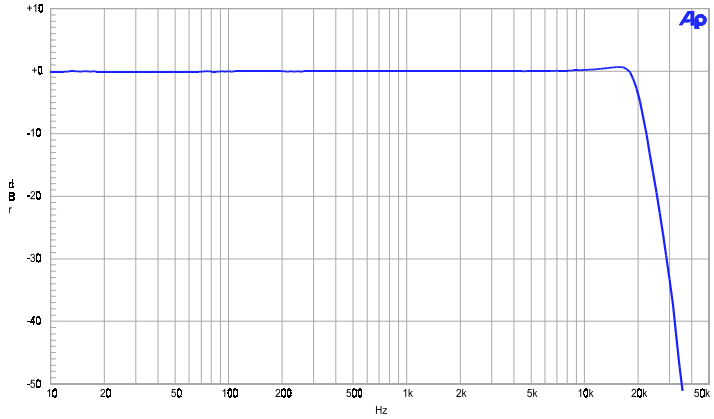

Figure 17. FLP-20K 20.0 kHz Quasi-elliptic sharp cutoff Low Pass Filter

Bandwidth Limiting, Low-Pass

FLP-300	300 Hz ±3%, 5-pole	
FLP-400	400 Hz ±3%, 5-pole	
FLP-500	500 Hz ±3%, 5-pole	
FLP-1K	1 kHz ±3%, 5-pole Butterworth	*see Figure 18*
FLP-3K	3 kHz ±3%, 7-pole Butterworth	
FLP-4K	4 kHz ±3%, 7-pole Butterworth	
FLP-8K	8 kHz ±3%, 7-pole Butterworth	*see Figure 19*
FLP-50K	50 kHz ±5%, 3-pole Butterworth	*see Figure 20*

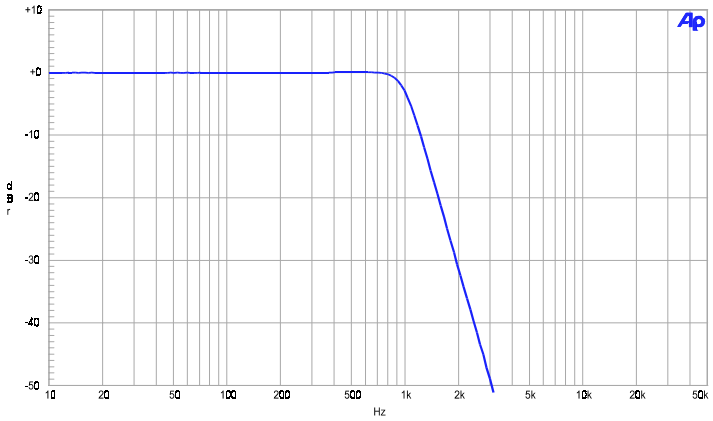

Figure 18. FLP-1K 1 kHz Low Pass 5-pole Butterworth Filter

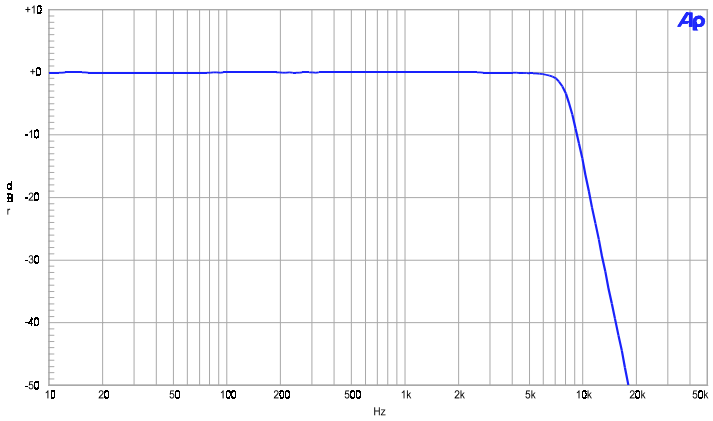

Figure 19. FLP-8K 8 kHz 7-pole Butterworth Low Pass Filter

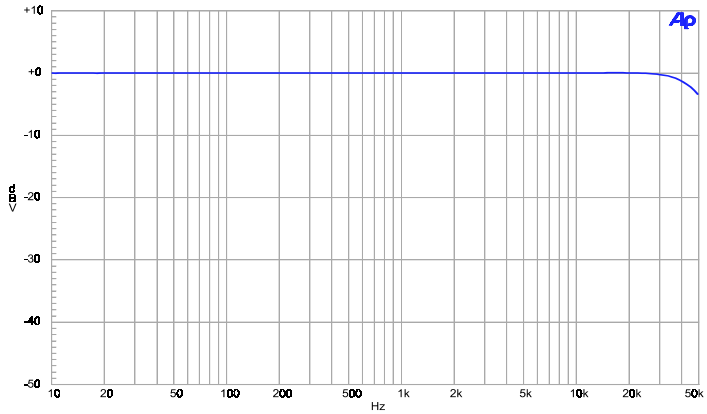

Figure 20. FLP-50K 50 kHz 3-pole Butterworth Low Pass Filter

Bandwidth Limiting, High-Pass

FHP-70	70 Hz ±3%, 8-pole	
FHP-400	400 Hz ±3%, 9-pole	*see Figure 21*
FHP-2K	2 kHz ±3%, 9-pole	

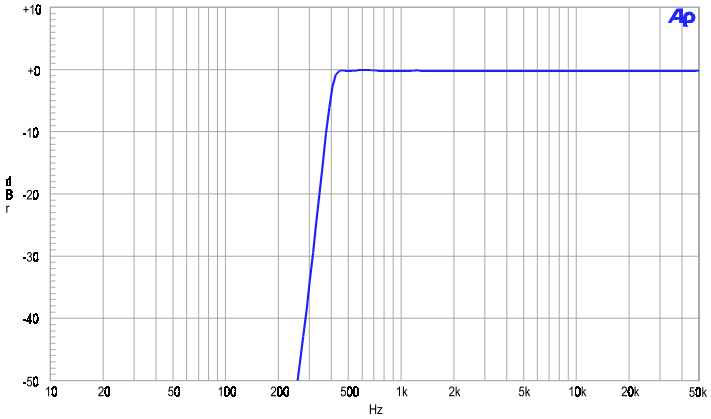

Figure 21. FHP-400 400 Hz 9-pole High Pass Filter

1/3-Octave (Class II) Bandpass Family

Family Response	Class II (4-pole) ±0.2 dB from 0.97 f_o to 1.03 f_o ; <-12 dB at 0.8 f_o and 1.25 f_o ; <-32 dB at 0.5 f_o and 2.0 f_o *see Figure 22*
FBP-120	f_o = 120 Hz
FBP-180	f_o = 180 Hz
FBP-250	f_o = 250 Hz
FBP-300	f_o = 300 Hz
FBP-400	f_o = 400 Hz
FBP-500	f_o = 500 Hz
FBP-600	f_o = 600 Hz
FBP-666	f_o = 666 Hz
FBP-800	f_o = 800 Hz
FBP-945	f_o = 945 Hz
FBP-1000	f_o = 1.00 kHz
FBP-1200	f_o = 1.20 kHz
FBP-1500	f_o = 1.50 kHz
FBP-2000	f_o = 2.00 kHz
FBP-3000	f_o = 3.00 kHz
FBP-3150	f_o = 3.15 kHz
FBP-4000	f_o = 4.00 kHz
FBP-4500	f_o = 4.50 kHz
FBP-5000	f_o = 5.00 kHz
FBP-6000	f_o = 6.00 kHz
FBP-8000	f_o = 8.00 kHz
FBP-10000	f_o = 10.0 kHz
FBP-12500	f_o = 12.5 kHz
FBP-15000	f_o = 15.0 kHz
FBP-16000	f_o = 16.0 kHz
FBP-20000	f_o = 20.0 kHz
FBP-22000	f_o = 22.0 kHz

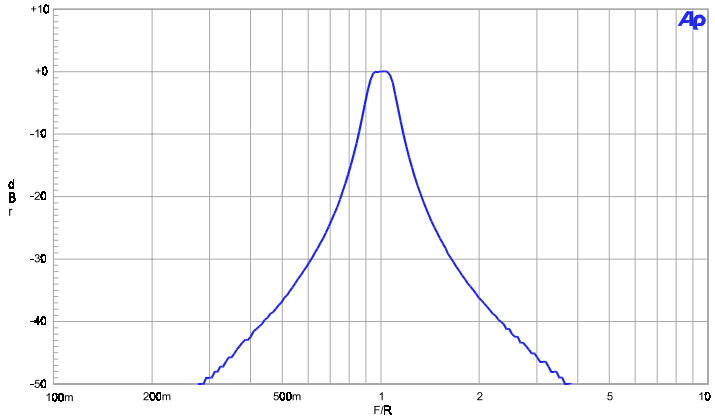

Figure 22. FBP-XXXX Fixed 1/3 Octave Band Pass Filter

Receiver Testing

FIL-RCR	200 Hz-15 kHz + 19.0 kHz notch	*see Figure 23*
FIL-IECR	20 Hz-15 kHz + 15.625 kHz notch	*see Figure 24*

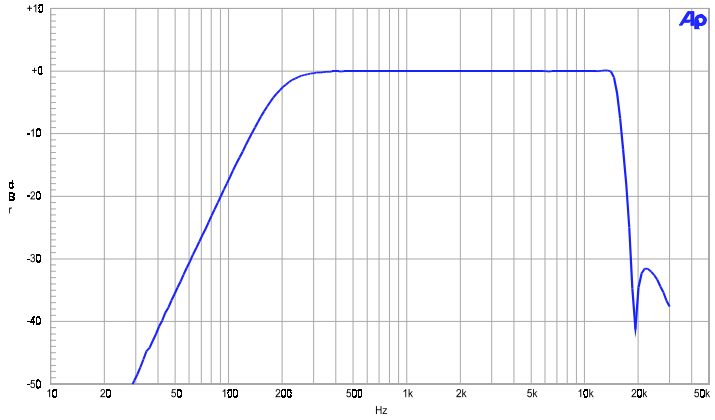

Figure 23. FIL-RCR 200 Hz to 15 kHz with 19 kHz (FM) notch Receiver Testing Filter

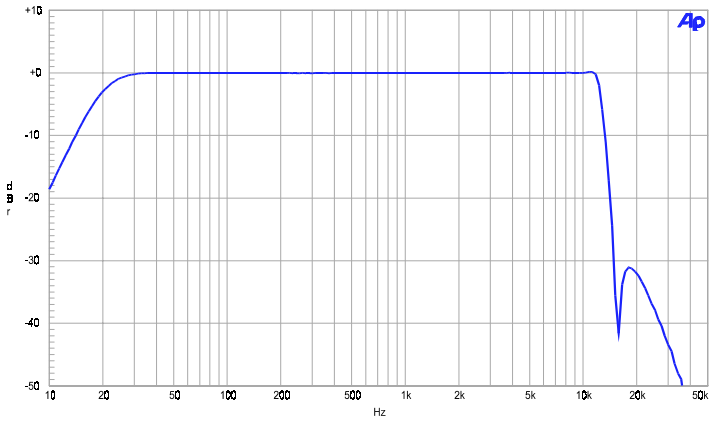

Figure 24. FIL-IECR 20 Hz to 15 kHz with 15.625 kHz (PAL) notch Receiver Testing Filter

Miscellaneous

FBP-500X	High-Q 500 Hz bandpass for CD dac linearity measurements *(see Figure 25)*
FLP-A20K	Apogee 20 kHz “brick wall” filter (OEM design) *(See Figure 26)*
FIL-USR	Kit for building custom filters

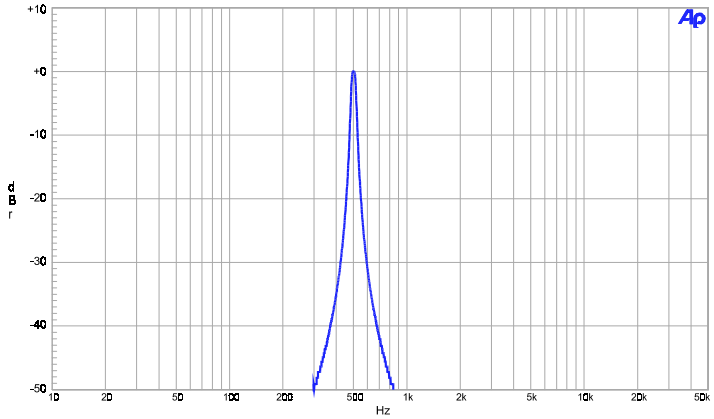

Figure 25. FBP-500X High-Q 500 Hz Band Pass Filter (for CD linearity testing)

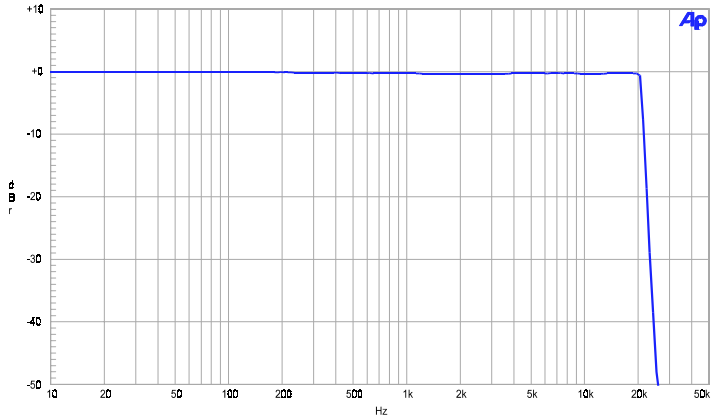

Figure 26. FLP-A20K Apogee "Brick Wall" 20 kHz Low Pass Filter

DSP Analysis of Analog Signals

Available only in models SYS-2422 and SYS-2522. Signals connected to the analog analyzer input connector may also be internally routed through stereo A/D converters for enhanced analysis capabilities. There are two selectable converters. The high resolution converter ("HiRes A/D") is optimized for signal analysis and FFT displays up to 30 kHz. It offers the best residual noise and distortion performance. The high bandwidth converter ("HiBW A/D") is optimized for signal analysis up to 120 kHz.

High Resolution Converter

A/D Resolution	24-bit sigma-delta
Sample Rate (SR)	7.2ks/s to 108ks/s variable; or 65.536ks/s fixed
Flatness (1 kHz reference)	±0.01 dB to 0.450 SR or 20 kHz, whichever is lower
Alias Rejection[18]	typ 115 dB for signals >0.554 SR
Distortion	-105 dB for SR ≤65.536 ks/s, -102 dB for SR up to 100 ks/s
Maximum usable BW	30 kHz with SR = 65.536 ks/s, 45 kHz with SR = 100 ks/s

High Bandwidth Converter

A/D Resolution	16-bit sigma-delta
Sample Rate (SR)	56 ks/s to 216 ks/s variable; or 131.072 ks/s or 262.144 ks/s fixed
Flatness (1 kHz ref)	±0.01 dB to 20 kHz, ±0.10 dB to 120 kHz (262.144 ks/s)
Alias Rejection[18]	typ 85 dB for signals >0.540 SR
Distortion	-92 dB for SR ≤216 ks/s, -90 dB with SR = 262.144 ks/s

FFT Signal Analyzer

(FFT)	
Acquisition Length	800 – 256 k samples in 11 steps
Transform Length	256 – 32768 samples in binary steps
Processing	48 bit

[18] *Alias rejection is provided by digital filters within the respective A/D converters.*

Windows *(see Figure 27 and Figure 28)*	Blackman-Harris (4 term with -92 dB sidelobe) Hann Flat-top Equiripple (-160 dB sidelobes) None None, sync to sine Hamming Gaussian Rife-Vincent 4-term Rife-Vincent 5-term
Amplitude Accuracy	±0.001 dB, 20 Hz – 20 kHz, using Flat-top window
Averaging	1 – 4096 in binary steps, averaging algorithm is power (spectrum only) or synchronous
Waveform Display Modes	Normal, interpolate, peak, max
Frequency Display Modes	Peak pick, individual bin
Sync to Sine Window	
Frequency Range	7^{th} bin to 45% of sample rate (21.6 kHz at 48 ks/s)
Amplitude Accuracy	±0.025 dB

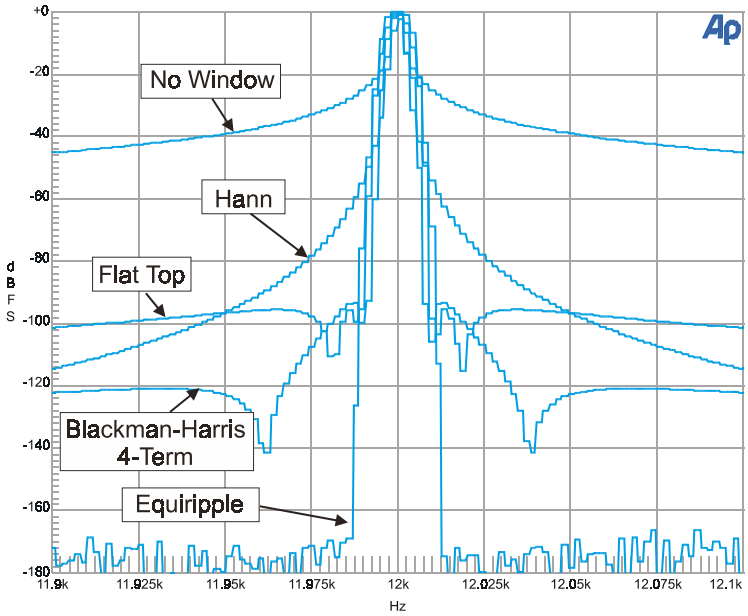

Figure 27. Windows available with FFT function (figure 1 of 2)

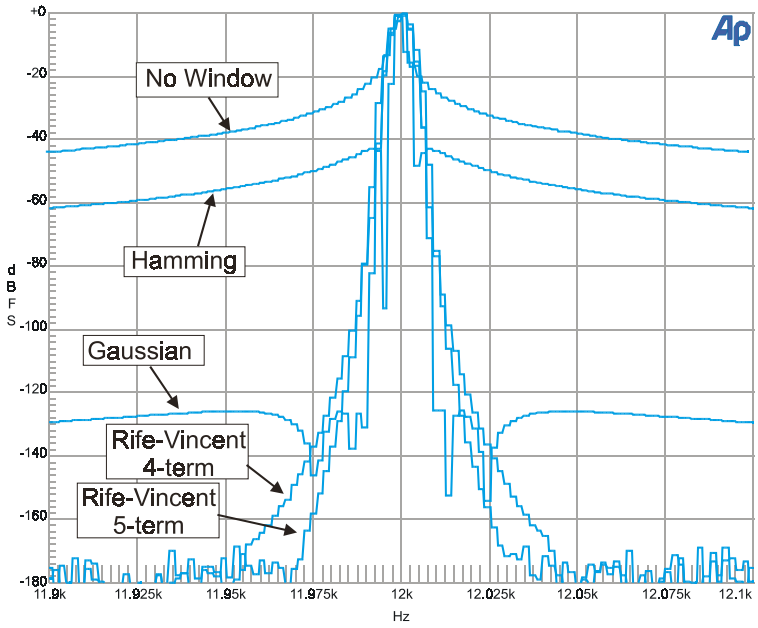

Figure 28. Windows available with FFT function (figure 2 of 2)

DSP Audio Analyzer *(ANALYZER)*

Wideband Level/Amplitude

Frequency Range	<5Hz to 45.8% of sample rate 5 Hz to 20.2 kHz at 44.1 ks/s 5 Hz to 22.0 kHz at 48 ks/s 5 Hz to 44.0 kHz at 96 ks/s
High pass Filters	<10 Hz, 4-pole Butterworth 22 Hz, 4-pole Butterworth 100 Hz, 4-pole Butterworth 400 Hz, 4-pole Butterworth 400 Hz, 10-pole elliptical *when not using notch filter or bandpass mode* (response is -120 dB for ≤220 Hz, ±0.1 dB for ≥400 Hz)
Low pass Filters	20 kHz 6-pole elliptic low-pass 15 kHz, 6-pole elliptic low-pass *both: 0.1dBpp ripple, ≥110 dB stopband attenuation*
Weighting Filters	ANSI-IEC “A” weighting, Type 0 CCIR QPk per CCIR Rec 468 CCIR RMS per AES 17 C-message per IEEE Std 743-1978 CCITT per CCITT Rec. P.53 “F” weighting corresponding to 15 phon loudness contour *(see Figure 29)*

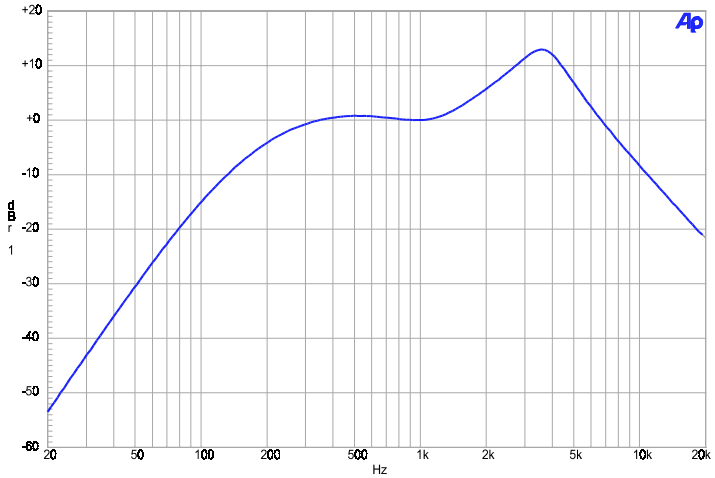

Figure 29. Digital Analyzer F-weighting curve

Narrow Band Amplitude

Frequency Range	<5Hz to 40% of sample rate 5 Hz to 17.6 kHz at 44.1 ks/s 5 Hz to 19.2 kHz at 48 ks/s 5 Hz to 38.4 kHz at 96 ks/s
Filter Shape	10-pole, Q=19 (BW = 5.3% of f_o) *(see Figure 30)*

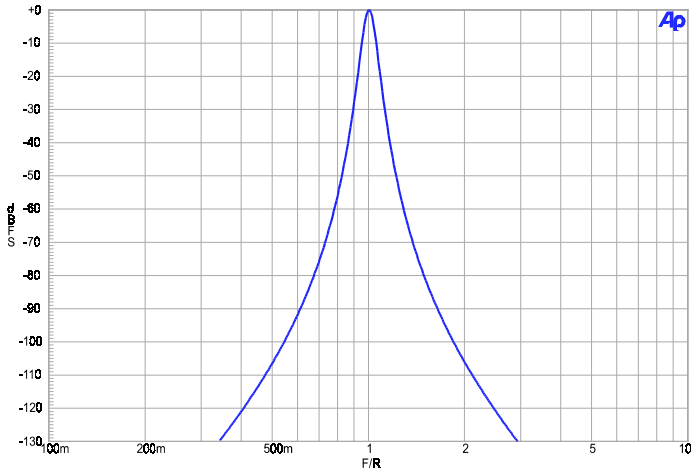

Figure 30. Digital Domain Band Pass filter response

THD + N Measurements

Frequency Range	<5Hz to 45% of sample rate 5 Hz to 19.9 kHz at 44.1 ks/s 5 Hz to 21.6 kHz at 48 ks/s 5 Hz to 43.2 kHz at 96 ks/s
High pass Filters	<10 Hz, 4-pole Butterworth 22 Hz, 4-pole Butterworth 100 Hz, 4-pole Butterworth 400 Hz, 4-pole Butterworth
Low pass Filters	20 kHz, 6-pole elliptic low-pass 15 kHz, 6-pole elliptic low-pass *both: 0.1dB pp ripple, ≥110 dB stopband attenuation*
Weighting Filters	ANSI-IEC "A" weighting, per IEC Rec 179 CCIR QPk per CCIR Rec 468 CCIR RMS per AES 17 C-message per IEEE Std 743-1978 CCITT per CCITT Rec. P.53 "F" weighting corresponding to 15 phon loudness contour *(see Figure 29)*

Frequency Measurements

Range	5 Hz to 47% of sample rate 5 Hz – 21.0 kHz at 44.1 ks/s 5 Hz – 23.0 kHz at 48 ks/s 5 Hz – 46.0 kHz at 96 ks/s
Accuracy	±0.01% of reading or 0.0001% of sample rate, whichever is greater
Resolution	0.003% of reading or 0.0001% of sample rate, whichever is greater

Phase Measurements

Measurement Ranges	±180, -90/+270, or 0/+360 degrees
Accuracy[19]	
10 Hz to 5 kHz	±0.5 degree
5 kHz to 20 kHz	±1 degree
20 kHz to 50 kHz	±2 degrees
Resolution	0.01 degree
Minimum Input	1 mV, both inputs

[19] *Both analog analyzer input channels must have same coupling (ac or dc) selection, and both DSP analyzer input channels must have same coupling (ac or dc) selection. Accuracy is valid for any input signal amplitude ratio up to ± 30 dB. Upper frequency range limited to 45% of sample rate.*

SMPTE IMD Measurements

Test Signal Compatibility	Any combination of 40 to 250 Hz (LF) and (2 kHz to 45% of sample rate) (HF) tones, mixed in any ratio from 1:1 to 5:1 (LF:HF)
IMD Measured	Amplitude modulation products of the HF tone. -3dB measurement bandwidth is 10 Hz to 750 Hz.
Measurement Range	0 to 20%
Accuracy	±0.5 dB
Residual IMD[20]	≤0.0025%, 60 + 7 kHz or 250 + 8 kHz

Quasi-Anechoic Acoustical Tester *(MLS)*

Signals	Four pink sequences, four white sequences
Frequency Range	Sample rate/2000 to sample rate/2
Frequency Resolution (Max)	1.465 Hz at 48.0 ks/s
Acquisition Length	32767 samples or 131071 samples
FFT Length	32768
Energy Time Windows	half Hann Hann <240 Hz > 8 kHz <120 Hz > 16 kHz
Time Windows (percent of data record to transition from 0 to full amplitude)	<5% <10% <20% <30%

Multitone Audio Analyzer (*FAST*TEST)

Acquisition Length	512 – 32768 samples in binary steps
Transform Length	512 – 32768 samples in binary steps
Processing	48 bit
Measurements	Level vs frequency (Response), Total distortion vs frequency, Noise vs frequency, Phase vs frequency, Crosstalk vs frequency, Masking curve
Frequency Resolution	2.93 Hz at 96.0 ks/s 1.345 Hz at 44.1 ks/s 1.465 Hz at 48.0 ks/s
Frequency Error Correction Range	±3%
Distortion	≤-115 dB

[20] *System specification measured with the System Two Cascade analog generator. Valid for input levels ≥ 200 mV rms.*

Digital Signal Generator

Available in the SYS-2500 and SYS-2522 configurations only. The System Two Cascade digital generator consists of a DSP signal generator, selectable pre-emphasis filters, two hardware dither generators, and several digital output stages supporting the most popular formats.

All digitally-generated sine variants, MLS, and IMD signals for the digital domain outputs are independently generated and may be selected simultaneously but independently from the concurrently available digital signals for the analog domain via the D to A converter outputs.

Digital Output Characteristics

Output Formats	AES/EBU (per AES3-1992) SPDIF-EIAJ Optical (Toslink®) General purpose serial General purpose parallel Serial interface to chip level via optional SIA-2322 accessory
Sample Rates	28.8 kHz – 100 kHz AES/EBU, 64 kHz – 200 kHz dual connector AES/EBU, general purpose serial; 8 kHz to 200 kHz parallel; independent of input sample rate
Sample Rate Resolution	1/64 Hz (approx. 0.0156 Hz)
Sample Rate Accuracy	±0.0002% [±2 PPM] using internal reference, lockable to external reference
Word Width	8 to 24 bits
Output impedance	
Balanced (XLR)	110 Ω
Unbalanced (BNC)	75 Ω approx

Digital Signal Generation

Sine Wave

Frequency Range	10 Hz to 47% of sample rate (22.56 kHz at 48 ks/s)
Frequency Resolution	Sample Rate ÷ 2^{23} (typically 0.006 Hz at 48 ks/s)
Flatness	±0.001 dB
Harmonics and Spurious Products	≤0.000001% [-160 dB]

Sine Burst *Sine burst with rectangular envelope*

Frequency Range	10 Hz to 47% of sample rate (22.56 kHz at 48 ks/s)
Frequency Resolution	Sample Rate ÷ 2^{23} (typically 0.006 Hz at 48 ks/s)
Interval	2 – 65536 cycles
Burst On	1 to number of Interval cycles minus 1
Flatness	±0.001 dB
Harmonics and Spurious Products	≤0.000001% [-160 dB]

Variable Phase Sine Wave *Two sine waves, same frequency, independently settable phase*

Frequency Range	10 Hz to 47% of sample rate (22.56 kHz at 48 ks/s)
Frequency Resolution	Sample Rate ÷ 2^{23} (typically 0.006 Hz at 48 ks/s)
Phase Range	±180 deg.
Phase Resolution	0.01 deg.
Flatness	±0.001 dB
Harmonics and Spurious Products	≤0.000001% [-160 dB]

Stereo Sine Wave *Sine wave of independent frequency and amplitude on each channel*

Frequency Range	10 Hz to 47% of sample rate (22.56 kHz at 48 ks/s) Stereo frequencies may be set independently for each channel
Frequency Resolution	Sample Rate ÷ 2^{23} (typically 0.006 Hz at 48 ks/s)
Flatness	±0.001 dB
Harmonics and Spurious Products	≤0.000001% [-160 dB]

Dual Sine Wave *Twin sine waves of independent frequency and settable amplitude ratio; applied to both output channels*

Frequency Range	10 Hz to 47% of sample rate (22.56 kHz at 48 ks/s)
Frequency Resolution	Sample Rate ÷ 2^{23} (typically 0.006 Hz at 48 ks/s)
Flatness	±0.001 dB
Harmonics and Spurious Products	≤0.000001% [-160 dB]
Amplitude ratio	0 dB to -120 dB

Sine + Offset *Sine wave plus a constant value*

Frequency Range	10 Hz to 47% of sample rate (22.56 kHz at 48 ks/s)
Frequency Resolution	Sample Rate ÷ 2^{23} (typically 0.006 Hz at 48 ks/s)
Offset Amplitude	Sinewave amplitude + |offset amplitude| ≤ 100% FS
Flatness	±0.001 dB
Harmonics and Spurious Products	≤0.000001% [-160 dB]

Shaped Sine Burst *Sine burst with raised cosine envelope (see Figure 31)*

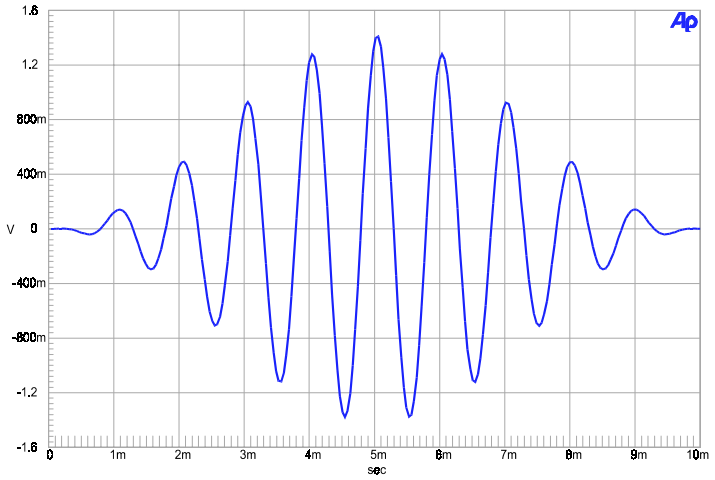

Figure 31. Shaped Sine Burst signal. (1 kHz, 10 cycles)

Frequency Range	10 Hz to 47% of sample rate (22.56 kHz at 48 ks/s)
Frequency Resolution	Sample Rate ÷ 2^{23} (typically 0.006 Hz at 48 ks/s)
Interval	2 - 65536 cycles
Burst On	1 to number of Interval cycles minus 1
Flatness	±0.001 dB
Harmonics and Spurious Products	≤0.000001% [-160 dB]

Square Wave

Frequency Range	≤1 Hz to 1/6 sample rate (7350 Hz at 44.1 ks/s, 8000 Hz at 48 ks/s, 16000 Hz at 96 ks/s)
Frequencies available	≤1 Hz to $f_s \div 6$, in even integer divisors
Even Harmonic Content	≤0.000001% [-160 dB]

SMPTE/DIN Waveform

Upper Tone Frequency Range	2 kHz to 47% of sample rate (22.56 kHz at 48 ks/s)
Lower Tone Frequency Range	40 Hz-500 Hz
Frequency Resolution	Sample Rate $\div 2^{23}$ (typically 0.006 Hz at 48 ks/s)
Flatness	±0.001 dB
Amplitude Ratio	1:1 to 10:1 [0 to 20 dB] (LF:HF)
Intermodulation Components	≤0.000001% [-160 dB] at 4:1 ratio

CCIF and DFD IMD Waveforms

Center Frequency Range	3000 Hz to (47% of sample rate - ½ IM frequency) (22.51 kHz at 48 ks/s; 20.67 kHz at 44.1 ks/s)
IM Frequency Range	80 Hz-2000 Hz
Frequency Resolution	Sample Rate $\div 2^{23}$ (typically 0.006 Hz at 48 ks/s)
Flatness	±0.001 dB
Intermodulation Components	≤0.000001% [-160 dB]

DIM IMD Waveform

Sine wave Frequency	100/21 * squarewave frequency (15 kHz at 44.1 ks/s; 14285.7 Hz at 48 ks/s)
Sine wave Frequency Resolution	Data Rate $\div 2^{23}$ (typically 0.006 Hz at 48 ks/s)
Square wave Frequency sample rate	
< 35 ks/s	1/10 sample rate
35 ks/s to 42 ks/s	1/12 sample rate
42 ks/s to 46 ks/s	1/14 sample rate (3150 Hz at 44.1 ks/s)
≥ 46 ks/s	1/16 sample rate (3000 Hz at 48 ks/s)
Amplitude Ratio	4:1 (squarewave:sinewave)
Distortion Components	≤0.000001% [-160 dB]
Even Harmonic Content	≤0.000001% [-160 dB]

Noise

Types	Pink, White, Burst, USASI

Special Signals

Monotonicity	Low level staircase waveform for D/A linearity testing
J-Test	Produces a maximum amount of data-induced jitter on low-bandwidth transmission links
Polarity	Two sinewaves phased for reinforcement with normal polarity
Walking Ones	A single binary one value “walked” from LSB to MSB

Walking Zeros	A single binary zero value “walked” from LSB to MSB
Constant Value (applies only to DC)	(Digital DC)
Bittest Random	Random binary states of all bits
Pass Thru	Passes the signal from the rear panel Ref Input
Resolution	32 bit when using triangular dither

Quasi-Anechoic Acoustical Tester *(See MLS, page 42)*

Signals	Four pink sequences, four white sequences
Frequency Range	DC to 50% of sample rate
Sequence Length	32767 samples or 131071 samples, automatically selected between 32 k or 131 k sequence as furnished by generator

Multitone Signals

Stored waveform consisting of multiple sine waves, each at independent frequency, amplitude, and phase

Number of Tones	1 to 128 typical, 8191 maximum
Frequency Range	DC to $f_s \div 2$
Frequency Resolution	Sample Rate $\div 2^{14}$ (typically 2.93 Hz at 48 ks/s)
Flatness	±0.001 dB
Residual Distortion	≤0.00001% [-140 dB]

Arbitrary Waveforms

Signal	Determined by the associated file specified in the panel drop-down box.
Number of Tones	1 – 8191
Length	256 – 16384 points per channel, user specified waveform. Utility is provided to prepare a time record file from user specified frequency, amplitude, and phase data.
Frequency Range	20 Hz to 47% of sample rate
Frequency Resolution	Sample Rate ÷ length of arbitrary waveform size (typ 2.92 Hz at 48 ks/s)

Dither *(all waveforms)*

Probability Distribution	Triangular or rectangular; true random; independent for each channel
Spectral Distribution	Flat (white) or Shaped (+6 dB/oct)
Amplitude	8 – 24 bit or off

Pre-Emphasis Filters *(all waveforms)*

Filter Shape	50/15 µs or J17
Response Accuracy	±0.02 dB 10 Hz to 45% sample rate
Residual Distortion	≤0.00003% [-130 dB]

AES/EBU Interface Generation

Interface Signal

Amplitude Range	(Fixed RISE/FALL time)
Balanced (XLR)	0 to 10.24 Vpp, ±(10% + 80 mV) into 110 Ω in 40 mV steps
Unbalanced (BNC)	0 to 2.048 Vpp, ±(8% + 16 mV) into 75 Ω in 8 mV steps
Optical (Toslink®)	0 to 256% of nominal intensity in 1% steps
Channel Status Bits	Full implementation, English language decoded, Professional or consumer or hex formats; independent in each channel
User Bits	set to 0
Validity Flag	selectable, set or cleared

AES/EBU Impairments

Variable rise/fall time	16 ns to 400 ns, ±20%
Induced Jitter	Selectable sinewave, squarewave, or wideband noise
Jitter Freq Range[21]	2.00 Hz – 200 kHz, <0.1 Hz resolution
Jitter Ampl Range[21]	0 – 1.27 UI (peak) in 0.005 UI steps; 1.3 – 12.7 UI (peak) in 0.05 UI steps
Jitter Accuracy	±(10% + 0.005 UI) at 500 Hz
Jitter Flatness	±1 dB, 100 Hz to 20 kHz
Residual Jitter[22]	
48 ks/s	≤0.010 UI [1.6 ns]
96 ks/s	≤0.020 UI [1.6 ns]
Spurious Jitter Products	typ <0.001 UI or 30 dB below jitter signal, whichever is larger
Normal Mode Noise	
Balanced	0 – 2.55 Vpp, ±(10% + 100 mV), in 10 mV steps
Unbalanced	0 – 635 mVpp, ±(10% + 25 mV), in 2.5 mV steps
Common Mode Freq	20 Hz to 40 kHz <0.1 Hz resolution
Common Mode Ampl	0 – 20 Vpp, ±(10% + 200 mV), in 80 mV steps
Cable Simulation	Multi-pole fit to AES 3-1992 filter to simulate the response degradation of a worst case long cable
Offset from reference	-64 to +63.5 UI, in 0.5 UI steps

21 Combinations of jitter amplitude and frequency must not result in greater than 50% reduction in transmitted bit width.

22 System specification including analyzer contribution. The following conditions must be met: (1) the jitter generator amplitude must be turned off or set for 0.0000 UI, (2) all other forms of impairment must be off or disabled, and (3) the digital output must be ≥1.0 Vpp (XLR) or ≥250 mVpp (BNC).

Reference Input Characteristics

A rear panel reference input is provided to synchronize the internal sample clock generator to an external signal. The internal sample rate (ISR) is not dependent upon the rate or characteristics of the external reference. OSR need not be at 1:1 ratio to reference but will be phase-locked to reference over full specified range of OSR and Reference inputs. Reference input jitter below 5 Hz will pass to the output; jitter above 5 Hz is attenuated 6 dB/octave.

Input Formats	AES/EBU (per AES 3-1992), NTSC/PAL/SECAM video, or squarewave
Input Sample Rates/ Frequency Range	28.8 kHz – 100 kHz AES/EBU, 8.0 kHz – 10.0 MHz squarewave
Sample Rate Resolution	
8 kHz – 65 kHz	1/128 Hz [0.0078125 Hz]
65 kHz – 256 kHz	1/32 Hz [0.03125 Hz]
256 kHz – 1 MHz	1/8 Hz [0.125 Hz]
1 MHz – 4 MHz	1/2 Hz [0.5 Hz]
4 MHz – 10 MHz	2 Hz
Minimum Input Amplitude	200 mVpp
Nominal Input Impedance	
AES/EBU (XLR)	110 Ω or >5 kΩ
Video (BNC)	75 Ω or >5 kΩ
Square wave (BNC)	75 Ω or >5 kΩ
Lock Range	±0.0015% [±15 PPM]
Input Delay from Reference Display	Measures delay from 0 to 127.9 UI in seconds, ±60 ns
Reference Rate Display	Measures approximate reference input rate

Reference Output Characteristics

A rear panel reference output is provided to drive devices under test that require their own reference input. The reference output signal is not jittered.

Output Format	AES/EBU (per AES 11-1994)
Output Sample Rates	28.8 kHz – 100 kHz AES/EBU; locked to front panel output
Status Bits	Format “Professional” Sample Rate indicates closest rate Type “Grade 2 reference” Origin “SYS2” Reliability flags implemented CRCC implemented Time of Day not implemented Sample Count not implemented
Output Delay from Reference Output	-64/+63.5 UI, ±(5% + 0.5 UI), in 0.5 UI steps
Residual jitter	≤2 ns p-p (120 Hz – 100 kHz)

Digital Analyzer

Available in the SYS-2500 and SYS-2522 configurations only.

Digital Input Characteristics

Input Formats	AES/EBU (per AES 3-1992) Dual Connector AES/EBU SPDIF-EIAJ Dual Connector SPDIF-EIAJ Optical (Toslink®) General purpose serial General purpose parallel Serial interface to chip level via optional SIA-2322 accessory
Sample Rates	28.8 kHz – 100 kHz AES/EBU, 64 kHz – 200 kHz Dual Connector AES/EBU, 8 kHz to 200 kHz parallel, general purpose serial, SIA-2322; independent of output sample rate
Word Width	8 to 24 bits
Nominal Input impedance	
AES/EBU	110 Ω or ≥ 2.5 kΩ
SPDIF-EIAJ	75 Ω or ≥ 3 kΩ

Embedded Audio Measurements

Wideband Level/Amplitude *(ANALYZER)*

Range	0 dBFS to <-140 dBFS
Frequency Range	<5Hz to 45.8% of sample rate 5 Hz to 20.2 kHz at 44.1 ks/s 5 Hz to 22.0 kHz at 48 ks/s 5 Hz to 44.0 kHz at 96 ks/s
Accuracy	±0.01 dB, 0 dBFS to -120 dBFS
Flatness	±0.01 dB, 15 Hz – 22 kHz, with <10 Hz high-pass filter selection
High pass Filters	<10 Hz, 4-pole Butterworth 22 Hz, 4-pole Butterworth 100 Hz, 4-pole Butterworth 400 Hz, 4-pole Butterworth 400 Hz, 10-pole elliptical *when not using notch filter or bandpass mode* (response is -120 dB for ≤220 Hz, ±0.1 dB for ≥400 Hz)
Low pass Filters	20 kHz 6-pole elliptic low-pass 15 kHz, 6-pole elliptic low-pass
Weighting Filters	ANSI-IEC “A” weighting, Type 0 CCIR QPk per CCIR Rec 468 CCIR RMS per AES 17 C-message per IEEE Std 743-1978

	CCITT per CCITT Rec. P.53 "F" weighting corresponding to 15 phon loudness contour *(see Figure 29, page 29)*
Residual Noise	-140 dBFS unweighted -142 dBFS A-weighted -134 dBFS CCIR RMS -127 dBFS CCIR QPk -140 dBFS 20 kHz LP -140 dBFS 15 kHz LP -138 dBFS "F" weighting -150 dBFS CCITT -150 dBFS C Message

Narrow Band Amplitude *(ANALYZER)*

Frequency Range	<5Hz to 40% of sample rate 5 Hz to 17.6 kHz at 44.1 ks/s 5 Hz to 19.2 kHz at 48 ks/s 5 Hz to 38.4 kHz at 96 ks/s
Filter Shape	10-pole, Q=19 (BW = 5.3% of f_o) *(see Figure 30, page 29)*
Residual Distortion	≤-150 dBFS

THD + N Measurements *(ANALYZER)*

Frequency Range	<5Hz to 47% of sample rate 5 Hz to 19.9 kHz at 44.1 ks/s 5 Hz to 21.6 kHz at 48 ks/s 5 Hz to 43.2 kHz at 96 ks/s
Residual THD+N	≤-140 dBFS *(see Figure 32, page 45)*
High pass Filters	<10 Hz, 4-pole Butterworth 22 Hz, 4-pole Butterworth 100 Hz, 4-pole Butterworth 400 Hz, 4-pole Butterworth
Low pass Filters	20 kHz, 6-pole elliptic low-pass 15 kHz, 6-pole elliptic low-pass *both: 0.1 dBpp ripple, ≥110 dB stopband attenuation*
Weighting Filters	ANSI-IEC "A" weighting, Type 0 CCIR QPk per CCIR Rec 468 CCIR RMS per AES 17 C-message per IEEE Std 743-1978 CCITT per CCITT Rec. P.53 "F" weighting corresponding to 15 phon loudness contour *(see Figure 29, page 29)*
Residual Noise	Same as Wideband Level/Amplitude

Phase Measurements

Measurement Ranges	±180, -90/+270, or 0/+360 degrees
Accuracy[23]	
10 Hz to 45% of sample rate	±0.05 degree
Resolution	0.01 degree
Minimum Input	-60 dBFS, both inputs

SMPTE IMD Measurements

Test Signal Compatibility	Any combination of 40 to 250 Hz (LF) and (2 kHz to 45% of sample rate) (HF) tones, mixed in any ratio from 1:1 to 5:1 (LF:HF)
IMD Measured	Amplitude modulation products of the HF tone. -3dB measurement bandwidth is 10 Hz to 750 Hz.
Measurement Range	0 to 20%
Accuracy	±0.5 dB
Residual IMD	≤-130 dB, 60 + 7 kHz or 250 + 8 kHz at 0 dBFS ≤-110 dB, 60 + 7 kHz or 250 + 8 kHz at -25 dBFS

Frequency Measurements *(ANALYZER)*

Range	5 Hz to 47% of sample rate (5 Hz-21.0 kHz at 44.1 ks/s) (5 Hz-23.0 kHz at 48.0 ks/s) (5 Hz-46 kHz at 96 ks/s)
Accuracy	±0.01% of reading or 0.0001% of sample rate, whichever is greater
Resolution	0.003% of reading or 0.0001% of sample rate, whichever is greater

FFT Spectrum Analyzer *(FFT)*

Acquisition Length	800 to 256 k samples in 11 steps
Transform Length	256-32768 samples in binary steps
Processing	48 bit
Windows *(see Figure 27, page 27, and Figure 28, page 28)*	Blackman-Harris (4 term with -92 dB sidelobe) Hann Flat-top (±0.001 dB) Equiripple (-145 dB sidelobes) None None, sync to sine Hamming Gaussian Rife-Vincent 4-term Rife-Vincent 5-term
Amplitude Accuracy	±0.001 dB, 20 Hz to 20 kHz, using Flat-top window

[23] *Both dsp analyzer input channels must have same coupling (ac or dc) selection. Accuracy is valid for any input signal amplitude ratio up to +/- 30 dB.*

Averaging	1-4096 in binary steps, averaging algorithm is power based or synchronous
Distortion Products	≤-160 dB
Waveform Display Modes	Normal, interpolate, peak, max
Frequency Display Modes	Peak pick, individual bin
Sync to Sine Window	
Frequency Range	7^{th} bin to 45% of sample rate (21.6 kHz at 48 ks/s)
Amplitude Accuracy	±0.025 dB
Spurious Products	≤-120 dB

Multi-Tone Audio Analyzer (*FAST*TEST)

Acquisition Length	512-32768 samples in binary steps
Transform Length	512-32768 samples in binary steps
Processing	48 bit
Measurements	Level vs frequency, Total distortion vs frequency, Noise vs frequency, Phase vs frequency, Crosstalk vs frequency, Masking curve
Frequency Resolution	1.345 Hz with 44.1 ks/s 1.465 Hz with 48.0 ks/s 2.93 Hz with 96 kHz
Frequency Error Correction Range	±3%
Distortion	≤-140 dB

Quasi-Anechoic Acoustical Tester *(MLS)*

Signals	Four pink sequences, four white sequences
Frequency Range	Sample rate/2000 to sample rate/2
Frequency Resolution (Max)	1.465 Hz at 48.0 ks/s
Acquisition Length	32767 samples, 131071 samples, automatically selected between 32 k or 131 k sequence as furnished by generator
FFT Length	32768
Energy Time Windows	half Hann Hann <240 Hz > 8 kHz <120 Hz > 16 kHz
Time Windows (percent of data record to transition from 0 to full amplitude)	<5% <10% <20% <30%

Digital Interface Measurements

AES/EBU Impairments, real time displays

Input Sample Rate	±0.0003% [±3 ppm] internal ref, ±0.0001% [±1 ppm] external ref
Output to Input Delay	Measures status propagation from the AES/EBU output to the input. Range is 0 to 1 frame, resolution ±60 ns.
AES/EBU Input Voltage	
XLR	100 mV to 10.24 Vpp, ±(5% + 50 mV)
BNC	25 mV to 2.048 Vpp, ±(5% + 12 mV)
Jitter Amplitude	(peak calibrated at 500 Hz)
50-100kHz BW	0 to 3.00 UI, ±(10% + 0.01 UI)
other BW selections	0 to 1.00 UI, ±(10% + 0.005 UI)
Jitter Flatness[24]	±1 dB, 100 Hz – 20 kHz
Residual Jitter[25]	
48 ks/s	≤0.010 UI [1.6 ns]
96 ks/s	≤0.020 UI [1.6 ns]
Jitter Spectrum	Spurious products are typically <0.0003 UI [-70 dBUI] or 40 dB below jitter signal, whichever is larger
Common Mode Ampl	0 to 20.48 Vpp, ±(10% + 300 mV), 315 Hz – 200 kHz
Cable Equalization	Per AES 3-1992
Channel Status Bits	Full implementation, English language decoded (Professional or Consumer) hex formats, independent in each channel
User Bits	Not displayed
Validity Flag	Displayed for each channel
Parity	Displayed for total signal (both channels combined)
Signal Confidence	Displayed for total signal (both channels combined)
Receiver Lock	Displayed for total signal (both channels combined)
Coding Error	Displayed for total signal (both channels combined)

24 50 Hz-100 kHz BW selection. Specification applies at 32.0, 44.1, 48.0, 64.0, 88.2, and 96.0 ks/s only. Flatness may be degraded at other sample rates.

25 System specification including generator contribution. The following conditions must be met: (1) the jitter generator amplitude must be turned off or set for 0.0000 UI, (2) all other forms of impairment must be off or disabled, and (3) the digital input must be ≥1.0 Vpp (XLR) or ≥250 mVpp (BNC).

Digital Interface Analyzer *(INTERVU)*

INTERVU operates in conjunction with an autoranged 8-bit A/D converter clocked at 80.0 MHz, providing interface signal measurements with >20 MHz bandwidth. INTERVU can display the interface signal in time or frequency domain, as an *eye* pattern, or probability graphs of amplitude or pulse width. INTERVU also can demodulate the jitter signal and display it in time or frequency domain or as a probability graph. The jitter signal or the data on the interface may be reproduced through the monitor loudspeaker.

AES/EBU Input Voltage	
Balanced	0 to 20.48 Vpp, ±(10% + 50 mV)
Unbalanced	0 to 4.096 Vpp, ±(8% + 12 mV)
Jitter Amplitude	0 to 5 UI pk, ±(5% + 0.015 UI)
Residual Jitter	≤0.01 UI (50 Hz – 1 MHz BW)
Spurious Jitter Products	≤0.001 UI, or ≤-60 dB below jitter signal
Common Mode Amplitude	0 to 20.48 Vpp, ±(30% + 50 mV), 20 kHz – 1 MHz
Jitter Probability Display	256 bins, autoranging
Input Probability Display	256 bins, autoranging
Bit Width Probability Display	8192 bins
Risetime	≤20 ns
Acquisition time / memory	19.66 ms / 1,572,864 samples

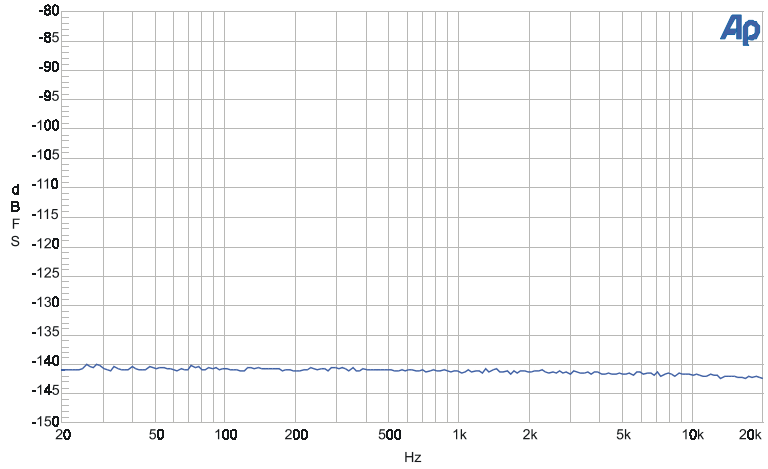

Figure 32. Typical Digital Domain system residual THD+N showing components below -140 dB

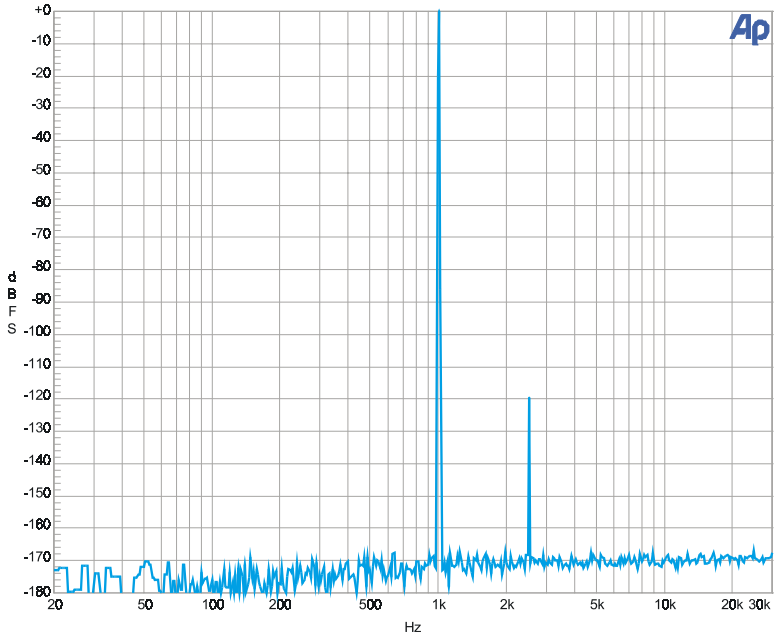

Figure 33. Illustration of typical Digital Domain FFT dynamic range. Signal is 0 dB 1 kHz with a secondary signal at –120 dB and 2.5 kHz.

Auxiliary Signals

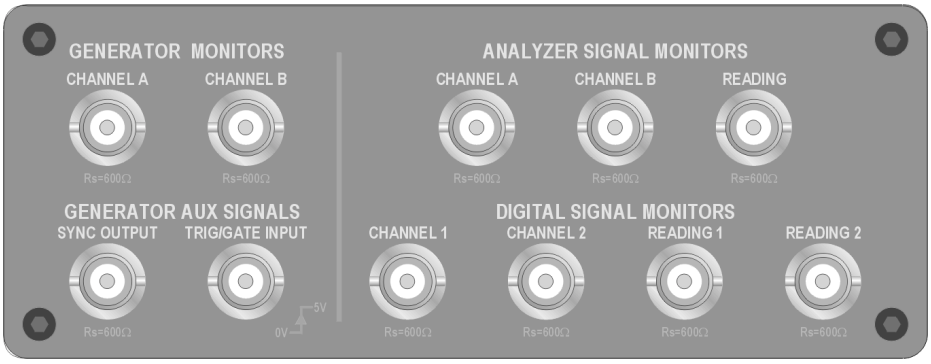

Figure 34. Monitors panel

Generator Signal Monitors *(all units except SYS-2500. See Figure 34)*

Channel A	Buffered version of the channel A analog generator signal. Amplitude is typically 2.8 Vpp.
Channel B	Buffered version of the channel B analog generator signal. Amplitude is typically 2.8 Vpp.

Generator Auxiliary Signals *(all units except SYS-2500. See Figure 34)*

Sync Output	LSTTL compatible signal that is intended to be used as a trigger for stable oscilloscope displays.
Trig/Gate Input	LSTTL compatible input, functional with option "BUR" only.

Analyzer Signal Monitors *(all units except SYS-2500. See Figure 34)*

Channel A	Buffered version of the channel A analog input signal. Amplitude is typically 0-3.6 Vpp.
Channel B	Buffered version of the channel B analog input signal. Amplitude is typically 0-3.6 Vpp.
Reading	Buffered version of the analog analyzer output signal after all filtering and gain stages. Amplitude is typically 0-3.6 Vpp.

Digital Signal Monitors *(SYS-2422 & SYS-2522 only. See Figure 34)*

Via four 24-bit D/A converters. Function monitored depends upon analyzer program loaded; for example, noise and distortion products after notch filter are monitored with "DSP Audio Analyzer" in its THD+N function.

Channel 1	Buffered version of the digital channel 1 signal
Channel 2	Buffered version of the digital channel 2 signal
Reading 1	Distortion of the digital channel 1 signal
Reading 2	Distortion of the digital channel 2 signal

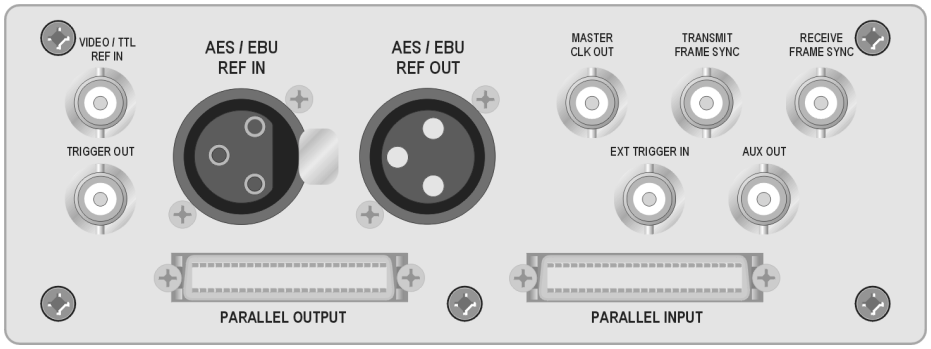

Figure 35. Miscellaneous digital I/O

Digital Interface Monitors *(SYS-2522 & SYS-2500 only. See Figure 35)*

Transmit Frame Sync	Squarewave at the programmed internal sample rate
Receive Frame Sync	Squarewave at the rate of the received AES/EBU signal
Master Clock Out	Squarewave at 256x the programmed output sample rate. Selectable between jittered and unjittered signals.

Miscellaneous Digital I/O *(SYS-2522 & SYS-2500 only. See Figure 35)*

Auxiliary Input	LSTTL compatible trigger input for dsp program data acquisition
Auxiliary Output	HCMOS signal, function under dsp program control
Trigger Output	HCMOS signal, coincident with period of generated signal waveform

Audio Monitor

All System Two Cascade configurations contain an internal loudspeaker and headphone jack for listening to the generator, analyzer, or digital signal monitor points described at left, including noise and distortion following analog or digital notch filters or the AES/EBU jitter signal. Use of the audio monitor does not preclude the use of any measurements.

Power Output	Typically 1 Watt

General / Environmental

Power Requirements	100/120/230/240 Vac (-10%/+6%), 50 – 60 Hz, 240 VA max
Temperature Range	
Operating	+5°C to +40°C
Storage	-40°C to +75°C
Humidity	90% RH to at least +40°C (non-condensing)
Altitude	2000 m (operating)
EMC[26]	Complies with 89/336/EEC, CISPR 22 (class B), and FCC 15 subpart J (class B)
Dimensions	
Width	16.5 inches [41.9 cm]
Height	6.0 inches [15.2 cm]
Depth	13.6 inches [34.5 cm]
Weight	Approximately 34 lbs [15.9 kg]
Safety	Complies with 73/23/EEC and 93/68/EEC. EN61010-1 (1990) + Amendment 1 (1992) + Amendment 2 (1995) Installation Category II – Pollution Degree 2.

Audio Precision, Inc.
PO Box 2209
Beaverton Oregon 97075-2209

US Toll Free: 1-800-231-7350 Tel: (503) 627-0832 Fax: (503) 641-8906
email: techsupport@audioprecision.com Web: www.audioprecision.com

26 *Emission and immunity levels are influenced by the shielding performance of the connecting cables. The shielding performance of the cables will depend on the internal design of the cable, connector quality, and the assembly methods used. EMC compliance was evaluated using Audio Precision XLR type cables.*