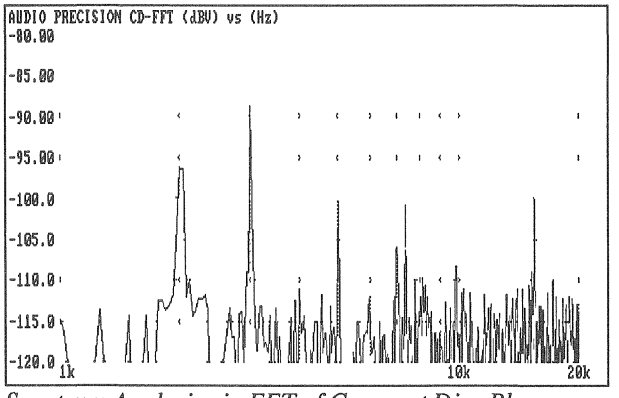
SYSTEM ONE + DSP
SYSTEM ONE DUAL DOMAIN (preliminary)

Audio Precision's new **System One + DSP** (Digital Signal Processor) and **System One Dual Domain** are revolutionary additions to the company's audio testing product line. They provide digitally-based analysis and synthesis of audio frequency signals. A reserved compartment in all System One mainframes also permits these capabilities to be fitted into a System One already in service. **System One + DSP** and **System One Dual Domain** add significant capability to the system's already-impressive measurement features. **System One + DSP** expands previous applications with greatly enhanced measurements of analog signals. **System One Dual Domain** has these same capabilities plus, for the first time in any test instrument, the ability to generate and measure audio signals in any combination of digital and analog domains.

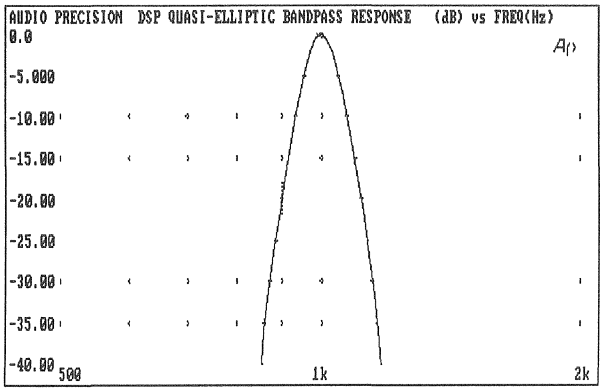
Enhanced Analog Measurement Capability

System One + DSP adds harmonic and spectrum analysis capability for users making analog measurements. By operating as a programmable high-selectivity bandpass filter of several possible shapes and selectivities (quasi-elliptic filter shown below) it may be used to measure individual harmonic distortion, depth of erasure of analog tapes, total harmonic distortion without noise, hum, and other wave analyzer-type measurements.

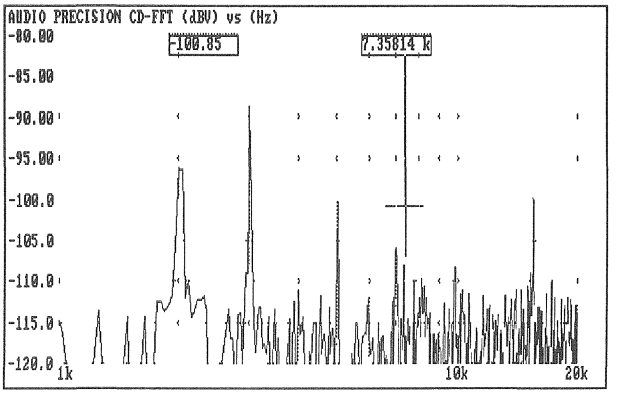
System One + DSP may also operate as a dual channel waveform-digitizer/FFT-spectrum analyzer. The figures below show the distortion and noise spectrum of a Compact Disc player reproducing a 1001 Hz signal from a test disc. The signal was acquired after System One's analog notch filter, which removed the fundamental. Harmonics are visible at 2, 3, 5, and 7 kHz in addition to products of uncertain origin at 7.35 kHz and 15.4 kHz. The second figure below shows the new



Spectrum Analysis via FFT of Compact Disc Player Reproducing 1001 Hz Tone. Signal Acquired Following System One Notch Filter.



DSP-Implemented Quasi-Elliptic Bandpass Filter for Individual Harmonic and Other Selective Measurements

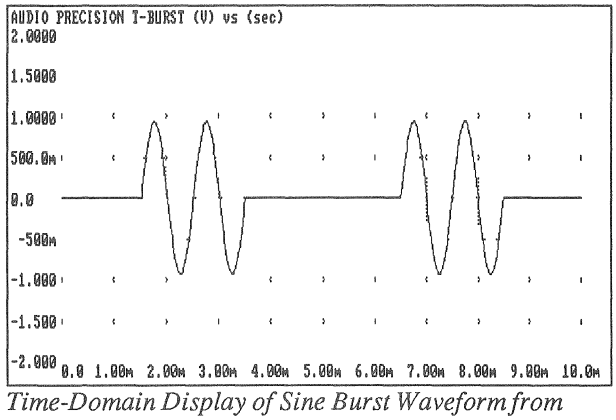


Spectrum of Figure Above, with Cursor Displaying Amplitude and Frequency of Non-Harmonic Product

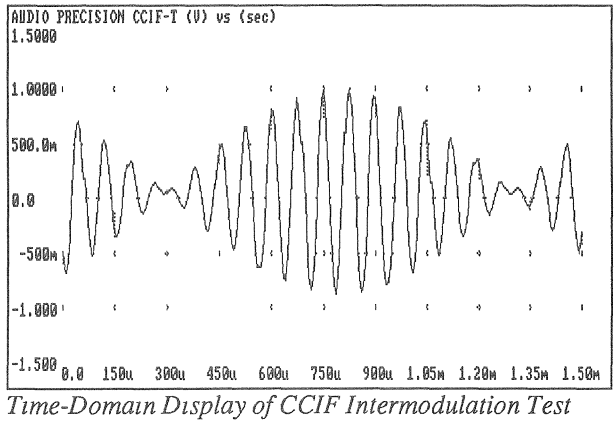
cursor feature used to display the amplitude and frequency of the 7.35 kHz product. Signals up to a maximum frequency of 80 kHz may be acquired with 16 bit resolution and record length up to 8k samples per channel (32k samples for **System One Dual Domain**). Frequency domain displays are obtained by FFTs of up to 8k lines. This will produce, for example, spectral analysis with approximately 3 Hz resolution across a 20 kHz bandwidth. For spectral analysis of wow and flutter, approximately 0.06 Hz resolution is available across the bandwidth below 200 Hz. Acquired waveforms may also be displayed in amplitude vs time (oscilloscope) format; see the figures below for examples.

Analog signals to be analyzed may be acquired from three sources:

- directly from dc-coupled fixed-range unbalanced input connectors on the DSP module front panel



Time-Domain Display of Sine Burst Waveform from System One BUR Option



Time-Domain Display of CCIF Intermodulation Test Signal with Tones at 13 kHz and 14 kHz

- after the balanced inputs and gain range selection circuitry of the analog input section of System One

- from the READING MONITOR OUTPUT of System One (following all analog processing and filtering).

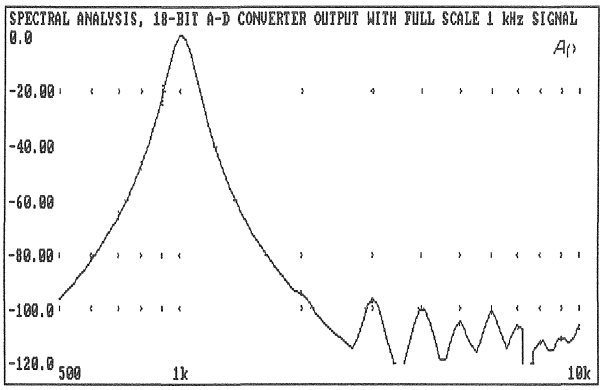
Signals acquired after the balanced inputs profit from the noise rejection of System One's high-CMRR inputs and have no high-frequency band limiting, but are not dc-coupled. Signals acquired after all analog processing can lead to extremely wide dynamic range measurements in many modes. For example, in THD+N mode System One's analog notch filter removes the fundamental sinewave signal, leaving only distortion and noise products. The DSP then converts this signal to the digital domain and further analyzes it via sharp bandpass filter or FFT, enabling distortion products to be resolved as low as 130 dB below the fundamental.

Extremely fast frequency response testing can be performed by **System One + DSP**. Using the pseudo-random pink noise source of System One's BUR option as a signal, the DSP can acquire a signal at the output of a device or system, perform an FFT spectrum analysis, and compare that to an FFT of a copy of the same pseudo-random signal stored in memory. Subtracting the measured data from the stored version gives the frequency response of the system, with the stimulus signal required for only a fraction of a second.

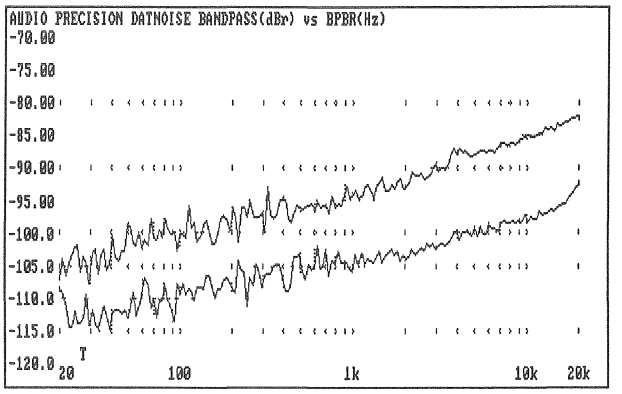
Acoustical measurements can also be made with **System One + DSP**. FFT analysis can be performed on loudspeaker signals with swept sine (chirp) or noise signals. Future DSP programs are planned to permit quasi-anechoic measurements even in spaces with acoustic reflections.

Digital Domain Measurements

System One Dual Domain is the world's first test instrument to offer audio signal generation and analysis in both analog and digital domains. The world of digital audio is expanding at a rapid rate with new products being introduced almost daily. A major stumbling block to their development and optimization has been the lack of test equipment which operates in the digital domain. **System One Dual Domain**, in addition to all the features of **System One + DSP** described above, has digital inputs and outputs which allow interfacing to most professional and consumer digital audio devices. Parallel and serial digital interfaces are



18-Bit A-D Converter Output, Acquired via Parallel Digital Interface and Analyzed with Swept Digital Bandpass Filter

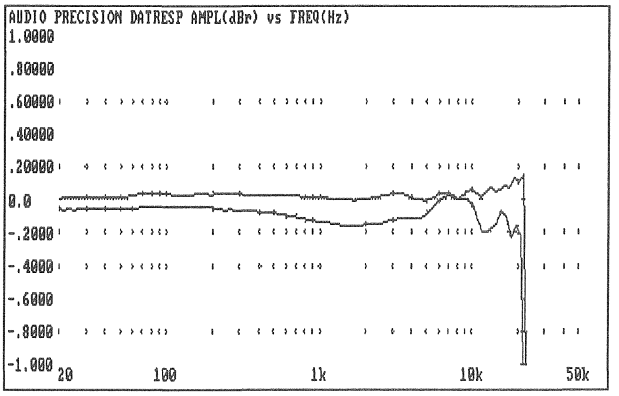


Spectral Analysis (via Analog Bandpass Filter) of RDAT Output with Analog (Upper Curve) and Digital (Lower Curve) Inputs

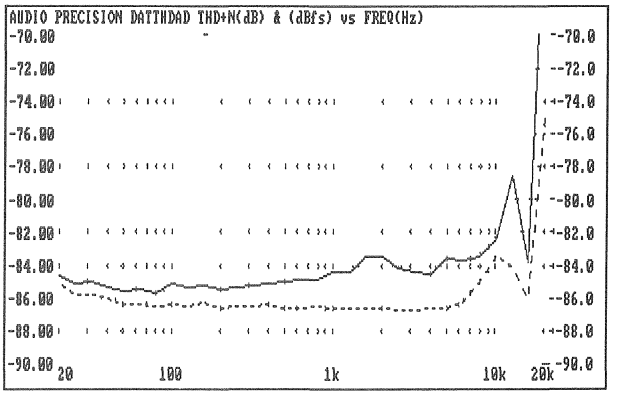
provided. The parallel interface allows connection to many A-D and D-A converters and most DSP devices. The serial input and output support the complete specification of the AES/EBU digital interface and are electrically compatible with the Sony Philips Digital Interface (SPDIF) for consumer products. This allows testing professional and consumer digital audio equipment in the digital domain, separating the effects of the A-D and D-A conversion portions of the equipment under test. The figure above shows a spectral analysis of an A-D converter, acquired via the parallel interface and analyzed with a swept digital bandpass filter. The figure below shows two overlaid frequency response measurements through the analog output of an RDAT recorder. The lower curve was obtained with analog input to the RDAT and the upper curve with SPDIF digital input, clearly showing that the response dip in the 1-2 kHz region and peak at 8 kHz are caused by the analog input circuitry or A-D converter. The upper curve also shows ripple in the 10-20 kHz region due to the oversampling digital filter in the RDAT output.

The figure above displays spectral analyses of the noise output of an RDAT with analog (upper curve) and digital (lower curve) inputs. Much of the higher noise level from the analog input may be dither deliberately added for purposes of linearization improvement. The figure at the bottom of this column shows THD+N versus frequency measurements of an RDAT, both made with analog input to the machine. The upper curve was measured with System One's analog capability. The lower curve results from digital acquisition and DSP analysis, using a digital notch filter and RMS detector.

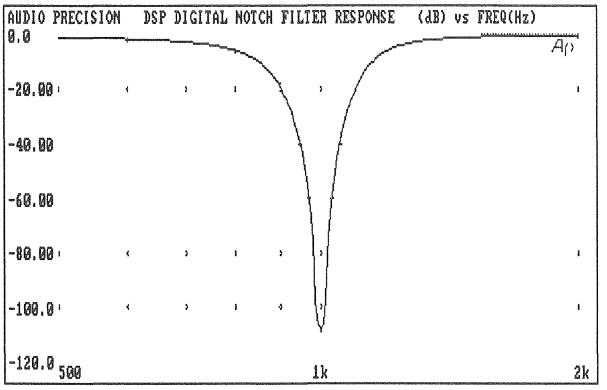
Signal processing in the digital domain can follow the same techniques as analog signal processing, except digitally implemented. Processing techniques available include RMS detection, high and low pass filters, weighting filters for noise measurements, and a digitally-implemented notch filter for THD+N measurements on a digitally-acquired signal. Digital-domain signals may thus be analyzed by techniques directly comparable to conventional analog signal analysis.



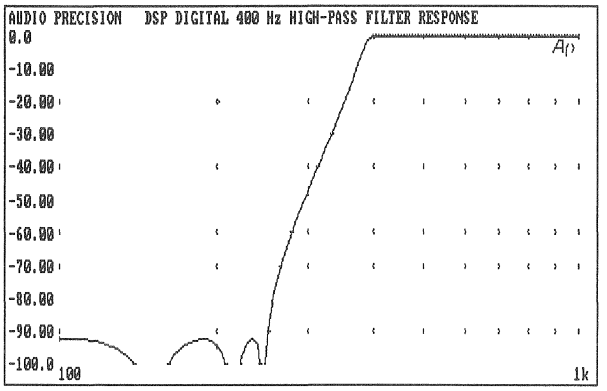
Frequency Response of RDAT. Lower Curve from Analog Input, Upper Curve from Digital Input



THD+N vs Frequency of RDAT from Analog Input. Upper Curve Analog Analysis, Lower Curve Digital Acquisition and Analysis



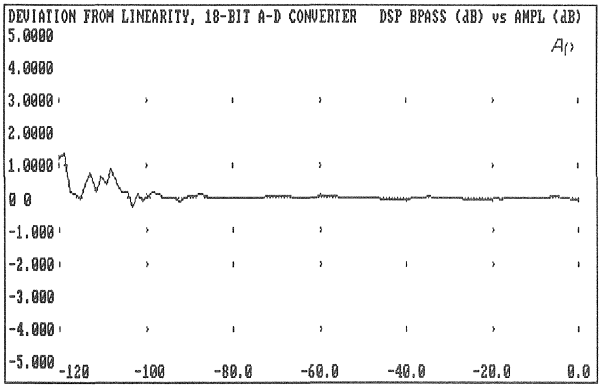
DSP Implementation of Notch Filter for THD+N Measurements on Digitally-Acquired Signals



DSP Implementation of 400 Hz High-Pass Filter

Data Manipulation and Presentation

DSP-processed measurement results may be graphed, compared to limits, and otherwise manipulated with standard System One software in the same manner that analog measurements are handled. The graph below shows deviation from perfect linearity of an 18-bit A-D converter. System One's (analog) generator drove the A-D converter input in a fixed-frequency 120-dB amplitude sweep. The digital output signal was acquired through the parallel digital interface, digitally bandpass filtered, and its amplitude digitally measured in the DSP module. The amplitude was then plotted versus generator amplitude by normal System One software in the PC, and the COMPUTE LINEARITY function of System One software used to calculate and graph deviation from perfect linearity. The digital stimulus available from the digital outputs of **System One Dual Domain** may be swept in an identical manner to System One's analog generator. DSP processed results or the entire digitized waveform may be saved to disk.

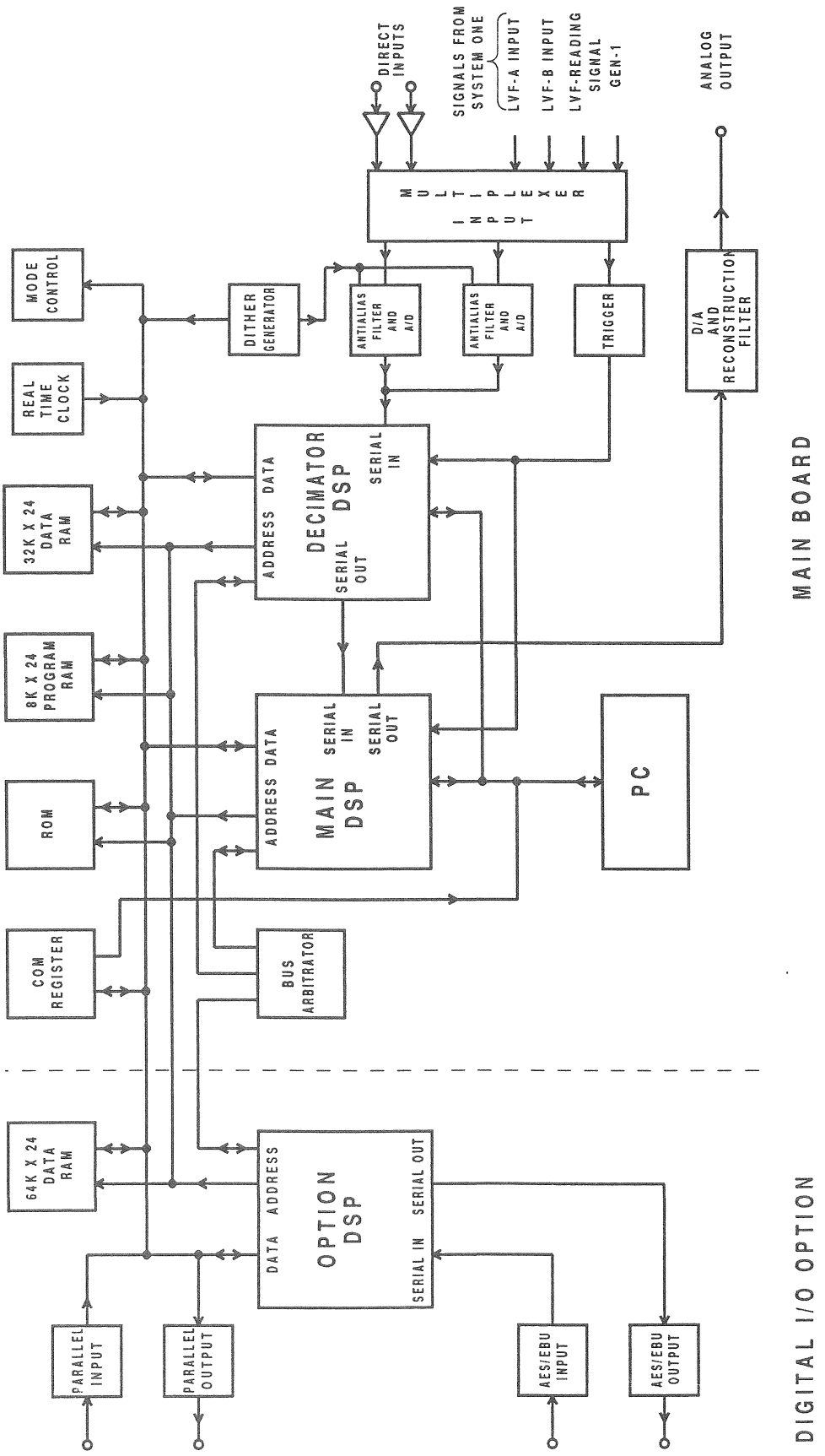


Deviation from Perfect Linearity, 18-Bit A-D Converter

Screen-displayed signals may be precisely analyzed with help from the new cursor feature of System One's new software version. Touching a horizontal arrow key (or mouse) brings a cursor and two or three numeric display windows onto the screen. The windows show the horizontal axis value and the vertical intercepts of the cursor line with the one or two data lines displayed on the graph.

Digital signal processing programs are downloaded from PC disk to the DSP chip and DSP program memory in **System One + DSP** and **System One Dual Domain**. This permits many more types of DSP programs to be available than could be stored in the chip, and enables future programs to be easily added.

System One + DSP provides analog input and output capability and 32k words of data memory. **System One Dual Domain** expands that memory to a total of 96k words and provides both serial and parallel digital inputs and outputs.


DIRECT INPUTS
SIGNALS FROM SYSTEM ONE
LVF-A INPUT
LVF-B INPUT
LVF-READING SIGNAL GEN-1
ANALOG OUTPUT
MULTIPLEXER
MODE CONTROL
DITHER GENERATOR
ANTIALIAS FILTER AND A/D
ANTIALIAS FILTER AND A/D
TRIGGER
D/A AND RECONSTRUCTION FILTER
REAL TIME CLOCK
32K X 24 DATA RAM
ADDRESS DATA
DECIMATOR DSP
SERIAL IN
SERIAL OUT
8K X 24 PROGRAM RAM
ROM
ADDRESS DATA
MAIN DSP
SERIAL IN
SERIAL OUT
PC
COM REGISTER
BUS ARBITRATOR
MAIN BOARD
64K X 24 DATA RAM
DATA ADDRESS
OPTION DSP
SERIAL IN
SERIAL OUT
PARALLEL INPUT
PARALLEL OUTPUT
AES/EBU INPUT
AES/EBU OUTPUT
DIGITAL I/O OPTION

System One + DSP Specifications (preliminary)

Processing	Two 24 bit 25 MHz third generation digital signal processors
Data Memory	32k x 24 bit (96k in **System One Dual Domain**)
Program Memory	8k x 24 bit
A/D related:	
Converter	Dual channel independent 16 bit
Sample rates	192k (80 kHz analog bandwidth), 48k, or 1k sample/second.
Analog source	Selectable A-monitor output, B-monitor output, Reading monitor output (analyzer output), generator monitor output, or front panel dc-coupled fixed-sensitivity inputs.
D/A related:	
Converter	16-bit, operating at 192k samples/second.

System One Dual Domain

System One Dual Domain has all the capabilities of **System One + DSP** described above, plus adding a third 24 bit 25 MHz digital signal processor, parallel and serial digital I/O, and expanded data memory to 96k words.

Parallel I/O	24 bit dual channel available on two 34 conductor connectors on rear panel (one for input, one for output). Channels are multiplexed on each connector. Data rates are selectable 32k, 44.1k, 48k, or 192k. Data strobe is included or may be externally supplied.
Serial I/O	Supports the full implementation of the AES/EBU digital interface. 20/24-bit data, parity, validity, and channel status bits are provided. The user bits are not supported. Electrically compatible with the Sony Philips Digital Interface (SPDIF).

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