

# Accuphase

CD TRANSPORT

## DP-90

MMB DIGITAL PROCESSOR

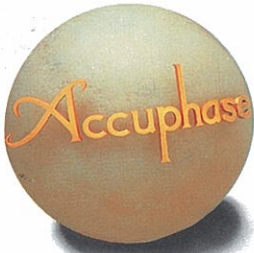
## DC-91

- HPC digital transmission system for high-quality transmission
- New MMB type D/A conversion system ensuring 20-bit resolution linearity and low noise
- Automatic detection of three sampling frequencies and three frequency accuracy levels



COMPACT  
disc  
DIGITAL AUDIO





# Accuphase Is Now Chal the Digital

In the year 1986, when the Compact Disc had begun to gain true acceptance, Accuphase created a sensation by introducing the separate-type CD Player DP-80/DC-81. Some of its highlights were a D/A converter system developed by Accuphase and built with discrete components for unprecedented precision, as well as the use of optical links and optical isolators for internal wiring, to assure freedom from digital interference. The sound quality of this CD reproduction system has gained highest praise worldwide.

The discrete multi-bit converter was further upgraded to 20-bit precision in the L version which continues to be used as a reference CD player to this day.

However, progress never stops. Now, in the 10th year since the introduction of the CD, Accuphase opens yet another chapter in the advancement of D/A conversion technology. We proudly introduce the revolutionary MMB (Multiple Multi-Bit) system. As the name implies, several 20-bit D/A converters are used in parallel (in the case of the DC-91 a full sixteen per channel), to provide hitherto unheard-of linearity and to reduce noise to the absolute theoretical limit.

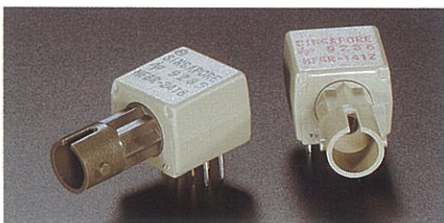
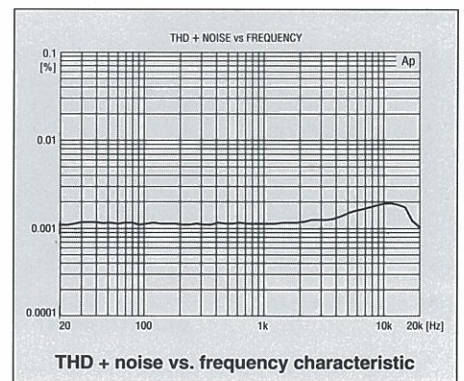
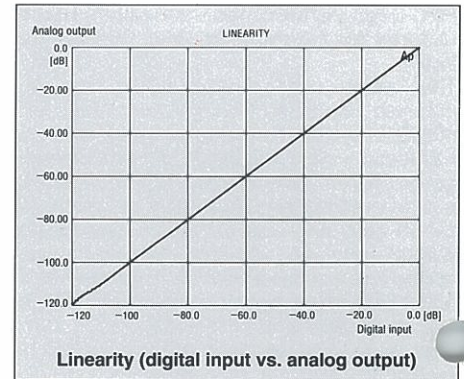
The link between the CD transport and processor units of course employs the optical principle, but it goes far beyond conventional designs. While optical links have become rather common these days, all too often one finds inferior, simplified implementations that

do not realize the full performance potential of this principle. It goes without saying that for Accuphase, only the best will do, and to this end, we have developed the innovative HPC digital input/output circuitry. HPC stands for "High Performance Connection". For optical links, it adopts the ST format that supports a data transfer rate of up to 150 megabits per second. This is as much as 25 times more than the 6 megabits actually required for digital audio, thus providing an ample safety margin. For balanced connections, HPC uses high-quality professional-standard links as employed for example in computer networks. This eliminates pulse distortion and jitter, resulting in drastically improved sound quality. Of course, EIAJ-standard optical and balanced connectors are also provided.

The CD Transport DP-90 features a laser pickup with an integrated RF amplifier, to guard against any kind of interference. The spindle, sled, focusing and tracking actuators, disk tray etc. are driven by balanced circuits to reduce internal noise that could interfere with the pickup output signal. The chassis is made from 8-mm solid aluminum capable of absorbing any kind of vibration arising either inside or outside the player. Top-notch mechanical as well as electrical design and construction assure highly precise restoration of the digital information.

The Digital Processor DC-91 incorporates the MMB D/A converter system which redefines the state of the art. As can be seen from the graph, response of digital input versus analog output is absolutely linear from very high to extremely low levels. Distortion and noise are virtually absent. In all aspects, this processor attains the theoretical limit of performance.

The digital inputs are all equipped for 24-bit DAI (Digital Audio Interface) connections. Digital signal processing for functions such as signal attenuation and optional phase reversal is also performed at 24-bit resolution, and a 24-

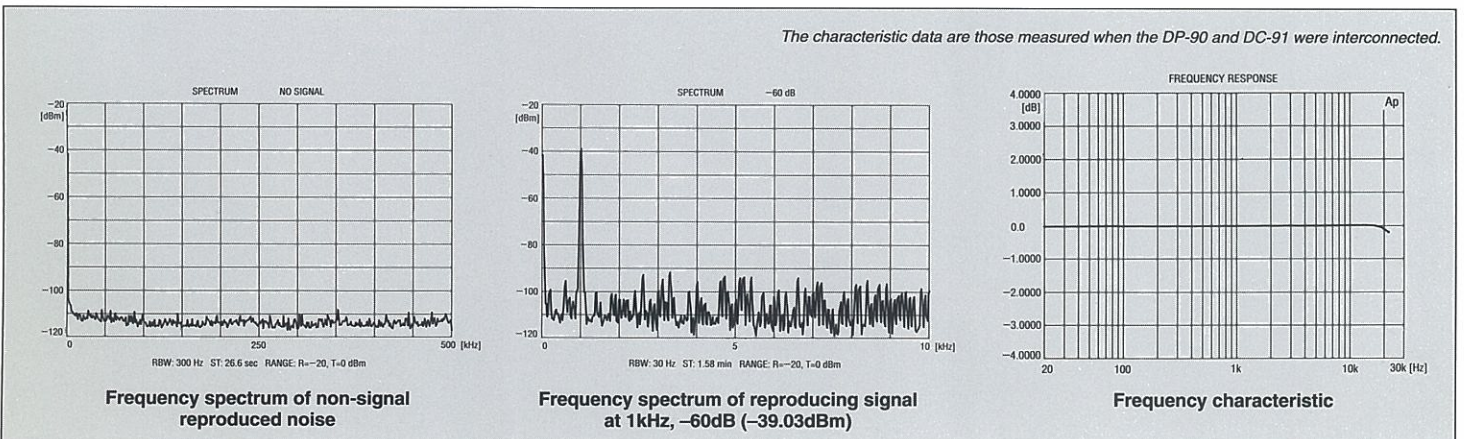


**HPC optical ultrahigh-speed link with data transfer rate of 150M BPS**

bit digital output is provided to allow for future expansion.

The number of formats that permit digital recording is currently on the increase, encompassing DCC, MD, DAT and recordable write-once CDs. To accommodate such components, the DC-91 has two sets of digital inputs and outputs (each with optical and coaxial connectors), and one set of HPC balanced connectors for professional equipment. The unit therefore can also serve as digital control center, opening up new vistas for the enjoyment of superb digital sources.

*The characteristic data are those measured when the DP-90 and DC-91 were interconnected.*





# Engineering to Revolutionize Audio World!

## TECHNICAL NOTES

### ■ MMB Type D/A Conversion System

In a D/A converter that converts a digital signal into an analog signal, a conversion error (that is, a difference from an ideal conversion characteristic) will always occur.

With the MMB Type D/A conversion system, this conversion error is minimized using a number of parallel-connected D/A converters, thus improving such characteristics as dynamic range, linearity, and the harmonic distortion factor.

Fig. 1 shows a block diagram of the MMB type D/A conversion system. The same digital signal is input to each D/A converter in the system and the conversion results of all the respective D/A converters are added together resulting in the total analog output from the system.

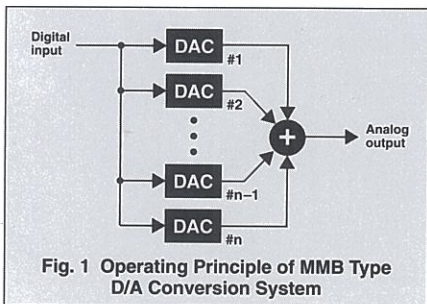


Fig. 1 Operating Principle of MMB Type D/A Conversion System

Because the outputs of all the respective converters will be added up, if an "n" number of converters are used, the total analog output will become a multiple of "n". However, how a conversion error occurs in the system differs from one converter to the other (as the error of one converter is a noncorrelated component independent of any other converters). Thus, the total analog output will not simply become a multiple of "n" but will be multiplied  $\sqrt{n}$  times. The output-to-noise ratio (a ratio between output level and noise level) with an "n" number of converters is  $1/\sqrt{n}$ . In other words, because the conversion error becomes  $1/\sqrt{n}$ , characteristics important to D/A converters such as dynamic range, linearity, and the harmonic distortion factor may be improved.

No. of converters	Output level	Noise level	Output level/Noise level
1	1	1	1
2	2	1.41	0.71
3	3	1.73	0.58
⋮	⋮	⋮	⋮
16	16	4	0.25
⋮	⋮	⋮	⋮
n	n	$\sqrt{n}$	$1/\sqrt{n}$

With the DC-91, 16 20-bit resolution D/A converters operate in parallel with one another. The conversion error of the system becomes 0.25 ( $=1/\sqrt{16}$ ) as compared with that when the number of converters is 1. As a result, conversion characteristics very close to those for the ideal 20-bit resolution converters have been implemented.

One great advantage of the MMB type D/A conversion system is that irrespective of the frequency

and level of a signal, improvements can be achieved at all frequencies and signal levels. Therefore, the problem of "linearity at minute signal levels", which has been considered to be a drawback of conventional multi-bit type D/A converters, can be solved at once.

Fig. 2 shows the total harmonic distortion (including noise) vs. frequency characteristic curves when the number of parallel-connected D/A converters was changed between one and 16 units. It can be seen that the higher the number of converters the better the distortion factor.

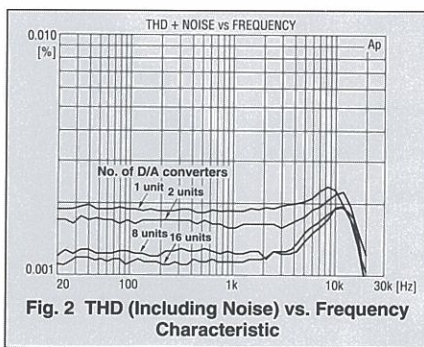


Fig. 2 THD (Including Noise) vs. Frequency Characteristic

### ■ Dither Signal

The digitization of the amplitude of an analog signal in A/D conversion is referred to as "quantization". When converting a large-level analog signal into a digital signal, the error of approximation in the quantization process (i.e., quantizing noise) cannot be heard as the error (quantizing noise) is hidden in the signal. However, if the level of an analog signal becomes smaller, the quantizing noise cannot be ignored for the analog signal. Because the quantizing noise in this case changes according to the signal level, it becomes audible detrimental noise.

To avoid such a phenomenon, A/D conversion is carried out after mixing a sort of noise scattered over a wide frequency band and called a dither signal into the analog signal. (In general, the level of a dither signal is 1/2 to 1 of the digital signal step.) By doing so, the overall noise level increases that much by the level of the mixed dither signal as shown in Fig. 3 (a), but harmonic distortion due to the quantizing noise when the level of an analog signal is very small can be reduced. In other words, a dither signal is a noise signal that causes the quantizing noise to be scattered over a wide frequency band so that the noise becomes inaudible.

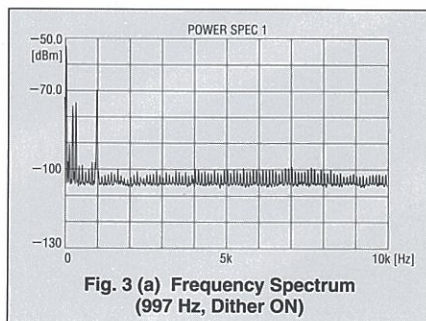


Fig. 3 (a) Frequency Spectrum (997 Hz, Dither ON)

With the DC-91, before D/A conversion (not A/D conversion), a dither signal is mixed into the digital signal in digital arithmetic processing. (As shown in Fig. 3 (b), Dither OFF (not to mix a dither signal) may be specified.) In this case, the dither signal functions to scatter the arithmetic error caused by the digital filter over a wide frequency band.

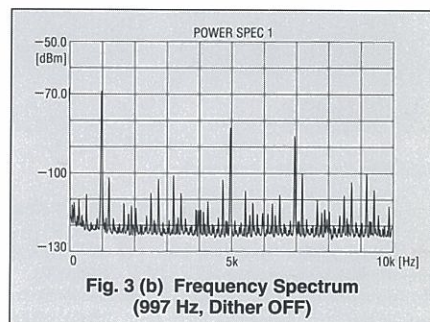


Fig. 3 (b) Frequency Spectrum (997 Hz, Dither OFF)

Fig. 4 shows the probability density curve of the dither signal adopted in the DC-91. This dither signal has a triangular probability density and its maximum amplitude value is  $\pm 1/2$  LSB of the input of a 20-bit resolution D/A converter (where LSB is the minimum unit of digital signal steps).

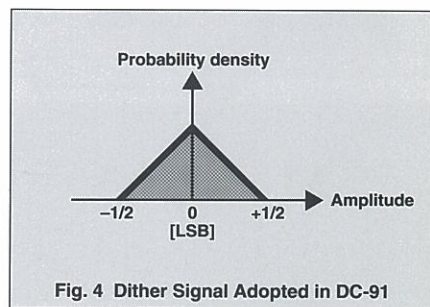


Fig. 4 Dither Signal Adopted in DC-91

Unlike the signals of 16-bit audio data as for CD players, DAT recorders, and broadcasting by BS, the amplitude of the dither signal is extremely small (1/32 of the minimum step of data whose maximum amplitude is 16 bits). While ordinary music signals are being reproduced in the Playback mode, the effect of the dither signal cannot be exhibited too well. However, the dither signal works well when reproducing an initial digital record source or a disc containing music recorded at low levels.





# DP-90

CD TRANSPORT

## High-quality transmission – HPC optical : ideal digital signal transmission.

## Rigid heavyweight structure with 8mm thick aluminum chassis

## Auto-lock mechanism that frees the CD transport

### HPC (High-Performance Connection) Digital Outputs for Flawless Transfer Characteristics

The optical connection principle that Acuphase introduced to the world with the DP-80/DC-81 system was adopted by the EIAJ and has found wide acceptance as a link for high-grade stereo components. But in order to ensure even higher data transfer precision, the DP-90 goes one step further. Its HPC optical output uses an ultra-fast Hewlett-Packard optical link that has a data transmission rate of 150M BPS. The supplied optical fiber cable for this connection is a multi-mode graded index type made of quartz glass, with a core/clad diameter of 50/125 μm. This eliminates pulse distortion and jitter, resulting in absolutely pure digital signal transmission.



HPC optical fiber cable



HPC balanced-type cable (110 ohms)

The DP-90 further provides a three-conductor HPC balanced output conforming to AES/EBU specifications, and a suitable cable with a characteristic impedance of 110 ohms and XLR type connectors is supplied. The balanced principle offers similar advantages as for analog signal transmission, namely effective rejection of externally induced noise. This output is especially useful for professional ap-

plications such as in broadcasting or recording studios. In addition, EIAJ-standard optical and coaxial outputs for connection to ordinary converters are also provided, so that the DP-90 is perfectly equipped for any situation.

### Laser Pickup with Integrated RF Amplifier for Minimum Noise

Since the output level of a laser pickup is very low, it is highly vulnerable to externally induced noise. To prevent such problems, the pickup used in the DP-90 employs a newly developed RF amplifier that is so compact that it can be directly integrated in the pickup assembly. Therefore, the high-level output signal is not affected by any kind of noise interference.

### Balanced Drive Circuitry for Servo Motors

The motors and actuators which drive the spindle, sled, focusing and tracking assembly, disc tray etc. require a rapidly fluctuating drive current, depending on the respective load condition. In conventional designs, such current fluctuations can affect the operation of other circuit areas, which in turn can lead to sound quality degradation. In the DP-90, two amplifiers arranged in a balanced configuration provide the drive currents to all actuators and

motors. Because there is no current flowing in the ground line, the operation of other circuits in the player remains entirely unaffected.

### 8-mm Thick Solid Aluminum Chassis

The mechanical assembly and the controller assembly are supported by a solid aluminum chassis that is 8 mm thick. The high rigidity of this chassis prevents acoustical or mechanical vibrations arising outside the player from affecting playback. This guarantees that the digital signal is always read off the disc with optimum precision.

### CD Transport Mechanism Designed for Superb Reliability and Long-Term Precision

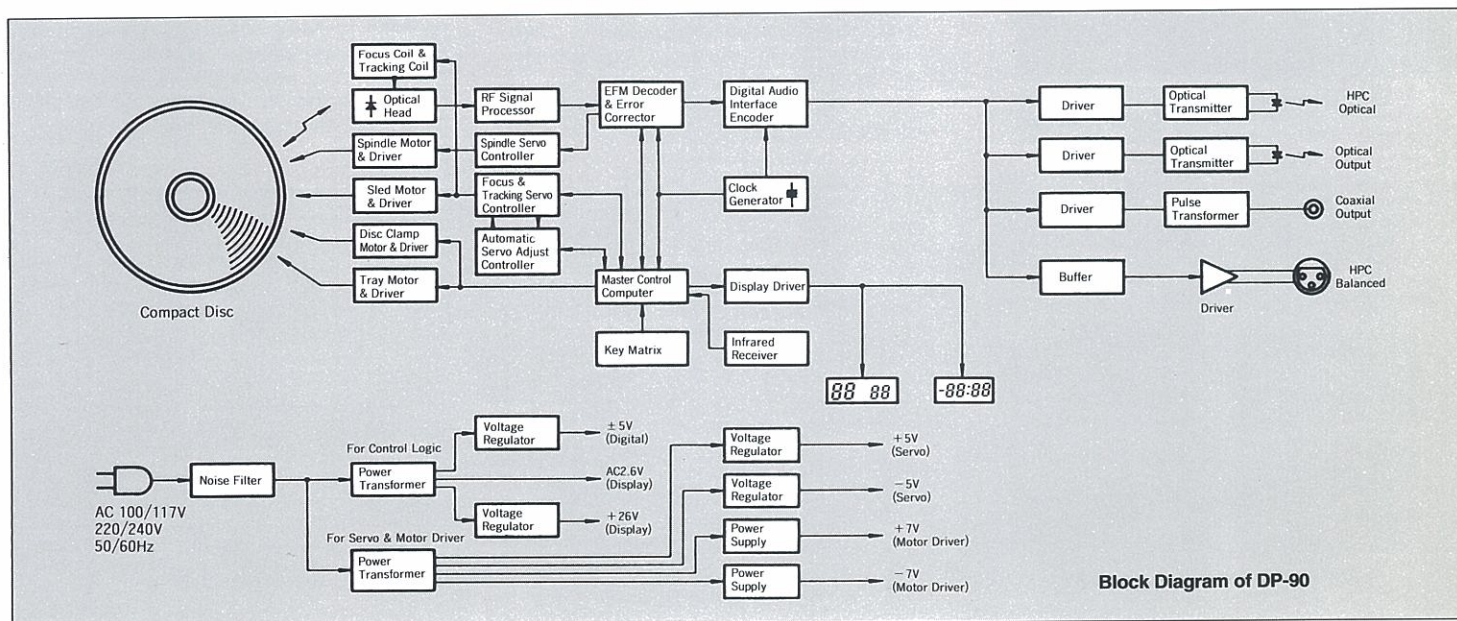
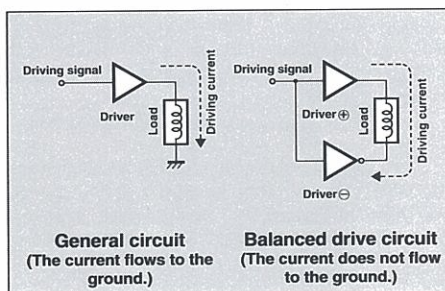
The extra-thick 3-mm spindle of the brushless disc drive motor is securely supported by sapphire bearings. This gives excellent wear resistance and assures stable drive conditions also after many years of use.

### Auto-lock Mechanism Prevents Tray Resonances

If the disc tray is separated from the rotating assembly during playback, resonances can degrade the signal quality. In the DP-90, the disc tray is firmly locked in place during playback, to eliminate any possibility of harmful resonances.

### Separate Power Supplies with Dual Transformers

The DP-90 has two separate transformers for handling different functions: one for the digital signal processing, microprocessor and display circuitry, and one for powering the spindle, sled, focusing and tracking and disc tray actuators, whose load fluctuates drastically. This assures highly stable, high-quality digital signal readout.





# and HPC balanced digital outputs are provided to implement thick solid aluminum chassis transporter from harmful resonances

## Gold-plated Printed Circuit Boards for Superb Sound Quality

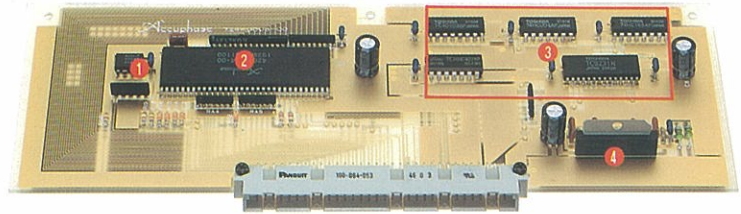
The separate controller board and transport units are connected via a motherboard, which virtually eliminates the need for internal wiring and greatly improves reliability. For optimum sound quality, all printed circuit boards employ gold-plated traces.

## Multifunction Remote Commander RC-9 (supplied with the DP-90)

The RC-9 can be used to remotely control both the DP-90 and the DC-91. In addition to the functions of these two units, the RC-9 is complete with a variety of other functions including Display On/OFF, Dimmer that controls the brightness of the display in three stages, Direct Play, Repeat, Programming, and Time display.



Remote  
Commander  
RC-9

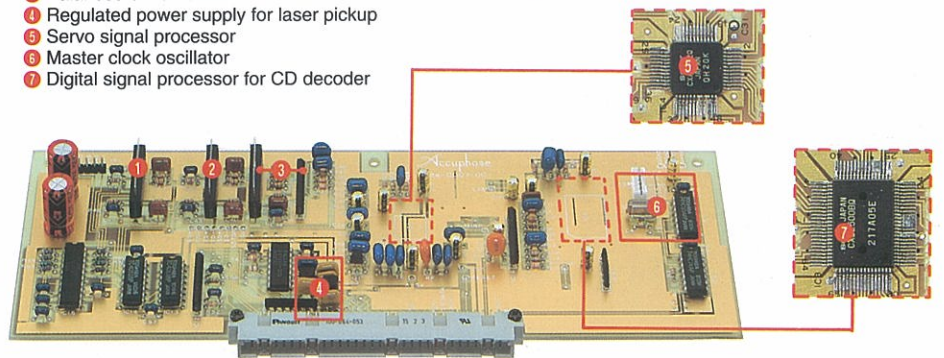


### ▲ System Control Assembly

- ① Memory IC
- ② 8-bit microprocessor for system control
- ③ DAI encoder IC group
- ④ Balanced driver for disc tray

### ▼ Actuator Control Assembly

- ① Balanced driver for focusing
- ② Balanced driver for tracking
- ③ Balanced driver for sled
- ④ Regulated power supply for laser pickup
- ⑤ Servo signal processor
- ⑥ Master clock oscillator
- ⑦ Digital signal processor for CD decoder





# DC-91

DIGITAL PROCESSOR

## Newly Developed MMB Principle Yields 20-bit Linearity and Minimum Noise

The D/A converter design is an essential criteria for sound quality. The DC-91 positively excels in this regard, thanks to its newly developed MMB converter system. The acronym MMB stands for "Multiple Multi-Bit" and refers to sixteen strictly selected 20-bit D/A converter elements which are connected in parallel. The improvement yielded by the parallel connection is exemplified by the fact that connecting two elements in parallel will yield twice the current but distortion and residual noise will increase only by a factor of 1.4. The improvement in terms of signal versus noise in this case is 3 dB. With several elements in parallel, the improvement can be calculated according to the following equation, where "n" is the number of parallel elements:

$$20 \log (1/\sqrt{n}) \text{ [dB]}$$

Since the DC-91 uses sixteen elements, the improvement is 12 dB.

As can be seen from the graph, response of digital input versus analog output is absolutely linear from very high to extremely low levels. Distortion and noise are also virtually absent, so that the converter attains the theoretical limits of performance. And even more importantly, the improvement provided by the MMB principle is not dependent on frequency or signal level. Linearity at very low levels — a weak point of conventional multi-bit converters — has been perfectly corrected.

## HPC (High Performance Connection) Digital Inputs

To receive the high-quality digital signals from the CD Transport DP-90, the DC-91 has dedicated HPC optical and balanced inputs. The optical input uses the same ultra-fast Hewlett-Packard link with a data transfer rate of 150 MBPS. The total absence of pulse distortion and jitter ensures absolutely pure digital signal transmission.

The HPC balanced link is totally impervious to externally induced noise and is therefore particularly suitable for installations where long cable runs are required. The output conforms to AES/EBU specifications, making it perfect for professional applications such as in broadcasting or recording studios.

## Thirteen Digital Inputs, Two Outputs and Three Sets of Terminals for Digital Recorders

Besides the HPC optical and balanced inputs, the DC-91 provides three optical and three coaxial inputs conforming to the EIAJ Digital Audio Interface standard. In addition, three sets of terminals for digital recording devices such as DAT, DCC, or MD devices are also provided. One of these is a balanced connection, which conforms to the AES/EBU professional format.

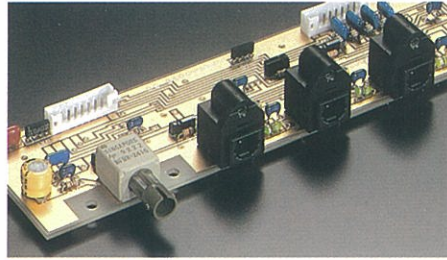
All digital inputs are designed internally to handle 24-bit audio data, to allow for future expansion. Two 24-bit digital outputs are also provided, making the unit ready for the next generation of digital audio components.

# Ultimate in multibit configuration — Imp

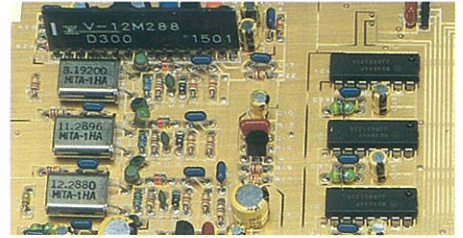
# the newly developed MMB D/A conversion

# Equipped with HPC digital inputs for hig

# Handles three different sampling freque



HPC optical and Toslink optical transmitters



## Absolute Phase Selection and Level Control in the Digital Domain

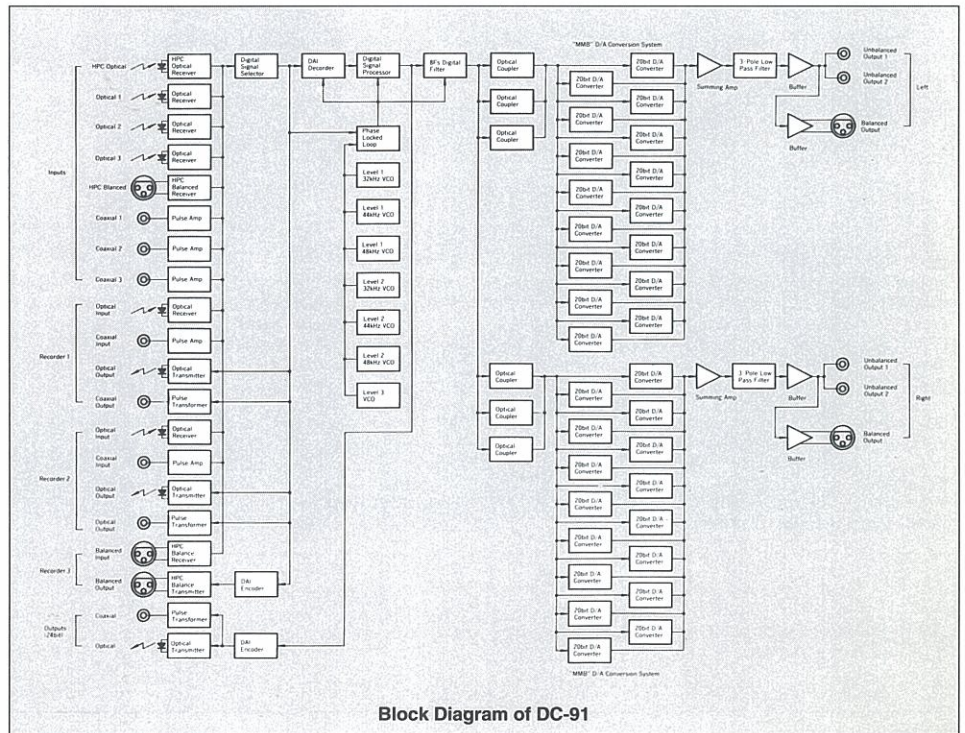
In a high-quality playback system, absolute phase can be critical. To prevent any possibility of sound quality degradation, the DC-91 allows absolute phase selection in the digital domain, thanks to the DSP (Digital Signal Processor) that has the capability to operate with 34-bit arithmetic precision. The signal level is also adjusted by the DSP chip with 24-bit output precision, which is 8 bits more than the 16-bit CD signal requires. This means that the level can be reduced by 8 bit (corresponding to -48 dB) before any degradation would occur. To further provide a safety margin, the control range is set to -40 dB.

## Input Selector with Memory

A unit with as many digital inputs and functions as the DC-91 could be a nightmare when it comes to remembering various signal levels, frequency precision levels, and phase settings. But the DC-91 is not only versatile, it is also easy to use, thanks to a built-in memory that stores all settings associated with every input.

## Automatic Selection of Three Sampling Frequencies and Automatic Detection of Frequency Precision in Three Stages

The number of digital program sources is increasing constantly, now encompassing DAT, DCC, MD, digital broadcast satellites, video discs with digital soundtrack, etc. The DC-91 can automatically detect and handle all three sampling frequencies currently in use. In addition, the EIAJ defines three levels of precision for sampling frequency accuracy: level I ( $\pm 50$  ppm), level II ( $\pm 1000$  ppm), and level III ( $\pm 12.5\%$ ). If the frequency lock range of a processor is wider than a high-precision source requires, sideband noise will degrade sound quality. The DC-91 uses three quartz oscillators for level I, three lithium tantalate oscillators for level II, and a CR oscillator for level III, resulting in a total of seven PLL oscillators optimized for their respective precision level. A microprocessor automatically selects the proper oscillator type, but manual override is also possible.



Block Diagram of DC-91



ments theoretical-limit performance as high as 20 bits with system.

quality digital signal transmission.

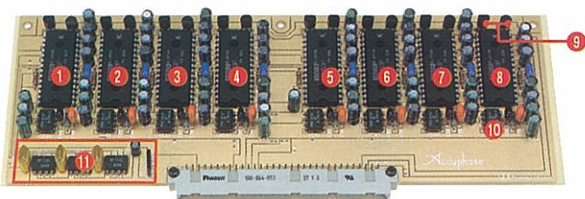
ies and automatically detects three frequency accuracy levels.

### Three Separate Power Transformers

Separate power transformers are provided for the digital circuits and for the left-channel and right-channel analog sections. Because of the

MMB principle, the DC-91 has a total of 32 D/A converters. Each converter in turn has a local regulator with a positive and negative regulated power supply, resulting in a total of 64

power supply circuits in this section alone. This lavish design extracts optimum performance from each converter.

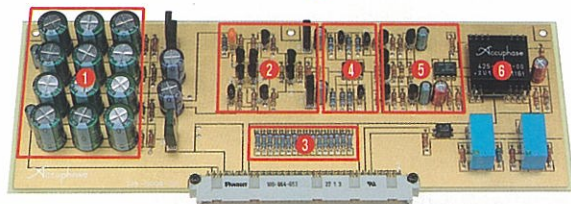


▲ **MMB D/A Converter Assembly**  
(Four boards of this assembly are used to make up the D/A conversion system.)

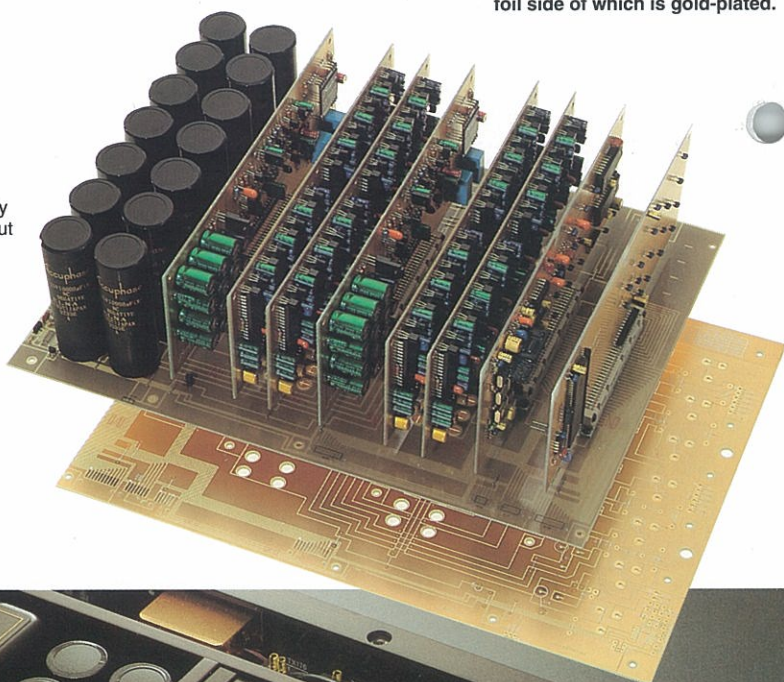
- ① - ⑧ High-precision 20-bit D/A converters (8 converters are parallel-connected per board.)
- ⑨ Positive/negative regulated power supply
- ⑩ Ultrahigh-precision IV converter
- ⑪ Ultrahigh-speed optoisolator

### ▼ Output Amplifier Assembly

- ① Filter & capacitor group for power supply
- ② Ultrahigh-speed amplifier for MMB output synthesis
- ③ Ultrahigh-precision resistor group for MMB output synthesis
- ④ 3-pole GIC filter
- ⑤ Unbalanced type output amplifier
- ⑥ Balanced type output amplifier

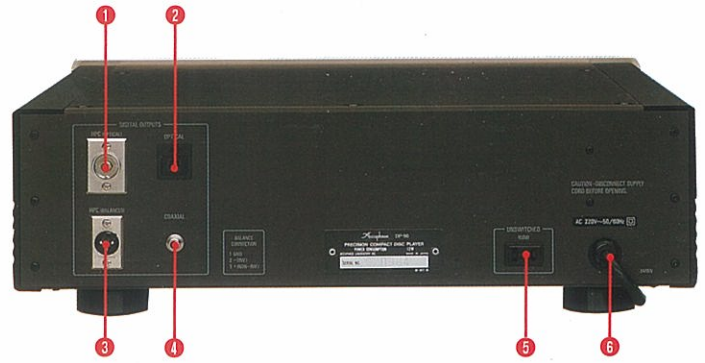
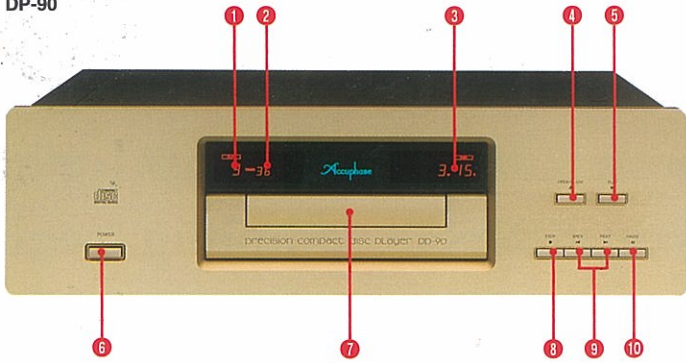


MMB D/A converter assemblies, digital modulation/demodulation assembly, system control assembly, and audio output assembly arranged neatly on the motherboard, the copper foil side of which is gold-plated.

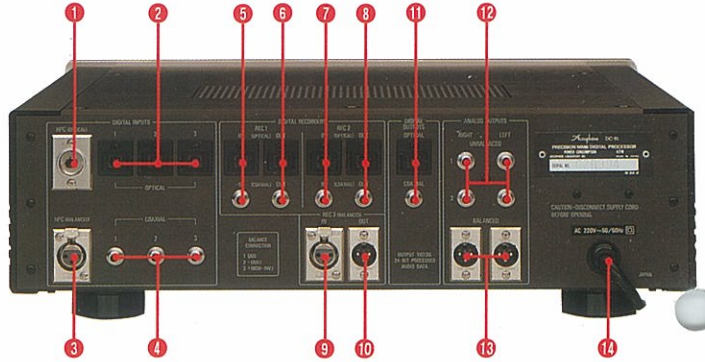
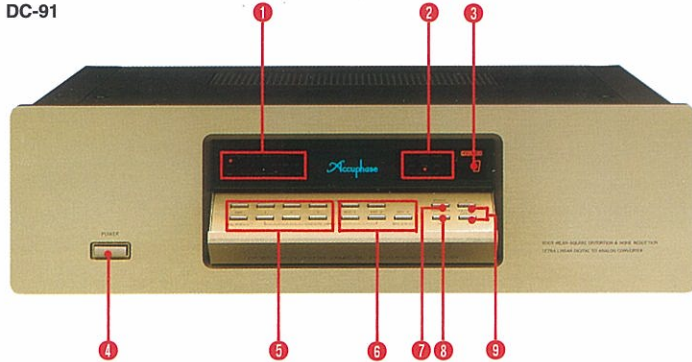




DP-90



DC-91



FRONT PANEL

DP-90

- 1 PLAY TRACK Indicator
- 2 TRACK/INDEX Indicator
- 3 TIME Indicator
- 4 Disc Tray OPEN/CLOSE Key
- 5 PLAY (Playback Start) Key
- 6 POWER Switch
- 7 Disc Tray
- 8 STOP Key
- 9 TRACK SEARCH Keys
- 10 PAUSE Key

DC-91

- 1 Input Position Indicators
- 2 EMPH, PHASE, and Sampling Frequency Indicators
- 3 LEVEL/-dB Indicator
- 4 POWER Switch
- 5 INPUT Selector Keys
- 6 REC-1, REC-2, REC-3 (Recorder) Selector Keys
- 7 PHASE (Output Phase) Selector Key
- 8 SFA (Sampling Frequency Accuracy) Key
- 9 OUTPUT LEVEL Adjust Keys

REAR PANEL

DP-90

- 1 HPC optical fiber output connector
- 2 Toslink optical fiber output connector
- 3 HPC digital output balanced type connector
- 4 Coaxial output jack
- 5 Unswitched AC outlet\*
- 6 AC power cord

DC-91

- 1 HPC optical fiber input connector
- 2 Toslink optical fiber input connector

- 3 HPC digital input balanced type connector
- 4 Coaxial input jacks
- 5 REC1 input connector (Toslink/Coaxial)
- 6 REC1 output connector for recording (Toslink/Coaxial)
- 7 REC2 input connector
- 8 REC2 output connector for recording
- 9 REC3 balanced-type input connector
- 10 REC3 balanced-type output connector for recording
- 11 24-bit digital output connector (Toslink/Coaxial)

- 12 Unbalanced type output jack for audio output
- 13 Balanced type output connector for audio output:
  - ① Ground, ② Inverted (-), ③ Non-inverted (+)
- 14 AC power cord

**\*Remarks:**  
The unswitched AC outlet may not be supplied depending on the safety standards or regulations applicable in the particular country to where the unit is destined.

GUARANTY SPECIFICATIONS

enrich life through technology

(Guaranty specifications are measured according to EIAJ standard CP-307.)

Performance Guaranty

All Accuphase product specifications are guaranteed as stated.

CD TRANSPORT DP-90

- **Product Type** Digital Compact Disc playback unit
- **Format** Standard CD format  
Error correction principle: CIRC  
Number of channels: 2  
Revolution speed: 500 - 200 rpm (constant linear velocity)  
Scan velocity: 1.2 - 1.4 m/s, constant
- **Data read Principle**  
Non-contact optical pickup (semiconductor laser)
- **Laser Type**  
GaAlAs (double heterodyne diode)
- **Digital Signal Output Format and Level (EIA)**  
Timing precision: Level I  
HPC optical: Output -19 to -14 dBm  
Wavelength 820 nm  
HPC balanced: 5 V<sub>p-p</sub>, 110 ohms  
OPTICAL: Output -21 to -15 dBm (EIAJ)  
Wavelength 660 nm  
COAXIAL: 0.5 V<sub>p-p</sub>, 75 ohms
- **Power Requirements** 100/117/220/240 V, 50/60 Hz
- **Power Consumption** 12 W

- **Maximum Dimensions**  
475 mm (18-3/4") width x 149 mm (5-7/8") height x 379 mm (14-15/16") depth
- **Weight**  
20.5 kg (45.2 lbs.) net  
25.5 kg (56.2 lbs.) in shipping carton

DIGITAL PROCESSOR DC-91

- **Product Type** Digital processor unit
- **Input/Output Format** Standard EIA format  
Quantization: 16 - 24 bit linear  
Sampling frequencies (automatic detection): 32 kHz, 44.1 kHz, 48 kHz  
Timing precision (automatic detection): Level I, II, III
- **Frequency Response** 4.0 - 20,000 Hz ±0.3 dB
- **D/A Converter** MMB type, 20-bit
- **Digital Filter**  
20-bit 8-times oversampling filter  
Digital deemphasis, Tolerance: ±0.001 dB
- **Total Harmonic Distortion**  
0.002% (20 - 20,000 Hz)
- **Signal-to-Noise Ratio** 120 dB
- **Dynamic Range** 98 dB
- **Channel Separation** 112 dB
- **Rated Output Level and Impedance**  
BALANCED: 2.5 V/50 ohms, XLR-type connector  
UNBALANCED: 2.5 V/50 ohms, RCA-type phono jack
- **Output Level Control**  
0 to -40 dB in 1-dB steps (digital control)

- **Digital Signal Input Format (EIA)**  
HPC optical: Input -30 to -10 dBm  
HPC balanced: minimum input 0.2 V, 250 ohms  
OPTICAL: Input -27 to -15 dBm  
COAXIAL: 0.5 V<sub>p-p</sub>, 75 ohms
- **Power Requirements** 100/117/220/240 V, 50/60 Hz
- **Power Consumption** 42 W
- **Dimensions**  
475 mm (18-3/4") width x 149 mm (5-7/8") height x 379 mm (14-15/16") depth
- **Weight**  
22.5 kg (49.7 lbs.) net  
27.5 kg (60.6 lbs.) in shipping carton

Remote Commander RC-9

(Supplied with DP-90, but also available as an option.)  
Remote control principle: infrared pulse  
Power supply: 3V DC (IEC R03 (size AAA) batteries x 2)  
Dimensions: 66 mm (2-5/8") x 225 mm (8-7/8") x 20 mm (13/16")  
Weight: 280 g (0.6 lbs.) (including batteries)

OPTIONAL PARTS

- HPC Optical Fiber Cable HLG-10 (1m)\*
  - HPC Balanced-type Cable HLC-10 (1m)\*
  - Toslink Optical Fiber Cable LG-10 (1m)
- \*Supplied with DP-90  
(Each cable is available with a length of 2m, 3m, and 5m.)



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