Technology Summary

No technology spared overturning conventional amp design precepts

1. World's first [Current Drive]

This ideal drive format is based on the headphone drive rule.　About 99.99% of headphones on the market today employ voltage drive.　A Copernicus style revolution from conventional voltage drive, the world's first return type [Current Drive] signal amplification circuit provides the ultimate high-resolution sound and unsurpassed drive power to realize both a feeling of transparency and counter position in sound playback. Most headphones employ a fundamental structure employing a linear motor that drives a diaphragm through a magnetic field to compress air, converting the movement to sound. The drive power from the magnetism= Power F (sound level) originates from Fleming's left-hand rule.　This rule states that Power F (sound level) is the product of the current I and the magnetic field B (F=I・B).　Voltage is not a parameter in this equation, indicating that the main component of drive power is current.　The World's first return type [Current Drive] amplification circuit was newly designed based on this basic principle and rule for headphones.

The newly developed [Current Drive] eliminates the need for a conventional impedance-reliant gain switch for each headphone.

2. [4-ply Stabilized Power Supply]

The use of four-ply Stabilized Power Supply succeeds in suppressing fluctuations in power supply to the final stage amp virtually to the point of elimination.

3. [One on One Direct Power] Power Supply Circuit

Power supply circuits and are positioned 1 to 1 in direct opposition to each AMP across the circuit board, achieving the ultimate short-path connection from power supply to AMP in this newly designed layout.

4. Drive Amp Final Stage [Condenser Elimination]

The sound idiosyncrasies of power supply condensers, considered unavoidable under conventional wisdom, have been eliminated.

5. [Advanced Current Segment] DAC

A predominance of ΔΣ converters constitutes the latest trend in DAC product adoption, and the Advanced Current Segment DAC (PCM1792A) harnesses the advantages of multi-bit based ΔΣ modulation.　This PCM1792A also employs a fundamental design for current addition and current output based on a standard power source.　Because it shares the same current drive design philosophy as the aforementioned E1, it unifies the worldview of sound creation and sound coloration championed by the E1.

Technology ①

[Current Drive]

- Current Drive is the ideal drive format based on the headphone movement rule.
- About 99.99% of headphones available on the market employ [voltage] drive.
- A Copernicus revolution from conventional voltage drive, the return format
- World's first Current Drive signal amplification circuit is newly developed.
- Current Drive realizes ultimate high-resolution sound and unsurpassed drive power for playback with both a feeling of transparency and counter position.
- Newly developed Current Drive eliminates the need for a conventional impedance-reliant gain switch for each headphone

・ General system for sound conversion

Headphones and speakers can be thought of as monitors. The movement of a motor (force) compresses air and converts the movement to sound. The power comes from Fleming's left-hand rule. In other words, force (sound level) is expressed as the product of current I and magnetic field B (F=I・B). Because voltage is not a parameter in this equation, current can be said to be the main actor in drive power energy.

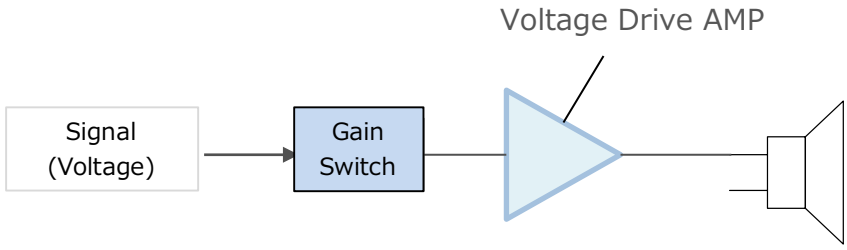
・Problems with Conventional [Voltage Drive]

Most headphones employ voltage drive in which the audio signal is connected to headphones by voltage. The headphone load resistance is converted to current in accordance with Ohm's law, possibly resulting in following types of problems.

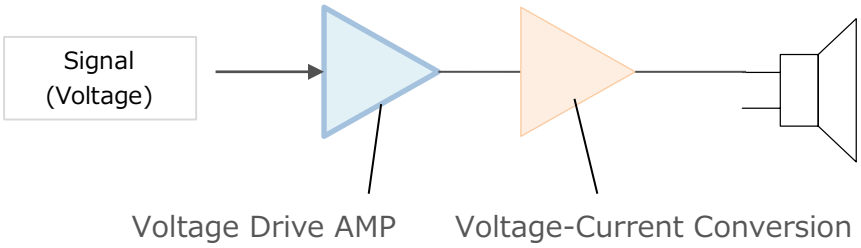
1. Difference in headphone load resistance (0.01Ω~100Ω) leads to in gain differential
   - A change in load resistance even at the same voltage results in a change in current
     = Change in force (sound level)
     = Same value as change in amplifier gain
   - For example 30Ω and 300Ω relatively high load headphones employing the same voltage have a 10:1 difference in current
     =10 times difference in gain (if the difference in voltage is not corrected, they will not be the same)
   - Because volume exceeds adjustable range, a gain switch is indispensible

2. Impacted by connection cable
   - Resistance from the connection cable is part of the amplifier load
   - The headphone load is connected in series, drive voltage is split with cable resistance.
   - Some of the energy is consumed by the connection cable
   - Connection cable has a capacity component and an impedance component
   - Energy consumed by the connection cable is not fixed with respect to the frequency
     = Impact on sound quality in principle (can be said that sound distortion is guaranteed)

3. Headphone resistance is not fixed with respect to frequency
   - Ideally, resistance would be fixed with respect to frequency
   - Due to impedance, there is additional resistance for high range sounds
     = Reduced current for high range causes distortion of high range characteristics
   - Mechanical resonance causes sharp increases in resistance at some frequencies
     = Additional resistance near Resonance point, current drops
   - Behavior at resonance points not interrelated to music signal
     = Difficult to call that accurate sound reproduction, this is a problem for headphones

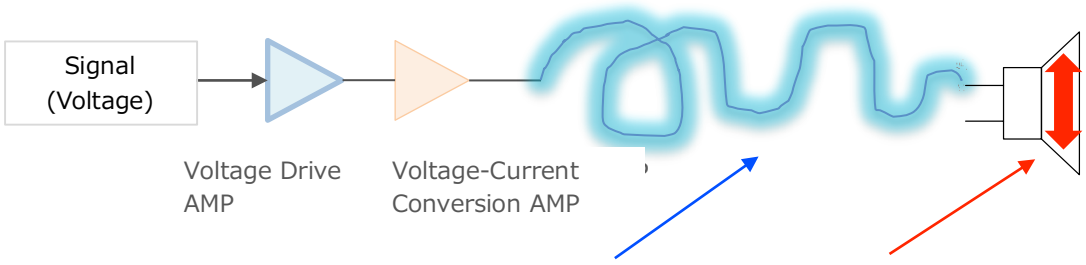


- In the case of E1 [Current Drive]



If a voltage to current conversion circuit is added behind the Voltage amplification AMP, it is becomes possible to flow current corresponding to the voltage. This circuit functions as a current drive AMP, not contributing to problems outlined in 1-3 above (without regard to headphone resistance or connection cable characteristics) ensuring that the current corresponding to the voltage value specified by the design flows through to the headphones. Accordingly, the need to furnish a gain switch is eliminated.

Voltage Drive AMP Voltage-Current Conversion AMP



[Transmission route by cable, etc.] [Electrical Characteristics of headphones]

No impact, realizes robust current drive for input signal

Technology ② ③ ④

[Four-ply Stabilized Power Supply] Other Power Source Circuits

・ Theoretical Role of Power Source and Problems Encountered

The role of the power source is to supply stable energy to the AMP and to serve as a standard for operation.

In actual appliances:

1. Noise from AC and fluctuations in voltage as a cause
2. Noise and fluctuations in voltage from power source circuits and parts themselves
3. Fluctuations in voltage due to load (AMP Load)

1-3 are among the conceivable problems that can be viewed as effects of AMP operation that may ultimately have a negative impact on sound quality.

Conventional technology (selection and combination of circuits and components) can be employed to suppress noise and fluctuations in voltage caused by 1 and 2 above. Fluctuation in voltage due to amp operation have deeply rooted causes as voltage may fluctuate due to operation of the AMP itself and these fluctuations not only may become apparent by may also have an impact on other AMPs and DA converters. When crosstalk between the multiple AMPs and DA converters within an appliance occurs, it can cause sound to become muddled and adverse impacts on sound expansion, imagery, reverberation, etc.

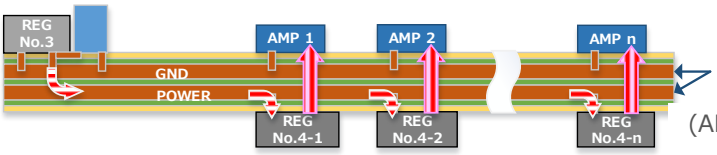
There are unique causes of amplifier operation not following the performance of the stabilized power supply from which it receives power. In battery drive systems in which the impact of 1 and 2 above is limited, because the shape of the batteries makes it difficult to connection to each AMP power supply terminal with the shortest connection, the impact of impedance from the wiring remains. This means that with a conventional power supply circuit structure, there are limits to the gains that can be achieved by tweaking wiring patterns.

・ Newly Developed [4-ply Stabilized Power Supply]

Stages 1 and 2 of the 4-Ply Stabilized Power Supply accomplish the function of generating voltage specific for each purpose while overcoming problems 1 and 2 through meticulous selection of circuits and components, whereas stages 3 and 4 rely on 200um thick hypoxic copper sheets for the power source and ground for low impedance connections that impart the 4th stage power supply with surety of operation. The 4th stage power supply is equipped with a drive amp that has characteristics superior to the AMP it supplies, allowing it to seize control of AMP operations and supply current free of any excess or deficiency.

・ Final Stage of Drive AMP [Elimination of Condenser]

To reduce the condenser load on the drive amp output as well as to narrow the fluctuation suppression capacity (gain) and frequency band, the condenser (bypass condenser) between the drive amp output and the AMP power supply terminal has been completely eliminated.



200μm hypoxic copper layer

(AMP=OPAMP, REG=Stabilized Power Supplies)

・ [One on One Direct Power - Power Supply Circuit]

Power supply circuits are positioned 1:1 directly opposite AMPs on the circuit board, providing the ultimate layout for minimizing the length of the connection to the AMP power supply terminals.
Additionally, the 4th stage power supply operates based on the highest benchmark low noise voltage reference standard with a temperature declination of 1ppm/°C or less.

・ Newly Developed [4-Ply Stabilized Power Supply] Conclusion

Unprecedented high-level refinements in circuits and circuit boards have resulted in previously unattainable characteristics that overcome the aforementioned issue 3. Voltage Fluctuations Due to Loads (AMP Load) while elimination a power supply condenser conventionally considered indispensible has eliminated another potential source of idiosyncrasies in sound performance.　The product aims for achieve the ultimate uniquely superior power supply circuit.

Technology ⑤

[Advanced Current Segment] DAC

Employs a fundamentally multi-bit Advanced Current Segment DAC (PCM1792A). This PCM1792A employs a fundamental design in which current is added and output based on a standard power supply. Because the E1 employs the same current drive design concept, using it unifies the worldview of sound championed by the EI. The recent trend in adoption of DAC products involves the predominant use of the ΔΣ format, but the reasons for using the multi-bit based Advanced Current Segment DAC (PCM1792A)are as follows:

Conventional [ΔΣ Format] Characteristics

1. Easier to produce industrially than multi-bit format
   = Degree of ΔΣ modulation, able to choose the noise level based on the sampling rate
2. Copious noise above the audible range necessitates late stage analogue processing
3. Accumulation of conversions from clock timing directs clock jitter toward the signal
   Because it has a direct impact, jitter has a large impact on signal reproducibility
   = PLL responding to various clock frequencies unable to reduce jitter to miniscule level, particularly DPLL has a tendency to become discreet when gain is turned high, causing jitter to have characteristic effects on signal reproducibility
4. Sound is generally delicate, flawless elegance awaits the temporal dispersion of energy

Characteristics of [Multi-bit Type] employed in the E1

1. If the high precision resistance array used to decide the amount of current to add to the signal requires laser trimming, it will not be used in production
2. Noise is primarily naturally occurring thermal noise
3. Clock jitter does not affect the signal level
4. Sound quality has profound mid-range and bass, brilliant sound production

Characteristics of [Advanced Current Segment] DAC (PCM1792A)

The PCM1792A combines the ΔΣ format's suitability for delicate expression with bright sound production characterized by robust mid-range and bass, employing a structure that can bring out the best in both formats. Specifically, from within the full scale, the lower18 bits are converted using ΔΣ modulation, after merging the multilevel step signal of the upper 6 bits, there is a process to add current to the signal. It has been designed with consideration to balancing suppression of clock jitter and high range noise, weak points of the ΔΣ format, with the ease of production that does not require laser trimming to avoid the weak points of the multi-bit format.

Technology ⑤

[Advanced Current Segment] DAC

PCM1792A [DSD playback]

DSD Playback does not require the DSD⇨PCM conversion employed by many DACs, the aforementioned ΔΣ modulation equipped current addition apparatus serves the role of a low-pass filter, undertaking direct analog conversion. Accordingly, this can be said to be a design capable of handling both PCM source material and DSD source material in the ideal manner.

Integrated Design from PCM1792A [Current Output] to AMP [Current Drive]

The fundamental design for standard power source based current addition and current output by the PCM1792A fit the same concept as the current drive from the analog stage of the E1. To draw out the maximum limit of this characteristic, the aforementioned 4th stage of the Stabilized Power Supply has been arranged for use by the PCM1792A, and the Left and Right channels are supplied separately. Digital noise is eliminated from the start, and analog power source terminals on which digital noise would ordinarily be observed with the recommended application show no fluctuations in voltage during any stage of the signal playback process.

Additionally, the condenser recommended for the application is a chemical condenser, but the E1 uses all film condensers. Moreover, tuning is conducted through repeated sound demonstrations using an array of resistors that includes high precision reference resistors with a tolerance of ±0.01% and a temperature coefficient of ±2ppm/°C.

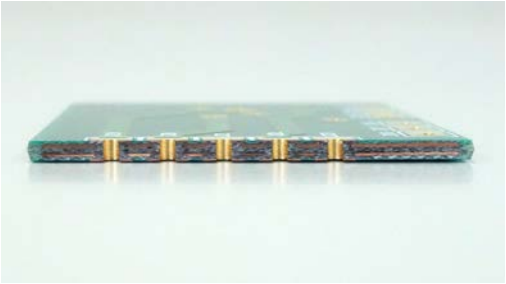
The same type of series design concept is followed for the analog circuits beyond the DAC DAC as for the aforementioned current drive, allowing the E1 to realize the objective of circuit design integrated by current drive from the digital section to the analog section.

Technology

・ The use of 4-ply circuit boards with ultra-thick copper sheets that exceed industry standards realizes high speed and ultra high-resolution via ultra-low impedance leads.

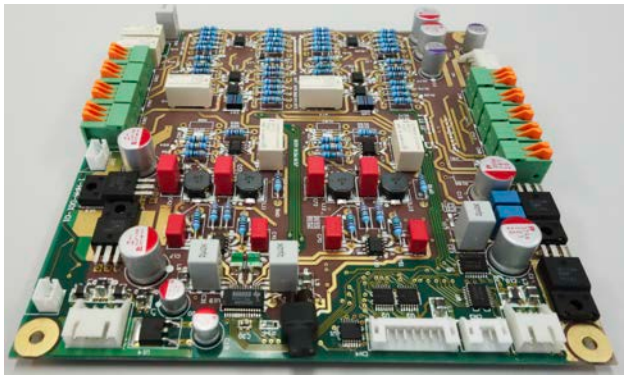
・Power source and ground leads in the 2nd and 3rd layers are 200μm thick hypoxic copper
It is often said that thick wires should be used as leads to the power source, but how about the circuit board? Circuit boards are essential for miniaturization and volume production, but conventional copper sheets are only about 35μm thick. Not only the aforementioned power source circuit but also the structure and manufacture of the circuit boards themselves have been achieved with great thoroughness and passion. We make low impedance power supply possible through the use of thick hypoxic copper foil sheets.

Cross-section of Circuit Board

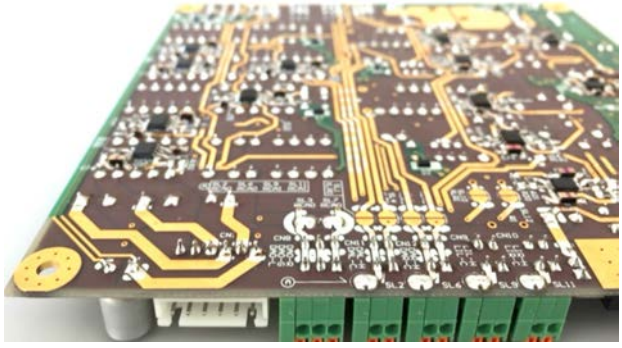


・ 100μm thick copper foil sheets used for signal layers (Layers 1 & 4)
Copper sheets exceeding industry standards are also used for signal use circuit boards. The analog section is not resist painted; it employs a gold flash specification that characterizes our emphasis on sound quality.

Face



Underside



Technology

・ 4-ply circuit boards employing ultra-thick copper sheets that exceed industry standards

・Due to the thick copper, even though these are glass epoxy circuit boards, once bent they will not return to shape.

・The circuit boards are about double the weight of general universal circuit boards. Heat conductivity is extremely highly.　Heat from a soldering iron quickly escapes, so the circuit board must be heated using an ordinary hotplate while each component is painstakingly soldered to the circuit board one at a time with great precision.

Technology

・ Left and Right Channels are completely independent on the circuit board

・ Including the power supply to the DA converter, the power supply to each AMP and the flow of the Left and Right signals have been made completely independent. This, of course, eliminates crosstalk between channels, but it also suppresses crosstalk within a channel to a negligible minimum.