SHARP

The Heart and Soul of the Next Generation Audio System

1 BIT
AMPLIFIER
SM-SX100

The Reproduction of the Performance Space

Sharp believes that the keywords in sound reproduction for the 21st century will be "High-Speed Sampling 1-Bit Signal". This technology makes possible the reproduction of inaudible sounds in nature.

Setting the standard for the next generation audio, 1-bit audio delivers high-speed sampling, high-order $\Delta\Sigma$ (delta-sigma) modulation coding and genuine sound transmission. It is these features that reproduce atmosphere.

1-bit performance – the new way of reproducing original sound, the performance space itself. Never before reproduced or captured faithfully, experience the new dimension of sound for the forthcoming century.

Turkish Bell Ringing at 100 kHz:
Each extremely detailed, high frequency sound rings out suddenly from silence. Sounds and feeling which could not be experienced before are now vividly reproduced with 1-bit technology.

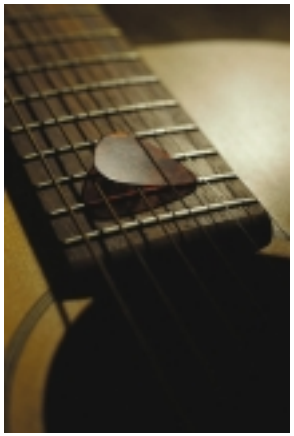
Peacock Green

Cocktail Blue

Black

"The breathing of the player, the sounds when his fingers touched the strings, the natural sounds the instrument made..."

"When I first heard of the theory of 1-bit audio, I intuitively knew that it was right. And I was shocked when I experienced firsthand how it improves sound quality. I can still recall the moment quite vividly. In 1997, after 7 years of research and development, we listened to a recorded sample sound using an experimental 1-bit recording system by our colleague Prof. Yoshio Yamasaki of Waseda University. Prof. Yamasaki chose the sound of an acoustic guitar as it was easily recordable. He recorded a professional studio guitarist with a microphone which captures up to 100 kHz sound and then encoded the analogue information into 1-bit digital signals. When the recording was played back we felt as if the guitarist was playing in front of us, although it had actually been recorded in the university's studio with very little reverberation.



The breathing of the player, the sounds when his fingers touched the strings, the natural sounds the instrument made – all captured and reproduced faithfully. We had never experienced reproduced sound so realistic before and all of us were amazed with the 1-bit signal's excellent ability to reproduce audio information. We realised that 1-bit signal has the ability of 'time resolution' and 'transient response' which are essential to reproduce music and the atmosphere of the performance space itself. We were greatly inspired by the experimentation and our dedication to developing the best possible 1-bit system was strengthened.

Without any deterioration of sound quality, the amplifier with 1-bit coding technology transmits thrilling musical realism. You will not feel like you are listening to reproduced sound – you will feel like you are right there in the studio. Our team urges you to experience the true sound of music firsthand."

Kiyoshi Masuda
Project Chief
Sharp CVI 2006 Project Team

Attaining True Fidelity

(Actual Size)

From a frequency domain to a time domain... In attempting to define perfect sound, recent articles in high-end-audio-related publications are concerned with transient response. The words "instantaneous response of sound" and "sense of high-speed" abound in these articles but what these expressions really imply is "control of time" one of the elements necessary to reproduce natural sounds. With its instantaneous transmission of sound, high-speed sampling 1-bit audio has the ability to reproduce every sound of every instrument and even the player's breathing. In other words, the 1-bit audio reproduces the performance space – naturally, infinitely.

(1-Bit Amplifier SM-SX100 Specifications) • Rated Power Output: 100 W + 100 W (8 Ω, 1 kHz) • Frequency Response: 5 – 100 kHz (+1, -3 dB) • Total Harmonic Distortion: 0.02 % (at 1 kHz, 1 W output) • Dynamic Range: 105 dB • A/D Noise Shaping: 7th-order ⊿Σ (delta-sigma) modulation • Input Terminals: ST-link optical digital input x 1, BNC coaxial digital input x 1, RCA coaxial digital input x 1, TOS-link optical digital input x 1, SACD exclusive 1-bit signal input x 1, RCA analogue input x 2, XLR balanced analogue input x 1 • Output Terminals: TOS-link optical digital output x 1, RCA analogue output x 1 • Dimensions (W x H x D): 472 x 89 x 462 mm (18-19/32" x 3-1/2" x 18-3/16") • Weight (Approx.) : 18.5 kg (40.8 lbs.)

High Resolution and Time Accuracy

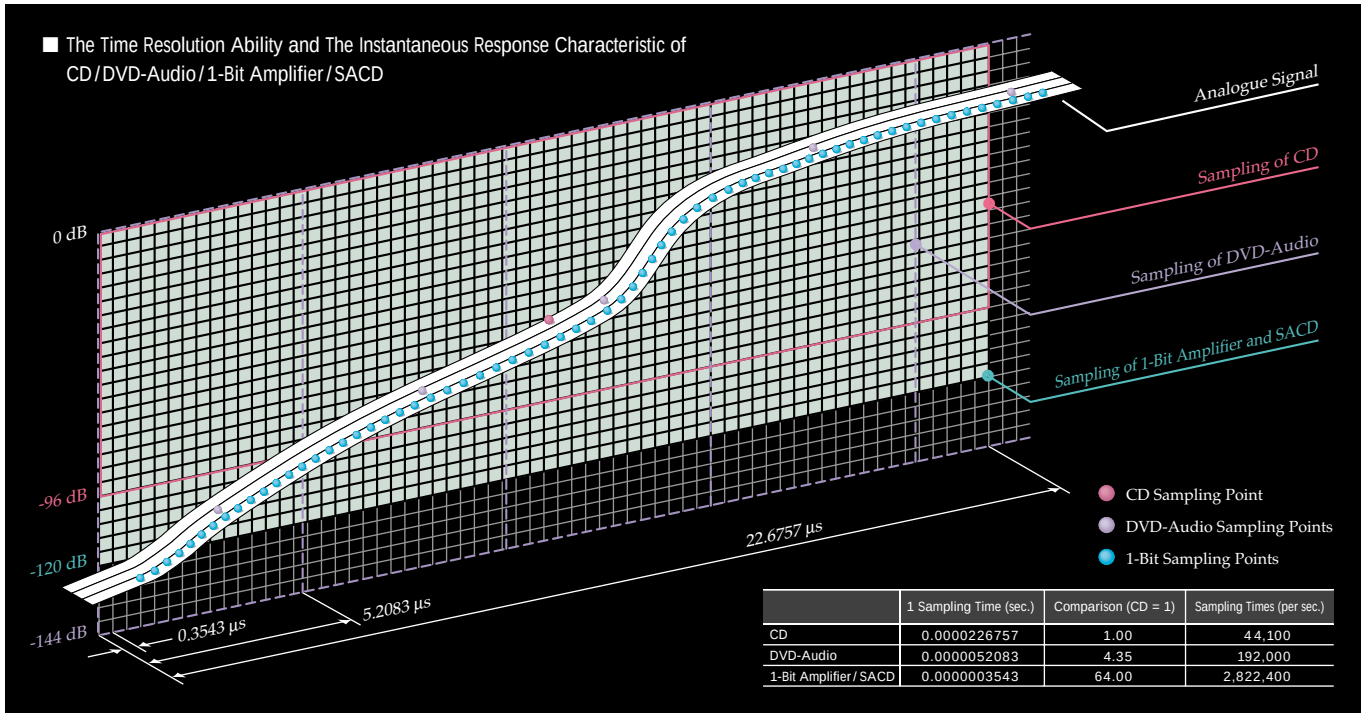
• ST-link optical digital input for high-class CD player and D/A converter connection, BNC coaxial digital input and TOS-link optical digital input. • SACD exclusive 1-bit signal input – direct 1-bit input from Sharp's forthcoming SACD player possible. • Analogue balanced input. • Safety RCA input terminals – no noise when connecting to a terminal even if unit is on. • Insulated double-pole speaker terminals – bi-wiring connection possible.

Quick transiency, wide frequency range and wide dynamic range are achieved by ⊿Σ (delta-sigma) modulation 1-bit coding technology with high-speed sampling (64 fs = 2.8224 MHz) and 7th-order noise shaping. Purity of sound is achieved by a simple sound transmission circuit that does not degrade, add or remove anything from the original signal. The result is a new concept for digital audio systems: high resolution. 1-bit's high resolution (time resolution ability) creates time accuracy which is essential for natural sound expression. 1-bit technology with its ultra-high sampling speed and millions of samples per second attains high-fidelity sound reproduction.

• The time resolution ability of CD's digital data is 22.6757 µs and the amplitude is analysed with 16-bit steps. The result is that sound fluctuations are leveled off every 22.6757 µs and sampled 44,100 times per second to create a digital signal representing analogue sound with 0 Hz – 20 kHz frequency range and 96 dB dynamic range. The graph on the right shows changes in an analogue sound wave and the sampling point of CD on the inner signal wave. When replayed, a series of digital signals at every 22.6757 µs are converted into analogue signals.

• The time resolution ability of 192 kHz high-sampling DVD-Audio's (DVD-A) digital data, shown as the middle wave on the same graph is 5.2083 µs and the amplitude is analysed with 24-bit steps. This results in producing a digital signal that represents an analogue signal with 0 Hz – 96 kHz frequency and 144 dB dynamic range. Compared to a CD's sampling time, the analogue signal is sampled 4.35 times faster (5.2083 µs versus 22.6757 µs). In other words, for each time a CD samples, DVD-Audio samples 4.35 times. Sound fluctuations are leveled off every 5.2083 µs and sampled 192,000 times per second. When replayed, digital signals every 5.2083 µs are connected continuously and converted into analogue signals.

• In the case of the 1-bit amplifier, analogue signals are processed by the 7th-order ⊿Σ modulation 1-bit coding circuit which samples at a frequency of 64 fs (2.8224 MHz). The 1-bit data which has the same sampling frequency as Super Audio CD's (SACD), 64 fs (2.8224 MHz), is transmitted to a high-speed switching circuit to generate signals to drive speakers. These 1-bit signals are very simple digital data which use only 1 or 0 to show the amplitude and have a time resolution ability of 0.3543 µs. A ⊿Σ modulation analogue circuit produces 1-bit signals every 0.3543 µs, which represents an analogue signal with 0 Hz – 100 kHz frequency range and 120 dB dynamic range to reproduce all sounds in nature. Compared to a CD's sampling time, the analogue signal is sampled 64 times faster (0.3543 µs versus 22.6757 µs). This means that the 1-bit amplifier samples the analogue signal 2,822,400 times per second. Its state is represented by the 64 sampling points on the front signal wave in the graph. The 1-bit signal, generated every 0.3543 µs, is used as a switch for the power supply, and an amplified 1-bit signal is created. It passes through a low-pass filter and becomes an analogue signal. This analogue signal, which is very close to the original sampled analogue sound, drives speakers. With 2.8224 MHz high-speed sampling and ⊿Σ modulation 1-bit processing circuit, a 1-bit amplifier produces almost-original sound with instantaneous response and a wide frequency range.



	1 Sampling Time (sec.)	Comparison (CD = 1)	Sampling Times (per sec.)
CD	0.0000226757	1.00	44,100
DVD-Audio	0.0000052083	4.35	192,000
1-Bit Amplifier/SACD	0.0000003543	64.00	2,822,400

Striving for Perfection

Digitalization of Pure and Rich Analogue Sound

Heralding the Next Generation Audio System

In the 17 years since the debut of Compact Disc (CD), rapid progress in digital and recording techniques has resulted in vast improvements in CD mastering. These improvements have made possible the invention of new high-quality audio package media, SACD and DVD-Audio, which have already begun to be warmly embraced in the market.

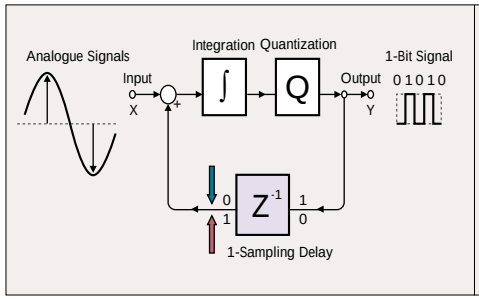
In 1995 Sharp proposed the "64 fs/1-bit theory" at the Advanced Digital Audio (ADA) conference of the Japan Audio Association, where the format of next generation digital audio was discussed. This proposal, derived from an ongoing joint study that started in 1990 for the next generation audio with Prof. Yoshio Yamasaki of Waseda University, was Sharp's answer to meet the exact needs of the next generation digital audio.

In 1996 the Advanced Audio conference was inaugurated, where discussions centred around numerous audio formats at the ADA conference.

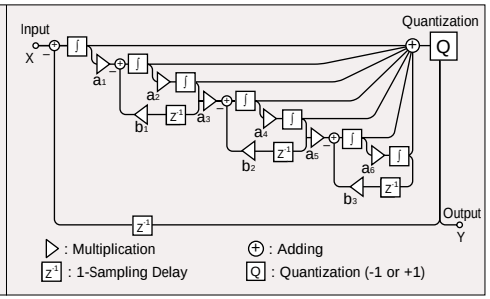
Since 1997 these proposals have been tested and "64 fs/1-bit" was chosen as one of the formats for the next generation audio system.

The concept of the next generation digital audio has been pushed forward by three technological advances: the expansion of recording media's capacity by shortening the wavelength of semiconductor lasers; speed improvement of the devices themselves; and the performance of playback/recording equipment surpassing that of CDs.

More important than these advances are the dreams and desires of music lovers and audiophiles who wish to listen to natural sound at its original quality. This requires the next generation audio system to reproduce 100 kHz sound of high-hat cymbals and over 100 dB dynamic range of orchestra sound in order to express the true sound of music including the atmosphere of performance spaces.



● ΔΣ (Delta-Sigma) Modulation Coding Technology and Coding Concept



● 7th-Order ΔΣ (Delta-Sigma) Modulation 1-Bit Quantizer with Partial Feedback

Is Digital Truly Essential to Achieve High Quality Sound?

The history of audio recording media is over a century old. The analogue vinyl disc format passed through several transition stages: extending playing time, reducing noise and distortion, and improving sound quality through expanding the reproduction range. The jump from vinyl disc to CD brought digital technologies for the first time to consumer audio equipment. These technologies further reduced noise and sound distortion while allowing audio systems to become compact and lightweight. With these benefits, CDs quickly gained dominance as the preferred audio format.

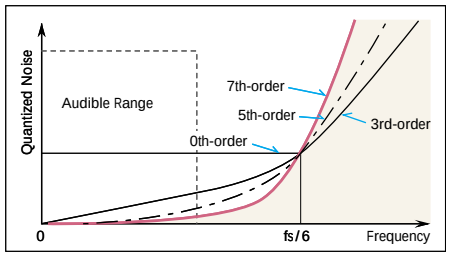
However, CD's reproduction range of high frequency sound is limited to 20 kHz, which is theoretically half of its sampling frequency, and its sound is quantized with 16-bit, which causes inferior sound quality with its peculiar transient noise. This is why CDs were first opposed by audiophiles as their sound lacked depth and sophistication.

These drawbacks were eventually overcome by software manufacturers and high-quality CDs are now available. But despite manufacturers efforts, CDs still can not perfectly record original sound sources which have a wider frequency response because of their sampling frequency of 44.1 kHz and 16-bit quantization. This will always be the limiting factor in CD technology.

Analogue vinyl discs on the other hand, despite their limited dynamic range in the high frequency, do have a reproduction range up to 40 kHz, twice that of CDs. They can reproduce reverberation and depth to create high-quality sound but due to their physical characteristics, analogue signals deteriorate while recording and transmitting. Thus the history of audio can be characterized as the avoidance of inferiority.

There is a school of thought where it is generally accepted that digital is good for conveying sound information. CDs rely on Pulse Code Modulation (PCM) multi-bit technology to digitalize audio analogue information. The present PCM multi-bit technology of a CD translates audio signals into digital data at every sampling point (44.1 kHz = 1/44,100 sec.) according to its quantized characteristic (16-bit = 65536 pieces). Although with this process it is necessary to decimate and complement information partly, CD sound has been considered superior as signal deterioration by analogue transmission is greater than the loss of information by digitalization.

"Best reproduction is attained if analogue signals are recorded and transmitted without



● The Number of Orders and Noise Shaping Effect

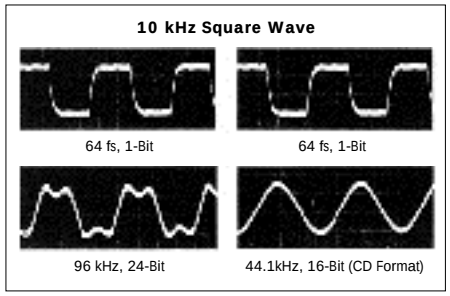
deterioration" – this is the idea that gave birth to the 1-bit concept.

High-Speed Sampling 1-Bit Coding Process

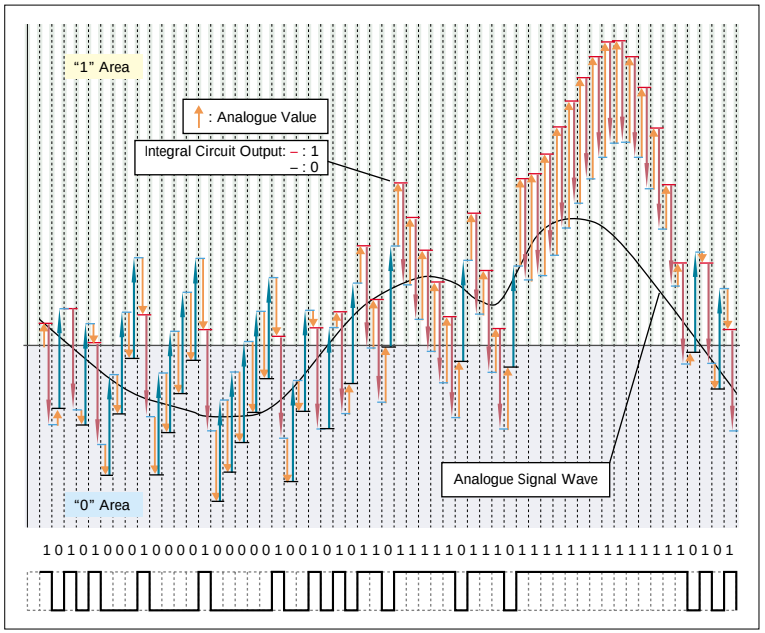
The dominant method for coding analogue signals into digital is PCM. The original analogue signal is sampled at a frequency more than double the bandwidth being transmitted, quantized and then converted into multi-bit encoded signals. In this system the sampling frequency (fs) determines the transmission bandwidth (fs/2) and the number of bits for quantization determines the dynamic range.

However, there is another coding technology which attains ample dynamic range in the audible range by increasing sampling frequency and shifting quantization noise to the high frequency spectrum. This is attained even though the number of bits for quantization used is small. This approach is based on a noise shaping technology that uses a ⊿Σ (delta-sigma) modulation to control the distribution of quantization noise.

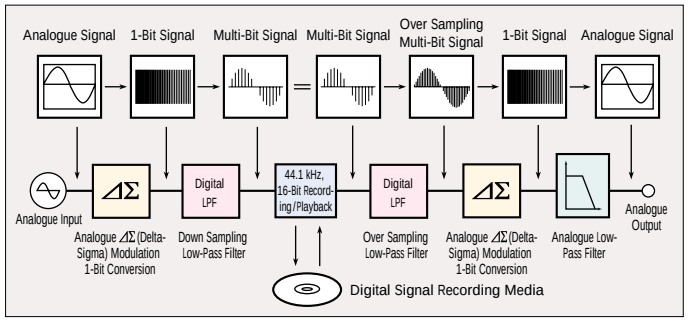
Binary signals quantized by this technology are transformed into 1-bit signals. Known as "⊿Σ A/D" and "1-bit A/D", this technology has found practical applications in a number of analogue-to-digital conversion devices. The 1-bit signal utilized at this time has a sampling frequency of 64 fs (fs = 44.1 kHz, 2.8224 MHz), and can guarantee a theoretical dynamic range of 120 dB (0 Hz to 20 kHz) and a frequency response of 0 Hz to 100 kHz by 7th-order ⊿Σ modulation.



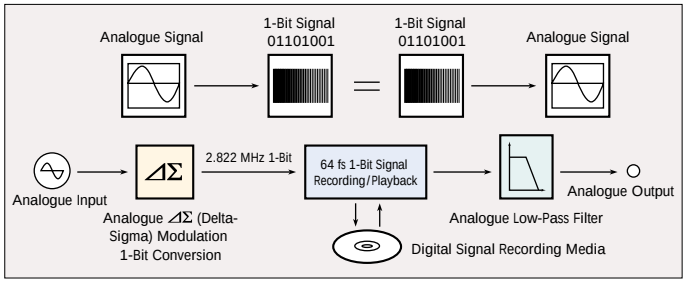
● Comparison of Transmission Ability between Multi-Bit and 1-Bit



● ⊿Σ (Delta-Sigma) Modulation Coding System Concept



● AD/DA Process by Multi-Bit PCM Conversion



● AD/DA Process by ⊿Σ (Delta-Sigma) Modulation 1-Bit Conversion

1-Bit Signals and PCM Multi-Bit Signals

While both 1-bit signals and PCM multi-bit signals are digital, there are great differences between the two. Multi-bit signals record each quantized sample as an absolute value, while 1-bit signals just record the fluctuation of the sample from the previous one. And unlike multi-bit signals, the information of 1-bit signals do not need any estimated decimation or complement.

This makes their characteristics similar to that of analogue signals. And while all digital signals need to be converted at the final stage into analogue signals to drive speakers, 1-bit signals do not require a D/A converter unlike multi-bit signals, and can be converted into analogue signals through a minimum process. To sum up, 1-bit signals with a simple conversion method modulate analogue signals onto the high frequency (64 fs) digital signals, remove digital signals in the high frequency range by a low-pass filter during playback, and then extract the original analogue signal without devices and circuits which tend to damage sound.

Even in the multi-bit processing, ⊿Σ modulation is used during the conversion between analogue signals and PCM. An intermediate step in this interchange process generates a 1-bit signal which is closer to the original analogue signal than PCM. With 1-bit it is possible to faithfully record and store the original signal due to the fewer processes to pass through. The original analogue signal can then be reconstructed using only a simple low-pass filter circuit. Fluctuations and noise in the transmission path will not lead to signal deterioration as 1-bit signal is digital. As it obtains both high-fidelity and flexibility which multi-bit signals cannot achieve, Sharp

The Dream Fulfilled

Capturing the Intimacy of Live Performances

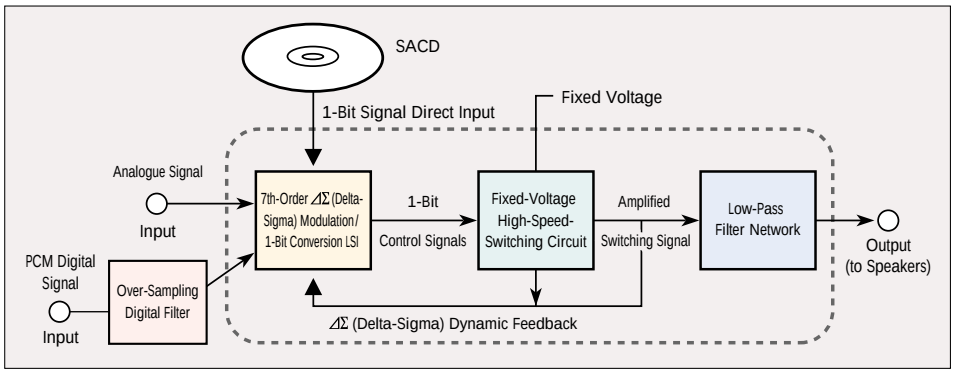
focused on development of the high-sampling rate 1-bit signal to establish a technology that will find practical application in amplification circuits.

The Growing Trend towards the 1-Bit Amplifier

The digitalization of audio software is developing rapidly. The next generation digital audio formats with the ability to reproduce original sound without fluctuations and an accuracy several times that of CDs, such as SACD and DVD-Audio, are making their debut.

Nevertheless, analogue amplifiers, that tend to use a lot of information during transmission, are still the mainstream to date. Addressing this issue, Sharp exhibited a prototype 1-bit amplifier with an SACD player at Audio Expo (Oct. '98 in Japan). Its performance was showered with praise: "instantaneous response of sound", "dramatic high-speed atmosphere", "the original sound produced through high fidelity", "surprising energy-efficiency and space-saving size". These 1-bit amplifier's benefits stunned our manufacturing partners, other audio-related companies, specialists and audiophiles. Since then, Sharp has made further improvements to the sound of the 1-bit amplifier.

The result is the SM-SX100 with specifications to suit high-end audio systems. Its instantaneous transient response, wide frequency range and wide dynamic range make it possible to reproduce original sound without compromise regardless of the source, new generation digital audio media or existing CDs.



• Amplification Process of 1-Bit Amplifier

1-Bit Amplifier Operation Concept

The class-D system is a widely-known operating system of amplifiers which amplifies audio signals by controlling time of the ON state by switching the high voltage. PWM signals with an analogue-like width on the time axis are used to control the switching. Sharp's SM-SX100 yields power amplification which maintains a 1-bit signal performance by adopting the concept of the class-D system and replacing the PWM signals with 1-bit signals which has precise quartz-crystal accuracy to control switching the fixed-voltage power.


7th-Order Delta-Sigma Chip A/D Converter

Extremely stable amplification of music signal faithful to the original analogue signal is made possible by "⊿Σ (delta-sigma) Dynamic Feedback" circuit which feedbacks fluctuations of the voltage power to the 7th-order ⊿Σ modulation LSI and corrects the 1-bit control signal in real time. The SM-SX100 obtains a 1-bit signal stream faithful to the input data by high-speed (64 fs, 2.8224 MHz) sampling ⊿Σ modulation.

The newly developed 1-chip 7th-order ⊿Σ modulation LSI plays a key part in this process to shift quantization noise to higher frequency and maintain a wide dynamic range in the audible band. At the final stage, the amplified switching signal is converted into an analogue signal used to drive the speakers by a low-pass filter network.

The SM-SX100 does not have any element of analogue amplification from the input through to the speaker output. Amplification with instantaneous transient response, an essential dynamic characteristic for musical reproduction, is made possible by the high level of time resolution achieved by the high-speed sampling 1-bit control signal processing and the high-speed switching synchronized to the sampling frequency. From the dynamic expression of a fortissimo from silence at a stroke, to the static expression of the deepening silence of a pianissimo fade-out, Sharp's 1-bit amplifier has the rare ability to reproduce all music expressions.

The Merits of 1-Bit Amplifiers

Pure music transmission, superior power efficiency and enhanced space efficiency – these are the advantages Sharp's 1-bit amplifier has over conventional amplifiers.

By inputting 1-bit signals recorded on SACDs, the next generation format, directly to the 7th-order ⊿Σ modulation LSI through the amplifier's exclusive 1-bit SACD input terminal, it is possible to digitally convey music signals without loss from the location where the music content was created to the point just in front of the speakers.

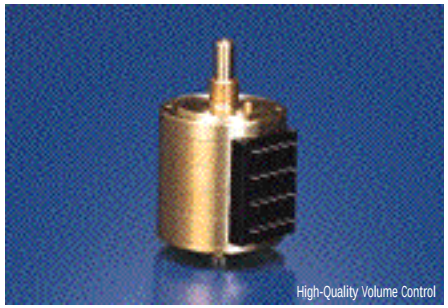
SM-SX100 achieves pure sound transmission as sound that passes through the microphone is transmitted digitally to the speakers.

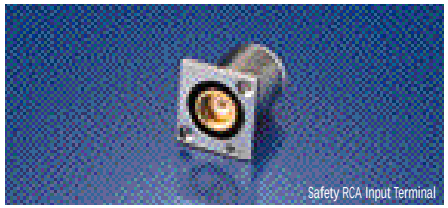
Conventional analogue amplifiers rely on the linearity between input and output. Class-A and class-AB systems with good linearity are adopted in analogue amplifiers but they are highly inefficient and consume a lot of energy for high power output. This is not ideal from an environmental viewpoint. 1-bit digital amplifiers, on the other hand, when compared

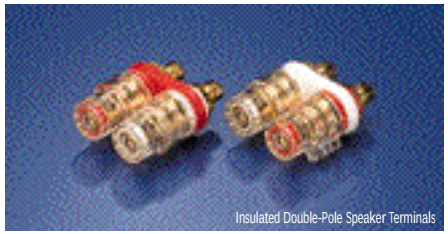
to conventional amplifiers, reduce heat radiation by four-fifths and use approximately half the power consumption due to their simple ON/OFF switching operation. This simple switching operation as well as other digital technologies not only allow for high energy-efficiency but space-saving size.

Features for the Ultimate Sound

- Structure – two piece construction that separates the power supply section and the 1-bit section from the control section to minimise mutual interference.
- Hand-picked parts – equipped with gold-plated connectors and metal film resistors for the inside wiring.
- High-quality volume control – equipped with gold-plated multi-connect wire brush and low distortion carbon ink.
- High frequency noise reduction characteristics – with copper-plated chassis and gold-plated oxygen-free copper-printed wiring board.
- Safety RCA input terminals – no noise when connecting to a terminal even if unit is on.
- Insulated double-pole speaker terminals – bi-wiring connection possible.
- SACD exclusive 1-bit signal input – direct 1-bit input from Sharp's forthcoming SACD player possible.
- ST-link optical digital input for high-class CD player and D/A converter connection, BNC coaxial digital input and TOS-link optical digital input.
- Analogue balanced input.
- Futuristic slim design attained by miniaturized 1-bit amplifier unit – changes the conventional design of analogue amplifiers.
- 3 colour variations.


High-Quality Volume Control


Safety RCA Input Terminal


Insulated Double-Pole Speaker Terminals

SM-SX100

1-Bit Amplifier General Specifications

Power Amplifier Section

• Amplification System	64 fs 1-Bit Switching (fs = 44.1kHz)
• Rated Power Output	100 W + 100 W (8 Ω) (10 – 20 kHz, Both Channels Driven) (Speaker Selector: 8 Ω) 100 W + 100 W (4 Ω) (10 – 20 kHz, Both Channels Driven) (Speaker Selector: 4 Ω)
• Frequency Response	5 Hz – 20 kHz (+1 dB, -1 dB) 5 Hz – 100 kHz (+1 dB, -3 dB)
• T.H.D.	0.02 % (at 1 kHz, 1 W)

Pre-Amplifier Section

• Sensitivity (Analogue Input)	350 mV rms/50 kΩ (1 kHz, 100 W)
• Dynamic Range	105 dB (5 Hz – 20 kHz)

Other Specifications

• A/D Noise Shaping	7th-Order ⊿Σ (Delta-Sigma) Modulation
• Sampling Frequency	2.8224 MHz (64 fs) (fs = 44.1 kHz)
• Master Clock Frequency	5.6448 MHz (128 fs) (fs = 44.1 kHz)
• Low Pass Filter	4th-Order Butterworth Type
• Multi – 1-Bit Conversion	32/44.1/48 kHz
• Power Source	120 V, 60 Hz (North America) 230 V, 50 Hz (Europe, Singapore) 110 – 127 V, 50/60 Hz (Others I) 220 – 240 V, 50/60 Hz (Others II)
• Dimensions (W x H x D)	472 x 89 x 462 mm (18-19/32" x 3-1/2" x 18-3/16")
• Weight (Approx.)	18.5 kg (40.8 lbs.)

** Design and specifications are current as of November 1999, but are subject to change without prior notice.*

SHARP

SHARP CORPORATION OSAKA, JAPAN

SHARP URL – http://www.sharp.co.jp