

SACD

A Technical Overview of the Format and Production Workflow

An Overview of the SACD format

An Overview of the SACD format

SACD vs. CD comparison (Part 1)

Items	Super Audio CD	CD
Disc Diameter (cm)	12	←
Disc Thickness (mm)	1.2	←
Center Hole Size (mm)	15	←
Track Pitch (μ m)	0.74	1.6
Data Volume (Mbytes)	4700*	780
Laser Wavelength (nm)	650	780
N/A	0.6	0.45

* Single Layer Disc

An Overview of the SACD format

SACD vs. CD comparison (Part 2)

	Super Audio CD	CD
Audio Signal Encoding	1-bit Direct Stream Digital	16-bit Linear PCM
Sampling Frequency (kHz)	2822.4 (64 times to CD)	44.1
Channel Number	2, 3, 3.1, 4, 4.1, 5, 5.1 *1	2
Maximum Track Number	255	99
Maximum Index Number	255	99
Maximum Recording Time	109min(2ch), 60-70min (2ch+5.1ch) *2	74
Supplementary Data (kbps)	73 ~ 900	43.2
Frequency Range (kHz)	DC ~ over 100 *3	DC~20
Dynamic Range (dB)	over 120 (~ 20kHz) *3	96

*1 Channel configuration in Multi-channel Track Area

*2 Typical playback time. (Varied up to the DST process gain.)

*3 Theoretical value

An Overview of the SACD format

SACD Disc family

Single Layer Disc

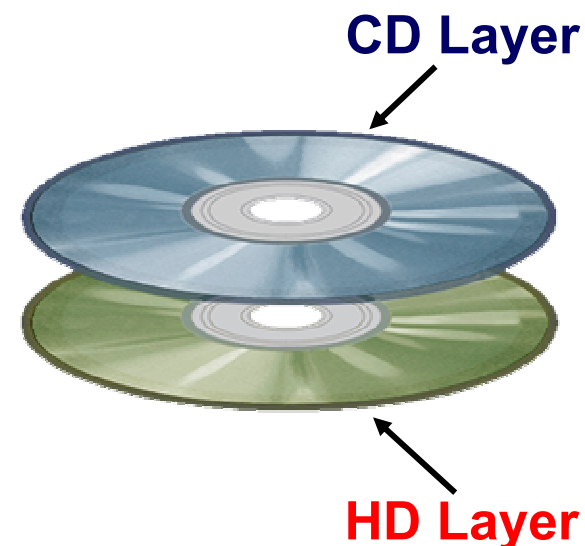
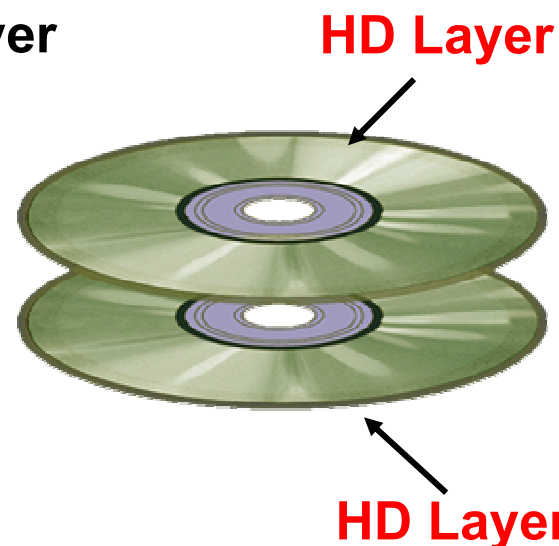
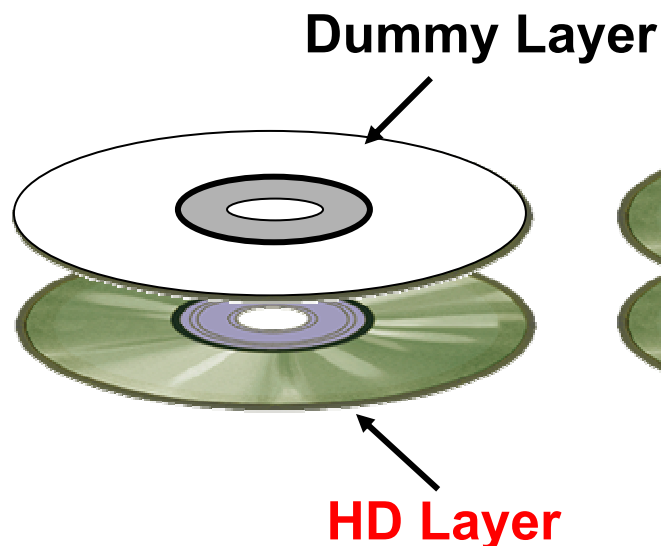
Super Audio CD Layer Only

Dual Layer Disc

Two Super Audio CD Layers
(for long playing time)

Hybrid Disc

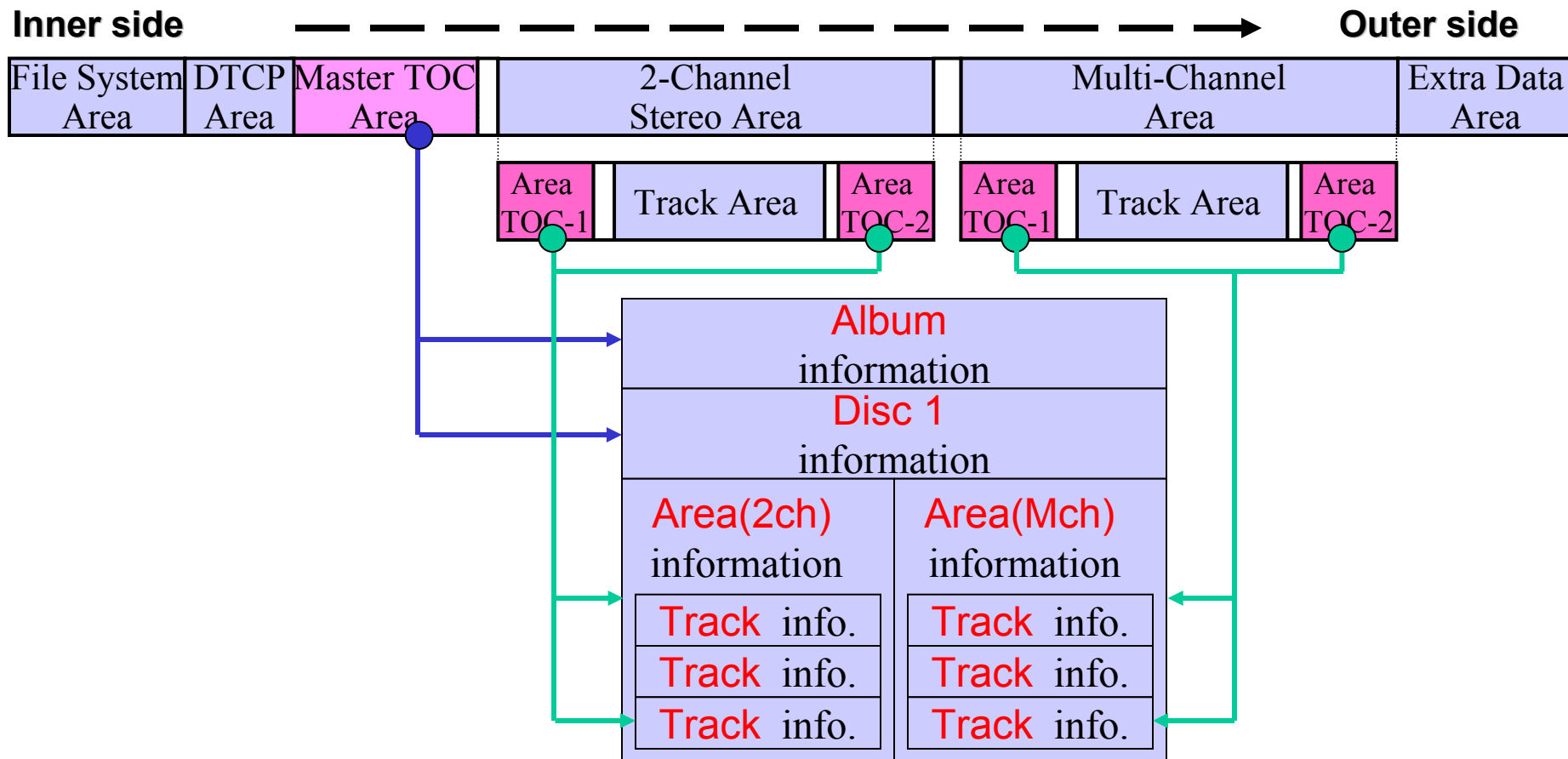
Super Audio CD Layer and
Regular CD Layer



HD Layer = Super Audio CD
CD Layer = Regular CD

An Overview of the SACD format

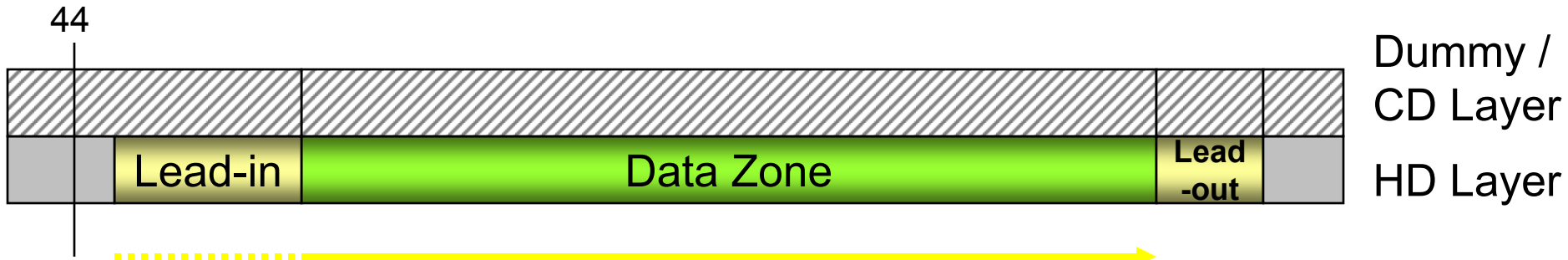
HD Layer Data Structure



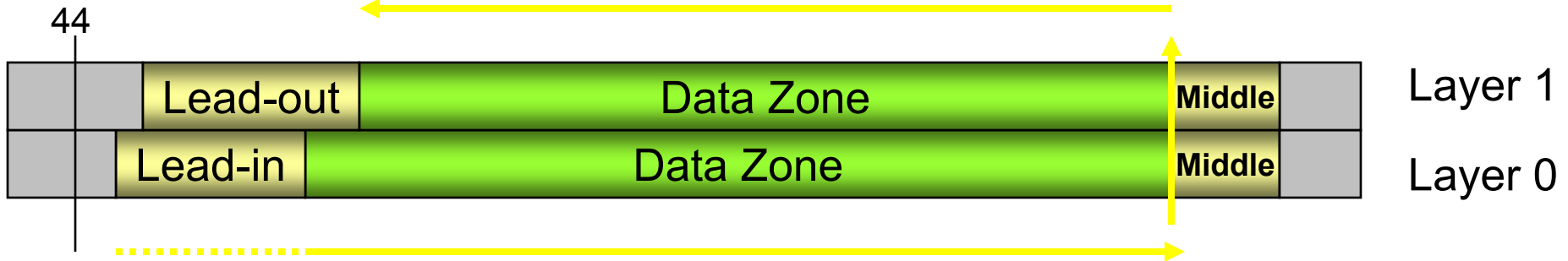
An Overview of the SACD format

Disc Tracking in HD Layer

■ Single Disc / Hybrid Disc



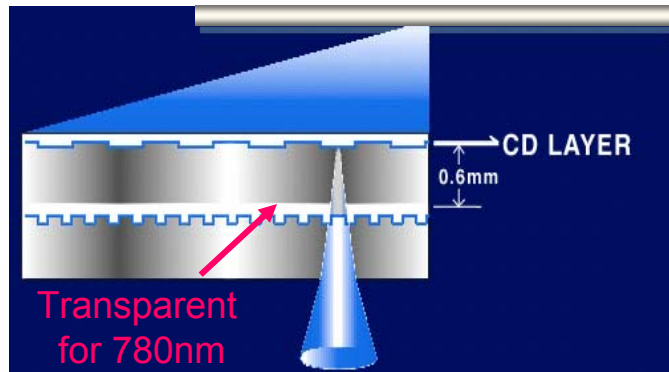
■ Dual Layer Disc



An Overview of the SACD format

Hybrid Disc Physical Structure and Data Readout

CD layer readout



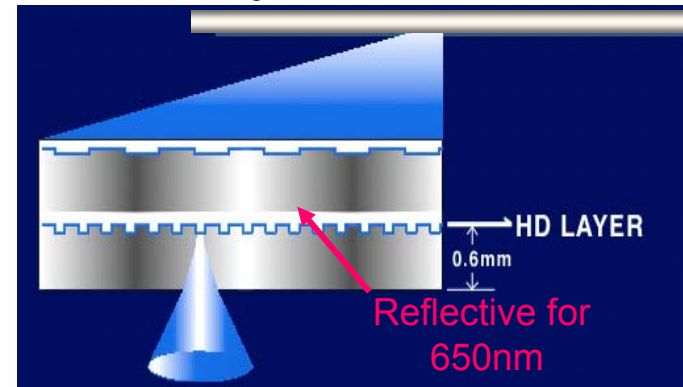
CD pickup Wavelength 780nm

Reflectivity of the CD layer

$R_{top} > 58\%$ at 780nm

$R_{top} > 35\%$ at 650nm

HD layer readout



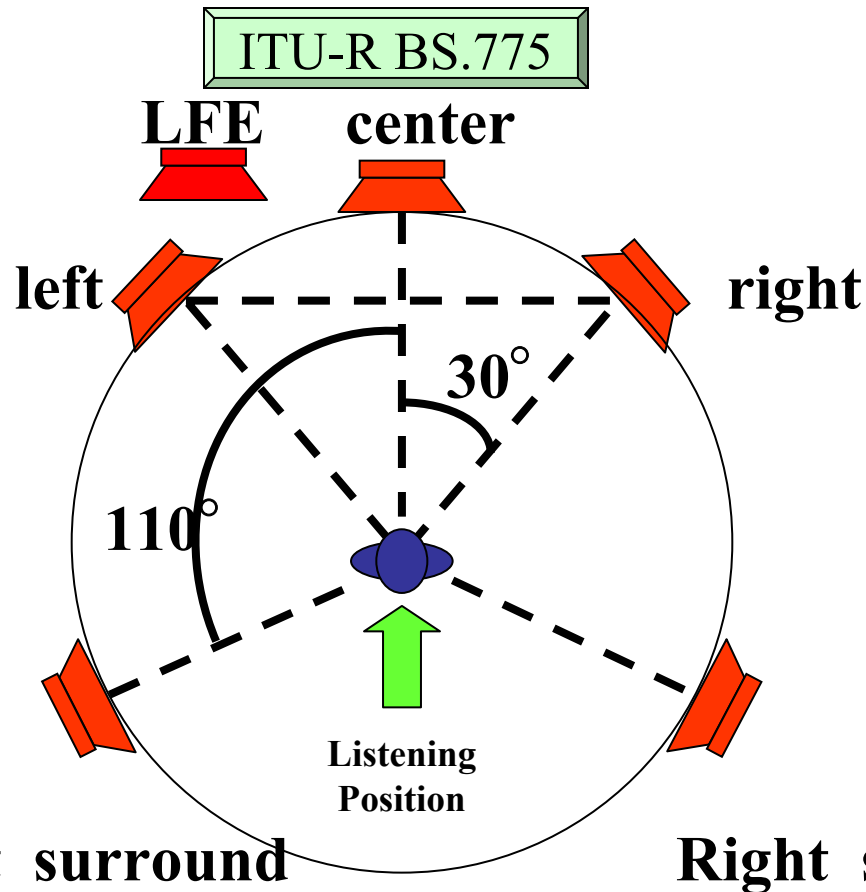
HD pickup Wavelength 650nm

Reflectivity of the HD layer
(Hybrid Disc)

$R_{top} = 15 \sim 30\%$

An Overview of the SACD format

Channel Configuration of SACD Multi-channel Disc



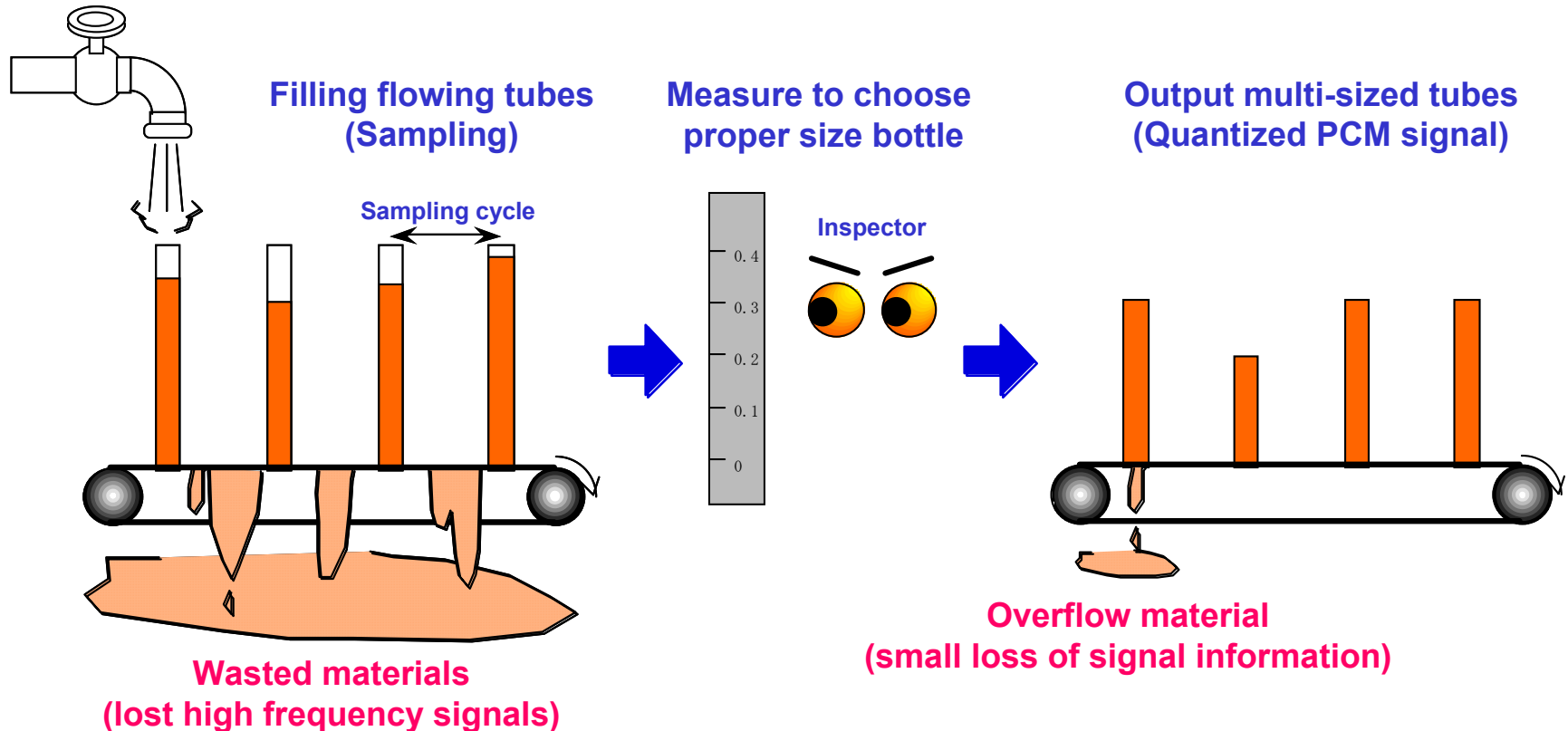
5-channel	3-ch + Mute 2-ch 4-ch + Mute 1-ch 5-ch
6-channel	3-ch + Mute 3-ch 4-ch + Mute 2-ch 5-ch + Mute 1-ch 3-ch + LFE + Mute 2-ch 4-ch + LFE + Mute 1-ch 5-ch + LFE

What is Direct Stream Digital?

An Overview of Direct Stream Digital

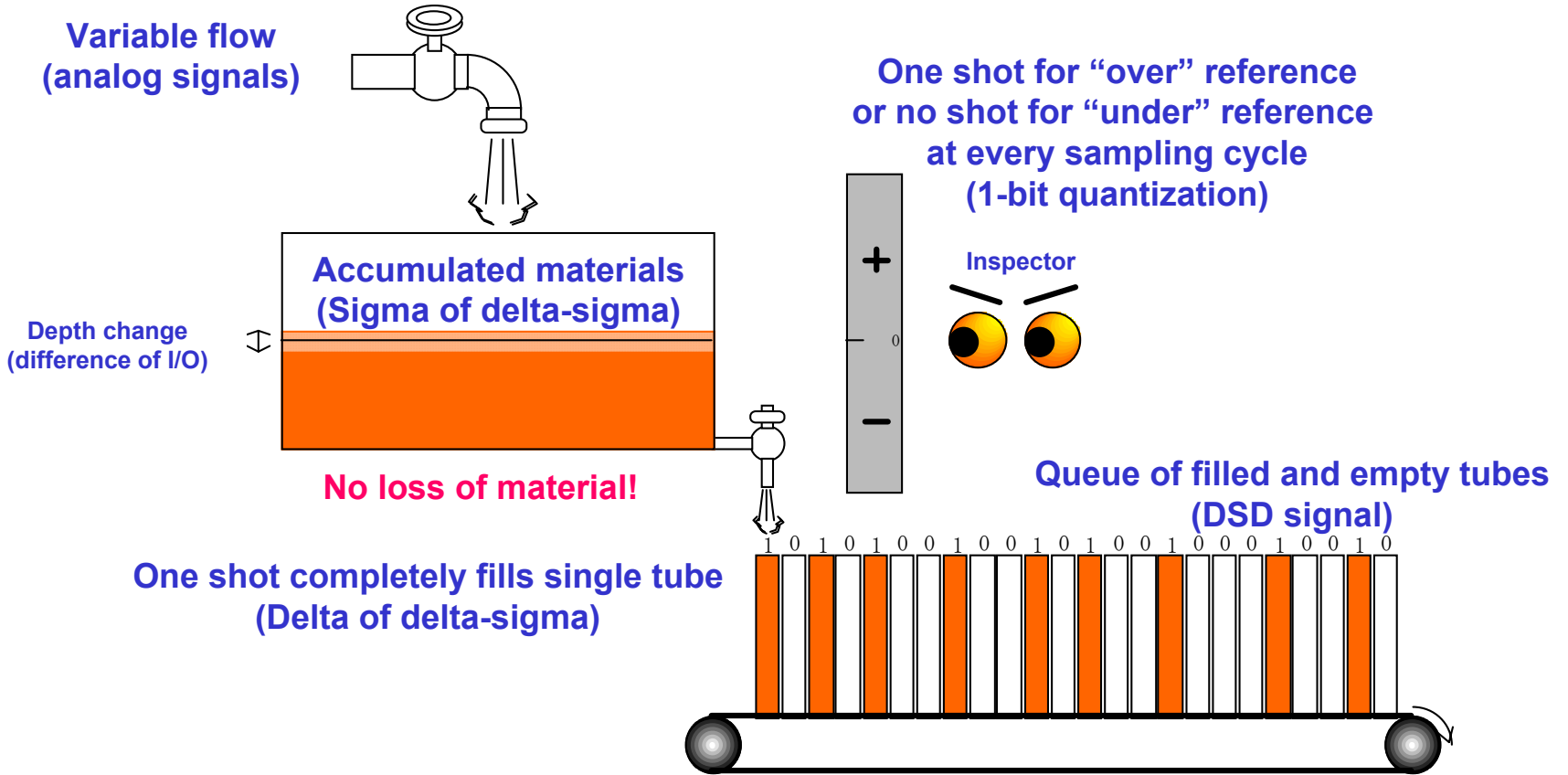
PCM (Pulse Code Modulation)

Variable flow
(analog signals)



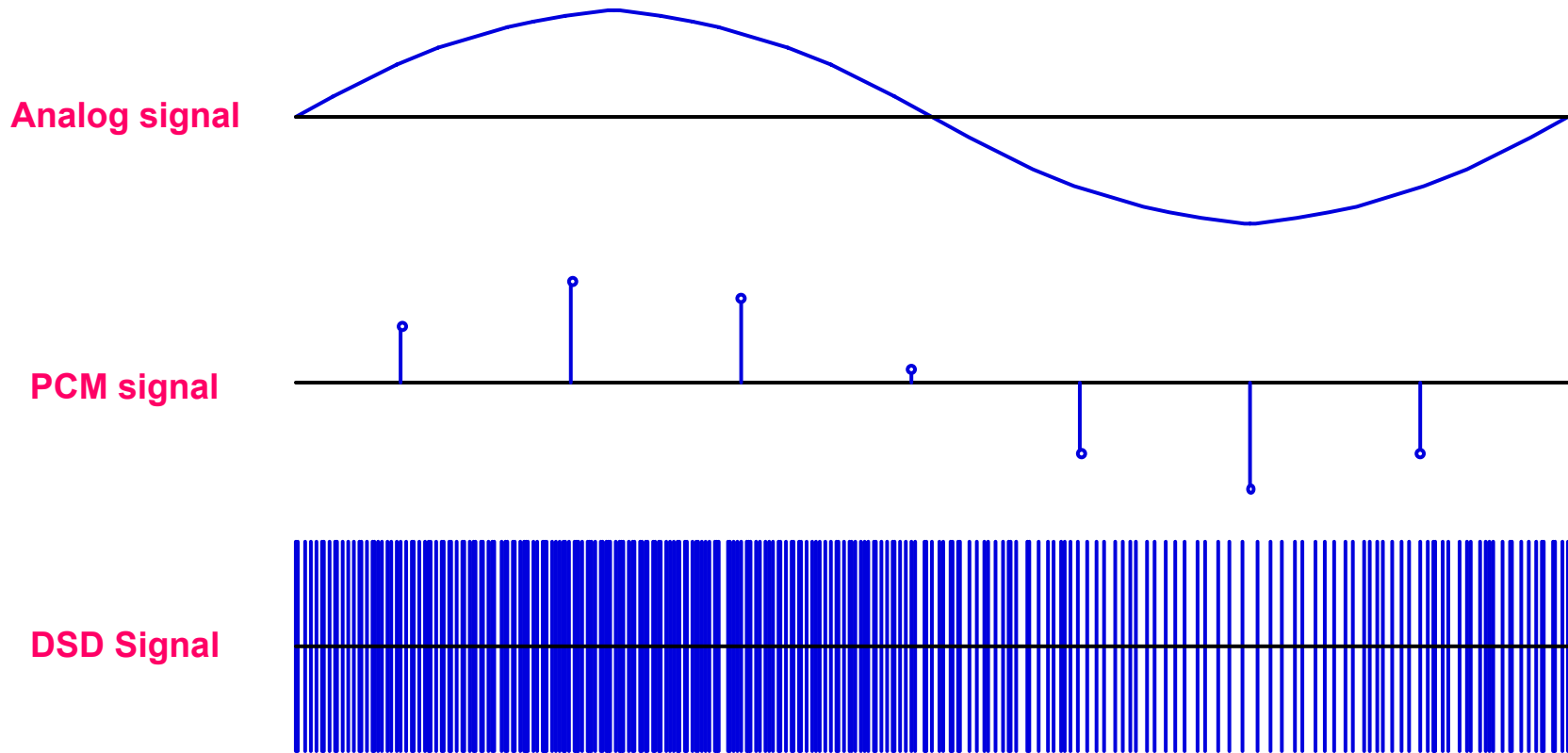
An Overview of Direct Stream Digital

DSD (1-bit Delta-Sigma Modulation)



An Overview of Direct Stream Digital

PCM vs. DSD

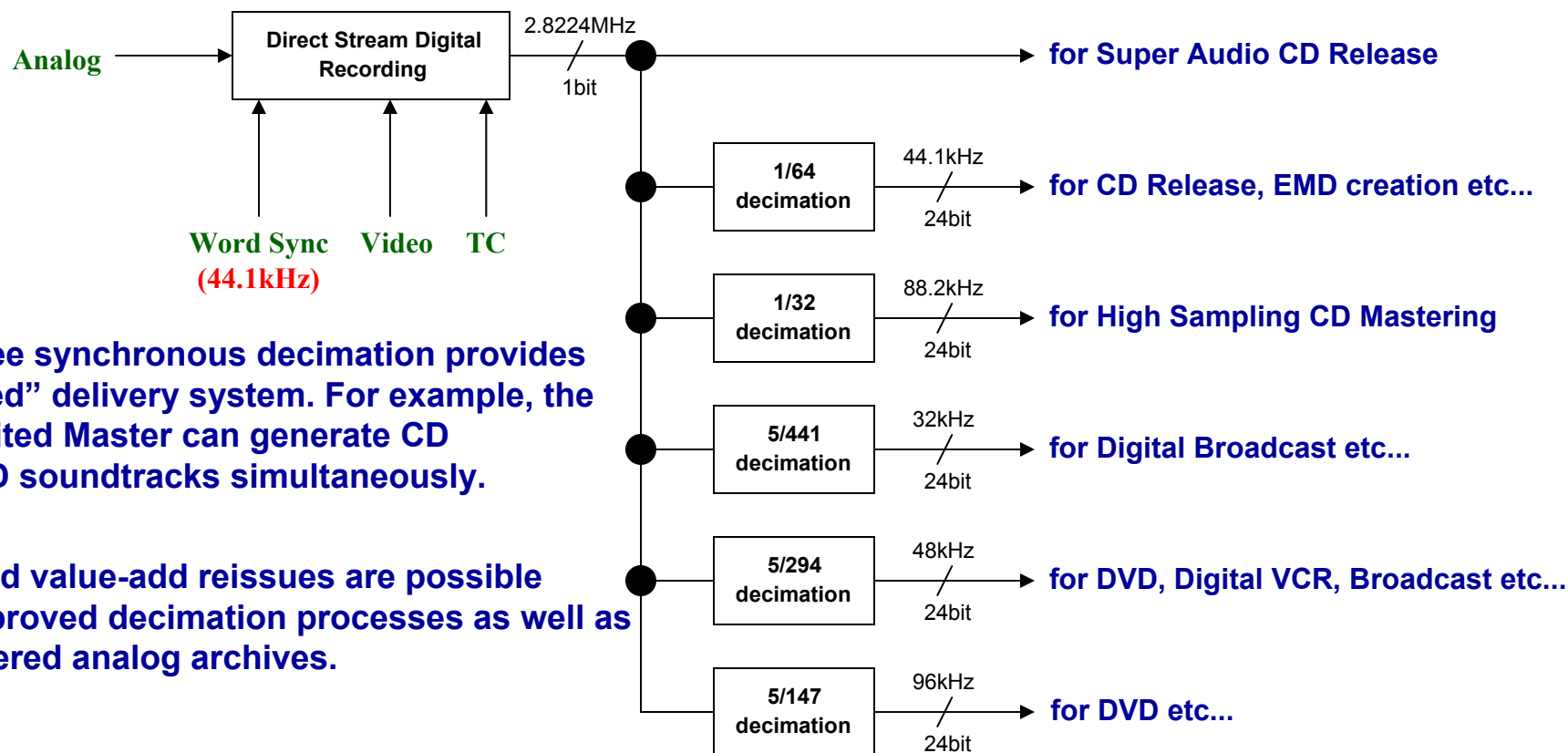


An Overview of Direct Stream Digital

Benefits of DSD production

An Overview of Direct Stream Digital

Synchronous Decimation to Various Delivery Mediums



Jitter-free synchronous decimation provides a “geared” delivery system. For example, the DSD Edited Master can generate CD and DVD soundtracks simultaneously.

Repeated value-add reissues are possible with improved decimation processes as well as re-mastered analog archives.

SACD Production Workflow

SACD Production Workflow

Direct Recording



Analog Master



PCM Master



Analog Multi-track



PCM Multi-track



Any Source Material to DSD Source

Analog Console



Digital Console



Analog to DSD

PCM to Analog

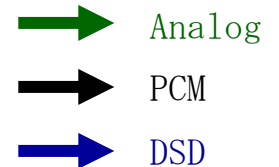
PCM to DSD

DSD-raw/SDIF-3

DSD Source

Stereo/Surround

DSD-raw/SDIF-3

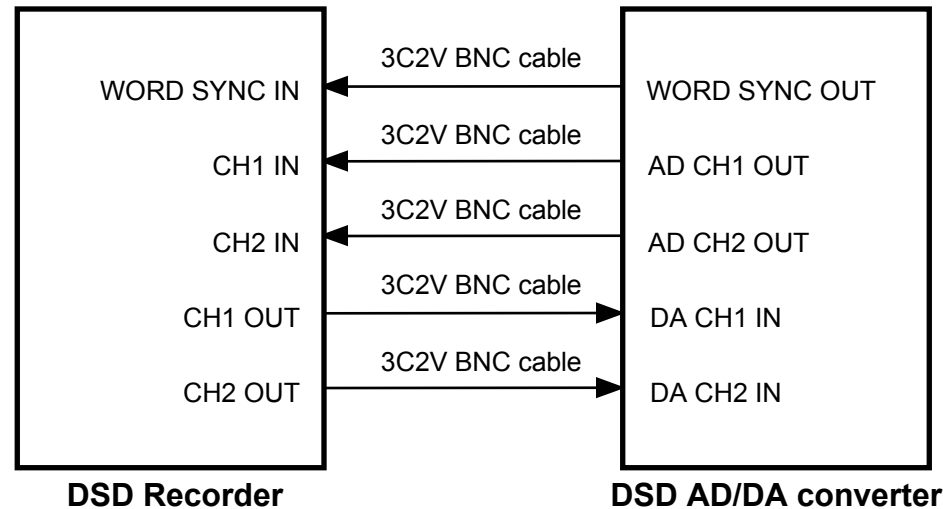


SACD Production Workflow

What is DSD-raw and SDIF-3?

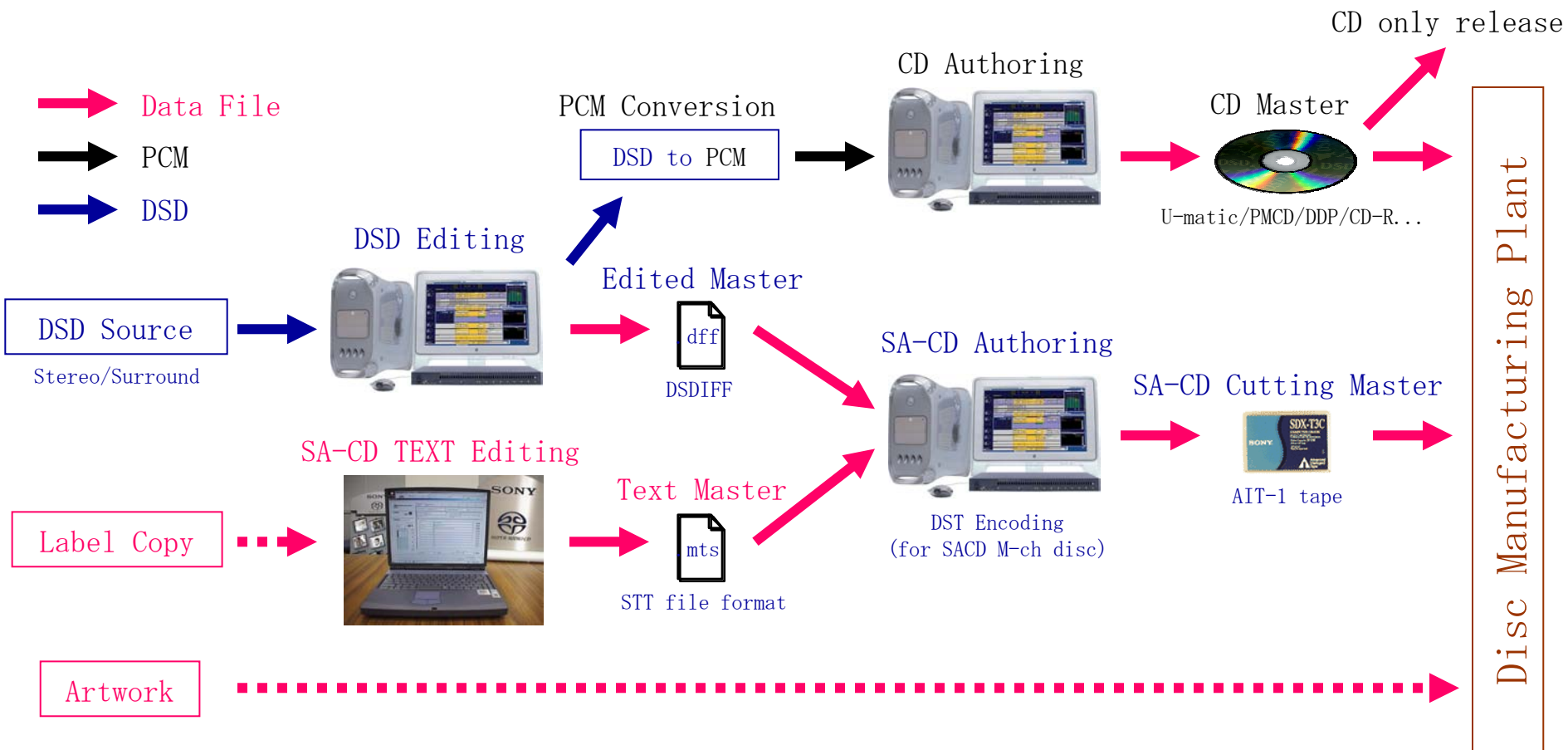
DSD-raw and SDIF-3 are the inter-connection digital I/O formats between DSD equipment such as AD/DA converters and the DSD Recorder. 75 ohm terminated BNC cables are used for one-way connection and 44.1kHz word sync is used for synchronization. (This is compatible with the physical layer of the SDIF-2 interface.)

For stable data transmission, SDIF-3 is recommended if available.



SACD Production Workflow

From DSD Source to SACD (Hybrid) Disc Manufacturing



SACD Production Workflow

DSDIFF (Direct Stream Digital Interchange File Format)

- **DSDIFF is the dedicated interchange file format for DSD data exchange between the DSD Editor (workstation) and the SA-CD Authoring system.**
- **At present, the specification is recognized as the standard exchange format for Edited Master. Compatibility is tested and confirmed by key 3rd parties.**
- **The specification and recommendations are available as free downloads from the following URL:**

[http://www.superaudiocd.philips.com/InformationCenter/NO/FArticleSummary
.asp?INodeId=3404&channel=3404&channelId=N3404A3601](http://www.superaudiocd.philips.com/InformationCenter/NO/FArticleSummary.asp?INodeId=3404&channel=3404&channelId=N3404A3601)

SACD Production Workflow

STT (SACD Tag-formed Text)

Unlike CD TEXT which was added later to the CD format, SA-CD TEXT was developed from the start as part of the SA-CD format. STT was developed as a file format for the textual data portion of the SA-CD authoring process. Considering its compatibility with CD TEXT and the support it has received from key 3rd parties, SA-CD TEXT is the de facto standard for text data exchange within the SACD format.

A free downloadable SA-CD TEXT editor application is available from the following URL. It will also simultaneously generate CD TEXT data for the CD layer. (At present, only Windows 2000 and XP are supported.)

<http://www.sonyoxford.co.uk/sacd-text-editor>

SACD Production Workflow

DST (Direct Stream Transfer) Encoding

DST (Direct Stream Transfer) is a dedicated loss-less compression algorithm for DSD. It guarantees bit-by-bit restoration similar to Zip compression for PC files.

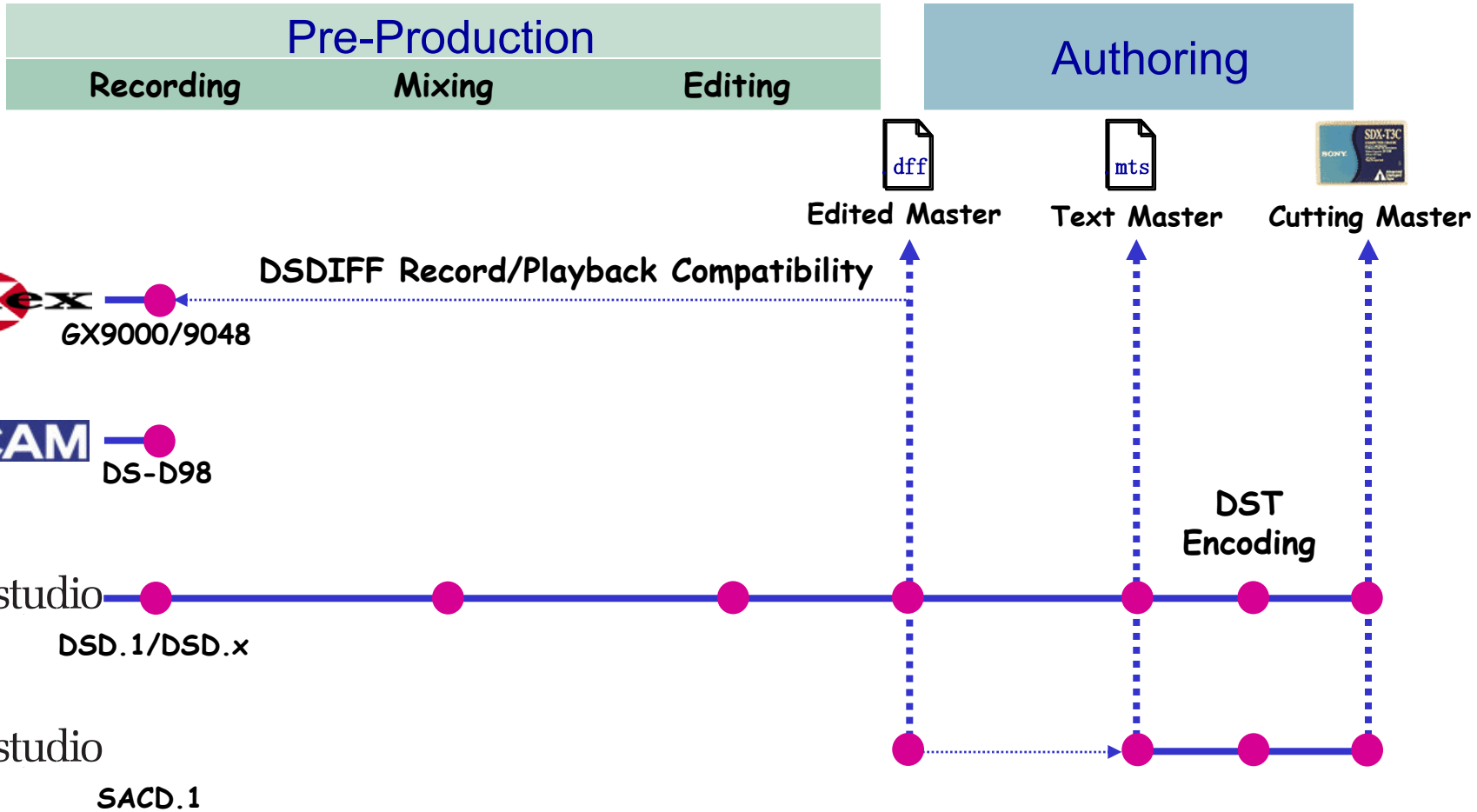
DST encoded data is stored in the SA-CD disc and decoded in an SA-CD player similar to the way standard document files are zipped and unzipped.



Because of the nature of the DSD signal, the compression gain of DST is fairly stable (about 2.5) compared to other PCM compression algorithms. As the DST gain is varied with the music contents, one needs to be mindfull of the total playback time.

SACD Production Workflow

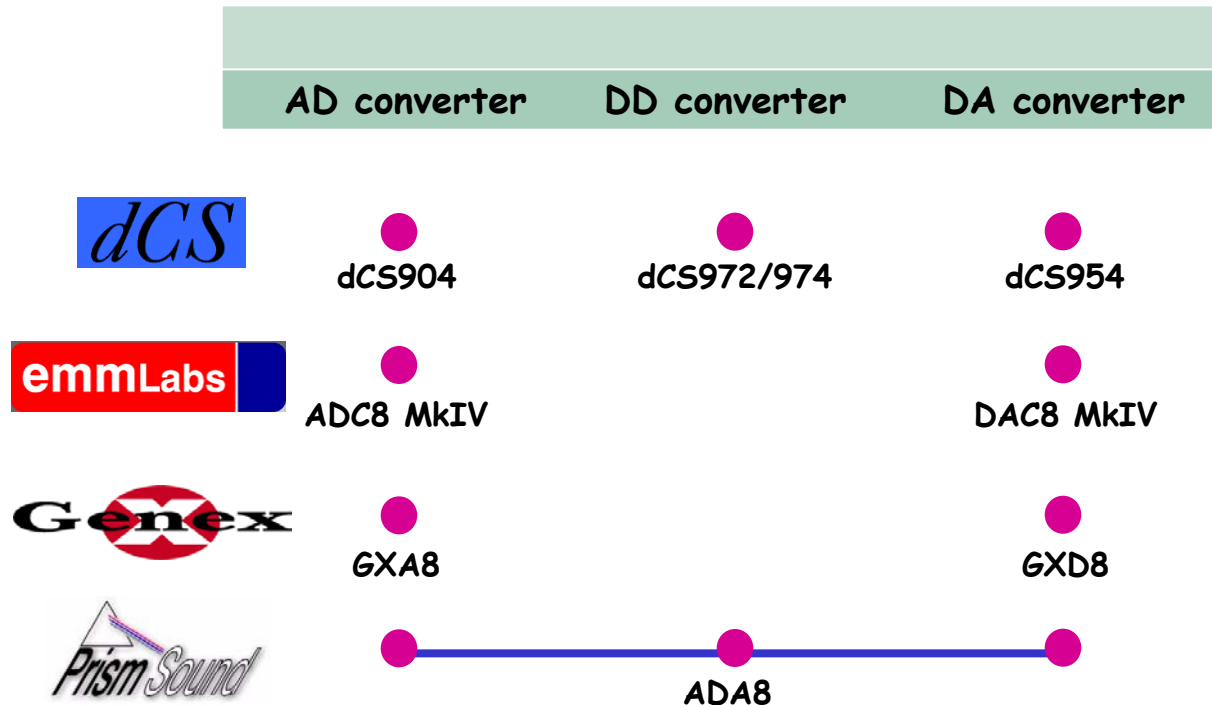
A Sampling of Available SACD Production Tools



SACD Production Workflow

A Sampling of Available SACD Production Tools

Converters



SACD Production Workflow

Other SACD Production Equipment

MYTEK DIGITAL/

<http://www.mytekdigital.com>

D-Master : 2ch DSD Recorder

(<http://www.mytekdigital.com/dmaster.htm>)



<http://www.ams-neve.com>

DSD option for Logic MMC : DSD I/O for Logic MMC

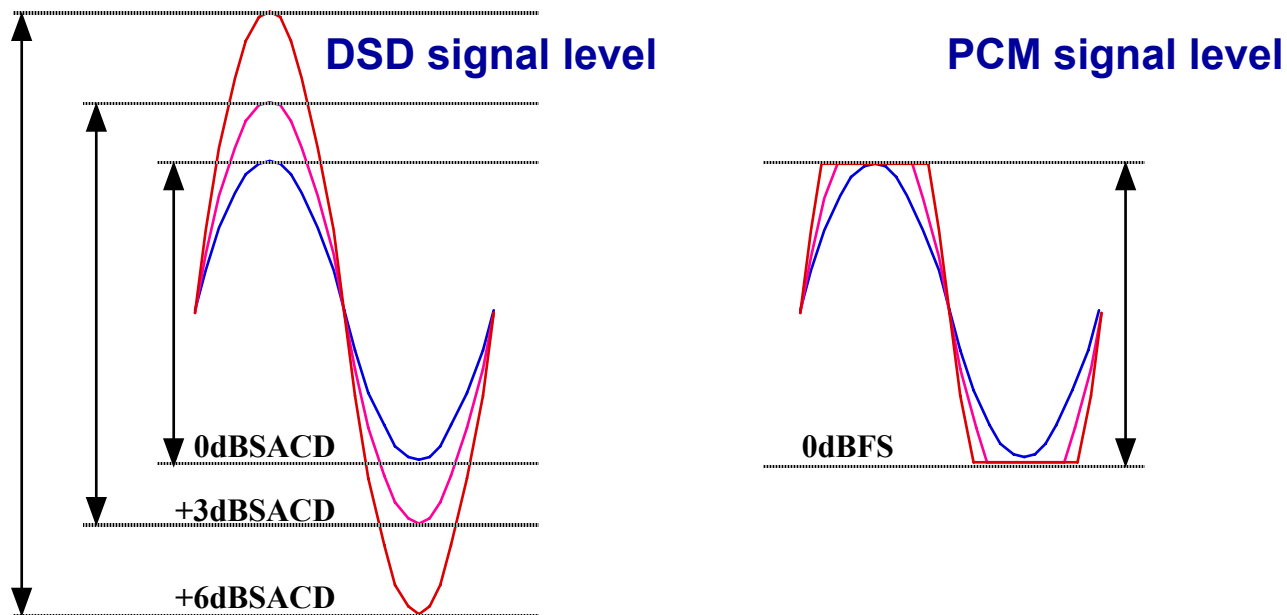
(<http://www.ams-neve.com/news/news.htm>)

SACD Production Notes

SACD Production Notes

Notes for Audio Signal Properties (ANNEX D.2)

Since the reference level of SACD (0dBSACD) corresponds to a sine wave with a peak amplitude of 50% of the theoretical maximum DSD signal level in ANNEX D.2, there is 6dB more headroom over 0dB for a DSD signal. However, the allowed maximum level on an SA-CD disc is highly restricted by ANNEX D.3.



SACD Production Notes

Notes for Audio Signal Properties (ANNEX D&E)

The normative specification (ANNEX D) and the informative specification (ANNEX E) are defined as the audio signal properties of SA-CD in the Scarlet Book.

ANNEX D.3 (Maximum peak signal : MaxPeak/MP)

Peak signal levels above +3.10 dB SA-CD in quasi DC-50kHz bandwidth determined in ANNEX D.3 (MaxPeak/MP) are not allowed.

ANNEX D.4 (Maximum high frequency noise power : HF)

The accumulated RMS signal + noise level of the DSD signal in 40kHz-100kHz bandwidth determined in ANNEX D.4 is maximally equal to the RMS level of an input sinewave with a peak amplitude of -20 dB SA-CD.

As the over level signals for ANNEX D.3 and D.4 is not allowed, be careful for signal levels in these bandwidth while editing and mastering.

Workflow for SACD production

Notes for Audio Signal Properties (ANNEX D&E)

ANNEX E.3 (Maximum DC offset : DC)

It is recommended that the DC Offset of the DSD signal on the disc is less than -50 dB SA-CD.

ANNEX E.2 in Scarlet Book v1.2 or lower (abolished in v1.3 : MF)

The recommended maximum peak level of the DSD signal in the 20kHz-50kHz bandwidth as specified in the prior ANNEX E.2 Scarlet Book v1.2 or lower is -28 dB SACD. This recommendation does not apply when the audio signal level in the DC-20kHz bandwidth is greater than that of the 20-50 kHz signal as defined above.

As the ANNEX E is an informative specification, “over” level signals for ANNEX E3 and former E.2 in Scarlet Book v1.2 or lower can be ignored. Therefore, signal levels in these bandwidths are NOT of concern while editing and mastering.

Workflow for SACD production

Notes for Audio Signal Properties (ANNEX D&E)

The specification of audio signal properties including ANNEX D&E is available as a free downloadable document from the following URL:

<http://www.superaudiocd.philips.com/InformationCenter/NO/FArticleSummary.asp?INodeId=2558&channel=2558&channelId=N2558A3398>

Workflow for SACD production

Notes for SA-CD TEXT data entry (1)

As the SA-CD TEXT format was carefully developed to utilize the information on the SA-CD booklet, SA-CD TEXT data entry is not a complicated task.

Therefore, it is preferable that the department responsible for label copyright issues rather than the studio input all SA-CD TEXT data to avoid data entry mistakes.

Although SA-CD TEXT is an option for SA-CD, it is strongly recommended that the following information entered and confirmed at a minimum.

‘Album Set Size’ and ‘Album Sequence_Number’
(Normally, ‘1’ is the default setting.)

Workflow for SACD production

Notes for SA-CD TEXT data entry (2)

SA-CD TEXT contains important information such as album title, performer name, and ISRC.

At a minimum, the following data entry is recommended.

- Album Title (Track Title) / Performer
- ISRC

Except for box sets, 'Album' information and 'Disc' information should be identical because it is a single disc.

For Hybrid disc production, the client may require CD TEXT in the CD layer. In this case, SA-CD TEXT information may be copied or transferred to CD-TEXT as it is largely compatible with the CD TEXT format.

Workflow for SACD production

Notes for SA-CD Authoring (1)

SA-CD Authoring marks the final production stage, where the Edited Master (EM) and Text Master (TM) are combined in order to generate the Cutting Master (CM) which is required for disc manufacturing.

It is vital that both the EM and TM are carefully assembled and confirmed since any errors and mistakes in either the EM or the TM will result in an incorrect CM. This is true even if the SA-CD Authoring system detects fatal errors while authoring.

The most important items to be chosen and confirmed is as follows:

- **Disc type (Single/Dual/Hybrid)**
- **DST encoding**
 - For standard 2ch only discs, DST is not recommended (although DST may be used to extend play time on 2 ch discs.)
 - As DST is mandatory for Multi-channel Area discs, *both* the 2ch and M-ch areas of such discs should be DST encoded.

Workflow for SACD production

Notes for SA-CD Authoring (2)

For Single/Hybrid discs, only one CM is required for HD layer mastering. For Dual layer discs, each layer needs its own individual CM (Therefore, such discs require two CM's.)

AIT-1 format tape is the CM delivery medium for delivery to the disc manufacturing plant. Alternate tape or disc formats are not acceptable and will be rejected by the manufacturer.

For the CD layer of a hybrid SACD, U-matic/CD-R/DDP/PMCD are acceptable as a CM. Please confirm with each manufacturer the desired CM format for the CD layer.

It is recommended that a CM report be generated for cross-checking purposes in both studio and factory.

Workflow for SACD production

Worldwide SA-CD Disc Manufacturing

