Next Generation 19 MM Recorder Technology

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Objective of Research Study

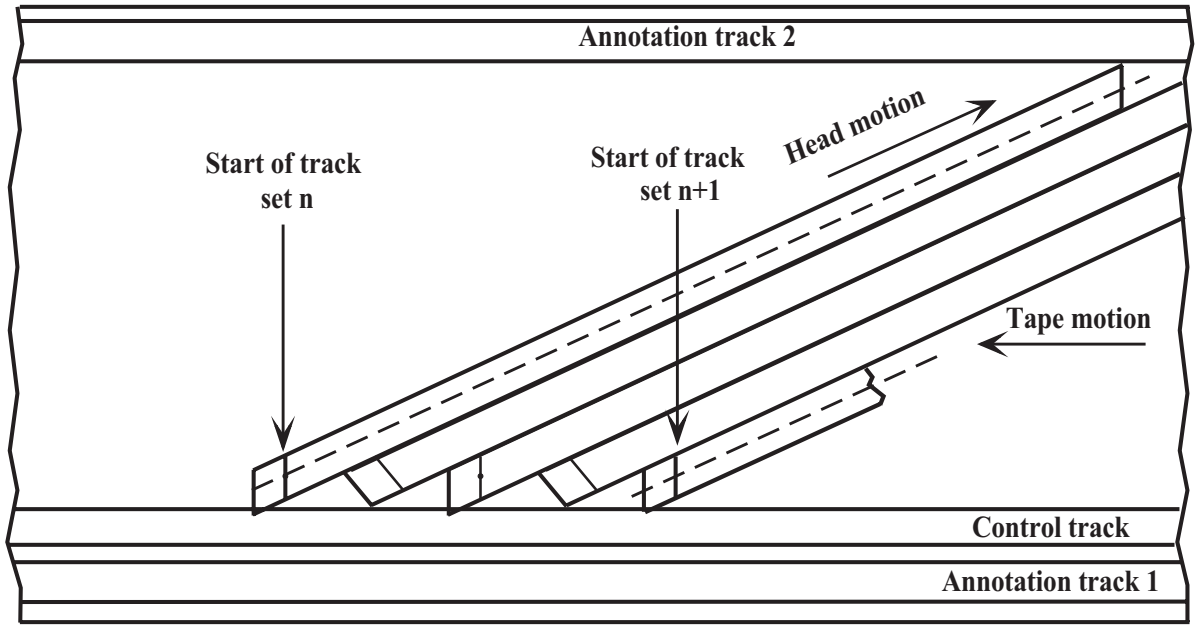
- Search for a path to higher performance
  - Data Rate / Capacity
  - Recorder / Format
- Examine maintaining some compatibility with ID-1 format

Target Specifications

	DIR-1000H	DIR-X	DIR-XX
User Data Transfer Rate	512 Mbps	1024 Mbps	2048 Mbps
Storage Capacity L	100 GByte	200 Gbyte	456 GByte
Media	Co-oxide 16μm	Co-oxide 16μm	Metal 13μm
Rec Data Rate/ch	88 Mbps	88 Mbps	176 Mbps
Rec Hds / Proc ch	16/8ch	32/16ch	32/16ch
Shortest Wavelength	0.89μm	0.89μm	0.49μm
Track Pitch	45μm	22.5μm	22.5μm
Writing Speed	39.5 m/sec	39.5 m/sec	42.8 m/sec
Tape Speed	847.5mm/sec	847.5mm/sec	918.0mm/sec
Scanner Rotation	110 rps-	110 rps	120 rps
Record Time/L-Cassette	26 min	26 min	29 min

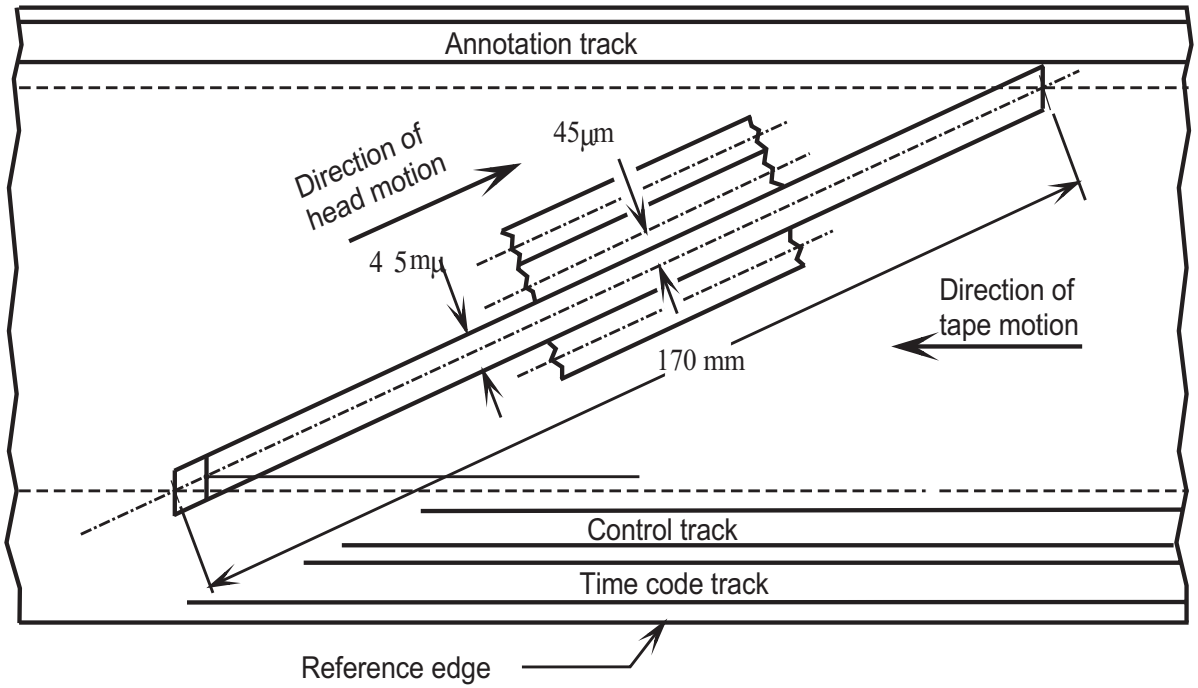
ID-1 Review

Track Set



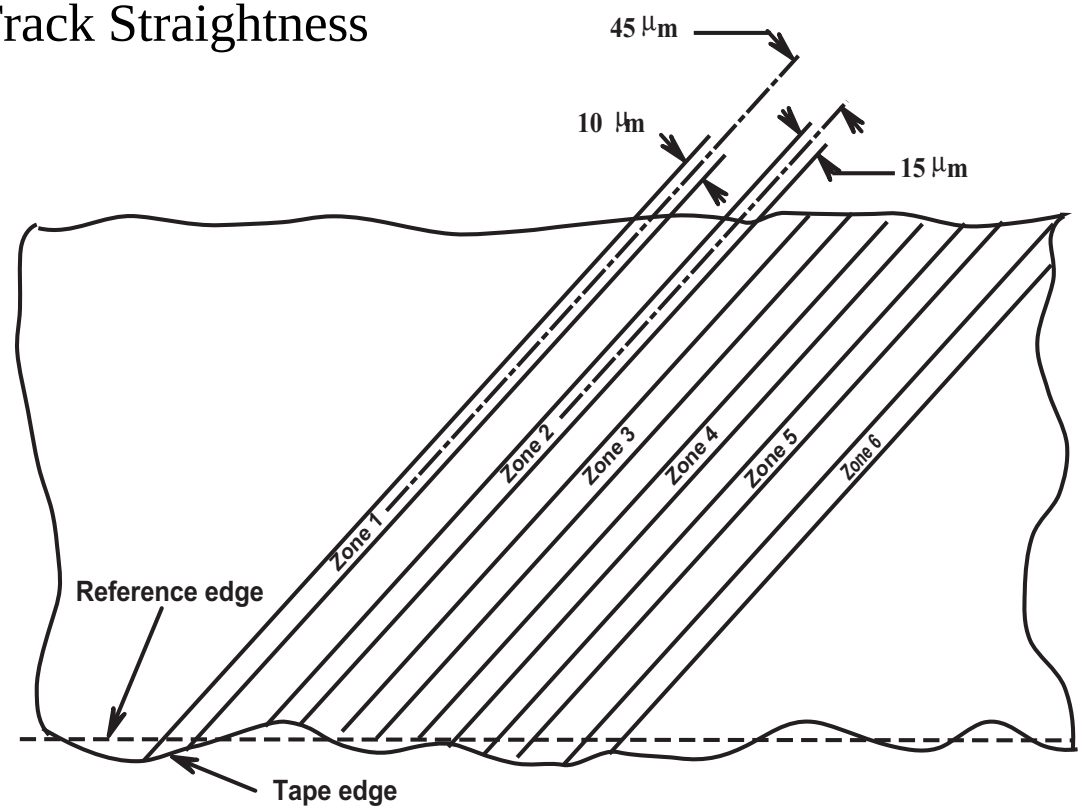
ID-1 Review

Helical Track Dimensions

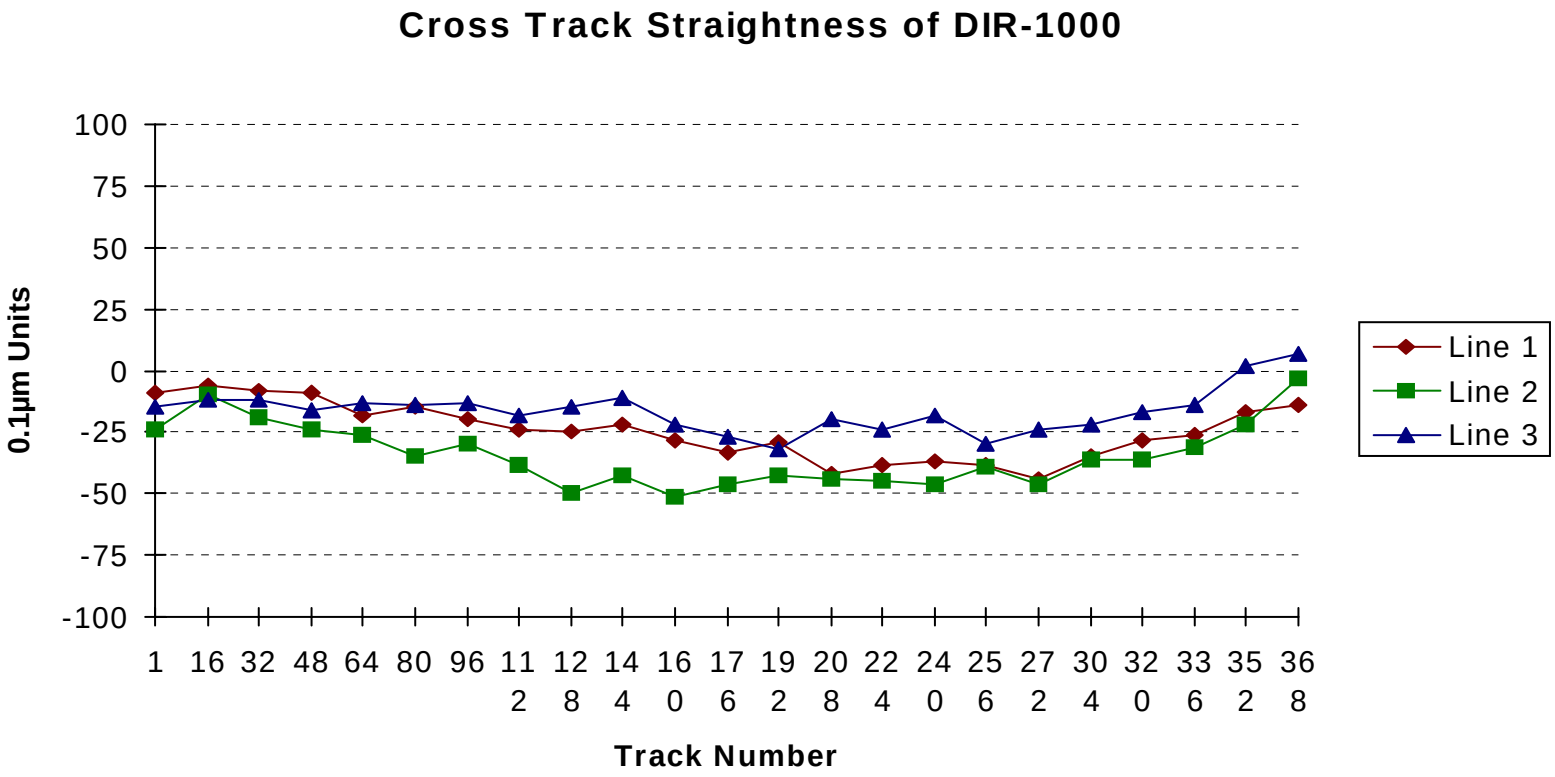


ID-1 Review

Track Straightness



ID-1 Review


Cross Track Straightness of DIR-1000
0.1µm Units
100
75
50
25
0
-25
-50
-75
-100
1
16
32
48
64
80
96
112
128
144
160
176
192
208
224
240
256
272
304
320
336
352
368
Track Number
Line 1
Line 2
Line 3

ID-1 Review

- User data - 36,108 Bytes/Track
- C1, C2 ECC Interleaved within the Track
- Track Set (144,432 Bytes) uniquely identified by 32 bit TSID on Control Track and by 22 bit plus track position ID in each Helical Track

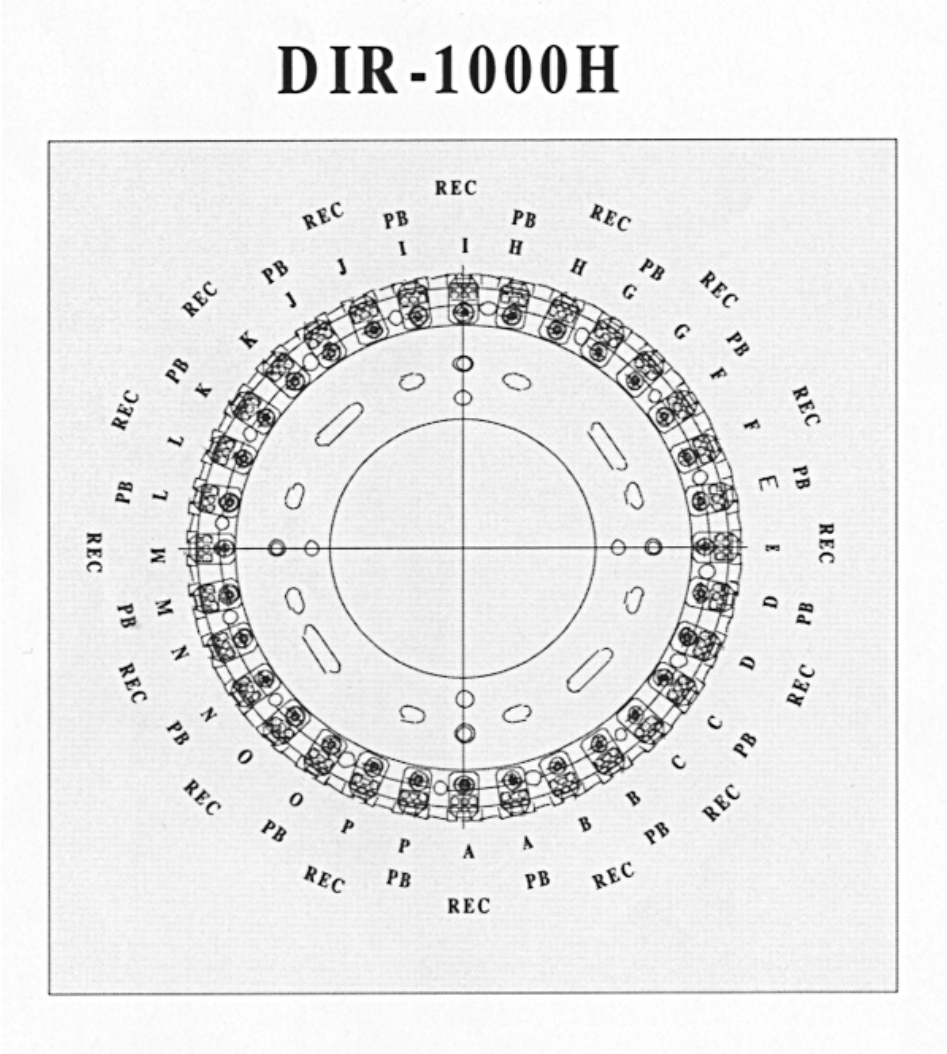
DD-1 Review

- User Data - 32,768 Bytes/Track
- C3 ECC Interleaved across Track Set

DIR-1000 to DIR-1000H

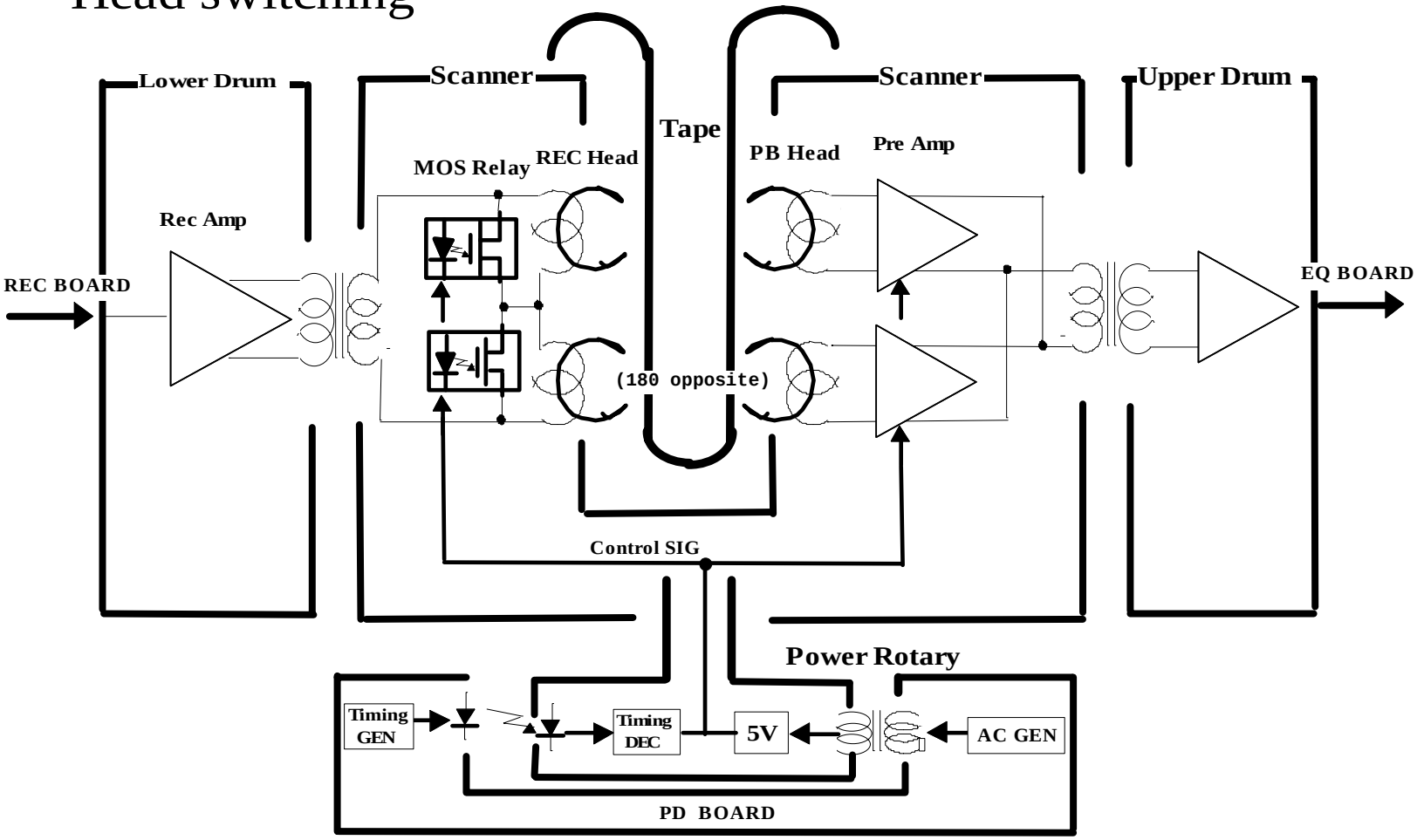
	DIR-1000	DIR-1000H
Record Data Rate / ch	88 Mbps	88 Mbps
Number of Heads	Rec: 8 / PB: 8	Rec: 16 / PB: 16
Number of Rotary Transformer Channels	Rec: 8 / PB: 8	Rec: 8 / PB: 8
Drum Rotation	110 rps	110 rps
Tape Speed	423.6 mm/s	847.2 mm/s

Scanner Head Drum



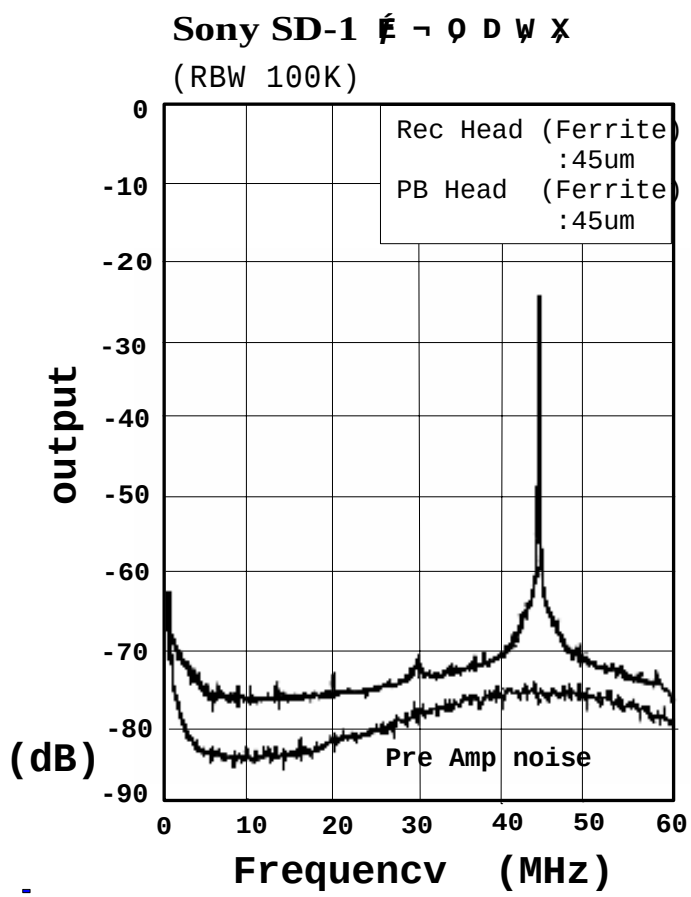
DIR-1000H

Head switching

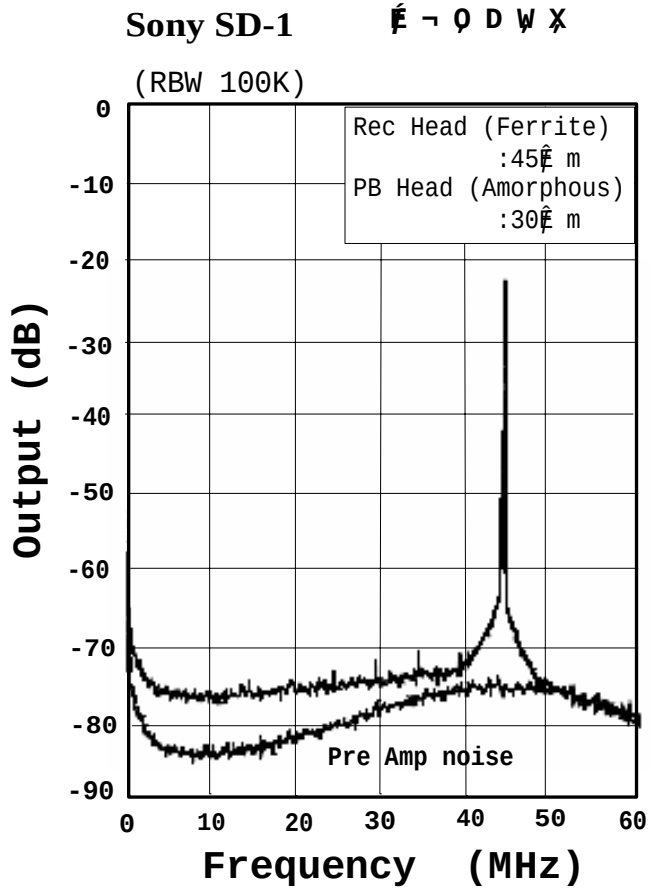


Noise Performance

DIR-1000



DIR-1000H



Recording One Gigabit/sec, 2X

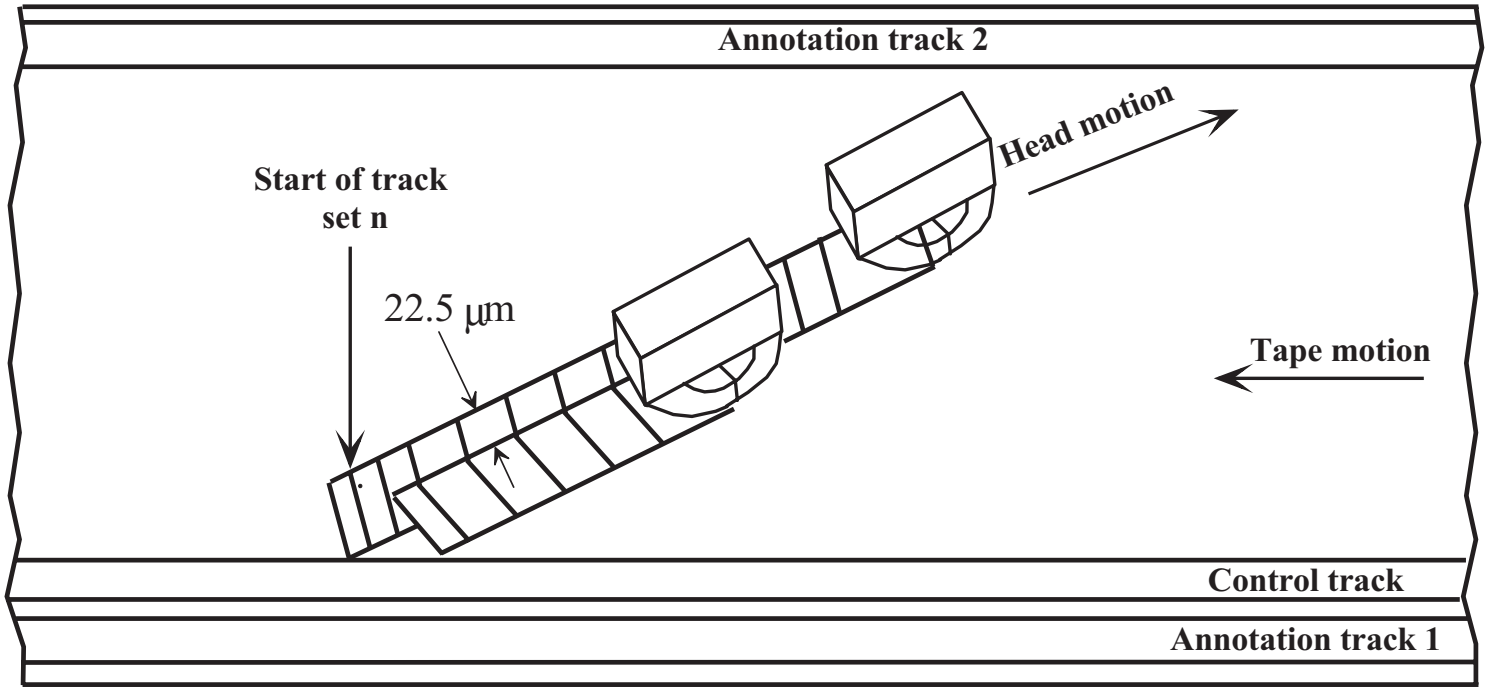
- DIR-X is possible by doubling the number of channels:
  - 32 record heads driven by 16 channels of electronics,
  - reducing the track width and pitch to 22.5 μm
- Several issues must be considered
  - How much compatibility with ID-1 format?
  - Recording DIR-X Track Set defined as 4 or 8 helical tracks?
  - ECC block size?

Compatibility with ID-1 Format

- Reading ID-1 format with narrow track heads is possible.

- If writing an ID-1 footprint is required for 1X recording there are two possibilities:
  - One method - have two sets of record heads (45 μm, 22.5 μm)
  - The other method - overwrite previously written wide tracks at half the tape speed which results in narrow tracks
    - This later case may require changing the channel coding from 8/9 to something with less low frequency content.

Overwrite Method



Recording DIR-X Track Set defined as 4 or 8 helical tracks?

- If 4 tracks
  - Longitudinal TSID must be written at double density.
    This is being studied.
  - The parameters of ID-1 and DD-1 apply.
- If 8 tracks
  - Helical track ID must be redefined in the track identification bits.
  - The TSID represents twice the data size or 288,864 bytes of user data.

ECC block size?

- The narrow tracks of the 2X recording theoretically degrades the signal to noise ratio by 3 db and thus the raw random errors by more than 3 orders of magnitude.

- It may be desirable to increase the ECC block size such that C2 is interleaved over entire Track Set (4 or 8 tracks) to improved the performance of the ECC.

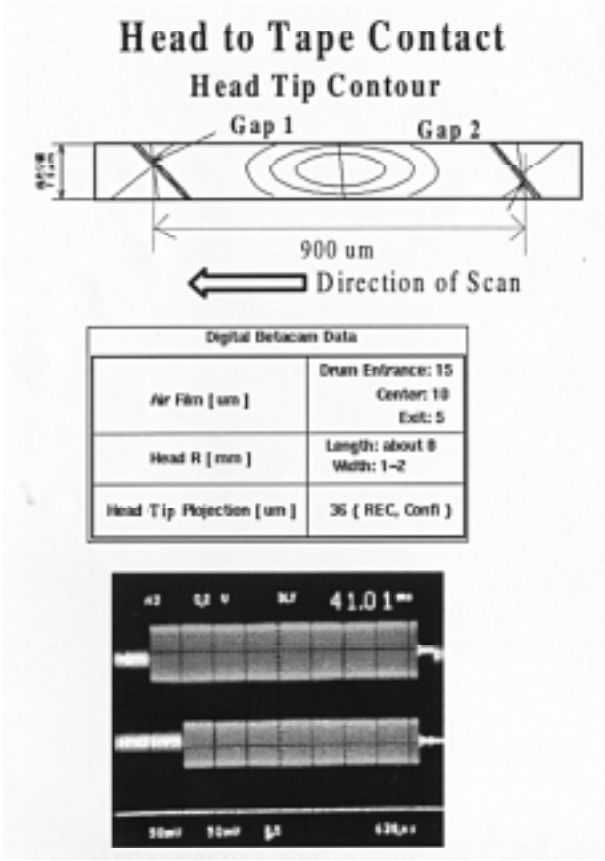
Advances in head technology

- Reference:
  IEEE Transactions on Magnetics, November 1994
  H. Ohmori, et al, “A Thin Film Head for HD-VCRs”
- The key advantages are:
  - high efficiency head
  - MIG allows recording MP tape at higher data-rates
    Amorphous PB heads - increased output from MP tape
  - small chip size -localized free air flux spray
  - small rubbing surface surrounded by non-magnetic ceramic
    allows for new low-noise Pre-amp design
    more head chips around the drum
  - higher frequency capability allow for higher channel data-rates

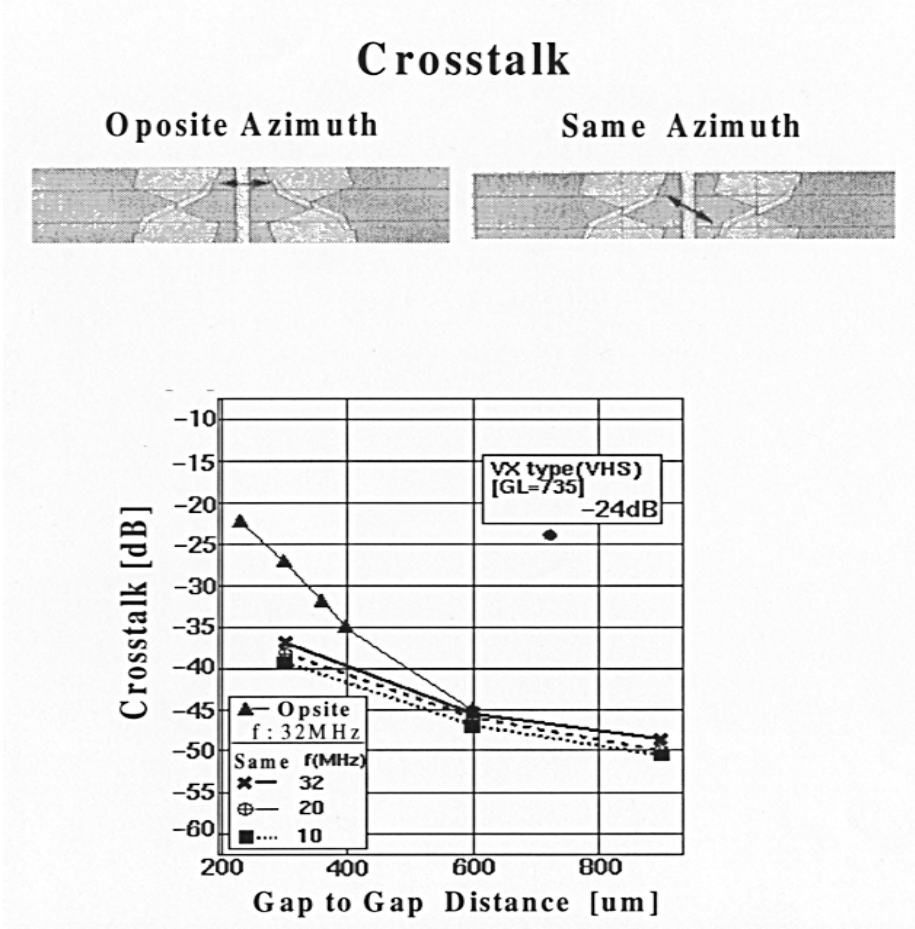
E-TF Heads

- One difficulty with E-TF heads is that gap widths are limited to between 20 - 25μm.
  - The reasons for this are economical production
  - difficulty in producing uniform layers.
- 45 μm track width recording not possible with E-TF heads.

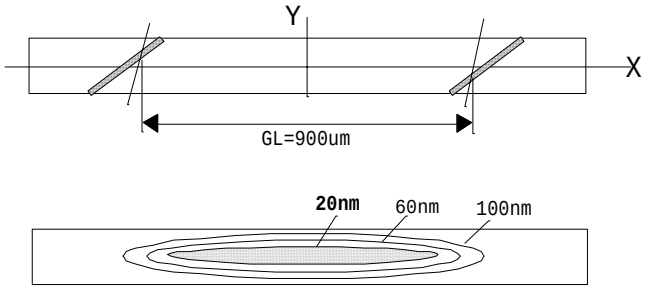
Embedded Thin Film Heads



Multiple Gap Head Tests

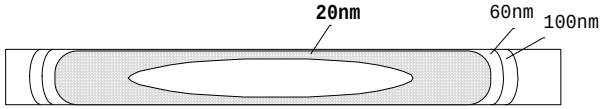


Contact Area / Tip Projection

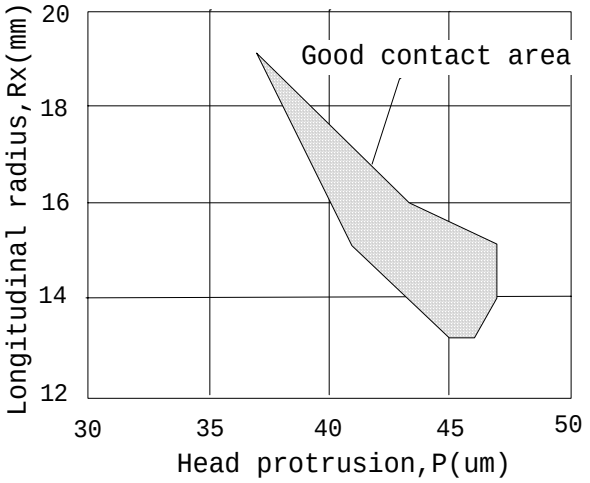


Head-1 Rx=10.5mm,Ry=2mm,P-40um,T=30gf

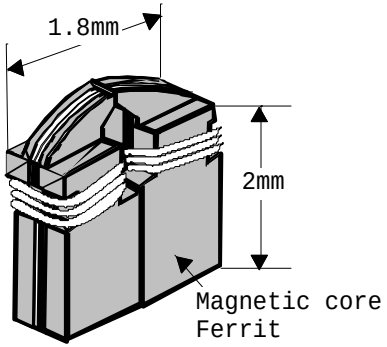
Head-2 Rx=15mm,Ry=2.5mm,P-45um,T=30gf



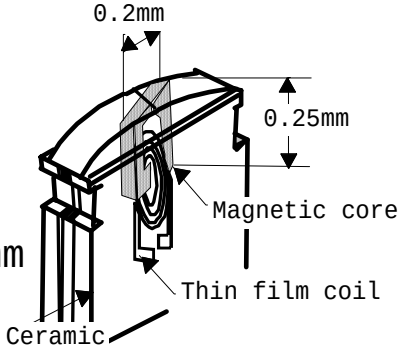
Head-3 Rx=15mm,Ry=4mm,P-45um,T=30gf



Rx=8mm



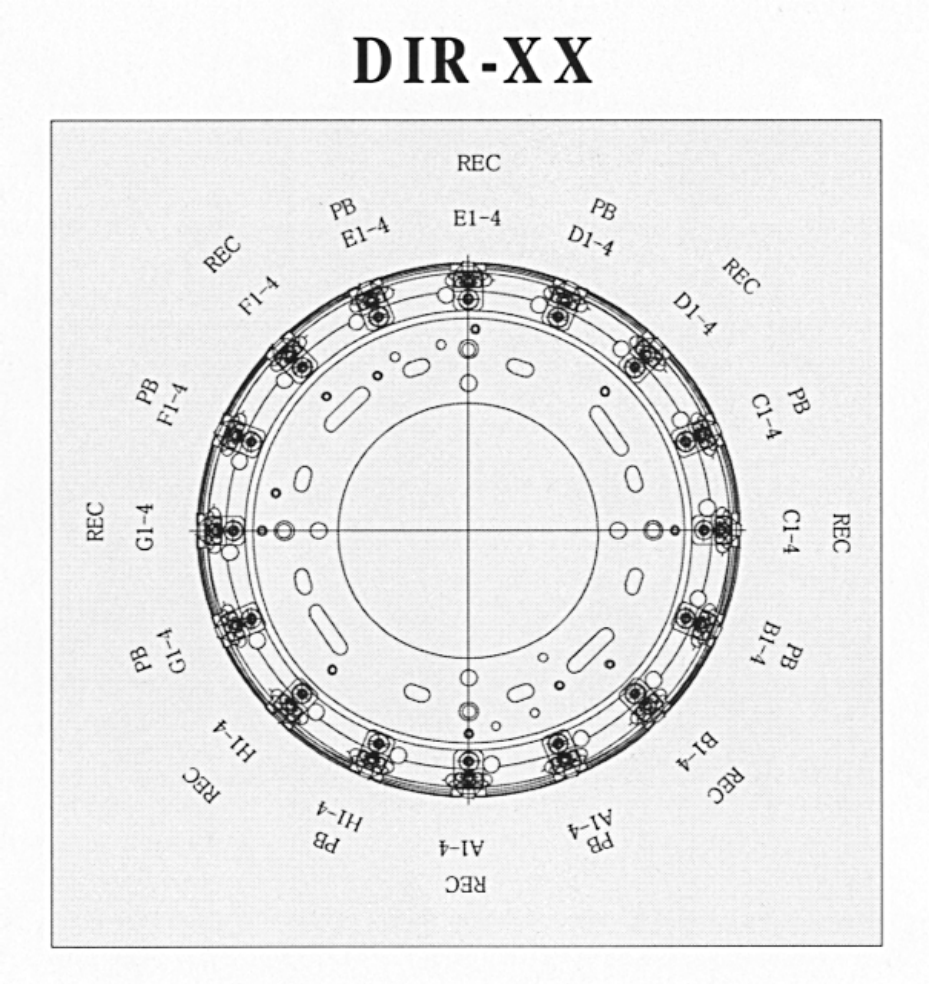
Rx=15mm



The Ultimate Possibility, 2 Gigabit/sec, 4X

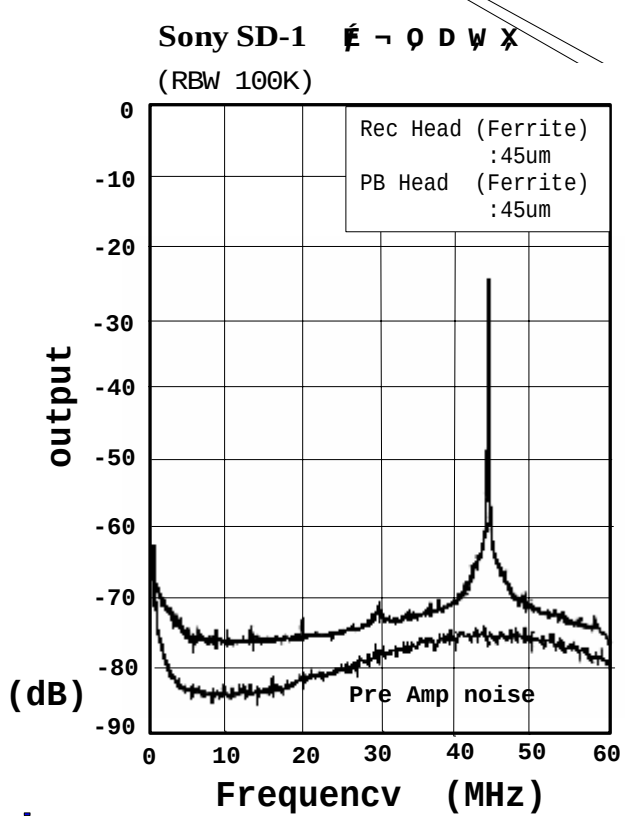
- DIR-XX achieved by doubling the channel data-rate over that of DIR-X
  - MP media allows higher density recording by 2x
  - Shortest wave length held to 0.49 μm by slightly increasing the writing speed, tape speed and scanner rotation (see table).
  - Record time (L-Cassette) is extended to 29 minutes by using 13 mm tape thickness.

Multigap Heads on Drum

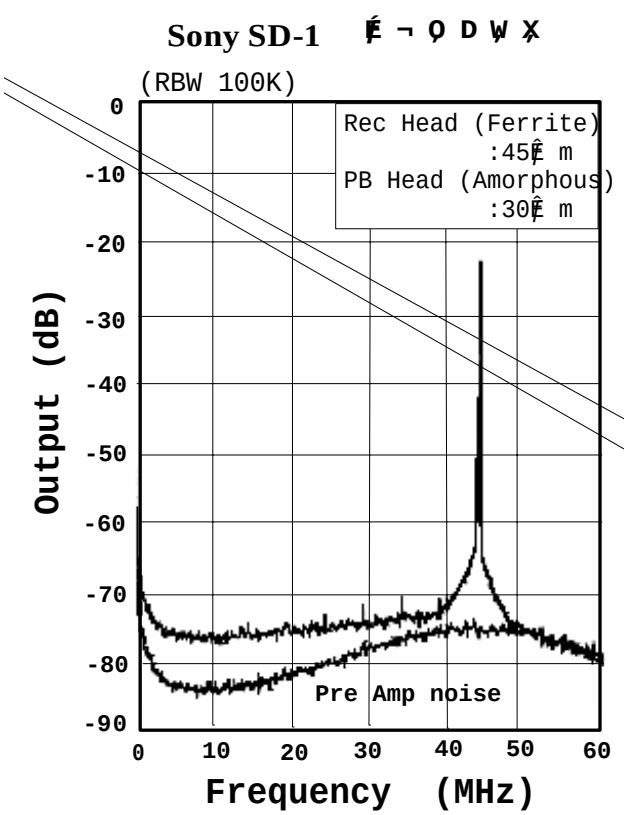


Noise Performance

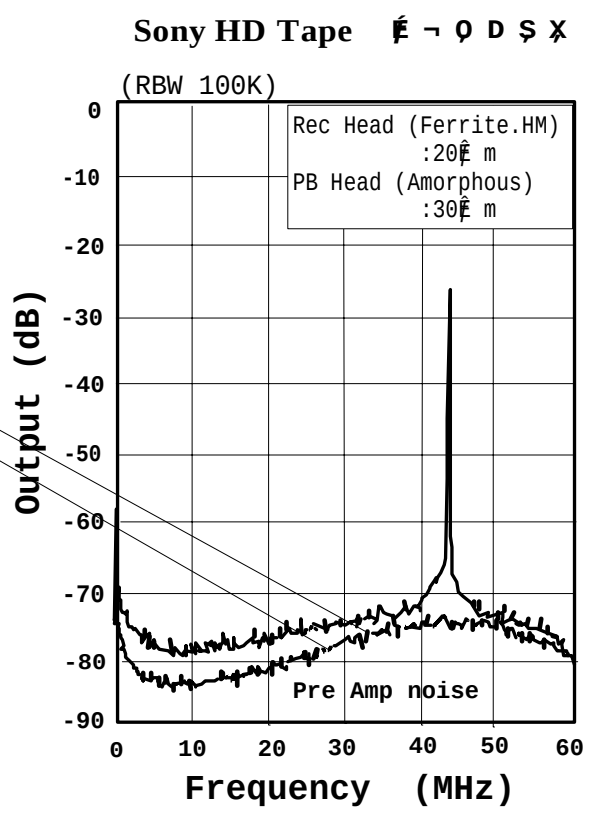
DIR-1000



DIR-1000H



DIR-XX



The Challenge

- Is it necessary for the new high performance implementation of DIR-X to have foreward compatibility with ID-1 format recorded tapes?
- If the answer is no, manufacturers can focus on implementing a new format for optimum performance, first at 1 Gbps, with the next generation implementation at 2 Gbps.
- The enabling technologies are within our grasp to accomplish these challenging projects.