·TEMPEST·

Field Engineering Training
1.0/1.2/2.1/2.5/3.2 GB
Fireball TM

March 19, 1996

Quantum®

Confidential

Tempest 1080/2160/3240
Program Review

Tempest Program Overview
Agenda

- Tempest Engineering Team
- Key Specification Comparison
- Leveraged Architecture
- Schedule Milestones
- P2 Build Summary
- Risk Summary

Tempest Engineering Team

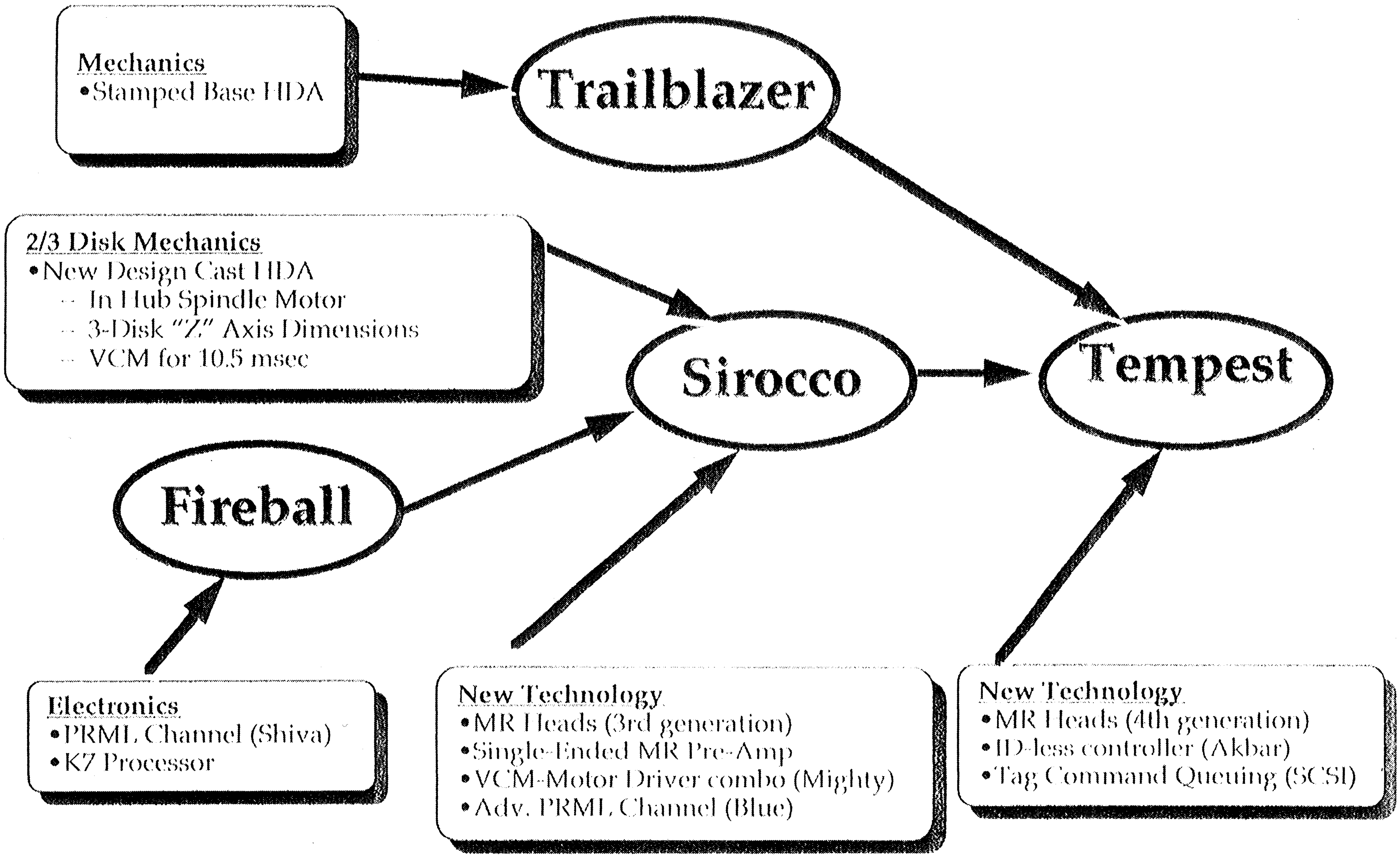
Dick Reiser	Engineering Program Manager
Dave Basehore	Mechanical Manager
Kathy Tang	Head/Media Engineering
Ben Miller	Read/Write and Servo Manager
Mike Morgan	Drive Engineering Manager
Joe Liu	Firmware Manager
Dan McFarland	Process Test Manager
Larry Toombs	Product Engineering Manager
Larry Rosier	MR Head Coordinator

Desktop Product Specifications

	Tempest	Sirocco	Fireball
■ Form Factor	3.5″ x 1.00″	3.5″ x 1.00″	3.5″ x 1.00″
■ Formatted Capacity (MB)	1080/2160/3240	1700/2550	640/1280
■ Seek Time (ms)	12/10.5/10.5	11	11
■ RPM	4500	4500	5400
■ Buffer	128K	128K	128K
■ Data Rate (max)	90Mb/s	72Mb/s	84Mb/s
■ Transfer Rate (MB/sec)			
- AT/PIO	6/16	6/16	6/16
- Fast Multiword DMA	16	16	16
- SCSI /SCSI-3	6/20	NA	6/10
■ Power (watts)			
- idle	3.7/4.0/5.0	4.2	4.0
- sleep/standby	<1.0	<0.8	<1.0
- operating	5.0/6.5/6.5	6.5	6.5
■ Acoustics (idle)			
- sound pressure (dBA)	32	32	32
- sound power (bels)	3.6	3.6	3.6
■ Interface	Fast ATA-2/ Ultra SCSI-3	Fast ATA-2	Fast ATA-2/ SCSI-3
■ MTBF (hrs)	400K	400K	500K
■ Volume Availability	5/96	3/96	3/95

Tempest

Leveraged Architecture



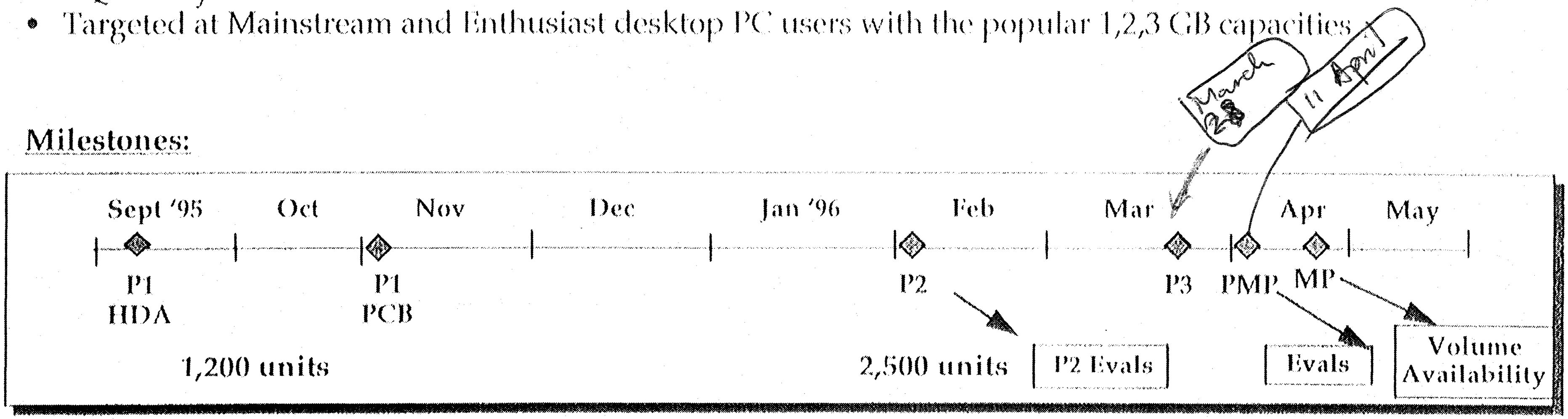
Tempest — 3 1/2" Program Overview

Tempest	1080 MB	90 Mb/sec	<12ms	4500rpm	Volume Avail: May '96
	2160, 3240 MB	90 Mb/sec	<11ms	4500rpm	Volume Avail: May '96

Program Highlights:

- 1080 MB per platter is the leading areal density in CQ2'96; 3,240MB is highest desktop capacity for CQ2-CQ3 '96 system launches
- Targeted at Mainstream and Enthusiast desktop PC users with the popular 1,2,3 GB capacities

Milestones:



Program Status:

- P2 build will start on 2/1 (HDA Assembly); 5 head and 5 media suppliers participating in build.
- 60K CSS in process with multiple head-media-motor combinations; DVT testing nearly complete

P2 Build Summary

Overall HDA Test Yield (Head/Media):

- 95.6%
  - Best 100% (25 Combinations)
  - Worst 60% (1 Combination)

Overall Self Scan/Final Test Yield:

		AT	SCSI
1080 MB		69.4%	68.1%
2160 MB		81.0%	77.4%
3240 MB		60.3%	66.1%
Overall	66.9%	65.6%	68.0%

P2 Build Summary (Continued)

Head/Media Yield:

- Head Vendor

• RHG-B	136 units	74%
• Alps	394	70%
• Read-Rite	109	68%
• TDK	451	72%
• Yamaha	128	70%

- Media Vendor

• AKCL	156 units	65%
• Fuji	511	86%
• Stor Media	80	72%
• MCC	420	90%
• Showa Denko	51	61%

P2 Build Issues

Servo Write

- » Clock Control (PLO Stability)
- » Motor Control (6000 RPM)
- » Code (Back-up & Re-Write)

1-Disk

- » 1 KHz Resonance of Upper Magnet Plate
- » Un-Parking Current
- » Seek Time (Distribution)

3-Disk

- » Seek Time (Distribution)

General

- » Servo Start-Up Robustness & Recal Robustness
- » Read Channel

Technical Risk Summary

MR Head Vendor Issues

- Alps Instability
- Yamaha Off Track Capability (Track Centering)

Media defects

- Media scratching reduced, next build will verify dynamic loading

Solutions for MR head unique properties

- MR Instability test (Too Sensitive)
- Thermal Asperities detection and correction algorithm within limited correction set-up (ECC level set to zero correction)

TEMPEST MECHANICAL DESIGN REVIEW

- For Quantum Field Engineering
- March 19, 1996
- Presented by Dave Basehore

Presentation Overview

- Design Goals for 1 Disk and 2/3 Disk HDAs
- <u>1 Disk HDA</u>
  - Design Characteristics
  - Performance to Date
- <u>2 / 3 Disk HDA</u>
  - Design Characteristics
  - Performance to Date
- Summary

Mechanical Design Goals

- Very Stiff and Low Runout HDAs to Support TMR
  - Support Sirocco HDA at 5850 TPI
  - Support Tempest HDA at 6775 TPI
- Achieve 3.6 Bels Acoustics Sound Power
- 11.0 ms. Average Seek to Read on 2/3 Disk HDA
- 12 ms. Average Seek to Read on 1 Disk HDA

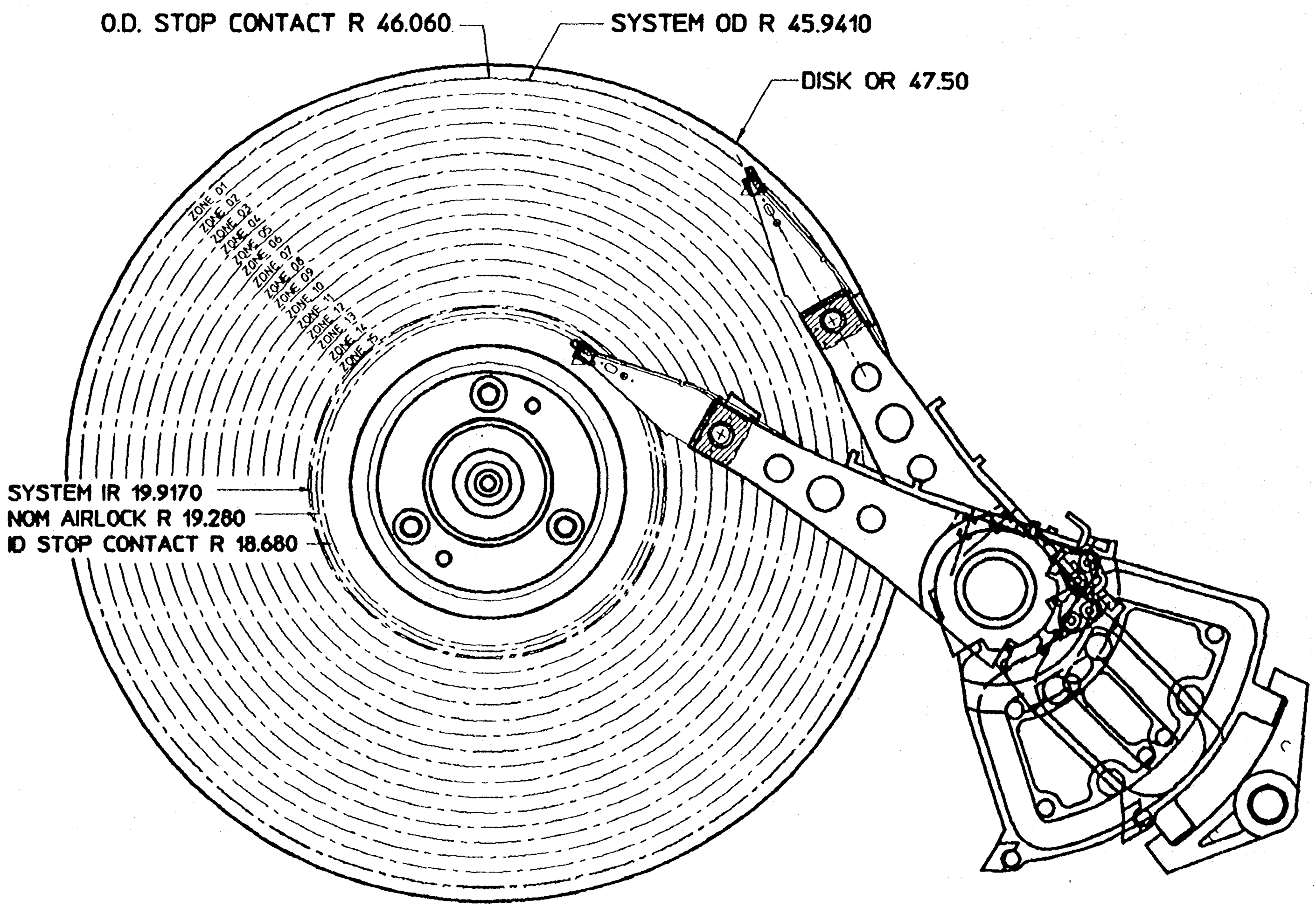
Design Strategy - 1 Disk and 2/3 Disk HDA Commonalities

- Same TrB Arm Length / Pivot Locations on Base That Supports Sirocco Microjog / Heads
- Same Head Skews / Data Stroke
- Both Use Air Lock
- Common PCBA will mount to both HDAs
- Same Heads and Media

MKE Manufacturing Strategy

- 1 Disk Tempest to be Built and Servowritten on Trailblazer Assembly Line
- 2/3 Disk Sirocco / Tempest to be Built and Servowritten on Fireball Assembly Line

	INSIDE RADIUS (mm)
SYSTEM ZONE	45.8648
ZONE 01	44.1528
ZONE 02	42.4383
ZONE 03	40.7238
ZONE 04	39.0119
ZONE 05	37.2974
ZONE 06	35.5854
ZONE 07	33.8709
ZONE 08	32.1589
ZONE 09	30.4444
ZONE 10	28.7325
ZONE 11	27.0180
ZONE 12	25.3060
ZONE 13	23.5915
ZONE 14	21.8796
ZONE 15	20.1651



TRACK MAP - TEMPEST

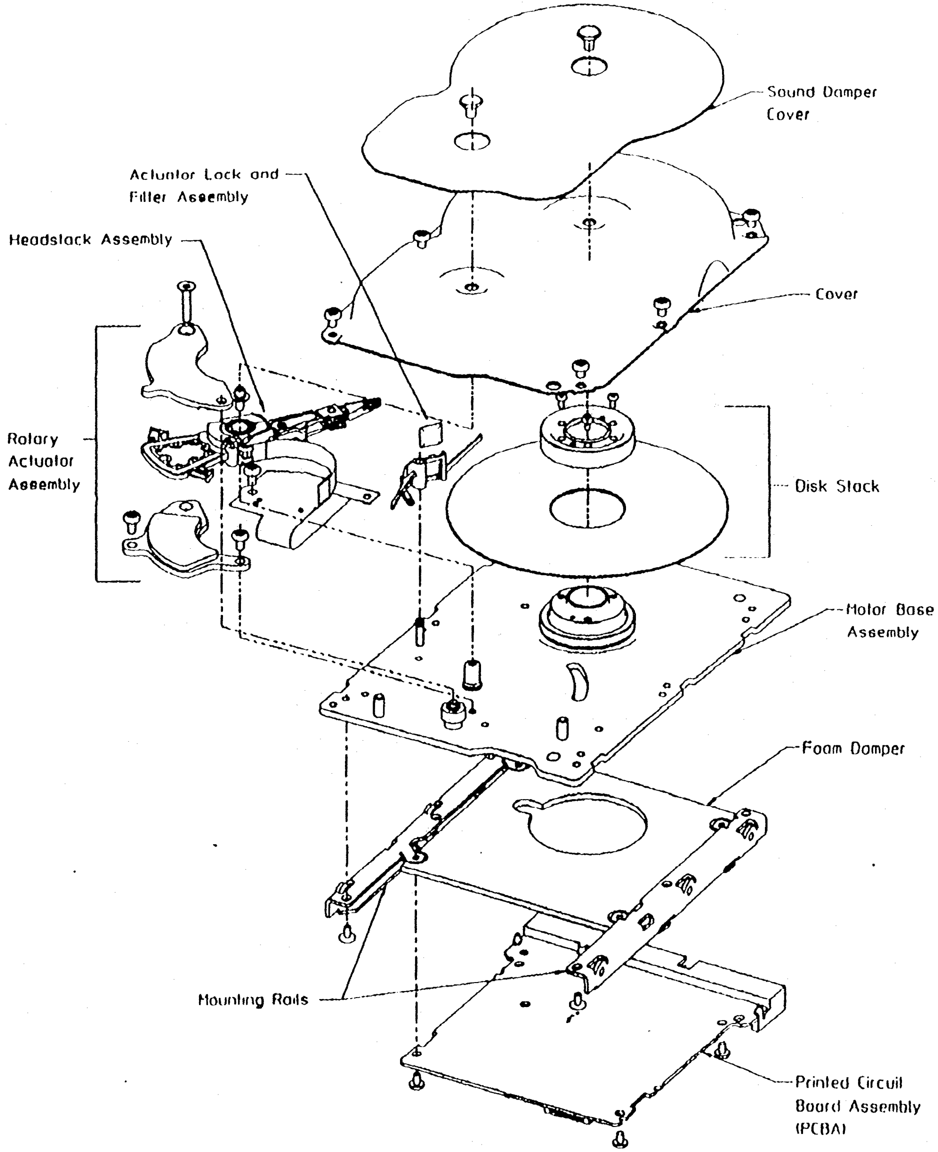
(1D, 2D & 3D)

3/5/96

1 Disk HDA Design

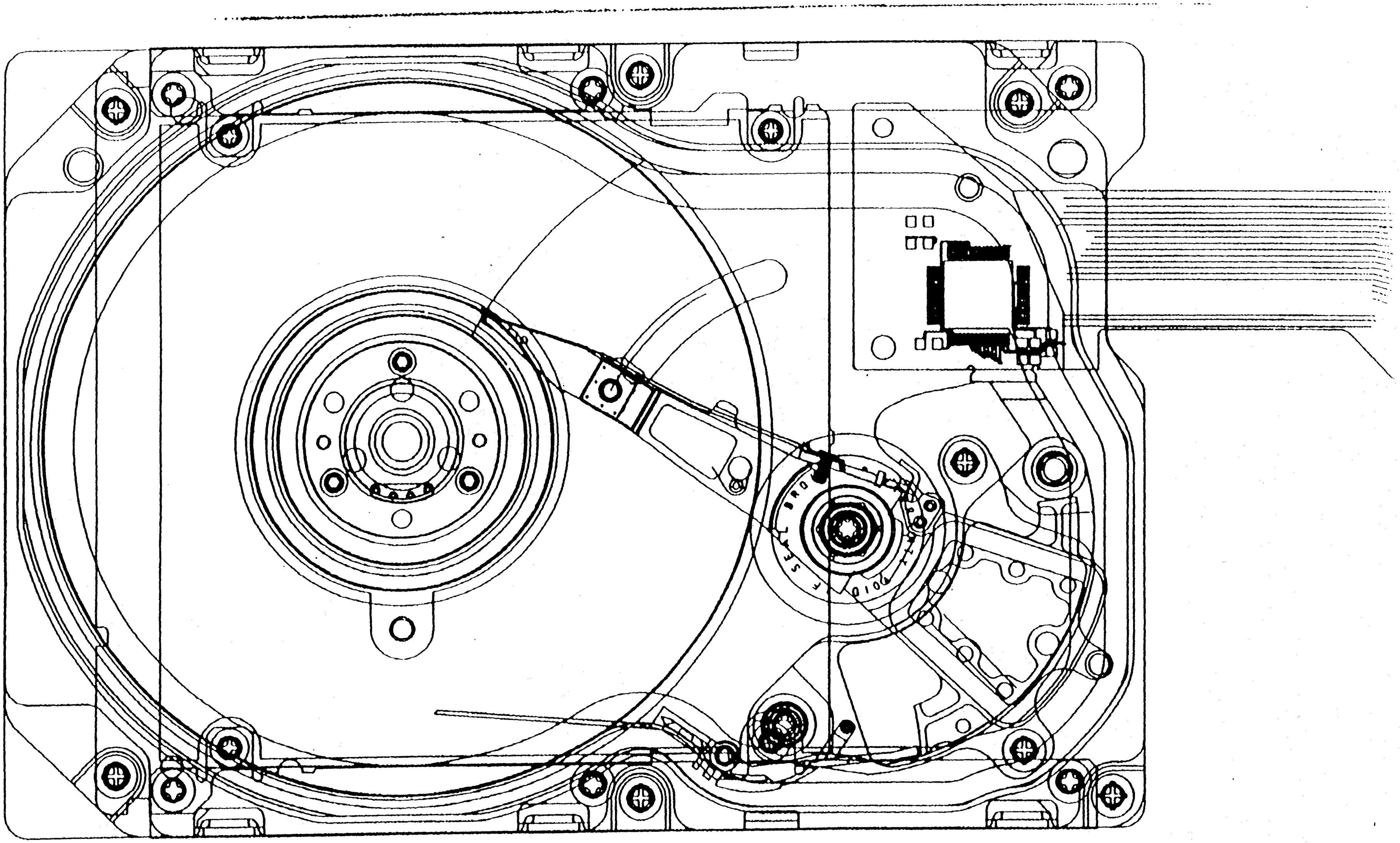
- Mechanical Assembly Overview
- Commonality with Trail Blazer
- Commonality with 2 / 3 Disk
- Base / Motor Disk / Stack Assembly
- Actuator Assembly
- Voice Coil Motor Assembly
- Air Lock Design
- Cover Design

Tempest 1 Disk HDA Overview



One Disk HDA Architecture

- Trailblazer modified for one disk HDA
  - Lowest cost existing HDA platform
  - Stamped Cover and Stamped Base

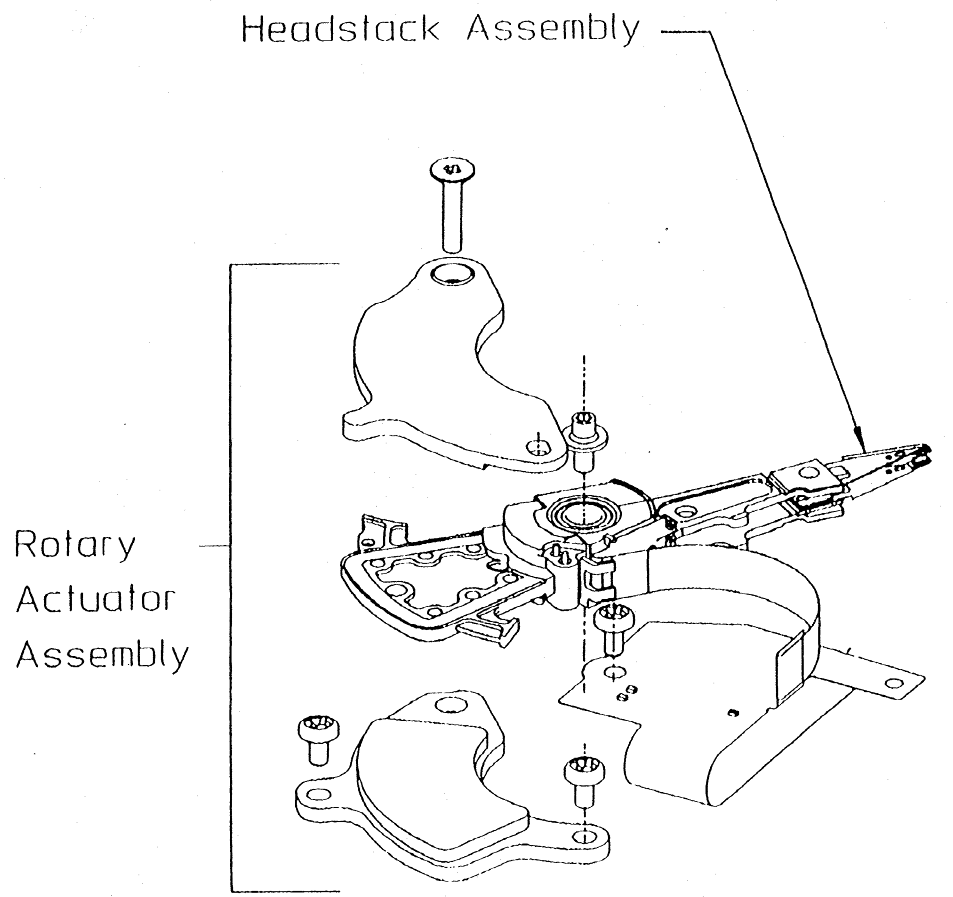


SIROCCO / TEMPEST 1D HDA PLAN VIEW

1 Disk Latch Asm

- Design Changes From Trail Blazer
  - Modified TrB A/L to accomodate disk elevation change
  - Same function as TrB latch (slider play when latched)

1 Disk Actuator Assembly



Actuator / VCM Asm

- Differences from Trailblazer
  - One disk actuator (J=30 gm cm2)
    - One disk only Eblock, arms centered to coil for symmetry
    - Different coil thickness for balancing actuator
      - 1.3 mm vs 1.8 mm thick
    - Modified Coil for 12.0 ms. Seek Time
      - .130 mm diameter wire
      - 121 turns, R=12.3 ohms
    - Currently same rotor molding tooling
  - Modify top magplate to hold FPCB at loop exit
  - Flex guide design for one disk FPCB
  - Bottom magplate / magnet same as TrB

1 Disk VCM Comparison with Trailblazer

Parameter	Tempest 1 Disk	Trail Blazer 1 Disk
Max Torque Constant (gm cm/A)	342	560
Head Gap Radius (cm)	54.42	54.41
Total Inertia (gm cm2)	30.0	36.5
Coil Resistance @ 22 Deg C (Ohms)	12.34	18
Maximum Gap Flux (Gauss)	3950	3950
Coil # of Turns	121	198
Coil Wire Diameter (mm)	.130	.135
Magnet Material Energy Product (MgOe)	36	36
1/3 Stroke Move Time (mechanical ms)	8.03	10.40
Average Seek Time Specification (ms)	12.0	14.0
Estimated Allowance for Settle Time (ms)	3.97	3.60

FPCB Asm

- Design for MR head requirement

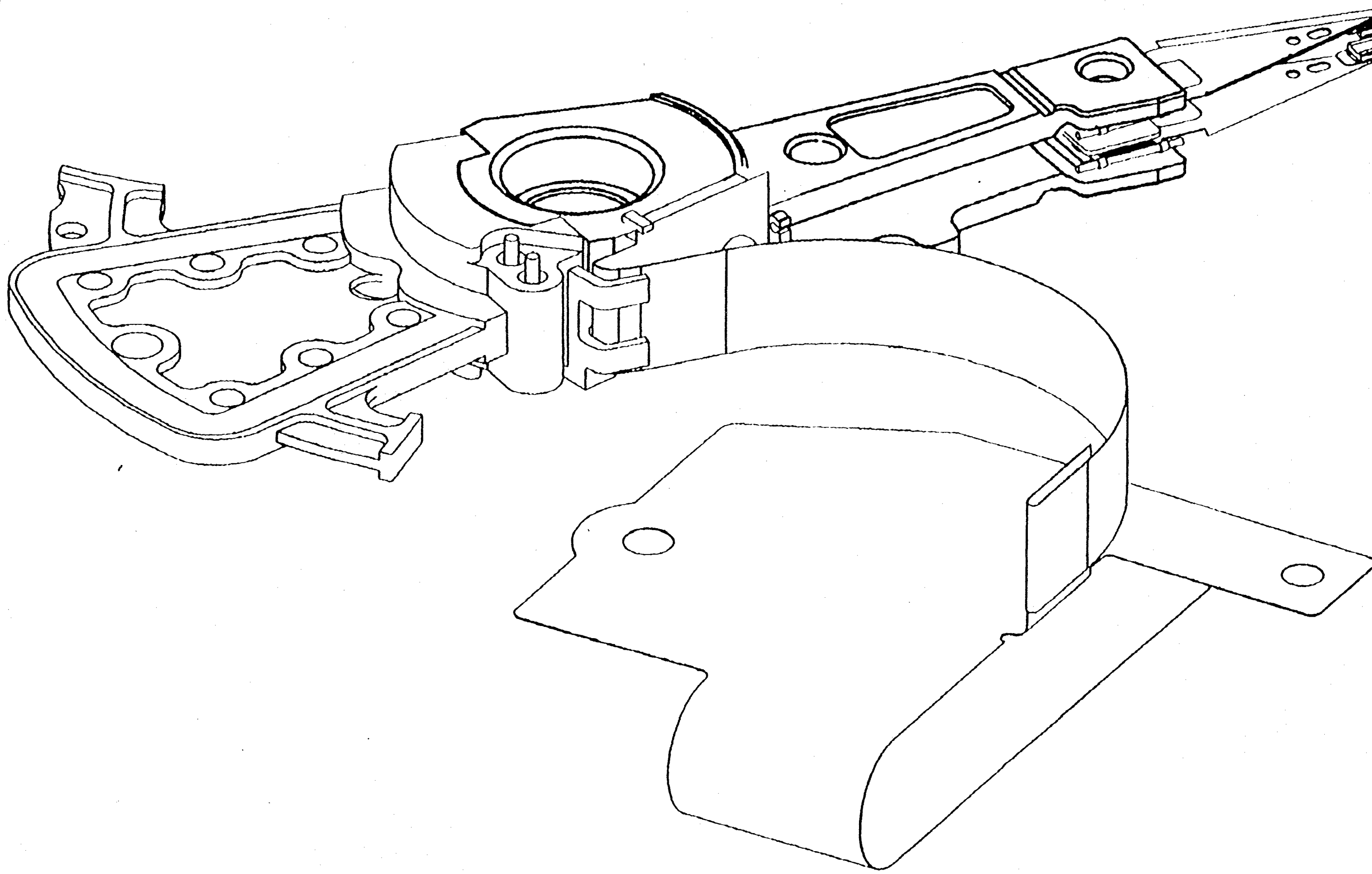
- Pre-Amp IC on Actuator

    - Min lead length from pre-amp to head

    - Shorter loop than Fireball (30 mm vs 36 mm)

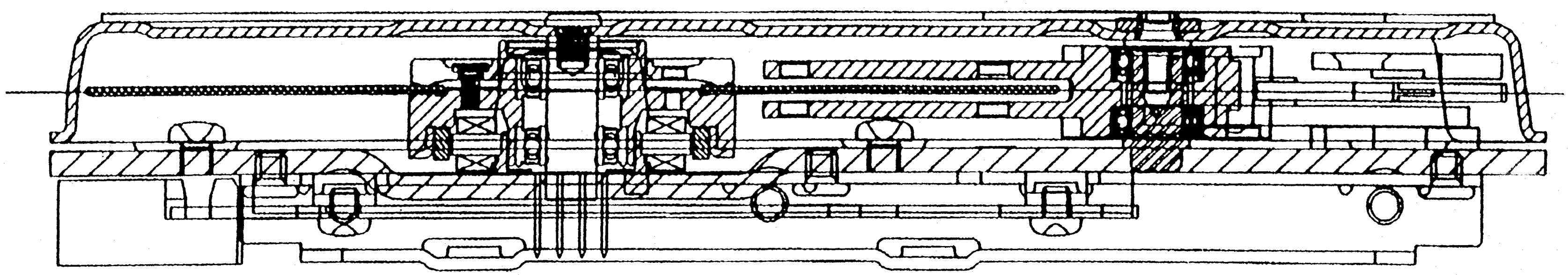
    - Optimize material thickness, width for lower bias

1 Disk Headstack Assembly



HGA Design

- MR Head HGA
  - MR transducer
  - TPC and NPAB slider design for constant flying ht vs. radius
  - Semi-tubeless design
  - Type 850 thru etch (same as FB)
  - .7366 mm Z-ht (same as TrB)
  - 5 gm load / 2.5 mil suspension



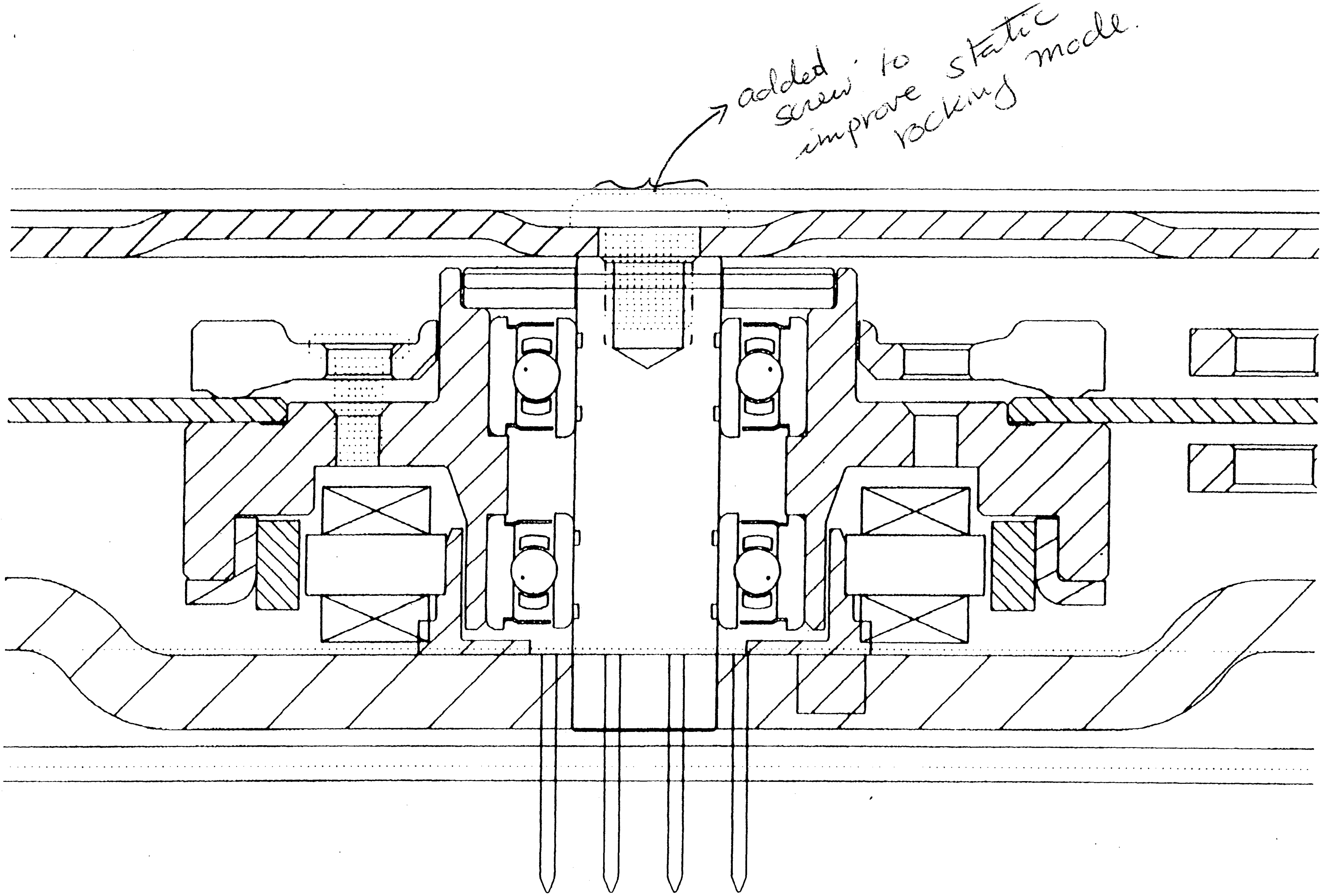
SIROCCO / TEMPEST 1D HDA SIDE VIEW

Motor / Base Asm

- Differences from Trailblazer
  - Tied shaft with labyrinth seal for contamination control
  - Move TrB bearings closer due to space for labyrinth seal
  - Move disk elevation to center of actuator coil
  - Tighter NRRO specification of 8 uin needed for TMR
  - FPCB mounting points move for short loop
  - Plate modified to widen FPCB channel area

1 Disk Spindle Motor Comparison with Trailblazer

Parameter	Tempest 1 Disk	Trail Blazer 1 Disk
Rotational Speed (RPM)	4500	4500
Torque Constant (gmf cm/A)	140	140
Coil Resistance (Ohms)	8.5 +/- 10%	8.5 +/- 10%
Coil Inductance (mH)	1.2 +/- .4	1.2 +/- .4
Static Rocking Mode (Hz.)	$\geq$ 480	$\geq$ 320
NRRO (micro in. - radial P-P)	8	12
Imbalance (mg cm)	50	50
Average Run Current (milli amps)	140	140
BEMF (Volts / KRPM)	1.67	1.67
Bearing Size	1150	1150
Lubrication	Multemp	Andok C
Minimum Starting Torque (gmf - cm)	81	81



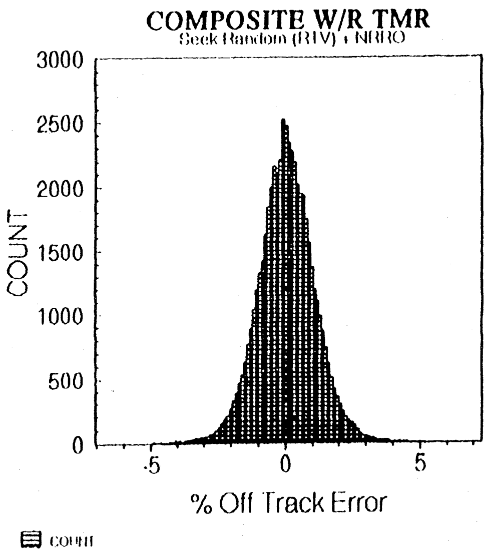
TEMPEST ONE DISK SPINDLE MOTOR

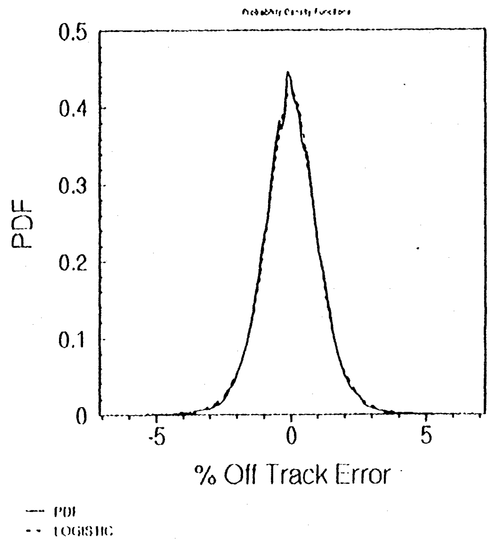
1 Disk Misc Parts

- Cover Asm:
  - Modified clock head opening for different disk elevation
  - No other change to Trailblazer
- Crash Stops:
  - Location of stops same as Trailblazer
  - Diameter and Durometer Adjusted
- Disk Clamp:
  - Clamp Modified for Additional Data Stroke

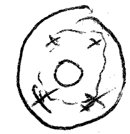
1 Disk Performance

- TMR Data
- Mechanical Resonance Data
- Acoustics Data

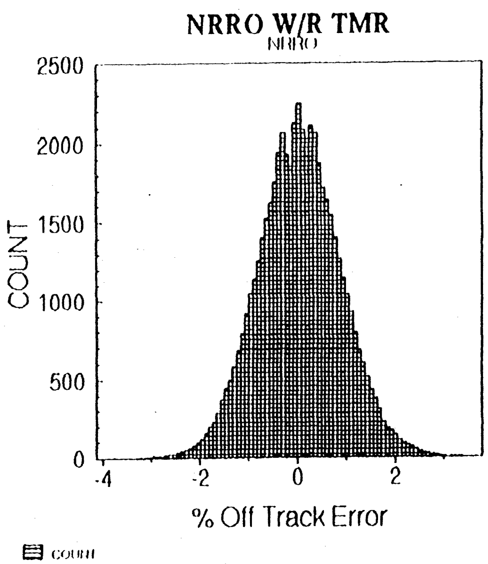


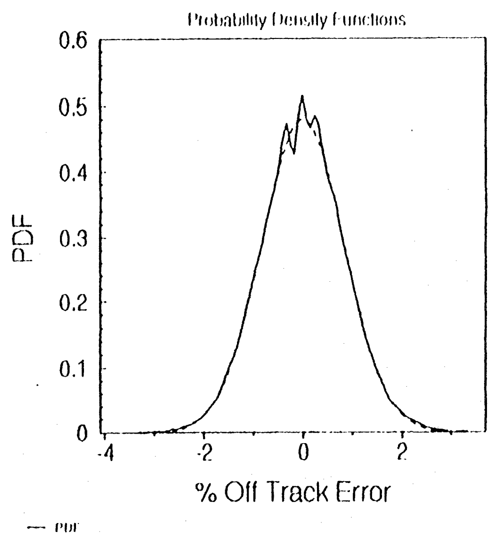


DriveID 381566623104
HDA Variation Code roomtem
3 σ = 3.23 %
Population Estimate, Based
on Cumulative Peak Method.
3 σ (est) = 3.56 % (.59K events)
08-25-1995



Seeking (Random)

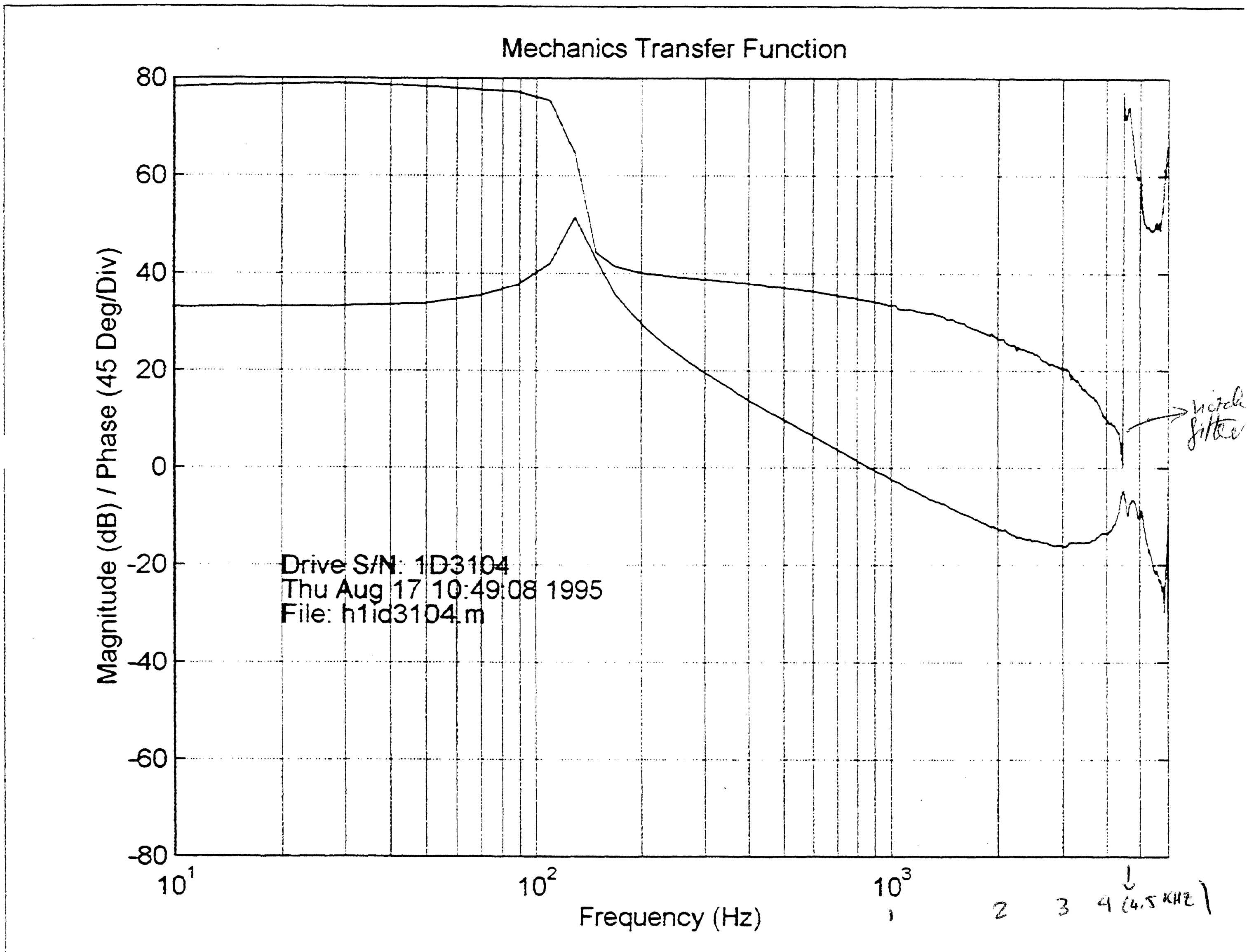


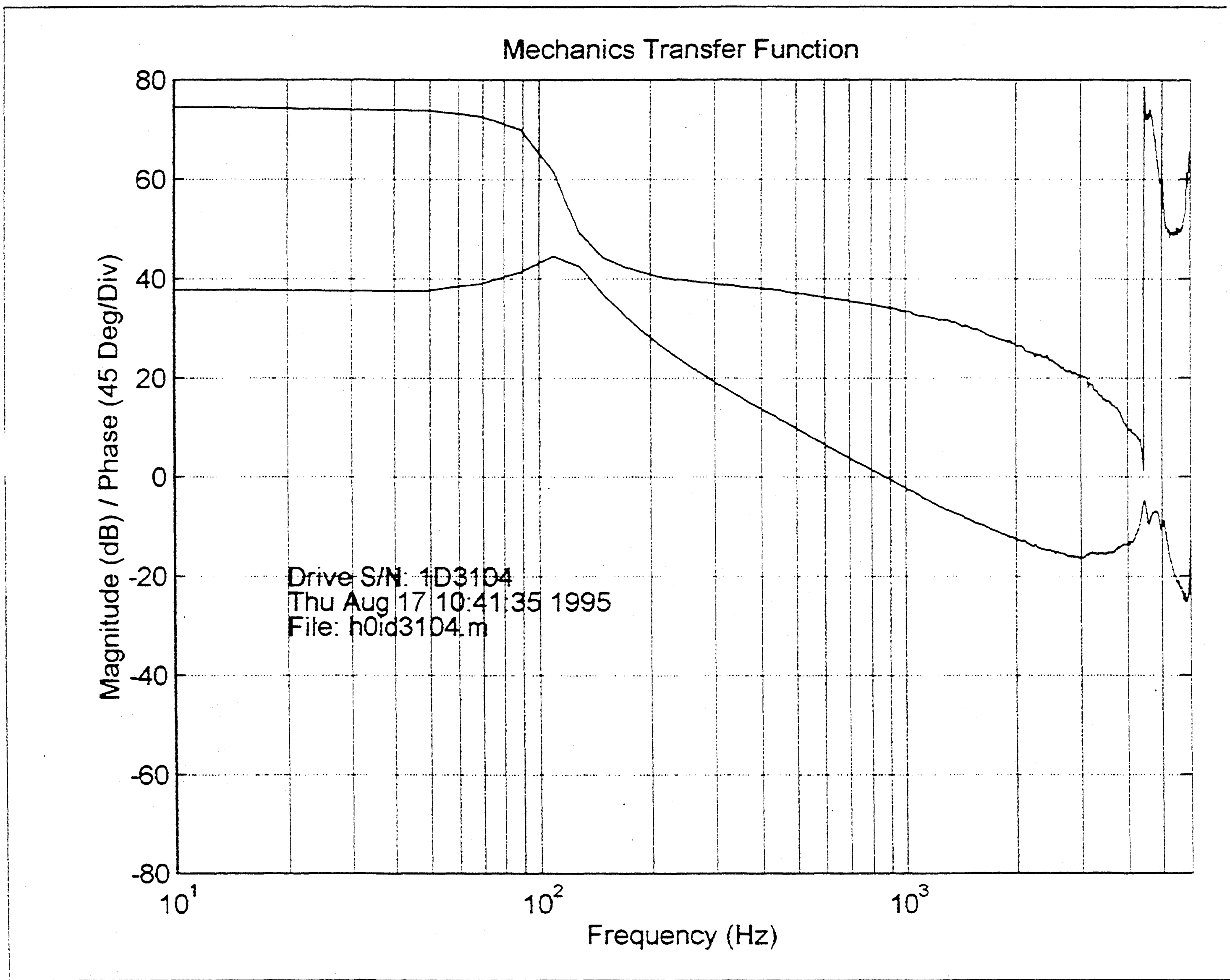


non-Seeking.

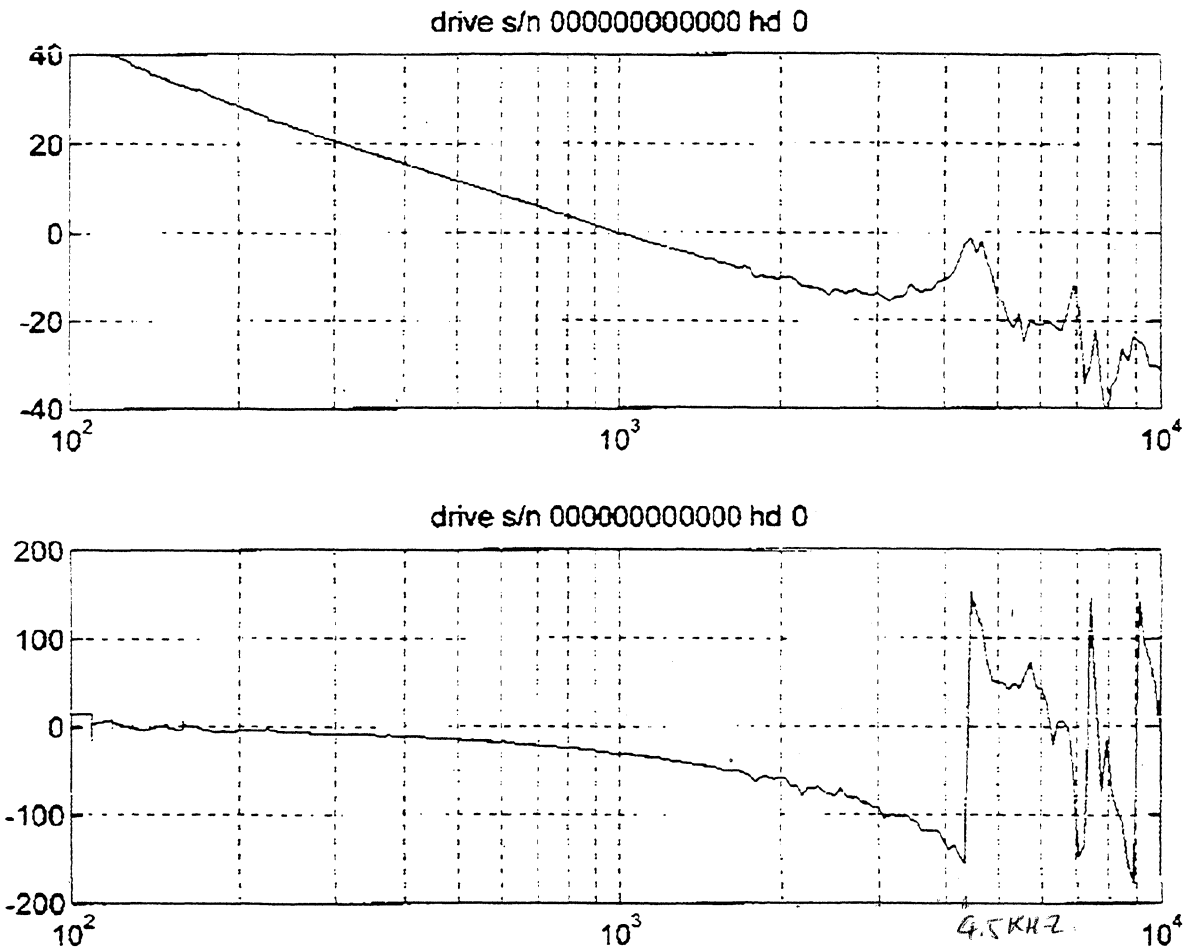
3 σ = 2.49 %
3 σ Population Estimate = 2.64 %

6500 TPI


Mechanics Transfer Function
Magnitude (dB) / Phase (45 Deg/Div)
80
60
40
20
0
-20
-40
-60
-80
Drive S/N: 1D3104
Thu Aug 17 10:49:08 1995
File: h1id3104.m
10^1
10^2
10^3
Frequency (Hz)
2
3
4 (4.5 KHz)

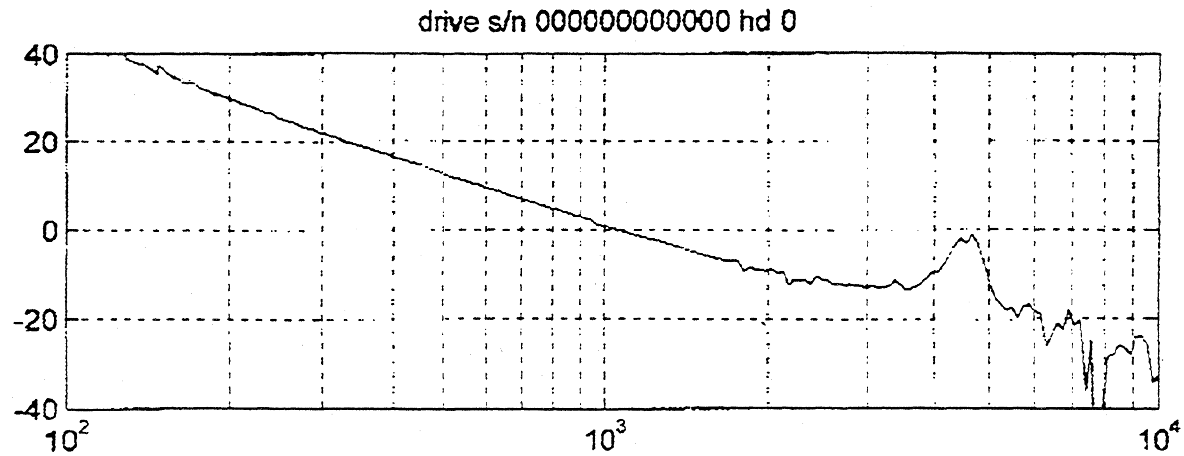

Mechanics Transfer Function
Magnitude (dB) / Phase (45 Deg/Div)
80
60
40
20
0
-20
-40
-60
-80
10^1
10^2
10^3
Frequency (Hz)
Drive S/N: 1D3104
Thu Aug 17 10:41:35 1995
File: h0id3104.m

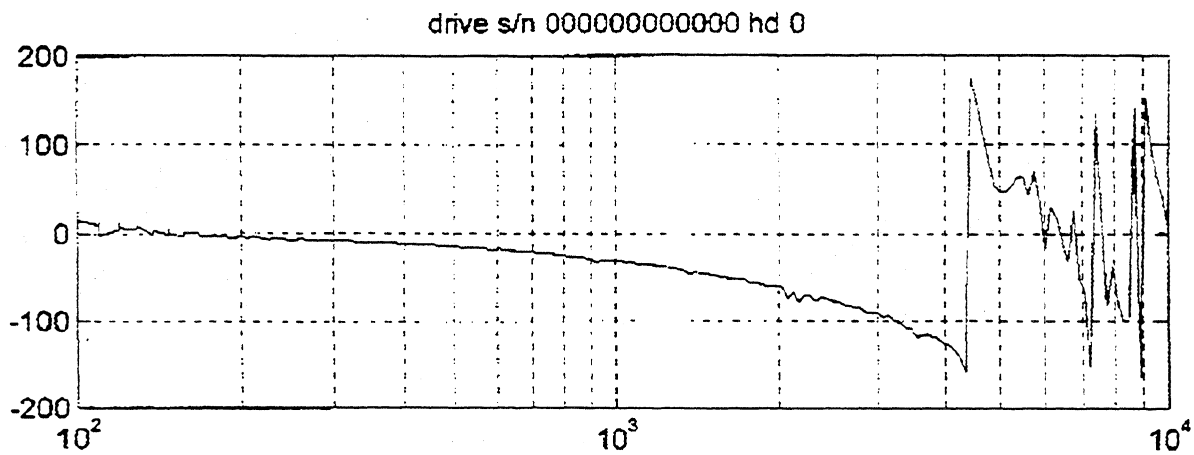
S/N 381577794229



S/N 94229

4k 3815777 94220

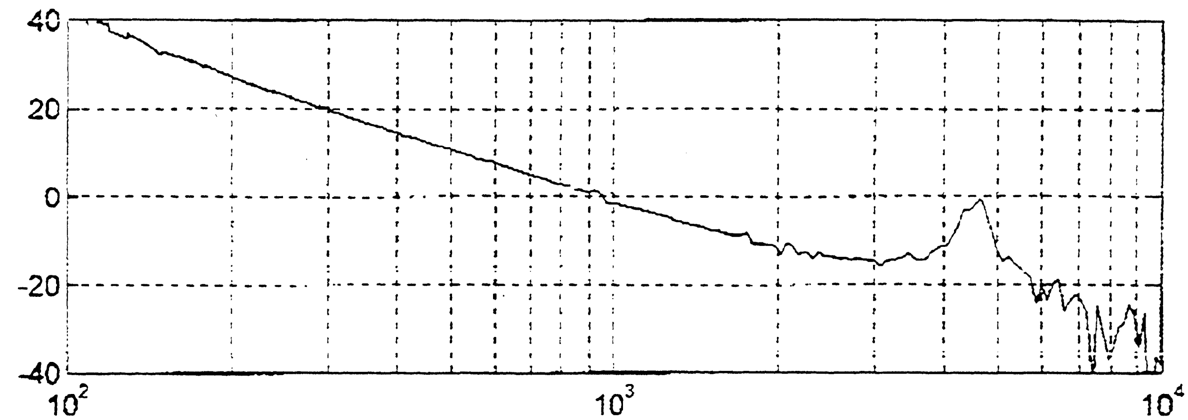




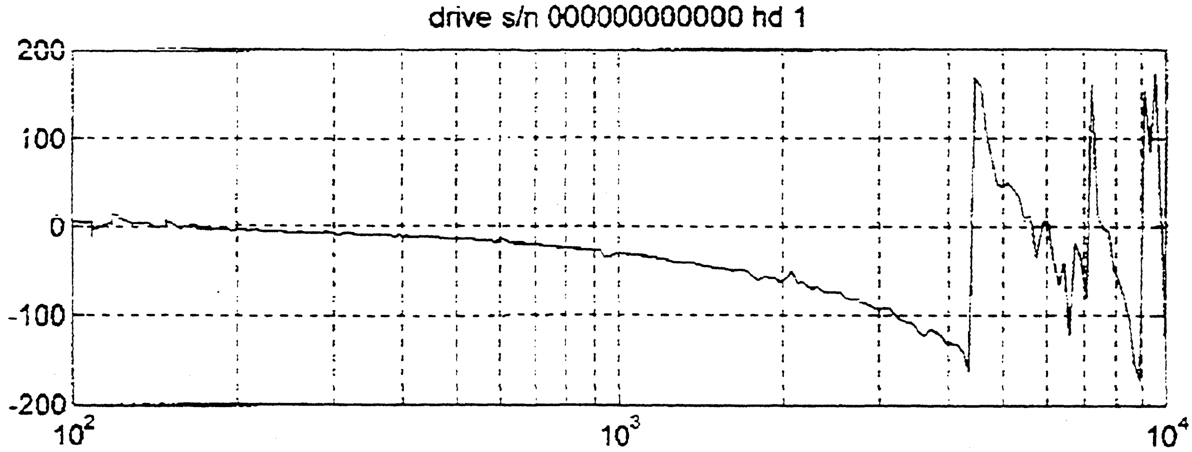
S/N 3815777
94220

S/N 3815777 94220

drive s/n 000000000000 hd 1



drive s/n 000000000000 hd 1



SN/ 3815 777
94220

SIROCCO/1D/E2/ACOUSTIC SOUND

4/3/95 F. H & T.K.

1. Two thickness of PCBs are used for this measurement. One is 1.2 mm thick, another is 0.8 mm.
2. Perform @ Qntm acoustic chamber in building 5. B&K-2123 analyzer is the tester.
3. Sound power(Bel) and sound pressure(dB) are measured per ANSI spec.
4. Due to chamber availability, and the first 10 drives results indicate that : No significant deviation between thick and thin PCB. Therefore, thick PCB is used thereafter.

S/N	THICK PCB/DOWN		THICK PCB / UP		THIN PCB / DOWN		THIN PCB / UP		MOTOR
	Pressure	Power	Pressure	Power	Pressure	Power	Pressure	Power	
650011	28.10	3.36	30.50	3.47	28.40	3.39	31.20	3.46	PMDM/FMA013-NMB,FF,Mult/AKC,Mcage
650014	29.80	3.48	32.60	3.56					PMDM/FMA010-NMB,FF,Mult/AKC,Mcage
650017	27.00	3.19	30.30	3.27	27.30	3.21	30.30	3.27	PMDM/FMA002-NMB,FF,Mult/AKC,Mcage
650021	29.70	3.44	32.60	3.50					PMDM/FMA004E,NMB,FF,Mult/AKC,Mcage
650023	29.50	3.42	32.10	3.47					PMDM/FMA002E,NMB,FF,Mult/AKC,Mcage
651001	28.50	3.25	30.40	3.34					PMDM/FMM003-NMB,FF,Mult/Mult,Mcage
631001	29.40	3.47	31.80	3.52					N10950802-NMB,FF,Mult/AKC,Mcage
631004	28.70	3.39	29.90	3.34	28.60	3.40	32.70	3.56	N1N950807-NMB,FF,Mult/AKC,Mcage
650001	27.80	3.12	29.00	3.16	27.40	3.18	28.80	3.18	N20950810-NSK,FF,Mult/AKC,Pcage
650005	27.80	3.14	28.70	3.13					N20950811-NSK,FF,Mult/AKC,Pcage
630011	27.30	3.12	28.50	3.14	27.20	3.11	28.40	3.12	N5N950834-NSK,FF,Mult/Mult,Pcage
630013	27.30	3.08	28.40	3.06					N5N950832-NSK,FF,Mult/Mult,Pcage
610032	26.80	3.11	29.20	3.15	27.90	3.19	30.00	3.20	OHZU-NSK,FF,xx/xx,Mcage
610034	25.90	3.04	28.30	3.10	27.30	3.13	28.30	3.10	OHZU-NSK,FF,xx/xx,Mcage
610035	26.70	3.11	29.20	3.19	27.70	3.21	30.30	3.24	OHZU-NSK,FF,xx/xx,Mcage
630001	28.00	3.19	29.50	3.27	28.20	3.26	29.30	3.25	OHZU-NMB,FF,xx/xx,Mcage
630002	28.00	3.33	30.50	3.32	29.10	3.39	30.90	3.36	OHZU-NMB,FF,xx/xx,Mcage
*610004	32.30	3.60	37.80	3.79					OHZU-NMB,FF,xx/xx,Mcage
610021	27.50	3.19	29.40	3.24					OHZUE-NMB,LS,AKC/AKC,Mcage
610022	28.10	3.27	30.50	3.37					OHZUE-NMB,LS,AKC/AKC,Mcage
610023	27.30	3.18	28.80	3.19					OHZUE-NMB,LS,AKC/AKC,Mcage
631012	28.00	3.18	29.90	3.24					N30950817-NSK,LS,AKC/AKC,Pcage
Average**	**27.43**	**3.20**	**29.49**	**3.24**	**27.91**	**3.25**	**30.02**	**3.27**	
Average	**28.16**	**3.26**	**30.36**	**3.31**					

Comments:
1. On limited samples, idle acoustic, Thick PCB is quieter than thin PCB by 0.5 dB (S. pressure) and 0.04 Bel (S. power).
2. On OHZU samples, NSK bearing is quieter than NMB bearing, about 1.5 dB.(S. pressure)
3. * Drive 610004, acoustic is off spec.(s. pressure = 35 dB, max.). Further FA will be followed.
4. ** Average on the drive testing data with both thick and thin PCB.

1 Disk Acoustics

SIROCCO/1D/E2/ACOUSTIC SOUND

TEST RESULTS SMMARY

1. Based on the data from thick PCB/Down, Idle run.

2. Sound pressure = dB, Sound power = Bel.

3. Results by vendor:

Vendor	Pressure	Power	sample size
OZHU	27.29	3.18	8
PMDM	28.76	3.36	6
Nidec	28.04	3.21	7

4. Results by lubricant type:

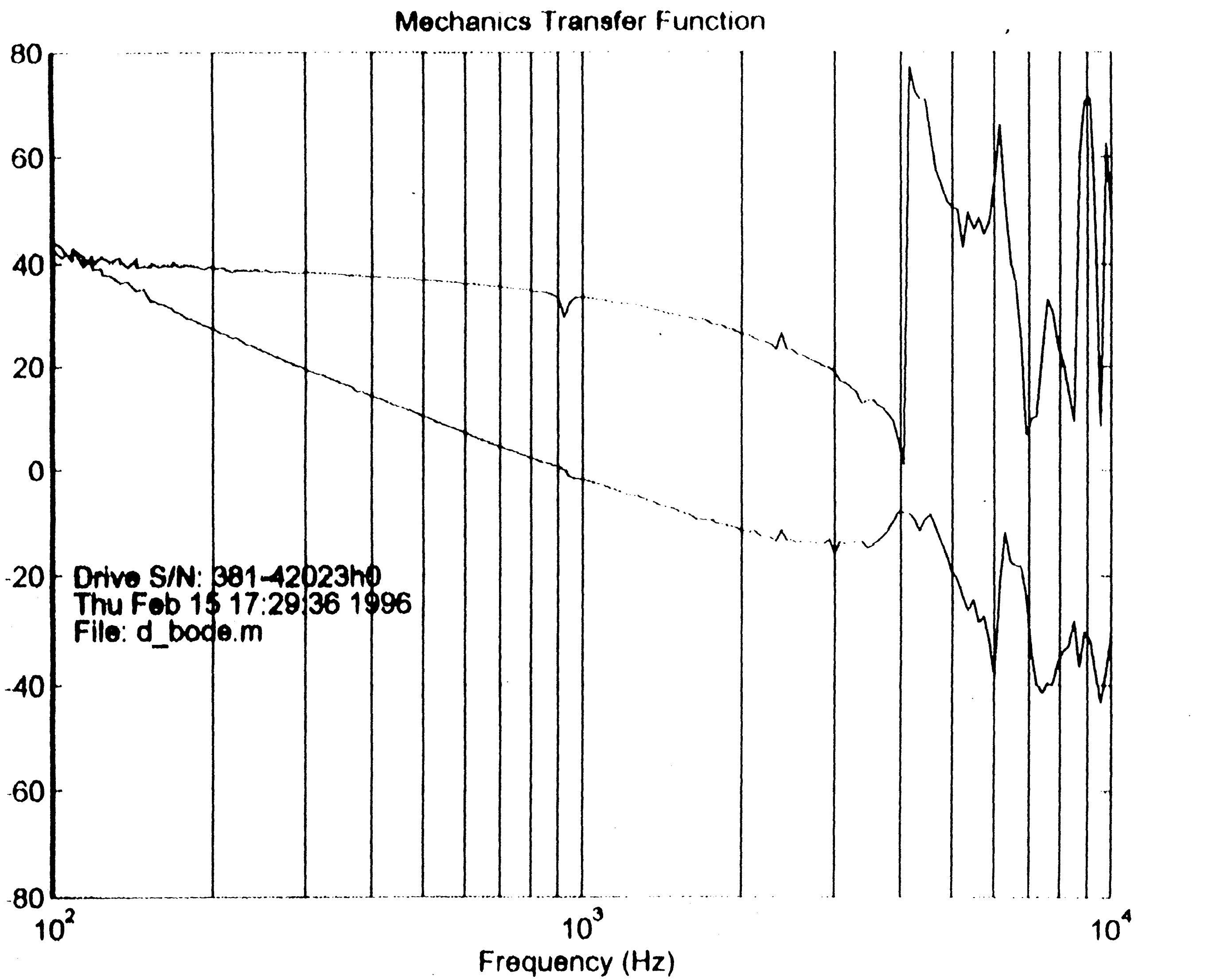
FF = Ferro-Fluid seal, M=Multemp, A=AKC.

Lubricant	Pressure	Power	sample size
FF,M/M	27.70	3.15	3
FF,M/A	28.64	3.33	9
LS, A/A	27.73	3.21	4

1 DISK ACOUSTICS

1 Disk Data Update

- From P2 Build
- Completed on 2/21/96

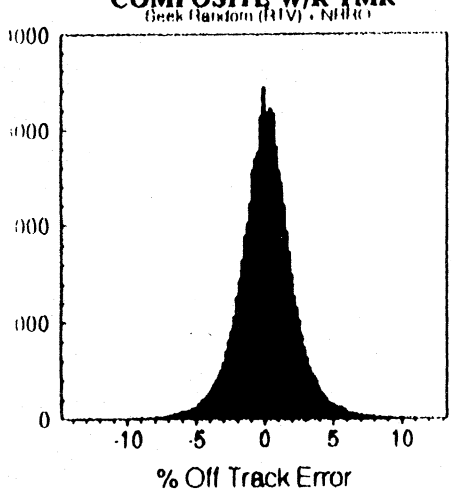


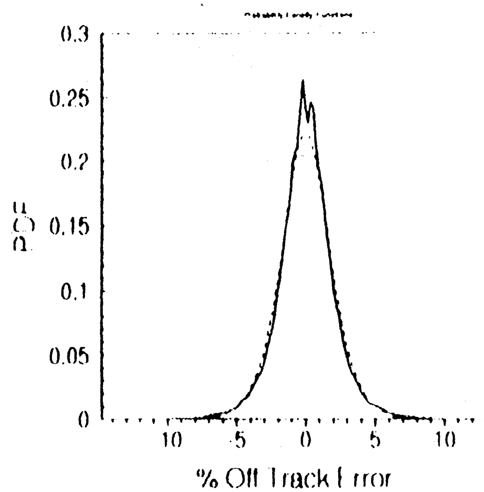
BODE PLOT

2/15/96

PZ HDA - 1 DISK

COMPOSITE W/R TMR



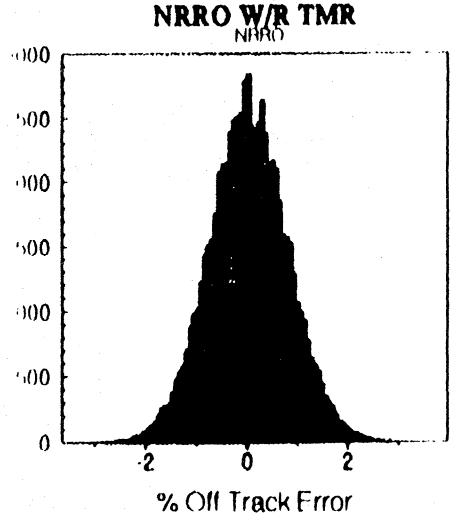


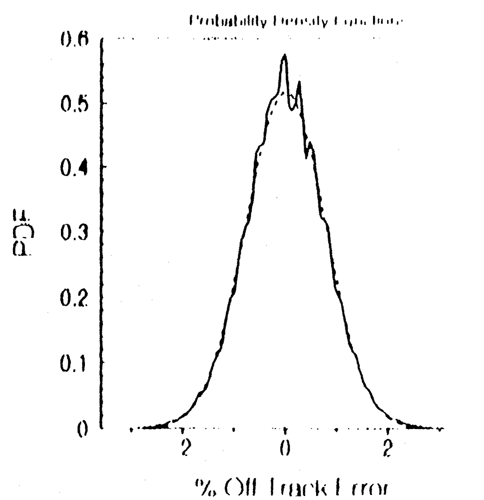
DriveID 381688842023
HDA Variation Code p2test
3 σ = 6.12 %
Population Estimate, Based
on Cumulative Peak Method.
σ (real) = 7.05 % ([illegible] events)
[illegible]

TMR DATA

P2 HDA - 1 DISK

NRRO W/R TMR





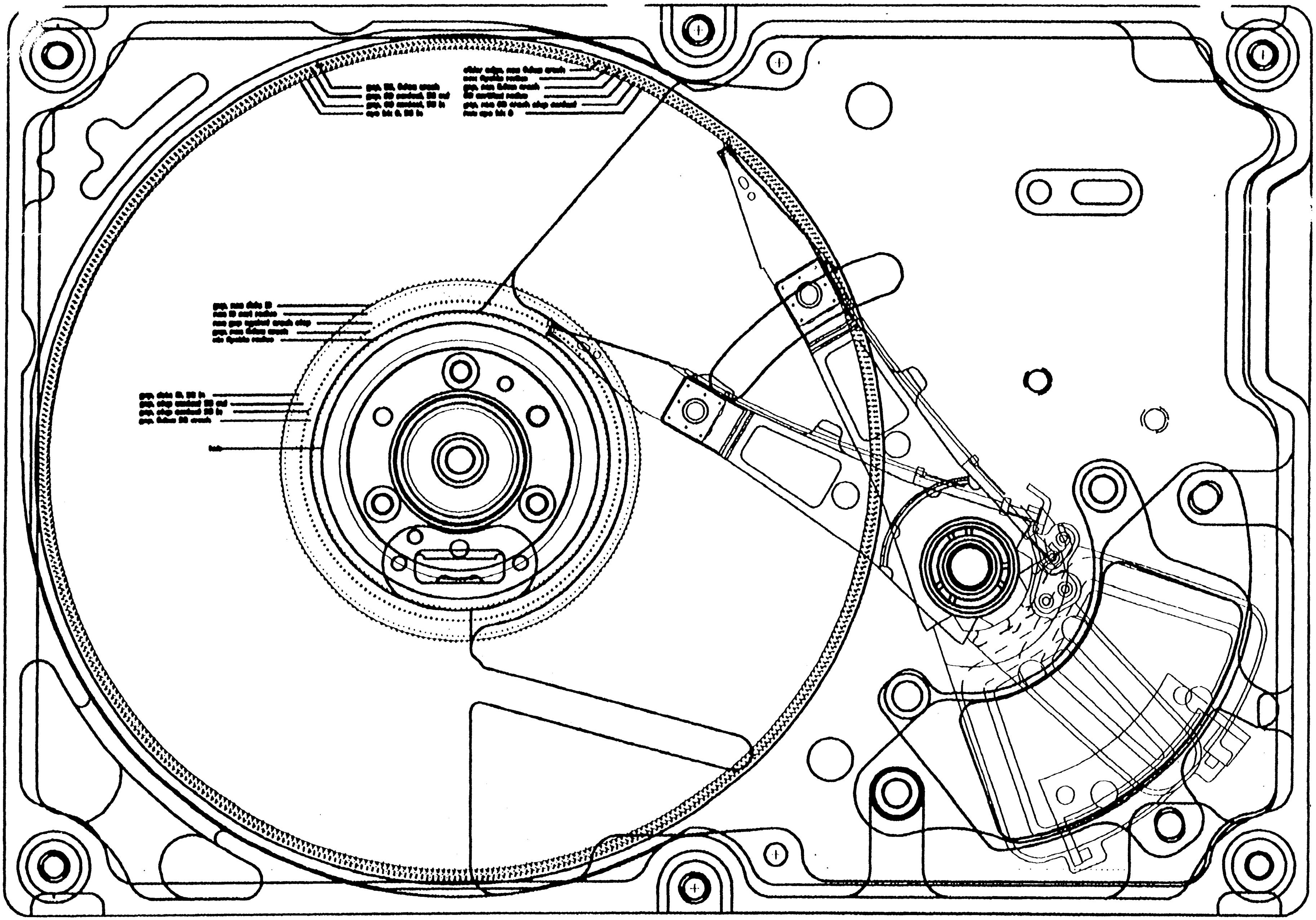
3 σ = 2.31 %
σ Population Estimate = 2.45 %

2 / 3 Disk HDA Design

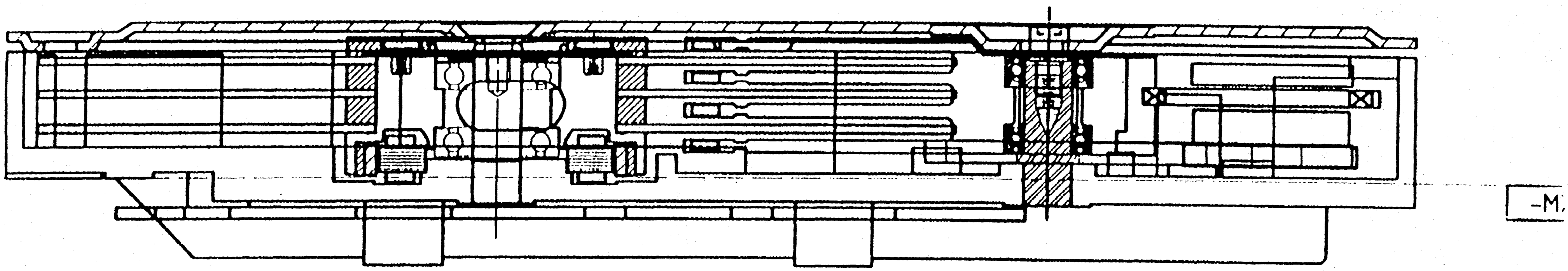
- Mechanical Assembly Overview
- Commonality with Sirocco
- Commonality with Fireball
- Base / Motor / Disk Stack Assembly
- Actuator Assembly
- Voice Coil Motor Assembly
- Air Lock Design
- Cover Design

2/3 Disk Commonalities with Fireball

- 2/3 Disk HDA Base Casting Is Compatible with Fireball Assembly Line and Servowriter
- Actuator Assembly Is Compatible with Fireball Assembly Line
- Air Lock is Same Basic Design with Slight Geometry Modifications
- VCM Magnet Plates, Coil Plan View, and Flex Mounting Are Same as Fireball
- PCBA Mounting Holes on Base Are Compatible with Fireball and Trail Blazer Hole Pattern

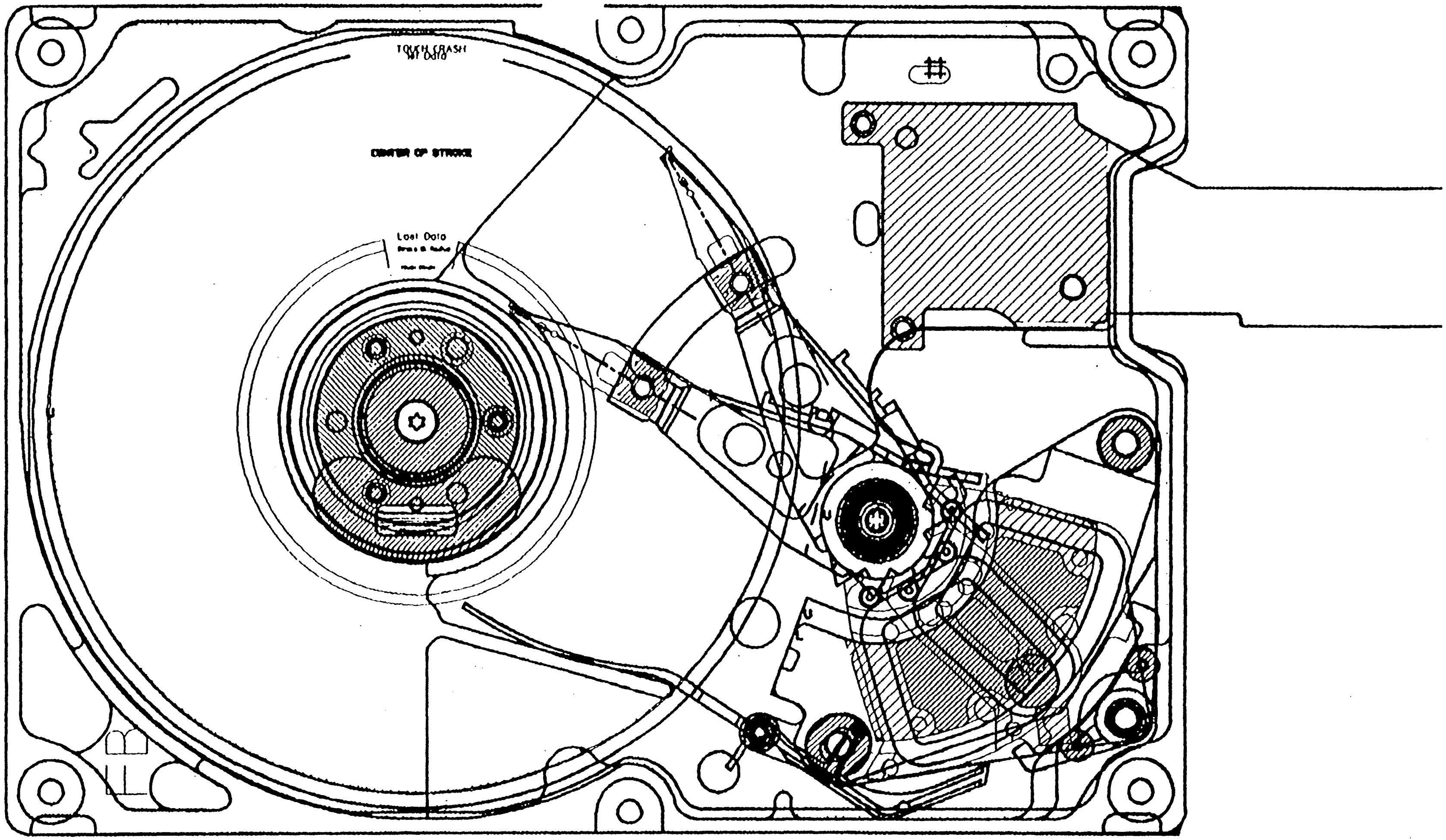


Plan View of 2/3 Disk HDA Design



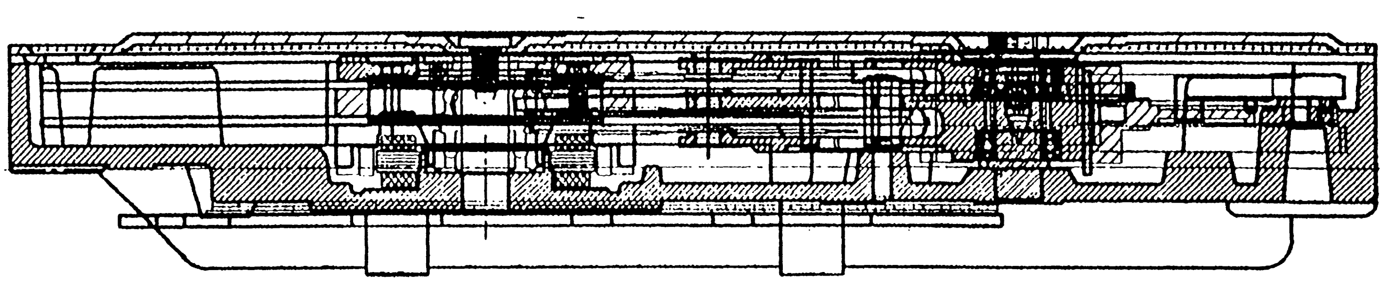
Cross Section View of 2/3 Disk HDA Design

TOP VIEW



Fireball 1.08 Gb 2disk HDA

SIDE VIEW



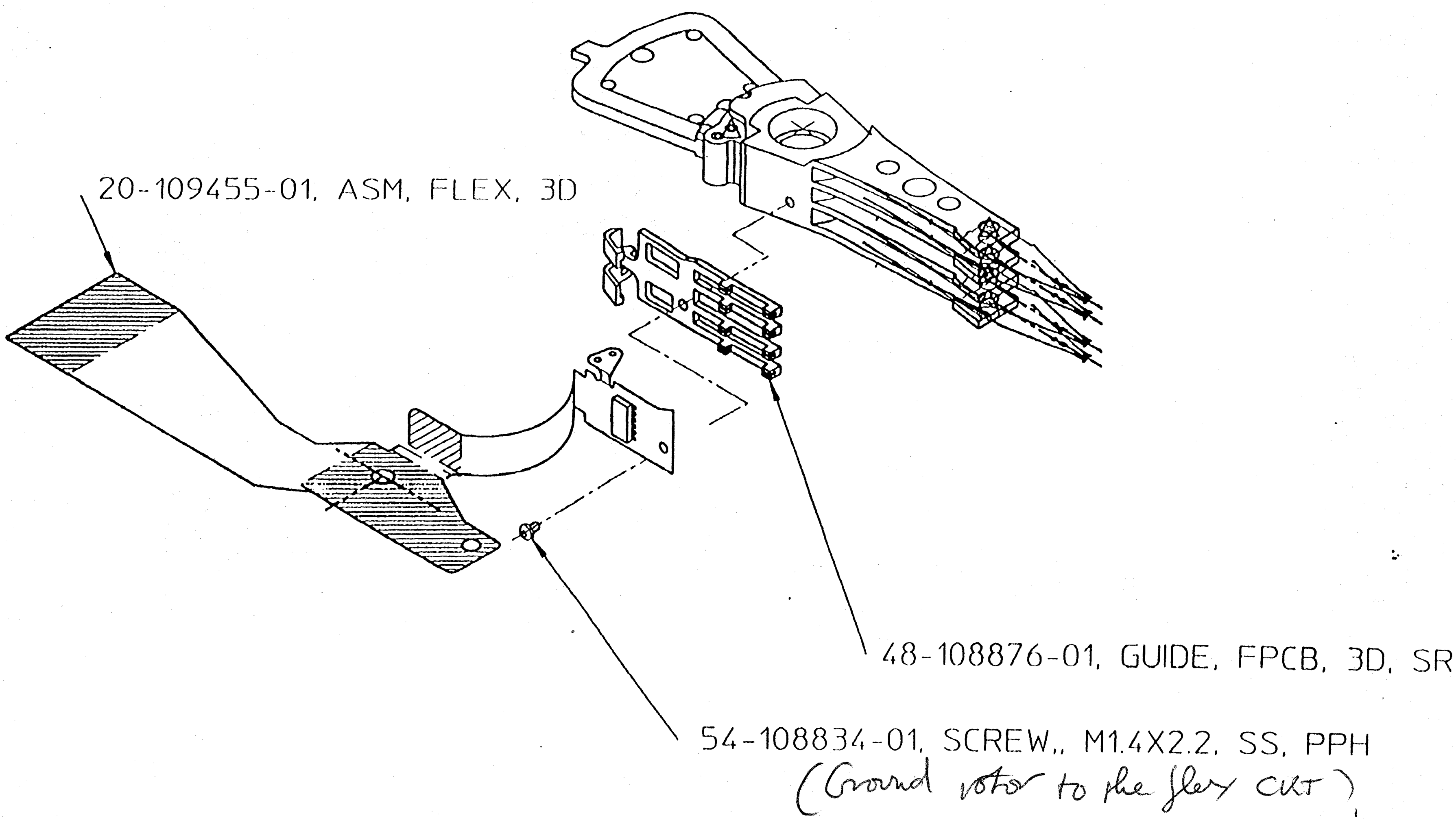
-MX-

Actuator Assembly

- Cast / Machined Aluminum Rotor for 10 ms. Access Time
- Same Plan View as for TrailBlazer
- Standard Suspension Swage Mount for Hutchinson Type 850
- Same Bearings as Fireball
- Top of Shaft Fixed to Cover for Support
- Lower Resistance Coil than Fireball

2/3 Disk VCM Comparison with Fireball

Parameter	2/3D Tempest	2D Fireball
Max Torque Constant (gm cm/A)	730	540
Head Gap Radius (cm)	54.42	52.07
Total Inertia (gm cm2)	43	35
Coil Resistance @ 22deg C (Ohms)	11.2	13.8
Max Gap Flux (Gauss)	7900	5700
Coil # of turns	180	185
Coil wire diameter (mm)	0.160	0.146
Magnet material energy product (MgOe)	41	40
1/3 Stroke Move Time (mechanical)-(ms)	6.6	7.25
Average Seek Time (spec)-(ms)	11.5	10.5
Estimated allowance for settle time-(ms)	4.9	3.25



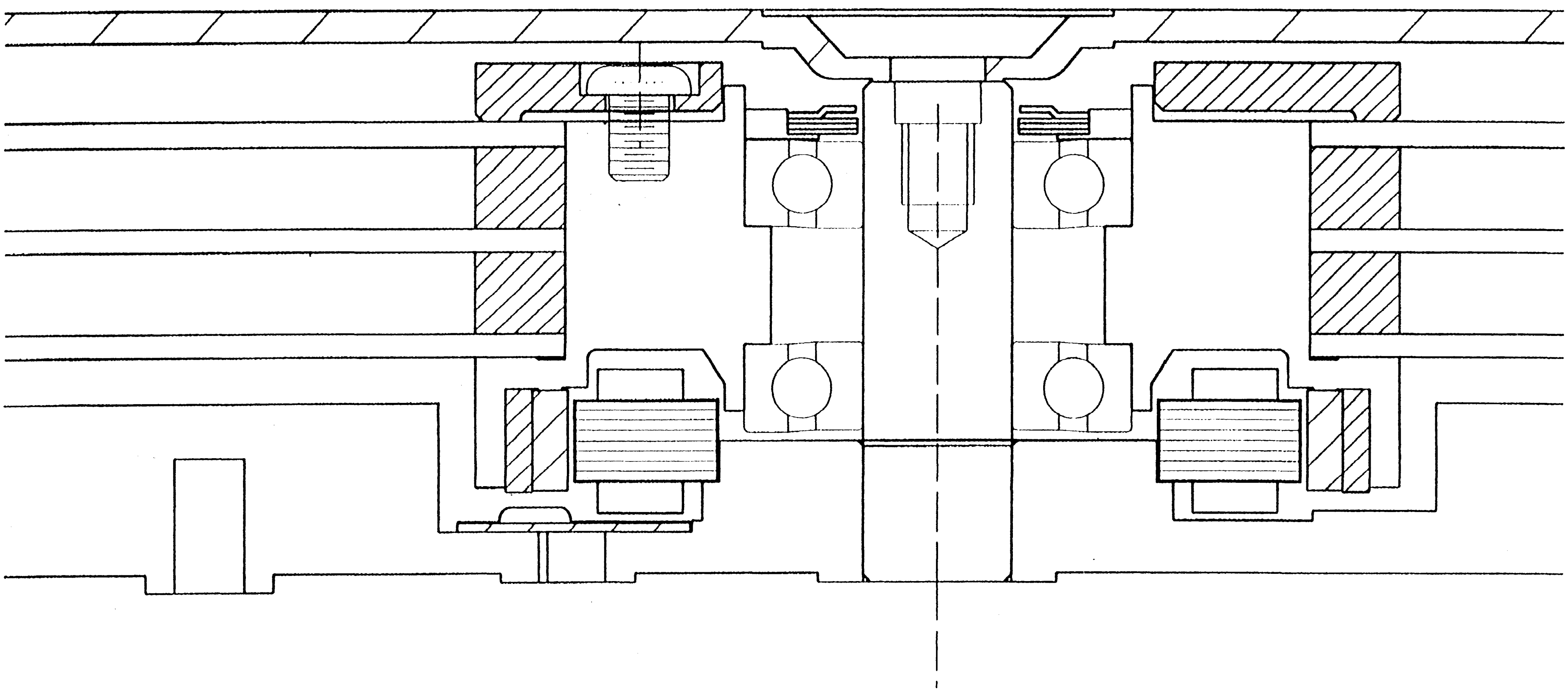
TEMPEST 6 head actuator

Flex PCB

- Design for Small Dynamic Loop with Minimum Force Bias
- Preamp IC on Rotor
- 2 Disk : 16 Traces to Heads
- 3 Disk : 24 Traces to Heads
- 24 Pin ZIF Connector to PCBA

Base Casting Design

- Basic Die Cast Aluminum Bowl Approach like Fireball
- Increased Wall Thickness at Bottom for Reduced Acoustics
- Machined PCBA Mounting Pads for Tolerance Control
- PCBA Mounting Plane to Accommodate PLCC Package Heights of Shiva and Mighty ICs
- Interface to Push Rod Servowriter Like Trail Blazer



Cross Section View of 2/3 Disk HDA In the Flange Motor

Spindle / Motor Design

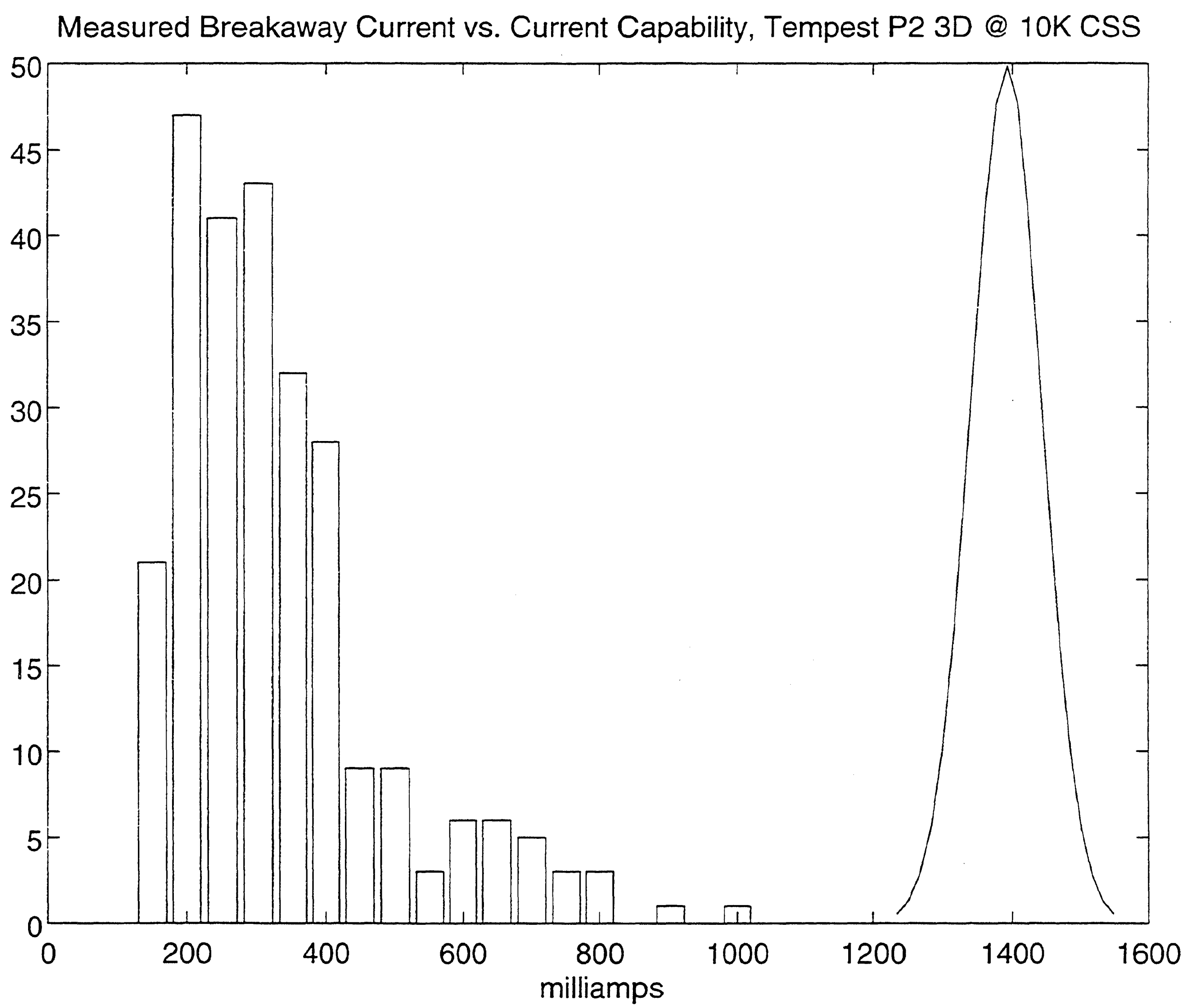
- 12 Pole Motor vs. 8 Pole Motor
- Benefits :
  - Enables Lower Power Consumption
  - Lower Acoustics Due to Lower Radial Forces - No Assymetry
  - Higher Km than 8 Pole - More Starting Torque
  - Provides Design Margin for Head / Media Friction
- Pin Connector Interface to PCBA Like 1 Disk HDA

2/3 Disk Spindle Motor Comparison with Fireball

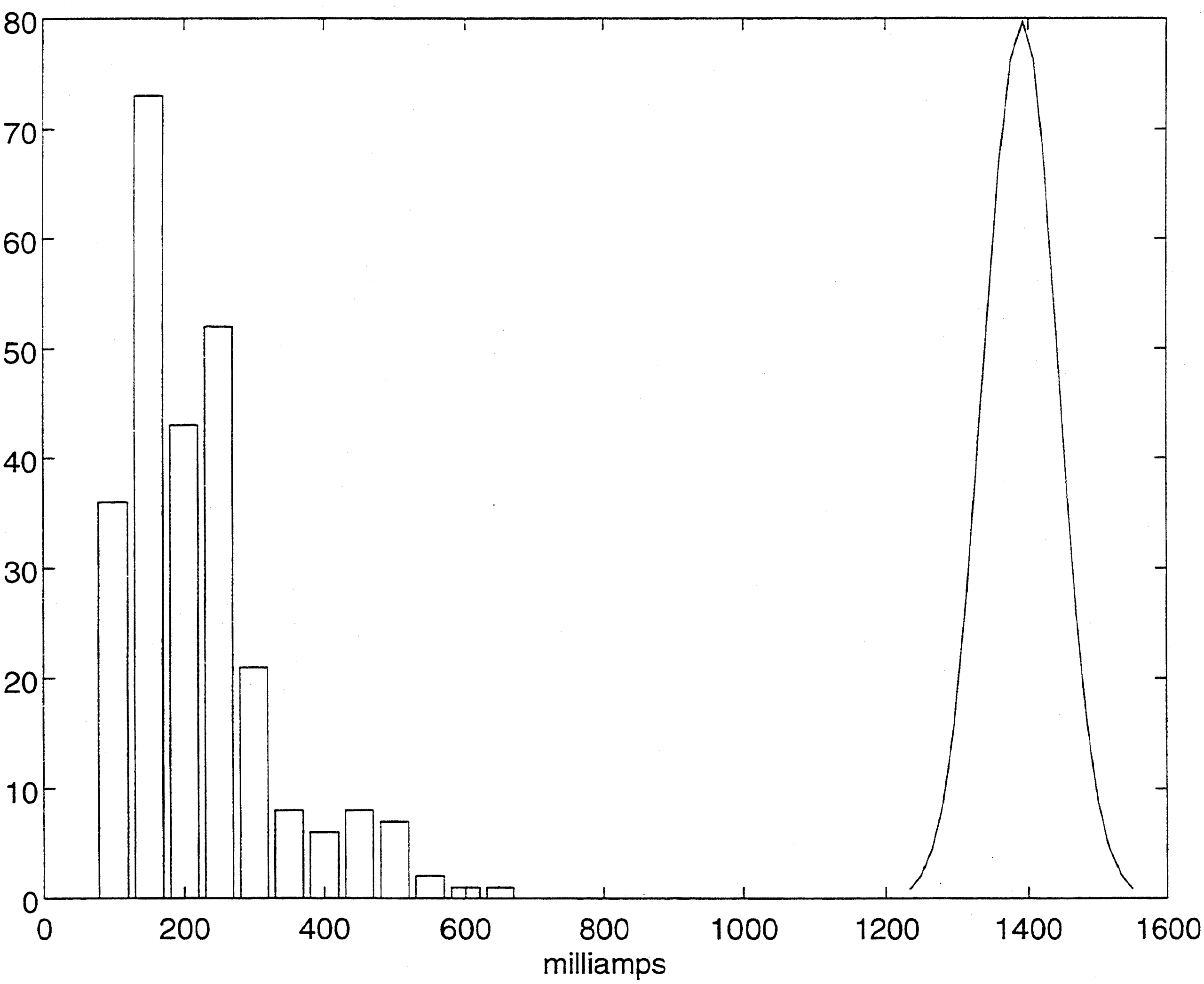
Parameter	Tempest 2/3 Disk	Fireball 2 Disk
Rotational Speed (RPM)	4500	5400
Torque Constant (gmf cm/A)	170	140
Coil Resistance (Ohms)	6.0 +/- 10%	6.2 +/- 10%
Coil Inductance (mH)	1.8 Max	.9 +/- 15%
Static Rocking Mode (Hz.)	> 485	> 470
NRRO (micro in. - radial P-P)	8 Max	10 Max
Imbalance (mg cm)	50	50
Average Run Current (milli amps)	56 (no load)	< 185
BEMF (Volts)	8 +/- 5 %	7.77
Bearing Size	1350	1150
Lubrication	Multemp	Andok C
Number of Poles	12	8
Minimum Starting Torque (gmf-cm @ 1.0 amp)	132	85
Starting Torque (gmf-cm @ 1.2 amp)	158	

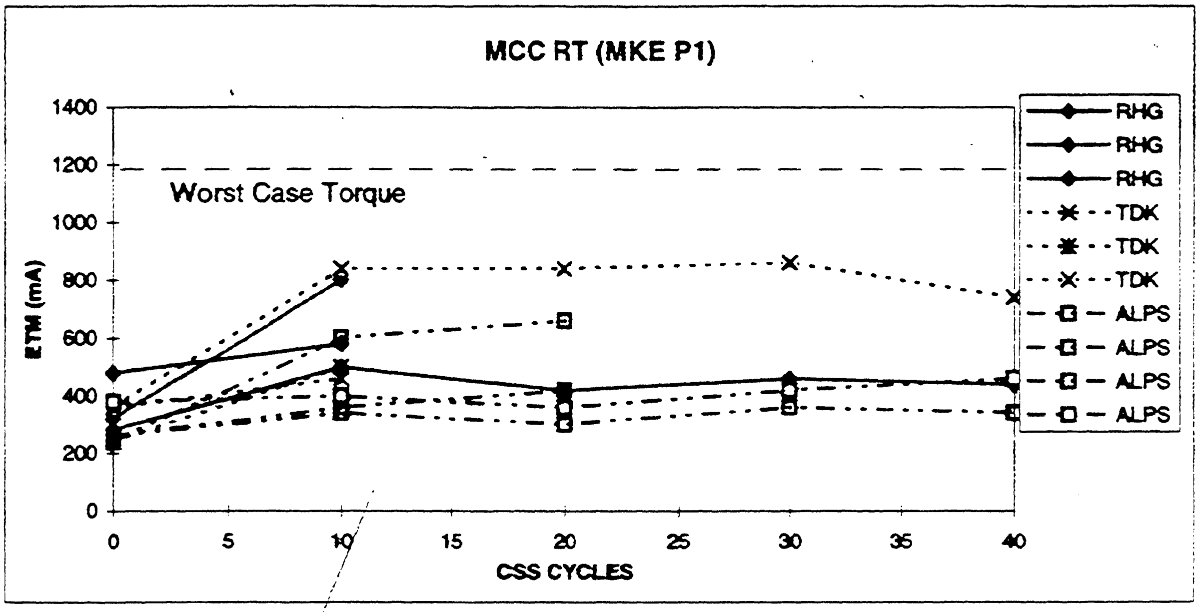
Spindle / Motor Design

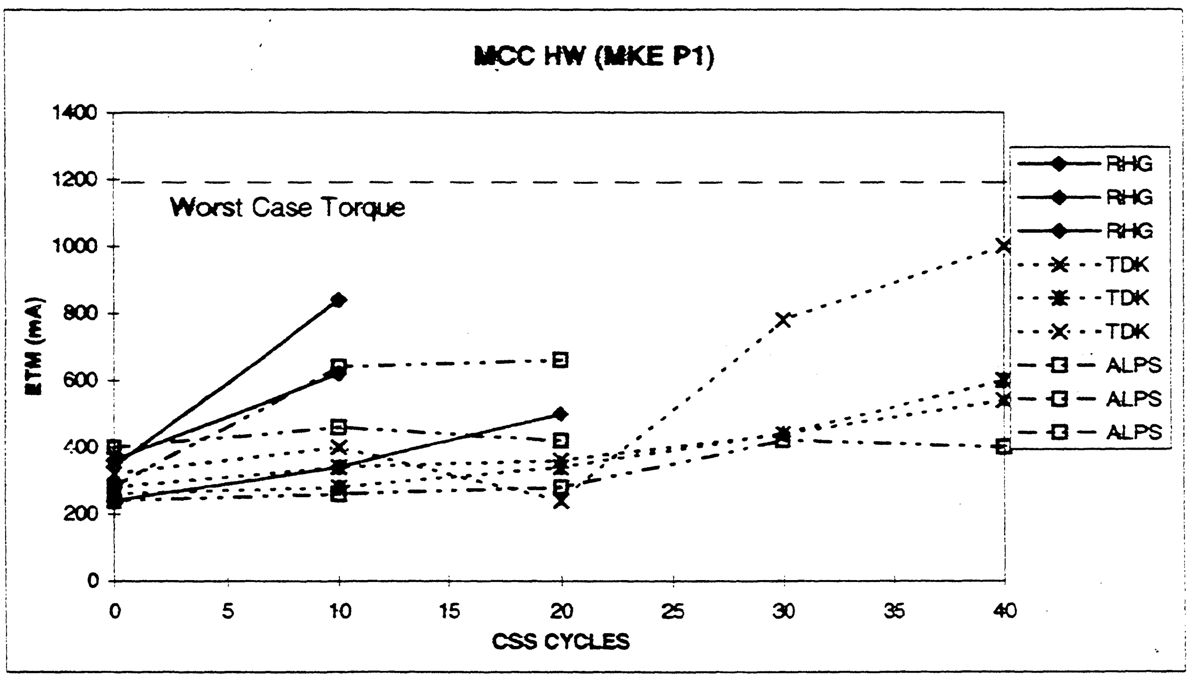
- Stationary Shaft Design Supported at Both Ends
- In the Flange Motor Selected :
  - For Less Cost than In the Hub Motor
  - Enables Use of 1350 Bearing vs. 1150 Bearing
- 1350 Bearing Benefits :
  - Enables Detuning the Rocking Mode from the Bearing Frequencies
  - Stiffer and Better for Shock and Vibration
- Lower Acoustics, NRRO, and Power Consumption with 1350 Bearing

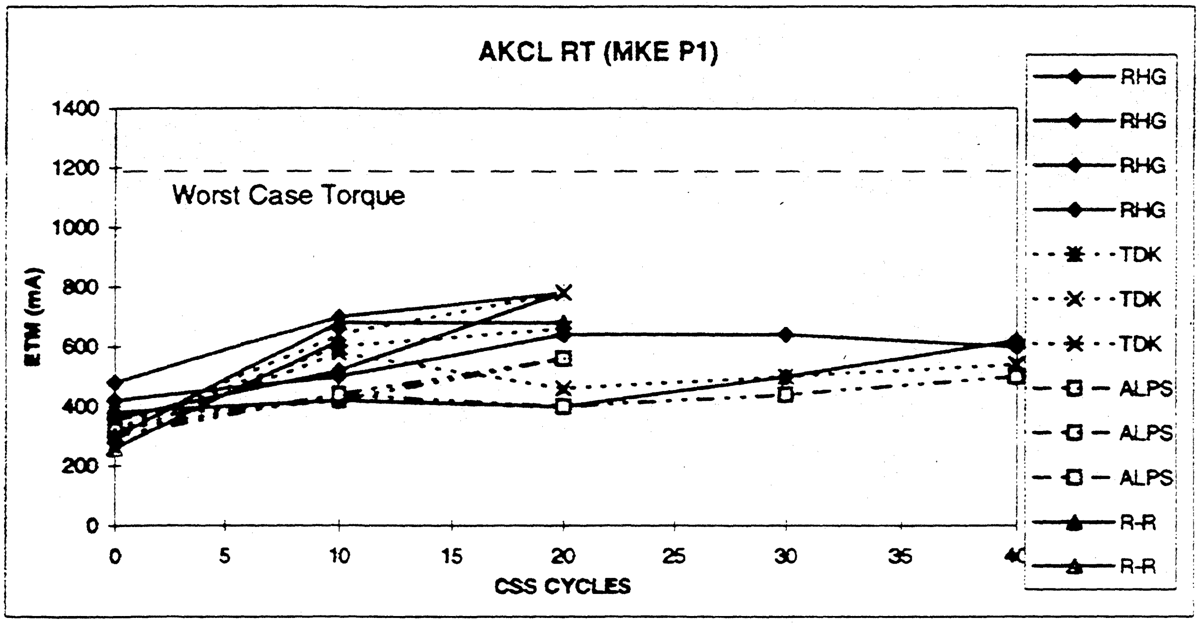

Measured Breakaway Current vs. Current Capability, Tempest P2 3D @ 10K CSS
50
45
40
35
30
25
20
15
10
5
0
0
200
400
600
800
1000
1200
1400
1600
milliamps

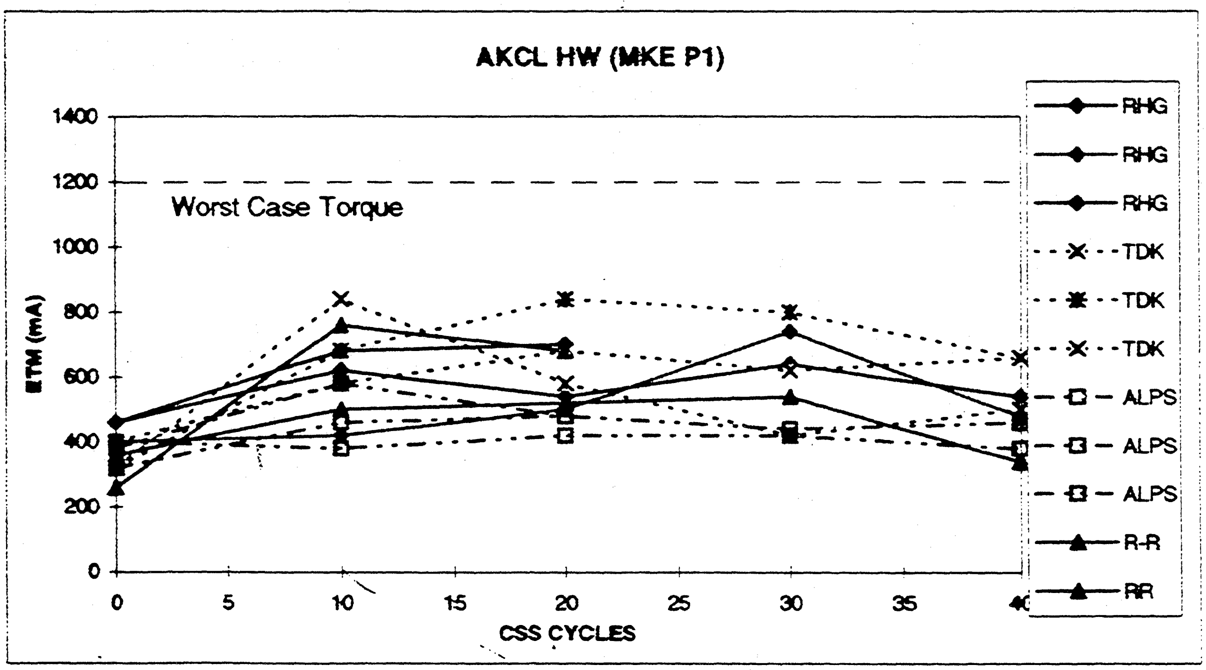
Measured Breakaway Current vs. Current Capability, Tempest P2 2D @ 10K CSS, Extrapolated



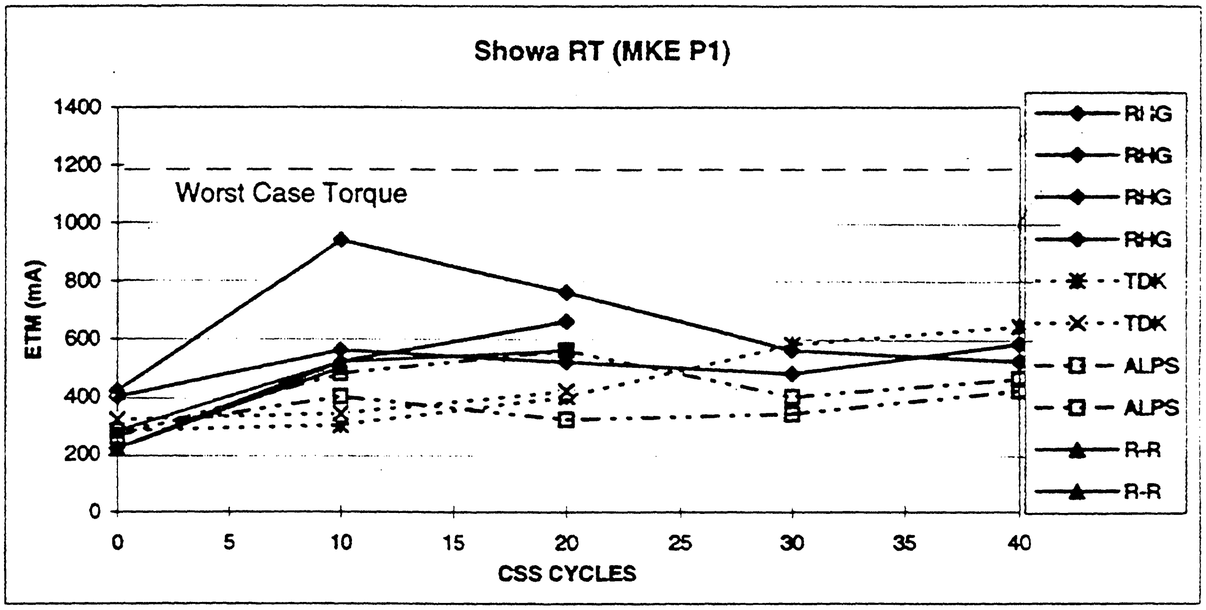

MCC RT (MKE P1)
1400
1200
1000
800
600
400
200
0
Worst Case Torque
ETM (mA)
0
5
10
15
20
25
30
35
40
CSS CYCLES
RHG
RHG
RHG
TDK
TDK
TDK
ALPS
ALPS
ALPS
ALPS


MCC HW (MKE P1)
1400
1200
1000
800
600
400
200
0
Worst Case Torque
ETM (mA)
0
5
10
15
20
25
30
35
40
CSS CYCLES
RHG
RHG
RHG
TDK
TDK
TDK
ALPS
ALPS
ALPS

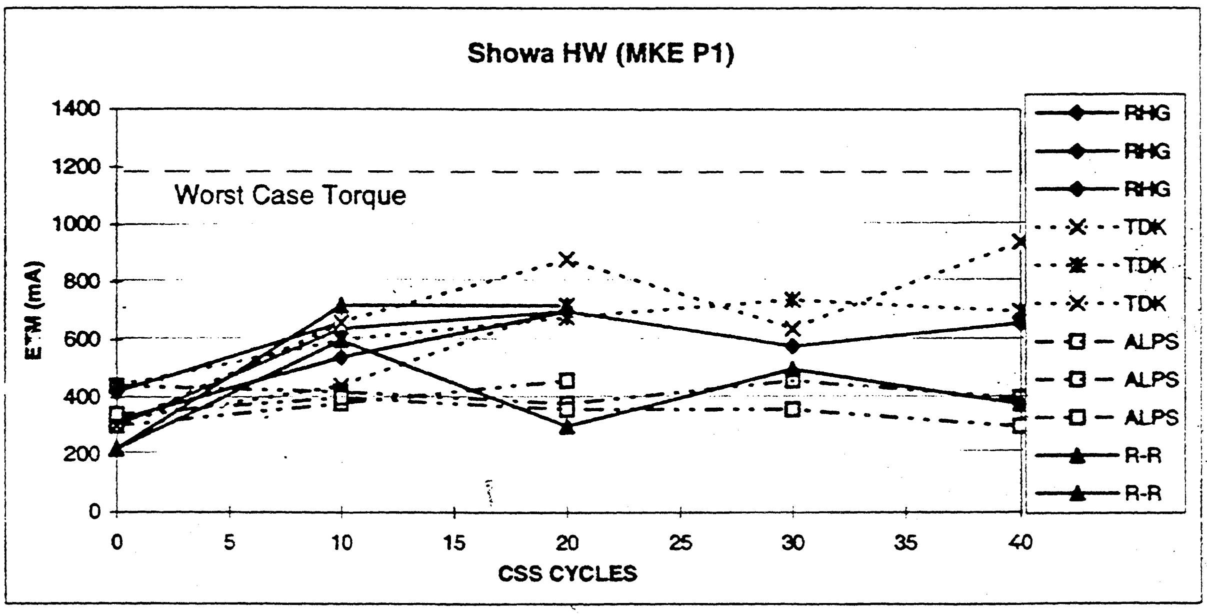

AKCL RT (MKE P1)
Worst Case Torque
ETM (mA)
CSS CYCLES
RHG
RHG
RHG
RHG
TDK
TDK
TDK
ALPS
ALPS
ALPS
R-R
R-R


AKCL HW (MKE P1)
Worst Case Torque
ETM (mA)
CSS CYCLES
RHG
RHG
RHG
TDK
TDK
TDK
ALPS
ALPS
ALPS
R-R
RR

SHOWA



Showa RT (MKE P1)
1400
1200
1000
800
600
400
200
0
ETM (mA)
Worst Case Torque
0
5
10
15
20
25
30
35
40
CSS CYCLES
RHG
RHG
RHG
RHG
TDK
TDK
ALPS
ALPS
R-R
R-R



Showa HW (MKE P1)
1400
1200
1000
800
600
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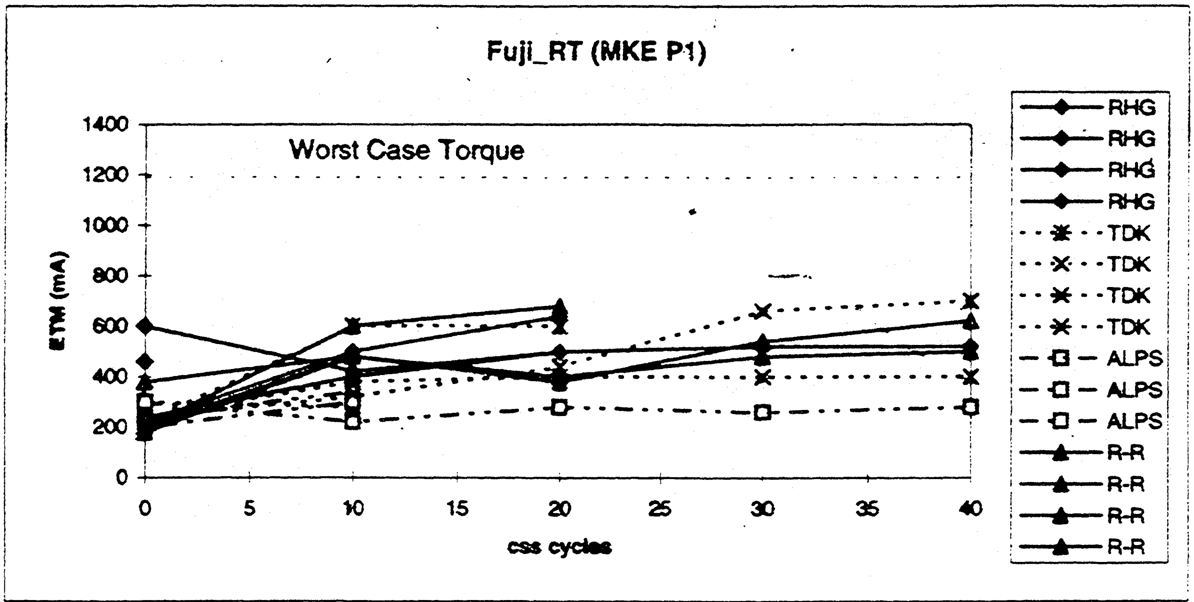
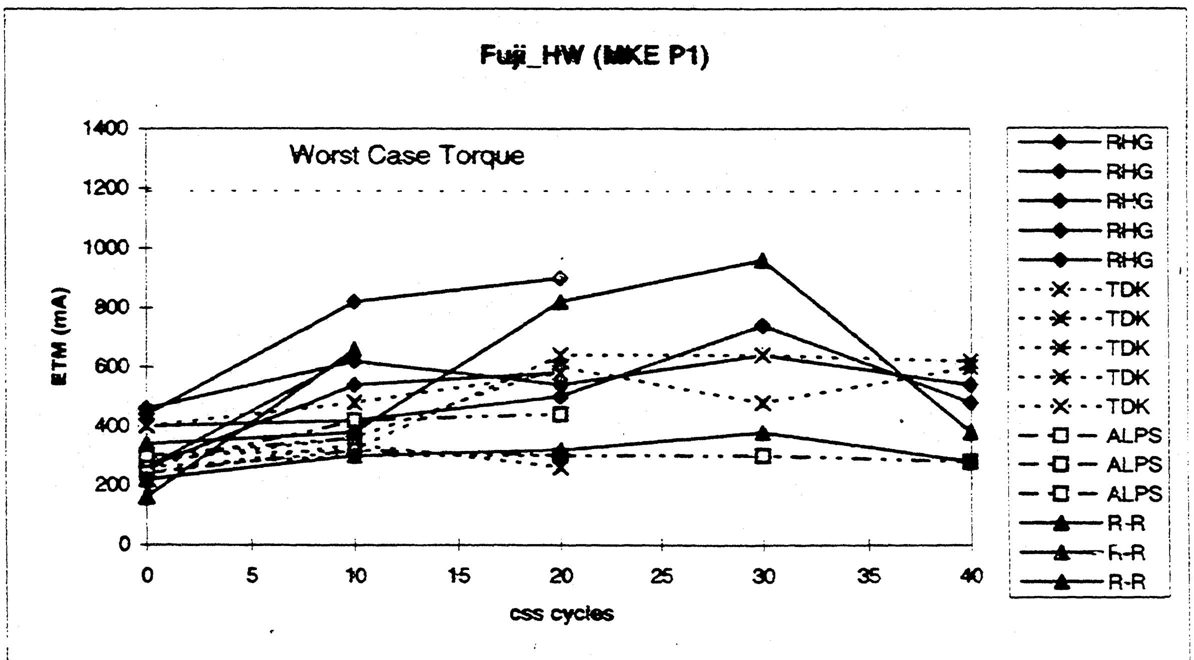
200
0
ETM (mA)
Worst Case Torque
0
5
10
15
20
25
30
35
40
CSS CYCLES
RHG
RHG
RHG
TDK
TDK
TDK
ALPS
ALPS
ALPS
R-R
R-R


Fuji_RT (MKE P1)
Worst Case Torque
1400
1200
1000
800
600
400
200
0
ETM (mA)
0
5
10
15
20
25
30
35
40
css cycles
RHG
RHG
RHG
RHG
TDK
TDK
TDK
TDK
ALPS
ALPS
ALPS
R-R
R-R
R-R
R-R


Worst Case Torque
1400
1200
1000
800
600
400
200
0
ETM (mA)
0
5
10
15
20
25
30
35
40
css cycles
RHG
RHG
RHG
RHG
RHG
TDK
TDK
TDK
TDK
TDK
ALPS
ALPS
ALPS
R-R
R-R
R-R

File Name = Mitypwr.mcd
Ali Kheymehdooz on Sep./25/1995
This MathCad file calculates the power dissipation in Mighty motor driver chip in 1/3 stroke seek and also the start up current for Tempest 3 platter HDAs. Total of 9 pages

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Summary:

This report consists of two main parts. Part one calculates the power dissipation of the Mighty chip durnig 1/3 stroke seek for 3 platter HDA, part two (pages 8 and 9) calculates the spindle start up current capability for 3 platter HDA.

Part (1) Mighty power dissipation is done in three part:

1. Spindle section during run
2. VCM section during 1.3 stroke seek
3. Idle Power which is the bias currents drawn from the supplies to keep the chip operating.
4. Total seek time =10.2 ms.

In doing the power calculation some assumptions were made to simplify the calculations.

1. Seek current was averaged over accel and decel.
2. BEMF voltage during seek was calculated using nominal VCM mechanical parameters.
3. Seek time was divided into two major segment, accel and decel.
4. Total seek time and VCM current value during decel was obtained from simulation result.

Conclusion:

Power calculation:

The maximum safe junction temperature for Mighty is 150 deg. C. It is seen that under typical conditions the junction temperature is below that and under extreme worst case this value is exceeded by 32 degree. The power dissipated during seek is 4.8w nominal and 5.67w max. with 50% duty cycle on the seek the total power including spindle and bias power is 2.8w nominal and 3.7w max.

This analysis was compared with Matlab simulation result. It is seen that the total seek power values match to within 10%, however individual Accel and Decel powers do not match. The reason for this could be in addition to all the above assumptions the fact that the currents for accel and decel were linearly approximated where the actual waveforms are not linear.

One possible way to reduce the power dissipation is to change the decel current profile (increase current) and/or decrease the decel time. In the present simulation we have anticipate function where the decel point is anticipated and the current is reduced gradually ahead of the switch point which will reduce the overall decel current. We could shorten the anticipation. It should also be noted that these values are all based on calculations and simulations, next step will be to measure the power and temperature during 1/3 stroke seek to verify the calculations.

Start up current:

Mighty operates in a closed loop current control at start up to limit the start up current, the Minimum start up current under closed loop control [redacted].

Another possible solution to increasing the start current is to disable the closed loop control by putting Mighty [redacted]or Position Detection or Induction Sense Mode), doing this the start up current is then limited by the voltage drop across the spindle output drivers, the spindle motor resistance, sense resistor and the 12V power supply, [redacted].

Part (1). 1. Spindle power dissipation during run is calculated by knowing the runcurrent of the spindle by means of measurement

$Vcc12\_nom := 12$ **Volt** $Vcc12\_max := 13.2$ **Volt** $Vcc12\_min := 10.8$ **Volt , 12v power supply**

Current thru 5 and 12 volt supply at idle

$Ivcc12\_nom := 0.02$ **Amp typical** $Ivcc12\_max := 0.033$ **Amp maximum**
$Ivcc5\_nom := 0.005$ **Amp typical** $Ivcc5\_max := 0.008$ **Amp maximum**

$Irun\_nom := 0.160$ **Amp** $Irun\_max := 0.200$ **Amp, current thru spindle**

$Rspindle\_nom := 6.0$ **Ohm at 25 deg. C, spindle winding resistance from spec.**
$Rspindle\_max := Rspindle\_nom \cdot 1.10$ $Rspindle\_max = 6.6$ **Ohm at 70 Deg. C**
$Rspindle\_min := Rspindle\_nom \cdot 0.9$ $Rspindle\_min = 5.4$ **Ohm at 25 Deg. C**

$Rsense\_nom := 0.33$ **Ohm, sense resistor**
$Rsense\_max := Rsense\_nom \cdot 1.05$ $Rsense\_max = 0.347$ **Ohm**
$Rsense\_min := Rsense\_nom \cdot 0.95$ $Rsense\_min = 0.314$ **Ohm**

$V\_bemf\_nom := 8.0$ **BEMF Voltage at 4500 rpm, from spec.**
$V\_bemf\_max := V\_bemf\_nom \cdot 1.05$ $V\_bemf\_max = 8.4$ **Volt**
$V\_bemf\_min := V\_bemf\_nom \cdot 0.95$ $V\_bemf\_min = 7.6$ **Volt**

Total power drawn from the 12 volt supply

$Total\_Vcc12\_power\_nom := Vcc12\_nom \cdot Irun\_nom$
$Total\_Vcc12\_power\_nom = 1.92$ **Watts**

$Total\_Vcc12\_power\_max := Vcc12\_max \cdot Irun\_max$
$Total\_Vcc12\_power\_max = 2.64$ **Watts**

Power dissipated in the spindle and the sense resistors

$Pd\_in\_spindle\_and\_Rsense\_nom := Irun\_nom^2 \cdot (Rspindle\_nom + Rsense\_nom)$
$Pd\_in\_spindle\_and\_Rsense\_nom = 0.162$ **Watts**

$Pd\_in\_spindle\_and\_Rsense\_min := Irun\_max^2 \cdot (Rspindle\_min + Rsense\_min)$
$Pd\_in\_spindle\_and\_Rsense\_min = 0.229$ **Watts**

Power dissipated due to BEMF voltage

$Pd\_bemf\_nom := V\_bemf\_nom \cdot Irun\_nom$ $Pd\_bemf\_nom = 1.28$ **Watts**
$Pd\_bemf\_min := V\_bemf\_min \cdot Irun\_max$ $Pd\_bemf\_min = 1.52$ **Watts**

Power dissipated in Mighty spindle drivers is the total power minus the power dissipated in spindle and sense resistors and the BEMF power.

$Pd\_spm\_drivers\_nom := Total\_Vcc12\_power\_nom - Pd\_in\_spindle\_and\_Rsense\_nom - Pd\_bemf\_nom$
$Pd\_spm\_drivers\_nom = 0.478$ **Nominal power dissipation in spindle drivers (Watts)**

$Pd\_spm\_drivers\_max := Total\_Vcc12\_power\_max - Pd\_in\_spindle\_and\_Rsense\_min - Pd\_bemf\_min$
$Pd\_spm\_drivers\_max = 0.891$ **Maximum power dissipation in spindle drivers, (Watts)**

2. VCM power dissipation during 1/3 stroke seek is calculated using VCM mechanical parameter and the simulated current profile. The mechanical parameters are used to calculate the BEMF voltage during seek. The calculation is divided into two parts, acceleration and deceleration.

$J := 4300 \cdot gm \cdot mm^2$ $\quad J := \frac{J}{1000 \cdot gm \cdot m^2}$ $\quad J = 4.3 \cdot 10^{-6}$ **Inertia of the motor and disks in Kg.m^2**

$Kt := 700$ **gm.cm/Amp** $\quad Kt := \frac{Kt \cdot 9.8}{10^5}$ $\quad Kt = 0.069$ **Kg.m/Amp Torque constant**

$Ke := Kt$ $\quad Ke = 0.069$ **BEMF constant, V/rad/sec**

$Seek\_time := 10.2$ **Total seek time, ms.**

Some PCB component value relevant to the calculation.

$R2\_nom := 6340$ **Ohm**

$R2\_max := R2\_nom \cdot 1.010$ $\quad R2\_max = 6.403 \cdot 10^3$ **Ohm**

$R2\_min := R2\_nom \cdot 0.99$ $\quad R2\_min = 6.277 \cdot 10^3$ **Ohm**

$R1\_nom := 10000$ **Ohm**

$R1\_max := R1\_nom \cdot 1.010$ $\quad R1\_max = 1.01 \cdot 10^4$ **Ohm**

$R1\_min := R1\_nom \cdot 0.99$ $\quad R1\_min = 9.9 \cdot 10^3$ **Ohm**

$Rsense\_nom := 0.33$ **sense resistor,Ohm**

$Rsense\_max := Rsense\_nom \cdot 1.05$ $\quad Rsense\_max = 0.347$ **Ohm**

$Rsense\_min := Rsense\_nom \cdot 0.95$ $\quad Rsense\_min = 0.314$ **Ohm**

$Rvcm\_nom := 12$ **VCM resistance, Ohm from spec.**

$Rvcm\_max := Rvcm\_nom \cdot 1.05$ $\quad Rvcm\_max = 12.6$ **Ohm**

$Rvcm\_min := Rvcm\_nom \cdot 0.95$ $\quad Rvcm\_min = 11.4$ **Ohm**

$Vdrop\_drv\_nom := 1$ **Drop across output drivers (volt) of Mighty from spec.**

$Vdrop\_drv\_min := 0.8$ **Drop across output drivers (volt)**

$Vdrop\_drv\_max := 1.2$ **Drop across output drivers (volt)**

$Amp\_Gain\_nom := 4$ **VCM sense amp. gain in the current loop inside Mighty, from spec.**

$Amp\_Gain\_min := Amp\_Gain\_nom \cdot 0.95$ $\quad Amp\_Gain\_min = 3.8$

$Amp\_Gain\_max := Amp\_Gain\_nom \cdot 1.05$ $\quad Amp\_Gain\_max = 4.2$

$$Gm\_nom := \frac{R2\_nom}{Amp\_Gain\_nom \cdot Rsense\_nom \cdot R1\_nom} \qquad Gm\_nom = 0.48$$ **Amp/Volt**

$$Gm\_min := \frac{R2\_min}{Amp\_Gain\_max \cdot Rsense\_max \cdot R1\_max} \qquad Gm\_min = 0.427$$ **Amp/Volt**

$$Gm\_max := \frac{R2\_max}{Amp\_Gain\_min \cdot Rsense\_min \cdot R1\_min} \qquad Gm\_max = 0.543$$ **Amp/Volt**

$Volt\_cmd\_nom := 1.98$ **Volt output of the PWM decoder inside Mighty**

$Volt\_cmd\_max := 2.06$

$Volt\_cmd\_min := 1.90$

Commanded current thru the PWML and PWMH (DAC)

$Icmd\_nom := Gm\_nom \cdot Volt\_cmd\_nom$ $\quad Icmd\_nom = 0.951$ **Amp**

$Icmd\_min := Gm\_min \cdot Volt\_cmd\_min$ $\quad Icmd\_min = 0.811$ **Amp**

$Icmd\_max := Gm\_max \cdot Volt\_cmd\_max$ $\quad Icmd\_max = 1.118$ **Amp**

Available current from the 12v power supply at t=0

$$Iavail\_nom\_00 := \frac{Vcc12\_nom - Vdrop\_drv\_nom}{Rsense\_nom + Rvcm\_nom} \qquad Iavail\_nom\_00 = 0.892$$ **Amp**

$$Iavail\_min\_00 := \frac{Vcc12\_min - Vdrop\_drv\_max}{Rsense\_max + Rvcm\_max} \qquad Iavail\_min\_00 = 0.742$$ **Amp**

$$Iavail\_max\_00 := \frac{Vcc12\_max - Vdrop\_drv\_min}{Rsense\_min + Rvcm\_min} \qquad Iavail\_max\_00 = 1.059$$ **Amp**

Commanded current Icmd is greater than available current Iavail, so I_avail is used to calculate the BEMF voltage since we can not ask for more current than what is available from the supply. Next we calculate the BEMF voltage at specific times according to the seek currnt profile. BEMF is calculated using VCM mechanical parameters and Icmd_nom.

$Accel\_time := 3.2$ **Total accel time, ms.**

$t1 := 0.5 \cdot 10^{-3}$ $t2 := 3.2 \cdot 10^{-3}$ **Times at which BEMF voltage is calculated**

BEMF voltage calculation based on nominal available current

$\alpha\_nom := \frac{Kt \cdot Iavail\_nom\_00}{J}$ $\alpha\_nom = 1.423 \cdot 10^{4}$ **Nom. angular acceleration rad/sec^2**

$\omega 1\_nom := \alpha\_nom \cdot t1$ $\omega 1\_nom = 7.116$ **Nom. angular velocity at time t1 (0.5ms), rad/sec**

$\omega 2\_nom := \alpha\_nom \cdot t2$ $\omega 2\_nom = 45.544$ **Nom. angular velocity at time t2 (3.2ms), rad/sec**

BEMF voltage calculation based on maximum available current

$\alpha\_max := \frac{Kt \cdot Iavail\_max\_00}{J}$ $\alpha\_max = 1.689 \cdot 10^{4}$ **Max. angular acceleration rad/sec^2**

$\omega 1\_max := \alpha\_max \cdot t1$ $\omega 1\_max = 8.444$ **Max. angular velocity at time t1 (0.5ms), rad/sec**

$\omega 2\_max := \alpha\_max \cdot t2$ $\omega 2\_max = 54.043$ **Max. angular velocity at time t2 (3.2ms), rad/sec**

$Vbemf\_00ms := 0.0$ **Bemf voltage at 0.0msec or at start**

$Vbemf\_05ms\_nom := Ke \cdot \omega 1\_nom$ $Vbemf\_05ms\_nom = 0.488$ **Nom. Bemf voltage at 0.5msec**
$Vbemf\_32ms\_nom := Ke \cdot \omega 2\_nom$ $Vbemf\_32ms\_nom = 3.124$ **Nom. Bemf voltage at 3.2msec**

$Vbemf\_05ms\_max := Ke \cdot \omega 1\_max$ $Vbemf\_05ms\_max = 0.579$ **Max. Bemf voltage at 0.5msec**
$Vbemf\_32ms\_max := Ke \cdot \omega 2\_max$ $Vbemf\_32ms\_max = 3.707$ **Max. Bemf voltage at 3.2msec**

$Vbemf\_ave\_nom := \frac{Vbemf\_32ms\_nom - Vbemf\_05ms\_nom}{2}$ **Average nominal bemf voltage, Volt**

$Vbemf\_ave\_max := \frac{Vbemf\_32ms\_max - Vbemf\_05ms\_max}{2}$ **Average maximum bemf voltage, Volt**

Next available current at t1, t2 and average current during acceleration is calculated, average current during accel is calculated in two parts, one is from 0 to 0,5ms and the other is from 0.5 ms to 3.2ms. then the current is averaged thru the accel time as follows

$Iavail\_nom\_05ms := \frac{Vcc12\_nom - Vdrop\_drv\_nom - Vbemf\_05ms\_nom}{Rsense\_nom + Rvcm\_nom}$ $Iavail\_nom\_05ms = 0.853$ **Amp**

$Iavail\_nom\_32ms := \frac{(Vcc12\_nom - Vdrop\_drv\_nom) - Vbemf\_32ms\_nom}{Rsense\_nom + Rvcm\_nom}$ $Iavail\_nom\_32ms = 0.639$ **Amp**

$$Iavail\_nom\_accel := \frac{\left(\frac{0 + Iavail\_nom\_05ms}{2}\right) \cdot 0.5 + \left(\frac{Iavail\_nom\_05ms + Iavail\_nom\_32ms}{2}\right) \cdot 2.7}{Accel\_time}$$

$Iavail\_nom\_accel = 0.696$ **Average nom. current during accel. is averaged over two segments. Amp**

$$Iavail\_max\_05ms := \frac{Vcc12\_max - Vdrop\_drv\_min - Vbemf\_05ms\_max}{Rsense\_min + Rvcm\_min}$$

Iavail_max_05ms = 1.009 **Amp**

$$Iavail\_max\_32ms := \frac{Vcc12\_max - Vdrop\_drv\_min - Vbemf\_32ms\_max}{Rsense\_min + Rvcm\_min}$$

Iavail_max_32ms = 0.742 **Amp**

$$Iavail\_max\_accel := \frac{\left(\frac{0 + Iavail\_max\_05ms}{2}\right)\cdot 0.5 + \left(\frac{Iavail\_max\_05ms + Iavail\_max\_32ms}{2}\right)\cdot 2.7}{Accel\_time}$$

Iavail_max_accel = 0.818 **Average max. current during accel. is averagde over two segments. Amp**

In the above Iavail_nom,max_accel current calculation, current at t=0 is set to zero due to the inductor which does not let the current rise instantly.

Icmd_max is now greater than Iavail_max so Iavail_max is used to calculate the average current and the power dissipation. Total power dissipation in the Mighty VCM drivers is total 12v supply power minus the dissipated power in sense and VCM resistors and the power dissipation due to the BEMF voltage

$$Pd\_accel\_nom := (Vcc12\_nom - Vbemf\_ave\_nom - Iavail\_nom\_accel\cdot(Rsense\_nom + Rvcm\_nom))\cdot Iavail\_nom\_accel$$

Pd_accel_nom = 1.463 **Nominal power dissipation during accel in the Mighty output drivers, watts**

$$Pd\_accel\_max := (Vcc12\_max - Vbemf\_ave\_max - Iavail\_max\_accel\cdot(Rsense\_min + Rvcm\_min))\cdot Iavail\_max\_accel$$

Pd_accel_max = 1.683 **Maximum power dissipation during accel in the Mighty output drivers, watts**

Now the decel portion, decel portion is divoided into 4 segments, average current for each segment is calculated, then average current for the whole decel time is calculated based on the simulated current profile.

Idecel_1 := 0.0	**Amp at start of the decel t=0**
Idecel_2 := 0.7	**Amp from 0 to 0.5ms into the decel**
Idecel_3 := 0.5	**Amp from 0.5ms to 3.5ms into the decel**
Idecel_4 := 0.3	**Amp from 3.5ms to 4.5ms into the decel**
Idecel_5 := 0.0	**Amp from 4.5ms to 7ms into the decel**

Decel_time := Seek_time - Accel_time **miliseconds, total decel time**

Average decel current is the average over the four decel segment. from start of decel to 3.5ms into the decel and from 3.5 ms till the end of the decel which is 7ms

$$Iave\_decel := \frac{\left(\frac{Idecel\_1 + Idecel\_2}{2}\right)\cdot 0.5 + \left(\frac{Idecel\_2 + Idecel\_3}{2}\right)\cdot 3.0 + \left(\frac{Idecel\_3 + Idecel\_4}{2}\right)\cdot 1.0 + \left(\frac{Idecel\_4 + Idecel\_5}{2}\right)\cdot 2.5}{Decel\_time}$$

Iave_decel = 0.393 **Ave. decel current**

Again the total power dissipation in the Mighty VCM drivers is total 12v supply power minus the dissipated power in sense and VCM resistors and the power dissipation due to the BEMF voltage

$$\text{Pd\_decel\_nom} := ((\text{Vcc12\_nom} - \text{Vbemf\_ave\_nom}) - \text{Iave\_decel}\cdot(\text{Rsense\_nom} + \text{Rvcm\_nom}))\cdot\text{Iave\_decel}$$

$\text{Pd\_decel\_nom} = 3.329$ **Nominal power dissipation during decel in the Mighty output, watts**

$$\text{Pd\_decel\_max} := ((\text{Vcc12\_max} - \text{Vbemf\_ave\_max}) - \text{Iave\_decel}\cdot(\text{Rsense\_min} + \text{Rvcm\_min}))\cdot\text{Iave\_decel}$$

$\text{Pd\_decel\_max} = 3.992$ **Nominal power dissipation during decel in the Mighty output, watts**

Total power during one seek cycle is the Pd_accel_nom,max + Pd_decel_nom,max

$\text{Pd\_seek\_nom} := \text{Pd\_accel\_nom} + \text{Pd\_decel\_nom}$ $\text{Pd\_seek\_nom} = 4.793$ **Nominal power dissipation during one seek in the Mighty output, watts**

$\text{Pd\_seek\_max} := \text{Pd\_accel\_max} + \text{Pd\_decel\_max}$ $\text{Pd\_seek\_max} = 5.675$ **Max. power dissipation during one seek in the Mighty output, watts**

Total seek time is 10.2 ms based on simulatioin and it is also assumed that 10.2 ms is given between each seek so the total power dissipation during seek should be averaged out as follows

$$\text{Pd\_ave\_seek\_nom} := (\text{Pd\_accel\_nom} + \text{Pd\_decel\_nom})\cdot\frac{\text{Seek\_time}}{2\cdot\text{Seek\_time}}$$

$\text{Pd\_ave\_seek\_nom} = 2.396$ **Nominal power dissipation during 1/3 seek in the Mighty output, watts**

$$\text{Pd\_ave\_seek\_max} := (\text{Pd\_accel\_max} + \text{Pd\_decel\_max})\cdot\left(\frac{\text{Seek\_time}}{2\cdot\text{Seek\_time}}\right)$$

$\text{Pd\_ave\_seek\_max} = 2.838$ **Max. power dissipation during 1/3 seek in the Mighty output, watts**

3. Total bias power in 12 and 5 volt supply is:

$\text{Pd\_bias\_Vcc12\_nom} := \text{Ivcc12\_nom}\cdot\text{Irun\_nom}$ $\text{Pd\_bias\_Vcc12\_nom} = 0.003$ **Nom. 12v bias power Watts**
$\text{Pd\_bias\_Vcc12\_max} := \text{Ivcc12\_max}\cdot\text{Irun\_max}$ $\text{Pd\_bias\_Vcc12\_max} = 0.007$ **Max. 12v bias power Watts**

$\text{Pd\_bias\_Vcc5\_nom} := \text{Ivcc5\_nom}\cdot\text{Irun\_nom}$ $\text{Pd\_bias\_Vcc5\_nom} = 8\cdot10^{-4}$ **Nom. 5v bias power Watts**
$\text{Pd\_bias\_Vcc5\_max} := \text{Ivcc5\_max}\cdot\text{Irun\_max}$ $\text{Pd\_bias\_Vcc5\_max} = 0.002$ **Max. 5v bias power Watts**

Now the total power in Mighty is the sum of the power dissipated in spindle output srivers, in the VCM output drivers and the bias power drawn from the supplies to keep the Mighty operational.

$Pd\_total\_nom := Pd\_ave\_seek\_nom + Pd\_spm\_drivers\_nom + Pd\_bias\_Vcc5\_nom + Pd\_bias\_Vcc12\_nom$

$Pd\_total\_nom = 2.878$ **Total nominal power in Mighty, watts**

$Pd\_total\_max := Pd\_ave\_seek\_max + Pd\_spm\_drivers\_max + Pd\_bias\_Vcc5\_max + Pd\_bias\_Vcc12\_max$

$Pd\_total\_max = 3.737$ **Total maximum power in Mighty, watts**

To calculate the junction temperature in Mighty we need to know the Thermal resistance of the package which is as indicated below.

$Rth\_ja\_nom := 30$ **Nominal junction to ambient thermal resistance for Mighty package (52 pin PLCC), degree C/watt from Mighty spec.**

$Rth\_ja\_max := 34$ **Max. junction to ambient thermal resistance for Mighty package (52 pin PLCC), degree C/watt from Mighty spec.**

$Tambient := 55$ **Ambient temperature, degree C.**

$Tjunction\_nom := Rth\_ja\_nom \cdot Pd\_total\_nom + Tambient$ $Tjunction\_nom = 141.347$ **Nom. junction temp. degree C.**

$Tjunction\_max := Rth\_ja\_max \cdot Pd\_total\_max + Tambient$ $Tjunction\_max = 182.07$ **Max. junction temp. degree C.**

Part (2) **Spindle start up current is calculated using two different Rsense values (0.33 and 0.25 ohm). In closed loop start up the current is independant of the power supply and in open loop start up the current depends on power supply, Rsense, Spindle motor resistance and the voltage drop across the drivers.**

$Vcc12\_nom := 12$ **Volt** $Vcc12\_max := 13.2$ **Volt** $Vcc12\_min := 10.8$ **Volt , 12v power supply**

$Kt\_nom := 170$ **Torque constant in g.f.cm/A, it is degraded due to non perfect commutation points at start up.**

$Kt\_deg\_nom := Kt\_nom \cdot 0.8$ $Kt\_deg\_nom = 136$

$Kt\_deg\_min := Kt\_deg\_nom \cdot 0.92$ $Kt\_deg\_min = 125.12$

$Kt\_deg\_max := Kt\_deg\_nom \cdot 1.08$ $Kt\_deg\_max = 146.88$

$Rspindle\_nom := 6.0$ **Ohm at 25 deg. C, spindle winding resistance from spec.**
$Rspindle\_max := Rspindle\_nom \cdot 1.10$ $Rspindle\_max = 6.6$ **Ohm at 70 Deg. C**
$Rspindle\_min := Rspindle\_nom \cdot 0.9$ $Rspindle\_min = 5.4$ **Ohm at 25 Deg. C**

$Rsense\_nom := 0.33$ **Ohm, sense resistor**
$Rsense\_max := Rsense\_nom \cdot 1.05$ $Rsense\_max = 0.347$ **Ohm**
$Rsense\_min := Rsense\_nom \cdot 0.95$ $Rsense\_min = 0.314$ **Ohm**

$Spm\_ampgain\_nom := 5$ **Spindle sense amp. gain in the current loop inside Mighty**
$Spm\_ampgain\_min := Spm\_ampgain\_nom \cdot 0.98$ $Spm\_ampgain\_min = 4.9$
$Spm\_ampgain\_max := Spm\_ampgain\_nom \cdot 1.02$ $Spm\_ampgain\_max = 5.1$

$Vdrop\_drv\_nom := 1.0$ **Drop across spindle output drivers (volt) of Mighty from spec.**
$Vdrop\_drv\_min := 0.8$ **Drop across spindle output drivers (volt)**
$Vdrop\_drv\_max := 1.7$ **Drop across spindle output drivers at Tj = 125 deg. C(volt)**

$Cur\_cmd\_nom := 1.74$ **Voltage at SPWMFLT correspondint to 100% duty cycle of the PWM input**
$Cur\_cmd\_min := Cur\_cmd\_nom \cdot 0.95$ $Cur\_cmd\_min = 1.653$
$Cur\_cmd\_max := Cur\_cmd\_nom \cdot 1.05$ $Cur\_cmd\_max = 1.827$

Inside Mighty there is a closed current loop control which limits the start up current according to the following formula.

$$Ispm := \frac{Cur\_cmd \cdot \%DUTY}{Rsense \cdot Cur\_ampgain \cdot 100}$$

At start up the duty cycle is 100% so the formula reduces to the following

Spindle start up current using the above variables

$$Ispm\_nom := \frac{Cur\_cmd\_nom}{Spm\_ampgain\_nom \cdot Rsense\_nom}$$ $Ispm\_nom = 1.055$ **Amp**

$$Ispm\_min := \frac{Cur\_cmd\_min}{Spm\_ampgain\_max \cdot Rsense\_max}$$ $Ispm\_min = 0.935$ **Amp**

$$Ispm\_max := \frac{Cur\_cmd\_max}{Spm\_ampgain\_min \cdot Rsense\_min}$$ $Ispm\_max = 1.189$ **Amp**

Spindle start up torque is calculated using nominal Kt and above min, nom, and max current values.

Spm_start_torq_nom = Kt_deg_nom·Ispm_nom	Spm_start_torq_nom = 143.418	**Start up torque, gmf.cm**
Spm_start_torq_min = Kt_deg_min·Ispm_min	Spm_start_torq_min = 117.038	**Start up torque, gmf.cm**
Spm_start_torq_max = Kt_deg_max·Ispm_max	Spm_start_torq_max = 174.69	**Start up torque, gmf.cm**

Now if Rsense were changed to 0.25 ohm instead of 0.33 ohm the start up torque would increase as shown below

Rsense_nom := 0.25	**Ohm, sense resistor**	
Rsense_max := Rsense_nom·1.05	Rsense_max = 0.263	**Ohm**
Rsense_min := Rsense_nom·0.95	Rsense_min = 0.237	**Ohm**

Spindle start up current using the above variables

$$Ispm\_nom := \frac{Cur\_cmd\_nom}{Spm\_ampgain\_nom \cdot Rsense\_nom}$$ Ispm_nom = 1.392 **Amp**

$$Ispm\_min := \frac{Cur\_cmd\_min}{Spm\_ampgain\_max \cdot Rsense\_max}$$ Ispm_min = 1.235 **Amp**

$$Ispm\_max := \frac{Cur\_cmd\_max}{Spm\_ampgain\_min \cdot Rsense\_min}$$ Ispm_max = 1.57 **Amp**

Spindle start up torque is calculated using nominal Kt and above min, nom, and max current values.

Spm_start_torq_nom = Kt_deg_nom·Ispm_nom	Spm_start_torq_nom = 189.312	**Start up torque, gmf.cm**
Spm_start_torq_min = Kt_deg_min·Ispm_min	Spm_start_torq_min = 154.49	**Start up torque, gmf.cm**
Spm_start_torq_max := Kt_deg_max·Ispm_max	Spm_start_torq_max = 230.591	**Start up torque, gmf.cm**

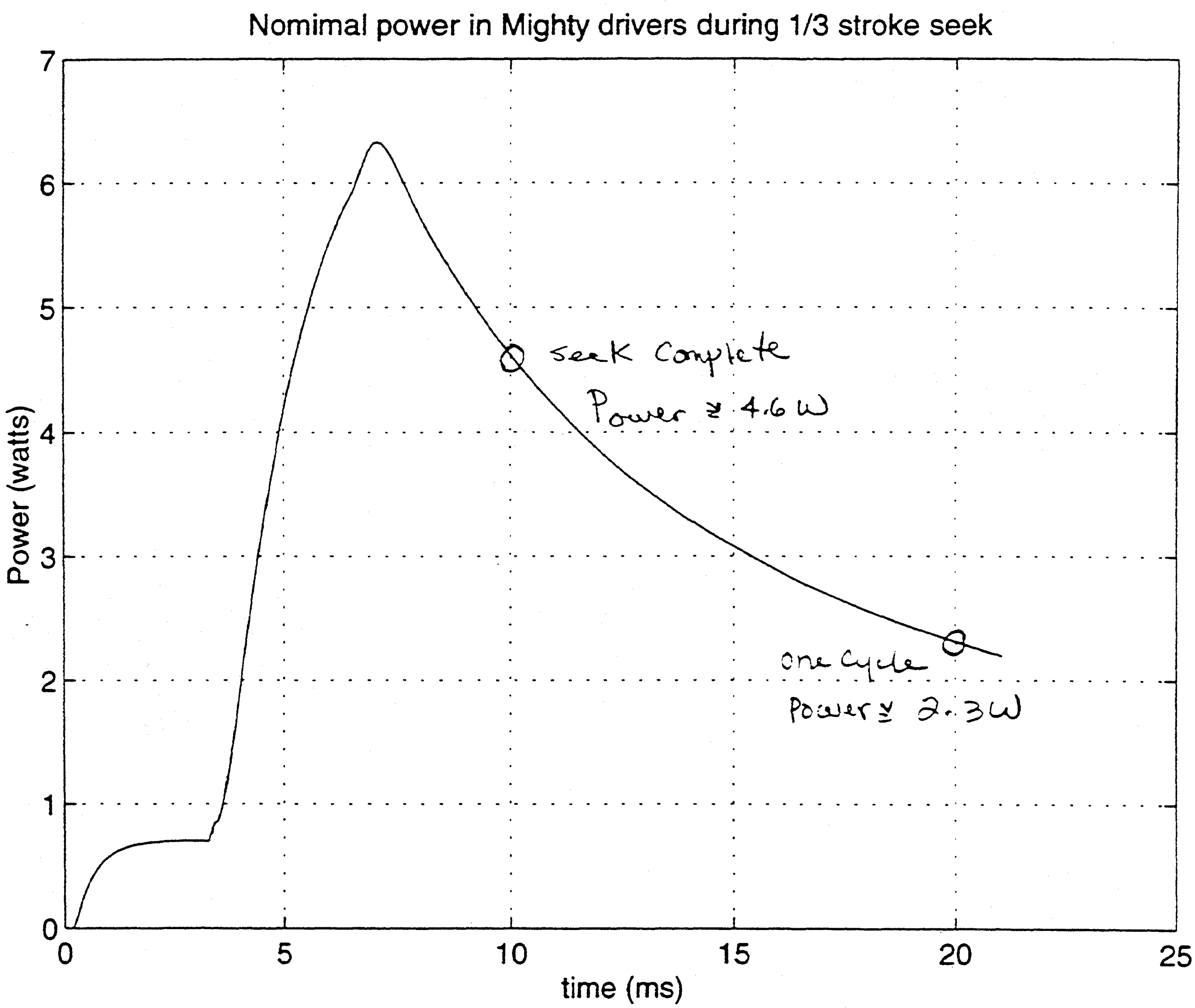
There is also the possibility to disable the closed current loop control during start up by putting Mighty into the Induction Sense Mode. In this mode the start up current is limited only by the power supply and the spindle motor resistance, in that case the numbers will look like below.

$$Ispm\_st\_rpd\_nom := \frac{Vcc12\_nom - Vdrop\_drv\_nom}{Rspindle\_nom}$$ Ispm_st_rpd_nom = 1.833

$$Ispm\_st\_rpd\_min := \frac{Vcc12\_min - Vdrop\_drv\_max}{Rspindle\_max}$$ Ispm_st_rpd_min = 1.379

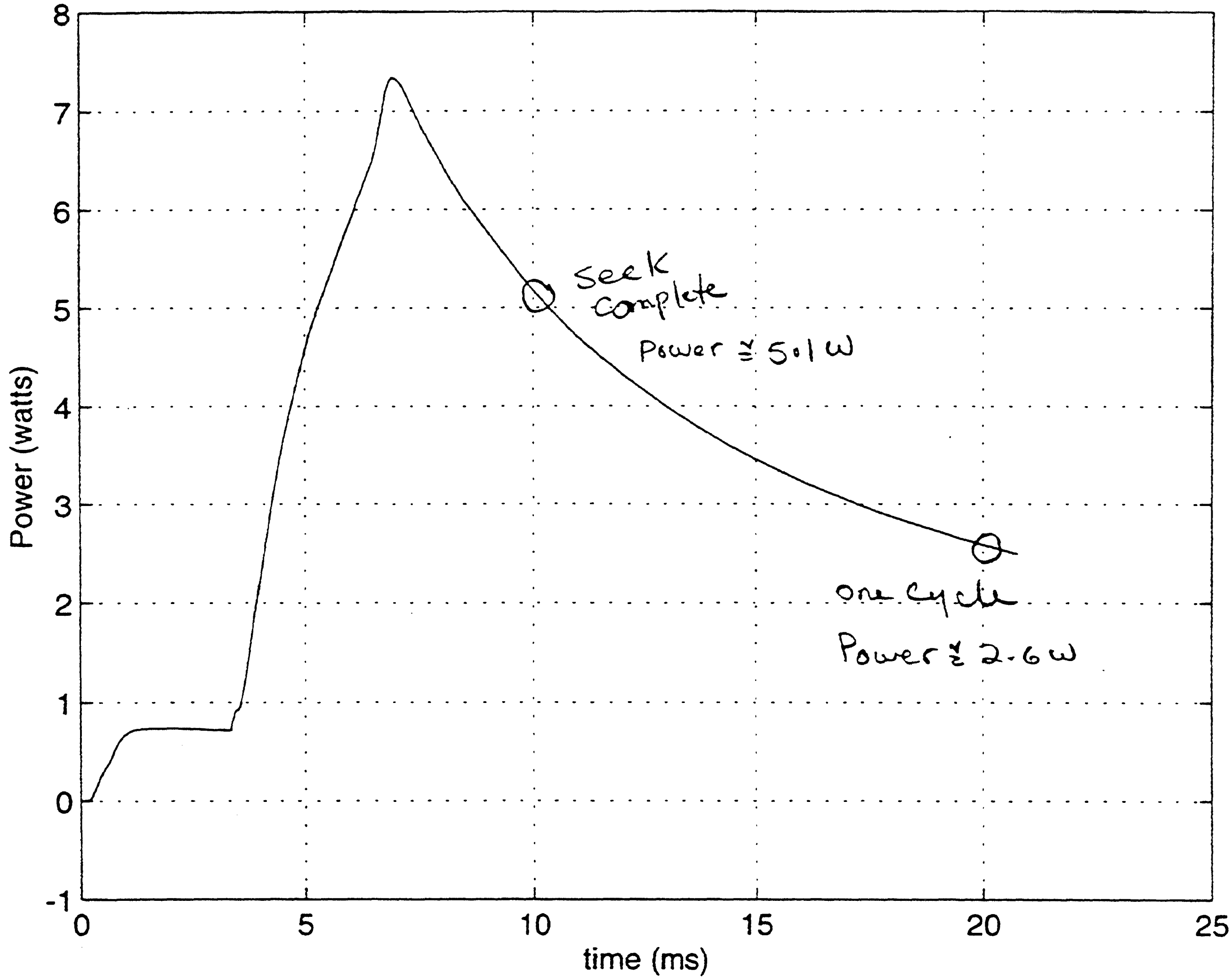
$$Ispm\_st\_rpd\_max := \frac{Vcc12\_max - Vdrop\_drv\_min}{Rspindle\_min}$$ Ispm_st_rpd_max = 2.296

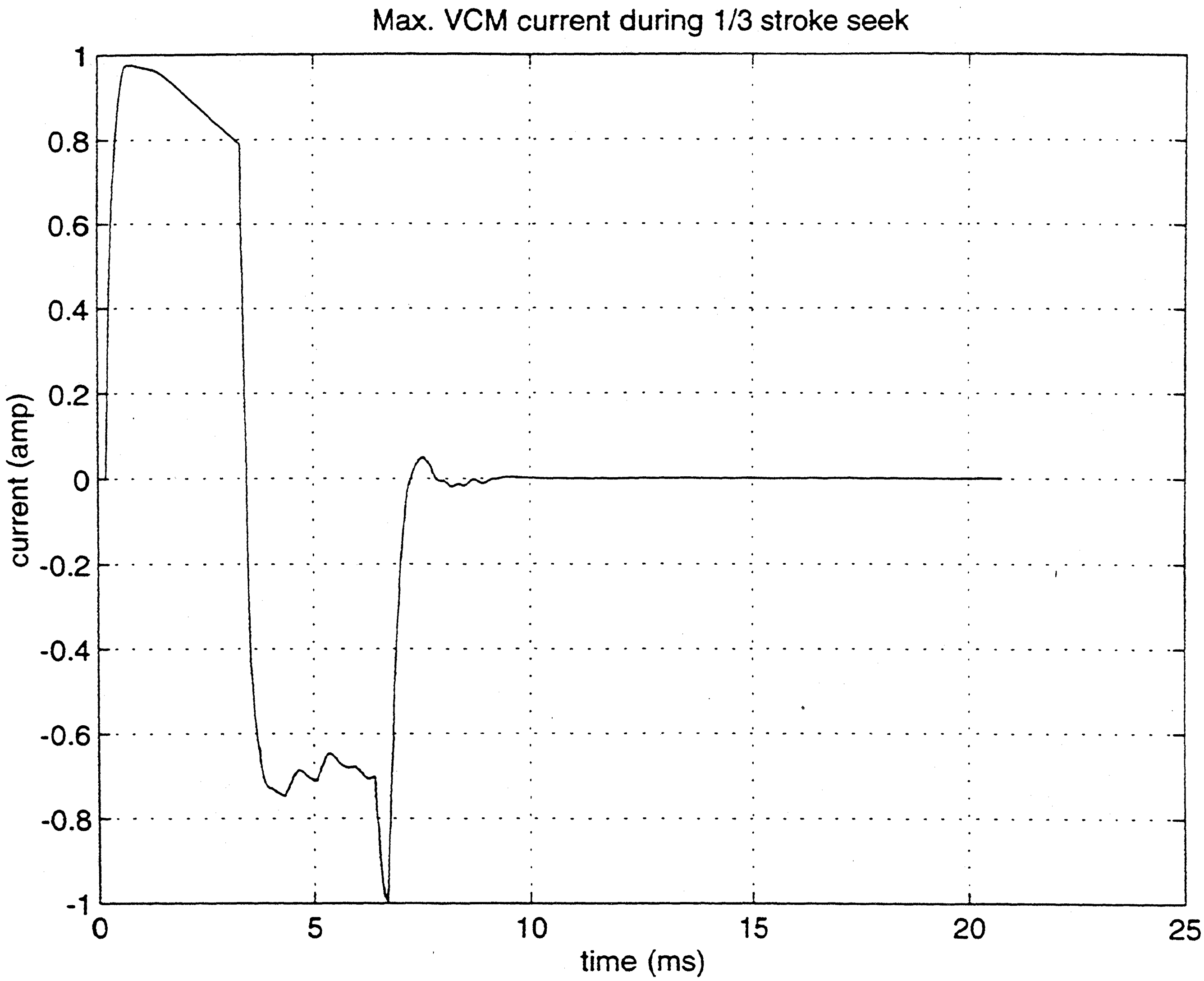
Spm_st_torq_rpd_nom := Kt_deg_nom·Ispm_st_rpd_nom	Spm_st_torq_rpd_nom = 249.333	**Start up torque, gmf.cm**
Spm_st_torq_rpd_min := Kt_deg_min·Ispm_st_rpd_min	Spm_st_torq_rpd_min = 172.514	**Start up torque, gmf.cm**
Spm_st_torq_rpd_max := Kt_deg_max·Ispm_st_rpd_max	Spm_st_torq_rpd_max = 337.28	**Start up torque, gmf.cm**

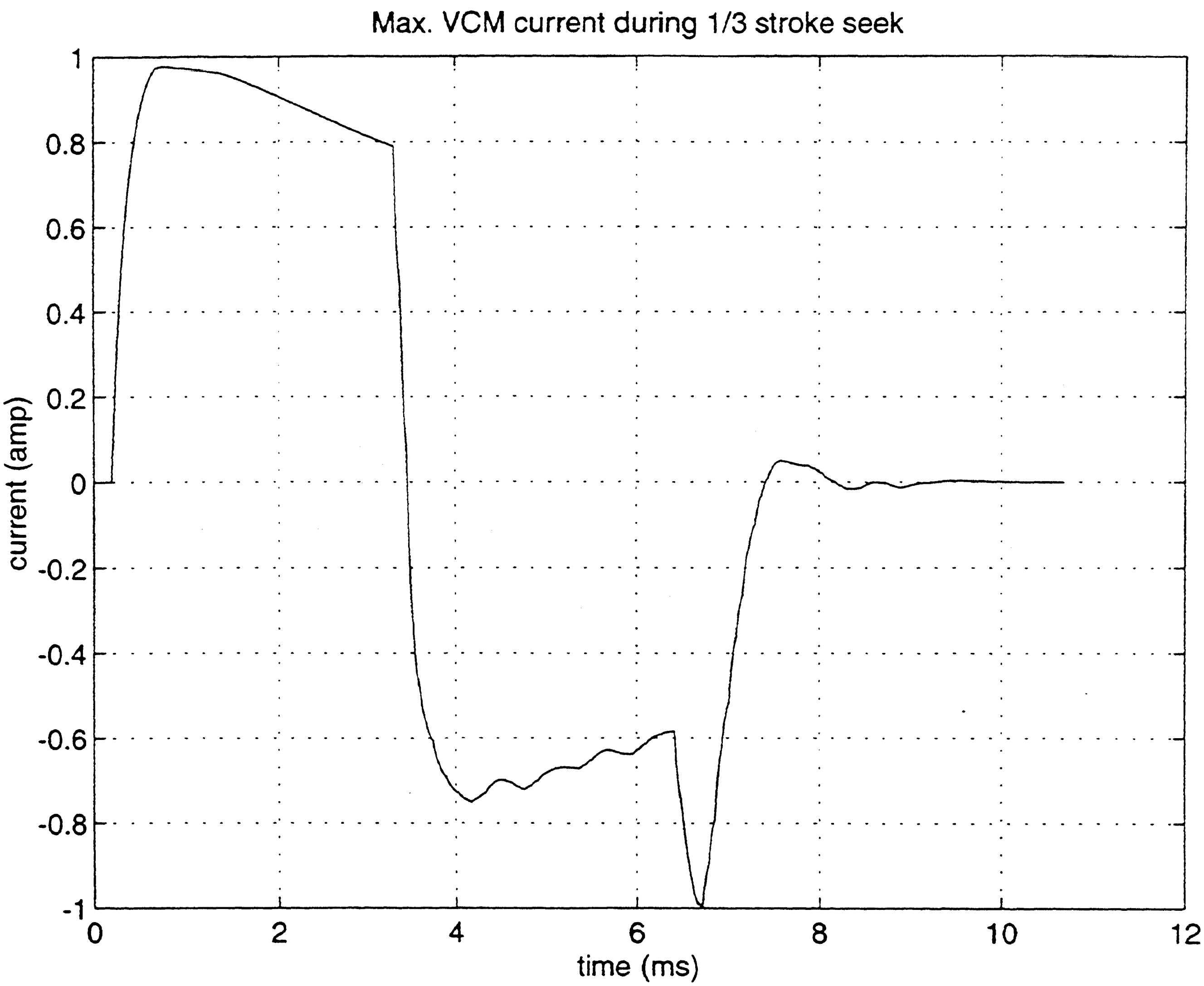


Nomimal power in Mighty drivers during 1/3 stroke seek
Power (watts)
time (ms)
0
1
2
3
4
5
6
7
0
5
10
15
20
25
seek Complete
Power ≅ 4.6 W
one cycle
Power ≅ 2.3 W

Max. power in Mighty during 1/3 stroke seek

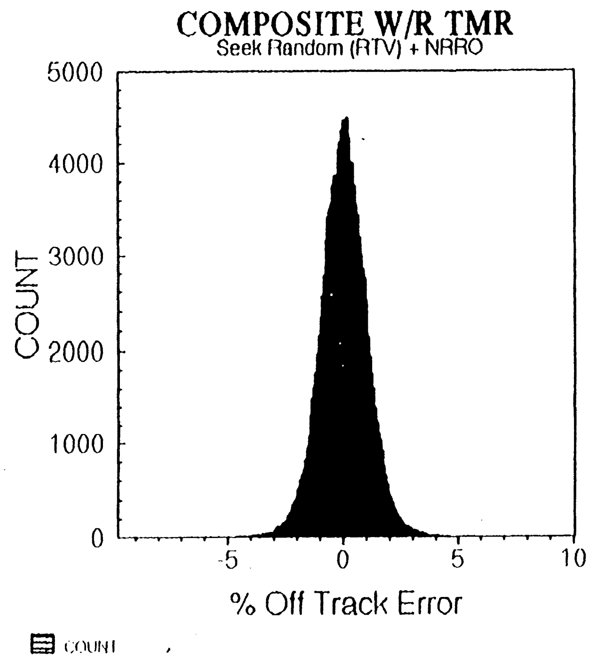


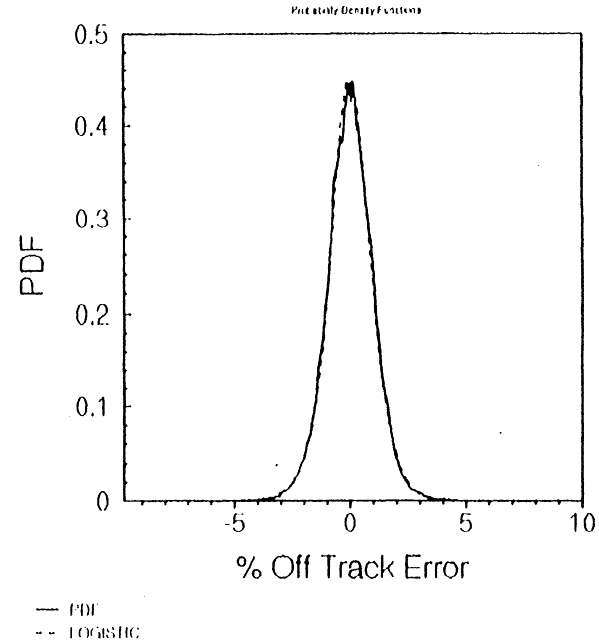

Max. VCM current during 1/3 stroke seek
current (amp)
time (ms)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
5
10
15
20
25


Max. VCM current during 1/3 stroke seek
current (amp)
time (ms)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
2
4
6
8
10
12

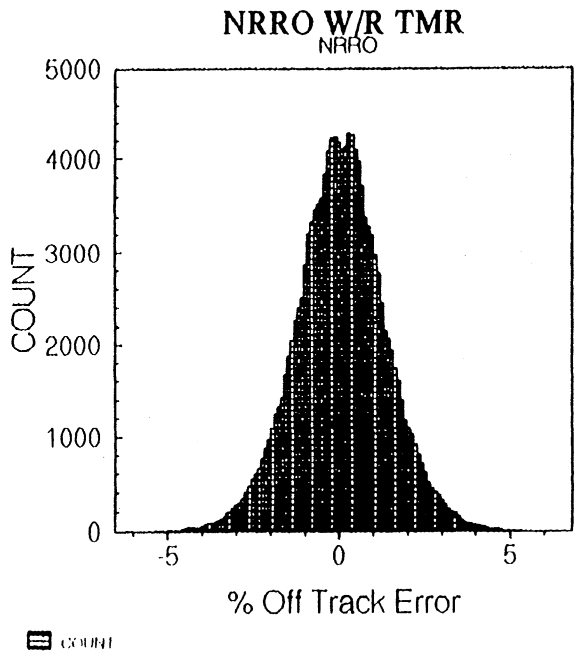
2 / 3 Disk Performance - P1 Reference

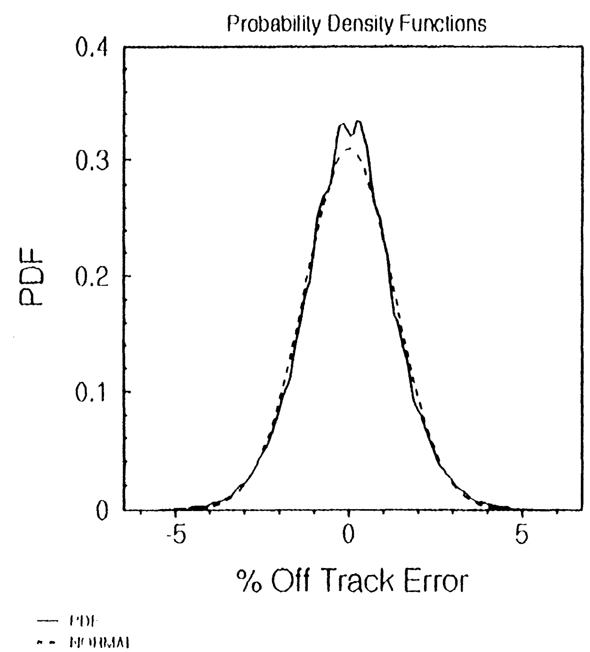
- TMR Data
- Mechanical Resonance Data
- Acoustics Data
- Shock and Vibration Data





DriveID 382577721228
HDA Variation Code roomtem
3 σ = 3.03 %
Population Estimate, Based
on Cumulative Peak Method.
3 σ (est) = 3.52 % (1.49K events)
10-22-1995

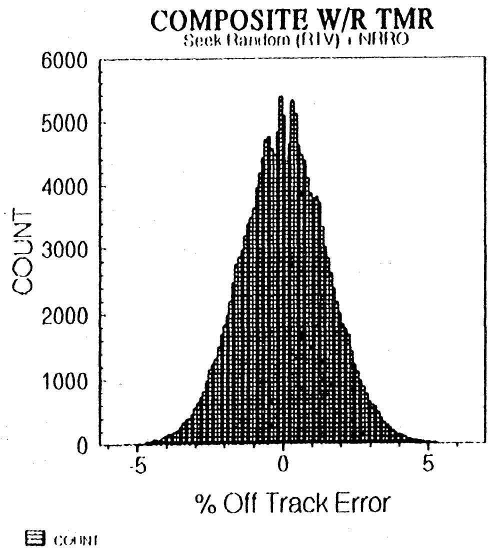


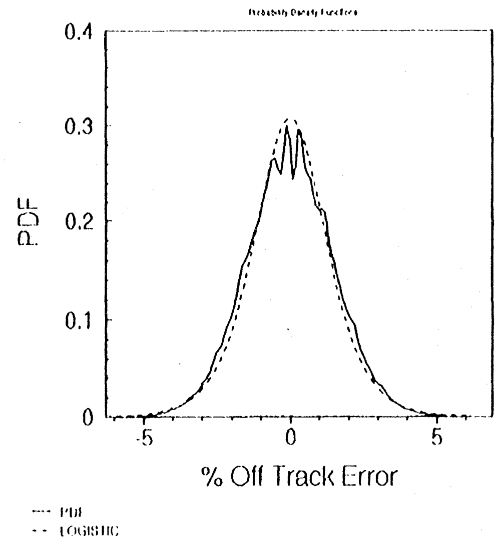


3 σ = 3.88 %
3 σ Population Estimate = 4.43 %

6,500 TPI

2 DISK TMR





DriveID 383566682216

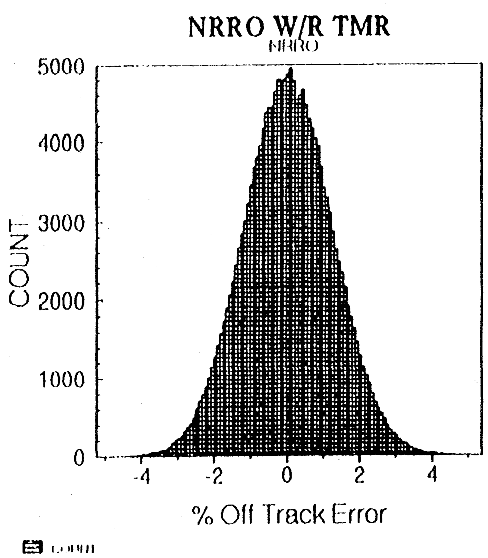
HDA Variation Code roomtem

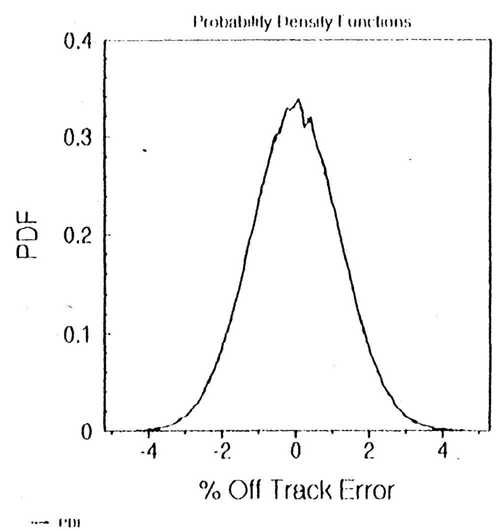
3 σ = 4.42 %

Population Estimate, Based on Cumulative Peak Method.

3 σ (est) = 4.47 % (1.98K events)

10 19 1995



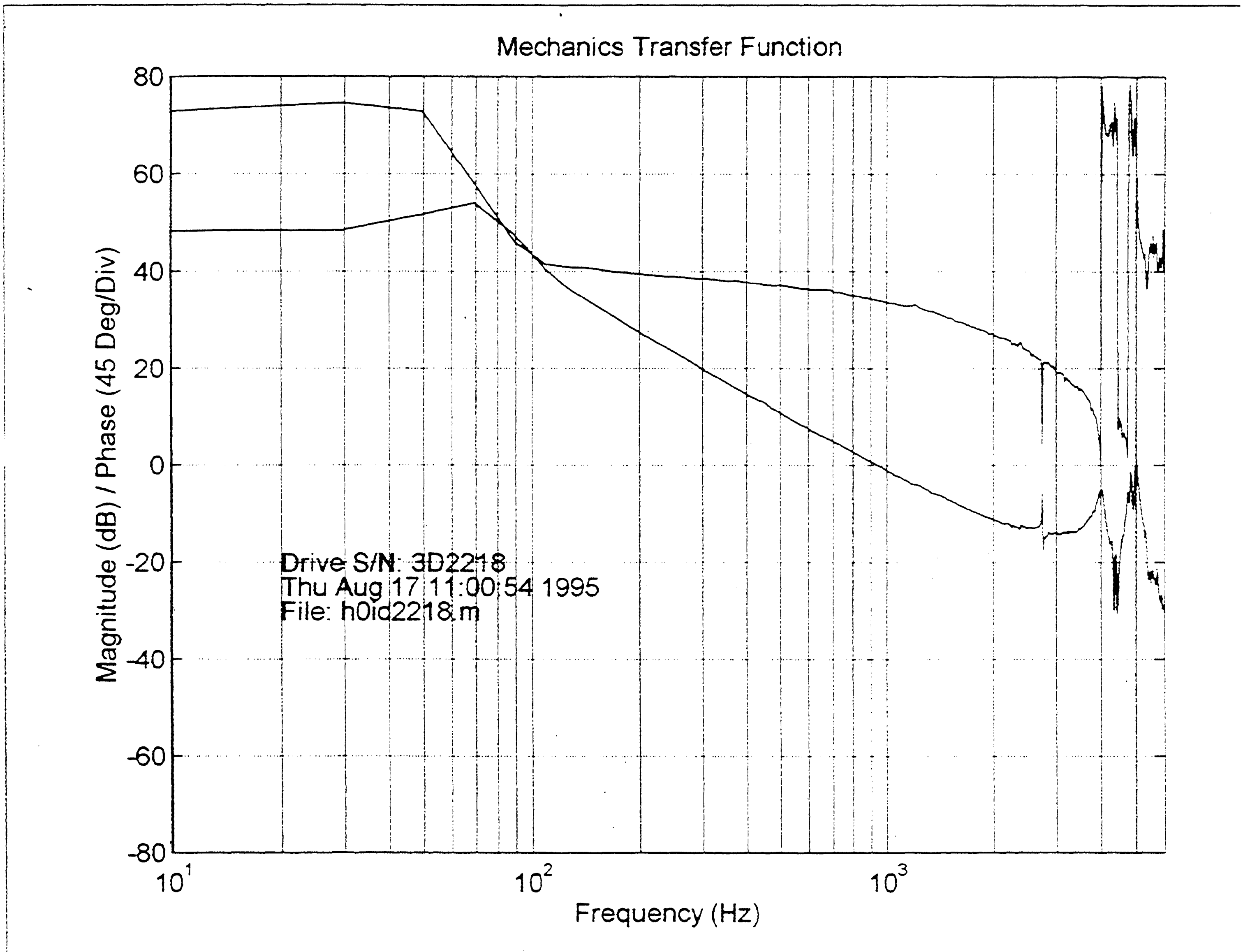


3 σ = 3.63 %

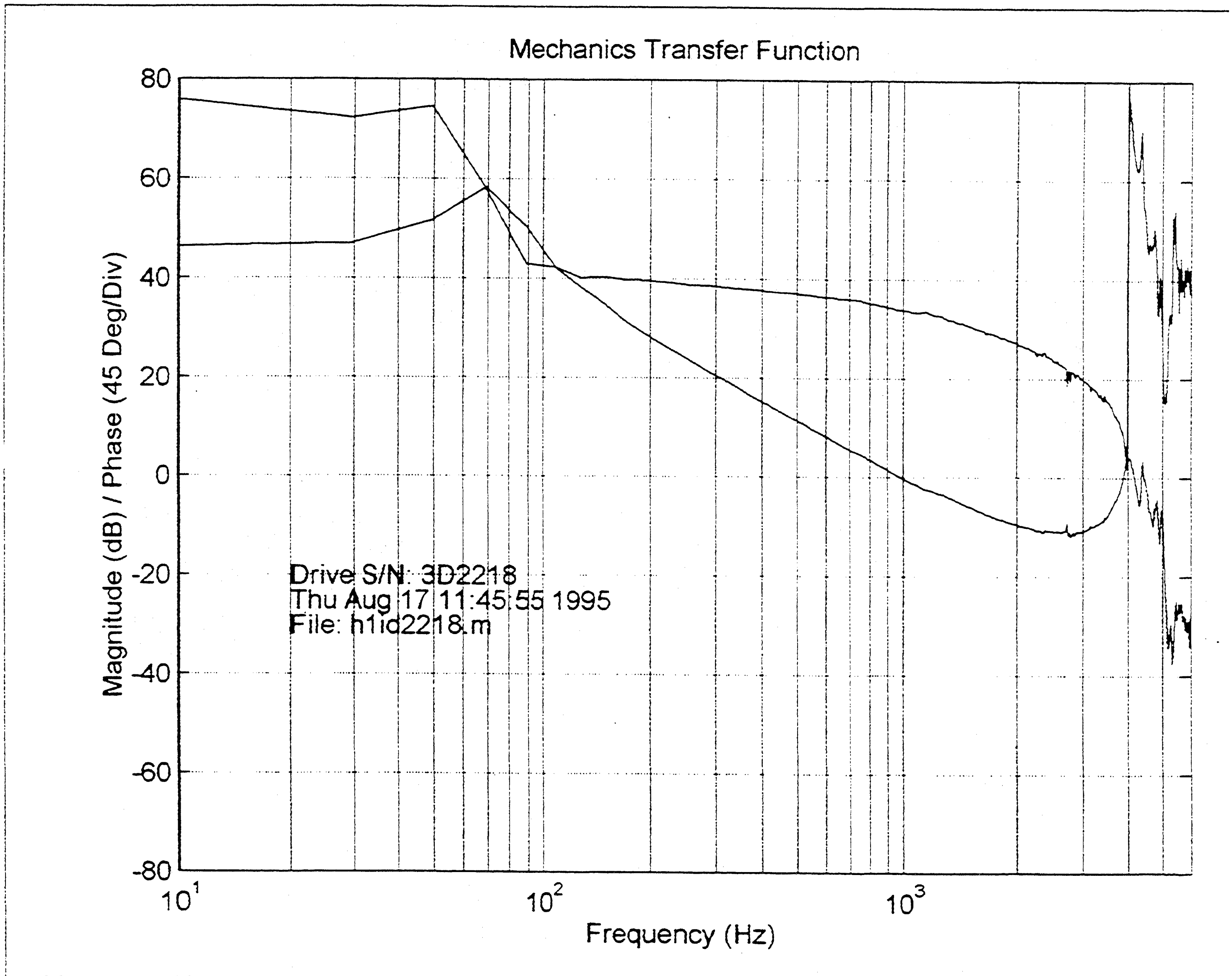
3 σ Population Estimate = 3.72 %

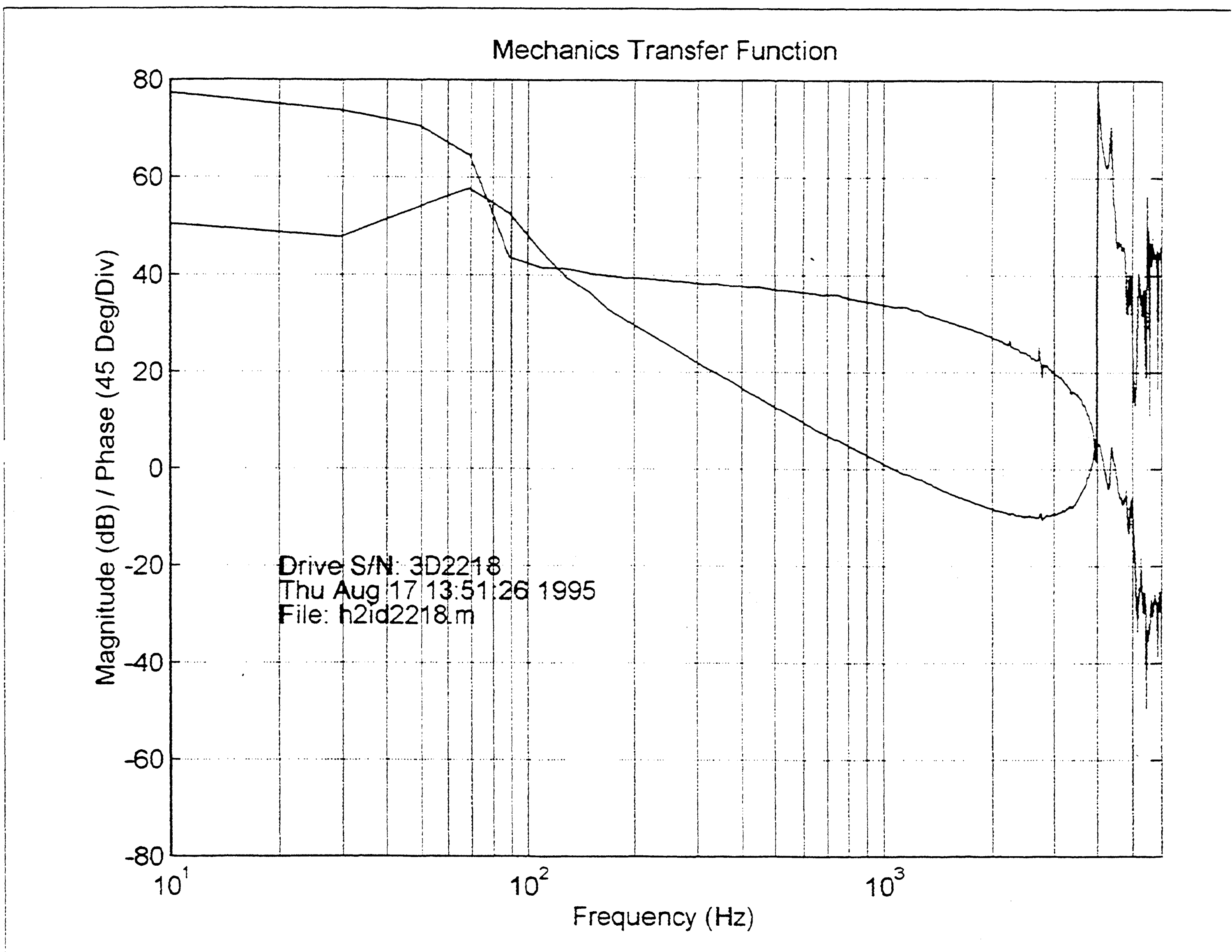
6,500 TPI

3 Disk TMR

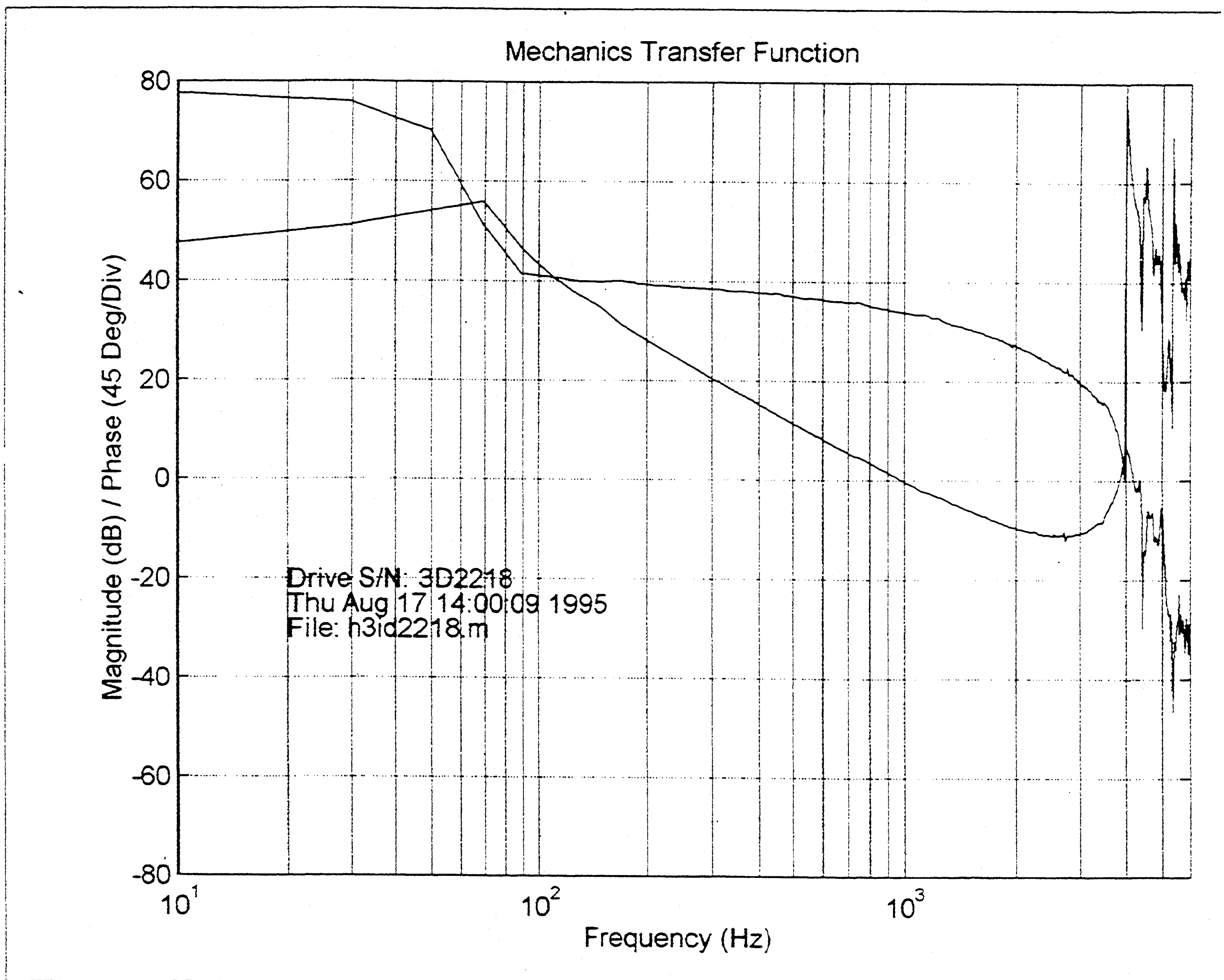


Mechanics Transfer Function
Magnitude (dB) / Phase (45 Deg/Div)
80
60
40
20
0
-20
-40
-60
-80
10^1
10^2
10^3
Frequency (Hz)
Drive S/N: 3D2218
Thu Aug 17 11:00:54 1995
File: h0id2218.m

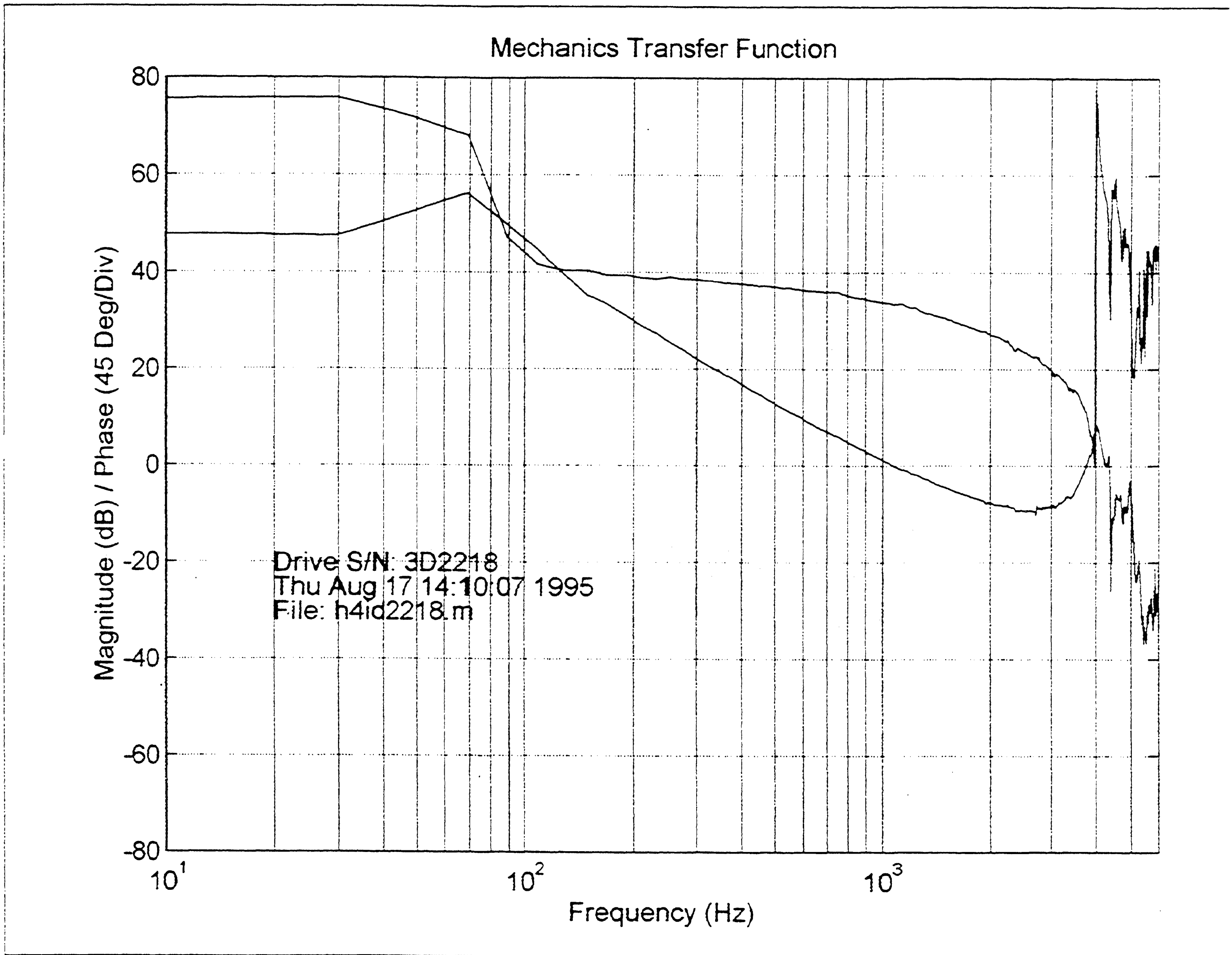

Mechanics Transfer Function
Magnitude (dB) / Phase (45 Deg/Div)
Frequency (Hz)
80
60
40
20
0
-20
-40
-60
-80
10^1
10^2
10^3
Drive S/N: 3D2218
Thu Aug 17 11:45:55 1995
File: h1id2218.m

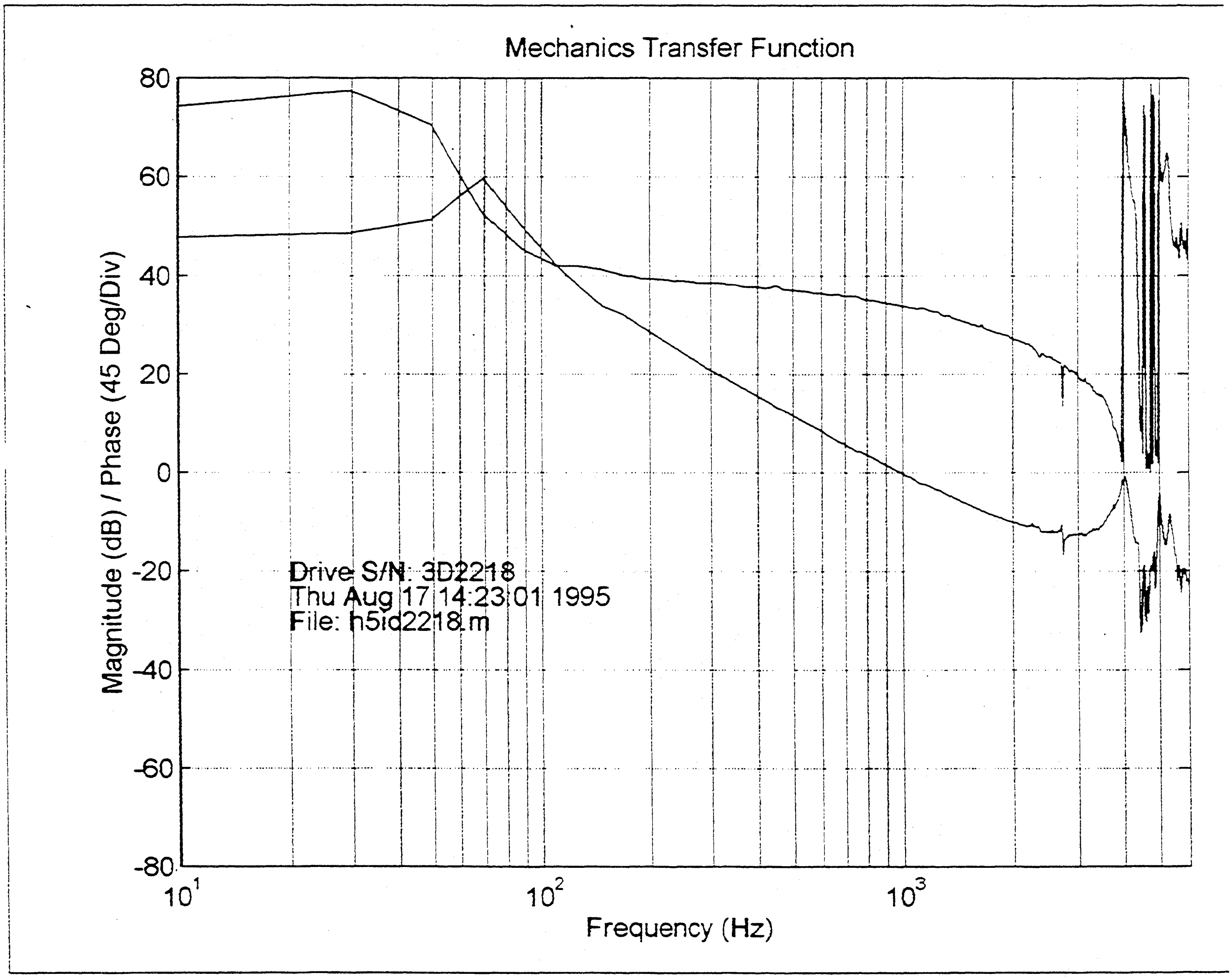


Mechanics Transfer Function
Magnitude (dB) / Phase (45 Deg/Div)
80
60
40
20
0
-20
-40
-60
-80
10^1
10^2
10^3
Frequency (Hz)
Drive S/N: 3D2218
Thu Aug 17 13:51:26 1995
File: h2id2218.m



Mechanics Transfer Function
Magnitude (dB) / Phase (45 Deg/Div)
80
60
40
20
0
-20
-40
-60
-80
10^1
10^2
10^3
Frequency (Hz)
Drive S/N: 3D2218
Thu Aug 17 14:00:09 1995
File: h3id2218.m


Mechanics Transfer Function
80
60
40
20
0
-20
-40
-60
-80
Magnitude (dB) / Phase (45 Deg/Div)
10^1
10^2
10^3
Frequency (Hz)
Drive S/N: 3D2218
Thu Aug 17 14:10:07 1995
File: h4id2218.m


Mechanics Transfer Function
Magnitude (dB) / Phase (45 Deg/Div)
80
60
40
20
0
-20
-40
-60
-80
Drive S/N: 3D2218
Thu Aug 17 14:23:01 1995
File: h5id2218.m
10^1
10^2
10^3
Frequency (Hz)

P1 Acoustic Results at MKE

\ll units in bels

Motor/#disk	Ohzu 3D NMB	Ohzu 3D NSK	PMDM 3D	Nidec 3D	Ohzu 2D	PMDM 2D	Nidec 2D
	3.5504	3.4284	3.5494	3.8985	3.3779	3.6135	3.7940
	3.6295	3.7307	3.5952	3.9078	3.4934	3.4618	3.7737
	3.5973	3.4489	3.6286	3.8916	3.6562	3.5290	3.7680
	3.5698	3.7251	3.4809	3.8458	3.5978	3.6411	3.7235
	3.4998	3.6328	3.5573	4.1274	3.2546	3.5697	3.5871
	3.4947	3.6127	3.5606	4.0210	3.5283	3.5289	3.7613
	3.6210	3.8672	3.5419	3.8050	3.6589	3.4946	3.6691
	3.6270	3.5507	3.5081	4.0240	3.4416	3.5161	3.6630
	3.6172	3.6508	3.6198	3.8928	3.3034	3.4960	3.4772
	3.8696	3.3757	**3.8966**	4.0091	3.4180	**3.9073**	3.7198
\verage	3.6076	3.6023	3.5938	**3.9423**	3.4730	3.5758	**3.6937**
Stdev	0.1049	**0.1538**	0.1158	0.0988	**0.1401**	0.1289	0.0988
avg -high	3.5785		3.5602			3.5390	
Stdev -high	**0.0533**		**0.0486**			**0.0585**	
Diff. 3D-2D	Nidec	PMDM	Ohzu				
	0.2486	**0.0180**	0.1320				
ll Average	3.6412						
verage w/o lidec	**3.5705**						

2/3 DISK HDA ACOUSTICS AT TM P1

Sirocco P2 Acoustic Noise Data: Idle Sound Power, PCB Up

S/N	Nidec NSK	PMDM NMB	Ohzu 1,2,3 NSK	Ohzu 4,5 NMB
80709	38.970			
51723	37.928			
54611		35.676		
53602		36.702		
31625		35.249		
54601		35.505		
33204			36.625	
35110			36.203	
34213			36.281	
35108			34.950	
30718	39.581			
80701	38.725			
30714	37.250			
30721	38.717			
30717	37.700			
81728	38.989			
52709	38.568			
50720	38.508			
53603		36.940		
53601		37.370		
35107			35.860	
35114			36.013	
35102			35.979	
34206			34.467	
53611		34.575		
12609		36.086		
32610		35.872		
54602		34.378		
34214			34.741	
33208			35.597	

Count	10	10	10	0
Avg	38.494	35.835	35.672	#DIV/0!
1 Sigma	0.688	0.976	0.719	#DIV/0!
Avg+3sig	40.558	38.765	37.829	#DIV/0!
Min	37.250	34.378	34.467	0
Max	39.581	37.370	36.625	#DIV/0!

2/3 DISK HDA ACOUSTICS AT SR P2

SIROCCO/P1/2D HDA/20020 w. OHZU MOTOR
SUMMARY
OFFTRACK DURING SHOCK AND VIBRATION
7/27/95

Remarks:
1. Shock = 20G, 3 ms, HS
2. Vibration = 1.0G, P-P, 0 - 600 Hz
3. N/A = Head signal bad. No data measured available.
4. Head location = cy. 100. (OD)
5. One head+suspension+wire = 0.1128g, J w.r.t. pivot center = 5 g-mm.

I. BASELINE

		VIBRATION								SHOCK	
		FREQ	AMPL	FREQ	AMPL	FREQ	AMPL			RATE	AMPL
S/N	Head	(Hz)	(% OT)	(Hz)	(% OT)	(Hz)	(% OT)		DIR	(% OT/WDG)	(% OT)
20020	3	282	9.88	413	8.69	541	7.76		IN	1.06	21.75
	2	N/A							N/A		
	1	282	9.84	412	8.62	541	10.92		IN	1.00	22.11
	0	282	9.53	426	9.23	543	9.55		IN	1.06	21.88

II. Add Imbalancing = 2.93 g-mm.

		FREQ	AMPL	FREQ	AMPL	FREQ	AMPL			RATE	AMPL
S/N	Head	(Hz)	(% OT)	(Hz)	(% OT)	(Hz)	(% OT)		DIR	(% OT/WDG)	(% OT)
20020	3	281	8.60	401	6.88	540	7.00		IN	0.79	17.67
	2	N/A							N/A		
	1	281	8.14	406	7.00	540	10.16		IN	0.83	19.04
	0	281	8.27	405	7.00	542	8.23		IN	0.80	17.34

2 DISK OPERATING

SHOCK AND VIBRATION

7/95 [redacted]

TEMPEST 3D HDA # 682215 (NIDEC MOTOR)

<u>Shock and Vib. testing condition</u>:

1) Vibration: 1.0G, P-P, 10-600 Hz

2) Shock : 20G, 3ms, Half sine pulse.

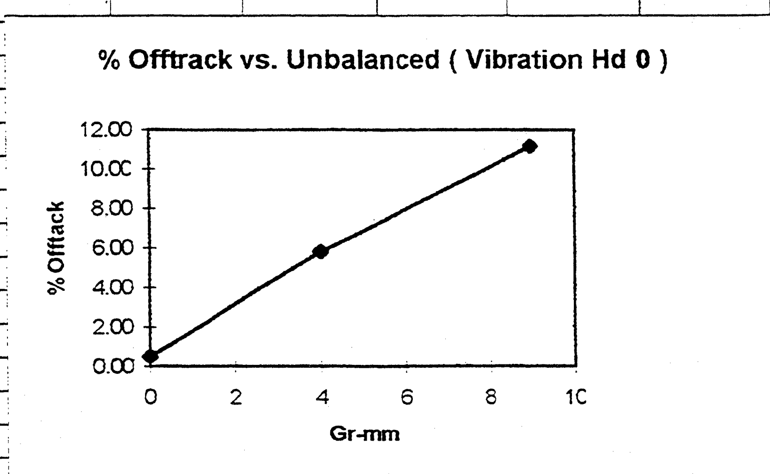
3) Head location @ cyl 100, X-axis

3 DISK VIBRATION TE.

TEMPEST

8/95

			VIBRATION	
			Unbalanced	
Head		% OT	% OT	% OT
		0 gr-mm	4 gr-mm	9 gr-mm
		0	4	9
0		0.50	5.83	11.16
1		0.37	6.12	11.58
2		0.63	6.02	11.09
3		0.40	5.93	11.37
4		0.50	5.93	10.74
5		0.50	5.93	11.47



SIROCCO P3 Drives OP-VIB TEST STATUS:

Jan.5,1996 / Jan.10 1996 update

1. Qntm OP-VIB SPEC : 5-300 Hz, 1.0G, P-P / 300-500 Hz, 0.5G, P-P.
2. Run testing per latest version of :
   - 2.1 ATATSR - Ver.2.07
   - 2.2 ATADIAG - Ver.3.27x1
   - 2.3 Update SA31.07X3 (see Jim Godwin's note on Dec.28,1995.)
3. Baseline run (no vibration).
   - 3.1 Using random logic scan, dissuper, only echo the unrecoverable error.
4. OP-VIB run on shaker per spec.
   - 4.1 Using Qntm OPVIB script file to perform random read/write & compare the data in buffer, if any miscompared error occurs, echo the error.
5. Received 6 2-disks drives and 1 3-disks drive. Unfortunately, 3-disks drive failed on baseline run.
6. On Jan.8, received 3 3-disks drives.
7. Apple spec. 7.a. 0.5G,0-P,5-300Hz, No soft error allowed.
   → 7.b. 1.0G, 0-P, 5-300Hz, No non-recoverable error allowed.
8. Drive #94038 run Apple 7.a, super mode on, recovered error(53h)- bump detected showing.
   Request F/W group to offer an appropriate script to rerun Apple 7.a. (only echo the soft error).

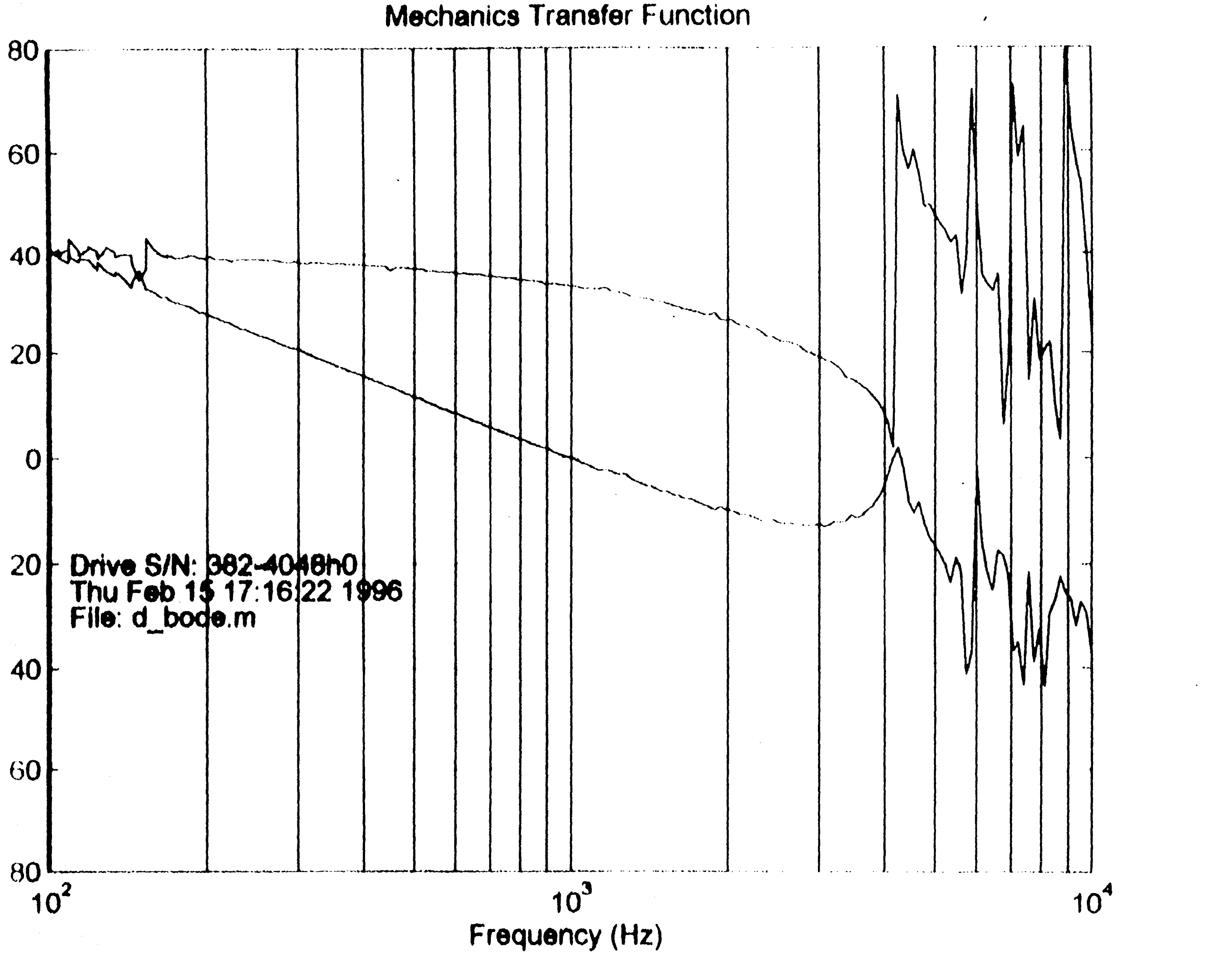
Testing results:

		Baseline	**OP-VIB Run**		**Run per Apple 7.b**	
Drive S/N	**Motor Vendor**	**Run**	**Y direction**	**X direction**	**Y directio**	**X direction**
2 Disks Drives						
66227	Ozu motor	OK	pass	pass		
66225	Ozu motor	OK	pass	pass		
26035	Ozu motor	OK	pass	pass		
26042	Ozu motor	OK	pass	pass	Pass	Pass
26014	Ozu motor	OK	pass	pass	Pass	Pass
26001	Ozu motor	OK	pass	pass		
3 Disks Drives						
12005	Ozu motor	Error - ID not found, give to Roy for F/A.				
71007	Ozu motor	OK	Pass	Pass		
71047	Ozu motor	OK	Pass	Pass	Pass	Pass
94038	PMDM motor	OK	Pass	Pass	Pass	Pass

2/3 DISK SR –
OPERATING –
VIBRATION –
1/10/96

2/3 *Disk Data Update*

- From P2 Build
- Completed on 2/21/96

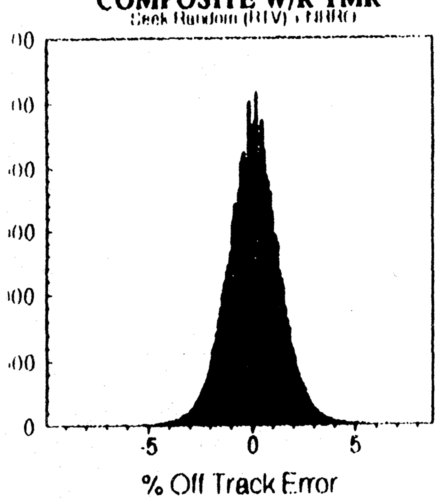


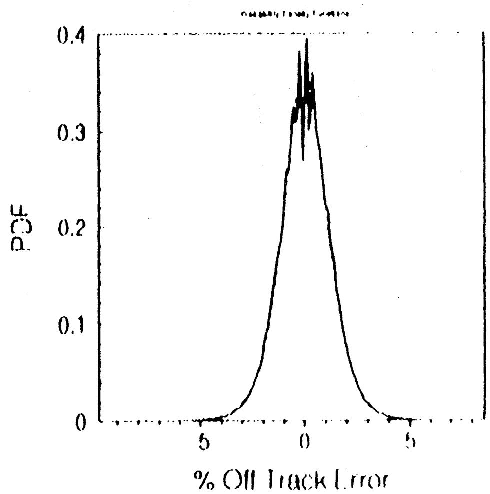
BODE PLOT

2/15/96

P2 HDA - 2 DISK

COMPOSITE W/R TMR





DriveID 382688874128

HDA variation Code [illegible]

3 σ = 3.79 %

Population Estimate, Fitted

via Cumulative Peak Method

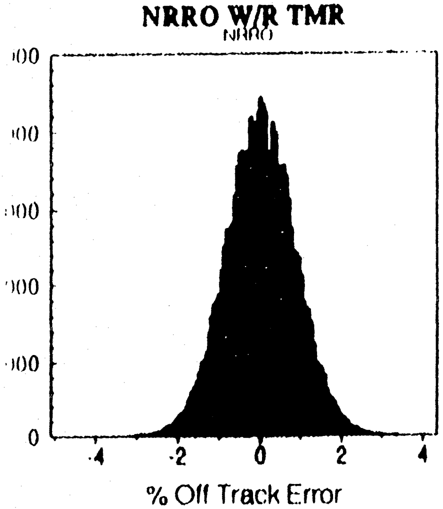
3 σ result = 4.52 % ([illegible] events)

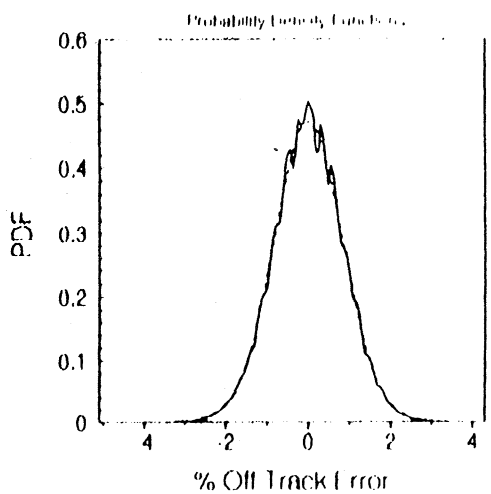
[illegible]

TMR DATA

P2 HDA - 2 DISK

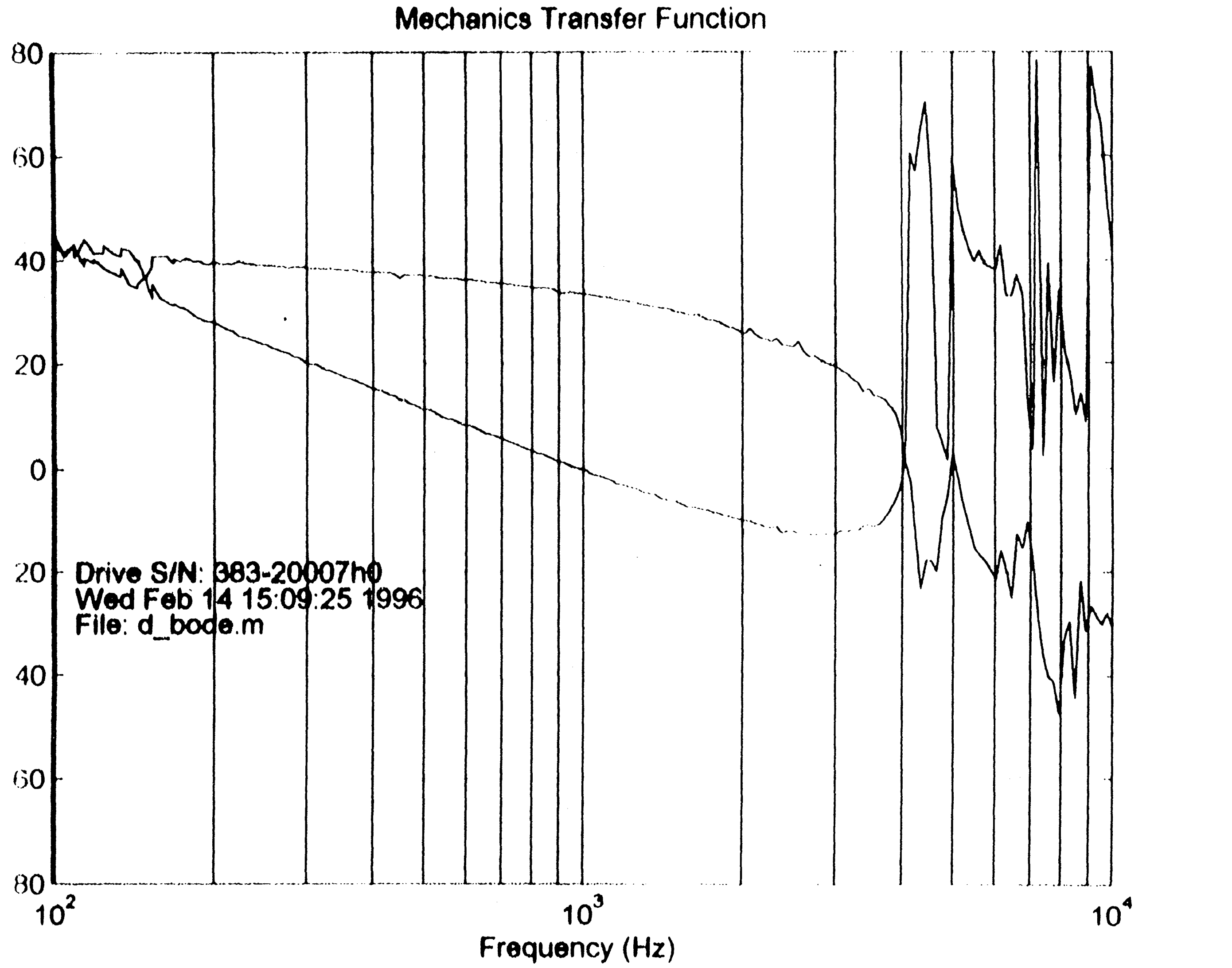
NRRO W/R TMR





3 σ = 2.54 %

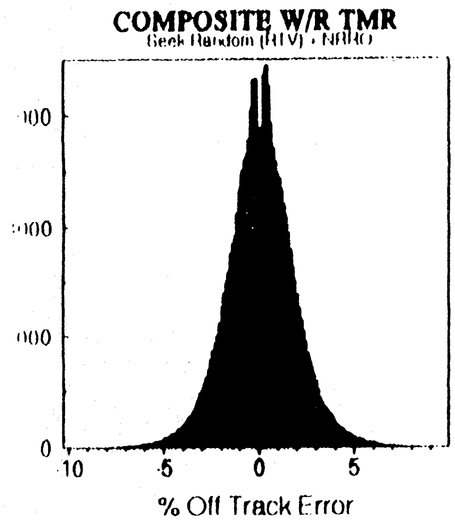
3 σ Population Estimate [illegible]

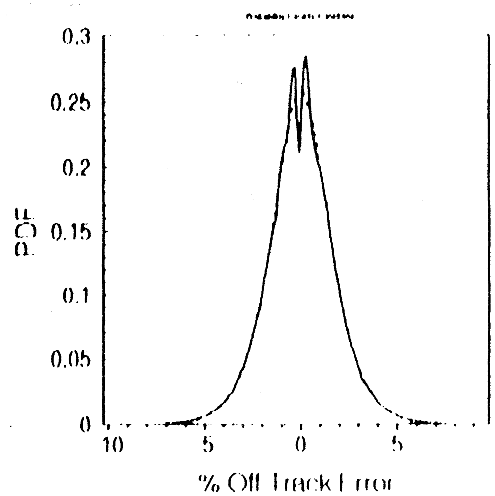


BODE PLOT

2/14/96

P2 HDA - 3 DISK





DriveID 383688849020

HDA Variation Code p2pass

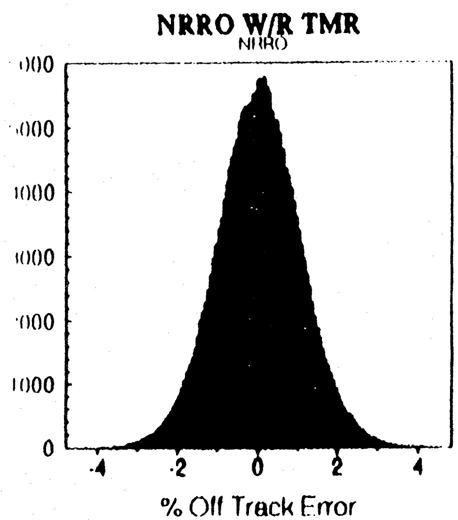
3σ = 5.30 %

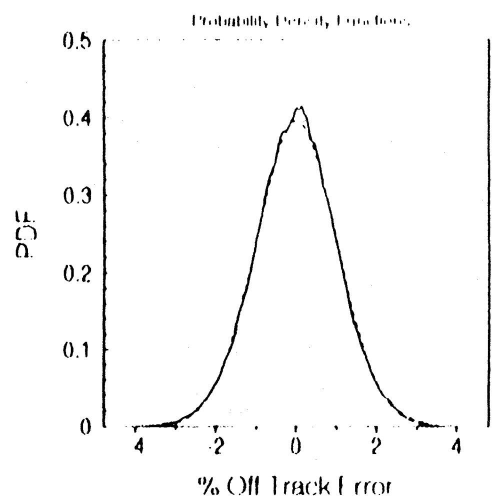
Population Estimate, Based on Cumulative Peak Method

3σ (est) = 5.40 % ([illegible] events)

TMR DATA

P2 HDA - 3 DISK





3σ = 3.04 %

1Disk Mechanical Design Summary - New Features

- Tied Spindle Shaft for Improved Shock and Vibration
- Modified Rotor Assembly for 12.0 ms. Seek Time
- Preamp IC on E Block to Support MR Heads
- Reduced Diameter Clamp and Disk Hub for Maximum Disk Real Estate
- Multemp Spindle Grease for Lower Acoustics

2/3 Disk Mechanical Design Summary - New Features

- 2.8 mm Disk Spacing vs. 3.0 mm on Fireball and 4.0 mm on Lightning to Support 3 Disks
- Die Cast Low Inertia Rotor for 3 Disk HDA with Preamp IC on E Block
- 12 Pole Tied End Spindle/Motor with Laby Seal and Pin Connector
- 8 Microin. NRRO vs. 12 Microin. NRRO on FB
- Steel Cover for Lower Acoustics
- Flex PCB Supports up to 24 Head Traces With Preamp IC on Rotor

Future Test Plans for P2 Drives

- Rotary Shock and Vibration at Quanta Labs
  - 2560 rad/sec **2 at 3 ms. half sine **operating** shock
  - 15,000 rad/sec **2 at 3 ms. half sine **non operating** shock
  - 128 rad/sec **2 from 20 - 300 Hz. **operating** vibration
- Translational Operating Shock and Vibration
  - With Latest Servo Code
  - Verify Sirocco Testing Success
- Additional Altitude Testing of Air Locks
  - Test to Failure -- 10,000 ft. and greater
  - All Magnet Suppliers

Mechanical Summary

- No Major Design Issues Remaining
- Working with MKE on Manufacturing Issues - Process and Cost Related
- Test Data to Date Indicates That 1 Disk and 2/3 Disk HDAs Are Meeting Tempest Specifications

TEMPEST

R/W FE TRAINING

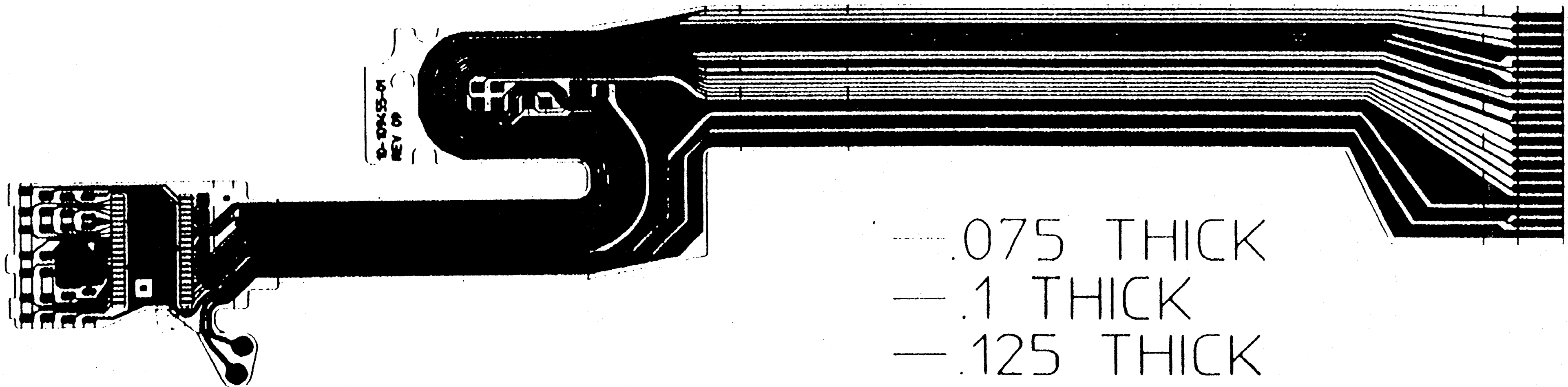
TOPICS

1. FLEXCABLE LAYOUT
2. PREAMP
3. READ/WRITE CHANNEL RECORDING SPECIFICATIONS
4. READ/WRITE CHANNEL HIGHLIGHTS
5. R/W CHANNEL TRAINING - FACTORY ADJUSTED PARAMETERS
6. READ CHANNEL ADAPTATION
7. CHANNEL PERFORMANCES
8. ERROR CHECKING AND CORRECTION METHODS (ECC)
9. DATA TRACK FORMATS
10. PRML CHANNEL SPECIFICS; MAGNETO-RESISTIVE HEAD

READ/WRITE FLEX CABLE

. Signal Paths

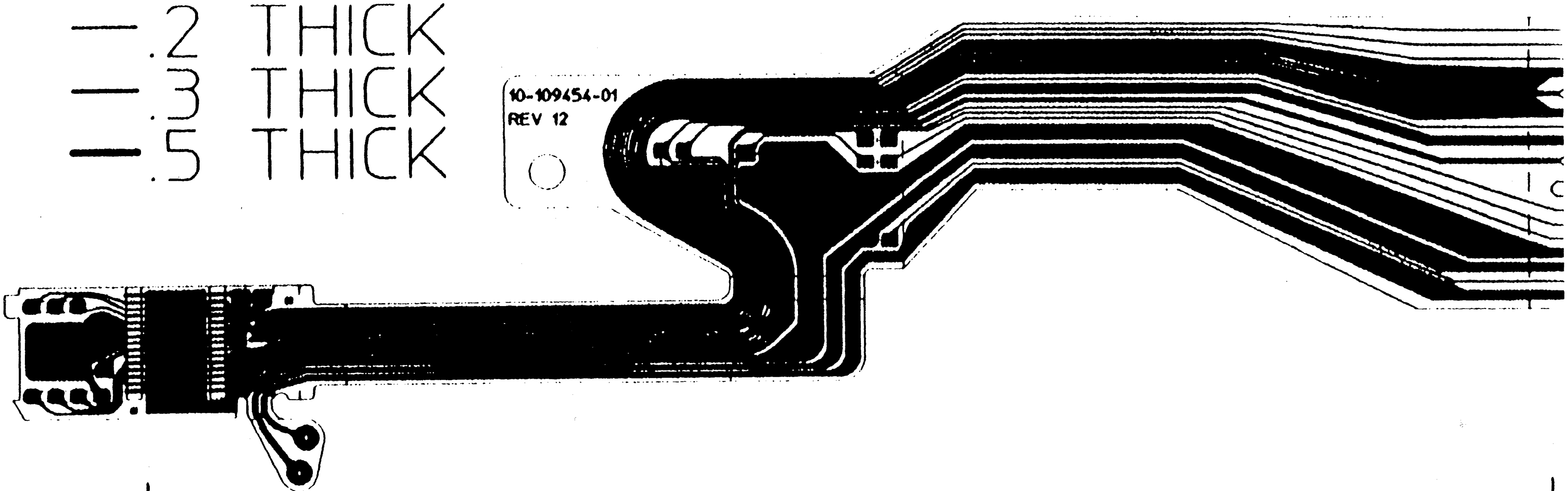
. Grounding Paths



.075 THICK
.1 THICK
.125 THICK
.2 THICK
.3 THICK
.5 THICK

PGØ4

.075 THICK
.1 THICK
.125 THICK
.2 THICK
.3 THICK
.5 THICK



PREAMP

. Features

. Design History

. Preamp Specifications

Preamp features:

. Current Bias/Current Sense Architecture

. Single + 5V Power Supply (+/- 10%)

. Single Ended I/P, Differential O/P

. Chip On Arm (Close to Heads)

Preamp Specifications:

. Norminal Voltage Gain: 240 V/V @ Rmr = 20 Ohms

. Bandwidth: 65Mhz @ -1 dB, 140Mhz @ -3dB

. Equivalent-Input-Noise: 0.68 nV/Sqrt Hertz (Max) @ Rmr = 20 Ohms

. Series Termination Resistor at Preamp-Output: ~50 Ohms

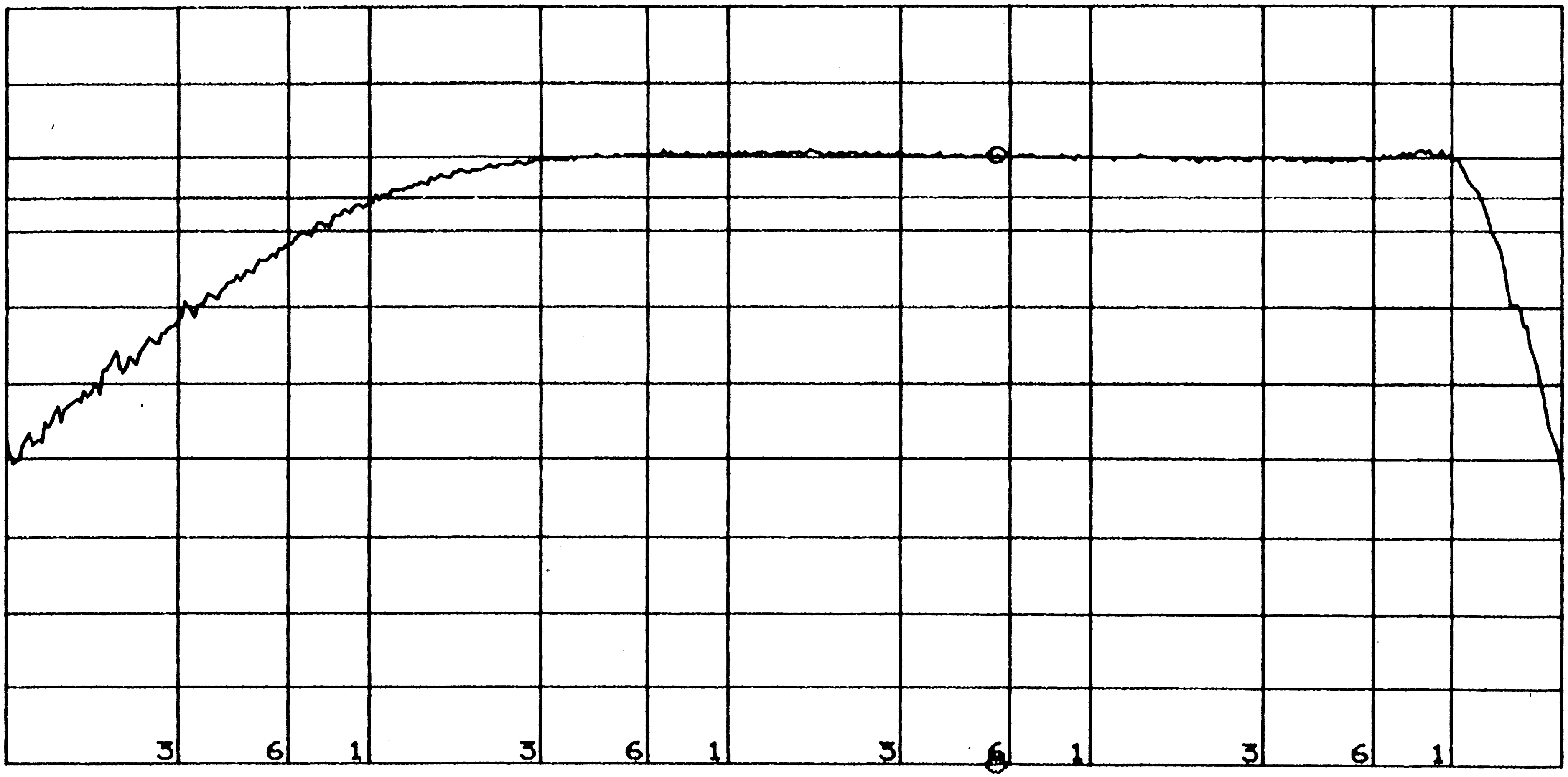
. Write Current: - Programmable from 10mA to 35mA
- Rise/False 3.7 nSec Typical (I_w=25mA, L_{tf} =180nH, R_{tf}=15 Ohms, L_{lead} = 50nH)

. Bufferd Head Voltage Monitor

. PSRR 50dB @ 25 Mhz

ES6 PREAMP

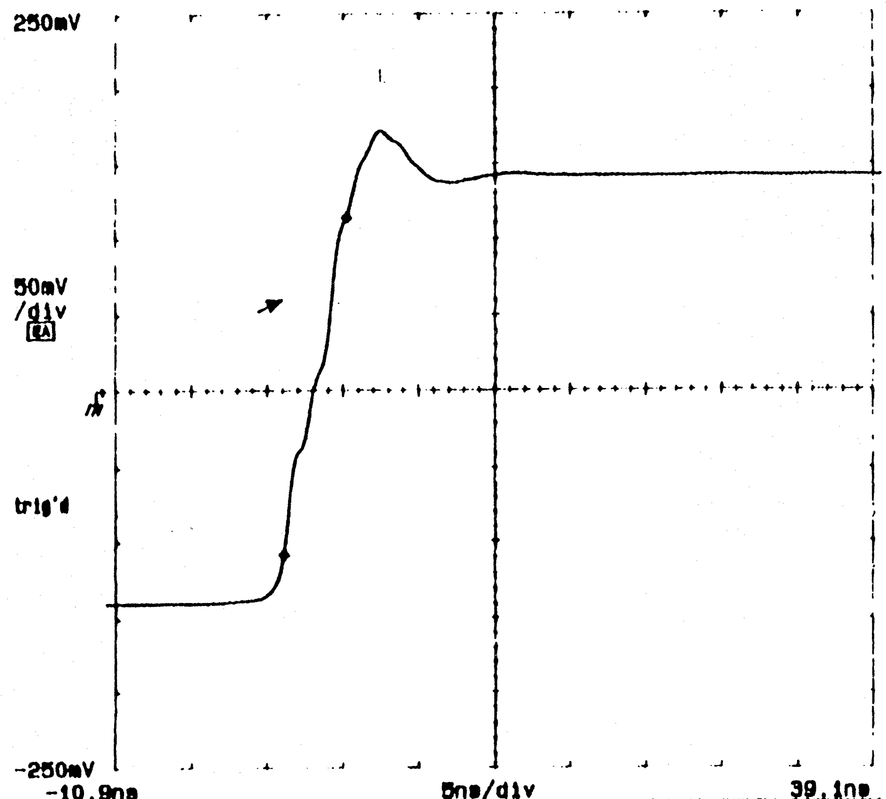
NETWORK Cor CONECT RDX-RDY E.A.M
A: REF B: REF ΔCRS_A -3.04630 dB
55.00 90.00 WIDTH 118 318 860.158 Hz
[dB] [deg]



DIV DIV START 10 000.000 Hz
5.000 5.000 STOP 200 000 000.000 Hz
RBW: 1 KHz ST: 4.33 sec RANGE: R= 10, T= 10dBm

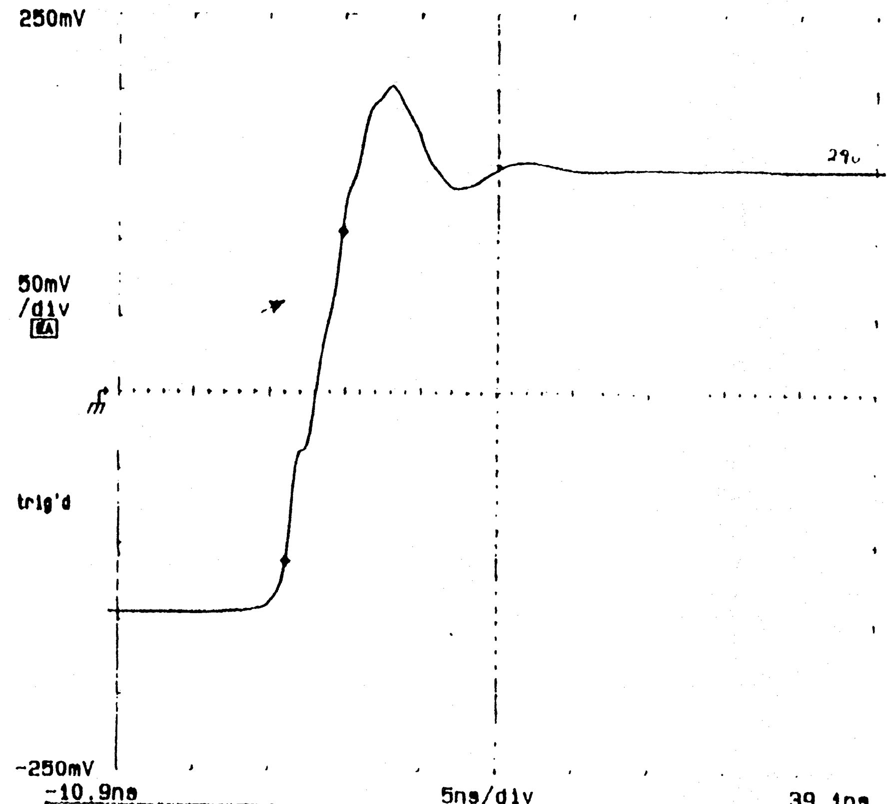
PG-09

11403A DIGITIZING OSCILLOSCOPE (exp: 3.3, dig: 3.0, dsy: 3.10)
date: 13-NOV-95 time: 14:47:03 Instrument ID# B011345



v1= -107.6mV v2= 114.6mV Δv= 222.2mV	t1= 200.0ps t2= 4.300ns Δt= 4.100ns 1/Δt= 243.9MHz	Cursor Type Paired Dots	Cursor 1 200.0ps Cursor 2 4.300ns
		Page to Previous Menu	Remove/Clr Wfm 1 Avg (L1) Main

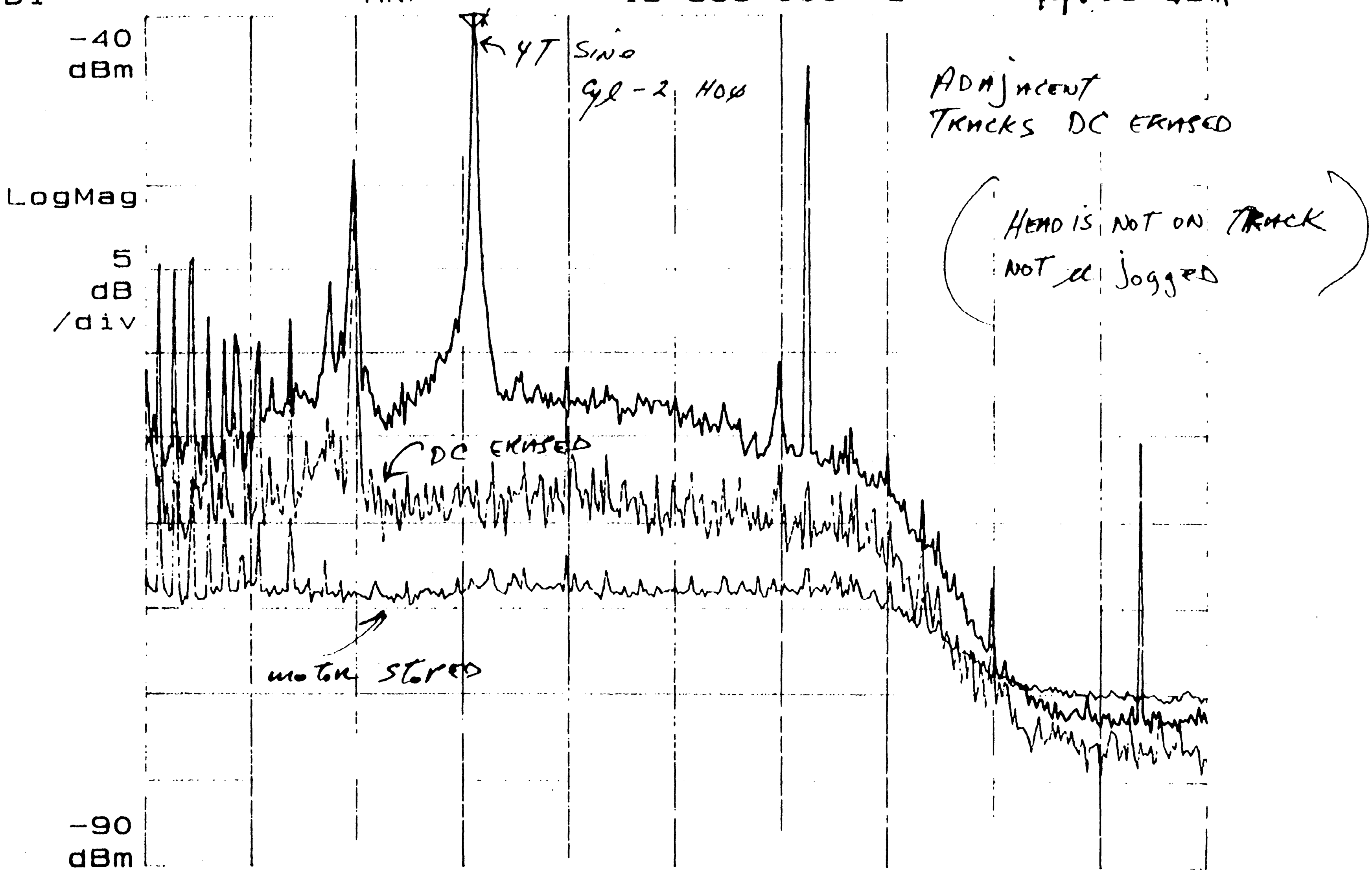
11403A DIGITIZING OSCILLOSCOPE (exp: 3.3, dig: 3.0, dsy: 3.10)
date: 13-NOV-95 time: 14:53:35 Instrument ID# B011345



v1= -110.0mV v2= 106.2mV Δv= 216.2mV	t1= 200.0ps t2= 3.900ns Δt= 3.700ns 1/Δt= 270.3MHz	Cursor Type Paired Dots	Cursor 1 200.0ps Cursor 2 3.900ns
		Page to Previous Menu	Remove/Clr Wfm 1 Avg (L1) Main

PG10

Gate Dly: 10 uS   Gate Lngth: 20 uS   3-May 1993 19:59
Res BW: 17 000 Hz   VBW: Off   Swp Time: 33.6 mSec
A: D1   Mkr   15 569 000 Hz   -14.09 dBm



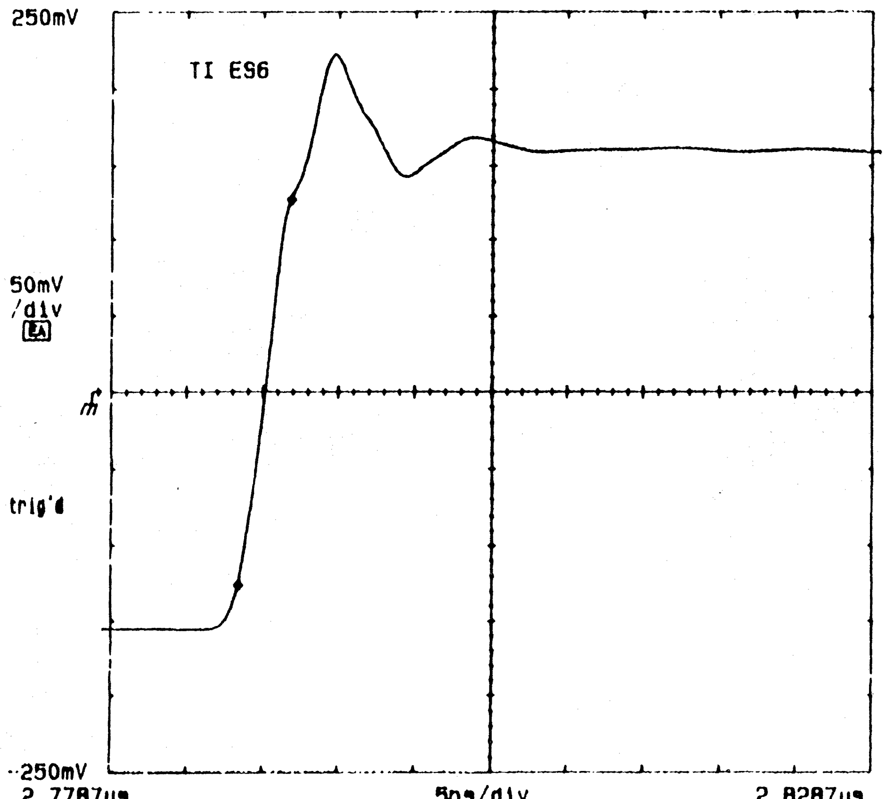
Start: 100 000 Hz   Stop: 50 000 000 Hz

AVERAGING   AVG 17

PG11

11403A DIGITIZING OSCILLOSCOPE (exp: 3.3, dig: 3.0, dsy: 3.10)
date: 7-DEC-95 time: 14: 24: 27 Instrument ID# B011345

0°C

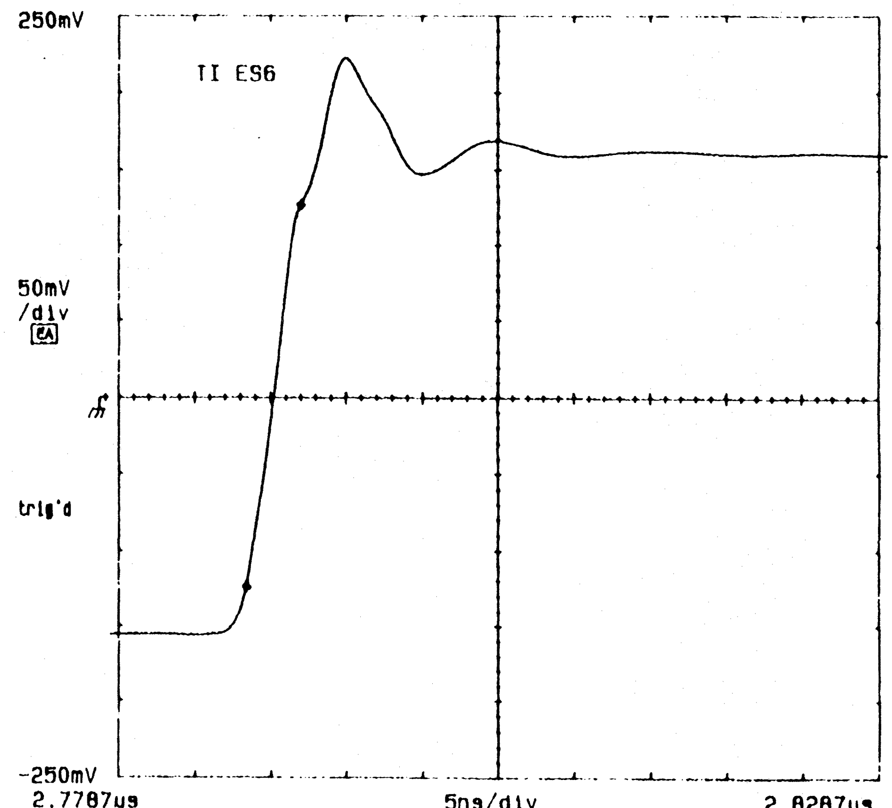


v1= -125.2mV v2= 128.4mV Δv= 253.6mV	t1= 2.787us t2= 2.791us Δt= 3.500ns 1/Δt= 285.7MHz	Cursor Type Paired Dots	Cursor 1 2.787us Cursor 2 2.791us
		Page to Previous Menu	Remove/Clr Wfm 2 Avg (L1) Window 1

11403A DIGITIZING OSCILLOSCOPE (exp: 3.3, dig: 3.0, dsy: 3.10)
date: 7-DEC-95 time: 13: 44: 44 Instrument ID# B011345

50°C.

E.A.M

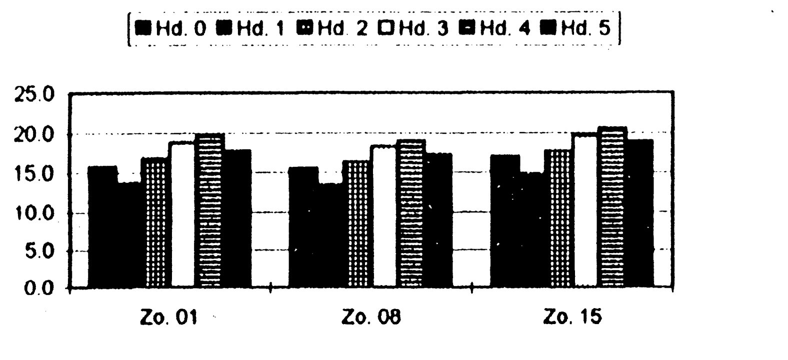


v1= -123.1mV v2= 128.0mV Δv= 251.1mV	t1= 2.787us t2= 2.791us Δt= 3.600ns 1/Δt= 277.8MHz	Cursor Type Paired Dots	Cursor 1 2.787us Cursor 2 2.791us
		Page to Previous Menu	Remove/Clr Wfm 2 Avg (L1) Window 1

Note: With old Pre-Amp

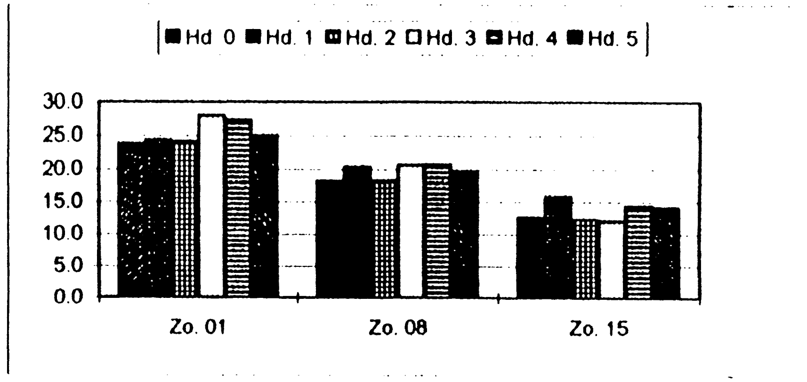
SNR Measurement. (dB)

	Zo. 01	Zo. 08	Zo. 15
Hd. 0	15.8	15.5	17.1
Hd. 1	13.8	13.5	14.5
Hd. 2	16.9	16.4	17.7
Hd. 3	18.8	18.3	19.7
Hd. 4	19.6	19.0	20.6
Hd. 5	17.8	17.3	18.9



NLTS Measurement. (%)

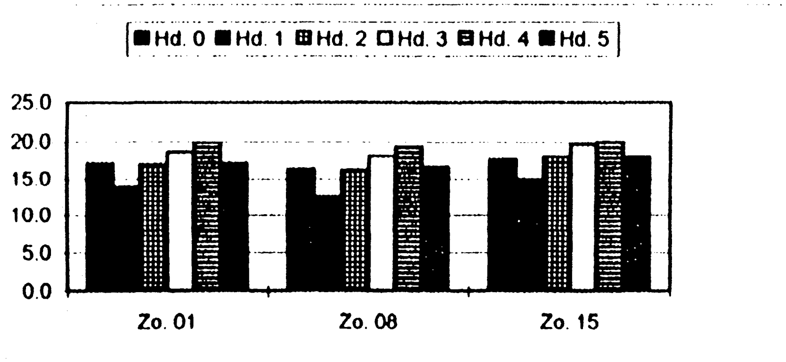
	Zo. 01	Zo. 08	Zo. 15
Hd. 0	23.8	18.1	12.7
Hd. 1	24.3	20.4	15.9
Hd. 2	24.1	18.2	12.4
Hd. 3	28.0	20.6	12.1
Hd. 4	27.4	20.7	14.3
Hd. 5	25.0	19.6	14.1



Note: With new Pre-Amp

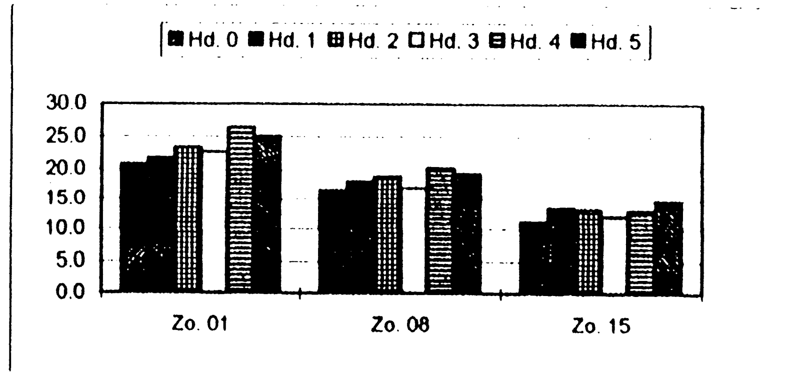
SNR Measurement. (dB)

	Zo. 01	Zo. 08	Zo. 15
Hd. 0	17.2	16.4	17.7
Hd. 1	13.9	12.6	15.0
Hd. 2	17.1	16.3	18.1
Hd. 3	18.7	18.2	19.7
Hd. 4	19.9	19.3	20.0
Hd. 5	17.2	16.7	18.1



NLTS Measurement. (%)

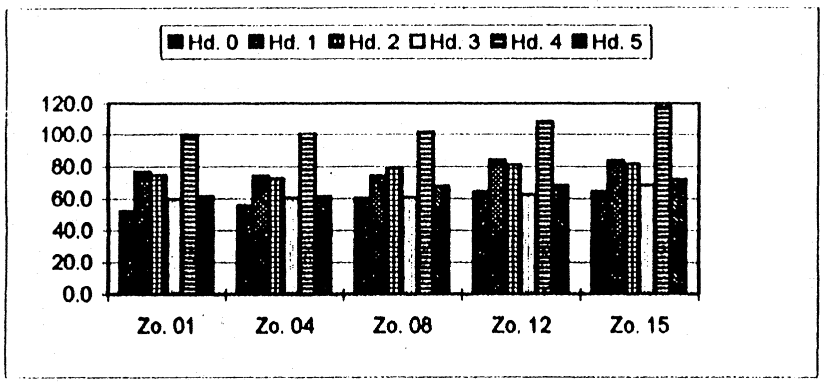
	Zo. 01	Zo. 08	Zo. 15	
Hd. 0	20.8	16.5	11.3	-3.0
Hd. 1	21.8	18.0	13.6	-2.5
Hd. 2	23.4	18.9	13.4	
Hd. 3	22.7	16.9	12.2	-5.3
Hd. 4	26.6	20.3	13.2	
Hd. 5	25.1	19.3	14.6	



Drive: 3_31. Note: With ES6 preamp / No Damping Resi

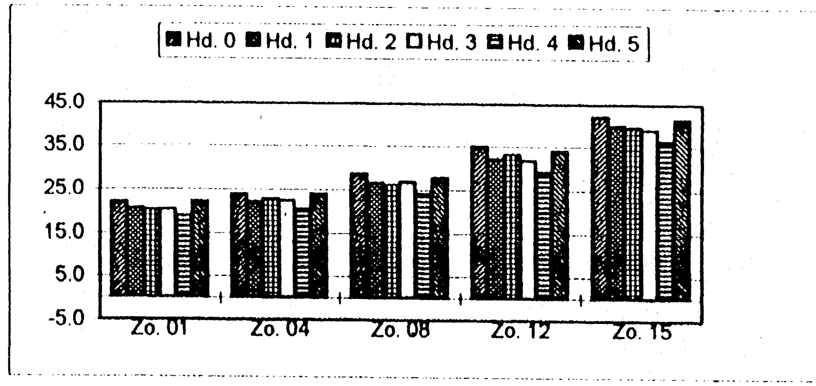
Amplitude Measurement. (mv)

	Zo. 01	Zo. 04	Zo. 08	Zo. 12	Zo. 15
Hd. 0	52.3	56.1	60.6	64.6	64.6
Hd. 1	76.7	74.0	74.0	83.8	83.7
Hd. 2	74.7	72.8	79.0	80.9	81.5
Hd. 3	59.5	60.5	60.7	62.6	68.5
Hd. 4	99.7	100.3	101.9	108.4	117.3
Hd. 5	61.6	61.6	67.6	68.1	72.4



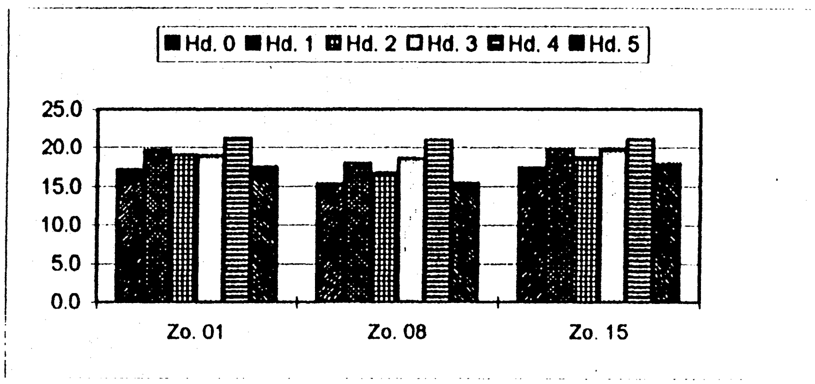
PW50 Measurement. (ns)

	Zo. 01	Zo. 04	Zo. 08	Zo. 12	Zo. 15
Hd. 0	22.1	23.9	28.6	35.0	42.2
Hd. 1	20.7	22.2	26.7	32.2	39.9
Hd. 2	20.3	23.0	26.3	33.2	39.6
Hd. 3	20.4	22.5	26.8	32.0	39.1
Hd. 4	19.0	20.6	24.2	29.2	36.3
Hd. 5	22.3	24.1	27.9	34.0	41.5



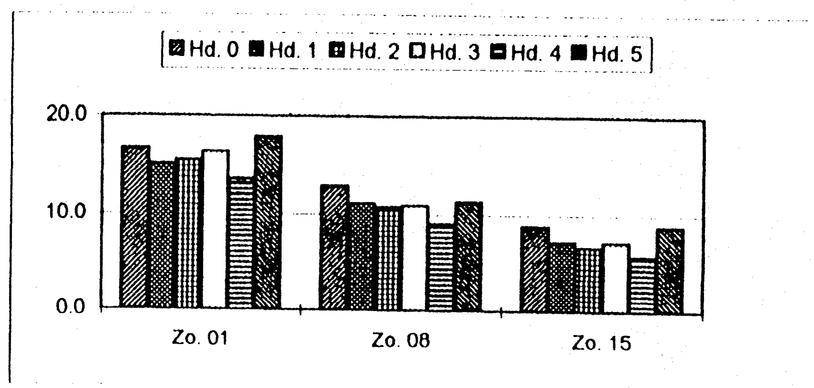
SNR Measurement. (dB)

	Zo. 01	Zo. 08	Zo. 15
Hd. 0	17.1	15.4	17.4
Hd. 1	19.5	18.0	19.7
Hd. 2	19.0	16.7	18.7
Hd. 3	18.9	18.6	19.6
Hd. 4	21.3	21.0	21.1
Hd. 5	17.5	15.5	17.9



NLTS Measurement. (%)

	Zo. 01	Zo. 08	Zo. 15
Hd. 0	16.6	12.9	8.8
Hd. 1	15.0	11.1	7.2
Hd. 2	15.4	10.8	6.6
Hd. 3	16.3	10.9	7.1
Hd. 4	13.5	9.0	5.7
Hd. 5	17.9	11.3	8.8



READ/WRITE CHANNEL RECORDING SPECS:

. HIGH FREQUENCY TAA:	350 uV
. PW50	442 nm
. RESOLUTION:	70 %
. NLTS	25% (5th harmonic method)
. MR ASYMMETRY:	15 %
. OVERWRITE:	30 dB

HIGHLIGHTS OF READ/WRITE CHANNEL IC's

. 100 Mb/Sec (Max) DATA RATE

. MR BIAS CURRENT DAC.

. MR SIGNAL ASYMMETRY COMPENSATION

. FULLY ADAPTIVE 10 TAPS DIGITAL FIR

. THERMAL ASPERITY (T.A.) DETECTION AND COMPENSATION

FUNCTIONAL BLOCK DIAGRAM

@ DATA READ CHANNEL

. DATA READ CHANNEL USE PARTIAL-RESPONSE MAXIMUM-LIKELIHOOD (PRML) DETECTION TECHNIQUE.

. AGC LOOP

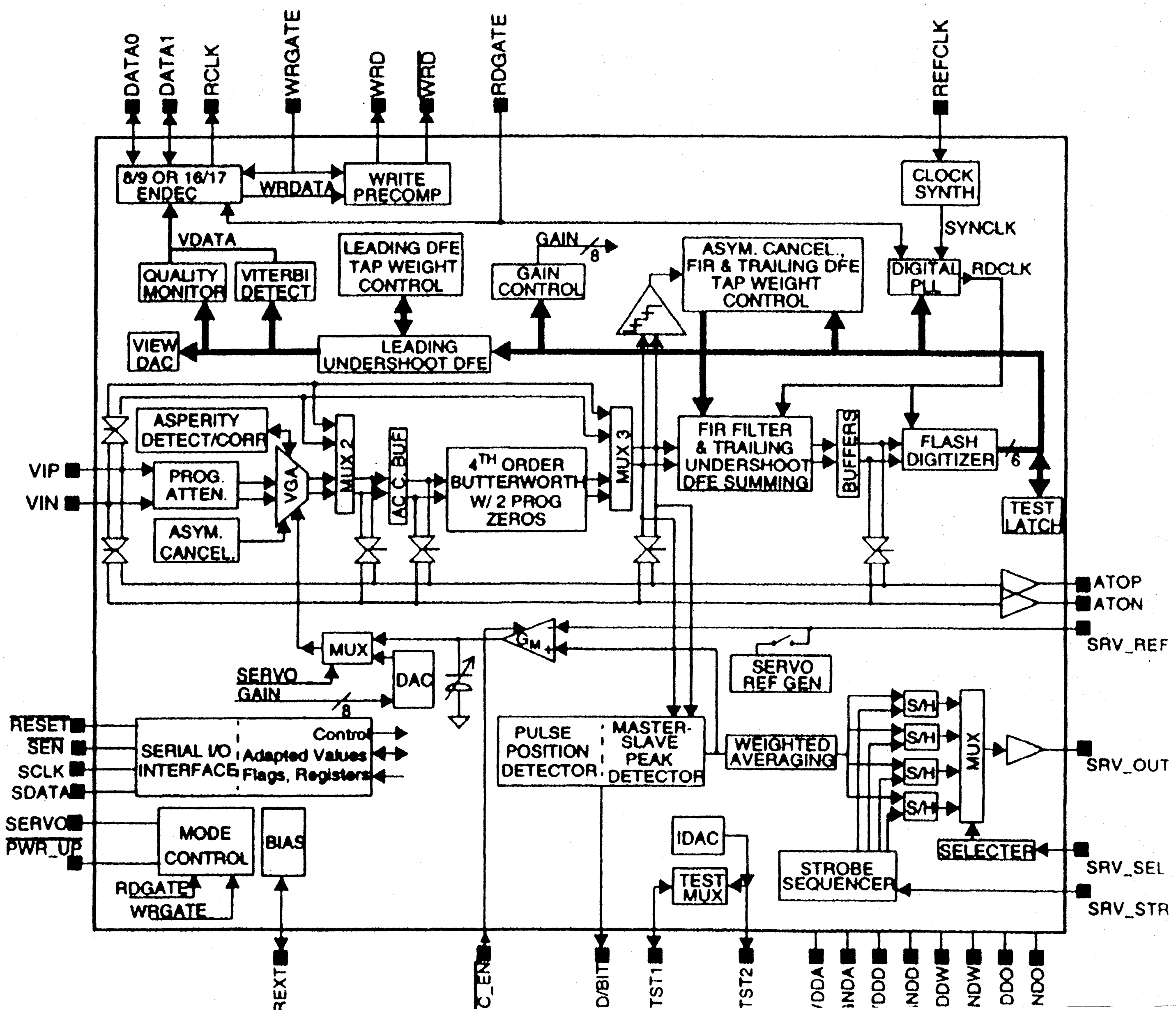
. TIMING LOOP

@ SERVO CHANNEL

. TO RECOGNIZE THE GRAYCODE, THE SERVO CHANNEL USES PEAK-DETECTION TECHNIQUE WITH THRESHOLD AND/OR POLARITY QUALIFICATION.

. SERVO DEMODULATOR- CONSISTS OF A MASTER SLAVE PEAK DETECTOR, AN WEIGHTED AVERAGING CIRCUIT.

Read/Write Channel IC - Functional Block Diagram



PG 18

Read/Write Channel - Digital Phase Lock Loop Block Diagram

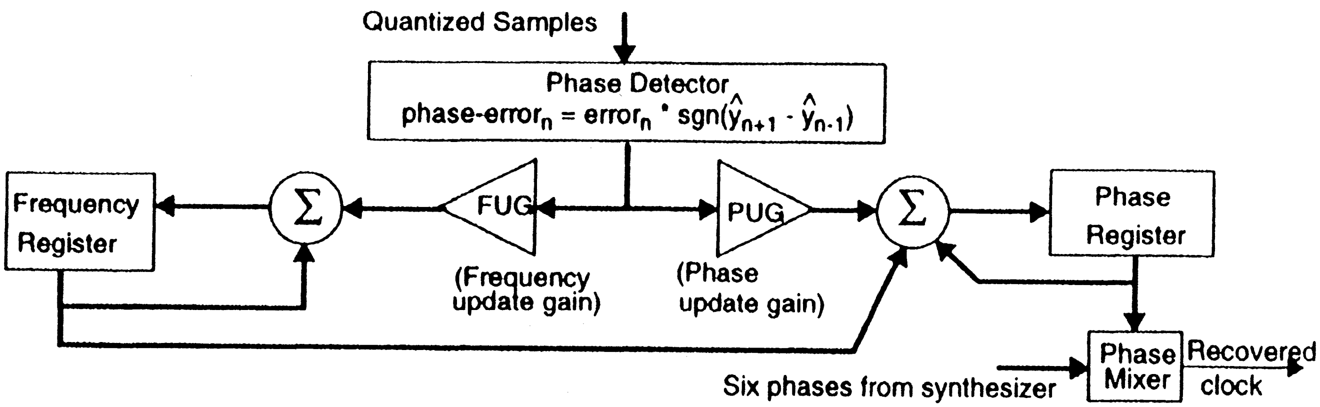
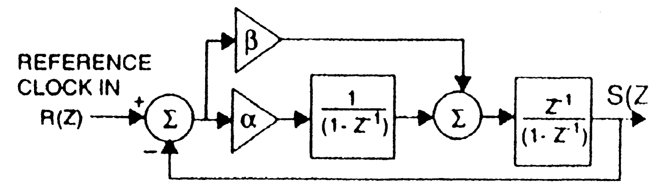


Figure 7. Digital PLL Block Diagram.

Functional Description (continued)

and two poles at

$$Z_{poles} = 1 - \left[\frac{\alpha + \beta}{2}\right]\left[1 \mp \sqrt{1 - \frac{4\alpha}{(\alpha + \beta)^2}}\right]$$



$$\frac{S(Z)}{R(Z)} = \frac{Z(\alpha + \beta) - \beta}{Z^2 + Z(\alpha + \beta - 2) + (1 - \beta)}$$

Figure 16. Two-Parameter Model of Synth. PLL.

$$\frac{\beta^2}{\alpha} = \frac{I_{po} \times ICPM \times K_o \times C_1 R^2}{2\pi M\left[1 + \frac{C_2}{C_1}\right]^3}$$

AT&T Proprietary
Use Pursuant to Company Instructions

Read Channel - Viterbi Detector Block Diagram

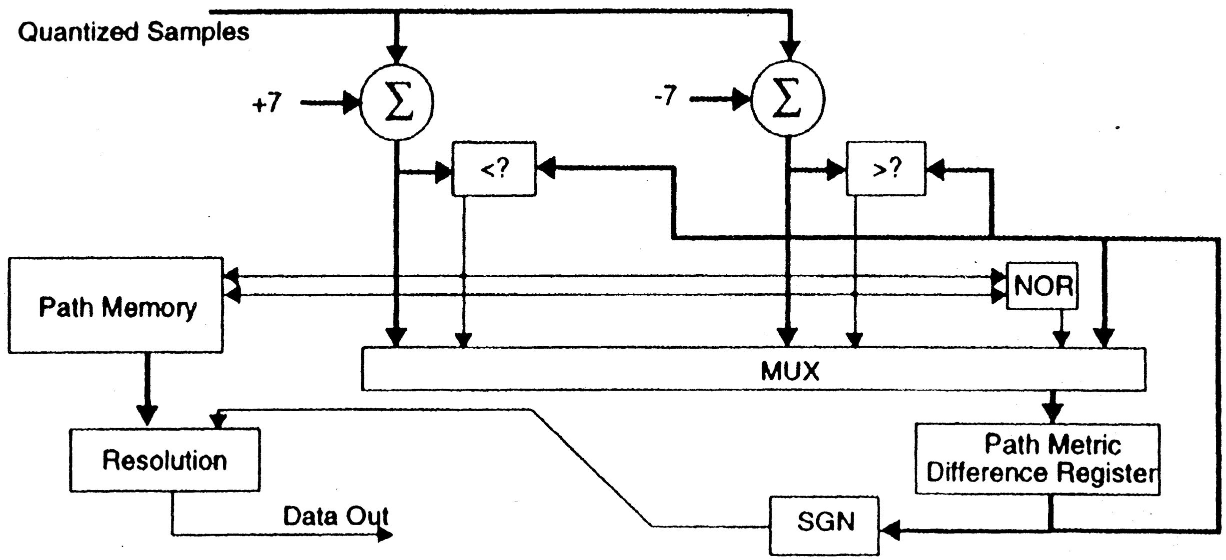
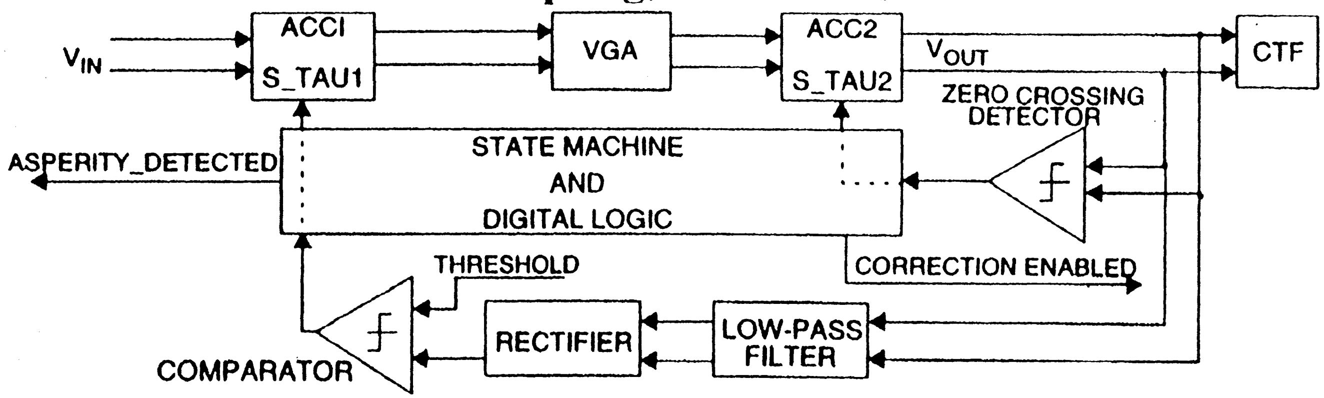


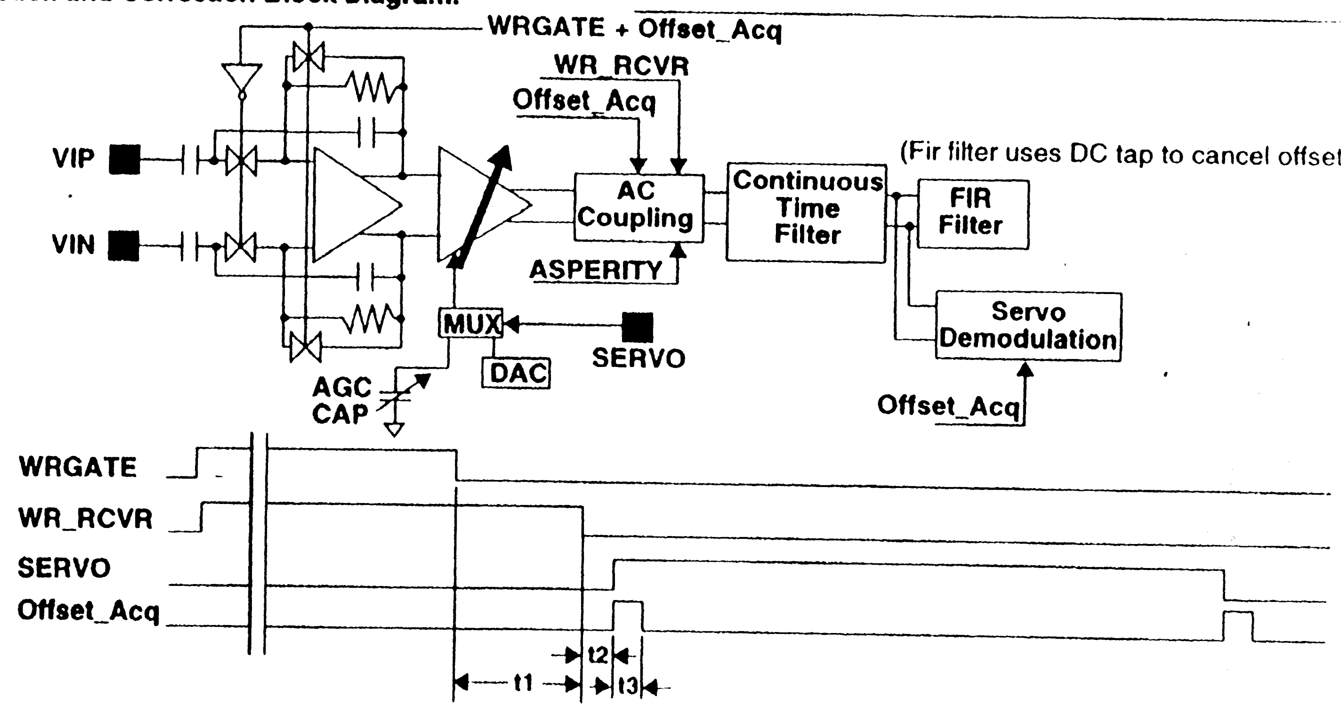
Figure 8. Viterbi Detector Block Diagram.
AT&T Proprietary
Use Pursuant to Company Instructions

Read Channel - AC Coupling, Offset Acquisition and TA Block Diagram



Note: For clarity only single-ended shown.

Figure 9. Thermal Asperity Detection and Correction Block Diagram.



Servo block Diagram

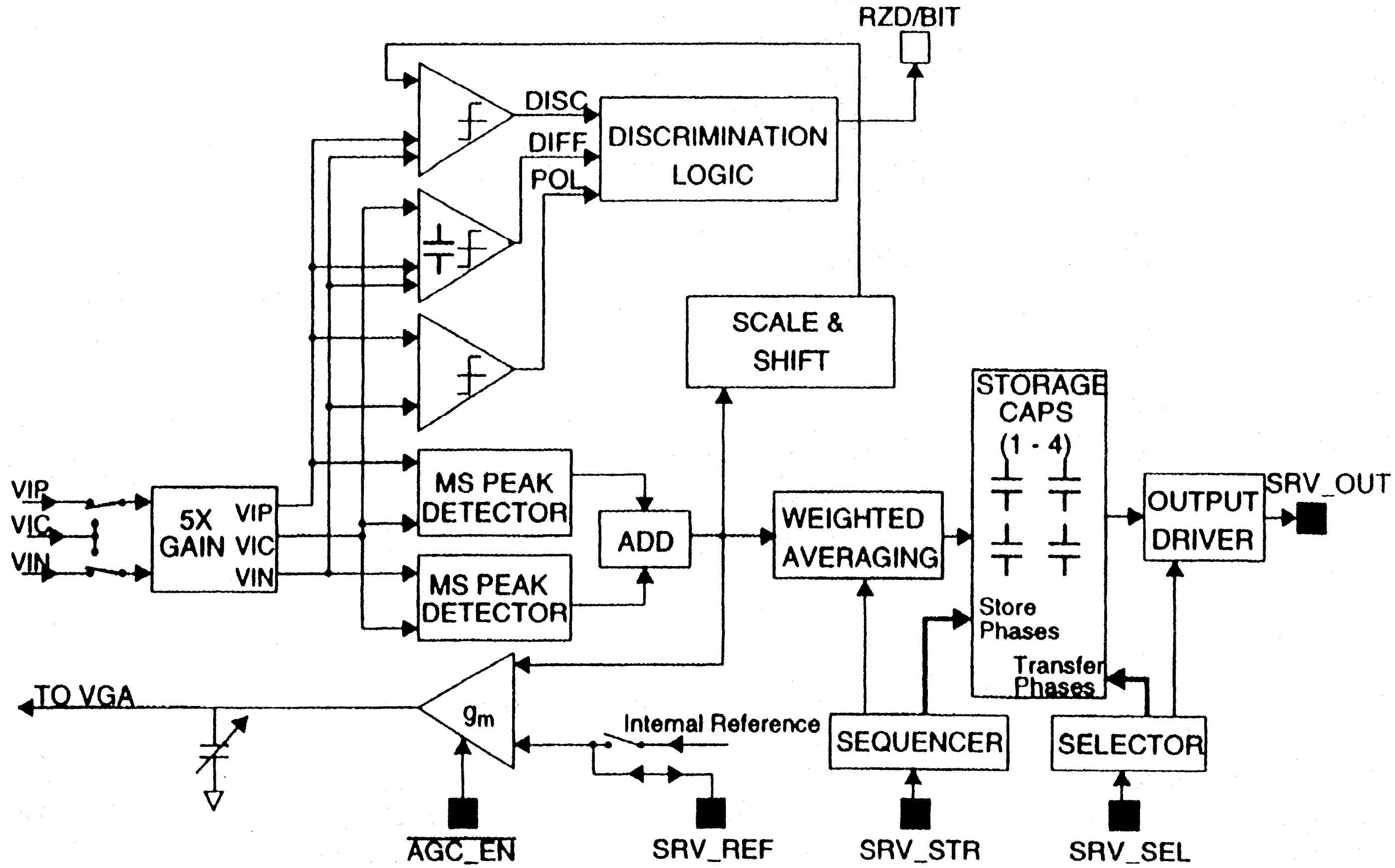


Figure 18. Servo Block Diagram.

Servo Polarity Qualification and Mode of Operations

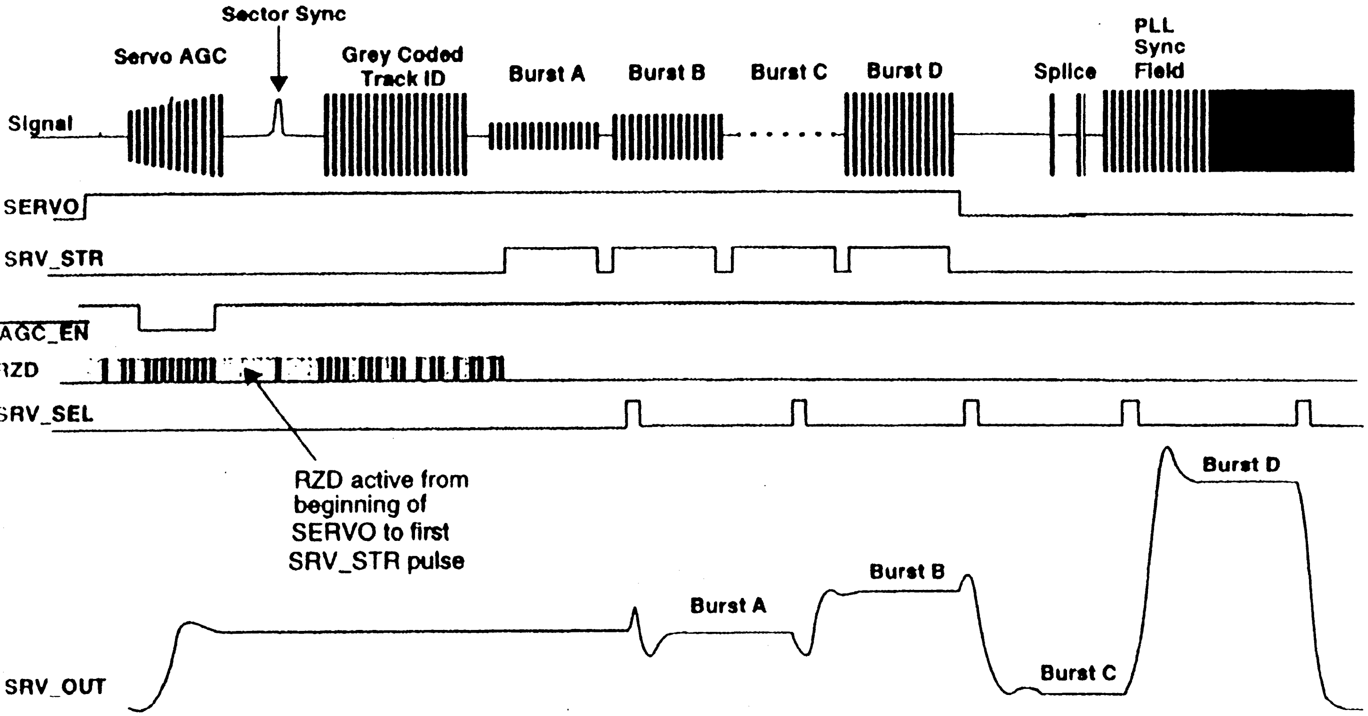
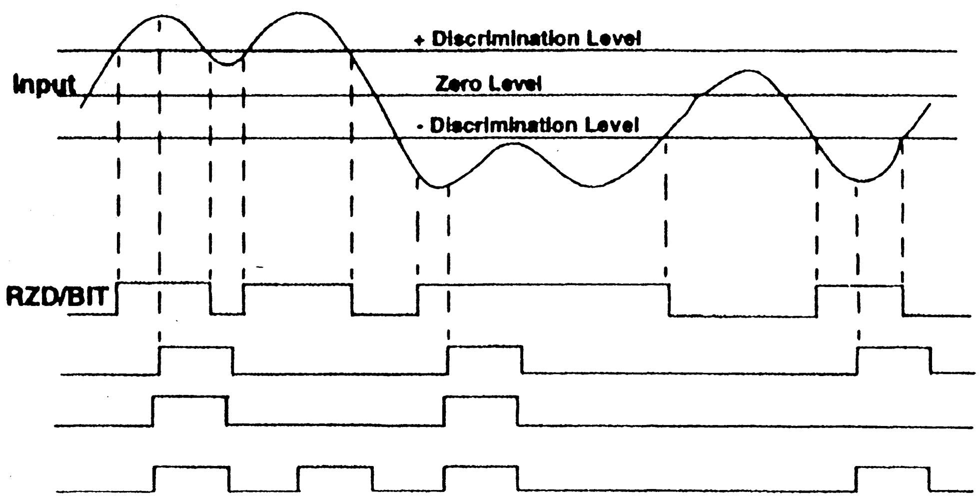


Figure 19. Servo Mode Operations.



POSONLY = 0

POL_HRD	RZDBIT	MODE
0	0	BIT
0	1	RZD
1	0	RZD HARD POLARITY
1	1	RZD POLARITY EASY

Figure 20. Servo Polarity Qualification Modes.

R/W CHANNEL TRAINING:

MR Bias Current, MR Asymmetry Cancellation and Micro-jog

. In "Selfscan" The MR bias current is adjusted such that the minimum MSE (mean-squared-error) is achieved.

. Upon the selection of MR bias current, the "MR Asymmetry Cancelation" control range is adjusted to assure that the percentage asymmetry of a target head is within the compensation range.

. Micro-jog calibrates the MR read-element offset from the center of the track.

R/W CHANNEL TRAINING:
Factory Adjusted Parameters

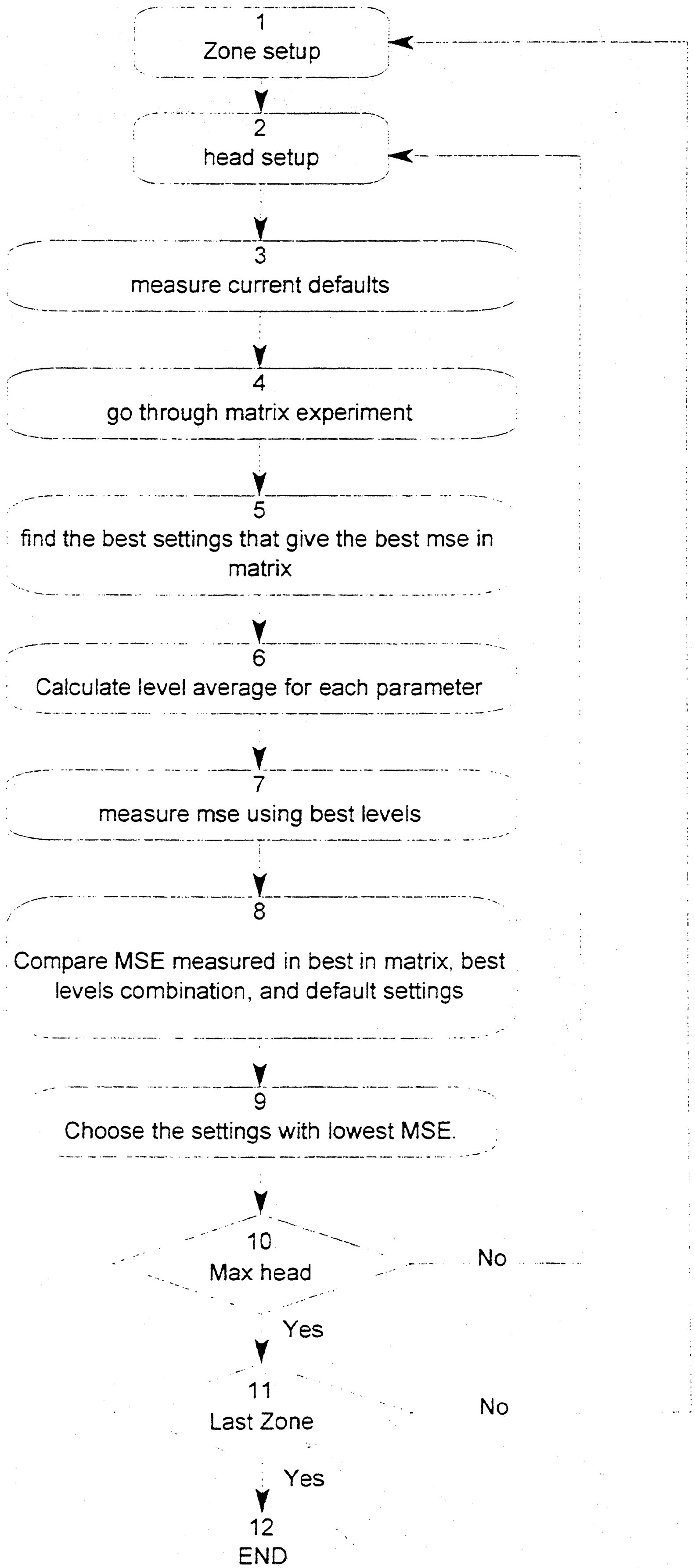
. In "Selfscan" Write-Precomp,Cut-Off and Boost (of the continuous filter) and Tap4 (of the FIR filter) are all adjusted.

. The "TAGUCHI" algorithm is used which essentially adjust all the parameters at once! Speeding up the tuning process.

. The proper "OPTIMUM" values for each head and zone are stored and used to "PRESET" the channel upon head and zone selection.

Friday, March 1, 1996

Adaptives Algorithm



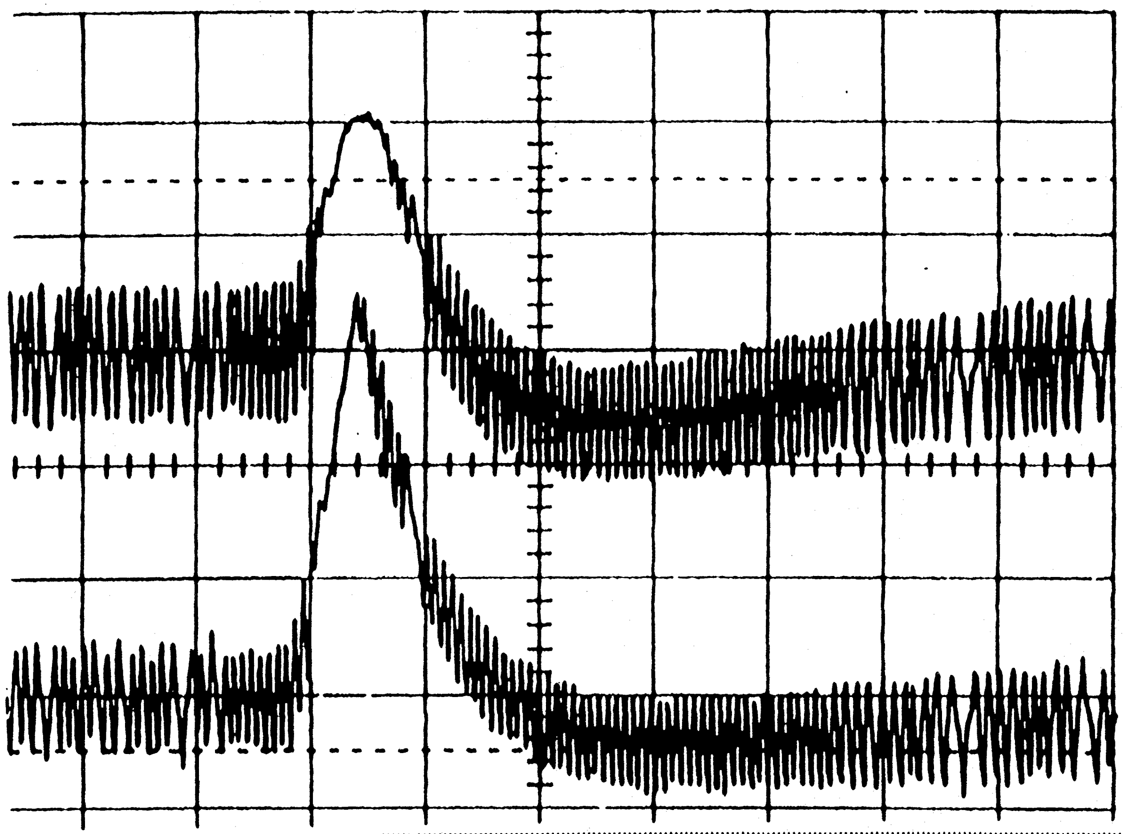
"ON-THE-FLY" ADAPTATION

. READ CHANNEL CONSTANTLY ADAPTS ITS RESPONSE VIA THE FIR FILTER IN ORDER TO MINIMIZE THE MSE (Mean-Squared- Error)

. THE FIR ADAPTATION FEATURE COUNTERS ANY VARIATIONS TO THE CHANNEL RESPONSE CAUSED BY COMPONENT AGING, TEMPERATURE AND ANY OTHER SLOW CHANGING PHENOMENA THAT COULD DEGRADE THE CHANNEL PERFORMANCE.

THERMAL ASPERITY (TA)

. TA is a generic name given to all incidents that involve heat induced read-back amplitude distortion.



T.A. DETECTION AND COMPENSATION

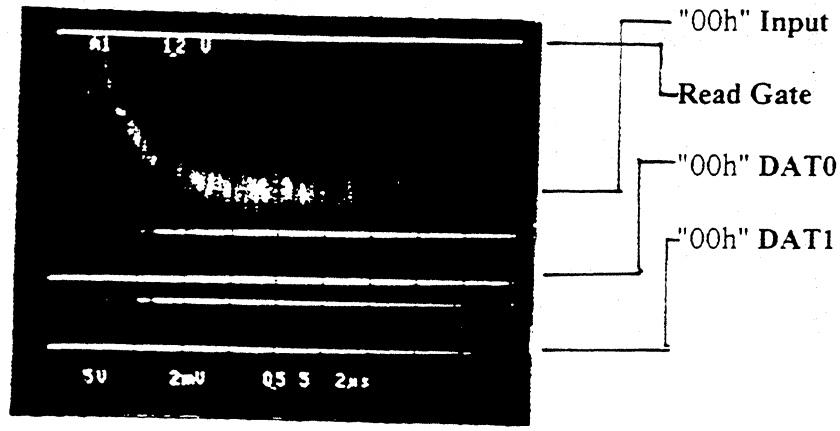
. **Detect the rising edge of the TA**

. **Keep the PLL and AGC loop from changing (Hold the AGC and Timing Loop-Gain)**

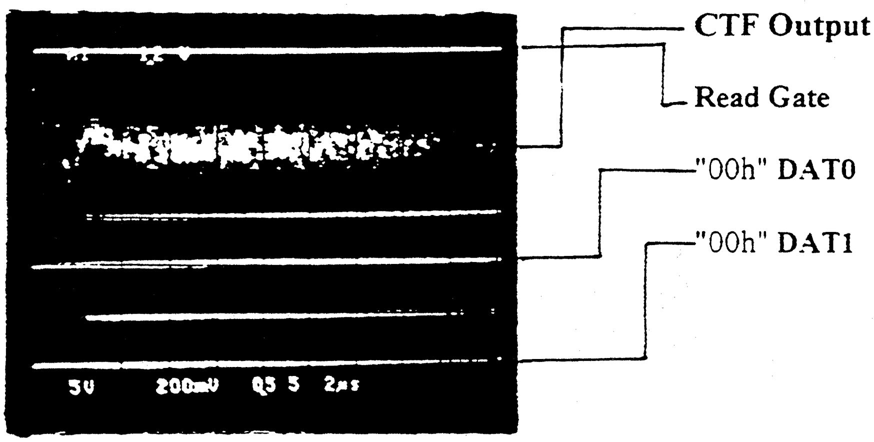
. **Move the coupling pole such that the TA decays faster**

BLUE EVALUATION TEST RESULTS
T.A. PERFORMANCE @ AM Field

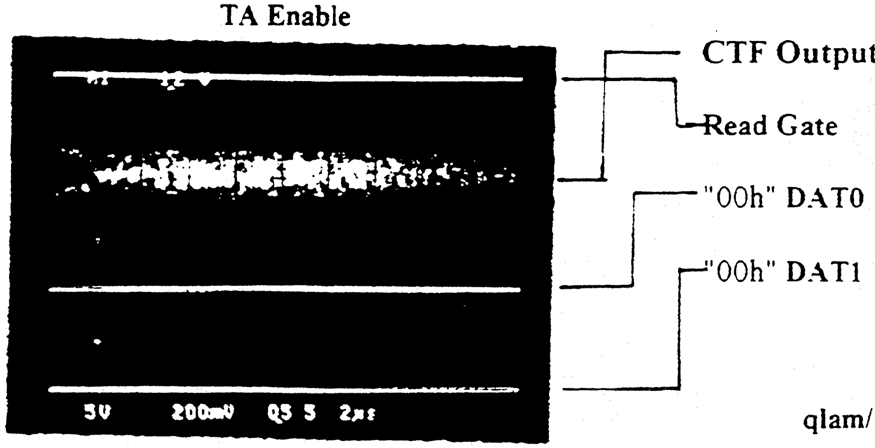
TA Disable



TA Disable



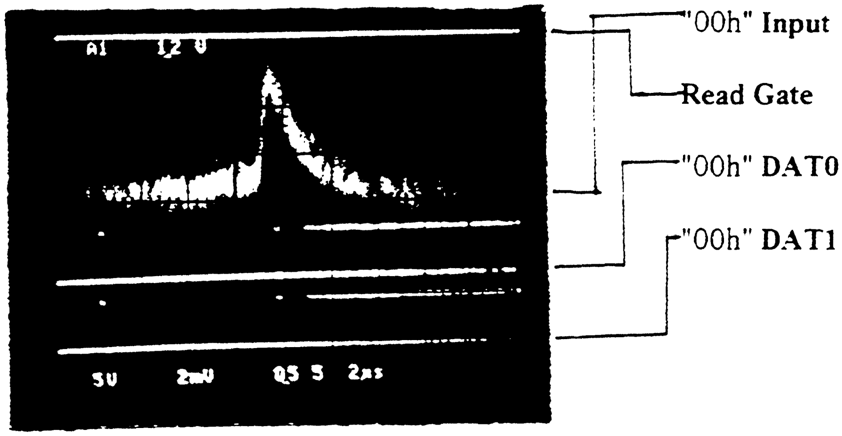
TA Enable



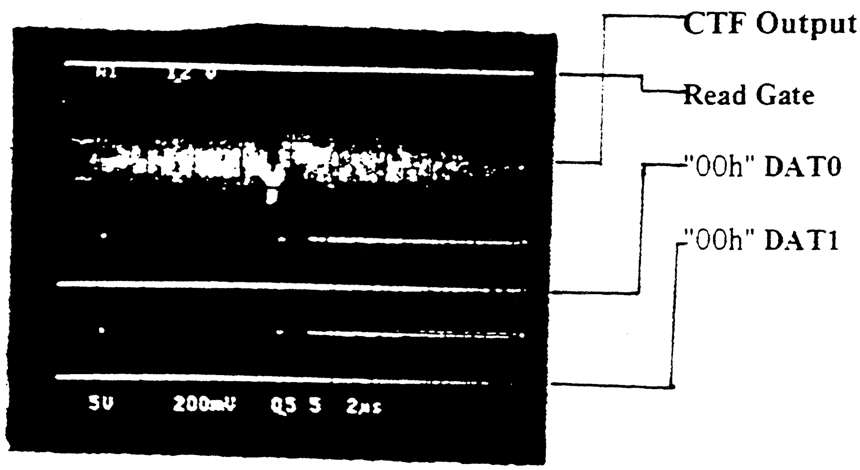
qlam/dduong

BLUE EVALUATION TEST RESULTS
T.A. PERFORMANCE @ DATA Field

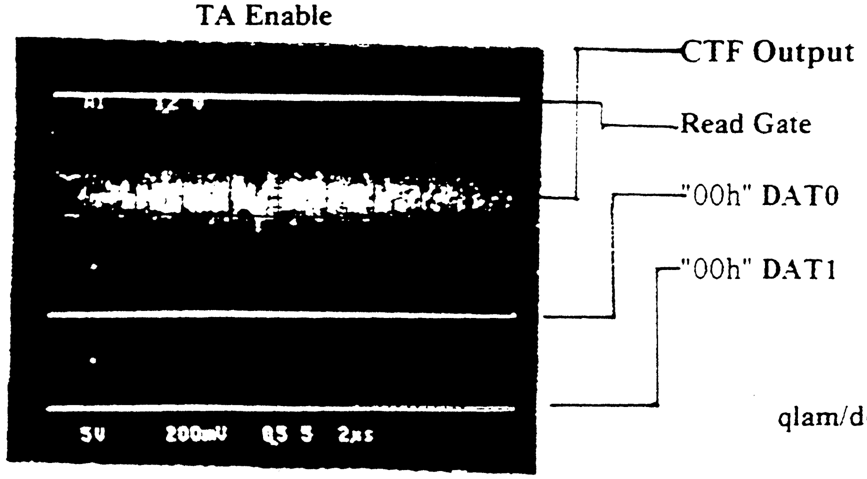
TA Disable



TA Disable



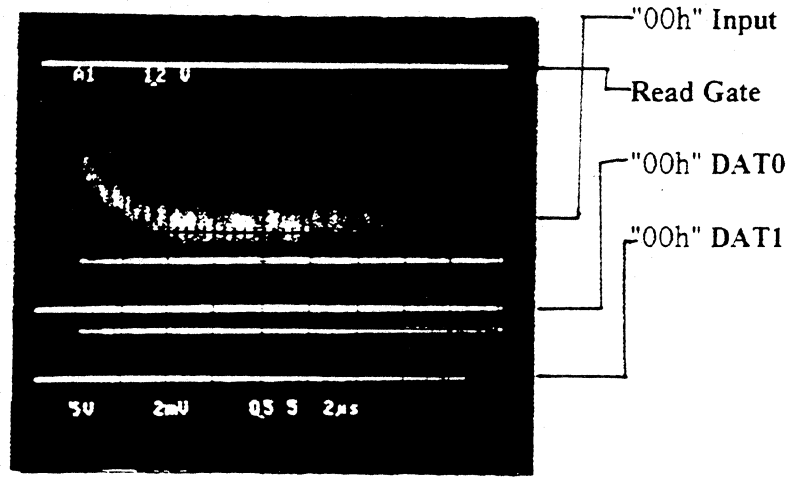
TA Enable



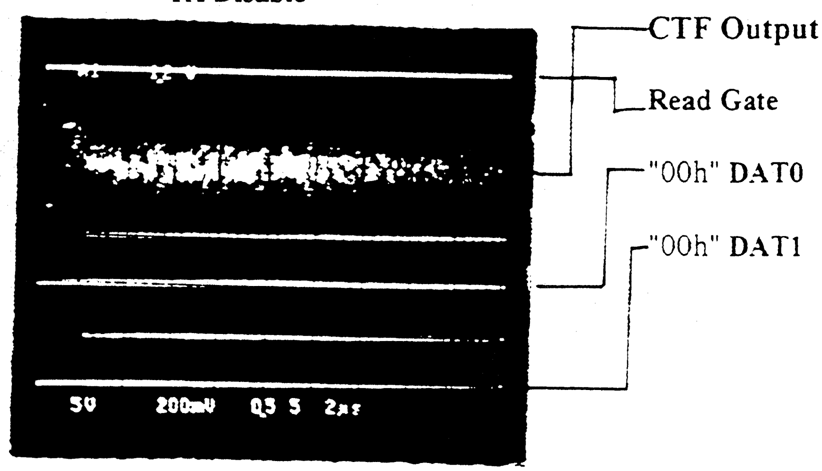
qlam/dduong

BLUE EVALUATION TEST RESULTS
T.A. PERFORMANCE @ ZPR Field

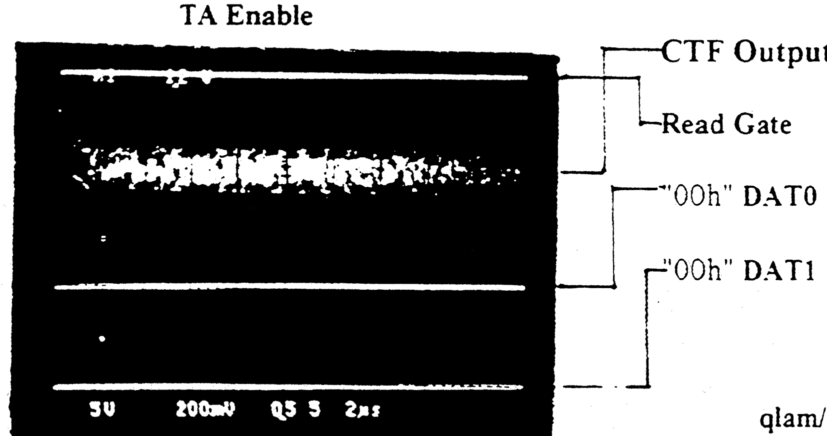
TA Disable



TA Disable

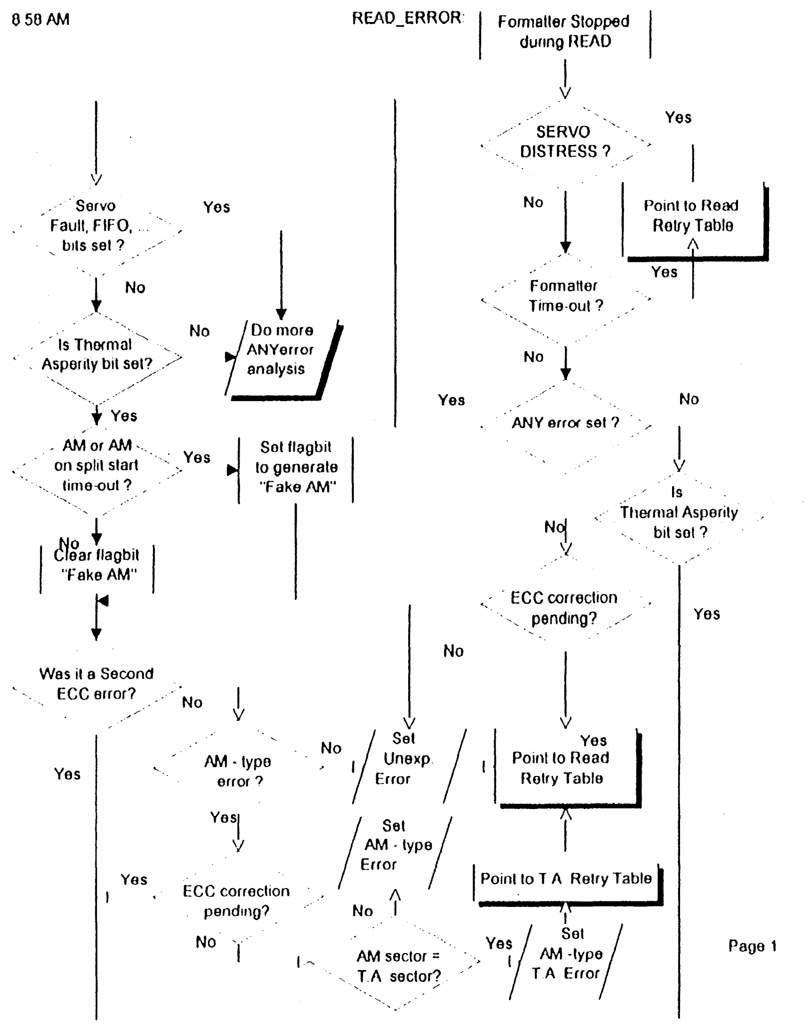


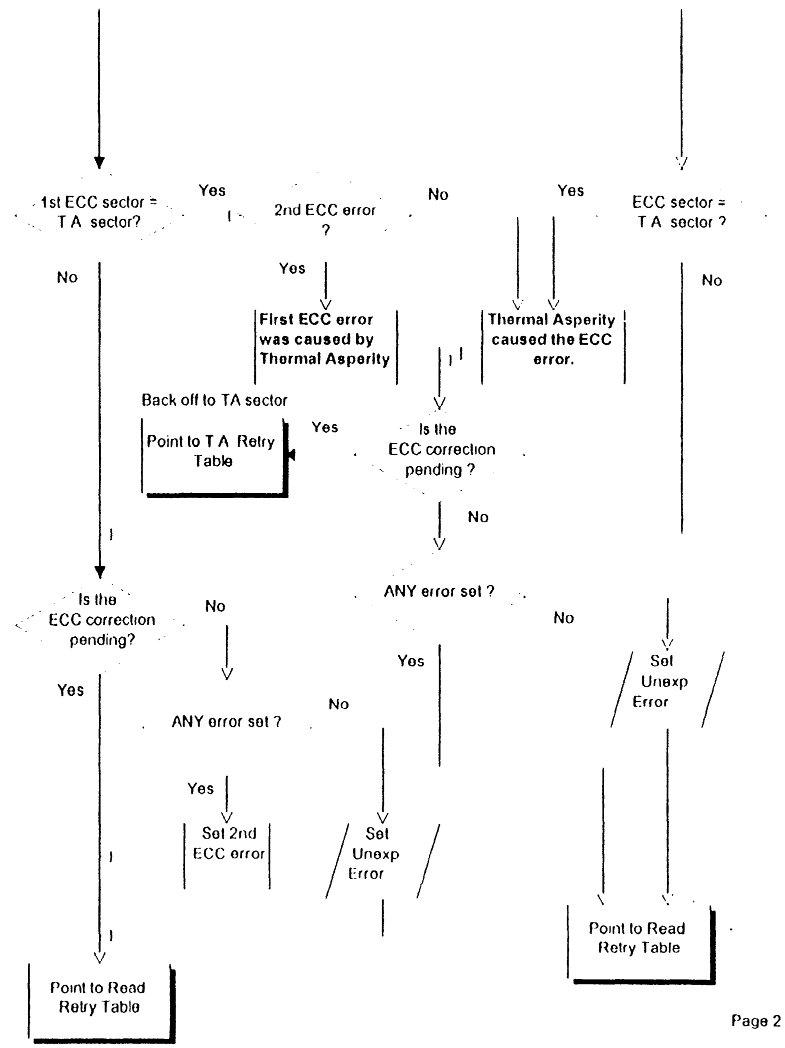
TA Enable



qlam/dduong

C:\ABC\TUTORIAL\THER_ASP.AF3 Thermal Asperity Recovery Flow, Tempest 11/16/95
Monday, August 14, 1995
8:58 AM





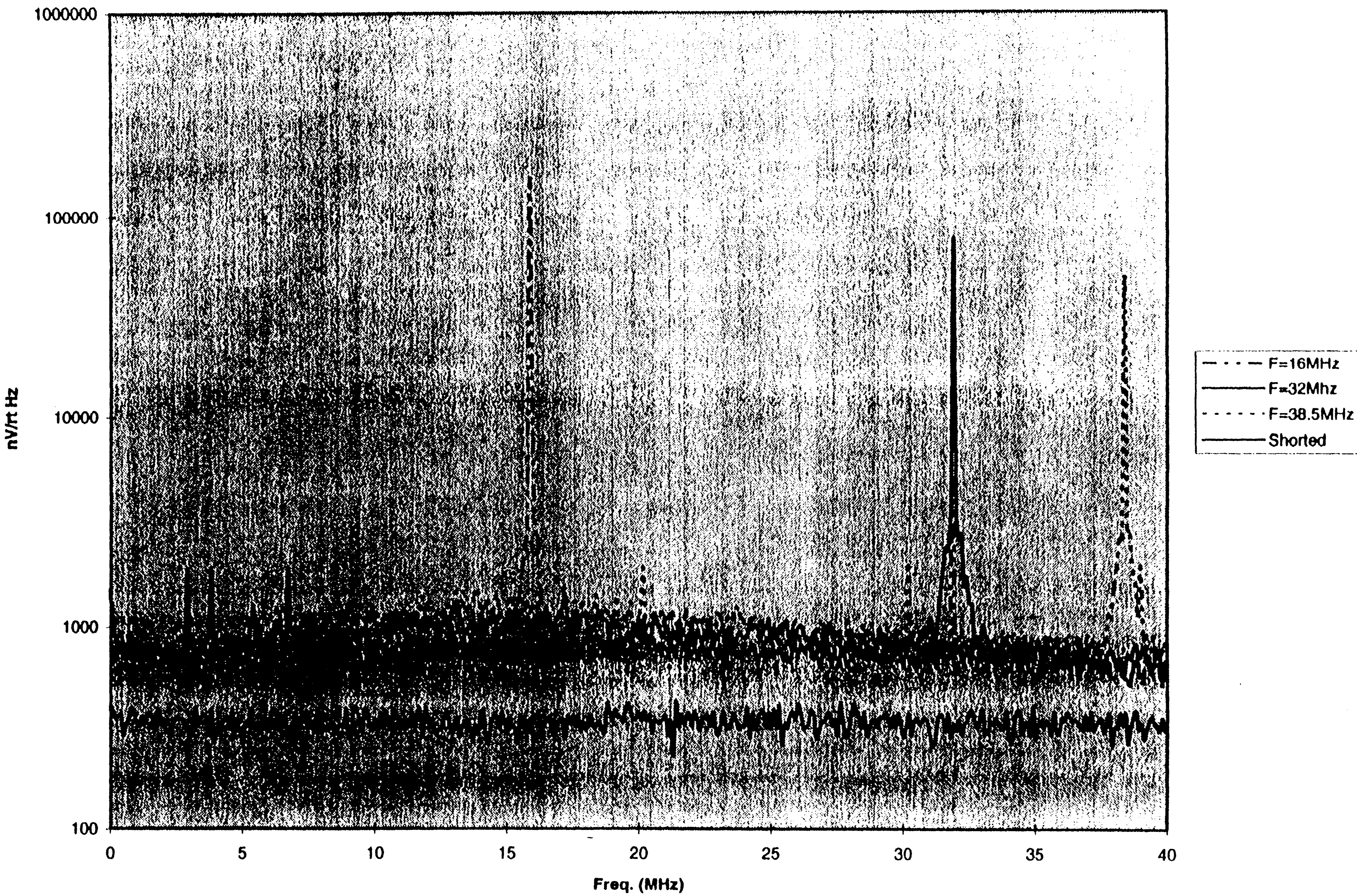
PG 33

CHANNEL PERFORMANCE
HEAD/MEDIA NOISE EVALUATION

Noise Evaluation for Tempest Head/Media/Guzik Electronics							
Test Conditions	Freq(MHz)	Signal(Vrms)	Signal 0-Pk(V)	Noise(Vrms)	Total NP(V^2)	SNR	Comment
Head Shorted				2.17E-03	4.70E-06		Guzik Electronic Noise
1) Head off disk surface (DC erase, Ir=12mA)*				3.66E-03	1.34E-05		Electronic + head noise
2)Head on Surface DC erase Ir=0*				3.59E-03	1.29E-05		Electronic + head noise
DC erase Ir=12mA				4.23E-03	1.79E-05		Elec+head+disk DC erase noise
Transition Noise	16	0.069	1.96E-01	5.27E-03	2.78E-05	22.37	Elec+head+disk tran. noise
	32	0.04	1.14E-01	6.40E-03	4.10E-05	16.01	
	38.5	0.027	7.72E-02	6.61E-03	4.37E-05	12.32	

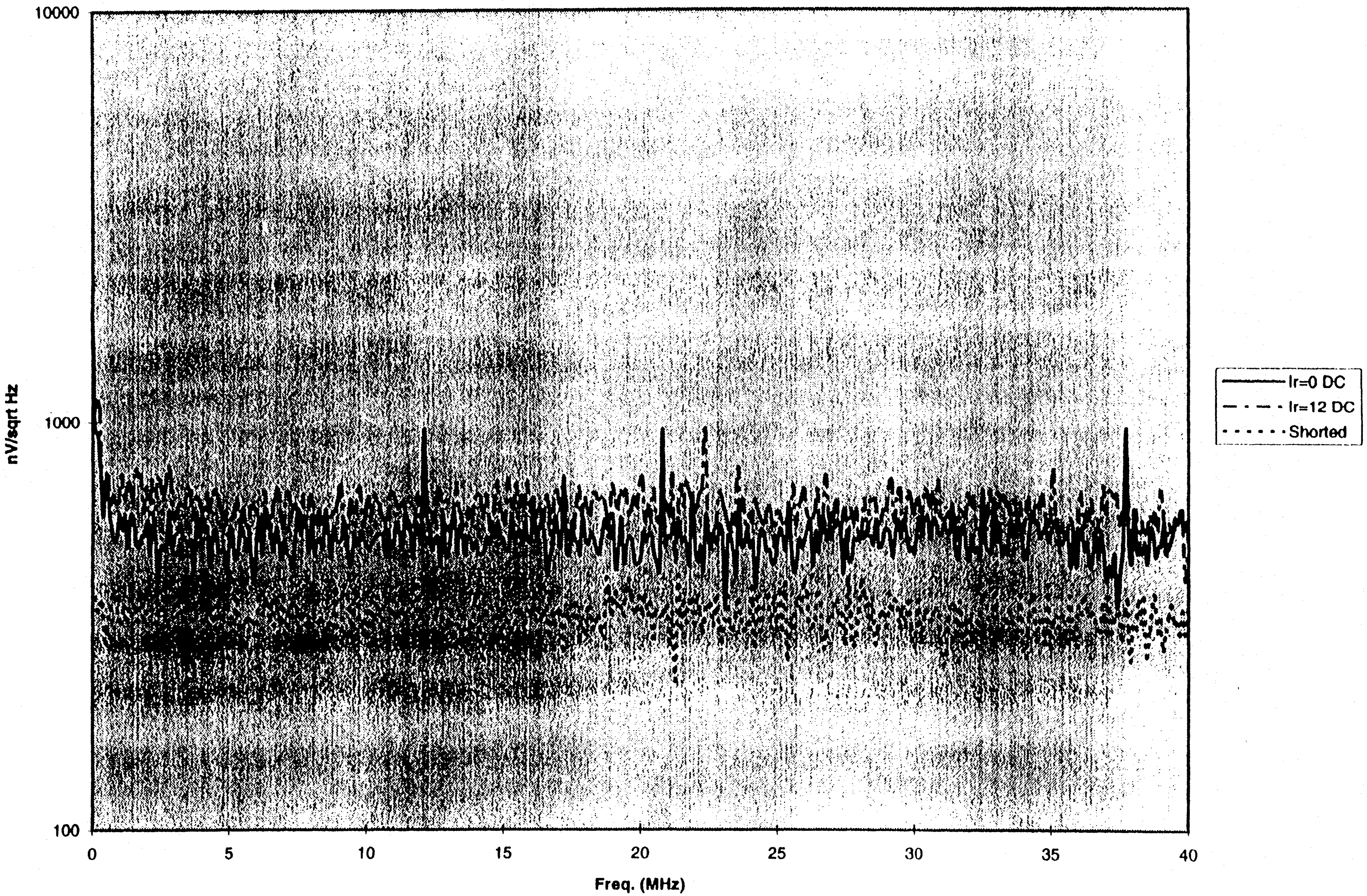
Noise at case 1 = noise at case 2. So when bias current =0, media has no effect on noise spectrum.

Sheet2 Chart 3



PG 35

Sheet1 Chart 3



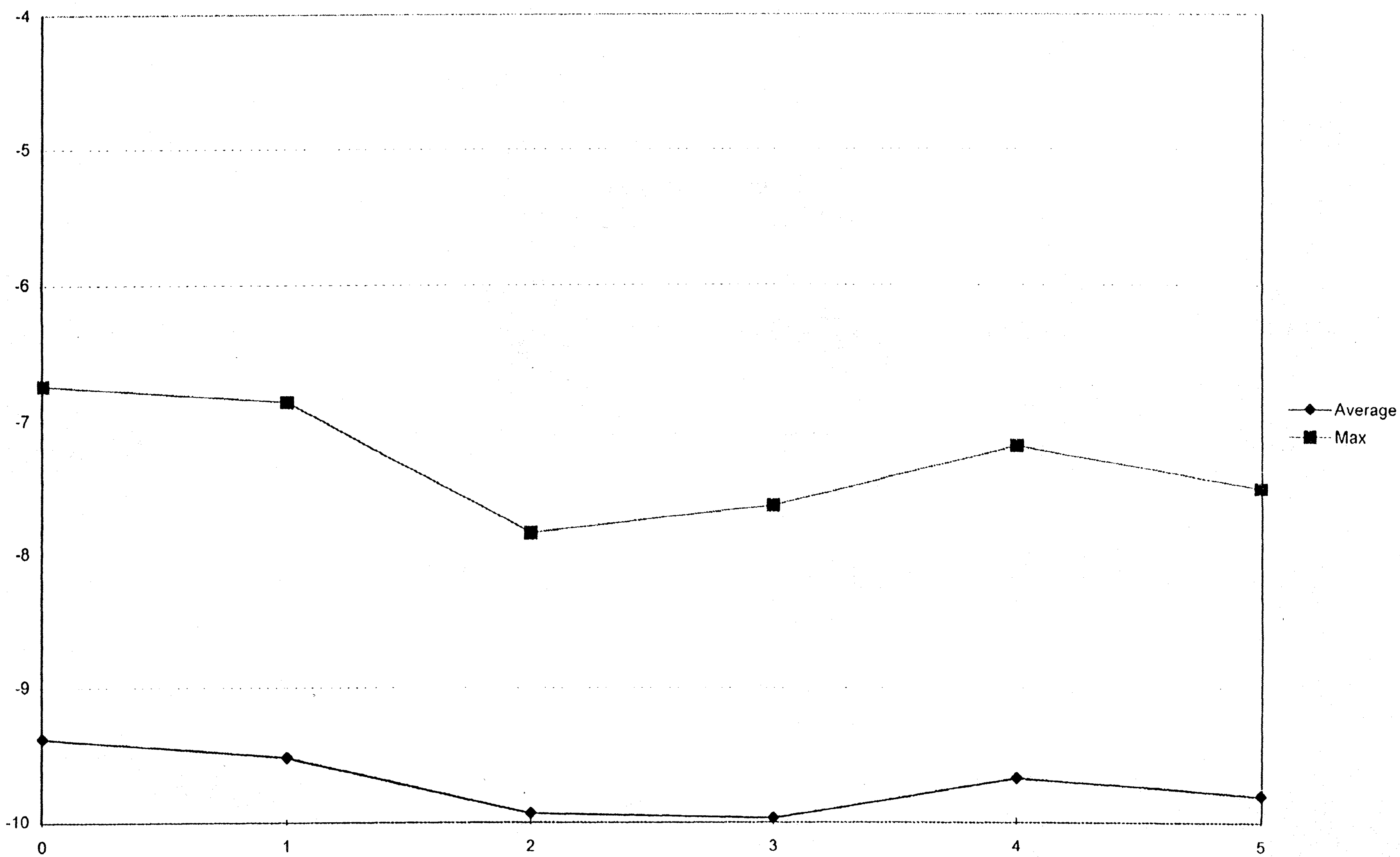
PG 36

CHANNEL PERFORMANCE - BIT-ERROR-RATE

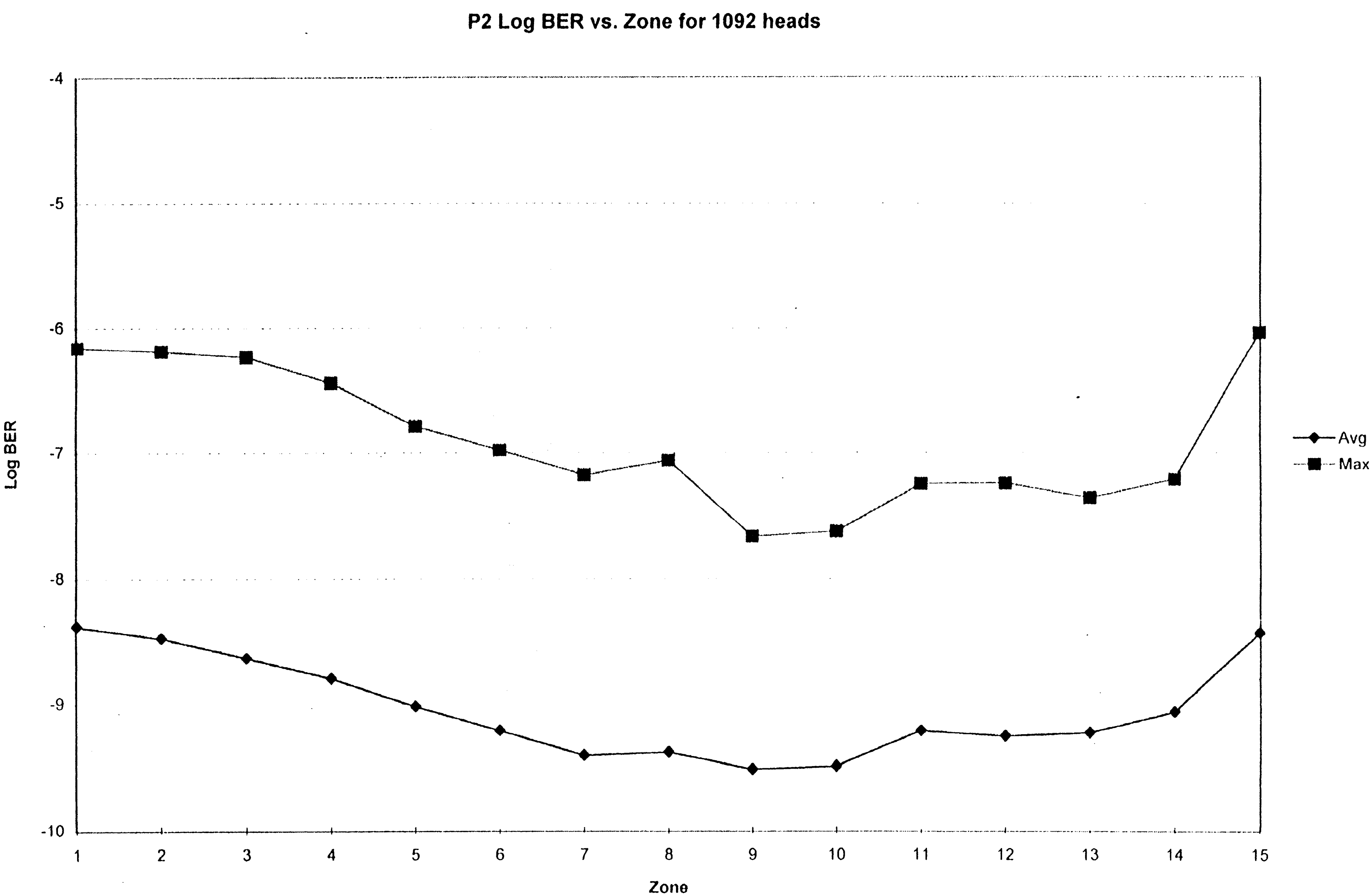
. **Mean of Log_{10} (BER) is -9.22**

. **None of the heads failed the Raw-Error-Rate Objective of < 10E-6**

P2 Log Raw BER vs Head for 1092 heads



PG38


P2 Log BER vs. Zone for 1092 heads
Log BER
-4
-5
-6
-7
-8
-9
-10
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Zone
Avg
Max

PG39

CHANNEL PERFORMANCE - OTC/TMR

ERROR CHECKING AND CORRECTION

- REED SOLOMON CODE
- FOUR WAYS INTERLEAVE
- "ON THE FLY" DOUBLE BURST CORRECTION
- TRIPLE BURST CORRECTION

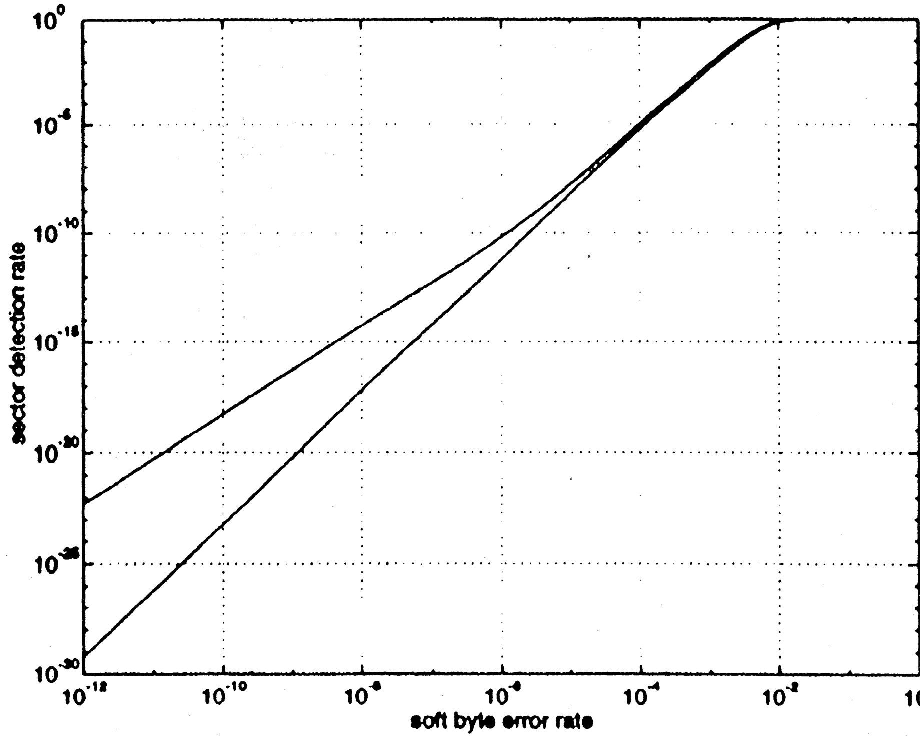
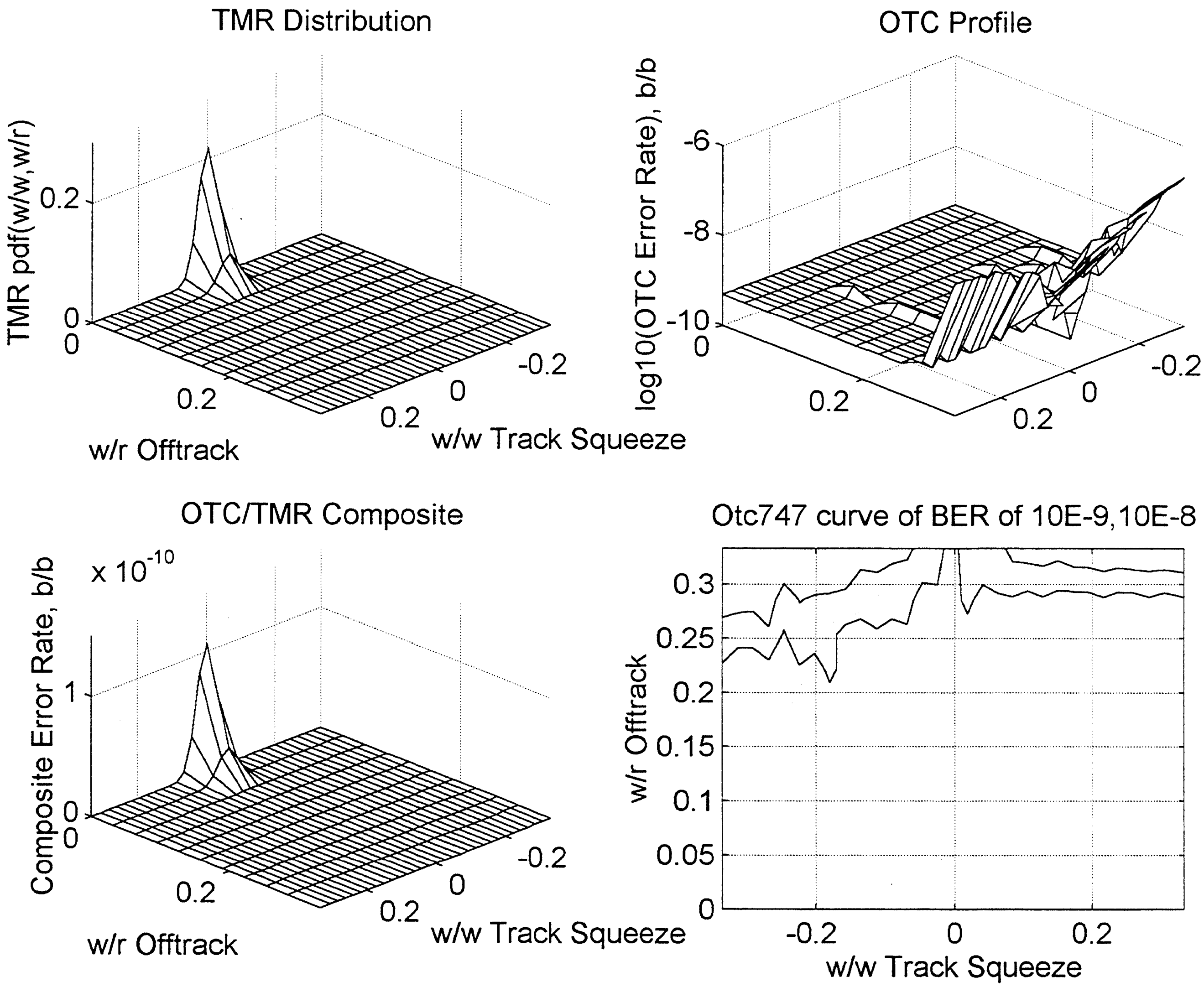
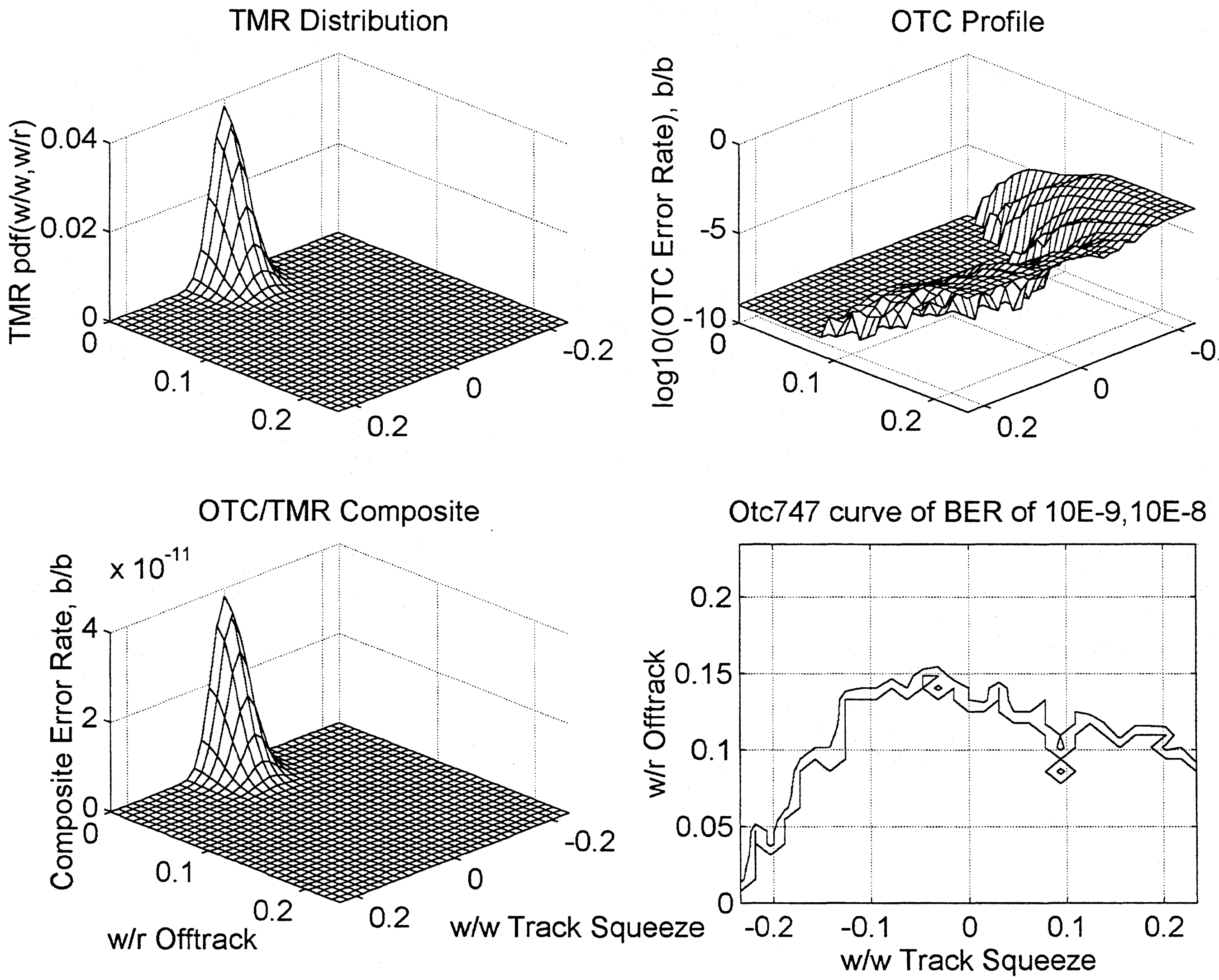


Figure 7-2 Sector Error Code for 16/17 Code



TMR Distribution
TMR pdf(w/w,w/r)
0.2
0
0
0.2
w/r Offtrack
-0.2
0
0.2
w/w Track Squeeze
OTC Profile
log10(OTC Error Rate), b/b
-6
-8
-10
0
0.2
-0.2
0
0.2
OTC/TMR Composite
Composite Error Rate, b/b
x 10^-10
1
0
0
0.2
w/r Offtrack
-0.2
0
0.2
w/w Track Squeeze
Otc747 curve of BER of 10E-9,10E-8
w/r Offtrack
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.2
0
0.2
w/w Track Squeeze



TMR Distribution
TMR pdf(w/w,w/r)
0.04
0.02
0
0
0.1
0.2
-0.2
0
0.2
OTC Profile
log10(OTC Error Rate), b/b
0
-5
-10
0
0.1
0.2
-0.
0
0.2
OTC/TMR Composite
Composite Error Rate, b/b
x 10^-11
4
2
0
0
0.1
0.2
-0.2
0
0.2
w/r Offtrack
w/w Track Squeeze
Otc747 curve of BER of 10E-9,10E-8
w/r Offtrack
0.2
0.15
0.1
0.05
0
-0.2
-0.1
0
0.1
0.2
w/w Track Squeeze

DATA TRACK FORMAT

. "IDLESS" FORMAT

. 6775 TPI

. 128 KFCI MAX.

. 813 Mb/sq inch

. RECORDING CODE 16/17

. DATA RATE 86.05 Mb/sec

. 15 DATA ZONES

. 110-216 SECTORS PER TRACK

TEMPEST 1.08 GB

2/15/96 Q. LAM REV 1

Req Cap	1280	MBytes	
Spare	2	(Sctrs/cyl)	
Surfaces	2	(surfaces)	for 2 or 3 disks change this number to 4 or 6 respectively.
Rod	1.8091	inches	
Rid	0.7939	inches	
Stroke	1.0152	inches	
RPM	4500	rpm	
Trot	13333.33	uSec	
Frot	75.0000	Hz	
TPI	6775.0	Trks/inch	
Tot tracks	6878	Trks/head	
Trks/zone	439	Trks/zone	
max. FCI	128	116	
% of req	85.91%		
Cap/drive	1099.65	Mbytes	
	2147758	sectors	

Data Format	Bytes	uSec Zone 0	uSec Zone 15
Wiggle Rec	2	0.19	0.36
Clock Sync	2	0.19	0.36
Clock Jitter	1	0.09	0.18
Asic Delay	1	0.09	0.18
PLL delay	1	0.09	0.18
Total	7	0.65	1.24
PLL Size	18	1.67	3.20
Data AM	1	0.09	0.18
Read Delay	4	0.37	0.71
Data bytes	512	47.60	91.00
Data ECC	28	2.60	4.98
Delta MR	2	0.19	0.36
Total	565	52.53	100.42
Split OH	19	1.77	3.38

Srv Fq	40	MHz
Srv Clk	25	nSec
Nwdgs	90	Smpls
Wg-Wg	148.148148	uSec
SmplFq	6750	Hz
Tservo	19.025	uSec
Tdata	129.123	uSec
Srv OH	12.84%	
Fmt OH	10.49%	

P50	17.4 uinch	441.96 nm
code	**parameters**	
(user) m	16	
(channel) n	17	
d	0	

Wedge Format	Clock [T]	Time [uS]
Gap	168	4.200
AGC	72	1.800
Sync	42	1.050
SAM	37	0.925
Index	18	0.450
Trk #	117	2.925
pre-A	9	0.225
AB-bursts	96	2.400
CD-bursts	96	2.400
post-D	24	0.600
BCV	64	1.600
Wedge #	18	0.450
Total	761	19.025
Squelch		1.500

Zone	Zone Rid	Inner Cyl #	Cyls	Max. KFCI	Max. KBPI	Data Rate [Mb/s]	Chnl rate [MHz]	1/4T [MHz]	Tchannel [nsec]	ns/byte [nsec]	Bytes/ Wg-Wg	pst-wg [bytes]	Sect time [µs]	pre-wg [bytes]	Sect/Wg w/o split	Time left [µs]	Split Sector	Srs/trk /w spare	Zone Cap /surface	# of User Sectors	P50/Tch
OD	1.8042																				
System	1.8013	-1	20	67.65	64	54.04	57.42	14.355	17.416	148.03	872	5	83.639	5	1	44.004	44	134	1361920	5320	1.177
1	1.7338	456	457	111.90	105	86.05	91.43	22.857	10.938	92.97	1388	5	52.527	5	2	23.139	36	216	50306560	196510	1.947
2	1.6664	913	457	113.34	107	83.76	89.00	22.250	11.236	95.51	1351	5	53.961	5	2	20.247	30	210	48902656	191026	1.972
3	1.5989	1370	457	113.16	107	80.25	85.26	21.316	11.728	99.69	1295	5	56.326	5	2	15.475	21	201	46796800	182800	1.969
4	1.5315	1827	457	112.24	106	76.24	81.00	20.250	12.346	104.94	1230	5	59.290	5	2	9.494	11	191	44456960	173660	1.953
5	1.4640	2284	457	111.50	105	72.40	76.92	19.231	13.000	110.50	1168	5	62.433	5	2	3.153	1	181	42117120	164520	1.940
6	1.3966	2741	457	111.43	105	69.02	73.33	18.333	13.636	115.91	1114	5	65.489	5	1	62.475	82	172	40011264	156294	1.939
7	1.3291	3198	457	110.22	104	64.97	69.03	17.258	14.486	123.13	1048	5	69.569	5	1	58.323	72	162	37671424	147154	1.918
8	1.2616	3655	457	110.53	104	61.85	65.71	16.429	15.217	129.35	998	5	73.082	5	1	54.748	64	154	35799552	139842	1.923
9	1.1942	4112	457	110.88	104	58.73	62.40	15.600	16.026	136.22	947	5	76.963	5	1	50.798	56	146	33927680	132530	1.929
10	1.1267	4569	457	111.75	105	55.84	59.33	14.833	16.854	143.26	901	5	80.941	5	1	46.750	48	138	32055808	125218	1.944
11	1.0593	5026	457	111.61	105	52.44	55.71	13.929	17.949	152.56	846	5	86.199	5	1	41.399	40	131	30417920	118820	1.942
12	0.9918	5483	457	115.00	108	50.59	53.75	13.438	18.605	158.14	816	5	89.349	5	1	38.193	35	125	29014016	113336	2.001
13	0.9244	5940	457	118.96	112	48.77	51.82	12.955	19.298	164.04	787	5	92.680	5	1	34.803	30	120	27844096	108766	2.070
14	0.8569	6397	457	122.64	115	46.61	49.52	12.381	20.192	171.63	752	5	96.974	5	1	30.433	25	115	26674176	104196	2.134
15	0.7939	6824	427	127.84	120	45.01	47.83	11.957	20.909	177.73	726	5	100.416	5	1	26.930	21	110	23830016	93086	2.224

Total = 6845

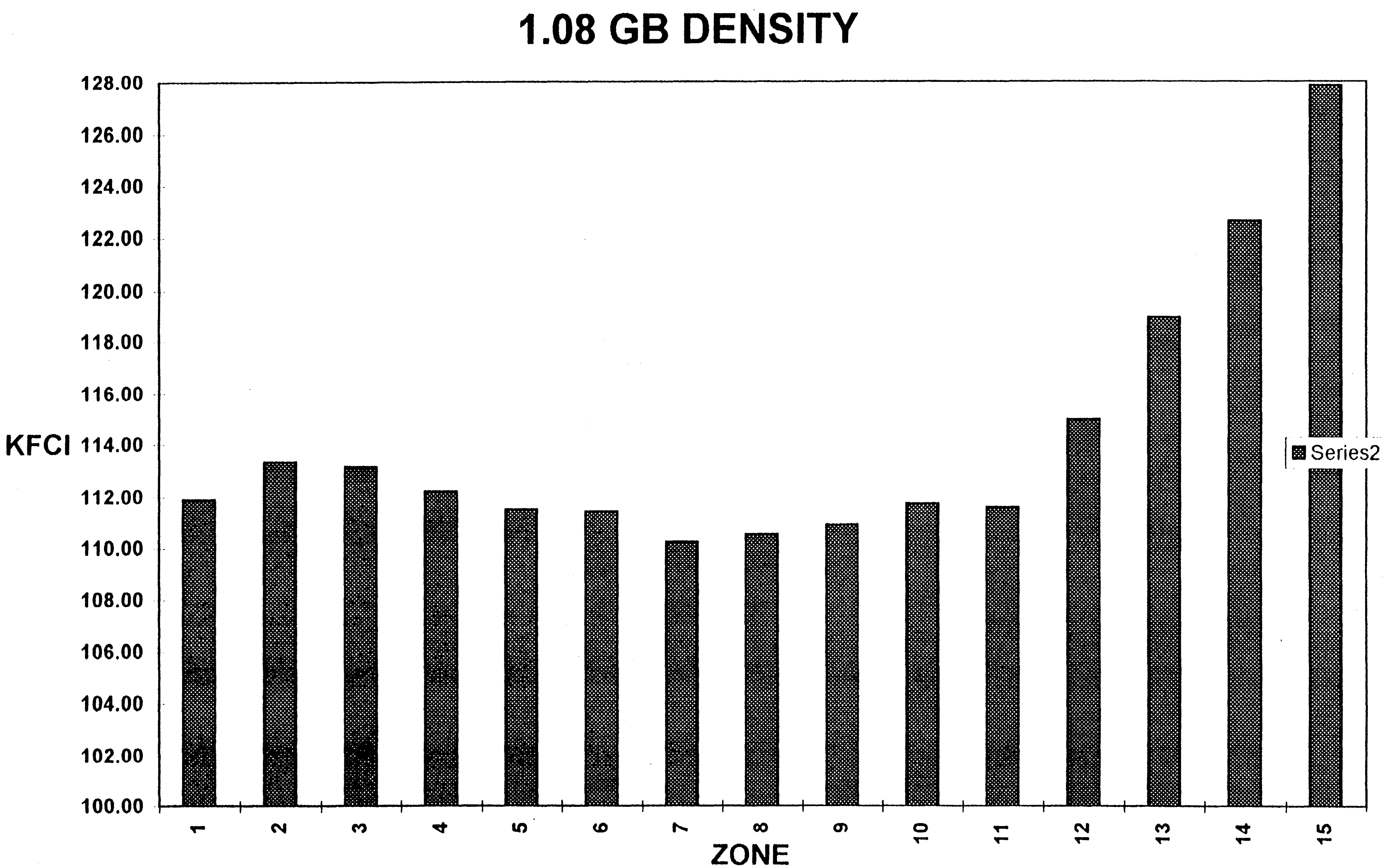
Total = 2147758

ZONE FCI

Total cap. 1099.7

M Bytes/surface = 549.826048

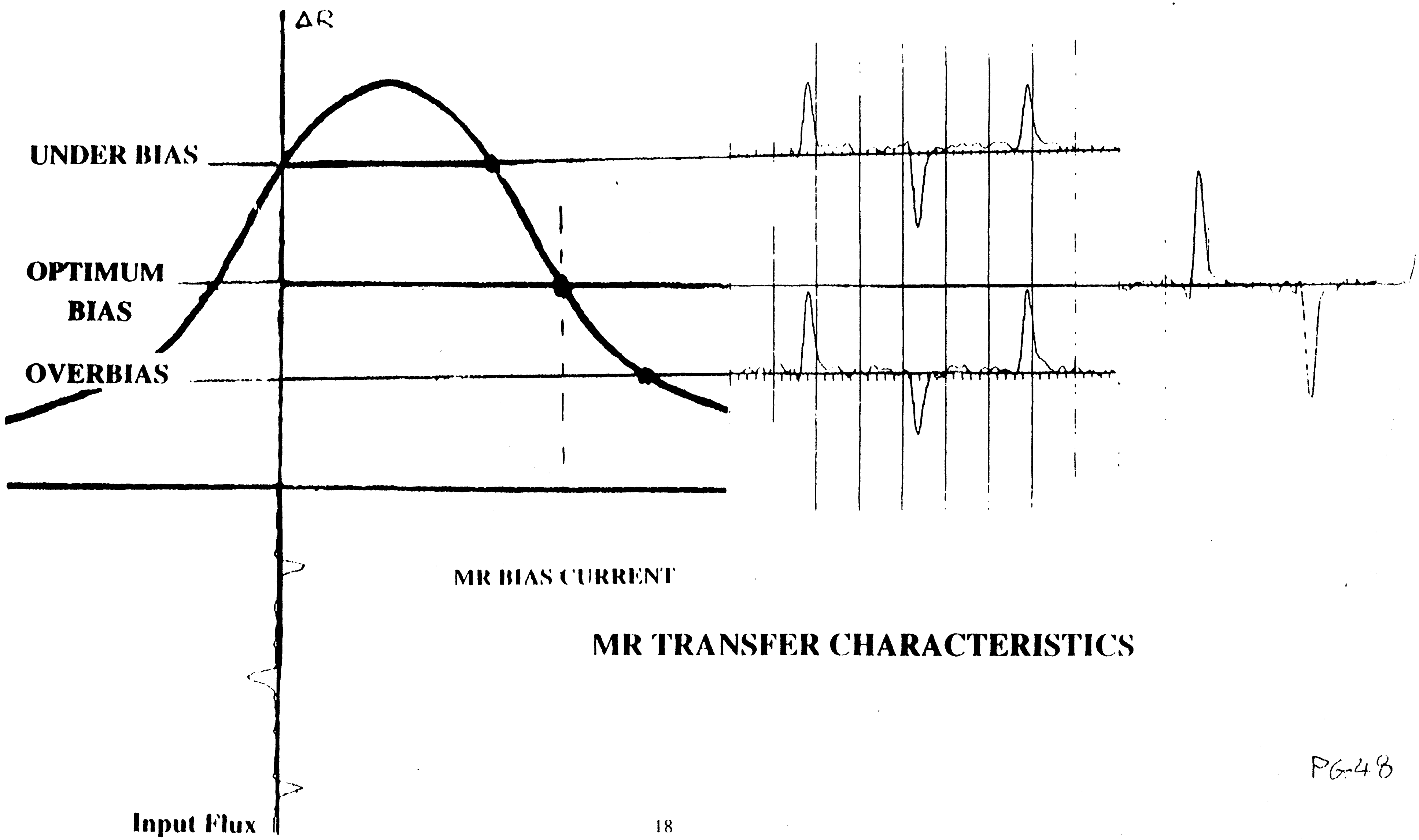
PG45


1.08 GB DENSITY
128.00
126.00
124.00
122.00
120.00
118.00
116.00
114.00
112.00
110.00
108.00
106.00
104.00
102.00
100.00
KFCI
Series2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
ZONE

PG46

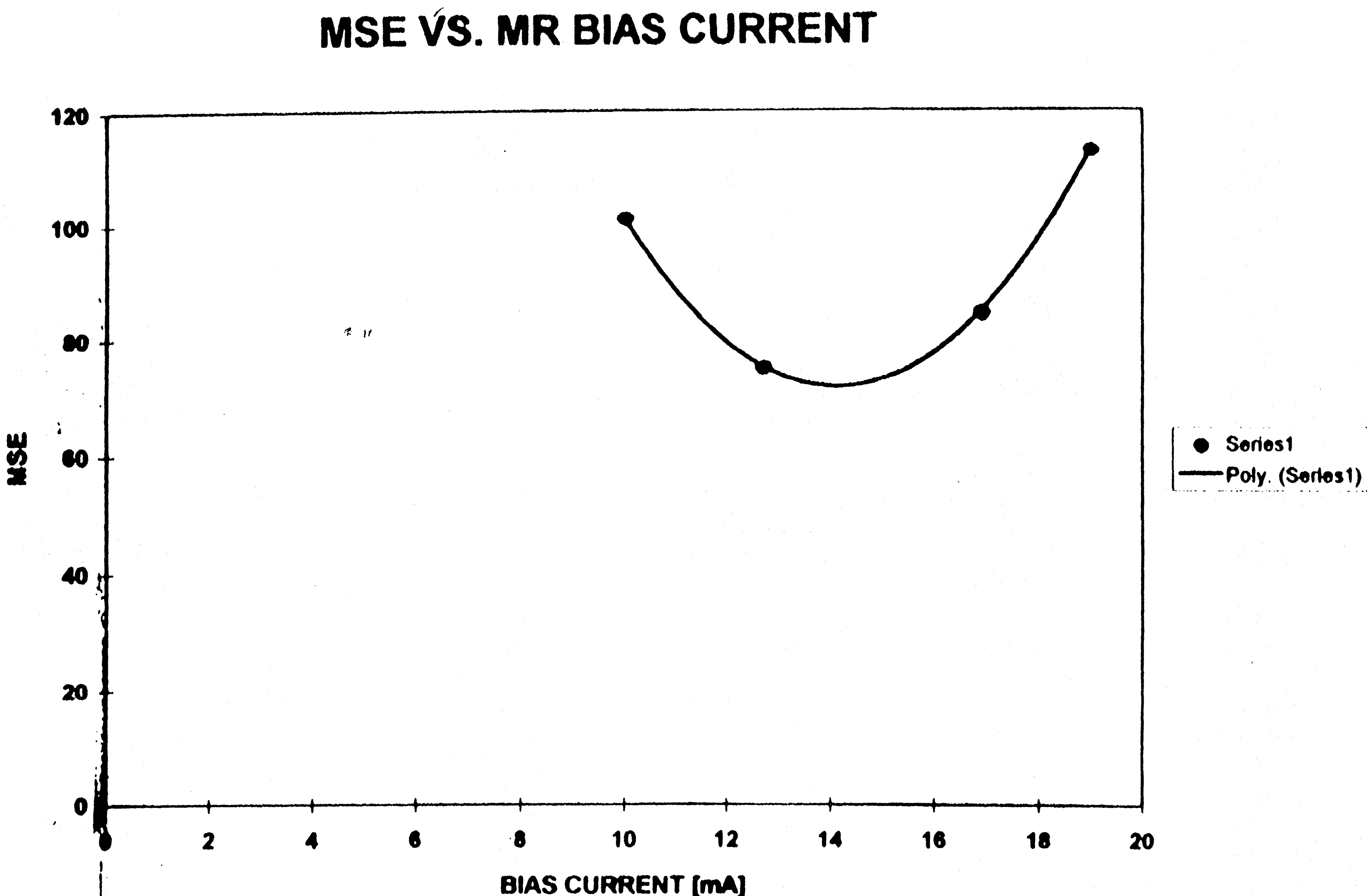
PRML CHANNEL SPECIFICS - MAGNETO-RESISTIVE HEAD

- MR TRANSFER CHARACTERISTICS
- MSE vs BIAS CURRENT
- BER vs MSE
- MSE vs SNR
- BER vs SNR



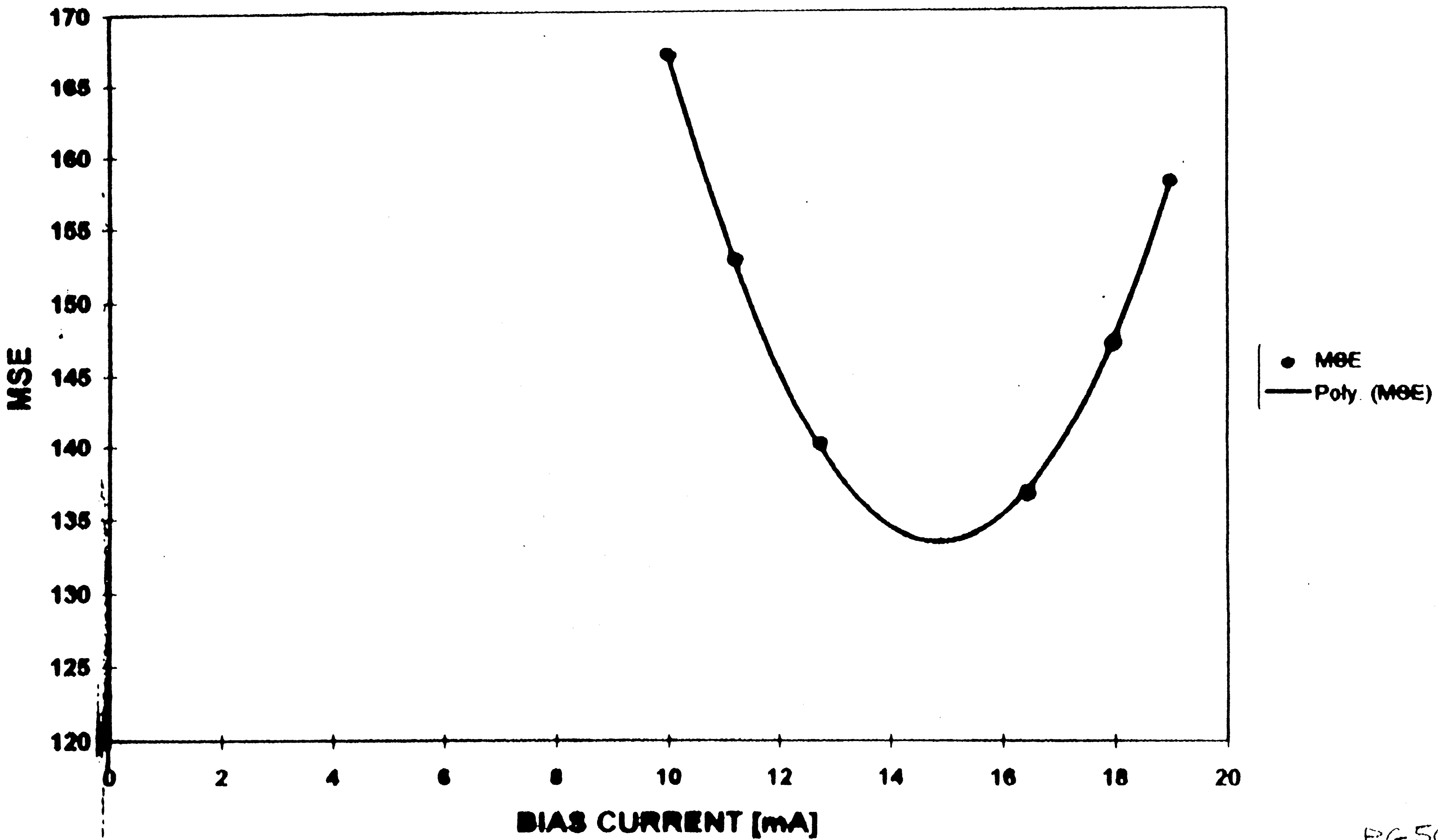
MR TRANSFER CHARACTERISTICS

PG-48


MSE VS. MR BIAS CURRENT
120
100
80
60
40
20
0
MSE
0
2
4
6
8
10
12
14
16
18
20
BIAS CURRENT [mA]
Series1
Poly. (Series1)

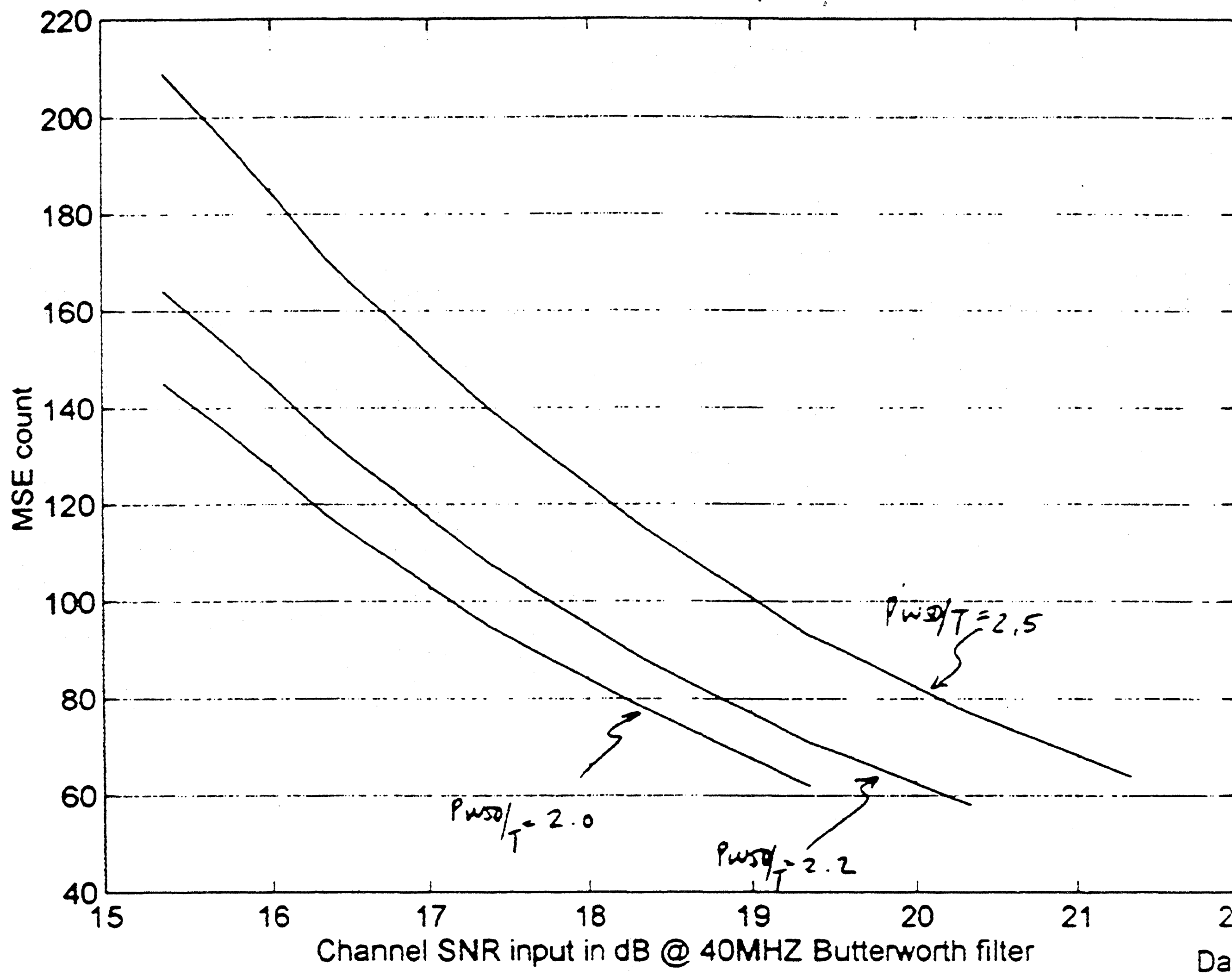
PG49

MSE VS. MR BIAS CURRENT

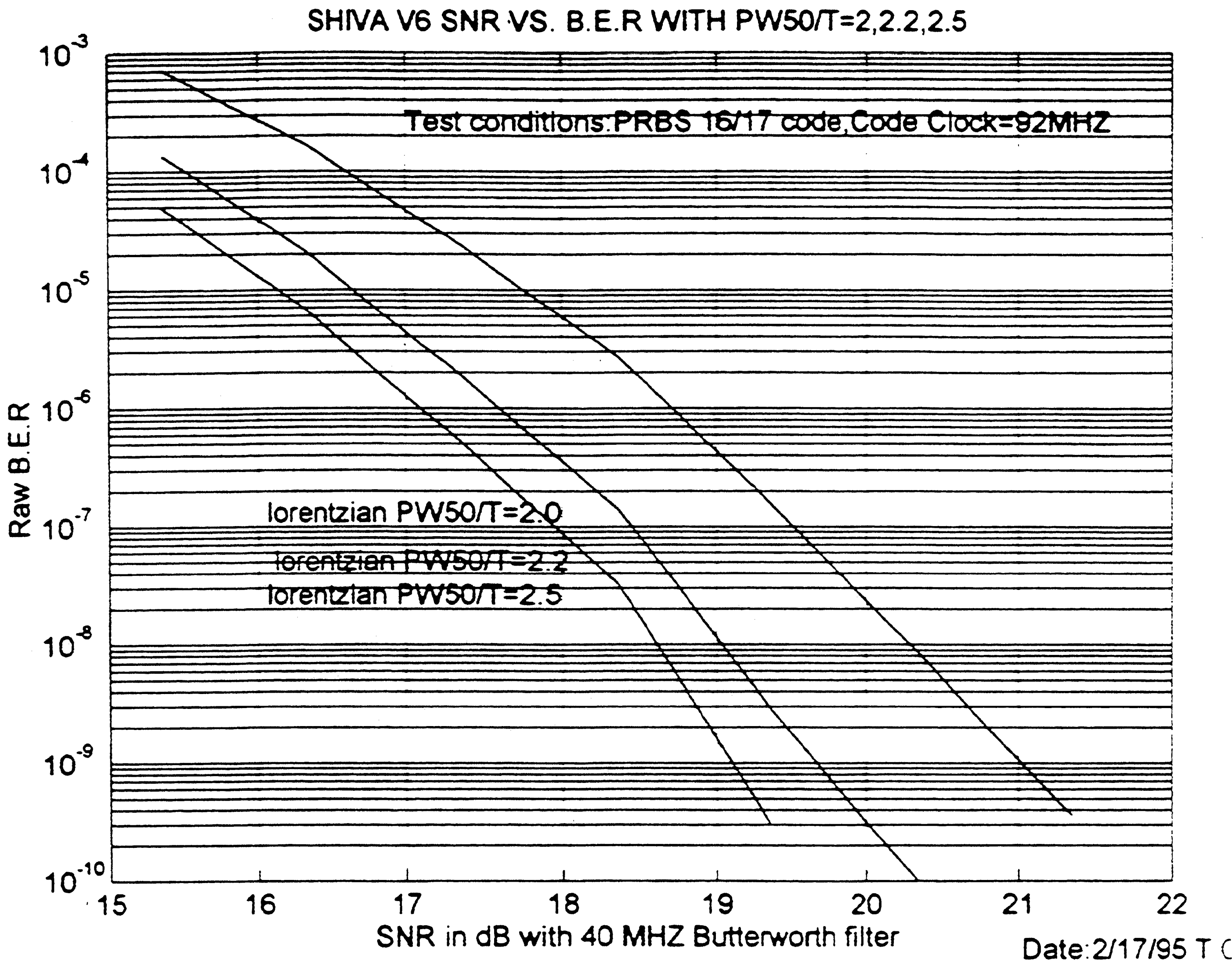


PG 50

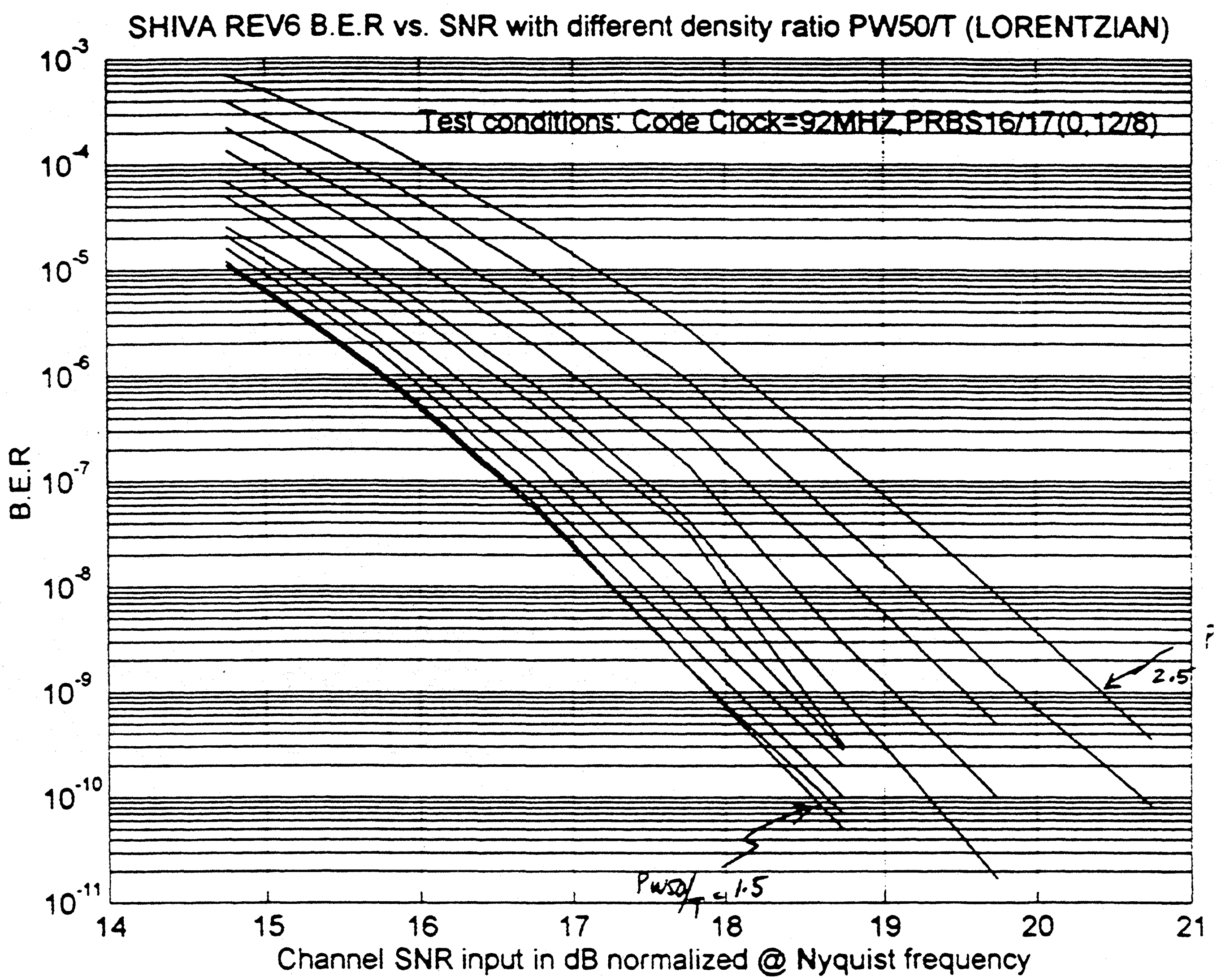
SHIVA rev6 MSE versu SNR channel input with PW50/T=2,2.2,2.5



Date


SHIVA V6 SNR VS. B.E.R WITH PW50/T=2,2.2,2.5
Test conditions:PRBS 16/17 code,Code Clock=92MHZ
Raw B.E.R
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9
10^-10
lorentzian PW50/T=2.0
lorentzian PW50/T=2.2
lorentzian PW50/T=2.5
15
16
17
18
19
20
21
22
SNR in dB with 40 MHZ Butterworth filter
Date:2/17/95 T

4.52


SHIVA REV6 B.E.R vs. SNR with different density ratio PW50/T (LORENTZIAN)
Test conditions: Code Clock=92MHZ,PRBS16/17(0,12/8)
B.E.R
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
14
15
16
17
18
19
20
21
Channel SNR input in dB normalized @ Nyquist frequency
2.5
PW50/T = 1.5

2/23/9

3

TOPICS

- Key Features
- Tempest/Fireball Comparison
- Modes of Operation
- Pre-Production Results

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Key Features

- Embedded Sector Digital Servo System.
- Leveraged from Fireball Program.
- Differences due to MR Head:
  - Microjog Control.
  - Three-Pass Servowrite per Data Track.
  - Four-Servo-Burst Pattern.

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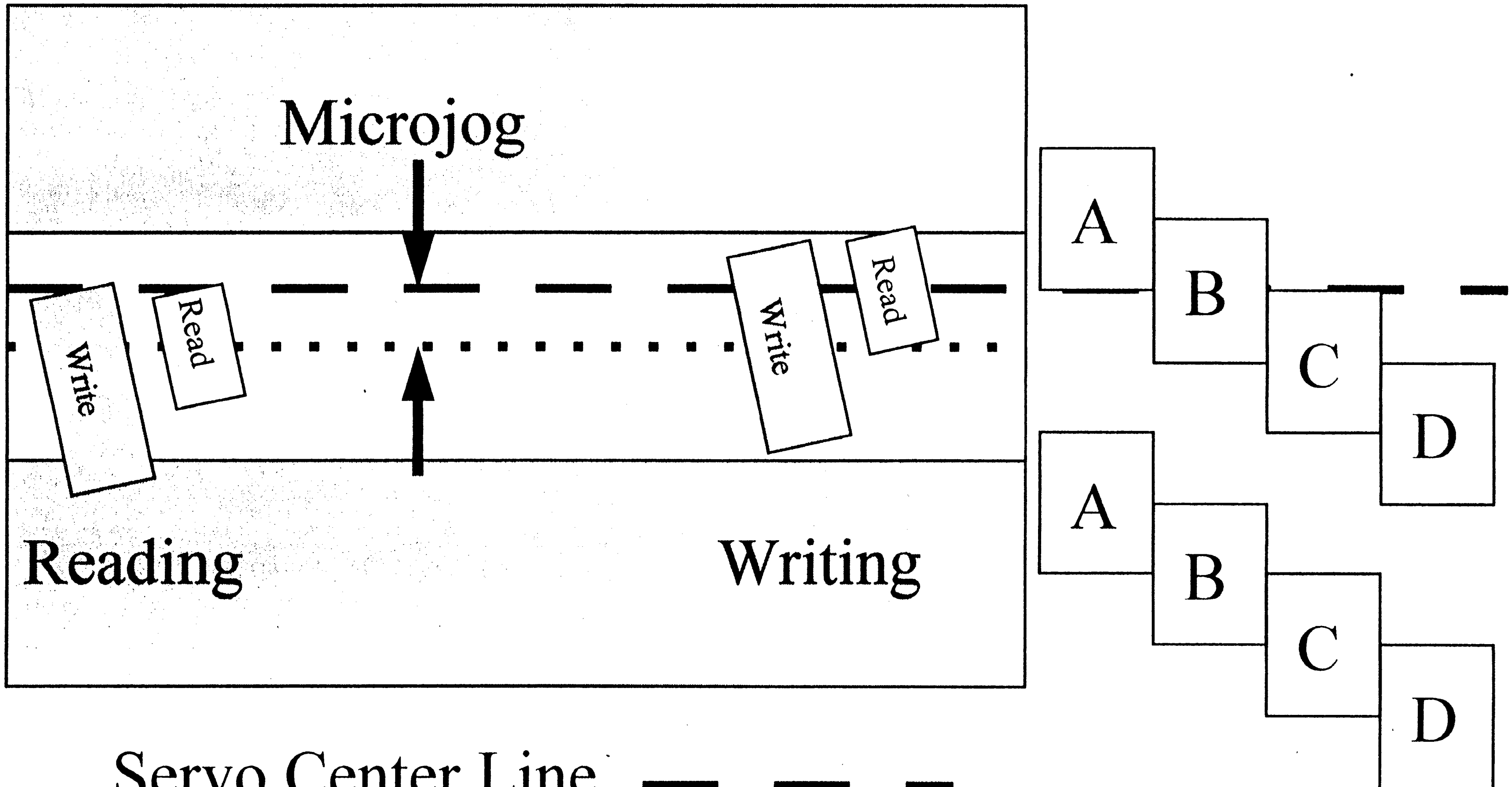
Microjogging



Servo Center Line — — —

Data Center Line . . . .

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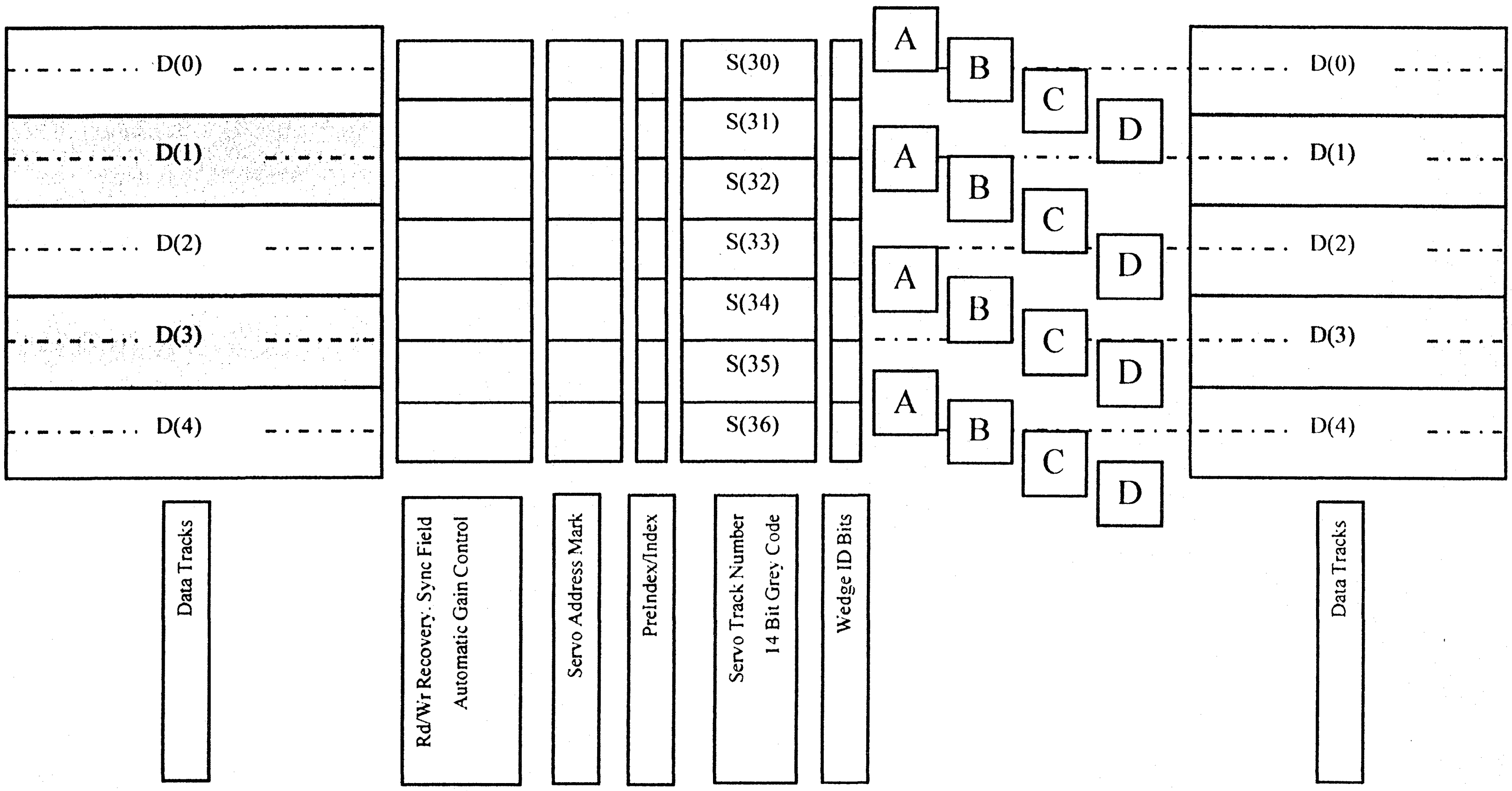
Servo Wedge Format



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Servo System Comparison

Mechanical

	Fireball 1080	Sirocco	Tempest
Ave Seek Time (msec)	10.5/12	11.0	12.0 / 10.5
TPI	4200	5850	6775
Total Cylinders	3886	5946	6875
RPM	5400	4500	4500
Sample Period (μsec)	146.2	148.1	148.1
Sample Freq (Hz)	6840	6750	6750
Wedges/Track	76	90	90
Arm Radius (inch)	2.050	2.142	2.142
Inertia (Gm-Cm^2)	36.4	43.0	30.0 / 43.0
Torque Const. (Gm-Cm/Amp)	557.8	730.0	436.0 / 760.0

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Servo System Comparison (Cont.)

Firmware

	Fireball 1080	Sirocco	Tempest
Structure	Single ISR	Same	Same
On-Track ISR Time (μsec)	45/146	48/148	58/148
Servo Config Page 18	Yes	Yes	Yes
Servo Zone Page 21	16 zones	24 zones	27 zones
Control Delay (μsec)	30	33	42
Digital Notch Filter	Yes	Yes	Yes
Max Head Velocity (ips)	100	100	100
Idle Seek Mode	Yes	Yes	Yes
Spindle Control	Hardware	Firmware	Firmware
Microjog Control	N/A	Yes	Yes

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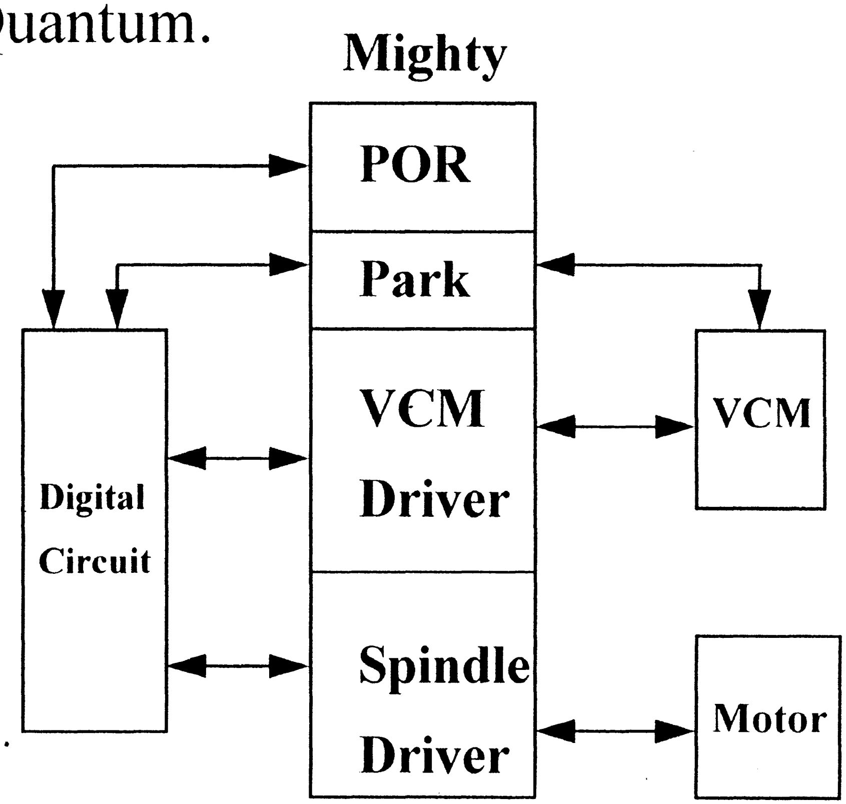
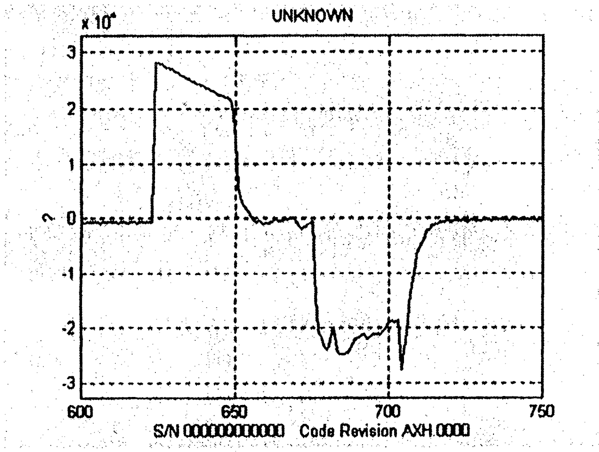
Mighty Overview

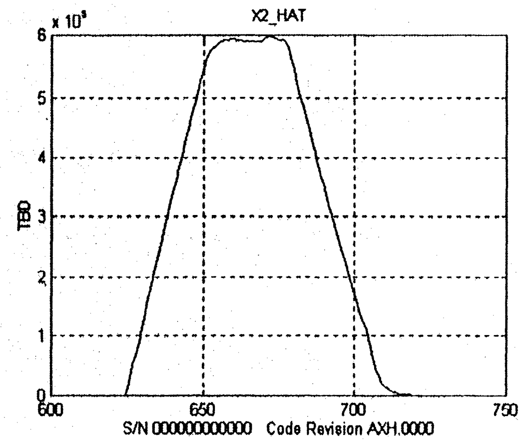
- Analog Combo Chip Designed by Quantum.
  - Spindle Motor Driver
    - 1.7 Amp peak.
    - Rotor Position Detection (RPD) at start up.
    - Programmable linear or PWM.
    - Active braking.
  - Voice Coil Motor Driver
    - 0.8 Amp peak.
    - External control loop compensation.
    - Enable, retract, disable modes.
  - Power Monitor & Retract Circuit
    - +5/+12V monitor threshold +/- 2% accuracy.
    - Retract works down to 2 V.
    - Programmable retract voltage.
    - Internal thermal sense circuitry.
    - Sleep mode.



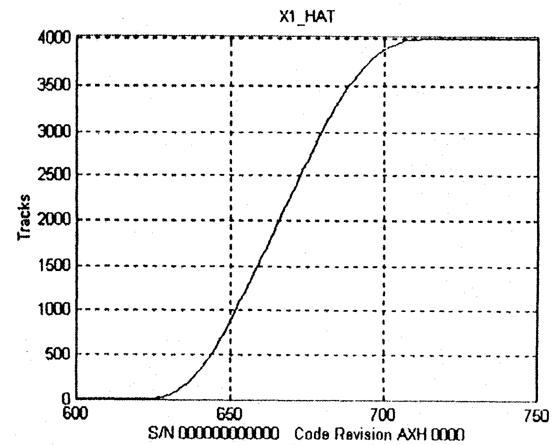
Servo Modes



Acceleration



Velocity



Position

- Velocity Mode
  - Accel
  - Coast
  - Decel
  - Linear Velocity
  - Linear Velocity Low BW
- Position Mode
  - Settle
  - On-Track

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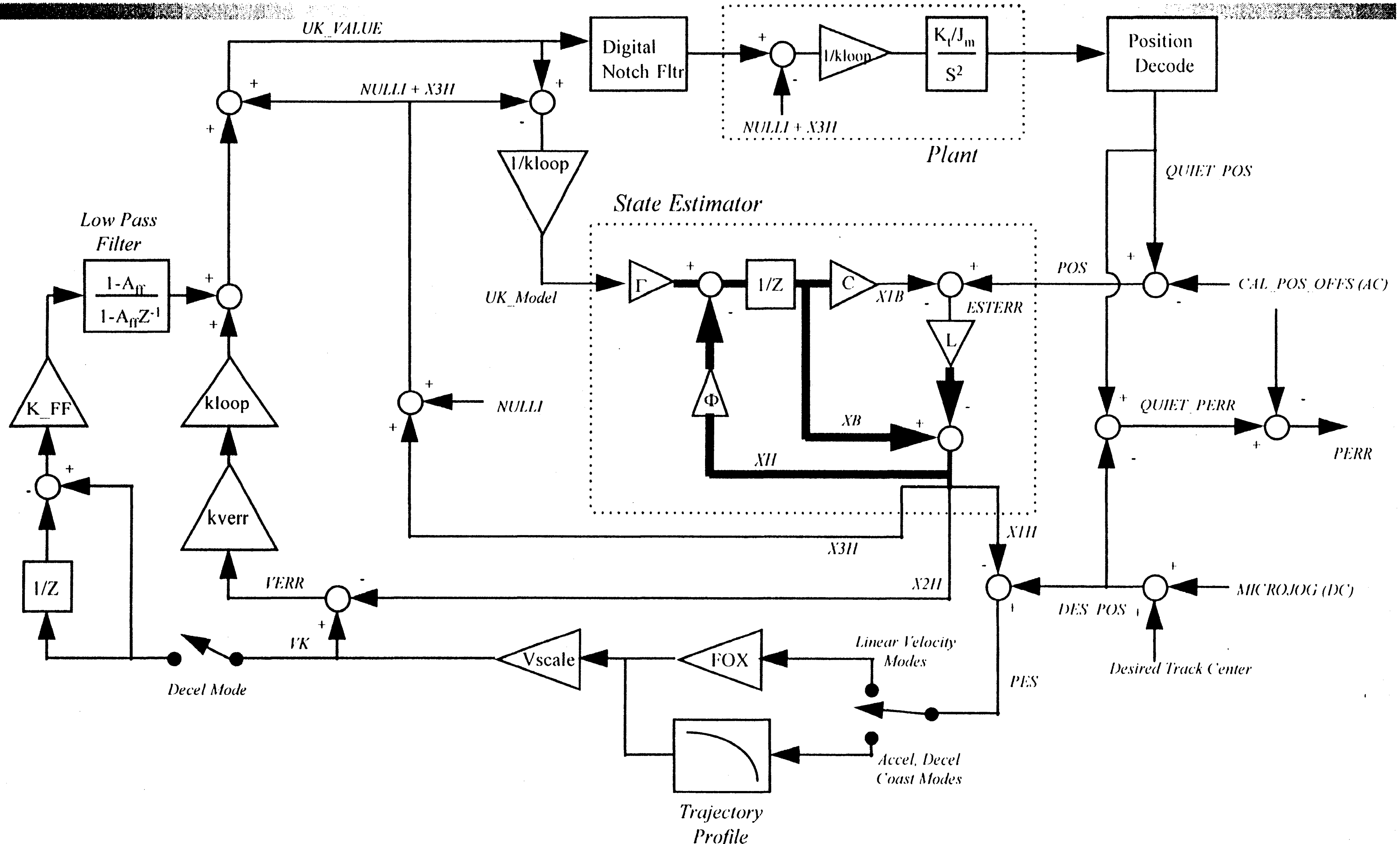
Velocity Mode



J Humel
10.24.95

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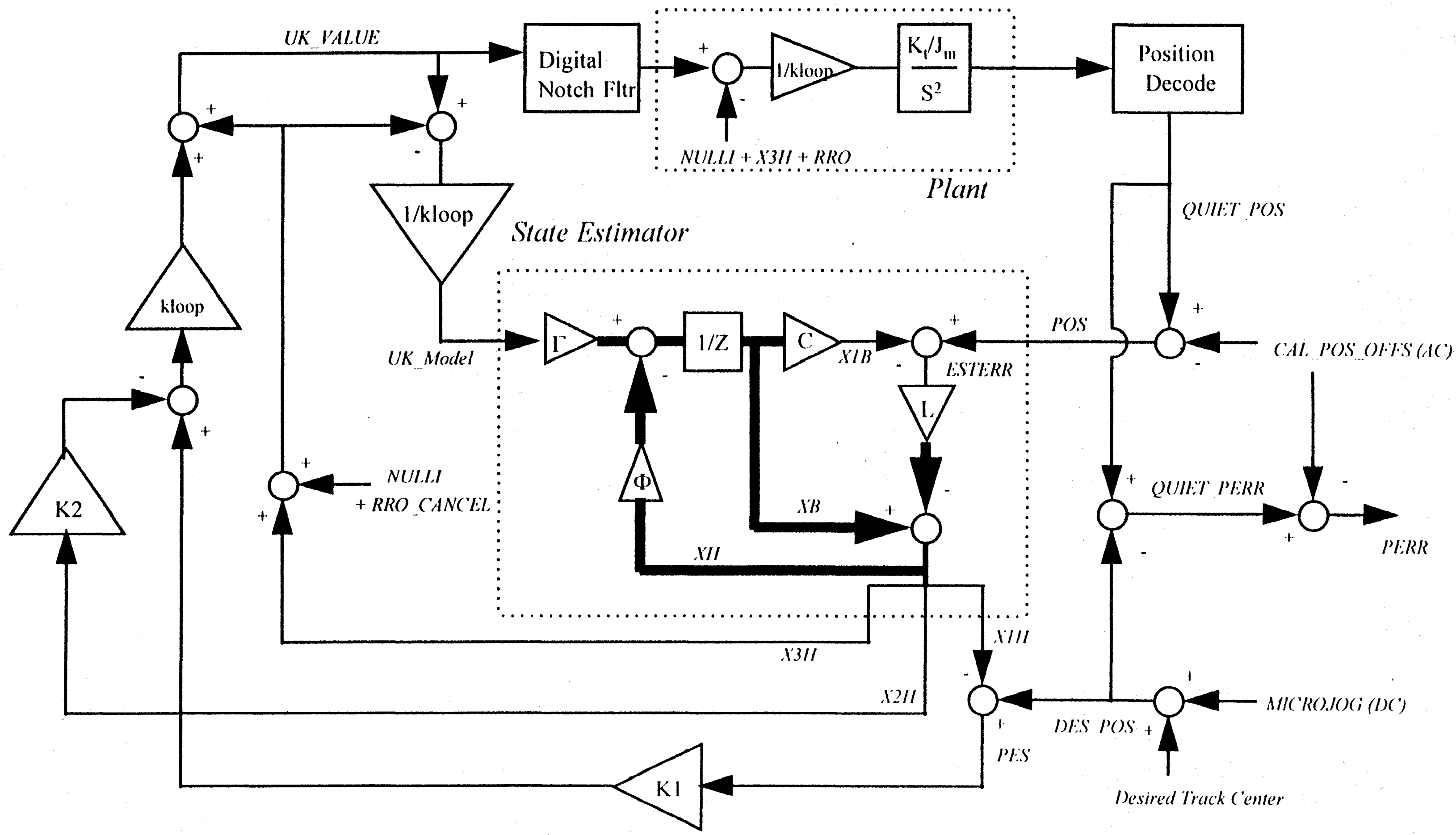
Position Mode



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Recalibration

	INIT_DEFAULT	CSUM_TST	RAM_TST	COARSE_SLP	MAP_HEADS	FINE_SLP	NULLI	KLOOP	RRO	ADJ_KLOOP_CAL	SEQ_TST	RD_SYS_CYL	REZERO	SEEK_FF_ADAPTATION
INIT_SERVO	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
START_DRIVE_SETUP	◆			◆	◆	◆	◆	◆	◆	◆		◆	◆	◆
COLD_RCAL_SETUP	◆			◆	◆	◆	◆	◆	◆	◆		◆	◆	◆
DW_LOADER	◆			◆	◆	◆	◆	◆	◆	◆			◆	◆
FULL_RESEEK_SETUP	◆			◆		◆	◆							◆
FAST_RCAL_SETUP													◆	◆
SHORT_RESEEK_SETUP														◆

TMR Budget (Proposed)

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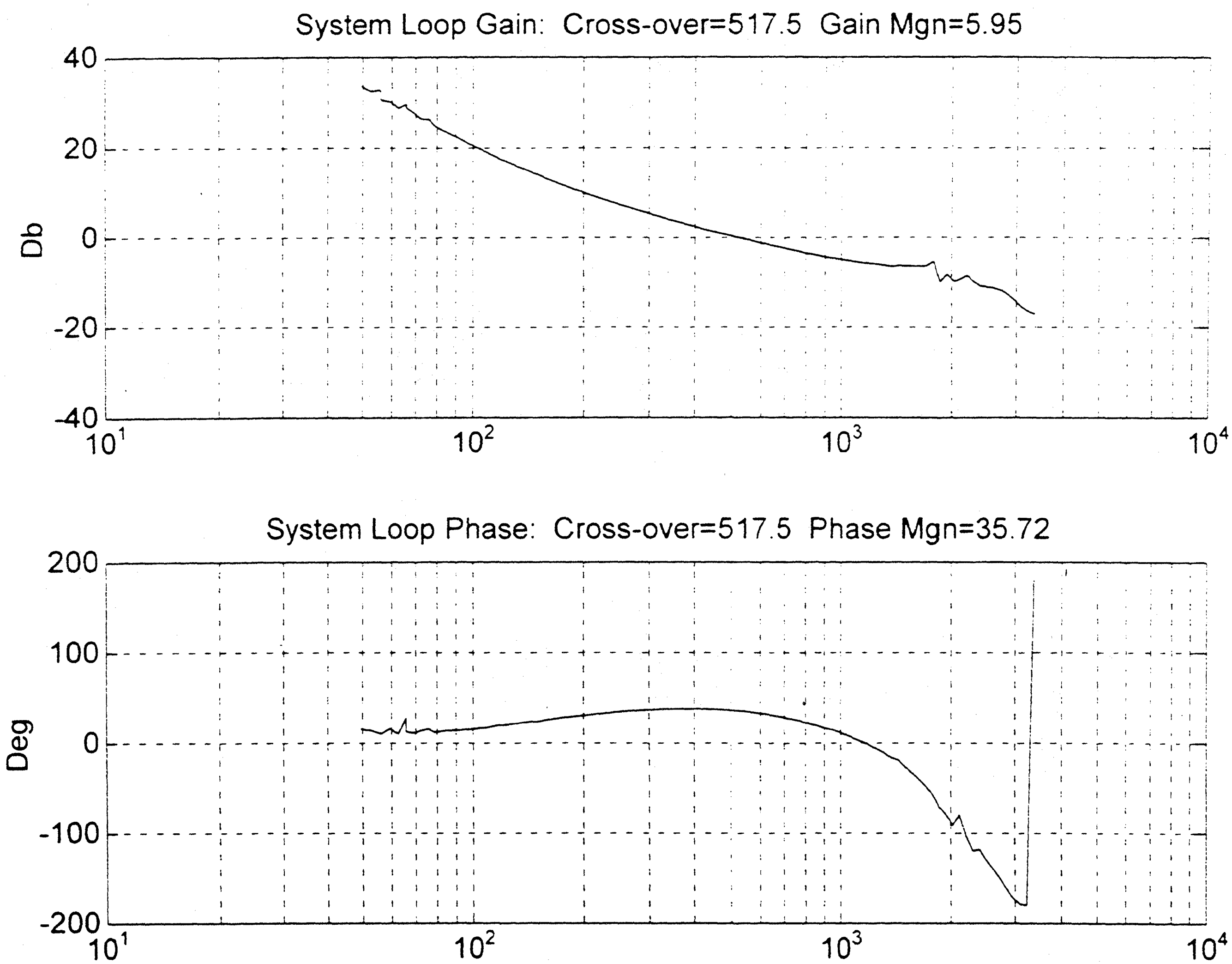
Description	Dist. Type	Distribution Parameters (all unit in tracks)			
Spindle NRRO	Normal	Mean =	0.00%	3 Sigma =	1.76%
Servo Dither					
Write	Normal	Mean =	0.00%	3 Sigma =	2.40%
Read	Normal	Mean =	0.00%	3 Sigma =	3.19%
Settling Transient					
Random Seek, Write	Measured	Mean =	0.00%	99.74% Level =	3.49%
Random Seek, Read	Measured	Mean =	0.00%	99.74% Level =	5.58%
RRO Residual					
Write mode	Normal	Mean =	0.00%	3 Sigma =	3.57%
Read mode	Normal	Mean =	0.00%	3 Sigma =	4.64%
Microjog Inaccuracy					
Read mode	Normal	Mean =	0.00%	3 Sigma =	1.16%
Servowriter Errors (W/W only)					
DC Component	Normal	Mean =	0.00%	3 Sigma =	0.63%
AC Component	Normal	Mean =	0.00%	3 Sigma =	3.07%
Operating Vibration (Worst Case)					
	Measured	Mean =	0.00%	99.74% Level =	5.52%
Operating Shock					
Write Bump Limits + Uncertainty	Uniform	Min =	-13.76%	Max =	13.76%
Nominal TPI	6775				
Nominal Track Pitch (μ")	147.6				

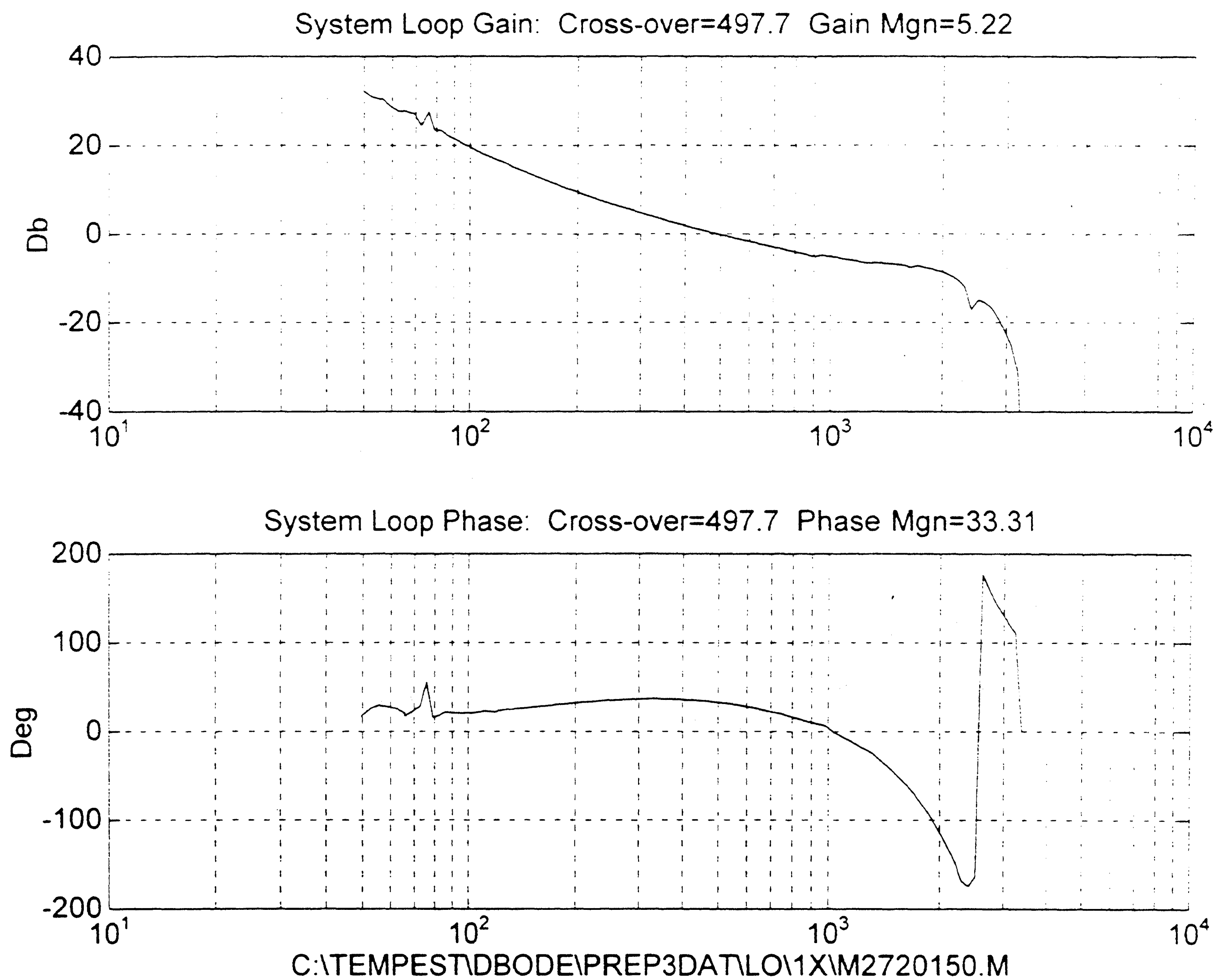
Pre-production Results

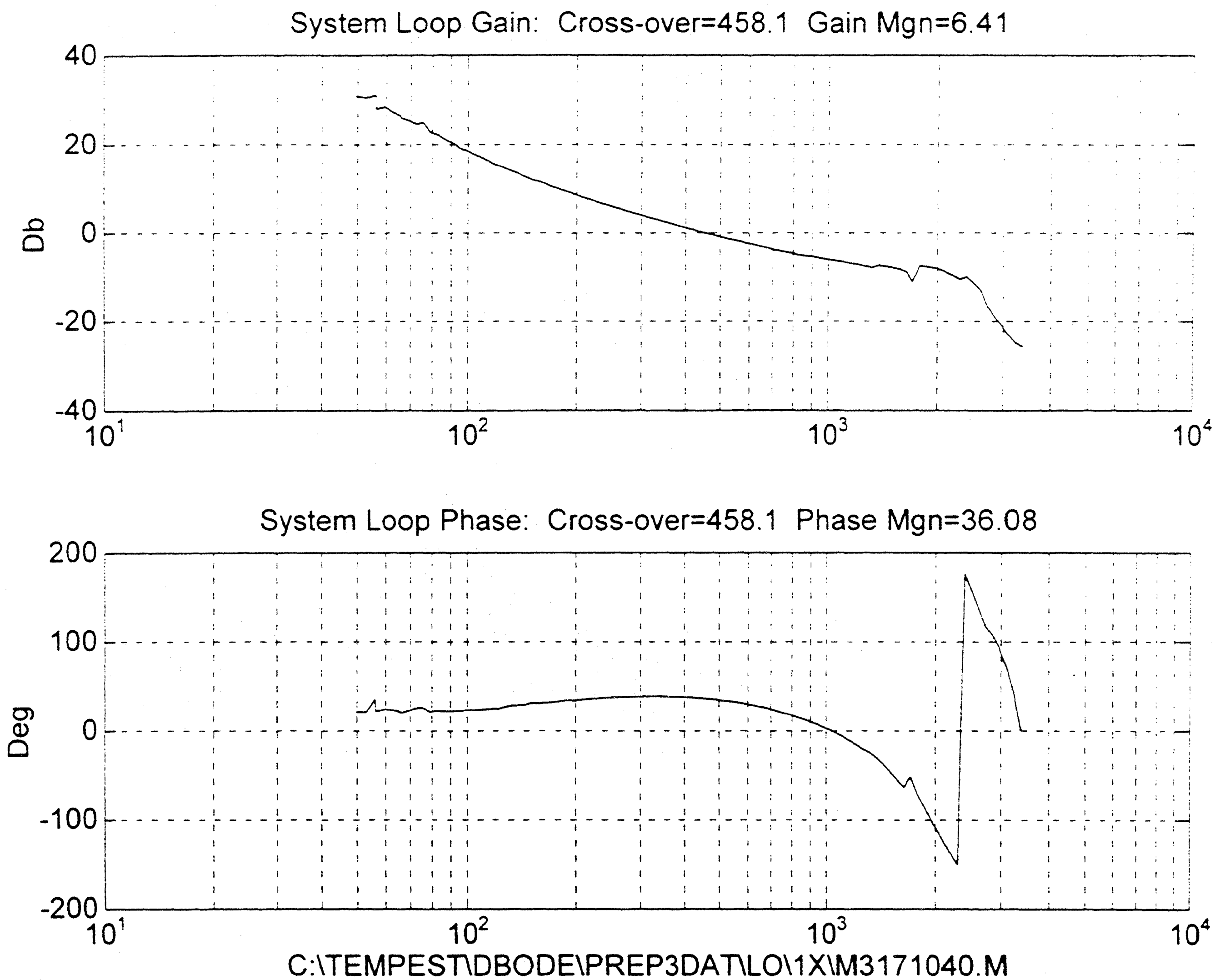
Bode Plots



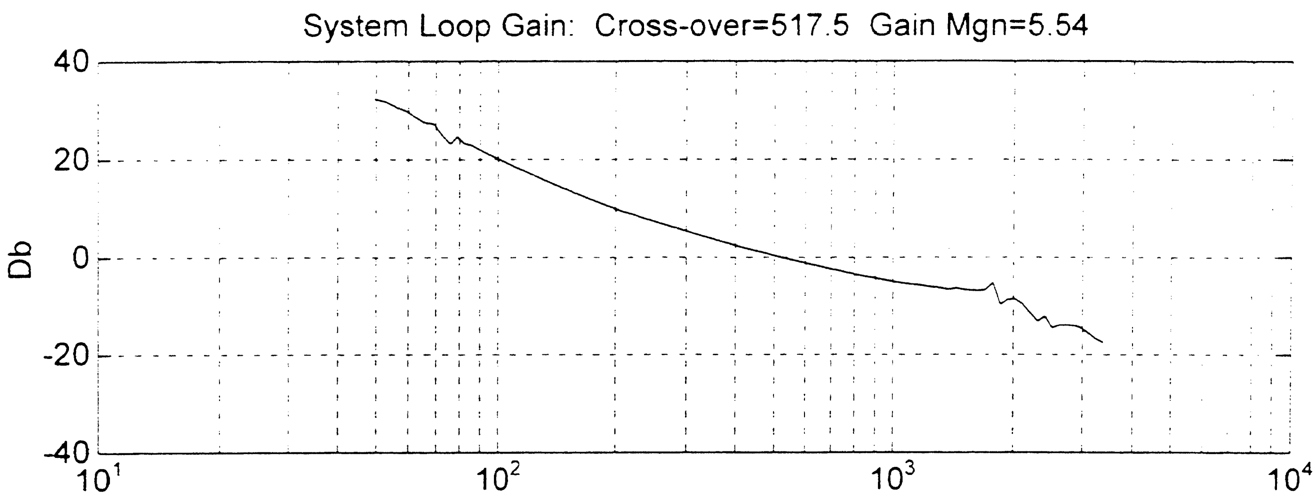
C:\TEMPEST\DBODE\PREP3DAT\LO\1X\M1220050.M

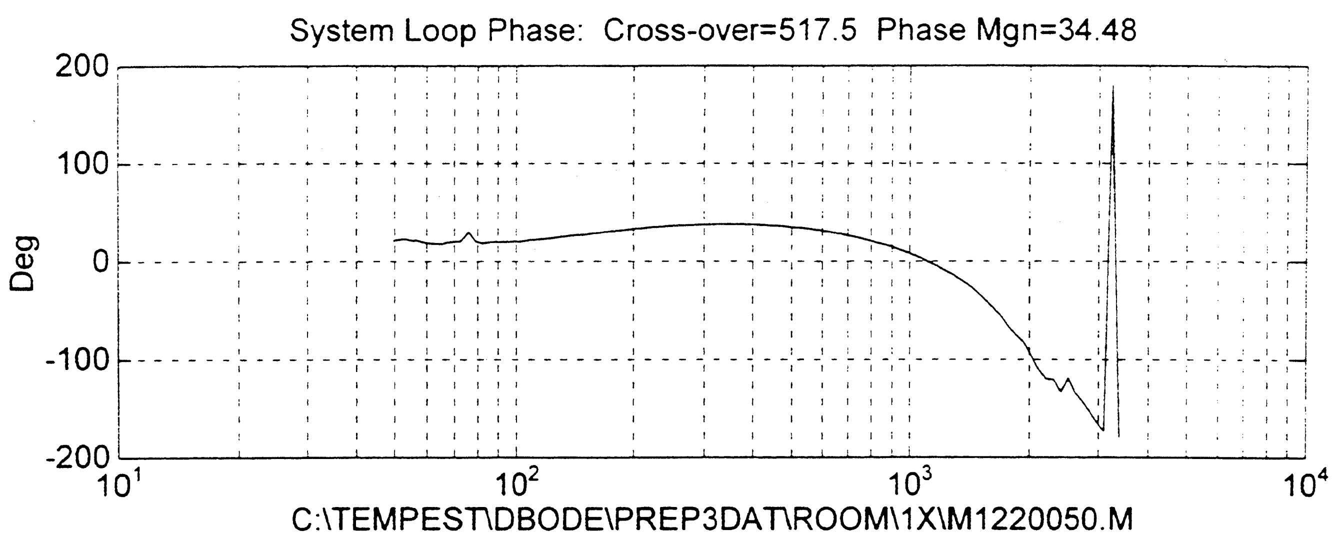
head
SN
No. Disks
MD/OD

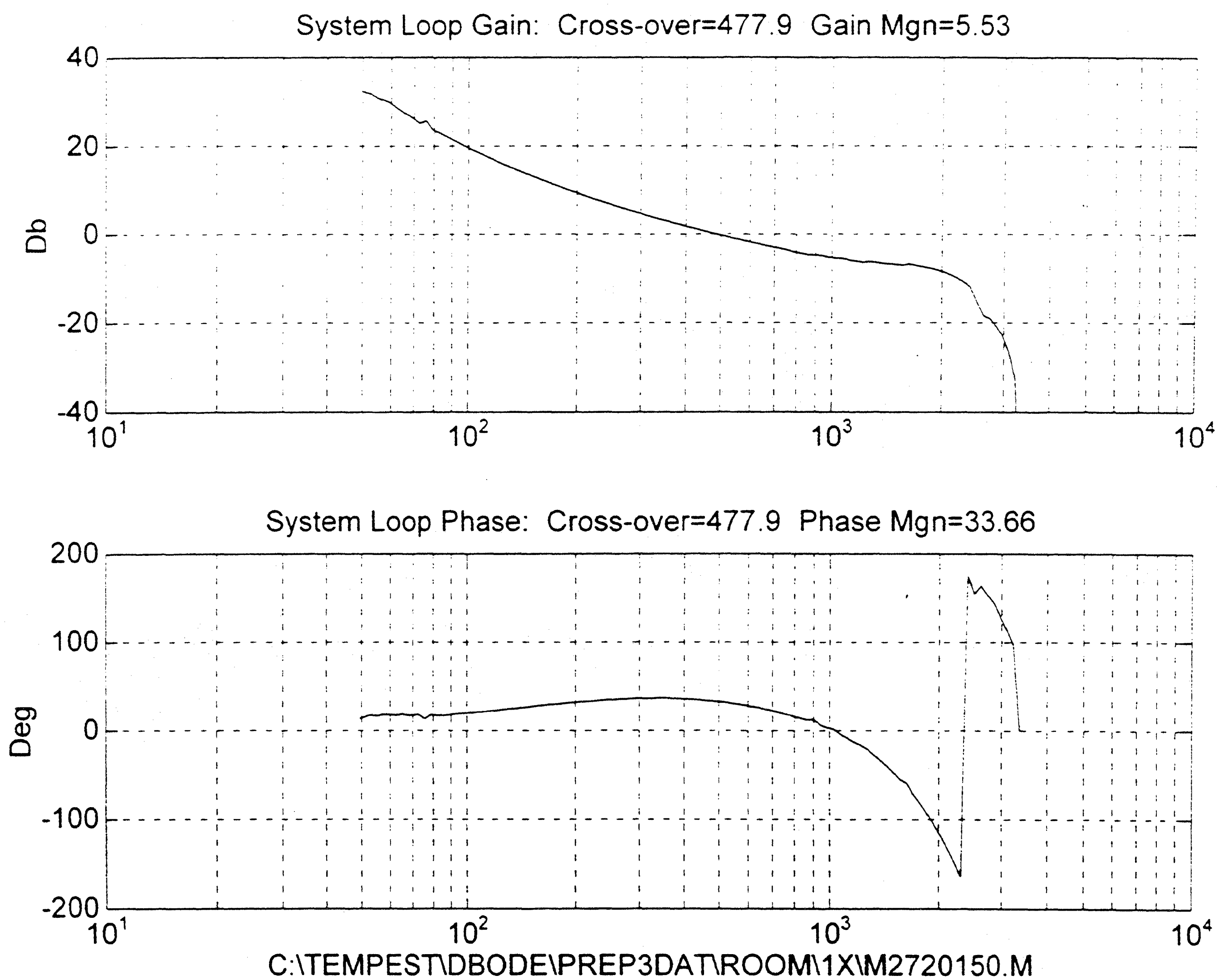

System Loop Gain: Cross-over=497.7 Gain Mgn=5.22
40
20
0
-20
-40
Db
10^1
10^2
10^3
10^4
System Loop Phase: Cross-over=497.7 Phase Mgn=33.31
200
100
0
-100
-200
Deg
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\LO\1X\M2720150.M

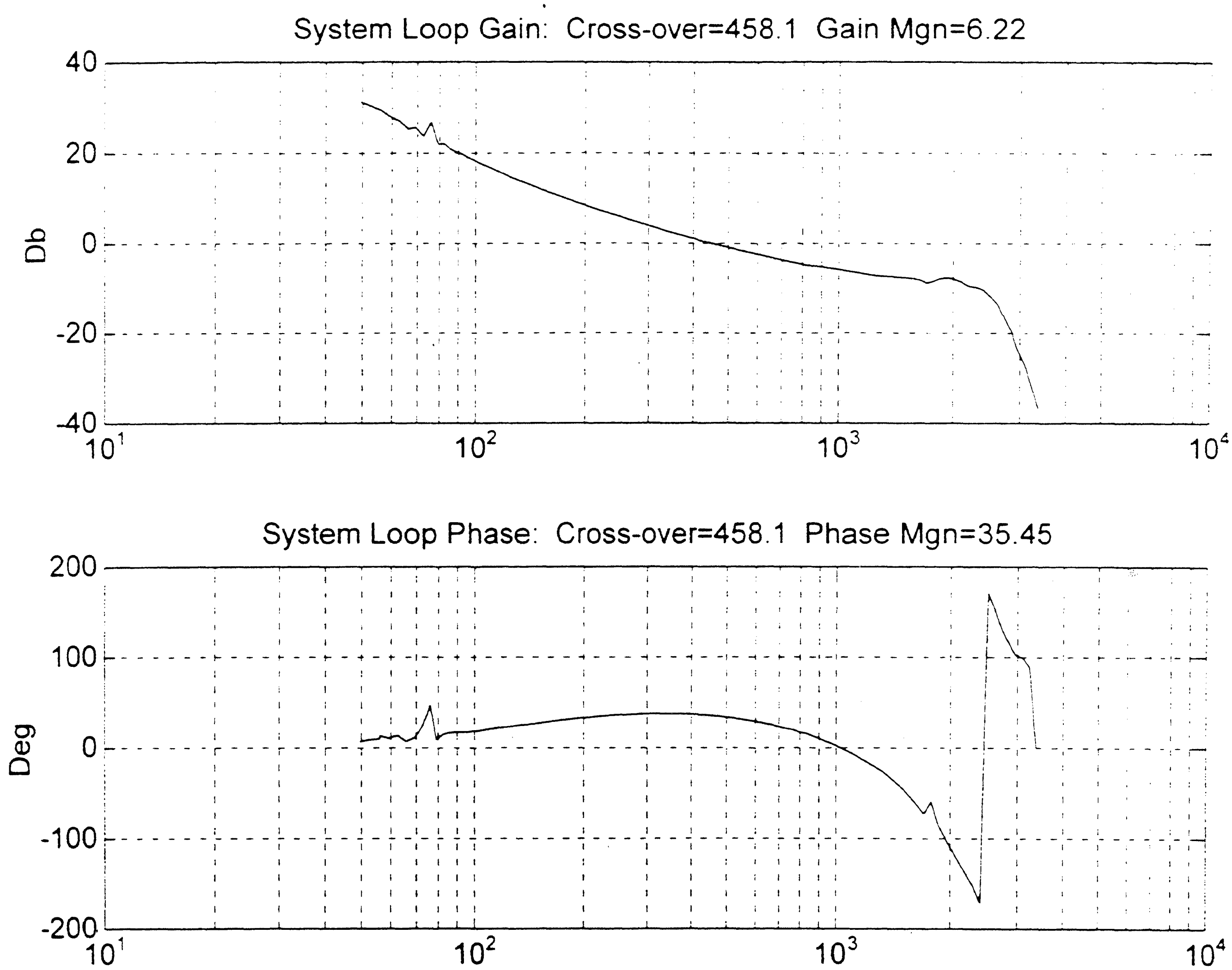


System Loop Gain: Cross-over=458.1 Gain Mgn=6.41
40
20
0
-20
-40
Db
10^1
10^2
10^3
10^4
System Loop Phase: Cross-over=458.1 Phase Mgn=36.08
200
100
0
-100
-200
Deg
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\LO\1X\M3171040.M


System Loop Gain: Cross-over=517.5 Gain Mgn=5.54
40
20
0
-20
-40
Db
10^1
10^2
10^3
10^4


System Loop Phase: Cross-over=517.5 Phase Mgn=34.48
200
100
0
-100
-200
Deg
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\ROOM\1X\M1220050.M


System Loop Gain: Cross-over=477.9 Gain Mgn=5.53
40
20
0
-20
-40
Db
10^1
10^2
10^3
10^4
System Loop Phase: Cross-over=477.9 Phase Mgn=33.66
200
100
0
-100
-200
Deg
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\ROOM\1X\M2720150.M



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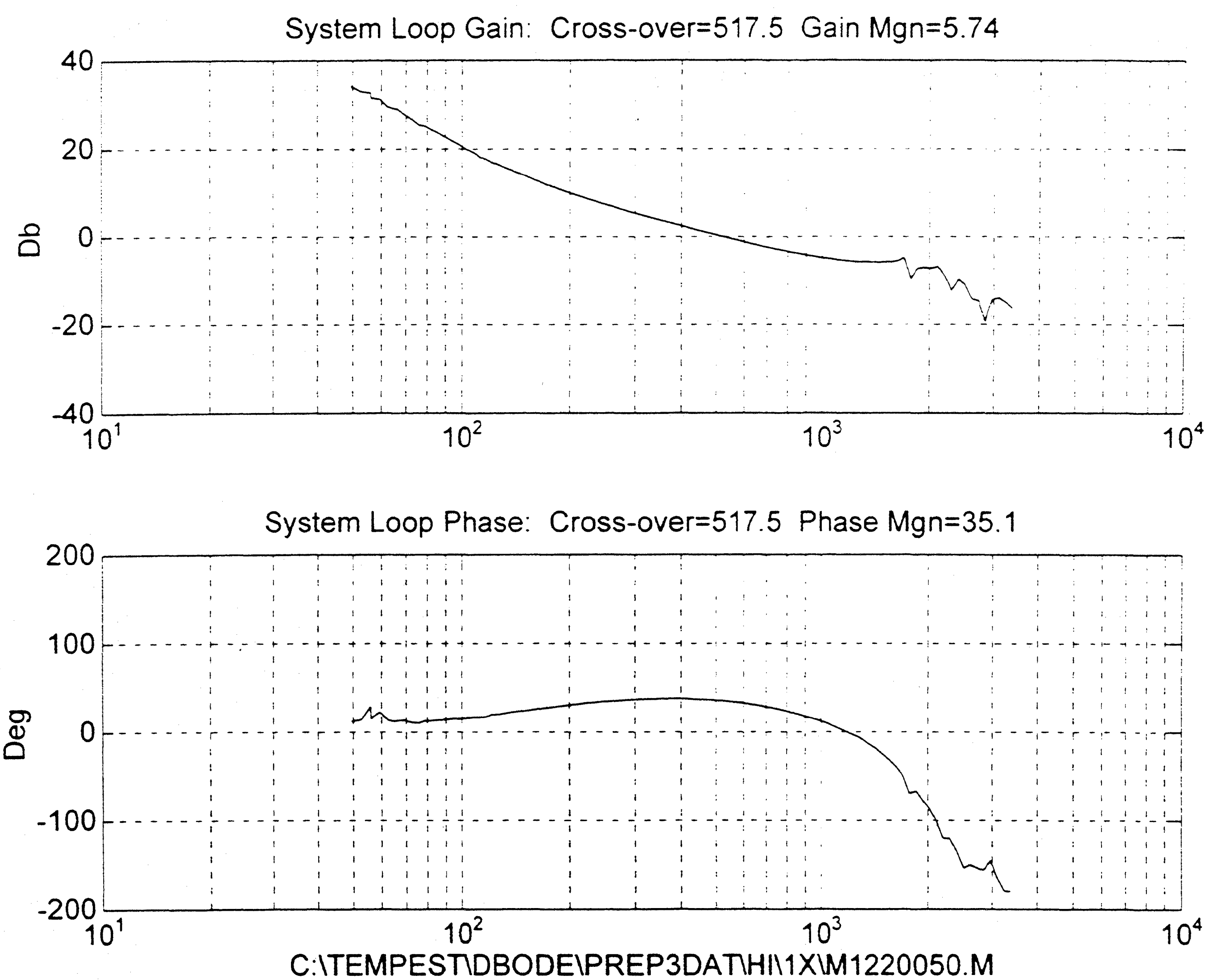
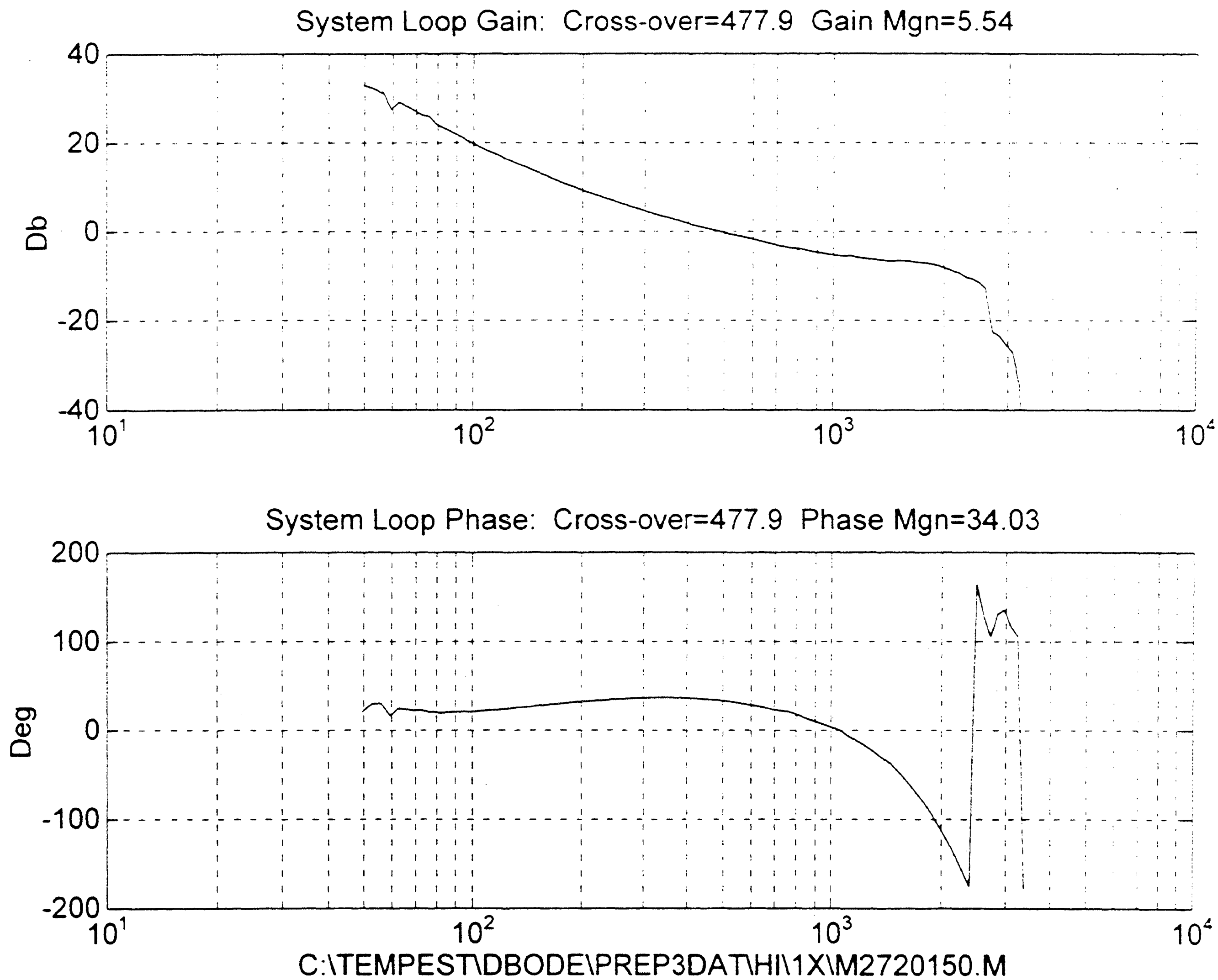
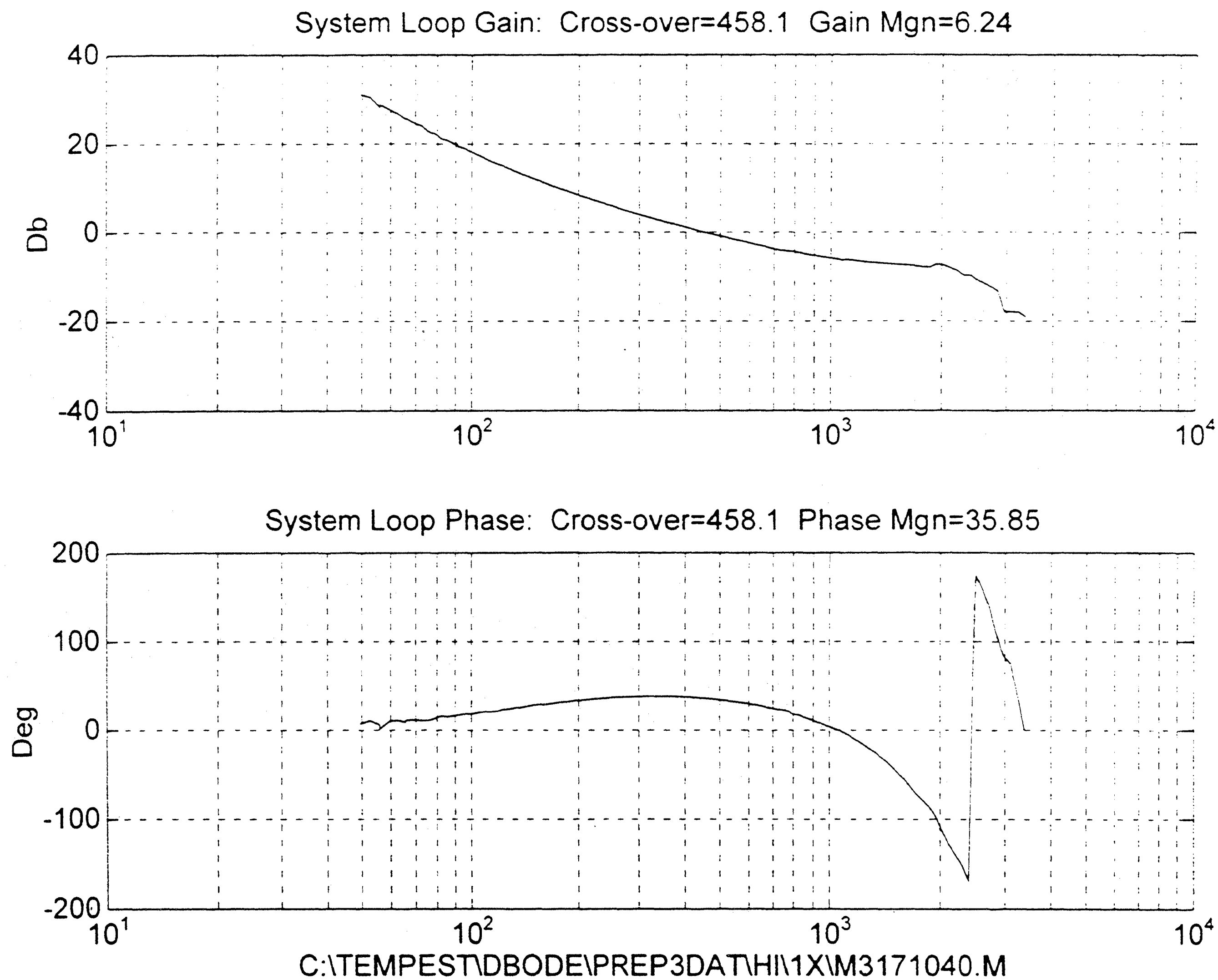
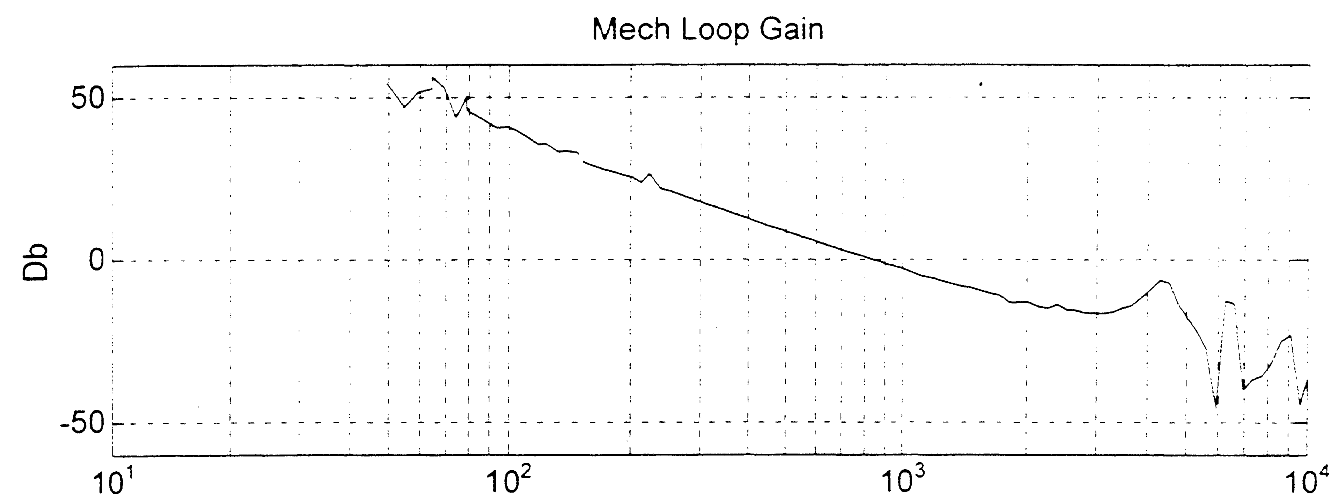
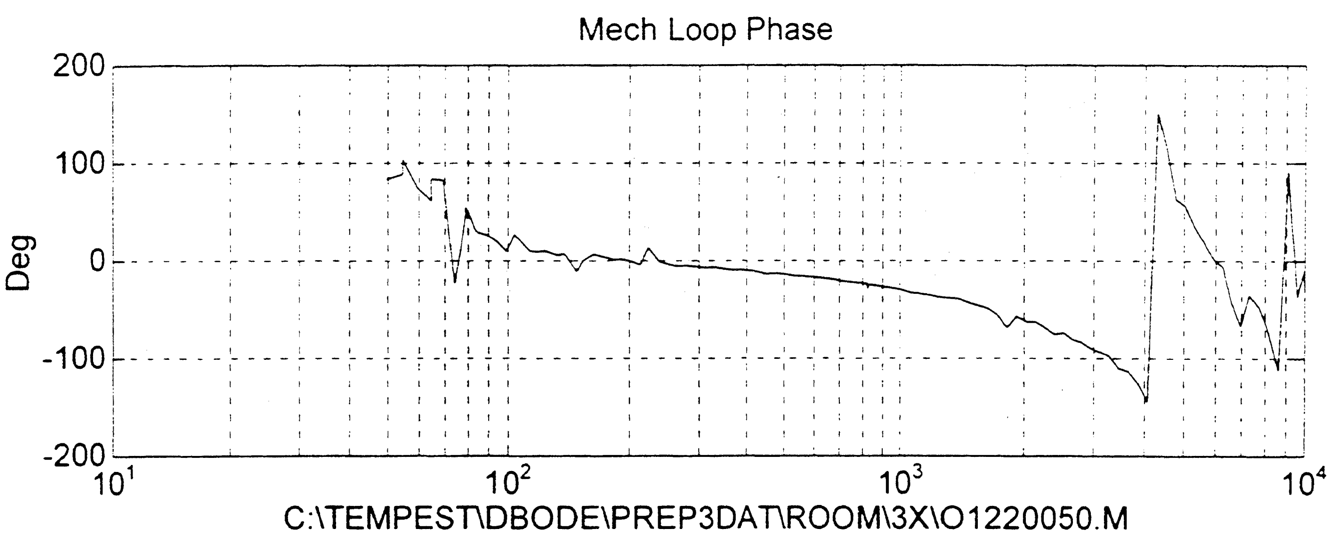

System Loop Gain: Cross-over=517.5 Gain Mgn=5.74
40
20
0
-20
-40
Db
10^1
10^2
10^3
10^4
System Loop Phase: Cross-over=517.5 Phase Mgn=35.1
200
100
0
-100
-200
Deg
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\HI\1X\M1220050.M


System Loop Gain: Cross-over=477.9 Gain Mgn=5.54
Db
40
20
0
-20
-40
10^1
10^2
10^3
10^4
System Loop Phase: Cross-over=477.9 Phase Mgn=34.03
Deg
200
100
0
-100
-200
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\HI\1X\M2720150.M

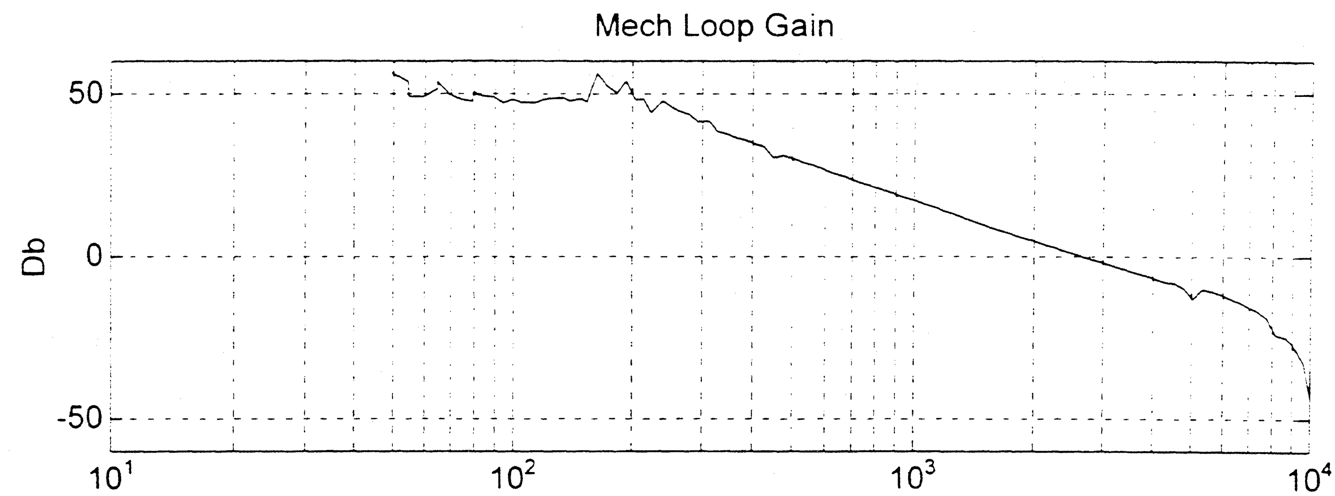

System Loop Gain: Cross-over=458.1 Gain Mgn=6.24
Db
40
20
0
-20
-40
10^1
10^2
10^3
10^4
System Loop Phase: Cross-over=458.1 Phase Mgn=35.85
Deg
200
100
0
-100
-200
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\HI\1X\M3171040.M

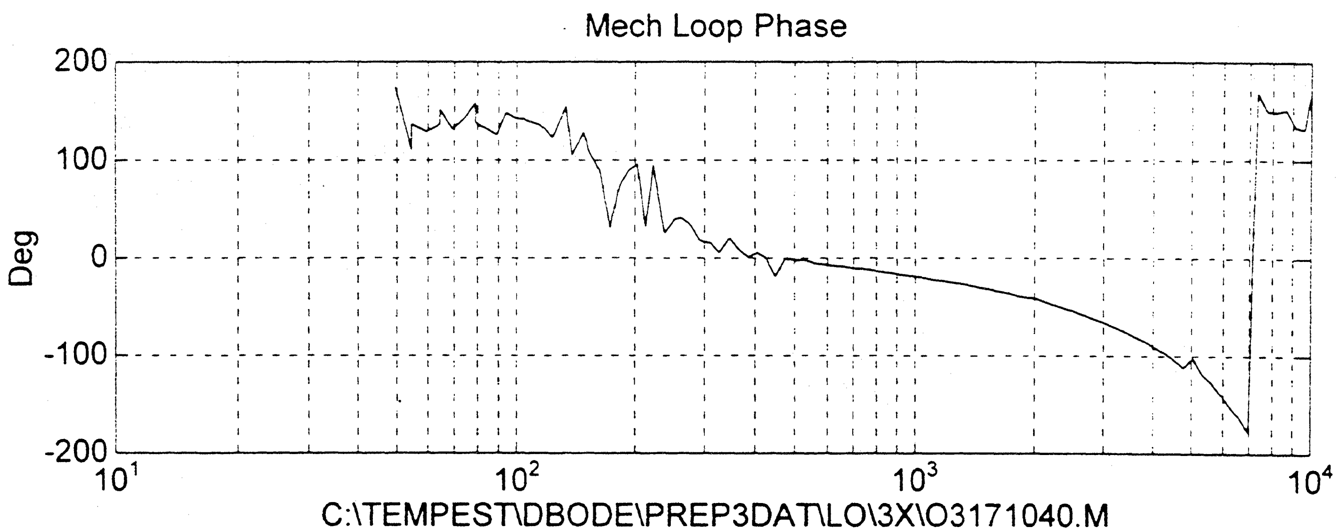


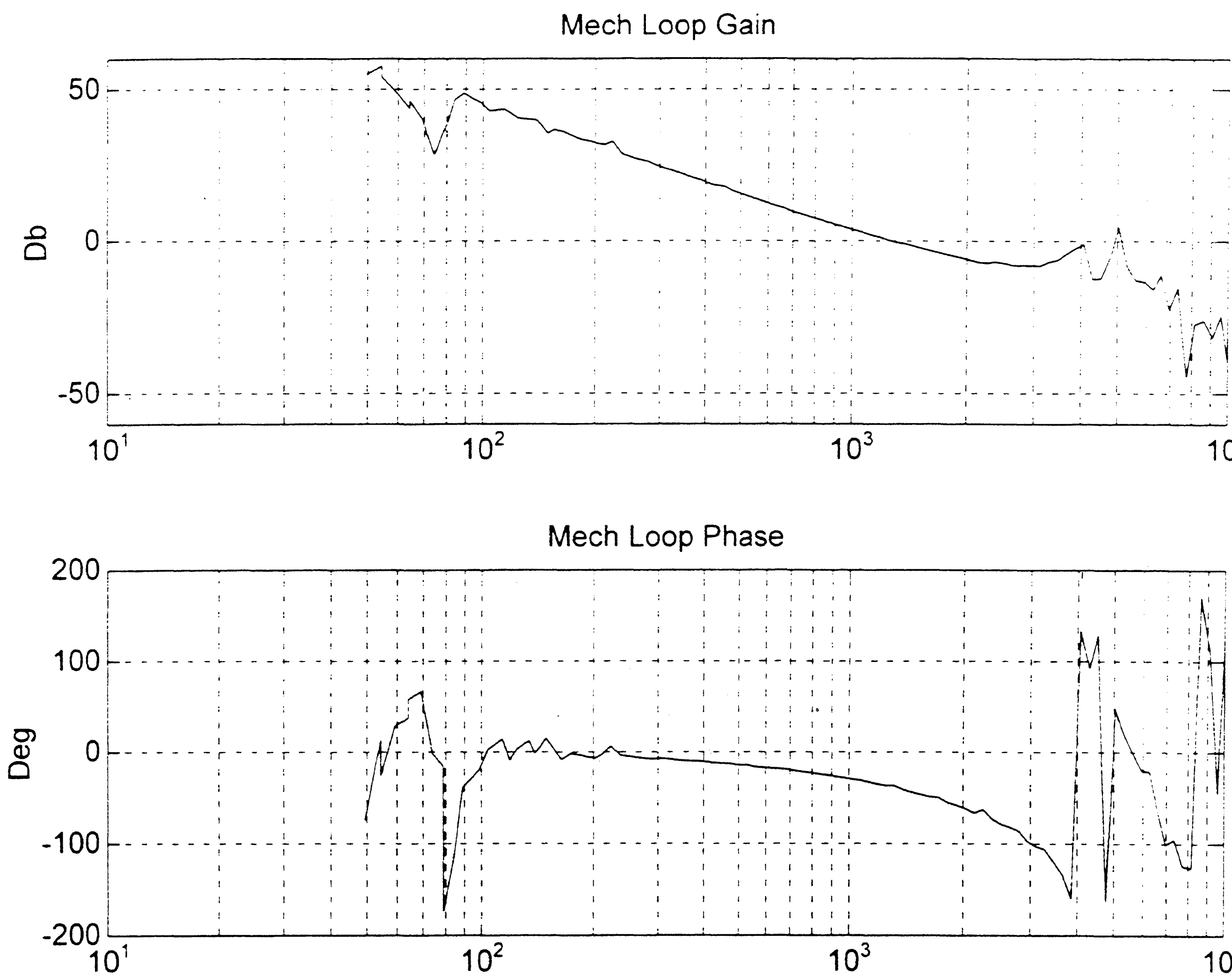
Mech Loop Gain
50
0
-50
Db
10^1
10^2
10^3
10^4



Mech Loop Phase
200
100
0
-100
-200
Deg
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\ROOM\3X\O1220050.M


Mech Loop Gain
50
0
-50
Db
10^1
10^2
10^3
10^4


Mech Loop Phase
200
100
0
-100
-200
Deg
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\LO\3X\O3171040.M



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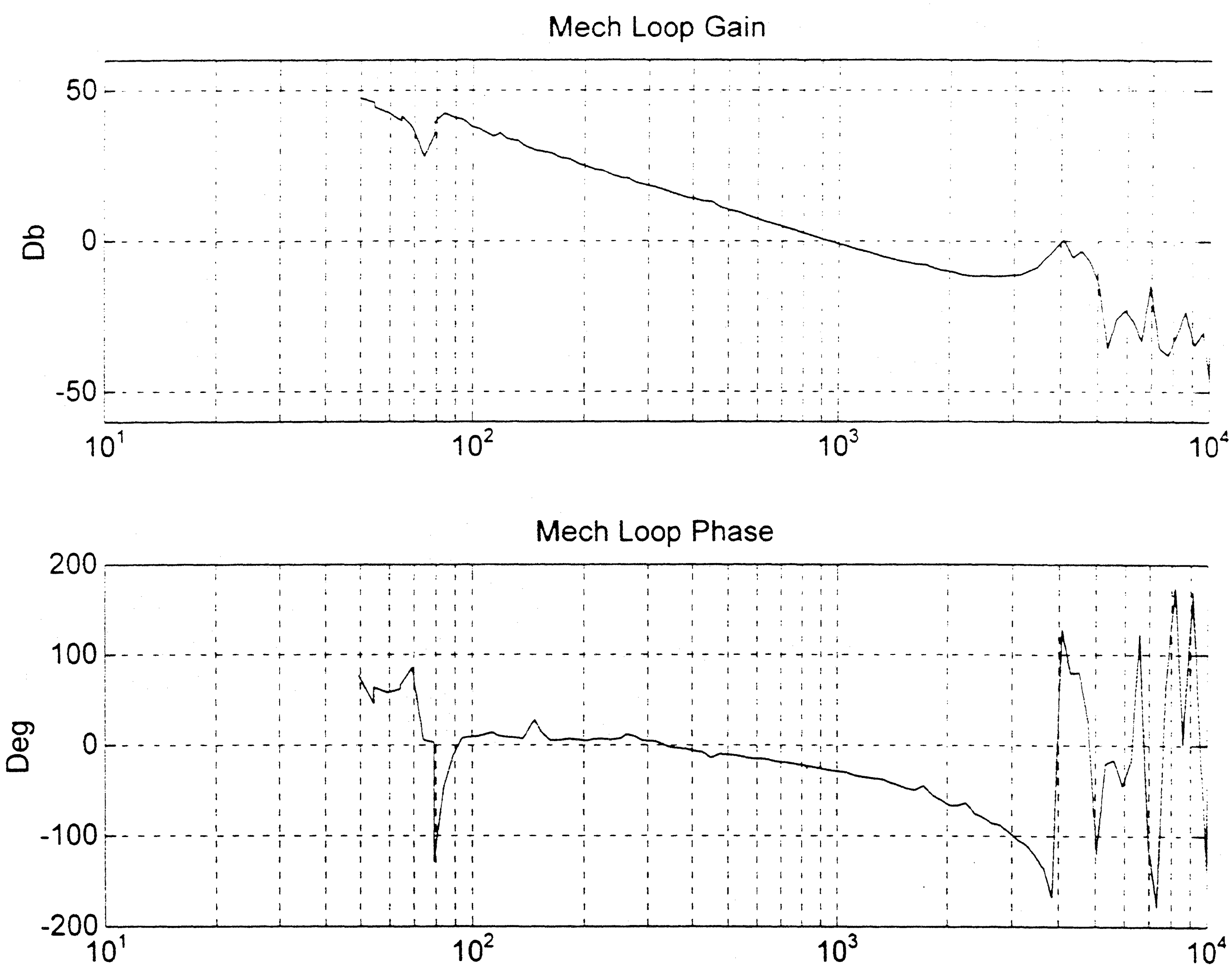

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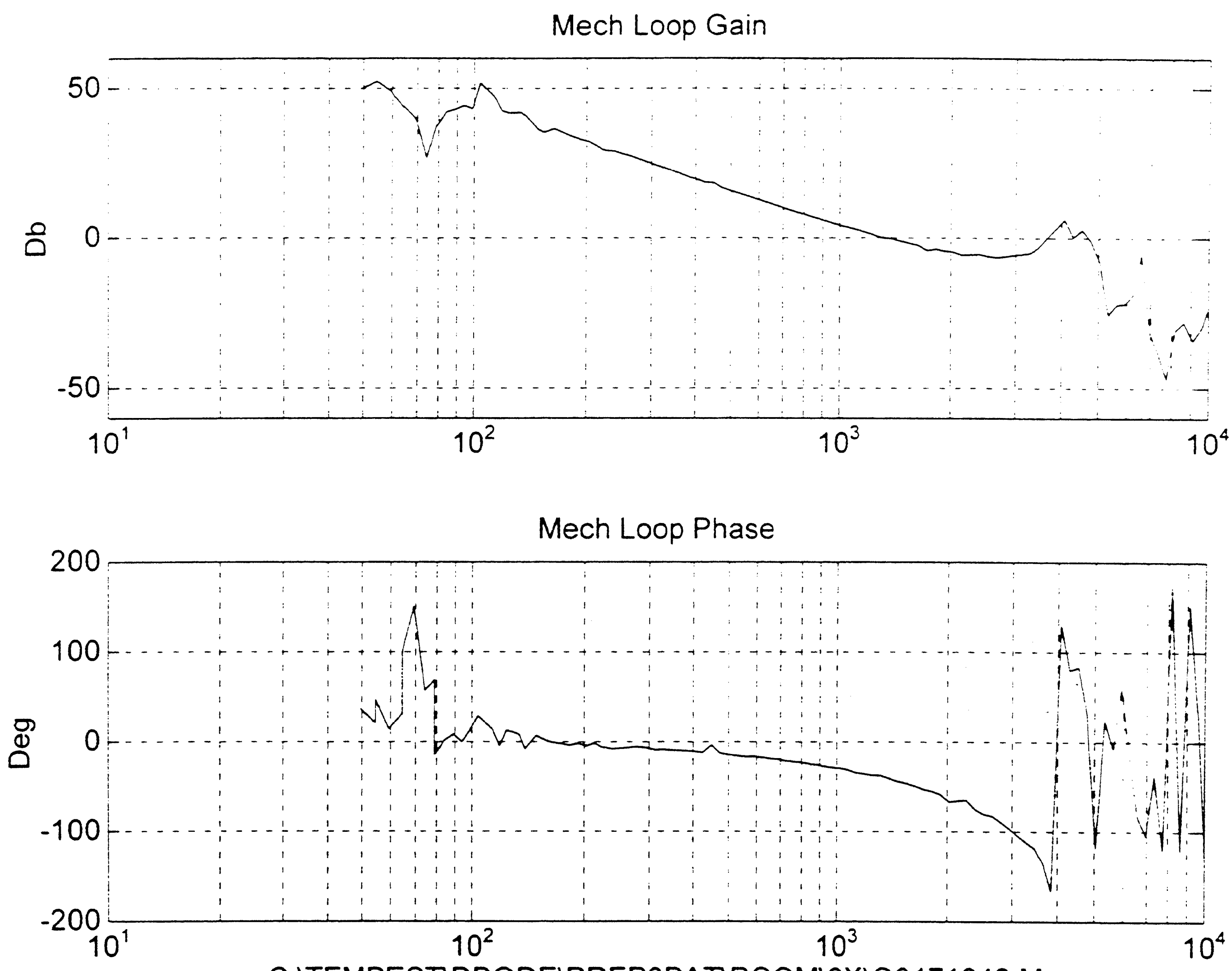

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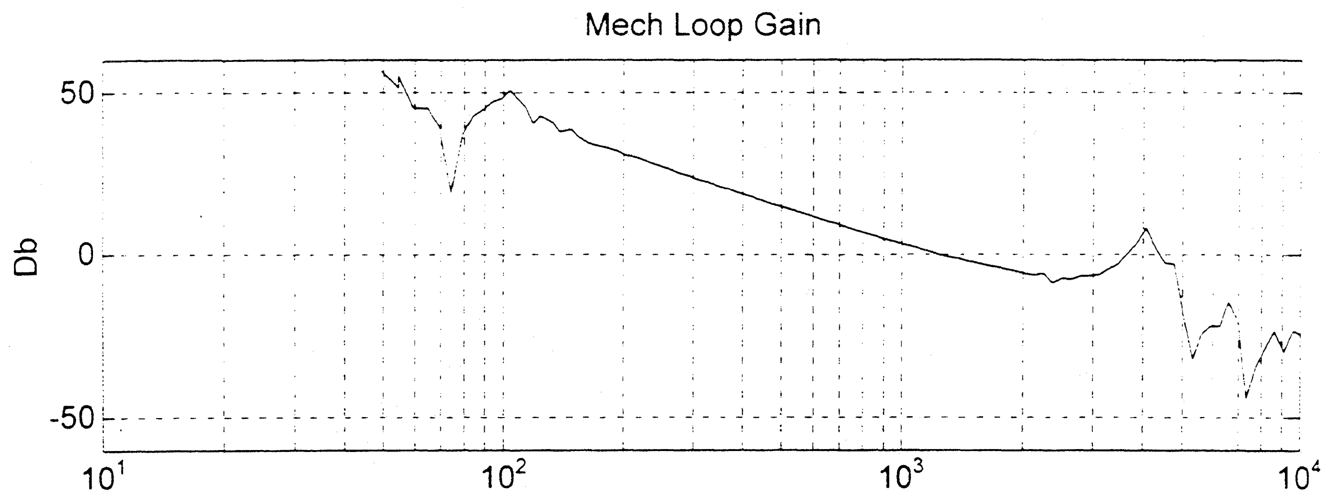

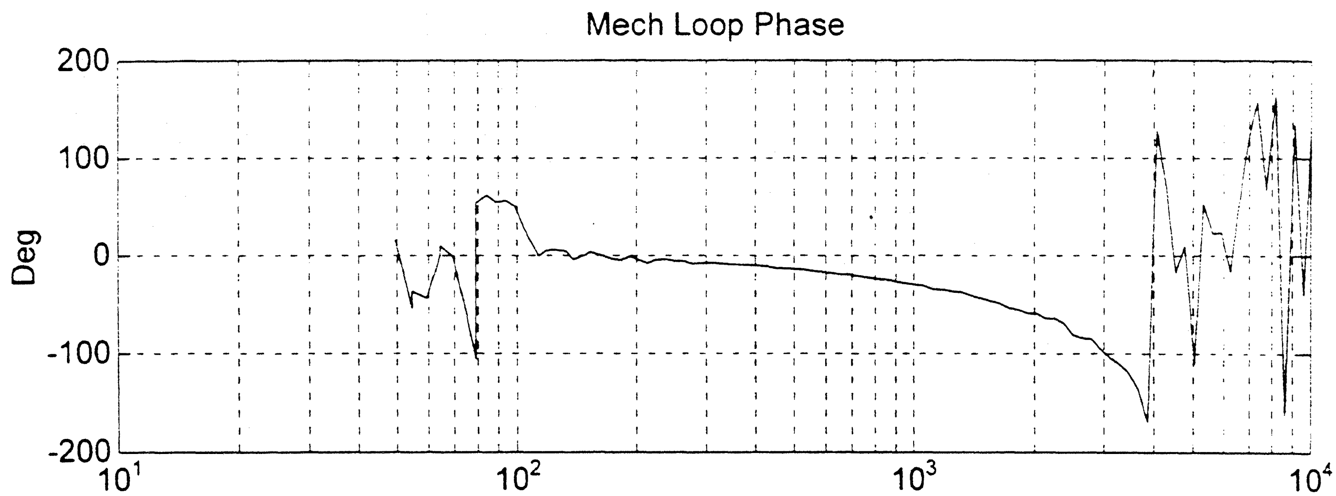

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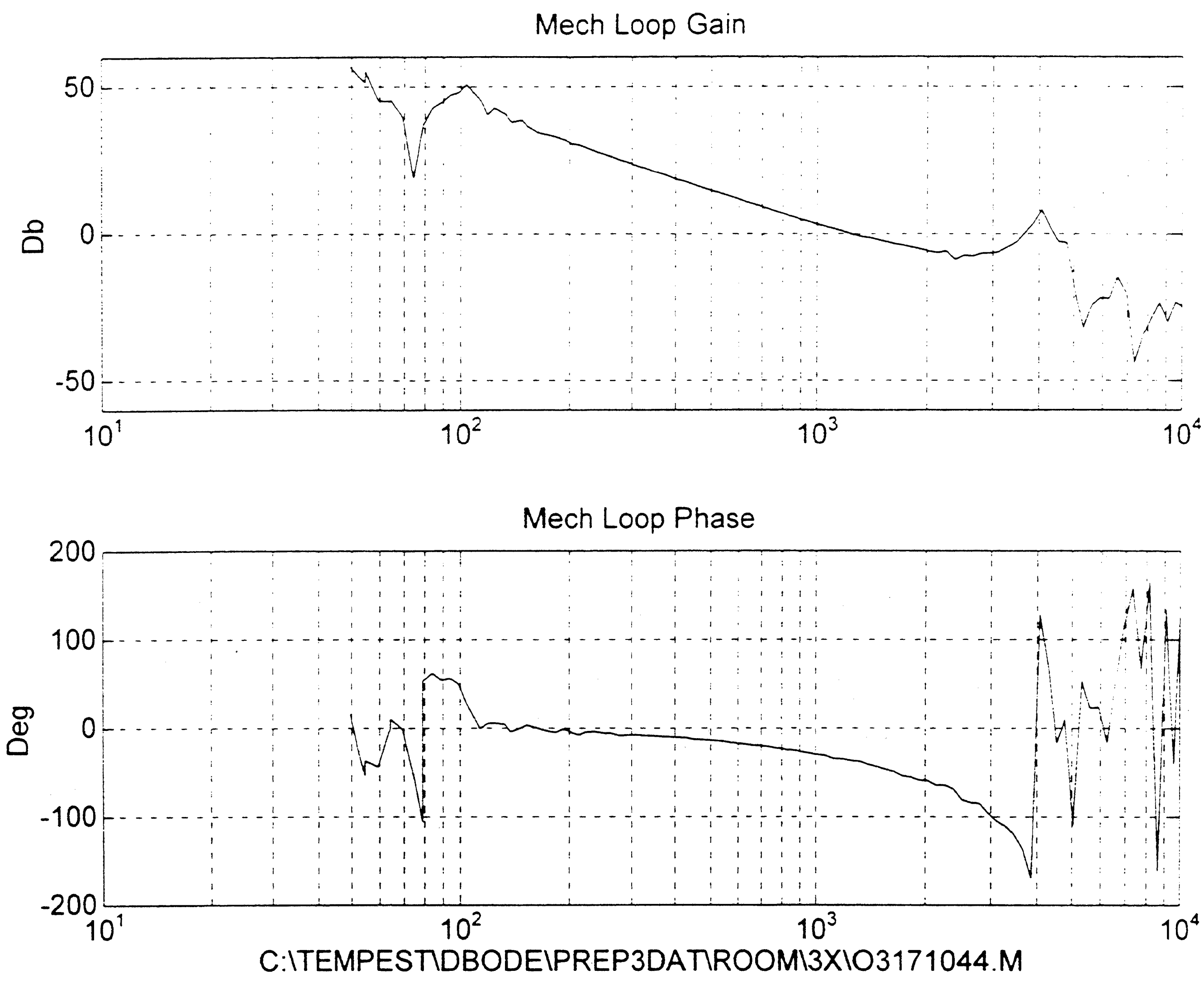
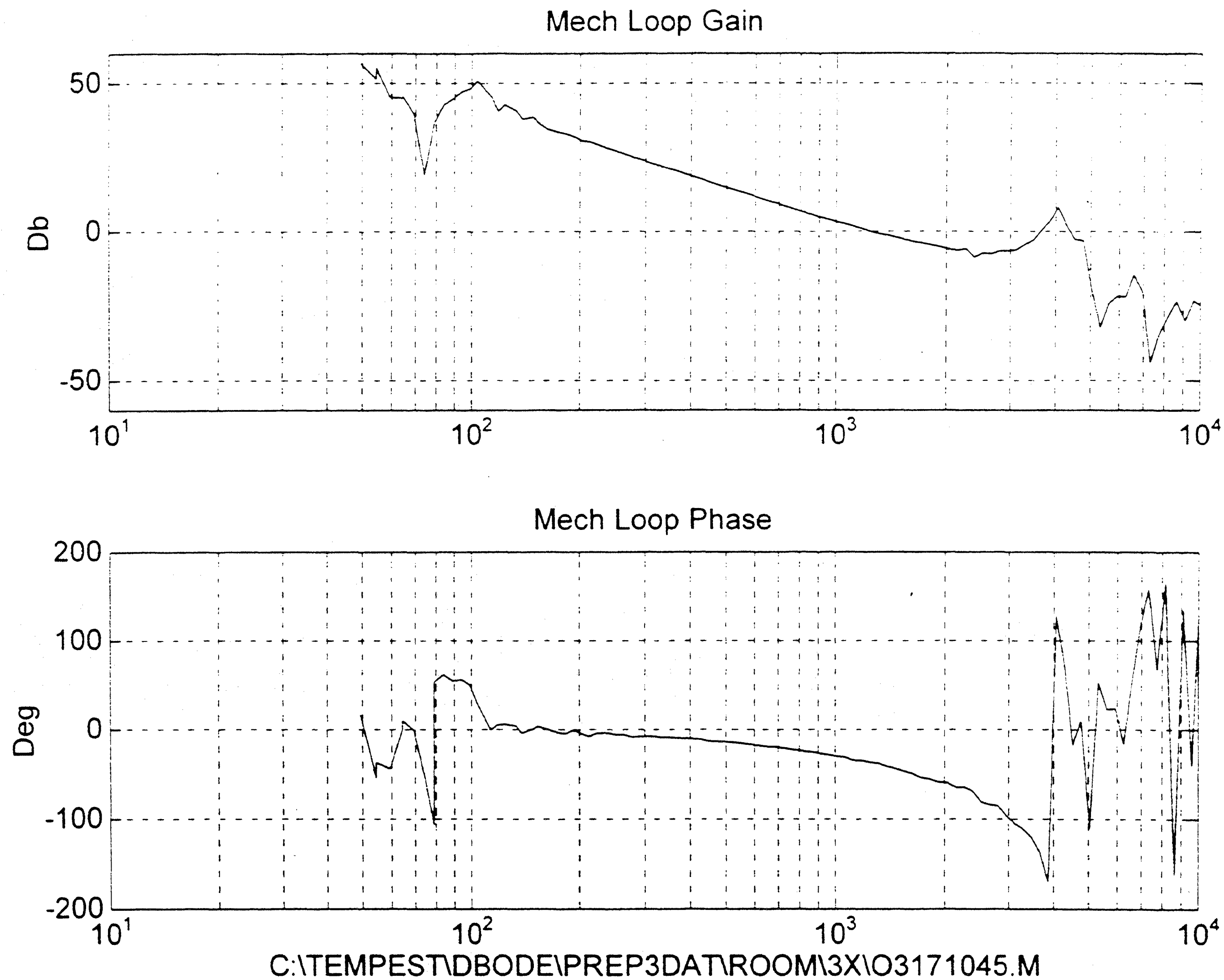
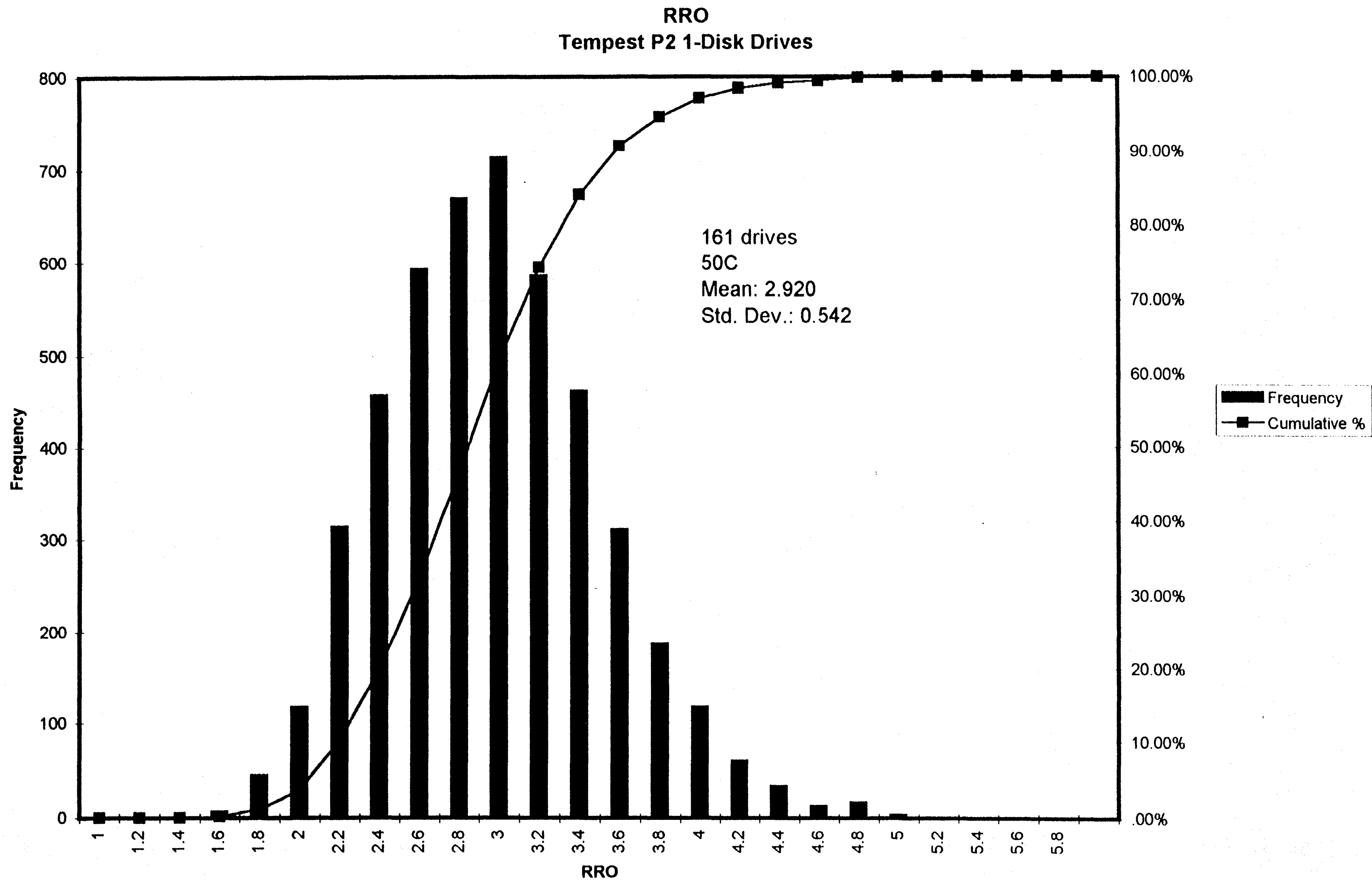

Mech Loop Gain
Db
50
0
-50
10^1
10^2
10^3
10^4
Mech Loop Phase
Deg
200
100
0
-100
-200
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\ROOM\3X\O3171044.M

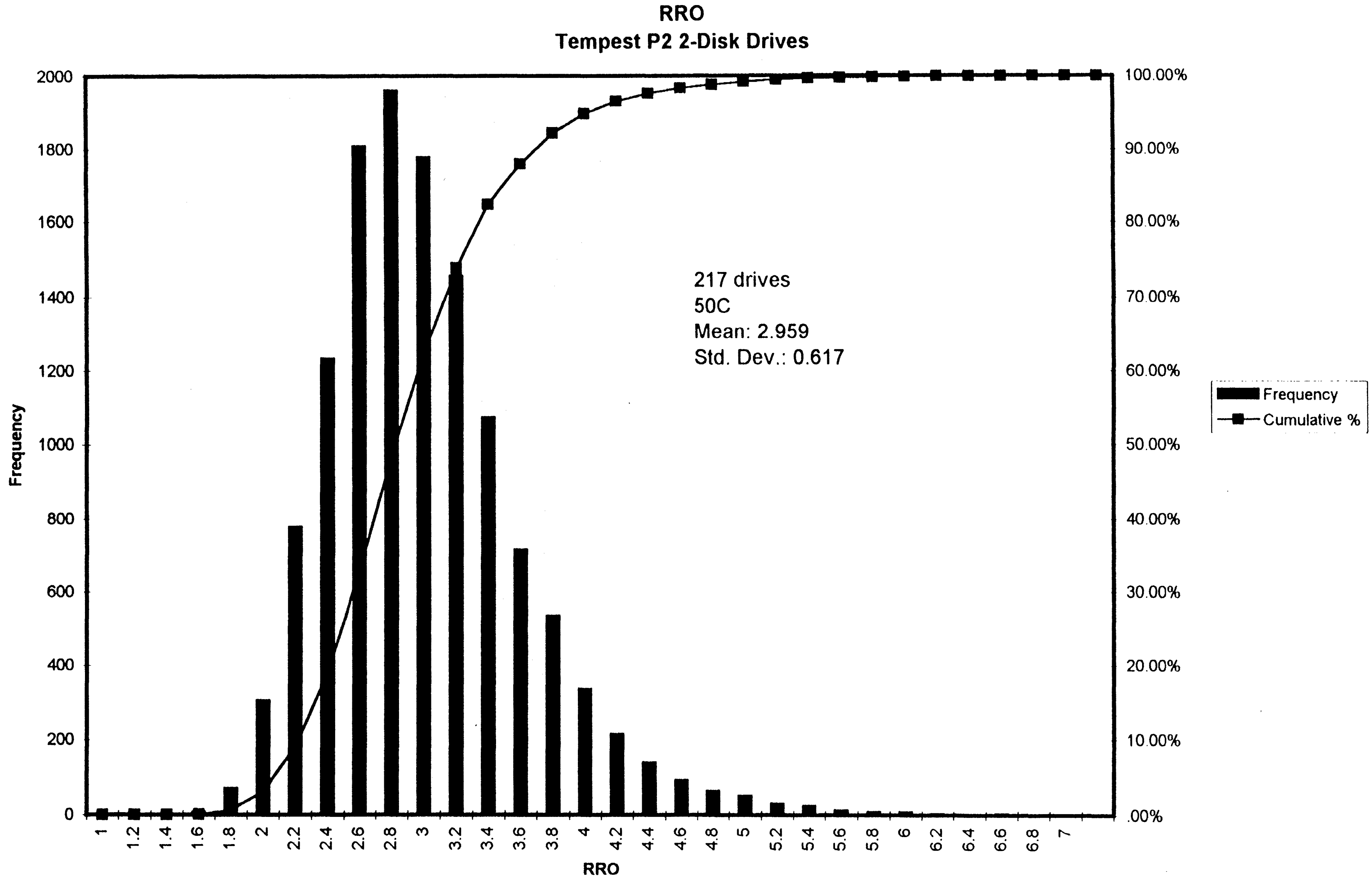

Mech Loop Gain
50
0
-50
Db
10^1
10^2
10^3
10^4
Mech Loop Phase
200
100
0
-100
-200
Deg
10^1
10^2
10^3
10^4
C:\TEMPEST\DBODE\PREP3DAT\ROOM\3X\O3171045.M

.TEMPEST.

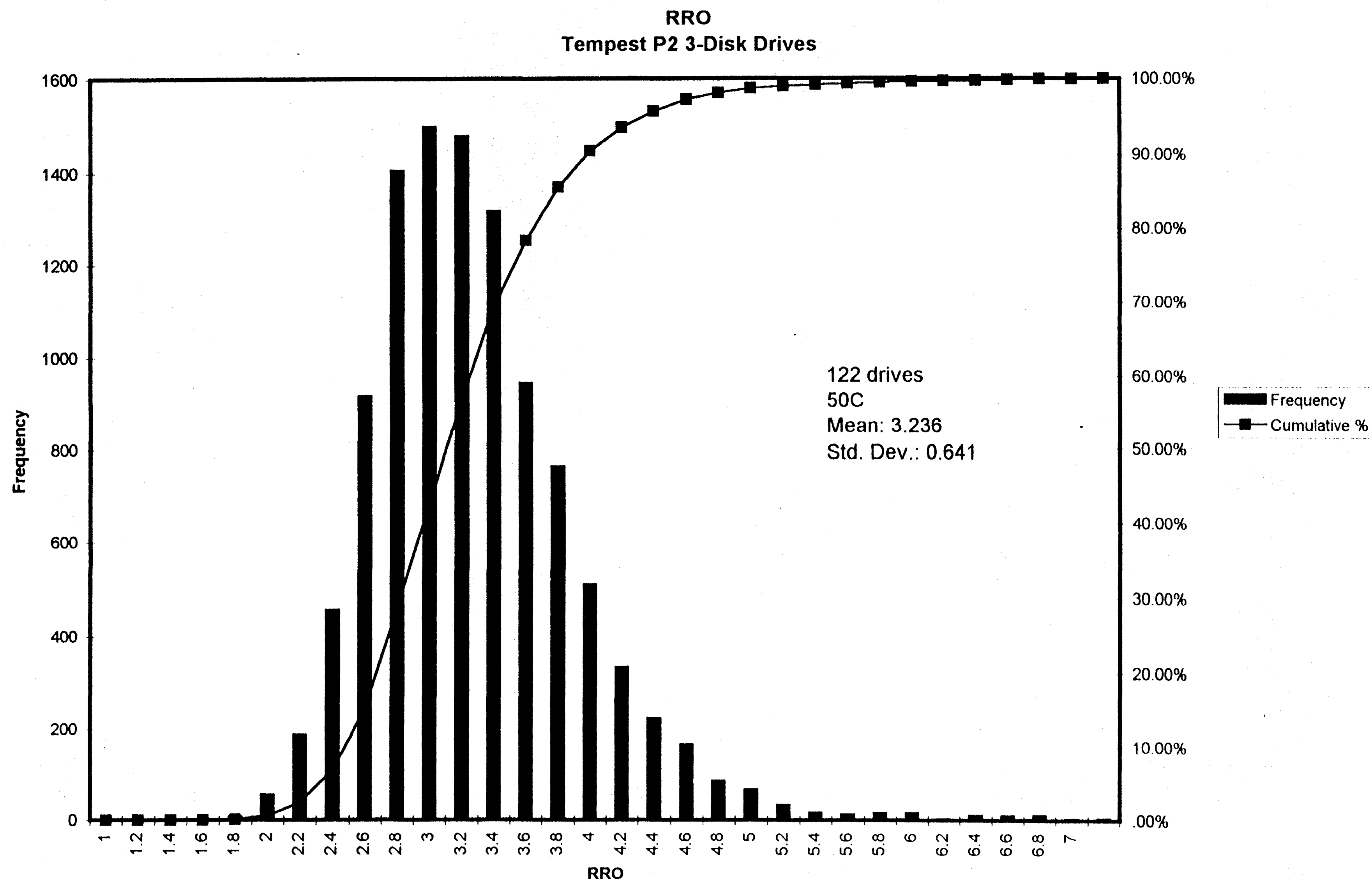
Pre-production Results

Runout Measurements

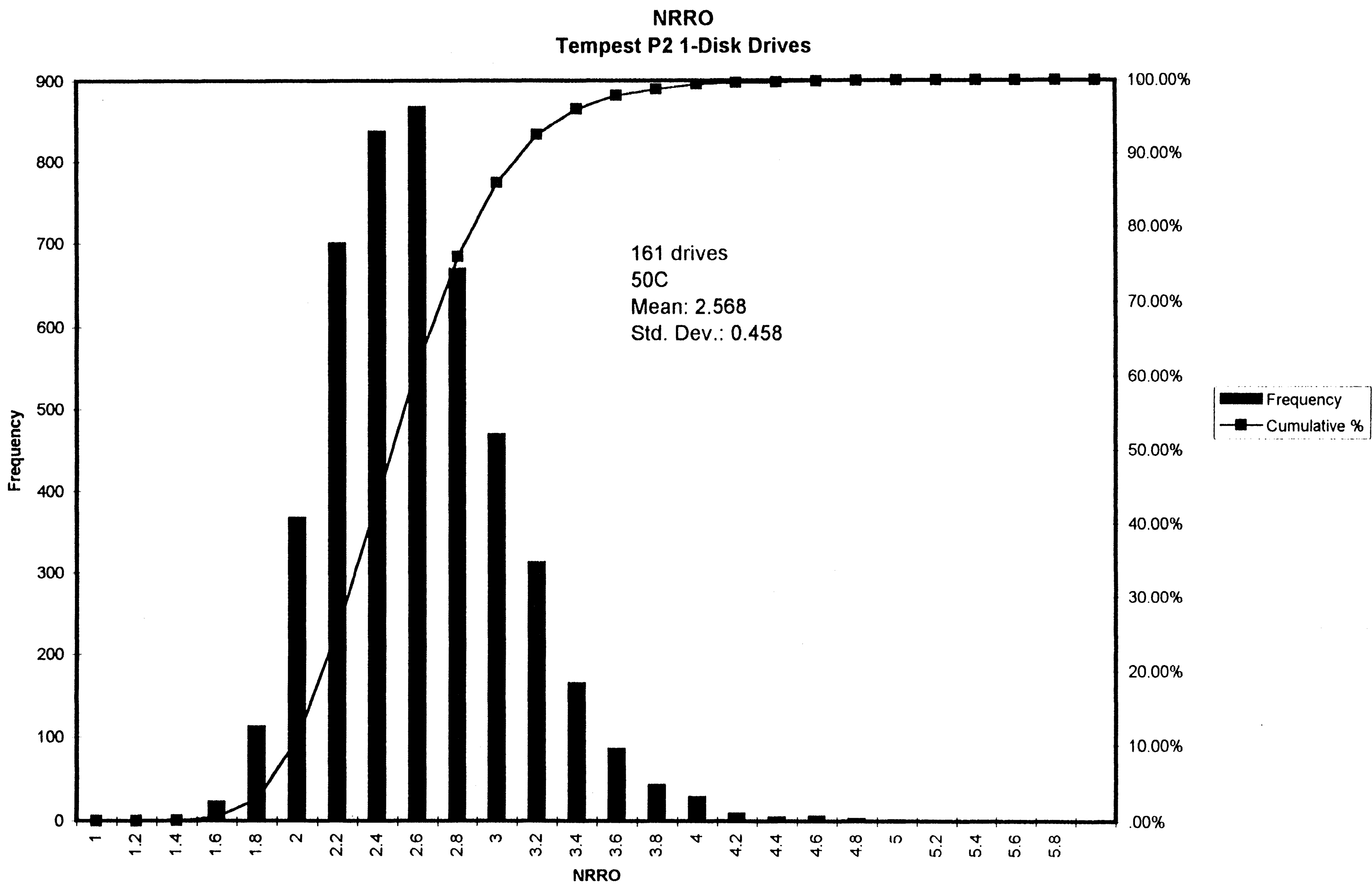

RRO
Tempest P2 1-Disk Drives
161 drives
50C
Mean: 2.920
Std. Dev.: 0.542
Frequency
Cumulative %
800
700
600
500
400
300
200
100
0
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
.00%
1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4 4.6 4.8 5 5.2 5.4 5.6 5.8
RRO

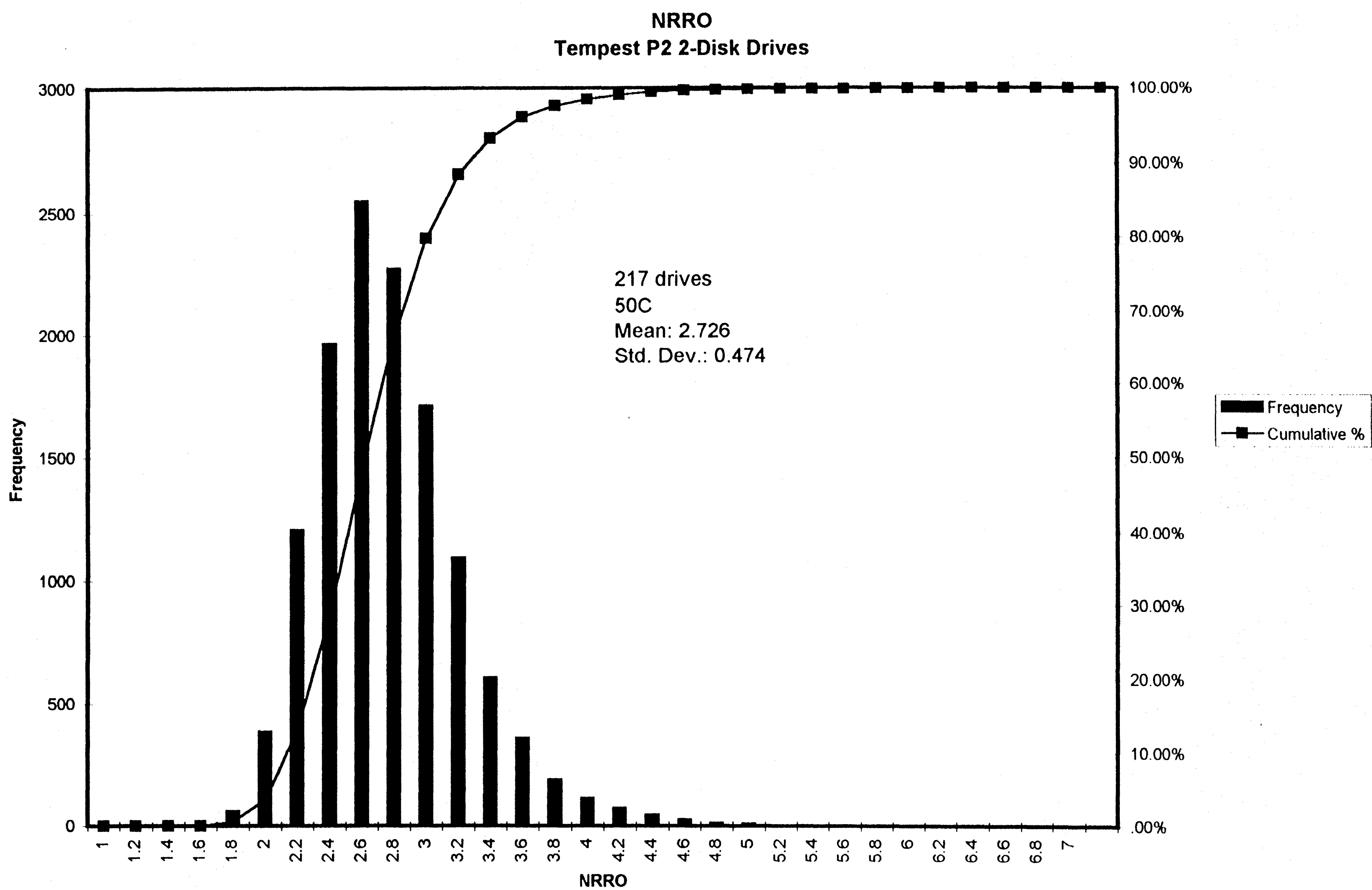


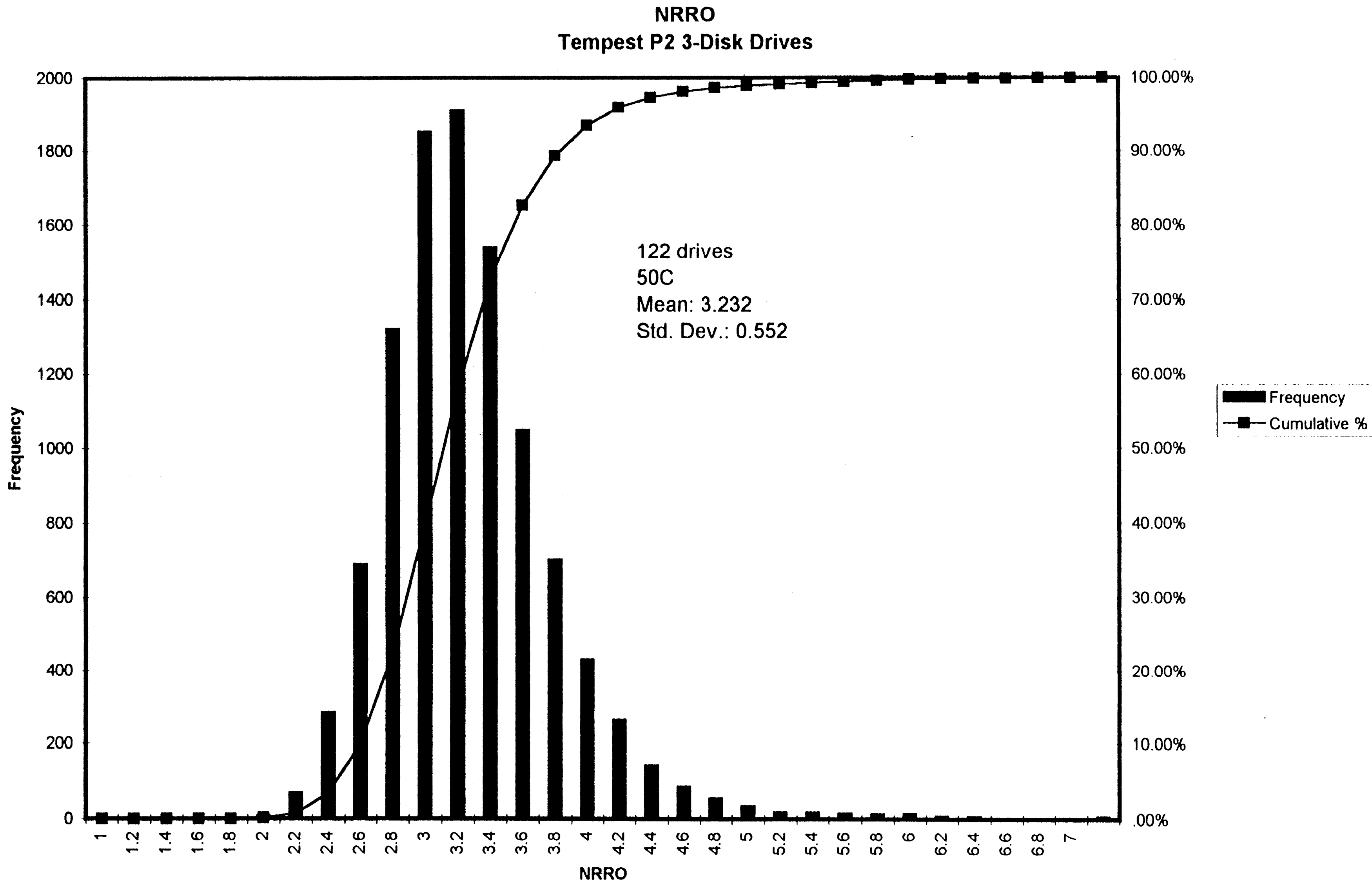
RRO
Tempest P2 2-Disk Drives
217 drives
50C
Mean: 2.959
Std. Dev.: 0.617
Frequency
RRO
Frequency
Cumulative %
2000
1800
1600
1400
1200
1000
800
600
400
200
0
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
.00%
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2
6.4
6.6
6.8
7



RRO
Tempest P2 3-Disk Drives
1600
1400
1200
1000
800
600
400
200
0
Frequency
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
.00%
122 drives
50C
Mean: 3.236
Std. Dev.: 0.641
Frequency
Cumulative %
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2
6.4
6.6
6.8
7
RRO


NRRO
Tempest P2 1-Disk Drives
161 drives
50C
Mean: 2.568
Std. Dev.: 0.458
Frequency
Cumulative %
NRRO
0
100
200
300
400
500
600
700
800
900
.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%
90.00%
100.00%
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5
5.2
5.4
5.6
5.8


NRRO
Tempest P2 2-Disk Drives
217 drives
50C
Mean: 2.726
Std. Dev.: 0.474
Frequency
Cumulative %
NRRO
0
500
1000
1500
2000
2500
3000
.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%
90.00%
100.00%
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2
6.4
6.6
6.8
7

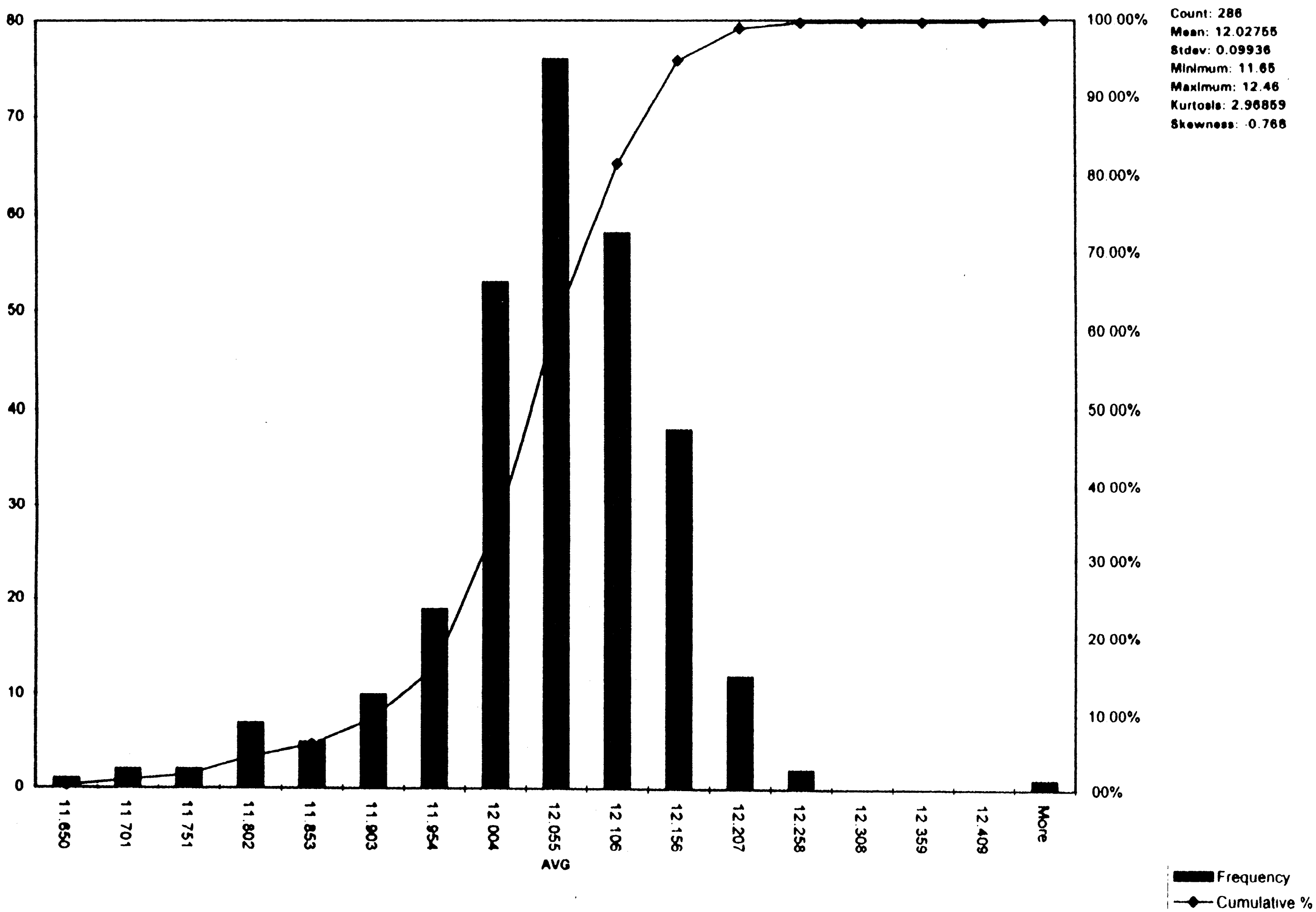

NRRO
Tempest P2 3-Disk Drives
122 drives
50C
Mean: 3.232
Std. Dev.: 0.552
Frequency
Cumulative %
NRRO
0
200
400
600
800
1000
1200
1400
1600
1800
2000
.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%
90.00%
100.00%
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2
6.4
6.6
6.8
7

.TEMPEST.

Pre-production Results

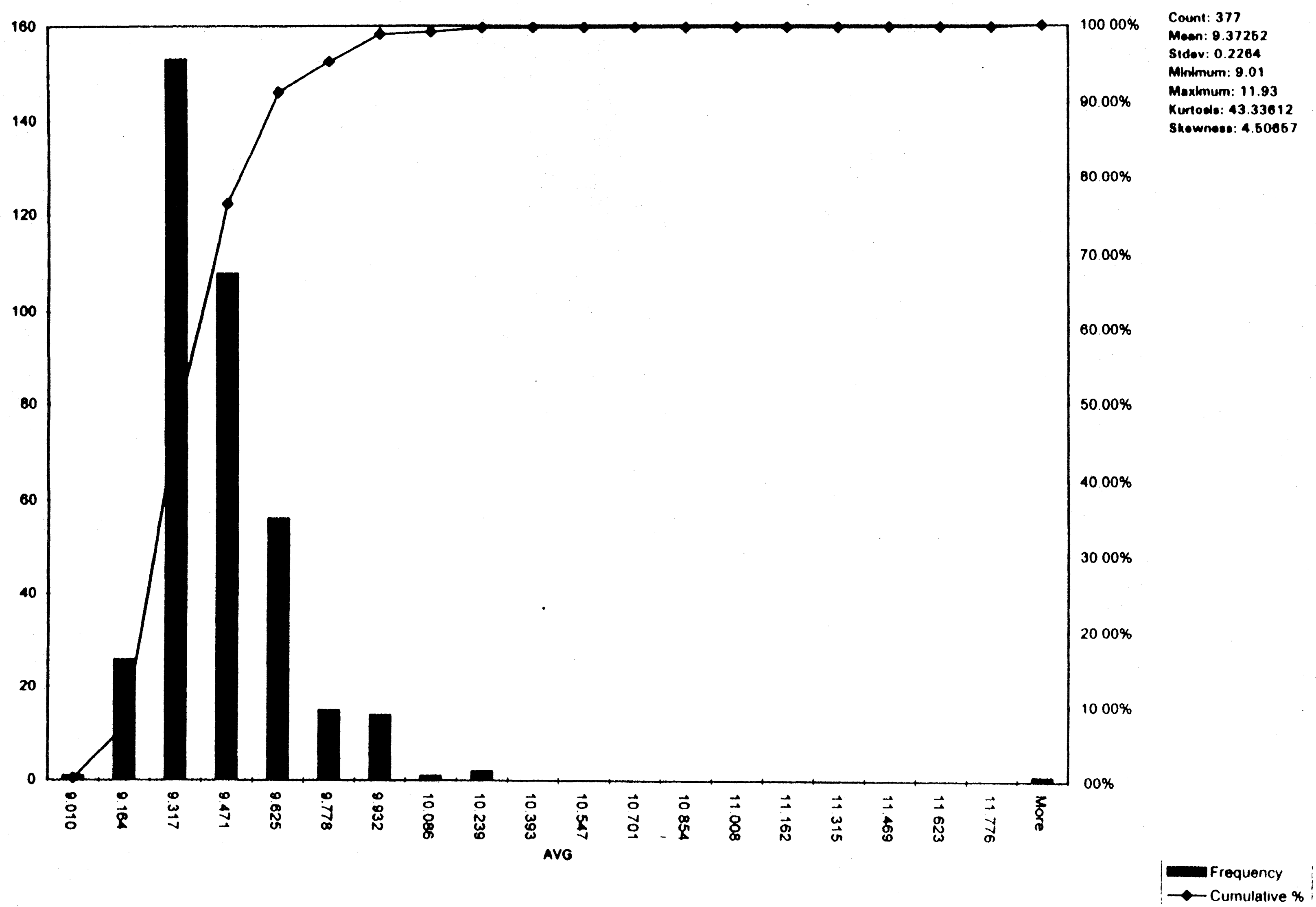
Seek Times

Average Random Seek 1 Disk Histogram

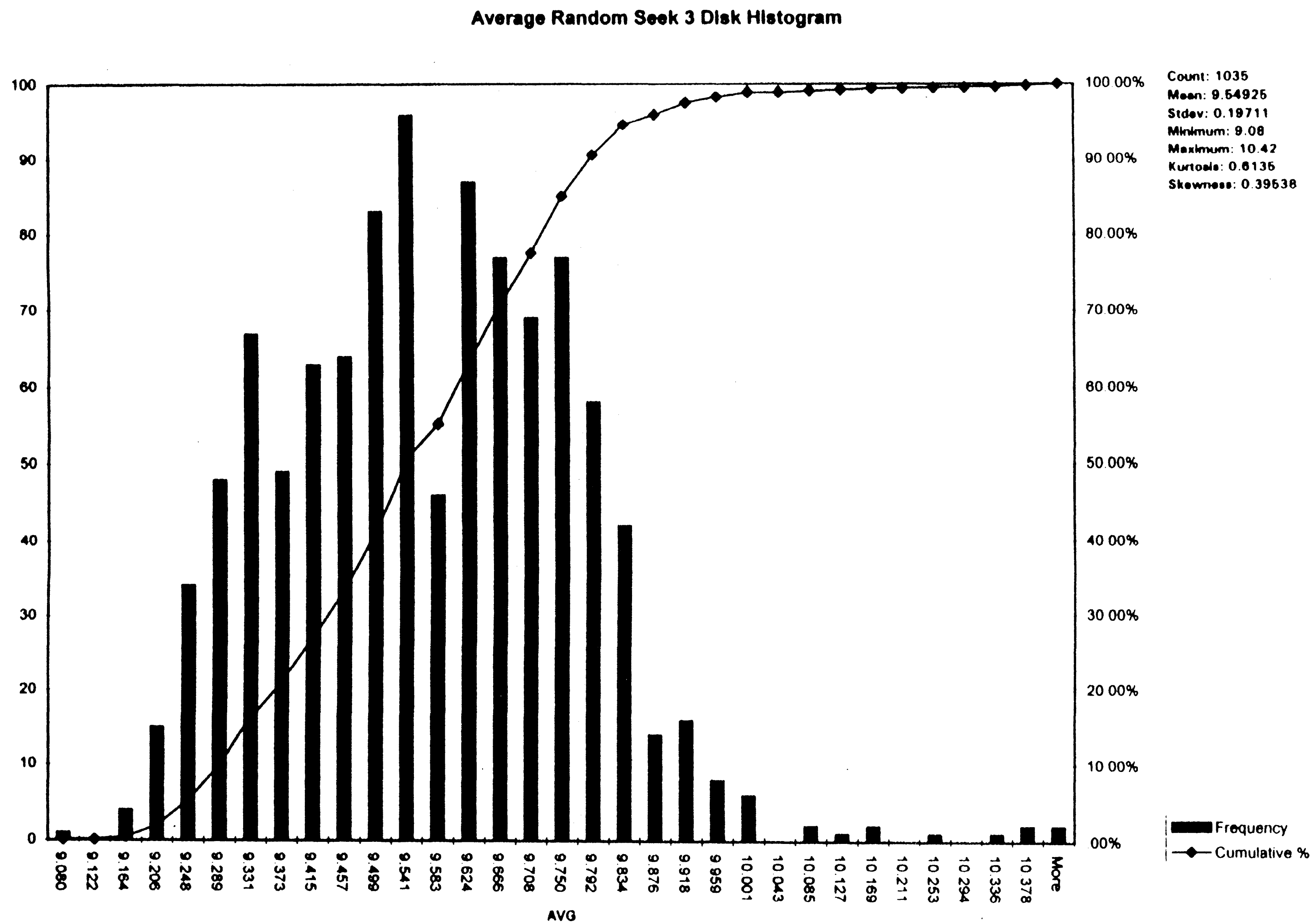


D.Nordin,x6214

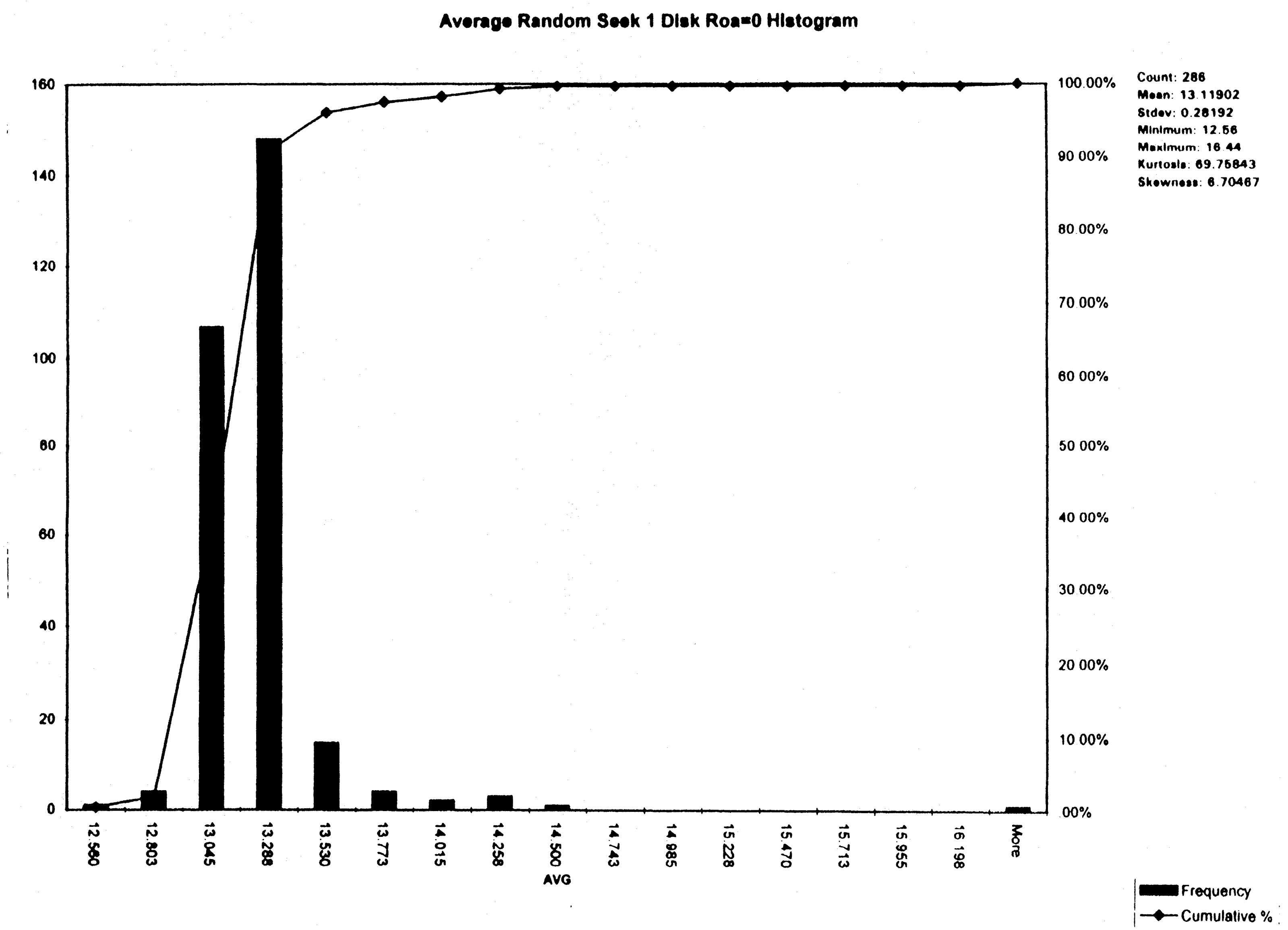
Average Random Seek 2 Disk Histogram



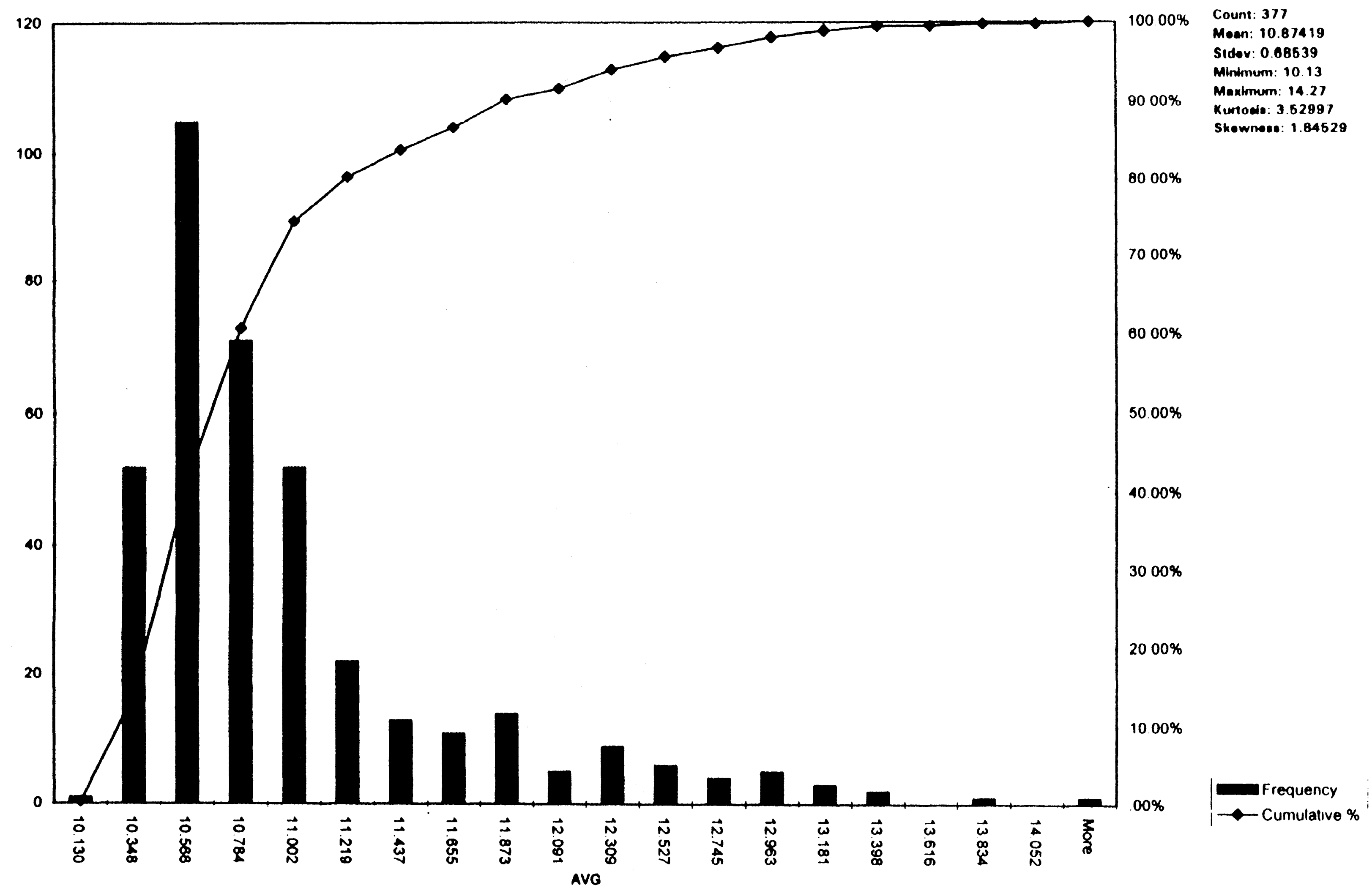
D Nordin x6214



D.Nordin,x6214


Average Random Seek 1 Disk Roa=0 Histogram
160
140
120
100
80
60
40
20
0
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
.00%
12.560
12.803
13.045
13.288
13.530
13.773
14.015
14.258
14.500
14.743
14.985
15.228
15.470
15.713
15.955
16.198
More
AVG
Count: 286
Mean: 13.11902
Stdev: 0.28192
Minimum: 12.56
Maximum: 16.44
Kurtosis: 69.75843
Skewness: 6.70467
Frequency
Cumulative %

Average Random Seek 2 Disk Roa-0 Histogram



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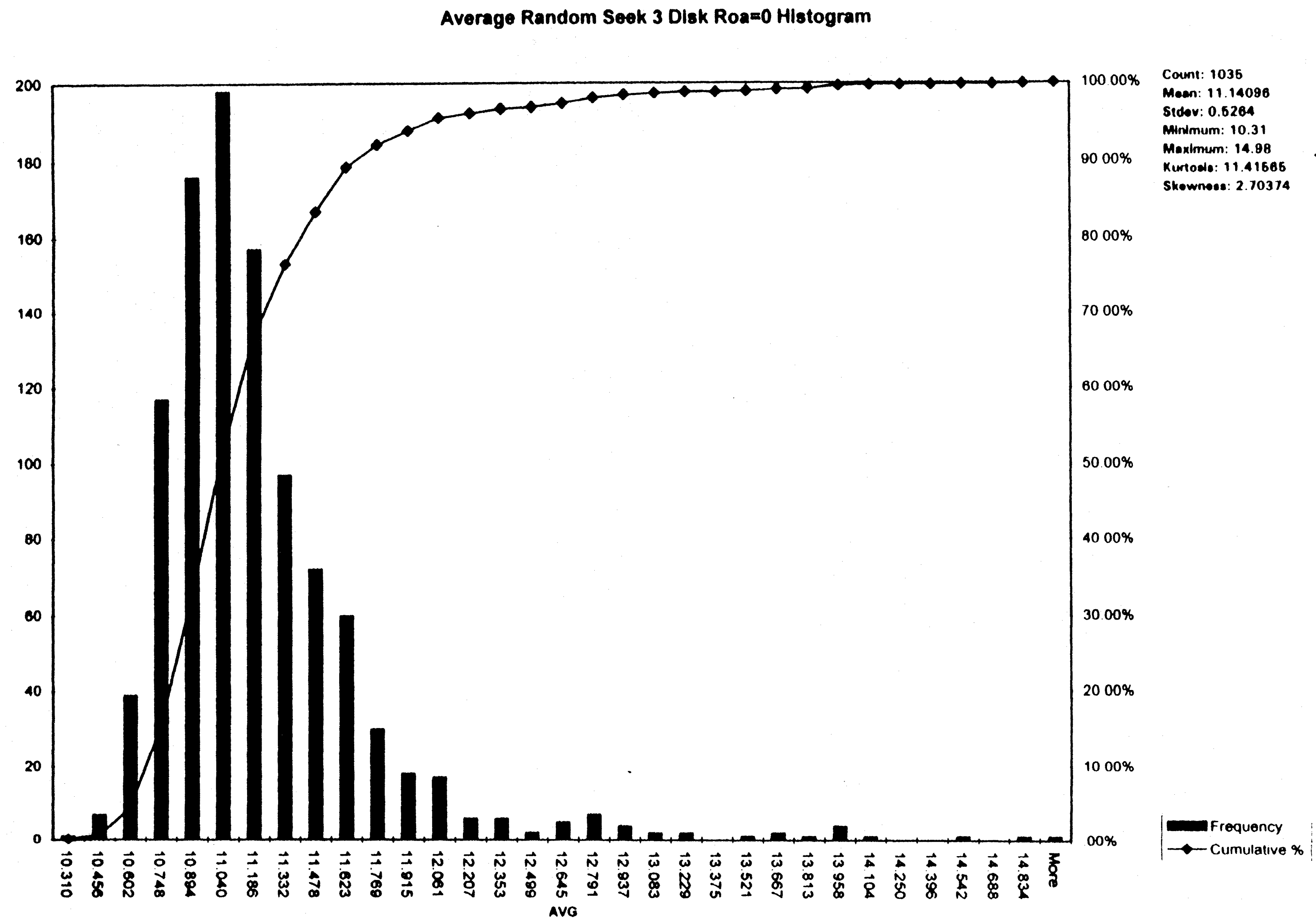


D.Nordin, x6214

FE TEMPEST TRAINING
MARCH 19, 1996

TEMPEST TRAINING AGENDA

- OVERVIEW
- BLOCK DIAGRAM
- DESIGN HIGHLIGHTS
- KEY COMPONENTS
- AKBAR FEATURES
- PCB TEST RESULTS
- PCB LAYOUT

.TEMPEST.

OVERVIEW

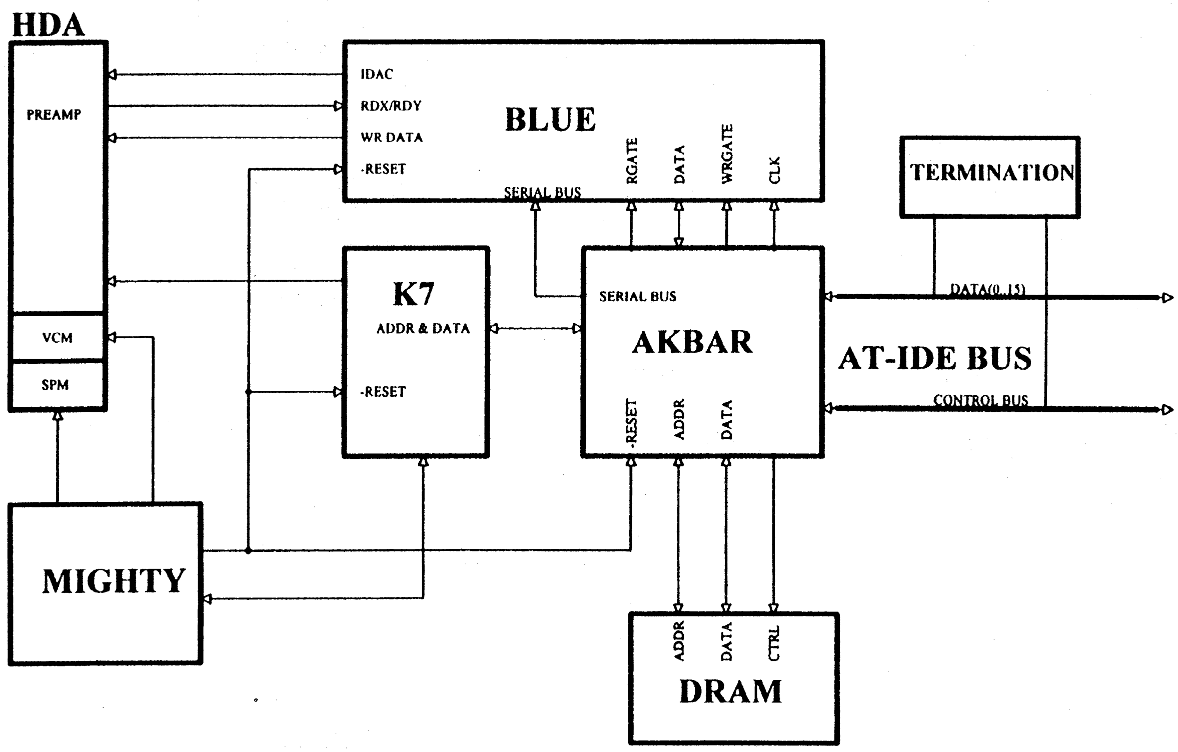
- The Tempest PCBA design follows a common Quantum electrical architecture. The implementation of this architecture is nearly identical to Sirocco. The major difference is the Akbar interface/controller IC in place of Raion.

- There are a couple of advantages for using Akbar.

  - The read channel bandwidth has been expanded from 85 Mb/s to 120 Mb/s. This allows us to take advantage of higher performance read channels and achieve higher bit densities (BPI) on each data track.

  - Akbar allows us to use ID-less formatting. This gives us a slight capacity increase (higher format efficiency) and the removal of ID fields makes it easier for us to accommodate MR head read and write geometries.

- We are entering the P3 phase of drive testing at MKE with our P3 AT PCBA. This board is based on the Akbar-A3 interface/controller IC, the Blue-3 and -3HD PRML read channel ICs and the Mighty-8D spindle motor/VCM controller IC.



TEMPEST AT BLOCK DIAGRAM

PCBA DESIGN HIGHLIGHTS

COMPONENTS

- The PCBA design is leveraged heavily from Sirocco and Fireball. There are five major ICs.

  - The K7 micro-controller is common to Sirocco and Fireball.

  - The Blue PRML read channel is common to Sirocco and derived from Shiva, which is used by Fireball.

  - The Mighty Spindle Motor/VCM IC is a die-shrunk version of the part used by Sirocco.

  - The DRAM is the same memory configuration (64Kx16) as Sirocco and Fireball. However, those products use 80ns parts while Akbar is designed to use 70ns DRAMs.

- The only significant Tempest architecture change from Sirocco is the use of the Akbar interface ASIC in place of Raion. Both Akbar and Raion are derived from Leo, which is used by Fireball.

  - Akbar implements ID-less formatting by replacing the SEQ block from Leo with the FMTR block. This results in greater track format efficiency, yielding a capacity increase of about 4%. It also provides for an easier accommodation of the read and write element offsets with MR head designs.

  - Akbar supports a higher read channel data rate.

  - An APLL has been added to control the Buffer clock.

  - The I/O cells for the IDE interface has been improved.

  - All other functional blocks are derived from Leo.

PCBA DESIGN HIGHLIGHTS

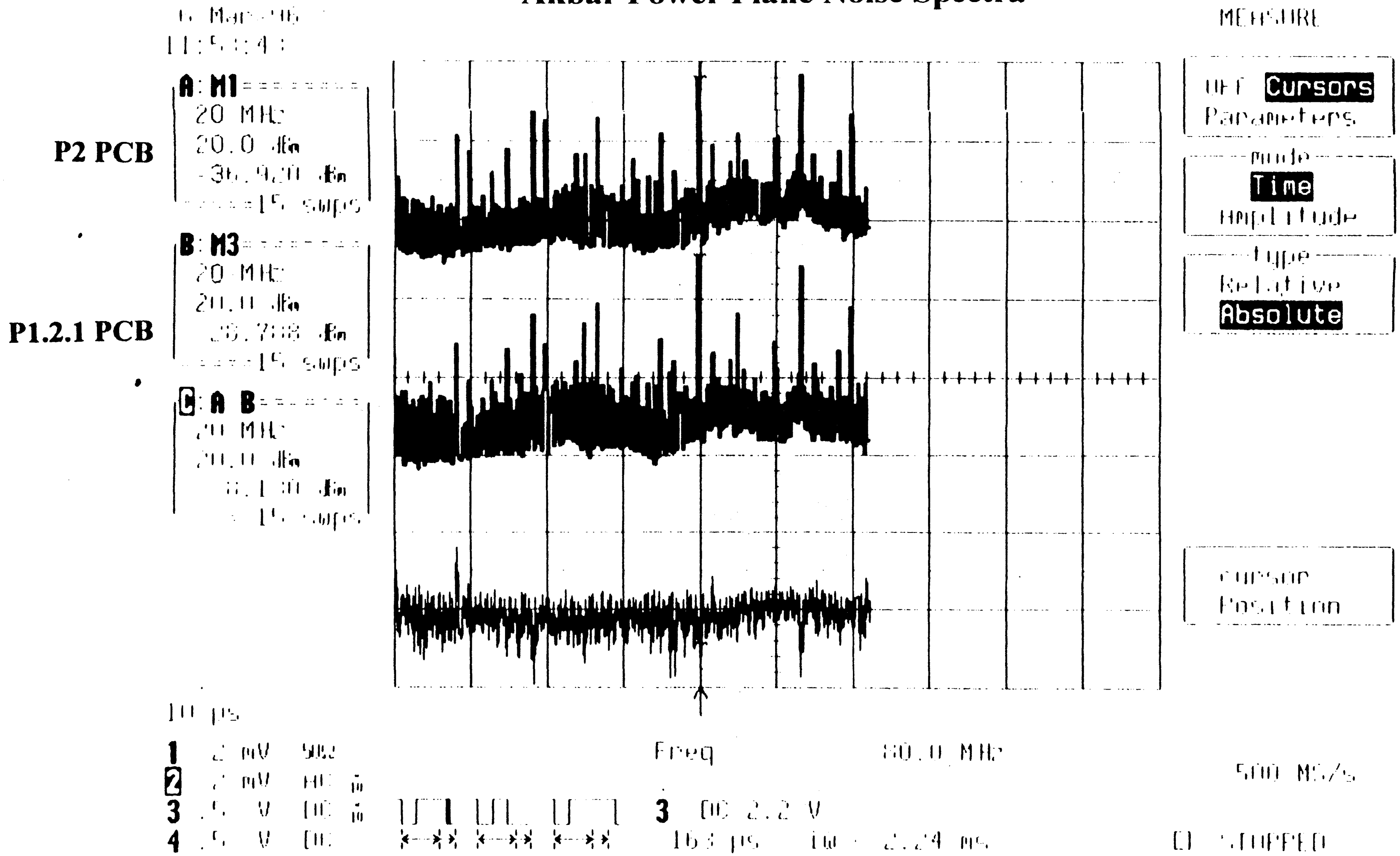
PCB NOISE REDUCTION

- An enlarged isolated power plane has been added around the Akbar . This helps to prevent interface noise from coupling into other sensitive components through the power plane.

- De-coupling capacitors have been chosen for the Akbar power plane to filter specific frequencies which have been prominent in the past.

- Dampening resistors or de-coupling capacitors have been added to some of the digital control lines from the Akbar and K7. This prevents noise from coupling into the read channel and pre-amplifier through the digital control signals.

Akbar Power Plane Noise Spectra



PCBA DESIGN HIGHLIGHTS

SCSI

- The SCSI PCBA will be leveraged heavily from the AT PCBA. The SCSI PCB layout has been derived from the AT PCB to minimize differences from the AT layout. This ensures common electrical functionality. The only significant differences are due to pinout changes with the Akbar-SCSI IC and the SCSI interface termination requirements.

- The interface design is targeted to support the SCSI-3 Fast-20 mode of operation (Ultra-SCSI). This will require the use of the Akbar-S3 interface IC.

PCBA DESIGN HIGHLIGHTS

.TEMPEST.

MISCELLANEOUS

- The footprint of the PCBA is narrower than that for Fireball and Sirocco to accommodate our 1-disk HDA.
- Both 1-disk and 2/3-disk HDA designs use hard pin spindle motor contacts (TrailBlazer-style). This is common with Sirocco.
- Tempest AVL is common to Sirocco for more than 90% of the parts.

KEY COMPONENTS

CURRENT STATUS

- **Akbar-AT**

  Based on Leo-AT (Fireball) with ID-less format and higher read channel bandwidth added.

  - P3 Build: 3/96 using Akbar-A3

  - Akbar-A3 was previously used in the P2 build

- **Blue**

  Based on Shiva (Fireball) with thermal asperity (TA) detection and MR bias current control added.

  - P3 Build: 3/96 using Blue-3 and -3HD

  - Blue-3HD is a smaller die-version of Blue-3. The advantage is higher production volumes and reduced cost.

  - Both Blue versions were previously used in the P2 build

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KEY COMPONENTS

- **Mighty**

  Tempest will use v8, which is a die-shrunk version of the v7 part used by Sirocco. Panasonic is expected to be a second source.

  - P3 Build: 3/96 using Mighty-8D

  - Mighty-8D was previously used in the P2 Build

- **Akbar-SCSI**

  Based on Leo-SCSI (Fireball) with Akbar-AT modifications and improvements.

  - P3 SCSI Build: 3/96 using Akbar-S3

  - Akbar-S3 will include a fix for a write problem observed only in Ultra-SCSI mode of operation and an improper data latch problem during the message out phase

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KEY COMPONENTS

TARGET AVL (APPROVED VENDOR LIST)

IC Description	Vendor
Interface ASIC, Akbar-A3	TI
Interface ASIC, Akbar-S3	TI
Microprocessor, K7	NEC
Read Channel, Blue-3 and -3HD	Lucent Tech (AT&T)
SPM/VCM Controller, Mighty-8	Phillips, Panasonic
DRAM, 70nS	Hitachi, Mitsubishi, NEC, OKI, Sanyo, TI, Toshiba
Preamp	TI

Additional component vendors are common with Sirocco.

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AKBAR-AT FEATURES

<<< Akbar = Leo + modifications >>>

Disk Formatter (FMTR)

- Replaces Leo's Sequencer (SEQ) block with the Formatter (FMTR) block to implement the ID-less format.
- ID-less format only (no sector headers).
- Supports 120 Mb/s transfer rate.
- Supports multiple read/write ASIC interfaces.
- Programmable parameters: sector size (up to 4KB), address mark time out, PLL length and extended write gate.
- Supports 3-segment split of sector data.

Servo Controller (TNA)

- Uses Leo's Servo Control (TNA) block.
- Supports target track ID comparison.

Buffer Controller (BFR)

- Uses Leo's Buffer Control (BFR) block with modifications.
- Supports DRAM with standard and extended data out modes of operation.
- Programmable DRAM timing and buffer allocation.

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AKBAR-AT FEATURES (CONTINUED)

Host Interface (AT/Beavis)

- Uses Leo's AT Interface block with 16.6 MB/s support.

ECC Block (Error Correction Control)

- ECC capability has been expanded from 3-way to 4-way interleave. Cross check bytes have also been expanded from 2 bytes to 4 bytes.

All Other Functional Blocks are Equivalent to Leo's

- Analog to Digital converter (ADC).
- Serial interface (SER).
- Microprocessor interface (uPI).
- Spindle Motor/VCM interface (MTR).

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PCB TEST RESULTS

IDE INTERFACE TESTING

- Passed PIO mode 4 testing with at least 18% timing margin on a 133 Mhz system. Drive level ATA termination helped to minimize distortion and ringing on the IDE interface.

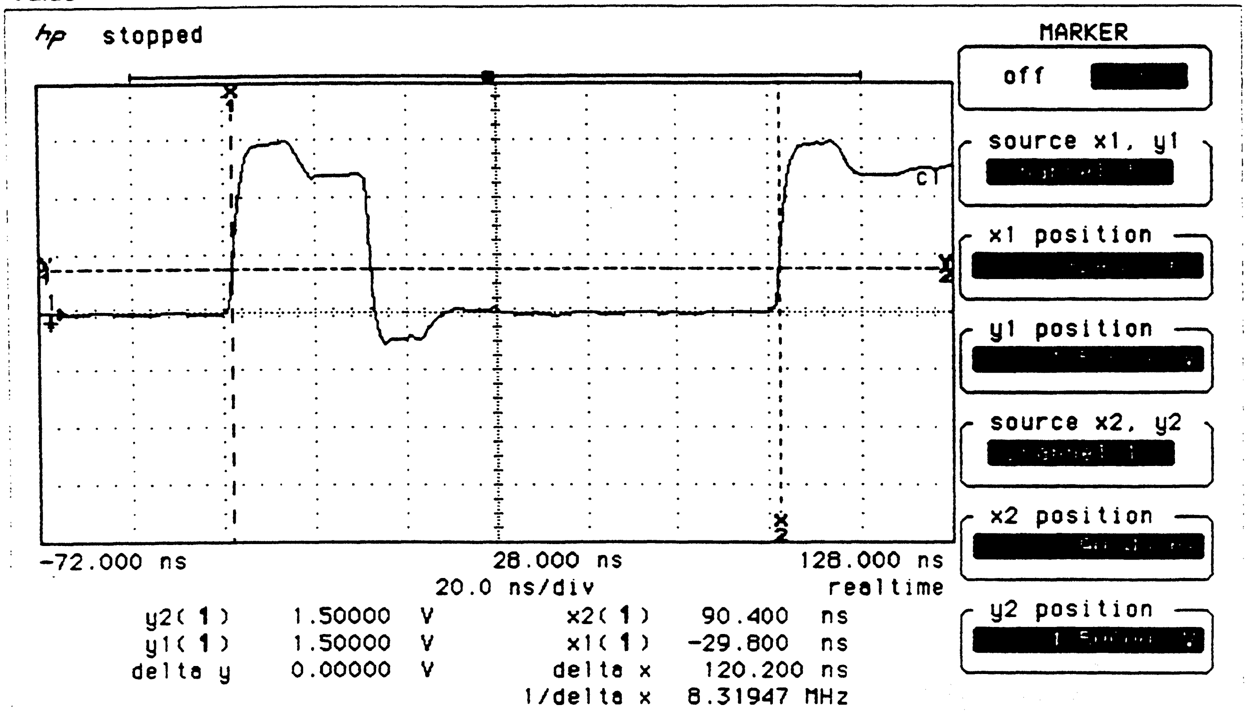
- Passed DMA mode 2 testing with at least 22% timing margin on a 133 Mhz system.

PCB TEST RESULTS (CONTINUED)

EMI TESTING

- System level radiated and conducted noise are well within FCC class B specifications.
- The drive can withstand a radiated electrical field of 8 V/m at all frequencies from 10 Khz to 1 Ghz without customer mode errors. This is twice the specification.
- The drive can withstand a radiated magnetic field of 12 Gauss at all frequencies from 30 hz to 1 Ghz without customer mode errors. This is also twice the specification.

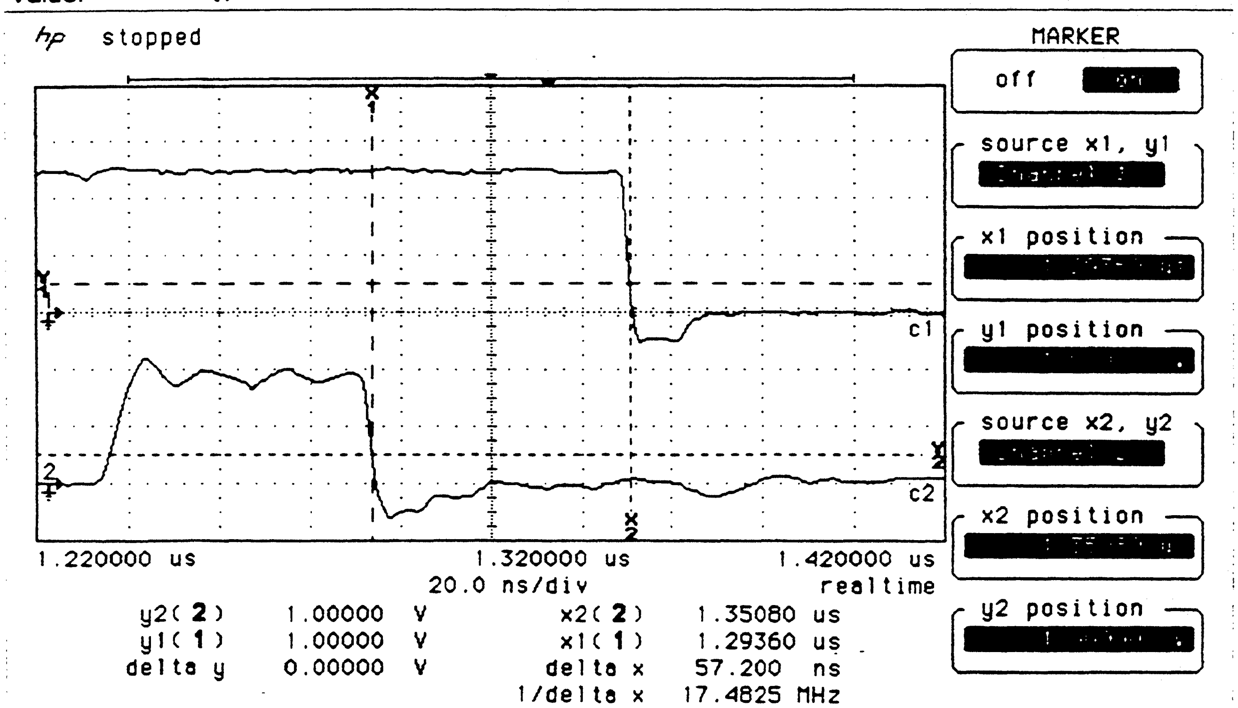
Value: t0



Top Trace: DIOR-

Bottom Trace:

Value: t1



Top Trace: DIOR-

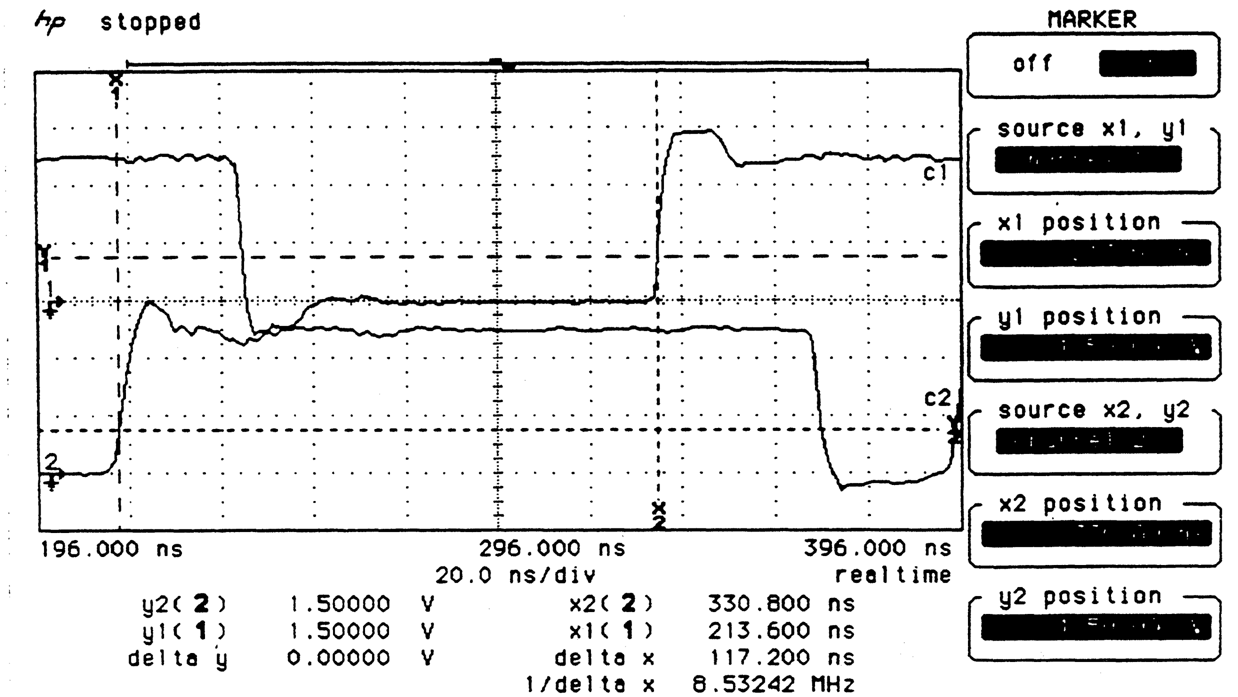
Bottom Trace: CS1-

PIO Timing Measurement

Test Platform:	PENTIUM 133MHz
Chip set / Bridge chip:	TRITON
Quantum product (s/n):	TEMPEST P1 381577791102
ASIC:	AKBAR A3
Transfer Mode	PIO mode 4

	Timing Parameters		**measured**	**min**	**max**	**margin**	**margin**
	Discription	**value**	**(ns)**	**(ns)**	**(ns)**	**(ns)**	**(%)**
1	Cycle time	**t0**	120.2	120			
2	Address valid to DIOR-/DIOW- setup	**t1**	57.2	25		32.2	56
3	DIOR-/DIOW- Pulse width	**t2**	89.6	70		19.6	22
4	DIOR-/DIOW- recovery time	**t2i**	30.4	25		5.4	18
5	DIOW- data setup	**t3**	117.2	20		97.2	83
6	DIOW- data hold	**t4**	35.6	10		25.6	72
7	DIOR- data setup	**t5**	73	20		53	73
8	DIOR- data hold	**t6**	45.6	5		40.6	89
9	DIOR- data tristate	**t6z**	18.5		30	11.5	38
10	Addr valid to IOCS16- assertion	**t7**			n/a		
11	Addr valid to IOCS16- released	**t8**			n/a		
12	DIOR-/DIOW- to address valid hold	**t9**	848	10		838	99
13	Read data valid to IODRY active	**tRd**		0		0	
14	IORDY setup time	**tA**					
15	IORDY pulse width	**tB**			1250	1250	

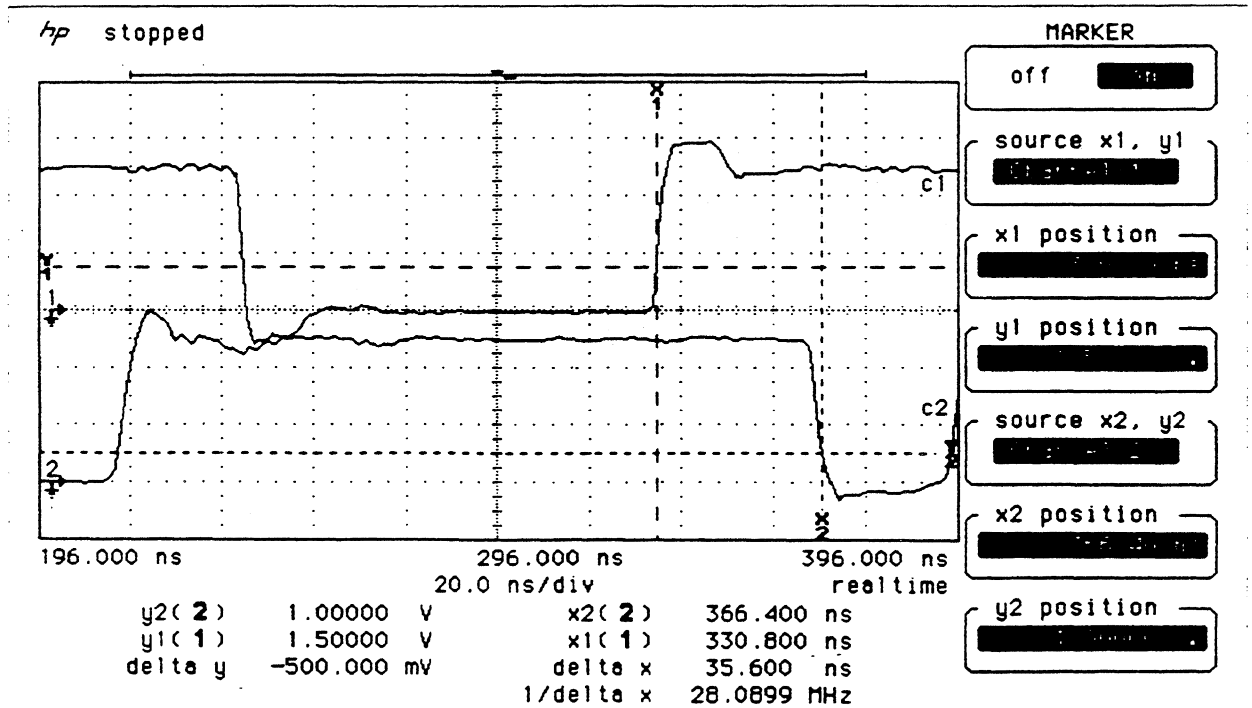
Value: t3



Top Trace: DIOW-

Bottom Trace: DD4

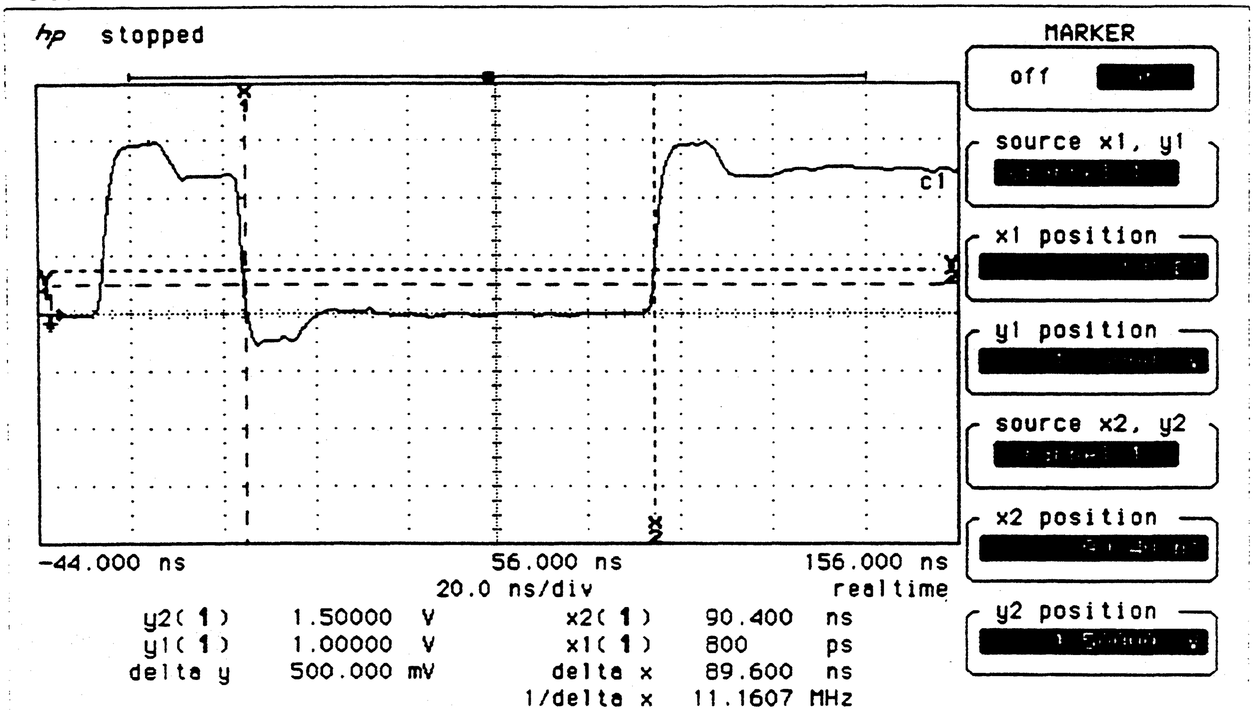
Value: t4



Top Trace: DIOW-

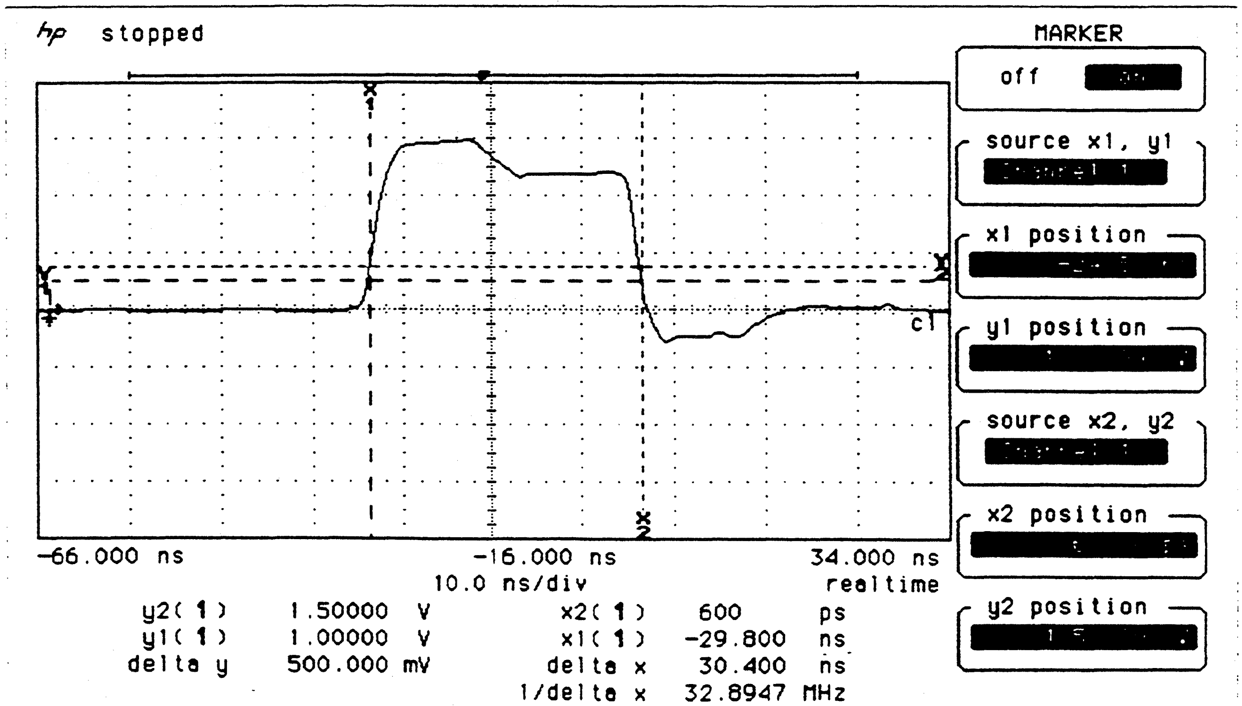
Bottom Trace: DD4

Value: t2



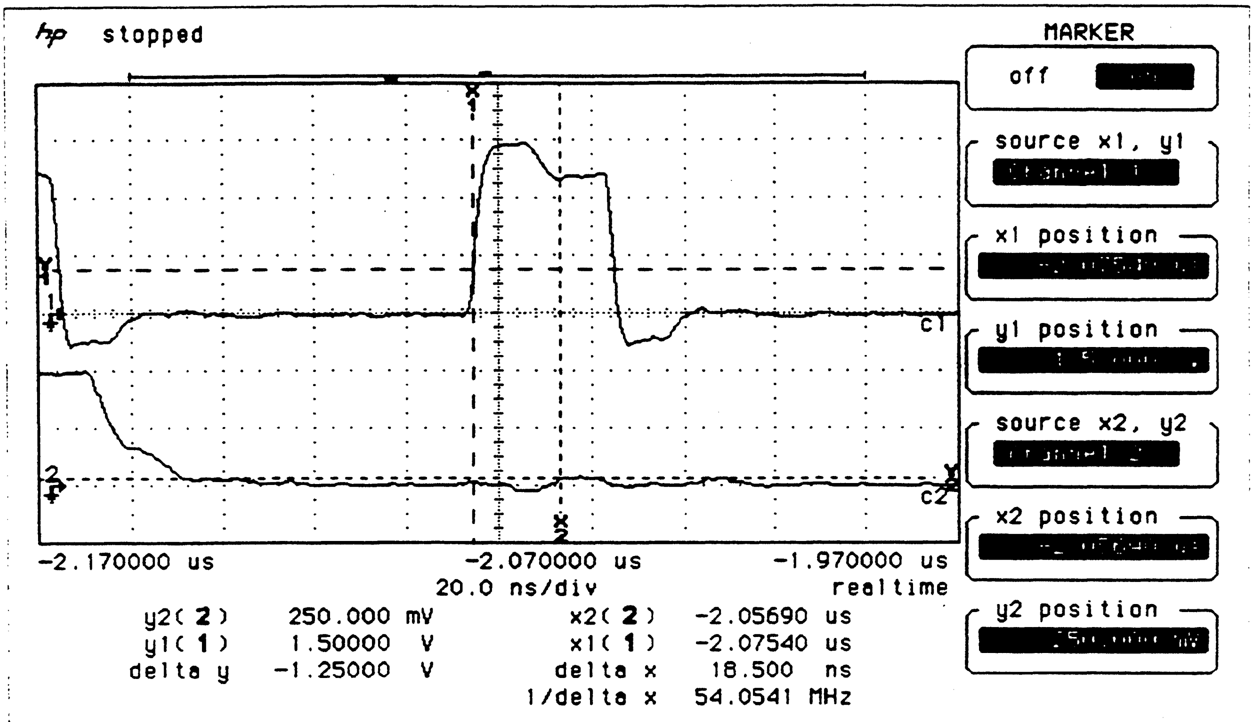
Top Trace: DIOR-
Bottom Trace: CS1-

Value: t2i



Top Trace: DIOR-
Bottom Trace: CS1-

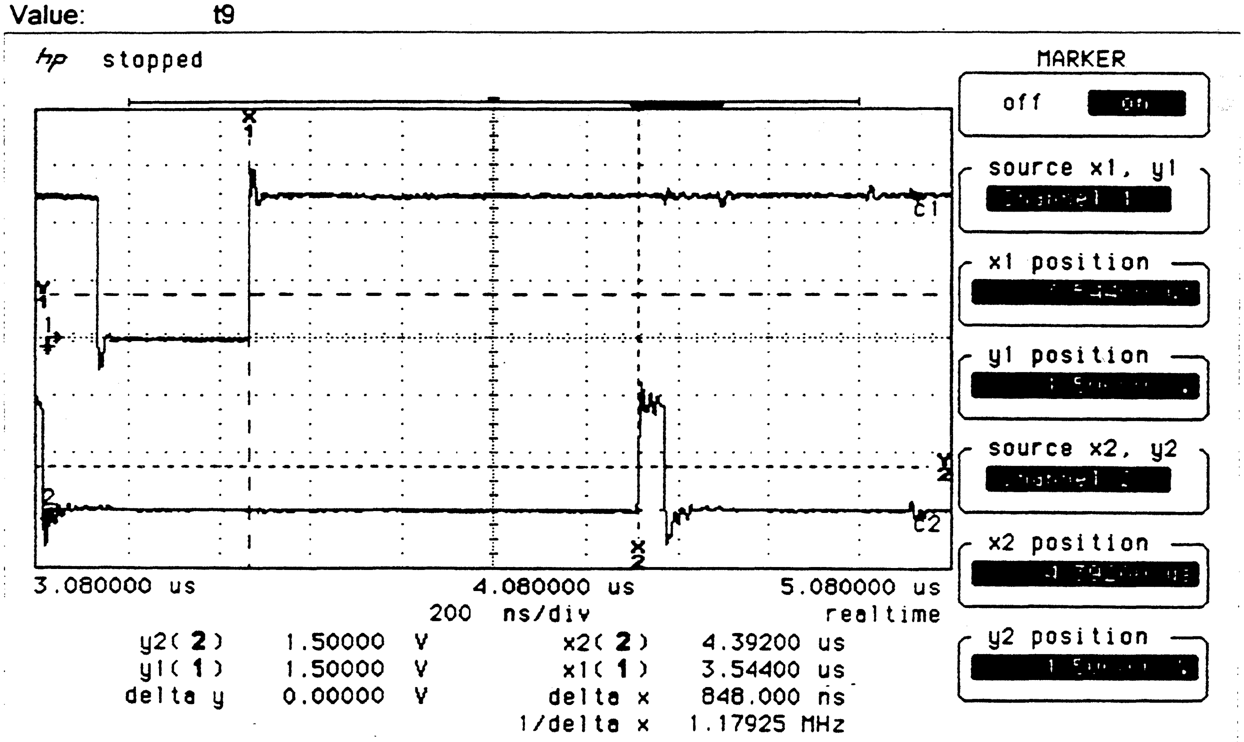
Value: t6z



Top Trace: DIOR-

Bottom Trace: DD4

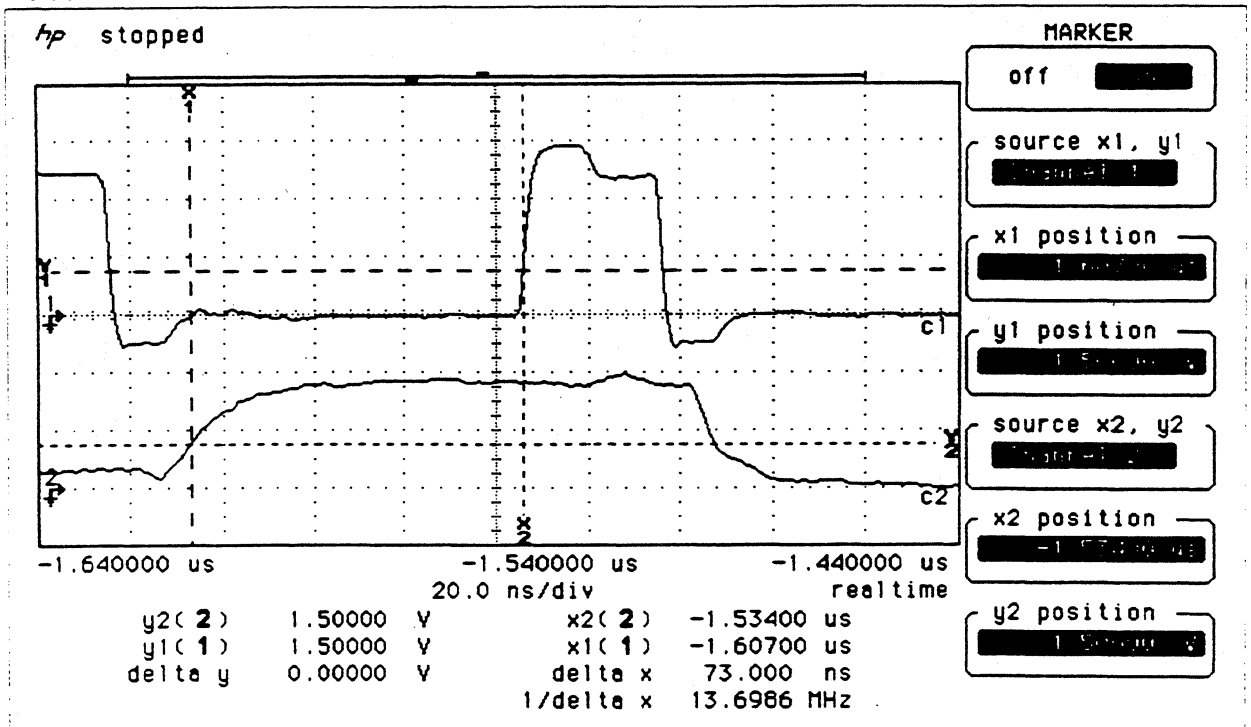
Value: t9



Top Trace: DIOR-

Bottom Trace: CS1-

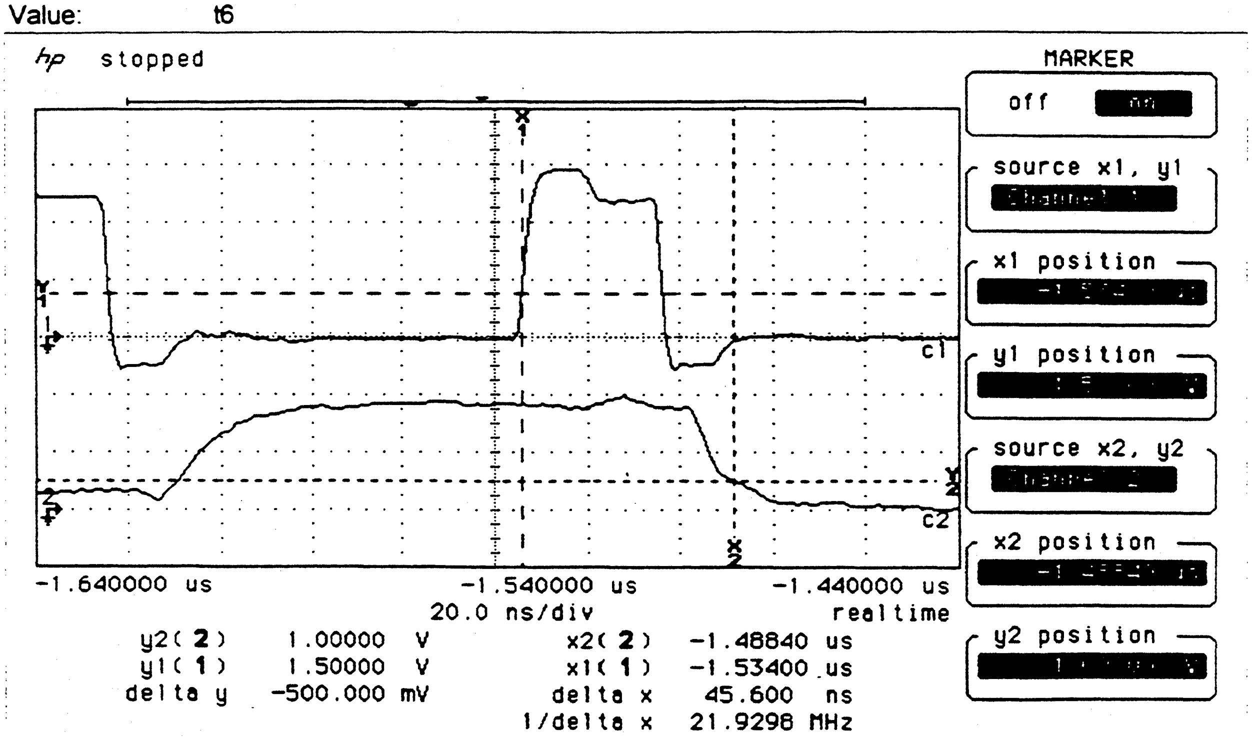
Value: t5



Top Trace: DIOR-

Bottom Trace: DD4

Value: t6



Top Trace: DIOR-

Bottom Trace: DD4

DATE: 12/20/95

PERFORMED FOR: QUANTUM
TEST SPECIMEN: TEMPEST HDD

MODEL NO: TEMPEST 1080A
SERIAL NO: 381577794216

115 VAC RETURN LINE

150 KHz to 500 KHz			
The Largest Signal is:	0.150	MHz	34.9 dBuV
Spec at this frequency is:			66.0 dBuV
The next largest signal is:	0.150	MHz	34.9 dBuV
Spec at This Frequency is:			66.0 dBuV
			PASSED
500 kHz to 5.0 MHz			
The Largest Signal is:	0.671	MHz	40.5 dBuV
Spec at This Frequency is:			56.0 dBuV
The next largest signal is:	0.671	MHz	40.5 dBuV
Spec at This Frequency is:			56.0 dBuV
			PASSED
5.0 MHz to 30 MHz			
The Largest Signal is:	9.070	MHz	44.2 dBuV
Spec at This Frequency is:			60.0 dBuV
The next largest signal is:	9.070	MHz	44.2 dBuV
Spec at This Frequency is:			60.0 dBuV
			PASSED

COMMENTS:

VERIFIED BY [signature] ____________________

____

DMA Timing Measurement

Test Platform:	PENTIUM 133 MHZ
Chip set / Bridge chip:	TRITON
Quantum product (s/n):	TEMPEST P1 SN#381577791102
ASIC:	ARBAK A3
Transfer Mode	DMA mode between 0 and 1

Timing Parameters

	Description	value	measured	min	max	Mode 2 margin	margin (%)
1	Cycle time	t0	120.4	120			
2	DIOR-/DIOW- active time	tD	89.6	70		19.6	22
3	DIOR- data access	tE	17.6				
4	DIOR- data hold	tF	49.2	5		44.2	90
5	DIOR- data setup	tGr	72	20	n/a		72
6	DIOW- date setup	tGw	85.2	20		65.2	77
7	DIOW- date hold	tH	33.6	10		23.6	70
8	DMACK- to DIOR-/DIOW- setup	tI	29.8	0		29.8	
9	DIOR-/DIOW- to DMACK- hold	tJ	30	5		25	83
10	DIOR- negated pulse width	tKr	30.6	25		5.6	18
11	DIOW- negated pulse width	tKw	30.5	25		5.5	18
12	DIOR- to DMARQ delay	tLr	19		35	16	46
13	DIOW- to DMARQ delay	tLw	18.2		25	6.8	27
14	DMACK- to tristate	tZ	13		25	12	48

DATE: 12/20/95
FILE:

PERFORMED FOR: QUANTUM
TEST SPECIMEN: TEMPEST DRIVE

MODEL NUMBER: TEMPEST 1080A
SERIAL NUMBER: 381577794216

LOCATION: HORIZ POL

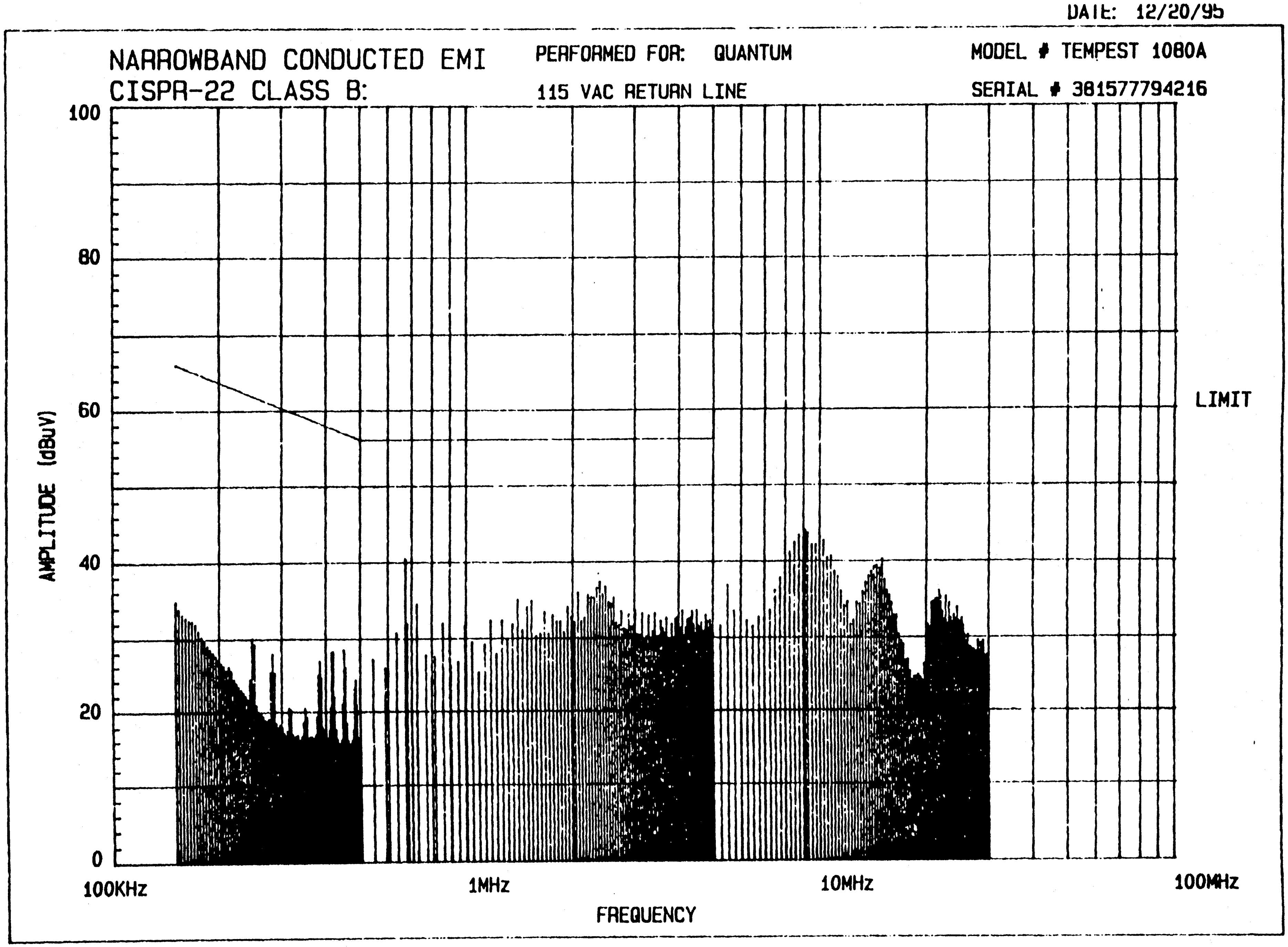
FINAL CISPR 22-B RADIATED RESULTS:

Freq MHz	Analyzer Reading dBuV	CF dB	Correct Reading dBuV/m	Spec Limit dBuV/m	margin dB	Ht cm	Angle Deg
79.89	31.0	-16.5	14.52	30.00	15.48	150	360
120.03	26.7	-11.6	15.09	30.00	14.91	150	356
159.95	23.7	-12.6	11.14	30.00	18.86	150	360

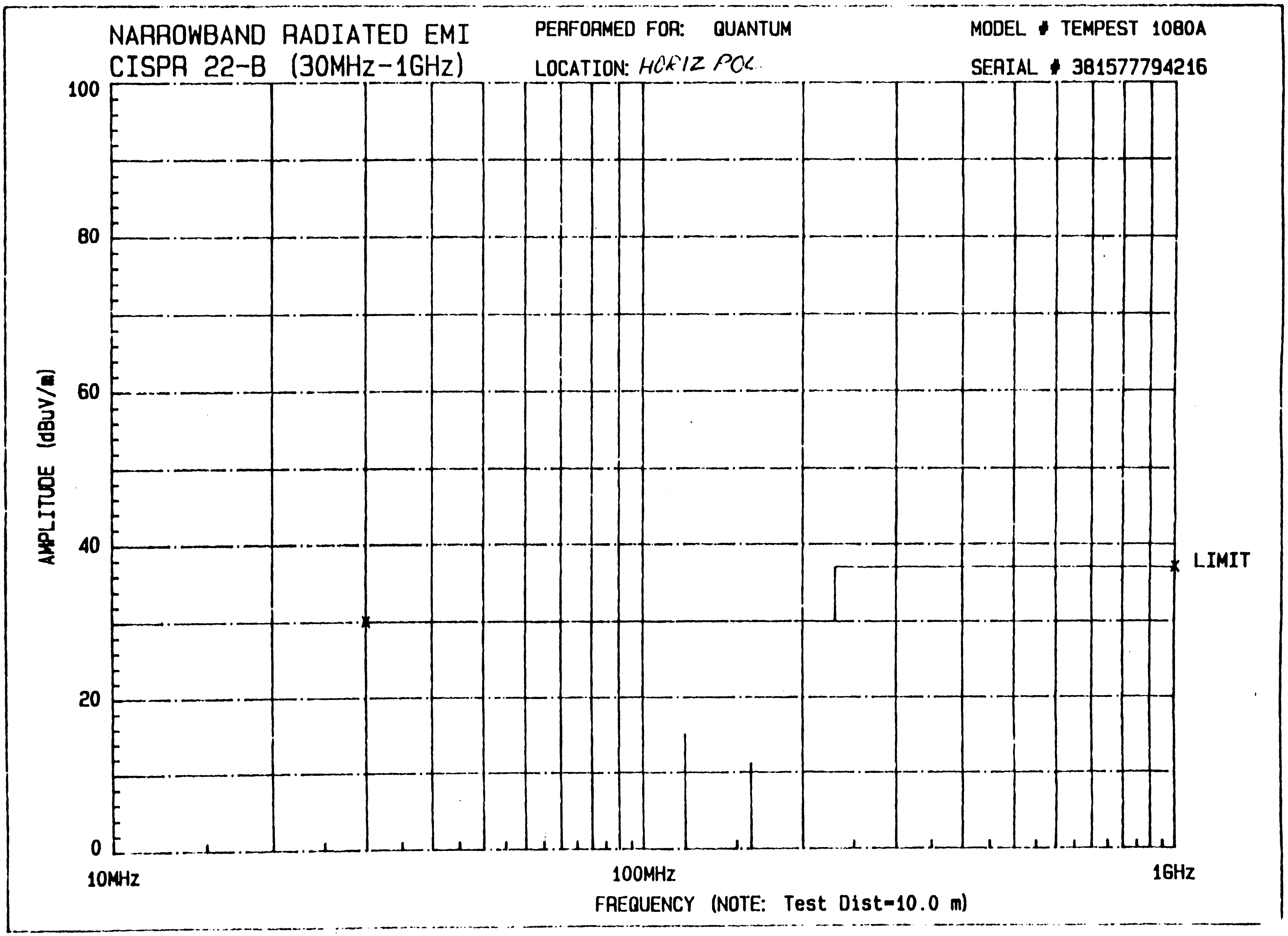
NONE OUT OF SPECIFICATION

COMMENTS: Test Dist = 10.0 m. QP Detector ON.
SAMPLE CALCULATION:
At 159.95 MHz
Analyzer Reading = 23.70 dBuV
Correction Factor,CF,= AF 11.24 dB + Cable 3.20 dB
-Preamp Gain 27.00 dB =-12.56 dB
CORRECTED READING = 11.14 dBuV/m

VERIFIED BY ____________________


DATE: 12/20/95
NARROWBAND CONDUCTED EMI
CISPR-22 CLASS B:
PERFORMED FOR: QUANTUM
115 VAC RETURN LINE
MODEL # TEMPEST 1080A
SERIAL # 381577794216
100
80
60
40
20
0
AMPLITUDE (dBuV)
LIMIT
100KHz
1MHz
10MHz
100MHz
FREQUENCY

DATE: 12/20/95


NARROWBAND RADIATED EMI
CISPR 22-B (30MHz-1GHz)
PERFORMED FOR: QUANTUM
LOCATION: HORIZ POL
MODEL # TEMPEST 1080A
SERIAL # 381577794216
100
80
60
40
20
0
AMPLITUDE (dBuV/m)
LIMIT
10MHz
100MHz
1GHz
FREQUENCY (NOTE: Test Dist=10.0 m)

DATE: 12/20/95
FILE:

PERFORMED FOR: QUANTUM
TEST SPECIMEN: TEMPEST DRIVE

MODEL NUMBER: TEMPEST 1080A
SERIAL NUMBER: 381577794216

LOCATION: VERT POL

FINAL CISPR 22-B RADIATED RESULTS:

Freq MHz	Analyzer Reading dBuV	CF dB	Correct Reading dBuV/m	Spec Limit dBuV/m	margin dB	Ht cm	Angle Deg
80.00	38.8	-16.4	22.35	30.00	7.65	150	289
120.05	32.8	-11.6	21.19	30.00	8.81	150	356
160.06	24.9	-13.4	11.51	30.00	18.49	150	360

NONE OUT OF SPECIFICATION

COMMENTS: Test Dist = 10.0 m. QP Detector ON.
SAMPLE CALCULATION:
At 160.06 MHz
Analyzer Reading = 24.90 dBuV
Correction Factor,CF,= AF 10.41 dB + Cable 3.20 dB
-Preamp Gain 27.00 dB =-13.39 dB
CORRECTED READING = 11.51 dBuV/m

VERIFIED BY [signature]

DATE: 12/20/95

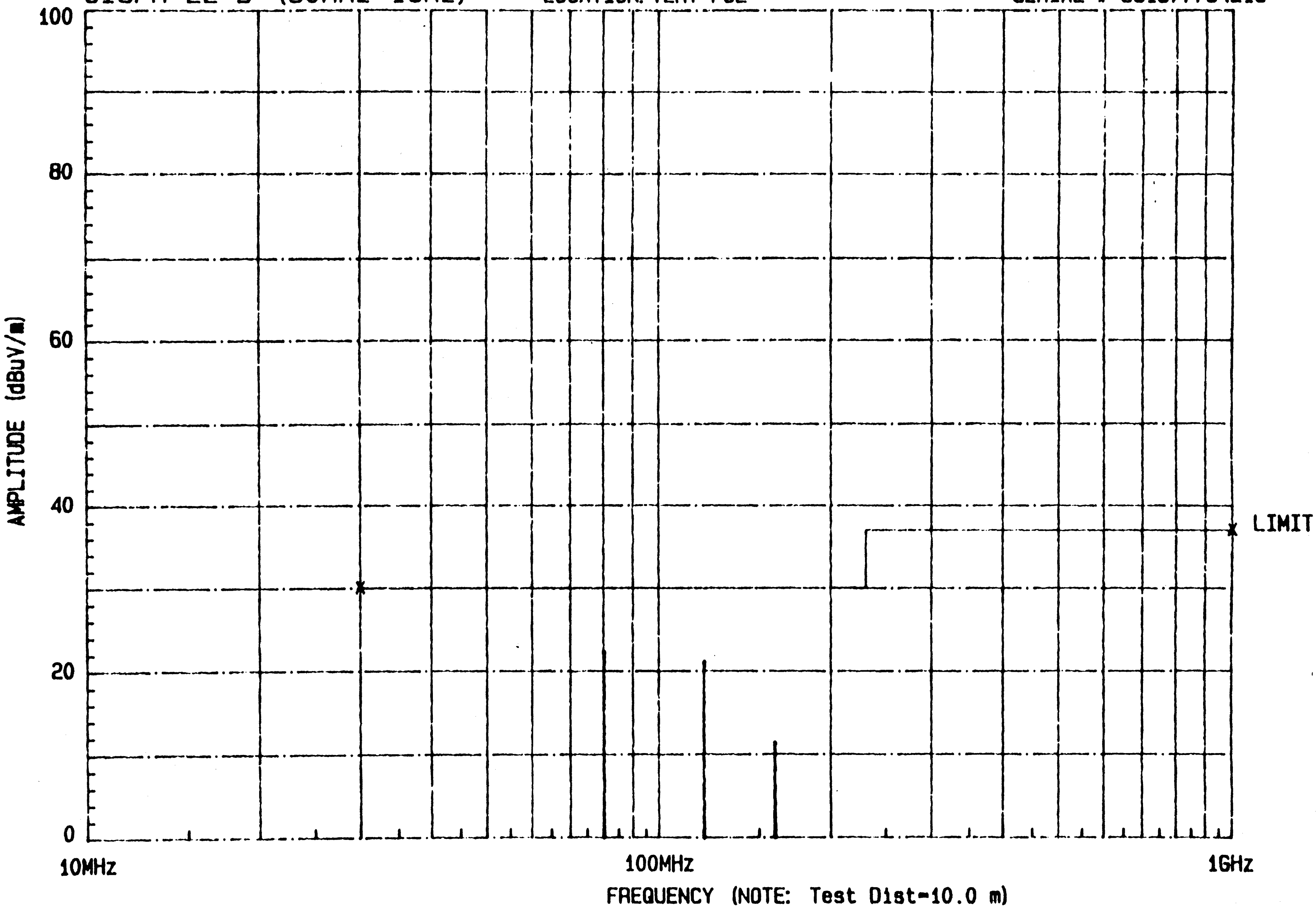
NARROWBAND RADIATED EMI
CISPR 22-B (30MHz-1GHz)

PERFORMED FOR: QUANTUM

LOCATION: VERT POL

MODEL # TEMPEST 1080A

SERIAL # 381577794216



DATE: 01 FEBRUARY 1996
FILE:

PERFORMED FOR: QUANTUM
TEST SPECIMEN: HARD DISK DRIVE

MODEL NO: TEMPEST 1080A
SERIAL NO: 381577751304

ELECTRIC FIELD

RADIATED SUSCEPTIBILITY RESULTS:

FREQUENCY RANGE	RADIATED LEVEL	LIMIT	
10KHz to 20KHz	> 8.0 V/m	8.0 V/m	PASSED
20KHz to 40KHz	> 8.0 V/m	8.0 V/m	PASSED
40KHz to 80KHz	> 8.0 V/m	8.0 V/m	PASSED
80KHz to 150KHz	> 8.0 V/m	8.0 V/m	PASSED
150KHz to 300KHz	> 8.0 V/m	8.0 V/m	PASSED
300KHz to 600KHz	> 8.0 V/m	8.0 V/m	PASSED
600KHz to 1.2MHz	> 8.0 V/m	8.0 V/m	PASSED
1.2MHz to 2.5MHz	> 8.0 V/m	8.0 V/m	PASSED
2.5MHz to 5.0MHz	> 8.0 V/m	8.0 V/m	PASSED
5.0MHz to 10.0MHz	> 8.0 V/m	8.0 V/m	PASSED
10.0MHz to 20.0MHz	> 8.0 V/m	8.0 V/m	PASSED
20.0MHz to 40.0MHz	> 8.0 V/m	8.0 V/m	PASSED
40.0MHz to 60.0MHz	> 8.0 V/m	8.0 V/m	PASSED
60.0MHz to 80.0MHz	> 8.0 V/m	8.0 V/m	PASSED
80.0MHz to 100.0MHz	> 8.0 V/m	8.0 V/m	PASSED
100.0MHz to 200.0MHz	> 8.0 V/m	8.0 V/m	PASSED
200.0MHz to 400.0MHz	> 8.0 V/m	8.0 V/m	PASSED
400.0MHz to 600.0MHz	> 8.0 V/m	8.0 V/m	PASSED
600.0MHz to 800.0MHz	> 8.0 V/m	8.0 V/m	PASSED
800.0MHz to 1.0GHz	> 8.0 V/m	8.0 V/m	PASSED

VERIFIED BY Jim Gallard

DATE: 5 FEBRUARY 1996
FILE:

PERFORMED FOR: QUANTUM CORPORATION
TEST SPECIMEN: HARD DISK DRIVE

MODEL NO: TEMPEST 1080A
SERIAL NO: 381577751304

MAGNETIC SUSCEPTIILITY TEST:

FREQUENCY RANGE	MAGNETIC FIELD	LIMIT	
30 - 100 Hertz	>12.0 Gauss	12.0 Gauss	PASSED
100- 500 Hertz	>12.0 Gauss	12.0 Gauss	PASSED
500-1000 Hertz	>12.0 Gauss	12.0 Gauss	PASSED
1000-5000 Hertz	>12.0 Gauss	12.0 Gauss	PASSED
5000-10000 Hertz	>12.0 Gauss	12.0 Gauss	PASSED
10000-50000 Hertz	>12.0 Gauss	12.0 Gauss	PASSED
50000-100000 Hertz	>12.0 Gauss	12.0 Gauss	PASSED
100000-500000 Hertz	>12.0 Gauss	12.0 Gauss	PASSED
500000-1000000 Hertz	>12.0 Gauss	12.0 Gauss	PASSED
100000-3000000 Hertz	>6.0 Gauss	6.0 Gauss	PASSED

COMMENTS:

VERIFIED BY

TEMPEST P3 AT FINAL

80-111402-01

MIGHTY REV 8D
AKBAR AT 3
BLUE 3

PAGE 1

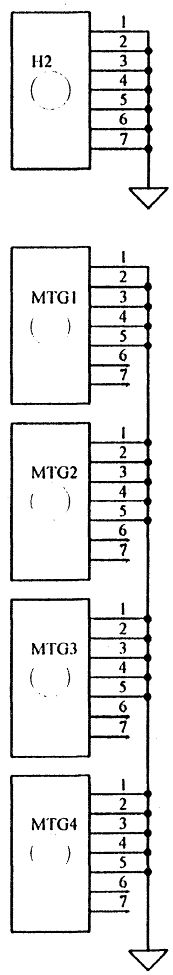
\AT1.SCH

PAGE2

\AT2.SCH

PAGE 3

\AT3.SCH

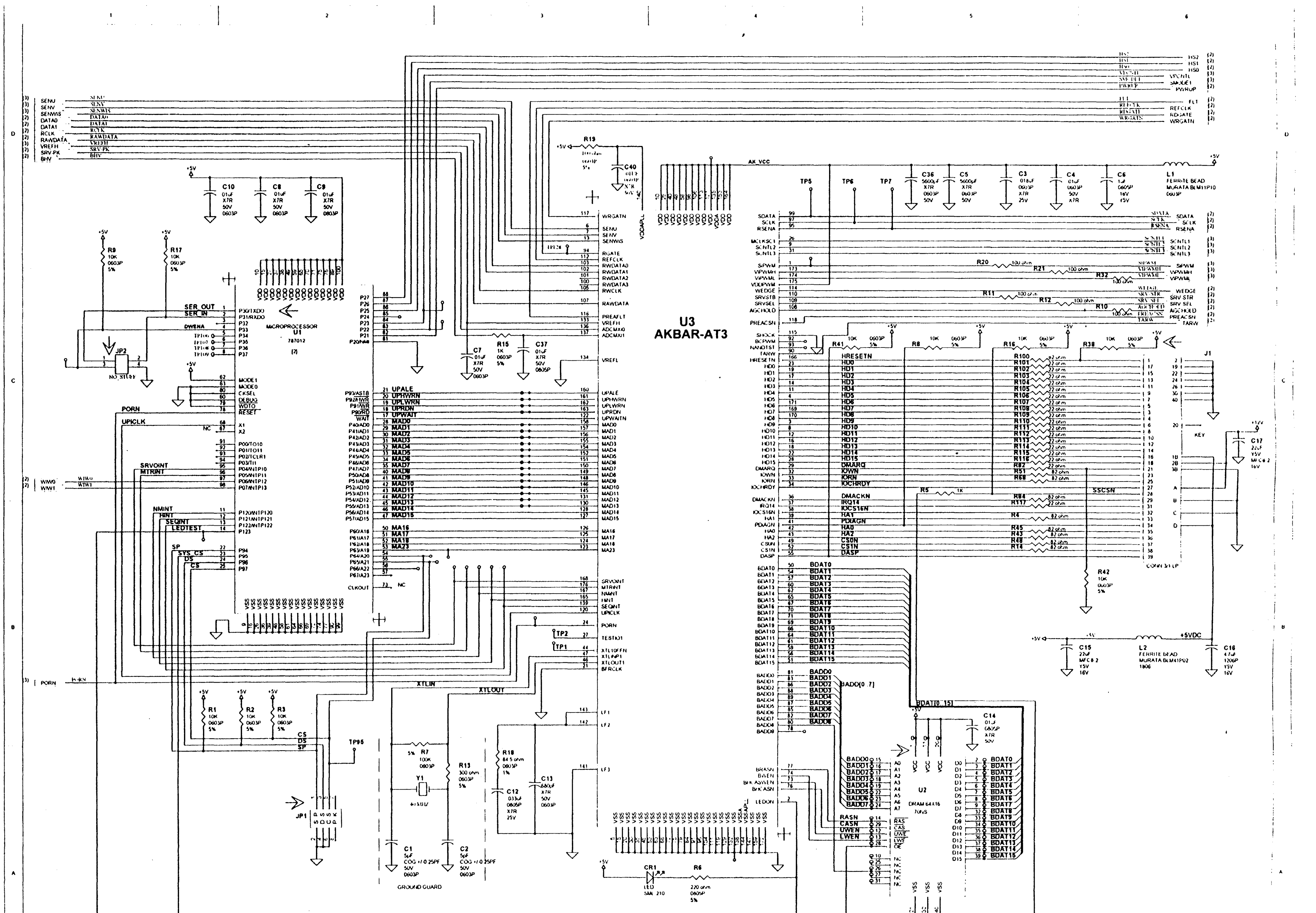


AT-P3

FUD2
NEAR POWER PINS

FUD4
NEAR R/W CONNECTOR

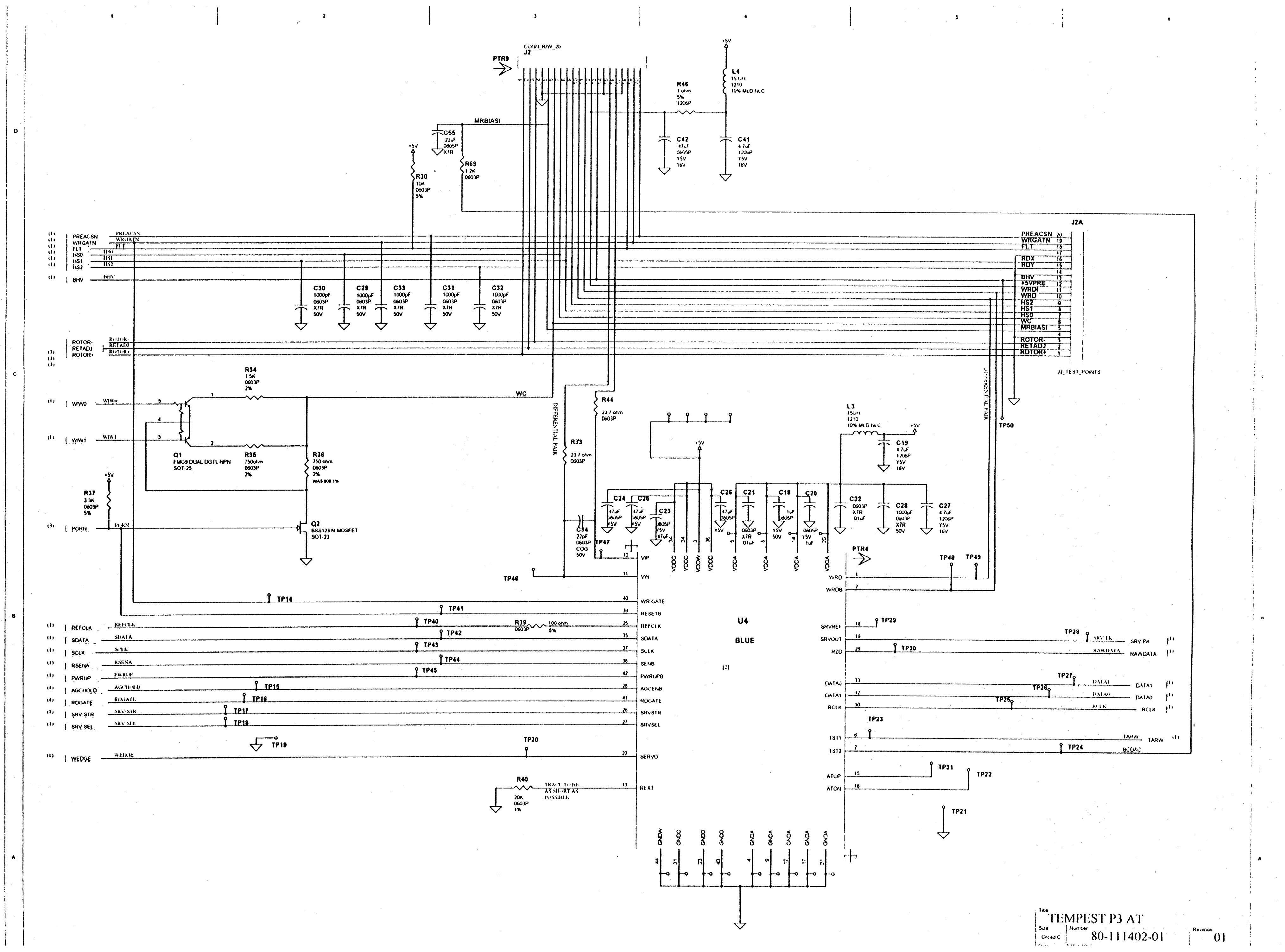
Title: TEMPEST P3 AT		
Size: Orcad A	Number: 80-111402-01	Revision: 01
Date: 7-Mar-1996		Sheet 0 of 3



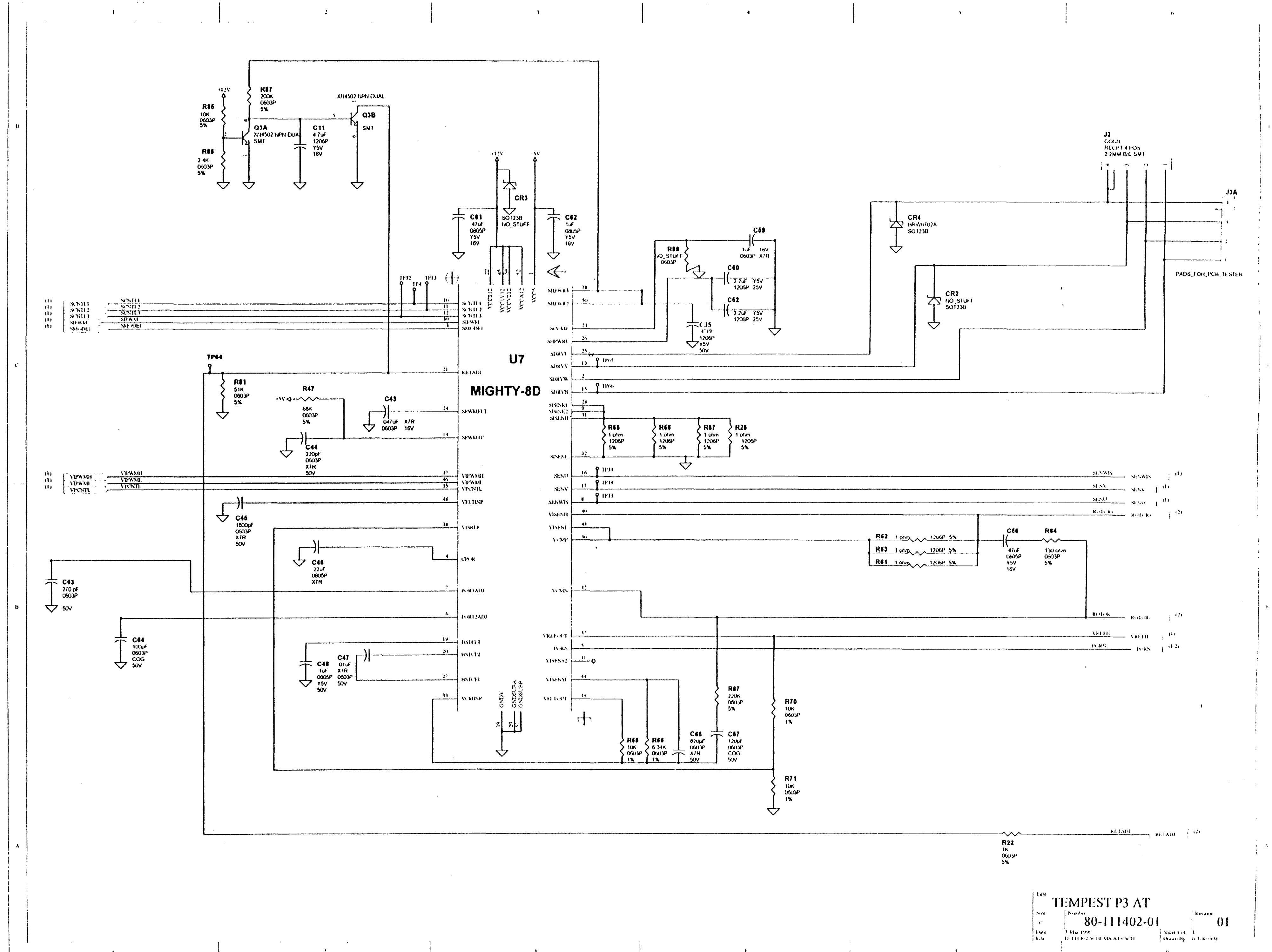
TEMPEST P3 AT

Number: 80-111402-01

Revision: 01

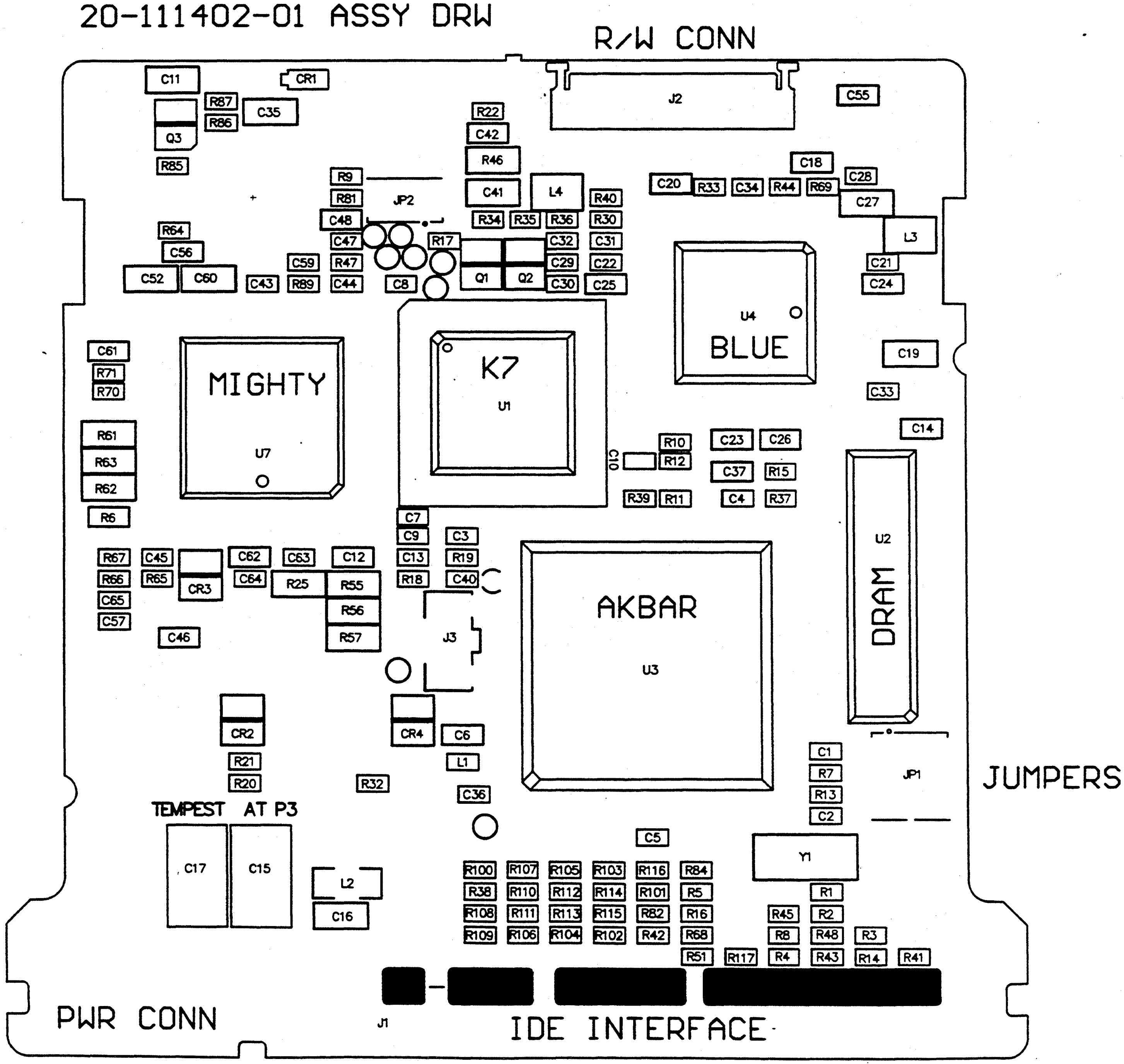


CONN_R/W_20
J2
PTR9
+5V
L4
15 uH
1210
10% MLD NLC
R46
1 ohm
5%
1206P
MRBIASI
C55
22uF
0603P
X7R
C42
47uF
0605P
Y5V
16V
C41
4.7uF
1206P
Y5V
16V
R30
10K
0603P
5%
R69
1.2K
0603P
PREACSN
WRGATN
FLT
HS0
HS1
HS2
BHV
C30
C29
C33
C31
C32
1000pF
0603P
X7R
50V
J2A
PREACSN
WRGATN
FLT
RDX
RDY
BHV
+5VPRE
WRDI
WRD
HS2
HS1
HS0
WC
MRBIASI
ROTOR-
RETADJ
ROTOR+
J2_TEST_POINTS
ROTOR-
RETADJ
ROTOR+
R34
1.5K
0603P
2%
WC
WIW0
WIW1
Q1
FMG9 DUAL DGTL NPN
SOT-25
R35
750ohm
0603P
2%
R36
750 ohm
0603P
2%
WAS 909 1%
R37
3.3K
0603P
5%
PORN
Q2
BSS123 N MOSFET
SOT-23
DIFFERENTIAL PAIR
R44
23.7 ohm
0603P
R33
23.7 ohm
0603P
DIFFERENTIAL PAIR
TP50
L3
15uH
1210
10% MLD NLC
C19
4.7uF
1206P
Y5V
16V
C24
C25
C23
C26
C21
C18
C20
C22
C28
C27
C34
22pF
0603P
COG
50V
TP47
TP46
VIP
VIN
VDDO
VDDA
PTR4
TP48
TP49
WRD
WRDB
U4
BLUE
WR GATE
RESETB
REFCLK
SDATA
SCLK
SENB
PWRUPB
AGCENB
RDGATE
SRVSTR
SRVSEL
SERVO
REXT
TP14
TP41
TP40
TP42
TP43
TP44
TP45
TP15
TP16
TP17
TP18
TP19
TP20
R39
100 ohm
0603P
5%
REFCLK
SDATA
SCLK
RSENA
PWRUP
AGCHOLD
RDGATE
SRV-STR
SRV-SEL
WEDGE
R40
20K
0603P
1%
TRACE TO BE AS SHORT AS POSSIBLE
SRVREF
SRVOUT
RZO
DATA0
DATA1
RCLK
TST1
TST2
ATOP
ATON
TP29
TP28
TP30
TP27
TP26
TP25
TP23
TP24
TP31
TP22
TP21
SRV-PK
RAWDATA
DATA1
DATA0
RCLK
TARW
BCDAC
GNDW
GNDD
GNDA
TEMPEST P3 AT
80-111402-01
Revision 01


U7
MIGHTY-8D
Q3A
XN4502 NPN DUAL
SMT
Q3B
XN4502 NPN DUAL
R87
200K
0603P
5%
R85
10K
0603P
5%
R86
2.4K
0603P
5%
C11
4.7uF
1206P
Y5V
16V
CR3
SOT23B
NO_STUFF
C61
47uF
0805P
Y5V
16V
C62
1uF
0805P
Y5V
16V
J3
RECPT 4 POS
2.2MM B/E SMT
J3A
PADS_FOR_PCB_TESTER
CR4
SOT23B
C59
1uF
16V
0603P
X7R
R88
NO_STUFF
0603P
C60
2.2uF
Y5V
1206P
25V
C52
2.2uF
Y5V
1206P
25V
C35
1206P
Y5V
50V
CR2
NO_STUFF
SOT23B
TP64
R81
51K
0603P
5%
R47
68K
0603P
5%
C43
.047uF
X7R
0603P
16V
C44
220pF
0603P
X7R
50V
C45
1800pF
0603P
X7R
50V
C46
22uF
0805P
X7R
C63
270 pF
0603P
50V
C64
100pF
0603P
COG
50V
C48
1uF
0805P
Y5V
50V
C47
.01uF
X7R
0603P
50V
R55
1 ohm
1206P
5%
R56
1 ohm
1206P
5%
R57
1 ohm
1206P
5%
R25
1 ohm
1206P
5%
R62
1 ohm
1206P 5%
R63
1 ohm
1206P 5%
R61
1 ohm
1206P 5%
C66
47uF
0805P
Y5V
16V
R64
130 ohm
0603P
5%
R67
220K
0603P
5%
R70
10K
0603P
1%
R71
10K
0603P
1%
R65
10K
0603P
1%
R66
6.34K
0603P
1%
C65
82uF
0603P
X7R
50V
C67
120pF
0603P
COG
50V
R22
1K
0603P
5%
RETADJ
TEMPEST P3 AT
80-111402-01
01

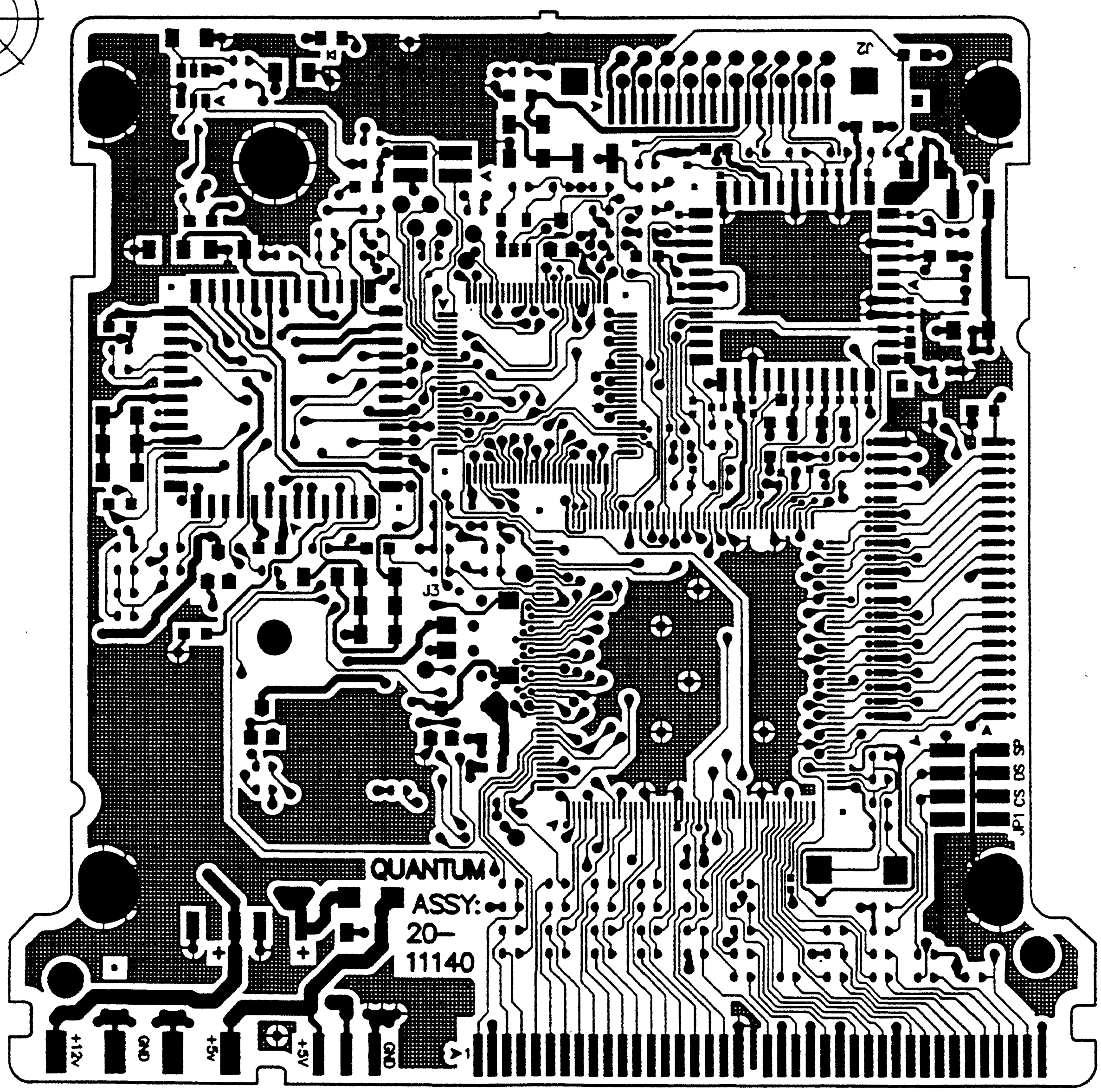
TEMPEST AT P3

20-111402-01 ASSY DRW



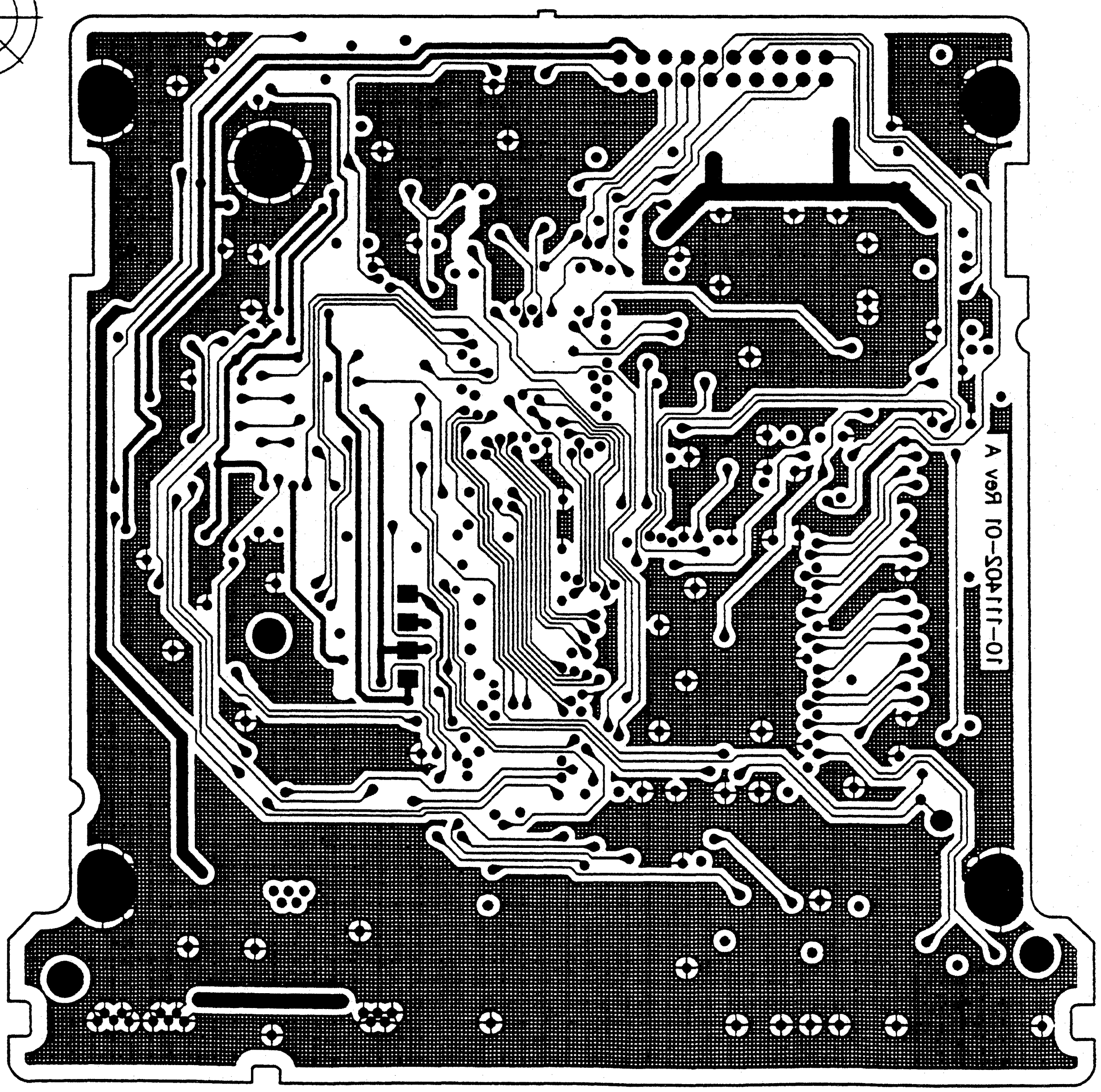
COMP	
Last Edit 3/3/96 JOHN F. BINNS	

TEMPEST AT P3 AKBAR-AT3 MIGHTY-8D BLUE-3 10-111402-01 REV A



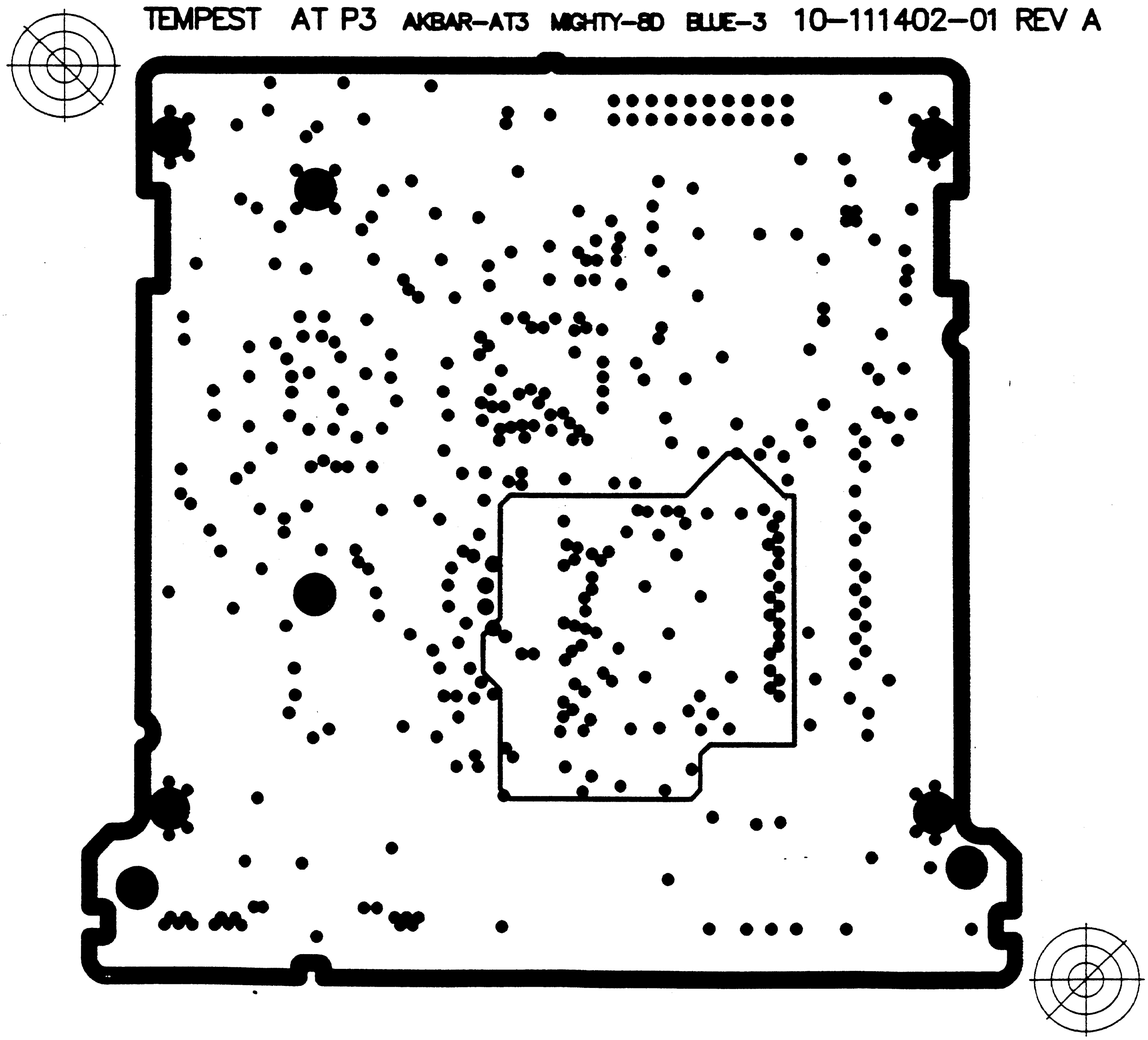
BACK	
Last Edit 3/3/96 JOHN F. BINNS	

TEMPEST AT P3 AKBAR-AT3 MIGHTY-8D BLUE-3 10-111402-01 REV A



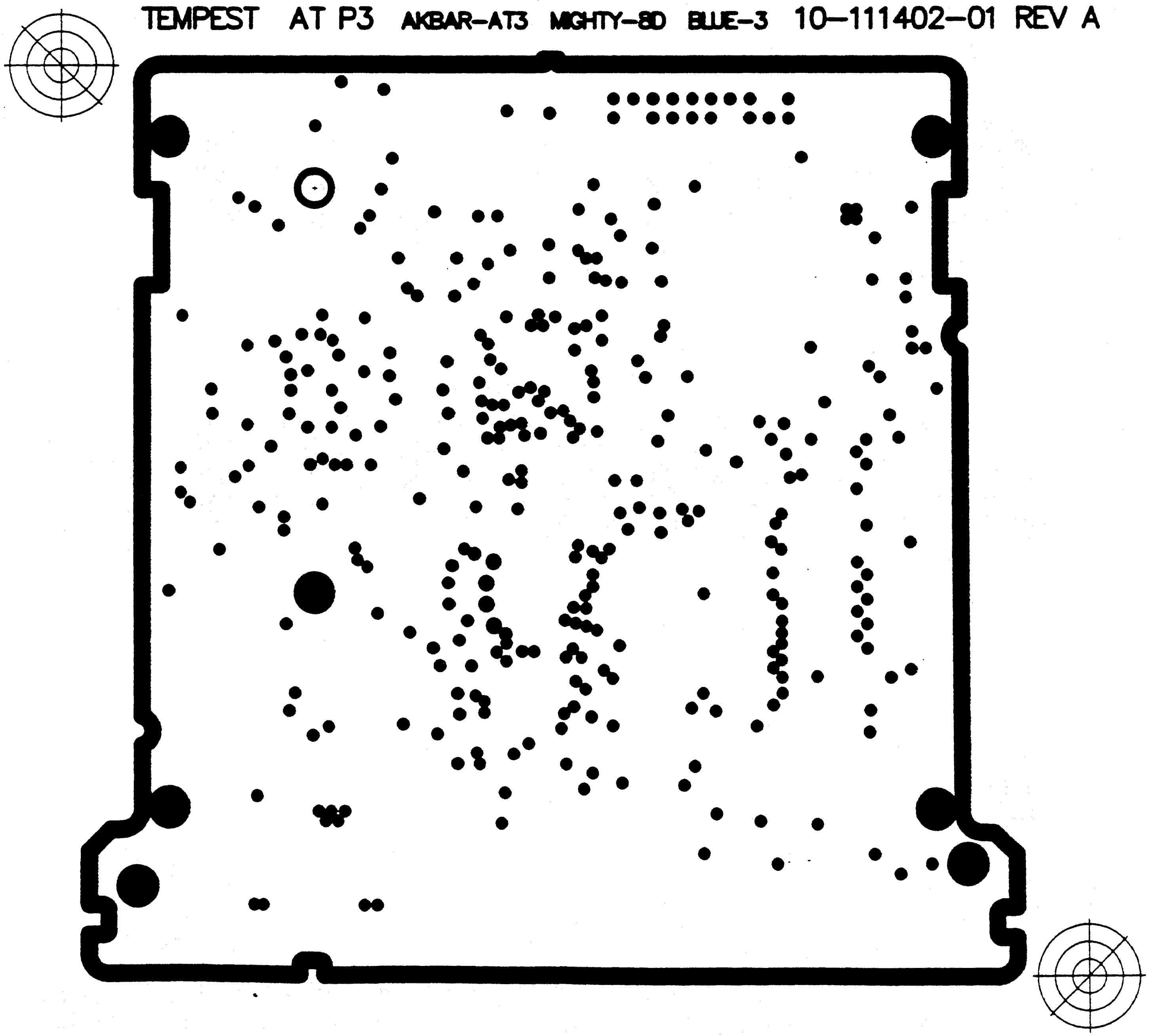
	VOLT PLANE
Last Edit 3/3/96 JOHN F. BINNS	

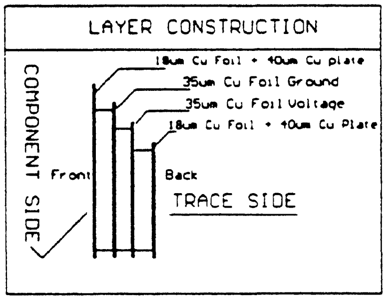
TEMPEST AT P3 AKBAR-AT3 MIGHTY-8D BLUE-3 10-111402-01 REV A



	GND PLANE
Last Edit 3/3/96 JOHN F. BINNS	

TEMPEST AT P3 AKBAR-AT3 MIGHTY-8D BLUE-3 10-111402-01 REV A





1. MATERIAL: 0.8mm THK GLASS EPOXY TYPE: FR4 1oz CU CLAD 4 SIDES.

   Must be made of a UL Recognized material and traceable per Quantum Corporation specification number 70-104654-01, and manufactured by a UL Recognized printed circuit board supplier. Printed circuit boards must be marked in the copper layer with UL recognized manufactures logo and type code, as designated in the UL Recognized directory.

2. BOARD: SELECTIVE PLATED BOARD, SOLDERMASK OVER BARE COPPER.

   SOLDER PLATE 60/40 AFTER SOLDERMASKING. HOT AIR LEVEL.

   TENT HOLES BACKSIDE.

   SOLDERMASK TYPE: WET PHOTO-IMAGE

   PLATE-THROUGH ALL HOLES WITH COPPER. MINIMUM PLATING THK: 1oz EXCEPT WHERE PLATING IS NOT REQUIRED.

   THIS BOARD DOES NOT HAVE A SILKSCREEN.

3. DRILL: ALL HOLES TO BE DRILLED +/- .003 INCH WITH RESPECT TO CENTER OF DRILLED PAD, OR AS INDICATED TOLERANCE IS DIRECTED IN THE DRILL SCHEDULE.

   ALL HOLES ARE FINISHED SIZE AFTER PLATING UNLESS INDICATED OTHERWISE INDICATED IN THE DRILL SCHEDULE.

HOLE TOLERENCE	TOOL	HOLE SIZE	HOLE COUNT	NOTE	PLATE-THRU	TYPE
+.003/-.010	T1	23 MIL	486	INITIAL START DRILL DIA	YES	VIA AND P/G PADS
+/-.003	T2	28 MIL	2	FINISHED SIZE	NO	COMP MTG HOLE
+/-.003	T3	39 MIL	4	FINISHED SIZE	NO	PIN CLEARANCE
+/-.003	T4	122 MIL	1	FINISHED SIZE	NO	
+/-.003	T5	126 MIL	5	FINISHED SIZE	NO	
+/-.003	T6	127 MIL	2	FINISHED SIZE	NO	
	TOTALS:		500			

Note: Board dimensional information contained on sheet 2 of this drawing.

TEMPEST FIRMWARE

- Overview
- Comparison with Fireball
- Diskware & Overlays
- ASIC Features
- ID-less format
- Cache
- Defect Management
- ECC
- Thermal Asperity Recovery
- SMART
- Current Status

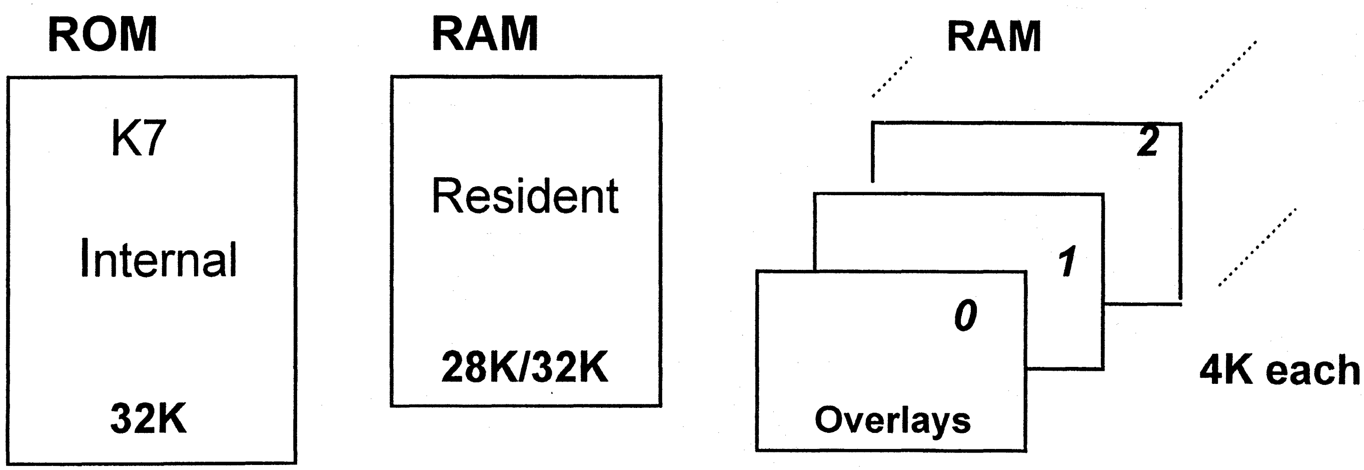
OVERVIEW

- K7 Micro Controller
  - ➢ 32-bit internal
  - ➢ 33 MHz, pipeline processing
  - ➢ 32K of firmware in ROM
  - ➢ 32K RAMware in external RAM
- Akbar ASIC
  - ➢ Formatter
  - ➢ Reed-Solomon ECC
  - ➢ Host interface (AT / SCSI)
  - ➢ Buffer management
  - ➢ Analog to Digital Converter
  - ➢ Servo control
- Firmware leveraged
  - ➢ AT leveraged from Fireball; with periodical updates
  - ➢ SCSI interface code leveraged from Grand Prix
- Cache
  - ➢ Dynamically segmented cache
  - ➢ Concurrent read and write
  - ➢ Cache size: 76K bytes

Comparison with Fireball

	Fireball	*Tempest*
Processor	K7	K7
Controller	Leo	Akbar
Sector format	ID-after-wedge	ID-less
ECC	3-way interleaving	4-way interleaving
Cache size	84K bytes	76K bytes
Defects allowance	511	1,227
SMART	Phase 3.5	Phase 4
SCSI interface	10 MB/s	20 MB/s
SCAM	Level 1	Level 2
SCSI command queuing	none	Tagged

Diskware & Overlays



Overlays:

0	Defect management, logical-to-physical
1	Super commands
2	Diagnostic software & Selfscan supports
3	Servo diag. routines, SMART
4	SCSI error logging commands
5	Additional SCSI commands
6	future expansion

ASIC FEATURES

- Formatter
  - ➢ ID-less controller
  - ➢ 4-way interleaving ECC
  - ➢ Wedge number comparison for ID-less
- Read/write
  - ➢ Channel rate up to 120 Mb/s
  - ➢ Thermal asperity recovery support
- IDE
  - ➢ LBA mode
  - ➢ Transfer rate up to 16.6 MB/s
  - ➢ PIO mode 4
  - ➢ DMA Multi-word mode 2
- SCSI
  - ➢ AutoSCSI - significant protocol automation
  - ➢ Ultra SCSI - 20 MB/s synchronous transfer

THE ID-LESS EVOLUTION

Traditional ID Before Sector (Pioneer)

Wedge	ID	SECTOR 0	ID	SEC 1 part 1	Wedge	SECTOR 1 part 2	ID	SECTOR 2 part 1	Wedge

ID After Wedge (Thunderbolt) (sirocco) Pseudo IDless.

Wedge	ID	SECTOR 0	SECTOR 1 part 1	Wedge	ID	SEC 1 part 2	SECTOR 2 part 1	Wedge

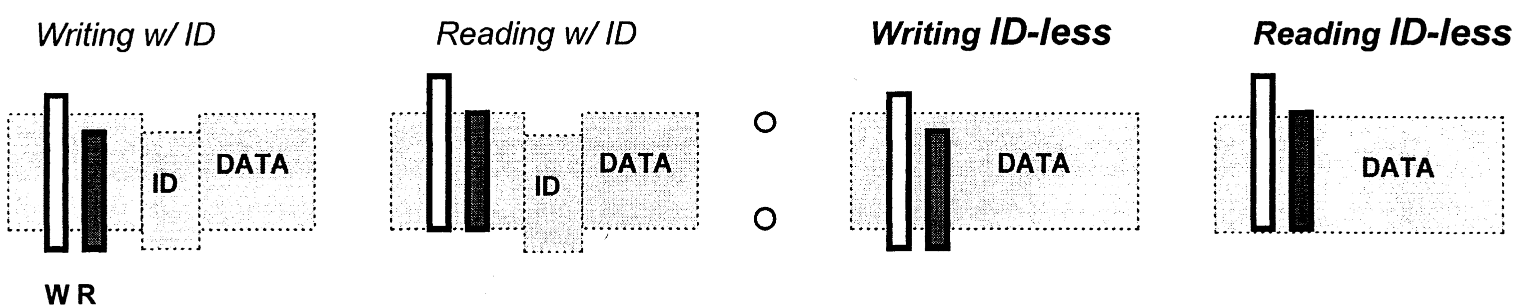
ID-less TEMPEST

Wedge	SECTOR 0	SECTOR 1 part 1	Wedge	SEC 1 part 2	SECTOR 2	Wedge

ID-LESS FORMAT

Benefits

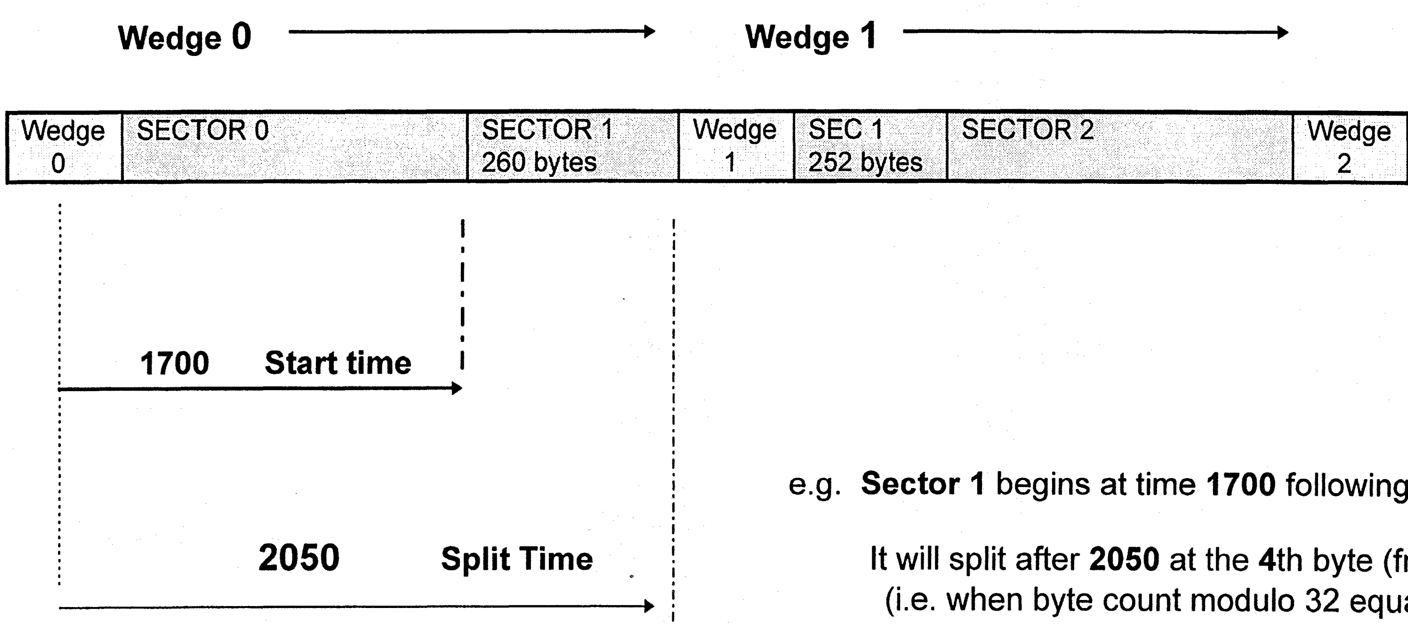
- Capacity — Gaining about 4% of track real-estate
- Throughput — No IDs to read, no need to correct ID error
- MR Heads — No need to retrieve IDs when writing sectors; Less concerns for the MR/write elements offset



Challenge

- Firmware overheads for defect management and track skewing

LOOKING FOR AN ID-LESS SECTOR



e.g. **Sector 1** begins at time **1700** following wedge **0**,

It will split after **2050** at the **4**th byte (from group of 32 bytes) (i.e. when byte count modulo 32 equals Break count)

Sector Descriptor

Wedge #	0
Start time	1700
Break count	4

CACHE

- Leveraged from Fireball
- Dynamically segmented cache
  - ➢ Segment size is determined by request size and prefetch amount
- Concurrent reading and writing
  - ➢ Prefetch data while sending cache hit data to host
  - ➢ Finish writing data to disk while sending cache hit data to host
  - ➢ Finish writing while caching incoming write data from host
- Enhancements in Tempest
  - ➢ Overhead reduced - Maximum of 10 cache segments
  - ➢ Extended prefetch in “sequential mode” - Prefetch until segment is full
  - ➢ “Auto-read” threshold increased to 40 sectors - More prefetch hits

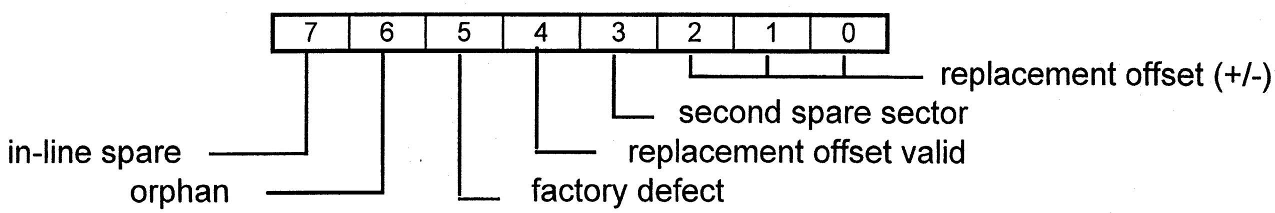
Defect Management

- Based on traditional defect sparing scheme with revised ID-less interface
- Four spares per *system* track
- Two *in-line* spares per data cylinder; unlimited *off-line* spares
- Accommodates 1,227 maximum defects per drive
- Defect table is hashed to expedite defect lookup
- "Transparent auto-reallocation" to eliminate data loss

Defect entry in working-list:

Status
Replacement cyl offset
Defect cyl low
Defect head / cyl high
Defect sector

Status byte:



ECC

- ECC hardware upgraded to handle higher soft error rate
  - ➢ Extended four-way interleaving -- 6 x 4 redundancy bytes
  - ➢ Improved robustness -- 4 cross-check bytes
- Single-burst "on-the-fly" correction up to 32 bits (0.7 mS max.)
- Double-burst "on-the-fly" correction up to 64 bits (1.1 mS max.)
- Triple-burst correction of up to 96 bits (2.2 mS max.)

THERMAL ASPERITY RECOVERY

- Hardware

  Shiva Blue

  Real-time baseline compensation, AGC and timing coasting
  Generates detection signal to the controller
  Force Address Mark detection for sync field error

  Akbar

  Registers the sector number of the asperity
  Registers the position and length of the asperity

- Firmware

  - Invoke only if error is analyzed to be caused by T.A.

  The retry algorithm is:

  1. Enable Blue's detection and compensation feature
  2. Determine off-track read position (best-of-3)
  3. If address mark problem, using the best position, apply F.A.M.

S.M.A.R.T.

(**S**elf-**M**onitor **A**nalysis and **R**eporting **T**echnology)

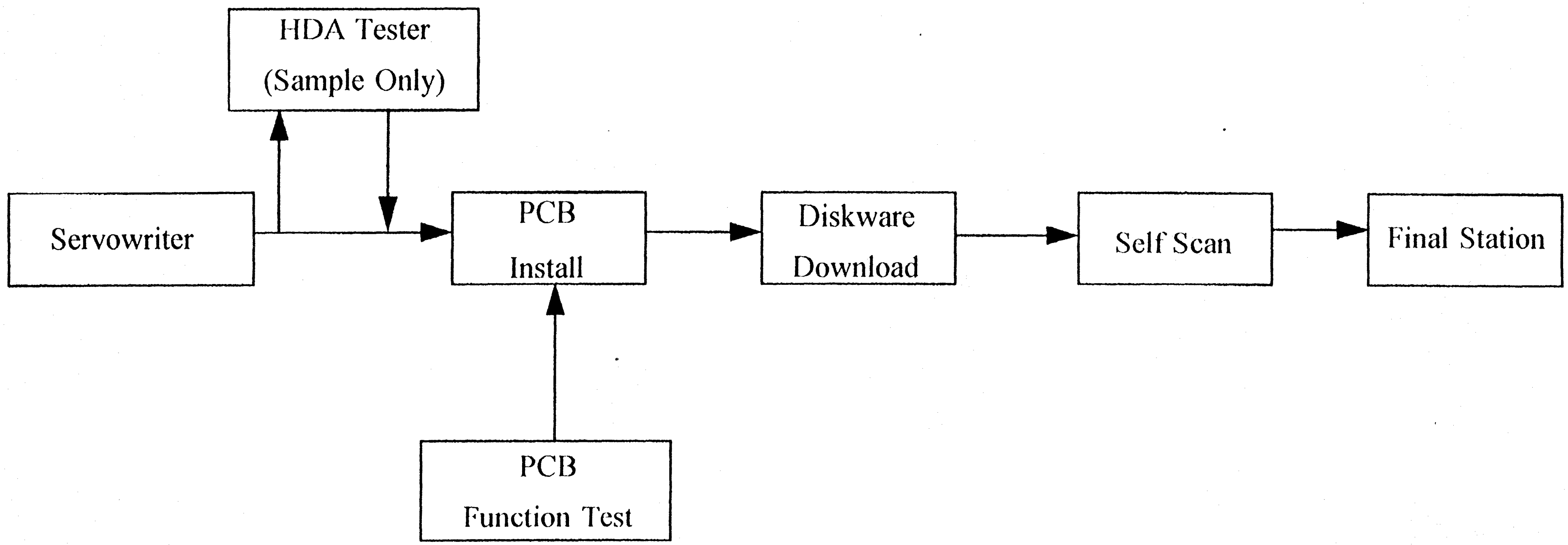
- Formally known as DPA (Drive Parameter Analysis)
- Leveraged from Fireball SMART 3.5 code, monitoring:
  - Power on hours
  - Number of start/stops
  - Number of power cycles
  - Spin-up time
  - Number of grown defects
  - Seek error rate
  - Number of recal retries
- Additional Phase 4 attribute:
  - Raw error rate measurement
- Additional Phase 4 features:
  - Enable/disable automatic off-line command
  - Off-line immediate command

CURRENT STATUS

- Operational:
  - ➢ Reading and writing
  - ➢ Error correction and recovery
  - ➢ Read and write caching
  - ➢ Fine tuned cache performance
  - ➢ Defect management, auto-reallocation
  - ➢ Tagged command queuing
  - ➢ Selfscan
- Outstanding Issues:
  - ➢ Fixing bugs
  - ➢ Streamline thermal asperity recovery
  - ➢ SMART data collection and threshold setting
  - ➢ Customer-specific compatibility testing

TEST PROCESS

MP TEST PROCESS FLOW



SERVOWRITE & HDA TEST PROCESS

SERVOWRITER HIGHLIGHTS

FIREBALL	SIROCCO	TEMPEST
5400 RPM	4500 RPM	Fast Write
Gang Write	Stagger Write	Stagger Write
2 Passes/Track	3 Passes/Track	3 Passes/Track
4100 TPI	5850 TPI	6775 TPI
3 Burst Pattern	4 Burst Pattern	4 Burst Pattern
76 Wedges	90 Wedges	90 Wedges
1 Or 2 Disk HDA	2 Or 3 Disk HDA	1 Disk HDA
3 Position	4 Position	2,3 Disk HDA
		4 Position

SERVOWRITER TESTS

- SAM to SAM Check
  - Checks Circumferential Position of Wedges
- Parametric Tests
- Stroke Test
- Servo Verify
  - Process Monitor on 1 Surface - Sampled Process

SERVO WEDGE WRITE PROCESS

- Staggered Head Writing
- 1/3 Track Stepping
- Laser System for Radial Positioning
- Clock Head/Clock Track for Circumferential Positioning
- Process Data Written on Super Cylinders (ID Cylinders)
- Fastwrite Process

SERVOWRITER FASTWRITE PROCESS

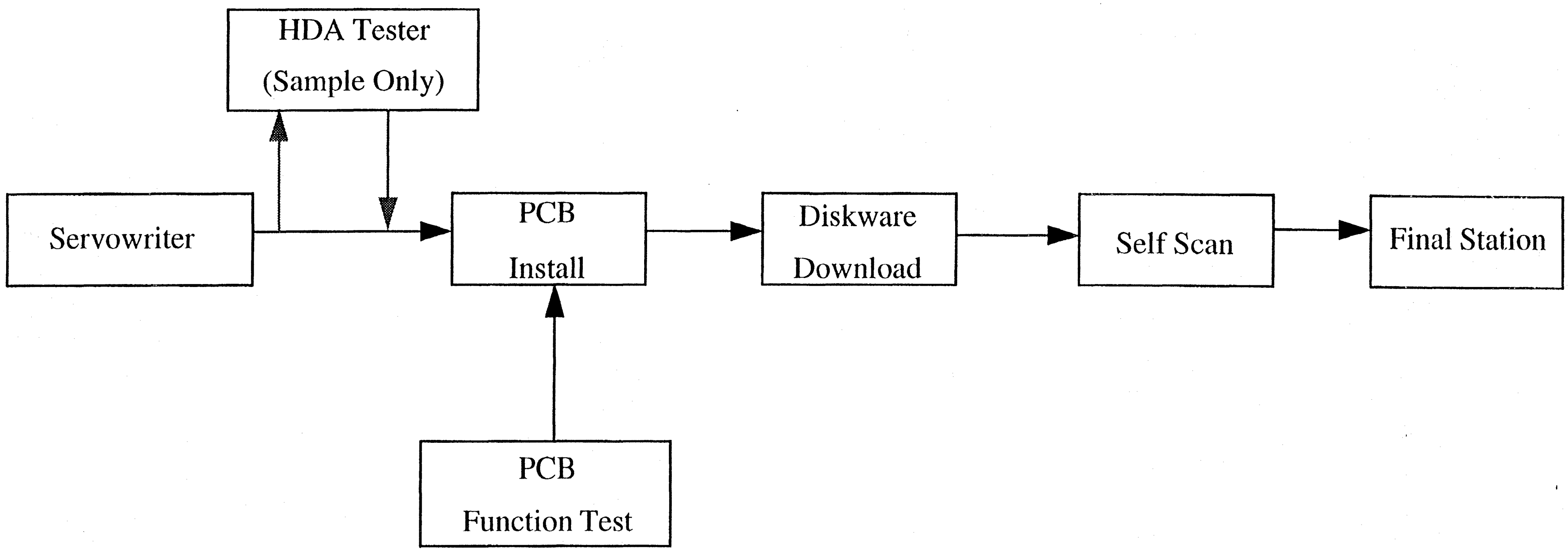
- Product Speed: 4500 RPM
- Servowrite Speed: 6000 RPM
- 1 Disk Product Enters Mass Pro At 6000 RPM
- 2/3 Disk Product Enters Mass Pro at 4500 RPM, Then Upgrades to 6000 RPM At A Later Date

HDA TESTS (Sample Only)

- MR Resistance
- LF TAA
- HF TAA
- Resolution
- Modulation
- Overwrite
- PW 50
- Non-Linear Transition Shift
- Signal to Noise
- Asymmetry Test

SELF SCAN TEST PROCESS

PRODUCTION TEST PROCESS FLOW



PCB FUNCTIONAL TEST

- Test Functionality Of Each PCB Subsection
  - ➤ Spin Up Captive HDA
  - ➤ Controller Buffer RAM Test
  - ➤ Perform Seek Test
  - ➤ Read/Write Test
  - ➤ DMA Test
  - ➤ Connectivity Test (AT)
    - Slave Present, Cable Select, PIO Mode

DISKWARE STATION

- Prepares drive for selfscan testing
  - ➤ Spin up
  - ➤ Initialize system tracks
    - Calibrate read channel for system zone
    - Map any media defects in system area
    - Load default configuration parameters
  - ➤ Write diskware to HDA
  - ➤ Write selfscan test script to HDA

SELF SCAN TEST PROCESS

- Tests are similar or equivalent to tests in Digital Scan
- Self scan resides in diskware
  - Selfscan is only loaded during production testing
- Tests are specified by S/S script
  - Diskware station writes S/S script
- S/S starts by detecting S/S script (Password)
  - Optimize Drive Performance
  - Test Drive Functionality / Performance
  - Scan and Map Media Defects
  - Measure Soft Error Rate

TEMPEST TEST ENHANCEMENTS

TEMPEST	FIREBALL
MR Bias Optimization	N/A
MR Head Stability Test	N/A
MR Microjog Calibration	N/A
"Taguchi" Channel Optimization	One Parameter At A Time
Test Time Optimization	

.TEMPEST.

SELF SCAN TEST FLOW

- Buffer RAM Test
- Kloop Servo Optimization
- MR Bias Current Calibration
- Input Attenuation Calibration
- Micro Jog W/R MR Calibration
- Adaptive Data Channel Calibration
- MR Head Stability Check
- Servo Wedge Verify
- Repeatable/Nonrepeatable Runout
- Sequential Head Switch Test
- Fixed LengthSeek Test
- Random Seek Test
- Offtrack Read Capability
- Physical Sector Defect Scan
- Inline Defect Sparing (Format inline)
- Logical Sequential/Random Scan
  (BER Measurement)
  confidence mode (all retries on??)
- Start/Stop Test

PERFORMANCE OPTIMIZATION

- MR Bias Current Calibration
- Kloop Optimization
  - ➤ Maximize servo performance and stability
- MR Microjog Calibration
  - ➤ Calibrate Microjog Offset for Each Head
- Channel Optimization (Minimize MSE)
  - ➤ Input Attentuator Calibration
  - ➤ Optimize Write Precompensation
  - ➤ Optimize Continuous Time Filter (Boost/Bandwidth)
  - ➤ Tap 4 Optimization For FIR Filter

FUNCTIONALITY / PERFORMANCE TESTS

- Buffer RAM Test
- Runout Test
  - Measures repeatable and nonrepeatable runout
  - Test at multiple locations on each surface for all heads
- Servo Wedge Verify
  - Map servo defects
  - Verify radial/circumferential wedge position
- Start Stop Test
  - Test the spin-up time

FUNCTIONALITY / PERFORMANCE TESTS

- Head Switch / Single Track Seek Test
- Random Seek Test
- Fixed Length Seek Test
  - Third Stroke/Full Stroke Seeks
- Offtrack Read Test
  - Verifies Offtrack Read Margins

DEFECT SCAN

- Physical Sequential Scan
  - ➤ Multiple scan patterns
- Logical Random Scan
  - ➤ Random reads and writes
  - ➤ Maps defective sectors

ERROR RATE MEASUREMENT

- Logical Scan (retries on??)
  - Combination of sequential and random scans
  - Logs recovered error by type (sense key & sense code)
  - Logs soft errors per head and per drive

where is confidence mode test??

.TEMPEST.

FINAL STATION

- Self Scan Report ✓
- Power Cycle Test ✓
- Write/Read with Full Compare ✓ (all retries on)
- Generic Ship Configuration —

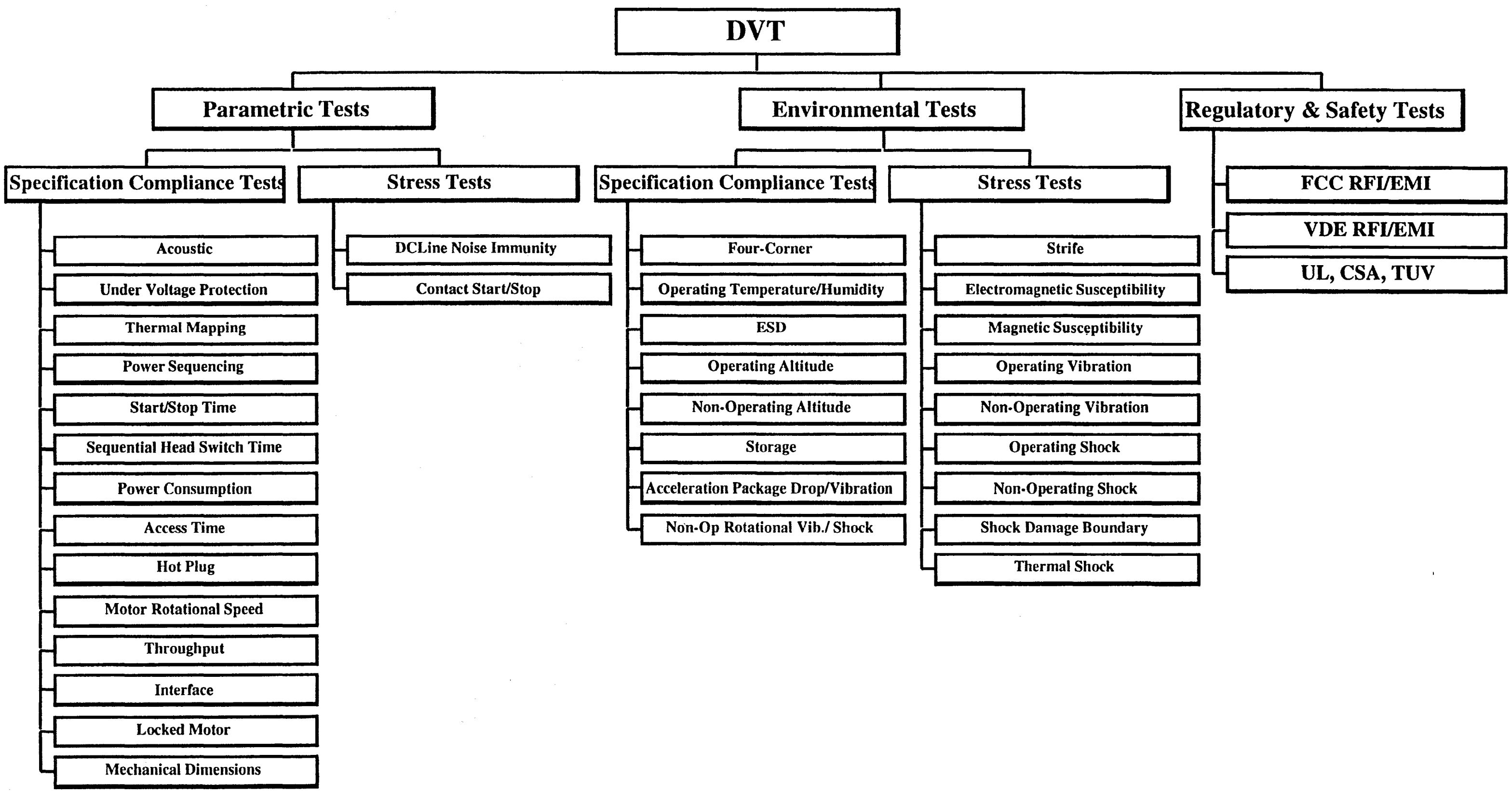
TEMPEST

Design Verification Test (DVT)

TEMPEST DVT

- **Overview**
- **Status**
- **Plan**

TEMPEST DVT Overview



TEMPEST DVT Status

- **Parametric Tests:**
  - » **100% Completed (P1')**
- **Environmental Tests:**
  - » **58% Completed (P1')**
  - » **42% Testing in FMT/DMT**
- **Regulatory & Safety Tests:**
  - » **100% Completed**

Tempest DVT Status (cont.)

- ***Parametric Tests***

Test	Drive Level	Status	Failure Mode	Corrective Action
Under Voltage Protection	P1'	Pass		
Motor Rotational Speed	E3	Pass		
Power Sequencing	E3	Pass		
Locked Motor	P1'	Pass		
Mechanical Dimension	E3	Pass		
Acoustic	P2	Fail	Idle mode 36.7dB, spec 35	Nidec/PMDM Motor improvement
Thermal Mapping	P1'	Pass		
Start/Stop Times	P1'	Pass		
Sequential Head/Cyl Switch	P1'	Fail	Head switch within spec.< 95%.	Optimize servo code & Read channel
Power Consumption	P1'	Fail	Standby , Sleep over 1.5 Watts	Power management , F/W up date
Access Time	P1'	Fail	Seek time Over 12mS(1dk)	1-dk -Actuator Coil change
Hot Plug	P1'	Pass		
DC Line Noise	P1'	Fail	Akbar burnt	TI F/A and simulate testing
CSS	P1	Fail	40KCSS, crash stop banging,	Servo code, Hd-ABS/Media process/lube
Throughput	P1'	Pass		
Interface	P1'	Pass		

Tempest DVT Status (cont.)

■ Environmental Tests

Test	Drive Level	Status	Failure Mode	Corrective Action
Storage	P2	Test in DMT		
Non-Op. Rotational Vib./Shoc	P2	Test in DMT		
Thermal Shock	P2	Test in DMT		
Four-Corner	P2 (16 Drs.)	1 of 16 failed	22-115F,unused servo error 2	Optimize servo and read channel
			(cold temp, seek complete error)	
Op. Thermal Humidity	P2	Test in DMT		
Operating Altitude	P1'	Pass		
Non-Oprating Altitude	P2	Test in DMT		
Accelerating Package Drop	P2	Test in DMT		
Strife	P2	Test in DMT		
ESD	P1	Pass		
EMS	P1'	Pass		
MS	P1'	Pass		
Operating Vibration	P1'	Pass		
Non-Operating Vibration	P1'	Pass		
Operating Shock	P1'	Pass		
Non-Operating Shock	P1'	Pass		
Shock Damage Boundary	P2	Test in DMT		

Tempest DVT Status (cont.)

- **Regulatory & Safety Tests**

Test	Drive Level	Status	Failure Mode	Corrective Action
EMI	P2	Pass		
UL,CSA, TUV	P1	InProgress		

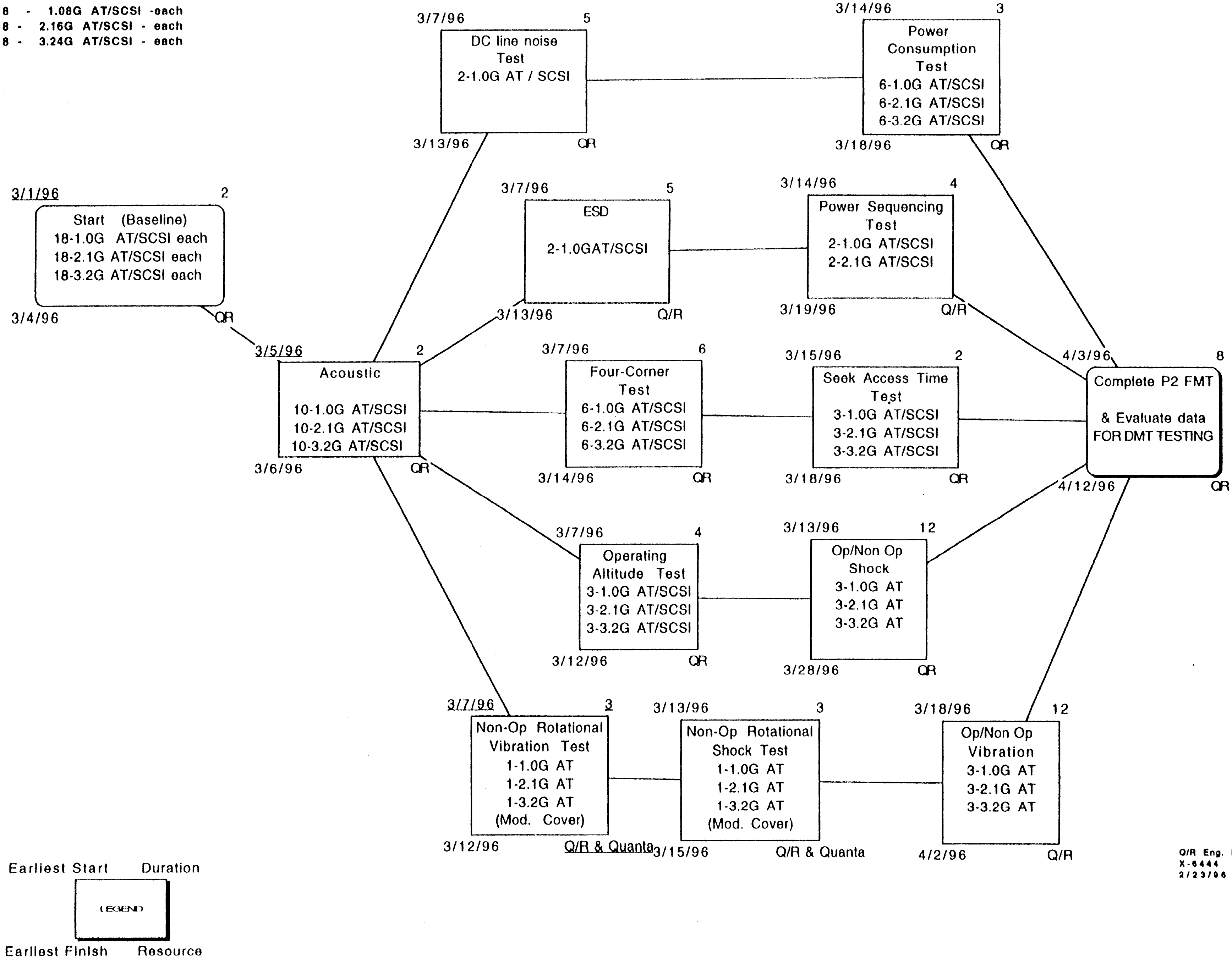
TEMPEST DVT

• P2 FMT PLAN	START :	3/1/96
	END :	3/15/96
• P2 DMT PLAN	START :	3/19/96
	END :	5/30/96

Tempest (AT) P2 / FMT TEST-Plan (Rev. 2)

TEMPEST FMT Test Plan

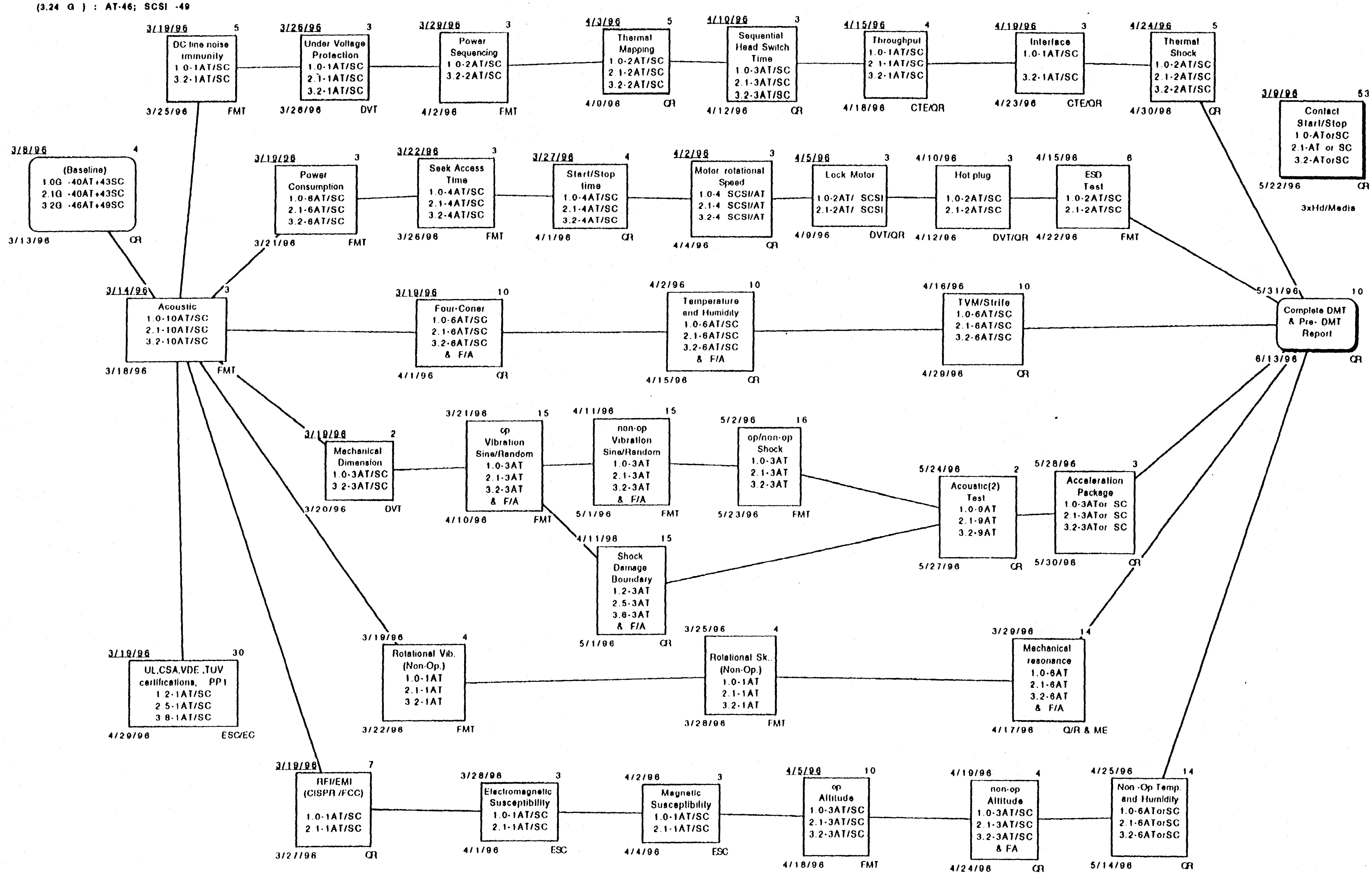
18 - 1.08G AT/SCSI -each
18 - 2.16G AT/SCSI - each
18 - 3.24G AT/SCSI - each

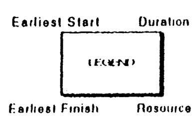


Q/R Eng. Patrick Ho
X-6444
2/23/96

Tempest (AT/SCSI) Product-P2 DMT Qual. Plan, REV 2.0

Drives Required
(1.08G): AT-40; SCSI -43
(2.16G) : AT-40; SCSI -43
(3.24 G) : AT-46; SCSI -49





NOTE: In the Resource of each test, FMT/DVT represent data availbale in that test, no test will be conducted in DMT if passing in DVT/FMT

Q/R Engineer Patrick Ho
x- 6444
Date 2/23/96

TEMPEST FE TRAINING

HEADS AND MEDIA, MARCH 1996

BY KATHY TANG

OVERVIEW

- Tempest Heads and Media Design Specification
- Fly Height Budget Model
- PP1 and PP2 Drive CSS Data
- PP2 HDA Test and Selfscan Data
- PP2 Supplier Issues
- Other MR Related Issues

I. Tempest Heads and Media Design Specification
1. Head Design Specification

	Fireball	**Sirocco**	**Tempest**
Areal Density (Mbpsi)	380	600	784
Track Density (TPI)	4200	5850	6775
Linear Density (KFCI)	99	115	123
RPM	5400	4500	4500
Fly Height (nom/min) (u”)	2.25/1.75	2.75/2.25	2.50/2.00
Slider Size	50%	50%	50%
ABS with COC	TPC, NPAB	TPC, NPAB	TPC, NPAB
Suspension	850LSF	850LSF	850LSF
Load Beam Thickness	3 mil	2.5 mil	2.5 mil
Preload (Gram)	5.0	5.0	5.0

Tmpsta. Upd

	Fireball	**Sirocco**	**Tempest**
Writer Head Design	Inductive TF	Inductive TF	Inductive TF
Write Turns	42	15	12-15
Write Pole Width (μm)	4.7	3.5	3.0
Write Gap Length (μm)	0.25	0.45	0.4
Read Head Design	TF Inductive	MR	MR
MR Transverse Bias		SAL	SAL
MR Longitudinal Bias		HB or Exch. Bias	HB or Exch. Bias
Nominal Read Width (μm)		2.6	2.4
Read and Write Width Relation			Magnetic Read width < optical write width
Minimum Read width (μm)			1.8
Read Gap Length (μm)		0.3	0.3
Read DC resistance		15 to 30	17 to 40

2. MR Head Structures

Head Vendor	Air Bearing	Transverse Bias	Longitudinal Bias	MR Resistance(Ω)	WRITE Turns
QUANTUM	NPAB	SAL	Hard Magnet	28	15
TDK	TPC,XNP	SAL	Exchange Bias	29	14
ALPS	TPC	SAL	Hard Magnet	22	12
Read-Rite	TPC	SAL	Hard Magnet	27	15
Yamaha	TPC	SAL	Hard Magnet	24	12

3. Media Design Specification

	Units	**Fireball**	**Sirocco**	**Tempest**
Brδ	G-μm	270-290	130	125
Coercivity	Oe	1800-2000	2200	2200
Carbon Thickness	A	125-150	125-150	125-150
Glide Height	nm (μ”)	38 (1.5)	38 (1.5)	30 (1.2)
Substrate		Al, 95x31.5	Al, 95x31.5	Al, 95x31.5
Texture		Full Surface	Full Surface	Full Surface
CSS	cycles	40k	40k	40k

MEDIA STRUCTURE

	Alloy	Texture	Carbon	Lube
Fuji	CoCrTa-based	Full	DLC	Z-dol
MCC	CoCrTa-based	Full	H-C/A-C	Z-dol/Demnum
AKCL	CoNiPt	Full	H-C	
Showa-Denka	CoCrTa-based	Full	Normal Carbon	

II. FLY HEIGHT BUDGET

1. Head Fly Height Model-Lognormal Distribution

   Fly height distribution at HGA level (5000 RHG P1 heads)

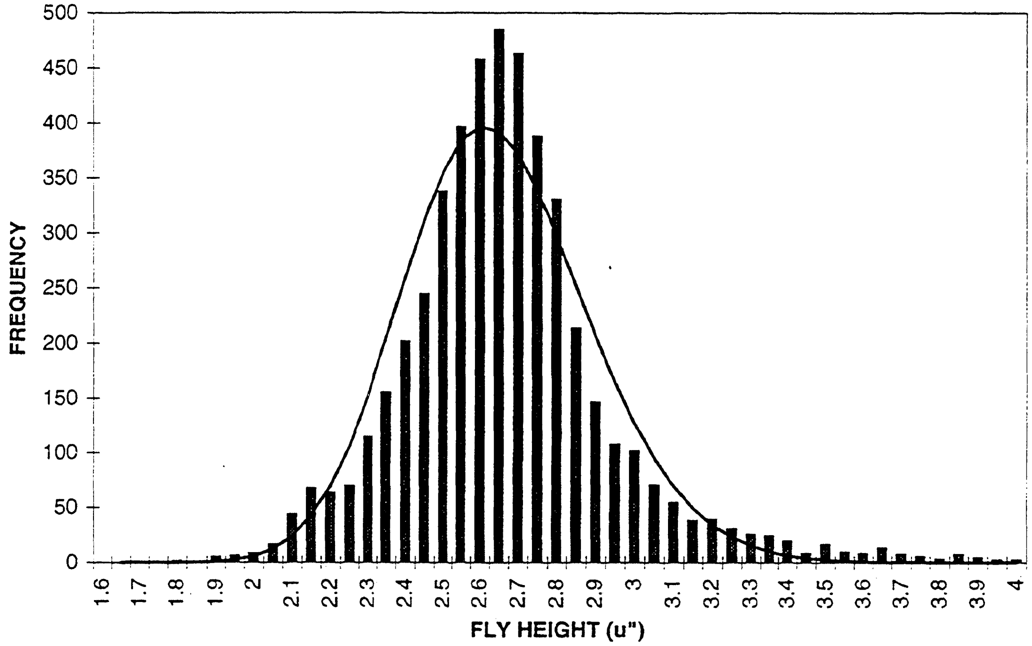
   Fly height distribution at HSA level (staking effect)

2. Disk Glide Model-Weibull Distribution

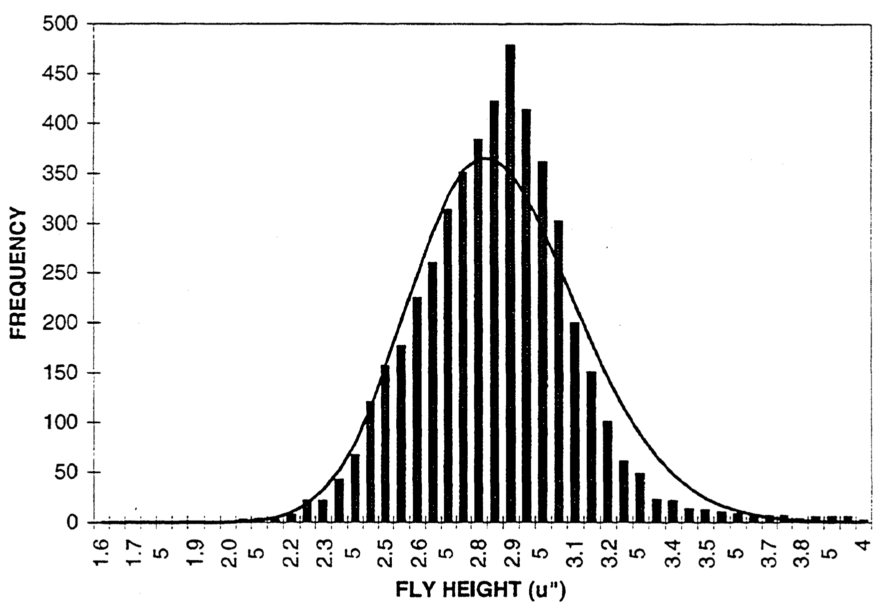
3. Total Clearance at sea level and 10k feet.

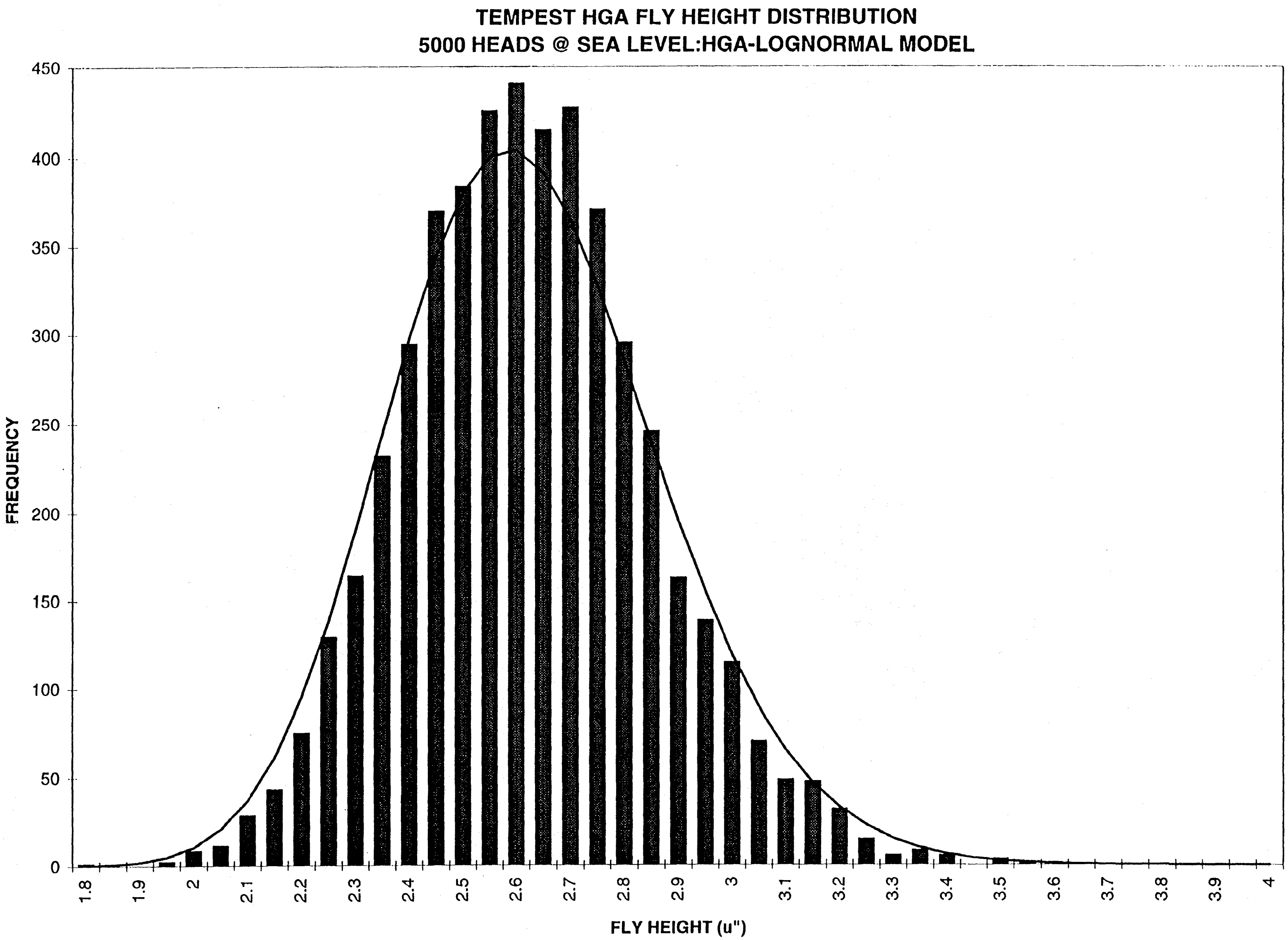
4. Data package:
   Flying height profile and 3 sigma range for each head vendors.
   Disk Glide Avalanche Curves at 3 radius for each disk vendors at P2 build.
   Disk Glide Hits Avalanche and Yield Curves

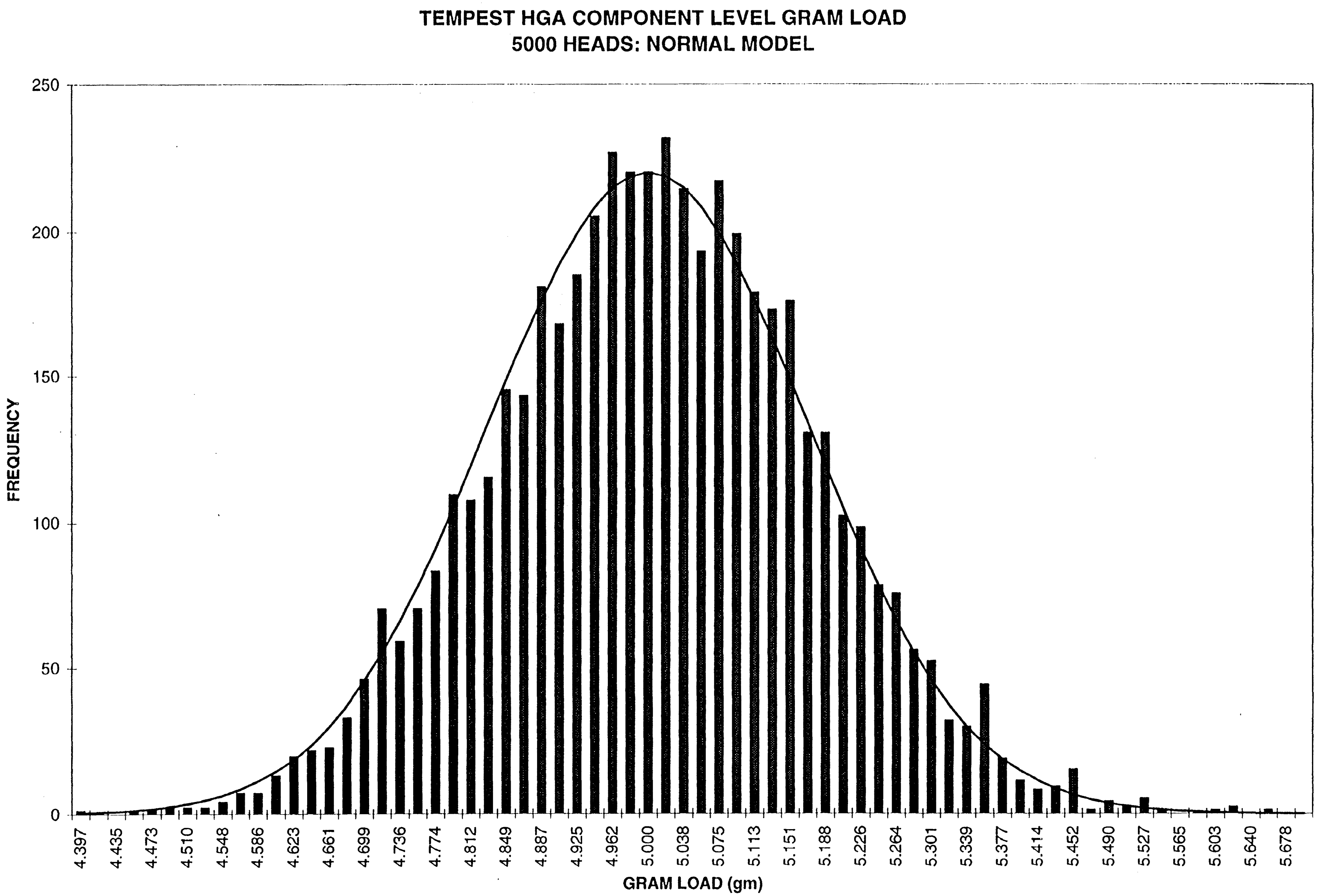
RHG P1 ID

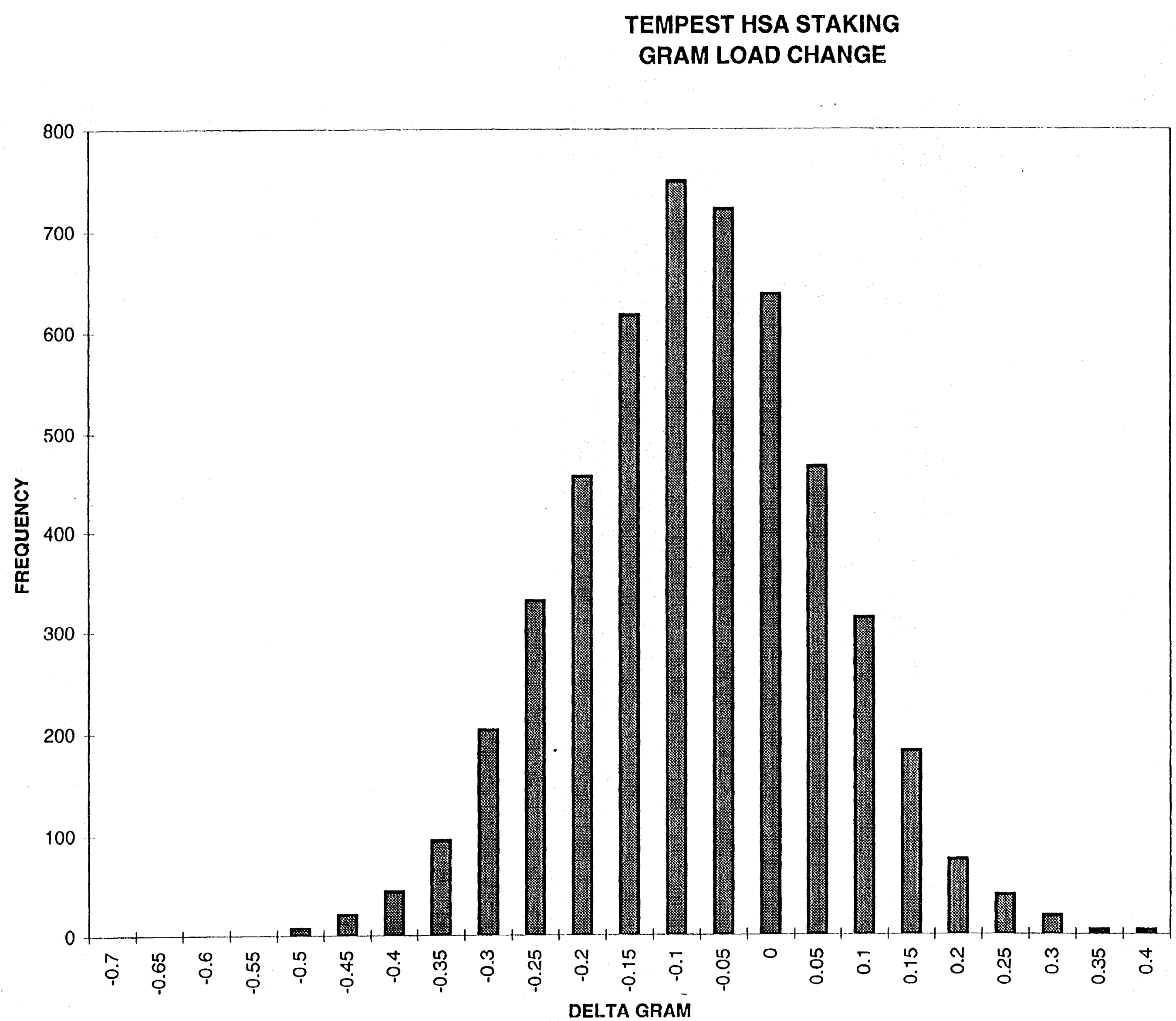


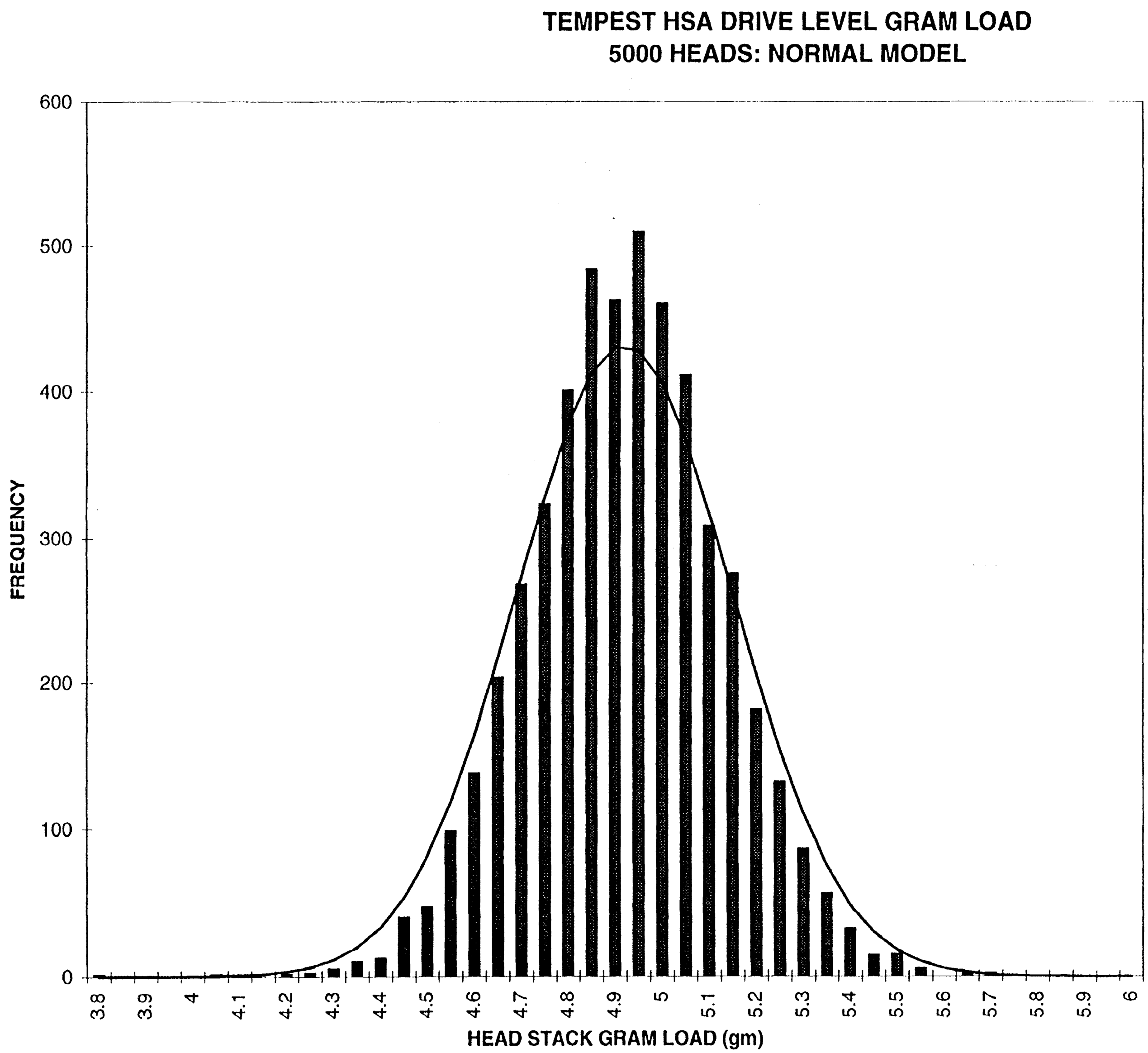
RHG P1 OD

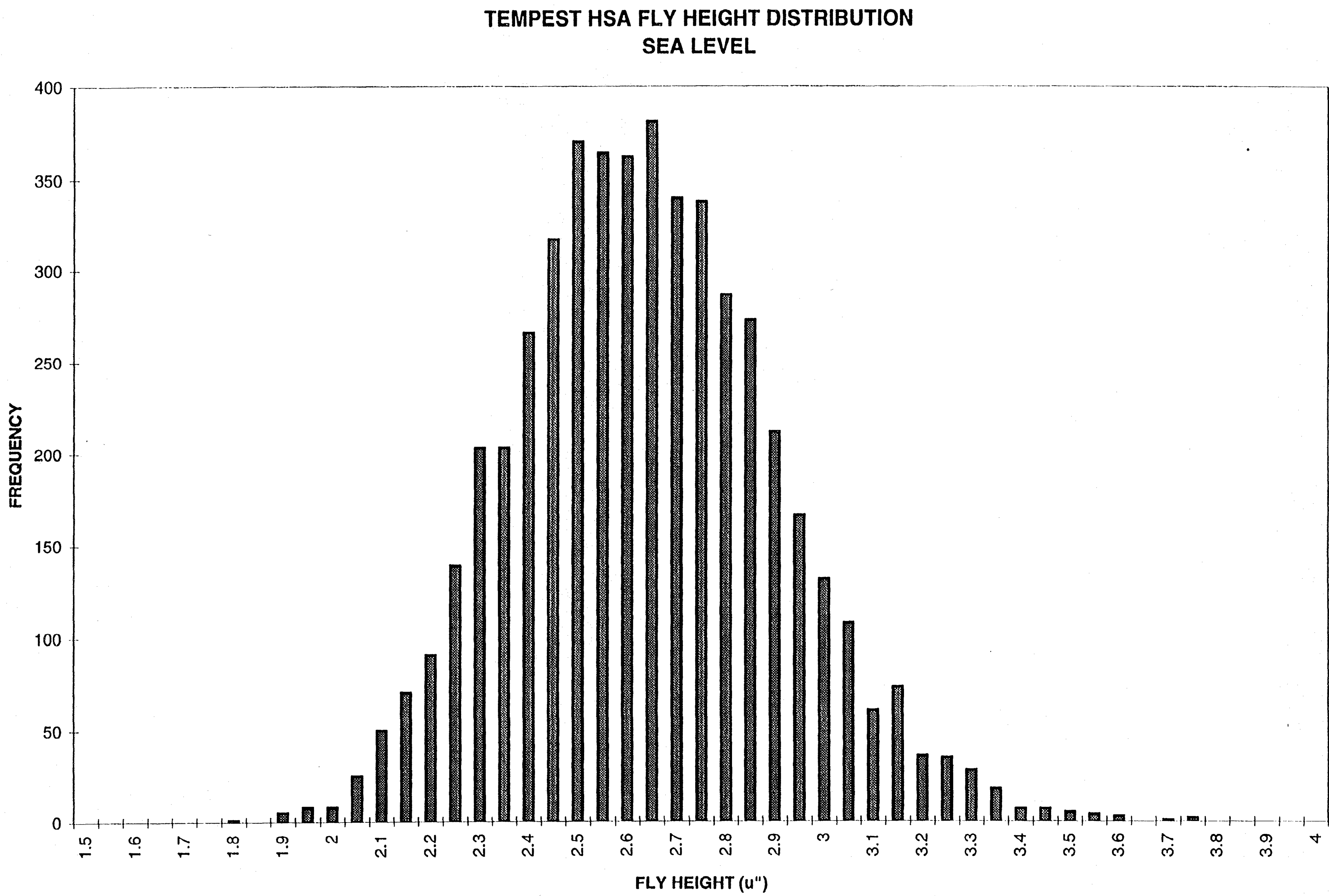


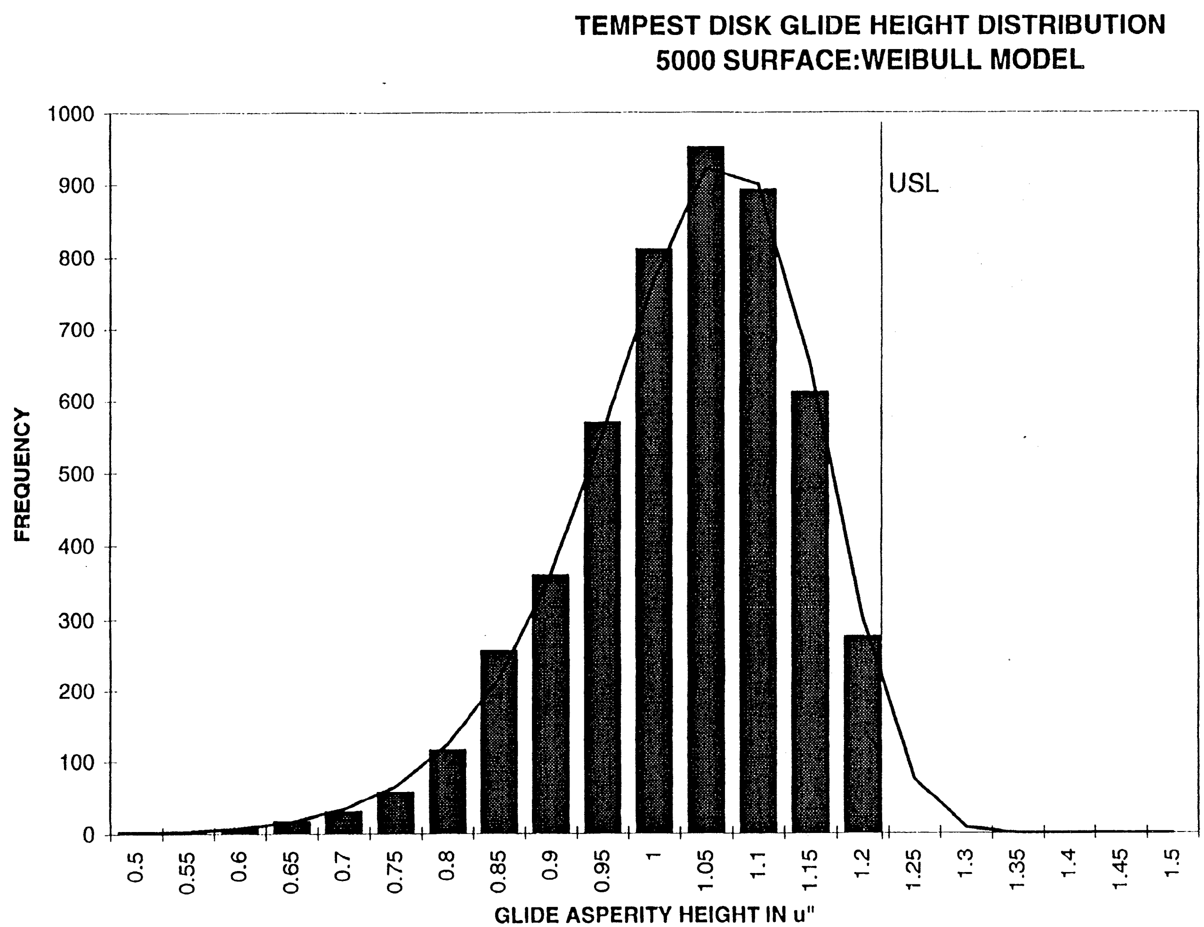

TEMPEST HGA FLY HEIGHT DISTRIBUTION
5000 HEADS @ SEA LEVEL:HGA-LOGNORMAL MODEL
FREQUENCY
0
50
100
150
200
250
300
350
400
450
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4
FLY HEIGHT (u")

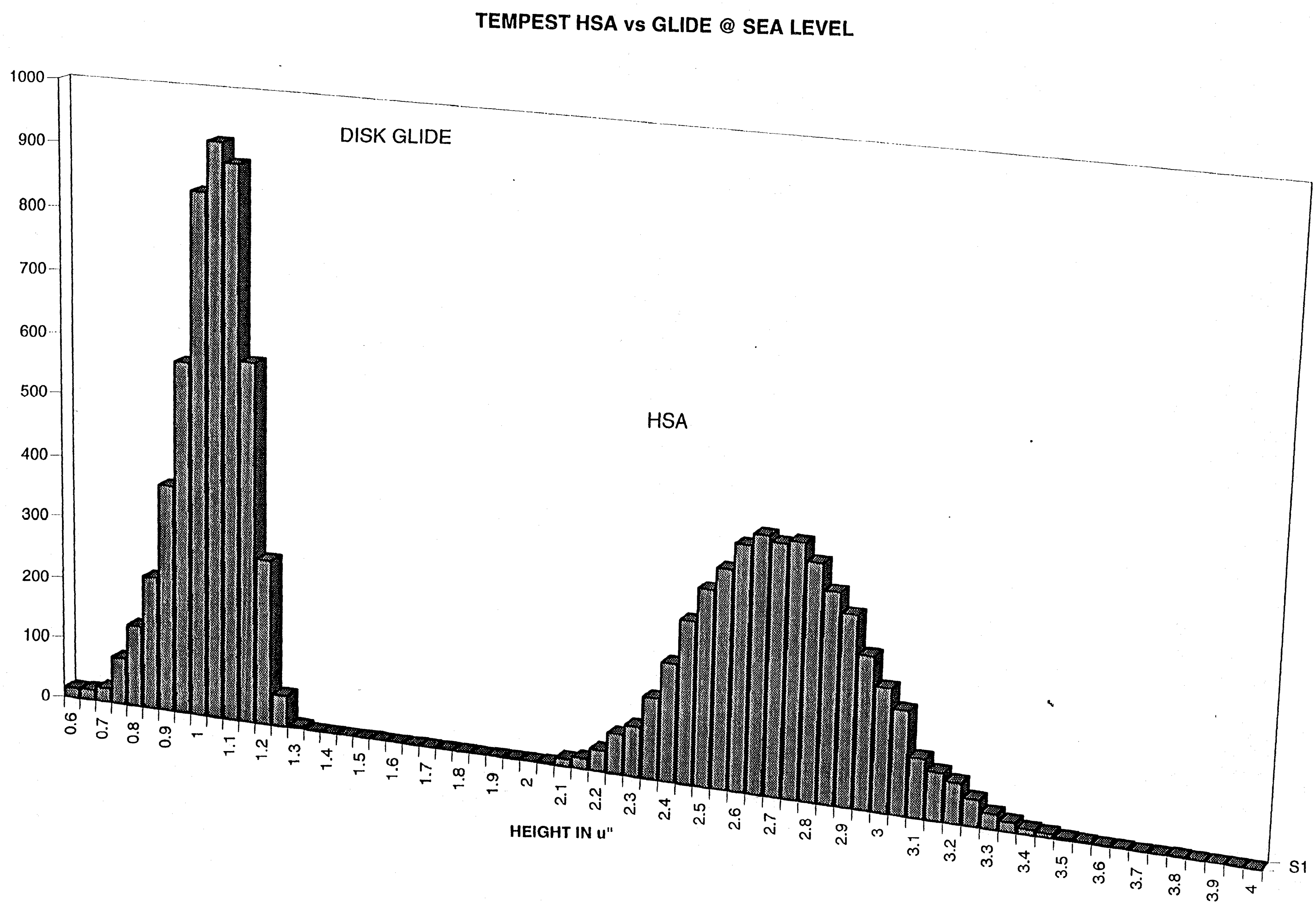

TEMPEST HGA COMPONENT LEVEL GRAM LOAD
5000 HEADS: NORMAL MODEL
FREQUENCY
250
200
150
100
50
0
4.397
4.435
4.473
4.510
4.548
4.586
4.623
4.661
4.699
4.736
4.774
4.812
4.849
4.887
4.925
4.962
5.000
5.038
5.075
5.113
5.151
5.188
5.226
5.264
5.301
5.339
5.377
5.414
5.452
5.490
5.527
5.565
5.603
5.640
5.678
GRAM LOAD (gm)

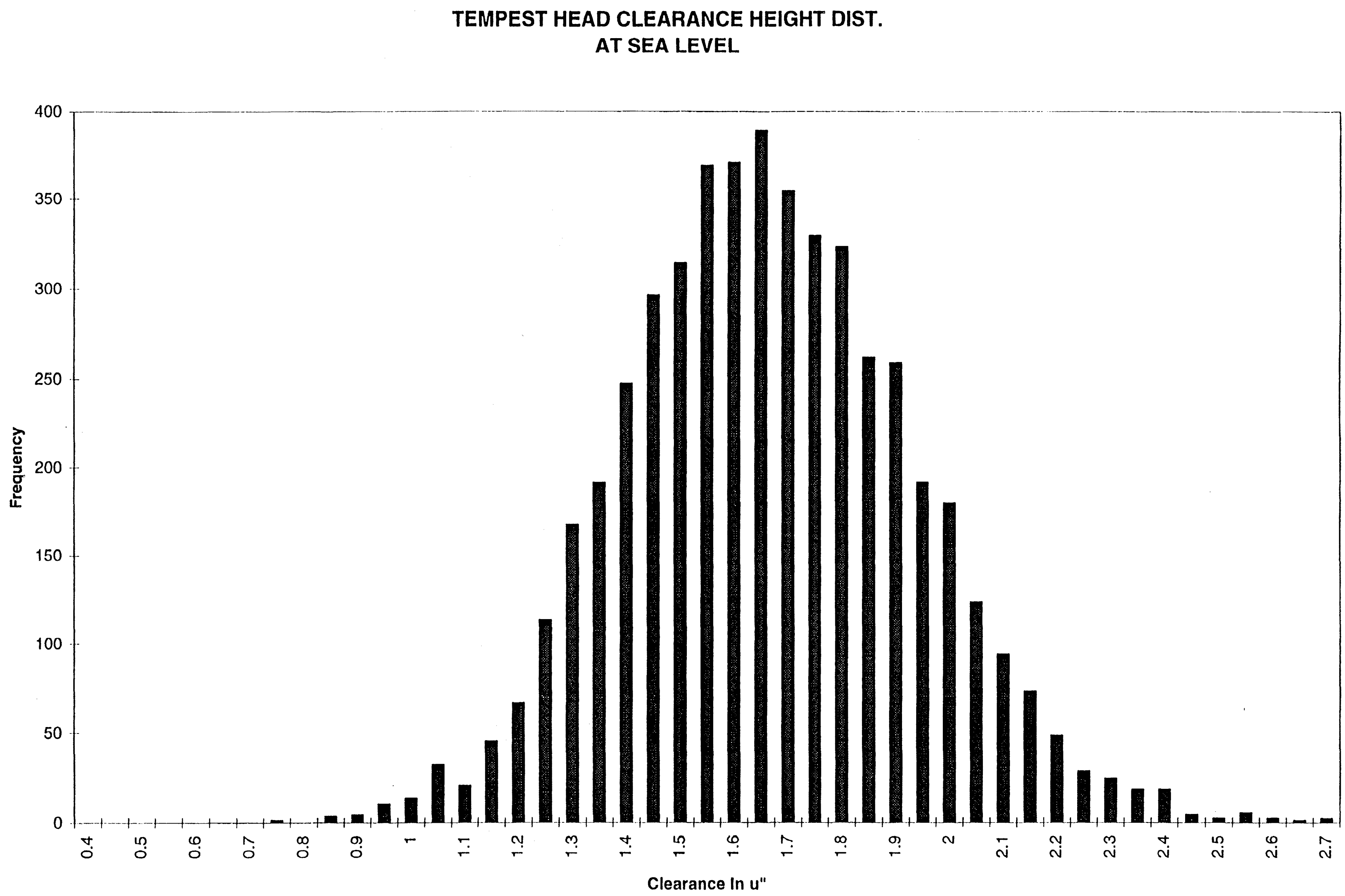

TEMPEST HSA STAKING
GRAM LOAD CHANGE
FREQUENCY
800
700
600
500
400
300
200
100
0
-0.7
-0.65
-0.6
-0.55
-0.5
-0.45
-0.4
-0.35
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
DELTA GRAM

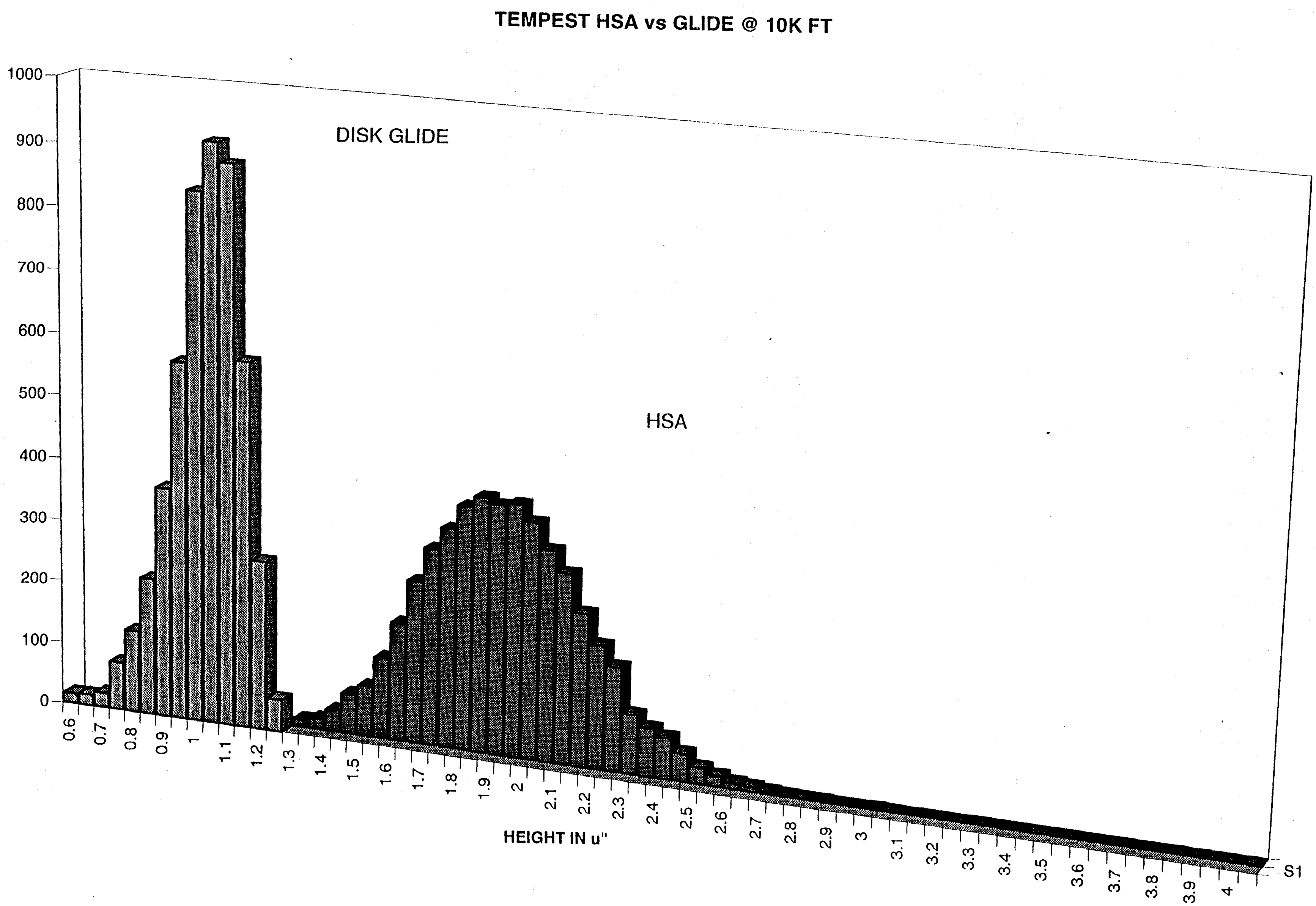

TEMPEST HSA DRIVE LEVEL GRAM LOAD
5000 HEADS: NORMAL MODEL
FREQUENCY
600
500
400
300
200
100
0
3.8
3.9
4
4.1
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5
5.1
5.2
5.3
5.4
5.5
5.6
5.7
5.8
5.9
6
HEAD STACK GRAM LOAD (gm)

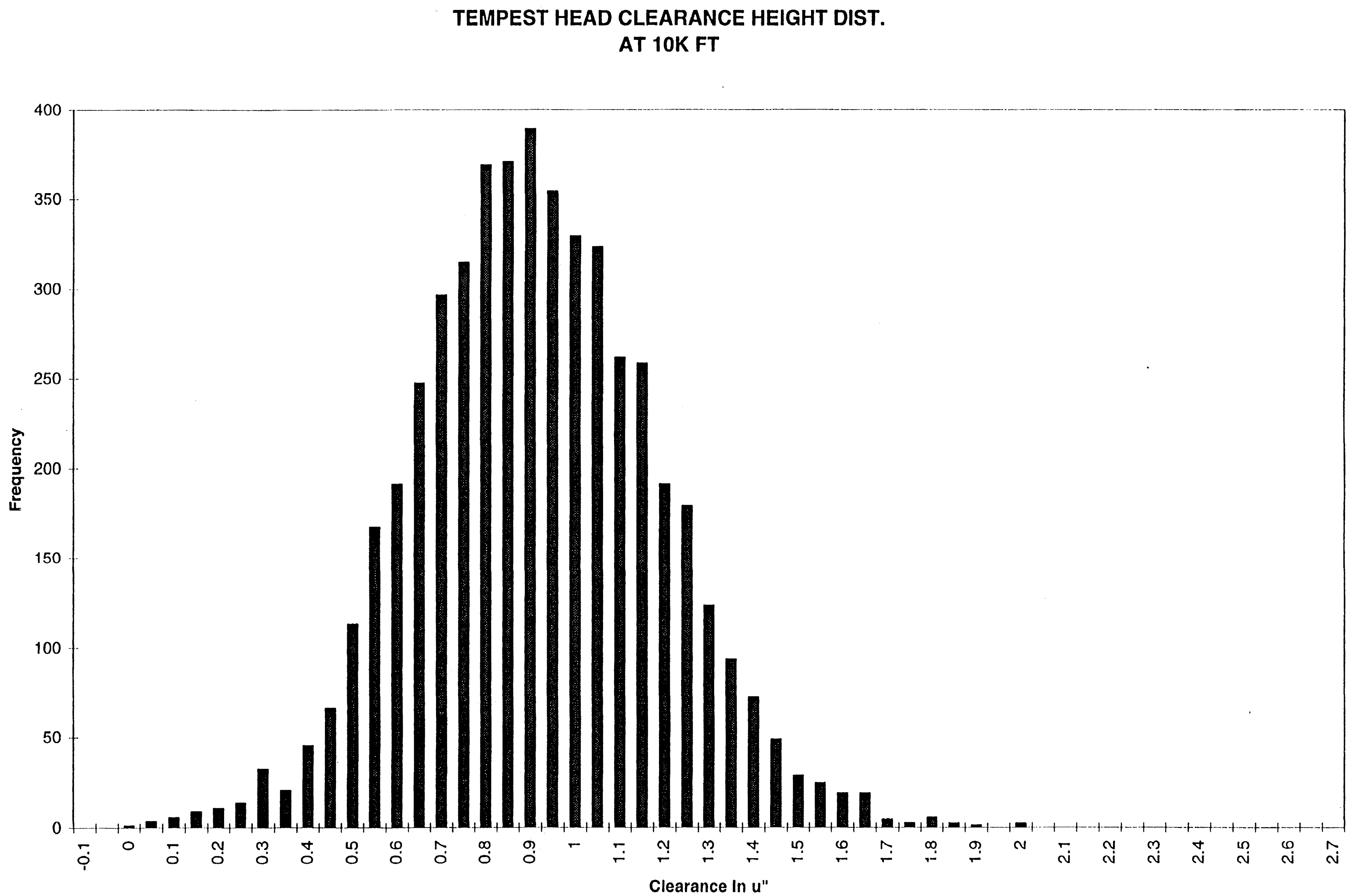

TEMPEST HSA FLY HEIGHT DISTRIBUTION
SEA LEVEL
FREQUENCY
400
350
300
250
200
150
100
50
0
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4
FLY HEIGHT (u")

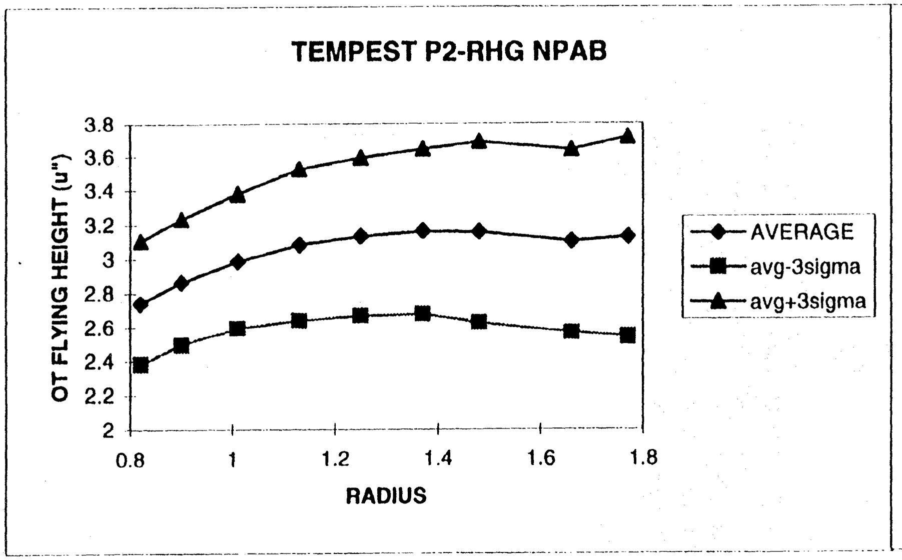

TEMPEST DISK GLIDE HEIGHT DISTRIBUTION
5000 SURFACE:WEIBULL MODEL
FREQUENCY
1000
900
800
700
600
500
400
300
200
100
0
USL
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
1.3
1.35
1.4
1.45
1.5
GLIDE ASPERITY HEIGHT IN u"

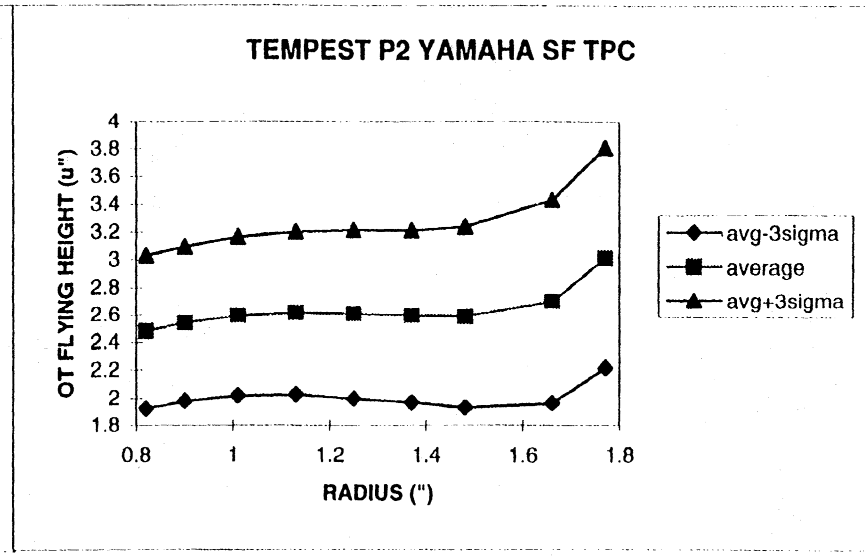

TEMPEST HSA vs GLIDE @ SEA LEVEL
1000
900
800
700
600
500
400
300
200
100
0
DISK GLIDE
HSA
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4
S1
HEIGHT IN u"

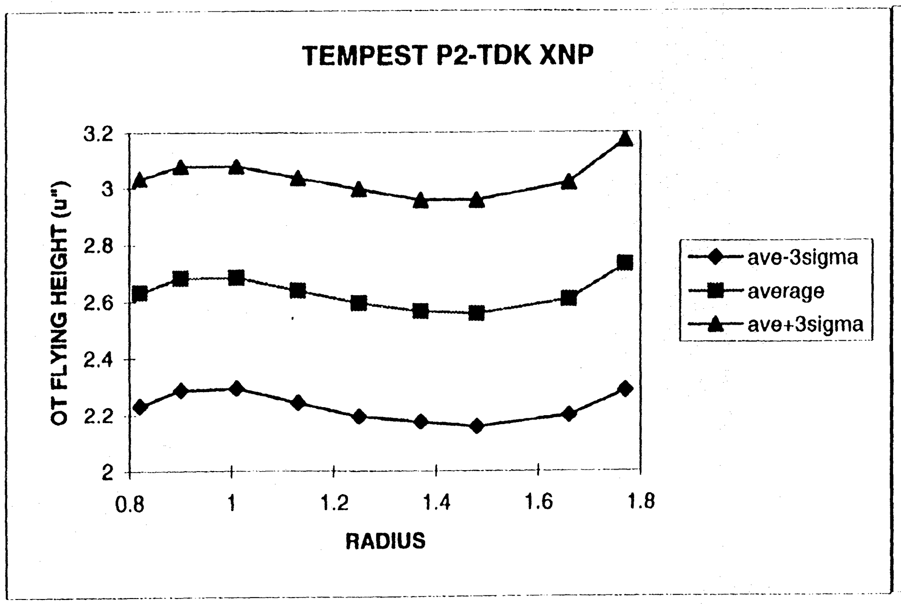

TEMPEST HEAD CLEARANCE HEIGHT DIST.
AT SEA LEVEL
Frequency
400
350
300
250
200
150
100
50
0
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
Clearance In u"

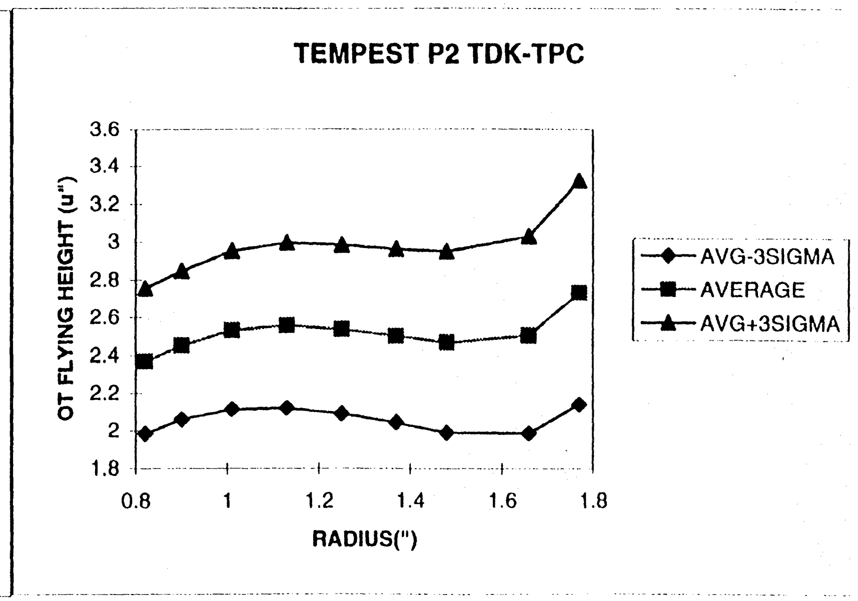

TEMPEST HSA vs GLIDE @ 10K FT
1000
900
800
700
600
500
400
300
200
100
0
DISK GLIDE
HSA
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4
HEIGHT IN u"
S1

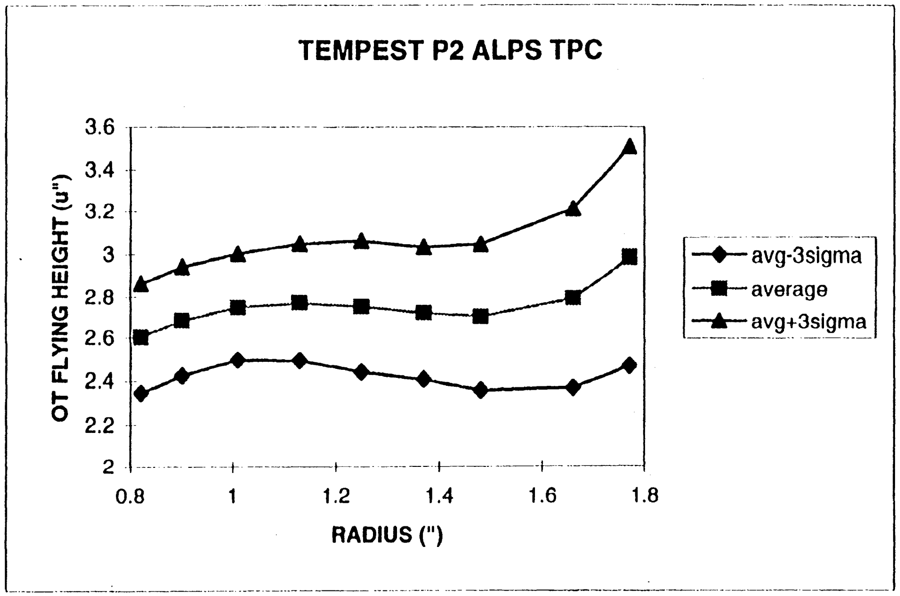

TEMPEST HEAD CLEARANCE HEIGHT DIST.
AT 10K FT
Frequency
400
350
300
250
200
150
100
50
0
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
Clearance In u"

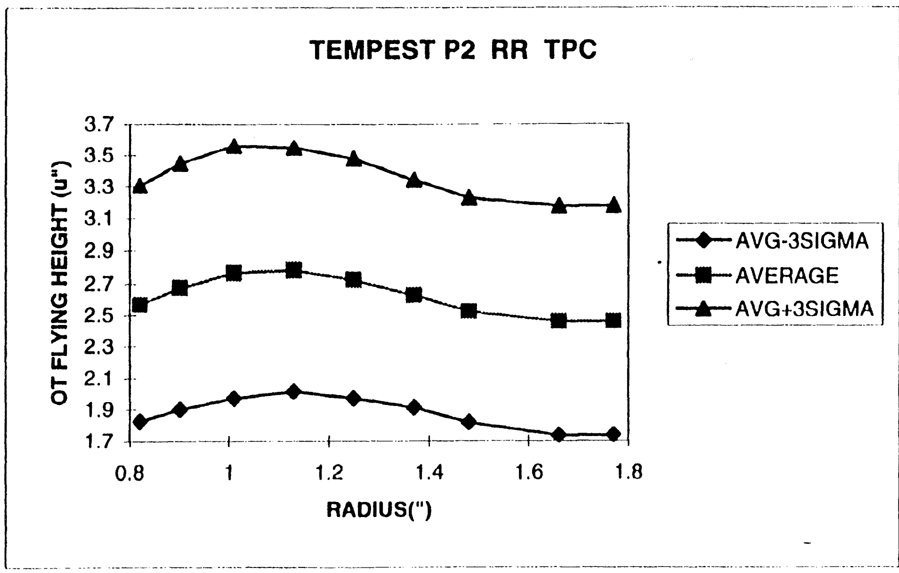

TEMPEST P2-RHG NPAB
OT FLYING HEIGHT (u")
RADIUS
AVERAGE
avg-3sigma
avg+3sigma
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
0.8
1
1.2
1.4
1.6
1.8


TEMPEST P2 YAMAHA SF TPC
OT FLYING HEIGHT (u")
RADIUS (")
avg-3sigma
average
avg+3sigma
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
0.8
1
1.2
1.4
1.6
1.8


TEMPEST P2-TDK XNP
OT FLYING HEIGHT (u")
RADIUS
ave-3sigma
average
ave+3sigma
3.2
3
2.8
2.6
2.4
2.2
2
0.8
1
1.2
1.4
1.6
1.8


TEMPEST P2 TDK-TPC
OT FLYING HEIGHT (u")
RADIUS(")
AVG-3SIGMA
AVERAGE
AVG+3SIGMA
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
0.8
1
1.2
1.4
1.6
1.8


TEMPEST P2 ALPS TPC
OT FLYING HEIGHT (u")
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
0.8
1
1.2
1.4
1.6
1.8
RADIUS (")
avg-3sigma
average
avg+3sigma


TEMPEST P2 RR TPC
OT FLYING HEIGHT (u")
3.7
3.5
3.3
3.1
2.9
2.7
2.5
2.3
2.1
1.9
1.7
0.8
1
1.2
1.4
1.6
1.8
RADIUS(")
AVG-3SIGMA
AVERAGE
AVG+3SIGMA

SHOWA DENKO

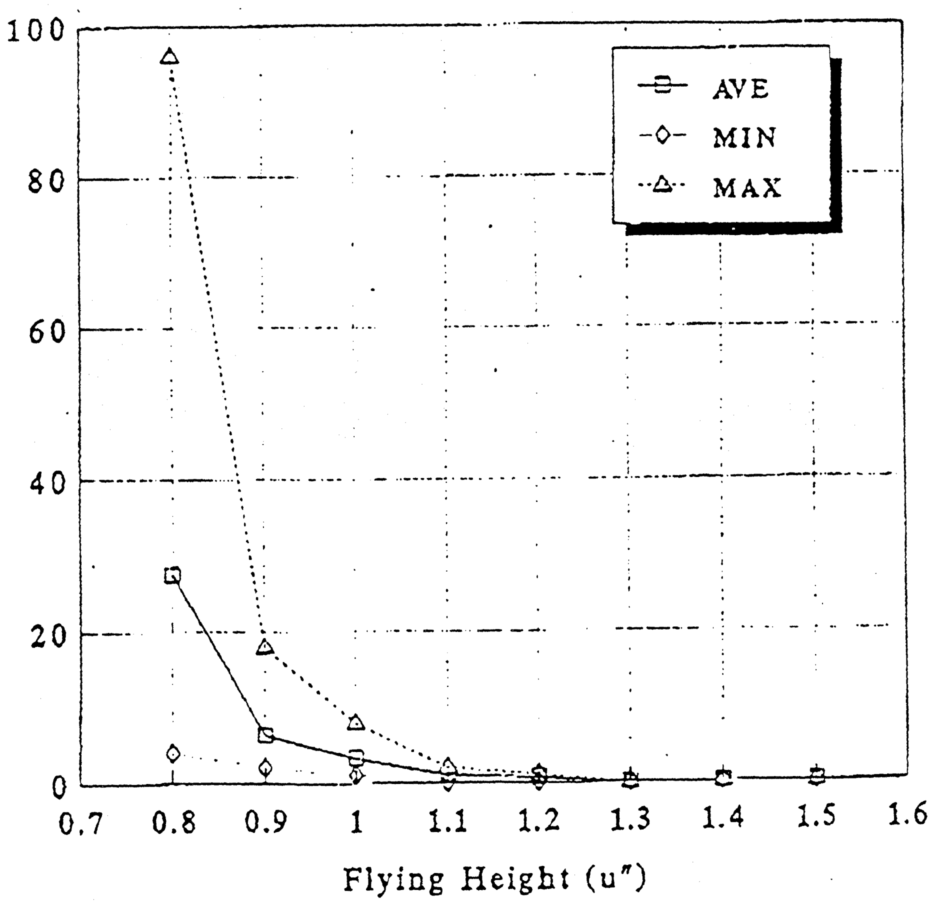
SPUTTERED THIN FILM DISK	No. QTT-950904
	Sheet 10 of 10

Glide Avalanche Curve

Glide Avalanche Curve

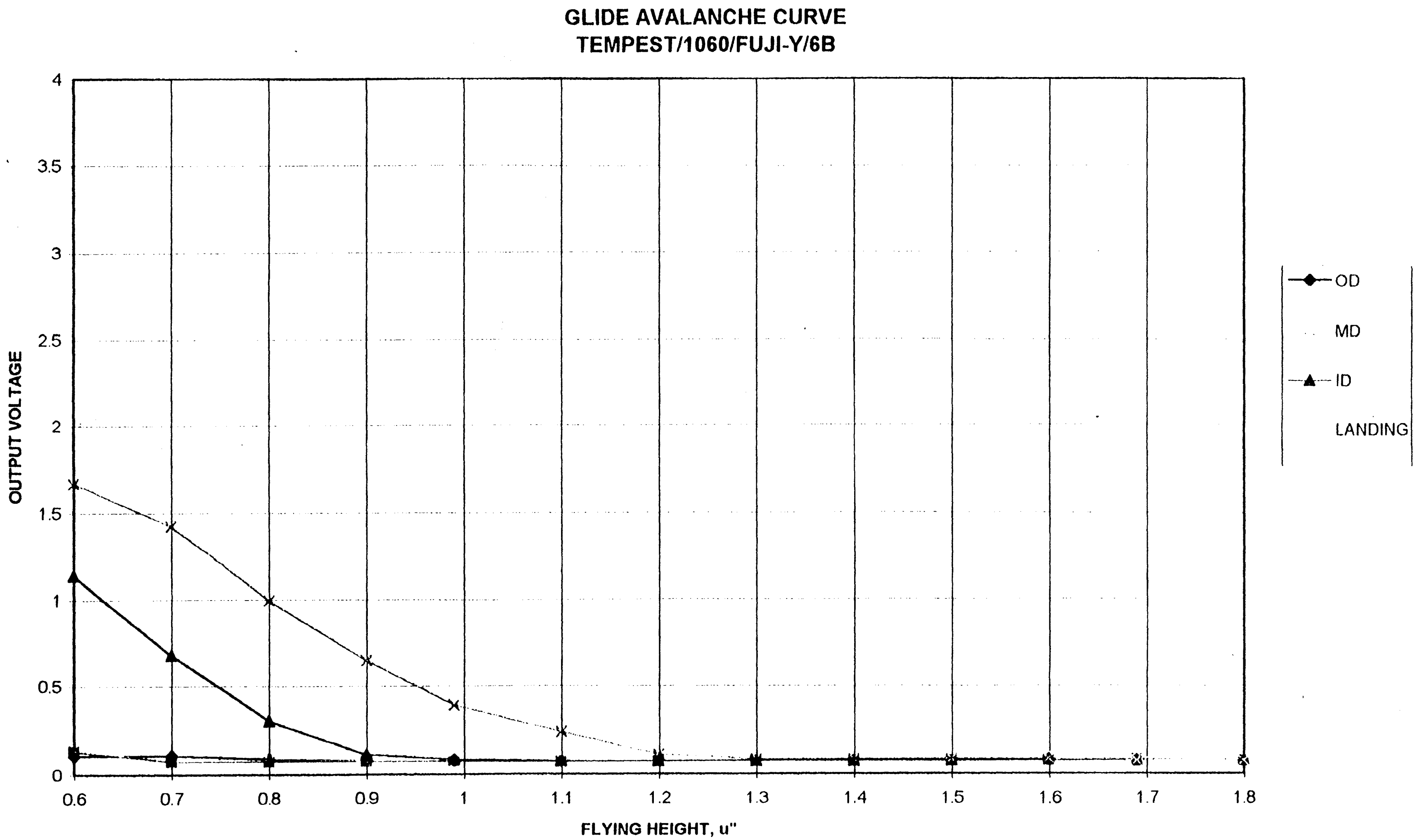
TEMPEST

Lot No.QTT-950904



HITACHI RG570 Glide Tester
Glide-Write 50% Type2 Head

ESV-062.LGB EXCEL:R13F3446.XLS



12/20/95

III. PP1 and PP2 Drive CSS Data

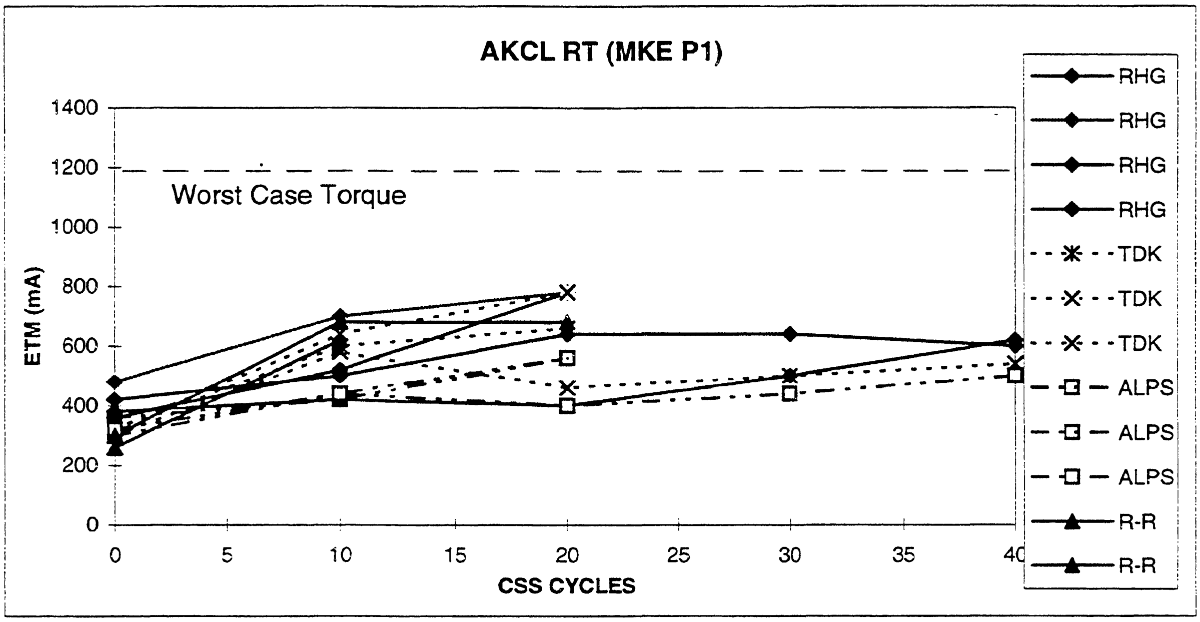
CSS Test Environment

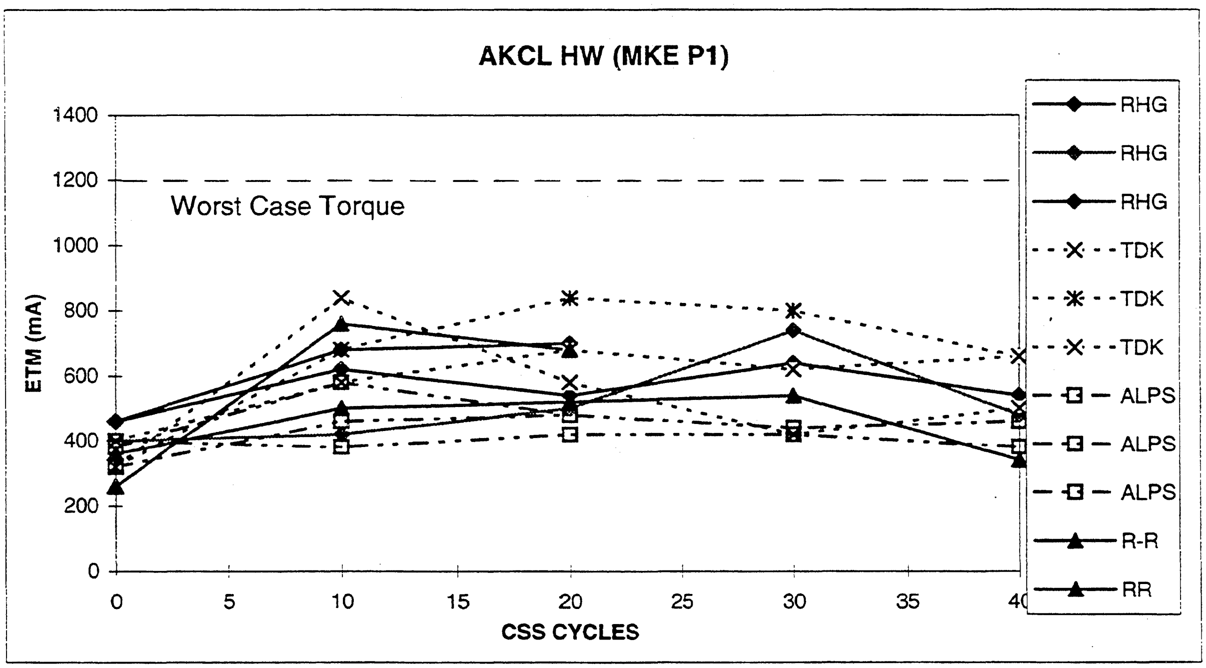
Ambient	$23 \pm 3^{0}C$ $(50 \pm 3)\%$ RH
Hot and Dry	$50 \pm 3^{0}C$ $(15 \pm 3)\%$ RH
Warm and Wet	$32 \pm 3^{0}C$ $(80 \pm 3)\%$ RH

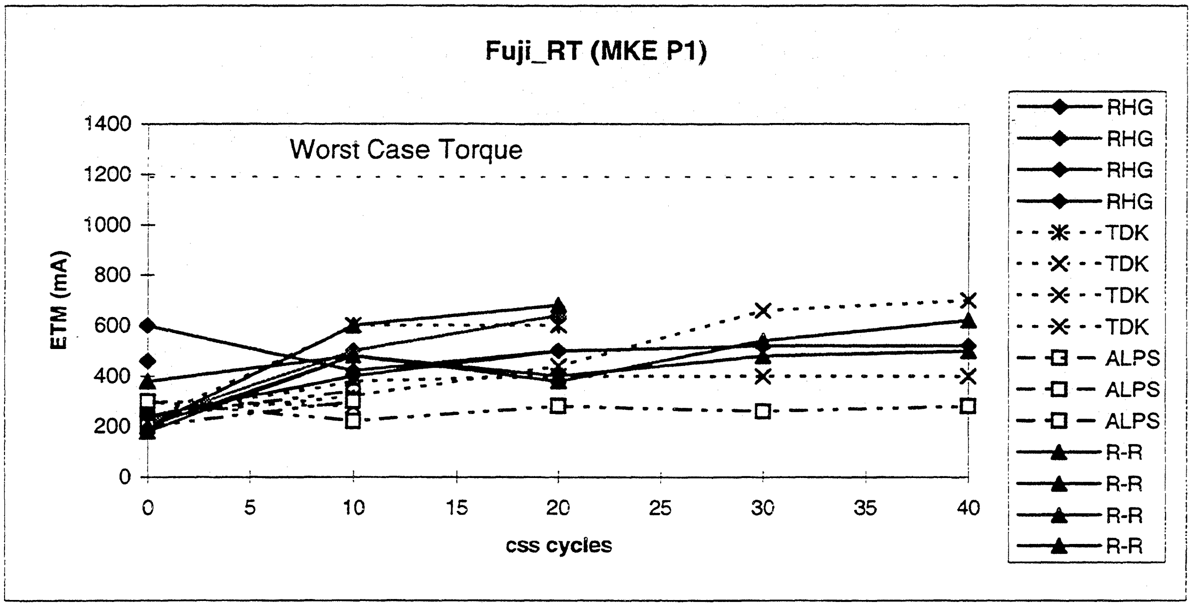
Test parameter:

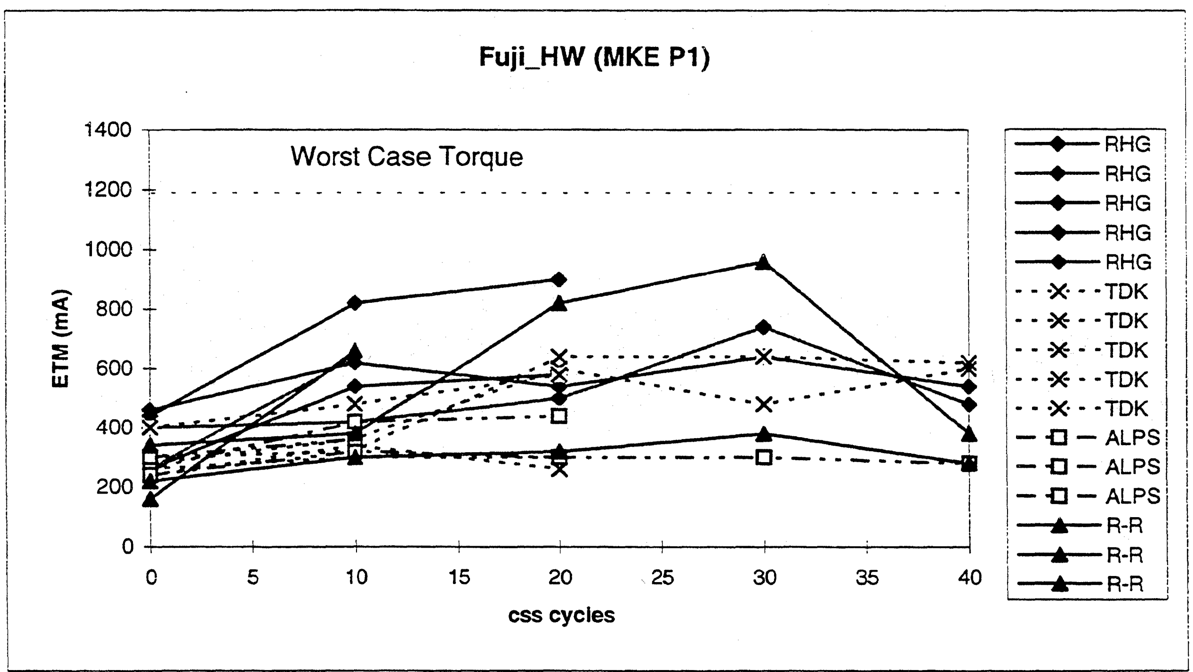
Spinup with srecal and drive in ready mode, then spindown.
Breakaway Torque after every 10k cycles and 24hr soak.
Sequential read at every 10k cycles.

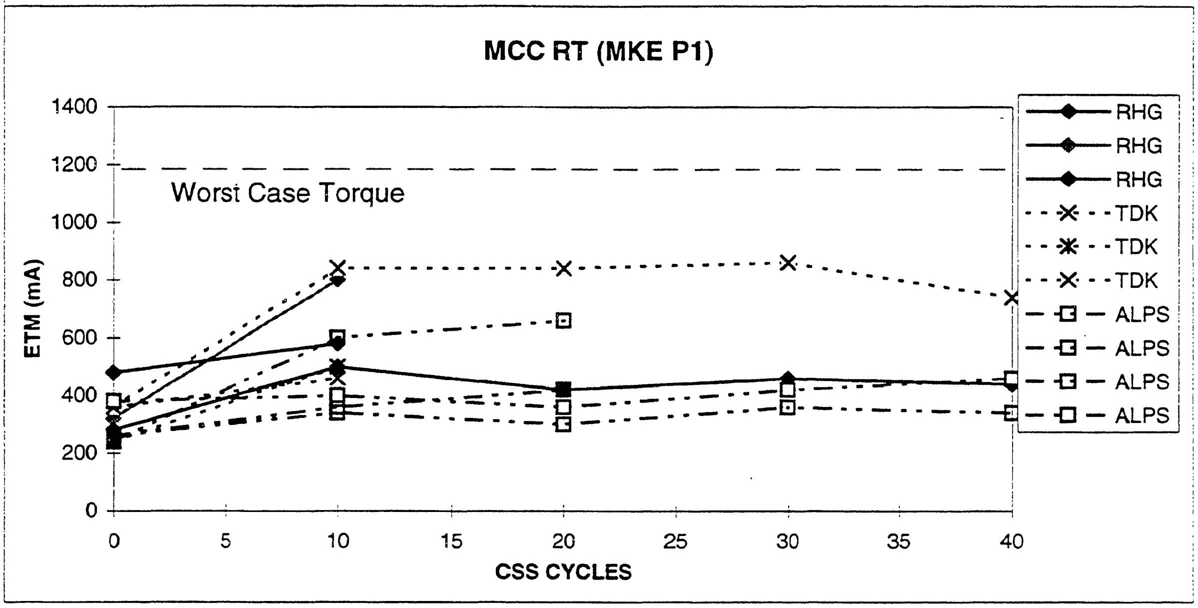
Test Matrix: every head vendors vs. every disk vendors


AKCL RT (MKE P1)
1400
1200
Worst Case Torque
1000
800
600
400
200
0
ETM (mA)
0
5
10
15
20
25
30
35
40
CSS CYCLES
RHG
RHG
RHG
RHG
TDK
TDK
TDK
ALPS
ALPS
ALPS
R-R
R-R


AKCL HW (MKE P1)
1400
1200
Worst Case Torque
1000
800
600
400
200
0
ETM (mA)
0
5
10
15
20
25
30
35
40
CSS CYCLES
RHG
RHG
RHG
TDK
TDK
TDK
ALPS
ALPS
ALPS
R-R
RR


Fuji_RT (MKE P1)
Worst Case Torque
ETM (mA)
1400
1200
1000
800
600
400
200
0
0
5
10
15
20
25
30
35
40
css cycles
RHG
RHG
RHG
RHG
TDK
TDK
TDK
TDK
ALPS
ALPS
ALPS
R-R
R-R
R-R
R-R


Fuji_HW (MKE P1)
Worst Case Torque
ETM (mA)
1400
1200
1000
800
600
400
200
0
0
5
10
15
20
25
30
35
40
css cycles
RHG
RHG
RHG
RHG
RHG
TDK
TDK
TDK
TDK
TDK
ALPS
ALPS
ALPS
R-R
R-R
R-R


MCC RT (MKE P1)
1400
1200
1000
800
600
400
200
0
ETM (mA)
Worst Case Torque
0
5
10
15
20
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CSS CYCLES
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RHG
TDK
TDK
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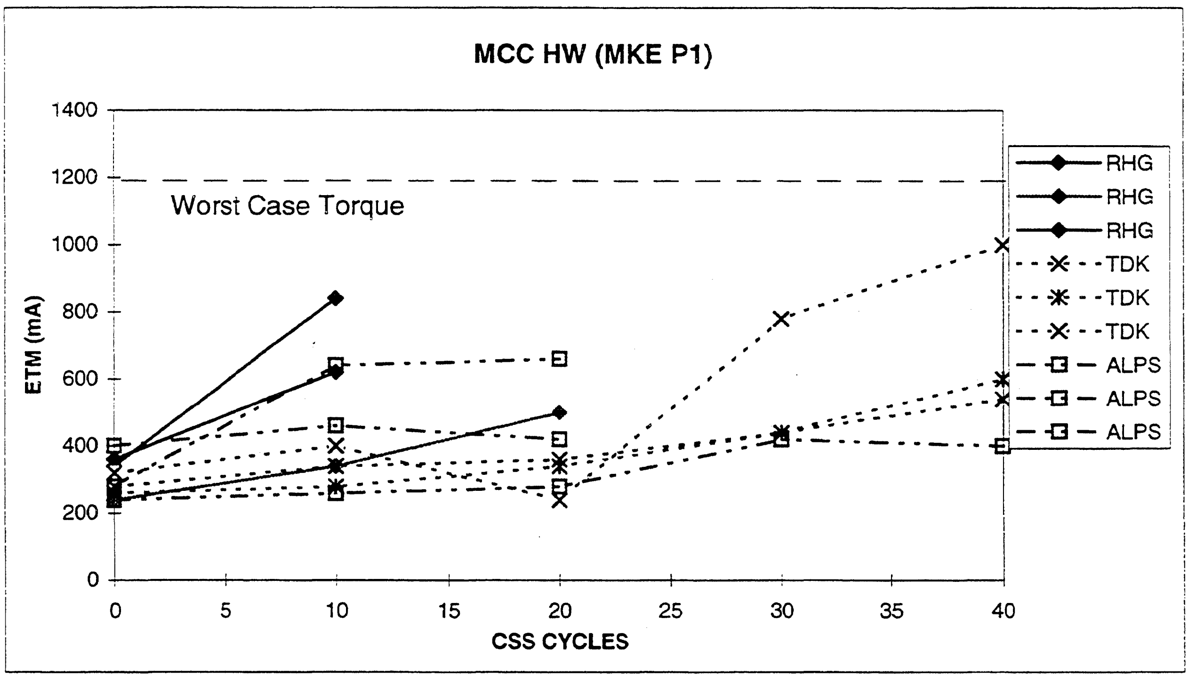
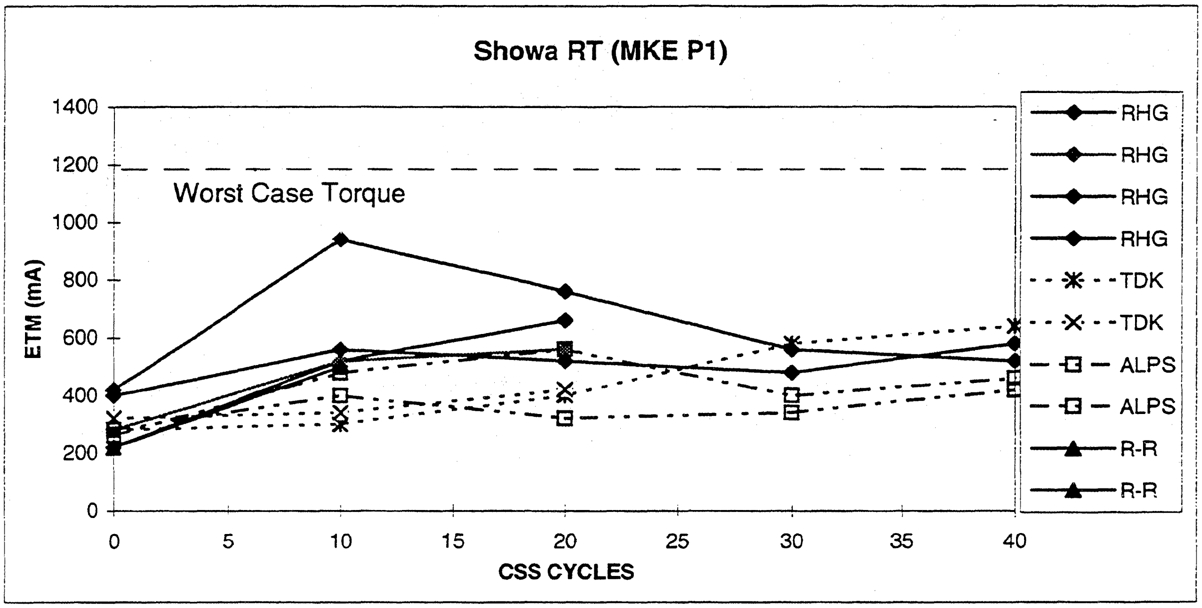
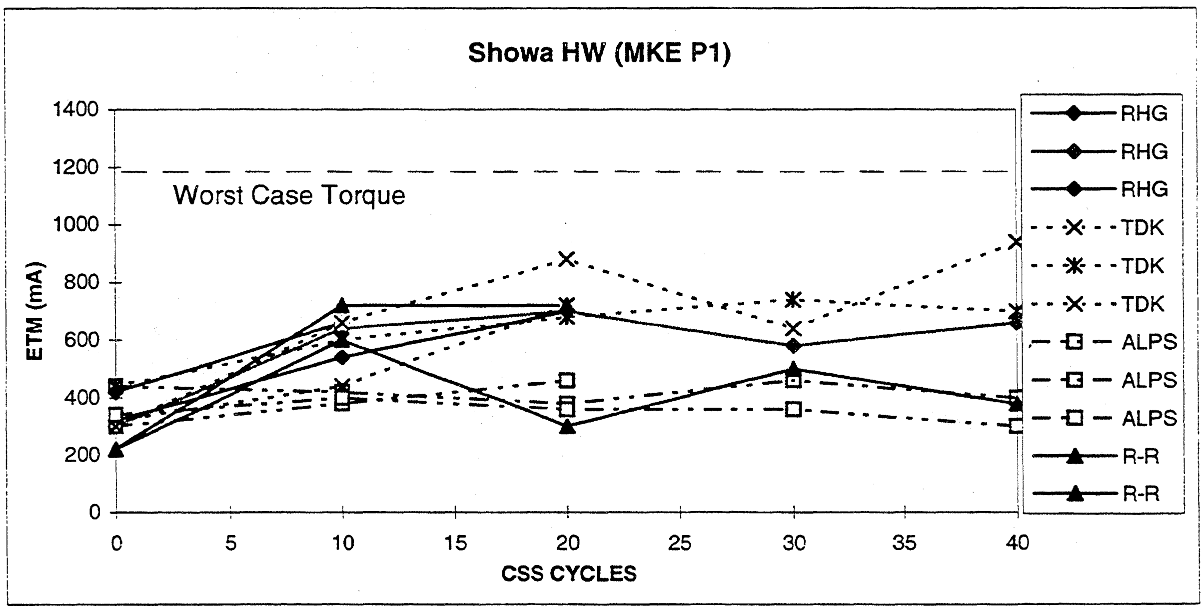
ALPS
ALPS
ALPS
ALPS


MCC HW (MKE P1)
1400
1200
1000
800
600
400
200
0
ETM (mA)
Worst Case Torque
0
5
10
15
20
25
30
35
40
CSS CYCLES
RHG
RHG
RHG
TDK
TDK
TDK
ALPS
ALPS
ALPS

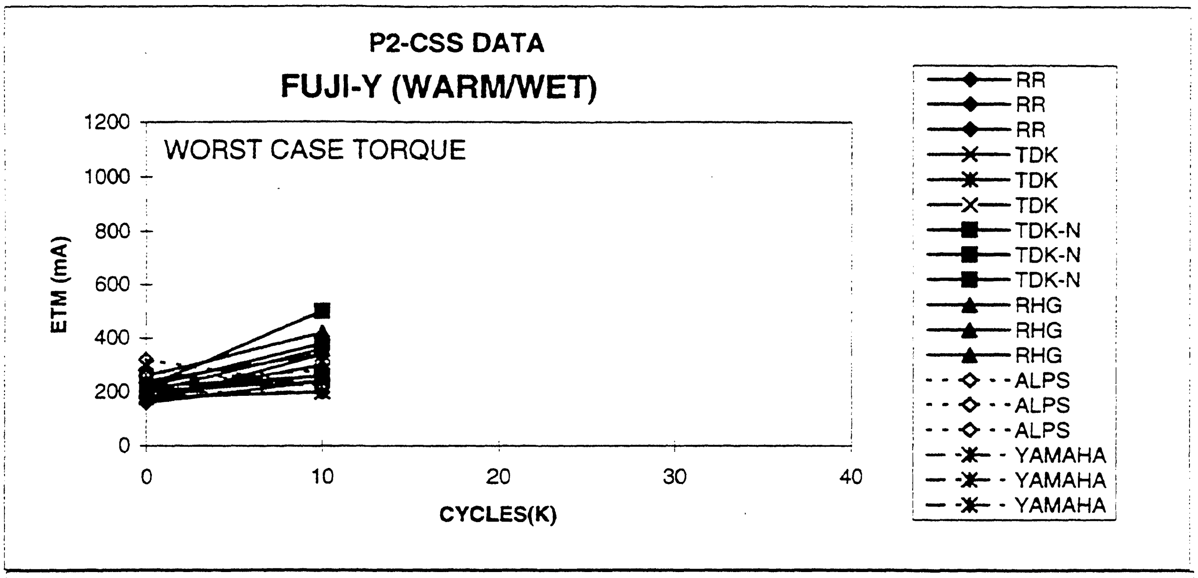
SHOWA

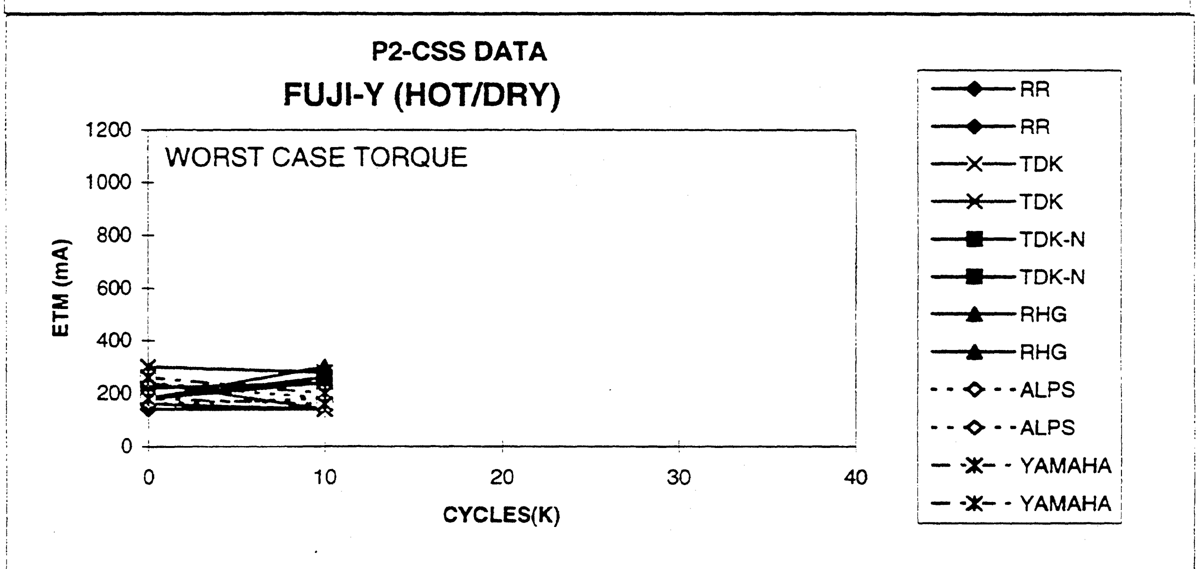


Showa RT (MKE P1)
Worst Case Torque
ETM (mA)
CSS CYCLES
RHG
RHG
RHG
RHG
TDK
TDK
ALPS
ALPS
R-R
R-R



Showa HW (MKE P1)
Worst Case Torque
ETM (mA)
CSS CYCLES
RHG
RHG
RHG
TDK
TDK
TDK
ALPS
ALPS
ALPS
R-R
R-R


P2-CSS DATA
FUJI-Y (WARM/WET)
WORST CASE TORQUE
ETM (mA)
1200
1000
800
600
400
200
0
0
10
20
30
40
CYCLES(K)
RR
RR
RR
TDK
TDK
TDK
TDK-N
TDK-N
TDK-N
RHG
RHG
RHG
ALPS
ALPS
ALPS
YAMAHA
YAMAHA
YAMAHA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FUJI-Y (HOT/DRY)
WORST CASE TORQUE
ETM (mA)
1200
1000
800
600
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200
0
0
10
20
30
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CYCLES(K)
RR
RR
TDK
TDK
TDK-N
TDK-N
RHG
RHG
ALPS
ALPS
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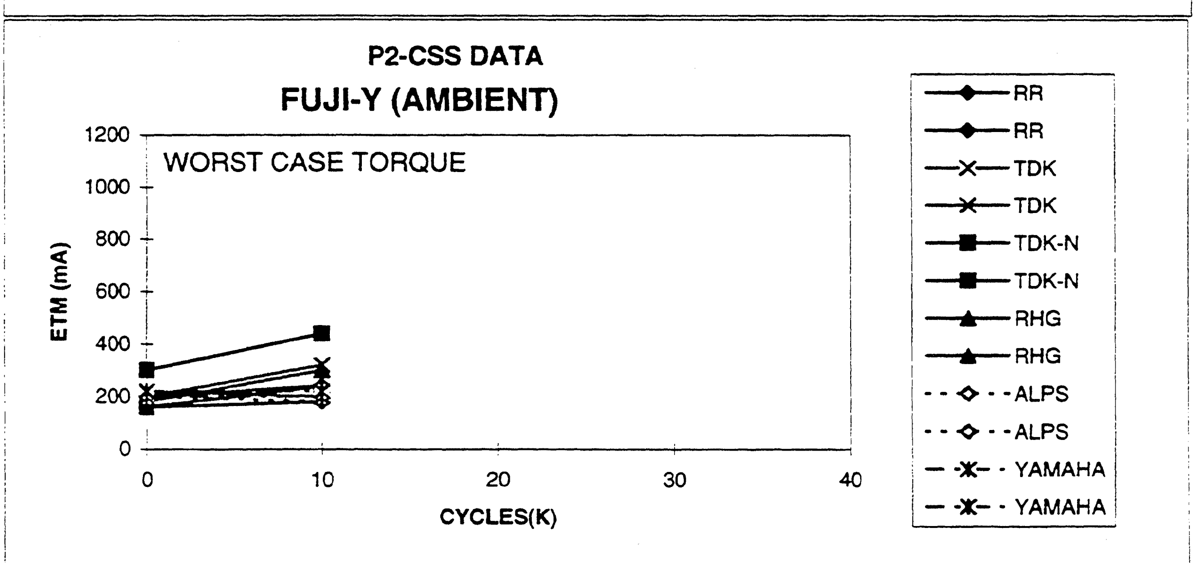
YAMAHA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ETM (mA)
1200
1000
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200
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0
10
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CYCLES(K)
RR
RR
TDK
TDK
TDK-N
TDK-N
RHG
RHG
ALPS
ALPS
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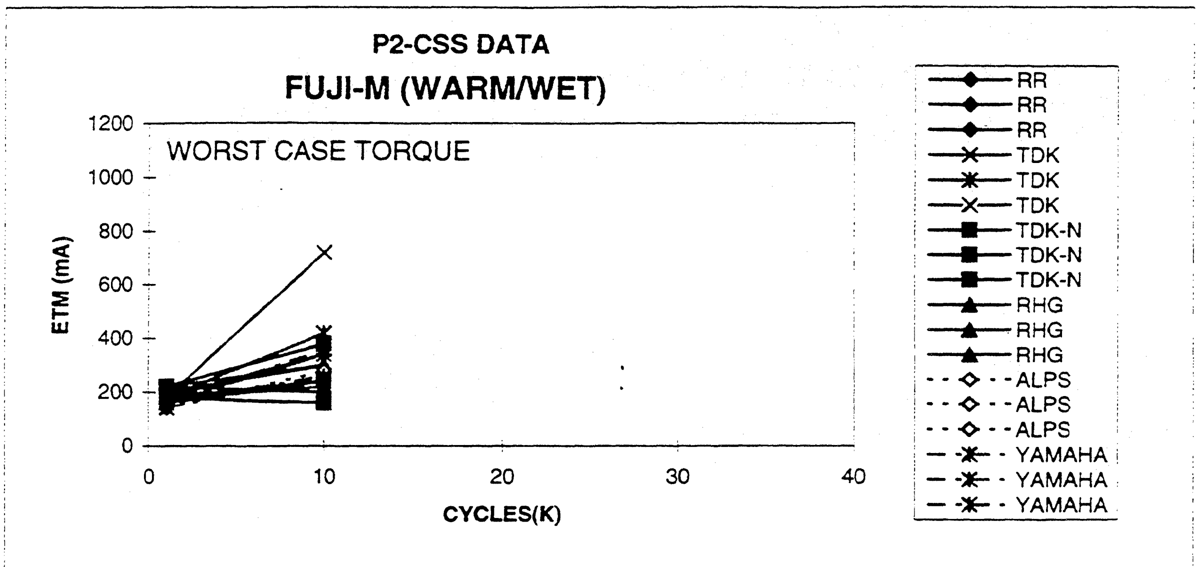
YAMAHA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WORST CASE TORQUE
ETM (mA)
1200
1000
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CYCLES(K)
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TDK
TDK-N
TDK-N
TDK-N
RHG
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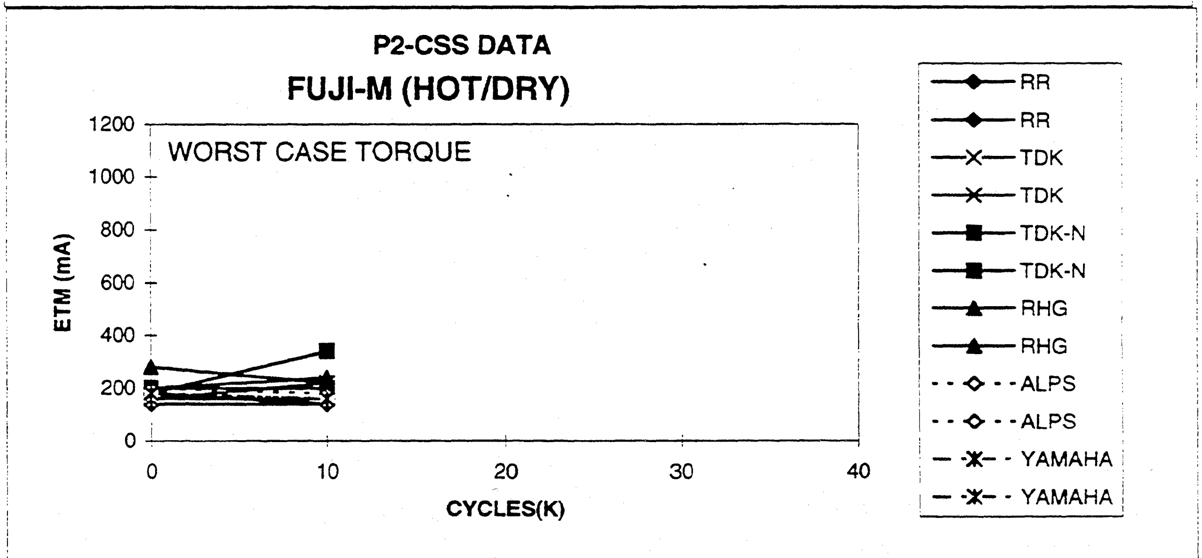
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FUJI-M (HOT/DRY)
WORST CASE TORQUE
ETM (mA)
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CYCLES(K)
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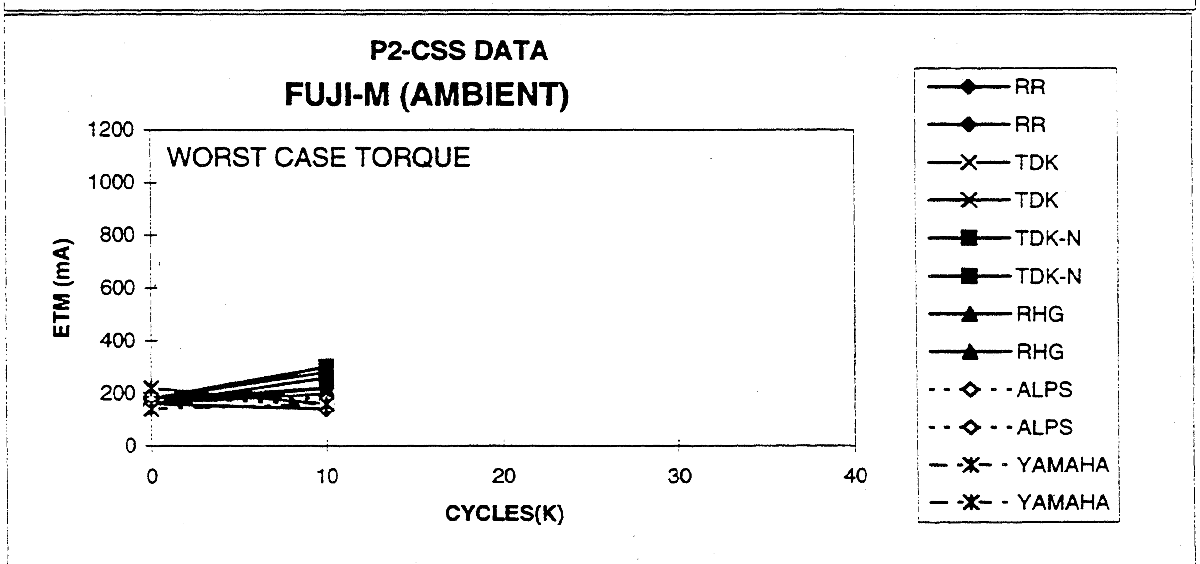
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FUJI-M (AMBIENT)
WORST CASE TORQUE
ETM (mA)
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CYCLES(K)
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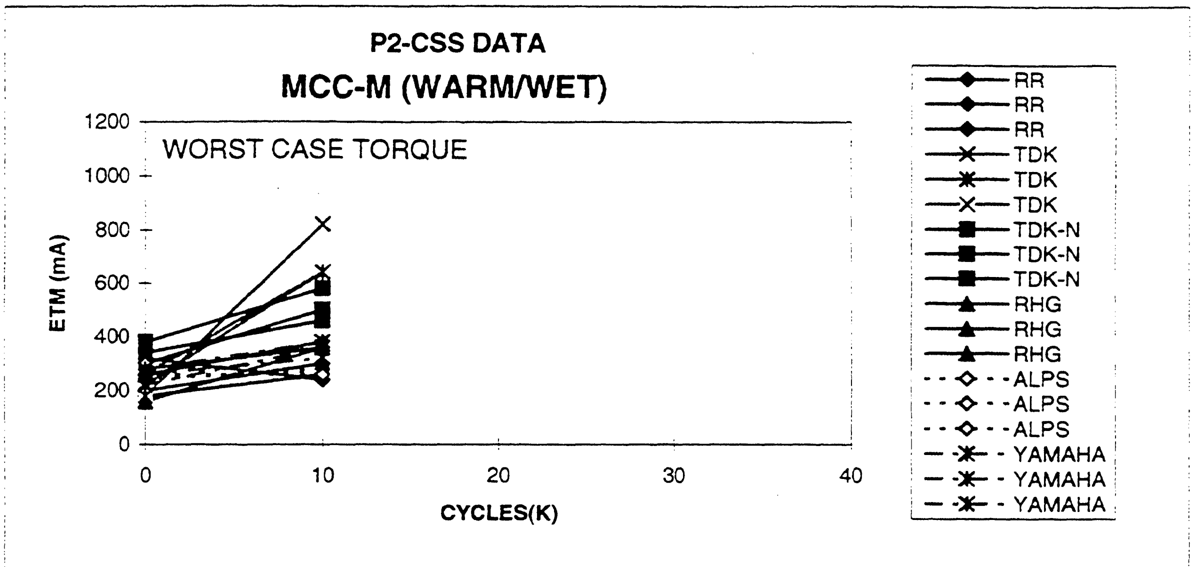
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MCC-M (WARM/WET)
WORST CASE TORQUE
ETM (mA)
1200
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CYCLES(K)
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TDK
TDK-N
TDK-N
TDK-N
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RHG
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ALPS
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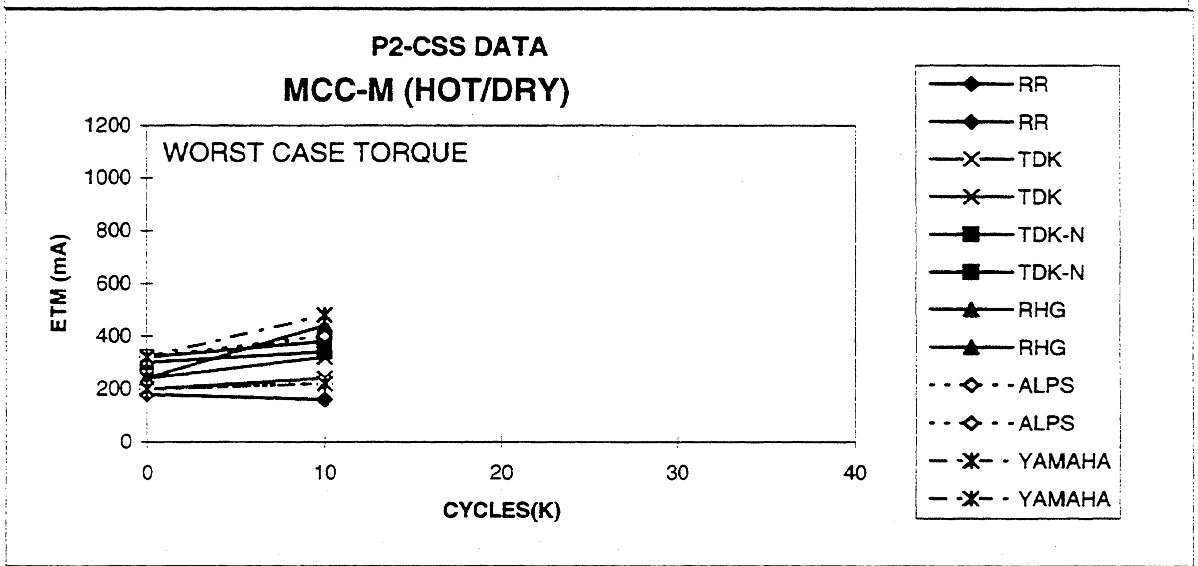
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MCC-M (HOT/DRY)
WORST CASE TORQUE
ETM (mA)
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CYCLES(K)
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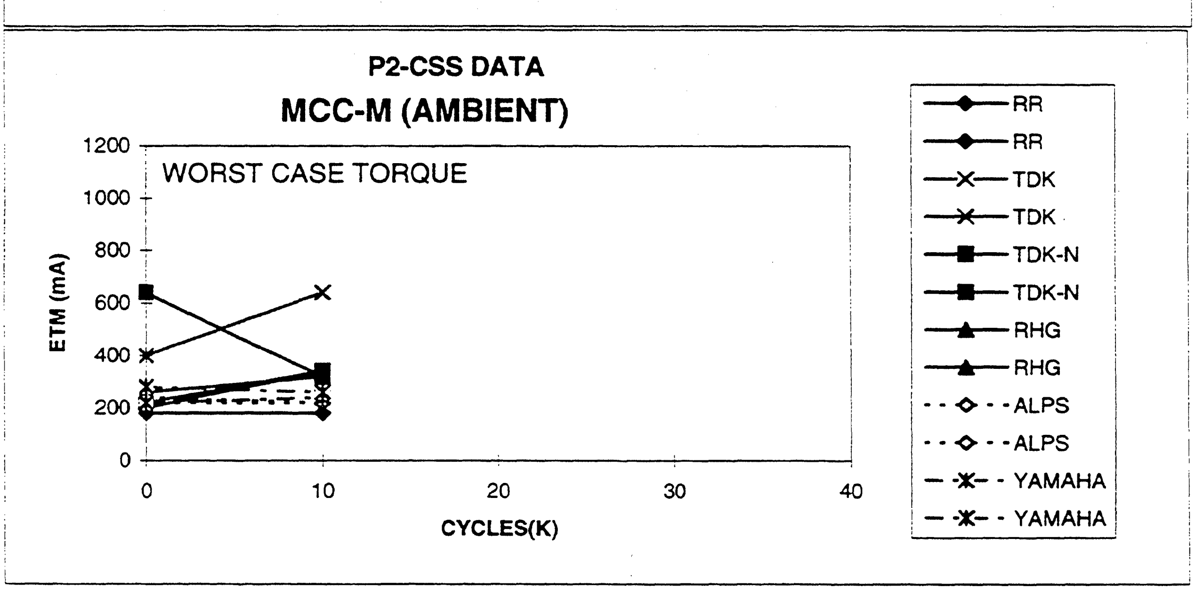
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MCC-M (AMBIENT)
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ETM (mA)
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CYCLES(K)
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RHG
RHG
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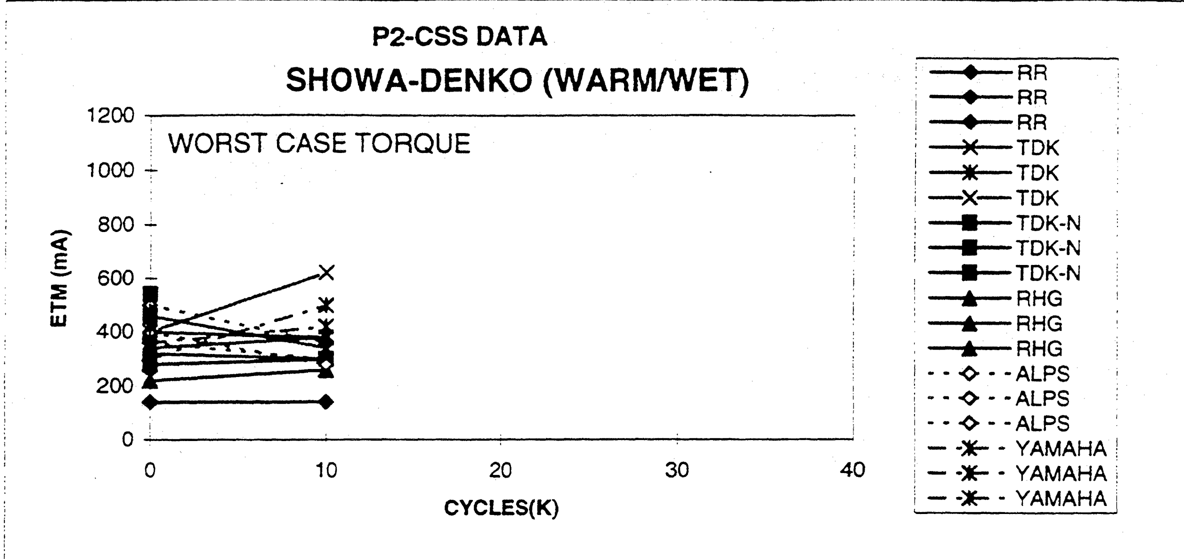
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CYCLES(K)
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TDK-N
TDK-N
RHG
RHG
RHG
ALPS
ALPS
ALPS
YAMAHA
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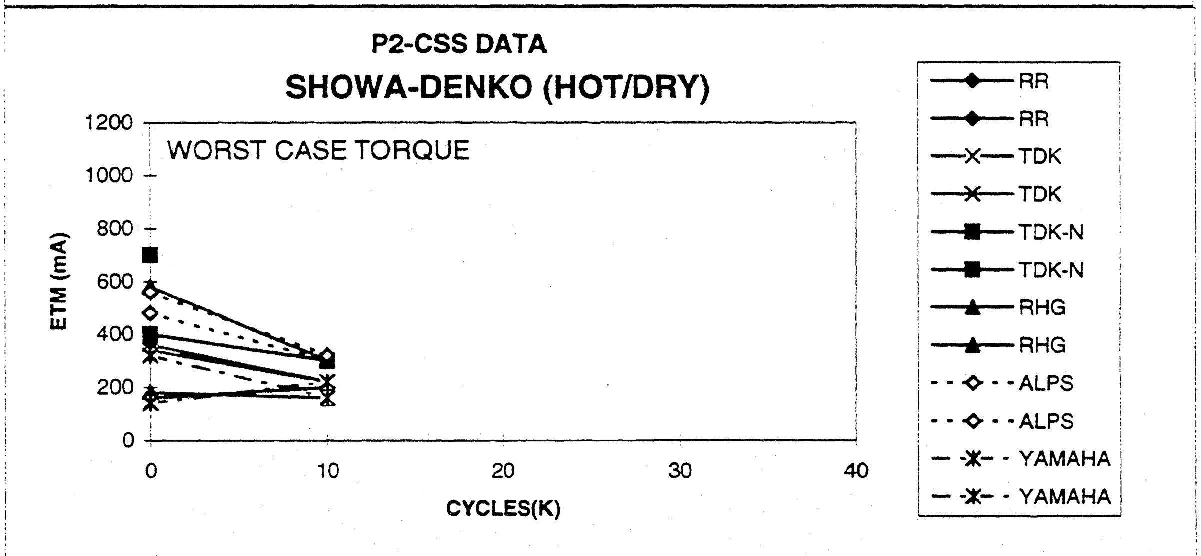
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SHOWA-DENKO (HOT/DRY)
WORST CASE TORQUE
ETM (mA)
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CYCLES(K)
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TDK-N
TDK-N
RHG
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ALPS
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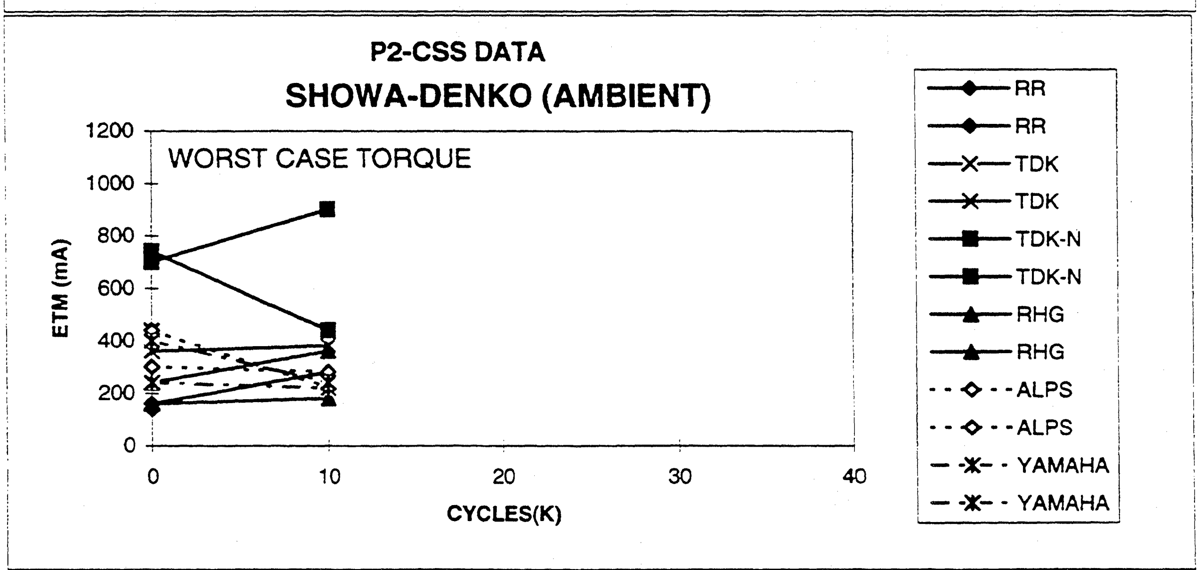
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SHOWA-DENKO (AMBIENT)
WORST CASE TORQUE
ETM (mA)
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CYCLES(K)
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TDK-N
TDK-N
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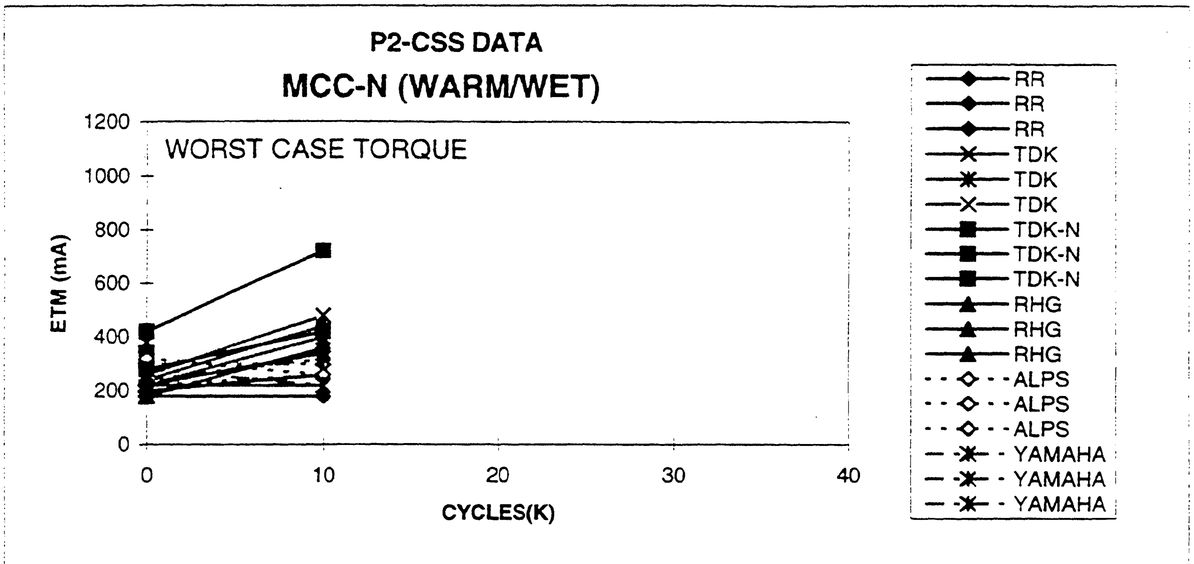
P2-CSS DATA
MCC-N (WARM/WET)
WORST CASE TORQUE
ETM (mA)
CYCLES(K)
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1200
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RR
TDK
TDK
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TDK-N
TDK-N
TDK-N
RHG
RHG
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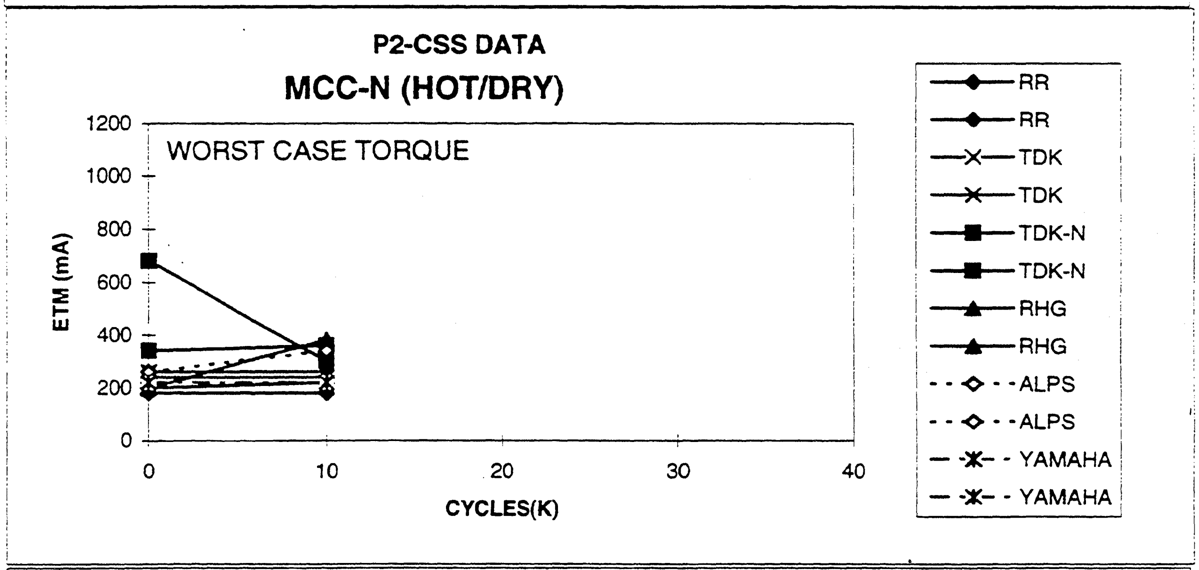
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ETM (mA)
CYCLES(K)
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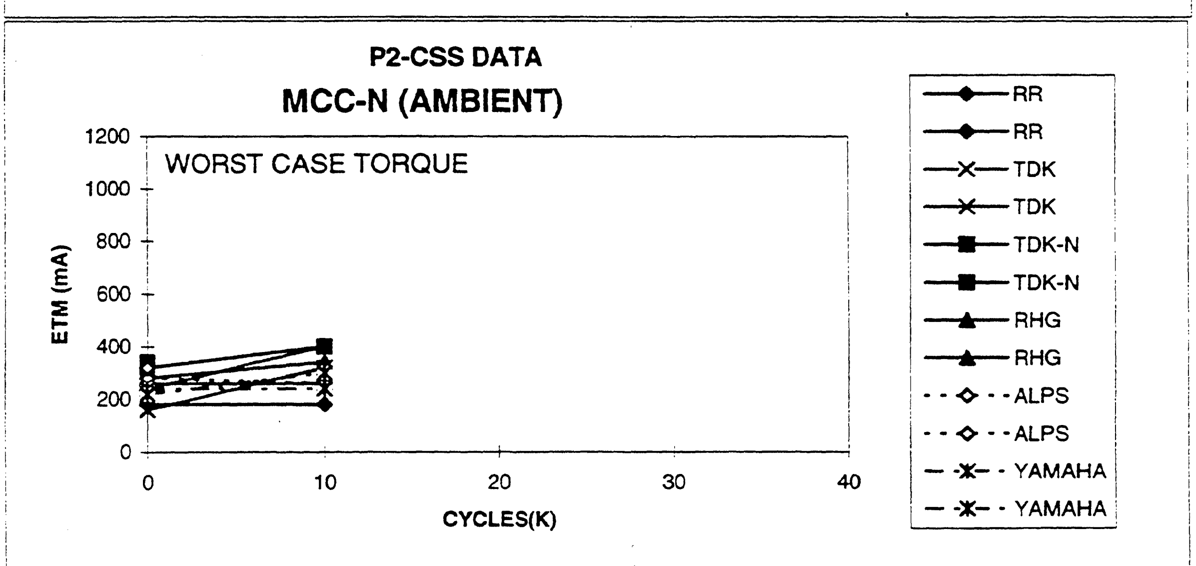
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MCC-N (AMBIENT)
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ETM (mA)
CYCLES(K)
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TDK-N
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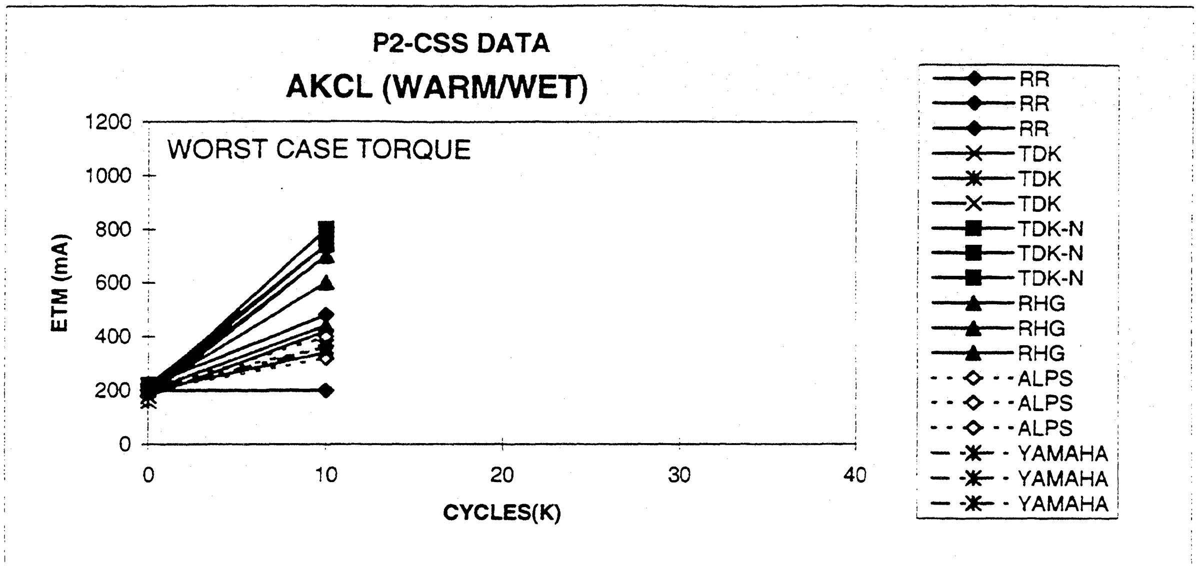
P2-CSS DATA
AKCL (WARM/WET)
WORST CASE TORQUE
ETM (mA)
1200
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CYCLES(K)
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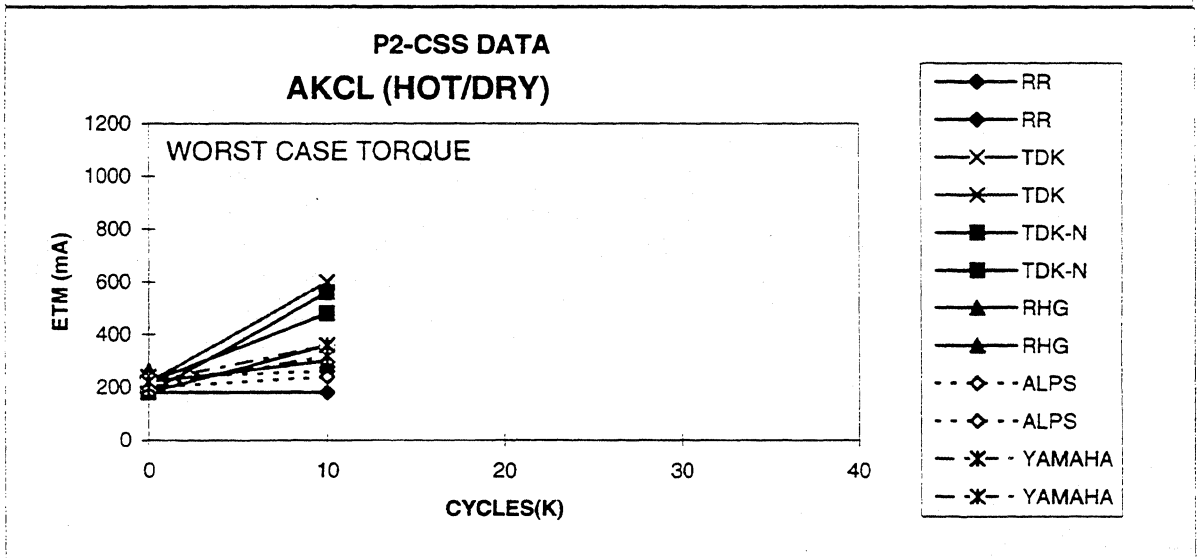
P2-CSS DATA
AKCL (HOT/DRY)
WORST CASE TORQUE
ETM (mA)
1200
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CYCLES(K)
RR
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TDK
TDK
TDK-N
TDK-N
RHG
RHG
ALPS
ALPS
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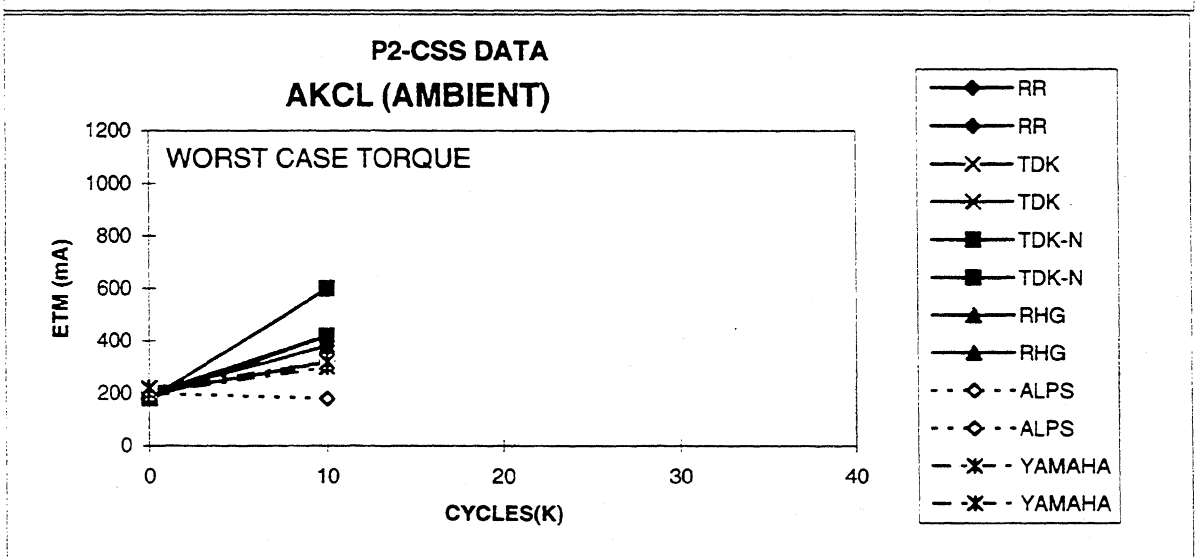
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AKCL (AMBIENT)
WORST CASE TORQUE
ETM (mA)
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CYCLES(K)
RR
RR
TDK
TDK
TDK-N
TDK-N
RHG
RHG
ALPS
ALPS
YAMAHA
YAMAHA

IV. PP2 Drive HDA and Selfscan Data

Data supplied from P2 drive testing

1. Parametrics (TAA, PW50, Asym, NLTS, Resol, SNR)
2. MR resistance
3. MR head instability test (COV, MSE variation)
4. raw-error rate
5. Off-track capability
6. Media defect map

Tempest P2 Head/Media Mean Parametrics

	RHGS	RHGB	TDK	TDKN	Alps	Yamaha	RR
HFTAA (mV)	83.6	86.7	109	93.9	90.2	98.3	139
Asymmetry (<±20%)	3.8	-1.9	-0.1	-1.2	1.5	-1.4	-4.9
IACSN (dB)	20.8	20.9	21.3	21.0	21.2	21.4	22.6
Pos. PW50/T	1.69	1.77	1.77	1.76	1.83	1.85	1.82
Neg. PW50/T	1.76	1.75	1.79	1.75	1.85	1.83	1.74
OW @MD (>30dB)	36.0	33.9	35.0	36.1	36.1	34.3	35.2
NLTS @OD (<25%)	13.6	14.3	15.9	13.4	17.4	18.6	14.8
Resolution (>70%)	83.3	83.1	80.8	81.8	81.5	80.4	82.3
Pos. Mod. (%)	5.6	5.5	6.7	6.8	6.6	6.0	6.6
Neg. Mod. (%)	-5.8	-5.8	-6.8	-6.9	-6.7	-6.3	-6.8
Resistance (17 to 40Ω)	27.5	26.4	20.5	22.8	22.6	23.8	22.7
COV (<2.5%)	0.7	0.8	0.8	0.9	1.7	1.2	1.6
Microjog @ MD (μstep)	-328	-273	-19	10	-256	126	-583

ii. MEDIA SUPPLIER STATUS

Disk Vendor	Technical Issues	Improvement Plan
MCC	1. Glide Improvement	Texture and contamination control
	2. CSS stiction	Lube and Carbon
AKCL	1. NLTS, OW	Mrt and Hc optimization
	2. CSS stiction	lube
Fuji	1. site qualification	

VI. MR SPECIAL ISSUES

- **Thermal Asperity**

  Head/Media Clearance Control (1.2u"Glide/2.0u" min fly height)

  "Blue" Read/Write Channel/Akbar Controller TA Recovery

- **MR Head Instability**

  MR Head Design & Process Improvement

  100% Screening by Head Vendors with On-Track COV and Additional Test

  100% Drive Screen Test

  Recovery Algorithms in Read/Write Channel

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Follows: **Supplier Review** Tab

- **MR Reliability**

Process Control

Nominal Current Density: 2x10^7 A/cm^2

Stripe Height Control --Dynamic Bow Compensation during Lapping (MP)

Long Term and Accelerated Correlation and Enforcement of Accelerated Tests

Quantum reliability tests of Tempest heads from all the vendors have been finished. The following specifications are going to be enforced on head suppliers.

1 Accelerated Reliability Test

2. Temperature Rise vs. Bias Current

3. Head/Media Breakdown Voltage Spec.

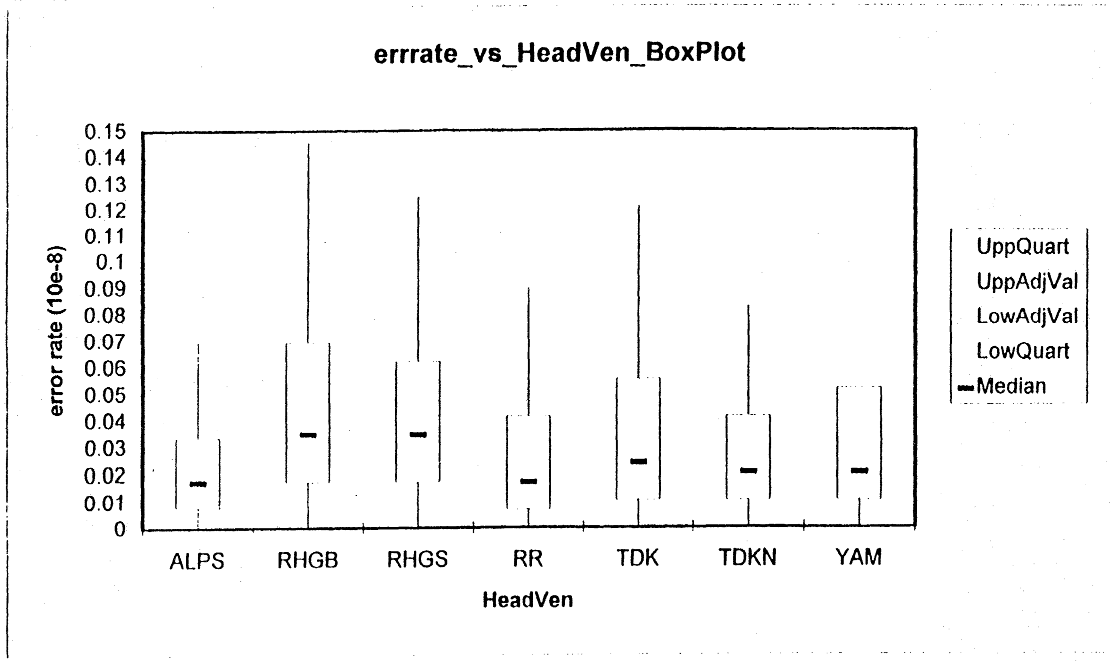
- **ESD**

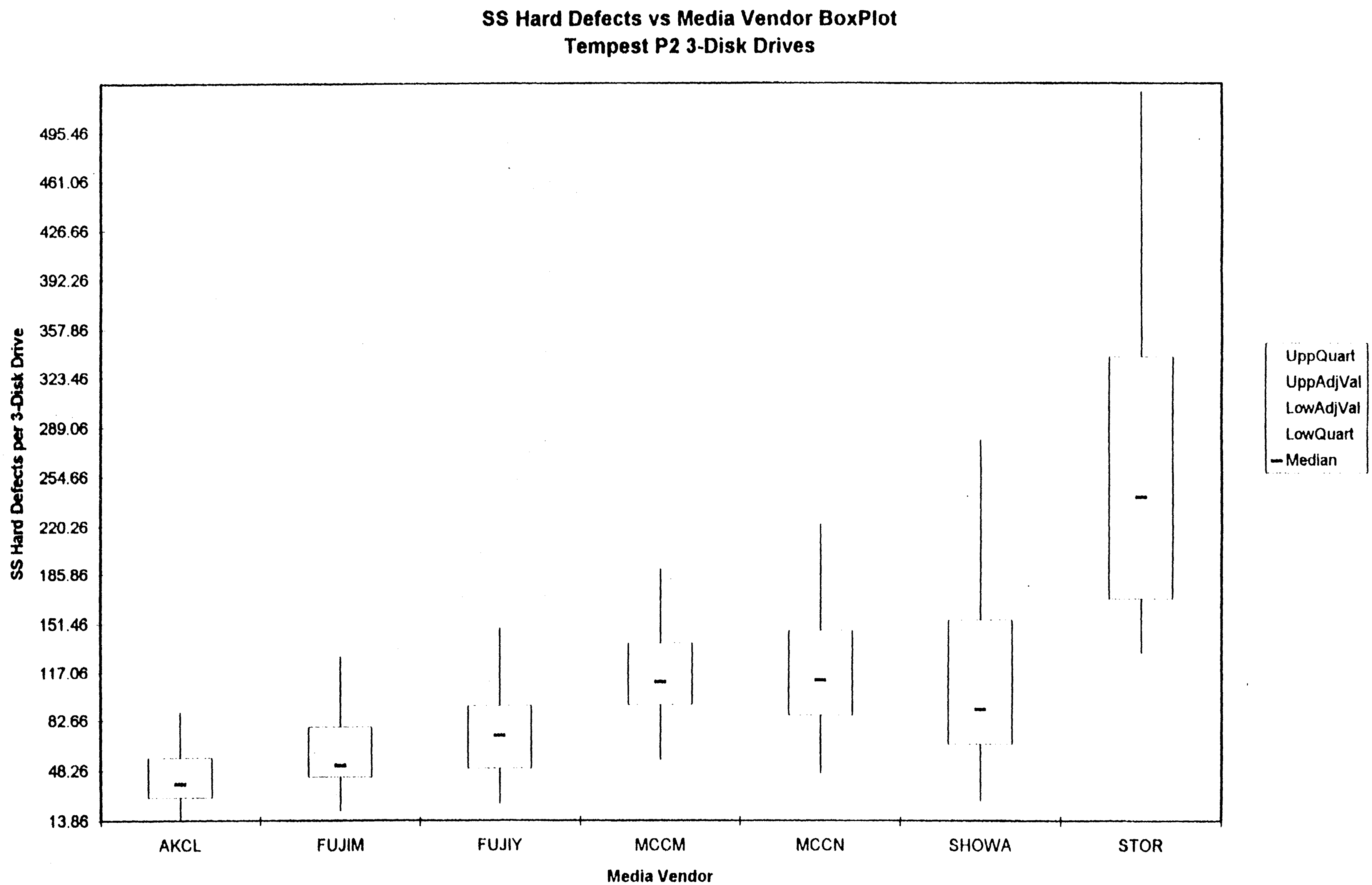
ESD Precautions at Head Manufacture
ESD Protections at MKE Assembly

Tempest P2 Head/Media Mean Parametrics

	Fuji-M	Fuji-Y	MCMM	MCCN	AKCL	Showa	StorM
HFTAA (mV)	99.5	102	94.8	93.9	102	101	108
Asymmetry (<±20%)	0.0	-1.1	-0.7	-0.7	-0.4	-0.7	-0.2
IACSN (dB)	21.9	21.6	21.0	21.0	21.0	21.1	21.5
Pos. PW50/T	1.81	1.80	1.76	1.77	1.83	1.79	1.75
Neg. PW50/T	1.81	1.79	1.75	1.76	1.83	1.77	1.76
OW @MD (>30dB)	36.5	35.7	35.9	35.8	32.6	35.3	34.8
NLTS @OD (<25%)	16.1	14.7	14.9	15.2	17.6	14.0	15.5
Resolution (>70%)	81.3	81.7	82.3	81.9	81.0	82.2	82.7
Pos. Mod. (%)	6.0	6.4	7.1	7.0	5.6	5.7	5.8
Neg. Mod. (%)	-6.1	-6.4	-7.1	-6.9	-6.2	-5.7	-6.3
COV (<2.5%)	1.1	1.1	1.1	1.1	1.0	1.1	1.1
Microjog @ MD (μstep)	-180	-198	-139	-183	-207	-216	-211

Group	ALPS	RHGB	RHGS	RR	TDK	TDKN	YAM
Mean	0.045753	0.062308	0.054534	0.045773	0.085196	0.035445	0.055565
IQR	0.025763	0.052039	0.0451	0.034693	0.0451	0.031223	0.041631
# Pts	1806	444	228	468	1372	378	574





SS Hard Defects vs Media Vendor BoxPlot
Tempest P2 3-Disk Drives
SS Hard Defects per 3-Disk Drive
495.46
461.06
426.66
392.26
357.86
323.46
289.06
254.66
220.26
185.86
151.46
117.06
82.66
48.26
13.86
AKCL
FUJIM
FUJIY
MCCM
MCCN
SHOWA
STOR
Media Vendor
UppQuart
UppAdjVal
LowAdjVal
LowQuart
Median

V. PP2 Supplier Issues

i.Head Supplier Status

Head Vendor	Technical Issues	Improvement Plan
RHG	1. TAA Distribution Stripe Height Control 2. Head Yield Improvement	Dynamic Bow- Compensation (MP) Process Control
TDK	1. CSS 2. Stripe Height Control	ABS Lapping process control DBC (MP)
ALPS	1. Escape of Unstable Head 2. NLTS	Process Improvement and tighter screening Yoke structure
Yamaha	1. Read Track Width	Add a screening process
Read-Rite	1. Minimum flying height 2. Head Yield Improvement	increase the average flying height