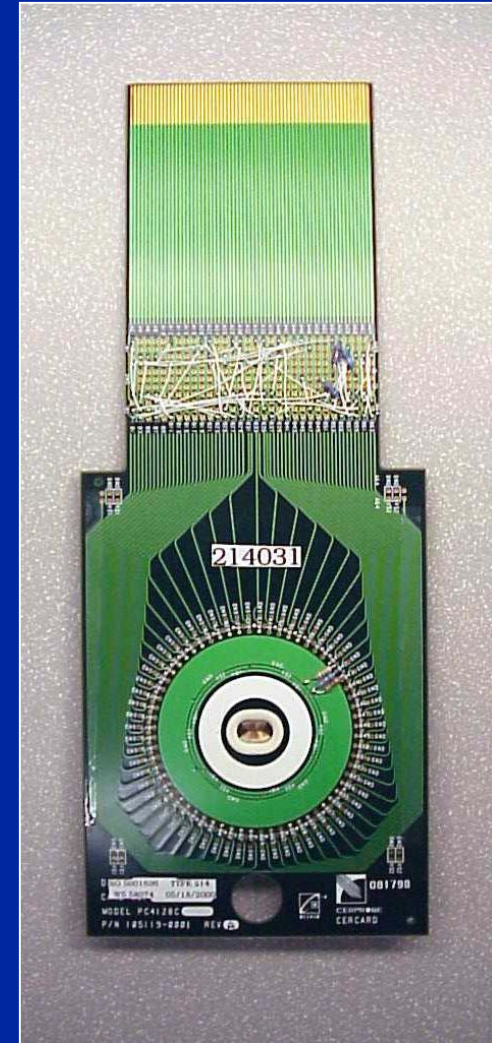


Overview

- Problem statement
- Solution summary
- Wafer probing at Seagate
- Data integrity risks
- Key improvements
- Results



Problem Statement

At any given time, the factory has hundreds of probe cards on hand.

Cards are repaired and used on multiple shifts, 24/7.

There is a chance that non-conforming probe cards will make it to the test floor and cause scrap.

How do we minimize that chance?



tester



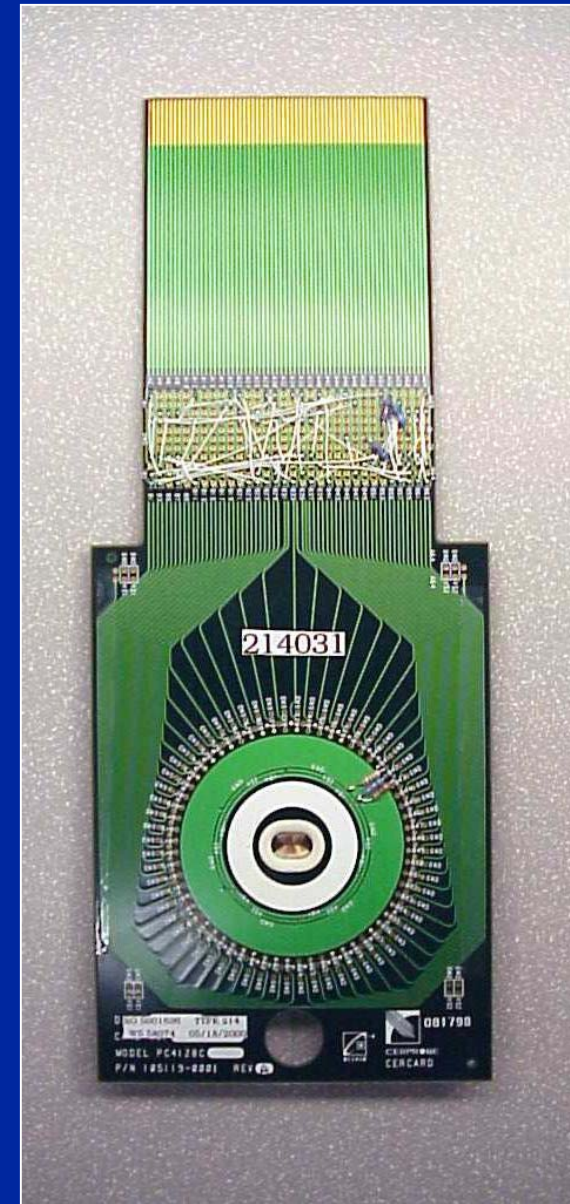
probe cards



analyzer

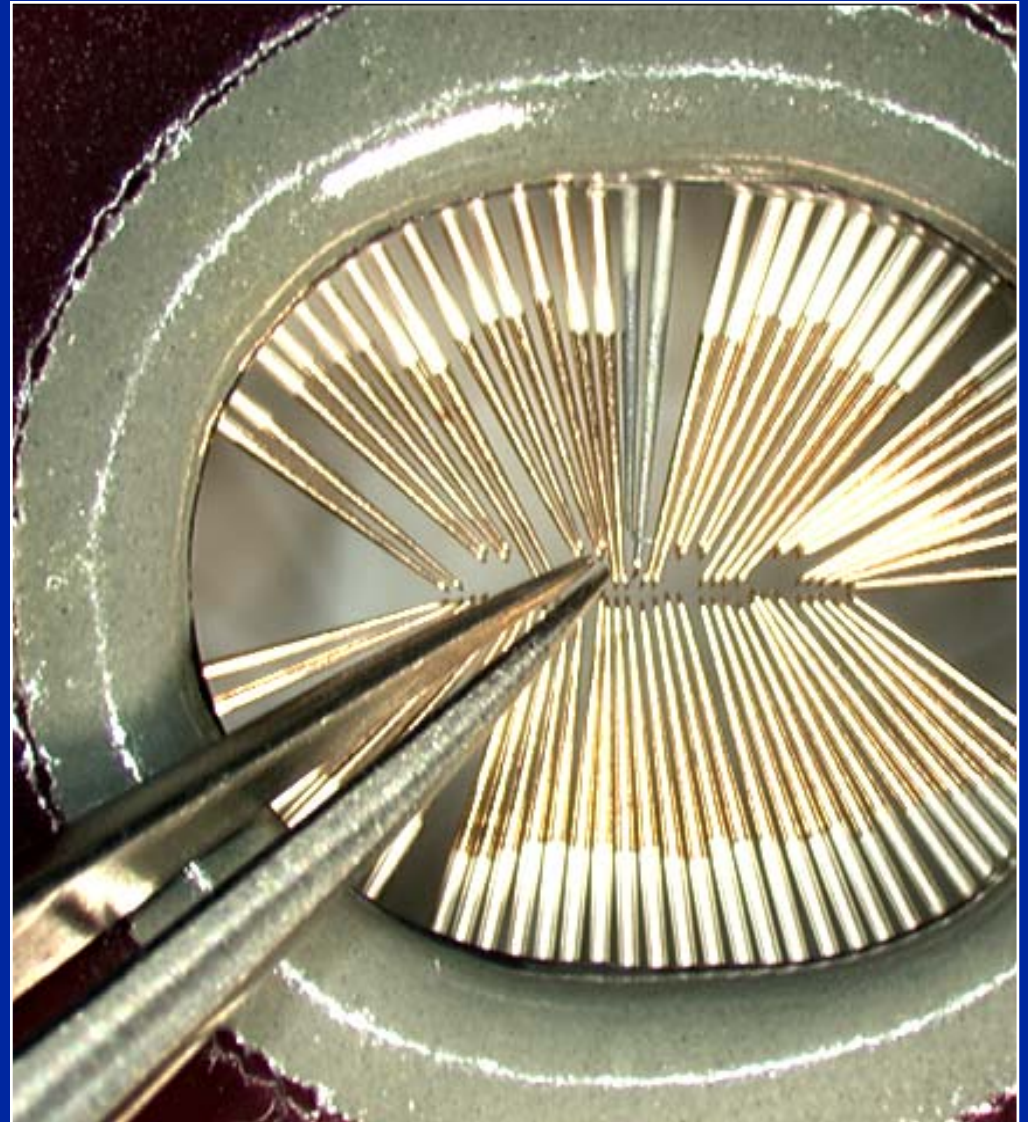
Wafer Probing at Seagate/Recording Head Operations

- The read/write heads for disc drives are probed in wafer form. A wafer can contain tens of thousands of heads.
- The large number of heads to be probed requires several hundred probe cards in various configurations.
- Though the number of probes per card is relatively small, the tip density and frequency of touchdowns is high.
- Keeping track of the repair status of each probe card is critical to the quality of the test operations.



Probe Card Fit for Use?

How do we verify
a probe card is fit
for use?



Probe Card Analyzer

In order to verify a probe card is fit for use, it is tested on a probe card analyzer.

The analyzer measures critical physical and electrical probe card parameters:

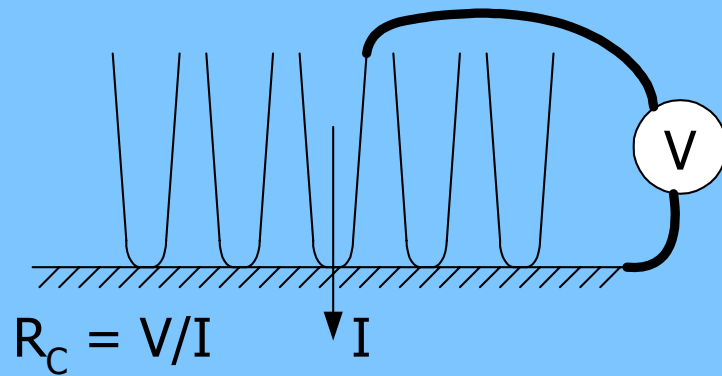
- Contact resistance
- Leakage current
- Alignment
- Planarity



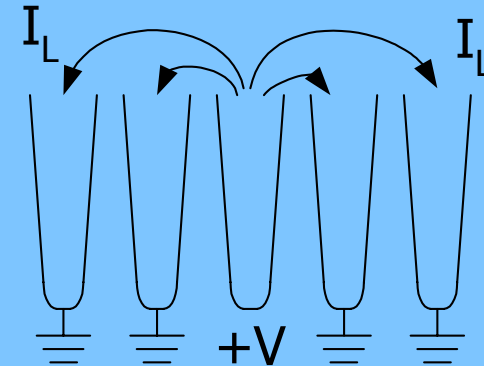
Applied Precision model PRV2
probe card analyzer

Probe Card Analyzer Tests

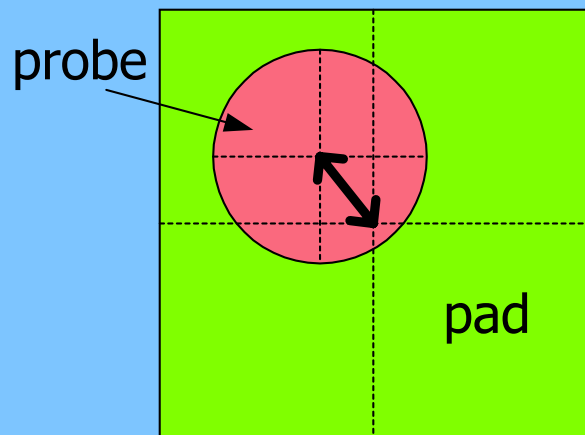
Contact Resistance



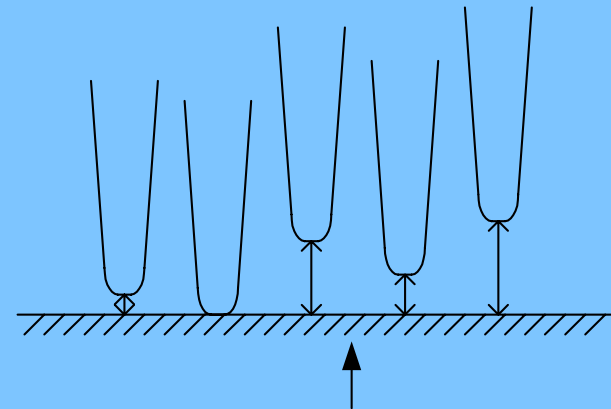
Leakage Current



X-Y Alignment



Planarity



Probe Cards Used on Test Floor

After analyzer verification, conforming probe cards are sent from card repair to the test floor where they will be used.

The world is happy... what could go wrong??



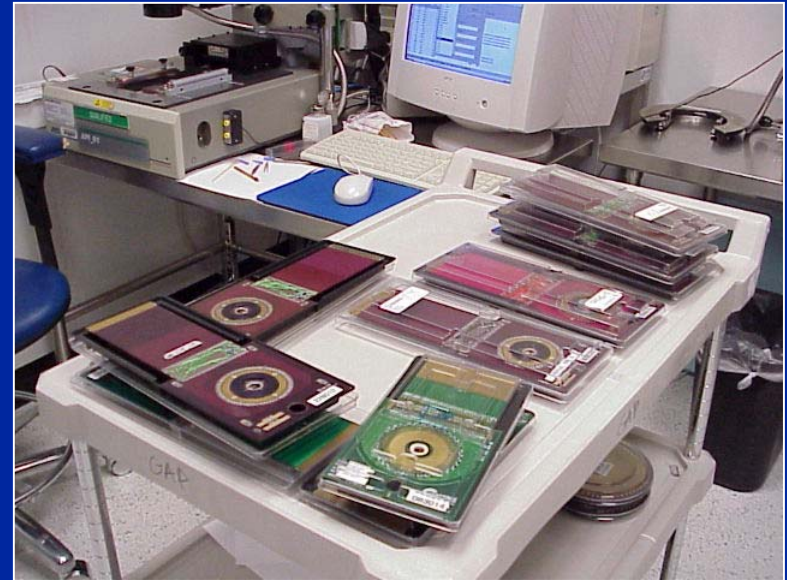
Seagate recording head wafer test station

Data Integrity Risk- Cards Unsorted

Segregating good cards from bad cards- necessary but not sufficient.

Factors that increase chance of cards being out of place:

- Large number of cards in a given area
- Poor communication at shift changeovers
- Insufficient training



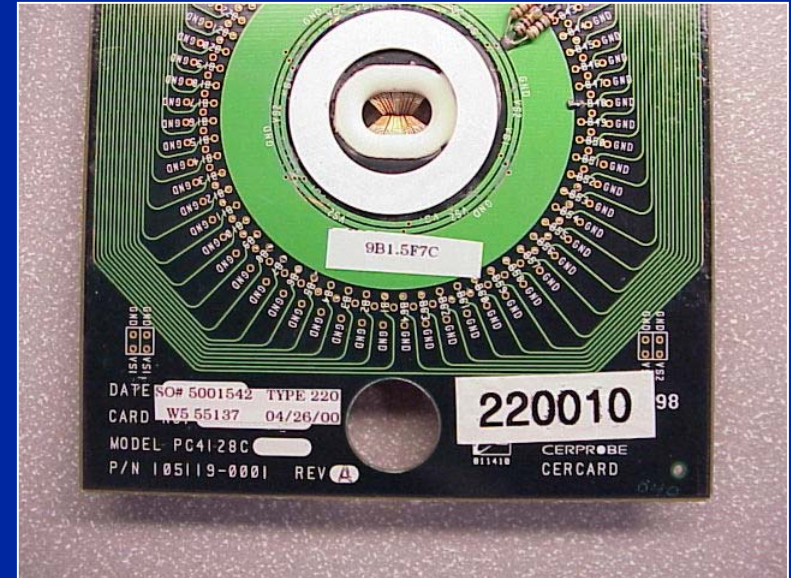
Data Integrity Risk- ID Entered Incorrectly

Each probe card is given a unique 6-digit ID number.

This number must be entered

- at the card analyzer
- at the wafer tester

If the IDs are entered incorrectly, analyzer data and/or probe data will be linked to the wrong card number.

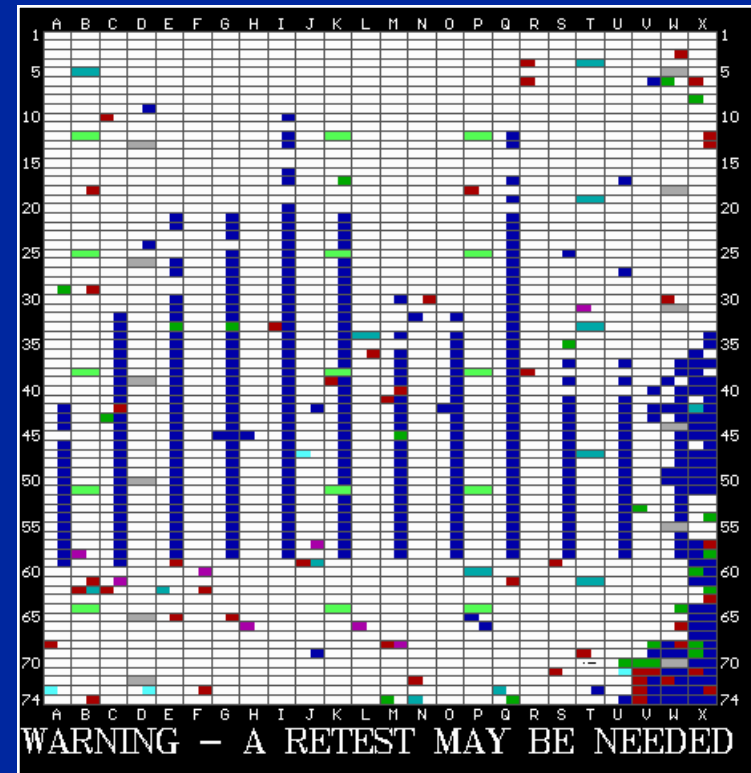


Card	#	Start Full Test
CT220	10	Partial Test...
CAL_1VX2		Read Only
CAL_5000		Cancel
CAL_5VX2		Help
CAL1000X		Product
CAL5000V		Vendor
CT214		Comments
CT215		Tech
CT216		
CT220		
CT221		
CT223		
CT228		
CT235		
CT237		
CT2ES		
CT3ES		
CT402		
CT411		
CT999		
ELEC_CAL		
EXAMPLE		
PGB_064		
PGB_128		

Misprobe Can Result

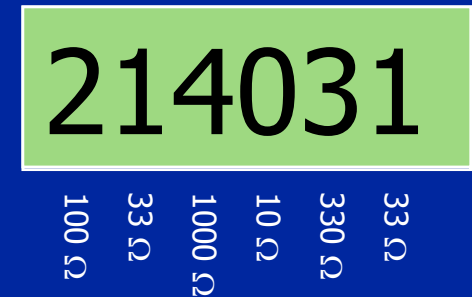
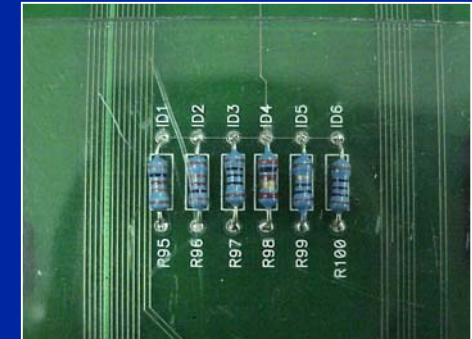
With data mismatch, a non-conforming probe card can fall through the cracks, get to the test floor.

The columnar pattern in this wafer map shows the effect of misprobe due to such a card.



Error-Proof Data Entry: Card ID Resistors

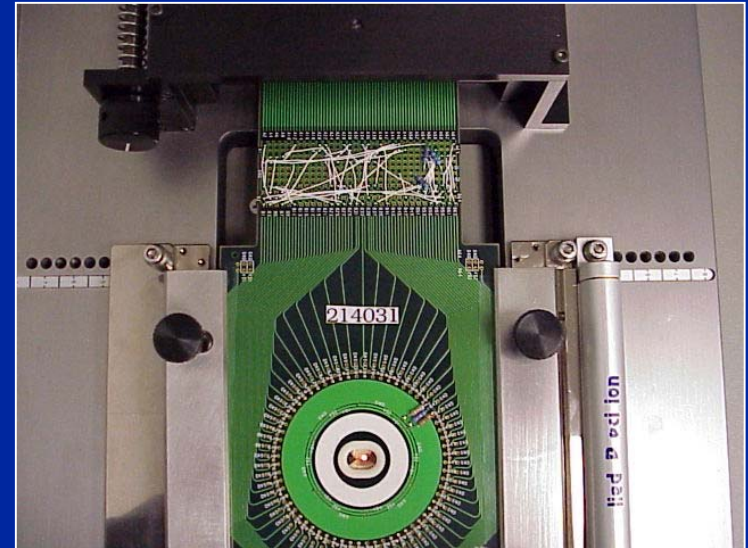
d (digit) Value	Target Value = $10^{*(d/2 + 1)}$ (Ohms)	Actual Resistor Value (Ohms)	Lower Limit = $10^{*(d/2 + 0.75)}$ (Ohms)	Upper Limit = $10^{*(d/2 + 1.25)}$ (Ohms)
< (short)	-	-	minus infinity	5.62
0	10.0	10	5.62	17.8
1	31.6	33	17.8	56.2
2	100	100	56.2	178
3	316	330	178	562
4	1.00 k	1 k	562	1.78 k
5	3.16 k	3.3 k	1.78 k	5.62 k
6	10.0 k	10 k	5.62 k	17.8 k
7	31.6 k	33 k	17.8 k	56.2 k
8	100 k	100 k	56.2 k	178 k
9	316 k	330 k	178 k	562 k
> (open)	-	-	562 k	plus infinity



- Six resistors are placed on each probe card.
- Each resistor represents a digit in the six-digit card ID.
- ID digits are encoded according to the table above.
- Resistor values are spaced on a log scale to minimize readback error.

ID Readback at Probe Card Analyzer

- On request from Seagate, Applied Precision wrote a version of analyzer software with the resistor reading feature.
- Channels to be read are specified in the card's reference file.
- ID channels are scanned.
- Analyzer software writes resistance values to a file.
- User-written software decodes resistance values into digits.
- Card ID is automatically derived with no chance of operator error.



RES	CHANNELS
103.1	RES46, 33
37.4	RES45, 33
1009.6	RES44, 33
13.5	RES20, 33
302.5	RES19, 33
33.2	RES18, 33

ID Readback at Wafer Tester

- Wafer tester contains six dedicated channels to measure card ID resistors.
- Operator plugs probe card into tester.
- ID channels are scanned.
- Tester software decodes resistance values into digits.
- Card ID is automatically derived with no chance of operator error.



```
DOS Prompt - flip

Results of card ID test #1:
Digit 1: 2 <103.678> 2.03
Digit 2: 1 < 37.490> 1.15
Digit 3: 4 < 1.013k> 4.01
Digit 4: 0 < 13.467> 0.26
Digit 5: 3 <384.965> 2.97
Digit 6: 1 < 33.613> 1.05

Hit enter to stop: _

<: -inf to 5.6
0: 5.6 to 17.8
1: 17.8 to 56.2
2: 56.2 to 177.8
3: 177.8 to 562.3
4: 562.3 to 1.8k
5: 1.8k to 5.6k
6: 5.6k to 17.8k
7: 17.8k to 56.2k
8: 56.2k to 177.8k
9: 177.8k to 562.3k
>: 562.3k to +inf

21403
```

Analyzer Summary File

- On request from Seagate, Applied Precision wrote a version of analyzer software with the summary file feature.
- The summary file contains analyzer results for each test performed, as well as the ID resistor values.

```
Card Name: CT214      Card s/n: 31      Test#: 3
Date: 05/01/2000
Last Test Start Time: 10:30:30      End Time: 10:31:56
File Name: CT214.31\CPT_0003
Product:
Vendor:
Comments:
Tech:
```

```
Card ID
ID#      CHANNELS      RESISTANCE (ohms)
1        46,33          103
2        45,33          37.4
3        44,33          1009
4        20,33          13.5
5        19,33          302
6        18,33          33.2
```

```
Test Results
PASS      FAIL      NF      TEST TYPE
60        0         0       Leakage
57        3         0       Contact Resistance
59        1         0       Vision Alignment
57        3         0       Planarity
```

```
-----
233       7         0       Totals
```


Analyzer Summary File

- For each card tested, a summary file is written to a network drive.
- Software on the tester reads the summary file.
- The software determines if the card can be used for probing:
 - Date/time of analyzer testing
 - Results of analyzer tests
 - Card IDs read by analyzer and tester match

```
Card Name: CT214   Card s/n: 31   Test#: 3
Date: 05/01/2000
Last Test Start Time: 10:30:30   End Time: 10:31:56
File Name: CT214.31\CPT_0003
Product:
Vendor:
Comments:
Tech:

Card ID
ID#   CHANNELS   RESISTANCE (ohms)
1     46,33      103
2     45,33      37.4
3     44,33      1009
4     20,33      13.5
5     19,33      302
6     18,33      33.2

Test Results
PASS  FAIL      NF      TEST TYPE
60    0         0       Leakage
57    3         0       Contact Resistance
59    1         0       Vision Alignment
57    3         0       Planarity
-----
233   7         0       Totals
```



Summary File- ID Mismatch

Card Name: CT214 Card s/n: 31
Test#: 3
Date: 05/01/2000
Last Test Status Time: 11:20:00
File Name: **CT214.31** CPT_0003
Product:
Vendor:
Comments:
Tech:

Card ID

ID#	CHANNELS	RESISTANCE
1	46,33	103
2	45,33	37.4
3	44,33	1009
4	20,33	13.5
5	19,33	302
6	18,33	33.2

mouse

Card Name: CT220 Card s/n: 11
Test#: 5
Date: 05/20/2001
Last Test Status Time: 8:45:12
File Name: **CT220.11** CPT_0005
Product:
Vendor:
Comments:
Tech:

Card ID

ID#	CHANNELS	RESISTANCE
1	46,33	100
2	45,33	101
3	44,33	13.2
4	20,33	13.4
5	19,33	104
6	18,33	337

214031 = 214031
No error

resistors

220011 ≠ 220023
Data entry error

Probe Card Database- Disposition

The following parameters are specified for each probe card:

- Analyzer info
 - Hours since last analyzer test
 - Results of each analyzer test (C, L, A, P)
 - Summary file security
- Touchdowns (TDs) since last test
- ID mismatch condition
- Special cause marked by operator

```

      hrs --failed-- -not fnd--
# Card Analyzer Time      left C L A P C L A P Disposition
1 228001 16_May_2000 21:03:56 0 0 0 0 0 0 0 0 0 0 0 ok
2 228002 11_May_2000 21:37:50 0 0 0 0 0 0 0 0 0 0 0 API code 14 days
3 228003 27_May_2000 15:00:20 0 5 0 0 0 0 0 0 0 0 0 API days
4 228004 06_May_2000 19:47:01 0 0 0 0 0 0 0 0 0 0 0 API days
5 228005 17_May_2000 21:15:12 130 0 0 0 0 0 0 0 0 0 0 ok
6 228006 16_May_2000 20:18:20 105 0 0 0 0 0 0 0 0 0 0 ok
7 228007 17_May_2000 07:52:58 116 0 0 0 0 0 0 0 0 0 0 ok
8 228008 17_May_2000 20:22:00 129 1 0 2 0 0 1 2 API
9 228009 14_May_2000 05:07:32 42 0 0 0 0 0 0 0 0 0 0 ok
10 228010 16_May_2000 20:15:48 105 0 0 0 0 0 0 0 0 0 0 ok
11 228011 17_May_2000 07:31:33 118 0 0 0 0 0 0 0 0 0 0 ok
12 228012 16_May_1999 19:16:23 0 0 0 0 0 0 0 0 0 0 0 API code 15
13 228013 16_May_2000 21:07:20 105 0 0 0 0 0 0 0 0 0 0 ok
14 228014 16_May_1999 13:16:19 0 0 0 0 0 0 0 0 0 0 0 API code 30
15 228015 27_May_2000 08:33:46 0 1 0 0 0 0 0 0 0 0 0 API days
16 228016 13_May_1999 05:56:28 0 0 0 0 0 0 0 0 0 0 0 API code 14
17 228017 16_May_1999 19:48:48 0 0 0 0 0 0 0 0 0 0 0 API code 14
18 228018 17_May_2000 20:22:52 129 0 0 0 0 0 0 0 0 0 0 ok
19 228019 16_May_2000 13:50:39 98 0 0 0 0 0 0 0 0 0 0 ok
20 228020 18_May_2000 08:03:52 133 0 0 0 0 0 0 0 0 0 0 ok

All type 228 cards (MR 88 2050 multide) listed.
Hit enter for card summary:
bad means   = 5 ( 25.0%)
failed analyzer = 10 ( 50.0%)
too many IDs = 0 (  0.0%)
too many days = 5 ( 25.0%)
all bad cards = 10 ( 50.0%)
good cards   = 10 ( 50.0%)
Hit enter to continue:

```

All probe card parameters must conform to specs. If not, software disallows use.

Multiple Card View

#	Card	Analyzer Time	hrs left	--failed--				-not fnd--				Disposition
				C	L	A	P	C	L	A	P	
1	228001	10_May_1999_14:03:55	0	0	0	0	0	0	0	0	0	API code 14 days
2	228002	11_May_2000_21:37:50	0	0	0	0	0	0	0	0	0	API days
3	228003	27_Apr_2000_15:00:29	0	5	0	0	0	0	0	0	0	API days
4	228004	06_May_2000_19:47:01	0	0	0	0	0	0	0	0	0	API days
5	228005	17_May_2000_21:15:12	130	0	0	0	0	0	0	0	0	ok
6	228006	16_May_2000_20:10:20	105	0	0	0	0	0	0	0	0	ok
7	228007	17_May_2000_07:52:58	116	0	0	0	0	0	0	0	0	ok
8	228008	17_May_2000_20:22:08	129	1	0	0	2	0	0	1	2	API
9	228009	14_May_2000_05:07:32	42	0	0	0	0	0	0	0	0	ok
10	228010	16_May_2000_20:15:48	105	0	0	0	0	0	0	0	0	ok
11	228011	17_May_2000_09:31:33	118	0	0	0	0	0	0	0	0	ok
12	228012	16_May_1999_19:16:23	0	0	0	0	0	0	0	0	0	API code 15
13	228013	16_May_2000_21:07:39	106	0	0	0	0	0	0	0	0	ok
14	228014	16_May_1999_13:16:19	0	0	0	0	0	0	0	0	0	API code 30
15	228015	27_Apr_2000_08:33:46	0	0	1	0	0	0	0	0	0	API days
16	228016	13_May_1999_05:26:28	0	0	0	0	0	0	0	0	0	API code 14
17	228017	16_May_1999_19:48:48	0	0	0	0	0	0	0	0	0	API code 14
18	228018	17_May_2000_20:32:53	129	0	0	0	0	0	0	0	0	ok
19	228019	16_May_2000_13:50:39	98	0	0	0	0	0	0	0	0	ok
20	228020	18_May_2000_00:03:52	133	0	0	0	0	0	0	0	0	ok

All type 228 cards (MR RS 2050 multidi) listed.
Hit enter for card summary:

```
bad reasons      = 5 < 25.0%>
failed analyzer = 10 < 50.0%>
too many IDs     = 0 < 0.0%>
too many days   = 5 < 25.0%>
all bad cards   = 10 < 50.0%>
good cards      = 10 < 50.0%>
```

Hit enter to continue:

Single Card View

```
MS-DOS Prompt - pcarddb

Card 240018 for MR CC 4860 (multidie)

status 5: tips dirty
        card needs repair then checking

last use:   by 091745 on Fri 30 Mar 01 04:46:30 on prober 17
last check: by 054801 on Thu 29 Mar 01 18:10:04 (7 days ago)
last repair: by 054801 on Thu 29 Mar 01 18:09:59 (7 days ago)
card build:  by 054801 on Tue  6 Mar 01 12:32:16 (30 days ago)

card has used up 13306/63360 TDs = 79.0% life left, 100.1 quad's worth
card has used up 7/7 days = NO LIFE LEFT
card has been repaired 1 times
card has seen 186284 total touchdowns since build, 372.6 quad's worth

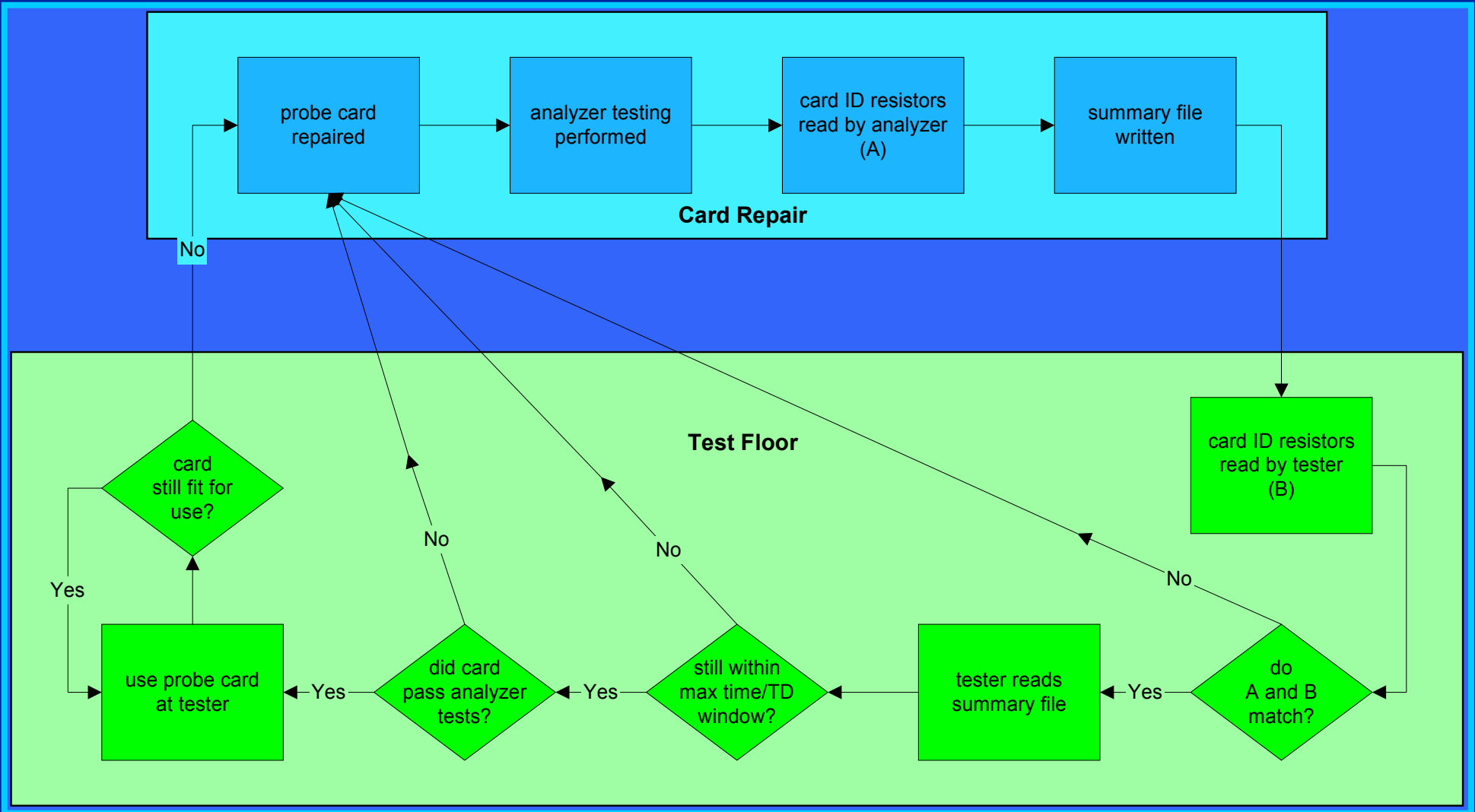
* card 240018 has an invalid analyzer file header- return to card repair
* card 240018 is overdue for the analyzer- return to card repair
* card 240018 failed the      contact res test- return to card repair

        tips      tips
        failed    missing
contact res      1          0      test FAILED
leakage          0          0      test passed
xy alignment     0          0      test passed
planarity        0          0      test passed

This card needs some work. Software will NOT allow probing.

Hit enter: _
```

Process Flow



Result

- Before start of project, analyzer data entry error rate assumed to be $\sim 1\%$.
- After software was implemented, error rate was found to be significantly $> 1\%$.
- Feedback from system has continuously driven error rate down.
- Some level of human error will continue, but it will no longer contribute to card-induced misprobe.

Thank You

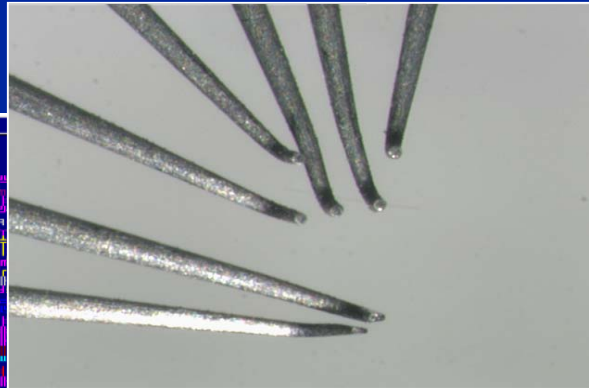
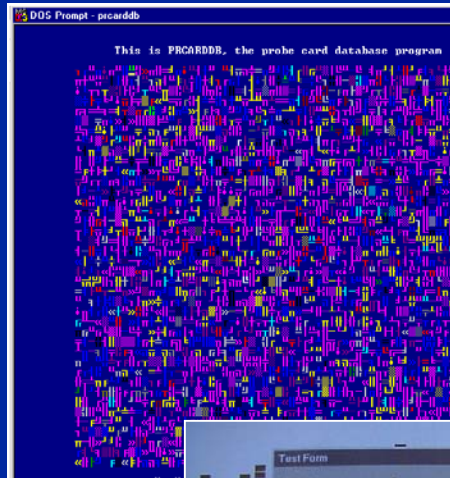
Thanks to Bob Heiligenberg and Kjell Lundberg at Applied Precision for their efforts on the custom analyzer software.

Isolated traces

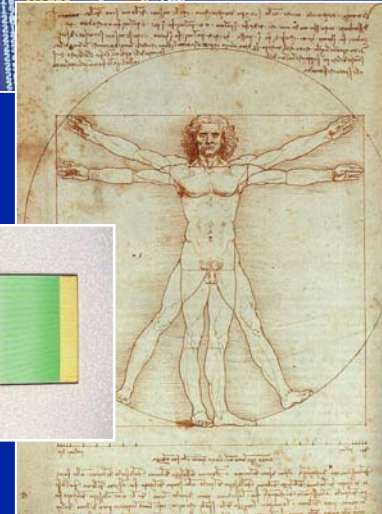
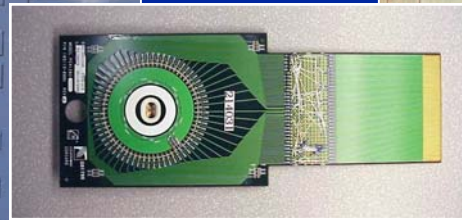
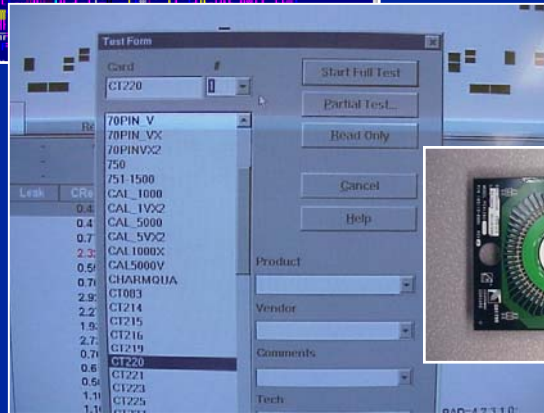


make happy faces.

Questions?



Card	hrs	2TD	hrs	CLAP	API	API	Analyzer	owner
0	8	100	0	CLAP	ok	ok	PrCard84	
175	100	135	0	CLAP	ok	ok	PrCard84	
111	83	77	0	CLAP	ok	ok	PrCard84	
0	8	13	0	CLAP	bad	bad	Prober108	
14	100	13	0	CLAP	ok	ok	PrCard84	
15	34	13	0	CLAP	ok	ok	PrCard84	
13	100	13	0	CLAP	ok	ok	PrCard84	
0	8	17	0	CLAP	bad	bad	Prober101	
0	8	25	0	CLAP	ok	ok	PrCard84	
0	8	59	1	CLAP	bad	bad	PrCard.MONIT	
11	17	1	0	CLAP	ok	ok	PrCard84	
11	83	76	0	CLAP	ok	ok	PrCard84	
216017	17	0	0	CLAP	ok	ok	PrCard84	
216018	17	0	0	CLAP	bad	bad	PrCard.MONIT	
216019	17	0	0	CLAP	ok	ok	PrCard84	
216020	17	0	0	CLAP	bad	bad	PrCard84	
216021	17	0	0	CLAP	ok	ok	PrCard84	
216022	17	0	0	CLAP	ok	ok	PrCard84	
216023	17	0	0	CLAP	ok	ok	PrCard84	
216024	17	0	0	CLAP	ok	ok	PrCard84	
216025	17	0	0	CLAP	ok	ok	PrCard84	
216026	17	0	0	CLAP	ok	ok	PrCard84	
216027	17	0	0	CLAP	ok	ok	PrCard84	
216028	17	0	0	CLAP	ok	ok	PrCard84	
216029	17	0	0	CLAP	ok	ok	PrCard84	
216030	17	0	0	CLAP	ok	ok	PrCard84	
216031	17	0	0	CLAP	ok	ok	PrCard84	
216032	17	0	0	CLAP	ok	ok	PrCard84	
216033	17	0	0	CLAP	ok	ok	PrCard84	
216034	17	0	0	CLAP	ok	ok	PrCard84	
216035	17	0	0	CLAP	ok	ok	PrCard84	
216036	17	0	0	CLAP	ok	ok	PrCard84	
216037	17	0	0	CLAP	ok	ok	PrCard84	
216038	17	0	0	CLAP	ok	ok	PrCard84	
216039	17	0	0	CLAP	ok	ok	PrCard84	
216040	17	0	0	CLAP	ok	ok	PrCard84	
216041	17	0	0	CLAP	ok	ok	PrCard84	
216042	17	0	0	CLAP	ok	ok	PrCard84	
216043	17	0	0	CLAP	ok	ok	PrCard84	
216044	17	0	0	CLAP	ok	ok	PrCard84	
216045	17	0	0	CLAP	ok	ok	PrCard84	
216046	17	0	0	CLAP	ok	ok	PrCard84	
216047	17	0	0	CLAP	ok	ok	PrCard84	
216048	17	0	0	CLAP	ok	ok	PrCard84	
216049	17	0	0	CLAP	ok	ok	PrCard84	
216050	17	0	0	CLAP	ok	ok	PrCard84	
216051	17	0	0	CLAP	ok	ok	PrCard84	
216052	17	0	0	CLAP	ok	ok	PrCard84	
216053	17	0	0	CLAP	ok	ok	PrCard84	
216054	17	0	0	CLAP	ok	ok	PrCard84	
216055	17	0	0	CLAP	ok	ok	PrCard84	
216056	17	0	0	CLAP	ok	ok	PrCard84	
216057	17	0	0	CLAP	ok	ok	PrCard84	
216058	17	0	0	CLAP	ok	ok	PrCard84	
216059	17	0	0	CLAP	ok	ok	PrCard84	
216060	17	0	0	CLAP	ok	ok	PrCard84	
216061	17	0	0	CLAP	ok	ok	PrCard84	
216062	17	0	0	CLAP	ok	ok	PrCard84	
216063	17	0	0	CLAP	ok	ok	PrCard84	
216064	17	0	0	CLAP	ok	ok	PrCard84	
216065	17	0	0	CLAP	ok	ok	PrCard84	
216066	17	0	0	CLAP	ok	ok	PrCard84	
216067	17	0	0	CLAP	ok	ok	PrCard84	
216068	17	0	0	CLAP	ok	ok	PrCard84	
216069	17	0	0	CLAP	ok	ok	PrCard84	
216070	17	0	0	CLAP	ok	ok	PrCard84	
216071	17	0	0	CLAP	ok	ok	PrCard84	
216072	17	0	0	CLAP	ok	ok	PrCard84	
216073	17	0	0	CLAP	ok	ok	PrCard84	
216074	17	0	0	CLAP	ok	ok	PrCard84	
216075	17	0	0	CLAP	ok	ok	PrCard84	
216076	17	0	0	CLAP	ok	ok	PrCard84	
216077	17	0	0	CLAP	ok	ok	PrCard84	
216078	17	0	0	CLAP	ok	ok	PrCard84	
216079	17	0	0	CLAP	ok	ok	PrCard84	
216080	17	0	0	CLAP	ok	ok	PrCard84	
216081	17	0	0	CLAP	ok	ok	PrCard84	
216082	17	0	0	CLAP	ok	ok	PrCard84	
216083	17	0	0	CLAP	ok	ok	PrCard84	
216084	17	0	0	CLAP	ok	ok	PrCard84	
216085	17	0	0	CLAP	ok	ok	PrCard84	
216086	17	0	0	CLAP	ok	ok	PrCard84	
216087	17	0	0	CLAP	ok	ok	PrCard84	
216088	17	0	0	CLAP	ok	ok	PrCard84	
216089	17	0	0	CLAP	ok	ok	PrCard84	
216090	17	0	0	CLAP	ok	ok	PrCard84	
216091	17	0	0	CLAP	ok	ok	PrCard84	
216092	17	0	0	CLAP	ok	ok	PrCard84	
216093	17	0	0	CLAP	ok	ok	PrCard84	
216094	17	0	0	CLAP	ok	ok	PrCard84	
216095	17	0	0	CLAP	ok	ok	PrCard84	
216096	17	0	0	CLAP	ok	ok	PrCard84	
216097	17	0	0	CLAP	ok	ok	PrCard84	
216098	17	0	0	CLAP	ok	ok	PrCard84	
216099	17	0	0	CLAP	ok	ok	PrCard84	
216100	17	0	0	CLAP	ok	ok	PrCard84	



Feel free to contact me at
scott.d.dobbins@seagate.com / 952-844-7145