Impedance and EMC Characterization Data of Embedded Capacitance Materials

Istvan Novak

SUN Microsystems
One Network drive
Burlington, MA 01803

Outline

- Impedance measurement setup
- Close-field radiation setup
- Probes
- 20”x10” test boards
  - Impedances
  - radiation
- 10”x5” test boards
  - Impedances
  - radiation
- Conclusions

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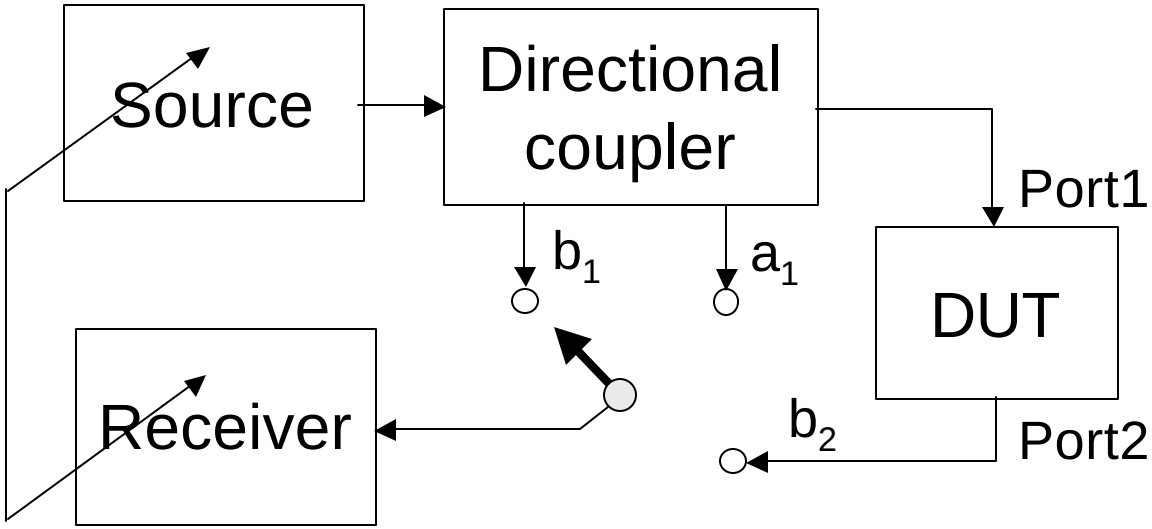
Vector Network Analyzer



HP4396
100kHz-1.8GHz
2-port S21 measurements

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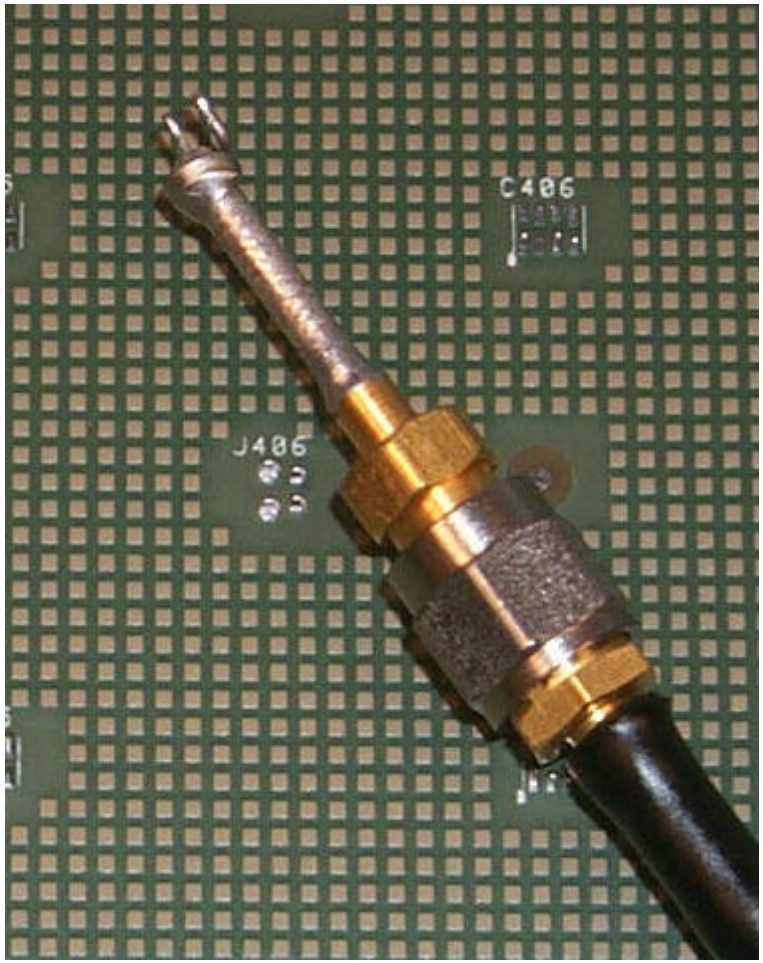
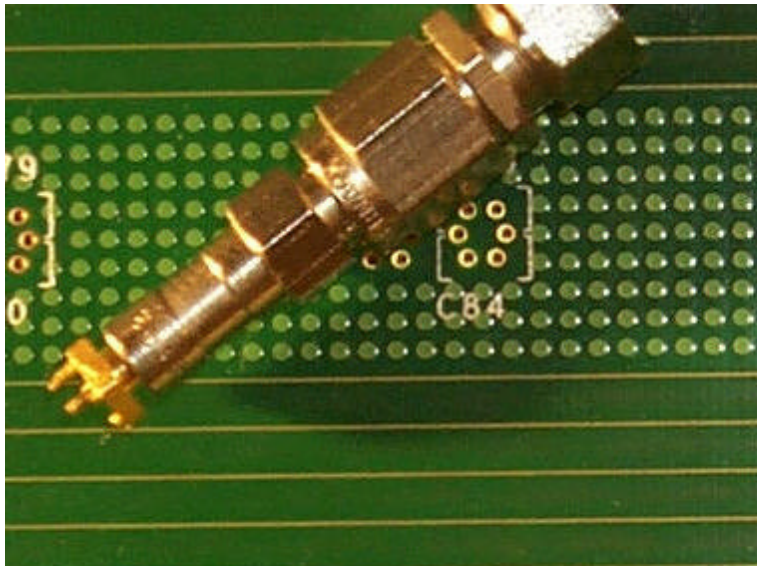
Probes



Small loop
Non-solder connections



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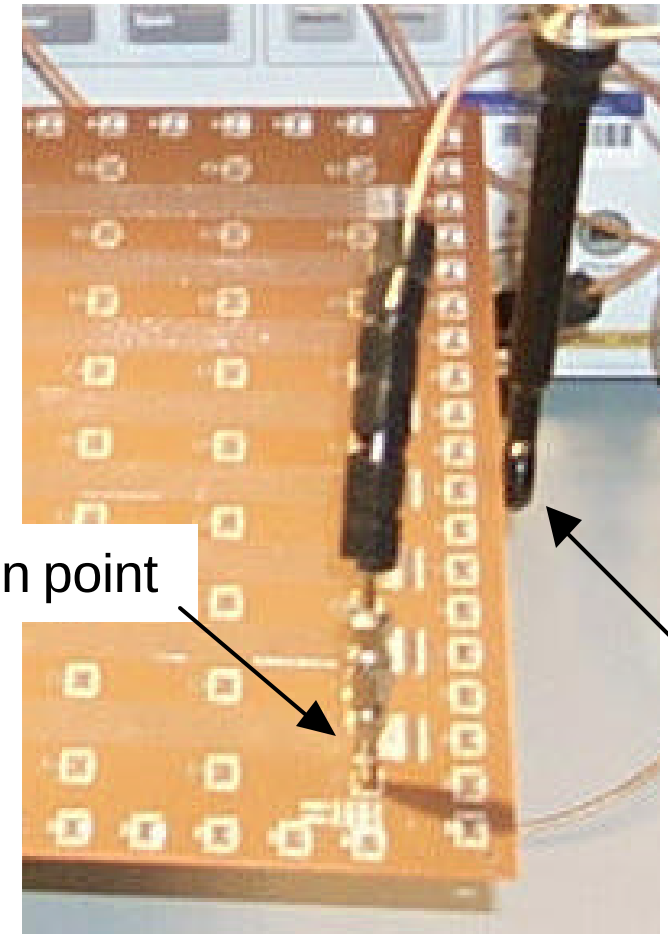
EMC Probing



Excitation point:

VNA Port 1

Pick-up loop:

VNA Port 2

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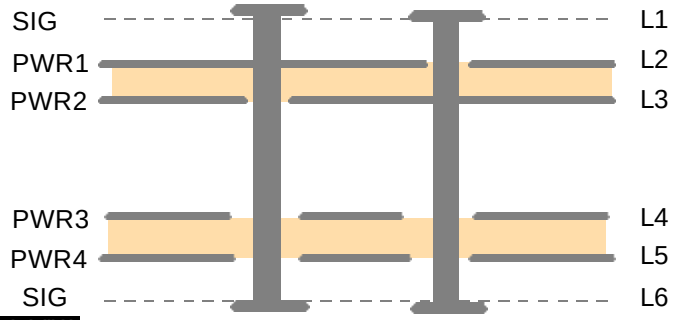
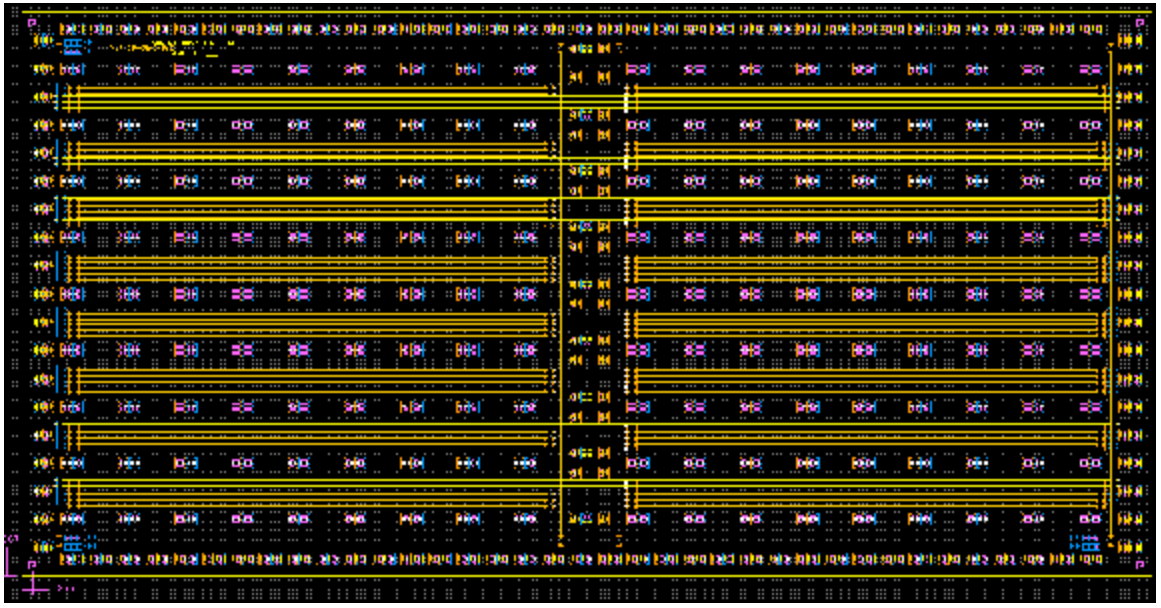
20”x10” Test Boards

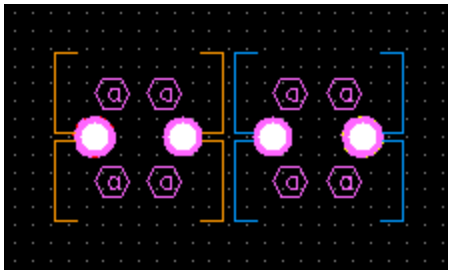
Stackup:



Top view:



Test points:



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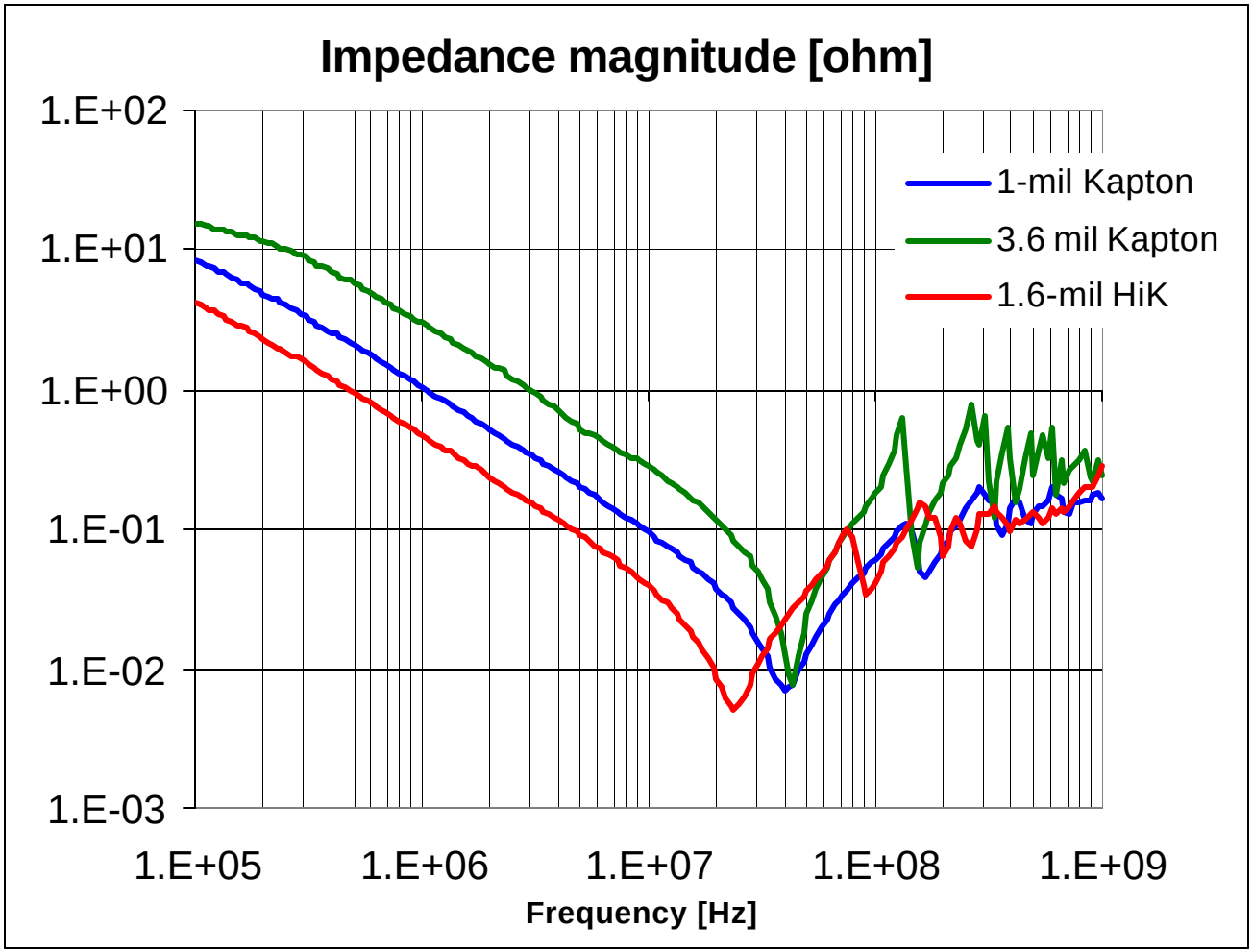
Self-Impedance Comparison



Bare board

Corner

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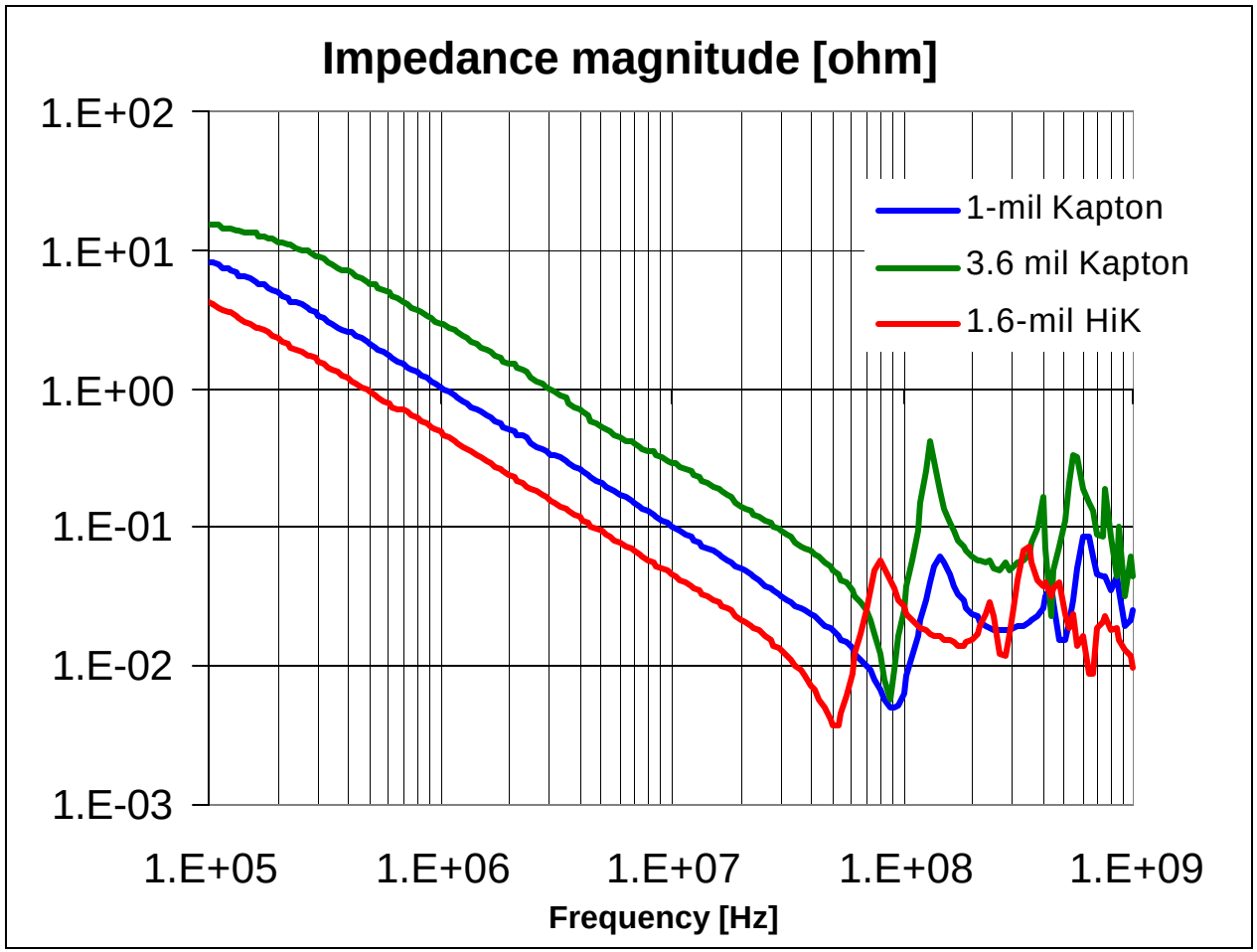
Transfer Impedance Comparison



Bare board

Corner to

center

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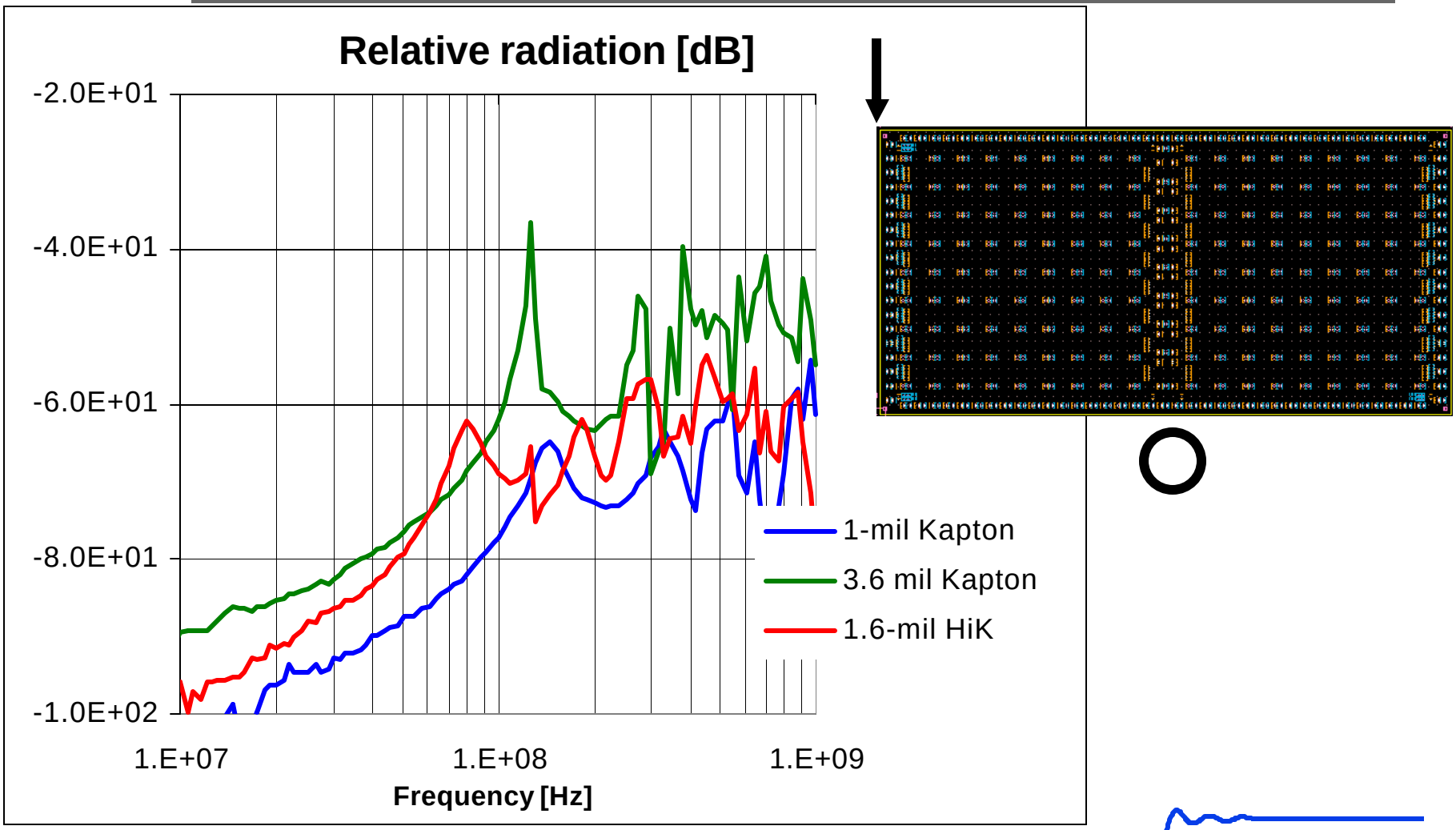
Close-Field Radiation



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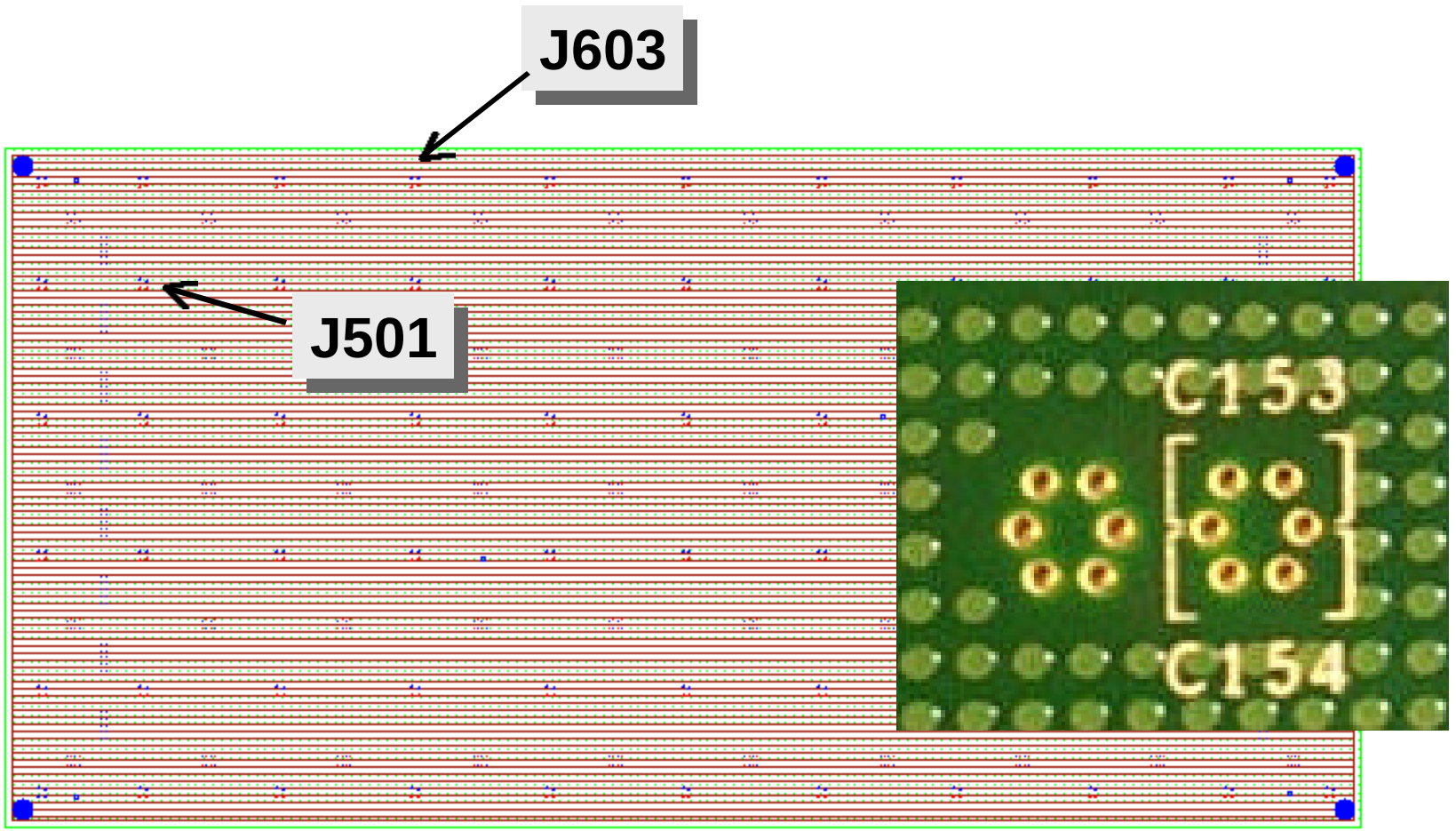
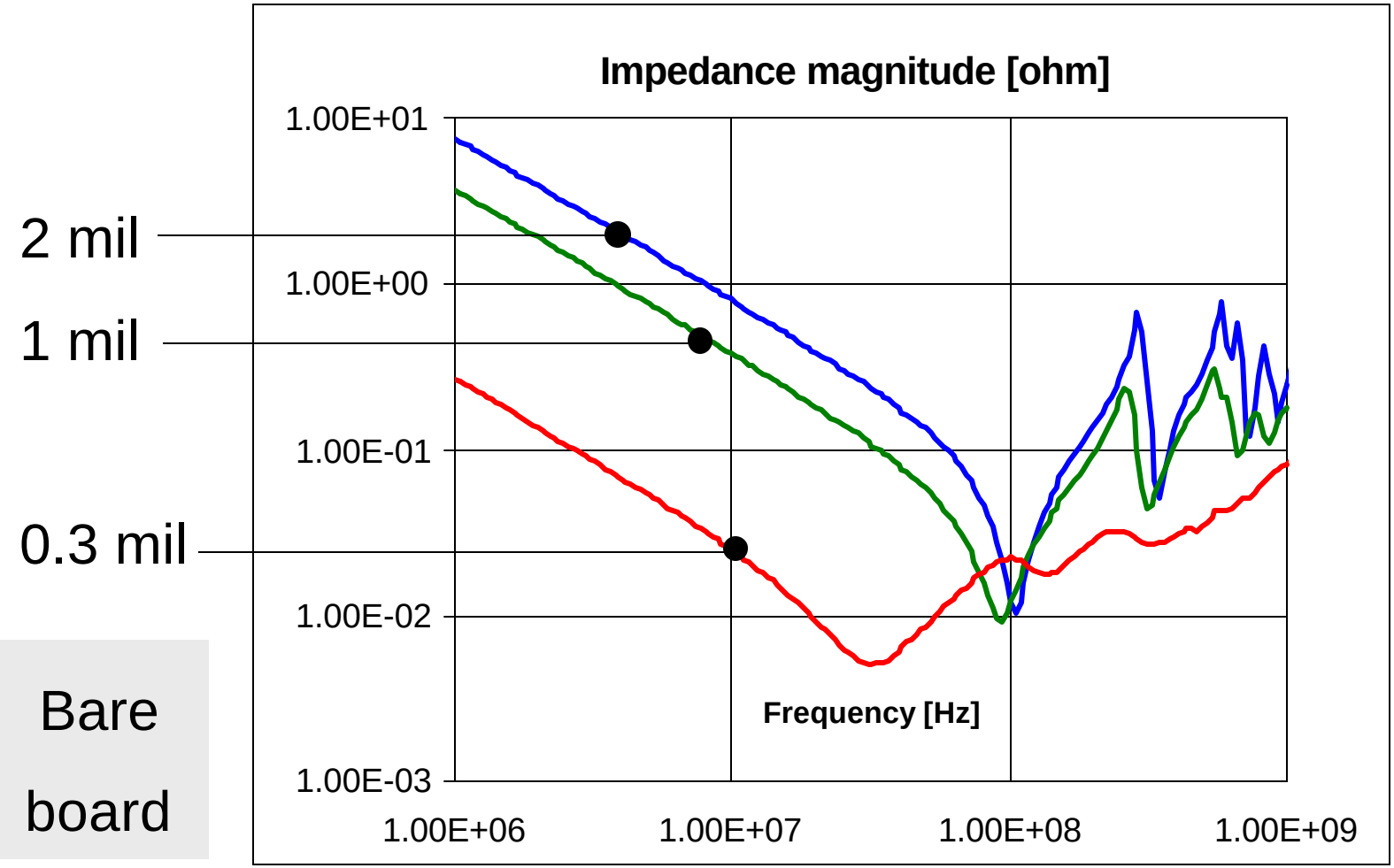
10”x5” Test Boards



Self-Impedance Magnitude at J501



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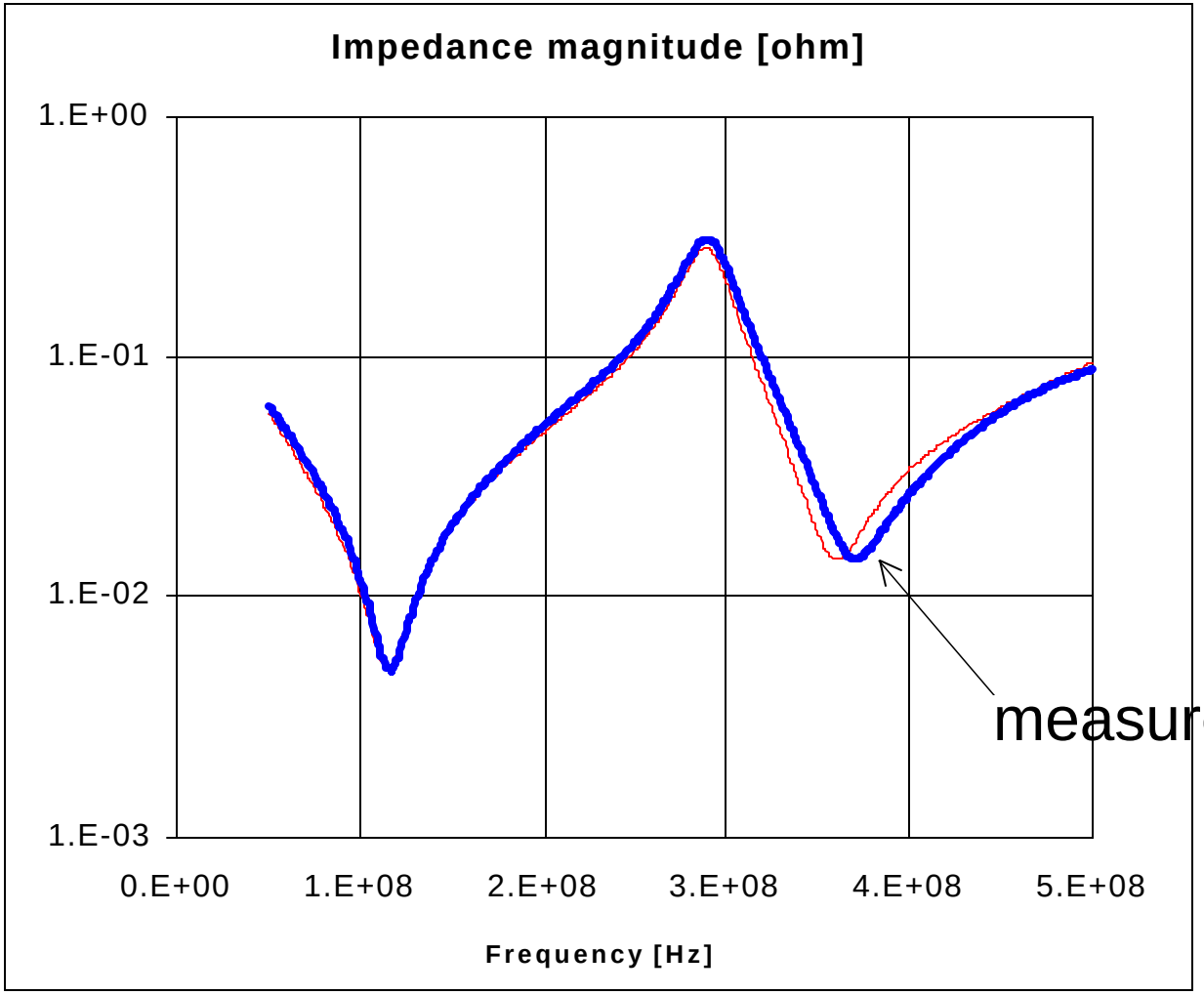
Impedance Correlation



10”x5”

2x2-mil

Bare

Corner

Self-Z

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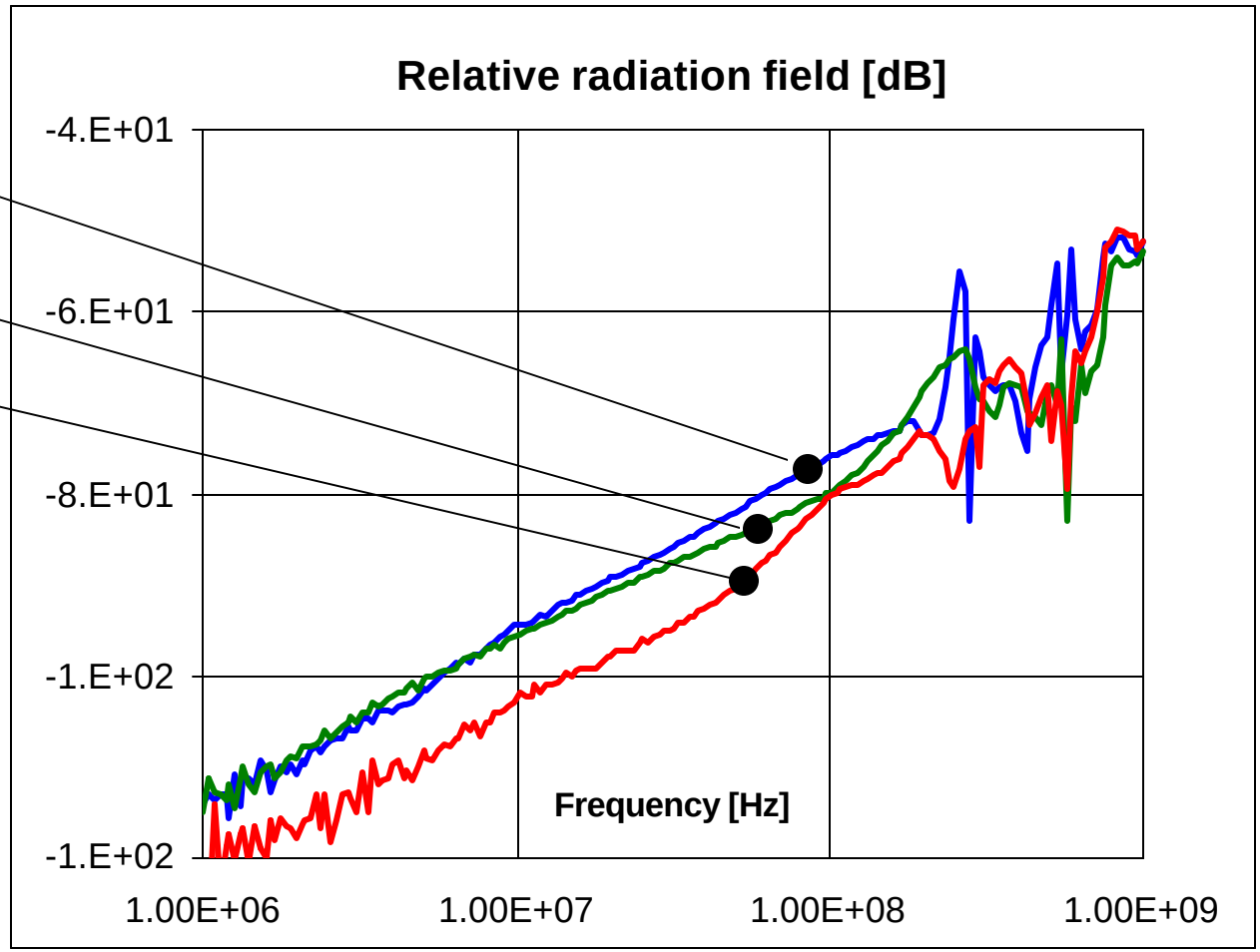
Close-Field Radiation J501-J603



2 mil

1 mil

0.3 mil

Bare board

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Measured Self-Impedance Surfaces

The following slides show the

- Measured self impedance magnitudes on
- 1”x1” grid over a 10”x5” PCB
- Bare PCB
- 1 x 2-mil epoxy-glass laminate on the left
- 1 x 0.3 mil laminate on the right
- Linear autoscale on top charts
- Fixed logarithmic scale on bottom charts

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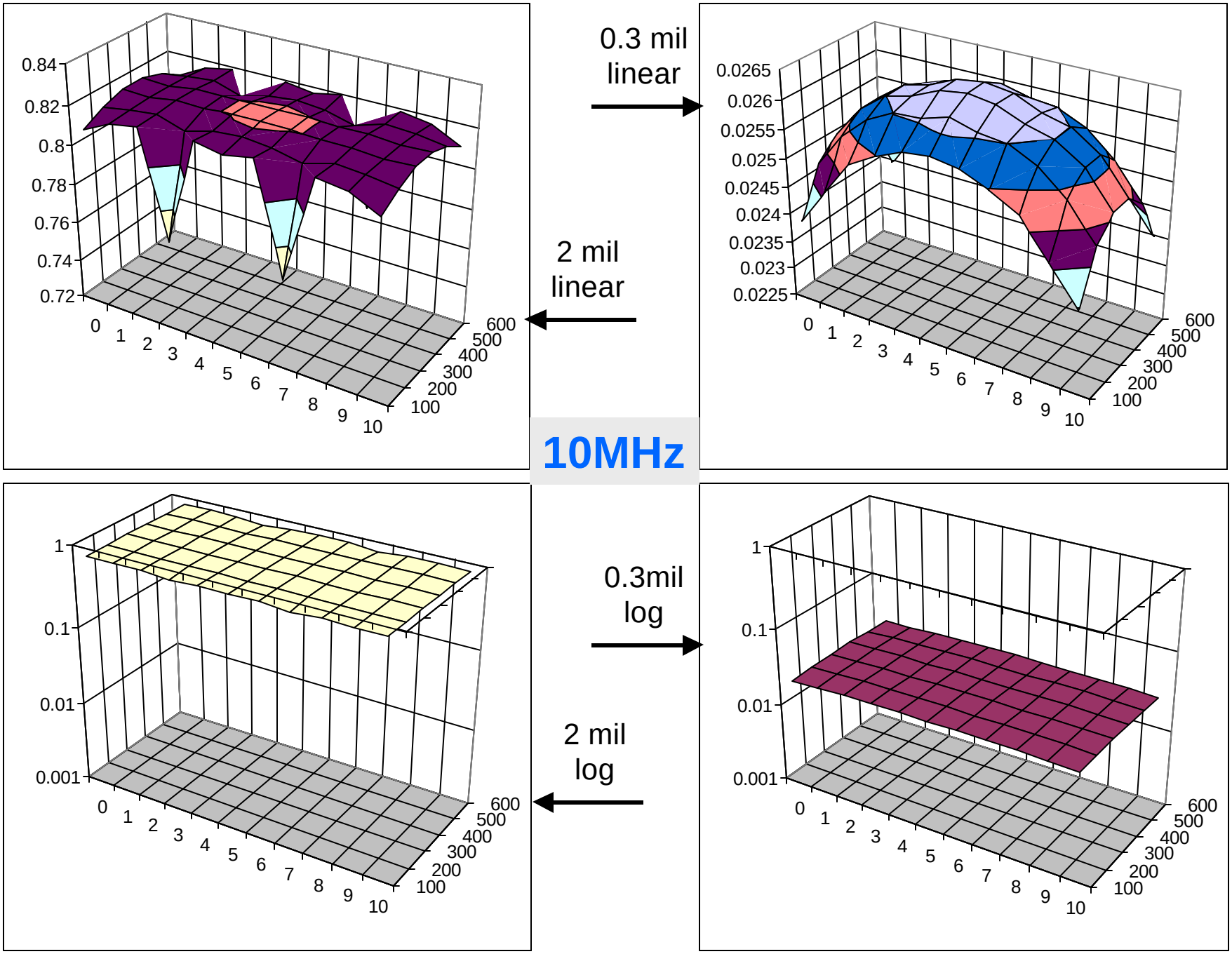
0.3 mil
linear
2 mil
linear
10MHz
0.3mil
log
2 mil
log
0.84
0.82
0.8
0.78
0.76
0.74
0.72
0.0265
0.026
0.0255
0.025
0.0245
0.024
0.0235
0.023
0.0225
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
100 200 300 400 500 600

Conclusions

- High-frequency low impedances measured by 2-port VNA S21
- Also suitable for close-field EMI check
- High-frequency self impedance depends on plane separation
- Dielectric constant is less important at high frequencies

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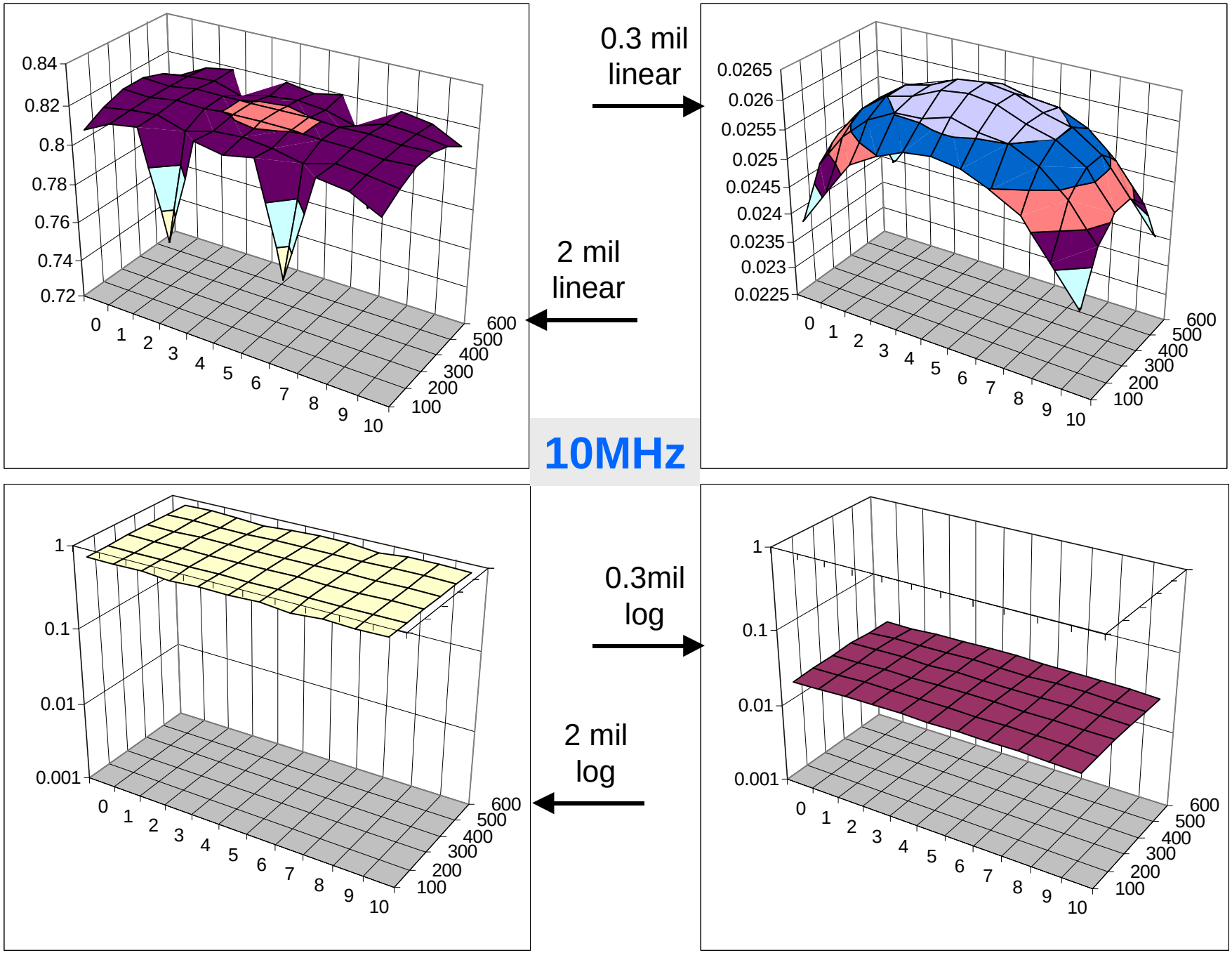
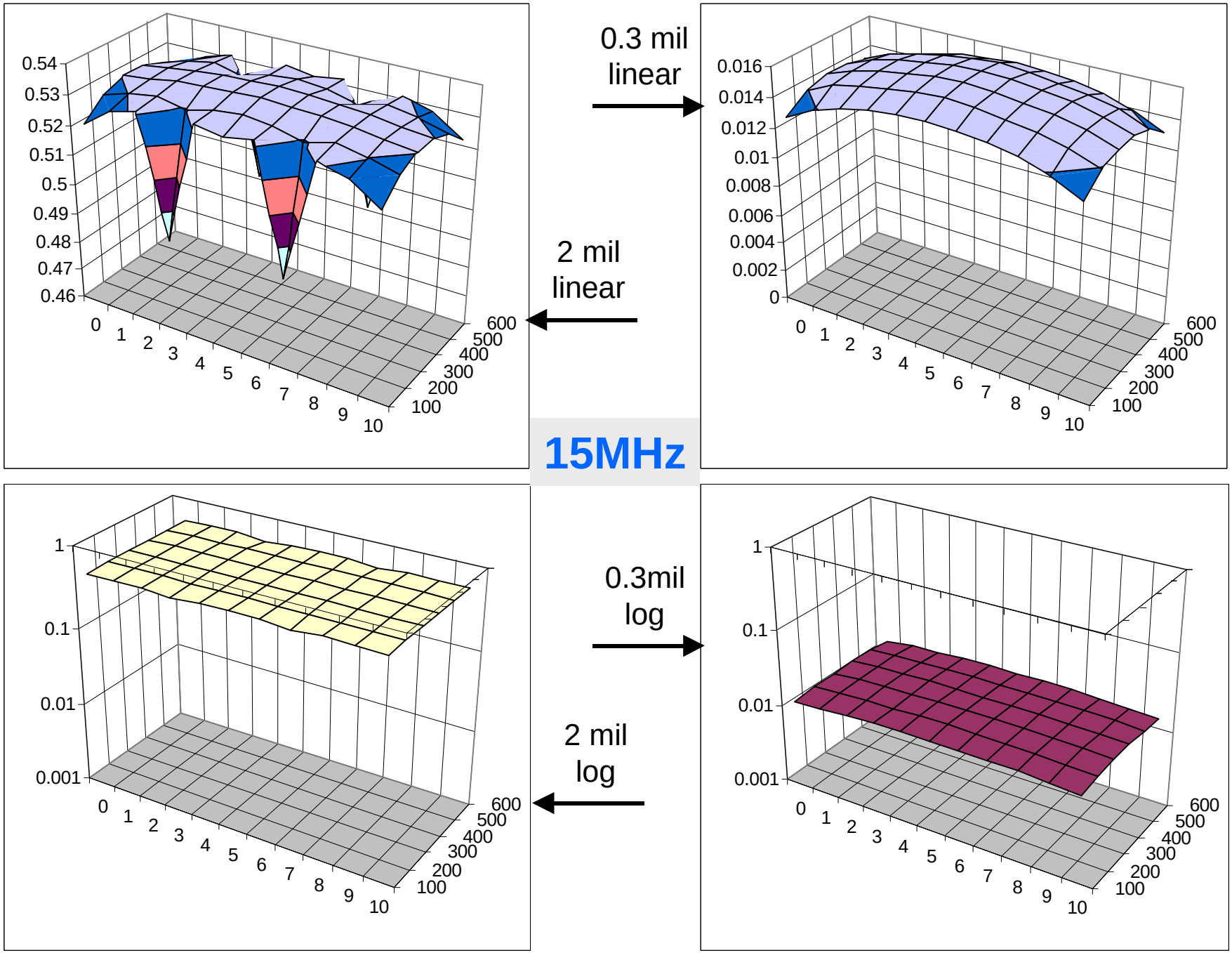
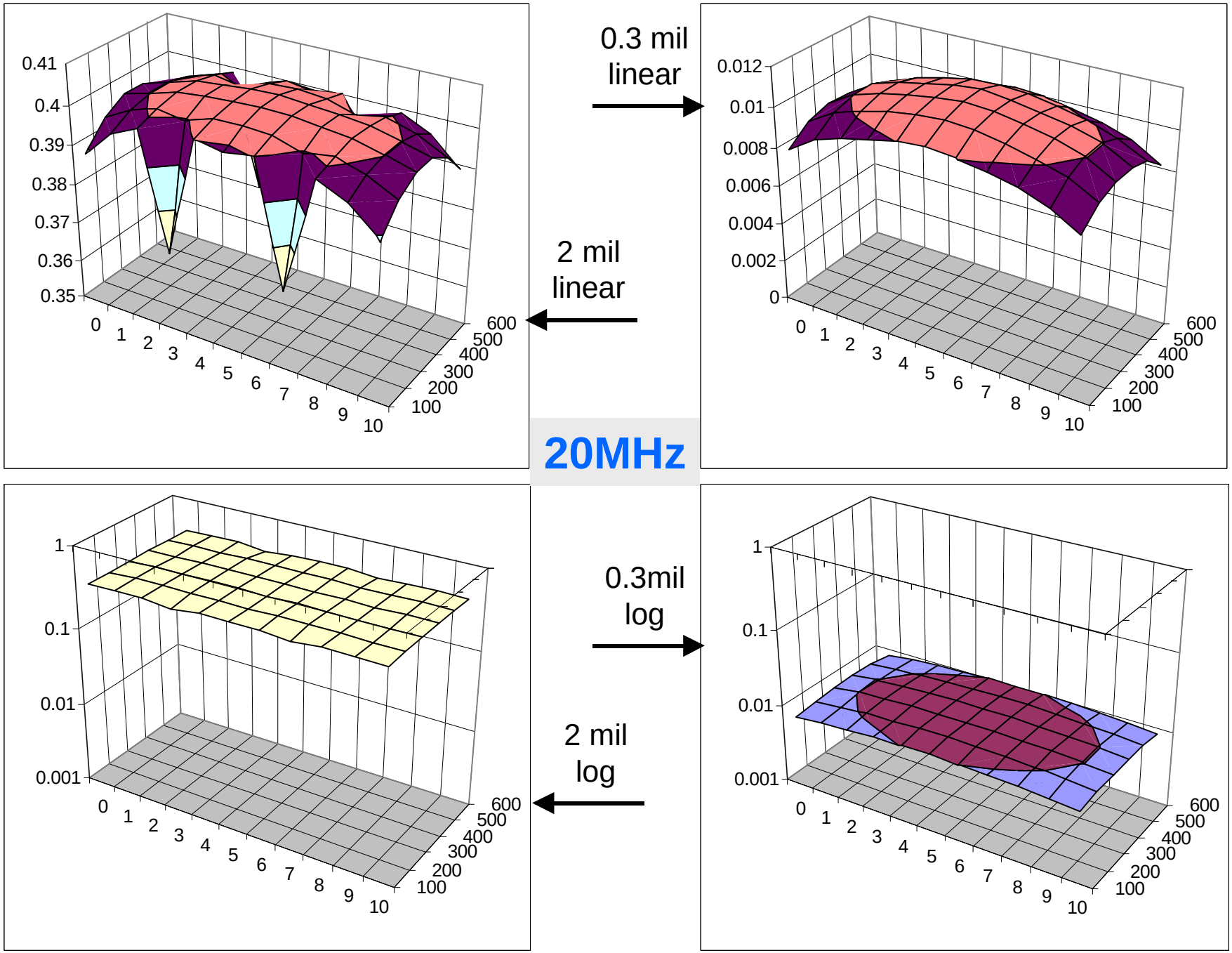
Measured Self-Impedance Surfaces

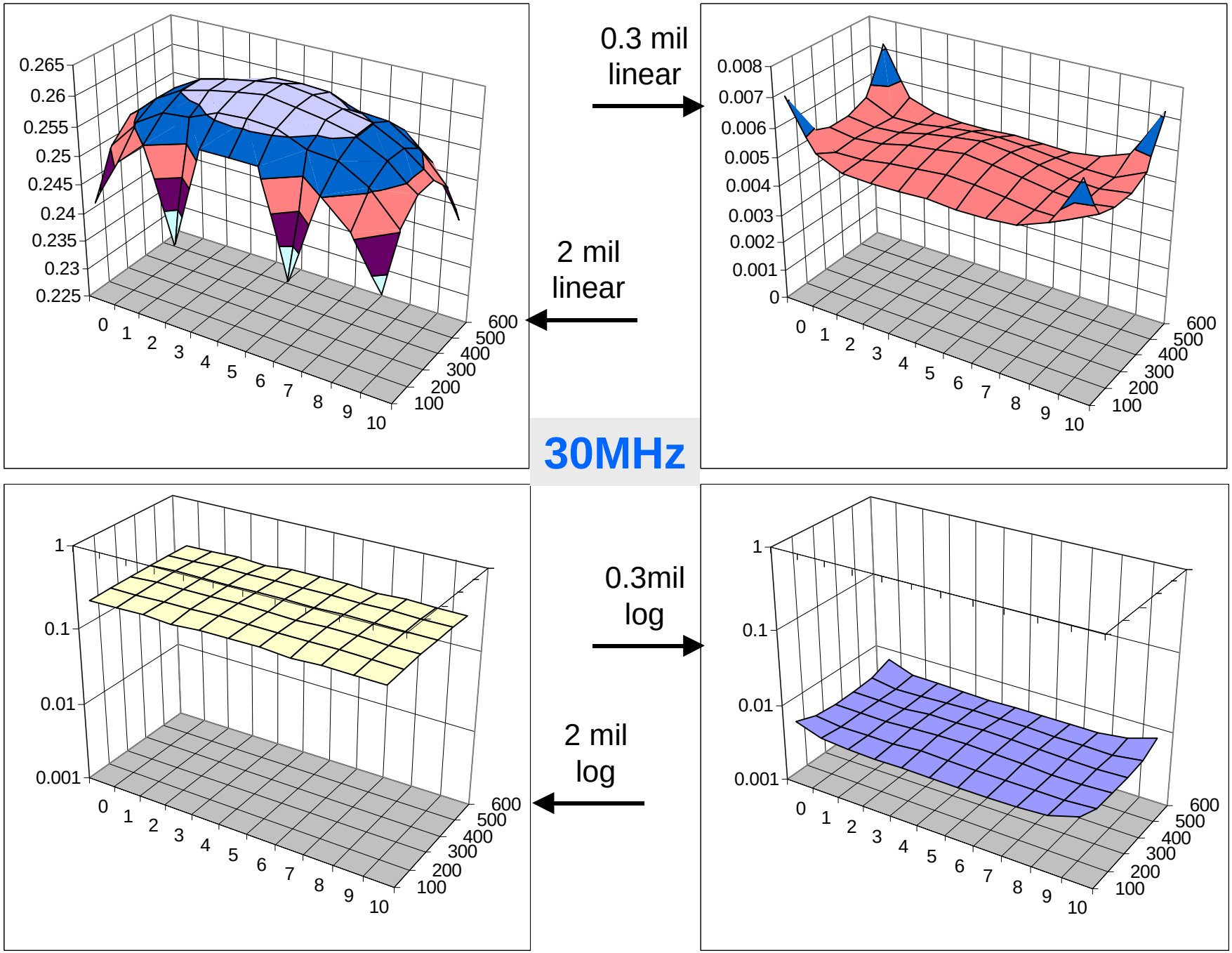
The following slides show the

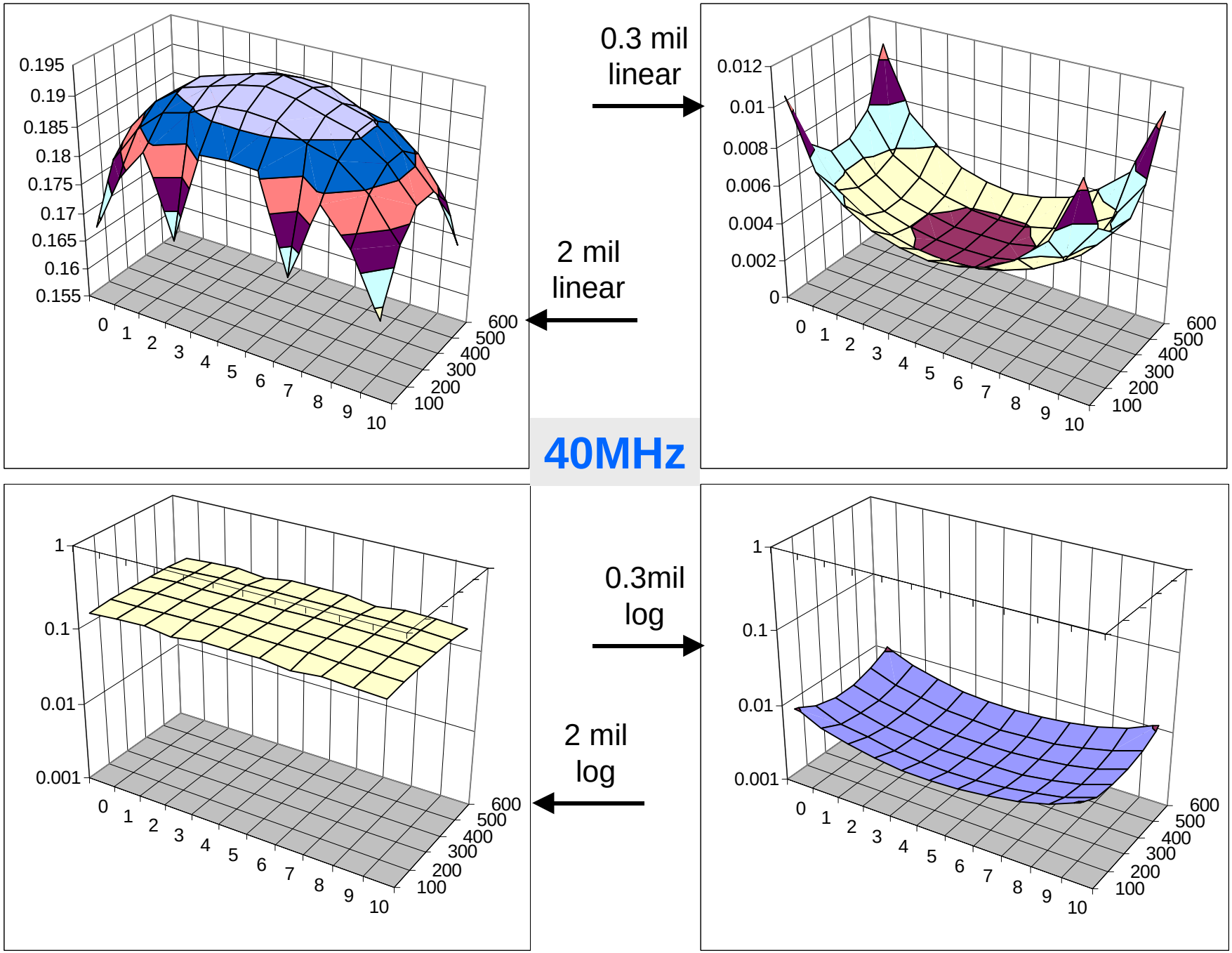
- Measured self impedance magnitudes on
- 1”x1” grid over a 10”x5” PCB
- Bare PCB
- 1 x 2-mil epoxy-glass laminate on the left
- 1 x 0.3 mil laminate on the right
- Linear autoscale on top
- Fixed logarithmic scale on bottom

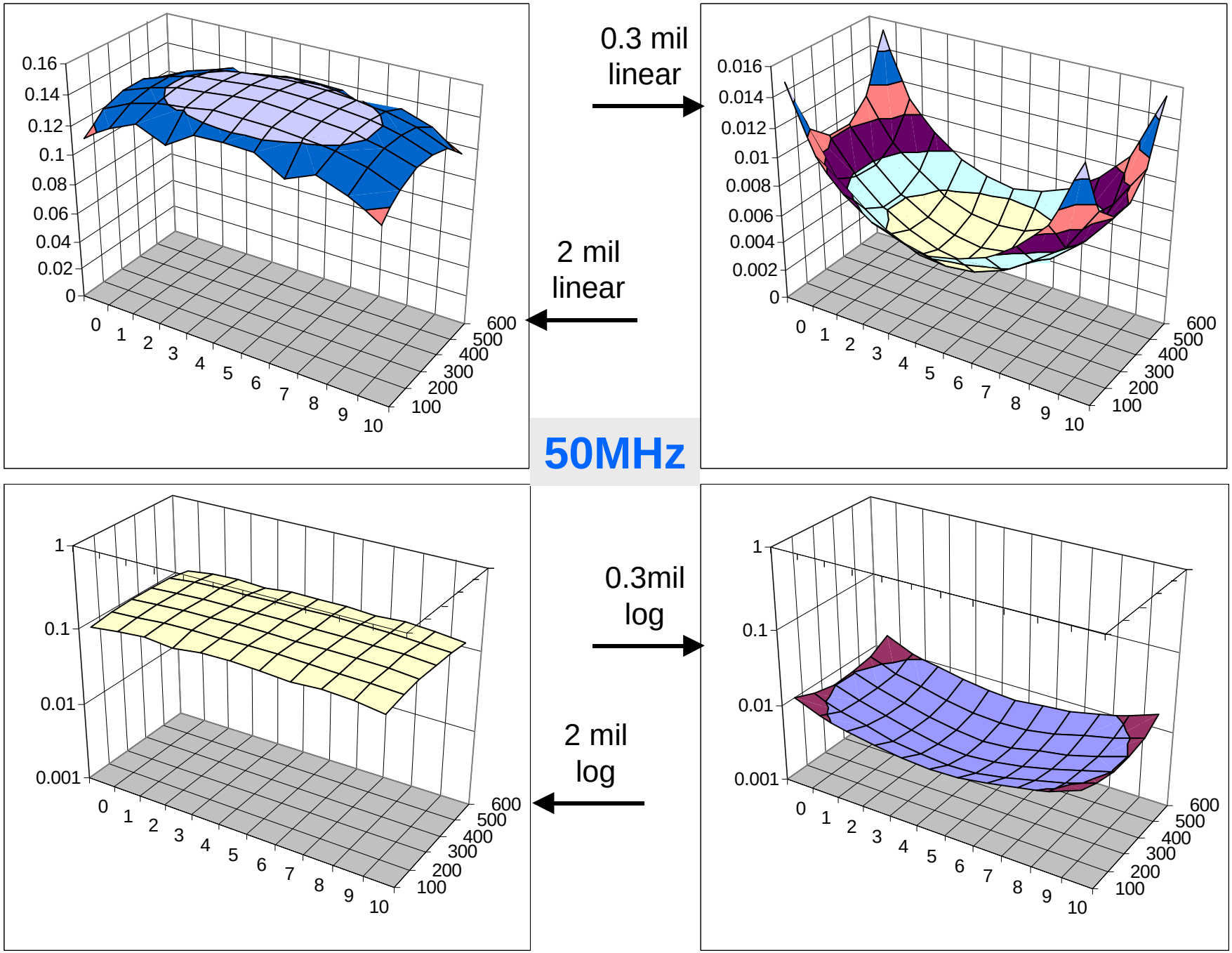

0.3 mil
linear
2 mil
linear
10MHz
0.3mil
log
2 mil
log
0.84
0.82
0.8
0.78
0.76
0.74
0.72
0.0265
0.026
0.0255
0.025
0.0245
0.024
0.0235
0.023
0.0225
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
100 200 300 400 500 600

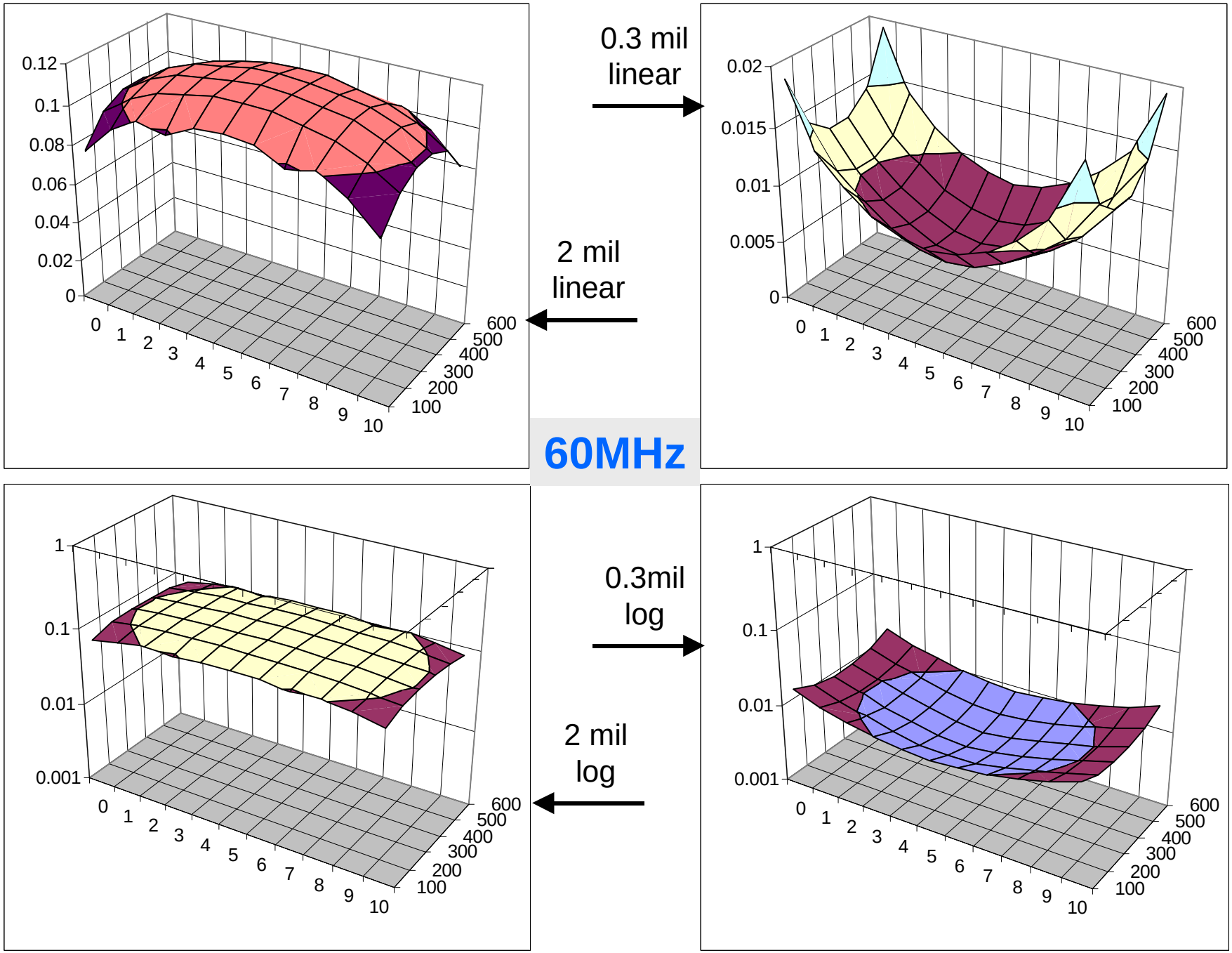

0.3 mil
linear
2 mil
linear
15MHz
0.3mil
log
2 mil
log
0.54
0.53
0.52
0.51
0.5
0.49
0.48
0.47
0.46
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
600 500 400 300 200 100

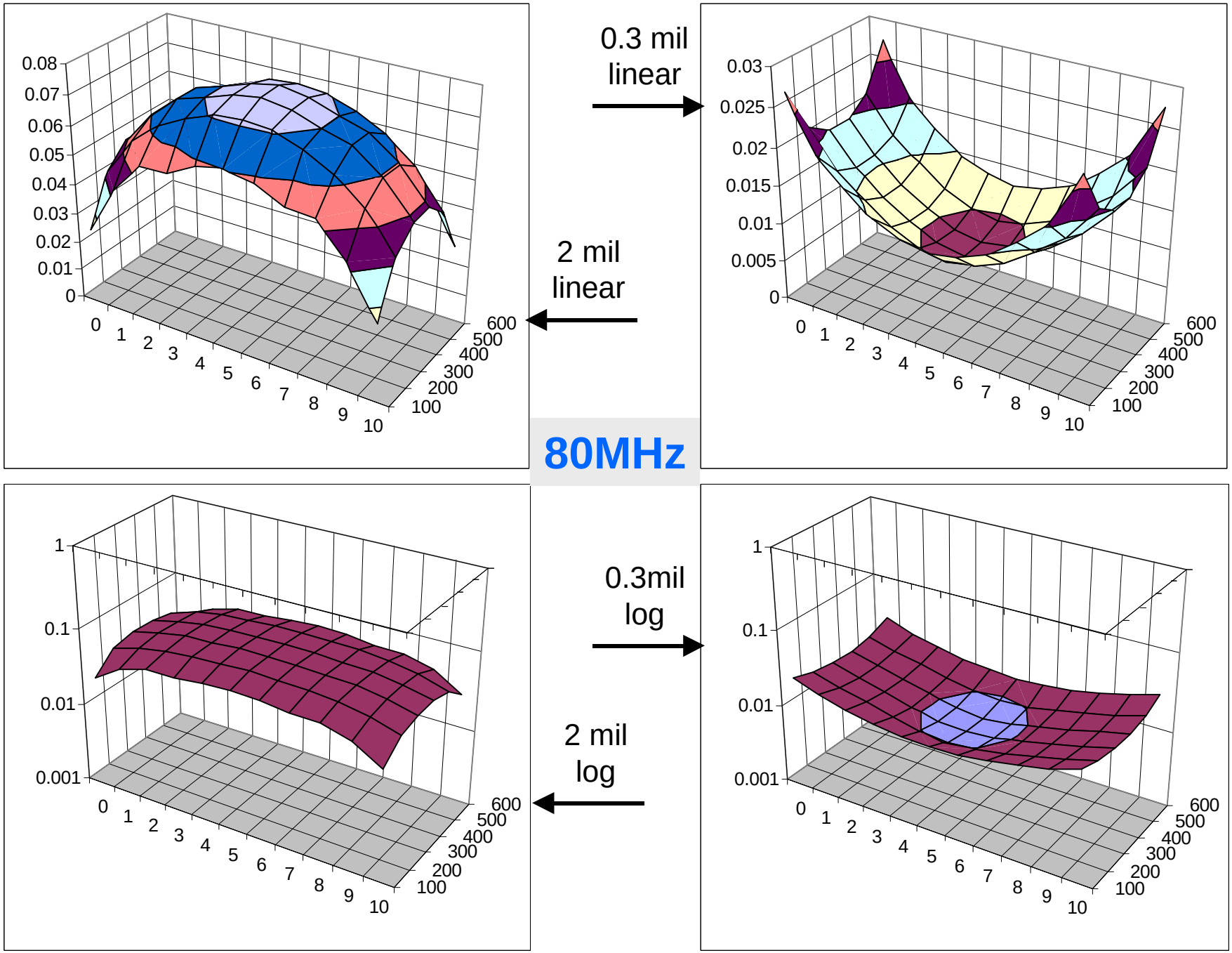

0.3 mil
linear
2 mil
linear
20MHz
0.3mil
log
2 mil
log
0.41
0.4
0.39
0.38
0.37
0.36
0.35
0.012
0.01
0.008
0.006
0.004
0.002
0
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
100 200 300 400 500 600

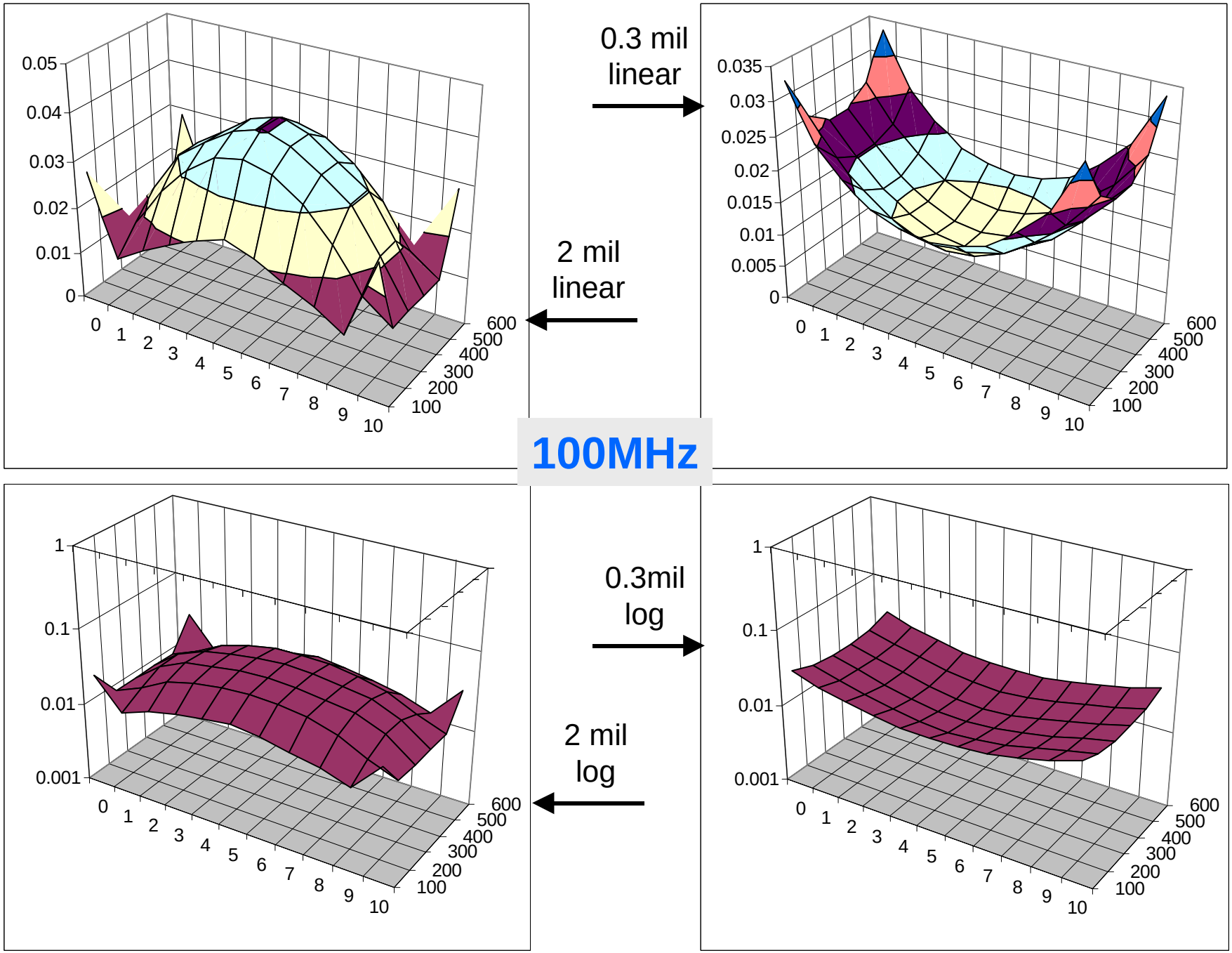

0.3 mil
linear
2 mil
linear
30MHz
0.3mil
log
2 mil
log
0.265
0.26
0.255
0.25
0.245
0.24
0.235
0.23
0.225
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
600 500 400 300 200 100

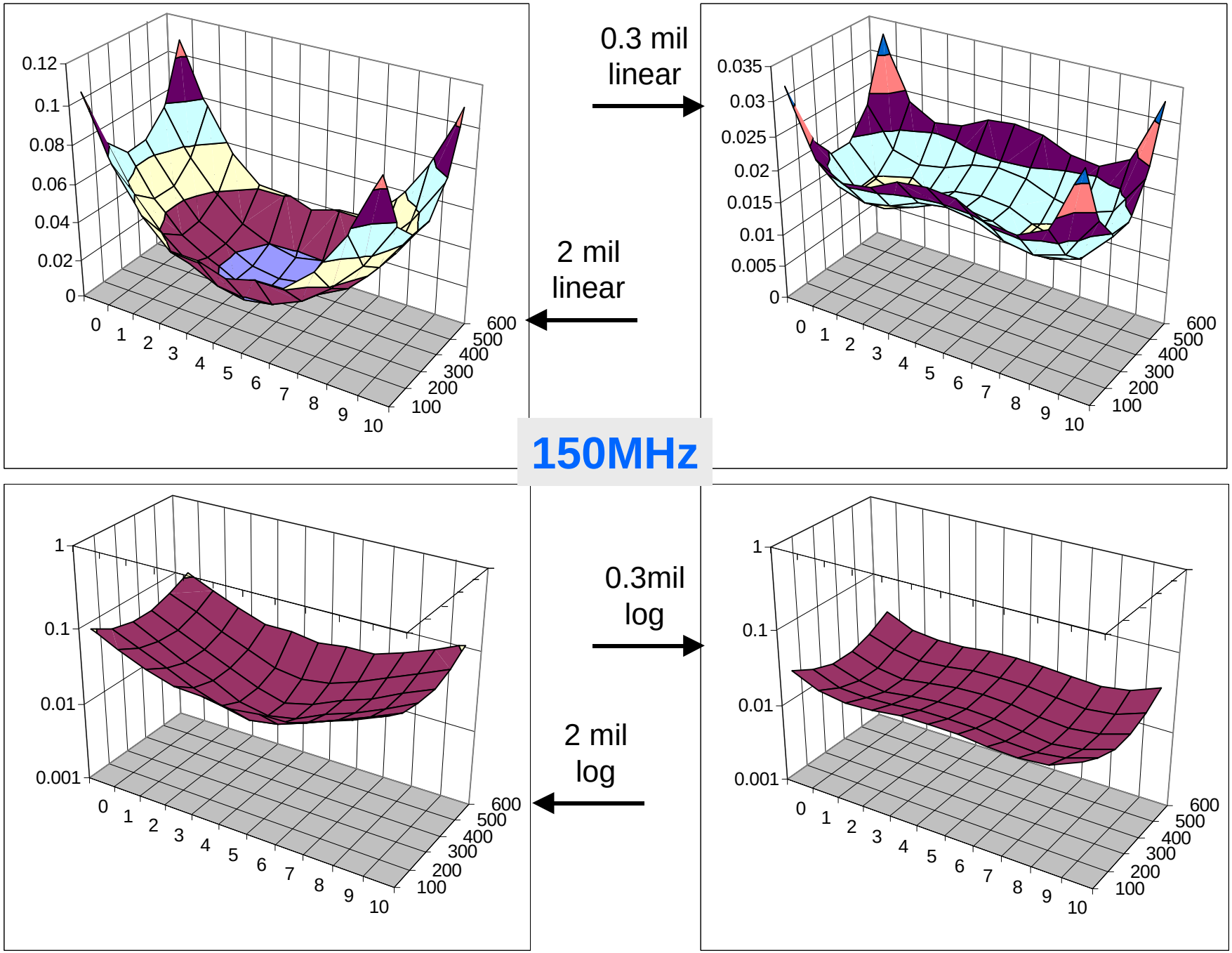

0.3 mil
linear
2 mil
linear
40MHz
0.3mil
log
2 mil
log
0.195
0.19
0.185
0.18
0.175
0.17
0.165
0.16
0.155
0.012
0.01
0.008
0.006
0.004
0.002
0
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
100 200 300 400 500 600

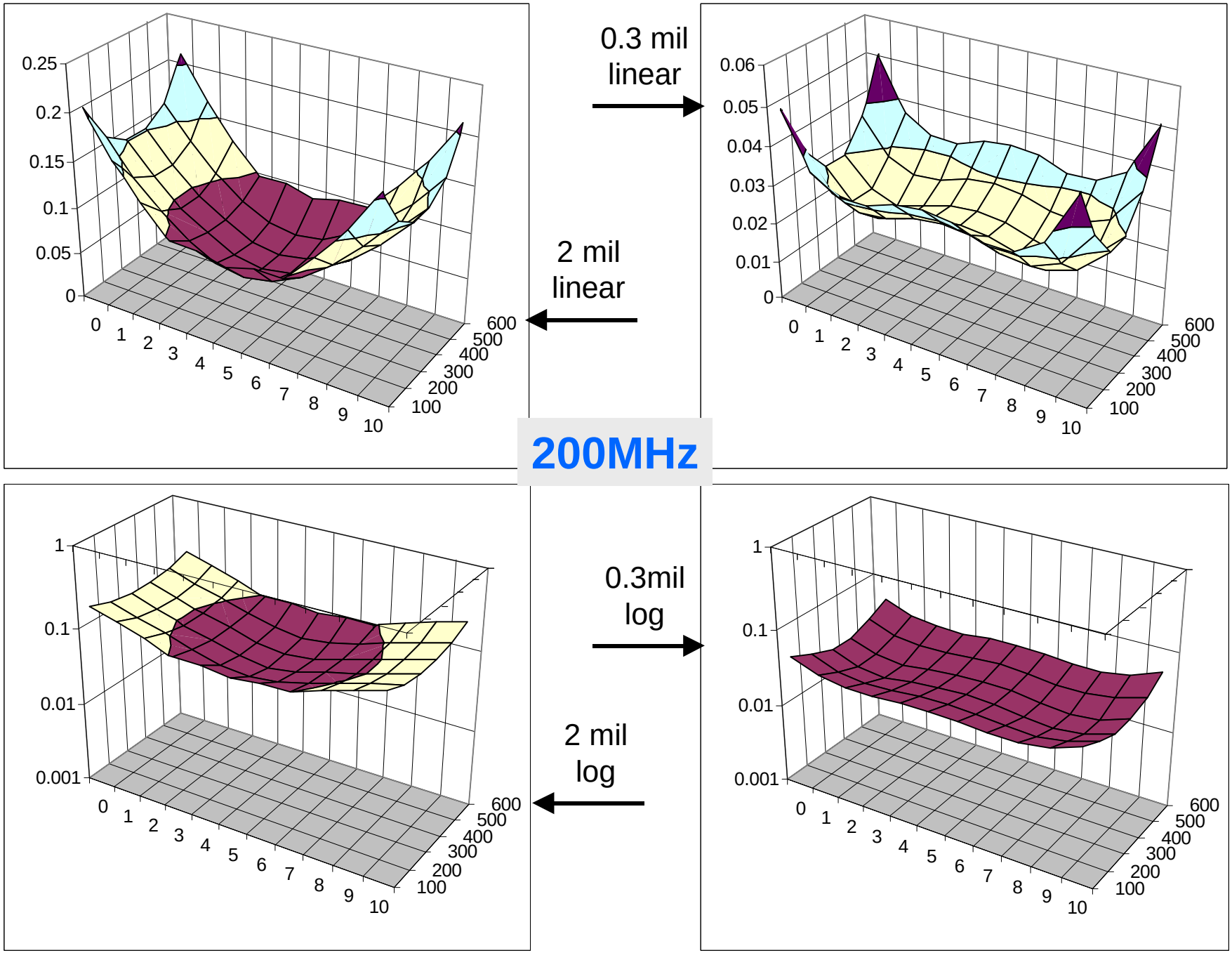

0.3 mil
linear
2 mil
linear
50MHz
0.3mil
log
2 mil
log
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
600
500
400
300
200
100

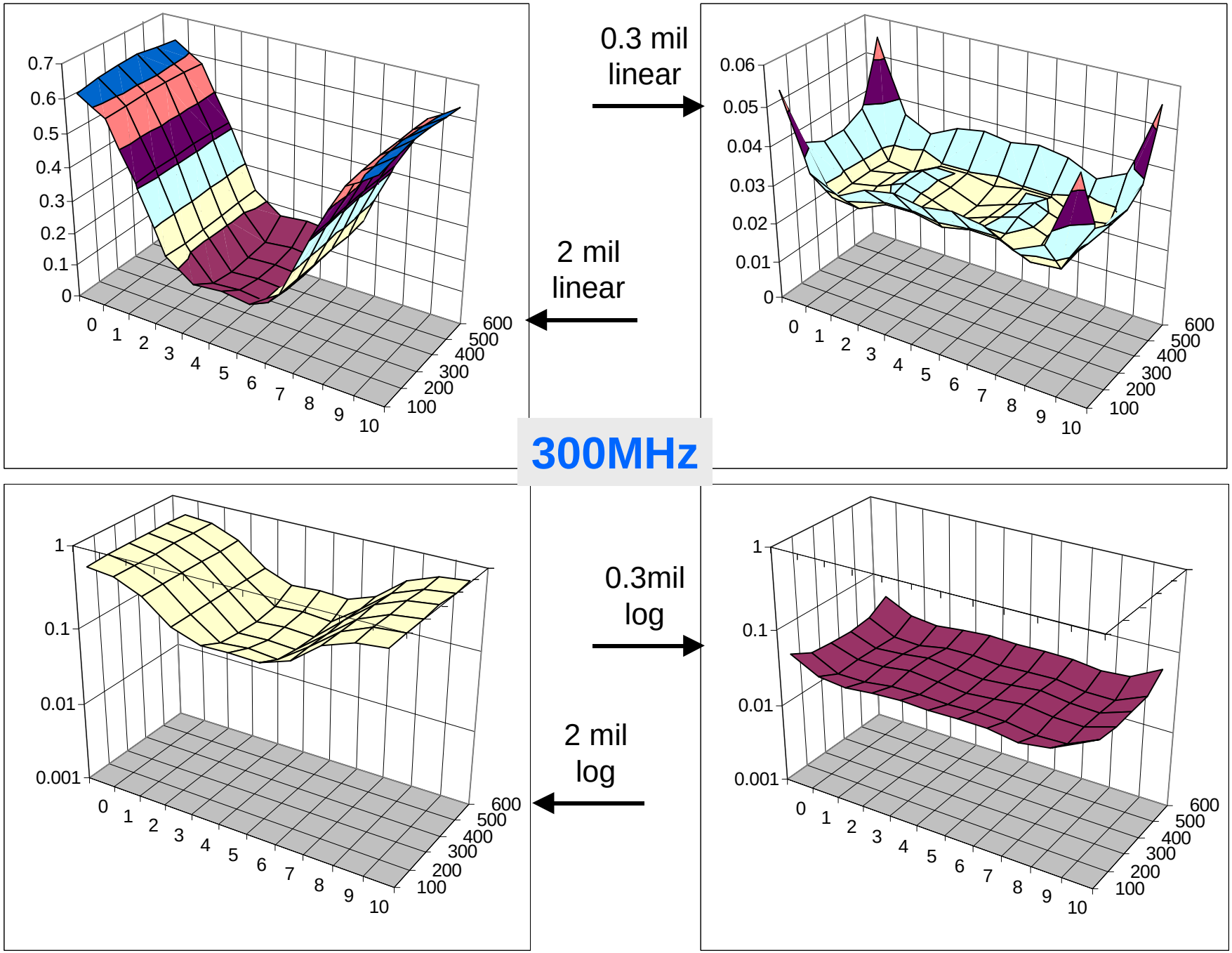

0.3 mil
linear
2 mil
linear
60MHz
0.3mil
log
2 mil
log
0.12
0.1
0.08
0.06
0.04
0.02
0
0.02
0.015
0.01
0.005
1
0.001
0 1 2 3 4 5 6 7 8 9 10
100 200 300 400 500 600

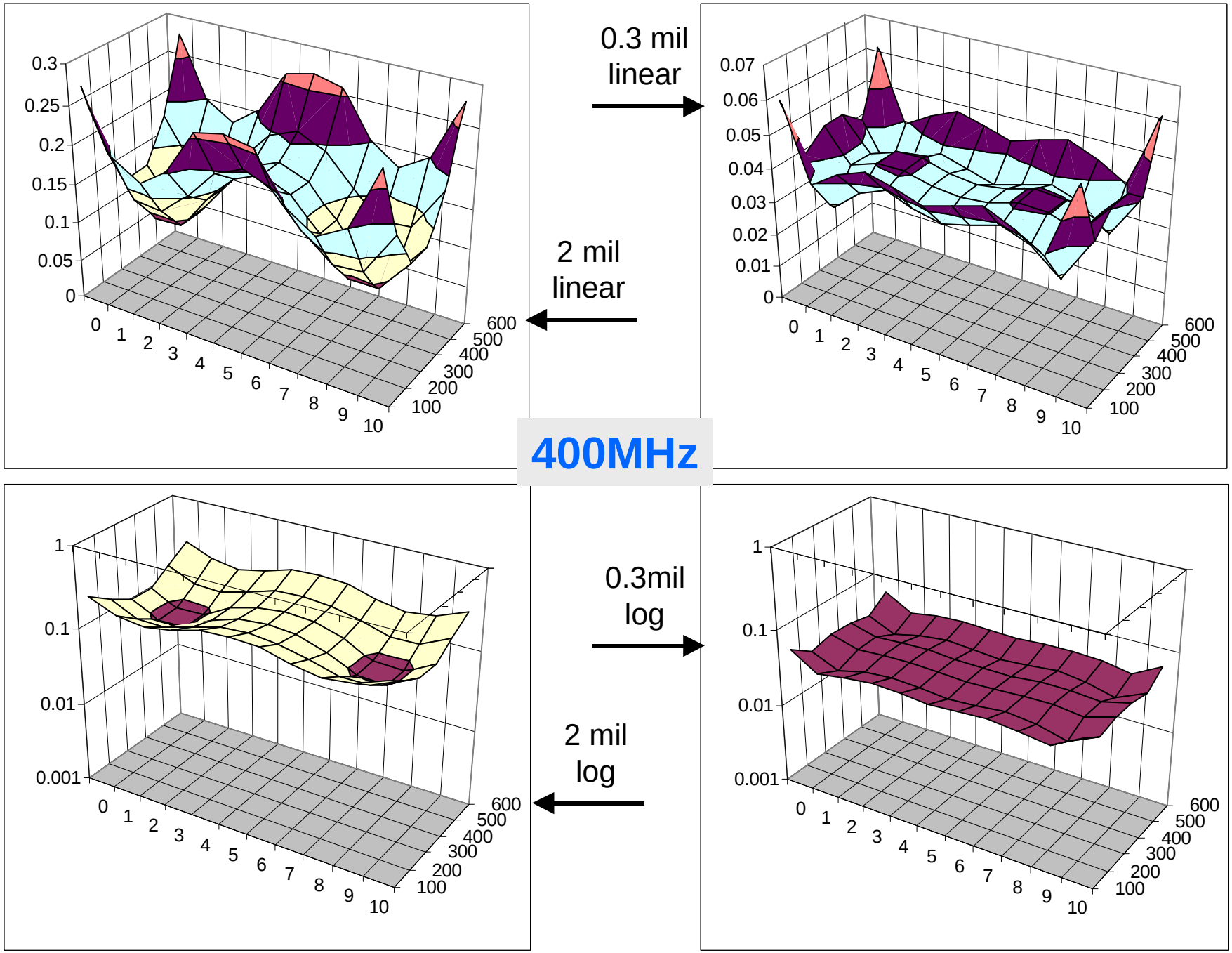

0.3 mil
linear
2 mil
linear
80MHz
0.3mil
log
2 mil
log
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.03
0.025
0.02
0.015
0.01
0.005
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
600 500 400 300 200 100

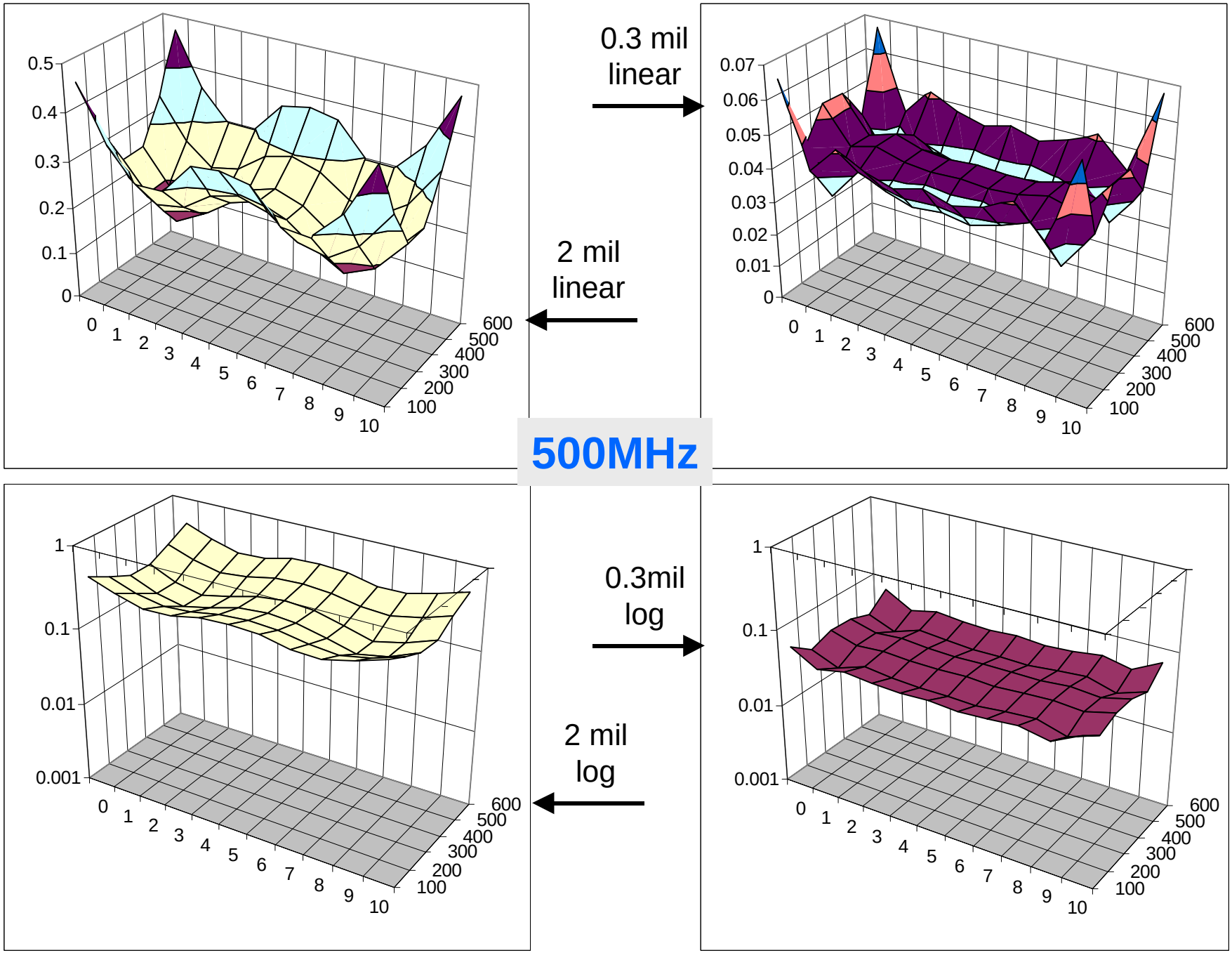

0.3 mil
linear
2 mil
linear
100MHz
0.3mil
log
2 mil
log
0.05
0.04
0.03
0.02
0.01
0
0.035
0.025
0.015
0.005
1
0.1
0.001
0 1 2 3 4 5 6 7 8 9 10
100 200 300 400 500 600

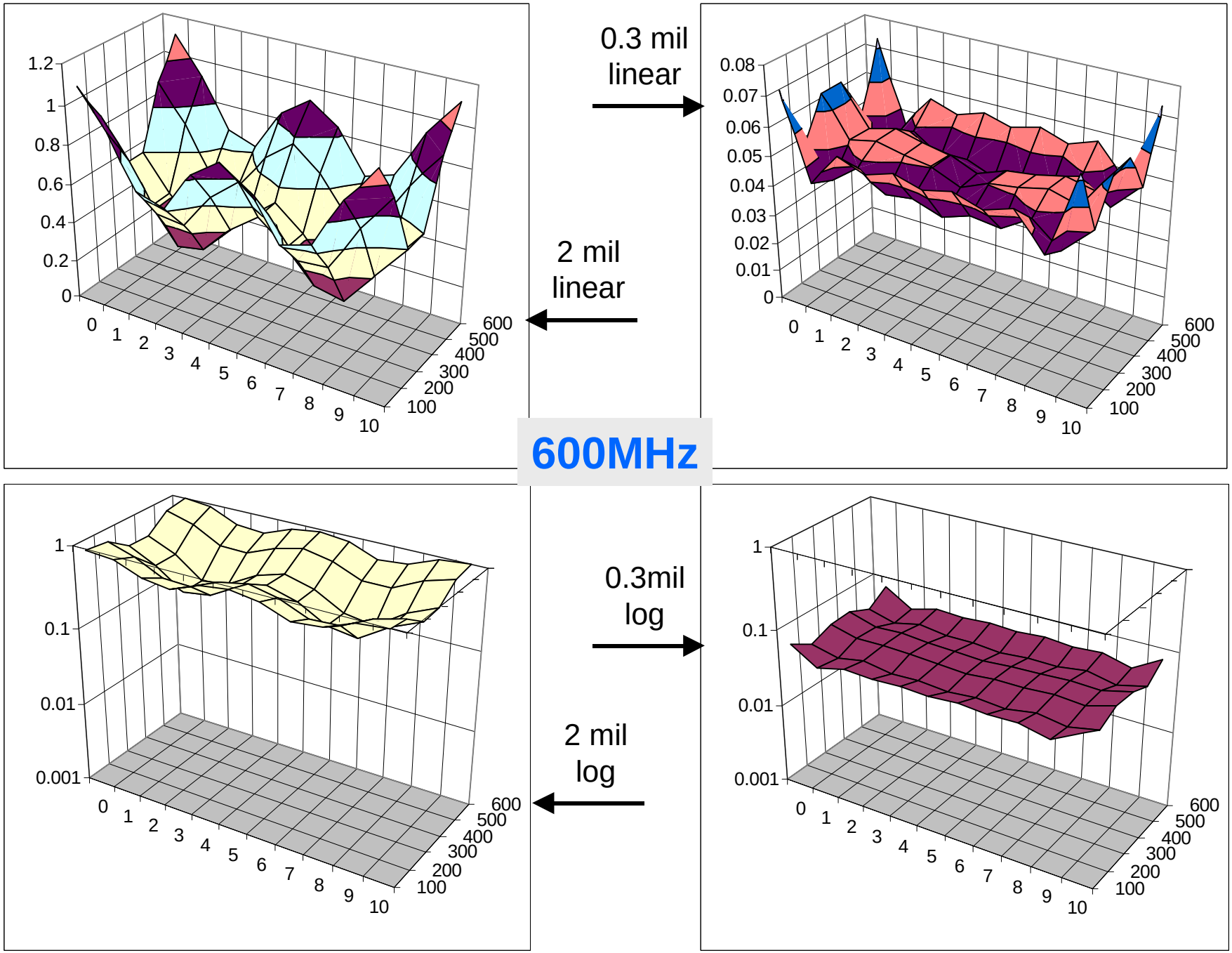

0.3 mil
linear
2 mil
linear
150MHz
0.3mil
log
2 mil
log
0.12
0.1
0.08
0.06
0.04
0.02
0
0.035
0.03
0.025
0.02
0.015
0.01
0.005
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
100 200 300 400 500 600

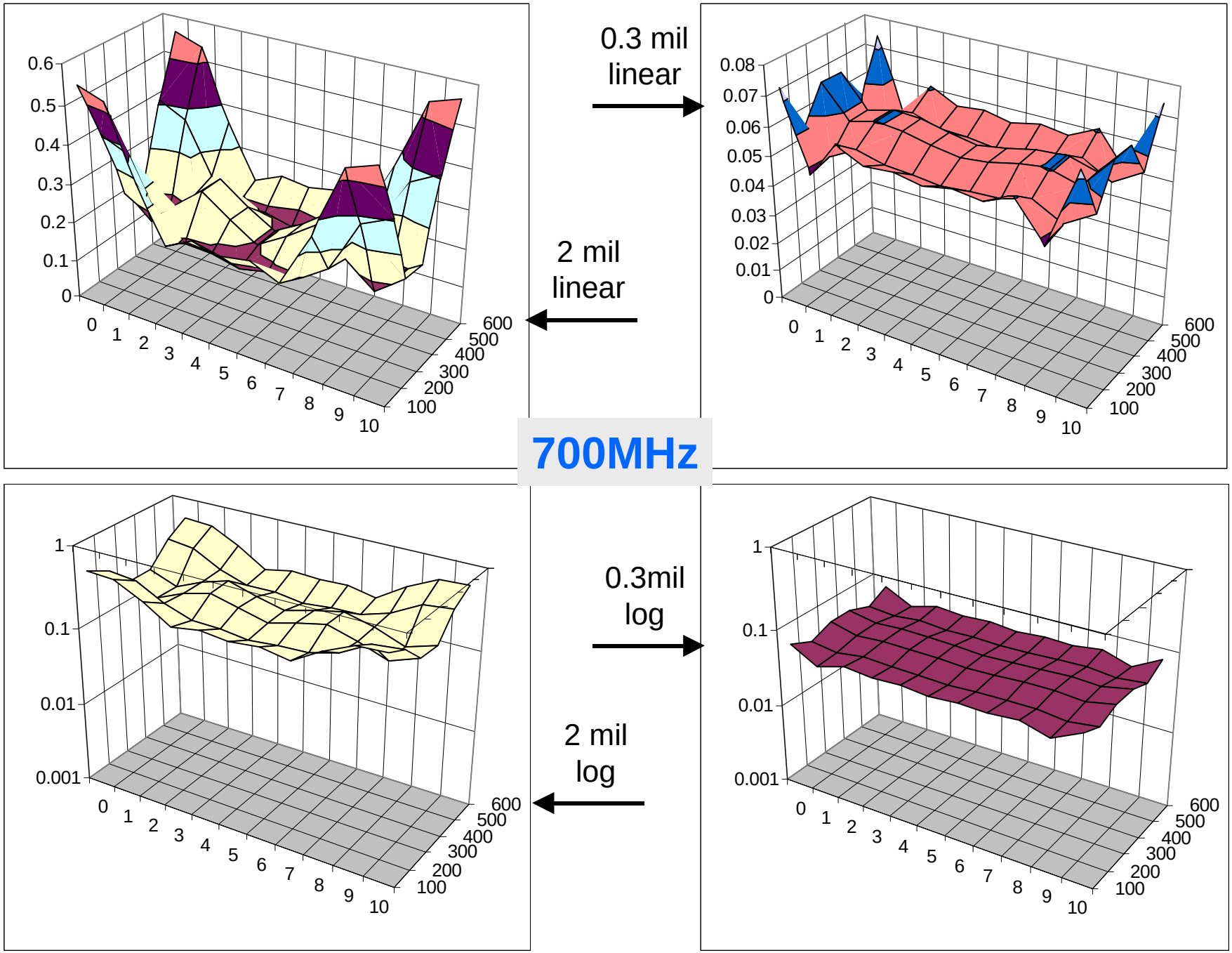

0.3 mil
linear
2 mil
linear
200MHz
0.3mil
log
2 mil
log
0.25
0.2
0.15
0.1
0.05
0
0.06
0.05
0.04
0.03
0.02
0.01
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
100 200 300 400 500 600

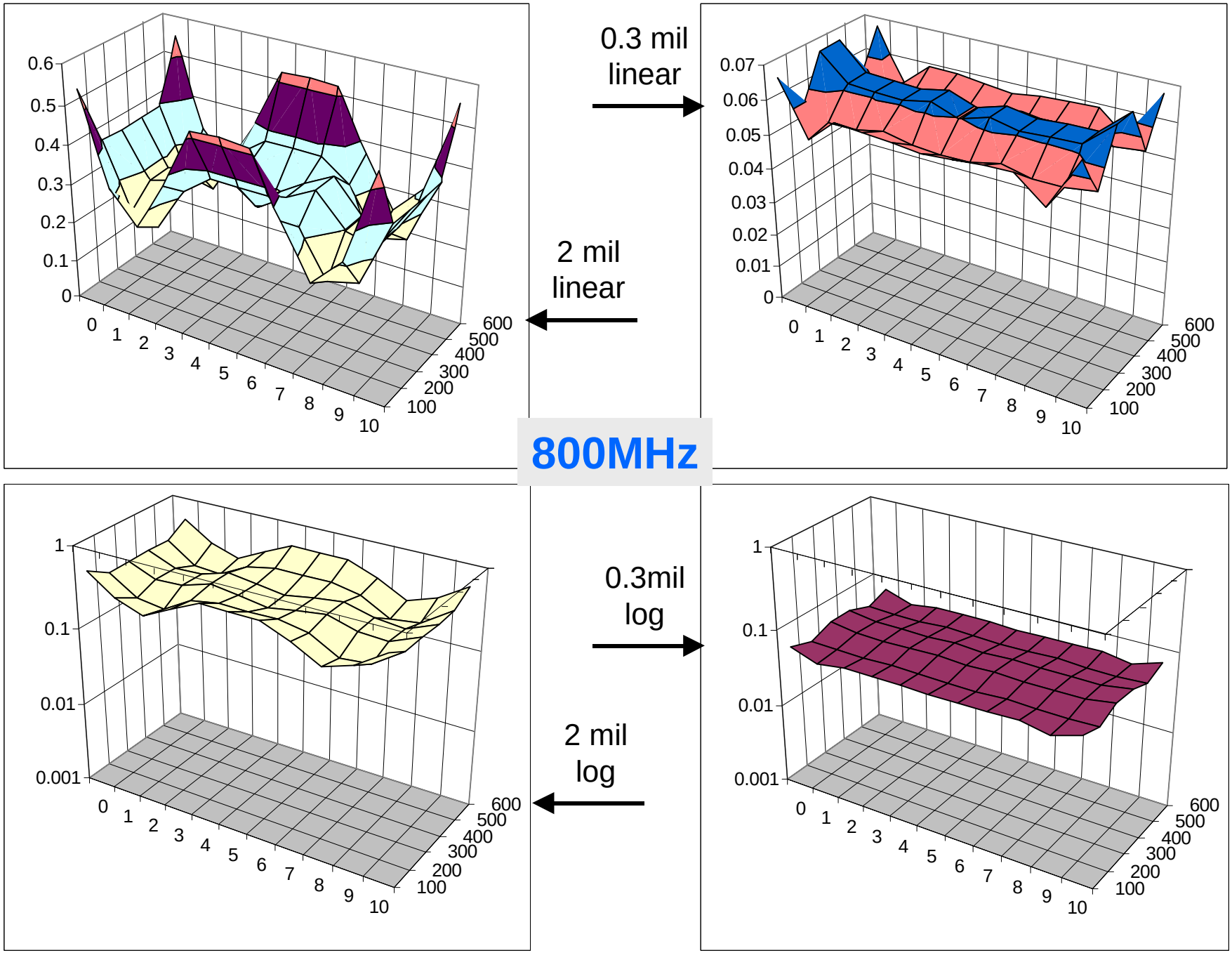

0.3 mil
linear
2 mil
linear
300MHz
0.3mil
log
2 mil
log
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.06
0.05
0.04
0.03
0.02
0.01
1
0.001
0 1 2 3 4 5 6 7 8 9 10
600
500
400
300
200
100

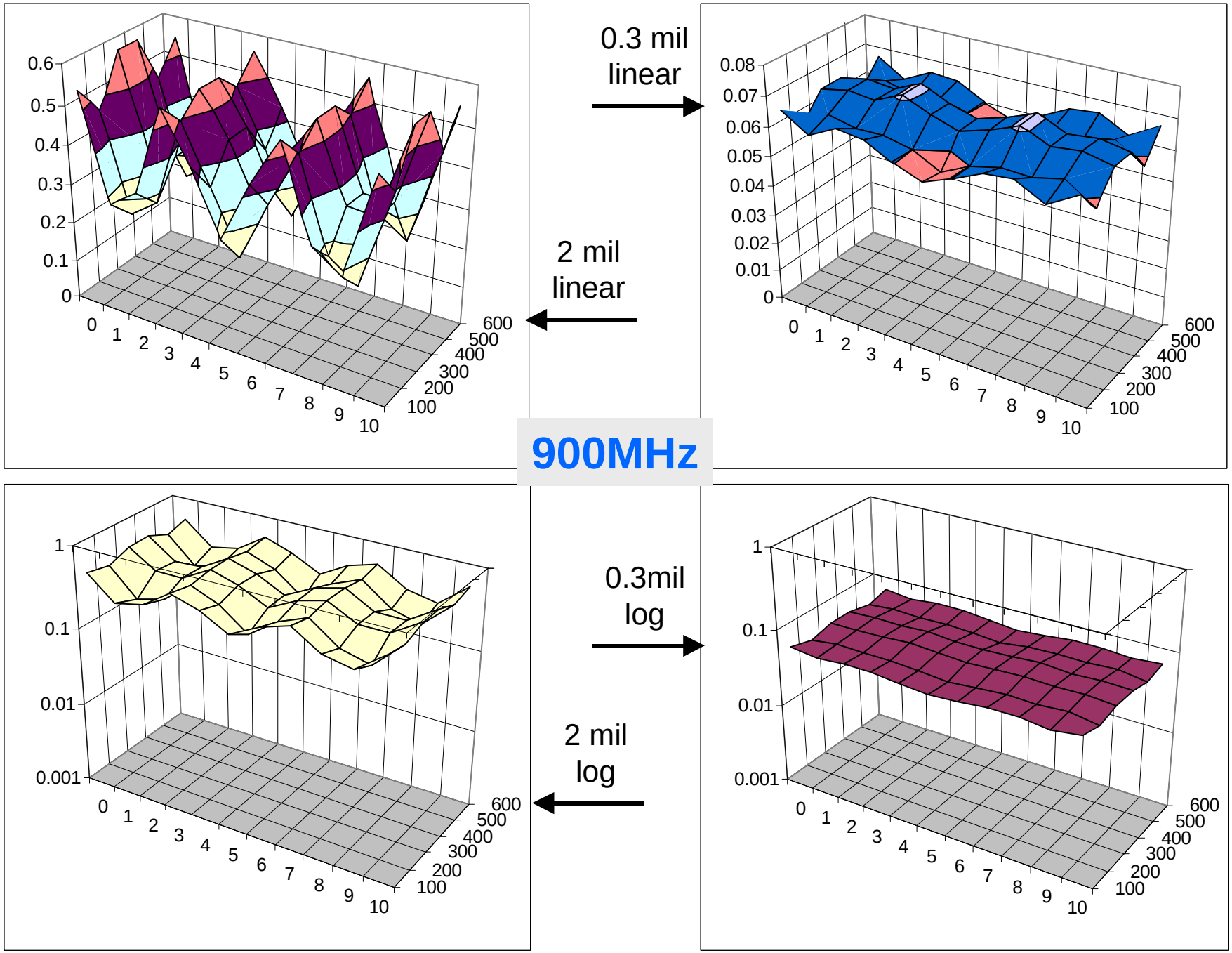

0.3 mil
linear
2 mil
linear
0.3mil
log
2 mil
log
400MHz
0.3
0.25
0.2
0.15
0.1
0.05
0
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1
0.1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
600 500 400 300 200 100

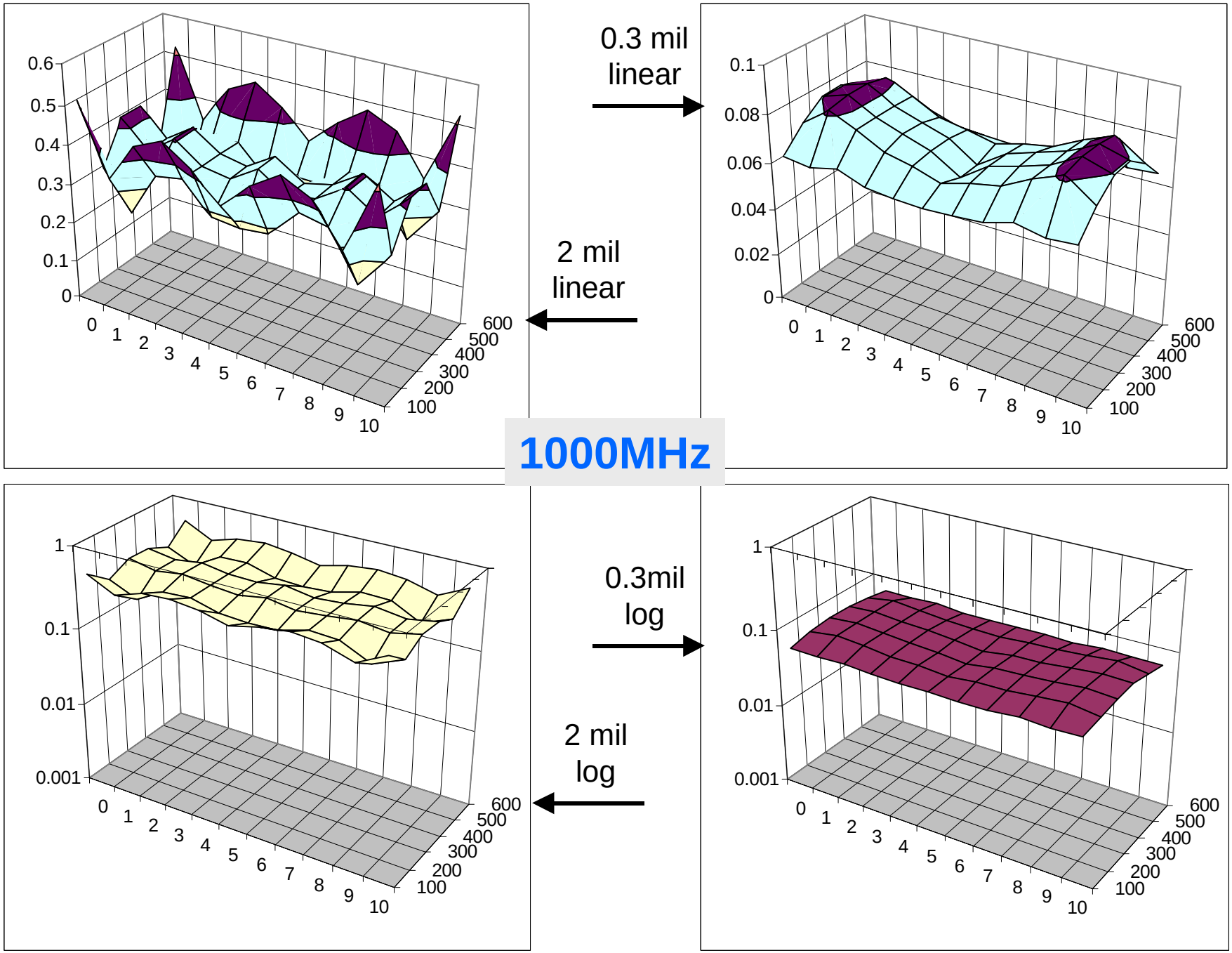

0.3 mil
linear
2 mil
linear
500MHz
0.3mil
log
2 mil
log
0.5
0.4
0.3
0.2
0.1
0
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1
0.001
0 1 2 3 4 5 6 7 8 9 10
100 200 300 400 500 600


0.3 mil
linear
2 mil
linear
600MHz
0.3mil
log
2 mil
log
1.2
1
0.8
0.6
0.4
0.2
0
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.1
0.001
0 1 2 3 4 5 6 7 8 9 10
600
500
400
300
200
100


0.3 mil
linear
2 mil
linear
700MHz
0.3mil
log
2 mil
log
0.6
0.5
0.4
0.3
0.2
0.1
0
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1
0.001
0 1 2 3 4 5 6 7 8 9 10
600
500
400
300
200
100


0.3 mil
linear
2 mil
linear
800MHz
0.3mil
log
2 mil
log
0.6
0.5
0.4
0.3
0.2
0.1
0
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1
0.001
0 1 2 3 4 5 6 7 8 9 10
600
500
400
300
200
100


0.3 mil
linear
2 mil
linear
900MHz
0.3mil
log
2 mil
log
0.6
0.5
0.4
0.3
0.2
0.1
0
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1
0.001
0 1 2 3 4 5 6 7 8 9 10
600
500
400
300
200
100


0.3 mil
linear
2 mil
linear
1000MHz
0.3mil
log
2 mil
log
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
0.08
0.06
0.04
0.02
1
0.01
0.001
0 1 2 3 4 5 6 7 8 9 10
600
500
400
300
200
100