DSP-PM06 Test Plug

Electrical Performance Distribution

Robert Jackson
Fluke Networks

E-Mail: support@flukenetworks.com

Tel: 1 800 283 5853 (toll free)

Intl: + 1 425 446 4519

Abstract:

This document contains the results of de-embedding measurements of PM06 test plug electrical properties. The properties were measured and accumulated on random samples over a period time, representing multiple production lots.

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1. Overview

When specifying a category 6 cabling system, it is desirable to maintain interoperability between various category 6 component manufacturers. As opposed to category 5 and 5e systems, category 6 parametric requirements are far more stringent. These stringent requirements suggest the need for an accurate and repeatable field test system. Within this system, a critical component is the link interface adapter. In particular, the plug (RJ45) that makes electrical connection with the installed link has a considerable influence on the overall link performance - especially the test parameter near-end-crosstalk (NEXT). To achieve a category 6 open cabling system that is not vendor specific, both the TIA and IEC define the physical properties and electrical performance of the RJ45 plug.

It has been noted in field-testing and has been documented in various industry publications that a variance in measured link performance is observed when different test plugs and/or adapters are used to measure the same link. Though there are several reasons, a dominant factor is the variance in the link interface RJ45 plug. Category 6 jacks are specifically designed to electrically cancel crosstalk introduced by the mating plug. Connecting hardware designers target very specific electrical properties to achieve the cancellation of undesirable properties such as NEXT and FEXT. Designers of connecting hardware rely on consistent properties of the mating plug and when these properties vary from the anticipated values, non-optimum cancellation (compensation) results and lower link margins are observed.

Why do plugs have so much variance? The primary reason is the fundamental design of the RJ45 plug. Originally designed to be a very inexpensive termination directly to a cable, the RJ45 interconnect has been pushed to increasingly higher levels of performance. Unfortunately, even with current designs incorporating wire management techniques, the electrical consistency is limited by the repeatable skill of an assembler manually terminating a cable to the plug. Consistent electrical performance requires precise geometric alignment of all current carrying paths in the plug.

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PM06 test plug design eliminates variability

The PM06 is the result of development efforts focused on producing an RJ45 test interface plug that facilitates consistent, repeatable and accurate measurements of category 6 links. The unique design of the PM06 fully complies with all plug specifications of the Cat 6 component standard (ANSI/TIA/EIA-568-B.2-1) and achieves centered performance (37 dB) for the 36-45 critical pair combination. A test plug possessing these qualities allows for objective performance testing independent of the connecting hardware manufacturer.

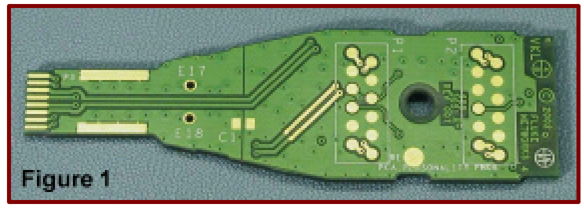
Figure 1

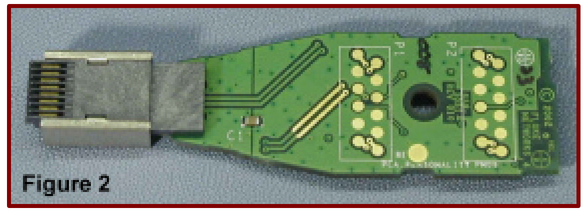
Figure 2

As can be seen in Figures 1 and 2, the design completely eliminates all discrete wires into the RJ45 tip replacing them with precise PCB patterns. It consists of a contact block that is mounted on a printed circuit board with the electrical properties tuned through the dimensions of traces on the printed circuit board. This design approach takes the current carrying paths to a new level of geometric consistency and repeatability, which results in excellent electrical performance. One can also note that the PM06 was designed with a high level of geometric symmetry. This provides a means to cross-check the results of de-embedding the 12-36 and 36-78 wire pair combinations against each other, and to cross-check the results of de-embedding the 12-45 and 45-78 wire pair combinations against each other.

2. Summary

The completed assembly of the PM06 is shown in Figures 3 and 4. Measurements were made on similar units taken from production stock.


Figure 3

Figure 4

In the following sections, this document displays tabulated and graphical summaries of all the data collected during a sample interval of several weeks. Random samples were selected from 10 manufacturing lots spread over 5 weeks of production. In order to represent the extensive data set for easy consumption, a graphical format was selected. In some cases only "worst case" data is displayed – which will be noted in the particular section.

The focus of data collection was to build a true statistical representation of the PM06 electrical properties. Since all manufactured items have parametric tolerances, the question quickly becomes; "How consistent is it?". The data contained herein answers that question with regard to both NEXT and Return Loss properties of the PM06.

One will notice that only magnitude data was collected to establish statistical distributions. Over the course of development, Fluke Networks engineering has observed the extreme consistency of the phase relationship of the NEXT coupling. By far, the greatest variance in the PM06 design is that absolute magnitude of the coupling coefficient. As such, magnitude variance is presented for review. As a point of reference, representative full swept frequency data sets showing both magnitude and phase are included for completeness.

Upon review of the data one can conclude that the PM06 is simply the best CAT6 test interface that is commercially available. Considering the quality and consistency of PM06 electrical properties, the PM06 is unsurpassed in accurate measurement of links for category 6 compliance and production testing of category 6 jacks.

(For in-depth technical discussion, refer to the papers listed in section 3.)

3. Technical Reference

Fluke Networks Corp. actively participates in TIA technical discussions and has submitted numerous papers to various TIA committees. Contact Fluke Networks Corp. for copies of the following:

For detailed technical discussion of PM06 Return Loss properties, refer to TIA paper from Fluke Networks Corp. **"Test plug return loss consistency per TIA/EIA-568-B.2 and B.2.1" February 2003.**

For detailed performance of plug NEXT properties refer to the contribution to the TIA TR42.7.1 committee titled: "**Proposal to adjust de-embedding reference jack vectors and/or use direct probing method to become the reference measurement method**". **February 2003.**

Plug FEXT properties are described in a separate document titled "**FEXT test results on reference centered category 6 test plugs**". **February 2003.** The measured performance is well within the ranges as defined in TIA/EIA-568-B.2-1. It has been established that this performance is also extremely consistent between multiple samples of test plugs.

4. Parametric Data

4.1 NEXT Performance

The requirements for NEXT are very challenging. For the 36-45, 12-36, 36-78 wire pair combinations tight requirements are applicable for magnitude and phase. For the 12-45, 45-78 wire pair combinations there are minimum requirements for magnitude, and if the magnitude is below a defined level, phase requirements do apply as well. For the 12-78 wire pair combination, there is only a minimum requirement for magnitude.

Both de-embedding with a Stewart reference jack and Direct Probe measurement techniques were performed on a population of 156 units. The following tables and graphs detail the results. Statistical distributions are given at frequencies of 100 and 250 MHz.

De-embedded NEXT Statistical Summary

36-45	Average dB	Min dB	Max dB	Std Dev dB	Median dB	TIA Specified Range (Magnitude) dB
@ 100MHz	-37.019	-37.25	-36.66	.106	-37.027	-36.4 to -37.6
@ 250MHz	-29.061	-29.35	-28.71	.113	-29.073	-29.64 to -28.44

12-36	Average dB	Min dB	Max dB	Std Dev dB	Median dB	TIA Specified Range (Magnitude) dB
@ 100MHz	-48.66	-49.25	-47.82	0.22	-48.68	-46.5 to -49.5
@ 250MHz	-40.67	-41.22	-39.84	0.23	-40.69	-38.54 to -41.54

36-78	Average dB	Min dB	Max dB	Std Dev dB	Median dB	TIA Specified Range (Magnitude) dB
@ 100MHz	-48.56	-49.10	-47.68	.22	-48.57	-46.5 to -49.5
@ 250MHz	-40.61	-41.16	-39.70	.23	-40.63	-38.54 to -41.54

12-45	Average dB	Min dB	Max dB	Std Dev dB	Median dB	TIA Specified Range (Magnitude) dB
@ 100MHz	-66.72	-67.78	-66.11	0.31	-66.72	-57 max (below –70 no phase)
@ 250MHz	-59.17	-59.96	-58.47	0.31	-59.20	-49.04 max (below -62.04 no phase)

45-78	Average dB	Min dB	Max dB	Std Dev dB	Median dB	TIA Specified Range (Magnitude) dB
@ 100MHz	-63.93	-64.54	-62.87	.25	-63.93	-57 (below –70 no phase)
@ 250MHz	-56.73	-57.42	-56.03	.23	-56.73	-49.04 (below -62.04 no phase)

12-78	Average dB	Min dB	Max dB	Std Dev dB	Median dB	TIA Specified Range (Magnitude) dB
@ 100MHz	-78.04	-79.09	-76.21	0.62	-78.21	-60 max
@ 250MHz	-69.53	-70.56	-68.39	0.41	-69.58	-52.04 max

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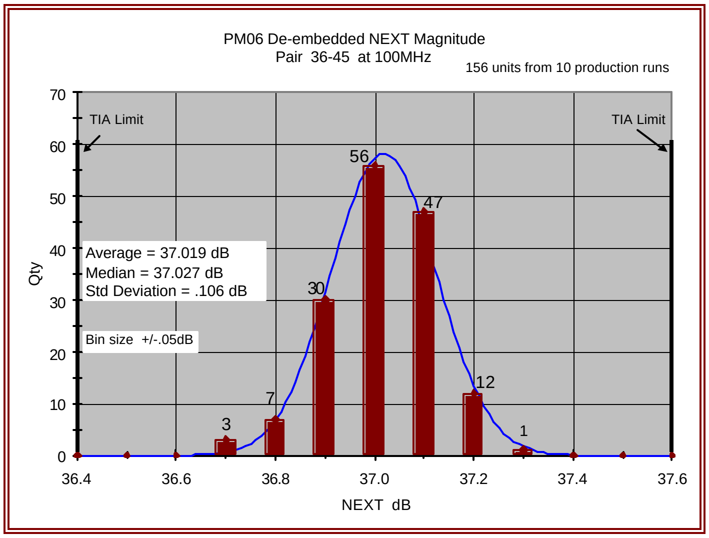
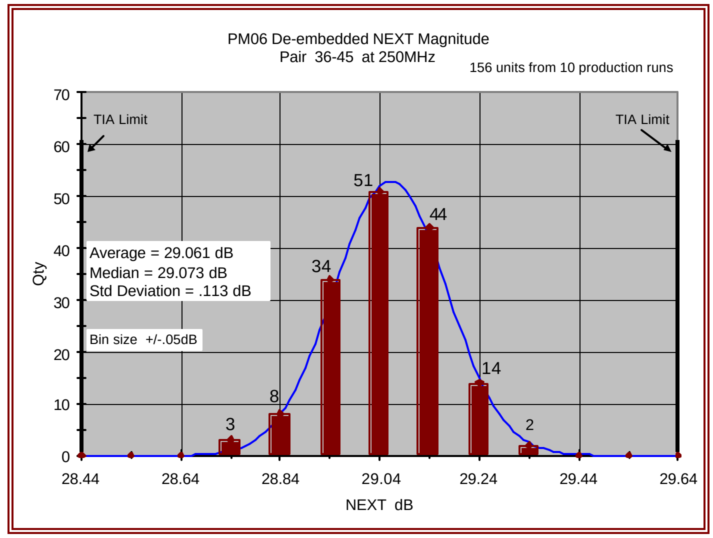
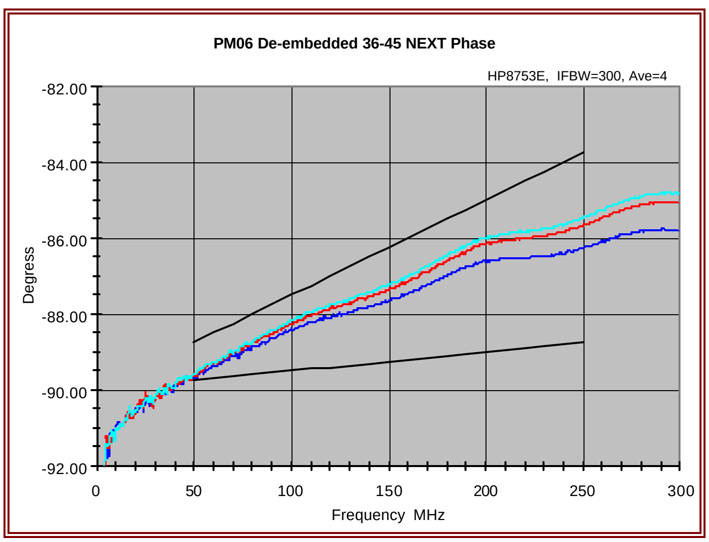
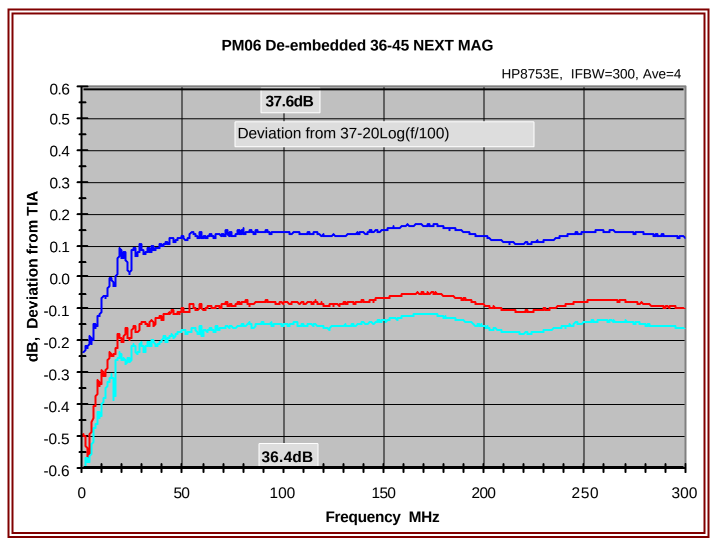
Graphical Results

NEXT 36-45 Pair









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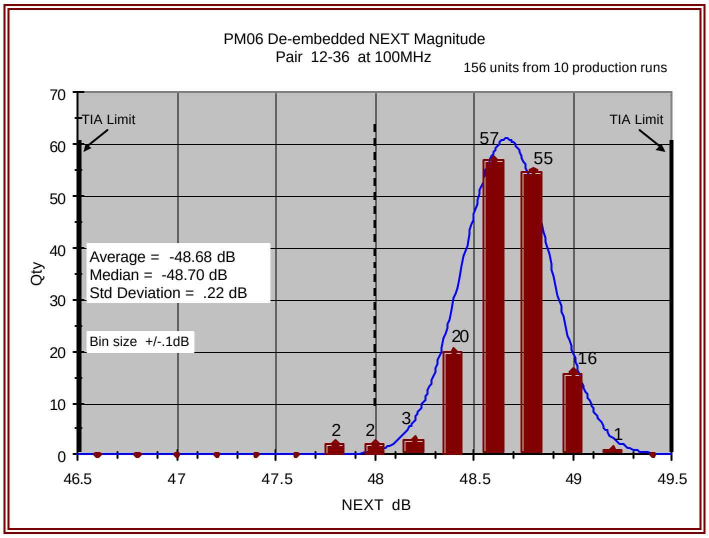

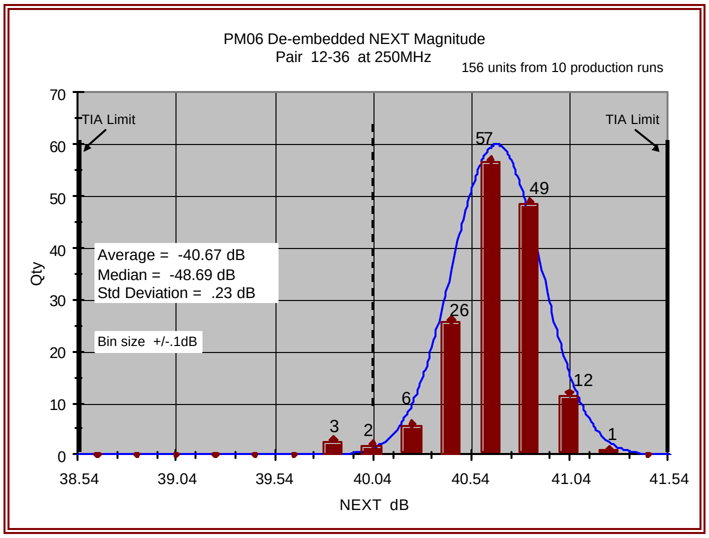

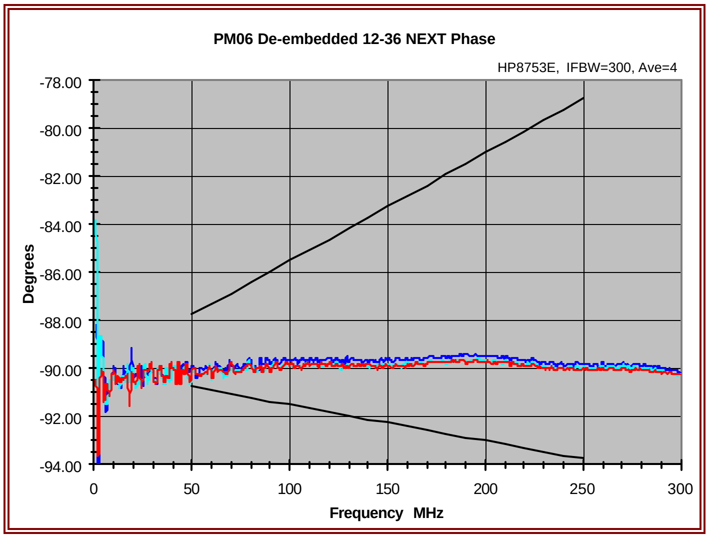

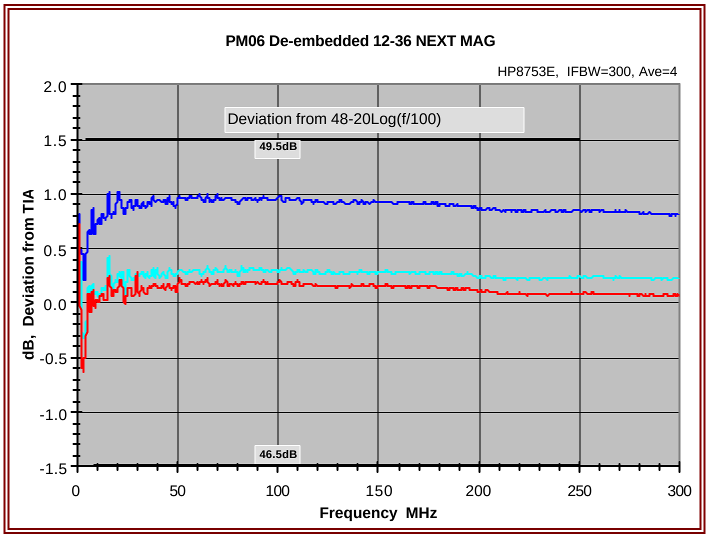

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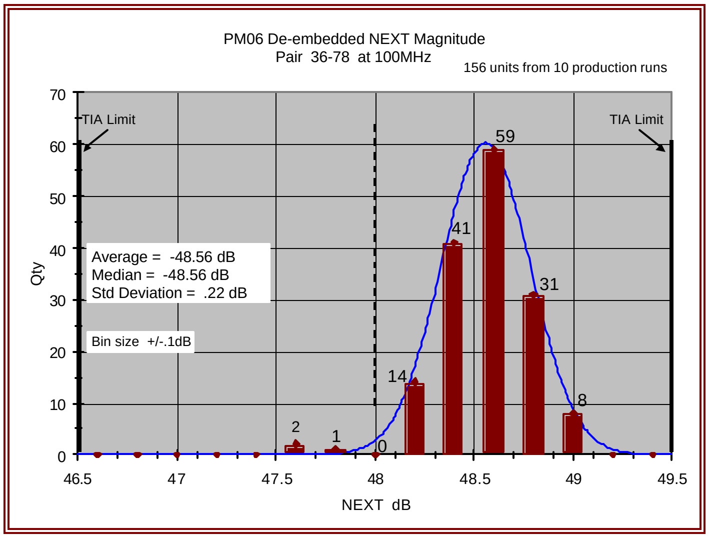
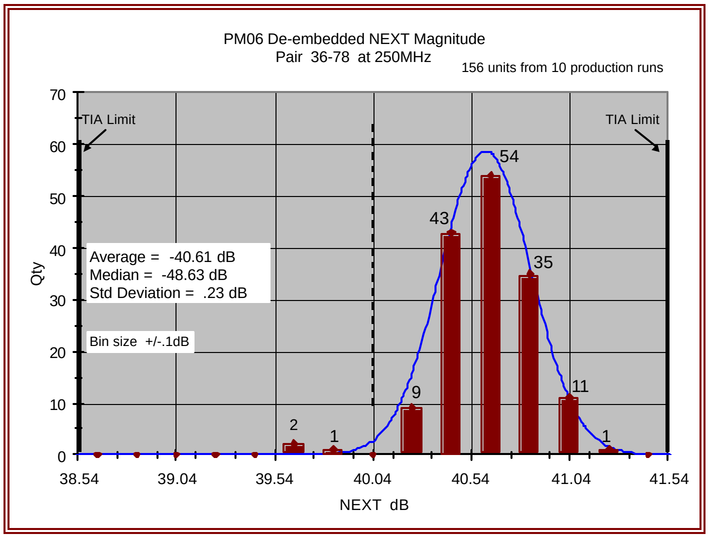
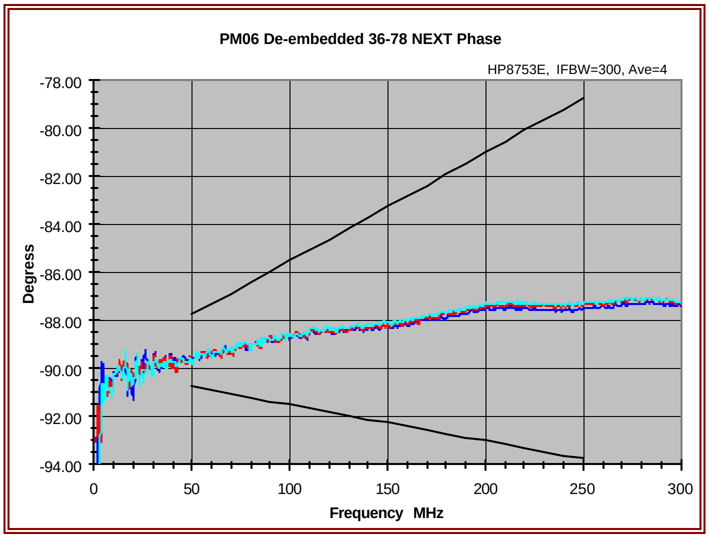
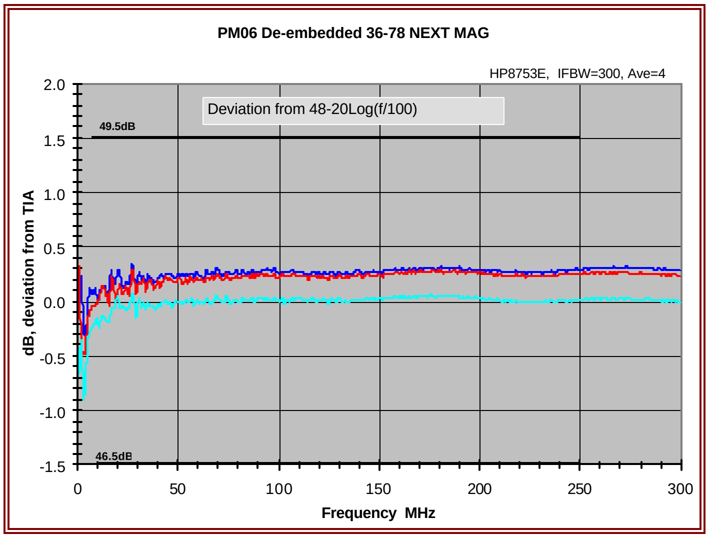
NEXT 36-78 Pair









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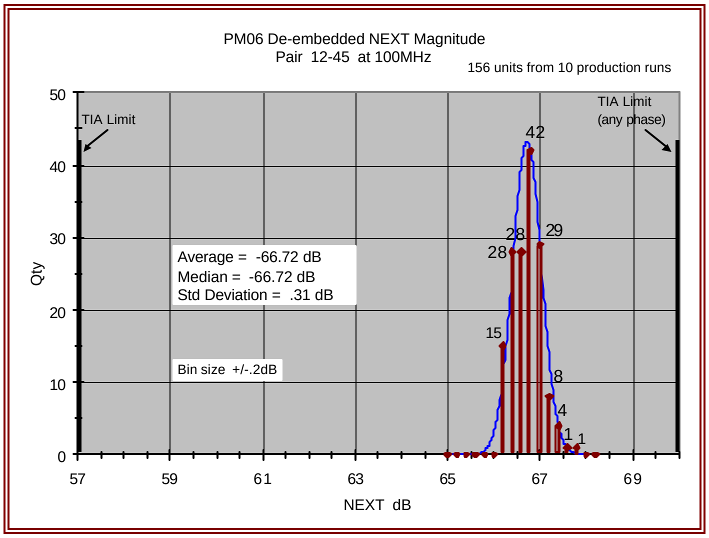

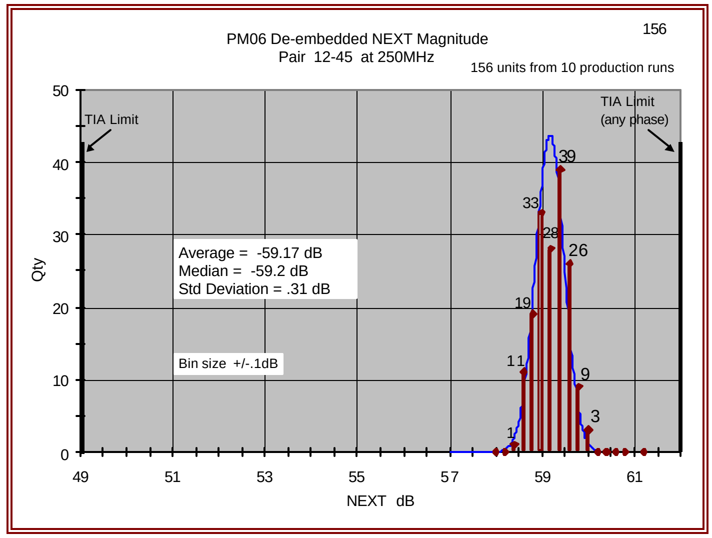

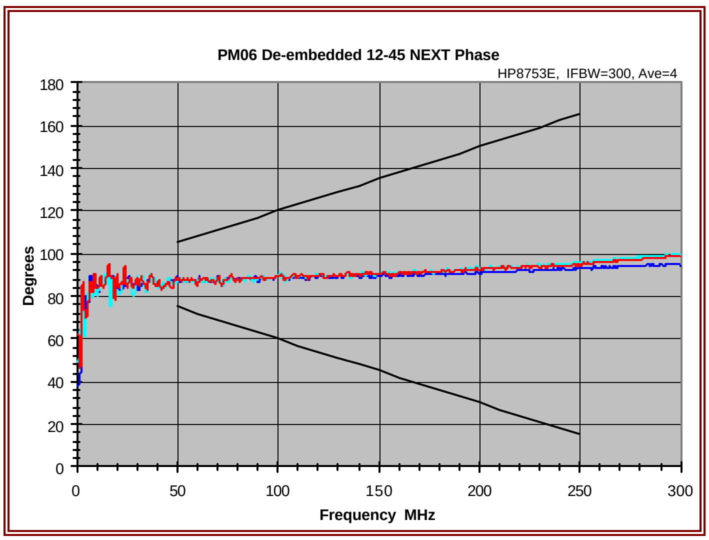

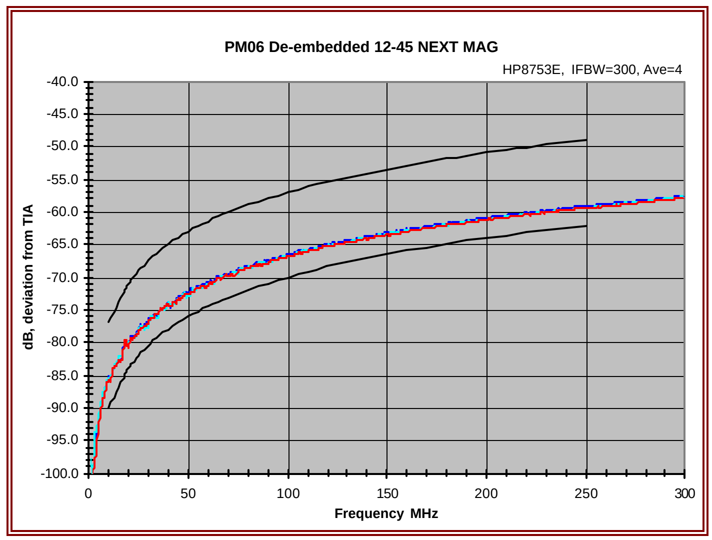

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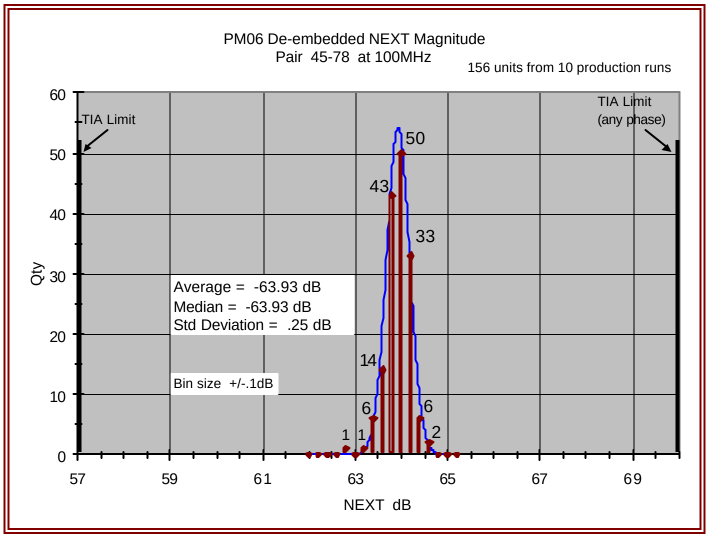

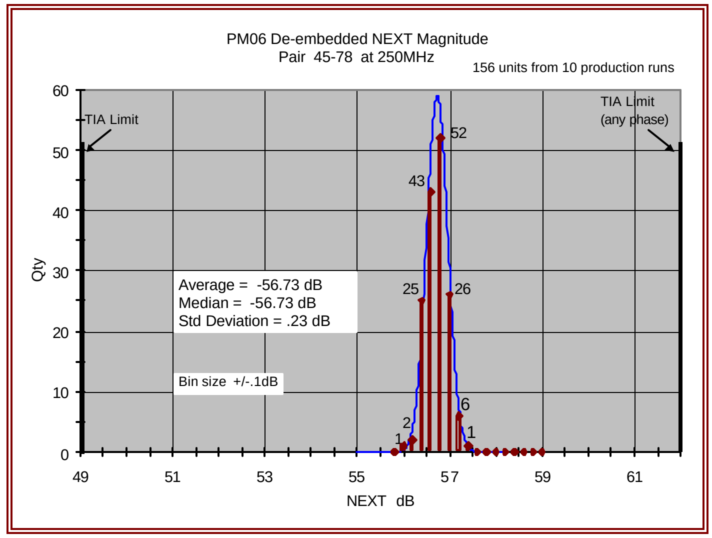

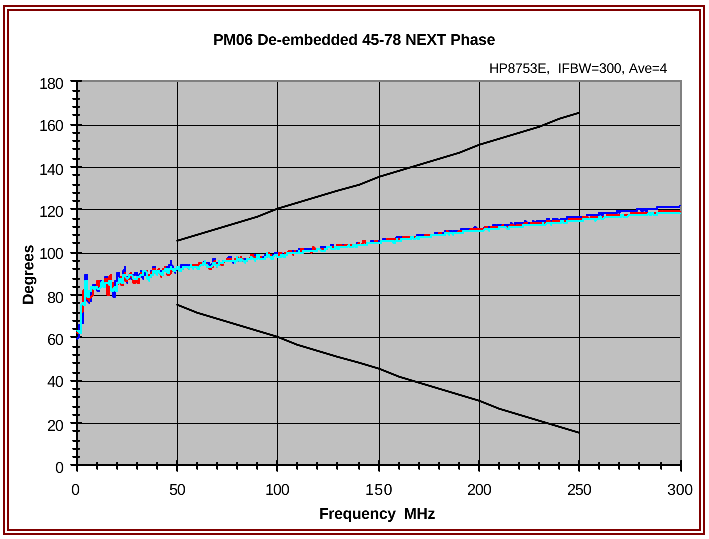

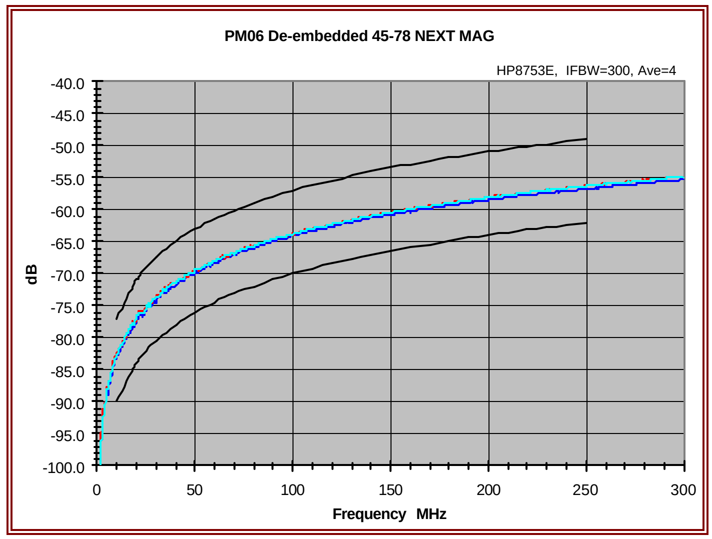

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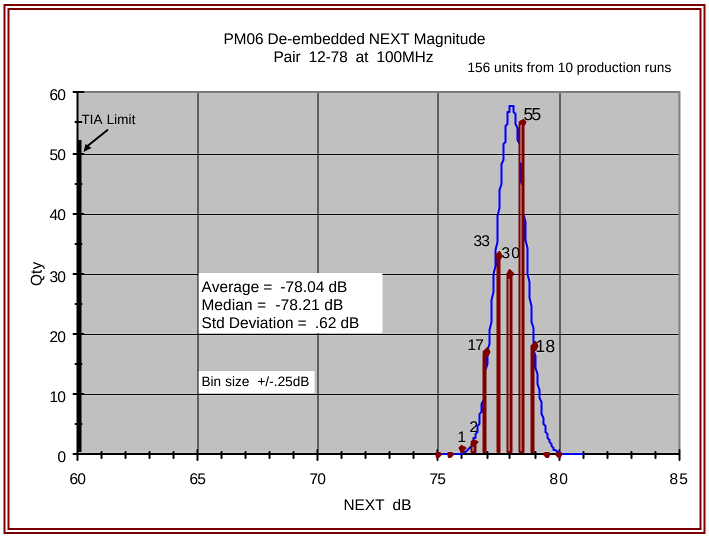
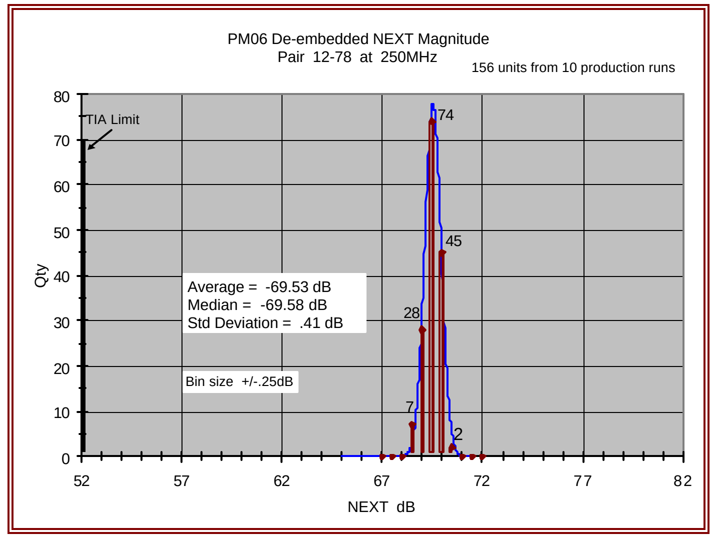
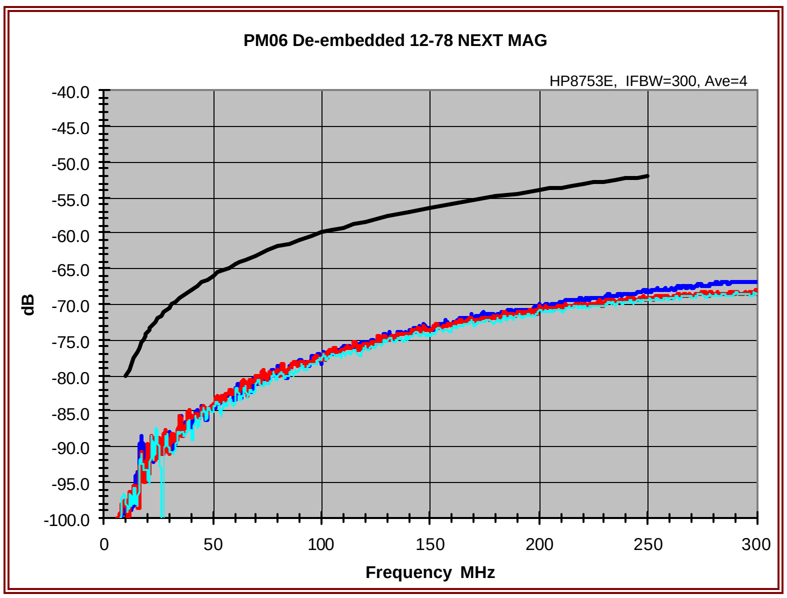
NEXT 12-78 Pair







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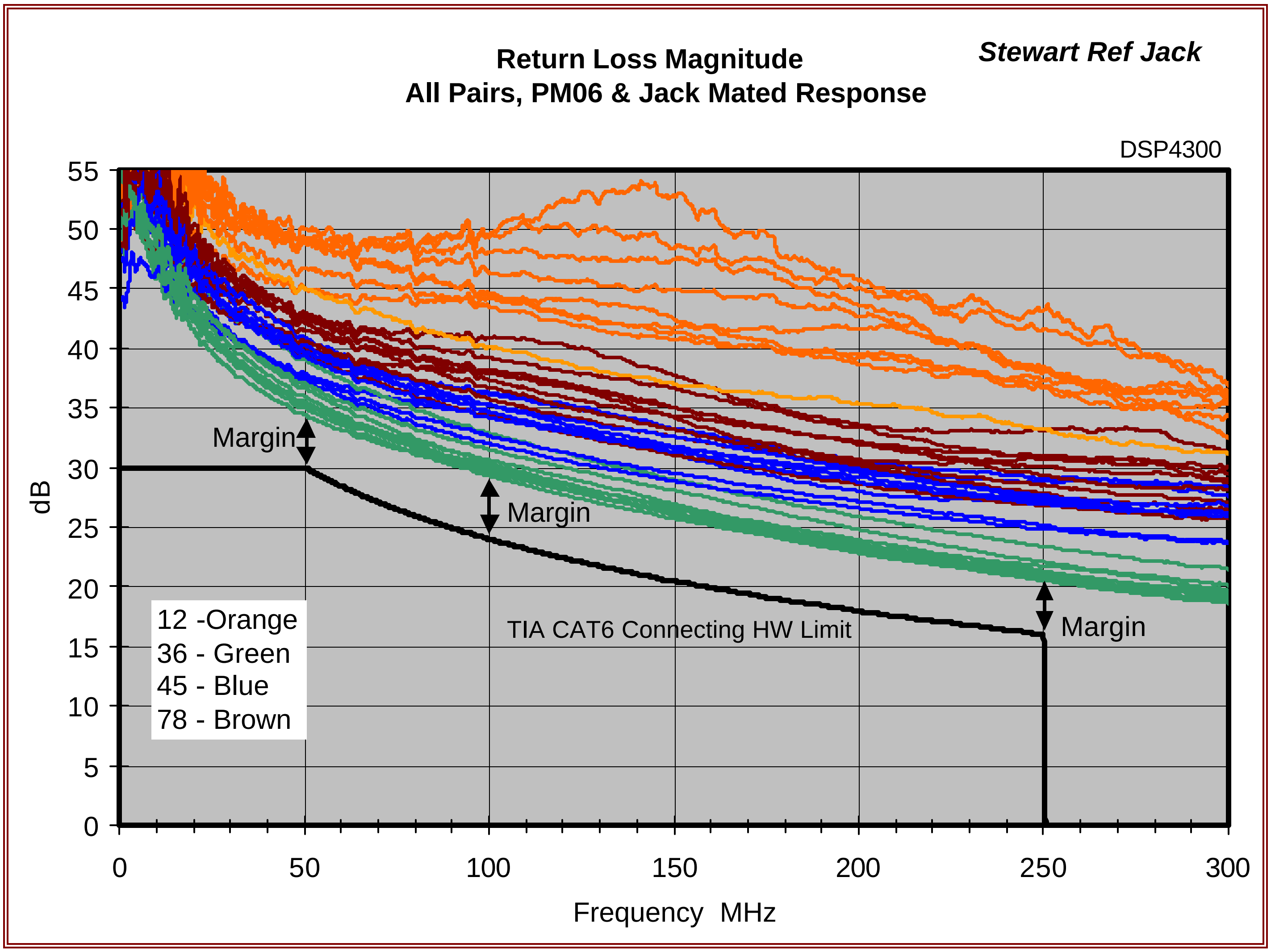
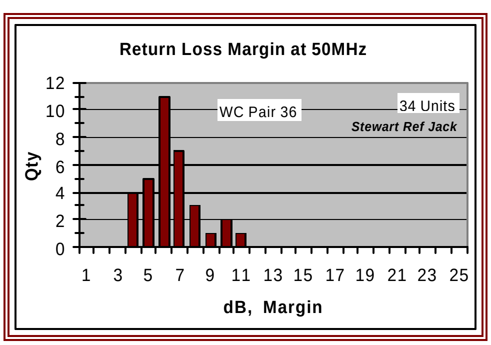
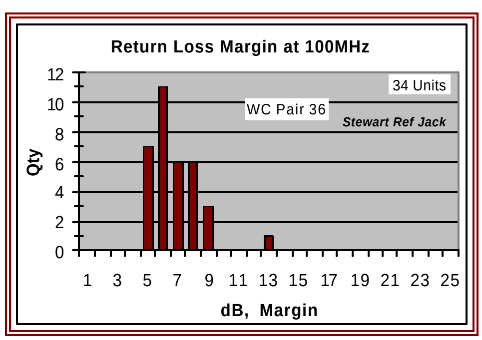
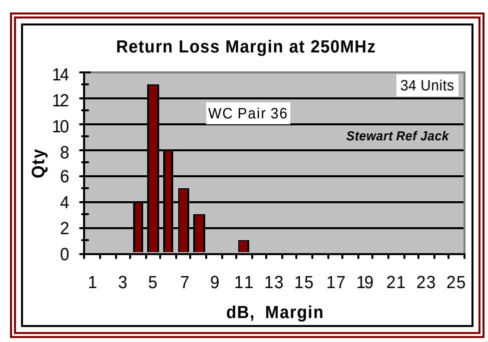
4.2 Return Loss Performance

The results show that excellent return loss properties are obtained when the PM06 is mated with category 6 jacks. Of the 156 units used for NEXT analysis, a sub-sample of 34 units was selected for Return Loss characterization. The graphs display a limited family of curves showing RL magnitude with a given jack. In addition, a margin distribution at selected frequencies of 50 MHz, 100 MHz and 250 MHz are shown for the worst-case pair. The first graphs show the Return Loss performance when mated with a Stewart Reference Jack. The remaining data, labeled MFR A through E, represent a sampling of both domestic and European CAT6 connector manufacturers.









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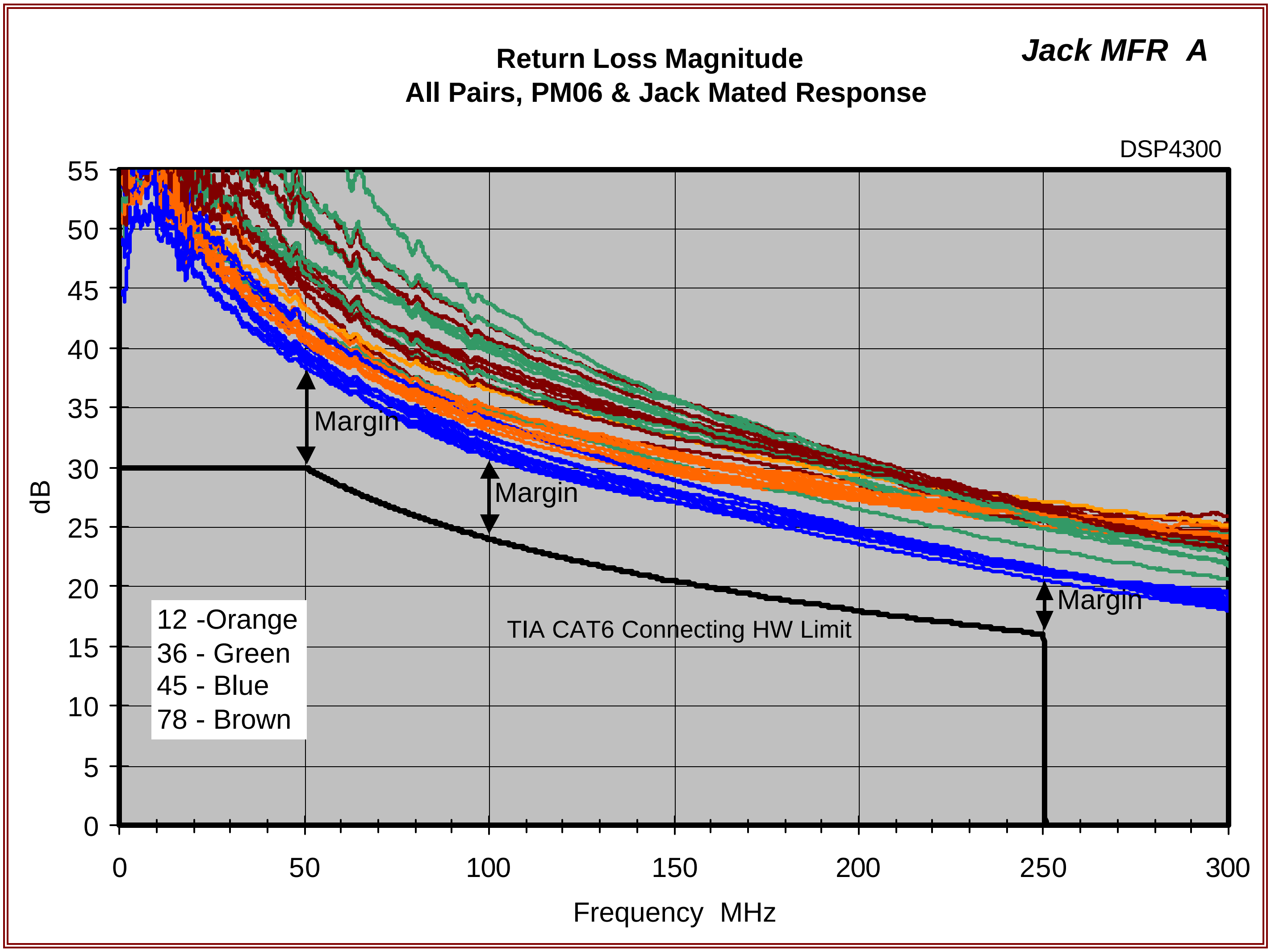

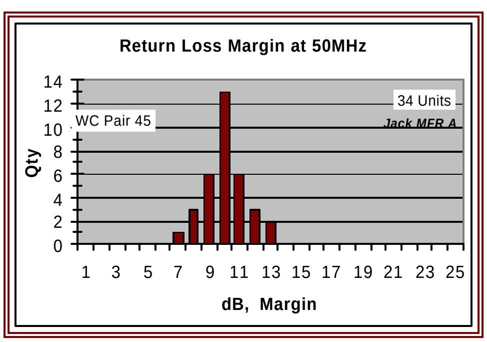

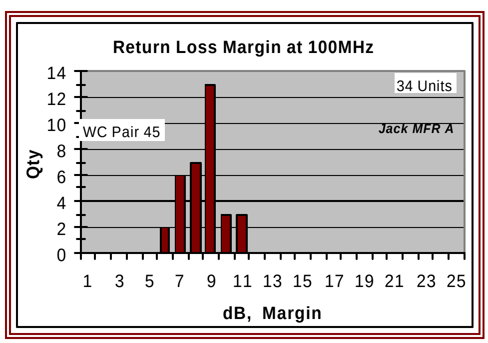

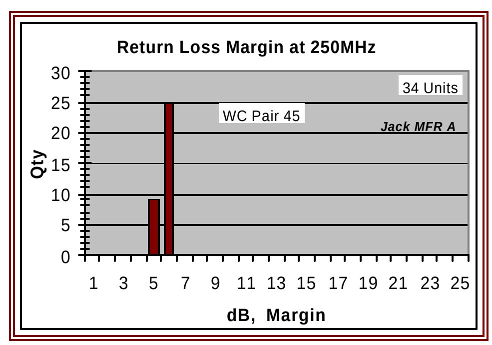

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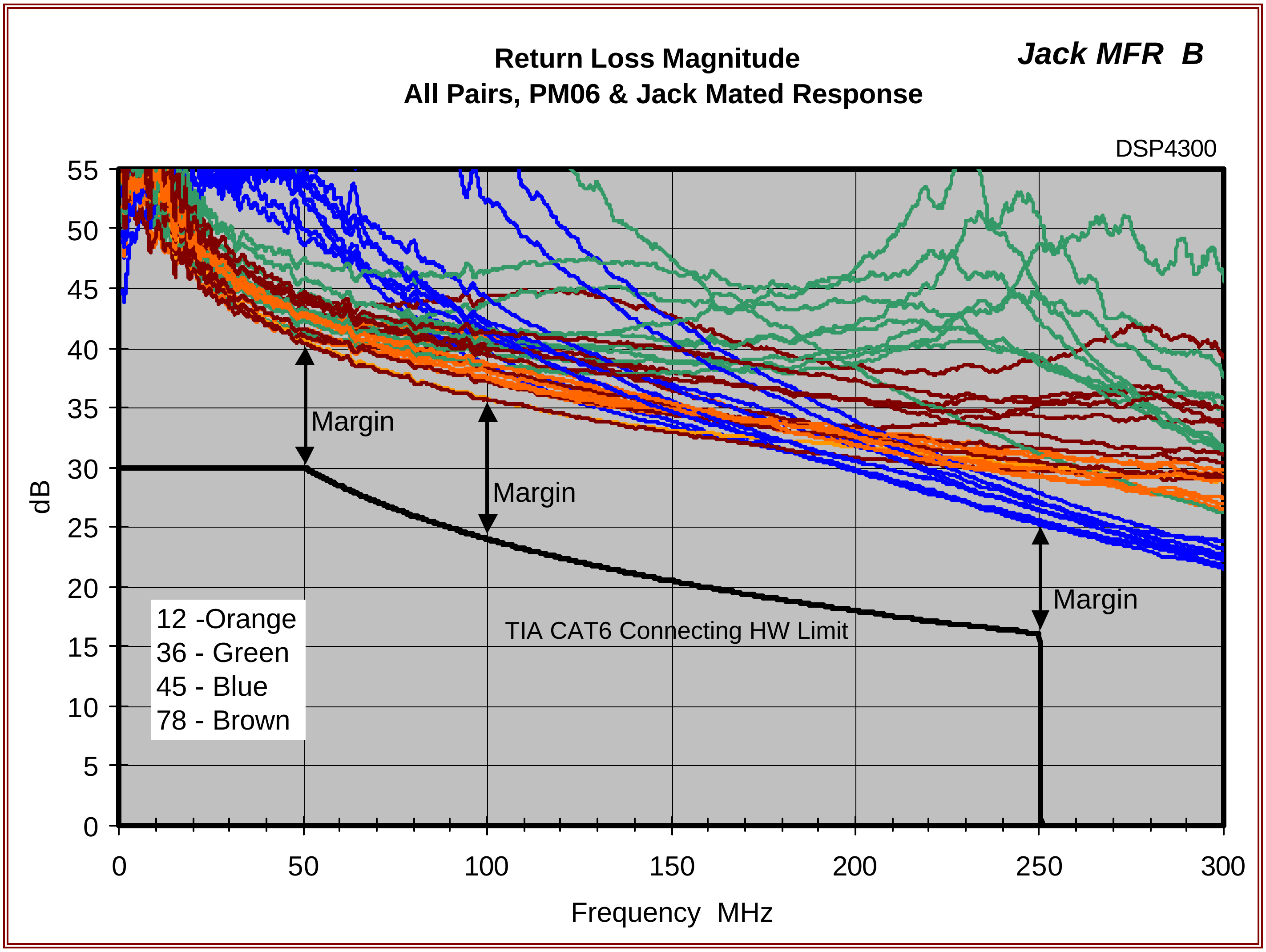
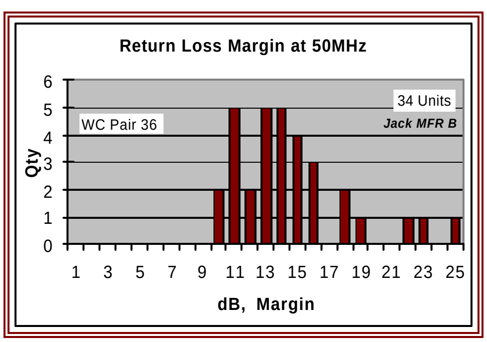

Return Loss Magnitude
All Pairs, PM06 & Jack Mated Response
Jack MFR B
DSP4300
dB
Frequency MHz
Margin
Margin
Margin
TIA CAT6 Connecting HW Limit
12 -Orange
36 - Green
45 - Blue
78 - Brown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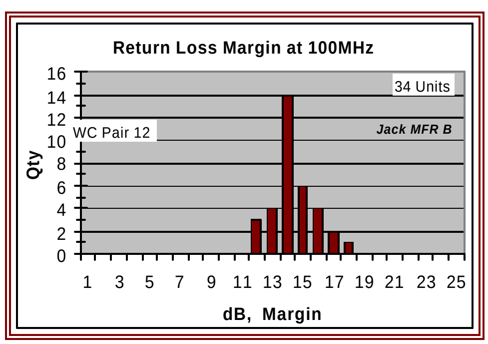
WC Pair 36
34 Units
Jack MFR B
Qty
dB, Margin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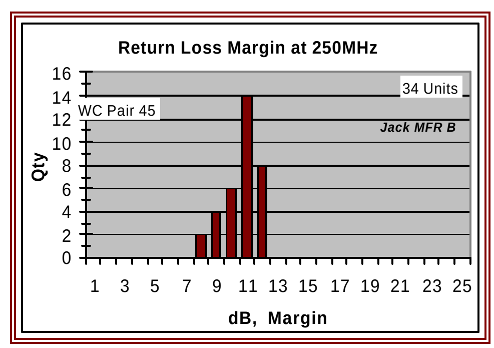
WC Pair 12
34 Units
Jack MFR B
Qty
dB, Margin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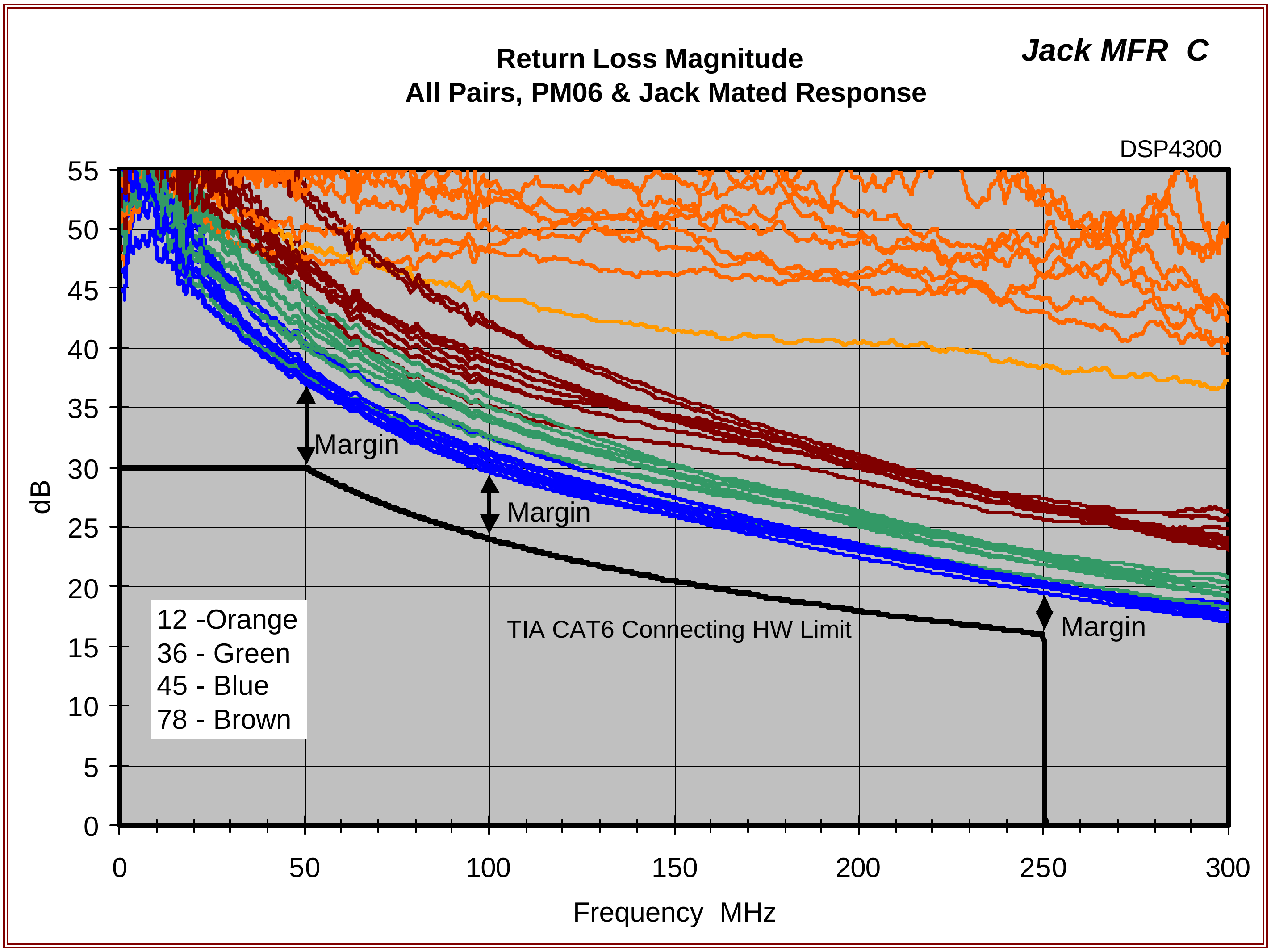
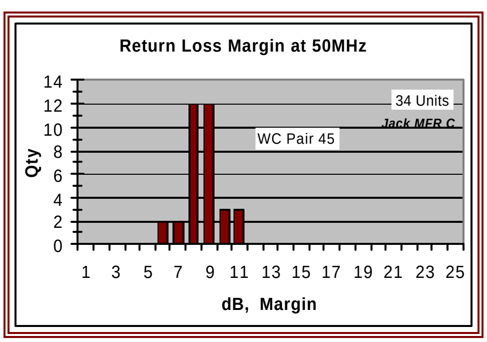
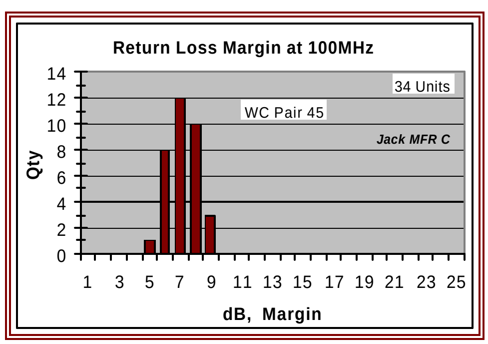
WC Pair 45
34 Units
Jack MFR B
Qty
dB, Margin


Jack MFR C
Return Loss Magnitude
All Pairs, PM06 & Jack Mated Response
DSP4300
dB
Margin
Margin
Margin
12 -Orange
36 - Green
45 - Blue
78 - Brown
TIA CAT6 Connecting HW Limit
Frequency MHz
0
5
10
15
20
25
30
35
40
45
50
55
0
50
100
150
200
250
300


Return Loss Margin at 50MHz
34 Units
Jack MFR C
WC Pair 45
Qty
dB, Margin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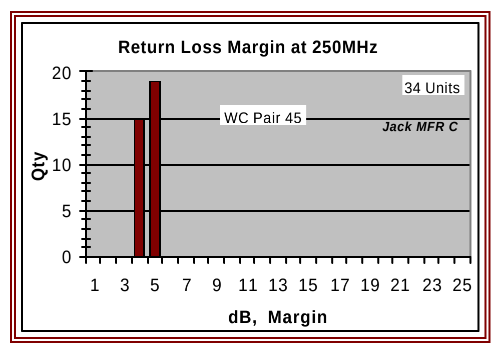
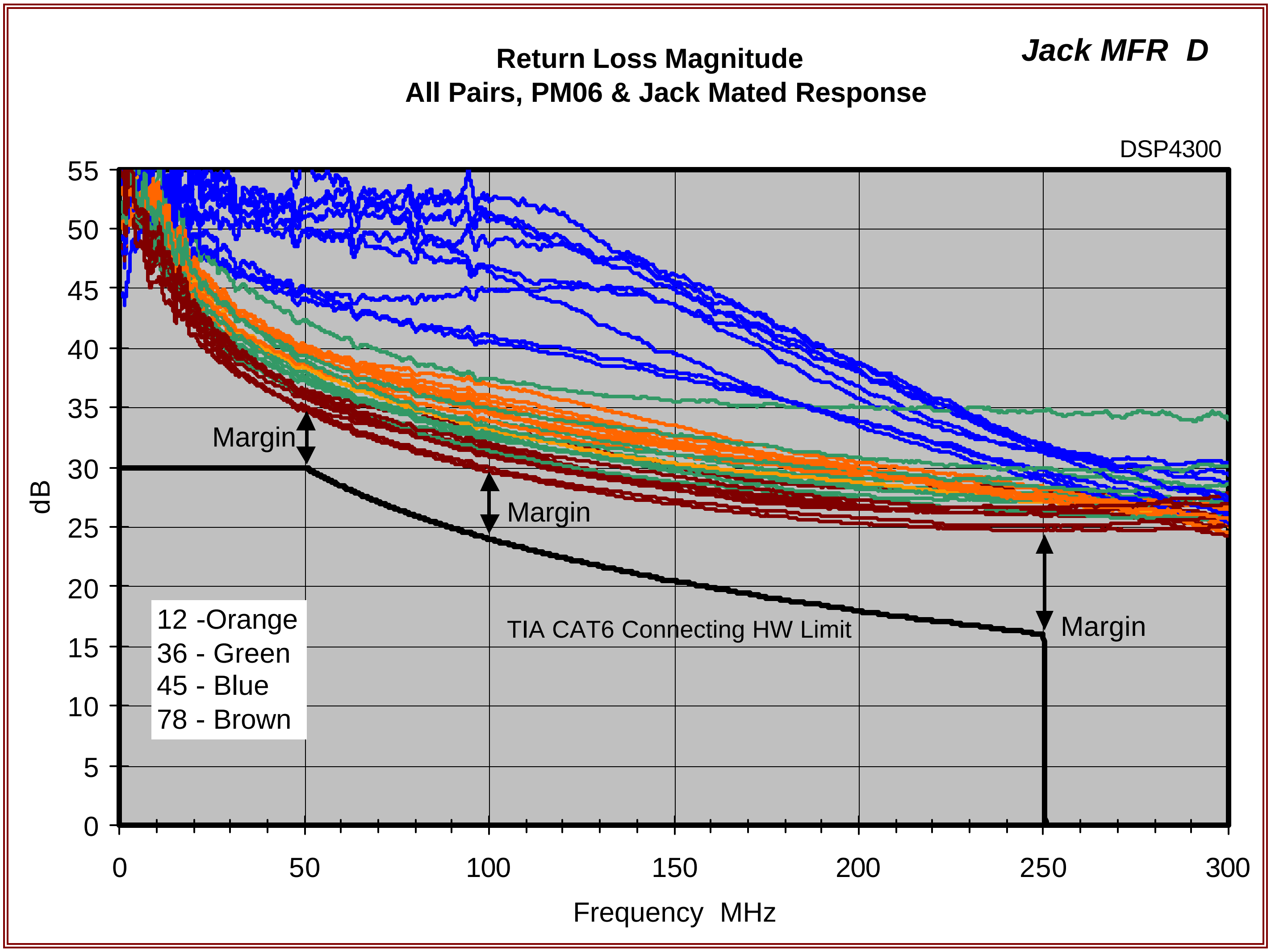
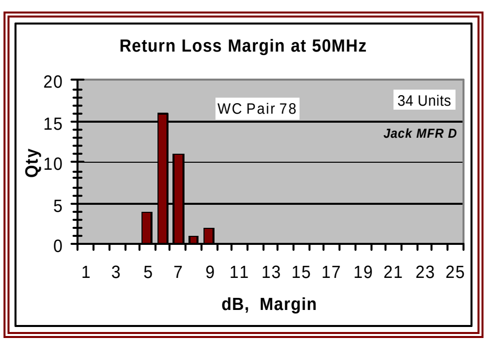
34 Units
WC Pair 45
Jack MFR C
Qty
dB, Margin


Return Loss Margin at 250MHz
34 Units
WC Pair 45
Jack MFR C
Qty
dB, Margin


Return Loss Magnitude
All Pairs, PM06 & Jack Mated Response
Jack MFR D
DSP4300
dB
Frequency MHz
Margin
Margin
Margin
TIA CAT6 Connecting HW Limit
12 -Orange
36 - Green
45 - Blue
78 - Brown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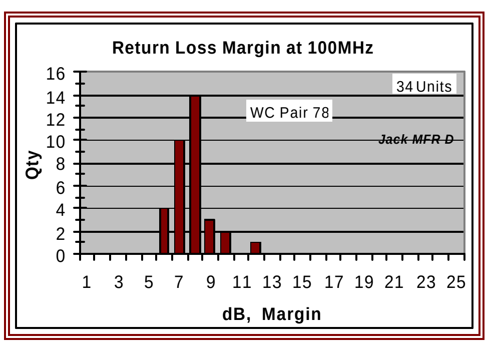
Qty
WC Pair 78
34 Units
Jack MFR D
dB, Margin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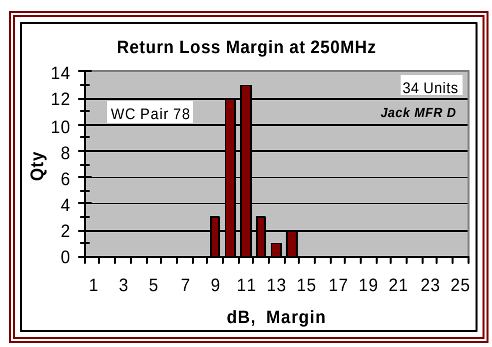
WC Pair 78
34 Units
Jack MFR D
dB, Margin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Qty
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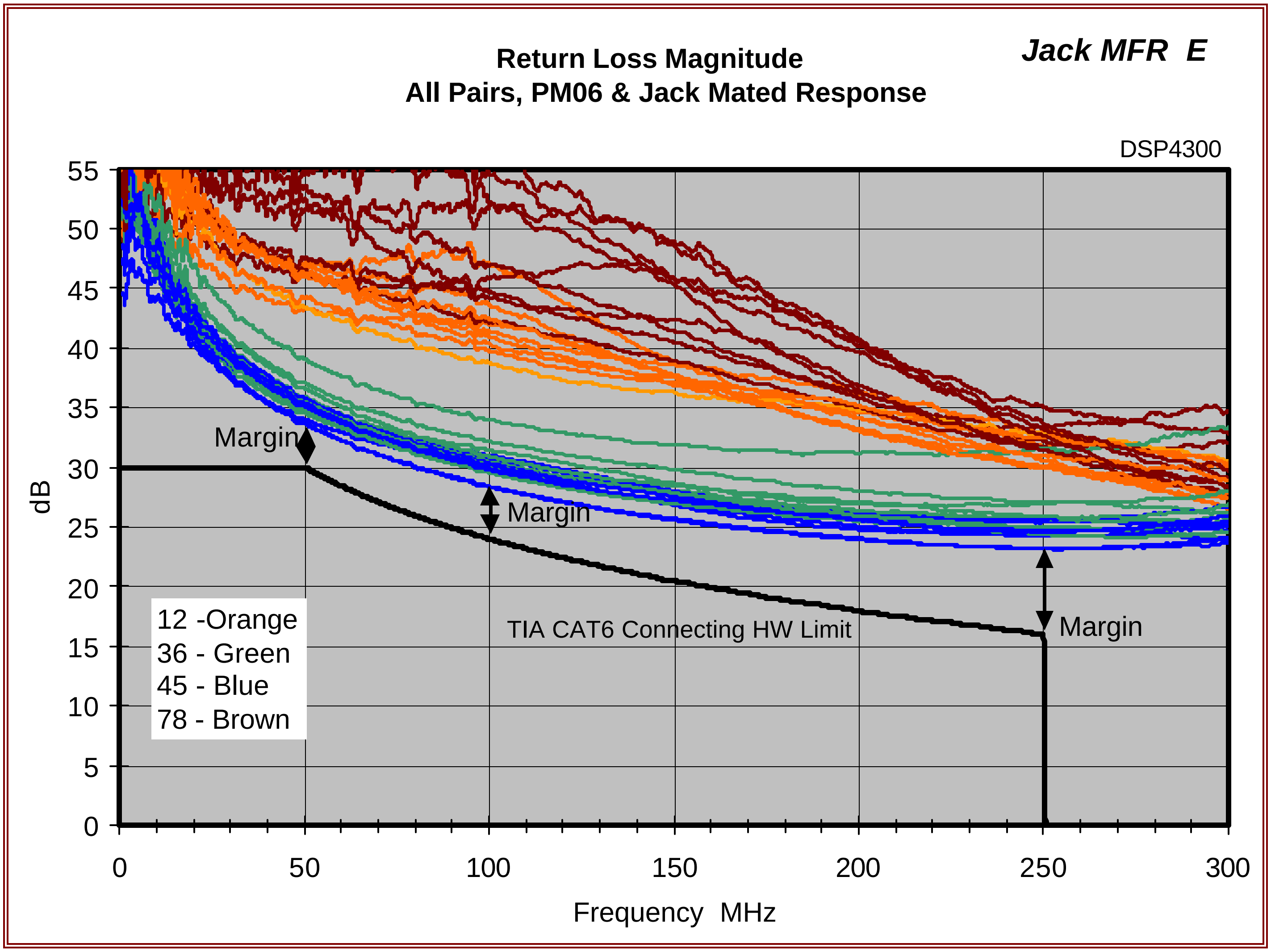
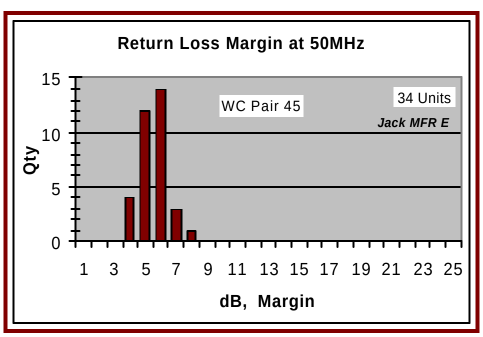
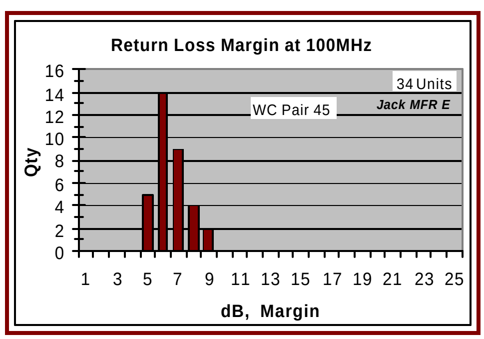
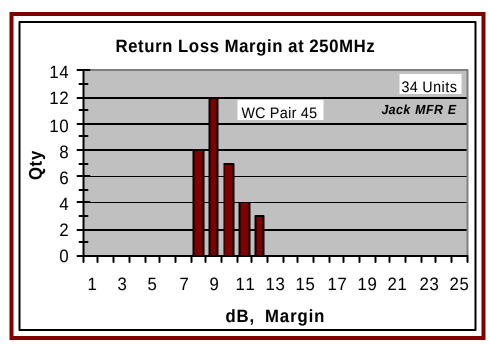
34 Units
Jack MFR D
dB, Margin


Return Loss Magnitude
All Pairs, PM06 & Jack Mated Response
Jack MFR E
DSP4300
dB
Frequency MHz
Margin
Margin
Margin
TIA CAT6 Connecting HW Limit
12 -Orange
36 - Green
45 - Blue
78 - Brown


Return Loss Margin at 50MHz
WC Pair 45
34 Units
Jack MFR E
Qty
dB, Margin


Return Loss Margin at 100MHz
34 Units
WC Pair 45
Jack MFR E
Qty
dB, Margin

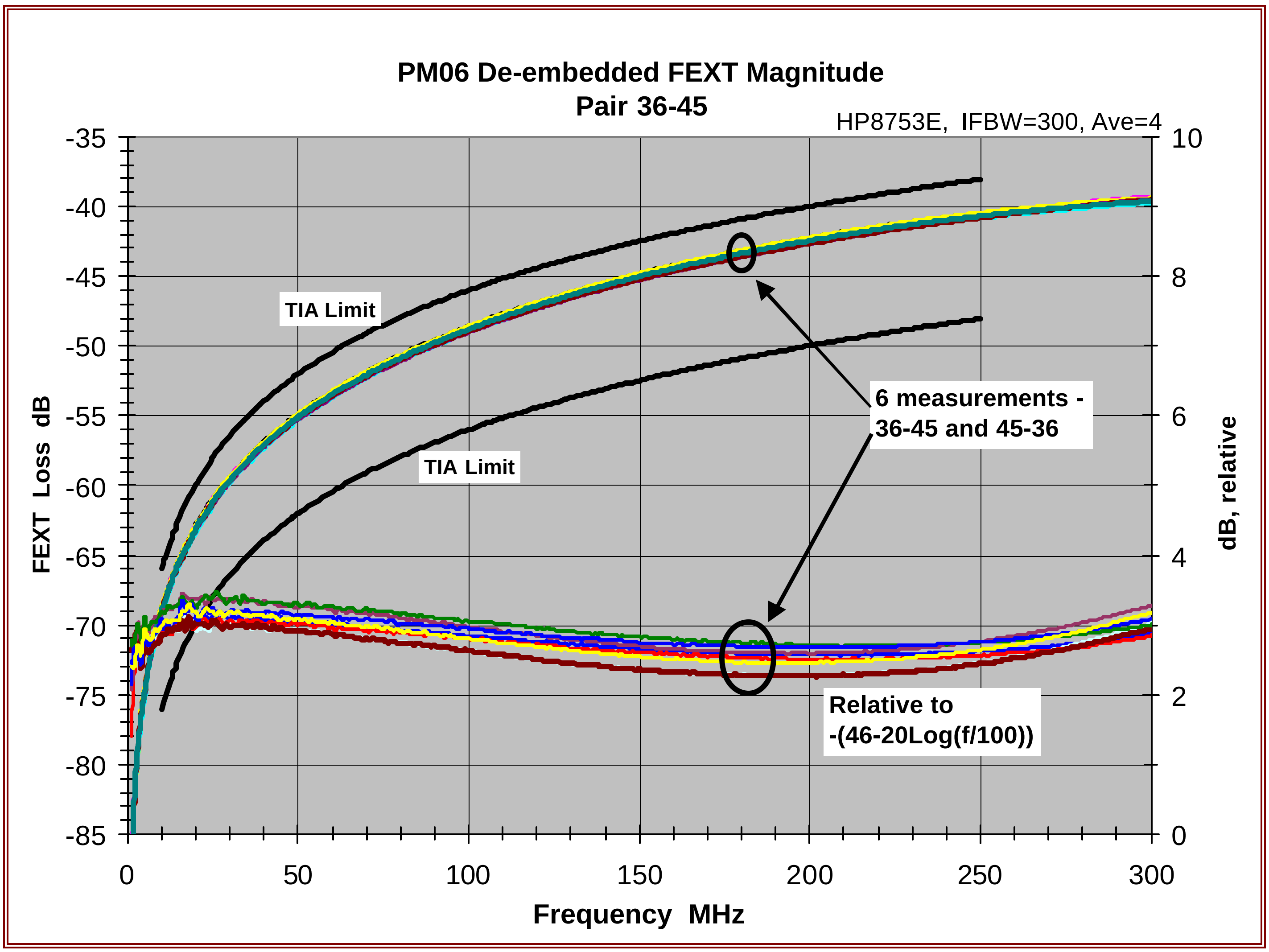

Return Loss Margin at 250MHz
34 Units
WC Pair 45
Jack MFR E
Qty
dB, Margin

4.3 FEXT Performance

The following graphs display a representative sample of production PM06 units. The family of curves displayed exhibits the tight grouping of FEXT performance. As in the case of NEXT performance, it was discovered early in development that FEXT performance was also extremely consistent in both magnitude and phase. For an amplified view, the scale on the right side of the magnitude plots indicates the difference between the lower TIA logarithmic function limit and the measured value.

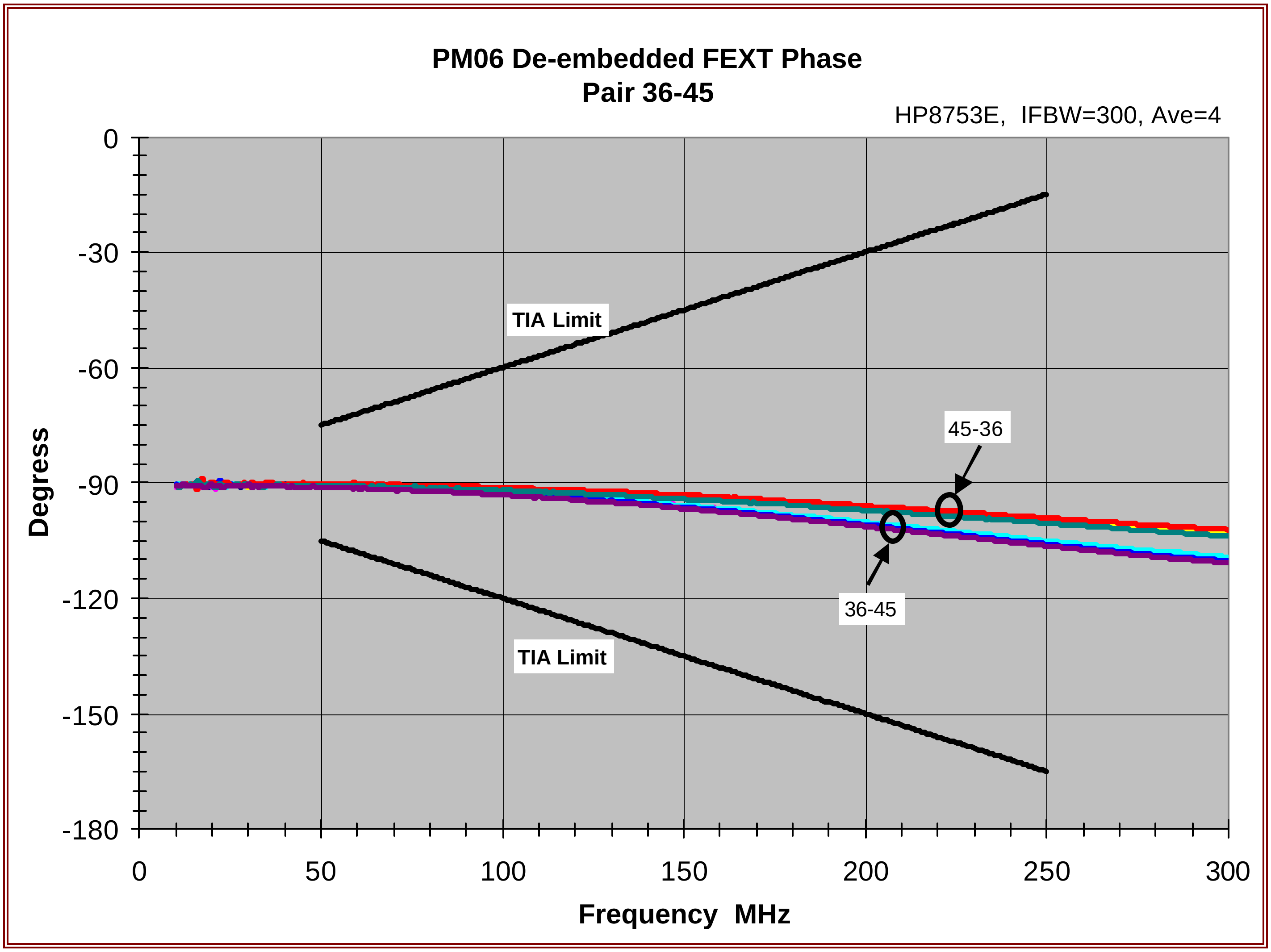
All twelve (12) combinations of FEXT performance easily meet the TIA requirements and display extreme consistency from unit to unit.

FEXT for the 36-45 and 45-36 wire pair combinations

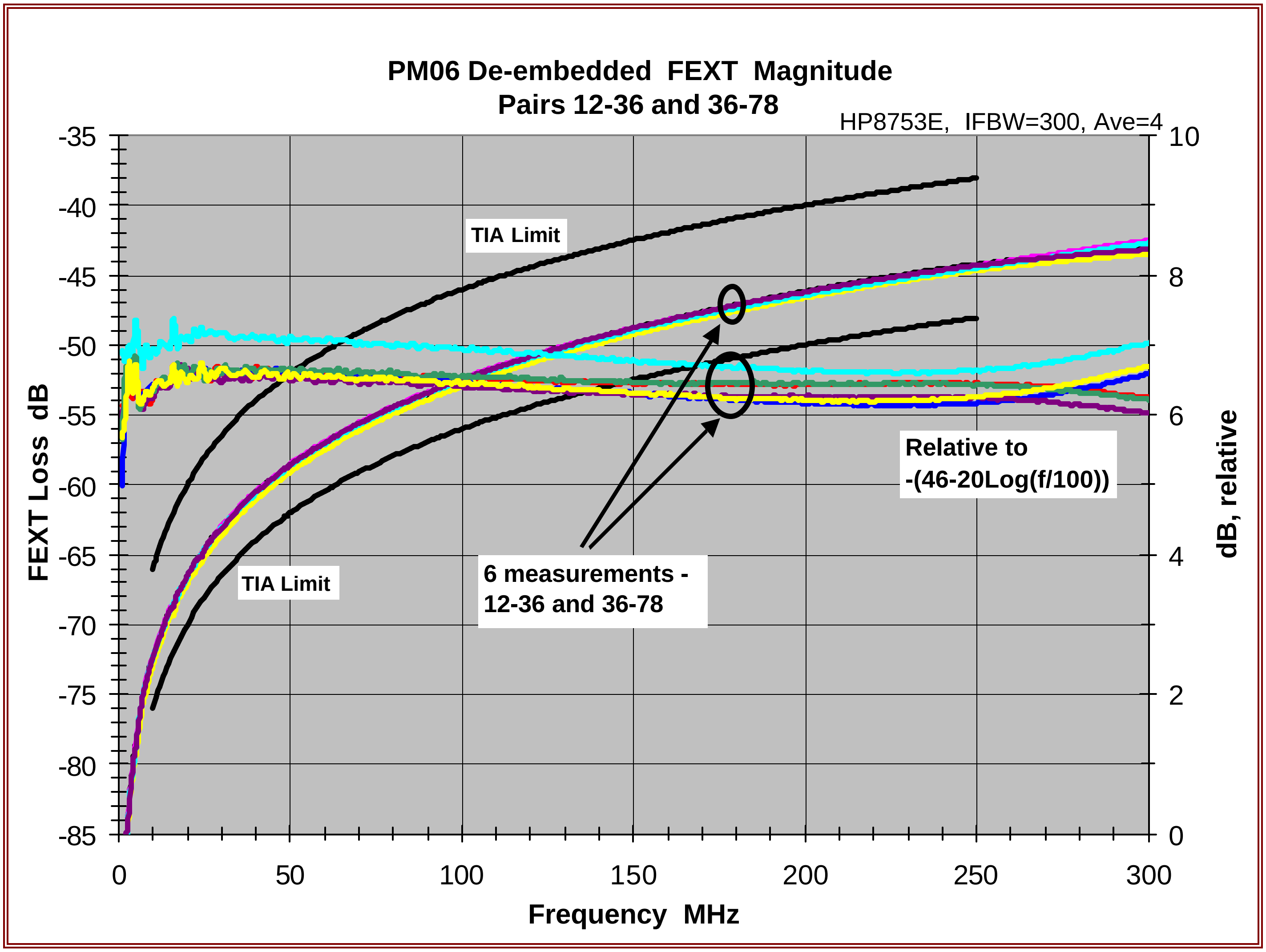


In the magnitude plot, the margin relative to the lower (dB) limit for the 36-45 wire pair combination is shown for higher resolution; see the right scale of the magnitude plot. Observe that all test plugs perform in a very narrow range, approx. 2.8 dB above the minimum value.

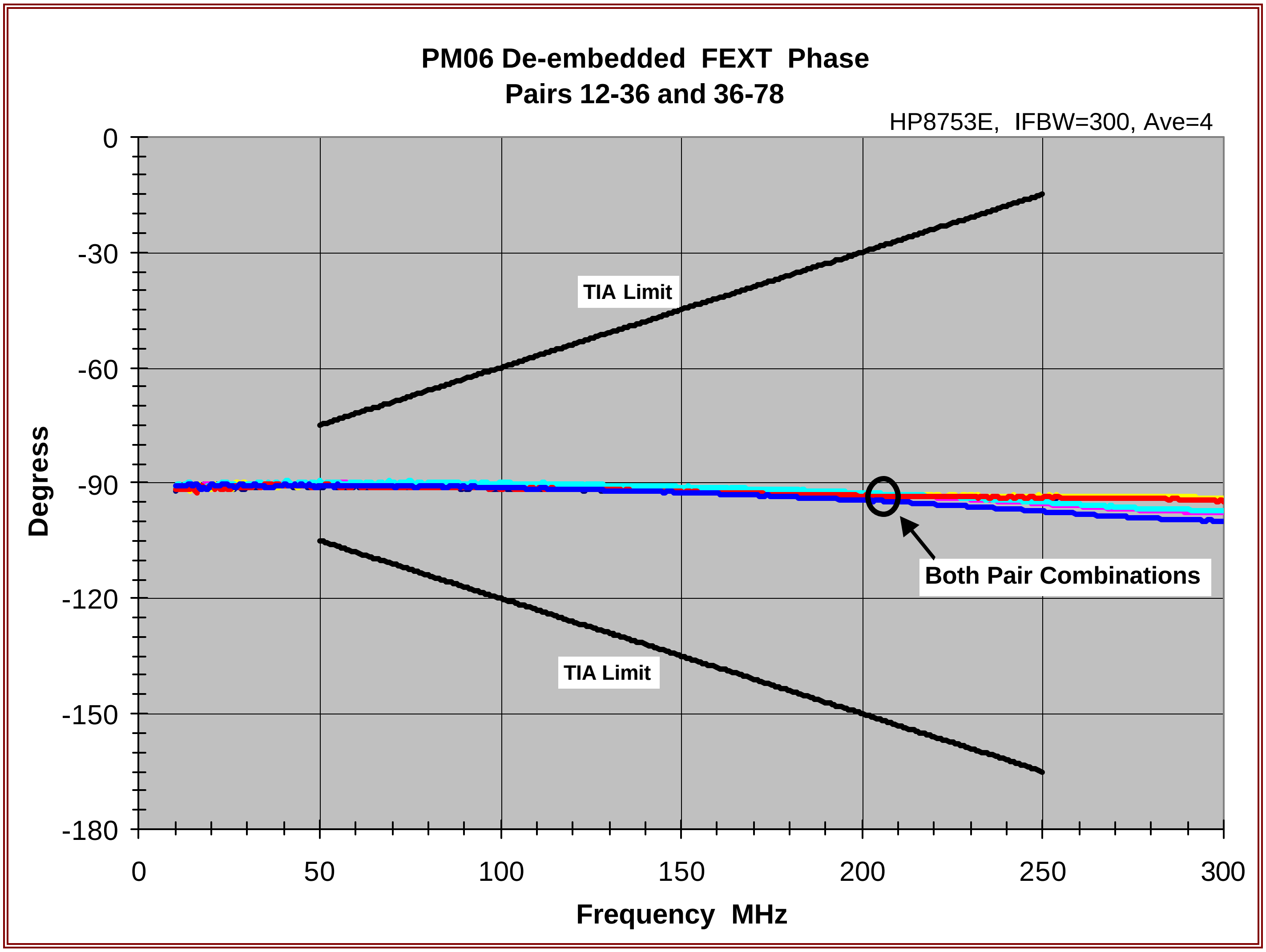
In the phase plot, all test plug samples perform very near 90 °. A very slight difference (though inconsequential) in phase response is observed between measurement of 36-45 and 45-36 combinations.



FEXT for the 12-36 and 36-78 wire pair combinations



In the magnitude plot, the margin relative to the lower (dB) limit for the 12-36 and 36-78 wire pair combinations is shown for higher resolution; see the scale at the right side of the magnitude plot. Again observe that all test plugs perform in a very narrow range, approx. 6.5 dB above the minimum value. Also, the 12-36 and 36-78 wire pair combinations appear to perform virtually identical, emphasizing the symmetric properties of the design.


PM06 De-embedded FEXT Phase
Pairs 12-36 and 36-78
HP8753E, IFBW=300, Ave=4
TIA Limit
TIA Limit
Both Pair Combinations
Degress
Frequency MHz
0
-30
-60
-90
-120
-150
-180
0
50
100
150
200
250
300

Other pair combinations: 12-45, 45-78 and 12-78

Though not shown graphically, the less critical combinations perform in a similar fashion showing the same consistency and repeatability from unit to unit in both magnitude and phase. All of these combinations easily meet the TIA requirements. The following table lists average values for these parameters at notable frequencies. In addition, the 12-45 and 45-78 wire pair combinations perform virtually identical, emphasizing the symmetric properties of the design.

PM06 FEXT Magnitude			
Frequency	12-45, 45-12	45-78, 78-45	12-78, 78-12
@ 100 MHz	-71.5 dB	-71.5 dB	-75.0 dB
@ 250 MHz	-65.0 dB	-65.0 dB	-67.5 dB

The 12-45 and 45-78 combinations perform approx. 15 dB above the minimum requirement (there is no maximum requirement): The 12-78 wire pair performs approx. 20 dB above the minimum value (no maximum requirement), There are no specified phase requirements for the 12-45, 45-78 and 12-78 wire pairs FEXT.

Refer to section 3.0 for additional technical information.

E-mail: support@flukenetworks.com