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PoDL for NGAUTO- Technical and Economic Feasibility

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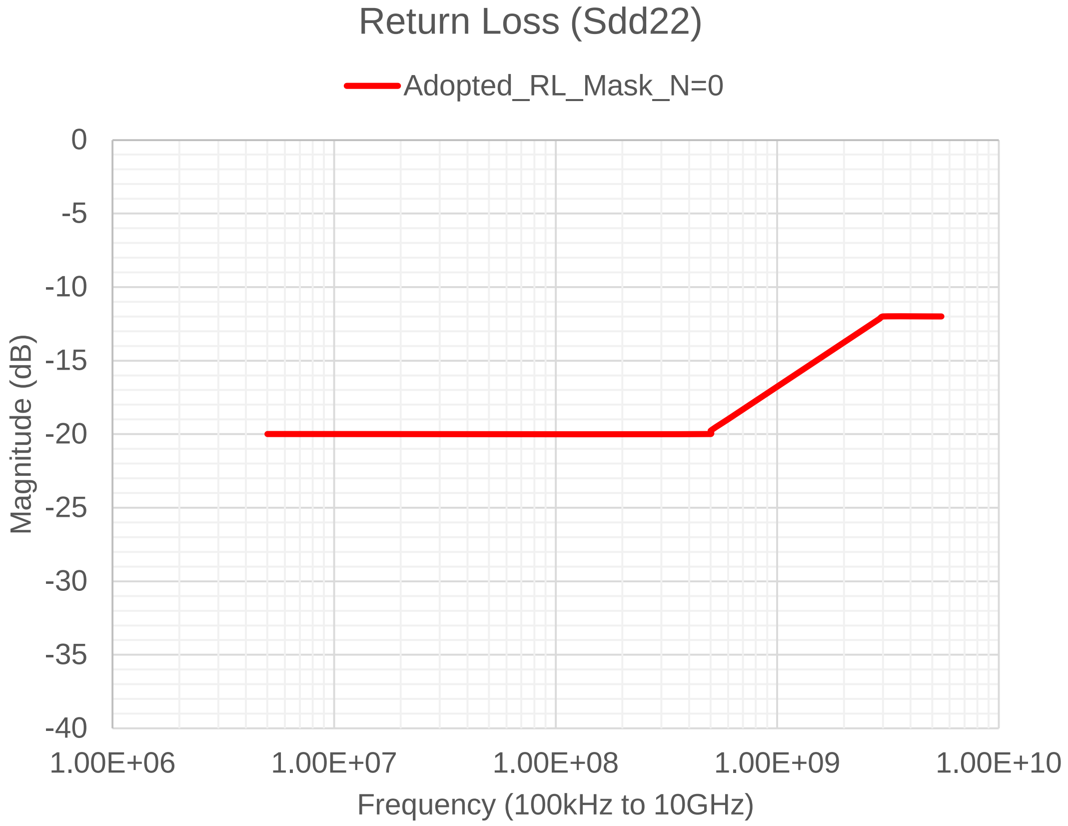
Presentation Outline

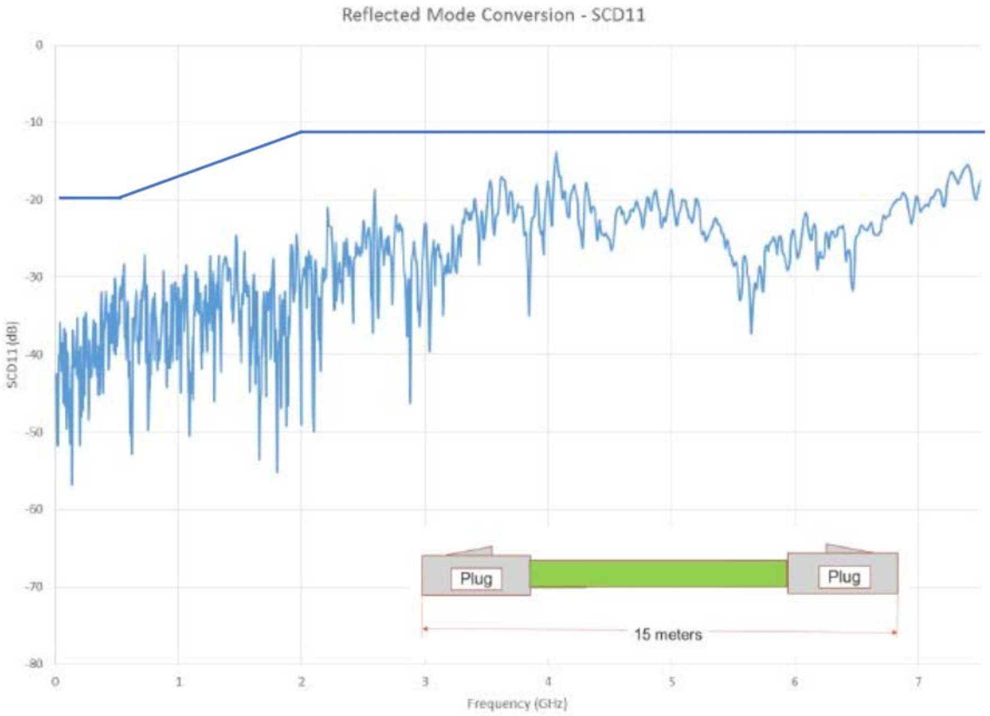
- Review NGAUTO Adopted and Proposed Link Electrical Specifications
  - Return and Mode Conversion Loss
- MDI vs Link Segment Electrical Characteristics for 100BASE-T1 and 1000BASE-T1
- Proposal for MDI Electrical Characteristics for NGAUTO
- Feasibility of PoDL with Proposed MDI Limits
  - Measurement Setup
  - Measured Data
- Conclusion

NGAUTO Link Electrical Specifications

- Reference: http://www.ieee802.org/3/ch/public/jan18/wienckowski_3ch_01a_0118.pdf
  - Adopted Return Loss
    - Mask defined from 5MHz to 5.5GHz



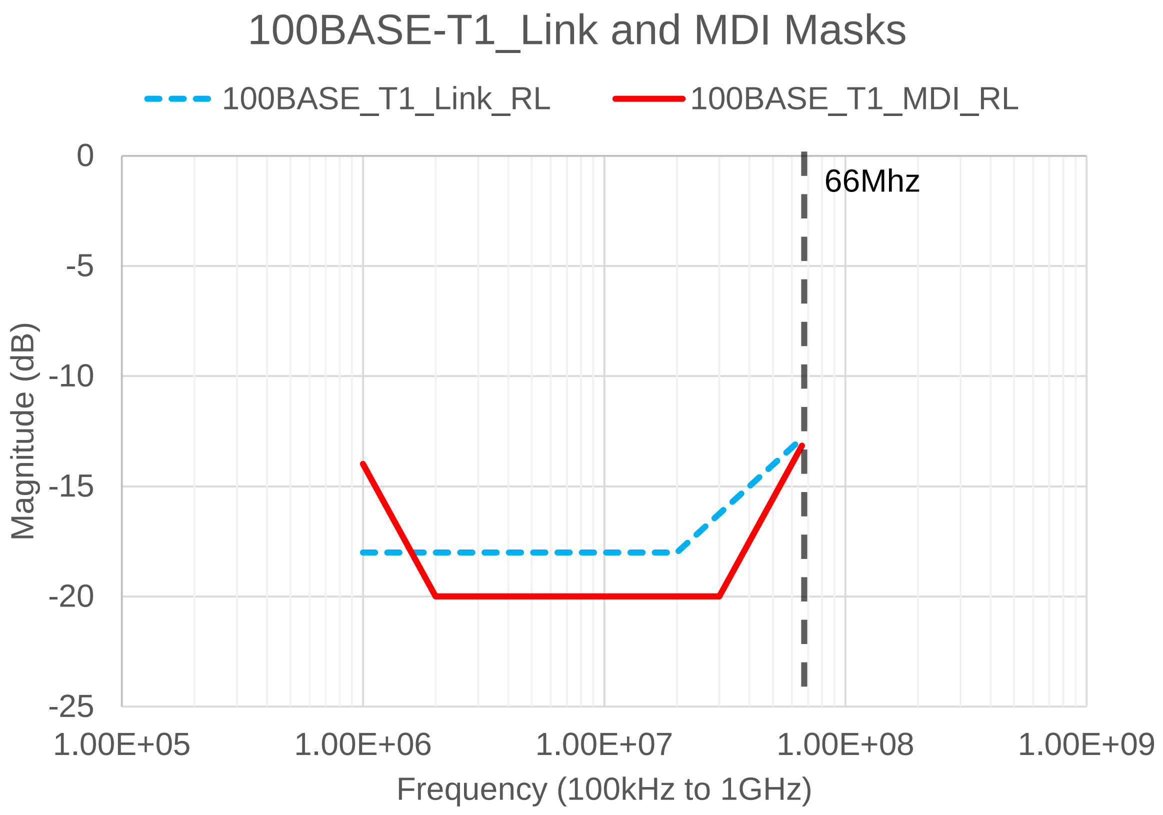
  - Proposed Mode Conversion
    - Relaxed due to shielded cables



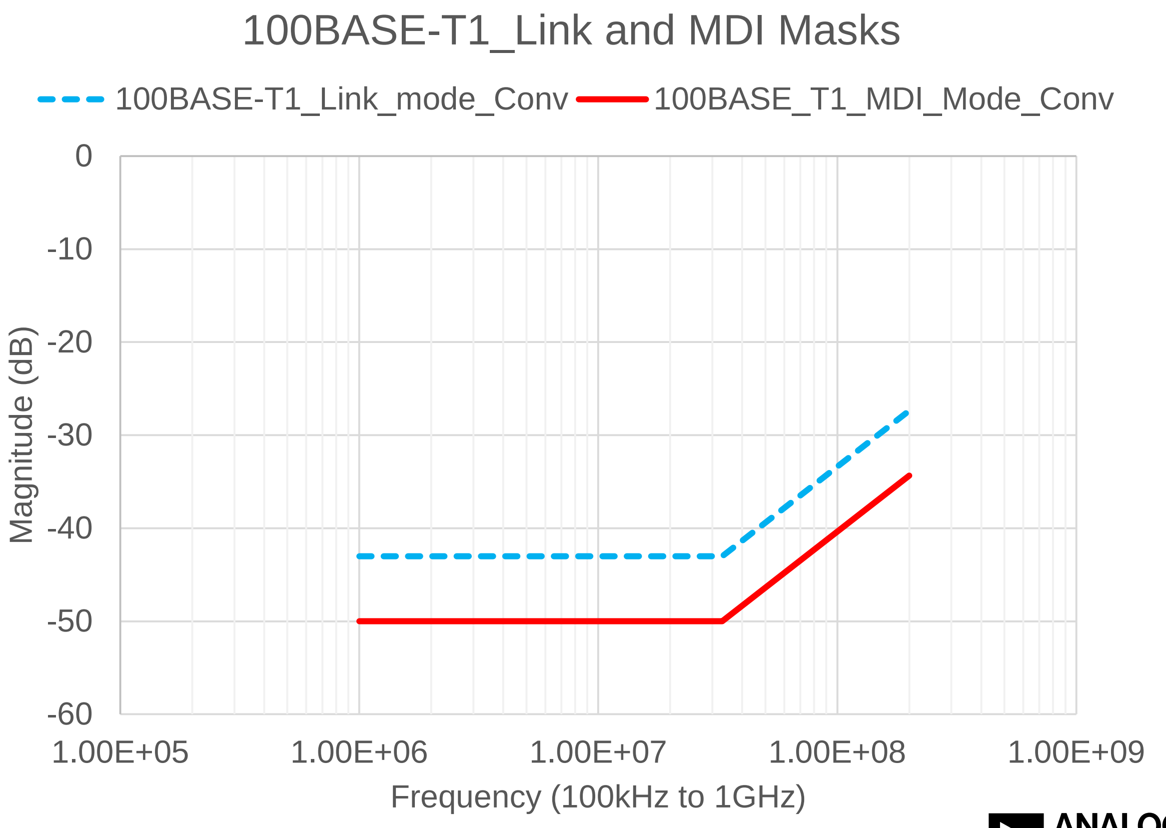
wienckowski_3ch_01a_0118

Electrical Characteristics and Baud Rate – 100BASE-T1

- Reference: 802.3bw with PoDL
- Return Loss
  - Return Loss Mask Limited at Max. Baud Rate of 66MHz



- Mode Conversion
  - MDI Mode Conversion Limit more stringent than Link Limit by 7dB



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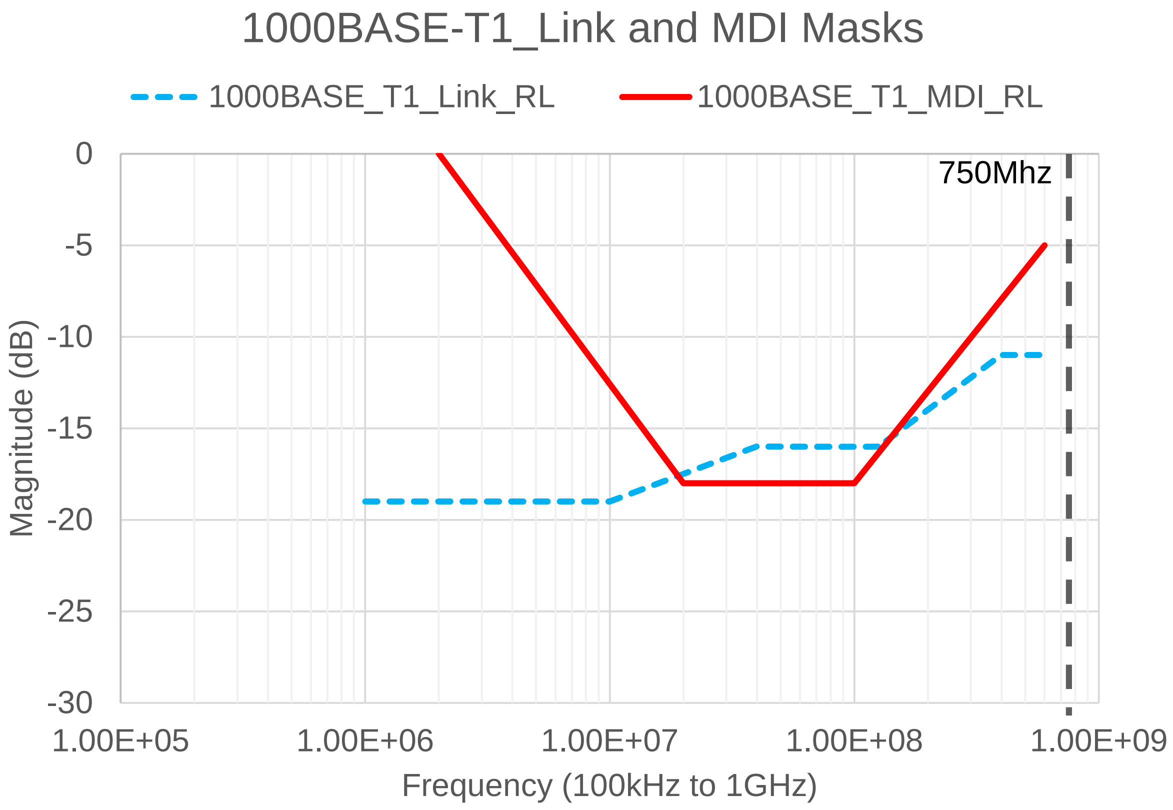
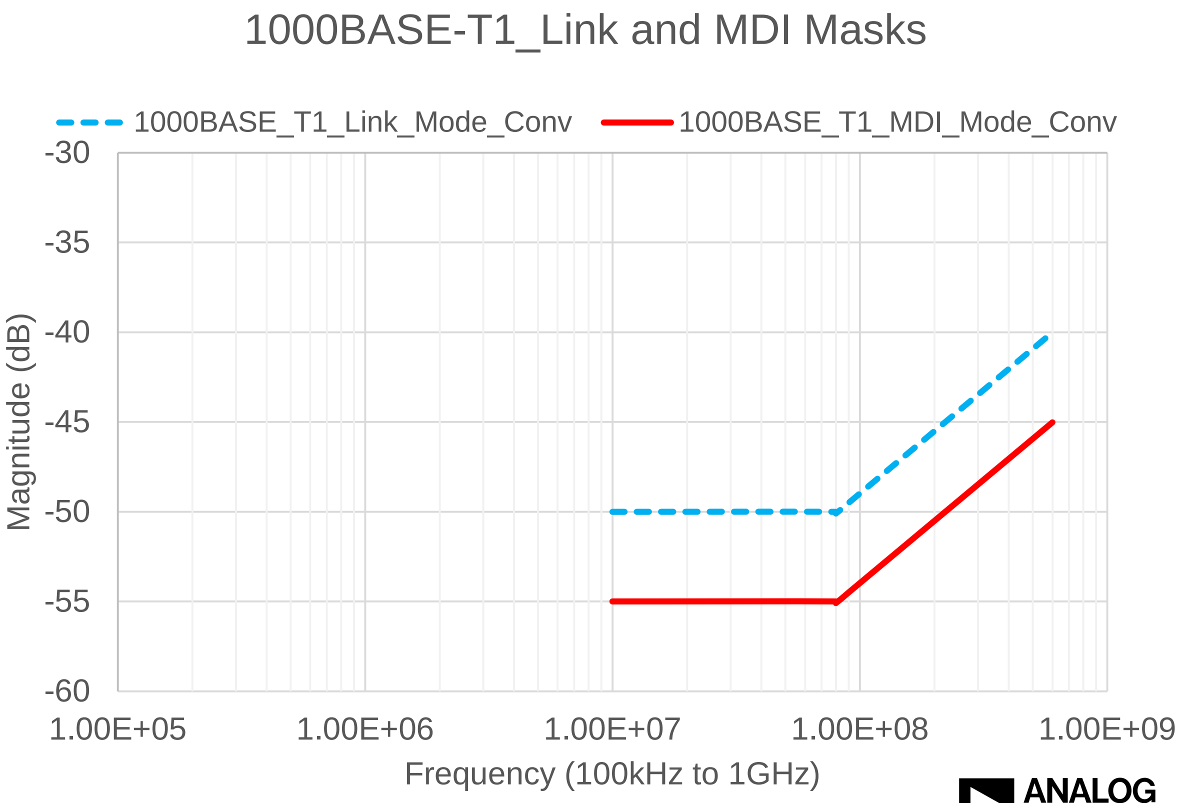
Electrical Characteristics and Baud Rate – 1000BASE-T1

- Reference: 802.3bp

- Return Loss
  - Return Loss Mask Limited at 600MHz under Max. Baud Rate of 750MHz

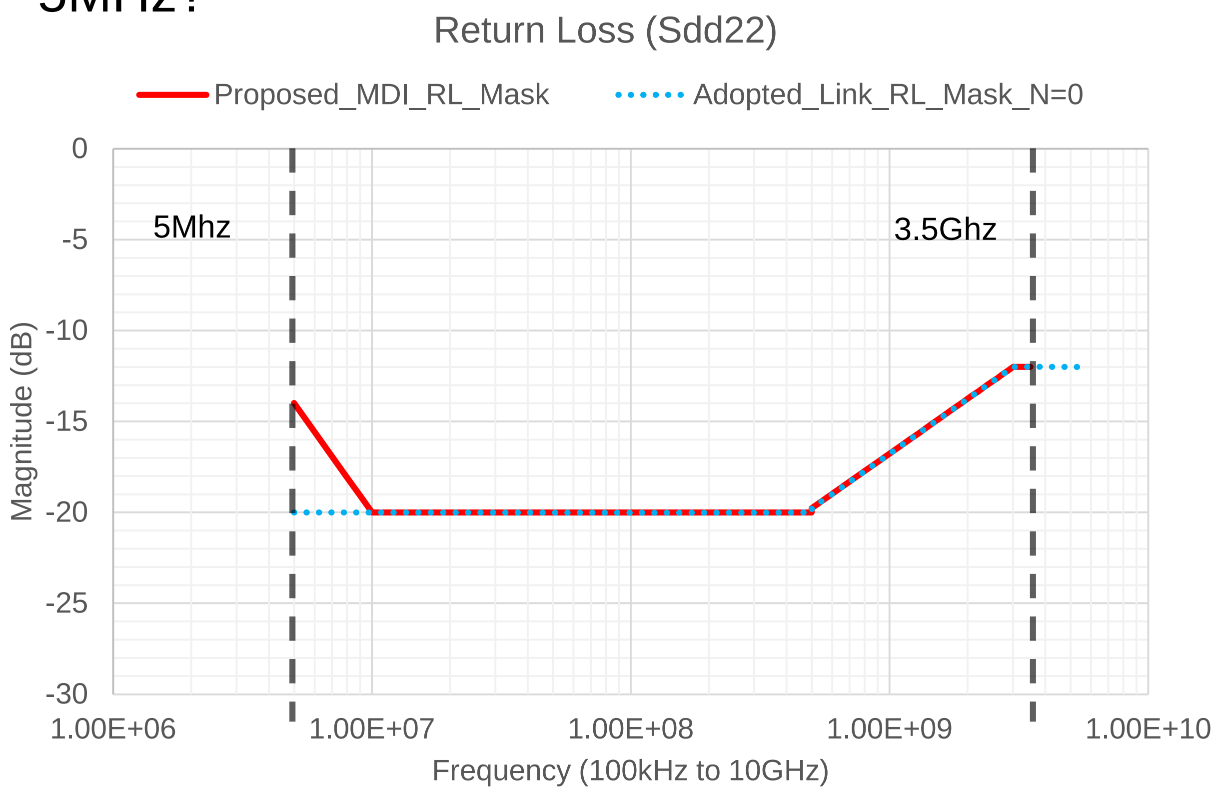


- Mode Conversion
  - MDI Mode Conversion Limit more stringent than Link Limit by 5dB

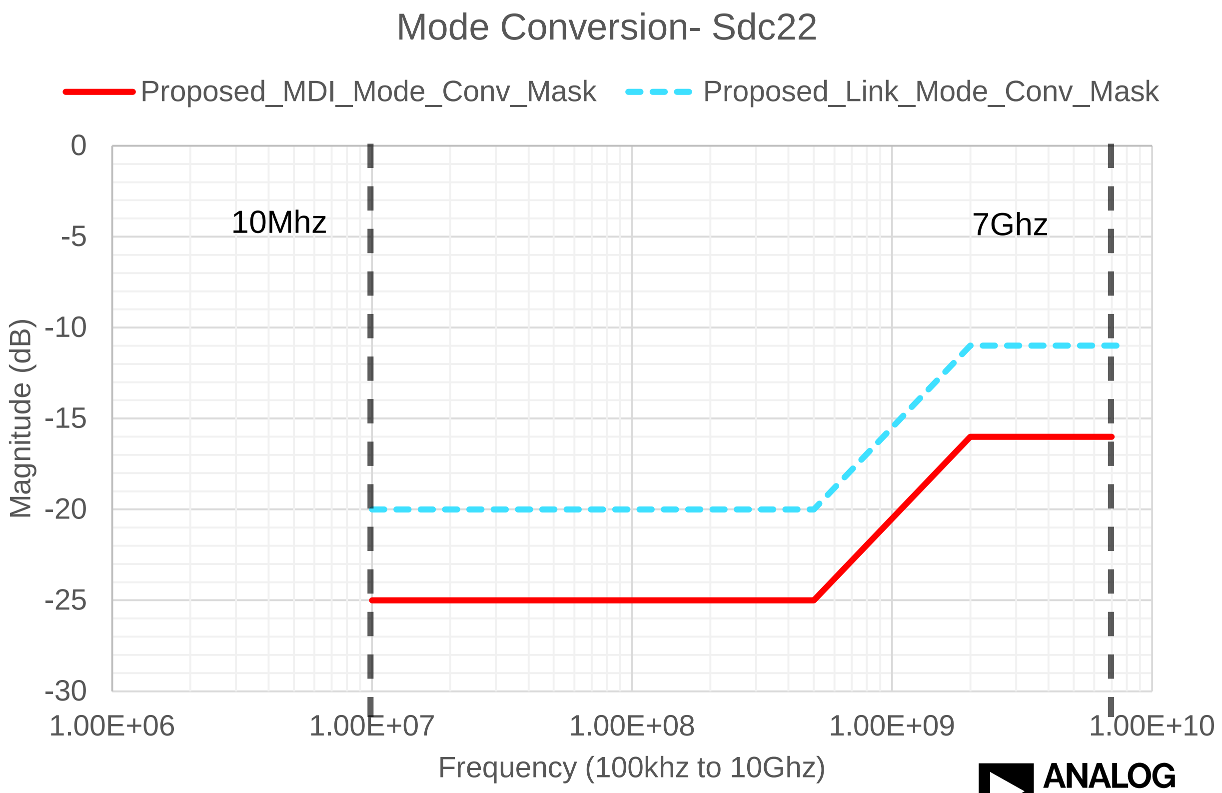


NGAUTO Proposed MDI Electrical Specifications

- Can the **MDI Return Loss Mask** be considered up to (or less than) the proposed baud rate of 3.5GHz?
- Can the mask start frequency be considered 5MHz?



- Can the **MDI Mode Conversion Mask** be made 5dB more stringent than the Link Mode Conversion Mask with frequency from 10MHz to 7Ghz?



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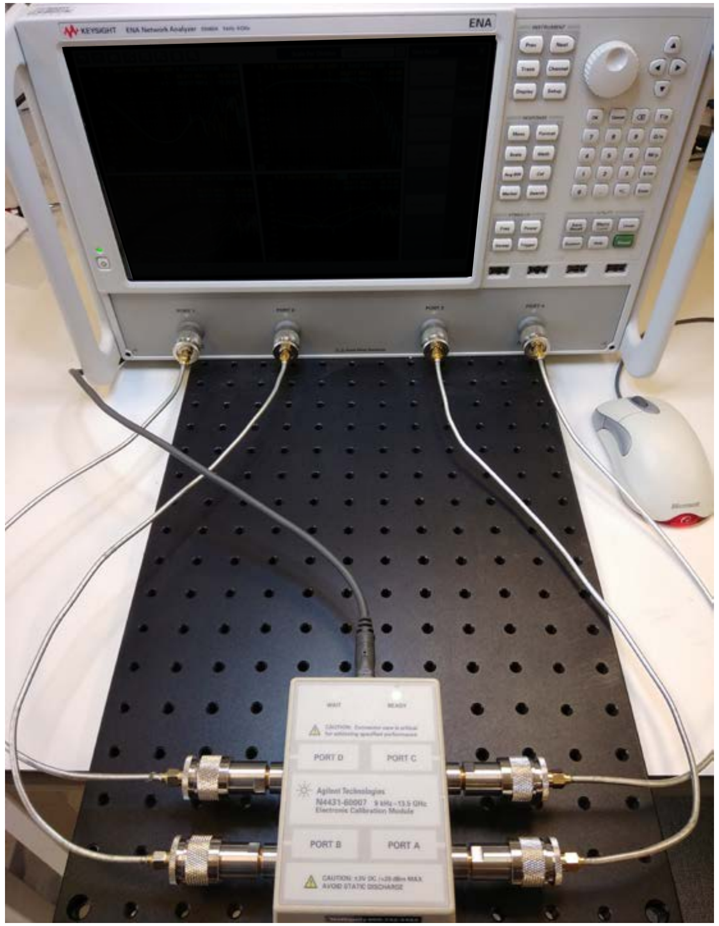
Feasibility of PoDL with Proposed MDI Limits

In continuation of previous work:

http://www.ieee802.org/3/NGAUTO/public/feb17/agardner_3NGAUTO_01a_0217.pdf

Measurement Setup

- Keysight Network Analyzer- E5080A (9kHz to 9GHz)
- Amphenol RF Rigid Cables
- Calibration using Ecal Module – N4431 60007
- Baseline measurement using Coax SMA stubs
- 2Port Configuration used with on board termination resistors



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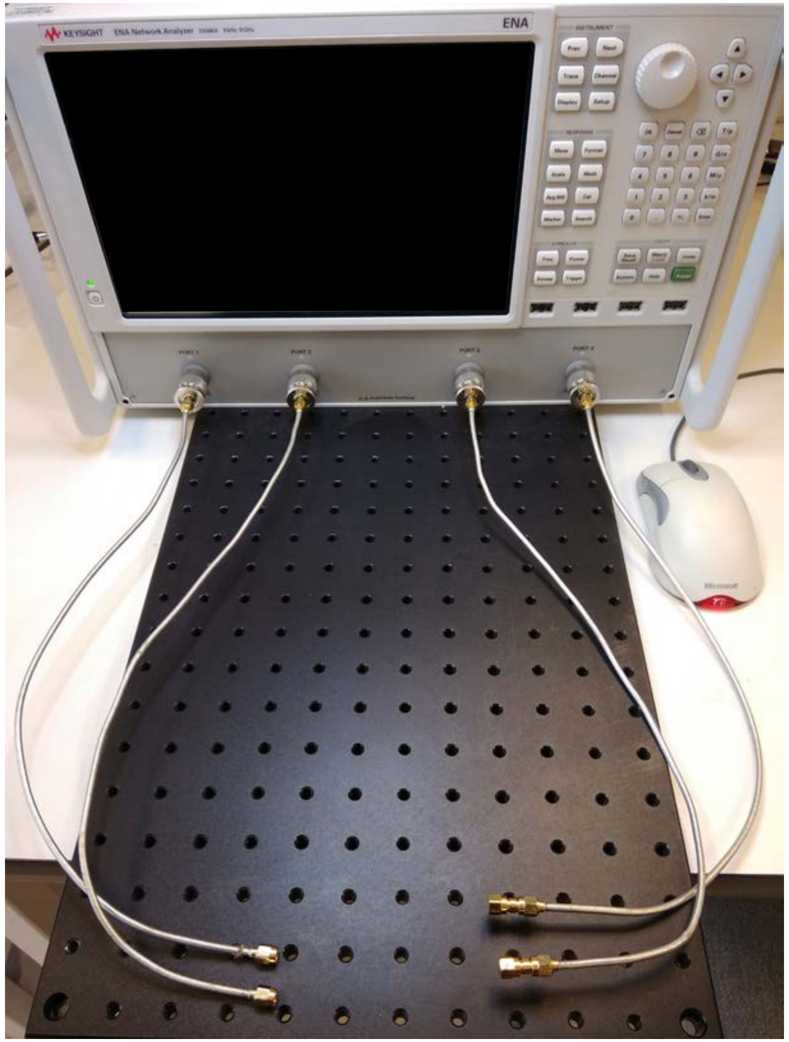
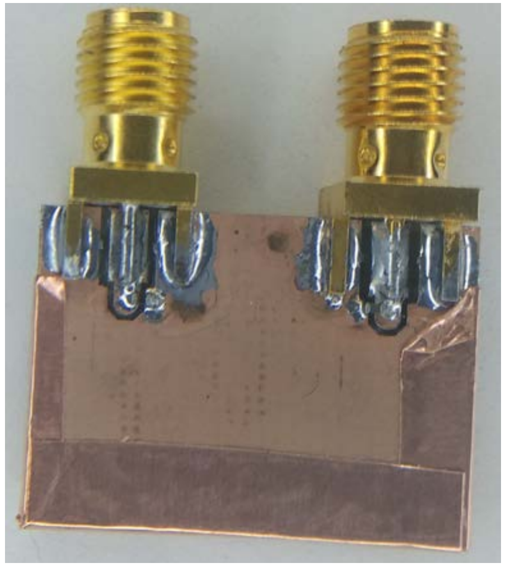
Test Fixtures and Baselines

- Copper Clad Boards using in-lab CNC:LPKF Protomat M 60
- 1oz Cu FR4 with 62 mil Board thickness
- Copper tape used to tie the two GND planes together
- Cable and Calibration baseline using SMA stubs
- Board Layout and Termination Resistor baseline using only termination resistors
- Two types of termination resistors:
  - 0402 1% 50ohm generic resistors from digikey
  - 0402 1% 50ohm HF thin film – ATC 504L Series UBR



Baseline with SMA stubs



Baseline with termination resistors

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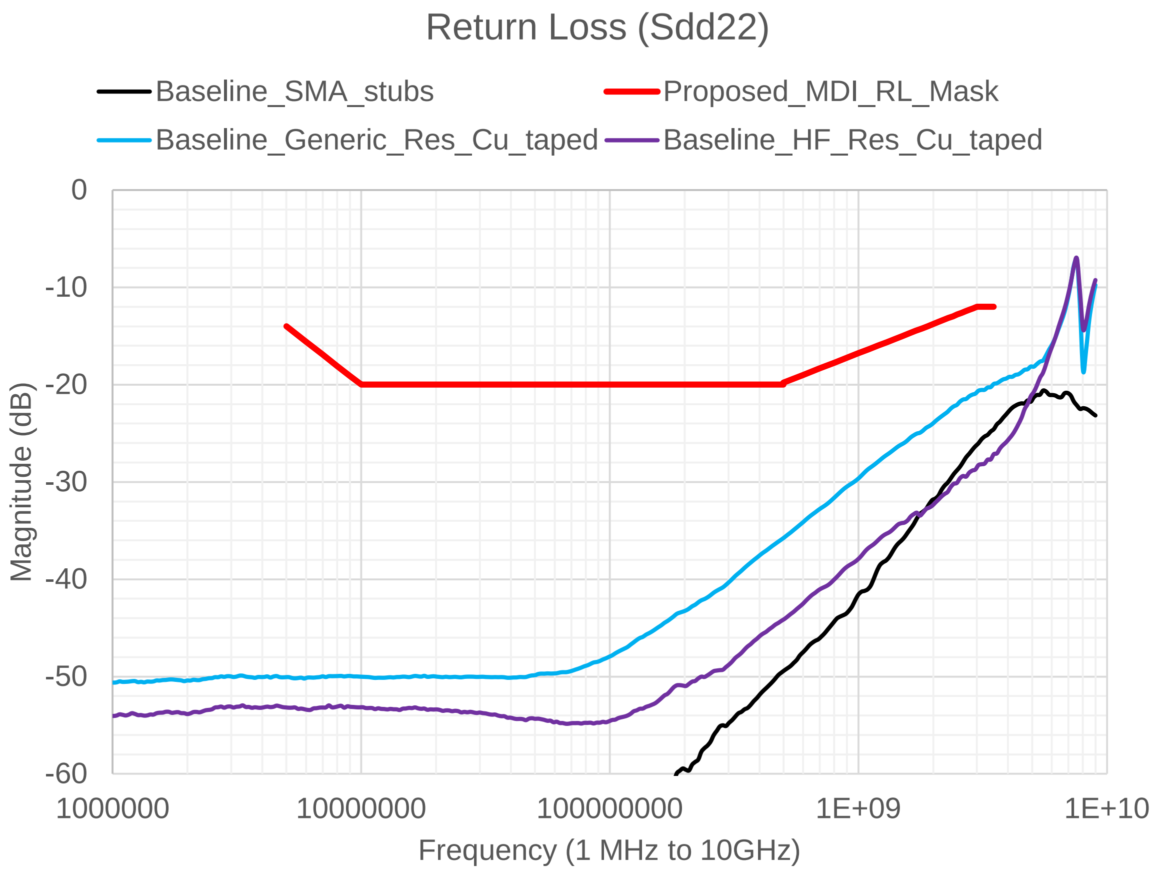
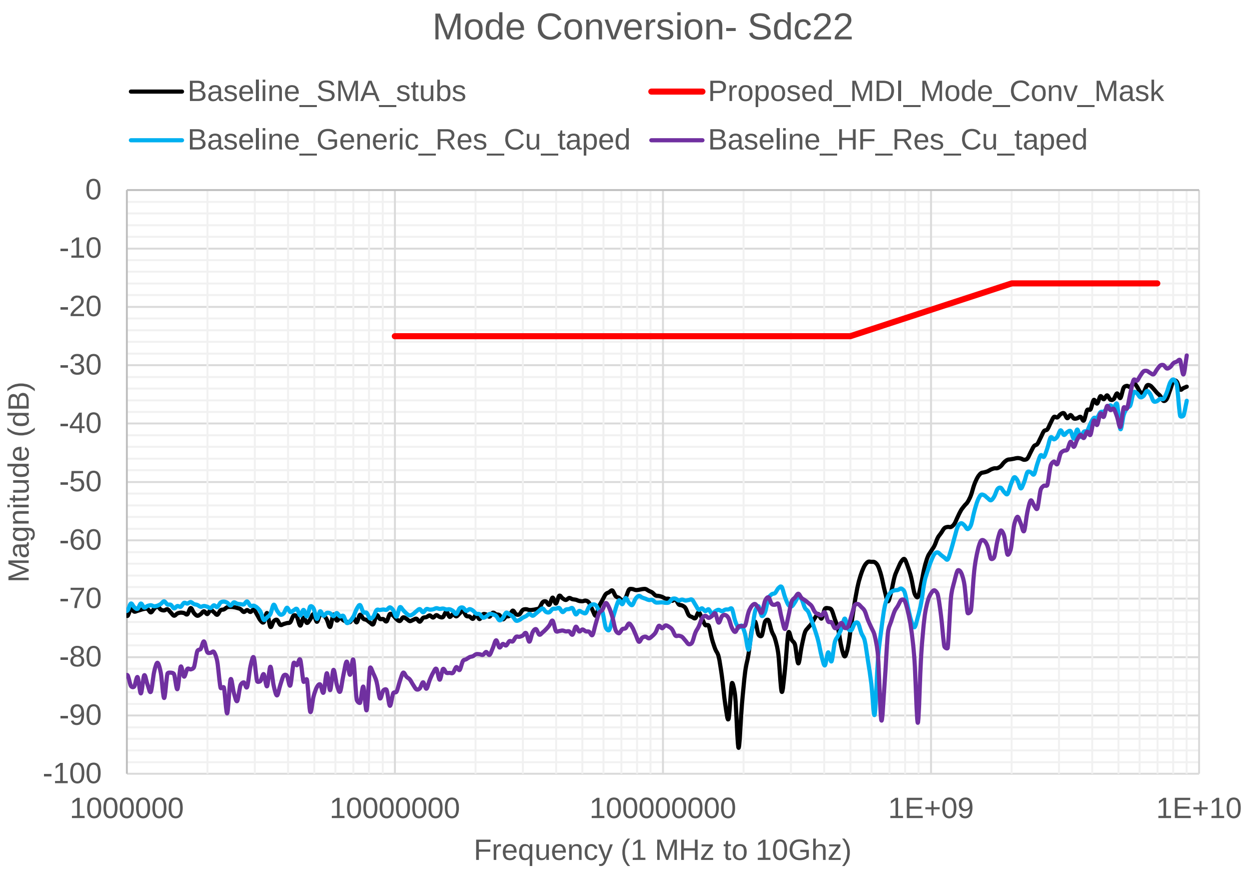
Test Fixtures and Baselines- Results



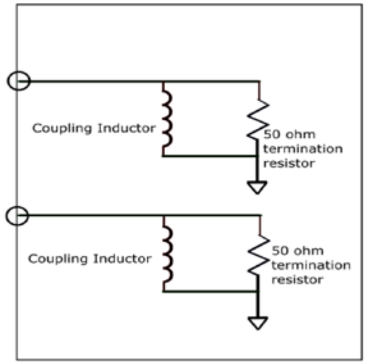


- Return Loss degradation at higher frequencies can be attributed to package inductance of term resistors
- Moved to 0402 package from 0603 to improve this
- 0201 package not tested since HF 0402 resistors match performance of SMA stubs above 2GHz

Power Coupling Inductors and Test Fixtures

Increasing Current Rating

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (20℃ rise)
PFL3215-153	15	+/- 20%	3.2 X 2.3 X 1.5	240mA
PFL3215-103	10	+/- 20%	3.2 X 2.3 X 1.5	300 mA
1205POC-103	10	+/- 20%	3.2 X 1.4 X 2.36	420mA- 20% Drop
PFL4514- 153	15	+/- 20%	4.9 X 3.4 X 1.4	440mA
PFL4517- 822	8.2	+/- 20%	4.9 X 3.4 X 1.7	500mA
WA8514	5.6	+/- 20%	4.34 X 1.98 X 1.02	600 mA
PFL4514- 682	6.8	+/- 20%	4.9 X 3.4 X 1.4	860 mA

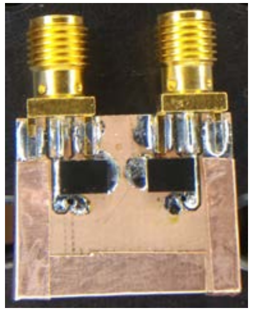


Schematic


PFL3215-153

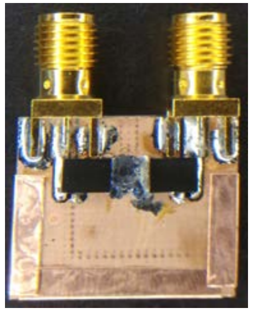

PFL3215-103


1205POC-103


PFL4514-153


PFL4517-822


WA8514

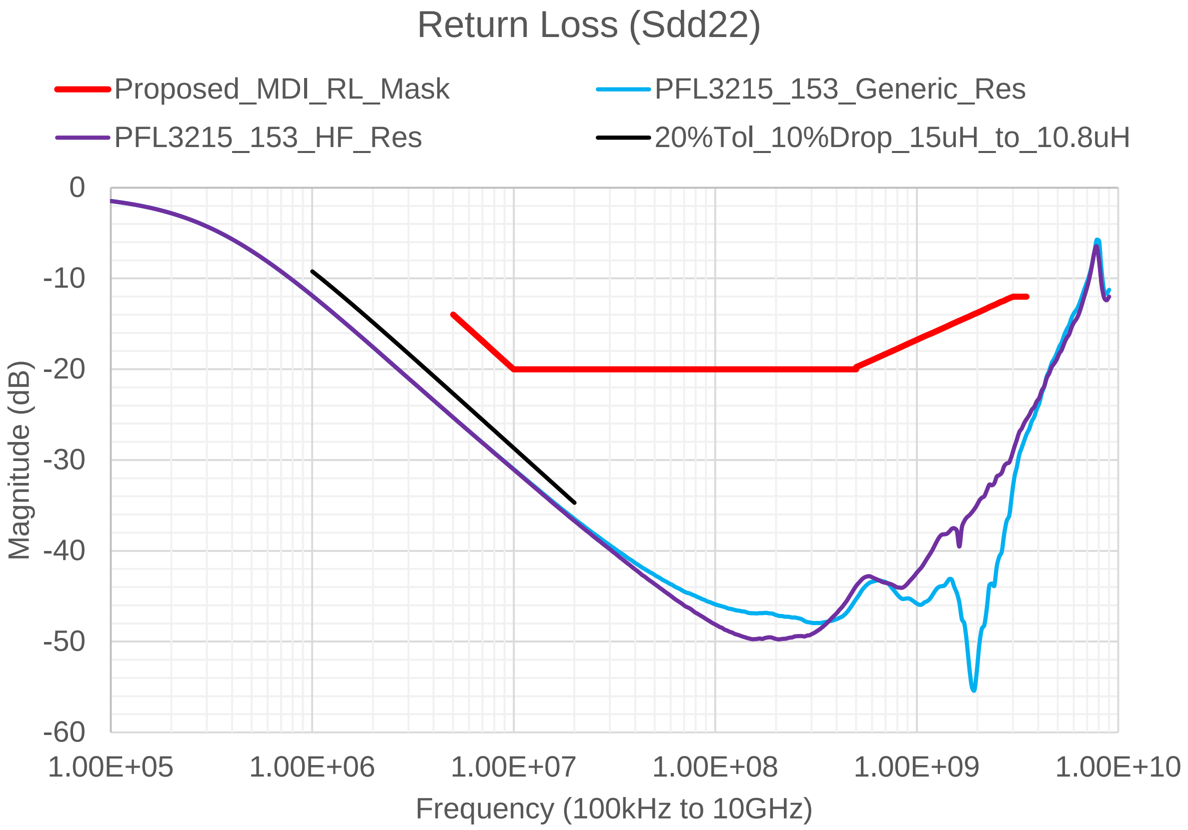

PFL4514-682

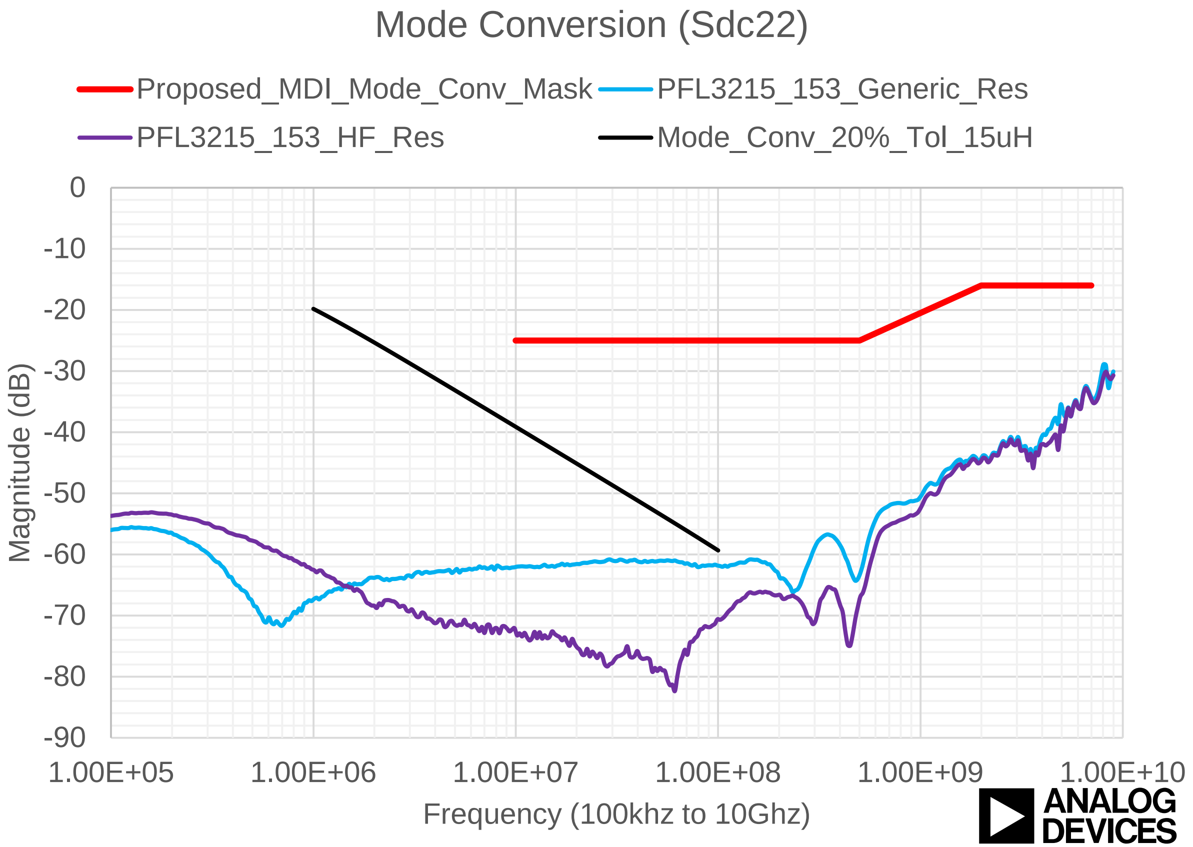
*Detailed Current Ratings shown in Backup Slides

Measured Data

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (20℃ rise)
PFL3215-153	15	+/- 20%	3.2 X 2.3 X 1.5	240mA

Max. Ambient Temp. with 240mA : 105℃ | Max. Part Temperature : 125℃

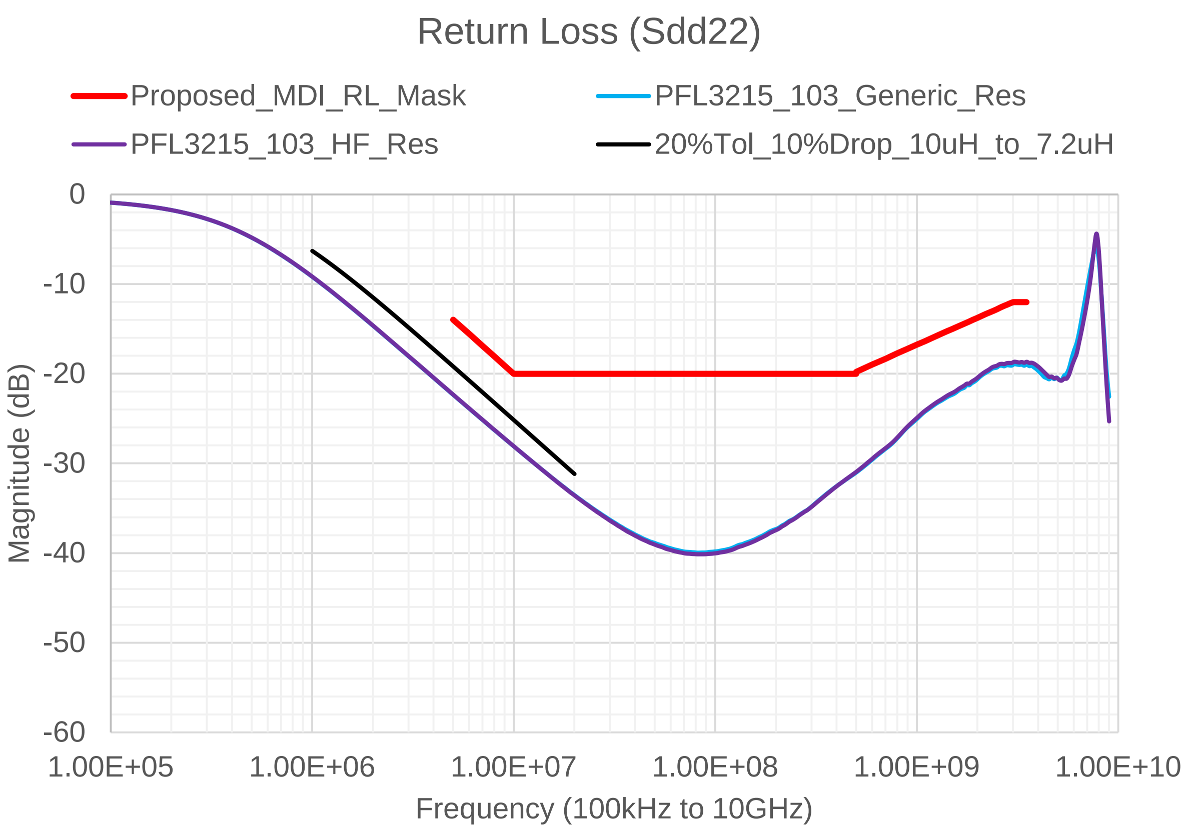


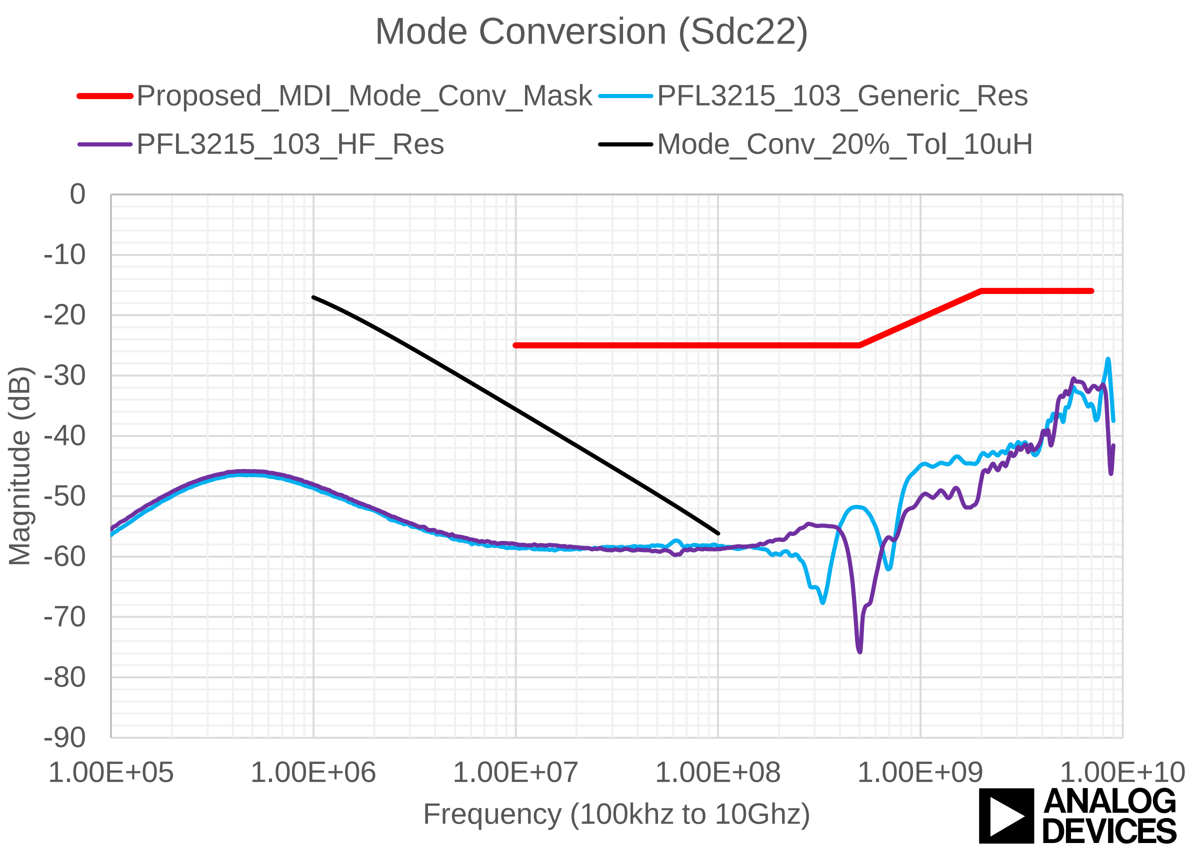


Measured Data

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (20℃ rise)
PFL3215-103	10	+/- 20%	3.2 X 2.3 X 1.5	300 mA

Max. Ambient Temp. with 300mA : 105℃ | Max. Part Temperature : 125℃

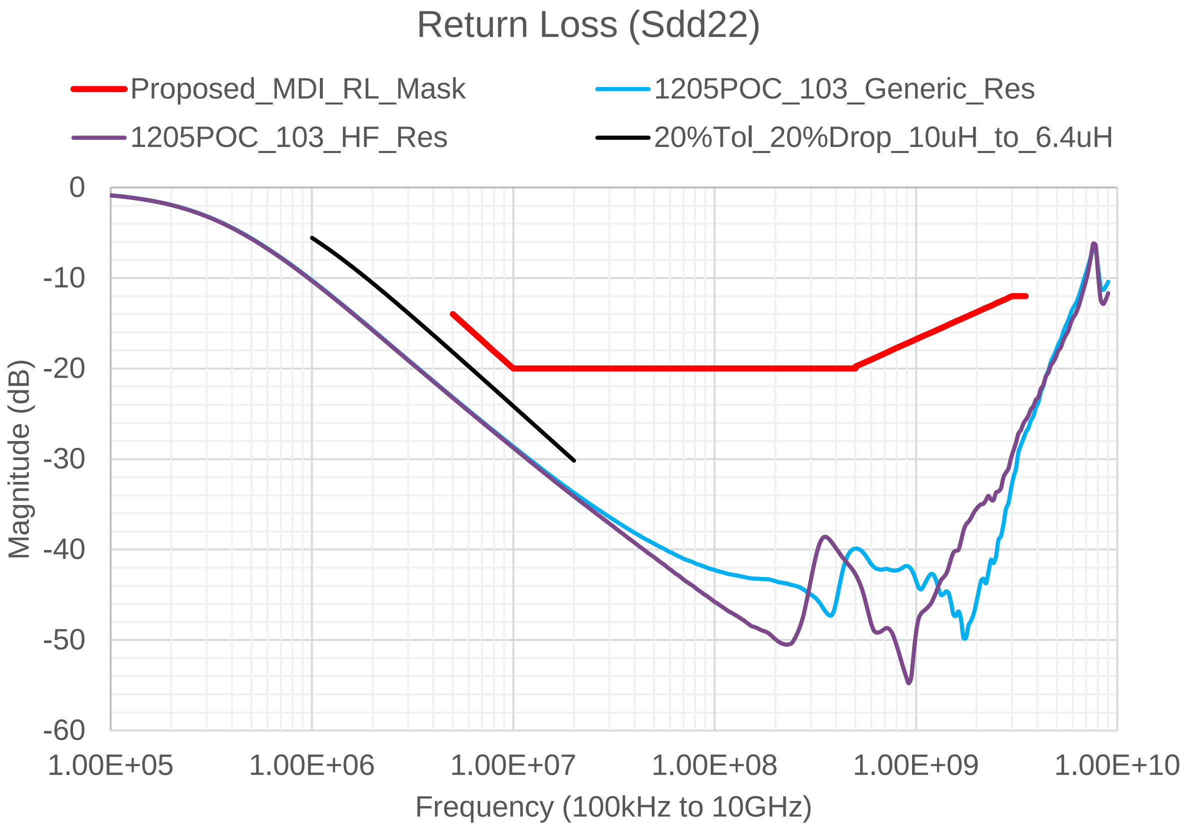


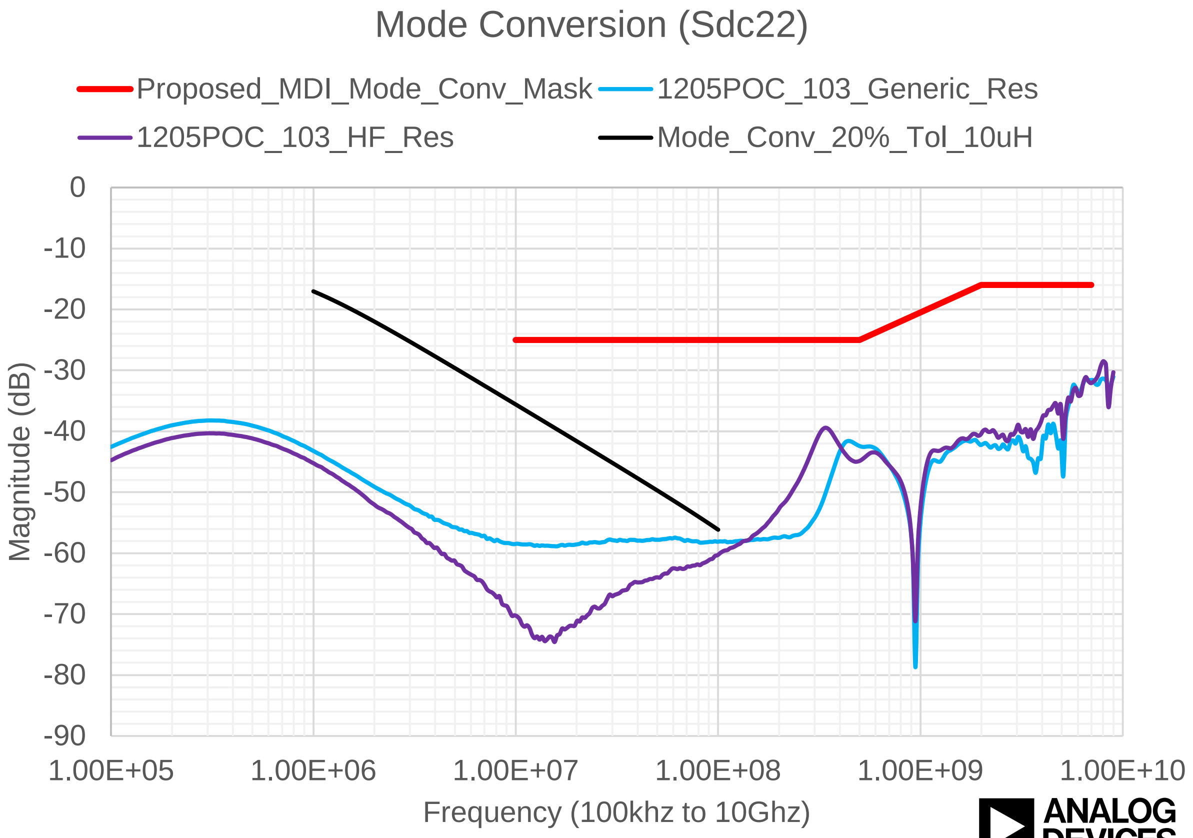


Measured Data

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (20% Drop)
1205POC-103	10	+/- 20%	3.2 X 1.4 X 2.36	420mA

Max. Ambient Temp. with 420mA : 125℃ | Max. Part Temperature : 140℃

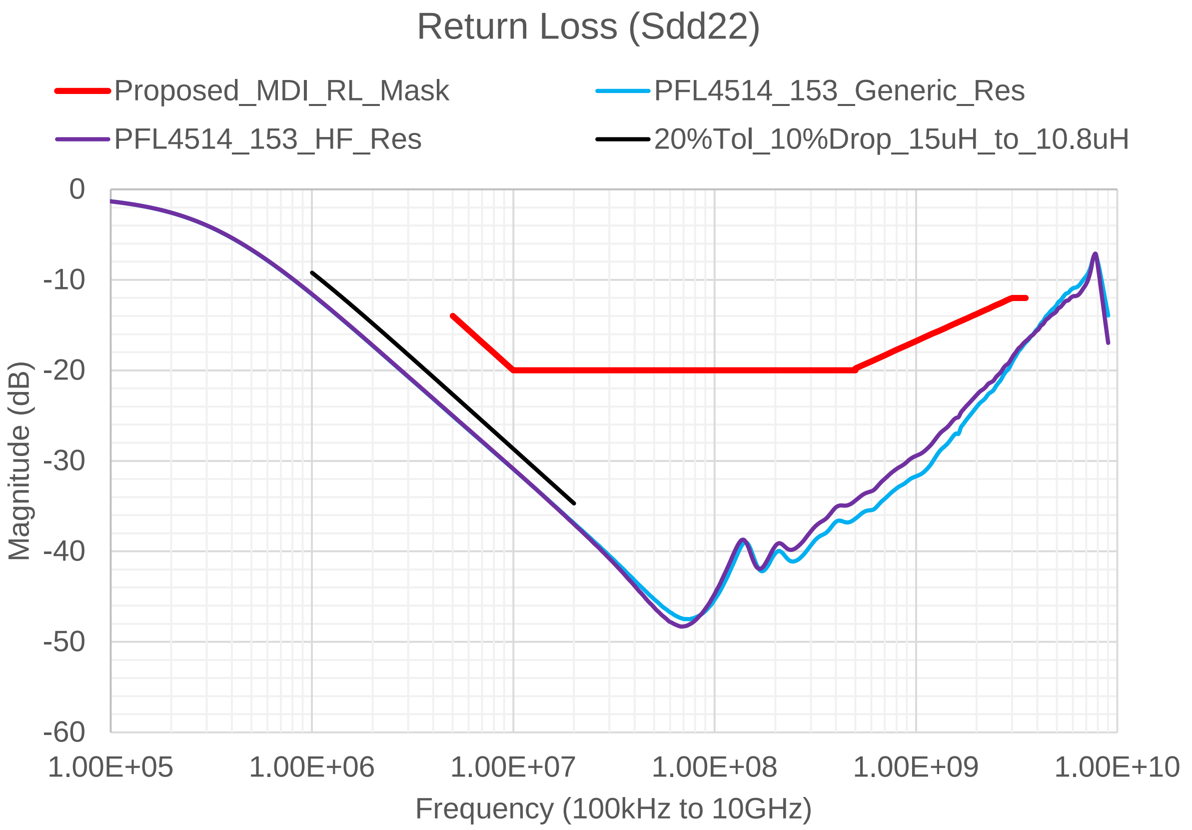


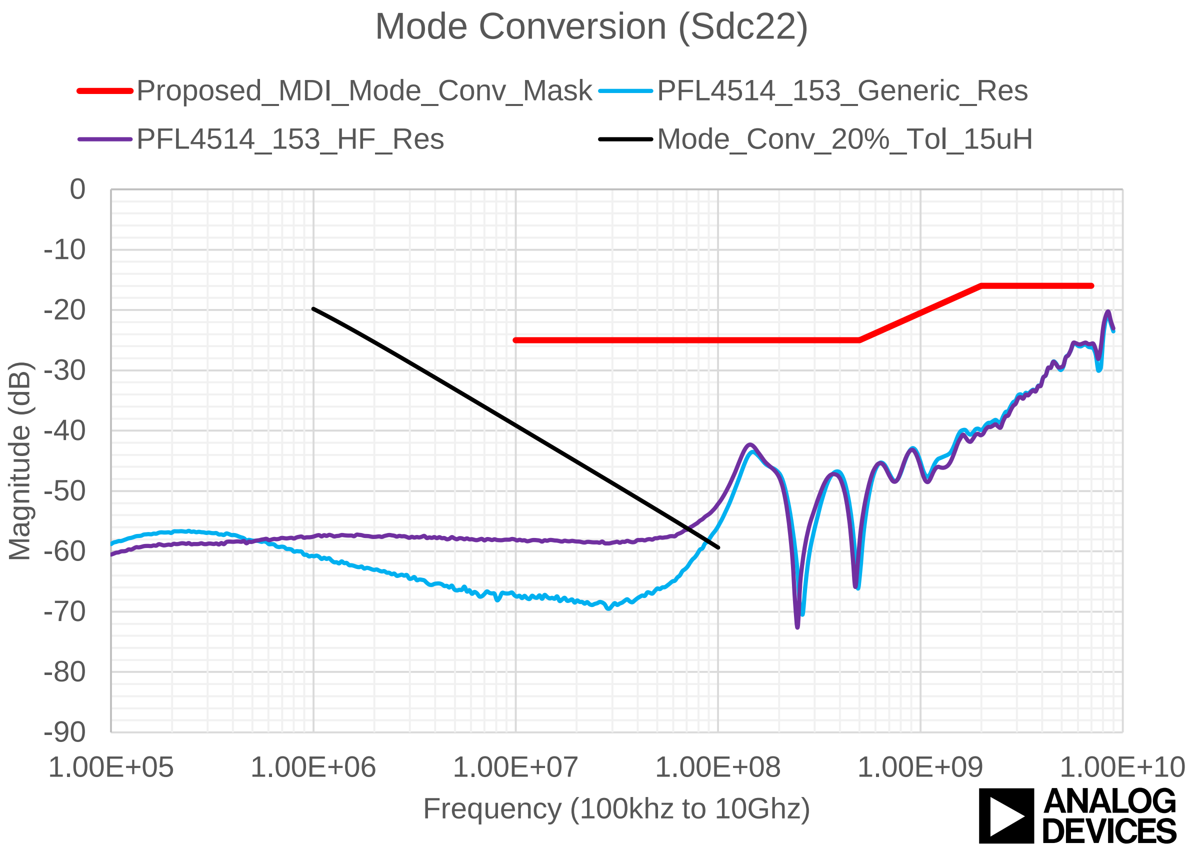


Measured Data

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (20℃ rise)
PFL4514- 153	15	+/- 20%	4.9 X 3.4 X 1.4	440mA

Max. Ambient Temp. with 440mA : 105℃ | Max. Part Temperature : 125℃





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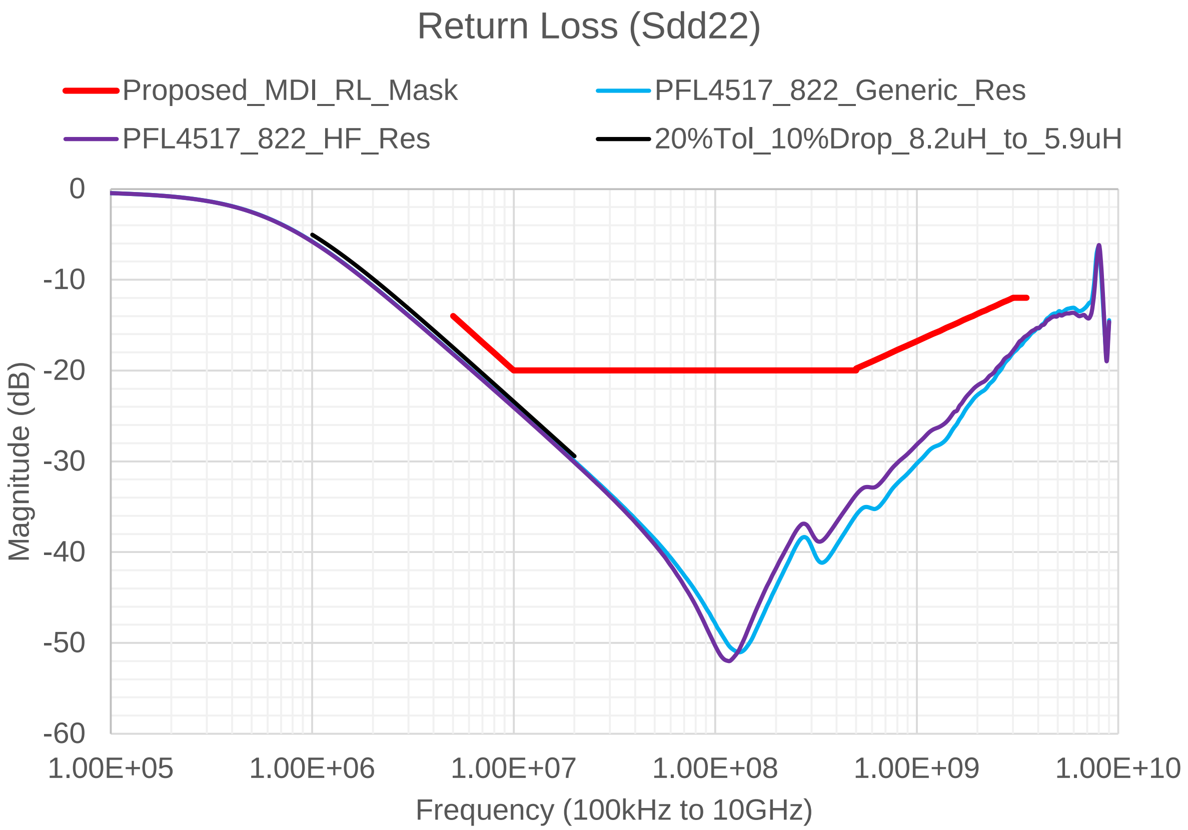
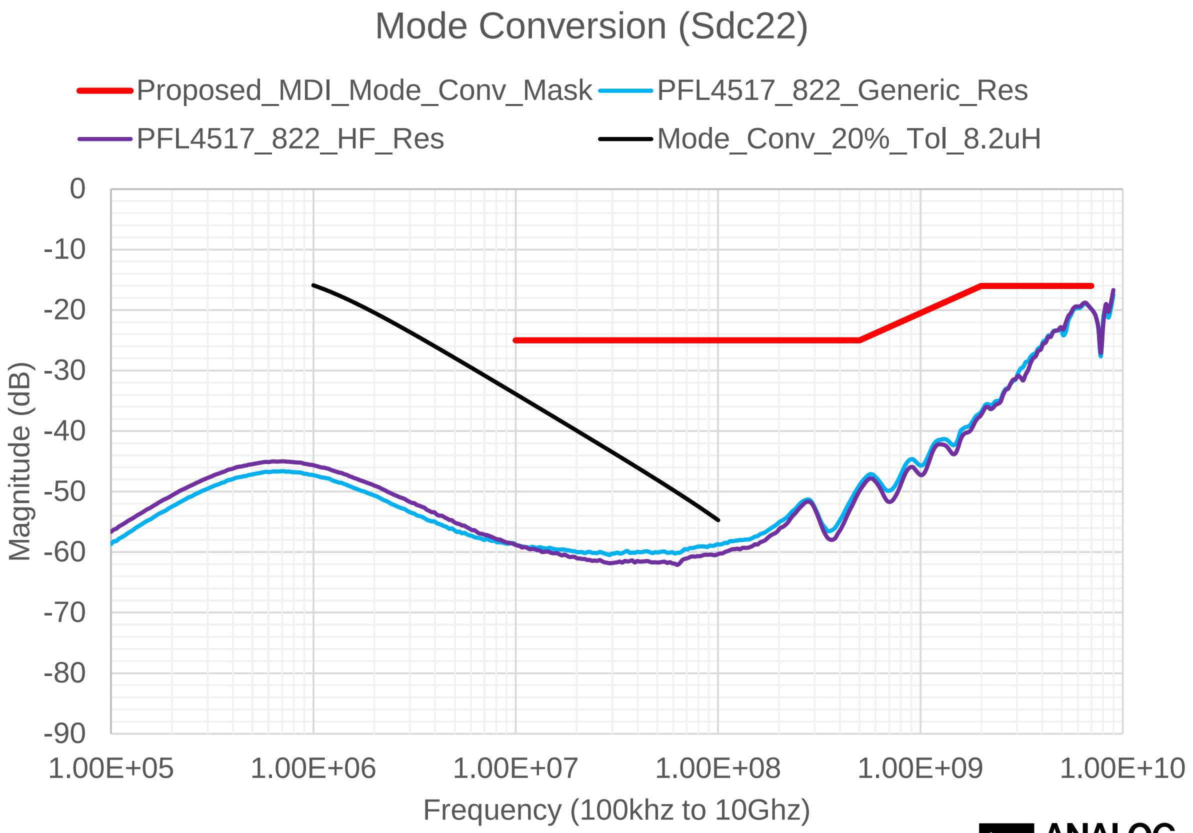
Measured Data

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (20℃ rise)
PFL4517- 822	8.2	+/- 20%	4.9 X 3.4 X 1.7	500mA

Max. Ambient Temp. with 500mA : 105℃ | Max. Part Temperature : 125℃



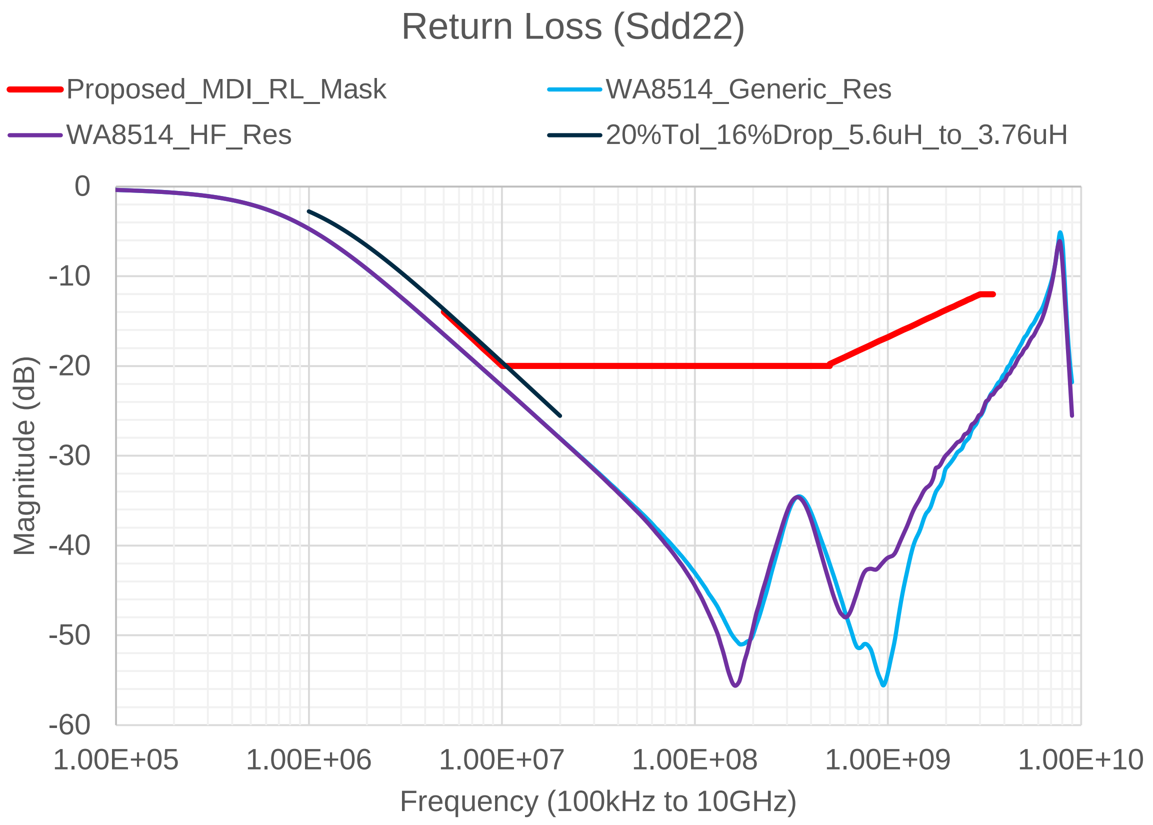


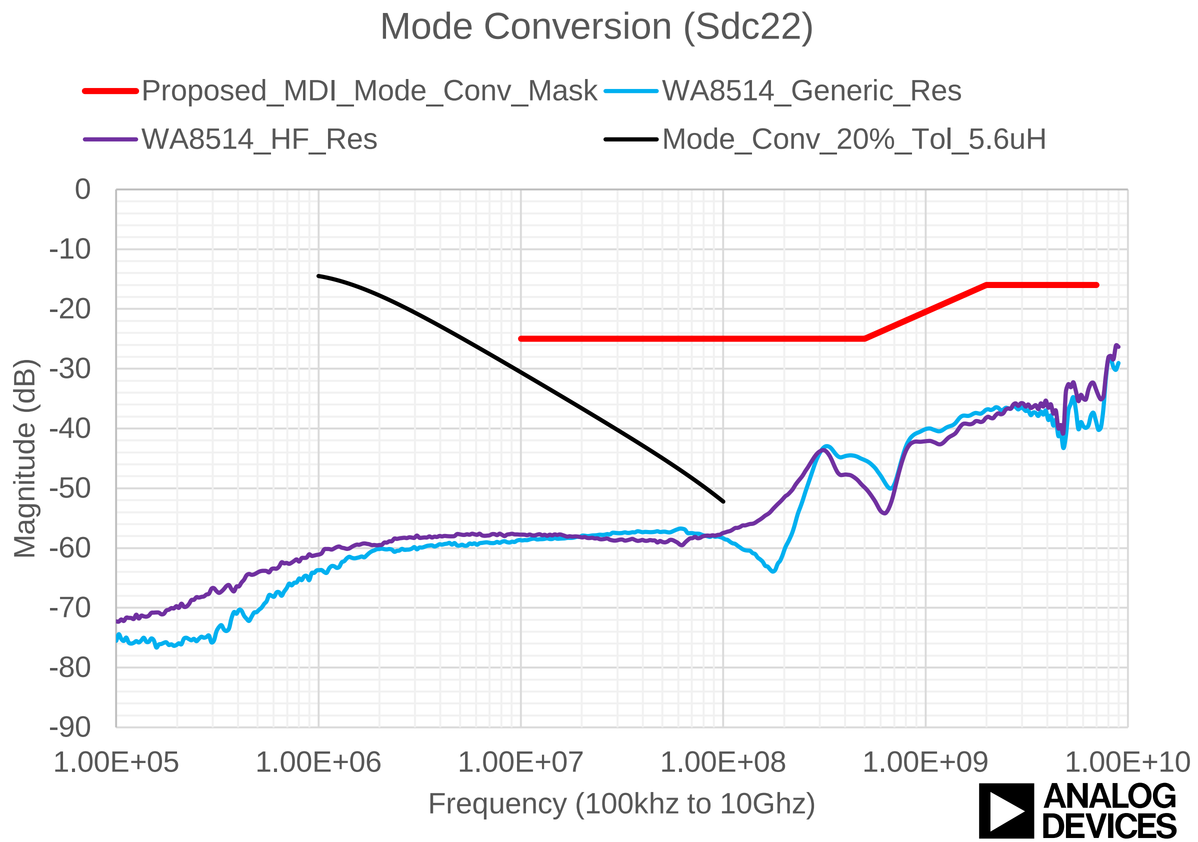
*Measured data shows that tolerance numbers are realistic and need to be accounted for

Measured Data

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (20℃ rise)
WA8514	5.6	+/- 20%	4.34 X 1.98 X 1.02	600 mA

Max. Ambient Temp. with 600mA : 125℃ | Max. Part Temperature : 145℃





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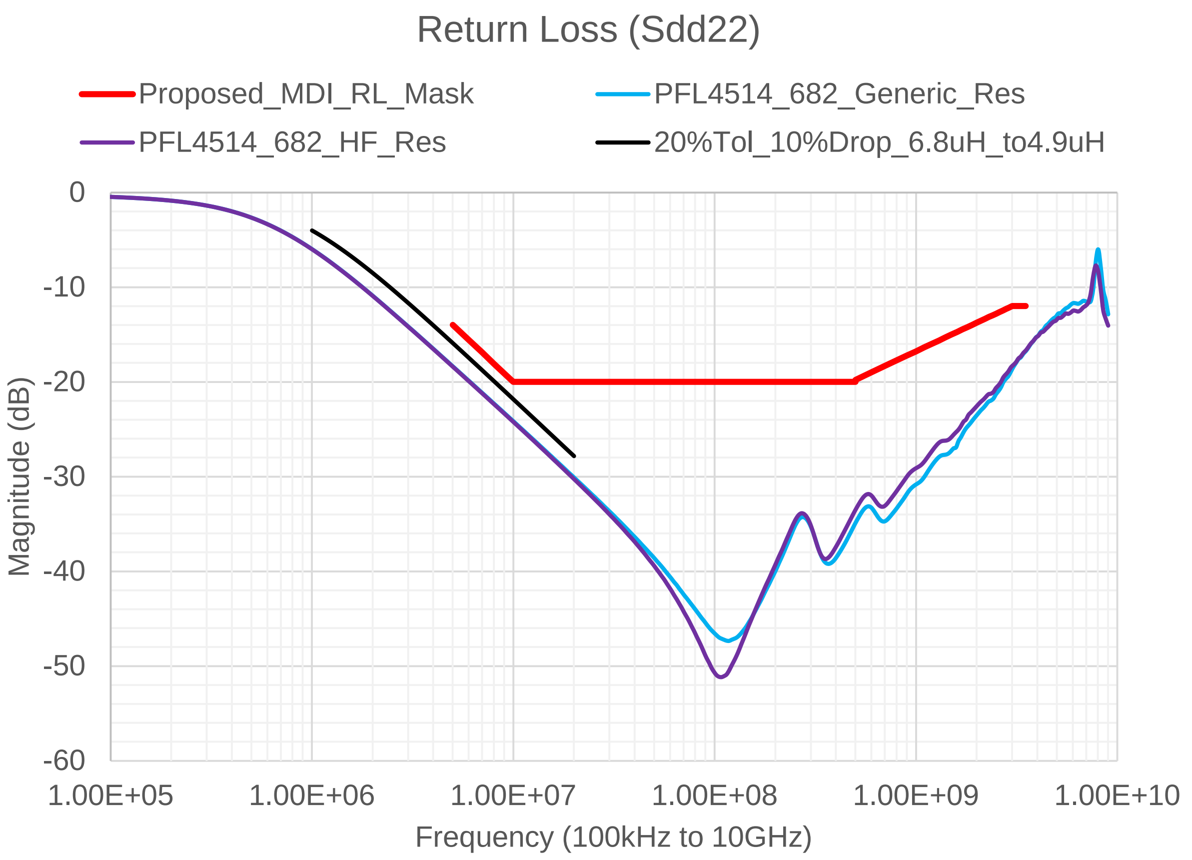
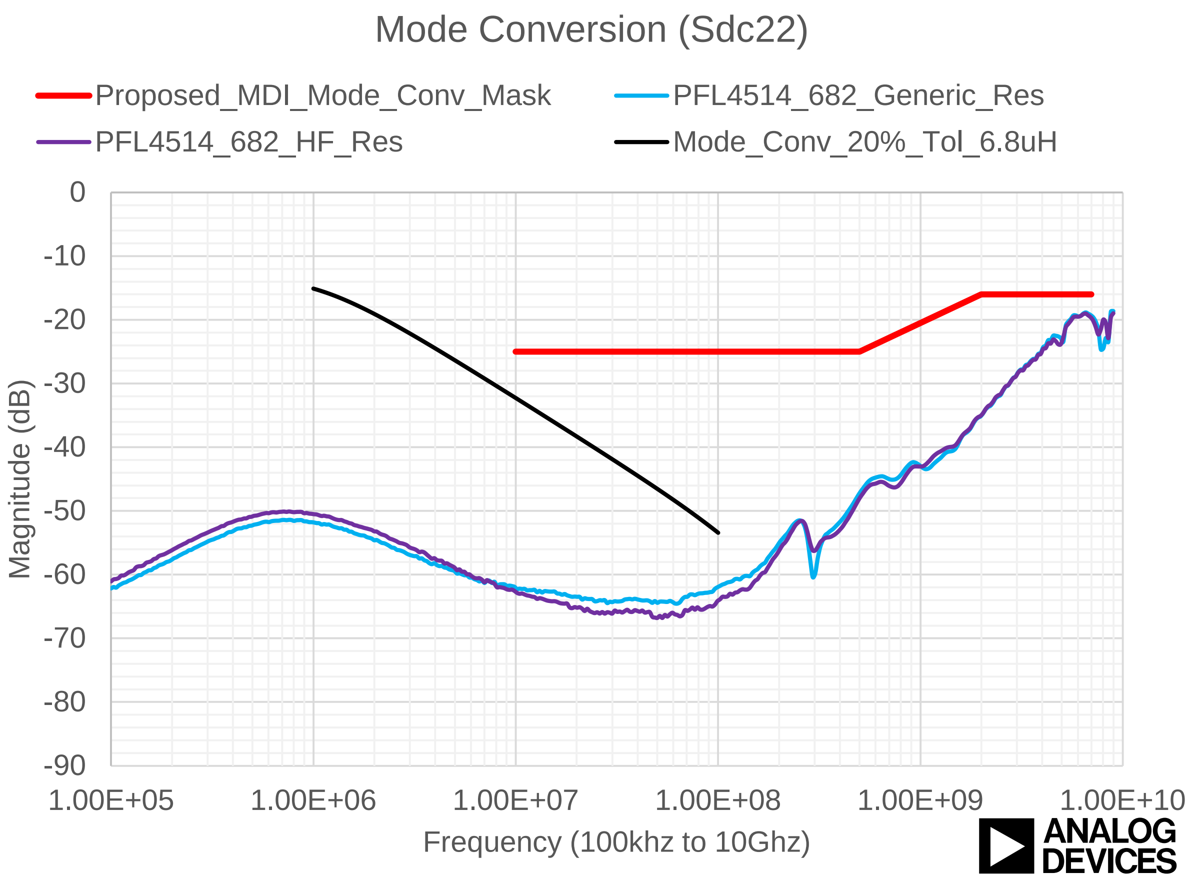
Measured Data

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (20℃ rise)
PFL4514- 682	6.8	+/- 20%	4.9 X 3.4 X 1.4	860 mA

Max. Ambient Temp. with 860mA : 105℃ | Max. Part Temperature : 125℃





Conclusion

- Commercial Off the Shelf inductors can provide sufficient MDI performance
- Good Current capacity and Small Footprint achievable
- Same size, Higher OCL ➔ Reduced Current rating

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (20℃ rise)	
PFL3215-153	15	+/- 20%	3.2 X 2.3 X 1.5	240mA	**20% reduced Current**
PFL3215-103	10	+/- 20%	3.2 X 2.3 X 1.5	300 mA	
PFL4514- 153	15	+/- 20%	4.9 X 3.4 X 1.4	440mA	**49% reduced Current**
PFL4514- 682	6.8	+/- 20%	4.9 X 3.4 X 1.4	860 mA	

- Inductors which can operate at 125℃ ambient available:

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (125℃ ambient)
1205POC-103	10	+/- 20%	3.2 X 1.4 X 2.36	430mA
WA8514	5.6	+/- 20%	4.34 X 1.98 X 1.02	600 mA

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Thank You!

QUESTIONS? FEEDBACK?

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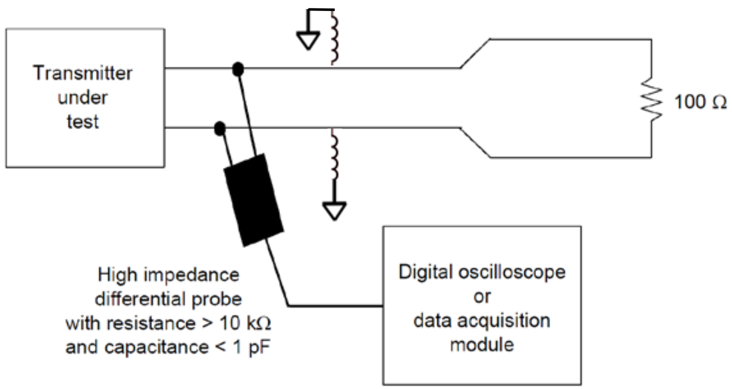
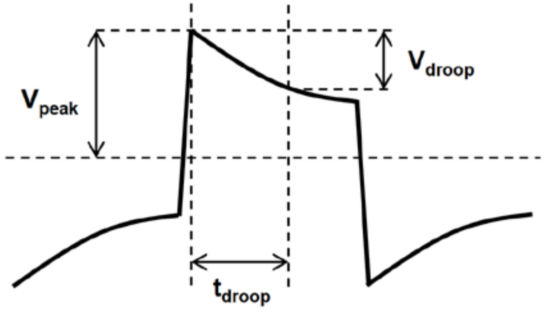
Backup Slides

Transmitter Droop with Power Coupling Inductors

- References:
  - www.ieee802.org/3/bu/public/may14/gardner_3bu_1_0514.pdf
  - IEEE 802.3bp standard
- Transmitter Droop Test Fixture- with Power Coupling Inductors added
- PHY AC coupled with 22nF Caps





Droop=100×(V_{droop}/V_{peak}) %

- 1000BASE-T1 specifies 10% droop over 12ns period (t_{droop})
- NGAUTO Droop percentage can be approximated as:
  - %Droop = $100 \times 1 - (e^{\frac{t_{droop}}{\frac{2 \times L}{R}}})$
  - Where R = 50ohms and L = OCL of Power Coupling Inductor

Power Coupling Inductors- current ratings

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Current Rating (20℃ rise)	Current Rating (10% Drop)	Current Rating (20% Drop)	Current Rating (30% Drop)	Drop (assumed) at I_{RMS} limit
PFL3215-153	15	+/- 20%	3.2 X 2.3 X 1.5	240mA	350mA	420mA	440mA	**10%**
PFL3215-103	10	+/- 20%	3.2 X 2.3 X 1.5	300 mA	500mA	550mA	600mA	**10%**
1205POC-103	10	+/- 20%	3.2 X 1.4 X 2.36	430mA- 15℃ rise	200mA	420mA	650mA	**20%**
PFL4514- 153	15	+/- 20%	4.9 X 3.4 X 1.4	440mA	770mA	990mA	1100mA	**10%**
PFL4517- 822	8.2	+/- 20%	4.9 X 3.4 X 1.7	500mA	1400mA	2100mA	2300mA	**10%**
WA8514	5.6	+/- 20%	4.34 X 1.98 X 1.02	600 mA	-	-	730mA	**16%**
PFL4514- 682	6.8	+/- 20%	4.9 X 3.4 X 1.4	860 mA	1100mA	1500mA	1700mA	**10%**