Common Mode Filters (Part 2)

X2Y® ® Capacitors

vs.

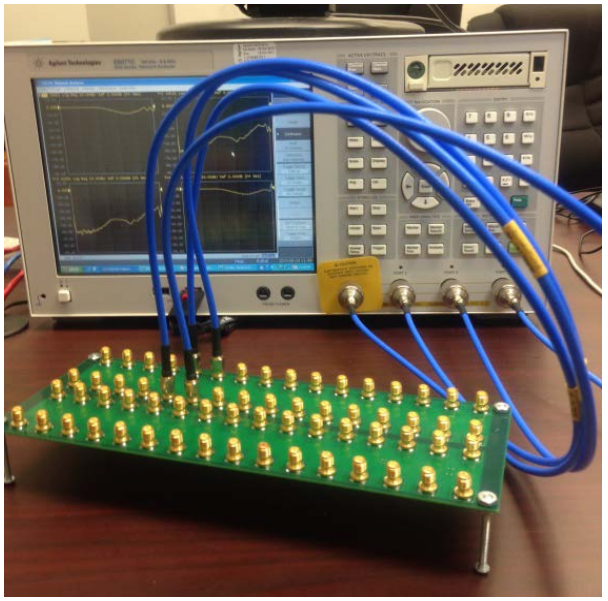
Common Mode Chokes

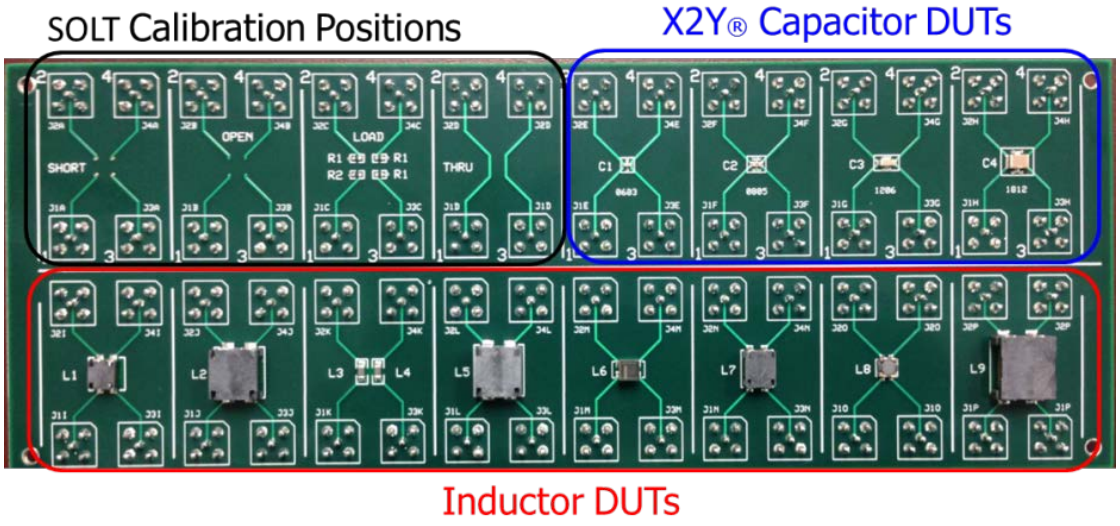
Objective

- This presentation is a continuation of testing shown in Common Mode Filters (Part1)
- Use 4-port, mixed-mode measurements to evaluate and compare the performance of single component, dual line CM filters used for DC powerline filtering:
  - Common mode chokes (CMCs)
    - CMCs are selected by sorting highest volume stocked at a top electronic component distributor
  - X2Y®
    - 1206 size, 100nF rated capacitance

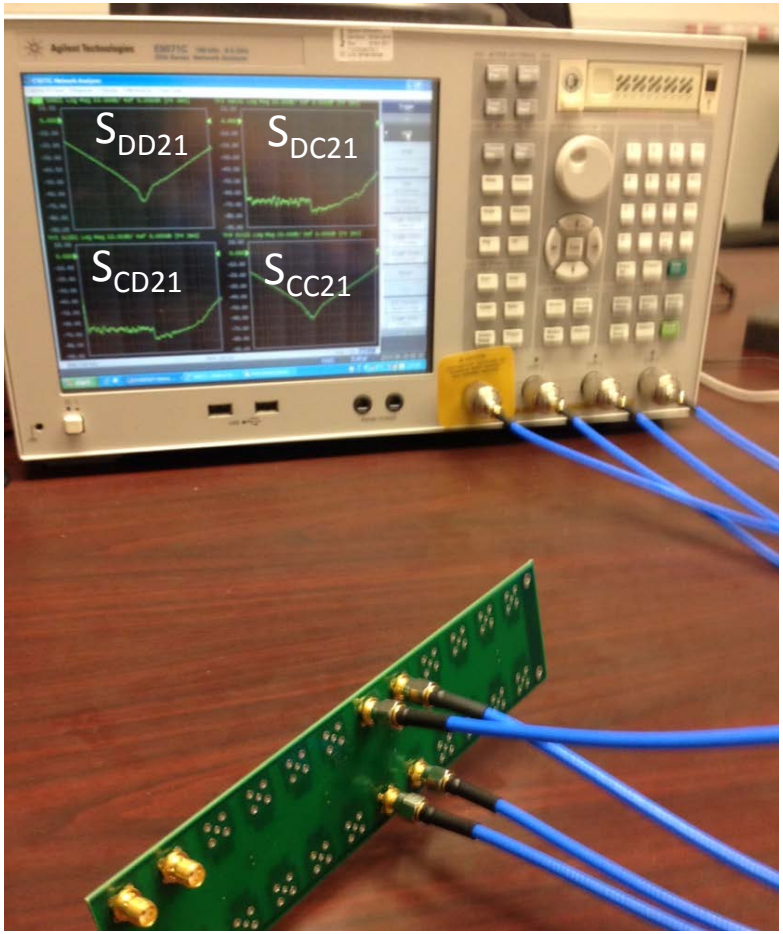
Test Setup

- Measurement Equipment
  - Agilent E5071C ENA Network Analyzer
- Test Board
  - FR-4, Dk of 4.6 +/-0.2, thickness 0.059“
  - Dielectric spacing, top layer to inner GND layer is 0.012“
  - Vertical mount SMAs
- Test Method / Data Focus
  - Mixed-mode S-parameters.
  - Balanced Device Characterization





Key Parameters Tested



- **S_{DD21}**
  - describes the DUT's differential response to a differential stimulus.
- **S_{DC21}**
  - Describes common to differential mode conversion, which is related to the susceptibility of a device to EMI.
- **S_{CD21}**
  - Describes differential to common mode conversion, which is related to the generation of EMI.
- **S_{CC21}**
  - describes the DUT's common-mode response to a common-mode stimulus.

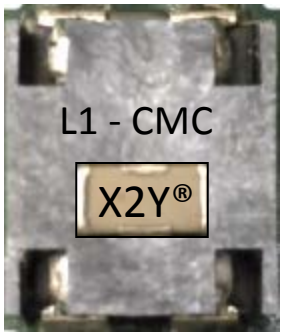
Method Source: Balanced Device Characterization, Agilent Technologies

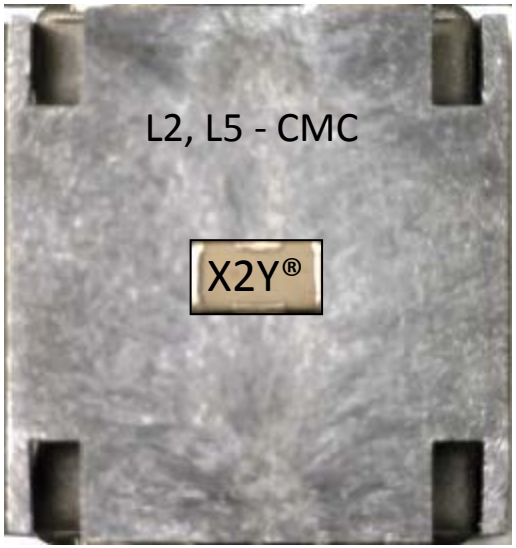
DUTs

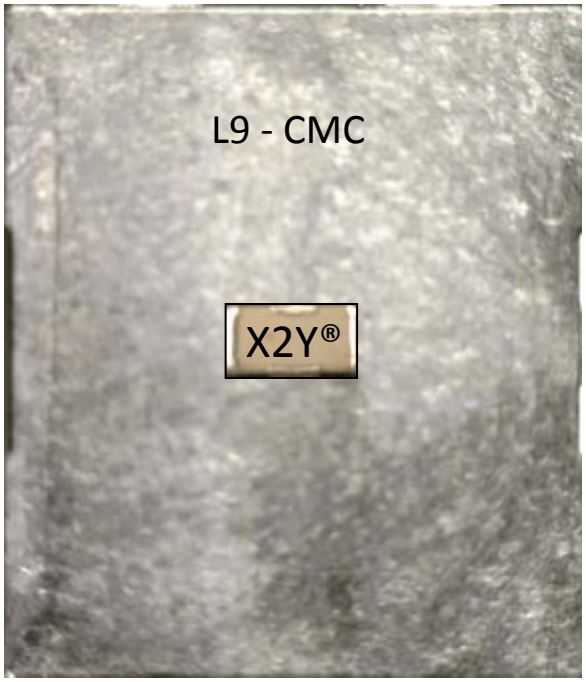
DUT#	Type	Impedance @ Frequency	Current Rating (Max)	DC Resistance (DCR) (Max)	Size / Dimension	Appearance (not to scale)
C3	X2Y®	N/A (in bypass)	N/A (in bypass)	0	0.120“ L x 0.060" W x 0.05“ H	
L1(A)	CM Choke	300 Ohm @ 100MHz	5A	10 mOhm	0.276" L x 0.236" W x 0.138“ H	
L1(B)	CM Choke	700 Ohm @ 100MHz	4A	15 mOhm	0.276" L x 0.236" W x 0.138“ H	
L2	CM Choke	700 Ohm @ 100MHz	8A	6 mOhm	0.472" L x 0.433" W x 0.236“ H	
L5(A)	CM Choke	300 Ohm @ 100MHz	5A	10 mOhm	0.472" L x 0.433" W x 0.236“ H	
L5(B)	CM Choke	1 kOhm @ 100MHz	6A	14 mOhm	0.472" L x 0.433" W x 0.236“ H	
L6(A)	CM Choke	600 Ohm @ 100MHz	1.4A	120 mOhm	0.197" L x 0.197" W x 0.177"	
L6(B)	CM Choke	600 Ohm @ 100MHz	1.4A	120 mOhm	0.197" L x 0.197" W x 0.098"	
L6(C)	CM Choke	600 Ohm @ 100MHz	1.4A	120 mOhm	0.197" L x 0.197" W x 0.098"	
L6(D)	CM Choke	600 Ohm @ 100MHz	1.4A	120 mOhm	0.197" L x 0.197" W x 0.098"	
L7	CM Choke	700 Ohm @ 100MHz	5A	10 mOhm	0.354" L x 0.276" W x 0.177"	
L8	CM Choke	230 Ohm @ 100MHz	3A	50 mOhm	0.185" L x 0.177" W x 0.079"	
L9	CM Choke	550 Ohm @ 100MHz	10A	4 mOhm	0.591" L x 0.512" W x 0.236"	

DUT Source: Digi-Key ELECTRONICS

Footprint Comparisons

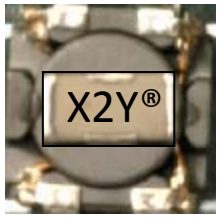




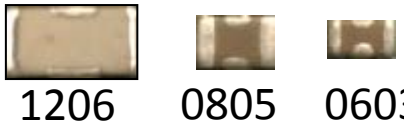


L6 - CMC

L8 - CMC



X2Y®



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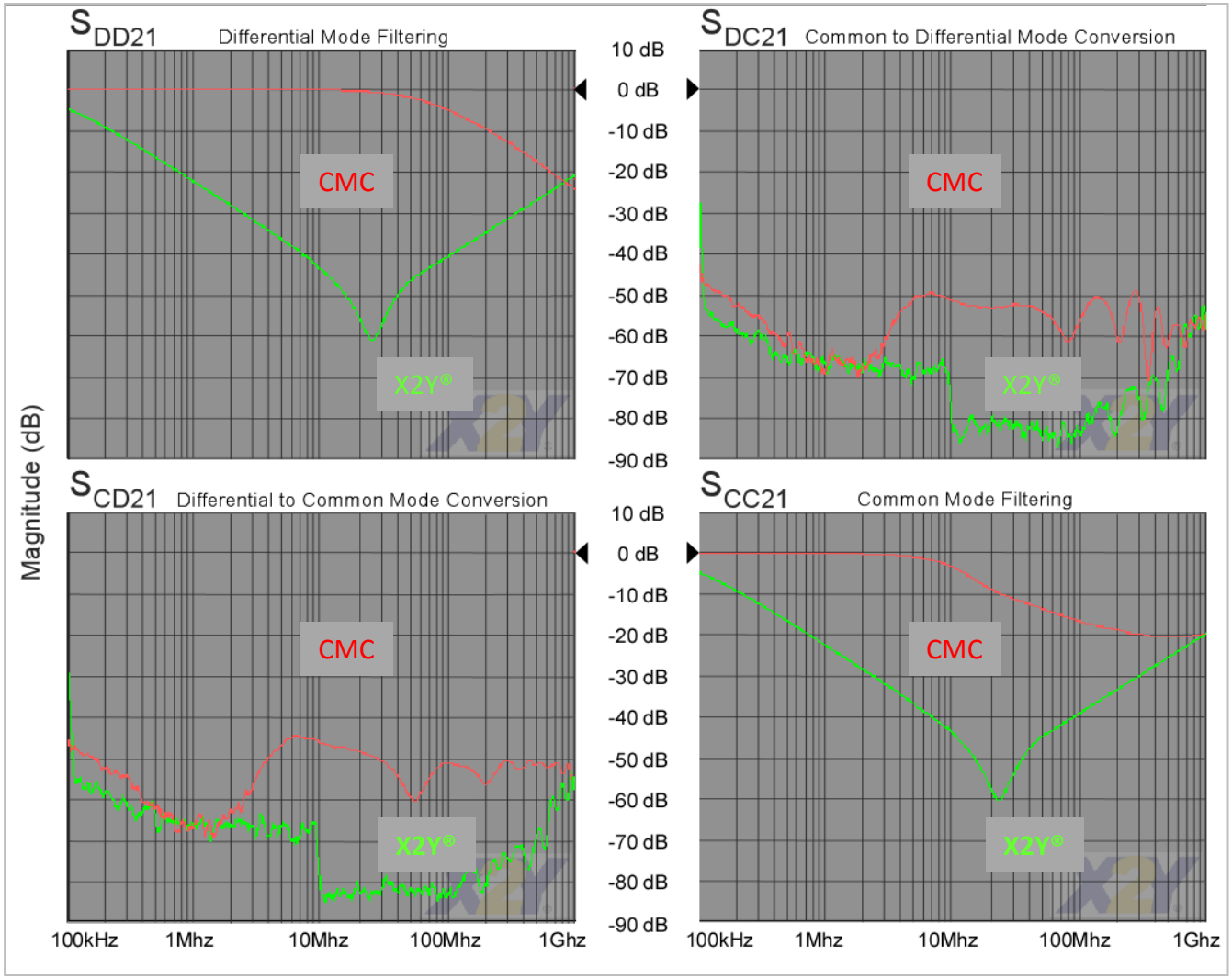
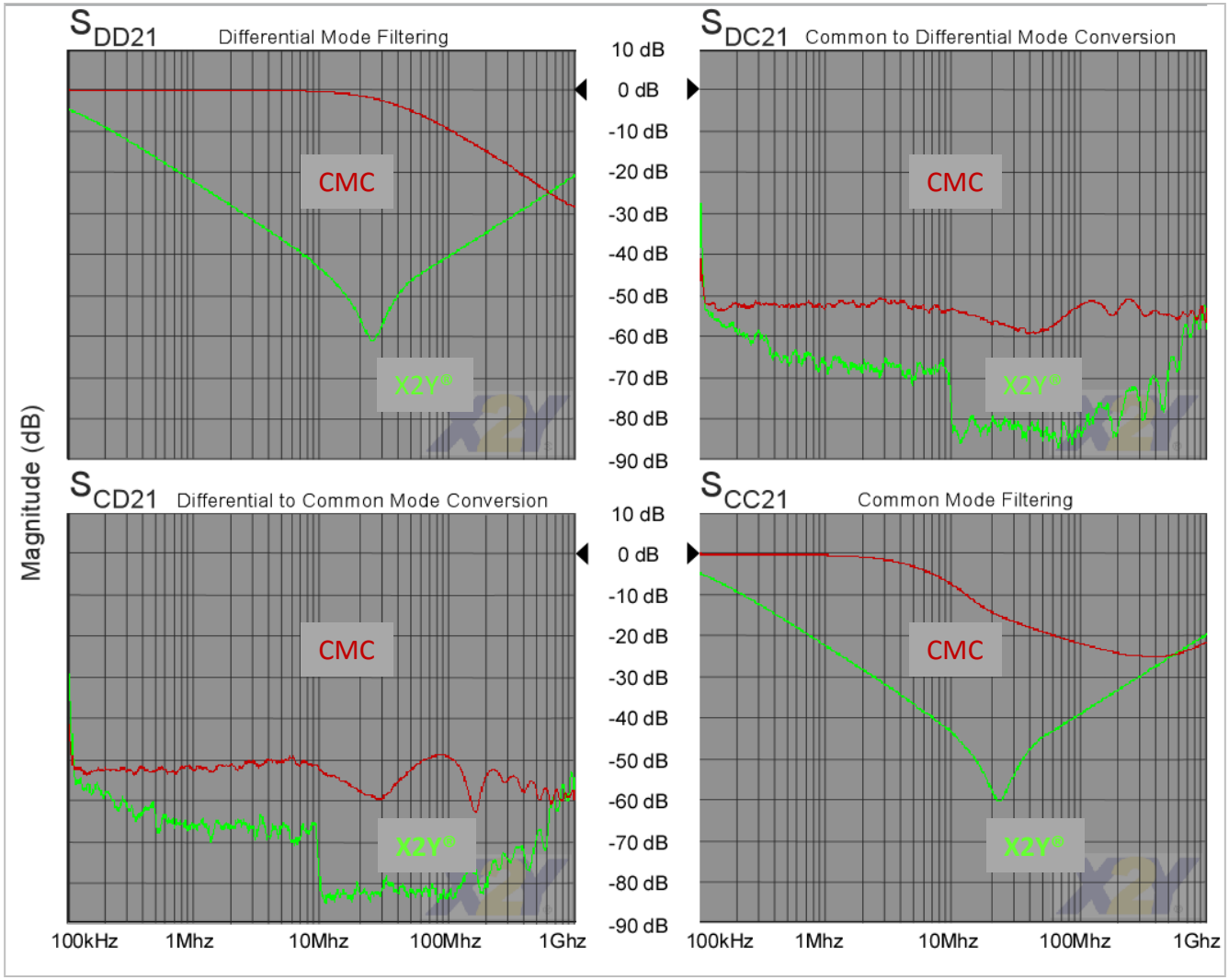
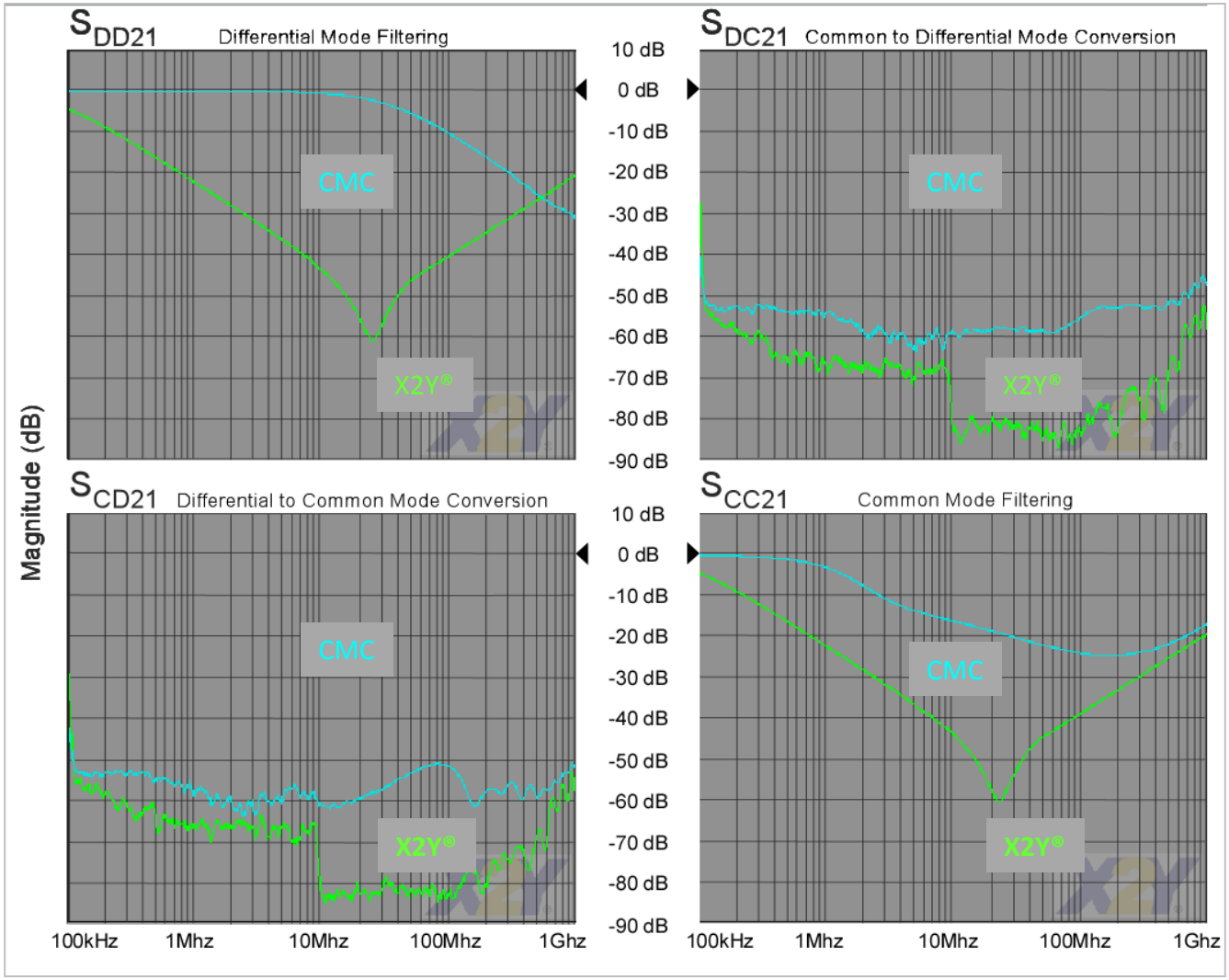
Mixed-Mode Analysis, L1(A) vs. C3



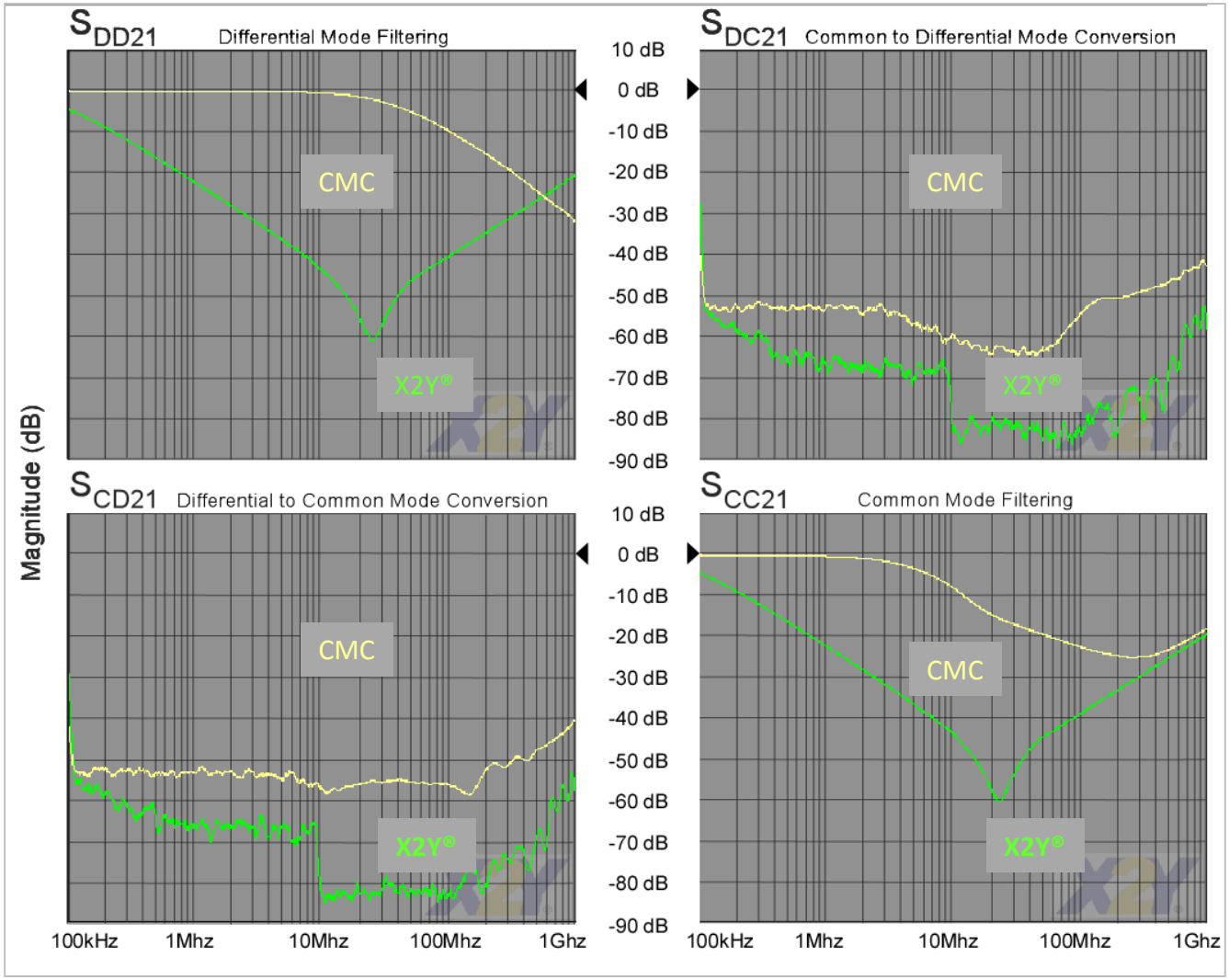
Mixed-Mode Analysis, L1(B) vs. C3



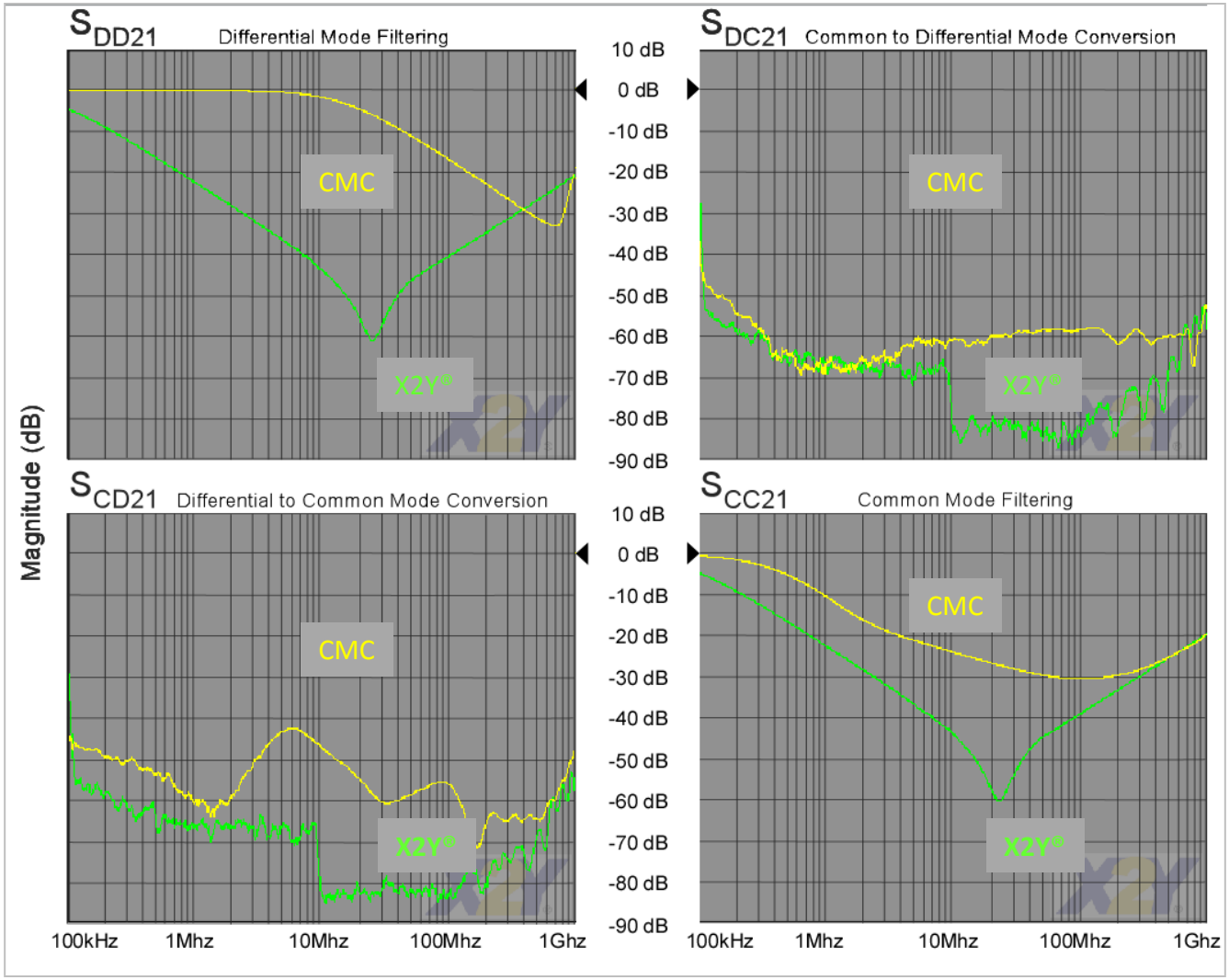
Mixed-Mode Analysis, L2 vs. C3



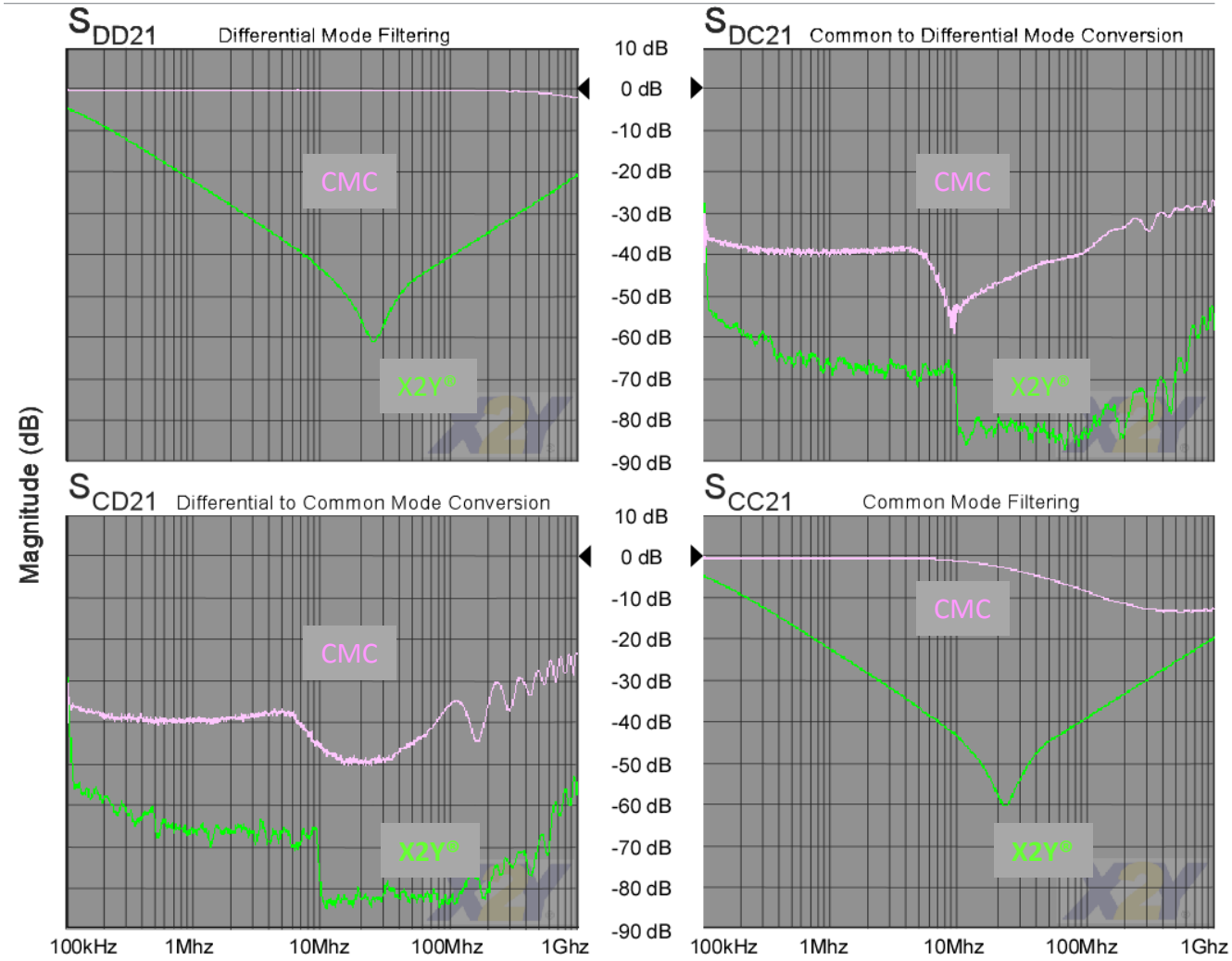
Mixed-Mode Analysis, L5(A) vs. C3



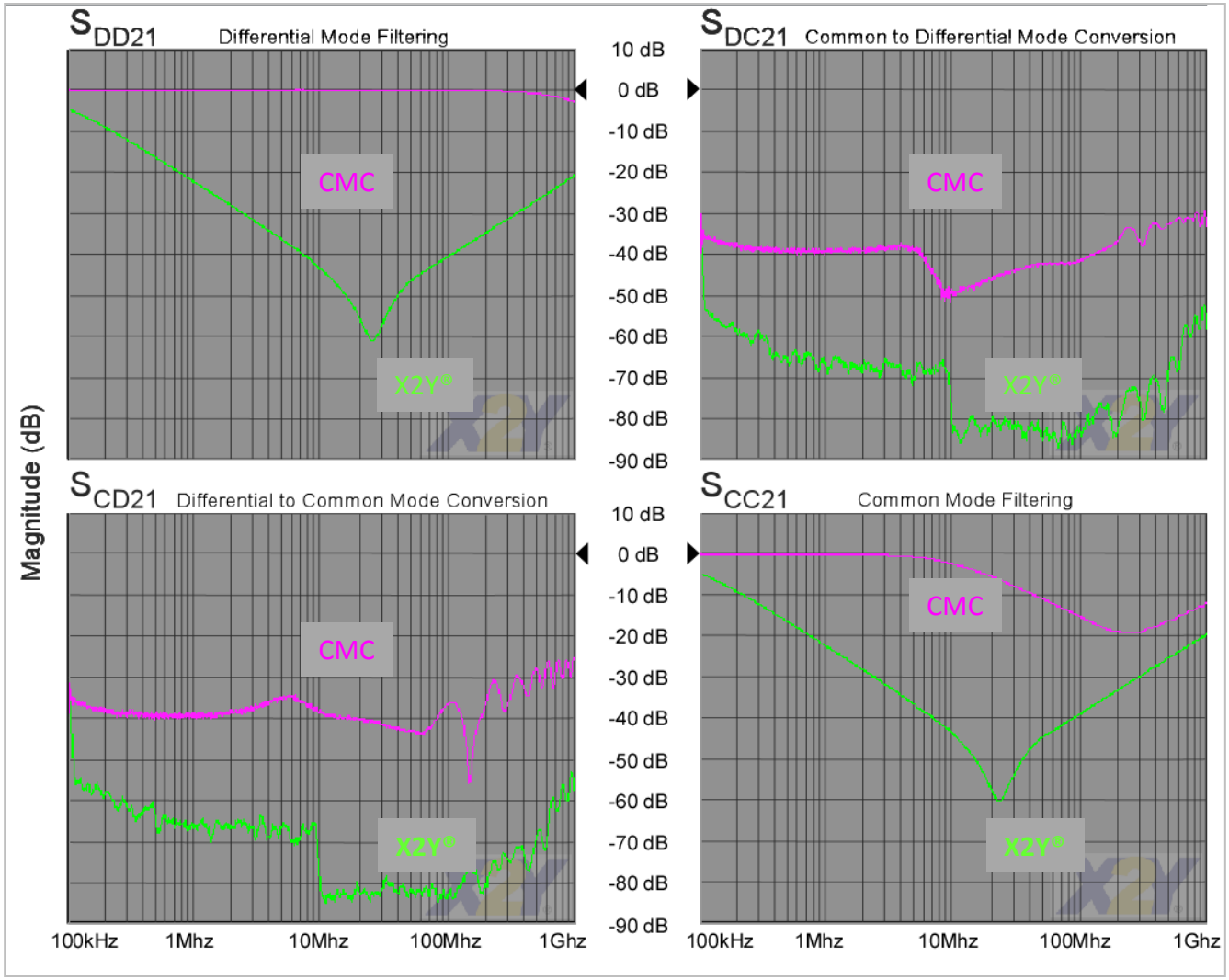
Mixed-Mode Analysis, L5(B) vs. C3



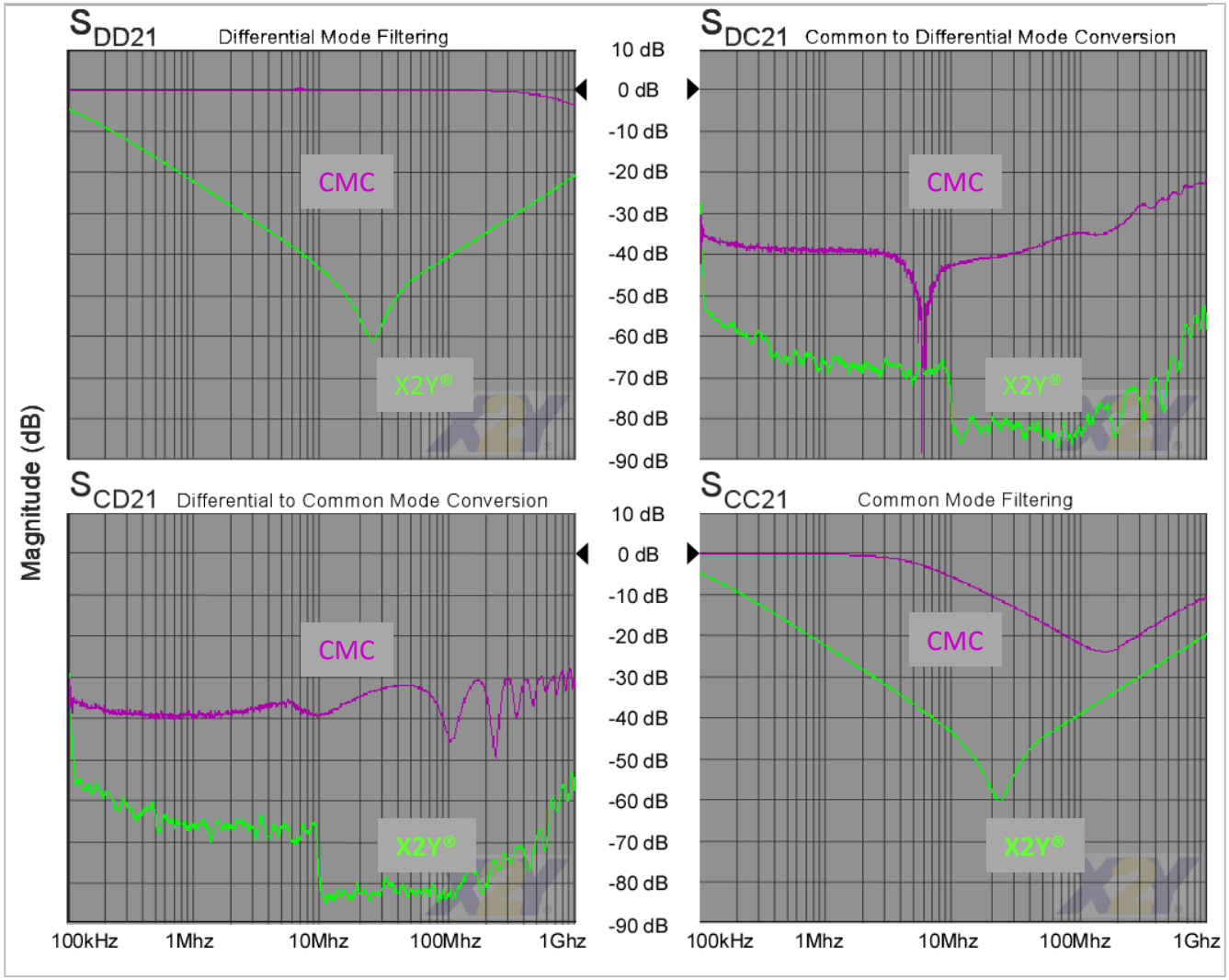
Mixed-Mode Analysis, L6(A) vs. C3



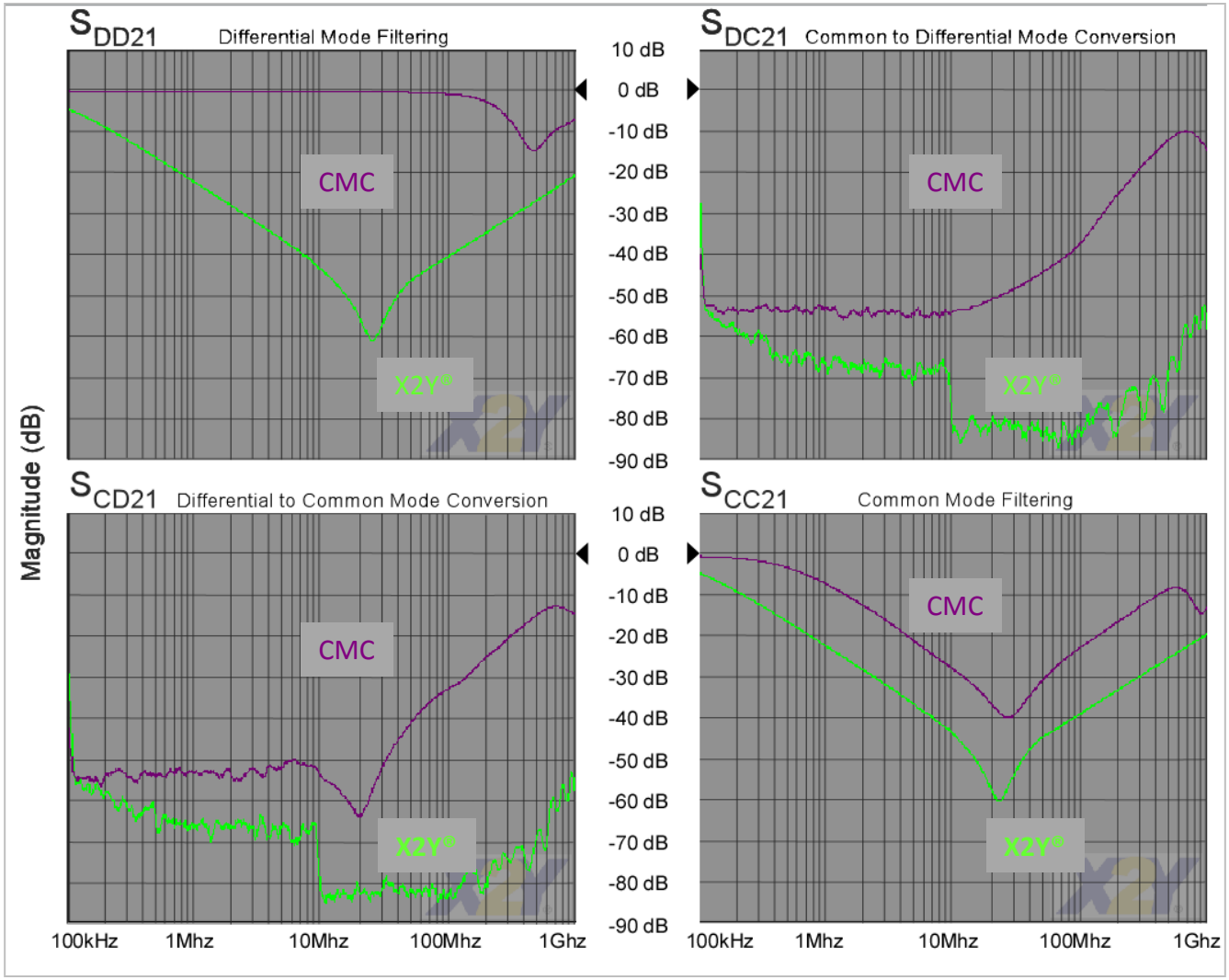
Mixed-Mode Analysis, L6(B) vs. C3



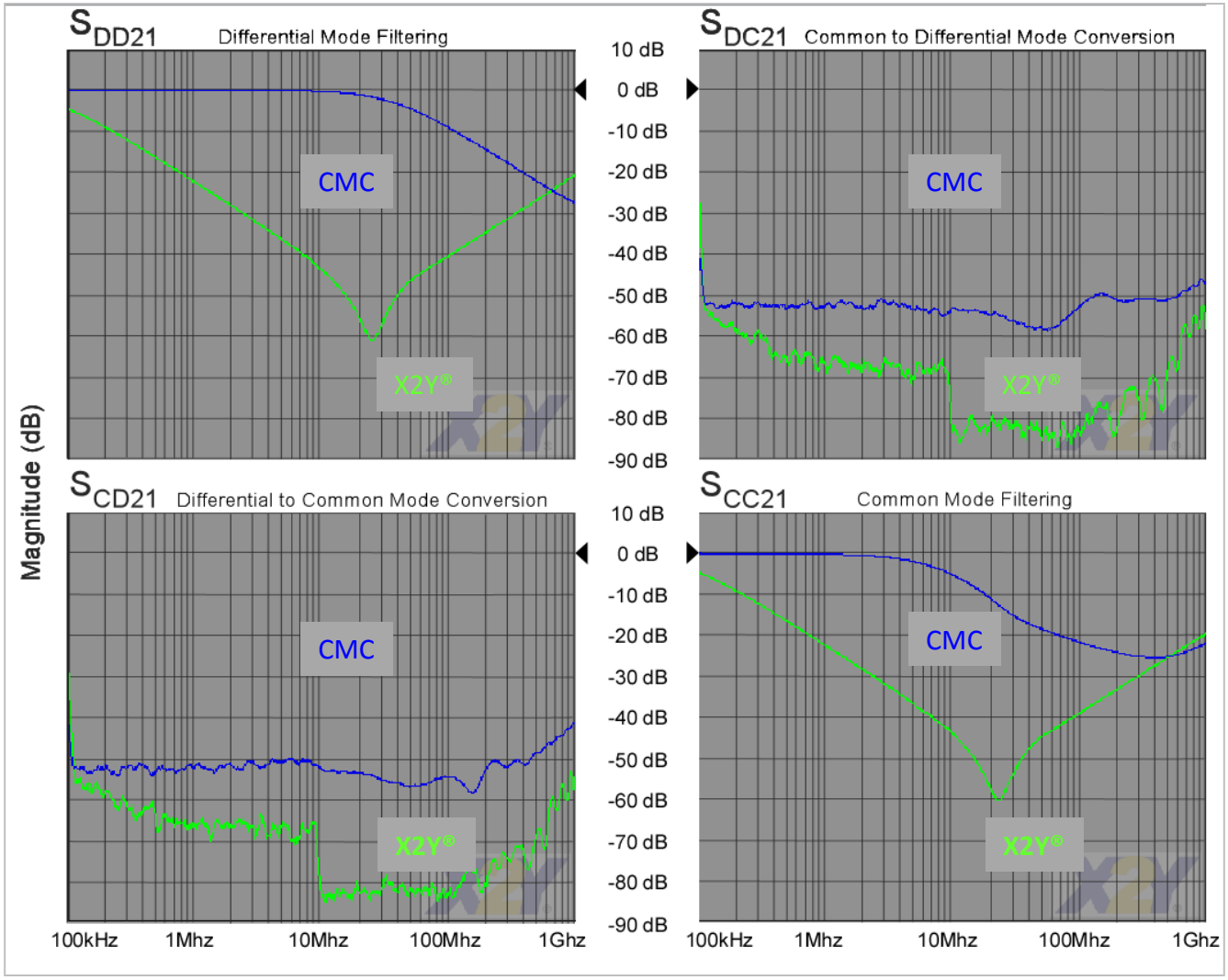
Mixed-Mode Analysis, L6(C) vs. C3



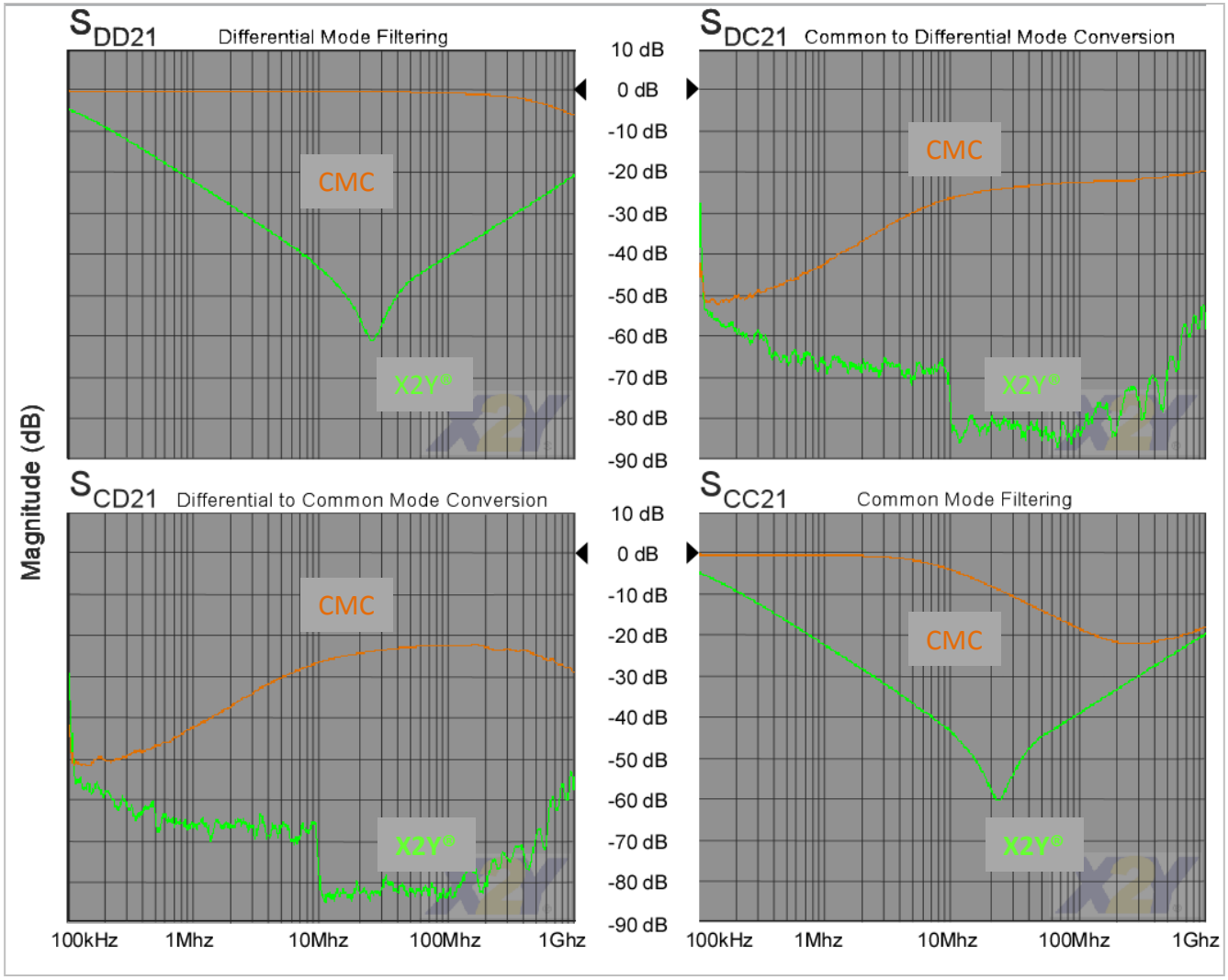
Mixed-Mode Analysis, L6(D) vs. C3



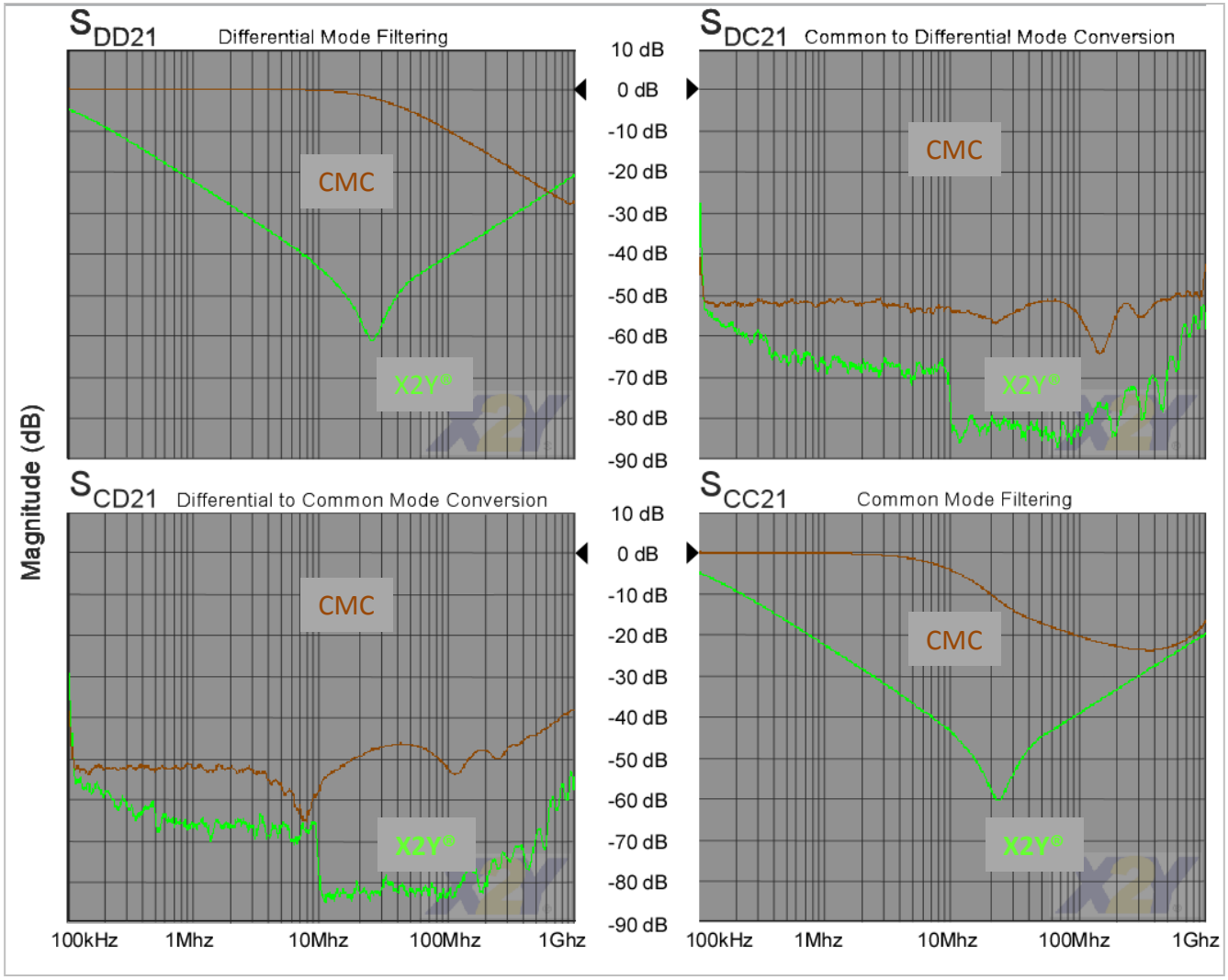
X2Y® vs. L7



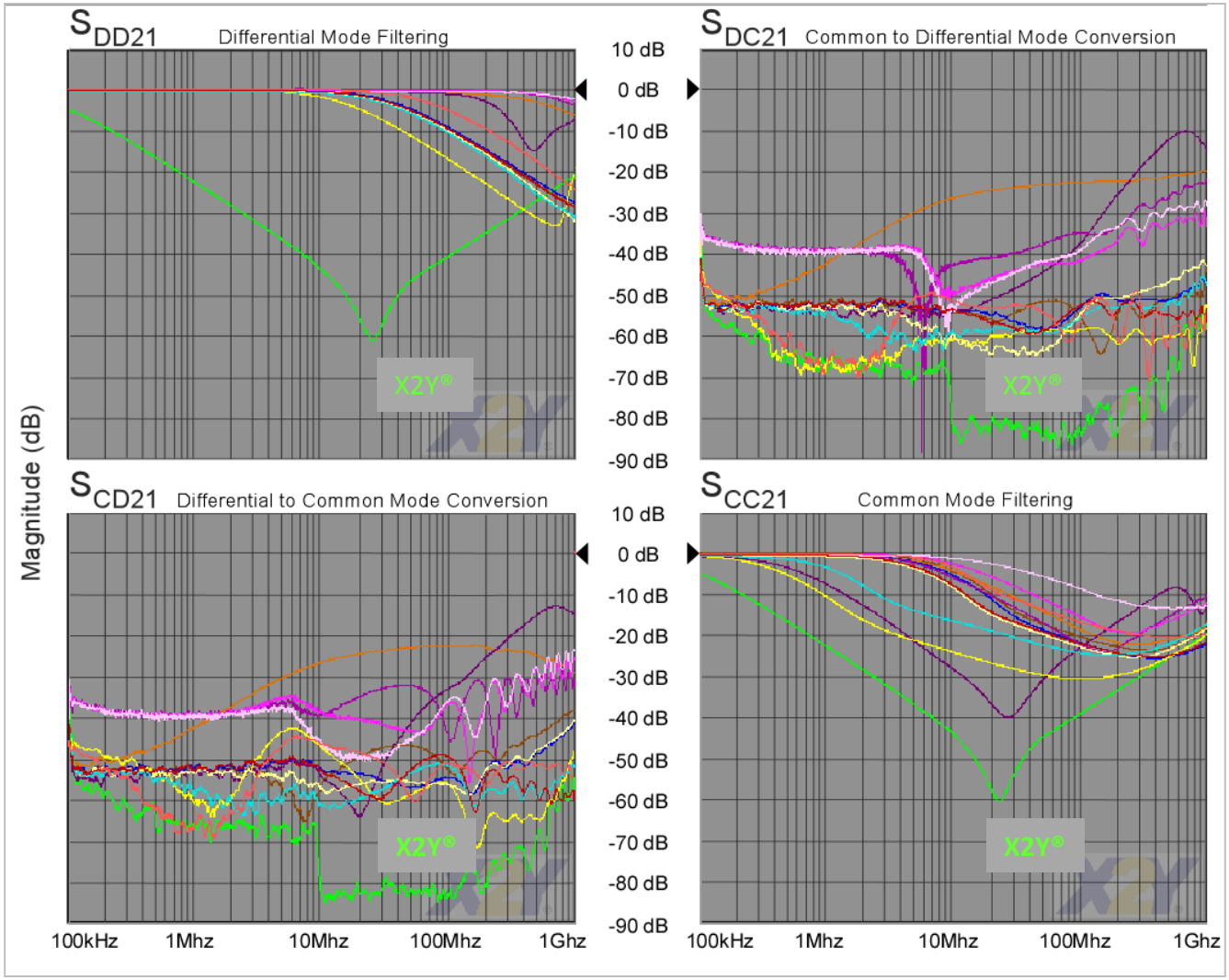
X2Y® vs. L8



X2Y® vs. L9



Data Trend, X2Y® vs. All CMCs



Conclusion

- X2Y® 100nF X7R exhibits the lowest mode conversion vs. all CMCs tested
  - Common to differential mode conversion increases susceptibility to EMI (S_{DC21}).
  - Differential to common mode conversion results in radiated emissions (S_{CD21}).
- The data indicates CMCs require additional filter components to match X2Y's performance
- X2Y has the smallest footprint on the PCB
- X2Y is a cost reduction vs. the CMCs