Filter Design Guidance for UCC12050 EMI Mitigation

Input Filter Component Considerations

EMI Mitigation Techniques

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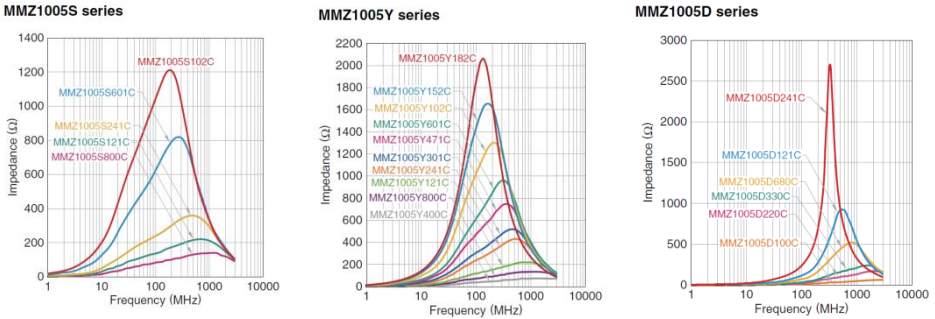
Ferrite Bead Selection

- Ferrite beads are selected based upon:

1. Current rating – 120 mA is the worst case input current expected for UCC12050. Select input ferrite beads with minimum 150 mA. Contact the bead manufacturer and ask for DC bias curves (examples shown on following slides).

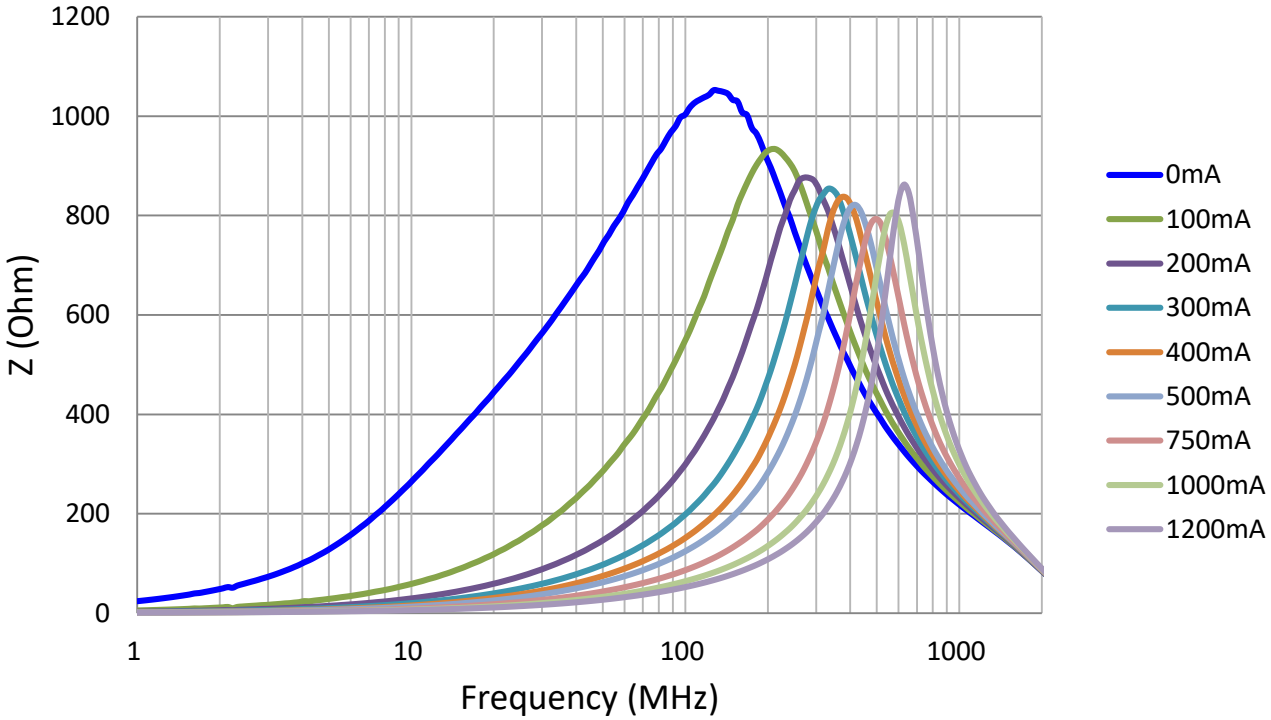
$$I_{IN} = \frac{P_{O(MAX)}}{n \times V_{IN(MIN)}} = \frac{0.5\ W}{0.6 \times 4.5\ V} = 225\ mA$$

1. Impedance (Z) vs frequency (F) – Impedance response can be very high over a narrow frequency band or not as high over a wider frequency band (examples shown below). Response is based on material type . Start with highest impedance over widest frequency band of interest, as shown on following slide. Once we determine a specific frequency where radiated EMI is problematic, we may adjust the ferrite bead selection to be optimal around that frequency. Examples of impedance vs frequency:

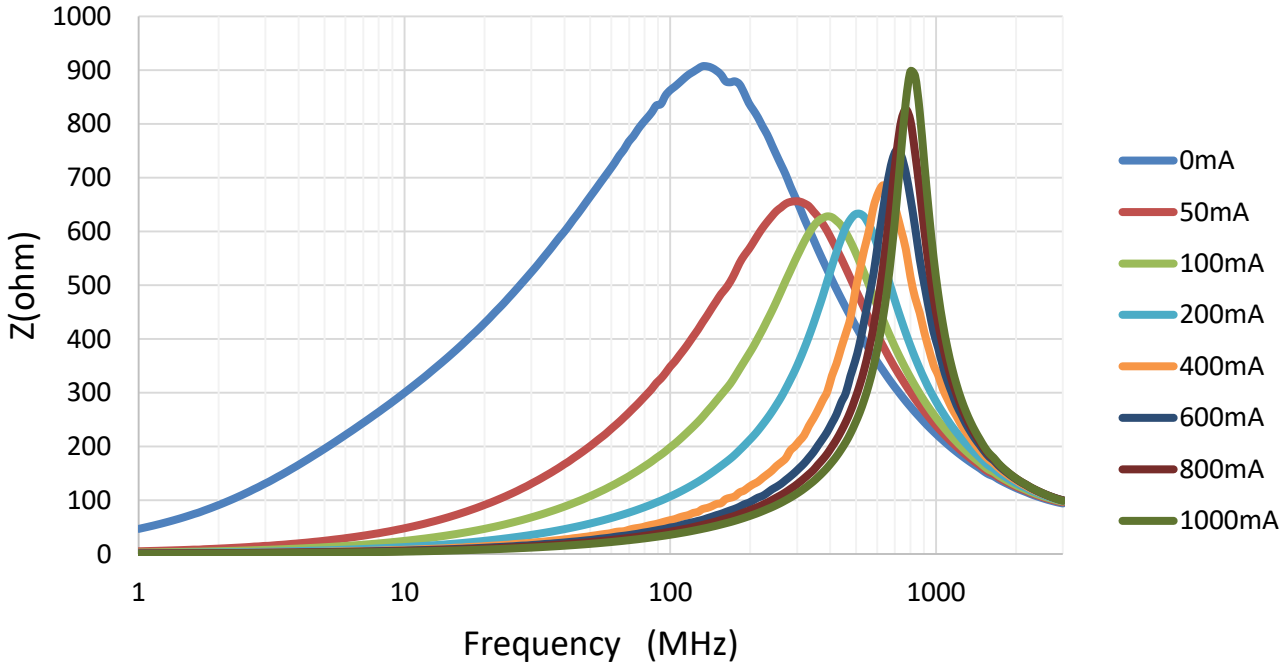


2. DC Resistance (DCR) – Important for overall efficiency but from EMI point of view this should be the last parameter considered.

BLM18SP102SH, DC Bias Effect



BLM18KG102SH, DC Bias Effect

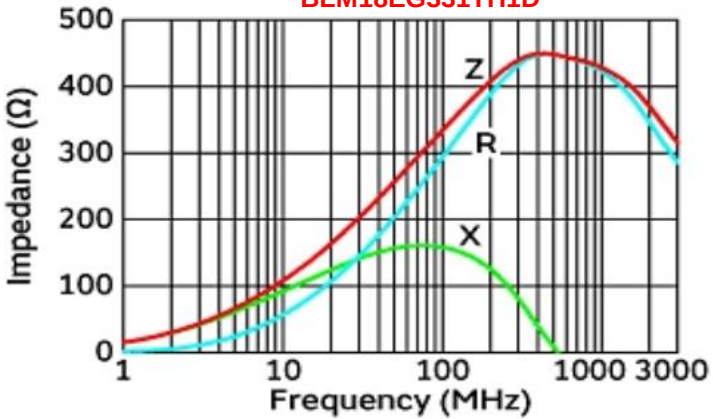


UCC12050, Initial Bead Selection

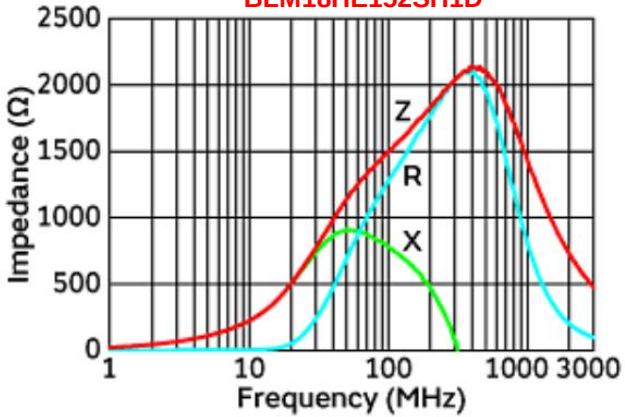
- CISPR 32, Class B frequency of interest: 30 MHz<F<1 GHz – Select beads that have high Z over your frequency where the EMI is failing.
- Trade off between I_{MAX}, Z, F, DCR

Part	MFR	Z (100MHz)	Z(300MHz)	Z(1GHz)	I_{MAX}	Temp	DCR	Pkg	Comment
BLM18EG331TH1D	Murata	330 Ω	-	450 Ω	500 mA	-55 °C<T<125 °C	210 mΩ	0603	AEC-Q200
BLM18HE152SH1D	Murata	1.5 kΩ	-	1.5 kΩ	500 mA	-55 °C<T<125 °C	500 mΩ	0603	AEC-Q200

BLM18EG331TH1D

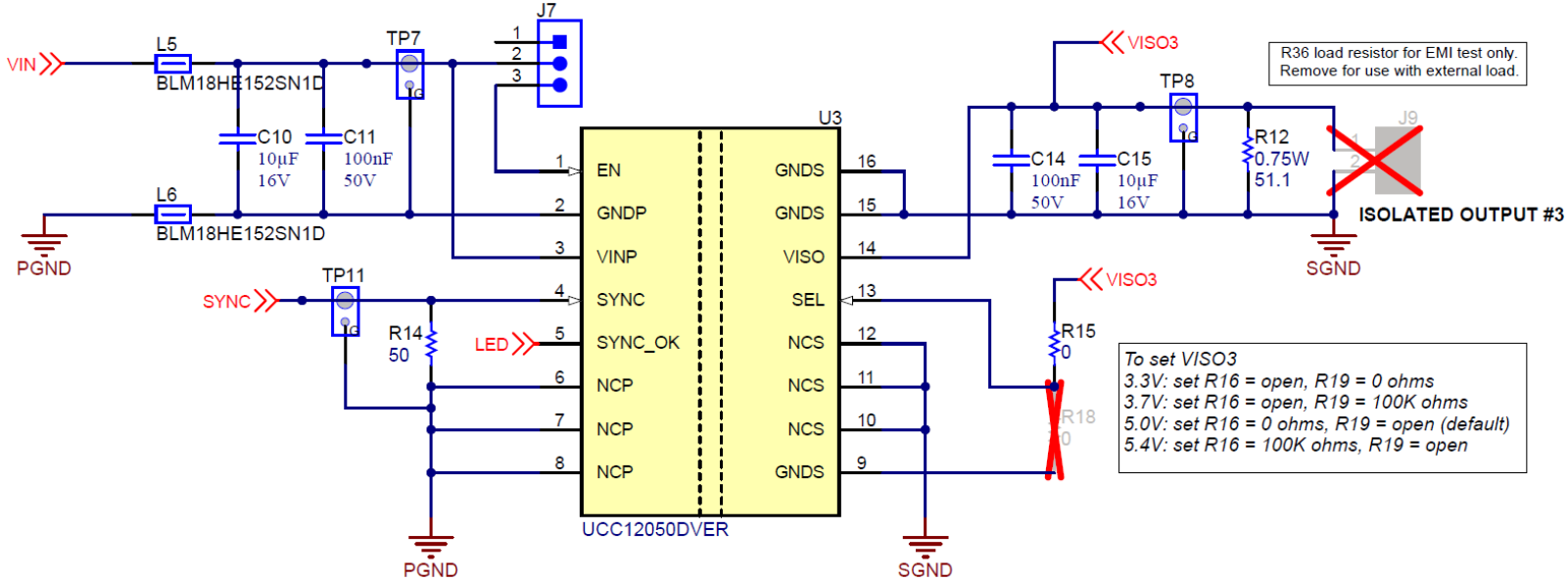


BLM18HE152SH1D



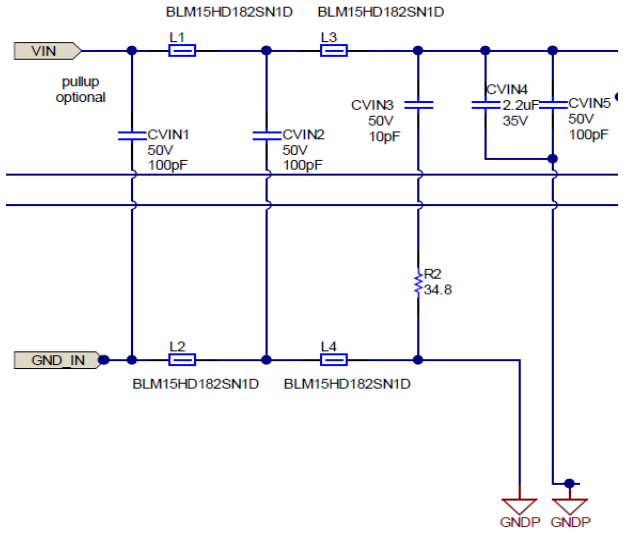
- Start with BLM18HE152SH1D
- Higher impedance
- Higher DCR

UCC12050, Input Ferrite Bead Example



- **Ferrite Beads for EMI Mitigation:**
  - Use of ferrite beads work best where there is a cable interface to the UCC12050
  - We have a cable interface on the input side from the 5V dc VIN – Ferrite beads, L5, L6 are used on the input side
  - We have no cable interface on the output side because the load (R12) is directly on the PCB – no ferrite beads are necessary in this case. If the load to the UCC12050 is off the PCB and uses a cable interface, ferrite beads can be used on the output side, similar to the input side.

UCC12050, Ferrite Bead + MLCC EMI Filter Example

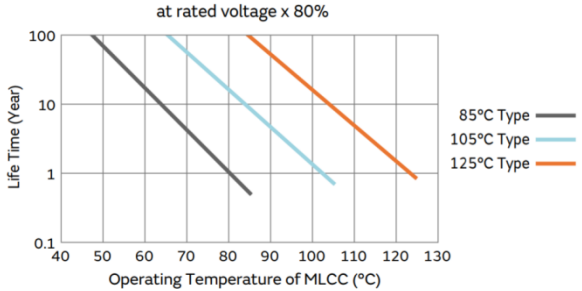


Murata GCM Type, COG, 0402, Capacitor Range

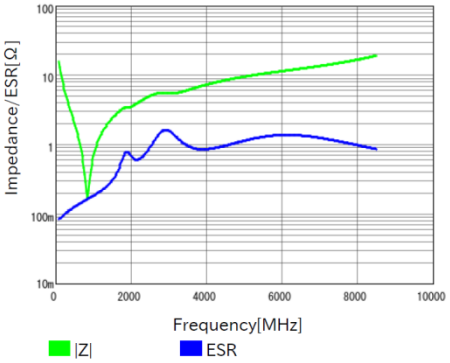
Maximum operating temperature	LxW	Rated Voltage	Capacitance (pF: 0.1 1 10 100 1000 / μF: 0.01 0.1 1 10 100 1000)	Capacitance range
125°C	1.0x0.5mm	50Vdc		0.10pF - 1000pF
150°C	1.0x0.5mm	50Vdc		0.10pF - 1000pF

High dielectric constant type

Available Under development

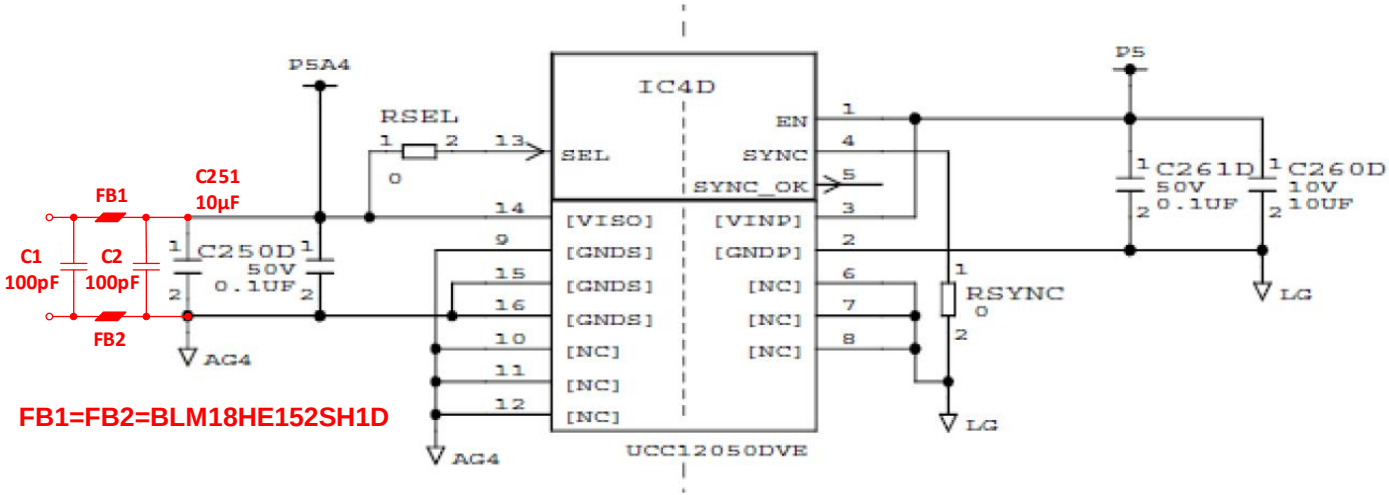


COG, 0402, 100pF, SRF~1GHz



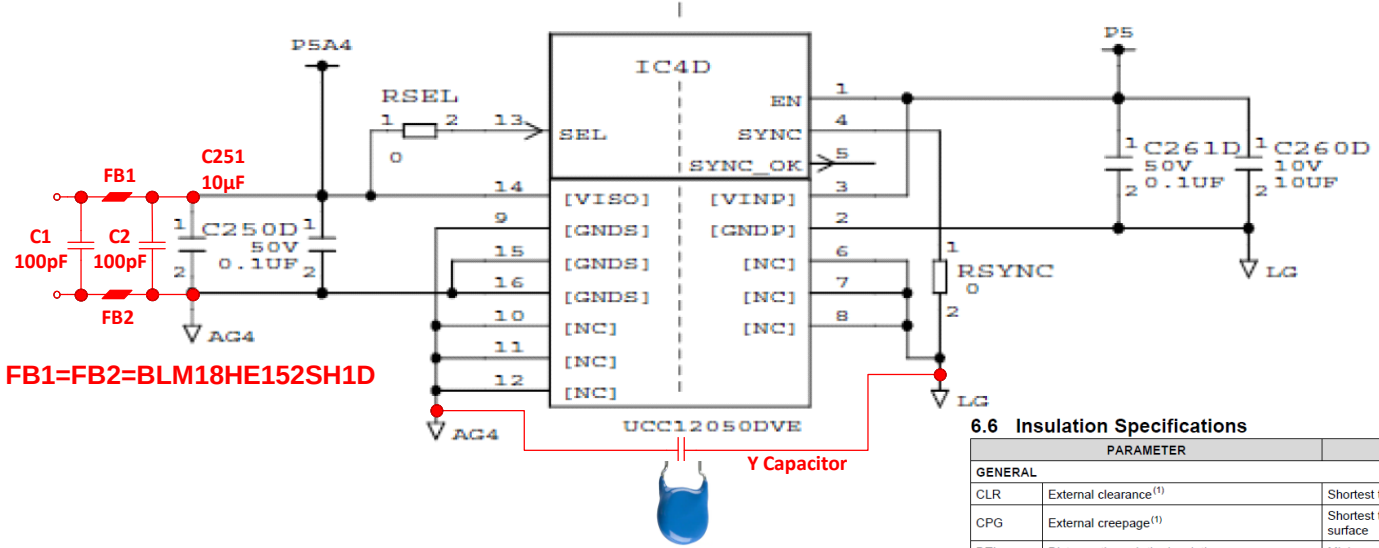
- **Ferrite Beads used with MLCC for EMI Filter Design:**
  - Ferrite Beads used with MLCC capacitors to form complex EMI filter networks
  - Apply <80% rated voltage
  - 50 V, 0402 input EMI filter capacitors easily meet 80% voltage rating requirement
  - Next level of EMI performance is Murata NFM low ESL, 3 terminal EMI filter MLCC

UCC12050 Output EMI Filter: Example



- **Ferrite Beads used with MLCC for EMI Filter Design:**
  - Output ferrite beads help when the load is dynamic (switching, clocks, high speed digital, etc)
  - **When PCB is properly designed, no ferrite beads will be required to pass CISPR32, Class B**
  - Above recommendation is to try and improve failed CISPR 32, Class B
  - Assure the GND plane is being used effectively
  - C1 and C2 may not be needed but can be tested as shown above

UCC12050 Y-Capacitor: Example



FB1=FB2=BLM18HE152SH1D

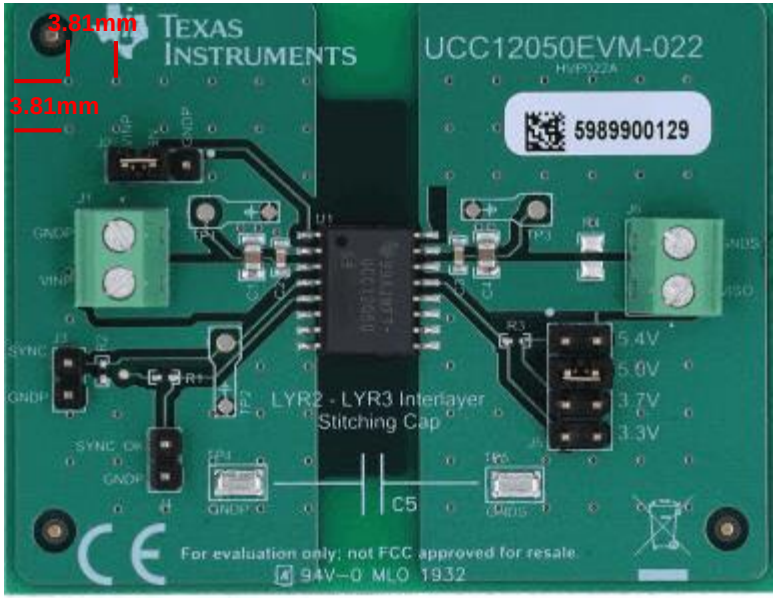
- **Addition of external primary-secondary, Y-capacitor:**
  - **Used to reduce CM noise, improve EMI**
  - Provides low impedance path across transformer
  - Reduces common mode noise
  - Choose capacitor with similar voltage rating as UCC12050
  - TDK CK45 series is one example up to 3 kV rating

6.6 Insulation Specifications

PARAMETER		TEST CONDITIONS	VALUE	UNIT
GENERAL				
CLR	External clearance(1)	Shortest terminal-to-terminal distance through air	> 8	mm
CPG	External creepage(1)	Shortest terminal-to-terminal distance across the package surface	> 8	mm
DTI	Distance through the insulation	Minimum internal gap (internal clearance)	> 120	µm
CTI	Comparative tracking index	DIN EN 60112 (VDE 0303-11); IEC 60112	> 600	V
	Material group	According to IEC 60664-1	I	
	Overvoltage Category	Rated mains voltage ≤ 300 V_{RMS}	I-IV	
		Rated mains voltage ≤ 600 V_{RMS}	I-IV	
		Rated mains voltage ≤ 1000 V_{RMS}	I-III	
DIN V VDE V 0884-11:2017-01(2) (Planned Certification Targets)				
V_{IORM}	Maximum repetitive peak isolation voltage	AC voltage (bipolar)	1414	V_{PK}
V_{IOWM}	Maximum working isolation voltage	AC voltage (sine wave) Time dependent dielectric breakdown (TDDB) test	1000	V_{RMS}
		DC voltage	1414	V_{DC}
V_{IOTM}	Maximum transient isolation voltage	$V_{TEST} = V_{IOTM}$, t = 60s (qualification); $V_{TEST} = 1.2 \times V_{IOTM}$, t = 1s (100% production)	7071	V_{PK}
V_{IOSM}	Maximum surge isolation voltage(3)	Test method per IEC 62368-1, 1.2/50 µs waveform, $V_{TEST} = 1.6 \times V_{IOSM} = 10000\ V_{PK}$ (qualification)	6250	V_{PK}

Stitch Vias: TI UCC12050EVM-022 PCB

- **PCB needs more vias and possibly larger size:**
  - **Should use TI UCC12050EVM-022 as guideline**

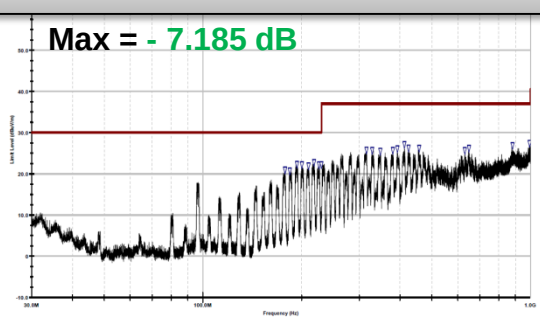
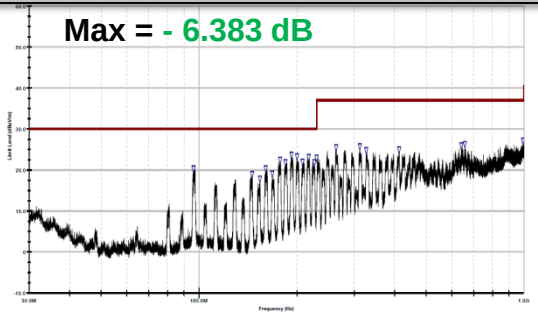
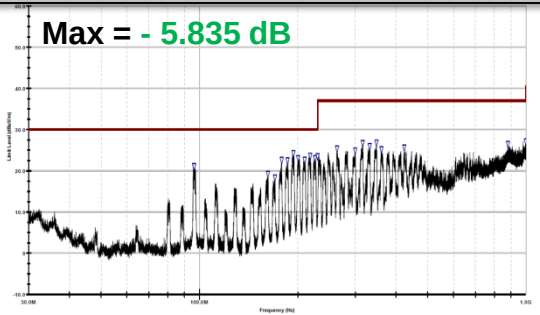


- **UCC12050EVM=022 via pattern**
  - **12 mil hole size, 30 mil outer ring**
  - **3.81 x 3.81mm via grid**
  - **See UCC12050EVM-022 User Guide for additional guidance on inner layer connections**

EMI:

EVM configuration: no ferrite beads , no LDO, no stitch capacitors, on 2 layer PCB
Tested to CISPR32 Limit, in 10m chamber, on same day, in same certified lab.

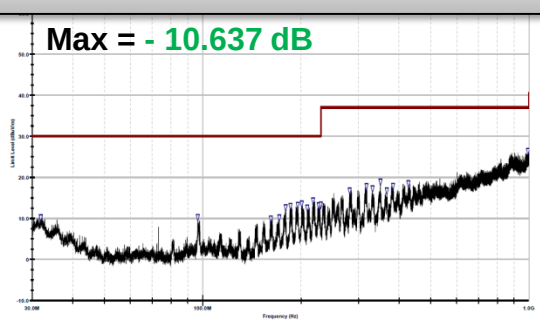
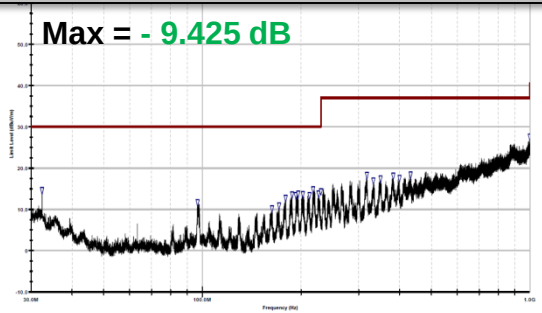
- **Lower radiated emissions with SSM** – Passed CISPR32, 10m chamber with 0mA, 50mA, 100mA loads.
- UCC12050 has >5dB margin

	0mA Load	50mA Load	100mA Load
UCC12050	Max = - 7.185 dB 	Max = - 6.383 dB 	Max = - 5.835 dB 

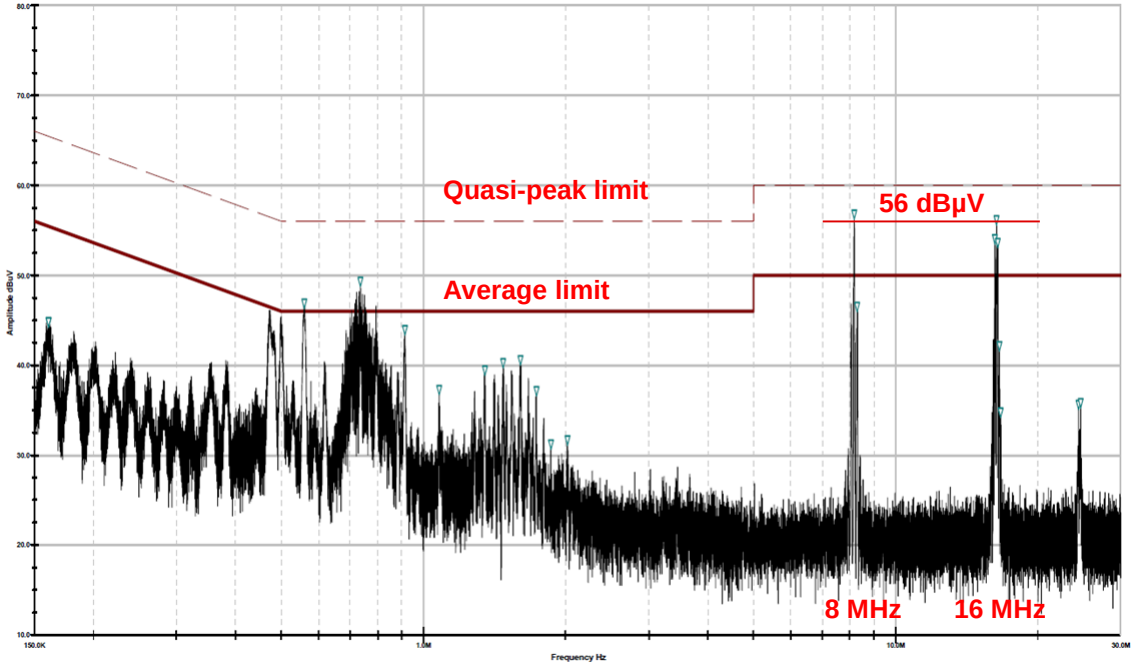
EMI:

UCC12050EVM-022
Tested to CISPR32, Class B Limit, in 10m chamber

- **Lower radiated emissions with SSM and integrated PCB stitch capacitor** – Passed CISPR32, Class B, 10m chamber with 0mA, and 100mA loads.
- UCC12050 has >9dB margin.

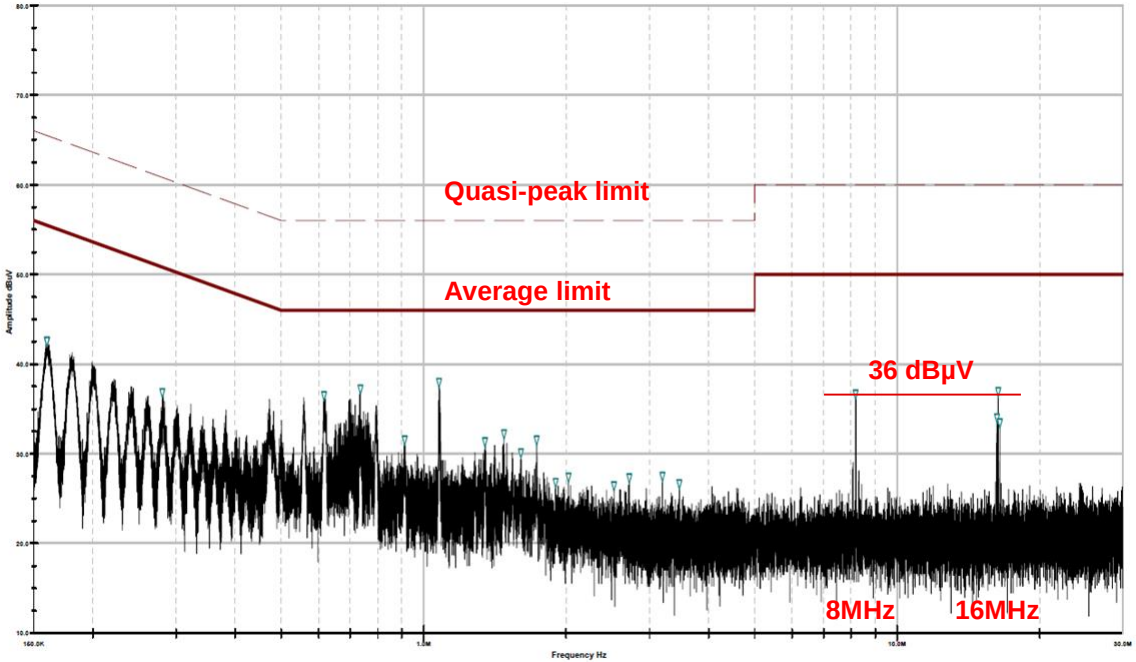
	0mA Load	Original Vendor EVM Configuration	100mA Load
UCC12050	**Max = - 10.637 dB** 	UCC12050: Original EVMs as available • **Ferrite beads: No** • **Input LDO: No** • **PCB Stitch Capacitor: Yes 4 layers**	**Max = - 9.425 dB** 

UCC12050 CISPR 32, Class B Conducted Emissions



- CISPR32, Class B
  - 150kHz<F<30MHz
- No board level EMI filter added
- No ferrite beads

UCC12050 CISPR 32, Class B Conducted Emissions



- CISPR32, Class B
  - 150 kHz<F<30 MHz
- No board level EMI filter added
- 2x input (VINP, GNDP) ferrite beads added
  - Murata BLM15HD182SN1
  - FB rating: 1.8 kΩ at 100 MHz
  - 20 dB reduction at 8 MHz and 16 MHz