

Application Note

How to Pass CISPR32 Class B for UCC33420-Q1



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ABSTRACT

UCC33xxx-Q1 is a family of integrated isolated bias (IIB), DC/DC modules operating at 64MHz, switching frequency. Due to its high frequency, aiming low EMI can be a challenge if the appropriate layout and EMI components are not utilized. This app note is intended to explain how to pass CISPR32, class B for UCC33xxx-Q1 family. Guidelines for proper setup, EMI filter component selection and PCB layout to meet the CISPR 32 standard and achieve low emissions for both Conducted Emissions (CE) and Radiated Emissions (RE) are presented. Passing the limits of CISPR32 are required for industrial applications such as PLC I/O modules, medical equipment, energy storage systems, industrial and telecom power distribution boards. The target audience is field applications, systems and application engineers as well as any engineer interested in EMI for DC/DC converters.

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1 Introduction

Smaller DC/DC bias supplies, such as IIB modules with small component footprint and high-power density are becoming more in demand in numerous applications. IC level transformers with isolation technologies using high frequency power conversion are the main technology drivers enabling smaller IC packages and higher power density. One of the challenges of this trend is EMI. UCC33xxx-Q1 family of devices is part of this trend with ultra-small 4x5x1- mm³ package and 64MHz switching frequency.

In order to deliver the power from the primary to the secondary side, UCC33xxx-Q1 use a burst frequency in the range of 100kHz-500kHz depending on the load condition. The burst frequency can be explained as low frequency buckets and within these buckets the device switches at a high frequency of 64MHz.

For CE, whose frequency range is 150kHz-30MHz, a pi filter is used to mitigate the burst frequency magnitudes. For RE, whose range is 30MHz-200MHz, the switching frequency and the harmonics are the target and the PCB layout plays a crucial role to keep the target below the limits.

Table 1-1. Frequency Types for UCC33420-Q1

UCC33420-Q1 Frequency Type	Frequency Range
Burst frequency	100kHz-500kHz
Switching frequency	64MHz

2 Setup, EMI Filter, and Layout

2.1 Setup

The following guidelines are recommended for the setup.

- For CE, an external, 5V power supply is used to provide power to the device under test (DUT) through the line impedance stabilization networks (LISNs). As required by the CISPR 32 test standard, the LISNs are placed and connected to a metal conductive floor and must be at least 80cm away from the DUT. The DUT must then be placed on a non-conductive table at least 10cm away from the external power supply.
- For RE, a low noise power supply is used to power the DUT. It is very important that the connection from the power supply to the DUT is short and tightly coupled. As seen in [Figure 2-3](#), a twisted pair is used to connect both.



Figure 2-1. CISPR 32 CE Setup



Figure 2-2. CISPR 32 RE Setup



Figure 2-3. DUT for RE

2.2 EMI Filter

A pi filter was used to mitigate the burst frequency harmonics in the 100-500kHz range. A 2.2μH DM inductor with two 22μF capacitors on each side are selected. The DM inductor is fully shielded to minimize coupling coming from the H-field of the transformer. [Table 2-1](#) shows the DM inductor selection depending on power level. The CE results for UCC33420-Q1 5V/5V, Pout=1.5W are shown in [Figure 2-5](#).

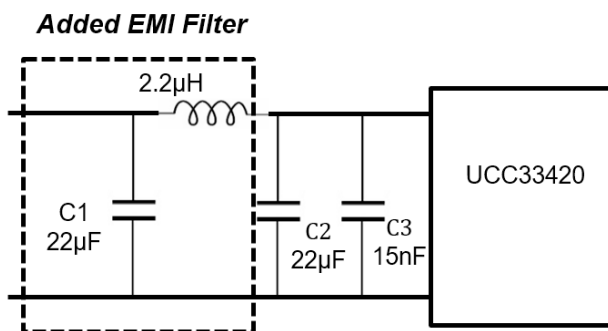


Figure 2-4. UCC33420-Q1 EMI Filter

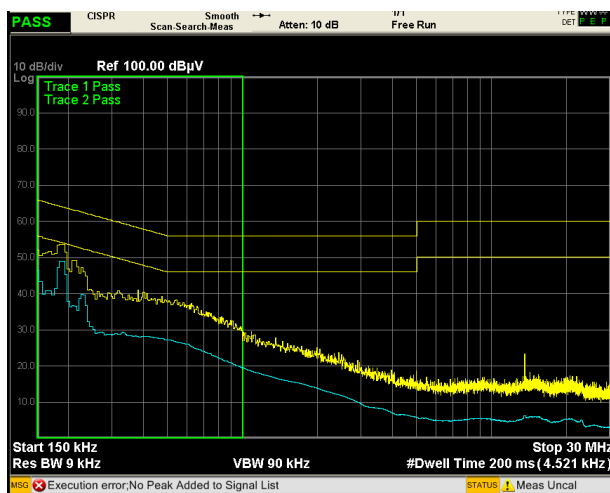


Figure 2-5. UCC33420 5V/5V Pout=1.5W CE

Table 2-1. DM Inductor selection

Power level	DM Inductor
0.5W	2.2uH, 0603, 800mA, PN:74479763222
1W, 1.5W	2.2uH, 0805, 2.1A, PN: 74479275222

2.3 Layout

The PCB layout plays an important role for achieving passing EMI results, and this is especially true for RE. The following layout guidelines are recommended:

- Due to the H-field coming from integrated transformer, the placement of ground planes on both sides of the device is crucial for passing RE. The ground planes provide low impedance at the return of the switching loop when used to connect the ground pins of the device on both sides. Moreover, these planes act as Faraday shields, mitigating the H-field coming from the transformer. PCB assembly images are shown in [Figure 2-7](#).
- High frequency decoupling capacitors must be placed as close as possible to the input and output pins. The 0402-capacitor case size offers the lowest ESL and highest self-resonant frequency (SRF) for achieving low impedance at the 64MHz, fundamental switching frequency. 15nF values were selected to achieve the lowest impedance. The impedance vs. frequency plot of is shown in [Figure 2-9](#).
- Placing copper beneath the DM inductor is not recommended. The high frequency currents can find a sneak path to bypass the inductor if copper is placed underneath which creates a parasitic capacitance.
- A keep out zone (KOZ) across the EMI filter area is recommended to avoid any bypass of the HF currents that travel in the switching loop. In this case a 1mm KOZ is used.
- The DM inductor is recommended to be placed away from the noise source to avoid any coupling from the H-field of the transformer. Many times, a DM inductor, such as the LC filter of a buck converter, is already present at the output of the pre-regulator.

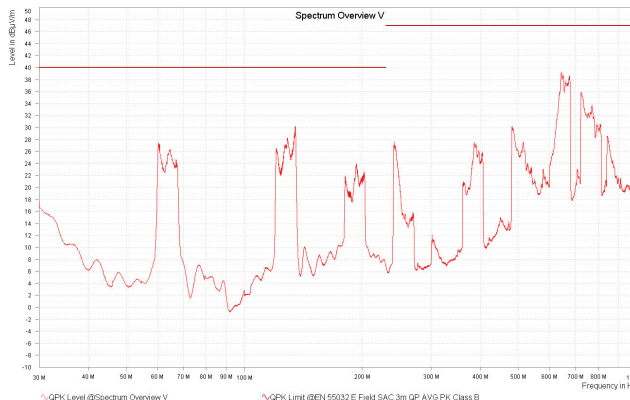


Figure 2-6. UCC33420 5V/5V Pout=1.5W RE

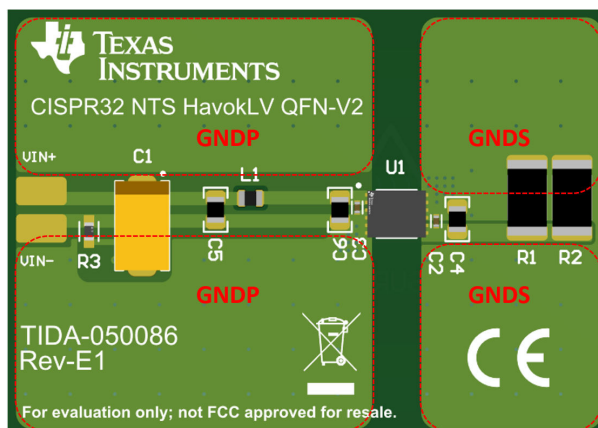


Figure 2-7. UCC33420 CISPR32 Layout

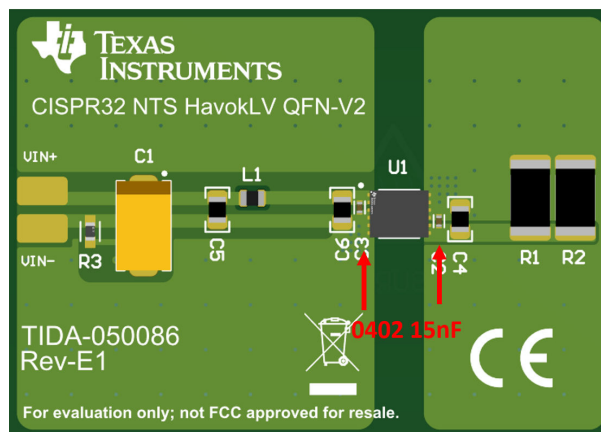


Figure 2-8. 0402 15nF caps in the PCB

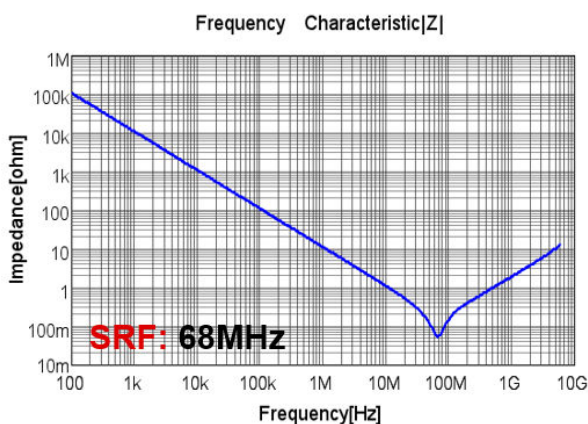


Figure 2-9. 0402 15nF - Impedance vs. Frequency

2.4 Damping RC Network

For CE, the DUT is powered by a power supply through the LISNs. The LISNs have a 50μH inductance that must be dampened such that the output impedance after the LISNs is not higher than the input impedance of the DC/DC converter. For this reason, an RC damping network is used at the input of UCC33420-Q1 after the LISN. In a real system, if UCC33420-Q1 has a pre-regulator at the input side that decouples the power supply from the LISNs, the RC damping network is not needed. Figure 2-10 and Figure 2-11 show the damping network schematic and layout.

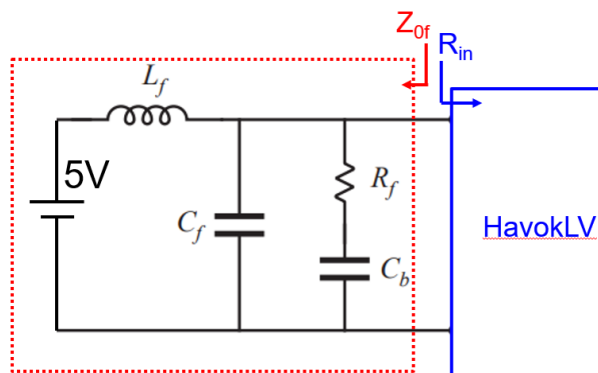


Figure 2-10. RC Network Schematic

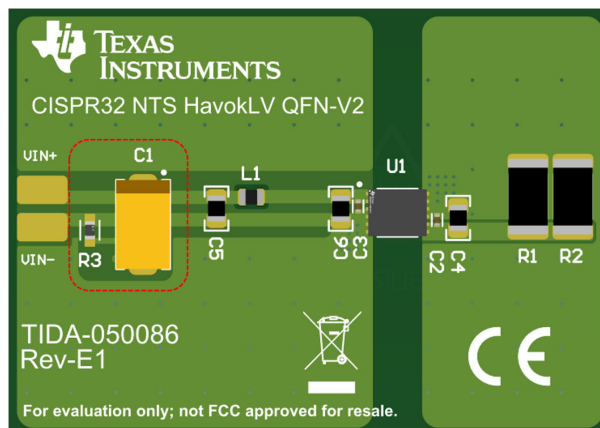


Figure 2-11. RC Network in the layout

2.5 Schematic

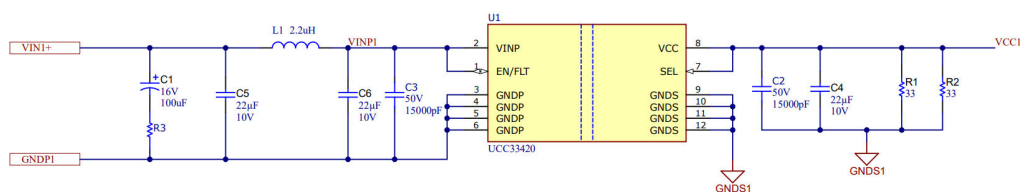


Figure 2-12. Schematic

2.6 Layout

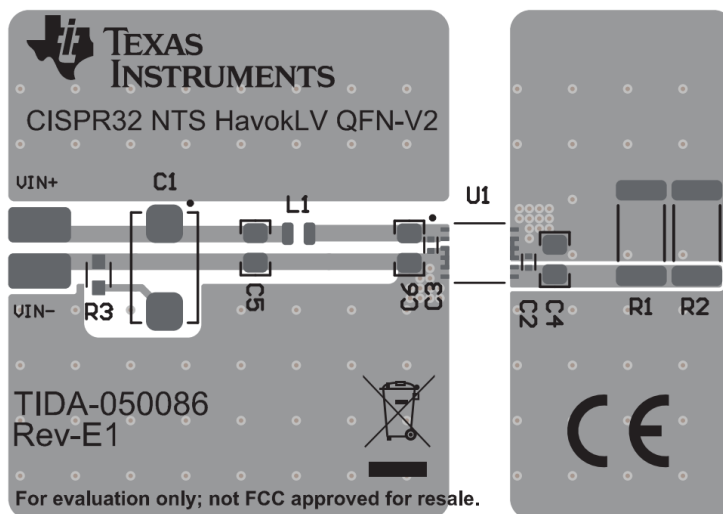


Figure 2-13. Top Layer

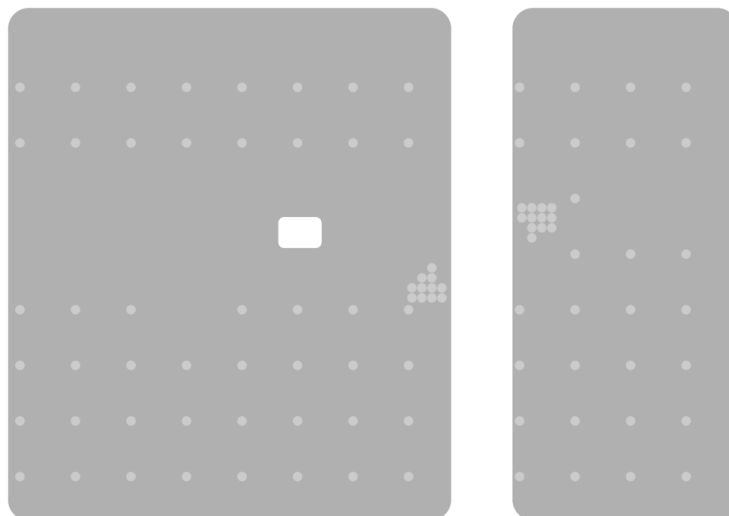


Figure 2-14. Inner Layers and Bottom Layer

2.7 EMI Results

2.7.1 Conducted Emissions - CE

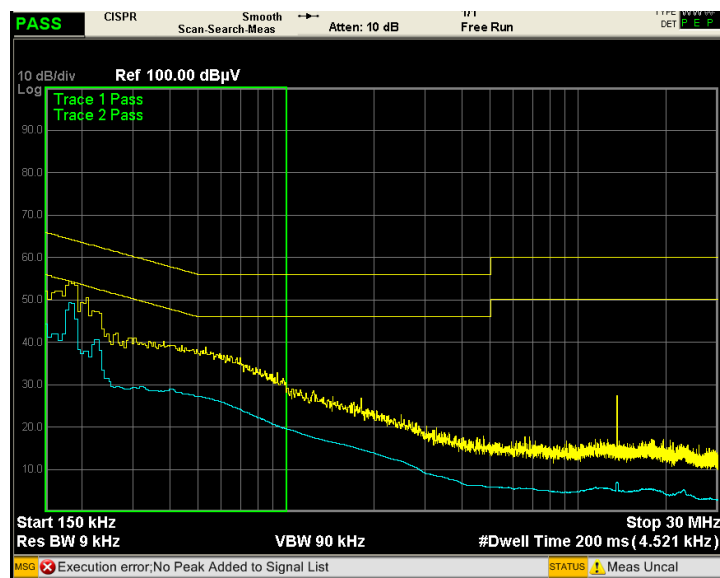


Figure 2-15. HS LISN - UCC33420 5V/5V Pout=1.5W

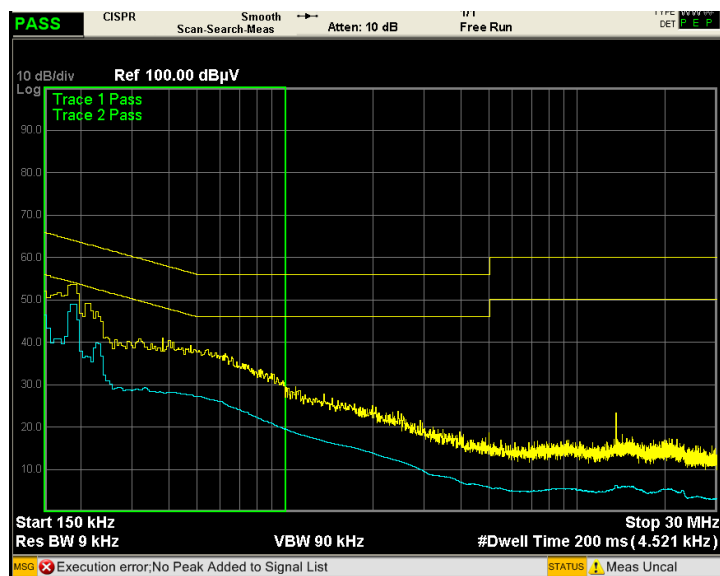


Figure 2-16. LS LISN - UCC33420 5V/5V Pout=1.5W

2.7.2 Radiated Emission – RE

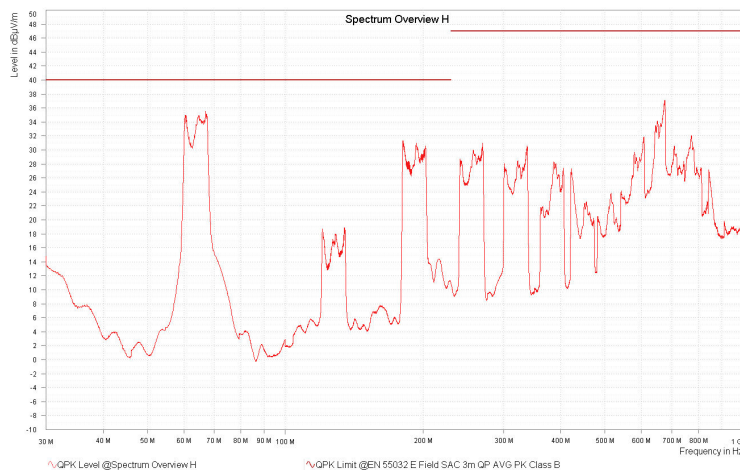


Figure 2-17. Horizontal - UCC33420 5V/5V Pout=1.5W

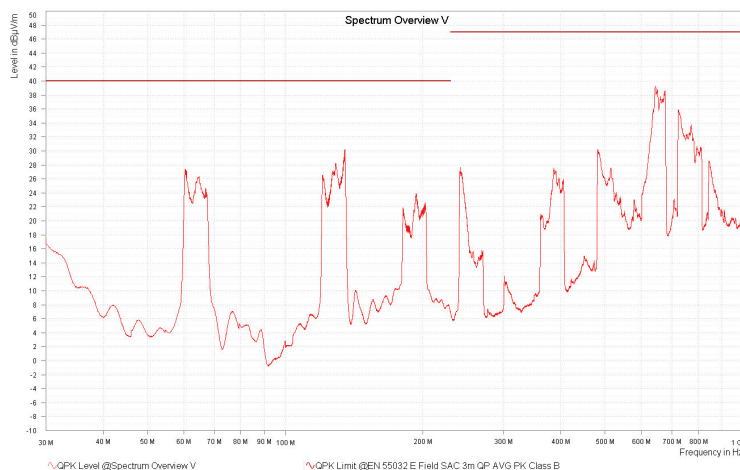


Figure 2-18. Vertical - UCC33420 5V/5V Pout=1.5W

2.8 Bill Of Materials - BOM

Table 2-2. Bill Of Materials - BOM

Designator	Quantity	Part Number	Manufacturer	Description
PCB1	1	TIDA-050086	Any	Printed Circuit Board
C1	1	293D107X9016D2TE3	Vishay-Sprague	CAP, TA, 100 μ F, 16V, +/- 10%, 0.6 Ω , SMD
C2, C3	2	GCM155R71H153KA55D	Murata	CAP, CERM 0.015 μ F, $\pm$ 10%, 50V, X7R, 0402 (1005 Metric)
C4, C5, C6	3	GRM21BZ71A226ME15L	MuRata	CAP, CERM, 22 μ F, 10 V, +/- 20%, X7R, 0805
L1	1	74479275222	Würth Elektronik	WE-PMCI SMT Power Molded Chip Inductor, size 0805, 2.2 μ H, 2.1A, 190m Ω
R1, R2	2	CRCW251233R0JNEG	Vishay-Dale	RES, 33 Ω , 5%, 1 W, AEC-Q200 Grade 0, 2512
R3	1	CPF0603B1R0E1	TE Connectivity	1 Ω $\pm$ 0.1% 63mW, SMD, 0603 (1608 Metric) thin film
U1	1	UCC33420QRAQRQ1	Texas Instruments	1.5W, High-Density, >3kV _{RMS} Isolated DC-DC Converter

3 Summary

UCC33xxx-Q1 passes CISPR32, class B with several dB μ V of margin due to proper EMI filter selection and carefully applied PCB layout techniques. For CE, the burst frequency magnitudes were mitigated due to proper selection of EMI filter components used to design a pi filter at the primary side. An RC damping network was designed and selected to dampen the DM inductance resonant effect of the LISNs. For RE, ground planes were used to connect the ground pins of the device to improve the switching loop performance and the pins were spread over the available footprint of the system for H field mitigation. The 0402 15nF capacitors were selected to provide low impedance at the switching frequency.

4 References

1. International Electrotechnical Commission, [CISPR32 - International Standards](#), standards.
2. Texas Instruments, [An overview of conducted EMI specifications for power supplies](#), marketing white paper.
3. Texas Instruments, [UCC33420-Q1](#), product page.
4. Texas Instruments, [UCC33421-Q1](#), product page.

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