Test Report: PMP22682

5-V_{IN} to 5-V_{OUT}, 100-mA, low-EMI, 5-kV_{RMS} Reinforced Isolation DC/DC Power Supplies Reference Design

1 Description

This reference design uses four, UCC12050 High-Efficiency, Low-EMI, 5-kV_{RMS} Reinforced Isolation, DC-DC Converters on a single printed circuit board. The reference design includes additional provisions such as ferrite beads for optimized low-EMI emissions. Output voltages, VISO, can be selected for 3.3 V, 3.7 V, 5 V (default) and 5.4 V. Each of the four outputs includes a 100-mA, 500-mW load resistor commanding maximum output power by default but can easily be changed to accommodate any desired output load, up to 500 mW for any single converter. A single SMB input connector (J3) is included to allow easy and convenient connection to the input voltage source through a shielded input cable. The primary intent of this reference design is to investigate the impact that multiple high frequency converters have on EMI according to the CISPR 32, class B test standard. Applications include isolated bias supplies for isolated data converters, amplifiers and motor drivers used in industrial, factory automation and grid infrastructure systems.

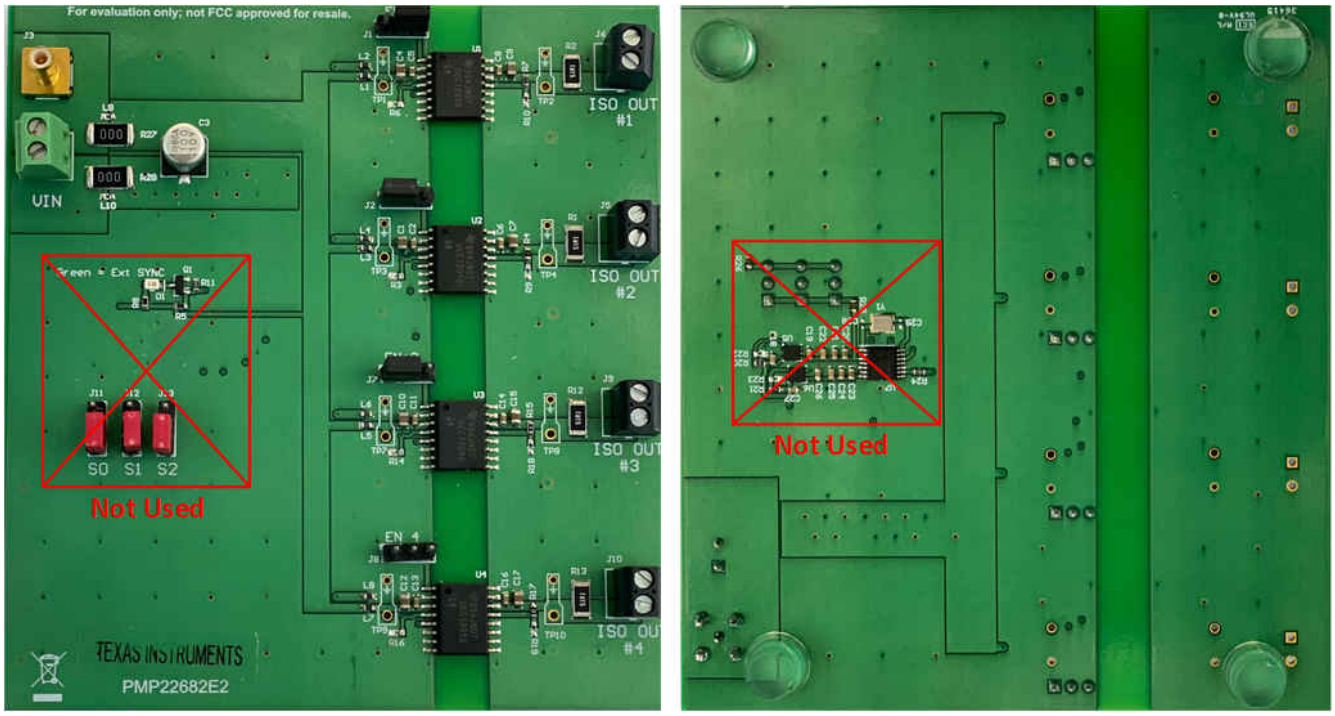

Figure 1-1. Top and Bottom Board View

2 Device Description

The UCC12050 is a fully-integrated, DC/DC converter with 5-kV_{RMS} reinforced isolation rating designed to provide efficient power to isolated circuits that require a bias supply with a well-regulated output voltage. The device integrates a transformer and DC/DC controller with a proprietary architecture to provide 500 mW of isolated power with high efficiency and low EMI.

The UCC12050 integrates protection features for increased system robustness. The device also includes an enable pin, synchronization capability, and a user selectable, regulated 3.3-V, 3.7-V, 5-V, or 5.4-V output option. The UCC12050 is a low-profile, miniaturized solution offered in a wide-body SOIC package with > 8-mm creepage and clearance. Additional information is found in the *UCC12050 High-Efficiency, Low-EMI, 5-kV_{RMS} Reinforced Isolation DC-DC Converter Data Sheet*.

3 Efficiency

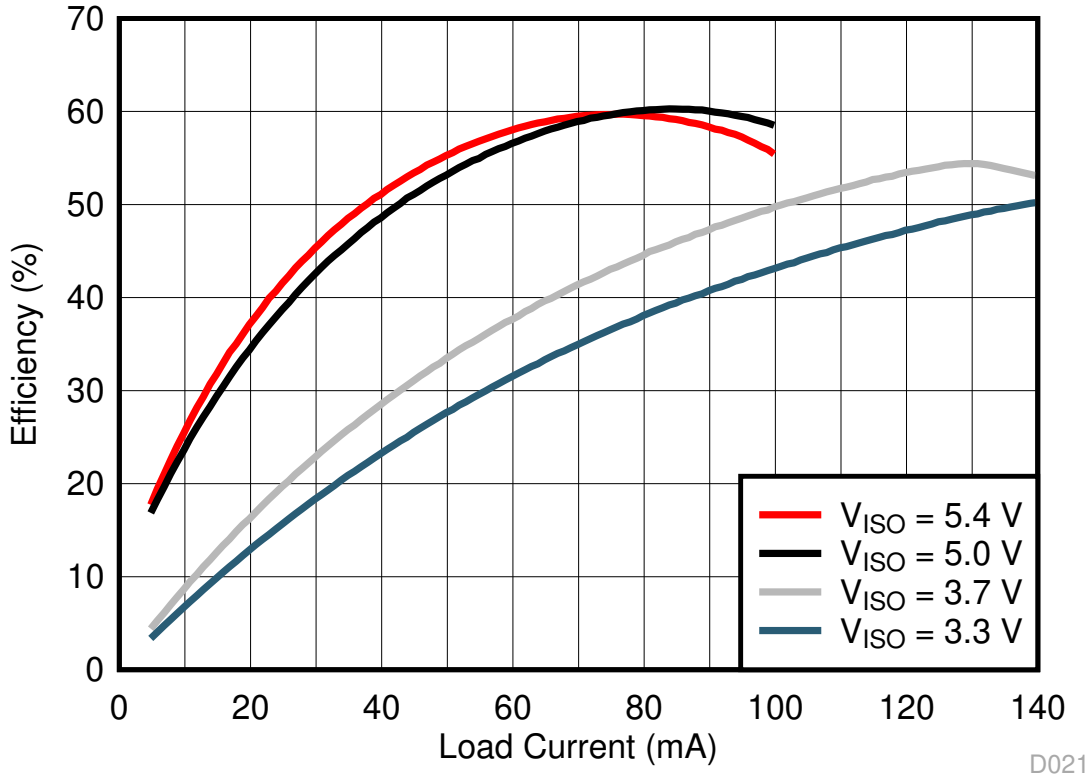

Figure 3-1. 5-V Input Typical Efficiency vs Load, V_{INP} = 5.0 V, T_A = 25°C, (UCC12050 Data Sheet, Page 1)

4 Start-up

Start-up shown is for a single output (ISO OUTPUT 1), V_{INP} = 5 V, V_{ISO} = 5 V, P_{OUT} = 500 mW, start-up begins 492 µs after EN is HIGH.

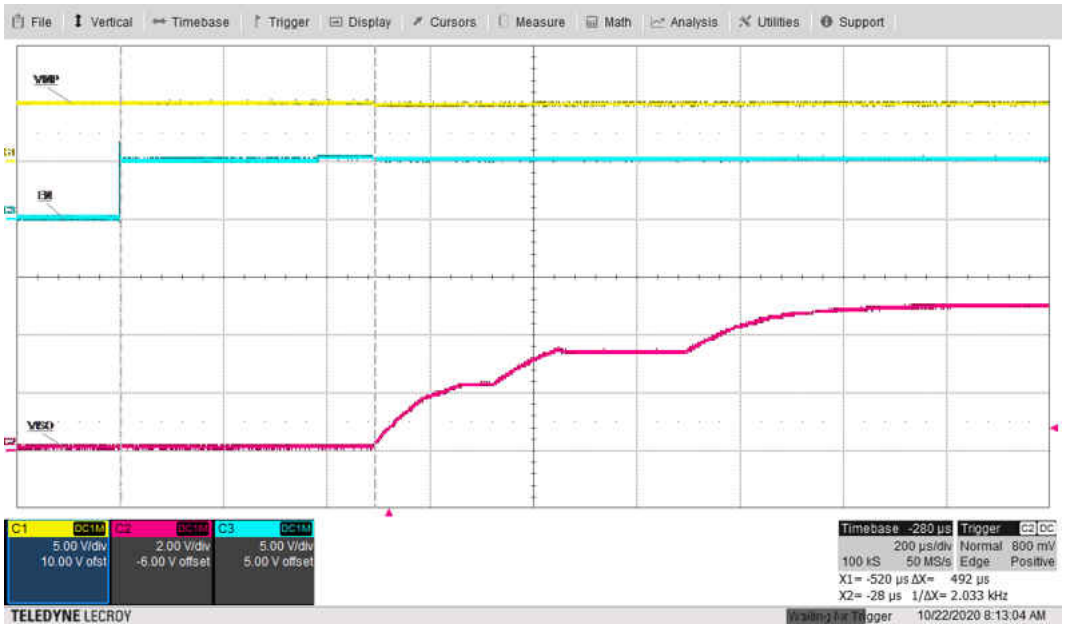

Figure 4-1. CH1: V_{INP}, CH2: EN, CH3: V_{ISO} (5 V)

5 Shutdown

Shutdown shown is for a single output (ISO OUTPUT 1). V_{INP} = 5 V, V_{ISO} = 5 V, P_{OUT} = 500 mW. Shutdown begins 43 µs after EN is LOW.

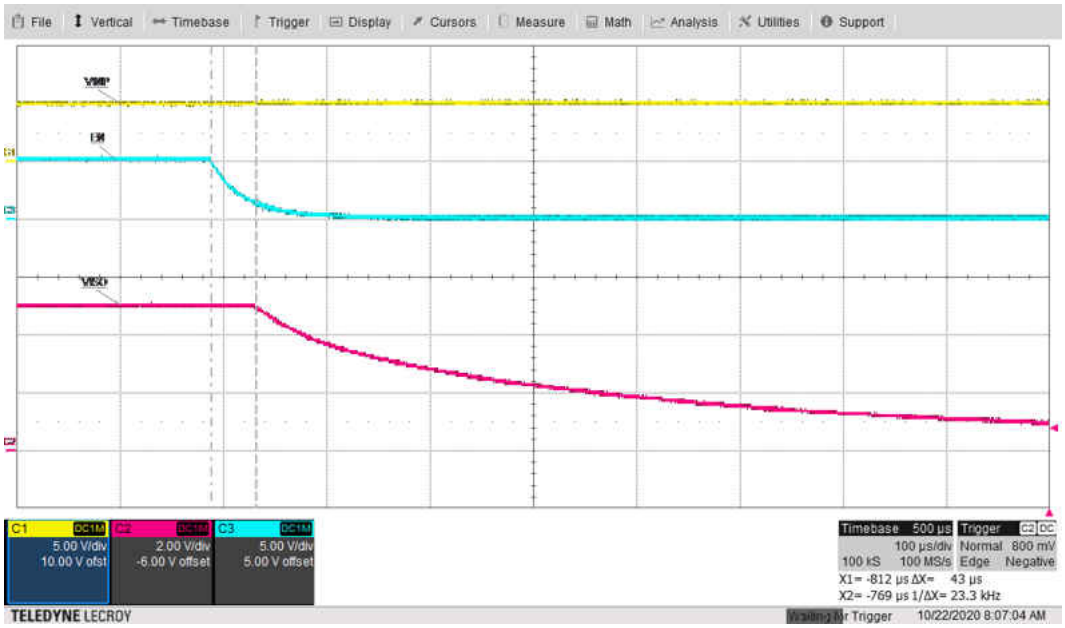

Figure 5-1. CH1: V_{INP}, CH2: EN, CH3, V_{ISO} (5 V)

6 Output Voltage Ripple

Output ripple voltage shown in the following figures is for a single output (ISO OUTPUT 1), V_{INP} = 5 V, V_{ISO} = 5 V, P_{OUT} = 500 mW. The 25-kHz, low-frequency modulation in Figure 6-1 is a result of the UCC12050 spread spectrum modulation (SSM) used to reduce the EMI peak harmonic content.

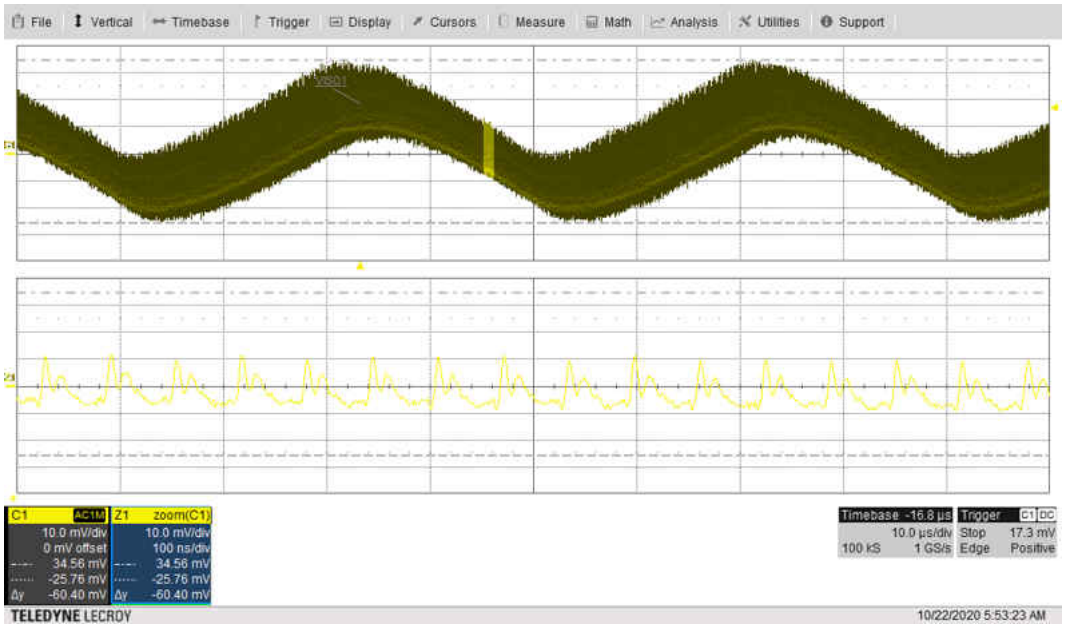

Figure 6-1. V_{ISO1} (5 V) Modulated AC Ripple Voltage About 60 mV, 25 kHz

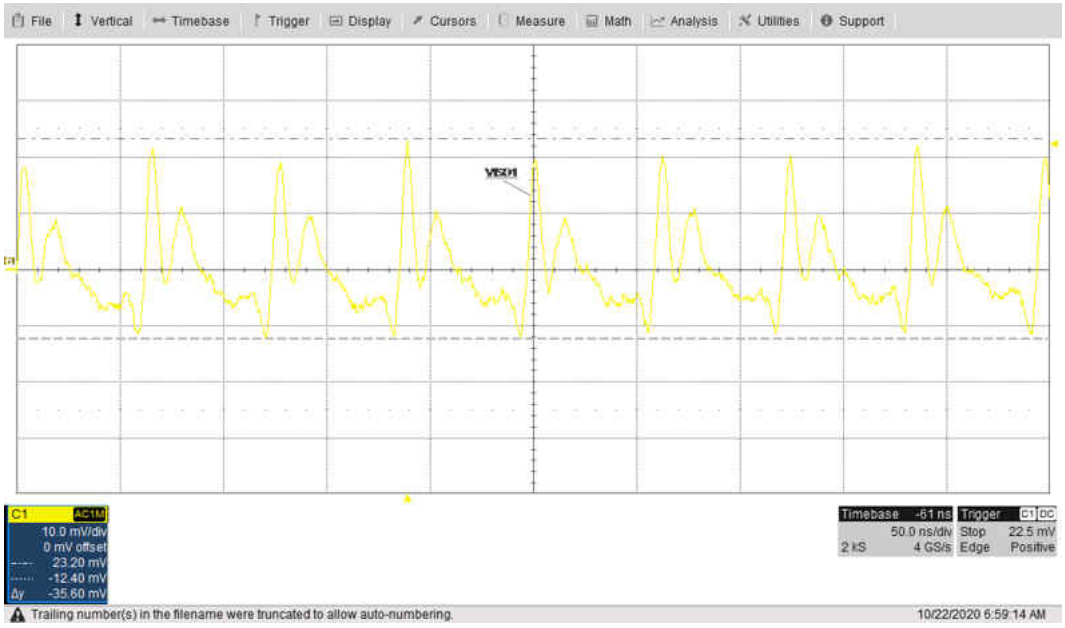

Figure 6-2. V_{ISO1} (5 V) High Frequency, AC Ripple Voltage About 35 mV, 16 MHz

7 EMI Results

The following test results were obtained from an independent certified lab where radiated emissions test data was taken against the CISPR 32 EMI test standard. A shielded anechoic test chamber with appropriate height and distance defined by CISPR 32 was used to verify performance against CISPR 32, class B limits from 30 MHz to 1 GHz, 10 m, horizontal and vertical antenna orientation.

8 Test Setup

The test configuration shown in Figure 8-2 uses a 6-V, DC battery as the input voltage source to the test the EVM. For the purpose of reducing 6 V to about 5.4 V, a diode is used in series with the return connection to the DC battery. A short, shielded BNC to SMB cable is used to connect the battery to the test EVM. A toroid clamp is used to minimize the EMI effect of the cable.

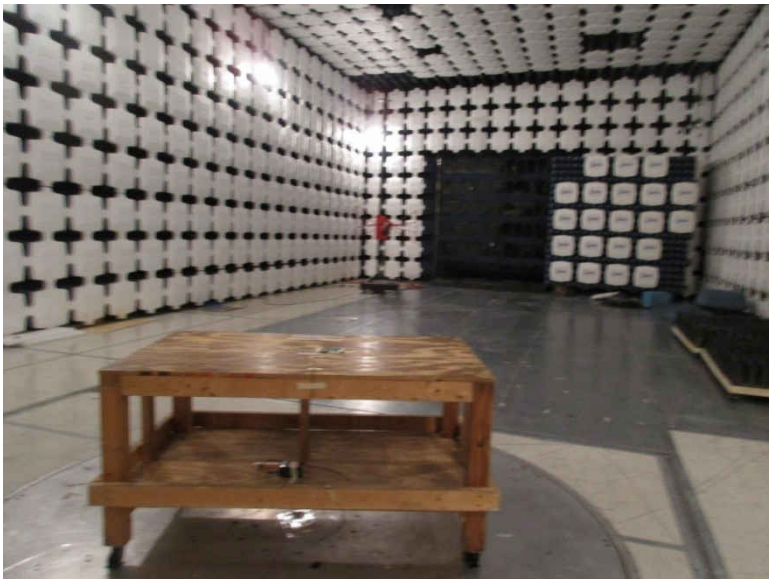

Figure 8-1. Anechoic Chamber – CISPR 32 Radiated EMI Test

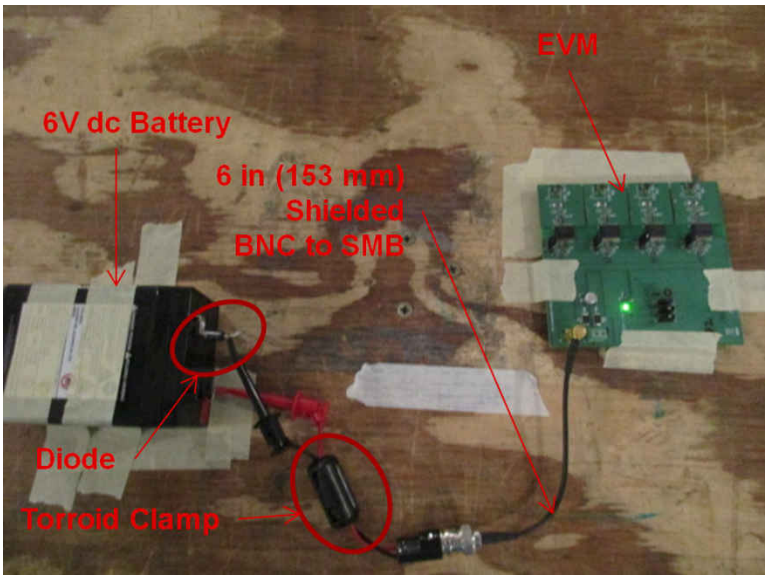

Figure 8-2. CISPR 32 V_{INP} Battery to EVM Test Setup

8.1 EMI Scans - Single UCC12050, 5 V_{OUT}, 100 mA

The test results shown in Figure 8-3 and Figure 8-4 demonstrate measured radiated emissions for a single, 5-V, UCC12050 operating at full load where Figure 8-3 shows the result when the receiving antenna is orientated horizontally and Figure 8-4 shows the result when the receiving antenna is orientated vertically.

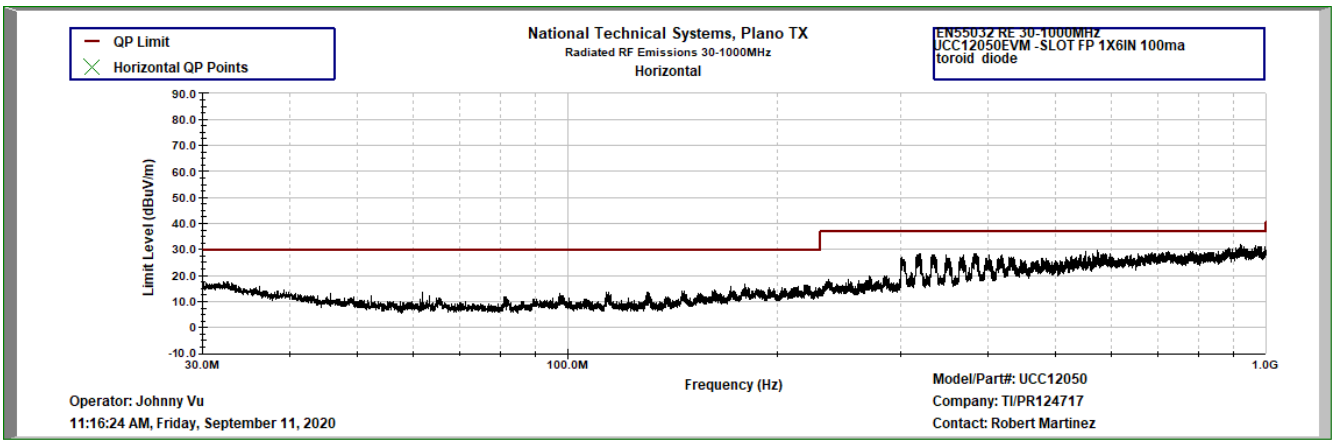

Figure 8-3. Horizontal, Ferrite Beads L1, L2, –5.15 dB (920 MHz), 100 % Load (500 mW)

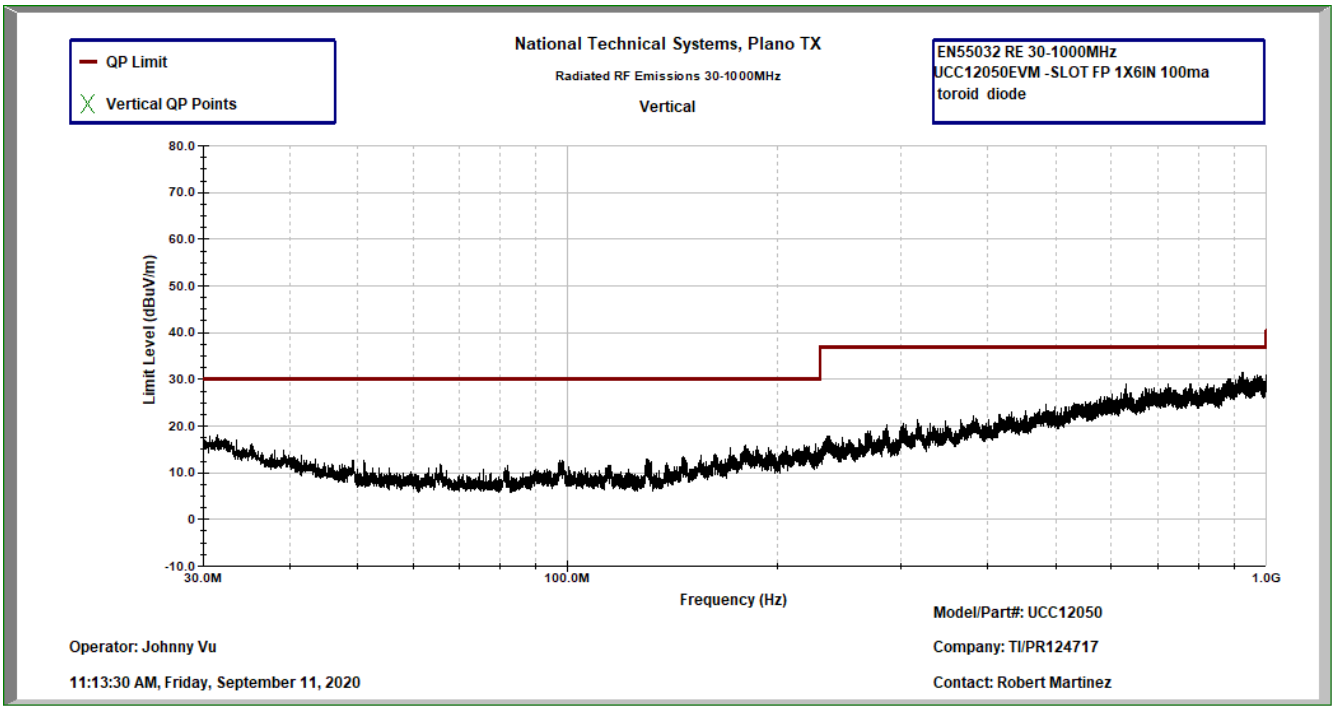

Figure 8-4. Vertical, Ferrite Beads L1, L2, –5.38 dB (930 MHz), 100 % Load (500 mW)

8.2 EMI Scans - 4x UCC12050, 5 V_{OUT}

The test results shown in Figure 8-5 through Figure 8-8, demonstrate the radiated emissions for a four, 5-V, UCC12050 converters operating simultaneously at 25% load and 100% load. Cases where the receiving antenna is orientated horizontally and vertically are labeled accordingly. Figure 8-7 and Figure 8-8 show the effect of removing all ferrite beads and should be considered as the worst case without any PCB, EMI mitigation.

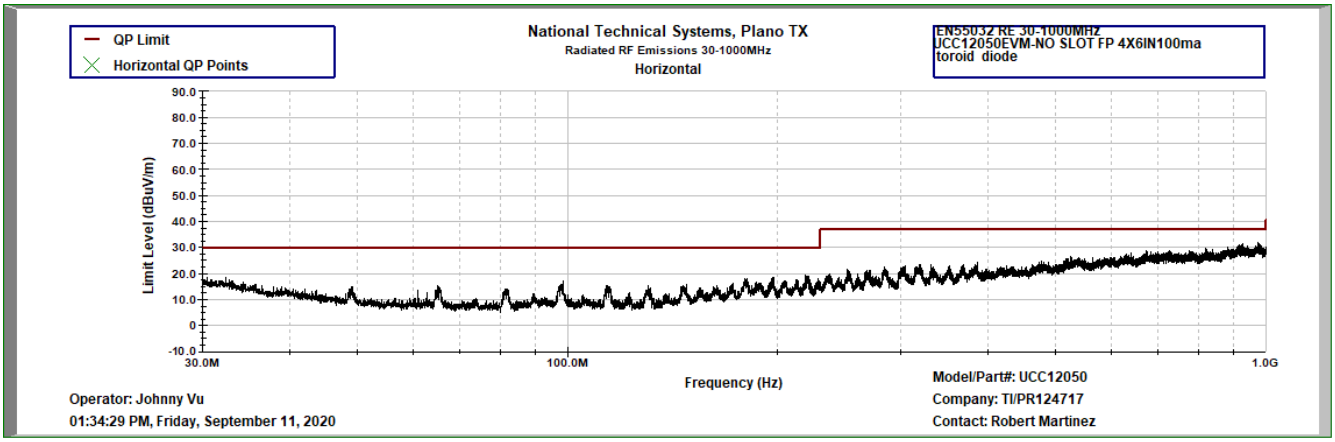

Figure 8-5. Horizontal, Ferrite Beads L1-L8, –5.06 dB (975 MHz), 100% Load (500 mW)

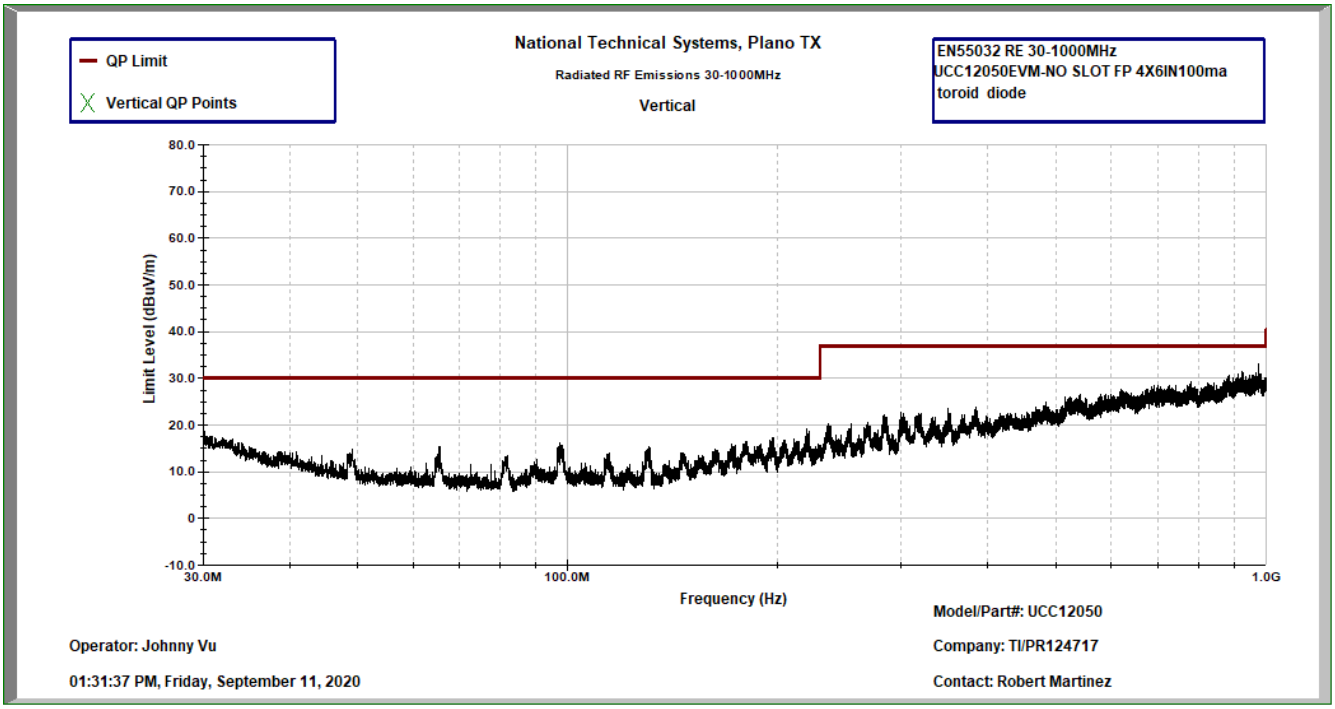

Figure 8-6. Vertical, Ferrite Beads L1-L8, –3.97 dB (975 MHz), 100% Load (500 mW)

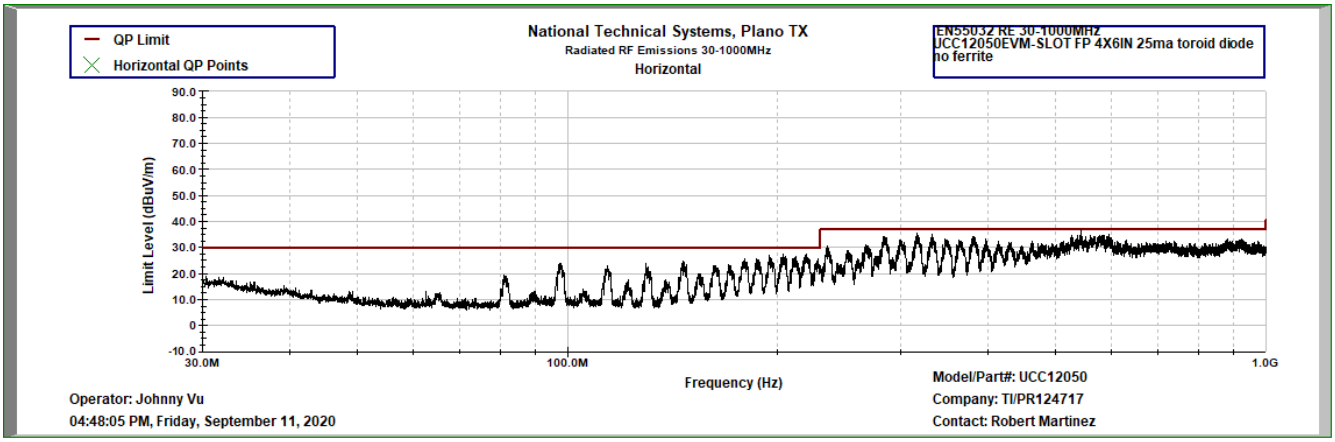

Figure 8-7. Horizontal, no Ferrite Beads, –0.11 dB (544 MHz), 25% Load (125 mW)

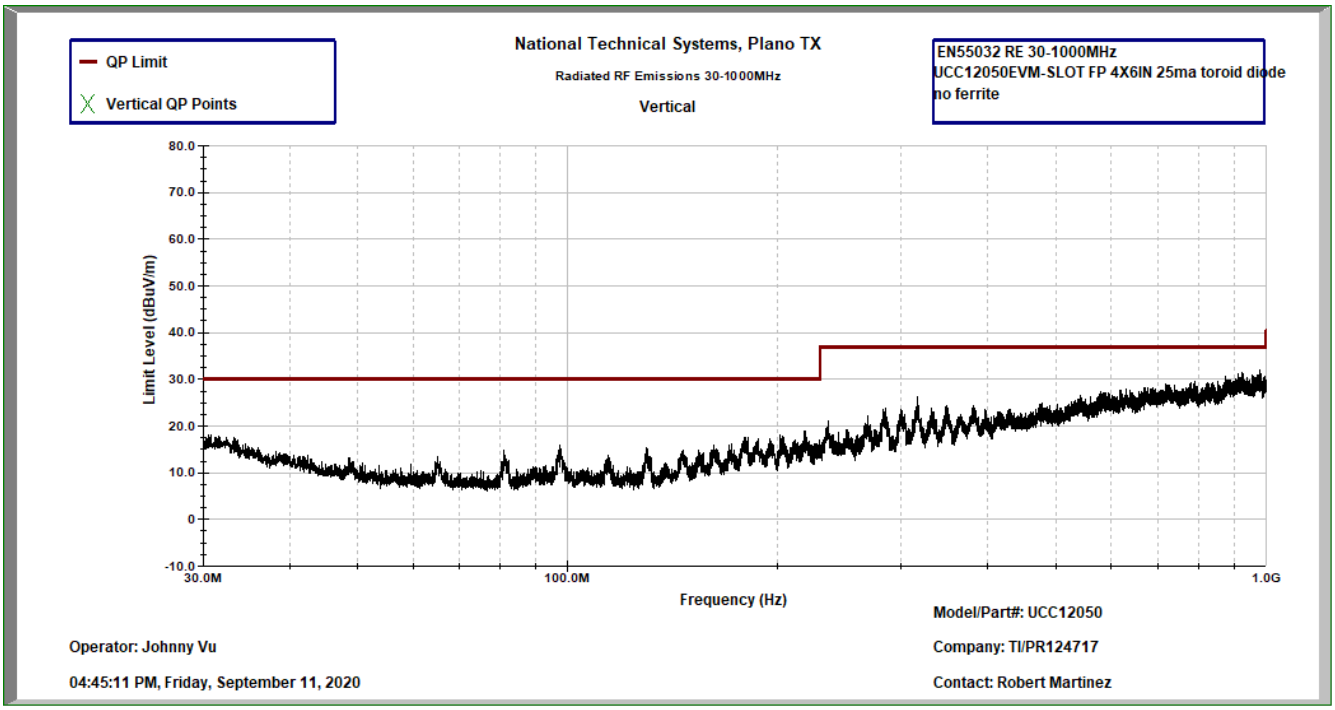

Figure 8-8. Vertical, no Ferrite Beads, –4.83 dB (980 MHz), 25% Load (125 mW)

8.3 EMI Scans - Conclusion

A comparison between a single, 5-V, 500-mW, UCC12050 (Figure 8-3, Figure 8-4) vs four, 5-V, 500-mW, UCC12050 converters (Figure 8-5, Figure 8-6) demonstrates almost no notable difference in radiated EMI, under identical operating conditions. Cable length, shielding and relative cable position is critical to radiated EMI CISPR 32 results. The UCC12050 includes SSM which greatly reduces sharp harmonic peaks, offering significant benefits for passing radiated EMI. Four UCC12050 converters have been shown to pass CISPR 32, class B without external ferrite beads (Figure 8-7, Figure 8-8). Ferrite beads placed at the input of each UCC12050 have been shown to significantly improve radiated EMI.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265