*Technical White Paper*

# *Best in Class Radiated Emissions EMI Performance with Isolated Amplifiers*

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**ABSTRACT**

Several industrial and automotive applications require some type of isolation to protect the digital circuitry from the high-voltage circuit performing a function. Texas Instruments has an extensive portfolio of isolated amplifiers and data converters featuring a capacitive isolation barrier to help customers address their isolated data conversion needs. Texas Instruments' capacitive isolation barrier allows for exceptional reliability, often over 100 years of operation. For more information on TI's capacitive isolation barrier, please review the Isolation website.

Radiated emissions testing is common in these applications to verify the system does not produce radiated emissions that exceed the defined levels which may negatively impact other components or circuits in the system. Please see this *Understanding electromagnetic compliance tests in digital isolators* marketing white paper for a more in-depth description of EMI. The magnitude of acceptable radiation and testing procedure for radiated emissions is put in place by the Comité International Spécial des Perturbations Radio, also known as CISPR. Industrial applications measure according to the CISPR 11 standard, while automotive applications measure to the CISPR 25 standard. For more information on the CISPR standards and their respective magnitudes over frequency, please see this *An overview of conducted EMI specifications for power supplies* marketing white paper.

This document shows the radiated emissions electromagnetic interference (EMI) performance for Texas Instruments' isolated amplifiers, including the AMC1300B-Q1, AMC1300, AMC1302, and AMC1311 as well as radiated emissions performance for previous isolated amplifier generations.

For radiated emissions EMI guidance for the AMC3301 family, please see this *Best Practices to Attenuate AMC3301 Family Radiated Emissions EMI* application note.

## Table of Contents



## List of Figures



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# 1 Introduction

In isolated amplifiers with a capacitive isolation barrier, radiated emissions can be created when the capacitors that span the barrier are charged and discharged to transmit data in the form of either a 1 or a 0. The charges flow through the differential capacitors in opposite directions mostly canceling each other, however any difference in magnitude or time between these charge flows results in electro-magnetic energy injected between the isolated grounds GND1 and GND2. Because of the nature of the isolation barrier, the energy is unable to find a conductor to return to the source. With no path back to the source, the energy radiates from the device pins (and any traces or PCB planes they are connected to) in the form of radiated emissions. This radiation can extend to frequencies significantly above the amplifier signal bandwidth and data rates, since it is caused by timing mismatches in the pico-second range.

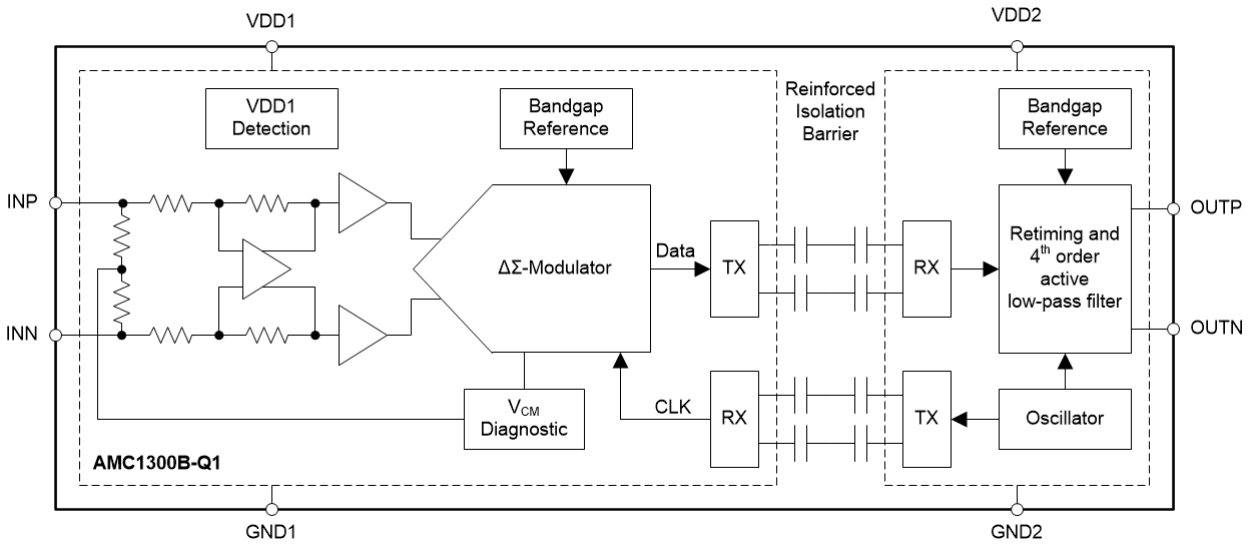


**Figure 1-1. Isolated Amplifier Block Diagram**

Within the recent years, there have been significant improvements to the architecture of Texas Instruments isolated amplifiers to optimize radiated EMI performance. Beginning in 2018 with the ISO224, isolated amplifiers from Texas Instruments began to use on or off keying (OOK) signal modulation compared to previously used pulse coding. The OOK modulation enabled significantly improved Common-Mode Transient Immunity levels. Then in 2020, the AMC1300B-Q1 was the first isolated amplifier that significantly reduced the amount of energy crossing over the isolation barrier, which reduces the radiated emissions, providing sufficient margins to the standard specifications. These design changes, as well as a re-designed isolated signal path, are now present in the entire Texas Instruments isolated amplifier portfolio, with the exception of the AMC1100, AMC1200, and ISO224 devices. The optimized timing and amplitude in the signal chain yields a reduction of radiated emissions EMI at high frequencies to an even lower level.

The following sections show the radiated emissions EMI performance for the Texas Instruments' isolated amplifiers. The current generation of isolated amplifiers radiated emissions performance is shown by using the AMC1300B-Q1 as an example, while the ISO224 and AMC1200 are used to show data for the previous generation devices. The radiated emissions scans were all performed according to the standards set in place by CISPR 11. All tests were performed using the AMC1300EVM printed circuit board (PCB) with the inputs shorted to ground, transformer driver (U3) removed, and external 3.6 V batteries with short leads. Each scan shows the horizontal sweep results from the device under test (DUT) in blue as well as the ambient scan overlaid in red to show the noise floor of the chamber. Both CISPR 11 Class A and Class B limits are shown on the plots as well. The horizontal polarization was selected because the emissions levels detected by the test equipment’s antenna were higher than for the vertical polarization, due to alignment with the PCB.



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## 2 Current Generation of Texas Instruments Isolated Amplifiers Radiated Emissions Performance

The isolated amplifiers from Texas Instruments such as the AMC1300B-Q1, AMC1300, AMC1302, and AMC1311 incorporate several years of radiated emissions EMI performance advancements, including, but not limited to: an optimized analog signal chain, the amount of energy crossing over the isolation barrier was more closely managed, and OOK data transmission. As shown in Figure 2-1, these devices have excellent radiated emissions EMI performance, with only a few high frequency radiated emissions visible above the noise floor of the chamber. These high-frequency emissions are visible around 820 Mhz with 20 dB of margin and extends to 980 MHz with 16 dB of margin.

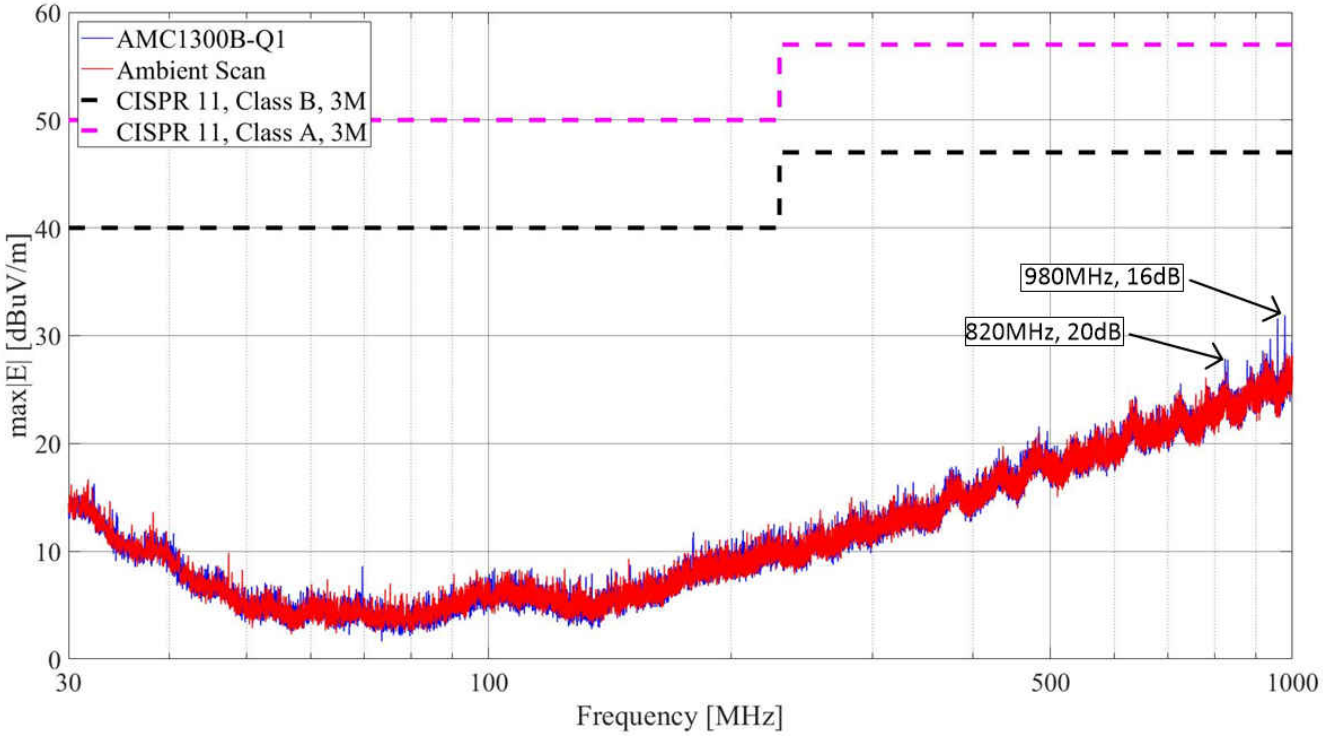


**Figure 2-1. AMC1300B-Q1 CISPR 11 Radiated Emissions EMI Scan**


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# 3 Previous Generations of Texas Instruments Isolated Amplifiers Radiated Emissions Performance

Released in 2018, the ISO224 closely managed the energy crossing over the isolation barrier, and added OOK data transmission. The radiated emissions EMI scan shown in Figure 3-1 was performed using the ISO224 and the emissions are first seen around 540 Mhz with 18 dB of margin and continues to 1 GHz which is the CISPR 11 test limit, with 6 dB of margin at 940 MHz.

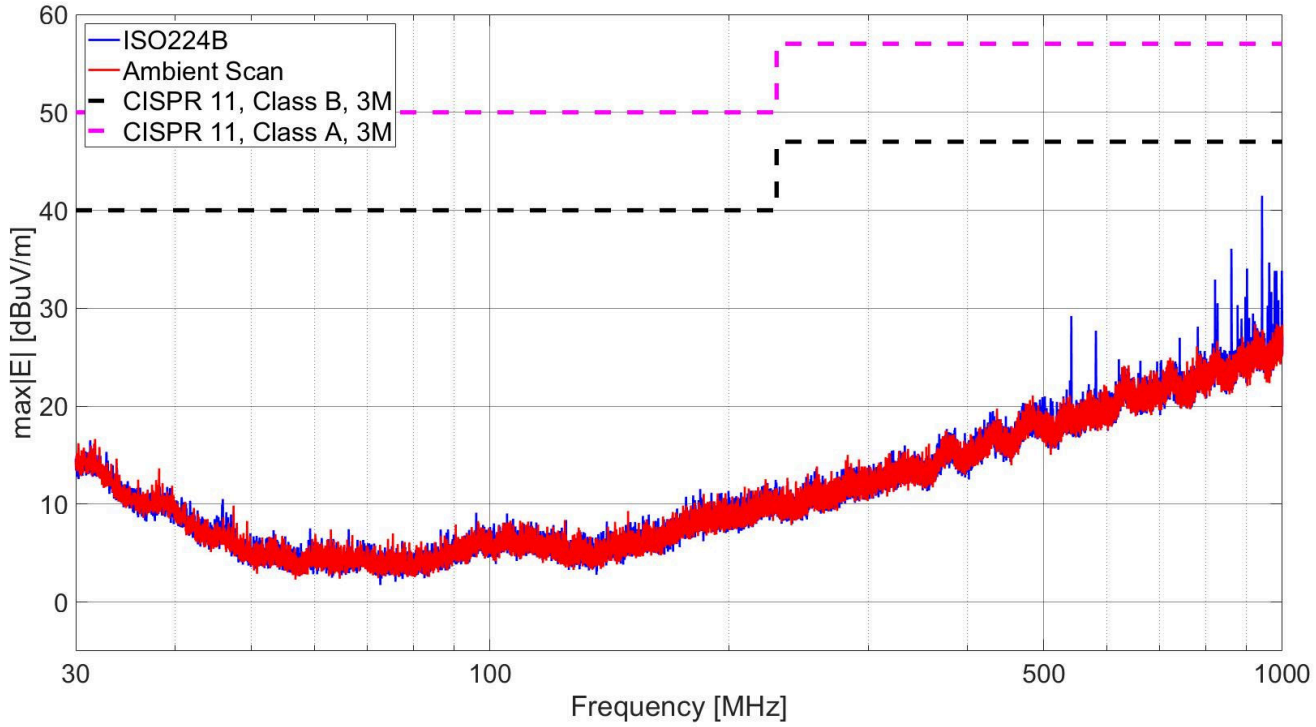


**Figure 3-1. ISO224 CISPR 11 Radiated Emissions EMI Scan**



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Texas Instruments released the AMC1100 and AMC1200 isolated amplifiers in 2011. These devices feature a basic isolation barrier and meet the CISPR 11 Class A and Class B standards with sufficient margin.

As shown in Figure 3-2, the AMC1200 has several radiated emissions peaks above the noise floor, however, there is a significant amount of margin available to the CISPR class B limit shown in black. The noise peaks in the 100 MHz to 230 MHz region have 24 dB of margin from the CISPR11 Class B limit, while the noise peaks in the higher frequency range, 480 MHz to 630 MHz, have 13 dB of margin.

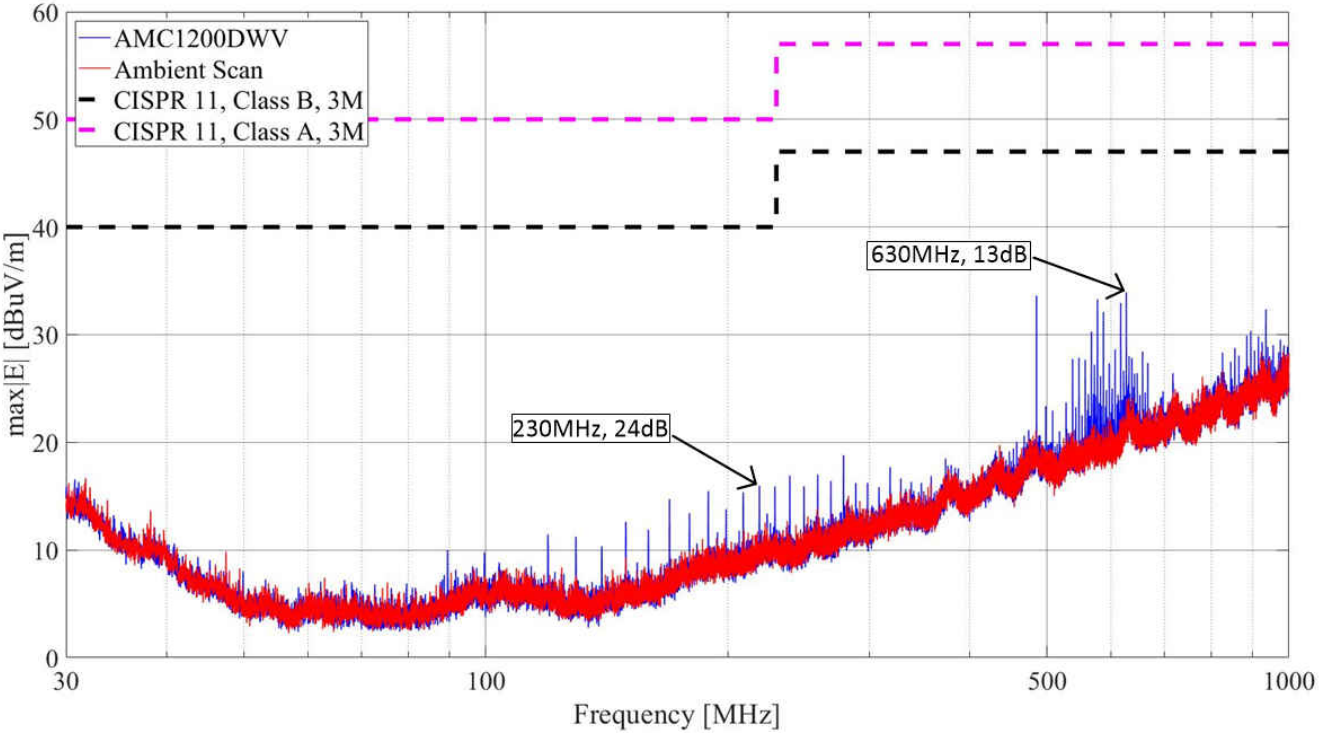


**Figure 3-2. AMC1200 CISPR 11 Radiated Emissions EMI Scan**


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## 4 Conclusion

Over the past several years, capacitive isolation has been a popular choice for many customers in need of isolated amplifiers and data converters due to the long term reliability and strong analog performance. When using the re-designed isolated amplifiers from Texas Instruments, including AMC1300B-Q1, AMC1300, AMC1302, and AMC1311, customers can confidently create designs featuring the high reliability and high analog performance that capacitive isolation brings, with best in class radiated emissions EMI performance.



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## 5 References


- Texas Instruments, *Understanding Electromagnetic Compliance Tests in Digital Isolators* application note.
- Texas Instruments, *An Overview of Conducted EMI Specifications for Power Supplies* application note.
- Texas Instruments, *Best Practices to Attenuate AMC3301 Family Radiated Emissions EMI* application note.




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# 6 Revision History

| Changes from Revision * (June 2020) to Revision A (March 2023) | Page |
|---|---|
| • Updated the numbering format for tables, figures, and cross-references throughout the document | 1 |
| • Added *AMC1300*, *AMC1302*, and *AMC1311* throughout the publication | 1 |
| • Updated *ISO224 CISPR 11 Radiated Emissions EMI Scan* image | 4 |



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