Application Note

Minimizing Charger EMI with DRSS: Practical Benefits and Lab Validation Techniques

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ABSTRACT

This application note explains the concept and benefits of Dual Random Spread Spectrum (DRSS) in minimizing charger EMI, with a focus on BQ25773 operation and configuration. Practical guidance is provided for evaluating EMI performance in the lab, including recommended test setups, and comparison of EMI spectra with DRSS enabled versus disabled. Results demonstrate how enabling DRSS can reduce the effects of EMI to meet IEC-CISPR 32 EMI specifications.

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1 Introduction

Spread spectrum also know as frequency dithering is widely used in switching regulators to reduce electromagnetic interference (EMI) by converting a narrowband signal into a wideband signal, which spreads energy across multiple frequencies, rather than concentrating the energy at the fundamental switching frequency and the harmonics. Conservation of energy requires the total energy to remain constant, but by spreading this energy across multiple frequency bands, peak energy is minimized. As a result, nearby sensitive circuits is less perturbed by the interference. Figure 1-1 illustrates how manipulating the clock frequency over time has the effect of spreading energy generated by a switching circuit.

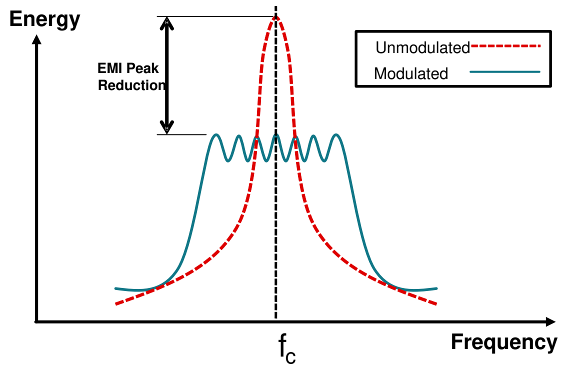


Figure 1-1. EMI Reduction by Spread Spectrum, Frequency Modulation

2 Dual Random Spread Spectrum (DRSS)

Traditional approaches such as analog triangular dithering and pseudorandom modulation can effectively reduce peak EMI in certain ranges, but these approaches often struggle to maintain consistent performance across multiple resolution bandwidths (RBWs). These challenges become especially important in charger designs that must satisfy conducted EMI requirements without introducing excessive ripple, audible tones, or stability concerns.

Dual Random Spread Spectrum (DRSS) addresses these limitations by combining two independent layers of variation: a low-frequency triangular sweep and a higher-frequency pseudorandom component. The triangular sweep provides a controlled and predictable frequency deviation, while the pseudorandom modulation prevents repetitive spectral patterns that can accumulate into secondary peaks. By combining these two mechanisms, DRSS verifies that the switching frequency never stays at any single value long enough to create dominant narrowband emissions. This improves peak EMI performance across multiple frequency bands while maintaining stable, efficient operation, producing a smoother spectral profile and lower peak amplitudes without noticeably affecting average switching behavior.

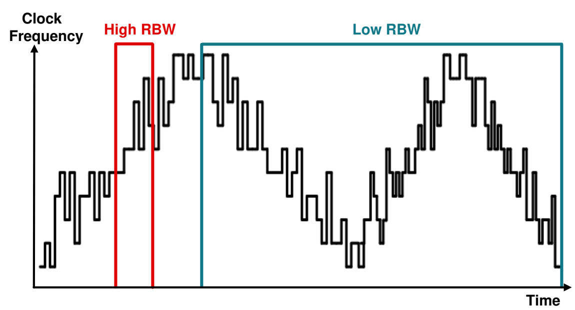


Figure 2-1. Implementation of DRSS

3 Why is DRSS Needed?

IEC-CISPR 32 is an international radio disturbance standard for multimedia equipment (MME). The standard establishes requirements that provide an adequate level of protection for the radio spectrum and specifies procedures to verify the reproducibility of measurement and the repeatability of results.

With the demand for higher-efficiency chargers, the need for faster switching continues to grow. Faster switching speeds, however, lead to increased EMI. In addition, the shift towards higher DC input voltages and higher inductor current, such as those associated with the EPR range, further amplifies EMI challenges. Due to project constraints, it can be difficult for battery charger systems to meet emission limits using layout and filtering alone. To help support compliance with IEC-CISPR 32, some newer charger devices incorporate DRSS to improve system-level EMI performance without the need for layout changes.

4 BQ25773 DRSS Evaluation

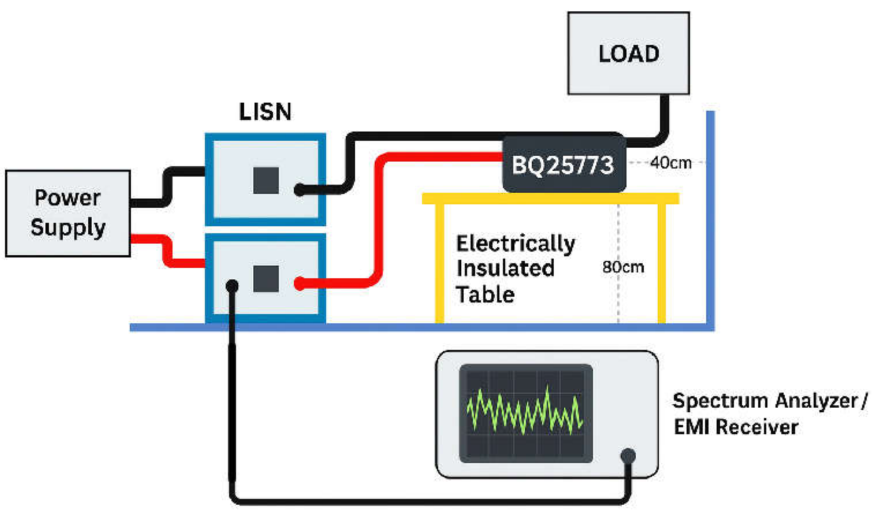
The BQ25773 is one of TI's battery chargers that integrates Dual Random Spread Spectrum to help reduce switching-related EMI. While the specific implementation details mentioned below can vary by device, the underlying DRSS concept and the EMI benefits apply broadly across all of TI's battery chargers that support this feature.

4.1 Equipment

To evaluate the functionality the DRSS feature on the BQ25773, the following equipment is required:

1. **TI EVM:** BQ25773 evaluation module (EVM).
2. **EMI Analyzer/Signal cable:** A Rhode & Schawarz ESRP3 or equivalent CISPR compliant EMI Test Receiver.
3. **EMC Test Chamber:** Shielded room for electromagnetic compatibility (EMC) testing.
4. **LISN'S:** Two line impedance stabilization networks (LISN's), one for each power line.
5. **Power Supply:** DC power supply capablsu of supplying 20V at 5A.
6. **Load**: Kepco BOP36-6M, DC 0 to ±36V, 0 to ±6A, or equivalent. When testing without a real battery, connect 2000uF of capacitance across the battery input.
7. **Computer:** A computer with at least one USB port and a USB cable.
8. **Communication Kit** EV2400 or equivalent communication adapter.

4.2 Equipment Setup



Use the following steps to evaluate the functionality of the BQ25773 DRSS Feature

1. Connect the 36V power supply to the input of both LISNs, one for each power line.
2. Connect the output of the LISN's to the input of the BQ25773 EVM (J1).
3. Connect the load/battery simulator to output of the BQ25773 EVM (J3).
4. Connect the EMI Analyzer signal cable to the positive LISN signal output.
5. Use the EV2400 communicate with the BQ25773 to configure the board per the *BQ2577xEVM Evaluation Module*.
6. Configure the EMI receiver for CISPR32 evaluation. The required settings depend on the CISPR 32 version being used and the specific emi receiver model
7. Use REGx3D[3:4] to configue DRSS frequency dithering.

When evaluating DRSS functionality, TI recommends first capturing the conducted EMI measurement under normal operation with dithering disabled and then evaluate with dithering enabled.

4.3 Evaluation and Results

All DRSS tests results were evaluated under the same test conditions 36V/4A input, 15.4V/9A output, approximately 140W, 600kHz switching frequency.

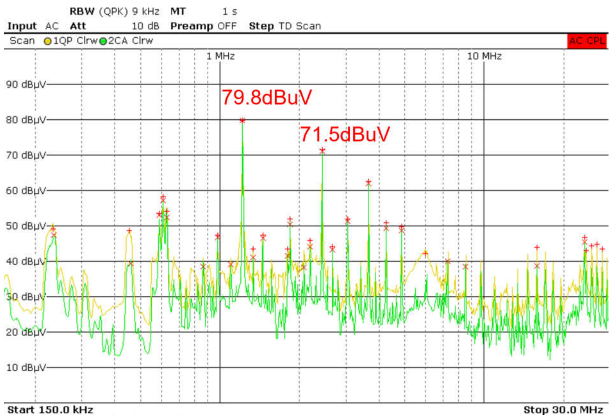


Figure 4-1. No Dithering (Disabled)

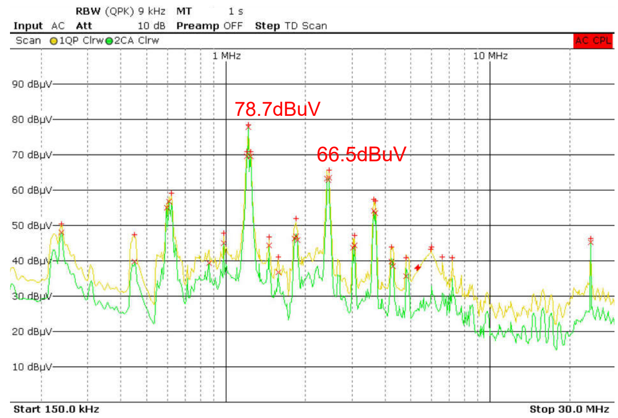


Figure 4-2. 1X Dithering (±2%)

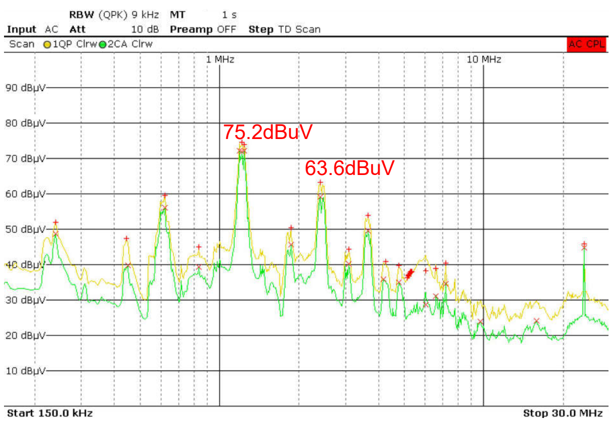


Figure 4-3. 2X Dithering (±4%)

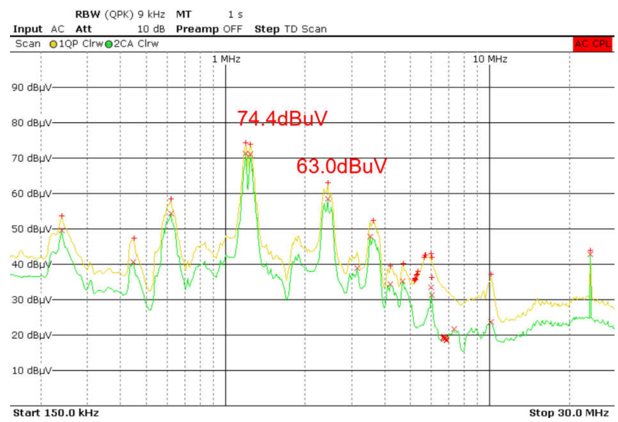


Figure 4-4. 3X Dithering (±6%)

With dithering disabled, the baseline EMI quasi-peak is 79.8dBuV at approximately 1.2MHz, which corresponds to roughly twice the switching frequency (600kHz). Enabling ±2% dithering results in a slight reduction of the noise peak compared to no dithering, but limited overall improvement. Increasing the dithering range to ±4% results in a more noticeable reduction in the noise peak, demonstrating that dithering the switching frequency helps to lower the dominant EMI peak. The best EMI performance is achieved with ±6% dithering, where the noise peak is reduced by approximately 5.4-8.5dBuV relative to the baseline. Overall, these results show a clear trend that DRSS can be used reduce the magnitude of the dominant EMI quasi-peak.

5 Summary

This application note describes the benefits of Dual Random Spread Spectrum (DRSS) in minimizing charger EMI. Practical guidance is provided for evaluating DRSS using the BQ25773 EVM, including recommended test setups, and comparison of EMI spectra with DRSS enabled versus disabled. The results confirm the DRSS feature can be used effectively to reduce peak EMI to meet IEC-CISPR 32 EMI specifications.

6 References

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- Texas Instruments, *EMI Reduction Technique, Dual Random Spread Spectrum*, application note.