How SYNC Logic Affects EMI Performance for Dual-Channel Buck Converters

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ABSTRACT

The LMR140X0 series of buck regulators from TI are monolithic, integrated circuits with an internal MOSFET switch. The LMR140X0 device is widely used in automotive and industrial applications. In these applications, a multichannel buck converter is needed. The LMR140X0 has a frequency synchronization function. This application report discusses how SYNC logic affects EMI performance of a dual-channel buck converter.

First, this report describes the FFT analysis for two buck converters working in different modes. Next, the bench test is provided to verify the theories. Last, a conducted EMI performance comparison between the same-phase mode, phase-shift mode, and free-run mode, are presented.

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1 Introduction

The LMR140x0 is a 40-V, step-down regulator with an integrated high-side MOSFET. With a wide input range, this device is suitable for various applications, from industrial to automotive. In these applications including multi rails, step-down converters sharing the same input are needed. A multichannel buck converter can avoid the AM frequency range, reduce the solution size, and it is easy to choose an inductor. The LMR140X0 has a frequency synchronization function. This application report discusses how SYNC logic affects EMI performance for dual-channel buck converter.

2 FFT Simulation for Two Independent Buck Converters

Figure 1 shows the SIMPLIS simulation model for a dual-channel buck converter. The input voltage is 12 V and the target voltage for the dual output is 5 V and 3.3 V. By using this model, users can do FFT analysis for the input current in the same-phase mode and phase-shift mode.

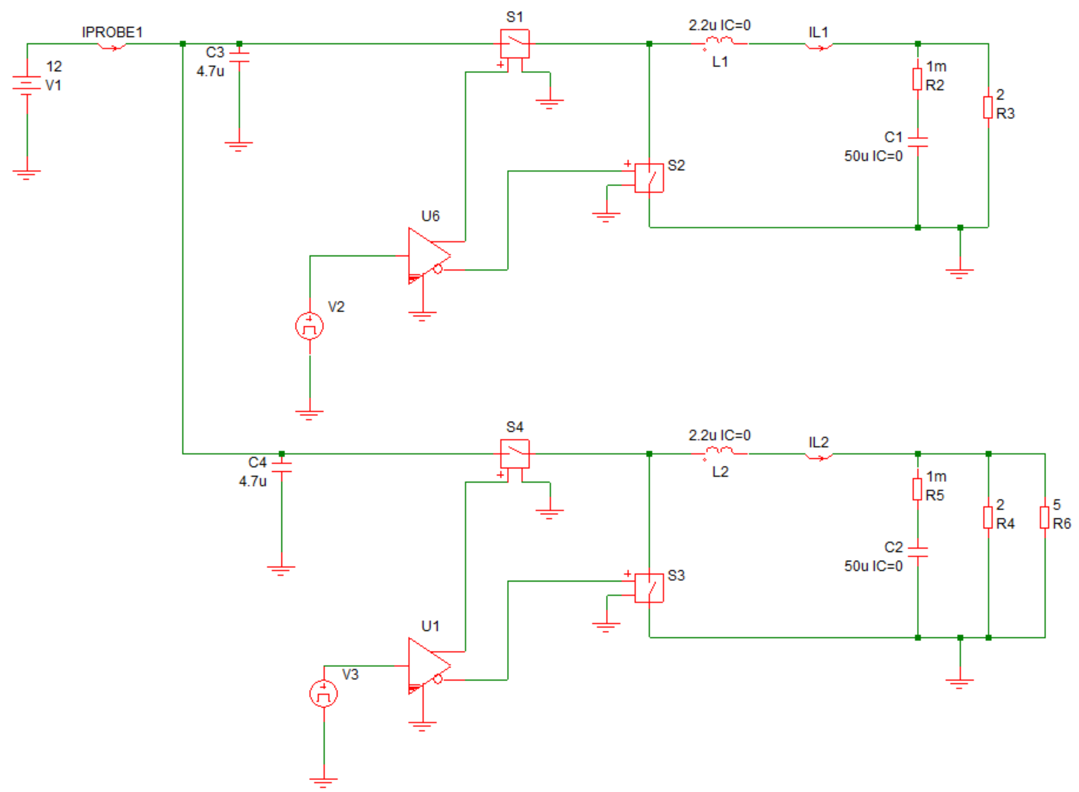

Figure 1. SIMPLIS Model of Dual-Channel Buck Converter

Figure 2 and Figure 3 show the FFT results for the input current in the same-phase mode and phase-shift mode. The phase-shift mode reduces the first harmonic of the switching frequency. The second harmonic becomes dominant after the phase-shift mode.

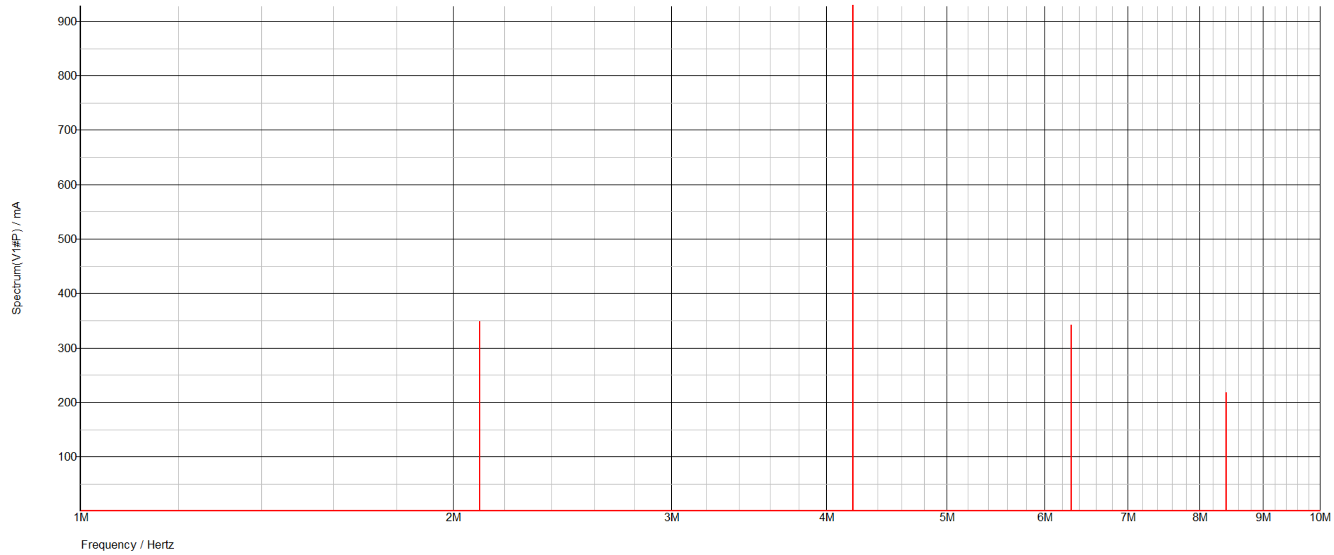

Figure 2. FFT Analysis Result in Phase-Shift Mode

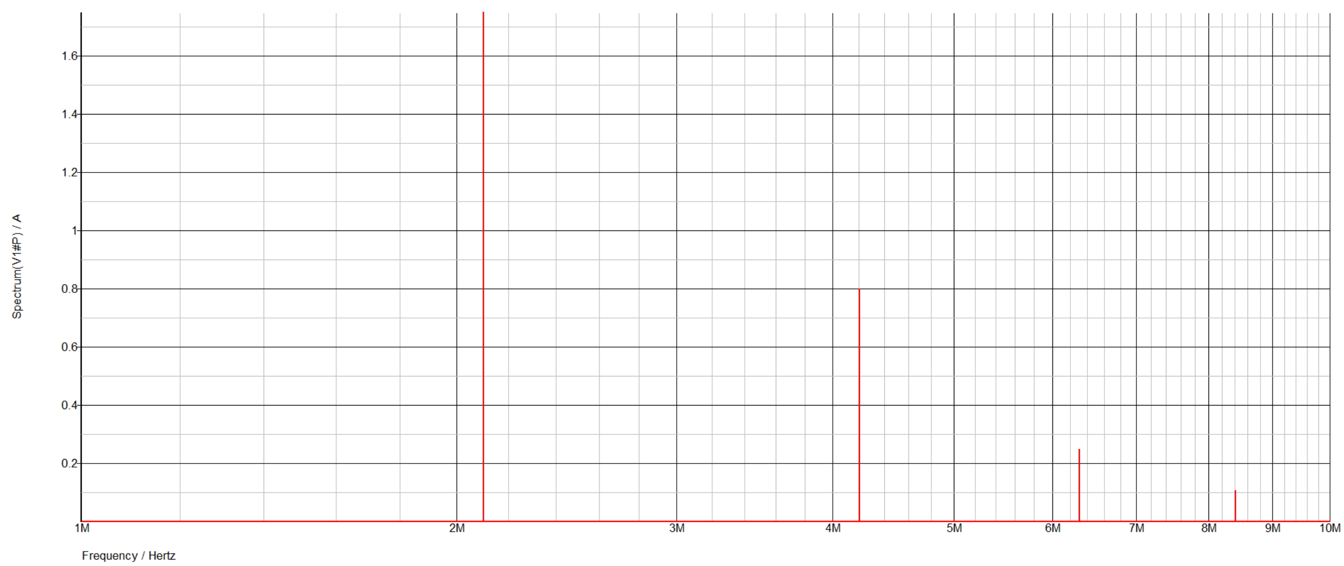

Figure 3. FFT Analysis Result in Same-Phase Mode

3 Bench Verification

This section introduces a use case about how to realize two buck converter work using the SYNC logic working in different modes. We take LMR14030 as an example. Input and output parameters are shown in Table 1.

Table 1. Specifications

PARAMETER	SPECIFICATION
V_{in_Min}	12-V DC
V_{out1}	5 V, 2.5-A DC
V_{out2}	3.3 V, 2.31-A DC
Target switching frequency	2.2 MHz

Figure 4 shows the overall schematic of the LMR14030 configured for a dual-channel buck converter that can work in different modes. The SYNC pin is controlled by the LMC555, to generate a different signal to control the SYNC pin in the same-phase mode, phase-shift mode, and free-run working mode.

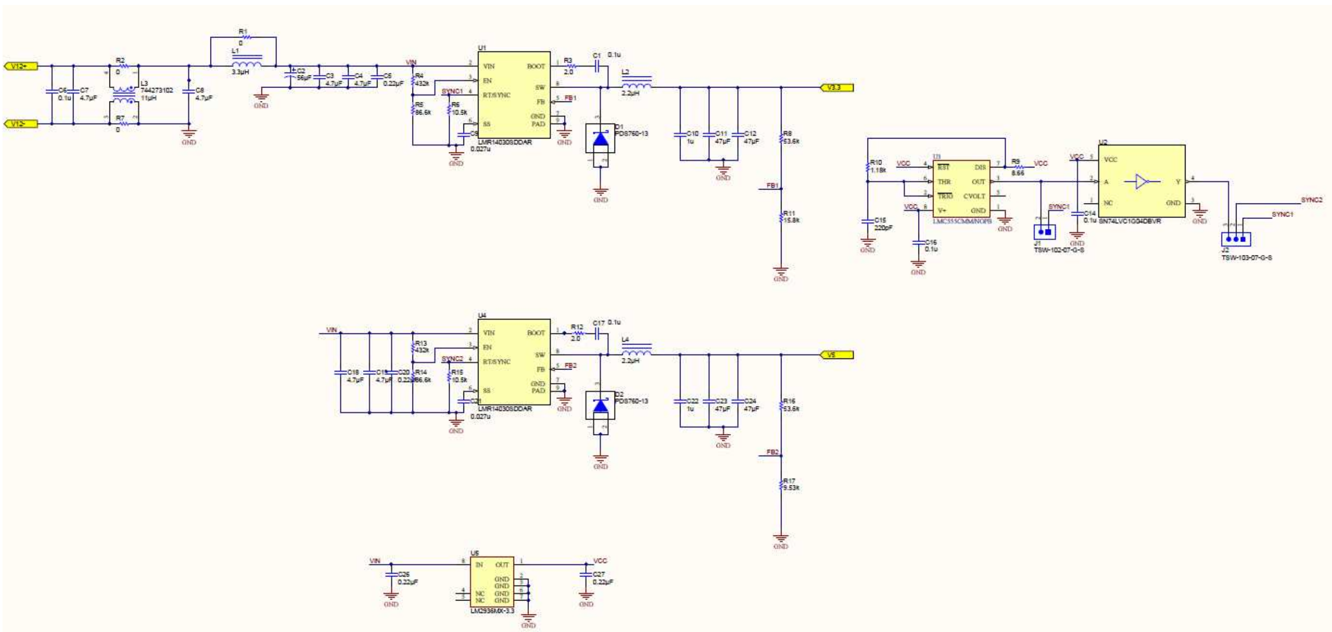

Figure 4. LMR14030 Two-Buck Converter Schematic

Figure 5, Figure 6, and Figure 7 show the two switching-node waveforms in the same-phase mode, phase-shift mode, and free-run working mode.

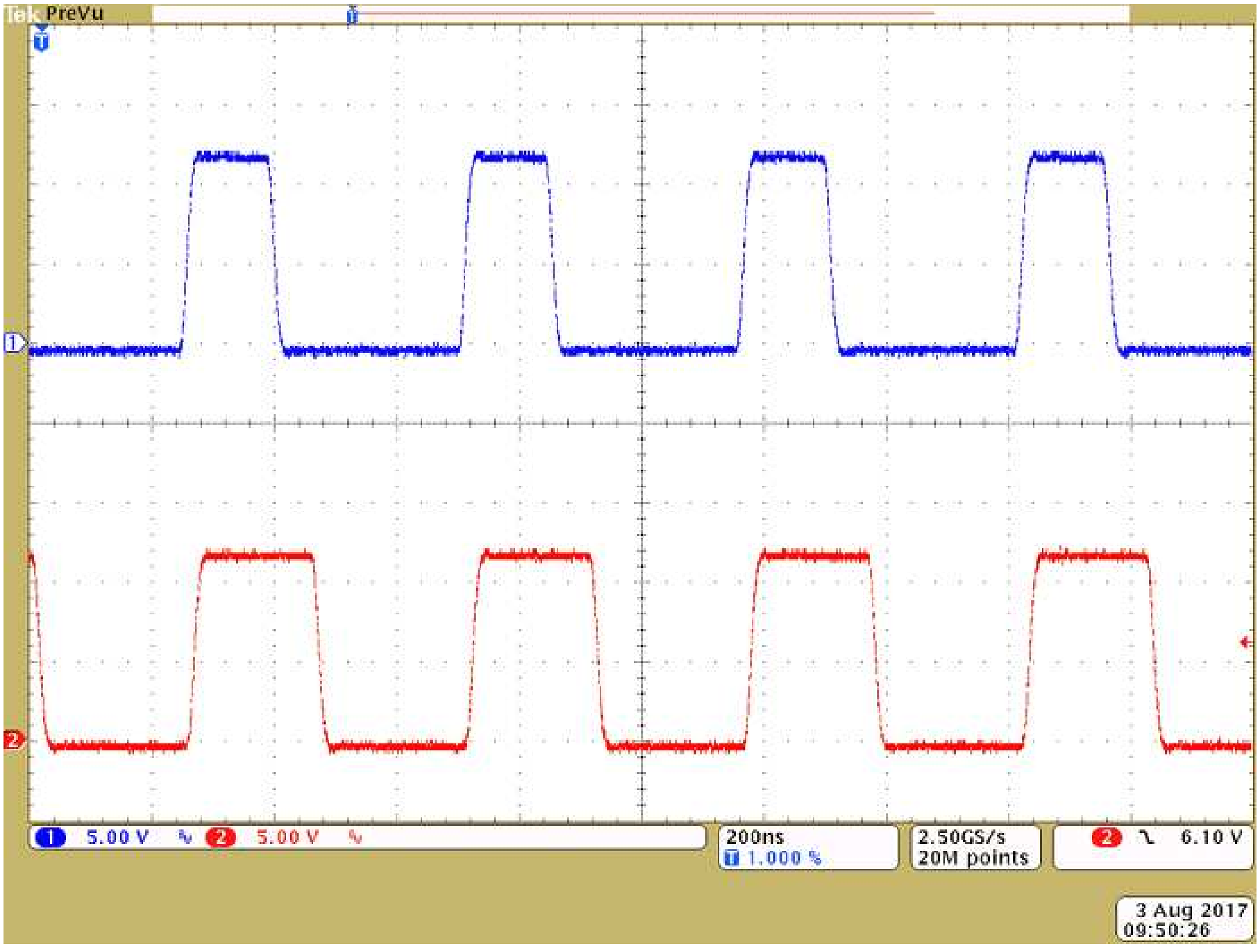

Figure 5. Waveforms for Same-Phase Mode

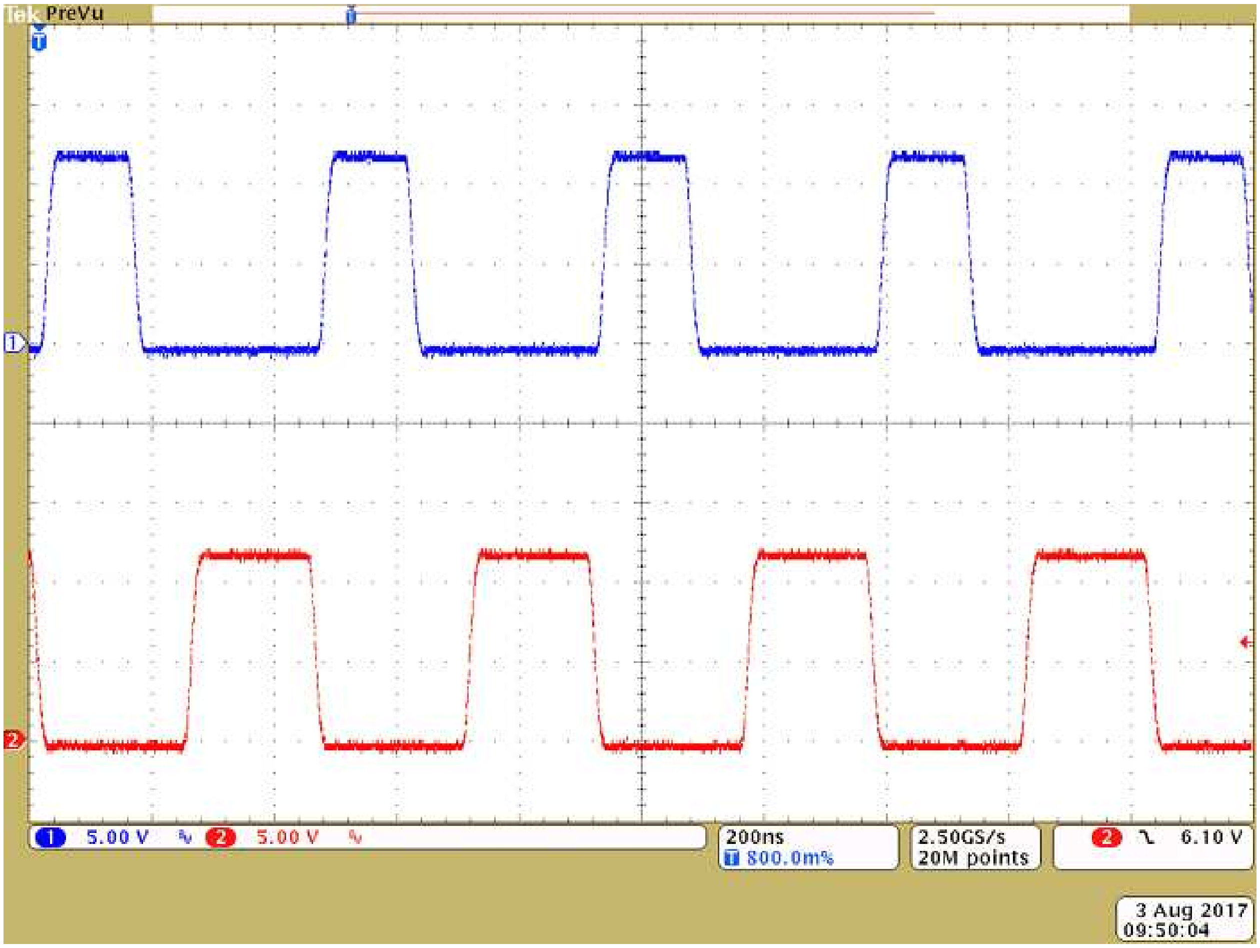

Figure 6. Waveforms for Phase-Shift Mode

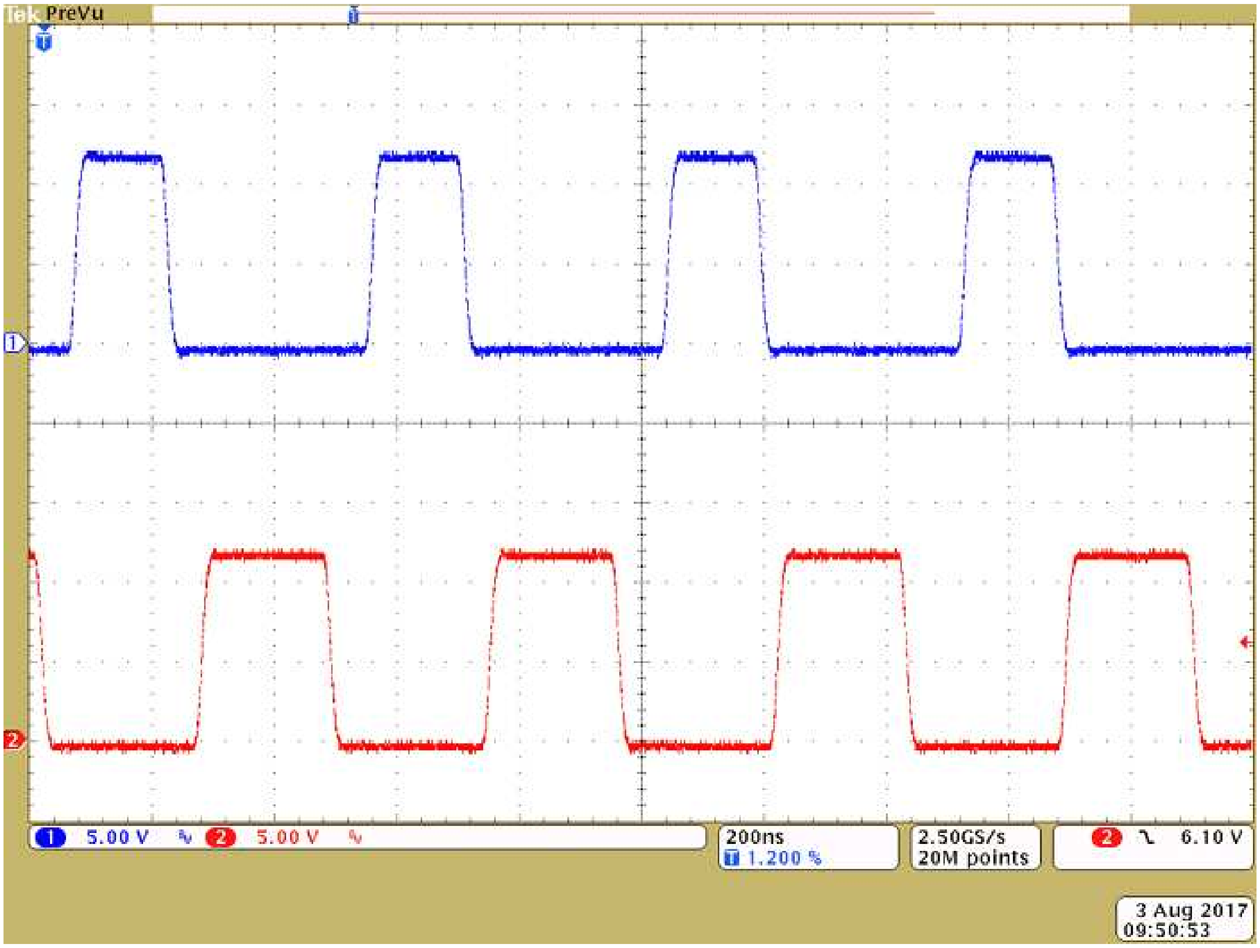

Figure 7. Waveforms for Free-Run Mode

4 Conducted EMI Comparison Between Same-Phase Mode and Phase-Shift Mode

Figure 8 and Figure 9 show the EMI performance in the same-phase mode and phase-shift mode, for the peak and average measurements, respectively. The red line shows the data in same-phase mode and the green line shows that in phase-shift mode. Developers can use the current probe to separate the differential mode and common mode.

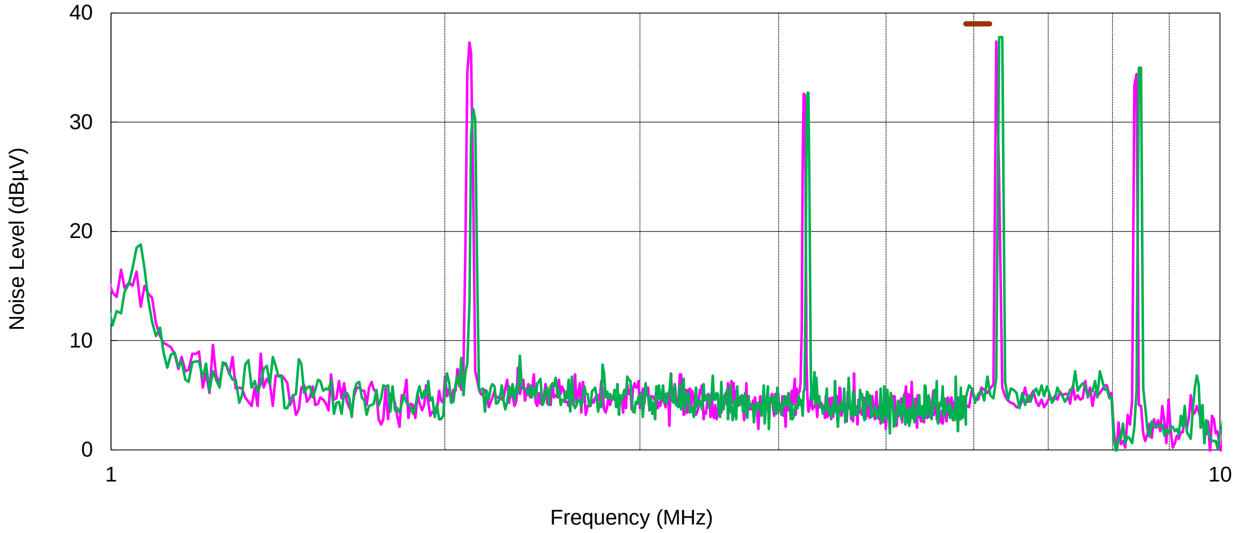

Figure 8. Peak Measurement of Same-Phase Mode and Phase-Shift Mode

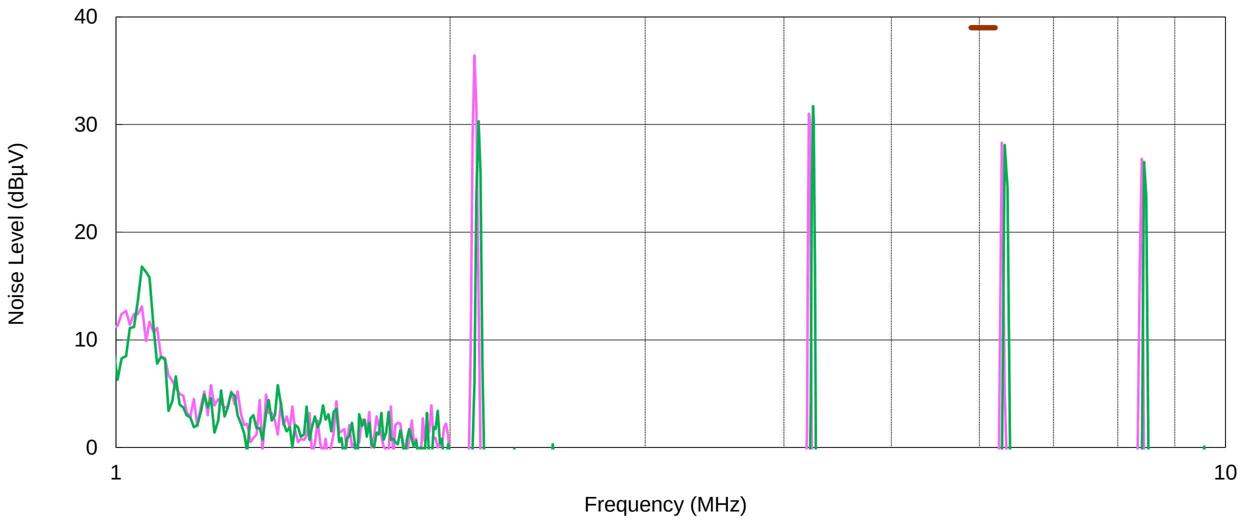

Figure 9. Average Measurement of Same-Phase Mode and Phase-Shift Mode

4.1 Differential Mode: Conducted, EMI Comparison Between Same-Phase Mode and Phase-Shift Mode

The result of the FFT analysis reflects the differential-mode, conducted, EMI performance. Figure 10 and Figure 11 show the EMI performance in differential mode, for the peak and average measurements, respectively. The red line shows the data in the same-phase condition, and the green line shows the data in the phase-shift condition. The phase-shift condition reduces the first harmonic of the switching frequency , as shown. The phase-shift condition also reduces the volume of input of the differential EMI filter. The FFT simulation results are verified.

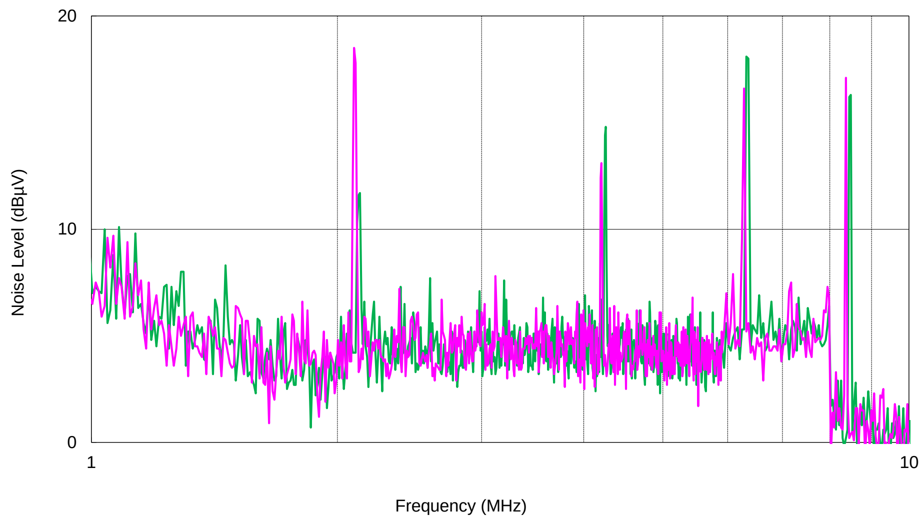

Figure 10. Peak Measurement of Differential Mode

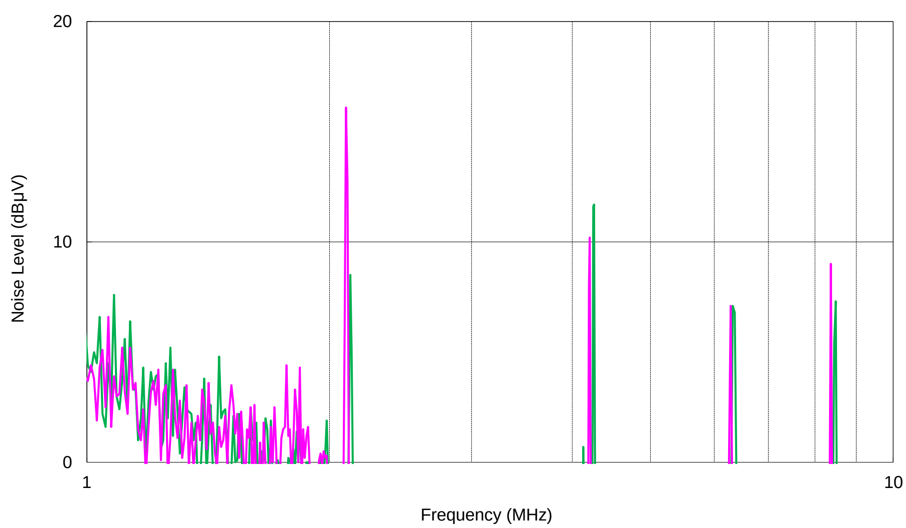

Figure 11. Average Measurement of Differential Mode

4.2 Common-Mode: Conducted EMI Comparison Between Same Phase and Phase Shift

Figure 12 and Figure 13 show the common-mode EMI performance, for peak and average measurements, respectively. The red line shows the data in the same-phase condition, and the green line shows the data in the phase-shift condition. The phase-shift condition can make the common mode performance better in low frequency, but the condition makes the common mode performance worse in high frequency.

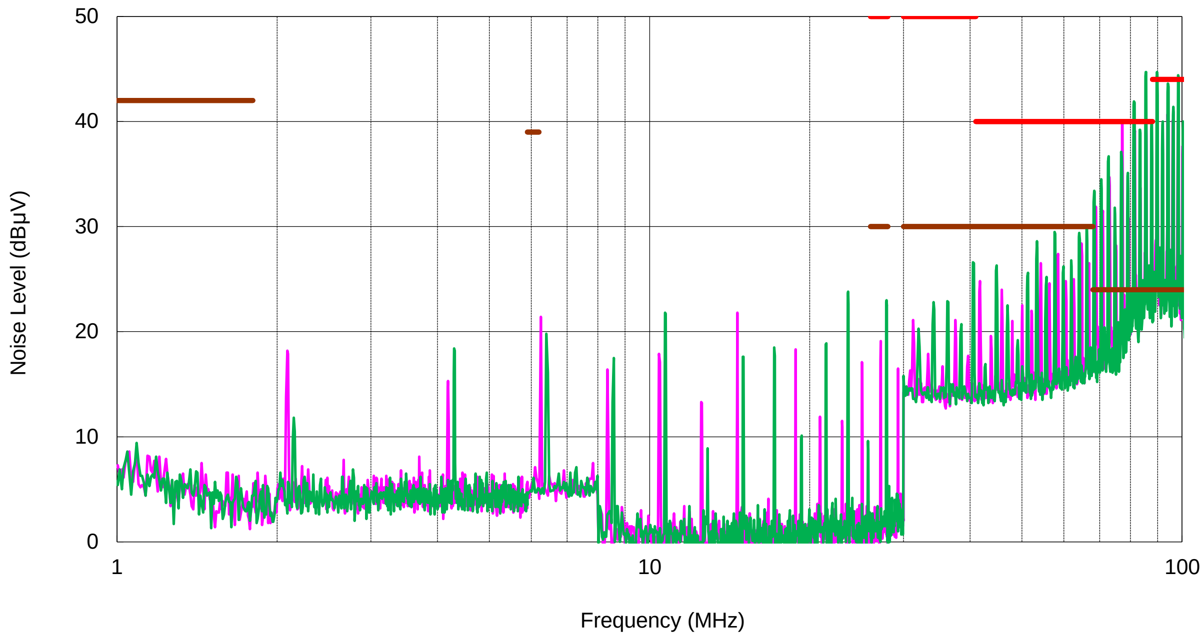

Figure 12. Peak Measurement of Common-Mode

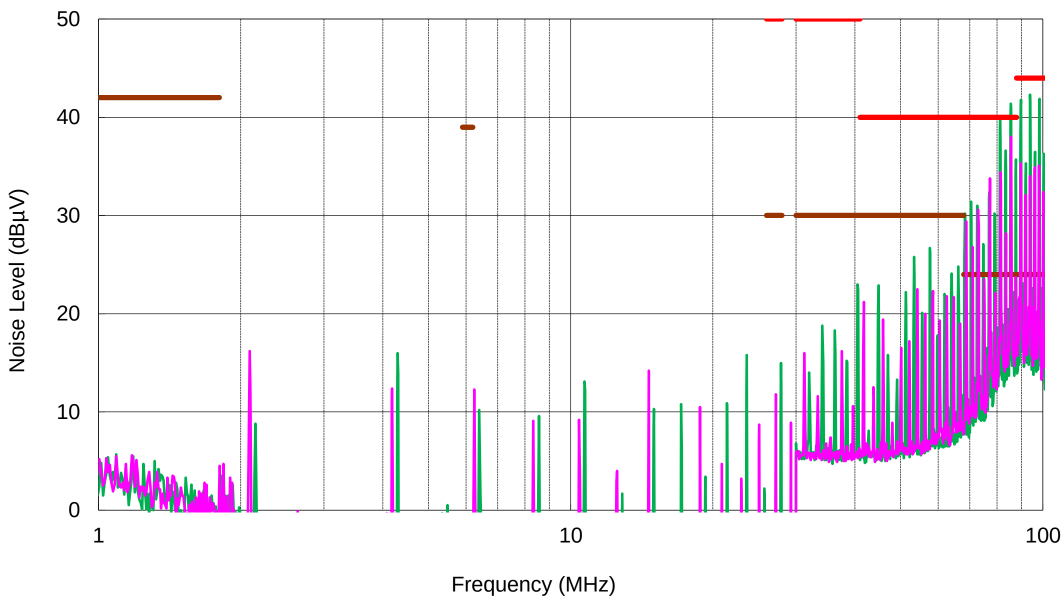

Figure 13. Average Measurement of Common-Mode

5 Conducted EMI Comparison Between Free-Run Mode and Phase-Shift Mode

Figure 14 and Figure 15 show the conducted EMI comparison for the peak and average measurements, respectively. The red line shows the data in the free-run condition, and the green line shows the data in the phase-shift mode. The phase-shift mode can reduce the first harmonic of the switching frequency, as shown.

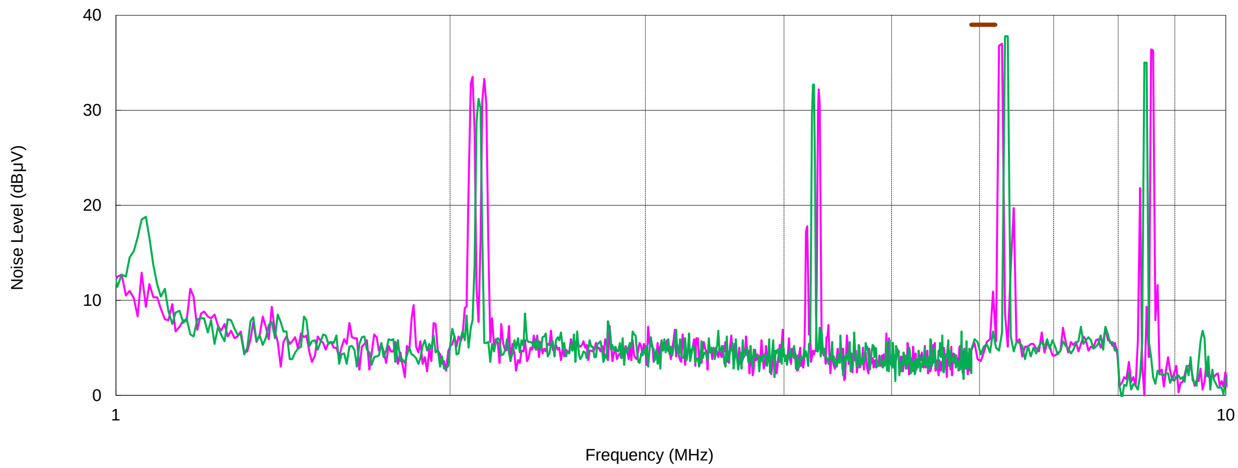

Figure 14. Peak Measurement of Free-Run Mode and Phase-Shift Mode

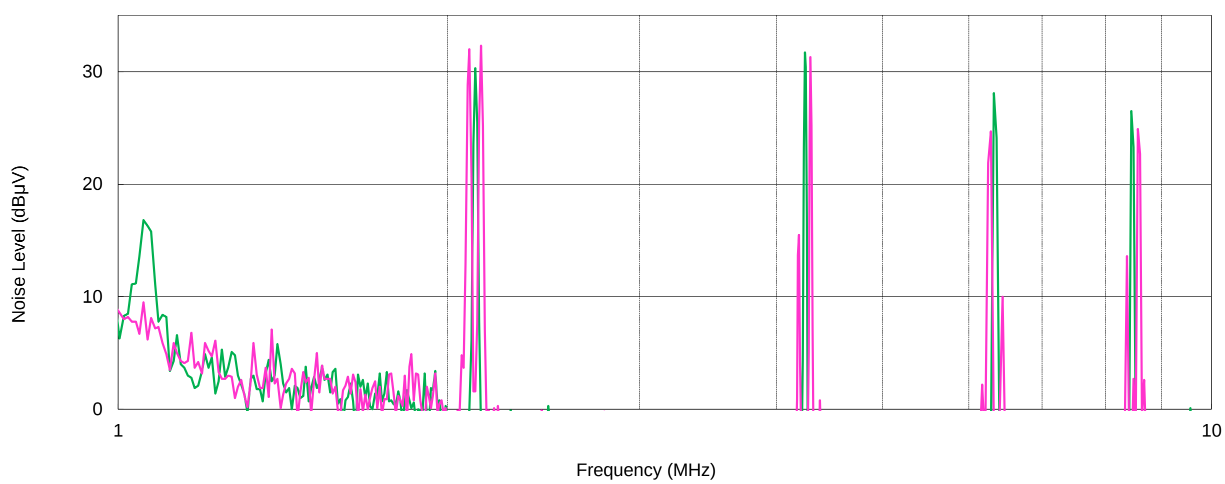

Figure 15. Average Measurement of Free-Run Mode and Phase-Shift Mode

6 Summary

This application note discusses how SYNC logic affects EMI performance on two, independent buck converters. Using the LMR14030 as an example, a dual-channel, buck-converter prototype is built. The phase-shift mode reduces the first harmonic of the switching frequency.

7 References

- Texas Instruments, *How to Extend Buck Regulator to Positive Buck-boost Configuration*, application report
- Texas Instruments, *LMR14050 SIMPLE SWITCHER® 40 V 5 A, 2.2 MHz Step-Down Converter with 40 μA IQ*, data sheet

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