

# Application Note

## DA14535 Requirements for Spurious Reduction

AN-B-099

### Abstract

*This document contains guidelines for implementing a RFIO filter to reduce conducted and radiated spurious emissions in Bluetooth® low energy applications using Renesas DA14535 System-on-Chip.*

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## DA14535 Requirements for Spurious Reduction

### 1 Terms and Definitions

SoC	System on Chip
LE	Low Energy
DUT	Device under Test
SDK	Software Development Kit
SMA	SubMiniature version A

### 2 References

- [1] [UM-B-083](#), SmartSnippets™ Toolbox, User Manual, Renesas Electronics.
- [2] [UM-B-119](#), DA14585/DA14531 SW Platform Reference Manual, Renesas Electronics.

**Note 1** References are for the latest published version, unless otherwise indicated.

## DA14535 Requirements for Spurious Reduction

### 3 Introduction

This document provides information on implementing a three-component Pi filter for Renesas DA14535 System-on-Chip (SoC) in 2.4 GHz Bluetooth® Low Energy (LE) applications. It specifically addresses the conducted performance in the spurious domain.

### 4 Filter Configuration

A range of different filter configurations have been considered and assessed in terms of performance, cost, and size. The assessment concluded that the best configuration was a Pi filter. The Pi filter configuration gives the best harmonic suppression with minimal power loss at fundamental frequencies. Lower cost solutions were eliminated because they did not deliver the same level of suppression whilst having greater impact on power loss. The size of the components is not critical, but to implement a small footprint, filter 0201 components have been used.

#### 4.1 Pi filter

Figure 1 shows the filter topology.

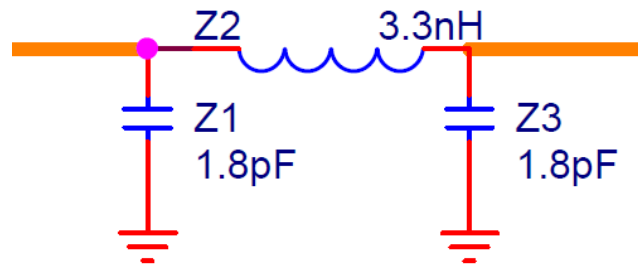


Figure 1. Pi filter topology

The components used include:

- Capacitors: 1.8 pF, 0201, Murata, PN: GRM0335C1H1R8CA01.
- Inductor: 3.3 nH, 0201, Murata, PN: LQP03TN3N3B02.

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4.2 Simulated performance

Figure 2 shows the transfer function and return loss.

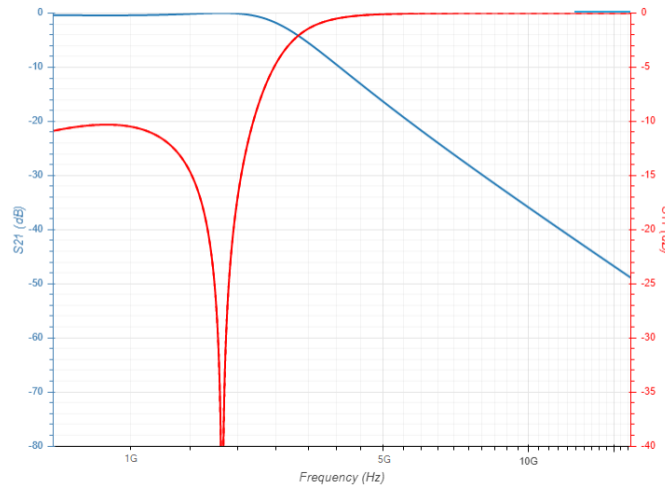


Figure 2. Transfer function and return loss of Pi filter

The simulated loss at fundamental power is ~0.35 dB while providing a second harmonic suppression of ~15 dB.

4.3 Measured performance

The influence of the daughterboard on the filter function was measured with a calibrated network analyzer connected through the SMA connectors to the filter on the daughterboard.

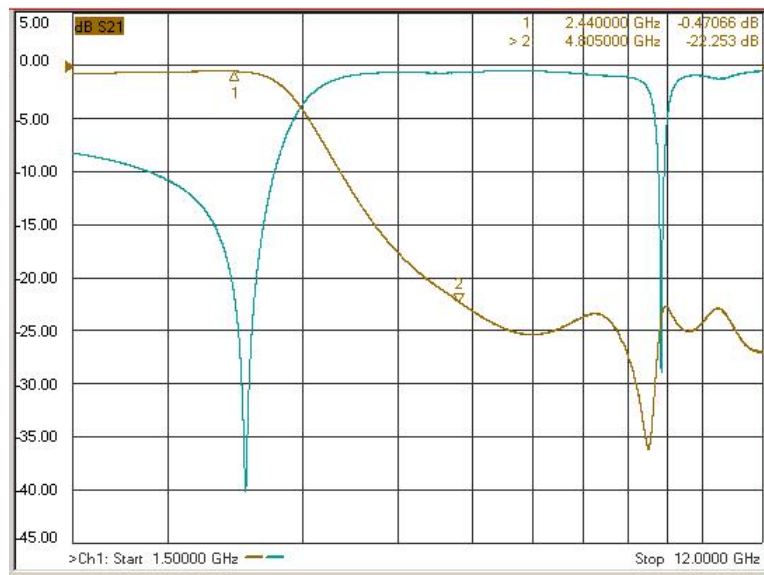


Figure 3. Measurement results of the Pi filter

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### 5 Conducted Performance

The measurements are performed using a calibrated spectrum analyzer and RF cables. The levels are measured at the SMA output of the device under test (DUT). All measurements are calibrated for cable losses.

The production test software (prod\_test.hex) from Renesas DA14535 SDK is used to set the device into Bluetooth LE TX and RX mode. This can be done with RF master of SmartSnippets Toolbox or with prodtest.exe using the commands "cont\_pkt\_tx" and "start\_pkt\_rx" (see Ref. [1] and Appendix 6.3 in Ref. [2]).

#### 5.1 TX measurements

##### 5.1.1 Conducted limits

There are different limits specified for the conducted TX measurements. Table 1 shows the limits for ETSI, FCC, and Japan.

**Table 1. Specification limits for conducted TX measurements**

Measurement	ETSI	FCC	Japan
TX Conducted	-30 dBm	-20 dBc	-26 dBm

##### 5.1.2 Measurement results

The test is performed at 2440 MHz, room temperature, and normal operating conditions. Measurements are done in burst mode, modulated signal.

**Table 2. Fundamental power and harmonics, Conducted mode, PA in 4 dBm mode**

	Fundamental	Second harm	Third harm	Fourth harm	Fifth harm
Without RFIO filter	3.56	-49.57	-42.50	-42.23	-38.43
With RFIO filter	2.83	-57.50	-62.27	-62.17	-63.30

**Note 1** All values in dBm.

#### 5.2 RX measurements

##### 5.2.1 Conducted limits

Limits for the conducted RX measurements can be found in Table 3.

**Table 3. Specification limits for conducted RX measurements**

Measurement	ETSI	Japan	Korea
RX conducted	-47 dBm	-47 dBm	-54 dBm

##### 5.2.2 Measurement results

The test is performed at 2402 MHz and the measurement frequency is 4882 MHz ( $2 \times (2440 + 1 \text{ MHz})$ ).

**Table 4. LO leakage in Conducted mode results**

Measurement	Without RFIO filter	With RFIO filter
LO Leakage Power	-42.18 dBm	-61.26 dBm

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Revision History

Revision	Date	Description
1.0	Nov 13, 2023	Initial version.

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## DA14535 Requirements for Spurious Reduction

### Status Definitions

Status	Definition
DRAFT	The content of this document is under review and subject to formal approval, which may result in modifications or additions.
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