# DA14533 Requirements for Spurious Reduction

This document contains guidelines for implementing a RFIO filter to reduce conducted and radiated spurious emissions in Bluetooth® low energy applications using Renesas DA14533 System-on-Chip.

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# 1. Terms and Definitions

| | |
|---|---|
| SoC | System-on-Chip |
| LE | Low Energy |
| DUT | Device under Test |
| RX | Receiver |
| SDK | Software Development Kit |
| SMA | SubMiniature version A |
| TX | Transmitter |

# 2. References

[1] UM-B-083, SmartSnippetsTM Toolbox, User Manual, Renesas Electronics.

[2] UM-B-119, DA1453x/DA1458x SW Platform Reference Manual.

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

# 3. Introduction

This document provides information on implementing a three-component Pi-filter for Renesas DA14533 System-on-Chip (SoC) in 2.4 GHz Bluetooth® Low Energy (LE) applications and 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.

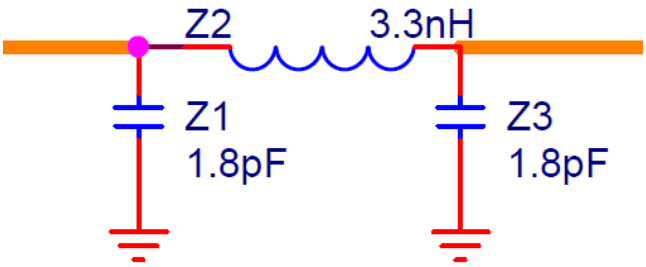


**Figure 1. Pi-filter topology**

The components used include:

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

## 4.2 Simulated Performance

Figure 2 shows the transfer function and return loss.

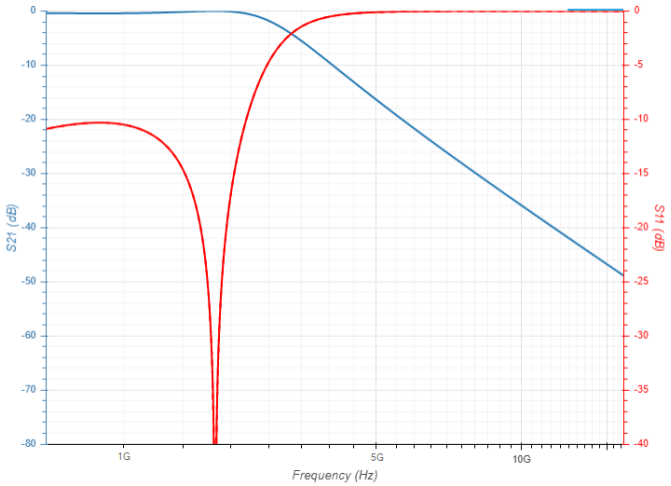


**Figure 2. Transfer function and return loss of Pi-filter**

The simulated loss of 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**

# 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 DA14533 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 | 4.29 dBm | -43.56 dBm | -42.03 dBm | -47.85 dBm | -36.17 dBm |
| With RFIO filter | 3.79 dBm | -58.8 dBm | -72.6 dBm | -74.3 dBm | -65.5 dBm |

## 5.2 RX Measurements

### 5.2.1 Conducted Limits

Table 3 shows limits for the conducted RX measurements.

**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 × (2440 + 1 MHz)).

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

| Measurement | Without RFIO filter | With RFIO filter |
|---|---|---|
| LO Leakage Power | -39.26 dBm | -55.26 dBm |

# 6. Revision History

| Revision | Date | Description |
|---|---|---|
| 01.00 | Mar 14, 2025 | First version. |

## 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. |
| APPROVED or unmarked | The content of this document has been approved for publication. |

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