# AN4148
# Application note

## Using the SPIRIT1 transceiver under ARIB STD-T93 in the 315 MHz band

**By Placido De Vita**

## Introduction

The SPIRIT1 is a very low power RF transceiver, intended for RF wireless applications in the sub-1 GHz band. It is designed to operate both in the license-free ISM and SRD frequency bands at 169, 315, 433, 868, 915 and 920 MHz.

The ARIB (Japanese association of radio industries and businesses) was established in response to several trends such as the growing internationalization of telecommunications, the convergence of telecommunications and broadcasting, and the need for promotion of radio related industries. The scope of the ARIB organization is to define the basic technical requirements for standard specifications of radio equipment.

This application note outlines the expected performance when using the SPIRIT1 under ARIB STD-T93 [2] in the 315 MHz band. For details on the regulatory limits in the 315 MHz frequency band, please refer to the ARIB STD-T93 regulations [2].

These can be downloaded from www.arib.or.jp/english/index.html

# Contents

# 1 An overview of ARIB STD-T93 regulation

The ARIB STD-T93 standard provides for telemetry radio equipment designed to automatically indicate and/or record the results obtained by measuring instruments located remotely; telecontrol radio equipment for transmission of signals to activate, change or deactivate the functions of devices located remotely by means of radio waves; data transmission radio equipment intended for the transmission of information to be processed primarily by machines, or of previously processed information that uses the frequency of 315 MHz. Expected application is air pressure monitoring equipment for tire and keyless entry systems for automotive. Audio and sound data is eliminated from this regulation.

The operating frequency band is defined as above 312 MHz to below 315.25 MHz. The antenna power for frequencies above 312 MHz and below 315.25 MHz must be below 25 µW (- 16 dBm) EIRP (equivalent isotropically radiated power). Also, antenna power (EIRP) shall be below 205 uW (- 6.9 dBm) when the center of the frequency band added deviation of frequency to occupied frequency band is between 312 MHz and 315.05 MHz.

There are no specific requirements for the modulation method, modulation rate, frequency deviation, coding type, and adjacent channel leakage power.

The permissible value for an occupied bandwidth (the bandwidth such that the mean power radiated below its lower frequency limit and above its upper frequency limit are each equal to 0.5% of the total mean power radiated by a given emission) shall be 1 MHz.

“Spurious emission” refers to the emission on a frequency or frequencies which are outside the permitted bandwidth and the level of which may be reduced without affecting the corresponding transmission of information, including a high harmonic emission, a low harmonic emission, a parasitic emission and an intermodulation product, but excluding an out-of-band emission.

“Out-of-band emission” refers to the emission which results from the modulation process on a frequency or frequencies outside the permitted bandwidth.

“Unwanted emission” refers to the emission consisting of the spurious emission and the out-of-band emission.

“Permissible value of the unwanted emission intensity” refers to the permissible value defined according to the mean power of unwanted emissions of each modulated frequency supplied to the feeder. Permissible value of the unwanted emission intensity is shown in *Table 1*.

For the receiver part, a conducted spurious component is defined. Permissible value of the receiver conducting spurious components is defined in *Table 2*.

**Table 1. value of the permissible value of the unwanted emission intensity**

| Frequency band [GHz] | Maximum permissible value of the unwanted emission intensity | | Reference bandwidth |
|---|---|---|---|
| | [nW] e.i.r.p. | [dBm] e.i.r.p. | |
| Below 1 | 250 | - 36 | 100 kHz |
| Above 1 | 1000 | - 30 | 1 MHz |

**Table 2. value of the conducted spurious component at receiver**

| Frequency band [GHz] | Maximum permissible value of the unwanted emission intensity | | Reference bandwidth |
|---|---|---|---|
| | [nW] EIRP | [dBm] EIRP | |
| Below 1 | 4 | -54 | 100 kHz |
| Above 1 | 4 | -54 | 1 MHz |

# 2 Application circuit

*Figure 1* shows an image of the SPIRIT1 application board. The application is made up of 2 boards: a daughterboard and a motherboard. The daughterboard contains the SPIRIT1 with the circuits necessary for it to work. For correctly functionality, the daughterboard must be plugged into the motherboard (see *Figure 2*) by two header 5x2 connectors (J6 and J7).

The motherboard is provided with an STM32L152VBT6 microcontroller to correctly program the transceiver. The microcontroller is programmed with firmware developed for the SPIRIT1 application. A graphical user interface (GUI) is developed to correctly program the SPIRIT1.

The daughterboard is provided with a 52 MHz XTAL to provide the correct oscillator to the SPIRIT1.

The SPIRIT1 has an internal SMPS that drastically reduces power consumption, making it the best-in-class for application on this bandwidth. The SMPS is fed from the battery (1.8 V to 3.6 V) and provides the device with a programmable voltage (1.4 V typical). An SMA connector is present to connect the board to an antenna or to instrumentation to verify the correct functionality and verify the ETSI standard request.

A few of passive devices (inductors and capacitors) are used for matching/filtering in the power amplifier (PA) and balun network for the receiver.

To reduce application costs, the SPIRIT1 is designed to work without an external antenna switch. The daughterboard is designed to show the SPIRIT1 functionality in this condition. Clearly, an application with antenna switch can be realized, but this is not described in this document.

**Figure 1. SPIRIT1 application daughterboard**

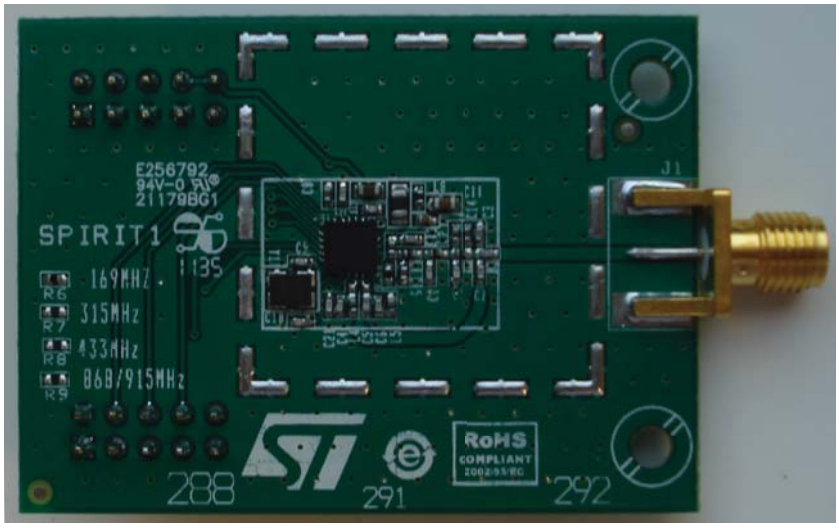


**Figure 2. SPIRIT1 application daughterboard plugged into the motherboard**

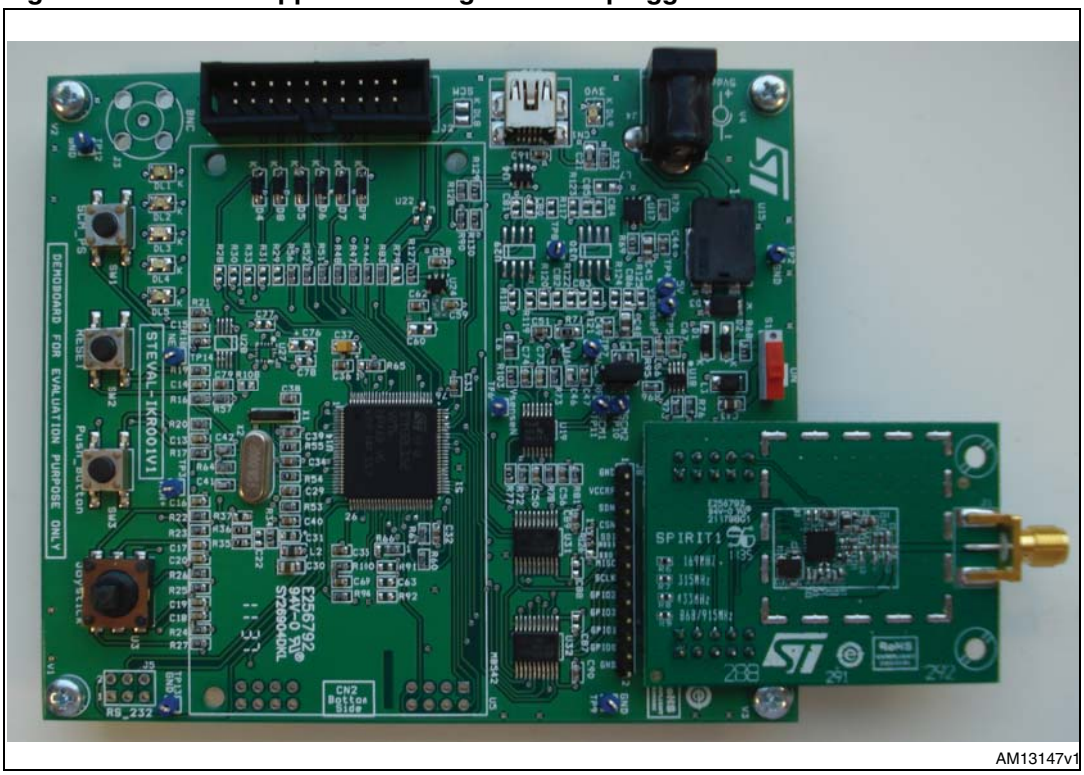
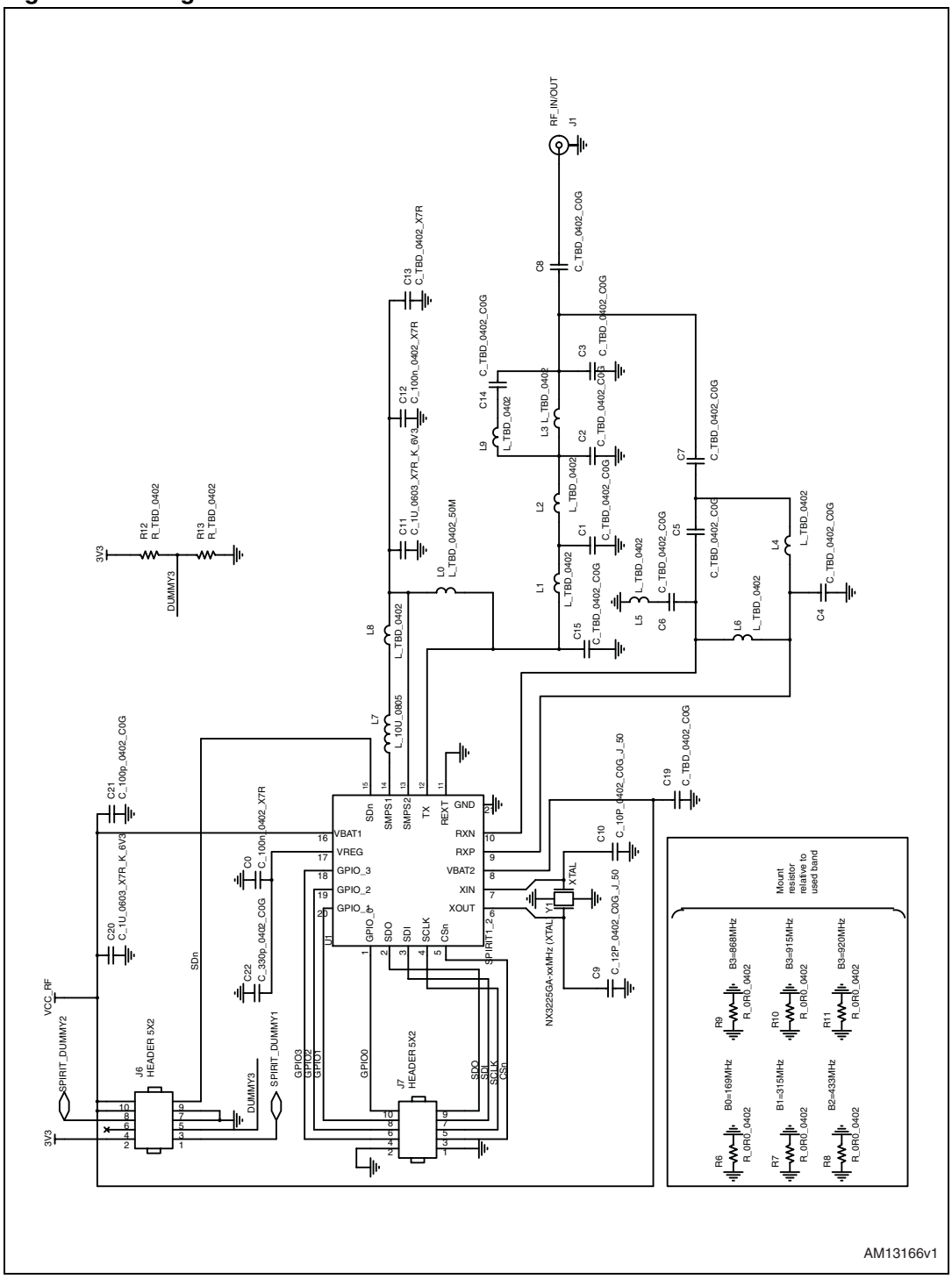


**Figure 3. Daughterboard schematic**



# 3 Transmitter parameter

All of the measurements reported here are measured using the following parameters: Tc = 25 °C, Vdd = 3.0 V, f = 313.5 MHz (middle frequency of the useful bandwidth), unless otherwise specified.

The maximum output power of the SPIRIT1 in this band is 10 dBm, so all the measurements are performed at the levels required by the standard, that is - 16 dBm.

The permissible value for an occupied bandwidth defined in the standard is 1 MHz. The occupied bandwidth from the SPIRIT1 when the maximum permitted data rate and deviation are used is lower than 1 MHz, so no measurements are performed to verify this parameter.

There are no specific requirements in the standard about setting of detector or video bandwidth (VBW) of the spectrum analyzer used for the measurement. The detector will be set to peak, the video bandwidth will be set equal to the resolution bandwidth, and the display will be set to peak hold.

## 3.1 Permissible values for spurious emission intensity

“Spurious emission” refers to the emission on a frequency or frequencies which are outside the permitted bandwidth and the level of which may be reduced without affecting the corresponding transmission of information, including a high harmonic emission, a low harmonic emission, a parasitic emission and an intermodulation product, but excluding an out-of-band emission.

“Out-of-band emission” refers to the emission which results from the modulation process on a frequency or frequencies outside the permitted bandwidth.

“Unwanted emission” refers to the emission consisting of the spurious emissions and the out-of-band emissions.

“Permissible value of the unwanted emission intensity” refers to the permissible value defined according to the mean power of unwanted emissions of each modulated frequency supplied to the feeder. Permissible values of the unwanted emission intensity are shown in *Table 1*. The measurements performed are printed in *Figure 4* and *5*. From these images it is possible to see that all of the requirements are met.

**Figure 4. TX spurious emission below 1 GHz**

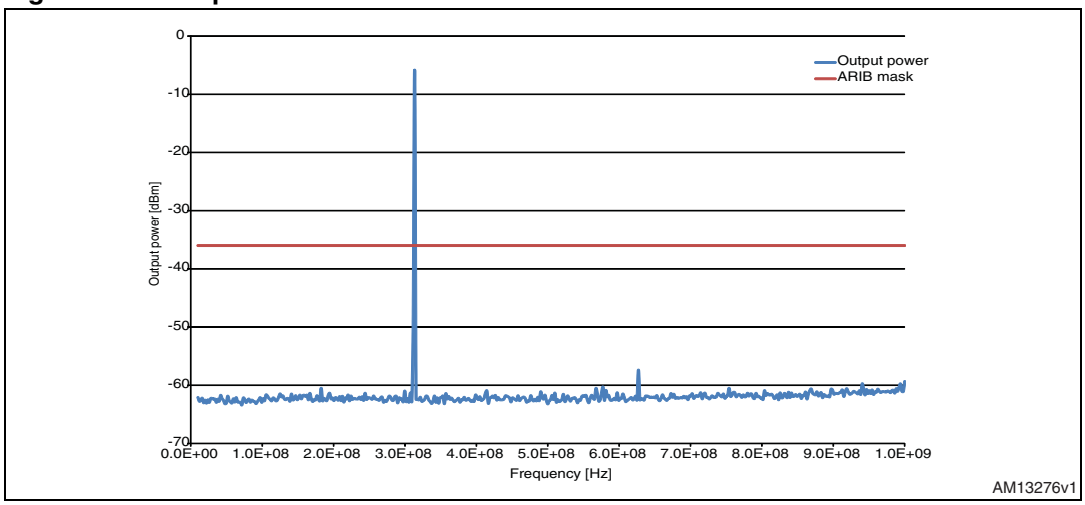
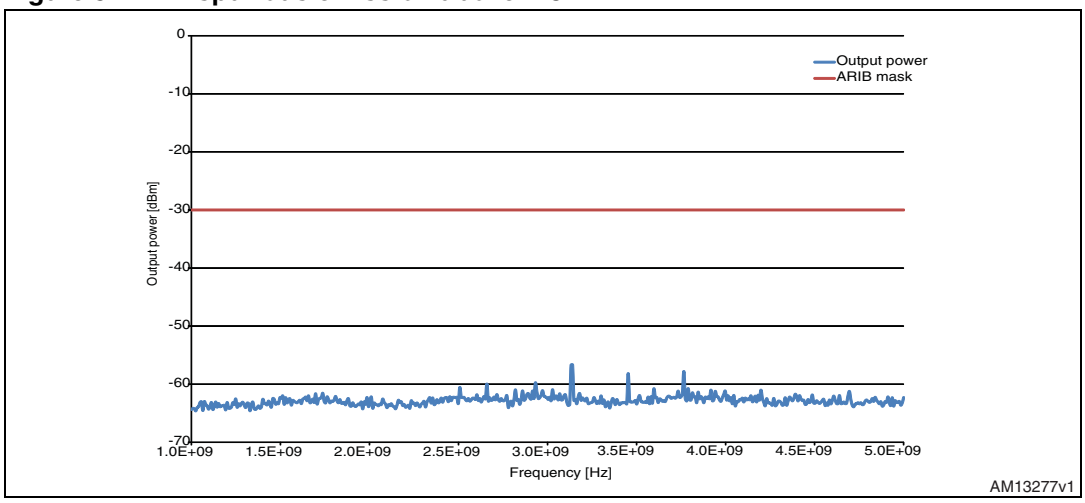



**Figure 5. TX spurious emission above 1 GHz**



# 4 Receiver parameter

ARIB compliance in ARIB STD-T93 [2] in the 312 to 315.25 MHz band only pertains to emissions and harmonics. There are no receiver sensitivity, selectivity or blocking measurements to comply with ARIB STD-T93 standard [2].

## 4.1 Conducted spurious component at receiver

Spurious radiation from the receiver are components at any frequency, radiated by the equipment. The spurious emission strength at the antenna input must be less than the values in *Table 2*.

The measurement results are shown in *Figure 6* and *7*. All standard requirements are met from the SPIRIT1 in receiver mode.

**Figure 6. TX spurious emission below 1 GHz**

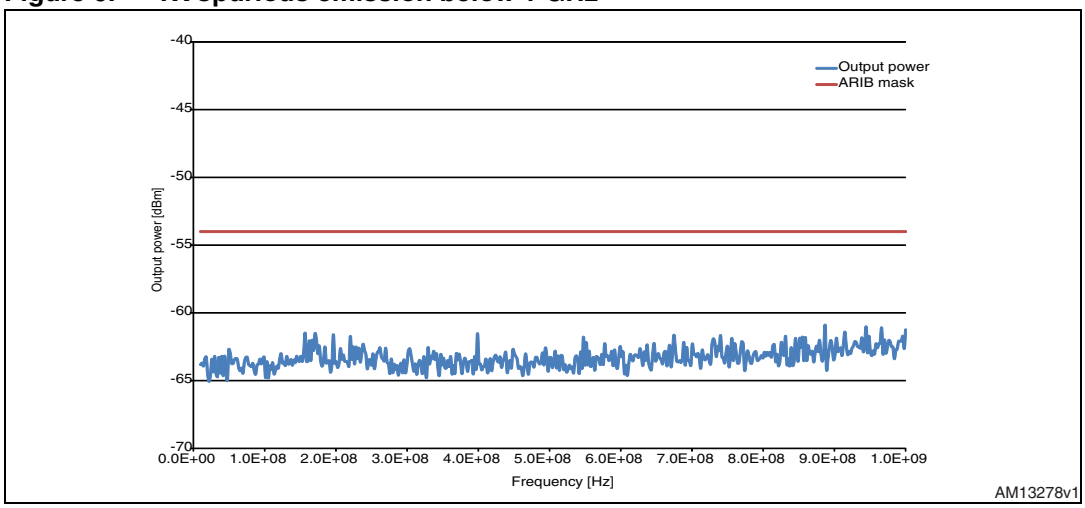
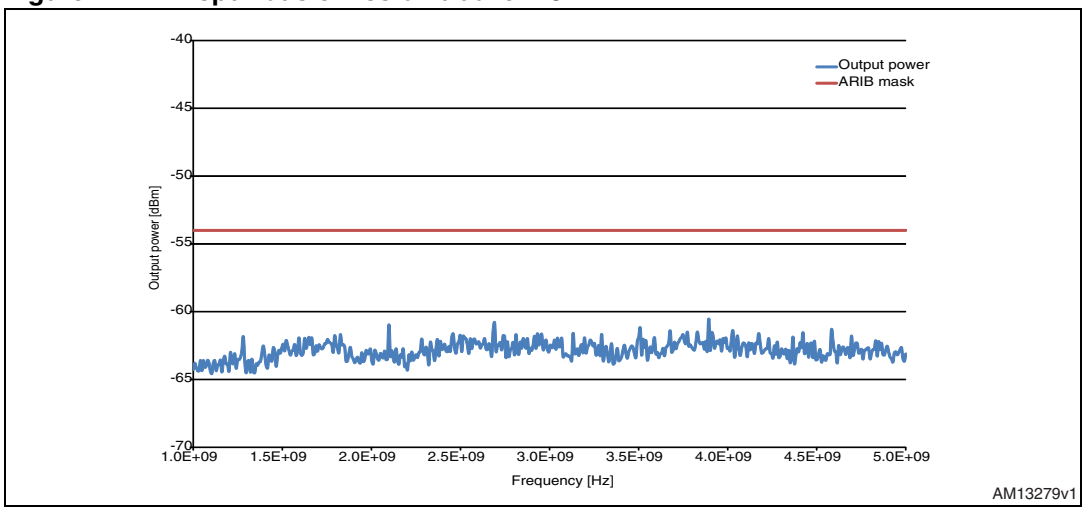



**Figure 7. TX spurious emission above 1 GHz**



# 5 Reference

1. SPIRIT1 datasheet
2. ARIB STD-T93: “315 MHz band telemeter, telecontrol and data transmission radio equipment for specified low-power radio station”

# 6 Revision history

Table 3. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 06-Aug-2012 | 1 | Initial release. |