Application note

SAW filter usage for the ST25RU3993-EVAL board

Introduction

The Japanese UHF RFID radio standard ARIB STD-T106 and the corresponding test method document TELEC – T240 defines the permitted Japanese out-of-band emission frequencies. To comply with these requirements when operating at full power (30 dBm), a SAW filter has to be fitted to the ST25RU3993-EVAL boards transmit path.

This document describes:

1. The definition of a suitable SAW filter and how to fit this filter on the ST25RU3993-EVAL board.
2. How to increase the output power of the ST25RU3993-EVAL board.
3. A measurement methodology carried out according to the ARIB STD-T106 standard and the corresponding test method description TELEC – T240.
4. A set of results for the selected SAW filter together with the associated analysis.

1 Acronyms

Table 1. List of used acronyms

Acronym	Definition
SAW	Surface acoustic wave
UHF	Ultra high frequency
RFID	Radio frequency identification
ARIB STD-T106	Japanese standard for 920MHz-band RFID equipment for premises radio station (association of radio industries and businesses)
TELEC – T240	Method of measurement for radio equipment for premise radio station using the frequency of 916.7MHz and more to 920.9MHz or less (telecom engineering center)
PA	Power amplifier
GUI	Graphical user interface
IC	Integrated circuit
PCB	Printed circuit board
S21	Forward transmission coefficient

2 Board modifications

2.1 SAW filter characteristics

In order to insert the SAW filter, the ST25RU3993-EVAL board requires a modification which is outlined in Section 2.2 and Section 2.3 .

In the ARIB STD-T106 standard, there are four high power channels (1W) available for the Japanese UHF RFID frequency band [1]:

- 916.8 MHz
- 918.0 MHz
- 919.2 MHz
- 920.4 MHz

ARIB STD-T106 defines the maximum emission levels to avoid cross channel interference.

In order to limit cross channel the SAW filter must be placed on the TX-path of the reader. The selected SAW filter type is TA1471A which is manufactured by TAI-SAW TECHNOLOGY [2]. The typical frequency characteristic of the selected SAW filter is illustrated Figure 1 and Figure 2.

Figure 1. Typical frequency characteristic of the TA1471A

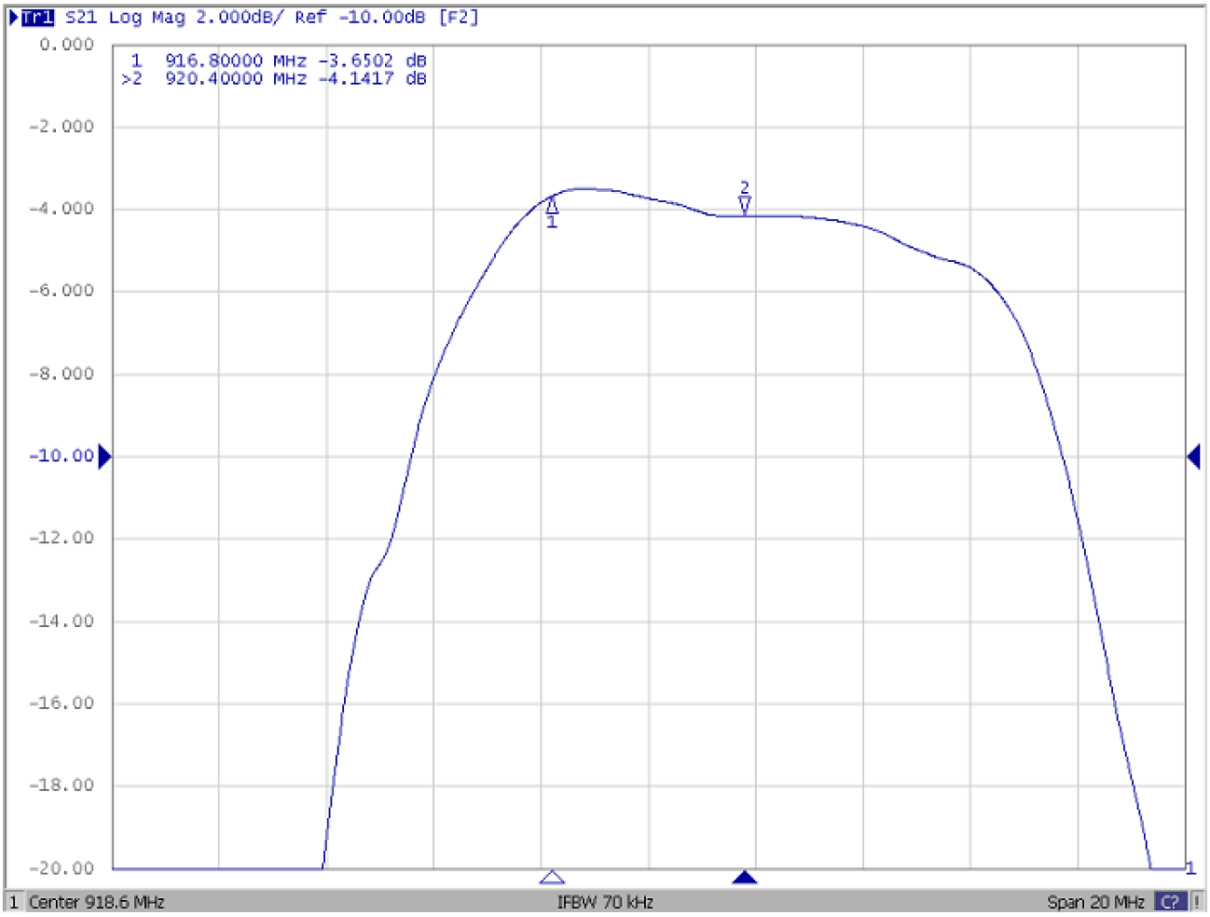
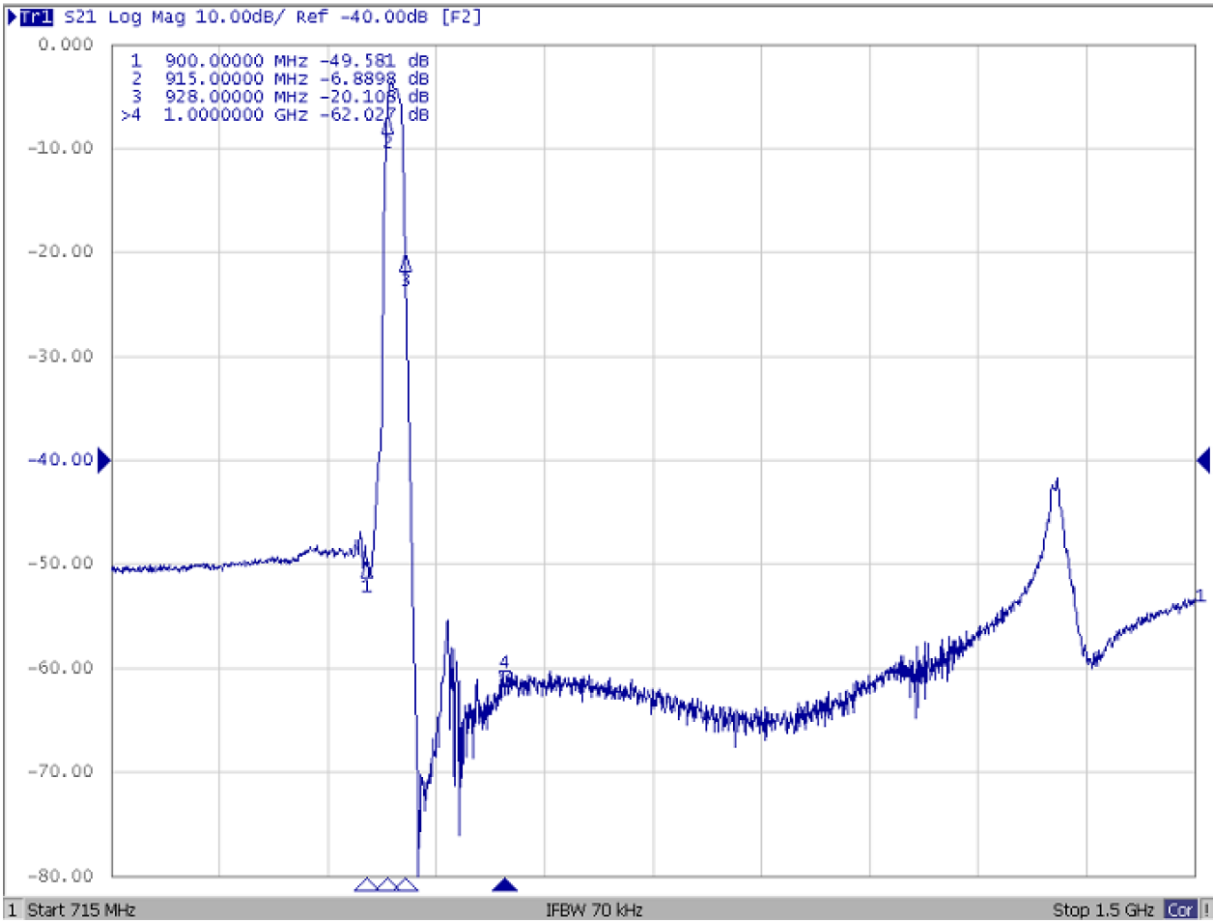


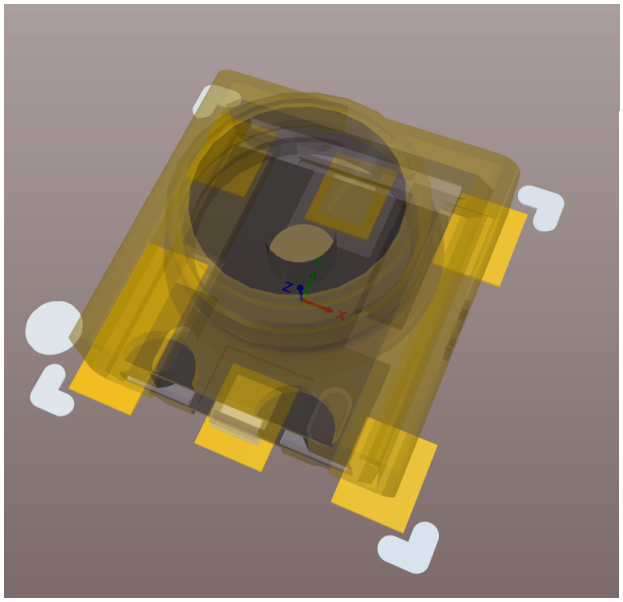
Figure 2. **Overview of the SAW filter frequency characteristic**



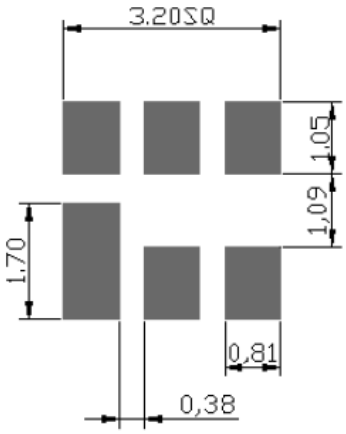
2.2 SAW filter mounting

The ST25RU3993-EVAL board is designed to accommodate either a 50 Ohm coax testpoint or a SAW filter on J1. Both components share the same footprint (see Figure 3).

Figure 3. Coax switch and SAW filter footprint

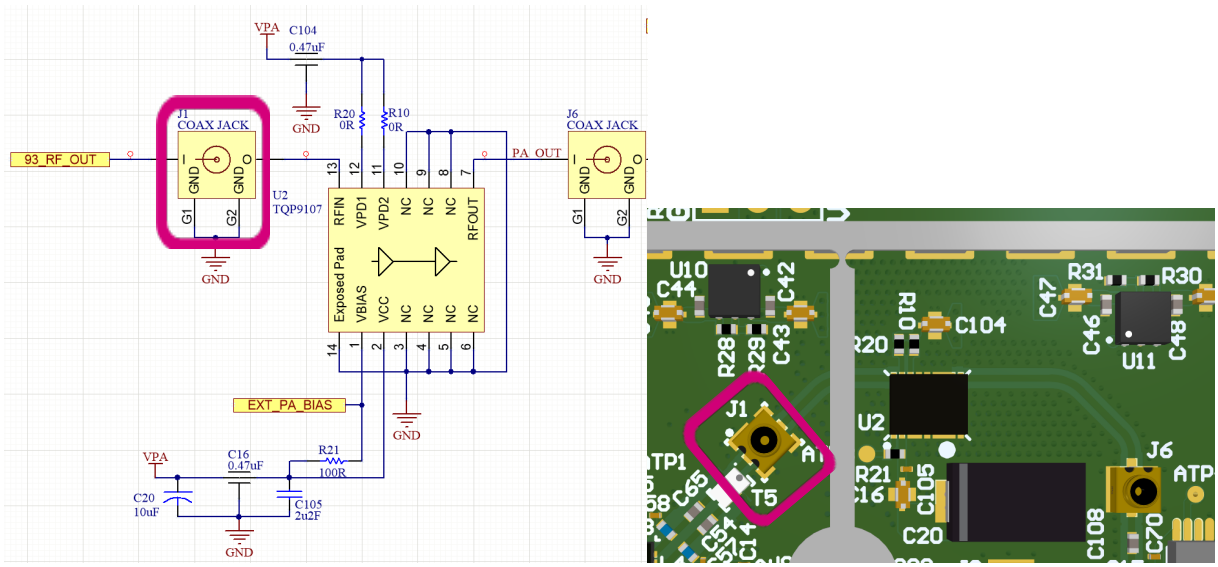


PCB Footprint:



The J1 footprint is located between the ST25RU3993 IC U5 and the power amplifier U2. Figure 4 illustrates the schematic and layout of this section highlighting the position of J1.

Figure 4. Schematic and layout of the external power amplifier section

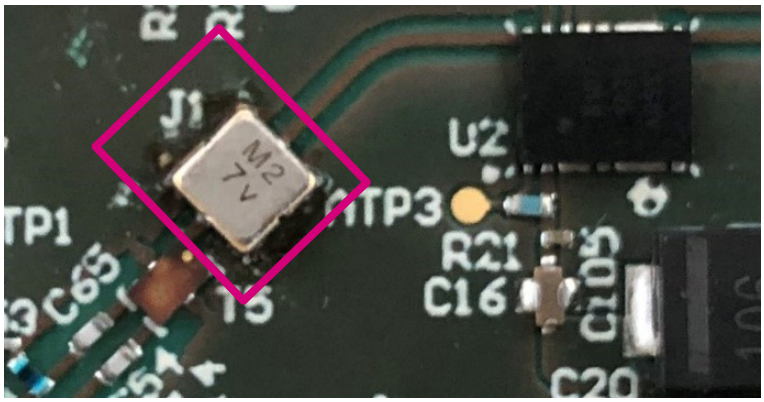


Note: For more information refer to [3]

To remove the coax switch on J1, preheat the PCB from the bottom before unsoldering it.

After removing J1 and cleaning the footprint area, solder the SAW filter to the board as illustrated in Figure 5 (pink mark).

Figure 5. **SAW filter mounting**



2.3 External power supply for the PA

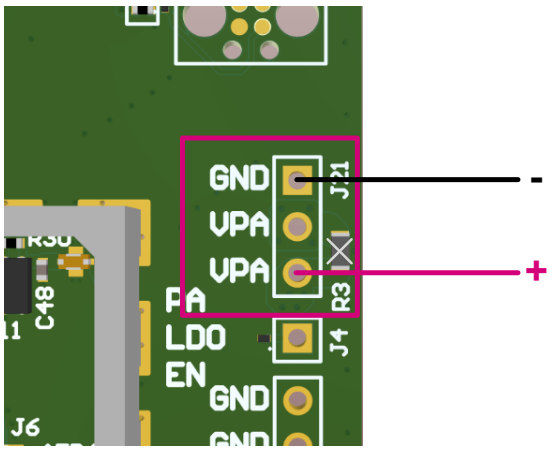
When fitting a SAW filter on the transmission path, the output power available to the reader is reduced by the power used and dissipated by the introduction of the SAW filter. To compensate for the additional power consumption, the power amplifier on the ST25RU3993-EVAL board must be supplied with a higher voltage level. A higher supply voltage level requires an external voltage supply for the power amplifier on the ST25RU3993-EVAL board.

The ST25RU3993-EVAL board is designed to optionally supply the power amplifier with an external voltage source.

In order to supply the power amplifier with this external supply, the resistor R3 must be removed. The external voltage supply is then connected as shown in Figure 6.

Note: The minimum supported current is 800 mA. The maximum voltage is 5 V.

Figure 6. **External supply of the PA to increase output power**



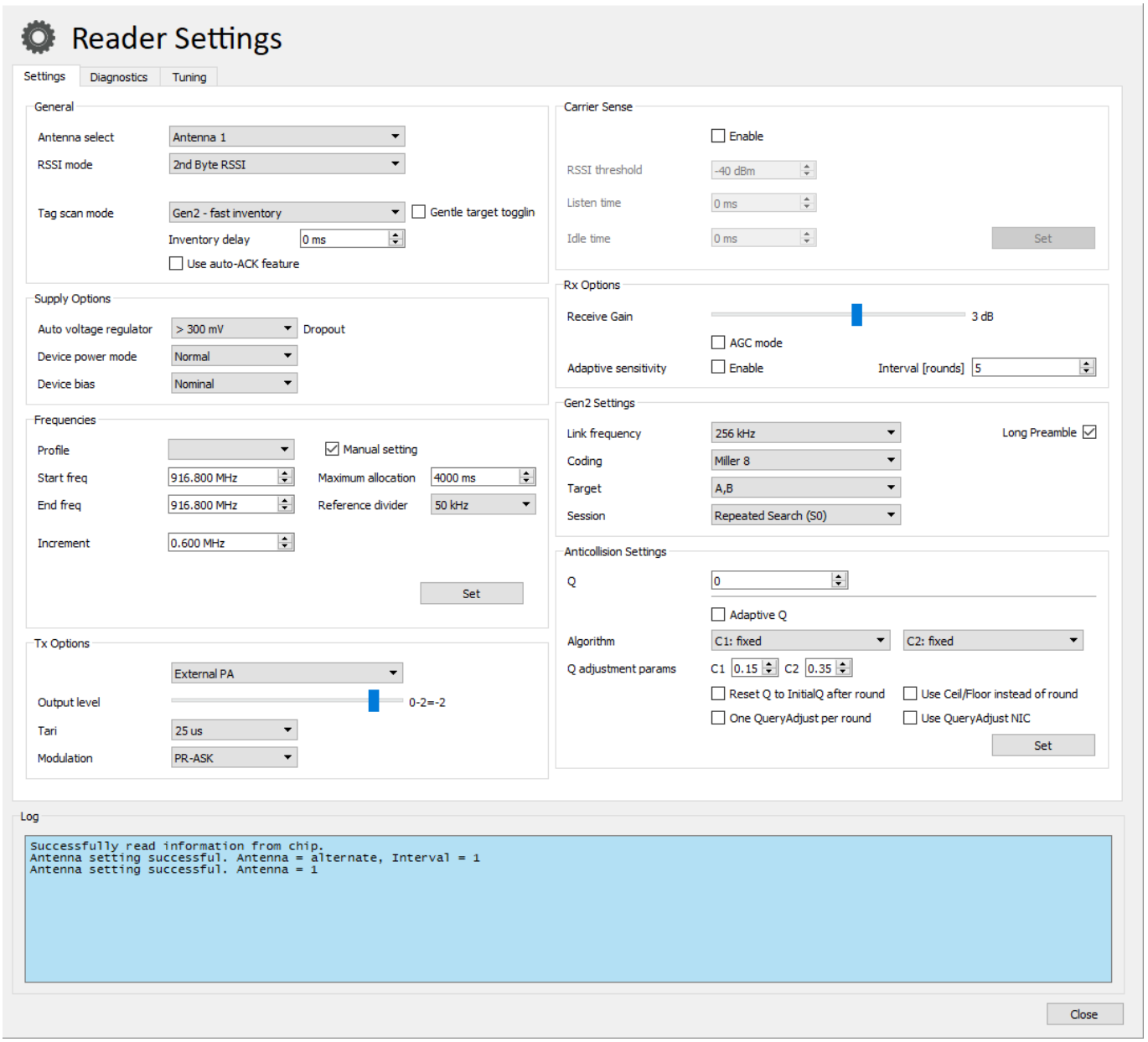
3 Measurement setups

This section outlines the setup to perform emission measurements which proves that the installation of the SAW filter allows the ST25RU3993-EVAL board to comply with requirements of ARIB STD-T106.

3.1 Reader settings

Figure 7 shows the reader settings required for the emission measurements which can be configured in the ST25RU3993-EVAL board GUI [4].

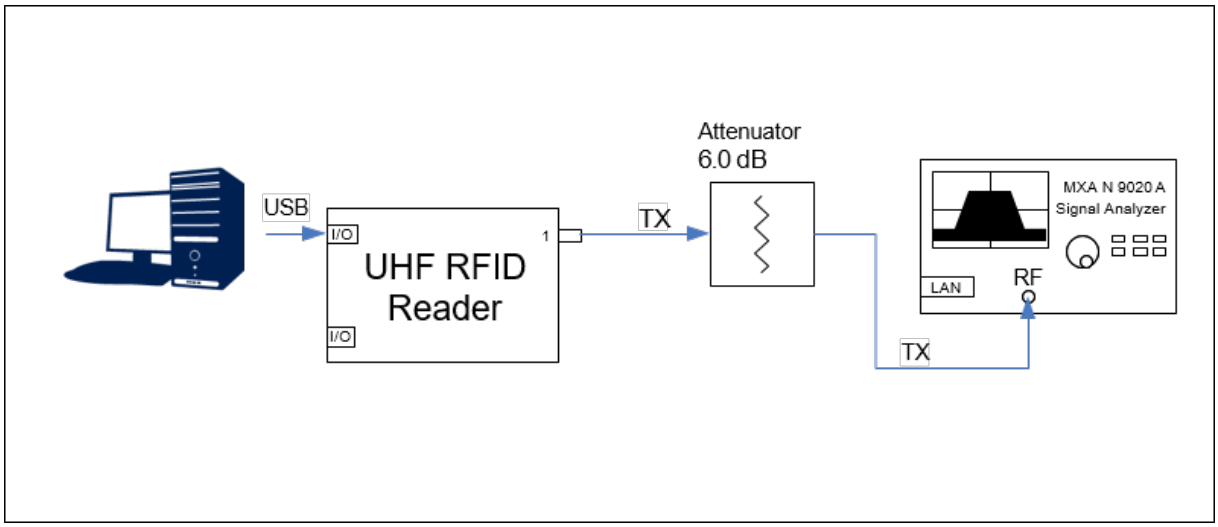
Figure 7. Reader settings



3.2 Adjacent channel leakage power measurement

The reader's antenna port is directly connected to the signal analyzer via a 6 dB attenuator. (see Figure 8).

Figure 8. Adjacent channel leakage power measurement - block diagram



4 Adjacent channel leakage power (TELEC – T240) results

ARIB STD-T106 states the following limits:

- The spectral power at both edges of a radio channel shall be ≤ 10 dBm.
- The leakage power in a unit radio channel adjacent to a radio channel (200 kHz) shall be ≤ 0.5 dBm.

These results are described in detail in [1].

Figure 9 and Figure 10 show the TELEC – T240 test results. The main different with the ARIB STD-T106 standard is the lower resolution bandwidth and lower video bandwidth (see reference [5] for more details).

Figure 9. Adjacent channel leakage power results without SAW filter (TELEC – T240)

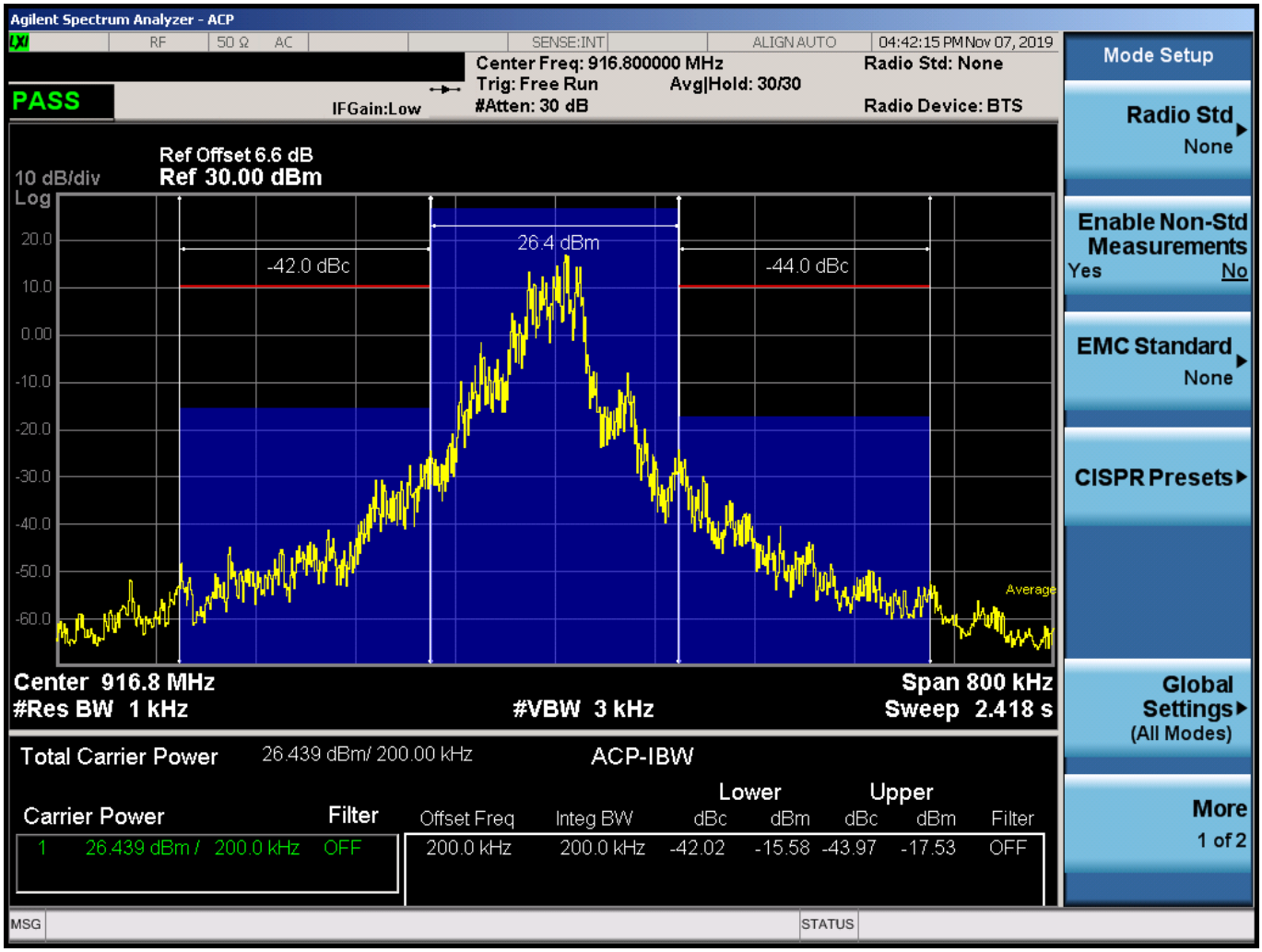
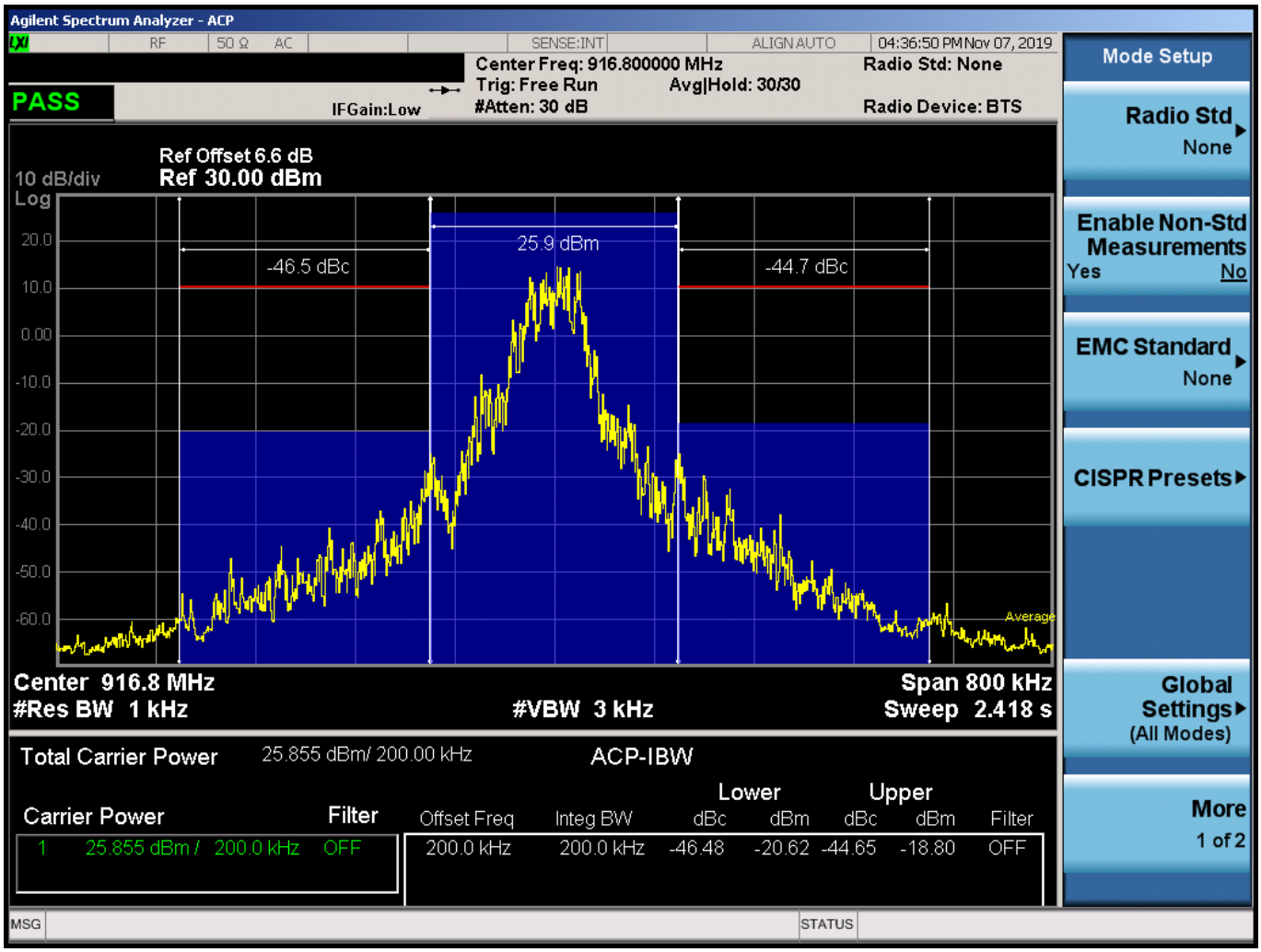


Figure 10. Adjacent channel leakage power results with SAW filter (TELEC – T240)



The leakage power is shown in Figure 9.

The adjacent channel leakage power results according TELEC – T240 are summarized in Table 2

Table 2. Summary of the adjacent channel leakage power results (TELEC – T240)

Reader	L. spectral power (916.6 MHz)	U. spectral power (917 MHz)	L. leakage power (916.6 MHz)	U. leakage power (917 MHz)
without SAW filter	-15.6 dBm	-17.5 dBm	-42 dBc	-44 dBc
withSAW filter	-20.6 dBm	-18.8 dBm	-46.5 dBc	-44.7 dBc

The following conclusions can be made:

- The spectral power passes the limit of ≤ 10 dBm at both edges of a radio channel with and without SAW filter.
- The leakage power in a unit radio channel adjacent to a radio channel passes the limits of ≤ 0.5 dBm with and without SAW filter.

5 Conclusion: adjacent channel leakage power

The results in Figure 9 and Figure 10 demonstrate that the SAW filter improves the leakage power levels for lower radio channel at the lower band edge. This is especially visible in the lower adjacent channel where the measurement results are significantly improved.

The improvements for the other radio channels in the allowed band are negligible due to the pass band characteristics of the SAW filter in use.

6 Reference

Table 3. Document reference list

	Reference documents
[1]	ARIB_STD-T106, *920MHz-band RFID equipment for premises radio station.*
[2]	Tai-SAW_Technology, *SAW Filter 918.6 MHz, Model No.: TA1471A, Datasheet*.
[3]	*ST25RU3993-EVAL board* UM2353.
[4]	*ST25RU3993-EVAL board software* UM2268.
[5]	TELEC_T240, *Method of measurement for radio equipment for premise radio station using the frequency of 916.7MHz and more to 920.9MHz or less,* 2004.

Revision history

Table 4. **Document revision history**

Date	Revision	Description of changes
19-Nov-2019	1	Initial release.

Contents

List of figures

List of tables