



Using the AX-SFJK / AX-SFJK-API under ARIB STD-T108

APPLICATION NOTE

ABSTRACT

This application note outlines the expected performance when operating the AX-SFJK / AX-SFJK-API Sigfox™ verified transceiver under ARIB STD-T108 v1.0. Lab measurements show that the AX-SFJK / AX-SFJK-API meet the ARIB STD-T108 requirements. The evaluation kit DVK-SFJK-1-GEVK v1.0 (PCB marked F143-MINI-DVK-ARIB REV 1.0) was used for measurements.

ARIB-STD-T108 REQUIREMENTS

The AX-SFJK / AX-SFJK-API transmit at 923.2 MHz with transmit power < 20 mW (13 dBm). It operates under the ARIB-STD-T108 as a “Low Power Radio Station” in the frequency band $922.3 \text{ MHz} < f < 928.1 \text{ MHz}$, using one unit radio channel of 200 kHz BW centered at 923.2 MHz. The corresponding spectral mask defining the limits for TX operation is given in Table 1 and Figure 1: The limit on emissions into the lower and upper adjacent channels is -15 dBm. Below the lower adjacent channel and above the upper adjacent channel the -36 dBm limit from the 915 MHz to 930 MHz band applies. $N = 1$ for AX-SFJK / AX-SFJK-API.

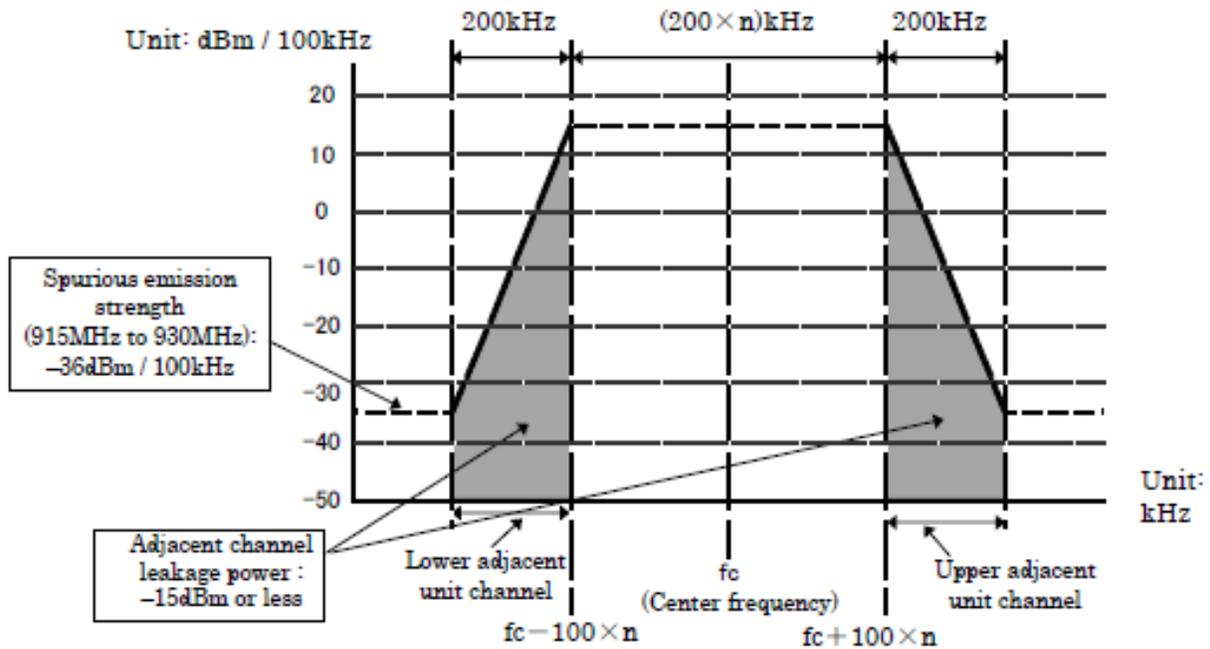
Table 3-16 Permissible Values for Unwanted Emission Intensity (Antenna input)

Frequency band	Spurious emission strength (average power)	Reference bandwidth
$f \leq 710 \text{ MHz}$	-36 dBm	100 kHz
$710 \text{ MHz} < f \leq 900 \text{ MHz}$	-55 dBm	1M Hz
$900 \text{ MHz} < f \leq 915 \text{ MHz}$	-55 dBm	100 kHz
$915 \text{ MHz} < f \leq 930 \text{ MHz}^*$ (Except for $ f-f_c \leq (200+100 \times n) \text{ kHz}$ if bandwidth of unit radio channel is 200 kHz, except for $ f-f_c \leq (100+50 \times n) \text{ kHz}$ if bandwidth of unit radio channel is 100 kHz. Except for $ f-f_c \leq (100+100 \times n) \text{ kHz}$ if frequency band is $915.9 \text{ MHz} \leq f \leq 916.9 \text{ MHz}$ and $920.5 \text{ MHz} \leq f \leq 922.3 \text{ MHz}$. Where n is a number of unit radio channels constituting the radio channel and is an integer from 1 to 5)	-36 dBm	100 kHz
$930 \text{ MHz} < f \leq 1000 \text{ MHz}$	-55 dBm	100 kHz
$1000 \text{ MHz} < f \leq 1,215 \text{ MHz}$	-45 dBm	1M Hz
$1,215 \text{ MHz} < f$	-30 dBm	1M Hz

* Permissible Values for Unwanted Emission Intensity in $915 \text{ MHz} < f \leq 925 \text{ MHz}$ shall be -55 dBm/100 kHz, before July 24, 2012.

Table 1: Permissible Values for Unwanted Emission Intensity. For AX-SFJK / AX-SFJK-API operation at 923.2 MHz the bandwidth of the unit radio channel is 200 kHz and $n = 1$. The RMS detector should be used.

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(Note: Center frequency is one of frequencies shown in Table 3.11 to Table 3.15 of 3.2.3 Radio channel and n is a number of unit radio channels constructing a radio channel.)

Figure 1. The limit on emissions into the lower and upper adjacent channels is -15 dBm. Below the lower adjacent channel and above the upper adjacent channel the -36 dBm limit from the 915 MHz to 930 MHz band applies. N = 1 for AX-SFJK / AX-SFJK-API.

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Conducted TX Measurement Results

The following figures display the results of conducted measurements on the AX-SFJK evaluation kit

DVK-SFJK-1-GEVK v1.0 (PCB marked F143-MINI-DVK-ARIB REV 1.0), showing compliance with the limits described above.

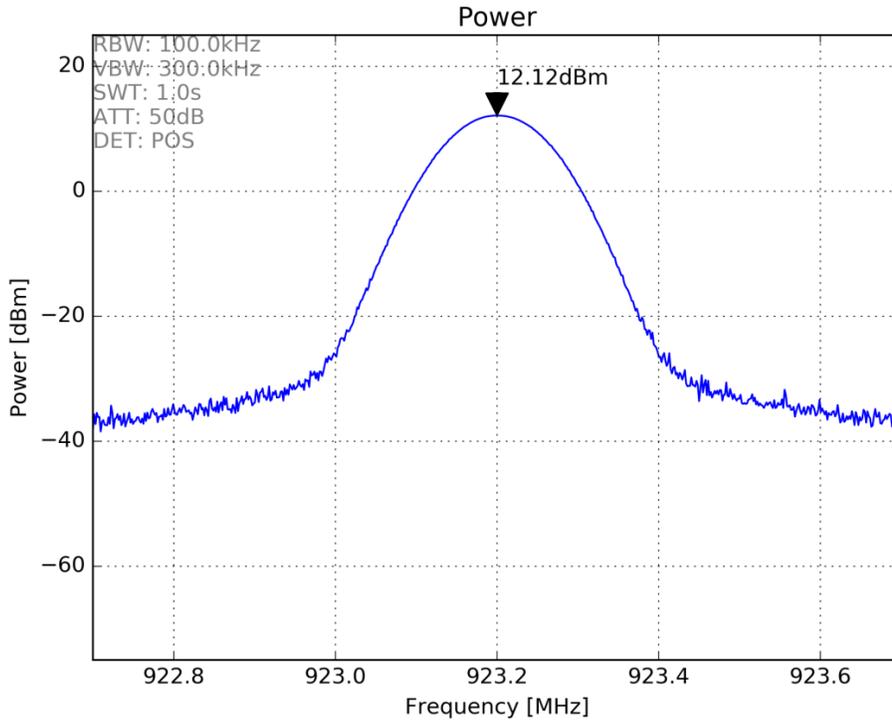


Figure 2. Channel power measurement. The regulatory limit is 13 dBm.

Emissions in the spurious domain

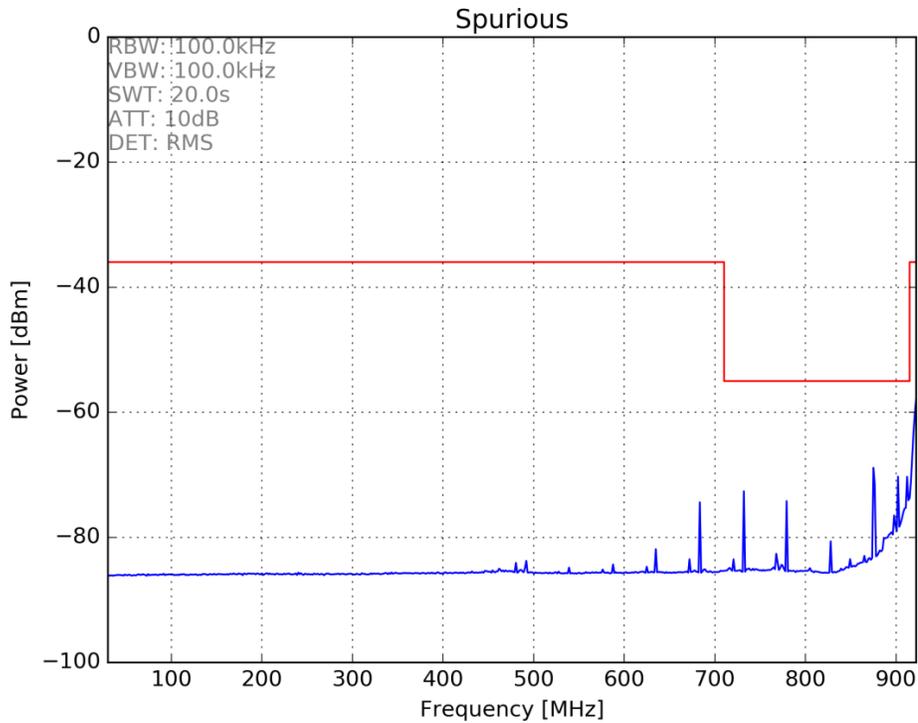


Figure 3. Spurious emission 40 MHz – 915 MHz. The transmit frequency is 923.2 MHz. (Note: The region from 710 MHz -- 900 MHz shall be measured with RBW = 1 MHz, rather than 100 kHz. It is shown separately in Figure 4).

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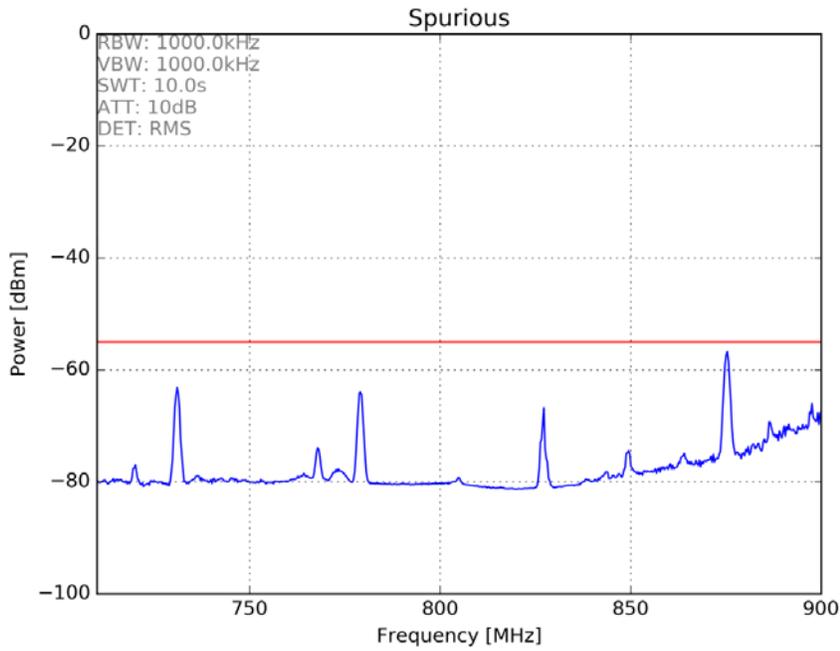


Figure 4. Spurious emission 710 MHz – 900 MHz. The transmit frequency is 923.2 MHz.

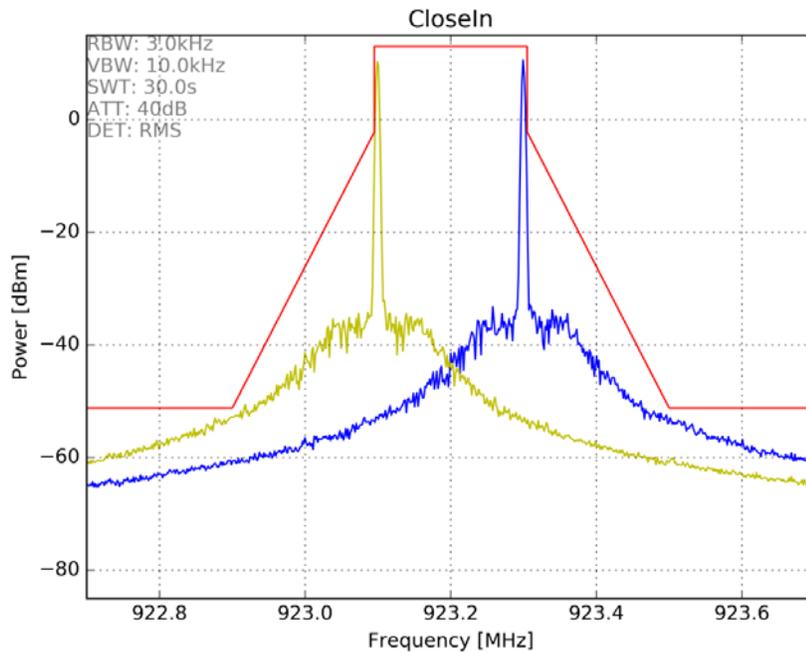


Figure 5. Close in spectrum.

The device uses one unit radio channel of 200 kHz BW centered at 923.2 MHz. The regulatory limit is -36dBm in 100 kHz RBW from 915.0 to 922.9 MHz and from 923.5 MHz to 930.0 MHz. The measurement was performed with RBW= 3 kHz. The red limit line represents the limits from Figure 1 corrected by 15.2 dB = $10 \cdot \log_{10}(100/3)$ dB to account for the difference in RBW. (The corrected limit line applies to continuous energy, rather than localized peaks. The + 13dBm in-band region is not corrected.) The two

spectra show transmissions at the edges of the frequency range utilized by the device, 923.2 MHz +/- 96 kHz, to show compliance at the most critical points (922.9 MHz and 923.5 MHz). Note: In the default configuration the device only transmits at 923.2 MHz +/- 18 kHz. The +/- 96 kHz represent a possible future extension of the Sigfox standard. The regions from 915.0 MHz – 922.2 MHz and 924.2 MHz – 930.0 MHz are not displayed. There are no significant peaks in this region.

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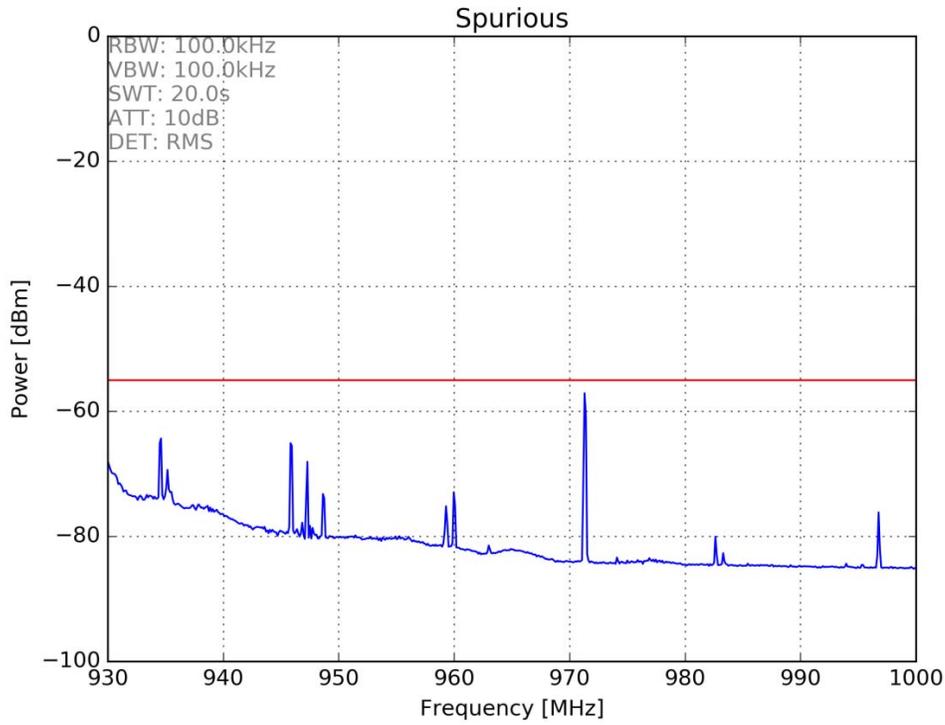


Figure 6. Spurious emission 930 MHz – 1000 MHz. The transmit frequency is 923.2 MHz.

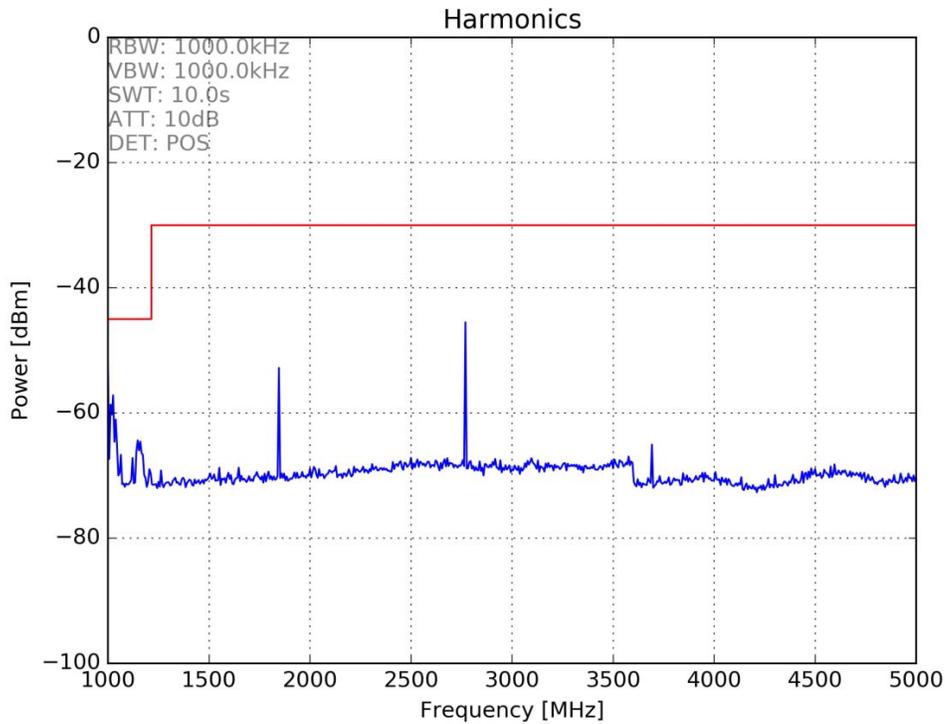


Figure 7. Spurious emission 1000 MHz – 5000 MHz. Transmit frequency is 923.2 MHz.

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Table 1: Adjacent channel leakage power. TX of modulated carrier at the center frequency 923.2 MHz as well as at the highest and lowest frequencies utilized by the device, 923.2 MHz +/- 96 kHz. The regulator limit is -15 dBm.

Channel	Energy [dBm]	Measurement Conditions
Lower Adjacent Channel (922.9 MHz – 923.1 MHz)	-45.6	TX modulated carrier (AT\$CB=-1,1) at 923.2 MHz, RBW=1 kHz, VBW = 3 kHz, detector RMS
Upper Adjacent Channel (923.3 MHz – 923.5 MHz)	-45.7	TX modulated carrier (AT\$CB=-1,1) at 923.2 MHz, RBW=1 kHz, VBW = 3 kHz, detector RMS
Lower Adjacent Channel (922.9 MHz – 923.1 MHz)	-35.4	TX modulated carrier (AT\$CB=-1,1) at 922.24 MHz, RBW=1 kHz, VBW = 3 kHz, detector RMS
Upper Adjacent Channel (923.3 MHz – 923.5 MHz)	-34.7	TX modulated carrier (AT\$CB=-1,1) at 923.296 MHz, RBW=1 kHz, VBW = 3 kHz, detector RMS

Reducing spurious emissions

The spectrum of the AX-SFJK / AX-SFJK-API (evaluation kit DVK-SFJK-1-GEVK v1.0, PCB marked F143-MINI-DVK-ARIB REV 1.0) contains a spurious peak 48 MHz above the carrier frequency, at 971.2 MHz. The power of this spur is close to the regulatory limit of -55dBm, according to Figure 6. In typical applications this spur is suppressed by the limited bandwidth of the antenna.

However, if necessary, this peak can be reduced by increasing the filtering action of filter stage adjacent to the antenna (see Figure 8). This is a low pass filter with a notch around 1230 MHz. The parallel tank LF1 || CF3 determines the position of the notch. The capacitors CF1 and CF2 determine the steepness and depth of the notch. It is recommended to adjust the values of CF1 and CF2.

Change	Measured reduction of spur at 971.2 MHz	Measured reduction of TX power at 923.2 MHz
CF1, CF2 4 pF → 4.7 pF	1.5 dB	0.25 dB
CF1, CF2 4 pF → 5.6 pF	3 dB	0.5 dB

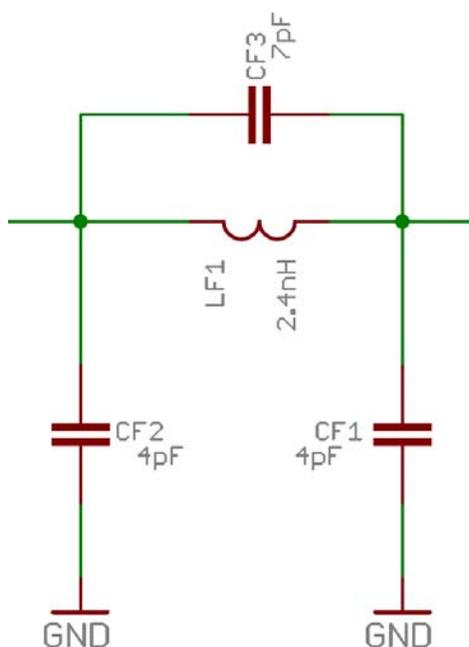


Figure 8. Low pass filter used in evaluation kit DVK-SFJK-1-GEVK v1.0. (PCB marked F143-MINI-DVK-ARIB REV 1.0).

References

[ARIB STD-T108 English Translation](#)

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