

Si446x AND FCC PART 90 COMPLIANCE AT 450–470 MHz

1. Introduction

This application note demonstrates the compliance of Si446x RFICs with the regulatory requirements of FCC Part 90 in the 450-470 MHz band. As will be shown, best compliance is obtained when the RFIC is configured for a transmit power level of approximately +10 dBm. Any of the chips within the Si446x family (e.g., Si4460, Si4461, Si4463, Si4464, Si4467, or Si4468) can provide this level of transmit power and could be used to demonstrate compliance; the measurements presented within this document were taken with a Si4463-B1 RFIC mounted on a 4463-PCE20C460-EK RFSW Pico RF Test Card (see "5. Reference Design Schematic" on page 34).

The Si446x chip was configured to transmit at the desired power level(s) by appropriate settings of the PA_PWR_LVL property. Various data rates and deviations were chosen in order to comply with the permissible channel spacings and occupied bandwidths. The tests were performed at room temperature with a supply voltage of $V_{DD}=3.3$ V.

1.1. Summary of Measured Results

A summary of measured results is provided in Table 1. An overview of the measured results may be stated as follows:

- The Spectral Emissions Mask D requirements cannot be met on a limited number of mathematically predictable channels, due to spurious sidebands related to harmonics of the crystal oscillator. Compliance with Masks C, D, and E can be achieved on all other channels.
- The Adjacent Channel Power requirements for equipment with 25 kHz channel bandwidth can be met with the chip default PLL loop bandwidth of 200 kHz, but cannot be met for reduced values of PLL loop bandwidth (e.g., 50 kHz, such as may be desirable for improved Spectral Emissions Mask performance).

Table 1. Summary of Measured Results

Spec Par	Parameter	Condition	Limit	Measured	Margin
90.205(h)	Power and Antenna Height Limits		+33 dBm	+10.43 dBm	22.57 dB
90.207	Types of Emissions	2GFSK or 4GFSK	F1D		Comply
90.209(b)(5)	Bandwidth Limitations	2GFSK DR=2.4K Dev=2.0K	6 / 11.25 / 20kHz	5.27 kHz	0.73 kHz
		2GFSK DR=3.6K Dev=3.0K	6 / 11.25 / 20kHz	7.76 kHz	3.49 kHz
		2GFSK DR=4.8K Dev=4.0K	6 / 11.25 / 20kHz	10.29 kHz	0.96 kHz
90.210	Emission Masks	Mask C	(see mask)	(see plots)	Comply
		Mask D	(see mask)	(see plots)	Fails on few channels, complies elsewhere
		Mask E	(see mask)	(see plots)	Comply

Table 1. Summary of Measured Results (Continued)

90.213	Frequency Stability	6.25 kHz Chan BW	± 1.0 ppm	N/A	N/A
		12.5 kHz Chan BW	± 2.5 ppm	N/A	N/A
		25 kHz Chan BW	± 5.0 ppm	N/A	N/A
90.214	Transient Frequency Behavior	6.25 kHz Chan BW	± 6.25 kHz ± 3.125 kHz ± 6.25 kHz	Negligible	Comply
90.217	Exemptions from Technical Standards	F < 800 MHz, P < 120 mW		N/A	N/A
90.221	Adjacent Channel Power	Fofst = 25 kHz	-55 dBc (or -36 dBm)	-63.83 dBc	8.83 dB
		Fofst = 50 kHz	-70 dBc (or -36 dBm)	-36.77 dBm	0.77 dB
		Fofst = 75 kHz	-70 dBc (or -36 dBm)	-38.45 dBm	2.45 dB
90.203 (j)(5)	Spectrum Efficiency	4GFSK SR=2.4K DR=4.8K Dev=0.4K	4.8 kbps/6.25 kHz	(see plots)	Comply

2. Summary of FCC Part 90 Requirements in the 450–470 MHz Band

The main requirements of FCC Part 90 in the 450-470 MHz band are summarized in this section. Many subparagraphs of FCC Part 90 are applicable to wider frequency ranges which include the desired 450-470 MHz band; these instances are noted below.

FCC Part 90 is only concerned with performance of the transmitter, and contains no requirements on receiver performance.

2.1. FCC Part 90.205(h) Power and Antenna Height Limits

The maximum allowable station effective radiated power (ERP) is dependent upon the station's antenna height above average terrain (HAAT) and required service area (in kilometers). The standard provides a table which lists the allowed transmit power for several combinations of antenna HAAT and required service area. The lowest power entry in this table is 2 watts maximum ERP for a service area of 3 kilometers and an antenna HAAT of 15 meters. This operational scenario is most applicable to the applications served by the Si446x family of chips and is the power level considered within this application note.

2.2. FCC Part 90.207 Types of Emissions

Modulation type F1D, including 2(G)FSK and 4(G)FSK, is permitted. Most measurements performed within this document were taken with 2GFSK modulation; however, 4GFSK modulation was selected to demonstrate compliance with the Spectrum Efficiency requirements of 90.203 (j)(5). Some measurements were also taken in CW mode for the purpose of demonstrating the effect of the selected modulation protocol upon the measured performance.

2.3. FCC Part 90.209(b) (5) Bandwidth Limitations

The standard provides a table which specifies the channel spacing and bandwidths for each frequency band. Within the 406-512 MHz band, the required channel spacing is 6.25 kHz and the permissible authorized bandwidths are 6 kHz, 11.25 kHz, or 20 kHz. The standard provides for authorizing these bandwidths for older equipment that was designed to operate with 6.25 kHz, 12.5 kHz, or 25 kHz bandwidths.

2.4. FCC Part 90.210 Emission Masks

The standard provides a table which specifies the required spectral emissions mask, depending upon the frequency band of operation and the channel bandwidth. Each emission mask is assigned an alphabetic letter designation (e.g., Mask A, Mask B, etc.) The spectral emission masks that apply to operation within the 421-512 MHz band are Masks C, D, and E. The descriptions of these spectral emission masks are summarized as follows.

2.4.1. Emission Mask C

Equipment designed to operate with a 25 kHz channel bandwidth must meet the requirements of Emission Mask C. The power of any emission must be attenuated below the unmodulated carrier output power (P, in watts) as follows:

- On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5 kHz, but not more than 10 kHz: At least $83 \log(f_d / 5)$ dB.
- On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth: At least $29 \log(f_d^2 / 11)$ dB or 50 dB, whichever is the lesser attenuation.
- On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least $43 + 10 \log(P)$ dB, where P is the power in watts.

This spectral emission mask is shown in graphical form in the plot of Figure 1, assuming a transmitter with an output power of $P = 1$ watt.

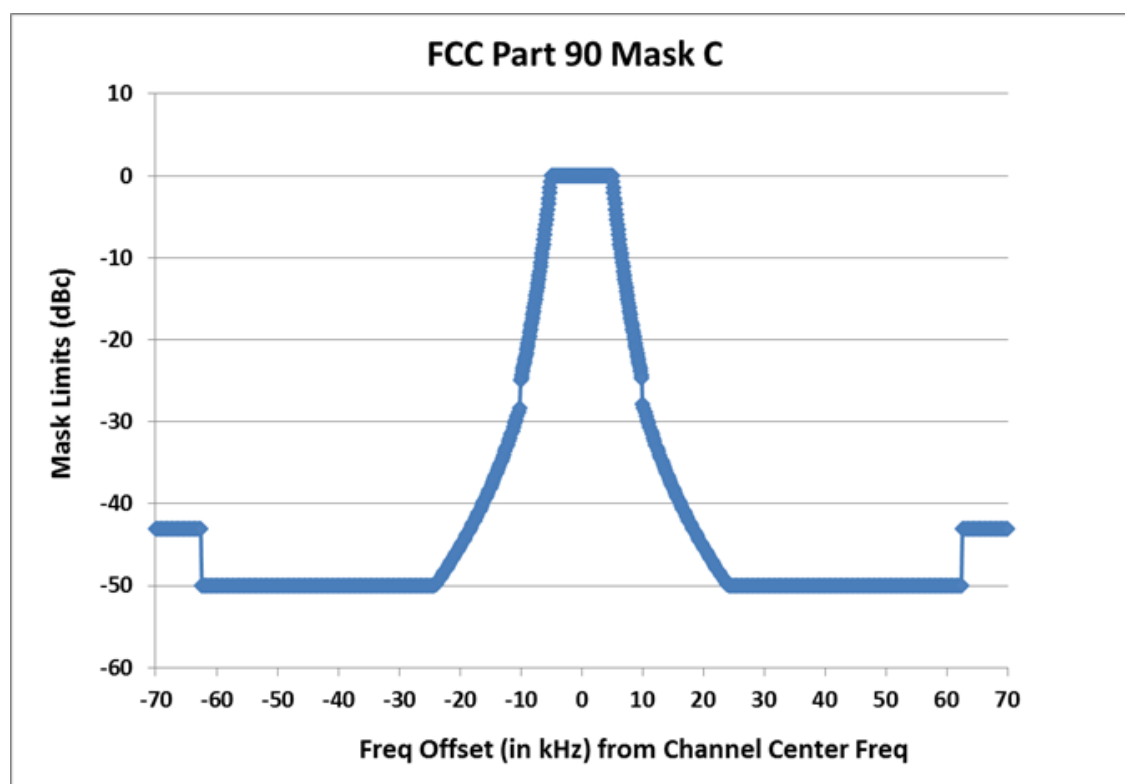


Figure 1. Emission Mask C (Pout=1W)

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2.4.2. Emission Mask D

Equipment designed to operate with a 12.5 kHz channel bandwidth must meet the requirements of Emission Mask D. Any emission must be attenuated below the power (P, in watts) of the highest emission contained within the authorized bandwidth as follows:

- On any frequency from the center of the authorized bandwidth f_0 to 5.625 kHz removed from f_0 : Zero dB.
- On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least $7.27(f_d - 2.88)$ dB.
- On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least $50 + 10 \log(P)$ dB or 70 dB, whichever is the lesser attenuation.

This spectral emission mask is shown in graphical form in the plot of Figure 2, assuming a transmitter with an output power of $P = 1$ watt. The standard requires that the measurement is taken using a spectrum analyzer resolution bandwidth of $\text{ResBW}=100$ Hz and using Peak Hold mode, for frequency offsets up to 50 kHz from the edge of the authorized bandwidth.

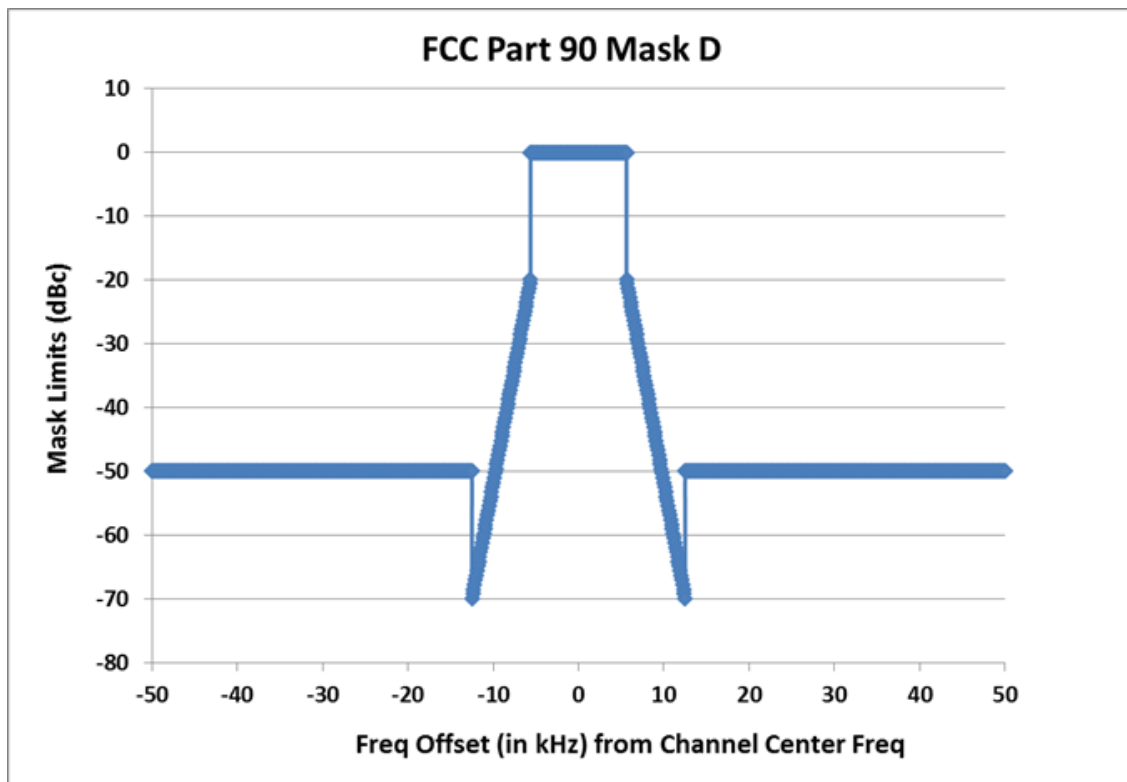


Figure 2. Emission Mask D ($P_{out}=1W$)

2.4.3. Emission Mask E

Equipment designed to operate with a 6.25 kHz or less channel bandwidth must meet the requirements of Emission Mask E. Any emission must be attenuated below the power (P, in watts) of the highest emission contained within the authorized bandwidth as follows:

- On any frequency from the center of the authorized bandwidth f_0 to 3.0 kHz removed from f_0 : Zero dB
- On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 3.0 kHz but no more than 4.6 kHz: At least $30 + 16.67(f_d - 3 \text{ kHz})$ or $55 + 10 \log(P)$ or 65 dB, whichever is the lesser attenuation.
- On any frequency removed from the center of the authorized bandwidth by more than 4.6 kHz: At least $55 + 10 \log(P)$ or 65 dB, whichever is the lesser attenuation.

This spectral emission mask is shown in graphical form in the plot of Figure 3, assuming a transmitter with an output power of $P = 1$ watt. The standard requires that the measurement is taken using a spectrum analyzer resolution bandwidth of $\text{ResBW}=100$ Hz and using Peak Hold mode, for frequency offsets up to 50 kHz from the edge of the authorized bandwidth.

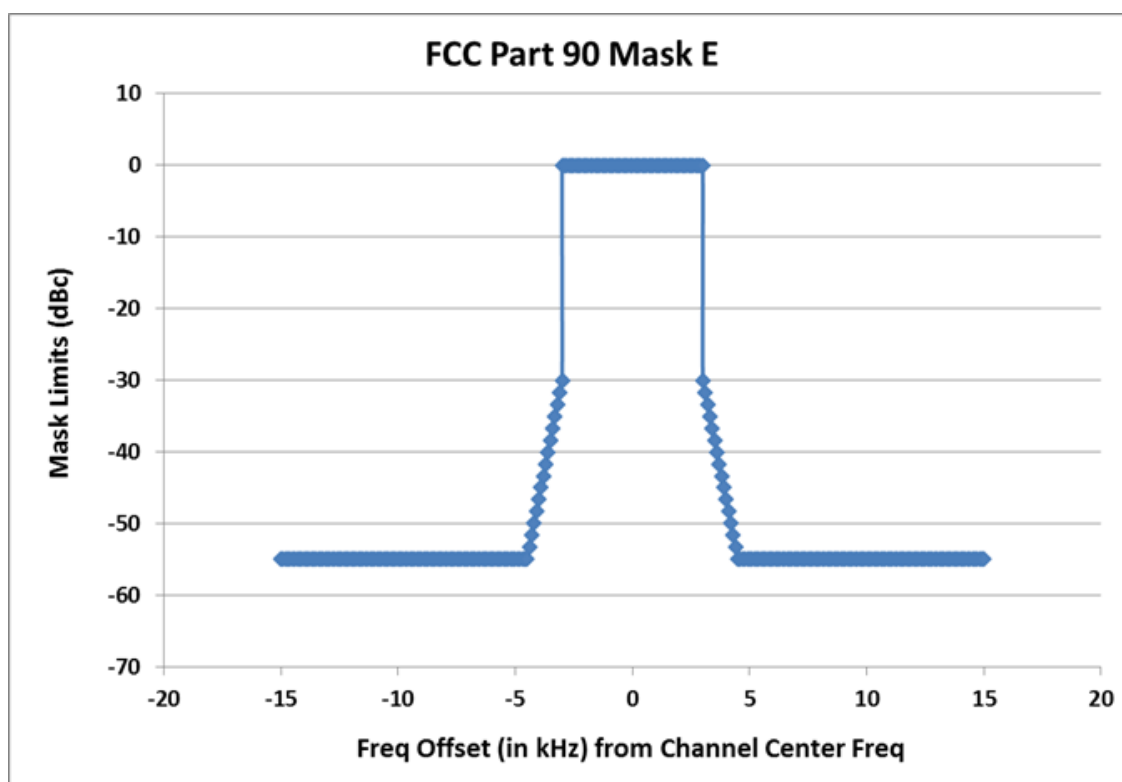


Figure 3. Emission Mask E (Pout=1W)

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