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Si47xx Programming Guide

1. Introduction

This document provides an overview of the programming requirements for the Si4704/05/06/07/1x/2x/3x/4x/84/85 FM transmitter/AM/FM/SW/LW/WB receiver. The hardware control interface and software commands are detailed along with several examples of the required steps to configure the device for various modes of operation.

2. Overview

This family of products is programmed using commands and responses. To perform an action, the system controller writes a command byte and associated arguments, causing the device to execute the given command. The device will, in turn, provide a response depending on the type of command that was sent. Section "4. Commands and Responses" on page 6 and section "5. Commands and Properties" on page 7 describe the procedures for using commands and responses and provide complete lists of commands, properties, and responses.

The device has a slave control interface that allows the system controller to send commands to and receive responses from the device using one of three serial protocols (or bus modes): 2-wire mode (I^2C and SMBUS compatible), 3-wire mode, or SPI mode.

Section "6. Control Interface" on page 206 describes the control interface in detail.

Section "7. Powerup" on page 214 describes options for the sequencing of VDD and VIO power supplies, selection of the desired bus mode, provision of the reference clock, RCLK, and sending of the POWER_UP command.

Section "8. Powerdown" on page 221 describes sending the POWER_DOWN command and removing VDD and VIO power supplies as necessary.

Section "9. Digital Audio Interface" on page 222 describes the digital audio format supported and how to operate the device in digital mode.

Section "10. Timing" on page 225 describes the CTS (Clear to Send) timing indicating when the command has been accepted and in most cases completed execution, and the STC (Seek/Tune Complete) timing indicating when the Seek/Tune commands have completed execution.

Section "11. FM Transmitter" on page 231 describes the audio dynamic range control, limiter, pre-emphasis, recommendations for maximizing audio volume for the FM transmitter.

Section "12. Programming Examples" on page 235 provides flowcharts and step-by-step procedures for programming the device.

Table 1. Product Family Function

Part Number	General Description	FM Transmitter	FM Receiver	AM Receiver	SW/LW Receiver	WB Receiver	RDS	High Performance RDS	RPS	SAME	Digital Input	Digital Output	Embedded FM antenna	AEC-Q100 Qualified	Package Size (mm)
Si4700	FM Receiver		✓												4x4
Si4701	FM Receiver with RDS		✓				✓								4x4
Si4702	FM Receiver		✓												3x3
Si4703	FM Receiver with RDS		✓				✓								3x3
Si4704	FM Receiver		✓										✓		3x3
Si4705	FM Receiver with RDS		✓				✓	2				✓	✓		3x3
Si4706[1]	High Performance RDS Receiver		✓				✓	✓				✓	✓		3x3
Si4707[1]	WB Receiver with SAME					✓				✓					3x3
Si4708	FM Receiver		✓												2.5x2.5
Si4709	FM Receiver with RDS		✓				✓								2.5x2.5
Si4710	FM Transmitter	✓									✓		✓		3x3
Si4711	FM Transmitter with RDS	✓					✓				✓		✓		3x3
Si4712	FM Transmitter with RPS	✓							✓		✓		✓		3x3
Si4713	FM Transmitter with RDS & RPS	✓					✓		✓		✓		✓		3x3
Si4720	FM Transceiver	✓	✓						✓		✓		✓		3x3
Si4721	FM Transceiver with RDS	✓	✓				✓		✓		✓	✓	✓		3x3
Si4730	AM/FM Receiver		✓	✓											3x3
Si4731	AM/FM Receiver with RDS		✓	✓			✓	2				✓			3x3
Si4734	AM/SW/LW/FM Receiver		✓	✓	✓										3x3
Si4735	AM/SW/LW/FM Receiver with RDS		✓	✓	✓		✓	2				✓			3x3
Si4736	AM/FM/WB Receiver		✓	✓		✓									3x3
Si4737	AM/FM/WB Receiver with RDS		✓	✓		✓	✓					✓			3x3
Si4738	FM/WB Receiver		✓			✓									3x3
Si4739	FM/WB Receiver with RDS		✓			✓	✓					✓			3x3
Si4740[1]	AM/FM Receiver		✓	✓										✓	4x4

Notes:
1. Si4706, Si4707, and Si474x are covered under NDA.
2. High Performance RDS is available in Si4705/31/35/85-D50 and later.

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Table 1. Product Family Function (Continued)

Part	Description														Size
Si4741[1]	AM/FM Receiver with RDS	✓	✓			✓	✓				✓		✓		4x4
Si4742[1]	AM/LW/SW/FM/WB Receiver	✓	✓	✓	✓								✓		4x4
Si4743[1]	AM/LW/SW/FM/WB Receiver with RDS	✓	✓	✓	✓	✓	✓				✓		✓		4x4
Si4744[1]	AM/LW/SW/FM Receiver	✓	✓	✓									✓		4x4
Si4745[1]	AM/LW/SW/FM Receiver with RDS	✓	✓	✓		✓	✓				✓		✓		4x4
Si4749[1]	High-Performance RDS Receiver					✓	✓						✓		4x4
Si4784	FM Receiver	✓									✓				3x3
Si4785	FM Receiver with RDS	✓				✓	2				✓				3x3

Notes:
1. Si4706, Si4707, and Si474x are covered under NDA.
2. High Performance RDS is available in Si4705/31/35/85-D50 and later.

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3. Terminology

- $\overline{\text{SEN}}$—Serial enable pin, active low; used as device select in 3-wire and SPI operation and address selection in 2-wire operation.
- SDIO—Serial data in/data out pin.
- SCLK—Serial clock pin.
- $\overline{\text{RST}}$ or RSTb—Reset pin, active low
- RCLK—External reference clock
- GPO—General purpose output
- CTS—Clear to send
- STC—Seek/Tune Complete
- NVM—Non-volatile internal device memory
- Device—Refers to the FM Transmitter/AM/FM/SW/LW/WB Receiver
- System Controller—Refers to the system microcontroller
- CMD—Command byte
- COMMANDn—Command register (16-bit) in 3-Wire mode (n = 1 to 4)
- ARGn—Argument byte (n = 1 to 7)
- STATUS—Status byte
- RESPn—Response byte (n = 1 to 15)
- RESPONSEn—Response register (16-bit) in 3-Wire mode (n = 1 to 8)

4. Commands and Responses

Commands control actions, such as power up, power down, or tune to a frequency, and are one byte in size. Arguments are specific to a given command and are used to modify the command. For example, after the TX_TUNE_FREQ command, arguments are required to set the tune frequency. Arguments are one byte in size, and each command may require up to seven arguments. Responses provide the system controller status information and are returned after a command and its associated arguments are issued. All commands return a one byte status indicating interrupt state and clear-to-send the next command. Commands may return up to 15 additional response bytes. A complete list of commands is available in "5. Commands and Properties".

Table 2 shows an example of tuning to a frequency using the TX_TUNE_FREQ command. This command requires that a command and three arguments be sent and returns one status byte. The table is broken into three columns. The first column lists the action taking place: command (CMD), argument (ARG), status (STATUS), or response (RESP). The second column lists the data byte or bytes in hexadecimal that are being sent or received. An arrow preceding the data indicates data being sent from the device to the system controller. The third column describes the action.

Table 2. Using the TX_TUNE_FREQ Command

Action	Data	Description
CMD	0x30	TX_TUNE_FREQ
ARG1	0x00	
ARG2	0x27	Set Station to 101.1 MHz
ARG3	0x7E	(0x277E = 10110 with 10 kHz step size)
STATUS	→0x80	Reply Status. Clear-to-send high.

Properties are special command arguments used to modify the default device operation and are generally configured immediately after power-up. Examples of properties are TX _PREEMPHASIS and REFCLK_FREQ. A complete list of properties is available in Section "5. Commands and Properties".

Table 3 shows an example of setting the REFCLK frequency using the REFCLK_FREQ property by sending the SET_PROPERTY command and five argument bytes. ARG1 of the SET_PROPERTY command is always 0x00. ARG2 and ARG3 are used to select the property number, PROP (0x0201 in this example), and ARG4 and ARG5 are used to set the property value, PROPD (0x8000 or 32768 Hz in the example).

Table 3. Using the SET_PROPERTY Command

Action	Data	Description
CMD	0x12	SET_PROPERTY
ARG1	0x00	
ARG2 (PROP)	0x02	REFCLK_FREQ
ARG3 (PROP)	0x01	
ARG4 (PROPD)	0x80	32768 Hz
ARG5 (PROPD)	0x00	
STATUS	→0x80	Reply Status. Clear-to-send high.

The implementation of the command and response procedures in the system controller differs for each of the three bus modes. Section "6. Control Interface" on page 206 details the required bit transactions on the control bus for each of the bus modes.

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5. Commands and Properties

There are four different components for these product families:

1. FM Transmitter component
2. FM Receiver component
3. AM/SW/LW component
4. WB component

The following four subsections list all the commands and properties used by each of the component.

5.1. Commands and Properties for the FM/RDS Transmitter (Si4710/11/12/13/20/21)

The following two tables are the summary of the commands and properties for the FM/RDS Transmitter component applicable to Si4710/11/12/13/20/21.

Table 4. FM/RDS Transmitter Command Summary

Cmd	Name	Description	Available In
0x01	POWER_UP	Power up device and mode selection. Modes include FM transmit and analog/digital audio interface configuration.	All
0x10	GET_REV	Returns revision information on the device.	All
0x11	POWER_DOWN	Power down device.	All
0x12	SET_PROPERTY	Sets the value of a property.	All
0x13	GET_PROPERTY	Retrieves a property's value.	All
0x14	GET_INT_STATUS	Read interrupt status bits.	All
0x15	PATCH_ARGS*	Reserved command used for patch file downloads.	All
0x16	PATCH_DATA*	Reserved command used for patch file downloads.	All
0x30	TX_TUNE_FREQ	Tunes to given transmit frequency.	All
0x31	TX_TUNE_POWER	Sets the output power level and tunes the antenna capacitor.	All
0x32	TX_TUNE_MEASURE	Measure the received noise level at the specified frequency.	Si4712/13/20/21
0x33	TX_TUNE_STATUS	Queries the status of a previously sent TX Tune Freq, TX Tune Power, or TX Tune Measure command.	All
0x34	TX_ASQ_STATUS	Queries the TX status and input audio signal metrics.	All
0x35	TX_RDS_BUFF	Queries the status of the RDS Group Buffer and loads new data into buffer.	Si4711/13/21
0x36	TX_RDS_PS	Set up default PS strings.	Si4711/13/21
0x80	GPIO_CTL	Configures GPO1, 2, and 3 as output or Hi-Z.	All except Si4710-A10
0x81	GPIO_SET	Sets GPO1, 2, and 3 output level (low or high).	All except Si4710-A10

***Note:** Commands PATCH_ARGS and PATCH_DATA are only used to patch firmware. For information on applying a patch file, see "7.2. Powerup from a Component Patch" on page 216.

Table 5. FM Transmitter Property Summary

Prop	Name	Description	Default	Available In
0x0001	GPO_IEN	Enables interrupt sources.	0x0000	All
0x0101	DIGITAL_INPUT _FORMAT[1]	Configures the digital input format.	0x0000	All except Si4710-A10
0x0103	DIGITAL_INPUT _SAMPLE_RATE[1]	Configures the digital input sample rate in 1 Hz steps. Default is 0.	0x0000	All except Si4710-A10
0x0201	REFCLK_FREQ	Sets frequency of the reference clock in Hz. The range is 31130 to 34406 Hz, or 0 to disable the AFC. Default is 32768 Hz.	0x8000	All
0x0202	REFCLK_PRESCALE	Sets the prescaler value for the reference clock.	0x0001	All
0x2100	TX_COMPONENT_ENABLE	Enable transmit multiplex signal components. Default has pilot and L-R enabled.	0x0003	All
0x2101	TX_AUDIO_DEVIATION	Configures audio frequency deviation level. Units are in 10 Hz increments. Default is 6825 (68.25 kHz).	0x1AA9	All
0x2102	TX_PILOT_DEVIATION	Configures pilot tone frequency deviation level. Units are in 10 Hz increments. Default is 675 (6.75 kHz)	0x02A3	All
0x2103	TX_RDS_DEVIATION[2]	Configures the RDS/RBDS frequency deviation level. Units are in 10 Hz increments. Default is 2 kHz.	0x00C8	Si4711/13/21
0x2104	TX_LINE_INPUT_LEVEL	Configures maximum analog line input level to the LIN/RIN pins to reach the maximum deviation level programmed into the audio deviation property TX Audio Deviation. Default is 636 mV$_{PK}$.	0x327C	All
0x2105	TX_LINE_INPUT_MUTE	Sets line input mute. L and R inputs may be independently muted. Default is not muted.	0x0000	All
0x2106	TX_PREEMPHASIS	Configures pre-emphasis time constant. Default is 0 (75 µs).	0x0000	All
0x2107	TX_PILOT_FREQUENCY	Configures the frequency of the stereo pilot. Default is 19000 Hz.	0x4A38	All

Notes:
1. Digital Audio Input feature (property DIGITAL_INPUT_FORMAT and DIGITAL_INPUT_SAMPLE_RATE) is supported in FMTX component 2.0 or later.
2. RDS feature (command TX_RDS_BUFF, TX_RDS_PS and RDS properties 0x2103, 0x2C00 through 2C07) is supported in FMTX component 2.0 or later.
3. Limiter feature (LIMITEN bit in TX_ACOMP_ENABLE and property TX_LIMITER_RELEASE_TIME) is supported in FMTX component 2.0 or later.

Table 5. FM Transmitter Property Summary (Continued)

Prop	Name	Description	Default	Available In
0x2200	TX_ACOMP_ENABLE[3]	Enables audio dynamic range control and limiter. Default is 2 (limiter is enabled, audio dynamic range control is disabled).	0x0002	All
0x2201	TX_ACOMP_THRESHOLD	Sets the threshold level for audio dynamic range control. Default is –40 dB.	0xFFD8	All
0x2202	TX_ACOMP_ATTACK_TIME	Sets the attack time for audio dynamic range control. Default is 0 (0.5 ms).	0x0000	All
0x2203	TX_ACOMP_RELEASE_TIME	Sets the release time for audio dynamic range control. Default is 4 (1000 ms).	0x0004	All
0x2204	TX_ACOMP_GAIN	Sets the gain for audio dynamic range control. Default is 15 dB.	0x000F	All
0x2205	TX_LIMITER_RELEASE_TIME[3]	Sets the limiter release time. Default is 102 (5.01 ms)	0x0066	All except Si4710-A10
0x2300	TX_ASQ_INTERRUPT_SOURCE	Configures measurements related to signal quality metrics. Default is none selected.	0x0000	All
0x2301	TX_ASQ_LEVEL_LOW	Configures low audio input level detection threshold. This threshold can be used to detect silence on the incoming audio.	0x0000	All
0x2302	TX_ASQ_DURATION_LOW	Configures the duration which the input audio level must be below the low threshold in order to detect a low audio condition.	0x0000	All
0x2303	TX_ASQ_LEVEL_HIGH	Configures high audio input level detection threshold. This threshold can be used to detect activity on the incoming audio.	0x0000	All
0x2304	TX_ASQ_DURATION_HIGH	Configures the duration which the input audio level must be above the high threshold in order to detect a high audio condition.	0x0000	All
0x2C00	TX_RDS_INTERRUPT_SOURCE[2]	Configure RDS interrupt sources. Default is none selected.	0x0000	Si4711/13/21

Notes:
1. Digital Audio Input feature (property DIGITAL_INPUT_FORMAT and DIGITAL_INPUT_SAMPLE_RATE) is supported in FMTX component 2.0 or later.
2. RDS feature (command TX_RDS_BUFF, TX_RDS_PS and RDS properties 0x2103, 0x2C00 through 2C07) is supported in FMTX component 2.0 or later.
3. Limiter feature (LIMITEN bit in TX_ACOMP_ENABLE and property TX_LIMITER_RELEASE_TIME) is supported in FMTX component 2.0 or later.

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Table 5. FM Transmitter Property Summary (Continued)

Prop	Name	Description	Default	Available In
0x2C01	TX_RDS_PI[2]	Sets transmit RDS program identifier.	0x40A7	Si4711/13/21
0x2C02	TX_RDS_PS_MIX[2]	Configures mix of RDS PS Group with RDS Group Buffer.	0x0003	Si4711/13/21
0x2C03	TX_RDS_PS_MISC[2]	Miscellaneous bits to transmit along with RDS_PS Groups.	0x1008	Si4711/13/21
0x2C04	TX_RDS_PS_REPEAT_COUNT[2]	Number of times to repeat transmission of a PS message before transmitting the next PS message.	0x0003	Si4711/13/21
0x2C05	TX_RDS_PS_MESSAGE_COUNT[2]	Number of PS messages in use.	0x0001	Si4711/13/21
0x2C06	TX_RDS_PS_AF[2]	RDS Program Service Alternate Frequency. This provides the ability to inform the receiver of a single alternate frequency using AF Method A coding and is transmitted along with the RDS_PS Groups.	0xE0E0	Si4711/13/21
0x2C07	TX_RDS_FIFO_SIZE[2]	Number of blocks reserved for the FIFO. Note that the value written must be one larger than the desired FIFO size.	0x0000	Si4711/13/21

Notes:
1. Digital Audio Input feature (property DIGITAL_INPUT_FORMAT and DIGITAL_INPUT_SAMPLE_RATE) is supported in FMTX component 2.0 or later.
2. RDS feature (command TX_RDS_BUFF, TX_RDS_PS and RDS properties 0x2103, 0x2C00 through 2C07) is supported in FMTX component 2.0 or later.
3. Limiter feature (LIMITEN bit in TX_ACOMP_ENABLE and property TX_LIMITER_RELEASE_TIME) is supported in FMTX component 2.0 or later.

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Table 6. Status Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT

Bit	Name	Function
7	CTS	**Clear to Send.** 0 = Wait before sending next command. 1 = Clear to send next command.
6	ERR	**Error.** 0 = No error 1 = Error
5:3	Reserved	Values may vary.
2	RDSINT	**RDS Interrupt.** 0 = RDS interrupt has not been triggered. 1 = RDS interrupt has been triggered.
1	ASQINT	**Signal Quality Interrupt.** 0 = Signal quality measurement has not been triggered. 1 = Signal quality measurement has been triggered.
0	STCINT	**Seek/Tune Complete Interrupt.** 0 = Tune complete has not been triggered. 1 = Tune complete has been triggered.

5.1.1. Commands and Properties for the FM/RDS Transmitter

Command 0x01. POWER_UP

Initiates the boot process to move the device from powerdown to powerup mode. The boot can occur from internal device memory or a system controller downloaded patch. To confirm that the patch is compatible with the internal device library revision, the library revision should be confirmed by issuing the POWER_UP command with Function = 15 (query library ID). The device will return the response, including the library revision, and then moves into powerdown mode. The device can then be placed in powerup mode by issuing the POWER_UP command with Function = 2 (transmit) and the patch may be applied. Only the STATUS byte will be returned in the response stream in transmit mode. The POWER_UP command configures the state of DIN (pin 13), DFS (pin 14), and RIN (pin 15) and LIN (pin 16) for analog or digital audio modes and GPO2/INT (pin 18) for interrupt operation. The command configures GPO2/INT interrupts (GPO2OEN) and CTS interrupts (CTSIEN). If both are enabled, GPO2/INT is driven high during normal operation and low for a minimum of 1 µs during the interrupt. The CTSIEN bit is duplicated in the GPO_IEN property. The command is complete when the CTS bit (and optional interrupt) is set.

Note: To change function (e.g., FM TX to FM RX), issue the POWER_DOWN command to stop the current function; then, issue POWER_UP to start the new function.

Note: Delay at least 500 ms between powerup command and first tune command to wait for the oscillator to stabilize if XOSCEN is set and crystal is used as the RCLK.

Available in: All

Command Arguments: Two

Response Bytes: None (FUNC = 2), Seven (FUNC = 15)

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	0	0	0	0	0	1
ARG1	CTSIEN	GPO2OEN	PATCH	XOSCEN	FUNC[3:0]			
ARG2	OPMODE[7:0]							

ARG	Bit	Name	Function
1	7	CTSIEN	**CTS Interrupt Enable.** 0 = CTS interrupt disabled. 1 = CTS interrupt enabled.
1	6	GPO2OEN	**GPO2 Output Enable.** 0 = GPO2 output disabled, (Hi-Z). 1 = GPO2 output enabled.
1	5	PATCH	**Patch Enable.** 0 = Boot normally 1 = Copy non-volatile memory to RAM, but do not boot. After CTS has been set, RAM may be patched

ARG	Bit	Name	Function
1	4	XOSCEN	**Crystal Oscillator Enable.** 0 = Use external RCLK (crystal oscillator disabled). 1 = Use crystal oscillator (RCLK and GPO3/DCLK with external 32.768 kHz crystal and OPMODE=01010000). See Si47xx Data Sheet Application Schematic for external BOM details.
1	3:0	FUNC[3:0]	**Function.** 0–1, 3–14 = Reserved. 2 = Transmit. 15 = Query Library ID.
2	7:0	OPMODE[7:0]	**Application Setting** 01010000 = Analog audio inputs (LIN/RIN) 00001111 = Digital audio inputs (DIN/DFS/DCLK)

Response (to FUNC = 2, TX)

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT

Response (to FUNC = 15, Query Library ID)

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT
RESP1	PN[7:0]							
RESP2	FWMAJOR[7:0]							
RESP3	FWMINOR[7:0]							
RESP4	RESERVED[7:0]							
RESP5	RESERVED[7:0]							
RESP6	CHIPREV[7:0]							
RESP7	LIBRARYID[7:0]							

RESP	Bit	Name	Function
1	7:0	PN[7:0]	**Final 2 digits of part number.**
2	7:0	FWMAJOR[7:0]	**Firmware Major Revision.**
3	7:0	FWMINOR[7:0]	**Firmware Minor Revision.**
4	7:0	RESERVED[7:0]	**Reserved, various values.**
5	7:0	RESERVED[7:0]	**Reserved, various values.**
6	7:0	CHIPREV[7:0]	**Chip Revision.**
7	7:0	LIBRARYID[7:0]	**Library Revision.**

Command 0x10. GET_REV

Returns the part number, chip revision, firmware revision, patch revision and component revision numbers. The command is complete when the CTS bit (and optional interrupt) is set. This command may only be sent when in powerup mode.

Available in: All

Command arguments: None

Response bytes: Eight

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	0	1	0	0	0	0

Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT
RESP1	PN[7:0]							
RESP2	FWMAJOR[7:0]							
RESP3	FWMINOR[7:0]							
RESP4	PATCH$_H$[7:0]							
RESP5	PATCH$_L$[7:0]							
RESP6	CMPMAJOR[7:0]							
RESP7	CMPMINOR[7:0]							
RESP8	CHIPREV[7:0]							

RESP	Bit	Name	Function
1	7:0	PN[7:0]	**Final 2 digits of Part Number**
2	7:0	FWMAJOR[7:0]	**Firmware Major Revision**
3	7:0	FWMINOR[7:0]	**Firmware Minor Revision**
4	7:0	PATCH$_H$[7:0]	**Patch ID High Byte**
5	7:0	PATCH$_L$[7:0]	**Patch ID Low Byte**
6	7:0	CMPMAJOR[7:0]	**Component Major Revision**
7	7:0	CMPMINOR[7:0]	**Component Minor Revision**
8	7:0	CHIPREV[7:0]	**Chip Revision**

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Command 0x11. POWER_DOWN

Moves the device from powerup to powerdown mode. The CTS bit (and optional interrupt) is set when it is safe to send the next command. This command may only be sent when in powerup mode. Note that only the POWER_UP command is accepted in powerdown mode. **If the system controller writes a command other than POWER_UP when in powerdown mode, the device does not respond. The device will only respond when a POWER_UP command is written. GPO pins are powered down and not active during this state. For optimal power down current, GPO2 must be either internally driven low through GPIO_CTL command or externally driven low.**

Note: In FMTX component 1.0 and 2.0, a reset is required when the system controller writes a command other than POWER_UP when in powerdown mode.

Note: The following describes the state of all the pins when in powerdown mode:
GPIO1, GPIO2, and GPIO3 = 0
DIN, DFS, RIN, LIN = HiZ

Available in: All

Command arguments: None

Response bytes: None

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	0	1	0	0	0	1

Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT

Command 0x12. SET_PROPERTY

Sets a property shown in Table 5, "FM Transmitter Property Summary," on page 8. The CTS bit (and optional interrupt) is set when it is safe to send the next command. This command may only be sent when in powerup mode.

See Figure 29, "CTS and SET_PROPERTY Command Complete tCOMP Timing Model," on page 226 and Table 45, "Command Timing Parameters for the FM Transmitter," on page 227.

Available in: All

Command Arguments: Five

Response bytes: None

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	0	1	0	0	1	0
ARG1	0	0	0	0	0	0	0	0
ARG2	$PROP_H[7:0]$							
ARG3	$PROP_L[7:0]$							
ARG4	$PROPD_H[7:0]$							
ARG5	$PROPD_L[7:0]$							

ARG	Bit	Name	Function
1	7:0	Reserved	Always write to 0.
2	7:0	$PROP_H[7:0]$	**Property High Byte.** This byte in combination with $PROP_L$ is used to specify the property to modify. See Section "5.1.2. FM/RDS Transmitter Properties" on page 31.
3	7:0	$PROP_L[7:0]$	**Property Low Byte.** This byte in combination with $PROP_H$ is used to specify the property to modify. See Section "5.1.2. FM/RDS Transmitter Properties" on page 31.
4	7:0	$PROPD_H[7:0]$	**Property Value High Byte.** This byte in combination with $PROPV_L$ is used to set the property value. See Section "5.1.2. FM/RDS Transmitter Properties" on page 31.
5	7:0	$PROPD_L[7:0]$	**Property Value Low Byte.** This byte in combination with $PROPV_H$ is used to set the property value. See Section "5.1.2. FM/RDS Transmitter Properties" on page 31.

Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT

Command 0x13. GET_PROPERTY

Gets a property shown in Table 5, "FM Transmitter Property Summary," on page 8. The CTS bit (and optional interrupt) is set when it is safe to send the next command. This command may only be sent when in powerup mode.

Available in: All

Command arguments: Three

Response bytes: Three

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	0	1	0	0	1	1
ARG1	0	0	0	0	0	0	0	0
ARG2	$PROP_H[7:0]$							
ARG3	$PROP_L[7:0]$							

ARG	Bit	Name	Function
1	7:0	Reserved	Always write to 0.
2	7:0	$PROP_H[7:0]$	**Property Get High Byte.** This byte in combination with $PROP_L$ is used to specify the property to get.
3	7:0	$PROP_L[7:0]$	**Property Get Low Byte.** This byte in combination with $PROP_H$ is used to specify the property to get.

Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT
RESP1	X	X	X	X	X	X	X	X
RESP2	$PROPD_H[7:0]$							
RESP3	$PROPD_L[7:0]$							

RESP	Bit	Name	Function
1	7:0	Reserved	Reserved, various values.
2	7:0	$PROPD_H[7:0]$	**Property Value High Byte.** This byte in combination with $PROPV_L$ will represent the requested property value.
3	7:0	$PROPD_L[7:0]$	**Property Value High Byte.** This byte in combination with $PROPV_H$ will represent the requested property value.

Command 0x14. GET_INT_STATUS

Updates bits 6:0 of the status byte. This command should be called after any command that sets the STCINT, ASQINT, or RDSINT bits. When polling this command should be periodically called to monitor the STATUS byte, and when using interrupts, this command should be called after the interrupt is set to update the STATUS byte. The command is complete when the CTS bit (and optional interrupt) is set. This command may only be sent when in powerup mode.

Available in: All

Command arguments: None

Response bytes: None

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	0	1	0	1	0	0

Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT

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Command 0x30. TX_TUNE_FREQ

Sets the state of the RF carrier and sets the tuning frequency between 76 and 108 MHz in 10 kHz units and steps of 50 kHz. For example 76.05 MHz = 7605 is valid because it follows the 50 kHz step requirement but 76.01 MHz = 7601 is not valid. The CTS bit (and optional interrupt) is set when it is safe to send the next command. The ERR bit (and optional interrupt) is set if an invalid argument is sent. Note that only a single interrupt occurs if both the CTS and ERR bits are set. The optional STC interrupt is set when the command completes. The STCINT bit is set only after the GET_INT_STATUS command is called. This command may only be sent when in powerup mode. The command clears the STC bit if it is already set. See Figure 28, "CTS and STC Timing Model," on page 226 and Table 45, "Command Timing Parameters for the FM Transmitter," on page 227.

Available in: All

Command arguments: Three

Response bytes: None

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	1	1	0	0	0	0
ARG1	0	0	0	0	0	0	0	0
ARG2	$FREQ_H[7:0]$							
ARG3	$FREQ_L[7:0]$							

ARG	Bit	Name	Function
1	7:0	Reserved	Always write to 0.
2	7:0	$FREQ_H[7:0]$	**Tune Frequency High Byte.** This byte in combination with $FREQ_L$ selects the tune frequency in units of 10 kHz. The valid range is from 7600 to 10800 (76–108 MHz). The frequency must be a multiple of 50 kHz.
3	7:0	$FREQ_L[7:0]$	**Tune Frequency Low Byte.** This byte in combination with $FREQ_H$ selects the tune frequency in units of 10 kHz. The valid range is from 7600 to 10800 (76–108 MHz). The frequency must be a multiple of 50 kHz.

Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT

Command 0x31. TX_TUNE_POWER

Sets the RF voltage level between 88 dBμV and 115 dBμV in 1 dB units. Power may be set as high as 120 dBμV; however, voltage accuracy is not guaranteed. A value of 0x00 indicates off. The command also sets the antenna tuning capacitance. A value of 0 indicates autotuning, and a value of 1–191 indicates a manual override. The CTS bit (and optional interrupt) is set when it is safe to send the next command. The ERR bit (and optional interrupt) is set if an invalid argument is sent. Note that only a single interrupt occurs if both the CTS and ERR bits are set. The optional STC interrupt is set when the command completes. The STCINT bit is set only after the GET_INT_STATUS command is called. This command may only be sent when in powerup mode. The command clears the STC bit if it is already set. See Figure 28, "CTS and STC Timing Model," on page 226 and Table 45, "Command Timing Parameters for the FM Transmitter," on page 227.

Available in: All

Command arguments: Four

Response bytes: None

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	1	1	0	0	0	1
ARG1	0	0	0	0	0	0	0	0
ARG2	0	0	0	0	0	0	0	0
ARG3	RFdBμV[7:0]							
ARG4	ANTCAP[7:0]							

ARG	Bit	Name	Function
1	7:0	Reserved	Always write to 0.
2	7:0	Reserved	Always write to 0.
3	7:0	RFdBμV[7:0]	**Tune Power Byte.** Sets the tune power in dBμV in 1 dB steps. The valid range is from 88–115 dBμV. Power may be set as high as 120 dBμV; however, voltage accuracy is not guaranteed.
4	7:0	ANTCAP[7:0]	**Antenna Tuning Capacitor.** This selects the value of the antenna tuning capacitor manually, or automatically if set to zero. The valid range is 0 to 191, which results in a tuning capacitance of 0.25 pF x ANTCAP.

Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT

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Command 0x32. TX_TUNE_MEASURE

Enters receive mode (disables transmitter output power) and measures the received noise level (RNL) in units of dBµV on the selected frequency. The command sets the tuning frequency between 76 and 108 MHz in 10 kHz units and steps of 50 kHz. For example 76.05 MHz = 7605 is valid because it follows the 50 kHz step requirement but 76.01 MHz = 7601 is not valid. The command also sets the antenna tuning capacitance. A value of 0 indicates autotuning, and a value of 1–191 indicates a manual override. The CTS bit (and optional interrupt) is set when it is safe to send the next command. The ERR bit (and optional interrupt) is set if an invalid argument is sent. Note that only a single interrupt occurs if both the CTS and ERR bits are set. The optional STC interrupt is set when the command completes. The STCINT bit is set only after the GET_INT_STATUS command is called. This command may only be sent when in powerup mode. The command clears the STC bit if it is already set. See Figure 28, "CTS and STC Timing Model," on page 226 and Table 45, "Command Timing Parameters for the FM Transmitter," on page 227.

Available in: Si4712/13/20/21

Command arguments: Four

Response bytes: None

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	1	1	0	0	1	0
ARG1	0	0	0	0	0	0	0	0
ARG2	$FREQ_H[7:0]$							
ARG3	$FREQ_L[7:0]$							
ARG4	ANTCAP[7:0]							

ARG	Bit	Name	Function
1	7:0	Reserved	Always write to 0.
2	7:0	$FREQ_H[7:0]$	**Tune Frequency High Byte.** This byte in combination with $FREQ_L$ selects the tune frequency in units of 10 kHz. In FM mode the valid range is from 7600 to 10800 (76–108 MHz). The frequency must be a multiple of 50 kHz.
3	7:0	$FREQ_L[7:0]$	**Tune Frequency Low Byte.** This byte in combination with $FREQ_H$ selects the tune frequency in units of 10 kHz. In FM mode the valid range is from 7600 to 10800 (76–108 MHz). The frequency must be a multiple of 50 kHz.
4	7:0	ANTCAP[7:0]	**Antenna Tuning Capacitor.** This selects the value of the antenna tuning capacitor manually, or automatic if set to zero. The valid range is 0–191.

Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT

Command 0x33. TX_TUNE_STATUS

Returns the status of the TX_TUNE_FREQ, TX_TUNE_MEASURE, or TX_TUNE_POWER commands. The command returns the current frequency, output voltage in dBμV (if applicable), the antenna tuning capacitance value (0–191) and the received noise level (if applicable). The command clears the STCINT interrupt bit when INTACK bit of ARG1 is set. The CTS bit (and optional interrupt) is set when it is safe to send the next command. This command may only be sent when in powerup mode.

Available in: All

Command arguments: One

Response bytes: Seven

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	1	1	0	0	1	1
ARG1	0	0	0	0	0	0	0	INTACK

ARG	Bit	Name	Function
1	7:1	Reserved	Always write to 0.
1	0	INTACK	**Seek/Tune Interrupt Clear.** If set this bit clears the seek/tune complete interrupt status indicator.

Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT
RESP1	X	X	X	X	X	X	X	X
RESP2				READFREQ$_H$[7:0]				
RESP3				READFREQ$_L$[7:0]				
RESP4	X	X	X	X	X	X	X	X
RESP5				READRFdBμV[7:0]				
RESP6				READANTCAP[7:0]				
RESP7				RNL[7:0]				

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RESP	Bit	Name	Function
1	7:0	Reserved	Returns various data.
2	7:0	READFREQ$_H$[7:0]	**Read Frequency High Byte.** This byte in combination with READFREQ$_L$ returns frequency being tuned.
3	7:0	READFREQ$_L$[7:0]	**Read Frequency Low Byte.** This byte in combination with READFREQ$_H$ returns frequency being tuned.
4	7:0	Reserved	Returns various data.
5	7:0	READRFdBµV[7:0]	**Read Power.** Returns the transmit output voltage setting.
6	7:0	READANTCAP [7:0]	**Read Antenna Tuning Capacitor.** This byte will contain the current antenna tuning capacitor value.
7	7:0	RNL[7:0]	**Read Received Noise Level (Si4712/13 Only).** This byte will contain the receive level as the response to a TX Tune Measure command. The returned value will be the last RNL measurement (or 0 if no measurement has been performed) for the TX Tune Freq and TX Tune Power commands.

Command 0x34. TX_ASQ_STATUS

Returns status information about the audio signal quality and current FM transmit frequency. This command can be used to check if the input audio stream is below a low threshold as reported by the IALL bit, or above a high threshold as reported by the IALH bit. The thresholds can be configured to detect a silence condition or an activity condition which can then be used by the host to take an appropriate action such as turning off the carrier in the case of prolonged silence. The thresholds are set using the TX_ASQ_LEVEL_LOW and TX_ASQ_LEVEL_HIGH properties. The audio must be above or below the threshold for greater than the amount of time specified in the TX_ASQ_DURATION_LOW and TX_ASQ_DURATION_HIGH properties for the status to be detected. Additionally the command can be used to determine if an overmodulation condition has occurred or the limiter has engaged, as reported by the OVERMOD bit, in which case the host could reduce the audio level to the part. If any of the OVERMOD, IALH, or IALL bits are set, the ASQINT bit will also be set. The ASQINT bit can be routed to a hardware interrupt via the GPO_IEN property.

Clearing the IALH or IALL interrupts will result in the TX_ASQ_DURATION_LOW or TX_ASQ_DURATION_HIGH counters being rearmed, respectively, to start another detection interval measurement. The command clears the ASQINT interrupt bit and OVERMOD, IALH, and IALL bits when the INTACK bit of ARG1 is set. The CTS bit (and optional interrupt) is set when it is safe to send the next command. This command may only be sent when in powerup mode.

Note that the TX_ASQ_DURATION_LOW and TX_ASQ_DURATION_HIGH counters start and the TX_ASQ_STATUS command will only return valid data after a call to TX_TUNE_FREQ, TX_TUNE_POWER, or TX_TUNE_MEASURE.

Available in: All

Command arguments: One

Response bytes: Four

Command

Bit	D7	D6	D5	D4	D3	D2	D1	D0
CMD	0	0	1	1	0	1	0	0
ARG1	0	0	0	0	0	0	0	INTACK

ARG	Bit	Name	Function
1	0	INTACK	**Interrupt Acknowledge.** 0 = Interrupt status preserved. 1 = Clears ASQINT, OVERMOD, IALDH, and IALDL.

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Response

Bit	D7	D6	D5	D4	D3	D2	D1	D0
STATUS	CTS	ERR	X	X	X	RDSINT	ASQINT	STCINT
RESP1	X	X	X	X	X	OVERMOD	IALH	IALL
RESP2	X	X	X	X	X	X	X	X
RESP3	X	X	X	X	X	X	X	X
RESP4	INLEVEL[7:0]							

RESP	Bit	Name	Function
1	2	OVERMOD	**Overmodulation Detection.** 0 = Output signal is below requested modulation level. 1 = Output signal is above requested modulation level.
1	1	IALH	**Input Audio Level Threshold Detect High.** 0 = Input audio level high threshold not exceeded. 1 = Input audio level high threshold exceeded.
1	0	IALL	**Input Audio Level Threshold Detect Low.** 0 = Input audio level low threshold not exceeded. 1 = Input audio level low threshold exceeded.
2	7:0	Reserved	**Returns various values.**
3	7:0	Reserved	**Returns various values.**
4	7:0	INLEVEL[7:0]	**Input Audio Level.** The current audio input level measured in dBfs (2s complement notation).

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