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Si4012 Crystal-less FSK/OOK RF Transmitter

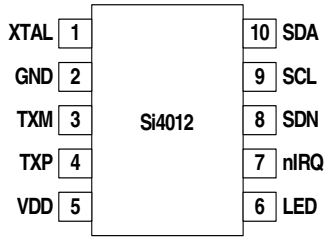
Features

- Frequency range
  - 27–960 MHz
- Output power range
  - –13 to +10 dBm
- Low Power Consumption
  - OOK
    14.2 mA @ +10 dBm
  - FSK
    19.8 mA @ +10 dBm
- Data rate:
  - Up to 100 kbaud FSK
  - Up to 50 kbaud OOK
- FSK and OOK modulation
- Power supply = 1.8 to 3.6 V
- Automatic antenna tuning
- Programmable ramp rate
- Crystal-less operation
  - ±150 ppm: 0 to 70° C
  - ±250 ppm: –40 to 85° C
  - Optional crystal input for applications requiring tighter tolerances
- Ultra low standby current <10 nA
- Integrated voltage regulator
- 255 byte FIFO
- Low battery detector
- SMBus Interface
- –40 to +85 °C temperature range
- 10-Pin MSOP Package, RoHs compliant
- Low BOM

Ordering Information:
See page 43.

Pin Assignments

Si4012



Patents pending

Applications

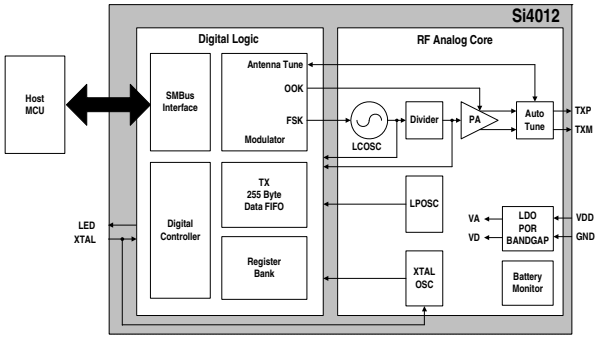
- Wireless MBus T1-mode
- Remote control
- Home security & alarm
- Personal data logging
- Toy control
- Wireless PC peripherals
- Remote meter reading
- Remote keyless entry
- Home automation
- Industrial control
- Sensor networks
- Health monitors

Description

Silicon Laboratories' Si4012 is a fully-integrated crystalless CMOS high-data-rate RF transmitter designed for the sub-GHz ISM band. This chip is optimized for battery powered applications requiring low standby currents and high output transmit power.

The device offers advanced radio features including continuous frequency coverage from 27–960 MHz, adjustable output power of up to +10 dBm, and data rates up to 100 kbaud in FSK mode. The Si4012's high level of integration offers reduced BOM cost while simplifying overall system design.

Functional Block Diagram



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1. Electrical Specifications

Table 1. Recommended Operating Conditions[1]

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Supply Voltage	V_{DD}		1.8	—	3.6	V
Supply Voltage Slew Rate		Initial Battery Insertion[2]	20	—	650	mV/ us
Input Voltage		Digital Input Signals	–0.3	—	V_{DD} + 0.3	V

Notes:
1. All specifications guaranteed by production test unless otherwise noted. Production test conditions and max limits are listed in "1.1. Definition of Test Conditions" on page 7.
2. Recommend bypass capacitor = 1 µF; slew rate measured 1 V < V_{DD} ,< 1.7 V.

Table 2. DC Characteristics*

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Power Saving Modes	$I_{Shutdown}$	Lowest current mode	—	10	—	nA
	I_{Idle}	Register values retained, lowest current consumption idle mode	—	600	—	µA
TX Mode Current @ 10 dBm	I_{TX_OOK}	OOK, Manchester encoded	—	14.2	—	mA
	I_{TX_FSK}	FSK	—	19.8	—	mA

***Note:** All specifications guaranteed by production test unless otherwise noted. Production test conditions and max limits are listed in "1.1. Definition of Test Conditions" on page 7.

Table 3. Si4012 RF Transmitter Characteristics[1]
(TA = 25 °C, VDD = 3.3 V, RL = 550 Ω, unless otherwise noted)

Parameter	Test Condition	Min	Typ	Max	Unit
Frequency Range (F_{RF})[2]		27	—	960	MHz
Frequency Noise (rms)[3]	Allen deviation, measured across 1 ms interval	—	0.3	—	ppm
Phase Noise @ 915 MHz	10 kHz offset	—	–70	—	dBc/Hz
	100 kHz offset	—	–100	—	dBc/Hz
	1 MHz offset	—	–105	—	dBc/Hz
Frequency Tuning Time		—	5	—	ms
Carrier Frequency Accuracy	0 °C ≤ T_A ≤ 70 °C	–150		+150	ppm
	–40 °C ≤ T_A ≤ 85 °C	–250		+250	ppm
Frequency Error Contribution with External Crystal		–10	—	+10	ppm
Transmit Power[4]	Maximum programmed Tx power, with optimum differential load, V_{DD} > 2.2 V	—	10	—	dBm
	Minimum programmed TX power, with optimum differential load, V_{DD} > 2.2 V	—	–13	—	dBm
	Power variation vs temp and supply, with optimum differential load, V_{DD} > 2.2 V	–1.0	—	0.5	dB
	Power variation vs temp and supply, with optimum differential load, V_{DD} > 1.8 V	–2.5	—	0.5	dB
	Transmit power step size from –13 to 6.5 dBm	—	0.25	—	dB
PA Edge Ramp Rate Programmable Range	OOK mode	0.34	—	10.7	us
Data Rate	OOK	0.1	—	50	kbaud
	FSK	0.1	—	100	kbaud
FSK Deviation	Max frequency deviation	—	275	—	ppm
	Deviation resolution	—	2	—	ppm
	Deviation accuracy	±(4 ppm + 2% pk-pk target FSK deviation in ppm)			ppm
OOK Modulation Depth		60	—	—	dB
Antenna Tuning Capacitive Range (Differential)	315 MHz	2.4	—	12.5	pF

Notes:
1. All specifications guaranteed by production test unless otherwise noted. Production test conditions and max limits are listed in "1.1. Definition of Test Conditions" on page 7.
2. The frequency range is continuous over the specified range.
3. The frequency step size is limited by the frequency noise.
4. Optimum differential load is equal to 4 V/(11.5 mA/2 x 4/PI) = 550 Ω. Therefore the antenna load resistance in parallel with the Si4012 differential output resistance should equal 600 Ω.

Table 4. Low Battery Detector Characteristics*

(TA = 25° C, VDD = 3.3 V, RL = 550 Ω, unless otherwise noted)

Parameter	Test Condition	Min	Typ	Max	Unit
Battery Voltage Measurement Accuracy		—	2	—	%

***Note:** All specifications guaranteed by production test unless otherwise noted. Production test conditions and max limits are listed in "1.1. Definition of Test Conditions" on page 7.

Table 5. Optional Crystal Oscillator Characteristics*

(TA = 25° C, VDD = 3.3 V, RL = 600 Ω, unless otherwise noted)

Parameter	Test Condition	Min	Typ	Max	Unit
Crystal Frequency Range		10	—	13	MHz
Input Capacitance (GPIO0)	GPIO0 configured as a crystal oscillator; XO_LOWCAP=1	—	3	—	pF
	GPIO0 configured as a crystal oscillator; XO_LOWCAP=0	—	5.5	—	pF
Crystal ESR	GPIO0 configured as a crystal oscillator; XO_LOWCAP=1	—	—	120	Ω
	GPIO0 configured as a crystal oscillator; XO_LOWCAP=0	—	—	80	Ω
Start-Up Time	Crystal oscillator only, 60 mH motional arm inductance	—	9	50	ms

***Note:** All specifications guaranteed by production test unless otherwise noted. Production test conditions and max limits are listed in "1.1. Definition of Test Conditions" on page 7.

Table 6. Thermal Conditions

Parameter	Symbol	Value	Unit
Ambient Temperature	T_A	–40 to 85	°C
Junction Temperature	T_{OP}	–40 to 90	°C
Storage Temperature	T_{STG}	–55 to 125	°C

Table 7. Absolute Maximum Ratings[1,2]

Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD}	–0.5 to 3.9	V
Input Current[3]	I_{IN}	10	mA
Input Voltage[4]	V_{IN}	–0.3 to (V_{DD} + 0.3)	V

Notes:

1. Permanent device damage may occur if the absolute maximum ratings are exceeded. Functional operation should be restricted to the conditions as specified in the operational sections of this data sheet. Exposure beyond recommended operating conditions for extended periods may affect device reliability.
2. Handling and assembly of these devices should only be done at ESD-protected workstations.
3. All input pins besides V_{DD}.
4. For GPIO pins configured as inputs.

1.1. Definition of Test Conditions

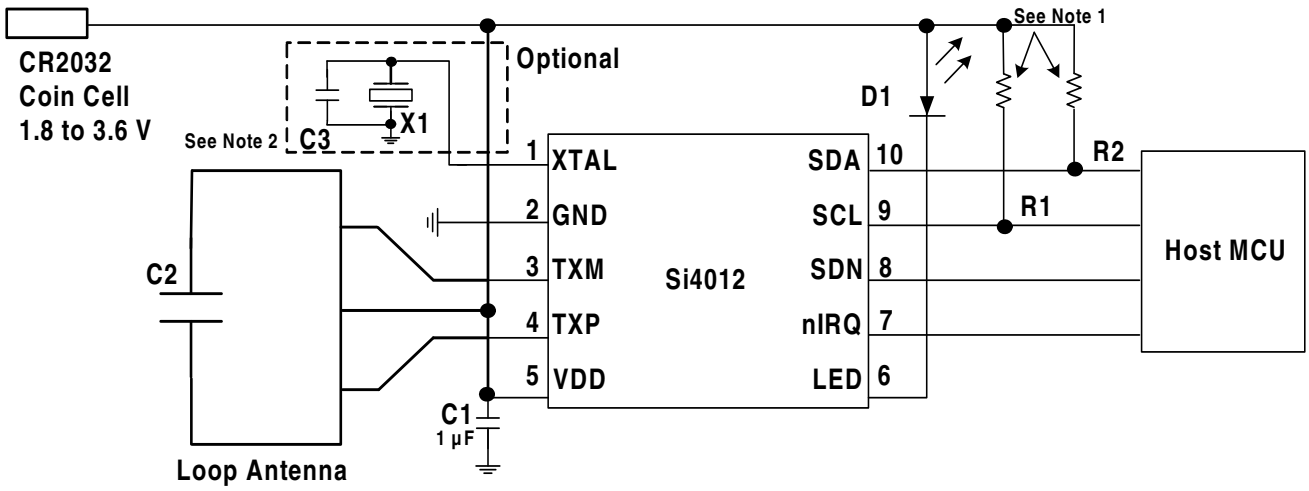
Production Test Conditions:

- T_A = +25 °C.
- V_{DD} = +3.3 VDC.
- TX output power measured at 100 MHz.
- All RF output levels referred to the pins of the Si4012 (not the RF module).

Qualification Test Conditions:

- T_A = –40 to +85 °C.
- V_{DD} = +1.8 to +3.6 VDC.
- All RF output levels referred to the pins of the Si4012 (not the RF module).

2. Typical Application Schematic



Notes:

1. The Si4012 has internal 50 kΩ pull-up resistors. Additional optional external pull-up resistors may be added should the board design required it.
2. See note about how to choose the value of C3 in "5.2.10. PROPERTY: XO_CONFIG" on page 39.

3. Functional Description

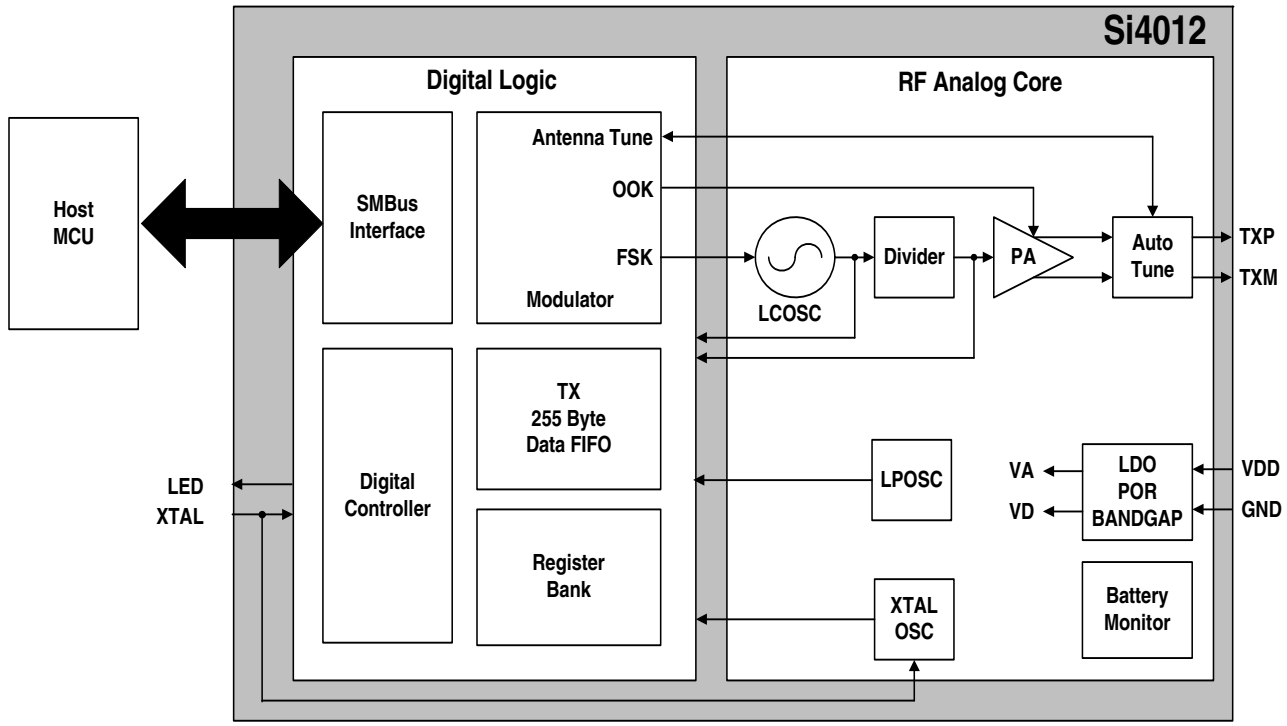


Figure 1. Si4012 Functional Block Diagram

The Si4012 is a fully-integrated, crystal-less, sub-GHz CMOS RF transmitter offering industry-leading RF performance, high integration, flexibility, low BOM, small board area, and ease of design.

The device is designed to operate with any host MCU via a serial interface while optimized for battery-powered applications. The Si4012 operates from voltages ranging from 1.8 to 3.6 V and offers an ultra-low standby current consumption of less than 10 nA.

The embedded power amplifier can be programmed to supply from –13 dBm up to +10 dBm, while the patented automatic antenna tuning circuit ensures that the resonant frequency and impedance matching between the PA output and the connected antenna are configured for optimum transmit efficiency and low harmonic content.

Users may configure the device for either FSK or OOK modulation with supported symbol rates of up to 100 kbps. To ensure the lowest system cost, the Si4012 can be used without an external crystal or frequency reference by leveraging Silicon Labs' patented and proven crystal-less oscillator technology. This technology offers better than ±150 ppm carrier frequency stability over the temperature range of 0 to +70 °C and ±250 ppm carrier frequency stability over the industrial temperature range of –40 to + 85 °C. No production alignments are necessary since all RF functions are integrated into the device.

4. Host MCU Interface

4.1. SMBus Interface

The SMBus interface is implemented as a bidirectional 2-wire interface (SCL, SDA) with the host configured as master and the Si4012 configured as slave. Both standard (100 kbps) and fast (400 kbps) modes are supported with 7-bit addressing. The default device address is 1110000x, where x is the R/W bit.

4.1.1. Design Recommendation

In designs with multiple SMBus devices, it is recommended to use separate SMBus buses where possible since all attached SMBus devices will wake on bus traffic to confirm address. This process can lead to better battery life compared to systems with single-bus designs.

4.2. SMBus Flow Control

The SCL and SDA pins are configured as open drain requiring external pull-up resistors. Flow control is implemented using the open drain configuration as shown below.

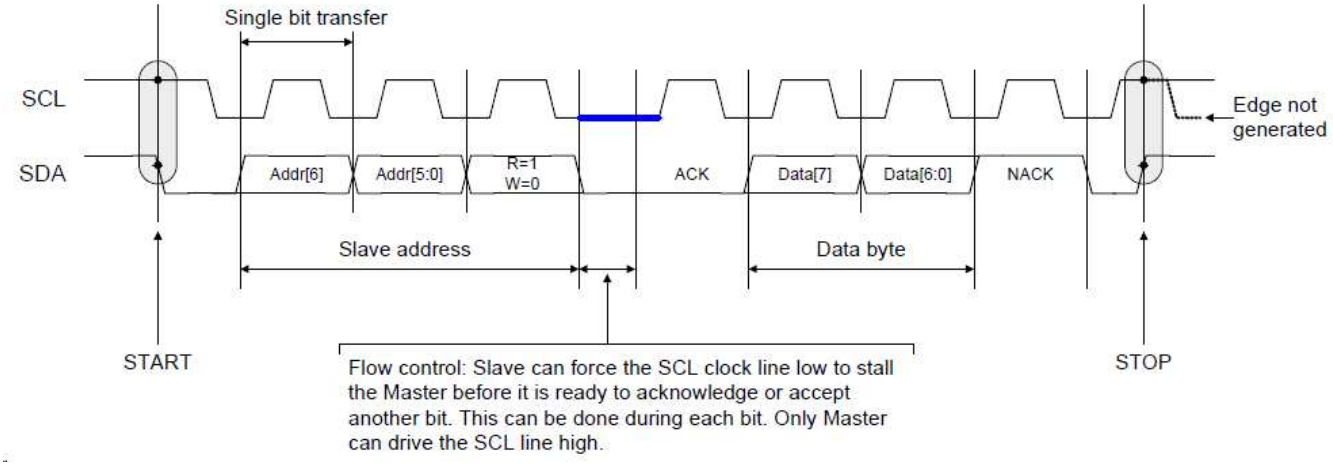


Figure 2. WRITE Operation from Master to Slave

The data (SDA) pin never changes when SCL = 1 during bit data transfers. If it changes, it indicates a START or STOP condition generated by the master/host. After the START condition, a 7-bit address is sent to the Si4012/slave by the host/master, followed by a single bit determining what is going to drive SDA (i.e., a write or read operation). For a WRITE operation, the master drives the following SDA bits, and the slave sends ACK/NAK bits. For a READ operation, the slave drives the data bits, and the master responds with ACK/NACK.

Figure 2 shows a write operation from MASTER to SLAVE. Shortly after the R/W bit is received, the SLAVE device holds the SCL line low (blue line), thus stalling the master. The master will detect when SCL is released by the slave and will clock in the ACK/NACK bit from the slave (ACK shown above). By this, the slave (Si4012) can service each incoming byte and manage flow control to the host.

4.3. Host Interrupts

An nIRQ line from the Si4012 to the host is used to issue interrupts to the host. The host can then read the interrupt status and clear interrupts from the Si4012 via the SMBus interface.

4.4. Operating Mode Control

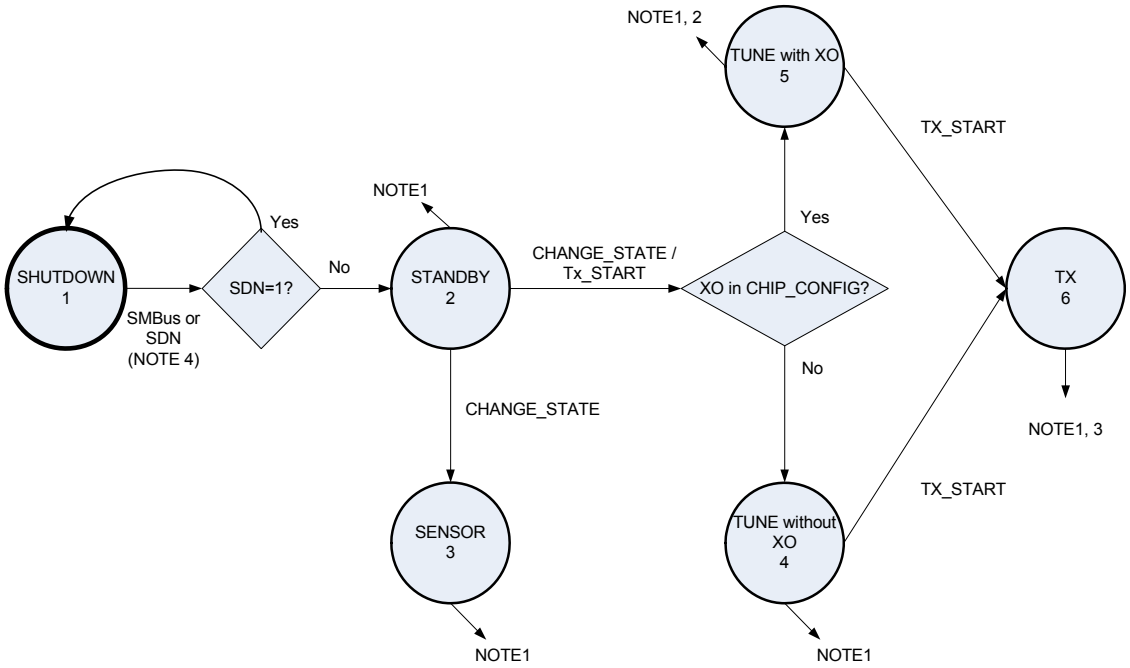


Figure 3. State Machine Diagram

Transition Notes

1. Transition to any state (including SHUTDOWN) using the CHANGE_STATE command. Alternatively, transition to SHUTDOWN using the SDN pin.
2. If a CHANGE_STATE command to the XO TUNE state is issued (even if already in the XO TUNE state), then an XO TUNE operation is carried out immediately. This enables close control of timing (fastest execution) for a subsequent TX_START command. In the TUNE state, a tune operation is carried out in the interval specified in TUNE_INTERVAL.
3. Transition to end state specified in the TX_START command or TX_STOP command.
4. If coming out of the SHUTDOWN via SMBus, an SMBus “wake-up” byte is required. This byte is discarded, and normal SMBus communication can proceed after the power on reset (ipor) is asserted to the host.

State Descriptions

The Si4012 has six power modes, which are summarized below. Further details on the IC configuration in these modes can be found in "5.1.5. COMMAND: CHANGE_STATE" on page 22.

- **SHUTDOWN**—Lowest current consumption; the majority of hardware blocks are powered down.
- **STANDBY**—Low power state with fast SMBus response.
- **SENSOR**—Same as STANDBY, but the battery is measured periodically.
- **TUNE**—Periodic tuning state. A tune is performed on any CHANGE_STATE to TUNE command and then periodically based on the interval defined in TUNE_INTERVAL. This provides faster transition to TX. If XO is enabled, XO will be used during tune operation.
- **TX**—Transmission state.

Table 8. Power Modes

Mode	Circuit Blocks								I_{VDD}	Response Time to TX (without XO)	Response Time to TX (with XO Early Enable)
	Digital LDO	SMBUS	SYS CLK	LBD	LC	XTAL	DIV	PA			
Shut-down	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	10 nA	22.2 ms	22.2 ms
Standby	ON	ON	SLOW	OFF	OFF	OFF	OFF	OFF	600 µA[3]	6.6 ms	6.6 ms[4]
Sensor		ON	FAST	ON	OFF	OFF	OFF	OFF	610 µA[3]	6.6 ms	6.6 ms[4]
Tune without XO		ON	FAST	OFF	ON[1]	OFF	ON[1]	ON[1]	Note[2]	370 µs	—
Tune with XO		ON	FAST	OFF	ON[1]	ON	ON[1]	ON[1]	Note[2]	—	370 µs

Notes:

1. The LC, DIV, and PA are turned on as needed during the Tune operation.
2. See the tune section from Tune Start to PA Tune in the charts below for current consumption in Tune with XO and Tune without XO.
3. The current consumption at Standby and Sensor does not include the power consumed by the internal XO circuitry. XO should be turned off with SET_PROPERTY/CHIP_CONFIG to save power if external XO is not used or if tuning is not happening soon when external XO is present.
4. The response time assumes external XO stays enabled prior to TX.

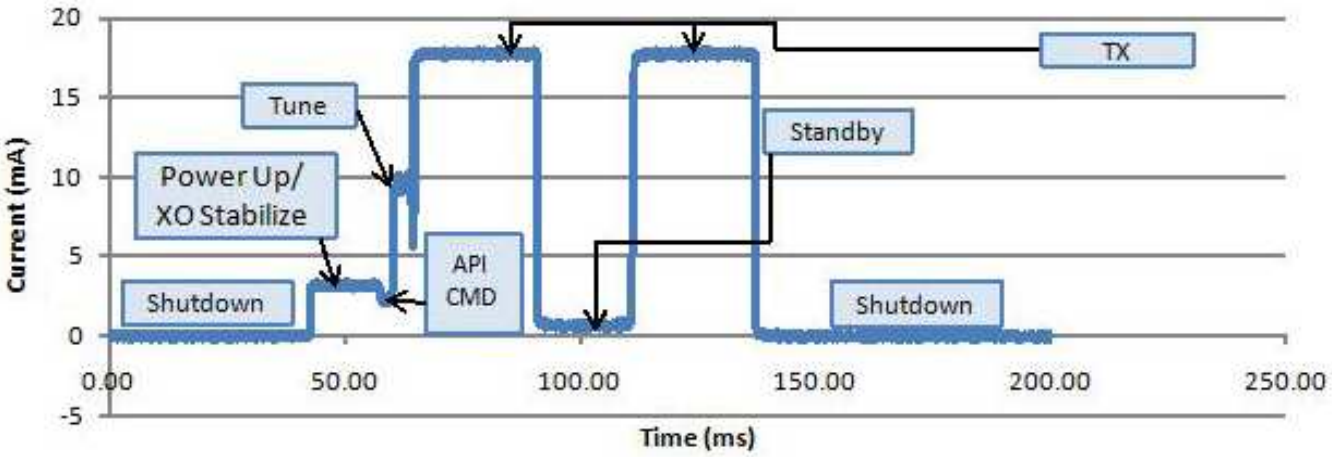


Figure 4. Current Consumption with XO

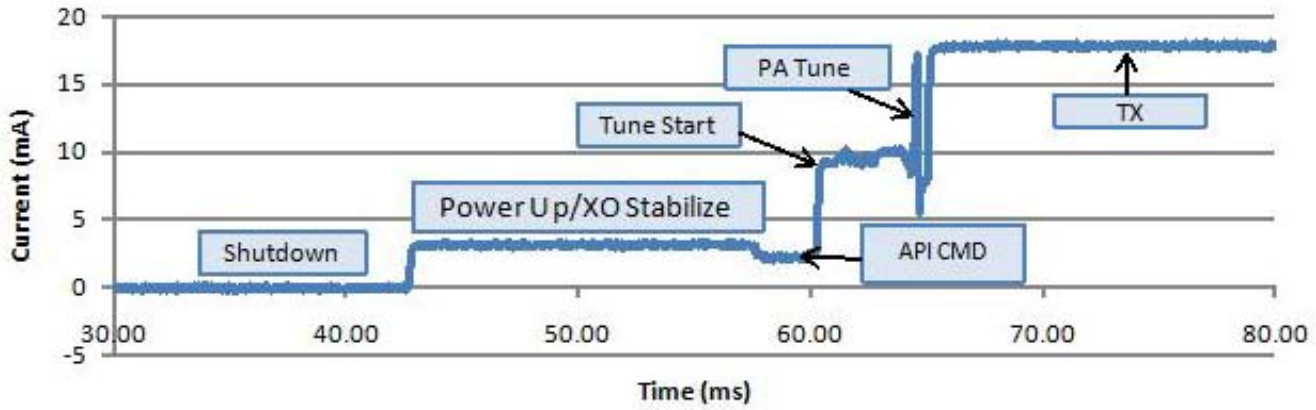


Figure 5. Current Consumption with XO (Upscaled between 30 and 80 ms)

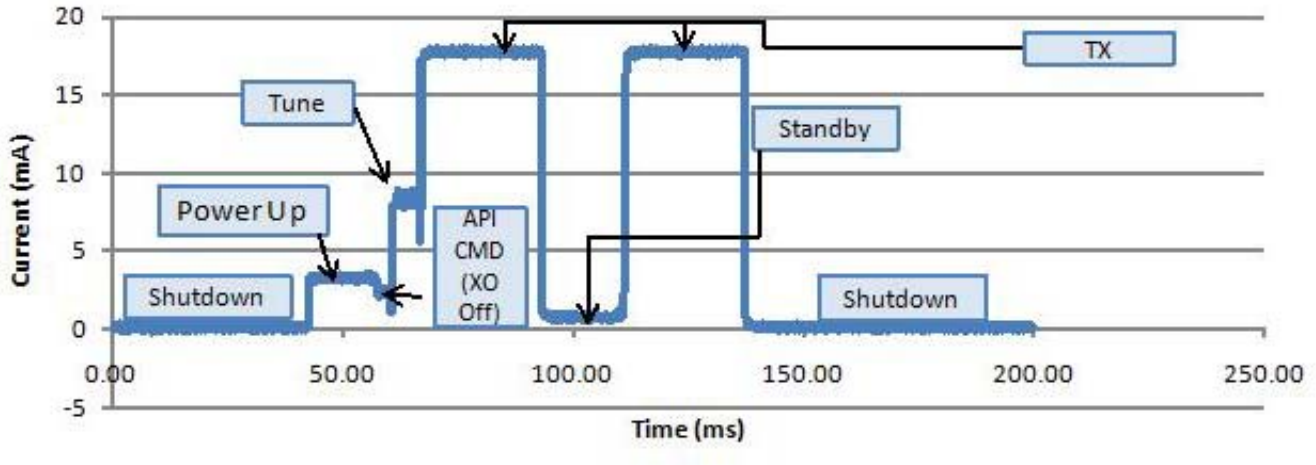


Figure 6. Current Consumption without XO

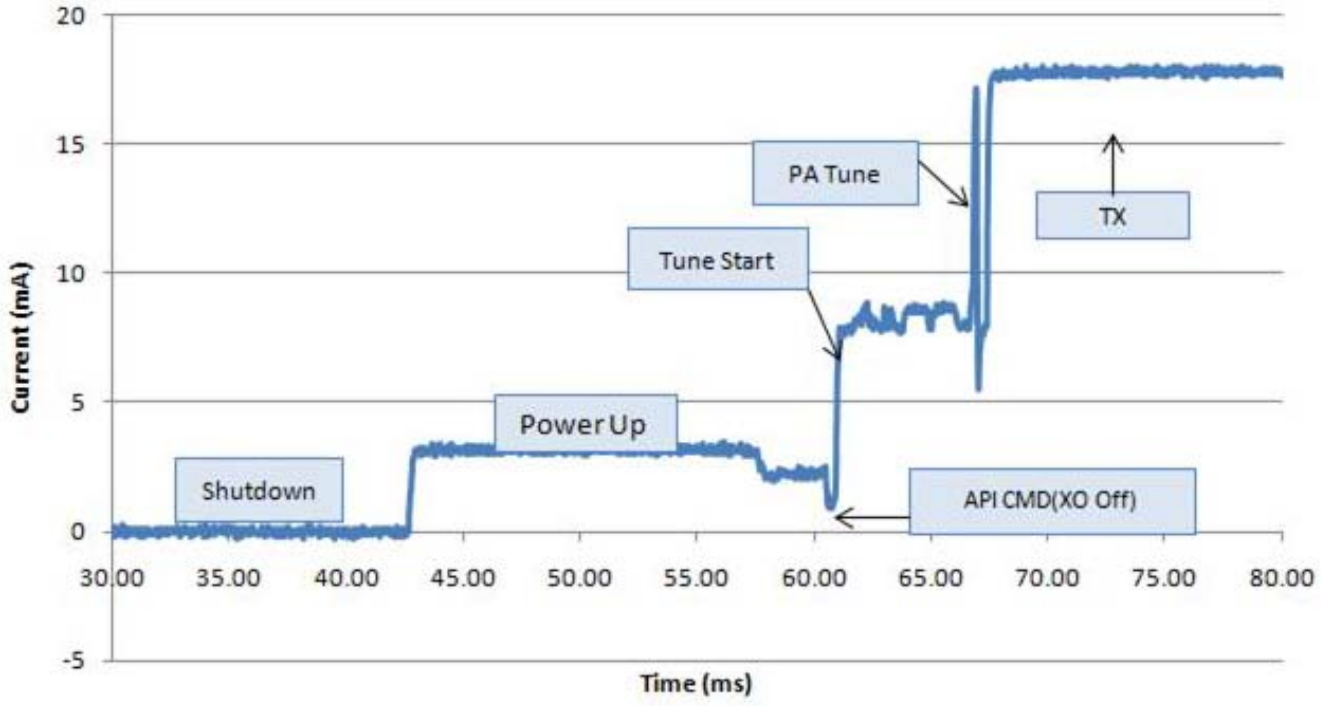


Figure 7. Current Consumption without XO (Upscaled between 30 and 80 ms)

5. Command Structure

The Si4012 has been designed to complete commands in the shortest time possible and to support both polled or event driven (interrupt based) modes. For longer operations, commands are implemented as launch commands. When the result of the launched command is completed, status is returned to the host via host polling or as an interrupt (if enabled). The status is obtained over the SMBus.

For example, when a TX_START command is launched, the Si4012 will parse the command, check it for errors, and return the status to the host immediately; it will also start the TX process. The host can then either poll for an error or “packet sent” or receive an interrupt on nIRQ.

All host commands consist of a 1-byte opcode followed by 0 or more arguments. All responses from the Si4012 consist of a 1-byte top level status followed by 0 or more data values.

Command Structure:

Bit	7	6	5	4	3	2	1	0
CMD								
ARG1								
ARG2								
…								
ARGn								

Response Structure:

Bit	7	6	5	4	3	2	1	0
STATUS	CTS	Err[6:0]						
DATA1								
DATA2								
…								
DATAn								

A CTS (Clear to Send) indicates that the Si4012 has received the command and that the host can send another command. The CTS does not necessarily mean the command has been processed. The host should poll interrupt status or use interrupts (nIRQ) to get execution status for deferred operations.

Err[6:0] indicates an error has occurred if it is non-zero. See the “error codes” section for a full list of available error codes.

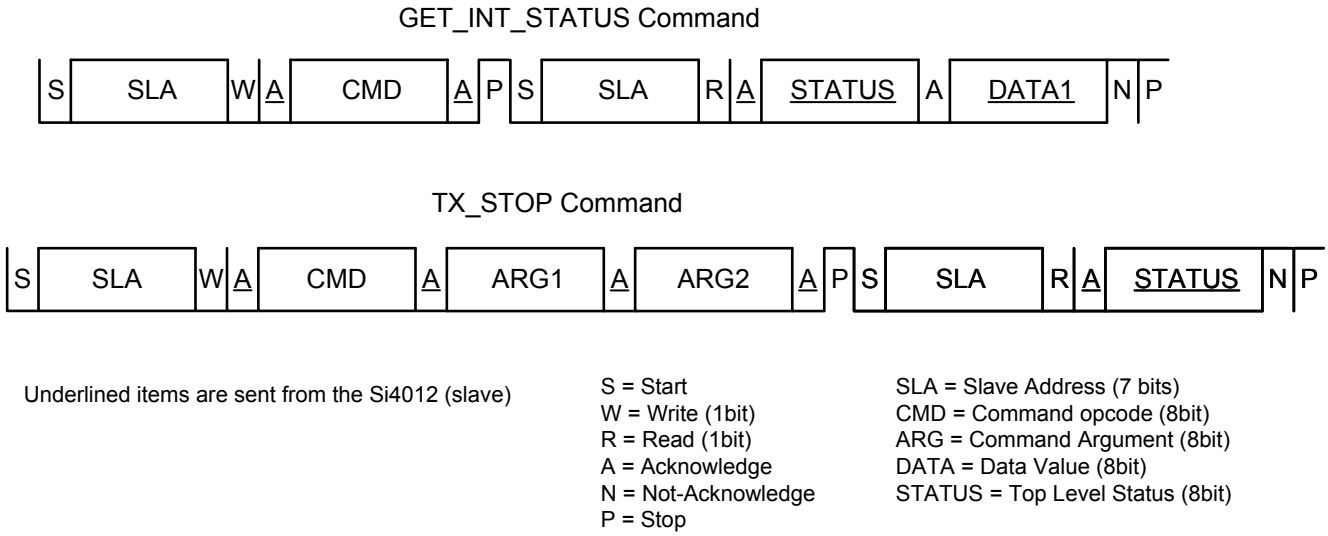


Figure 8. SMBus Sequence Example

Figure 8 above demonstrates two examples using the SMBus command sequence.

5.1. Commands

Table 9 lists the commands available via the SMBus and described in the following sections.

Table 9. Commands Available via SMBus

Section	Command	Description
5.1.1	Get_Rev	Device revision information
5.1.2	Set_Property	Sets device properties
5.1.3	Get_Property	Gets device properties
5.1.4	LED_CTRL	LED Control
5.1.5	Change_State	Configures device mode
5.1.6	Get_State	Get device mode
5.1.7	TX_Start	Start data transmission
5.1.8	Set_Int	Enable interrupts
5.1.9	Get_Int_Status	Read & clear interrupts
5.1.10	Init_FIFO	Clears Tx FIFO
5.1.11	Set_FIFO	Stores data in FIFO for Tx
5.1.12	TX_Stop	Stops transmission
5.1.13	Get_Bat_Status	Gets battery status

5.1.1. COMMAND: GET_REV

Purpose: Return product and revision information for the device.
ARG: None
DATA: Product ID, Revision ID.
Command:

GET_REV Command	7	6	5	4	3	2	1	0
CMD	0x10							

Response:

GET_REV Reply	7	6	5	4	3	2	1	0
STATUS	CTS	Err						
DATA1	ProdId[31:24]							
DATA2	ProdId[23:16]							
DATA3	ProdId[15:8]							
DATA4	ProdId[7:0]							
DATA5	RevisionID_RMIDU[47:40]							
DATA6	RevisionID_RMIDU[39:32]							
DATA7	RevisionID_RMIDL[31:24]							
DATA8	RevisionID_RVID[23:16]							
DATA9	RevisionID_FWIDU[15:8]							
DATA10	RevisionID_FWIDL[7:0]							

5.1.2. COMMAND: SET_PROPERTY

Purpose: Set a property common to one or more commands. These are similar to parameters for a command but are not expected to change frequently and may be controlled by the higher software layers. Setting properties may not cause the device to take immediate action, however the property will take effect once a command which uses it is issued. See the "Properties" section of this document for details on properties.

ARG: PROP_ID[7:0]— Selects the property to set.
DATA[n:0]—Value of the property. The length varies depending on the PROP_ID, up to 6-byte in big Endian can be specified.

DATA: None

Command:

SET_PROPERTY Command	7	6	5	4	3	2	1	0
CMD	0x11							
ARG1	PROP_ID[7:0]							
ARG2	PROP_DATA1, MSB of Property 's value							
ARG3	PROP_DATA 2							
ARG4	PROP_DATA 3							
ARG5	PROP_DATA 4							
ARG6	PROP_DATA5							
ARG7	PROP_DATA6							

Response:

SET_PROPERTY Reply	7	6	5	4	3	2	1	0
STATUS	CTS	Err						

5.1.3. COMMAND: GET_PROPERTY

Purpose: Return the value of a specified property. See "5.2. Properties" on page 32 for details on properties.

ARG: PROP_ID[7:0]—Selects the property to retrieve.

DATA: DATA[n:0] —Value of the specified property, the length varies depending on the PROP_ID, up to 6 bytes

Command:

GET_PROPERTY Command	7	6	5	4	3	2	1	0
CMD	0x12							
ARG1	PROP_ID[7:0]							

Response:

GET_PROPERTY Reply	7	6	5	4	3	2	1	0
STATUS	CTS	Err						
DATA1	PROP_DATA1, MSB of Property's value							
DATA2	PROP_DATA 2							
DATA3	PROP_DATA 3							
DATA4	PROP_DATA 4							
DATA5	PROP_DATA5							
DATA6	PROP_DATA6							

5.1.4. COMMAND: LED_CTRL

Purpose: Turn on/off LED if LED driver is enabled.

ARG: LedOn—If LED driver is enabled, turn LED on if set, otherwise, turn LED off. If LED driver is not enabled, LedOn is ignored if set.

DATA: None

Command:

LED_CTRL Command	7	6	5	4	3	2	1	0
CMD	0x13							
ARG1								LedOn

Response:

LED_CTRL Reply	7	6	5	4	3	2	1	0
STATUS	CTS	Err						

Notes: If LEDOn is set, the Si4012 checks the LedIntensity setting set by the host in SET_PROPERTY/LED_INTENSITY. If the LedIntensity is 0, LED driver will be disabled. Err is set to 0x0A to report this condition.

5.1.5. COMMAND: CHANGE_STATE

Purpose: Change state to IDLE or SHUTDOWN. The device will change to the specified state at the earliest time possible. If changing into IDLE state, ARG2 specifies the idle mode.

Table 10.

Mode	Circuit Blocks								I_{VDD}	Response Time to TX (without XO)	Response Time to TX (with XO Early Enable)
	Digital LDO	SMBUS	SYS CLK	LBD	LC	XTAL	DIV	PA			
Shut-down	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	15 nA	22.2 ms	22.2 ms
Standby	ON	ON	SLOW	OFF	OFF	OFF	OFF	OFF	600 µA[3]	6.6 ms	6.6 ms[4]
Sensor		ON	FAST	ON	OFF	OFF	OFF	OFF	610 µA[3]	6.6 ms	6.6 ms[4]
Tune without XO		ON	FAST	OFF	ON[1]	OFF	ON[1]	ON[1]	Note[2]	370 µs	—
Tune with XO		ON	FAST	OFF	ON[1]	ON	ON[1]	ON[1]	Note[2]	—	370 µs

Notes:
1. The LC, DIV and PA are turned on as needed during the Tune operation.
2. See the tune section from Tune Start to PA Tune in the charts below for current consumption in Tune with XO and Tune without XO.
3. The current consumption at Standby and Sensor does not include the power consumed by the internal XO circuitry. XO should be turned off with SET_PROPERTY/CHIP_CONFIG to save power if external XO is not used or if tuning is not happening soon when external XO is present.
4. The response time assumes external XO stays enabled prior to TX.

ARG:

- State[1:0]—state to transition to.
  - 00 IDLE – Go to idle mode state using the idle mode specified.
  - 01 SHUTDOWN – Go to shutdown state.
  - 10–11 – Reserved.
- IdleMode[2:0]—IDLE mode if changing to idle state.
  - 000 Standby – Low Power State
  - 001 Sensor – Enable Low Battery Detector
  - 010 Tune – Periodic tuning
  - 011–111 – Reserved

DATA: None

Command:

CHANGE_STATE Command	7	6	5	4	3	2	1	0
CMD	0x60							
ARG1							State[1:0]	
ARG2						IdleMode[2:0]		

Response:: None if changing to SHUTDOWN, otherwise

CHANGE_STATE Reply	7	6	5	4	3	2	1	0
STATUS	CTS	Err						

Notes:

1. Changing state among different idle modes is allowed.
2. State can also be changed via TX_START/TX_STOP.
3. An alternative way to transition to SHUTDOWN is by setting SDN pin to high.
4. SMBus activity or setting SDN pin to low will take the device out of shut down state.

5.1.6. COMMAND: GET_STATE

Purpose: Get chip state and status.
ARG: None
DATA:

- State[1:0]—current state
  - 00 Idle
  - 01 Reserved
  - 10 TX
- AutoTX—current AutoTX setting
- IdleMode[2:0]. If State is Idle
  - 000 Standby – Low power state
  - 001 Sensor – Enable Low Battery Detector
  - 010 Tune – Periodic tuning
- DTMod[1:0] if State is TX
  - 00 – FIFO Mode
  - 01 – CW Mode
  - 10 – PN9-0 Mode
  - 11 – PN9-1 Mode
- ActTxPktSize—actual packet sent in the last transmission
- PrevError —error code if error occurred in the previous operation

Command:

GET_STATE Command	7	6	5	4	3	2	1	0
CMD	0x61							

Response:

GET_STATE	7	6	5	4	3	2	1	0
STATUS	CTS	Err						
DATA1						AutoTX	State[1:0]	
DATA2						IdleMode[2:0]/DTMod[1:0]		
DATA3	ActTxPktSize[15:8]							
DATA4	ActTxPktSize[7:0]							
DATA5	PrevError							

5.1.7. COMMAND: TX_START

Purpose: Start transmission and go to a designated state after the packet is transmitted. This is an asynchronous operation. Transmission may not have been started when response is sent back the host.

ARG:

- Packet Size[15:0] to be transmitted
- State to transition to when transmission is completed.
- AutoTX—Enable/Disable FIFO Auto-TX

  1: Auto-Transmit Enabled.
  Transmission will start when the FIFO level reaches the auto transmit threshold specified in ffautotxthr in FIFO_THRESHOLD. If ffautotxthr=0, transmission will start immediately.

  0:Auto-Transmit Disabled.
  Transmit will start immediately until the data specified in the PacketSize is transmitted, or all the data in the FIFO is exhausted, whichever occurs first. If the FIFO becomes empty before the specified packet length is transmitted a FIFO underflow error will occur.

- State[1:0]—State to transition to when transmission is completed.

  00: IDLE—Go to idle state when the packet transmission completes based on the idle mode.

  01: SHUTDOWN—Go to shutdown state when the packet transmission completes.

  10–11: Reserved.

- IdleMode[2:0] if State is Idle; DTmod[1:0] if State is TX.

  Idle Mode 000 Standby – Low power state
  001 Sensor – Enable Low Battery Detector
  010 Tune – Periodic tuning

- DTMod[1:0] 00 – FIFO Mode
  01 – CW Mode
  10 – PN9-0 Mode
  11 – PN9-1 Mode

DATA: Current data size in the FIFO when TX_START is received.

Command:

TX_START Command	7	6	5	4	3	2	1	0
CMD	0x62							
ARG1	PacketSize[15:8]							
ARG2	PacketSize[7:0]							
ARG3						AutoTX	State[1:0]	
ARG4						IdleMode[2:0]		
ARG5	DTMod[1:0]							