

## BROADCAST ANALOG TUNING DIGITAL DISPLAY AM/FM/SW RADIO RECEIVER

### Features

- Worldwide FM band support (64–109 MHz)
- Worldwide AM band support (504–1750 kHz)
- SW band support (Si4844 only) (2.3–28.5 MHz)
- Selectable support for all AM/FM regional bands
- 2-wire control interface
- Mono/Stereo and valid station indicator
- Digital volume support
- Bass/Treble support
- Minimal BOM components with no manual alignment
- Excellent real-world performance
- Automatic frequency control (AFC)
- EN55020 compliant
- Two AAA batteries with 2.0 to 3.6 V supply voltage (T = 25 °C)
- Wide range of ferrite loop sticks and air loop antenna support
- 24-pin SSOP package
- RoHS compliant

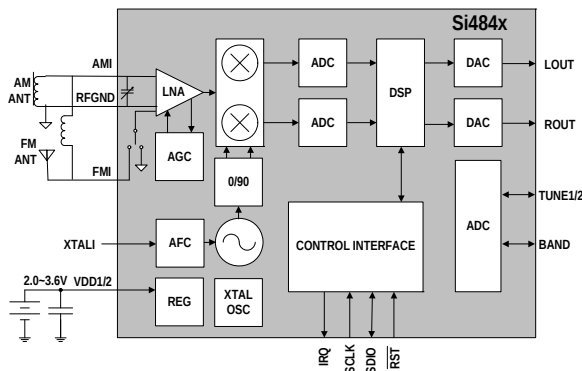
### Applications

- Table and portable radios
- Stereos
- Mini/micro systems
- Boom boxes
- Clock radios
- Modules for consumer electronics
- Entertainment systems
- Toys, lamps, and any application needing an AM/FM radio
- Mini HiFi
- iPhone docking

### Description

The Si4840/44 is the first analog-tuned digital-display digital CMOS AM/FM/SW radio receiver IC that integrates the complete receiver function from antenna input to audio output. Working with Host MCU (I<sup>2</sup>C-compatible 2-wire control interface), frequencies, and stereo/mono information can be displayed on LCD, while the analog-tune features are kept. Leveraging Silicon Laboratories' proven and patented digital low intermediate frequency (low-IF) receiver architecture, the Si4840/44 deliver superior RF performance and interference rejection. The superior control algorithm integrated in Si4840/44 provides easy and reliable control interface while eliminating all the manual tuned external components used in traditional solution.

### Functional Block Diagram



**Ordering Information:**  
See page 20.

### Pin Assignments

#### Si4840/44-A10 (SSOP)

|        |    |    |       |
|--------|----|----|-------|
| LNA_EN | 1  | 24 | LOUT  |
| IRQ    | 2  | 23 | ROUT  |
| TUNE1  | 3  | 22 | DBYP  |
| TUNE2  | 4  | 21 | VDD2  |
| BAND   | 5  | 20 | VDD1  |
| NC     | 6  | 19 | XTALI |
| NC     | 7  | 18 | XTALO |
| FMI    | 8  | 17 | SCLK  |
| RFGND  | 9  | 16 | SDIO  |
| NC     | 10 | 15 | RST   |
| NC     | 11 | 14 | GND   |
| AMI    | 12 | 13 | GND   |

This product, its features, and/or its architecture is covered by one or more of the following patents, as well as other patents, pending and issued, both foreign and domestic: 7,127,217; 7,272,373; 7,272,375; 7,321,324; 7,355,476; 7,426,376; 7,471,940; 7,339,503; 7,339,504.



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## 1. Electrical Specifications

**Table 1. Recommended Operating Conditions<sup>1,2</sup>**

| Parameter                                                                                                                                                                                                                                                                                                                                                                                                                                      | Symbol       | Test Condition | Min | Typ | Max | Unit    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|----------------|-----|-----|-----|---------|
| Supply Voltage <sup>3</sup>                                                                                                                                                                                                                                                                                                                                                                                                                    | $V_{DD}$     |                | 2   | —   | 3.6 | V       |
| Power Supply Powerup Rise Time                                                                                                                                                                                                                                                                                                                                                                                                                 | $V_{DDRISE}$ |                | 10  | —   | —   | $\mu s$ |
| <b>Notes:</b><br>1. Typical values in the data sheet apply at $V_{DD} = 3.3$ V and 25 °C unless otherwise stated.<br>2. All minimum and maximum specifications in the data sheet apply across the recommended operating conditions for minimum $V_{DD} = 2.7$ V.<br>3. Operation at minimum $V_{DD}$ is guaranteed by characterization when $V_{DD}$ voltage is ramped down to 2.0 V. Part initialization may become unresponsive below 2.3 V. |              |                |     |     |     |         |

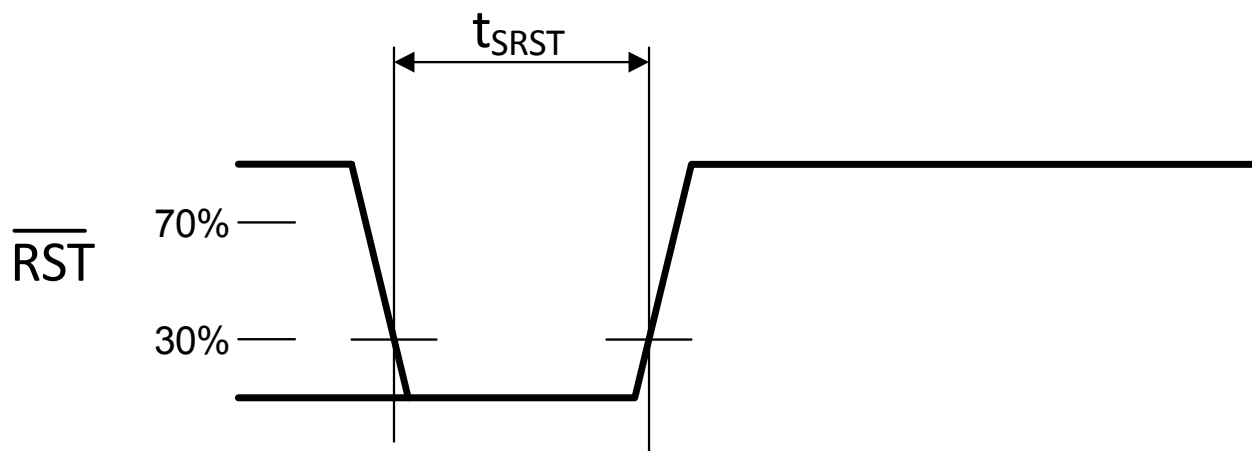
**Table 2. DC Characteristics**

( $V_{DD} = 2.7$  to 3.6 V,  $T_A = -15$  to 85 °C)

| Parameter                                                                                                                                                                            | Symbol     | Test Condition | Min | Typ  | Max | Unit    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------------|-----|------|-----|---------|
| <b>FM Mode</b>                                                                                                                                                                       |            |                |     |      |     |         |
| Supply Current <sup>1</sup>                                                                                                                                                          | $I_{FM}$   |                | —   | 21.0 | —   | mA      |
| Supply Current <sup>2</sup>                                                                                                                                                          | $I_{FM}$   | Low SNR level  | —   | 21.5 | —   | mA      |
| <b>AM/SW Mode</b>                                                                                                                                                                    |            |                |     |      |     |         |
| Supply Current <sup>1</sup>                                                                                                                                                          | $I_{AM}$   |                | —   | 17.0 | —   | mA      |
| <b>Supplies and Interface</b>                                                                                                                                                        |            |                |     |      |     |         |
| $V_{DD}$ Powerdown Current                                                                                                                                                           | $I_{DDPD}$ |                | —   | 10   | —   | $\mu A$ |
| <b>Notes:</b><br>1. Specifications are guaranteed by characterization.<br>2. LNA is automatically switched to higher current mode for optimum sensitivity in weak signal conditions. |            |                |     |      |     |         |

**Table 3. Reset Timing Characteristics** $(V_{DD} = 2.7 \text{ to } 3.6 \text{ V}, T_A = -15 \text{ to } 85 \text{ }^{\circ}\text{C})$ 

| Parameter                           | Symbol            | Min | Typ | Max | Unit          |
|-------------------------------------|-------------------|-----|-----|-----|---------------|
| $\overline{\text{RST}}$ Pulse Width | $t_{\text{SRST}}$ | 100 | —   | —   | $\mu\text{s}$ |

**Figure 1. Reset Timing**

**Table 4. 2-Wire Control Interface Characteristics<sup>1,2,3</sup>**

(V<sub>DD</sub> = 2.7 to 3.6 V, T<sub>A</sub> = -15 to 85 °C)

| Parameter                                | Symbol                                 | Test Condition | Min                               | Typ | Max | Unit |
|------------------------------------------|----------------------------------------|----------------|-----------------------------------|-----|-----|------|
| SCLK Frequency                           | f <sub>SCLK</sub>                      |                | 0                                 | —   | 400 | kHz  |
| SCLK Low Time                            | t <sub>LOW</sub>                       |                | 1.3                               | —   | —   | μs   |
| SCLK High Time                           | t <sub>HIGH</sub>                      |                | 0.6                               | —   | —   | μs   |
| SCLK Input to SDIO ↓ Setup (START)       | t <sub>SU:STA</sub>                    |                | 0.6                               | —   | —   | μs   |
| SCLK Input to SDIO ↓ Hold (START)        | t <sub>HD:STA</sub>                    |                | 0.6                               | —   | —   | μs   |
| SDIO Input to SCLK ↑ Setup               | t <sub>SU:DAT</sub>                    |                | 100                               | —   | —   | ns   |
| SDIO Input to SCLK ↓ Hold <sup>4,5</sup> | t <sub>HD:DAT</sub>                    |                | 0                                 | —   | 900 | ns   |
| SCLK input to SDIO ↑ Setup (STOP)        | t <sub>SU:STO</sub>                    |                | 0.6                               | —   | —   | μs   |
| STOP to START Time                       | t <sub>BUF</sub>                       |                | 1.3                               | —   | —   | μs   |
| SDIO Output Fall Time                    | t <sub>f:OUT</sub>                     |                | $20 + 0.1 \frac{C_b}{1\text{pF}}$ | —   | 250 | ns   |
| SDIO Input, SCLK Rise/Fall Time          | t <sub>f:IN</sub><br>t <sub>r:IN</sub> |                | $20 + 0.1 \frac{C_b}{1\text{pF}}$ | —   | 300 | ns   |
| SCLK, SDIO Capacitive Loading            | C <sub>b</sub>                         |                | —                                 | —   | 50  | pF   |
| Input Filter Pulse Suppression           | t <sub>SP</sub>                        |                | —                                 | —   | 50  | ns   |

**Notes:**

1. When V<sub>D</sub> = 0 V, SCLK and SDIO are low impedance.
2. When selecting 2-wire mode, the user must ensure that a 2-wire start condition (falling edge of SDIO while SCLK is high) does not occur within 300 ns before the rising edge of RST.
3. When selecting 2-wire mode, the user must ensure that SCLK is high during the rising edge of RST, and stays high until after the first start condition.
4. The Si484x delays SDIO by a minimum of 300 ns from the V<sub>IH</sub> threshold of SCLK to comply with the minimum t<sub>HD:DAT</sub> specification.
5. The maximum t<sub>HD:DAT</sub> has only to be met when f<sub>SCLK</sub> = 400 kHz. At frequencies below 400 kHz, t<sub>HD:DAT</sub> may be violated as long as all other timing parameters are met.

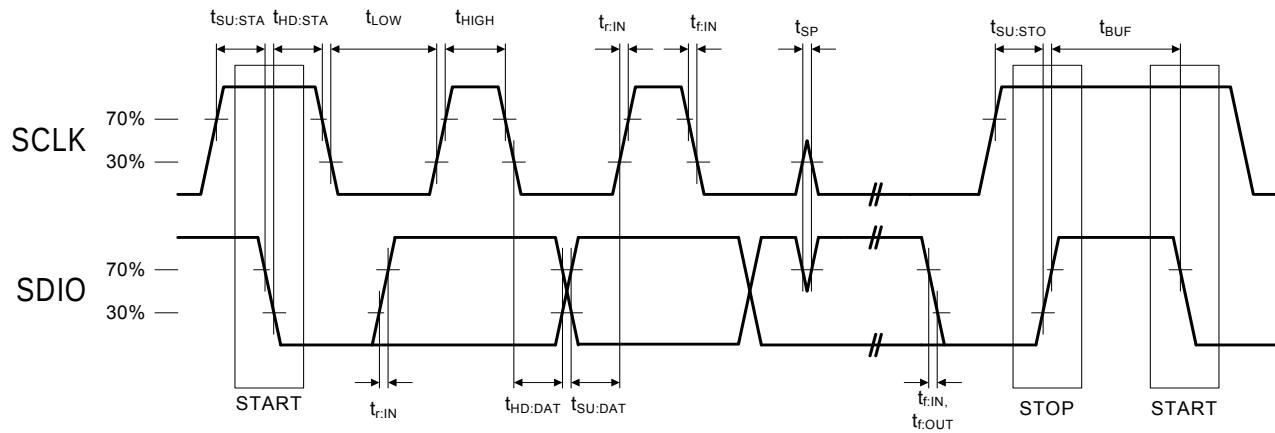


Figure 2. 2-Wire Control Interface Read and Write Timing Parameters

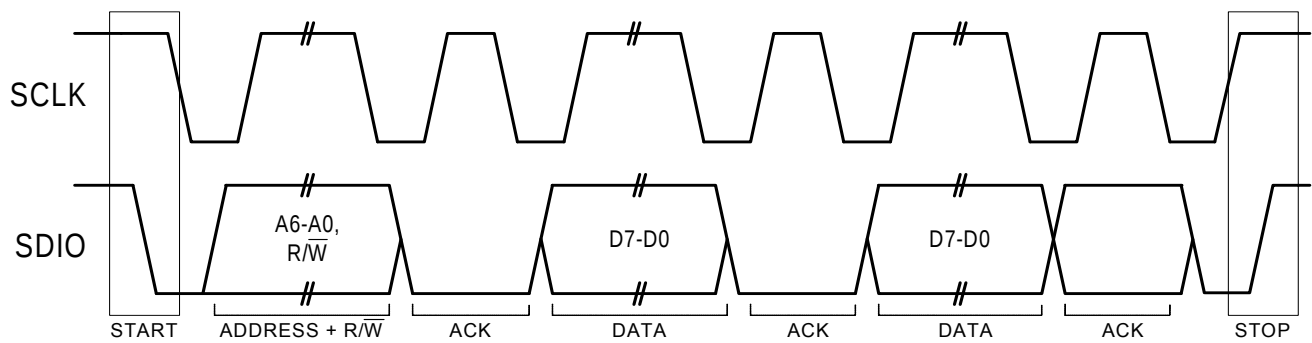


Figure 3. 2-Wire Control Interface Read and Write Timing Diagram

**Table 5. FM Receiver Characteristics<sup>1,2</sup>**

(V<sub>DD</sub> = 2.7 to 3.6 V, TA = –15 to 85 °C)

| Parameter                                       | Symbol          | Test Condition  | Min | Typ | Max | Unit              |
|-------------------------------------------------|-----------------|-----------------|-----|-----|-----|-------------------|
| Input Frequency                                 | f <sub>RF</sub> |                 | 64  | —   | 109 | MHz               |
| Sensitivity with Headphone Network <sup>3</sup> |                 | (S+N)/N = 26 dB | —   | 2.2 | —   | μV EMF            |
| LNA Input Resistance <sup>4,5</sup>             |                 |                 | —   | 4   | —   | kΩ                |
| LNA Input Capacitance <sup>4,5</sup>            |                 |                 | —   | 5   | —   | pF                |
| AM Suppression <sup>4,5,6,7</sup>               |                 | m = 0.3         | —   | 50  | —   | dB                |
| Input IP <sub>3</sub> <sup>4,8</sup>            |                 |                 | —   | 105 | —   | dBμV EMF          |
| Adjacent Channel Selectivity <sup>4</sup>       |                 | ±200 kHz        | —   | 50  | —   | dB                |
| Alternate Channel Selectivity <sup>4</sup>      |                 | ±400 kHz        | —   | 65  | —   | dB                |
| Audio Output Voltage <sup>5,6,7,12</sup>        |                 |                 | —   | 80  | —   | mV <sub>RMS</sub> |
| Audio Mono S/N <sup>5,6,7,9,10</sup>            |                 |                 | —   | 55  | —   | dB                |
| Audio Stereo S/N <sup>3,4,5,7,9,10</sup>        |                 |                 | —   | 55  | —   | dB                |
| Audio Frequency Response Low <sup>4</sup>       |                 | –3 dB           | —   | —   | 30  | Hz                |
| Audio Frequency Response High <sup>4</sup>      |                 | –3 dB           | 15  | —   | —   | kHz               |
| Audio Stereo Separation <sup>5,11</sup>         |                 |                 | —   | 40  | —   | dB                |
| Audio THD <sup>5,6,11</sup>                     |                 |                 | —   | 0.1 | 0.5 | %                 |
| Audio Output Load Resistance <sup>4,10</sup>    | R <sub>L</sub>  | Single-ended    | 10  | —   | —   | kΩ                |
| Audio Output Load Capacitance <sup>4,10</sup>   | C <sub>L</sub>  | Single-ended    | —   | —   | 50  | pF                |
| Powerup/Band Switch Time <sup>4</sup>           |                 |                 | —   | —   | 110 | ms                |

**Notes:**

1. Additional testing information is available in “AN603: Si4840/44 DEMO Board Test Procedure.” Volume = maximum for all tests. Tested at RF = 98.1 MHz.
2. To ensure proper operation and receiver performance, follow the guidelines in “AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines.” Silicon Laboratories will evaluate schematics and layouts for qualified customers.
3. Frequency is 64~109 MHz.
4. Guaranteed by characterization.
5. V<sub>EMF</sub> = 1 mV.
6. F<sub>MOD</sub> = 1 kHz, MONO, and L = R unless noted otherwise.
7. Δf = 22.5 kHz.
8. |f<sub>2</sub> – f<sub>1</sub>| > 2 MHz, f<sub>0</sub> = 2 x f<sub>1</sub> – f<sub>2</sub>.
9. B<sub>AF</sub> = 300 Hz to 15 kHz, A-weighted.
10. At L<sub>OUT</sub> and R<sub>OUT</sub> pins.
11. Δf = 75 kHz.
12. Tested in Digital Volume Mode.

**Table 6. AM/SW Receiver Characteristics<sup>1, 2</sup>**(V<sub>DD</sub> = 2.7 to 3.6 V, T<sub>A</sub> = -15 to 85 °C)

| Parameter                                  | Symbol          | Test Condition                                    | Min | Typ | Max  | Unit              |
|--------------------------------------------|-----------------|---------------------------------------------------|-----|-----|------|-------------------|
| Input Frequency                            | f <sub>RF</sub> | Medium Wave (AM)                                  | 504 | —   | 1750 | kHz               |
|                                            |                 | Short Wave (SW)                                   | 2.3 | —   | 28.5 | MHz               |
| Sensitivity <sup>3,4,5</sup>               |                 | (S+N)/N = 26 dB                                   | —   | 30  | —    | μV EMF            |
| Large Signal Voltage Handling <sup>5</sup> |                 | THD < 8%                                          | —   | 300 | —    | mV <sub>RMS</sub> |
| Power Supply Rejection Ratio <sup>5</sup>  |                 | ΔV <sub>DD</sub> = 100 mV <sub>RMS</sub> , 100 Hz | —   | 40  | —    | dB                |
| Audio Output Voltage <sup>3,6,8</sup>      |                 |                                                   | —   | 60  | —    | mV <sub>RMS</sub> |
| Audio S/N <sup>3,4,6</sup>                 |                 |                                                   | —   | 55  | —    | dB                |
| Audio THD <sup>3,6</sup>                   |                 |                                                   | —   | 0.1 | 0.5  | %                 |
| Antenna Inductance <sup>5,7</sup>          |                 |                                                   | 180 | —   | 450  | μH                |
| Powerup/Band Switch Time <sup>5</sup>      |                 | From powerdown                                    | —   | —   | 110  | ms                |

**Notes:**

1. Additional testing information is available in "AN603: Si4840/44 DEMO Board Test Procedure." Volume = maximum for all tests. Tested at RF = 520 kHz.
2. To ensure proper operation and receiver performance, follow the guidelines in "AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines." Silicon Laboratories will evaluate schematics and layouts for qualified customers.
3. FMOD = 1 kHz, 30% modulation, 2 kHz channel filter.
4. B<sub>AF</sub> = 300 Hz to 15 kHz, A-weighted.
5. Guaranteed by characterization.
6. V<sub>IN</sub> = 5 mV<sub>rms</sub>.
7. Stray capacitance on antenna and board must be < 10 pF to achieve full tuning range at higher inductance levels.
8. Tested in Digital Volume Mode.

**Table 7. Reference Clock and Crystal Characteristics**(V<sub>DD</sub> = 2.7 to 3.6 V, T<sub>A</sub> = -15 to 85 °C)

| Parameter                                     | Symbol | Test Condition | Min  | Typ    | Max | Unit |
|-----------------------------------------------|--------|----------------|------|--------|-----|------|
| <b>Reference Clock</b>                        |        |                |      |        |     |      |
| XTALI Supported Reference Clock Frequencies   |        |                | —    | 32.768 | —   | kHz  |
| Reference Clock Frequency Tolerance for XTALI |        |                | -100 | —      | 100 | ppm  |
| <b>Crystal Oscillator</b>                     |        |                |      |        |     |      |
| Crystal Oscillator Frequency                  |        |                | —    | 32.768 | —   | kHz  |
| Crystal Frequency Tolerance                   |        |                | -100 | —      | 100 | ppm  |
| Board Capacitance                             |        |                | —    | —      | 3.5 | pF   |

**Table 8. Thermal Conditions**

| Parameter            | Symbol        | Min | Typ | Max | Unit |
|----------------------|---------------|-----|-----|-----|------|
| Thermal Resistance*  | $\theta_{JA}$ | —   | 80  | —   | °C/W |
| Ambient Temperature  | $T_A$         | –15 | 25  | 85  | °C   |
| Junction Temperature | $T_J$         | —   | —   | 92  | °C   |

**\*Note:** Thermal resistance assumes a multi-layer PCB with the exposed pad soldered to a topside PCB pad.

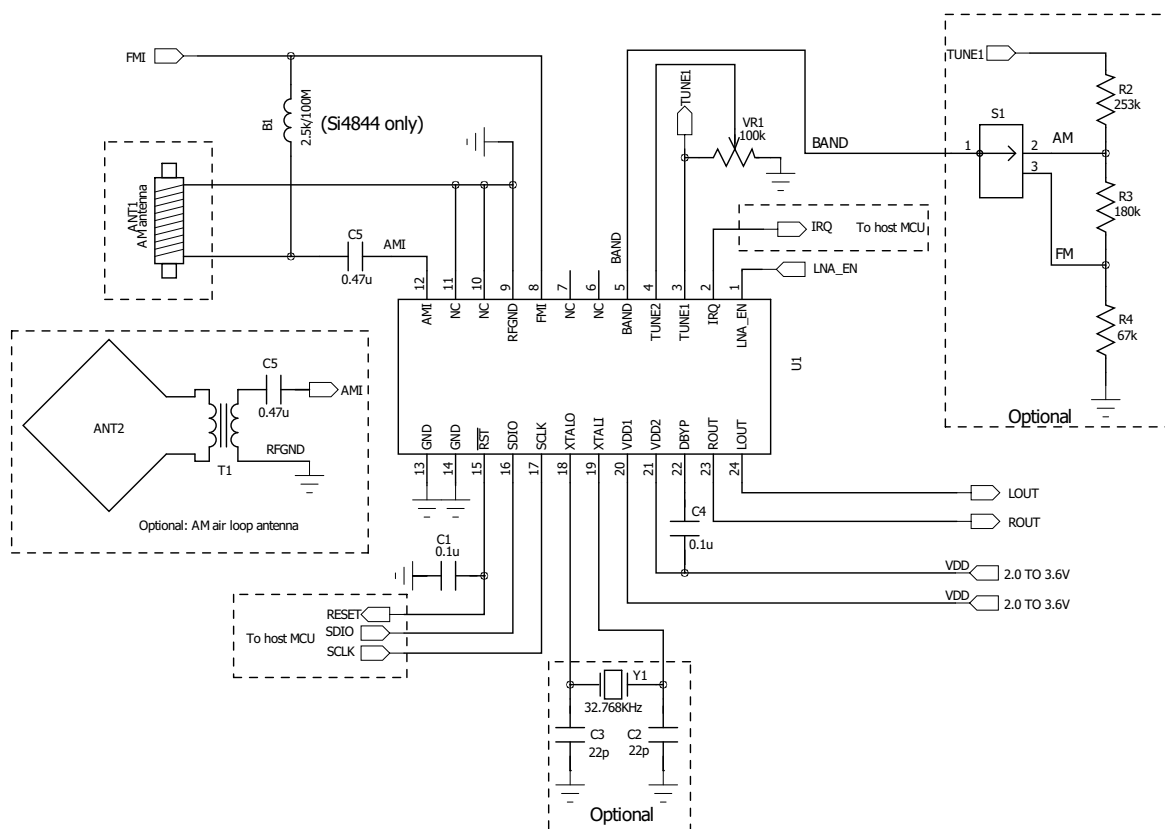
**Table 9. Absolute Maximum Ratings<sup>1,2</sup>**

| Parameter                   | Symbol    | Value       | Unit     |
|-----------------------------|-----------|-------------|----------|
| Supply Voltage              | $V_{DD}$  | –0.5 to 5.8 | V        |
| Input Current <sup>3</sup>  | $I_{IN}$  | 10          | mA       |
| Operating Temperature       | $T_{OP}$  | –40 to 95   | °C       |
| Storage Temperature         | $T_{STG}$ | –55 to 150  | °C       |
| RF Input Level <sup>4</sup> |           | 0.4         | $V_{PK}$ |

**Notes:**

1. Permanent device damage may occur if the above 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. The Si4840/44-A10 devices are high-performance RF integrated circuits with certain pins having an ESD rating of < 2 kV HBM. Handling and assembly of these devices should only be done at ESD-protected workstations.
3. For input pins RST, SDIO, SCLK, XTALO, XTALI, BAND, TUNE2, TUNE1, IRQ, and LNA\_EN.
4. At RF input pins, FMI, and AMI.

## 2. Typical Application Schematic



### Notes:

1. Place C4 close to VDD2 and DBYP pins.
2. All grounds connect directly to GND plane on PCB.
3. Pin 6 and 7 leave floating.
4. To ensure proper operation and receiver performance, follow the guidelines in "AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines." Silicon Labs will evaluate the schematics and layouts for qualified customers.
5. Pin 8 connects to the FM antenna interface and pin 12 connects to the AM antenna interface.
6. Place Si484x as close as possible to antenna jack and keep the FMI and AMI traces as short as possible.

## 3. Bill of Materials

**Table 10. Si4840/44-A10 Bill of Materials**

| Component(s)               | Value/Description                                                                          | Supplier                 |
|----------------------------|--------------------------------------------------------------------------------------------|--------------------------|
| C1                         | Reset capacitor 0.1 $\mu$ F, $\pm$ 20%, Z5U/X7R                                            | Murata                   |
| C4                         | Supply bypass capacitor, 0.1 $\mu$ F, $\pm$ 20%, Z5U/X7R                                   | Murata                   |
| C5                         | Coupling capacitor, 0.47 $\mu$ F, $\pm$ 20%, Z5U/X7R                                       | Murata                   |
| B1                         | Ferrite bead 2.5 k/100 MHz                                                                 | Murata                   |
| VR1                        | Variable resistor (POT), 100 k, $\pm$ 10%                                                  | Kennon                   |
| U1                         | Si484x AM/FM/SW Analog Tune Digital Display Radio Tuner                                    | Silicon Laboratories     |
| ANT1                       | Ferrite stick, 180–450 $\mu$ H                                                             | Jiaxin                   |
| <b>Optional Components</b> |                                                                                            |                          |
| C2, C3                     | Crystal load capacitors, 22 pF, $\pm$ 5%, COG<br>(Optional: for crystal oscillator option) | Venkel                   |
| Y1                         | 32.768 kHz crystal (Optional: for crystal oscillator option)                               | Epson or equivalent      |
| ANT2                       | Air loop antenna, 10-20 $\mu$ H                                                            | various                  |
| S1                         | Band switch                                                                                | Any, depends on customer |
| R2                         | Resistor, 253 k, $\pm$ 1%,                                                                 | Venkel                   |
| R3                         | Resistor, 180 k, $\pm$ 1%                                                                  | Venkel                   |
| R4                         | Resistor, 67 k, $\pm$ 1%                                                                   | Venkel                   |

## 4. Functional Description

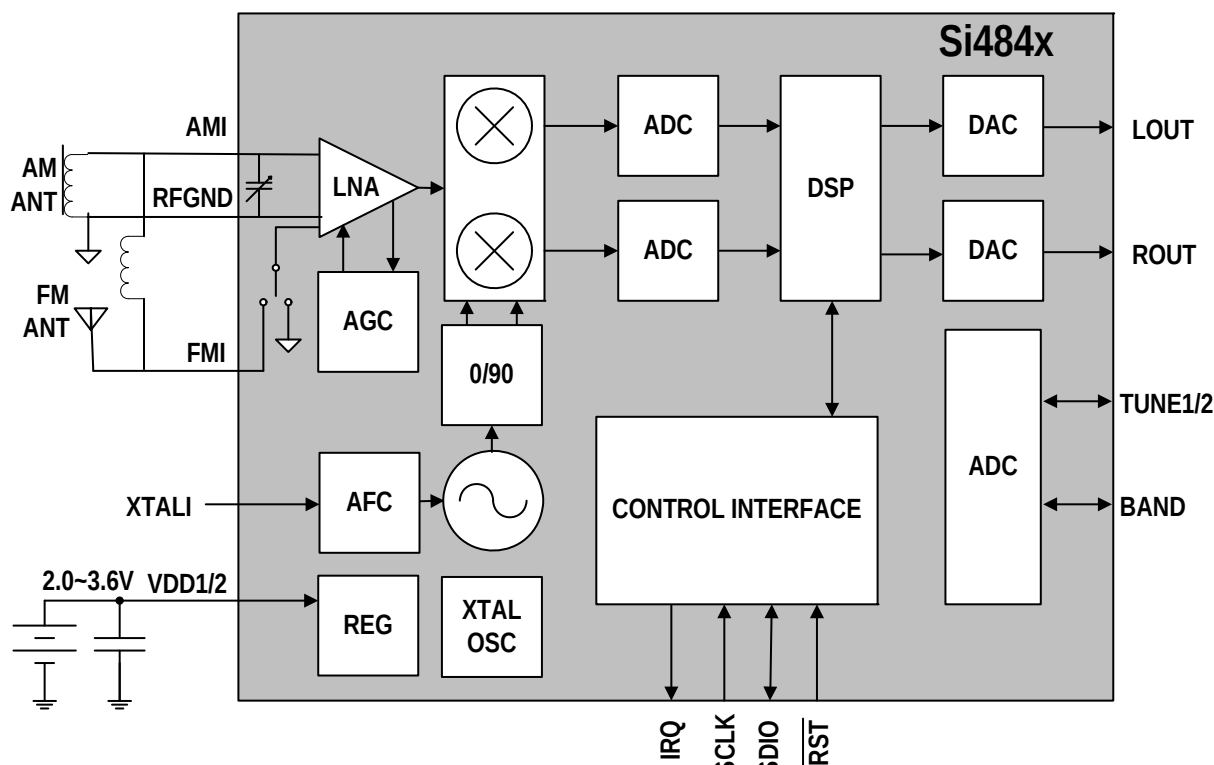


Figure 4. Si4840/44-A10 Functional Block Diagram

### 4.1. Overview

The Si4840/44-A10 is the first analog-tuned digital-display digital CMOS AM/FM/SW radio receiver IC that integrates the complete receiver function from antenna input to audio output. Working with an external MCU with LCD/LED driver, Si4840/44-A10 can output the AM/FM/SW frequencies, band, Bass/Treble and stereo/mono information to display on LCD/LED, while using a simple potentiometer at the front end for analog-tune. Leveraging Silicon Laboratories' proven and patented digital low intermediate frequency (low-IF) receiver architecture, the Si4840/44 delivers superior RF performance and interference rejection in AM, FM and SW bands. Additionally, the digital core provides advanced audio conditioning for all environments, removing pops, clicks, and loud static in variable signal conditions. The superior control algorithm integrated in Si4840/44-A10 provides easy and reliable control interface while eliminating all the manual tuned external components used in traditional solutions.

Like other successful audio products from Silicon Labs, Si4840/44-A10 offers unmatched integration and PCB space savings with minimum external components and small board area on a single side PCB. The high integration and complete system production test simplifies design-in, increases system quality, and improves manufacturability. The receiver has very low power consumption, runs off two AAA batteries, and delivers the performance benefits of high performance digital radio experience with digital display to the legacy analog-tuned radio market.

The Si4840/44-A10 provides good flexibility in using the chip. The frequency range of FM/AM/SW bands, mono/stereo threshold, de-emphasis value, AM tuning step, AM soft mute level/rate, and Bass/Treble can be either configured by the MCU or by using external hardware to make a selection. The reference clock of the FM tuner can be either provided by the crystal, or by the host MCU within tolerance.

Si4840/44-A10 also has flexibility in selecting bands and configuring band properties, enabling masked Host MCU for multiple projects, and reducing the cost of development. Four tuning preferences are available to meet different tuning preference requirements.

## 4.2. FM Receiver

The Si4840/44-A10 integrates a low noise amplifier (LNA) supporting the worldwide FM broadcast band (64 to 109 MHz).

Pre-emphasis and de-emphasis is a technique used by FM broadcasters to improve the signal-to-noise ratio of FM receivers by reducing the effects of high frequency interference and noise. When the FM signal is transmitted, a pre-emphasis filter is applied to accentuate the high audio frequencies. All FM receivers incorporate a de-emphasis filter which attenuates high frequencies to restore a flat frequency response. Two time constants are used in various regions. The de-emphasis time constant can be chosen to be 50 or 75  $\mu$ s. Refer to "AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines."

The Si4840/44-A10 also has advanced stereo blending that employs adaptive noise suppression. As a signal quality degrades, the Si4840/44-A10 gradually combines the stereo left and right audio channels to a mono audio signal to maintain optimum sound fidelity under varying reception conditions. The Si4840/44-A10 can output a stereo signal to MCU with LCD/LED driver to display on the LCD/LED so that the user can easily discern the signal quality.

The stereo on signal is defined using both RSSI and the Left and Right separation levels as these two specifications are the primary factors for stereo listening. The criteria can be set between two conditions: the Left and Right channels are separated by more than 6 dB with RSSI at >20 dB or Left and Right channels are separated by more than 12 dB with RSSI at >28 dB. The selection can be set up using different values of the external resistor or configured by the host MCU. Refer to "AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines." The user can also refer to the "AN610: Si484x-A Programming Guide" for those who want to configure the value by host MCU.

## 4.3. AM Receiver

The highly integrated Si4840/44-A10 supports worldwide AM band reception from 504 to 1750 kHz with five sub-bands using a digital low-IF architecture with a minimum number of external components and no manual alignment required. This patented architecture allows for high-precision filtering, offering excellent selectivity and SNR with minimum variation across the AM band. Similar to the FM receiver, the Si4840/44-A10 optimizes sensitivity and rejection of strong interferers, allowing better reception of weak stations.

To offer maximum flexibility, the receiver supports a wide range of ferrite loop sticks from 180–450  $\mu$ H. An air loop antenna is supported by using a transformer to increase the effective inductance from the air loop. Using a 1:5 turn ratio inductor, the inductance is increased by 25 times and easily supports all typical AM air loop antennas, which generally vary between 10 and 20  $\mu$ H.

A 9, 10 kHz tuning step can be chosen by the external resistor or host MCU according to the different regions, and AM soft mute level can be programmed by the host MCU to have different tuning experiences. Refer to "AN610: Si484x-A Programming Guide" and "AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines" for more details.

## 4.4. SW Receiver

The Si4844 supports short wave band receptions from 2.3 to 28.5 MHz in 5 kHz step size increments. Si4844 supports extensive short wave features such as minimal discrete components and no factory adjustments. The Si4844 supports using the FM antenna to capture short wave signals. Refer to "AN610: Si484x-A Programming Guide" and "AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines." for more details.

## 4.5. Frequency Tuning

A valid channel can be found by tuning the potentiometer that is connected to the TUNE1 and TUNE2 pin of the Si4840/44-A10 chip.

To offer easy tuning, the Si4840/44-A10 also outputs the tuned information to the MCU with LCD/LED driver to display. It will light up the icon on display if the RF signal quality passes a certain threshold when tuned to a valid station. Four tuning preferences are available. The user can choose to have the best performance (volume, stereo/mono effect) only at the exact channel, or the best performance in a larger range. Refer to "AN610: Si484x-A Programming Guide" for more details.

## 4.6. Band Select

The Si4840/44-A10 supports worldwide AM band with five sub-bands, US/Europe/Japan/China FM band with five sub-bands, and SW band with 16 sub-bands. Si4840/44-A10 provides the flexibility to configure the band and band properties at either the MCU side or the Tuner side, enabling masked MCU for multiple projects. For details on band selection, refer to "AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines" and "AN610: Si484x-A Programming Guide".

#### 4.7. Bass and Treble

The Si4840/44-A10 further supports Bass/Treble tone control for superior sound quality. The Si4840/44-A10 can be set to be default normal, or programmed by the host MCU I<sup>2</sup>C-compatible 2-wire mode. FM has nine levels Bass/Treble effect and AM/SW has seven levels Bass/Treble effect. For further configuration details, refer to "AN610: Si484x-A Programming Guide."

#### 4.8. Volume Control

The Si4840/44-A10 not only allows users to use the traditional PVR wheel volume control through an external speaker amplifier, it also supports digital volume control programmed by the host MCU. Si4840/44-A10 can be programmed to be Bass/Treble mode only or digital volume mode only; it can also be programmed to have the digital volume coexist with Bass/Treble in two modes. Refer to "AN610: Si484x-A Programming Guide" and "AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines" for more details.

#### 4.9. Stereo Audio Processing

The output of the FM demodulator is a stereo multiplexed (MPX) signal. The MPX standard was developed in 1961, and is used worldwide. Today's MPX signal format consists of left + right (L+R) audio, left – right (L–R) audio, a 19 kHz pilot tone.

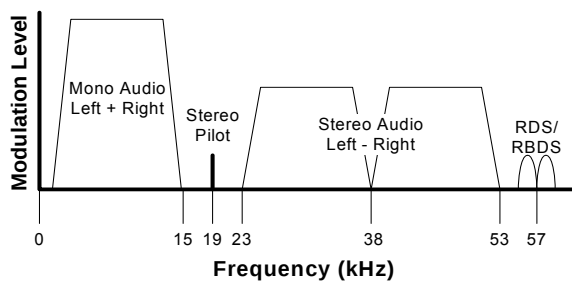


Figure 5. MPX Signal Spectrum

##### 4.9.1. Stereo Decoder

The Si4840/44-A10's integrated stereo decoder automatically decodes the MPX signal using DSP techniques. The 0 to 15 kHz (L+R) signal is the mono output of the FM tuner. Stereo is generated from the (L+R), (L–R), and a 19 kHz pilot tone. The pilot tone is used as a reference to recover the (L–R) signal. Output left and right channels are obtained by adding and subtracting the (L+R) and (L–R) signals respectively.

##### 4.9.2. Stereo-Mono Blending

Adaptive noise suppression is employed to gradually combine the stereo left and right audio channels to a mono (L+R) audio signal as the signal quality degrades to maintain optimum sound fidelity under varying reception conditions. Three metrics, received signal strength indicator (RSSI), signal-to-noise ratio (SNR), and multipath interference, are monitored simultaneously in forcing a blend from stereo to mono. The metric which reflects the minimum signal quality takes precedence and the signal is blended appropriately.

All three metrics have programmable stereo/mono thresholds and attack/release rates. If a metric falls below its mono threshold, the signal is blended from stereo to full mono. If all metrics are above their respective stereo thresholds, then no action is taken to blend the signal. If a metric falls between its mono and stereo thresholds, then the signal is blended to the level proportional to the metric's value between its mono and stereo thresholds, with an associated attack and release rate.

#### 4.10. Stereo DAC

High-fidelity stereo digital-to-analog converters (DACs) drive analog audio signals onto the LOUT and ROUT pins. The audio output may be muted.

#### 4.11. Soft Mute

The soft mute feature is available to attenuate the audio outputs and minimize audible noise in very weak signal conditions. Advanced algorithm is implemented to get a better analog tuning experience. The soft mute feature is triggered by the SNR metric. The SNR threshold for activating soft mute is programmable, as are soft mute attenuation levels and attack and decay rates.

#### 4.12. Reference Clock

The Si4840/44-A10 supports RCLK input (to XTALI pin) with the spec listed in Table 7. It can be shared with the host MCU to save extra crystal.

An onboard crystal oscillator is available to generate the 32.768 kHz reference when an external crystal and load capacitors are provided. Refer to "AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines" for more details.

#### 4.13. Memorizing Status

The Si4840/44-A10 provides the feature to memorize status from the last power down with a simple design on PCB, including frequency of the FM/AM/SW station. Refer to "AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines" for details.

## 4.14. Programming with Commands

To ease development time and offer maximum customization, the Si484x provides a simple yet powerful software interface to program the receiver. The device is programmed using commands, arguments, properties, and responses.

To perform an action, the user writes a command byte and associated arguments, causing the chip to execute the given command. Commands control an action such as powerup the device, shut down the device, or get the current tuned frequency. Arguments are specific to a given command and are used to modify the command.

Properties are a special command argument used to modify the default chip operation and are generally configured immediately after powerup. Examples of properties are de-emphasis level, RSSI seek threshold, and soft mute attenuation threshold.

Responses provide the user information and are echoed after a command and associated arguments are issued. All commands provide a 1-byte status update, indicating interrupt and clear-to-send status information.

For a detailed description of the commands and properties for the Si484x, see "AN610: Si484x-A Programming Guide".

## 5. Commands and Properties

**Table 11. Si4840/44-A10 FM Receiver Command Summary**

| Cmd                                                                                                                                                                                                                                                                                           | Name            | Description                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------------------------------------------------|
| 0xE0                                                                                                                                                                                                                                                                                          | ATDD_GET_STATUS | Get tune freq, band and etc status of the device          |
| 0xE1                                                                                                                                                                                                                                                                                          | ATDD_POWER_UP   | Power up device, band selection and band properties setup |
| 0xE2                                                                                                                                                                                                                                                                                          | ATDD_AUDIO_MODE | Audio output mode: get/set audio mode and settings        |
| 0x10                                                                                                                                                                                                                                                                                          | GET_REV         | Returns the revision information of the device.           |
| 0x11                                                                                                                                                                                                                                                                                          | POWER_DOWN      | Power down device.                                        |
| 0x12                                                                                                                                                                                                                                                                                          | SET_PROPERTY    | Sets the value of a property.                             |
| 0x13                                                                                                                                                                                                                                                                                          | GET_PROPERTY    | Retrieve a property's value.                              |
| <b>Note:</b> The si4840/44 has its own power up and get status commands which is different from previous si47xx tuner parts. To differentiate, we use "ATDD_POWER_UP" and ATDD_GET_STATUS to denote the ATDD specific commands instead of the general si47xx "POWER_UP" and "STATUS" commands |                 |                                                           |

**Table 12. Si4840/44-A10 FM Receiver Property Summary**

| Prop   | Name                           | Description                                                                                                                                                                                             | Default          |
|--------|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| 0x1100 | FM_DEEMPHASIS                  | Sets deemphasis time constant. Default is 75 $\mu$ s.                                                                                                                                                   | 0x0002           |
| 0x1300 | FM_SOFT_MUTE_RATE              | Sets the attack and decay rates when entering and leaving soft mute.                                                                                                                                    | 0x0040           |
| 0x1301 | FM_SOFT_MUTE_SLOPE             | Configures attenuation slope during soft mute in dB attenuation per dB SNR below the soft mute SNR threshold. Default value is 2.                                                                       | 0x0002           |
| 0x1302 | FM_SOFT_MUTE_MAX_ATTENUATION   | Sets maximum attenuation during soft mute (dB). Set to 0 to disable soft mute. Default is 16 dB.                                                                                                        | 0x0010           |
| 0x1303 | FM_SOFT_MUTE_SNR_THRESHOLD     | Sets SNR threshold to engage soft mute. Default is 4 dB.                                                                                                                                                | 0x0004           |
| 0x1207 | FM_STEREO_IND_BLEND_THRESHOLD  | Sets the blend threshold for stereo indicator. Default value is band dependent (either 0x9F or 0xB2)                                                                                                    | 0x9F<br>0xB2     |
| 0x1800 | FM_BLEND_RSSI_STEREO_THRESHOLD | Sets RSSI threshold for stereo blend. (Full stereo above threshold, blend below threshold.) To force stereo, set this to 0. To force mono, set this to 127. Default value is 49 dB $\mu$ V.             | 0x0031           |
| 0x1801 | FM_BLEND_RSSI_MONO_THRESHOLD   | Sets RSSI threshold for mono blend (Full mono below threshold, blend above threshold). To force stereo, set this to 0. To force mono, set this to 127. Default value is band dependent (either 8 or 7). | 0x0008<br>0x0007 |
| 0x4000 | RX_VOLUME                      | Sets the output volume.                                                                                                                                                                                 | 0x003F           |
| 0x4001 | RX_HARD_MUTE                   | Mutes the audio output. L and R audio outputs may be muted independently.                                                                                                                               | 0x0000           |
| 0x4002 | RX_BASS_TREBLE                 | Sets the output bass/treble level                                                                                                                                                                       | 0x0004           |
| 0x4003 | RX_ACTUAL_VOLUME               | Read the actual output volume                                                                                                                                                                           | 0x003F           |

**Table 13. Si4840/44-A10 AM/SW Receiver Command Summary**

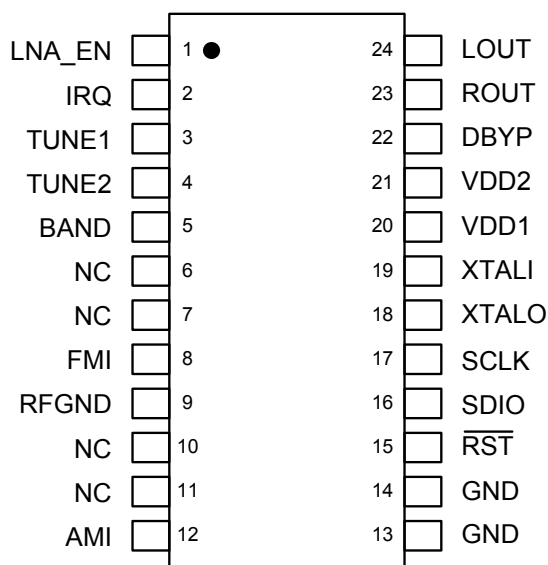
| Cmd                                                                                                                                                                                                                                                                                            | Name            | Description                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------------------------------------------------|
| 0xE0                                                                                                                                                                                                                                                                                           | ATDD_GET_STATUS | Get tune freq, band and etc status of the device          |
| 0xE1                                                                                                                                                                                                                                                                                           | ATDD_POWER_UP   | Power up device, band selection and band properties setup |
| 0xE2                                                                                                                                                                                                                                                                                           | ATDD_AUDIO_MODE | Audio output mode: get/set audio mode settings.           |
| 0x10                                                                                                                                                                                                                                                                                           | GET_REV         | Returns the revision information of the device.           |
| 0x11                                                                                                                                                                                                                                                                                           | POWER_DOWN      | Power down device.                                        |
| 0x12                                                                                                                                                                                                                                                                                           | SET_PROPERTY    | Sets the value of a property.                             |
| 0x13                                                                                                                                                                                                                                                                                           | GET_PROPERTY    | Retrieve a property's value.                              |
| <b>Note:</b> The si4840/44 has its own power up and get status commands which is different from previous si47xx tuner parts. To differentiate, we use "ATDD_POWER_UP" and ATDD_GET_STATUS to denote the ATDD specific commands instead of the general Si47xx "POWER_UP" and "STATUS" commands. |                 |                                                           |

**Table 14. Si4840/44-A10 AM/SW Receiver Property Summary**

| Prop   | Name                         | Description                                                                                                   | Default |
|--------|------------------------------|---------------------------------------------------------------------------------------------------------------|---------|
| 0x4000 | RX_VOLUME                    | Sets the output volume.                                                                                       | 0x003F  |
| 0x4001 | RX_HARD_MUTE                 | Mutes the audio output. L and R audio outputs may be muted independently.                                     | 0x0000  |
| 0x4002 | RX_BASS_TREBLE               | Sets the output bass/treble level                                                                             | 0x0003  |
| 0x4003 | RX_ACTUAL_VOLUME             | Read the actual output volume                                                                                 | 0x003F  |
| 0x3300 | AM_SOFT_MUTE_RATE            | Sets the attack and decay rates when entering and leaving soft mute.                                          | 0x0040  |
| 0x3301 | AM_SOFT_MUTE_SLOPE           | Configures attenuation slope during soft mute in dB attenuation per dB SNR below the soft mute SNR threshold. | 0x0002  |
| 0x3302 | AM_SOFT_MUTE_MAX_ATTENUATION | Sets maximum attenuation during soft mute (dB). Set to 0 to disable soft mute.                                | 0x0010  |
| 0x3303 | AM_SOFT_MUTE_SNR_THRESHOLD   | Sets SNR threshold to engage soft mute.                                                                       | 0x0008  |

## 6. Pin Descriptions

### 6.1. Si4840/44-A10



| Pin Number(s) | Name   | Description                                                 |
|---------------|--------|-------------------------------------------------------------|
| 1             | LNA_EN | Enabling SW external LNA                                    |
| 2             | IRQ    | Interrupt Request                                           |
| 3             | TUNE1  | Frequency tuning                                            |
| 4             | TUNE2  | Frequency tuning                                            |
| 5             | BAND   | Band selection and De-emphasis/Stereo separation selection  |
| 6,7           | NC     | No connect. Leave floating.                                 |
| 8             | FMI    | FM RF inputs. FMI should be connected to the antenna trace. |
| 9             | RFGND  | RF ground. Connect to ground plane on PCB.                  |
| 10, 11        | NC     | Unused. Tie these pins to GND.                              |
| 12            | AMI    | AM RF input. AMI should be connected to the AM antenna.     |
| 13, 14        | GND    | Ground. Connect to ground plane on PCB.                     |
| 15            | /RST   | Device reset (active low) input                             |
| 16            | SDIO   | Serial data input/output                                    |
| 17            | SCLK   | Serial clock input                                          |
| 18            | XTALO  | Crystal oscillator output                                   |
| 19            | XTALI  | Crystal oscillator input                                    |
| 20            | VDD1   | Supply voltage. May be connected directly to battery.       |
| 21            | VDD2   | Supply voltage. May be connected directly to battery.       |
| 22            | DBYP   | Dedicated bypass for VDD                                    |
| 23            | ROUT   | Right audio line output in analog output mode               |
| 24            | LOUT   | Left audio line output in analog output mode                |

## 7. Ordering Guide

| Part Number*                                                                                                                                                                                                        | Description                       | Package Type     | Operating Temperature/Voltage |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------------------|-------------------------------|
| Si4840-A10-GU                                                                                                                                                                                                       | AM/FM Broadcast Radio Receiver    | 24L SSOP Pb-free | –15 to 85 °C<br>2.0 to 3.6 V  |
| Si4844-A10-GU                                                                                                                                                                                                       | AM/FM/SW Broadcast Radio Receiver | 24L SSOP Pb-free | –15 to 85 °C<br>2.0 to 3.6 V  |
| <b>*Note:</b> Add an “(R)” at the end of the device part number to denote tape and reel option. The devices will typically operate at 25 °C with degraded specifications for $V_{DD}$ voltage ramped down to 2.0 V. |                                   |                  |                               |

## 8. Package Outline: Si4840/44-A10

The 24-pin SSOP illustrates the package details for the Si4840/44-A10. Table 15 lists the values for the dimensions shown in the illustration.

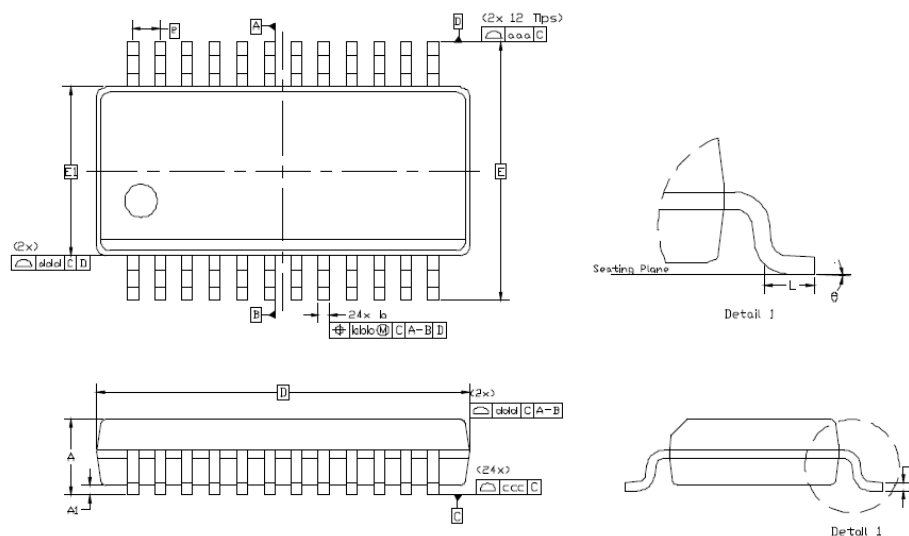


Figure 6. 24-Pin SSOP

Table 15. Package Dimensions

| Dimension | Min       | Nom | Max  |
|-----------|-----------|-----|------|
| A         | —         | —   | 1.75 |
| A1        | 0.10      | —   | 0.25 |
| b         | 0.20      | —   | 0.30 |
| c         | 0.10      | —   | 0.25 |
| D         | 8.65 BSC  |     |      |
| E         | 6.00 BSC  |     |      |
| E1        | 3.90 BSC  |     |      |
| e         | 0.635 BSC |     |      |
| L         | 0.40      | —   | 1.27 |
| θ         | 0°        | —   | 8°   |
| aaa       | 0.20      |     |      |
| bbb       | 0.18      |     |      |
| ccc       | 0.10      |     |      |
| ddd       | 0.10      |     |      |

**Notes:**

1. All dimensions shown are in millimeters (mm) unless otherwise noted.
2. Dimensioning and Tolerancing per ANSI Y14.5M-1994.
3. This drawing conforms to the JEDEC Solid State Outline MO-137, Variation AE.
4. Recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components.

## 9. PCB Land Pattern: Si4840/44-A10

Figure 7 illustrates the PCB land pattern details for the Si4840/44-A10-GU SSOP. Table 16 lists the values for the dimensions shown in the illustration.

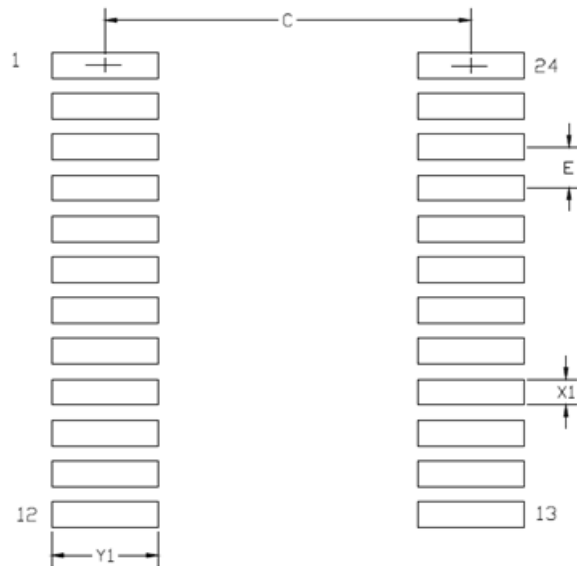


Figure 7. PCB Land Pattern

Table 16. PCB Land Pattern Dimensions

| Dimension | Min       | Max  |
|-----------|-----------|------|
| C         | 5.20      | 5.40 |
| E         | 0.635 BSC |      |
| X1        | 0.35      | 0.45 |
| Y1        | 1.55      | 1.75 |

**General:**

- 1. All dimensions shown are in millimeters (mm) unless otherwise noted.
- 2. This land pattern design is based on the IPC-7351 guidelines.

**Solder Mask Design:**

- 3. All metal pads are to be non-solder mask defined (NSMD). Clearance between the solder mask and the metal pad is to be 60  $\mu$ m minimum, all the way around the pad.

**Stencil Design:**

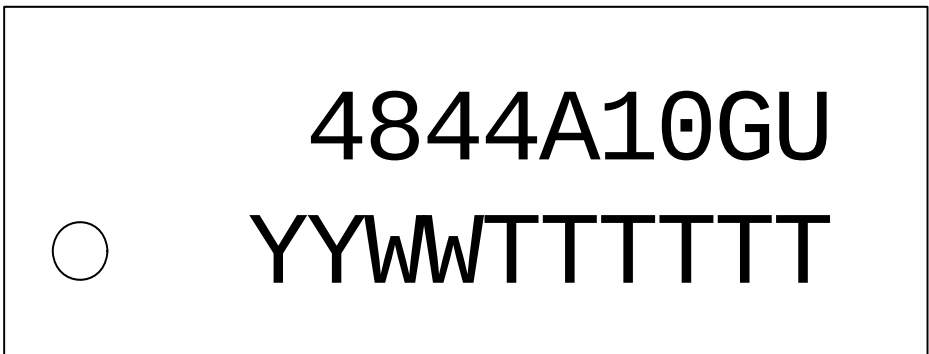
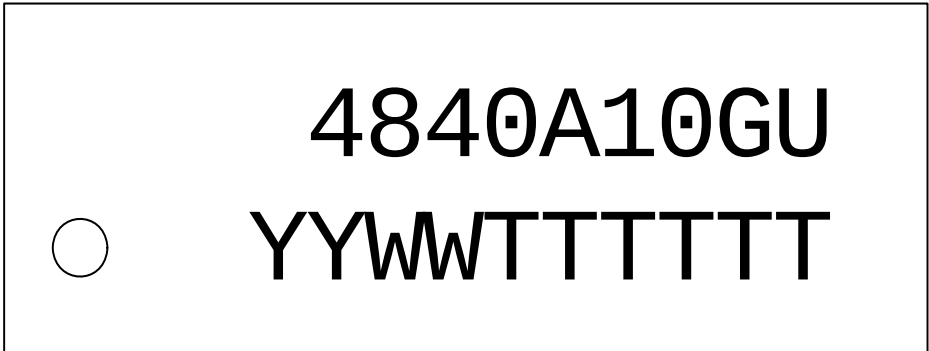
- 4. A stainless steel, laser-cut, and electro-polished stencil with trapezoidal walls should be used to assure good solder paste release.
- 5. The stencil thickness should be 0.125 mm (5 mils).
- 6. The ratio of stencil aperture to land pad size should be 1:1 for all perimeter pads.

**Card Assembly:**

- 7. A No-Clean, Type-3 solder paste is recommended.
- 8. The recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components.

10. Top Markings

10.1. Si4840/44-A10 Top Mark



|                 |                                                            |                                                  |
|-----------------|------------------------------------------------------------|--------------------------------------------------|
| Mark Method:    | YAG Laser                                                  |                                                  |
| Line 1 Marking: | Device identifier                                          | 4840A10GU = Si4840-A10<br>4844A10GU = Si4844-A10 |
| Line 2 Marking: | YY = Year<br>WW = Work week<br>TTTTTT = Manufacturing code | Assigned by the Assembly House.                  |

## 11. Additional Reference Resources

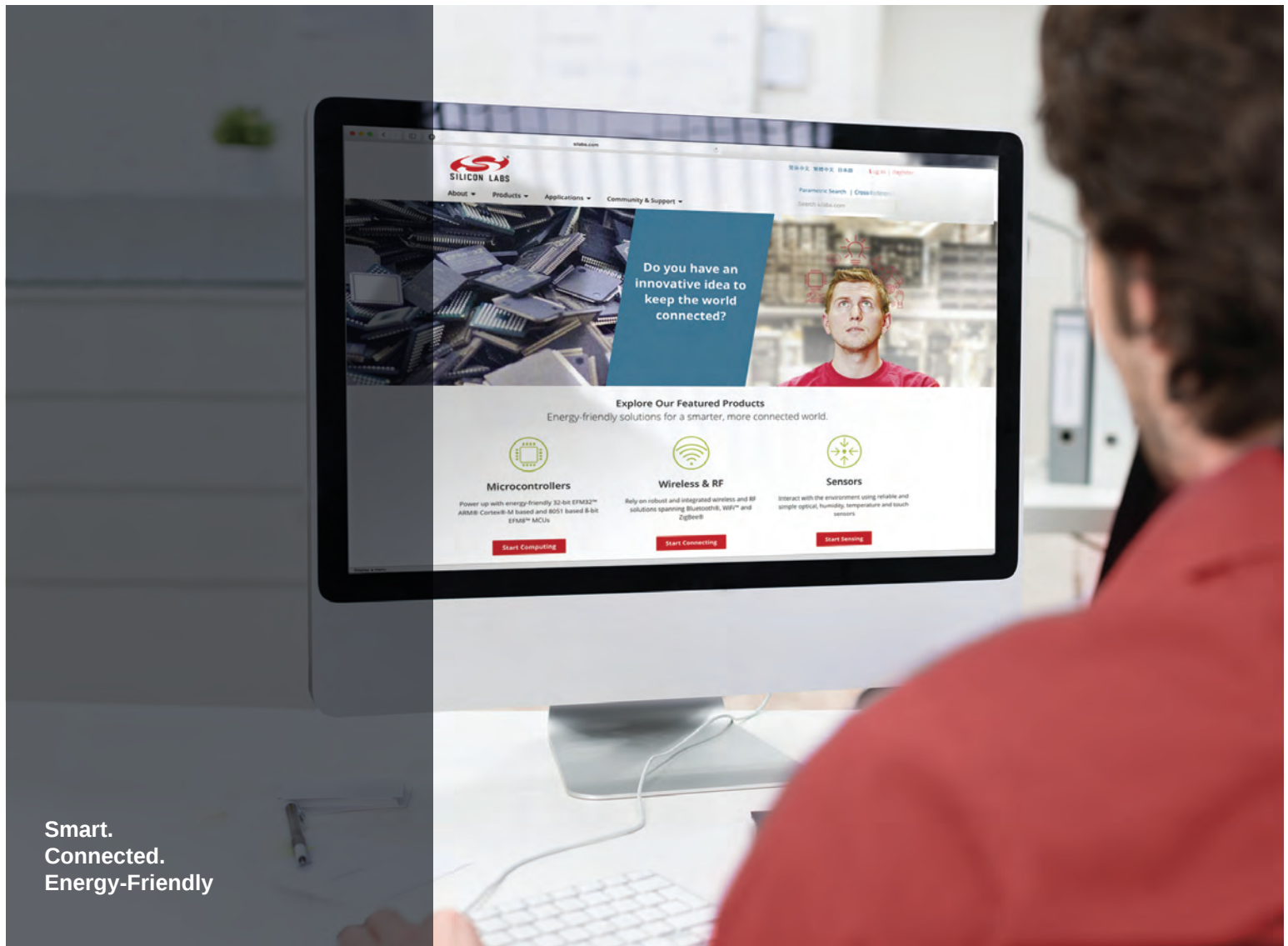
Contact your local sales representatives for more information or to obtain copies of the following references:

- EN55020 Compliance Test Certificate
- AN602: Si484x-A Antenna, Schematic, Layout, and Design Guidelines
- AN603: Si4840/44-DEMO Board Test Procedure
- Si4840/44-DEMO Board User's Guide
- AN610: Si484x-A Programming Guide

## DOCUMENT CHANGE LIST

### Revision 0.4 to Revision 1.0

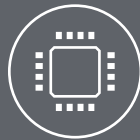
- Updated Block Diagram
- Updated Table 3 “Reset Timing Characteristics” and Figure 1, “Reset Timing,”
- Updated Table 5, “FM Receiver Characteristics”
- Updated Table 8, “Thermal Conditions”
- Updated Table 9, “Absolute Maximum Ratings”
- Updated Section “2. Typical Application Schematic ”
- Updated Section “3. Bill of Materials ”
- Updated Section “4.7. Bass and Treble”
- Removed previous Section “4.10. Received Signal Qualifiers”
- Updated Section “4.13. Memorizing Status”
- Updated Section “4.14. Programming with Commands”
- Updated Table 13, “Si4840/44-A10 AM/SW Receiver Command Summary”
- Updated Table 16, “PCB Land Pattern Dimensions”



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