

Si483x-B/Si4820/24 ANTENNA, SCHEMATIC, LAYOUT, AND DESIGN GUIDELINES

1. Introduction

This document provides general Si483x-B/Si4820/24 design and AM/FM/SW antenna selection guidelines, including schematic, BOM and PCB layout. All users should follow the Si483x-B/Si4820/24 design guidelines presented in Section 2 and Section 3 and choose the appropriate antennas based on the applications and device used according to Sections 4 through 8.

Table 1. Part Selection Guide

† Part Number	† General Description	Function			FM Antenna		AM Antenna		SW Antenna
		FM Receiver	AM Receiver	SW Receiver	Headphone	Whip	Ferrite Loop	Air Loop	Whip
Si4831-B30	Wheel-tuned AM/FM Receiver	†	†		†	†	†	†	
Si4835-B30	Wheel-tuned AM/FM/SW Receiver	†	†	†	†	†	†	†	†
Si4835-B31	Wheel-tuned AM/FM/SW Receiver, Enhanced SW Tuning Feel	†	†	†	†	†	†	†	†
Si4820-A10	Entry Level Wheel-tuned AM/FM Receiver, Mono Audio	†	†		†	†	†	†	
Si4824-A10	Entry Level Wheel-tuned AM/FM/SW Receiver, Mono Audio	†	†	†	†	†	†	†	†

AN555

2. Frequency Band Definition and Selection

Five FM bands and five AM bands are defined for the Si4831-B/Si4820. The Si4835-B/Si4824 has 16 SW bands available. In each FM band, the parts also offer two de-emphasis selections and two LED stereo separation threshold selections, which result in a total of 41 combinations. This section shows the detailed band definition and selection information.

2.1. Band Definition

For the Si483x-B/Si4820/24, the FM band definition is a combination of frequency range, de-emphasis and LED stereo separation threshold. Customers should choose the band according to not only frequency range, but also de-emphasis setting and LED stereo separation requirements. For AM and SW, simply choose the band according to the frequency range desired.

Table 2. Band Sequence Definition

Band Number	Band Name	Band Frequency Range	De-emphasis	Stereo LED on Threshold (Only for Si483x-B)	Total R to GND (k Ω , 1%)
Band1	FM1	87–108 MHz	50 μ s	Separation = 6 dB, RSSI = 20	47
Band2	FM1	87–108 MHz	50 μ s	Separation = 12 dB, RSSI = 28	57
Band3	FM1	87–108 MHz	75 μ s	Separation = 6 dB, RSSI = 20	67
Band4	FM1	87–108 MHz	75 μ s	Separation = 12 dB, RSSI = 28	77
Band5	FM2	86.5–109 MHz	50 μ s	Separation = 6 dB, RSSI = 20	87
Band6	FM2	86.5–109 MHz	50 μ s	Separation = 12 dB, RSSI = 28	97
Band7	FM2	86.5–109 MHz	75 μ s	Separation = 6 dB, RSSI = 20	107
Band8	FM2	86.5–109 MHz	75 μ s	Separation = 12 dB, RSSI = 28	117
Band9	FM3	87.3–108.25 MHz	50 μ s	Separation = 6 dB, RSSI = 20	127
Band10	FM3	87.3–108.25 MHz	50 μ s	Separation = 12 dB, RSSI = 28	137
Band11	FM3	87.3–108.25 MHz	75 μ s	Separation = 6 dB, RSSI = 20	147
Band12	FM3	87.3–108.25 MHz	75 μ s	Separation = 12 dB, RSSI = 28	157
Band13	FM4	76–90 MHz	50 μ s	Separation = 6 dB, RSSI = 20	167
Band14	FM4	76–90 MHz	50 μ s	Separation = 12 dB, RSSI = 28	177

Table 2. Band Sequence Definition (Continued)

Band Number	Band Name	Band Frequency Range	De-emphasis	Stereo LED on Threshold (Only for Si483x-B)	Total R to GND (k Ω , 1%)
Band15	FM4	76–90 MHz	75 μ s	Separation = 6 dB, RSSI = 20	187
Band16	FM4	76–90 MHz	75 μ s	Separation = 12 dB, RSSI = 28	197
Band17	FM5	64–87 MHz	50 μ s	Separation = 6 dB, RSSI = 20	207
Band18	FM5	64–87 MHz	50 μ s	Separation = 12 dB, RSSI = 28	217
Band19	FM5	64–87 MHz	75 μ s	Separation = 6 dB, RSSI = 20	227
Band20	FM5	64–87 MHz	75 μ s	Separation = 12 dB, RSSI = 28	237
Band21	AM1	520–1710 kHz			247
Band22	AM2	522–1620 kHz			257
Band23	AM3	504–1665 kHz			267
Band24	AM4	520–1730 kHz			277
Band25	AM5	510–1750 kHz			287
Band26	SW1	5.6–6.4 MHz			297
Band27	SW2	5.95–6.2 MHz			307
Band28	SW3	6.8–7.6 MHz			317
Band29	SW4	7.1–7.6 MHz			327
Band30	SW5	9.2–10 MHz			337
Band31	SW6	9.2–9.9 MHz			347
Band32	SW7	11.45–12.25 MHz			357
Band33	SW8	11.6–12.2 MHz			367
Band34	SW9	13.4–14.2 MHz			377
Band35	SW10	13.57–13.87 MHz			387
Band36	SW11	15–15.9 MHz			397
Band37	SW12	15.1–15.8 MHz			407
Band38	SW13	17.1–18 MHz			417
Band39	SW14	17.48–17.9 MHz			427
Band40	SW15	21.2–22 MHz			437
Band41	SW16	21.45–21.85 MHz			447

2.2. Si483x-B/Si4820/24 Band Selection

Refer to Figure 1 below for the band selection circuits. Selecting a band determines the resistance value from the band select pin to GND.

To select a specific band, you need to ensure two things:

1. Total value of resistance from the BAND to GND is equal to the value specified in Table 2
2. Total resistance from TUNE1 to GND is 500 k Ω in 1% tolerance

The following sections describe some commonly used bands and their respective selection circuits.

2.2.1. Typical 12-band application

Figure 1 and Table 3 illustrate the band and resistor value details for a typical 12-band application.

Table 3. Typical 12-Band Selection

Band Number	Band Name	Band Frequency Range	De-emphasis	Stereo LED on Threshold (Only for Si483x-B)	Total R to GND (kΩ, 1%)
Band3	FM1	87–108 MHz	75 μs	Separation = 6 dB, RSSI = 20	67
Band15	FM4	76–90 MHz	75 μs	Separation = 6 dB, RSSI = 20	187
Band19	FM5	64–87 MHz	75 μs	Separation = 6 dB, RSSI = 20	227
Band21	AM1	520–1710 kHz			247
Band26	SW1	5.6–6.4 MHz			297
Band28	SW3	6.8–7.6 MHz			317
Band30	SW5	9.2–10 MHz			337
Band32	SW7	11.45–12.25 MHz			357
Band34	SW9	13.4–14.2 MHz			377
Band36	SW11	15–15.9 MHz			397
Band38	SW13	17.1–18 MHz			417
Band40	SW15	21.2–22 MHz			437

2.2.2. Typical 2-band Application for Europe

Table 4 and Figure 2 show the band and resistor value details for a typical European 2-band application.

Table 4. Typical European 2-Band Selection

Band Number	Band Name	Band Frequency Range	De-emphasis	Stereo LED on Threshold (Only for Si483x-B)	Total R to GND (k Ω , 1%)
Band2	FM1	87–108 MHz	50 μ s	Separation = 12 dB, RSSI = 28	57
Band22	AM2	522–1620 kHz			257

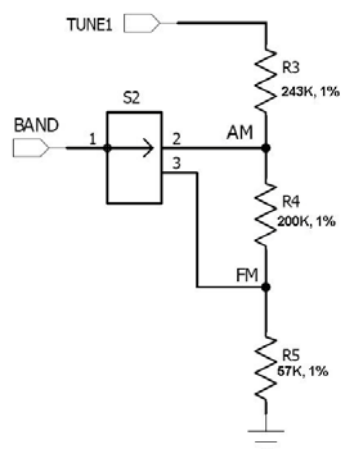


Figure 2. Typical 2-Band Selection Circuit for Europe

AN555

2.2.3. Typical 2-band application for US

Table 5 and Figure 3 show the band and resistor value details for a typical 2-band application for the U.S.

Table 5. Typical U.S. 2-Band Selection

Band Number	Band Name	Band Frequency Range	De-emphasis	Stereo LED on Threshold (Only for Si483x-B)	Total R to GND (k Ω , 1%)
Band4	FM1	87–108 MHz	75 μ s	Separation = 12 dB, RSSI = 28	77
Band21	AM1	520–1710 kHz			247

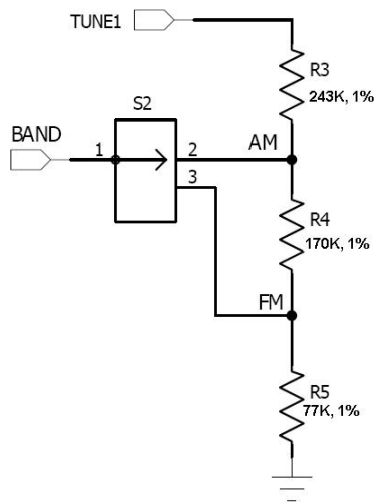


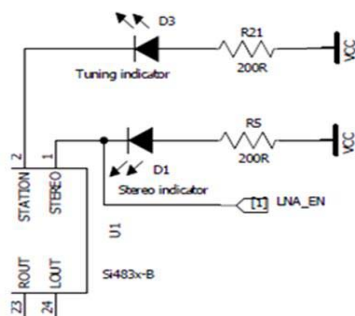
Figure 3. Typical 2-Band Selection Circuit for US

3. Si483x-B/Si4820/24 SSOP Schematic and Layout

This section shows the typical schematic and layout required for optimal Si483x-B/Si4820/24 performance.

There are basically two working modes for the Si483x-B: "Volume" and "Bass/Treble" modes. Adding a pull-up resistor of 10 k on pin2 STATION sets the chip in "Volume" mode and removing the pull-up resistor sets the chip in "Bass/Treble" mode, as illustrated in Figure 4. When working in Bass/Treble mode, the Bass/Treble can be controlled via two push buttons with eight levels or by a slide switch with two or three levels. When working in "Volume" mode, tuner audio output volume can be adjusted with 2 push buttons in 32 steps (2 dB per step). Additionally, the default power up volume level can be set with pull-up/down resistors. Compared with the Si483x-B, Si4820/24 only works in "Volume" mode, not "Bass/Treble" mode. The following sections describe in detail the applications circuits for different working modes.

"Bass/Treble" mode



"Volume" mode

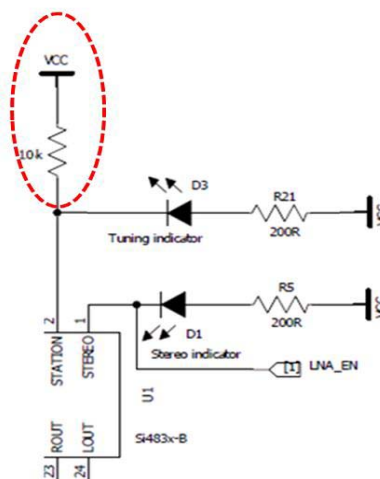


Figure 4. Si483x-B Mode Selection

3.1. Si483x-B/Si4820/24 Basic Volume Mode Applications Circuits

Figure 5 and Figure 6 illustrate the basic applications circuits for typical 4-band FM/AM radios if using Si4831-B/Si4820 or 12-band FM/AM/SW radios if using Si4835-B/Si4824. The chip works in "Volume" mode without internal volume adjustment. Volume control can be performed at audio amplifier circuit stage. For Si483x-B, the pull-up resistor R42 of 10K for pin 2 STATION is a must for this application.

C6 and C15 are required bypass capacitors for VDD1/VDD2 power supply pin 20/21. Place C6/C15 as close as possible to the VDD1/VDD2 pin 20/21 and DBYP pin 22. These recommendations are made to reduce the size of the current loop created by the bypass cap and routing, minimize bypass cap impedance and return all currents to the DBYP pin.

Pin 22 is the dedicated bypass capacitor pin. Do not connect it to power supply GND on PCB.

Pin 13 and pin 14 are the GND of the chip, these pins must be well connected to the power supply GND on PCB.

Pin 9 is the RFGND of the chip, it must be well connected to the power supply GND on PCB.

When doing PCB layout, try to create a large GND plane underneath and around the chip. Route all GND (including RFGND) pins to the GND plane.

C4 and/or C7 (4.7uF) are ac coupling caps for receiver analog audio output from pin 23 and/or pin 24. The input resistance of the amplifier R, such as a headphone amplifier, and the capacitor C will set the high pass pole given by Equation 1. Placement location is not critical.

$$f_c = \frac{1}{2\pi RC}$$

Equation 1.

C2 and C3 (22 pF) are crystal loading caps required only when using the internal oscillator feature. Refer to the crystal data sheet for the proper load capacitance and be certain to account for parasitic capacitance. Place caps C2 and C3 such that they share a common GND connection and the current loop area of the crystal and loading caps is minimized.

Y1 (32.768 kHz) is an optional crystal required only when using the internal oscillator feature. Place the crystal Y1 as close to XTALO pin 18 and XTALI pin 19 as possible to minimize current loops. If applying an external clock (32.768 kHz) to XTALI, leave XTALO floating.

Do not route digital signals or reference clock traces near pin 6 and 7. Do not route Pin 6 and 7. These pins must be left floating to guarantee proper operation.

Pin 16, 17 are volume control or bass/treble control pins for using tuner internal volume control function or bass/treble control function. In this basic application circuit, the tuner internal volume control function is not used, just connect the two pins to GND.

VR1 (100K / 10%), R27, C1, C13 constitute the tuning circuit. 10 kΩ at 10% tolerance is recommended for VR1.

1P12T switch S2 together with resistor ladder constitute band select circuits. Si4831/Si4820 includes all AM and FM bands as defined in above section 2.1, Si4835/Si4824 includes all AM, FM and SW bands.

Q1(2SC9018) together with it's peripherals B6, C30,31,33,36, R31,32,34,41 is the LNA circuit for all SW bands, the LNA is switched off by LNA_EN signal in AM and FM mode controlled by Si4835/Si4824.

For Si4820/24, do not route pin 23. This pin must be left floating to guarantee proper operation.

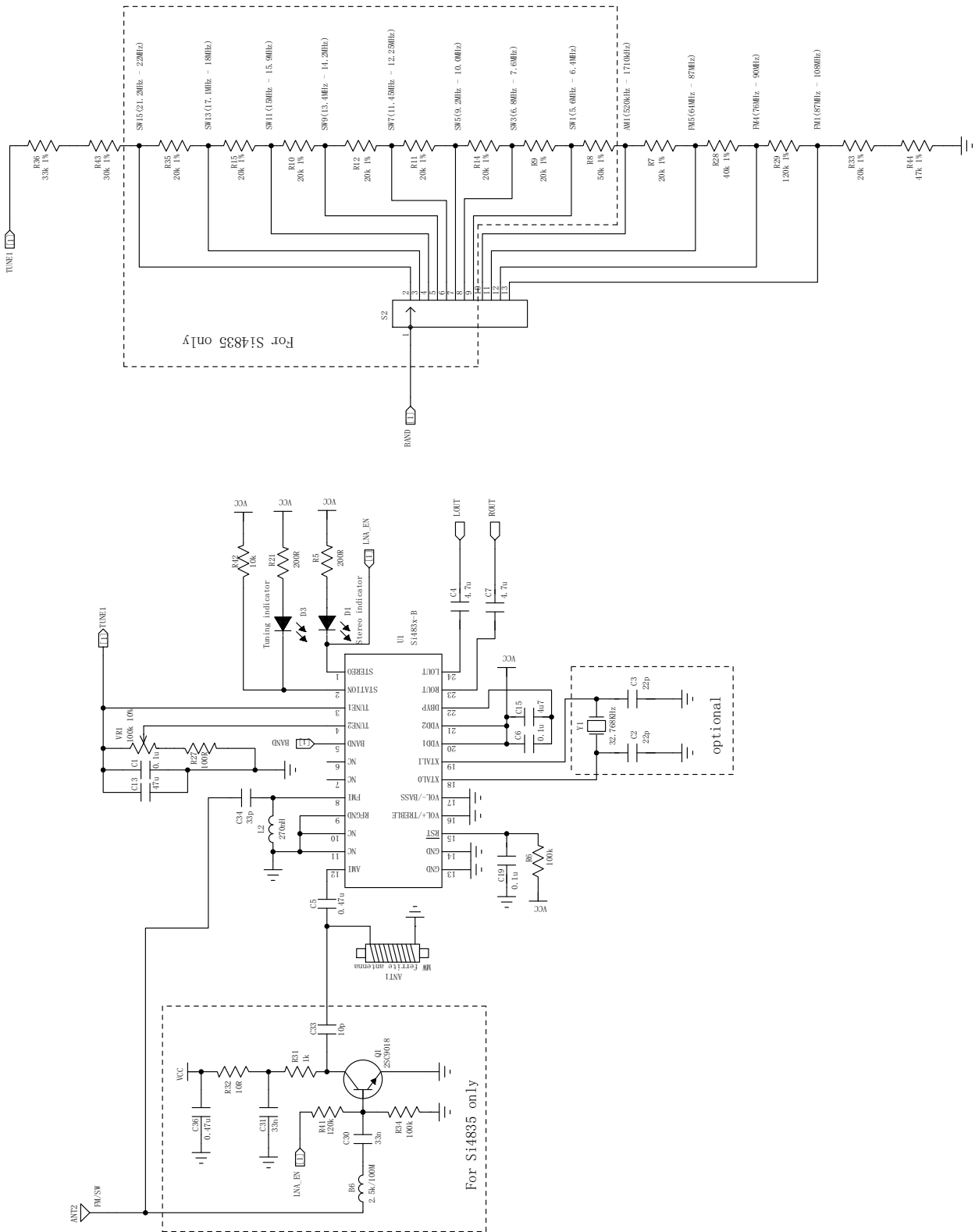


Figure 5. Si483x-B Basic Volume Mode Applications Circuit

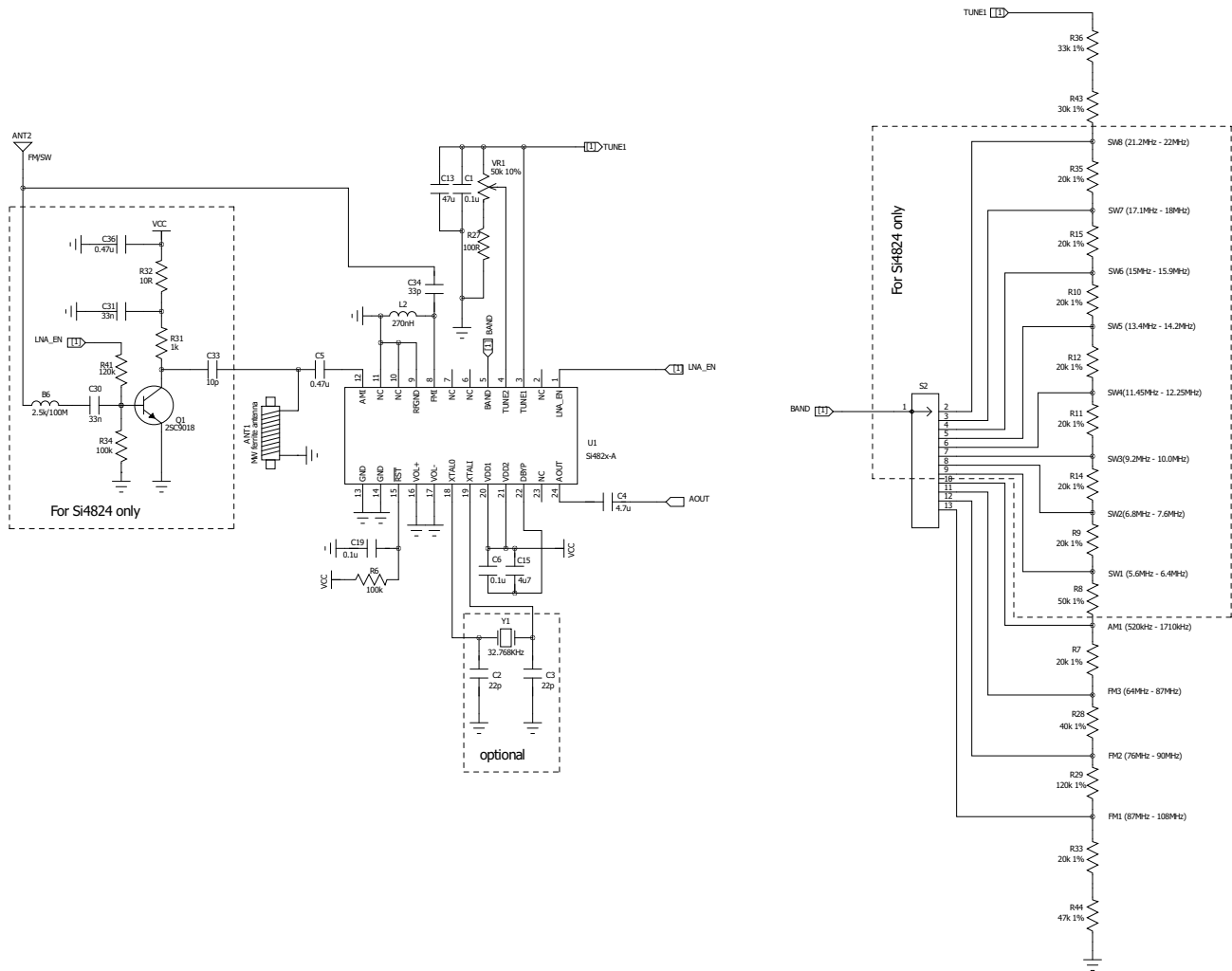


Figure 6. Si4820/24 Basic Volume Mode Applications Circuit

3.2. Si483x-B Applications Circuits with 9-level Bass/Treble Control via 2 Push Buttons

Figure 7 sets Si483x-B in Bass/Treble mode by removing the pull-up resistor of pin 2 STATION. Pushing button S3 once increases bass effect by one level, and pushing button S4 once increases treble effect by one level. By pressing and holding one of the buttons, the bass or treble effect will automatically step through all levels until reaching their maximums. There are nine levels for bass/treble control.

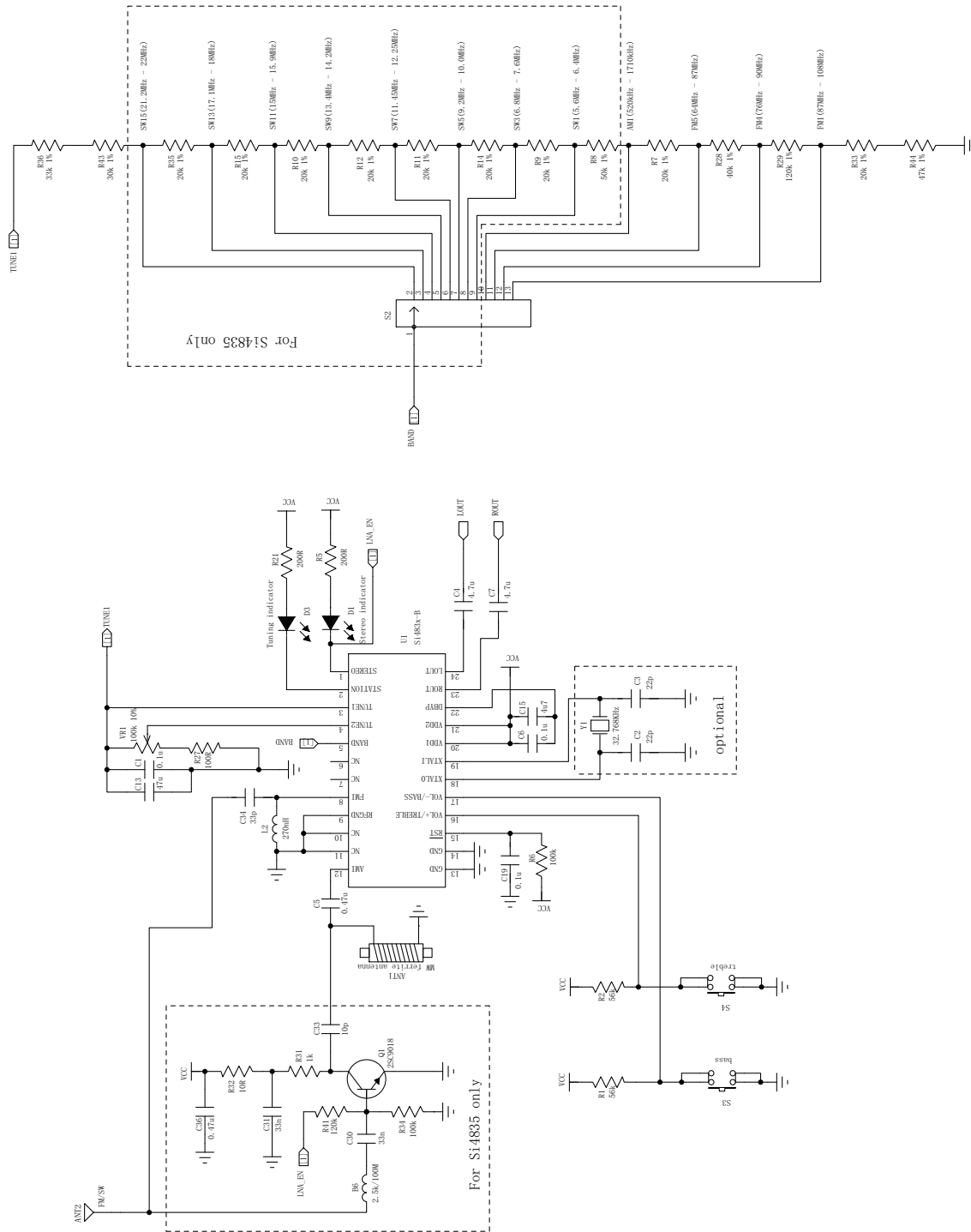


Figure 7. Si483x-B Applications Circuit with 9-Level Bass/Treble Control

3.3. Si483x-B Applications Circuits with 3-level Bass/Treble Control via Slide Switch

Figure 8 sets Si483x-B in Bass/Treble mode by removing the pull-up resistor of pin 2 STATION. Slide switch S5 controls bass/treble effect in three levels, bass/normal/treble.

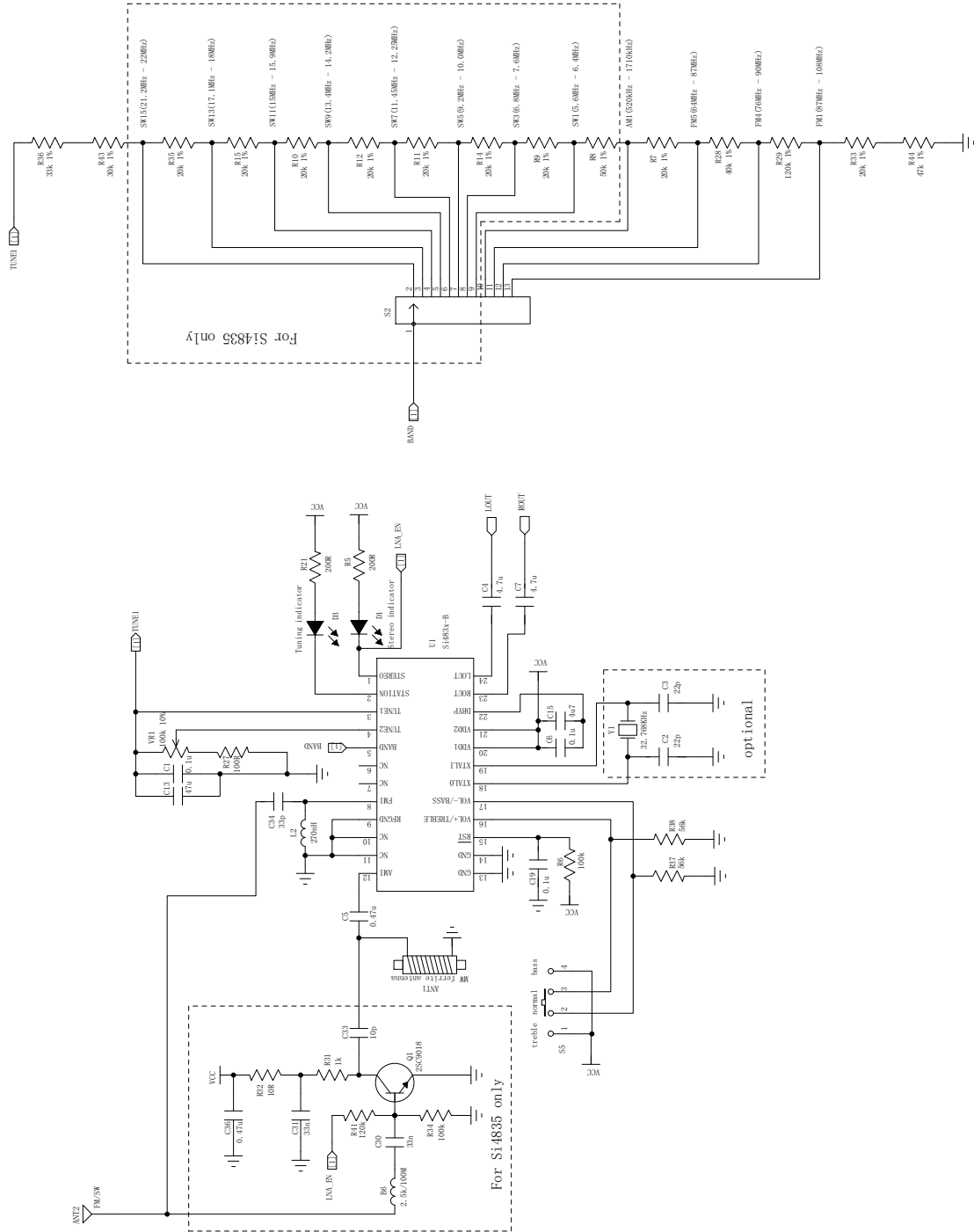


Figure 8. Si483x-B 3-Level Bass/Treble Mode Applications Circuits

3.4. Si48x-B/Si4820/24 Application Circuits with 32-Level Volume Control via 2 Push Buttons

Figure 9 sets Si483x-B in "Volume" mode by adding the pull-up resistor R42 of 10K at pin 2 STATION. Figure 10 illustrates the application circuit for Si4820/24. Pressing button S3 once decreases the volume level by 2 dB; pressing button S4 once increases the volume level by 2 dB. A total of 32 steps (2 dB per step) are available for the push button volume control. If pressing and holding S3 or S4, tuner volume will step through all levels until reaching the minimum or maximum, respectively.

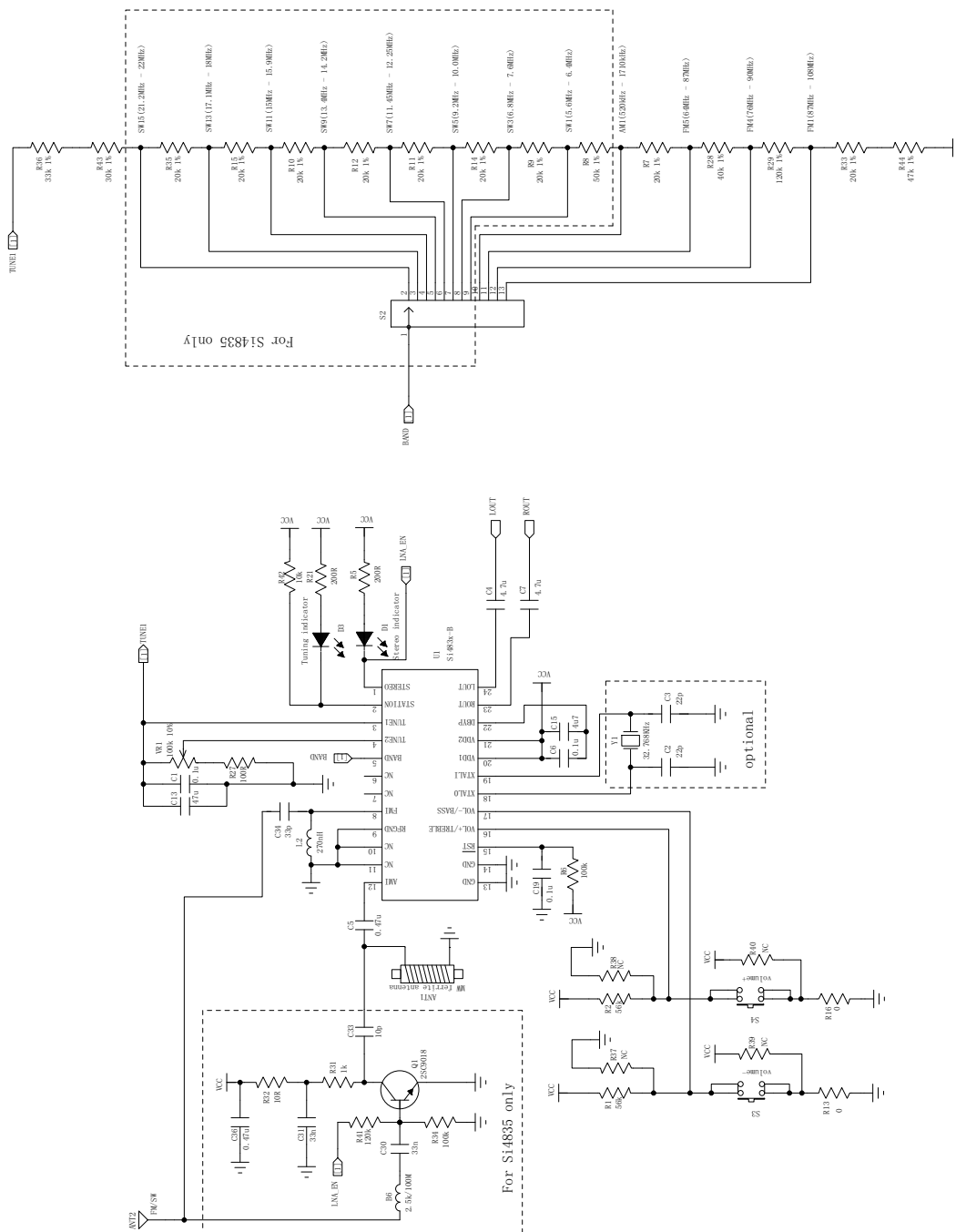


Figure 9. Si483x-B Applications Circuits with 32-Level Volume Control

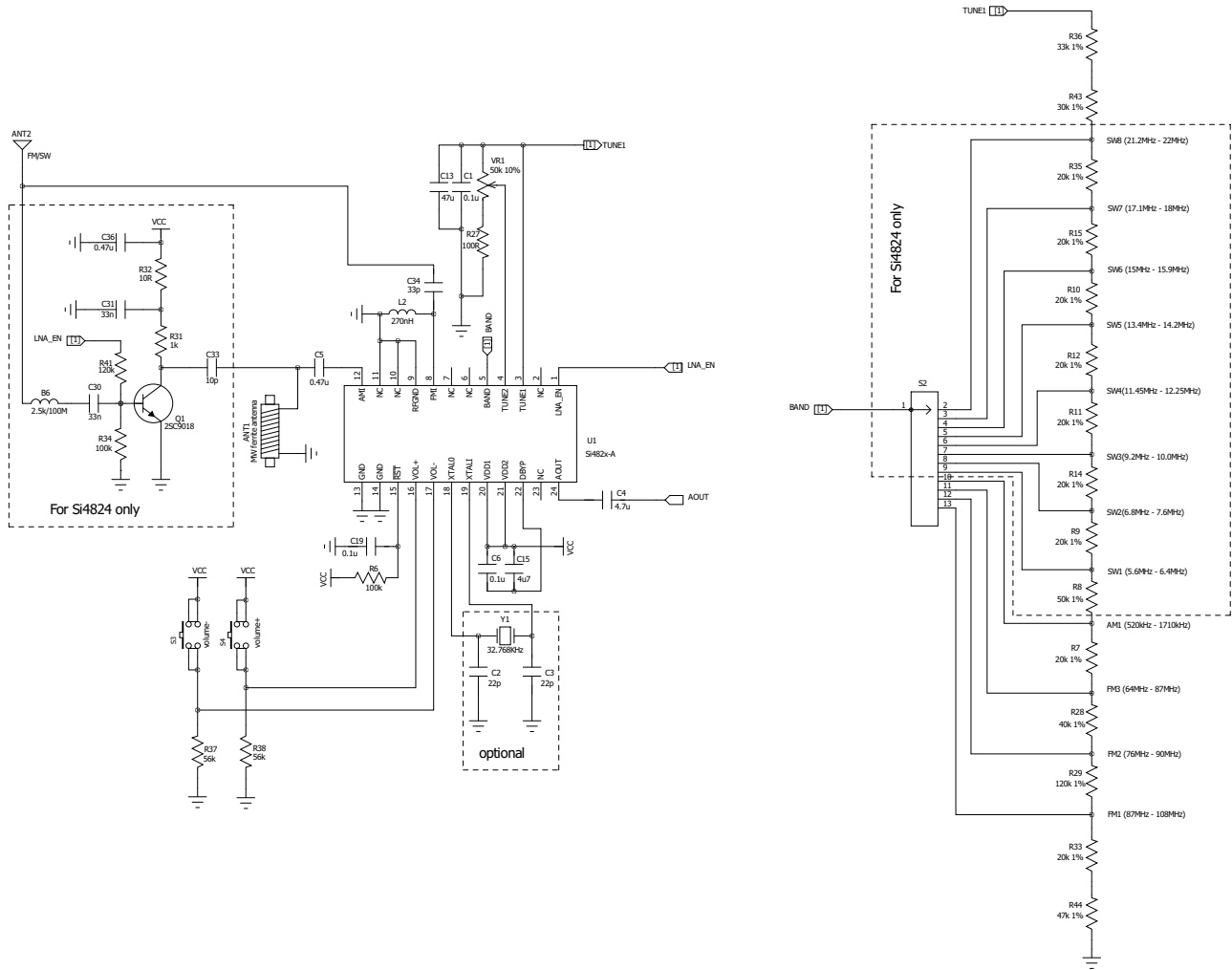


Figure 10. Si4820/24 Applications Circuit with 32-Level Volume Control

At the device power up, Si483x-B/Si4820/24 will put the output volume at some default levels according to the push button configurations as shown in Figure 11. There are four default volume level choices. Adding pull-down resistors to both pin 16 and 17 sets the default volume to maximum, typically 80 mVrms for FM and 60 mVrms for AM. Different pin 16 and 17 pull-up/down resistor combinations can set the default volume to either Max, Max-6dB, Max-12dB or Max-18dB. For example, in Figure 9, two pull-up resistors are connected to pin 16 and pin 17, which sets the default volume to Max-18dB.

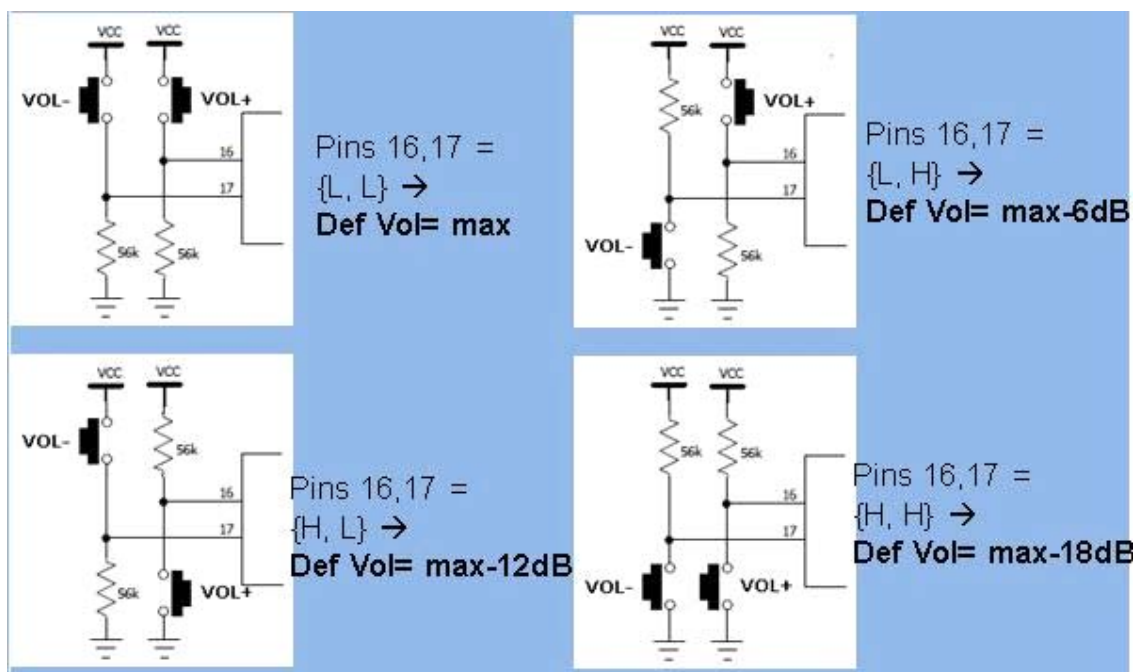


Figure 11. Si483x-B/Si4820/24 Default Volume Selection in Volume Mode

3.5. Application Circuits for Memorization of User Settings

Si483x-B/Si4820/24 has high retention memory (HRM) built-in that can memorize the last volume and bass/treble settings so that at the next power up, the unit will automatically restore the volume and bass/treble settings before the last power off. The unit requires pin 20 Vdd1 to be connected to an always-on power source such as battery terminals.

During power off/on cycling, there is a low probability that the user setting data in HRM can be corrupted by transient. If the tuner finds that the stored data in HRM is corrupted at power on, it will switch to use the default volume or bass/treble setting. To safeguard the integrity of HRM data, users are advised to ensure that the Reset pin (RSTB) voltage goes down to $0.3 \cdot VDD$ before the VDD2 voltage drops to 1.65 V during the power off process. A 2P2T, power on/off switch S3 in Figure 12 is recommended, with one pole of S3 short pin15 RSTB to GND immediately at the power off event.

Applying always-on power supply voltage to Vdd1 and using 2P2T power on/off switch to connect RSTB will also improve the tuned channel consistency before power off and after power on. Si483x-B/Si4820/24 memorizes the last tuned station before power off and restores the original tuned station at power up after confirming that there is not a large enough position change on PVR during the power off/on cycle.

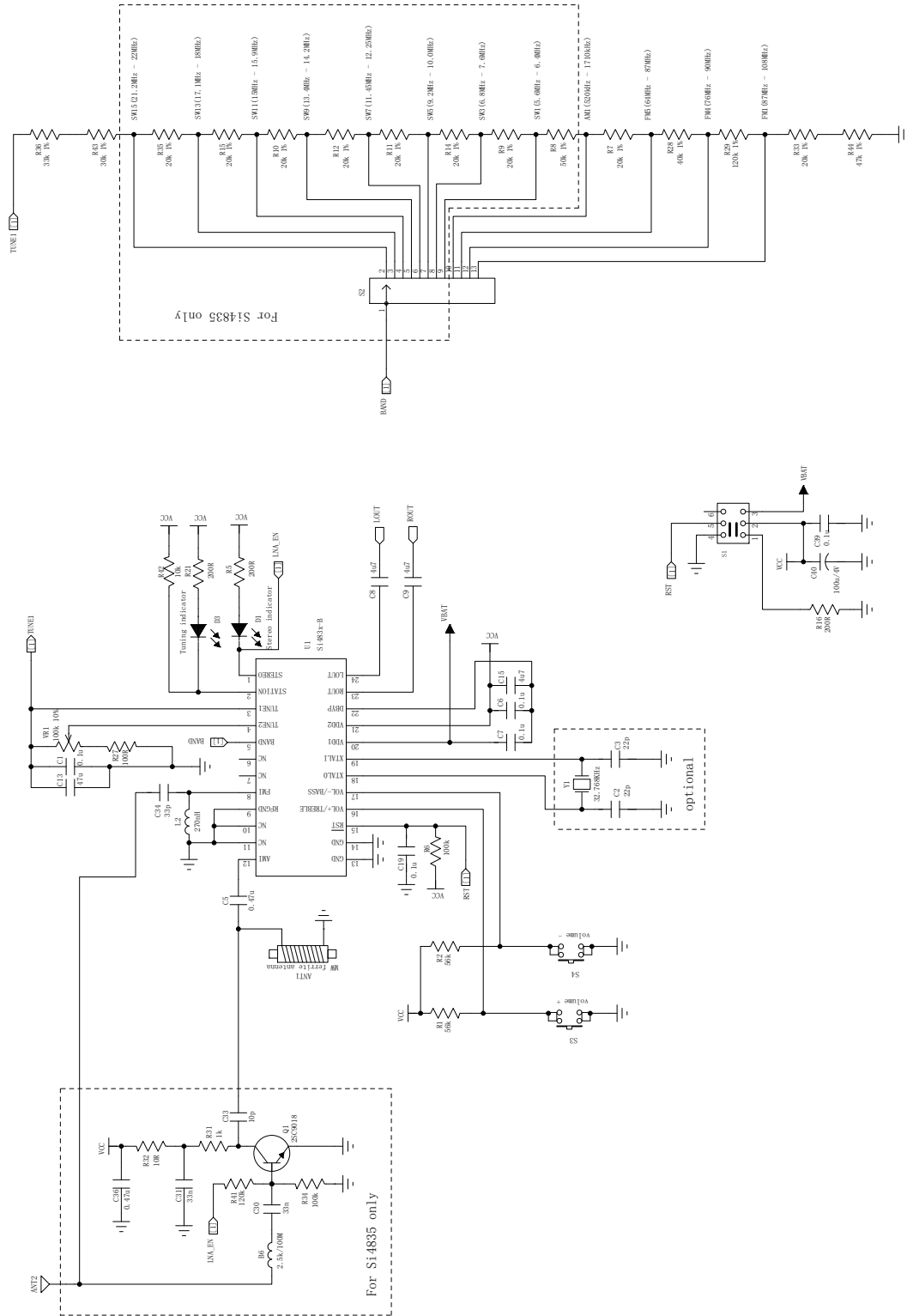


Figure 12. Si483x-B Applications Circuits with User Setting Memory

3.6. Si483x-B/Si4820/24 Bill of Materials

3.6.1. Si483x-B/Si4820/24 Basic Volume Mode Applications Circuit BOM

Table 6. Si483x-B Basic Volume Mode Applications Circuit BOM

Component(s)	Value/Description	Supplier
C4,C7,C15	Capacitor 4.7 μ F, \pm 20%, Z5U/X7R	Murata
C13	Capacitor 47 μ F, \pm 20%, Z5U/X7R	Murata
C1,C6,C19	Supply bypass capacitor, 0.1 μ F, \pm 20%, Z5U/X7R	Murata
C36	Supply bypass capacitor, 0.47 μ F, \pm 20%, Z5U/X7R	Murata
C34	RF coupling capacitors, 33 pF, \pm 5%, COG	Murata
L2	Inductor 270 nH.	Murata
R5,R21	LED biasing resistors, 200 Ω , \pm 5%	Venkel
VR1	Variable resistor (POT), 100 k Ω , , \pm 10%	Kennon
D1,D3	Station and Stereo indicating LEDs	Any, depends on customer
U1	Si483xB AM/FM/SW Analog Tune Analog Display Radio Tuner	Silicon Laboratories
R6	Resistor, 100 k Ω , \pm 5%	Venkel
R27	Resistor, 100 Ω , , \pm 5%	Venkel
R28	Band switching resistor, 40 k Ω , , \pm 1%	Venkel
R44	Band switching resistor, 47 k Ω , , \pm 1%	Venkel
R36	Band switching resistor, 33 k Ω , , \pm 1%	Venkel
R43	Band switching resistor, 30 k Ω , , \pm 1%	Venkel
R7,R33	Band switching resistor, 20 k Ω , , \pm 1%	Venkel
R29	Band switching resistor, 120 k Ω , , \pm 1%	Venkel
S2	Band switch	Shengda
C2, C3	Crystal load capacitors, 22 pF, \pm 5%, COG (Optional: for crystal oscillator option)	Venkel
Y1	32.768 kHz crystal (Optional: for crystal oscillator option)	Epson
ANT2	Whip antenna	Various
ANT1	MW ferrite antenna 220 μ H	Jiaxin Electronics

Table 7. Si4820/24 Basic Volume Mode Applications Circuit BOM

Component(s)	Value/Description	Supplier
C4,C7,C15	Capacitor 4.7 μ F, \pm 20%, Z5U/X7R	Murata
C13	Capacitor 4.7 μ F, \pm 20%, Z5U/X7R	Murata
C1,C6,C19	Supply bypass capacitor, 0.1 μ F, \pm 20%, Z5U/X7R	Murata
C36	Supply bypass capacitor, 0.47 μ F, \pm 20%, Z5U/X7R	Murata
C34	RF coupling capacitors, 33 pF, \pm 5%, COG	Murata
L2	Inductor 270 nH	Murata
VR1	Variable resistor (POT), 100 k, \pm 10%	Kennon
U1	Si4820/24 AM/FM/SW Analog Tune Analog Display Radio Tuner	Silicon Laboratories
R6	Resistor, 100 k, \pm 5%	Venkel
R27	Resistor, 100 Ω , \pm 5%	Venkel
R28	Band switching resistor, 40 k, \pm 1%	Venkel
R44	Band switching resistor, 47 k, \pm 1%	Venkel
R36	Band switching resistor, 33 k, \pm 1%	Venkel
R43	Band switching resistor, 30 k, \pm 1%	Venkel
R7,R33	Band switching resistor, 20 k, \pm 1%	Venkel
R29	Band switching resistor, 120 k, \pm 1%	Venkel
S2	Band switch	Shengda
C2, C3	Crystal load capacitors, 22 pF, \pm 5%, COG (Optional: for crystal oscillator option)	Venkel
Y1	32.768 kHz crystal (Optional: for crystal oscillator option)	Epson
ANT2	Whip antenna	Various
ANT1	MW ferrite antenna 220 μ H.	Jiaxin Electronics

Table 8. Si4835-B/Si4824 Additional BOM (for 8 SW Bands)

Component(s)	Value/Description	Supplier
C36	Capacitor, 0.47 μ F, \pm 20%, Z5U/X7R	Murata
C33	Capacitor capacitors, 10 pF, \pm 5%, COG	Murata
C30-31	Capacitor capacitors, 33 nF, \pm 5%, COG	Murata
B6	Ferrite bead, 2.5k Ω , 100 MHz	Murata
Q1	RF transistor, 2SC9018.	ETC
R34	Resistor, 100 k Ω , \pm 5%	Venkel
R41	Resistor, 120 k Ω , \pm 5%	Venkel
R32	Resistor, 10R, \pm 5%	Venkel
R31	Resistor, 1k Ω , \pm 5%	Venkel
R9-12,R14-15,R35	Band switching resistor, 20 k Ω , \pm 1%	Venkel
R8	Band switching resistor, 50 k Ω , \pm 1%	Venkel

3.6.2. Additional BOM for Applications Circuit with 9-level Bass/Treble Control via Push Buttons

Table 9. Si483x-B Additional BOM for 9-Level Bass/Treble Control

Component(s)	Value/Description	Supplier
R1-2	Resistor, 56 k Ω , \pm 5%	Venkel
S3-4	Button switch	Various

3.6.3. Additional BOM for Application Circuit with 3-level Bass/Treble Control via Slide Switch

Table 10. Si483x-B Additional BOM for 3-Level Bass/Treble Control

Component(s)	Value/Description	Supplier
R37-38	Resistor, 56 k Ω , \pm 5%	Venkel
S5	Slide switch	Shengda

3.6.4. Additional BOM for Application Circuit with 32-level Volume Control via Push Buttons

Table 11. Si483x-B Additional BOM for 32-Level Volume Control

Component(s)	Value/Description	Supplier
R1-2	Resistor, 56 k Ω , \pm 5%	Venkel
S3-4	Button switch	Various

Table 12. Si4820/24 Additional BOM for 32-Level Volume Control

Component(s)	Value/Description	Supplier
R37-38	Resistor, 56 k Ω , \pm 5%	Venkel
S3-4	Button switch	Various

3.6.5. Additional BOM for Application Circuit with Memorization of User Settings

Table 13. Si483x-B Additional BOM for User Setting Memory

Component(s)	Value/Description	Component(s)
R1-2	Resistor, 56 k Ω , \pm 5%	Venkel
S3-4	Button switch	Various
S1	2P2T slide switch	Shengda
R16	Resistor, 200R, \pm 5%	Venkel
C40	Supply bypass electrolytic capacitor, 100 μ F, 4 V	Any
C39	Supply bypass capacitor, 0.1 μ F, \pm 20%, Z5U/X7R	Murata

3.7. Si483x-B/Si4820/24 PCB Layout Guidelines

- 1-layer PCB is used for Si483x-B/Si4820/24
- GND routed by large plane
- Power routed with traces
- 0402 component size or larger
- 10 mil traces width
- 20 mil trace spacing
- 15 mil component spacing
- Recommended to keep the AM ferrite loop antenna at least 5 cm away from the tuner chip
- Keep the AM ferrite loop antenna at least 5 cm away from MCU, audio AMP, and other circuits which have AM interference

Place Vdd1/Vdd2 bypass capacitor C6, C15 as close as possible to the supply (pin 20/pin 21) and DBYP (pin 22). Do not connect the DBYP (pin 22) to the board GND.

Place the crystal as close to XTALO (pin 18) and XTALI (pin 19) as possible.

Route all GND (including RFGND) pins to the GND plane underneath the chip. Try to create a large GND plane underneath and around the chip.

Do not route pin 6 and 7. These pins must be left floating to guarantee proper operation.

Keep the Tune1 and Tune2 traces away from pin 6 and pin 7. Route Tune1 and Tune2 traces in parallel and the same way.

Place C1, C13 as close to pin3 TUNE1 as possible.

For Si4820/24, do not route pin 23, leave it floating to guarantee proper operation.

Copy the Si483x-B layout example as much as possible when doing PCB layout.

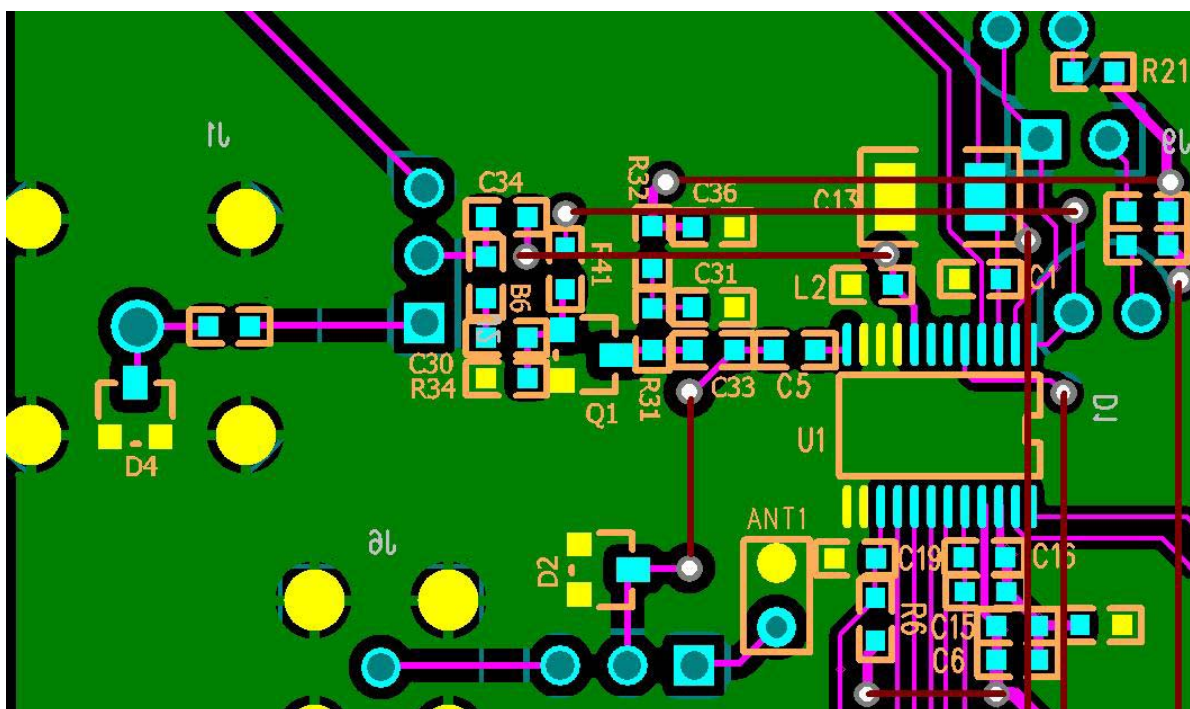


Figure 13. Si483x-B PCB Layout Example

4. Headphone Antenna for FM Receive

The Si483x-B/Si4820/24 FM Receiver component supports a headphone antenna interface through the FMI pin. A headphone antenna with a length between 1.1 and 1.45 m suits the FM application very well because it is approximately half the FM wavelength (FM wavelength is ~3 m).

4.1. Headphone Antenna Design

A typical headphone cable will contain three or more conductors. The left and right audio channels are driven by a headphone amplifier onto left and right audio conductors and the common audio conductor is used for the audio return path and FM antenna. Additional conductors may be used for microphone audio, switching, or other functions, and in some applications the FM antenna will be a separate conductor within the cable. A representation of a typical application is shown in Figure 14.

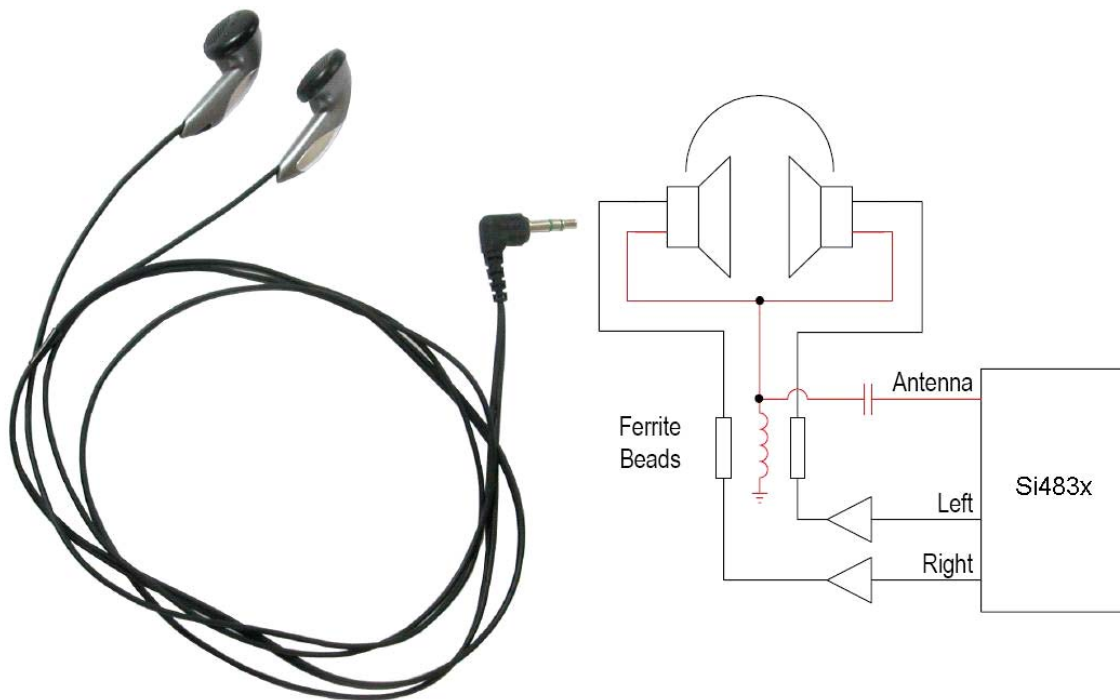


Figure 14. Typical Headphone Antenna Application

4.2. Headphone Antenna Schematic

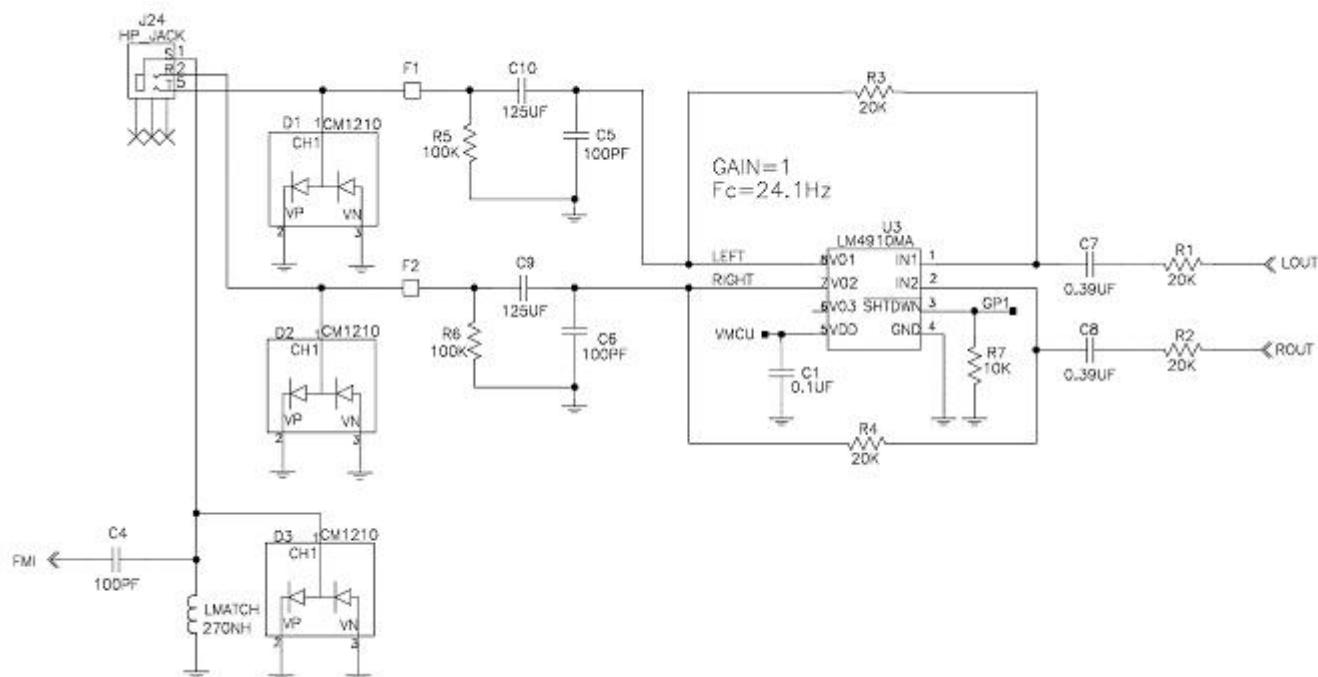


Figure 15. Headphone Antenna Schematic

The headphone antenna implementation requires components LMATCH, C4, F1, and F2 for a minimal implementation. The ESD protection diodes and headphone amplifier components are system components that will be required for proper implementation of any tuner.

Inductor LMATCH is selected to maximize the voltage gain across the FM band. LMATCH should be selected with a Q of 15 or greater at 100 MHz and minimal dc resistance.

AC-coupling capacitor C4 is used to remove a dc offset on the FMI input. This capacitor must be chosen to be large enough to cause negligible loss with an LNA input capacitance of 4 to 6 pF. The recommended value is 100 pF to 1 nF.

Ferrite beads F1 and F2 provide a low-impedance audio path and high-impedance RF path between the headphone amplifier and the headphone. Ferrite beads should be placed on each antenna conductor connected to nodes other than the FMIP such as left and right audio, microphone audio, switching, etc. In the example shown in Figure 15, these nodes are the left and right audio conductors. Ferrite beads should be 2.5 kΩ or greater at 100 MHz, such as the Murata BLM18BD252SN1. High resistance at 100 MHz is desirable to maximize RSHUNT, and therefore, RP. Refer to “AN383: Si47xx Antenna, Schematic, Layout, and Design Guidelines,” Appendix A—FM Receive Headphone Antenna Interface Model for a complete description of RSHUNT, RP, etc.

ESD diodes D1, D2, and D3 are recommended if design requirements exceed the ESD rating of the headphone amplifier and the Si483x-B/Si4820/24. Diodes should be chosen with no more than 1 pF parasitic capacitance, such as the California Micro Devices CM1210. Diode capacitance should be minimized to reduce CSHUNT and, therefore, CP. If D1 and D2 must be chosen with a capacitance greater than 1 pF, they should be placed between the ferrite beads F1 and F2 and the headphone amplifier to minimize CSHUNT. This placement will, however, reduce the effectiveness of the ESD protection devices. Diode D3 may not be relocated and must therefore have a capacitance less than 1 pF. Note that each diode package contains two devices to protect against positive and negative polarity ESD events.

C9 and C10 are 125 uF ac coupling capacitors required when the audio amplifier does not have a common mode output voltage and the audio output is swinging above and below ground.

Optional bleed resistors R5 and R6 may be desirable to discharge the ac-coupling capacitors when the headphone cable is removed.

Optional RF shunt capacitors C5 and C6 may be placed on the left and right audio traces at the headphone amplifier output to reduce the level of digital noise passed to the antenna. The recommended value is 100 pF or greater, however, the designer should confirm that the headphone amplifier is capable of driving the selected shunt capacitance.

The schematic example in Figure 15 uses the National Semiconductor LM4910 headphone amplifier. Passive components R1 R4 and C7 C8 are required for the LM4910 headphone amplifier as described in the LM4910 data sheet. The gain of the right and left amplifiers is R3/R1 and R4/R2, respectively. These gains can be adjusted by changing the values of resistors R3 and R4. As a general guide, gain between 0.6 and 1.0 is recommended for the headphone amplifier, depending on the gain of the headphone elements. Capacitors C7 and C8 are ac-coupling capacitors required for the LM4910 interface. These capacitors, in conjunction with resistors R1 and R2, create a high-pass filter that sets the audio amplifier's lower frequency limit. The high-pass corner frequencies for the right and left amplifiers are:

$$f_{\text{CRIGHT}} = \frac{1}{2\pi \times R1 \times C7} \times f_{\text{CLEFT}} = \frac{1}{2\pi \times R2 \times C8}$$

Equation 2.

With the specified BOM components, the corner frequency of the headphone amplifier is approximately 20 Hz.

Capacitor C1 is the supply bypass capacitor for the audio amplifier. The LM4910 can also be shut down by applying a logic low voltage to the number 3 pin. The maximum logic low level is 0.4 V and the minimum logic high level is 1.5 V.

The bill of materials for the typical application schematic shown in Figure 15 is provided in Table 14. Note that manufacturer is not critical for resistors and capacitors.

4.3. Headphone Antenna Bill of Materials

Table 14. Headphone Antenna Bill of Materials

Designator	Description
LMATCH	IND, 0603, SM, 270 nH, MURATA, LQW18ANR27J00D
C4	AC coupling cap, SM, 0402, X7R, 100 pF
D1, D2, D3	IC, SM, ESD DIODE, SOT23-3, California Micro Devices, CM1210-01ST
U3	IC, SM, HEADPHONE AMP, National Semiconductor, LM4910MA
R1, R2, R3, R4	RES, SM, 0603, 20 kΩ
C7, C8	CAP, SM, 0603, 0.39 UF, X7R
C5, C6	CAP, SM, 0402, C0G, 100 pF
R5, R6	RES, SM, 0603, 100 kΩ
F1, F2	FERRITE BEAD, SM, 0603, 2.5 kΩ, Murata, BLM18BD252SN1D
C1	CAP, SM, 0402, X7R, 0.1 μF
R7	RES, SM, 0402, 10 kΩ

4.4. Headphone Antenna Layout

To minimize inductive and capacitive coupling, inductor LMATCH and headphone jack J24 should be placed together and as far from noise sources such as clocks and digital circuits as possible. LMATCH should be placed near the headphone connector to keep audio currents away from the chip.

To minimize CSHUNT and CP, place ferrite beads F1 and F2 as close as possible to the headphone connector.

To maximize ESD protection diode effectiveness, place diodes D1, D2, and D3 as close as possible to the headphone connector. If capacitance larger than 1 pF is required for D1 and D2, both components should be placed between FB1, FB2, and the headphone amplifier to minimize CSHUNT.

Place the chip as close as possible to the headphone connector to minimize antenna trace capacitance, CPCBANT. Keep the trace length short and narrow and as far above the reference plane as possible, restrict the trace to a microstrip topology (trace routes on the top or bottom PCB layers only), minimize trace vias, and relieve ground fill on the trace layer. Note that minimizing capacitance has the effect of maximizing characteristic impedance. It is not necessary to design for 50 Ω transmission lines.

To reduce the level of digital noise passed to the antenna, RF shunt capacitors C5 and C6 may be placed on the left and right audio traces close to the headphone amplifier audio output pins. The recommended value is 100 pF or greater; however, the designer should confirm that the headphone amplifier is capable of driving the selected shunt capacitance.

4.5. Headphone Antenna Design Checklist

- Select an antenna length of 1.1 to 1.45 m.
- Select matching inductor LMATCH to maximize signal strength across the FM band.
- Select matching inductor LMATCH with a Q of 15 or greater at 100 MHz and minimal dc resistance.
- Place inductor LMATCH and headphone connector together and as far from potential noise sources as possible to reduce capacitive and inductive coupling.
- Place the chip close to the headphone connector to minimize antenna trace length. Minimizing trace length reduces CP and the possibility for inductive and capacitive coupling into the antenna by noise sources. This recommendation must be followed for optimal device performance.
- Select ferrite beads F1-F2 with 2.5 k Ω or greater resistance at 100 MHz to maximize RSHUNT and, therefore, RP.
- Place ferrite beads F1-F2 close to the headphone connector.
- Select ESD diodes D1-D3 with minimum capacitance.
- Place ESD diodes D1-D3 as close as possible to the headphone connector for maximum effectiveness.
- Place optional RF shunt capacitors near the headphone amplifier's left and right audio output pins to reduce the level of digital noise passed to the antenna.

5. Whip Antenna for FM Receiver

A whip antenna is a typical monopole antenna.

5.1. FM Whip Antenna Design

A whip antenna is a monopole antenna with a stiff but flexible wire mounted vertically with one end adjacent to the ground plane.

There are various types of whip antennas including long, non-telescopic metal whip antennas, telescopic metal whip antennas, and rubber whip antennas. Figure 16 shows the telescopic whip antenna.



Figure 16. Telescopic Whip Antennas

The whip antenna is capacitive, and its output capacitance depends on the length of the antenna (maximum length ~56 cm). At 56 cm length, the capacitance of the whip antenna ranges from 18 to 32 pF for the US FM band. The antenna capacitance is about 22 pF in the center of the US FM band (98 MHz).

5.2. FM Whip Antenna Schematic

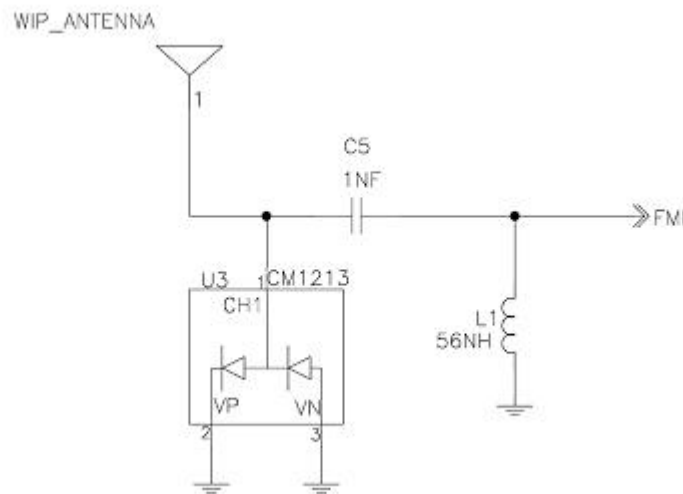


Figure 17. FM Whip Antenna Schematic

L1 (56 nH) is the matching inductor and it combines with the antenna impedance and the FMI impedance to resonate in the FM band.

C5 (1nF) is the ac coupling cap going to the FMI pin.

U3 is a required ESD diode since the antenna is exposed. The diode should be chosen with no more than 1 pF parasitic capacitance, such as the California Micro Device CM1213.

5.3. FM Whip Antenna Bill of Materials

Table 15. FM Whip Antenna Bill of Materials

Designator	Description
WIP_ANTENNA	Whip Antenna
L1	Tuning Inductor, 0603, SM, 56 nH, MURATA, LQW18AN56nJ00D
C5	AC coupling capacitor, 1 nF, 10%, COG
U3	IC, SM, ESD DIODE, SOT23-3, California Micro Devices, CM1213-01ST

5.4. FM Whip Antenna Layout

Place the chip as close as possible to the whip antenna. This will minimize the trace length between the device and whip antenna, which will minimize parasitic capacitance and the possibility of noise coupling. Place inductor L1 and the antenna connector together and as far from potential noise sources as possible. Place the ac coupling capacitor, C5, as close to the FMI pin as possible. Place ESD diode U3 as close as possible to the whip antenna input connector for maximum effectiveness.

5.5. FM Whip Antenna Design Checklist

- Maximize whip antenna length for optimal performance.
- Select matching inductor L1 with a Q of 15 or greater at 100 MHz and minimal dc resistance.
- Select L1 inductor value to maximize resonance gain from FM frequency (64 MHz) to FM frequency (109 MHz)
- Place L1 and whip antenna close together and as far from potential noise sources as possible to reduce capacitive and inductive coupling.
- Place the chip as close as possible to the whip antenna to minimize the antenna trace length. This reduces parasitic capacitance and hence reduces coupling into the antenna by noise sources. This recommendation must be followed for optimal device performance.
- Place ESD U3 as close as possible to the whip antenna for maximum effectiveness.
- Select ESD diode U3 with minimum capacitance.
- Place the ac coupling capacitor, C5, as close to the FMI pin as possible.

6. Ferrite Loop Antenna for AM Receive

Two types of antenna will work well for an AM receiver: a ferrite loop antenna or an air loop antenna. A ferrite loop antenna can be placed internally on the device or connected externally to the device with a wire connection. When the ferrite loop antenna is placed internally on the device, it is more susceptible to picking up any noise within the device. When the ferrite loop antenna is placed outside a device, e.g., at the end of an extension cable, it is less prone to device noise activity and may result in better AM reception.

6.1. Ferrite Loop Antenna Design

The following figure shows an example of ferrite loop antennas. The left figure is the standard size ferrite loop antenna, which is usually used in products with a lot of space, such as desktop radios. The right figure is the miniature size of the loop antenna compared with a U.S. 10-cent piece (dime). It is usually used in small products where space is at a premium, such as cell phones. If possible, use the standard size ferrite loop antenna as it has a better sensitivity than the miniature one.

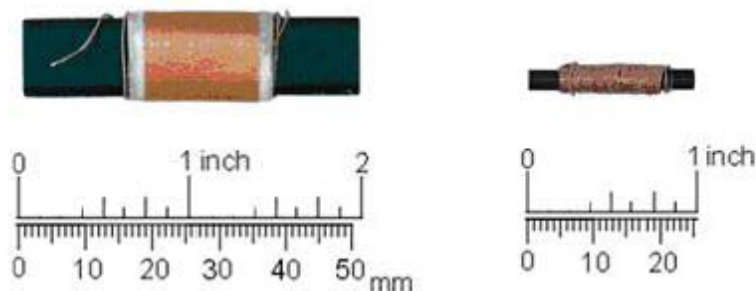


Figure 18. Standard and Miniature Ferrite Loop Antennas

A loop antenna with a ferrite inside should be designed such that the inductance of the ferrite loop is between 180 and 450 μH for the Si483x-B/Si4820/24 AM Receiver.

Table 16 lists the recommended ferrite loop antenna for the Si483x-B/Si4820/24 AM Receiver.

Table 16. Recommended Ferrite Loop Antenna

Part #	Diameter	Length	Turns	Ui	Type	Application
SL8X50MW70T	8 mm	50 mm	70	400	Mn-Zn	Desktop Radios
SL4X30MW100T	4 mm	30 mm	100	300	Ni-Zn	Portable Radios (MP3, Cell, GPS)
SL3X30MW105T	3 mm	30 mm	105	300	Ni-Zn	
SL3X25MW100T	3 mm	25 mm	110	300	Ni-An	
SL5X7X100MW70T	5x7 mm	100 mm	70	400	Mn-Zn	Desktop Radios

The following is the vendor information for the ferrite loop antennas:

Jiaxin Electronics

Shenzhen Sales Office

email: sales@firstantenna.com

Web: www.firstantenna.com

6.2. Ferrite Loop Antenna Schematic

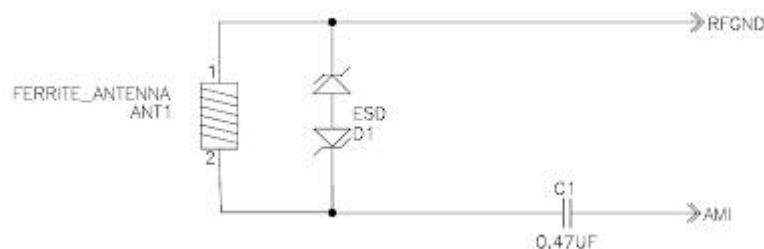


Figure 19. AM Ferrite Loop Antenna Schematic

C1 is the ac coupling cap going to the AMI pin and its value should be 0.47 μ F.

D1 is an optional ESD diode if there is an exposed pad going to the AMI pin.

6.3. Ferrite Loop Antenna Bill of Materials

Table 17. Ferrite Loop Antenna Bill of Materials

Designator	Description
ANT1	Ferrite loop antenna, 180–450 H
C1	AC coupling capacitor, 0.47 μ F, 10%, Z5U/X7R
D1*	ESD diode, IC, SM, SOT23-3, California Micro Devices, CM1213-01ST
*Note: Optional; only needed if there is any exposed pad going to the AMI pin.	

6.4. Ferrite Loop Antenna Layout

Place the chip as close as possible to the ferrite loop antenna feedline. This will minimize the trace going to the ferrite antenna, which will minimize parasitic capacitance as well as the possibility of noise sources coupling to the trace.

The placement of the AM antenna is critical because AM is susceptible to noise sources causing interference in the AM band. Noise sources can come from clock signals, switching power supply, and digital activities (e.g., MCU). When the AM input is interfaced to a ferrite loop stick antenna, the placement of the ferrite loop stick antenna is critical to minimize inductive coupling. Place the ferrite loop stick antenna as far away from interference sources as possible. In particular, make sure the ferrite loop stick antenna is away from signals on the PCB and away from even the I/O signals of the chip. Do not route any signal under or near the ferrite loop stick. Route digital traces in between ground plane for best performance. If that is not possible, route digital traces on the opposite side of the chip. This will minimize capacitive coupling between the plane(s) and the antenna.

To tune correctly, the total capacitance seen at the AMI input needs to be minimized and kept under a certain value. The total acceptable capacitance depends on the inductance seen by the chip at its AM input. The acceptable capacitance at the AM input can be calculated using the formula shown in Equation 3.

$$C_{\text{Total}} = \frac{1}{(2\pi f_{\text{max}})^2 L_{\text{effective}}}$$

Where:

C_{Total} = Total capacitance at the AMI input

$L_{\text{effective}}$ = Effective inductance at the AMI input

f_{max} = Highest frequency in AM band

Equation 3. Expected Total Capacitance at AMI

The total allowable capacitance, when interfacing a ferrite loop stick antenna, is the effective capacitance resulting from the AMI input pin, the capacitance from the PCB, and the capacitance from the ferrite loop stick antenna. The inductance seen at the AMI in this case is primarily the inductance of the ferrite loop stick antenna. The total allowable capacitance in the case of an air loop antenna is the effective capacitance resulting from the AMI input pin, the capacitance of the PCB, the capacitance of the transformer, and the capacitance of the air loop antenna. The inductance in this case should also take all the elements of the circuit into account. The input capacitance of the AMI input is 8 pF. The formula shown in Equation 3 gives a total capacitance of 29 pF when a 300 uH ferrite loop stick antenna is used for an AM band with 10 kHz spacing, where the highest frequency in the band is 1750 kHz.

6.5. Ferrite Loop Antenna Design Checklist

- Place the chip as close as possible to the ferrite loop antenna feedline to minimize parasitic capacitance and the possibility of noise coupling.
- Place the ferrite loop stick antenna away from any sources of interference and even away from the I/O signals of the chip. Make sure that the AM antenna is as far away as possible from circuits that switch at a rate which falls in the AM band (504–1750 kHz).
- Recommend keeping the AM ferrite loop antenna at least 5 cm away from the tuner chip.
- Place optional component D1 if the antenna is exposed.
- Select ESD diode D1 with minimum capacitance.
- Do Not Place any ground plane under the ferrite loop stick antenna if the ferrite loop stick antenna is mounted on the PCB. The recommended ground separation is 1/4 inch or the width of the ferrite.
- Route traces from the ferrite loop stick connectors to the AMI input via the ac coupling cap C1 such that the capacitance from the traces and the pads is minimized.

7. Air Loop Antenna for AM

An air loop antenna is an external AM antenna (because of its large size) typically found on home audio equipment. An air loop antenna is placed external to the product enclosure making it more immune to system noise sources. It also will have a better sensitivity compared to a ferrite loop antenna.

7.1. Air Loop Antenna Design

Figure 20 shows an example of an air loop antenna.



Figure 20. Air Loop Antenna

Unlike a ferrite loop, an air loop antenna will have a smaller equivalent inductance because of the absence of ferrite material. A typical inductance is on the order of 10 to 20 μH . Therefore, in order to interface with the air loop antenna properly, a transformer is required to raise the inductance into the 180 to 450 μH range.

T1 is the transformer to raise the inductance to within 180 to 450 μH range. A simple formula to use is as follows:

Typically a transformer with a turn ratio of 1:5 to 1:7 is good for an air loop antenna of 10 to 20 μH to bring the inductance within the 180 to 450 μH range.

Choose a high-Q transformer with a coupling coefficient as close to 1 as possible and use a multiple strands Litz wire for the transformer winding to reduce the skin effect. All of this will ensure that the transformer will be a low loss transformer.

Finally, consider using a shielded enclosure to house the transformer or using a torroidal shape core to prevent noise pickup from interfering sources.

A few recommended transformers are listed in Table 18.

Table 18. Recommended Transformers

	Transformer 1	Transformer 2	Transformer 3
Vendor	Jiixin Electronics	UMEC	UMEC
Part Number	SL9x5x4MWTF1	TG-UTB01527S	TG-UTB01526
Type	Surface Mount	Surface Mount	Through Hole
Primary Coil Turns (L1)	12T	10T	10T
Secondary Coil Turns (L2)	70T	55T	58T
Wire Gauge	ULSA / 0.07 mm x 3	n/a	n/a
Inductance (L2)	380 μ H \pm 10% @ 796 kHz	184 μ H min, 245 μ H typ @ 100 kHz	179 μ H min, 263 μ H typ @ 100 kHz
Q	130	50	75

The following is the vendor information for the above transformer:

Vendor #1:

Jiixin Electronics

Shenzhen Sales Office

email: sales@firstantenna.com

Web: www.firstantenna.com

Vendor #2:

UMEC USA, Inc.

Website: www.umec-usa.com

www.umec.com.tw

7.2. Air Loop Antenna Schematic

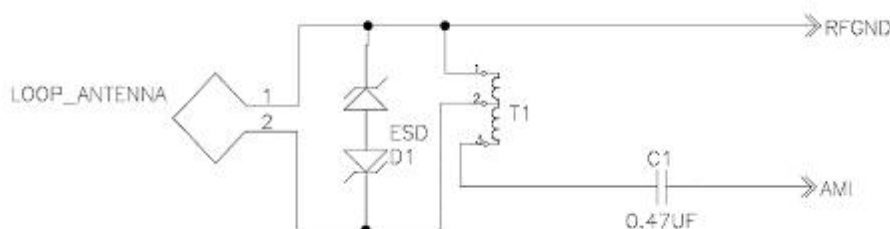


Figure 21. AM Air Loop Antenna Schematic

C1 is the ac coupling cap going to the AMI pin and its value should be 0.47 uF.

D1 is a required ESD diode since the antenna is exposed.

7.3. Air Loop Antenna Bill of Materials

Table 19. Air Loop Antenna Bill of Materials

Designator	Description
LOOP_ANTENNA	Air loop antenna
T1	Transformer, 1:6 turns ratio
C1	AC coupling capacitor, 0.47 μ F, 10%, Z5U/X7R
D1	ESD diode, IC, SM, SOT23-3, California Micro Devices, CM1213-01ST

7.4. Air Loop Antenna Layout

Place the chip and the transformer as close as possible to the air loop antenna feedline. This will minimize the trace going to the air loop antenna, which will minimize parasitic capacitance and the possibility of noise coupling.

When an air loop antenna with a transformer is used with the Si483x-B/Si4820/24, minimize inductive coupling by making sure that the transformer is placed away from all sources of interference. Keep the transformer away from signals on the PCB and away from even the I/O signals of the Si483x-B/Si4820/24. Do not route any signals under or near the transformer. Use a shielded transformer if possible.

7.5. Air Loop Antenna Design Checklist

- Select a shielded transformer or a torroidal shape transformer to prevent noise pickup from interfering sources
- Select a high-Q transformer with coupling coefficient as close to 1 as possible
- Use multiple strands Litz wire for the transformer winding
- Place the transformer away from any sources of interference and even away from the I/O signals of the chip. Make sure that the AM antenna is as far away as possible from circuits that switch at a rate which falls in the AM band (504–1750 kHz).
- Route traces from the transformer to the AMI input via the ac coupling cap C1 such that the capacitance from the traces and the pads is minimized.
- Select ESD diode D1 with minimum capacitance.

8. Whip Antenna for SW Receiver

SW reception usually uses whip antennas, the same as FM.

8.1. SW Whip Antenna Design

A whip antenna is a monopole antenna with a stiff but flexible wire mounted vertically with one end adjacent to the ground plane.

There are various types of whip antennas, including long non-telescopic metal whip antennas, telescopic metal whip antennas, and rubber whip antennas. Figure 22 shows the telescopic whip antenna.



Figure 22. Telescopic Whip Antenna for SW

8.2. SW Whip Antenna Schematic

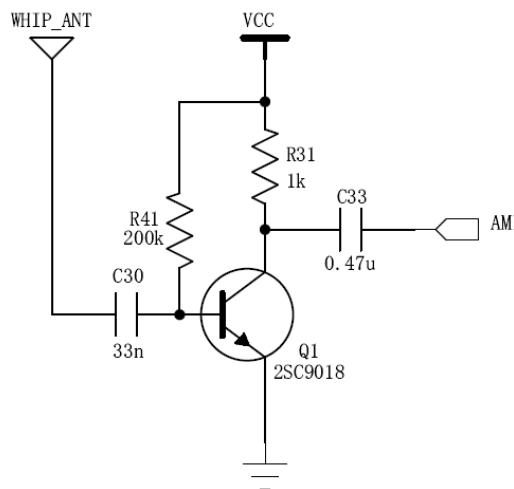


Figure 23. SW Whip Antenna Schematic

Q1 2SC9018 is a low noise RF transistor and it constitutes a LNA to amplify the SW signal coming from the whip antenna.

C30 (33nF) is the ac coupling cap between whip antenna and LNA input.

C33 (0.47uF) is the ac coupling cap going to the AMI pin.

R31, R41 are bias resistors of the transistor.

8.3. SW Whip Antenna Bill of Materials

Table 20. SW Whip Antenna Bill of Materials

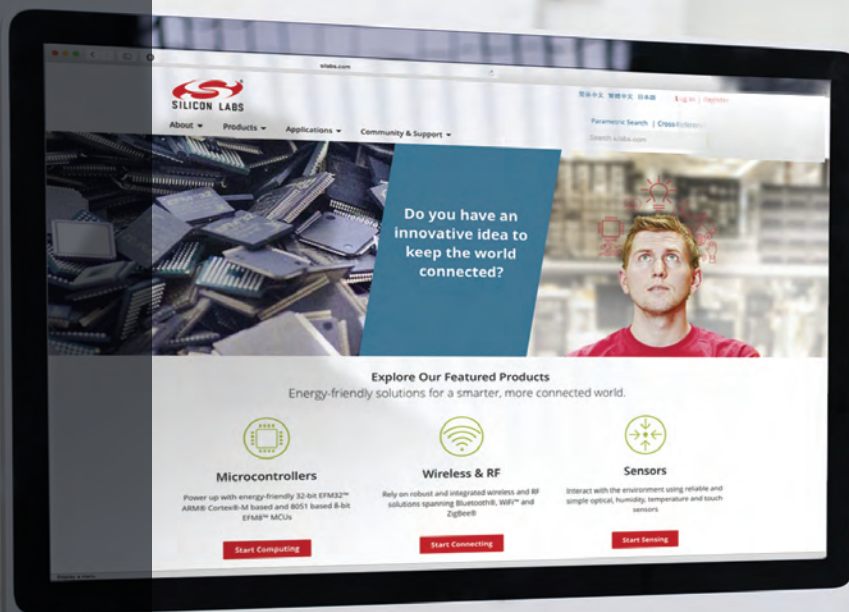
Designator	Description
WHIP_ANTENNA	Whip Antenna
Q1	Low noise RF transistor, 2SC9018
C30	AC coupling capacitor, 33 nF, 10%, COG
C33	Coupling capacitor, 0.47 μ F, \pm 20%, Z5U/X7R
R31	Resistor, 1 k, \pm 5%
R41	Resistor, 200 k, \pm 5%

8.4. SW Whip Antenna Layout

Place the chip and 2SC9018 as close as possible to the whip antenna feedline. This will minimize the trace going to the whip antenna, which will minimize parasitic capacitance as well as the possibility of noise sources coupling to the trace.

8.5. SW Whip Antenna Design Checklist

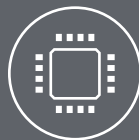
- Maximize whip antenna length for optimal performance.
- Place Q1 and whip antenna close together and as far from potential noise sources as possible to reduce capacitive and inductive coupling.
- Place the chip as close as possible to the whip antenna to minimize the antenna trace length. This reduces parasitic capacitance and hence reduces coupling into the antenna by noise sources. This recommendation must be followed for optimal device performance.
- Place the ac coupling capacitor C33, as close to the AMI pin as possible.



Smart.
Connected.
Energy-Friendly



Products
www.silabs.com/products



Quality
www.silabs.com/quality



Support and Community
community.silabs.com

Disclaimer

Silicon Laboratories intends to provide customers with the latest, accurate, and in-depth documentation of all peripherals and modules available for system and software implementers using or intending to use the Silicon Laboratories products. Characterization data, available modules and peripherals, memory sizes and memory addresses refer to each specific device, and "Typical" parameters provided can and do vary in different applications. Application examples described herein are for illustrative purposes only. Silicon Laboratories reserves the right to make changes without further notice and limitation to product information, specifications, and descriptions herein, and does not give warranties as to the accuracy or completeness of the included information. Silicon Laboratories shall have no liability for the consequences of use of the information supplied herein. This document does not imply or express copyright licenses granted hereunder to design or fabricate any integrated circuits. The products must not be used within any Life Support System without the specific written consent of Silicon Laboratories. A "Life Support System" is any product or system intended to support or sustain life and/or health, which, if it fails, can be reasonably expected to result in significant personal injury or death. Silicon Laboratories products are generally not intended for military applications. Silicon Laboratories products shall under no circumstances be used in weapons of mass destruction including (but not limited to) nuclear, biological or chemical weapons, or missiles capable of delivering such weapons.

Trademark Information

Silicon Laboratories Inc., Silicon Laboratories, Silicon Labs, SiLabs and the Silicon Labs logo, CMEMS®, EFM, EFM32, EFR, Energy Micro, Energy Micro logo and combinations thereof, "the world's most energy friendly microcontrollers", Ember®, EZLink®, EZMac®, EZRadio®, EZRadioPRO®, DSPLL®, ISOmodem®, Precision32®, ProSLIC®, SiPHY®, USBXpress® and others are trademarks or registered trademarks of Silicon Laboratories Inc. ARM, CORTEX, Cortex-M3 and THUMB are trademarks or registered trademarks of ARM Holdings. Keil is a registered trademark of ARM Limited. All other products or brand names mentioned herein are trademarks of their respective holders.



Silicon Laboratories Inc.
400 West Cesar Chavez
Austin, TX 78701
USA

<http://www.silabs.com>