

Si4825/36-A ANTENNA, SCHEMATIC, LAYOUT, AND DESIGN GUIDELINES

1. Introduction

This document provides general Si4825/36-A design and AM/FM/SW antenna selection guidelines, including schematic, BOM and PCB layout. All users should follow the Si4825/36-A design guidelines presented in Section 2 and Section 3, and choose the appropriate antennas based on the applications and device used according to Section 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
Si4825	Entry Level Wheel-tuned AM/FM/SW Receiver, Mono Audio	†	†	†	†	†	†	†	†
Si4836	Wheel-tuned AM/FM/SW Receiver, Stereo Audio	†	†	†	†	†	†	†	†

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2. Frequency Band Definition and Selection

Eighteen FM bands, five AM bands, and eighteen SW bands are defined for Si4825/36-A. In FM band, the parts also offer two de-emphasis selections and two stereo LED indication threshold selections. In SW band, the part offers 18 wide bands or 18 narrow bands. This section shows the detailed band definition and selection information.

2.1. Band Definition

For the Si4825/36-A, the FM band definition is a combination of frequency range, de-emphasis and stereo LED indication threshold (Si4836-A only). Customers should choose the band according to the frequency range, as well as de-emphasis setting and stereo LED indication requirements. For AM and SW, simply choose the band according to the frequency range desired.

Table 2. Band Sequence Definition for Si4836-A

Band Number	Band Name	Band Frequency Range	De-emphasis (FM) Channel Space (AM)	Stereo LED on Conditions	Total R to GND (k Ω , 1%)
Band1	FM1	87–108 MHz	50 μ s	Separation = 6 dB, RSSI = 20	47
Band2	FM2	87–108 MHz	50 μ s	Separation = 12 dB, RSSI = 28	57
Band3	FM3	87–108 MHz	75 μ s	Separation = 6 dB, RSSI = 20	67
Band4	FM4	87–108 MHz	75 μ s	Separation = 12 dB, RSSI = 28	77
Band5	FM5	86.5–109 MHz	50 μ s	Separation = 6 dB, RSSI = 20	87
Band6	FM6	86.5–109 MHz	50 μ s	Separation = 12 dB, RSSI = 28	97
Band7	FM7	87.3–108.25 MHz	50 μ s	Separation = 6 dB, RSSI = 20	107
Band8	FM8	87.3–108.25 MHz	50 μ s	Separation = 12 dB, RSSI = 28	117
Band9	FM9	87.3–108.25 MHz	75 μ s	Separation = 6 dB, RSSI = 20	127
Band10	FM10	87.3–108.25 MHz	75 μ s	Separation = 12 dB, RSSI = 28	137
Band11	FM11	76–90 MHz	50 μ s	Separation = 6 dB, RSSI = 20	147
Band12	FM12	76–90 MHz	50 μ s	Separation = 12 dB, RSSI = 28	157
Band13	FM13	64–87 MHz	50 μ s	Separation = 6 dB, RSSI = 20	167
Band14	FM14	64–87 MHz	50 μ s	Separation = 12 dB, RSSI = 28	177
Band15	FM15	76–108 MHz	50 μ s	Separation = 6 dB, RSSI = 20	187
Band16	FM16	76–108 MHz	50 μ s	Separation = 12 dB, RSSI = 28	197

Table 2. Band Sequence Definition for Si4836-A (Continued)

Band Number	Band Name	Band Frequency Range		De-emphasis (FM) Channel Space (AM)	Stereo LED on Conditions	Total R to GND (k Ω , 1%)
Band17	FM17	64–108 MHz		50 μ s	Separation = 6 dB, RSSI = 20	207
Band18	FM18	64–108 MHz		50 μ s	Separation = 12 dB, RSSI = 28	217
Band19	AM1	520–1710 kHz		10 k		227
Band20	AM2	522–1620 kHz		9 k		237
Band21	AM3	504–1665 kHz		9 k		247
Band22	AM4	522–1728 kHz / 520–1730 kHz		9 k / 10 k		257
Band23	AM5	510–1750 kHz		10 k		267
Band24	SW1	SW Wide Band	SW Narrow Band			277
		2.3–10.0 MHz	2.30–2.49 MHz			
Band25	SW2	3.2–7.6 MHz	3.20–3.40 MHz			287
Band26	SW3	3.2–10.0 MHz	3.90–4.00 MHz			297
Band27	SW4	3.7–12.5 MHz	4.75–5.06 MHz			307
Band28	SW5	3.9–7.5 MHz	5.6–6.4 MHz			317
Band29	SW6	5.6–22 MHz	5.95–6.2 MHz			327
Band30	SW7	5.8–12.1 MHz	6.8–7.6 MHz			337
Band31	SW8	5.9–9.50 MHz	7.1–7.6 MHz			347
Band32	SW9	5.9–18.0 MHz	9.2–10 MHz			357
Band33	SW10	7.0–16.0 MHz	11.45– 12.25 MHz			367
Band34	SW11	7.0– 23.0 MHz	11.6–12.2 MHz			377
Band35	SW12	9.0–16.0 MHz	13.4–14.2 MHz			387
Band36	SW13	9.0–22.0 MHz	13.57– 13.87 MHz			397
Band37	SW14	9.5–18.0 MHz	15–15.9 MHz			407
Band38	SW15	10.0–16.0 MHz	17.1–18 MHz			417
Band39	SW16	10.0–22.0 MHz	17.48–17.9 MHz			427
Band40	SW17	13.0–18.0 MHz	21.2–22 MHz			437
Band41	SW18	18.0–28.5 MHz	21.45– 21.85 MHz			447

Table 3. Band Sequence Definition for Si4825-A

Band Number	Band Name	Band Frequency Range	De-emphasis (FM) Channel Space (AM)	Total R to GND (k Ω , 1%)
Band1	FM1	87–108 MHz	50 μ s	57
Band2	FM2			
Band3	FM3	87–108 MHz	75 μ s	77
Band4	FM4			
Band5	FM5	86.5–109 MHz	50 μ s	97
Band6	FM6			
Band7	FM7	87.3–108.25 MHz	50 μ s	117
Band8	FM8			
Band9	FM9	87.3–108.25 MHz	75 μ s	137
Band10	FM10			
Band11	FM11	76–90 MHz	50 μ s	157
Band12	FM12			
Band13	FM13	64–87 MHz	50 μ s	177
Band14	FM14			
Band15	FM15	76–108 MHz	50 μ s	197
Band16	FM16			
Band17	FM17	64–108 MHz	50 μ s	217
Band18	FM18			
Band19	AM1	520–1710 kHz	10 K	227
Band20	AM2	522–1620 kHz	9 K	237
Band21	AM3	504–1665 kHz	9 K	247
Band22	AM4	522–1728 kHz / 520–1730 kHz	9 K/10 K	257

Table 3. Band Sequence Definition for Si4825-A (Continued)

Band Number	Band Name	Band Frequency Range		De-emphasis (FM) Channel Space (AM)	Total R to GND (k Ω , 1%)
Band23	AM5	510–1750 kHz		10 K	267
Band24	SW1	SW Wide Band	SW Narrow Band		277
		2.3–10.0 MHz	2.30–2.49 MHz		
Band25	SW2	3.2–7.6 MHz	3.20–3.40 MHz		287
Band26	SW3	3.2–10.0 MHz	3.90–4.00 MHz		297
Band27	SW4	3.7–12.5 MHz	4.75–5.06 MHz		307
Band28	SW5	3.9–7.5 MHz	5.6–6.4 MHz		317
Band29	SW6	5.6–22 MHz	5.95–6.2 MHz		327
Band30	SW7	5.8–12.1 MHz	6.8–7.6 MHz		337
Band31	SW8	5.9–9.50 MHz	7.1–7.6 MHz		347
Band32	SW9	5.9–18.0 MHz	9.2–10 MHz		357
Band33	SW10	7.0–16.0 MHz	11.45–12.25 MHz		367
Band34	SW11	7.0–23.0 MHz	11.6–12.2 MHz		377
Band35	SW12	9.0–16.0 MHz	13.4–14.2 MHz		387
Band36	SW13	9.0–22.0 MHz	13.57–13.87 MHz		397
Band37	SW14	9.5–18.0 MHz	15–15.9 MHz		407
Band38	SW15	10.0–16.0 MHz	17.1–18 MHz		417
Band39	SW16	10.0–22.0 MHz	17.48–17.9 MHz		427
Band40	SW17	13.0–18.0 MHz	21.2–22 MHz		437
Band41	SW18	18.0–28.5 MHz	21.45–21.85 MHz		447

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2.2. Band Selection

Refer to Figure 1 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

Table 4 and Figure 1 illustrate the band and resistor value details for a typical 12-band application for Si4836-A.

Table 4. Typical 12-Band Selection

Band Number	Band Name	Band Frequency Range		De-emphasis (FM) Channel Space (AM)	Stereo LED on Conditions (Only for Si4836-A)	Total R to GND (K Ω , 1%)
Band3	FM3	87–108 MHz		75 μ s	Separation = 6 dB, RSSI = 20	67
Band17	FM17	64–108 MHz		50 μ s	Separation = 6 dB, RSSI = 20	207
Band19	AM1	520–1710 kHz		10 k		227
Band20	AM2	522–1620 kHz		9 k		237
Band25	SW2	SW Wide Band	SW Narrow Band			287
		3.2–7.6 MHz	3.20–3.40 MHz			
Band26	SW3	3.2–10.0 MHz	3.90–4.00 MHz			297
Band32	SW9	5.9–18.0 MHz	9.2–10 MHz			357
Band33	SW10	7.0–16.0 MHz	11.45–12.25 MHz			367
Band34	SW11	7.0–23.0 MHz	11.6–12.2 MHz			377
Band36	SW13	9.0–22.0 MHz	13.57–13.87 MHz			397
Band37	SW14	9.5–18.0 MHz	15–15.9 MHz			407
Band39	SW16	10.0– 22.0 MHz	17.48–17.9 MHz			427

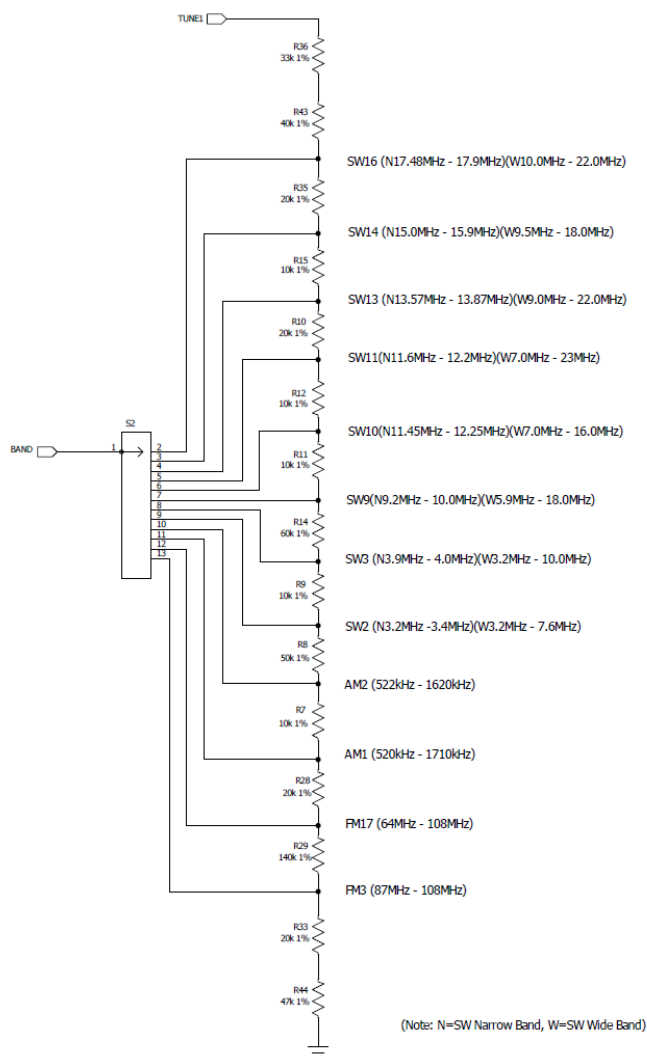


Figure 1. Typical 12-Band Selection Circuit

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2.2.2. Typical 2-band Application for Europe

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

Table 5. Typical European 2-Band Selection

Band Number	Band Name	Band Frequency Range	De-emphasis (FM) Channel Space (AM)	Stereo LED on Conditions (Only for Si4836-A)	Total R to GND (k Ω , 1%)
Band2	FM2	87–108 MHz	50 μ s	Separation = 12 dB, RSSI = 28	57
Band20	AM2	522–1620 kHz	9 k		237

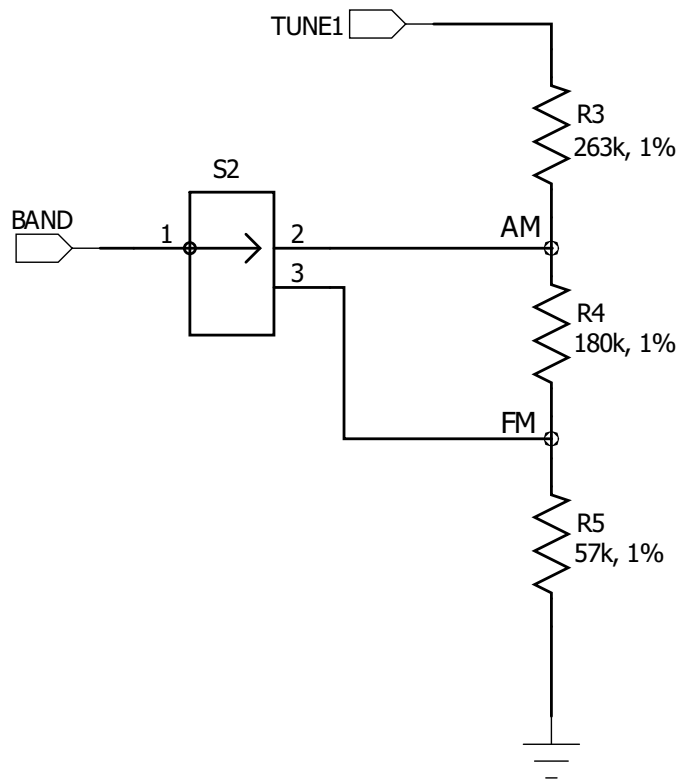


Figure 2. Typical 2-Band Selection Circuit for Europe

2.2.3. Typical 2-band Application for US

Table 6 and Figure 3 show the band and resistor value details for a typical 2-band application for the U.S.

Table 6. Typical U.S. 2-Band Selection

Band Number	Band Name	Band Frequency Range	De-emphasis	Stereo LED on Threshold (Only for Si483x-A)	Total R to GND (k Ω , 1%)
Band4	FM4	87–108 MHz	75 μ s	Separation = 12 dB, RSSI = 28	77
Band19	AM1	520–1710 kHz	10 k		227

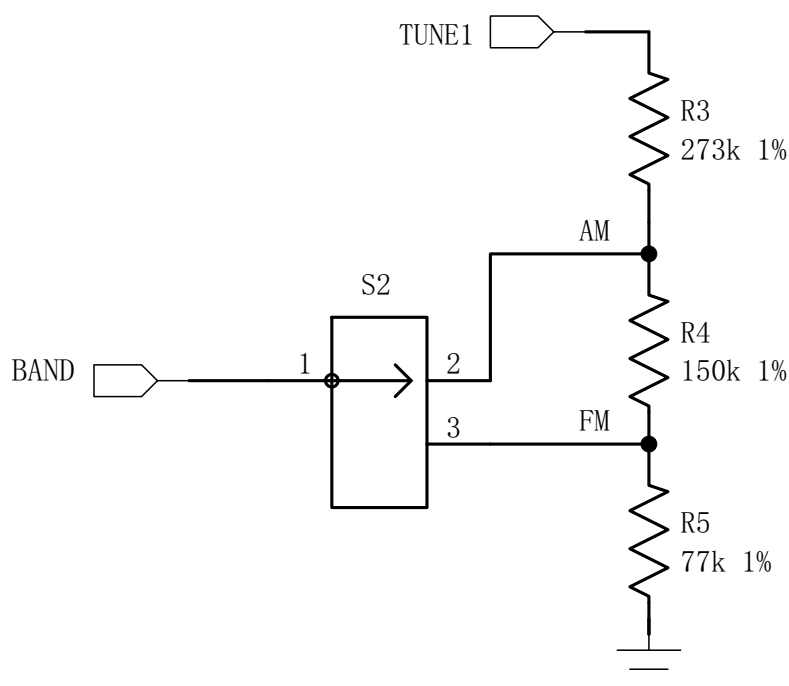


Figure 3. Typical 2-Band Selection Circuit for US

3. Si4825/36-A SOIC Schematic and Layout

This section shows the typical schematic and layout required for optimal Si4825/36-A performance.

The Si4825/36-A offers eighteen wide SW bands or eighteen narrow SW bands. The wide/narrow SW bands are selected via an external pin pull up/down resistor, as illustrated in Figure 4. The Si4825-A configures the Pin 1 as the wide/narrow SW band selection pin. As the chip integrates about 50 kΩ internal pull down resistor for Pin 1, the external pull down resistor is omitted. The Si4836-A configures Pin 11 as the wide/narrow SW band selection pin.

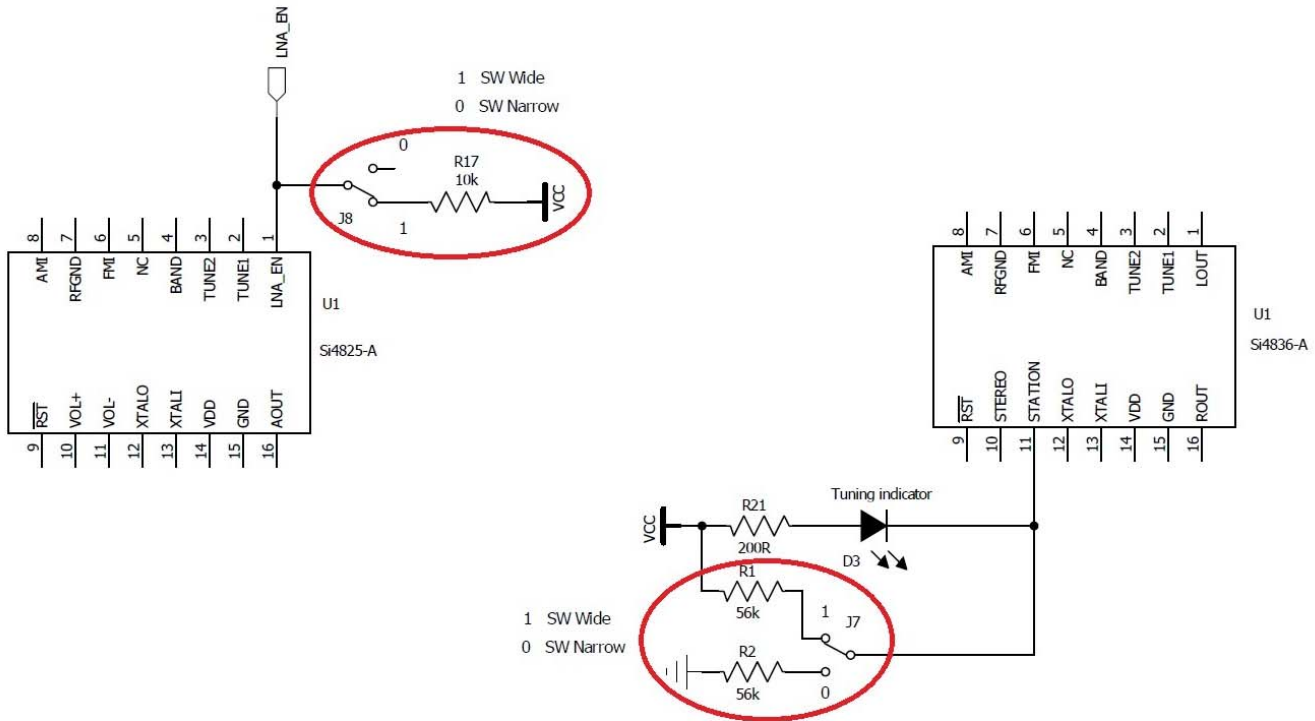


Figure 4. Si4825/36-A SW Wide/Narrow Band Selection

3.1. Si4825/36-A Basic Applications Circuits

Figure 5 and Figure 6 are the Si4825/36-A basic application circuits for typical 12-band FM/AM/SW radios.

C16 and C15 are required bypass capacitors for VDD power supply Pin 14. Place C16 and C15 as close as possible to the VDD Pin 14. This placement will reduce the size of the current loop created by the bypass cap and routing, minimize bypass cap impedance, and return all currents to GND.

Pin 15 is the GND of the chip; it must be well connected to the power supply GND on PCB.

Pin 7 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 (4.7 μF) are ac coupling caps for receiver analog audio output from Pin 1 and/or Pin 16. 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.

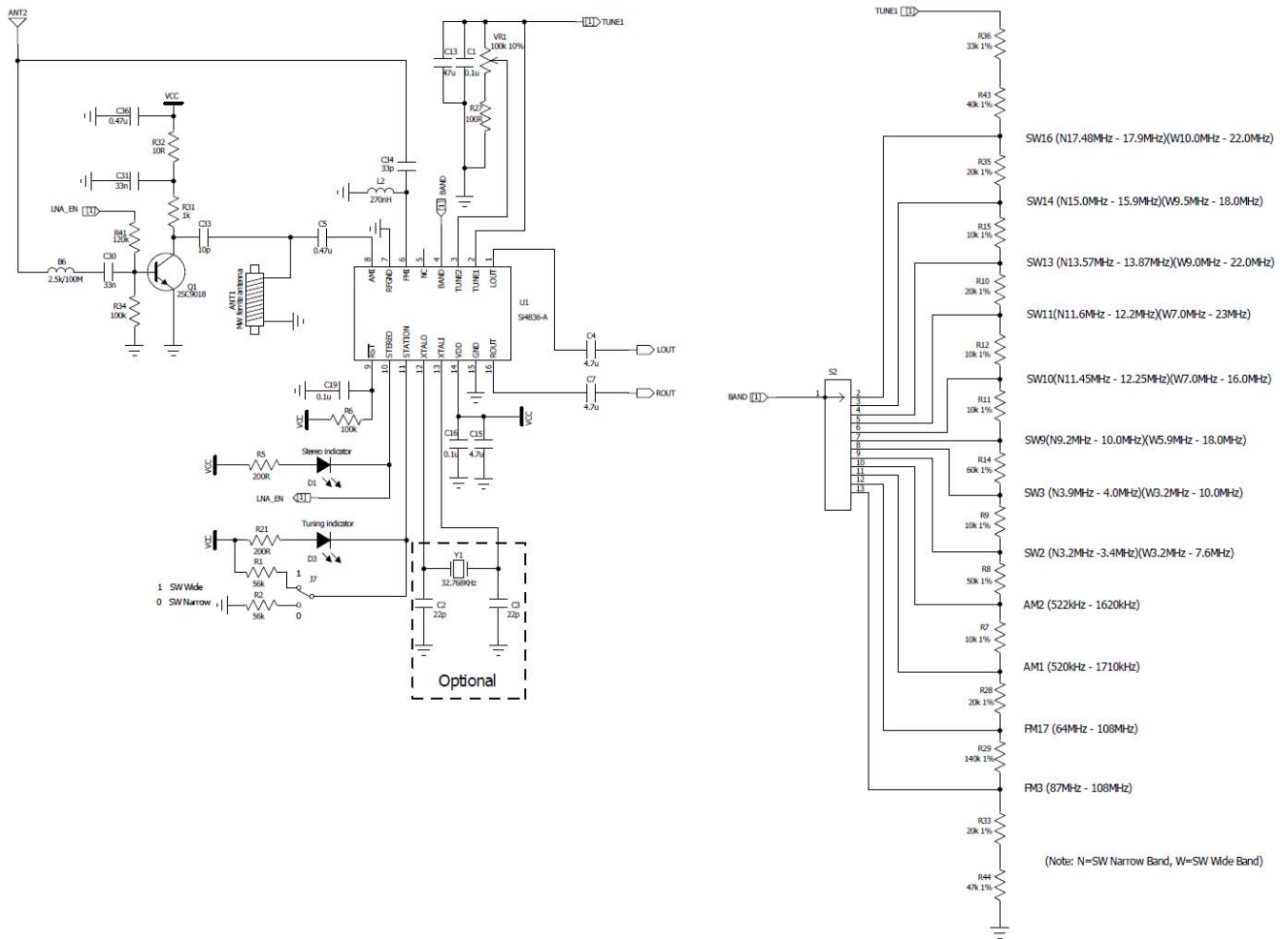


Figure 6. Si4836-A Basic Applications Circuit

3.2. Si4825-A Applications Circuit with Internal Volume Adjustment via 2 Push Buttons

The Si4825-A supports internal volume adjustment via two push buttons. Figure 7 is the Si4825-A applications circuit with internal volume adjustment. 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, the tuner volume will step through all levels until reaching the minimum or maximum, respectively.

The chip Si4836-A works without internal volume adjustment. Volume control can be performed at the audio amplifier circuit stage.

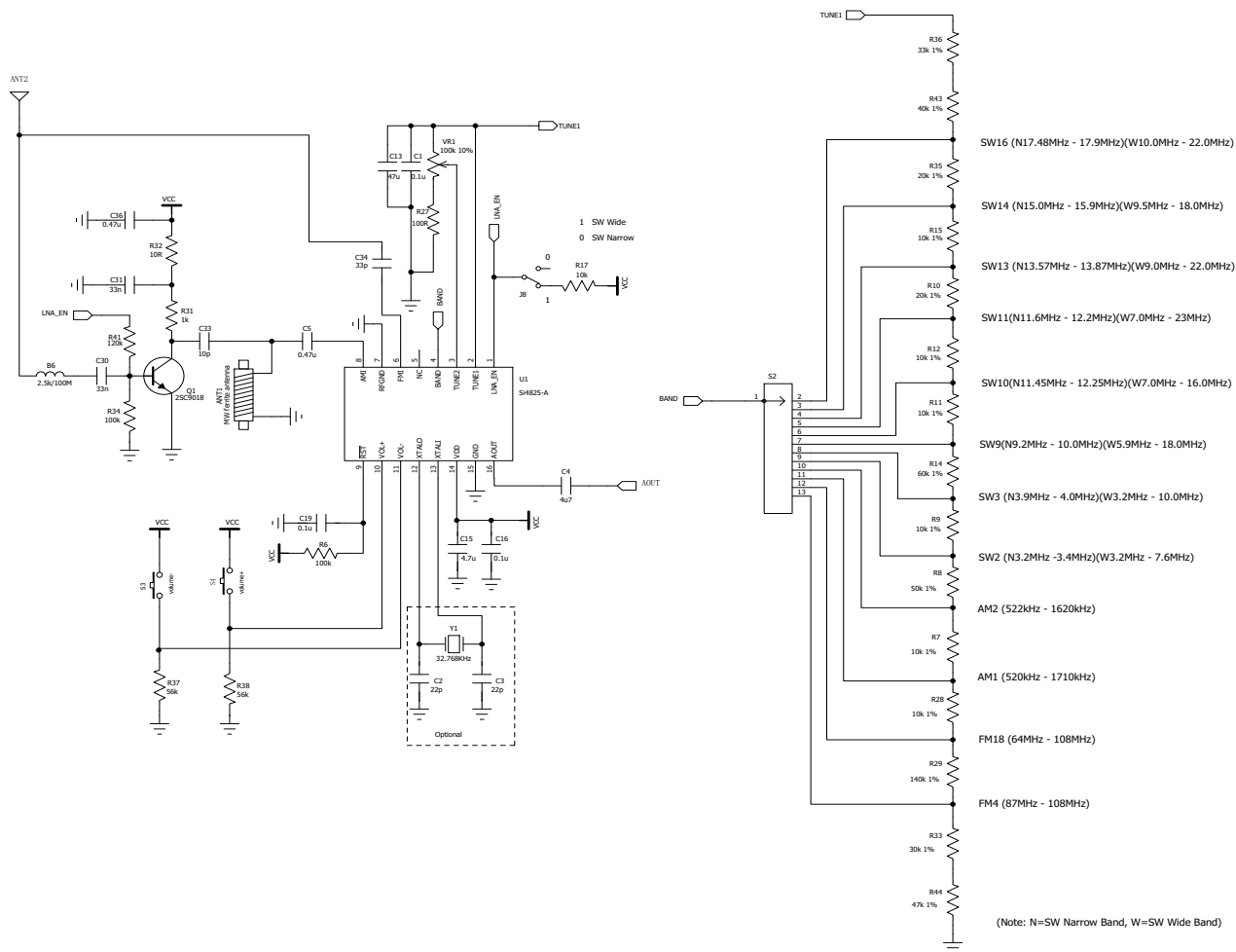


Figure 7. Si4825-A Applications Circuit with Internal Volume Adjustment

At the device powerup, Si4825-A will put the output volume at some default levels according to the push button configurations as shown in Figure 8. The Si4825-A has four default volume level choices. Adding pull-down resistors to both Pin 10 and 11 sets the default volume to maximum, typically 80 mVrms for FM and 60 mVrms for AM. Different Pin 10 and 11 pull-up/down resistor combinations can set the default volume to either Max, Max-6 dB, Max-12 dB or Max-18 dB. For example in Figure 5, two pull-down resistors are connected to Pin 10 and Pin 11, which sets the default volume to Max.

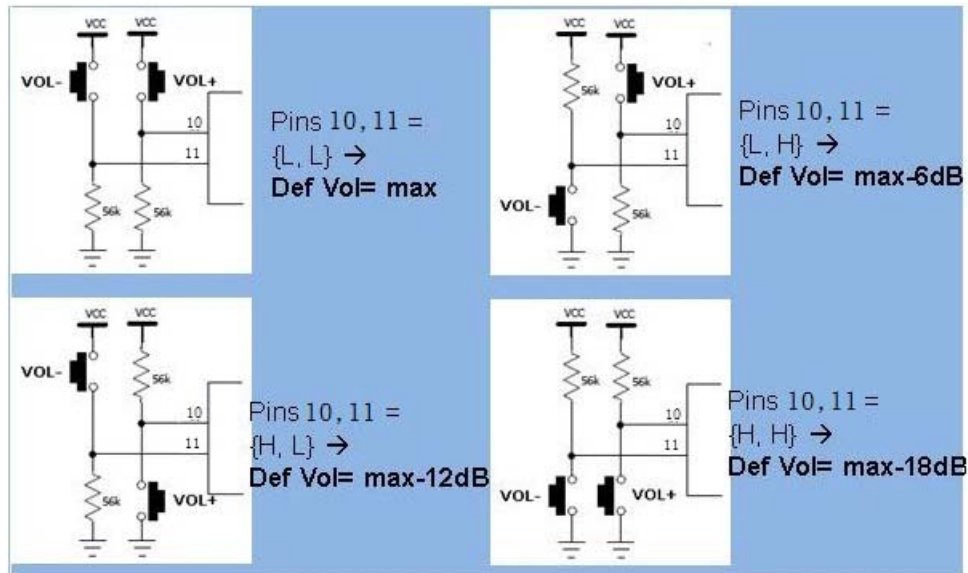


Figure 8. Si4825-A Default Volume Selection

3.3. Si4836-A Applications Circuit with Bass/Treble Control via 1 Push Button

The Si4836-A further supports bass and treble tone control for superior sound quality. When the tuner uses the external reference clock RCLK, Pin 12 can be configured for tone control with the push button for cyclic switching of three tone levels (bass/normal/treble). If the user does not want to use the bass/treble tone control, Pin 12 must be connected to a 56k external pull down resistor. When the tuner uses the crystal, the user cannot use the bass/treble control.

Figure 8 is the Si4836-A applications circuit with bass/treble tone control. Push button S3 controls the bass/treble effect.

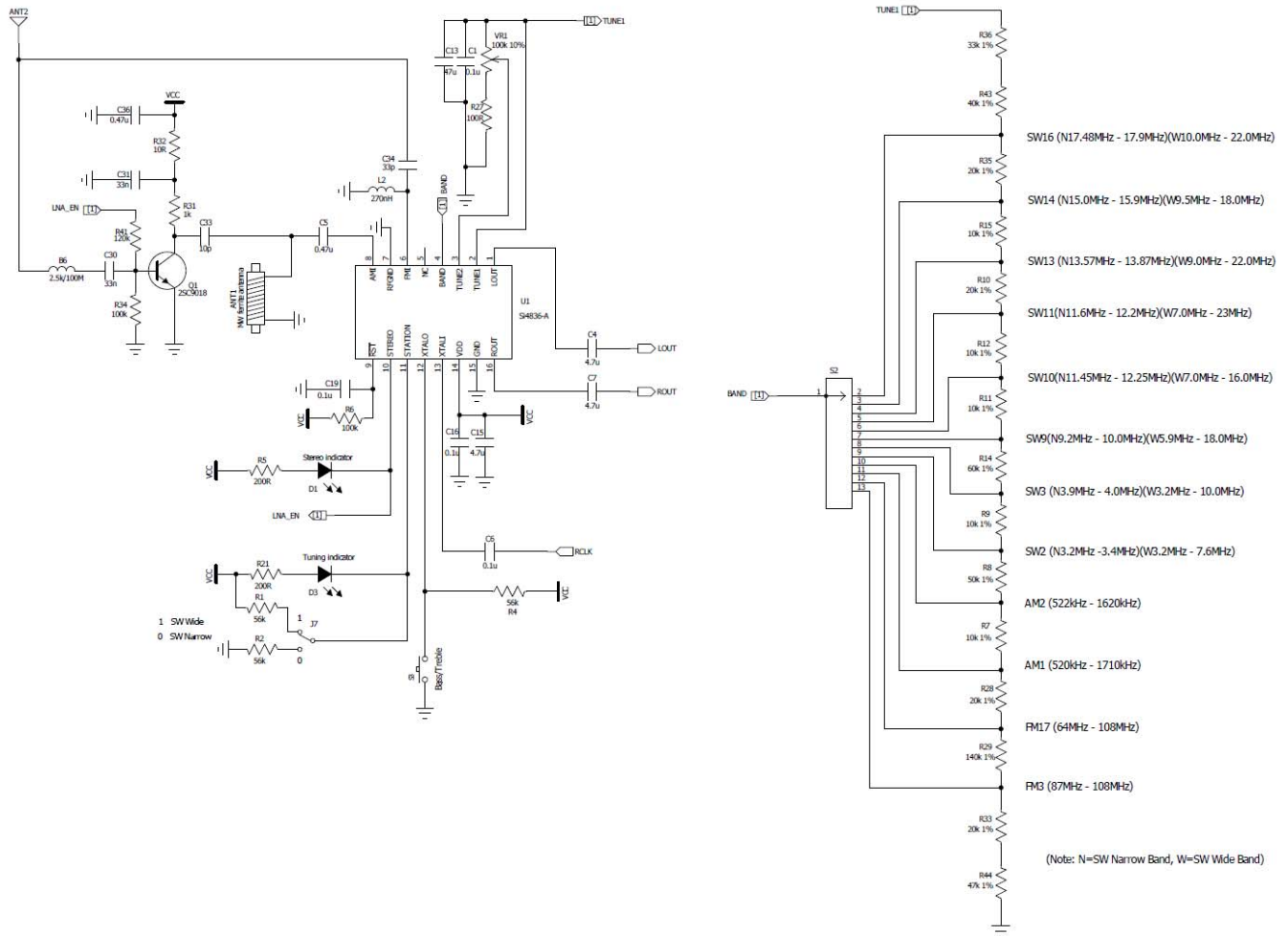


Figure 9. Si4836-A Applications Circuit with Bass/Treble Control

3.4. Application Circuits for Memorizing User Settings

The Si4825/36-A has high retention memory (HRM) built-in that can memorize the last volume/bass/treble settings so that at the next power up, the unit will automatically restore the volume and bass/treble settings to those before the last power off. If user does not use the HRM, the tuner will restore the default volume/bass/treble setting at each power up.

To memorize the user settings, Pin 14 VDD needs to be connected to an always-on power source. Force Pin 9 RSTB voltage to below $0.3 \cdot VDD$ to power off Si4825/36.

In Figure 10, the Pin 14 VDD is connected to battery VBAT. A 2P2T power on/off switch S3 is recommended one pole of S3 short Pin 9 RSTB to GND to power off the tuner.

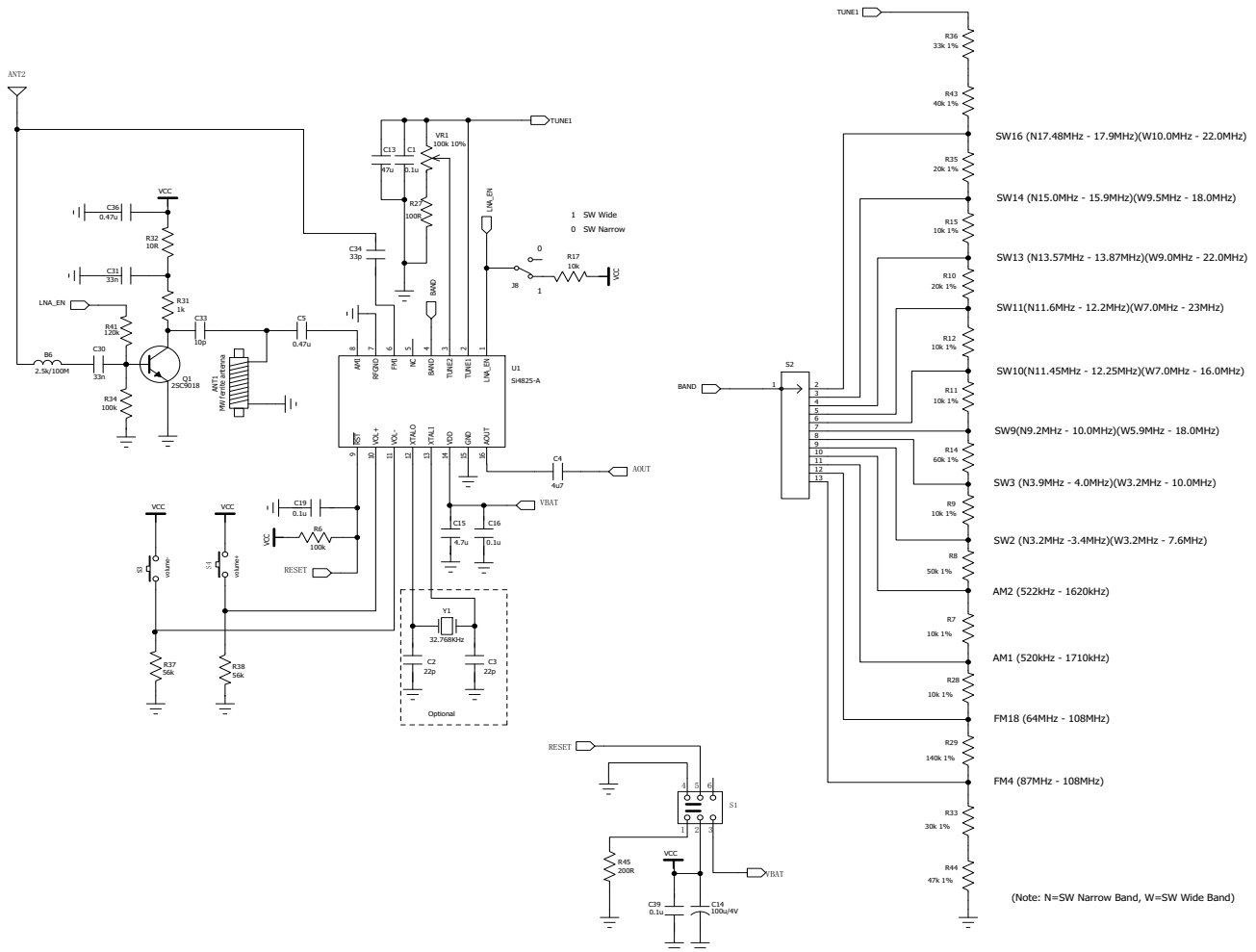


Figure 10. Si4825-A Applications Circuit with User Setting Memory

3.5. Si4825/36-A Bill of Materials

3.5.1. Si4825-A Basic Applications Circuit BOM

Table 7. Si4825-A Basic Applications Circuit BOM

Component(s)	Value/Description	Supplier
C4,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
C5,C36	Supply bypass capacitor, 0.47 μ F, \pm 20%, Z5U/X7R	Murata
C34	RF coupling capacitors, 33 pF, \pm 5%, COG	Murata
C33	Capacitor capacitors, 10 pF, \pm 5%, COG	Murata
C30,C31	Capacitor capacitors, 33 nF, \pm 5%, COG	Murata
VR1	Variable resistor (POT), 100 k Ω , \pm 10%	Changtaier
U1	Si4825-A AM/FM/SW Analog Tune Analog Display Radio Tuner	Silicon Laboratories
R32	Resistor, 10 Ω , \pm 5%	
R27	Resistor, 100 Ω , \pm 5%	Venkel
R31	Resistor, 1 k Ω , \pm 5%	Venkel
R17	Resistor, 10 k Ω , \pm 5%	Venkel
R6,R34	Resistor, 100 k Ω , \pm 5%	Venkel
R41	Resistor, 120 k Ω , \pm 5%	Venkel
R7,R9,R11,R12,R15, R28	Band switching resistor, 10 k Ω , \pm 1%	Venkel
R43	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
R29	Band switching resistor, 140 k Ω , \pm 1%	Venkel
R10,R35	Band switching resistor, 20 k Ω , \pm 1%	Venkel
R8	Band switching resistor, 50 k Ω , \pm 1%	Venkel

Table 7. Si4825-A Basic Applications Circuit BOM (Continued)

Component(s)	Value/Description	Supplier
R14	Band switching resistor, 60 k Ω , \pm 1%	Venkel
R33	Band switching resistor, 30 k Ω , \pm 1%	Venkel
S2	Band switch	Shengda
J8	Slider switch	Shengda
B6	Ferrite bead, 2.5K/100 MHz	Murata
Q1	RF transistor, 2SC9018	ETC
ANT2	Whip antenna	Various
ANT1	MW ferrite antenna 220 μ H	Jiaxin Electronics
Optional		
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

3.5.2. Additional BOM for Si4825-A Applications Circuit with Internal Volume Adjustment

Table 8. Additional BOM for Si4825-A Applications Circuit with Internal Volume Adjustment

Component(s)	Value/Description	Supplier
R37, R38	Resistor, 56 k Ω , \pm 5%	Venkel
S3, S4	Push button	Various

3.5.3. Additional BOM for Si4825-A Applications Circuit with User Setting Memory

Table 9. Additional BOM for Si4825-A Applications Circuit with User Setting Memory

Component(s)	Value/Description	Supplier
R37, R38	Resistor, 56 k Ω , \pm 5%	Venkel
S3, S4	Push button	Various
S1	2P2T slide switch	Shengda
R45	Resistor, 200 Ω , \pm 5%	Venkel
C14	Supply bypass electrolytic capacitor, 100 μ F, 4V	Various
C39	Supply bypass capacitor, 0.1 μ F, \pm 20%, Z5U/X7R	Murata

3.5.4. Si4836-A Basic Applications Circuit BOM

Table 10. Si4836-A Basic 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,C16,C19	Supply bypass capacitor, 0.1 μ F, \pm 20%, Z5U/X7R	Murata
C5,C36	Supply bypass capacitor, 0.47 μ F, \pm 20%, Z5U/X7R	Murata
C34	RF coupling capacitors, 33 pF, \pm 5%, COG	Murata
C33	Capacitor capacitors, 10 pF, \pm 5%, COG	Murata
C30,C31	Capacitor capacitors, 33 nF, \pm 5%, COG	Murata
VR1	Variable resistor (POT), 100 k Ω , \pm 10%	Changtaier
U1	Si4836-A AM/FM/SW Analog Tune Analog Display Radio Tuner	Silicon Laboratories
R32	Resistor, 10 Ω , \pm 5%	Venkel
R27	Resistor, 100 Ω , \pm 5%	Venkel
R31	Resistor, 1 k Ω , \pm 5%	Venkel
R6,R34	Resistor, 100 k Ω , \pm 5%	Venkel
R41	Resistor, 120 k Ω , \pm 5%	Venkel
R5,R21	Resistor, 200 Ω , \pm 5%	Venkel
R1,R2	Resistor, 56 k Ω , \pm 5%	Venkel
R7,R9,R11,R12,R15	Band switching resistor, 10 k Ω , \pm 1%	Venkel
R43	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
R29	Band switching resistor, 140 k Ω , \pm 1%	Venkel
R10,R28,R33,R35	Band switching resistor, 20 k Ω , \pm 1%	Venkel
R8	Band switching resistor, 50 k Ω , \pm 1%	Venkel
R14	Band switching resistor, 60 k Ω , \pm 1%	Venkel
S2	Band switch	Shengda
J7	Slide switch	Shengda
L2	Inductor 270 nH	Murata
B6	Ferrite bead, 2.5 k/100 MHz	Murata

Table 10. Si4836-A Basic Applications Circuit BOM (Continued)

Component(s)	Value/Description	Supplier
Q1	RF transistor, 2SC9018	ETC
D1,D3	Station and Stereo indicating LEDs	Various
ANT2	Whip antenna	Various
ANT1	MW ferrite antenna 220 μ H	Jiaxin Electronics
Optional		
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 or equivalent

3.5.5. Additional BOM For Si4836-A Applications Circuit With Bass/Treble Control

Table 11. Additional BOM for Si4836-A Applications Circuit with Bass/Treble Control

Component(s)	Value/Description	Supplier
R4	Resistor, 56 k Ω , \pm 5%	Venkel
C6	Capacitor, 0.1 μ F, \pm 20%, Z5U/X7R	Murata
S3	Push button	Various

3.6. Si4825/36-A PCB Layout Guidelines

- 1-layer PCB is used for Si4825/36-A
- 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

Place VDD bypass capacitor C16, C15 as close as possible to the power supply pin (Pin 14).

Place the crystal as close to XTALO (Pin 12) and XTALI (Pin 13) 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 5. This pin must be left floating to guarantee proper operation.

Keep the Tune1 and Tune2 traces away from Pin 5, route Tune1 and Tune2 traces in parallel and the same way.

Place C1, C13 as close to Pin 2 TUNE1 as possible.

Refer to the Si4836-A Layout example as much as possible when doing Si4825/36-A PCB layout.

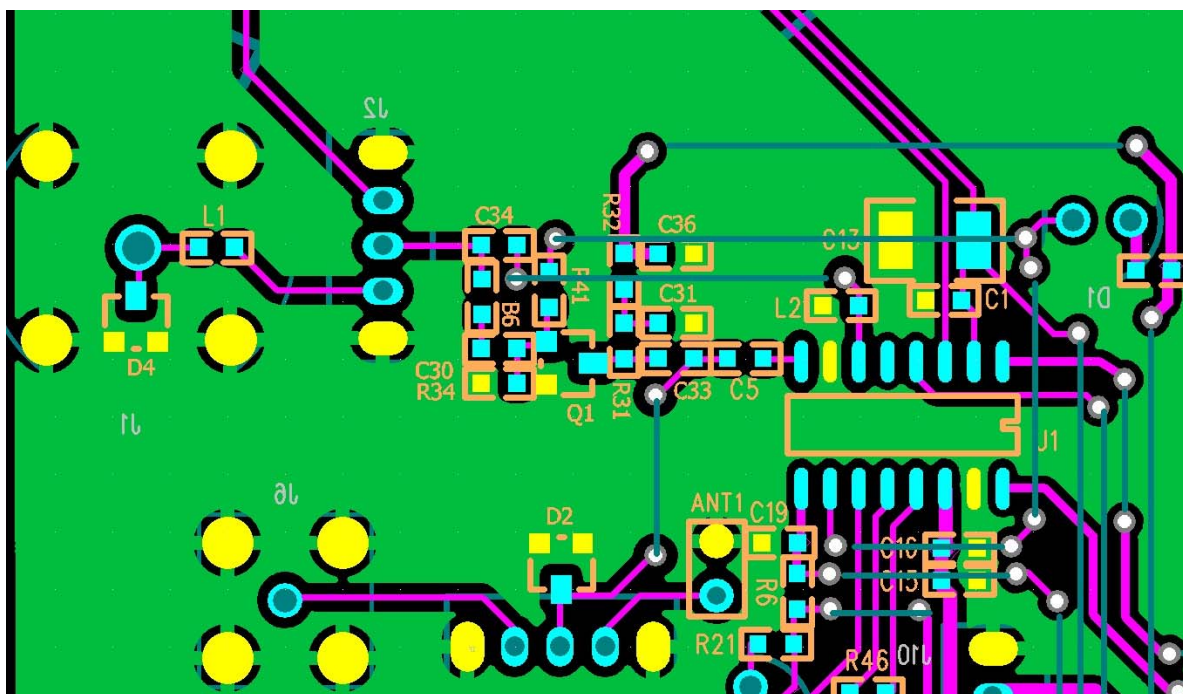


Figure 11. Si4836-A PCB Layout Example

4. Headphone Antenna for FM Receive

The Si4825/36-A 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 at least three 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 12.

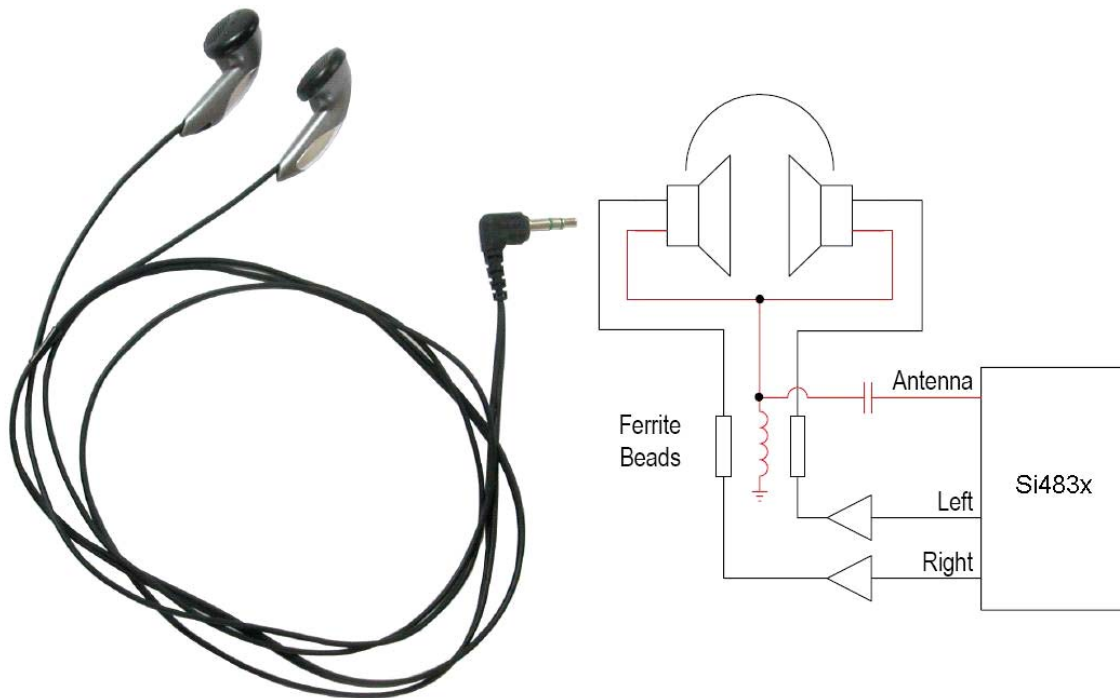


Figure 12. Typical Headphone Antenna Application

4.2. Headphone Antenna Schematic

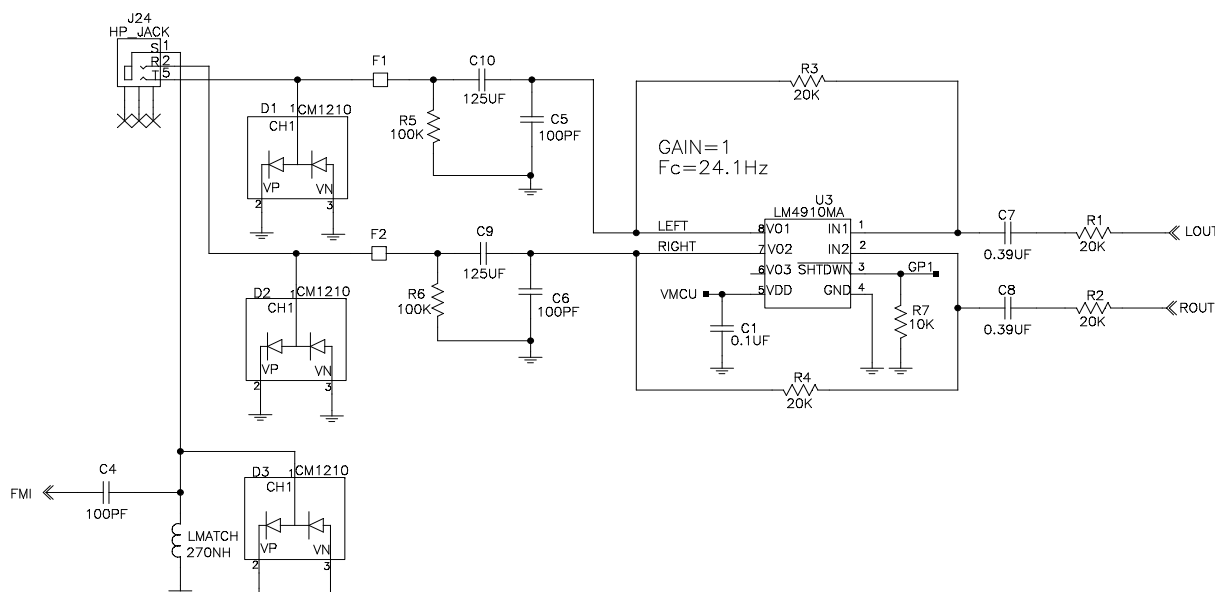


Figure 13. Headphone Antenna Schematic

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 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 13, these nodes are the left and right audio conductors. Ferrite beads should be 2.5 k Ω 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 Si4825/36-A. 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. As Diode D3 may not be relocated, it must 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 13 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 are $R3/R1$ 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:

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

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 also can be shut down by applying a logic low voltage to Pin 3. 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 13 is provided in Table 12. Note that manufacturer is not critical for resistors and capacitors.

4.3. Headphone Antenna Bill of Materials

Table 12. 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 μF, 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 closely as possible to the headphone connector.

To maximize ESD protection diode effectiveness, place diodes D1, D2, and D3 as near to the headphone connector as possible. 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 near to the headphone connector as possible 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 14 shows the telescopic whip antenna.



Figure 14. 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

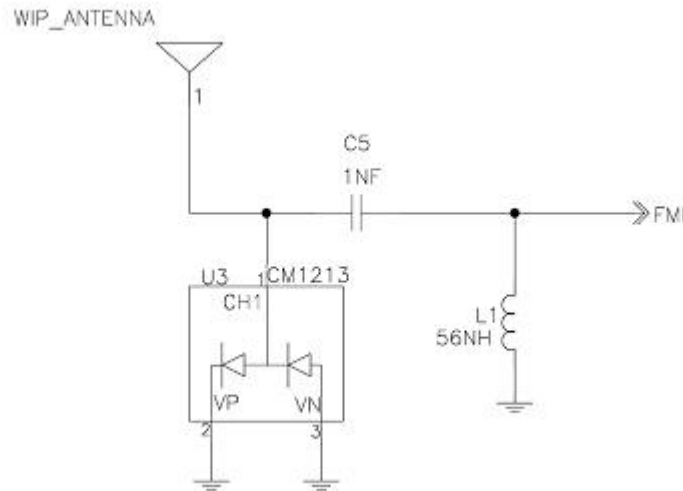


Figure 15. FM Whip Antenna Schematic

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 (1 nF) 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 13. 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 near to the whip antenna as possible. 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 near 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.

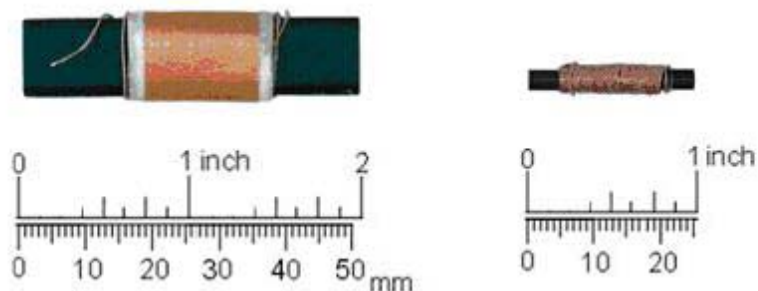


Figure 16. Standard and Miniature Ferrite Loop Antennas

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 Si4825/36-A AM Receiver.

Table 14 lists the recommended ferrite loop antenna for the Si4825/36-A AM Receiver.

Table 14. 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

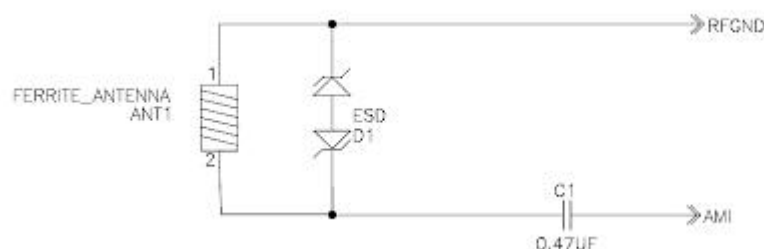


Figure 17. AM Ferrite Loop Antenna Schematic

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 15. Ferrite Loop Antenna Bill of Materials

Designator	Description
ANT1	Ferrite loop antenna, 180–450 μ 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 28 pF when a 300 uH ferrite loop stick antenna is used for an AM band, 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 18 shows an example of an air loop antenna.



Figure 18. 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:

$$L_{\text{equivalent}} = N^2 L_{\text{AIRLOOP}}$$

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 16.

Table 16. Recommended Transformers

	Transformer 1	Transformer 2	Transformer 3
Vendor	Jiaxin 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

The following is the vendor information for the above transformer:

Vendor #1:

Jiaxin 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

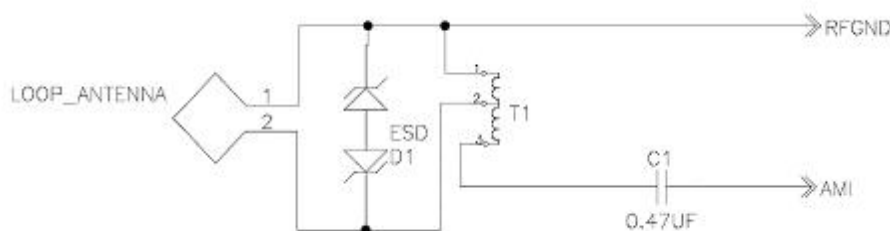


Figure 19. AM Air Loop Antenna Schematic

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

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

7.3. Air Loop Antenna Bill of Materials

Table 17. 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 Si4825/36-A, 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 Si4825/36-A. 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 20 shows the telescopic whip antenna.



Figure 20. Telescopic Whip Antenna for SW

8.2. SW Whip Antenna Schematic

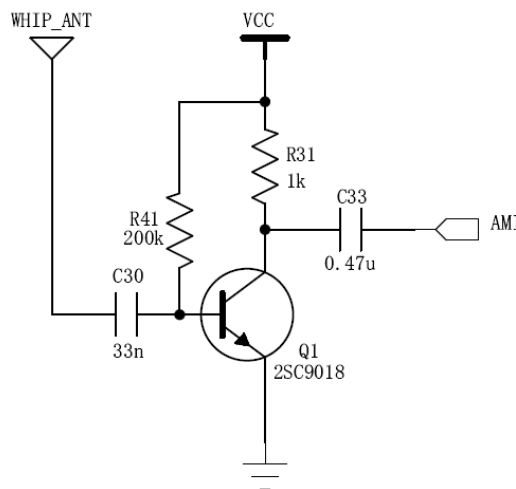


Figure 21. SW Whip Antenna Schematic

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

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

C33 (0.47 μ F) 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 18. 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.

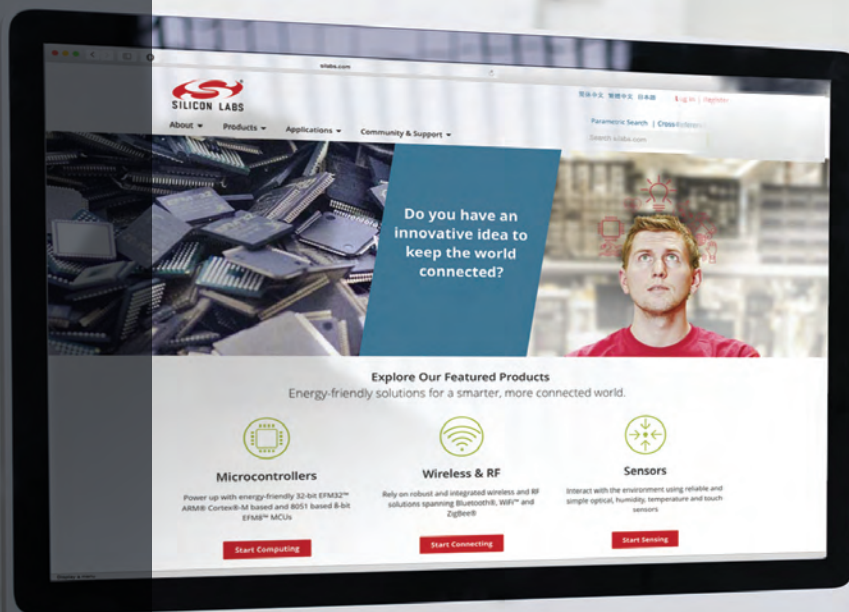
8.5. SW Whip Antenna Design Checklist

- 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.

DOCUMENT CHANGE LIST

Revision 0.1 to Revision 0.2

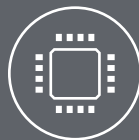
- Added new Table 3 for the band definition of Si4825-A.
- Updated all the Si4825 schematic figures and the BOM tables.



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