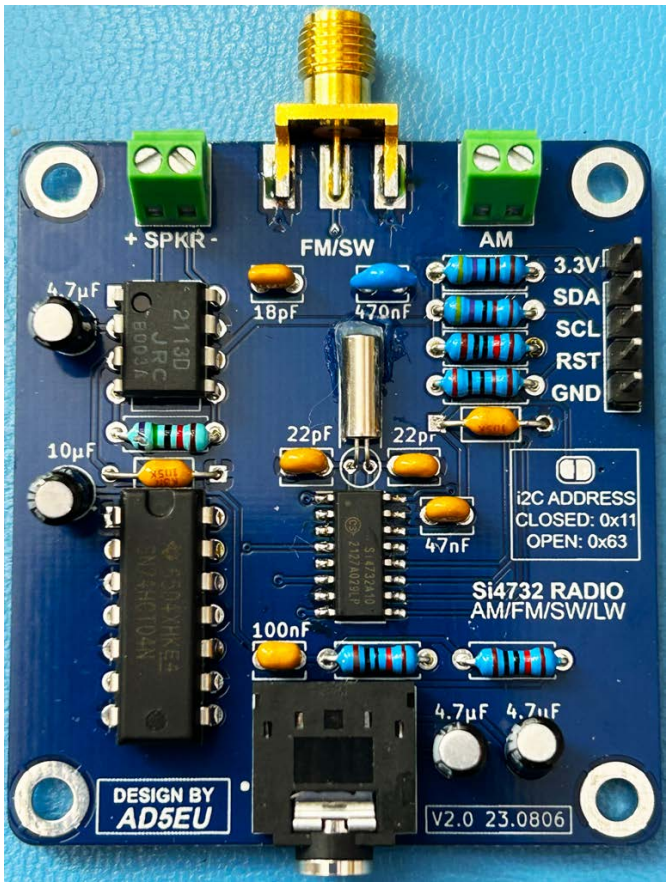
Si4732 Multi-band Radio Through Hole Technology (THT) and Supporting Controller



Developed By
Nancy Gail Daniels
AD5EU

Introduction

The popularity of Skyworks (nee Silicon Labs) based radios has expanded a great deal over the last several years based largerly on the excellent core Arduino library developed by Ricardo Lima Caratti. The library (PU2CLR Si4735) is available on github at https://github.com/pu2clr/SI4735. Beyond the core library a large number of developers have coded a variety of Arduino applications supporting a variety of displays and user interfaces.

Although there are a number of electronic schematics for radios, radio how to projects (several developed by the author) these tend to rely on surface mount component technology which can be difficult for the casual hobbyist to assemble. Compete radios, such as the ATS25 are available as well.

Given the size of the Facebook group (Si47XX for Radio Experimenters) has grown to nearly 7000 people there is evidently a great deal of interest in radio experimentation. In May 2023 the author was gently challenged to develop a radio which component technology which was more approachable by a broad spectrum of experimenters.

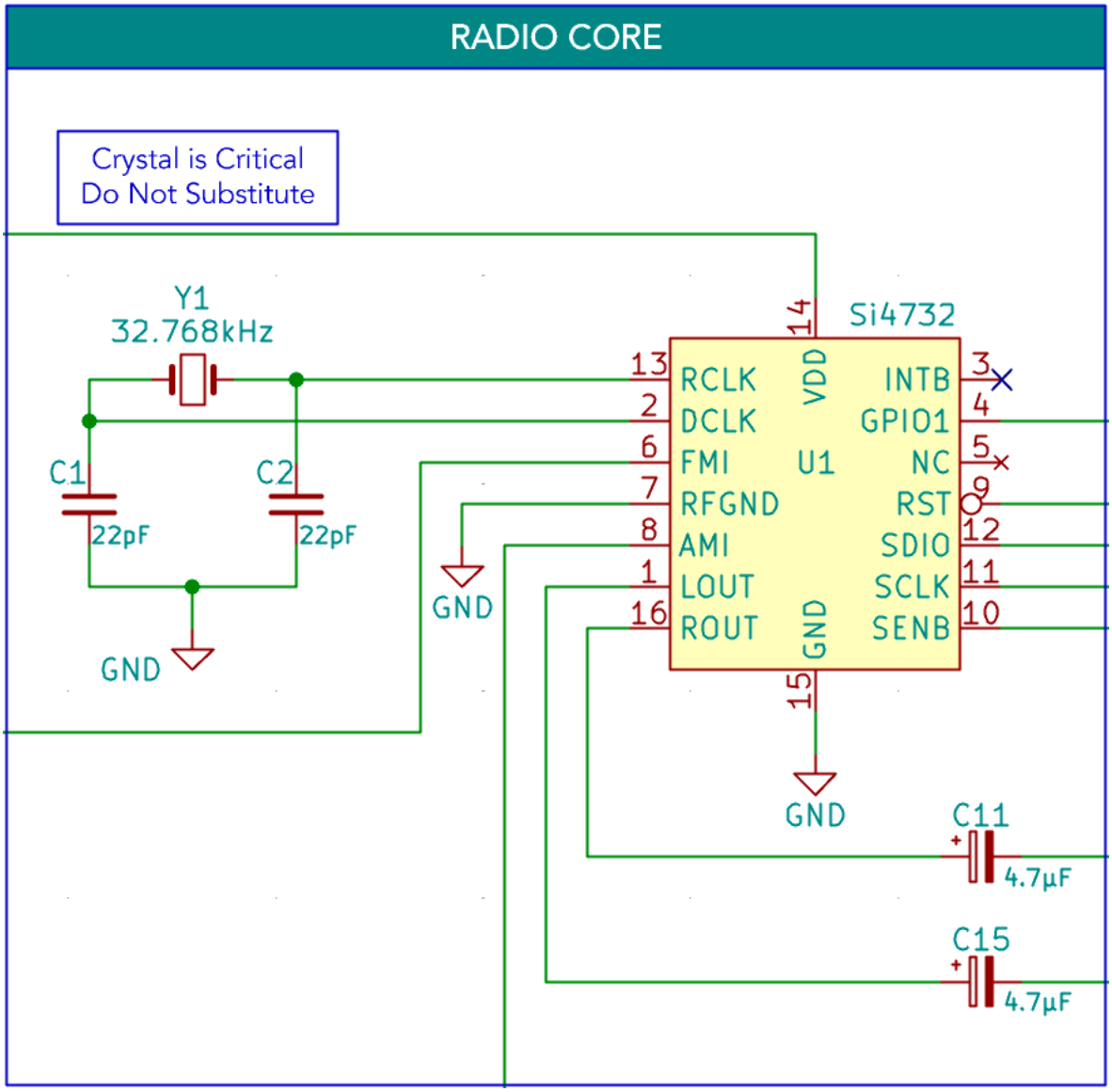
This project proved to be somewhat more difficult than originally expected, not because of the electronic complexity of the radio, which is well understood, but rather from the standpoint of finding "through hole technology" components appropriate for building a full function radio economically. After two iterations a "bullet proof" design was developed along with an Arduino controller/display board. The core radio module can be built in single unit quantities for ~$20USD excluding the cost of the PCB (available from a variety of suppliers for ~$5.00USD plus shipping).

A complete radio with display, Arduino controller and controls can by built for approximately double this cost.

Radio Core

The core radio is based on the Si4732 chip. This device internally has the same chip as the Si4735 radio chip, but is in a more hobbyist friendly in a 16 pin SOIC (Small Outline IC) package. This is the only surface mount devices in the radio (through hole packages of the Si473x are not made by Skyworks), but with a relatively large 1.27mm (0.05") pin pitch can be soldered with a little care, and perhaps some form of magnification.

The Si4732 chip only requires a few support components – excluding an audio amplifier just nine (9) capacitors and four resistors.

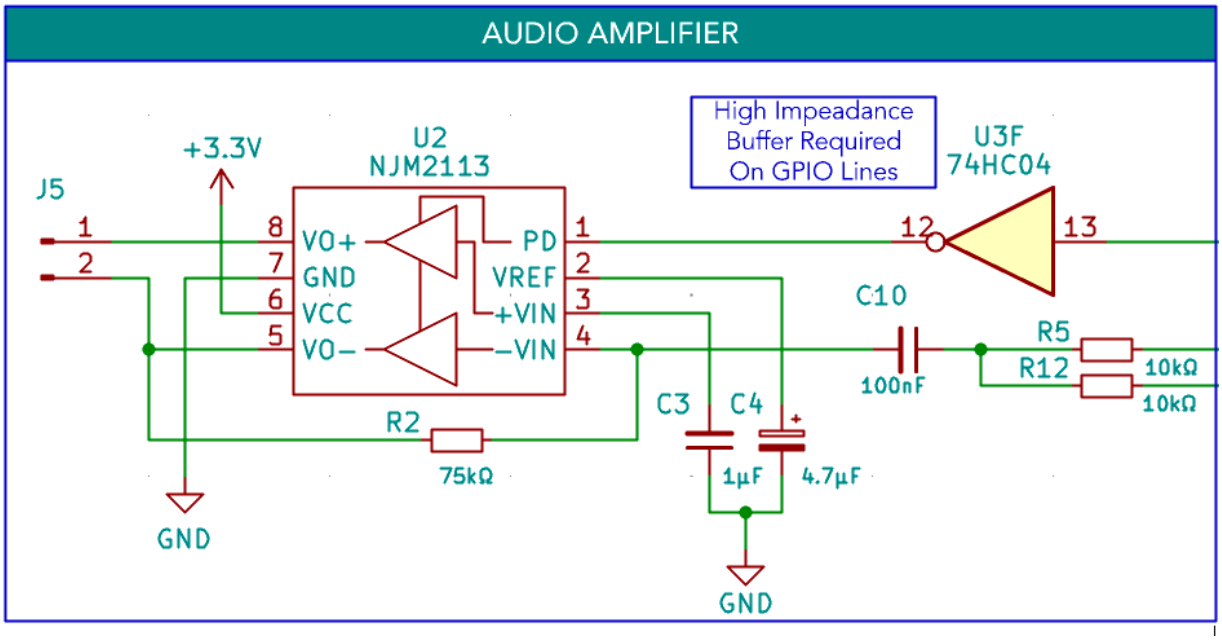


The only critical component (DO NOT SUBSTITUE) is the 32.768kHz crystal required by the Si473x radio. A number of hobbyist of have attempted to build Si473x radios have had issues making the radio work due to the sensitivity of the radio chip to this component. The recommended crystal is the ECS Inc. ECS-.327-12.5-8X available for ~$0.50USD. If this crystal is not available to you, insure that you pick a substitute crytal with the following characteristics:

Load Capacitance: 12.5pf - CRITICAL
Equivalent Series Resistance: 35kΩ - CRITICAL
Tolerance: ±20ppm (tighter tolerance, e.g. ±10ppm acceptable)

Amplifier

The NJM2113 (Japan Radio Corporation) audio amplifeier compliments the radio . This chip was chosen as it has adequate power for most speakers used in a portable radios (0.4W Class AB), is relatively inexpensive ($1USD), includes internal muting circuitry simplifying the design and is packaged in and easy to assemble 8pin DIP package. The amplifier requires an additional three capacitors, two resistors an a very inexpensive logic chip.



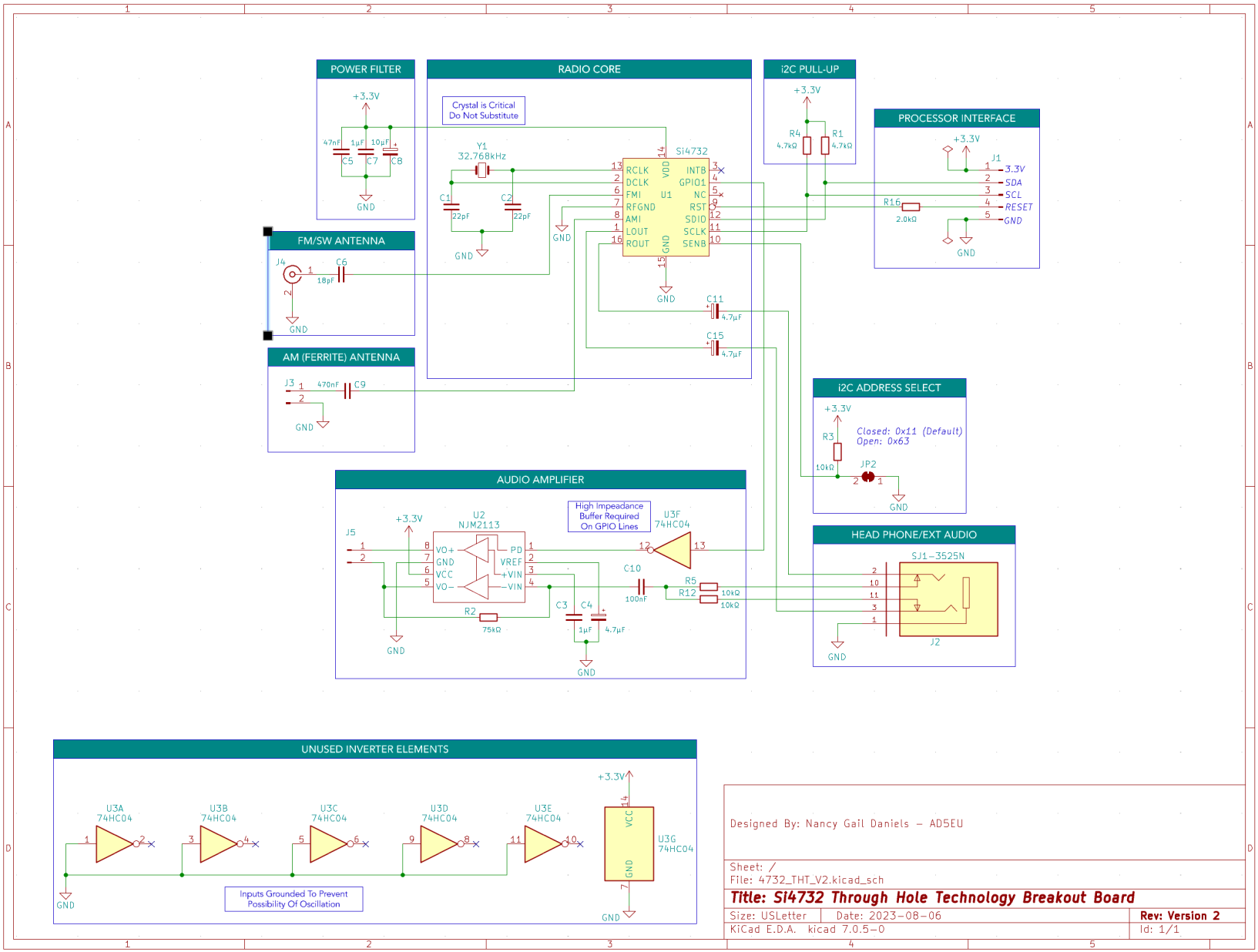
A design feature of this radio is that it uses one of the built in I/O lines of the Si473x chip to control muting saving a pin an I/O pin on the support microcontroller. The I/O lines on the Si473x must not have any electrical loading when the radio boots, or it will hang (not function). A low cost ($0.20USD) logic chip provides the necessary isolation between the mute circuit of the amplifier and the radio chip. Although the 74HCT04 chip used is relatively large (14 pin DIP package) and only 1/6th of the chip is used, it is the simplest least expensive solution the designer could find.

Complete Radio

The complete radio has a total of 27 components:

12	Capacitors	7	Resistors
1	Crystal	3	Chips (Radio/Amplifier/Logic)
5	External Jacks (FM+SW, AM, Speaker, Headphones, Interface)		

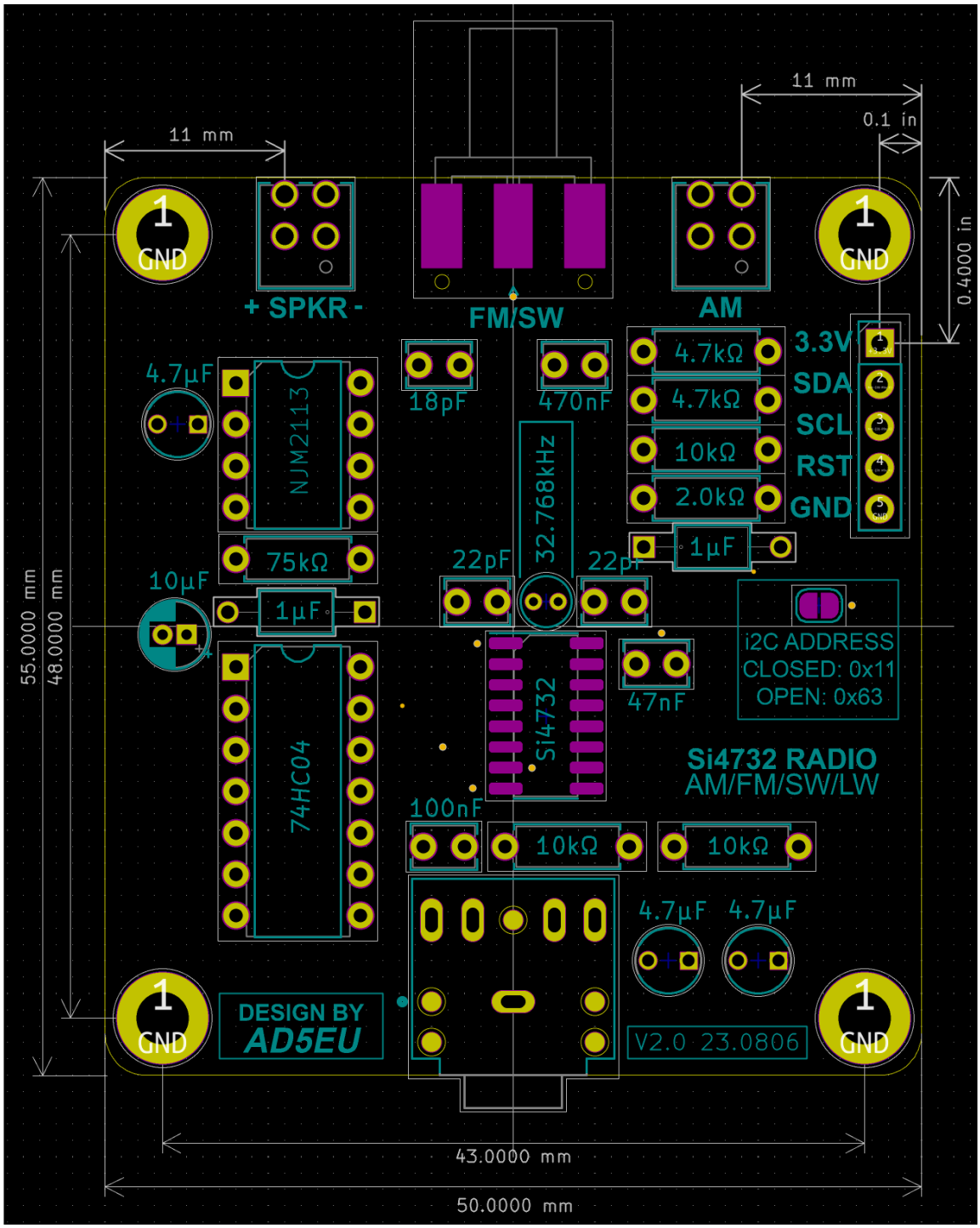
The following two pages illustrate the complete schematic and show the bill of materials for the radio.


POWER FILTER
+3.3V
47nF
C5
1µF
C7
10µF
C8
GND
RADIO CORE
Crystal is Critical
Do Not Substitute
Y1
32.768kHz
C1
22pF
C2
22pF
GND
Si4732
U1
RCLK
DCLK
FMI
RFGND
AMI
LOUT
ROUT
VDD
GND
INTB
GPIO1
NC
RST
SDIO
SCLK
SENB
C11
4.7µF
C15
4.7µF
i2C PULL-UP
+3.3V
R4
4.7kΩ
R1
4.7kΩ
PROCESSOR INTERFACE
+3.3V
J1
3.3V
SDA
SCL
RESET
GND
R16
2.0kΩ
FM/SW ANTENNA
J4
C6
18pF
GND
AM (FERRITE) ANTENNA
J3
470nF
C9
GND
i2C ADDRESS SELECT
+3.3V
R3
10kΩ
Closed: 0x11 (Default)
Open: 0x63
JP2
GND
AUDIO AMPLIFIER
J5
+3.3V
U2
NJM2113
VO+
GND
VCC
VO−
PD
VREF
+VIN
−VIN
High Impeadance
Buffer Required
On GPIO Lines
U3F
74HC04
C10
100nF
R5
10kΩ
R12
10kΩ
R2
75kΩ
C3
1µF
C4
4.7µF
GND
HEAD PHONE/EXT AUDIO
SJ1-3525N
J2
GND
UNUSED INVERTER ELEMENTS
U3A
74HC04
U3B
74HC04
U3C
74HC04
U3D
74HC04
U3E
74HC04
U3G
74HC04
+3.3V
VCC
GND
GND
Inputs Grounded To Prevent
Possibility Of Oscillation
Designed By: Nancy Gail Daniels – AD5EU
Sheet: /
File: 4732_THT_V2.kicad_sch
Title: Si4732 Through Hole Technology Breakout Board
Size: USLetter
Date: 2023-08-06
Rev: Version 2
KiCad E.D.A. kicad 7.0.5-0
Id: 1/1

Bill of Materials				Si4732 Radio - Through Hole Component Design				Version 2.0 23.0809		
Desig	Qty	Value		Description	Package	Vendor	Vendor PN	Digikey/*Mouser*	Price US$	Extention
C1, C2	2	22pF	±5% 50V C0G/NP0	Capacitor	Radial 4x2.6mm P2.50mm	Vishay	K220J15C0GF5TL2	BC1005CT-ND	$0.27	$0.54
C3, C7	2	1µF	±10% 25V X7R	Capacitor	Axial 4.32xD2.54mm	Kemet	C410C105K3R5TA	399-C410C105K3R5TA-ND	$0.30	$0.60
C5	1	47nF	±10% 50V X7R	Capacitor	Radial 4x2.6mm P2.50mm	Vishay	K473K15X7RF53L2	BC5153-ND	$0.24	$0.24
C6	1	18pF	±5% 50V C0G/NP0	Capacitor	Radial 4x2.6mm P2.50mm	Vishay	K180J15C0GF5TL2	BC1004CT-ND	$0.27	$0.27
C8	1	10µF	±20% 16V Bipolar	Capacitor	Radial_D4.0mm P1.50mm	Panasonic	ECE-A1CKA100	P807-ND	$0.27	$0.27
C9	1	470nF	±10% 50V X7R	Capacitor	Radial 4x2.6mm P2.50mm	TDK	FG18X7R1H474KRT06	445-173276-1-ND	$0.32	$0.32
C10	1	100nF	±10% 50V X7R	Capacitor	Radial 4x2.6mm P2.50mm	Vishay	K104K15X7RF5TL2	BC1084CT-ND	$0.23	$0.23
C4, C11, C15	3	4.7µF	±20% 25V Bipolar	Capacitor	Radial_D4.0mm_P2.50mm	Panasonic	ECE-A1EN4R7U	P1175-ND	$0.24	$0.72
D1	1	T1 LED	16mcd	LED	3mm	Kingbright	WP132XID	754-1211-ND	$0.34	$0.34
J1	1	Conn_01x05_Pin	1x5	Header	2.54mm Vertical	Harwin	M20-9990546	952-2268-ND	$0.26	$0.26
J2	1	2 SW Jack	3.5mm/1/8"	Connector	12x14.3x5mmxP5 RA	CUI	SJ1-3525N	CP1-3525N-ND	$1.11	$1.11
J3, J5	2	Terminal Block	1x2	Connector	2x1 Screw terminal P2.54mm	Phoenix	1725656	277-1273-ND	$1.68	$3.36
J4	1	SMA	Female	RF Conn	SMA EdgeMount Horizontal	Molex	732511153	900-0732511153-ND	$3.99	$3.99
R1, R4	2	4.7kΩ	±1% 0.25W	Resistor	L6.4xD2.4mm	Yageo	MFR-25FBF52-4K7	MFR-25FBF52-4K7-ND	$0.10	$0.20
R2	1	75kΩ	±1% 0.25W	Resistor	L6.4xD2.4mm	Stackpole	RNF14FTD75K0	RNF14FTD75K0CT-ND	$0.10	$0.10
R3, R5, R12	3	10kΩ	±1% 0.25W	Resistor	L6.4xD2.4mm	Yageo	MFR-25FBF52-10K	10.0KXBK-ND	$0.10	$0.30
R16	1	2.0kΩ	±1% 0.25W	Resistor	L6.4xD2.4mm	Yageo	MFR-25FBF52-2K	2.00KXBK-ND	$0.10	$0.10
U1	1	Si4732	AM/FM/SW	Radio	SOIC 16 3.9mm P1.27mm	Skyworks	SI4732-A10-GS	336-5736-ND	$4.70	$4.70
U2	1	NJM2113	400mW	Amplifier	DIP-8_W7.62mm	Nisshinbo	NJM2113D	2129-NJM2113D-ND	$1.06	$1.06
U3	1	74HC32	Hex Inverter	Logic	DIP-14_W7.62mm	TI	SN74HC04N	296-1566-5-ND	$0.49	$0.49
Y1	1	32.768kHz	±20ppm 12.5pF	Crystal	XTAL_ECS-.327-12.5-8X-C	ECS	ECS-.327-12.5-8X	X1123-ND	$0.32	$0.32
									Total	$19.52

PCB

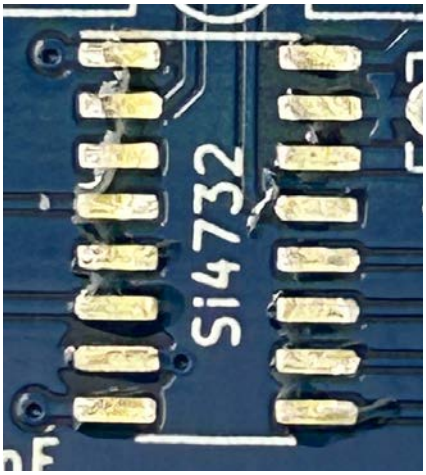
The radio is built using a 50mm (1.97”) x 55mm (2.16”) double sided PCB with M3 (3mm) mounting holes spaced 43mm(1.69”) and 46mm (1.81”) apart respectively.

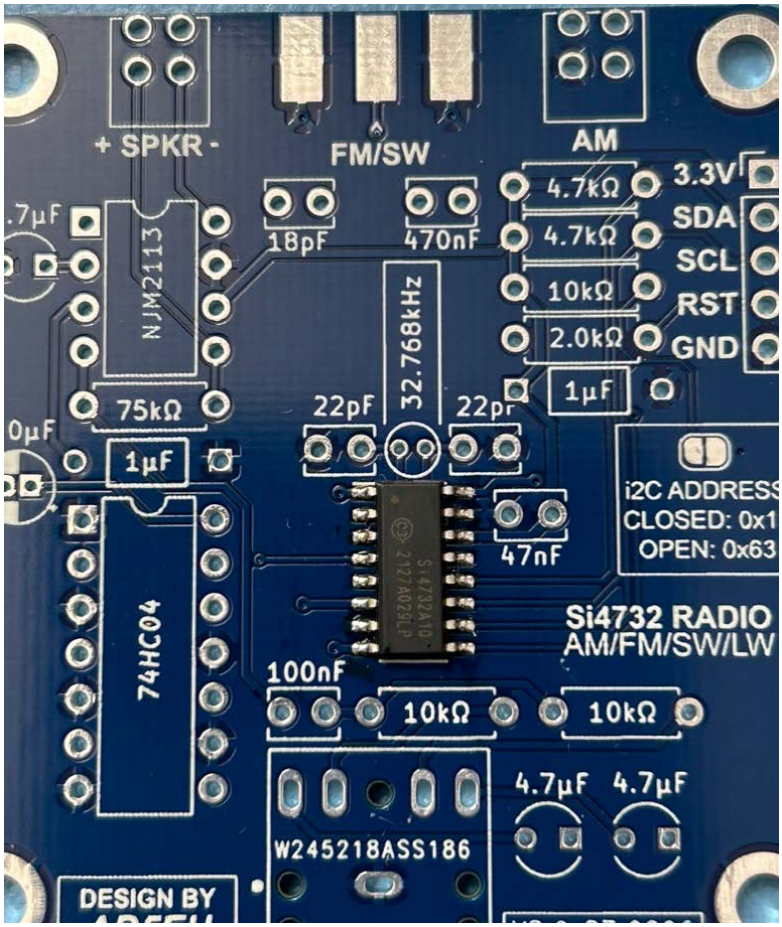


Assembly

The radio module can be assembled in less than an hour. The following are the suggested steps for assembling the radio.

Step 1 – The Si4732 chip
The Si4732 is the most difficult part of the board assembly. Although not required, depositing (electronic grade) flux on the Si4732 pads will make soldering the Si4732 easier (shown to the right)



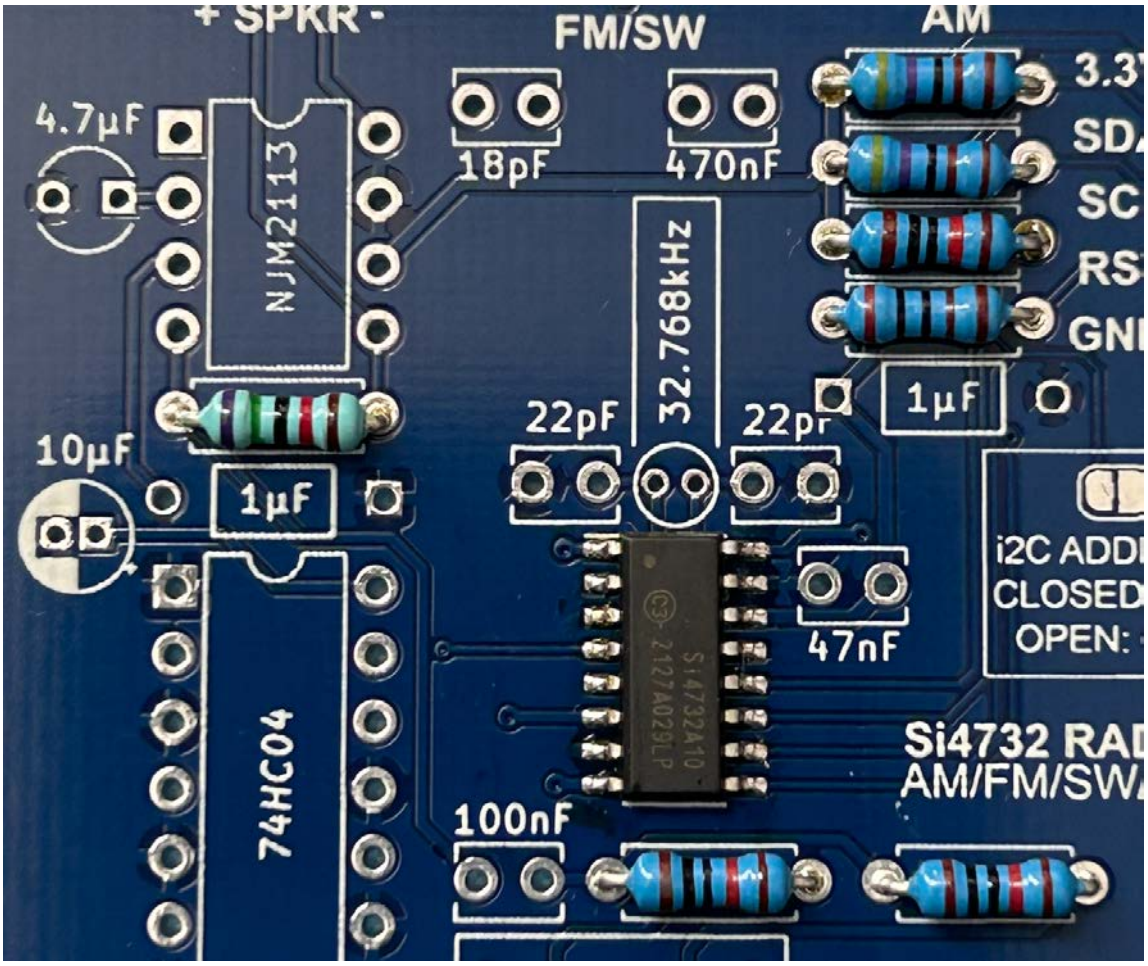


Note the Si4732 chip is sensitive to static electricity and it is recommended that you “ground yourself” while handling the chip to insure it is not damaged.

Step 2 – Resistors

The next step is to solder on the 7 resistors on the board. In the picture below 1% tolerance resistors are used and as such the color coding may be unfamiliar:

Purple Green Black Red	75.0kΩ	Yellow Purple Black Brown	4.70kΩ
Brown Black Black Red	10.0kΩ	Red Black Black Brown	2.00kΩ

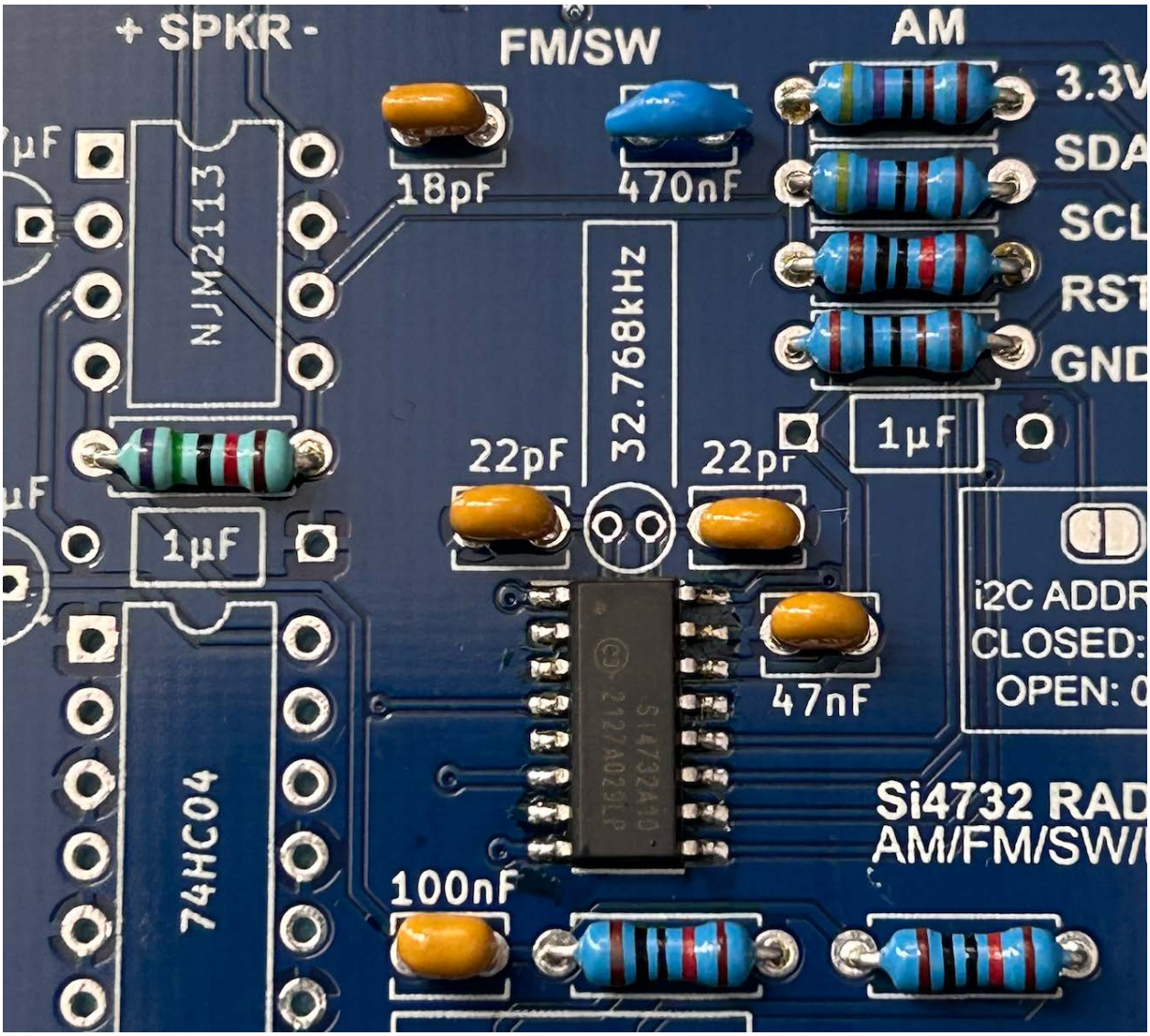


In small quantities 1% resistors can be purchased for the same price as lower tolerance 5% resistors. If you have 5% resistors on hand tolerance is not critical and more commonly available 5% resistors can be used:

Purple Green Orange	75kΩ	Yellow Purple Red	4.7kΩ
Brown Black Orange	10.0kΩ	Red Red Red	2.2kΩ

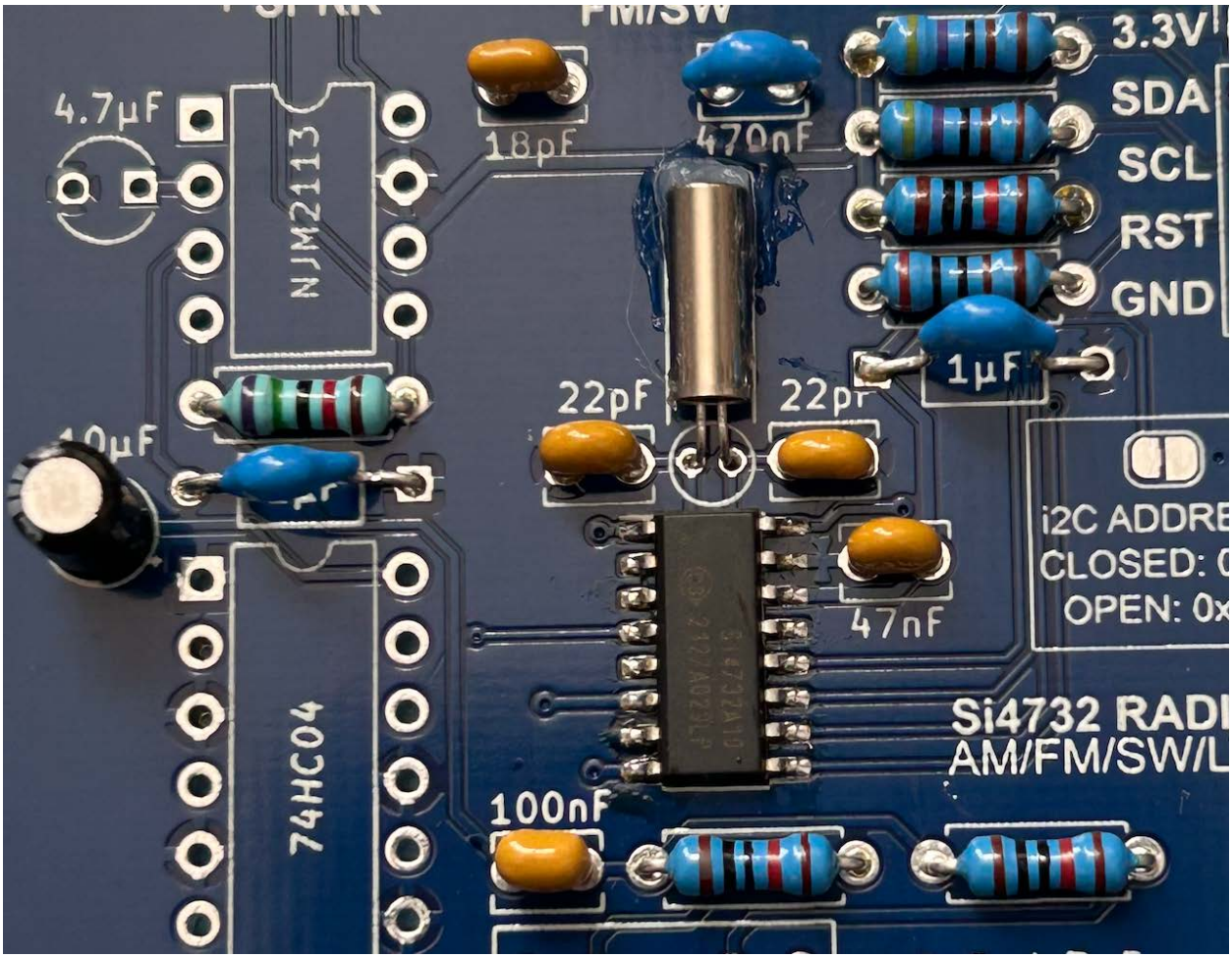
Step 3 – Small Capacitors

Insert and solder the 5 small capacitors. Note that four of the 5 capacitors look exactly the same but differ in value by several orders of magnitude – be very careful not to mix up the capacitors.



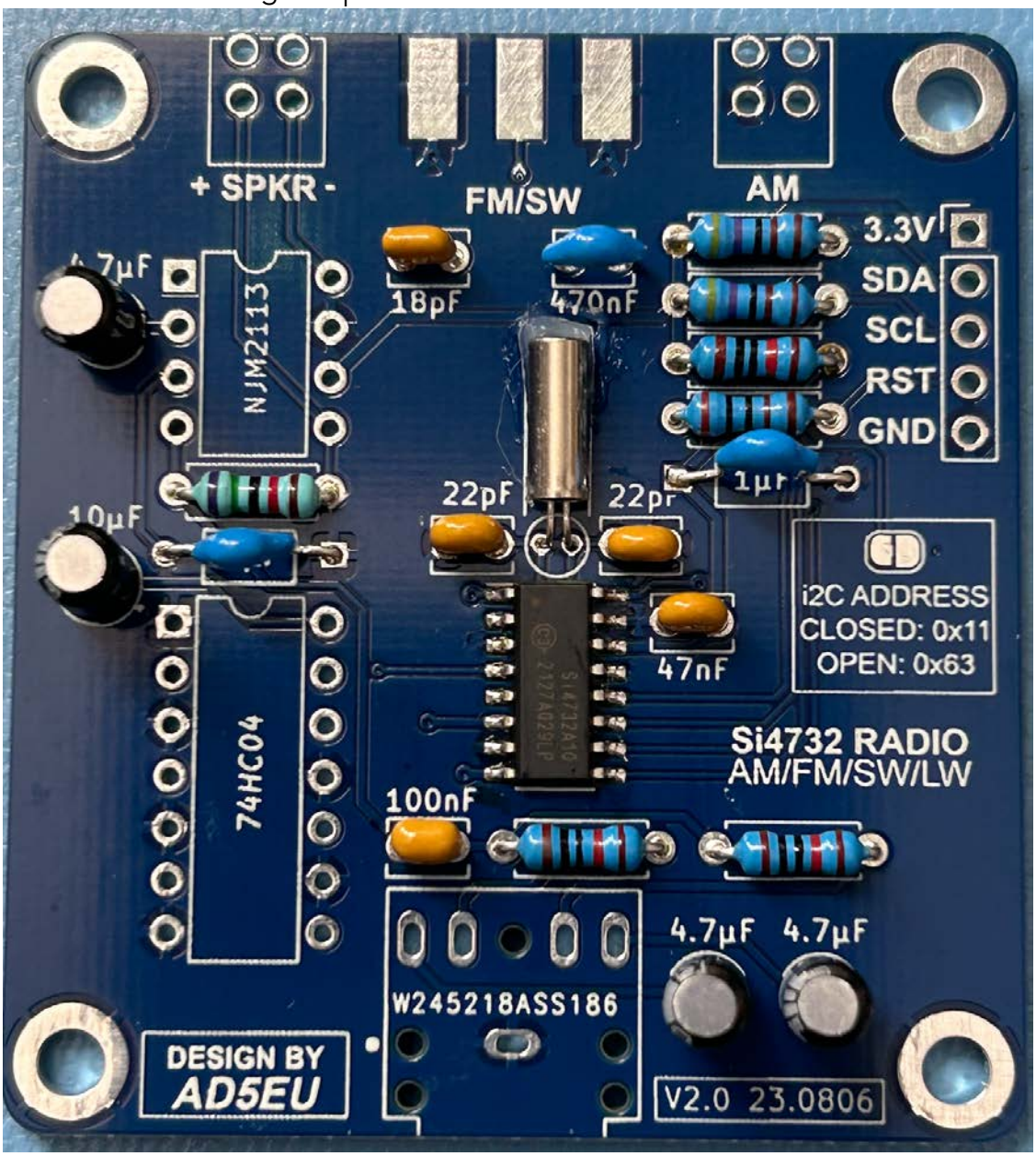
Step 4 – Crystal

Next insert the 32.768kHz crystal. You will notice that the lead spacing on the crystal is quite small and care must be taken when soldering not to accidentally “bridge” solder across the leads. Although not required, a small dab of silicone underneath the crystal will make the radio less susceptible to damage from shock (physically dropping the completed radio).



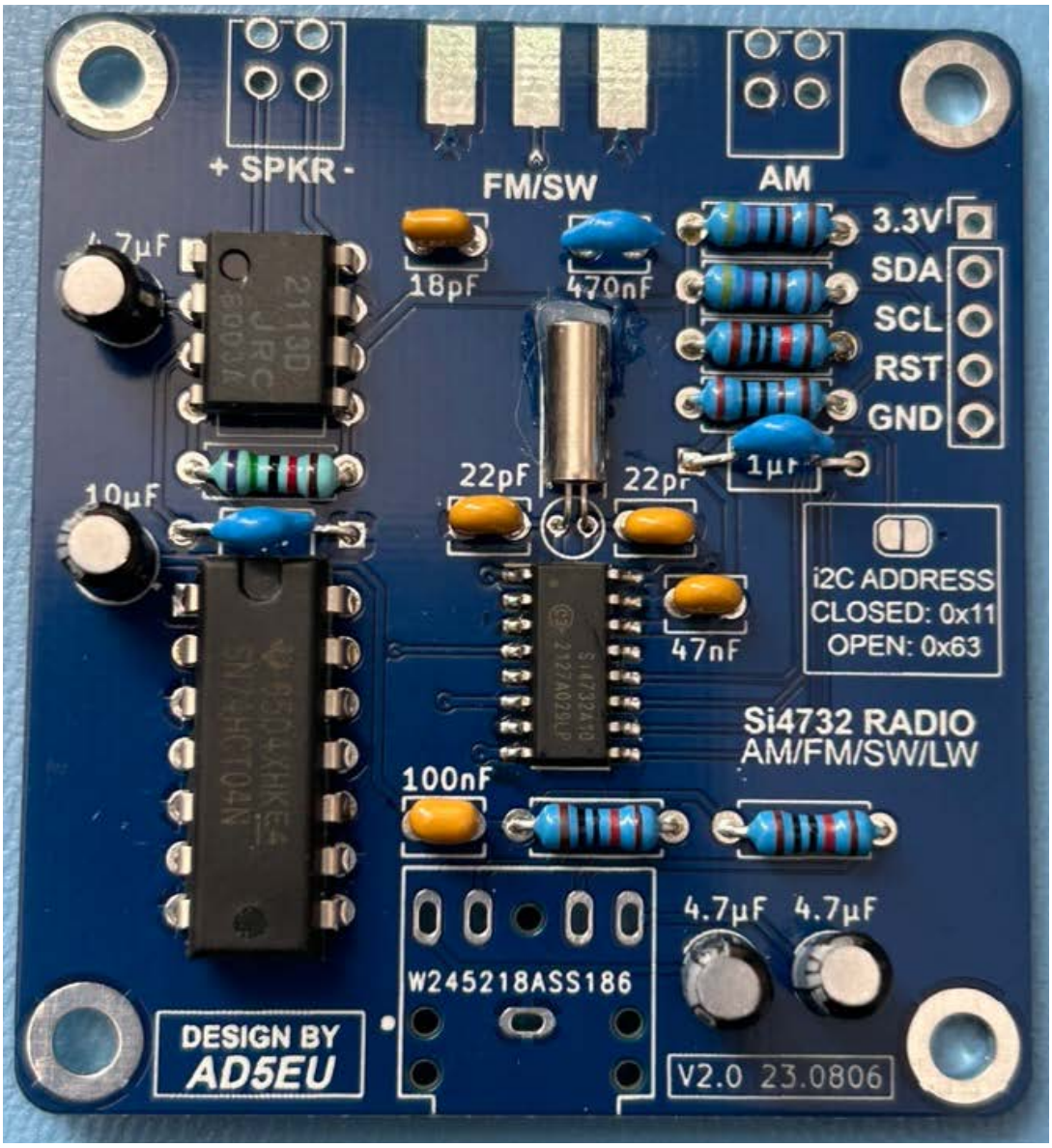
Step 5 – Large capacitors

Next insert the 6 larger capacitors.



Step 6 – Amplifier and Logic Chip

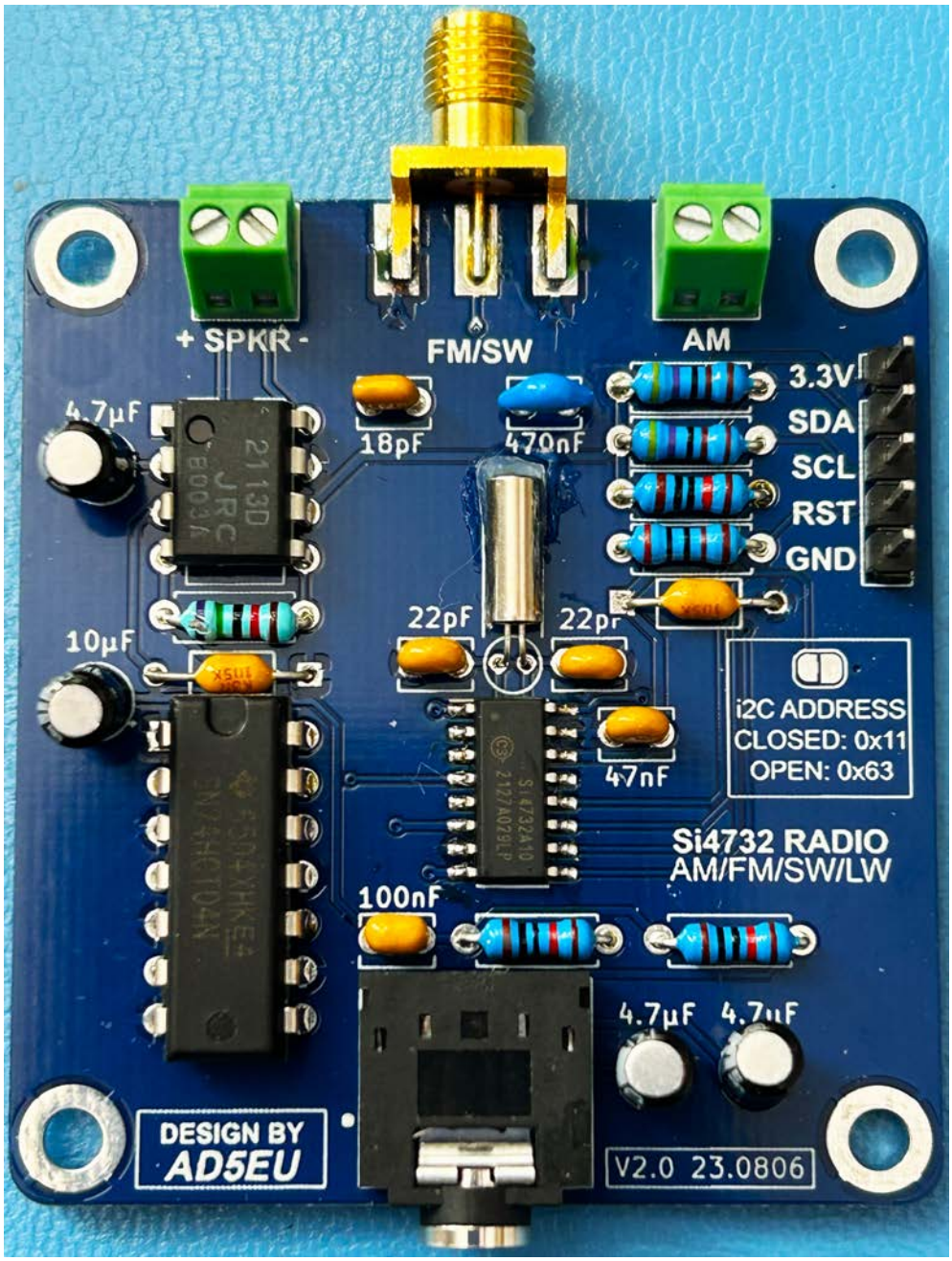
Next insert the amplifier (NJM2113) and logic chip (74HCT04). When inserting these chips insure that pin 1 (indicated by the insets/indents on the upper part of the chip) is oriented correctly.



Step 7 – Connectors

The last step before the radio is ready to test is to insert the 5 connectors

SMA jack for Shortwave and FM antenna
Two (2) Terminal blocks for the external speaker and AM antenna
3.5mm Audio Jack for Headphones
5 pin) 0.1 header pins for connection to the Arduino



Testing

To test the radio, the 5 pin connector needs to be connected to your Arduino. The key when pairing the radio with an Arduino is that the Si4732 radio board requires 3.3V and does not have any on board voltage regulator. It is therefore recommended that legacy 5V Arduino boards are NOT used with the board.

One of the least expensive and capable Arduino variants is based on the Raspberry Pi RP2040. Although the following is based on the Adafruit Feather RP2040 any of the RP2040 Arduino variants can be used. Only 5 connections are required.