RFBitBanger Manual

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NOTE: If you intend to be able to use the RFBitBanger without a computer available to view this document, print out these instructions and keep them with your radio.

Make a note of the calibrated crystal frequencies here in case the nonvolatile memory of the radio is corrupted. This can be found in the "Xtal Freq" under the "Cfg" menu. This frequency is usually close to 25 MHz.

Radio Serial Number	Crystal Frequency (Hz)

NOTE: The operator of the radio is responsible for compliance with all applicable telecommunications regulations, especially those regarding operating high frequency transmitters. An amateur radio license is generally required to be permitted to transmit with this radio in most countries.

Introduction

The RFBitBanger is a self-contained high frequency long-distance two-way transceiver radio (frequencies 1.8 MHz to 30 MHz). It is designed to be easy to build, easy to maintain, easy to operate, and able to communicate hundreds or thousands of kilometers with low levels of RF power. It can be built without any surface mount parts. It is constructed from the minimum number of specialized parts so that replacement parts can be located more easily. The design of this radio prioritizes robustness and maintainability over efficiency. Parts have been selected on the basis of high availability and low cost when performance is not significantly compromised. The radio has many features included intended to make long-distance contacts easier to conduct.

The RFBitBanger is intended to be self-contained so that only the transceiver itself is needed to communicate alphanumeric messages long distances. The radio specializes in text-based transactions, through CW, RTTY, or a new protocol created for this radio called SCAMP which uses forward error correction to achieve more reliable transmission. It provides keyboard input to make control easier, but the transceiver can be operated from just five buttons. The radio can also be controlled remotely using a sound card, so that FSK modes, for example, FT8 may also be used. Therefore it is hoped that this can be used for ordinary contacts, but also be usable and maintainable should there we widespread supply chain or communications disruptions. This radio receives dual sideband DSB and can transmit voice (phono) upper or lower sideband (USB/LSB) using a frequency tracking/PLL and envelope modulation method.

This radio is intended to be able to be assembled and maintained off the grid without access to parts suppliers. The parts should be sufficiently inexpensive so that many replacement parts can be kept on hand. Where possible, there should be multiple vendors that can provide similarly working parts. For example, the ATMEGA328P is used in the transceiver which is one of the most common microcontrollers available as it is used in the Arduino Uno and Nano, and furthermore Logic Green has a part that is designed to be a near drop-in replacement. The SI5351A is used as a frequency synthesizer, which is readily available in the form of a prototyping board, and there is also a work-alike MS5351 part. LM358 and LM386 are used which are produced by many manufacturers. A diode ring mixer is constructed from 1N4148 diodes which are some of the most commonly available diodes. The 2N7000 is used as an RF MOSFET, which is very similar to the BS170 except for the 2N7000 having a pinout of source-gate-drain, and the BS170 having the opposite pinout drain-gate-source. The MOSFET is the most likely part to be damaged. At the time of this writing 2N7000 transistors can be bought for approximately $0.03 each USD in quantity 100. The HD44780-type displays are probably the most common LCDs available.

The radio is first and foremost intended to be used with low-bandwidth modes such as CW and RTTY. A new protocol called SCAMP was created especially for this radio. SCAMP is designed to be simple enough to be implemented on an 8-bit microcontroller but incorporates features such as forward error correction. It has several modes which can be selected based on desired symbol rate and receiving conditions, and user selectable levels of redundancy which can be increased to compensate for poor receiving conditions. This protocol is both described in a standards document and has an open source implementation included with the RFBitBanger.

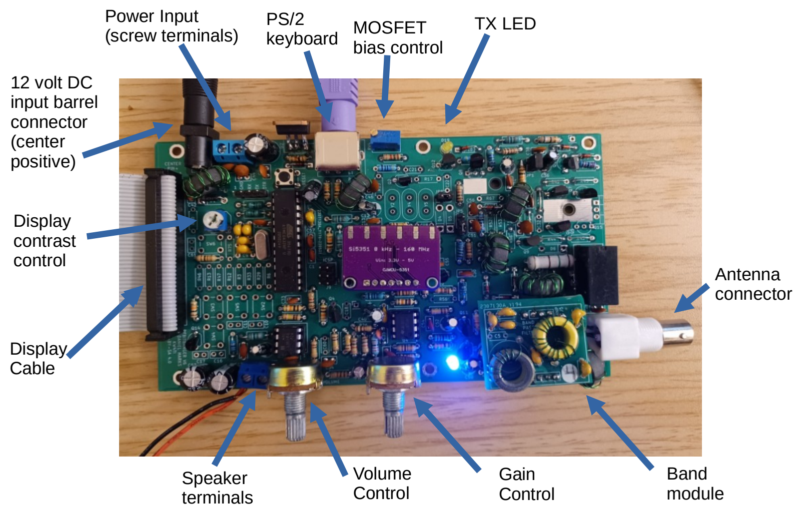
Features and specifications

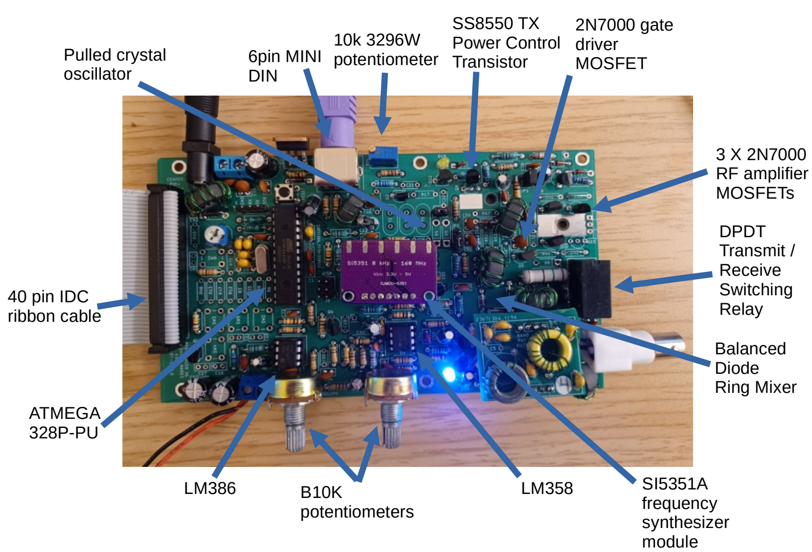
The RFBitBanger has the following features and specifications:

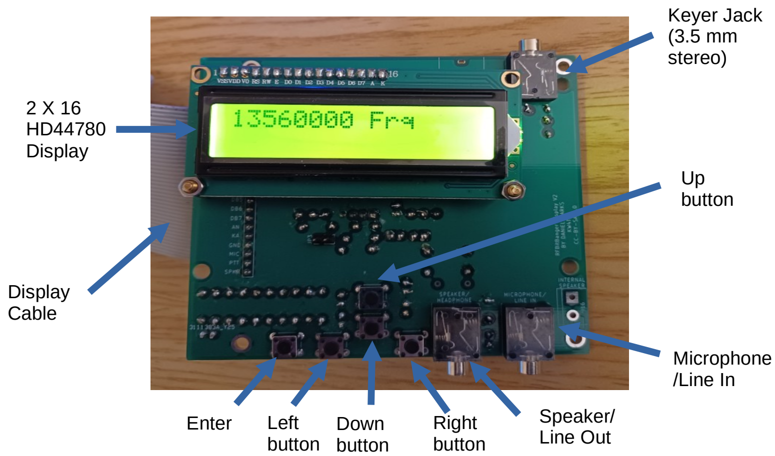
- Supports the high frequency (HF) band between 1.8 and 30 MHz, with the best performance obtained at the 80m, 60m, 40m, 30m, and 20m bands (3.5 to 14.35 MHz).
- Uses a simple direct conversion receiver architecture with demodulation using a double sideband (DSB) balanced ring mixer. This does not require any specialized integrated circuits, only 1N4148 diodes and 2N3904 NPN transistors.
- Achieves 4 W or greater radiated power on the 80 to 20 m bands.
- Supports CW (Morse code) transmission and reception, with a built-in decoder.
- Supports RTTY (radio teletype) transmission and reception.
- Supports a new protocol called SCAMP for teletype-like communication that is narrow bandwidth and uses forward error correction.
- Supports upper sideband (USB) or lower sideband (LSB) voice/phono communication using a frequency tracking/PLL and envelope modulation method.
- Has an external control mode which can be used with the audio card of a PC for FSK data protocols, for example FT8.
- Supports replaceable bandpass modules for each frequency band.
- All functions can be controlled with five buttons, even alphanumeric message entry.
- Supports an external PS/2 keyboard for easier message entry.
- Signal strength bar graph to aid in tuning.
- Has an external speaker for listening to audio and data signals.
- Volume and gain control potentiometers.

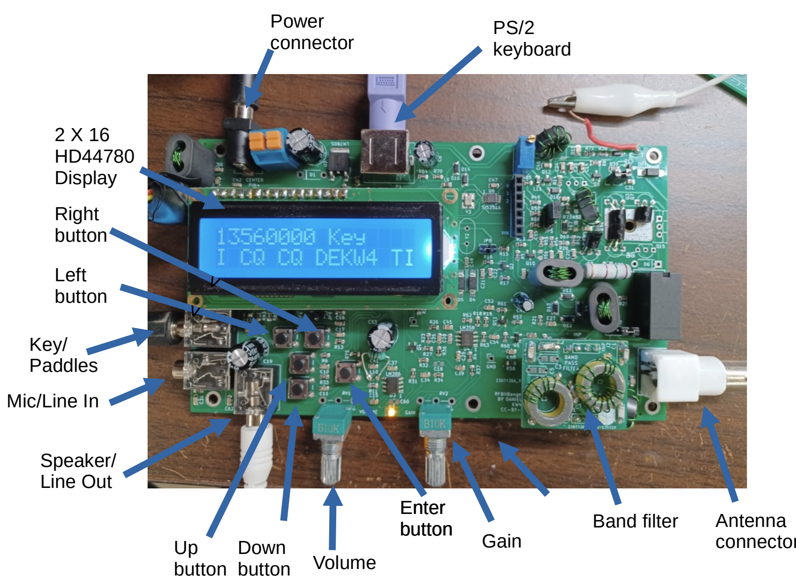
- External microphone, line out, and keyer jacks.
- A jumper can be pulled to support full break-in QSK.

Radio Ports






Keyer Jack (3.5 mm stereo)
2 X 16 HD44780 Display
13560000 Frq
Up button
Display Cable
Microphone /Line In
Enter
Left button
Down button
Right button
Speaker/ Line Out


Power connector
PS/2 keyboard
2 X 16 HD44780 Display
13560000 Key
I CQ CQ DEKW4 TI
Right button
Left button
Key/ Paddles
Mic/Line In
Speaker/ Line Out
Up button
Down button
Volume
Enter button
Gain
Band filter
Antenna connector

Before operating the transceiver

Check the following before operating the transceiver:

- For the through-hole version of the RFBitBanger, check that the main transceiver PCB and the display PCB are connected using a 40-pin IDC ribbon cable.
- A 12V to 14.6V DC power supply is connected to the barrel jack or screw terminals. The center pin of the barrel jack is positive.
- Connect an antenna for a particular frequency band to the antenna connector. This antenna may operate only on a single band, or may be designed to operate on multiple bands.
- Insert a bandpass module, which has dual 4 pin sockets, onto the dual 4-pin connectors. One of the pin sockets and pins is silkscreened “INP,” and the other of the pin sockets is silkscreened “OUT.” Plug the 4 pin socket on the band module marked “INP” to the 4 pin port on the transceiver marked “INP.” Similarly, plug the 4 pin socket on the band module marked “OUT” to the 4 pin port on the transceiver marked “OUT.” Check to make sure that both are firmly secured and are not offset by a pin.
- Ensure the bandpass module is appropriate to the frequencies being used. Consult the bandpass module table to determine which band module is indicated for each set of frequencies. A white spot on the band module silkscreen is reserved so that a number indicating the identity of the band module can be written on it.
- A PS/2 keyboard may be connected to the mini 6 pin DIN connector if used.
- If operating using a sound card, connect 3.5 mm stereo patch cables, one from the SPEAKER/HEADPHONE output of the transceiver to the microphone input of the sound card, and a second from the MICROPHONE/LINE IN of the transceiver to the line output of the sound card. Jumpers JP6/JP9 on the SMT version and jumpers JP3/JP4 on the RFBitBanger display board should be closed if a microphone input is used, and left open if line-level input is used.
- If using a key, connect it to the keyer jack. If using a push-to-talk (PTT) button, this can be connected to the keyer jack. The “dit” paddle of a keyer or a straight key may be used as the PTT button. The dah paddle should not be pressed when input audio is present.

Bandpass module frequency ranges

Bandpass module / number	Frequencies (Hz)
160 m / “16”	1800000 – 2000000
80 m / “8”	3500000 – 4000000
60 m / “6”	5250000 – 5450000
40 m / “4”	7000000 – 7300000
30 m / “3”	10000000 – 10150000
20 m / “2”	14000000 – 14350000
17 m / “17”	18068000 – 18168000
15 m / “15”	21000000 – 21450000
12 m / “12”	24890000 – 24990000
10 m / “10”	28000000 – 29700000

Gain, volume, and sensitivity

The RFBitBanger has two potentiometer controls for adjusting reception: gain and volume. The gain control determines the amount of amplification of a demodulated radio frequency before it is decoded by digital processing or amplified for the audio speaker. When adjusting the gain so that a signal can be decoded off of the air, there is a bar graph on the upper right hand corner of the display. Increasing the gain (turning the knob clockwise) increases the magnitude of the signal as shown on the bar graph. It also increases the loudness of the sound in the speaker or headphones. There are four bar positions of the bar graph. The ideal setting of the gain is such that the magnitude of the bar graph barely reaches the fourth bar. If the gain is too high, the noise is overly amplified and reduces the ability of the noise to be distinguished from the signal. If the gain is too low, the signal is insufficient to be decoded. If there is strong interference near the decoded signal, decreasing the gain may help the digital processing reject the interference while keeping enough of the desired signal to decode.

The maximum gain is over 120 dB (amplifying 1 uV to 1 V) to ensure that the sensitivity of the receiver is limited only by the noise in the receiver and not the gain. However, at the highest gain and volume settings, one will notice some microphonic noise, especially with no antenna connected, when buttons are pressed in the speaker as even tiny vibrations of circuit board components are amplified to produce an audible signal. This is normal and generally does not prevent successful decoding of signals.

The volume does not affect the signal being decoded by the digital processing, only the loudness of the sound in the speaker or headphones. Therefore the gain should be adjusted for the most accurate digital processing (signal level in the bar graph), and the volume adjusted for the desired loudness. The loudness control is generally set to a much higher setting for an external speaker than headphones. When connecting the speaker output to a computer line-in, the volume should be set at a low level as to not exceed the limits of the analog-to-digital converter.

The RFBitBanger is a direct conversion receiver with a VFO generated by a fractional phase-locked-loop integrated circuit (SI5351A) or a crystal oscillator. A fractional phase-locked-loop integrated circuit generates many spurious frequencies internally in the process of synthesizing an output frequency. Because of the high sensitivity of the RFBitBanger receiver, and the fact that it is a direct conversion receiver, these frequencies can be detected by the receiver and unfortunately interfere with a desired signal. This is an unfortunate disadvantage of a PLL synthesizer and the simple direct conversion architecture used. These frequencies tend to be confined to 1-10 Hz bandwidths and so can be worked around by tuning the frequency slightly.

Operating the menu system

The user interface consists of an alphanumeric LCD and five buttons, the buttons being up, down, left, right, and enter. The transceiver can be completely controlled using only these give buttons: menus of the transceiver may be navigated, and numbers and messages may be entered using these buttons. If a PS/2 keyboard is connected, the four arrow keys of the PS/2 keyboard act as the left/right/up/down buttons, and the enter key on the keyboard acts as the enter key on the transceiver. Numbers and alphanumeric messages can be entered using the keyboard as well. For example, the frequency may be changed in the “Frq” menu option using either the numeric keys or the arrow keys.

To navigate a menu, the up/down buttons are used, and to select a menu option, the left/right buttons or the enter buttons are pressed.

The radio main menu:

The 2 by 16 LCD display is divided into several areas:

```
07000000 Frq||||
  CQ CQ DE KW4TI
```

In the main menu, the current frequency is displayed at the upper left. The current menu option is displayed next to it (for example “Frq”), and to the right of that is a signal strength bar indicating the signal strength of the signal being decoded in the current mode.

The bottom line is reserved for decoded text. For example, if “CW” transmission mode is selected, when CW is decoded, the message scrolls across the bottom line of the display.

When entering an alphanumeric message, the top line is replaced by the message being entered.

Pressing the up/down buttons cycles through the various main menu options, with three letters indicating the option being displayed in the top line. An option can be selected by pressing the left or right button, or the enter button.

Changing the frequency

```
07000000 Frq||||
  CQ CQ DE KW4TI
```

To change the VFO frequency, select the “Frq” option. If the left button is pressed, the cursor is placed on the rightmost (least significant) digit. If the right button or enter button is pressed, the cursor is placed on the leftmost (most significant) digit.

Pressing the up/down button on a digit increments or decrements that digit by one.   The frequency is immediately changed, and the demodulated audio can be heard in the speaker.

When tuning the frequency for best reception of a data mode, the signal strength bar can be used. For on-off keying modes, such as CW, the signal strength bar pulses with the transmission. Tune the frequency for the maximum bar length when the signal is received. For frequency-shift keying modes, such as RTTY or SCAMP, tune the signal strength bar so that the bar is as long as possible, and the bar is on constantly. The frequency-shift keying mode consists of two tones, and if the signal strength indicates a strong signal when only one of the two tones occurs, the frequency is only aligned with one of the two tones, and should be changed by a small amount (less than 250 Hz) so that both tones cause the signal strength bar to remain at a high level. For very low data rate modes, often 1 to 10 Hz increment adjustments may be necessary to maximize the signal.

The buttons are used in lieu of a rotary encoder to change frequency as replacements for buttons may be more readily improvised than a replacement rotary encoder.

Scanning for a signal

```
07000000 ScF||||
  CQ CQ DE KW4TI
```

The RFBitBanger can automatically scan for a signal with high signal strength. The “ScF” option scans for a signal “fast” or with 100 Hz scan increments, while the “ScS” option scans for a signal “slow” with 30 Hz scan increments. Select the “ScF” or “ScS” option with the up/down buttons. Pressing the right button scans with increasing frequency starting at the current frequency, while pressing the left button scans with decreasing frequency starting at the current frequency. Pressing the enter button aborts scanning.

The RFBitBanger will step in a 100 or 30 Hz increments until it finds a high strength signal. It will then back up and scan back over the last 300 Hz of bandwidth with smaller 10 Hz steps to maximize the signal strength. The RFBitBanger stops once it maximizes the signal. If the signal is not found when backing up, three attempts are made are finding the signal, and if this fails, the scanning is resumed to look for a new strong signal.

Selecting a transmission mode

```
CW       TrM||||
  CQ CQ DE KW4TI
```

To select the transmission mode, the "TrM" menu option may be selected. The transmission mode can then be selected using the left and right buttons, with the enter button selecting a transmission mode. As of the time of writing, these are the available modes:

- CW continuous wave (Morse code) with the BFO 667 Hz below the transmitted frequency (USB).
- USB. Upper sideband voice (phono) transmission.
- LSB. Lower sideband voice (phono) transmission.
- RTTY, or radioteletype 45/170, that is 45.45 symbols per second with a 170 Hz separation between mark and space frequencies, with the space frequency 583 Hz above the VFO, and the mark frequency 750 Hz above the VFO.
- RTTYREV, or radioteletype 45/170 on the lower sideband, with the space frequency 750 Hz below the VFO, and the mark frequency 583 Hz below the VFO.
- SCAMPFSK, the standard SCAMP FSK mode. Use this mode by default for SCAMP communications. See the SCAMP protocol description document for more details (26 bits/s).
- SCAMPOOK, the standard SCAMP OOK mode (26 bits/s).
- SCFSKFST the higher symbol rate FSK SCAMP (83 bits/s).
- SCFSKSLW the slow symbol rate FSK SCAMP (14 bits/s).
- SCOOKSLW the slow symbol rate OOK SCAMP (14 bits/s).
- SCFSKVSL the very slow symbol rate FSK SCAMP (7 bits/s).

Generally the slower the symbol rate, the high the signal-to-noise ratio and the lower the communications error rate.

If a new mode is selected, the "Mode Set" message appears briefly.

Because USB/LSB uses audio input rather than key/paddle or text input, transmission is activated differently. Rather than using the "Key" or "Tx" modes, the push-to-talk (PTT) button is pressed, and one speaks into a microphone plugged into the MIC/Line In jack, and the transmitter is automatically keyed. The PTT input is the same as the "dit" paddle/straight key input. One will not receive a band-change warning in this instance. For sufficient amplification of the audio signal, the gain jumpers (JP6/JP9 on SMT board or JP3/JP4 on display board) should be placed on the microphone audio circuit. While one is transmitting, the signal strength bar shows the magnitude of the audio signal. Speak so that it fills the entire range of the bar, but only briefly peaks at the end of the range rather than spending most of its time peaked, so that the audio is not overmodulated.

Reviewing the receive buffer

```
07000000 Rxv||||
OLD MESSAGE CQCQ
```

To review the received decoded message buffer, the “Rxv” option may be selected. If the option is selected with the enter or right button, the leftmost edge of the buffer is shown. If the option is selected with the left button, the rightmost edge of the buffer is shown. The left/right buttons may be used to move through the receive buffer to show its entire contents across the bottom line of the display. New decodes are added to the message buffer when received. Press the enter button to leave the review mode.

Transmit message mode

```
_
  CQ CQ DE KW4TI
```

To enter and transmit a message, select the “Tx” option. If the right or enter button is pressed, the cursor is placed at the left edge of the transmit buffer. If the left button is pressed, the cursor is placed at the right edge of the transmit buffer. Any previous message remains in the transmit buffer until it is deliberately cleared or power is lost. To enter a character, the up and down buttons may be used to scroll through the available characters with which a message may be composed at the current cursor position. The left or right buttons may be used to change the cursor position. If a PS/2 keyboard is present, this may be used to enter a message.

When one has finished composing the message, the enter button can be pressed. The top line then contains transmit options, which may be viewed using the up and down buttons, and selected with the enter button. The options are:

- Return: return to message composition.
- Txmit: transmit the message immediately. As the message is transmitted, the outgoing message is scrolled across the display, with the cursor indicating the current symbol being transmitted. Pressing enter again aborts the transmission.
- Quit: leave the transmit message mode back to the main menu. The contents of the transmit message buffer are preserved.
- Clear: clear the contents of the transmit buffer and re-enter the transmit buffer compose mode, with the cursor at the left edge of the buffer.

Band change warning

If one attempts to transmit at a frequency that does not correspond to an amateur frequency band, the following message is displayed when entering transmit, keying, and external control modes:

```
13560000 Tx ||||
Unknown band
```

For example, this is an ISM band frequency (13.56 MHz), which is not a valid amateur radio band frequency, and so the RFBitBanger reminds the operator that this is not a valid frequency.

If one attempts to transmit in a known band, but this band is different than the last band in which the radio transmitted, the following message is displayed:

```
14074000 Tx ||||
Chg band module
```

For example, if the last transmission was in the 40 meter band, perhaps 7.074 MHz, and a transmit is attempted in the 20 meter band, at 14.074 MHz, this message is displayed.

When these messages are displayed, the right button may be pressed to proceed, or the left button may be pressed to return to the main menu.

When one attempts to transmit with the radio the first time after powering on, the “Chg band module” message is displayed to remind the operator to check to see if the installed band module is appropriate for the transmit frequency.

The “Band Warn Off” under the configuration “Cfg” may be set to 1 to eliminate this warning. However, having the wrong band module inserted when transmitting may cause damage to the output RF transistors, so it is wise to keep the warning turned on so that one is reminded to change the band module any time the transmit band is changed.

Keying Mode

```
07000000 Key||||
  CQ CQ DE KW4TI
```

Keying mode may be entered by selecting the “Key” option. “Keying Mode” is briefly displayed when entering this mode. To exit this mode, press the enter button, and “Keying Exit” is briefly displayed. The CW transmission mode is automatically selected when entering the keying mode. In this mode, one can use an external key or the buttons to send CW. Either a straight key may be used, in which case the tip of the connector is the key, or an iambic key is supported, with the tip being the dit and the ring being the dah. The CW WPM should be configured if iambic key is used to control the lengths of the dits, dahs, and interelement pauses. The down button can be used to key the transmitter in straight key mode. The transmitted signal at the shown VFO frequency and the BFO frequency is 667 Hz below the VFO frequency. Incoming CW transmissions are decoded with the built-in CW decoder if these fall within the receive filter centered at the VFO frequency. Outgoing transmissions are also decoded.

If the "CW Practice" option in the configuration "Cfg" menu is set to 1, the transceiver does not transmit when in the keying mode and decodes the keyed input, so that one can practice keying with the built-in radio CW decoder.

External Control Mode

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07074000 Ext||||
```

External control mode may be used to operate the transceiver using a sound card with FSK modes. This would be commonly used for FT8 and other modes of WSJTX. Digital mode software should be configured for VOX rig control as the presence of a tone is used to key the transmitter. Before entering the external control mode, the frequency should be set to the VFO frequency assuming upper sideband modulation (for example 7.074 MHz for FT8 in the 40 m band). Select the external control mode and press the enter button, and the "Ext Mode" message is displayed briefly. Tones received in the microphone input port prompt the transmitter to key up and transmit the tone at an offset from the VFO frequency. The received audio is transmitted through the speaker/headphone jack. The volume and gain should be set at a moderate level so that the software can decode the signal. Pressing the enter button leaves the external control mode, with the message "Ext Exit" being displayed briefly.

Configuration Mode

```
CW WPM
20
```

The configuration mode brings up a menu of items that can be changed to customize the radio's operation and calibrate the crystal frequency. Each item is a number that may be changed by using the left and right buttons to select a digit, up and down buttons to change the digit, and the enter button to accept the change. The options are:

- Quit: return to the main menu.
- Save Conf: save the configuration in EEPROM to be restored on power-up.

- Calib Xtal Src: calibrate the crystal frequency by tuning to an external transmission (see procedure).
- Wide Filters: 0 for narrowband standard filters for CW and RTTY decode, 1 for wide filters.
- Backlight: backlight off (0) or on (1).
- CW WPM: send speed for CW in words per minute.
- SSB Gain: a number from 0-31 indicating the gain of the audio signal.
- SCAMP Resync: how often a resync signal should be sent during a SCAMP transmission. Zero means only send at the beginning of a transmission. A nonzero number indicates a sync to be resent again after the number of frames have been transmitted. More frequent resync transmissions prevents desynchronization at the receiver.
- SCAMP Repeat: how many times each SCAMP frame should be repeated. The default is one, which means each frame should be sent only once, but it can be increased to try and ensure the message gets through.
- RTTY Repeat: how many times letters and figures codes should be repeated. The default is one, but more repeats can help the receiver be more resistant to selecting the wrong character set.
- RIT Shift Freq: The RIT (Receiver Incremental Tuning) frequency is an offset that the receiving frequency should be from the transmitting frequency. Normally this is zero, so that a transmitted and received signal occur at the same frequency. By specifying a nonzero RIT shift frequency, the receive frequency may be above or below the transmit frequency.
- RIT Dir 0+ 1-: This specifies the direction of the frequency shift for RIT. 0 means that the receive frequency is higher than the transmit frequency by the shift frequency, 1 means the receive frequency is lower than the transmit frequency by the shift frequency.
- Sidetone Freq: frequency in Hz that should be sounded over the speaker (not over the transmission) when a dit or dah is transmitted.
- Sidetone On: whether or not a sound should occur over the speaker when a dit or dah is transmitted. 0 is no sidetone, 1 adds sidetone.
- Ext Fast Mode: set to one for a faster but less accurate way to measure external tone frequency in external control mode which is useful for faster FSK modes. Generally set this to zero for WSJTX.
- Ext LSB: directs the external control mode to transmit on the lower side band (=1) rather than the upper side band (=0). Generally leave this zero.

- CW Iambic: Iambic paddle mode (1) or straight key mode (0).
- CW Iambic Type: Iambic mode B (1) or iambic mode A (0).
- Iambic switch: swap the dit and dah paddles (1) or do not swap (0).
- CW Practice: if this equals one, then the radio does not transmit in Keyer mode and decodes the keyed input.
- CW Mark->Spaces: Determine the spaces timing from the marks timing when decoding CW, rather than determining these independently.
- CW Smooth: Smooth the received amplitude envelope when decoding CW, which is helpful when decoding slow CW in heavy noise. It is recommended to use smooth or sticky interval at a given time, but not both.
- CW Sticky Interval: Increase/decrease the amount of time before a change in or mark or space is registered when decoding CW. It is recommended to use smooth or sticky interval at a given time, but not both. A longer sticky interval (6 to 9) is useful for slower CW receive speeds with noisy conditions.
- Band Warn Off: If this equals one, disable band change warnings. If this equals zero, display a band change warning when first transmitting on startup, and also when transmitting on a different band than before.
- Erase on send: erase the outgoing message buffer after sending the message (1), or keep the outgoing message buffer and it must be manually erased (0).
- Xtal Freq: the frequency of the crystal on the SI5351A oscillator. It can be calibrated using a frequency counter by setting the Xtal Freq to 25000000 Hz, setting the VFO frequency to 25000000 Hz, and then measuring the frequency on jumper JP5 with the frequency counter. This frequency can then be entered as the Xtal Freq. If the crystal calibration becomes corrupted, changing the Xtal Freq back to 25000000 Hz can be useful as a default calibration.

Calibrating the crystal oscillator frequency with a source on the air

The crystal in the radio can be calibrated using a broadcasted frequency standard such as WWV at 10 MHz. Here is the procedure for doing so:

1. Turn on the radio and wait 15 minutes or so for the crystal to reach an equilibrium temperature.

2. Set the transmission mode to CW.

3. Set the VFO frequency (in the Frq menu option) to the nominal calibration frequency, for example, for WWV at 10 MHz, set the VFO to 10000000.

4. Tune the VFO frequency down until the signal strength bar indicates a maximum amplitude. One should be able to get the signal strength to vary on a scale of +/- 10 Hz. Make sure the calibration signal is in the upper sideband (the BFO frequency is below the calibration frequency). If one increases the VFO frequency, the beat frequency tone should lower in pitch, and if one decreases the VFO frequency, the beat frequency tone should raise in pitch, if the calibration frequency is above the BFO frequency. If it is reversed, decrease the VFO frequency by approximately 1300 Hz and tune again for maximum amplitude.

5. Once the signal strength bar is maximized in amplitude, enter the “Cfg” menu option and the “Calib Xtal Src.”

6. Use the buttons to enter the actual nominal frequency. The frequency should already be filled in with a value close to the actual nominal frequency. For example, if the broadcasted frequency is 10 MHz, enter 10000000 and press the enter button.

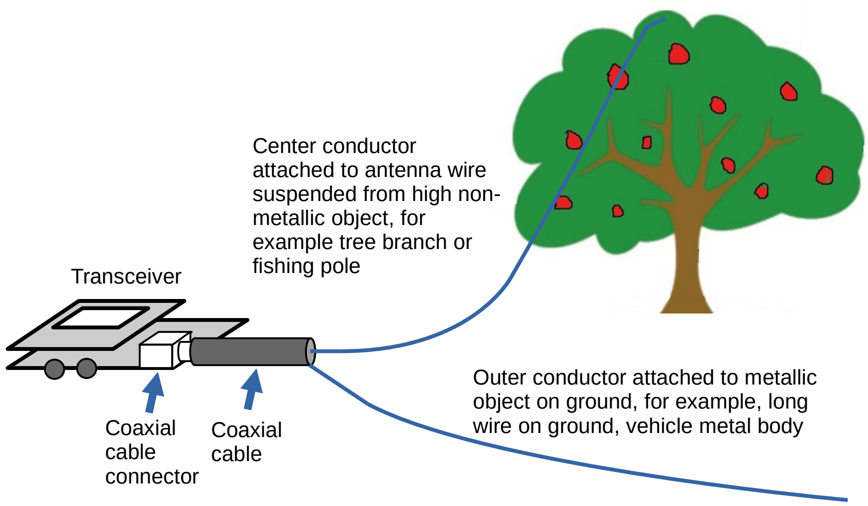
7. The radio performs an adjustment of the crystal frequency. Save the data to EEPROM memory and turn the radio off and on to have the calibration take effect.

8. Select the “Xtal Freq” in the “Cfg” menu. This should show the calibrated crystal frequency.

9. Set the radio to CW mode and tune to the actual nominal frequency. The signal strength should now be peaked at the nominal frequency if the procedure is performed properly.

10. Write this frequency on the front page of this document to save it in case the calibration should be erased from the EEPROM memory.

Constructing a wire antenna



A quarter-wavelength wire antenna can be easily constructed for a particular frequency band. The length of an antenna for a frequency band with a given wavelength is 0.235 to 0.24 times the wavelength, so for example, for the 40 meter band, the antenna length would be 9.4 to 9.6 m. If more objects are closer to the antenna, or the antenna element is closer to the ground, the antenna length tends to be shorter. In feet, the antenna length is 0.75 to 0.79 times the band wavelength in meters, so for example, for the 40 meter band, the antenna length is 30 to 31.6 feet long. If you are unsure of how long the antenna should be, start off with the antenna cut long because it is much more difficult to add length to an antenna than to cut off length. The following table shows the range of antenna lengths for the common bands:

Bandpass module / number	Antenna length range (meters)	Antenna length range (feet)
160 m / “16”	36.8 – 38.4 m	120.0 – 126.4 ft (120’0” – 126’5”)
80 m / “8”	18.4 – 19.2 m	60.0 – 63.2 ft (60’0” - 63’2”)
60 m / “6”	13.8 – 14.4 m	45.0 – 47.4 ft (45’0” - 47’5”)

40 m / “4”	9.2 – 9.6 m	30.0 – 31.6 ft (30’0” – 31’7”)
30 m / “3”	6.9 – 7.2 m	22.5 – 23.7 ft (22’6” – 23’8”)
20 m / “2”	4.6 – 4.8 m	15.0 – 15.8 ft (15’0” – 15’10”)
17 m / “17”	3.9 – 4.1 m	12.7 – 13.5 ft (12’8” – 13’6”)
15 m / “15”	3.45 – 3.6 m	11.3 – 11.8 ft (11’4” – 11’10”)
12 m / “12”	2.75 – 2.9 m	9.0 – 9.5 ft (9’0” – 9’6”)
10 m / “10”	2.3 – 2.4 m	7.5 – 7.9 ft (7’6” - 7’11”)

The antenna system consists of two parts: the wire antenna, which needs to be cut to the correct length and suspended from a high, nonconductive object such as a tree branch, and the ground, which is a large metallic object placed on or near the ground. The ground may be a long wire on the ground, a metal plate or sheet metal shed, a metal vehicle body, a water pipe, or other such improvised metal objects. Do not use pipes containing natural gas or other flammable contents as the ground.

The transceiver has two types of connections for antennas: a coaxial cable connection and a screw terminal connection. The coaxial cable connection is a metallic round connector over which a coaxial cable is connected. The coaxial cable has an inner conductor surrounded by an insulating dielectric, and an outer conductor which surrounds the inner conductor. The inner and outer conductor may be carefully separated so that they are not touching or electrically shorted together by ensuring the insulator between them remains intact. The antenna wire can be attached to the inner conductor by twisting the two wires together, or alternatively soldering or crimping them together. The outer conductor can be twisted with the ground wire, or the ground wire can be tied tightly around the conductor. Keep the wire connecting the outer conductor and the ground object (for example vehicle body) as short as possible, and try to get the end of the antenna wire as high as possible. For example, one might be able to tie the end of the antenna wire to a weight and throw the weight up into a tree.

The transceiver may be equipped with screw terminals for the antenna and ground wire connections rather than a coaxial connector. If this is the case, the terminal closer to the corner of the circuit board is the antenna terminal and should be marked “ANT” while the ground terminal is further from the corner of the circuit board and should be marked “GND.” A small screwdriver may be used to loosen the antenna terminal screw and open and widen the gap which holds the wires. One should see the gap widen as one loosens the screw. Insert the end of the wire into the gap and tighten the screw in order to secure it. The gap closes as the screw is tightened, clasping the wire. After the screw is tightened, give the wire a gentle tug to make sure it is being held firmly by the terminal.

Using the built-in RF ammeter

There is a built-in RF ammeter that can be used to optimize the antenna length for maximum power output. This is enabled by removing a shorting jumper from JP2. The red LED D16 glows brighter as the RF current through the antenna port increases. The power and LED brightness is maximized when the length of the antenna is slightly less than one-quarter wavelength at the frequency used as explained in the previous section. Output power can be transmitted briefly by entering Keying mode and using the down button to key up the transmitter. A dummy load such as a 50 ohm, 3 watt resistor may be attached to see how brightly the LED should glow with a matched antenna. A ground should be connected to the radio such as a large metallic object or counterpoise wire. The jumper JP2 should be replaced for normal operation. It is normal for the red LED to glow weakly during normal transmission even with JP2 shorted.

To tune an antenna, start with the antenna wire longer than the expected. Test the antenna by attempting to transmit. Note the level of glowing of the LED, and compare the brightness of glowing to that of the 50 ohm dummy load resistor. Disconnect the antenna wire from the transmitter, shorten it about 5 cm at a time by clipping the end of the wire, reconnect the new end into the transmitter, and transmit again. As the wire is shortened, it should become a more efficient radiator and the LED should gradually get brighter. The antenna may not be able to light up the LED quite as brightly as the dummy load, but the levels should be comparable.

Choosing a frequency band

High frequency radio waves (1.8 MHz to 30 MHz) rely on a number of effects to be able to propagate around the world, and it is beyond the scope of this document to describe these effects. Propagation on a particular frequency band depends on the time of day, season, and current solar activity, among other factors. Some simple rules of thumb may be used to select a frequency band.

The frequency band that is most likely to be available at any time is the 40 m band (7000 to 7300 kHz in Region 2, 7000 to 7200 kHz other regions), and so if the most reliable communication is required, this band should be considered first. It is generally available both during the daytime and at nighttime, with night propagation being slightly better.

During the day, the most likely frequency band that is useful is the 20 m band (14000 to 14350 kHz). This band typically becomes available in the early morning and lasts until dusk. Propagation is most likely on this band between two stations that are both on the daylight side of the planet.

During the night, a useful frequency band is the 80 m band (3500 to 4000 kHz). This band becomes available in early evening and lasts until dawn. During summer months, lightning strikes and thunderstorms can create a significant noise background heard as pops in the receiver. Propagation is most likely on this band between two stations that are both on the nighttime side of the planet.

The 60 m, 30 m, 17 m, and 12 m bands are known as WARC bands and tend to be less frequented, but also less congested, than the main three bands of 20, 40, and 80 m bands.

Each band generally has a “band plan” which indicates which types of transmissions that are favored by amateur radio operators on particular frequency ranges inside the band. A response is more likely if the transmission type conforms to the band plan. Generally, the lowest frequencies of a band are reserved for low bandwidth modes such as CW, RTTY, and low bandwidth data modes, and the higher frequencies tend to be phone/AM/SSB and high bandwidth data modes.   For example, CW is most often communicated in CW in the 80 meter band at 3500-3570 kHz, in the 40 meter band at 7000-7070 kHz, and in the 20 meter band at 14000-14070 kHz. These are not hard limits and only guidelines. Because the RFBitBanger specializes in low bandwidth modes, a response is more likely to a call on the lower frequencies on a band as permitted by one’s station license.

International Amateur Radio Union Emergency Communications Frequencies

The following is a table of the frequencies designated by the IARU for emergency communications. This does not include other frequencies that countries designate for emergency communications. Because of message traffic congestion, one may need to connect on a nearby frequency up to 20 kHz from the designated frequency.

Region 1 Europe, Africa, Russia, Middle East west of the Persian Gulf (kHz)	Region 2 North America, South America, Greenland (kHz)	Region 3 East Asia, India, Australia, New Zealand, Oceania, Middle East east of the Persian Gulf (kHz)
3760	3750 or 3985	3600
7110	7060, 7240, or 7275	7110
14300	14300	14300
18160	18160	18160
21360	21360	21360

The IARU has information about published emergency communications frequencies:

https://www.iaru-r1.org/about-us/committees-and-working-groups/emcomm/emergency-communications-frequencies/

Write down any emergency frequencies below:

Frequency (kHz)	Description

Listening to terrestrial AM broadcasts and shortwave stations with the RFBitBanger

The RFBitBanger may be used to listen to AM (amplitude modulation) stations in the terrestrial broadcast band in the range of 530 to 1700 kHz, however, it is not ideal for doing so. If the radio receiver is tuned to an AM broadcast station, a strong tone is likely to be heard as well as a “warbling” sound. This is because the demodulator of the RFBitBanger uses a mixer, not an envelope detector, as a typical AM broadcast receiver would use. However, if one tunes the receive frequency so that the tone is as low frequency as possible as to be inaudible, so that the receiver frequency is closely aligned with the carrier frequency of the AM station, the tone and warbling effects are minimized and the station can become clearly audible. However, this may require tuning the radio to a frequency accuracy better than 10 Hz.

Similarly, shortwave radio stations that use AM broadcasting can be similarly tuned. The following are common shortwave broadcast bands:

Frequency Range	
2.3 – 2.5 MHz	Mostly used locally in tropical regions.
3.2 – 3.4 MHz	Mostly used locally in tropical regions.
3.9 – 4.0 MHz	Mostly used in the Eastern Hemisphere after dark.
4.75 – 4.995 MHz	Mostly used locally in tropical regions.
5.9 – 6.2 MHz	Night-time reception year-round.
7.2 – 7.45 MHz	Good reception at night, 7.2 – 7.3 MHz is in 40 m amateur radio band in ITU Region 2.
9.4 – 9.9 MHz	Night-time reception year-round, during the day at various times of the year.
11.6 – 12.1 MHz	Best during the summer and around sunset every season.
13.57 – 13.87 MHz	Used in Europe and Asia, best in summer.
15.1 – 15.83 MHz	Daytime reception is good, nighttime intermittent, best season is summer.
17.48 – 17.9 MHz	Daytime reception is good, nighttime intermittent, best season is summer.

Constructing the RFBitBanger

The RFBitBanger is designed to have options for its construction:

- A SI5351A may be used as the oscillator for the VFO. A SI5351A and crystal may be soldered directly to the PCB, or a SI5351A module may be plugged into the PCB through a seven pin socket.
- A pulled crystal oscillator may also be used as the VFO, which can tune over a narrow bandwidth.
- The RFBitBanger may be constructed to not require the display PCB. The push buttons may be added to the main PCB, or may be added to the display PCB. The HD44780 display itself can be attached to the main PCB or the display PCB. Push buttons should not be soldered onto the main PCB and the display PCB at the same time or both sets of buttons may become inoperable.
- The MOSFETs may either be 2N7000 or BS170 types. 2N7000 types have the order of the leads as source-gate-drain, while BS170 have the order as drain-gate-source, and so BS170s may be used in place of the 2N7000s if these are soldered in the opposite way.
- Transistors Q3, Q5, Q6, Q7, and Q8 may be placed in contact with the PCB so that the PCB can act as a heatsink. Holes in the PCB can be used with appropriate screws, nuts, and washers (4/40 or M3) to put pressure on the transistors against the PCB, and heatsink compound between the transistors and the PCB can also help heat conduction.
- Two different types of potentiometers are supported: B10K-types, and ALPS miniature types, both being 10k in maximum resistance.
- The 100 uH axial RF choke inductors can be wound on small ferrite beads or cores if the axial inductors are not available, as the value of the inductance is not sensitive.

Schematic indications and footprints

- Resistors and capacitors that are marked as “NC” indicate no connection and should be omitted.
- Resistors that are marked as “0R” mean 0 ohms and may be substituted with a zero ohm resistor or a wire.
- All resistors are ¼ watt through-hole types, except where as indicated.

- 10 nF and 100 nF are 2.5 mm lead spacing ceramic disc capacitors, all others are 5 mm lead spacing capacitors, except for a few 10 and 100 nF capacitors that also have 5 mm lead spacing.
- All TO-92 devices use a wide lead spacing for easy mounting and repair.

Winding and mounting the toroids

- The wire used should be a minimum of 0.5 mm diameter (26 AWG) magnet wire.
- The wire enamel may be removed from the wire by drawing the wire through sandpaper several times with gentle pressure applied. A razor blade may also be used to scrape the enamel off carefully, as the copper wire cuts easily.
- L4 and L6 are RF chokes wound on T37-43 or T50-43. There should be at least 12 turns of 0.5 mm wire on these toroids. These will stand up on the PCB.
- T4 is a bifilar common-mode choke wound on a T37-43 or T50-43 core. Twist two magnet wires together for a total length of approximately 30 cm. Wind them together around the core at least 7 times. Separate the two pairs of wires on each side and use a continuity tester to determine which wire is connected to the other on each side. Keep the two ends of the two wires together on each side; do not swap the ends of the wires. Solder one of the connected wires between the pads marked 1 and 2, and the other connected wire between be pads marked 3 and 4. If the two ends of the two wires are kept together and soldered into pads 1 and 3, and the other two ends of the two wires are soldered into the other two pads 2 and 4, the toroid should stand up freely on the PCB and not be twisted over by the wires. The silkscreening shows the pads that are connected together by wires through the ferrite core.
- T1 and T2 are trifilar (three winding) balun transformers wound on a T37-43 or T50-43 core. Twist three wires together for a total length of approximately 30 cm. Wind them together around the core at least 5 times. Separate the ends of the three wires on each side and use a continuity tester to determine which wire on each side is connected to each wire on the other side. Keep each end of the three wires separated on each side; do not swap the ends of the wires. Solder one of the connected wire between the pads marked 1 and 2, another of the wires between the pads marked 3 and 4, and a last of the three wires between the pads marked 5 and 6. If the three ends of the wires are kept together on one side and soldered in pads 1, 3, and 5, and the other three ends of the wires are kept together on the other side and soldered in the pads market 2, 4, and 6, the toroid should stand up freely on the PCB and not be twisted over by the wires.
- T3 is the current sampling transformer. There are five turns around T3 that connect to the two pads with the undulating line between them. There is a single turn (a wire passing through) the

center of the toroid which is soldered between the two pads that are connected by the dotted line.

- The toroids on the band pass filter PCBs are on T37-2 or T50-6 forms. Wind the indicated number of turns through the toroid and solder the toroid down to the PCB through the mounting holes. These lay flat on the PCB.

Jumpers used on the main PCB

JP1: This is normally shorted, and is removed for full break in QSK.

JP2: This is shorted to take the RF current sample LED out of the circuit, or opened so that the RF sample LED grows brightly with added RF current at the antenna port.

JP4: This may be placed to bypass the output bandpass filter. The transceiver should always be operated with a bandpass filter in order to comply with telecommunications regulations, however, in an emergency, this jumper may be placed to bypass the filter so that a signal may be transmitted.

JP5: This selects either the SI5351A oscillator or the pulled crystal oscillator.

JP8: This should be shorted if the pulled crystal oscillator is not used.

JP6/JP9: SMT only-Closed when a microphone is attached to input, open for line-level audio input.

Jumpers used on the display PCB (through-hole only)

JP1, JP2: Swap RX/TX to tip/ring of 3.5 mm jack used for a serial connection.

JP3/JP4: Closed when a microphone is attached to input, open for line-level audio input.

Adjustment potentiometers

RV3: This is used to adjust the contrast on the LCD. If the LCD appears blank or has dark bars on it, adjust this so that the letters appear.

RV4: This is the MOSFET bias adjustment. This should be adjusted so that the bias on the MOSFET gates Q3, Q5, Q6, Q7, Q15 is 2.0 to 2.5 volts. If power consumption is excessive when transmitting, this voltage may be reduced. The voltage on the MOSFET gates can be measured using a voltmeter either at the center lead of Q3, Q5, Q6, or Q7, or at the cathode of diode D17.

Connecting the main and display PCB

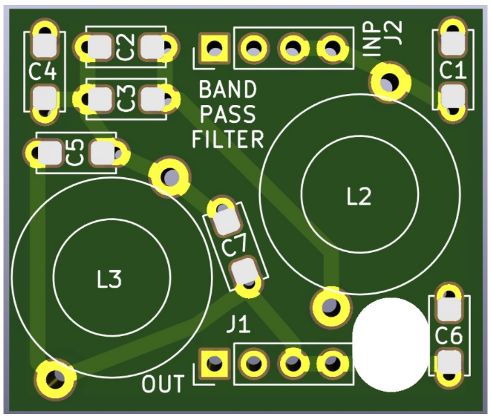
A 40 pin dual female IDC ribbon cable is used to connect the main and display PCB. A short cable can be made by pressing two 40 pin IDC female connectors onto a 40 pin ribbon cable, all of which often can be found from old IDE cables. If the cable is too long, often the connector can be pried off the cable and reclamped at another place.

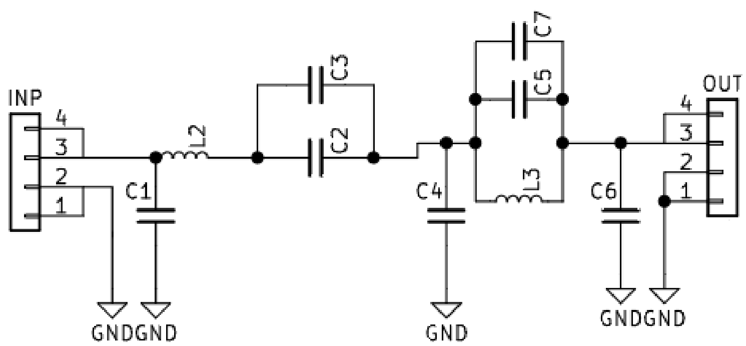
Constructing the serial resonant bandpass filters

Each serial resonant bandpass filter is assembled onto a small PCB that plugs into the main PCB in the lower right corner. There are two pin sockets on the filter, the input socket “INP” and the output socket “OUT” which are connected to the same silkscreened sockets on the main PCB. The components used in each filter are denoted in the table below. The capacitors C2 and C3 may be either a single capacitor of the full value, or two capacitors that add up to the total capacitance. The range of capacitance and two common values capacitances that add up to the total capacitance are suggested in the table. Similarly, C5 and C7 may be a single capacitor or two capacitors that add up to the total capacitance shown in the table. There are two inductors L2 and L3. These should be wound onto the toroid types given, for example T50-6 (which is a ½ inch or 50/100” diameter toroid made of type 6 powder iron core material and is a yellow color, or T37-2 (which is a 37/100” diameter toroid made of type 2 powder iron core material and is a red color). For the smallest values of inductance, an air core inductor may be used, which is wound on a 1/4” or 3/8” diameter form. A drill bit is convenient to use as a form. The wire used is 1 mm diameter or 18 AWG so that it more readily holds its shape. The inductance of the air core may be fine tuned by separating the coils to decrease the inductance.

The capacitors used in the serial resonant bandpass filter should be NP0/C0G which have low loss and a nearly constant capacitance with temperature. The capacitors found in most ceramic capacitor assortment kits are X7R or Y5V type and are unfortunately unsuitable, and so it is likely that NP0/C0G types have to be specially obtained. Unfortunately, through-hole ceramic disc NP0/C0G capacitors have become quite rare and expensive as of the time of this writing. Mica capacitors can also be substituted as well, but may be even harder to obtain. For this reason, 1206-size NP0/C0G surface mount capacitors are recommended to be used. These are relatively inexpensive and large enough to handle so that most people comfortable who can solder ceramic disc capacitors can also solder 1206-size surface mount capacitors. The surface mount capacitors can be held with tweezers or tacked down temporarily with tape so that one terminal of the capacitor is soldered, at which point the temporary support can be removed and the other terminal soldered. The footprints on the serial resonant filter PCB are designed to take either a 1206 surface mount or a ceramic disc through-hole capacitor, and a 0805-size capacitor can be attached as well.

The 4 pin headers should be added last to the serial resonant bandpass PCB as this will make the PCB easier to assemble. These should be inserted into the bottom side of the PCB. There is a white region of the silkscreen on which a number indicating the filter band may be written.





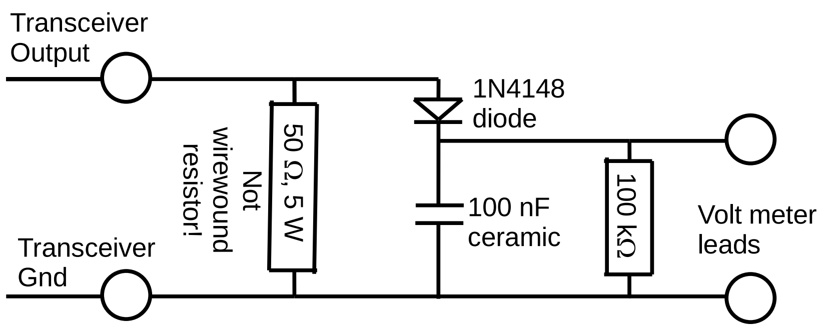
Under normal circumstances, the transceiver should be operated with the appropriate bandpass filter so that when transmitting, the signal being transmitted complies with telecommunications regulations. However, in an emergency, the JP4 jumper may be closed to bypass the bandpass filter. The resulting radiated signal will be inefficient and rich in harmonics, however, the signal should be able to be received.

Serial resonant bandpass filters component values

Band	C1	C2+C3	C4, C6	C5+C7	L2	L3
80 m	680 pF	2200 pF	2200 pF	680 pF	1.45 uH T50-6 or T37-2, 19 turns air coil, 1 mm wire, 13-14 turns around 12.5 mm (1/2” drill bit) form	0.68 uH T50-6 or T37-2, 13 turns air coil, 1 mm wire, 10-11 turns around 9.5 mm (3/8” drill bit) form
60 m	470 pF	1500 pF	1500 pF	470 pF	1.05 uH T50-6 or T37-2, 16 turns air coil, 1 mm wire, 10-11 turns around 12.5 mm (1/2” drill bit) form	0.49 uH T50-6 or T37-2, 8-9 turns air coil, 1 mm wire, 15-16 turns around 9.5 mm (3/8” drill bit) form
40 m	330 pF	1000 pF	1000 pF	330 pF	0.77 uH T50-6 or T37-2, 12 turns air coil, 1 mm wire, 12-13 turns around 9.5 mm (3/8” drill bit) form	0.36 uH T50-6 or T37-2, 8 turns air coil, 1 mm wire, 7-8 turns around 9.5 mm (3/8” drill bit) form
30 m	220 pF	680 pF	680 pF	220 pF	0.54 uH T50-6 or T37-2, 11 turns air coil, 1 mm wire, 9-10 turns around 9.5 mm (3/8” drill bit) form	0.25 uH T50-6 or T37-2, 7 turns air coil, 1 mm wire, 5-6 turns around 9.5 mm (3/8” drill bit) form
20 m	150 pF	470 pF	470 pF	150 pF	0.39 uH T50-6, 9 turns, air coil, 1 mm wire, 7-8 turns around 9.5 mm (3/8” drill bit) form	0.18 uH T50-6, 5 turns air coil, 1 mm wire, 4-5 turns around 9.5 mm (3/8” drill bit) form
17 m	100 pF	390 pF	390 pF	100 pF	0.32 uH T50-6, 8 turns air coil, 1 mm wire, 5-6 turns around 9.5 mm (3/8” drill bit) form	0.14 uH T50-6, 5 turns air coil, 1 mm wire, 5-6 turns around 9.5 mm (3/8” drill bit) form
15 m	68 pF	330 pF	330 pF	100 pF	0.26 uH T50-6, 8 turns air coil, 1 mm wire, 5-6 turns around 9.5 mm (3/8” drill bit) form	0.12 uH T50-6, 5 turns air coil, 1 mm wire, 5-6 turns around 6.25 mm (1/4” drill bit) form
12 m	47 pF	330 pF	330 pF	100 pF	0.22 uH T50-6, 7 turns air coil, 1 mm wire, 5-6 turns around 9.5 mm (3/8” drill bit) form	0.10 uH T50-6, 4 turns air coil, 1 mm wire, 5-6 turns around 6.25 mm (1/4” drill bit) form
10 m	33 pF	270 pF	220 pF	82 pF	0.19 uH T50-6, 7 turns air coil, 1 mm wire, 4-5 turns around 9.5 mm (3/8” drill bit) form	0.09 uH T50-6, 4 turns air coil, 1 mm wire, 4-5 turns around 6.25 mm (1/4” drill bit) form

Nominal air-core inductance values calculated from 1 mm diameter wire with 1 to 1.5 mm turn spacing. When in doubt, an extra turn or two can be added to the coil length and the inductance decreased by spacing coils apart.

It is helpful to adjust the spacing between the turns on the inductors because this allows finer adjustment to maximize power. Once the desired spreading of the turns is achieved, an adhesive such as cyanoacrylate glue can hold the turns in place. A simple circuit can be used to measure the power output of the transceiver as shown below. The CW mode with a straight key (down button) may be used to transmit a continuous signal for measurement. A dummy load of 50 ohm and 5 W resistor is used, and it should be a thick or thin film metal resistor or a carbon resistor, but not a wirewound resistor. A diode is used to rectify the RF voltage and it is measured on a ceramic capacitor using a voltmeter (for example a multimeter or galvanometer). The voltage output V is the peak RF voltage, and the RF power P can be calculated by $P = V^2/100$ so for example 20 V peak output voltage corresponds to 4 W of RF power.



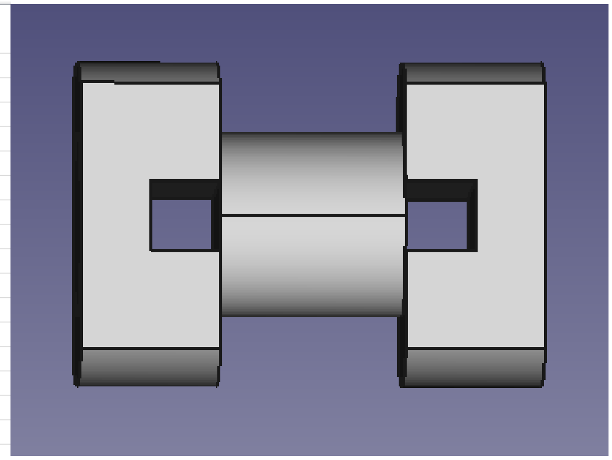
3-D printable parts in the RFBitBanger project

There are a number of helpful 3-D printable forms included in the RFBitBanger project. These were designed with the FreeCAD software (https://www.freecad.org/) as parametric models and so their dimensions can be modified by changing values in a spreadsheet.

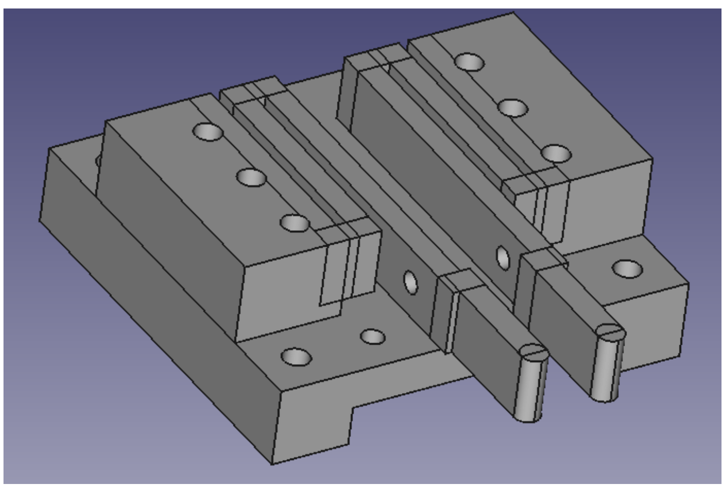
RFBitBanger Case for SMT version: a case consists of three files “TopCase-SMT.stl,” “BottomCase-SMT.stl,” and “ButtonExtension.stl.” The “TopCase-SMT” and “BottomCase-SMT” files are a top and bottom piece that clamp over the SMT version of the radio. They are held together by 4-40 X ½” screws and nuts or M2.5 X 12 screws and nuts. Five “ButtonExtension” parts are used to push through the “Topcase-SMT” part so that the buttons on the PCB can be pressed from the outside of the case.

“InductorBobbin” and “AxialInductorBobbin”: these are parametric FreeCAD files that can be used to design printable coil forms for air core inductors. The various dimensions of the form are entered at the top of the form and the part is modified to conform to these dimensions. At the same time, the wire diameter may be entered to determine the pitch. The inductance, resistance, and reactance of the coil form with the given wire diameter and number of turns is calculated, and the form dimensions may be adjusted to achieve a desired inductance. The axial inductor bobbin and the corresponding spreadsheet is shown below.

A	B	C	D	E	F
			750.00 nH	360.00 nH	180.00 nH
Bobbin Diameter	4.00 mm		5.75 mm	5.00 mm	4.00 mm
Bobbin Length	4.00 mm		7.50 mm	5.50 mm	4.00 mm
Lip Diameter	7.00 mm				
Lip Length	3.00 mm				
Lip Hole Diameter	1.50 mm				
WireDiameter	0.50 mm				
Calculated Turns	8				
Turns	8				
Frequency (Hz)	14.00 MHz				
Wheeler's Inductance	173.46 nH				
Q	77.95				
Reactance	15.26 Ohm				
Resistance	0.20 Ohm				
Wire Length	100.53 mm				



“PaddlesKey” and “PaddlesKeyGroundCenter”: two iambic keys, the difference between them being that the ground center is the more common arrangement with the two paddles wire to the tip and ring of the jack and a grounded post between the paddles, while the other arrange is with the less common arrangement with two posts wired to the tip and the ring, and each paddle grounded.



Troubleshooting problems with the RFBitBanger

If the RFBitBanger stops functioning, usually it is due to a few types of problems.

First, make sure the gain and volume are turned up so that the audio can be heard and that the speaker is connected.

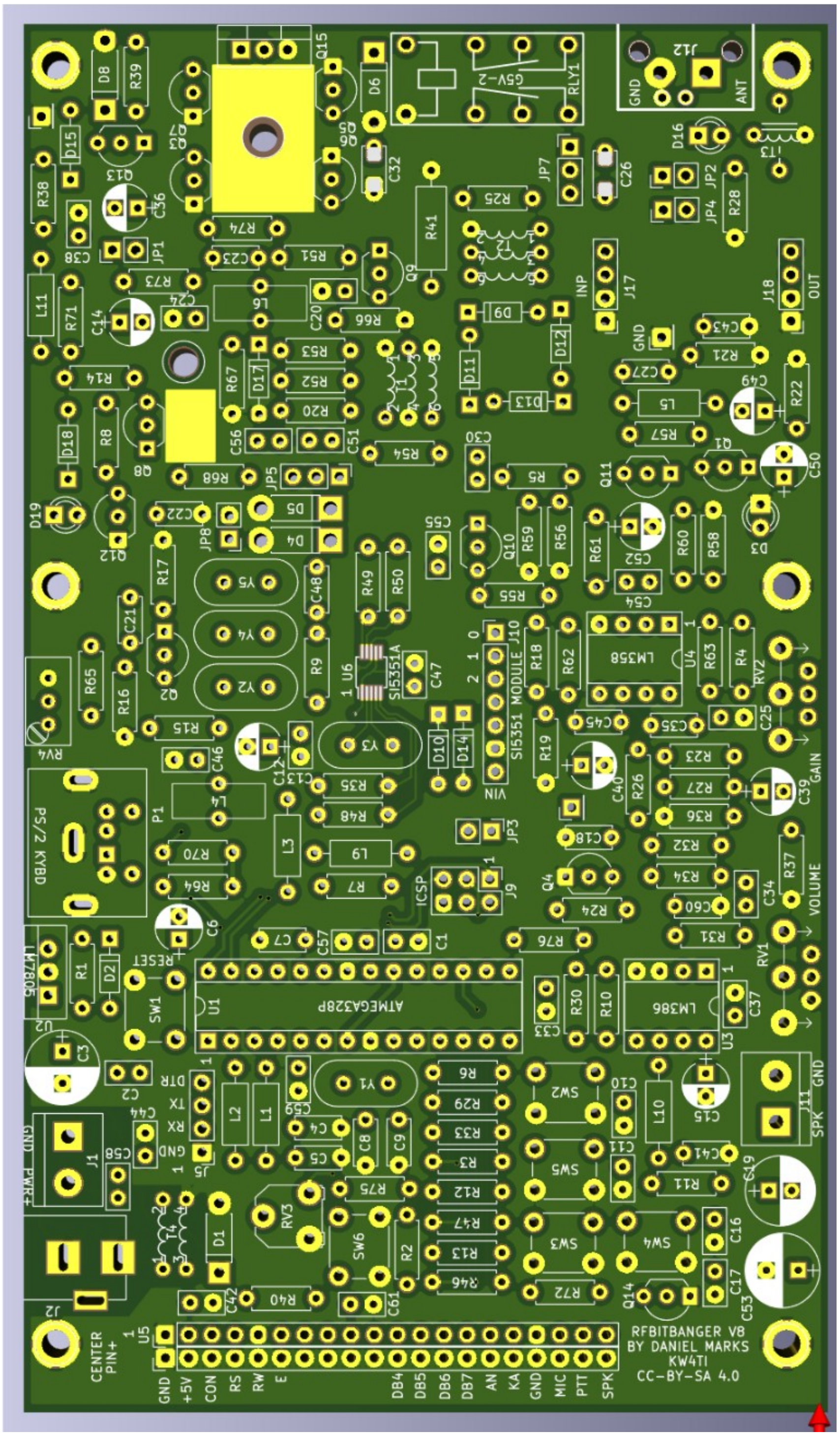
Like any electronic device, 90% of the time when there is a failure, it is because of a mechanical problem. It can be, for example, a loose cable or a worn connector. One can gently push on a questionable connector or part with one's finger to determine if it is making intermittent contact. If so, sometimes the problem is because the connector is worn and needs to be replaced. If integrated circuits are socketed, push the integrated circuits back into their sockets to make sure these are firmly seated and no pins are bent out of the socket. Near the integrated circuit socket, the digit "1" has been silkscreened to indicate the position of pin 1 of the integrated circuit. The side of the integrated circuit with pin 1 is usually marked with a notch on the edge of the package, or a dot on the package in the corner with pin 1. Cables should also be pushed back onto their pins to make sure they are seated properly, and are not offset by a row or column of pins.

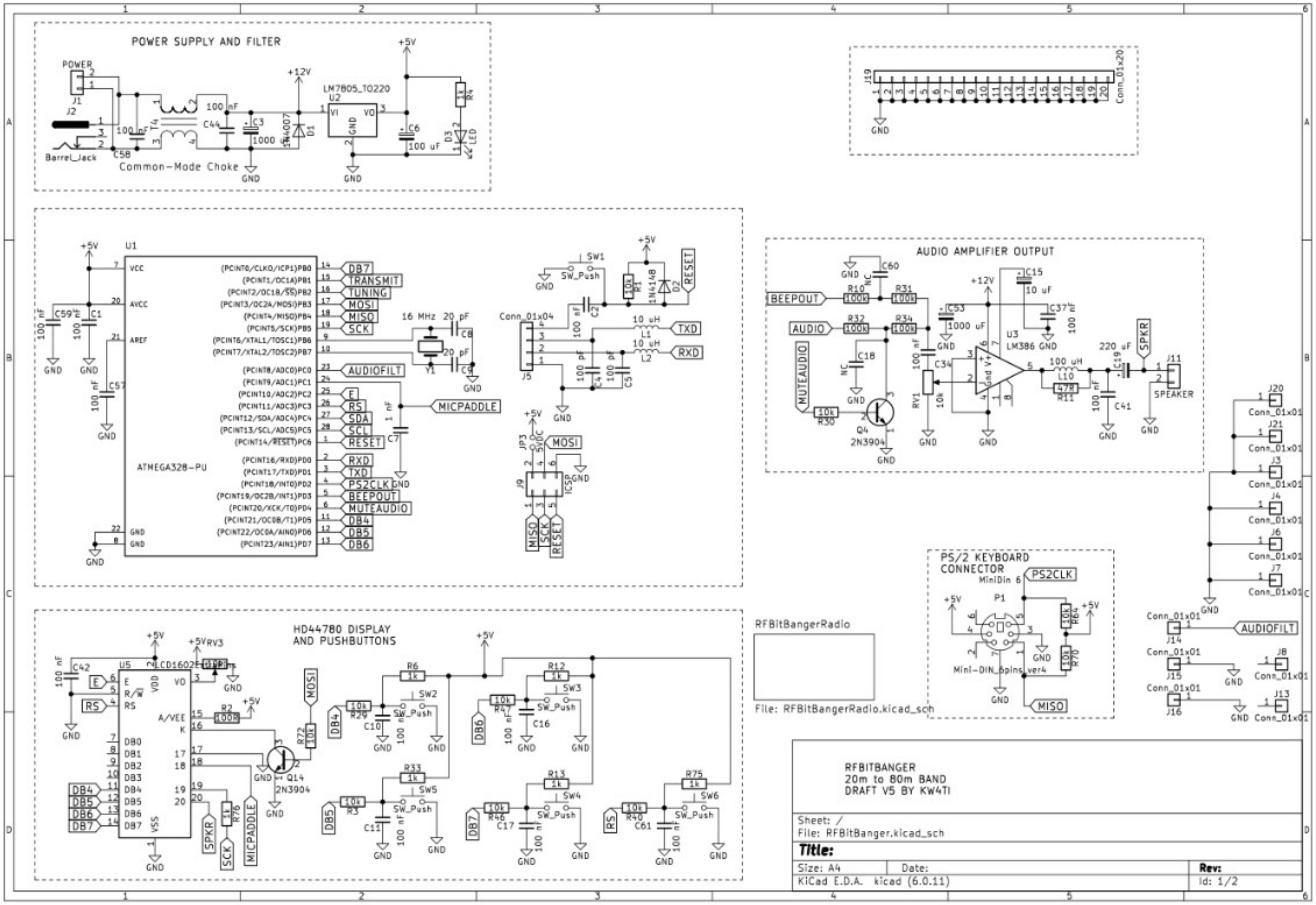
Sometimes it is because of a solder joint that has either cracked, because solder is a brittle metal, or because the solder joint was not formed properly. In either case, one can reheat the solder joint with a soldering iron to melt and reform the joint. There is usually little risk in reheating a solder joint, so any questionable connections can be reheated as needed as long as the heat is applied only long enough for the solder to melt. If electricity is not available, there are soldering irons that are heated by butane torches, or the end of a metal rod can be heated and placed in contact with the solder joint.

If the radio does not transmit, it is likely that one or more of the 2N7000 transistors which are positions Q3,Q5,Q6, and Q7 could be damaged. If when transmitting, one or more of the transistors becomes too hot to touch in a few seconds, this transistor has likely failed. The transistor should be removed and replaced. The flat side of the transistor should face the same direction as the flat side of the half-circle showing the orientation of the transistor on the silk screen.

The thin magnet wires on the toroids should be inspected to see there are any kinks or cuts as these are rather thin and can be severed easily. If the wire on the toroid is broken, it can be replaced with an insulated wire that is thin enough to be wrapped a sufficient number of times around the toroid.

Schematic and PCB Layout of the Main PCB





POWER SUPPLY AND FILTER
Common-Mode Choke
LM7805_TO220
ATMEGA328-PU
AUDIO AMPLIFIER OUTPUT
LM386
PS/2 KEYBOARD
CONNECTOR
HD44780 DISPLAY
AND PUSHBUTTONS
RFBitBangerRadio
File: RFBitBangerRadio.kicad_sch
RFBITBANGER
20m to 80m BAND
DRAFT V5 BY KW4TI
Sheet: /
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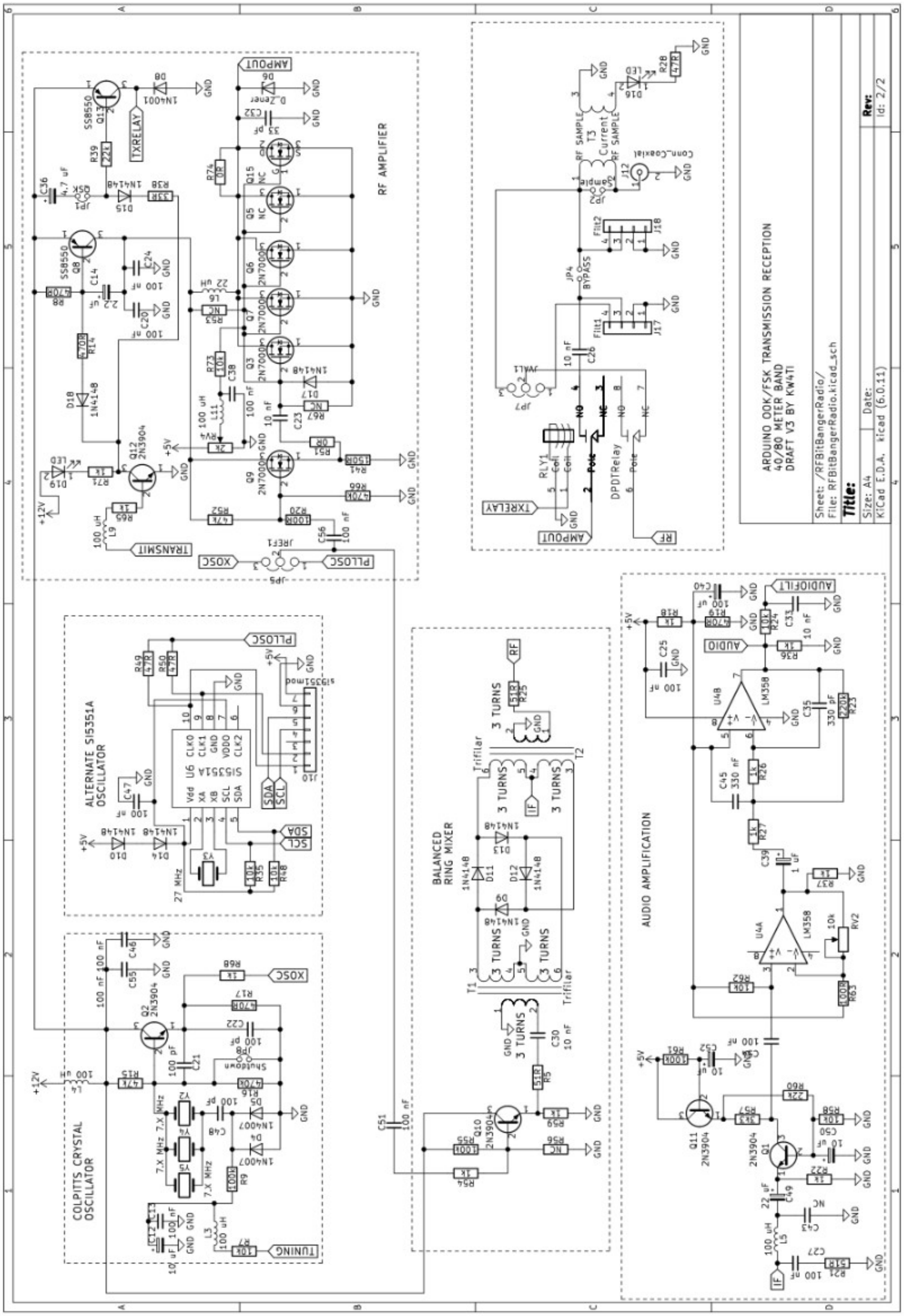
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad (6.0.11)
Id: 1/2



ARDUINO OOK/FSK TRANSMISSION RECEPTION
40/80 METER BAND
DRAFT V3 BY KW4TI
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Title:
Size: A4
Date:
KiCad E.D.A. kicad (6.0.11)
Rev:
Id: 2/2
RF AMPLIFIER
COLPITTS CRYSTAL OSCILLATOR
ALTERNATE SI5351A OSCILLATOR
BALANCED RING MIXER
AUDIO AMPLIFICATION

Bill of Materials, Main PCB

Ref	Value	Footprint
C1	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C2	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C3	1000 uF	10 mm, 25 V radial electrolytic capacitor
C4	100 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C5	100 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C6	100 uF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C7	1 nF	50 V, 5 mm lead spacing ceramic disc capacitor
C8	20 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C9	20 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C10	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C11	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C12	10 uF	5 mm, 25 V radial electrolytic capacitor
C13	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C14	2.2 uF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C15	10 uF	5 mm, 25 V radial electrolytic capacitor
C16	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C17	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C18	NC	Open circuit
C19	220 uF	8 mm, 25 V radial electrolytic capacitor
C20	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C21	100 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C22	100 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C23	10 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C24	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C25	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C26	10 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C27	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C30	10 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C32	33 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C33	10 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C34	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C35	330 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C36	4.7 uF	5 mm, 25 V radial electrolytic capacitor
C37	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C38	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C39	1 uF	5 mm, 25 V radial electrolytic capacitor
C40	100 uF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C41	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor

C42	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C43	NC	50 V, 2.5 mm lead spacing ceramic disc capacitor
C44	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C45	330 nF	50 V, 5 mm lead spacing ceramic disc capacitor
C46	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C47	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C48	100 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C49	22 uF	5 mm, 25 V radial electrolytic capacitor
C50	10 uF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C51	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C52	10 uF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C53	1000 uF	10 mm, 25 V radial electrolytic capacitor
C54	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C55	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C56	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C57	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C58	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C59	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C60	NC	NC
C61	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
D1	1N4007	DO-41 axial diode
D2	1N4148	DO-35 axial diode
D3	LED	LED 3 mm
D4	1N4007	DO-41 axial diode
D5	1N4007	DO-41 axial diode
D6	D_Zener	optional zener diode DO-41 1N4757A
D8	1N4007	DO-41 axial diode
D9	1N4148	DO-35 axial diode
D10	1N4148	DO-35 axial diode
D11	1N4148	DO-35 axial diode
D12	1N4148	DO-35 axial diode
D13	1N4148	DO-35 axial diode
D14	1N4148	DO-35 axial diode
D15	1N4148	DO-35 axial diode
D16	LED	RED LED 3 mm
D17	1N4148	DO-35 axial diode
D18	1N4148	DO-35 axial diode
D19	LED	LED 3 mm
J1	POWER	5.08 mm spacing screw terminal block
J2	Barrel_Jack	Dc Barrel Jack 2.5 mm
J5	Conn_01x04	4 pin header 2.54 mm pitch
J9	ICSP	2 by 3 (6 pins) header 2.54 mm pitch
J10	si5351mod	7 pin socket 2.54 mm pitch

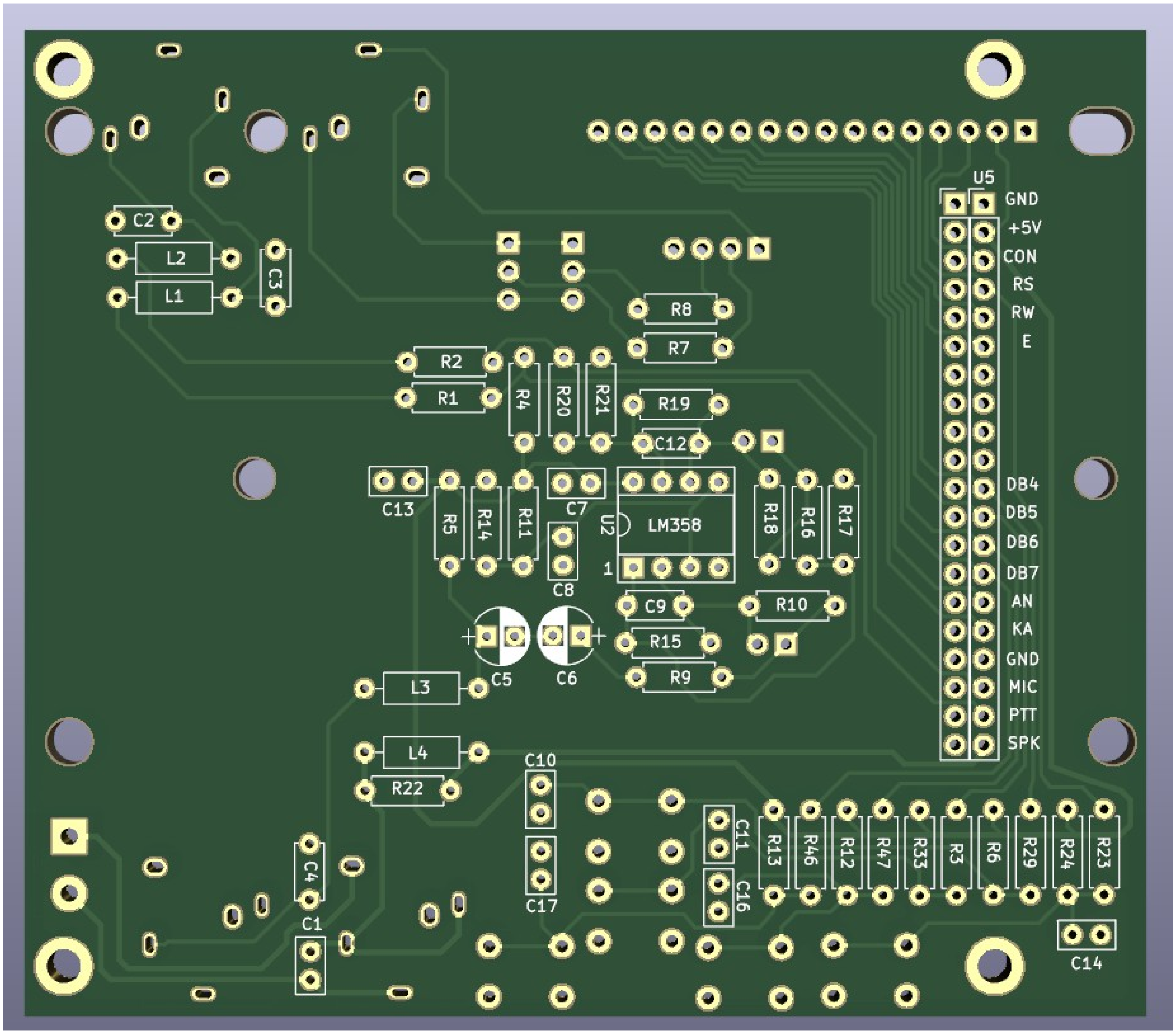
J11	SPEAKER	5.08 mm spacing screw terminal block
J12	Conn_Coaxial	PCB BNC Board Edge Connector e.g. (LCSC C2837588, Shenzhen Kinghelm Elec KH-BNC75-3511)
J17	Filt1	4 pin header 2.54 mm pitch
J18	Filt2	4 pin header 2.54 mm pitch
J19	Conn_01x20	20 pin header 2.54 mm pitch
JP1	QSK	2 pin header 2.54 mm pitch
JP2	Sample	2 pin header 2.54 mm pitch
JP3	5VDC	2 pin header 2.54 mm pitch
JP4	BYPASS	2 pin header 2.54 mm pitch
JP5	JREF1	3 pin header 2.54 mm pitch
JP7	JVAL1	3 pin header 2.54 mm pitch
JP8	Shutdown	2 pin header 2.54 mm pitch
L1	10 uH	10 uH axial inductor, 100 mA maximum
L2	10 uH	10 uH axial inductor, 100 mA maximum
L3	100 uH	100 uH axial inductor, 100 mA maximum
L4	100 uH	RF choke, FT37-43 or FT50-43, wind to instructions
L5	100 uH	100 uH axial inductor, 100 mA maximum
L6	22 uH	RF choke, FT37-43 or FT50-43, wind to instructions
L9	100 uH	100 uH axial inductor, 100 mA maximum
L10	100 uH	100 uH axial inductor, 100 mA maximum
L11	100 uH	100 uH axial inductor, 100 mA maximum
P1	Mini-DIN_6pins_ver4	MiniDin 6 female connector, e.g. (LCSC C77848, CONNFLY DS1093-01-PN60)
Q1	2N3904	TO-92 NPN transistor, EBC
Q2	2N3904	TO-92 NPN transistor, EBC
Q3	2N7000	TO-92 N-channel MOSFET, SGD
Q4	2N3904	TO-92 NPN transistor, EBC
Q5	NC	Optional fourth TO-92 MOSFET, EBC
Q6	2N7000	TO-92 N-channel MOSFET, SGD
Q7	2N7000	TO-92 N-channel MOSFET, SGD
Q8	SS8550	TO-92 PNP transistor (LCSC C8541), 1.5A max collector current, EBC
Q9	2N7000	TO-92 N-channel MOSFET, SGD
Q10	2N3904	TO-92 NPN transistor, EBC
Q11	2N3904	TO-92 NPN transistor, EBC
Q12	2N3904	TO-92 NPN transistor, EBC
Q13	SS8550	TO-92 PNP transistor (LCSC C8541), 1.5A max collector current, EBC
Q14	2N3904	TO-92 NPN transistor, EBC
Q15	NC	NC (optional TO-220 MOSFET, e.g. IRF510), GDS
R1	10k	¼ watt axial resistor metal film
R2	100R	¼ watt axial resistor metal film

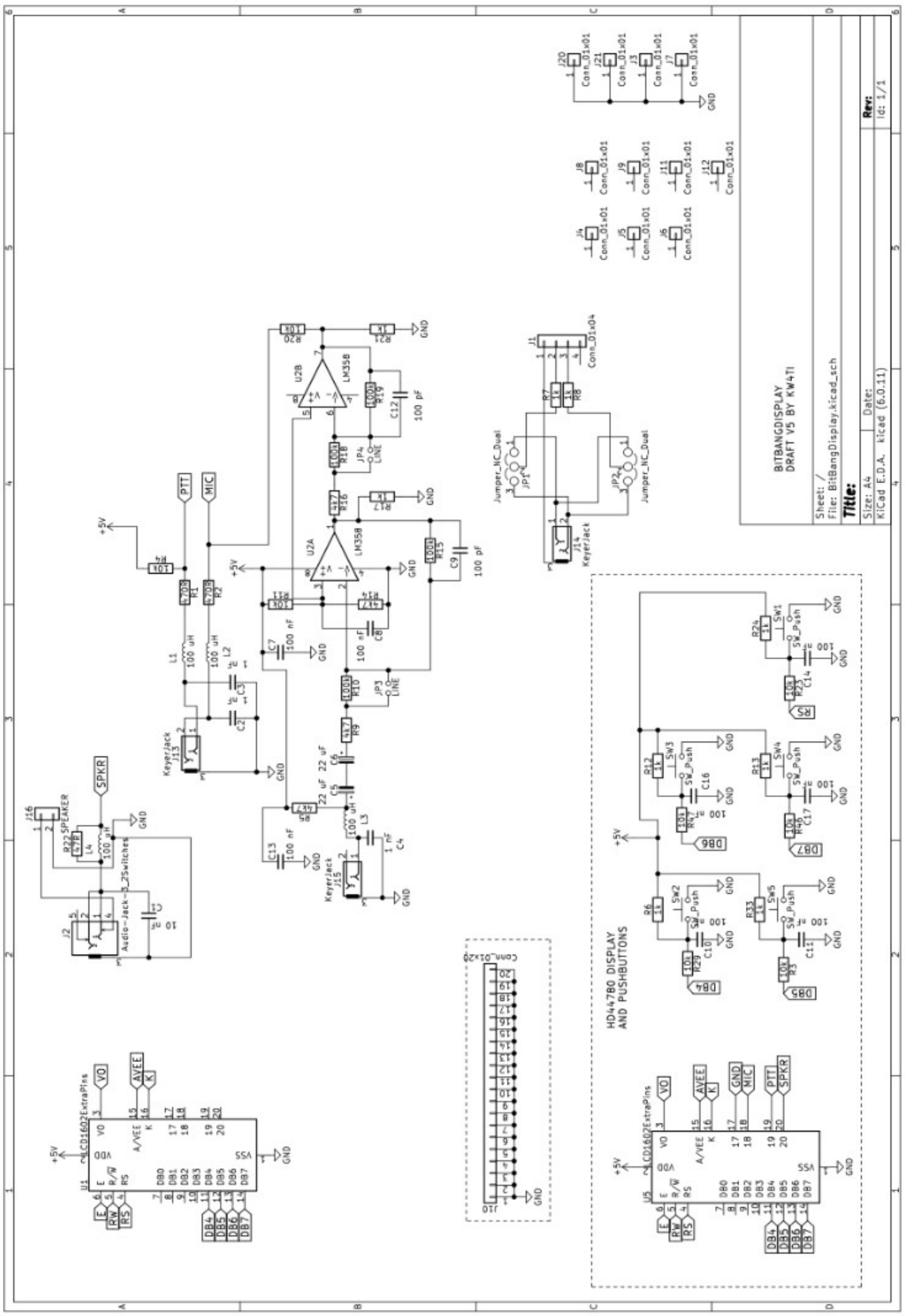
R3	10k	¼ watt axial resistor metal film
R4	1k	¼ watt axial resistor metal film
R5	51R	¼ watt axial resistor metal film
R6	1k	¼ watt axial resistor metal film
R7	10k	¼ watt axial resistor metal film
R8	470R	¼ watt axial resistor metal film
R9	100k	¼ watt axial resistor metal film
R10	100k	¼ watt axial resistor metal film
R11	47R	¼ watt axial resistor metal film
R12	1k	¼ watt axial resistor metal film
R13	1k	¼ watt axial resistor metal film
R14	470R	¼ watt axial resistor metal film
R15	47k	¼ watt axial resistor metal film
R16	470k	¼ watt axial resistor metal film
R17	470R	¼ watt axial resistor metal film
R18	1k	¼ watt axial resistor metal film
R19	470R	¼ watt axial resistor metal film
R20	100R	¼ watt axial resistor metal film
R21	51R	¼ watt axial resistor metal film
R22	1k	¼ watt axial resistor metal film
R23	220k	¼ watt axial resistor metal film
R24	10k	¼ watt axial resistor metal film
R25	51R	¼ watt axial resistor metal film
R26	1k	¼ watt axial resistor metal film
R27	1k	¼ watt axial resistor metal film
R28	47R	¼ watt axial resistor metal film
R29	10k	¼ watt axial resistor metal film
R30	10k	¼ watt axial resistor metal film
R31	100k	¼ watt axial resistor metal film
R32	100k	¼ watt axial resistor metal film
R33	1k	¼ watt axial resistor metal film
R34	100k	¼ watt axial resistor metal film
R35	10k	¼ watt axial resistor metal film
R36	1k	¼ watt axial resistor metal film
R37	1k	¼ watt axial resistor metal film
R38	33R	¼ watt axial resistor metal film
R39	22k	¼ watt axial resistor metal film
R40	10k	¼ watt axial resistor metal film
R41	150R	**2 watt** axial resistor metal film
R46	10k	¼ watt axial resistor metal film
R47	10k	¼ watt axial resistor metal film
R48	10k	¼ watt axial resistor metal film
R49	47R	¼ watt axial resistor metal film

R50	47R	¼ watt axial resistor metal film
R51	0R	Wire jumper
R52	47k	¼ watt axial resistor metal film
R53	NC	Open circuit
R54	1k	¼ watt axial resistor metal film
R55	100k	¼ watt axial resistor metal film
R56	NC	Open circuit
R57	3k3	¼ watt axial resistor metal film
R58	10k	¼ watt axial resistor metal film
R59	1k	¼ watt axial resistor metal film
R60	22k	¼ watt axial resistor metal film
R61	100k	¼ watt axial resistor metal film
R62	10k	¼ watt axial resistor metal film
R63	100R	¼ watt axial resistor metal film
R64	10k	¼ watt axial resistor metal film
R65	1k	¼ watt axial resistor metal film
R66	470k	¼ watt axial resistor metal film
R67	NC	Open circuit
R68	1k	¼ watt axial resistor metal film
R70	10k	¼ watt axial resistor metal film
R71	1k	¼ watt axial resistor metal film
R72	10k	¼ watt axial resistor metal film
R73	10k	¼ watt axial resistor metal film
R74	0R	Wire jumper
R75	1k	¼ watt axial resistor metal film
R76	1k	¼ watt axial resistor metal film
RLY1	DPDTRelay	Omron G5V-2 type DPDT relay, e.g. Hongfa HK19F, 12 volt coil, LCSC C42803
RV1	10k	B10K potentiometer
RV2	10k	B10K potentiometer
RV3	10k	10k trimmer-type potentiometer (e.g. BOURNS 3306P-1-103, LCSC C840697)
RV4	2k	2k 3296W-type potentiometer, e.g. LCSC C118206
SW1	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057
SW2	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057
SW3	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057
SW4	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057
SW5	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057

SW6	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057
T1	Trifilar	Transformer (balun) on FT37-43, FT50-43 core, wind according to instructions
T2	Trifilar	Transformer (balun) on FT37-43, FT50-43 core, wind according to instructions
T3	RF Current Sampler	Transformer on FT37-43, FT50-43 core, wind according to instructions
T4	Common-Mode Choke	Transformer on FT37-43, FT50-43 core, wind according to instructions
U1	ATMEGA328-PU	ATMEGA328P-PU 28 pin DIP microcontroller
U2	LM7805_TO220	LM7805 5 volt regulator
U3	LM386	LM386 8-pin DIP speaker amplifier
U4	LM358	LM358 8-pin DIP dual opamp
U5	LCD1602ExtraPins	20 pin header 2.54 mm pitch
U6	SI5351A	SI5351A integrated circuit (only install if no module)
Y1	16 MHz	HC-49 16 MHz crystal
Y2	7.X MHz	HC-49 crystal for pulled oscillator
Y3	25 MHz	25 MHz crystal for SI5351A (only install if no module)
Y4	7.X MHz	HC-49 crystal for pulled oscillator
Y5	7.X MHz	HC-49 crystal for pulled oscillator

Schematic and PCB Layout of the Display PCB

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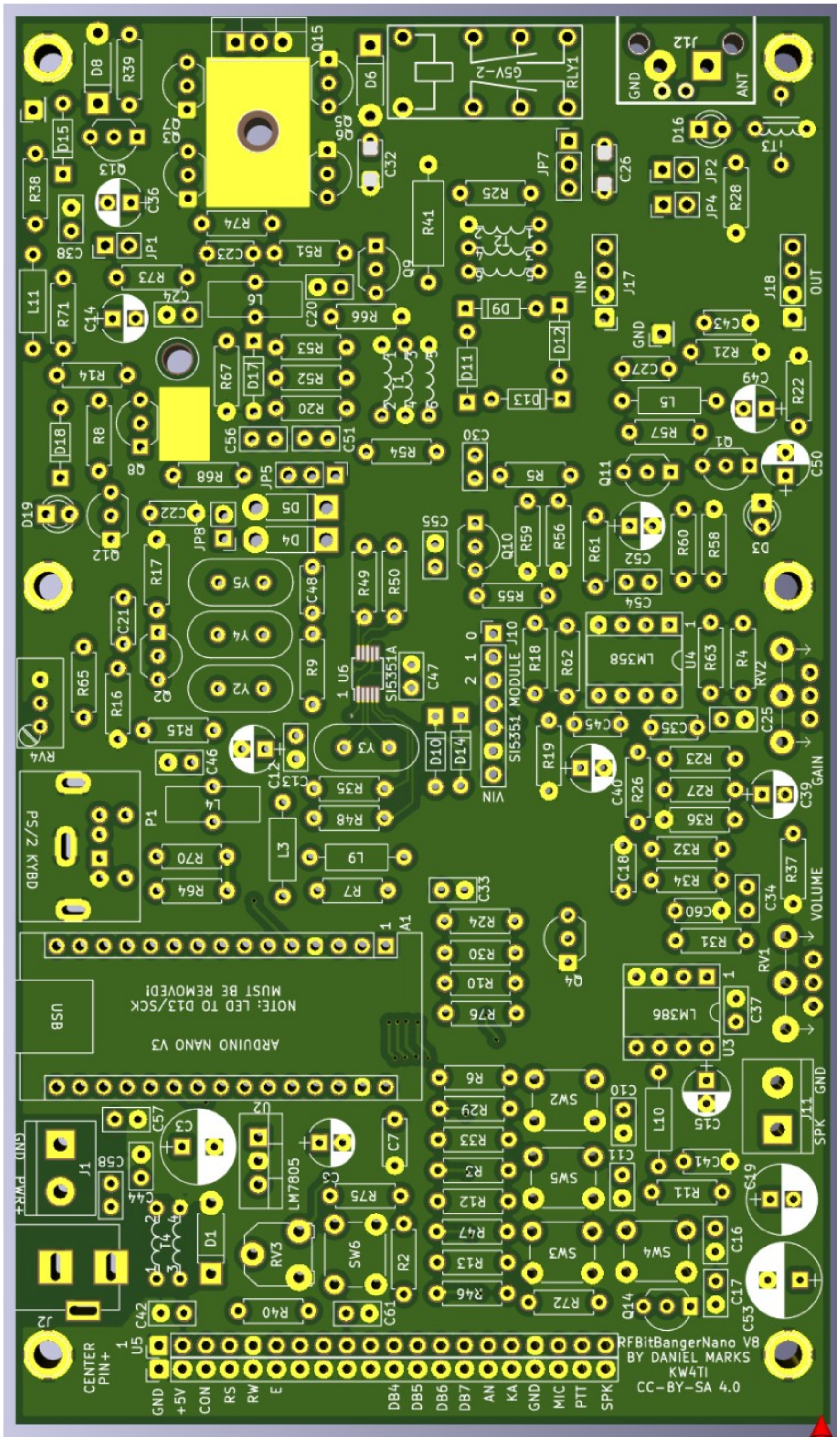
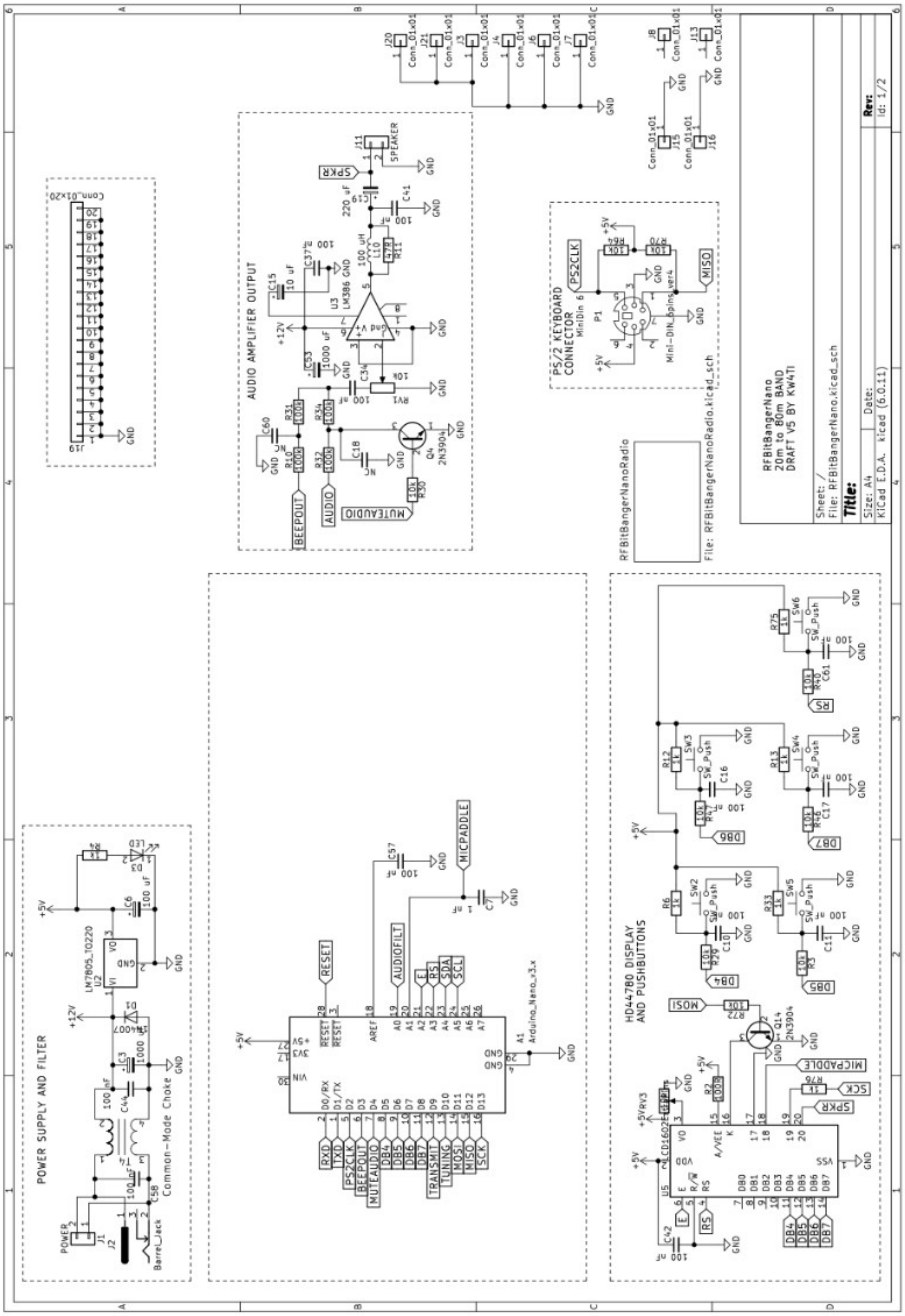
KiCad E.D.A. kicad (6.0.11)
Rev:
Id: 1/1
HD44780 DISPLAY
AND PUSHBUTTONS
LM358
PTT
MIC
SPKR
GND
+5V

Bill of Materials, Display PCB

Ref	Value	Component
C1	10 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C2	1 nF	50 V, 5 mm lead spacing ceramic disc capacitor
C3	1 nF	50 V, 5 mm lead spacing ceramic disc capacitor
C4	1 nF	50 V, 5 mm lead spacing ceramic disc capacitor
C5	22 uF	5 mm, 25 V radial electrolytic capacitor
C6	22 uF	5 mm, 25 V radial electrolytic capacitor
C7	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C8	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C9	100 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C10	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C11	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C12	100 pF	50 V, 5 mm lead spacing ceramic disc capacitor
C13	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C14	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C16	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
C17	100 nF	50 V, 2.5 mm lead spacing ceramic disc capacitor
J1	Conn_01x04	4 pin header 2.54 mm pitch
J2	3.5 mm stereo jack	3.5 mm stereo jack (Korean Hroparts Elec, PJ-3240-5A, LCSC C148514)
J10	Conn_01x20	20 pin header 2.54 mm pitch
J13	3.5 mm stereo jack	3.5 mm stereo jack (Korean Hroparts Elec, PJ-3240-5A, LCSC C148514)
J14	3.5 mm stereo jack	3.5 mm stereo jack (Korean Hroparts Elec, PJ-3240-5A, LCSC C148514)
J15	3.5 mm stereo jack	3.5 mm stereo jack (Korean Hroparts Elec, PJ-3240-5A, LCSC C148514)
J16	Speaker connector	5.08 mm spacing screw terminal block
JP1	Jumper_NC_Dual	3 pin header 2.54 mm pitch
JP2	Jumper_NC_Dual	3 pin header 2.54 mm pitch
JP3	LINE	2 pin header 2.54 mm pitch
JP4	LINE	2 pin header 2.54 mm pitch
L1	100 uH	100 uH axial inductor, 100 mA max
L2	100 uH	100 uH axial inductor, 100 mA max
L3	100 uH	100 uH axial inductor, 100 mA max
L4	100 uH	100 uH axial inductor, 100 mA max
R1	470R	¼ watt axial resistor metal film
R2	470R	¼ watt axial resistor metal film
R3	10k	¼ watt axial resistor metal film

R4	10k	¼ watt axial resistor metal film
R5	4k7	¼ watt axial resistor metal film
R6	1k	¼ watt axial resistor metal film
R7	1k	¼ watt axial resistor metal film
R8	1k	¼ watt axial resistor metal film
R9	4k7	¼ watt axial resistor metal film
R10	100k	¼ watt axial resistor metal film
R11	10k	¼ watt axial resistor metal film
R12	1k	¼ watt axial resistor metal film
R13	1k	¼ watt axial resistor metal film
R14	4k7	¼ watt axial resistor metal film
R15	100k	¼ watt axial resistor metal film
R16	4k7	¼ watt axial resistor metal film
R17	1k	¼ watt axial resistor metal film
R18	100k	¼ watt axial resistor metal film
R19	100k	¼ watt axial resistor metal film
R20	10k	¼ watt axial resistor metal film
R21	1k	¼ watt axial resistor metal film
R22	47R	¼ watt axial resistor metal film
R23	10k	¼ watt axial resistor metal film
R24	1k	¼ watt axial resistor metal film
R29	10k	¼ watt axial resistor metal film
R33	1k	¼ watt axial resistor metal film
R46	10k	¼ watt axial resistor metal film
R47	10k	¼ watt axial resistor metal film
SW1	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057
SW2	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057
SW3	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057
SW4	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057
SW5	SW_Push	6 mm normally open push button, e..g Diptronics DTS-62K-V, LCSC C100057
U1	LCD1602ExtraPins	16 pin header 2.54 mm pitch, HD44780 display
U2	LM358	8 pin DIP socket
U5	LCD1602ExtraPins	20 pin header 2.54 mm pitch


RFBitBangerNano V8
BY DANIEL MARKS
KW4TI
CC-BY-SA 4.0
CENTER PIN+
GND
+5V
CON
RS
RW
E
DB4
DB5
DB6
DB7
AN
KA
GND
MIC
PTT
SPK
SI5351 MODULE
VOLUME
GAIN
INP
OUT
ANT
PS/2 KYBD


POWER SUPPLY AND FILTER
AUDIO AMPLIFIER OUTPUT
PS/2 KEYBOARD CONNECTOR
HD44780 DISPLAY
AND PUSHBUTTONS
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20m to 80m BAND
DRAFT V5 BY KW4TI
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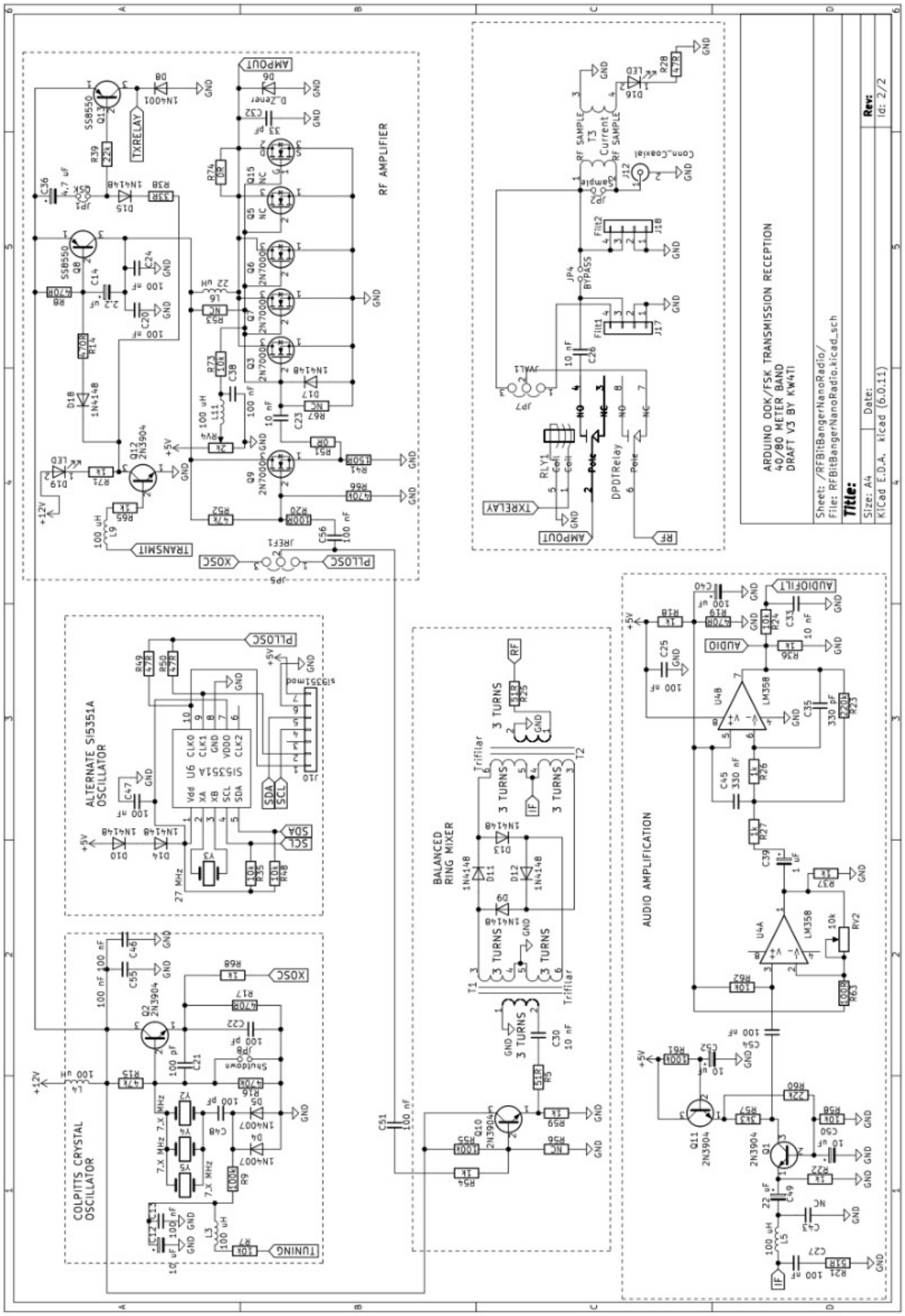
RF AMPLIFIER
ALTERNATE SI5351A OSCILLATOR
COLPITTS CRYSTAL OSCILLATOR
BALANCED RING MIXER
AUDIO AMPLIFICATION
ARDUINO OOK/FSK TRANSMISSION RECEPTION
40/80 METER BAND
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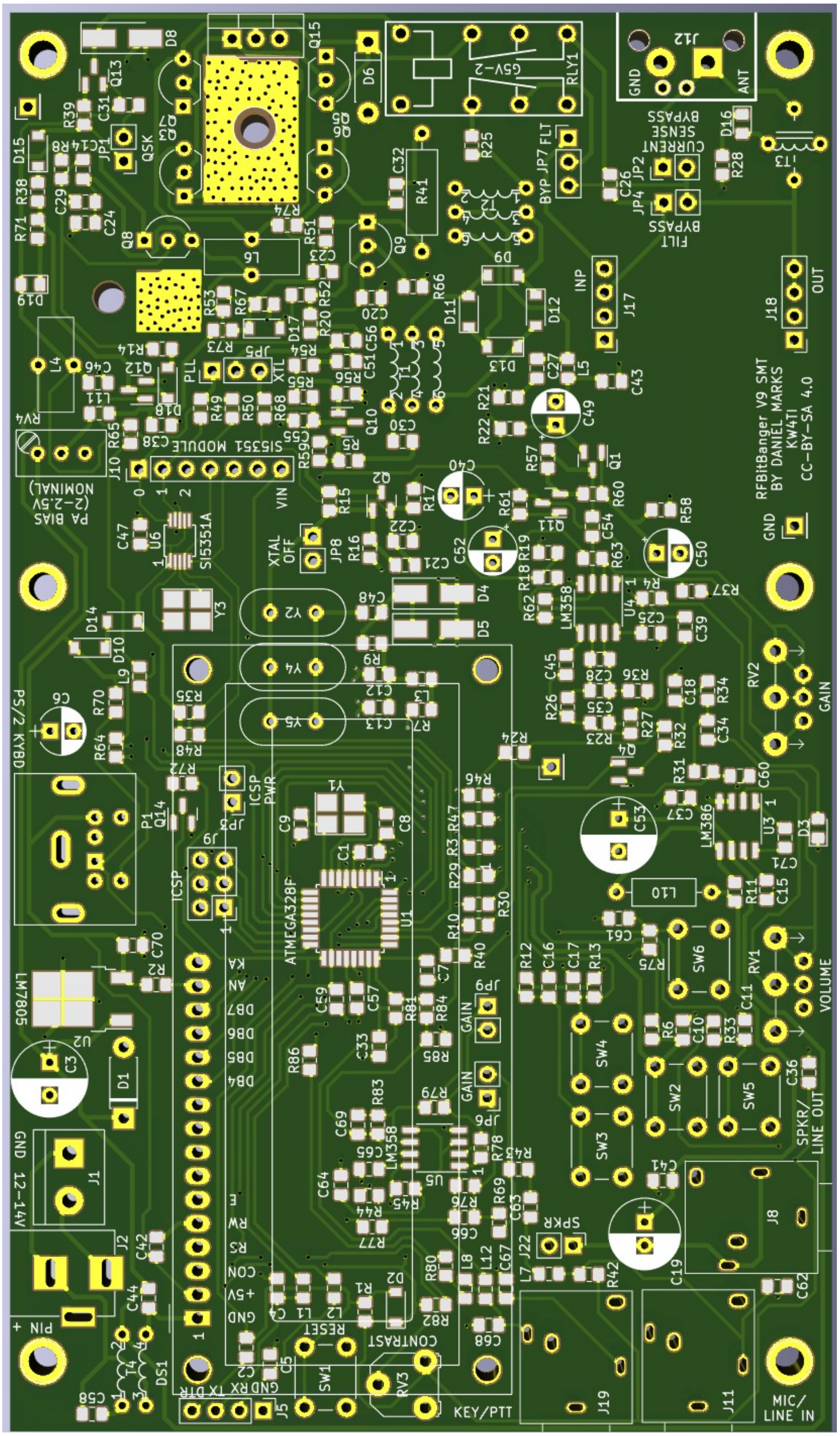
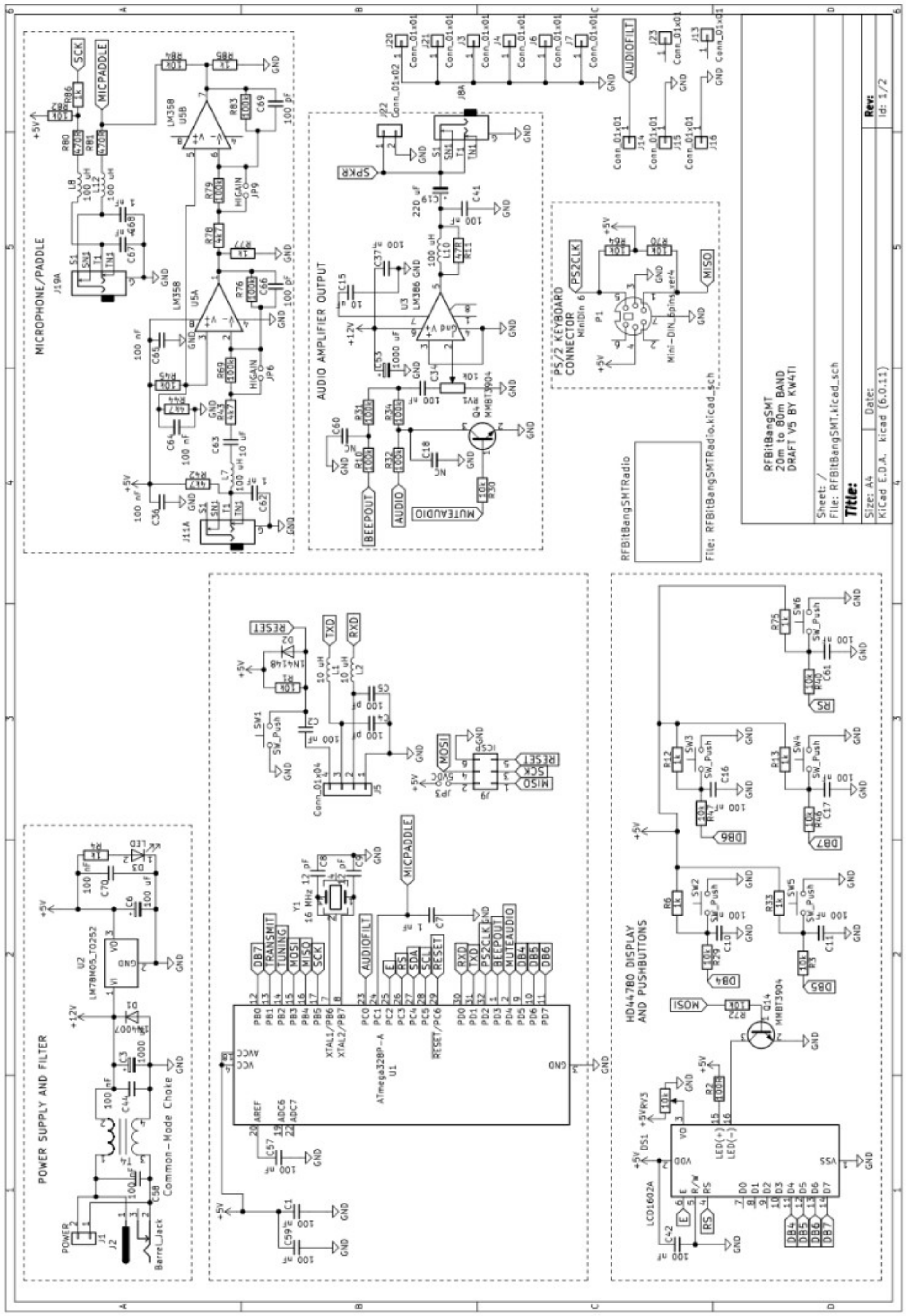
KiCad E.D.A. kicad (6.0.11)
Rev:
Id: 2/2


RFBitBanger V9 SMT
BY DANIEL MARKS
KW4TI
CC-BY-SA 4.0
ATMEGA328P
SI5351 MODULE
LM7805
LM386
PA BIAS
(2-2.5V
NOMINAL)
PS/2 KYBD
12-14V
GND
ANT
VOLUME
GAIN
SPKR/
LINE OUT
MIC/
LINE IN
KEY/PTT
CONTRAST
RESET
ICSP


POWER SUPPLY AND FILTER
MICROPHONE/PADDLE
AUDIO AMPLIFIER OUTPUT
PS/2 KEYBOARD CONNECTOR
HD44780 DISPLAY AND PUSHBUTTONS
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RFBitBangSMT
20m to 80m BAND
DRAFT V5 BY KW4TI
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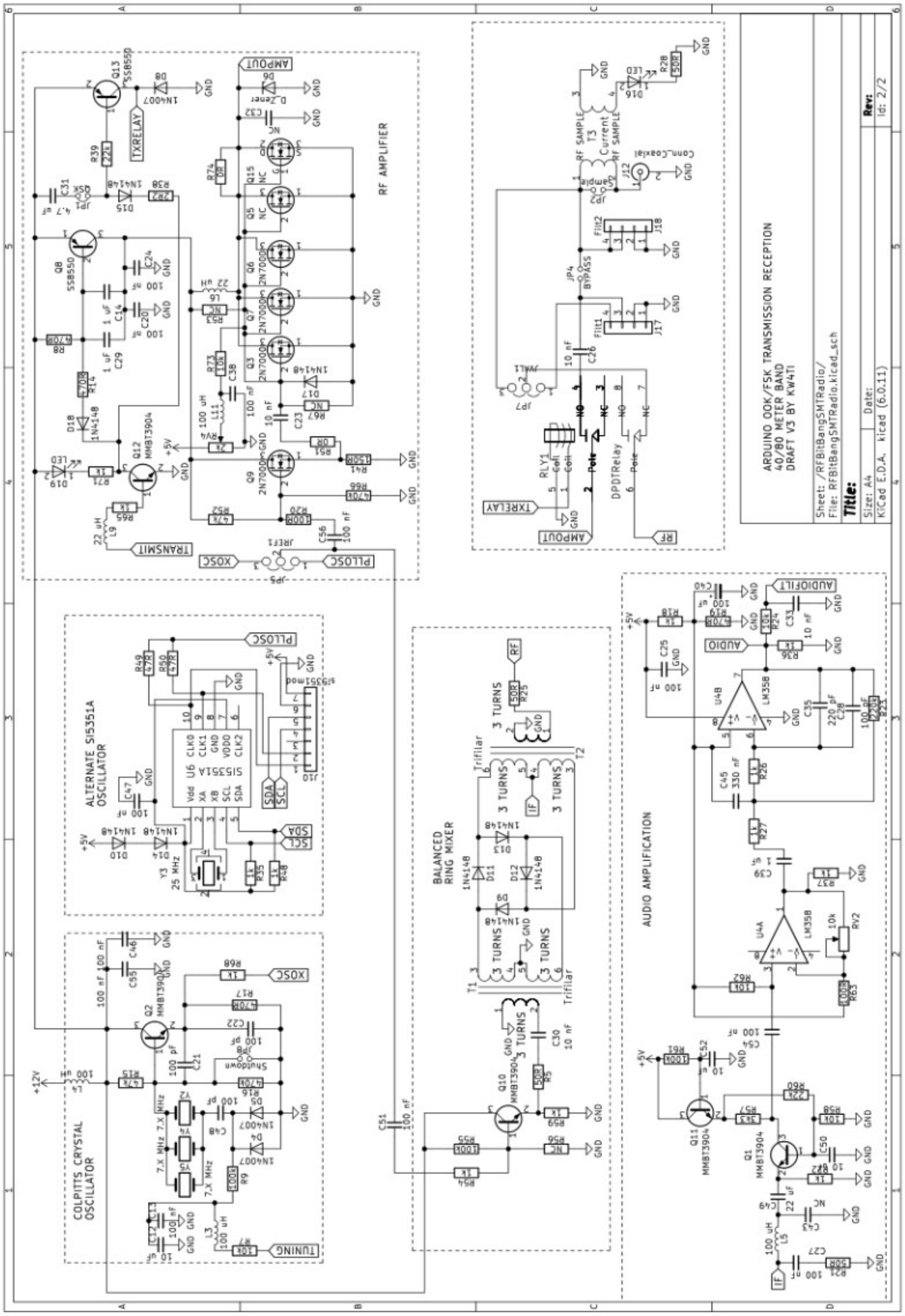
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40/80 METER BAND
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KiCad E.D.A. kicad (6.0.11)
Rev:
Id: 2/2
RF AMPLIFIER
ALTERNATE SI5351A OSCILLATOR
COLPITTS CRYSTAL OSCILLATOR
BALANCED RING MIXER
AUDIO AMPLIFICATION

Arduino Uno/Nano equivalent pins to ATMEGA328P

If one constructs the transceiver using an Arduino Uno/Nano and point-to-point wiring, here is the correspondence between the Arduino Uno/Nano pins and the ATMEGA328P pins:

PD0	2	Digital Pin 0
PD1	3	Digital Pin 1
PD2	4	Digital Pin 2
PD3	5	Digital Pin 3
PD4	6	Digital Pin 4
PD5	11	Digital Pin 5
PD6	12	Digital Pin 6
PD7	13	Digital Pin 7
PB0	14	Digital Pin 8
PB1	15	Digital Pin 9
PB2	16	Digital Pin 10
PB3	17	Digital Pin 11
PB4	18	Digital Pin 12
PB5	19	Digital Pin 13
PC0	23	Analog Input 0
PC1	24	Analog Input 1
PC2	25	Analog Input 2
PC3	26	Analog Input 3
PC4	27	Analog Input 4
PC5	28	Analog Input 5
PC6	1	Reset
AREF	21	Analog Reference (Leave Open)
AVCC	20	Analog Voltage (Connect to +5V)
VCC	7	LM7805 5V output
GND	8,22	GND

Programming the ATMEGA328P/Arduino

The RFBitBanger software has been created to be compiled in the Arduino IDE environment with the Arduino Uno/Nano as a target. The ATMEGA328P operates at a frequency and with fuse bits identical to the standard Arduino Uno/Nano configuration. The Arduino bootloader may be flashed onto the ATMEGA328P. To do this, a ISP programmer such as the ArduinoISP or ATTinyUSB may be connected to the ICSP connector and the “Burn Bootloader” may be invoked in the Arduino development environment with the “Arduino Uno” or “Arduino Nano” selected as the target / board.

This programs the bootloader and the correct fuse bits for operation of the ATMEGA328P with the RFBitBanger software.

A serial/TTL USB interface (e.g. CP2102 or CH340) may be used to program the ATMEGA328P once the bootloader is installed. The four pin header J5 has a ground pin, RX, TX, and DTR/reset pins. The ground on the RFBitBanger should be connected to the serial programmer ground, the RX pin on the RFBitBanger should be connected to the TX pin on the serial programmer, the TX pin on the RFBitBanger should be connected to the RX pin on the serial programmer, and the DTR pin should be connected to the DTR pin on the serial programmer. Once these are connected, the RFBitBanger can be programmed using the Upload Sketch function of the Arduino IDE. The RFBitBanger needs to be powered on to be programmed. The serial programmer should be able to reset the ATMEGA328P through the DTR pin to invoke the bootloader, but if it fails to do so, holding down the reset button on the RFBitBanger after invoking the Upload Sketch function and releasing it when it starts to attempt to upload usually allows successful contact with the bootloader.

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