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 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 $3.00 USD in quantity 100. The HD44780-type displays are probably the most common LCDs available.

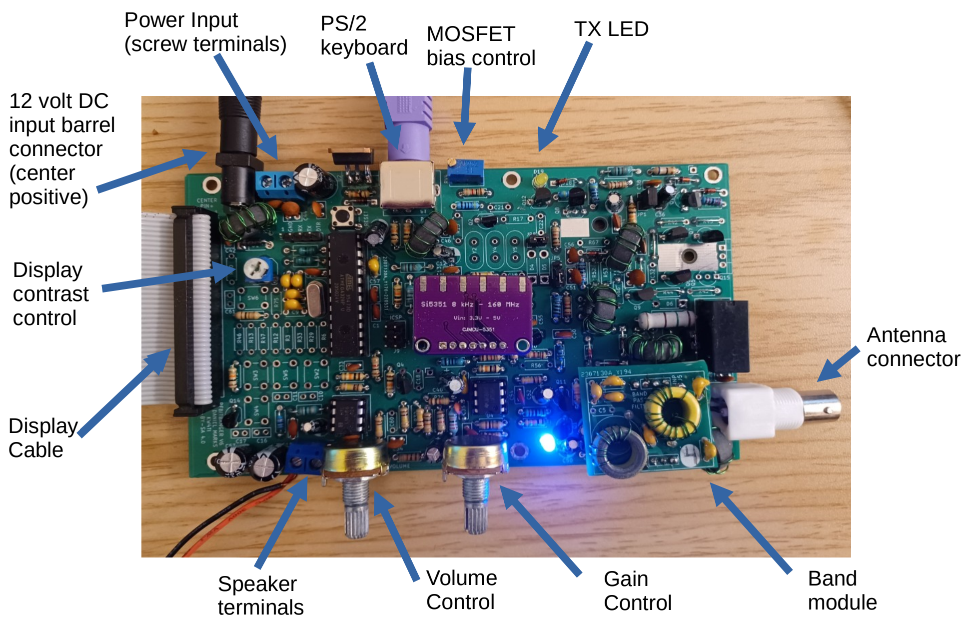
The radio is first and foremost intended to be used with low-bandwidth modes such as CW and RTTY. A new protocol called SCAMP was created especially for this radio. SCAMP is designed to be simple enough to be implemented on an 8-bit microcontroller but incorporates features such as forward error correction. 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.

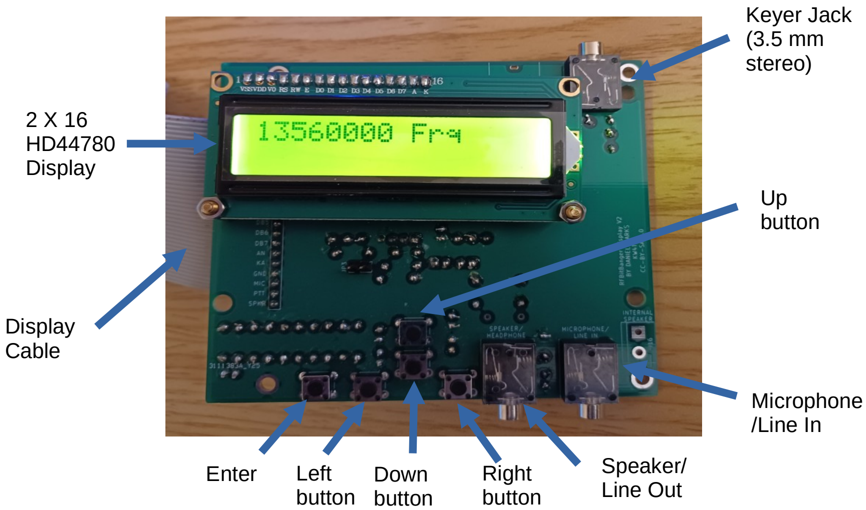
Features and specifications

The RFBitBanger has the following features and specifications:

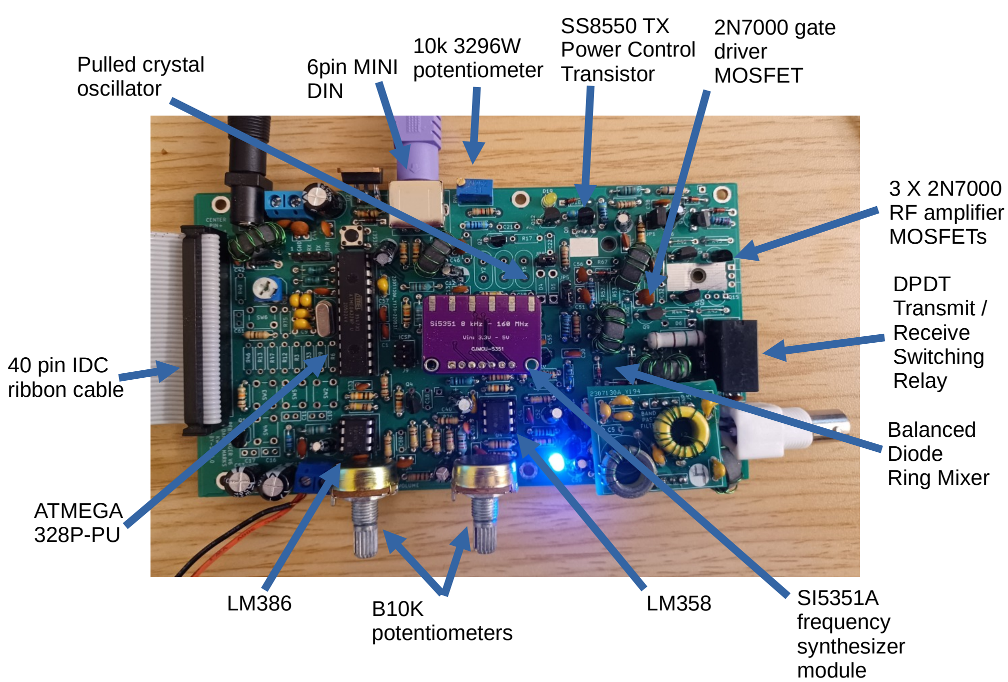
- Supports the high frequency (HF) band between 1.8 and 30 MHz, with the best performance obtained at the 80m, 60m, 40m, 30m, and 20m bands (3.5 to 14.35 MHz).
- Uses a simple direct conversion receiver architecture with demodulation using a double sideband (DSB) balanced ring mixer. This does not require 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.
- 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


Power Input
(screw terminals)
PS/2
keyboard
MOSFET
bias control
TX LED
12 volt DC
input barrel
connector
(center
positive)
Display
contrast
control
Display
Cable
Antenna
connector
Speaker
terminals
Volume
Control
Gain
Control
Band
module



Major Components



Before operating the transceiver

Check the following before operating the transceiver:

- 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 is plugged into 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.
- If using a key, connect it to the keyer jack.

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

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.

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 with the transmitted/decoded signal 667 Hz above the VFO frequency (USB).

- 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.
- SCAMPOOK, the standard SCAMP OOK mode.
- SCFSKFST the higher symbol rate FSK SCAMP.
- SCFSKSLW the half symbol rate FSK SCAMP.
- SCOOKSLW the half symbol rate OOK SCAMP.

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

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. Currently only straight key is supported, however, the circuitry is present to support iambic keys (tip/ring). The down button can be used to key the transmitter, or alternately, the tip of the keyer jack can be grounded (for example by a straight key plugged into the jack). The transmitted signal is 667 Hz above the VFO frequency. Incoming CW transmissions are decoded with the built-in CW decoder if these fall within the receive filter centered at 667 Hz from 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, so that one can practice keying with the built-in radio CW decoder.

TODO: add iambic A & B support.

External Control Mode

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07074000 Ext||||
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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. 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.
- CW WPM: send speed for CW in words per minute.
- 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.
- 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 Practice: if this equals one, then the radio does not transmit in Keyer mode, but still decodes keying.
- 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.

- 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.

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 5 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 5 MHz, set the VFO to 5000000.
4. Tune the VFO frequency down until the signal strength bar indicates a maximum amplitude. This should nominally be 667 Hz below the calibration frequency, but is typically slightly different, possibly by several hundred Hz, due to error in the crystal frequency. Make sure the VFO frequency is below and not above the calibration frequency. If the VFO frequency is below the calibration frequency, pressing the up button to increase the VFO frequency should lower the pitch of the tone heard in the speaker.
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 5 MHz, enter 5000000 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. Write this frequency on the front page of this document to save it in case the calibration should be erased from the EEPROM memory.

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, for example, 9 to 9.5 m for a 40 m band antenna. 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.

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.
- 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.

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.

Jumpers used on the display PCB

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

JP3: Open for unity gain of the first stage, closed for a gain of 20.

JP4: Open for unity gain of the second amplification stage, closed for a gain of 20. Gain is typically for amplifying microphone input. Gain should not be required for line-level inputs.

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 3.0 volts. If power consumption is excessive when transmitting, this voltage may be reduced. The voltage on the MOSFET gates can either be measured directly on the center lead of Q3, Q5, Q6, or Q7, or on the cathode of diode D17.

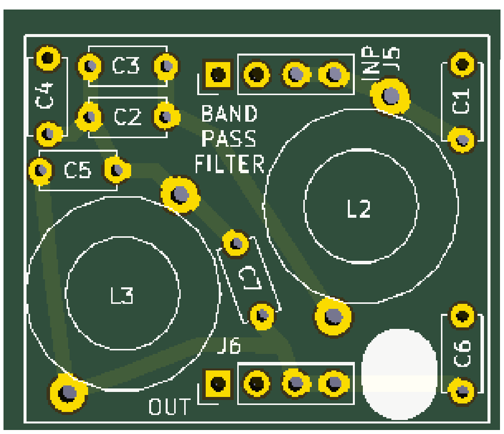
Connecting the main and display PCB

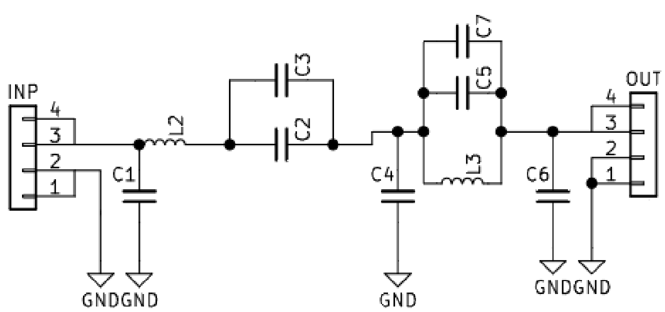
A 40 pin dual female IDC ribbon cable is used to connect the main and display PCB. A short cable can be made by pressing two 40 pin IDC female connectors onto a 40 pin ribbon cable, all of which often can be found from old IDE cables. If the cable is too long, often the connector can be pried off the 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 4 pin header sockets should be added last to the 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.



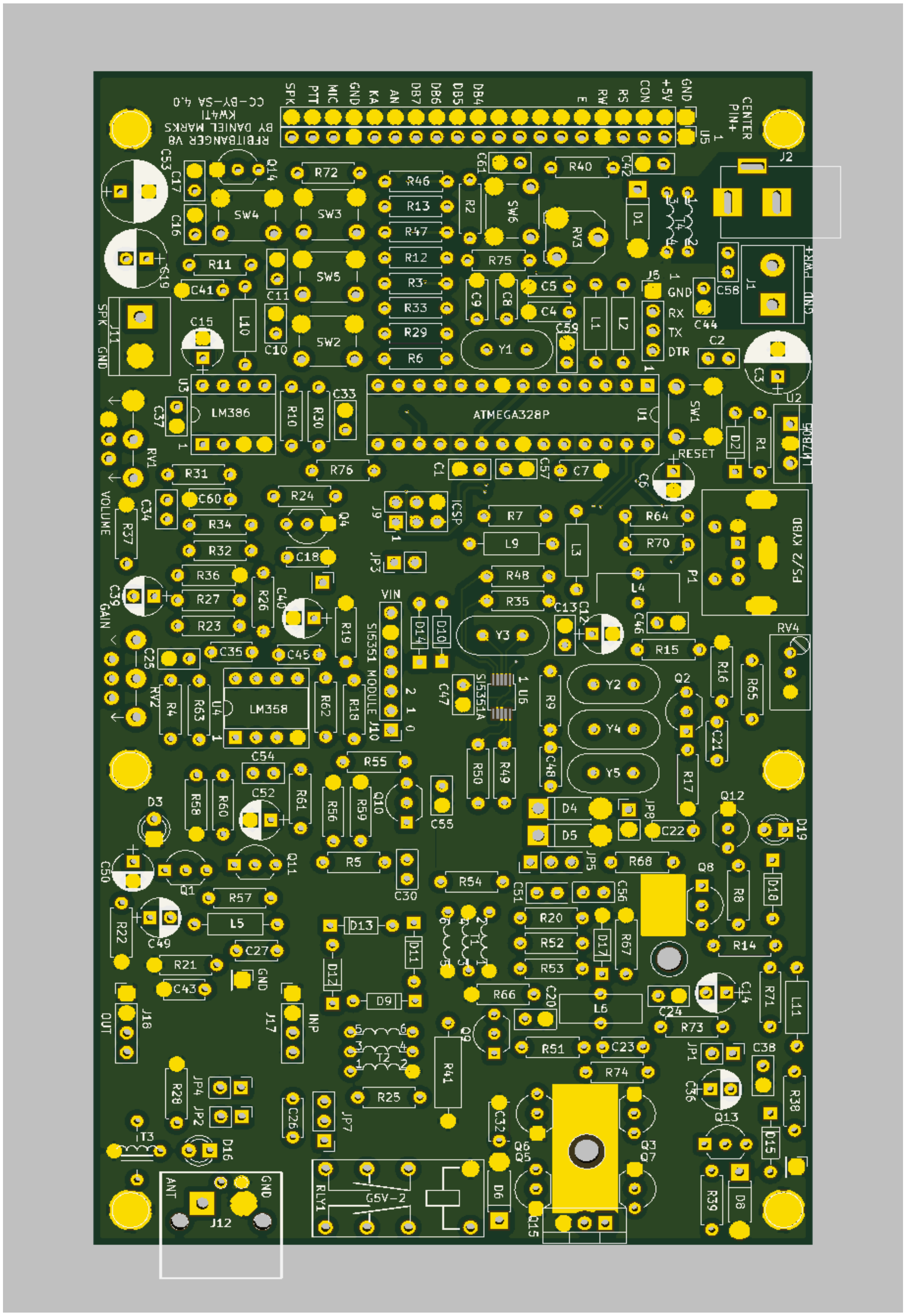


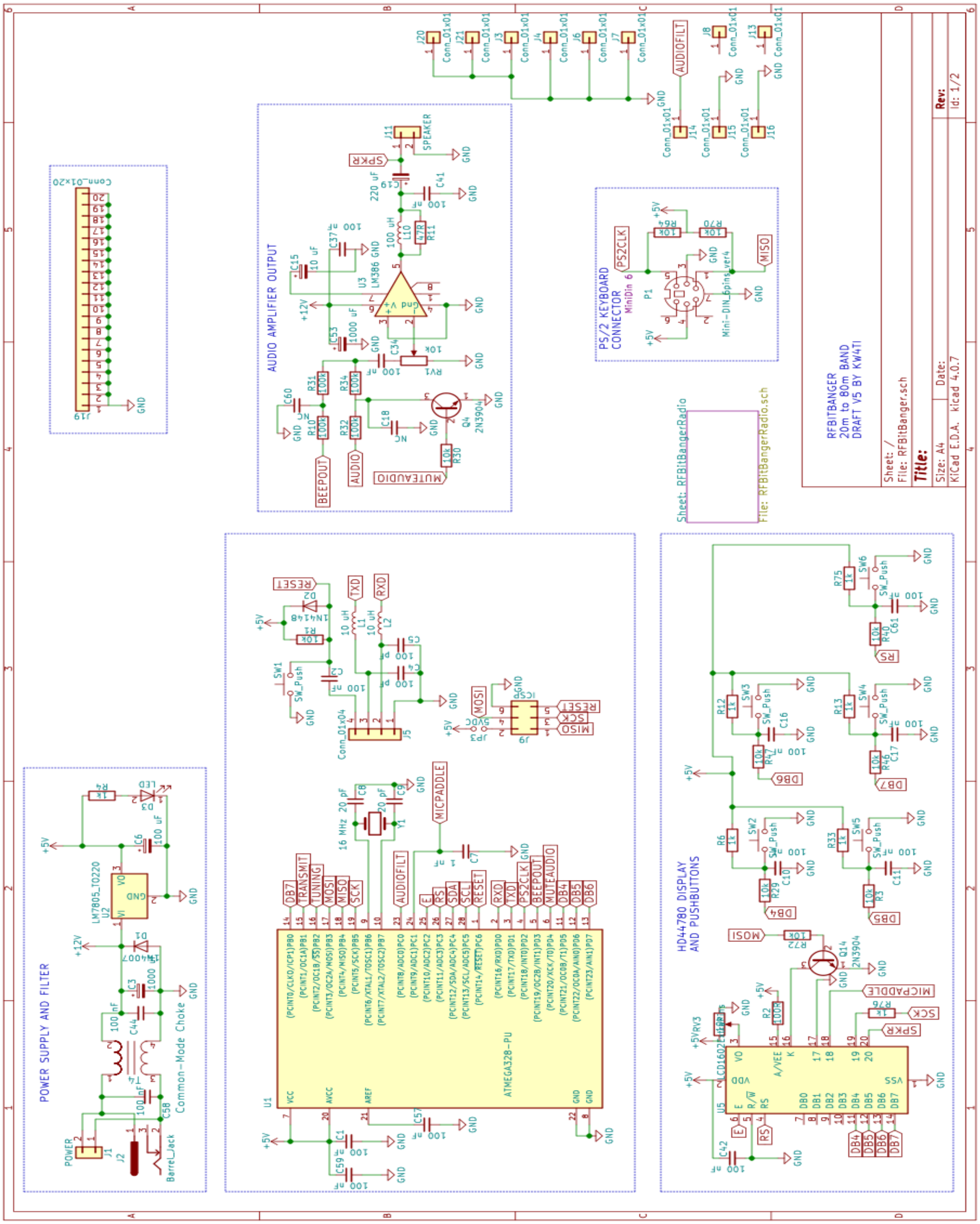
Serial resonant bandpass filters component values

Band	C1	C2+C3	C4, C6	C5+C7	L2	L3
80 m	1000 pF	2200 to 2500 pF 2000+330 pF	2200 pF	680 pF	1.45 uH T50-6 or T37-2 , 19 turns	0.68 uH T50-6 or T37-2, 13 turns
60 m	600 pF	1500 to 1700 pF 1000+680 pF	1500 pF	470 pF	1.05 uH T50-6 or T37-2, 16 turns	0.49 uH T50-6 or T37-2, 11 turns
40 m	440 pF	1000 to 1250 pF 470+680 pF	1000 pF	330 pF	0.77 uH T50-6 or T37-2, 14 turns	0.36 uH T50-6 or T37-2, 9 turns
30 m	300 pF	680 to 820 pF, 330+470 pF	660 pF	220 pF	0.54 uH T50-6 or T37-2, 11 turns	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	200 pF	470 to 620 pF, 220+330 pF	470 pF	150 pF	0.39 uH T50-6, 10 turns, air coil, 1 mm wire, 7-8 turns around 9.5 mm (3/8” drill bit) form	0.18 uH T50-6, 6 turns air coil, 1 mm wire, 4-5 turns around 9.5 mm (3/8” drill bit) form
15 m	100 pF	330 pF, 150+150 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
10 m	47 pF	220 to 270 pF, 100+150 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

Air core coils can be fine-tuned by adding an extra turn and spacing coils apart.

Schematic and PCB Layout of the Main PCB




POWER SUPPLY AND FILTER
AUDIO AMPLIFIER OUTPUT
PS/2 KEYBOARD CONNECTOR
HD44780 DISPLAY AND PUSHBUTTONS
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RFBITBANGER
20m to 80m BAND
DRAFT V5 BY KW4TI
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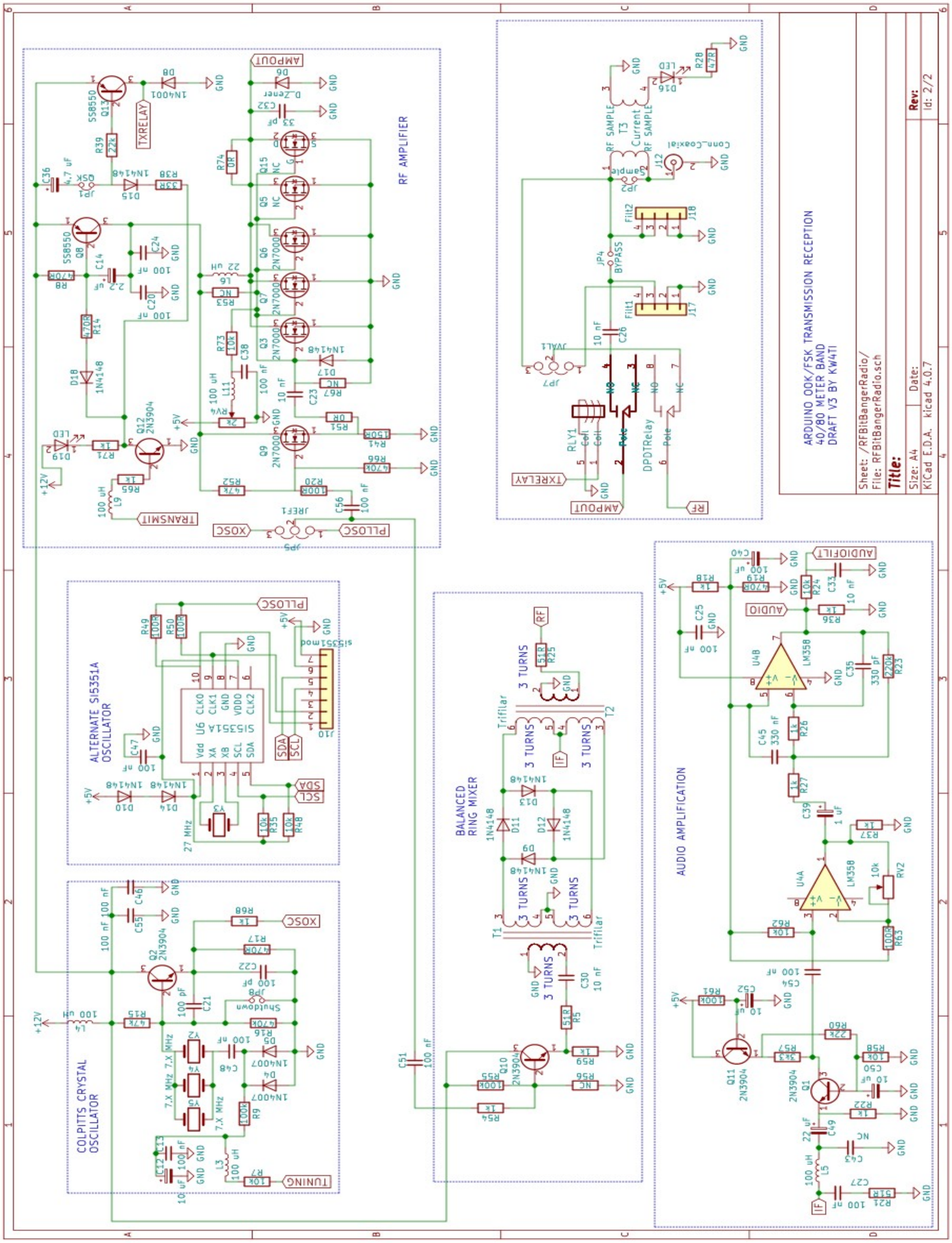
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad 4.0.7
Id: 1/2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ALTERNATE SI5351A OSCILLATOR
COLPITTS CRYSTAL OSCILLATOR
BALANCED RING MIXER
AUDIO AMPLIFICATION
ARDUINO OOK/FSK TRANSMISSION RECEPTION
40/80 METER BAND
DRAFT V3 BY KW4TI
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Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad 4.0.7
Id: 2/2

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

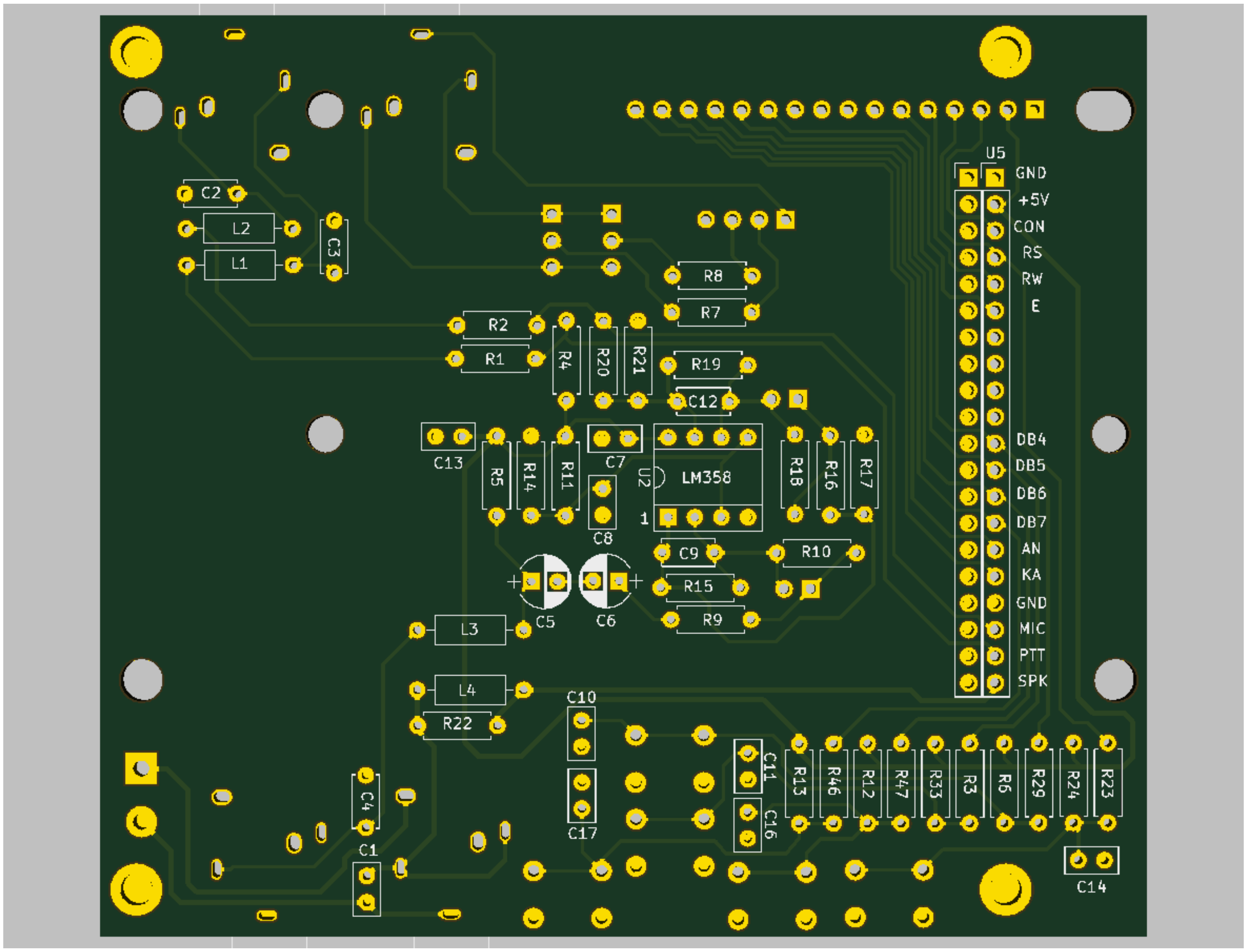
J19	Conn_01x20	20 pin header 2.54 mm pitch
JP1	QSK	2 pin header 2.54 mm pitch
JP2	Sample	2 pin header 2.54 mm pitch
JP3	5VDC	2 pin header 2.54 mm pitch
JP4	BYPASS	2 pin header 2.54 mm pitch
JP5	JREF1	3 pin header 2.54 mm pitch
JP7	JVAL1	3 pin header 2.54 mm pitch
JP8	Shutdown	2 pin header 2.54 mm pitch
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

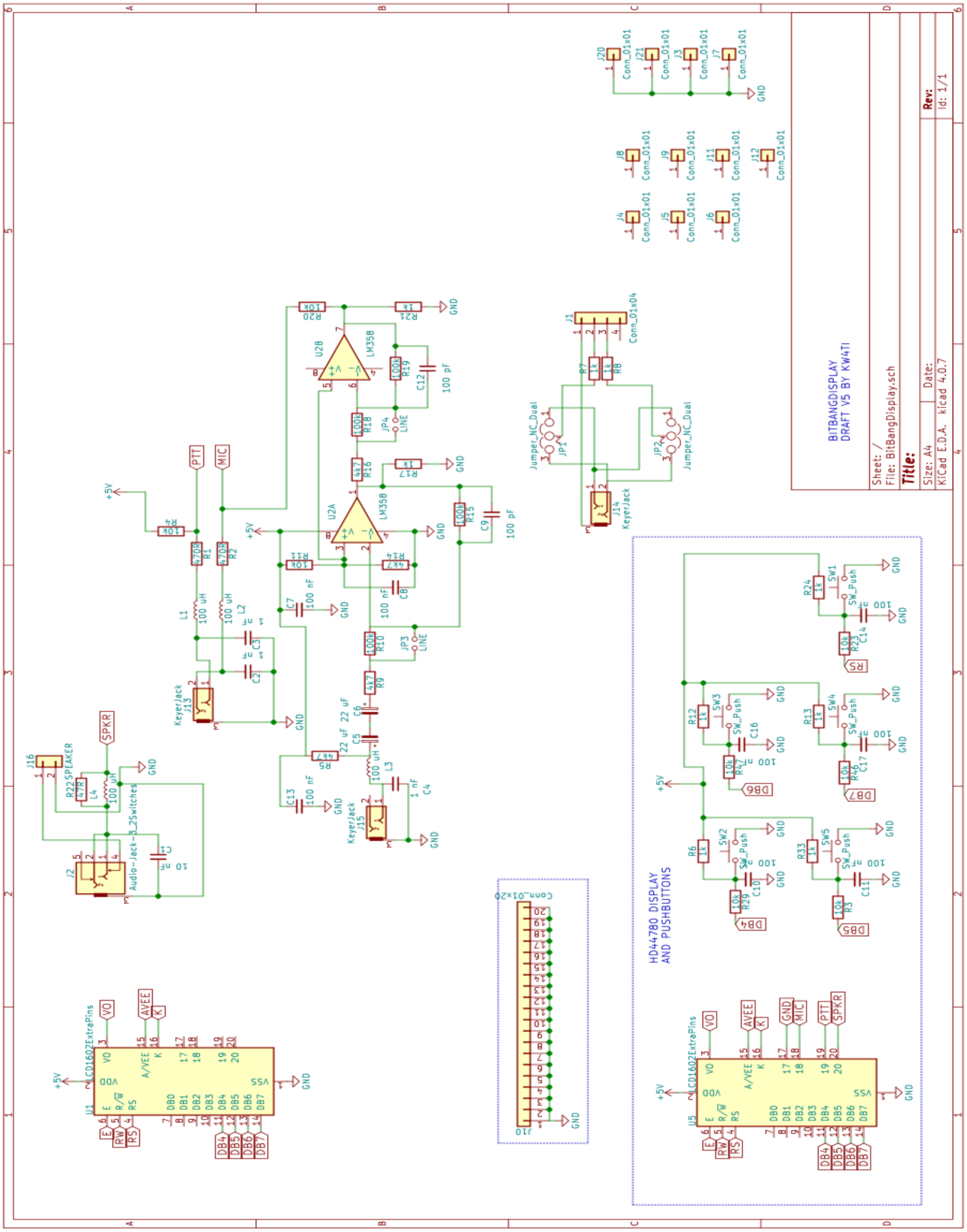
R11	47R	¼ watt axial resistor metal film
R12	1k	¼ watt axial resistor metal film
R13	1k	¼ watt axial resistor metal film
R14	470R	¼ watt axial resistor metal film
R15	47k	¼ watt axial resistor metal film
R16	470k	¼ watt axial resistor metal film
R17	470R	¼ watt axial resistor metal film
R18	1k	¼ watt 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	100R	¼ watt axial resistor metal film
R50	100R	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





BITBANGDISPLAY
DRAFT V5 BY KW4TI
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Rev:
KiCad E.D.A. kicad 4.0.7
Id: 1/1
HD44780 DISPLAY
AND PUSHBUTTONS

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

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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Alphabetical Index

2N7000....2, 15
Amateur radio....1, 11
Antenna....6, 14, 17
Arduino....2, 32f.
ATMEGA328P....2, 27, 32f.
Balun....16, 27
Band change warning....11, 13
Bandpass module....3, 6
Bifilar....16
BS170....2, 15
Calibrating the crystal oscillator frequency....13
Common-Mode Choke....16, 27
Configuration....11f., 32
Current sampling transformer....16
CW....2f., 8f., 11ff.
EEPROM....12, 14
External control mode....3, 12f.
FT8....2f., 12
Jumpers....16f.
Keyer....3, 6, 12f.
Keying Mode....8f., 11f., 14
LCD....8
License....1, 34
LM358....2, 27, 31
LM386....2, 27
PCB Layout....20, 28

Potentiometers....3, 15
PS/2 keyboard....3, 6, 8, 10
Pulled crystal....15, 17
QSK....3, 16, 24
Receive....10, 12
Ribbon cable....6, 17
RTTY....2f., 9, 12f.
SCAMP....2f., 9f., 12f.
Scanning for a signal....9
Schematic....15, 20, 28
Serial resonant bandpass filters....17, 19
SI5351A....2, 13, 15, 17, 27
Signal strength....3, 8f., 14
Speaker....3, 6, 8, 12ff., 24, 27, 30
Transmit....1, 10ff.
Trifilar....16, 27
VFO....8f., 12ff.