Yaesu Transverter Sequencer in a Mini DIN

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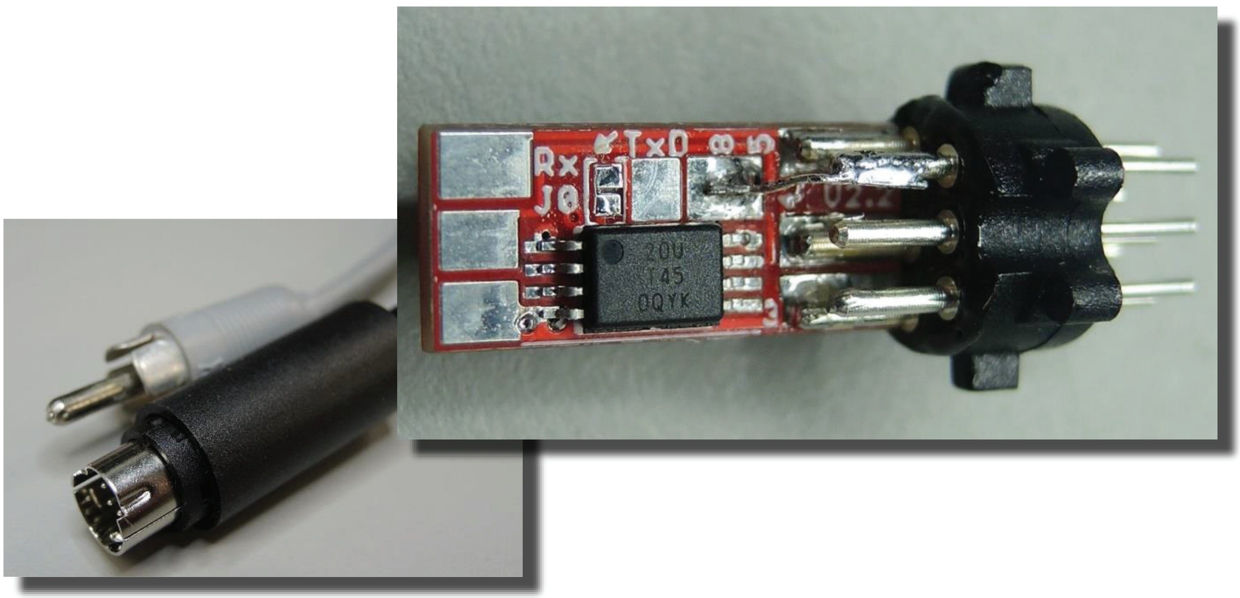
Version

This document is for printed circuit board version 2.2



Overview & Features:

The key function of a transverter sequencer is to make sure the transverter, and associated equipment, such as a transmit – receive relay or power amplifier, have time to safely switch to transmit before RF power is applied. Then, on switching from transmit to receive, the sequencer will also insure RF power is removed before transitioning and provides a delay that is long enough to prevent relay chattering during CW operation. This microprocessor controlled circuit does that while fitting into the 8-pin Mini DIN connector used with the Yaesu ACC port. This sequencer has the following function and features

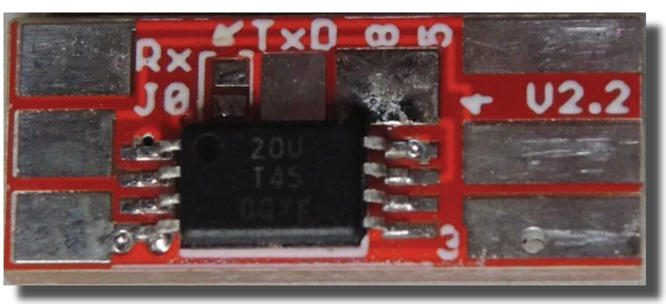
- Uses the ACC Tx-Gnd open collector output to sense a request to change state between transmit and receive.
    - On changing state from receive to transmit, it drives the PTT output while also creating a programmable delay (StartDelay) that inhibits RF power by controlling the TxInh pin until the system has had time to switch.

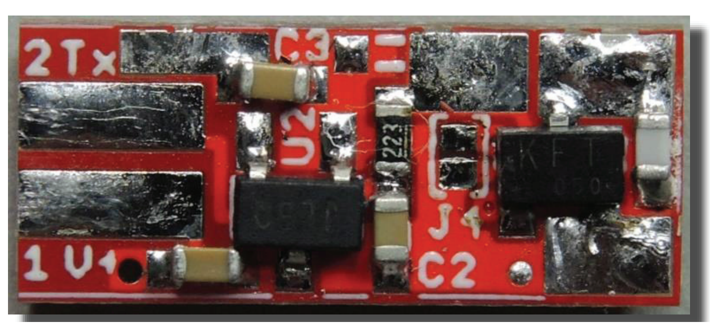
- On changing state from transmit to receive, it provides a delay (Hangtime) extending the transition to avoid excessive Tx/Rx relay switching during CW operation. After Hangtime expires the PTT state is changed. Four default Hangtimes are provided in the firmware. These delays are programmed as defaults in the firmware and can be selected at build time dependine on the mode being used and CW speed. 25 ms is used for SSB or digital modes, 300 ms is recommended for code speeds greater than 30 words per minute, 650 ms for code speeds greater than 15 words per minute and 1000 ms for code speeds greater than 10 words per minute.

- The PTT output is an open drain configuration that, during assembly, can be populated as either high or low during transmit.
- StartDelay is programmable and defaults to delaying TxInh for 25 ms after PTT changes state when transitioning from receive to transmit.
- Hangtime delay can be selected to be 30, 300, 650 or 1000 milliseconds by shorting solder jumpers when populating the PCB.
- Provides pins for TxD, RxD, and GND at the rear of the PCB to allow easier connection to external rig controllers through the Mini DIN connector.
- Operates over a wide voltage range, six to fifteen volts, and uses minimal current, about 1.5 mA.

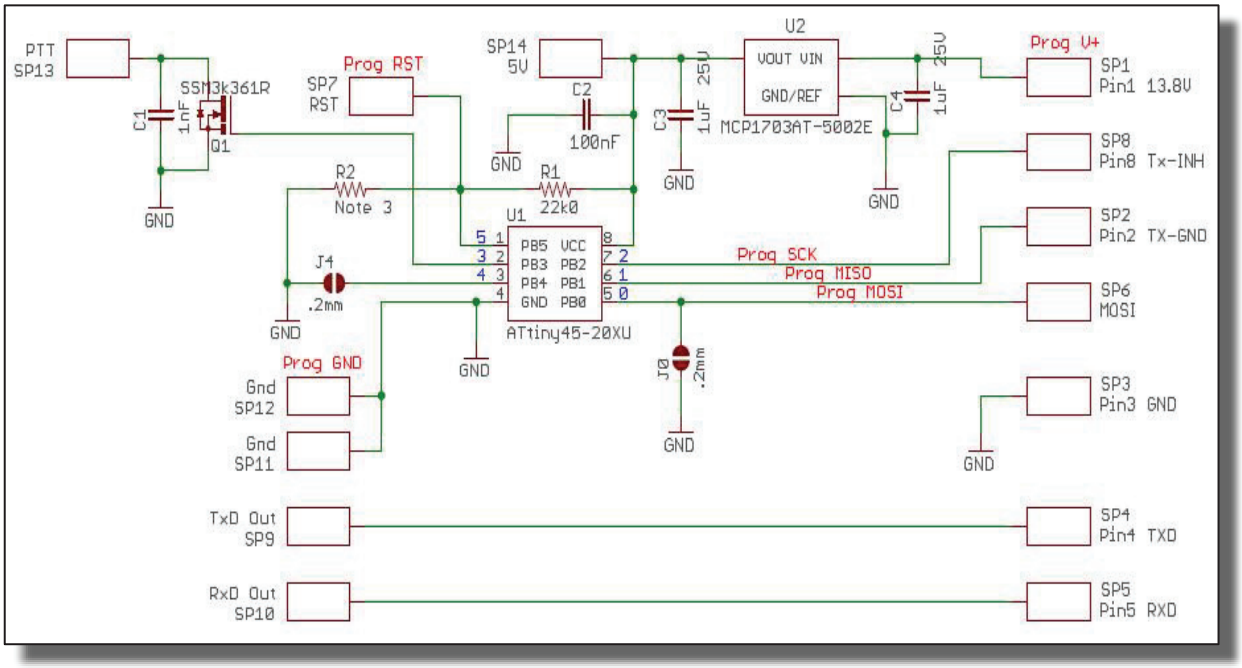
Important Note:

This controller provides only two delay times, one while transitioning from receive to transmit and a longer delay when transitioning from transmit to receive. If your set-up requires a multi-stage sequencer, for instance, removing power to a pre-amp then keying the transceiver then enabling a power amplifier, the additional delay sequences must be done elsewhere.





Circuit Description



Mini DIN Sequencer V2.2 Circuit Schematic

Hardware

The circuit is powered by the ACC port’s 13.8V supply pin.
A MCP1703 five volt low drop out regulator U2 provides the supply voltage for the microcontroller. C3 and C4 provide bypassing for the regulator to insure its stability.
U1, an Atmel ATtiny45 processor in an 8 pin small outline package, is the heart of the controller. This micro has six I/O pins and the design uses 4 as inputs and 2 as outputs.
Pins 2 and 7 are programmed as outputs. Pin 2 (PB3) drives the gate of Q1, a 100 Volt 3 Amp N channel FET. The drain of this device is the Push to Talk (PTT) output. C1 is an RF bypass capacitor. Pin 7 (BP2) connects to the ACC pin 2, Tx-Inh. Tx-Inh is used to prohibit or enable the transceiver’s RF output.
Pins 1, 3, 5, and 6 are programmed as inputs. Pin 1 (PB5) is programmed as an analog input, and is connected to a voltage divider formed by R1 and R2. The voltage at pin one determines whether the PTT output is active high or low. If R2 is not installed, the voltage at Pin 1 will be five volts and active low is used. If R2 is present it lowers the voltage measured at pin 1 and active high is used. Pin3 (PB4) and pin 5 (PB0) are configured as inputs with internal pull-up’s enabled. The two inputs are programmed to form a two bit binary word with PB4 set as the most significant bit. Together they are used to select Hangtime. If jumpers J0 or J4 are left open the internal pullups will take the inputs high, if the jumpers are soldered closed

the inputs are held at ground. Hangtime delays are programmable. The default values chosen are:

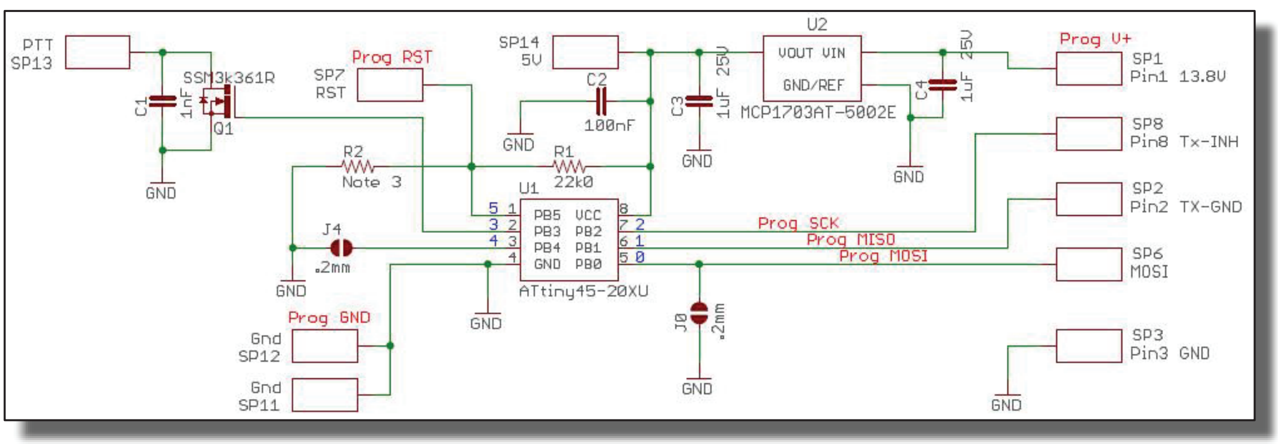
J0	J4	Hangtime (ms)
Open	Open	25
Short	Open	300
Open	Short	650
Short	Short	1000

Pin6 (PB1) connects to the ACC port's TX-GND pin (pin2) and is used to sense a request to transmit. The input is configured with its internal pull-up on so is high until the TX-GND pin is pulled low by the transceiver. Solder pads are provided on the PCB so that in circuit serial programming can be used to program the processor. Separate documents are provided describing the wiring hook-up and programming procedure.

Firmware

The ATtiny uses the Arduino programming environment. Install a copy of the Arduino integrated design environment and load the sequencer ino file into it to follow along as you go through the firmware description.

Circuit Schematic version 2.2



Inputs

1. TX-GND on PB1 – senses a request to transmit high= key-up or Rx, low=key-down or Tx.
2. Jumpers J0 on PB0 and J4 on PB4 set hangtime during initialization
3. Analog voltage on PB5 is used to sense whether PTT is active high or active low. R2 (33k Ohms) must be installed for active high.

Outputs

1. PTT on PB3 – an open drain is used to indicate transmit or receive state to the connected transverter. If active low is selected high, or off = Rx; low, or on =Tx. Opposite is true if active high.

2. Tx-Inh on PB2 – inhibits RF output power from a connected transceiver when high, and enables transmit power through the setup when low

Notes on Routines & Variables

1. The 'elapsedMillis' routine is used to allow input state changes to be monitored while the StartDelay or Hangtime is being counted in the background.
2. The variable 'StartDelay' is used to hold back RF power until the transverter has had time to safely switch from receive to transmit.
3. The variable 'Hangtime' is used to prevent the transverter from changing states from transmit back to receive in between Morse characters. Hangtime selected will depend on the user's code speed. A Hangtime of 25 ms is provided for digital or SSB work, and it is the 'default' i.e. both J0 and J4 are open.

Setup

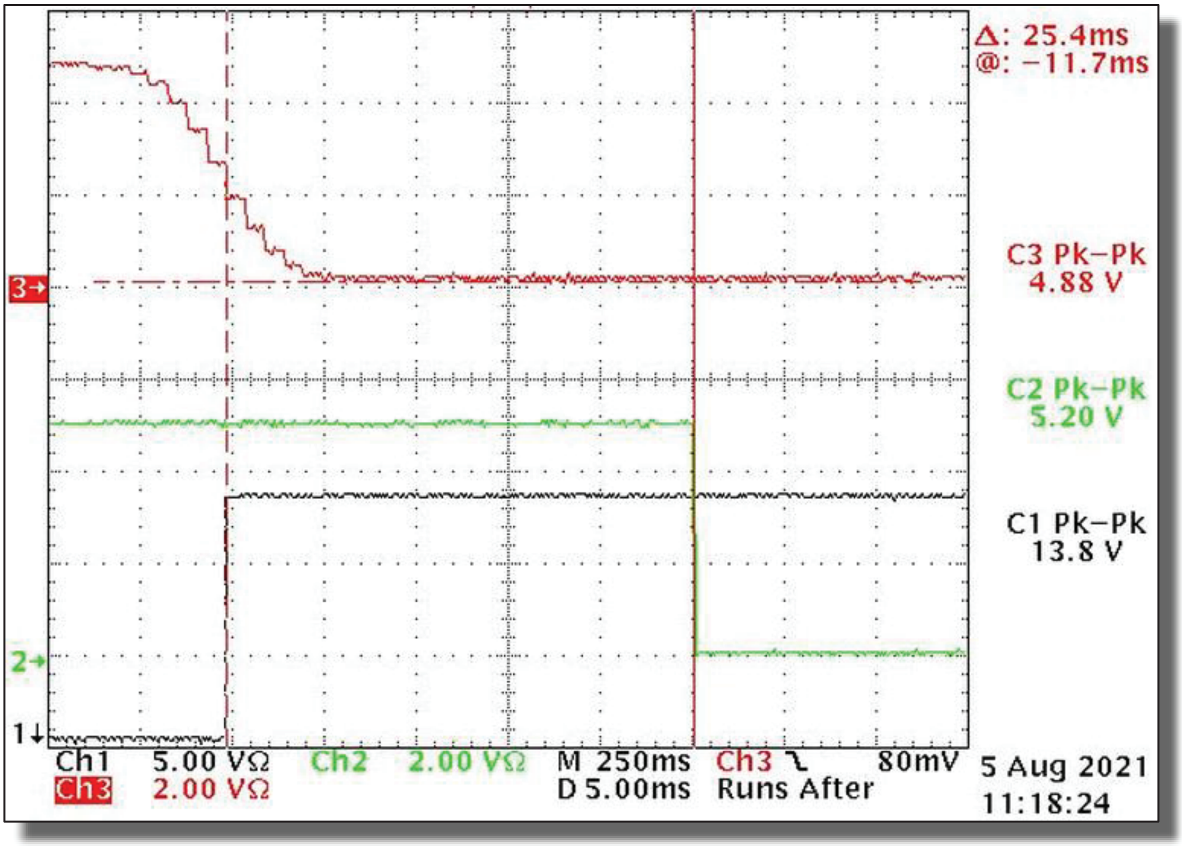
1. The voltage at PB5 is measured. If <= 3.5V, but higher than digital LOW, R2 (33k Ohms) is installed so PTT transmit mode is set to active high otherwise the measured voltage without R2 will be at the supply voltage and the transmit mode will be set to active low. The PTTState is initialized.
2. Inputs PB0 and PB4 form a two bit word used to select the hangtime from four possible options. These digital inputs have their pull-ups enabled so if the jumpers attached to these inputs are open the input will be high, if soldered short to ground the input will read low. PB4 forms the MSB. A switch routine is used to select the hangtime.
3. To minimize current consumption after initialization, the internal pull-ups and the analog converter are turned off.

Loop

1. Tx-Gnd is monitored and the program loops until TxGnd goes (or is) low.
2. PTT is toggled and routine monitors for a TxGnd state change while waiting for the StartDelay to expire. If TxGnd changes before StartDelay expires the StartDelay timer is reset.
3. StartDelay expires (TxGnd has remained low for StartDelay), so TxInh is taken low to enable RF through the system
4. The firmware monitors Tx-Gnd for a state change to high, indicating request to transition from Tx to Rx (key-up).
5. When a Tx-Gnd high is sensed, the Hangtime counter is started.
6. If Tx-Gnd goes low during the hangtime (key-down sensed), the Hangtime counter is reset.
7. If Hangtime expires, TX-GND has been high for longer than the Hangtime, so TxInh is taken high, preventing RF from entering the system, then after a short delay, the PTT state is toggled into the receive state.
8. The firmware loops back to the beginning of the loop routine and waits for TX-GND to go low.

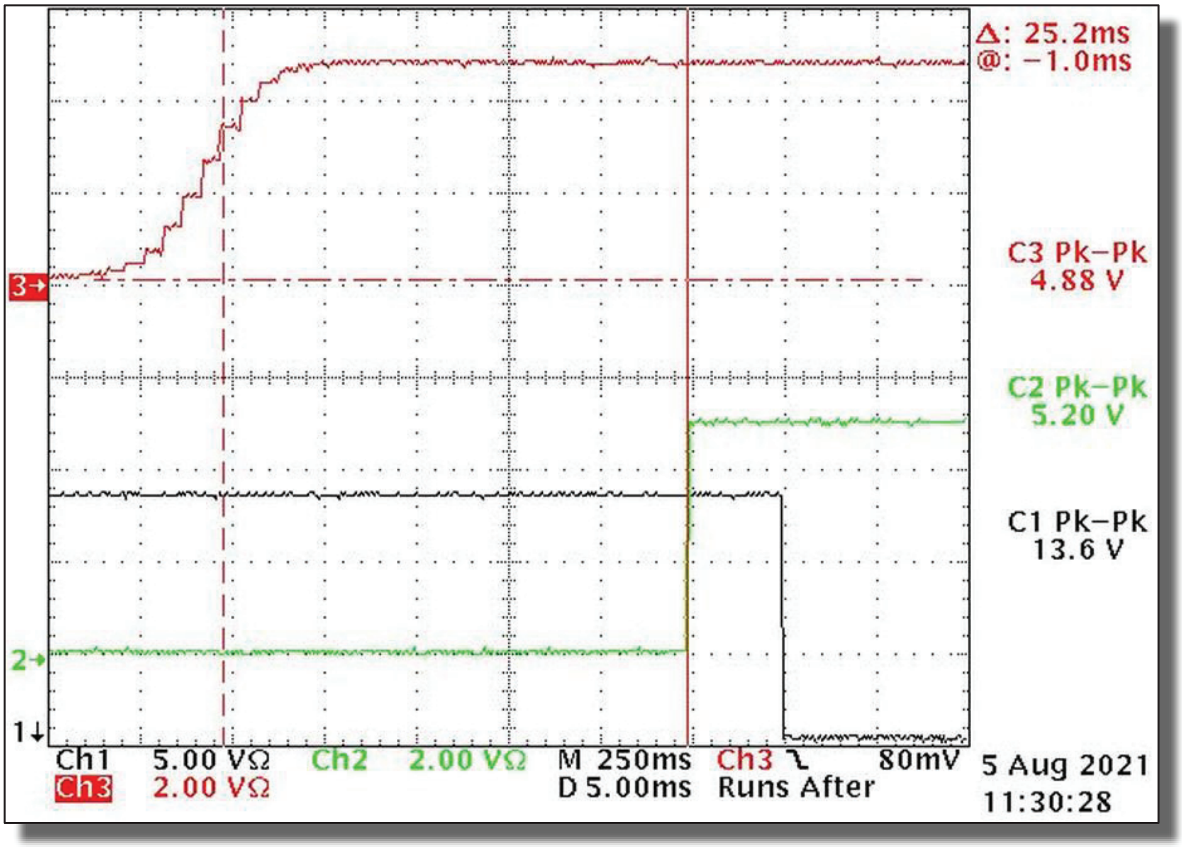
Timing Measurements

In the following scope trace records, trace 1 is the sequencer's PTT output, trace 2 the TxInh output to the ACC connector pin 8, and trace 3 is TxGnd input from the ACC connector pin2.



StartDelay (PTT active high)

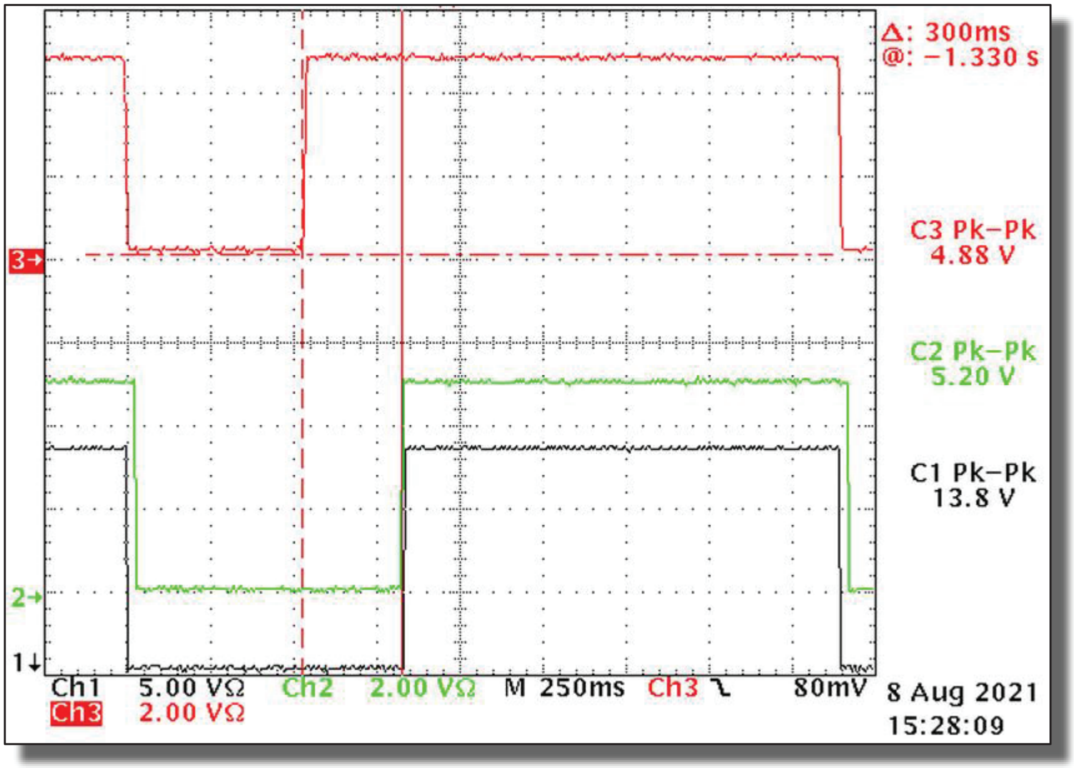
StartDelay is programmed to be 25ms. PTT is active high. The transceiver's TxGnd open collector output goes low indicating a request to transmit. PTT goes hi telling the transverter to set up for transmit mode, and TxInh delays RF output from the transceiver for 25 ms giving the transverter time to change state to transmit before RF is allowed though the system.



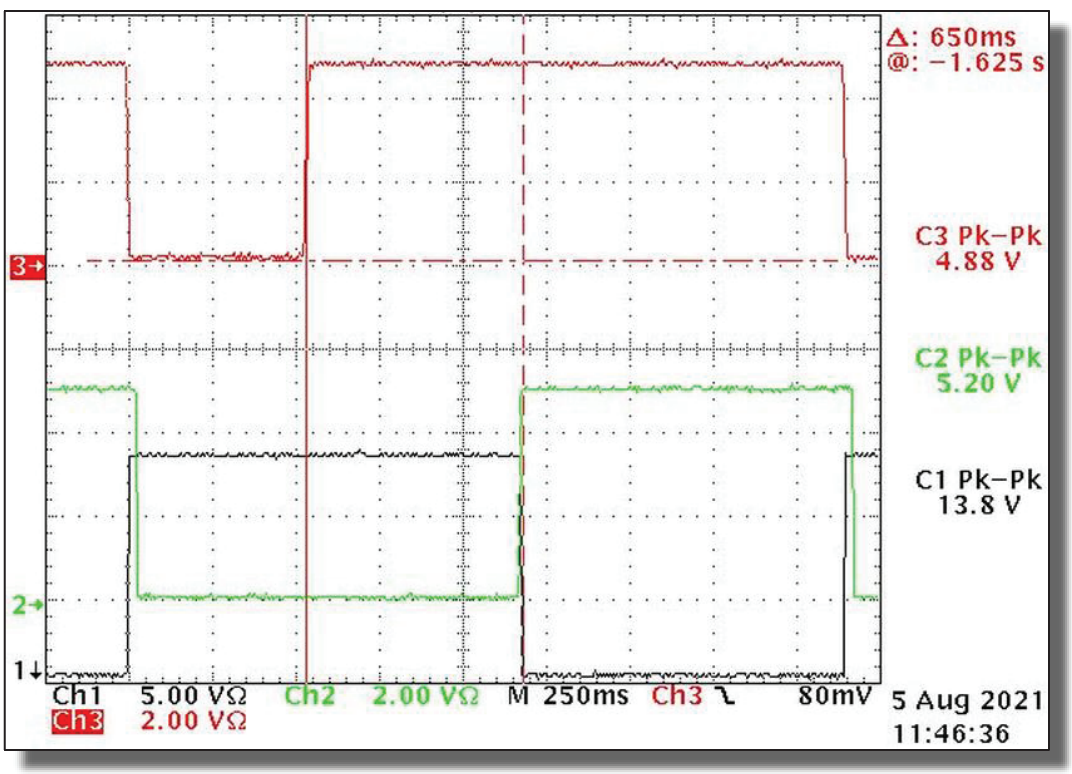
Hangtime Delay 25 ms (PTT active high)

Hangtime delay is programmed to be 25ms. PTT is active high. The transceiver's TxGnd open collector output goes high indicating a request to return to the receive state. Hangtime delays the start of a transition to receive for 25 ms. At that time TxInh goes high disabling the transceivers RF output. A further delay of 5 ms is built into the system to insure that TxInh always inhibits RF before the transverter is allowed to switch state back to receive. After the further 5 ms delay, PTT goes low, allowing the transverter to switch to the receive state. The 5 ms delay is arbitrary. It insures that TxInh always precedes PTT to insure that there is no RF in the system when PTT commands the transverter to change state back to receive. If TxGnd is re-triggered before TxInh goes high the Hangtime delay is extended until TxGnd once again goes low. If TxGnd is retriggered after TxInh goes high, a StartDelay is invoked. The 5 ms delay is the same for all Hangtime and therefore has the most impact with the 25 ms Hangtime making it 30 ms

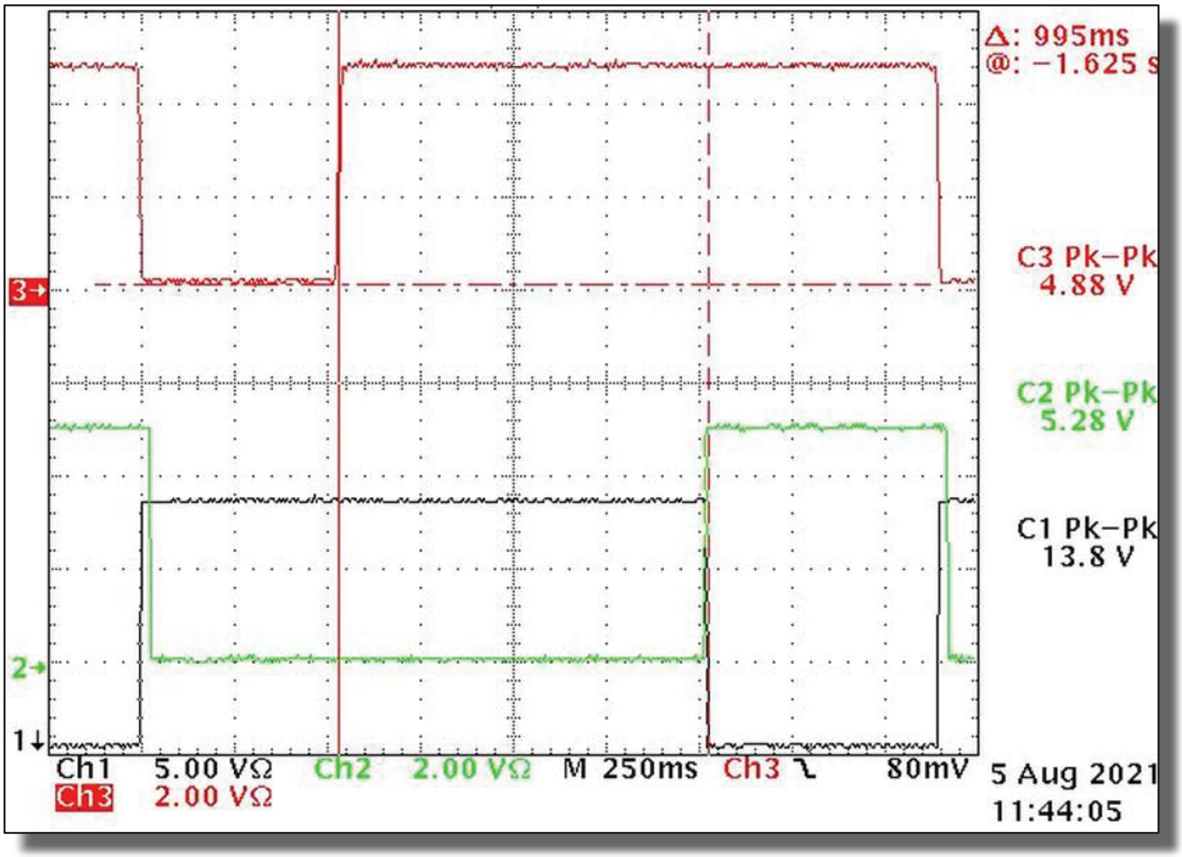
Hangtime can also be configured for 300,650, or 1000 ms



300 ms Hangtime Delay (PTT active low)



650 ms Hangtime Delay (PTT active high)



1000 ms Hangtime Delay (PTT active high)

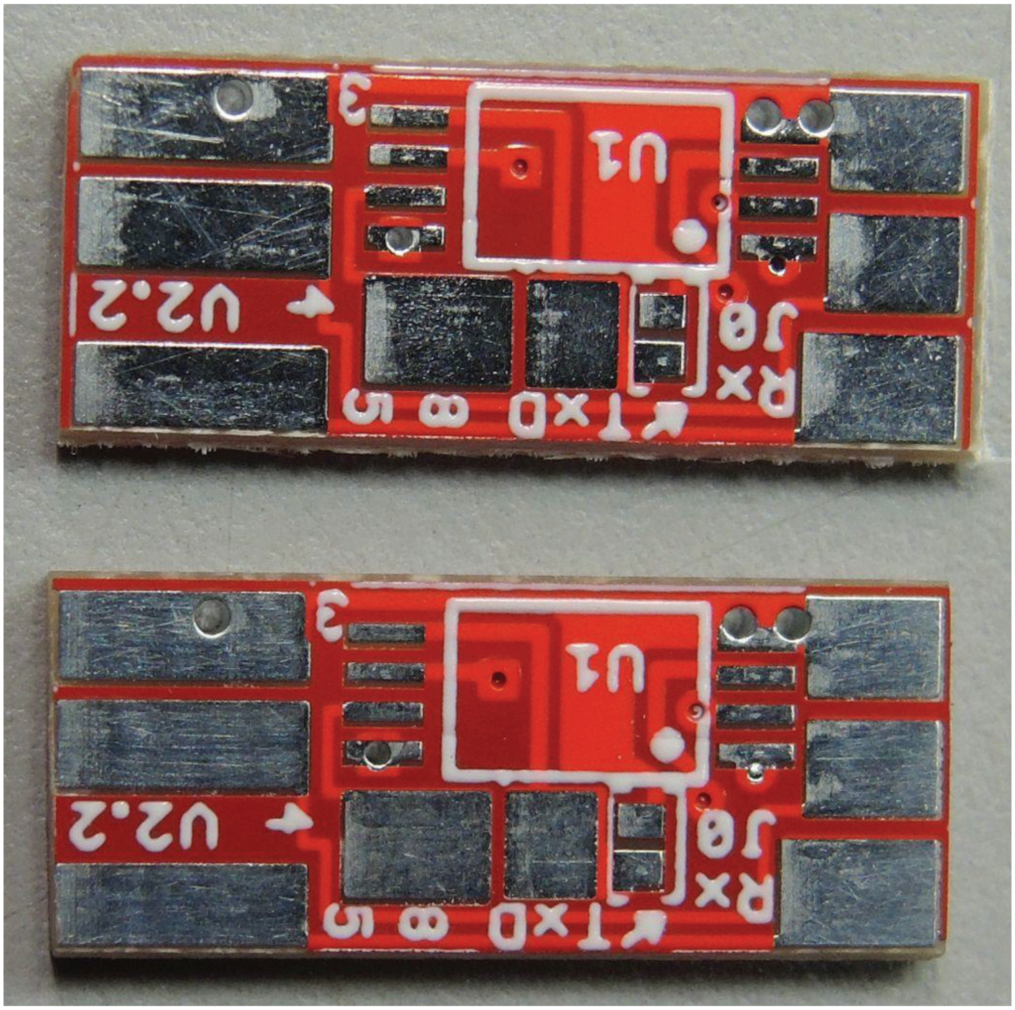
Assembly Guidelines

Start by dry fitting the PCB in the Mini DIN connector. It's a tight fit and the PCB was Vcut so the edges are not as precise as routing would be. As a result the PCB may be just a bit longer and wider than desired. The PCB must NOT extend past the end of the metal shield surrounding the DIN connector.

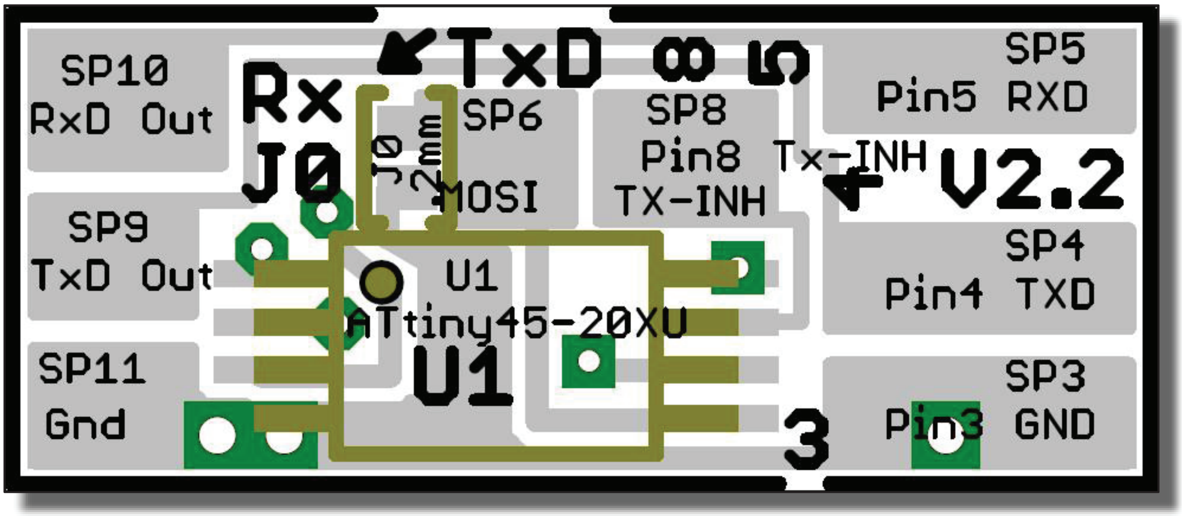
Disassemble the 8 pin Mini Din connector. The Mini Din has 3 rows of pins, 2 pins in the first row (1, 2) and a second and third row of three pins (3, 4, 5, & 6, 7, 8).

Fit the PCB into the DIN connector pushing it all the way into the connector while aligning it carefully between the first two rows of pins with pins 1 and 2 to the PCB bottom and 3, 4, 5 to the PCB top.

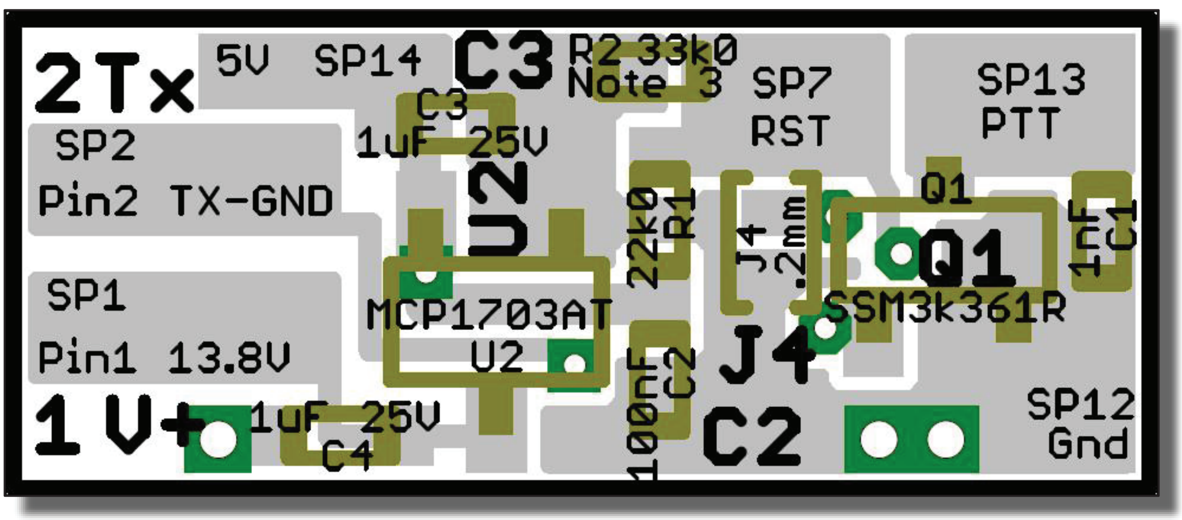
Place the metal shield around the PCB and check for clearances. If the board is too long or wide, file a bit off the PCB like the image below which shows a PCB before and after filing. Be careful not to cut into the pads.



Populate all the components on both sides of the PCB. As the PCB is small, there wasn't room to provide identification for all components on the silk screen, so use the PCB top and bottom layouts below to identify part locations. The PCB top side has three Mini DIN solder pads. The bottom has two.
Components are fairly tightly packed on this board, and when they share a common connection area solder pad like C2 and R1, soldering can be a bit tricky as the solder tends to spread into the adjacent component's pad area. For best results solder the end of the component that abuts the already installed component first.



1. ***Install all top side components***
   - ☐ U1 ATtiny45-20XU - Solder pin 4 first. Align the device for best fit then solder pin 8 followed by the remaining pins
   - ☐ J0 Solder jumper short if Hangtime is to be 650 or 1000 ms

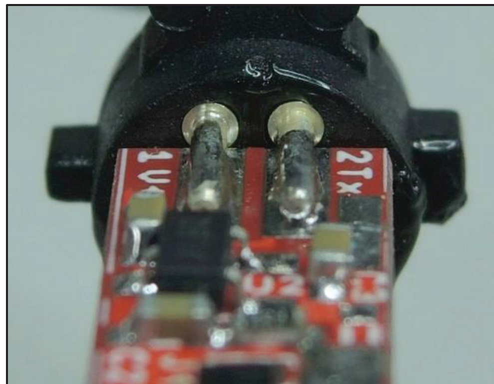


2. ***Install all bottom side components***
   - ☐ R1 22k0
   - ☐ R2 33k0 - install only if PTT is active high
   - ☐ C3 1uF 25V MLCC
   - ☐ C4 1uF 25V MLCC
   - ☐ C2 100nF 50V
   - ☐ J4 Solder jumper short if Hangtime is to be 300 or 1000 ms
   - ☐ Q1 SSM3K361R Nch MOSFET
   - ☐ C1 1nF

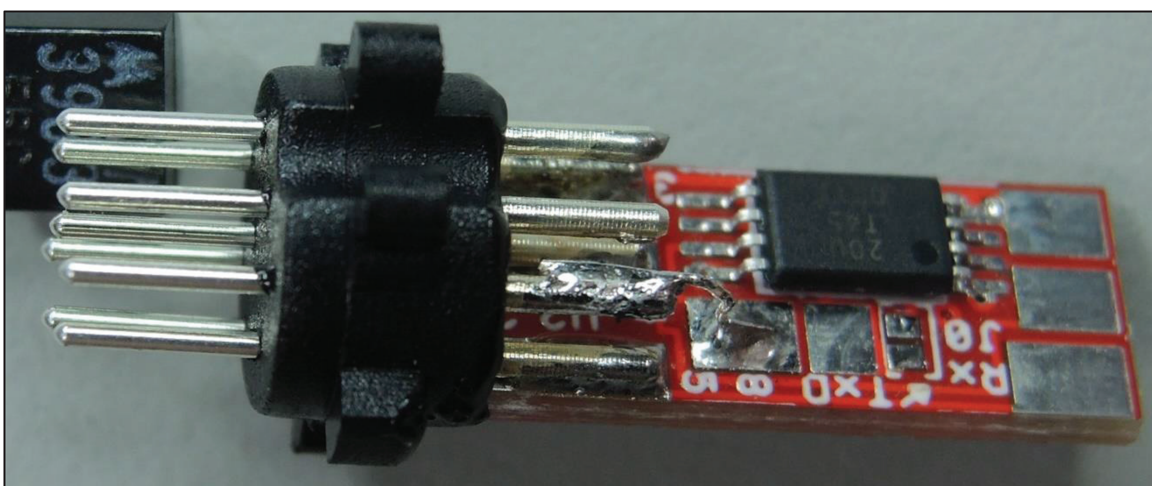
- U1 MCP1703AT-5002E
- Program the microcontroller if it is not pre-programmed

3. Carefully inspect the PCB soldering for bridges or incomplete solder joints especially on U1 and the jumpers.

Assembly & Test



Again fit the Mini DIN connector and PCB together pushing the PCB all the way into the connector. Solder pin 4.
Check PCB alignment to the connector. The PCB must be centered and placed tightly against the Mini DIN connector's body.
Place the connector and PCB in the Mini DIN metal shell and check alignment. The fit is tight so there isn't much room for misalignment. Adjust the PCB location if necessary to make sure it fits within the Mini DIN's metal surround casing.
Solder the remaining Mini DIN pins to the PCB and check to insure there isn't any solder bridging between the PCB pads or Mini DIN pins.
Strip the insulation from the piece of 30 gage wire-wrap wire and solder Pin 8 of the Mini DIN connector to the SP8 solder pad on the PCB.



- Wire soldered from SP8 to Mini DIN pin 8

Functional Verification Testing

These initial tests insure that there are no short circuits that could damage the transceiver's ACC port. A multimeter with probes capable of probing the sequencer PCB will be required for these tests.

a. Measure the resistance between SP1 marked 13.8V with the meter's positive probe lead and SP12 marked Gnd. Because of the capacitors in the supply line and the voltage used on resistance range of the multimeter the reading may start off in the kiloohm range but with a few pokes it should go very high, in the megaohms range.
    - ☐ SP1 to SP12 resistance __________ ohms.

b. Measure the resistance between SP2 marked Tx-Gnd with the meter's positive lead and SP12 marked Gnd. It too should be very high, in the megaohms range.
    - ☐ SP2 to SP12 resistance __________ ohms.

Check that the voltage regulator is working. For this test a variable voltage source is required as well as a multimeter.

a) Attach the variable voltage source to the PCB by solder jumper wires onto the PCB side of the Mini DIN 13.8V pin (pin 1) and ground at SP12. Set the voltage source to 5.0 volts and apply power to the circuit. Using the multimeter, monitor the voltage between ground and the 5V solder pad SP14. The voltage should be 5.0 V +/- 0.15V
    - ☐ SP14 to Gnd voltage __________ volts.

b) Increase the supply voltage to 5.5 volts. The voltage at SP14 should stabilize at 5.0 V +/- 0.15V
    - ☐ SP14 to Gnd voltage __________ volts.

c. Increase the supply voltage to 6.0 volts. Record the 6.0 volt reading and calculate the difference in voltage between the 5.5 and 6.0 measurements. It should be less than 0.05 volts. If the voltage increases more than 0.1 volts, do not go further or the microcontroller will be damaged. There is something wrong with the voltage regulator that must be fixed before proceeding any further.
    - ☐ Reading with 6.0 volts applied __________ volts.
    - ☐ 5.5 to 6.0 voltage difference __________ volts.

d. Increase the supply voltage to 15.0 volts. The voltage at SP14 should not vary by more than 0.15V from the 6.0 volt reading.
    - ☐ 6.0 to 15.0 voltage difference __________ volts.

The following tests will verify that the circuit is switching correctly but of course can't assess the delays. This test will use the FT-817 in both receive and transmit mode. When placing the transceiver in transmit mode, any power or band will do. The easiest way to make the FT-817 transmit continuously is to use the PTT switch on the microphone. You will also need a power supply for the transverter with an output voltage of between 12 and 14 volts, a dummy load, and a multimeter with a probe lead capable of probing the sequencer PCB terminals, and a leaded resistor. Any quarter or half watt resistor with a value anywhere between 1,000 and 10,000 ohms will do.

Tack solder one end of the resistor to the PTT solder pad SP13. Connect the other end of the resistor to the positive terminal of the external power source.

Place a dummy load on the transceiver's RF output.

Plug the Mini DIN sequencer assembly into the transceiver's ACC socket.

Connect the multimeter ground to any convenient ground point on the transceiver.

Connect the transceiver to the external power source.

Turn the transceiver on and keep it in receive mode. For measuring convenience turn the rig upside down.

a. Measure and record the power supply voltage when the transceiver is transmitting. This voltage will be used as a reference for other measurements
   - ☐ Power supply voltage during Tx __________ V.
b. Measure the voltage at SP1 marked 13.8V, that's also Pin 1 of the Mini Din connector. It should be within 0.75 volts of the power supply voltage
   - ☐ SP1 voltage __________ V.
c. Measure and record the voltage at SP14, the output of the five volt regulator. It should be 5 volts +/ 0.15 volts.
   - ☐ SP14 voltage __________ V.
d. Measure the voltage at SP13 PTT. If the sequencer is configured for PTT active low the measured voltage should be within 100 mV of the supply voltage. If the sequencer is configured for PTT active high, the voltage should be less than 100 mV.
   - ☐ SP13 PTT voltage __________ V.
e. Measure the voltage at Tx-GND pin 2 of the Mini DIN connector. It should be within .05 volts of the voltage measured at the output of the 5 volt regulator.
   - ☐ TX-GND pin 2 voltage __________ V.
f. Using the microphone PTT switch place the transceiver in transmit mode and measure the voltage at Tx-Gnd pin 2 of the Mini DIN connector. It should be under 100mV.
   - ☐ TX-GND pin 2 voltage in transmit __________ mV.
g. With the transceiver again in transmit mode and measure the voltage at PTT SP 13. If the sequencer is configured for PTT active low the measured voltage should less than 100 mV. If the sequencer is configured for PTT active high, the voltage should be within 100 mV of the supply voltage.
   - ☐ PTT SP13 voltage in transmit __________ V.

Place the transceiver in receive mode. Turn the transceiver right side up for measuring convenience.

h. Measure the voltage at SP8 TxInh or Pin 8 of the Mini DIN connector. It should be within 50 millivolts of the voltage measured at SP14
   - SP8 voltage __________ V.

i. Place the transceiver in transmit mode and measure the voltage at SP8 marked TxInh. It should be under 100mV.
   - SP8 voltage in transmit __________ mV.

Turn the transceiver off and carefully remove the Mini Din plug & PCB assembly by wiggling it out of the socket. Unsolder the resistor from the PTT solder pad and remove it.

Final Assembly

In the following steps install the push to talk control cable of your choice that will connect the sequencer to the transverter's push to talk input.
Place the 15mm long 7mm diameter piece of heat shrink and the Mini DIN outer shell over the end of the connecting cable.
Solder the cable's positive lead to SP13 (PTT), and negative lead to SP12 (GND).

If rig control is to be used solder its cable leads to the SP9 the TxD Out, SP10 RxD Out, and SP11 Gnd, pins on the sequencer PCB.

It's a good idea just to check the cable continuity before assembling the connector.

Complete the assembly of the Mini DIN connector.
Slip the 15 mm length of 7mm diameter heat-shrink over the PCB assembly to prevent any possible shorts to the Mini DIN's metal case. Install the Mini DIN's metal shield around the connector and PCB assembly then place the plastic case parts over the connector. Push the Mini DIN cover part way over the assembly. Insert the Mini DIN into the ACC socket then push the cover onto the connector so that it is just shy of the rear panel. Don't push it too far on or it will become difficult to near impossible to disassemble the connector if needed.

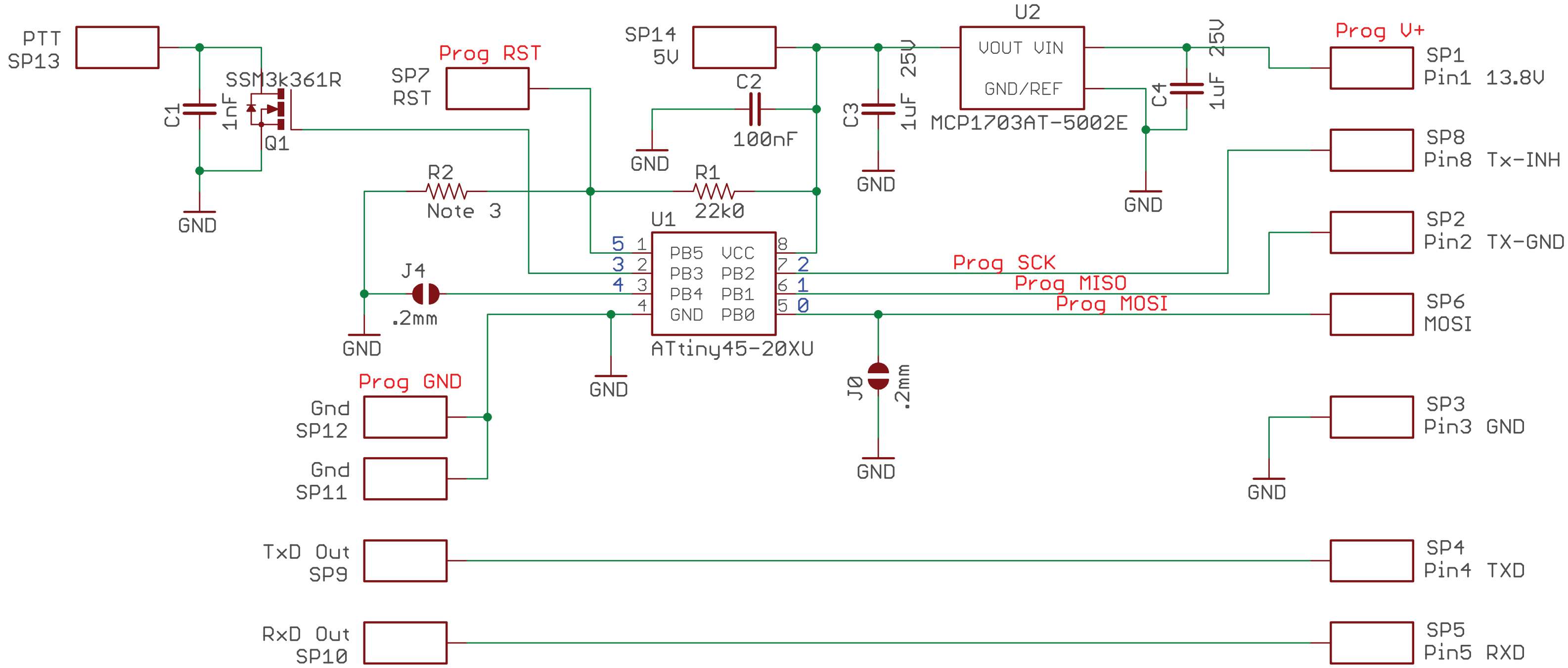
Notes about driving higher current loads and relays with the PTT output

1. The PTT drain output is an SSM3k361 Nch MOSFET rated for a maximum 100 volts V_{DSS} and a maximum drain current of 3.5 amps so should be robust for most applications. It does have a maximum on resistance of 95 milliohms when driven from the five volt processor so when driving high current loads do keep in mind that it's a tiny SOT23 device. Power dissipation should be limited to under 0.75 Watts, and to do this the maximum drive current should be kept to under one amp.

2. The PTT drain has no transient protection so when driving inductive loads like relays, transient protection must be provided externally.
3. With PTT active high applications note that there is no internal bias supply for the drain. To make the output high, a bias must be supplied from external circuitry. When active hi (in transmit) the PTT drain will be open circuit. In receive, PTT will be driven to ground.

FT817 Mini-DIN Sequencer

Qty	Value	Device	Part ID	Source	Part No. or Vendor ID
Resistors					
1	22k0	RESISTOR 1608 (0603) 1%	R1	Digi-Key	RMCF0603FT22K0CT-ND
1	33k0	RESISTOR 1608 (0603) 1%	R2	Digi-Key	RMCF0603FT33K0CT-ND
Capacitors					
1	1nf	CAP_NONPOLARIZED 1608 (0603) 5% NPO 50V	C1	Digi-Key	311-1080-1-ND
1	0.1uF	CAP_NONPOLARIZED 1608 (0603) 10% X7R 50V	C4	Digi-Key	1276-1000-1-ND
2	1uF 25V	CAP_NONPOLARIZED 1608 (0603) 10% X5R 50V	C2,C3	Digi-Key	490-16608-1-ND
IC's & Transistors					
1	MC1703AT	MCP1703AT-5002E/CB	U2	Digi-Key	MCP1703AT-5002E/CBCT-ND
1	SSM3K361R,LF	Nch SOT23-F 100V 3.5A 1V VGSth range	Q2	Digi-Key	SSM3K361RLFCT-ND
1	ATTINY45-20XU	ATTINY45-20XU	U1	Digi-Key	ATTINY45-20XU-ND
Enclosure, Hardware, Connectors & Other Parts					
1	PCB	15.5 x 6.5 x1.2 mm		VE3CZO	
1	interconnect wire	2cm 30ga wire wrap wire		VE3CZO	
1	heat shrink	7mm dia. X 15 mm long		eBay	hifispot168
1	8pin Mini-DIN	Male in-line connector		Digi-Key	CP-2080-ND



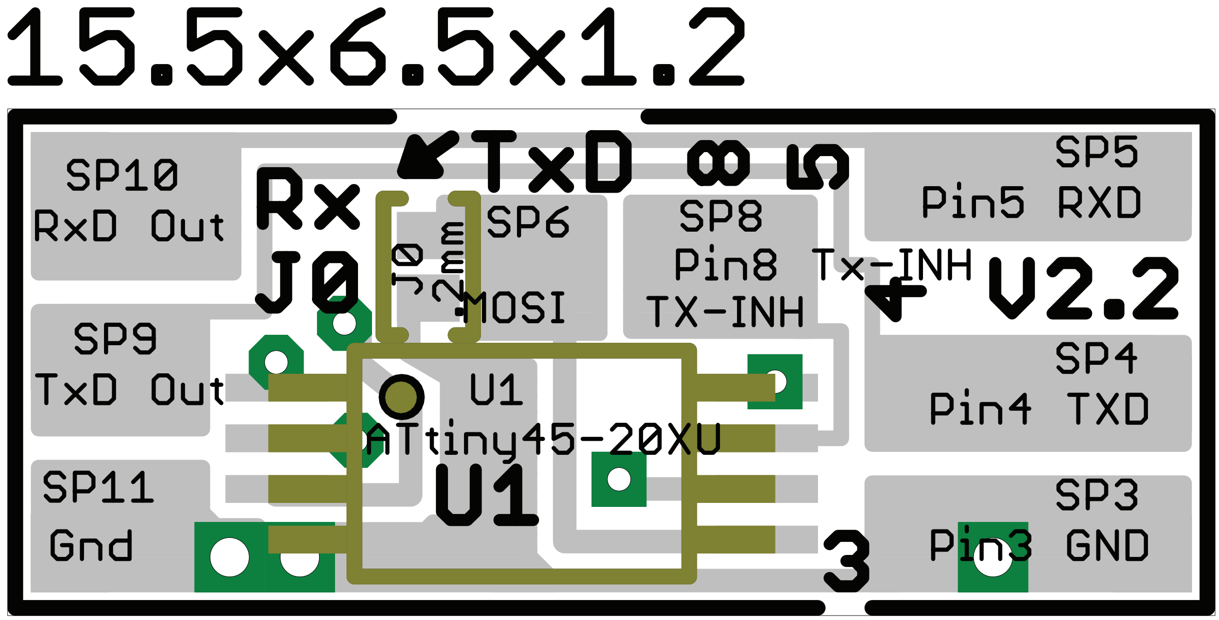
Notes

1) Connections for ICSP shown in red, Prog V+ must be >8V.
   Don't forget the cap on reset when programming!! It must be added externally.
2) Arduino pin numbers shown in blue
3) PTT active hi install R2 33k0 PTT active low do not install R2
4) Shorting jumpers J4 or J0 changes Hangtime (*=jumper shorted)

J4	J0	Hangtime(ms)
		25ms
*		250ms
	*	650ms
*	*	1000ms

8 Pin Mini-DIN Xvtr I/F

File: FT817 Mini-DIN sequencer V2.2	
Author: VE3CZO	REV: V2.2
Date: 01-Aug-21 15:40	1/1



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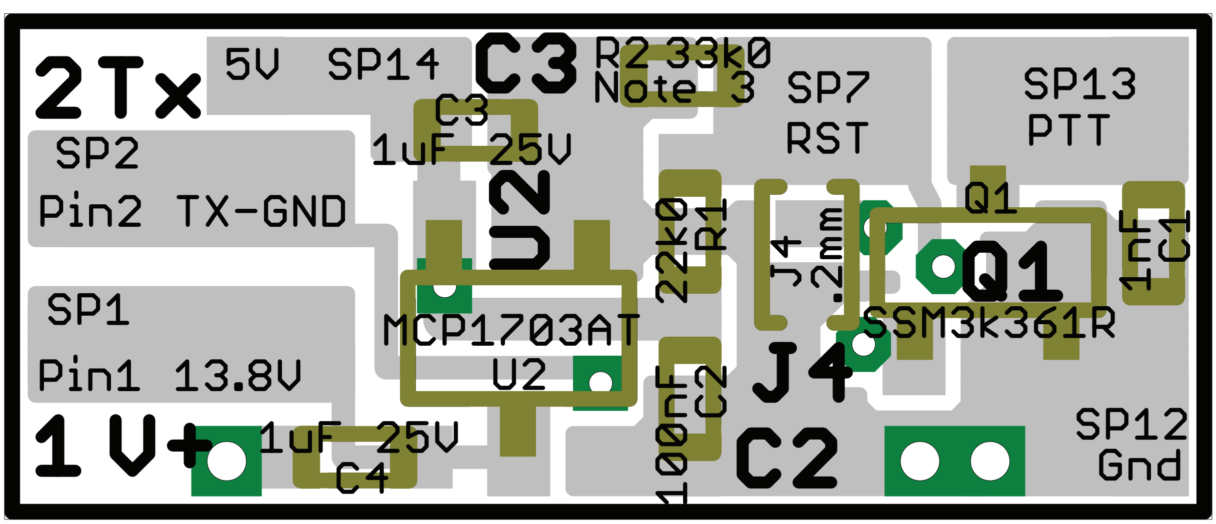

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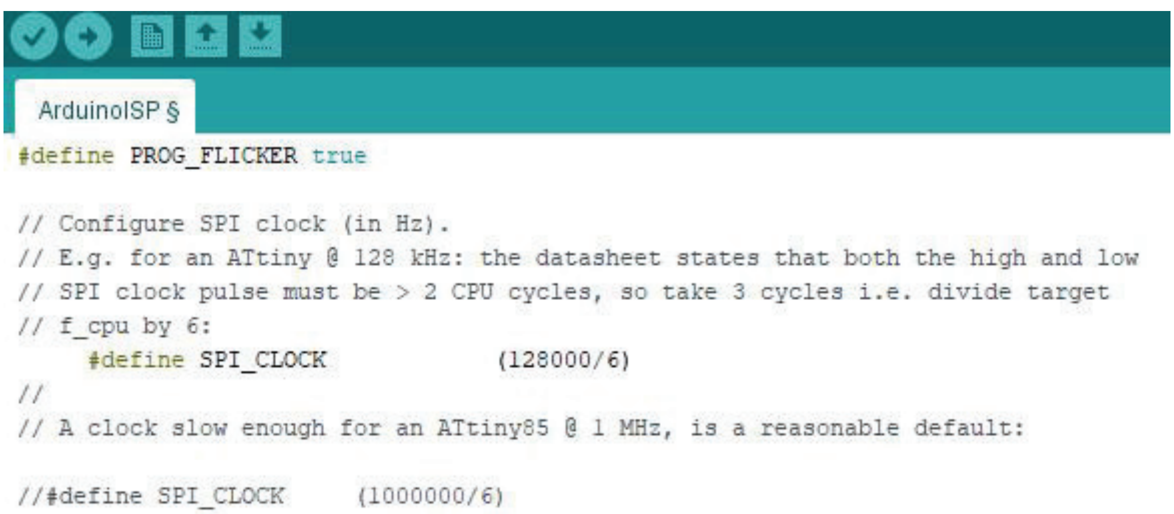
ATTiny Programming for the Mini DIN sequencer using an Arduino Nano

As the ATtiny doesn't have a communications port programming in with the Arduino IDE is a bit more complicated than simply plugging in a USB connector. The In Circuit Serial Programming (ICSP) port will be used for programming.

1. Program the Arduino Nano as an ISP programmer
    a. Attach a Nano to the computer via USB cable. Do NOT connect the Nano to any other circuity at this point or you'll likely get programming errors.
    b. Download and / or open the Arduino IDE. The Download can be found here: https://www.arduino.cc/en/software
    c. Navigate to 'File' then 'Examples' then 'ArduinoISP' then move the mouse right to reveal 'ArduinoISP' option and select it to load the program.
        i. As the wiring to the ATtiny is a bit of a rats nest we will modify the 'ArduinoISP' script to use a lower programming speed, i.e. 128k. This speed will also work when programming a device for any clock speed, it simply slows down the programming rate and may be useful with the additional lead lengths needed to connect the sequencer to the programmer.
        ii. Navigate to the 'Configure SPI clock (in Hz.)' section of the sketch. Uncomment the line #define SPI_CLOCK (128000/6)
        iii. Comment out the line #define SPI_CLOCK (1000000/6)
        iv. This changes the programming rate from 1MHz to 128 kHz



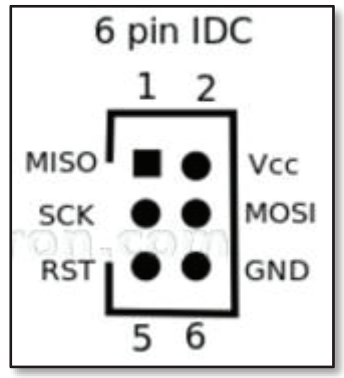
    d. Navigate to the 'Tools' menu then 'Board:' then 'Arduino AVR boards' and select 'Arduino Nano'
    e. Again navigate to the 'Tools' menu then 'Processor' then select 'ATmega328P' Note if this fails to program correctly you may have an older boot loader in

which case go back to the 'Tools' 'Processor' and select 'ATmega328P (Old Bootloader).

f. Again navigate to the 'Tools' menu then 'Port:' and make sure the correct com port is selected.

g. Program the Nano. Navigate to the right arrow in a circle icon near the top of the screen and select it or navigate to the 'Sketch' menu item then select 'Upload'

2. Put together a programming jig. Solder pads are provided on the sequencer PCB for wires that can be connected as indicated in the table below. Keep the wire lengths under about 10 cm. It's convenient to use a solderless breadboard as a host for the Nano and wires but not absolutely necessary. The Nano ICSP header can also be used instead of the D pins with the exception of the reset pin which must be connected to D10 on the Nano. Don't forget to add a 10 uF capacitor from RST (+) to Gnd (-) on the Nano.



Function	*ATtiny physical pin*	*Sequencer Solder Pad*	*Nano Pin*	*Nano ICSP 6 pin header*
Reset	1	SP7	D10	D10 (not on ISP)
MOSI	5	SP6	D11	4
MISO	6	SP2 (DIN Pin2)	D12	1
SCK	7	SP8 (DIN Pin8)	D13	3
V+	8	SP1 (DIN Pin1)	5V	2
GND	4	SP11 or SP12	GND	6
10uF cap			RST to Gnd	

3. Prepare the ATTiny 45 for programming with a bootloader
   a. Download the ATTinyCore to add these boards to the boards manager
      i. Click on 'File' then 'Settings'
      ii. In the 'Additional Boards Manager URLs:' section near the bottom of the window paste the following link
      iii. http://drazzy.com/package_drazzy.com_index.json
      iv. Click on 'OK'
   b. Click on 'Tools' then 'Board: 'Arduino Nano', then right and click on 'Boards Manager'
   c. In the 'Filter your search…' at the top of the window type in 'ATTinyCore'
   d. Click on the 'ATTinyCore window area.
   e. Close the 'Boards Manager' window.
   f. Click on 'Tools' then 'Board: …' and navigate to 'ATTiny Core'

   g. Select ‘ATtiny 25/45/85’
   h. Clock on ‘Tools’ then ‘Chip: …’ then navigate to and select ‘ATtiny45’
   i. Click on ‘Tools’ then ‘Clock: …’ then navigate to ‘1MHz internal’
   j. Leave other menu items in the ‘Tools’ section in their defaults.
   k. Click on ‘Tools’ then ‘Port’ and check that the correct port is still selected.
   l. Click on ‘Tools’ then ‘Programmer’. Navigate to and select ‘Arduino as ISP (ATTinyCore)’
4. Load the Mini-DIN sequencer sketch
   a. Click on ‘File’ then ‘Open’
   b. Navigate to and select the ‘Sequencer for Ver2.2 hw_V2.2a.ino’
   c. Make any desired changes to the StartDelay or Hangtime but if you do make changes save the file with a different name.
5. Add elapsedMillis to the Arduino library
   a. Under the ‘Tools’ menu click on ‘Manage Libraries’
   b. In the library manager search for ‘elapsedMillis’ and install the latest version
6. Click on the ‘Tools’ menu and check that all the options for board, chip, clock speed, and port are still valid.
7. Burn the Bootloader and then the sequencer sketch
   a. Click on the ‘Tools’ menu then select ‘Burn Bootloader’
   b. Upload the sketch using the right arrow in the circle in a menu near the top or click on ‘Sketch’ then ‘Upload’
8. Unsolder all the programming leads from the sequencer and try it out!