Introduction to Soldering and Kit Building

with Cam, W4XXV

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Overview

This course will focus on the skills needed to assemble and solder basic electronic kits and from-scratch fabrication with a focus on amateur radio related kits. Progression through this learning series will end with a usable, fixed frequency CW transceiver system.

The idea of this course is that we will progressively cover more technically challenging builds, with the final goal of a completed system. Along the way we will cover basic component identification, simple multimeter measurements, strategies for assembly, and useful tips to help builds go a little more smoothly. It is understood that not all kits come with instructions and may require research and outside guidance to assemble. We will cover basic sourcing and assembly of a scratch-built projects as well.

**No amateur license is required to assemble and listen with these components, or to transmit into the dummy load. Transmitting CW over the air will require at least a technician license using the 7.030 MHz crystal. Consult band privileges for your license level for other frequencies.*

Caution:

We will be using sharp cutting tools, and hot, molten metal that can damage your kitchen table, or your body. Please use caution, and always use safety glasses when performing these tasks. Trimmed component leads are sharp and can go flying as they are snipped. These discarded leads should be carefully disposed of.
If you choose to follow along with this course, you are doing so at your own risk.

Tools Required

- Work desk/area with close available outlet
- Multimeter w/capacitance
- Soldering iron/solder
- Flush cutters
- Small needle nose pliers
- Small Phillips screwdriver
- Tape measure
- Hand drill w/#50 drill bit
- Battery pack

Tools Recommended

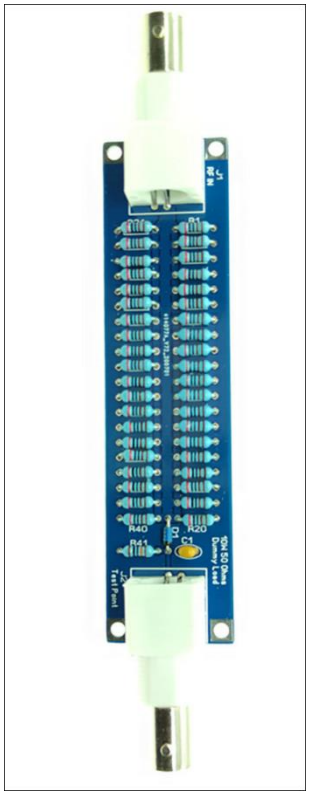
- Silicone mat
- Helping hands
- Magnification with light
- Hot melt glue gun
- Box cutter for scraping magnet wire
- Packing foam to poke components into

Kits/Parts Required

Note: Make sure to select "Kit" for some items on eBay so they do not come assembled. Allow at least 6 weeks for delivery from China.

- 10 Watt Dummy Load Kit – eBay - $10
- QRPGuys EFHW Antenna 40m-15m with Tuner – qrpguys.com - $30 + shipping
- 50' speaker wire (for making antenna) – get from anywhere – estimate $15
- Power pack/battery holder with plug – eBay - $8
- Pixie CW transceiver kit – eBay - $8
  (we will add a 7.030 Mhz crystal – ask instructor for sources)
- Band-Pass Filter from-scratch parts – ask instructor for sources – estimate $15
- Earbuds or headphones with 1/8" (3.5mm) plug – get from anywhere
- Morse straight key with 1/8" (3.5mm) mono plug – ask instructor for sources
- 2 x BNC jumper cables (50 ohm) – eBay - $2 each in packs of 5

Unit 1: Setup, Soldering, and a Dummy Load



Unit Overview

This kit illustrates a simple design with no instructions available.

- Parts identification and inventory
- Use of multimeter
- Soldering setup
- Good solder joints
- Parts placement and order
- Trimming leads

Tools Needed

- Work area
- Soldering Iron
- Solder
- Multimeter
- Flush cutters
- Foam block or empty egg carton
- Sharpie and tape to mark on

Kits/Parts Needed

- 10 Watt Dummy Load Kit

Standards/Expectations

This unit will cover basic components of the kit we are building, how to test and organize parts. We will then walk through the first steps of setting up your soldering iron, and work area. Assembly steps will be showing tips for mounting, soldering, and trimming components. Final assessment will be how to do basic tests of the assembled unit.

Kit Inventory

- ☐ Main Board
- ☐ 1 x resistor (100k ohms)
- ☐ 40 x resistor (2k ohms)
- ☐ 2 x BNC connectors
- ☐ 1 x capacitor (10000 pF labeled 103)
- ☐ 1 x diode

Build Procedure

Inventory all items using a check sheet, multimeter, and organizational method. Identify all components and ensure all are within spec. Replace any components from personal inventory (you will acquire parts through the years).

There are two basic assembly paths people follow. By usable/testable stage or by component size. We will use the component sizing as our projects aren't very complicated.

Start assembly using shortest components to tallest. My recommended general order for kits is resistors, diodes, disk capacitors, transistors, crystals, electrolytic capacitors, IC sockets, LEDs, inductors, other large components, then insert ICs into sockets.

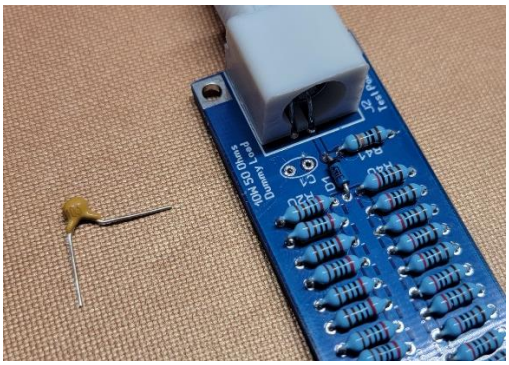
Heat soldering iron (700F/370C for lead based, 750F/400C for lead free). Dampen sponge. Tin the tip.

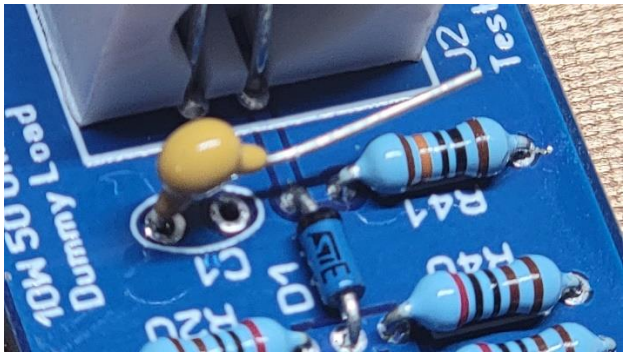
We start with the 40 x 2k diodes (R1 – R40). Learn to bend components, place through holes, spread leads to hold, then solder correctly. Optional “plink” test to listen for bad solder joint. Clip leads to top of soldered joint. Optional testing at J1 by testing resistance between two smaller holes. Each additional resistor should drop the measured resistance. For more fun, chart the measurements as you go. Once all 40 are soldered, resistance should read close to 50 Ohms.

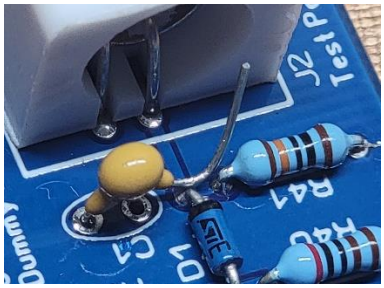
*Solder R41.

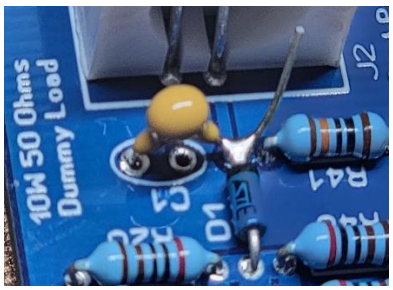
*Solder D1, noting the direction of the diode. The strip goes in the direction of the diode print arrow.

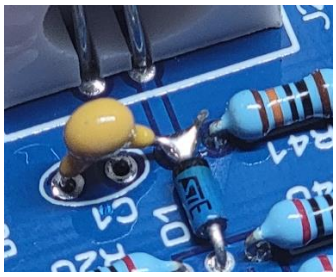
*C1 note: There is a problem with this printed motherboard as pointed out by NI2O, and we will need to do a modification for C1. The pad closest to the center of the board for C1 should be electrically connected to the signal line, but it is not. The grounding side of C1 works correctly. The fix for this will be to first bend one lead of C1 at an angle 90 degrees away from the other lead. Solder in the straight lead in the hole closest to the board edge with the angled lead pointing directly across R41. Now bend the second lead down to touch the stripped lead of the diode, and solder the leads together, making sure not to use so much solder that it drips down on the board. Once satisfied, trim the leads of C1. See pictures for details.









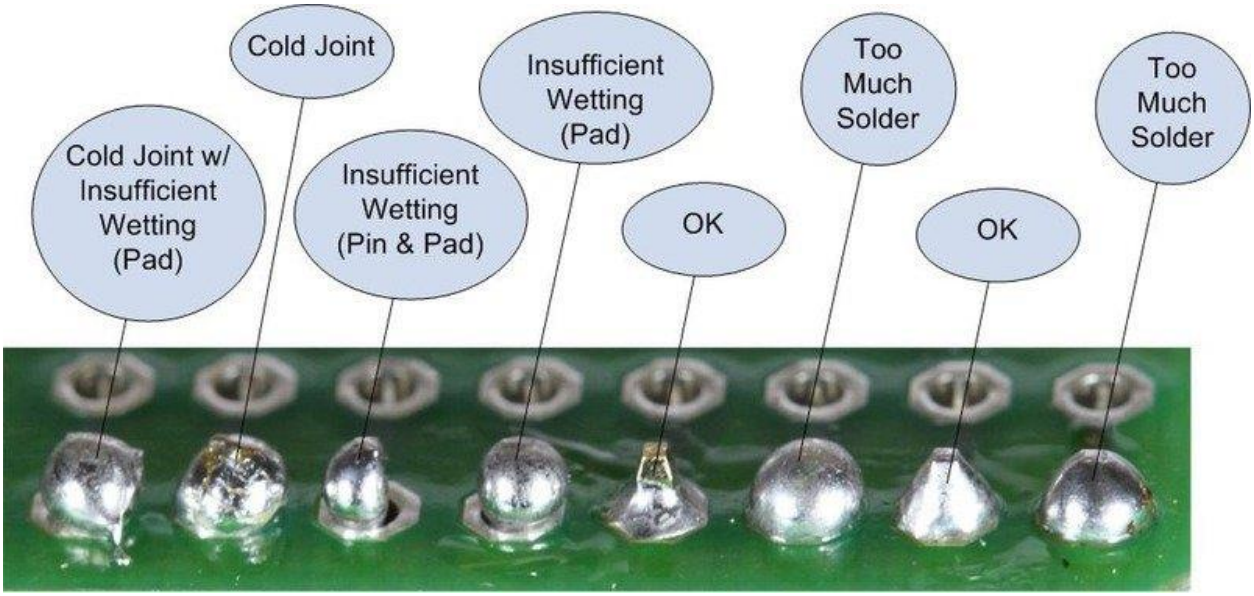


Solder J1, J2.

**Denotes testing circuit for power measurements.*

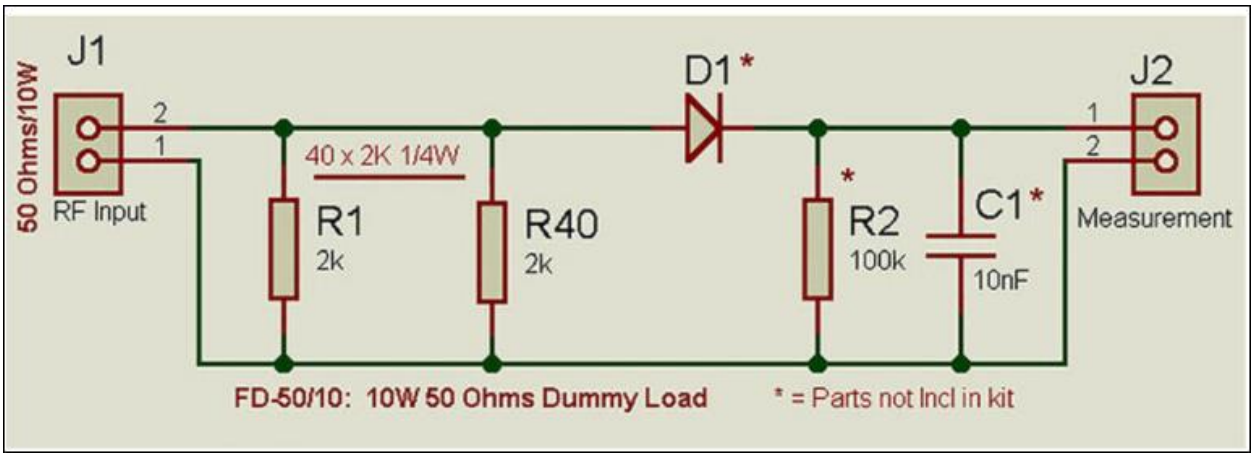
*Power measurements can be taken during transmission from J2 using a multimeter in DC volt measurement mode. Make sure not to transmit more than 10 watts into dummy load. Power (watts) = peak voltage * peak voltage / 100*

Example: If voltage shows 15V, this indicates 2.25 watts.
*(15 * 15 / 100 = 2.25)*



Taken from https://learn.adafruit.com/adafruit-guide-excellent-soldering/common-problems

Schematic



Resources

Dummy Load Kit – https://www.ebay.com/itm/284255931683

Adafruit Guide to Excellent Soldering - https://learn.adafruit.com/adafruit-guide-excellent-soldering

Ultimate guide to soldering - https://www.techspray.com/ultimate-guide-to-electronic-soldering

Common Soldering Problems - https://learn.adafruit.com/adafruit-guide-excellent-soldering/common-problems

Unit 2: Toroids, EFHW Mini Tuner

Unit Overview

This kit illustrates a good design with very good instructions.

- Parts identification and inventory
- Toroid winding
- Magnet wire prepping
- Parts placement and order

Tools Needed

- Work area
- Soldering Iron
- Solder
- Multimeter
- Flush cutters
- Foam block or empty egg carton
- Sharpie and tape to mark on
- Needle nose pliers
- Phillips screwdriver
- Measuring tape
- Chopstick (optional)
- Box cutter (optional)

Kits/Parts Needed

- QRPGuys EFHW Antenna 40m-15m with Tuner
- 50’ speaker wire
- Crimp-on spade connectors (optional)
- Shrink wrap (optional)

Standards/Expectations

This unit will cover basic components of the kit we are building, how to test and organize parts. Assembly steps will be showing tips for mounting, soldering, trimming components, winding of round toroids, and prepping magnet wire for soldering. Assembly of antenna connections require basic hand tools. Final assessment will be how to do basic tests of the assembled unit. We will also give directions on creating a wire antenna to attach and use with the tuner.

Build Procedure

Inventory all items.

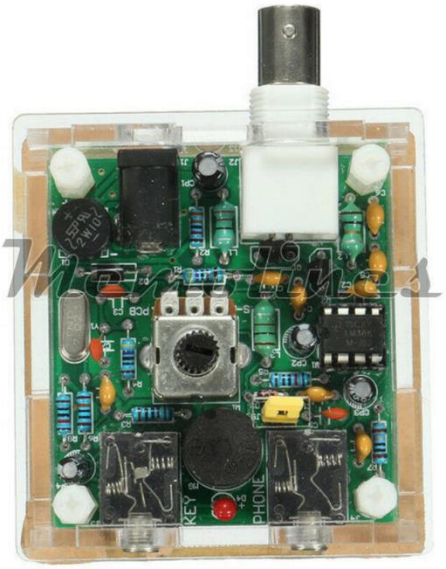
Follow directions from assembly manual. Link to PDF is below.

Resources

Kit - https://qrpguys.com/end-fed-half-wave-sota-antenna-tuner

QRPGuys EFHW 40m-15m assembly manual - https://qrpguys.com/wp-content/uploads/2021/06/efhw_40m_tuner_assy_041121.pdf

Unit 3: CW Transceiver



Unit Overview

This kit illustrates a morphing (over time) design with instructions you must obtain yourself.

- Parts identification and inventory
- Parts placement and order
- Trimming leads

Tools Needed

- Work area
- Soldering Iron
- Solder
- Multimeter
- Flush cutters
- Foam block or empty egg carton
- Sharpie and tape to mark on

Kits/Parts Needed

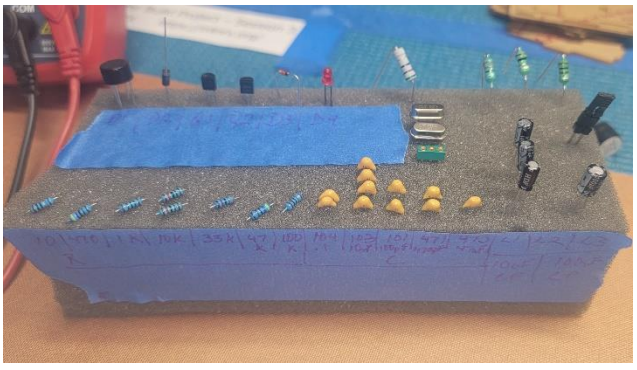
- Pixie CW transceiver kit
- 7.030 Mhz crystal
- First BNC jumper cable
- Crystal socket (optional)
- Battery pack
- Earbuds
- Morse keyer with 1/8” plug (or use Key Modification as shown below)

Standards/Expectations

This unit will cover basic components of the kit we are building, how to test and organize parts. Assembly steps will be showing tips for mounting, soldering, and trimming components. Final assessment will be how to do basic tests of the assembled unit, and power up. Optional customization will be the crystal socket allowing the operator to swap crystals for different frequencies.

Build Procedure

Inventory all items.



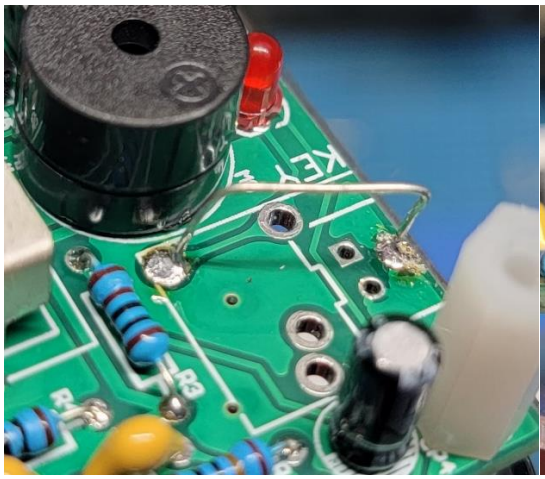
Follow instruction for “Production process” in Kit User Manual PDF, replacing the crystal with the 7.030MHz version and/or the crystal socket for a bit of frequency agility.

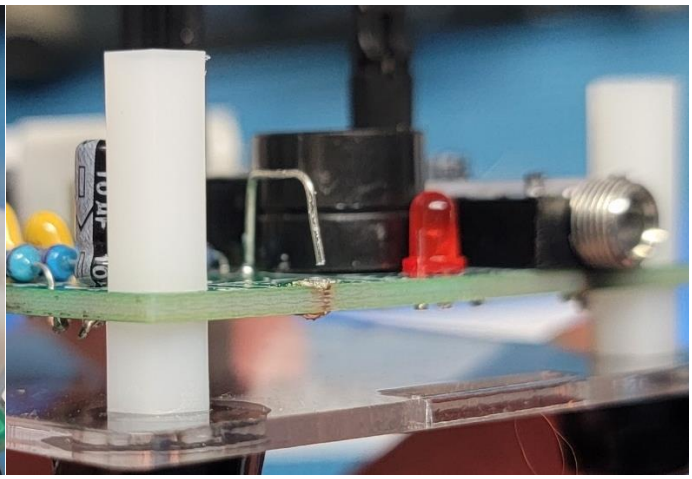
If you are don’t have a morse key, do not install J3, and use the procedure below for “Key Modification”.

Key Modification

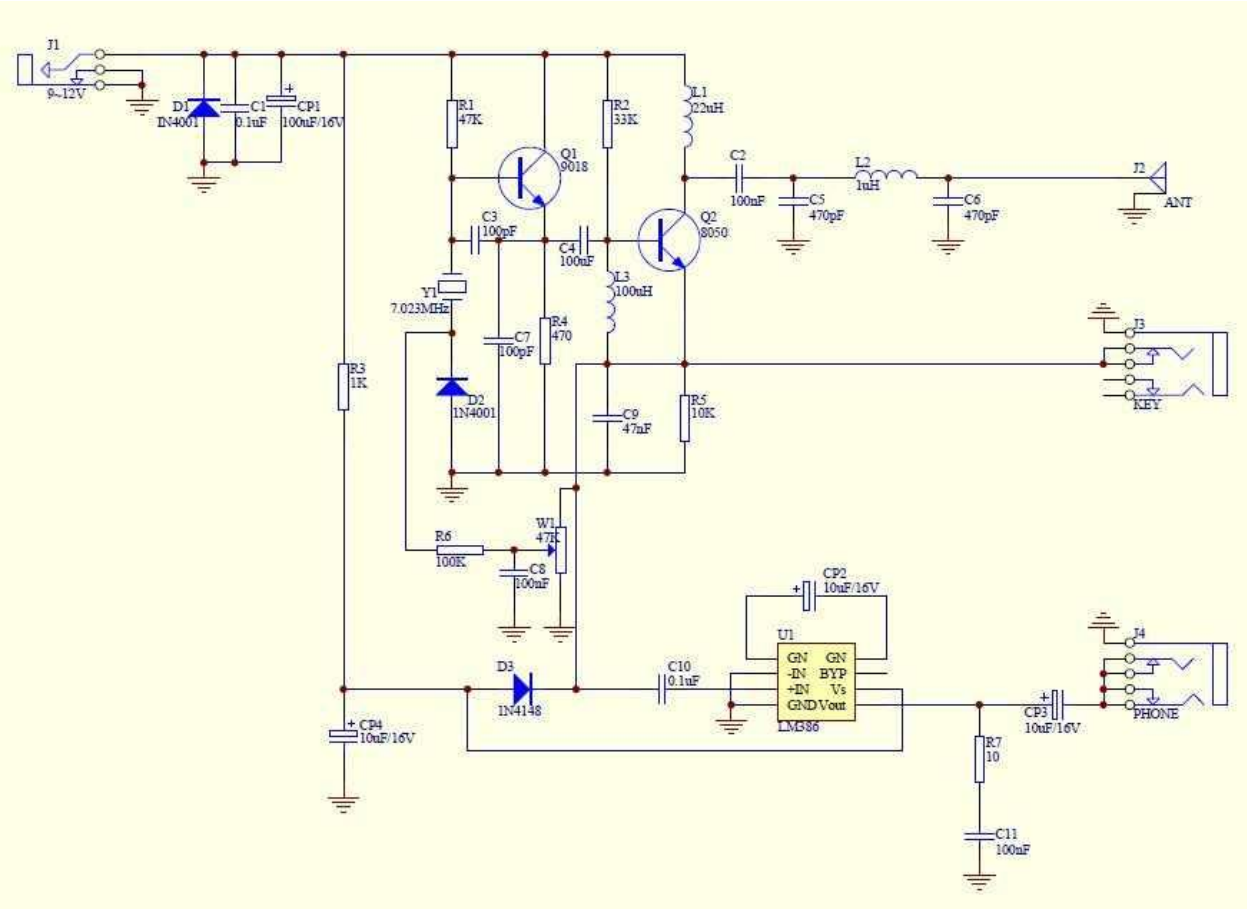
If the builder doesn't have a keyer, one option is to build a key switch out of one of the cut leads from another component. The discarded long lead from D1 would work, or the lead from the 50 ohm resistor not installed.

When constructing the Pixie, do not install the keyer 1/8" jack (J3). Instead, fill in the J3 hold closest to the edge (the ground connection) with solder. Then solder in the discarded lead so its length is protruding up from the board into the empty hole next to the buzzer in the corner of the J3 printed placeholder (see illustration). Once soldered, bend the lead about 1/8" above the board toward the soldered ground point. Bend the lead again where it passes over the ground point. Trim the lead (if needed) so the end of the lead is just above the ground point. Keying of the transmitter will be possible by pressing on this lead, so it contacts the ground point. It should have enough spring to return to its normally open position.





Circuit Diagram



Resources

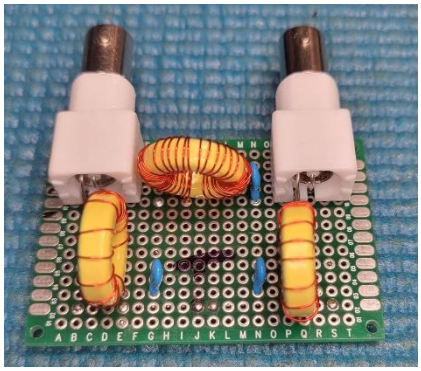
Kit – https://www.amazon.com/Acxico-7-023MHz-Shortwave-Transmitter-Transceiver/dp/B08213K1QJ/

S-Pixie QRP Kit User Manual - https://drive.google.com/file/d/1r7zqxizzS1LNcf61YkK0G2ivac9imDOi/view

How the Pixie Transceiver Works - https://w1sye.org/wp-content/uploads/2017/01/NCRC_PixieOperation.pdf

Unit 4: Scratch Building Band-Pass Filter

Unit Overview



This unit demonstrates building simple circuit designs with no kits available

- Sourcing components
- Reading schematics
- Filter design
- Parts identification and inventory
- Use of multimeter
- Soldering setup
- Good solder joints
- Parts placement and order
- Trimming leads

Tools Needed

- Work area
- Soldering Iron
- Solder
- Multimeter
- Flush cutters
- Foam block or empty egg carton
- Sharpie and tape to mark on
- Hand drill
- #50 or 3/32” drill bit (0.070” hole for bulkhead mount of BNC)
- Hot melt glue gun/glue (optional, and can be used as workaround if no drill is available)

Kits/Parts Needed

- Band Pass Filter Parts
  - 3 x T-68-6 core toroids
  - 2 x 13” of #28 magnet wire (11 turns) (0.55 uH)
  - 1 x 29” of #28 magnet wire (35 turns) (5.5 uH)
    Note: Mine measured 5.5 uH at 33 turns, evenly spaced
  - 2 x 1000 pF capacitor 1kV
  - 1 x 100 pF capacitor 1kV
  - 2 x PCB Mount Right Angle BNC Female bulkhead connectors
  - 4cm x 6cm Breadboard
  - 6” bare hookup wire
- Second BNC jumper cable

Standards/Expectations

This unit will cover basic identification and sourcing of components needed to complete a build. Assembly steps will be showing tips for layout planning, mounting, soldering, and trimming components. Final assessment will be how to do basic tests of the assembled unit, and it's use in the transceiver system.

Notes

The purpose of this unit isn't so much to follow directions, but to show you that you can find simple designs for electronic circuits that meet a need you have, source the parts, and construct something that will work without the need for a kit. The breadboard used as the base for this project is one of many basic designs that you can use to construct your circuit. There are many construction techniques available to the electronic workbench, so you will need to find something that works for you and your own style. The directions given below are for those not yet comfortable in branching out on their own, but if you think you can construct the unit using the circuit diagram, I encourage you to try.

Build Procedure

Note the labeling of the PCB for rows and columns. My board was labeled the same orientation on both sides of the board so that marked location A-01 corresponds to marked location T-01 on the other side. We will understand the components to be mounted on the top side of the board, and most soldering will be done from the bottom side. ***For these instructions, we will reference the indexing location labels as seen from the opposite side of the mounted components (bottom of the board)***. Ignore the labels on the top side. To help, you may wish to use a marker to mark through the labels on the top of the board.

[ ] Inventory all items.

[ ] Drill the PCB to accept BNC bulkhead connectors using a 5/64" drill bit. Using the PCB grid for location, drill out the hole locations A, E, P, T along row 12. Holding the PCB with row 14 at the top, insert the first BNC bulkhead connector with the BNC hanging off the top of the board (pointing away from the board) by placing the thicker alignment pins into holes A and E of row 12. The soldering connectors should insert into C-11 and D-09. The solder pins will need to be bent to accommodate. The fit will be tight, so wiggle until the BNC connector is flush with the top of the PCB. Do the same with the second BNC, aligning pins with P and T on row 12, and circuit connections protruding through R-11 and S-09. Solder connections to pads.

[ ] Next, we will wind toroids. Start with toroids L1 and L3, wrap each with 11 turns. Layout assumes that you wrap in the direction described: holding toroid so hole is going left to right, pass each turn through the middle from right to left, wrapping around the outside away from your body. Once completed, spread wraps evenly. Finished windings should locate corresponding with the layout shown in the board views below. Continue with wrapping L2 with 34 turns, then spread wraps evenly, with finished windings just across from each other.

[ ] We will now mount capacitors C1 into N-03/N-05 and C3 into G-05/G-03. Make sure capacitors are flush, then solder the base of the leads to the pads. Insert C2 into locations G-10/G-12, make flush, and solder. We will not trim the leads until we have completed our circuits.

[ ] Test fit L1 into P-03/R-05, pulling the leads through until the toroid is flush on the top side. Note the excess wire length. We can now trim these leads to about one inch to make it easier to handle. After

trimming, remove the toroid. We will now use the flush cutters, or a razor blade to scrape the enamel coating off the magnet wire where the wire would protrude through the PCB. Removal of this enamel will allow the wire to be soldered on the other side of the board. Be careful not to cut the wire, but just scrape off the color. Once both wire ends are scraped, re-mount into the correct location on the board, then solder the wires to the pads so they are physically mounted. Try to keep some tension on the wires so the toroids don't flop around after the installation. We can use hot melt glue for final secure after build.

[ ] Do the same operation with L3 into C-03/E-05, and L2 into J-12/L-10.

[ ] We will now create the ground plane of the project. Strip the 6" of solid hook-up wire of all of its jacket. This can be done by stripping off in 1-inch segments of the jacket at a time, gripping one side of the wire with needle-nose pliers.

[ ] Working from the bottom of the PCB, solder one end of the wire to the "BNC out" jack solder connection that should be protruding through D-09 so that the wire is flat against the PCB, oriented as the black wire is shown in the "board views", "bottom view" in the instruction sheet. Once attached, we will then bend the wire at location B-02, laying the wire along row 02. Solder the wire onto the pad at B-02. Bend the wire toward the top of the board at location S-02 and tack the wire onto that pad as well. Run the wire to meet the "BNC In" solder connection protruding through S-09. Trim the remaining wire that runs past this point. Go back and solder the wire onto J-02 and K-02 for strength.

[ ] We will now make connections to this ground plane. Bend leads from C3 protruding through G-03 down and over the ground plane wire, and solder them together. Do the same from C1 protruding through N-03. Trim these leads beyond the ground plane.

[ ] Now make connections to the ground plane for L3 and L1 from leads protruding through C-03 and P-03. Trim any excess leads beyond the ground plane.

We will now work on the signal path.

[ ] Bend the lead from C2 protruding through G-10 towards C-11, making sure to route around the connection at D-10. Solder the lead to the BNC connection protruding through C-11. Trim any of the C2 lead beyond C-11.

[ ] Bend the lead from C2 protruding through G-12 towards J-12 for L2. Solder to join both at J-12. Trim excess lead from C2.

[ ] Bend the lead from C3 protruding through G-05 towards G-10 for C2, and solder to join at G-10. Trim excess lead from C3.

[ ] Bend the lead from L3 protruding through E-05 towards G-05 for C3, and solder to join at G-05. Trim excess lead from L3.

[ ] Bend the lead from L2 protruding through location L-10 towards "BNC In" location R-11. Solder between the two and cut excess lead from L2.

[ ] Bend the lead from C1 protruding through N-05 towards last wire connection (L2 to "BNC In"). Solder to join C1 to that wire. Trim excess lead from C1.

[ ] Bend the L1 lead protruding through R-05 towards the top of C1 protruding through N-05 and solder. Trim any excess from the L1 lead.

[ ] Verify all connections are soldered, and clean, and have not unsoldered themselves. Trim any excess wires, and make sure inadvertent connections weren't made.

[ ] Optionally use hot melt glue on the top side of the PCB to attach the toroids to the PCB.

Test Circuit

- Visual inspection to ensure electrical connections are made.
- Pay special attention to magnet wire leads to ensure the coating was removed, and solder has taken to the wire.

Schematic

From "Band-Pass Filters for HF Transceivers" by Lew Gordon, K4VX

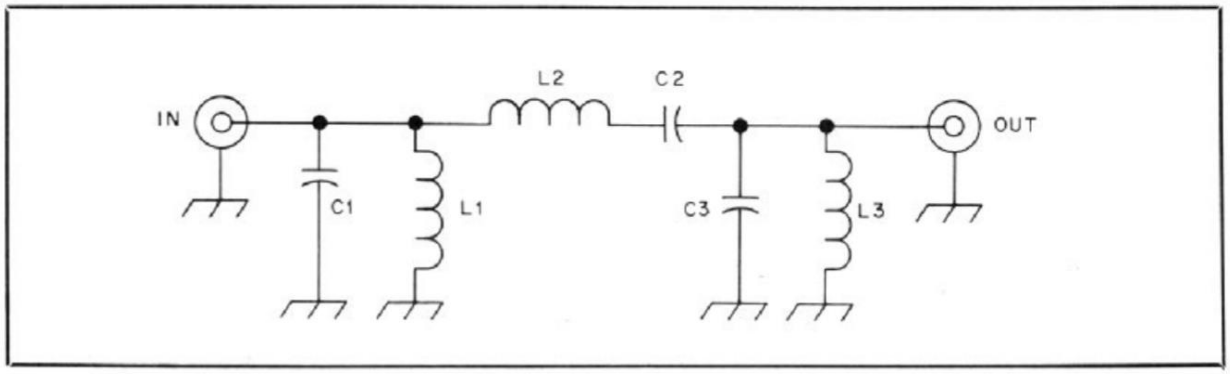
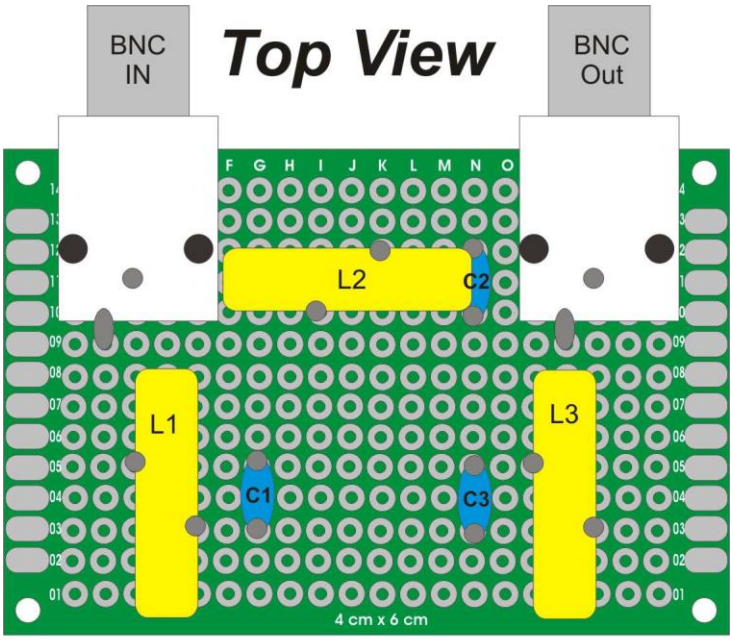
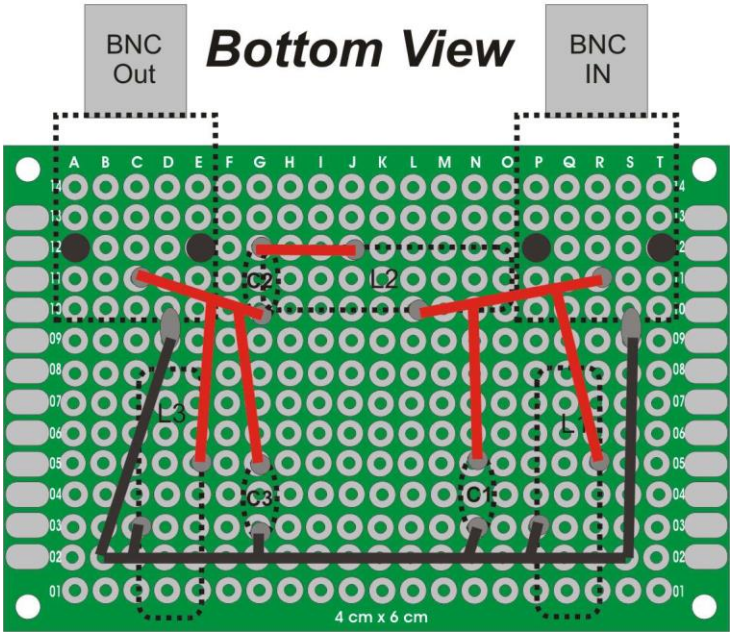


Fig 1—Schematic diagram of the three-pole Butterworth band-pass filters.

Board Views


BNC
IN
Top View
BNC
Out
L2
C2
L1
L3
C1
C3
4 cm x 6 cm


BNC
Out
Bottom View
BNC
IN
C2
L2
L3
C3
C1
4 cm x 6 cm

Resources

Kit – From instructor, or source your own components, design yourself

Band-Pass Filters for HF Transceivers by Lew Gordon, K4VX - https://www.arrl.org/files/file/Technology/tis/info/pdf/8809017.pdf

Elsie – Electrical filter design and analysis program - http://www.tonnesoftware.com/

Elsie Filter File - https://www.n4nrv.org/wp-content/uploads/2021/09/40M-Band-Pass-Elsie.LCT

Unit 5: Assembly and Use of System (optional)

Unit Overview

- Assembly of completed system
- Use of completed system
- Basic troubleshooting

Tools Needed

Kits/Parts Needed

- All assembled kits

Standards/Expectations

This unit will cover basic understanding of the completed system build, to address any final troubleshooting of components, and for follow-up information paths.

About CW transmitting

With the pixie transceiver, you don't have a good way to filter signals that aren't talking to you. This means that you will hear a lot of stations with high and low pitches. The pixie transmits with an offset of about 700 hertz (Hz). Signals you hear close to 700 Hz (+- 200 Hz) tone are either in your way or trying to contact you. Try not to step on them. What does 700 Hz sound like? Check the resources below or find an app for your phone.

Also, the pixie knob control on top of the unit controls the frequency you are listening to, so you can bring stations into a better tone to listen to. It does NOT change your transmitting frequency.

Procedure

Understand how to send your callsign with the basic "CQ" message (substitute your own callsign in the message).

"CQ CQ DE CALLSIGN"

Set up your EFHW antenna by raising the end of the antenna in the air as high as possible. Leaning at an angle is acceptable. Just get it as high as possible. The counterpoise wire should string along the ground in any direction convenient. Connect both antenna and counterpoise to your constructed EFHW tuner. Ensure your EFHW tuner "operate/tune" switch is in the "operate" position.

Using a BNC jumper, connect the antenna tuner to the "BNC out" of your band pass filter.

Using the other BNC jumper, connect the "BNC in" of your band pass filter to your pixie transceiver.

Connect your headphones or powered speaker to the audio jack on the pixie, and your straight key to the key jack. Ensure your crystal is inserted and is labeled for a frequency your amateur radio license has privileges to transmit on.

Connect the 12v power pack to your pixie, and turn on the power.

You should now hear at least some static coming through the pixie, and possibly other morse code stations. Turn your EFHW tuner knob back and forth to find the position that gives the loudest response of static. You are now tuned somewhat, but we will now use the tuning feature on the EFHW tuner.

Change the EFHW tuner “operate/tune” switch to the “tune” position. Wait for an opportunity when others are not transmitting. Paying attention to the SWR LED indicator on the EFHW tuner, key your transmitter, and turn the EFHW tuner knob back and forth to dim the SWR LED to it’s minimum. At half luminosity of the LED, your SWR should be under 2:1 SWR, and should be fine for transmitting without damage to the transmitter. Un-key the transmitter. Move the EFHW tuner “operate/tune” switch to the “operate” position. You are now ready to transmit your message.

Send “CQ CQ DE CALLSIGN” pause for 6 seconds and send again. Do this about 3-6 times.

If anyone on the Reverse Beacon Network or PSK Reporter heard you (and your CW was readable by a machine), you’re callsign will now have reports available. See links in resources below.

Resources

- 700 Hz Test Tone - https://www.youtube.com/watch?v=-AAjAiB7ViU
- Reverse Beacon Network - http://www.reversebeacon.net/
    - 7MHz - http://www.reversebeacon.net/dxsd1/dxsd1.php?f=6
- PSK Reporter - https://pskreporter.info/

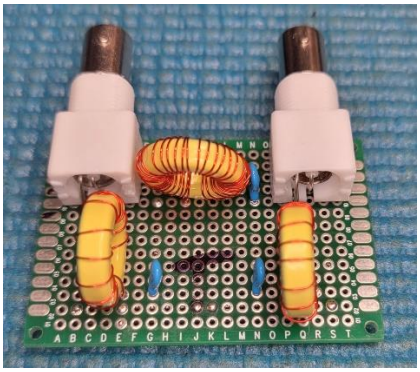
Pics of Items and Finished Kits

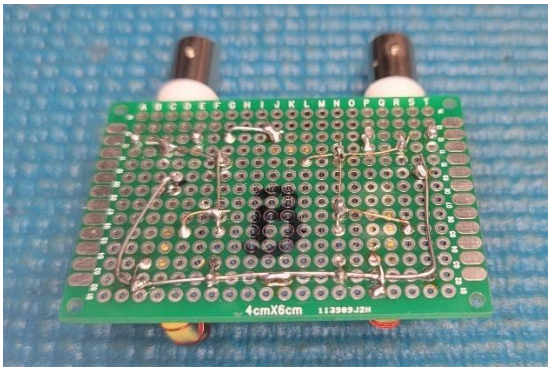
Battery Pack 12v

QRPguys EFHW Tuner

Pixie CW Transceiver

7Mhz Band-Pass Filter





BNC jumper

Links to Kits and Recommended Items

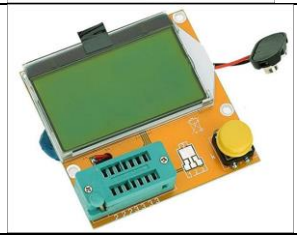
(Can always be out of date. Please ask if you can't find something)

Similar items can be sourced local from Harbor Freight, Hobby Lobby, hardware stores, and the like.

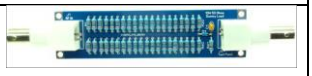
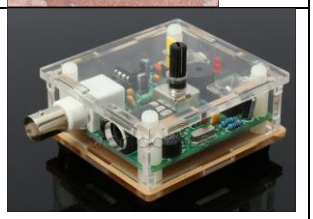
Must Have Tools (or substitute with equivalent)			
Item	**Link**	**Cost**	**Pic**
Flush cutters	https://www.amazon.com/Hakko-CHP-170-Micro-Cutter/dp/B00FZPDG1K/	$8	
Needle Nose Pliers	https://www.amazon.com/Tools-VISE-GRIP-Pliers-6-Inch-2078216/dp/B000A0OW2M/	$9	
Screwdriver – multi bit	https://www.amazon.com/Screwdriver-Industrial-Strength-Klein-Tools/dp/B0015SBILG/	$15	
Soldering Iron kit – with solder	https://www.amazon.com/Adjustable-Temperature-Controlled-Thermostatic-Electronics/dp/B08LNGN14L/	$19	
Multimeter – auto ranging with capacitance	https://www.amazon.com/Astro AI-Multimeter-Resistance-Transistors-Temperature/dp/B071JL6LLL/	$37	

Measuring Tape	https://www.amazon.com/Measuring-Tape-Measure-Kutir-Retractable/dp/B01ENWNRVE/	$14	

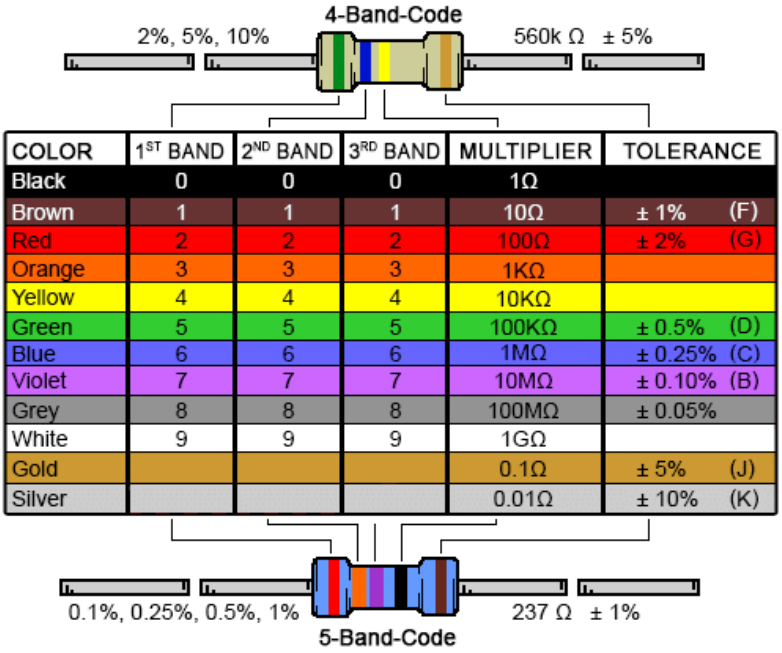
Nice to Have Tools

Item	Link	Cost	Pic
Helping Hands	https://www.amazon.com/ProsKit-900-015-Helping-Hands-Soldering/dp/B002PIA6Z4/	$11	
Silicone Soldering Mat	https://www.amazon.com/Kaisi-Insulation-Silicone-Position-Soldering/dp/B07DGVRYL3/	$17	
Solder 60/40	https://www.amazon.com/YI-LIN-Electrical-Soldering-0-22lbs/dp/B08RHMPJW3/	$9	
LCR-T4 Multifunctional Tester	https://www.amazon.com/dp/B01MYU0QI3/	$15	

Kits Needed

Item	Link	Cost	Pic
Dummy Load kit	https://www.ebay.com/itm/284255931683	$11	
EFHW Tuner Kit	https://qrpguys.com/end-fed-half-wave-sota-antenna-tuner	$30 + shipping	
Pixie CW Transceiver Kit	https://www.ebay.com/itm/224088383528?hash=item342cb56028:g:AnkAAOSwY3BZDd3~ https://www.amazon.com/Acxico-7-023MHz-Shortwave-Transmitter-Transceiver/dp/B08213K1QJ/	$9	
Battery Pack with plug (batteries as well)	https://www.ebay.com/itm/253900500007 https://www.amazon.com/abcGoodefg-Battery-Holder-Plastic-Storage/dp/B078NK9GS2/	$8	
Speaker Wire (get something cheap)	https://www.amazon.com/Speaker-GearIT-Meters-Theater-Speakers/dp/B00HZWYXFO/	$15	
BNC Jumpers (50 Ohm)	https://www.ebay.com/itm/272899377390 https://www.amazon.com/uxcell-Coaxial-Jumper-Cable-RG174/dp/B07T6KXRCB/	$11	

Component Value Charts



COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	100MΩ	± 0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

Taken from https://www.digikey.com/-/media/Images/Marketing/Resources/Calculator/resistor-color-chart.png?la=en-US&ts=4db603f5-4e9b-4759-84b7-21a04d18b1a8

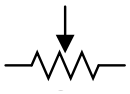
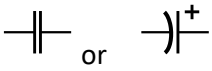
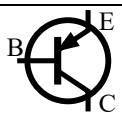
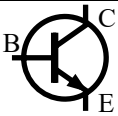
Capacitance Conversion

picofarad	nanofarad	microfarad	Code	picofarad	nanofarad	microfarad	Code
pF	nF	µF		pF	nF	µF	
10	0.01	0.00001	100	4700	4.7	0.0047	472
15	0.015	0.000015	150	5000	5	0.005	502
22	0.022	0.000022	220	5600	5.6	0.0056	562
33	0.033	0.000033	330	6800	6.8	0.0068	682
47	0.047	0.000047	470	10000	10	0.01	103
100	0.1	0.0001	101	15000	15	0.015	153
120	0.12	0.00012	121	22000	22	0.022	223
130	0.13	0.00013	131	33000	33	0.033	333
150	0.15	0.00015	151	47000	47	0.047	473
180	0.18	0.00018	181	68000	68	0.068	683
220	0.22	0.00022	221	100000	100	0.1	104
330	0.33	0.00033	331	150000	150	0.15	154
470	0.47	0.00047	471	200000	200	0.2	204
560	0.56	0.00056	561	220000	220	0.22	224
680	0.68	0.00068	681	330000	330	0.33	334
750	0.75	0.00075	571	470000	470	0.47	474
820	0.82	0.00082	821	680000	680	0.68	684
1000	1	0.001	102	1000000	1000	1	105
1500	1.5	0.0015	152	1500000	1500	1.5	155
2000	2	0.002	202	2000000	2000	2	205
2200	2.2	0.0022	222	2200000	2200	2.2	225
3300	3.3	0.0033	332	3300000	3300	3.3	335

Taken from https://www.digikey.com/-/media/Images/Marketing/Resources/Calculator/capacitance-conversion-table.png?la=en-US&ts=373a63b5-6e0f-49d8-8a69-027753b03d84

Appendix A – Multimeter Component Measurement Chart

All readings are taken with component removed from the circuit.

Component	Schematic Symbol(s)	Multimeter Mode	Notes
Resistor		Ohms Ω	Touch test leads to either side of component and read measurement.
Variable Resistor		Ohms Ω	To measure total resistance (rating of the variable resistor) touch test leads to opposite sides of component and read measurement. To check variable resistance, touch outside and center tap to test leads, and read measurement as you rotate the component shaft.
Capacitor		Capacitance 	Touch test leads to either side of component and read measurement. If capacitor is polarized, the negative test lead should be used on the negative or stripped side of the capacitor.
Variable Capacitor		Capacitance 	Touch test leads to component leads and read measurement as you rotate the component shaft.
Diode		Diode or Ohms (9v multimeters only) 	(Diode mode) Touch positive test lead to anode and negative (or common) lead to the component cathode. Stripe is normally printed closer to cathode side. Measurement will be forward voltage needed for current to flow. (Ohms mode) Touch positive test lead to anode and lead to the component cathode. Measurement should indicate low resistance. Swap test leads and test again. This test should show infinite resistance.
LED		Diode 	(Diode mode) Touch positive test lead to anode (normally longer component lead) and negative (or common) test lead to the component cathode. The LED should light. Swap test leads and test again. It should not illuminate. You can test as a standard diode as well.
PNP Transistor		Diode 	Test as if it is two diodes C->|B and E->|B
NPN Transistor		Diode 	Test as if it is two diodes B->|C and B->|E
Inductor		Ohms Ω	Touch test leads to either side of component and read measurement. Should indicate low resistance (under 10 ohms)

Appendix B – Class Supplemental Material Packing List

Packing List – Intro to Soldering – W4XXV

- 7.030 Mhz crystal
- Crystal Socket
- Band Pass Filter Parts
    - 3 x T-68-6 core toroids
    - 2 x 13” of #28 magnet wire (11 turns) (0.55 uH)
    - 1 x 29” of #28 magnet wire (34 turns) (5.5 uH)
      Note: Mine measured 5.5 uH at 33 turns, evenly spaced
    - 2 x 1000 pF capacitor 1kV (102)
    - 1 x 100 pF capacitor 1kV (101)
    - 2 x PCB Mount Right Angle BNC Female bulkhead connectors
    - 4cm x 6cm Breadboard
    - 6” bare hookup wire (black)