

RPi Zero W WSPR Amplifier

ARROW (w8rp.org) Build Sessions Aug 2019

- A 100mW+ HF transmit amplifier daughterboard for the Raspberry Pi Zero W**
- Direct connection of dipole antenna**
- Select one of two HF band low-pass filters via jumper. 30M LPF built-in; 2nd LPF user-supplied.**
- OLED direct plug-in**

What's Needed

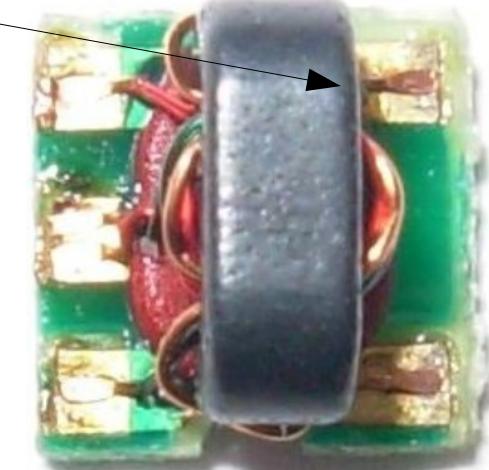
- safety glasses
- soldering iron, solder, flux
- voltmeter
- HDMI monitor, mini-HDMI to HDMI cable
- USB keyboard+mouse (trackpad) combo or separate devices with powered USB hub
- magnifying glasses
- tape measure
- WiFi internet access
- needle-nose pliers

What's Optional

- a Linux/MAC/Windows PC with built-in or USB SD card reader
 - **USB volt/current meter**
 - Oscilloscope, 50MHz+
 - VNA

Warnings !

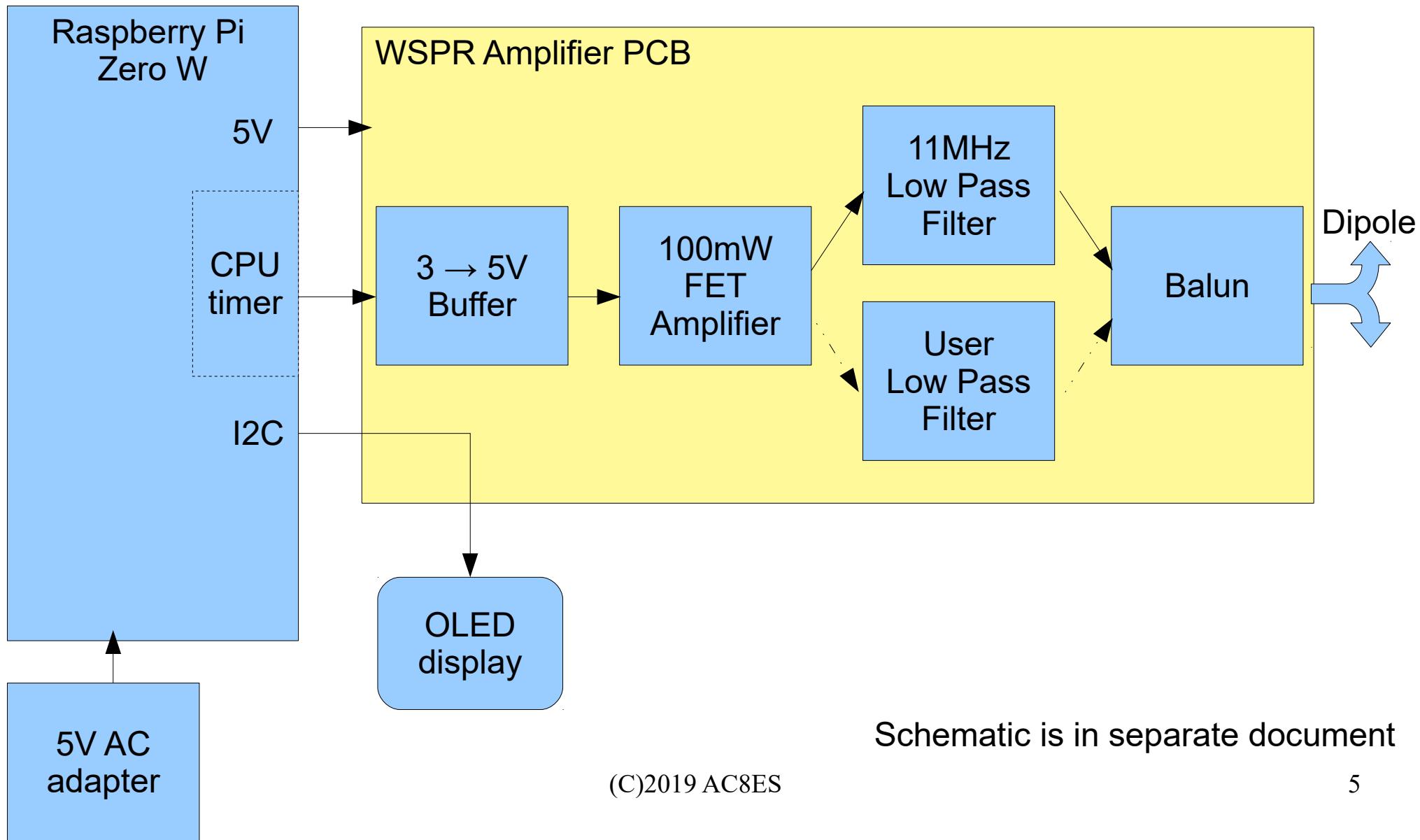
- Use caution around the balun area, as its fragile wires are easily damaged
- Do not remove or insert the uSD card, amplifier board, or cables while the RPi is powered
- Use care when inserting/removing the easily-damaged uSD card; do not bend or twist it
- When inserting or removing a cable, grasp the board connector in one hand, and insert/remove the cable with the other; this will reduce stress on the connector's solder joints
- Avoid powering down by simply turning power off; use the Pi menu (X-Windows) or the `sudo shutdown now` command
- When running the WSPR or other transmitting programs in X-Windows, moving *any* window around on the screen will lock up the operating system (run these from the console)



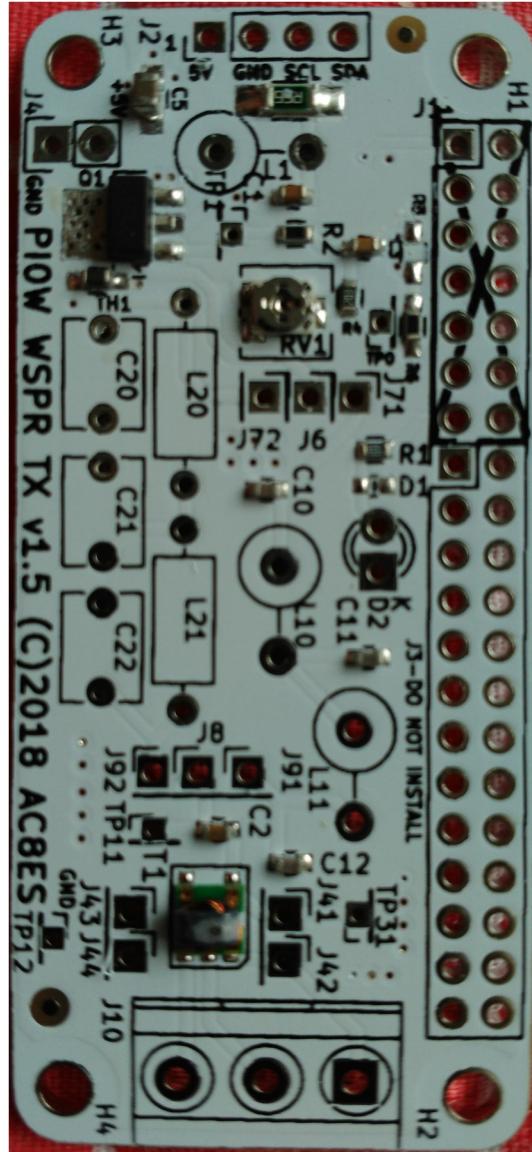
Kit Contents



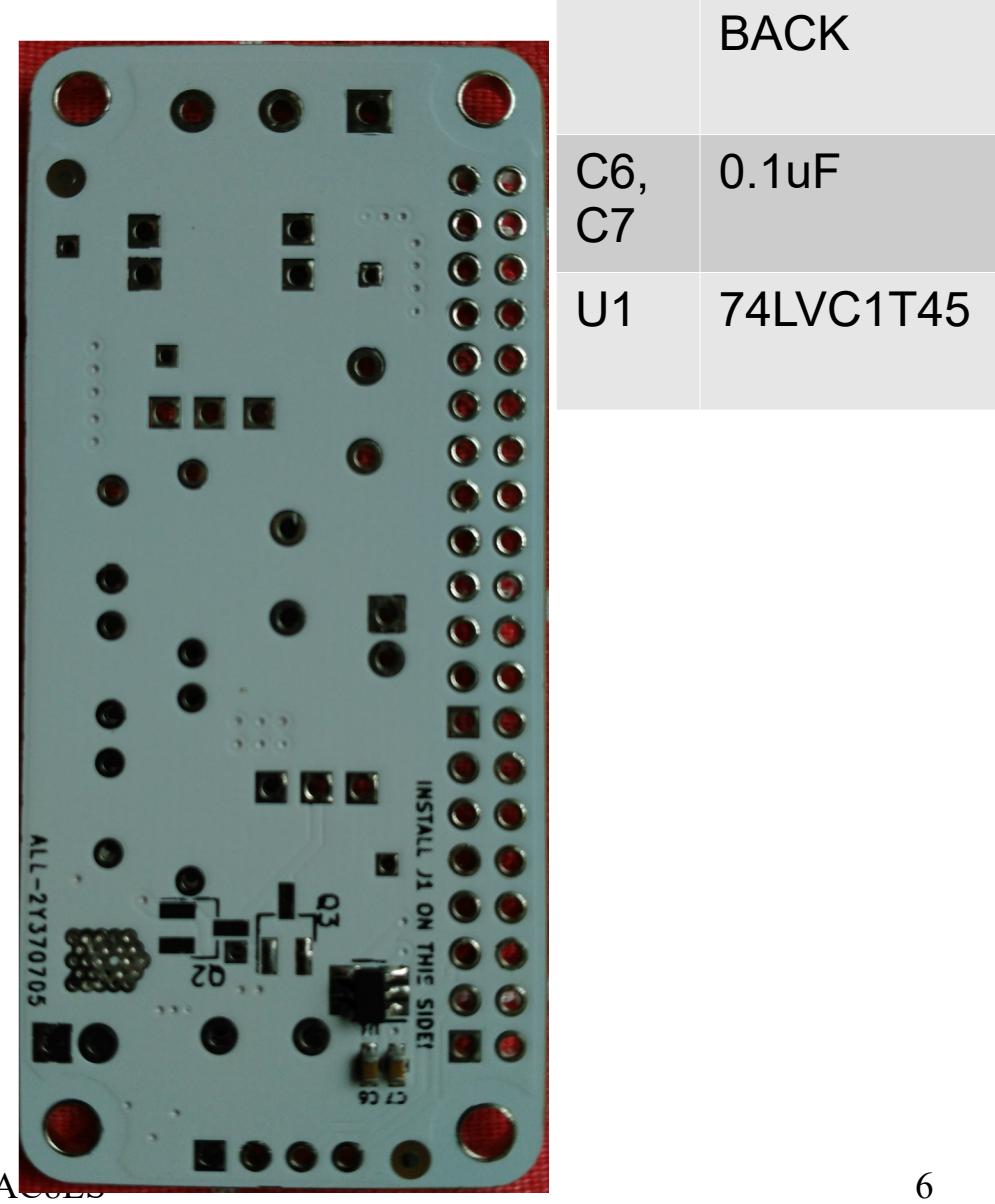
Block Diagram



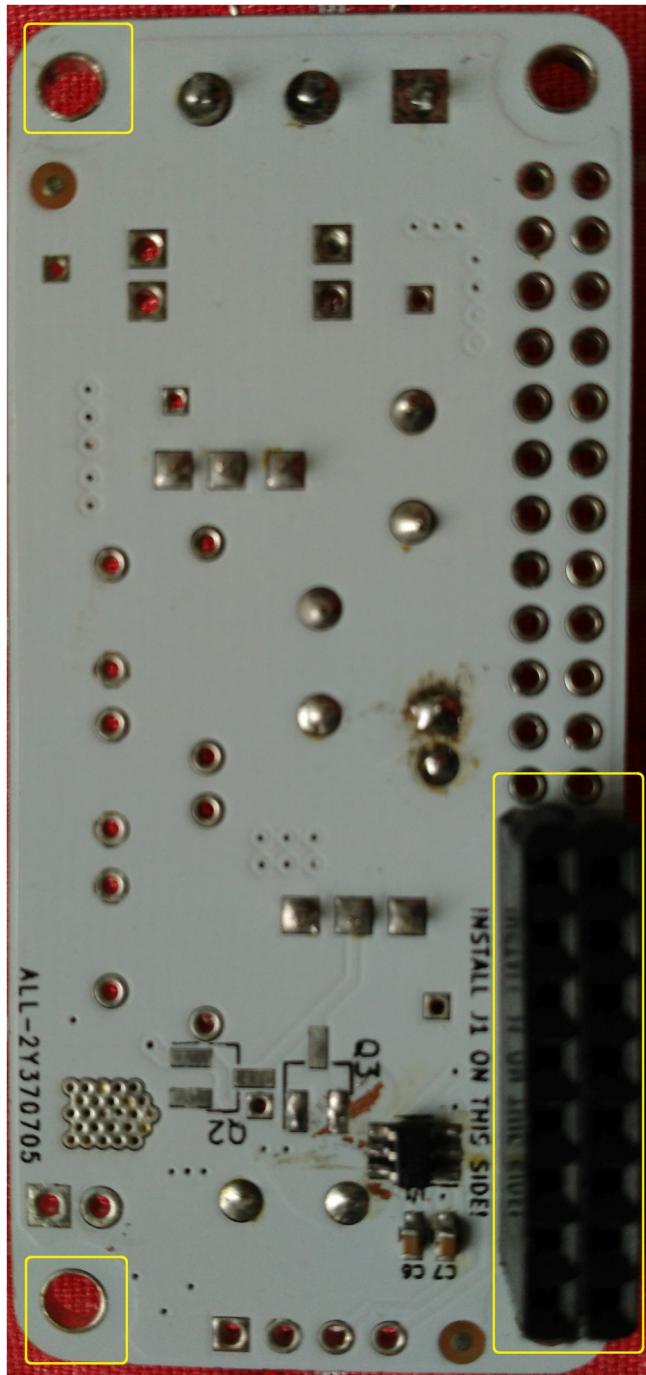
Surface-Mount Components Installed



	FRONT
C2, C3	0.1uF
C10, C12	430pF
C1	10-18nF
C11	680pF
C5	10uF
R1	270-330Ω
R2, R6	47-51Ω
R4	20kΩ
R55	0.56Ω
RV1	50kΩ
TH1	10kΩ 4250K
T1	MABA- 009488- 61HWCA
Q1	ZXMN6A07Z



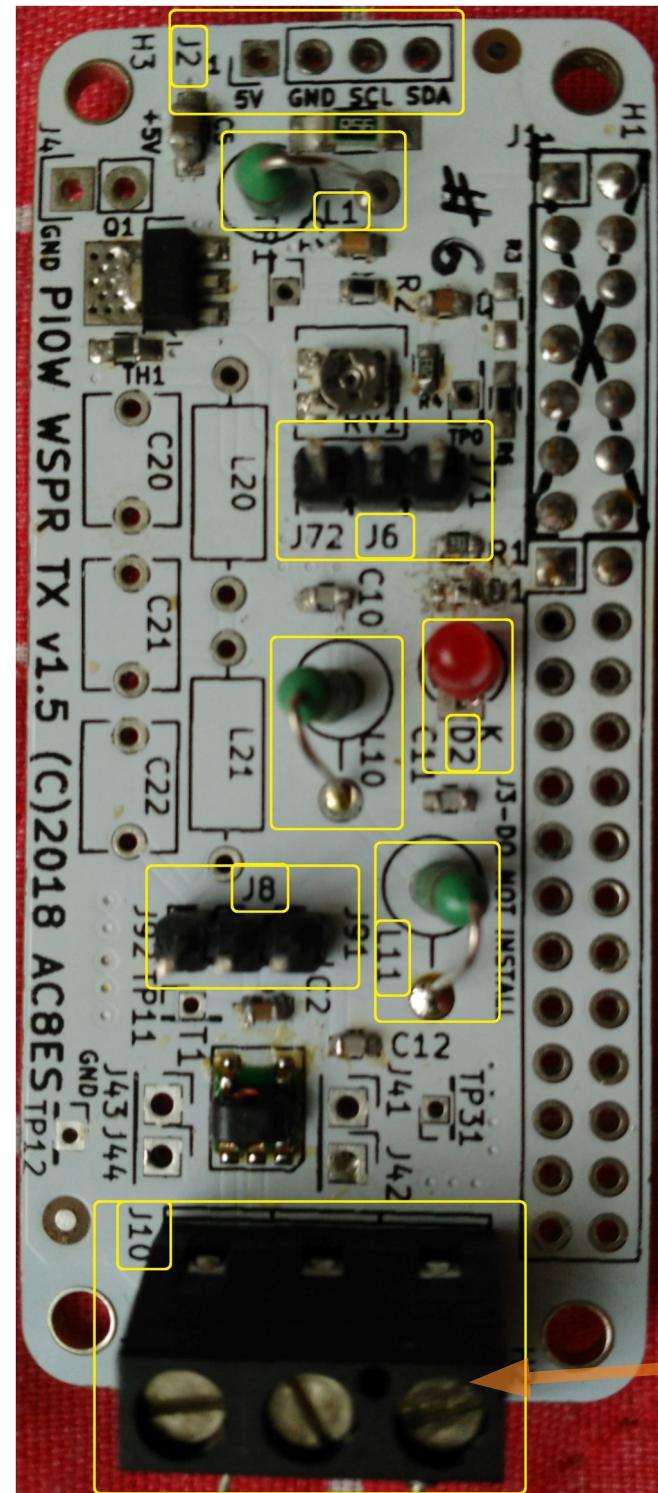
Back Installation



<input checked="" type="checkbox"/> completed		BACK
<input type="checkbox"/>	J1	2x7 or 2x8 female header socket



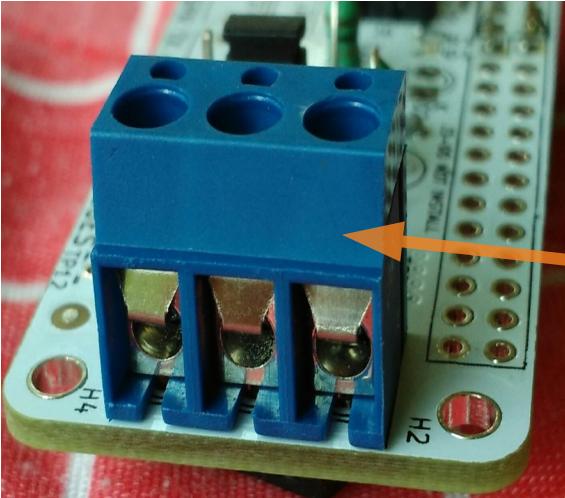
Front Installation



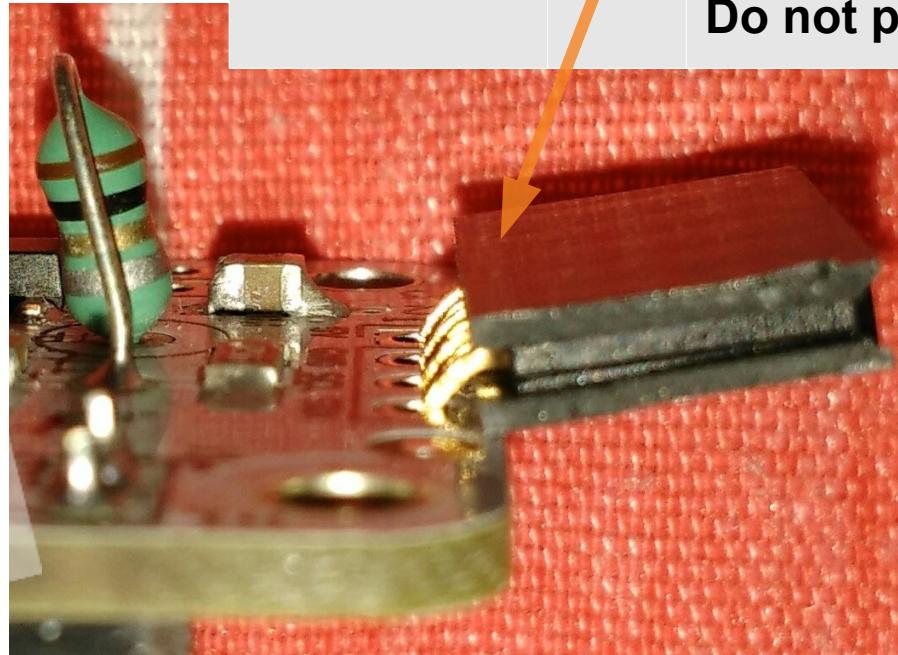
<input checked="" type="checkbox"/> completed		FRONT
<input type="checkbox"/>	D2	LED – short lead at flat is cathode [K]
<input type="checkbox"/>	L1	1uH
<input type="checkbox"/>	L10	1uH
<input type="checkbox"/>	L11	1uH
<input type="checkbox"/>	J6	3-position header
<input type="checkbox"/>	J8	3-position header
	J10	See next page!



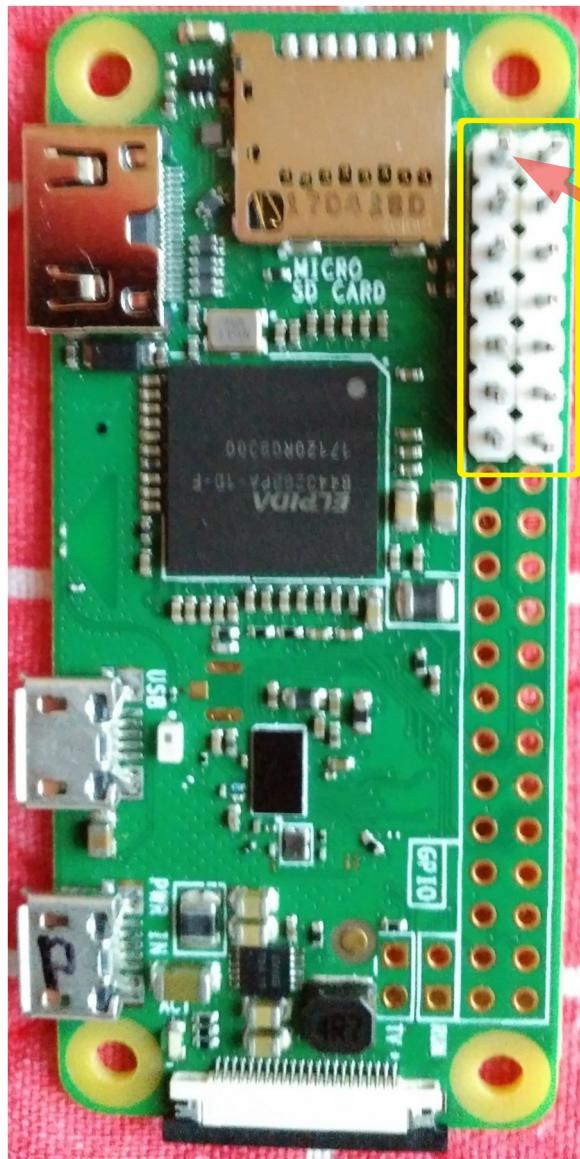
Front Installation



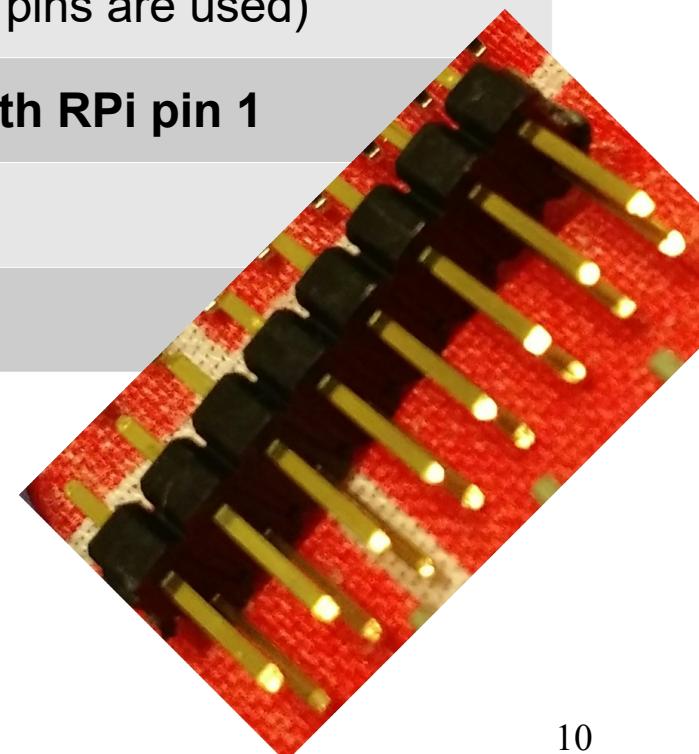
FRONT		
<input checked="" type="checkbox"/> completed	J10	3-position screw terminal
<input type="checkbox"/>	J2	4-position OLED header
Insert header from top until pins are flush back side		
Bend header to be nearly parallel to PCB		
Adjust header as needed after soldering each pin		
Do not plug OLED in yet.		



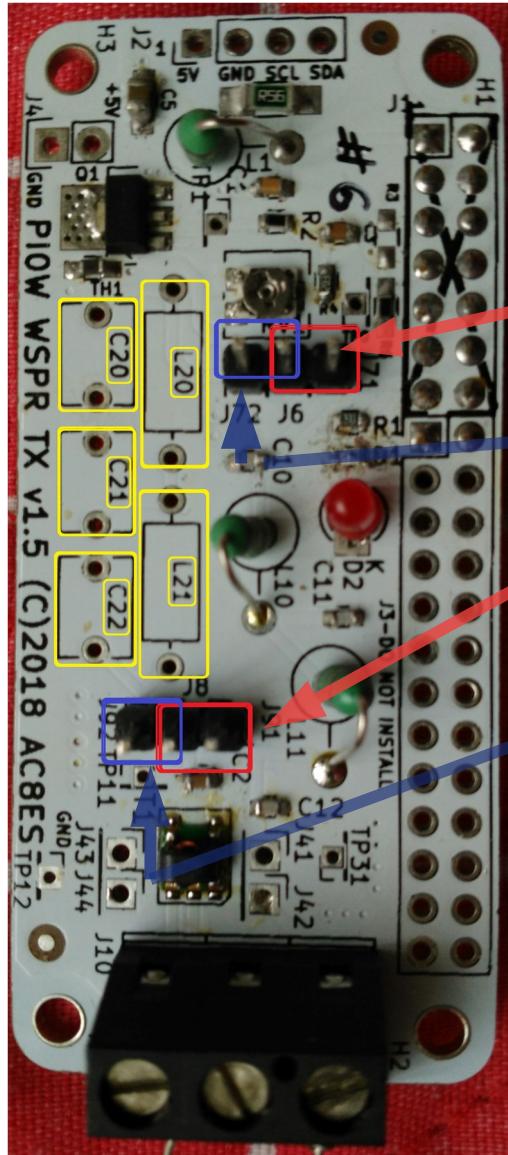
Rpi Zero W Installation



<input checked="" type="checkbox"/> completed		BACK
<input type="checkbox"/>	J0	2x7 or 2x8 male header
		(only 14 pins are used)
		align with RPi pin 1

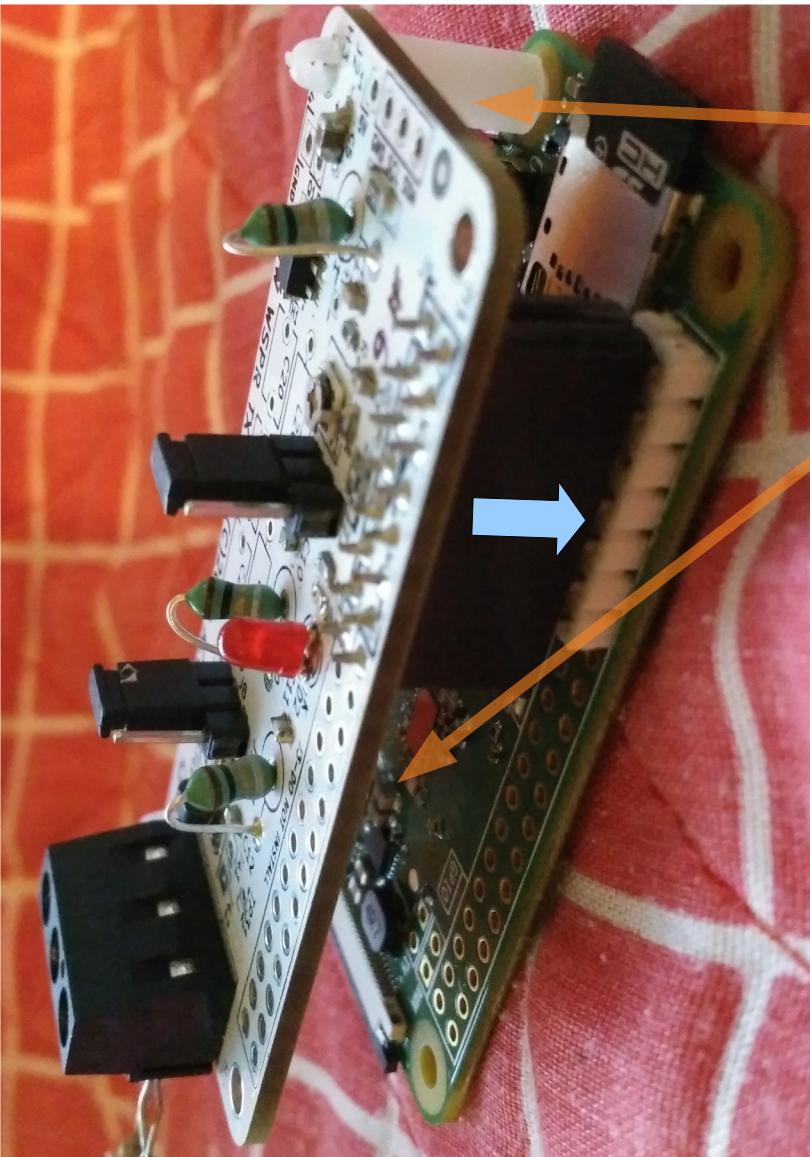


Low Pass Filter



<input checked="" type="checkbox"/> completed	<input type="checkbox"/>	Place jumpers here for the 30m LPF						
λ_{target}	80m	40m	30m	20m	14m	10m		
<input checked="" type="checkbox"/> com pleted	F_{cutoff} MHz	4	8	11	16	22	33	
<input type="checkbox"/>	C20, pF	1200	560	430	300	220	150	
<input type="checkbox"/>	C21, pF	1200	560	430	300	220	150	
<input type="checkbox"/>	C22, pF	1800	910	680	470	330	220	
<input type="checkbox"/>	L20, μH	2.7	1.5	1	0.68	0.56	0.33	
<input type="checkbox"/>	L21, μH	2.7	1.5	1	0.68	0.56	0.33	

Assembly with RPi

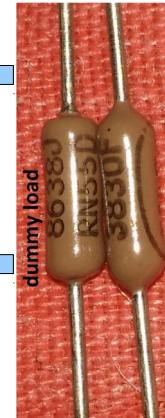


<input checked="" type="checkbox"/> completed	Snap the two standoffs onto the Pi Zero, on long-edge corner holes opposite header
<input type="checkbox"/>	<i>Carefully align the WSPR socket onto the RPi header pins and push the WSPR board <i>straight down</i></i>
<input type="checkbox"/>	Snap the two nylon standoffs into the RPi mounting holes
<input type="checkbox"/>	

Bias Adjustment



1
2
3



completed



Connect two 383Ω resistors in parallel to J10-1 and J10-3.



Keep the resistors installed until ready to connect an antenna.



Turn VR1 **fully clockwise**, using the mini-screwdriver



Be prepared to unplug power if anything is hot or if there's smoke!

Apply 5V power [see photo top-right]; do not plug in HDMI cable or USB peripherals yet.



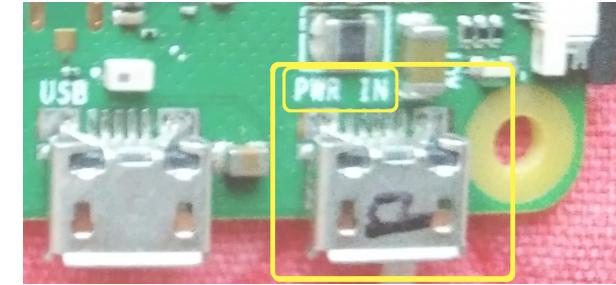
Connect a voltmeter between TP1 and GND



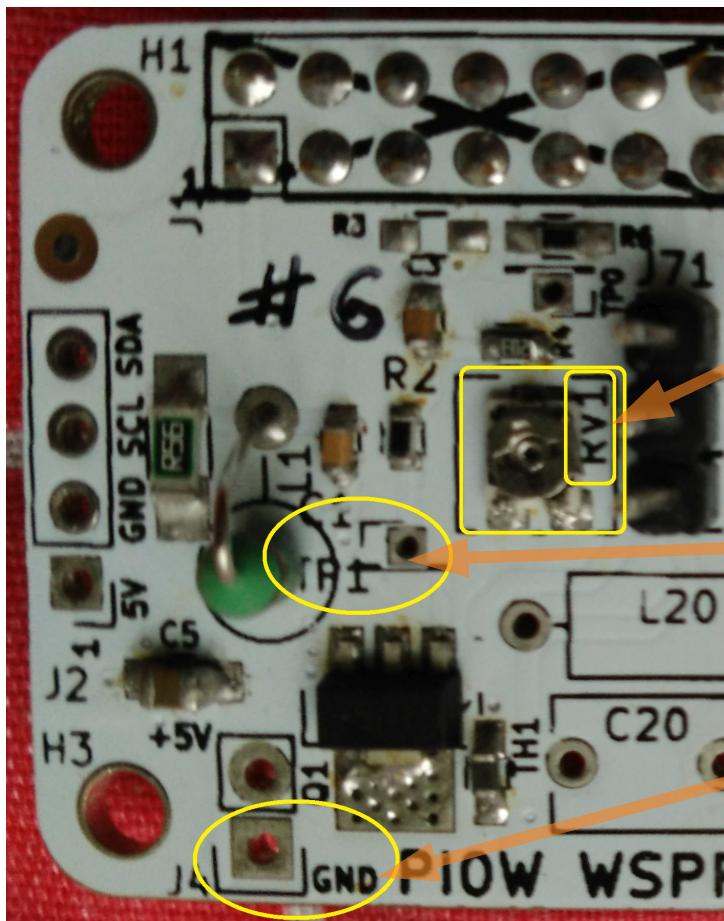
Slowly adjust VR1 for 0.9 to 1.0 V between TP1 and GND



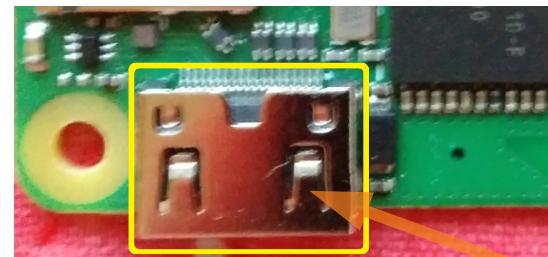
Disconnect 5V power



USB Power



RPi Zero W Startup

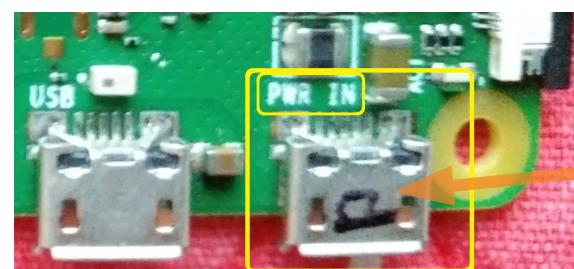


completed



miniHDMI port

Install the uSD card into the slot.
uSD card contacts are facing the PCB.
Install carefully!! Card is fragile



USB port

Connect a keyboard and mouse via USB hub



USB power

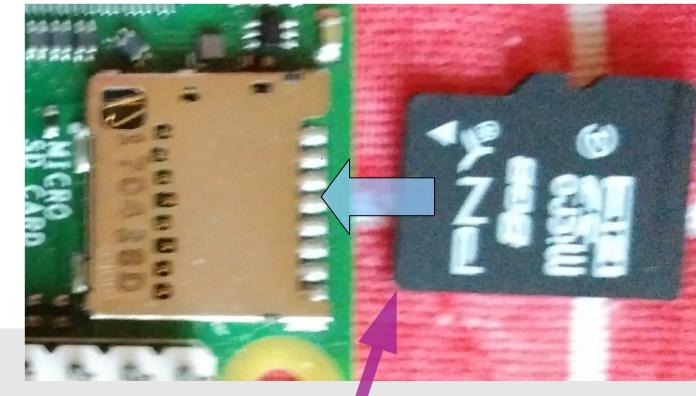
Connect 5V USB power

login as

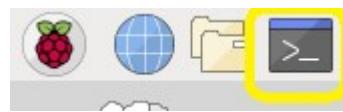
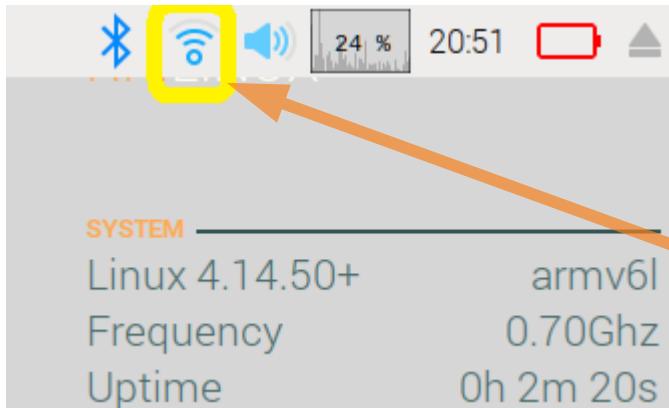
username: pi
password: raspberry

enter

startx

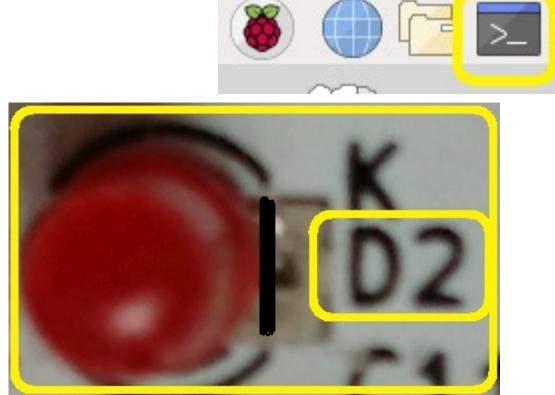


RPi Zero W Startup



completed		
<input type="checkbox"/>	WiFi connect	Click WiFi icon, follow prompts to connect to a network If using UM guest network, open web browser, agree to terms
<input type="checkbox"/>	NTP check	Allow a minute or two for clock time to update
<input type="checkbox"/>	Terminal window	Click to open a command terminal
<input type="checkbox"/>	enter	<code>cd /home/pi/Desktop</code> Keep the terminal window open for the next step

LED Test



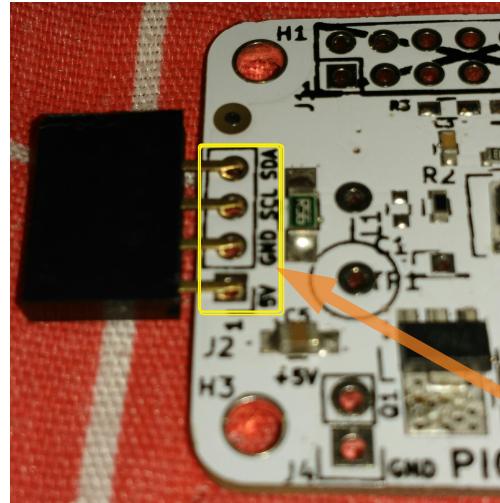
<input checked="" type="checkbox"/> completed		
<input type="checkbox"/>	Terminal window	at <i>/home/pi/Desktop</i>
<input type="checkbox"/>	enter	<code>sudo ./raspi-gpio27.sh</code>
<input type="checkbox"/>	verify	LED should blink for about 1 second

RF Test with Scope



<input checked="" type="checkbox"/> completed		
<input type="checkbox"/>	Terminal window	at /home/pi/Desktop
<input type="checkbox"/>	dummy load still connected?	Connect two 383Ω resistors in parallel to J10-1 and J10-3.
<input type="checkbox"/>	Connect scope to load	J10-3 (gnd), J10-1 (signal) Set scope for ~10V pk-pk, ~10ns/division
<input type="checkbox"/>	enter	<code>sudo ./wspr.sh</code>
<input type="checkbox"/>	wait	Up to two minutes for transmission to start. WSPR protocol starts TX on the even minute, lasts for just under two minutes.
<input type="checkbox"/>	verify	Power output at resistor
<input type="checkbox"/>	calculate	$P = (0.707 * V_{pk})^2 / R$
<input type="checkbox"/>	stop: enter	<ctrl>C

OLED Test



<input checked="" type="checkbox"/> completed		
<input type="checkbox"/>	Terminal window	Prepare to power down
<input type="checkbox"/>	enter	<code>sudo shutdown now</code>
<input type="checkbox"/>		Turn off 5V power
<input type="checkbox"/>	OLED	Plug in display; ensure that the Vcc, GND, SCL, and SDA pins match up
<input type="checkbox"/>		Turn on 5V power
<input type="checkbox"/>	At console, enter	<code>cd Desktop</code>
	enter	<code>./oled.sh</code>
<input type="checkbox"/>	verify	on OLED: Hello world!
	stop: enter	<code><ctrl>C</code>

Operational Setup

<input checked="" type="checkbox"/> completed		
<input type="checkbox"/>	From console, enter	startx
<input type="checkbox"/>	From X-Windows desktop	Right-click, wspr.sh, select edit
<input type="checkbox"/>	In “leafpad” editor	Edit the call sign and grid square
<input type="checkbox"/>		Save file and exit editor
<input type="checkbox"/>	Open a file window	Navigate to <i>home/pi/Desktop/tools/luma.examples/examples</i>
<input type="checkbox"/>	Edit OLED banner text	Right-click banner_medium_hello.py , select Thony (simple mode)
<input type="checkbox"/>		Edit the “Hello” (line 95) and “world” (line 97) text to, e.g., your call sign and frequency
<input type="checkbox"/>		Save file and exit editor

Antenna Connection



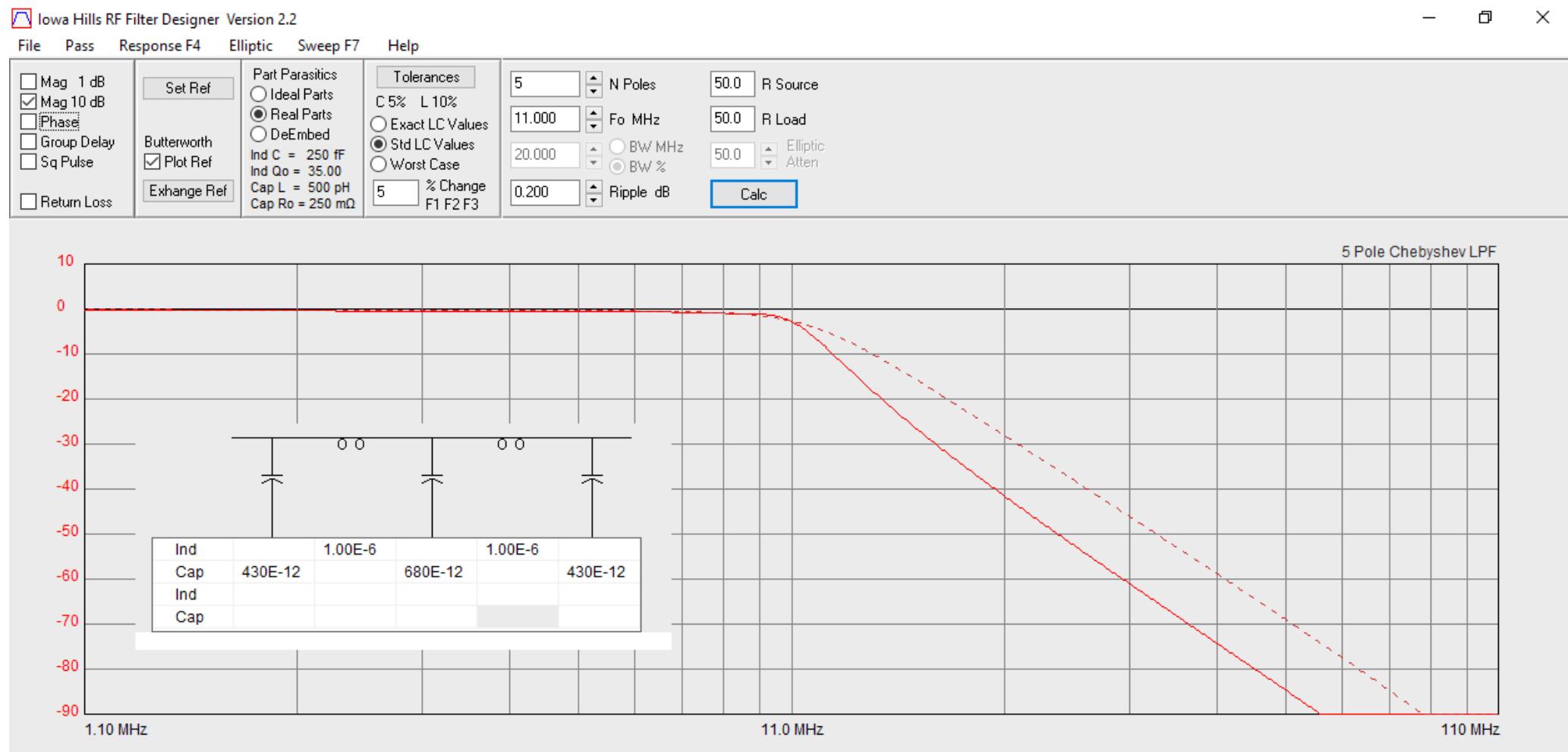
<input checked="" type="checkbox"/> completed		
<input type="checkbox"/>	enter	sudo shutdown now
<input type="checkbox"/>		Turn off 5V power
<input type="checkbox"/>	Dummy load	Remove and save 2x 383Ω resistors from J10-1, J10-3 (200Ω connection)
<input type="checkbox"/>	Connect antenna	WARNING: ends of antenna are sharp and could cause injury. Use safety glasses when handling antenna. Connect one antenna lead to J10-1, and the other to J10-2 (50Ω connection)
<input type="checkbox"/>	Cut antenna	Each exposed lead should theoretically be 23' 1" long (7m 3cm), but you should initially make them a bit longer for tuning 23" 7" (7m18cm)

Operation

<input checked="" type="checkbox"/> completed		
<input type="checkbox"/>	Drop down to console	Pi menu...Shutdown...Exit to command line
<input type="checkbox"/>	From console enter	cd home/pi/Desktop
<input type="checkbox"/>	enter	./oled.sh & (ampersand runs script in background)
<input type="checkbox"/>	enter	./wspr.sh (no ampersand)
<input type="checkbox"/>	Wait	Up to two minutes for transmission to start
<input type="checkbox"/>	To quit program, enter	<ctrl>C
<input type="checkbox"/>	To shut down, enter	sudo shutdown now
<input type="checkbox"/>		Turn off 5V power

Appendix: 30m LPF Design

<http://www.iowahills.com/8DownloadPage.html>



Acknowledgements

- Thanks to W8ARU for design tips, reviews, and for doing lots of the surface-mount soldering. If you get a board that works, it was probably his; if it doesn't work, I probably soldered that one.
- Thanks to my sister for making at least two dozen trips to Micro Center for obtaining the Raspberry Pi Zero Ws. One at a time.
- Filter design software from
<http://www.iowahills.com/8DownloadPage.html>
- Thanks to EAE Sales for donating to the Arrow Comm. Association's bus trip. The Edsyn soldering station worked great! <https://www.eaesales.com/>

Notes

- A fork of the WSPR software, with GPIO control for the LED is here:
<https://github.com/jglandorf/WspryPi.git>
- KiCAD files for this project are here:
https://github.com/jglandorf/wspr_pi0.git
- An image of the uSD Card is here:
https://github.com/jglandorf/wspr_pi0.git/RPi0_usdCardImage