World of QRP

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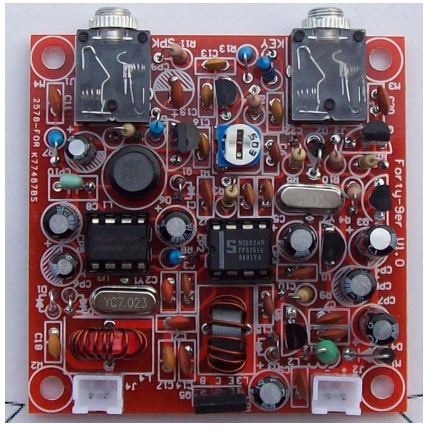


Agenda

- Introduction
- Operation
- QRP History
- Classic QRP radios
- Common Architecture
- Modern kits
- Antennas
- Challenges & Solutions
- Conclusion

Introduction

What is the appeal of QRP ?

1. **Challenge**: Long distance communication with the power of flashlight batteries.

2. **Simplicity**: Most QRP equipment is a kit / homebrewed and is easy to operate
   User knows function of each component.

3. **Nostalgia**: Reliving the old days when contacts were made with primitive equipment and each contact was an achievement.

Definition

QRP = “Reduce power“

QRP enthusiast’s goal ➔ Use minimum power possible to carry out the desired communications

The difference between 100 watts and 1 watt is only 20 dB or (3.3 S units)

- 5 Watts (max) CW /FT8
- 10 Watt (max) SSB

QRPp (extreme QRP): Sub-watt region

- Using 100 milliwatts, 10 milliwatts or 1 milliwatt

Commonly used benchmark is ratio of distance / power

- Montreal - Charleston, SC: 1000 miles with 1000 watts ➔ 1 mile / watt
- Montreal - Charleston, SC: 1000 miles with 1 watt ➔ 1000 miles / watt
- Montreal - Eastern Australia: 10000 miles with 1 watt ➔ 10,000 miles / watt
- Montreal - Eastern Australia: 10000 miles with 0.001 watt ➔ 10,000,000 miles / watt

Operation

QRP station can be implemented in one of three ways:

1. Regular transceiver with power dialed down to 1 to 10 watts

2. QRP transmitter + conventional receiver

3. QRP specific transceiver(*)

*Many QRP specific transceivers use simple DCO receivers (i.e. less sensitivity than superhet).
You face two challenges here:

1. Low Tx power

2. Reduced Rx sensitivity

Operation

Factors to consider before attempting QRP:

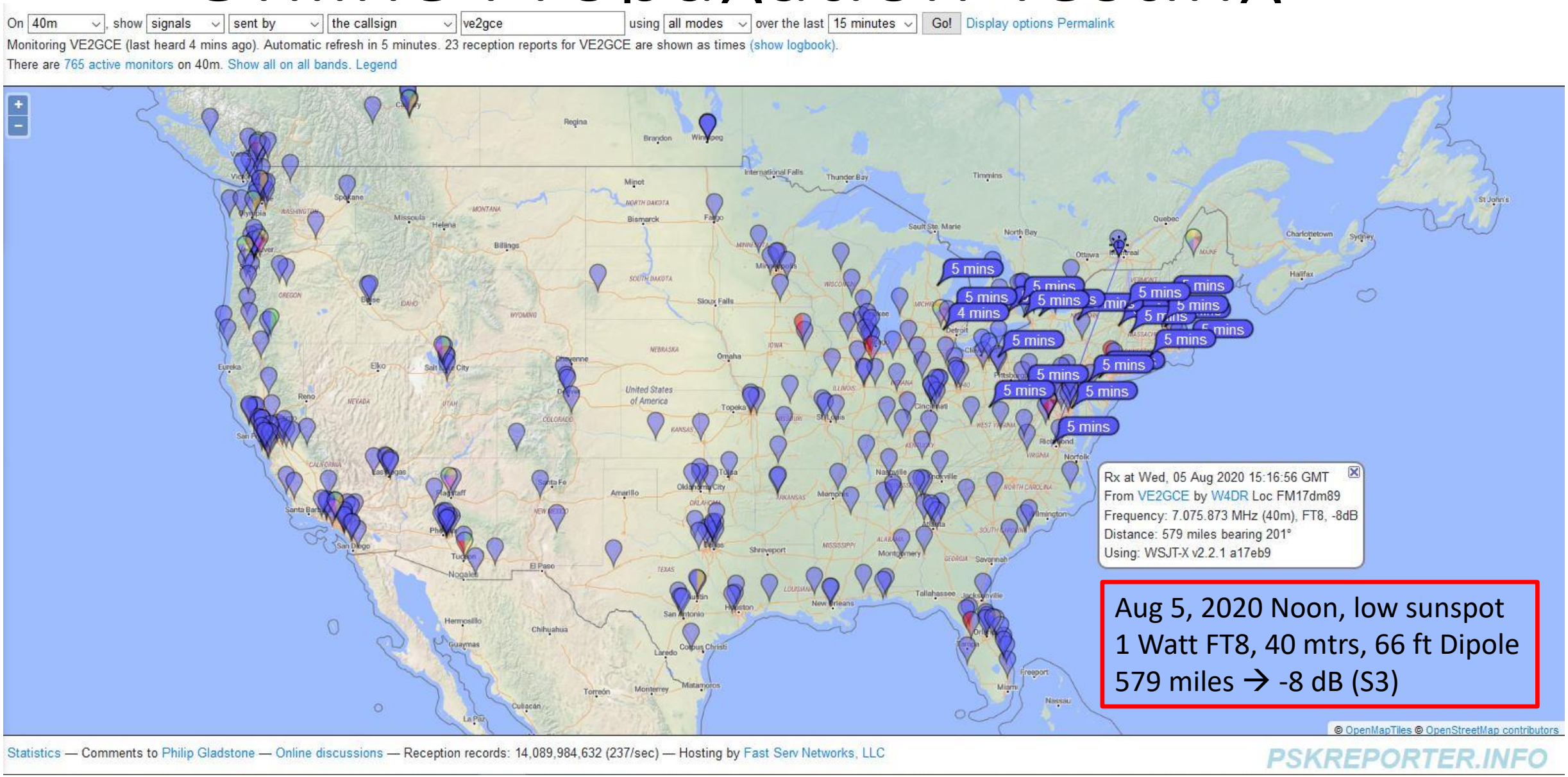
- Running QRP requires 10 times more patience than running at regular power levels
- Absolutely need to find empty frequency, it is very easy to get swamped by high power stations.
- Better to respond to CQ's from stronger stations rather than weak stations.
- Despite current low sunspot cycle period, QRP operation still possible.
- How to verify your signal is being received ?
  → Use web site pskreporter.info used by FT8 operators

Secrets for success:

1) Efficient antenna system on local end (more on this later)

2) Efficient antenna system on remote end
   → See pskreporter.info or qrz.com to get details of other operator's setup

Online Propagation Testing



FT8 vs S Units

Traditional S units

1. Faint—signals barely perceptible
2. Very weak signals
3. Weak signals
4. Fair signals
5. Fairly good signals
6. Good signals
7. Moderately strong signals
8. Strong signals
9. Extremely strong signals

- FT8 can be copied as low as S0 (-26 dB)
- CW (DX) copy requires at least S1 (-20 dB)
- SSB Rx requires usually at least S3 (-8 dB)
- Every 6 dB = 1 S unit

FT8 →

CW →

SSB →

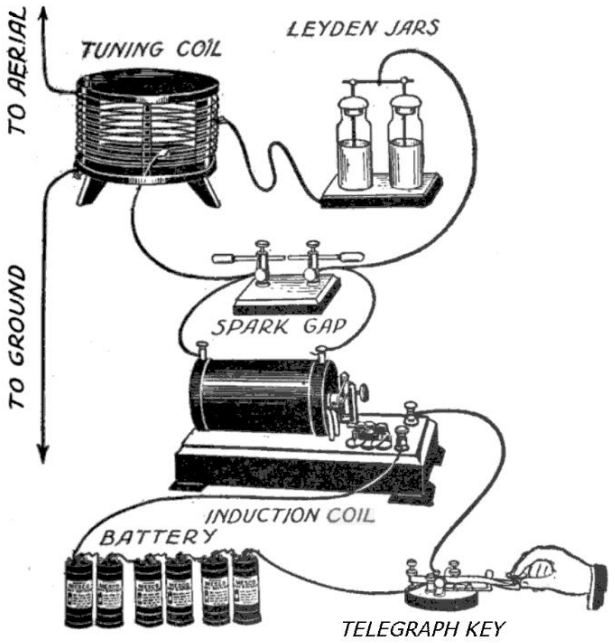
FT8 Report	S-meter
-26	S0
-25	
-24	
-23	
-22	
-21	
-20	S1
-19	
-18	
-17	
-16	
-15	
-14	S2
-13	
-12	
-11	
-10	
-9	
-8	S3

FT8 Report	S-meter
-8	S3
-7	
-6	
-5	
-4	
-3	
-2	S4
-1	
0	
1	
2	
3	
4	S5
5	
6	
7	
8	
9	
10	S6

FT8 Report	S-meter
10	S6
11	
12	
13	
14	
15	
16	S7
17	
18	
19	
20	
21	
22	S8
23	
24	
25	
26	
27	
28	S9

History: 1895-1920

- First QRP operator was Guglielmo Marconi in 1895.
- First transmitter was spark gap transmitter operated off of batteries.
- Transmitter was wide band and under 10 watts
- Primary mode of communication until World One.
- Early amateurs made spark gap transmitters from Ford model “T” ignition coils.



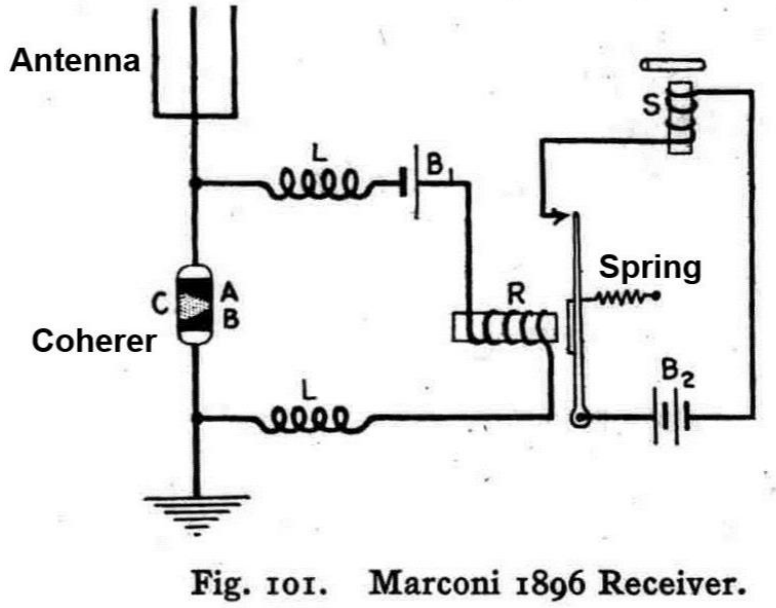


Fig. 101. Marconi 1896 Receiver.

History: 1920-1940

- Hams using tubes in their homebrew equipment, CW transmission more efficient than spark gap
- Receivers used were:
  - Tuned radio frequency: Cascaded RF stages, progressively unstable as frequency goes up
  - Super heterodyne: Superior receiver, complex and expensive because of RCA patent royalties
  - Super regenerative: Super regenerative detector
- Band changing was done by swapping out coil plug-ins
- Transmitters were mostly QRP, not by choice, but for economic and practical reasons.
  - Cheap audio output tubes used for transmitters (10-15 watts)
  - Commercial transmitter tubes were prohibitively expensive

History: Post 1945

- After World War 2, amateur radio landscape changes thanks to technology advances and war surplus.
- Price of transmitting tubes dropped
- Amateurs were able to build / buy equipment that operated above QRP range.
- 100 watt transmitters became the norm
- Simple QRP commercially manufactured equipment for new hams introduced.
- Most new hams built one tube transmitter combined with general coverage receiver.

QRP Specific Rigs

- In 1960's, QRP rigs with advanced features are introduced.
  - VFO, multiband, CW filter, etc.
- One of the most prolific kit mfg'ers was Heathkit
- Sadly, Heathkit out of business in 1992 after 45 yrs in the kit business.
- Many people associate QRP radios with low price
  - Ten Tec sold the Argonaut QRP radio for $300 in 1972 ($2000 in 2020)
- Majority of QRP rigs sold in past and present are kit radios.

QRP Specific Kits

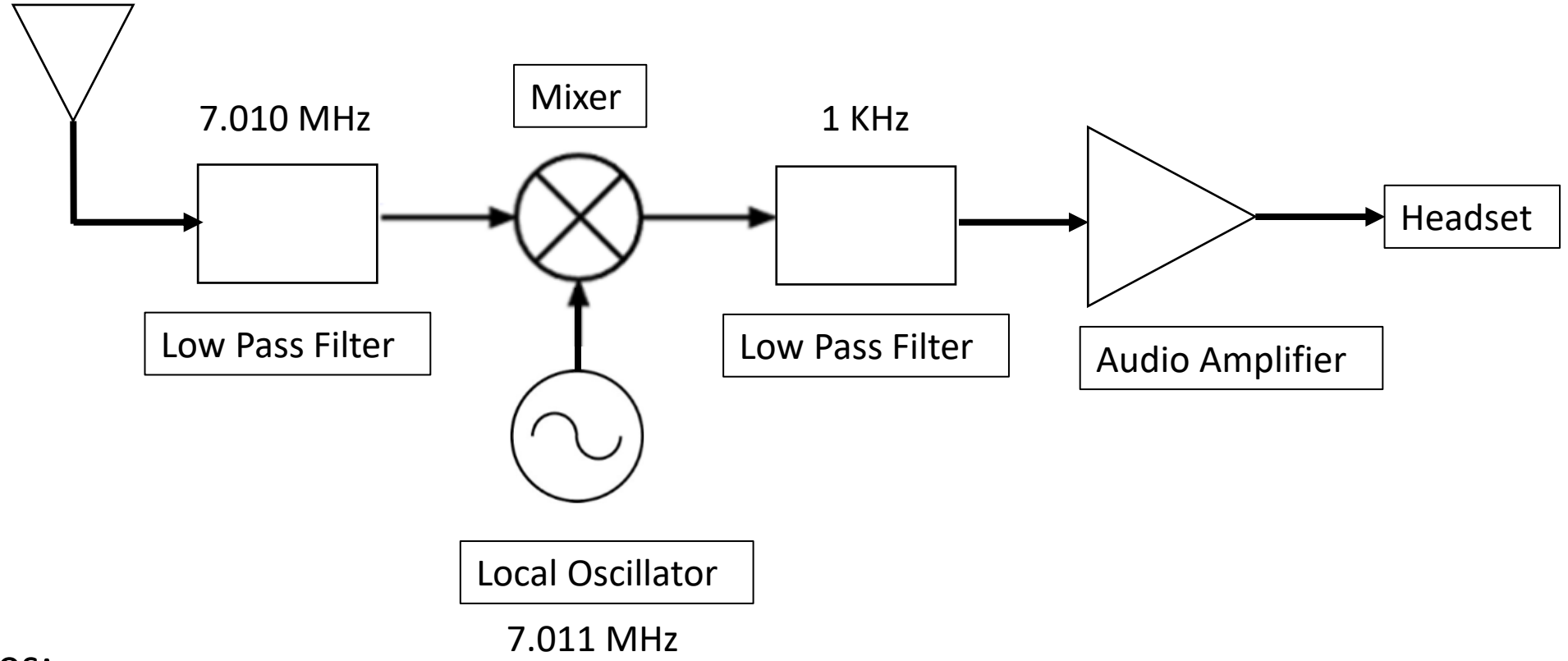
After the demise of Heathkit, many manufacturers started filling the void.

Most featured the following:

- Battery operation
- One band
- CW mode

- Major players include:
  - MFJ
  - Ten Tec (name means 10 watt technology)
  - Ramsey
- Recently many super-cheap Chinese QRP kits started appearing.

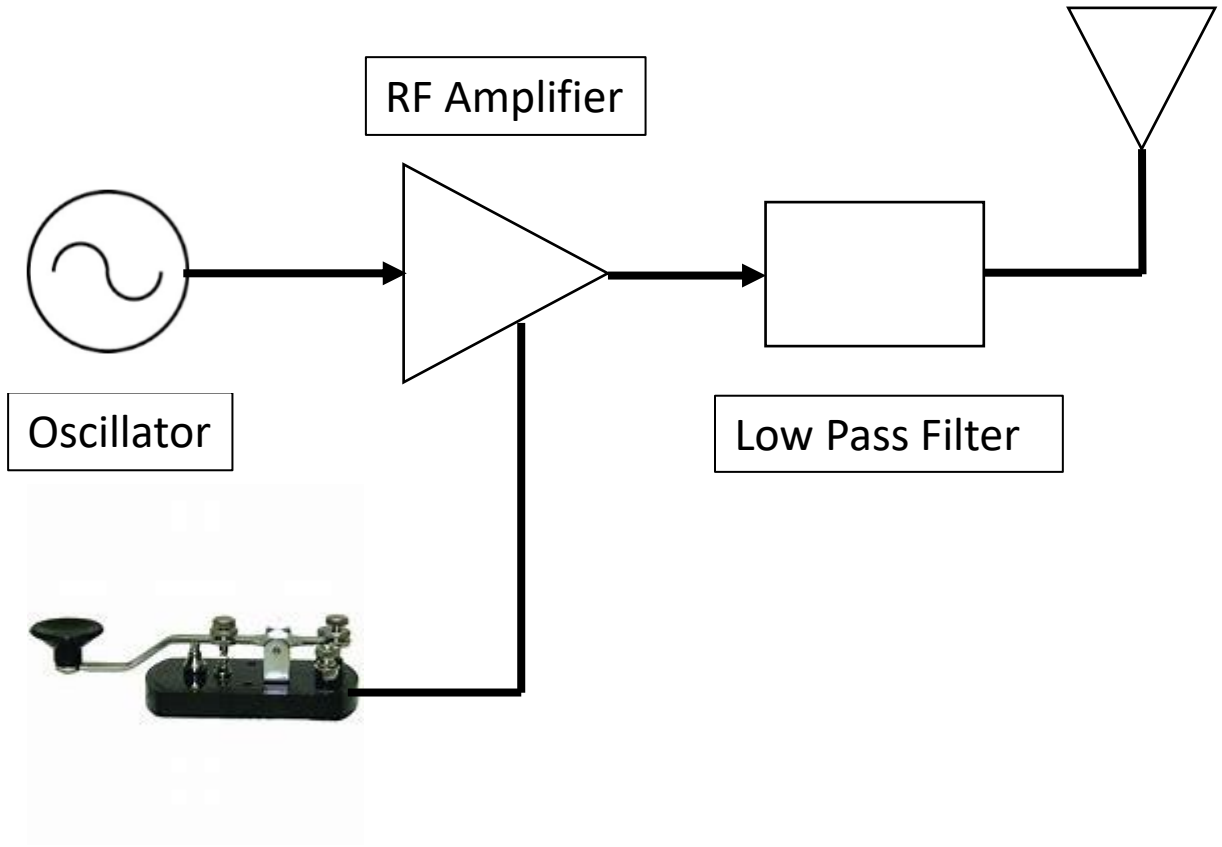
Architecture - Receiver



Typical features:

- RF LPF on front end. *LPF often used as TX output network*
- Local oscillator is often also TX oscillator
- DCO (Direct Conversion Operation), much simple for kit builders than super heterodyne
- Audio LPF followed by audio amplifier

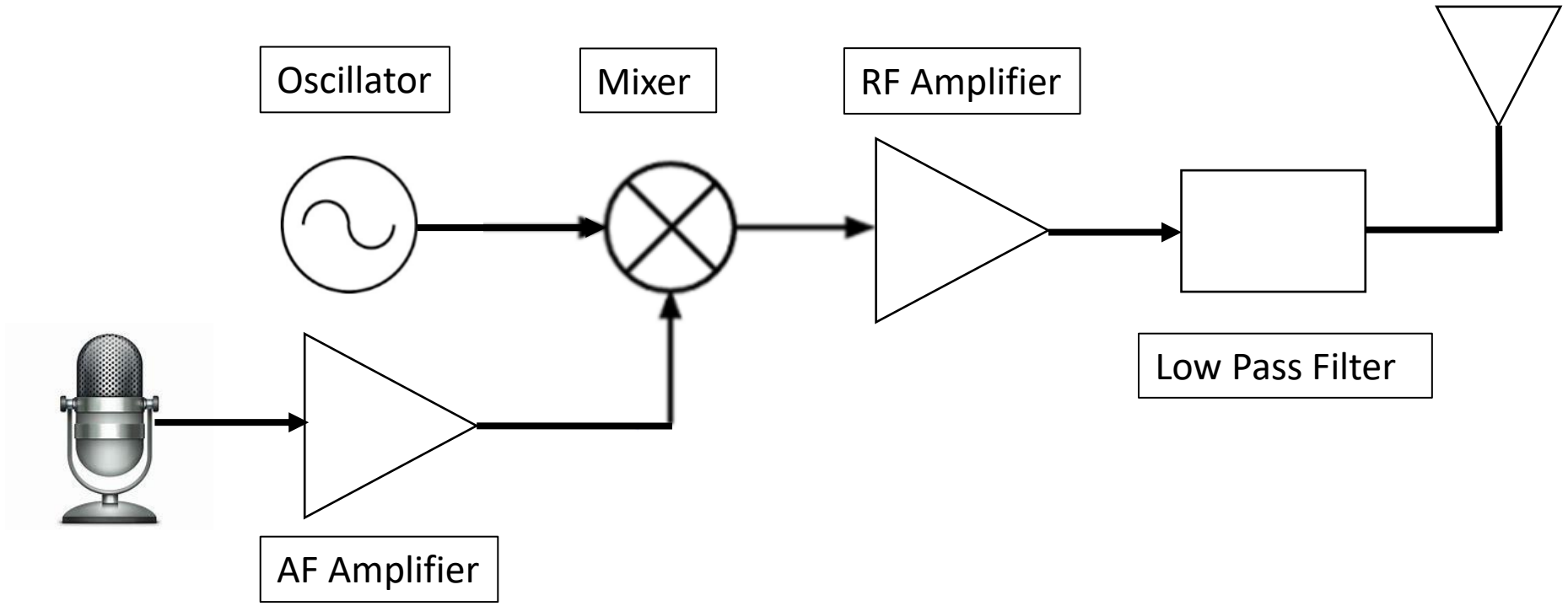
Architecture – Transmitter - CW



Typical features:

- Oscillator, often crystal controlled for stability
- RF Amplifier is 1 to 3 stages, resulting in 0.5 to 5 watts
- LPF TX output network
- CW most commonly used mode

Architecture – Transmitter - DSB



Typical features:

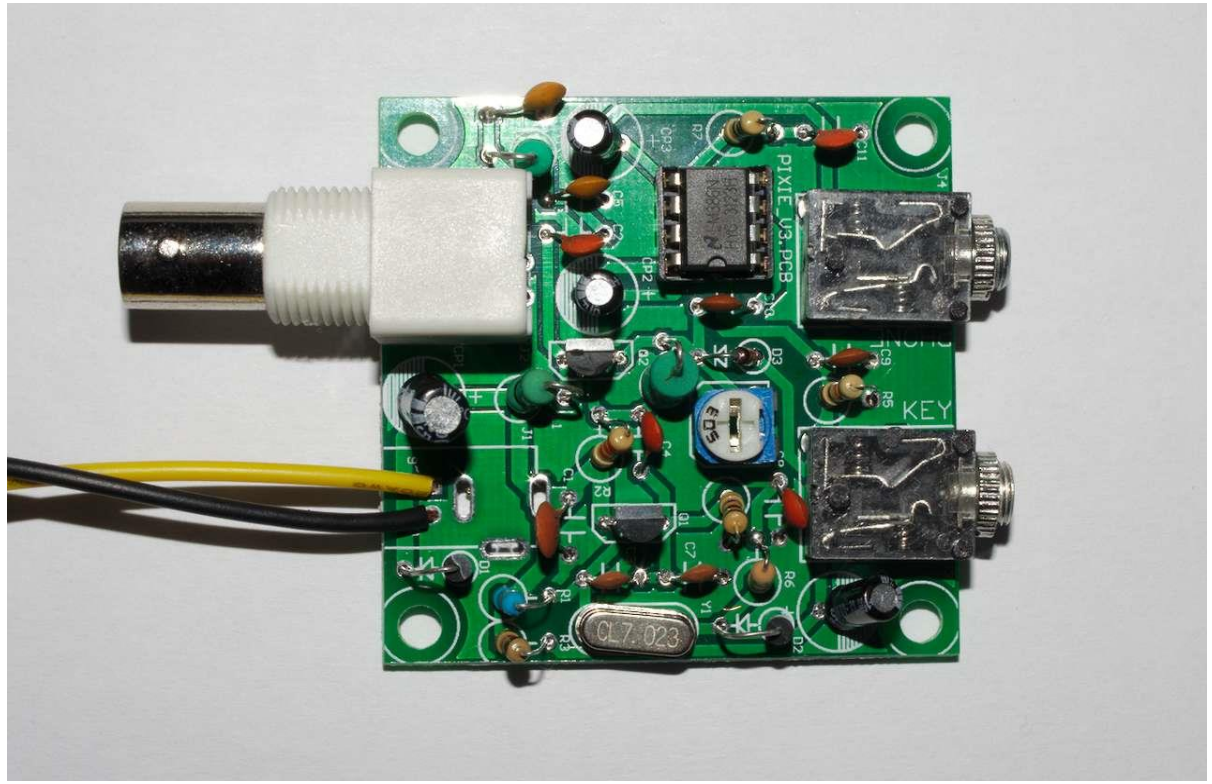
- Oscillator
- Audio amplifier for microphone or FT8 baseband data
- Mixer creates DSB by modulating carrier oscillator with audio
- RF Amplifier is 1 to 3 stages + LPF TX output network
- DSB simplifies design, not as efficient as SSB, but much better than AM.

Pixie

Simplest QRP transceiver using only 4 x semiconductors.
Original minimalist design by GM3OXX ‘FOXX’ in 1982
- 4 x transistors + manual T/R switch

Improved by RV3GM as ‘Micro-80’ in 1992
- Full break-in switching

Current Version by NorCal ‘Pixie’ in 1995.
- 2 x audio transistors replaced by LM386 chip



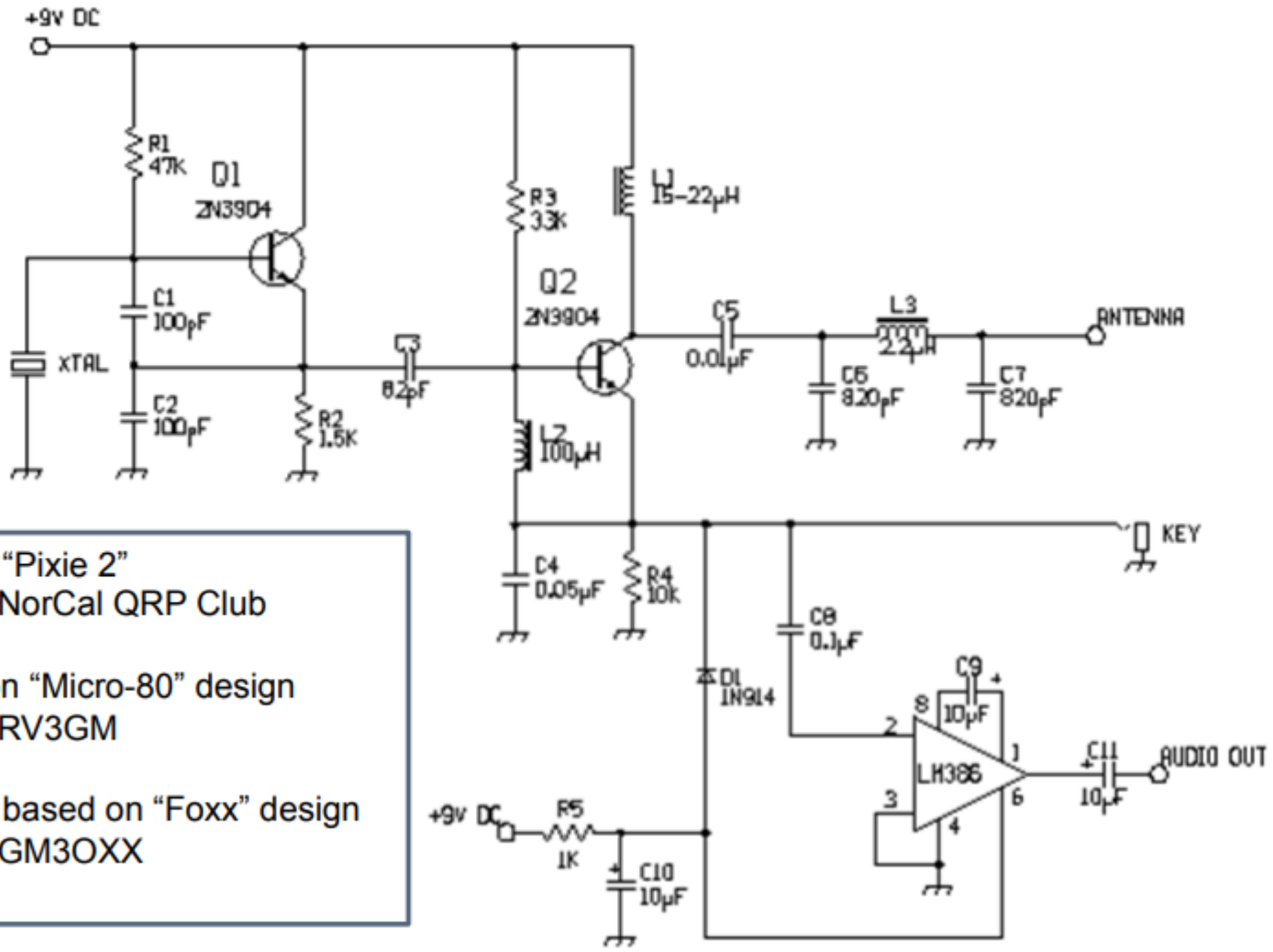
- CW Transceiver
  - One band: 40 meters
  - VXCO: 5 kHz tune range
  - Power source: 9 - 12 volts

- Transmitter
  - 2 stage transmitter + LPF
  - 500 milliwatts output

- DCO Receiver (crudely implemented)
  - Heterodyne: Antenna LPF + TX oscillator
  - Audio output LM386

➔ $10.00 Cdn on Amazon ($2.50 USD on eBay)

The Pixie Transceiver



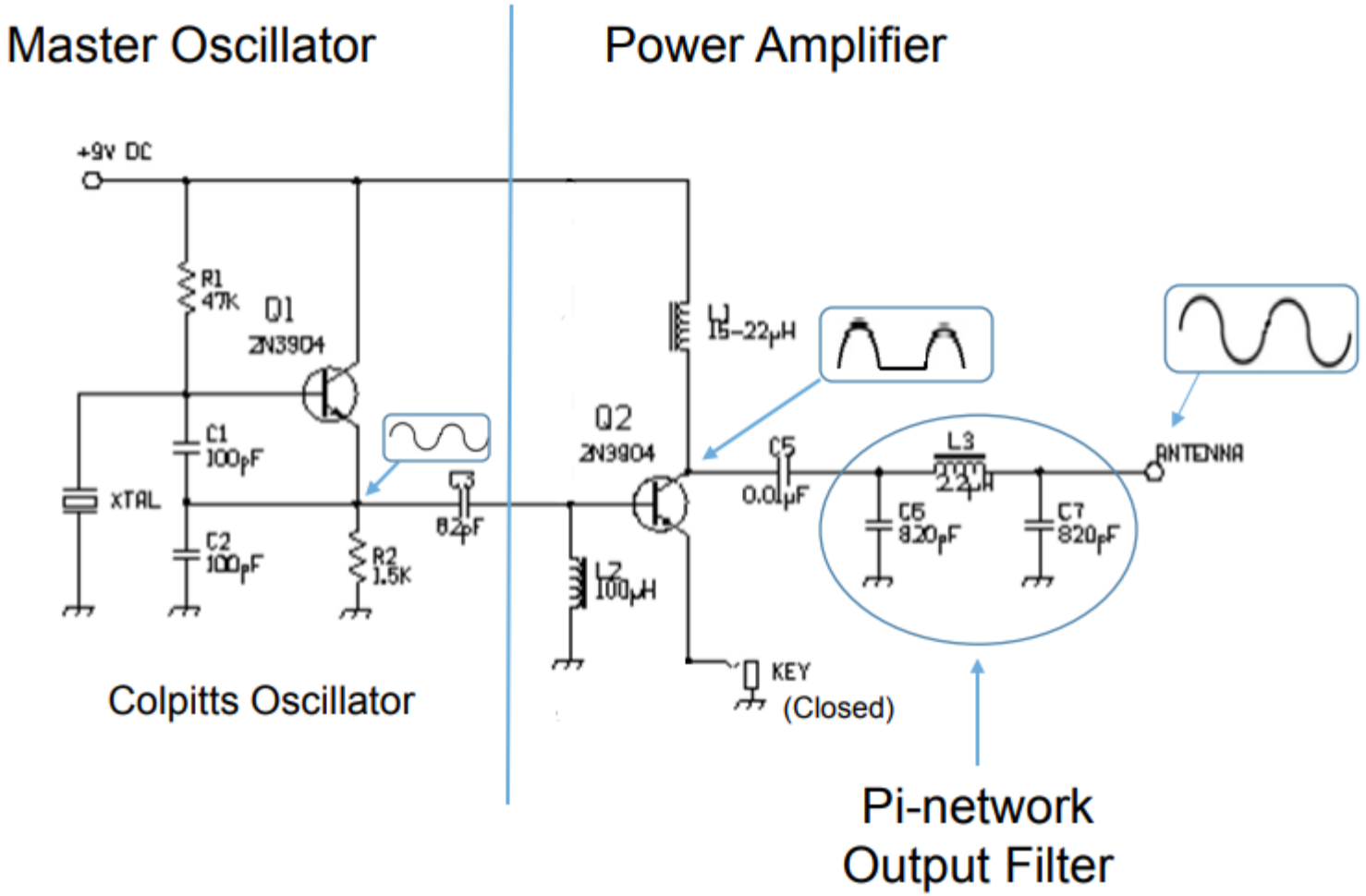
Original "Pixie 2"
c. 1995 NorCal QRP Club

Based on "Micro-80" design
c. 1992 RV3GM

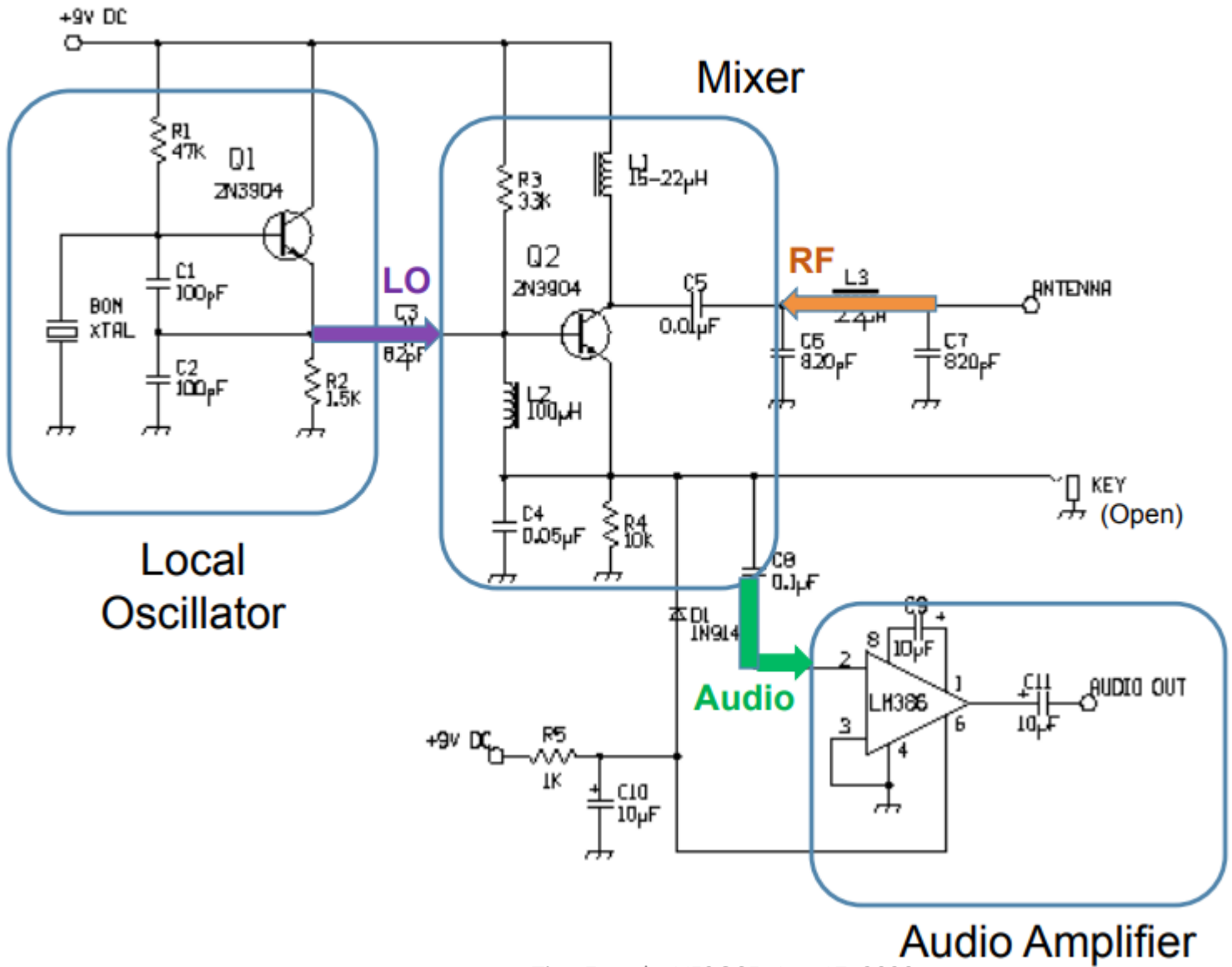
Loosely based on "Foxx" design
c. 1982 GM3OXX

Note: Pixie schematics taken from www.w1sye.com "How the Pixie transceiver works"

Pixie Key Closed - Transmitter



Pixie Key Open - Receiver



Forty-niner

Design by Wayne Burdick, N6KR, California NorCal QRP club 1996.

- Evolved from Pixie. Dedicated mixer, not relying on RF leakage
- 49'er refers to 40 meter operation and 9 volts power source and to California historical reference (i.e. gold miners of 1849)

- CW Transceiver
  - One band: 40 meters
  - VXCO: 5 khz tune range
  - Power source: 9 - 12 volts

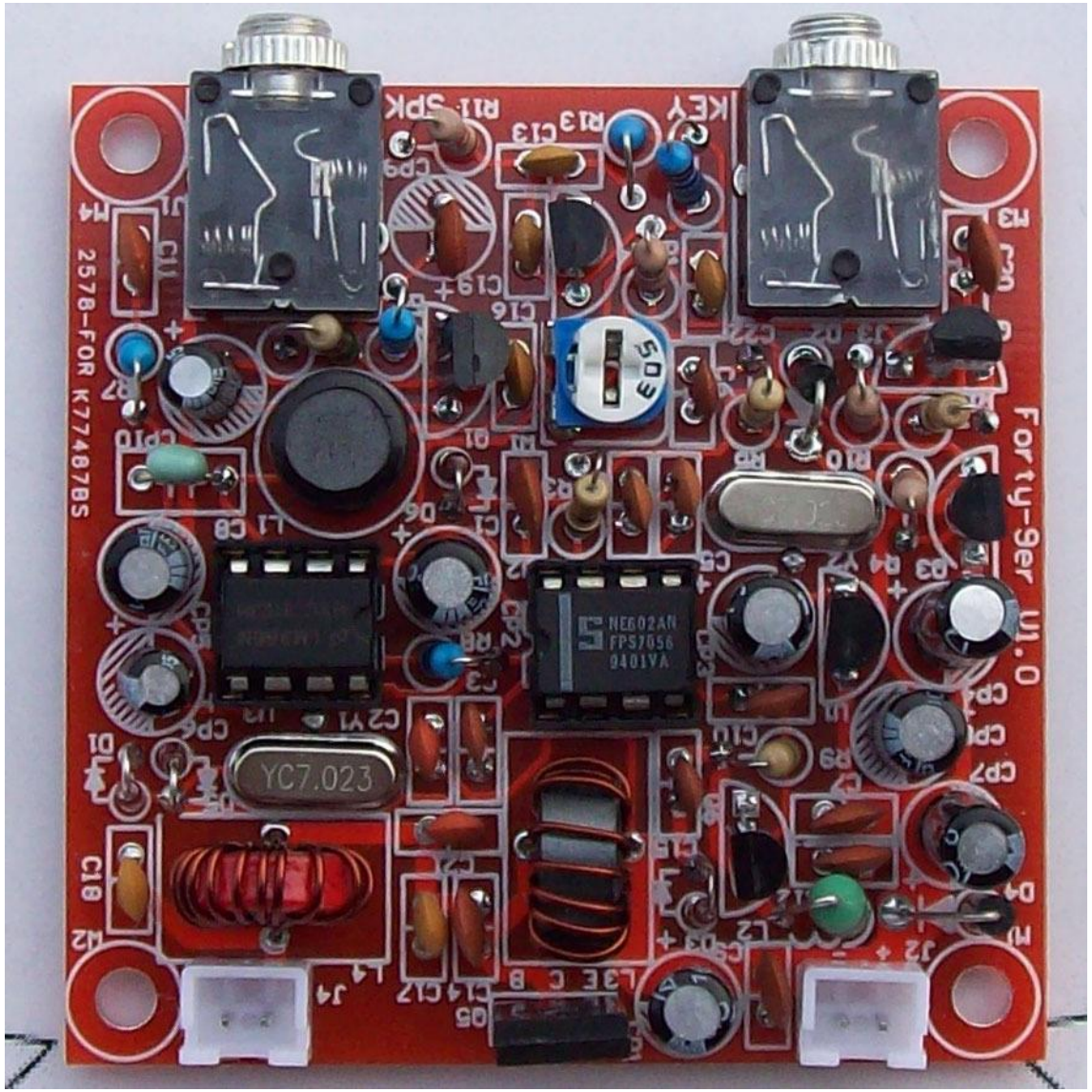
- Transmitter
  - 3 stage transmitter + LPF
  - 3 watts output

- DCO Receiver
  - Heterodyne mixer NE602
  - Audio output: LM380

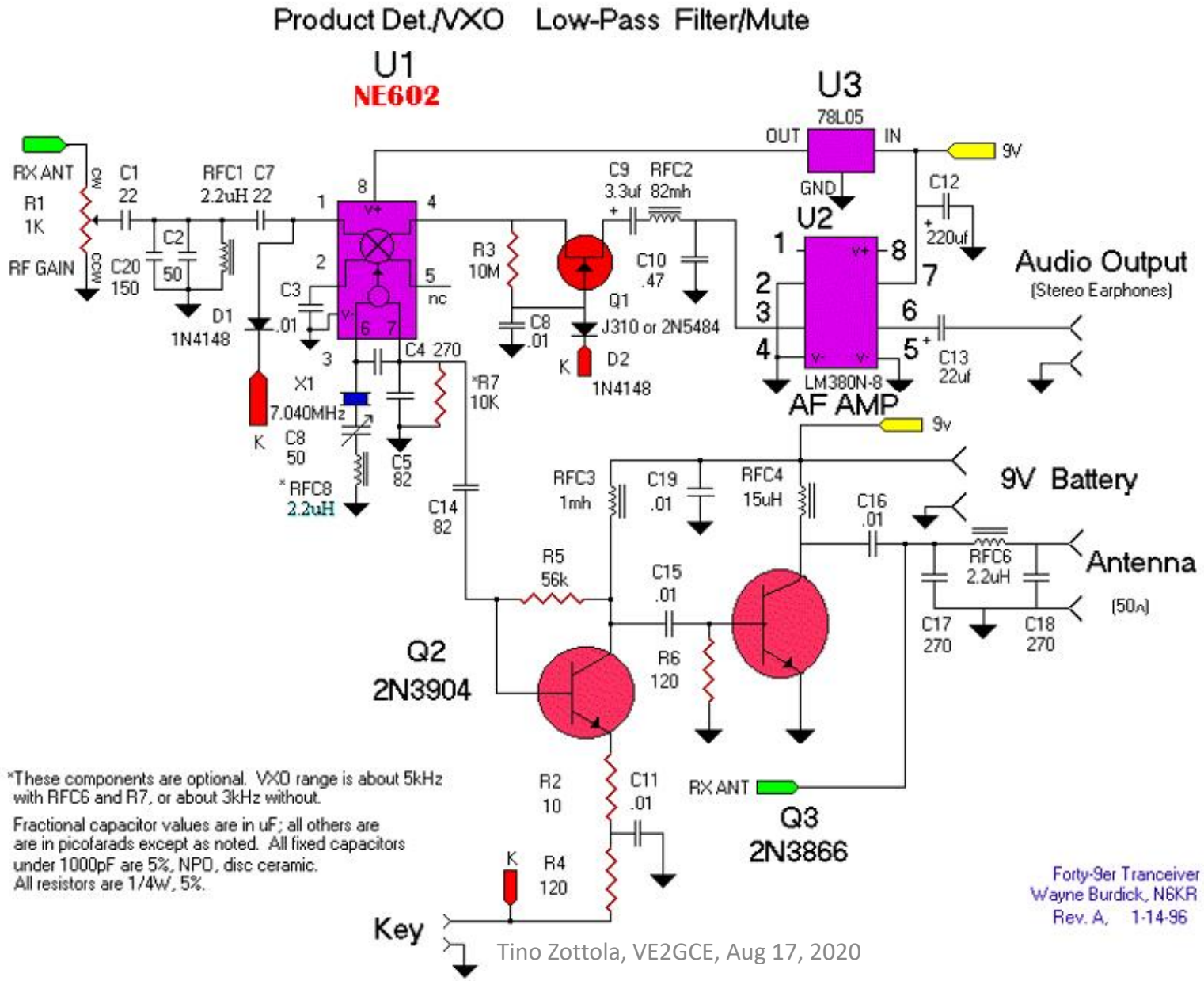
➔ Sells for $7.50 Cdn on Amazon

Current Chinese kits have additional features:

- Transistor side tone
- Xtal RX bandpass filter



Forty-niner


Product Det./VXO
Low-Pass Filter/Mute
U1
NE602
U3
78L05
OUT
IN
GND
9V
U2
LM380N-8
AF AMP
Audio Output
(Stereo Earphones)
RX ANT
R1
1K
RF GAIN
C1
22
C2
50
C20
150
RFC1
2.2uH
C7
22
D1
1N4148
C3
.01
X1
7.040MHz
C8
50
*RFC8
2.2uH
C4
270
C5
82
C14
82
*R7
10K
R3
10M
C8
.01
C9
3.3uf
RFC2
82mh
C10
.47
Q1
J310 or 2N5484
D2
1N4148
C12
220uf
C13
22uf
9v
9V Battery
RFC3
1mh
C19
.01
RFC4
15uH
C16
.01
R5
56k
C15
.01
R6
120
Q2
2N3904
RFC6
2.2uH
C17
270
C18
270
Antenna
(50Ω)
R2
10
C11
.01
R4
120
Key
RX ANT
Q3
2N3866
*These components are optional. VXO range is about 5kHz with RFC6 and R7, or about 3kHz without.
Fractional capacitor values are in uF; all others are are in picofarads except as noted. All fixed capacitors under 1000pF are 5%, NPO, disc ceramic.
All resistors are 1/4W, 5%.
Forty-9er Tranceiver
Wayne Burdick, N6KR
Rev. A, 1-14-96

QRP Guys DSB Transceiver

Designed by Steve Weber (KD1JV), sold by QRP Guys (Australia)

- Evolved from the 49'er
- Supports CW, phone and FT8 via DSB

- DSB Transceiver
  - Multi band: 160-17 meters
  - Uses plug-in assembly with coils and xtal per band.
  - Crystal control or VFO option
  - Power source: 9 -12 volts

- Transmitter
  - LM358 Speech Amplifier (for DSB or FT8)
  - NE602 Mixer for TX oscillator and DSB modulation
  - 3 stage transmitter + LPF → 3 watts

- Receiver
  - Antenna LPF
  - DCO architecture: NE602 local oscillator and mixer
  - Audio output: LM358

QRP Guys DSB Transceiver

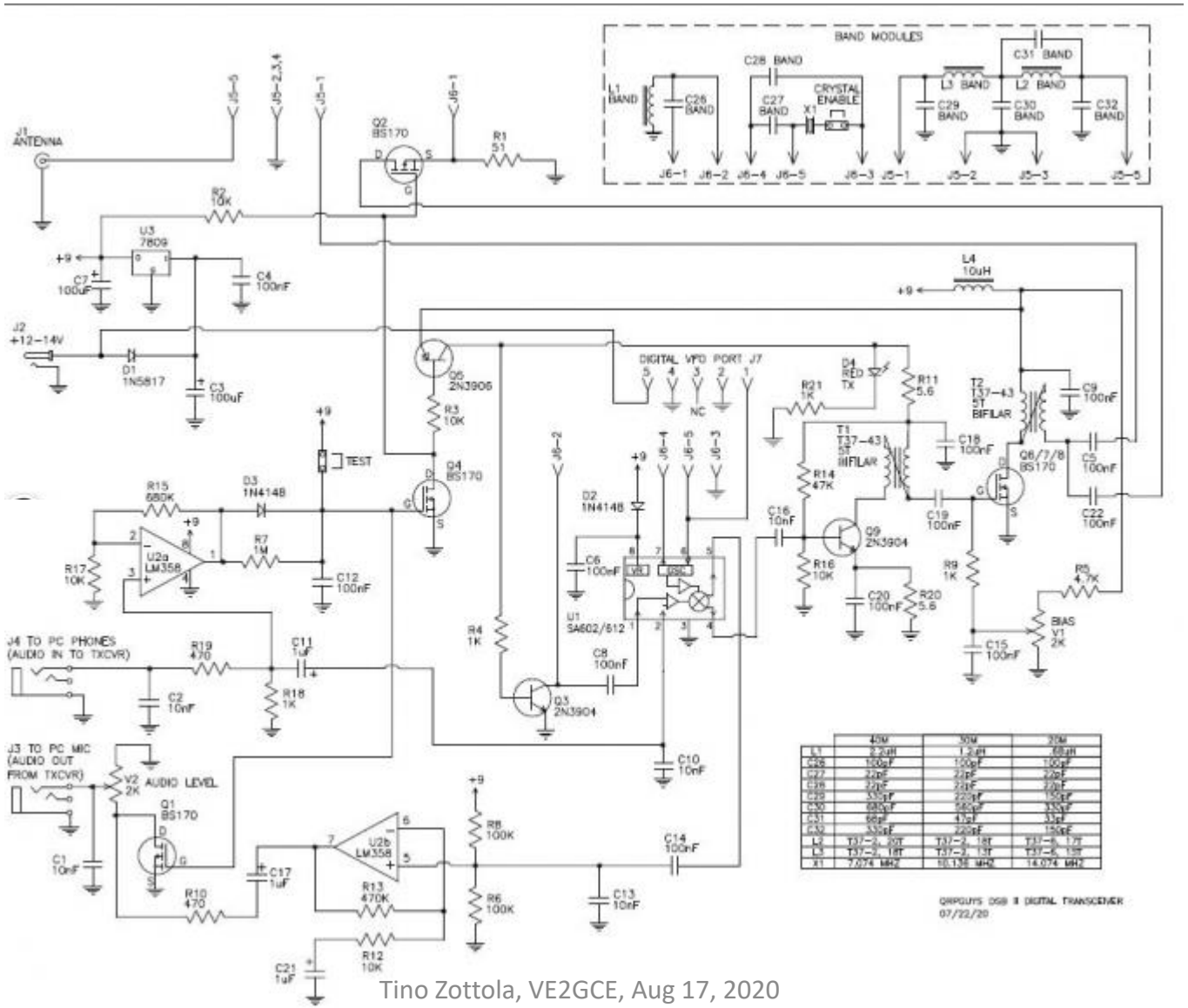
DSB transceiver shown with optional VFO ➔

Kit prices:

- $40.00 US for transceiver with 40/30/20m coils-xtal cards
- $30.00 US for Arduino based 160-17 meter digital VFO
- $10.00 US for 4 x blank PCBs for 160/80/17/xx meters

No Chinese kit exist at the moment, so prices are actual fair market prices.

QRP Guys DSB Transceiver



Antennas

- Antenna and feedline must be very efficient with minimal losses
- Does not necessary imply a tower and beam
- Antenna tuners can be used for a matching
- Better to tune antenna (i.e. cut to length) for perfect match

1) Horizontal antenna (i.e. dipole or Hertz)

<u>Pros:</u>

- Simple, cheap, no ground needed
- Efficient, good gain

<u>Cons:</u>

- Requires real estate (66 ft for 40 meters)

→ Tip: Inverted ‘V’ configuration can improve real estate footprint

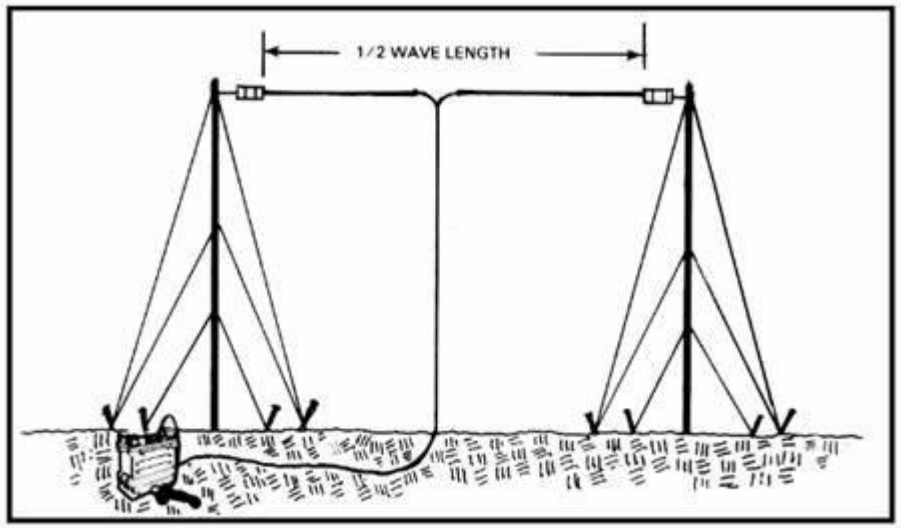


Figure 3-12. Center-fed Hertz antenna with two upright supports.

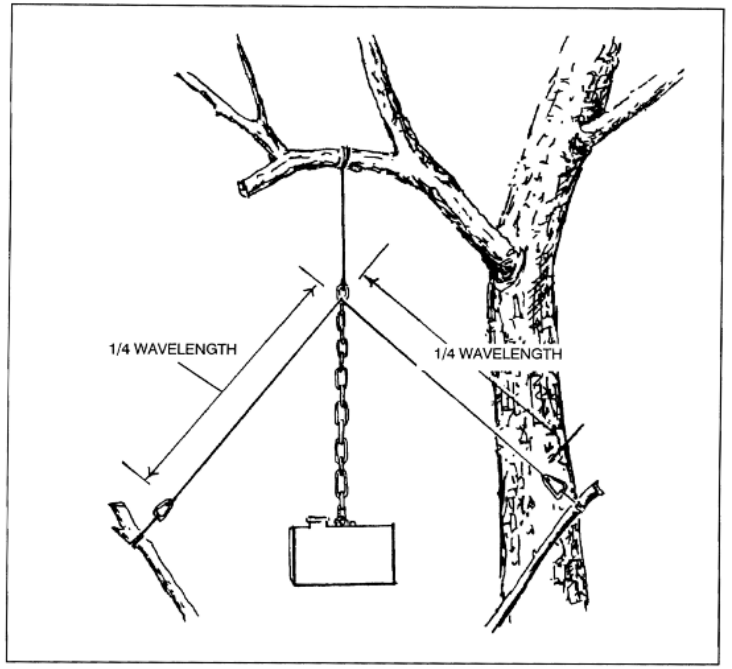


Figure D-10. Inverted Vee antenna.

Antennas

2) Vertical antenna (i.e. Marconi)

Pros:

- Real estate efficient
- Can be used for mobile and portable operation

Cons:

- Not as efficient as dipole, ground rod is not perfect counterpose, several dB of RX/TX loss

→ Secret to better performance, use ¼ wavelength counterpose radials instead of ground rod

→ Self standing antenna can be made with fiberglass rod (i.e. fishing pole)

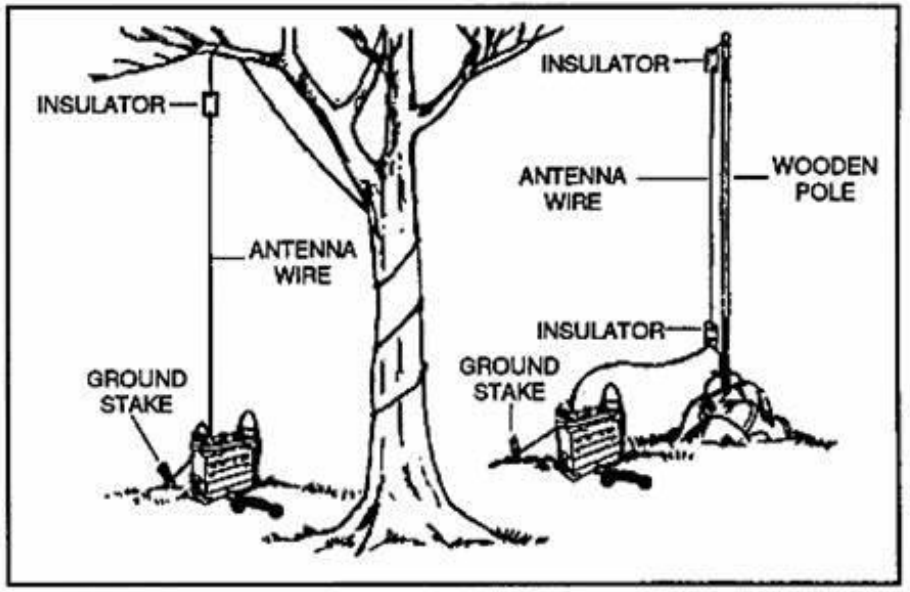
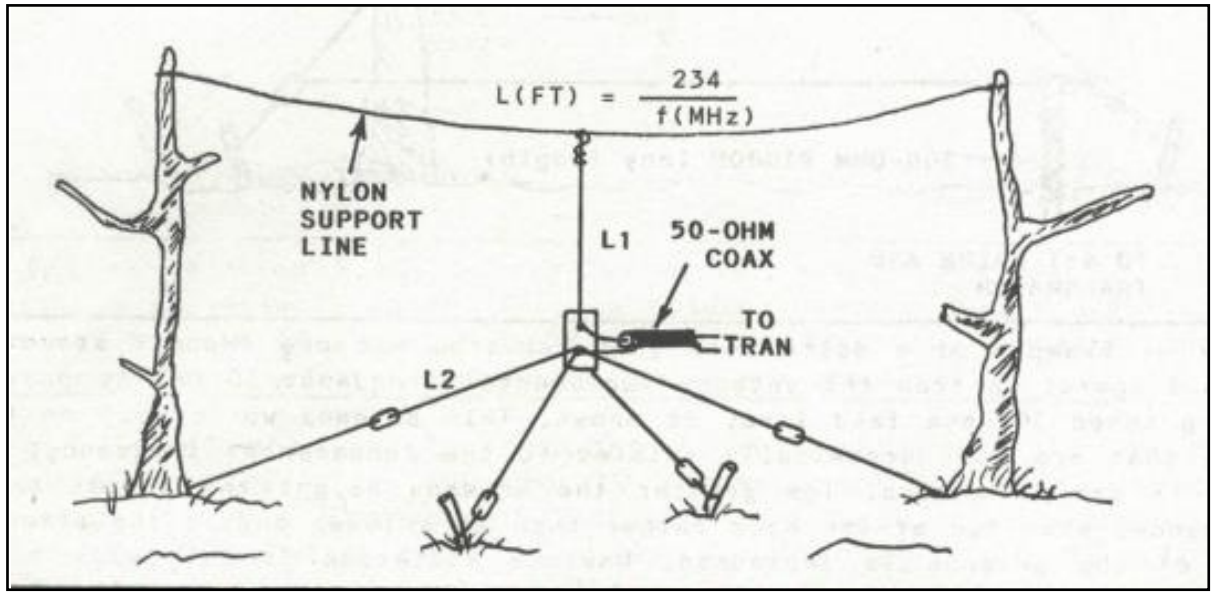
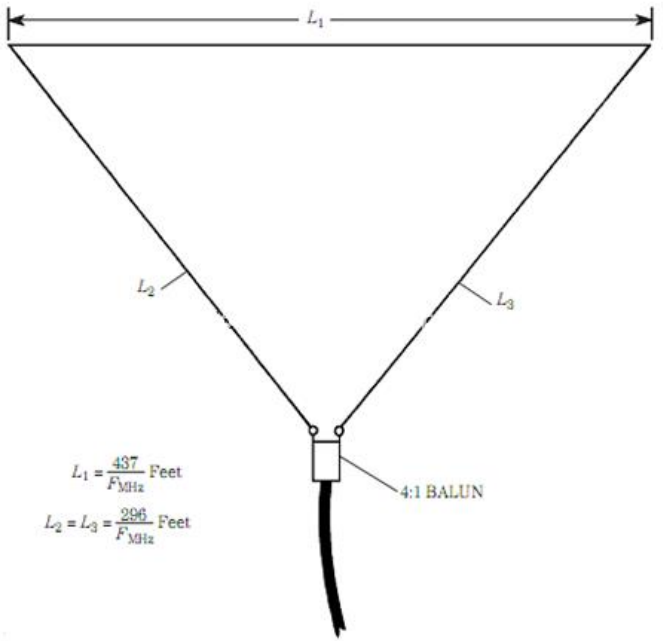


Figure 7-3. Field substitutes for support of vertical wire antennas.



Antennas

3) Delta Loop antenna (i.e. triangle)



<u>Pros:</u>

- Highly efficient, full wave
- Multiband
- Horizontal or vertical installation
- No ground needed

Variations include:

- Circular loop (more efficient than delta)
- Rectangular loop (less efficient than delta)

<u>Cons:</u>

- Uses twice the wire than used by ½ wave antennas

Antenna Test Instruments

- Field Strength Meter
  - Detecting rf leaks in feedline (i.e. coax, ribbon cable, etc)
  - Testing antenna improvements
  - Determining antenna emission patterns.
- Power meter
  - Useful for setting up or diagnosing most QRP transmitters
  - Built-in dummy load option is very useful
- SWR meter
  - Adjusting your antenna for maximum forwarded power and minimum reflected power
  - Cheaper CB radio units are good since they are designed for low power and have power meter built in.

Field Strength Meter

***** All great instruments, if your antenna system is working fine or close to it.**

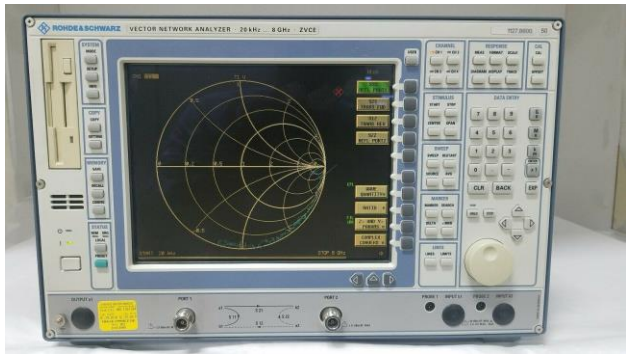
➔ So how do you characterize a new and non-optimal antenna system ???

QRP Wattmeter

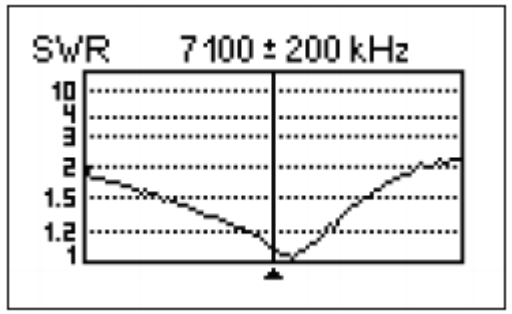
SWR / Wattmeter

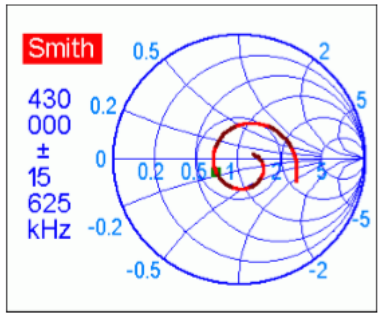
Antenna Analyzers

- In the past, characterization of an antenna system required an expensive ($10,000's) network analyzer:
  - Hewlett Packard
  - Rohde and Schwarz



  - Rig Expert introduced a cheaper device $200-$1200 (with subset of functionality):



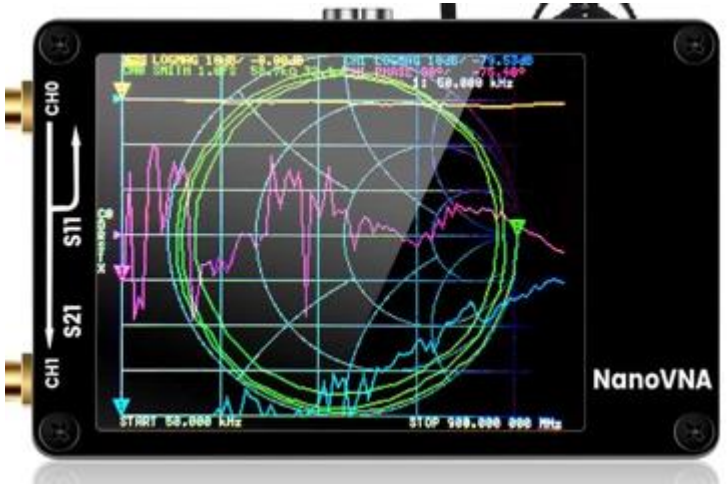


Aside: Ulrich Rohde (N1UL) is a very active operator on HF FT8

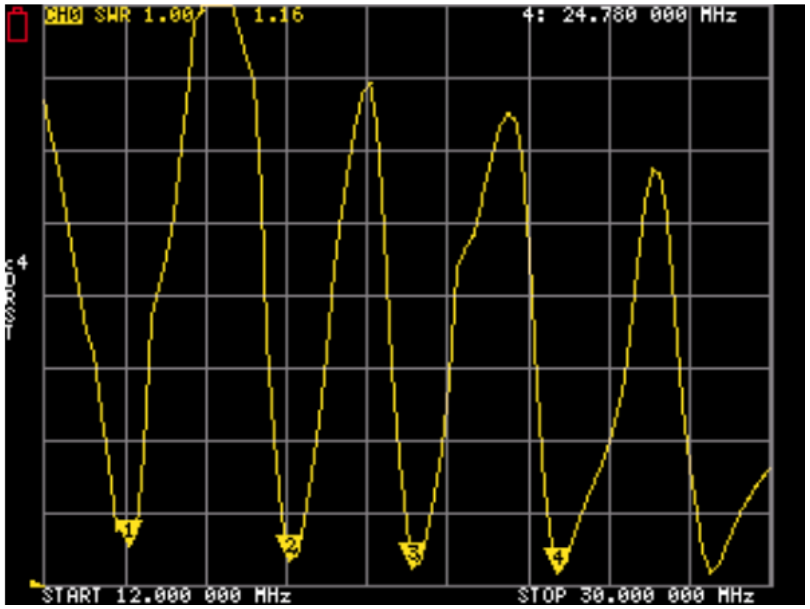
Nano VNA

Nano Vector Network Analyzer is more affordable solution

- $50 Cdn for unit and $30 Cdn for connector kit
- Comes calibration kit: Short, Open and 50 ohms
- Quality is OK, no case, consists of two sandwiched PCB
- 10 kHz to 1.5 gHz range
- Touch screen with mouse knob (+ M -)
- Capable of measuring the following:
  - Standing Wave Ratio (SWR)
  - Distance Along Coax to Significant Change (TDR)
  - Performance of Common Mode Chokes (Loss vs. Freq)
  - Coax Impedance (Zo) and Coax Loss
  - Capacitance & Inductance of Discrete Components
  - Resistive and Reactive Portions of Impedance (R + jX)
  - Smith Chart
  - Antenna Radiation Patterns (ERP)



Nano VNA: SWR



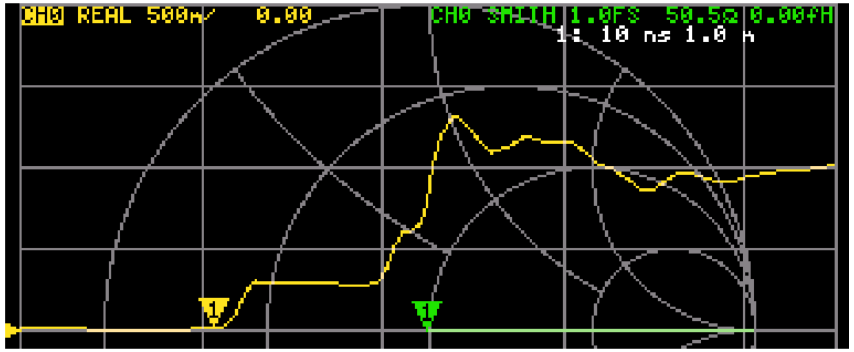
SWR mode testing a multi-trap 5-band beam
Start frequency = 12 MHz and end frequency = 30 MHz
Sweeps every second

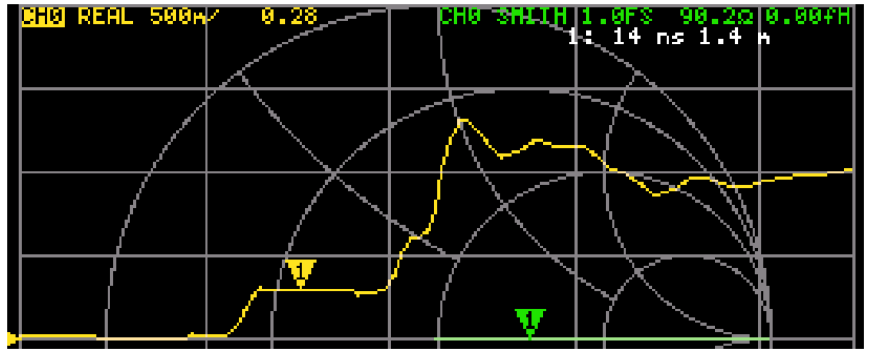
- SWR drops below 2:1 around 14, 18, 21, 24.5 and 28.5 MHz
- Pointer(*) at null (4) shows SWR = 1.16 @ 24.780 MHz

* Pointer can select any point on graph

Note: All Nano VNA examples taken from Doug Hart AA3S Powerpoint

Nano VNA:TDR



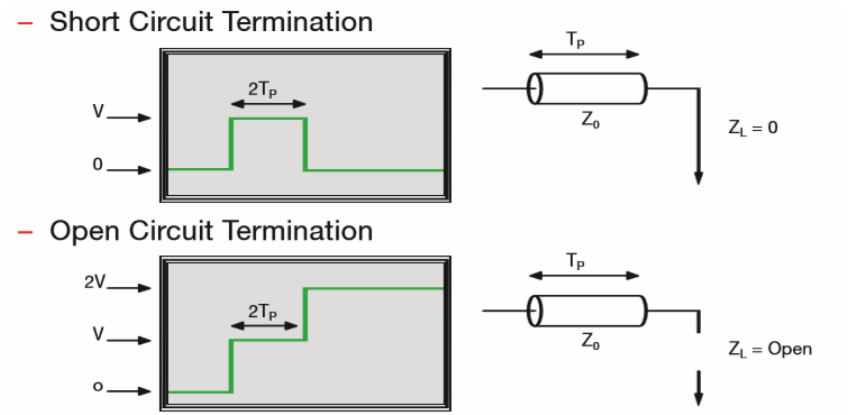


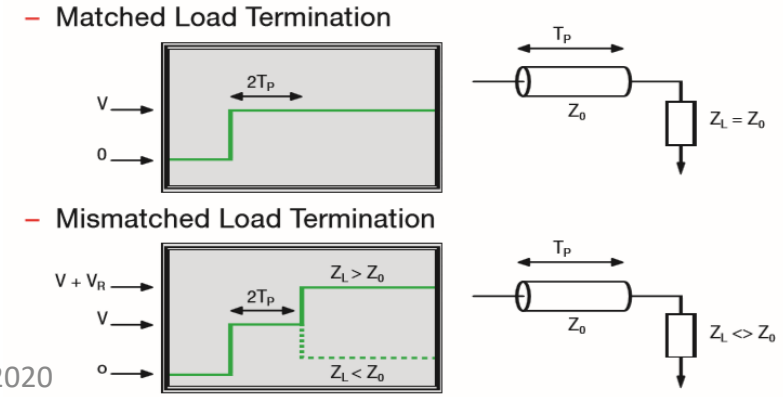
TDR Mode: Impedance vs distance

Example: 4 ft 50 ohm coax + 4 ft 93 ohm coax + open circuit

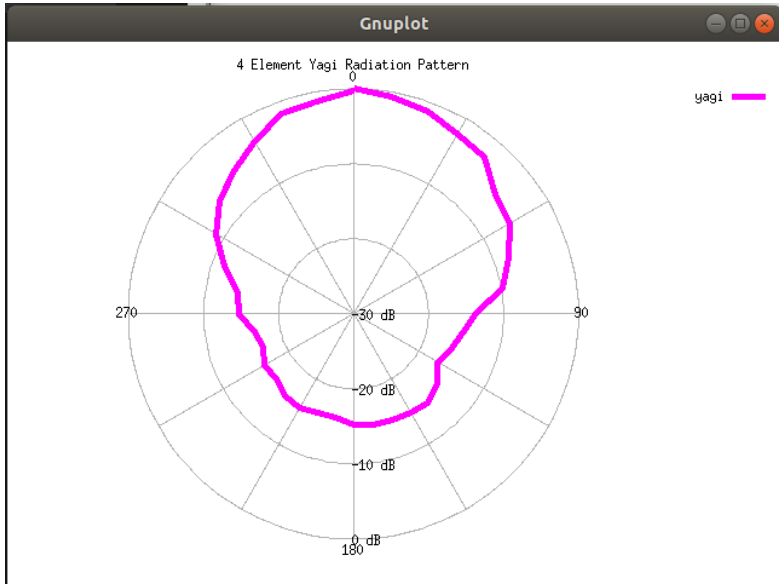
TDR and Smith chart Mode:

- 1st section measures 50.5 ohms @ 1 meter (3.2 ft)
- 2nd section measures 90.2 ohms @ 1.4 meter (4.6 ft)
- 3rd section measures infinity @ 2.5 meters (8.2 ft)





Nano VNA: Antenna Radiation



- Connect antenna UUT to the TX port (S11) of the NanoVNA via a long coax cable
- Connect omnidirectional whip antenna to the RX port (S21) of the NanoVNA.
- Measure and collect S21 readings for every 10 degree rotations of the antenna UUT
  → Rotate antenna or moving NanoVNA unit in a circular pattern
- Upload data to GNUPlot for to get radiation pattern

Note: Images and procedure from https://imgur.com/gallery/5zWhpTA

Conclusion / Recommendations

- Start QRP experience with a transceiver (power dialed down) or QRP TX + conventional receiver.

- Progress to QRP specific rig.
- You can get started in QRP as low as $7.50 Cdn for a kit. (not a typo)
- Avoid the Pixie, start with the 49’er or QRP Guys DSB rig (or better)

- Invest time and effort in a good antenna system and tools to optimize it.
- QRP requires much patience, difference operating style than QRO operation
- Always use a clear frequency.
- You will have better luck responding to a stronger rather weak station.
- Use online sites to find stations with superior antenna systems and see your reachability.

QRP Clubs

Northern California Club

- http://norcalqrp.org/
- http://www.ncqrpp.org/

North American QRP Club

- http://www.naqcc.info/

American QRP Club

- https://amqrp.org/

Flying Pigs Club

- http://www.fpqrp.org/

Resources

QRP Kits:

https://qrpguys.com/

https://amqrp.org/kits/kits.html

http://www.qrpkits.com/

https://qrp-labs.com/

http://www.crkits.com/

Vector Network Analyzer User Group:

https://groups.io/g/nanovna-users/

Books:

- QRL Handbook, ARRL, Doug Demaw, W1FB
- QRP Basic, Rev George Dodd, G3RJV
- Minimum QRP, Peter Parker, VK3VE
- Antenna Handbook, ARRL

Questions ?