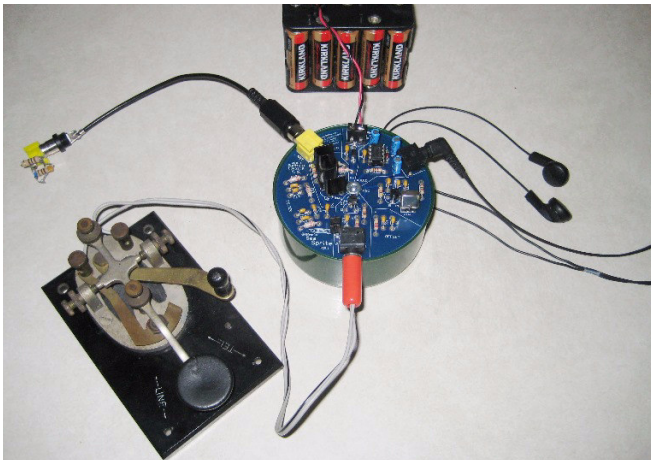
Sea Sprite

Minimalist Transceiver

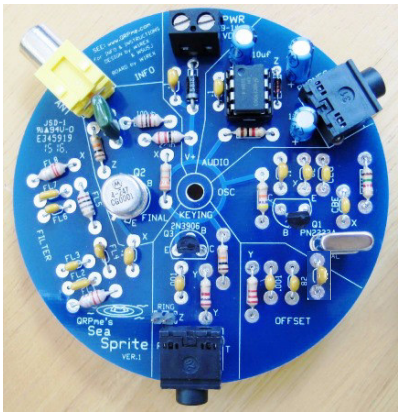
Assembly and User Guide

By: W5USJ CyM-Tech Documentation Services

For New Builders



Enhancing Your QRP Operating Enjoyment



Sea Sprite PCB Assembly Top View

Addendum:

No updates or revisions at this time.

Sea Sprite is a minimalist transceiver kit based on an original design called a Pixie.

This current version was developed with modifications by W5USJ and W1REX with PCB design and artwork by Rex Harper, W1REX; QRPme.com in Limerick, Me.

The kit is produced and supplied by Rex.

Table of Contents

Document Created with FrameMaker

Please study the entire guide before starting assembly.

Tools Needed

[-] Temperature Controlled Soldering Station with small tip or 25 to 35 watt soldering iron with small tip (1 to 2 mm)
[-] Silver-bearing Solder, Radio Shack 64-035 or equivalent preferred.
[-] Soldering tip cleaner
[-] Small Diagonal Cutters and/or End Cutters
[-] Small Needle Nose Pliers
[-] Pencil, Pen, and/or Highlighter
[-] BRIGHT work light
[-] Magnifying headpiece, lighted magnifying glass or flip-up lenses.
[-] Digital multi-meter - DMM, e.g., Circuit Specialists HH2205 or similar.
[-] Solder Sucker and/or Solder Wick
[-] Small multi-blade Screw Driver
[-] Wire Stripper
[-] RF Probe (RF measurement and trouble shooting)

Technical References

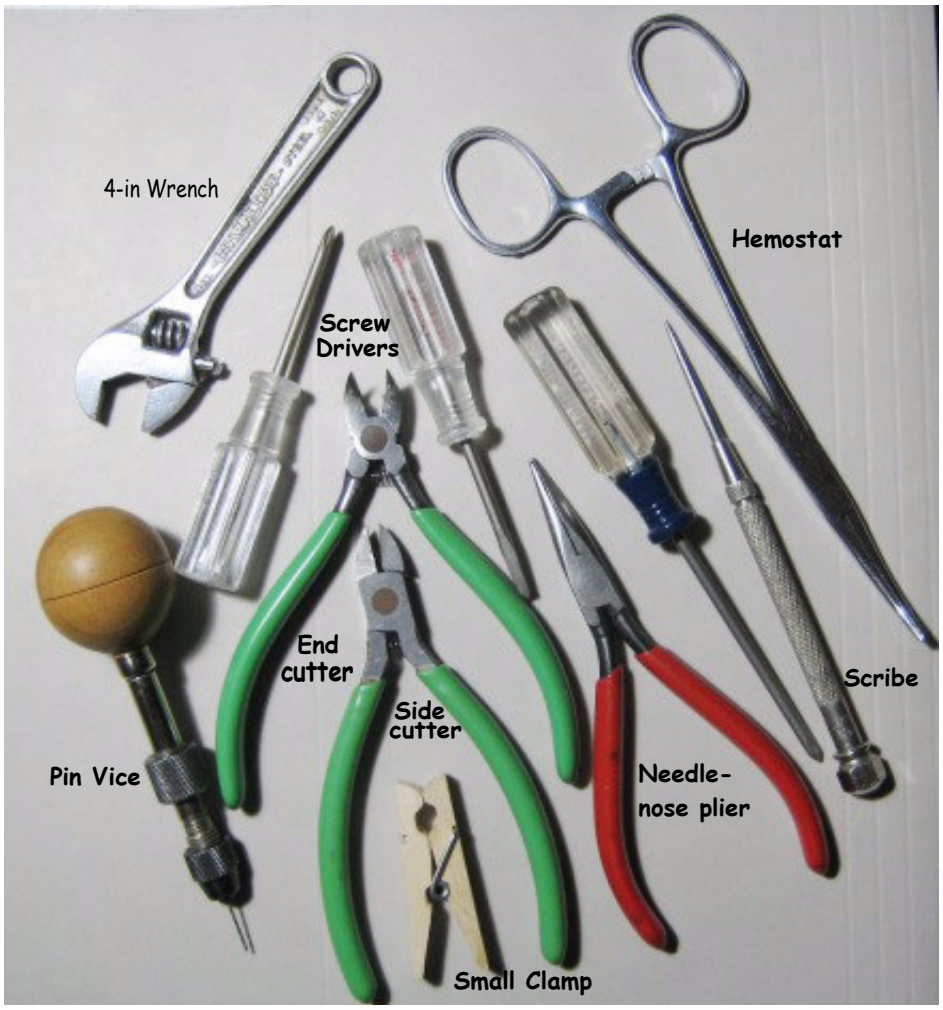
The ARRL Handbook for Radio Amateurs
The ARRL Operating Guide
The Internet.

Construction Techniques

[-] Inventory the parts using the list of materials (LOM)
[-] Pre-sort the components into groups to speed up assembly
[-] You can insert several parts at a time onto the board. When you insert a part bend the leads over slightly to hold the part in place, then solder all at the same time. Clip the leads flush.
[-] Most parts should be mounted as close to the board as possible. Transistors should be mounted about 1/4 inch above the board. Solder one lead on ICs or IC sockets and transistors then check to make sure the component is flush before soldering the remaining leads.
[-] Use a Temperature Controlled Soldering Station with small tip or 25 – 35 watt soldering iron with small tip. Conical or very small screw driver tips, 1 to 2 mm, are best.
[-] Use enough heat to solder quickly but to not burn the flux.
[-] DO NOT use a large soldering iron or soldering gun. Large solder tips lead to solder bridging. Too much heat can damage pads and traces.
[-] If you are a beginner, new to soldering, there are a number of resources on the web to help you; search *PCB Soldering Techniques.*
[-] Additional soldering information in the *Appendix* section.

Common Hand Tools and Solder Aids

Typical Hand Tool Suggestions



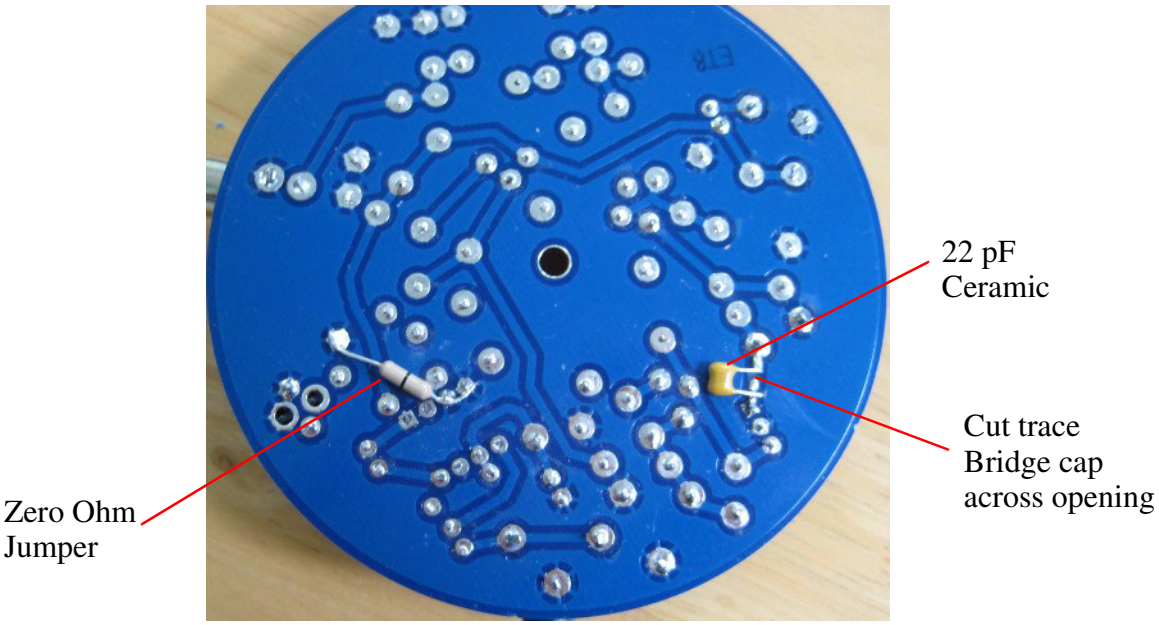
Preferred Solder De-solder Wick

Example

Solomon SR-976 Solder Station

Circuit Board Modifications (Mods)

These are the mods made to the no longer available rev1 PCBs.



Inventory Parts

[-] Use the LOM on page 5 to identify and categorize the kit parts.

Parts will be installed on the PCB in groups. Arrange the parts on the work space in the related groups.

List of Materials (LoM)

This section lists all the components used to assemble the Sea Sprite printed circuit board (PCB)

PCB

[-] 1– Round, Blue, Sea Sprite v1 Requires modifications

Capacitors

Qty Value Marking
[-] 1 – 22 pF 220
[-] 2 – 82 pF 820
[-] 2 - 100 pF 101
[-] 6 - 0.1 uF 104
[-] 1 – 0.047 uF 473
[-] 2 – 1000 pF 102 (FL2, FL7)
[-] 2 – 1200 pF 122 (FL3, FL6)
[-] 1 – 47 pF 470 (FL4)
[-] 3 – 10 uF electrolytic (polarized)
[-] 1 – 5 to 50 pF Trimmer

Resistors 1/4 Watt, 5%/Gold

[-] 1 – 2.7 k red, vio, red
[-] 1 – 2.2 k red, red, red
[-] 1 – 10 k brn, blk, orn
[-] 1 – 1.5 k brn, grn, red
[-] 1 – 1 k brn, blk, red
[-] 1 – 47 k yel, vio, orn
[-] 1 – 33 k orn, orn, orn

Inductors (Coils)

[-] 1 – 22 uH red, red, blk, gld
[-] 1 – 100 uH brn, blk, brn, gld
[-] 2 – 22 nH red, red slv, slv (FL1, FL8)
[-] 1 – 10 uH brn, blk, blk gld (FL5)

Continued:

Semi-conductors

Transistors
[-] 1 – 2N3906
[-] 1 – PN2222A'
[-] 1 – 2N3866 (house marked)

House Marked Example

Diodes (polarized)
[-] 1 – 1N914/1N4148
[-] 1 – 1N5818

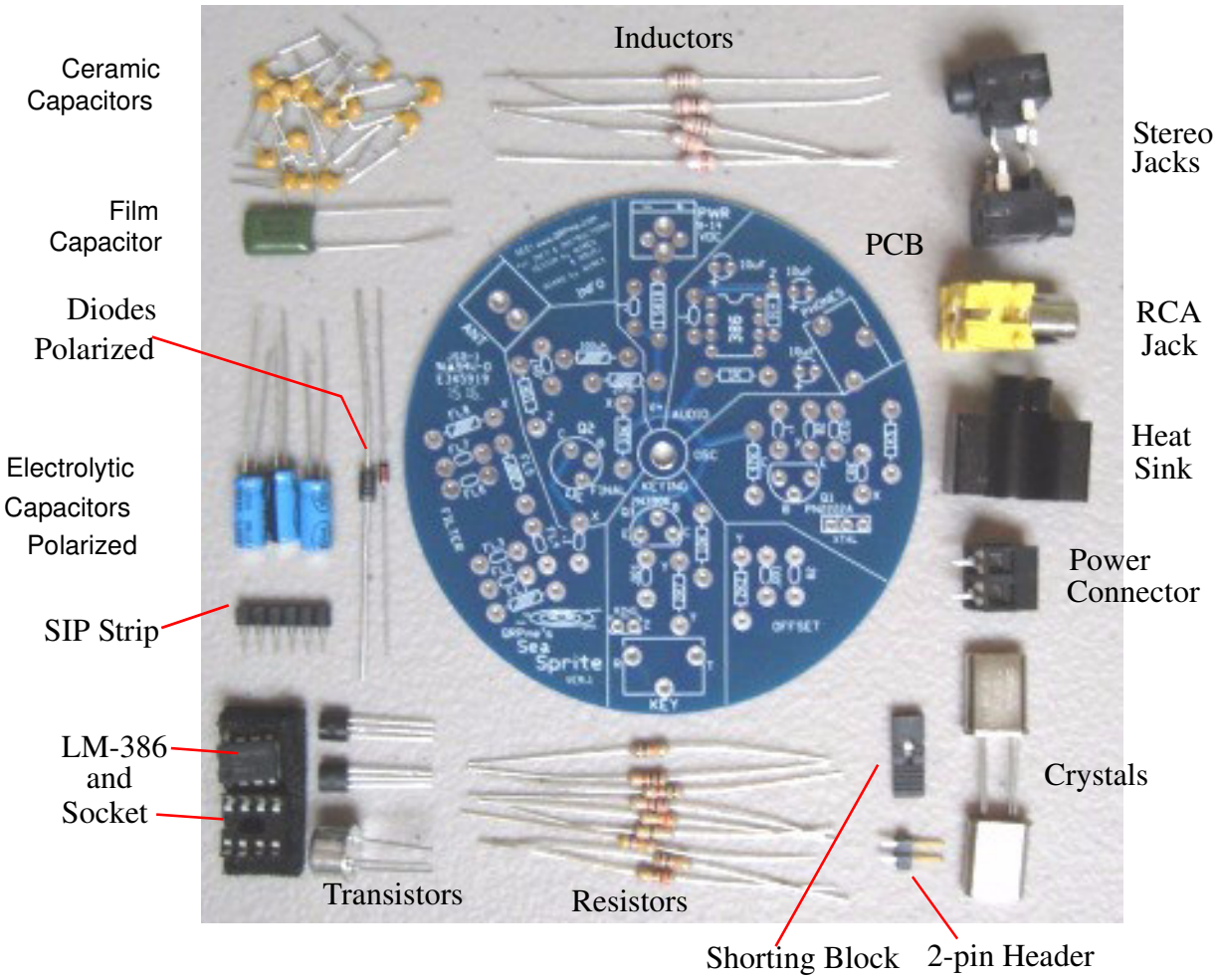
Integrated Circuit
[-] LM-386 audio amplifier

Miscellaneous

[-] 1 – Crystal 7122 kHz, 1 – 7047.5 kHz
[-] 2 – Stereo Jacks (key, audio)
[-] 1 – 2-pin Male Header
[-] 1 – Shorted Jumper Tab
[-] 1 – Two-terminal Compression Power Connector
[-] 1 – RCA Jack Antenna Connector
[-] 1 – TO-5 Heat Sink
[-] 1 – 8-pin SIP Socket
[-] 1 – 6-pin machined terminal strip
Cut the strip in sections of 3, 1, 1, 1

Component Identification

[-] Compare to LOM (list of materials)



[-] See the inductor and resistor color code charts on pages 20 and 21.

Inductor values are similar to resistor values except for decimal values.

Marking will be with 4 bands, 4th band Gold = 5%, Silver = 10%

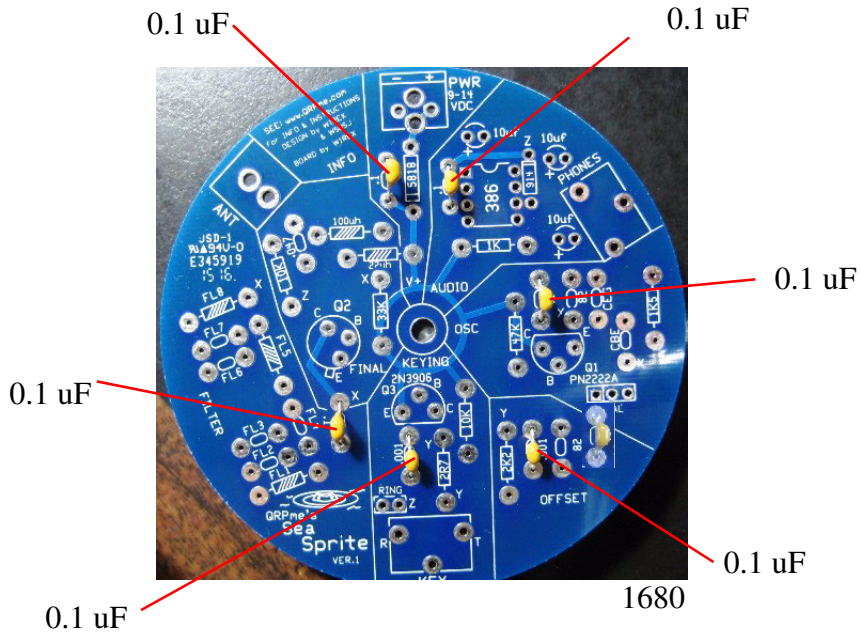
color, color, color, gold or silver - Inductors with whole number values
color, color, gold, gold or silver, 3rd band indicates value in tenths
color, color, silver, gold or silver, 3rd band indicates value in hundreths

Circuit Board Assembly

This section illustrates the assembly components is related groupings

Ceramic Capacitors (MLCC)

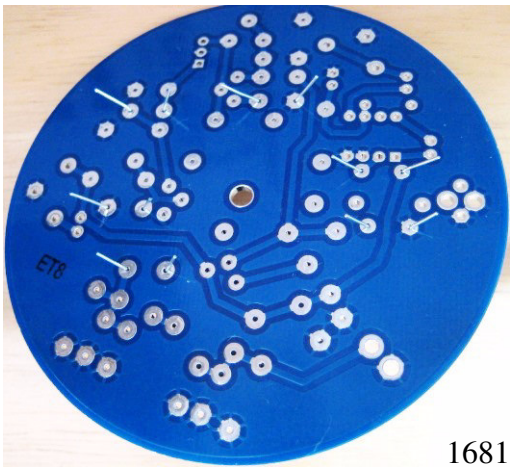
[-] Install 6 capacitors with the values shown in the illustration below



1680

Note: Board marking for the two at the bottom is .001 (102). Use two of the .1uF (104) capacitors instead.

[-] Bend leads slightly as they are inserted to hold parts in place.

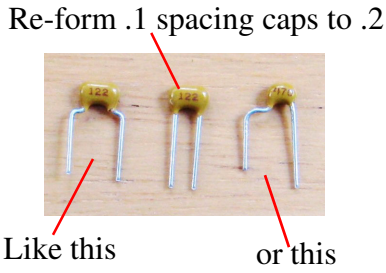


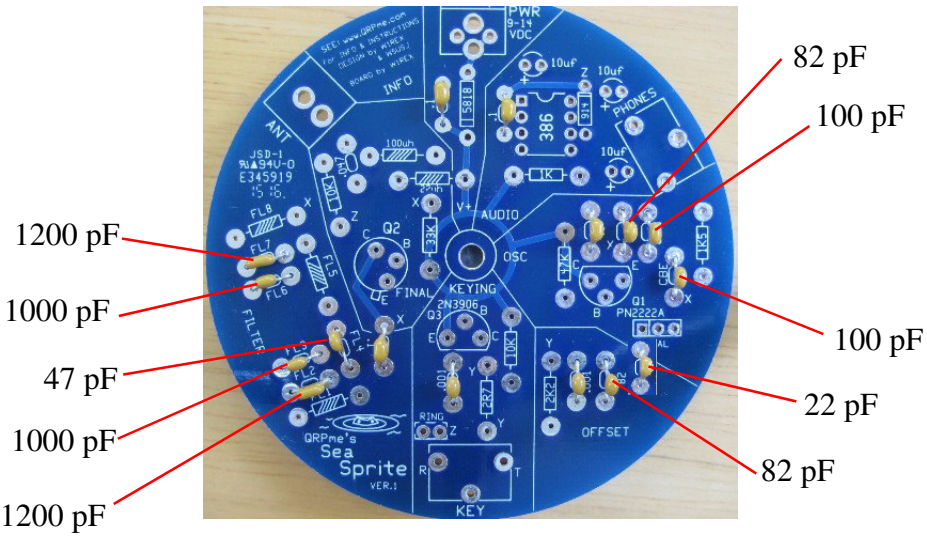
1681

[-] Ensure that the capacitors are seated against the board,...

[-] ...solder the leads and trim them off close to the board.

[-] Install 10 additional ceramic capacitors with values as shown in the illustration below.





[-] As shown in the previous example, bend leads slightly as they are inserted to hold parts in place.

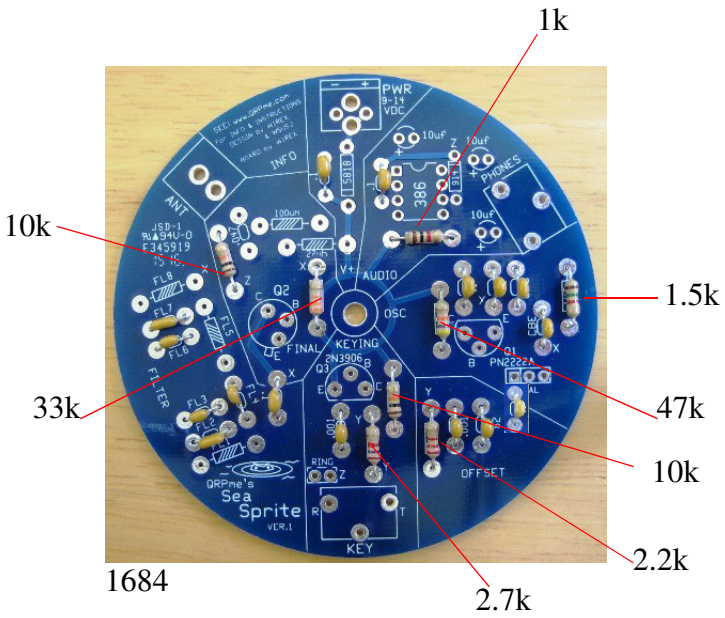
[-] Ensure that the capacitors are seated against the board,...

[-] ...solder the leads and trim them off close to the board.

[-] Note: Resistors, Inductors and Diodes all have lead spacing of 0.4 inches.

Resistors

[-] Install 8 resistors with values as shown in the illustration below



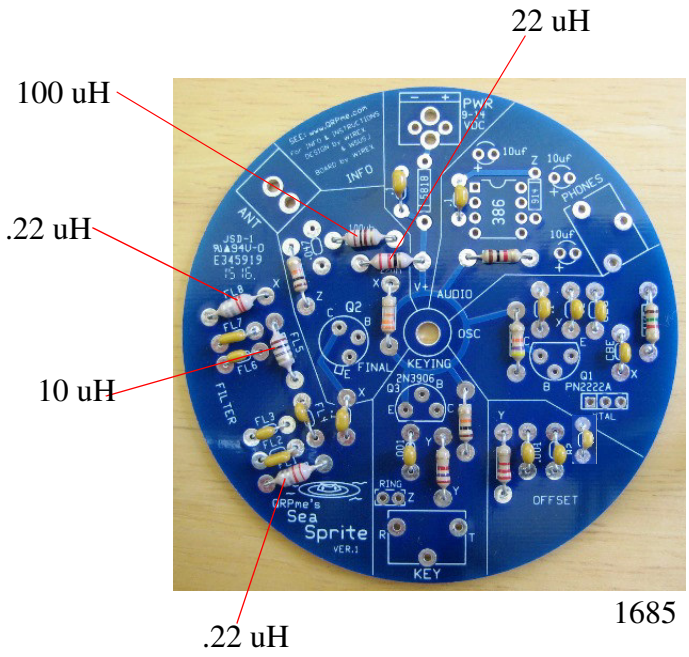
[-] As shown in the previous examples, bend leads slightly as they are inserted to hold parts in place.

[-] Ensure that the resistors are seated against the board,...

[-] ...solder the leads and trim them off close to the board.

Inductors

[-] Install 5 inductors with values as shown in the illustration below.



[-] As shown in the previous examples, bend leads slightly as they are inserted to hold parts in place.

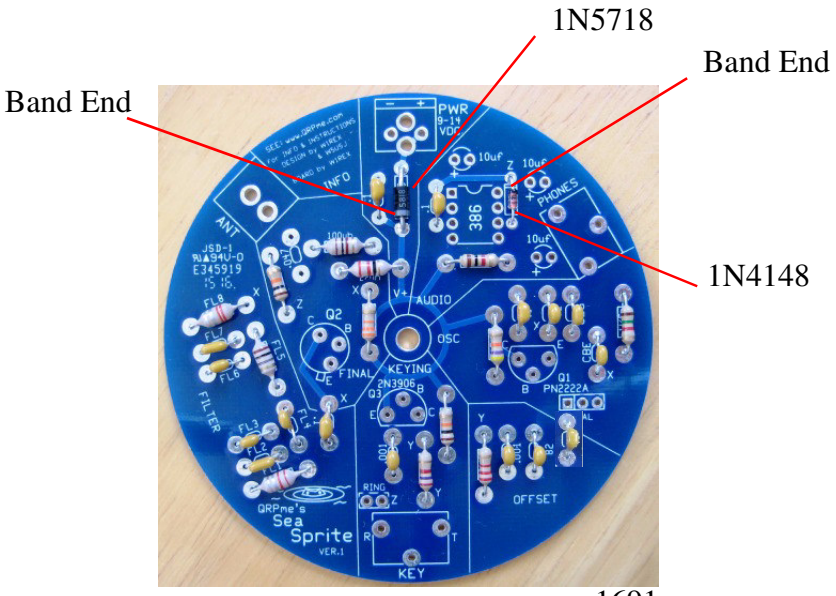
[-] Ensure that the inductors are seated against the board,...

[-] ...solder the leads and trim them off close to the board.

Diodes

[-] Install 2 diodes as shown in the illustration below

Note: diodes are polarized. Ensure that the band on the end of the diode matches the band marking on the PCB.



1691

[-] As shown in the previous examples, bend leads slightly as they are inserted to hold parts in place.

[-] Ensure that the diodes are seated against the board,...

[-] ... solder the leads and trim them off close to the board.

Sockets

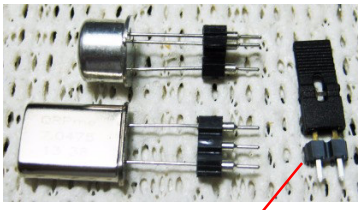
[-] Divide the SIP strip as shown in the side-bar picture.

As shown in the following illustration:

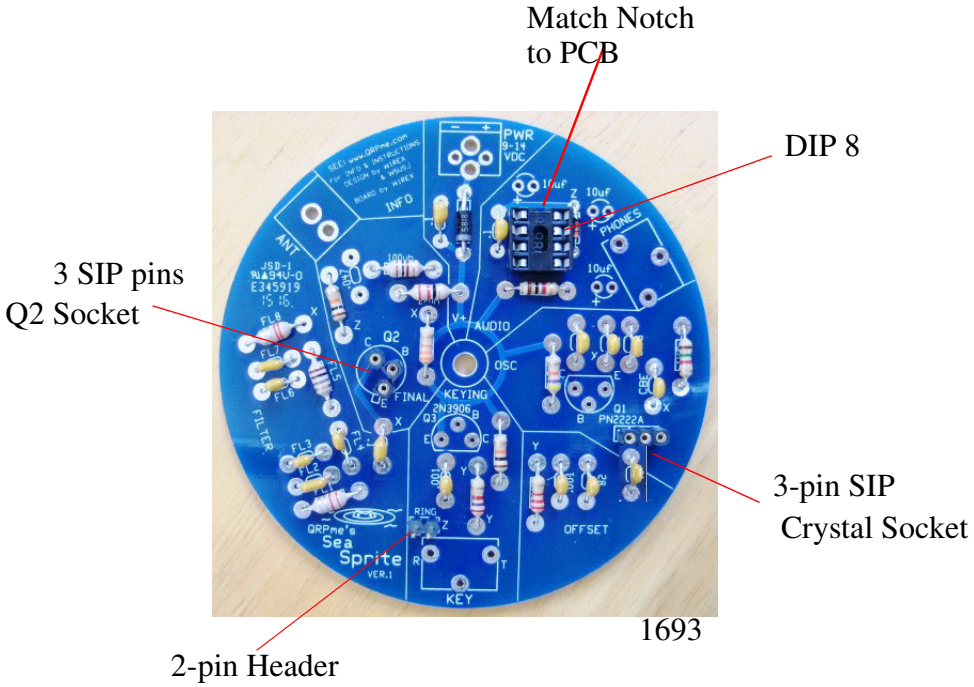
Divide SIP Strip

[-] Carefully align the pins and install DIP-8 socket. Tack-solder pins on opposite corners. Ensure that the socket is seated and solder the other pins.

Use related part as soldering holder



2-pin Header

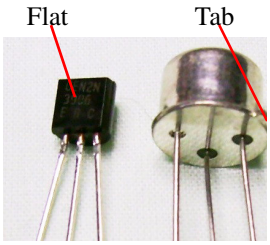


[-] Ensure that the parts are seated against the board before soldering.

[-] Solder the pins of each component as you install them.

[-] As shown in the side-bar picture, use the related part as a holder, install and solder 3 separate pins using the large transistor. Use a 3-pin strip and install using the crystal as a holder. Use the shorting block as a holder and install the 2-pin header.

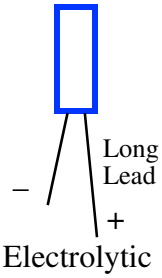
Tall Parts Remaining

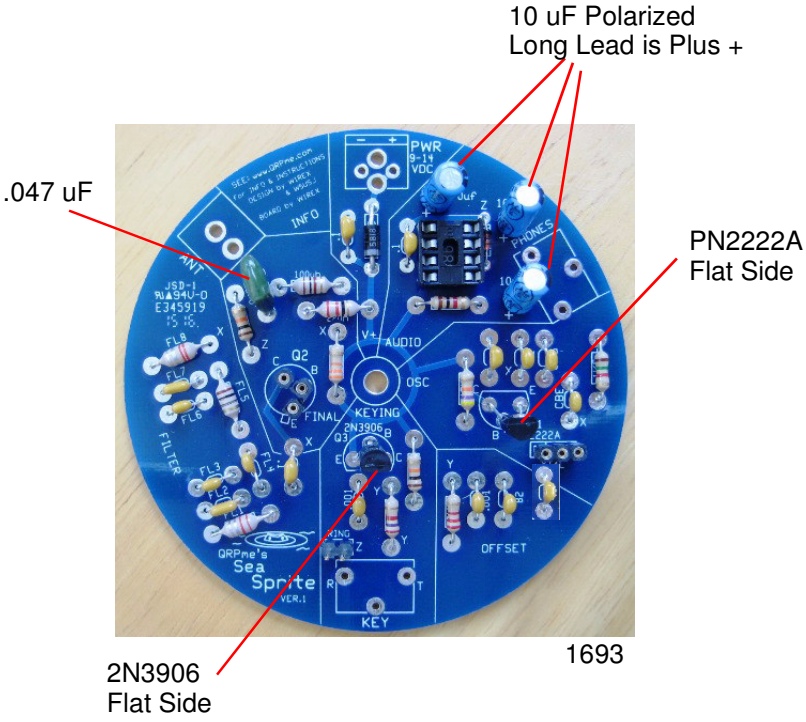


[-] Install 0.047 film capacitor as shown in the illustration below.

[-] Install PN2222A transistor with flat side oriented as indicated by the silk screen on the board. Position about 1/4 inch above the board

[-] Install 2N3904 transistor with flat side oriented as indicated by the silk screen on the board. Position about 1/4 inch above the board.





[-] Install 3 each 10uF electrolytic flush to the board surface. Orient them with the long lead inserted in the pad marked with a plus sign.

[-] As shown in the previous examples, bend leads slightly as they are inserted to hold parts in place.

[-] Ensure that the capacitors are seated against the board,...

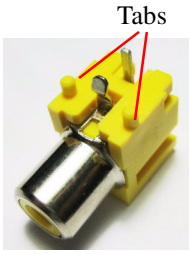
[-]...solder the leads and trim them off close to the board.

Interface Connectors

[-] Solder each of the following components as you go. Hold each part in place and tack-solder one terminal. Ensure that the part is **seated** against the board. Solder the remaining terminals.

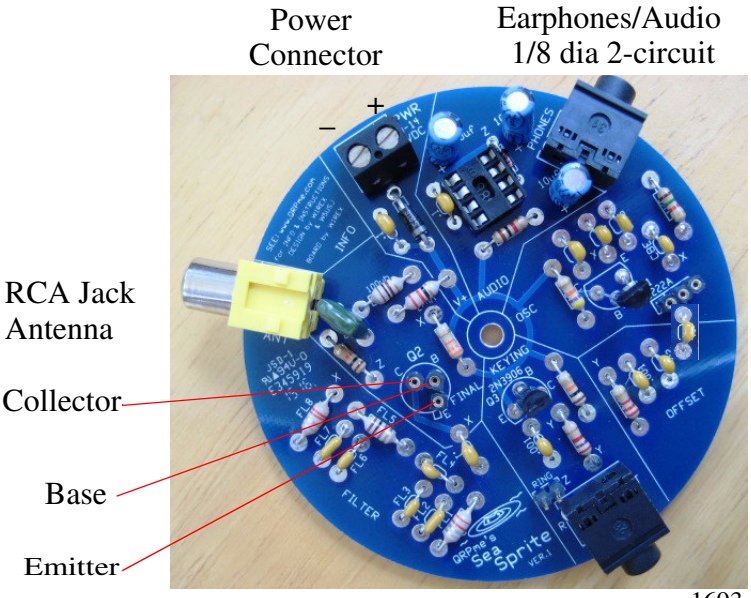
[-] Shear the two tabs flush off the bottom of the RCA jack. Install the jack.

[-] Install the power connector. The terminals for connection face toward the outer edge of the board



RCA Jack

[-] Install the audio jack. The audio jack will snap into position.



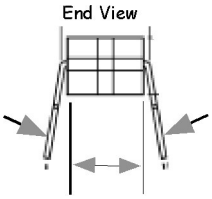
[-] Install the key/keyer jack. The key/keyer jack will snap into position.

Note: The headphone/audio jack uses standard 1/8 2-circuit plugs such as those found on ear buds. The jack is wired such that both circuits are connected together effectively putting the ear buds in parallel.

Key/Keyer terminals, using the same basic jack, are wired separately. Default is the plug tip connected. The ring terminal can be connected with the use of a shorting plug at the two-pin header terminals. The cable from a pair of ear buds is useful for connecting a key or electronic keyer.

Complete Assembly

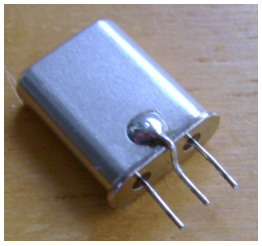
LM-386



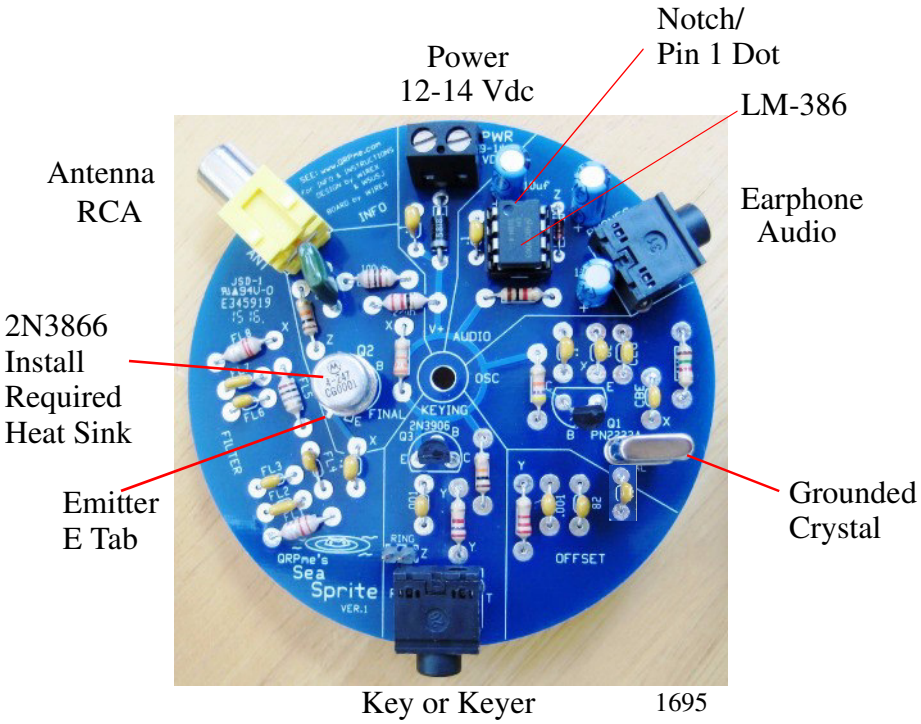
Gently bend leads to vertical to facilitate insertion into the socket

[-] Install the LM-386 into the socket. Carefully bend the leads to vertical position. Align the dot/notch end with the notch end of the socket. Align pins with socket and gently press down into the socket.

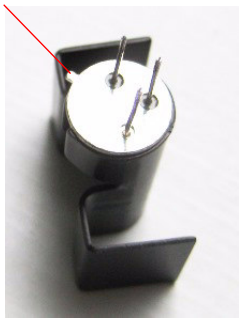
[-] Cut the leads on the crystal to 3/16 inch. Use one of the leads for the center pin ground. See the appendix for additional information to assemble the added lead. Insert the crystal into the socket.



Crystal with third pin for ground soldered on. Use socket as holder



Emitter



Transistor and Heat Sink Assembly.

[-] Cut the leads on the 2N3866 (house marked) to 1/4 inch. With the heat sink resting on the bench, press the transistor into the heat shrink. Note the orientation of the emitter tab relative to the heat sink.

[-] Insert the transistor heat sink assembly into the three pins of the transistor socket. Observe orientation.

Theory of Operation

The Sea Sprite is a simple minimalist direct conversion (DC) transceiver using only 4 active parts. The frequency of operation is controlled by the installed crystal. Its mode of operation is Morse code.

[-] Review the schematic on page xx

Receive Mode (key up)

When a signal within a few hundred hertz of the crystal frequency is received via the antenna it passes through the bandpass filter to the collector of Q2.

A signal from the oscillator Q1 is fed to the base of Q2 via the 82 pF capacitor connected between the two devices. Q2 is acting as a mixer and Q3 is off.

These two signals are mixed to produce signals that are the sum and difference of the combined signals. Only the difference signal is in the audio frequency range. The audio signal is fed from the emitter of Q2 to U1 pin 2 via the 0.1 uF coupling capacitor.

The audio signal is amplified by the LM-386 and produces a tone in the headphones.

Transmit Mode (key down)

When a key, connected between ground and the tip of the jack, is closed the 2.7k Ohm resistor connected to the base of Q3 and the emitter of Q2 are connected to ground.

Q2 becomes an RF amplifier increasing the amplitude of the signal coming from the oscillator.

At the same time, the 0.1 uF capacitor and the muting diode at U1 are grounded cutting off – muting – the LM-386 audio amplifier.

Q3 is now on and causes the transmit frequency to shift depending on the value of the **O** capacitor. The **O** capacitor can also be a trimmer for adjustment.

Sending Signals

Manipulating the key produces either a solid tone (key down) or morse code if key down is regulated such that morse characters are created. See the code chart on page xx.

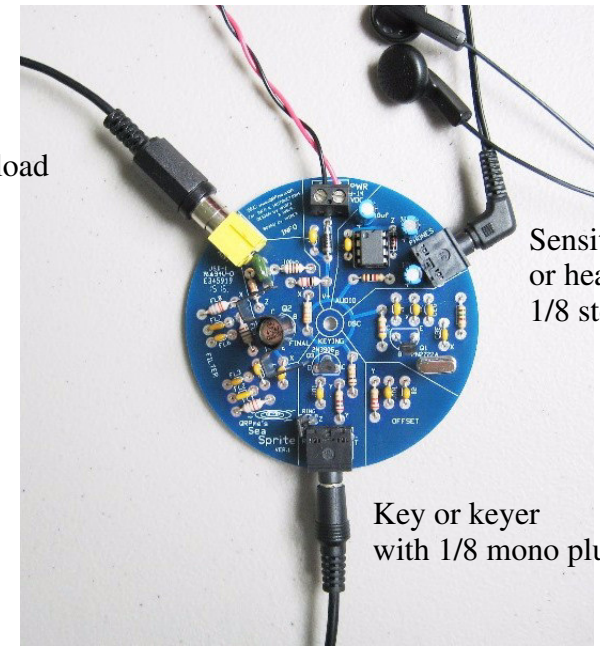
Note that a “key” can be either a straight key, or an electronic keyer. A manual “straight key” can be fashioned in many forms that result in regulated contact closures.

Setup and Test

Caution: Do not use the typical wall wart type power supply for power. They are not regulated and designed to produce output voltage only at the rated AC input voltage and output current. If the output current is low, the voltage will be higher, also the reverse. Damage is possible.

Power supply, 12 V battery
or regulated power supply.

50 Ohm
dummy load



Sensitive ear buds
or headphones with
1/8 stereo plug

Key or keyer
with 1/8 mono plug.

[-] Connect a 50 Ohm dummy load to the antenna jack.

[-] Connect earphones or headphones to the audio jack.

[-] Connect a key to the key jack.

[-] Connect a 12 V battery or regulated power source to the power connector. Observe polarity. The Sprite is polarity protected so it won't be damaged with a reversed connection. But it won't work either.

[-] Listen to the audio, you should hear a hissing sound.

[-] Touch pin 2 of LM-386 with a short wire used as a probe. You should hear a loud hum.

[-] Press the key and measure power as described in the following section.

Measuring Power

An easy way to measure power is with a meter designed for the purpose. However, if one isn't available, there are two simple devices that will suffice. One is a peak detector, the other is an RF probe.

Peak Detector

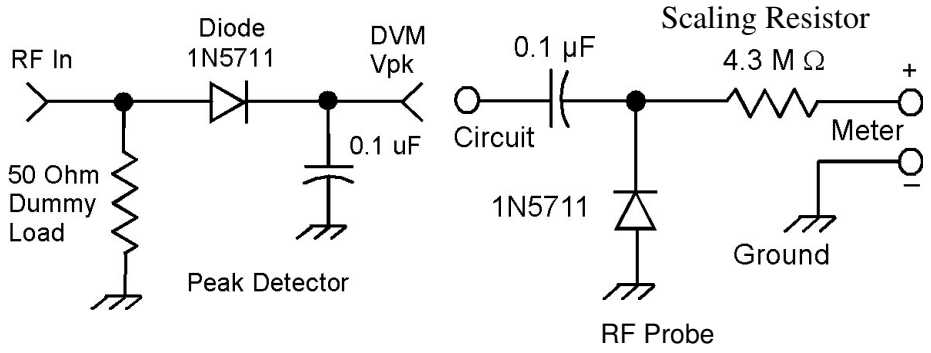
A peak detector is basically a half-wave rectifier. The diode conducts on the positive 1/2 of a sine wave and charges the capacitor to the peak value.

Power Calculation using a peak detector

$$Po = ((Vpk \times 0.707) + 0.3)^2 / Rload$$

Convert Vpk to RMS, add Vdiode, square the sum and divide by 50.

Note: Rload is typically 50 Ohms simulating a properly matched antenna input feed impedance.



RF Probe

The RF probe is used with a 10 M Ohm 1% DMM to measure the equivalent RMS value of the detected RF voltage.

Scaling Resistor: For 10 Meg meter = 4.14 Meg. For 11 Meg meter = 4.55 Meg. The 4.3 Meg scaling resistor is a compromise between both. Very small difference in accuracy. The scaling resistor is equal to the meter Z x 0.414, e.g., for a 1 Meg meter R=414k (The $3 Harbor Freight meters are 1 Meg.)

Power Calculation using the RF Probe.

$$Po = Vrms^2 / Rload$$

RF power measurement using a properly calibrated RF probe is more accurate than the peak detector measurement.

The RF probe is also useful for tracing the presence and relative value of signals through the circuit. Impedance values (Rload) within the circuit are likely to be anything other than 50 Ohms. Unless the impedance is known, the measurement is only relative.

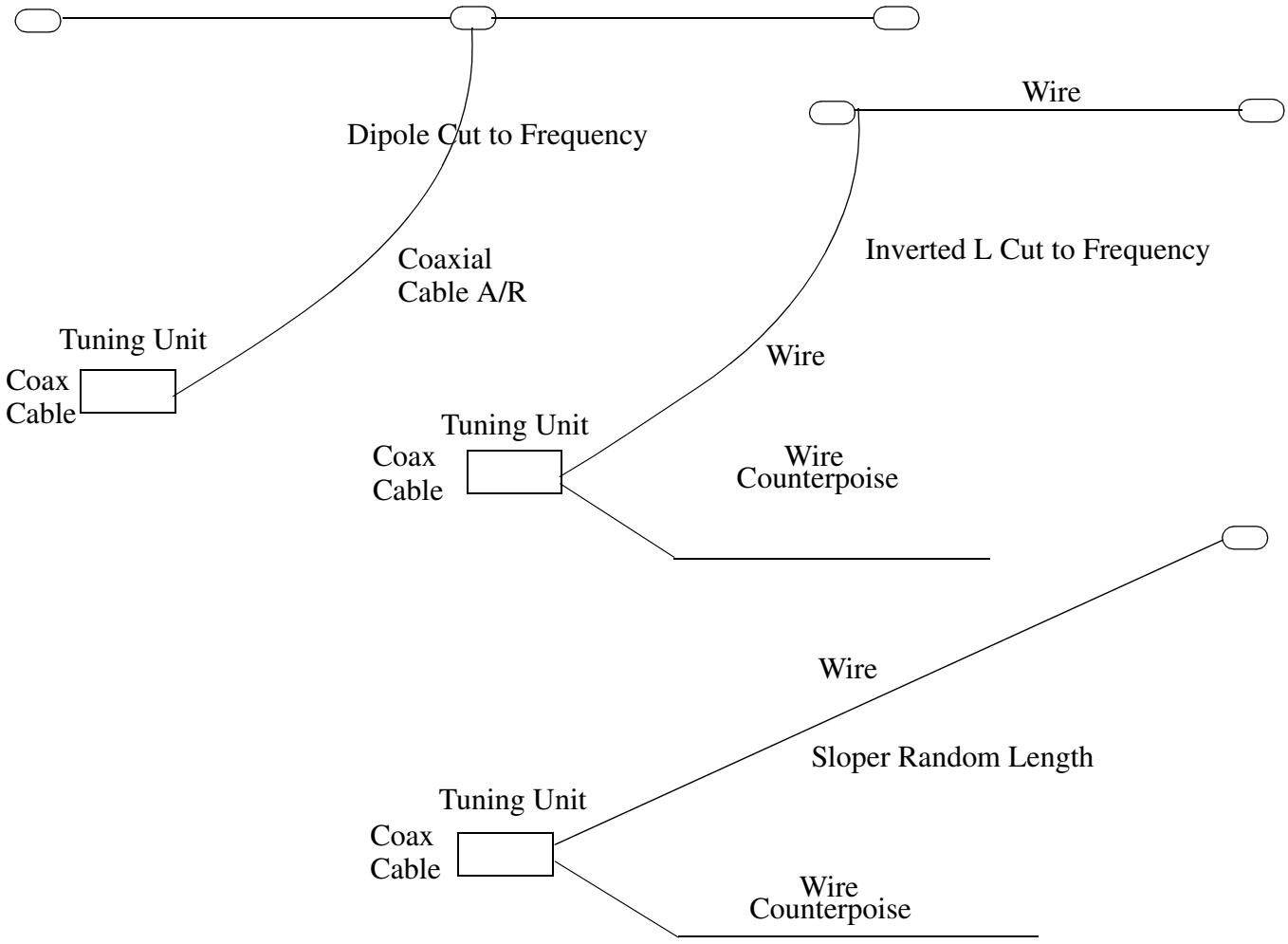
Operation on the Air

[-] With the exception of the dummy load, make the peripheral and power connections as described in the *Setup and Test* section.

Antenna

A good antenna is a requirement for communications success. It is even more important with a low power minimalist transceiver such as the Sea Sprite.

The two most common antennas are the dipole and a long wire with counterpoise. The antenna should be installed as high as is practicable.



[-] Connect a length of small coaxial cable between the Sprite and the tuning unit / matching unit.

[-] Transmit to other stations or listen to other stations close to your frequency.

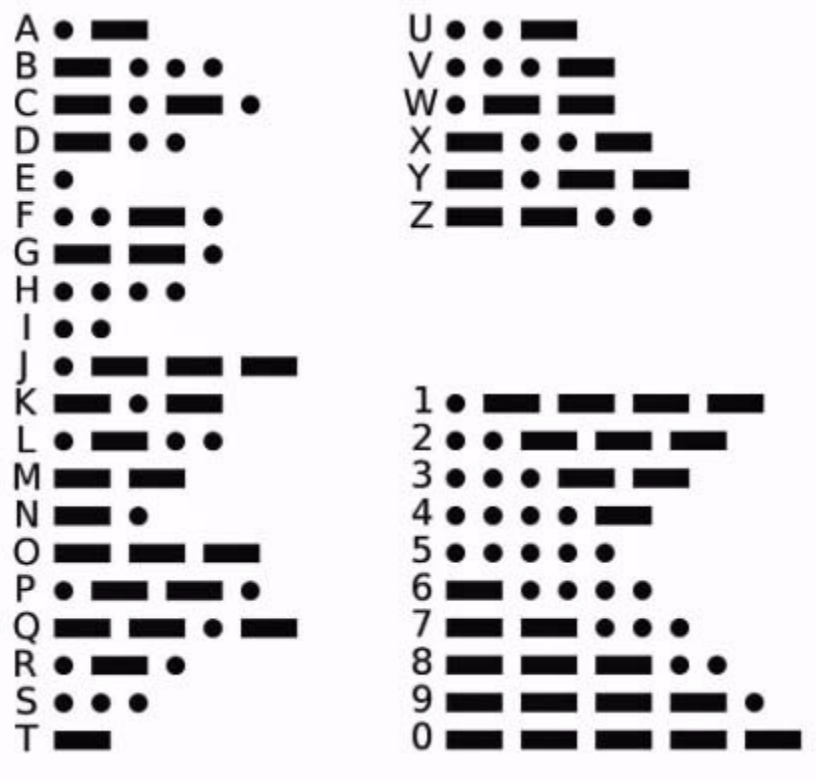
International Morse Code

Morse code is no longer required for any of the current Amateur Radio licenses.

However, Morse code is still popular and is 4 times more efficient as a mode of communications than the single sideband mode. Communications can be accomplished more often with much lower power under conditions where other modes fail. Some digital modes are more efficient, e.g., PSK 31.

Basic characters and numbers

1. The length of a dot is one unit
2. The length of a dash is three units
3. The space between parts of the same letter is one unit
4. The space between letters is three units
5. The space between words is 7 units



Extended Morse Character Set

Morse Code Character Set[1]

A	didah	• –
B	dahdididit	– •••
C	dahdidahdit	– • – •
D	dahdidit	– ••
E	dit	•
F	dididahdit	•• – •
G	dahdahdit	– – •
H	didididit	••••
I	didit	••
J	didahdahdah	• – – –
K	dahdidah	– • –
L	didahdidit	• – ••
M	dahdah	– –
N	dahdit	– •
O	dahdahdah	– – –
P	didahdahdit	• – – •
Q	dahdahdidah	– – • –
R	didahdit	• – •
S	dididit	•••
T	dah	–
U	dididah	•• –
V	didididah	••• –
W	didahdah	• – –
X	dahdididah	– •• –
Y	dahdidahdah	– • – –
Z	dahdahdidit	– – ••
1	didahdahdahdah	• – – – –
2	dididahdahdah	•• – – –
3	didididahdah	••• – –
4	dididididah	•••• –
5	dididididit	•••••
6	dahdidididit	– ••••
7	dahdahdididit	– – •••
8	dahdahdahdidit	– – – ••
9	dahdahdahdahdit	– – – – •
0	dahdahdahdahdah	– – – – –

Period [.]:	didahdidahdidah	• – • – • –	AAA
Comma [,]:	dahdahdididahdah	– – •• – –	MIM
Question mark or request for repetition [?]:	dididahdahdidit	•• – – ••	IMI
Error:	dididididididit	••••••••	HH
Hyphen or dash [–]:	dahdididididah	– •••• –	DU
Double dash [=]	dahdidididah	– ••• –	BT
Colon [:]:	dahdahdahdididit	– – – •••	OS
Semicolon [;]:	dahdidahdidahdit	– • – • – •	KR
Left parenthesis [(]:	dahdidahdahdit	– • – – •	KN
Right parenthesis [)]:	dahdidahdahddidah	– • – – • –	KK
Fraction bar [/]:	dahdididahdit	– •• – •	DN
Quotation marks ["]:	didahdididahdit	• – • • – •	AF
Dollar sign [$]:	didididahdididah	••• – • ••–	SX
Apostrophe [']:	didahdahdahdahdit	• – – – – •	WG
Paragraph [¶]:	didahdidahdidit	• – • – ••	AL
Underline [_]:	dididahdahdidah	•• – – • –	IQ
Starting signal:	dahdidahdidah	– • – •–	KA
Wait:	didahdididit	• – •••	AS
End of message or cross [+]:	didahdidahdit	• – • – •	AR
Invitation to transmit [K]:	dahdidah	– • –	K
End of work:	didididahdidah	••• – • –	SK
Understood:	didididahdit	••• – •	SN

Notes:

1. Not all Morse characters shown are used in FCC code tests. License applicants are responsible for knowing, and may be tested on, the 26 letters, the numerals 0 to 9, the period, the comma, the question mark, AR, SK, BT and fraction bar [DN].

2. The following letters are used in certain European languages which use the Latin alphabet:

Ä, Å	didahdidah	• – • –
Á, Â, À, Ã	didahdahdidah	• – – • –
Ç, Ĉ	dahdidahdidit	– • – ••
É, Ê, Ę	dididahdidit	•• – ••
È	didahdididah	• – ••–
Ě	dahdididahdit	– •• – •
Ó, Ô, Ó	dahdahdahdit	– – – •
Ñ	dahdahdidahdah	– – • – –
Ü	dididahdah	•• – –
Ż	dahdahdidit	– –••
Z	dahdahdididah	– –•• –
CH, Ş	dahdahdahdah	– – – –

3. Special Esperanto characters:

Ĉ	dahdidahdidit	– • – ••
Ŝ	didididahdit	••• – •
Ĵ	didahdahdahdit	• – – – •
Ĥ	dahdidahdahdit	– • – – •
Ŭ	dididahdah	•• – –
Ĝ	dahdahdidahdit	– – • – •

4. Signals used in other radio services:

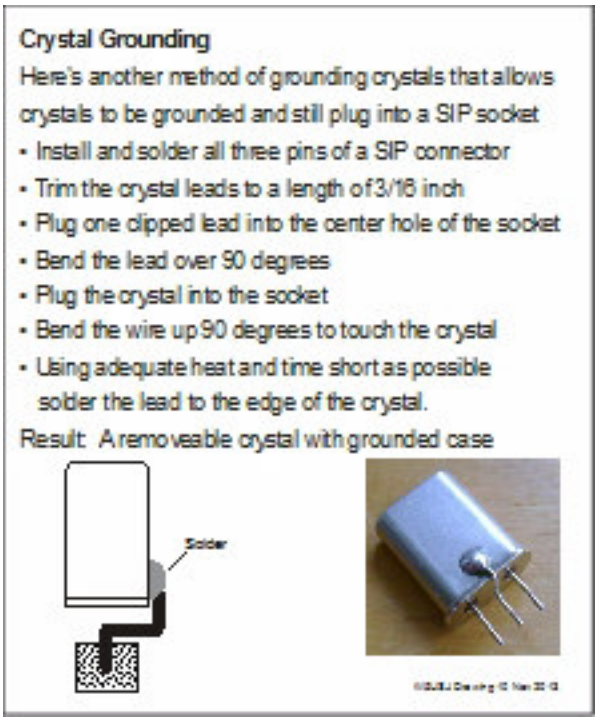
Interrogatory	dididahdidah	•• – • –	INT
Emergency silence	dididididahdah	•••• – –	HM
Executive follows	dididahdididah	•• – •• –	IX
Break–in signal	dahdahdahdahdah	– – – – –	TTTTT
Emergency signal	didididahdahdahdididit	••• – – – •••	SOS
Relay of distress	dahdididahdididahdidit	– •• – •• – ••	DDD

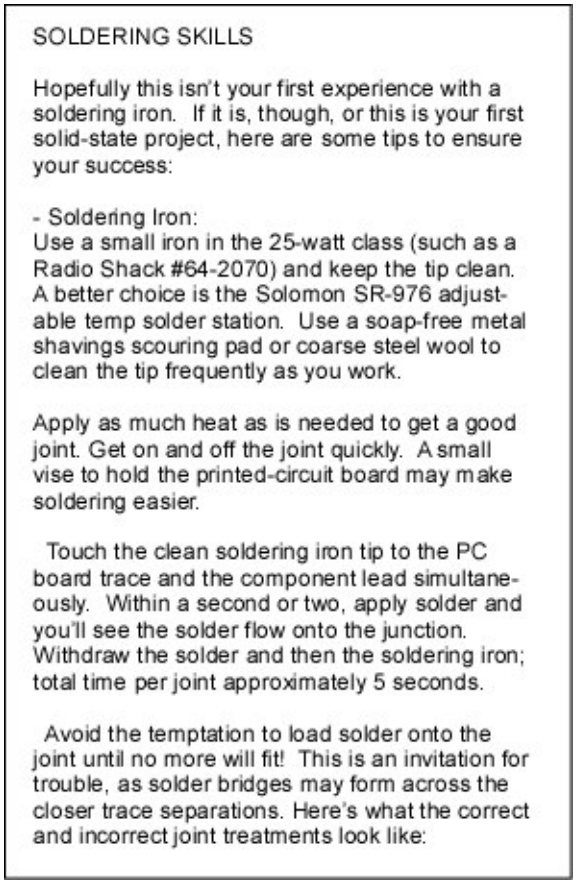
Appendix

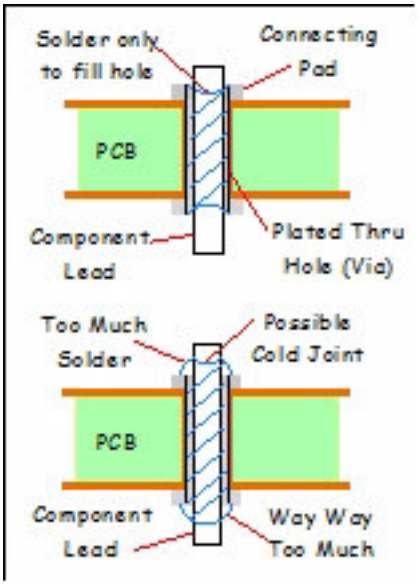
Convert sine wave voltages from one to another.

Given	Aver	RMS	Peak (Pk)	Pk to Pk
Aver	_	1.11	1.57	3.14
RMS	0.9	_	1.414	2.828
Peak (Pk)	0.637	0.707	_	2.0
Pk or Pk	0.32	0.3535	0.5	_

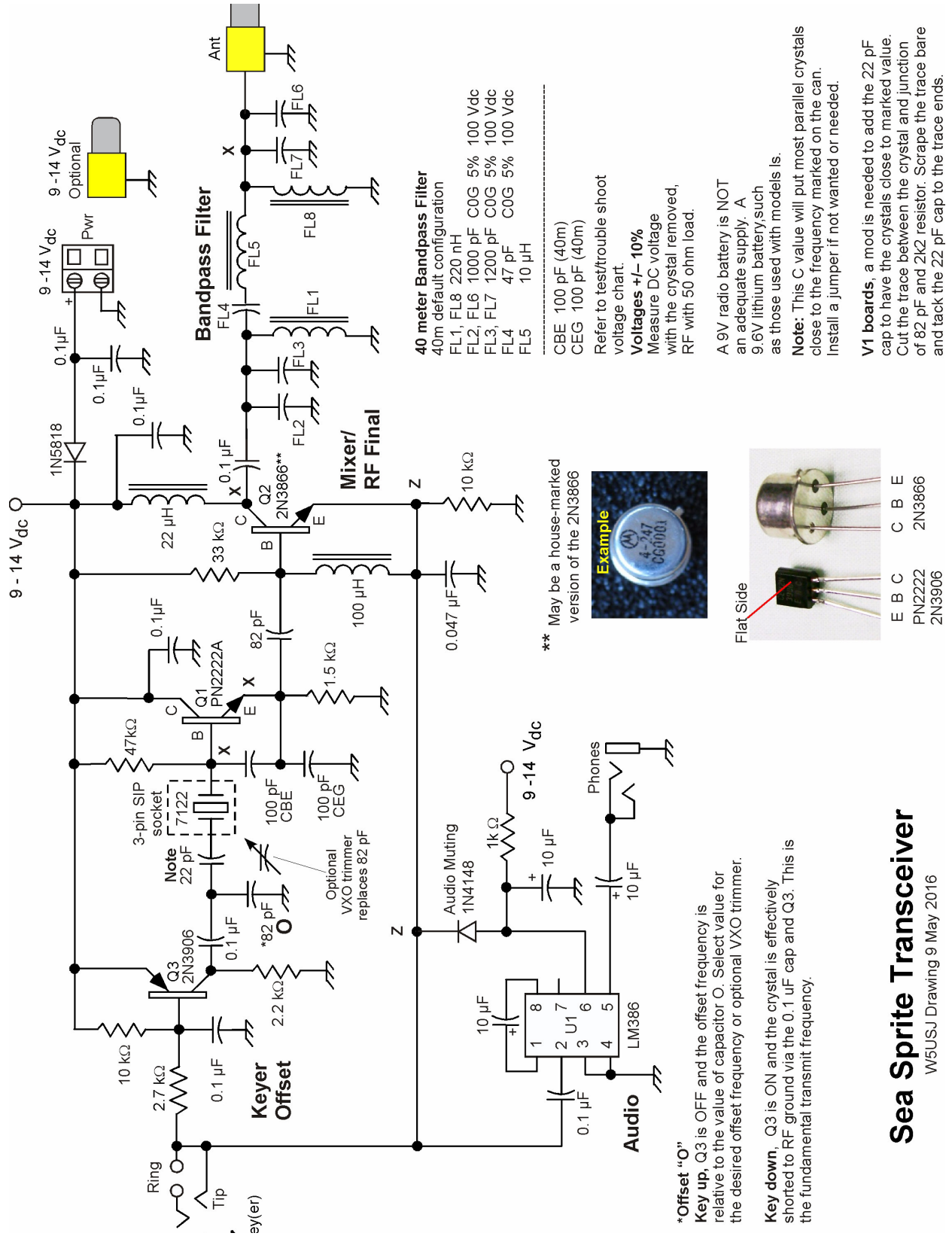
Example: Convert Vpk to RMS multiply Vpk x 0.707



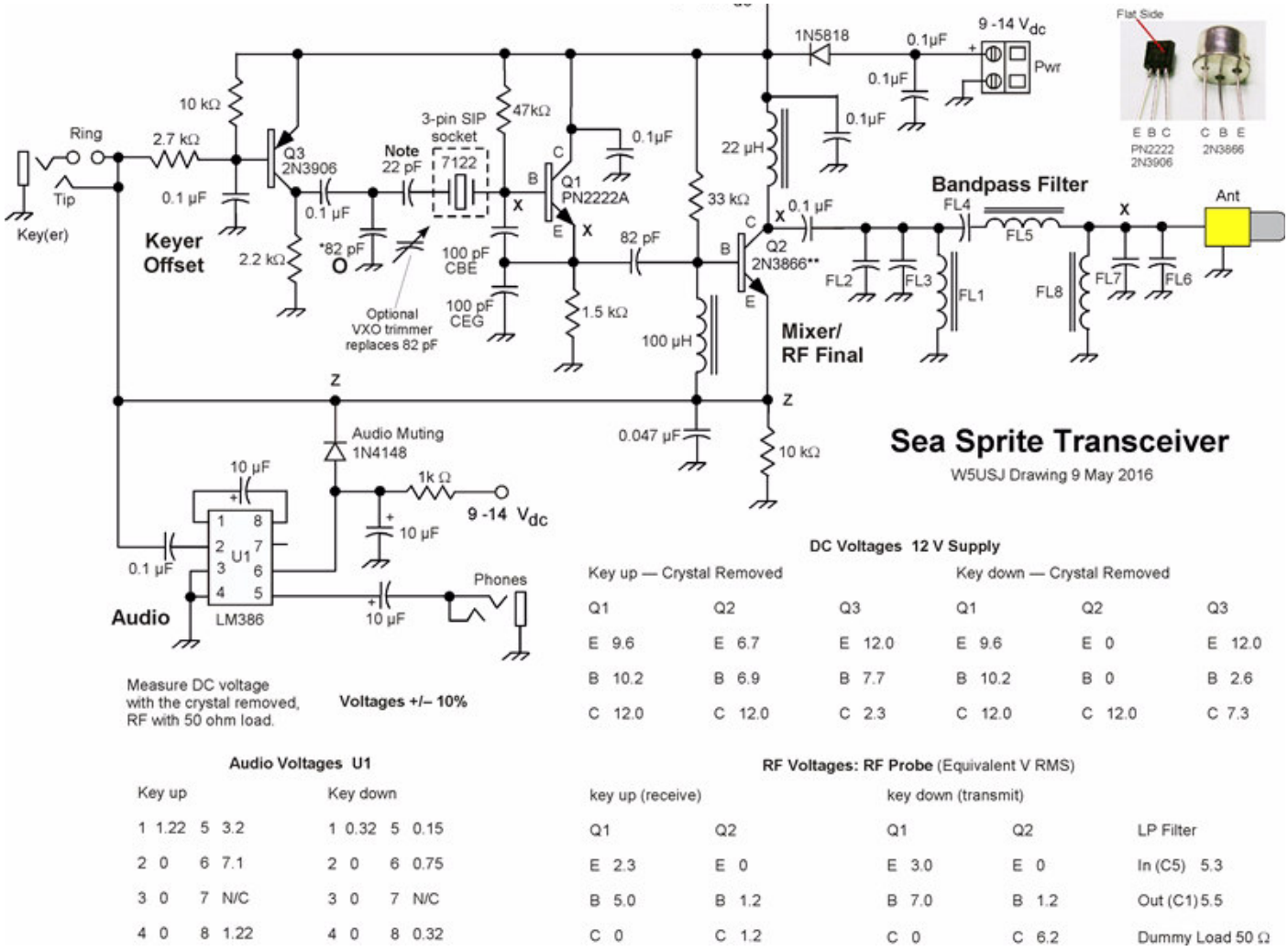




Schematic


Sea Sprite Transceiver
W5USJ Drawing 9 May 2016
Bandpass Filter
Mixer/
RF Final
Keyer
Offset
Audio
9 - 14 Vdc
9 -14 Vdc Optional
Ant
Ring
Tip
key(er)
1N5818
Pwr
0.1µF
22 µH
33 kΩ
Q2
2N3866**
10 kΩ
0.047 µF
100 µH
82 pF
1.5 kΩ
Q1
PN2222A
47kΩ
3-pin SIP
socket
7122
Note
22 pF
100 pF
CBE
100 pF
CEG
Optional
VXO trimmer
replaces 82 pF
*82 pF
Q3
2N3906
2.2 kΩ
10 kΩ
2.7 kΩ
0.1 µF
Audio Muting
1N4148
1k Ω
10 µF
LM386
U1
Phones
FL1
FL2
FL3
FL4
FL5
FL6
FL7
FL8
40 meter Bandpass Filter
40m default configuration
FL1, FL8 220 nH
FL2, FL6 1000 pF C0G 5% 100 Vdc
FL3, FL7 1200 pF C0G 5% 100 Vdc
FL4 47 pF C0G 5% 100 Vdc
FL5 10 µH
CBE 100 pF (40m)
CEG 100 pF (40m)
Refer to test/trouble shoot
voltage chart.
Voltages +/– 10%
Measure DC voltage
with the crystal removed,
RF with 50 ohm load.
A 9V radio battery is NOT
an adequate supply. A
9.6V lithium battery,such
as those used with models Is.
Note: This C value will put most parallel crystals
close to the frequency marked on the can.
Install a jumper if not wanted or needed.
V1 boards, a mod is needed to add the 22 pF
cap to have the crystals close to marked value.
Cut the trace between the crystal and junction
of 82 pF and 2k2 resistor. Scrape the trace bare
and tack the 22 pF cap to the trace ends.
** May be a house-marked
version of the 2N3866
Example
Flat Side
E B C
PN2222
2N3906
C B E
2N3866
*Offset "O"
Key up, Q3 is OFF and the offset frequency is
relative to the value of capacitor O. Select value for
the desired offset frequency or optional VXO trimmer.
Key down, Q3 is ON and the crystal is effectively
shorted to RF ground via the 0.1 uF cap and Q3. This is
the fundamental transmit frequency.

Voltage Chart

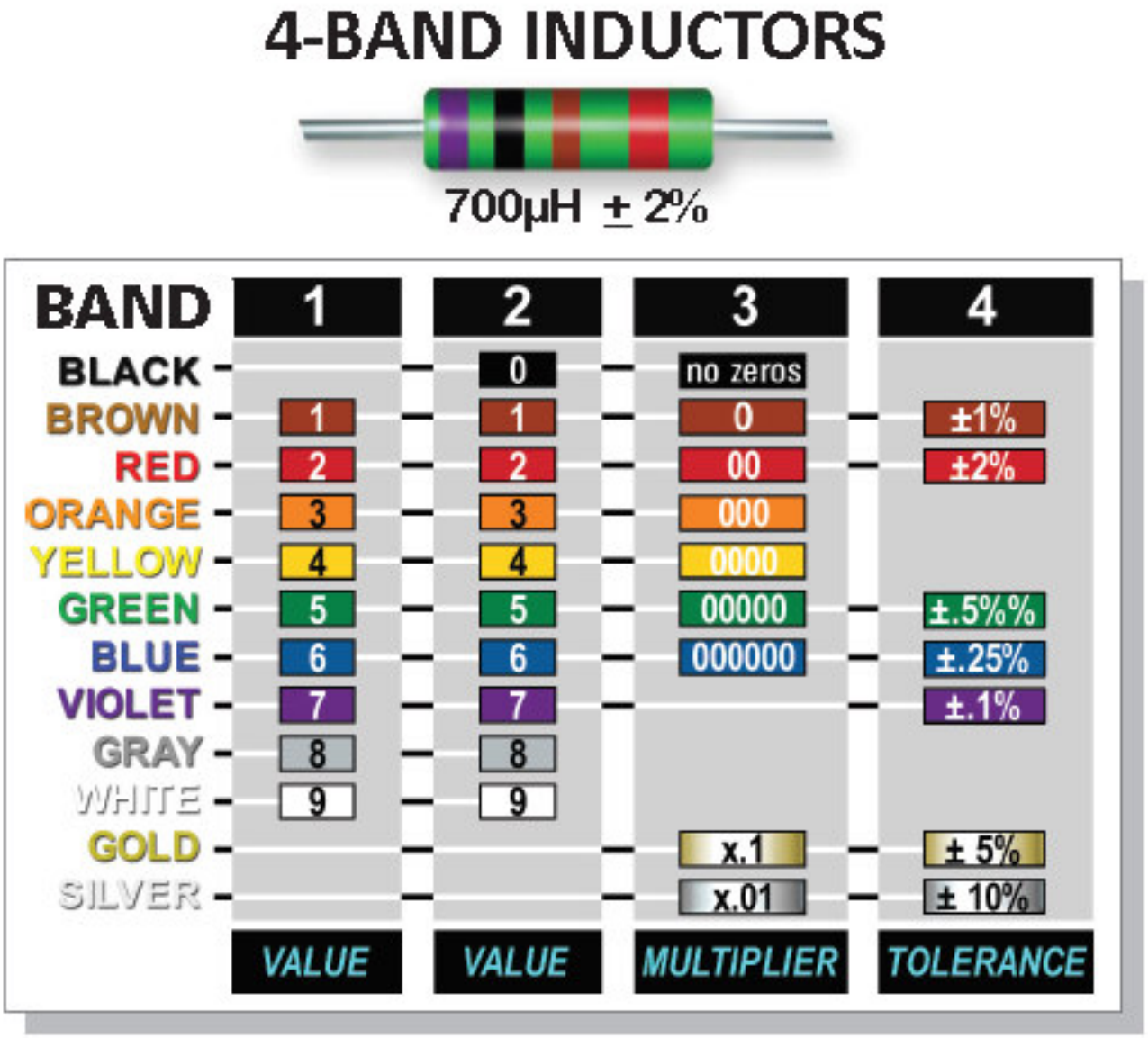


Measurements

Digital Voltmeter: A DVM (or DMM)
For best measurement results, use a meter with 10 megohm impedance and 1 % accuracy. A 1 megohm or less meter loads circuits and causes errors.

RF Probe:
Use an RF probe to measure the RF voltages occurring throughout the circuit.
A properly constructed and calibrated RF probe will allow tracing RF and also enable power measurement. The DC voltage derived from the probe is an equivalent RMS value.

Inductor Color Codes



Resistor Color Codes