

# Murania

## AM Receiver

# Assembly Manual

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In the late 1950s, the technology of radio was overturned by a revolution in electronics. The newly invented transistor enabled AM receivers to be constructed that were a fraction of the size of the now-obsolete tube circuits. Transistor radios soon became the new popular obsession, as a portable entertainment device that was the iPod of its day.

The low cost labor of post-War Asian manufacturers provided a substantial cost benefit that threatened to overtake the American brands, and in response, an import fee was imposed on these radios based on the number of transistors in each radio. Radios having two or fewer transistors were untaxed, as they were considered toys, and given the classification, 'Boy's Radios'.

The designers of Boy's Radios employed some creative design techniques to maximize the performance of these minimalist circuits, with sometimes amazing results. These simple tuned RF (TRF) receivers utilized techniques of reflexing and regeneration to boost the gain, permitting speaker volume from a small handful of inexpensive components. Many thousands of young (and not so young) people had their first exposure to the radio hobby from these simple sets.

Today, Boy's Radios are a highly sought after nostalgic collectable, commanding impressive prices on eBay and among collectors groups.

The Murania receiver was conceived as an opportunity for a new generation to experience the thrill of building and using a simple and effective AM radio receiver. Inspired by the classic design of these transistor radios, the Murania receiver is an ideal kit for a beginning builder, and can provide years of listening pleasure.

High quality, double sided, printed circuit board construction is used, with solder mask and silk screened component reference designators. A unique, construction technique is used in the Murania, called 'Pittsburg' construction, after the hometown of its inventor Joe, W0MQY. This method uses easy-to-handle through-hole components in a modified surface mount construction technique, where the back copper layer of the board forms a complete ground plane shielding the circuitry against hand effects. A pre-drilled silkscreened PCB enclosure is included, protecting the Murania circuit and making it into a handy portable set.

The Murania is simple enough to be constructed by beginners, and is rewarding enough to be enjoyed by experienced builders. Construction time is approximately 2 hours, depending on experience level.

The Murania is carefully kitted by volunteers from the Four State QRP Group. If you find that you are short a component, contact the email at the kit web page for replacement.

## How It Works

Like the original Boy's Radios, the Murania receiver uses two active semiconductor devices, but takes advantage of modern components to improve performance over the original circuits. One transistor is used as an audio amplifier, driving the speaker. The second device is a TA7642 integrated circuit, a three-legged TO-92 device that actually contains ten transistors, performing RF amplification, audio detection, and automatic gain control. This IC packs surprising performance into its tiny package, permitting the Murania to easily outperform the original Boy's Radios.

## First Steps

Before getting started with building the Murania, take some time to organize and familiarize yourself with the parts provided and check them against the Bill of Material. Building over a cookie sheet is recommended to minimize parts being lost. If parts are missing in your kit, send an email to the kitter listed on the kit website <http://www.4sqr.com/murania.php>. He will promptly provide replacements.

Schematic and parts-placement files are provided as part of documentation package. It is highly recommended to print a couple of copies for reference during construction. As you build, use a highlighter to mark off parts that have been soldered onto the PCB on one copy. When you think you are done, you can check that copy to verify that all of the parts have been installed.

There are a few basic tools and supplies required to construct the Murania receiver. You will need:

- Masking tape
- Fingernail polish (clear preferred)
- Fine grit sandpaper
- X-Acto or hobby knife
- A 25 to 30W soldering iron with pointed or wedge tip
- Fine rosin-core electrical solder
- Flat blade screwdriver
- Phillips screwdriver
- Diagonal wire cutters
- Needle-nose pliers
- Standard pliers or adjustable wrench
- 9-volt battery

A volt-ohmmeter is helpful for troubleshooting, but not necessary,

## How to Build with Pittsburg Construction

The construction technique used in the Murania receiver is unique, and may be

unfamiliar to most builders, but it is very easy to master. Through hole components are soldered to large pads on the surface of the board.

To install a component to the board, first take the component and bend the leads into a 'W' shape, as shown in the diagram. The body of the component is to stand up from the board by roughly 1/16", and the bends in the leads should be spaced so they line up roughly in the center of the solder pads for the part. With the soldering iron, heat one of the PCB pads of the component, and apply a small amount of solder. Then, grabbing the opposite lead of the component, reheat the solder, and put the component lead into the melted solder. Remove the iron, and allow the solder to cool before releasing the lead. With the component held in place on one leg, heat the pad of the opposite leg, and apply solder to it and the component lead. When this cools, retouch the first solder joint with a slight additional amount of solder to assure that it has a good, well-wetted joint.

When cutting the excess leads from the installed components, keep the body of your diagonal cutters parallel to the board so that the sharp tips of the cutters are not likely to scratch and damage the board traces or solder mask.



Figure 1: Lead preparation

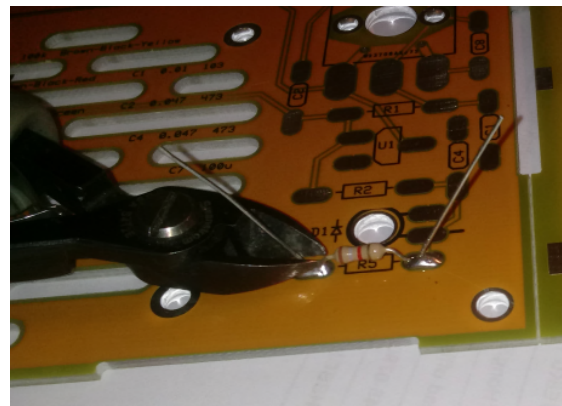


Figure 2: Trimming the leads

### Assembly

We are going to wind the antenna coil first. This is the most challenging part of the entire assembly, and most critical. To do this before anything else give you the best chance of getting it right the first time.

( ) Take the ferrite antenna rod, and cover it with a layer of masking tape. Cut a piece tape, two inches (5 cm) long, and then cut it down the middle to make two pieces 1/2" (12 cm) wide. Take the piece of magnet wire, and tape it down 1" (25mm) from the end of the rod, with a 2" (5cm) length of wire extending from the tape.

( ) Wind 37 turns of 22 AWG enameled wire around the rod. The wire must be applied snugly to the rod, with no space between adjacent turns. Be careful handling the copper

magnet wire so as not to kink it. Fix the end of the wire with the other piece of cut tape. Cut the ends of the wire to about 1 1/2" (37mm) long. With sandpaper or a hobby knife, remove the insulation from the last 1/2" (12cm) of the wire by sanding or gently scraping it off. Then set the finished coil assembly aside for later.

### Board Preparation

( ) The Murania is constructed of six PCB sections that come as part of multi-board panels separated by grooves. These grooves allow the boards to be separated by snapping them apart. Take each board and lay the groove on the edge of a table or workbench, and press down on each side. They will separate cleanly.

( ) The edges of the board will be rough where the boards are separated. Lay the piece of sandpaper flat on the work surface, and holding the board section perpendicularly, slide it on the sandpaper a few times until the edge is no longer rough.

( ) The appearance of the boards can be improved if the edges of the boards are colored black using a permanent marker.

### Power and Voltage Regulator

The Murania circuit uses a red LED as a voltage regulator for the receiver. The LED also serves as both a power-on lamp and a tuning indicator. This circuit will be installed and checked for proper operation before continuing.

( ) Take the rotary potentiometer, R3. With the shaft facing away, orient the three solder terminals facing downward. There are three solder lugs for the switch facing upward. With the diagonal cutters, snip off the one at upper right flush with the body of the potentiometer.

( ) Unscrew the nut and washer from the potentiometer shaft. The three large solder lugs for the volume control must be bent downward so that they contact the three solder pads on the PCB. Carefully do so, checking their position by temporarily inserting the control into the PCB to check the clearance between the solder lugs and the board.

( ) Once the potentiometer solder lugs are bent into the proper position, install the potentiometer into the PCB, placing the flat washer and nut onto the shaft. Tighten the nut onto the shaft using the pliers.

( ) Solder each of the three potentiometer solder lugs to the PCB.

( ) Locate C7, the 100uf electrolytic capacitor. This part looks like a black or blue can with two legs coming from one end. Notice that the capacitor has a colored stripe on one side marked with minus signs, indicating the polarity of the part. The silk screened

symbol for this part on the PCB shows a colored section, indicating where the stripe on the capacitor body is to be oriented.

( ) Bend the legs of the capacitor to contact the solder pads on the PCB, and solder into place. Trim the excess lead length.

( ) Locate the piece of hookup wire included in the kit. Cut a 1-1/2" (37mm) length. This is to connect between the bottom switch terminal on the volume control potentiometer and the lower solder pad of the capacitor C7, marked 'V+'. Strip back the insulation from the ends of the wire, and solder into place.

( ) Locate the 9-volt battery connector. Solder the red wire of the battery connector to the upper left switch contact on R3. Solder the black wire to the solder pad marked 'V-' on the right-most solder pad of the volume control R3.

( ) Bend the switch lugs on the potentiometer down as close as possible to the black shell of the potentiometer.

( ) With the component side of the PCB down, turn the shaft of the volume pot fully counter-clockwise, until the switch clicks. Attach one of the knobs to the potentiometer shaft using a fine screwdriver to tighten the set screw. Align the white marker on the knob with the 'off' line on the front panel silk screen.

( ) Locate R5, the 10k resistor. Its color code is brown-black orange. Install it into position at the lower right side of the PCB.

( ) Locate C4, a 0.047 uf ceramic capacitor, marked 473. Bend the leads, and solder to the board, trimming extra leads length when finished.

( ) Locate the LED, D1. As with the electrolytic capacitor, the LED has a polarity and proper orientation. Looking at the ringed flange on the body of the LED, you will notice that there is a flattened side. This indicates the cathode terminal of the LED. This lead is to be the upper lead when mounted. With the LED facing downward, and the cathode flat oriented away from you, bend the legs of the LED to the right. Place the LED through the hole in the PCB, and bend the legs into position to contact the solder pads on the PCB. Solder it into place and trim the excess leads.

( ) Now, we will test the LED. Connect the 9v battery to the battery connector. Rotate the shaft of R3 clockwise into the 'on' position. You should see the LED illuminate. If you have a volt-ohmmeter, check the voltage between the right hand terminal of R5 and one of the four holes in the corners of the board. The volt meter should read between 1.6 and 1.8 volts. This is the regulated voltage that is used by the radio IC.

( ) Remove the battery.

### Audio Amplifier

The Muriania receiver has a single stage of audio amplification that drives the speaker through a matching transformer.

( ) Locate the transistor Q1. It will be marked '2N3904'. Notice the transistor has a flat face, and that the PCB silk screen shows this face oriented to the right. Bend the center leg of the transistor to the right, and the two other legs backward to the left, and then upward to form the bends that will contact the PCB solder pads. Solder it in place, and trim the excess leads.

( ) Locate the transformer T1. This transformer has two windings, a primary and a secondary. The primary is marked 'P' on the body of the transformer, and also on the PCB silk screen, at the left of the component footprint. Use the sandpaper to lightly sand the two mounting tabs to roughen their surfaces. Bend the mounting tabs outward at right angles to the body of the transformer.

( ) Bend the six leads of the transformer outward, and check their alignment against the solder pads on the PCB. Solder the transformer mounting tabs to the board first, and then the six leads. Cut of the excess lead length.

( ) Locate C6, a 0.22uF capacitor. It is marked 224. Bend its leads, and install next to the audio transformer.

( ) Locate C5, a 0.01uF capacitor. It is marked 103. Bend its leads and install next to the audio transformer. Trim the leads of excess length after soldering.

( ) Locate R4, a 1.0M resistor. Its color code reads brown-black-green. Bend its leads, and install next to C5. Trim the leads of excess length.

( ) Mount the speaker to the front panel with its terminals facing to the left. The speaker is attached using the four, 3/8" 6-32 screws, with washers between the speaker and the panel to space the speaker frame up from the traces that run on the surface of the board. Apply the nuts to the top of the speaker, and tighten down. Place a tiny drop of fingernail polish to the exposed threads of the screws to lock the nuts in place.

( ) Connect the speaker to the audio transformer using the provided plastic insulated hookup wire. Cut two pieces slightly longer that what is required to connect between the speaker and the audio transformer. Strip back the insulation about 1/4" on both ends of each wire and connect between the speaker lugs and the center and upper right solder

pads of the audio transformer secondary.

### RF Detector

The Murania receiver utilizes one IC to do most of the heavy lifting in the circuit. This is the TA7642, a component that has its origins in the late 1960s. Equivalent to the ZN914 and MK484, this three legged component contains ten transistors, and performs the task of radio frequency amplification, audio detection, and automatic gain control. With the TA7642, it is possible to construct a Tuned Radio Frequency receiver with useful sensitivity and selectivity, using only a handful of components. This device served as the basis of many radio receivers that were the successors to the Boy's Radios.

The antenna coil L1 resonates with the variable capacitor C3 at the receiver frequency, and this tuned signal connects to the input of the IC. This small RF signal is amplified thousands of times by the IC, and converted to an audio signal at the output of the IC. This stronger the signal at the input, the lower the detected voltage at the IC output goes. This voltage is passed through R1 to C1, which filters off all the audio signals, leaving a DC level that is controlled by the level of RF signal applied to the IC input. The DC level applied to the IC input controls the RF gain of the IC, so this tends to even out the strength of signals appearing at the output of the IC – and effect called Automatic Gain Control.

( ) Locate C1. It is a 0.01uF ceramic disc capacitor, marked '103'. Bend the leads, and solder to the board. Trim the excess leads.

( ) Locate capacitor C2, a 0.047uF ceramic disk capacitor marked 473. Bend its leads, and solder to the board, trimming excess leads.

( ) Locate C8, a 47pF ceramic disc capacitor. It will be marked 47. Bend its leads, and solder to the board, trimming excess leads.

( ) Locate the TA7642 IC1. Notice the device has a flat face, and that the PCB silk screen shows this face oriented to the right. Bend the center leg of the transistor to the right, and the two other legs backward to the left, and then upward to form the bends that will contact the PCB solder pads. Solder it in place, and trim the excess leads.

( ) Locate R1, a 100k resistor. Its color code will be brown-black-yellow. Bend its leads, and solder to the board, trimming excess leads.

( ) Locate R2, a 1.0k resistor. Its color code will be brown-black-red. Bend its leads, and solder to the board, trimming excess leads.



- ( ) Take the variable capacitor C3. Hold it so that the shaft is facing down onto the work surface. At the upper surface of the variable capacitor, there will be four strap connections, one in each corner of the case. Snip them off flush with the case of the capacitor.
- ( ) Place the variable capacitor onto the PCB in its mounting position. Bend the leads to shape to contact the PCB solder pads. If the strap connections of the capacitor are too long and overlap onto the yellow board solder mask, trim the straps so they are shorter than the solder pads.
- ( ) Mount the variable capacitor to the PCB, using the two small M2.6 screws, oriented so that the side of the capacitor with the three connection straps is oriented downward
- ( ) Solder the strap connections of the variable capacitor to the solder pads on the PCB. Be careful not to accidentally melt the body of the capacitor.
- ( ) Locate the longer M2.6 screw and nylon standoff. This will be used to create the shaft of the variable capacitor. Insert the screw into the spacer, and then place a tiny drop of clear fingernail polish at the tip of the screw. Thread the screw into the center of the capacitor, and snug it down lightly using a screwdriver. The fingernail polish will serve as a thread locker preventing the shaft from coming loose easily.
- ( ) Mount the two white, adhesive-backed cable anchors to the black square on the PCB.
- ( ) Take the wound L1 assembly, and tin the stripped ends of the enameled wire. Solder these to the solder pads provided on the PCB. Using your ohmmeter, verify that there is a near-zero resistance between the two pads, indicating there is a good connection between them.
- ( ) Fold the extra wire length under the antenna rod. Using the two zip ties, attach the antenna rod to the cable anchors.
- ( ) Cut a piece of enameled magnet wire approximately 1 1/2" (37mm) long. Strip approximately 1/4" (6mm) of the insulation on each end. Bend into a hoop shape, and solder onto the solder pads labeled 'LOOP'. Bend the wire into a vertical loop, parallel to the axis of the antenna rod.
- ( ) Carefully inspect the PCB for any missing components. Check each solder joint for quality, touching up any questionable joints.

## Testing the Receiver

- ( ) Install the battery, and switch on the radio, turning the volume control to roughly its midway point.
- ( ) Slowly rotate the tuning control. You should hear numerous radio stations at good volume as you tune.
- ( ) The loop of wire between the variable capacitor and antenna coil can be adjusted to couple some of the amplified IC RF output back to its input to behave as a regenerative receiver. This lets you increase the gain and sharpness of tuning. Slightly twist the loop so that it either faces toward or away from the antenna coil. After each adjustment, sweep the tuning control, and you will notice that the receiver either increases or decreases sensitivity and selectivity. There will be a loop position that causes squealing and instability in the received signal. Aim to find a point slightly before that angle.

### Building the Enclosure

The Murania receiver includes a complete enclosure formed from printed circuit board material. Panels solder together using a low-wattage iron.

- ( ) Set the back panel of the enclosure on the work surface. Make certain the solder tabs are facing upward. Using masking tape, position the four side panels around the back, repositioning as necessary to eliminate any gaps in the corners. Solder the solder pads together to fix the panels in place. Remove the tape and inspect. Re-adjust the panel joints as necessary to make the joints as tight as possible.
- ( ) Attach the adhesive-backed battery clip to the mounting position on the back panel.
- ( ) Using four 6-32 x 3/8" screws, mount the four threaded standoffs to the corners of the bottom panel.
- ( ) Flip the front panel over, and verify that it will fit into the tabs of the side panels of the enclosure. With the soldering iron, re-adjust the fit of the side panels if necessary.
- ( ) Clip the battery into the battery holder, and then assemble the front panel into the enclosure using the remaining four screws.
- ( ) You are done! Enjoy the Murania!

### Hints for Best Results

The Murania receiver will perform on par with the inexpensive transistor radios that many of us grew up with. Because of the limited selectivity and AGC action of the receiver, a strong, nearby station may be heard over a large angle of the tuning dial. To hear weak signals that may be close by to the stronger station, rotate the receiver to take advantage of the directional nature of the antenna coil. If the antenna coil is pointed directly at a station, it cannot pick up its signal. This feature may be used to null out a strong offending signal, and hear weaker signal that are nearby in frequency.

As with any AM receiver, you will not have good results tryin to operate from inside a steel frame or metal building, and the structure will shield any receivers inside. You will notice that during evening hours you will hear many signals that are inaudible during the daytime – sometimes at distances of over a thousand miles away.

You will notice that the LED acts as a tuning indicator. The intensity of the light will dim as the signal is tuned in to its strongest. This handy feature aids in obtaining the best signal.

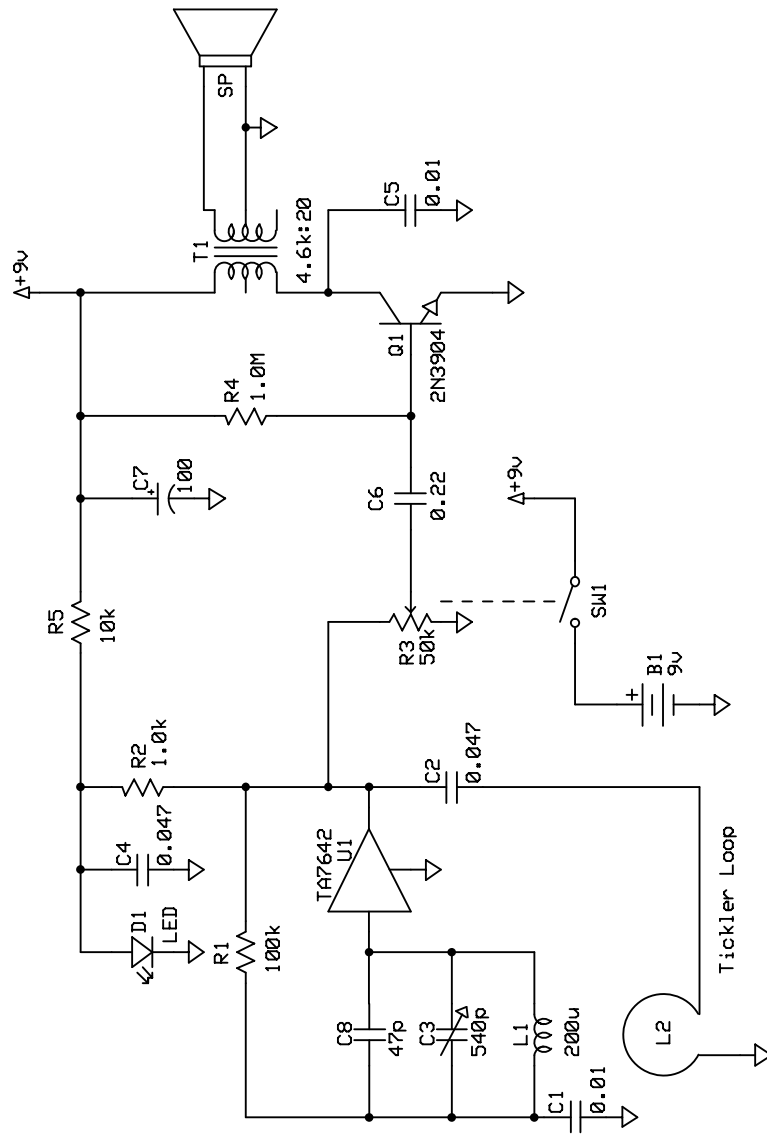


Figure 3: Murania Schematic

## Parts List

C1		0.01 Ceramic Disk
C2		0.047 Ceramic Disk
C3	2x270p	Polyvaricon
C4		0.047 Ceramic Disk
C5		0.01 Ceramic Disk
C6		0.22 Ceramic Disk
C7	100u	Electrolytic
C8	47p	Ceramic Disk
L1	200uH	Ferrite Rod
Q1	2N3904	TO-92
R1	100k	1/4W
R2	1.0k	1/4W
R3	50k, linear	Pot with Switch
R4	1.0M	1/4W
R5	10k	1/4W
SP	2.6" speaker	
T1	4.6k:20	Transformer
U1	TA7642	TO-92
D1	Red	T 1-3/4

Qty	Description
2	M2.6x4 screw
1	M2.6x12 screw
1	Nylon Standoff
2	Cable Mount
12	6-32 x 3/8", black screw
4	6-32 nut
4	# 6 flat washer
2	zip ties
1	6' # 22 AWG wire
2	knobs
1	9v holder
4	1" 6-32 standoff
1	9v Connector
1	6" 22 AWG stranded hookup wire