

Building and Operating: LF Converter
An SA612 based LF up-converter
from Jackson Harbor Press

Introduction:

The frequencies below the broadcast band are covered by few receivers on the market - those that do cover these frequencies are sometimes lacking in performance. This kit allows the owner of a ham band receiver (or transceiver) to listen to this band at a minimal cost with acceptable performance. There are a number of different stations to listen to on LF, including:

Military	24-26 KHz	strong computer modulated carriers
WWVB	60	time / frequency standard station in Colorado
Loran	100	pulse based navigational stations
Lowfers	160-190	Part 15 stations operating at less than 1 watt
beacons	200 - 280	low power aeronautical beacons located at airports
DGPS	290 - 330	stations that send correction signals for GPS receivers

See the web site for short recordings of some of the above stations in WAV format made with an Elecraft K2 fed by the LF converter..

The LF converter takes the band of frequencies from approximately 10 KHz to 300 KHz up to the 75, 30 or 20 meter ham bands (4 to 4.3, 10 to 10.3 or 14 to 14.3 MHz bands). The converter can be easily changed to another ham band (or another 300 KHz range) by changing the crystal. A socket is provided to make this easy to accomplish.

General notes on building the LF Converter

One decision the builder should make before starting construction of the LF converter kit is how the project will be mounted in the case. The LF converter should be mounted in an all metal case - a Screts or Altoids tin will work fine. It is important to keep the converter output shielded to prevent false signals from the 75, 30 or 20 meter band being received.

Sockets are provided for both the mixer IC and the crystal - the use of these sockets is optional. The sockets may adversely affect performance, but I find that it is very useful to be able to change the crystal and IC easily.

The components should be inserted a few at a time, soldered in place and then clip the leads. The pads and traces are small and delicate - a small tipped, low power (25 watts or less) soldering iron should be used.

Building the LF Converter

Step 1) Get the parts together: All of the board mounted components have been supplied but you will still have to provide off-board items to fully implement the kit. These items include:

- + 12V power connector
- Antenna input connector
- Output connector to receiver / transceiver, BNC or RCA phono will work fine
- metal case, an Altoids or other candy tin will work fine
- shielded cable, audio is fine for the input, RG-174 may work better for the output
- 4 sets mounting hardware, 4-40 sized

Step 2) Identify and orient the components: Most of the components should be fairly easy to identify and place - see the parts list and the parts placement diagram for descriptions. The electrolytic cap is clearly marked for polarity - be sure to orient the negative stripe correctly per the parts placement diagram. The yellow trimmer cap should be oriented with the flat side towards the crystal. The round side of the trimmer is the "ground" side - connecting this side to ground will minimize any capacitance shifts when a screwdriver is used to adjust the trimmer. The ferrite toroids used for L1 and L2 are small, .375 inch diameter, black donuts - the builder will wind 8 turns of hookup wire on each of them to form L1 and L2.

Step 3) Wind the toroids: There are two inductors used in this kit - they are identical - both should be wound with 8 turns of the hookup wire that is supplied with the kit. Start with a piece of wire about 7 inches long. Put one end of the wire through the hole of the toroid core and leave about 1 inch of wire exposed. Then start threading the other end of the wire around and

Building and Operating: LF Converter from Jackson Harbor Press

through the core of the toroid another 7 times. Each time the wire passes through the core counts as 1 turn. Even out the turns on the core as shown on the parts placement diagram. I've included regular hookup wire with the kit as it's easier to work with, magnet wire can also be used but the insulation is a little harder to remove..

step 4) Place and solder the components on the main circuit board: Use the parts placement diagram for information on the placement and orientation of the parts. Clip the leads after soldering. I would recommend that the builder insert parts by their profile (or height) above the circuit board starting with the lowest and working up.

- a) optional: DIP socket - should be inserted with the notch towards the left edge of the board
- b) optional: crystal SIP socket (3 pin) - should be inserted above the DIP socket at the X1 position.
- c) C7 and C8, the .1 uf caps (marked .1M or 104) near the DIP socket
- d) U2 (78L08 8V regulator) with flat side toward the top edge of the board.
- e) two .1 uf bypass caps (C1 and C2, marked .1M or 104) on either side of U2
- f) the toroids L1 and L2 should have their leads stripped and inserted at the left of the board
- g) .022 uf polyester cap (C5 marked 223J) between the two toroids
- h) .01 uf polyester caps (C4 and C6, marked 103J) at either side of the two toroids
- i) the yellow trimmer cap (C12) with the flat face towards the crystal socket
- j) the 68 pf cap (C10 marked 68J) in parallel with the top +8V trace
- k) the 270 pf cap (C11, marked 271J) next to the 8 pin DIP socket
- l) vertical 10 uf electrolytic cap (C3) at top right of board with negative stripe to the left edge of board
- m) C9 the .1 uf cap (marked .1M or 104)
- n) R1 the 240 (red-yellow-brown-gold) ohm resistor
- o) Q1 the PN2907 transistor - be sure to form the leads for the .1 inch lead spacing and also make sure to install the transistor with the flat face as shown on the parts placement diagram (away from C9).

Step 6) Check the board: Before proceeding, take the time to check the bottom of the board for solder bridges. Use the bottom view diagram as a guide to visually check for these shorts. It may help to clean the flux from the board and then use a strong light in conjunction with a magnifying glass to see these problems. Also, double check the orientation of the critical components such as the regulator (U2), the yellow trimmer cap, C12, and the 10 uf electrolytic cap, C3.. After you are convinced that the board is OK, connect 12V power to the top edge of the board as shown on the parts placement diagram. Now use a voltmeter to check that the regulated +8V is present on the top power trace. If it isn't, recheck your component orientation and soldering.

Now form the leads of IC U1 to fit in the socket, insert the IC and the crystal into their respective sockets, being sure to follow the parts placement diagram for proper orientation (pin 1 indicated by a notch or dimple should be to the top edge of the board. Finally, use shielded wire to connect the antenna input connector and receiver output connector as shown on the parts placement diagram. Install the board in the metal case.

Next, connect the antenna (a long wire is fine) and the receiver and power up the board. If you are using a transceiver, use the receive only antenna input if one is available. If you are using the normal transceiver antenna, realize that an accidental

Building and Operating: LF Converter from Jackson Harbor Press

transmission with the LF converter connected in place of the normal transmitting antenna or dummy load will probably damage the LF converter and possibly your transceiver.

You should be now be able to hear LF stations - the military stations from 24-26 KHz are very loud. WWVB is not quite as loud at 60 KHz. Loran at 100 KHz is often quite loud as well. See the web site for recorded LF transmissions.

Setup and operation: The LF converter requires one adjustment, tune in a station of known frequency, WWVB at 60 KHz is the best one since there are few other stations in the immediate "vicinity". Set your receiver frequency to 7.06, 10.06 or 14.06 MHz, and then use a small screwdriver to adjust C12 until you hear the modulated tone of WWVB at the correct offset frequency for your receiver (consult the manual for the receiver for the offset information for your radio). The Son of Zerobeat kit can be used to easily set the trimmer to within +/- 10 Hz.

The LF converter may suffer in performance in the presence of strong AM broadcast signals. The use may need to install some LC filter circuitry to minimize this problem.

Sometimes strong signals in the ham band (to which the LF signals are converted) may appear - this generally indicates that the shielding is poor between the LF converter and the receiver. Good quality BNC or RCA phono connectors and high quality coaxial cable should minimize this problem.

LF Antenna: Much information is available on the internet concerning LF antennas. There are many different types which should all work fine with the LF converter. Loop antennas including shielded loops and ferrite bar antennas are very popular. Active "whip" antennas also work well. Personally, I often just use my HF long wire antennas. Noise is a big problem on LF, especially in the spring-summer season. Directional antennas help to minimize noise pickup. Man made noise, especially from light dimming equipment can be a severe problem on LF.

Circuit description: The LF Converter circuit has the following major circuit blocks:

1) power supply: a 78L08 regulator is used along with bypass capacitors to convert a +12 to +13.8 volt (12 volts nominal) input voltage to 8 volts.

2) low pass filter: C4, C5 and C6 along with L1 and L2 form a simple 300 KHz low pass filter. Ferrite cores were used to minimize the number of turns required compared to powdered iron cores.

3) converter: The remaining components convert the band of frequencies from 0 to 300 KHz up to the receiver input frequency range of 4.0 to 4.3, 10.0 to 10.3 or 14.0 to 14.3 MHz.

Modification ideas:

1) extra front end filtering: One of the kit testers lives in the Chicago area, when he tried to listen to WWVB at 60 KHz, he encountered some heterodyne interference from two 50,000 watt AM stations in the Chicago area (WGN at 720 KHz and WBBM at 780 KHz). Unfortunately, $780 - 720 = 60$ KHz. One mod which helped him was an extra two sections of low pass filtering on the input with the same values and layout as the one in the kit. This was housed in the separate tin box but probably could also be fitted into the same box as the converter.

2) One kit tester noted that the input low pass filter is setup for 50 ohm termination but the NE602 input is more on the order of 1500 ohms. I tried putting a 51 ohm resistor in parallel with C6 - the results weren't startling, really didn't notice much difference between having the resistor in or out of the circuit. Perhaps a better approach would be an input filter designed for more realistic input and output impedances ?

3) The 8V regulator specified may be a little bit of overkill, a 6V regulator may work just as well and allow the use of a 9V battery to power the kit. 5V regulators are also a possibility, such as the 78L05.

4) One item often used by LF experimenters is a pre-amp. The extra gain may not be needed, but a simple JFET pre-amp with a PNP buffer transistor on the output will allow the user to drive the 50 ohm input impedance of the converter with better results.

Building and Operating: LF Converter from Jackson Harbor Press

The preamp can also be easily remoted, driving a long 50 ohm shielded cable - this allows the antenna (usually a loop) to be located away from man-made sources of noise. The loop antennas usually employed by serious LF enthusiasts (particularly the shielded variety) will probably require the use of a pre-amp.

5) Changes for the toroids - most people familiar with toroids use insulated magnet wire to make the windings - personally I'd rather use hookup wire since it's much easier to remove the insulation. Also, ferrite cores were used in this kit, powdered iron are normally used but they have two disadvantages, they'll require a more turns to get the inductance required. Also, the LF toroids (usually the gray T50-3 toroids).

6) Other frequency bands: Other crystals can be used at X1 - those with receivers which have provision for external converters can try non even megahertz crystals such as 3.579 MHz - these crystals can be the inexpensive "computer" type.

Supplemental information: For more information on the LF converter including the .WAV sound samples, please consult the Jackson Harbor Press web site:

<http://wb9kzy.com/lfconv.htm>

Please feel free to email with any questions, comments, suggestion or problems with this kit. My email address is:

wb9kzy@wb9kzy.com

Thanks for choosing the LF converter kit and
Best Regards,

Chuck Olson, WB9KZY

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Building and Operating: LF Converter from Jackson Harbor Press

List of parts included with the LF Converter kit

Ref	marking	Description
C1	.1M or 104	.1 uf multilayer ceramic .1" lead space cap
C2	.1M or 104	.1 uf multilayer ceramic .1" lead space cap
C3	10 uF 25 V	10 uf radial (upright) electrolytic capacitor
C4	103J	.01 uf polyester (dark red), .2" lead space cap
C5	223J	.022 uf polyester (dark red), .2" LS cap
C6	103J	.01 uf polyester (dark red), .2" lead space cap
C7	.1M or 104	.1 uf multilayer ceramic .1" lead space cap
C8	.1M or 104	.1 uf multilayer ceramic .1" lead space cap
C9	.1M or 104	.1 uf multilayer ceramic .1" lead space cap
C10	68	68 pf NPO ceramic disc capacitor, .2" lead space
C11	271J	270 pf NPO ceramic disc capacitor, .2" lead space
C12		yellow 7 to 40 pf ceramic trimmer capacitor
L1		8 turns on FT37-43 ferrite toroid
L2		8 turns on FT37-43 ferrite toroid
R1	240 ohms	red-yellow-brown-gold 1/4 watt resistor
Q1	PN2907	general purpose PNP bipolar transistor
U1	SA612	8 pin DIP, Philips mixer / oscillator IC
U2	78L08	8V, 100 ma regulator in TO-92 case
X1	10.000	10 MHz crystal (optionally 4 or 14 MHz)
		8 pin machined pin socket (for mixer, U1)
		3 pin machined pin socket (for X1)
		square main circuit board

Items you'll need to provide to complete the LF converter kit

- Metal case (an Altoids tin is fine)
- input antenna jack
- output jack
- +12V power jack
- solder