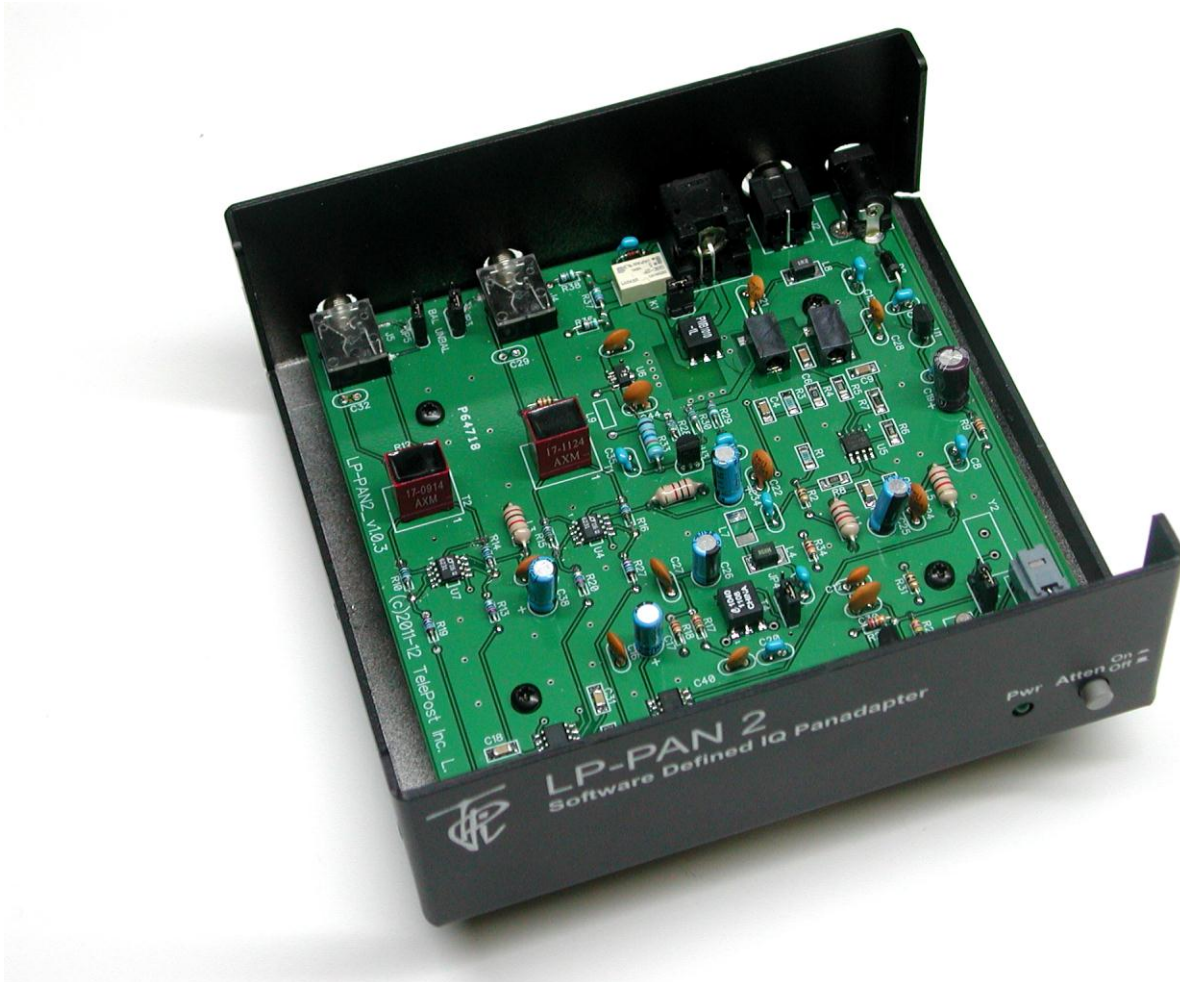


LP-PAN 2

Software Defined
IQ Panadapter



PRELIMINARY

Assembly Manual

June 2012
TelePost Incorporated
Rev. A6

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Introduction

Read Carefully Before Continuing.

Assembling LP-PAN 2 is a straightforward job, and you should have no trouble if you follow the instructions. Take special note of the connection diagram, and become familiar with the basics of how the various components fit together in the system.

If you get in trouble, help is an email away. There are plenty of helpful users on the LP-PAN 2 User Group, <http://groups.yahoo.com/group/LP-PAN>, or you can send an email to n8lp@telepostinc.com. Phone support is also available at 734-455-3716.

LP-PAN 2 Features

LP-PAN 2 is a software defined IQ direct conversion panadapter. Here is a list of current features...

- * Up to 192 kHz display on PC, sound card dependent
- * Quadrature Switching Detector for high dynamic range
- * Strong buffer amp with very high LO isolation.
- * Strong low noise preamp for exceptional noise figure
- * Excellent THD and IMD performance
- * Ground isolated inputs / outputs with mil spec audio xfmrs
- * Fully balanced architecture with low Z balanced and unbalanced outputs
- * Jumperable ground lift on RF input and audio outputs
- * Works with most SDR programs.
- * Point and click frequency control with PowerSDR / IF Stage, NaP3 or TRX-Pan.
- * LP-Bridge allows sharing of LP-PAN with almost any logger, and even programs such as CW-Skimmer
- * Powder coated aluminum enclosure with silk screened graphics.
- * Hardware or software mute
- * Available for IF frequencies of...
 - 8.215 MHz (Elecraft K3)
 - 8.83 MHz (Kenwood)
 - 9.0 MHz (FT5K, Orion)
 - 4.915 MHz (Elecraft K2)
 - 10.55 MHz (FT-950/2000)

Note: Specifications dependent on sound card, and subject to change. Cited values were taken with an E-MU 0204 USB sound card. All measurements also apply to E-MU 1212m and 1616m PCI cards, and M-Audio Firewire Audiophile 2496 card (limited only by 96 kHz display width). For latest sound card info, see www.telepostinc.com/soundcards.html

Parts List - Subject to change without notice. Pictures shown at end of parts list.

Pre-installed SMT parts

Quantity	Designation	Description
5	C5,11,18, 31, 39	0.01uF
2	C4, 6	0.1uF
1	C7	1uF
1	C9	0.22uF
1	L4	0.68uH
1	L8	1.2uH
2	L11, 12	0.18uH
2	R1, 3	1K 1%
1	R4	4.7K 1%
1	R5	200 ohm 1%
2	R6, 7	499 ohm 1%
1	R8	49.9 ohm 1%
1	T3	Toroid XFMR 1:1
1	T4	Toroid XFMR 4:1
1	U2	74HC/HCT163 Counter
2	U4,7	LT6231 Low Noise Op-Amp
1	U5	AD8007 Transconductance Amplifier
1	U6	Gali-74+
1	U8	SN74CBT3253D 4x2 Analog Multiplexer
1	U9	ADCMP600 Comparator

Through-Hole Parts

Quantity	Designation	Value
2	C1,10	10pF ceramic disc (marked 10) Fig. 3
11	C2,3,8,20,33,35,41, 42,45,46,47	0.1uF monolithic (marked 104) Fig. 1
10	C14,16,22,24,27,29, 32,37,43,44	0.01uF ceramic disc (marked 103) Fig. 3
5	C15,17,23,25,38	1uF (50V electrolytic) Fig. 2
2	C12,34	470pF (Marked 471) See Fig. 1
1	C13	390pF (Marked 391) Fig. 1
1	C19	100uF (16V electrolytic) Fig. 28
3	C21,28,40	0.001uF (Marked 102) Fig. 3
1	C26	10uF (25V electrolytic) Fig. 2
1	C30	100p ceramic disc (Marked 101) Fig. 3
1	C36	56pF ceramic disc (marked 56) Fig. 3
1	D1	Green LED Fig. 9
1	D2	1N4001 Fig. 18 (Black)
1	D3	1N4148 Fig. 18
1	J1	Insulated BNC connector Fig. 17
1	J2	2.5mm DC Power Connector Fig. 7
1	J3	RCA Jack Fig. 21
2	J4,5	3.5mm Stereo Audio Jack Fig. 20
4	JP1,3,4,5	3-pin Header Fig. 11
1	JP2	2-pin Header Fig. 11
5		2-pin Jumper Fig. 11

Parts List – Cont'd

Quantity	Designation	Value
1	K1	G6K-2P Relay
5	L1,2,3,5,6	1mH RF Choke (br-bk-rd) Fig. 5
1	Q1	MPS5179 transistor Fig. 10
4	R9,17,18,34	1K 5% 1/8W res. (br-bk-rd) Fig. 12
2	R2,31	10 ohm 1/8W res. (br-bk-bk) Fig. 12
1	R24	4.7K 5% 1/8W (yel-viol-rd) Fig. 12
4	R10,14,15,16	1.1K 1% 1/8W res. (br-br-bk-br-br) Fig. 12
4	R11,12,21,22	2K 5% 1/8W res. (rd-bk-rd) Fig. 12
4	R13,19,20,27	22 ohm 1% 1/8W res. (rd-rd-bk-gld-br) Fig. 12
1	R25	27K 5% 1/8W res. (rd-viol-or) Fig. 12
1	R26	470 ohm 5% 1/8W res. (yel-viol-br) Fig. 12
4	R28,29,36,38	95.3 ohm 1% 1/8W res. () Fig. 12
2	R30,37	71.5 ohm 1% 1/8W () Fig. 12
1	R33	53.6 ohm 1% 1/2W() Fig. 12
1	R35	10K 5% 1/8W res. (br-bk-or) Fig. 12
1	SW1	2PDT Pushbutton Switch & Keycap Fig. 6
2	T1,2	Audio Output Xfmr. Fig. 25
1	U1	78L05 5V Regulator Fig. 10
1	U3	78L09 9V Regulator Fig. 10
	Y1,Y2	See Table I, Page 6 2 nd xtal optional Figs. 24
1		PCB Fig. 26
1		Enclosure Fig. 27
1		Power Cord Fig. 8
6		1/4" Black Sheet metal screw Fig. 14
8		3/16" Black machine screw Fig. 15
4		1/4" standoff Fig. 13
4		Rubber feet Fig. 16

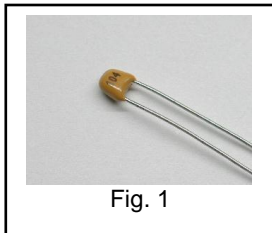


Fig. 1

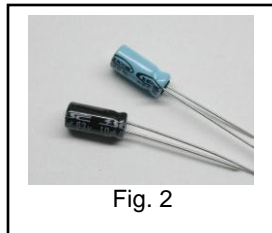


Fig. 2

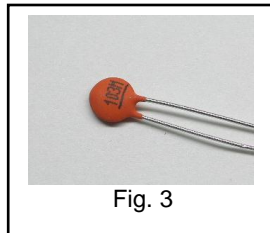


Fig. 3

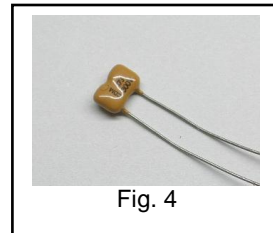


Fig. 4

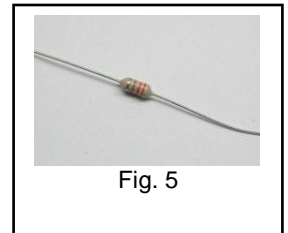


Fig. 5

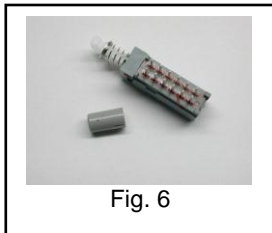


Fig. 6

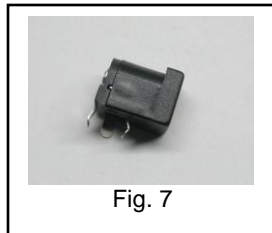


Fig. 7



Fig. 8

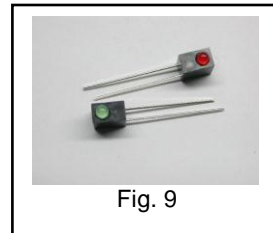


Fig. 9

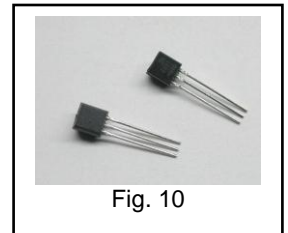


Fig. 10

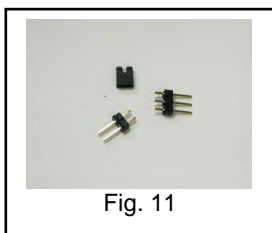


Fig. 11

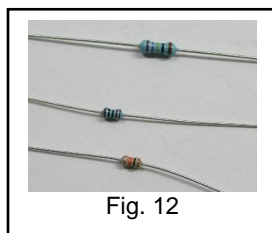


Fig. 12

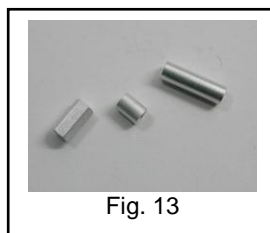


Fig. 13

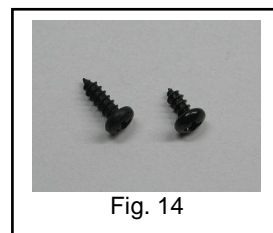


Fig. 14

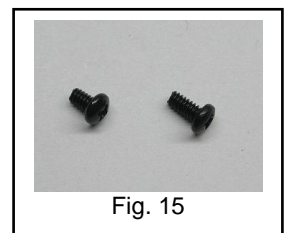
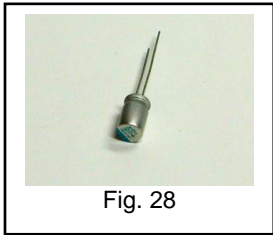
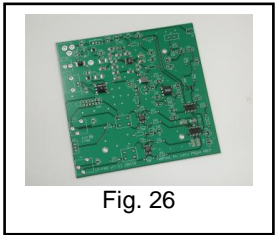
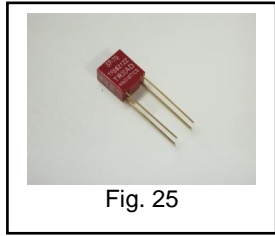
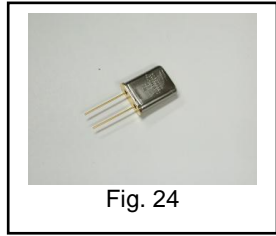
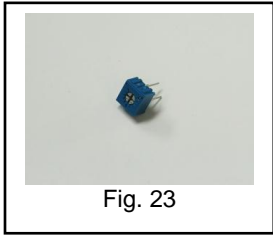
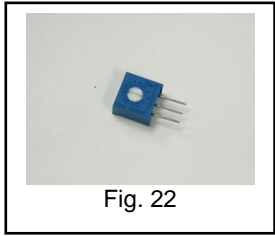
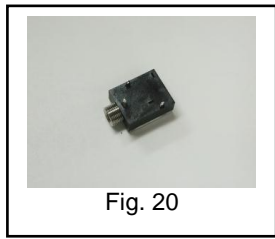
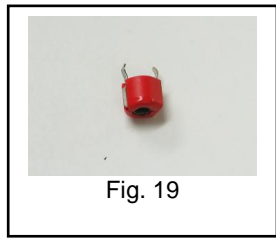
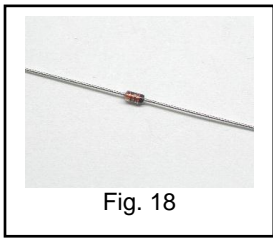
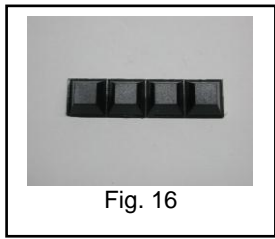


Fig. 15



Radio	Nominal IF (MHz)	Y1 (MHz)
Elecraft K2	4.915	19.68000
Elecraft K3	8.215	32.83600
Kenwood (w/SM-220 IF Output)	8.830	35.29600
TenTec Orion (II)	9.000	35.976
Yaesu FTdx5000	9.000	35.976
Yaesu FT-2000	10.550	42.224

Table I

Assembly

Important warnings – read this before starting assembly

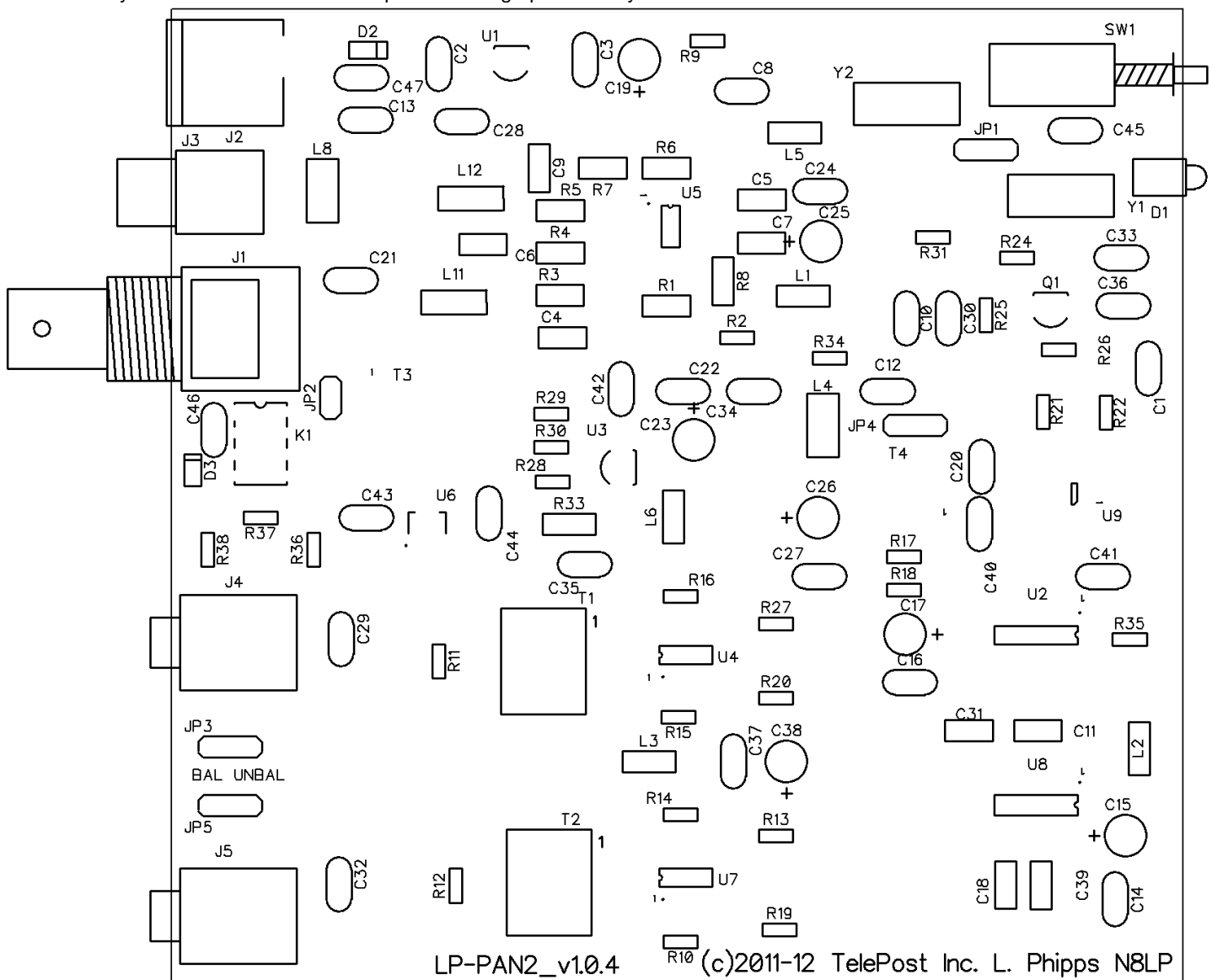
You should visually inspect all the solder pads/traces with a magnifier for any etching problems. This is done before shipping, but I recommend the builder do a second inspection as well. We do 100% continuity checks of all pads before shipment using computer controlled flying probes based on PCB netlist coordinates.

All of the SMT components are pre-installed on the main board for your convenience. SMT parts are supplied wherever necessary for performance or availability reasons. **CAUTION: Be very careful handling this board to avoid damage to the installed parts. Anti-static measures are highly recommended, such as use of an anti-static mat, grounded soldering iron and wrist band.**

You may wish to clean the flux from the board after assembly, although it is not necessary with most modern solders. A toothbrush and alcohol are good for this. Only use rosin core solder. Use of acid core solder voids the warranty. Lead-free solder is OK. The boards and all parts are RoHS compliant, but it will be more difficult to remove parts without damaging the board should you have to.

Overview

Below is the component placement diagram for the main PCB. These markings match the silk-screening on the PCB, but are repeated here for clarity. You can also cross out the parts on this graphic as they are installed.



You should check all parts before starting to allow you to start the process of obtaining replacement parts as soon as possible if needed. It is also a good idea to sort the parts in advance... egg cartons are handy for this (passive parts only). Many crafts stores, Like Michael's, also have nice plastic cases with dividers at low prices. If there is any doubt about component values, especially with the 1% resistors which can use strange markings, check them with your DMM.

Assembly Cont'd

Pre-assembly overview.

When assembly starts on page 9, it will roughly follow this order...

- Installation of resistors
- Installation of ceramic disc capacitors
- Installation of miscellaneous small parts
- Installation of miscellaneous large parts and connectors
- Installation of chokes

The idea is be able to lay the board flat as much as possible during construction, with lowest parts being installed first. The chokes are the lone exemption... they are installed last so as to make sure each circuit is drawing the right amount of current before continuing. This is done by monitoring total current draw of LP-PAN 2 while adding the chokes one by one.

You will need the following tools to complete assembly...

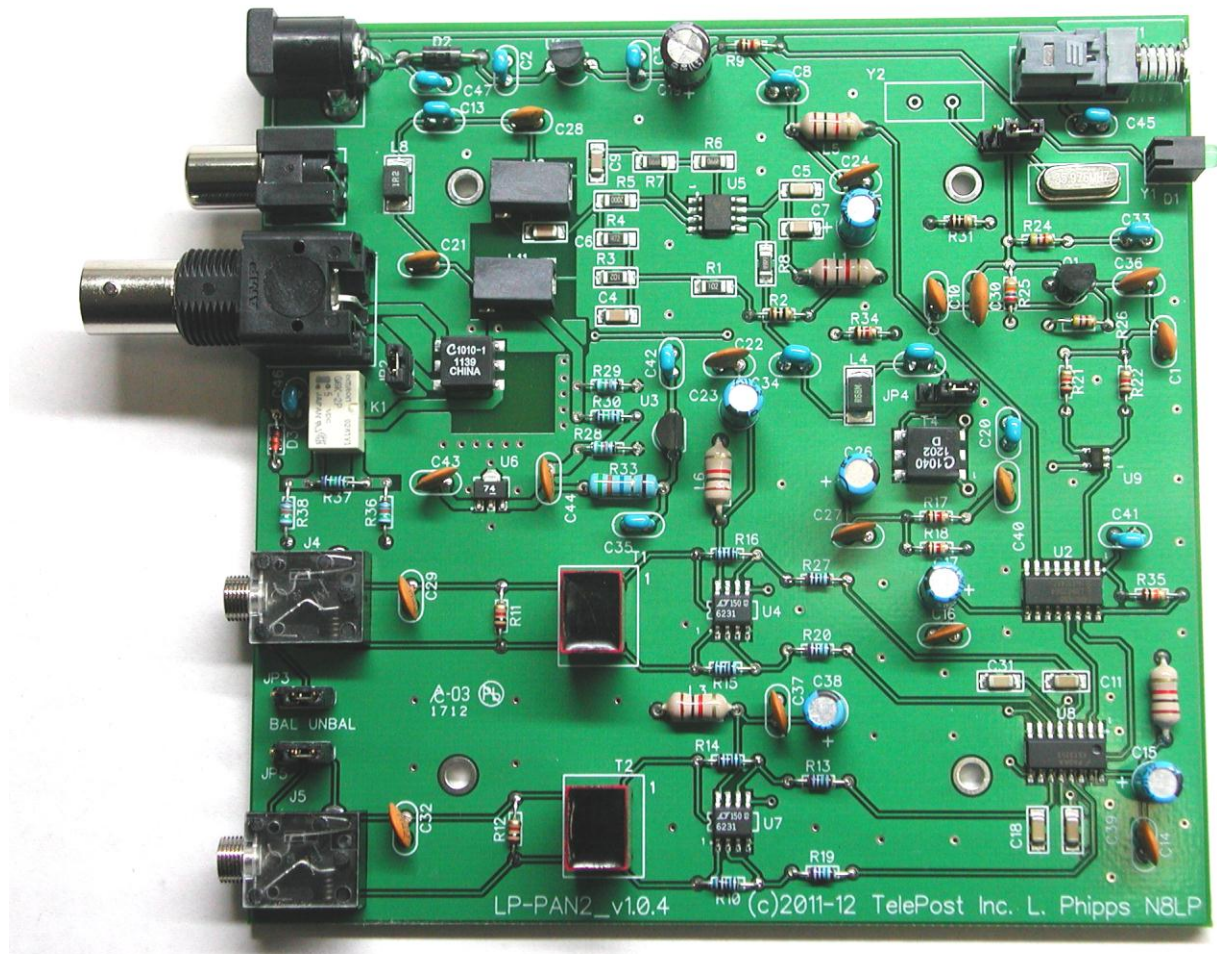
- Adjustable soldering iron – 800 degrees maximum
- Solder... 0.020" (0.51mm) diameter recommended for thermal pads. 60/40 alloy preferred where legal.
- Needle-nose pliers
- Wire cutters
- Small Philips head screwdriver
- Digital Multimeter

NOTE: The LP-PAN 2 is an intermediate level kit. I would peg the assembly time at about 3 hours, plus some time reading through the manual in advance. Take your time, and double-check your work, and you should have no problem. All critical parts are pre-installed.

Assembly Cont'd

Step-by-step assembly instructions.

Below is a picture of the assembled PCB. The SMT parts come pre-installed. The component layout diagram on page 7 provides another aid to component identification.



It is recommended that you print at least this portion of the manual to allow for easy reference while building, and to allow you to check off the steps as you complete them. Make sure your work area is static-free to avoid damage to the pre-installed SMT parts. It is also advisable to wear an anti-static wrist band and grounded soldering iron. Refer to the parts placement graphic on page 7 or the above picture for questions regarding parts placement.

- ❑ Install resistors. Solder and clip leads after about six parts are installed to minimize clutter. If you are unsure of the colors used by some of the manufacturers for the color code, especially the 1% parts, measure the value with a DMM. Occasionally, parts listed as 5% will be supplied as 1% due to availability when ordering. Double check with DMM. **Note: R33 will be installed later.**

- ❑ R2,31 10 ohm 1/8W res. (br-blk-bk)
- ❑ R9,17,18,34 1K 5% 1/8W res. (br-blk-rd)
- ❑ R10,14,15,16 1.1K 1% 1/8W res. (br-br-blk-br-br)
- ❑ R30,37 71.5 ohm 1% 1/8W res. ()
- ❑ R28,29,36,38 95.3 ohm 1% 1.8W res. ()
- ❑ R11,12,21,22 2K 5% 1/8W res. (rd-rd-blk-br-br)
- ❑ R13,19,20,27 22 ohm 1% 1/8W res. (rd-rd-bk-gld-br)
- ❑ R24 4.7K 5% 1/8W res. (yel-viol-rd)
- ❑ R35 10K 5% 1/8W res. (br-bk-or)
- ❑ R25 27K 5% 1/8W res. (rd-viol-or)
- ❑ R26 470 ohm 5% 1/8W res. (yel-viol-br)

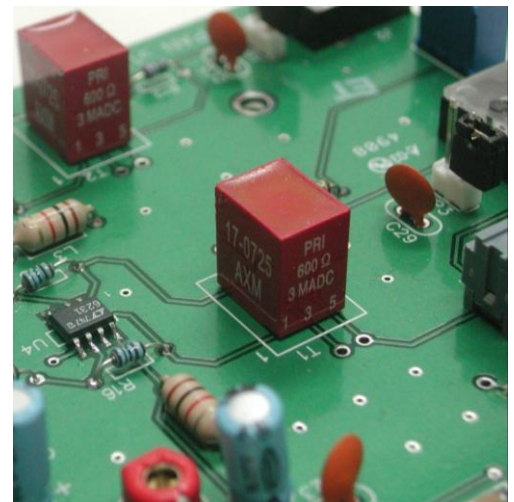
- ❑ Install the two audio jacks next, J4 & J5. Solder the center lead first, so that you can adjust the jacks to be parallel with the board edge before soldering the remaining pins.

Assembly Cont'd

- ❑ Install D2 & D3. Follow polarity markings on PCB.
- ❑ Install all 0.1 uF caps (marked 104) in small groups.
 - ❑ C2,3,8
 - ❑ C20,33,35
 - ❑ C41,42,45
 - ❑ C46,47
- ❑ Install all .01 uF caps (marked 103).
 - ❑ C14,16,22
 - ❑ C24,27,29
 - ❑ C32,37
 - ❑ C43,44
- ❑ Install remaining ceramic disc caps.

❑ C1,10	10pF ceramic disc (marked 10)
❑ C12,34	470pF ceramic disc (marked 471)
❑ C13	390pF ceramic disc (marked 391)
❑ C30	100pF ceramic disc (marked 101)
❑ C36	56pF ceramic disc (marked 56)
❑ C21,28,40	0.001uF ceramic disc (102)
- ❑ Install D1 (LED)
- ❑ Install Q1. Keep leads short.
- ❑ Install U1 & U3. Keep leads short.
- ❑ Install SW1
- ❑ Install K1. Be careful about the orientation markings as shown.
- ❑ Install J3. You will need to clip off the two plastic tabs on the bottom of the connector off before installing. Latch the rear pin first for strength, then solder the front pin.
- ❑ Install J2 power connector
- ❑ Install the one 2-pin and four 3-pin headers. Install a shorting jumper between pins at JP2. Install a jumper between pins 2 & 3 (the two pins toward the front of the board) of JP1, JP3, JP4 & JP5
- ❑ Install T1 and T2. Orient pin 1 near the silk-screened "1" marking, as shown.
- ❑ Install crystal, Y1. See Table I, page 6 for value.
- ❑ Install the electrolytic caps, taking care with polarity. The "+" lead is the longer one, "-" lead is marked with a black or white stripe, or blue semi-circle.

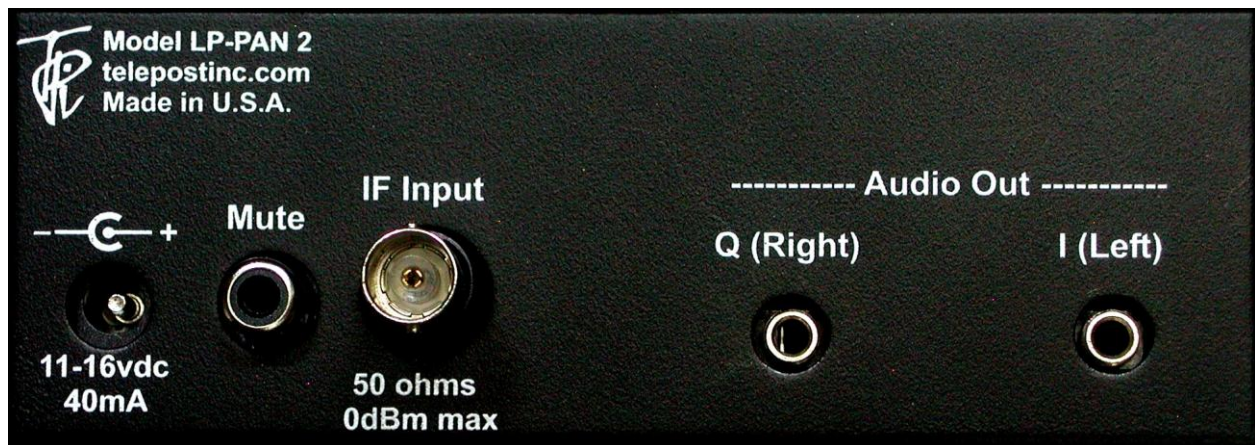
❑ C15,17,23,25,38	1uF (50V)
❑ C19	100uF (16V)
❑ C26	10uF (25V)
- ❑ Install RF connector J1



Assembly Cont'd

- ❑ Make sure that your bench is clean and the PCB is not sitting on any cut off component leads. Also, make sure that the attenuator is OFF (out position). Connect the supplied power cable to a supply of 11-16 VDC. The dashed white lead on the supplied power cable is the + lead (center pin). The green LED should light. Using your DMM, check for 5.0 VDC (+/- 0.25V) at pin 3 of U1 (the pin connected to C3), and 9.0VDC at pin 3 of U3. Monitor total current draw of LP-PAN 2 using the DMM or current meter on a power supply. Current draw should be about 23mA (with 13.8VDC applied).
- ❑ Power down.
- ❑ Install the 1mH ceramic chokes (br-blk-red) one at a time, and check LP-PAN 2 current draw as each one is added to verify no unexpectedly high changes to total current draw. Expected total current draw is shown after each choke. If your values vary significantly from these, check your work in the circuit affected by the most recently added choke. Refer to schematic.
- ❑ L1 ~31mA
- ❑ L2 ~32mA
- ❑ L3 ~38mA
- ❑ L5 ~38mA
- ❑ L6 ~43mA
- ❑ Install R33, 53.6 ohm, 1%, 1/2W res. Check total current draw. It should be ~122mA
- ❑ Activate the attenuator. You should hear the relay click and current draw should rise to 144mA.
- ❑ Attach the four rubber feet to the bottom of the enclosure.
- ❑ Install the PCB in enclosure using 3/16" black screws and 1/4" standoffs. Loosely install the standoffs on the bottom, and then slide the board into place, rear first. Attach the screws from the top while aligning the holes on the rear panel, then tighten the screws underneath.
- ❑ Install keycap on SW1.
- ❑ Install enclosure top.

Connections...



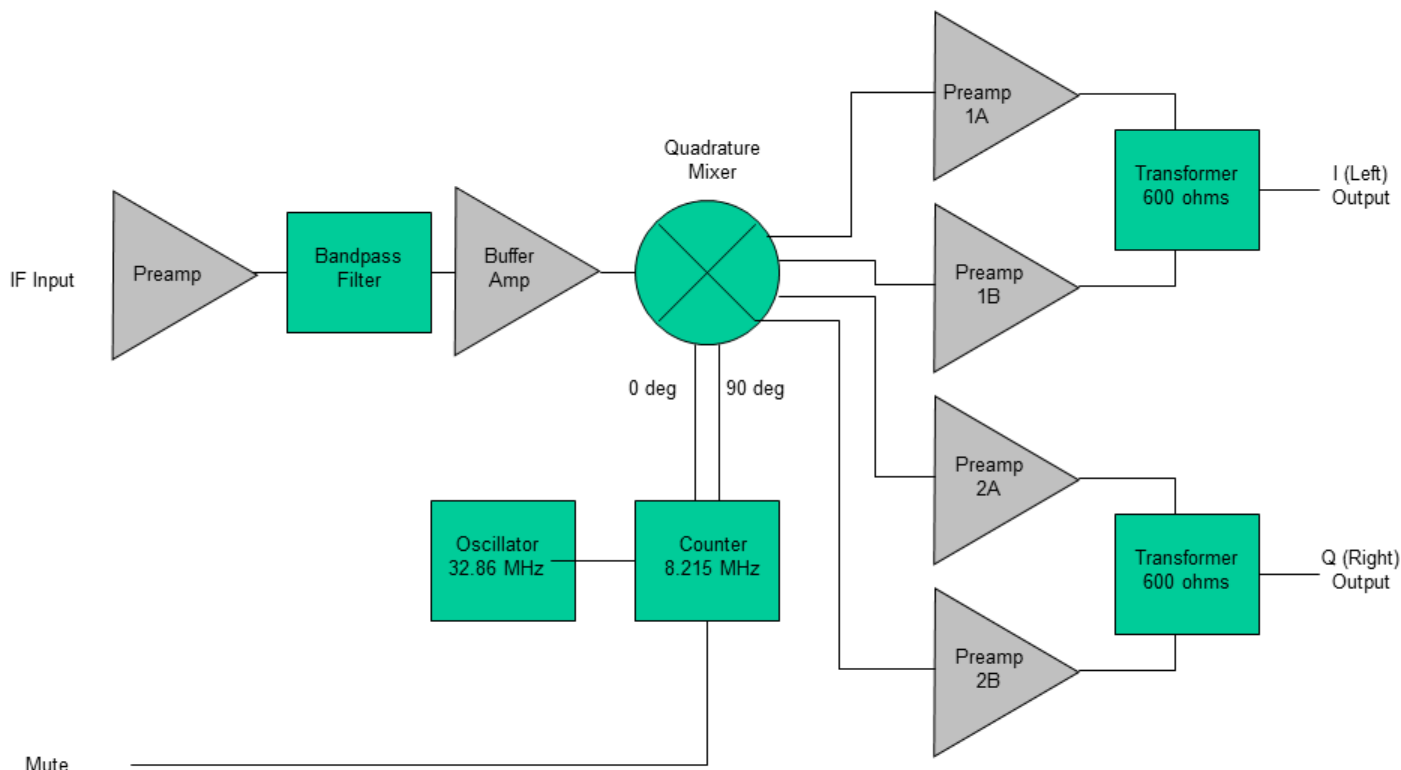
Power: 11-16 VDC, 140mA, center pin positive, 2.5mm. The lead with the white stripe on the supplied cable is +. Power can be derived from a wall wart, accessory power supply, RigRunner type manifold or the accessory power jack on the K3. In general, a supply with a linear regulator will provide lower overall noise floor and fewer visible spurs on the panadapter display than a switched regulator will.

Mute: Gnd to mute. 5VDC. This will not be used in most installations, a software mute is provided by the SDR software. See PowerSDR/IF or NaP3 help pages on the TelePost Inc. website for details.

IF Input: From rig's IF Output port.

I/Q Outputs: To sound card inputs. Outputs can be jumpered to be either balanced or unbalanced (unbalanced outputs require stereo jacks).

Circuit Description



LP-PAN 2 Block Diagram

LP-PAN 2 is a direct conversion quadrature receiver with baseband audio In-Phase (I) and Quadrature (Q) outputs. These outputs are fed to a high quality sound card for DSP processing in applications such as PowerSDR. The input is taken from the IF output connector of a receiver, and passes through a low noise preamp (3dB NF) with high IP3 rating (+40dBm). The signal has a very wide bandwidth, and is bandpass filtered in the front end of LP-PAN 2. This helps with out of band signals that are strong enough to get by the rig's input filters, and also blocks mixer products that might be present in the rig's IF output. Values shown are for Elecraft K3.

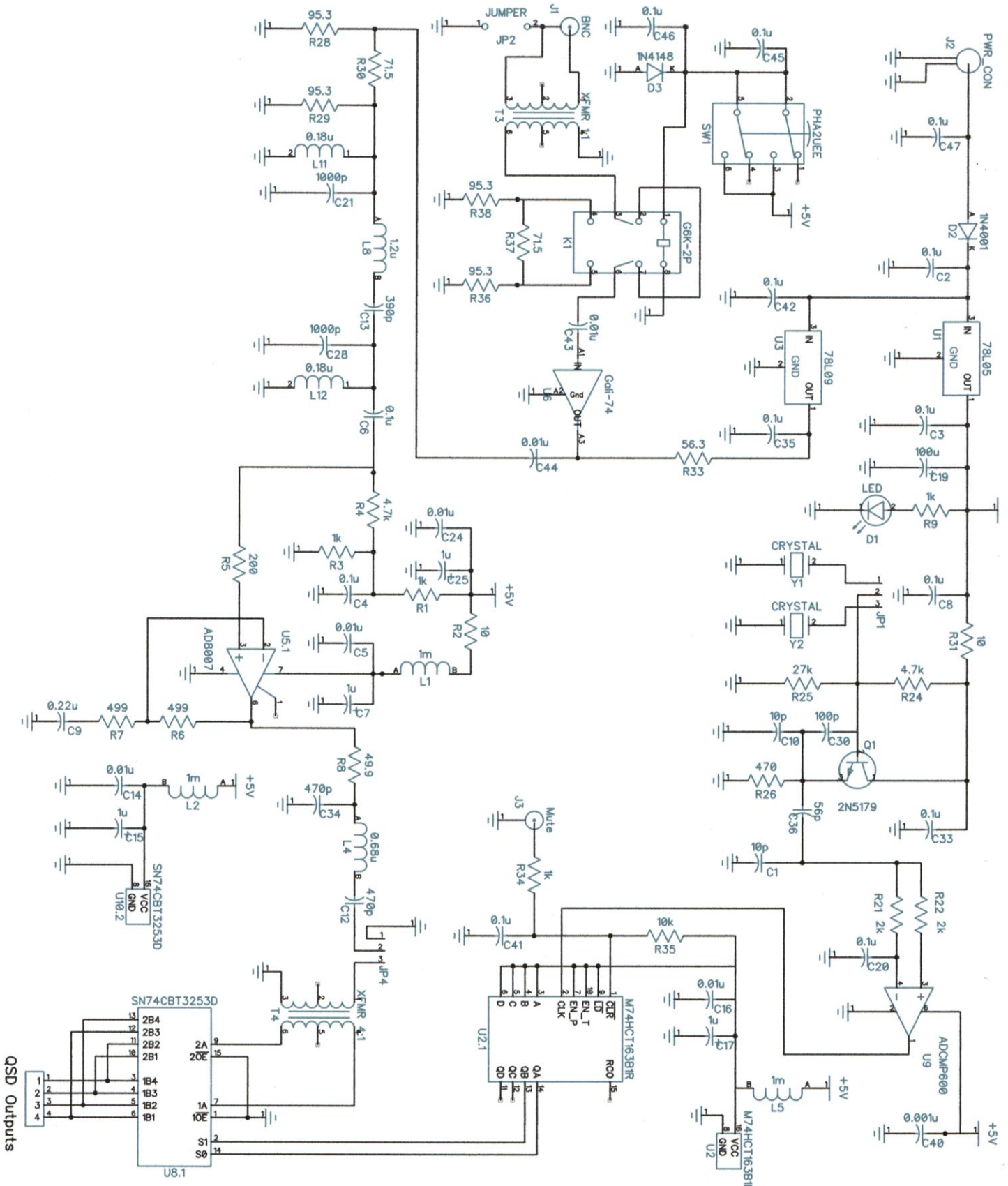
The filtered signal is then sent to a high isolation buffer amplifier. This amp isolates the rig from the strong L.O. signal present at the input of the quadrature mixer. The buffer amp has over 80 dB of isolation, and is capable of reducing the L.O. leakage to a level well below the rig's noise floor. The buffer has a high IP3 rating (>+40dBm) so as to not degrade the excellent IMD performance of rigs like the K3 and FTdx5000.

The quadrature mixer is operated in a doubly balanced configuration and provides balanced outputs to the audio preamps. Very low noise preamps with rail-to-rail outputs were chosen to maximize dynamic range. The preamps are direct coupled to a pair of very broadband Milspec transformers to preserve the balanced nature of the design, and minimize 2nd harmonic distortion. The outputs of the transformers can drive either balanced or unbalanced loads. The output Z was chosen to be low (150 ohms) to allow driving almost any sound card. We include internal 2K loads to set a maximum load Z when used with very high impedance sound cards. The load values were chosen experimentally for maximum gain and phase flatness.

By the selection of high quality precision parts, LP-PAN 2 provides a gain flatness of < 0.5% over the 100 kHz bandwidth of the audio chain, as well as a peak-to-peak phase error of under 0.5 degree. This contributes greatly to the high image rejection of LP-PAN, even with programs that use only one setting for gain/phase correction. With programs like Rocky, PowerSDR/IF and NaP3, which use dynamic gain/phase compensation, image rejection is about 80-90dB.

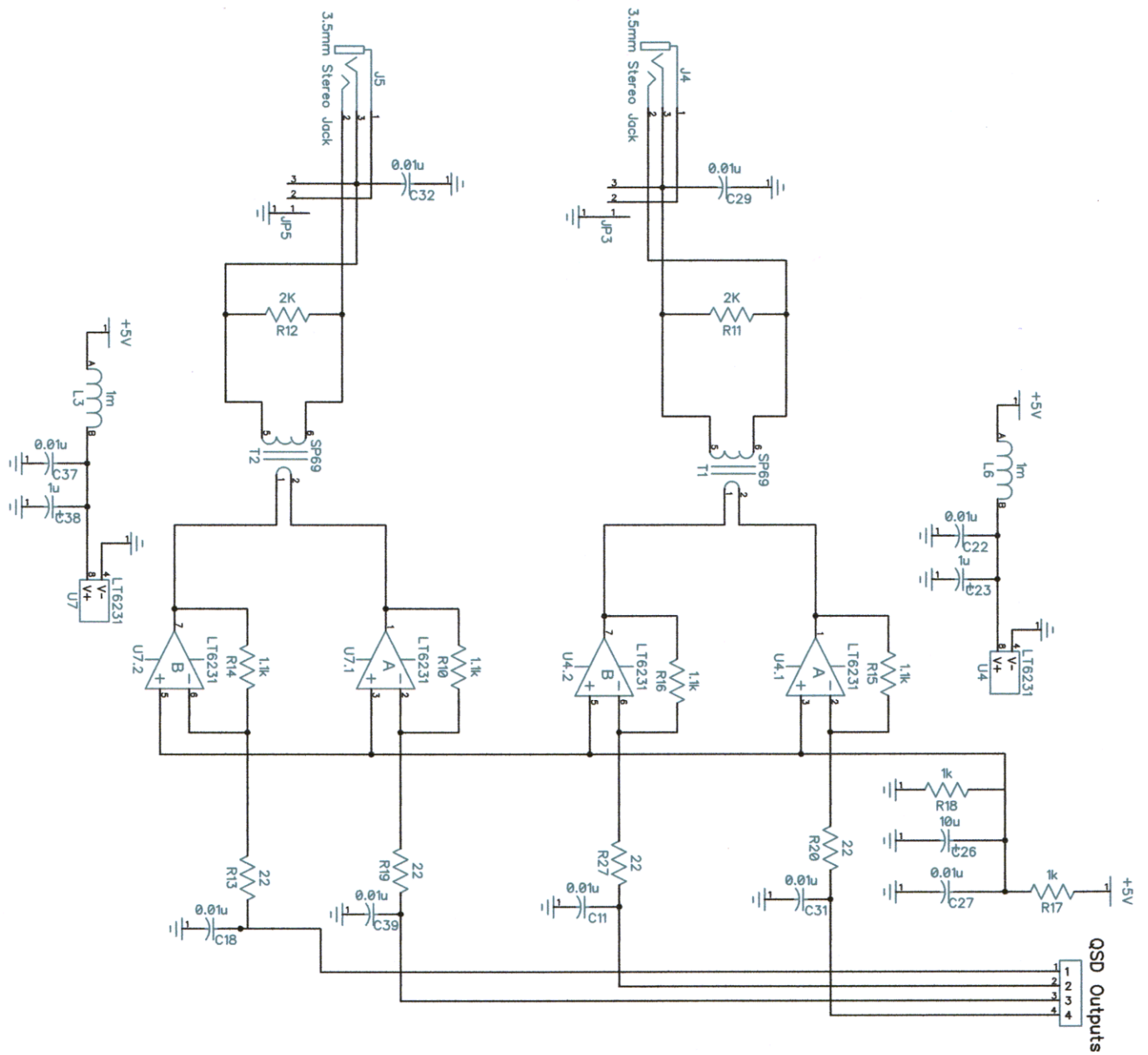
Schematic 1

Note: For best results, print schematics.



Schematic 2

Note: For best results, print schematics.



Specifications

Preliminary data subject to change without notice.
(sound card dependent... measured with E-MU 0204 USB sound card)

Measured with K3.

- * Approx. -140dBm noise floor with K3 preamp on
- * +5dBm maximum input with K3 attenuator on
- * ~115dBm single tone dynamic range from noise floor to clipping point
- * >80dB typical image rejection with PowerSDR-IF or NaP3 (using WBIR).
- * Better than +20dBm IP3 with two -15dBm signals spaced 2 - 20 kHz (composite value for K3/LP-PAN 2 combo)
- * THD ~ 0.005%
- * L.O. leakage, -110 dBm to -140 dBm (buffer inside K3 provides additional ~50dB)
- * 150 ohm output Z, balanced or unbalanced.
- * +2dBV (1.27 Vrms, 3.6V p-p) nominal output level at recommended maximum RF input
- * 8215 kHz, 8830 kHz, 9000 kHz, 4915 kHz, 10.55 MHz LO frequencies available
- * 11-16 VDC @ 140 mA
- * Dimensions: 5.125"(13.02cm) Deep x 5.375"(13.65cm) Wide x 2.125"(5.4cm) High

For more performance measurement data, see the LP-PAN 2 page on the TelePost Inc, website, at <http://www.telepostinc.com/LP-PAN.html>

For an up to date comparison of sound cards, check out the Sound Card page on the TelePost Inc, website. at <http://www.telepostinc.com/soundcards.html>

Warranty

Factory assembled LP-PANs are warranted against failure due to defects in materials and workmanship for two years from the date of purchase from TelePost Inc. Warranty does not cover damage caused by abuse, accident, improper or abnormal usage, improper installation, alteration, lightning or other incidence of excessive voltage or current.

Units built from kit are only covered against failure due to defects in materials, with the further limitation that any parts damaged as a result of improper kit assembly are not warranted. Parts delivered damaged or missing will be replaced by TelePost Inc. at company's expense, including shipping.

If failure occurs within the warranty period, return the LP-PAN 2 to TelePost Inc. at your shipping expense. The device will be repaired or replaced, at our option, without charge, and returned to you at our shipping expense. Repaired or replaced items are warranted for the remainder of the original warranty period. You will be charged for repair or replacement of the LP-PAN 2 made after the expiration of the warranty period or where, in our reasonable opinion, the damage is due to improper assembly of the kit.

TelePost Inc. shall have no liability or responsibility to customer or any other person or entity with respect to any liability, loss or damage caused directly or indirectly by use or performance of the product or arising out of any breach of this warranty, including, but not limited to, any damages resulting from inconvenience, loss of time, data, property, revenue or profit, or any indirect, special incidental, or consequential damages, even if TelePost Inc. has been advised of such damages.

Under no circumstances is TelePost Inc. liable for damage to your amateur radio equipment resulting from use of the LP-PAN 2, whether in accordance with the instructions in this Manual or otherwise.