LP-100

Digital Vector HF Wattmeter

Operating & Assembly Manual

June, 2006
TelePost Incorporated
Rev. B2

Compliance Statements…

Federal Communications Commission Statement (USA)

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

European Union Declaration of Conformity

TelePost Inc. declares that the product:

Product Name: Digital Vector RF Wattmeter
Model Number:LP-100
Conforms to the following Product Specifications:

EN 55022: 1998 Class B

following the provisions of the Electromagnetic Compatibility Directive 89/336/EEC, tested and verified 3-17-2006 at FCC accredited laboratory.

Industry Canada Compliance Statement

Canada Digital Apparatus EMI Standard

This Class B digital apparatus meets all the requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numerique de la classe B respecte toutes les exigences du Reglement sur le material brouilleur du Canada.

Copyright and Trademark Disclosures

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Introduction

The LP-100 is designed as an accurate instrument for monitoring station performance. It provides a number of unique features not seen before in a ham radio wattmeter.

The most obvious of these is the vector display. This display shows the complex impedance of the load in two ways. The top line of the display shows impedance in polar form… i.e., magnitude and phase of the impedance. The bottom line shows the real and imaginary components of impedance… i.e., R +jX. The parameters are displayed in a range of 0.1 to 999.9 ohms. Phase is displayed in 0.1 degree increments from 0-180 degrees.

Features include…

- PLED display with bargraphs for power and SWR, along with numerical readout for both
- Professional dBm / Return Loss display
- 50 mW to 2500W with four autoranging scales
- Power display resolution of 0.01 to 1W depending on scale
- Frequency coverage of 1.8-54 MHz, with automatic band-by-band compensation
- Z, R, X display from 0-999.9 ohms each
- Separate coupler with 50 ohm ports for uncluttered desktop
- Peak-hold numerical power readout with "hang" characteristic for power and SWR
- SWR accuracy < .15 (5%) from about .1W to 2500W, <.10 typical
- Power accuracy is 5% typical at any rated power level or frequency from .5W to 2500W after calibration, usable to 0.05W
- Can be easily matched in the field to external standard to within 0.1% on each band
- Power display is actual power delivered to the load (Fwd minus Ref power).
- SWR Alarm system with set points for Off, 1.5, 2.0. 2.5 and 3.0.
- Windows freeware Virtual Control Panel for software / remote control
- Support within TRX-Manager for direct remote monitoring
- Advanced charting capability for SWR, RL, Z, R, X and phase angle vs. frequency
- Built-in bootloader to allow for firmware upgrades to be downloaded and installed.
- Call sign screen saver to extend life of display
- Conforms to FCC Part 15 A & B, ICAS and CE radiated emission limits, tested and verified by accredited lab

This manual will address the assembly of the LP-100, initial checkout, calibration and operation. You may wish to read through the circuit description and study the schematic before beginning assembly to familiarize yourself with the project. It is highly recommended that you thoroughly read through the **Assembly** section before even unpacking the LP-100 kit.

Parts List

Pre-installed SMT parts

QTY	Part No.	Description
4	C9,10,12,13	0.01uF 50V
2	R4,18	Resistor 26.7 1% .25W
2	R5, 12	Resistor 49.9 1% .5W
2	R6,21	Resistor 56.2 1% .25W
2	R9, 27	Resistor 56.2 1% .5W
2	R10, 20	Resistor 422 1% .25W
1	R24	Resistor 174 1% .25W
1	R30	Resistor 120 1% .25W
1	R33	Resistor 32.6 1% .25W
1	R35	Resistor 75 1% .25W
1	D8	HSMS-2805 dual Schottky diode
1	U1	AD8302
1	U9	AD8367
1	U10	Gali-74 MMIC
1	T1	ADP-2-1 Transformer

Parts to be installed – main chassis

QTY	Part No.	Description
15	C1,2,5,6,7,11,14, 20,22,27,32,33,40,42,43	0.1uF 50V marked 104
2	C3,41	10uF 50V
1	C4	0.33uF 50V marked 334
8	C8,21,28,29,30,34,38,39	0.01uF 50V marked 103
7	C15,16,17,18,19,31,35	1uF 50V marked 105
2	C23,24	0.001 marked 102
2	C25,26	0.002 marked 202
1	C36	330pF 50V marked 331
1	D2	Rt. Ang. LED Red
1	D3	Rt. Ang. LED Green
1	D4	1N4001
1	D5	1N4148
1	RC1	ribbon cable assembly
2	J1,P1	16-pin DIL header for display
2	J2,7	BNC jack, rt. angle
1	J3	Power jack 2.5mm
1	J4	DB9 PCB mount
1	J6	Dual RCA PCB mount
1	JP1	2-pin SIL header & jumper
5	L1,2,3,5,7	1mh molded choke
2	L4, 6	470uH molded choke
1	Q1	2N4401
1	LCD-1	PLED display 20x2
2	R1,13	1M 1% 1/8w br-bl-bl-yel-br
3	R2,41,42	10k 5% 1/8w br-bl-or
2	R3,17	390 5% 1/4w or-wh-br (changed to 1K after ser. # 36)
6	R7,11,14,16,34,36	1k 5% 1/8W br-bl-red
1	R8	20k pot
1	R15	22k 5% 1/8W red-red-or
2	R19,29	4.7 5% 1/4W yel-viol-gold
1	R22	150k 1% 1/8W br-grn-bl-or-br
2	R23,25	10k 1% 1/8w br-bl-bl-red-br
1	R26	6.34k 1% 1/8W blue-or-yel-br-br
1	R31	100 5% 1/8W br-bl-br
1	R32	174 1% 1/8W br-viol-yel-bl-br
1	R37	57.6 1% 1/4W grn-viol-blue-gold-br (blue body)
1	R39	120 1% 1W br-red-bl-bl-br (rust color body)
1	RL1	Omron G5V-2-H1-DC5

Parts List cont'd

QTY	Part No.	Description
1	S1	CEM-1212C Piezo transducer
3	SW1, 2, 3	4mm tactile switch, rt. Angle & keycaps
1	T2	Toroid core FT37-61
1	U2	LM7805
1	U3	18F252 PIC
1	U4	TLC-271ACP
1	U5	MAX6225BEPA
1	U6	MAX232N
1	U7	LM34DZ
1	U8	MCP3304
1	Y1	Resonator 10 MHz
1	Pwr Cable	
1	Enclosure	Main
1	PCB	Main
1	Heatsink	for 7805
2	IC Socket	8-pin
2	IC Socket	16-pin (I no longer use a socket for the relay)
1	IC Socket	28-pin

Parts to be installed – coupler

QTY	Part No.	Description
1	Enclosure	Coupler
1	PCB	Coupler
2	T1, 2	Toroid cores FT140-61
2	UHF Connector	SO-239
2	BNC Connector	UG1094/U
2	BNC cable	6' M/M - RG174U
4	R3, 4, 9,10	75 ohm 1% 1W (2512 SMT)
8	R1, 2, 5-8, 11,12	301 ohm 1% 1W (2512 SMT)
2	Nylon bushings	One with 3/16" hole, one with ¼" hole
6	Adhesive Teflon® tape	2 long and 4 short pieces
1	Terminal Strip	2 lug terminal strip
1	Adhesive Label	Coupler Top Label

Parts to be installed – hardware

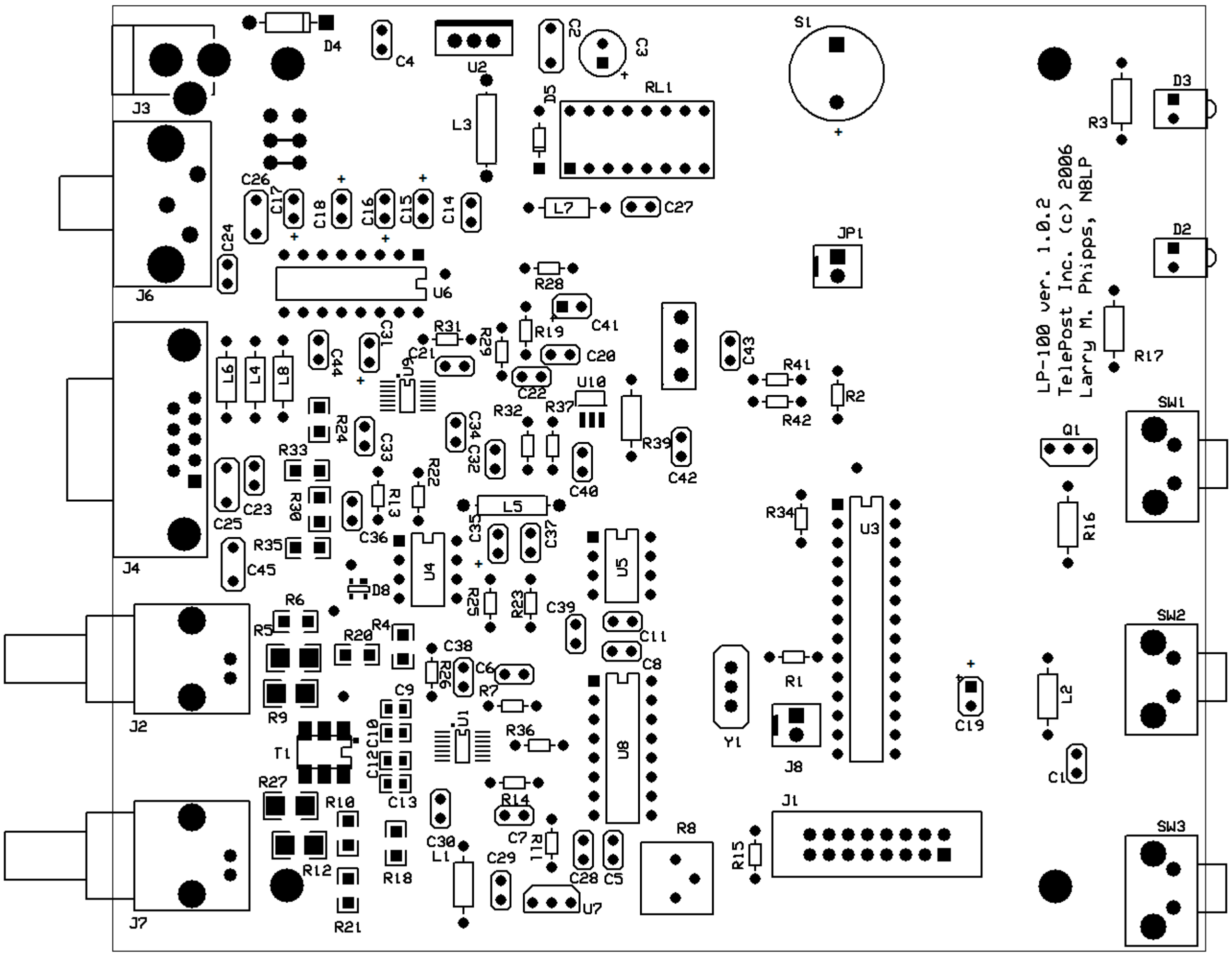
QTY	Part No.	Description
16		4-40 x 3/16" machine screws - black
13		4-40 nuts – 9 large, 4 small
8		4-40 x ¼" threaded standoffs
1		4-40 x 1.5" threaded standoff
6		#4 self-tapping screws – (1) ¼", (5) 3/8" – black
14		#4 self-tapping screws – ¼" – plated
15		#4 lockwashers
10		4-40 x 3/8" machine screws(for SO-239s and DB-9) starting with ser. #71
5		4-40 x 1/4" machine screws(remaining coupler screws and U2 heat sink)
8	Rubber Feet	(4) square for controller, (4) round for coupler
1		#4 Solder Lug
1	#20 wire for coupler xfmrs	(2) 45" lengths
1	#28 wire for controller xfmr	(2) 6" lengths
1	RG-142B/U Teflon® coax	(1) 2" length
1	RG-316U Teflon® coax	(1) 2" length
1		.25" piece of shrink wrap tubing

You should check all parts before starting to allow you to start the process of obtaining replacement parts as soon as possible. It is also a good idea to sort the parts in advance… egg cartons are handy for this (passive parts only). Note that the mix of hardware has changed a little over time. This was done in part to make sure that the screws for the long standoff post in the coupler don't bottom out.

Assembly

Overview

Below is a parts layout of 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. Note that several components with markings on the board are not included in the final product, namely… C37, C44, C45, R28, L8 and J8. J8 will be provided as part of a possible future external analog meter display option. Also, there are two artwork mistakes on the board. One requires the addition of a jumper from U4 pin 7 to pin 8. The other requires the reversal of U7.



All of the SMT components are pre-installed on this board for your convenience. SMT parts are supplied wherever necessary for performance or availablility 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.

At this point, it would be very smart to inspect all the solder pads for any problems, especially for early serial numbers. As of this writing, I have assembled (8) boards without a problem, but I had a customer email me with a picture of a pair of bad pads on U4 that weren't fully etched through and as a result the pads had a bridge to ground. Starting at serial # 0027 I started visually inspecting all the boards before shipping. I would recommend the builder do a second inspection as well.Better safe than sorry.

I recommend approaching assembly in the following order…

Install all IC sockets
Install resistors
Install capacitors
Install connectors and switches
Install 7805 regulator
Install chokes selectively

Assembly cont'd

This allows the board to remain flat during most of the construction. Following this order will also facilitate initial checkout. The chokes will be selectively installed to allow for checkout of various sections of the circuit.

Checkout will follow this order…

Verify proper +5vdc before powering any devices
Install L2, PIC and PLED and check display for proper PIC operation
Install L1, L3, U5, U7 and U8 and verify proper operation of ADC
Install L5 and U4 and verify proper power detection
Install L7 and verify proper frequency counter operation
Install U6 and verify proper serial port operation

The above checks will require only a DVM and the Calibration screens except for the power display check. To check the power display, you will need a transmitter and completed coupler. I will list expected current drain in red at each step so that you can verify that nothing is shorted in each section.

To calibrate the power readings of the LP-100 will require a minimum of an accurate 50-ohm dummy load and a means to measure rf voltage. A Cantenna type of load is not generally a good choice. The dummy load will need a diode peak detector output or you will need a calibrated oscilloscope to measure p-p rf voltage across the load. An alternative would be an accurate reference wattmeter.

To calibrate the impedance gain and phase detectors you will also need a 25 or 75 - 100 ohm dummy load. This can be easily made up out of inexpensive 3W, 5% metal oxide resistors, such as used in my LP-200 or the Elecraft DL-1. This calibration can be done with as little as 1W of power.

Alternatively, you can use a pair of 50 ohm dummy loads with coax adapters to allow them to be paralleled to provide 25 ohms. SWR calibration requires setting offset and slope adjustments for the AD8302 gain detector. Calibration of the AD8302 phase detector requires a delay line of known electrical length. You can get pretty close by using a high quality piece of poly dielectric RG-58, and calculate the electrical length in degrees using the following formula…

$$\text{Phase} = (360*L*F)/(984*VF)$$

Where Delay is in degrees, L is in feet and F in MHz. VF would be 0.66 for poly dielectric. Any convenient length of about 5-10' is acceptable, which would provide a delay of ~39 to 78 degrees at 14 MHz. You will find more about calibration in the **Calibration** section. I am contemplating an inexpensive calibration kit in the $25 range, which would include a switchable dummy load PCB and pre-cut delay line. I will also calibrate any assembled LP-100 kit free of charge if you will pay round-trip shipping to me.

You will need the following tools to complete assembly…

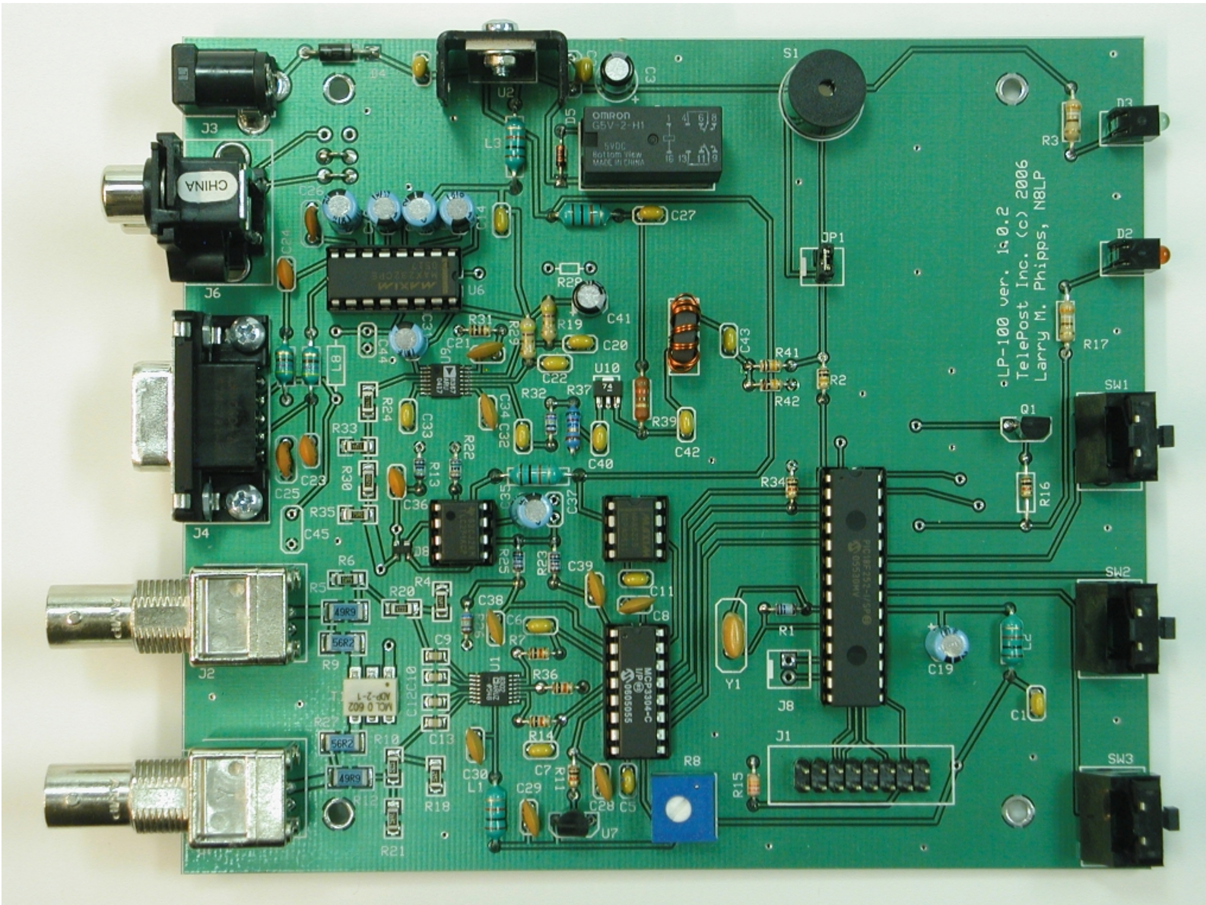
30-60W adjustable soldering iron
60/40 alloy solder… .020" diameter recommended for thermal pads
Needle-nose pliers
Wire cutters
Small Philips head screwdriver
Razor knife
Digital Multimeter

NOTE: The LP-100 is what I would call an intermediate level kit. If care is taken, you should have no difficulty building it. I would peg the assembly time at about 8 hours total, along with some reading through the manual in advance, and some time for calibration. Take your time, and double-check your work. It is somewhat difficult to cleanly remove incorrect parts which have thermal ground pads on them. I found in the many boards I have assembled that the thermal pads will accept solder well if you place the tip of the iron at the junction of the pad and wire. Extra heat may be required on these pads, however. I plan to eliminate the thermal pads on the top of the board and add more vias to compensate on future boards.

Assembly cont'd

Step-by-step assembly instructions for main board.

Below is a picture of the assembled PCB. The SMT parts come pre-installed.



It is recommended that you print this manual to allow for easy reference while building, and to allow you to check off the steps as you complete them. There will also be a table of calibration values you can enter as you do the calibration. This will enable you to return to the original settings should you need to in the future.

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. Refer to the parts placement graphic on page 6 for questions regarding parts placement. You can zoom into the pdf version of this document for easier parts identification if needed.

q Install all IC (and relay) sockets, keeping the board flat as you go to avoid gaps. Add a jumper wire from U4 pin 7 to U4 pin 8 at this time. This wire needs to be insulated from ground.

q Install resistors. To avoid messiness when trimming leads, I would do about 6 at a time. If you are unsure of the colors used by some of the manufacturers for the color code, measure the value with a DMM.

q Install all .01 uF caps (marked 103).

q Install all .1 uF caps (marked 104). This should be done in at least two batches.

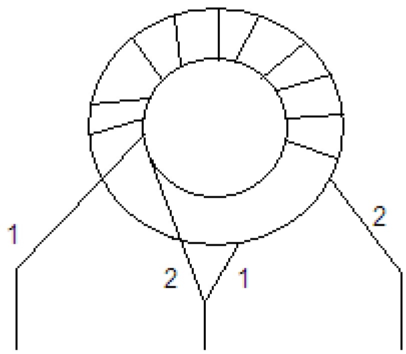
q Install remaining caps, leaving the 10 uF caps for last. Observe polarity on electrolytics. You may have to form the leads of the 1 uF caps to fit the small spacing of the holes. Also, some kits may be supplied with electrolytics for the 1 uF caps. Refer to the component placement guide for proper polarity since it is not marked on the silk-screen.

Assembly cont'd

q Install miscellaneous parts such as resonator, Piezo transducer, etc. NOTE: Remove the protective covering on the transducer before using. Also, the "+" lead goes to the side with the jumper, per the placement guide. Do not install chokes yet.

q Install connectors and switches. You will probably have to prop sections of the board up to ensure that the parts are flush with the board. Install the header on the PLED PCB. The header is installed on the back side of the PLED PCB with the long pins pointing away from the board.

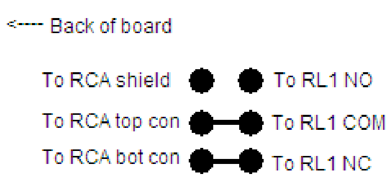
q Install 7805 regulator. Attach heatsink to the regulator before installing on PCB, using 4-40 x ¼"" machine screw and small hex nut.



q Install T2. This is a toroid xfmr. It is made up of 10 bifilar turns of the #28 enameled wire wound on a FT37-61 core. Bifilar means that the two wires are wound as a pair. See diagram above for wiring. Note: The drawing is representational, it does not show the actual number of turns. A turn is defined as a pass through the center of the core. Use an ohmmeter to verify the correct wiring. You will wind up with three leads, which will be inserted into the three holes indicated on the silk-screen. The lead with two wires goes to the center hole in the PCB. Make sure that the enamel is removed from then leads before soldering to ensure good contact.

q Install L4 and L6. The remaining chokes will be installed as part of the initial checkout of the board, in order to enable powering up of circuits individually.

q The jumpers for the PTT connector can be wired now. The normal wiring is shown on the component placement diagram at the beginning of this chapter, and below. This provides for a normally closed connection between the center conductors of the two RCA connectors. This will work for most rig/amp combinations. For more options for PTT wiring, check out the SteppIR Tuning Relay section of my webpage.



Normal connection for PTT loop-thru. The RCA connector wires go to the respective center conductors of the stacked jack. This configuration breaks the normally closed PTT connection from the rig to the amplifier when the alarm goes off.

q Attach the DB-9 connector to the PCB using 4-40 x 3/8" screws and small hex nuts.

q You can install RL1 at this time. The correct positioning is with the two separated pins toward the back of the board, next to the snubber diode, D5. I used to supply a socket for this, but have decided that there's really no need for it, and there's a risk of the relay working loose during shipment.

Assembly cont'd

Initial checkout of main board.

q Step 1. Make sure that your bench is clean and the PCB is not sitting on any cut off component leads. Connect supplied power cable to a supply of 12-15 VDC. The dashed white lead on the supplied power cable is the +lead (center pin). Using your DMM, check for 5.0 VDC at pin 3 of U2. The voltage should be within 0.25V of 5.0 VDC. ~7 mA. Note: All current readings are with the new 1K resistors installed instead of 390 ohm for the LED series resistors. They will be about 10 mA higher with the 390s.

q Remove power and install L2, U7, Y1 and the PIC. Remember that the silkscreen is backwards for U7. Temporarily connect the PLED display. Be careful to make sure there is nothing on your bench which could short out anything on the PLED PCB. The ribbon cable should be oriented as shown in the interior photo below. Make sure that the ribbon connectors are centered on the headers at both ends.

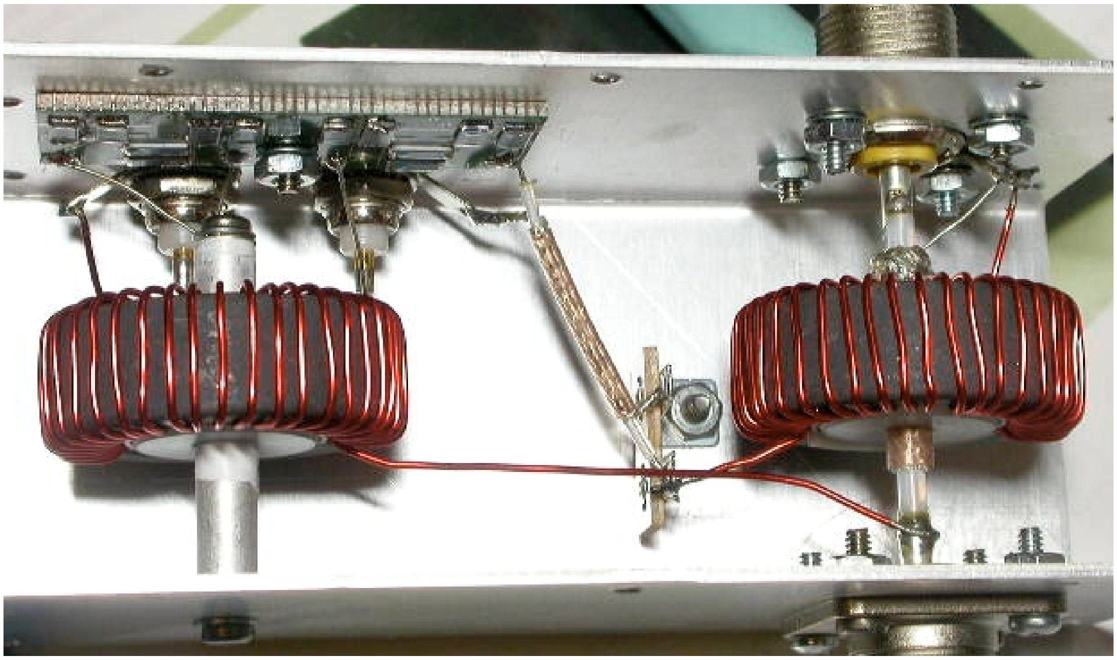
q Step 2. Power the board up again, and verify that you are seeing the "splash" screen with version and copyright information, followed by the main LP-100 screen. The screen should look like the screen on the photo at the top of the "Operation" section of this manual. You may have to play with R8, the PLED brightness pot to see this. If you don't see the display, see the troubleshooting section. The proper setting for the brightness pot is just at the point where the display reaches maximum brightness. This will ensure that the brightness drops to the proper level when the first step of the screen saver timer is reached. A finer adjustment can be made after the screen-saver starts. The correct voltage for the PLED at the junction of R8 and R15 is 3.0V at full brightness, approx. 2.4V in the screen saver mode. ~35 mA

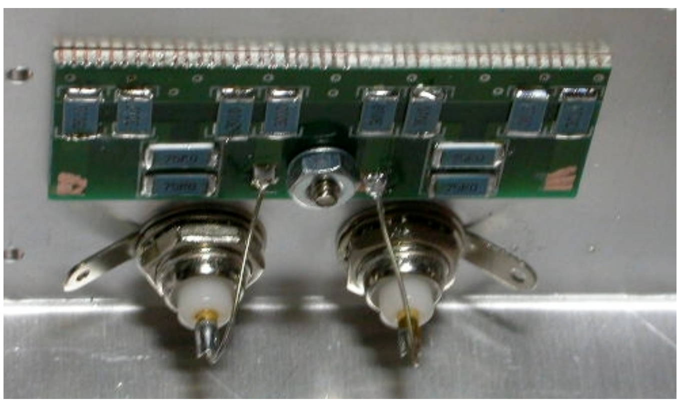
q Step 3. Install L1, L3, U5, and U8. ~82 mA. Temporarily enter the Calibrate mode by briefly pressing the Mode and Alarm buttons almost simultaneously. The Mode button should be pressed slightly ahead of the Alarm button. You should now see the first Calibrate screen, called "Offset". Once in the Calibrate mode, press the Mode button repeatedly until you get to the "Reference" screen. You should see something similar to the following. This screen shows the reference voltage generated by U1 (the gain/phase detector), the Received Signal Strength Indicator voltage from U9 (the AGC chip) and temperature in degrees F and C (from the temp sensor, U7).

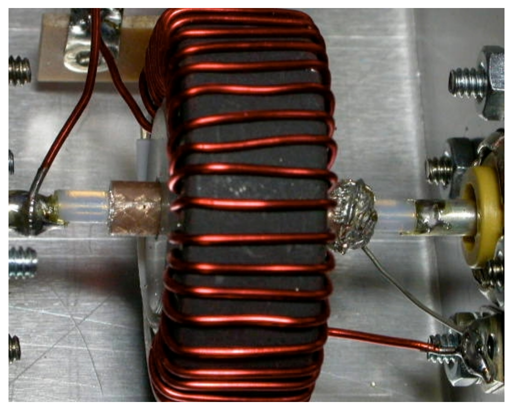
q Step 4. Install L5, L7, U4 and U6 and check the current. ~160 mA. If all is well, set the board aside until the coupler assembly is completed to allow checkout of the power detector circuit and frequency counter.

Assembly cont'd

Step-by-step assembly instructions for directional coupler.







Refer to the drawing and pictures during assembly of the coupler. These pictures are courtesy of Stan, W5EWA. Construction of the coupler consists of only a few steps. The main components are the transmission line, toroidal transformers and the attenuator PCB. The most critical step is the winding of the transformers. They are wound with 26 turns each of #20 enameled wire. The cores are wound in opposite directions, i.e. they should be mirror images of each other. The windings should be evenly spaced over ~60% of the core, as shown later. The cores are supported by nylon bushings, which are inserted into the core centers after winding. If the wires are wound tightly, the cores should fit snugly, but should not have to be forced. The cores should be wound by hand, don't use any tools on the cores or wires as they may break.

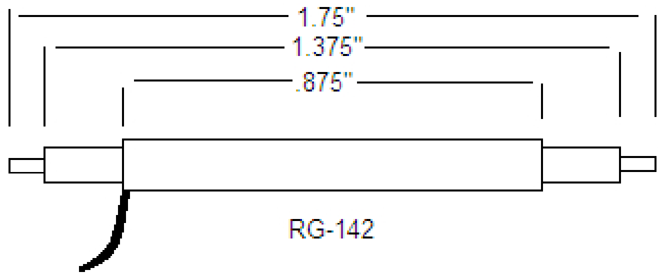
The bushing with the smaller hole is mounted between the SO-239 connectors, and supported by the RG-142 Teflon® coax. This piece of coax forms the primary winding of the current sampling transformer. The other transformer is supported by a long standoff which forms the primary of the voltage sampling transformer. One end of this standoff is grounded, and the other connects to the attenuator PCB. This standoff also includes a wrap of Teflon® plumbers tape to allow a tight fit. The transformer secondaries are wired as shown in the drawing. It is important that the cores be positioned as shown, and the wires be routed as shown. Improper routing or core orientation will affect performance, especially above 30 MHz.

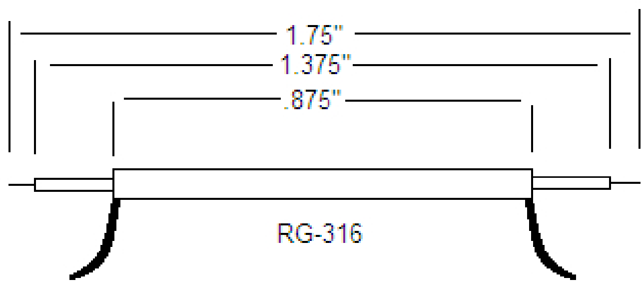
- q Install the two SO-239 UHF connectors using 4-40 x 3/8" machine screws, #4 lockwashers and large #4 hex nuts for 7 of the mounting holes. The remaining hole, uses 4-40 x 3/8" hardware and a solder lug as shown. The solder cups on the SO-239s should be facing upward.

- q Solder two short pigtails about 1.5" long into the center pin of the two BNCs. You can use cut ends from other parts for this. Install the two BNC connectors using the supplied special hardware, including solder lugs, as shown.

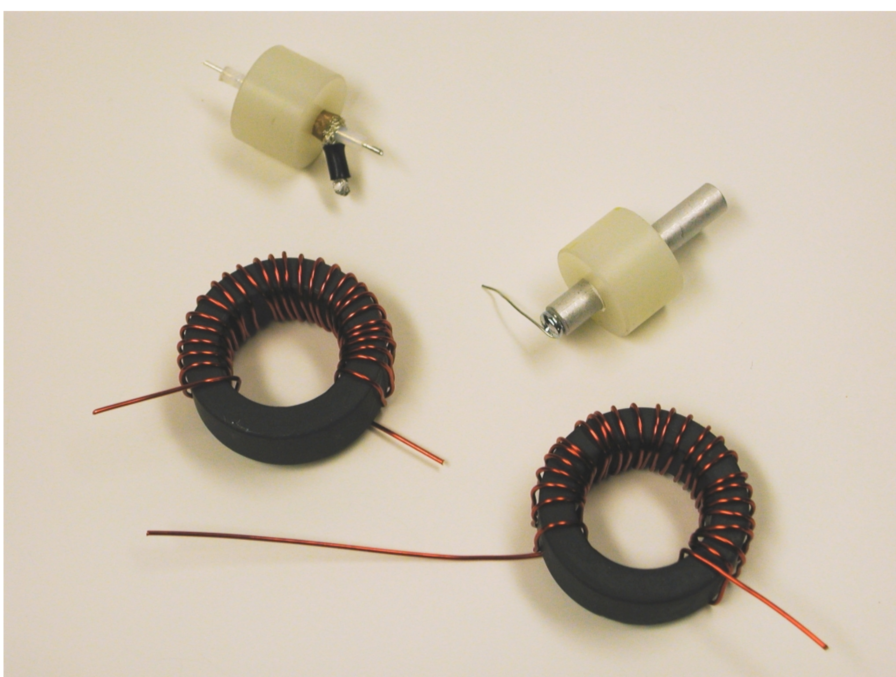
Assembly cont'd

- **q** Prepare the two pieces of coax as shown in the diagram. Make sure that the shield wires don't short out to the center conductor on either end. RG-142 is double silver shielded. You may find it easier to remove the outer shield to keep the twisted shield connection more flexible and easier to work with. Slip a short piece of heat shrink tubing over the shield and heat with a heat gun or hair dryer. An alternative, shown in W5EWA's pics above, is to cut the shield short, and then wrap a short pigtail of wire around it.



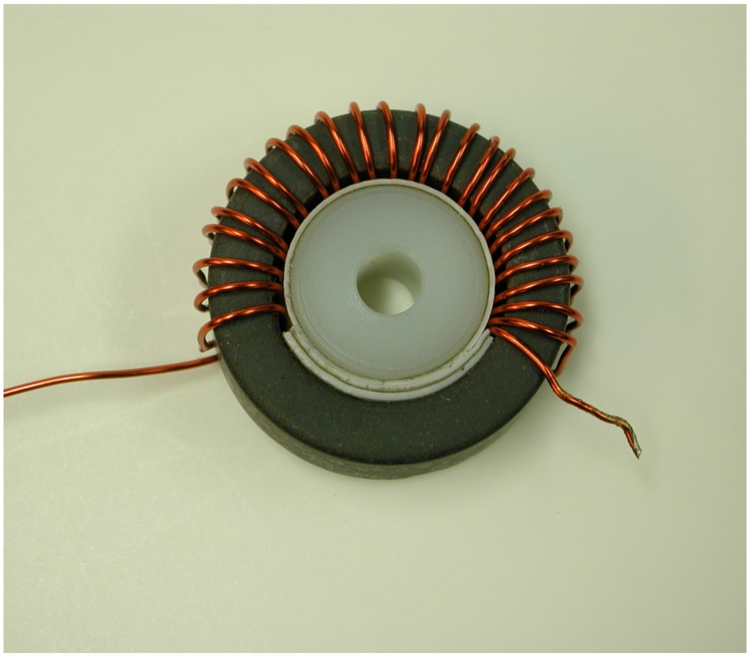


- **q** Wind 26 turns of #20 enameled wire on each of the FT140-61 cores.. The cores will be wound in opposite directions, so that the finished toroids will be mirror images of each other. A winding is defined as the wire passing through the center of the core. If you count windings on the outside edge of the core, your count will be one short of the actual number of turns. Mis-counting by one turn will give you a power reading error of 8%, and cause other problems as well. The current sampling xfmr is installed between the SO-239 connectors, and will be supported by the short piece of Teflon® coax. The voltage sampling xfmr is supported by the long standoff. Leave pigtails as shown on the wires for now, and scrape the enamel off the ends of the short leads. A razor or sandpaper is good for this. The short ones are 1" long, and the long one is 3"long. Wind the wire tightly. Use your fingers to keep the windings formed close to the cores on the inside.

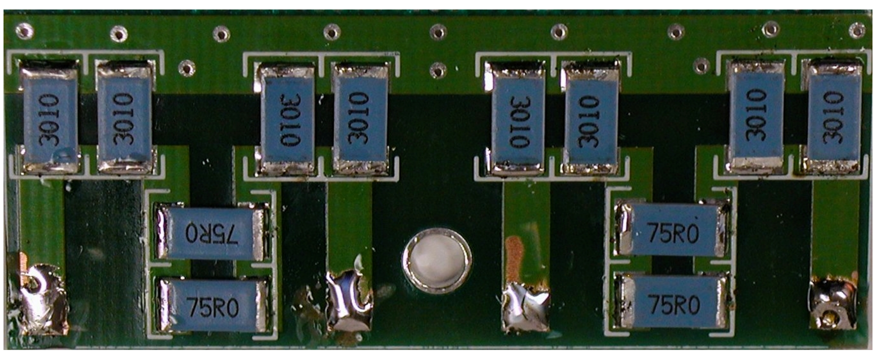


Assembly cont'd

- **q** Before slipping the nylon bushings into the wound cores, take the two long pieces of Teflon® tape, peel the paper off of the adhesive side, and wrap each of the nylon bushings with the Teflon® tape. Then take the medium pieces, remove the paper, and stick them in the cores between the windings, with the thicker one against the core. This will make for a tight fit inside the toroid cores, and will also serve to keep the windings properly positioned around the cores. Before sliding the cores in place, make sure that the inside of the windings is flat against the cores. Be careful when pushing the cores in place not to dislodge the Teflon® tape. See the picture below…



- **q** Solder the 12 SMT resistors onto the attenuator board as shown. Don't be afraid of this. These are VERY big parts as SMT goes. The resistor values are printed on the resistors. Use a fine tip on the soldering iron, and tin ONE of the PCB pads for each resistor with a small amount of solder before attempting to solder the resistors. Hold the resistors in place with a tweezers, and apply a little heat to the edge between each pad and the board until the solder flows between the resistor and pad. It is helpful to slide the resistor over the pad as it melts onto the solder drop, so that the other end exposes a little of the pad on the other side. Solder the other side in place by applying heat and solder to the edge where the resistor sits on the pad. Then go back to the tacked pad and touch up if necessary. Applying a little flux to the board ahead of time will help to hold the parts in place and aid in solder flow. To verify the proper installation of the resistors, use an ohmmeter to check the resistance of each bare stripline connection to ground. The mounting hole is grounded, as well as the long strip along the top edge. Each point should be about 83 - 84 ohms. If not, check your soldering.



- **q** Install the PCB onto the side of the coupler above the BNCs as shown. The board mounts with the hole near the bottom edge. Bend and solder the pigtails from the BNCs to the two striplines near the mounting hole.

Assembly cont'd

- q Solder one the short piece of RG-316U prepared earlier to the solder terminal on the bottom of the coupler, with the coax shield connecting to the grounded lug, and the center to the lug that connects to the current sampling xfmr.

- q Solder the center conductor from the other end of the coax to the remaining PCB stripline pad, and the shield to the ground lug on the center-most BNC.

- q Slide the current sampling transformer over the short piece of RG-142 as shown in the diagrams, being careful to position the windings and the coax shield as shown. This is a tight fit, but if you take your time and rotate the coax as you press it into place, you shouldn't have any trouble. There seems to be a little variation in the diameter of the RG-142, so you may find that you need to file the inside of the bushing a little to allow a good fit. This can be done with a small rat tail file or a rolled piece of sandpaper.

- q Before soldering the coax into the solder cups on the SO-239s, verify that the sides of the case bottom are parallel. This is important so that there is minimal tension on the coax when the screws are installed to hold the case halves together. The xfmr should be oriented level with the windings facing up before soldering. Solder the coax into the SO-239 connectors, and the shield wireto the solder lug on the XMTR connector. Cut the wire from the outside left of the transformer secondary to length and solder it to the lug on the XMTR connector.

- q Cut and solder the wire coming from the inside right side of the xfmr to the insulated lug on the solder terminal.

- q Slide the voltage sampling xfmr over the long threaded standoff. I have wrapped the standoff with two layers of plumbers Teflon® tape. Push the xfmr over the end with the tape on it until it protrudes about ½". Hold the assembly up to the chassis to make sure that the xfmr is centered between the sides. Looking at the inside picture of the completed coupler, make sure the short side of the standoff protrudes from the side of the xfmr with the short lead. Trim the excess tape from the end of the standoff.

- q Take a small pigtail of about 2" length and install it on the end of the assembly which faces the attenuator board. Use 4-40 x 1/4" hardware.

- q Attach the assembly to the side of the coupler using 4-40 x ¼" hardware. The pigtail should be facing the PCB. It is important that this assembly be attached firmly or you will see erratic operation.

- q Prepare and solder the short end of the toroid winding so that it connects to the solder lug on the right-most BNC. If the core is mounted correctly, this wire should come off the right side of the core from the inside. Solder the pigtail from the standoff to the stripline pad on the end of the PCB.

- q The long wire coming off the outside left side of the core goes to the output SO-239 as shown. Scrape the end of the wire and form a loop to go around the SO-239 center conductor. The wire should follow the path shown. For best phase accuracy at 50 MHz, a little coupling to the current xfmr secondary is desirable. Be careful not to overheat the SO-239 center conductor when soldering the wire.

- q Make sure that all connections are soldered well, and that the cores are level and centered between the case walls. Slip the top on and attach with (14) 4-40 x ¼" sheet metal screws.

- q Clean and wipe the top of the coupler. Carefully line up the top label and apply starting at one end and smoothing as you go to prevent the formation of bubbles.

Final Checkout and Assembly

Before going through the CAL screens, it is necessary to verify that the remaining basic circuits are working. Power up the LP-100, and verify that the current draw is correct. 160 mA

Connect the Current and Voltage ports of the controller and coupler together using the supplied 6' coax cables. You may want to bundle the cables using electrical tape to make for a neater installation, but it would be smart to mark one of the cables so as not to get them confused at a later date, otherwise 25 ohms will be 100 ohms!

Connect a 50 ohm dummy load to the LOAD port. Select the Fast mode for the display (lower case "w"), and apply a small amount of power. The Power and SWR bargraphs should deflect upward, and the numerical readouts should display a number reasonably close to the expected value. Switch to the vector display, and you should see values close to 50 ohms for Z and R, and close to zero for phase and X.

Next, enter CAL mode and scroll to the Fine screen. You should see the band indicated in the lower left corner during transmission. This should match the band you are transmitting on. The Band indicator should remain on the last used band after transmission.

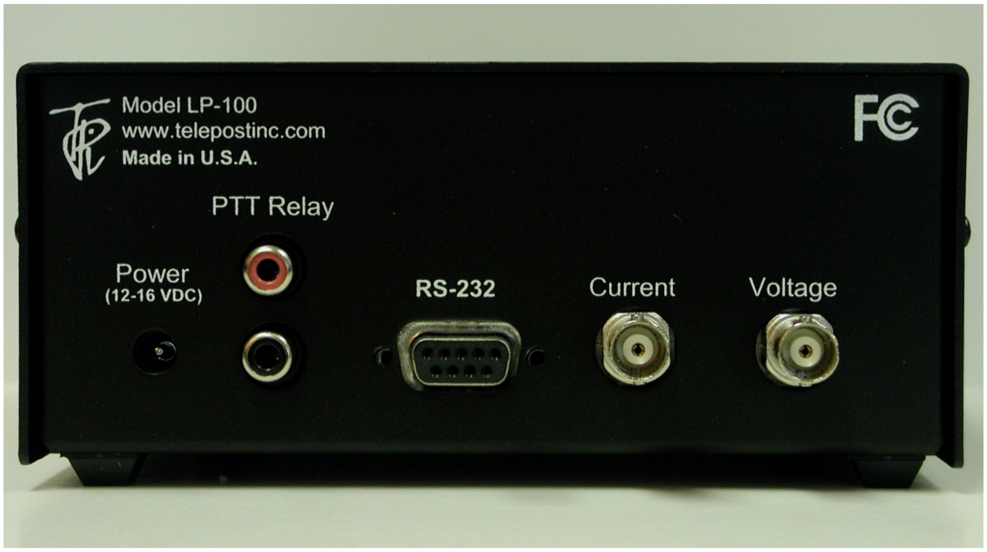
Assembly cont'd

Using the Alarm Set button, set the Alarm for "1.5". Remove the dummy load and transmit into the coupler at low power. The Red Alarm LED should light on the front panel, and the relay should click. If you have JP1 in place, the Piezo transducer should also sound. Note: the transducer will sound pretty loud since it's not inside a case at this point. Reconnecting the dummy load will cancel the alarm after a second or so. You can double-check the PTT connections with an ohmmeter at this time. The center conuctors of the RCA connectors whould be normally shorted together, and open with the alarm.

You are now ready to install the controller board in the case. First, install the 4-40 x ¼" threaded standoffs on the bottom of the case using 4-40 x ¼" black machine screws. Next, slide the board into the rear holes as you drop the front down toward the bottom. Be careful not to scrape the bottom of the board on the front panel as you slide it. You may have to bend the LEDs back a little to allow the board to slide down, and slightly press the switches as well.

Once the board is in place, align the front holes with the switches and LEDs, and screw the board down with four more 4-40 x ¼" black screws. The switch caps will be installed after calibration, in case a problem shows up that requires removal of the board from the case. The caps can be scratched during removal if they are installed.

Install the four remaining 4-40 x ¼" standoffs on the front of the PLED PCB, using four 4-40 x ¼" black machine screws, and tighten. Mount the PLED PCB to the front using the remaining black machine screws, and install the ribbon cable between the two PCBs as shown in the picture. Again, make sure that the ribbon jack lines up properly with the header pins. Don't forget to remove the protective film from the PLED display surface before mounting. The top cover will be installed after calibration.



Connections…
Power: 12-16 VDC, center pin +. The lead with the white stripe on the supplied cable is +
PTT: Loop the PTT between your amplifier and rig through the LP-100 using RCA connectors
RS-232: Connects to computer.
Current/Voltage: Connect to corresponding jacks on the coupler using supplied RG-174U cables.

Calibration

Enter the Calibrate mode again by hitting the Mode and Alarm buttons in an overlapping sequence as described in the Initial Checkout section. Below you will see a picture of each Calibrate screen along with a brief synopsis of what it does and what the controls adjust. The Mode button cycles through the various Calibrate screens, and the Dn/Up buttons allow adjustment of the Calibration constant for that screen.

	Allows adjustment of the accuracy of the op-amp detector and ADC to provide correct conversion values at low power levels. This adjustment is made by transmitting at a low power such as 1W, and matching the voltage on the display with the voltage at U8 pin 1 as read on a DMM.
	Adjusts overall power accuracy of the LP-100. This adjustment affects all frequencies equally, and is made by comparing the LP-100 power reading with an accurate reference. Acceptable reference measurement devices can be inexpensively made, and will be described later.
	Same as above, but adjusts the displayed power reading on a band-by-band basis. The built-in frequency counter detects the band you're on, and stores the CAL constant for each band automatically for 12 bands from 160m through 4m. The counter works from 50 mW to 2500W.
	This adjustment is used to calibrate the zero point (or offset) of the magnitude detector for proper display. It is made by transmitting into an accurate 50 ohm dummy load, and setting the screen to read 50.0. If your load is known to be close to 50 ohms, but not exactly, adjust for the value that matches your load. There are settings for HF and VHF. The proper CAL constant is automatically selected when you transmit.
	Similar to the Zero screen. This adjustment however is done with a value removed from 50 ohms. 25 or 75-100 ohms are good choices. The adjustment corrects the slope (or gain) of the magnitude detector. There is a little interaction between these two controls, so you need to touch up Zero after adjusting Slope.
	This adjustment is used to calibrate the zero point for phase detector. It is simply done transmitting into a high quality 50 ohm dummy load. The controls are then adjusted so that the display correctly shows zero degrees. Later firmware versions changed the Trim value to three digits.
	This adjustment is used to calibrate the slope of the phase detector. It is simply done by inserting a line with known delay into the Current input of the LP-100, and transmitting into a high quality 50 ohm dummy load. The controls are then adjusted so that the display correctly shows the line delay. If coax of known Velocity Factor is used, the line length in degrees can be simply calculated.
	This screen is used to match the readings of the low power and high power ADC inputs. It is done at a power level below 320W, which is the point at which the low power input reaches maximum. Its purpose is to allow compensating for any error in the 1% precision divider parts used in the high power input.
	Reference screen. Displays the reference voltage from the gain/phase detector, as well as the RSSI voltage (Received Signal Strength Indicator) from the AGC chip used in the frequency counter preamp. This voltage is proportional to the log of the RF input power to the LP-100. The screen also shows temperature in Deg F & C. There are no adjustments for this screen, it is used for troubleshooting purposes only.

The Trim value on the bottom display line is the CAL constant you are adjusting, and the value(s) to the left of it are the parameter being measured. As you change the Trim value with the Dn/Up buttons, the parameter will change value.

NOTE: Before proceeding to Calibration, check the LP-100 Update page, www.telepostinc.com/LP-100-Update, for the latest firmware revision. If it's later than yours, you should do the update before calibrating. Most firmware revisions will not affect calibration unless you purposely select "Program Data" in the Options menu in the MCLoader programming software. Check the Software section of this manual for more information. You can download MCLoader on the Update page, as well as the latest firmware hex file. There is a summary of update changes listed along with the files. This is a simple process, and offers a great way to keep your LP-100 current through multiple free updates.

Calibration Cont'd

Initial Calibration

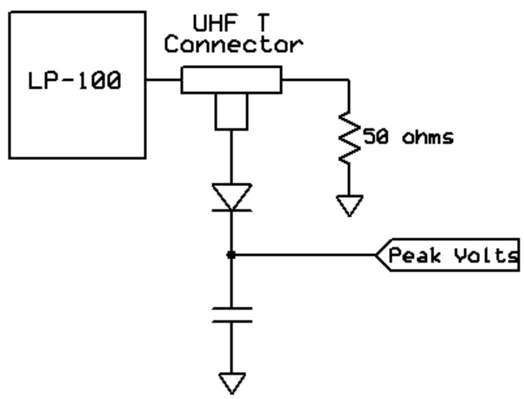
The first test requires only a DMM, and is simply accomplished by transmitting at a low power level… approximately 1-5W, and measuring the voltage at U8 pin 1. While in the CAL > Offset screen, adjust the Dn/Up buttons to match the meter reading of your DMM. Jot the Trim constant down for future reference. There is a page at the end of this manual to make that easy. NOTE: Normal use of the LP-100, including the flash programming of a new firmware version, will not disturb the saved CAL constants unless you have the MCLoader software set up to write "Program Data". Jotting the values down will allow you to return to your original settings in case you accidentally change a value by mistake.

The second screen allows for the adjustment of Master power sensitivity. This value will normally be left at 1.000 unless for some reason the Fine calibration values are unable to allow you to reach the proper settings. Both the Master and Fine power adjustments have a range of +/- 10% in .1% increments.

The Fine sensitivity adjustment is made while transmitting into the LP-100. The adjustments cannot be made unless you are transmitting, since the CAL memories are indexed to frequency, and the counter needs an input to supply the current frequency. NOTE: the last used frequency is displayed when not transmitting.

Before adjusting either of these parameters, it is necessary to provide an accurate means of measuring power that is independent of the LP-100. The simplest approach to this is to borrow a high quality meter like a Bird or Alpha to use as a reference, and connect it between the LP-100 and dummy load with a UHF male-male adapter.

The simplest, and probably most accurate method for doing this with simple tools is to use a high quality dummy load with a diode peak voltage detector and DMM. Here is the setup…



The following formula can be used to determine power.

P (watts)=(Vpk + .25) * (Vpk + .25) / 100

The diode is a 1N5711 Schottky diode, and the cap is .01uF. A convenient power level to use is 10W, as it is within the PIV specs of the 1N5711. 10W produces a peak voltage of ~31 V across a 50 ohm load. The diode will handle up to 40W, but I have only tested the circuit for accuracy at 10W. The voltage needs to be measured by a high impedance DMM with good accuracy. Most quality DMMs have > 1 meg input impedance, and many have > 10 meg input impedance.

The accuracy of this setup will mainly be related to the quality of the load. If the dummy load error is 5%, then the power calculation will be roughly 5% off. The actual diode drop will very likely be within about .2V of the assumed value in the formula, for a voltage error of under 1% at 100V. You can roughly guess at the RF resistance of your dummy load by measuring it at DC with a DMM, although that method will most likely be inaccurate at 50 MHz, and probably at 28 MHz as well. Make sure you measure the resistance with the load at operating temperature. Also, all connecting cables / adapters need to be as short as possible.

Calibration Cont'd

If you don't have access to these methods, you can send your completed LP-100 back to me for calibration if you are willing to pay for return shipping costs.

The first step in power calibration is to set the Master Trim value. This should be done on 1.8 or 3.5 MHz. Make sure the Fine Trim setting for this band is 1.000, then transmit at a known power level and adjust the Master Trim settings for the correct power reading.

To adjust the Fine power constants for each band, simply transmit on the band of interest and adjust the Dn/Up buttons for the correct power readings. Move through all bands in sequence until they have all been adjusted. You will notice that when you transmit now, the Trim value changes automatically based on the band.

The next series of adjustment screens are used to set up the gain/phase detector for proper Z, SWR and RL display. The first of these screens is the Gain Zero screen, which is used to center, or "zero-out" the gain comparator. A 50 ohm load is required for this adjustment. Simply transmit on a convenient band in the middle of the meter's range, such as 20m, at a convenient power level above about 2 watts. The display should show 50 ohms. If it does not, the use the Dn/Up buttons to adjust the display for 50 ohms. The value may change slightly with power, depending on how close to "typical" your AD8302 is, and show reduced but usable accuracy below 1 watt.

Next, switch to 6m if you have it, and transmit again. Use the Dn/Up buttons to set the value to 50 ohms on 6m. There are two Gain Zero constants to allow for deviations at the upper limit of the coupler… one for below 6m and one for 6m.

The next screen is the Gain Slope display. Switch back to the lower band for this adjustment. This is used to adjust the slope or gain of the gain comparator so that loads removed from the center (or 50 ohms) will display properly. You can use a load in the range of 20-25 ohms, or one in the range of 75-100 ohms for this adjustment. A convenient value is 25 ohms, which you can obtain by paralleling two 50 ohm dummy loads. If you don't have such devices, you can make your own using metal oxide power resistors and a PL-259 connector. 5W, 5% metal oxide resistors are available inexpensively from Mouser and Digikey and can be used for this adjustment. Any value in the above mentioned range, mounted inside a PL-259 should suffice to provide a load with 5% accuracy and a 5W-10W rating for short periods. You can measure the DC resistance of the load as a reasonable approximation of the RF impedance. If you make the Slope adjustment on a low band such as 80 or 40m, this measurement should suffice. Adjust the Dn/Up buttons to match your DC reading.

The final CAL adjustments for the gain/phase detector are the Phase Zero and Phase Slope adjustments. The Zero adjustment is done by transmitting into a high quality dummy load and setting the Dn/Up controls for a reading of "0.0" degrees. Make sure you remove the paralleled dummy load after the previous step. The display is in absolute value, so negative numbers will be positive. If you go too far, the displayed phase will therefore climb again. The correct setting is as close to zero as you can get, preferably on the positive side, but this isn't critical.

As mentioned in the Overview, adjusting the Phase Slope is simply a matter of matching the reading to a known delay line value. Again, the formula for determining delay in degrees is…

Phase Delay (Degrees) = (360*L*F)/(984*VF)

Where L is in feet and F in MHz. VF would generally be 0.66 for polyethylene dielectric. Foam dielectrics are generally have a VF of about .80. Check for the correct value of the coax type/brand you are using. Any convenient length of about 6-10' is acceptable. A 6' length will provide a delay of near 45 degrees at 14 MHz. This is a good range to use.

Insert the delay line into the Current cable between the controller and coupler, using a BNC barrel connector. Be sure to add the length of the barrel in your calculations. With a 50 ohm load, the phase should read close to the calculated value in degrees. If not, use the Dn/Up buttons to adjust the reading to the correct value.

Again, I am contemplating an inexpensive calibration kit in the $25 range, which would include a switchable dummy load PCB and pre-cut delay line. I will also calibrate any assembled LP-100 kit free of charge if you will pay round-trip shipping to me.

The last screen to adjust is the Hi/Lo screen. This is used to match the power readings for the high and low power ranges. If you transmit at a power of 100W, the two readings should roughly match. If not, adjust the Dn/Up buttons to match the readings. The Hi reading has less resolution, so it will jump around a little and you may not get an exact match. If that's the case, err on the high side.

Log all your constants for future reference, and you're done.

Calibration Cont'd

Final details

If everything has checked out to this point, you can complete the assembly of the controller by adjusting the LEDs on the front panel to line up with the holes, and snap the switch caps in place on the switches.

You can now install the cover on the controller. NOTE: The screw hole next to the PLED display requires the use of a 4-40 x ¼" self-tapping screw as opposed to the other 5 holes which use a 3/8" screw. This is important to avoid shorting of the PLED connector.

Operation

Operation of the LP-100 is straightforward, and designed to require a minimum of input once set up and calibrated. There are only three buttons which are used in combination to access all the menus on the LP-100. There are four main modes for the LP-100, which are accessed by momentarily pressing the "Mode" button. Pressing the button in mode 4 returns you to made 1. The mode status is saved in non-volatile memory, and the LP-100 will return to the saved mode upon powering up. There is also an automatic two-step screen saver mode which dims the screen after approx. 30 sec of inactivity, and marches your call sign across the screen after approx. 2 min. of inactivity. This is done to extend the life of the PLED display.

Mode

There are four selectable modes… Normal, Vector, dBm and Compression.
Normal mode is designed to display all the information you normally need on one screen. It displays power in three auto-ranging scales, and SWR, plus bar graphs for both.

Vector mode displays Z, Phase angle of Z, X and R. These values are relative to the "LOAD" connector, not the antenna. Antenna Z can be calculated by knowing the feedline length and using a program like TLW, or a Smith Chart. Note: The LP-100 cannot determine the sign of X automatically. You can easily do this experimentally though, by QSY'ing up or down 100 KHz or so and noting the relative change in X.

dBm mode uses professional dBm and RL (Return Loss) instead of watts and SWR to indicate power and load quality. The resolution is 0.1 dB for both.

Comp is a recent feature still under development. It displays peak and average power, and a dB ratio of peak/average. This can be useful for determining "talk power" and can be helpful in setting a compressor/clipper, or comparing such circuits. I am working on a better algorithm for the average reading that will be more stable. This feature will be operational in a future release of the firmware. All firmware and software upgrades for the LP-100 will be available for download from my website. The firmware upgrades can be easily flash programmed through the serial port with the supplied software.

Alarm

The Alarm button is used to set the SWR alarm set point. There are 5 choices… OFF, 1.5, 2.0, 2.5, 3.0. Each button press advances you to the next setting, and once again wraps around back to the first choice. Selecting OFF will cancel any alarm in progress.

Fast/Slow

This button toggles between a fast responding numerical display and a peak-hold display. In both cases, the bar graphs remain in fast mode. The "W" after the numerical power readout indicates which mode you are in. A capital "W" indicates peak mode, and a small case "w" indicates fast mode. Fast mode is best for taking accurate measurements, tuning or operating digital modes such as PSK or RTTY, peak is best for CW or SSB. Note: The Peak Mode is VERY fast, and will respond to a lip smack, mic button click, etc. Don't be alarmed by this… it is normal, and allow the LP-100 to provide an accurate indication of peak power. Unless a lot of compression is used, the peak reading will be somewhat higher than the indication with a carrier… as much as 30%.

Operation cont'd

CAL

The calibration modes can be accessed through this menu. To enter CAL mode, press Mode and Alarm in quick succession with a little overlap. This sounds tricky, but it's easy to master. Once in CAL mode, the Mode button is used to cycle through the calibration modes. There are 8 CAL screens…

Offset. Provides for calibrating the low level ADC converter accuracy.

Master. Adjusts the overall gain for power readout for all frequencies.

Fine. Adjusts gain by band for power readout, indexed by frequency. Frequency is determined automatically by a built-in frequency counter.

Gain Zero. Allows setting of zero point for magnitude detector for a Z readout of 50 ohms with a 50 ohm load.

Gain Slope. Allows setting the slope of the magnitude for proper Z at a value removed from 50 ohms. This can be done with any reasonable known load in the 25 or 75-100 ohm range.

Phase Zero. Allows setting the phase detector for zero degrees with a high quality 50 ohm load.

Phase Slope. Allows calibrating the phase detector. This requires a delay line of known value. In its simplest form, this can be done by calculating the electrical length of an existing piece of coax in the 3-10' range, and matching the readout to the calculated length at the frequency used for the calculation. More on this in the Calibration section.

Hi/Lo. This screen allows the matching of the direct and divided inputs to the ADC to account for any slight variations in the precision divider.

Reference. This screen display the reference voltage from the gain/phase detector, the RSSI output from the counter AGC amplifier and temperature in degrees F & C. It is only used for diagnostics.

After entering the CAL mode, these various screens can be accessed by cycling through them using the Mode button. In CAL mode, the Alarm button becomes a Dn button and the Fast/Slow button becomes Up. You can adjust the value of the CAL constant for each screen using these buttons. Holding a button down causes the value to continuously move up or down. The value of the CAL constant is stored in non-volatile memory. You may also want to write down your values on the page provided at the end of this manual.

Screen Saver
The screen saver dims the screen after approx. 30 sec of inactivity, and marches your call sign across the screen after approx. 2 min. of inactivity. This is done to extend the life of the PLED display. Check the software section of the manual for instructions on programming your callsign into the LP-100. Application of RF power will return the LP-100 to normal display. Alternatively, pressing the Fast/Slow button will do the same thing if not in Calibration Mode. Note: Make sure you are in the desired Fast/Slow mode after using the button to cancel the screen saver.

Normal Operation
In normal operation, the LP-100 is left in the Normal mode. For SSB or CW operation, you should use the Slow (or peak-hold) mode. This mode will show peak power and SWR and hold them for about 2-3 seconds unless a higher peak is detected, at which time the timer resets. Do not use this mode for steady-state power or SWR measurements, as it will be affected by momentary power fluctuations that many modern rigs have.

The peak power reading can be as much as 30% higher than steady-state power readings taken in the Fast mode. This is because of the ability of the transmitter or amplifier to deliver short bursts of higher power due mainly to power supply regulation issues. This is especially true of older amplifiers with unregulated power supplies. The peak detector in the LP-100 is very fast, and will grab even the smallest peak.

Peak SWR will show values a little higher than steady-state at times due to the wide dynamic range of the LP-100. As power drops to below 100 mW during speech, the SWR detector can sometimes grab a higher peak because of the lower accuracy at extreme low power levels. The worst-case error in this case should be < .10. For best accuracy during measurements, use the fast mode and at least .5 watts of power. The directivity of the LP-100 can easily be greater than 40 dB as you may have noticed during calibration, even at low power.

For digital modes or for tuning, you should switch to Fast mode for accurate display of power and SWR. Full accuracy should be attainable down to about 500 mW for both power and SWR. Good accuracy should still be maintained down to < 100 mW.

Operation cont'd

Normally, the SWR Alarm should be set for 2.0:1 unless you purposely operate with an antenna that is close to 2.0:1 SWR. It is up to you whether to enable the Piezo transducer, by using JP1. In any case, it is recommended that you loop your amplifier PTT through the LP-100. This not only helps protect your amplifier, but also the coupler in the LP-100… especially if you have an older amplifier which is capable of delivering full power into a high SWR load.

Vector Mode

In the vector mode, you can see the impedance of the load in two ways. The top line of the display shows the magnitude and phase of the complex impedance, and the lower line shows the resistive and reactive components, ie. R + jX. It is important to note here that the sign of the reactive, or imaginary component cannot be determined automatically by the LP-100. This is normally not a major problem, and can easily be determined with most loads by doing a simple test.

If you QSY up from your current frequency, and the reactance goes up, then the reactance is inductive (sign is "+"), and conversely if it goes down, then the reactance is capacitive (sign is "-"). A suitable distance is QSY is about 100 kHz or more. The LP-Plot program has the ability to determine sign automatically, since it can control your transmitter's frequency. When it plots a range of frequencies, it uses the slope of the reactance curve to determine sign, and plots the results accordingly.

It is important to remember that the impedance displayed on the screen is referenced to the coupler LOAD port. This value is related to actual feedpoint impedance of the antenna by factors relating to the characteristic Z of the line, line length and loss. I plan to add the ability to display actual antenna feedpoint Z into the LP-100 VCP and Plot programs by providing input boxes for feedline type and length.

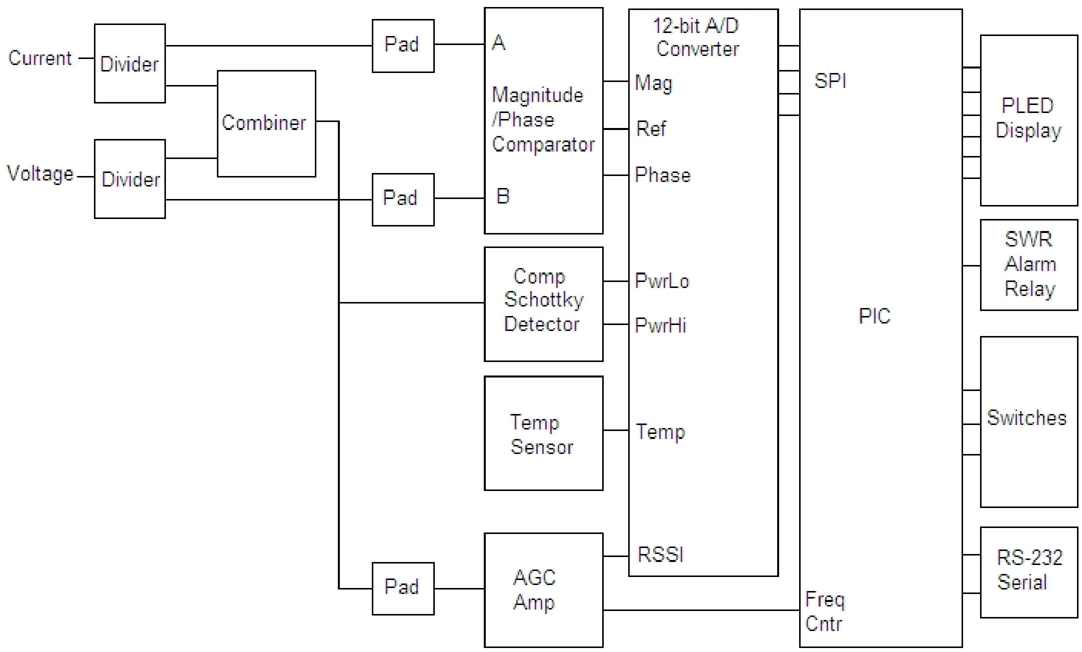
A simple way to provide reasonably accurate antenna Z on the LP-100 display would be to use a feedline which is a multiple of ½ wavelength in electrical length. There would still be some residual error due to feedline loss, but it would give a better representation of feedpoint Z. I am considering adding a CAL screen to allow selection of feedline loss to compensate for this, and I may also allow the future entry of feedline length and Zo data. There will be more info on this and other Impedance related subjects in the upcoming Appendix A.

dBm/RL Mode
Displays power in dBm and load integrity in dB of return loss.

Compression Mode
Under development. I started to add this as the LP-100 was nearing readiness for shipment. It will be completed in a future firmware update. It will show peak-to-average ratio, but I want to work on a steadier average algorithm before releasing it.

Circuit Description

The LP-100 is unique in it's design in several regards. Refer to the following block diagram during this discussion.



First, instead of using a coupler that produces forward and reflected power signals, the LP-100 uses a pair of transformers that sample current in the transmission line and voltage across the load. The samples are split into two paths, which provide signals to both the gain/phase comparator and the power detector.

With a 50 ohm non-reactive load, the levels of these two signals will be virtually identical, and the phase between them will be zero degrees. The combiner adds these two samples vectorially, providing a maximum output of 2x the input power with a perfect load, and proportionately less with less perfect loads.

The power sample is rectified in the Schottky diode detector, which uses a special dual diode package to eliminate errors associated with temperature tracking and forward / reverse voltage drop differences. The output of the detector is fed through precision voltage dividers to produce two power ranges, and in combination with a 12-bit A/D converter and precision 2.5V reference chip, provides an effective resolution of more than 13 bits.

The power sample also feeds an AGC amp which provides a constant, clean 5v p-p sine-wave output signal over a 50dB+ range of input power. This signal feeds the frequency counter in the PIC to allow automatic frequency detection at all power levels. This allows for automatic band-by-band calibration of the power readout of the LP-100.

The AGC amp also provides a DC "Received Signal Strength Indicator" which is used for a number of level detection tasks within the PIC. The A/D converter also receives temperature information from the temp sensor to compensate for any residual temperature related effects in the power detection circuitry.

The combiner also provides isolated signals to the gain/phase detector, providing 50dB of isolation between the signals, so that they can be accurately sampled at the input of the gain/phase comparator without affecting each other. The gain/phase comparator produces a DC voltage which is proportional to the log of the magnitude difference between its inputs, and another which is proportional to the phase difference between the inputs. These voltages are sampled by the A/D converter and the result is sent to the PIC over a Serial Peripheral Interface.

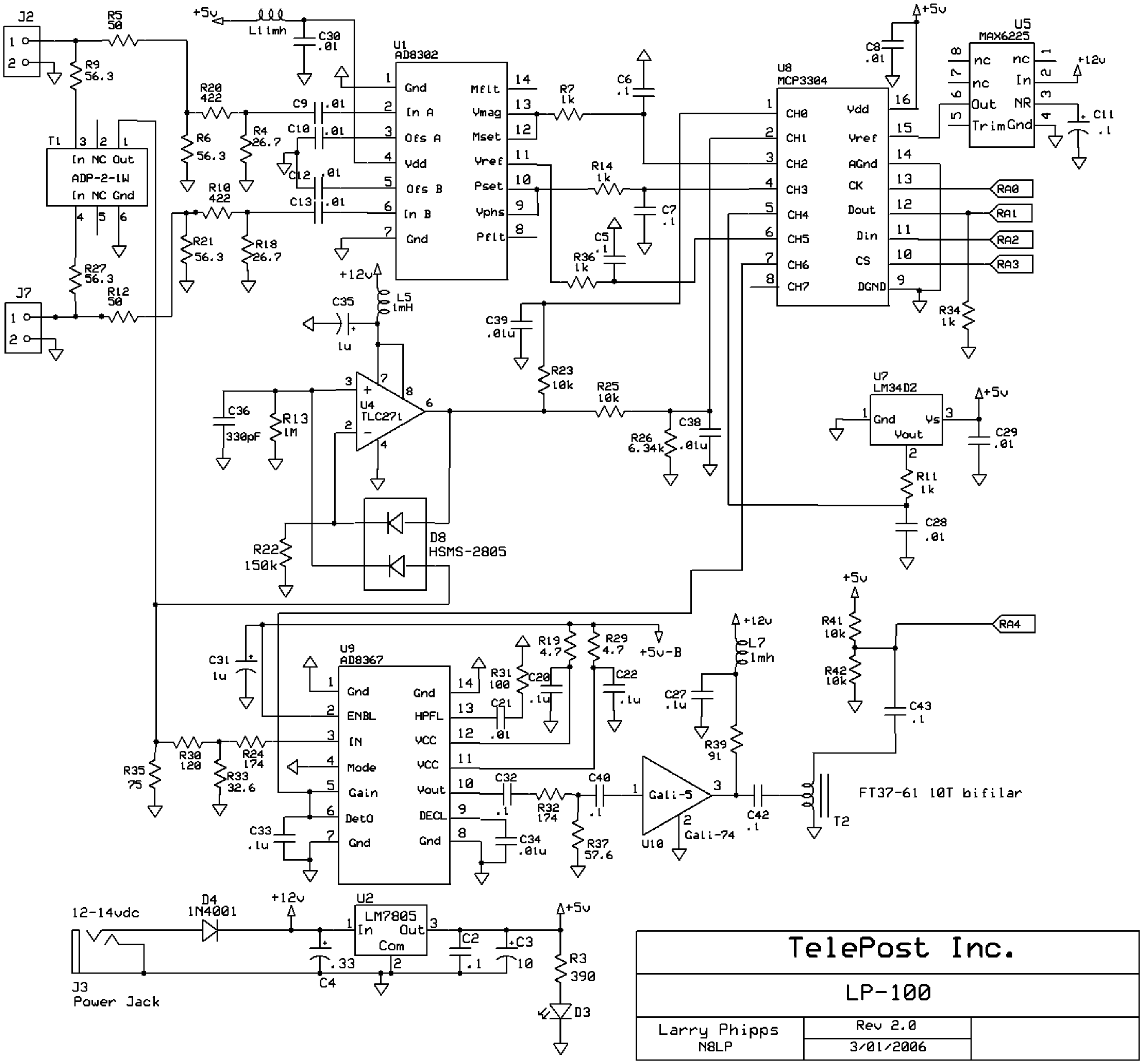
Remaining connections to the PIC include switch inputs for the three front panel switches, interfacing to the PLED display and an SWR alarm relay which is used to kill the PTT to your amplifier to protect both the antenna and amplifier. The SWR alarm also lights a front panel LED, and optionally can be jumpered to sound a piezo transducer. The PIC uses all these signals to calculate all the various displayed parameters.

Circuit Description cont'd

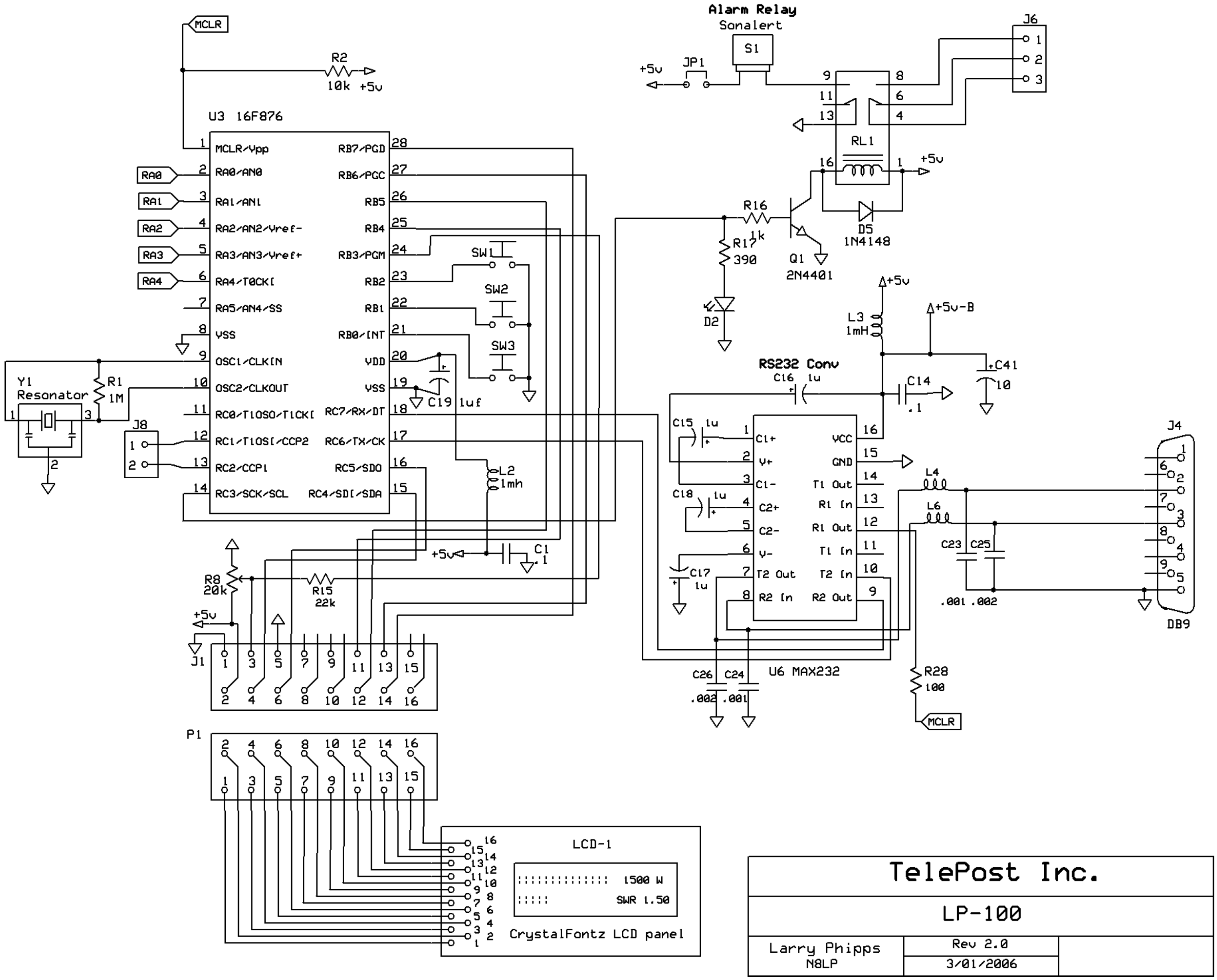
Finally, the PIC provides a standard RS-232 serial interface for remote control and monitoring of the LP-100. Functions of the LP-100 can be controlled from a Windows® "Virtual Control Panel" program, either locally or over a network connection, including the internet. The PIC's firmware can also be updated through downloadable hex files which can be "flashed" into the PIC's memory. A program entitled MicroCode Loader (MCLoader), from Mecanique®, is provided to do this.

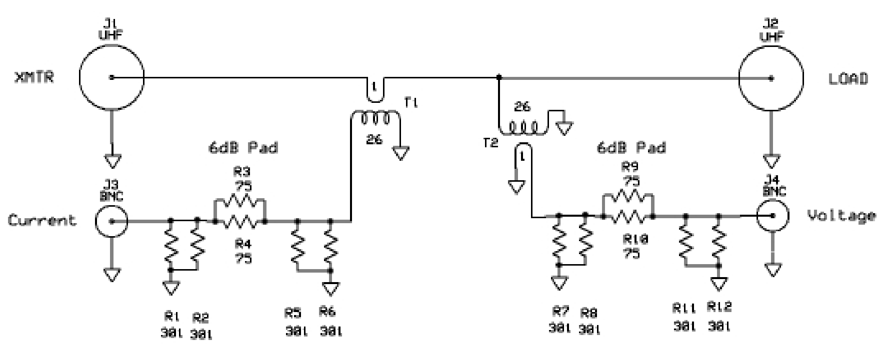
A Windows® charting program is also available to allow graphing of any of the LP-100s parameters including Z, R, X, SWR and phase angle vs. frequency. Future plans for the charting program include the possibility of a Smith Chart display, and I plan to add a translation function to both programs to allow for automatic transformation of coupler load Z to antenna feedpoint Z. The programs will provide for inputing feedline length and type for popular types of feedline.

Schematic Page 1



Schematic Page 2





Coupler Schematic

Troubleshooting

Below are some problems that have been reported and solutions. If you still have a problem, I am always available by email at larry@telepostinc.com and the newly formed LP-100 Yahoo Group is available at http://groups.yahoo.com/group/LP-100/
For excessive current, always check for solder bridges and proper orientation of ICs first. If a step calls for more than one IC to be added and current is excessive, remove the ICs and re-install one-by-one until you narrow the source of the high current.

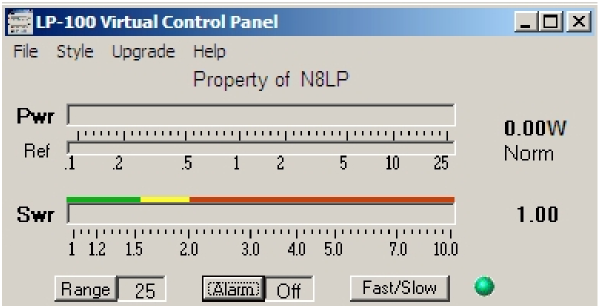
Problem	**Suggested solution**
No +5 VDC at Initial Checkout Step 1.	Check wiring of U2 and D5, and that the white-striped wire on the power cord is connected to the + lead of the supply.
Excessive current at Initial Checkout Step 1.	Check for proper polarity on D5.
Excessive current at Initial Checkout Step 2.	Check for proper placement of U7 and U3 (PIC).
Improper display at Initial Checkout Step 2.	Check setting of R8 to make sure the contrast is in range. Check that Y1 is soldered properly. Check that the PLED cable is installed properly. If all this checks out, the PIC firmware may be bad. Try flashing with the latest firmware on the LP-100-Updates page.
Excessive current at Initial Checkout Step 3.	Check for proper placement of the added ICs.
Incorrect operation of buttons.	Check for good ground lead connection on three tactile switches.
Incorrect values for RSSI or Temp.	Check U5 & U8 for proper orientation. Check output voltage of U5 at pin 6. It should be very close to 2.500 V. Check for proper orientation of U7 for Temp. Check soldering around U9 for RSSI.
Excessive current at Initial Checkout Step 4.	Check the added jumper between U4 pins 7&8 to make sure it is not touching ground. Check R39 and C42 for proper wiring.
Power reading is erratic	Make sure C37 wasn't installed. This part is shown on the silk-screening, but was deleted before production along with 4 other parts. This is covered in the Overview paragraph at the top of the Assembly section. Also, make sure that the standoff on coupler xfmr T2 is firmly bolted down and that the short wire is also solidly attached. Make sure that the two BNC connectors on the controller PCB are soldered properly.
Frequency counter is not registering the correct band	Check U9 by looking at the RSSI voltage on the Reference CAL screen. It should vary with applied RF power. Normal voltages are ~0.400V at 5W, ~0.660V at 100W. Also check the wiring of T2, and make sure the enamel has been removed from the wires, and that the wires are properly soldered to the pads.
Temperature is not being displayed	Check that U7 is installedm properly. Remember, the silk-screening is backwards for this part.

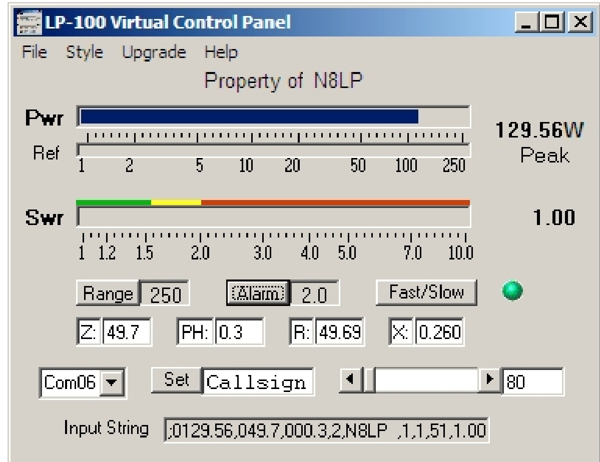
Troubleshooting cont'd

Software

LP-100 VCP

The LP-100 VCP (Virtual Control Panel) is provided for computer or remote operation of your LP-100 wattmeter. The LP-100 VCP allows you to control the basic functions of the LP-100, and it also allows you to monitor the LP-100 parameters remotely.





Control…
Alarm Set
Fast/Slow Mode
Call Sign Entry

Monitoring…
Power SWR
Impedance Phase
Resistance Reactance
Alarm Status

The are three views for the VCP, selectable under the Style pulldown. The two shown above, plus one which shows all but the setup info. The Menu choices provide the following functionality…

Style: Selects among the three views mentioned above
Upgrade: Launches the MCLoader program. This program can also be launched manually by adding a shortcut to the program.
Help: A work in progress.

The setup controls include Com port selection, callsign entry and a polling rate slider, adjustable from 50 msec to 5 sec. The normal setting is 80 msec, which gives an update rate of 12 samples per second. On slower computers, or over the internet, you can use a slower rate.

The buttons on the VCP perform the following functions…

Range: Allows switching the maximum power range of the display. Choices are 25, 250, 2500W and Auto for autoranging.
Alarm: Sets the SWR Alarm set point. Choices are Off,1.5,2.0,2.5,3.0. If the alarm on the LP-100 trips, the Alarm button turns red.
Fast/Slow: Switches between normal and peak-hold modes. The current mode is displayed under the power reading.

There are two other versions coming for use with TRX-Manager. The first, called LP-100 VCP Slave, allows the LP-100 to broadcast its data to TRX-Manager for display inside TRX-Manager, either locally or over the internet. The other, LP-100 VCP Master, allows the LP-100 to use TRX-Manager's remote telnet facility to make a remote connection between the LP-100 and the VCP. In addition to the LP-100 VCP, you can communicate with the LP-100 with a terminal program or your own software using the following commands…

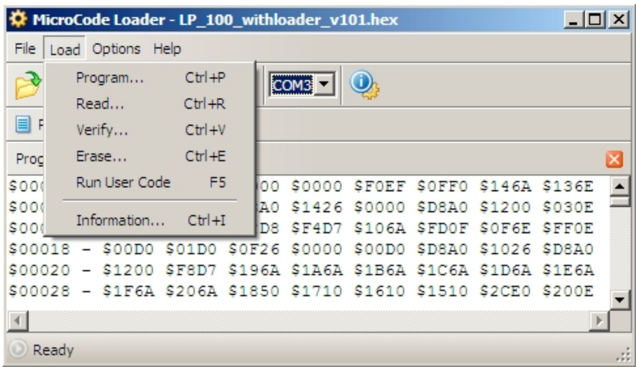
;A? Increments Alarm Set Point selection
;M? Increments Mode selection
;F? Toggles Power Fast/Slow selection
;C "Callsign" ? Sets callsign, where "Callsign" is a 6-digit alphanumeric value. Examples…
;CN8LP ? ;CWA1ABC? (Add spaces to pad out to 6 digits)
;P? Poll for data. Example of response…
;1457.00,49.3,005.0,2,N8LP ,0,2,61.6,1.02
From left to right, the comma separated values represent…

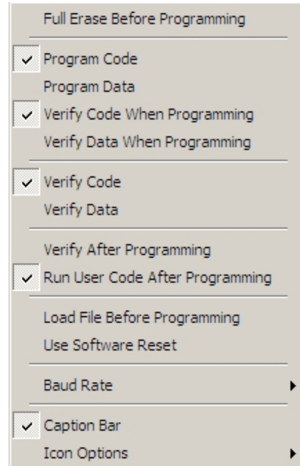
Power, Z, Phase, SWR Alarm Set Point: 0=off, 1=1.5, 2=2.0, 3=2.5, 4=3.0, Callsign (6 digits with space padding), Power range: 0=2500W, 1=250W, 2=25W, Peak Hold Mode: 0=Fast, 1= Peak Hold, dBm, SWR

The serial settings are 38,400 baud, 8 bits, no parity, 1 stop bit. Do not send CR or LF. NOTE: Firmware versions before 1.0.3 used a baud rate of 19,200 and did not report dBm or SWR values.

Software cont'd

MicroCode Loader

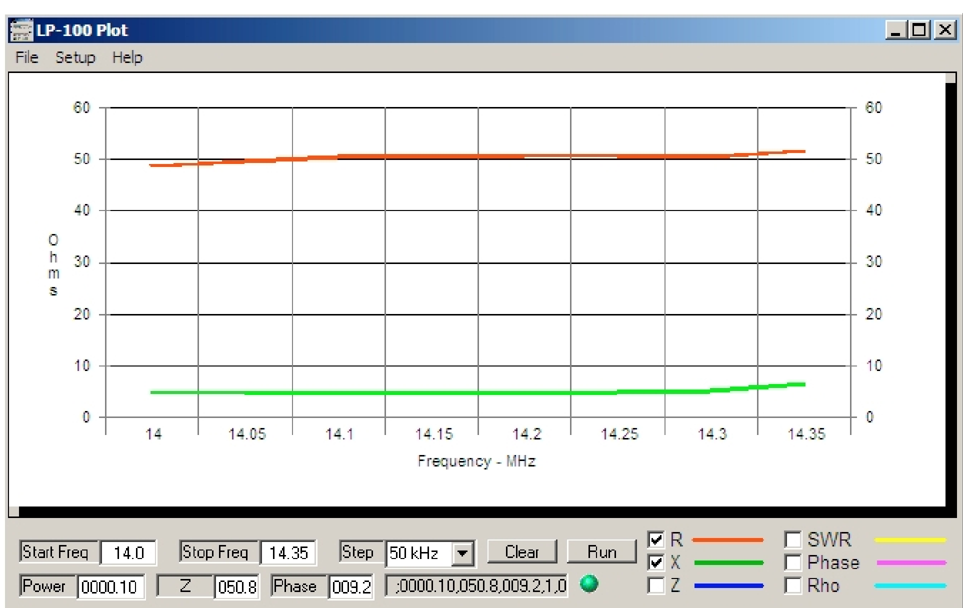




MicroCode Loader works with the MCLoader bootstrap loader program installed on your PIC. It allows the user to easily update the firmware in the LP-100. The correct settings for MicroCode Loader, found under the Options pulldown, are as shown. NOTE: If you select Program Data, the factory defaults will be loaded into your CAL constant table. All that is required is to download the latest version of the firmware from my website, save it to a convenient folder, such as C:\Program Files\LP-100-VCP\Updates and then program the PIC. Programming is done by either launching MicroCode Loader directly, or from the LP-100 VCP, setting the com port which is connected to the LP-100 and the Baud Rate to 19,200. Open the new firmware hex file and then click on "Program". You will see a message to Reset the PIC. This is done by cycling the power to the LP-100. After cycling power, close the Reset message window and click on "Program" again. A progress bar will show the progress of the programming, and the LP-100 will start again when programming is finished. The "Splash" screen will now indicate the new version.

LP-100 Plot

I am putting the finishing touches on the LP-100 Plot program. I will upload the files to my Downloads page as soon as I finish it up. For more information, visit my website.



Specifications
(after calibration)

Useful Power Range:	0.05W – 2500W
Power Accuracy:	5% typical down to 0.5W, 10% down to 0.10W, +/- 1LSB
SWR Range:	1.00 to 9.99
SWR Accuracy:	5% typical down to 0.5W, 10% down to 0.10W, +/- 1LSB
Impedance:	0-999.9 ohms Z, R and X, 5% typical accuracy
Phase:	0-180.0 degrees, 3 degrees or better typical accuracy
Frequency counter:	1 MHz to >100 MHz, 5% accuracy, +15 dBm sensitivity
Power handling	1500W continuous duty, 2500W peak
DC Power:	11-15 VDC @ 160 ma
Operating temp range:	0 to 50 degrees C
Size:	Controller: 5.1"x 5.1" x 2.6" Coupler: 2.25” x 2.25” x 5.00”

CAL Table

Description	Initial Date:	Date:	Date:	Date:
Offset Trim				
Master Power Trim				
Fine Power Trim – 160m				
80m				
60m				
40m				
30m				
20m				
17m				
15m				
12m				
10m				
6m				
4m				
Gain Zero HF Trim				
Gain Zero 6m Trim				
Gain Slope Trim				
Phase Zero Trim				
Phase Slope Trim				
Lo/Hi Power Trim				
Reference				

Log the initial CAL constants for your LP-100 in this table. If you ever make changes, you can log additional constants in the spaces provided.

Warranty

Factory assembled LP-100s are warranted against failure due to defects in materials and workmanship for 90 days 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-100 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-100 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-100, whether in accordance with the instructions in this Manual or otherwise.

Appendix A