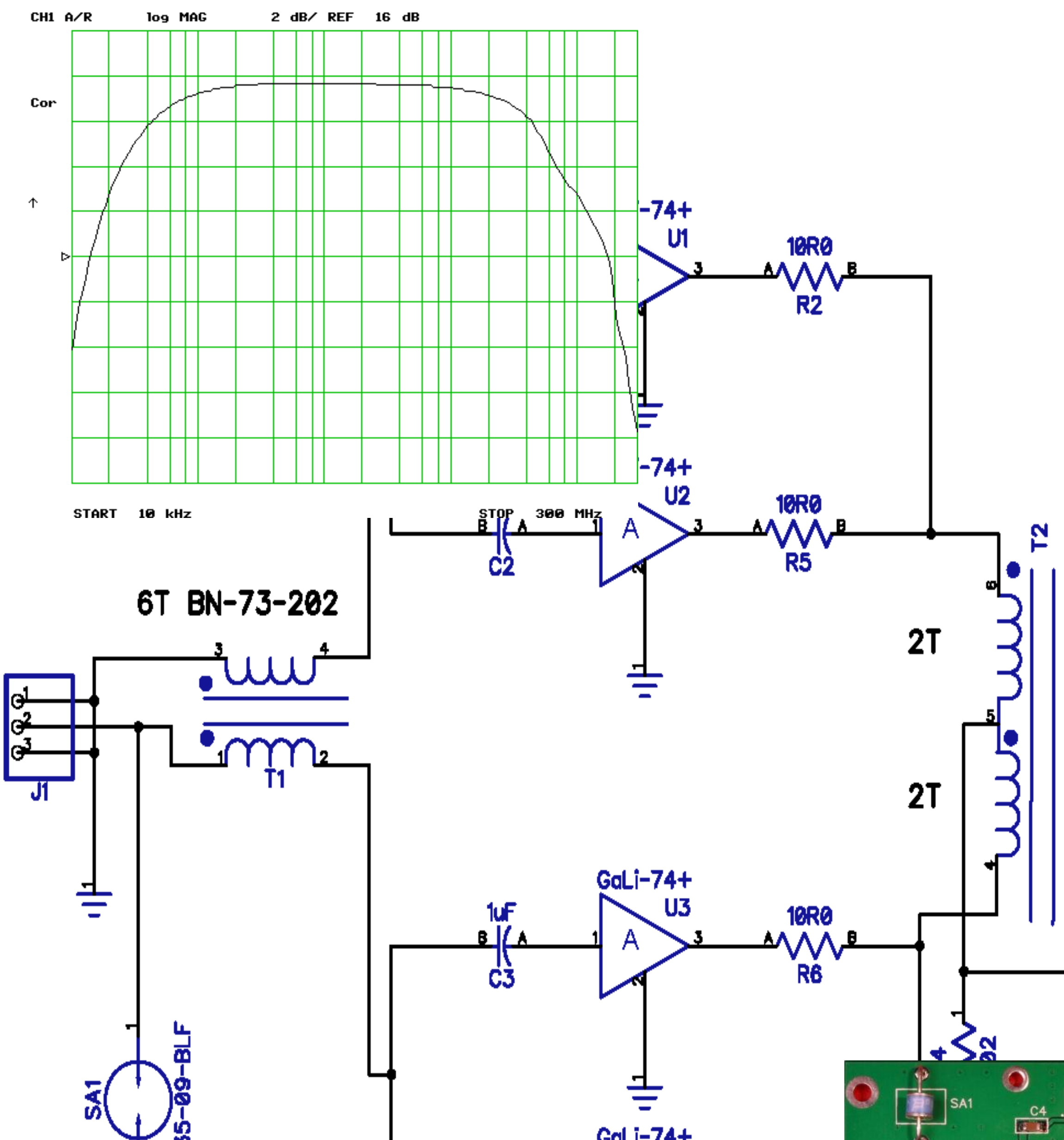
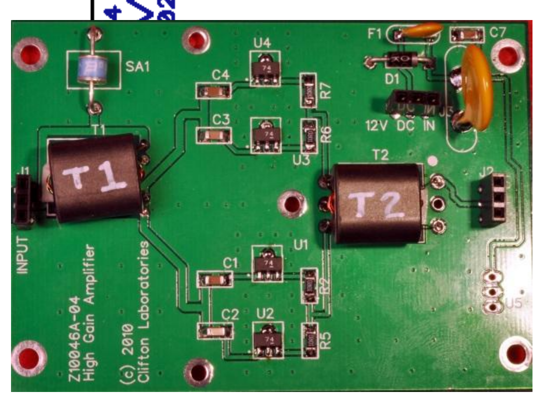
Clifton Laboratories

Z10046A High Gain Preamplifier Construction and Operations Manual



Revised 21 September 2010



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Model Z10046A High Gain Amplifier

Revised 21 September 2010

Trademarks and Copyright

Warranty

This warranty is effective as of the date of first consumer purchase.

What is covered: During the ninety (90) days after date of purchase, Clifton Laboratories will correct any defects in the Z10046A due to defective parts (kit or assembled) or workmanship (if purchased as an assembled unit) free of charge (post-paid). You must send the unit at your expense to Clifton Laboratories, but we will pay return shipping. Clifton Laboratories' warranty does not extend to defects caused by your incorrect assembly or use of unauthorized parts or materials or construction practices.

What is not covered: If the Z10046A is purchased as a kit, this warranty does not cover correction of assembly errors or misalignment; repair of damage caused by misuse, negligence, or builder modifications; or any performance malfunctions involving non-Clifton Laboratories accessory equipment. *The use of acid-core solder, water-soluble flux solder, or any corrosive or conductive flux or solvent will void this warranty in its entirety.* Whether purchased as an assembled unit or as a kit, also not covered is reimbursement for loss of use, inconvenience, customer assembly or alignment time, or cost of unauthorized service. Damage due to operating the Z10046A near a transmitting antenna is not covered under the warranty.

Limitation of incidental or consequential damages: This warranty does not extend to non-Clifton Laboratories equipment or components used in conjunction with our products. *Any such repair or replacement is the responsibility of the customer. Clifton Laboratories will not be liable for any special, indirect, incidental or consequential damages, including but not limited to any loss of business or profits.*

Under no circumstances is Clifton Laboratories liable for damage to your equipment connected to the Z10046A resulting from use of the Z10046A, whether in accordance with the instructions in this Manual or otherwise.

Table of Contents

Model Z10046A High Gain Amplifier 1
Specifications 3
Overview 3
Typical Measured Performance Plots 4
Frequency Response 4
Noise Figure 4
1 dB Compression Point and Saturated Output Power 4
Input SWR 4
OIP as Function of Idle Current 5
Assembly 6
R1, R2 and R4 selection. 6
T1 and T2 Turns Ratio 6
Component Location (bottom and top) 7
Recommended Assembly Order 7
Printed Circuit Board Assembly 7
Completed Z10046A View 15
Board Size and Mounting Hole Locations 17
Theory of Operation 18
Troubleshooting 20
Resistance Readings 21
Voltage Readings 22
Parts List 23

Specifications

Plots in this Manual are taken from production units but demonstrate typical, not warranted, performance. Clifton Laboratories offers an optional measured performance data for any Z10046A amplifier. Contact Clifton Laboratories for price and availability of measured data.

Overview

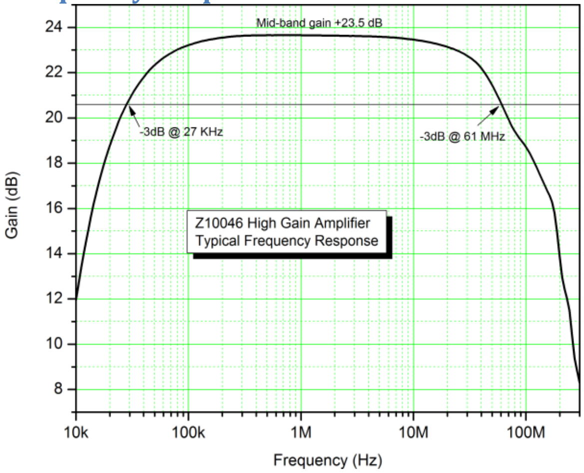
Parameter	Value
Dimensions	The Z10046A printed circuit board is 3.5 inches x 2.5 inches (88.9mm x 63.5mm). Recommend minimum enclosure height is 1.5 inches (38.1 mm).
DC Supply	The Z10046A requires 10.0V at a current (depending upon user selected bias resistor options) from 320 mA to 400 mA. A suitable 10.0V regulator is supplied with the Z10046A and can be used with supply voltages of 12.5V to 20V. Proper heat sinking of the 10V regulator is required.
Gain	23.5 dB nominal at 1 MHz
Frequency Range	-3 dB points are 50 KHz – 50 MHz [1]
Intermodulation [2]	Both second and third order output intercepts depend upon selected bias resistor options. OIP2 is typically +87 to +93 dBm; OIP3 is typically +42 dBm to +45 dBm.
1 dB Compression Point	+24.7 dBm output at 1 MHz.
Input SWR	Less than 1.5:1, 300 KHz-30 MHz
Isolation (reverse gain)	Typically 30 dB at 1 MHz

[1] Frequency response based upon standard transformer ratio of T1=6:6 turns, T2=2:2:4 turns. For improved lower frequency response, T1 may be increased to 7 turns and T2 wound as 3:3:6 turns. With these changes, the -3 dB points become 15 KHz and 40 MHz. Unless otherwise stated, performance data is for standard turns ratio.

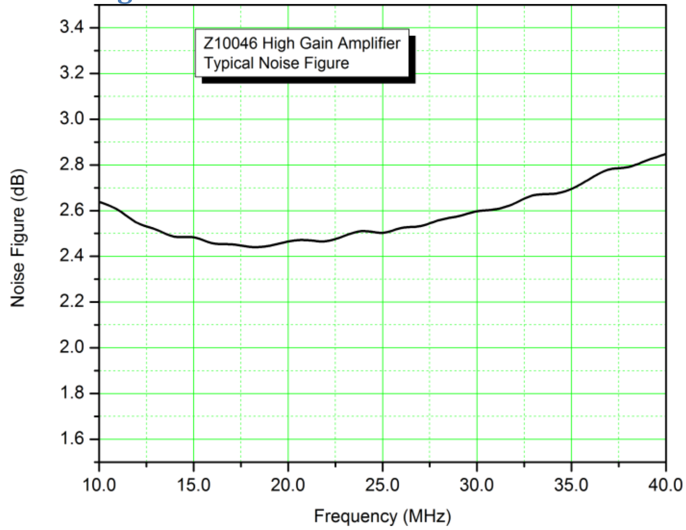
[2] Intermodulation measured with test tones of 3007 KHz and 4011 KHz, adjusted for 0 dBm output (each tone) after 30 minute thermal stabilization period. Second order intercept is a function of amplifier balance which is dependent, to some degree, upon the care the builder takes in construction and upon the PCB’s thermal balance. See plot of typical OIP2/OIP3 as function of idle current later in this manual.

Typical Measured Performance Plots

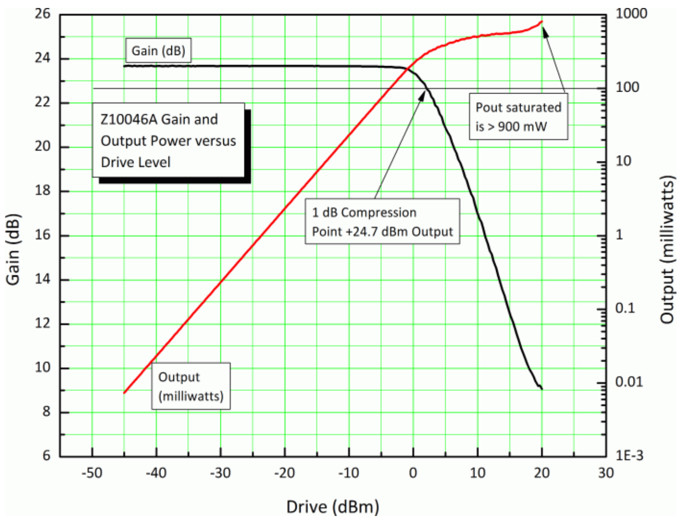
Frequency Response



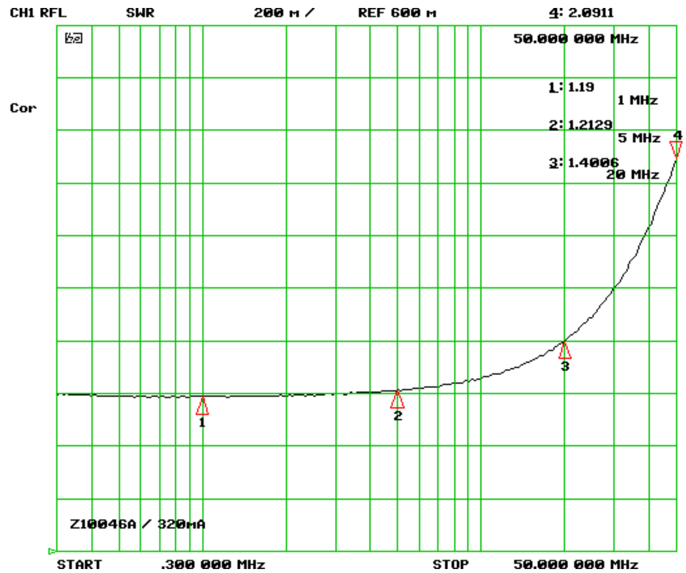
Noise Figure



1 dB Compression Point and Saturated Output Power

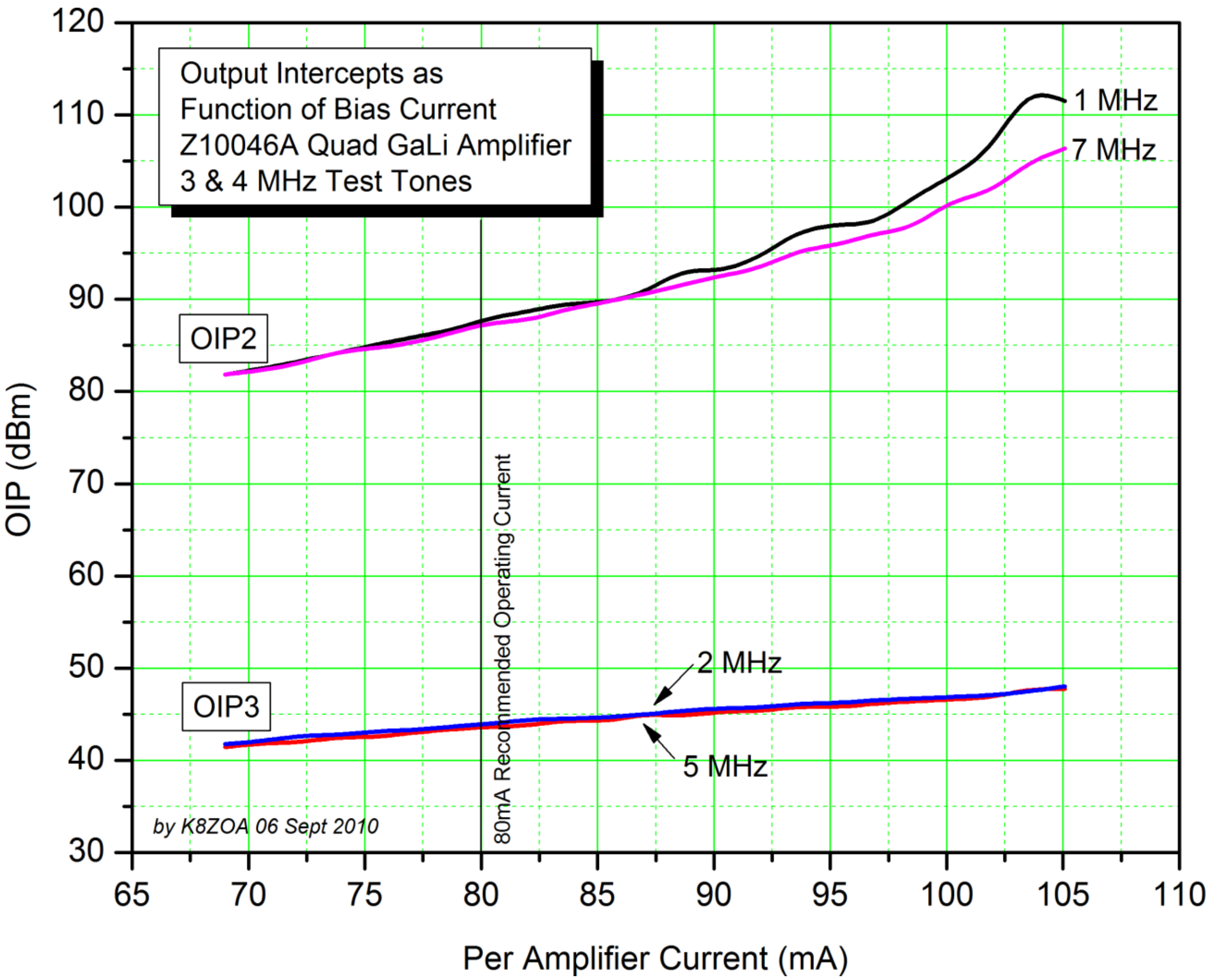


Input SWR



OIP as Function of Idle Current

Test conditions: Test tones of 1007 KHz and 4011 KHz, adjusted in level to achieve 0 dBm output (per tone). Supply voltage adjusted to vary idle current.



Assembly

R1, R2 and R4 selection.

The Z10046A uses four Mini-Circuits GaLi-74+ amplifier modules in parallel push-pull. The GaLi-74's bias current is determined by the series resistor string of R1, R3 and R4. Increased bias (lower value R1, R3 and R4) improves intermodulation distortion performance, but increases current drain and device temperature. The typical per device bias range runs from 80 mA to 100 mA, with 80 mA being the "recommended" current level and 130 mA being the maximum current rating.

When purchased, the Z10046A is shipped with bias resistors of one of three values:

Bias Resistor Value* (ohms)(R1, R3 & R4)	Nominal Idle Current per device w/ 10V supply (mA)	Typical OIP2 (dBm)	Typical OIP3 (dBm)	Typical Tmax (degrees F/C) PCB in open air
4.02	80	+87	+43	+131F/55
3.32	90	+90	+45	+134F/57
3.01	100	+93	+46	+140F/61

*Resistor value assumes series RF choke of 2.0 ohms is inserted between 10.0V regulator output and R1, R3 and R4 string.

Unless the particular application requires maximum intermodulation intercepts, Clifton Laboratories recommends 4.02 ohms for R1, R3 and R4, corresponding to 80 mA/device. Although higher bias current improves performance, increased operating temperature will reduce component life. (There is some unit-to-unit variation in idle current, OIP2, OIP3and Tmax. The values in the table are representative, but are not guaranteed.)

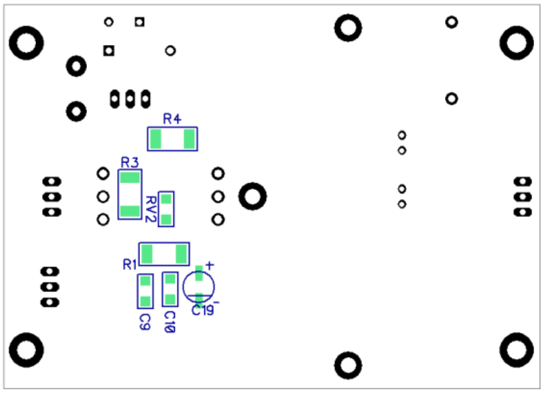
T1 and T2 Turns Ratio

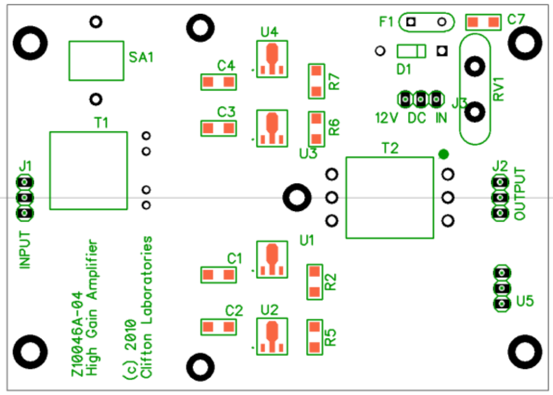
If improved performance below 50 KHz is required, and if some loss in gain above 30 MHz is acceptable, T1 and T2 may be modified with additional turns.

<table>
<tr><th rowspan="3">Transformer</th><th colspan="4">Standard Design</th><th colspan="4">Extended Low Frequency Performance</th></tr>
<tr><th rowspan="2">Turns Ratio</th><th colspan="3">Response</th><th rowspan="2">Turns Ratio</th><th colspan="3">Response</th></tr>
<tr><th>-1 dB</th><th>-2 dB</th><th>-3 dB</th><th>-1 dB</th><th>-2 dB</th><th>-3 dB</th></tr>
<tr><td>T1</td><td>6 turns bifilar</td><td rowspan="2">57 KHz-33 MHz</td><td rowspan="2">38 KHz-48 MHz</td><td rowspan="2">27 KHz-61 MHz</td><td>7 turns bifilar</td><td rowspan="2">32 KHz-28.8 MHz</td><td rowspan="2">20 KHz-39.2 MHz</td><td rowspan="2">15 KHz->40 MHz</td></tr>
<tr><td>T2</td><td>2 turns bifilar & 4 turns single wire</td><td>3 turns bifilar & 6 turns single wire</td></tr>
</table>

Sufficient wire is provided for either the standard design or the extended low frequency performance design.

Component Location (bottom and top)





Z10046A Copper Foil Thickness. The Z10046A PCB is constructed with copper thickness three times that of a typical PCB. This is done to aid thermal tracking of U1-U4, necessary for best 2nd order intermodulation performance. From the prospective of the builder, the extra copper thickness requires a larger soldering iron and possibly a higher temperature setting than used for normal printed circuit board assembly, particularly when soldering ground pads.

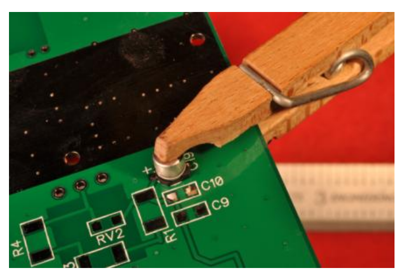
Recommended Assembly Order

Printed Circuit Board Assembly

<u>Bottom PCB Surface</u>

Note: RV2 is not used.

❑ Install C19, a 10uF capacitor, marked 10 EHA. The negative terminal of C19 is identified by the black stripe. Observe polarity when installing C19. If you have it, a small amount of liquid electronics grade solder flux can be applied to C19's pads.



I used a spring clothespin, with one side cut into a "V" shape to hold small parts in place while soldering.

❑ Install C9, a 1uF ceramic capacitor. This component is not marked.

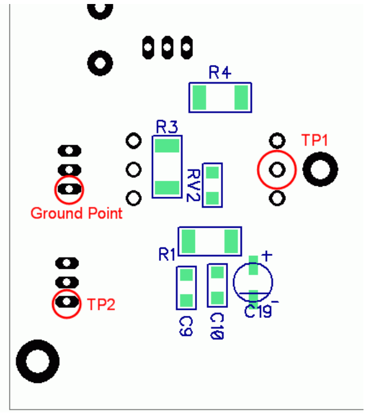
❑ Install C10, a 10pF ceramic capacitor. This component is not marked.

❑ Install R1, R3 and R4. The value of these three resistors depends upon the idle current option ordered at time of purchase. Possible values are 4.02 ohms (marked 4R02), 3.32 ohms (marked 3R32) and 3.01 ohms (marked 3R01).

❑ Perform a resistance and continuity check.

From TP1 and TP2 to ground should be high impedance. These two points have only leakage resistance of C19 which will normally be in the 1 megohm or greater range.

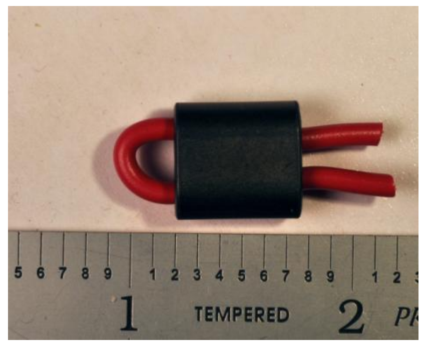
Between TP1 and TP2 should be the sum of R1, R3 and R4. This particular resistance will thus depend upon the selected values for R1, R3 and R4.



Top PCB Surface

Wind transformers T1 and T2

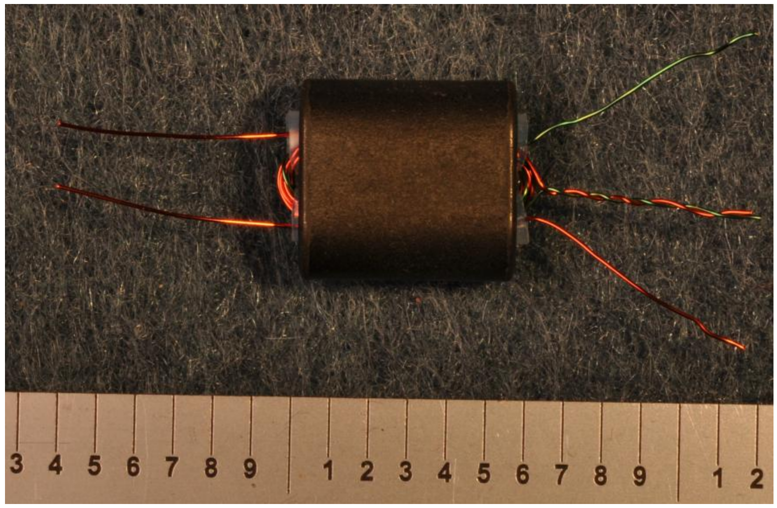
T1 and T2 are wound on multi-aperture (binocular) cores. When counting turns, remember that one turn requires the wire to pass through both holes. The photo at right shows one complete turn through a binocular core. Passing the wire through one hole counts as one-half of a turn.



Notes in winding T1 and T2

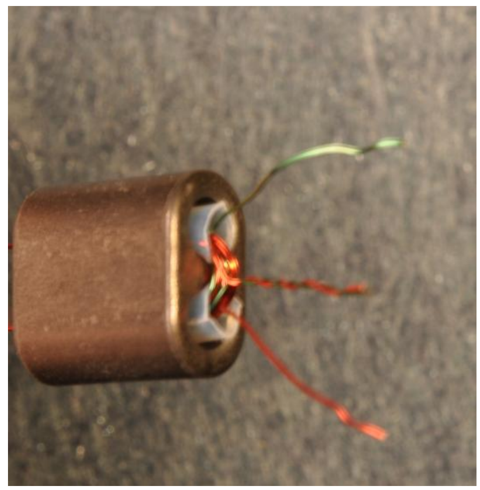
- T1 and T2 are ferrite cores and have sharp edges. To avoid wire damage caused by abrading the enamel insulation during winding, Teflon insert bushings are used..
- The magnet wire supplied with the Z10046A is “solder strippable” which means that the insulation will dissolve in molten solder. First wind the transformer and after winding clamp the transformer in place with a soft jaw vise. Cut the lead length to the recommended value and apply the soldering iron to the wire end. Add solder to form a ‘blob’ of molten solder. After a few seconds, the insulation will begin to dissolve. Work the soldering iron along the wire, adding fresh solder as necessary to maintain a blob of molten solder. Do not tin right up to the core; tin only to within 1/8th inch (3mm) of the core.

❑ Cut four bushings from the length of Teflon tubing. The bushings should slightly extend (between 1/16th and 1/32nd inch [1.5mm to 0.75mm]) from each end of the core when inserted.



When cutting the Teflon tubing, use a sharp hobby knife or a razor blade. Scissors or dull wire cutters can leave a ragged edge. After cutting, roll the tubing between your fingers to restore it to circularity.

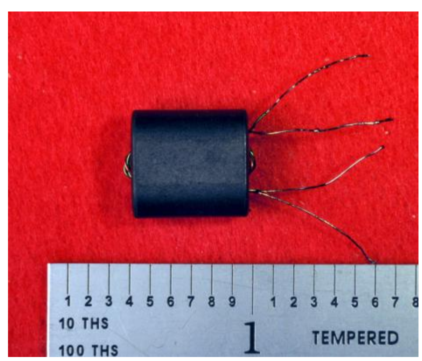
The tubing more or less "self centers" lengthwise if you first wind 1.5 turns of bifilar wire and gently pull the wire ends.



[Many of the photos in this manual show a transformer wound without a Teflon bushing. The photographs will be updated in a later edition of this Manual.]

The instructions for T1 below assume standard frequency response is desired. If extended low frequency response is desired, and some loss in high frequency response is acceptable, use the alternative winding ratios provided under the section T1 and T2 Turns Ratio. T1 will require 7 turns if extended low frequency response option is impelemnted. In this case T1's wire length will be 14 inches (350mm).

❑ T1: Cut lengths of no. 30 red and no. 30 green magnet wire 12 inches (300mm) long. Twist the red and green wires together with approximately 45 turns. (40 to 50 turns is OK.)



Install Teflon bushings in both core holes and wind the twisted wire through the core with 6 turns. When starting the winding, allow approximately one inch (25mm) of wire to extend from one hole.

After winding six turns, trim both twisted pair ends to extend approximately ¾ inch (18 mm) from the core end. Untwist the extended wires and tin using the procedure summarized above.

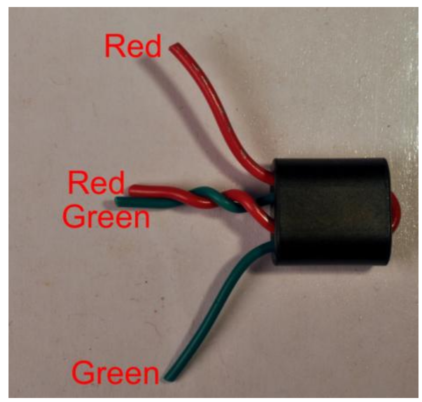
Set T1 aside.

The instructions for T2 below assume standard frequency response is desired. If extended low frequency response is desired, and some loss in high frequency response is acceptable, use the alternative winding ratios provided under the section T1 and T2 Turns Ratio. T1 will require 3 bifilar turns and 6 standard turns if extended low frequency response option is impelemnted. In this case T1's wire length will be 10 inches (250mm) for the bifilar winding and 12 inches (300mm) for the single wire winding.

❑ T2: Cut lengths of no. 30 red and no. 30 green magnet wire 8 inches (200 mm) long. Twist the red and green wires together approximately 30 turns (25 to 35 turns is OK.)

Install Teflon bushings in both core holes and wind two turns through the core. When starting the winding, allow approximately one inch (25mm) of wire to extend from one hole.

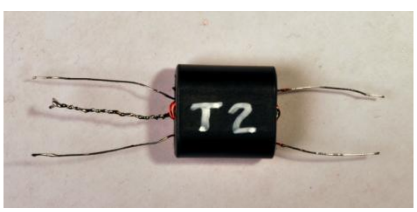
After winding two turns, trim both twisted end pairs to extend approximately ¾ inch (18 mm) from the core end. Untwist the extended wires. Both holes have red and green wires. Twist the red wire from one hole with the green wire from the other hole. This will yield a winding with three leads, as illustrated conceptually at the right.



Cut a length of red no. 30 magnet wire 10 inches (250 mm) long.

<u>Starting at the opposite end </u>(the end that does not have leads extending from it), wind four turns on the core. Allow approximately one inch (25 mm) of wire to extend when starting the winding.

When winding the four turns, it helps to bend the first winding leads against the side of the transformer core.



Cut the leads to approximately ¾ inch (16 mm) and tin. The completed transformer should match the photo below.

Set T2 aside for later installation.

❑ Install C1, C2, C3, C4 and C7, 1uF capacitors. These have no markings.
❑ Install R2, R5, R6 and R7, 10.0 ohm resistors, marked 10R0.
❑ Install U1, U2, U3 and U4, Gali-74+ devices, marked 74.

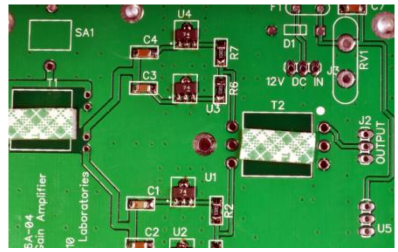
If you have liquid electronic grade soldering flux, apply a small amount to U1-U4 pads.

When installing U1-U4, I lightly tin one of the outside pads and slide the device into place while heating the pad with a soldering iron. When the device is aligned with the pad, remove the soldering iron and allow it to cool.

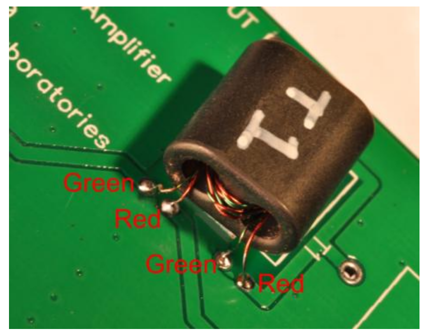
Solder the remaining pins and the large tab at the rear of the device. To reduce the risk of overheating the devices I normally solder the other outside pin of each device and then the center pins of each device and lastly the tab of each device. (Outside pin U1, outside pin U2, outside pin U3, outside pin U4, then center pin U1, center pin U2, etc.)

Note that these devices may be difficult to install as the Z10046A's thicker copper foil wicks away heat, particularly if the soldering iron has a small diameter tip.

❑ Cut two lengths ½ inch long (12 mm) of ¼ inch (6 mm) wide double side adhesive foam tape. Apply the tape to hold T1 and T2 in place as illustrated.



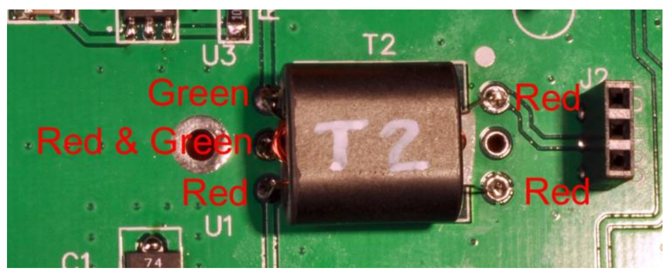
❑ Remove the protective paper from the foam at T1 and install T1 as illustrated in the photo below.



The red and green wires from each hole go to the two pads closest to the outside of the hole.

When pulling the leads through the hole, do not pull the wires tight against the core. Rather allow the leads to extend horizontally from the core and then bend downwards at a 90 degree angle. This will reduce the risk of abrading the wire against the core edges.

❑



Remove the protective paper from the foam at T2 and install T2 as illustrated at the right.

When pulling the leads through the hole, do not pull the wires tight against the core. Rather allow the leads to extend horizontally from the core and then bend downwards at a 90 degree angle. This will reduce the risk of abrading the wire against the core edges.

❑ Install 3-pin header sockets at J1, J2 and J3 and on the PCB at U5.

❑ Install the spark gap at SA1. This part is marked 90V. Space the spark gap approximately 1/8th inch (3mm) above the top surface of the printed circuit board.

❑ Install the 500 mA polyfuse at F1. This part is marked XF050.

❑ Install the over-voltage MOV at RV1. This part is marked 180M.

❑ Install diode D1. This part will be of the 1N400x family where X is a number from 1 to 7 and it will be marked as such. When installing D1, observe polarity; the band on the diode should be oriented to match the line marking on D1's silk screen outline.

☐ With an ohmmeter check the resistance to ground of TP2. It should not show a low resistance to ground. (Anything above 400 ohms is OK.)

☐ With an ohmmeter check the resistance to ground of the center pin of J1. It should be greater than 10K.

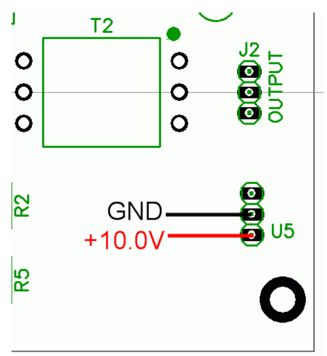
☐ In theory, both resistance checks should be in the mega-ohm range. However, if the windings of T1 or T2 are abraded, the windings will form a medium resistance connection to T1 or T2's core. (If you place the ohmmeter probes touching T1 or T2's core, you will measure a resistance in the 10 to 50 Kohm range, depending on size of the probe, pressure, etc.) Moveover, ohmmeters differ in the open circuit voltage they apply which can cause wildly different readings if one ohmmeter does not bias semiconductor junctions into conductivity but a second ohmmeter does.

No leakage should be observed between the primary and secondary windings if you have used Teflon bushings.

<u>Checkout with laboratory adjustable voltage power supply</u>

☐ If you have an adjustable voltage, current limited power supply, set it at 10.00 volts, with current limiting at 450 mA. ⚠ **DO NOT EXCEED 10.250 VOLTS OR DAMAGE MAY OCCUR TO U1-U4.**

⚠ **The DC resistance of RF choke L1 (approximately 2 ohms) is part of the current limiting resistance. When making the test described below temporarily connect L1 between the adjustable power supply positive output and the U5 +10V PCB pad.**



Connect the power supply to U5's socket as illustrated.

Observe the current draw. If it significantly exceeds the expected level (four times the individual GaLi-74 current draw based upon your selection of bias resistors), disconnect the power supply and troubleshoot the Z10046A.

For the resistor values supplied with the Z10046A, the current draw will be in the range 300 mA to 425 mA. Values outside this range should be investigated.

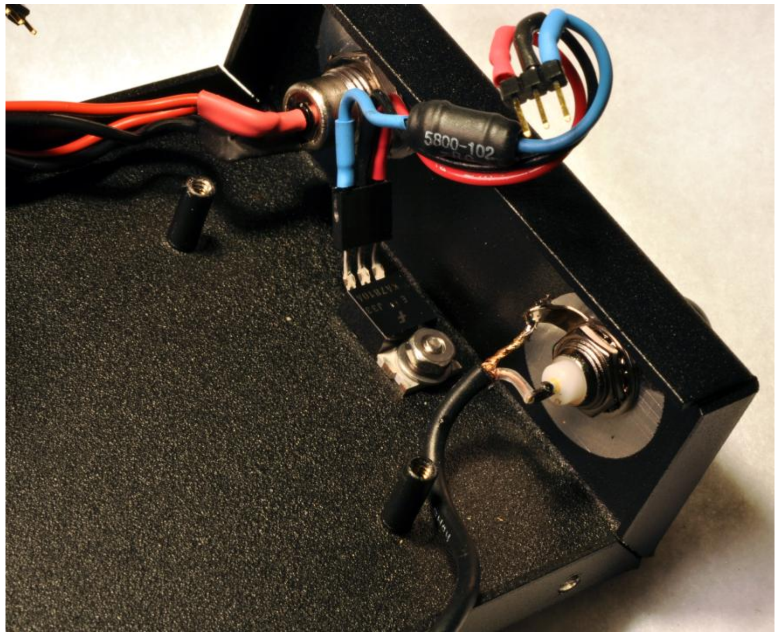
If the current draw appears correct, measure the current through U1-U4. To do this, measure the voltage drop across R2, R5, R6 and R7 (10.0 ohm resistors) and calculate the current in mA by dividing voltage drop by the resistance, 10 ohms. For example, if R2 has a voltage drop of 0.823 volts, U1's current draw is 0.823/10 = 82.3 mA.

U1-U4 should have quite similar current draws. Investigate any significant difference in current draw amongst U1-U4. (Typically the maximum difference is 3 or 4 mA.) The current draw will change as U1-U4 warm up and stabilize in temperature, and the most accurate readings will be obtained after a 10 or 15 minute temperature stabilization period.

Checkout without a variable power supply.

If you do not have a variable voltage power supply, it is necessary to use the 10.0V regulator supplied with the Z10046A as the 10.0V power source.

❑ U5 – 10.0V Regulator.



U5 is a 10.0V precision voltage regulator supplied with the Z10046A and intended to be part of the completed amplifier.

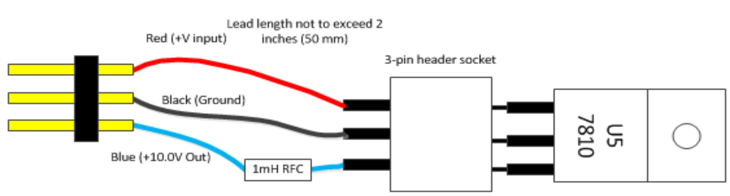
U5 will dissipate several watts of power and must be adequately heat sinked. Normally mounting U5 to the enclosure housing the Z10046A will provide adequate heat sinking.

In order to maintain the lowest feasible temperature gradient across U1-U4, U5 should be mounted along the center line of the printed circuit board and on the outside of the PCB. In order to avoid unwanted parasitic oscillations, the leads between U5 and the PCB should not exceed 2 inches (50mm).

The illustration at the right shows U5 installed in the Clifton Laboratories enclosure. Note that U5 is approximately centered and mounted approximately 0.5 inch (12mm) beyond the PCB edge.

Cut lengths of red and black wire to 2 inches (50mm). Strip both ends of each wire approximately 3/16th inch (5mm) and tin. Locate the 1 mH RF choke (Marked 5800-102) and trim the leads so that the choke body is centered and the overall length is 2 inches (50mm). Cut lengths of small diameter (1/16th inch or 1.5mm) blue heat shrink tubing and slide over the RF choke's leads. Approximately 1/8 inch (3mm) of the wire should be exposed at the ends. Apply heat to shrink the blue tubing.

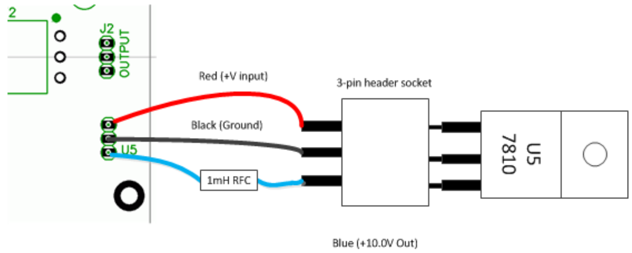
Wire a 3-pin header socket with red and black wires and the RF choke as shown below. Slip lengths (approximately ¼ inch (6mm)) of red, black and blue shrink tubing over the associated color wire (or, choke lead for the blue tubing) before making the solder connection. After the socket is soldered in place, slide the tubing over the joint and apply heat to shrink.



Slip a short length of heat shrink tubing (red for the red wire and black for the black wire) over the wire ends. Solder the red and black wires to a three pin header, but do not attach the blue lead from the RF choke. Follow the illustration at the right. Slide the shrink tubing over the joints and apply heat to shrink.

Plug the pin header into the printed circuit board socket at U5 following the polarity shown in the drawing at the right.

The photo shows an assembled jumper. I twisted the wires together as a matter of neatness; it is not electrically necessary.

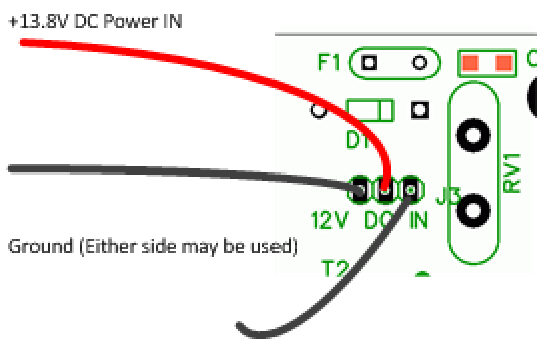


❑ Mount U5 using 4-40 hardware (supplied with the Z10046A) and attach the 3-pin header socket to U5. It may be a tight fit to push the socket over the pins. Orient the socket as shown in the illustrations.

Apply +13.8V to J3, DC Power in. J3's center pin is DC in; the two outside pins are ground. Either or both outside pins may be used.

Measure U5's output voltage (RF choke with blue heat shrink). It should be within the range 9.75V to 10.25V.

If U5's output voltage is within this range, remove the header pin from the PCB socket.



Remove DC input power and slip a short length of blue shrink tubing over the RF choke's free end lead. Solder to the remaining header pin. Slide the shrink tubing over the solder joint and apply heat to shrink.

.

❑ Reapply 13.8V to J3. Observe the current draw. If it significantly exceeds the expected level (four times the individual GaLi-74 current draw based upon your selection of bias resistors), disconnect the power supply and troubleshoot the Z10046A.

For the resistor values supplied with the Z10046A, the current draw will be in the range 300 mA to 425 mA. Values outside this range should be investigated.

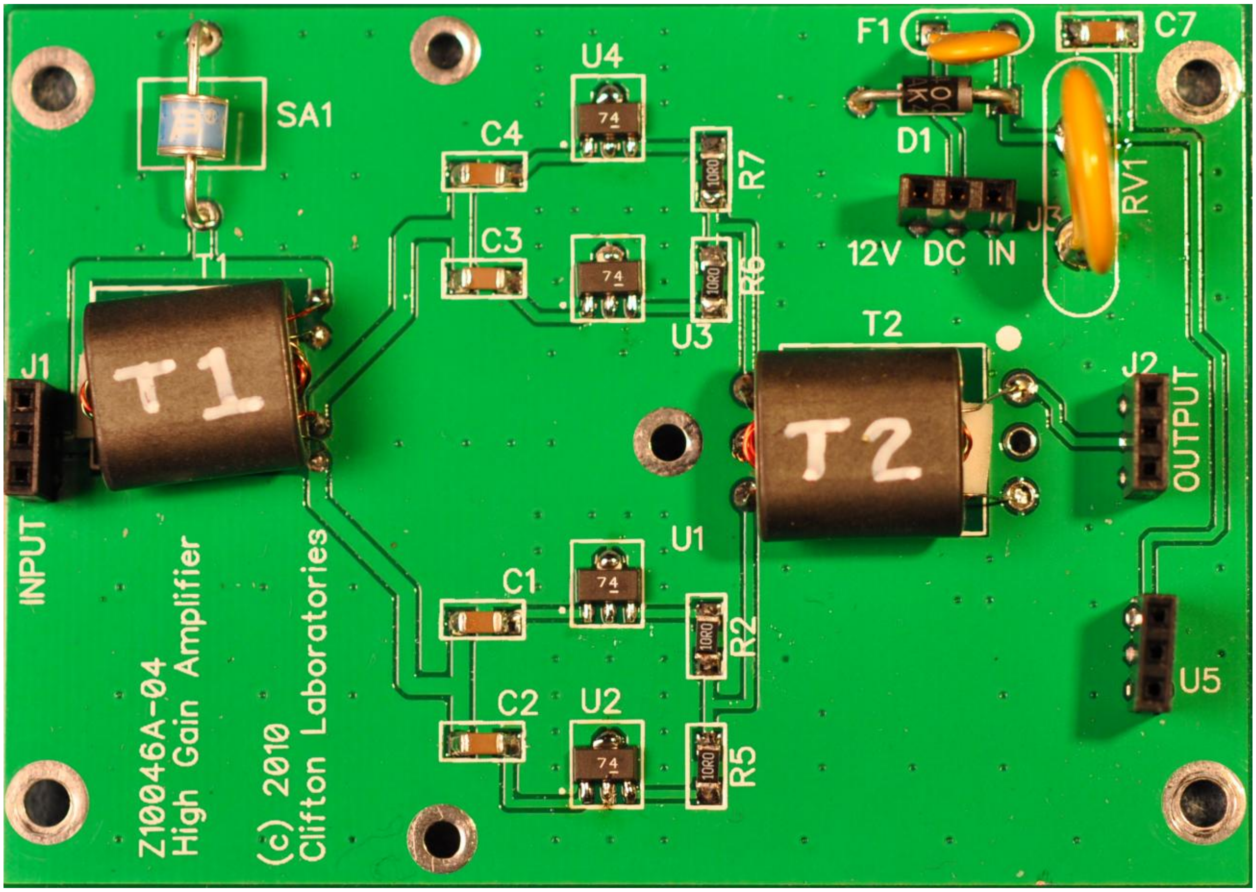
If the current draw appears correct, measure the current through U1-U4. To do this, measure the voltage drop across R2, R5, R6 and R7 (10.0 ohm resistors) and calculate the current in mA by dividing voltage drop by the resistance, 10 ohms. For example, if R2 has a voltage drop across it of 0.823 volts, U1's current draw is 0.823/10 = 82.3 mA.

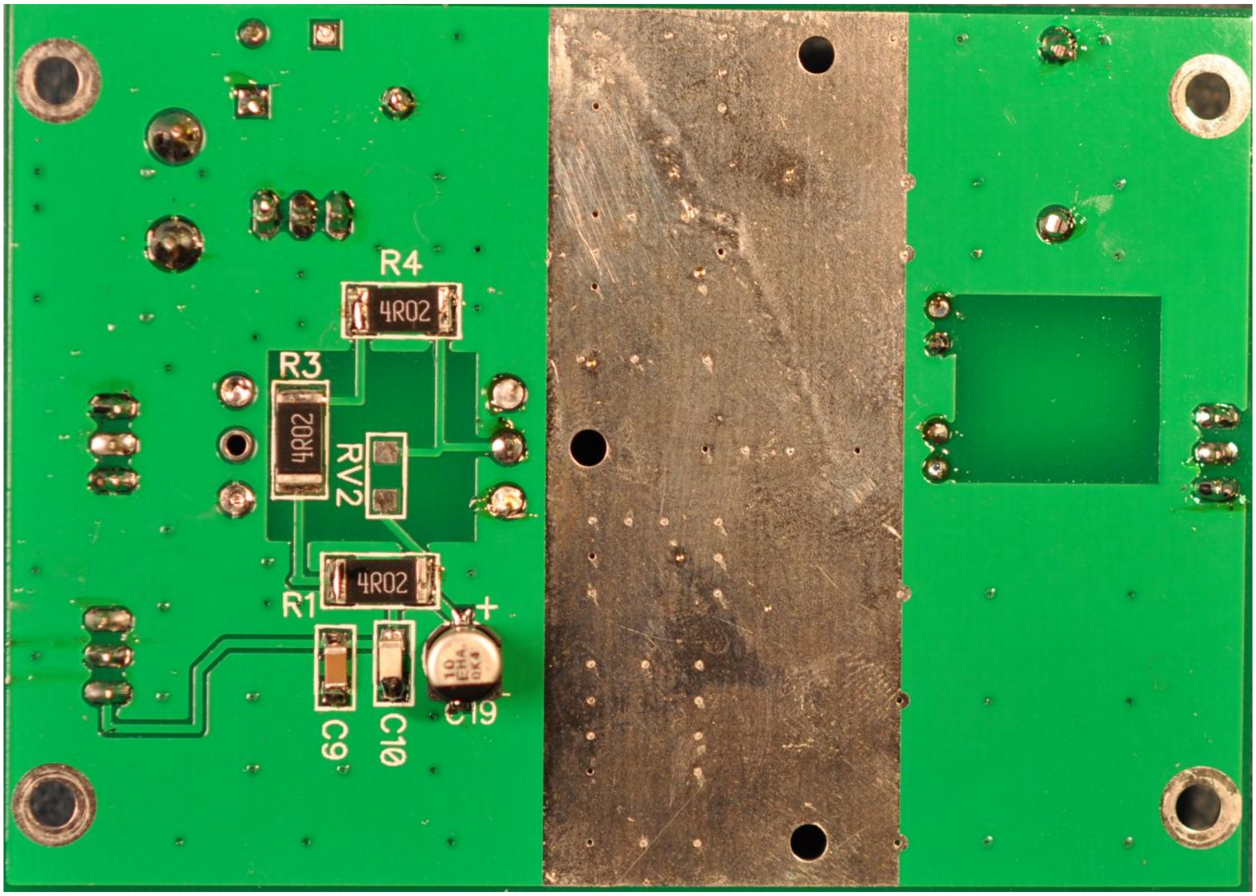
U1-U4 should have quite similar current draws. Investigate any significant difference in current draw amongst U1-U4. (Typically the maximum difference is 3 or 4 mA.) The current draw will change as U1-U4 warm up and stabilize in temperature, and the most accurate readings will be obtained after a 10 or 15 minute temperature stabilization period.

Measure the voltage at the output pin of U1-U4. Record the voltage and current in the table below.

Device	Current (mA)	Voltage (Volts)
U1		
U2		
U3		
U4		

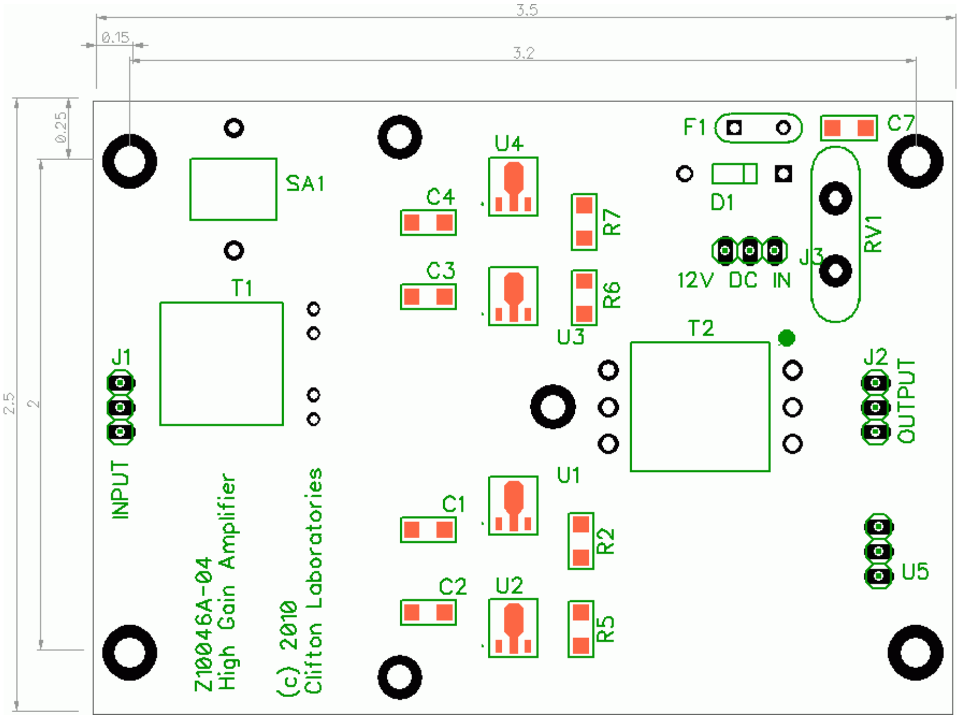
Completed Z10046A View

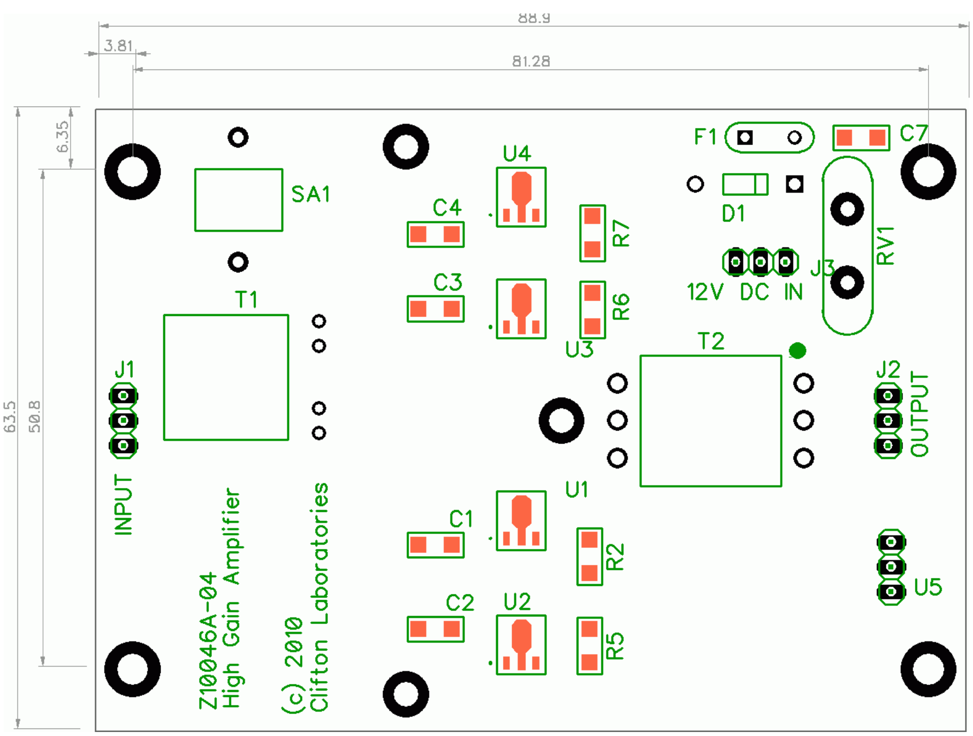



R4
4R02
R3
4R02
RV2
4R02
R1
C9
C10
C19

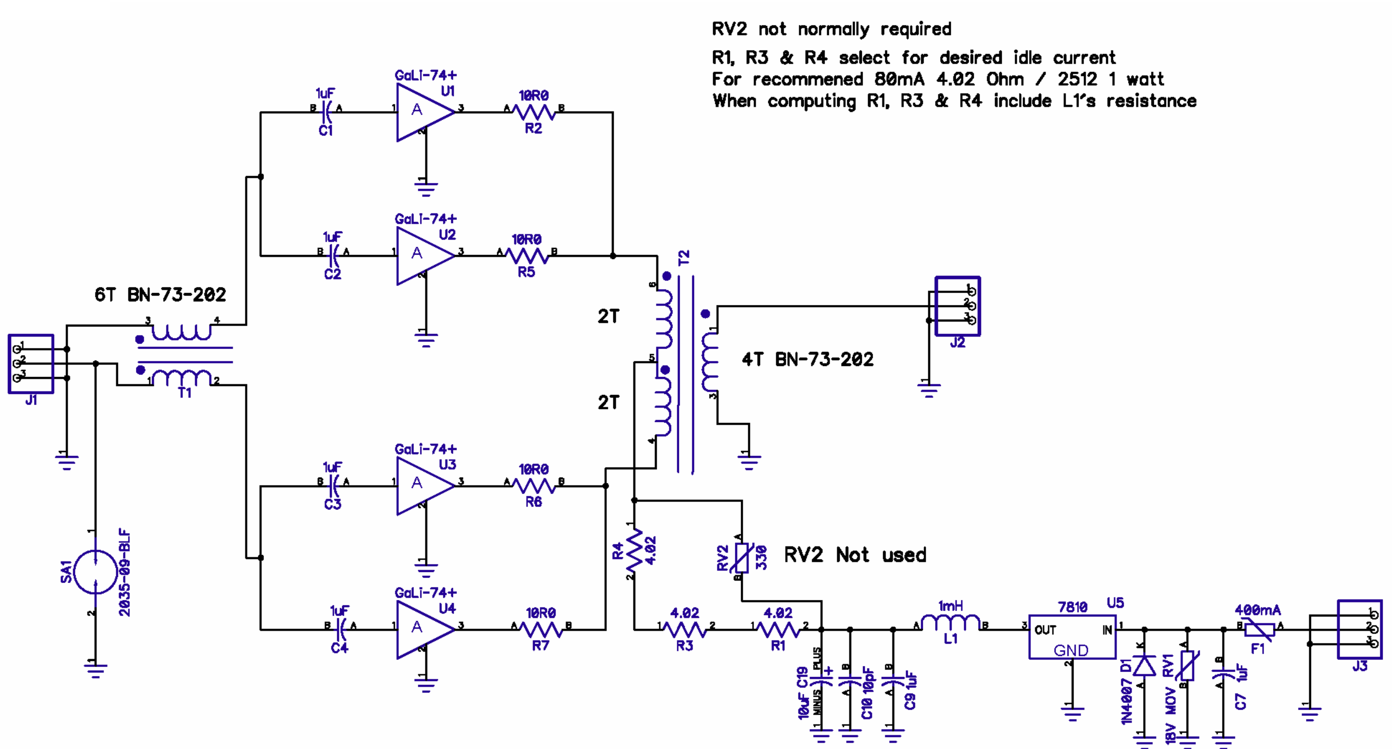
Board Size and Mounting Hole Locations

Mounting holes are for 4-40 hardware (0.125 inch / 3.2mm diameter). DO NOT USE THE THREE SMALLER HOLES TO MOUNT THE BOARD.





Theory of Operation



The Z10046A comprises four Mini-Circuits GaLi-74+ Monolithic Microwave Integrated Circuit (MMIC) amplifiers, U1-U4. The GaLi-74 amplifiers have 50 ohms input and output impedance and a typical gain of 25.1 dB, with OIP3 of +38 dBm and a 1 dB compression point (output) of +19 dBm. The GaLi-74's lower frequency limit is determined by the input coupling circuit, and the upper -3 dB point is 1 GHz. The noise figure is 2.7 dB.

Although a single GaLi-74 provides reasonable performance, it is possible to improve certain critical parameters by operating multiple devices. Paralleling two GaLi-74's results in an input and output impedance of 25 ohms. If this parallel combination is operated in push-pull, the input and output impedance is the sum of the push pull sections, or 50 ohms. Thus, four devices in parallel – push-pull provides a convenient 50 ohm input and output impedance. Since the signal is shared equally amongst four amplifiers, the output 1 dB compression point will improve approximately 6 dB over a single amplifier. Likewise, OIP3 will improve approximately 6 dB. Noise figure will remain unchanged, as does the frequency response.

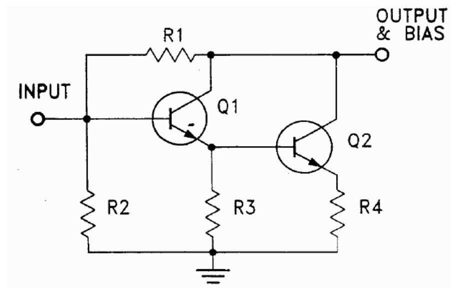
In order to convert the 50 ohm unbalanced input (J1) to balanced 50 ohm drive to the push-pull sections, a 1:1 balun is used. T1 is 6 bifilar turns on a Fair-Rite 73 material core, and provides acceptable unbalanced-to-balanced transformation over the frequency range 25 KHz – 60 MHz.

C1-C4 are DC blocking capacitors, as U1-U4 have DC voltage at their input pins.

The output 25 ohm amplifier sections are converted back to a single ended 50 ohm output by T2. In addition, T2 provides a convenient DC feed point.

The GaLi-74's output is both an RF output and DC feed point. Mini-Circuits' Application Note AN-60-010 provides the following description of the biasing network required for proper operation of its line of MMICs:

The internal circuit configuration is a Darlington pair, embedded in a resistor network as shown in the schematic diagram, Figure 1. Applying DC power to operate this kind of amplifier is simpler than biasing a transistor. Like a discrete bipolar transistor, this circuit is current-controlled rather than voltage-controlled. This means that for a range of current around a recommended value, the device voltage varies much less than in proportion to current. A constant-current DC source would be ideal for providing a stable operating point. By contrast, with most of these models the use of a constant-voltage DC source would cause the current to vary widely with small changes in supply voltage, temperature change, and device-to-device variations. Stable operating point needs an external series resistor between the amplifier and a DC voltage supply to approximate a constant-current source.



The Z10046A approximates a constant current source as recommended by Mini-Circuits, a fixed voltage supply and a series resistor. R1, R3 and R4, and the DC resistance of L1, form one part of the series resistor. However, simply connecting U1-U4 to the output transformer pins all outputs at the same voltage and yields unequal current sharing amongst the four devices. Small differences amongst U1-U4, either as a part of manufacturing tolerance or unequal temperature among U1-U4, cause current unbalance and degrades second order intercept. Equalizing resistors R2, R5, R6 and R7 permit U1-U4 to have slightly different terminal voltages and equalizes currents. 10 dB or more improvement in OIP2 is provided by adding the four equalizing resistors. Approximately 2 dB gain is lost as a consequence of the equalizing resistors.

L1, and the associated bypass capacitors, reduces broadband noise from U5, which would otherwise be coupled to the Z10046A’s output. U5’s noise contribution is most objectionable below 500 KHz, and is reduced to negligible levels by L1 and the associated bypass.

DC input power is over-voltage clamped by an MOV, RV1 and is short circuit protected by a positive temperature coefficient thermistor or Polyfuse, F1. Reverse voltage protection (in addition to that provided by U5) is accomplished by D1. SA1 is a spark gap intended to fire in the event of gross overvoltage on the input. SA1 fires at 90 volts, so it will not protect the Z10046A from damage, but is rather intended to reduce damage to equipment that might be connected to the Z10046A in the event of a nearby lightning strike.

Troubleshooting

Schematic diagrams are provided with typical voltage and resistance readings.

In troubleshooting the Z10046A, remember that the specific voltages on U1-U4 are a function of the bias resistor and U5's output voltage. In general, the most useful measurement technique, if U1-U4 are suspect, is to compare the voltage and current for all four devices. U1-U4 voltages and currents will closely track and any significant divergence should be investigated.

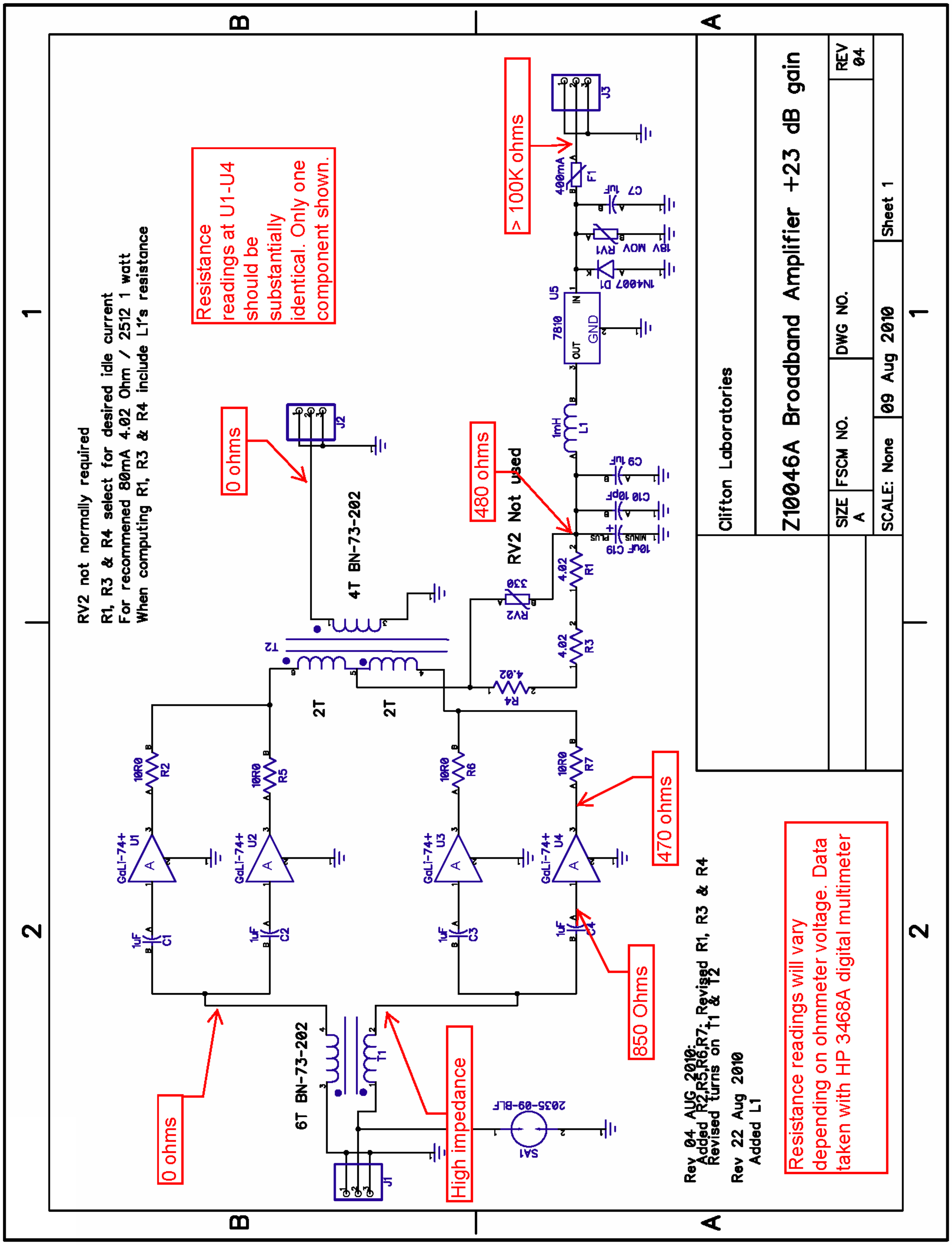
It is possible to measure individual bias current for U1-U4 by measuring the voltage drop across the associated 10R0 equalization resistors. The current in mA equals the drop across the 10R resistor (in millivolts) divided by 10.0.

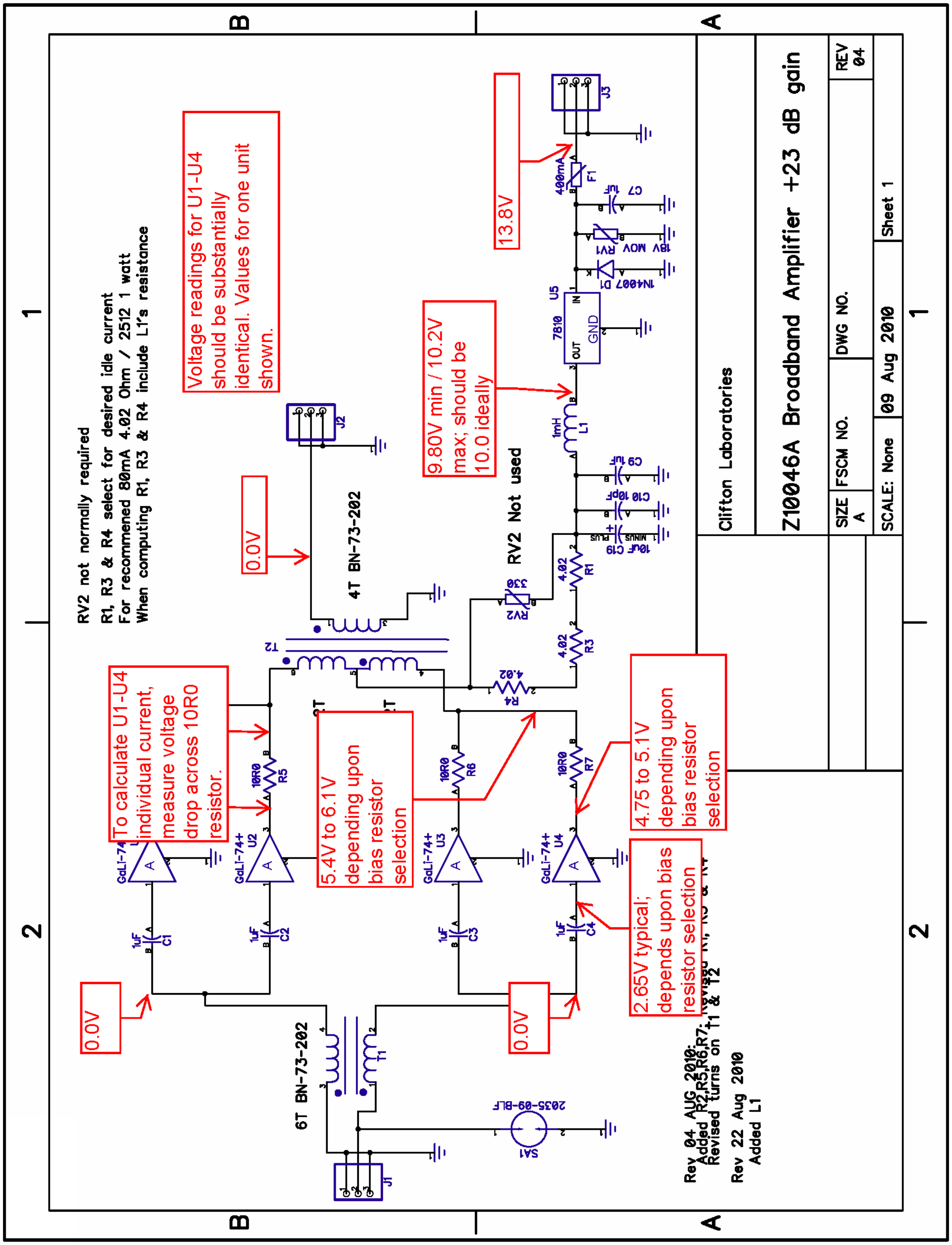
T1 and T2 are Fair-Rite 73 material ferrite and exhibits finite resistance. Placing ohmmeter probes on either T1 or T2 material will read in the tens of thousands of ohms. If T1's winding has abraded insulation, J1 resistance to ground will not be the expected near open circuit, but will be in the low to medium kilo-ohm range. If the transformer has been wound with Teflon sleeves, no such abrasion should occur and J1 should be near infinite resistance to ground. In most instances, however, amplifier performance will not be significantly degraded even if T1 has abraded winding insulation.

U1-U4 normally run warm, with a power dissipation in the 0.5 watt range for each device. Bias current is affected by temperature changes and it is normal to see a modest change in current consumption, on the order of 5% or less, from cold start to fully temperature stabilized operation.

Optimum second order intermodulation product performance requires U1-U4 to be isothermal, i.e., no major temperature difference from U1 to U4. The Z10046A PCB is designed to equalize temperature across U1-U4 under normal circumstances. However, it is possible that where a Clifton Laboratories provided enclosure is not used, issues related to thermal balance may occur. If 3rd order intermodulation performance is normal, but 2nd order intermodulation is somewhat below standard, temperature differentials amongst U1-U4 should be examined. In general, achieving high 2nd order intermodulation performance requires a high order of balance amongst U1-U4 and associated components. Hence, differential measurements among U1-U4 are a good way to approach troubleshooting.

Resistance Readings



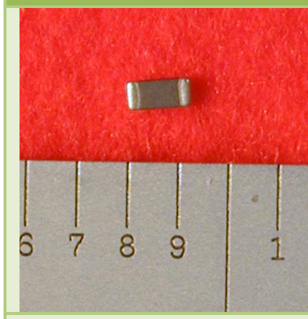
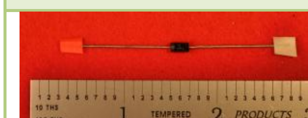
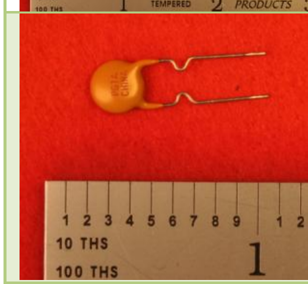
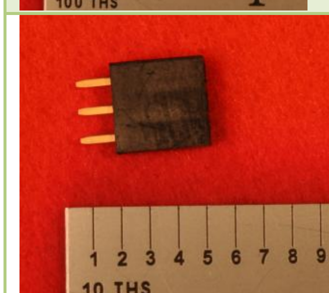


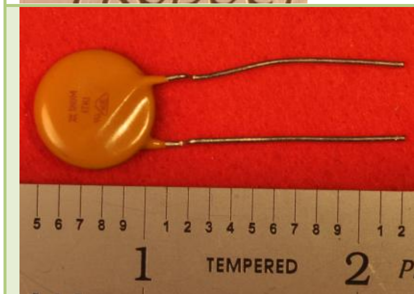
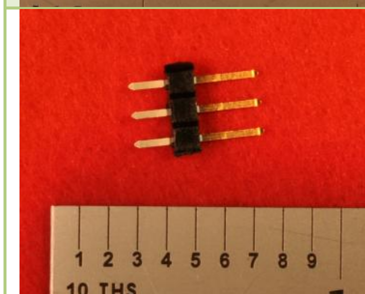
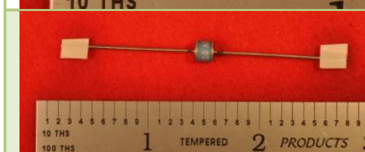
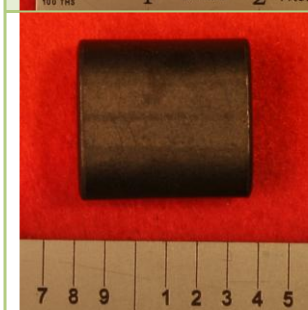
RV2 not normally required
R1, R3 & R4 select for desired idle current
For recommened 80mA 4.02 Ohm / 2512 1 watt
When computing R1, R3 & R4 include L1's resistance
Voltage readings for U1-U4 should be substantially identical. Values for one unit shown.
13.8V
9.80V min / 10.2V max; should be 10.0 ideally
0.0V
4T BN-73-202
RV2 Not used
To calculate U1-U4 individual current, measure voltage drop across 10R0 resistor.
5.4V to 6.1V depending upon bias resistor selection
4.75 to 5.1V depending upon bias resistor selection
2.65V typical; depends upon bias resistor selection
0.0V
0.0V
6T BN-73-202
2035-09-BLF
Rev 22 Aug 2010 Added L1
Clifton Laboratories
Z10046A Broadband Amplifier +23 dB gain
SIZE A
FSCM NO.
DWG NO.
REV 04
SCALE: None
09 Aug 2010
Sheet 1

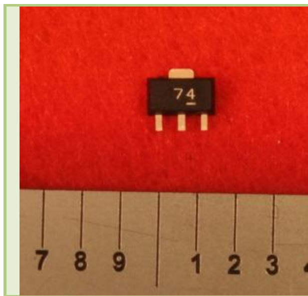
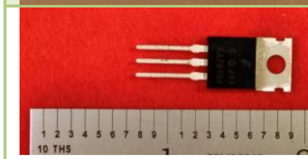
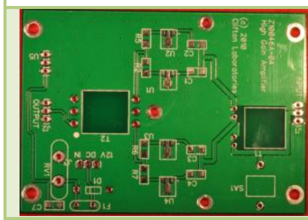
Parts List

The scale in the photograph is marked in inches and tenths of an inch (2.54mm).

Parts values in this manual are identified with the decimal point indicated by the multiplier digit. For example a 10.0 ohm resistor is identified as 10R0, a 1.0uF capacitor as 1u0, etc.

Photo	Component ID	Value	Marking	Quantity
	C1,C2,C3,C4,C7,C9	1uF, X7R, 50V 1206 ceramic capacitor	None	6
	C10	10pF, NP0/C0G, 50V 1206 ceramic capacitor	None	1
	C19	10uF, 25V 105°C electrolytic capacitor	10 EHA	1
	D1	1N4007	1N4007	1
	F1	500mA polyfuse	RXEF050S	1
	J1,J2,J3 & J4; U5 socket (and U5 PCB socket)	3 position, 0.1 inch spacing single row, 0.025 inch square pin header socket	PINHD-1X3	6
	R1, R3 & R4	1 watt, 2512 size resistor; value as determined by customer's selection of idle current.	Marking is nRnn where n is a digit from 0 to 9 and R indicates the decimal point. 4.02 ohms, for example, will be marked 4R02.	3

	R2, R4, R5 & R6	10R0	10R0	4
	RV1	18V MOV	180M	1
	Header Pins (male)		0.1 inch single row	12
	SA1	2035-09-BLF	90V	1
 	T1, T2	BN-73-202	None	2

	U1, U2,U3,U4	GaLi-74+	74	4
	U5	7810 three-terminal regulator; -2% tolerance or better	Depends upon supplier; part will have ‘7810’ in the marking, e.g., KA7810AETU	1
	Printed Circuit Board	Z10046A	Z10046A-X where X is the PCB revision number	1
None	Wire	No. 30 red & green		24
	Teflon Bushing	3 inches (75mm) 0.103 ID		
	L1	1 mH RF Choke		
None	Hookup wire	Red wire		3
None	Hookup wire	Black wire		3
None	Shrink tubing	Blue small shrink		3
None	Shrink tubing	Black 1/8” shrink		1
None	Shrink tubing	Blue 1/8” shrink		1
None	Shrink tubing	Red 1/8” shrink		1
None	Foam tape, double sided 1/4" wide			Approx. 1” (25mm) long
None	Voltage regulator screw	4-40 x 3/8" PanHead Philips 18-8 SS		1
None	Lockwasher	4-40 spring lockwasher 18-8 SS		1
None	Flat washer	4-40 hole 18-8 SS		1
None	Small pattern nut	4-40 thd 18-8 SS		1