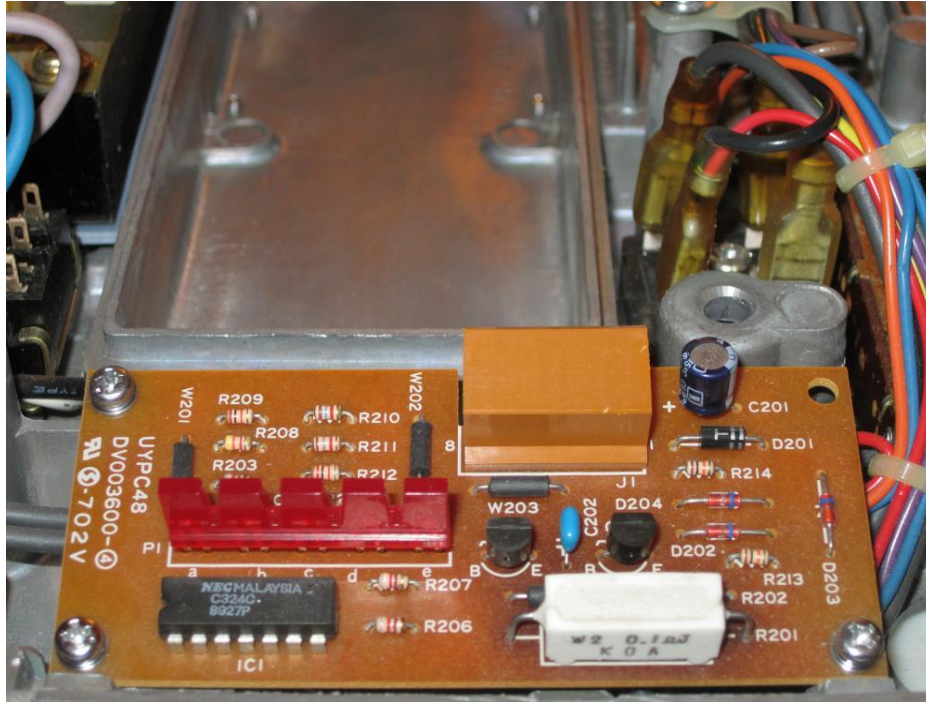


# Troubleshooting and Repairing the Electronics of the 20W Models of Olympus BH-2 Microscopes

Revision 7



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Document Revision History		
Revision	Description of Changes	Date
1	Initial release	June 17, 2014
2	Corrected error in circuit theory. Added vendor info, lamphouse repair procedure, and light preset control / switch information.	March 17, 2016
3	Replaced the lamp-house repair procedure with a reference to the stand-alone lamp-house repair document. Added information for more substitute parts (intensity slider, J103 socket, switches). Added images of preset PCB. Added author contact info.	February 16, 2017
4	Clarified PTE slide pots, added to Tamiya replacement for DW-1195, clarified 4mm Allen tool, added troubleshooting flowcharts, and updated to single-page schematic.	January 2, 2019
5	Added new PNP transistor type, LED array, and transistor installation and mounting details.	March 25, 2021
6	Corrected TO-3 mounting instructions. Minor revisions.	July 6, 2021
7	Show fuse holder on early 100V/115V bases. Add AC line cord information.	January 11, 2023

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## Introduction

This document provides a detailed description of the electrical circuitry in the Olympus 20W microscope stands in the BH-2 family, which includes the BHT and BHTU stands. The information contained herein is intended to supplement the information published in the Olympus repair manuals (see [Original Olympus Documentation](#) in this document) by providing additional circuit details and a complete theory of operation, as well as troubleshooting information and the correction of minor errors that were present in the circuit diagrams published in the Olympus manuals. This information was obtained by performing tear-down inspections of functional BHT/BHTU microscopes configured for 100V/115V operation.

## Safety Warnings and Disclaimers

The content of this document is provided for informational purposes only, with no expressed or implied warranties whatsoever, including, but not limited to, function, suitability, safety, accuracy, and completeness of information. Repairing your own microscope may seem like a hip and cool thing to do that will make you the envy of all your friends but *being dead* will not. Potentially lethal voltages are present inside these microscopes. Do not attempt repairs or troubleshooting if you lack the necessary skills, training, and confidence to safely perform repairs on AC line-powered electrical equipment. If you choose to attempt repairs or troubleshooting, do so at your own risk.

## Overview of Electrical Circuitry

The electrical circuitry of the Olympus BHT/BHTU microscopes resides completely within the base of the stand. Electrical power is provided by an AC inlet jack

on the back, where the AC line cord connects. There is a power switch on the front to turn the illumination on and off, and an intensity control on the right-hand side to vary the lamp voltage. There is a voltage-selector switch on the bottom of the base to allow operation under normal or low-line conditions, and enclosed within the base are a power transformer, a bridge rectifier, a printed circuit board, and a power transistor. A 6V/20W halogen lamp resides in the lamphouse on the rear of the stand. Later stands have a light-preset switch and a screwdriver-adjustable preset control, located just above the intensity slider (see [Figure 17](#)), to provide preset lighting intensity for photographic applications.

## Electrical Theory of Operation

The BHT/BHTU electronics performs two independent functions in response to a variable control signal from the intensity potentiometer. The first function is intensity control of the halogen lamp. To provide this, the dimmer circuitry varies the voltage applied to the lamp in response to this control signal. The second function is display of the lamp voltage via a four-segment LED bar-graph display. Details of both independent circuit functions are described in the sections below.

### Lamp Dimmer Circuitry

[Figure 1](#) is a simplified schematic diagram of the lamp-dimmer circuitry. This diagram contains the details necessary for an understanding of the basic operation of the lamp dimmer. Unnecessary details such as switching, fusing, electrical interconnects, and current limiting have been omitted for clarity. Refer to [Figure 64](#) for a complete and detailed schematic diagram of the BHT/BHTU electronics.

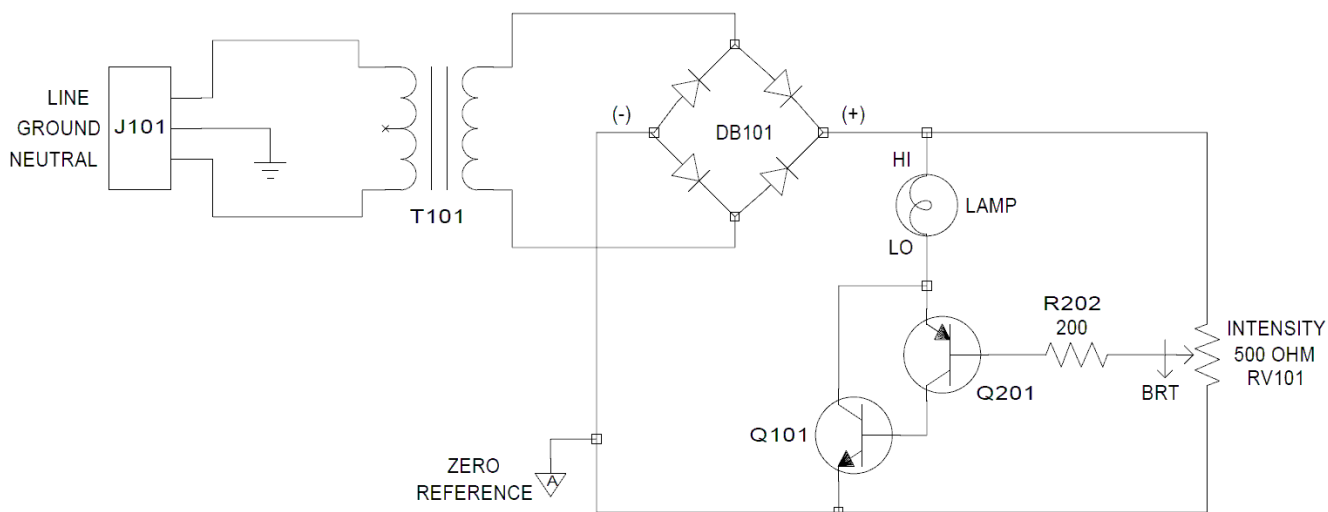


Figure 1 – Lamp dimmer circuitry (without current limiting)



Electrical power from the AC line is applied to the equipment via the AC line cord, which plugs into J101 on the back of the microscope base. Power transformer T101 converts the AC line voltage (120V or 240V, depending on which transformer is installed) to approximately 9.5VAC RMS on the secondary winding. The output of the secondary winding feeds into bridge rectifier DB101, whose full-wave-rectified output in turn feeds the lamp-dimmer circuitry. Bridge rectifier DB101 is necessary to provide DC to the lamp-dimmer circuitry, since transistors Q101 and Q201 in the dimmer circuit are bipolar junction devices which can conduct current in only a single direction.

Slide potentiometer RV101 controls the lamp intensity. When RV101 is adjusted for minimum intensity (i.e., the wiper is at the top end of its travel), the full output voltage of bridge rectifier DB101 is fed to the base of transistor Q201 via resistor R202. Under this condition, transistor Q201 will not conduct since the base-emitter junction is not forward biased, and there will be no collector current in Q201 and therefore no base current in transistor Q101. Without base current, transistor Q101 will be cutoff, and no current will flow through the lamp.

As potentiometer RV101 is moved from its minimum-intensity position in the direction of increasing intensity (i.e., the wiper is moved towards the zero-reference ground), the control signal feeding the base of transistor Q201 decreases, progressively forward biasing its base-emitter junction and allowing it to increasingly conduct collector current. Since the collector current of transistor Q201 is the base current

of transistor Q101, Q101 in turn begins to conduct increasing amounts of collector current, which flows through the halogen lamp. The lower the amplitude of the control signal from the potentiometer, the higher the resulting lamp voltage and corresponding lamp intensity.

The overall DC current gain of the lamp dimmer is considerable and is approximately equal to the product of the individual  $\beta$  values of transistors Q201 and Q101 (i.e.,  $\beta_{\text{OVERALL}} \sim \beta_{\text{Q201}} \times \beta_{\text{Q101}}$ ). Because of this high value for  $\beta_{\text{OVERALL}}$ , the halogen lamp will be fully illuminated with little base current in transistor Q201, thereby introducing only a minimal voltage drop across resistor R202. Neglecting this minimal drop, the voltage present on the bottom terminal of the lamp is approximately 0.7V higher than the control signal from the potentiometer at any setting of the potentiometer (excluding the minimum-intensity setting where there is no forward bias on the base-emitter junction of transistor Q201). This means that the lamp voltage may be adjusted from zero at one extreme of the intensity control to nearly the full output voltage of DB101 at the other extreme of the intensity control.

Figure 2 is the lamp-dimmer circuitry shown in Figure 1 with the addition of transistor Q202, resistor R201, and capacitor C202. These three components provide a current-limiting function for the dimmer, to prevent damage to the halogen lamp and to transistor Q101 in the event of power surges on the AC line, and also during power-up, when the cold lamp filament has relatively low resistance.

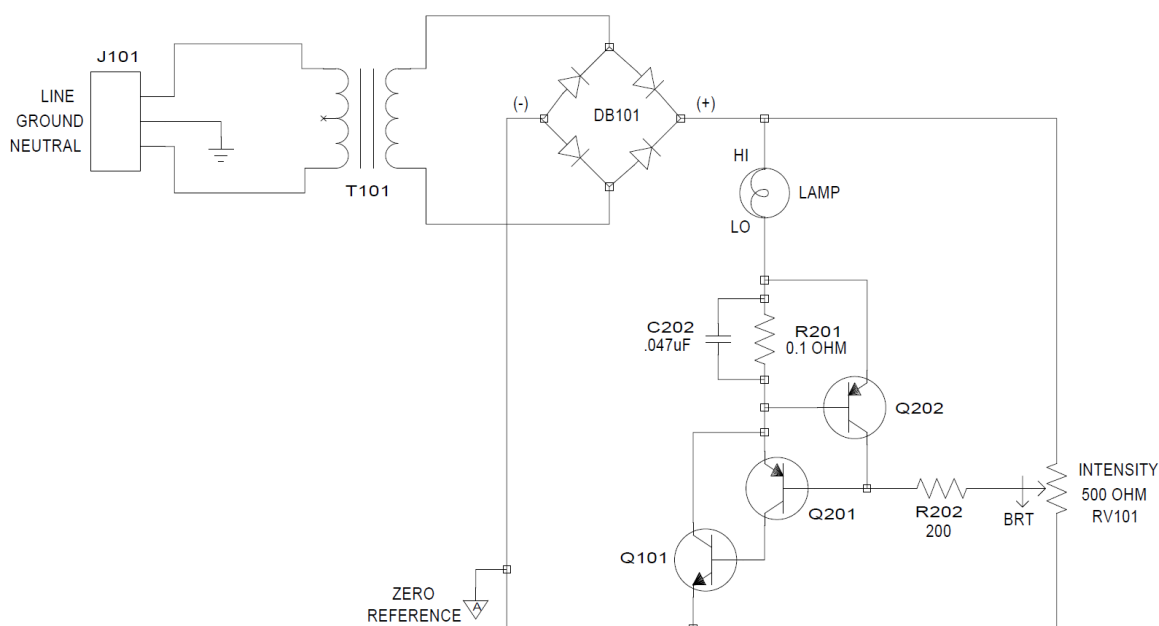


Figure 2 – Lamp dimmer circuitry (with current limiting)

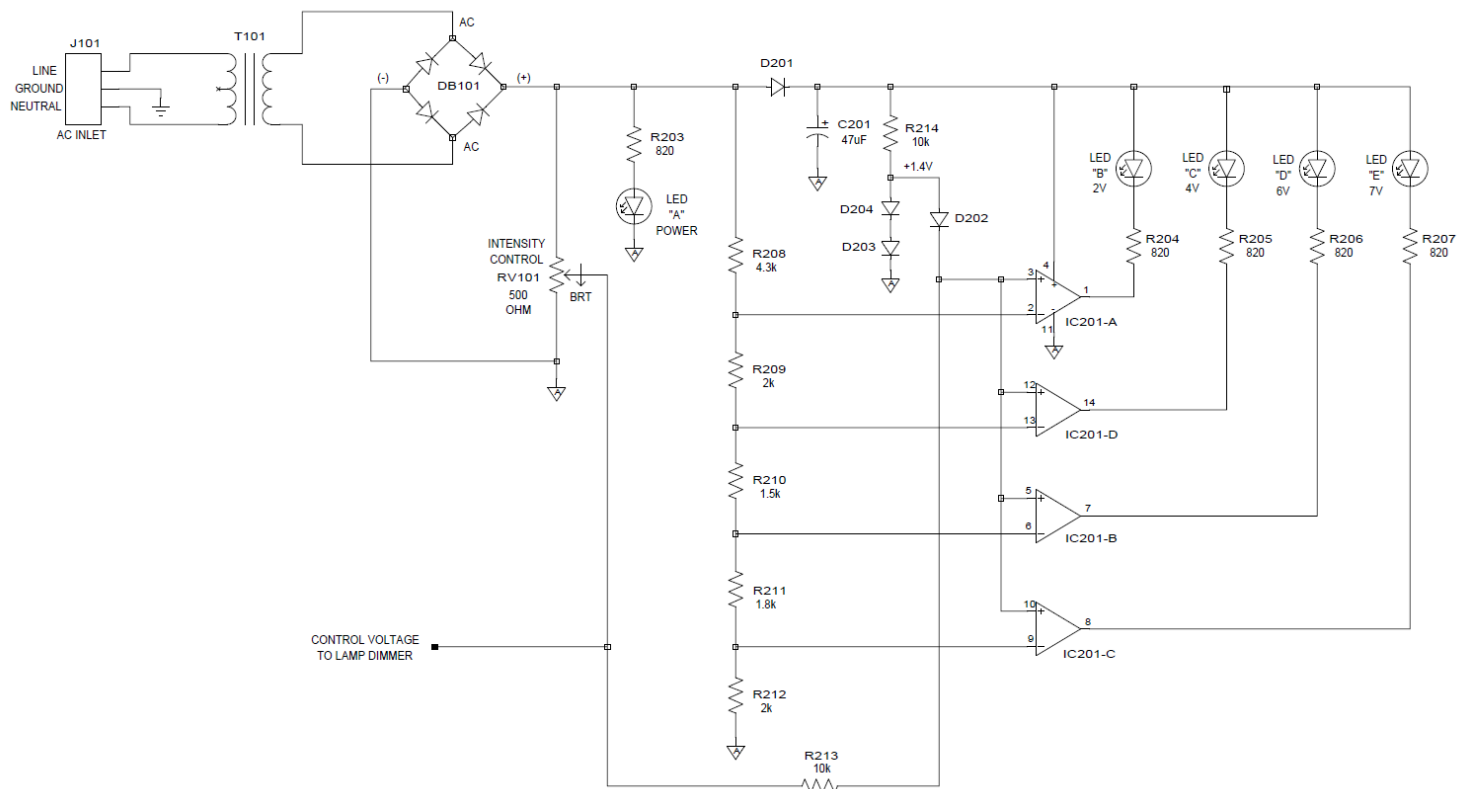
Resistor R201, the current-sensing resistor, is effectively in series with the halogen lamp. So long as the lamp current remains within the normal range, the resulting voltage drop across resistor R201 is insufficient to initiate conduction of transistor Q202, and the dimmer operates as described in the paragraphs above. However, if for any reason the lamp current gets high enough that the voltage drop across resistor R201 is sufficient to turn on transistor Q202, the resulting collector current of transistor Q202 shunts the base-emitter junction of transistor Q201, reducing its base current and in turn reducing the lamp current. This negative-feedback mechanism limits the peak lamp current to approximately 7.3A. Capacitor C202 provides low-pass filtering for the base of transistor Q202, preventing high-frequency noise or RF from affecting the lamp dimmer.

**Figure 48**, **Figure 49**, and **Figure 50** show the voltage waveforms on the halogen lamp and the current waveforms through the halogen lamp, with the dimmer operating at the 100%, 50%, and 20% settings of the intensity control, respectively. **Figure 51** shows the dimmer operating under current-limiting conditions at the 80% setting of the intensity control and with an abnormally low lamp resistance of 0.2Ω.

## LED Bar-Graph Display Circuitry

**Figure 3** is a simplified schematic diagram of the LED bar-graph display circuitry. This diagram contains the details necessary for an understanding of the basic operation of the LED bar-graph display. Unnecessary details such as switching, fusing, and electrical interconnects have been omitted for clarity. Refer to **Figure 64** of this document for a complete and detailed schematic diagram of the BHT/BHTU electronics.

This circuit successively illuminates four LEDs in the bar-graph module as the intensity control is moved from its minimum setting to its maximum setting. The variable output from the wiper of slide potentiometer RV101 acts as the control signal for the LED bar-graph display circuitry (as well as for the dimmer circuit described earlier), which feeds the non-inverting inputs of four op-amps used as comparators. The control signal is at maximum amplitude at the minimum-intensity setting and is at zero amplitude at the maximum-intensity setting. The four comparators each have specific switching thresholds, which are configured to allow the comparators to successively illuminate the LEDs at four pre-defined lamp voltages of 2V, 4V, 6V, and 7V, in response to the decreasing control signal from the intensity potentiometer.



**Figure 3 – LED bar-graph display circuitry**

### Filtered DC Power Supply

Diode D201 and capacitor C201 operate as a peak detector to produce filtered DC power from the full-wave-rectified output of bridge rectifier DB101. This filtered DC power line supplies power to the comparators and their respective LEDs. The AC ripple present on this line depends on the amount of current pulled by the comparators and LEDs. At minimal lamp intensity (i.e., with all four LEDs in the off state), very little current is required and the voltage on this line is approximately +12.1V with little AC ripple. As the lamp intensity is increased (and the LEDs begin to successively illuminate), the current drain on this line increases as does the resulting AC ripple. When the lamp is at maximum intensity, all four LEDs are illuminated and the AC ripple is at its maximum, resulting in an average voltage on the filtered DC power supply line of approximately +9.0V. **Figure 52** shows the ripple voltage on the filtered DC power supply line with the equipment operating under worst-case ripple conditions of maximum lamp intensity. The blue trace is the positive output of bridge rectifier DB101 and the green trace is the filtered DC power supply line.

### Comparator Thresholds

The switching thresholds of the four op-amp comparators are provided by a four-stage voltage divider consisting of resistors R208, R209, R210, R211, and R212. These thresholds are configured to allow the comparators to successively illuminate the LEDs at pre-defined lamp voltages of 2V, 4V, 6V, and 7V, in response to the decreasing control signal from the intensity potentiometer. **Figure 53** shows the threshold voltages on the inverting pins of the op-amp comparators. The green trace is the positive output of bridge rectifier DB101, from which the four threshold voltages are derived. The blue, red, cyan, and magenta traces are the threshold voltages on the inverting inputs of IC1-A, IC1-D, IC1-B, and IC1-C, respectively.

### Control-Signal Clamp

Resistors R213 and R214, and diodes D202, D203, and D204, clamp the voltage level of the intensity control signal from slide potentiometer RV101 to keep the non-inverting inputs of the comparators from ever dropping below approximately +0.7V. This is necessary to prevent the LEDs from illuminating briefly during the intervals where both the wiper of potentiometer RV101 and the comparator thresholds drop to zero at the zero crossings of the AC line. If both inputs to the comparators were allowed to simultaneously drop to zero, the comparators

would be in an indeterminate state, and depending on the input-offset voltage parameters of the specific op-amp devices, their outputs could pull low during these intervals, resulting in one or more LEDs not fully extinguishing when they should.

The operation of the control-signal clamp is as follows. Resistor R214 feeds a DC current through the two series-connected silicon diodes, D203 and D204, producing a potential on the anode of diode D204 two diode drops above ground (approximately +1.4V). The anode of diode D202 connects to this +1.4V node and its cathode connects to the non-inverting inputs of the four comparators. Resistor R213 couples the control signal from slide potentiometer RV101 to the non-inverting inputs of the comparators. Any time the control signal is low enough to forward bias diode D202, the voltage on the non-inverting inputs of the comparators is clamped to approximately +0.7V (i.e., one diode-drop less than +1.4V). As the voltage on the wiper of RV101 increases, diode D202 turns off and is effectively out of the circuit, thereby providing no further clamping action. This mechanism allows the intensity control signal to swing positive without restraint but prevents it from dropping below approximately +0.7V. **Figure 54** shows the waveform of the clamped control signal at the 50% setting of the intensity control, as measured at the non-inverting inputs of the comparators.

### Voltage Comparators

Integrated circuit IC1 is a NEC uPC324C quad operational amplifier. All four sections of IC1 are operated open-loop as voltage comparators and are configured to drive the four bar-graph LEDs in response to the clamped control signal from slide potentiometer RV101. Each of the four comparators illuminates their associated LED by driving its output low during the intervals where the clamped control signal drops below its respective threshold voltage and extinguishes its LED by driving its output high during the intervals where the clamped control signal exceeds its respective threshold voltage. **Figure 55** shows the operation of one of the comparators (IC1-B) with the 6V LED illuminated. In these waveforms, the intensity control is set to the 70% setting. The green waveform is the threshold voltage present on the inverting pin of IC1-B, and the blue waveform is the clamped control signal on the non-inverting pin of IC1-B. During the intervals where the control signal is below the threshold voltage, the comparator output pulls low, illuminating the 6V LED, and during the intervals where the control signal is clamped to approximately +0.7V (and is exceeding the threshold voltage), the comparator output pulls high, extinguishing



the 6V LED. If the setting of the intensity control is decreased to the point where the clamped control signal exceeds the threshold waveform, the 6V LED will completely extinguish. The operation of the remaining three comparators is similar to this one, differing only in their threshold voltages.

### **Power LED**

Resistor R203 and LED “A” function as the power-on indicator for the microscope. This network is powered by the full-wave-rectified output of DB101. Resistor R203 sets the current through, and therefore the brightness of, the power-on LED.

### **Errors in the Olympus Documentation**

While researching this document, a few errors were identified in the schematic diagram published in the *Olympus Research Microscope Series BH2 (BHS) Repair Manual*, as described below.

#### **Error in the Bar-Graph LEDs**

The Olympus manual shows the bar-graph LEDs wired with their cathodes connecting to their respective comparator outputs and with their anodes wired to their respective current-limiting resistors (see Detail 1 of [Figure 64](#)). The actual circuit configuration has the anodes of the four LEDs connected to the filtered DC power supply line and the cathodes connected to their respective current-limiting resistors. This is a minor discrepancy and either configuration would work equally well, but the as-built configuration is shown in this document.

#### **Error in the Control-Signal Clamping Network**

The Olympus manual shows the control-signal clamping network fed from the full-wave-rectified output of the bridge rectifier (see Detail 2 of [Figure 64](#)). The actual circuit configuration has this network fed from the filtered DC power supply line. This error is of greater consequence than the first, as the circuit published in the Olympus repair manual would not guarantee that the LEDs remain off around the zero crossings of the AC line.

#### **Clarification of Transformer Secondary Voltage**

The Olympus manual shows the secondary voltage of power transformer T101 as 9V. Actual measurements taken from functional BHTU equipment have shown a secondary voltage of approximately 10.7V<sub>AC</sub> (RMS) at minimum lamp intensity and approximately 9.6V<sub>AC</sub> (RMS) at maximum lamp intensity.

### **Removing the Electrical Base from the Stand**

To gain access to the electronics in the base of the BHT/BHTU stand, the electrical base must be removed

from beneath the stand. Be sure to take plenty of photographs during the disassembly process to make sure that everything can be correctly reassembled later. Before removing the electrical base, look at the right-hand side of the base, just above the intensity slider, and note whether a light-preset control and switch are present (see [Figure 17](#)). The earlier units did not include these components, but the later ones did.

Remove all the major components from the microscope stand (i.e., AC power cord, condenser, stage, eyepieces, viewing head, and objectives). Doing so will make the stand easier to maneuver and will prevent inadvertent damage to these components during disassembly and reassembly. Be sure to protect these components from dust and damage while they are not installed on the stand. After removing all of the components from the stand, cover the top of the arm (i.e., the nosepiece turret and the exposed mounting dovetail for the viewing head) with a clean plastic bag and secure this with a rubber band or adhesive tape to keep dust out of these openings. This is especially important on BHTU stands which have an optical correction lens located just below the viewing head to correct for the difference in tube length introduced with the reversed nosepiece.

With the stand in its normal upright position, remove the lamphouse from the back of the base. The lamphouse simply plugs into the base and can be removed by grasping it and pulling it straight back. Set the lamphouse aside to prevent damage. Do not touch the halogen lamp with your fingers, as oils from your skin may cause premature failure of the lamp. If the lamp is accidentally touched, clean it with isopropyl alcohol.

Carefully lay the stand on its back. Use a 4mm or 5/32” Allen tool to remove the four hex, socket-head cap screws from the bottom of the stand (see [Figure 4](#)). Hold the electrical base in place and set the stand in its normal upright position on a flat surface, being careful not to let the electrical base shift as you do so. Lift the stand from the electrical base by grasping the arm and lifting straight up until the bottom of the stand well clears the electrical base. If the unit contains a light-preset control and switch (see [Figure 17](#)), be sure to disengage the printed circuit board containing the preset control and switch from the notch in the side of the base before lifting the stand clear of the electrical base. Since there are fragile lighting components which are now exposed on the open bottom of the stand, place the stand on a clean, flat, clutter-free surface in its normal upright position to prevent damaging these fragile components.



Figure 4 – Bottom view of the BHT/BHTU electrical base

## Setting Up for Troubleshooting the Base

Set the electrical base on a suitable work surface. If the unit includes a light-preset control/switch (see [Figure 17](#)), orient the printed circuit board containing the control and switch such that it will not make contact with the chassis or any other electrically conductive items during the troubleshooting process.

### A Caution Regarding Equipment Safety Grounding

Never operate the microscope if the chassis bonding screw for the center ground pin of the AC inlet jack is loose or missing, or if the wire to this lug is cut or damaged (see [Figure 5](#) and [Figure 6](#)). These are critical safety components that protect the operator from electrical shocks by ensuring that the chassis of the microscope is always at a safe potential in the event of any electrical faults within the equipment. [Figure 5](#) shows the standard normal North American configuration, without a fuse holder, whereas [Figure 6](#) shows a rare version with a fuse holder.



Figure 5 – Safety-ground connection for the AC inlet jack (no fuse)

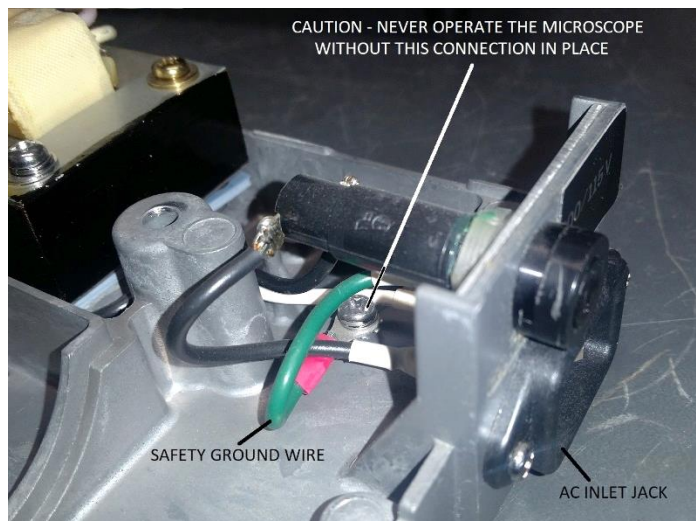


Figure 6 – Safety-ground connection for the AC inlet jack (with fuse)

### Before Applying Power to the Electrical Base

Before applying power to the electrical base, perform a thorough visual inspection of the electrical components and wiring. If any evidence of electrical shorting or any damaged components or wires are found, correct these issues before proceeding with equipment power-up. If any burned electrical components are found on the dimmer board, or if transistor Q101 is burned, do not apply power to the electrical base until either all burned components have been replaced and the cause of the burning has been identified and corrected, or the 8-pin J1 connector to the dimmer board has been unplugged to isolate the dimmer board from the positive output of bridge rectifier DB101. If the J1 connector on the dimmer board or its mating connector are charred (this is a relatively common occurrence), do not apply power to the electrical base without first isolating the output of the bridge rectifier from the dimmer board by unplugging the terminal containing the red and black wires from the positive pin of bridge rectifier DB101.

### Plug the Lamphouse into the Electrical Base

Carefully plug the lamphouse into J103 on the rear of the electrical base (see [Figure 7](#)) making sure both contact pins of the lamphouse engage the mating receptacles of J103. The lamphouse is normally supported by the two bifurcated alignment/support pins which insert into mating holes in the frame. The lamphouse will be fragile and unsupported when plugged into the electrical base without the stand, since the two alignment/support pins on the lamphouse will not be engaged with the mating holes on the stand. Do not touch the halogen lamp with your fingers, to prevent contaminants from getting on the glass.

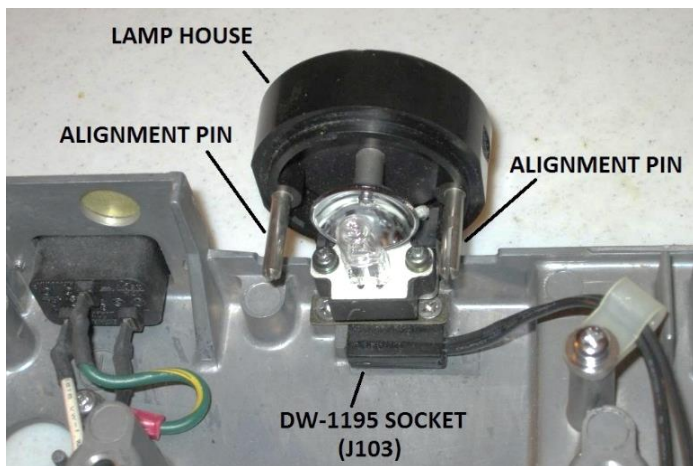


Figure 7 – Lamphouse plugged into the electrical base

### Plug the AC Line Cord into the AC Inlet Jack

With the AC line cord unplugged from the wall receptacle and with the AC power switch on the front of the equipment in the *OFF* position, plug the AC line cord into the AC inlet jack on the rear of the electrical base.

### Plug the AC Line Cord into Wall Receptacle

*Exercise extreme caution from this point forward, as potentially lethal line voltage will be present at various exposed points within the electrical base.*

Plug the AC line cord into a properly grounded wall receptacle. The electronics may now be operated as necessary for troubleshooting purposes.

### Troubleshooting the Electrical Base

The electronics in the BH-2 20W electrical base are relatively simple, and thanks to this simplicity, troubleshooting and repair can usually be performed using nothing other than a digital multimeter (DMM).

### Testing Semiconductor Devices with a DMM

The simplest method to locate the cause of problems in the electrical base, which is effective in most cases, is to use a DMM with a diode-test function to directly verify that the p-n junctions of the various diodes and transistors on the dimmer board, as well as power transistor Q101 and bridge rectifier DB101 on the chassis, are good.

### Testing the Bridge Rectifier

To test bridge rectifier DB101, set the DMM to the diode-test function and use the DMM to verify that the four diodes in the bridge are good, per the following procedure:

Disconnect the four terminals from the DB101 to isolate it from the rest of the circuitry. Connect the positive lead of the DMM to one of the two AC input pins of DB101. Connect the negative lead of the DMM to the positive

output pin of DB101. The DMM should show a normal forward-bias diode drop of +0.45V to +0.75V. Move the positive lead of the DMM to the other AC input pin of DB101. The DMM should show a normal forward-bias diode drop of +0.45V to +0.75V.

Connect the negative lead of the DMM to one of the two AC input pins of DB101. Connect the positive lead of the DMM to the negative output pin of DB101. The DMM should show a normal forward-bias diode drop of +0.45V to +0.75V. Move the negative lead of the DMM to the other AC input pin of DB101. The DMM should show a normal forward-bias diode drop of +0.45V to +0.75V.

If the above DMM readings pass, bridge rectifier DB101 is good, and the four terminals should be re-connected. If one or more of the above DMM readings fail, bridge rectifier DB101 is defective and must be replaced. When replacing the bridge rectifier, be sure to apply thermal paste to the mounting surface of the bridge rectifier before mounting the bridge rectifier onto the chassis, to facilitate proper thermal conduction to minimize the operating temperature of the part. Re-connect the four terminals after the bridge rectifier has been mounted onto the chassis.

### Testing the Power Transistor

To test power transistor Q101, remove the three screws securing the dimmer board to the chassis and unplug the 8-pin connector (J1) from the dimmer board. Set the DMM to the diode-test function and use the DMM to verify that Q101 is good, per the following procedure:

Connect the positive lead of the DMM to the base pin of Q101. Connect the negative lead of the DMM to the emitter pin of Q101. The DMM should show a normal forward-bias diode drop of +0.45V to +0.75V. Move the negative lead of the DMM to the collector pin of Q101. The DMM should show a normal forward-bias diode drop of +0.45V to +0.75V. Connect the positive lead of the DMM to the collector pin of Q101. Connect the negative lead of the DMM to the emitter pin of Q101. The DMM should show an open-circuit condition.

If the above DMM readings pass, power transistor Q101 is good, and the dimmer board should be re-installed onto the chassis after first plugging the 8-pin connector into J1 on the dimmer board. If one or more of the above DMM readings fail, power transistor Q101 is defective and must be replaced. When replacing Q101, be sure to apply thermal paste to both sides of the mica insulator before securing Q101 to the chassis, to facilitate proper thermal conduction. Also make sure to properly re-install the two nylon step washers and the plastic transistor cover, to



provide protection for Q101 against short-circuiting to the chassis or to other electrically conductive materials. Before proceeding, use a DMM (set to measure resistance) to verify that the metal case of Q101 is electrically isolated from the chassis.

#### Testing the Transistors on the Dimmer Board

To test PNP transistors Q201 and Q202 on the dimmer board, remove the three screws securing the dimmer board to the chassis, unplug the 8-pin connector (J1) from the dimmer board, and remove the dimmer board. Next, use a soldering iron to very carefully lift one lead, or remove entirely, power resistor R201 from the dimmer board. Removal of resistor R201 is necessary so that transistor Q202 can be electrically tested. Set the DMM to the diode-test function and use the DMM to verify that transistors Q201 and Q202 are good, per the following procedure.

Connect the negative lead of the DMM to the base pin of Q201. Connect the positive lead of the DMM to the emitter pin of Q201. The DMM should show a normal forward-bias diode drop of +0.45V to +0.75V. Move the positive lead of the DMM to the collector pin of Q201. The DMM should show a normal forward-bias diode drop of +0.45V to +0.75V. Connect the negative lead of the DMM to the collector pin of Q201. Connect the positive lead of the DMM to the emitter pin of Q201. The DMM should show an open-circuit condition. Repeat the above steps to test transistor Q202.

If the above DMM readings pass, transistors Q201 and Q202 on the dimmer board are good. If one or more of the above DMM readings fail, the respective transistor is defective and must be replaced. Re-install power resistor R201 after testing Q201 and Q202.

#### Testing the Diodes on the Dimmer Board

To test the diodes on the dimmer board, set the DMM to the diode-test function and use the DMM to verify that the diodes on the board are good, per the following procedure:

Connect the negative lead of the DMM to the cathode (banded end) of diode D201. Connect the positive lead of the DMM to the anode of diode D201. The DMM should show a normal forward-bias diode drop of +0.45V to +0.75V. Repeat the above steps to test diodes D202, D203, and D204.

If the above DMM readings pass, the diodes on the dimmer board are good and the dimmer board should be re-installed onto the electrical base. If one or more of the above DMM readings fail, the respective diode is

defective and must be replaced before re-installing the dimmer board.

#### In-Depth Troubleshooting

If the above component testing fails to reveal the cause of the problem, more in-depth troubleshooting will be required. Refer to the following sections for in-depth troubleshooting sequences.

#### Voltage Measurements Referenced in this Document

All voltage measurements referenced in this document were taken using a Fluke 87IV true-RMS reading DMM, and unless stated otherwise were measured on a 100V/115V electrical base with the voltage-selector switch set to the 115V position. Note that voltage measurements taken using a DMM that does not measure true RMS may differ from these referenced values.

The electrical circuitry in the BH-2 20W electrical base does not include any provision for connecting the electrical common of the dimmer circuitry (i.e., the *ground* reference for the dimmer board) to the metal chassis of the microscope stand. The fact that the electrical common is isolated from the chassis means that when performing electrical troubleshooting, it is not acceptable to clip the negative lead of a DMM to the chassis while probing the circuitry with the positive lead. This practice will not work with this equipment. Instead, the negative lead of the DMM should be connected to the negative pin of bridge rectifier DB101, which is the terminal with the brown and blue wires attached. Note that this electrical isolation only applies to the circuitry on the secondary side of the AC power transformer, and that the BH-2 20W electrical base does employ a robust equipment safety ground connection (see [A Caution Regarding Equipment Safety Ground](#)), which bonds the ground pin of the AC inlet jack to the equipment chassis for operator safety.

#### Testing the AC Switching and Power Transformer

The first step in testing the BHT/BHTU electrical base is to test the AC switching, power transformer and bridge rectifier, per the testing and troubleshooting sequence detailed in [Figure 56](#).

#### Testing the LEDs and Intensity Slide Control

After the AC Switching and power transformer have been tested, the next step is to test the LEDs and intensity slide control, per the testing and troubleshooting sequence detailed in [Figure 57](#).

#### Testing the Halogen Lamp Dimmer

After the LEDs and intensity slide control have been tested, the next step is to test the halogen lamp dimmer,

per the testing and troubleshooting sequence detailed in [Figure 58](#).

### Testing the Lamp-Intensity Preset Board

After the halogen lamp dimmer has been tested, the final step is to test the lamp-intensity preset board, per the testing and troubleshooting sequence detailed in [Figure 59](#).

### Common Problems with the Electrical Base

The electronics in the BHT/BHTU microscope stands have proven to be fairly reliable over the years, but with heavy usage and age, failures do occur. Among the most likely problems that will be encountered are intermittent or no lamp operation due to worn or oxidized contacts in the ceramic socket in the lamphouse, or in the J103 socket that the lamphouse plugs into. Erratic lamp intensity due to dust, dirt, oxidation, and wear within the intensity slide control is also frequently seen, as well as defects in the solder connections on the older-style (single-sided) dimmer boards. Later scopes used double-sided boards with plated-through holes that were much more reliable.

### Defective Socket in Lamphouse

The ceramic socket in the lamphouse may be replaced with a part described later in this document. It may also be possible to perform a temporary repair by disassembling the existing lamp socket and cleaning the oxidized contacts with emery paper, and re-assembling. This should be viewed as a temporary fix only.

### Defective Lamp-House Connector

The J103 (DW-1195) connector may be replaced with parts described later in this document. It may also be possible to perform a temporary repair, by using emery paper to remove oxidation from the contacts, and by using a sharp implement of some sort to re-shape the two socket contacts to close them up a bit, thereby improving their electrical contact with the mating pins on the lamphouse. This should be viewed as a temporary fix only.

### Defective Intensity Slide Control

A worn intensity control may be replaced with parts described later in this document. Dust, dirt, and oxidation inside the intensity control can usually be corrected by spraying a short blast of volume control/contact cleaner (after unplugging the AC line cord) into the intensity control and moving the slider throughout its full range of motion a few times to distribute the cleaner (item 15 of [Table 2](#)). Exercise caution when spraying the cleaner into the control, to minimize any overspray and blow-back onto nearby components. Be sure to allow the contact

cleaner sufficient time to evaporate out of the control before re-applying power to the electrical base.

### PCB Solder Defects

The early versions of the UYPC48 dimmer board were prone to failures due to defects in the solder connections, as described below.

### Versions of the Dimmer Board PCB

There were a few versions of the UYPC48 dimmer board manufactured by Olympus during the BH-2 production run. The differences between these versions are primarily in the design and fabrication of the printed circuit board (PCB), as described below.

### PCBs with Single-Sided Copper

The earliest versions of the UYPC48 dimmer boards were manufactured using FR4 printed circuit boards with a single layer of copper routing on the bottom side of the board and lacking plated-through vias. The resulting solder joints on these single-sided boards were quite fragile, and the copper component pads would easily lift if excess heat were used in soldering or de-soldering, or if any lifting force was inadvertently applied to the component pads while performing repairs. Subsequently, solder defects were a significant contributor to the overall failure rate of this early fielded equipment which used single-sided boards. It is not at all uncommon to see electrical failures in these earlier microscopes due to bad solder joints on a few of the physically large components which are subject to high physical stresses due to vibration, operational shock, and thermal changes.

Cold or fractured solder joints are commonly found on the leads of power resistor R201, which is a physically large component which runs hot during normal operation. Because R201 runs hot, these resistors were typically soldered onto the board such that the body of the resistor was slightly elevated from the surface of the PCB, thereby allowing airflow around the component to minimize heating of the FR4 PCB material and the subsequent discoloration that this can cause. Continual operation at these elevated temperatures, coupled with physical stresses on the solder joints due to the reliance on the component leads as the sole means of physical support for the component, have contributed to many BH-2 failures.

Another component on these early single-sided printed circuit boards where fractured solder joints are commonly found is the 8-pin connector, J1. The solder joints on the eight pins of this connector experience significant physical stresses any time the mating connector in the electrical



base is mated with or de-mated from J1 on the dimmer board. Additionally, due to the large physical size of this connector, any physical vibration, operational shocks, or thermal changes can also stress the solder joints of J1. The good news is that the repair for fractured solder joints is as simple as reflowing the solder joint, making sure to add a bit of fresh solder with flux to guarantee a clean, reliable solder joint.

### PCBs with Double-Sided Copper

Later in the production life of the BHT/BHTU microscopes, Olympus began to manufacture UYPC48 dimmer boards using double-sided printed circuit boards with plated-through vias on the component holes. Although these boards were more expensive to manufacture than the earlier single-sided version, they provided the best support possible for the component leads, thereby correcting a known reliability issue in the BH-2.

### Fuse Holder on the Electrical Base

All of the 220V/240V electrical bases, as well as perhaps the very earliest 100V/115V bases, feature a 5x20mm fuse holder, with a 630mA/250V fuse, mounted onto the rear of the electrical base casting. This fuse provides overload protection for the primary side of the power transformer.

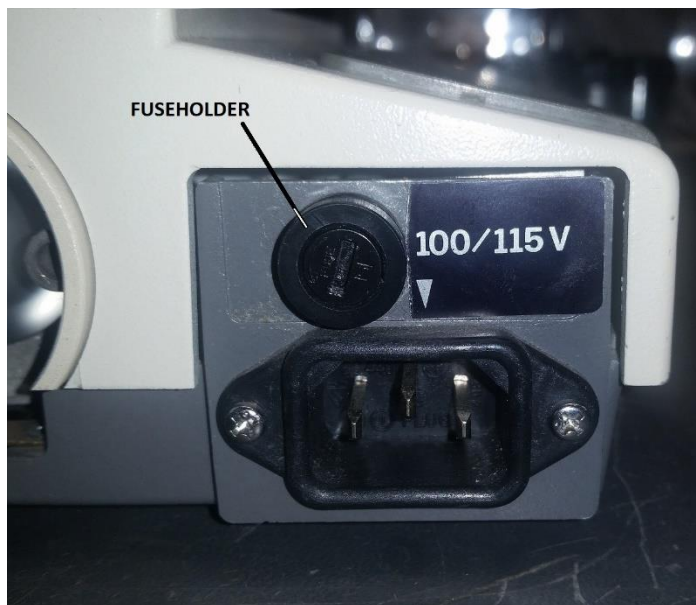


Figure 8 – Fuse holder on the rear of the electrical base

The fuse holder configuration shown in **Figure 6**, **Figure 8**, and **Figure 9** has been observed by the author in only a single (very early) 100V/110V BHTU stand to date. It has not been verified whether this fuse holder was factory installed, or whether it was a field modification to a standard North American electrical base.

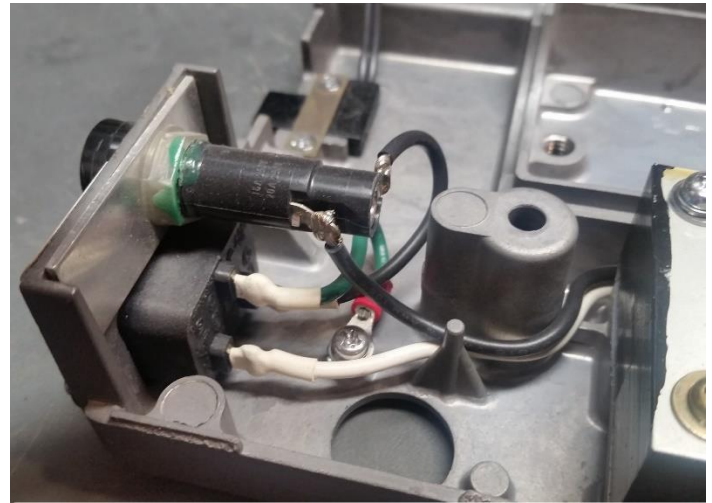


Figure 9 – Fuse holder wiring in the electrical base

### Obtaining Replacement Components

The BHT/BHTU microscopes are no longer supported by Olympus, and with few exceptions, factory replacement parts are not available. The good news is that the BHT/BHTU microscopes were very popular in their day, and because of this used or surplus stands and their various bits and pieces frequently show up for sale on eBay and other places, at very reasonable prices. So, in the absolute worst-case scenario, replacement electrical components can be salvaged from a spare electrical base.

Rather than cannibalizing an existing electrical base, however, is to better to find a suitable new exact replacement or substitute for any defective electrical components. Many components (or at least suitable substitutes for them) are still available from third-party suppliers. Substitutes for many of these components are described below, with sourcing and pricing listed in **Table 2**, when available. If exact replacements or their suggested substitute cannot be found, make sure that any substitute parts chosen for repairs have suitable electrical and mechanical specifications and that they are installed in such a way that it is not possible for the operator to contact any live voltage points while using the equipment.

### Replacing the Power Transformer

The good news is that the power transformer in the electrical base (see **Figure 10** and **Figure 11**) rarely fails. The bad news is that if it ever does fail, it will be impossible to locate a suitable substitute for it, due to the unique low-profile form factor that allows the transformer to fit within the base of the BHT/BHTU stand. If desired, the fuse holder shown in **Figure 6**, **Figure 8**, and **Figure 9** could be retrofitted into the North American version of the electrical base, to provide protection for the impossible-to-find power transformer.



Figure 10 – Power transformer mounted onto the electrical base

Given that a suitable substitute does not exist for this transformer, if the transformer ever does fail, that could be an excellent time to start on that LED-conversion project you've been dreaming about (using your old electrical base), while you are looking around for another functional electrical base to put into your microscope.



Figure 11 – Power transformer (110V/115V version)

### Replacing the Bridge Rectifier

The bridge rectifier is an S15VB10 (100V 15A) chassis-mount bridge rectifier with push-on electrical terminals (see [Figure 12](#) and [Figure 13](#)). This part is mounted to the chassis of the electrical base with a layer of thermal paste in the interface between the part and the chassis, to facilitate heat transfer.

Suitable substitutes for the S15VB10 bridge rectifier are the NTE5322, KBPC1501, or KBPC1502. The NTE5322 is available from Allied Electronics and from Amazon (item 2 of [Table 2](#)). If none of these parts can be found, look for a

suitable substitute with a continuous current rating of 15A or more and with a PIV rating of at least 100V.

When installing the replacement part, be sure to thoroughly clean any existing thermal paste from the mounting surface of the chassis first, then apply a layer of fresh thermal paste to the mounting surface (item 1 of [Table 2](#)) to facilitate heat flow and to prevent overheating and subsequent failure of the new bridge rectifier.

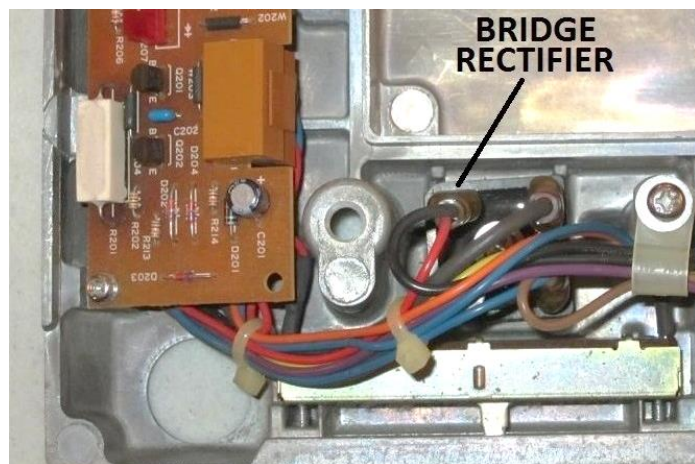


Figure 12 – Bridge rectifier mounted onto the electrical base

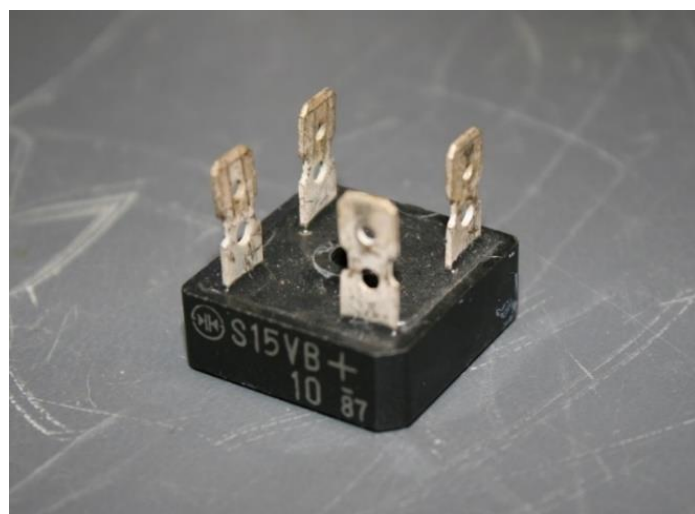


Figure 13 – The S15VB10 bridge rectifier

### Replacement for the Lamp-Intensity Slide Control

The lamp-intensity control is a 500Ω linear-taper slide potentiometer, which was originally manufactured by Noble (see [Figure 14](#) and [Figure 15](#)). This potentiometer has 45mm of travel, and the mounting holes are spaced 65mm on center. Drop-in replacements for this part are very difficult to find, since most manufacturers do not offer values lower than 1KΩ. However, dual-gang parts with a value of 1KΩ can be found, and these may be used if the two independent sides of the control are wired together, effectively placing the two 1KΩ sliders in



parallel, thereby functioning as a 500Ω slider. Bourns offers two such parts that may be used: PTE45-152A-102B1 and PTF45-152A-102B2. If neither of these parts can be found, then the single-gang 1K versions (PTE45-151A-102B1 and PTE45-151A-102B2) may be used instead (item 3 of [Table 2](#)) with only a slight impact on the linearity of the dimmer. This will not be noticeable to the operator. Note that the chassis will require minor modifications to allow the Bourns controls to properly fit.

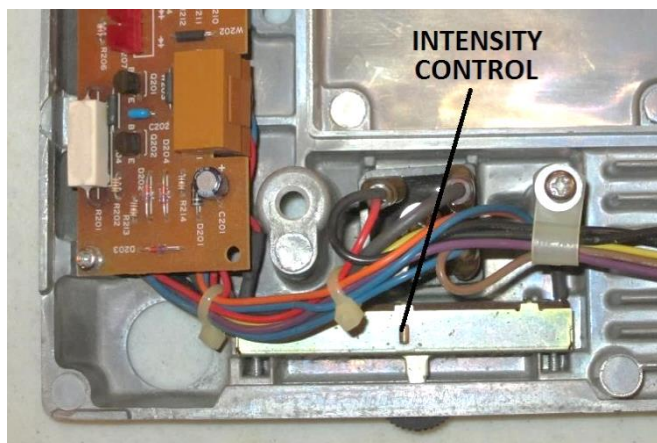


Figure 14 – Lamp-intensity slide potentiometer in electrical base



Figure 15 – Noble 500Ω slide potentiometer

### Parts for the Light-Preset Board

The light-preset printed circuit board, which is present on later stands, contains a single-turn, 500Ω linear-taper potentiometer and an Otax SPDT rocker switch (see [Figure 16](#)). When the rocker switch is in the *OFF* position, the slide potentiometer controls the lighting intensity, and when the switch is in the *ON* position, the screwdriver-adjustable potentiometer controls the lighting intensity (turning this potentiometer counter-clockwise increases the lamp intensity). The schematic

diagram for the light-preset board is included in [Figure 64](#) of this document. A replacement for the potentiometer could likely be found, if necessary. However, the rocker switch is more problematic, since it is this switch which physically supports the light-preset board in the chassis (see [Figure 17](#)), and an exact replacement would likely be needed.

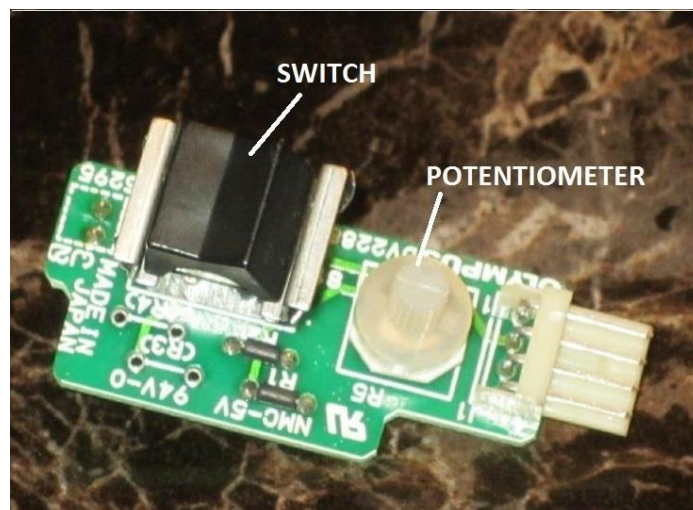


Figure 16 – Olympus DV2288-01 light-preset board

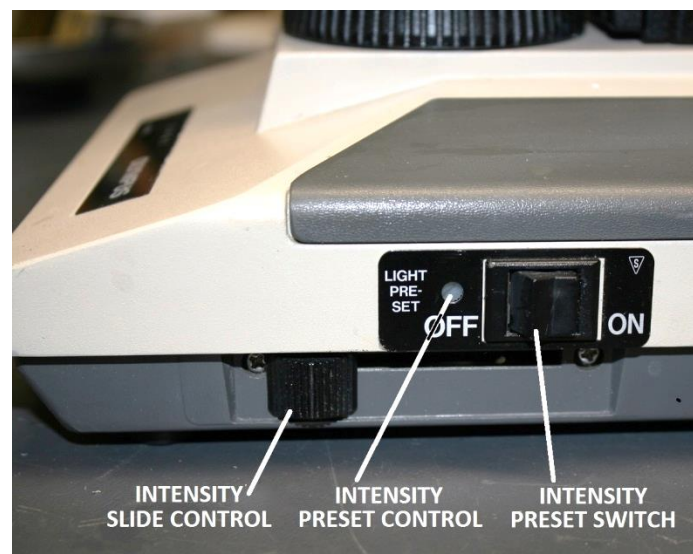


Figure 17 – Light preset switch and intensity control

Since this board is not necessary for basic operation of the illumination system, it may be removed and electrically bypassed if suitable replacement parts cannot be found, or to permit the installation of a newer electrical base into an earlier stand that does not have the chassis notch to accommodate this board. Refer to the procedure below to remove and bypass the light-preset board. It is also fairly simple to find two-pin and four-pin connectors compatible with the cabling in the electrical base, to

build-up a pass-through cable that can be plugged into an electrical base equipped for use with a light-preset board, to allow it to be operated without the preset board, or for bench servicing.



Figure 18 – Electrical connections to the light-preset board

#### Removing and Bypassing the Light-Preset Board

If not needed, the light-preset board can be bypassed by performing the following steps.

1. Disconnect the light-preset board from the electrical base by unplugging the two connectors from J1 and J2 on the printed circuit board.
2. Cut the two connectors off the wires, making the cuts as close to the connector shells as practical, to leave sufficient wire lengths for the remaining steps.
3. Carefully strip the ends of the two orange wires (both of which were connected to the four-pin connector) and solder them together, insulating the connection with heat-shrink tubing to prevent short-circuits to the bare chassis.
4. Carefully strip the ends of the two blue wires (one of which was connected to the two-pin connector and the other of which was connected to the four-pin connector) and solder them together, insulating the connection with heat-shrink tubing to prevent short-circuits to the bare chassis.
5. Carefully strip the ends of the two red wires (one of which was connected to the two-pin connector and the other of which was connected to the four-pin connector) and solder them together, insulating with heat-shrink tubing to prevent short-circuiting to the bare chassis.

Be sure to position the spliced wires such that they will not be pinched and will not interfere with the optical path

of the illumination system once the electrical base is reinstalled into the microscope stand.

#### Replacing the AC Power Switch

The AC power switch on the front of the electrical base (see [Figure 19](#) and [Figure 20](#)) is an Alps SDT-7 chassis-mounted DPST rocker switch with a TV-5 rating for UL/CSA. The enclosure of this switch is well sealed for reliability, and therefore this switch cannot be cleaned with control/contact cleaner, since there are no openings with which to inject the cleaner. The threaded mounting holes of this switch are spaced 35mm on center.

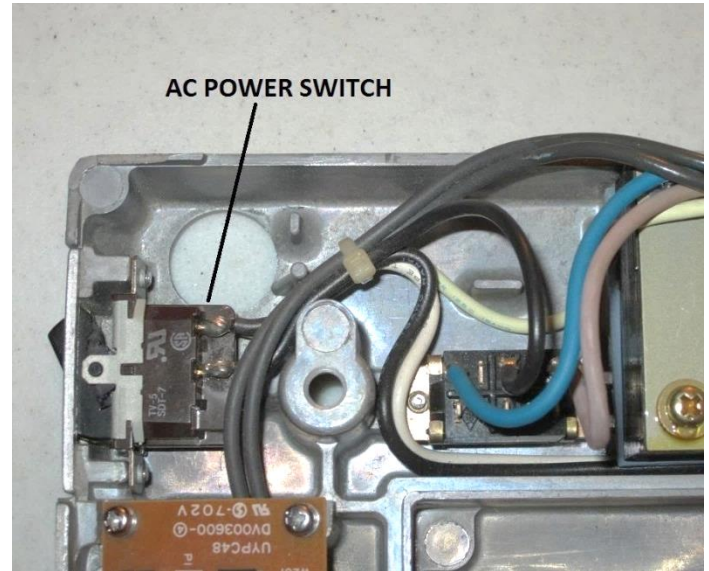


Figure 19 – The AC power switch mounted onto the electrical base

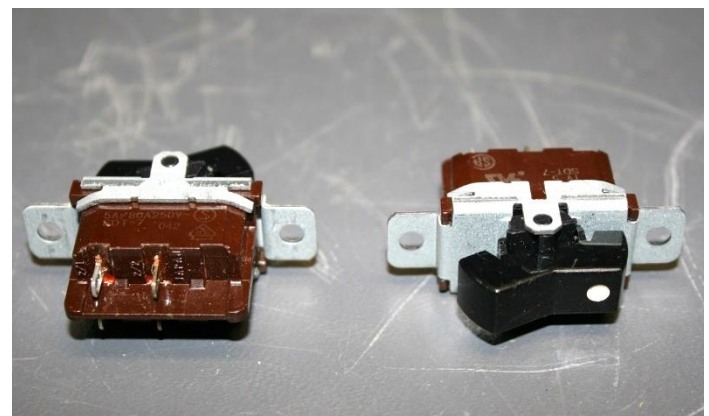


Figure 20 – The Alps SDT-7 AC power switch

#### Replacing the Voltage-Selector Switch

The voltage-selector switch on the bottom of the electrical base (see [Figure 21](#) and [Figure 22](#)) is a chassis-mount DPDT slide switch rated for 4A/125VAC and 2A/250VAC. The slide protrudes approximately 3/8" from the mounting surface and the mounting holes are spaced 1-1/8" on center. This switch may be replaced with a 30-



9182 part manufactured by Philmore (item 4 of [Table 2](#)) or, for 100V/115V equipment only, by a GF-624-6014 part manufactured by CW Industries (item 22 of [Table 2](#)).

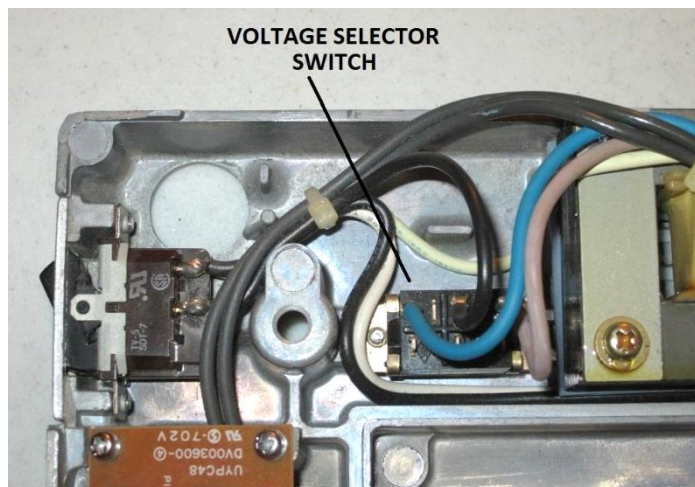


Figure 21 – Voltage-selector switch mounted onto electrical base

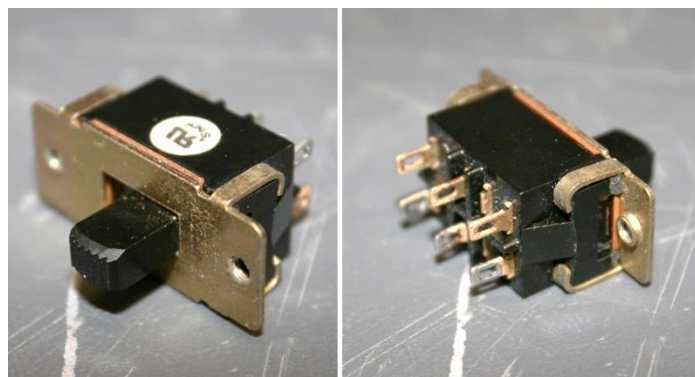


Figure 22 – The voltage-selector switch

There are openings on both ends of this switch through which control/contact cleaner may be sprayed while the slider is positioned at the opposite end (with power removed from the equipment). The low-voltage position of this switch is rarely needed, and if a suitable replacement cannot be found, the switch could simply be bypassed to hardwire the microscope to operate at its nominal operating voltage. Since only one pole on this switch is used, a SPDT replacement could also be used.

### Parts for the Dimmer Board

A replacement for the entire UYPC48 dimmer printed circuit board (see [Figure 23](#) and [Figure 24](#)) is rarely needed, since the circuitry on this board is simple and can usually be repaired when necessary. If a complete replacement is needed, refer to the next section. Suitable replacements for most components on the dimmer board can be readily found. The 5-LED array can be replaced with an NTE3150 red array (item 22 of [Table 2](#)), manufactured by NTE electronics. If this cannot be

found, the module could be replaced with five discrete rectangular LEDs, if necessary. The uPC324C op-amp can be replaced with the LM324C or LM324N, in the DIP package (item 21 of [Table 2](#)). Transistors Q201 and Q202 can be replaced with either 2N3906 or KSP94 PNP devices (item 18 and 24 of [Table 2](#)). See [Information Regarding Transistors in the BHT/BHTU](#) in this document for replacement instructions. Diode D201 can be replaced with a 1N4002 or 1N4004 rectifier diode (item 19 of [Table 2](#)) and diodes D202, D203, and D204 can be replaced with 1N916 or 1N4148 small-signal diodes (item 20 of [Table 2](#)). The 0.1Ω 5W power resistor (R201) runs very hot during normal operation, and because of this the solder joints can sometimes go bad. Re-soldering the leads of R201 may be enough to fix an inoperative lamp dimmer. Resistor R201 can be replaced with a Vishay CP0005R1000JE14 part (item 5 of [Table 2](#)).

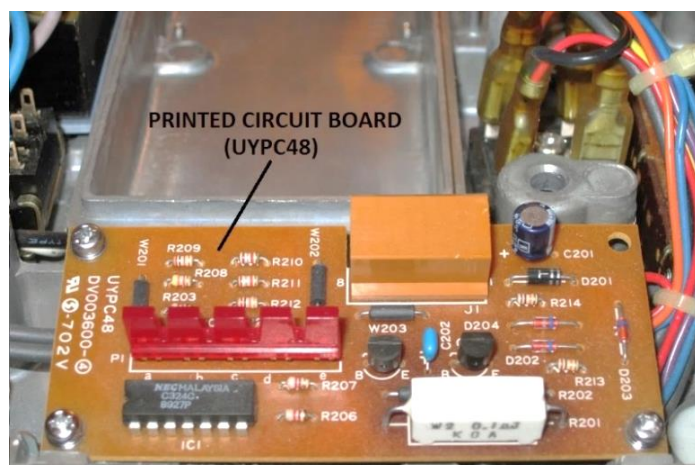


Figure 23 – UYPC48 dimmer board mounted onto electrical base

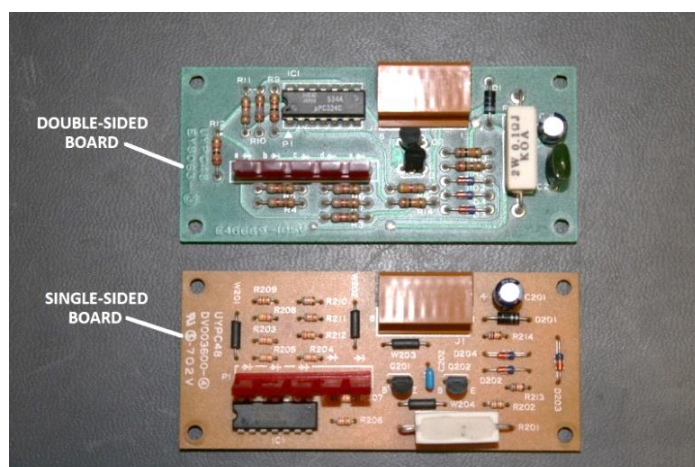


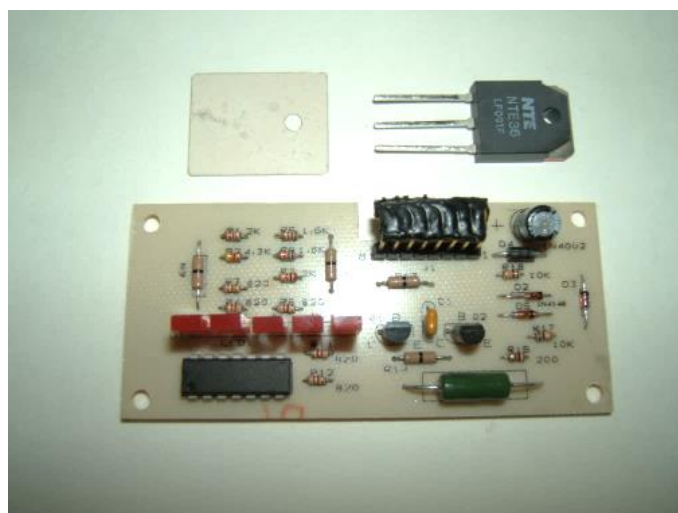
Figure 24 – Two versions of the UYPC48 dimmer board

### Replacement Dimmer Board

In the rare case that the UYPC48 dimmer board is damaged beyond repair, an aftermarket replacement (see



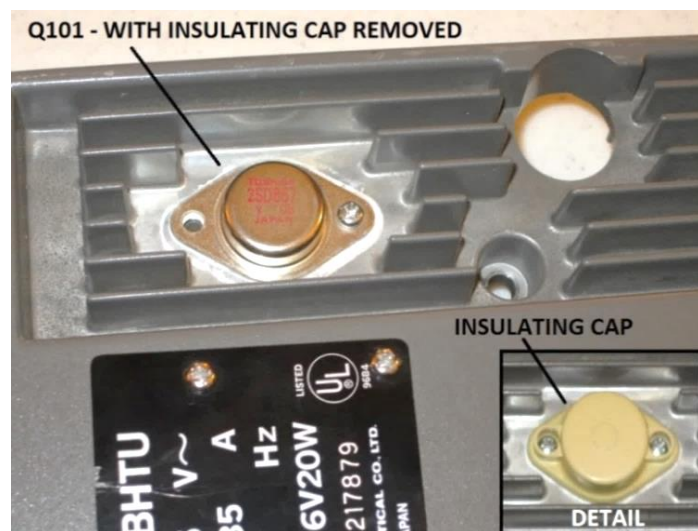
**Figure 25**, photo courtesy James Ritchey) is available from J.C. Ritchey Company, LLC (item 6 of [Table 2](#)). This board, which is a drop-in replacement for the original Olympus board, comes complete with a replacement power transistor and the necessary transistor-mounting insulator. No soldering is required for this option if only the circuit board needs to be replaced, but soldering is required if the power transistor is to be replaced at the same time. This looks to be a faithful reproduction of the original Olympus board and should perform well.



**Figure 25 – J.C. Ritchey BHT/BHTU dimmer board replacement kit**

### Replacing Power Transistor Q101

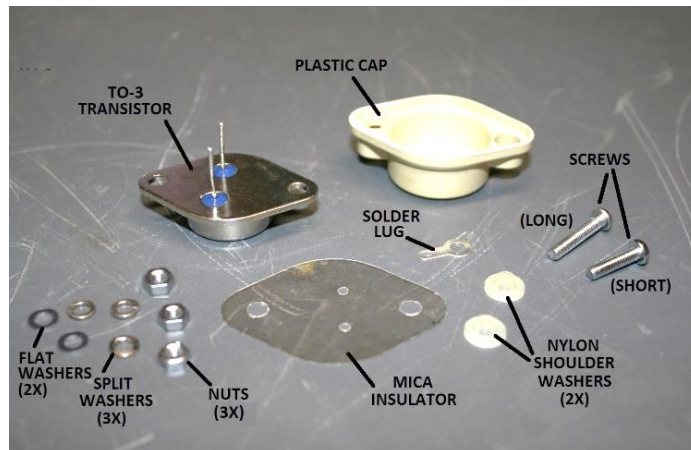
Power transistor Q101, which is mounted onto the chassis, is a Toshiba 2SD867 NPN power transistor in the old TO-3 metal package (see [Figure 26](#)).



**Figure 26 – 2SD867 power transistor on the bottom of the base**

This part, although obsolete, can still occasionally be found, but expect to pay \$20 or more for it when you find it. If the 2SD867 cannot be found, potential drop-in

replacements include the STMicroelectronics BUX10, the Microsemi 2N5672, and the NTE Electronics NTE327 (item 16 of [Table 2](#)), which are all in the same TO-3 package. The NTE36 part in the TO-3P insulated case is a good substitute (although not a direct physical drop-in) that is more readily available at a much lower price (item 7 of [Table 2](#)).



**Figure 27 – 2SD867 power transistor and mounting hardware**

Whichever option is chosen, the replacement transistor must be installed using proper mounting hardware to provide proper thermal performance and electrical isolation of the collector tab of the transistor from the equipment chassis. See the [Mounting Hardware for Power Transistor Q101](#) section for TO-3 transistor mounting instructions. In order to provide proper thermal performance of the new transistor, be sure to apply thermal paste (item 1 of [Table 2](#)) to both sides of the transistor insulator to enhance thermal conduction and prevent thermally induced failures of the new part. A suitable replacement for the plastic insulating cap for the original TO-3 part (see [Figure 26](#) and [Figure 27](#)) is manufactured by Keystone Electronics (item 17 of [Table 2](#)).

### Replacing the AC Inlet Jack

Connector J101 is an IEC 320 C14 (3-pin male) panel-mount AC power inlet connector (item 8 of [Table 2](#)). For the safety of the operator, always replace this part with an equivalent part (see [Figure 28](#) and [Figure 29](#)). After replacing the AC inlet jack and before operating the equipment, double check to make sure that the chassis-bonding screw for the ground (middle) terminal of the AC-inlet jack is present and securely tightened to the chassis, and that the green/yellow grounding wire is undamaged. This critical electrical connection keeps the chassis at a safe potential in the event of any electrical faults within the equipment and is absolutely necessary to guarantee operator safety. If a suitable replacement jack cannot be

located, a filler plate could be fabricated to take the place of the AC inlet jack, with a hole drilled to allow a suitably rated AC line cord to be installed with a strain-relief grommet. If this approach is chosen, be sure to securely bond the ground conductor of the AC line cord to the equipment chassis, as described above, to maintain operator safety.

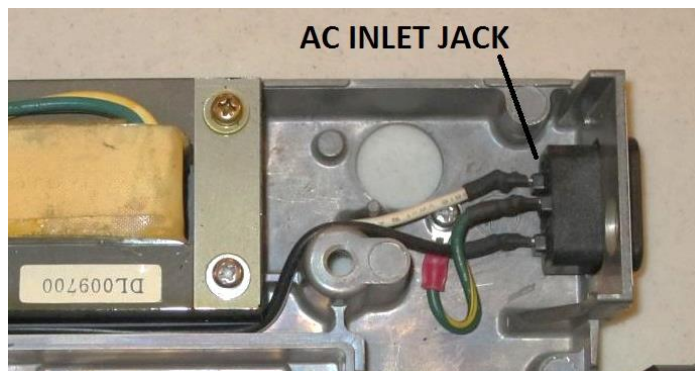


Figure 28 – AC-inlet jack (IEC-320 C14) mounted onto electrical base



Figure 29 – Suitable IEC 320 C14 AC-inlet jacks

### Replacing the AC Power Cord

The AC power cord (item 25 in [Table 2](#)) for North American (100V/115V) microscopes should have a standard NEMA 5-15P plug on one end, and an IEC-320 C13 plug on the other (see [Figure 30](#)). The AC power cord should have wire of AWG 18 or larger and should be UL listed for safety.



Figure 30 – NEMA 5-15P / IEC-320 C13 AC power cord

For some clinical, hospital, or patient care applications, it may be necessary, to use a hospital grade NEMA 5-15P to IEC-320 C13 AC power cord with the microscope.

### Replacing the LS20H Lamphouse

There were two styles of lamphouse used on the BHT/BHTU stands (see [Figure 31](#)). The original LS20H version supplied by Olympus as part number 5-LB402 did not have a metal reflector behind the bulb. Much later in the production life of the BHT/BHTU, Olympus upgraded to the LS20H-M/M2 (part number 5-S119), which includes a reflector behind the lamp to provide more usable light, in order to stay competitive with Nikon. Since the later LS20H-M and LS20H-M2 lamphouses are directly interchangeable with the earlier LS20H version, the later version should be used whenever possible, in order to have the brightest illumination your scope can provide.



Figure 31 – Without reflector (left) and with reflector (right)

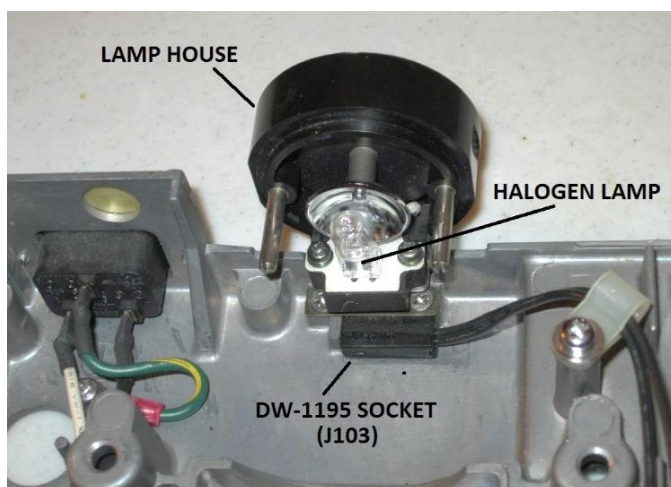


Figure 32 – Lamphouse plugged into the electrical base

### Repairing the LS20H Lamphouse

A lamphouse repair kit (see [Figure 33](#), photo courtesy James Ritchey) compatible with both versions of the LS20H lamphouse is available from J.C. Ritchey Company, LLC (item 9 of [Table 2](#)). This kit includes a replacement back cover and a new G4 lamp socket (which must be soldered in). This kit may be used to overhaul the LS20H, LS20H-M, or LS20H-M2 lamphouses. The plastic back



cover is included as part of the kit in case the original is damaged during disassembly of the lamphouse. With care, the original cover can almost always be removed intact and reused, but it is nice that J.C. Ritchey includes a new cover in their kit. As an alternative to rebuilding the lamphouse yourself (an option which may be especially attractive to those averse to soldering), defective lamphouses may be sent to J.C. Ritchey Company for in-house repair or for exchange with a previously repaired lamphouse (item 10 of [Table 2](#)).



Figure 33 – J.C. Ritchey lamphouse repair kit

As an alternative to the J.C. Ritchey lamphouse repair kit described above, a Bender and Wirth 990 lamp socket (item 11 of [Table 2](#)) may be purchased and used to replace the existing lamp socket in the lamphouse. Refer to the document titled [Repairing the 20W Lamphouse for the Olympus BH-2, CK2, and SZH Microscopes](#) for a complete description of the process for replacing the old socket with the Bender and Wirth equivalent.

#### Replacing the DW-1195 Lamphouse Socket

The lamphouse socket shown in [Figure 34](#), which is marked “DW-1195” (Olympus part number DJ-0278), interfaces with the two power pins on the LS20H or LS20H-M/M2 lamphouse, providing electrical power to the lamphouse. These sockets frequently develop intermittent electrical contacts because of the many mate/de-mate cycles to which they have been subjected over the service life of the microscope. Although replacements for this socket are no longer available from Olympus, a high-quality (albeit quite expensive) remanufactured replacement is available (see [Figure 35](#), photo courtesy James Ritchey) from Microscope Solutions (item 12 of [Table 2](#)).

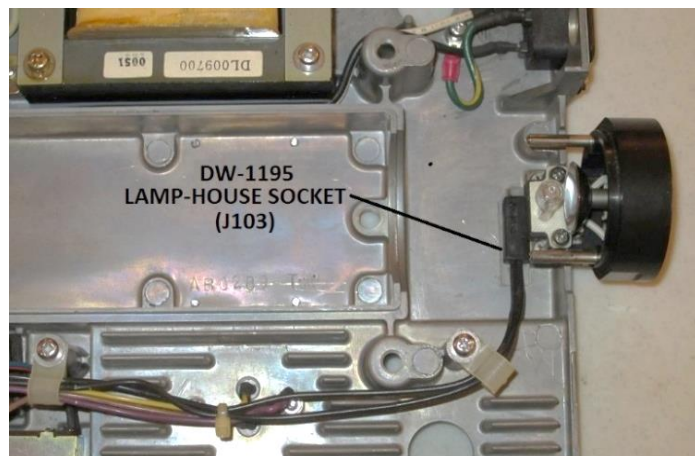


Figure 34 – The DW-1195 lamphouse socket (J103)

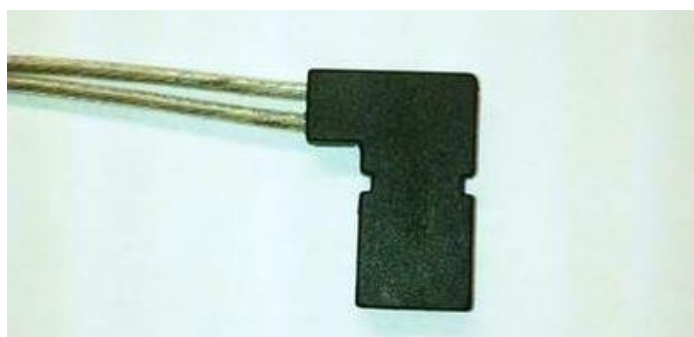


Figure 35 – Microscope Solutions lamp-house connector

#### Making A Replacement Lamphouse Socket

A much cheaper (although much less convenient) alternative to the Microscope Solutions replacement lamp-house connector is to make your own, starting from a readily available Tamiya-style 2-pin plastic connector, as shown in [Figure 36](#) (item 13 of [Table 2](#)).

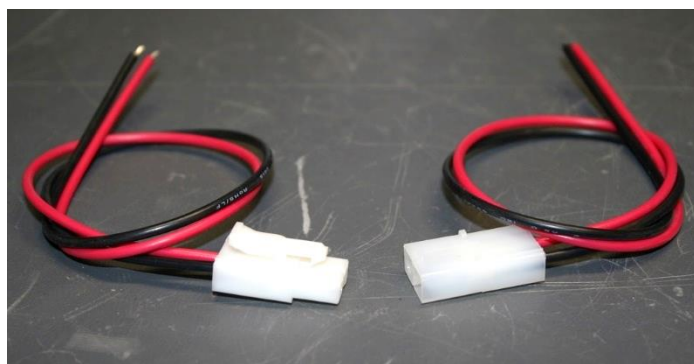
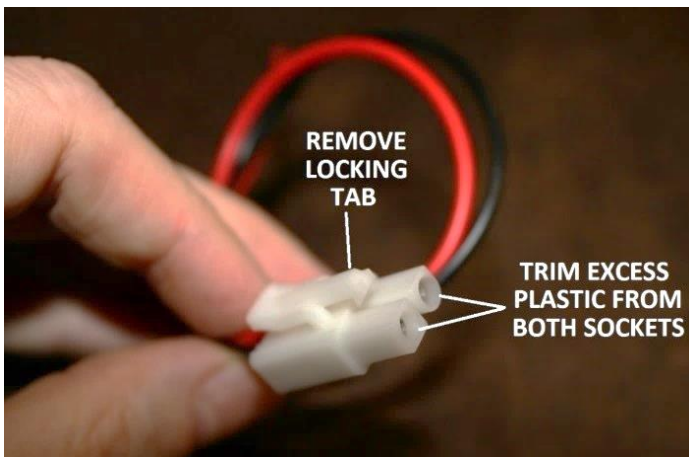


Figure 36 – Tamiya-style power connectors

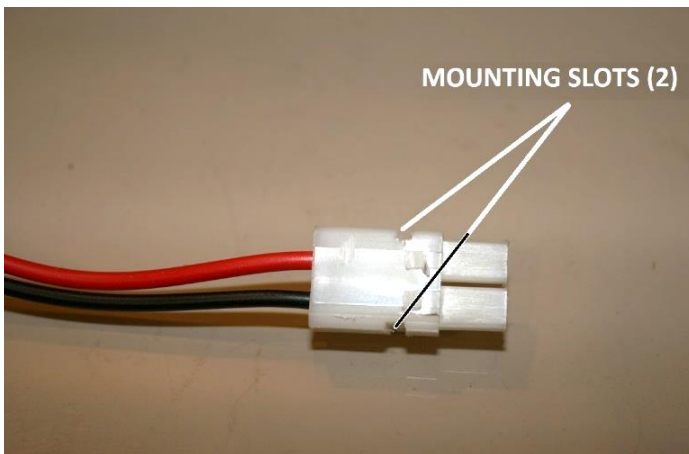
Although this Tamiya connector, which typically sells for just a few dollars, does not have the exact pin spacing as the original DW-1195 part, it is similar enough that it can be modified to work as an acceptable replacement. To make the Tamiya connector fit the application, first trim off the mounting clip and then trim back the plastic from

the two contact holes in the end of the plastic housing, using a sharp X-Acto® knife (see [Figure 37](#)).



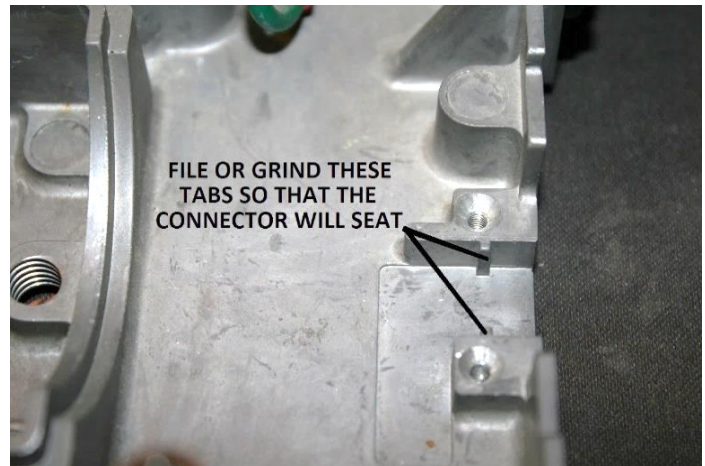
**Figure 37 – Trim the plastic housing of the Tamiya connector**

Next, using the original connector as a guide, carefully cut or file a pair of mounting slots into the sides of the plastic housing. Be careful to not make the slots too deep, or else the connector contact inserts will be exposed, thereby ruining the connector. Even if the contact inserts are not directly exposed, the remaining plastic in these slots can be very thin, and the locating tabs in the chassis mounting recess can bite through the plastic housing and make electrical contact with the contact inserts when the connector is mounted into the chassis recess, thereby damaging the dimmer circuitry when power is re-applied to the equipment.



**Figure 38 – Trimmed plastic housing with side slots cut-in**

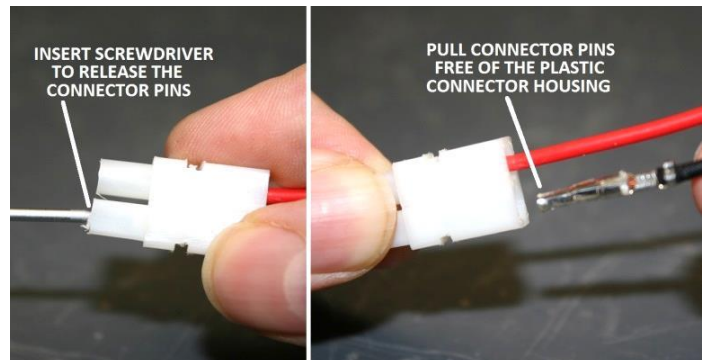
If everything has been done properly, the notches will be almost, but not quite deep enough to allow the connector to seat into the mounting recess of the chassis. Therefore, it will be necessary to file or grind away a bit of material from the locating tabs in the mounting recess (see [Figure 39](#)) to allow the connector to properly fit into the mounting recess of the chassis casting.



**Figure 39 – File or grind chassis until connector fits in the recess**

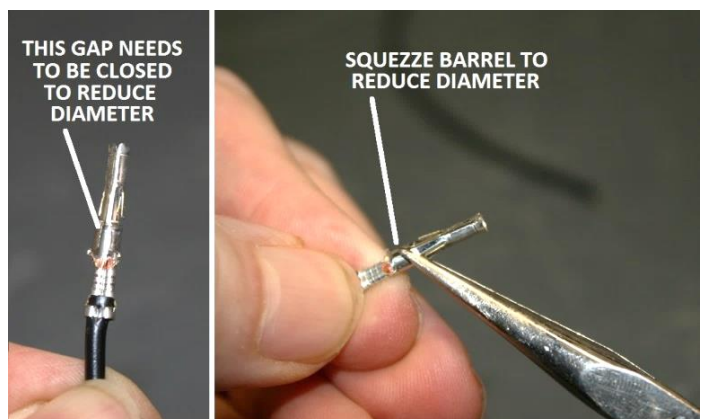
To provide an additional measure of protection against short-circuiting of the electrical contacts to the locating tabs of the chassis, remove the contacts and install heat-shrink tubing over them, per the follow procedure.

First, use a very small, slotted screwdriver to unlock and remove the contact inserts from the nylon connector housing (see [Figure 40](#)).



**Figure 40 – Remove the contacts from the connector housing**

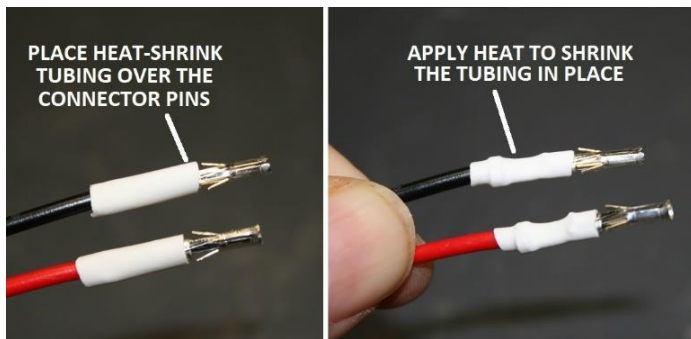
Then use needle-nose pliers to close the gap on the rolled barrel of the contact inserts, to reduce the diameter of the inserts so that, with heat-shrink tubing installed, they will fit back into the nylon housing (see [Figure 41](#)).



**Figure 41 – Squeeze the barrels of the contact inserts closed**

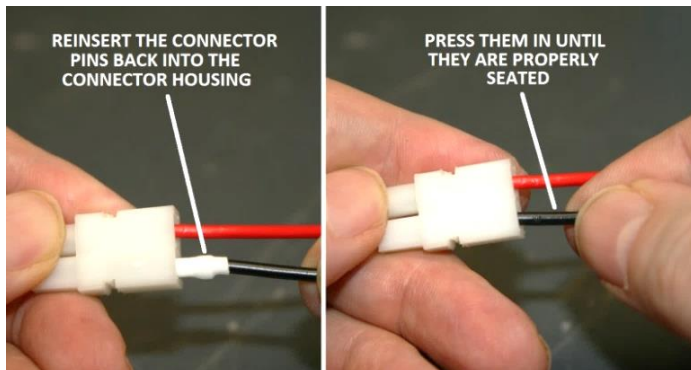


Next, apply a piece of heat-shrink tubing over both of the contact inserts and shrink them in place using an electric heat gun (see [Figure 42](#)).



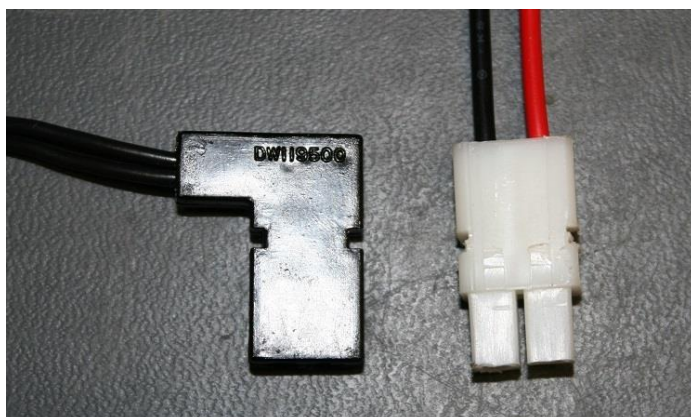
**Figure 42 – Install heat-shrink tubing over the contact inserts**

Finally, re-install the two contact inserts, with heat-shrink tubing in place for short-circuit protection, back into the nylon housing and press them in until they firmly seat (see [Figure 43](#)). Test the contacts to make sure they do not pull out when the wires are gently tugged.

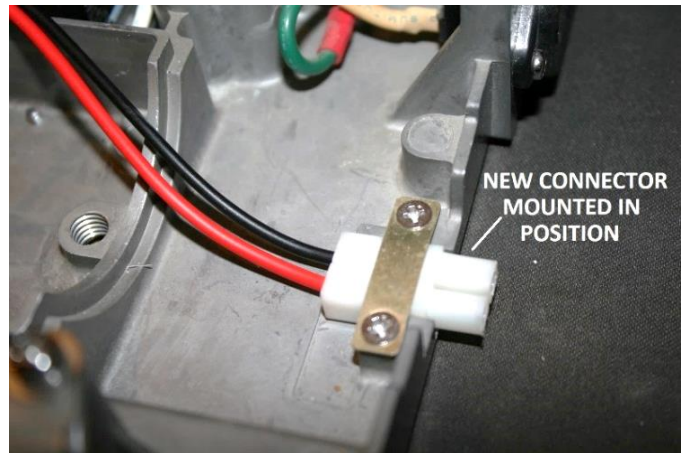


**Figure 43 –Reinsert the contact inserts into the connector housing**

The resulting replacement connector is shown in [Figure 44](#) (on the right), compared to the original DW-1195 connector (on the left). This replacement connector is a close-enough match to the original DW-1195 connector that it can be installed into the 20W electrical base and used as a functional replacement for the BHT/BHTU microscopes (see [Figure 45](#) and [Figure 46](#)).



**Figure 44 – Original (left) compared to modified Tamiya (right)**



**Figure 45 – Tamiya replacement installed in the electrical base**



**Figure 46 – Tamiya replacement ready for service**

### Replacing the Halogen Lamp

The BHT/BHTU microscopes use a Philips 7388 (or suitable equivalent) 6V/20W halogen projector lamp, as shown in [Figure 47](#) (item 14 of [Table 2](#)). This lamp has a clear quartz envelope and G4 base, along with a color temperature of 3200K and a color rendering index of 100.

The Philips 7388 lamp is rated for 475 lumens at its full-rated operating voltage, with an advertised operating life of 100 hours. Note that some “equivalent” lamps advertise an operating life of 200 hours, but these tend to have lower output intensity at the full-rated operating voltage.



**Figure 47 – Philips 7388 ESB halogen lamp**



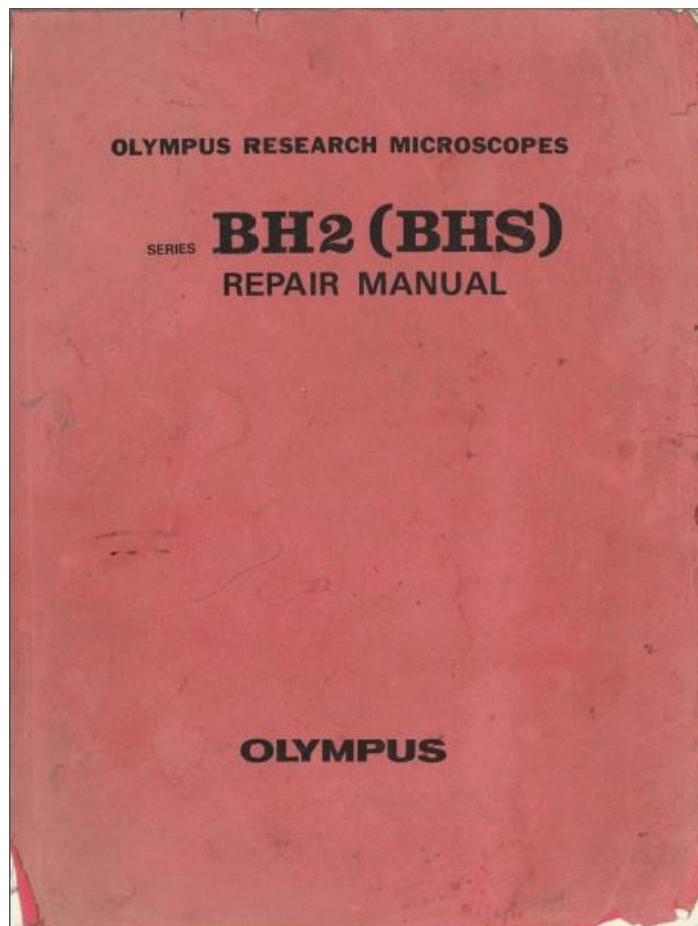
**Table 1** lists various manufacturer part numbers that can be used to replace the halogen lamp in the BHT/BHTU microscopes. Be careful using generic “made-in-China” lamps, as some of these do not produce nearly the intensity of the Philips 7388 lamps.

Manufacturer	Part Number
General Electric	778 (49718) or 788 (943117)
Nikon	79099
Olympus	8-C405
Osram	54261 or 64250 HLX
Philips	7388 (256784)
Reichert	11143
Swift	MA-780
Ushio	FHE/ESB (1000532)

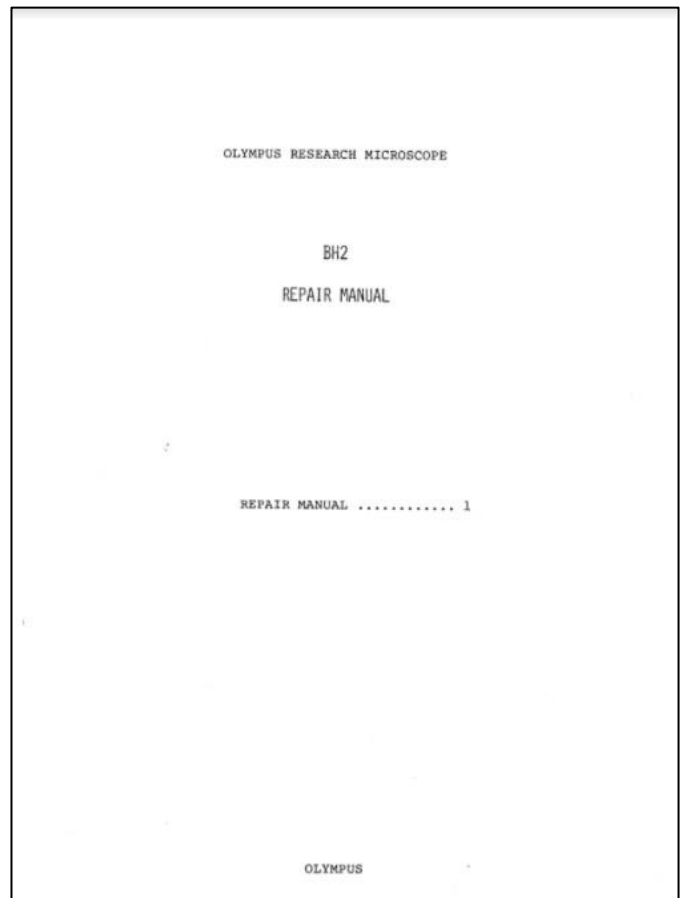
**Table 1 – Suitable replacement lamps for the BHT/BHTU**

### Original Olympus Documentation

Scanned versions of the following PDFs are available for download at various microscope-related hobbyist sites on the internet. These can also be found by searching for the titles in an internet search engine, such as Google.



**Olympus Research Microscopes Series BH2 (BHS) Repair Manual**



**Olympus Research Microscope BH2 Repair Manual**

### Acknowledgements

Special thanks to Jerry Clement, of J & H Microscope Services in Madison, Wisconsin, for providing information on lamphouse repairs and on the usage of Tamiya connectors to replace J103.

### How to Contact the Author

Please feel free to direct any questions or comments regarding this document (or Olympus BH-2 microscopes in general) to the author at the email address listed on the cover of this document.

## Lamp Dimmer Waveforms

The following waveforms are shown relative to the negative output of the bridge rectifier, which is the zero-reference point for the BHT/BHTU circuitry. These waveforms were produced using version 4.19e of the LTSpice IV circuit simulator.

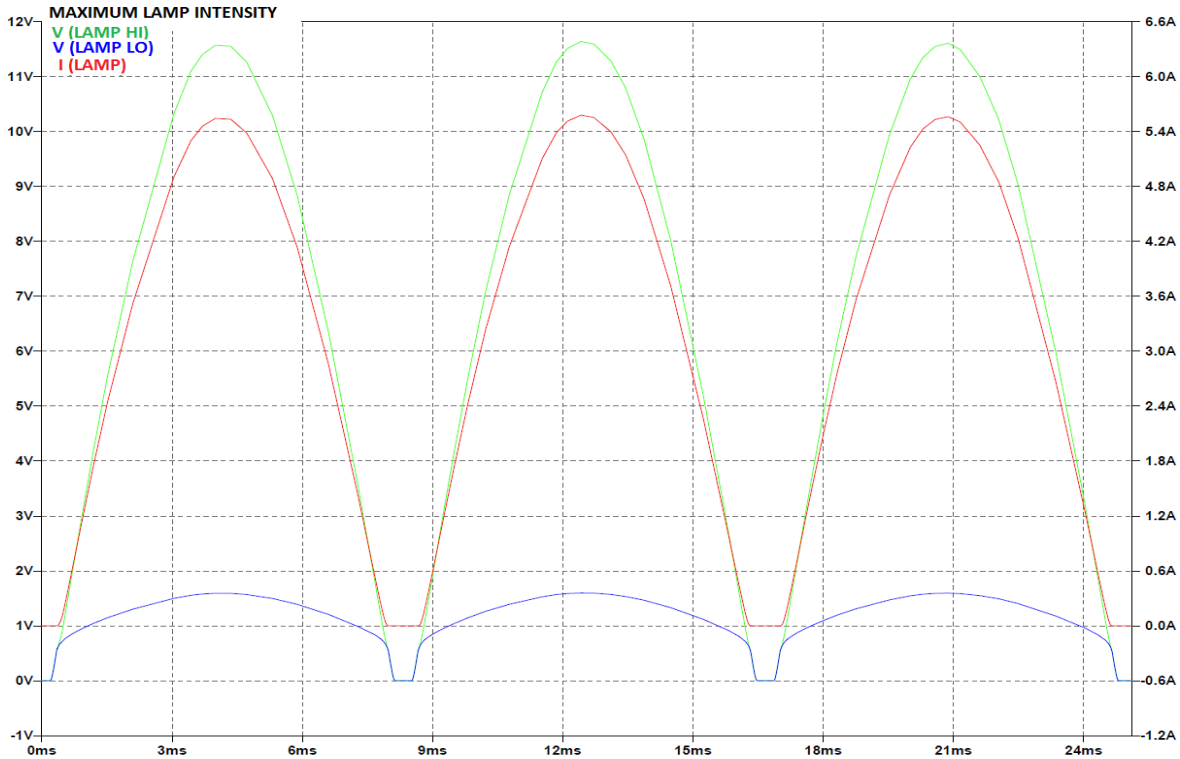


Figure 48 – Lamp waveforms at maximum intensity (100% setting of intensity control)

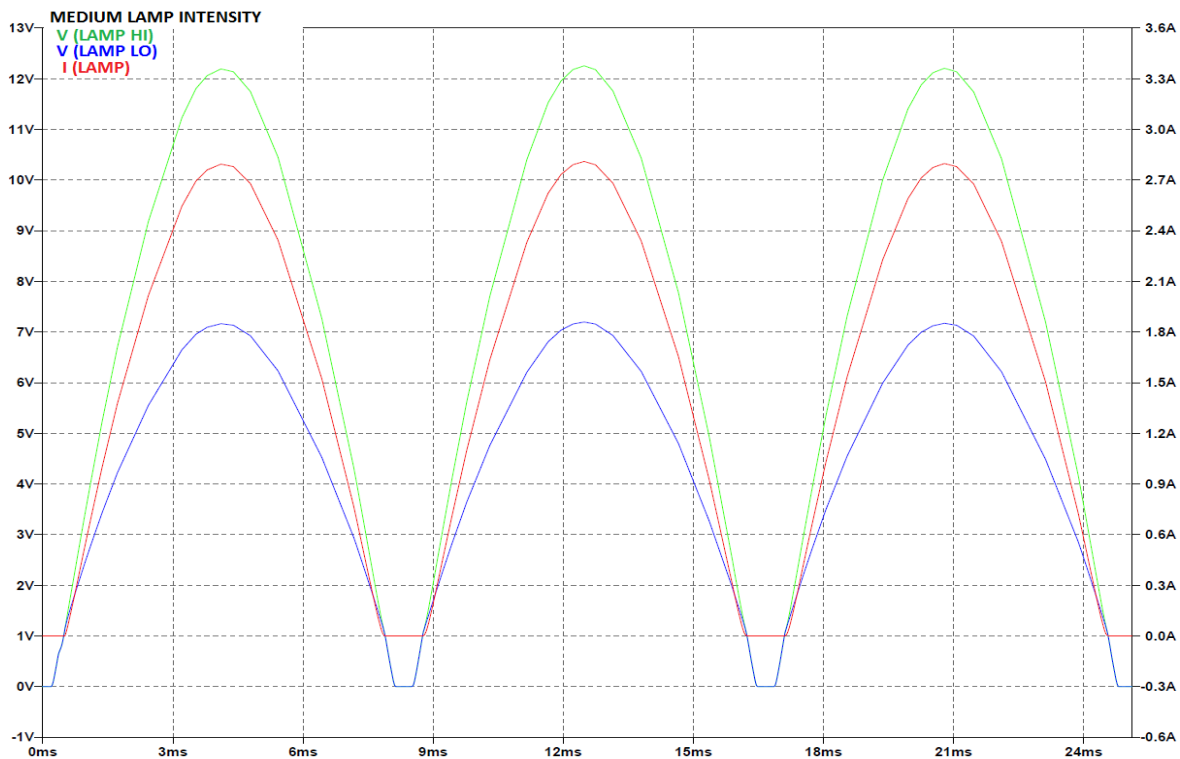


Figure 49 – Lamp waveforms at medium intensity (50% setting of intensity control)

## Lamp Dimmer Waveforms (continued)

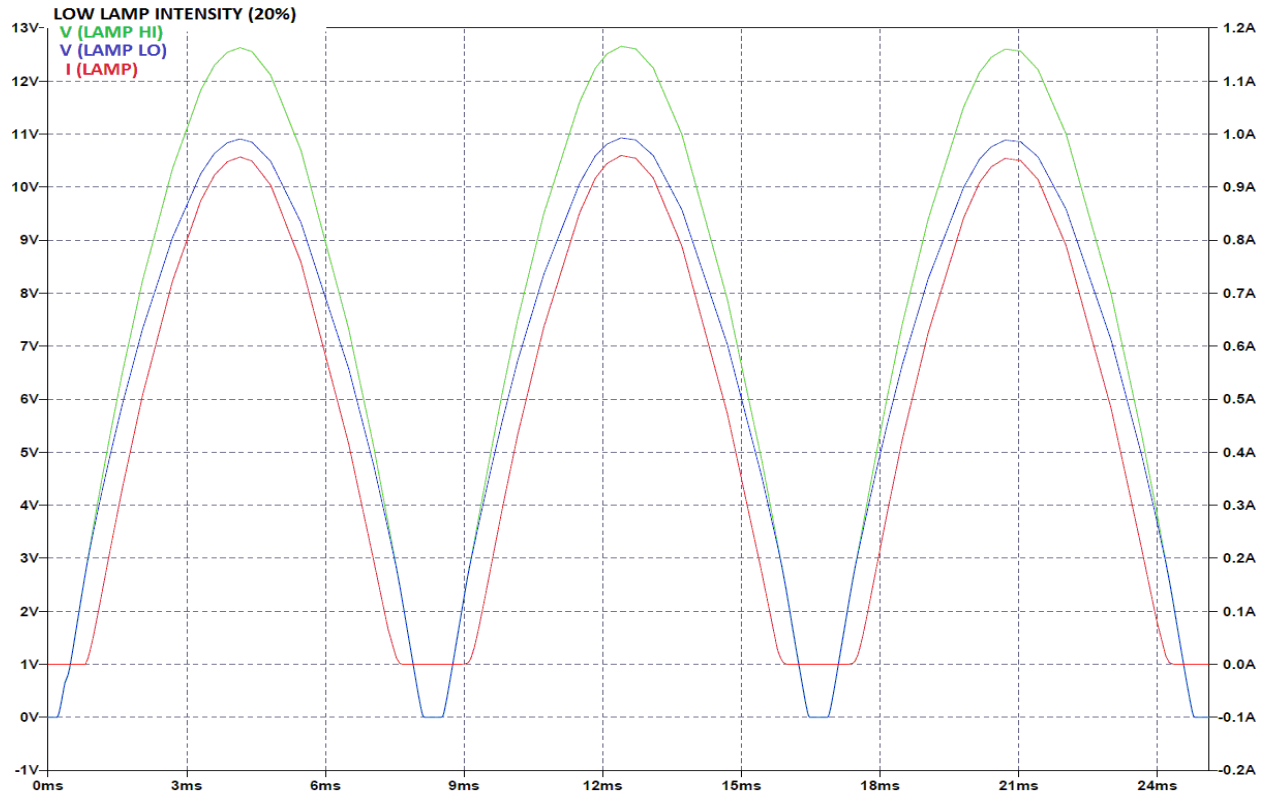


Figure 50 – Lamp waveforms at low intensity (20% setting of intensity control)

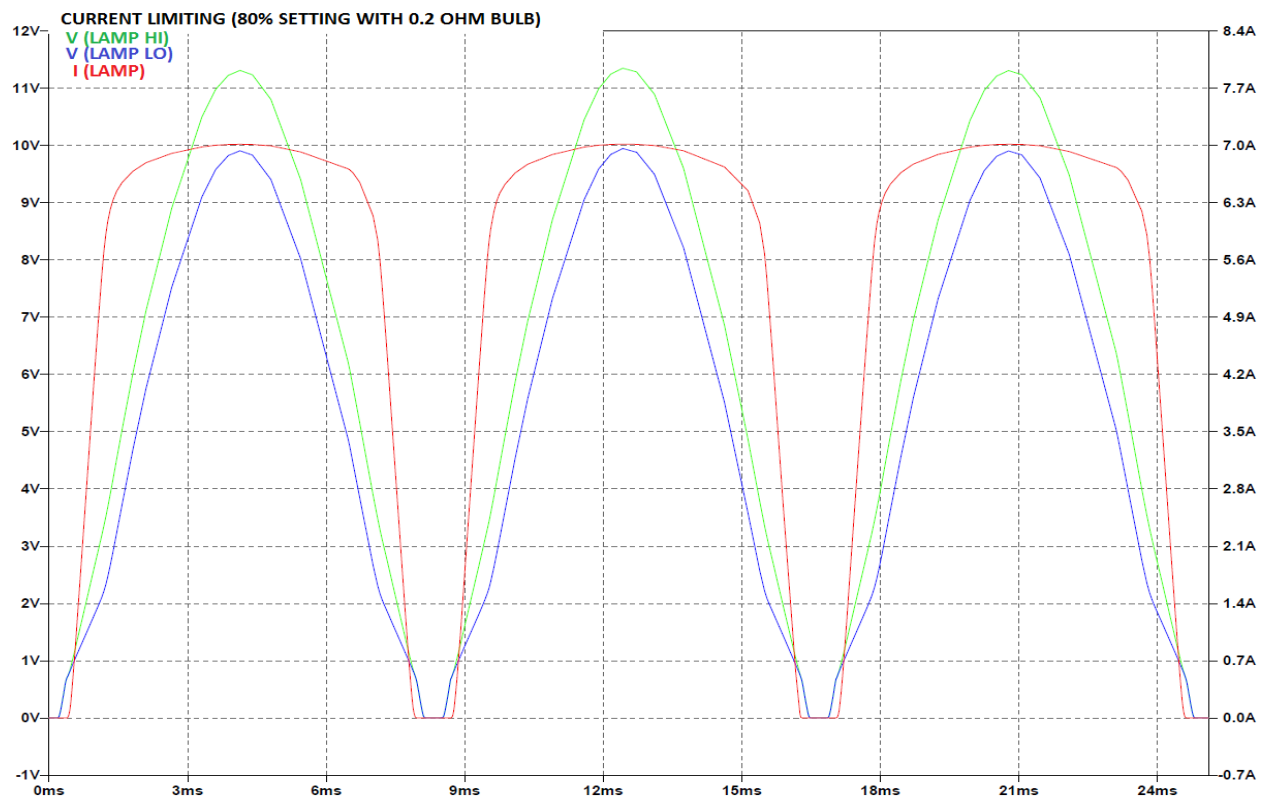
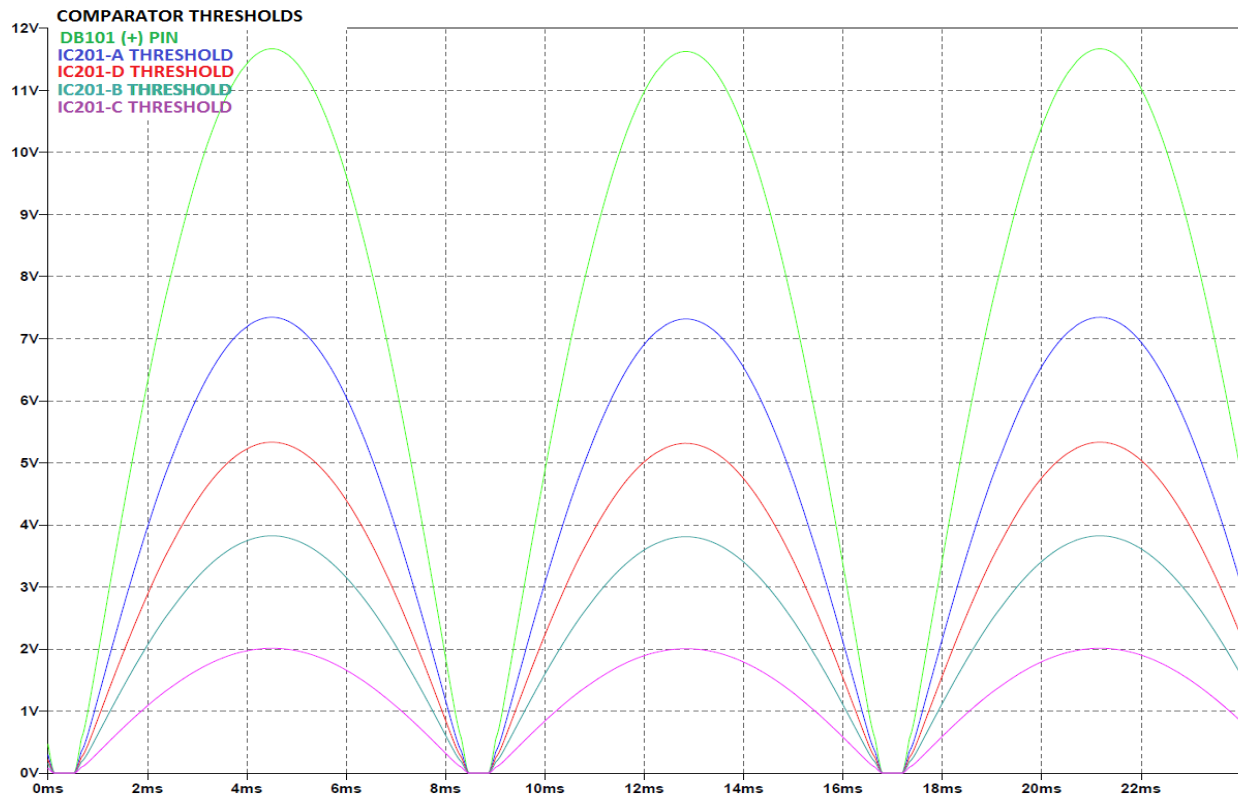
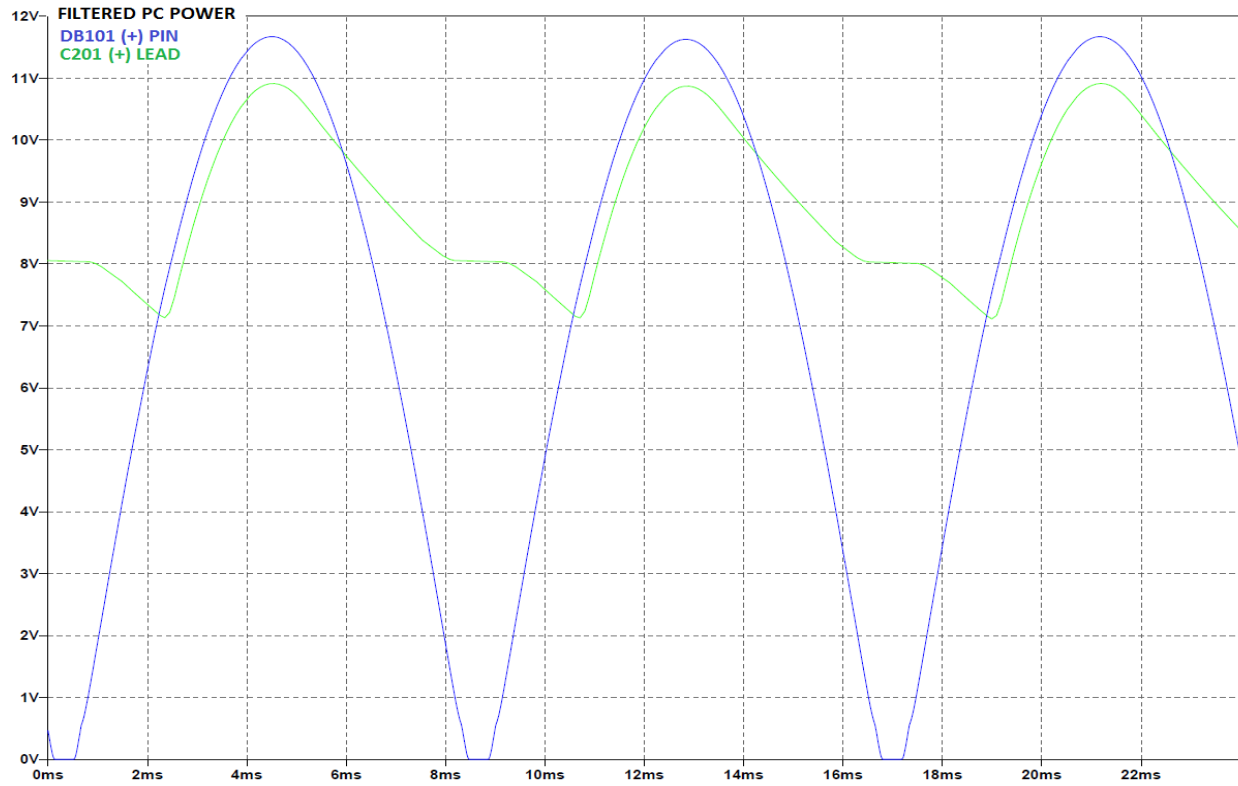


Figure 51 – Lamp waveforms during current limiting (80% setting of intensity control, lamp resistance =  $0.2\Omega$ )

## LED Bar-Graph Display Waveforms



## LED Bar-Graph Display Waveforms (continued)

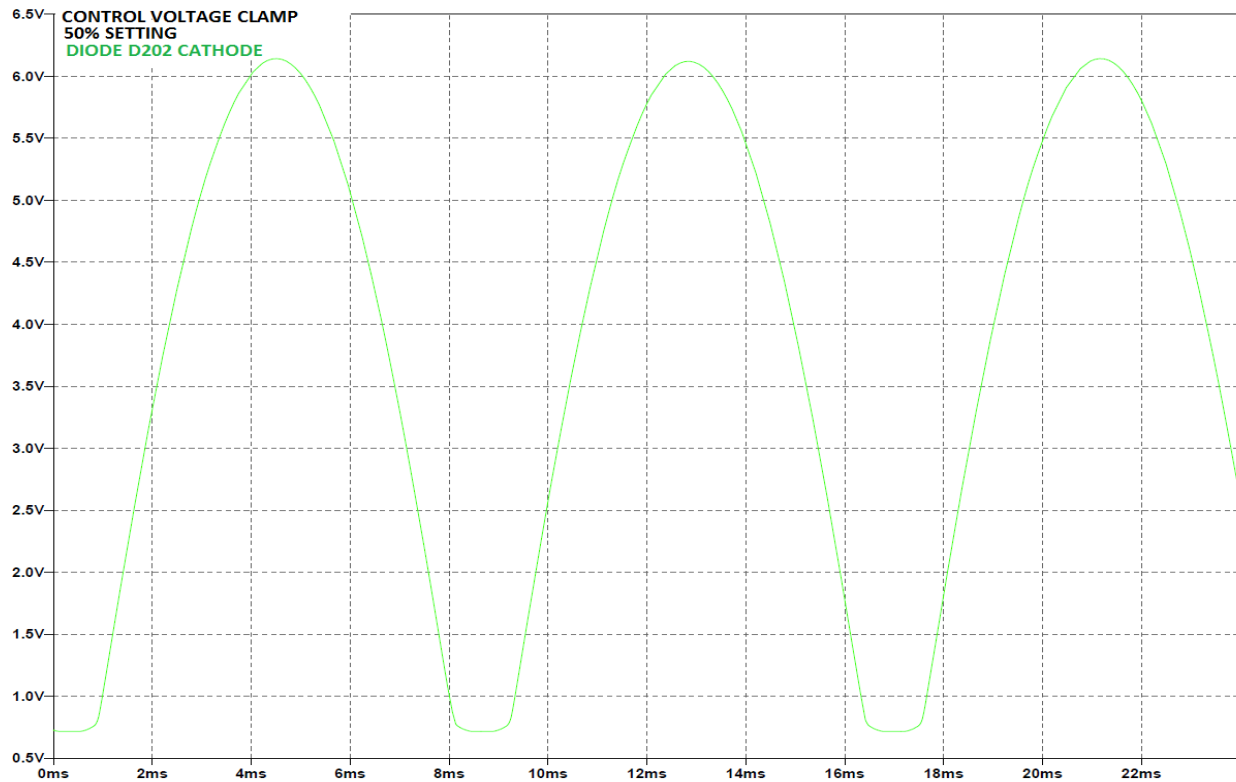


Figure 54 – Clamped control signal to comparators at medium lamp intensity (50% setting of intensity control)

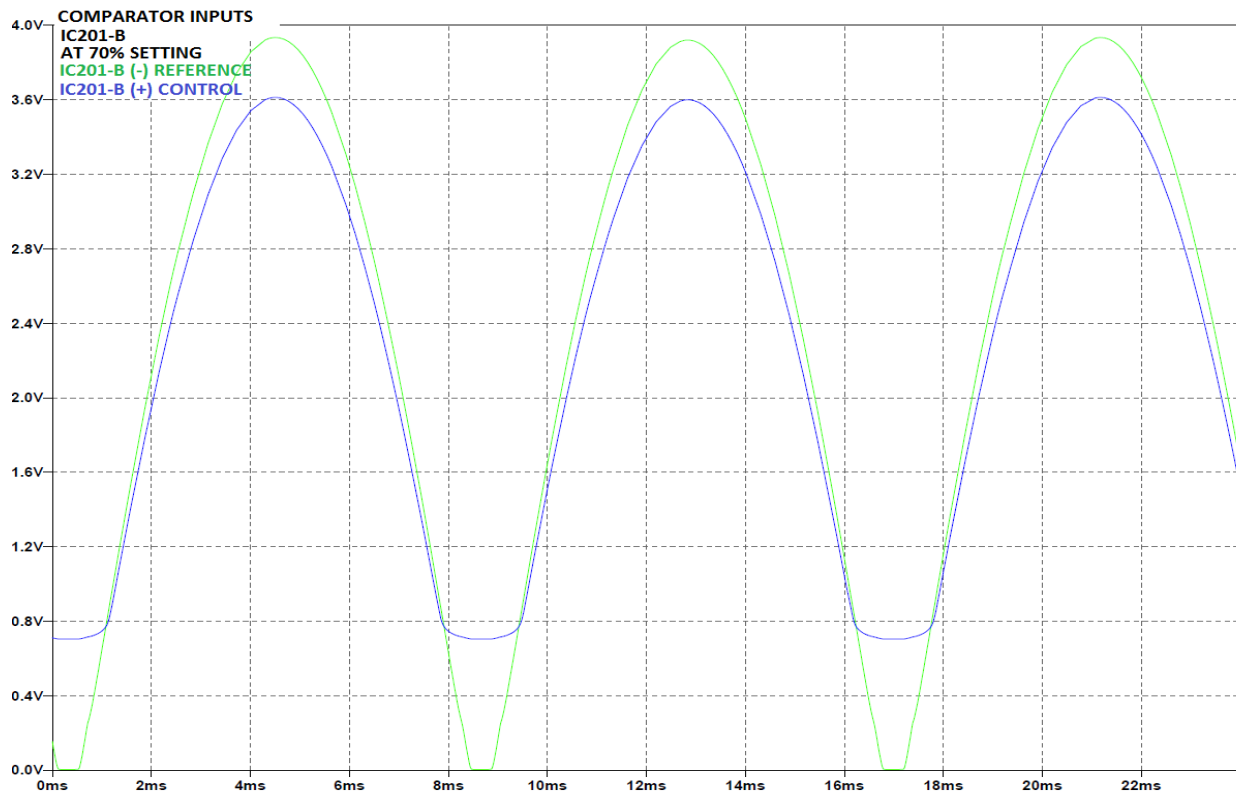


Figure 55 – Comparator IC1-B inputs with 6V LED illuminated (70% setting of intensity control)



## Troubleshooting Flowchart for Switching, Transformer, and Bridge rectifier

Be sure to read and the "Safety Warnings and Disclaimers" section of this document before proceeding with electrical troubleshooting or repairs.

This is the first sequence of testing that should be performed. Before starting, be sure to first perform a thorough visual inspection of the electrical base, looking for any damaged wiring. Correct any wiring issues before proceeding with troubleshooting.



Figure 56 – Troubleshooting flowchart for AC switching, power transformer, and bridge rectifier

## Troubleshooting Flowchart for LEDS and Intensity Slide Control

Be sure to read and the "Safety Warnings and Disclaimers" section of this document before proceeding with electrical troubleshooting or repairs.

Before performing this testing, perform the testing on the previous page to verify proper operation of the following sections:  
1 - AC power switching, power transformer, and bridge rectifier

All voltage measurements are referenced to the negative output pin of bridge rectifier DB101 (the terminal with blue and brown wires).

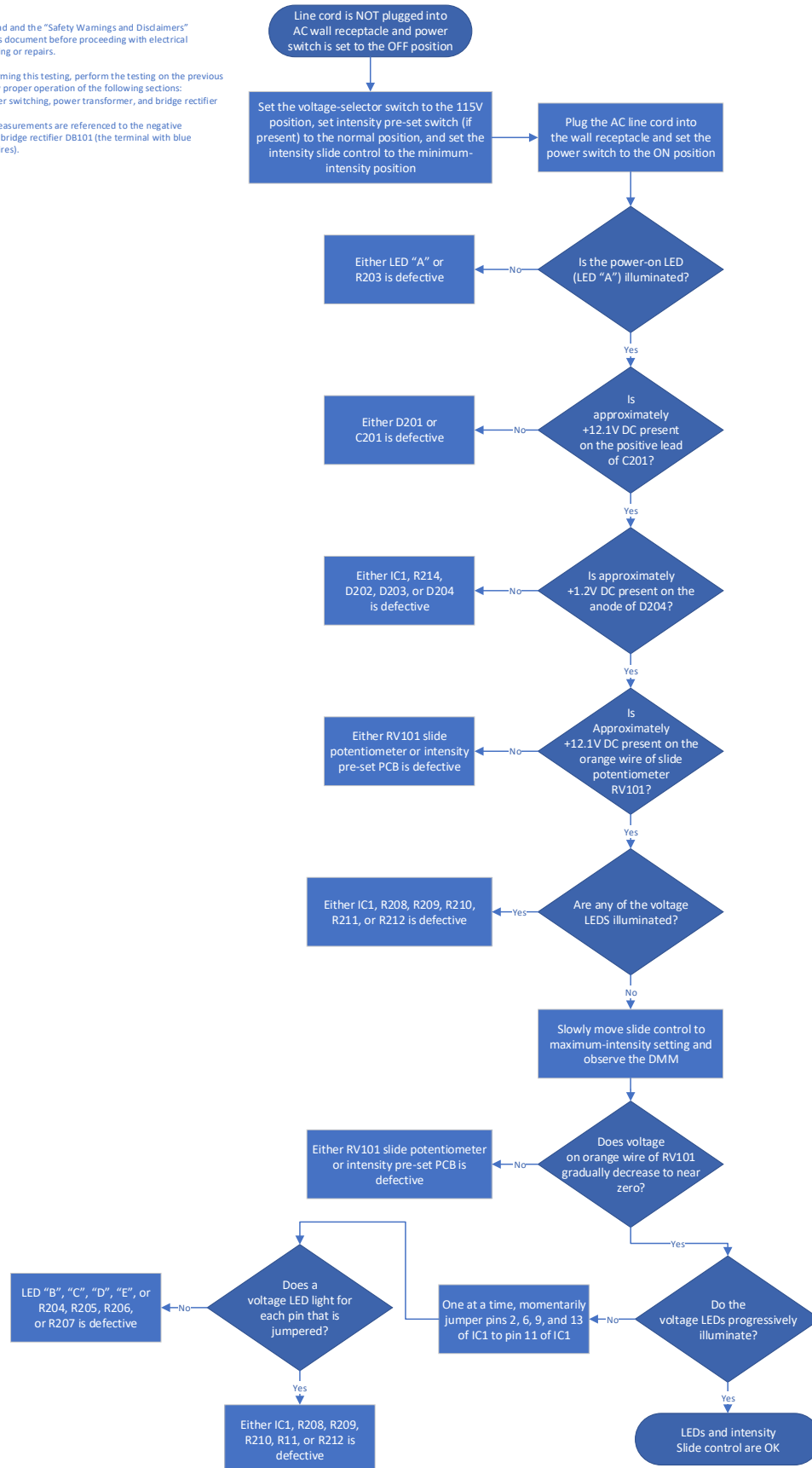


Figure 57 – Troubleshooting flowchart for LEDS and intensity slide control

## Troubleshooting Flowchart for the Halogen Lamp Dimmer

Be sure to read and the "Safety Warnings and Disclaimers" section of this document before proceeding with electrical troubleshooting or repairs.

Before performing this testing, perform the testing on the previous pages to verify proper operation of the following sections:

- 1 - AC power switching, power transformer, and bridge rectifier
- 2 - LEDs and Intensity Slide Control

All voltage measurements are referenced to the negative output pin of bridge rectifier DB101 (the terminal with the blue and brown wires).

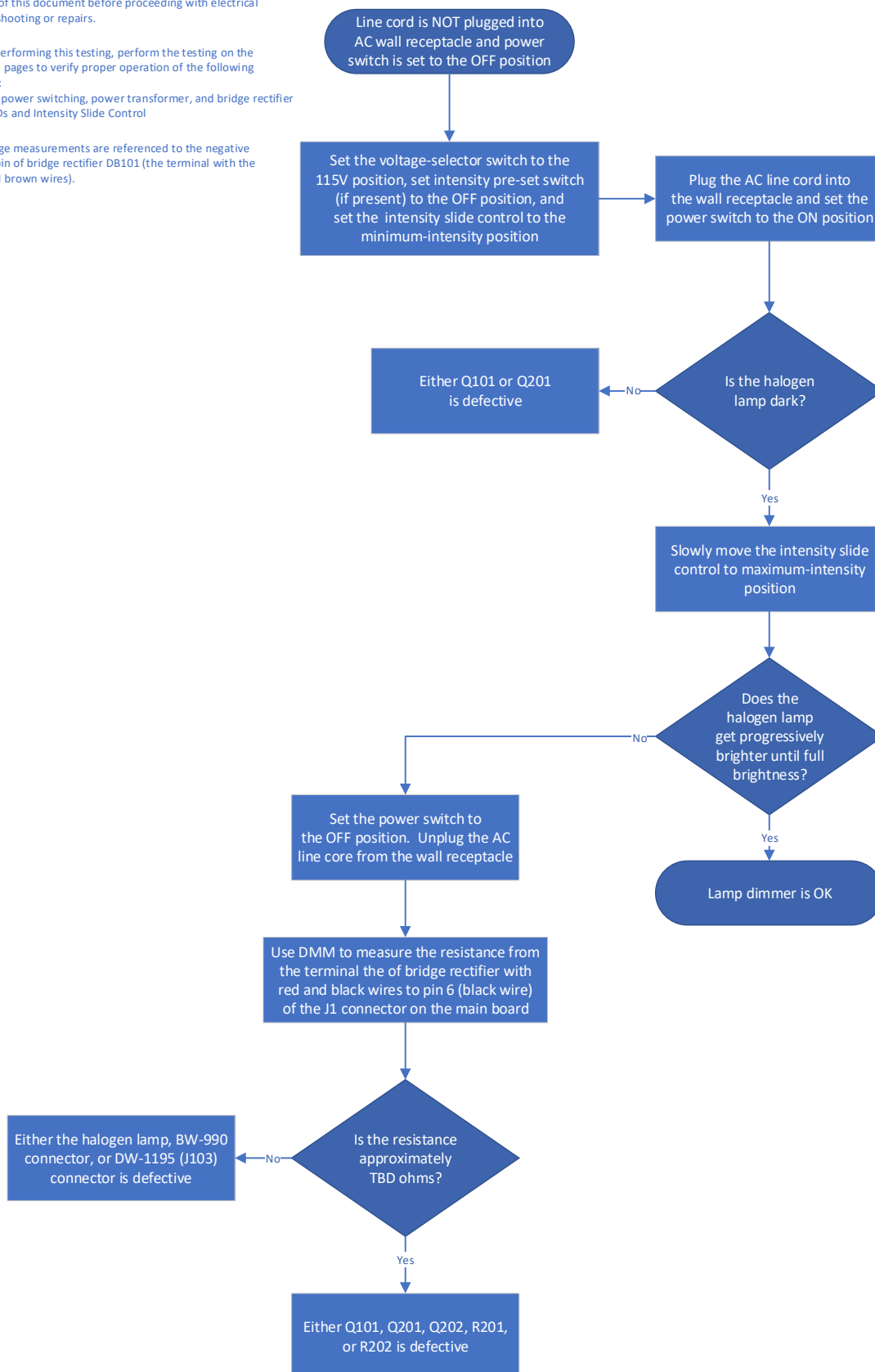


Figure 58 – Troubleshooting flowchart for halogen lamp dimmer



## Troubleshooting Flowchart for the Lamp-Intensity Preset Board

Be sure to read and the "Safety Warnings and Disclaimers" section of this document before proceeding with electrical troubleshooting or repairs.

Before performing this testing, perform the testing on the previous pages to verify proper operation of the following sections:  
 1 - AC power switching, power transformer, and bridge rectifier  
 2 - LEDs and Intensity Slide Control  
 3 - Halogen Lamp Dimmer

Note that the Intensity Preset Board is not present on early production BHT/BHTU stands.

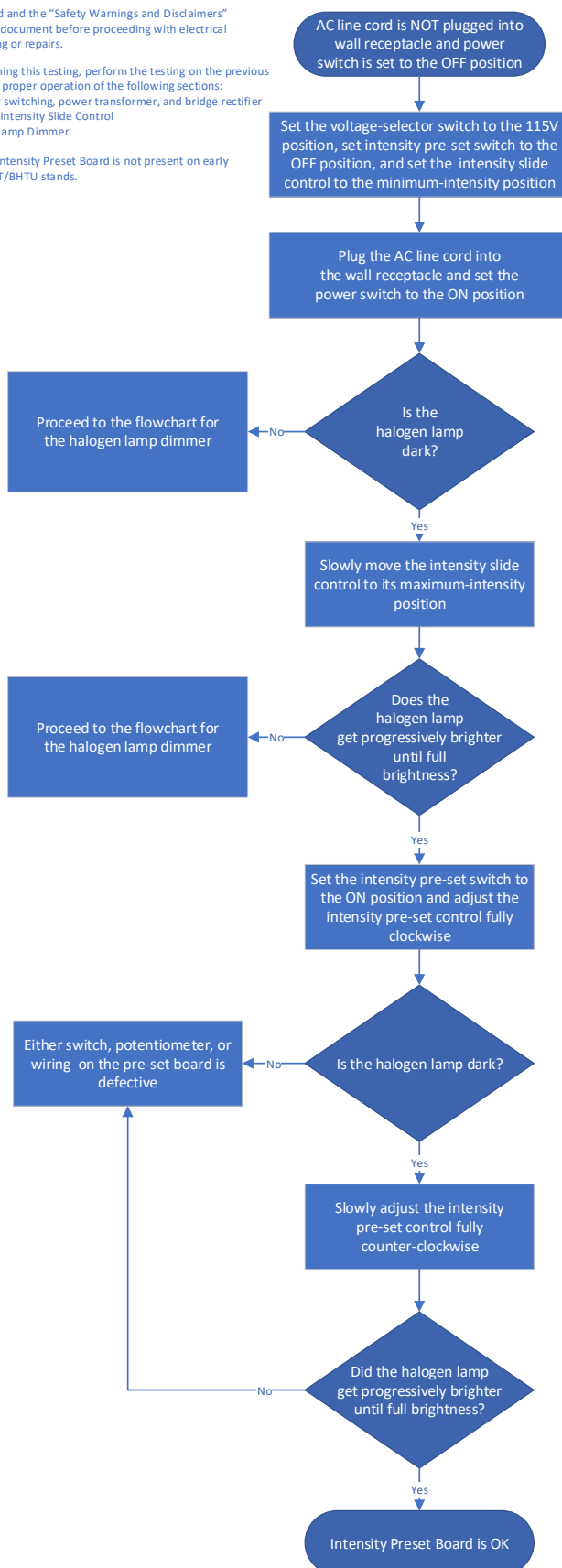


Figure 59 – Troubleshooting flowchart for lamp intensity preset board

## Information Regarding Transistors in the BHT/BHTU

### Replacing Transistors on the Dimmer Board

The original 2SA817 transistors used for Q1 and Q2 on the UYPC48 dimmer board in the BHT/BHTU are shown on the left-hand side of [Figure 60](#), while the recommended 2N3906 and KSP94 replacements are shown on the right-hand side. Note that the pin assignments differ between the original 2SA817 parts and the 2N3906 and KSP94 replacements, and because of this, care must be taken when installing replacements for the original transistors, in order for the replacements to function properly.

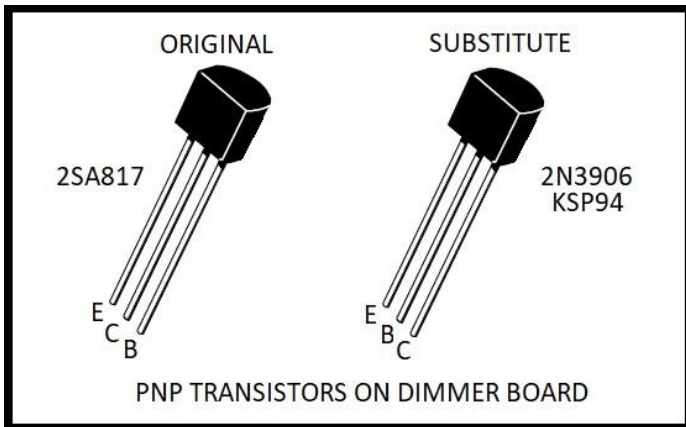


Figure 60 – PNP transistors for the UYPC48 dimmer board

The suggested method for installing these replacement transistors is to hold the replacement part above the mounting holes in the printed circuit board, with the flat of the TO-92 transistor case oriented the same as the original part was installed, and then pull the center (base) lead backwards, away from the flat on the case. Now insert this center (base) lead into the hole on the printed circuit board which is marked “B”. Next, insert the collector lead into the hole marked “C” and the emitter lead into the hole marked “E” (see [Figure 60](#)).

Press the transistor in until it is the desired height above the printed circuit board, and very carefully inspect the transistor to make none of the leads are contacting any of the other leads. Re-position the case of the transistor as necessary to guarantee sufficient clearance between the leads, such that there will not be any risk of short-circuiting of the leads when the microscope is put back into service.

Once there is sufficient clearance between the transistor leads, solder the transistor to the printed circuit board and trim any excess lead length from the bottom of the board, then clean any flux residue from the printed circuit board using a suitable solvent

(alcohol). Note: A short section of a suitable insulating tubing can be applied over the center (collector) lead of the transistor before insertion of the leads into the mounting holes of the printed circuit board, to prevent the leads from contacting each other.

### Mounting Hardware for Power Transistor Q101

Transistor Q101 is a 2SD867 NPN power transistor in the old TO-3 case style. This transistor is physically mounted to the chassis of the electrical base, using industry standard TO-3 mounting hardware, to provide sufficient heat sinking to prevent the transistor from failing prematurely due to overheating.

Since Q101 is not physically located on the UYPC48 dimmer board, electrical wires are used to connect Q101 to the dimmer board. Two of these wires (to the emitter and base terminals of Q101) utilize soldered connections, while the third uses a mechanical connection for the collector (i.e., the case of the TO-3 part) made by a solder lug secured in place by a screw, two nuts, a flat washer, and a pair of lock washers. The wiring connections to Q101 are shown in [Figure 61](#).

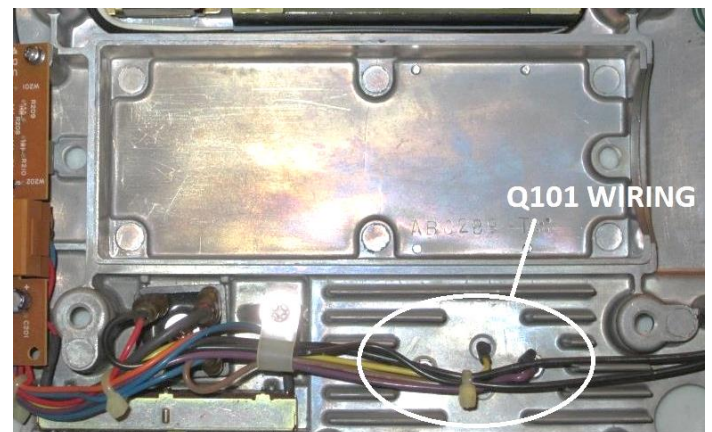


Figure 61 – Q101 connections on the top side of the electrical base

Transistor Q101 is physically located on the underside of the chassis of the electrical base (see [Figure 62](#)). The metal case of the transistor (i.e., the collector terminal) is insulated from the chassis of the electrical base by a TO-3 mica insulator (which is located between the transistor case and the chassis of the electrical base) and two nylon shoulder washers. Additionally, the metal case is further protected from inadvertent contact by a TO-3 plastic cover placed over the transistor case.



Figure 62 – TO-3 transistor on the underside of electrical base

In order to provide optimal thermal protection, a thin layer of thermal paste is present between the chassis of the electrical base and the mica insulator for Q101, as well as between the mica insulator and the metal case of Q101. This paste provides improved thermal conductivity from the transistor case to the chassis, to allow Q101 to operate cooler.

The TO-3 plastic cover is held in place over Q101, and transistor Q101 is secured to the chassis of the electrical base, using an m3x16 screw and an m3x12 screw, along with their associated nuts, washers, and nylon shoulder washers (see Figure 63). The nylon shoulder washers keep the mounting screws from contacting the chassis of the electrical base, otherwise the collector terminal of Q101 could be short to the metal chassis.

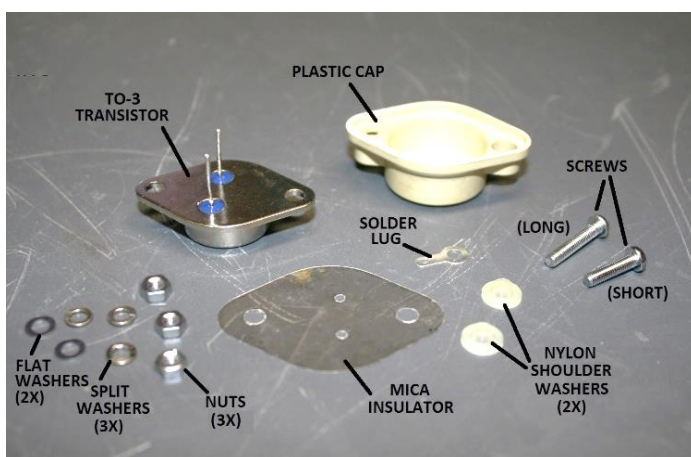


Figure 63 – TO-3 mounting hardware for Q101

### Installing Power Transistor Q101

The procedure to install Q101 is as follows.

- Clean the TO-3 mounting surface on the bottom of the chassis of the electrical base.
- Apply a thin layer of thermal compound to the mounting surface on the bottom of the chassis of the electrical base.
- Place the TO-3 mica insulator onto the mounting surface on the bottom of the chassis of the electrical base, in contact with the thermal paste. Be sure to align the holes in the mica insulator with the holes in the chassis.
- Press down on the insulator to eliminate any air gaps between it and the chassis and wipe away any thermal paste squeeze-out.
- Apply a thin layer of thermal compound to the mounting surface of the TO-3 transistor.
- Place the TO-3 transistor onto the mica insulator. Be sure to align the mounting holes and terminals of the transistor with the holes in the mica insulator.
- Press down on the TO-3 transistor to eliminate any air gaps between it and the mica insulator and wipe away any thermal paste squeeze-out.
- Place the plastic TO-3 cover over the TO-3 transistor. Make sure that the hole in the cover that is wide-open hole (i.e., not the recessed hole) goes over the mounting hole closest to the terminals of Q101 that are protruding through the holes in the chassis.
- While holding the plastic cover in place, place the m3x12 screw (the shorter of the two screws) through the hole in the plastic TO-3 cover that is recessed (i.e., not the wide-open hole).
- While holding the plastic cover and screw in place, put one of the nylon shoulder washers over the screw protruding through the top side of the chassis. Make sure that the shoulder drops into the drilled hole in the chassis.
- Place an m3 flat washer over the protruding screw and onto the nylon shoulder washer.
- Place an m3 split-lock washer over the protruding screw and onto the flat washer.
- Screw an m3 hex nut onto the protruding screw and spin it down until it contacts the split-lock washer.
- Snug the m3 hex nut, making sure the shoulder in the nylon washer remains fully seated in the drilled hole in the chassis.
- Place the m3x16 screw through the remaining (wide open) mounting hole in the plastic TO-3 cover.
- While holding the screw in place, place the remaining nylon shoulder washer over the screw protruding through to the top side of the chassis. Make sure that the shoulder drops into the drilled hole in the chassis.
- Place the remaining m3 flat washer over the protruding screw and onto the nylon shoulder washer.
- Place an m3 split-lock washer over the protruding screw and onto the flat washer.
- Screw an m3 hex nut onto the protruding screw and spin it down until it contacts the split-lock washer.
- Snug the m3 hex nut, making sure the shoulder in the nylon washer remains fully seated in the drilled hole in the chassis.
- Place the solder lug connected to the violet wire over the protruding screw and onto the m3 hex nut.
- Place the remaining m3 split-lock washer over the protruding screw and onto the solder lug.



- Screw the remaining m3 hex nut onto the protruding screw and spin it down to the split-lock washer.
- Snug the m3 hex nut.
- Solder the yellow wire to the base terminal of the TO-3 transistor, using heat-shrink tubing to insulate the connection.
- Solder the brown wire to the emitter terminal of the TO-3 transistor, using heat-shrink tubing to insulate the connection.

This completes the installation of power transistor Q101 onto the chassis of the electrical base.

## Sources for Replacement Parts and Supplies Referenced in this Document

**Table 2** lists the various supplies and replacement parts discussed in this document, along with their price and availability. The listed prices are accurate as-of July 2021 but are subject to change without notice.

Item	Description	Manufacturer	Manufacturer #	Vendor	Vendor #	Price
1	Thermal Paste	Arctic Silver 5	AS5-3.5G	Amazon	---	\$6.80
2	Bridge rectifier	NTE® Electronics	NTE5322	Allied	70215808	\$5.51
3	Potentiometer, Slide, 1KΩ	Bourns®	PTE45-151A-102B2	Mouser	652-PTE45-151A-102B2	\$6.05
4	Slide switch	Philmore Manufacturing	30-9182	Intertex	PH-30-9182	\$1.38
				Vetco	VUPN7964	\$1.99
5	Power resistor, ceramic, 0.1Ω 5W 5%	Vishay®	CP0005R1000JE14	Mouser	71-CP0005R1000JE14	\$0.69
6	Replacement for UYPC48 board w/ transistor	J.C. Ritchey Company, LLC	JC100	J.C. Ritchey Company, LLC	JC100	\$120.00
7	Power transistor, TO-3P	NTE® Electronics	NTE36	Allied Electronics	70215713	\$6.53
8	AC power connector, IEC 320 C14	(various)	(various)	Amazon	---	\$5.99
9	Repair kit for LS20H lamphouse, w/ back cover	J.C. Ritchey Company, LLC	JC120-1	J.C. Ritchey Company, LLC	JC120-1	\$30.00
10	In-house repair/exchange of LS20H lamphouse	J.C. Ritchey Company, LLC	JC120	J.C. Ritchey Company, LLC	JC120	\$75.00
11	Lamp socket, G4, ceramic	Bender & Wirth	BW-990	Bulbworks	BW.990	\$19.43
12	Socket connector, Olympus BH-2 and BX series	Microscope Solutions	MSOBXLC	Microscope Solutions	MSOBXLC	\$85.00
13	Power connector, Tamiya	---	---	Polulo Robotics and Electronics	1932	\$2.25
				Amazon	---	\$8.69
14	Halogen lamp, ESB	Philips	7388	Bulbtronics®	0000986	\$3.95
				Bulbworks	BW.ESB	\$6.62
			64250 HLX	Bulbworks	BW.ESB-OSR	\$6.95
15	Deoxit® Spray Contact Cleaner	Caig Laboratories	D5	Caig Laboratories	D5S-6	\$19.95
16	Power transistor, TO-3	NTE® Electronics	NTE327	Allied	70214626	\$20.64
17	Transistor cover, TO-3	Keystone® Electronics	4634	Digi-Key®	36-4634-ND	\$0.89
18	Transistor, 2N3906	Micro Commercial Components	2N3906	Digi-Key®	2N3906-APCT-ND	\$0.18
19	Diode, 1N4002	ON Semiconductor® (Fairchild)	1N4002	Digi-Key®	1N4002FSCT-ND	\$0.18
20	Diode, 1N916	ON Semiconductor® (Fairchild)	1N916	Digi-Key®	1N916-ND	\$0.10
21	IC, LM324N	Texas Instruments	LM324N	Digi-Key®	296-1391-5-ND	\$0.55
22	Slide switch	CW Industries	GF-624-6014	Digi-Key®	SW104-ND	\$1.34
23	Red LED array, 5-position	NTE Electronics	NTE3150	Galco	NTE3150	\$2.51
24	Transistor, KSP95	Various	KSP94	Arrow	KSP94TA	\$0.32
25	AC power cord, IEC-320 C13 to NEMA 5-15P, 6 feet, AWG 18, UL Listed	Various	Various	Amazon	Various	\$11.97

**Table 2 – Supplies and electrical components for the BHT/BHTU microscope stands**

## Sources for Replacement Parts and Supplies Referenced in this Document (continued)

**Table 3** lists the contact information for the vendors of the various supplies and electrical parts listed in **Table 2**.

Company Name	URL	Telephone #	Toll-Free #	Fax #	Email
Allied Electronics	<a href="http://www.alliedelec.com">www.alliedelec.com</a>	1-866-433-5722	1-888-761-7515	---	<a href="mailto:custservdept@bulbtronics.com">custservdept@bulbtronics.com</a>
Amazon	<a href="http://www.amazon.com">www.amazon.com</a>	---	1-800-280-4331	---	---
Arrow	<a href="http://www.arrow.com">www.arrow.com</a>	1-855-326-4757	---	---	---
Bulbtronics®	<a href="http://www.bulbtronics.com">www.bulbtronics.com</a>	---	1-800-588-2852	1-631-249-6066	<a href="mailto:custservdept@bulbtronics.com">custservdept@bulbtronics.com</a>
Bulbworks Specialty Lightbulbs and Sockets	<a href="http://www.bulbworks.com">www.bulbworks.com</a>	1-973-584-7171	1-800-334-2852	---	<a href="mailto:bulbwork@bulbworks.com">bulbwork@bulbworks.com</a>
Caig Laboratories, Inc.	<a href="http://www.caig.com">www.caig.com</a>	1-858-436-8388	1-800-224-4123	---	---
Digi-Key® Electronics	<a href="http://www.digikey.com">www.digikey.com</a>	1-218-681-6674	1-800-344-4539	---	<a href="mailto:sales@digikey.com">sales@digikey.com</a>
Galco	<a href="http://www.galco.com">www.galco.com</a>	---	1-800-575-5562	---	---
J.C. Ritchey Company, LLC	<a href="http://www.ritcheymicroscopeservice.com">www.ritcheymicroscopeservice.com</a>	1-740-862-9252	---	---	<a href="mailto:ritcheymicroscopeservice@hotmail.com">ritcheymicroscopeservice@hotmail.com</a>
Intertex Electronics	<a href="http://www.intertexelectronics.com">www.intertexelectronics.com</a>	1-210-820-3830	1-800-820-3908	1-210-820-3344	<a href="mailto:sales@intertexelectronics.com">sales@intertexelectronics.com</a>
Microscope Solutions	<a href="http://www.microscopesolutions.com">www.microscopesolutions.com</a>	1-919-321-4384	1-800-231-7910	1-919-552-3547	---
Mouser Electronics	<a href="http://www.mouser.com">www.mouser.com</a>	1-817-804-3888	1-800-346-6873	1-817-804-3899	<a href="mailto:sales@mouser.com">sales@mouser.com</a>
Newark Electronics	<a href="http://www.newark.com">www.newark.com</a>	---	1-800-463-9275	1-888-551-4801	<a href="mailto:techsupport@newark.com">techsupport@newark.com</a>
Pololu Robotics and Electronics	<a href="http://www.pololu.com">www.pololu.com</a>	1-702-262-6648	1-877-776-5658	---	<a href="mailto:support@pololu.com">support@pololu.com</a>
Vetco Electronics	<a href="http://www.vetco.net">www.vetco.net</a>	1-425-641-7275	---	1-425-641-7303	---

**Table 3 – Vendors for supplies and electrical components**



