PowerPlus Series 7.5
Troubleshooting Guide
For Customer Use

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Introduction

The purpose of this guide is to assist the user in the troubleshooting and repair of the PowerPlus Series 7.5 and newer units. It is geared toward the power supply only and not the precipitator portion of the collection process. The guide is divided into two sections. The first section deals with analyzing the cause of the problem, while the second section deals with specific procedures for testing and replacement of various components.

Only qualified trained personnel, with a complete understanding of the PowerPlus theory of operation and circuit topology should be attempting repair of the PowerPlus units. Lethal voltages exist within the unit.

Understanding PowerPlus Alarms

The troubleshooting process is usually called into play once a PowerPlus has recognized an alarm condition exists and has tripped off. An understanding of the alarm messages that are shown on the GVC display can be very helpful in the first step towards finding the problem. Below is a list of the alarm messages that can appear, along with their possible cause and solution.

- ***Undervoltage****:* Occurs when the kVDC is at or below a set value for a user-determined period of time, indicating a short circuit or high spark rates in the precipitator. The undervoltage trip level is adjustable.

  Cause: Short circuit or close clearances in the precipitator causing it to spark at low kV levels.
  Solution: Perform an open circuit test to verify if problem is in ESP. Correct problem in the field.

  Cause: Incorrect settings for undervoltage, spark rate, setback, fast recovery, and spark level.
  Solution: Change settings to correct values as described in the section on Changing Operating Parameters.

  Cause: Readout not calibrated properly.
  Solution: Recalibrate following instructions in the Calibration section.

- ***Overvoltage****:* Activated instantly if the kVDC exceeds its rating by 15%. This is a fixed setpoint. This usually indicates an open circuit condition.

  Cause: HV connection from the PowerPlus to the ESP section is not tight or secure.
  Solution: Perform a short circuit test to verify that the PowerPlus can produce rated mADC. If it does, the open is in the connection to the ESP. Find the loose or open connection and tighten it.

Cause: Incorrect PowerPlus rating entered for unit.
Solution: Change rating to correct value.

Cause: Readout not calibrated properly.
Solution: Recalibrate following instructions in the Calibration section

- ***Line Overcurrent**:* Activated if the line current exceeds its rating by 15%. This is a fixed setpoint. This alarm can be caused by excessive precipitator current, faulty primary component (ie, three phase rectifier bridge, DC bus capacitor, etc.), incorrect calibration, or a problem with the PowerPlus control board.

  Cause: Excessive precipitator current
  Solution: Make sure the current limit is properly set so the rating is not exceeded.

  Cause: Faulty primary component
  Solution: Identify which component is causing the excessive current and replace. Component may not be shorted since the fuses did not fail, but there may be excessive leakage current present.

  Cause: Incorrect PowerPlus rating entered for unit.
  Solution: Change rating to correct value.

  Cause: Readout not calibrated properly.
  Solution: Recalibrate following instructions in the Calibration section

- ***Output Overcurrent**:* Activated if the mADC exceeds its rating by 25%. This is a fixed setpoint. It can be caused by either the failure to sense a spark/arc, or incorrect calibration.

  Cause: Failure to sense a spark/arc.
  Solution: Make sure the spark/arc sensitivities are properly set. Adjust as necessary, using an oscilloscope on the feedback waveforms as verification.

  Cause: Incorrect PowerPlus rating entered for unit.
  Solution: Change rating to correct value.

  Cause: Readout not calibrated properly.
  Solution: Recalibrate following instructions in the Calibration section

- ***Overtemperature**:* The PowerPlus monitors both the IGBT heatsink temperatures and the HV tank oil temperature. If either of these temperatures reaches a fixed limit setpoint, the controller will reduced the Duty Cycle in an attempt to reduce the temperature of the affected device. The display will show the message *Temperature Limit* as it attempts to regulate the temperature. If the temperature continues to rise and the fixed alarm setpoint is reached the unit will trip on *Overtemperature*. The setpoint levels are listed below.

Description	IGBT Heatsink	HV Tank
Temperature Limit Activation	93C	85C
Temperature Limit Release	90C	80C
Temperature Trip	95C	87C

You should first determine which component is causing the alarm by reading the temperature values on the display.

Cause: Increase in ambient temperature
Solution: If the outside ambient is exceeding the rating, some means must be taken to lower the ambient temperature.

Cause: Problem with the IGBT fan
Solution: Verify that the IGBT fan is rotating and the air is flowing toward the heatsink. Also refer to the ***Fan Current Out of Range*** alarm below.

Cause: Problem with the heat exchanger (if applicable)
Solution: Verify that the enclosure heat exchanger (if applicable) is operating (both fans are rotating) and the exchanger is clean of dirt and dust.

Cause: Problem with the HV tank
Solution: Verify that the any radiator fans (if included) are rotating and the air is flowing. Verify the oil circulator internal to the tank is operational. Verify that system is properly calibrated and ratings are not being exceeded.

- ***Enclosure Over Temp:*** activates if the control enclosure temperature exceeds 65C (150F). This is a display only alarm and will not trip the unit. The Max. Duty Cycle will be limited to 80% and the *Temperature Limit* icon will appear.

  Cause: Increase in ambient temperature
  Solution: If the outside ambient is exceeding the rating, some means must be taken to lower the ambient temperature.

  Cause: Problem with the heat exchanger (if applicable)
  Solution: Verify that the enclosure heat exchanger (if applicable) is operating (both fans are rotating) and the exchanger is clean of dirt and dust.

  Cause: Problem with internal cooling fans
  Solution: Verify that the internal enclosure fans are operating.

- ***HV Tank Fault:*** Activated whenever maximum duty cycle is reached but low output KV and mADC, and high resonant current exists. This is indicative of a fault within the T/R tank section of the PowerPlus.

  Cause: A short circuit in the PowerPlus HV tank.
  Solution: Call NWL service.

- ***Liquid Level Low**:* Activated if the dielectric fluid level in the HV tank is low. It is activated by the liquid level switch within the HV tank.

  Cause: Possible tank leak
  Solution: Inspect the tank for leaks and call NWL service.

  Cause: Open in alarm sensing circuit
  Solution: Verify that 120 VAC is present at the input to the alarm circuit. If it is not, find the open in the circuit.

- ***Line VAC Abnormal**:* Activated if the incoming line voltage is outside of an acceptable pre-defined range. That voltage range is dependent upon the rated line voltage of the unit and is as follows:

Rated Line Voltage	Acceptable Range
380 VAC	285 – 440 VAC
400 VAC	300 – 460 VAC
415 VAC	360 – 520 VAC
480 VAC	360 – 520 VAC
(400-480) VAC	360 – 520 VAC

  If the line voltage returns to within the allowable range within 10 seconds, the PowerPlus will automatically re-energize the high voltage. If it again experiences the voltage out of range condition during ramp up, or if a second alarm occurs within 5 minutes, the unit will trip and stay off until the alarm is manually cleared.

  Cause: Incoming line voltage outside of the specified range.
  Solution: Change the tap at the power distribution transformer to bring the line voltage within specification.

  Cause: Loss of one of the incoming three phase lines.
  Solution: Correct the phase loss problem.

- ***Low DC Bus Voltage**:* Activated if the DC bus voltage is less than 120% of the line voltage. Since the low V Bus may have been caused by a low or unbalanced three phase line voltage, the PowerPlus will continue to monitor the line voltage for an additional 10 seconds after it trips. If the line voltage returns to within the acceptable range listed above, the unit will automatically re-energize the high voltage. If it again experiences the V Bus Low condition during ramp up, or if a second alarm occurs within 5 minutes, the unit will trip and stay off until the alarm is manually cleared.

  Cause: Failure of main fuse(s) on the input to the 3Ø bridge rectifier.
  Solution: Test for shorted 3Ø bridge rectifier, IGBT, or bus capacitor assembly. Replace failed component then replace the fuse(s).

Cause: Problem with contacts on main contactor or circuit breaker.
Solution: Verify all three phases are on the load terminals of the contactor and breaker. Replace contactor/breaker if required.

Cause: Phase imbalance or loss of one of the incoming three phase lines.
Solution: Correct the phase imbalance/loss problem.

- ***Fan Current Fault:*** Activated if the IGBT heatsink fan current is less than .5 amp or greater than 1.5 amp for 480 VAC fans and less than 1 amp or greater than 4 amp for 120 VAC fans (used on 21 kW and smaller units). If the tank fan experiences a current fault, the alarm will be annunciated, but the unit will not trip. The control will monitor the fluid temperature and go into a *Temperature Limit* or *Overtemp* trip condition.

  Cause: Problem with contacts on fan contactor
  Solution: Verify all three phases are on the load terminals of the fan contactor. Replace contactor if required.

  Cause: Open or short circuit of the fan motor winding.
  Solution: The winding of the fan motor are thermally protected with an internal temperature cutout. If the motor is hot, allow it to cool and see if it can be re-energized. If not replace motor. If it can be re-energized, determine cause of overheating.

- ***Main Contactor Fault:*** Activated if the main contactor fails to energize based on the status of the auxiliary contact. Since this alarm may have been caused by a low incoming line voltage, the PowerPlus will continue to monitor the line voltage for an additional 10 seconds after it trips. If the line voltage returns to within the acceptable range listed above, the unit will automatically re-energize the high voltage. If it again experiences the V Bus Low condition during ramp up, or if a second alarm occurs within 5 minutes, the unit will trip and stay off until the alarm is manually cleared.

  Cause: Main contactor not energizing.
  Solution: Check for 120 VAC at contactor coil. Check the small cylindrical fuse, F2, located on the D25166-01 I/O board of the control module. Verify that 120 VAC is present at the Aux. Main input on the control board. Repair any faulty connections or replace contactor or control board if required.

- ***Step Start Contactor Fault:*** Activated if the step start contactor fails to energize (based on the status of the auxiliary contact).

  Cause: Step start contactor not energizing.
  Solution: Check for 120 VAC at contactor coil. Check the small cylindrical fuse, F1, located on the D25166-01 I/O board of the control module. Verify

that 120 VAC is present at the Aux. Step input on the control board. Repair any faulty connections or replace contactor or control board if required.

- ***Fan Contactor Fault****:* Activated if the fan contactor fails to energize based on the status of the auxiliary contact. Since this alarm may have been caused by a low incoming line voltage, the PowerPlus will continue to monitor the line voltage for an additional 10 seconds after it trips. If the line voltage returns to within the acceptable range listed above, the unit will automatically re-energize the high voltage. If it again experiences the V Bus Low condition during ramp up, or if a second alarm occurs within 5 minutes, the unit will trip and stay off until the alarm is manually cleared.

  Cause: Fan contactor not energizing.
  Solution: Check for 120 VAC at contactor coil. Check the small cylindrical fuse, F3, located on the D25166-01 I/O board of the control module. Verify that 120 VAC is present at the Aux. Fan input on the control board. Repair any faulty connections or replace contactor or control board if required.

- ***Gate High Temp:*** Activates if the gate driver chip on the dual gate driver board exceeds 70 ºC. This trip is wired into the Auxiliary Alarm #1 circuit and is only on the Series 05 and later PowerPlus units. This alarm is not applicable to the Series 7.5 units. It is only used on Series 5 through Series 7 models.

  Cause: Gate driver board fan is not energizing.
  Solution: Check for broken wiring from fan to board. Replace driver board if required.

  Cause: Open or intermittent wiring to thermal switch.
  Solution: Check the 120 VAC wiring to J2 on the driver boards and on to J9-5 on the I/O board.

  Cause: Increase in ambient temperature
  Solution: Verify that the enclosure heat exchanger (if applicable) is operating and clean of dirt and dust. If the outside ambient is exceeding the rating, some means must be taken to either lower the temperature or de-rate (reduce the load on) the PowerPlus.

- ***Door Open***: Activates if any of the non-mechanically interlocked doors on the PowerPlus are open.

  Cause: Door left open
  Solution: Locate the open door and close it.

  Cause: The door switch mechanism is not fully engaged.
  Solution: Make sure the switch plunger is fully engaged upon door closing.

Cause: Open or intermittent wiring to door switch.
Solution: Verify that 120 VAC is present on the Door Limit Switch input of the control board. Repair any faulty connections.

- ***Low Battery:*** Signals that the battery in the controller's non-volatile RAM has dropped below an acceptable value.

  Cause: Problem with RAM chip
  Solution: Replace battery on RAM chip, then recalibrate following instructions in the Operators Manual.

- ***Loss of Memory:*** Shows that the parameters stored in RAM have been wiped out.

  Cause: Line surge or other electrical anomaly scrambles memory.
  Solution: Verify unit is properly grounded. Verify the quality of the incoming power.

  Cause: Failure of nonvolatile RAM.
  Solution: Replace RAM battery; then recalibrate following instructions in the Calibration section

- ***Auxiliary Alarm****:* Activated instantly if any of the customer supplied auxiliary alarm circuit are activated.

  Cause: One of the customer supplied auxiliary alarm circuits was activated.
  Solution: Check the specific auxiliary alarm circuit and correct the condition.

  Cause: Incorrect input to alarm circuit.
  Solution: Check the wiring to the auxiliary input and verify that the proper signal is being applied to the input. Correct if necessary.

- ***Hammer Feedback Alarm****:* Activated instantly if any of the customer supplied rotating hammer feedback alarms are activated. This alarm is only applicable if the PowerPlus includes the option rotating hammer control board.

  Cause: One of the rotating hammer motor starters is not energizing.
  Solution: Check the specific rotating hammer motor starter and correct the condition.

  Cause: Incorrect input to alarm circuit.
  Solution: Check the wiring to the hammer feedback alarm input and verify that the proper signal is being applied to the input. Correct if necessary.

A comparison of existing metering values for a given PowerPlus unit to a historical trend of metering values may also be helpful in troubleshooting problems. Below is a chart that summarizes the effect of the fault conditions on the metering values of the PowerPlus.

Troubleshooting Table

Condition	Vac	Iac	Vbus	Iresonant	kVdc	mAdc	SPM	Duty Cycle
High Input Line	H	LDC	H	HDC	N	HDC	N	N
Low Input Line	L	HDC	L	LDC	N	LDC	N	N
1 Blown Fuse	N	HDC or 0	L	LDC	LDC	LDC	LDC	N
2 or 3 Blown Fuses	N	L or 0	0	0	0	0	0	100%
IGBTs not firing (>=2)	N	L or 0	N	0	0	0	0	100%
1 IGBT not firing	N	LDC	N	LDC	LDC	LDC	LDC	N
HV tank short	N	L	N	H	L	L	0	100%
ESP short or reduced clearance	N	L	N	L	L	L to N	0 to N	L to N

Codes:
N- Normal
L- Lower than Normal
H- Higher than Normal
LDC- Lower than typical for a given Duty Cycle
HDC- Higher than typical for a given Duty Cycle

PowerPlus Procedures

Open Circuit Test

An open circuit test is used to determine whether a suspected short circuit or low clearance condition exists in the precipitator section or the PowerPlus. The test involves running the PowerPlus with no load connected to it. If the short circuit meter conditions (low kVDC, high mADC) still exist, the problem is in the PowerPlus. If the conditions reverse to high kVDC and no mADC, the PowerPlus is operating properly and the problem is in the bus duct or the precipitator section.

In order to perform the test, follow the instructions below.

1) Turn the HV OFF.
2) Place the main circuit breaker in the Off position.
3) Using the key interlock system, lock the breaker in the off position and remove the interlock key.
4) Following the key interlock sequence, lock the PowerPlus ground switch into the “Ground” position.
5) Entering through the HV access port, place a second external ground on HV bus away from the bushing, closer to the precipitator section. **FAILURE TO DO THIS WILL EXPOSE TEST PERSONNEL TO POTENTIALLY LETHAL VOLTAGES.**
6) Disconnect the HV bus from the HV bushing of the Power Plus unit at a point between the HV bushing and the second ground. **KEEP THE SECOND GROUND CONNECTED TO THE BUS, THUS GROUNDING THE PRECIPITATOR SECTION. FAILURE TO DO THIS WILL EXPOSE TEST PERSONNEL TO POTENTIALLY LETHAL VOLTAGES.** There must be at least 8 - 9 inches of clearance between the HV bushing of the Power Plus unit and the disconnected HV bus to insure that a flashover will not occur. If that clearance is not available, contact NWL for guidance.
7) Cover the HV duct access point.
8) At the Power Plus unit, lock the HV/GND switch in the HV position. Remove the interlock key and place it in the circuit breaker interlock.
9) Unlock the breaker and place it in the “ON” position.
10) Enter the 'Setpoint' screen and change the following parameters:
    A) U.V. Trip to 0kV.
    B) Voltage limit to 72% (for 83kVdc model set the V-limit to 61%)
11) Enter the 'MODE' screen and set the control mode to “MANUAL”.
12) Enter the ‘CONFIG’ screen and set the max duty cycle limit to its lowest setting.
13) Go to the “METER” screen.
14) Press the 'ON' button and use the <+> key to slowly increase the Duty Cycle 0.1% at a time with a several second wait between each increase..
15) Wait several seconds for the KV to stabilize. Record the duty cycle and corresponding kVdc indication.

16) Also watch the mAdc and AAC level as the Duty Cycle is increased. There should be no significant current during this test. If the current level increases to a significant level the HV should be turned off. This indicates a short circuit condition.
17) If the Power Plus model is operating normally you will be able to increase the KV up to the voltage limit setting of 70KV rating x 72%, (61% for the 83kVdc model types) voltage limit = ~51KV. The duty cycle level should be very low. If you are exceeding 30% duty cycle and not near 50kV then a problem most likely exists within the HV tank.
18) The Power Plus will have to be repaired if it failed this test.

Open-circuit test is complete.

1) Turn the HV off.
2) Lock the Power Plus circuit breaker in the OFF position.
3) Use the interlock key to lock the HV- Ground Switch in the Ground position.
4) Entering through the access port, reconnect the HV buss bar to the HV bushing of the PowerPlus unit.
5) Remove the ground jumper that was installed on the HV bus bar.
6) Cover the HV access port.
7) Lock the Ground Switch in the HV position. Remove the interlock key.
8) Use the key to place the main breaker switch to the “ON” position.
9) Enter the 'Setpoint' screen and restore the U.V. Trip and Voltage Limit to their original values.
10) Enter the 'Mode' screen and set the control mode to ‘SETPOINT.'
11) Enter the ‘CONFIG’ screen and set the max duty cycle to the original value.
12) The Power Plus is now ready for normal operation.

Short Circuit Test

A short circuit test is used to determine whether a suspected open circuit condition exists in the precipitator section or the PowerPlus. The test involves running the PowerPlus with the HV bushing shorted. If the open circuit meter conditions (high kVDC, low mADC) still exist, the problem is in the PowerPlus. If the conditions reverse to no kVDC and high mADC, the PowerPlus is operating properly and the problem is in the bus duct or the precipitator section.

In order to perform the test, follow the instructions below.

1) Turn the HV OFF
2) Place the main circuit breaker in the Off position.
3) Using the key interlock system, lock the breaker in the off position and remove the interlock key.
4) Following the key interlock sequence, lock the PowerPlus ground switch into the "Ground" position.
5) Entering through the HV access port, place a second external ground on the HV bushing.
6) Cover the HV duct access point.
7) At the Power Plus unit, lock the HV/GND switch in the HV position. Remove the interlock key and place it in the circuit breaker interlock.
8) Unlock the breaker and place it in the "ON" position.
9) At the display panel, set the UV trip setting, located in the **Setpoint** menu, to 0kV, thereby defeating the UV alarm.
10) At the display panel, set the **Mode** of control to "Manual-Mode".
11) Go to the "METER" screen.
12) Turn on HV.
13) While monitoring the secondary indications, slowly increase the duty cycle in increments of approximately 5%. The secondary current should rise to the maximum rated well before the 100% D.C. limit. Typically for a 28kW unit the 400mAdc limit is reached at approximately 35% duty cycle. The larger model types could reach up to and exceed 60% duty cycle.

Short circuit test is complete.

1) Turn the HV off.
2) Lock the Power Plus circuit breaker in the OFF position.
3) Use the interlock key to lock the HV- Ground Switch in the Ground position.
4) Entering through the access port, remove the external ground that was placed on the bushing.
5) Cover the HV access port.
6) Lock the Ground Switch in the HV position. Remove the interlock key.
7) Use the key to place the main breaker switch to the "ON" position.
8) Enter the 'Setpoint' screen and restore the U.V. Trip to it's original value.
9) Enter the 'Mode' screen and set the control mode to 'SETPOINT.'
10) The Power Plus is now ready for normal operation.

Power Electronics Testing

This procedure covers the inspection, testing, and repair of the power electronics section of the NWL PowerPlus Power Supply. Refer to the schematic for the specific size unit in question.

Visual Inspection

The power electronics section is located in the control enclosure of the PowerPlus unit. Most of the components are part of the IGBT heatsink assembly. Visually inspect the 3-phase rectifier, IGBTs, capacitors, gate drivers, and snubber board. Ensure all cable connections are tight.

Test the 3-Phase Rectifier

Use the diode-test function of a multimeter to test every diode in the 3-phase rectifier. Measure from the positive output to each of the 3-phase inputs. Also measure from the negative output to each of the 3-phase inputs. The forward-bias reading should be identical for all diodes in the rectifier bridge. When the three phase rectifier fails, it is typically a shorted internal diode, which would be indicated by a very low (<1 ohm) resistance reading.

If the rectifier is found to be bad, remove it and the thermal pad. Clean any residue left on the aluminum heat sink from the old thermal pad before mounting a new thermal pad and rectifier. Repeat the diode test on the new rectifier.

Test the IGBT Modules

Use a multimeter to check the resistance across the IGBT connections. A label on the side of each IGBT identifies the electrical connections. The emitter/collector junction should read either open or in the megohms. There is a diode mounted in reverse bias to each emitter/collector junction, so swap your test leads to test in both polarities. This junction should also pass a 500V megger test. This component will typically fail shorted.

The gate/emitter junction can be tested if the D25298-03 gate splitter board is connected to the IGBT. The cable from the gate driver board should also be connected to the gate splitter board. This junction should read 2 megohms or higher. Measuring the resistance of this junction without the gate splitter board and gate driver board connected to the IGBT will damage the IGBT.

If an IGBT has to be replaced, it is may be easier to remove the entire heat sink assembly and replace the IGBT with the heat sink assembly sitting on a work bench. The IGBT will be provided by NWL with the D25640-01 gate splitter board installed. The gate splitter board should only be mounted on the IGBT at an ESD-protected work station. The IGBT should not be handled without ESD-protection until the splitter board is installed.

The old thermal heat-sink pad should be removed and any residue left by the pad cleaned off. A new thermal heatsink pad should be installed with the new IGBT. The mounting screws should be gradually tightened in a cross pattern sequence to a torque of 26 lb-in max. The electrical connections should also be tightened to a maximum torque of 26 lb-in.

Repeat the multimeter and megger tests to ensure the new IGBT tests good.

Measure the DC Bus Capacitors

The DC bus capacitors are the short cylindrical capacitors that are mounted next the IGBT modules. Each capacitor has a value of 270uf. The quantity of capacitors connected in parallel is dependent upon the size of the PowerPlus. The quantity of capacitors used and the total capacitance is given in the table below.

PowerPlus Size	# of Capacitors	Total Capacitance
28 - 70 kW	4	1080 uf
84 - 120 kW	6	1620 uf
128-200 kW	16	4320 uf

A capacitor meter can be used to measure this value. Use a jumper wire to short out and fully discharge the capacitor bank before making a measurement.

Measure the AC Resonant Capacitors

The AC resonant capacitors will take various forms depending upon the kW size of the unit. On the Series 7.5 models, they are a tapped capacitor and may be mounted either in the control enclosure or in the HV tank. The quantity of capacitors connected in parallel and the tap configuration is dependent upon the size of the PowerPlus. The total capacitance is given in the table below.

PowerPlus Size	Total Capacitance
28 kW – 480 VAC	.50 uf
28 kW – 400 VAC	.875 uf
35 kW – 480 VAC	.75 uf
45 kW – 400 VAC	1.25 uf
56 kW – 480 VAC	1.0 uf
56 kW – 400 VAC	1.5 uf
56 kW – 380 VAC	1.5 uf
70 kW – 480 VAC	1.25 uf

A capacitor meter can be used to measure this value. Use a jumper wire to short out and fully discharge the capacitor bank before making a measurement.

On units rated higher than 70 kW, the resonant capacitor assembly is located within the HV tank and cannot be measured without de-tanking the unit.

Measure the Transformer's Primary Coil Resistance

The transformer's primary coil resistance can be measured at X1 and X2, as shown on the schematic. You will see these cables passing through the wall of the power electronics cabinet. Both cables are insulated with a white sleeving. One cable is connected to the bank of AC resonant capacitors. The other cable is connected to the output of the IGBT modules. This should not measure more than a few ohms.

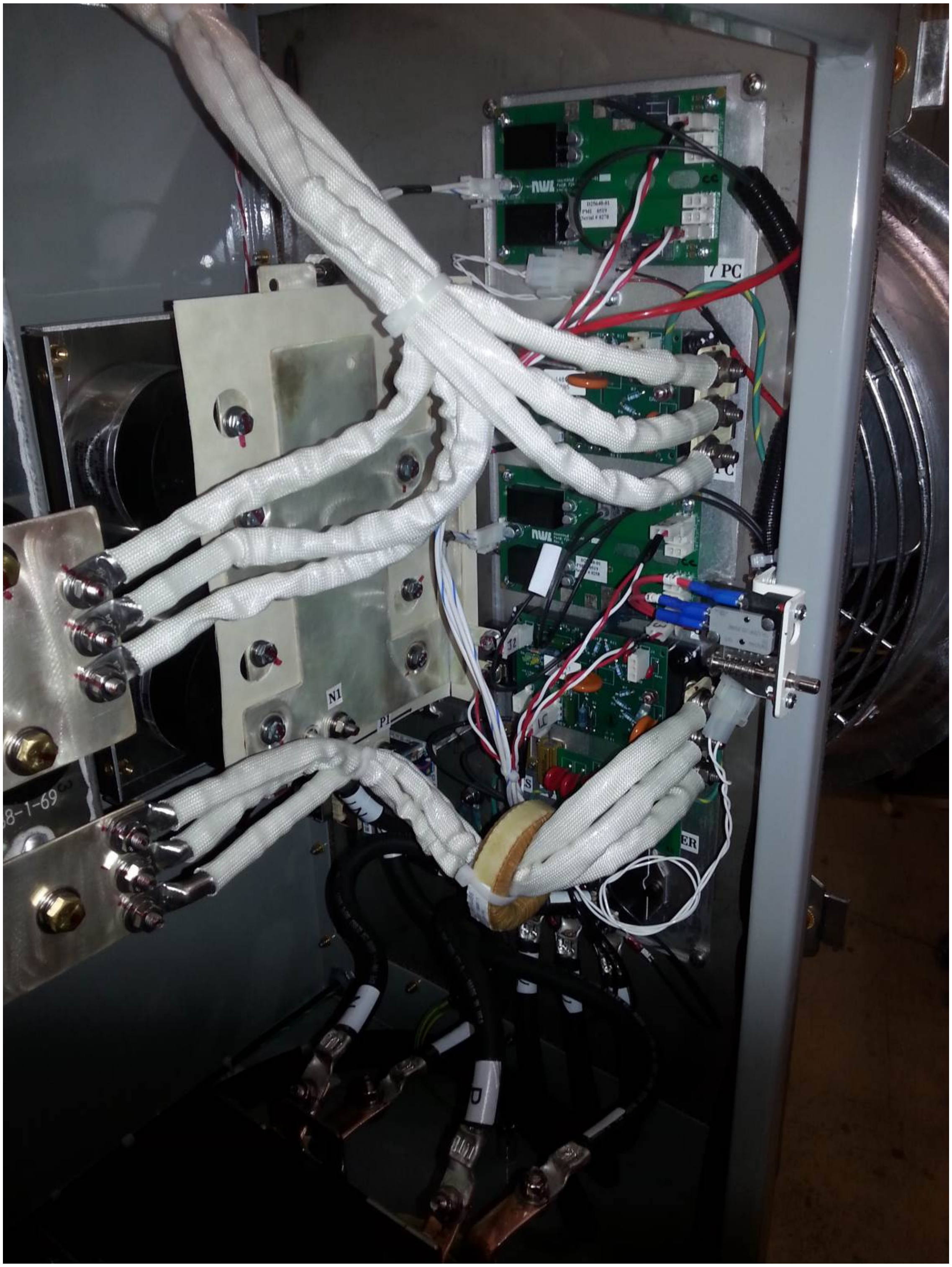
A measurement from X1-to-chassis ground and X2-to-chassis ground should show infinite resistance.

Replacing the IGBT's

Once it has been determined that an IGBT is shorted, it will need to be replaced. The method for replacement of an IGBT will differ somewhat based on the kW rating and the physical layout of the unit.

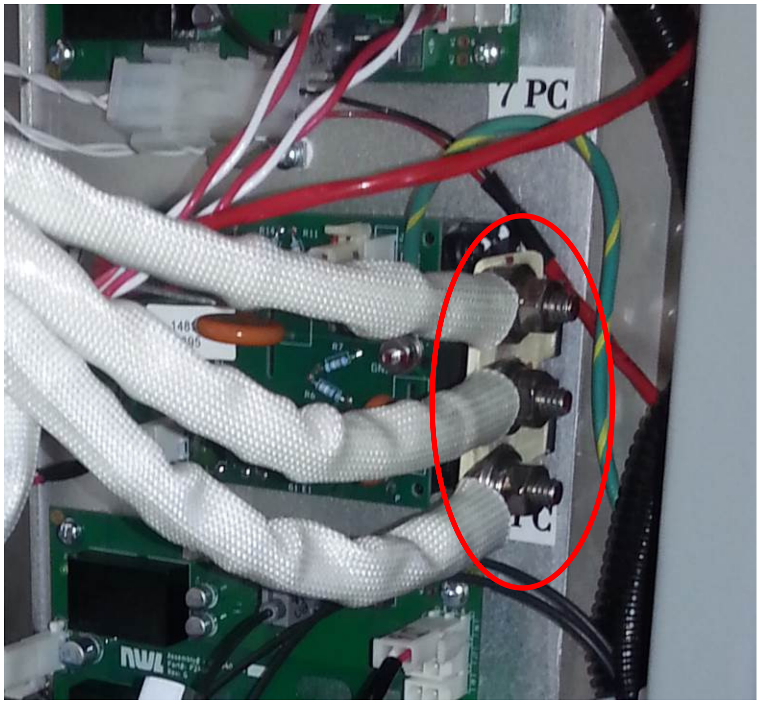
On PowerPlus units larger than 70 kW, the heat exchanger fan shrouding and protective plexiglass shield will have to be removed to access the IGBT's.

On units smaller than 70k, there is no shrouding.



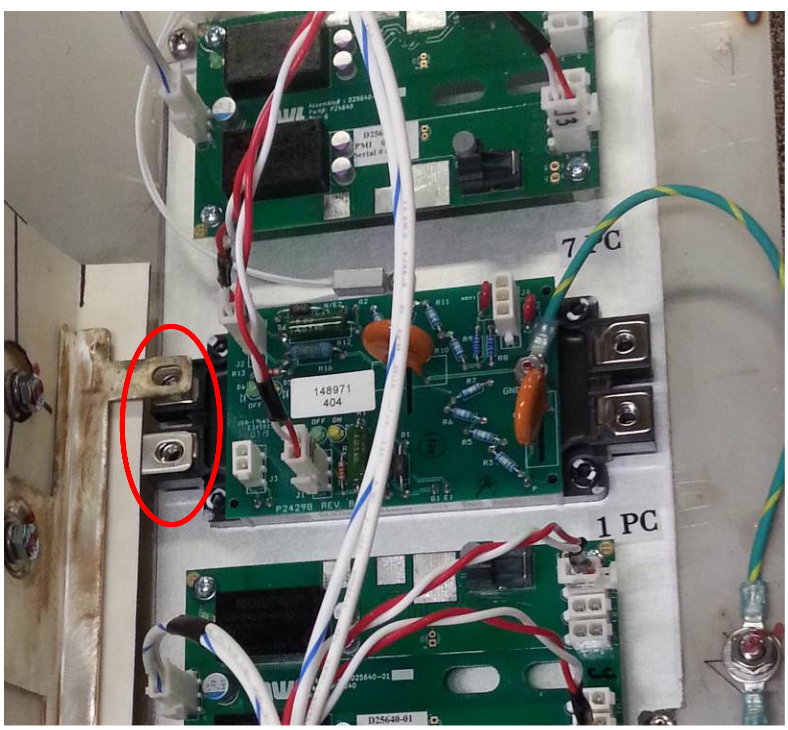
The layout of the heatsink will vary based on the kW rating of the unit. However, the method for the IGBT removal will remain the same.

1) Remove the large white power output wires from the IGBT's being replaced.

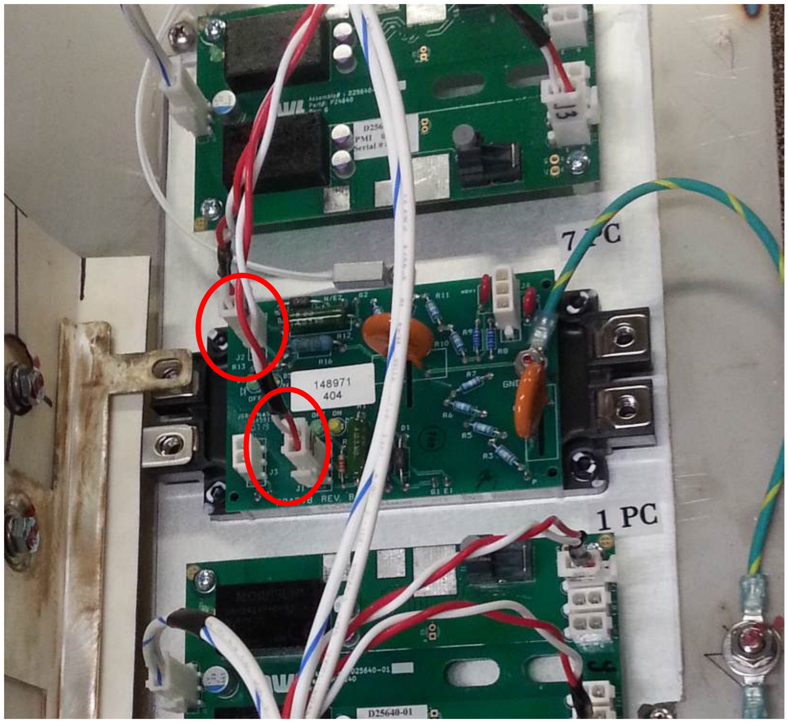


2) Move the wires out of the way to allow better access to the heatsink components.

3) Remove the two bolts connecting the DC bus caps to the input side of the IGBT's.

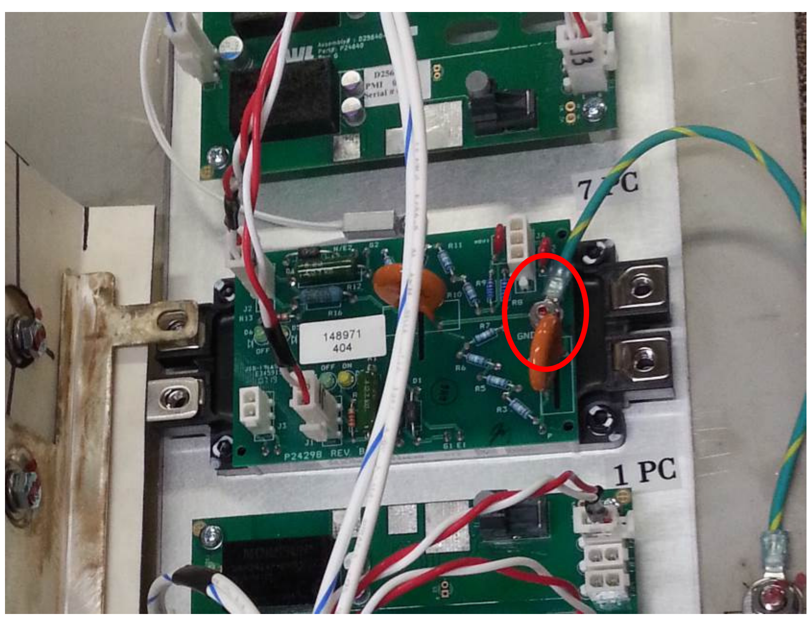


4) Unplug the two gate wire connectors, J1 & J2.

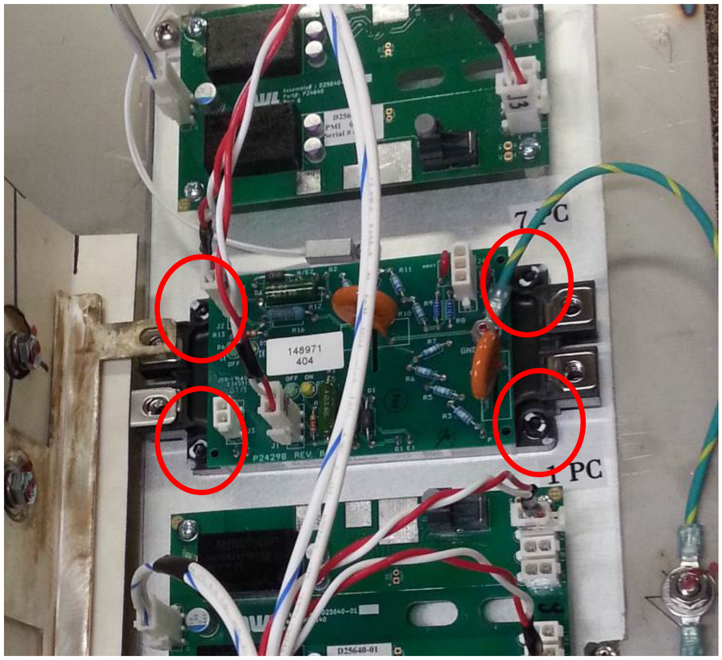


Ensure that the original location of these two cables is identified or recorded. Their exact location is critical to the operation of the unit. It is recommended to label each connector in such a manner that you feel confident that it will be re-plugged into the proper location at the end of the replacement process.

5) Disconnect the green ground wire.



6) Remove the hex headed IGBT mounting hardware.



7) The IGBT modules will not “lift” off and away from the heat-sink. To remove the IGBT modules apply a lateral force by twisting the module back and forth.

8) There is a thermal pad under the IGBT module. Ensure that the thermal pad is removed and discarded. The heat sink should then be wiped clean removing any thick, build-up areas of thermal compound material that may have been left on the heat-sink.

Installation of the IGBT modules is performed in the reverse order.

9) Install a new Thermal pad onto the bottom of the new IGBT module.

   The thermal pads have a protective cover on both sides. Remove the protective cover from one side and place the pad onto the back side of the IGBT module. Evenly press the pad onto the IGBT Module.

10) Remove the other protective cover and place the IGBT onto the heatsink assembly so that the mounting holes are aligned with the heatsink holes. Make sure that the IGBT module slides under the tabs for connection to the DC bus capacitor assembly.

11) Secure the IGBT to the heat-sink by re-installing the four hex head mounting bolts.

12) Re-install the green ground wire.

13) Reinstall the gate cables into their original locations.

14) Reinstall the two bolts that connect the IGBT module to the DC bus capacitor assembly.

15) Re-install the output bus and the large white power cables to the IGBT module.

The process is now complete.

Verification of the Gate Signals to the IGBT's for the Series 7.5 PowerPlus Units

For the purpose of this test the control and IGBT driver circuits must be able to be energized with the 120 VAC control power. However the 480 VAC power must be removed from the IGBT's. There are two different setup instructions depending upon whether a separate (external) 120 VAC source will be used to power the control circuits, or whether the incoming 3 phase power to the PowerPlus is the only power available. Both set of instructions are given below.

Setup Instructions using a separate (external) 120 VAC power source.

1) Turn off the main circuit breaker 1CB.
2) Remove 1FU, 2FU, and 3FU from the control transformer 1T.
3) Connect external 120VAC to secondary side of 1T (H and N on schematic). H is the hot side of the circuit and is also labeled as #23. N is the grounded neutral return and is also labeled #21. ***Particular attention must be paid to the polarity of the incoming power so as not to inadvertently connect the hot side of the source to the ground side of the control transformer, thereby causing a short circuit.*** **NOTE: If the source for the external 120 VAC is from a circuit with GFCI, the circuit may trip off. This condition will require the alternate configuration using the existing 3 phase power input as described below.
4) Set SW3-1 (located on the DSP control board in the ON position. SW3-1 is the leftmost dip switch on SW3. The switch is in the ON position when it is away from the relays located just below it. All of the other dip switches on SW3 should be in the OFF position which is towards the relays.
5) Turn on 120VAC external power **while leaving the main PowerPlus circuit breaker turned off.**

Setup Instructions using the existing incoming 3 phase power source.

1) Turn off the main circuit breaker 1CB.
2) Remove the large power fuses 4FU, 5FU, and 6FU.
3) Set SW3-1 (located on the DSP control board in the ON position. SW3-1 is the leftmost dip switch on SW3. The switch is in the ON position when it is away from the relays located just below it. All of the other dip switches on SW3 should be in the OFF position which is towards the relays.
4) Energize the main PowerPlus circuit breaker.
   Caution - There will now be high voltage present in the control enclosure.

Verifying the gate pulses on the DSP Control Module

1) Plug the GDU into the RJ45 port.
2) Set the U.V. Trip to zero.
3) Enter the 'Mode' screen and set the Control Mode parameter to Manual.
4) Connect a scope probe to TP17 on the I/O Board of the control module.
5) Connect the reference of the probe to TP24 (Ground).
6) Position the cursor on 'Duty Cycle' in the 'Mode' screen.
7) Press the 'ON' button on the display and ramp up the duty cycle to 100%.
8) Verify the pulses displayed on the oscilloscope are as shown in Fig.1A (10%) and 1B (100%).
9) Press the 'Off' button on the display.
10) Repeat Steps 4) through 9) with the scope probe connected to TP18 on the I/O board of the control module.
11) Press the 'Off' button on the display and remove the scope probe.

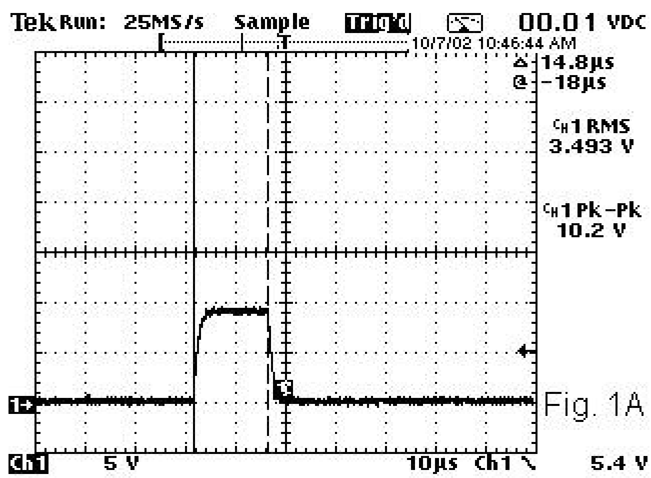


Fig. 1A - TP17 (& TP18) at 10% Duty Cycle

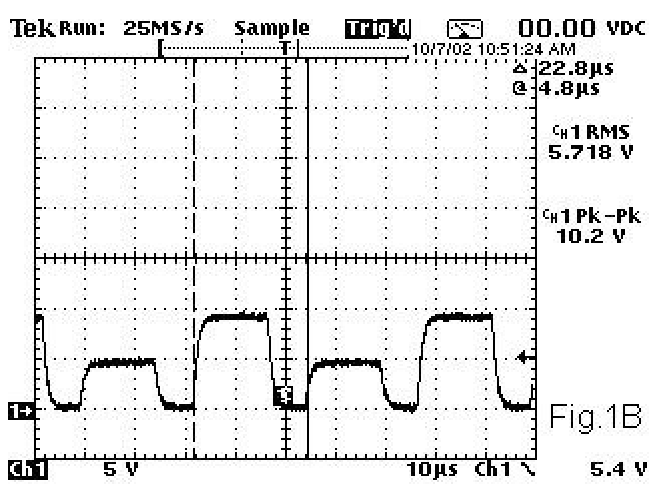


Fig. 1B - TP17 (& TP18) at 100% Duty Cycle

Verifying the gate pulse signals to the IGBT's for the 28 – 70 kW units.

This section assumes that the power has been properly configured to supply 120 VAC to the control sections and no line voltage is being fed to the IGBT's. It also assumes the gate signals at the DSP board have been checked.

1) Connect channel 1 scope probe to the gate of the IGBT gate board shown in Position 'A' on Fig.2. The connection points are shown in Fig.3.
2) Connect channel 2 scope probe to the gate of the IGBT gate board shown in Position 'C' on Fig.2. The connection points are shown in Fig.3.
3) Energize unit and ramp up to 100% duty cycle.
4) The pulses, as observed on the scope, should be in phase with each other as shown in Fig.4.
5) Press the 'Off' button on the display.
6) Change channel 2 scope probe to position 'B'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.5.
7) Press the 'Off' button on the display.
8) Change channel 2 scope probe to position 'D'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.5.
9) Press the 'Off' button on the display.
10) Remove all test probes.
11) Set the U.V. Trip to its previous setting (usually 10KV).
12) Enter the 'Mode' screen and set the Control Mode parameter to Setpoint.
13) Turn off the main circuit breaker (or removing the external 120 VAC).
14) Reinstall fuses 1FU, 2FU, and 3FU or fuses 4FU, 5FU, 6FU.
15) Place all of the dip switches on SW3 in the OFF position which is towards the relays.

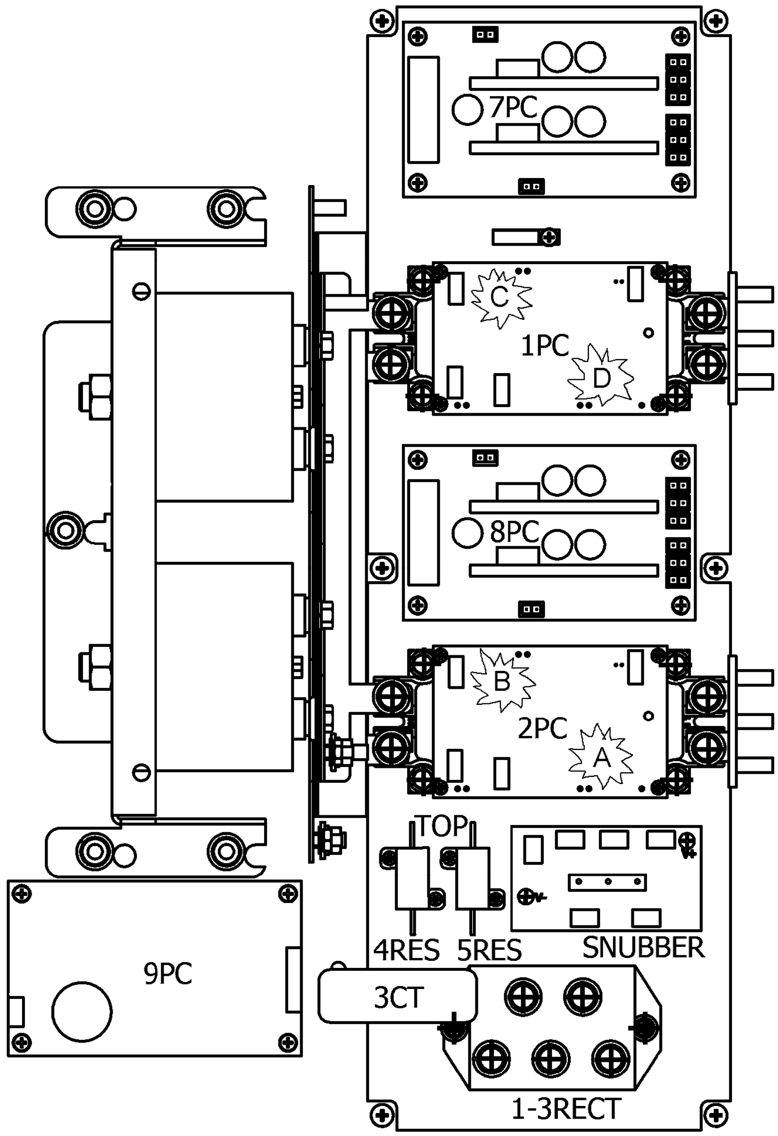
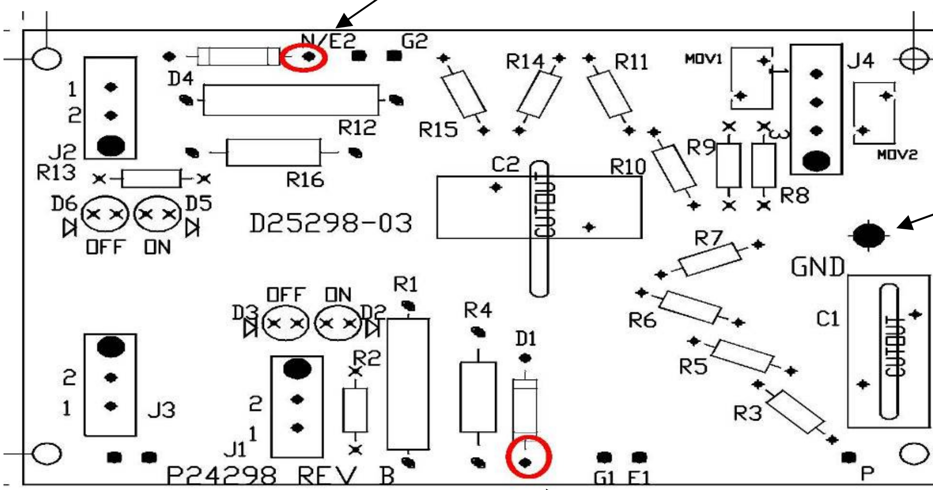


Fig. 2

Connect probe to D4 diode as shown for IGBT B & C.



Connect clip to ground screw.

Connect probe to D1 diode as shown for IGBT A & D.

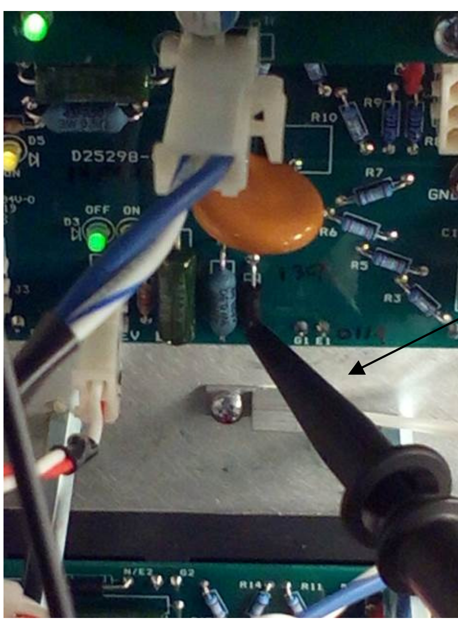


Fig. 3

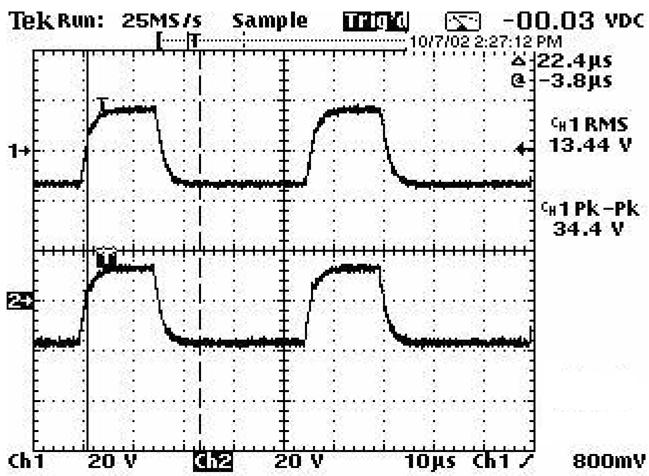


Fig. 4 - Pulses at IGBT probe connections at A & C – Duty Cycle 100%

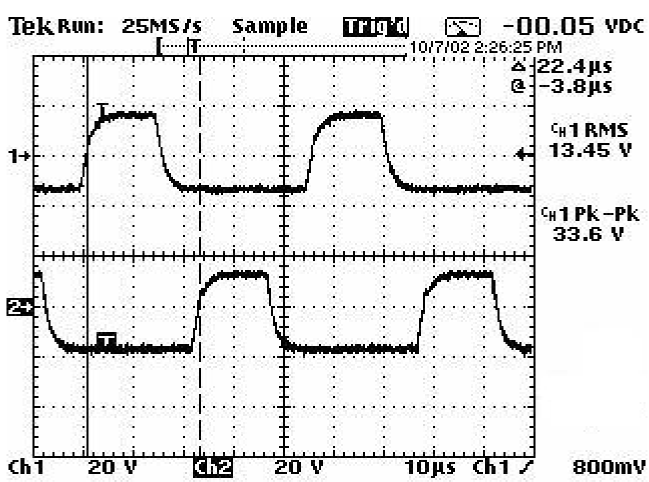


Fig. 5 - Pulses at IGBT probe connections at A & B and A & D – Duty Cycle 100%

Verifying the gate pulse signals to the IGBT's for the 84 - 120 kW units.

This section assumes that the power has been properly configured to supply 120 VAC to the control sections and no line voltage is being fed to the IGBT’s. It also assumes the gate signals at the DSP board have been checked.

1) Connect channel 1 scope probe to the gate of the IGBT gate board shown in Position 'A' on Fig.6. The connection points are shown in Fig.7.
2) Connect channel 2 scope probe to the gate of the IGBT gate board shown in Position 'C' on Fig.6. The connection points are shown in Fig.7.
3) Energize unit and ramp up to 100% duty cycle.
4) The pulses, as observed on the scope, should be in phase with each other as shown in Fig.8.
5) Press the 'Off' button on the display.
6) Change channel 2 scope probe to position 'E'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be in phase with each other as shown in Fig.8.
7) Press the 'Off' button on the display.
8) Change channel 2 scope probe to position 'G'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be in phase with each other as shown in Fig.8.
9) Press the 'Off' button on the display.
10) Change channel 2 scope probe to position 'B'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.9.
11) Press the 'Off' button on the display.
12) Change channel 2 scope probe to position 'D'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.9.
13) Press the 'Off' button on the display.
14) Change channel 2 scope probe to position 'F'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.9.
15) Press the 'Off' button on the display.
16) Change channel 2 scope probe to position 'H'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.9.
17) Press the 'Off' button on the display.
18) Remove all test probes.
19) Set the U.V. Trip to its previous setting (usually 10KV).
20) Enter the 'Mode' screen and set the Control Mode parameter to Setpoint.
21) Turn off the main circuit breaker (or removing the external 120 VAC).
22) Reinstall fuses 1FU, 2FU, and 3FU or fuses 4FU, 5FU, 6FU.
23) Place all of the dip switches on SW3 in the OFF position which is towards the relays.

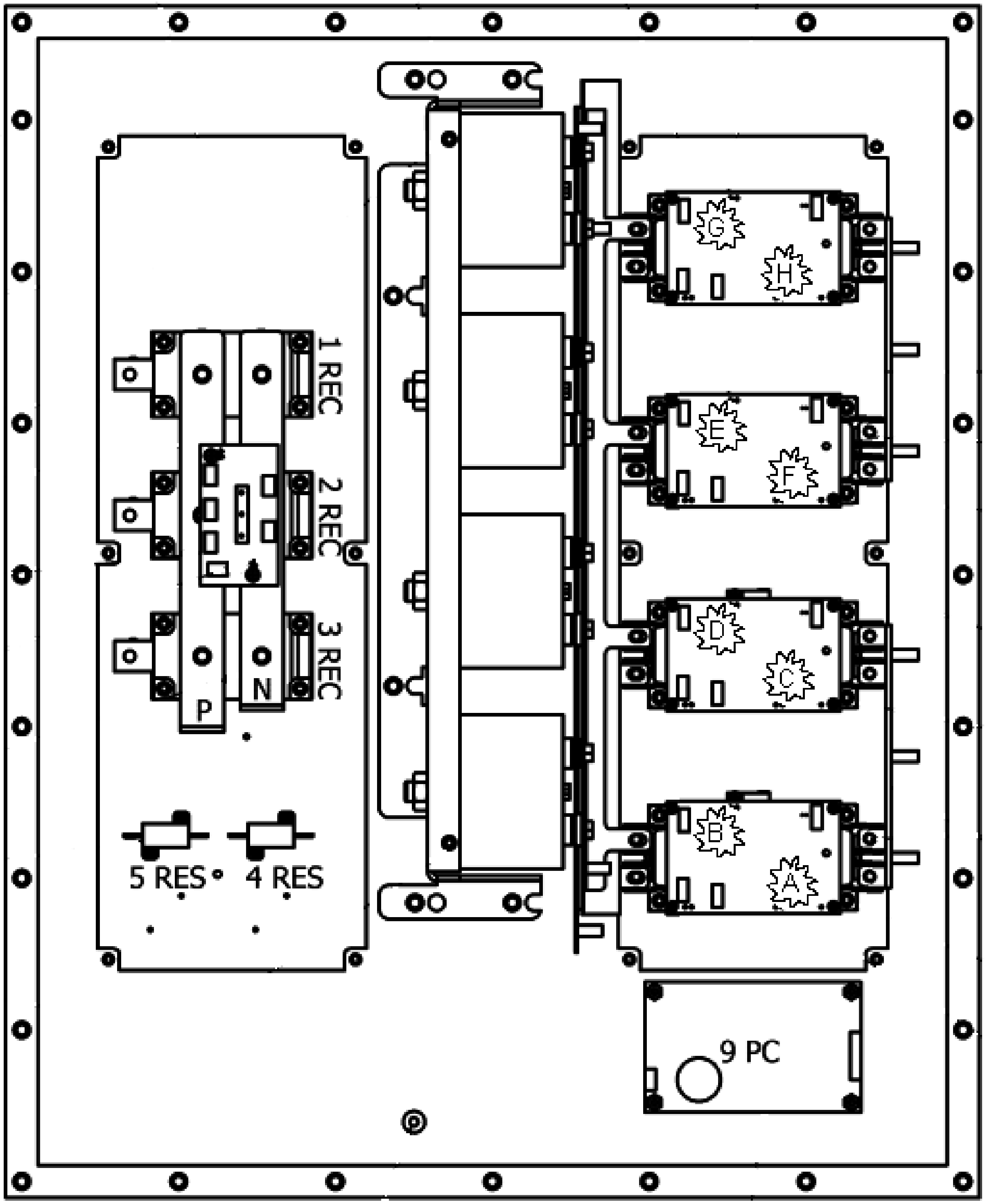
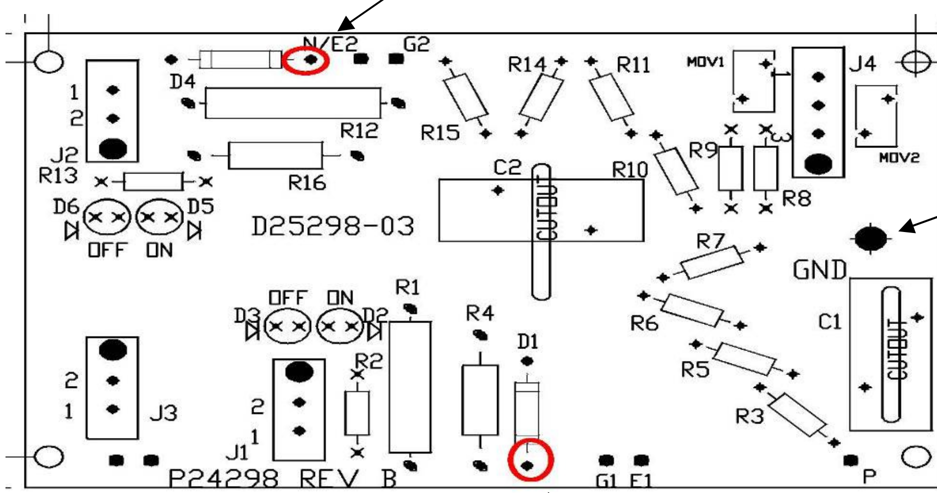


Fig. 6

Connect probe to D4 diode as shown for IGBT B, D, E, & G.



Connect clip to ground screw.

Connect probe to D1 diode as shown for IGBT A, C, F, & H.

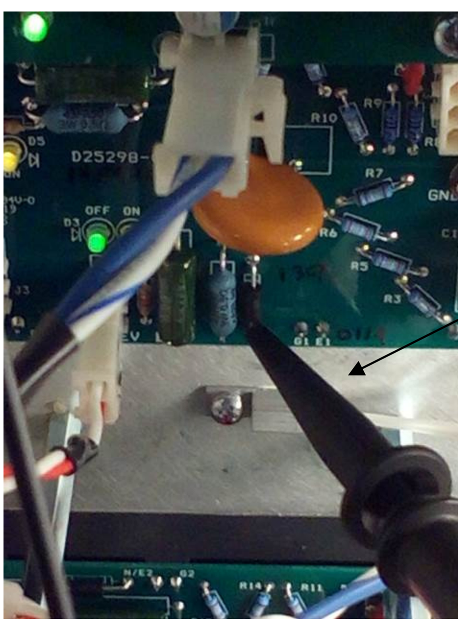


Fig. 7

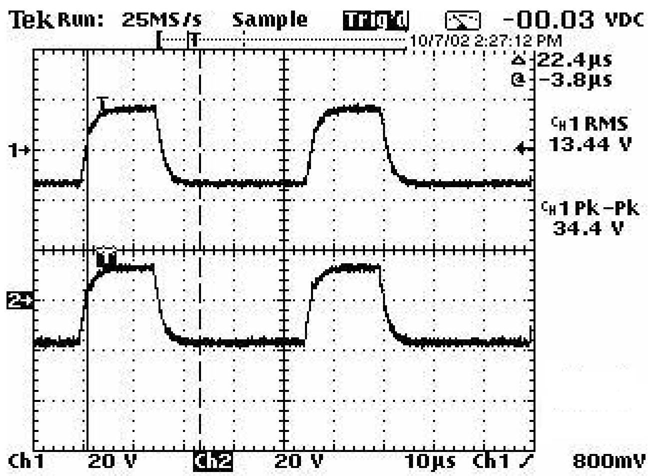


Fig. 8 - Pulses at IGBT probe connections at A & C, E, G – Duty Cycle 100%

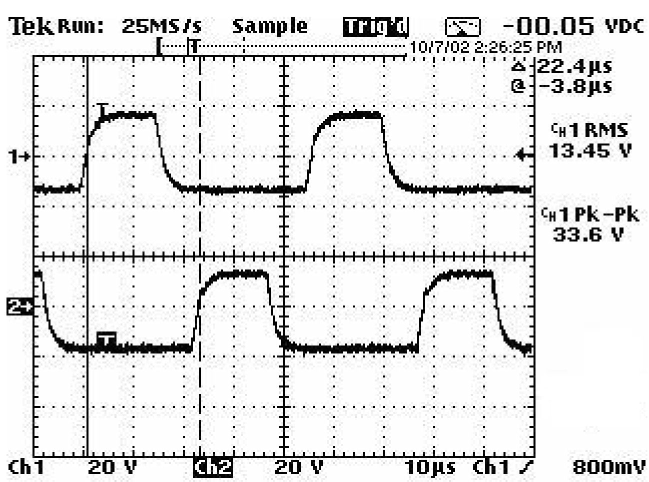


Fig. 9 - Pulses at IGBT probe connections at A & B, D, F, H – Duty Cycle 100%

Verification of the Gate Signals to the IGBT's for the 128 - 200 KW PowerPlus

This section assumes that the power has been properly configured to supply 120 VAC to the control sections and no line voltage is being fed to the IGBT's. It also assumes the gate signals at the DSP board have been checked.

1) Connect channel 1 scope probe to the gate of the IGBT gate board shown in Position 'A' on Fig.10. The connection points are shown in Fig.11.
2) Connect channel 2 scope probe to the gate of the IGBT gate board shown in Position 'C' on Fig.10. The connection points are shown in Fig.11.
3) Energize unit and ramp up to 100% duty cycle.
4) The pulses, as observed on the scope, should be in phase with each other as shown in Fig.12.
5) Press the 'Off' button on the display.
6) Change channel 2 scope probe to position 'E'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be in phase with each other as shown in Fig.12.
7) Press the 'Off' button on the display.
8) Change channel 2 scope probe to position 'G'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be in phase with each other as shown in Fig.12.
9) Press the 'Off' button on the display.
10) Change channel 2 scope probe to position 'I'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be in phase with each other as shown in Fig.12.
11) Press the 'Off' button on the display.
12) Change channel 2 scope probe to position 'K'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be in phase with each other as shown in Fig.12.
13) Press the 'Off' button on the display.
14) Change channel 2 scope probe to position 'M'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be in phase with each other as shown in Fig.12.
15) Press the 'Off' button on the display.
16) Change channel 2 scope probe to position 'O'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be in phase with each other as shown in Fig.12.
17) Change channel 2 scope probe to position 'B'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.13.
18) Press the 'Off' button on the display.

19) Change channel 2 scope probe to position 'D'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.13.
20) Press the 'Off' button on the display.
21) Change channel 2 scope probe to position 'F'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.13.
22) Press the 'Off' button on the display.
23) Change channel 2 scope probe to position 'H'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.13.
24) Press the 'Off' button on the display.
25) Change channel 2 scope probe to position 'J'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.13.
26) Press the 'Off' button on the display.
27) Change channel 2 scope probe to position 'L'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.13.
28) Press the 'Off' button on the display.
29) Change channel 2 scope probe to position 'N'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.13.
30) Press the 'Off' button on the display.
31) Change channel 2 scope probe to position 'P'. Energize unit and ramp up to 100% duty cycle. The pulses, as observed on the scope, should be out of phase with each other as shown in Fig.13.
32) Press the 'Off' button on the display.
33) Remove all test probes.
34) Set the U.V. Trip to its previous setting (usually 10KV).
35) Enter the 'Mode' screen and set the Control Mode parameter to Setpoint.
36) Turn off the main circuit breaker (or removing the external 120 VAC).
37) Reinstall fuses 1FU, 2FU, and 3FU or fuses 4FU, 5FU, 6FU.
38) Place all of the dip switches on SW3 in the OFF position which is towards the relays.

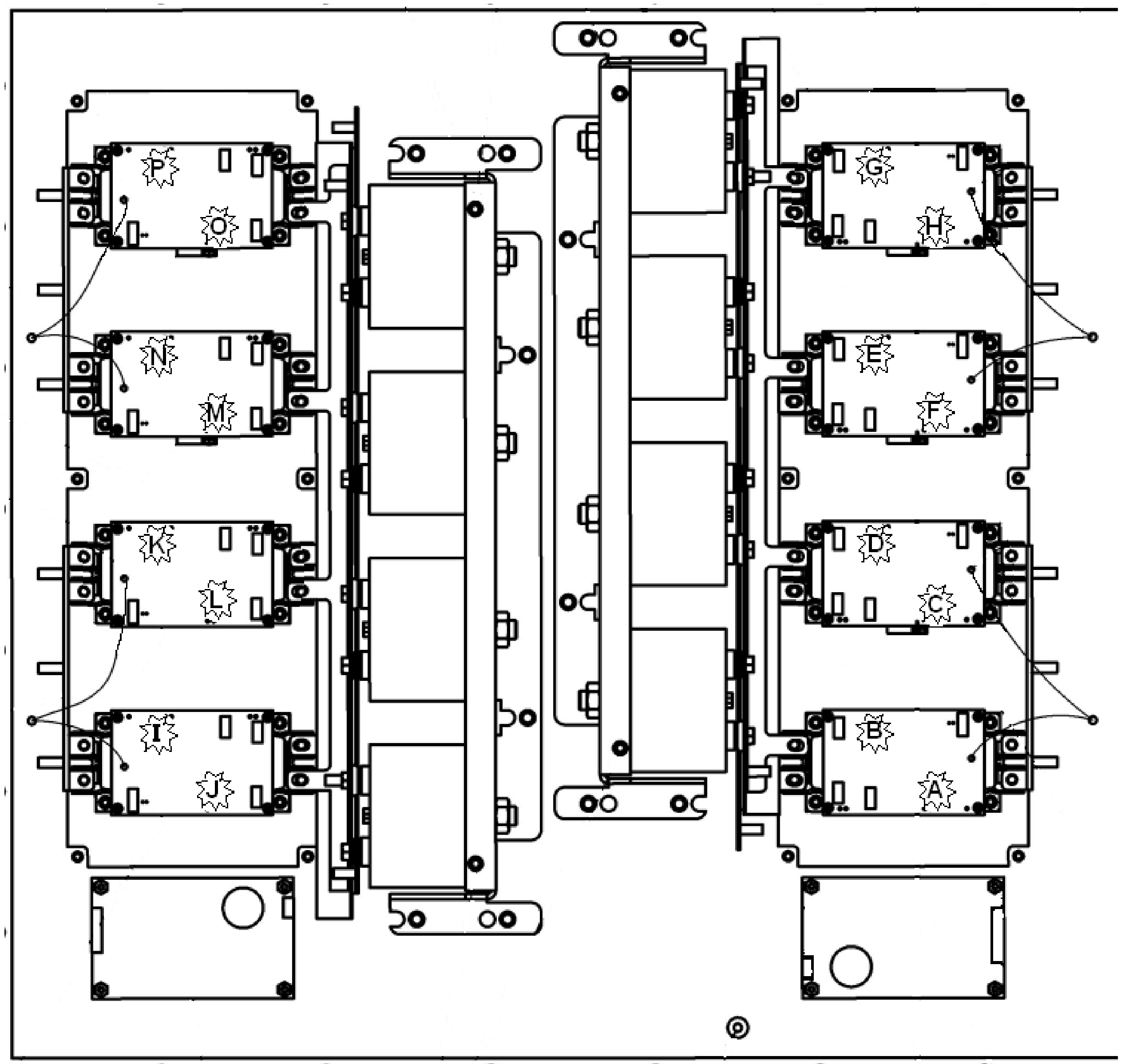
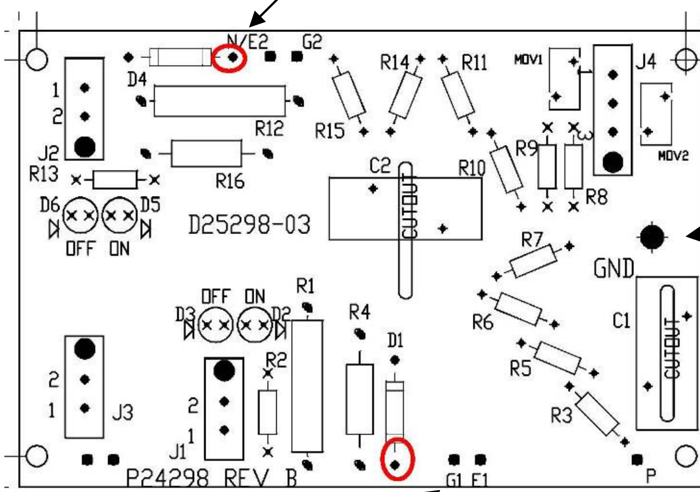
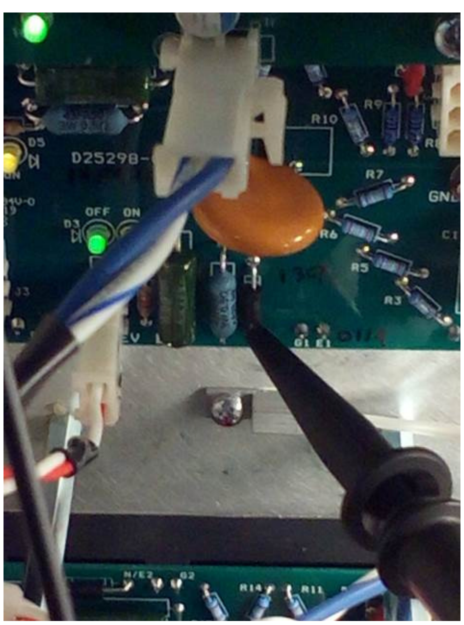


Fig. 10

Connect probe to D4 diode as shown for IGBT B, D, E, G, J, L, M, & O. The rightmost column of boards are oriented as shown with D4 at the top. The leftmost column of boards are turned upside-down, so D4 is on the bottom.



Connect clip to ground screw



Connect probe to D1 diode as shown for IGBT A, C, F, H, I, K, N, & P. The rightmost column of boards are oriented as shown with D4 at the top. The leftmost column of boards are turned upside-down, so D4 is on the bottom.

Fig. 11

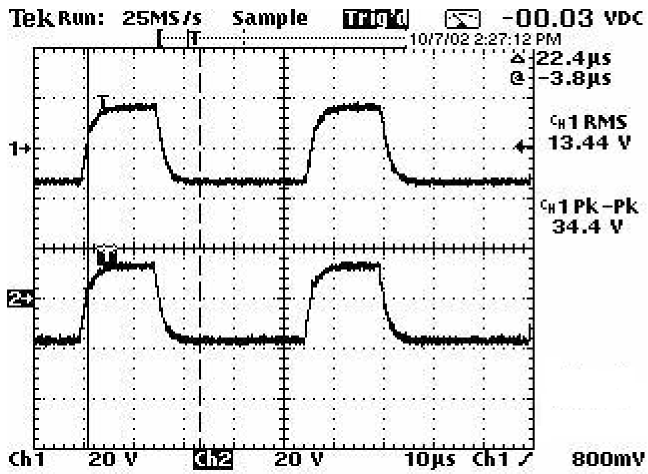


Fig. 12 - Pulses at IGBT probe connections at A & C, E, G, I, K, M, O – Duty Cycle 100%

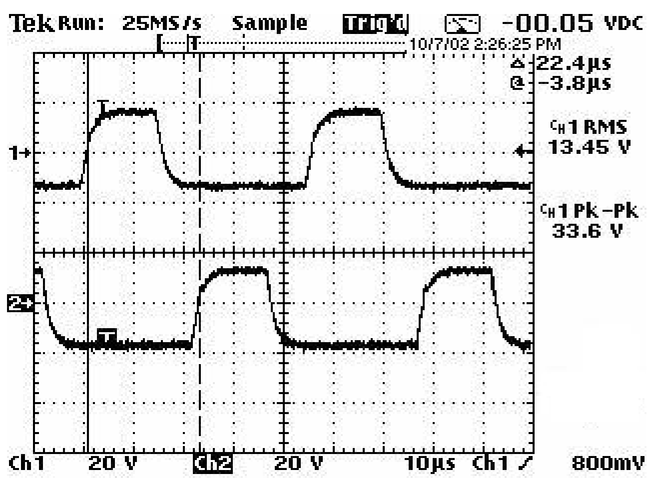


Fig. 13 - Pulses at IGBT probe connections at A & B, D, F, H, J, L, N, P – Duty Cycle 100%