



Q-switch Troubleshooting

Common Problems and Solutions

The front panel of Lee Laser Q-switch drivers lists four (4) FAULT INDICATORS that, when illuminated, indicate a status problem with the laser's Q-switch system. This technical bulletin will help you to determine the cause of the FAULT INDICATOR, and what action to take to correct the problem.

Note that three (3) of the FAULT INDICATORS are interlock conditions, and result in automatic switch OFF of the RF driver: "OVER TEMP", "HIGH VSWR" and "HIGH POWER". When these occur, the "LOW POWER" light also will become illuminated because the RF power has dropped below the setpoint for the "LOW POWER" light to be switched ON. **When the RF power is switched OFF, there is no longer Q-switch holdoff, and the laser will emit a CW (continuous) beam.**

OVER TEMP Interlock

An "OVER TEMP" interlock on the front panel of the Q-switch driver is caused by the Q-switch not being sufficiently cooled. When the Q-switch overheats, the RF power output from the Q-switch driver automatically will switch OFF.

1. Kink in Q-switch Water Hose

It is possible that the Q-switch has become overheated because of insufficient cooling water. One indicator of this is a "pressed mark" on the water hose to the Q-switch. We call this a "kink". If the water hose is kinked, then the flow of water will be reduced, and the Q-switch may overheat.

Action: Eliminate the "kink" in the water hose.

2. Restricted Water Flow of Q-switch Water Hose

Sometimes the water hose connections at the Q-switch will become too tight. When this happens, the hose will become compressed inside the fitting, and water flow through the Q-switch will be reduced or stopped altogether. This causes the Q-switch to overheat and an OVER TEMP interlock will occur.

Action: Check water hose connection fitting to be sure that it is not too tight. With the water hoses disconnected from the Q-switch, briefly switch ON the water pump to be sure that there is good water flow through the Q-switch hoses. Then, reconnect the water hoses.

3. Overheated DI Water

Overheating of the DI water in the laser cooling system reservoir also will cause the Q-switch to overheat. This can happen for several reasons:

- a. "city" water incoming to the laser is too warm (must be $< 20^{\circ}$ C)
- b. insufficient incoming "city" water volume to the laser (incoming pressure is too low, or drain pressure is too high)
- c. the water flow valve in the cooling system is not operating properly.

For lamp-pumped lasers, the DI water in the reservoir should be maintained about 29° C (85° F). The TEST DATA sheet in the Operation Manual shows the cooling system temperature set point (in degrees F). To maintain this temperature, the incoming cooling (city) water usually must be $< 20^{\circ}$ C.

If the DI water temperature becomes too high, the Q-switch may overheat, and RF power will be switched OFF. **After the RF power has been OFF for a short period of time, the Q-switch will cool and the RF power will once again switch ON.** The "LOW POWER" indicator will extinguish. If the Safety Shutter Interlock (see below) is connected, the safety shutter will OPEN.

Action: Measure the temperature of the DI water in the reservoir to be sure that it is near the setpoint as recorded on the TEST DATA sheet in the Operation Manual.

Note: It is possible for the laser's DI water cooling system to be sufficiently hot to cause an "OVER TEMP" Q-switch interlock condition, but not sufficiently hot to cause the laser itself to shut down. In this situation, the "OVER TEMP" interlock (and "LOW POWER" fault) may switch ON and OFF repeatedly.

HIGH VSWR Interlock

High VSWR is caused by an elevated level of reflected RF power back into the Q-switch driver.

Common sources of reflected RF power are:

1. **Poor connection of the RF power cable**
 - a. inside the Q-switch driver
 - b. between the Q-switch driver and the Q-switch

Action: Check all RF cable connections to ensure that they are tight

- 2. Defective RF power cable:** between the RF amplifier module (inside the Q-switch driver) and the Q-switch.

Action: Replace RF power cable where defective.

- 3. Defective Q-switch:** defective bond between transducer and the Quartz block inside the Q-switch.

Action: Replace Q-switch

To reset the Q-switch driver after a “HIGH VSWR” interlock condition, the Q-switch driver must be switched OFF for a period of five (5) seconds, and then switched ON.

HIGH POWER Interlock

This indicates that the RF output power level has exceeded the safe setpoint level for the RF amplifier inside the Q-switch driver. Usually it means that internal control of RF output power has been lost by the RF amplifier.

Action: Replace the RF amplifier.

To reset the Q-switch driver after a “HIGH POWER” interlock condition, the Q-switch driver must be switched OFF for a period of five (5) seconds, and then switched ON.

LOW POWER Fault

This indicates that RF power output from the RF amplifier is less than the set-point level required for Q-switch hold-off, or that there is zero (0) RF power output. Low RF power may have several causes:

1. When Laser System is Switched ON

When the Q-switch driver is switched ON from the OFF condition, RF power is not immediately applied to the Q-switch. The Q-switch driver will remain in a “warm-up” condition for approximately 30 seconds during which no RF power is applied to the Q-switch, and the LOW POWER fault indicator will illuminate.

After the 30-second “warm-up” period, an internal timer will automatically switch ON the RF Amplifier inside the Q-switch driver, and RF power will be available for the Q-switch. At this time, the LOW POWER fault indicator will extinguish.

2. Zero RF Output power

- a. From other interlock condition (OVER TEMP, HIGH VSWR, HIGH POWER) that causes the RF driver to switch itself off as a protection. In this situation, one or more of the other interlock FAULT INDICATORS also will be illuminated.

Action: See **OVER TEMP Interlock, HIGH VSWR Interlock and HIGH POWER Interlock** sections above

- b. From defective RF amplifier module

Action: Measure RF power at the Q-switch with an RF power (Watt) meter, if one is available. RF power should be near that value that is listed on the TEST DATA sheet at the front of the Operation Manual. Replace RF amplifier module if no RF power is present.

3. Low (but not zero) RF Power

- a. From weak RF amplifier module.

Action: Replace RF amplifier module.

- b. From Q-switched operation at high frequency (> 40 kHz).

Q-switch holdoff (no laser beam emitted) is achieved when full RF power is applied to the Q-switch. To produce a laser pulse, the Q-switch is switched OFF (all RF power removed) for a brief period of time (typically 8-10 μ s). As pulse rate (Q-switch frequency) is increased, the RF duty cycle (percent of RF ON time) becomes less, and the average RF output power level is reduced.

The Q-switch driver monitors average RF output power. If, because of operation at an elevated pulse frequency, the average RF power drops below the "LOW POWER" setpoint, then the "LOW POWER" indicator on the front panel of the Q-switch driver will illuminate.

Action: Verify that the cause of "LOW POWER" is operation at elevated pulse frequency. Disregard the "LOW POWER" indicator.

A "LOW POWER" fault alone does not switch OFF the Q-switch driver.

Safety Shutter Interlock Activation

Lee Laser Q-switch drivers contain an interlock circuit to prevent CW (continuous) emission of the laser beam in the event of an Q-switch interlock or fault condition. The SHUTTER BNC connector on the rear panel of the Q-switch driver provides a switched circuit that will open in the event of a Q-switch fault.

To activate the safety shutter interlock, connect a BNC cable from the SHUTTER BNC at the rear of the Q-switch driver to the REMOTE SHUTTER (J4) BNC at the rear of the laser power supply. Whenever a Q-switch interlock or fault condition occurs, the safety shutter will close.