TERAGON

LC11
Liquid Nitrogen
Level Controller

User Manual

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WARNING: THE LC11 CONTROLLER CONTAINS CMOS CIRCUITS WHICH ARE SUSCEPTIBLE TO DAMAGE BY ELECTROSTATIC DISCHARGE (ESD). STANDARD ESD HANDLING PRECAUTIONS SHOULD BE OBSERVED WHEN INSTALLING THE CONTROLLER.

WARNING: TRACES ON THE LC11 CIRCUIT BOARD CAN CARRY LETHAL VOLTAGES. INSTALLATION AND MAINTENANCE SHOULD ONLY BE PERFORMED BY A QUALIFIED ELECTRICAL TECHNICIAN. WHILE POWER IS APPLIED, CONTACT WITH THE CIRCUIT BOARD CAN LEAD TO DAMAGE, INJURY OR DEATH.

WARNING: CONTACT WITH LIQUID NITROGEN OR COLD NITROGEN GAS MAY CAUSE SERIOUS FROSTBITE OR BLINDNESS. NITROGEN GAS CAN CAUSE RAPID SUFFOCATION; USE AND STORE LIQUID NITROGEN ONLY IN WELL VENTILATED PLACES.

1. Overview

The LC11 Liquid Level Controller uses three LS10 Sensors to monitor and control the liquid nitrogen level in a cryogenic reservoir. The controller uses a solid-state relay to operate an external cryogenic solenoid valve. A typical LC11 application is shown in figure 1. Two of the sensors are used to control the liquid level and the third sensor provides either a high or low level alarm function. A jumper on the LC11 circuit board determines which type of alarm the controller uses.

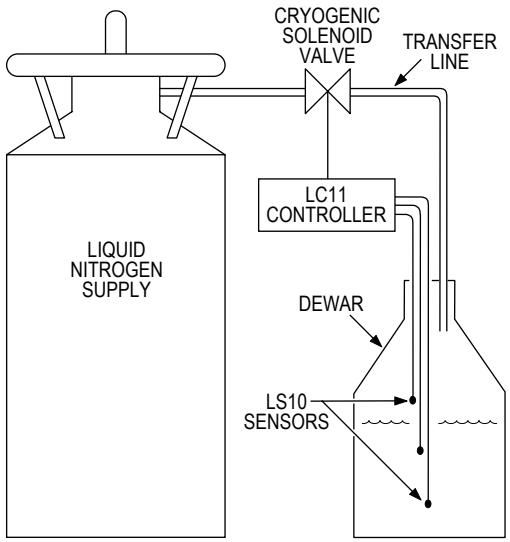


FIGURE 1. A typical LC11 application.

The function of each LS10 Sensor (high, low or alarm) is determined by the sensor's location within the reservoir. If the LC11 is configured for a low-level alarm, the liquid level will be controlled between the middle and upper sensors. The alarm function

will activate if the lowest sensor becomes dry. If the LC11 is configured for a high-level alarm, the liquid level will be controlled between the middle and lower sensors. The alarm function will activate if the highest sensor becomes wet. As a safety feature, the controller will not initiate (or continue) a fill operation if any sensor is unplugged.

As shown in figure 2, the LC11 circuit board is equipped with three jacks that accept the LS10 sensor plugs. Screw terminals are used to make all other connections to the LC11 circuit board. In addition to the power and valve terminals, the controller also has STATUS, FILLING and ALARM outputs as well as a TOGGLE input. The figure also shows the location of the alarm jumper. If the jumper is installed, the LC11 operates with a low level alarm function. If the jumper is removed, the LC11 operates with a high level alarm function.

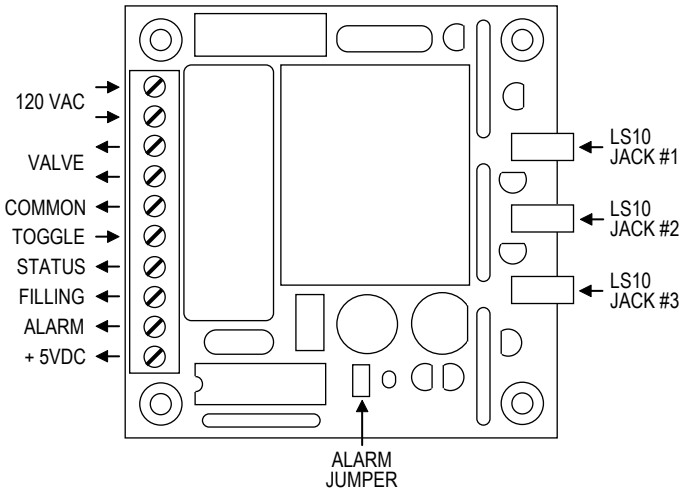


FIGURE 2. The LC11 circuit board.

The STATUS output indicates that the sensors are installed and operating properly. If all sensors are functioning, the STATUS output is connected to COMMON. Otherwise the STATUS output flashes between COMMON and open to indicate a fault condition. The FILLING output can be used by external equipment to monitor the LC11's filling status. This open-collector output is connected to COMMON only when the solid state relay is activated. The ALARM output indicates if either a level alarm condition has occurred or if any of the sensors are unplugged, shorted, or noisy. This is also an open-collector output that is connected to COMMON when active. The TOGGLE input permits external control over the filling process. It can be used to change the controllers current state (waiting or filling) or to override the controller.

The controller requires three LS10 sensors to monitor the liquid level within the cryogenic reservoir. As shown in figure 3, each sensor has a sensing tip that is covered by a splash guard. The sensing tip is connected to the sensor plug by a twisted-pair of cryoflex leads. The 2.5 mm sensor plug mates with the sensor jacks provided on the LC11 circuit board. The LS10 Sensors are available with standard lead lengths of 2, 3, or 4 feet. Noncryogenic sensor extensions are available in 3, 6, and 10 foot lengths.

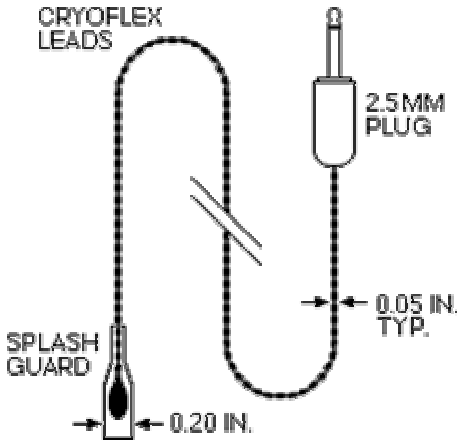


FIGURE 3. The LS10 Sensor.

The LC11 is powered from 120VAC (230VAC optional) and is supplied as a circuit board with screw terminals and mounting holes. Features of the LC11 include: 1) A watch dog timer for high reliability operation, 2) A metal-oxide-varistor (MOV) to protect the controller from voltage spikes on the power mains, 3) an opto-isolated 'zero-volt' switching relay to prevent electrical noise, and 4) A regulated 5VDC power supply that can be used to power external circuits such as lights or buzzers.

2. Installation

Proper site selection for the LC11 Controller is very important. The controller should not be placed where liquid OR COLD VAPOR will fall on it. In particular, cold exhaust vapors generated during the fill operation must be directed away from the controller. The LC11 circuit board has four mounting holes that accommodate #6 bolts. The circuit board should not be mounted flush against a conducting surface as this will 'short out' the traces on the bottom of the board: A 1/4-inch standoff is recommended when mounting the LC11 board. The alarm jumper should be removed if a high alarm function is required.

Position the LS10 sensors at the desired high, low and alarm positions within the LN_2 reservoir. For proper operation, the sensors must not be permitted to move due to the turbulence generated during the fill operation. Sensors should either be anchored in place or shielded from the turbulence within a shroud or tube. Anchoring can be accomplished using a length of stainless rod and nylon cable ties. Suitable materials for a shroud or tube include metals, PTFE, FEP, and phenolic. Be aware that inserting a warm tube into LN_2 is hazardous; liquid will spout from the upper end of the tube due to the boiling that occurs within the tube.

The LC11 Controller treats all sensors equivalently and any sensor can function as the high, low or alarm sensor. It is the position of the sensors within the reservoir (and the alarm jumper) that determine what function each sensor fulfills. There is no need to determine which sensor is plugged into which jack. Simply place the three sensors at the desired high, low and alarm positions within the reservoir and then insert the sensor plugs into any jack on the controller.

The remaining connections to the LC11 are made using the ten screw terminals on the circuit board. The following table gives the names, abbreviations, and functions for each of the terminals.

Terminal No.	Terminal Name	Abbreviation	Function
1	LINE HOT	LH	AC Input
2	LINE NEUTRAL	LN	AC Input
3	VALVE NEUTRAL	VN	AC Output
4	VALVE HOT	VH	AC Output
5	COMMON	C	DC Ground
6	TOGGLE	T	Logic Input
7	STATUS	S	Logic Output
8	FILLING	F	Logic Output
9	ALARM	A	Logic Output
10	+5VDC	5V	DC Output

Connect the solenoid valve leads to the VH and VN terminals. Connect any auxiliary circuits (lights, switched, etc.) to the appropriate input/output terminals. Finally, connect the unenergized power leads to the LH and LN terminals: ensure that the hot leg of the mains power is connected to the LH terminal. Apply power to the power leads to begin automated filling of the LN_2 reservoir.

3. Operation

When power is applied to the LC11 Controller, it first runs a diagnostic to determine if all LS10 sensors are installed and functioning properly. The controller checks if the sensors are shorted, unplugged, or excessively noisy. Immediately, the STATUS signal will indicate if the sensors are operating properly (see section 3.3). If both sensors are functioning properly, the LC11 begins analyzing their signals to determine if the sensors are wet or dry. The first wet/dry determinations require 23 seconds from the application of power; after which, the FILLING & ALARM outputs are updated and active level control begins.

If any LS10 sensor is damaged or unplugged, the LC11 will cease to control the LN_2 level until the problem is remedied. Power will no longer be routed to the VH terminal, the FILLING signal will not be active, the STATUS signal will indicate which sensors are faulty, and the ALARM signal will be activated. However, the controller can be forced to fill by using the TOGGLE input (see section 3.6). Once all the sensor problems are corrected, the LC11 will reset itself and rerun the sensor diagnostics. Active level control will then resume after 23 seconds.

The LC11 determines if each sensor is wet or dry based on the different thermal conductivities of liquid and gaseous nitrogen. This is done by intermittently biasing the sensors with a small amount of heat input. If the sensor is submerged in LN_2, the heat is conducted away from the sensor with negligible temperature rise. However, if the sensor is not submerged, a small but measurable temperature rise occurs at the end of the sensor. When operated at the temperature of liquid nitrogen, the total power dissipated by the three sensors is 132 mW. This corresponds to a quiescent boil-off rate of 1 liter of LN_2 every 2 weeks. The typical latency from when a sensor becomes wet and the

corresponding LC11 response is about 10 seconds. The typical latency from when a sensor becomes dry and the corresponding LC11 response is 29 seconds.

The alarm jumper determines how the LC11 responds to the various sensor signals. If the jumper is installed, the LC11 operates in a low level alarm mode. In this mode, the alarm output will be activated when all three sensors become dry. Filling is initiated when any two sensors become dry. Filling is terminated when all three sensors become wet. If the alarm jumper is removed, the LC11 operates in a high level alarm mode. In this mode, the alarm output will be activated when all three sensors become wet. Filling is initiated when all three sensors become dry; and filling is terminated when two sensor become wet. The following table summarizes the LC11 response to the sensor signals for each alarm mode.

# of Wet Sensors	Low Level Alarm Mode (Jumper Installed)	High Level Alarm Mode (Jumper Removed)
3	Not Filling	Not Filling with Alarm Active
2	Either Filling or Waiting	Not Filling
1	Filling	Either Filling or Waiting
0	Filling with Alarm Active	Filling

3.1 The LINE and VALVE Terminals

The line terminals (LH and LN) provide power to the controller and should be connected to the 120VAC (230VAC optional) mains. This line voltage is also routed to the valve terminals (VH and VN) when the controller attempts to fill. The LN (LINE NEUTRAL) terminal is directly connected to the VN (VALVE NEUTRAL) terminal on the LC11 circuit board. The LH (LINE HOT) terminal is connected to the input of the control relay. When the relay is closed by the controller, the voltage applied to LH appears on VH. It is important to correctly connect LH to the hot side of the mains since only this side is switched on an off by the controller.

3.2 The 5V and COMMON Terminals

The LC11 is equipped with a regulated 5VDC power supply that can be used to power external circuits. This makes it particularly easy to add indicators (lights, buzzers) to the controller's STATUS, FILLING or ALARM outputs. The COMMON terminal is the ground reference (0VDC) for the power supply. Up to 90mA may be drawn from the 5VDC terminal and returned via the COMMON terminal. The COMMON terminal can also be used to ground an external DC supply, if one is used with the STATUS, FILLING or ALARM outputs.

3.3 The STATUS Output

The STATUS output indicates if the sensors are installed and operating properly. The STATUS signal is an active-low open-collector output. If all three sensors are installed and functioning properly, the STATUS output is grounded (i.e. connected to COMMON). If the controller determines that any sensor is shorted, unplugged, or excessively noisy then STATUS flashes between ground and open. The number of flashes per second indicates which sensors are faulty: one flash per second for sensor #1,

two flashes per second for sensor #2, and three flashes per second for sensor #3. (See figure 2 for the sensor numbering.) If two sensors are faulty then every second STATUS will alternately flash for each sensor. If all three sensor are faulty then STATUS will flash 4 times per second. As shown in figure 4, a simple LED circuit connected between STATUS and 5V can be used to observe the STATUS signal. The LED flash patterns for all possible combinations of sensor faults are also shown.

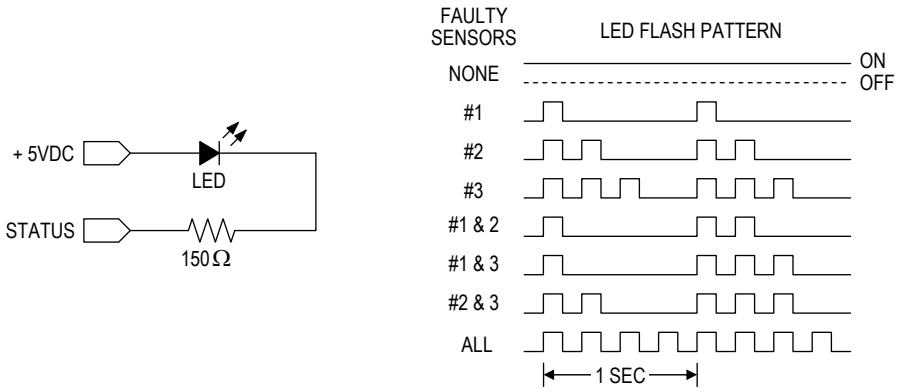
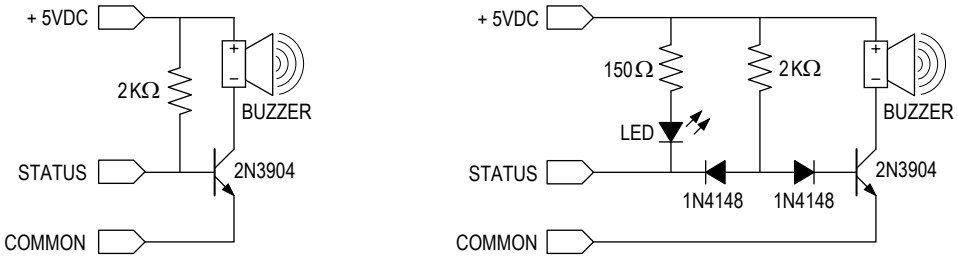


FIGURE 4. Using an LED to observe the STATUS output..

Alternately an audible signal can be generated from the STATUS output using either of the circuits in figure 5. The first circuit provides only the audible signal while the second provides both audible and visible signals. Note that a transistor is used to invert the STATUS signal so that the buzzer is silent when all sensor are operating properly. Since STATUS is an open-collector output, it can be used with external power supplies in excess of 5VDC. The voltage applied to STATUS should not exceed 40VDC relative to COMMON. The current sunk by STATUS should not exceed 150 mA and should not dissipate more than 350 mW.



BUZZER = International Comp. Corp. p/n BRT2821P-06 (Allied Elect. Stock No. 623-1931)

FIGURE 5. Circuits that generate audible signals from the STATUS output.

3.4 The FILLING Output

The FILLING output indicates if the controller is trying to fill the reservoir by applying power to the VALVE terminals. The FILLING output is an active-low open-collector output; it is grounded (i.e. connected to COMMON) while the controller is filling. A simple LED circuit, connected between FILLING and 5V, can be used to observe the FILLING signal, as shown in figure 6.

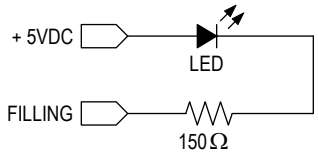


FIGURE 6. Using an LED to observe the FILLING output.

Since FILLING is an open-collector output, it can be used with external power supplies in excess of 5VDC. The voltage applied to FILLING should not exceed 40VDC relative to COMMON. The current sunk by FILLING should not exceed 150 mA and should not dissipate more than 350 mW.

3.5 The ALARM Output

The ALARM output indicates if the controller has detected an alarm condition. This can result from a low liquid level (alarm jumper installed), a high liquid level (alarm jumper removed), or if any sensor is unplugged, shorted, or excessively noisy. The ALARM output is an active-low open-collector output; it is grounded (i.e. connected to COMMON) while the alarm condition exists. The ALARM signal can be observed using an LED circuit as above or by using an audible siren as shown in figure 7.

FIGURE 7. Using a siren to make the ALARM output audible.

Since ALARM is an open-collector output, it can be used with external power supplies in excess of 5VDC. The voltage applied to ALARM should not exceed 40VDC relative to COMMON. The current sunk by ALARM should not exceed 150 mA and should not dissipate more than 350 mW.

3.6 The TOGGLE Input

The TOGGLE input provides immediate external control over the filling process. If the liquid level is between the high and low control points, then momentarily shorting the TOGGLE terminal to COMMON will cause the status of the controller to toggle from the filling state to the waiting state or vice versa. If the level is below the low control point, shorting TOGGLE to COMMON will disable filling until TOGGLE is released from COMMON. Finally, if the liquid level is above the high control point (or if any sensor is unplugged), TOGGLE can be used to override the controller and force-fill the reservoir. Usually, a normally-open momentary switch is wired between TOGGLE and COMMON as shown in figure 8.

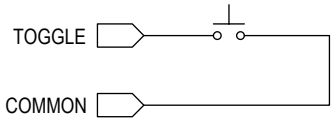


FIGURE 8. A momentary switch can be used to activate the TOGGLE input.

4. Specifications

Power: 120VAC @ 3Amps, 50-60 Hz (230VAC optional)
Size: 3.13 in. (L) x 3.0 in. (W) x 1.5 in. (H)
Fill Relay: 120VAC @ 2.5Amps, Zero-volt switching (230VAC optional)
Required Sensors: LS10, 3 each
Output Signals: STATUS, FILLING & ALARM, open-collector, active low
Max. Voltage: 40VDC relative to COMMON
Max. Current: 150 mA
Max. Power: 350 mW
Input Signal: TOGGLE, active low.
Output Power Supply: 5VDC @ 90mA max.
Screw Terminals: Accepts 14 to 30 AWG
Mounting Holes: 2.5 in. square pattern, 0.15 in. I.D.
Specifications are subject to change without notice.

5. Warranty

The LC11 Level Controller and LS10 Level Sensors are warranted to be free from defects in materials and construction for 1 year from the date of purchase. Neither the controller nor sensors contain any user serviceable parts and all warranty repairs must be performed by Teragon.

Every effort has been made to ensure the accuracy and completeness of both this manual and the LC11 system that it describes. Should you discover any error in either the manual or the LC11 system, we would be most grateful to hear from you regarding the oversight. Please contact us at tel: 415-664-6814, fax: 415-664-6745 or e-mail: sales@trgn.com. We thank you in advance for your assistance. The quality of our products and the satisfaction of our customers are our two greatest concerns.

