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most capable sensors

TRITON™ Switch Controller, Two-Input, Edge-Triggered, Toggle Function

TSC-2-ET-T

General Description

The TSC-2-ET-T is a switch controller for automating homes, offices, and factories. It features a high-power AC relay controlled by two IO-Link compatible inputs, implementing a toggle function upon activation of either input. The IO-Link inputs are compatible with industry-standard sensors, such as water level sensors, through-beam sensors, proximity sensors, magnetic sensors, and temperature sensors. Remote controls can be used in place of IO-Link sensors for manual operation, if desired. The TSC-2-ET-T supports both indoor and outdoor operation, and is designed specifically for harsh environments, such as factories and military installations.

The TSC-2-ET-T features a 5 A steady-state output rating and can withstand current surges up to 30 A, making it ideal for powering resistive and inductive loads that require high in-rush currents such as fans, lightbulbs, motors, pumps, and consumer electronics. An active snubber circuit is used to contain inductive kickbacks from switched loads (i.e., voltage spikes that can reach thousands of volts and damage unprotected relays), particularly from motors, pumps, and fans. Internal fuses protect both the input and output of the TSC-2-ET-T.

The IO-Link inputs are compatible with 24 VDC PNP-type sensors that are commonly found in industrial settings and factories. The TSC-2-ET-T acts as an IO-Link Master and is capable of suppling up to 200 mA of current through its M12-5 A-coded connectors to sensors or manual remote controls. The device features short-circuit protection and can withstand faults of infinite duration. Internal circuitry protects the IO-Link ports from electrostatic discharge and over/under voltage faults.

Commercial-off-the-shelf (COTS) logic chips, rather than microcontrollers, are used in the TSC-2-ET-T for high reliability and longevity in extreme environments.

Applications

- Factory Automation
- Security Systems
- Control Lights, Fans & Pumps
- Control Consumer Electronics & Hard-to-Reach Appliances
- Extend Switched Outlets

Features

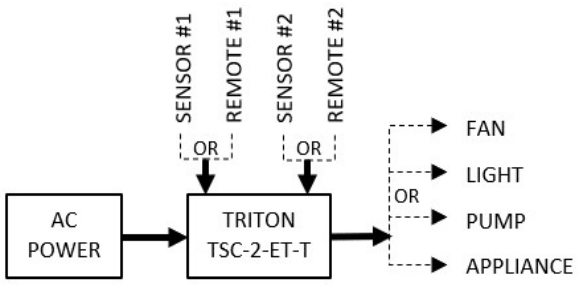
- IP66 Rated, Dust-Tight, Protected Against Powerful Water Jets
- Operating Temperature Range: -25° to 60°C
- Universal Power Supply: 85 VAC to 250 VAC
- Compatible with IO-Link PNP-Type Sensors
- Compatible with Resistive & Inductive Loads e.g., Bulbs, Motors, Pumps & Power Supplies
- EN/UL 62368-1 Power Supply Safety Approved
- 5 A Steady-State (30 A Surge) Output Current, Max
- Protected by Internal Replaceable Fuses

FUNCTION TABLE

Inputs		Output
IO-Link #1 P4: Q (IN)	**IO-Link #2 P4: Q (IN)**	**Switched AC Out***
L , Z	L , Z	No Change
L , Z	⎍	Toggle
L , Z	H	No Change
⎍	L , Z	Toggle
H	L , Z	No Change
H	⎍	Toggle
⎍	H	Toggle
⎍	⎍	Toggle
H	H	No Change

Note: H = HIGH Voltage Level
L = LOW Voltage Level
Z = High Impedance
⎍ = L or Z Transition to HIGH
* = Internal Jumper Sets ON or OFF State at Power Up

Typical Application



TSC-2-ET-T

TRITON™ Switch Controller, Two-Input, Edge-Triggered, Toggle Function

Absolute Maximum Ratings

AC Input Voltage.....85 VAC to 250 VAC
AC Input Current, Surge < 40 msec.....30.8 A
AC Input Frequency.....47 Hz to 63 Hz
AC Output Voltage.....250 VAC
AC Output Current, Surge < 40 msec.....30 A
Operating Temperature Range.....-25° to 60°C

IO-Link Supply Voltage.....24.2 VDC
IO-Link Supply Current, Surge < 50 msec.....400 mA
Short-Circuit Protected, Infinite Duration
IO-Link Input Voltage.....0 VDC to 30.0 VDC
Current into IO-Link Input at 30 VDC.....4.51 mA

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Electrical Characteristics

(Typical values are at an ambient temperature of 25° C)

PARAMETER	MIN	TYP	MAX	UNITS	NOTES & CONDITIONS
AC Input					
Operating Voltage	85	115/230	250	VAC	
Frequency	47	50/60	63	Hz	
Current, Full Load	5.4		30.8	A	Typical 5 A load (30 A surge) at 120/240 VAC plus 400 mA (800 mA surge) for IO-Link 2x
Current, No Load			11	mA	Quiescent current
In-Rush Current		20	50	A	115 VAC cold start plus 30 A load in-rush (max)
		40	70		230 VAC cold start plus 30 A load in-rush (max)
Protection, Fuse Rating		2		A	Slow blow, Littelfuse P/N: 35612000029
AC Output					
Operating Voltage	Same as input voltage				Switched through internal relay
Frequency	Same as input frequency				Switched through internal relay
Current, Full Load		5	30	A	Typical 5 A load (30 A surge for less than 40 msec) at 120/240 VAC
Current, Minimum Load	0			A	Safe to operate with no load
Contact Resistance, On			50	mΩ	
Contact Resistance, Off	1000			MΩ	AC output disconnected when relay is off
Protection, Fuse Rating		5		A	Slow blow, Littelfuse P/N: 35615000029
IO-Link					
Output Voltage	23.8	24.0	24.2	VDC	P1 (L+) relative to P3 (L-, 0V)
Output Source Current, Typ.		200	221	mA	Steady-state after 50 msec startup window
Output Source Current, Max		400	441	mA	During 50 msec surge startup window
IO-Link IN Active Voltage	11.0	24.0	30.0	V	P4 (Q, IN)
IO-Link IN Inactive Voltage	0		11.0	V	P4 (Q, IN) floating input acceptable for LOW
IO-Link IN Active Current	1.7	3.8	4.9	mA	At 11.04V, 24V, and 30V respectively

TSC-2-ET-T

TRITON™ Switch Controller, Two-Input, Edge-Triggered, Toggle Function

Electrical Characteristics (continued)

(Typical values are at an ambient temperature of 25° C)

Dynamic Characteristics					
Power Supply Startup Delay	55		140	msec	115 VAC / 230 VAC full load
Power Supply Hold-Up Time		8		msec	115 VAC, IO-Link at 400 mA and relay on
		60			230 VAC, IO-Link at 400 mA and relay on
Power Supply Switching Frequency		65		kHz	
Relay Operate Time			30	msec	
Relay Release Time			30	msec	
IO-Link Power, Turn-On Time	1.28	1.80	2.40	sec	Begins after power supply startup delay, above
IO-Link Startup Surge Current Window		50.1		msec	Begins after IO-Link turn-on time, above
IO-Link Input Debounce, Activate Time	103	127	169	µsec	P4 (Q, IN) transition from (LOW or Z) to HIGH
IO-Link Input Debounce, Deactivate Time	0.20	0.26	0.34	sec	P4 (Q, IN) transition from HIGH to (LOW or Z)
IO-Link Edge Trigger Delay	0	1	2	msec	Debounce activate to logic function
General					
Isolation: AC_In to IO-Link	4000			VAC	Class 1 construction
AC_In to Ground	2000				
IO-Link to Ground	500				
Earth Leakage Current			0.5	mA	250 VAC / 50 Hz (typ)
Mean Time Between Failure	450			khrs	MIL-HDBK-217F, Notice 2 25°C GB
Environmental					
Operating Temperature	-25		60	°C	With no icing or condensation
Operating Humidity	5		85	%RH	Non-condensing
Operating Altitude			5000	m	
Shock and Vibration	Tested according to EN60068-2-27, 10 - 500Hz, 5g (1H) for each X, Y and Z plane				
Ingress Protection	IP66: dust tight and protected against heavy seas or powerful jets of water				
EMC Emissions					
Conducted	Standard = EN55032, Test Level = Class B				
Radiated	Standard = EN55032, Test Level = Class B				
Power Supply Safety Approvals					
UL	Standard = UL62368-1				Information technology
EN	Standard = EN62368-1				Information technology
CE	Meets all applicable directives				
UKCA	Meets all applicable directives				

TSC-2-ET-T

TRITON™ Switch Controller, Two-Input, Edge-Triggered, Toggle Function

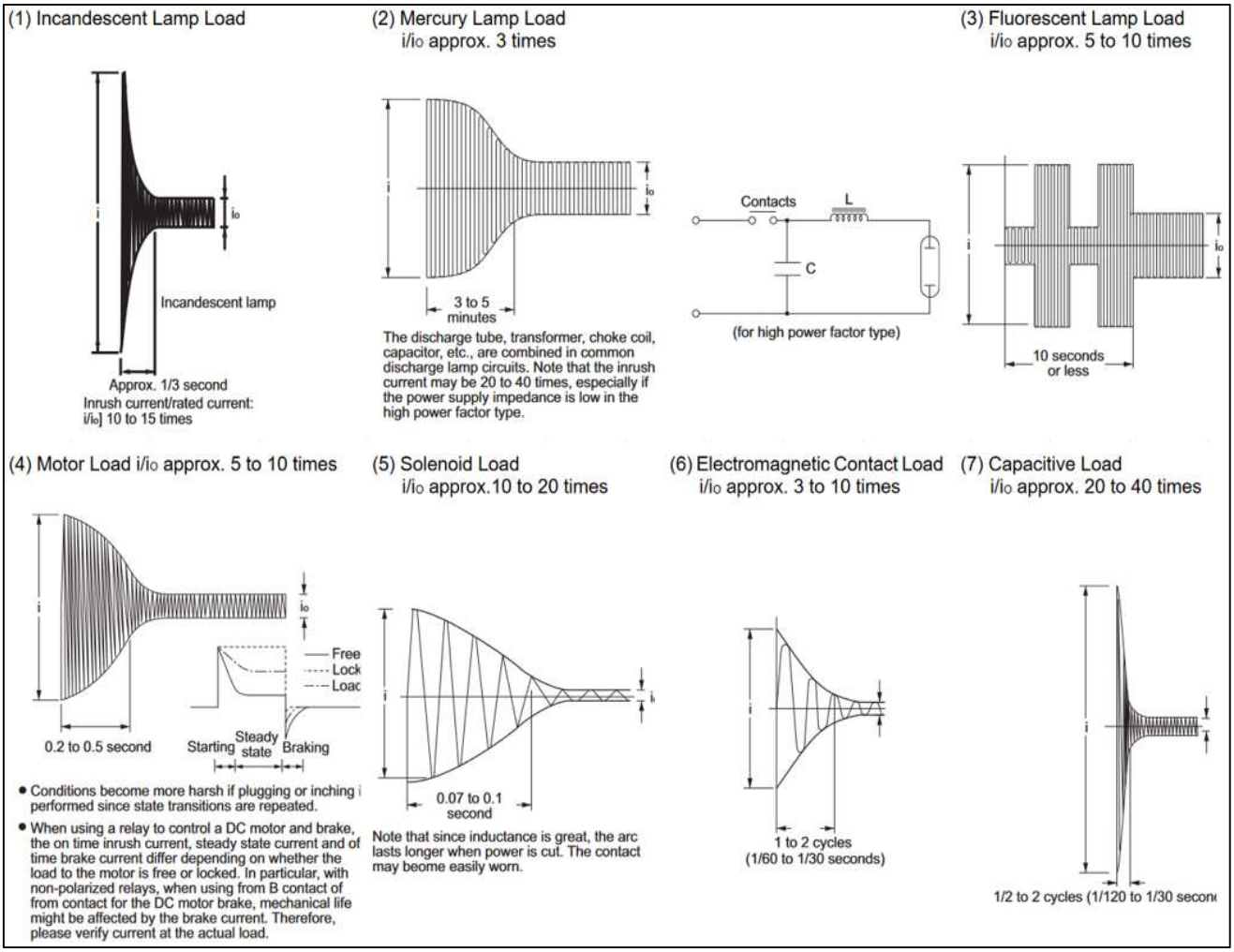
Detailed Description

The TSC-2-ET-T is a switch controller for automating homes, offices, and factories. It features a high-power AC relay controlled by two IO-Link inputs, implementing a toggle function upon activation of either IO-Link input. The IO-Link inputs are compatible with industry-standard sensors such as water level sensors, touch sensors, ultrasonic sensors, through-beam sensors, proximity sensors, magnetic sensors, and temperature sensors.

Example applications include:

- Controlling household fans of 200 Watts or less
- Controlling 3 or fewer 60-Watt incandescent lightbulbs
- Controlling 6 or fewer 42-Watt halogen lightbulbs (60-Watt equivalent)
- Controlling 3 or fewer 10-Watt LED lightbulbs (60-Watt equivalent)
- Controlling 30 or fewer 12-Watt Compact Fluorescent (CFL) lightbulbs (60-Watt equivalent)

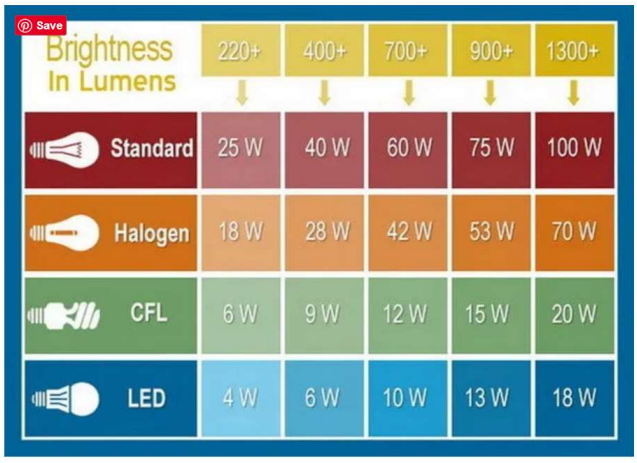
The TSC-2-ET-T is designed to handle surge currents that naturally occur when powering devices with inductive characteristics such as lightbulbs, motors, and switched-mode power supplies, as shown in the figure and table below.



TSC-2-ET-T

TRITON™ Switch Controller, Two-Input, Edge-Triggered, Toggle Function

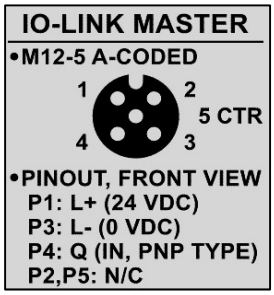
Type of Load (1 Each)	Load Type	Steady-State Current (Amps)	Surge Current (Amps)	Notes
Incandescent Bulb, 60 W	Resistive	0.5	7.5	Lower resistance when cold. Resistance increases as the bulb heats up. Transient surge is 15x steady-state and lasts approximately 50 msec to 333 msec.
CFL, 12W (60 W Equiv.)	Resistive / Capacitive (non-linear)	0.1	1.0	Power-on sequence (square wave) can last up to 10 seconds. Inrush current is 10x steady-state current. Creates THD due to non-linear current switching.
Halogen, 42W (60 W Equiv.)	Resistive	0.4	4.7	Inrush current can last between 10 ms and 100 ms. Inrush current is 13.3x steady-state current.
LED, 10W (60 W Equiv.)	Resistive / Capacitive (PF > 0.7)	0.1	8.3	Most LEDs have a power factor of 0.8 or better. Switching power supplies generate inrush currents of up to 100x nominal current. Transient lasts less than 1 msec.
Oscillating Fan, 200 W	Inductive (0.6<PF<0.8)	2.4	23.8	Inrush current can last up to 0.5 seconds and be 10x the steady-state current.



Watt Lumens LED CFL Incandescent light bulb chart

IO-Link

The TSC-2-ET-T features two IO-Link inputs configured in the Master mode, which provides power and connectivity to IO-Link Devices, i.e., 24 V digital inputs per IEC 61131-2. This technology is intended for use with simple sensors in factory automation and uses a point-to-point connection from each Device to the Master using three wires (24 V, 0 V, and a signal line) over distances up to twenty meters.



The TSC-2-ET-2 features two M12-5 A-coded female connectors, pinouts shown above. Each IO-Link connector can supply up to 200 mA of continuous current at 24 V to sensors, and they can handle surge currents up to 400 mA for 50 msec or less. The device features short-circuit protection (hiccup mode) and can withstand faults of infinite duration. Internal circuitry protects the IO-Link from electro-static discharge and over/under voltage faults.

The TSC-2-ET-T is activated (i.e., output toggled) upon shorting Pin 1 (24 V) to Pin 4 (Q). This type of switching circuit is commonly referred to as a PNP-type configuration, a typical sensor designation for high-side switches. The IO-Link inputs are edge-triggered and will only toggle the TSC-2-ET-T upon

transition of Pin 4 (Q) from LOW (or floating) to HIGH (between 11.04 V and 30.00 V). An internal pulldown resistor on Pin 4 (Q) eliminates the need to drive the input low, and leaving this line floating automatically drives the input LOW.

The IO-Link ports become operational approximately 1.9 seconds after AC power is applied to the TSC-2-ET-T, presenting power on Pin 1 (24 V) and making inputs ready for use on Pin 4 (Q).

The IO-Link input, Pin 4 (Q), uses internal debounce circuitry to ensure noisy signals to not false-trigger the device. The debounce time from from LOW (or floating) to HIGH (thus commanding the TSC-2-ET-T to toggle) is nominally 127 microseconds; and the debounce time from HIGH to LOW (or floating) is nominally 260 milliseconds.

Input Power Stage

The TSC-2-ET-T features a universal AC-DC power supply that can accommodate voltages and frequencies between 85 VAC to 250 VAC and 47 Hz to 63 Hz. It features a no-load current draw of only 11 mA, output short circuit protection, and over-current and over-voltage protection. The power supply is protected by an internal user-replaceable 2 A fuse and achieves Class B conducted & radiated emissions. It features both UL and EN safety approvals (UL62368-1 and EN62368-1) for information technology devices, ensuring safe, reliable operation.

The power supply becomes operational, i.e., 24 VDC present on Pin 1, between 55 msec and 140 msec after application of AC power, during which time an inrush current between 20 A and 40 A can be expected (at 115 VAC and 230 VAC, respectively). The power supply operates at a nominal switching frequency of 65 kHz.

The power supply features Class 1 construction ensuring isolation between AC input and DC output (4,000 VAC), AC input and ground (2,000 VAC), and DC output and ground (500 VAC).

Output Power Stage

The TSC-2-ET-T features an output power stage consisting of a 250 VAC, 30 Amp relay with an active snubber circuit to contain inductive kickbacks from loads (voltage spikes which can reach thousands of volts and damage unprotected relays), particularly from motors and switched-mode power supplies. The 30 A relay is derated to a 5 A continuous current (max) to ensure surge currents from switching loads do not exceed the 30 A relay rating, which is ensured by an internal user-replaceable 5 A fuse.

The relay has a contact resistance of 50 milliohms (max) and features an operate and release time of 30 milliseconds.

The maximum switching frequency of the TSC-2-ET-T is constrained by the switch debounce durations, described earlier, and the throughput of the logic circuitry, but is approximately no faster than 0.520 seconds from toggle on to toggle off (two times the debounce activate time, 127 microseconds, and deactivate time, 260 milliseconds).

The on/off state of the relay at power-on, i.e., when AC power is initially applied to the TSC-2-ET-T, is determined by an internal jumper, allowing the relay to start in either the ON or OFF state (default = relay OFF). This is useful, for example, when powering the TSC-2-ET-T from a wall switch and illuminating a bulb when entering a room. The IO-Link sensors could then be used to toggle the bulb off. This example shows the TSC-2-ET-T implemented as a 3-way light controller (one wall switch plus two sensors/manual remotes).

Internal Logic

The TSC-2-ET-T features logic circuitry that implements the toggle on/off functionality (see Function Table on page 1) using discrete logic chips to instantiate a three-bit state machine (current state, IO-Link input #1, and IO-Link input #2). The circuitry operates at a frequency of 1 kHz, scanning

the IO-Link debounce inputs 1,000 times per second for level changes.

Commercial-off-the-shelf (COTS) logic chips, rather than microcontrollers, are used in the TSC-2-ET-T for high reliability and longevity, especially in environments with electromagnetic interference (EMI) and electromagnetic coupling (EMC), such as factories and military facilities.

User Guide

The TSC-2-ET-T features the ability to be configured in several different configurations based on user needs. Two common configurations are described below, along with setup and maintenance instructions.

Preparing the Switch Controller for Use

These steps prepare the TSC-2-ET-T for use.

Step 1: Ensure the TSC-2-ET-T is not connected to AC power.

Step 2: Connect IO-Link compatible sensors or remote controls [devices] to the TSC-2-ET-T, as follows. At least one IO-Link device must be connected to the unit for operation.

- Align notch on device plug (male M12-4 or M12-5 A-Coded) with notch on TSC-2-ET-T jack (female M12-5 A-Coded), and gently insert the plug into the jack to make an initial connection.
- Using fingers (and never tools), tighten the threaded locking collar between plug and jack until just snug. Do not over tighten. It is normal for some threads on the collar to remain exposed after tightening (i.e., full insertion is not possible).

Step 3: Connect the TSC-2-ET-T to the AC load (e.g., fan, motor, bulb).

Step 4: Continue to the Normal (Default) OFF Configuration section or the Start-Up ON Configuration section based on user needs.

Normal (Default) OFF Configuration

The Normal (Default) OFF Configuration is ideal for situations where the TSC-2-ET-T is continuously connected to AC power, i.e., not switched on/off regularly. This mode differs from the Start-Up ON Configuration in that this mode has the AC load unpowered (OFF) when AC power is applied, and the Start-Up ON Configuration has the AC load powered (ON) when AC power is applied.

To use this mode, complete the following steps, but only after the TSC-2-ET-T has been prepared for use, see previous section.

Step 1: Plug the TSC-2-ET-T into an AC power source that is continually on.

Step 2: Activate the IO-Link device (sensor or remote) to toggle the load ON. Subsequent activations will toggle the load as described in the Function Table on page 1.

Start-Up ON Configuration

This mode is ideal for applications where AC power to the TSC-2-ET-T is switched regularly, for example, from a switch-controlled outlet.

A typical scenario for residential settings might involve a lamp connected to a switch-controlled outlet that illuminates a room upon entering and flipping a wall switch on. The TSC-2-ET-T can be inserted between the switch-controlled outlet and lamp to create a pseudo 3-way switch (wall switch + two IO-Link remotes). This configuration is particularly useful in bedrooms, where one would illuminate the room upon entering, lie down in bed, and switch the light off using IO-Link remotes installed on either side of the bed. During the night, the light could be toggled on using IO-Link remotes without stumbling through the dark to find the wall switch. Note: the TSC-2-ET-T can only toggle the lights if the main wall switch is on.

To use this mode, complete the following steps, but only after the TSC-2-ET-T has been prepared for use, including setting the internal jumper, shown below.

Step 1: Turn wall switch off and disconnect load from switch-controlled outlet.

Step 2: Plug the TSC-2-ET-T into the switch-controlled outlet, and plug the load into the TSC-2-ET-T.

Step 3: Turn wall switch on to activate TSC-2-ET-T and power the load.

Step 4: Toggle power to the load using an IO-Link device (sensor or remote), as described in the Function Table on page 1.

Step 5: Turn wall switch off at any time to deactivate the TSC-2-ET-T and turn the load off. Note: the TSC-2-ET-T will de-energize when the wall switch is turned off, and it can take up to 4 seconds before the TSC-2-ET-T (and load) can be turned back on anew using the wall switch.

Setting the Jumper

The following steps can be used to configure the TSC-2-ET-T for Normal (Default) OFF mode or Start-Up ON mode configurations.

Step 1: Disconnect the TSC-2-ET-T from AC power, load, and IO-Link devices.

Step 2: Remove four screws from the top of the enclosure using a #2 Phillips screwdriver. Remove lid.

Step 3: Before touching the electronics, dissipate static electricity from your body by touching a large piece of metal or earth ground.

Step 4: Locate header J2 on the circuit board (shown to right). Set black shunt jumper into positions 1 and 2 for Normal (Default) OFF mode, or positions 2 and 3 for Start-Up ON mode.

Step 5: Re-install lid using four screws and Phillips screwdriver.

Replacing the Fuses

The following steps can be used to replace the internal fuses (one for input AC power, and one for output AC power).

Step 1: Disconnect the TSC-2-ET-T from AC power, load, and IO-Link devices.

Step 2: Remove four screws from the top of the enclosure using a #2 Phillips screwdriver. Remove lid.

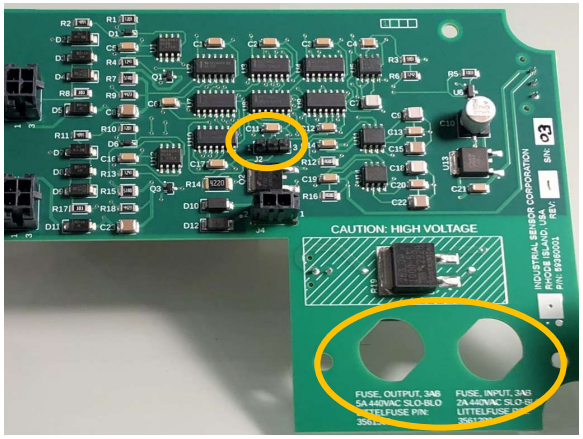
Step 3: Before touching the electronics, dissipate static electricity from your body by touching a large piece of metal or earth ground.

Step 4: Locate the fuses on the circuit board (shown in image below). The input fuse (2 A) is located on the right, and the output fuse (5 A) on the left.

Step 5: Using a straight-blade screwdriver, press down on the fuseholder cap until it depresses slightly into the fuseholder, and turn approximately 90° counter-clockwise to remove the fuse. Apply additional downward pressure, if necessary.

Step 6: Replace blown fuse(s) with the following part numbers only, working the steps in reverse order to return the unit to normal operating condition.

- 2A fuse: Littelfuse P/N: 35612000029
- 5A fuse: Littelfuse P/N: 35615000029



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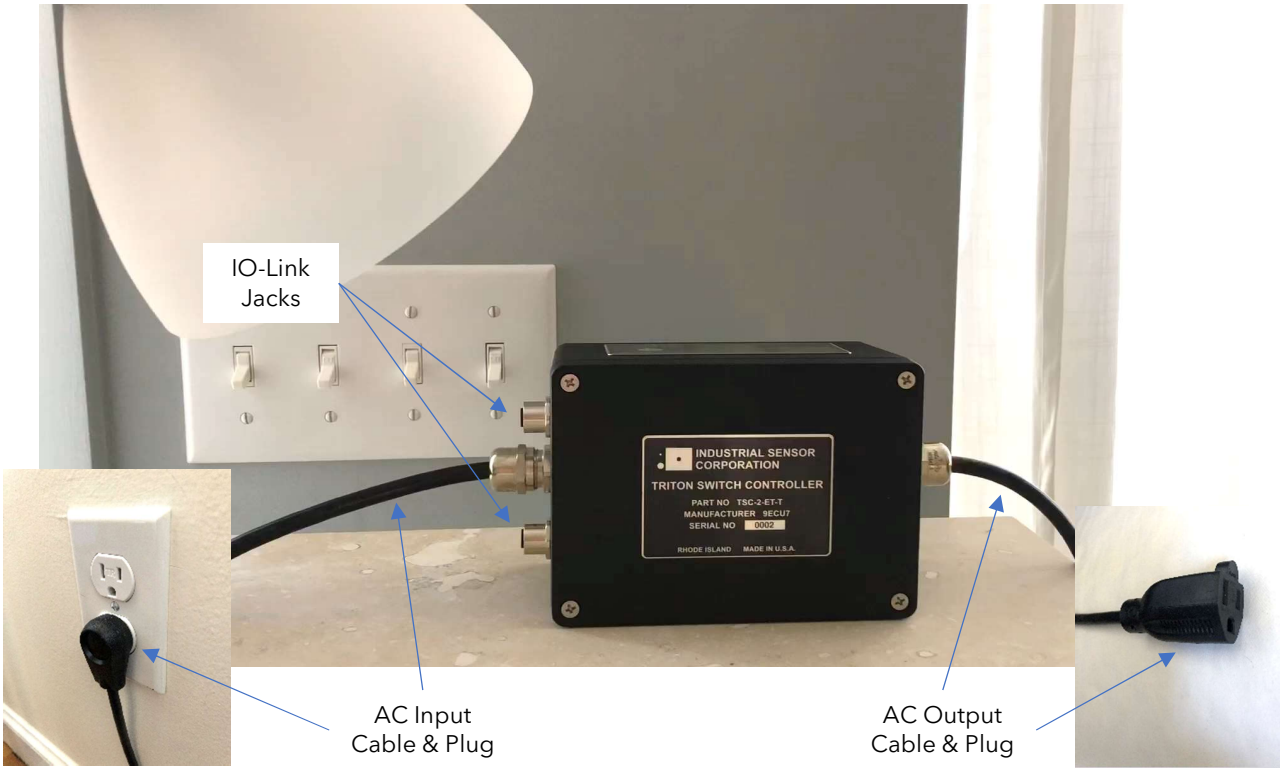
Mechanical Package



Enclosure Width:	108.4 mm [4.27"]
Enclosure Height:	75.4 mm [2.97"]
Enclosure Depth:	148.4 mm [5.94"]
AC Input Cord Length:	2.6 m [8' 7"]
AC Output Cord Length:	1.7 m [5' 7"]

TSC-2-ET-T

TRITON™ Switch Controller, Two-Input, Edge-Triggered, Toggle Function

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	3/23	Initial Release	-

References

Inrush Current Table: https://mediap.industry.panasonic.eu/assets/download-files/import/technical_information_relay_en.pdf
Bulb Type Chart: https://removeandreplace.com/2015/10/22/lamp-says-max-10w-bulb-can-i-use-a-60w-led-bulb/