

# EtherStop System Documentation (2022-06-17 DRAFT)

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This document provides a general overview of the setup and operation of EtherStop devices and systems. Refer to the documentation for specific products for more information on their setup and use. EtherStop devices are designed only for use with X-Laser projection systems and performance or proper function is not guaranteed with any other systems.

## System Overview

The EtherStop System is designed to simplify the setup and use of laser equipment by combining compliance signaling and network control signaling into a single inexpensive and common network cable. Most X-Laser professional laser equipment (Black Label and Red Label products) include EtherStop interfaces that support daisy-chaining EtherStop cabling from one projector to the next, allowing rapid and scalable show setups that perform reliably and comply with applicable regulatory requirements in most jurisdictions. Additional accessories like EtherStop distribution equipment provide additional flexibility and scalability.

**Note: While the EtherStop System uses standard Ethernet cables and connectors, EtherStop devices MUST NOT be connected to standard Ethernet devices except as specifically allowed by product documentation.**

## General Usage Rules

1. Only connect EtherStop devices as specifically allowed by product documentation.
2. Never connect EtherStop or Remote ports to standard Ethernet devices.
3. Always observe applicable cable length limits and other connection requirements when configuring an EtherStop system.
4. Always provide at least one EtherStop Pendant or other means of remotely terminating laser output independently of the main laser control system.
5. Ensure that all laser display areas are clearly visible to the operator at the location of the Pendant.
6. Where all laser display areas are not visible from the location of one Pendant/operator, always provide additional Pendants and personnel capable of disabling laser output in case of a problem in any laser display area.
7. Before every use of an EtherStop system, test all devices to ensure that the system is functioning properly and laser output can be disabled when needed from any control location.
8. **Never hesitate to disable laser output when a problem occurs. The safety of the audience, performers, and operators is ALWAYS more important than the show.**

## Compliance Signals

To comply with applicable regulatory standards in most jurisdictions, high power laser equipment must require specific control signals to enable laser output. These usually include a Remote Interlock signal and a Reset signal.

The Remote Interlock signal is used to remotely disable laser output independently of a primary control system in case of a system failure or another condition that would make laser output unsafe. The Remote Interlock signal is

fail-safe, meaning that laser output is disabled when an external signal is not present. The loss of the Remote Interlock signal will immediately disable laser output regardless of any other control signals.

The Reset signal is used to re-enable laser output after loss of power or after the Remote Interlock signal has been lost. After power has been restored and/or the Remote Interlock signal has been restored, laser output will not be enabled immediately. Momentarily activating the Reset signal after power and the Remote Interlock signal are restored will re-enable laser output after an emission delay period.

The EtherStop system also provides an Emission signal from the laser equipment back to the control location. The Emission signal provides immediate feedback on the state of the connected laser system(s) without needing any additional diagnostic equipment. Most X-Laser professional laser systems indicate their operational status via the emission indicator as shown below. Refer to specific product documentation for exceptions to this behavior or additional operational information.

<b>Behavior</b>	<b>State</b>
Off	Emission requirements are not met (no power, keyswitch not turned, or Remote Interlock signal not present)
Flashing once per 3 seconds	Emission requirements are met, and laser is ready to receive a Reset signal
Flashing once per second	Laser has received a Reset signal and is in the emission delay period. Laser output will be enabled after the emission delay period.
Solid On	Laser is ready to emit or is emitting. Operational control signals may cause laser output at any time.

*Note: where multiple laser systems are connected to one Pendant, the Emission indicator on the Pendant will be solid on when ANY of the connected lasers are capable of emitting.*

## **Regulatory Information**

All Class 3B and Class 4 laser systems must provide a Remote Interlock connector to comply with international regulations per IEC 60825-1, 6.4 and United States regulations per 21 C.F.R. §1040.10(f)(3).

All Class 4 laser equipment must require a manual reset before enabling laser output for compliance with international regulations per IEC 60825-1, 6.5 and United States regulations per 21 C.F.R. §1040.10(f)(10). Although only Class 4 laser systems are subject to this regulatory requirement, most Class 3B laser systems in X-Laser's professional laser families also require this reset step for consistency across models and improved user and audience safety.

All Class 3B and Class 4 laser systems are required to have a visible emission indicator for compliance with international regulations per IEC 60825-1, 6.7 and United States regulations per 21 C.F.R. §1040.10(f)(5). In most cases the emission indicator integrated into the laser system itself is sufficient to meet these requirements, but the remote Emission signal provided by the EtherStop system may help meet more specific emission indicator requirements for some situations.

Some jurisdictions or institutions may have additional laser safety or compliance requirements. Contact X-Laser to discuss consultation and custom design services if necessary to meet those requirements.

## Network Signals

Most EtherStop-equipped systems support standard 100BASE-TX Ethernet connections via built-in network interfaces. The signals required for Ethernet connectivity are carried alongside the compliance signals in the same cable. Some EtherStop-equipped devices do not contain any active network interfaces and can only pass Ethernet links from one device to another. Some EtherStop-equipped devices may provide other types of Network connectivity on dedicated Network ports, such as 1000BASE-T Gigabit Ethernet, fiber, and PoE. Refer to device documentation for more specific information on the capabilities of each of the device's ports.

## Typical Equipment

In most cases, an EtherStop system will consist of one or more laser projectors and an EtherStop Pendant. The Pendant provides a means of remotely terminating laser output independently of the primary control system, as well as re-enabling laser output after loss of power or activation of the Remote Stop switch on the pendant. The Pendant may also indicate the status of the connected laser projector(s) via the Emission indicator.

Some EtherStop systems will require additional equipment, such as auxiliary pendants that can be used to terminate laser output from other locations, or distribution equipment to convey EtherStop signals to larger numbers of laser projectors, or equipment spread over a larger area. Refer to specific product documentation or contact X-Laser sales and support for help selecting the right EtherStop equipment for your needs.

## Typical System Operation

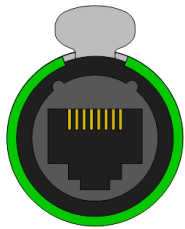
The following assumes one or more EtherStop Pendants connected to one or more laser systems. For information on the operation of other systems, refer to specific product documentation or contact X-Laser for assistance.

1. Ensure all EtherStop equipment is correctly connected and powered on.
2. Ensure that EtherStop Terminators are only installed where needed (typically only on unused Remote In ports on Pendants).
3. Ensure that the keyswitches (if present) on all connected laser systems and on all pendants are turned to the enabled position. In most cases, this is the position in which the key cannot be removed from the keyswitch.
4. Ensure that the Stop switches on all pendants are in the released position. Stop switches on EtherStop Pendants will latch in the down position once pressed, and the top of the switch must be twisted clockwise to release it.
5. Ensure that the Remote In port on all Pendants have either another pendant or an EtherStop Terminator connected.
6. At this point, the Emission indicators on all lasers should be flashing once every three seconds to indicate that they are ready to receive a Reset signal.
7. One at a time, activate each remote Stop switch and remote key switch on each Pendant. Verify that the Emission indicators on all lasers are off, indicating a loss of the Remote Interlock signal, when each switch is activated.

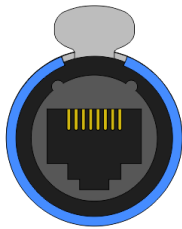
8. After verifying that every Stop and key switch in the system can disable laser output, restore all switches to the enabled position.
9. Press the Reset button on one of the Pendants. The Emission indicators on all lasers should begin flashing once per second, indicating that they are in the emission delay state.
10. After the emission delay period (typically ten seconds) the Emission indicators on all lasers should be illuminated, indicating that they are ready to emit.

## Port types

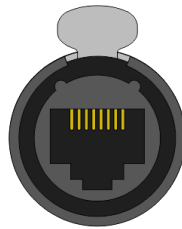
The EtherStop system includes three main types of ports: EtherStop, Remote, and Network. Each port type has one or more subtypes depending on the direction of signal flow (or power flow in the case of PoE ports).



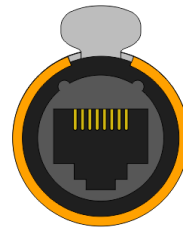
EtherStop Port  
Green Coding Ring



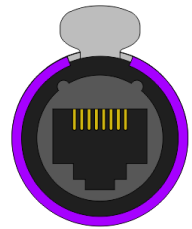
Remote Port  
Blue Coding Ring



Network Port  
Black/No Coding Ring



Network PSE Port  
(PoE Out)  
Orange Coding Ring



Network PD Port  
(PoE In)  
Violet Coding Ring

In most cases, EtherCON ports on X-Laser equipment will have colored coding rings to indicate their type. Some equipment, including older equipment or equipment with specialty connectors, will not have coding rings. In that case, refer to the port labeling or product documentation for the available port types.

### EtherStop

EtherStop ports carry both Network and Compliance signals. The Network signals use 100BASE-TX Ethernet signaling capable of transmitting or receiving up to 100Mbit/s. EtherStop ports are typically marked with **green** coding rings.

### Remote

Remote ports carry only Compliance signals, and cannot send or receive Network signals. Remote ports are typically marked with **blue** coding rings.

### Network

Network ports carry only Network signals, and cannot send or receive Compliance signals. These ports use standard Ethernet signaling and may be connected to other standard Ethernet devices. Network ports are typically marked with **black** coding rings, or do not have a coding ring.

## Network PSE Ports

Network PSE Ports are Network ports that also have Power-over-Ethernet (PoE) functionality. PSE ports can supply power to devices with Network PD ports, or other PoE compliant equipment. Refer to product markings or documentation for information on the specific PoE standard compliance and maximum power available on these parts. Network PSE ports are typically marked with **orange** coding rings.

## Network PD Ports

Network PD Ports are Network ports that also have Power-over-Ethernet (PoE) functionality. Equipment with Network PD ports can be powered via PoE when connected to a Network PSE port, or other PoE PSE compliant equipment. Refer to product markings or documentation for information on the specific PoE standard compliance and power requirements for these ports. Network PSE ports are typically marked with **violet** coding rings.

**WARNING: Do not use passive or 'always on' PoE injectors with an X-Laser equipment. Always use appropriate and standard-compliance PoE Equipment.**

## EtherStop/Remote Port Directions

EtherStop and Remote ports may be Out, In, or Thru ports. This refers to the direction of the Interlock and Reset signals on the port.

### Out Ports

'Out' ports send Interlock and Reset signals to, and receive Emission signals from downstream In or Thru ports.

Remote or EtherStop Out ports may connect to the following port types:

- Remote or EtherStop In
- Remote or EtherStop Thru

*Note: 'Thru' ports have additional connection requirements. See other sections below.*

Remote or EtherStop Out ports **MUST NOT** connect to the following port types:

- Remote or EtherStop Out
- Network (any type)

### In Ports

'In' ports receive Interlock and Reset signals from an upstream EtherStop Out port, and send Emission signals to the upstream EtherStop Out port.

Remote or EtherStop In ports may connect to the following port types:

- Remote or EtherStop Out
- Remote or EtherStop Thru

*Note: 'Thru' ports have additional connection requirements. See other sections below.*

Remote or EtherStop In ports MUST NOT connect to the following port types:

- Remote or EtherStop In
- Network (any type)

### Thru Ports

'Thru' ports are a special case of EtherStop port that allows EtherStop signals to be 'daisy chained' from one device to the next. Thru ports are always present in pairs, and each pair may consist of two Remote ports, two EtherStop ports, or one of each. Compliance signals can be received on either port and are passed through to the other port as well as connected to the device's internal compliance logic. The second Thru port in the pair can be connected to an In or Thru port on another device.

Remote or EtherStop Thru ports may connect to the following port types, provided that the Daisy Chaining Rules detailed later in this document are met:

- Remote or EtherStop Out
- Remote or EtherStop In
- Remote or EtherStop Thru

Remote or EtherStop Thru ports may NOT connect to the following port types:

- Network (any type)

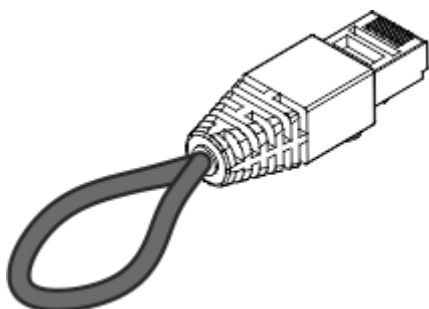
### Connecting EtherStop and Remote Ports

EtherStop and Remote ports may be directly connected to each other, but can only exchange Compliance signals. EtherStop ports can only exchange network signals with other EtherStop ports.

### Terminators

EtherStop Terminators are small devices that can be used to close the interlock signal on unused Remote or EtherStop In ports. During service or testing only, EtherStop Terminators may also be used to temporarily enable laser output from a laser projector.

**Note: EtherStop Terminators must not be used to enable laser output in place of an EtherStop Pendant during show setup or operation. Laser light show applications must have a properly connected and functional remote stop device such as an EtherStop Pendant to meet applicable safety and compliance requirements.**



## Daisy Chaining EtherStop devices

EtherStop devices that include Thru ports may be 'daisy chained' to allow Compliance and Network signals to be distributed to multiple devices. These chains of devices may include both Remote and EtherStop Thru port pairs, however only EtherStop Thru pairs will pass Network signals down the chain.

EtherStop daisy chains must be connected according to the rules given below.

### Daisy Chaining Rules

1. Each daisy chain begins at the EtherStop Out or Remote Out port of a device, which is connected to one Thru port on the first device in the chain.
2. The second Thru port on the first device is connected to one Thru port on the second device in the chain, and so on through all devices in the chain.
3. In addition to the Out port at the beginning of the chain, each daisy chain may include:
  1. up to ten Thru port pairs or
  2. up to nine Thru port pairs and one In port at the end of the chain.
4. Daisy chains may include any combination of Remote and EtherStop Thru port pairs.
5. Daisy chains must not include more than one Out port of any type.
6. If a daisy chain includes only Thru port pairs, the second port in the final pair **MUST NOT** be terminated.
7. The cable length of the entire daisy chains is subject to the Compliance Length Limit detailed later in this document.
8. If the daisy chain is used to convey network signals between devices, the cable lengths between adjacent devices in the daisy chain are subject to the Ethernet Length Limit.

## Cabling

EtherStop connections are made using standard network cable and connectors. Cable must be ANSI/TIA-568 Category 5 or better four-pair cable. Note that higher performance cable such as Category 6 may be used, but will not improve the performance of the EtherStop system. Most EtherStop equipment uses Neutrik EtherCON panel connectors, which will accept cables with EtherCON plugs or standard 8P8C modular plugs (8P8C plugs are often called 'RJ45' or 'Ethernet' plugs). Some EtherStop equipment uses standard 8P8C modular jacks which only accept standard 8P8C modular plugs.

Connectors must be properly installed on cables per ANSI/TIA-568. Note that all four pairs must be connected at both ends to support EtherStop functionality. In most cases cables may be wired crossover or straight through. Except as noted in specific product specifications, EtherStop network interfaces include Auto-MDI/X and will generally adapt to crossover or straight through connections as needed automatically. Note that some devices by other manufacturers may specifically require straight through or crossover connections even when connected to devices supporting Auto-MDI/X.

While the EtherStop systems has been designed to tolerate common wiring faults, ensure that all cabling is in good condition, connected properly, and protected from physical damage. Sufficiently ruggedized cable should be used in any situations where the cable will be subject to hard use or exposed to physical or mechanical damage.

## Cable Lengths

EtherStop systems are subject to length limits based on network signal requirements as well as compliance signal requirements.

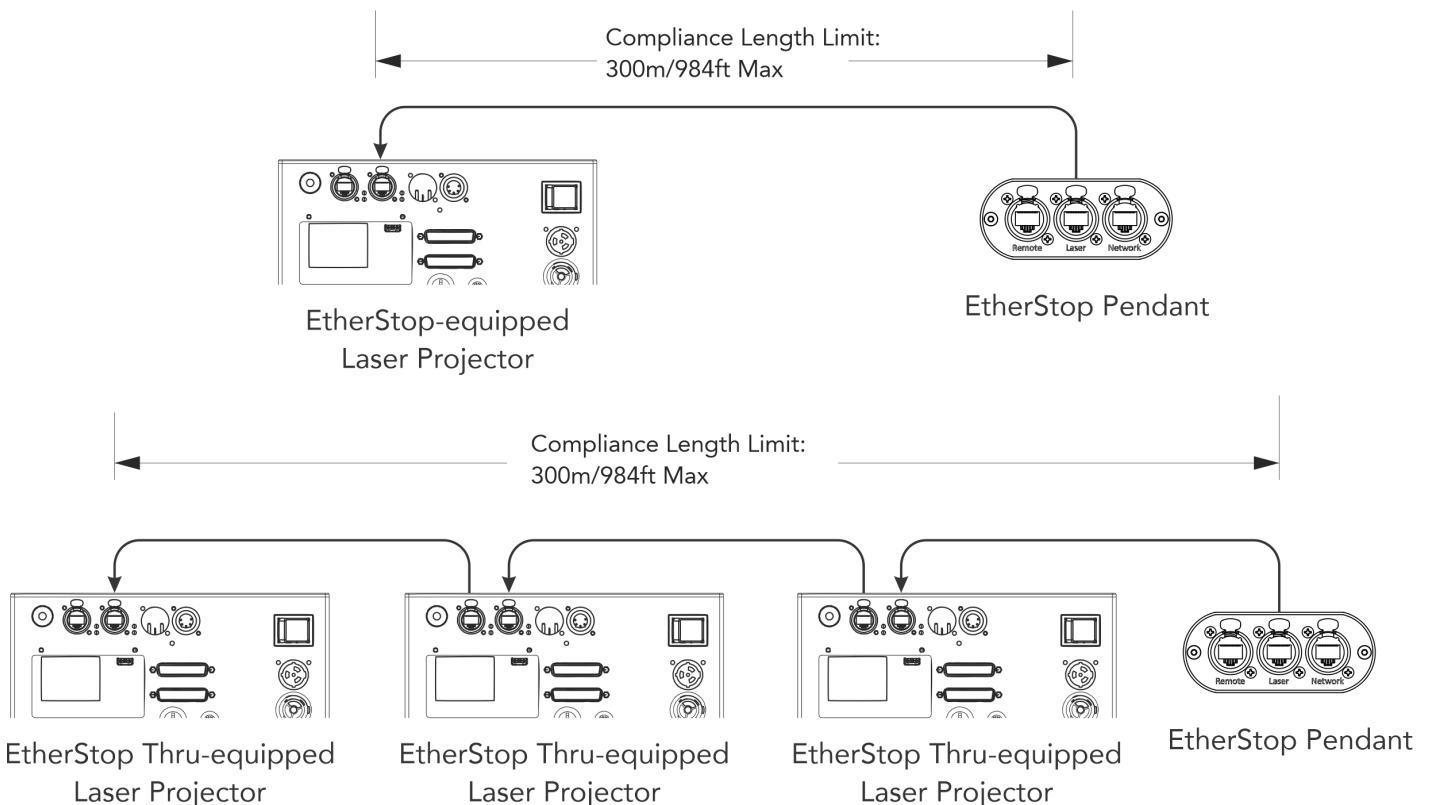
- Compliance Length Limit: 300m or 984ft
- Ethernet Length Limit: 100m or 328ft

The Compliance Length Limit applies to any single connection that carries Compliance Signals between two devices, or the total length of all connections in a daisy chain that carries Compliance signals to multiple devices.

EtherStop links carrying network data are subject to the Ethernet Length Limit of 100m or 328ft to comply with ANSI/TIA-568 requirements. This limit must be measured between adjacent active network devices. Note that Compliance Length Limit still applies, and where both Compliance and Ethernet Length Limits apply to a link, the shorter limit applies. Note that some EtherStop devices directly pass network signals from an EtherStop port to an associated Network port, and the cable length limit applies to the total cable length on both sides of these devices. Refer to device documentation to determine which ports if any are connected this way.

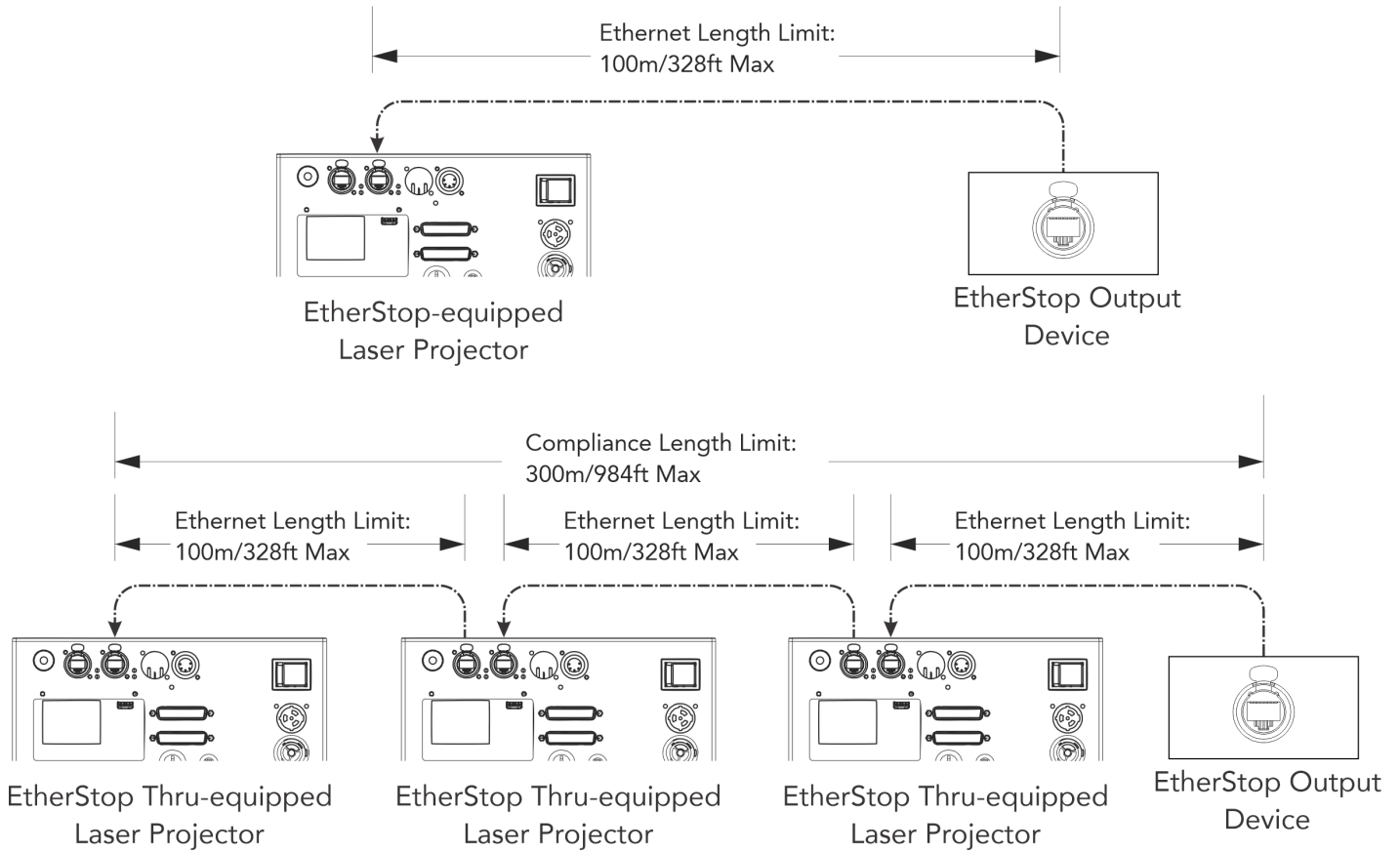
### Length Limits for Common EtherStop Systems

The following diagrams show how the Compliance and Ethernet Length Limits apply to some common EtherStop system configurations. Refer to specific product documentation for more detailed information on how these limits apply to specific devices.

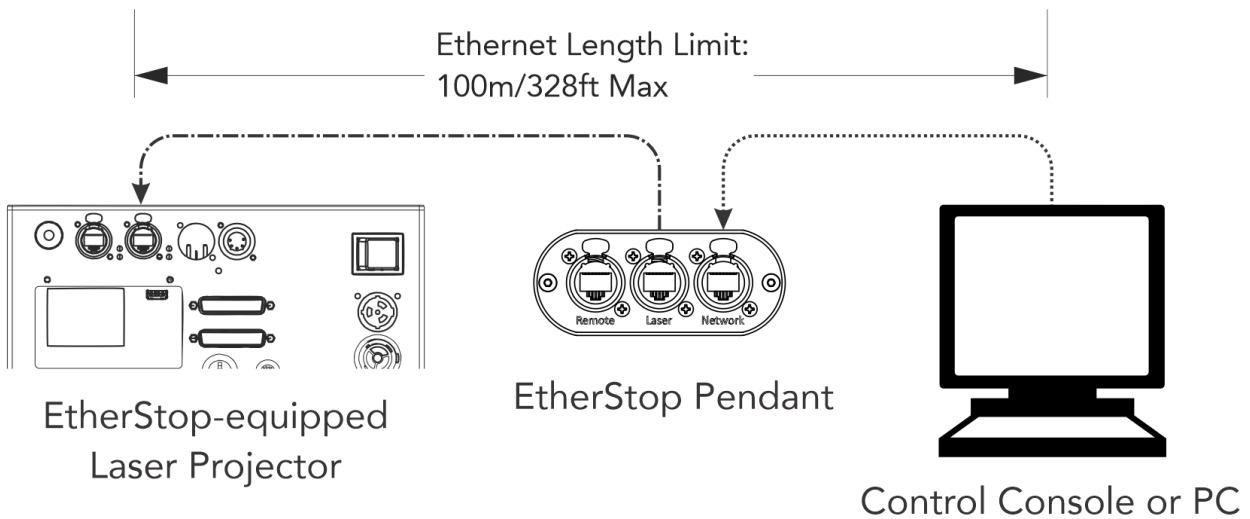


Because the link from the pendant to the laser(s) is only being used for Compliance signals only the Compliance length limit applies. The limit applies to a single link or to an entire daisy chain of EtherStop devices.

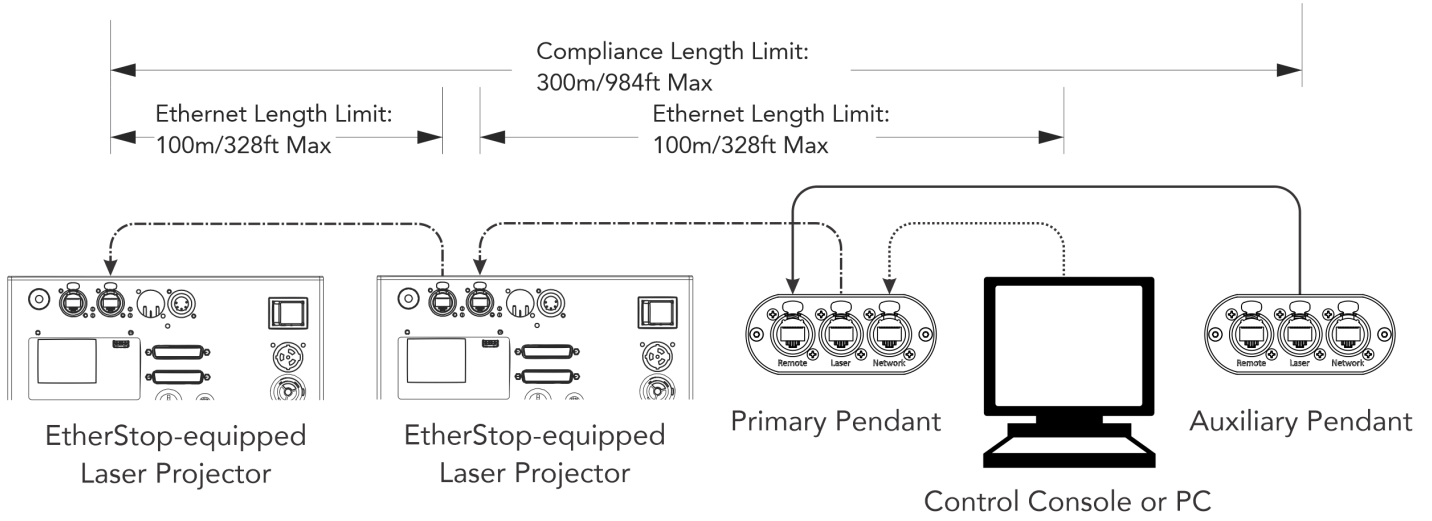
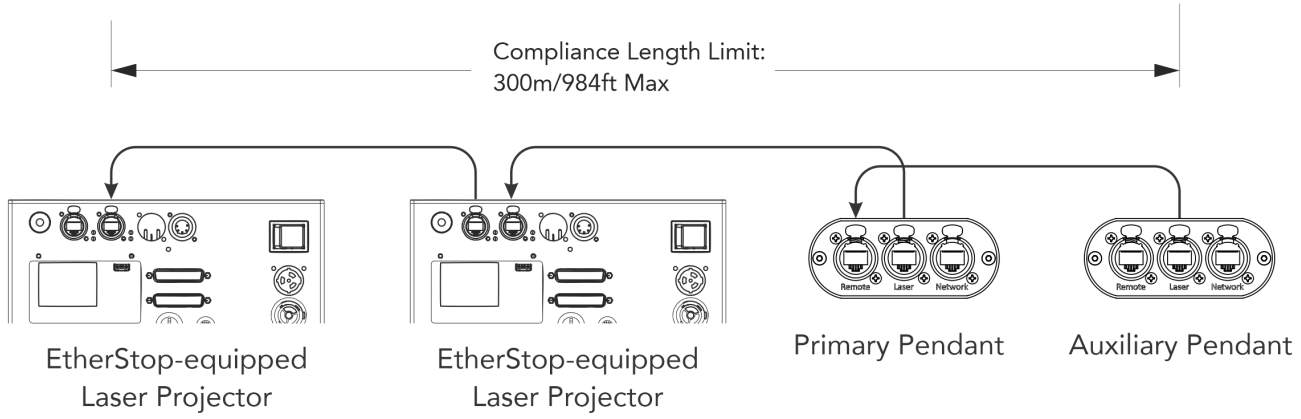




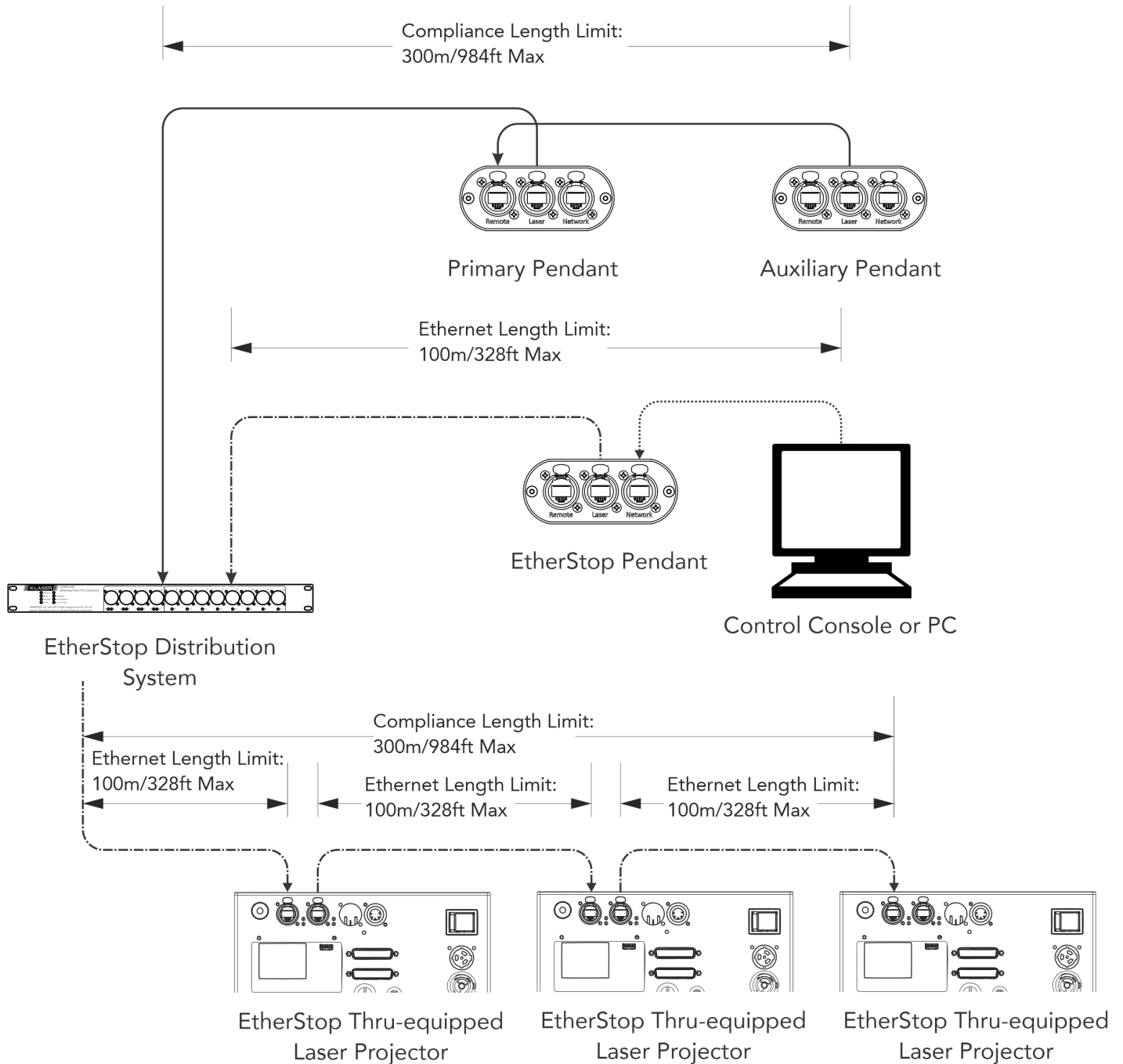
When EtherStop links are also providing network control signals to connected equipment, the Ethernet Length Limit applies to connections between adjacent devices. The Compliance Length Limit still applies to the total cable length of an EtherStop daisy chain.



Because EtherStop Pendants passively relay Ethernet signals between their Network and EtherStop connectors, the Ethernet Length Limit applies to the total cable length from the control system to the Pendant and from the Pendant to the Laser.



If an EtherStop Pendant at the beginning of an EtherStop daisy chain has an Auxiliary Pendant connected to its Remote In port, the total cable length from the Auxiliary Pendant to the last EtherStop device in the chain must be limited to 300m. In the top diagram above none of the EtherStop links are carrying Network data, so the Ethernet length limit does not apply. In the lower diagram, the Ethernet Length Limit applies between the control system and the first laser in the daisy chain and between adjacent lasers in the chain.



EtherStop systems using active distribution equipment may have a combination of length limits on different segments of the system.

## Electrical Information

Most EtherStop devices feature electrically isolated EtherStop interfaces: there is no direct electrical connection between the device's internal circuitry and the EtherStop interface circuitry. This prevents ground loops between EtherStop devices and reduces or eliminates the risk of damage to EtherStop devices in case of many common wiring faults. This isolation is functional only and is not intended to protect users against hazardous voltages. EtherStop and Remote ports feature basic overcurrent and overvoltage protection, but should never be connected to non-EtherStop/Remote ports.

**WARNING: Some inexpensive 'Power over Ethernet' PSE devices apply constant 48V power to their ports, and may damage or destroy EtherStop or Remote ports if connected. Always use IEEE 802.3 compliant PoE equipment, and NEVER connect EtherStop or Remote ports to PoE ports.**

The EtherStop system uses 5V signaling for Remote Interlock, Reset, and Emission signals. The voltage between any two Compliance signal lines in a properly connected EtherStop system is 6VDC. Higher voltages may be present on EtherStop systems improperly connected to non-EtherStop devices.