Network & Optical Fiber Requirements

Nova Near Detectors

Operation of the NOvA near detector in the underground configuration will require optical fiber connections to route both standard network traffic as well as custom timing signals between the DAQ equipment located in the underground caverns and components of the DAQ and timing systems that are located above ground.

For the near detector in the underground configuration, network connections within the detector are made with standard category-5E twisted pair cables and are aggregated by a CISCO 4948E high speed switch into a pair of redundant 10Gb/s uplinks. All controls traffic moving to the detector and data moving off the detector is routed through these uplinks. These uplinks connect to a router in the MINOS surface building which then bridges the connections onto the main Fermilab campus network. This configuration was first used for the Near Detector in the Surface Configuration (NDOS) and has been used successfully since 2010 to handle the controls and data flow for the detector.

The NOvA networking design avoids using copper network runs beyond the point to point connects with the NOvA front end systems that are on the detector and the power and timing infrastructure that is located in the relay racks that also house the master network switch. The ONLY connections running beyond this rack are single mode fiber with passive junctions for the timing lines. The following document describes these requirements in detail.

Near Detector Timing System

The timing system that provides the universal GPS time stamps and clocks for the front end systems. To do this the “master” timing distribution units (TDU), which contain the GPS receiver, are connected to “slave” TDUs which act as programmable delays and repeaters for the timing signals. With the production hardware, the connection between the master and slave TDUs can be either standard CAT5 copper Ethernet or single mode fiber optics.

For the NOvA near detectors, the master TDUs for each detector will be located in the Minos Service Building (MSB) in relay racks located in the north west utility area. Each of these master TDUs will need to be connected to a slave TDU that is located in relay racks in the underground cavern areas near the NOvA detectors. The approximate distance between these locations, assuming that the connections must run down the NuMI access shaft, is 1500 ft. This distance mandates the use of optical fiber.

Each master to slave timing connection will require two strands of single mode optical fiber. This fiber link cannot have any active repeaters, as those would degrade the quality of the timing singles that are sent down the connection. The fiber can have passive junctions which do not significantly affect the timing characteristics of the signals.

For general operations, each detector will use two (2) independent master/slave systems to provide redundancy and cross checks on the GPS locks. These systems will both in operation at the same time and both will require a dedicated fiber pair for each one.

Near Detector DAQ Readout Uplink

The DAQ readout system uses highspeed switches (Cisco 4948) to route traffic from the custom electronics that are on the detector to a large set of computers that are located in the Lattice Computing Center. This design requires that the switch located in the underground cavern areas have a set of fiber uplinks that run from it to the surface, where they are patched into the rest of the FNAL network infrastructure.

Each NOvA detector has one high speed DAQ switch with dual uplinks. Each uplink requires two single mode fiber strands. Each NOvA detector will also have one lower speed switch that routes lower priority traffic ("controls" traffic). This switch will also has dual uplinks and each uplink will require two single mode fiber strands.

Future and Auxiliary Detectors

There is a high probability that an auxiliary detector will be installed in front of or in close proximity to the NOvA near detector to either enhance the measurements that NOvA is performing or to perform specialized measures with the neutrino beam. This detector will require a timing system similar to, or linked with the NOvA timing system and which would use similar or identical hardware as is being currently deployed. This detector may also require additional networking hardware that would need fiber uplinks.

We anticipate that a future detector would need two fiber pairs for timing and two fiber pairs for networking.

Spare Fiber Lines

The systems that have been discussed all represent critical systems that can inhibit operation of the NOvA near detector. In the current design of the system, no single fiber or fiber pair is a single point of failure for the detector. The system is however susceptible to failure if two fiber pairs on the same system were damaged (i.e. both uplink pairs on a network switch, or both the timing links coming from the two independent TDU masters.) For this reason we require that four additional fiber pairs be available as spare lines which can be utilized as needed across the timing and network systems.

This number of spares reduces our susceptibility to systemic failure by allowing us to be tolerant to up to four simultaneous failures spread across three primary systems.

Summary

The following table summarizes the fiber that is required for the NOvA experiment:

Item	Origin	Destination	Fiber Pairs	Units	Total Fibers
Near Det. Timing	MSB Relay Racks	NOvA primary cavern relay racks	1	2	4
Near Det. Network (DAQ)	MSB Relay Racks	NOvA primary cavern relay racks	2	1	4
Near Det. Network (DCS)	MSB Relay Racks	NOvA primary cavern relay racks	2	1	4
Near Det. Spares Lines	MSB Relay Racks	NOvA primary cavern relay racks	4	1	8
Future/Aux. Detectors	MSB Relay Racks	NOvA primary cavern relay racks	4	1	8
				Nova Near Det. Total Fibers:	28
Near Det. 2 Timing	MSB Relay Racks	NOvA secondary cavern relay racks	1	2	4
Near Det. 2 Network (DAQ)	MSB Relay Racks	NOvA secondary cavern relay racks	2	1	4
Near Det. 2 Network (DCS)	MSB Relay Racks	NOvA secondary cavern relay racks	2	1	4
Future/Aux. Detectors at secondary cavern	MSB Relay Racks	NOvA secondary cavern relay racks	4	1	8
Near Det. 2 spare lines	MSB Relay Racks	NOvA secondary cavern relay racks	4	1	8
				Nova Near Det. 2 Total Fibers:	28

In total we believe that 56 fiber strands are needed for NOvA near detector operations.

We believe that NOvA will require a total of not less than 28 fiber strands run between the MSB relay racks and each of the detector caverns. The fibers should be single mode and use passive junctions for joining different segments of the runs.

The details of the location and design of the secondary cavern are not yet complete, but the fibers required for this area could be deployed prior to the construction of the cavern and stored/coiled until the cavern is complete.