Next Generation Adaptive Optics System

Safety System Interfaces

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INTRODUCTION

As part of the Next Generation Adaptive Optics (NGAO) System, a Safety System (SS) will be provided to safe guard personnel and equipment. The NGAO System will include Class 4 laser(s) which can be hazardous to personnel and equipment if not operated properly. The safety system will provide proper safety interlocks to ensure the laser(s) are operating within safety guidelines. The safety system will be a Programmable Logic Controller that will interface to multiple subsystems. These interfaces provide sensor feedback to the safety system as well as allowing the safety system to provide status to these subsystems. This document specifies the interfaces between the safety system and NGAO subsystems.

References

1.1 Referenced Documents

Documents referenced in the requirements are listed in Table 1. Copies of these documents may be obtained from the source listed in the table.

Ref. #	Document #	Revision or Effective Date	Source	Title
1	TBD	TBD	WMKO	NGAO Safety System Requirement
2	Laser System Interface Signals.xls	1.0	WMKO	NGAO Laser System Interface Signals

Table 1: Reference Document.

1.2 Acronyms and Abbreviations

Table 2 defines the acronyms and abbreviations used in this document.

Acronym/Abbreviation	Definition
AAS	Aircraft Avoidance System
AO	Adaptive Optics
BTS	Beam Transfer System
LIS	Laser Interface System
LSE	Laser Service Enclosure
NC	Normally Opened
NGAO	Next Generation Adaptive Optics System
NO	Normally Closed
SS	Safety System
TBD	To Be Determined
TBD	To Be Determine
TFS	Telescope Facility System
TTL	Transistor-Transistor Logic
VDC	Volt Direct Current
WMKO	W.M.K. Observatory

Table 2: Acronyms and Abbreviations.

2 LASER SYSTEM CONFIGURATION

The SS communicates with six subsystems shown in Figure 1. Documents ref TBD provides the requirements for each of the subsystems. The subsequent sections shall provide a description of the interfaces to these subsystems.

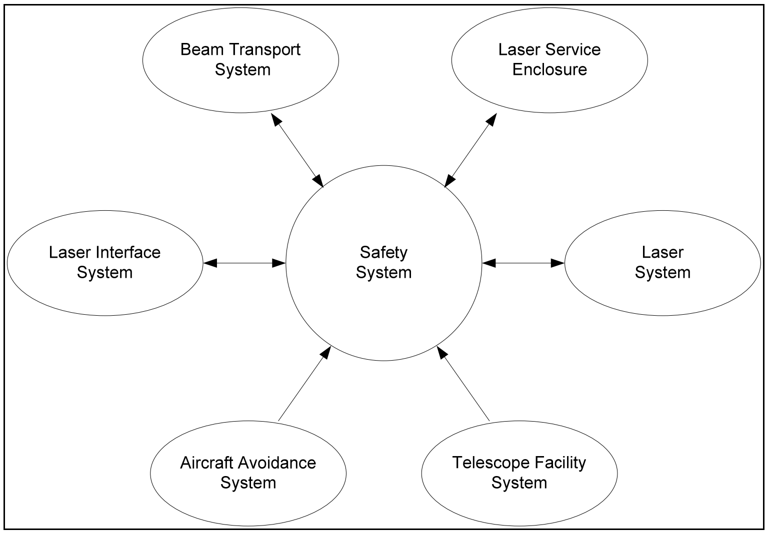


Figure 1: Laser System and interfaces

The SS controller is located in the laser service enclosure (LSE). Figure 2 shows a conceptual LSE for the laser system(s) and the SS. This configuration is a hybrid of the K1 laser system and current K2 laser system. The laser and its electronics are enclosed in a clean room environment with a double door entry system to contain laser radiation. The SS is in the vicinity to monitor the environment.

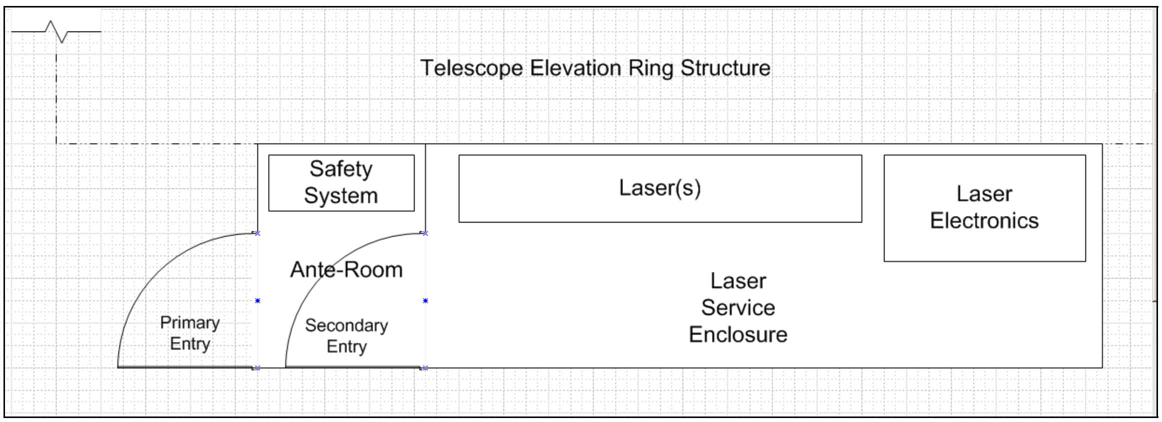


Figure 2: Laser System Configuration

3 GENERAL LASER SAFETY

3.1 Personnel Safety

The SS's highest priority is to protect personnel from hazards. These hazards include exposure to radiation, fire, and electrical hazards. To ensure personnel are not expose to radiation hazards, measures are taken either to control or contain the radiation. Controls can take the form of administrative, engineering or a combination of both. An example of administrative is to disallow personnel in the area when hazardous radiation exists. Engineering controls include electronics that prevent hazardous radiation from escaping an enclosure. Combination of both may include rules that personnel use proper eyewear when expose to hazardous radiation.

The radiation is contained by ensuring the enclosures and tubes the beam travels in are encapsulated, switch inputs from these enclosures provide the status. **Table 3** shows the switch inputs.

#	Switch inputs from	Subsystem
1	Laser Enclosure (s)	Laser
2	LSE Primary Door	LSE
3	LSE Secondary Dorr	LSE
4	Laser Beam Tube (s)	Laser Transport System
5	Beam Transport Optical Bench Cover	Beam Transport Optical Bench
6	Laser Launch Telescope Cover	Launch System
7	Dome Entry (s)	Facility Subsystem

Table 3: Enclosure Switches

Fire hazards are controlled by the use of proper materials and fabrication methods. In case there is a fire, proper extinguishing agents and notification shall be used to assure safety for personnel and equipment. Electrical hazards are generally controlled by proper fabrication and grounding techniques.

3.2 Equipment Safety

In addition to personnel safety, the SS shall protect the equipment from damage. These safety measures includes the sensing of the operational environment is within the tolerance of the equipment used. These two focuses make up the core of the SS and control.

4 SAFETY SYSTEM CONTROLLER ELECTRONICS INTERFACE

4.1 Inputs

The SS controller is expected to use compatible input devices similar to those in the **Table 4**. External devices with galvanic switches connected to the digital input signals must be capable of driving 100mA.

#	Input types	Device	Description
1	Temperature	1746-NTn*	Analog inputs for Thermocouples
2	Digital Inputs	1746-IBn*	Digital inputs with opto-isolators
3	TTL Inputs	1746-IGn*	TTL voltage inputs

4	Analog voltage Inputs	1746-NIn	Analog voltage inputs

**n represents the number of channels on the board*

Table 4: Safety System Electronics Inputs

4.2 Outputs

The SS controller is expected to use compatible output devices similar to those in the following figure:

#	Output types	Device	Description
1	Digital Output	1746-OBPn*	24VDC Analog Output with opto-isolators
2	TTL Output	1746-OGn*	TTL voltage inputs
3	Analog voltage Outputs	1746-OBPn*	24VDC Output (1Amp)

**n represents the number of channels on the board*

Table 5: Safety System Electronics Outputs

4.3 Network and Communications

The SS controller is expected to use the following formats for network and communications:

#	Communication	Cable Format	Description
1	Network	Category 5	Ethernet
2	RS232 Serial	DB9 pin	Serial communication

Table 6: Safety System Controller Network and Communications

4.4 Failed Safe Logic

Critical equipment dealing with personnel safety must use failed safe logic. The definition of failed safe logic is that a failure in the wiring or lost of power will result in the system going into a safe condition. Also in cases where failure of a device is critical, a secondary device is needed as a back-up.

5 Laser Service Enclosure

5.1 Electronics Interface

5.1.1 Personnel Safety

Containing radiation will require sensing of controlled areas via switches on doors or panels and notifying personnel as to the status of the laser system. To contain laser radiation, any enclosure in contact with Class 2 or greater radiation must include a switch to provide status of the enclosure, either open or close. The SS will sense these switches and take appropriate measures to ensure hazardous radiation is contained. The following table contains switches sensed by the SS and control SS to protect personnel safety.

#	Measurement	Direction	Interface	Description
1	Primary Door Switch	LSE to SS	Galvanic Switch	NC if door is closed
2	Secondary Door Switch	LSE to SS	Galvanic Switch	NO if door is closed
3	Laser Stop Inside LSE	LSE to SS	Galvanic Switch	NC if there is no laser stop

4	Laser Stop Outside LSE	LSE to SS	Galvanic Switch	NC if there is no laser stop
5	Entry/Exit Request	LSE to SS	Galvanic Switch	NO if there is no request
6	Door Lock	SS to LSE	Digital Voltage	24VDC to relay to release LSE door lack
7	System Status	SS to LSE	Digital Voltage	24VDC to LEDs to provide system status

Figure 3: Electronics Interface with LSE

The second part of controlling laser radiation is to inform personnel on the status of the laser system. An indicator panel is provided to personnel at the entry of each enclosure providing status. Status is divided into three categories as stated in the table below:

#	Indicator	Description
1	Red	Hazardous radiation exposure, do not enter.
2	Amber	Laser is ON; but hazardous radiation is contained; enter with caution
3	Green	Laser is OFF or no hazardous radiation exists; enter.

Table 7: Laser System Status

5.1.2 Fire Safety

To protect personnel and equipment, the LSE will include measures to sense smoke/fire, to provide notification, and to extinguish the fire without damage to equipment. To sense smoke and fire, the laser enclosure will include smoke/fire sensors that will be tied to the SS. The SS will take appropriate actions such as shutting down the laser system and notify the facility fire alarm system. The sensors shall provide a galvanic relay to notify the SS of a problem. In return, the SS shall provide a galvanic relay to the facility fire alarm system to sound a facility wide alarm. The facility fire alarm system is considered part of the TFS and is shown in Section 7.1. The following table shows the interfaces for fire safety:

#	Measurement	Direction	Interface	Description
1	Smoke/Fire sensor (s)	LSE to SS	Galvanic Switch	NC if there is no fire or smoke
2	Siren/Enunciator	SS to LSE	Galvanic Switch	NO if there is no fire or smoke

Table 8: Laser Service Enclosure Fire/Smoke Safety Interfaces

5.1.3 Equipment Safety

The laser system shall be delivered with its own safety features meeting laser safety standard Z136.1. The SS shall ensure the environment the laser system operates in is within the specification of the laser system. These include temperature, humidity, the availability of coolant, and pneumatics. The following table show the measurement and interfaces with the LSE:

#	Measurement	Direction	Interface	Description
1	Room Temperature (s)	LSE to SS	Thermocouple, J-K	Thermocouples located throughout the LSE.
2	Glycol Temperature In	LSE to SS	Thermocouple, J-K	Thermocouple located in a thermal well of the glycol in plumbing

3	Glycol Temperature Out	LSE to SS	Thermocouple, J-K	Thermocouple located in a thermal well of the glycol out plumbing
4	Glycol Flow Sensor	LSE to SS	Galvanic Switch	NC if flow is > set threshold
5	Humidity Sensor	LSE to SS	Galvanic Switch	NC if humidity < set threshold
6	Pneumatic Pressure	LSE to SS	Galvanic Switch	NC if pressure > set threshold

Table 9: Laser Service Enclosure Sensors to Safety System

5.2 Mechanical Interface

The LSE shall provide mating points for the SS as located in Figure 2.

6 LASER

6.1 Electronics Interface

For signal integrity, each status or command will have two signals defined as signal high and its complement signal low. Signal high is represented as a “1” and signal low is represented by a “0”. All signals will be TTL compatible. The differential state between the signals will determine the status or command. The maximum drain current of a TTL high will be 200mA.

The SS will employ compatible devices similar to the Allen Bradley input/output models: 1746-IG and 1746-OG. The appendix provides the signal formats for these modules.

Any indeterminate stats such as both the signal and its complement being high and or low will be an invalid state. When such a state occurs, the receiver of the signal will go into its failed safe state for that signal.

6.1.1 Laser Interface Signals

The following table shows the expected signals and their definition between the laser SS and the laser system:

#	Item	Direction	Description
1	5VDC Power and Ground	Laser to SS	Provides the voltage reference between the two systems.
2	Laser Status	Laser to SS	Informs SS if laser is ON or OFF
3	Laser Fault Status	Laser to SS	Informs SS if laser has faulted
4	Laser Shutter Status	Laser to SS	Informs SS the status of the laser shutter
5	Laser Shutter Status Fault	Laser to SS	Informs the SS the shutter has faulted
6	Laser Shutdown Command	SS to Laser	Commands the laser to shutdown
7	Laser Shutter Command	SS to Laser	Command the laser shutter to open

Table 10: Interface Signals

6.1.1.1 Laser Status

The laser is OFF when the *Laser Status+* is high and the *Laser Status-* is low. The laser is ON when the *Laser Status+* is low and the *Laser Status-* is high. All other states are invalid.

6.1.1.2 Laser Fault Status

The laser is faulted when the *Laser Fault+* is high and the *Laser Fault-* is low. The laser not faulted when the *Laser Fault+* is low and the *Laser Fault-* is high. All other states are invalid and considered faulted.

6.1.1.3 Laser Shutter Status

The laser shutter is opened when the *Laser Shutter+* is high and the *Laser Shutter-* is low. The laser shutter is closed when the *Laser Shutter+* is low and the *Laser Shutter-* is high. All other states are invalid.

6.1.1.4 Laser Shutter Fault Status

The laser shutter is faulted when the *Laser Shutter+* is high and the *Laser Shutter-* is low. The laser shutter is operational when the *Laser Shutter+* is low and the *Laser Shutter-* is high. All other states are invalid and considered faulted.

6.1.1.5 Laser Shutdown Command

The laser is commanded to shutdown when the *Laser Shutdown+* is high and the *Laser Shutdown-* is low. The laser is allowed to operate when the *Laser Shutdown+* is low and the *Laser Shutdown-* is high. All other states are invalid and the shutter must shutdown upon these states.

6.1.1.6 Laser Shutter Command

The laser is commanded to close its shutter when the *Laser Shutter+* is high and the *Laser Shutter-* is low. The laser is commanded to open its shutter when the *Laser Shutdown+* is low and the *Laser Shutdown-* is high. All other states are invalid and the shutter is to remain closed.

6.2 Mechanical Format

The mechanical interface between the SS and the laser system will b a MS3120F14-15S or equipment. The pin location is represented in the table below:

#	Item	Description
A	Shield	Overall shield for cable
B	5VDC	5VDC power
C	5VDC common	5VDC power reference
D	Laser Status	Informs SS if laser is ON
E	Laser Status compliment	Informs SS if laser is ON (compliment)
F	Laser Fault	Informs SS the laser faulted
G	Laser Fault compliment	Informs SS the laser faulted compliment
H	Laser Shutter Status	Informs SS shutter status
J	Laser Shutter Status compliment	Informs SS shutter status compliment

K	Laser Shutter Fault Status	Informs SS shutter fault status
L	Laser Shutter Fault Status compliment	Informs SS shutter fault status compliment
M	Laser Shutdown	Informs the laser to shutdown
N	Laser Shutdown compliment	Informs the laser to shutdown compliment
P	Laser Shutter Command	Informs the laser to open its shutter
R	Laser Shutter Command compliment	Informs the laser to open its shutter compliment

Table 11: Mechanical Interface and Pin-out

7 TELESCOPE FACILITY SYSTEM

The telescope facility system (TFS) provides information to the SS to shut the laser system off in an emergency. The fire alarm system is considered part of the facilities. The SS will inform the fire alarm system in case of smoke/fire. In addition, the facility may interface with the laser system if it becomes necessary for the dome environment to become a non-safe eye hazard area, Class 2 or greater. Similar to the LSE, dome enclosure switches will be fed to the SS and the SS will provide notification to personnel prior to entering the dome area.

7.1 Electronics Interface

Table 12 shows the signals from the TFS to the SS.

#	Item	Direction	Type	Description
1	Dome Enclosure (s)	TFS to SS	Galvanic switch	NC unless activated
2	Facility E-STOP	TFS to SS	Galvanic switch	NC unless activated
3	Facility Fire Alarm System	SS to TFS	Galvanic Switch	NO if there is no fire or smoke
4	System Status	SS to TFS	Digital Voltage	24VDC to LEDs to provide system status

Table 12: AAS signals to Safety System

7.2 Mechanical Interface

The SS will provide an indicator panel with the lights showing the condition of the laser. A panel with indicators described in Table 13 shall be provided at entry/egress points.

#	Indicators	Description
1	Red	Hazardous radiation exposure, do not enter.
2	Amber	Laser is ON; but hazardous radiation is contained; enter with caution
3	Green	Laser is OFF or no hazardous radiation exists; enter.

Table 13: Dome Indicator Panels

8 LASER INTERFACE SYSTEM

The Laser System Interface (LIS) is a computer or server communication with the SS. This computer will communicate via a serial connection with the SS.

8.1 Mechanical Interface

The mechanical interface will be a DB9 connection running the RS232 format with hardware flow control. The SS will host a DB9 male connector. The SS's DB9 connector is female. The pin-out of the connection is shown in the table below.

Pin	Abbreviation	Description
1	DCD	Carrier Detect
2	RxD	Receive Data
3	TxD	Transmit Data
4	DTR	Data Terminal Ready
5	G	Common Ground
6	DSR	Data Set Ready
7	RTS	Request to Send
8	CTS	Clear to Send
9	RI	Ring Indicator

Table 14: Serial Connection Pin-out

8.2 Software Interface

The software interface is provided in document TBD. This interface specifies the format of the data and the data description between the Laser System Interface and the SS.

9 BEAM TRANSPORT SYSTEM

The Beam Transport System (BTS) relays the beam from the laser system to the centrally projected launch telescope behind the prime focus location on the telescope. Due to the high power of the laser beam, the beam must be contained within a specific volume of space. If the beam escapes this volume, it is possible for these contact points to become heated and worst case catching on fire. To prevent this, position sensors will be located throughout the beam path to ensure the beam is operating within the specified regions. The BTS will also incorporate a final shutter in addition to the laser shutter that is part of the laser system. The combination of these two shutters provides the redundancy necessary for this function. For personnel safety, indicators will be provided at the BTS servicing location to provide system status and a method to disable (close) the shutter sending the beam into the BTS.

9.1 Electronics Interface

**There is likely there will be more than one position sensor.*

Table 15 provides the interface signals between the BTS and the SS.

#	Item	Direction	Type	Description
1	Position Sensor(x)	BTS to SS	Analog Voltage	Position of the beam on the x-axis of position sensor.*
2	Position Sensor(y)	BTS to SS	Analog Voltage	Position of the beam on the y-axis of position sensor.*

3	Position Sensor(Sum)	BTS to SS	Analog Voltage	Power of the beam on position sensor.*
4	Final Shutter Close Switch	BTS to SS	Galvanic switch	NC when the shutter is closed.
5	Final Shutter Open Switch	BTS to SS	Galvanic switch	NC when the shutter is closed.
6	Cover Switches	BTS to SS	Galvanic switch	NC when covers are closed
7	Disable shutter to BTS	BTS to SS	Galvanic switch	NC to enable shutter to BTS
8	Final Shutter Command	SS to BTS	Digital Voltage	24VDC to command shutter to open
9	System Status	SS to BTS	Digital Voltage	24VDC to LEDs to provide system status

**There is likely there will be more than one position sensor.*

Table 15: BTS signals with SS

10 AIRCRAFT AVOIDANCE SYSTEM

The aircraft avoidance system (AAS) provides information to the SS for the permissive to open the final shutter. Opening of the final shutter can impact personnel safety with hazardous radiation inside the dome or in the airspace above Mauna Kea. Sensors such as the spotters' stops, aircraft detection cameras and/or health of these systems are inputs to the final shutter permissive.

10.1 Electronics Interface

The following table provides the signals between the SS and the AAS:

#	Item	Direction	Type	Description
1	East Spotter Stop	AAS to SS	Galvanic switch	NC unless activated
2	West Spotter Stop	AAS to SS	Galvanic switch	NC unless activated
3	East Spotter Connected	AAS to SS	Galvanic switch	NC when spotters unit is online
4	West Spotter Connected	AAS to SS	Galvanic switch	NC when spotters unit is online
5	Narrow field camera	AAS to SS	Galvanic switch	NC when aircraft is not detected
6	Narrow field camera health	AAS to SS	Galvanic switch	NC when camera is up and operating
7	Wide field camera	AAS to SS	Galvanic switch	NC when aircraft is not detected
8	Wide field	AAS to SS	Galvanic switch	NC when camera is up and

	camera health			operating

Table 16: AAS signals to Safety System

10.2 Mechanical Interface

The mechanical interface between the AAS spotters' equipment and the SS will be a MS3120F14-10S or compatible equipment. There may be an East and West Spotters' pack. The pin location is represented in the table below:

#	Item	Description
A	Shield	Overall shield for cable
B	24VDC	24VDC power
C	24VDC common	24VDC power reference
D	West spotter stop	Opens when activated
E	West spotter connected	Opens when not connected
F	Spare	
G	Spare	
H	Spare	
J	Spare	
K	Spare	

Table 17: Spotter's Interface to SS

11 APPENDIX: ALLEN BRADLEY MODULES

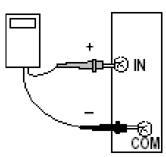
Sourcing TTL Input Module (1746-IG16)

Specification		Catalog Number 1746-IG16 (RTB)
Voltage Category		5V dc TTL source
Operating Voltage		4.5 to 5.5V dc source 50 mV peak-to-peak ripple max.
Number of Inputs		16
Points per Common		16
Backplane Current Draw	5V	0.140A
	24V	0.0A
Signal Delay (max.)		on = 0.25 ms off = 0.50 ms
Off-State Voltage (max.)		2.0V dc ①
Off-State Current (max.)		4.1 mA
Nominal Input Current		3.7 mA at 5V dc

① TTL inputs are inverted (–0.2 to +0.8 = low voltage = True = on). Use a NOT instruction in your program to convert to traditional True = High logic.

RTB = Removable Terminal Block.

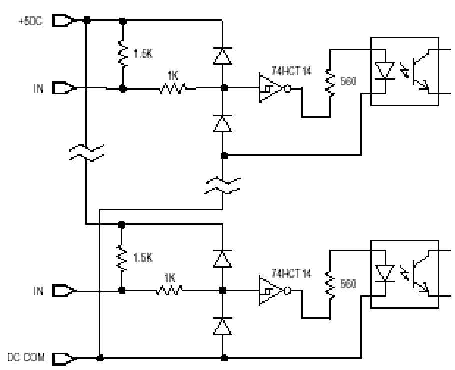
On/Off-State Voltage Range



(Measure voltage from common terminal to input terminal.)

TTL inputs are inverted (– 0.2 to +0.8 = low voltage = True = On).

Circuit and Wiring Diagrams



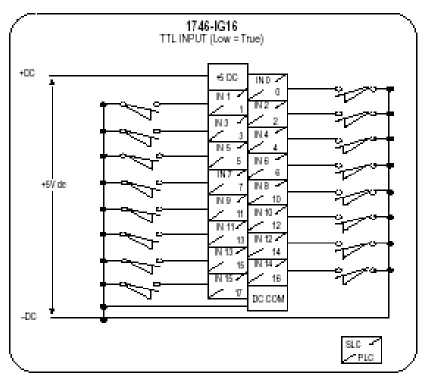


Figure 4: Allen Bradley 1746-IG16 Input Module

Sinking TTL Output Module (1746-OG16)

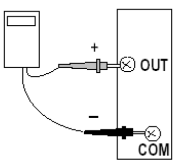
Specification		Catalog Number 1746-OG16 (RTB)
Voltage Category		5V dc TTL ①
Operating Voltage Range		4.5 to 5.5V dc 50 mV peak-to-peak ripple maximum 495 MA maximum at 5V dc
Number of Outputs		16
Points per Common		16
Backplane Current Draw	5V	0.180A
	24V	0.0A
Signal Delay (max.) (Resistive Load)		on = 0.25 ms / off = 0.5 ms
Off-State Leakage (max.)		0.1 mA
Load Current (min.)		0.15 mA
Continuous Current (max.)		24 mA

① TTL outputs are inverted (0–0.4V dc = low voltage = True = On). Use a NOT instruction in your ladder program to convert to traditional True = High logic.

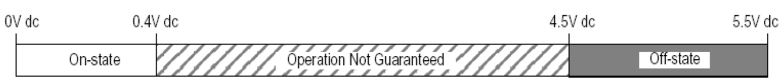
RTB = Removable Terminal Block.

NA = not applicable.

On/Off-State Voltage Range

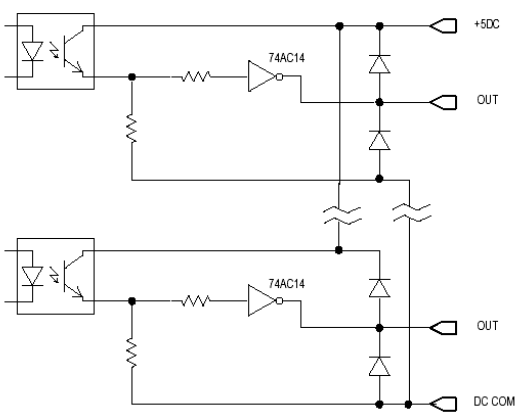


(Measure voltage from common terminal to output terminal.)



TTL inputs are inverted (0–0.4V dc = low voltage = True = On).

Circuit and Wiring Diagrams



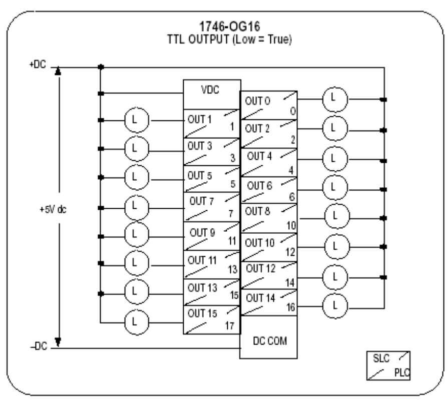


Figure 5: Allen Bradley 1746-OG16 Module

Sinking DC Input Modules (1746-IB8, -IB16, -ITB16, -IB32)

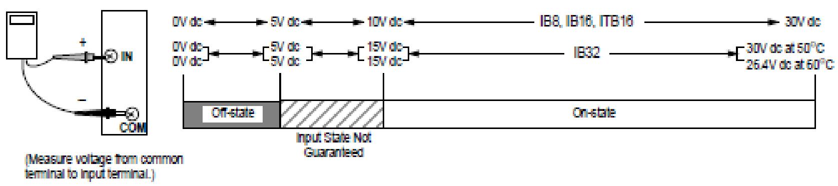
Specification		Catalog Number			
		1746-IB8	1746-IB16 (RTB)	1746-ITB16 (RTB) (Fast Response)	1746-IB32[1]
Voltage Category		24V dc sink			
Operating Voltage		10 to 30V dc sink			15 to 30V dc at 50°C sink 15 to 26.4V dc at 60°C sink
Number of Inputs		8	16	16	32
Points per Common		8	16	16	8
Backplane Current Draw	5V	0.050A	0.085A	0.085A	0.106A
	24V	0.0A	0.0A	0.0A	0.0A
Signal Delay (max.)		on = 8 ms off = 8 ms	on = 8 ms off = 8 ms	on = 0.3 ms[2] off = 0.5 ms	on = 3 ms off = 3 ms
Off-State Voltage (max.)		5V dc	5V dc	5V dc	5V dc
Off-State Current (max.)		1 mA	1 mA	1.5 mA	1.6 mA
Nominal Input Current		8 mA at 24V dc			

[1] The 32-point input modules are fused to protect external wiring, one fuse per common. These fuses are non-replaceable and are rated at 2.5A.

[2] Typical signal delay for these modules: on=0.10 ms, off=0.25 ms at 24V dc.

RTB = Removable Terminal Block.

On/Off-State Voltage Range



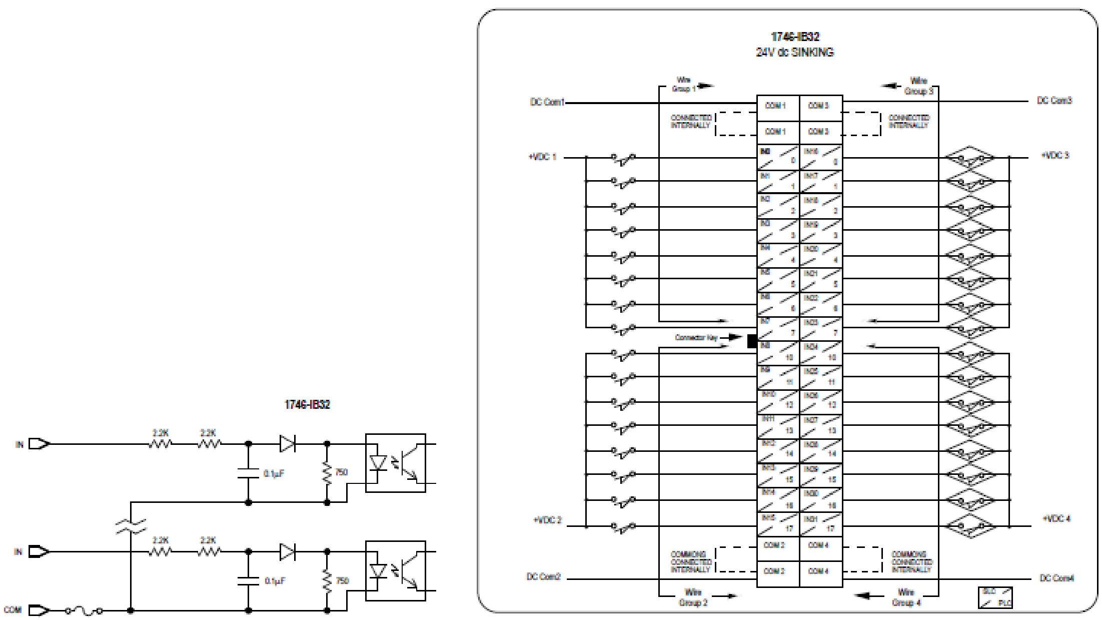


Figure 6: Allen Bradley 1746-IB32 Module

High Current Sourcing DC Output Modules (1746-OBP8, -OBP16)

Specification		Catalog Number	
		1746-OBP8 (RTB)①	1746-OBP16 (RTB)①②
Voltage Category		24V dc	
Operating Voltage		20.4 to 26.4V dc source	
Number of Outputs		8	16
Points per Common		4	16
Backplane Current Draw	5V	0.135A	0.250A
	24V	0.0A	0.0A
Signal Delay (max.) (Resistive Load)		on = 1.0 ms / off = 2.0 ms	on = 0.1 ms / off = 1 ms
Off-State Leakage③ (max.)		1 mA	
Load Current (min.)		1 mA	
Continuous Current (max.)	Per Point	2.0A at 60°C	1.5A at 30°C 1.0A at 60°C
	Per Module	8.0A at 0° to 60°C	6.4A at 0° to 60°C
On-State Voltage Drop (max.)		1V at 2A	1V at 2A
Surge Current④ (max.)	Per Point	4A for 10 ms	4A for 10 ms
	Per Module	32A for 10 ms	32A for 10 ms

① The 1746-OBP8, Series B and later, and 1746-OBP16 provide fast turn-off delay for inductive loads. Fast off delay for inductive loads is accomplished with surge suppressors on this module. A suppressor at the load is not needed unless another contact is connected in series. If this is the case, a 1N4004 diode should be reverse wired across the load. This defeats the fast turn-off feature. Comparative turn-off delay times for 1746-OB8/-OV8 and 1746-OB16E, Series B and later/-OBP8, Series B and later/-OBP16/-OVP16, when switching Bulletin 100-B110 (24W sealed) contactor, are: 1746-OB8/-OV8 off delay = 152 ms; 1746-OB16E, Series B and later/-OBP8, Series B and later/-OBP16/-OVP16 off delay = 47 ms.

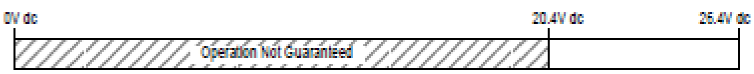
② A fused common and blown fuse LED are provided on this module. For replacement fuse, use catalog number 1746-F8 or Littlefuse 322010. Refer to page 9 for additional information.

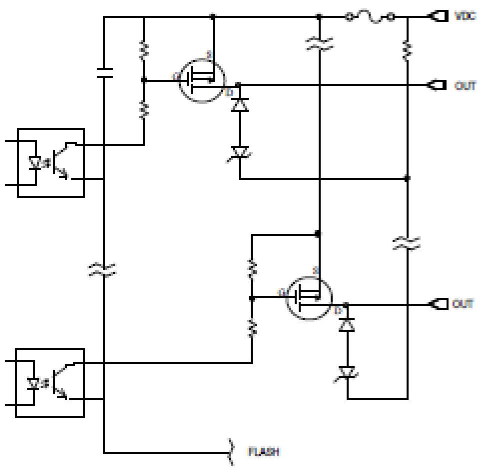
③ To limit the effects of leakage current, a loading resistor can be connected in parallel with your load. For 24V dc operation use a 5.6k ohm, 1/2W resistor.

④ Repeatability is once every 1 second at 30 °C. Repeatability is once every 2 seconds at 60°C.

RTB = Removable Terminal Block.

Operating Voltage Range





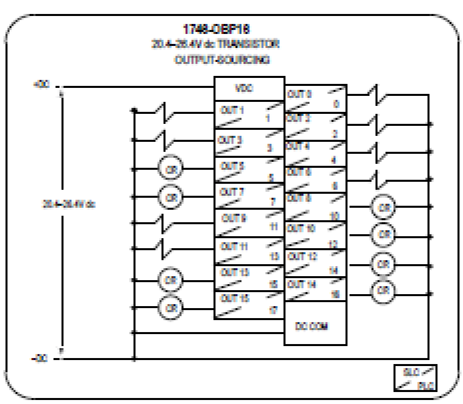


Figure 7: Allen Bradley Module 1746-OBP-16

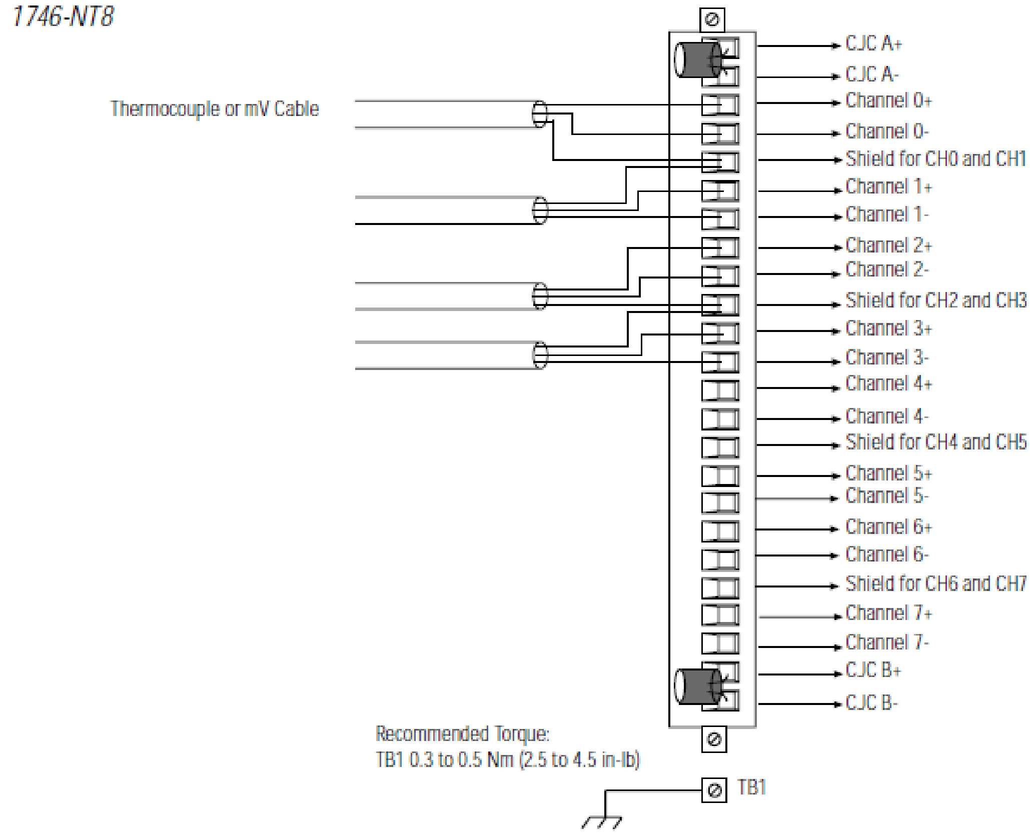


Figure 8: Allen Bradley Module 1746-NT8 Wiring

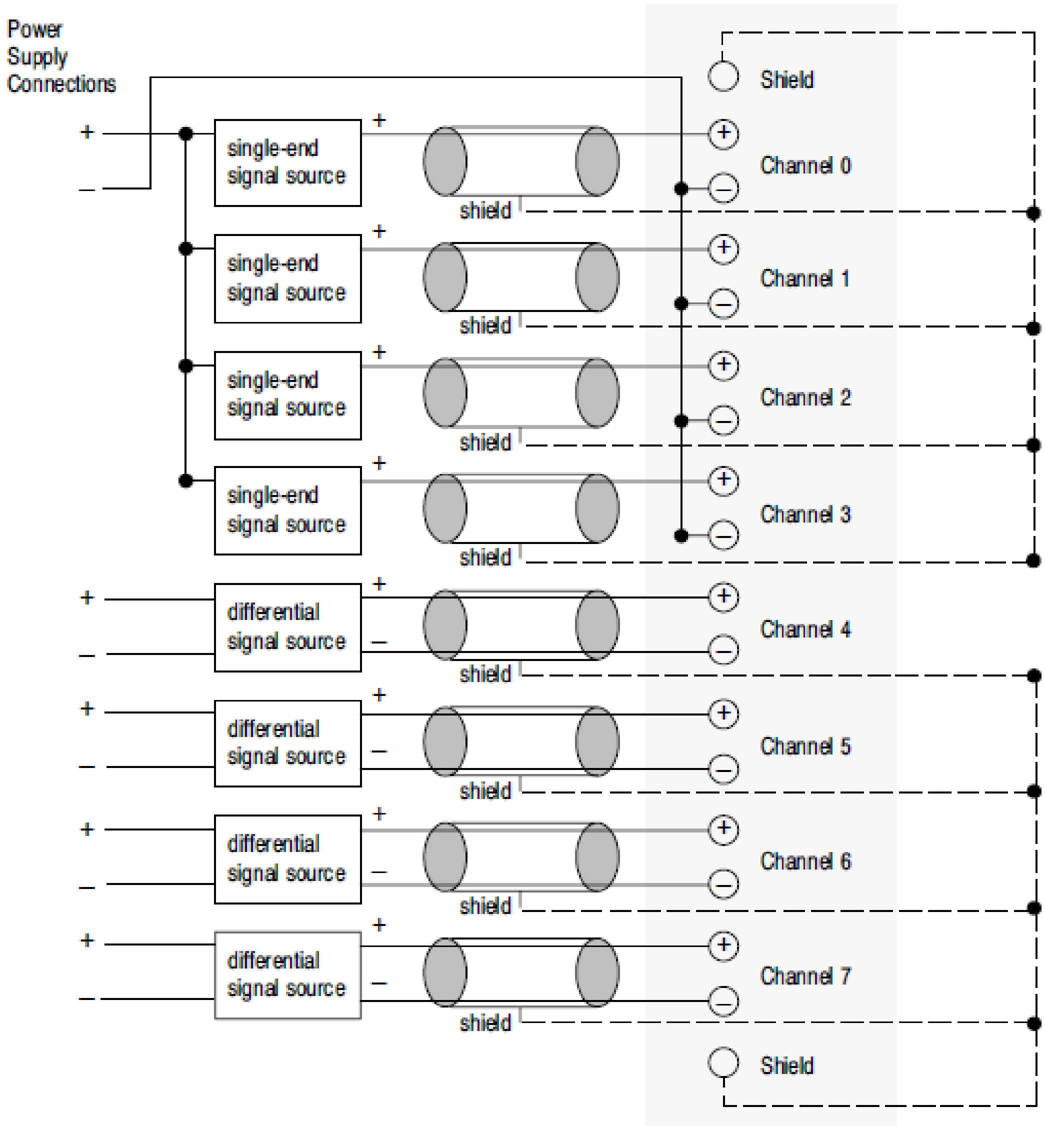


Figure 9: Typical Wiring for Allen Bradley Module 1746-NI8 (Single and Differential Ended)