MAC VALVES, INC.

DOCUMENT NUMBER

TITLE: Control Manual for MAC EtherCAT® MI/O-67 Manifold

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Control Manual
For
MAC Valves EtherCAT
MI/O-67 Serial Manifold
10/31/2018

1. System Overview

A. EtherCAT®

EtherCAT® is protocol which started with Beckhoff controllers and has migrated to other devices sharing a common control network. It is an EtherNet based system and supervised by the EtherCAT® Technology Group.

Unlike EtherNet I/P, EtherCAT® does not depend on an IP Address inside the network. It is an auto-incremental addressing system which looks at the network slaves and assigns the addresses in order. Thus, pre-assigning IP Addresses to the slaves is not necessary.

The master (a PC or PLC with its network scanner) and slave devices are connected via a standard D-coded M12 connector on an Ethernet cable. The valve and electronics' +24VDC will have to be supplied to the MI/O-67 manifold via an additional cable.

The MAC MI/O-67 Serial Manifold is a slave device within the EtherCAT® network. Thus, it will respond to all of the commands associated with the network like any other node of its type.

Each manifold occupies a single node on the network. The system is highly configurable using a large variety of modules. These modules are: Digital I/O, Analog I/O (0-10V or 4-20mA), and Valve Driver modules. Up to twelve of these modules in any combination can reside on a single valve stack. It all starts with the Communications Module and a valve stack.

The main communications module is call the Comms Module. This is the frontend interface to the network and the EtherCAT® Master. It can operate 32 valve drivers for the stack valves, route power for the stack valves and electronics, and control the CAN bus backplane which interfaces to the modules.

The stack will come fully assembled***. However, if a need arises to add or subtract***

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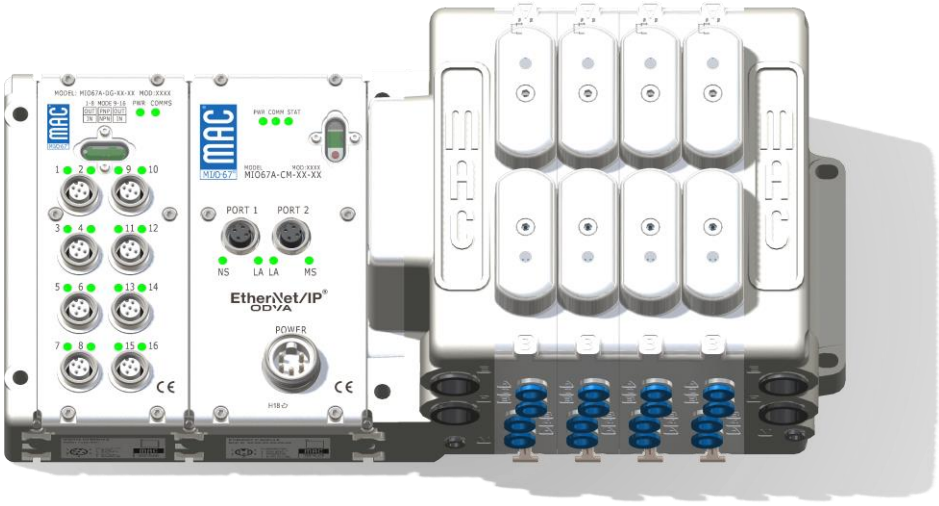
modules, turn off all power and air prior to changing the module configuration. These modules are not designed to be hot swapped.

The valve stack can operate up to 32 solenoids in any combination of double and single solenoid valves. It is set up for 24VDC valves. A four valve stack (92 series) with the Comms Module is shown in **Figure 1**.

Figure 1 Typical Stack



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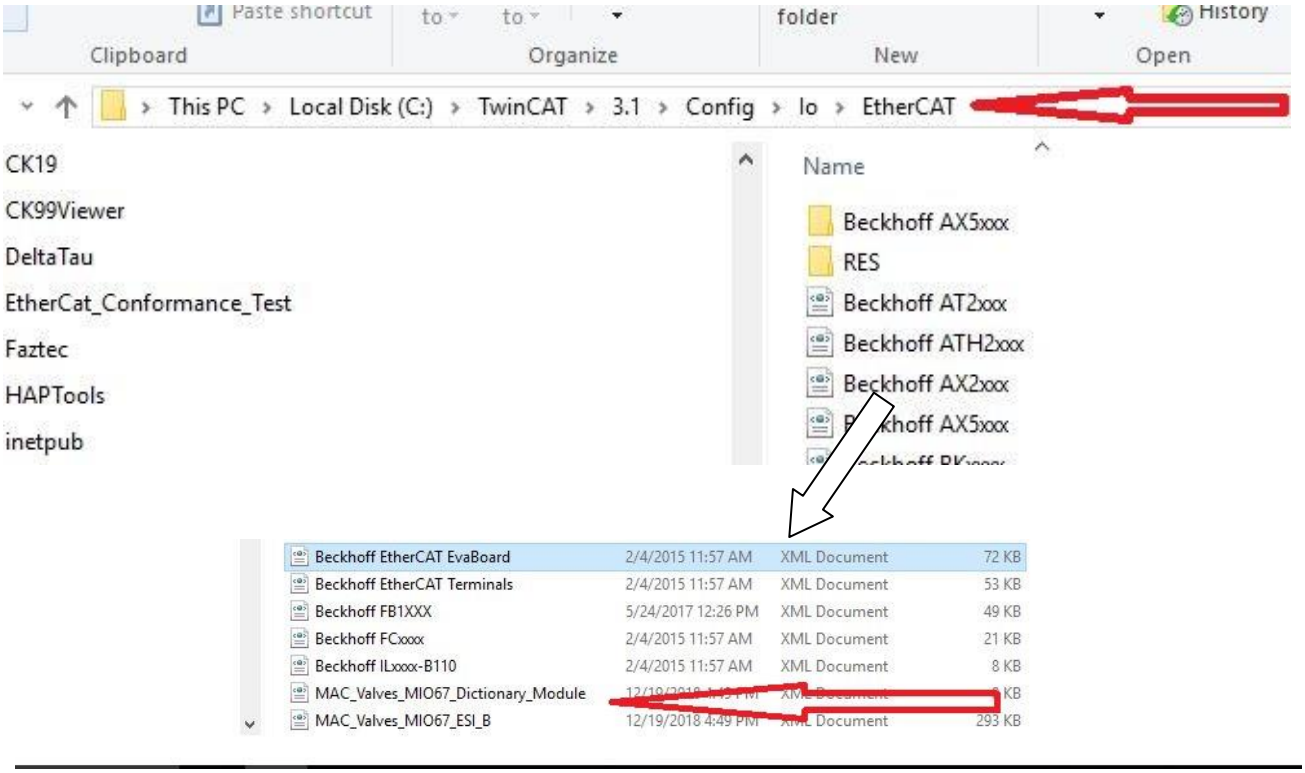
System Setup

A. ESI Loading

The product has files which tell the controller its identity. These files are called EtherCAT® Slave Information Files (or ESI files for short). To use these files, first, load the ESI file into the software directory of the master so it can be used for the slaves. For purpose of examples, this manual will use Beckhoff TwinCat3® software. Other software and versions might look different but they will operate basically the same.

The two files which are loaded into the Master's subdirectory are named: MAC_Valves_MIO67_Dictionary_Module and MAC_Valves_MIO67_ESI_B. They are both in .XML format. Copy these files as shown in **Figure 2**.

Figure 2 ESI Loading



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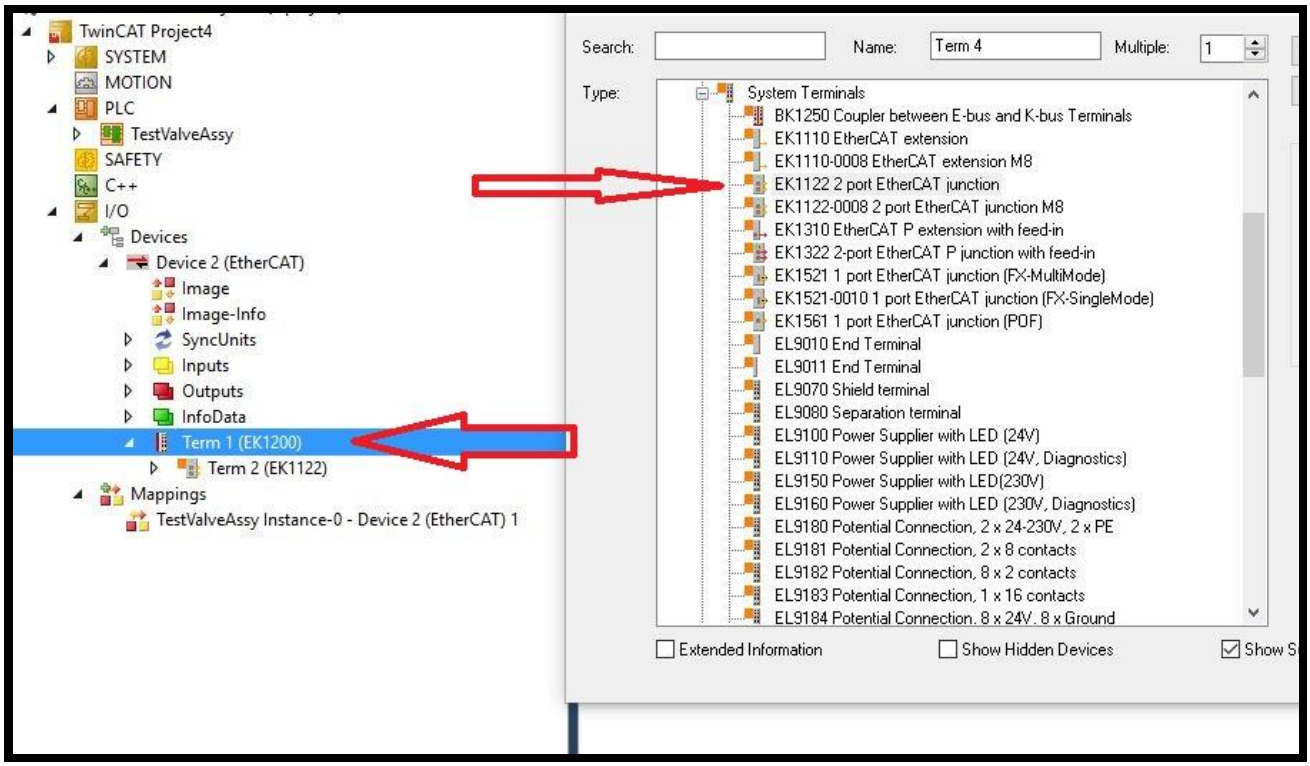
B. Project Creation

The next step in getting a new network set up is to load the EtherCAT® interface into the system.

After creating a new project, this interface module must be added to the network. In this example, there will be one MI/O-67 node and are using an EK1122 EtherCAT® module as the driving element. Some controllers have this feature built in. Shown below is a project with the EK1122 module attached.

To add the EK1122, right click on EK1200, where a menu will appear. Select "Add New Item" and another menu will appear. From that menu, select EK1122 as shown. The EK1122 will then be added to the project tree as shown in **Figure 3**.

Figure 3 EtherCAT® Slice Loading



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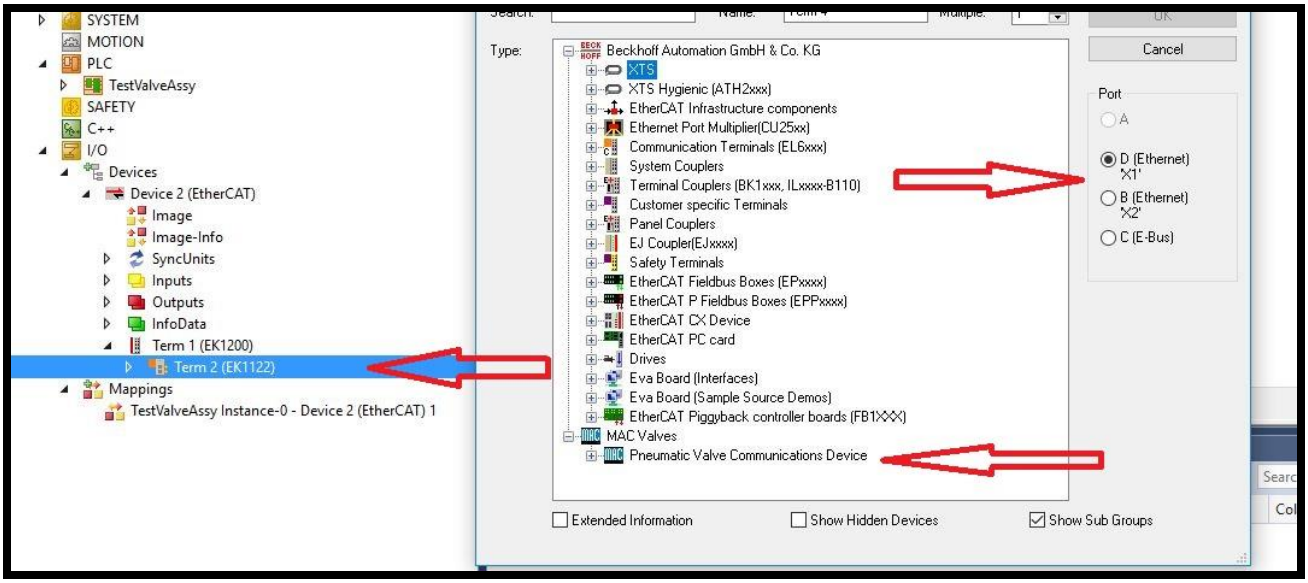
C. Valve Stack Addition

Next, the MAC Valves MI/O-67 must be loaded into the network. Right click on the EK1122 icon and again add a new item.

This time, select which EtherCAT® node (connector) to use and select the MAC Valves Pneumatic Valve Communications Device module shown in **Figure 4**. Repeat these steps for each new valve stack.

Figure 4 MI/O-67 Loading



D. Valve Stack Module Addition

If your valve stack happens to have one or more of the modules included, then the next step is to bring this information into the controller.

This is done by selecting the stack in the tree on the left. A menu will appear on the right of the screen. Select the "Slots" tab on the top where the slots will appear for the valves stack plus the module names.

There are twelve slots for modules on this product. Plus, there are twelve possible module types. Note, the Power Plus Module is called out as a Valve Driver +PI on the list. The module called out as just Valve Driver is for future development. This is shown in **Figure 5.**

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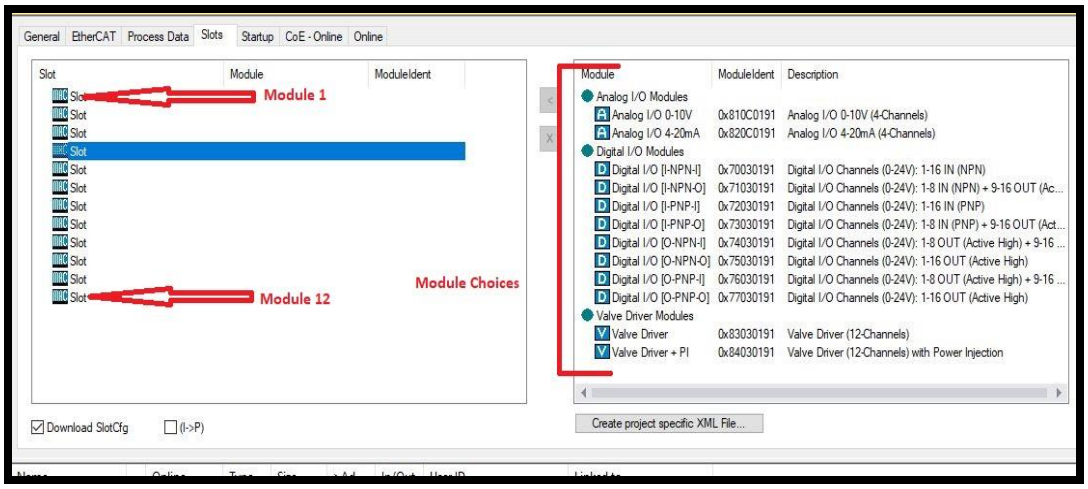
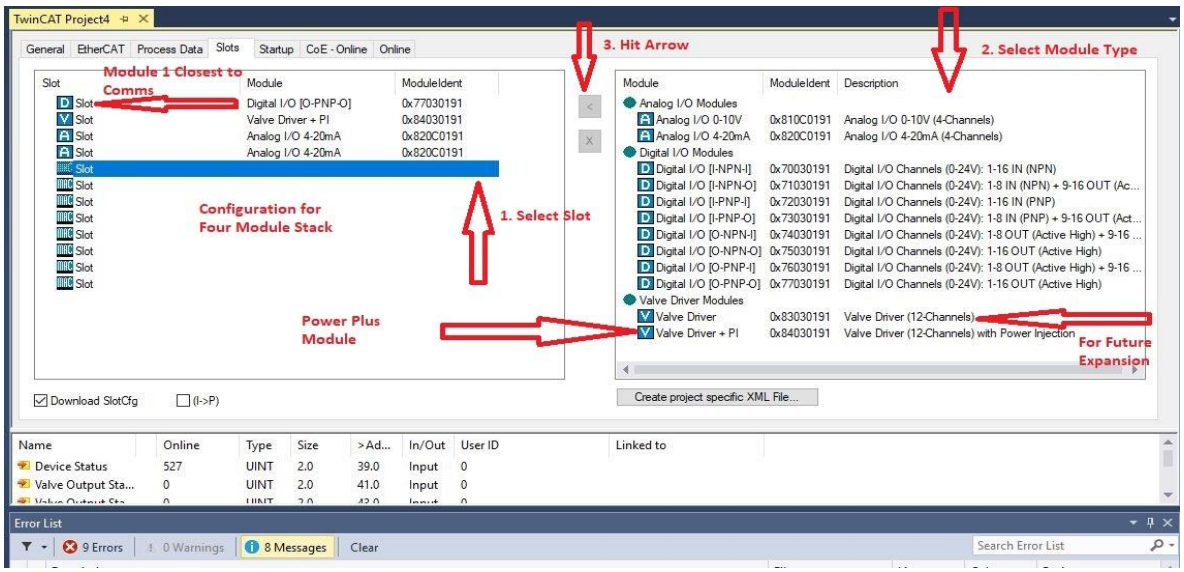
Figure 5 MI/O-67 Module Slot Loading



To add modules, select the slot (top slot is closest to the Comms Module), select the desired module type, and select the < arrow as shown in **Figure 6.**

In the example below, the module has a Digital I/O (all outputs) on Slot 1, Power Plus Module on Slot 2, and two Analog I/O 4-20mA Modules on Slots 3 and 4. Notice the Module Ident is unique to each module type.

Figure 6 Module Loading Example



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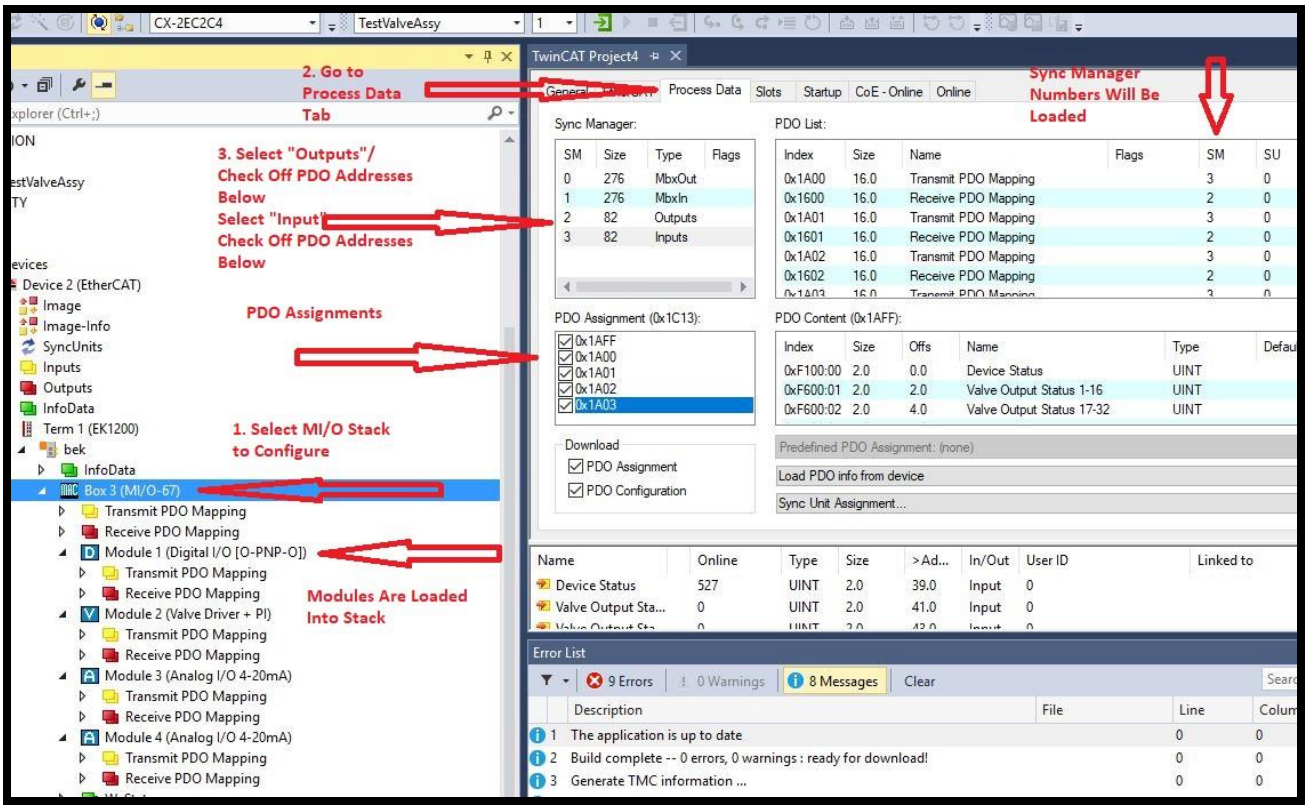
Load the modules onto the stack by first selecting the stack and pulling down the Process Data tab. Select the “Outputs” and “Inputs” and check off the PDO address assignments. The modules will then appear on the stack to the left as shown in **Figure 7**.

Figure 7 Process Data Load



Sync Manager Rx PDO

Index = 1c12h
SubIndex = 0, Access = RW, Assigned PDO =01h (default), valid range 0-13
SubIndex = 1, Access = RW, Assigned PDO = 16ffh
SubIndex = 2-13, Access = RW, Assigned PDO = 0000h (default)

Sync Manager Tx PDO

Index = 1c12h

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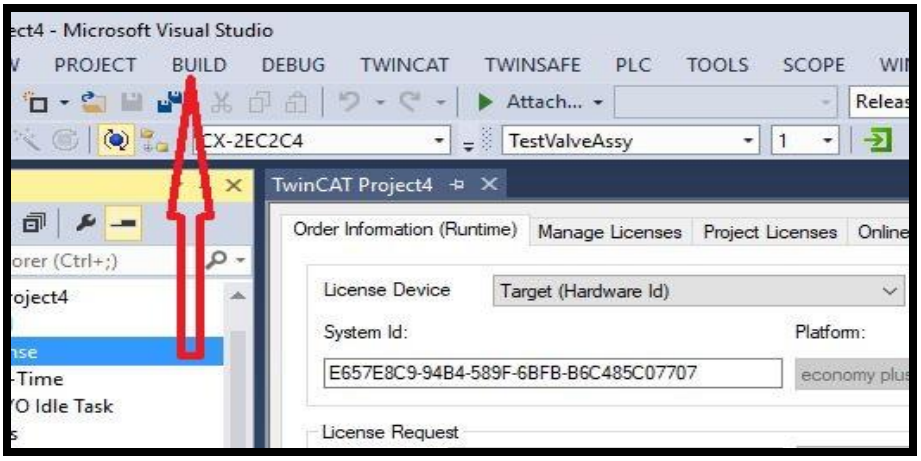
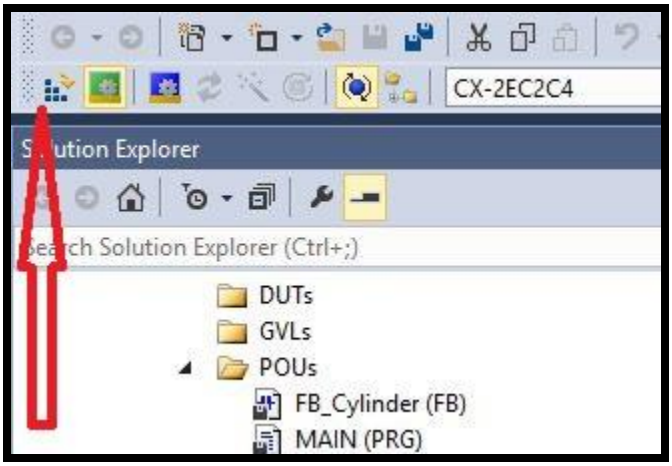
To finish the loading process, first, “Build” the project. Pull down the “Build” menu, select “Build TwinCAT (project name)” as shown in **Figure 8**.

Figure 8 Build Function



Next, select “Activate Configuration” as shown in **Figure 9**.

Figure 9 Configuration Activation



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3. Valve Structure

A. Applicable MAC Valve Series for the MI/O-67

Following are the valves, which can be used with the MI/O-67 Valve Manifold:

92 Series	36 Series
42 Series	46 Series

For other valve types, please consult the factory

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4. Power Wiring and Connectors

A. Connectors-Power

There are two versions for the power connector on the Comms Module. The first one is a five pin version shown in **Figure 10**. The functions of each pin are illustrated in **Figure 11**.

Also shown is **Figure 10** are the two communications M12 connectors label “In” and “Out”.

Below the communications connectors are a series of four LEDs. They track the data exchange, run status, and if the module has errors with the communications.

The three LEDs on the top edge are for the CANbus backplane health. Their uses are defined in Section 15, Troubleshooting Guide.

Figure 10 EtherCAT® Comms Module

If it is desired to add or subtract modules from the stack, ***it is very important to remove all the power prior to connecting or discounting the modules. Failure to do this could result in module damage.***

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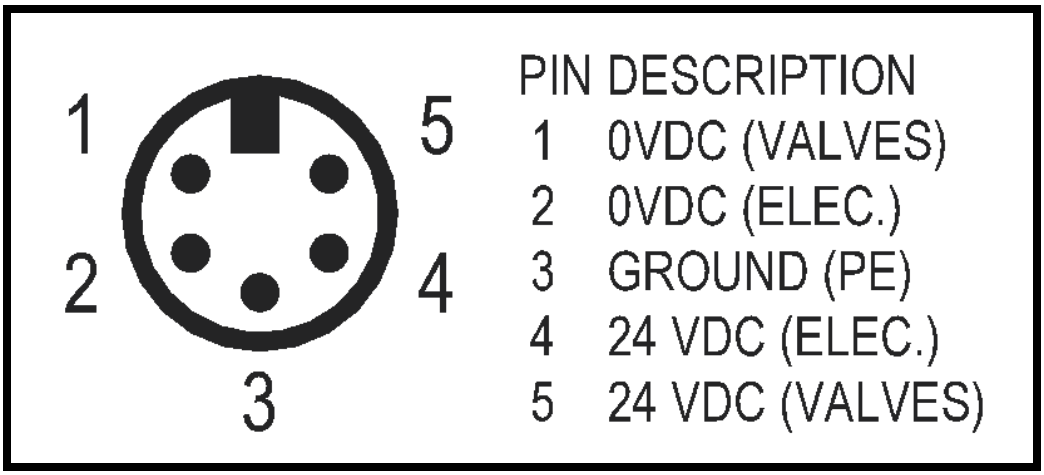
There are two separate power systems on the power connector. The first is the +24VDC required for the valves. The largest current a single valve can consume is 500mA. The maximum current through this line is 8.0A. The second being the power required for the electronics. With this set up, it is possible to run the electronics independent of the valves. If it is desirable to keep the electronics "awake," while the valve power is off, then two separate power supplies will be necessary. By disconnecting the valve power supply and keeping the electronics supply active, the node will stay online but the valves will not operate. Please note that it is also important to make a connection to the Earth.

Figure 11 Power Connector Pin-Out



The other version is a four pin connector as shown in **Figure 12**. The pin out for this option is shown in **Figure 13**.

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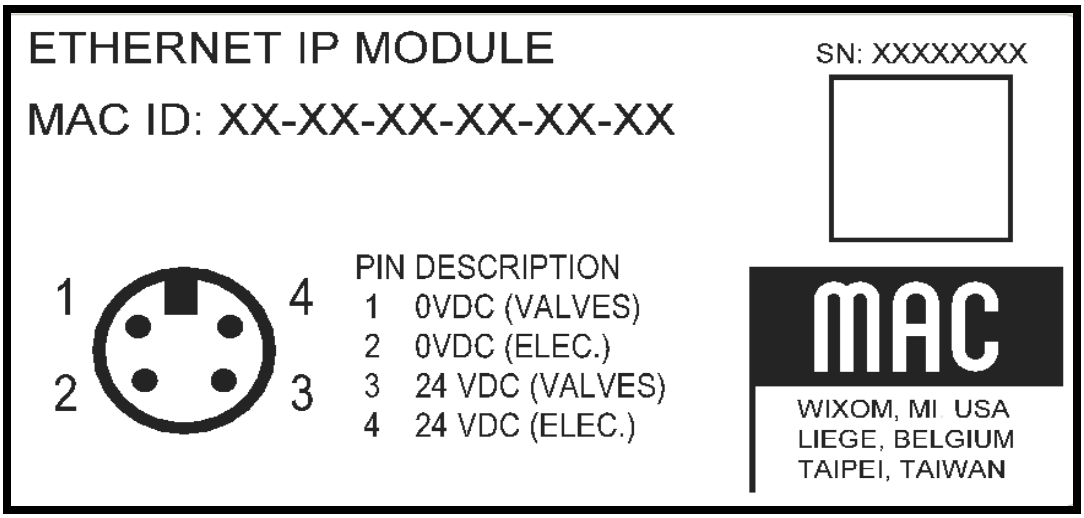
Figure 12 Comms Module, 4 pin Power Connector

Figure 13 Power Connector, 4 Pin, Pin-Out



As stated earlier, the MI/O-67 system has two power paths for the valves and the

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modules as shown in **Figure 14**. In addition to that, the Power Plus Module uses an external power connector to operate the valves connected to that module which is independent of both the electronics power and valve power from the Comms Module.

a. Valve Power

The first power system is for the valves on the stack. It is isolated from the electronics power and thus can be separately disconnected if desired. It can pass up to 7.6A at 24VDC maximum. To calculate the total power for the valve line, use the following formula:

Total Current (Amps) = Number of Valves x (Valve Wattage/24) +0.4A $\leq$ 7.6 Amps.

If there are valves of different wattages on the stack then each group of wattages must be added up separately. Thus:

Total Current (Amps) = [Number of Valves (Wattage1) x (Valve Wattage1/24)] + [Number of Valves (Wattage2) x (Valve Wattage2/24] + [Number of Valves (Wattage3) x (Valve Wattage3/24] + [Number of Valves (Wattage4) x (Valve Wattage4/24)] …..etc.

Note: Valve wattage must be $\leq$ 12 watts per channel at 24VDC.

b. Electronics Power

There is an isolated power line which also can handle up to 8 Amps at 24VDC. This line is used for the EtherCAT® electronics, module electronics, sensors/loads for the various modules, and the electronics (but not the outputs) of the Power Plus Module.

i. Comms Module

The Comms Module will consume 140mA from the 8A total. Thus, for additional modules, and assuming there is 8A available at the connector, the first module will have 7.86A maximum to work with.

ii. Analog Module, Current

The Analog Module can operate 4 channels of 4-20mA outputs at the same time. If all the channels are running at maximum output the module will consume 130mA from the electronics power allotment per module.

iii. Analog Module, Voltage

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Like the Analog Current Module above, the Analog Voltage Module has four channels which can output 10V at a maximum of 16mA per channel. This module will consume, at maximum output, 115mA per module from the electronics power allotment.

iv. Digital I/O Module

The modes of the Digital I/O Module must be considered when calculating the module's current draw.

If the module is run completely as an output unit, then the total current draw will be 60mA (for the module) + (number of channels used up to 16 x current load of the outputs). For example, if there are 16 outputs at 250mA per device, then the current draw will be 60mA + (16 x 250mA) = 4.06A. Care must be taken with this module because the individual channel maximum outputs are 0.5A and if the unit is loaded down to the maximum (16 x 0.5A) it is possible to completely load the entire stack and take the EtherCAT® communications off line.

If the module is used only as an input unit, then the draw of the sensors must be taken into account. This works out as 60mA for the module and then the current draw of each sensor x the number of sensors on the module. For example, if there are 16 Hall Effect proximity sensors on the module and each sensor draws 2mA, then the total current draw for the module will be 60mA + (16 x 2mA) = 92mA total.

Using the module as a combination input/output module will require using both input and output current calculations plus the module current draw (60mA).

v. Power Plus Module

The Power Plus Module can operate up to 12 0.5A loads (valves, outputs, etc.). However, this power does not come from the electronics total. The module itself draws 100mA.

c. Power Distribution

The stack's power distribution is shown in **Figure 14**. Note, the Electronics power handles all the module electronics plus the I/O electronics for the Digital and Analog I/O Modules. This is routed through the backplane along with the CAN control signals. The stack valve power comes from the Comms Module power. The Power Plus Module has a separate source for its loads.

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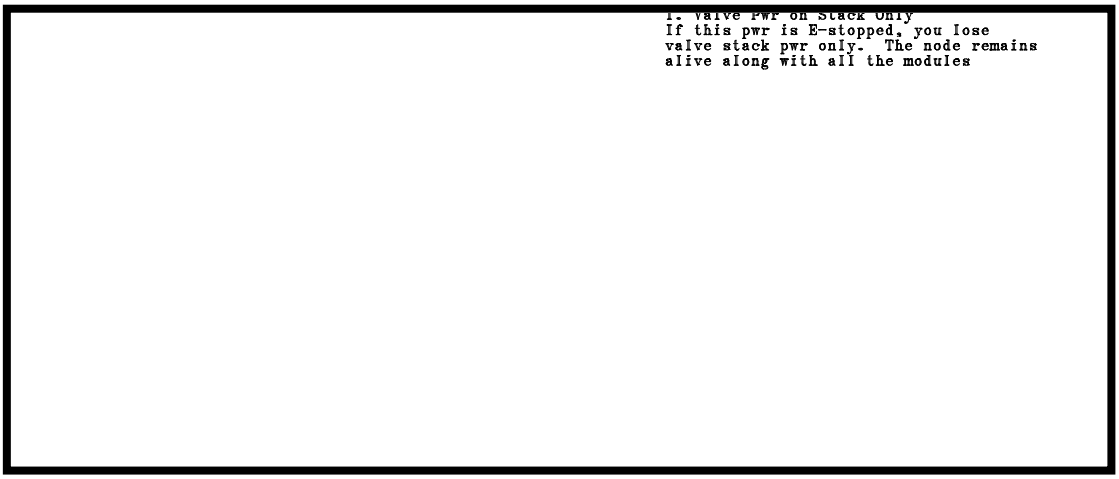
Figure 14 Stack Power Distribution



This connector has two isolated power channels. The first is the +24VDC required for the valves. The largest current a single valve channel can consume is 500mA. However, the maximum total current for the valve power is limited to 8.0A. Thus if all 32 channels are to be operated and you include the current required to operate the valve drivers, then the per channel maximum is 0.225A.

With this system, it is possible to run the electronics independent of the valves. If it is desirable to keep the electronics "awake," while the valve power is off, then two separate power supplies will be necessary. By disconnecting the valve power supply and keeping the electronics supply active, the node will stay online but the valves will not operate.

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5. Network Connection

A. Connectors, EtherCAT® Communications

There are two EtherCAT® connectors shown in **Figure 10**. For purposes of communications, the "In" should be wired closest to the master PLC. Refer to EtherCAT®'s wiring topology for a complete description.

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6. Valve Operation Example – Beckhoff TwinCat3®

A. Stack Valve Outputs

To operate the valves from the Comms Module, go to the "Receive PDO Mapping" section of the stack which is to be controlled.

Each group of 16 valve channels is labeled in the stack tree.

In our example in **Figure 15**, valve channel 1 is being forced on.

To do this, select "Valve Output State 1-16", "Online" tab on the right, "Force", and place a "1" in the dialog box as shown.

Figure 16 lists the valve channels versus the byte value.

Figure 15 Stack Valve Operation

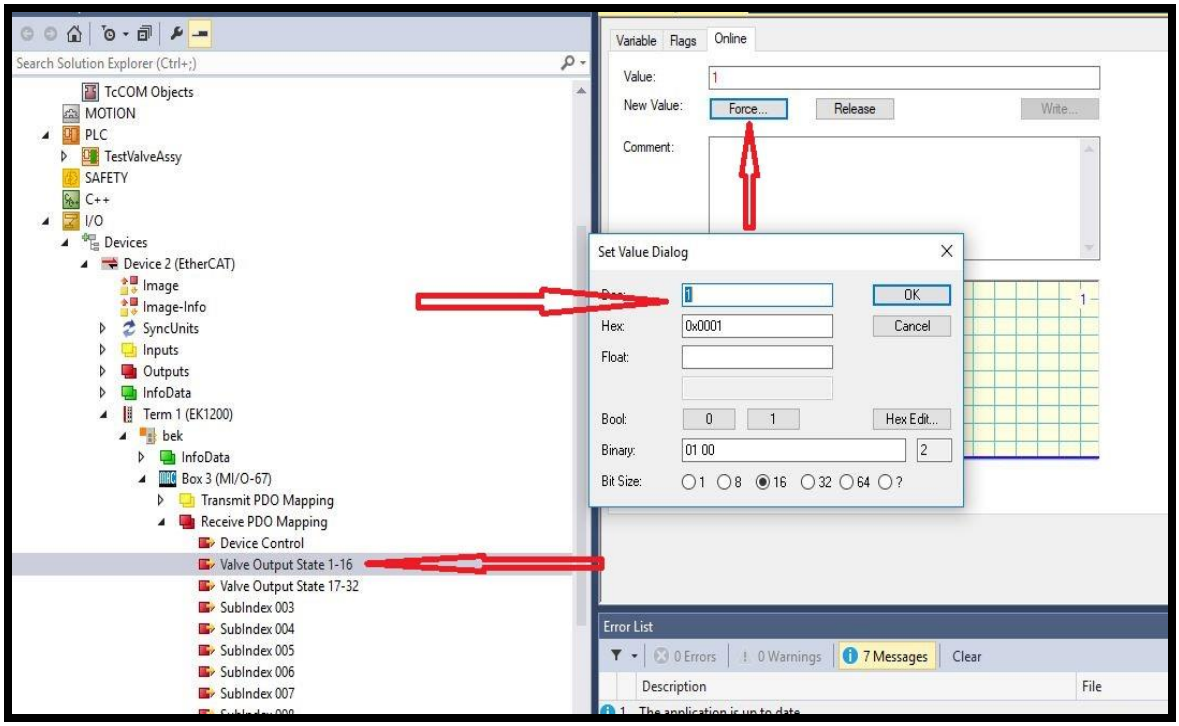

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Figure 16 Stack Valve Channels

Word	Channel	Hex Value
Valve Output State 1-16	1	0x0001
	2	0x0002
	2	0x0004
	4	0x0008
	5	0x0010
	6	0x0020
	7	0x0040
	8	0x0080
	9	0x0100
	10	0x0200
	11	0x0400
	12	0x0800
	13	0x1000
	14	0x2000
	15	0x4000
	16	0x8000
Valve Output State 17-32	17	0x0001
	18	0x0002
	19	0x0004
	20	0x0008
	21	0x0010
	22	0x0020
	23	0x0040
	24	0x0080
	25	0x0100
	26	0x0200
	27	0x0400
	28	0x0800
	29	0x1000
	30	0x2000
	31	0x4000
	32	0x8000

B. Valve Configuration, Open Load Detection

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If Open Load Detection is desired, then the configuration of the Comms Module must be set accordingly.

To set up this configuration, referring to **Figure 17**, select the module desired (Box3(MI/O-67)) , and select the Coe tag on the top.

From there go down and find Index F801. Select this index and place the desired channels on Open Load Detect according to **Figure 17**. Note Bytes 4-7 are not used.

Figure 17 shows the Open Load Detection configured for Channel 1.

Figure 18 lists the various channel configurations.

Figure 17 Open Load Detection Configuration

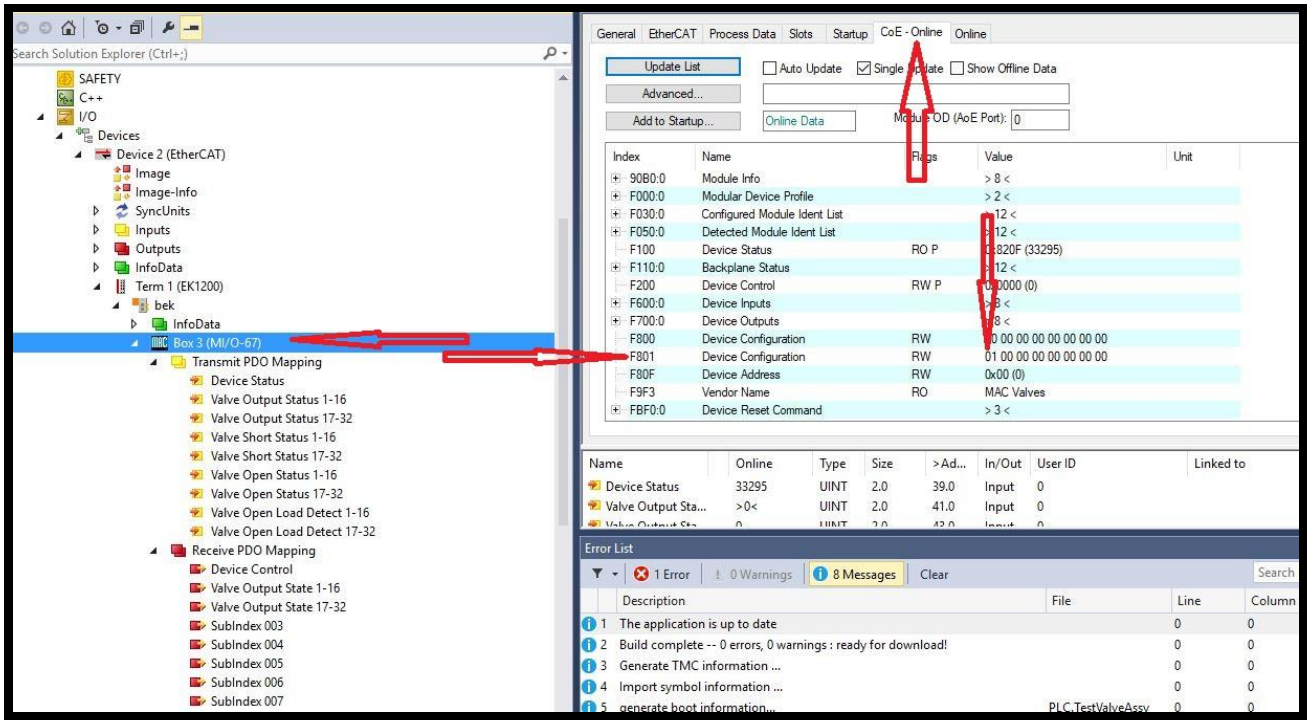

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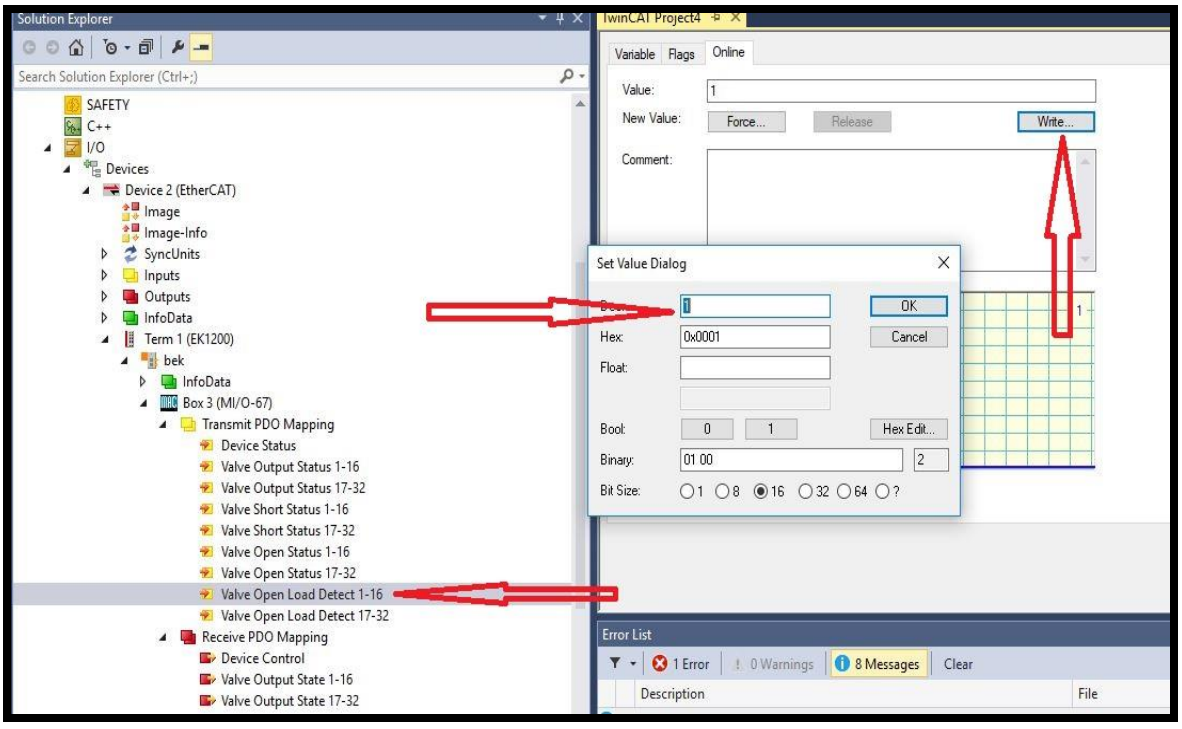
Figure 18 Open Load Detection Channel List

Output	Byte	0	1	2	3	4	5	6	7
1		01	00	00	00	00	00	00	00
2		02	00	00	00	00	00	00	00
3		04	00	00	00	00	00	00	00
4		08	00	00	00	00	00	00	00
5		10	00	00	00	00	00	00	00
..		..		..	..	00	00	00	00
30		00	00	00	20	00	00	00	00
31		00	00	00	40	00	00	00	00
32		00	00	00	80	00	00	00	00

In the example below in **Figure 19**, Open Load Detection has been set on Output 1, 2 only as shown in Index F801 in **Figure 19**. The configuration is echoed back in Valve Open Load Detect 1-16 and the fault is show in Valve Open Status 1-16. Note, the corresponding output must be OFF for the Open Load Detection to be active.

Figure 19 Setting Open Load Detection



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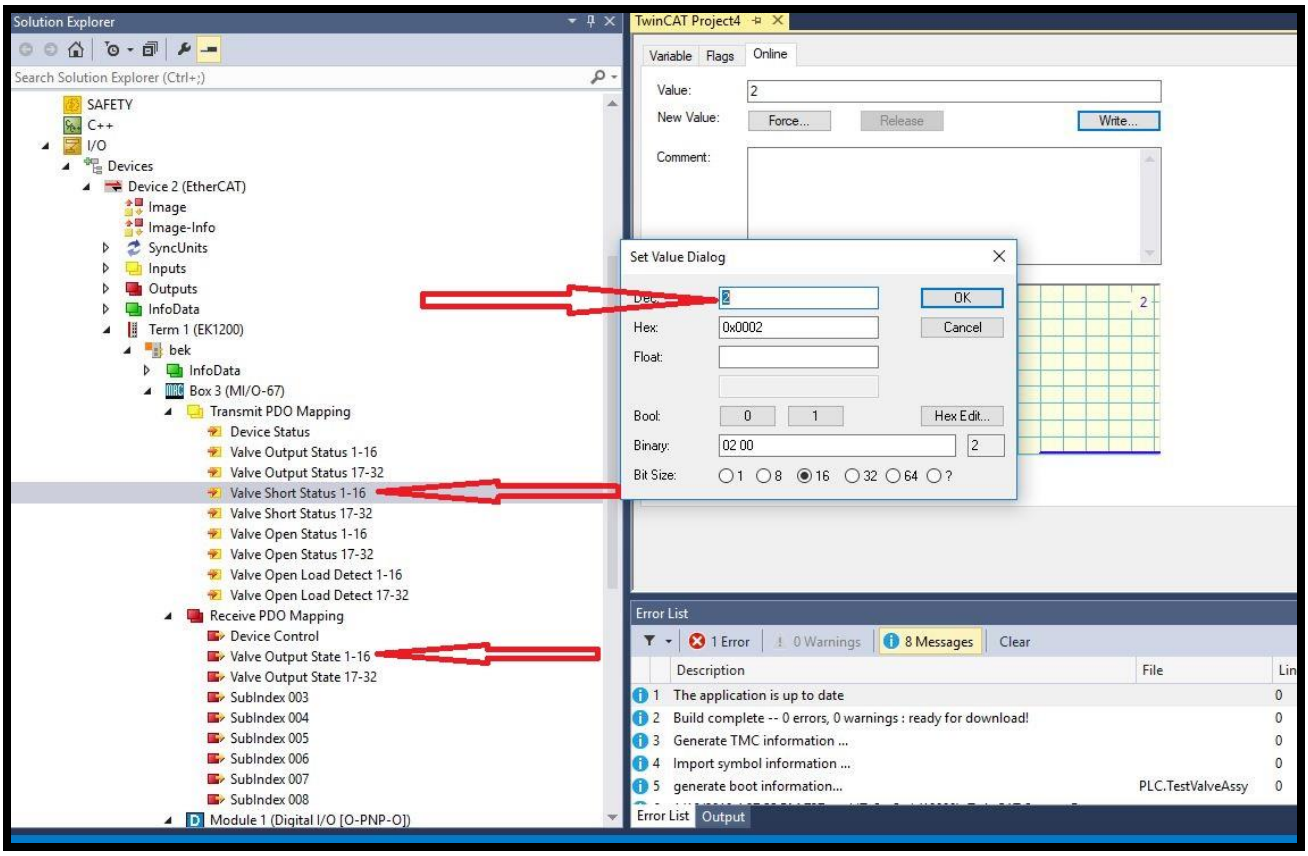
C. Valve Configuration, Short Circuit Detection

Short circuit detection is always active. It is detected when a valve output has a shorted load and the output is ON.

Shown below in **Figure 20**, a short is induced into Valve Channel 2. The Short Circuit Detection relays back the fault.

Figure 20 Valve Channel Short Circuit Detection



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7. Analog I/O (0-10V or 4-20mA) Module, Non-Configurable Type

A. Connectors

The four connectors for these modules on the top of the MI/O-67 are shown in **Figure 21**. The pin outs can be found in **Figure 22**.

Each module has four channels on four different connectors. The modules themselves are either 0-10V I/O or 4-20mA I/O.

Figure 21 Analog I/O Module, Non-Configurable Type

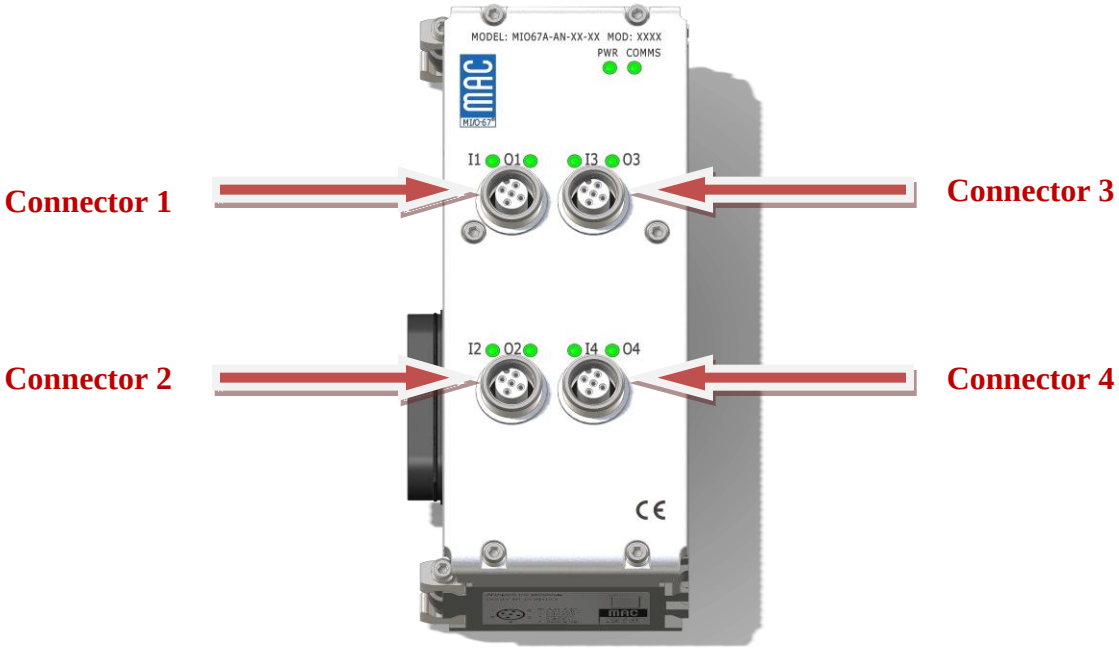

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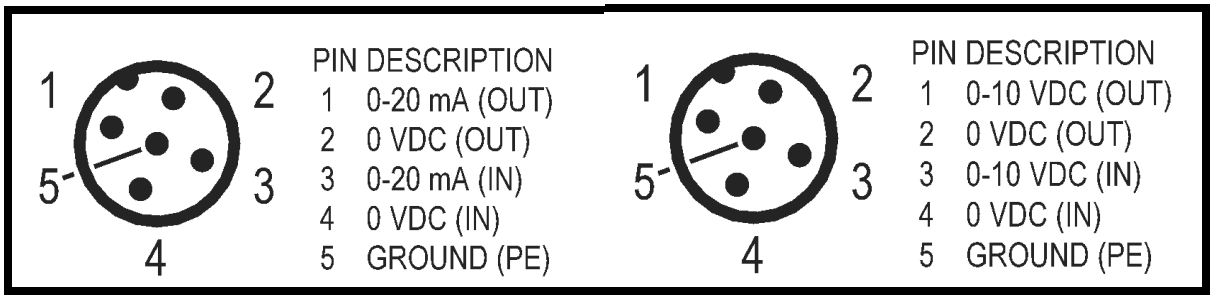
Figure 22 Analog I/O Pin-Out



B. Inputs

Each connector has an analog input (either 4-20mA or 0-10V depending on module type). To read an input, select the Module, Input Number (Connector Number), and Write.

The valve is scaled according to **Figure 23**. Some minor scale adjustment might be necessary to get an exact value.

Figure 23 Scaling

Voltage	Hex Value	Current	Hex Value
0.0V	0x0000	4.0mA	0x02AE
2.5V	0x0358	8.0mA	0x055C
5.0V	0x06B0	12.0mA	0x080A
10.0V	0x0D60	20.0mA	0x0D60

Figure 25, is an example of operating an input from Module 3, Connector 1 at approximately 12mA.

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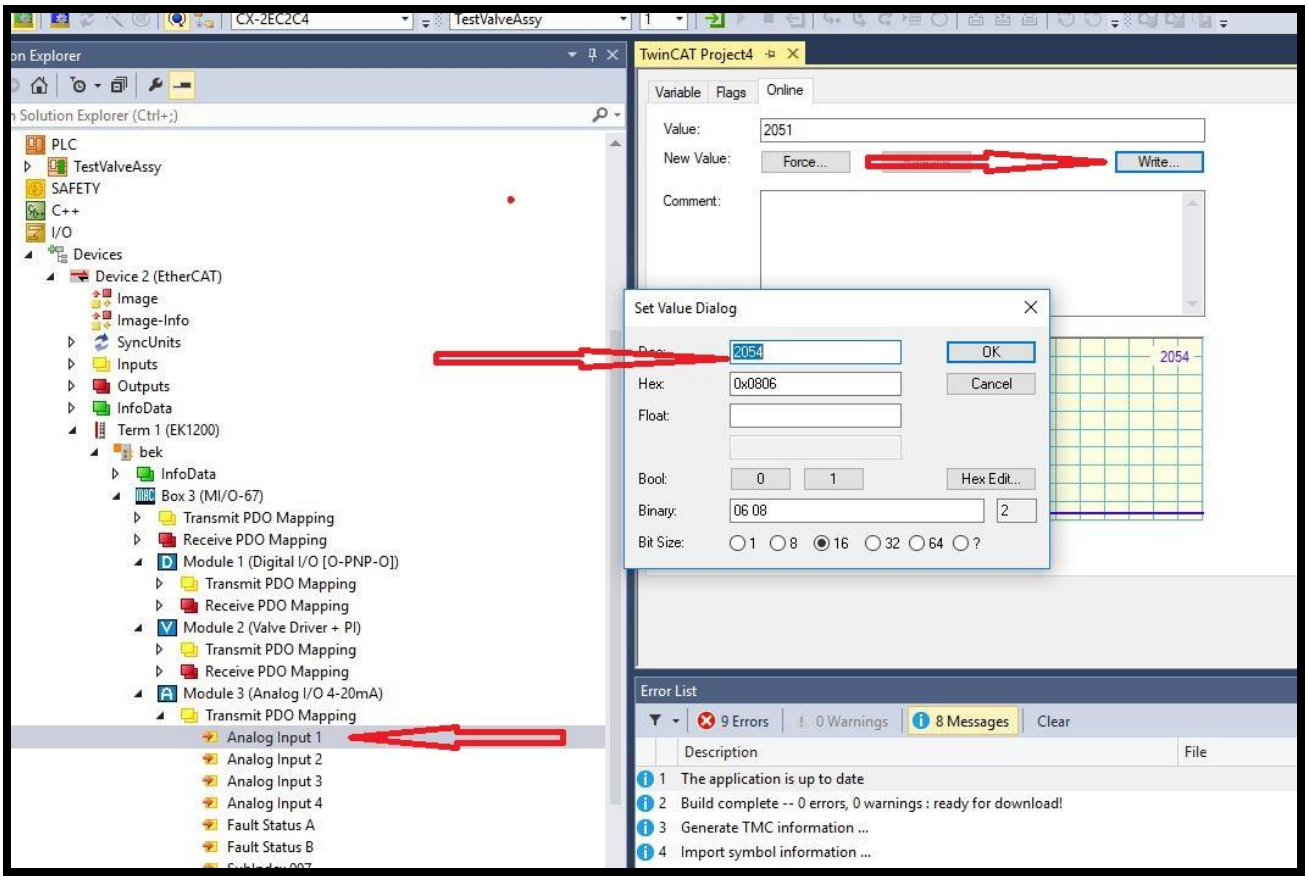
Figure 24 Analog I/O Input Example



C. Outputs

Each connector also has an analog output (either 4-20mA or 0-10V depending on module type). To write an output, go to Module, Analog Output, and Force.

The example in **Figure 26** shows a 20mA output on Module 3, Connector 1.

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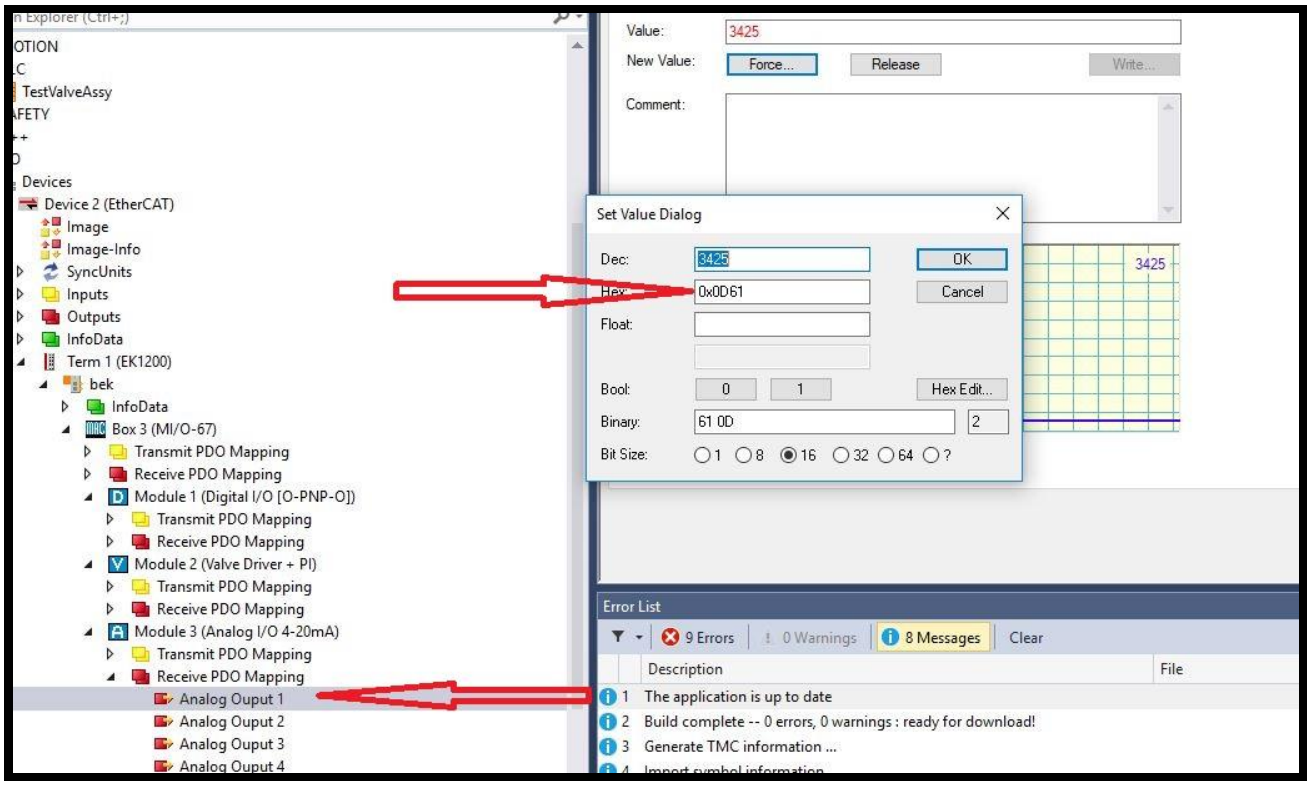
Figure 25 Analog I/O Module, Output Example



8. Analog I/O (0-10V or 4-20mA) Module, Configurable Type

A. Connectors

The four connectors for these modules on the top of the MI/O-67 are shown in **Figure 27**. The pin outs can be found in **Figure 28**.

The pin out for each connector is dependent on whether it is configured as an Output or Input.

Each module has four channels on four different connectors. The modules themselves are either 0-10V I/O or 4-20mA I/O.

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Figure 26 Analog I/O Module, Configurable Type

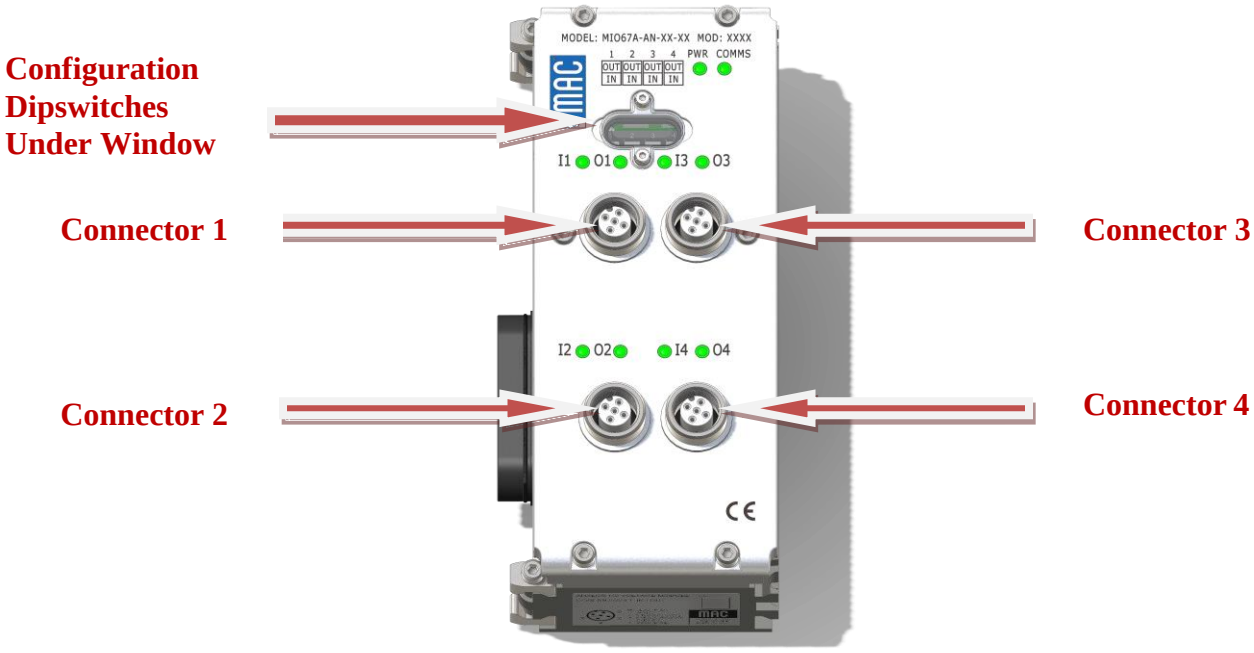

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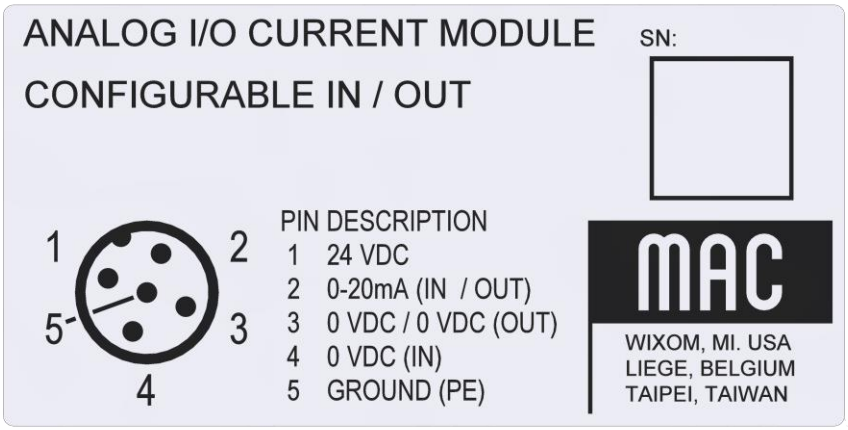
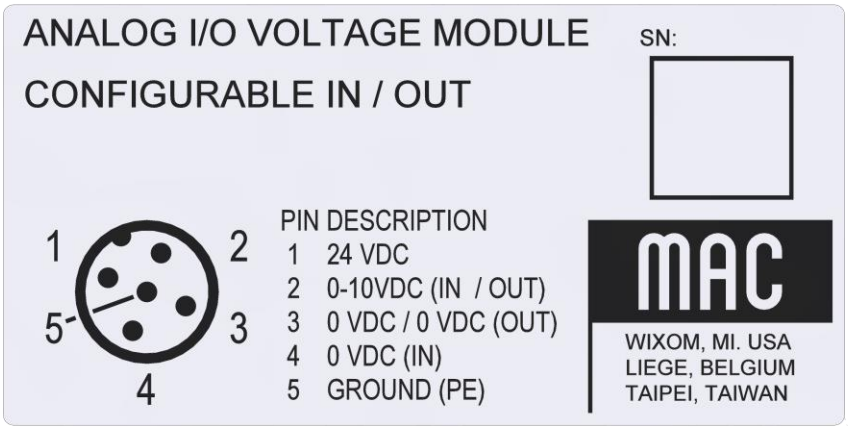
Figure 27 Analog Module, Configurable Type, Pin-Out





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As shown in **Figure 28**, depending on how the connectors are configured sets the pin-out for that connector. For example, if you have a 0-10V module and you configure a connector to act as an output, then Pin 2 is the Positive output and Pin 3 is the Negative Output along with the common for the 24VDC. If you have a 4-20mA module and you configure a connector to act as an Input, then Pin 2 is the Positive input and Pin 4 is the Negative Input.

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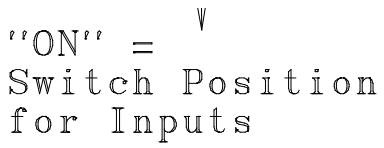
B. Module Configuration

Each connector on the module can be configured as an Analog Output or an Analog Input. The type depends on whether you have an Analog Current Module, an Analog Voltage Module.

The configuration is done by way of the four dipswitches under the window on the module near the top as shown in **Figure 29**.

Figure 28 Dipswitch Configuration



If there was only one module on the stack, Byte X would be Byte 2. If the Digital I/O module was the second module of a two module stack, then Byte X would be Byte 6. The values below are given in hex format. This will also be discussed in the Byte

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Definition, Configuration Section 9-A.

C. Indicator LEDs

Each connector has two LEDs near them. The LEDs are solid green when everything is running normally. They will change to red when there is either an overvoltage (for the current module) or overcurrent (for the voltage module) fault.

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9. Digital I/O Module

A. Connectors

Shown in **Figure 30** is a typical Digital I/O Module. For the eight connectors in **Figure 31**, Channels 1 and 2 are on the upper left connector, Channels 7 and 8 are the lower left connector, Channels 9 and 10 are on the upper right connector, and Channels 15 and 16 are on the lower right connector. The pin outs can be found in **Figure 32**.

The module can be configured for sixteen inputs, sixteen outputs, or eight inputs and eight outputs. Bank A is for Channels 1-8 and Bank B is for Channels 9-16. The Banks will come into play when configuring the module for either eight inputs (Bank A) and eight outputs (Bank B) or eight outputs (Bank A) and eight inputs (Bank B).

Also shown in **Figure 27** is the window for access to the mode selector dipswitches.

The load wiring/sensor wiring is shown in **Figure 29**.

Figure 29 Digital I/O Module

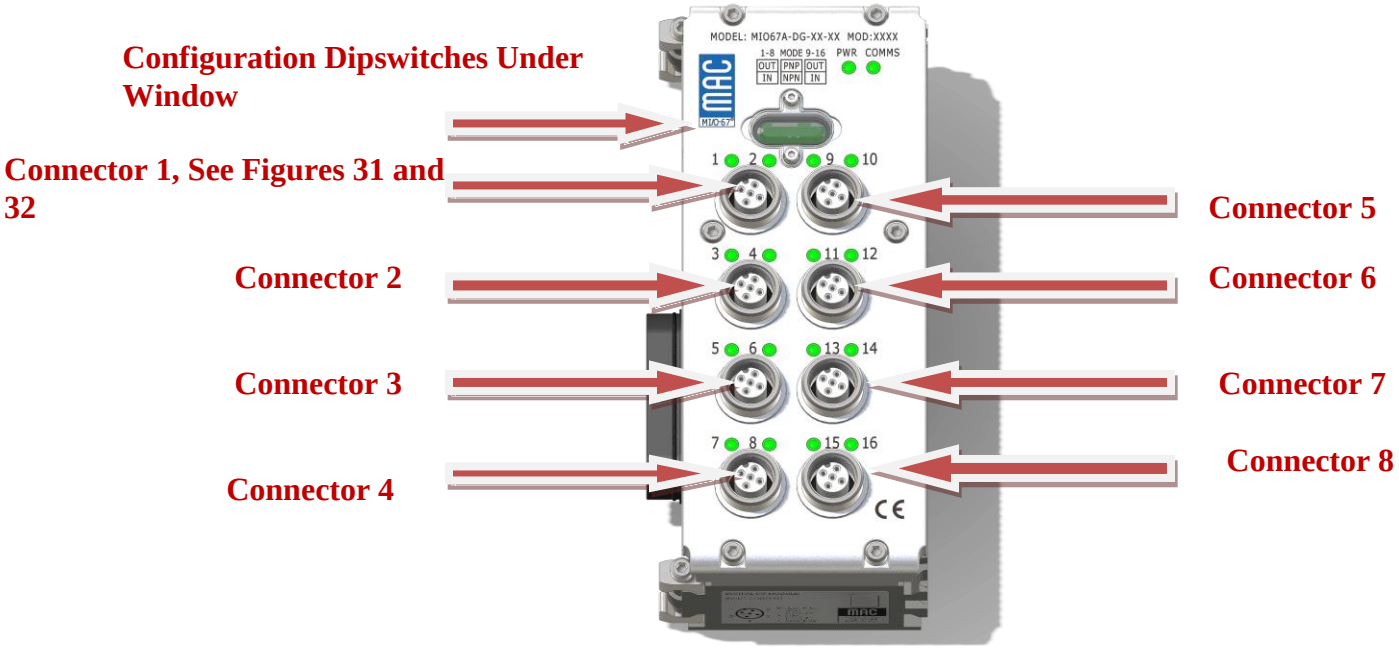

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Figure 30 Digital I/O Pin-Out, Connectors 1-8 Typical

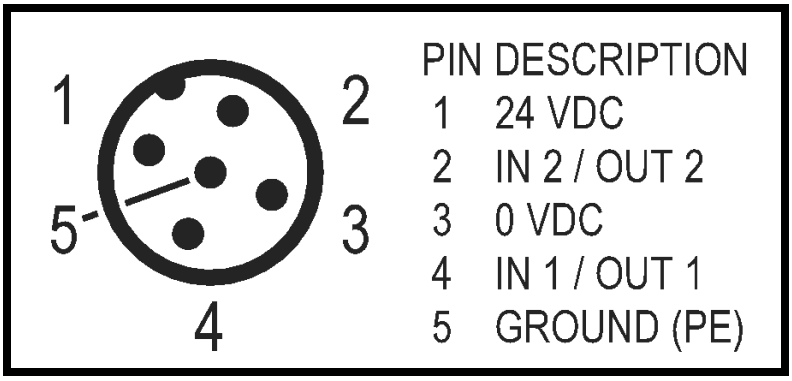
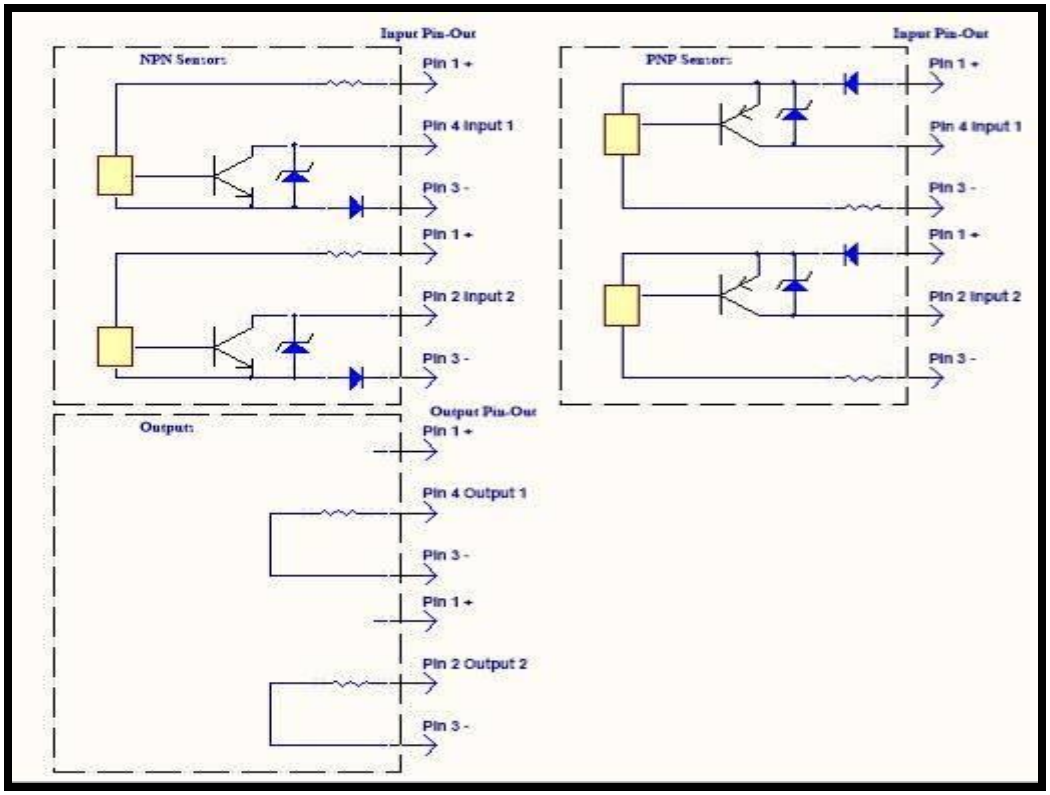


Figure 31 Sensor/Load Wiring



B. Dipswitch Configuration

As previously state, the module is broken down into two banks of 8 points. The left 4 connectors are considered Bank A and the right 4 connectors are considered Bank B. The dipswitches shown in **Table 3** will set the bank function of being either input or

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output connectors for these modules. The pin outs can be found in **Figure 26**.

Left to Right as shown in **Table 3**, where 0 = off position (dipswitch position away from top edge of board) and 1 = on position (dipswitch position is closer to top edge of board) for the switches:

Table 3 Dipswitch Position

Dipswitch			**Bank A**	**Bank B**
A	**B**	**C**		
0	0	0	Input/NPN	Input/NPN
0	0	1	Input/NPN	Output
0	1	0	Input/PNP	Input/PNP
0	1	1	Input/PNP	Output
1	0	0	Output	Input/NPN
1	0	1	Output	Output
1	1	0	Output	Input/PNP
1	1	1	Output	Output

C. Inputs

The module can operate with either 0, 8, or 16 inputs depending on the configuration. See **Table 3** above.

In **Figure 30**, Inputs 1 and 2, on Module 1, Connector 1 are both toggled and read.

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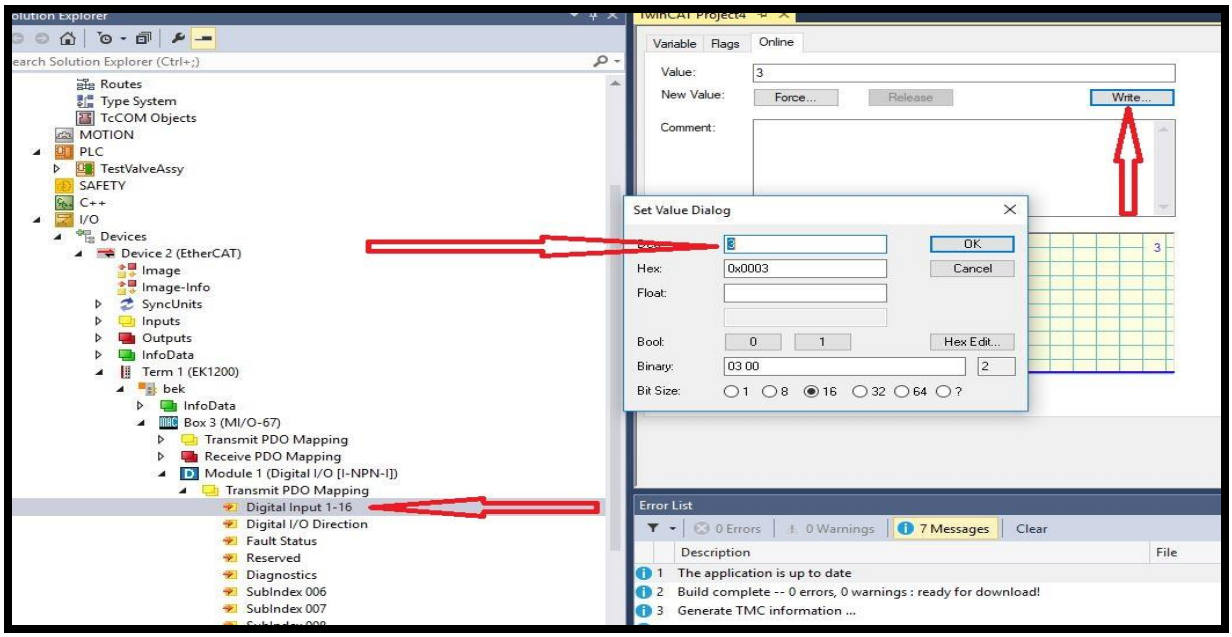
Figure 32 Digital I/O Input Example



D. Outputs

Similar to the Inputs, the Digital I/O Module can operate 0, 8, or 16 outputs on each module. **Figure 34** shows a 16 output module with output 1 being force on.

Each output can drive up to a 12W load but care must be taken as to not use up the 8A limit for the electronics power.

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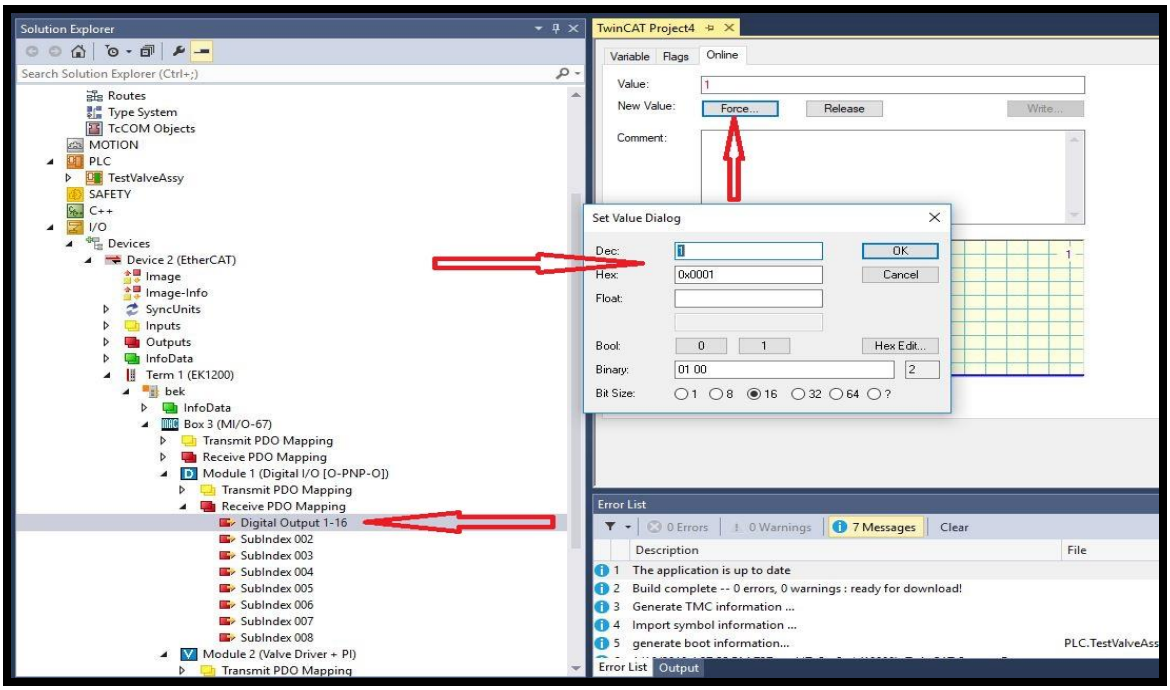
Figure 33 Digital I/O, Output Example



E. Indicator LEDs

Each connector has two LEDs near them. The LEDs are solid green when the change is active (driving an output load or sensing an input).

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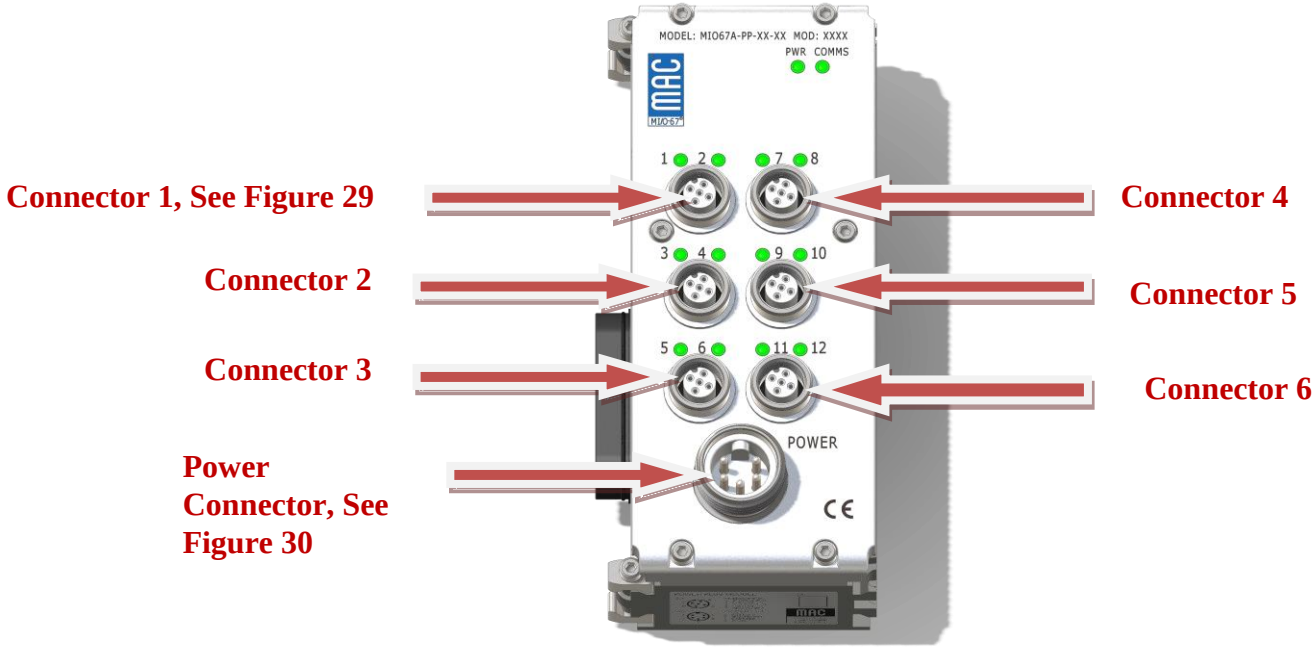
10. Power Plus Module

A typical Power Plus Module is shown in **Figure 35**. In this view there are six M12 connectors and one mini power connector. The M12 connectors each have two output points. Channels 1 and 2 are on connector 1 located on the upper left. Channels 5 and 6 are on the M12 connector on the lower left, Channels 7 and 8 are on the M12 connector in the upper right, and Channels 11 and 12 are on the M12 connector in the lower right.

Power for the outputs come from the mini connector at the bottom.

Figure 34 Power Plus Module



A. Connectors

As stated above, this module will have six connectors (twelve outputs total, two outputs per connectors) for external valve operation plus an external power connection.

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B. Wiring

Shown below in **Figure 36** are the load connections to drive a valve or other 12W or less loads on the Power Plus Module. Note; each connector has two outputs. There are six of these connectors, each with two outputs per connector on the module. The wiring for these connectors is show in **Figure 37**.

The power to operate the electronics of the module comes from the Comms Module Electronics power. The load power comes from the mini connector on the module and is wired according to **Figure 38**. The outputs cannot be operated without power from the mini connector. If this power is absent, the channel LEDs will be solid red and an error message will be sent to the PLC.

Figure 35 Pin Out, Power Plus Module, Output Connector

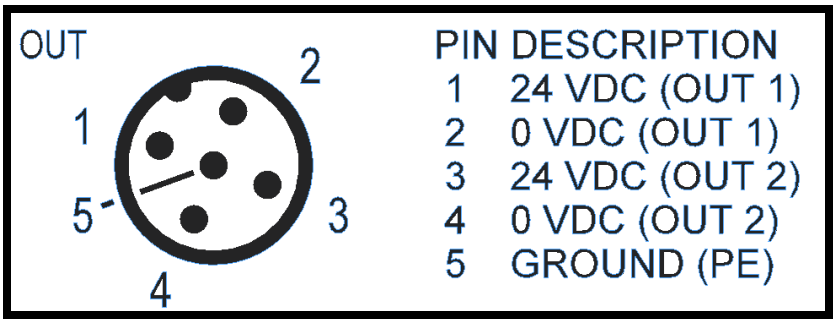

Figure 36 Power Input Connector

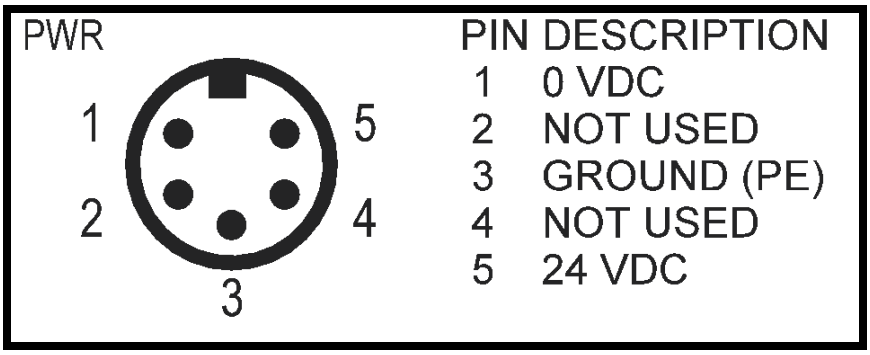

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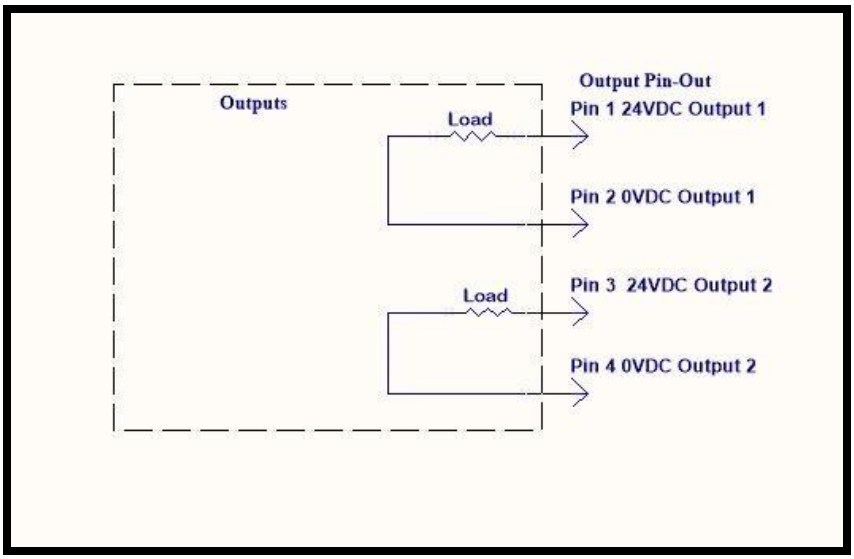
Figure 37 Output Connector Load Wiring



In **Figure 39**, the 1st Output is forced on from a Power Plus Module in Slot 2.

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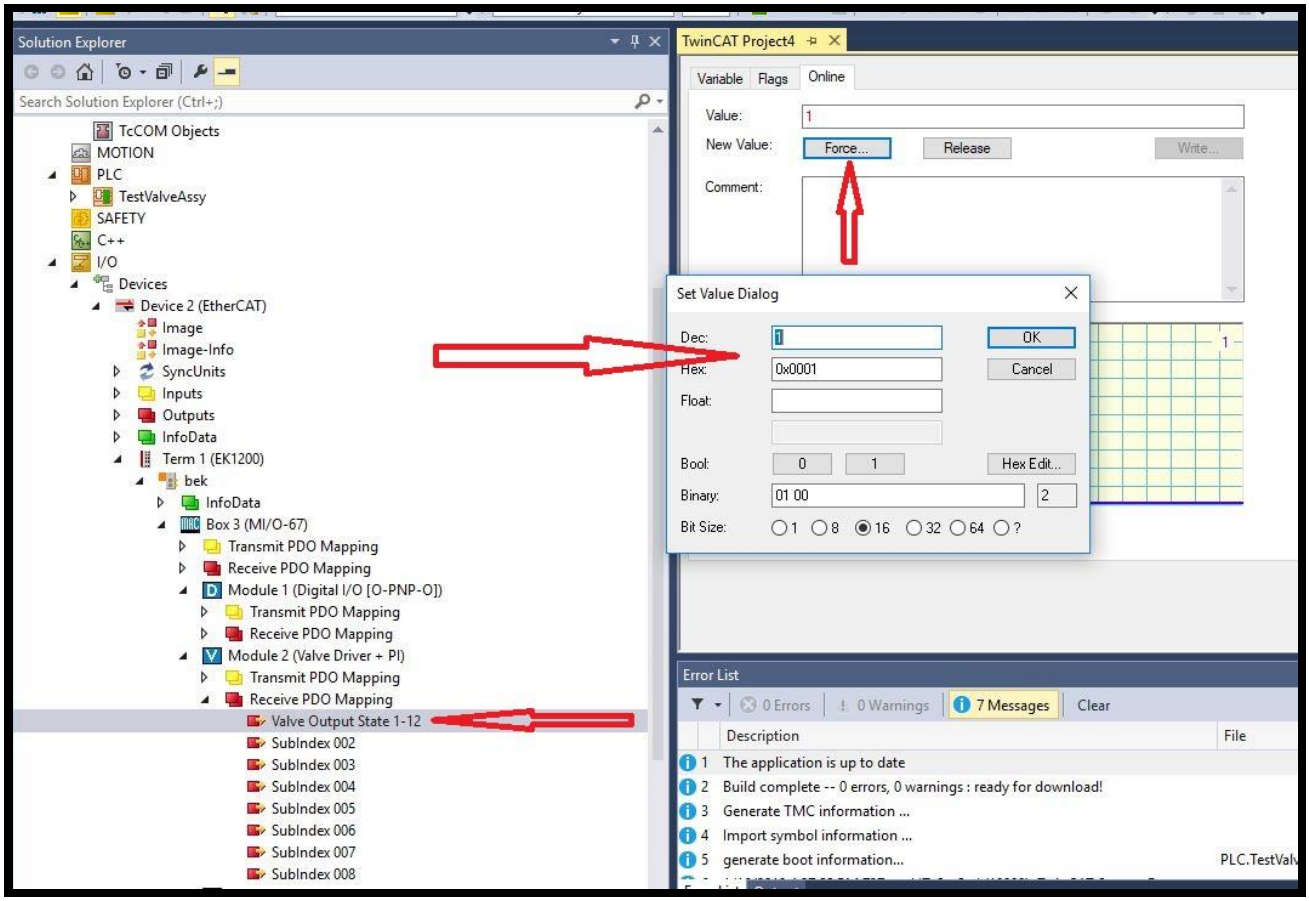
Figure 38 Power Plus Module, Output Example



C. Indicator LEDs

Each connector has two LEDs near them. The LEDs are solid green when the change is active (driving an output load). If there is no output power to the module, the LEDs will be solid red.

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11. Network Connection

A. Connectors - EtherCAT®

There are two EtherCAT® connectors shown in **Figure 10**. The one on the left is labeled “In’ and the one on the right is labeled “out”. For purposes of communications, the “In” should be wired closest to the master PLC.

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12. Power Handling

The MI/O-67 system has two power paths for the valves and the modules as described in **Section 4a,b** and shown in **Figure 15**. In addition to that, the Valve Driver Module has two versions. One version, which is still under development, will take the valve power for this module directly from the backplane. The other version, called the Power Plus Module, has a separate connector for external power which drives the loads on this module.

A. Valve Power

The first power system is for the valves on the stack. It is isolated from the electronics power and thus can be separately disconnected if desired. It can pass up to 8A at 24VDC maximum. The Comms Module valve driver circuit will consume 400mA so the total current for the valves is 7.6A. To calculate the total power for the valve line, use the following formula:

Total Current (Amps) = Number of Valves x (Valve Wattage/24) $\leq$ 7.6 Amps.

If there are valves of different wattages on the stack then each group of wattages must be added up separately. Thus:

Total Current (Amps) = [Number of Valves (Wattage1) x (Valve Wattage1/24)] + [Number of Valves (Wattage2) x (Valve Wattage2/24] + [Number of Valves (Wattage3) x (Valve Wattage3/24] + [Number of Valves (Wattage4) x (Valve Wattage4/24)] …..etc.

Note: Valve wattage must be $\leq$ 12 watts at 24VDC.

B. Electronics Power

There is an isolated power line which also can handle up to 8 Amps at 24VDC. This line is used for the EtherCAT® electronics, module electronics, and all sensors and loads on the various modules.

In general, the power consumed by a Comms Module alone is 140mA.

C. Power Calculation Tool

MAC Valves has a tool which is available to help in the power calculation for the current draw from the MI/O-67. Please contact your local distributor for further assistance.

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13. Backplane Index Table

The MI/O-67 operates in two stages. The first stage is the outside protocol which connects the master PLC to the Comms Module. In this case, it is EtherCAT®. From there, the device hands off information in both directions (send and receive) to a backplane which asks as a connection portal between the modules. This information is transferred to the master and could be useful for system setup and troubleshooting. Below are some of these Index and their descriptions. The "nn"below are variables which for example 6010h would be the Module Input registry for the second module after the Comms Module.

Index (hex)	Name	SubIndex Number	Type	Description
6nn0h	Module Inputs	0	UINT8	0-12 Represents Backplane module index (0 = module 1)
		1-8 (Data)		

Example: Module 2, Digital I/O, Connector 1, Input 1, Reading Toggle
6010h SubIndex 6010:01 Value: 0x0001

7nn0h	Module Output	0	UINT8	0-12 Represents Backplane module index (0 = module 1)
		1-8 (Data)		

Example: Module 1, Digital I/O, Connector 1, Output 1-8, All Off,
See figure below:

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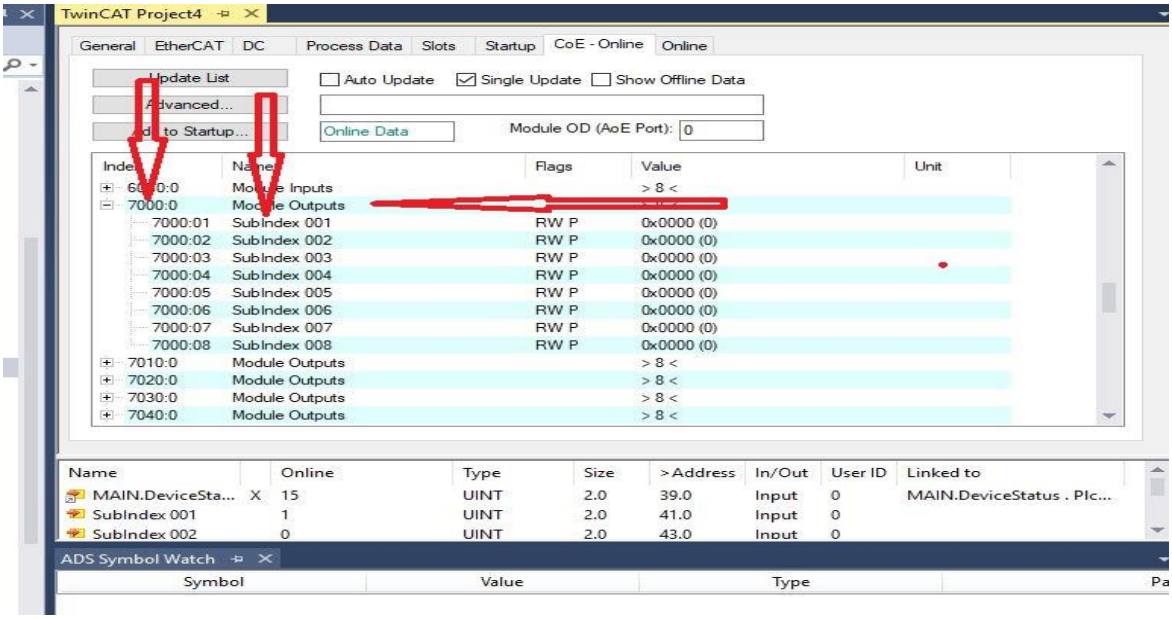
Figure 39 Index 7000h Module Outputs



Some other objects of interest are:

F030h	Configured Module Ident List		UINT8	Number of Modules Configured

If the value is 0x0000 = no modules configured
SubIndex lists type of modules in this location
F031h-F03Ch

F050h	Detected Module Ident List		UINT8	Detected Configuration

If the valve is 0x0000 = no modules detected
SubIndex lists type of modules in this location
F051h-F05Ch

F100h	Device Status	0	UINT16	Comms health status

If this value is 0x0001, then the configuration for the modules is not correct. In normal operation, it should be 0x000f.

F600h	Device Inputs SubIndex 1-8	0	UNIT8	Comms Module Inputs Command echo, Open Load, etc
F700h	Device Output	0	UNIT8	Comms Module Outputs

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14. Process Data Mapping

The MI/O-67 operates 13 transmit and 13 receive process data mapping objects. Each module along with the Comms Module has its own transmit and receive mappings. There also is a Local Timestamp Object at index 0x10F8 which can be optionally mapped to a process data object.

Listed below are the module objects.

Receive PDO

Index	Module Number	Assigned by Default?
0x1600	1	No
0x1601	2	No
0x1602	3	No
0x1603	4	No
0x1604	5	No
0x1605	6	No
0x1606	7	No
0x1607	8	No
0x1608	9	No
0x1609	10	No
0x160A	11	No
0x160B	12	No
0x16FF	Comms	Yes, Sync Manger 2

Transmit PDO

Index	Module Number	Assigned by Default?
0x1A00	1	No
0x1A01	2	No
0x1A02	3	No
0x1A03	4	No
0x1A04	5	No
0x1A05	6	No
0x1A06	7	No
0x1A07	8	No
0x1A08	9	No
0x1A09	10	No
0x1A0A	11	No
0x1A0B	12	No
0x1AFF	Comms	Yes, Sync Manger 2

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15. Module Configuration Codes

Each module type has a unique code for the configuration. Below is a list of the modules and their codes.

Module (Type)	Code (hex)
Analog, Non-Configurable, Current	0x820c0191
Analog, Configurable, Current	0x820c0191
Analog, Non-Configurable, Voltage	0x810c0191
Analog, Configurable, Voltage	0x810c0191
Power Plus	0x84030191
Digital, Input Only, NPN	0x70030191
Digital, Bank A NPN, Bank B Output	0x71030191
Digital, Input Only, PNP	0x72030191
Digital, Bank A PNP, Bank B Output	0x73030191
Digital, Bank A Output, Bank B NPN	0x74030191
Digital, Output Only	0x75030191
Digital, Bank A Output, Bank B PNP	0x76030191
Digital, Output Only	0x77030191

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16. Specifications

General Specifications

Item	Specifications
Operating ambient temperature	0~+50°C (consult the factory for higher temperature operation)
Operating ambient humidity	10~90% RH (no condensation)
Vibrating resistance	5G (10~55 Hz, 0.5mm)
Impact resistance	10G
Dielectric strength	500VAC 60 Hz for 1 sec. (between external terminal and case)
Insulation resistance	10Mohm
Operating atmosphere	No corrosive gases

EtherCAT® Performance Specifications

Item	Specification
Transmission Speed	100Mbit
Transmission Distance	100m between nodes
Transmission Media	CAT-5 Ethernet cable
Protocol	EtherCAT®

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CE EMC Directive Certification

Item	Specification
Radiated Emissions	CISPR 16-2-3 Ed 4.1(2019-09)
AC Mains Conducted Emissions	CISPR 16-2-1 Ed 3.1(2017-06)
Electro-Static discharge Immunity	IEC61000-4-2 Ed 2.0(2008-12)
Radiated, Radio Frequency Electromagnetic Immunity	IEC61000-4-3 Ed 3.2(2010-04)
Electrical Fast Transcient/Burst Immunity	IEC61000-4-4 Ed 3.0(2012-04)
Immunity to Surges	IEC61000-4-5 Ed 3.1(2017-08)
Conducted, Radio Frequency Electromagnetic Immunity	IEC61000-4-6 Ed 4.0(2013-10)
Power Frequency Magnetic Field Immunity	IEC61000-4-8 Ed 2.0(2009-09)

17. Troubleshooting Guide

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A. Troubleshooting

In the event of difficulties, in either operation or installation of the MI/O-67, have a number of fault detection tools available. Along with the short/open detection mentioned above, the Comms Module has two groups of LEDs which can help to get the manifold online in the event of problems.

Below the EtherCAT® Ports, there are four LEDs labeled RUN, LA, LA, and ERR. Along the top of the Comms Module are three LEDs.

For RUN:

State	Description
Off	No Power or in "INIT" state
Green	Operational state
Green Flashing	Pre-Operational state
Red Flashing	If RUN and ERR turns red, this is a fatal event. It forces the bus interface to a physically passive state

For LA (for both):

State	Description
Off	No power or link not sensed
Green	Link sensed, no traffic detected
Green Flickering	Link sensed, traffic detected

For ERR

State	Description
Off	No error or no power
Red Blinking	Invalid configuration
Red, Single Flash	Unsolicited state change
Red, Double Flash	Watchdog timed out
Red, Flickering	Booting error detected

For Comm (Backplane Communications):

State	Description
Off	No power
Green Flashing	OK
Red	Fatal Error
Red Flashing	Recoverable fault

For Stat (Backplane Status)

State	Description
Off	No Link/No Activity

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Green	Run Mode
Green Flashing	Standby Mode

For PWR

State	**Description**
Off	No Power
Green Flashing	Normal

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Appendix A PDO Listing

A. Receive PDO

Index	Name
0x1600	Module1 Assigned by Default = No
0x1601	Module2 Assigned by Default = No
0x1602	Module3 Assigned by Default = No
0x1603	Module4 Assigned by Default = No
0x1604	Module5 Assigned by Default = No
0x1605	Module6 Assigned by Default = No
0x1606	Module7 Assigned by Default = No
0x1607	Module8 Assigned by Default = No
0x1608	Module9 Assigned by Default = No
0x1609	Module10 Assigned by Default = No
0x160a	Module11 Assigned by Default = No
0x160b	Module12 Assigned by Default = No
0x16ff	Comms Module Assigned by Default = Yes, (Sync Manager 2)

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B. Transmit PDO

Index	Name
0x1a00	Module 1 Assigned by Default = No
0x1a01	Module 2 Assigned by Default = No
0x1a02	Module 3 Assigned by Default = No
0x1a03	Module 4 Assigned by Default = No
0x1a04	Module 5 Assigned by Default = No
0x1a05	Module 6 Assigned by Default = No
0x1a06	Module 7 Assigned by Default = No
0x1a07	Module 8 Assigned by Default = No
0x1a08	Module 9 Assigned by Default = No
0x1a09	Module 10 Assigned by Default = No
0x1a0a	Module 11 Assigned by Default = No
0x1a0b	Module 12 Assigned by Default = No
0x1aff	Comms Module Assigned by Default = Yes, (Sync Manager 3)

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C. Basic Device Info

Index	Name	SubIndex	Access	Value
1000h	Device Type	0	RO	00001389
1001h	Error Register	0	RO	00h
1003h	Pre-defined Error Field	0	RW	00h
	Error Field	1..5	RO	(errorcode)
1008h	Device Name	0	RO	“MIO-67”
1009h	Hardware Version	0	RO	xxx.yyy.zzz
100ah	Software Version	0	RO	xxx.yyy.zzz
F100h	Device Status	0	RO	(statuscode)
F110h	Backplane Status	0	RO	“0ch”
	Entry	1-12	RO	(modulestatus)
F200h	Device Control	0	RW	“0000h”
F9f3h	Vendor Name	0	RO	“MACValves”

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D. Receive PDO Mapping

Index	Name	SubIndex	Access	Value
16nnh	Receive PDO Mapping	0	RW	
	Mapped Objects	1-119	RW	

Mapped Object 1-8 (=7nn0mm10h, nn = 0-12..module number, mm = 1-8 mapped objects)

16ffh	Receive PDO Mapping	0	RW	09h
	Mapped Object 001	1	RW	10h
	Mapped Object 002	2	RW	110h
	Mapped Object 003	3	RW	210h
	Mapped Object 004	4	RW	310h
	Mapped Object 005	5	RW	410h
	Mapped Object 006	6	RW	510h
	Mapped Object 007	7	RW	610h
	Mapped Object 008	8	RW	710h
	Mapped Object 009	9	RW	810h
	Mapped Object	10-119	RW	00000000h

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E. Transmit PDO Mapping

Index	Name	Subindex	Access	Value
1annh	Transmit PDO Mapping	0	RW	
	Mapped Objects	1-119	RW	

Mapped Object 1-8 (=6nn0mm10h, nn = 0-12..module number, mm = 1-8 mapped objects)
Mapped Object 9-119 (=00000000h—default, nn = 0-12, 0 = module 1, mm = 1-8)

1affh	Transmit PDO Mapping	0	RW	09h
	Mapped Object 001	1	RW	10h
	Mapped Object 002	2	RW	11h
	Mapped Object 003	3	RW	210h
	Mapped Object 004	4	RW	310h
	Mapped Object 005	5	RW	410h
	Mapped Object 006	6	RW	510h
	Mapped Object 007	7	RW	610h
	Mapped Object 008	8	RW	710h
	Mapped Object 009	9	RW	810h
	Mapped Object 010-119	10-119	RW	00000000h

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F. Device Reset Options

Index	Name	SubIndex	Access	Value
Fbf0h	Device Reset Command	0	RO	03h
	Command	1	RW	Device Reset: 74 65 73 65 72 00h --Reset the device Factory Reset: 74 65 73 65 72 66h --Resets the device, restores all non-volatile application parameters and network configuration settings to factory defaults

G. Module IDs

Index	Name	SubIndex	Access	Value
F030h	Configured Module ID List	0	RO	0ch
	Entry	1-12	RW	0000000000000000h
F050h	Detected Module ID List	0	RO	0ch
	Entry	1-12	RO	0000000000000000h

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H. I/O PDOs

Index	Name	SubIndex	Access	Value
F600h	Device Inputs	0	RO	num of entries = 08h
	Entry	1-8	RW	
F700h	Device Outputs	0	RO	num of entries =08h
	Entry	1-8	RW	
6nn0h	Module Inputs	0	RO	nn=0-12 (0=Module 1)
	Entry	1-8	RO	Mod nn's rec. TPDO data
7nn0h	Module Outputs	0	RO	nn=0-12 (0=Module 1)
	Entry	1-8	RW	Mod nn's rec. RPDO data

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I. Module Configuration

Index	Name	SubIndex	Access	Value
8nn0h	Module Configuration	0	RW	
9nn0h	Module Info	0	RO	nn=0-12 (0=Module 1)
	Device Type	4	RO	All Module = 0x0191
	Vendor ID	5	RO	VendorID = 0 (no modules)
	Product Code	6	RO	Product Code=0 (no mdoules)
	Revision Number	7	RO	0
	Serial Number	8	RO	0

J. Comms Module Configuration

Index	Name	SubIndex	Access	Value
F800h	Device Configuration	0	RW	Default=00 00 00 00 00 00 00 00h
F801h	Device Configuration	0	RW	Default=00 00 00 00 00 00 00 00h

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Warning:

Under no circumstances are MAC Valves to be used in any application or system where failure of the valves or related components to operate as intended could result in injury to the operator or any other person.

- Do not operate outside of prescribed pressure or temperature ranges.
- Air supply must be clean. Contamination of valve can affect proper operation.
- Before attempting to perform any service on valve, consult catalog, P & O sheet, or factory for proper maintenance procedures. Never attempt service with air pressure to valve.
- If air line lubrication is used, consult catalog, P & O sheet, or factory for recommended lubricants.
- Before interfacing the product to any bus or serial system, consult the controller and bus manuals for proper usage.

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