SWITCHERGEAR
GEAR TO CONTROL YOUR POWER SWITCHES

Module DIO005

8-channel digital input/output
12-24 VDC isolated

REFERENCE MANUAL

Features

Standard module for SwitcherGear

Eight combined digital inputs & outputs

- *current-sourcing outputs (high-side switch)*
- *current-sinking inputs (IEC 61131-2 Type 3)*
- *12-24 VDC*

Channels are group isolated

Outputs are short-circuit protected

12-way pluggable screw terminal

Applications

Interfacing to industrial systems

Driving relay coils

Driving user interface indicators, buzzers, etc

Reading user interface switches, push-buttons, etc.

General Description

The DIO005 module is a digital input/output module for 12 V to 24 V logic. Each channel can be used as an input, an output or an input/output.

The logic inputs are current-sinking inputs that satisfy the switching requirements of IEC 61131-2 type 3 switches.

The output drivers are current-sourcing (high-side) switches. They can switch inductive loads and are fully protected against output faults.

The module is controlled by the host using a 3-wire serial interface.

The digital channels are group isolated and an external supply is required to power the isolated circuitry.

Ordering Information

Order Code	***Description***
`DIO005`	*SwitcherGear module, 8-channel digital input/output, 12-24 VDC, isolated*

Module Quick Start

1. **Set the configurable features.**

   Determine the feature settings that are required for the system under control. If necessary, change the default solder jumper settings. Refer to the Configuration section.

2. **Review the allocation of the MCU interface signals.**

   Confirm that the MCU interface signals connect to appropriate pins on the host MCU. Refer to your SwitcherGear configuration document and Table 3.

3. **Insert into the base slot.**

   Refer to your SwitcherGear configuration document for the location of modules.

4. **Connect the external wiring to the system connector.**

   Refer to Table 1 for the pin-out of the system connector.

Standard Interfaces

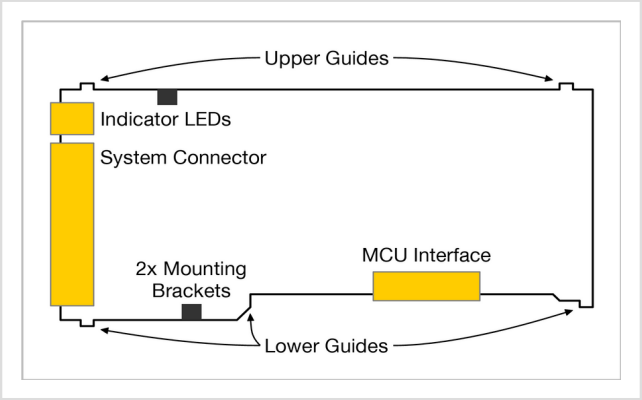

Figure 1: Parts of a SwitcherGear module.

System Connector

A 12-way pluggable screw terminal connector is used to connect system wiring to the DIO005 module. Table 1 shows the pin-out of this connector.

The connector can be keyed by inserting the supplied red coding keys into the slots on the header. The corresponding moulded key on the plug must be removed to allow insertion into the header.

Indicator LEDs

Miniature indicator LEDs on the front panel show the status of the logic inputs. Refer to Table 2 for details.

MCU interface

Refer to Table 3 for details of the digital and analogue signals provided by the DIO005 module.

Table 1: System connector

Pin	Signal	Description
1 (Top)	DIO0	Current-sinking input and current-sourcing output. Active-high.
2	DIO1	Current-sinking input and current-sourcing output. Active-high.
3	DIO2	Current-sinking input and current-sourcing output. Active-high.
4	DIO3	Current-sinking input and current-sourcing output. Active-high.
5	DIO4	Current-sinking input and current-sourcing output. Active-high.
6	DIO5	Current-sinking input and current-sourcing output. Active-high.
7	DIO6	Current-sinking input and current-sourcing output. Active-high.
8	DIO7	Current-sinking input and current-sourcing output. Active-high.
9	-	-
10	VDC	Positive supply input for isolated I/O channels.
11	COM	Negative supply input for isolated I/O channels.
12 (Bottom)	FIELDGND	External field ground.

Table 2: Indicator LEDs

Appearance	Left Column		Right Column	
	Colour	Description	Colour	Description
● ●	Green	Channel 0 input state	Green	Channel 4 input state
● ●	Green	Channel 1 input state	Green	Channel 5 input state
● ●	Green	Channel 2 input state	Green	Channel 6 input state
● ●	Green	Channel 3 input state	Green	Channel 7 input state

Table 3: MCU interface

Pin	Signal	Description
D0	CSn Data In	Chip select input for the data input interface. Active-low.
D1	SCLK	SPI clock input.
D2	SIMO	SPI data input.
D3	SOMI	SPI data output.
D4	CSn Data Out	Chip select input for the data output interface. Active-low.
D5	FAULTn	Fault output. Active-low.
D6	-	-
D7	-	-
D8	-	-
D9	-	-
D10	-	-
D11	-	-
A0	-	-
A1	-	-
A2	-	-
A3	-	-

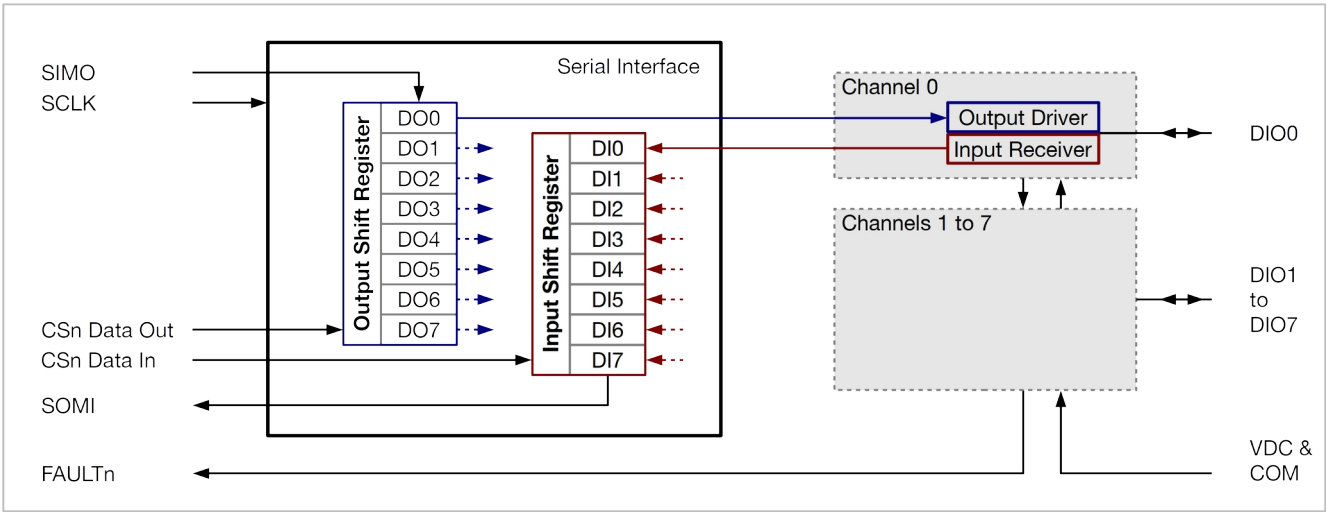

Figure 2: Functional block diagram of the DIO005 module. The MCU interface is on the left and the system connector is on the right.

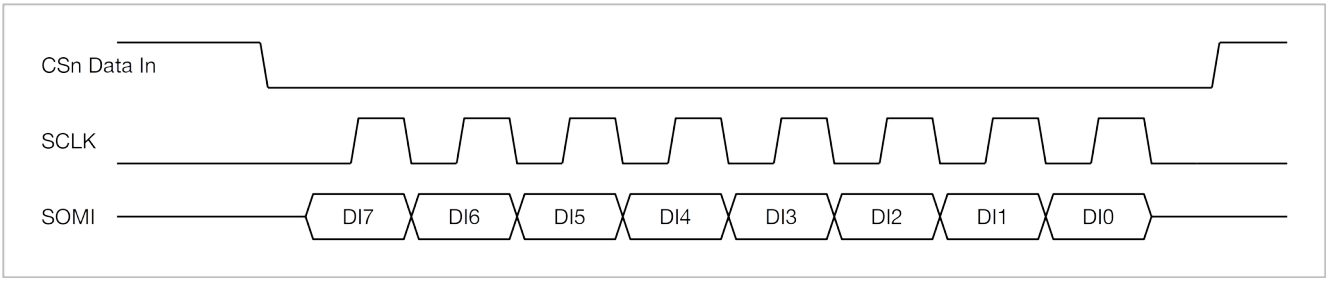

Figure 3: SPI bus operation for reading data from input receivers.

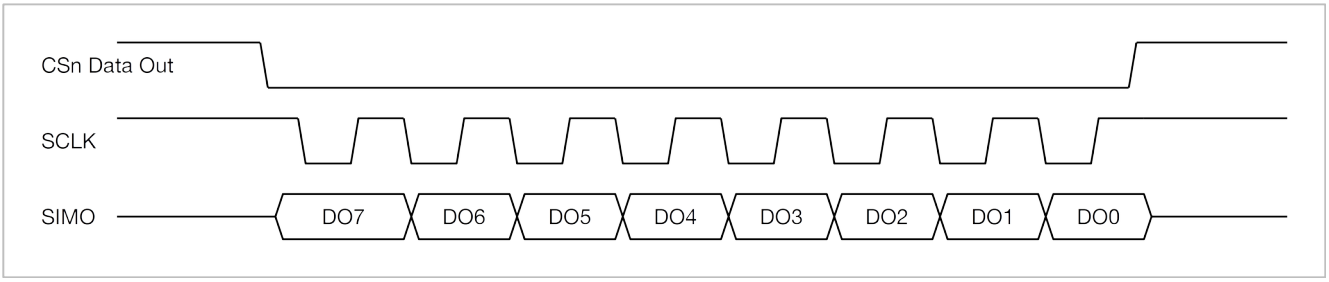

Figure 4: SPI bus operation for writing data to output drivers.

Refer to the SwitcherGear configuration document for your specific SwitcherGear unit for information on the mapping of the module signals to the host microcontroller on the base board.

Configuration

The DIO005 module has no user configurable hardware features.

Functional Description

The DIO005 module is an 8-channel digital input/output module for 12 V to 24 V. As shown in Figure 2, the signal chain consists of a serial interface and, for each channel, an input receiver and output driver.

The voltage on each DIOx terminal determines the digital input state. A voltage below the low-level input threshold voltage is logic '0'. The inputs have hysteresis to ensure clean logic transitions. The state of each digital input is indicated by the front panel indicator LEDs. Each digital input has a controlled current sink that pulls the DIOx terminal voltage low and also limits the maximum input current.

The output driver on each DIOx terminal is a high-side switch that sources current from VDC to a load that is connected to COM. The outputs can switch inductive loads and are fully protected against load faults.

Serial Interface

The DIO005 module uses a 3-wire serial interface to receive commands from the host microcontroller, as shown in Figure 3 and Figure 4.

External Power Supply

An external power supply must be connected to the system connector terminals VDC and COM. This supply powers the input receiver circuitry, the output driver circuitry and provides the load current for the output drivers.

The external power supply can be derived from the same power supply unit as the control supply for the SwitcherGear unit, or from a separate power supply unit.

Isolation

The DIOx, VDC and COM terminals are galvanically isolated from the SwitcherGear controller. The DIOx terminals are group-isolated, i.e. they all share the same VDC and COM supply voltages.

The purpose of the isolation in the DIO005 module between the input/output channels and the SwitcherGear controller is to prevent ground loops that may introduce electrical interference. In this scenario, the working voltage across the isolation barrier is typically no more than 10 V. The isolation barrier must not be used to isolate mains supplies.

Faults

Faults in the DIO005 modules are reported on the FAULTn output signal of the MCU interface. The signal is active-low. During normal operation the signal is logic high. The signal will change to a logic low state when any of the following fault conditions occur:

- the voltage of the external VDC supply is below the undervoltage shutdown threshold
- an error condition in the receivers of the input interface
- an over-temperature condition in the drivers of the output interface
- an internal data transmission error

Applications Information

Wiring

Input devices are wired between the DIOx terminals and the VDC supply, as shown in Figure 5. Input devices may be mechanical contacts as shown in the figure – switches, push buttons, relay contacts, etc. The digital outputs of sensors, variable speed drives, etc. can also be connected to the DIOx terminals if they are of the current-source output type and meet the current and voltage requirements.

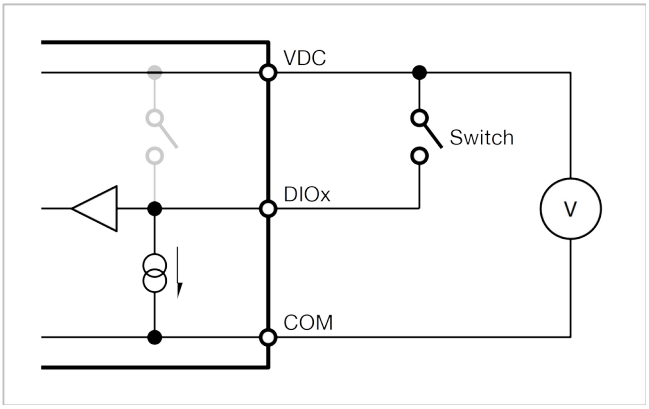

Figure 5: Wiring of an input device with switch contacts.

Loads are wired between the DIOx terminals and the COM supply, as shown in Figure 6. Examples of loads include indicators, sounders, relay coils, solenoids, etc. The digital inputs of variable speed drives, etc. can also be connected to the DIOx terminals if they are of the current-sink input type and meet the voltage requirements.

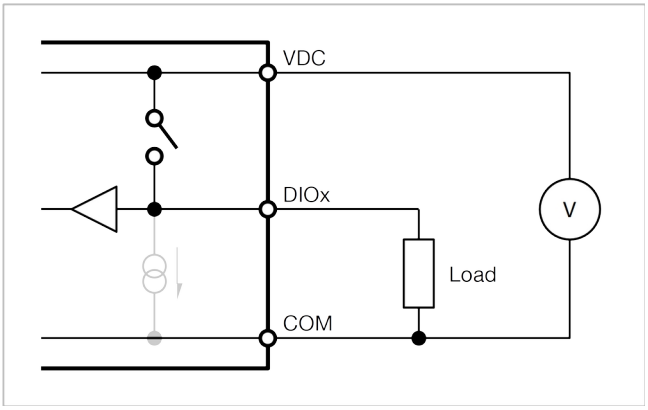

Figure 6: Wiring of a load device.

The output drivers can also be used as a switched power supply to provide power to other devices, as long as the operating current of the device is within the rating of the driver.

Multiple channels may be wired in parallel in order to increase the output current capability – refer to **Electrical Characteristics**.

The loads described above are driven directly by the output drivers of the module. However, there are other types of loads that must not be connected directly to the DIOx outputs. You must use an appropriate intermediate relay to switch the following types of loads. The coil of the relay is driven by one or more DIOx outputs, and the contacts of the relay are used to switch the load.

- 12-24 VDC loads with a current rating that is greater than the rating of the DIOx outputs
- DC loads that are connected to a DC supply that is not the same as the system connector COM voltage
- AC loads connected to a mains supply

The input receivers are always active and can be used to read the state of the corresponding output driver. This can be used in high-integrity systems to verify that a demanded output state is actually present at the DIOx terminal.

Host MCU

Texas Instruments C2000

When using a C2000 microcontroller, the serial interface signals of the module should be connected to either a SPI peripheral or a multi-channel buffered serial port (McBSP, which has a SPI mode). The CSn signal can be driven by either a strobe pin under the control of the SPI resource, or a GPIO pin under user control. This allocation is summarised in Table 4.

Table 4: C2000 pins allocation for serial interface

MCU Interface Signal	**C2000 Pin Allocation**	
	SPI Perpheral	**McBSP Peripheral**
SCLK	SCLK	CLKX
SIMO	SIMO	DX
SOMI	SOMI	DR
CSn **(peripheral control)**	$\overline{\text{SPISTE}}$	FSX
CSn **(user control)**	GPIO	GPIO

SwitcherWare Library

The SwitcherWare Library from Denkinetic includes code resources to handle the low-level hardware configuration and provide a simple-to-use interface for the DIO005 module. See the SwitcherWare documentation for the class `ModuleDIO005` for more informa-

tion. The SwitcherWare library also includes examples for using the DIO005 module and many others.

Warnings

The terminals of the system connector (DIOx, VDC, COM) must not be connected to a mains supply or circuits connected to a mains supply.

The length of cables connected to the system connector must not be longer than 30 m.

The user is responsible to ensure that the cables and connectors used for external wiring have insulation and/or separation distances that provide isolation from live parts and from earth.

Electrical Characteristics

The following specifications apply for V_{DC} = 12 V to 24 V, T_A = 25 °C, unless otherwise noted.

Parameter	Conditions	Min	Typ	Max	Unit
INPUTS					
Low-Level Input Threshold Voltage		7			V
High-Level Input Threshold Voltage				11	V
Input Hysteresis Voltage			0.7		V
Input Current Limit		2.3		3.4	mA
Input Resistance	Linear region before current limit		1.7		kΩ
Debounce Time			1		ms
OUTPUTS					
On-State Resistance			150	200	mΩ
Load Current	One channel		0.5		A
	Two channels in parallel		0.8		A
	Four channels in parallel		1.6		A
Short Circuit Current	Initial peak, 700 µs		1.4		A
	Long duration		1.1		A
Turn-On Time	Load 47 Ω		65	120	µs
Turn-Off Time	Load 47 Ω		90	170	µs
ISOLATED SUPPLY, VDC					
Voltage Range		11		34	V
Under Voltage Shutdown				10.5	V
Current Consumption	Inputs and outputs inactive		15	25	mA
Isolation Voltage, RMS	Between DIO005 module COM supply and SwitcherGear controller COM supply			100	V

Timing Characteristics

The following specifications apply for V_{DC} = 12 V to 24 V, T_A = 25 °C, unless otherwise noted.

Parameter	Conditions	Min	Typ	Max	Unit
SCLK Frequency, Data In				5	MHz
SCLK Frequency, Data Out				15	MHz

Revision History

Revision	Date	Changes From Previous Release
1	21 Oct 2019	▪ Original release.
2	03 Aug 2020	▪ Updated figures 5, 6.