SWITCHERGEAR
GEAR TO CONTROL YOUR POWER SWITCHES

# Module DIN001

## Single-channel digital interface
## Isolated incremental encoder

**REFERENCE MANUAL**

***Features***

*Standard module for SwitcherGear*

*A, B and Z (index) channels*

*Single-ended and differential input modes*

*+5 V power supply output for encoder power*

*Galvanic isolation*

*Supply sense inputs*

***Applications***

*Connection of incremental encoder to SwitcherGear*

*Variable speed drives*

*Shaft angular speed measurement*

***General Description***

*The DIN001 module is a SwitcherGear interface for incremental encoders. It includes a 5 V supply to power and other features to enable use with many incremental encoders.*

***Ordering Information***

| ***Order Code*** | ***Description*** |
|---|---|
| `DIN001` | *SwitcherGear module, single-channel digital interface, isolated incremental encoder* |

## 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

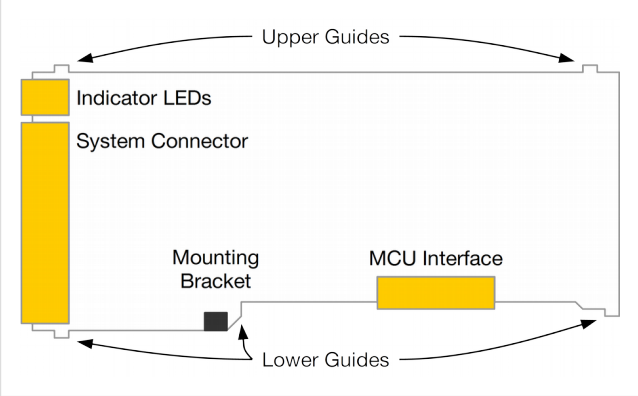


**Figure 1: Parts of a SwitcherGear module.**

**System Connector**

A 12-way pluggable terminal strip connector is used to connect system wiring to the DIN001 module.

Table 1 shows the pin-out of this connector. The connections for each channel are arranged in groups to facilitate wiring to the external encoder.

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**

Eight miniature indicator LEDs on the front panel show the status of the module. Refer to Table 2 for details.

**Table 1:** System connector

| Pin | Signal | Description |
|---|---|---|
| 1 | A+ | Incremental encoder A signal input for differential and single-ended input modes. |
| 2 | A− | Incremental encoder $\overline{A}$ signal input for differential input mode. |
| 3 | B+ | Incremental encoder B signal input for differential and single-ended input modes. |
| 4 | B− | Incremental encoder $\overline{B}$ signal input for differential input mode. |
| 5 | Z+ | Incremental encoder Z signal input for differential and single-ended input modes. |
| 6 | Z− | Incremental encoder $\overline{Z}$ signal input for differential input mode. |
| 7 | SENSE HI | Sense input for +5 VDC supply, or safe-high input. |
| 8 | SENSE LO | Sense input for 0 VDC supply, or safe-low input. |
| 9 | - | - |
| 10 | +5V | Power supply output, +5 VDC |
| 11 | COM | Power supply output, 0 VDC |
| 12 | FIELDGND | |

**Table 2:** Indicator LEDs

| Appearance | Left Column | | Right Column | |
|---|---|---|---|---|
| | Colour | Description | Colour | Description |
| 🟢 🔴 | Green | Signal A | Red | Fault active |
| 🟢 ⚪ | Green | Signal B | - | - |
| 🟢 ⚪ | Green | Signal Z | - | - |
| 🟢 ⚪ | Green | +5V | - | - |

**Table 3:** MCU interface

| Pin | Signal | Description |
|---|---|---|
| D0 | SIGNALA | Incremental encoder A signal output. |
| D1 | SIGNALB | Incremental encoder B signal output. |
| D2 | SIGNALZ | Incremental encoder Z signal output. |
| D3 | FAULTn | Fault output. Active-low. |
| D4 | - | - |
| D5 | - | - |
| D6 | - | - |
| D7 | - | - |
| D8 | - | - |
| D9 | - | - |
| D10 | - | - |
| D11 | - | - |
| A0 | - | - |
| A1 | - | - |
| A2 | - | - |
| A3 | - | - |

### MCU interface

Refer to Table 3 for details of the digital and analogue signals provided by the DIN001 module.

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

### Signal Input Mode

The inputs of the DIN001 module can be configured to accept single-ended or differential signals by setting the unbalance solder jumpers on the rear of the module, as shown in Table 4. Each input is configured separately by a solder jumper, but all three inputs should be set to the same signal input type.

**Table 4: Configuration of signal input mode**

| Signal Input Mode | Unbalance Jumpers A, B, C |
|---|---|
| Differential (default) | Open |
| Single-ended | Short |

### Sense Input Open-Circuit Detection

The open-circuit detection capability of the sense inputs can be configured by setting the sense default solder jumpers as shown in Table 5.

**Table 5: Configuration of sense input open-circuit detection**

| Behaviour Of Sense Input When Open-Circuit | Sense Jumpers VDC, GND |
|---|---|
| Normal operation (default) | Open |
| Fault | Short |

### Solder Jumpers

Modules are supplied with all solder jumpers in the open state. These default feature settings are highlighted in grey in the configuration tables.

If a different configuration is required for your application, you must change the solder jumper settings before using the SwitcherGear.

Solder jumpers allow configuration of SwitcherGear modules. They function like a switch to control the features of the module. Jumpers consist of two adjacent pads on the rear side of the module circuit board. The jumper can be shorted (switch closed) by making a solder bridge across the pads. The jumper can be opened (switch open) by removing the solder bridge.

The solder jumpers are intended for one-time-only configuration. No warranty is provided for damage to solder jumpers. Only skilled personnel who are trained in correct soldering technique should undertake the configuration of the solder jumpers. Incorrect technique or excessive temperature can result in the pads of the solder jumper detaching from the circuit board, rendering the jumper permanently open-circuit.

Observe the following precautions when configuring solder jumpers:

- Anti-static handling procedures.
- Turn off power before removing or inserting modules.
- Use a fine-tip soldering iron with adjustable temperature.
- Use only lead free solder and compatible tools.
- Use the minimum temperature required to perform the task.
- Do not heat the jumper for more than 5 seconds. Allow to cool before re-applying heat.
- To remove solder from a jumper, use a narrow (e.g. 1.5 mm) fluxed solder wicking braid.

# Functional Description

The DIN001 module provides a complete interface for connecting an incremental encoder to SwitcherGear. The interface is galvanically isolated to eliminate grounding problems.

### Signal Inputs

There are three digital input channels, A, B and Z. The channels are identical, but the naming convention implies the usage for each.

The A and B channels are used for the pulsed signals that contain the position information. Each edge transition of the signals represents an incremental **change** in the measured position. It is not possible to know the absolute position from the A and B signals. The relative order of pulses between the signals indicates the direction of motion.

The Z, or index, channel is used to indicate a fixed absolute position in the range of the encoder. This is typically required for synchronous motor applications, where the absolute position of the rotor must be know.

Each input can be configured as a single-ended input or a differential input to accommodate the commonly used signal types. When configured for single-ended input mode, the complementary inputs ($\overline{A}$, $\overline{B}$ and $\overline{Z}$) must be left unconnected.

The inputs have a high resistance at DC and are AC terminated. The AC termination minimises the effect of signal reflections when long cables are used.

### Sense Inputs

Correct operation of the encoder is dependent on operation of the encoder within the manufacturer's specified operating conditions, in particular the supply voltage. Long wires introduce resistive voltage drops that can cause the supply voltage at the encoder's terminals to fall below specification. Operation with a low supply voltage can cause the encoder to generate unreliable output signals. In many applications, the consequences of this on safety can be severe. The DIN001 module can measure the supply voltage at the encoder's terminals and generate a warning if it is too low. The output can be used by the host microcontroller to take action to prevent a potentially unsafe condition.

Two comparator inputs on the front panel connector, SENSE HI and SENSE LO, provide remote sensing of the supply and ground voltages. Because these inputs draw negligible current, there is no voltage drop along the sensing conductors. This means that the voltage at the sense inputs is a true measurement of the voltage at the encoder's supply terminals.

A fault is detected when the voltage on the SENSE LO input is higher than its fault threshold voltage. By default, the SENSE LO input is biassed to COM by a high value resistor.

Similarly, a fault is detected when the voltage on the SENSE HI input is lower than its fault threshold voltage. By default, the SENSE HI input is biassed to +5V by a high value resistor.

If the SENSE LO and SENSE HI inputs are not used, they can be left unconnected and the default bias resistors will inhibit the generation of faults.

If the SENSE LO and SENSE HI inputs are to be used as fault sensing inputs, the default biassing arrangement should be changed. The inputs should be configured so that they are biassed to the mid-supply. In this case, an open-circuit fault in the sense wiring

will generate a fault. See Sense Input Open-Circuit Detection for configuration details.

The SENSE LO and SENSE HI input signals are filtered to prevent transients from generating a fault output.

**Power Supply**

The DIN001 module provides a +5V supply to power the external incremental encoder. The power supply is protected against overload and short-circuit. Operation of the output current limit activates the FAULTn signal on the module-base interface.

**Fault Output**

The DIN001 module generates an active-low fault output to the host microcontroller when:

- the current limit of the +5V power supply is active; or
- the voltage on the SENSE LO input is above its fault threshold voltage; or
- the voltage on the SENSE HI input is below its fault threshold voltage.

# Applications Information

**Sense Inputs**

The conductors used for the +5V and COM supply lines must be rated so that the voltage drop caused by the wiring resistance does not cause the encoder to detect an under-voltage condition at its terminals.

The supply sense inputs should be connected to the supply sense terminals of the encoder, if they are present. If the encoder does not provide supply sense outputs, or provides only one of these sense outputs, the corresponding SENSE LO and SENSE HI pins should be wired instead to the supply terminals at the encoder. This will provide protection against faults in the sections of supply wiring that are monitored.

Instead of sense outputs, some encoders provide a digital status output to indicate **power good** or **fault**. This digital information can be connected to the appropriate sense input of the DIN001 module to retain the protection functionality. The used inputs should be configured for open-circuit detection.

**Choice of Incremental Encoder**

Supply Voltage

To take advantage of the power supply in the DIN001 module, the encoder must be able to operate from +5V with a suitable current consumption.

Signal Output Type

The outputs from the incremental encoder can be either single-ended signals or differential signals. The choice depends on the length of the cable and the level of electrical noise in the environment.

Single-ended signals require only one conductor per signal, but can be corrupted by noise picked up in long cables. Single-ended signals are also known by other names, including CMOS and unbalanced signals.

Differential signals use two conductors per signal, which provides high signal integrity in electrically noisy environments. Differential signals are also known by other names, including RS-422 or balanced signals.

Pulses Per Revolution

Incremental encoders are available in a wide range of resolution options, quoted as pulses per revolution (PPR). Low resolution encoders start at 100 PPR, with resolutions above 4096 PPR available for specialist applications.

The choice typically depends on the following factors:

- application
- whether the encoder is used to measure angular position or angular velocity
- minimum shaft speed
- maximum shaft speed
- capabilities of host microcontroller

Applications such as field oriented control of electrical machines typically use encoders with high resolution, e.g. 1024 to 8192 PPR.

The measurement of velocity is typically enhanced by the use of an encoder with high resolution and high accuracy.

The frequency of the output pulses is related to the shaft speed according to

$$FREQ = PPR \times RPM / 60,$$

where **RPM** is the shaft speed in revolutions per minute.

The PPR must be chosen so that the pulse frequency at the maximum shaft speed is within the capability of the encoder and the DIN001 module.

Sense or Fault Outputs

For increased safety through the detection of encoder faults, the encoder should have supply sense outputs or a fault output.

**External Wiring**

The pluggable terminal strip can accept bare conductors with cross sectional area in the range 0.15 $mm^2$ to 1.5 $mm^2$. The acceptable range for conductors terminated with bootlace ferrules is 0.25 $mm^2$ to 0.5 $mm^2$.

It is recommended to use screened cable to connect the incremental encoder to the DIN001 module. The screen should be connected to the DIN001 module using the FIELDGND pin on the front panel connector.

**Isolation**

The power supply and input circuitry of the DIN001 module are galvanically isolated from the SwitcherGear circuitry. This isolation barrier is intended to be used as functional insulation for the purpose of breaking ground loops, etc. It must not be used to provide isolation from power system voltages.

# Warnings

The length of cables connected to the module front panel 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.

The user is responsible to ensure that cables and connectors used for external wiring that carry live voltages have insulation and/or separation distances that provide protection against indirect contact.

The user is responsible to ensure that the installation provides protection against direct contact.

# Electrical Characteristics

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

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| A+, A–, B+, B–, Z+, Z– INPUTS | | | | | |
| Voltage Range | | –7 | | 12 | V |
| Input Threshold Voltage | | | | | |
| Single-ended input mode | | | 2.35 | | V |
| Differential input mode | | | –100 | | mV |
| Input Hysteresis | | | 40 | | mV |
| DC Input Resistance | | 12 | | | kΩ |
| AC Termination Resistance | | | 120 | | Ω |
| DYNAMIC | | | | | |
| Input Pulse Frequency | | 0 | | 2000 | kHz |
| Input Pulse Width | | 40 | | | ns |
| Propagation Delay | | 50 | | 120 | ns |
| Pulse Skew | | | | 15 | ns |
| Channel-To-Channel Skew | | | | 10 | ns |
| SENSE INPUTS | | | | | |
| SENSE HI Input | | | | | |
| Fault threshold voltage | Falling input voltage | $V_{OUT}$ – 550 | $V_{OUT}$ – 500 | $V_{OUT}$ – 450 | mV |
| Hysteresis voltage | | | 50 | | mV |
| SENSE LO Input | | | | | |
| Fault threshold voltage | Rising input voltage | 450 | 500 | 550 | mV |
| Hysteresis voltage | | | –50 | | mV |
| Filter Time Constant | | | 1 | | ms |
| DC Input Resistance | Open-circuit detection disabled | | 100 | | kΩ |
| | Open-circuit detection enabled | | 50 | | kΩ |
| POWER SUPPLY OUTPUT | | | | | |
| Output Voltage, $V_{OUT}$ | Load current 100 mA | 4.7 | | 5.2 | V |
| Load Regulation | | | 0.17 | 0.25 | V/A |
| Current Limit | | 0.4 | | 0.6 | A |
| ISOLATION | | | | | |
| Peak isolation voltage | | | | 3 | kV |

**Revision History**

| Revision | Date | Changes From Previous Release |
|---|---|---|
| 1 | 16 Apr 2014 | ▪ Original release. |
| 2 | 17 Oct 2014 | ▪ Updated naming and format. |
| 3 | 8 Dec 2017 | ▪ Updated for SwitcherGear |