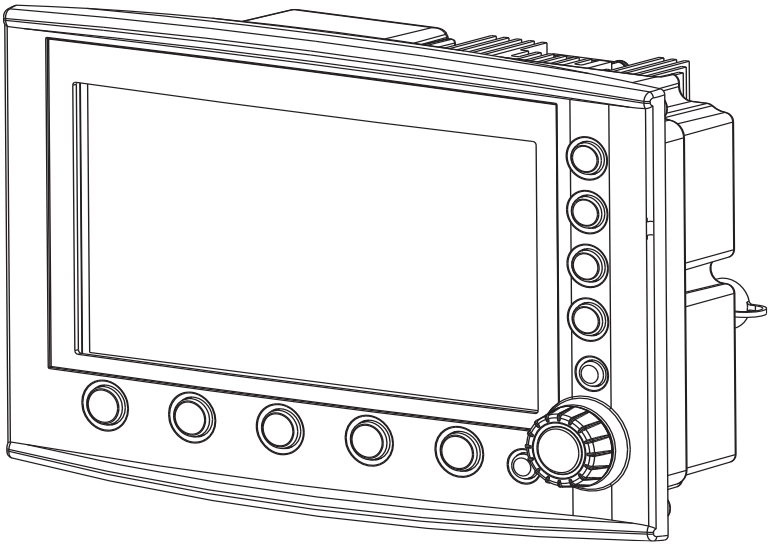
# IQAN-MDL2
# Instruction book

Publ no HY33-8401-IB/UK
Edition 2011-08-04



ENGINEERING YOUR SUCCESS.

# 1 Introduction

These instructions are to be used as a reference tool for the vehicle manufacturer's design, production, and service personnel.

The user of these instructions should have basic knowledge in the handling of electronic equipment.

## Warnings

Sections marked with a symbol in the left margin, must be read and understood by everyone using the system, carrying out service work, or making changes to hardware and software.

The different symbols used in this manual are defined below.

**WARNING**

Sections labeled *WARNING* with a caution symbol in the left margin, indicate that a hazardous situation exists. We use warnings, marked with the warning symbol, in two ways.

- As a strong recommendation about work practices when using the product in the machine (e.g. routines when updating an application). This use is common to the term 'hazardous situation', that a person is exposed to a hazard.
- As a way of pointing out important information for the machine designer that in some way relates to safety. This includes the design of the physical machine, and also the application program being developed for the control system.

Not all document sections that contain information about safety are marked with a warning symbol (there would be warnings everywhere). Failure to comply with the recommendations can cause unintentional, and unexpected behavior of the control system. This can potentially cause death, serious injury or property damage.

**NOTICE**

Sections labeled *NOTICE* with a notice symbol in the left margin, indicate there is important information about the product. Ignoring this could result in less than optimal performance, or damage to the product.

Contact the manufacturer if there is anything you are not sure about or if you have any questions regarding the product and its handling or maintenance.

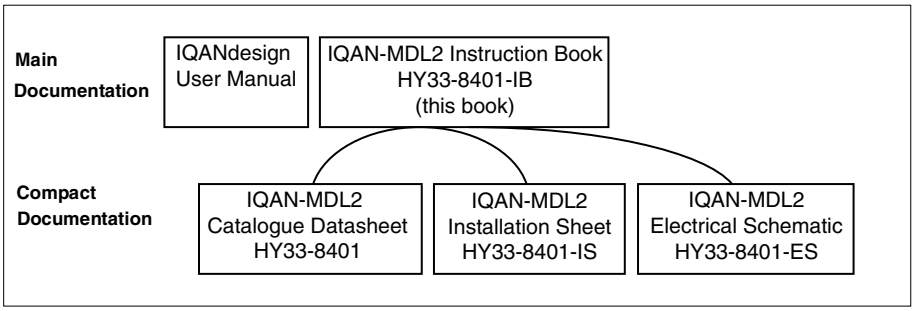
The term "manufacturer" refers to Parker Hannifin Corporation.

# Overview of relevant documentation

The following publications are relevant for users of this product.

The main documentation contains information that is not found elsewhere.

The additional documentation contains product information in a compact format, for details on the information found in those documents, consult this manual.




The IQAN-MDL2 module documentation system.

# 2 Precautions

Work on the hydraulics control electronics may only be carried out by trained personnel who are well-acquainted with the control system, the machine and its safety regulations.

**WARNING**
Make sure that you have sufficient knowledge before designing, modifiying or servicing the control system.

Read the relevant sections of this document before conducting any work on the control system.

**WARNING**
This product is not field repairable.

**NOTICE**
As much as possible of the welding work on the chassis should be done before the installation of the system. If welding has to be done afterwards, the electrical connections on the system must be disconnected from other equipment. The negative cable must always be disconnected from the battery before disconnecting the positive cable. The ground wire of the welder shall be positioned as close as possible to the place of the welding. The cables on the welding unit shall never be placed near the electrical wires of the control system.

# Read This

## Design of control system

**WARNING**
Risk of injury may be introduced by design of control system!

This product is designed to control hydraulic outputs. The control application must be designed using basic safety principles so that unintentional movement is avoided.

The machine must be equipped with an emergency stop that stops all movement. Please refer to section Emergency stop, on page 11.

### Before you start

Read this document, as a minimum sections 1-7

Read the IQANdesign software user manual section on 'application safety'.

## Start-up, maintenance, and diagnostics

For all personnel carrying out installation, commissioning, maintenance or troubleshooting.

**WARNING**
Work on the hydraulics control electronics may only be carried out by trained personnel who are well-acquainted with the control system, the machine and its safety regulations.

### Before you start,

Read section Start-up, on page 29.

### Additional information for service

Mounting and maintenance instruction book.

### Additional information for diagnosing the system

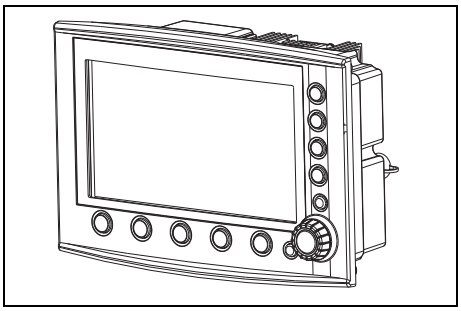
Read section System Diagnostics, on page 30, and see Appendix B, on page 36, in this document.

Use the IQANrun software user manual as a reference.

# 3 Product description

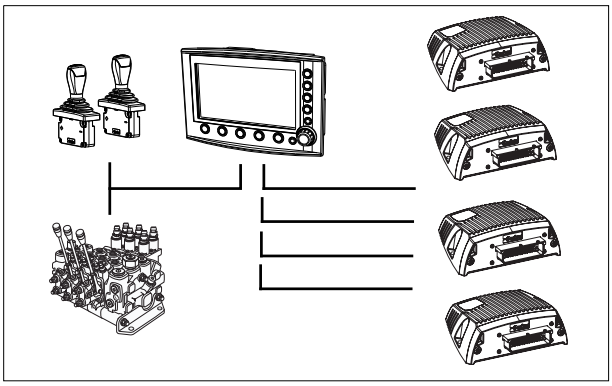
## IQAN-MDL2

The IQAN-MDL2 is a combined display and bus master capable of running applications created by IQANdesign software. Built on a 32-bit platform the unit has large computational power and is capable of controlling complex applications.



The IQAN-MDL2 module.

## System overview



A typical MDL2 system.

The master module, IQAN-MDL2, is the central unit in an IQANsystem. IQAN-MDL2 is a driver information unit and a bus master that is intended for the high-end range of mobile hydraulic applications. The IQAN system is a CAN (Controller Area Network) bus control system for total vehicle control (e.g. engine, transmission, working hydraulics, supervision). In most applications the MDL2 display can replace all mechanical dial-type instruments.

The display in the module has very high optical performance across a wide operating temperature range and over a wide range of ambient light.

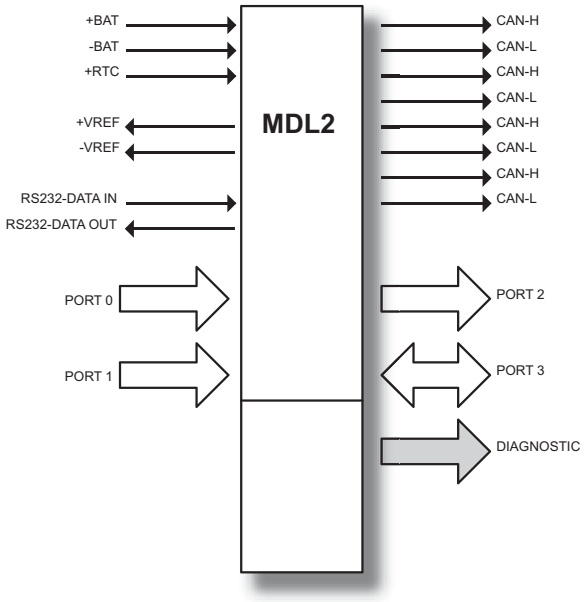
IQAN-MDL2 has three main roles in a vehicle's control system; master control unit, information display and data gateway to other systems.

The MDL2 has four CAN interfaces that support ICP (IQAN CAN Protocol) for IQAN bus communication. The buses may also be configured for SAE J1939 or Generic user defined protocols (e.g. CANopen). Additionally, any of the CAN buses may be used for diagnostic purposes. The unit has two diagnostic communication ports: RS232 and USB. An additional RS232 connection in the main connector is dedicated for external modems.

The IQAN-MDL2 also has multiple inputs and outputs that are designed to be flexibly configured using IQAN software for measurement and control.

All I/O are EMI filtered and protected against short circuit to -BAT and +BAT.

# I/O




## Voltage inputs

The IQAN-MDL2 module has eight (8) *voltage inputs* VIN-A thru VIN-H for connection of 0-5 Vdc signals. These inputs can be configured as *digital inputs* for reading switches. *Voltage inputs* and *digital inputs* share positions, see below.

(8) Voltage inputs VIN-A, VIN-B, VIN-C, VIN-D.....VIN-H

or

(8) digital inputs DIN-E, DIN-F, DIN-G, DIN,H..... DIN-L

## Digital inputs

The MDL2 module has four (4) *digital inputs* DIN-A thru DIN-D. DIN-B and DIN-C are multi-purpose and can be configured in other ways.

## Frequency inputs

### Frequency

The input pin DIN-B may be configured as a *frequency input.*

### Directional frequency

The input pins DIN-B and DIN-C may be configured as a *directional frequency input* for either a *quadrature input* or *directional input.* Quadrature signals consist of two 90 degree square waves and are *phase-dependent*. Directional inputs have one square wave for the frequency plus a signal that is high or low to show direction and are considered *level dependent*.

Quadrature and directional inputs can operate in 2 modes. *Speed* which is frequency with direction and *position* which is a pulse count with direction.

*Digital inputs, frequency input* and *directional frequency input* share positions, see below.

(4) Digital inputs DIN-A, DIN-B, DIN-C, DIN-D

or

(3) digital inputs DIN-A, DIN-C, DIN-D and frequency input FIN-A

or

(2) digital inputs DIN-A, DIN-D and quadrature input DFIN-A+, DFIN-A-

## Proportional outputs

The MDL2 module has two (2) double *proportional outputs* for controlling proportional valves. These outputs can control two bi-directional valve sections or two single solenoid devices (ie. proportional cartridge valves). The proportional outputs can be used in different modes.

### Current mode

*Current mode* (current closed loop) proportional signals can be selected and the parameters configured using IQAN software. As a current output the specified frequency mA signal is sent to the valve solenoid. The return line is monitored and the signal is modified by the controller to maintain the commanded output as the solenoid coil heats up etc.

### PWM mode

*PWM mode* (voltage open loop) proportional signals can be selected and the parameters configured using IQAN software. As a PWM output the specified frequency MR% duty cycle signal is sent to the valve solenoid. The return line is not monitored. This type of output is intended for Pulsar® type valves

For flexibility the proportional outputs may also be configured as up to two (2) *on/off outputs* and up to four (4) *on/off intputs*. The *proportional outputs*, *on-off outputs* and *on-off inputs* share positions, see below.

(2) double proportional outputs COUT-A, COUT-B (PWMOUT-A, PWMOUT-B)

or

(2) on/off outputs DOUT-G, DOUT-H. Configuring as DOUT's allows the CRET pins to be used as on/off inputs, (4) total, DIN-M thru DIN-P.

In order to increase the performance of proportional outputs when controlling proportional valves, the dither frequency can be adjusted.

## High power On/Off outputs

The IQAN-MDL2 module has six (6) *on/off outputs* that are high-side power outputs. These outputs may not be configured as proportional, see below.

(6) On/off outputs DOUT-A thru DOUT-F

## CAN related functions

The IQAN-MDL2 uses a CAN-bus (CAN = Controller Area Network) to communicate with IQAN expansion modules and other systems. The CAN-bus is a robust communication protocol that is widely used and well proven within the automotive industry. The unit has four (4) CAN buses, CAN-A thru CAN-D. The buses may be configured using IQAN software to be ICP (ICP = IQAN CAN Protocol), SAE J1939 or Generic user defined CAN protocol (e.g. CANopen).

## Communication

The communication interfaces are used for uploading/downloading applications or diagnostics and typically are connected to a computer.

### CAN

The IQAN-MDL2 has 4 CAN buses. Any of the CAN buses may be used for communication and diagnostics. A CAN communication card is required to be installed in your PC to use this feature.

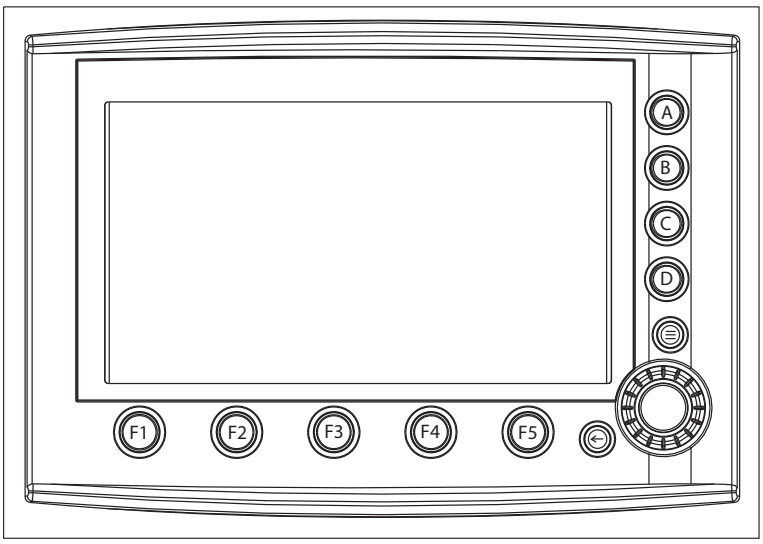
### RS232

The IQAN-MDL2 has two(2) RS232 interfaces. One is in the 42 pin main connector C1 and is used to interface with external RS232 inputs (i.e. modems). The other is in the C2 connector, a separate 10 pin connector, and is used for communicating with a PC.

### USB

The MDL2 has a USB (device only) connection on connector C2. USB is a complement to RS232 for high speed PC communication and diagnostics, for maximum voltage on USB pins, see Appendix A, on page 31.

## HMI (human machine interface)




The IQAN-MDL2 front panel HMI.

### Features

IQAN-MDL2 has a 6.5" transflective screen for easy readability in a wide range of ambient light conditions. There are eleven buttons and a rotary encoder knob for input and menu selection. The functionality of the different contols are listed below

## Encoder

The encoder is of the Jog shuttle type (rotary knob with pushbutton). Pushing the knob equals 'enter'. The knob can be programmed so that its pushbutton feature can act as a virtual input button and perform some function depending on the current display page. Rotating the shuttle knob can be programmed to adjust values, select from items in a table or cycle thru display pages.

## Buttons

The buttons are arranged on the bottom and right hand side of the display.

- F1 thru F5 function buttons.
  Programmable 'softkeys' that may be configured by the user to bring up a display page, bring up an adjustment group or act as a virtual input.
- A thru D function buttons.
  Programmable 'softkeys' that may be configured by the user to bring up a display page, bring up an adjustment group or act as a virtual input.
- Menu button (three horizontal lines).
  Always brings up the Menu page. It is not programmable.
- 'Esc' or BACK button (left arrow).
  Returns you to the previous display page. May be configured by the user to bring up a display page or act as a virtual input.

## Display

### Brightness

The brightness is easily adjusted by pressing the 'menu' button and following the prompts to the backlight settings section.

### Burn-in

The MDL's TFT display, like other computer viewing screens can have a ghost picture occur if a static image is left on the display for extended periods of time. For the best viewing over the life of the product we recommend using the screensaver functionality to prevent the burn-in of a display page image.

**NOTICE**

To avoid burn-in, use the screensaver on the display.

### Maintenance

The 6.5" transflective display is a high quality viewing interface and reasonable care should be taken to maintain it.

The display can be cleaned with an LCD cleaning solution found in many stores. Use a lightly dampened lint-free, non-abrasive cloth when cleaning the display.

**NOTICE**

To avoid scratches, do not wipe or clean a dry display.

### Appearance

Please refer to the IQANdesign software manual for display programming information.

## Fan

The unit has a cooling fan and heatsink to remove heat from inside the enclosure.

### Maintenance

First clean the metal fins and fan housing with a brush to remove loose dirt and dust. Avoid pushing debris into the fan.

After that, we recommend that you clean in between the curved metal fin section and fan housing with a small brush or cotton swab to remove trapped dirt.

**NOTICE**

Do not use compressed air to blast dirt off of the fan and heatsink. You may cause damage to the fan!

## Memory for logging

The unit has an internal memory dedicated for logging events. Memory logging is stored in 16Mbyte data flash with a power-fail-safe file system.

# 4 Safety

## Internal diagnostics

The module performs a number of self-checks that improve safety. Checks include monitoring of voltage supplies, checksums on memory and a watchdog that monitors software execution. The module is using a real time operating system which supervises software execution.

If a critical error is detected, the module is stopped, with CAN bus and outputs off.

## CAN-bus interruption

The IQAN-MDL2 communicates with expansion modules on the CAN-bus. Both the master and the modules check for any interruptions in CAN-bus communication. If an error occurs the master will use zero or an application defined error value for the module inputs, and the module outputs will be off.

The error will be presented with a related message on the IQAN-MDL2 display.

## Current check

For the proportional outputs when used in current mode, a current check is performed. If an error is detected, this will be indicated on the master module display, and the output will shut off.

The module can detect open-circuit, short-circuit to +BAT/-BAT or short-circuit to other proportional output and return pins.

## Emergency stop

**WARNING**

Risk of injury! The emergency stop must disconnect the power supply to the module; do not connect the emergency stop as a signal input only.

The emergency stop must be installed so that the risk of reverse feed of the module is avoided, see section Emergency stop, on page 16.

# 5 Mounting

## Mounting the IQAN-MDL2

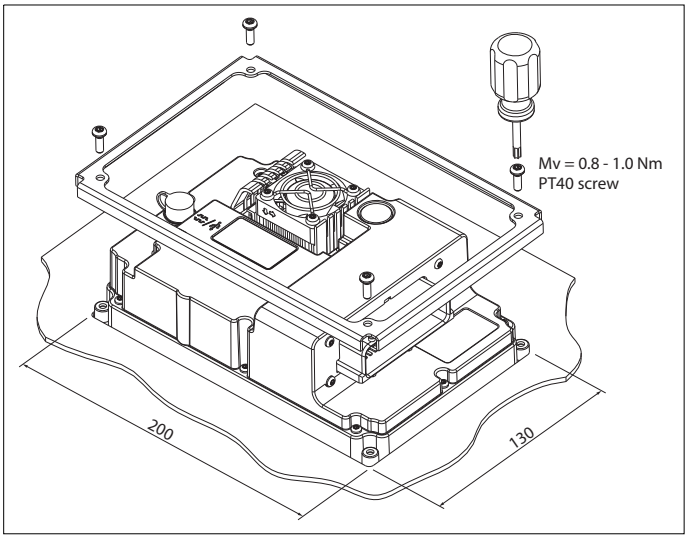
**NOTICE**
The IQAN-MDL2 module should be mounted according to the following instructions:

- Locate the module eliminating the risk for the cabling to be folded, crushed or damaged in any way. Ensure the cabling cannot pull, twist or induce sideload on the connector.
- Locate the module so that physical impact is avoided.
- Locate the module so that air can circulate to eliminate excess heat. Ensure that no external heat, e.g. from the engine or heater, is transferred to the module.
- Locate the module to protect it from pressure washing and water directly spraying on the face or similar. Protect the rear of the module from any type of spray or moisture. The unit must be protected from spraying water!
- Locate the module so that the PC connector in the back of the unit is accessible.
- Locate the module so that the display is easily viewed.

**NOTICE**
The IQAN-MDL2 module must not be placed in any marine related or similar continuously damp environment without external protection.

### Dashboard assembly

When installing in a dash panel the recommended panel thickness is 1.0 - 3.5 mm. Use type PT4 screws to mount (included with bracket).




Mounting of the MDL2 with bracket.

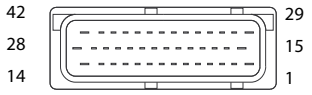
### Fan

Allow at least 100mm (3.94") airspace for proper operation of the cooling fan.

**NOTICE**
Do not install into an enclosure that restricts airflow.

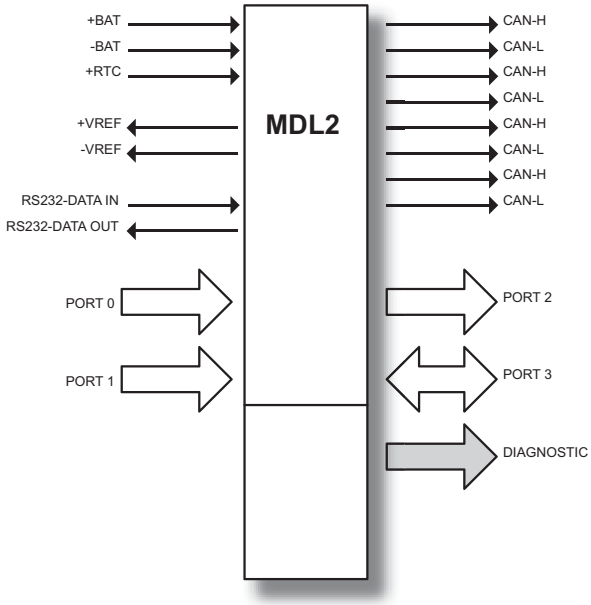
# 6 Installation

## Connector C1




*= The connector contains two types of terminals; MT (Micro Timer) and JPT (Junior Power Timer).

| | | |
|---|---|---|
| **Connector kit** | **Parker no. 5031063** | |
| Housing | Amp no. 1-963226-1 | |
| Casing | Amp no. 0-965643-1 | |
| Pin types* | Amp no. 963711-2 (MT) | Amp no. 929938-1 (JPT) |
| Cables | 0,75-1,0 mm² (MT) | 1,5-2,5 mm² (JPT) |
| Seals | Amp no. 963530-1 (MT) | Amp no. 828905-1 (JPT) |
| Plugs (for empty pos.) | Amp no. 963531-1 (MT) | Amp no. 828922 (JPT) |
| IQAN crimping tool references | Blue handle, pos. A<br>use blue extraction tool | Red handle, pos. B<br>use yellow extraction tool |
| **IQAN tool kit** | **Parker no. 5031061** | |



# Connector pin assignments

| Logical Symbol | Pin No. | (I)nput or (O)utput | Function description and/or Signal name(s) |
|---|---|---|---|
| +BAT | 28 | - | Power supply, positive. |
| -BAT | 15 | - | Power supply, negative ground |
| +RTC | 42 | - | Power supply for Real Time Clock, positive |
| +VREF | 14 | - | Voltage reference for external sensors. Sourcing +5V. |
| -VREF | 1 | - | Voltage reference for external sensors. Return (0V). |
| CAN-A-H | 2 | - | CAN high voltage bus line, will be HIGH in dominant state. |
| CAN-B-H | 4 | - | |
| CAN-C-H | 6 | - | |
| CAN-D-H | 8 | - | |
| CAN-A-L | 3 | - | CAN low voltage bus line, will be LOW in dominant state. |
| CAN-B-L | 5 | - | |
| CAN-C-L | 7 | - | |
| CAN-D-L | 9 | - | |
| RS232-TD | 30 | - | RS232 data out |
| RS232-RD | 31 | - | RS232 data in |
| P0 | | | P0 is an 8 pin input port with alternate functions on four inputs. |
| | | | **VIN** **DIN** |
| P0.0 | 18 | I | VIN-A DIN-E |
| P0.1 | 19 | I | VIN-B DIN-F |
| P0.2 | 20 | I | VIN-C DIN-G |
| P0.3 | 21 | I | VIN-D DIN-H |
| P0.4 | 32 | I | VIN-E DIN-I |
| P0.5 | 33 | I | VIN-F DIN-J |
| P0.6 | 34 | I | VIN-G DIN-K |
| P0.7 | 35 | I | VIN-H DIN-L |
| | | | Note: DIN-E to DIN-L have high impedance inputs (62K Ohm). |
| P1 | | | P1 is a 4 pin input port with alternate functions on two inputs. |
| | | | **DIN** **FIN** **DFIN** |
| P1.0 | 22 | I | DIN-A - - |
| P1.1 | 23 | I | DIN-B FIN-A DFIN-A+ |
| P1.2 | 36 | I | DIN-C - DFIN-A- |
| P1.3 | 37 | I | DIN-D - - |
| P2 | | | P2 is an 6 pin output port. |
| | | | **DOUT** |
| P2.0 | 13 | O | DOUT-A |
| P2.1 | 27 | O | DOUT-B |
| P2.2 | 41 | O | DOUT-C |
| P2.3 | 12 | O | DOUT-D |
| P2.4 | 26 | O | DOUT-E |
| P2.5 | 40 | O | DOUT-F |

| Logical Symbol | Pin No. | (I)nput or (O)utput | Function description and/or Signal name(s) | | |
|---|---|---|---|---|---|
| P3 | | | P3 is a 6 pin input/output port with alternative functions. | | |
| | | | **COUT** | **PWMOUT** | **DIN/DOUT** |
| P3.0 | 11 | O | COUT-A | PWMOUT-A | DOUT-G |
| P3.1 | 25 | O/I | CRET-A+ | PWMRET-A+ | DIN-M |
| P3.2 | 39 | O/I | CRET-A- | PWMRET-A- | DIN-N |
| P3.3 | 10 | O | COUT-B | PWMOUT-B | DOUT-H |
| P3.4 | 24 | O/I | CRET-B+ | PWMRET-B+ | DIN-O |
| P3.5 | 38 | O/I | CRET-B- | PWMRET-B- | DIN-P |
| | | | *Notes:*<br>*If a COUT block (COUT-x, CRET-x+, CRET-x-) is used, all three pins are configured as COUT.*<br>*If a PWMOUT block (PWMOUT-x, PWMRET-x+, PWMRET-x-) is used, all three pins are configured as PWMOUT.*<br>*If a DIN-x or DOUT-x is used in a block (COUT-x, CRET-x+, CRET-x-), all three pins are configured as corresponding DIN-x and DOUT-X.*<br>*DIN-I to DIN-T are equipped with clamping diode, risk for backending.* | | |

Shaded positions are Junior Power Timer pins. Unshaded positions are Micro Timer pins. See section Connector C1, on page 13 for wire, seal, pin number and crimping tool information. The IQAN tool kit is found in the 'IQAN accessories' datasheet.

# Supply voltage

**WARNING**
Before any installation of the IQAN system can take place, make sure the ignition lock is turned off and the battery is disconnected.

## Emergency stop

Make sure an *Emergency Stop* disconnecting the power supply, is easily accessible at any time. The figure below shows how to connect the emergency stop.

## Connecting of Supply Voltage

The supply voltage, should be within the operating range, see Appendix A, on page 31. Connect the supply voltage to +BAT, position 28 and -BAT, position 15. Protect the module by using a fuse. Requisite fuse level should be 20 A, fast (F).

## RTC supply

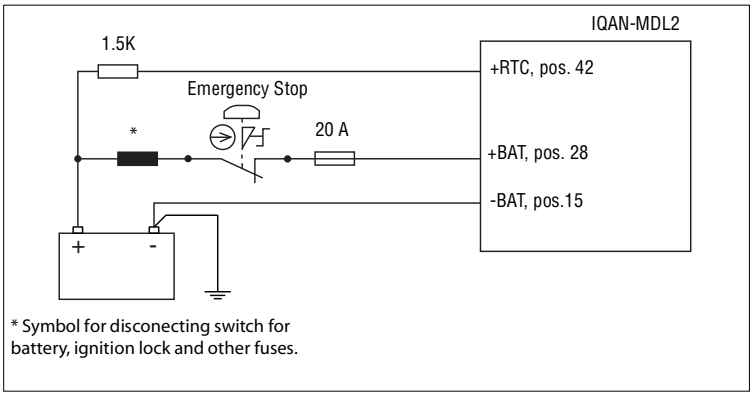
The *real time clock,* +RTC, requires a separate positive power connection. Connect the supply voltage to +RTC, position 42 through a 1.5K ohm resistor. The resistor should be as close to the battery as possible for safety.

**WARNING**
Risk of injury!

To reduce the risk for uncontrolled supply of the IQAN-MDL2, i.e a short circuit between the +RTC cable and +BAT, a resistor must be connected between the battery and the +RTC input. This is important as this line is not controlled by an emergency stop.

The resistor should be placed close to the battery, as the “protected” part, is the cable between the resistor and the unit.

This will prevent the +RTC wire from powering up the unit if shorted to +BAT. The same possibility exists from a short to CRET wires when they are used as digital inputs; refer to section DIN-M to DIN-P, on page 22.




Connecting the emergency stop and voltage supply.

**NOTICE**
Do not use the chassis as the negative terminal.

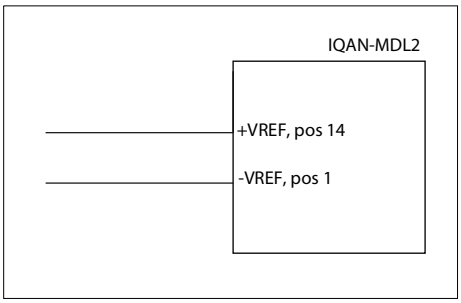
## Polarity reversal

The IQAN-MDL2 module is protected against power supply polarity reversal, provided an external fuse, max 20 A (Fast) is being used.

If this fuse is not used, polarity reversal can damage the unit.

## Reference voltage, VREF

The IQAN-MDL2 module is internally equipped with a voltage regulator to generate the reference voltage *VREF*. The standard reference voltage will feed different kinds of sensors, potentiometers and joysticks.



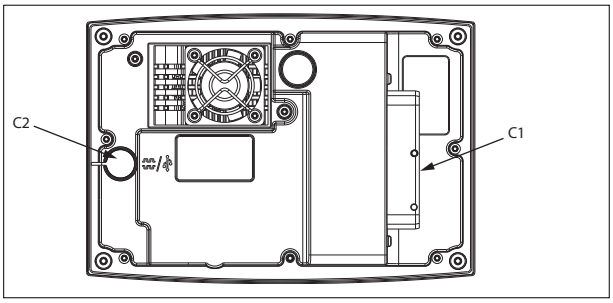

VREF positions.

**NOTICE**

Maximum load for the *VREF* is different according to 12/24 Vdc power supply, see Appendix A, on page 31.

# Diagnostic interfaces

IQAN software includes many tools for tuning, measuring, accessing logs and otherwise checking the performance or troubleshooting your control system. To use the diagnostic tools with the IQAN-MDL2 you may choose between different ways to connect to the unit.




C1 and C2 connector locations.

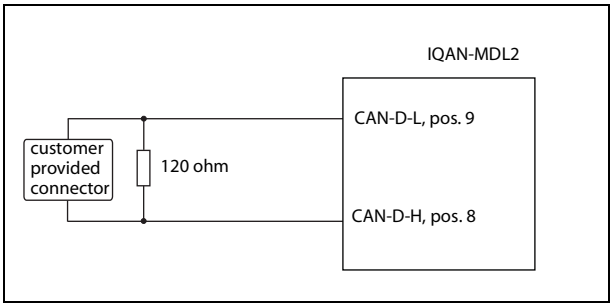
## CAN diagnostics connection

One of the four CAN buses of the IQAN-MDL2 may be dedicated for diagnostics.

Reserving a bus for diagnostics ensures that signals are not interrupted by other bus traffic. A high-speed CAN interface is needed to use this feature. Contact Parker for information about supported CAN interfaces.

A termination resistor is usually required at the CAN interface on the PC. Parker part number 5030182 or an equivalent 120 ohm resistor may be used. A flying lead cable may be connected to the IQAN-MDL2 to provide a connector interface. The connection from IQAN-MDL2 to diagnostic CAN interface can then be made quite easily. It is recommended that the connector be a sealed, automotive type. When not being used this connector should be protected from the environment with a cover or mating blank plug.

The recommended wiring to the IQAN-MDL2 connector C1 is shown below.




Connecting for CAN bus diagnostics.

## RS232 connection C2

For uploading, downloading and other communication with your computer, connector C2 and 10 position cable 5030103 may be used for serial communication. The C2 connector should not be used for permanent mounting to a computer.

## USB connection C2

For uploading, downloading and other communication with your computer, connector C2 and 10 position cable 5030110 may be used for USB communication. The C2 connector should not be used for permanent mounting to a computer.

## USB and "ground loops" (differences in ground potential)

When systems consisting of machines, modules, computers and other devices with different ground potentials are connected by a USB cable, a ground loop may be created. The grounds may only differ by a few millivolts, or by much more. This can be significant when compared to the low level voltage signals that are used in USB data transmission.

**NOTICE**

Protect the PC and unit from damage due to ground loops and surges!

Ground loops can cause problems in communicating and in extreme cases the amount of current flow can damage the USB transceiver in the PC or the module.

A recommended way to prevent ground loops is to ensure that your system includes USB isolation. Isolation protects your PC from damage and preserves the integrity of your data by physically separating the electrical connections between the PC and the unit.

*Good*: Using a battery-powered laptop can prevent the formation of accidental ground loops and short circuits. This protection only holds true, however, as long as the laptop is not also connected to self-powered devices such as printers.

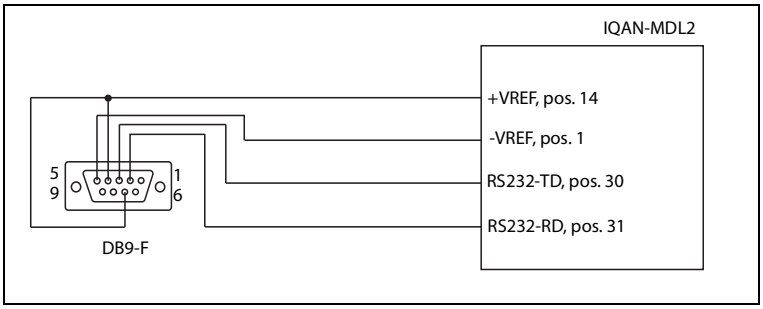
*Better*: Isolation can be provided by adding an isolated USB hub between the PC and the unit.

*Best*: Use a CAN-USB interface with galvanic isolation and communicate with unit via CAN bus. This setup is used in the automotive industry for diagnostics

## RS232 modem connection, C1

The IQAN-MDL2 has an *RS232 interface* in connector C1 to communicate with external landline, wireless or satellite modems for remote diagnostic capabilities. A flying lead cable may be connected to the IQAN-MDL2 to provide a DB9F connector interface. The cables of this type are available from electronic supplier catalogs. The connection from IQAN-MDL2 to modem can then be made with the modem manufacturer's supplied cable.

The recommended wiring to the IQAN-MDL2 connector is shown below.

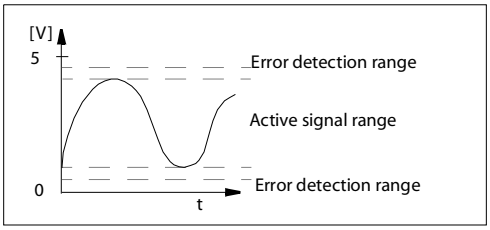



Connecting for external RS232 modem.

# Voltage inputs

## Connecting sensors to the voltage inputs

The sensor signal range must be 0-5 Vdc. To detect signal errors such as short circuits or interruptions the active signal range should be within 0.5-4.5 Vdc.




Active signal range.

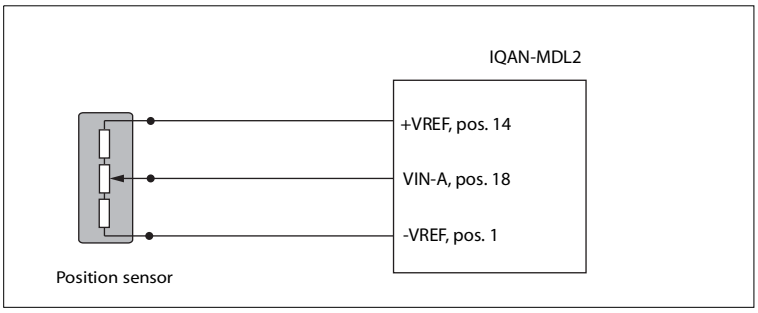
The current consumption related to the voltage input is negligible.

## Connecting potentiometers to the voltage inputs

The positive terminal of the sensor is connected to the +VREF position and the corresponding negative terminal to the -VREF position. The signal is connected to the appropriate VIN position. The recommended values on resistors for good linearity and error detection are; 100 ohm padding/1kohm-potentiometer/100 ohm padding.

**EXAMPLE**

Connect the positive and negative terminals of the position sensor to +VREF, position 14, and -VREF, position 1, respectively. Then connect the sensor signal to VIN-A, position 18.




Connecting VREF and potentiometer signal VIN-A.

**NOTICE**

The negative terminal of the sensor must not be connected to the chassis.
Maximum load for VREF position: see Appendix A, on page 31.

## Connecting other 3 wire sensors

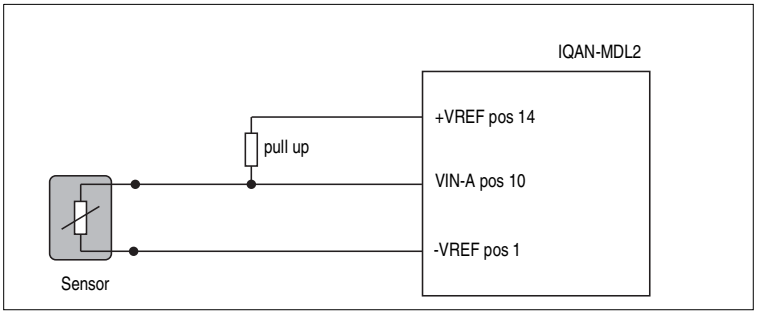
The same type of connection shown for potentiometers is used for other 3 wire sensors supplied with power from the regulated 5VDC supply, VREF. This includes active temperature sensor IQAN-ST, pressure sensor IQAN-SP and Hall-effect levers IQAN-LST or IQAN-LSL.

### Connecting a 2- wire temperature sensor

When you connect a PTC (positive temperature coefficient) temperature sensor you may need to use a pull up resistor on the input signal. Please check the technical data for your specific temperature sensor.

**EXAMPLE**

Connect the negative terminal of the temperature sensor to -VREF, position 1, and the signal to VIN-A, position 18. The pull up resistor will be connected between VIN-A, position 18 and +VREF, position 14.




Connecting -VREF and temperature sensor signal VIN-A.

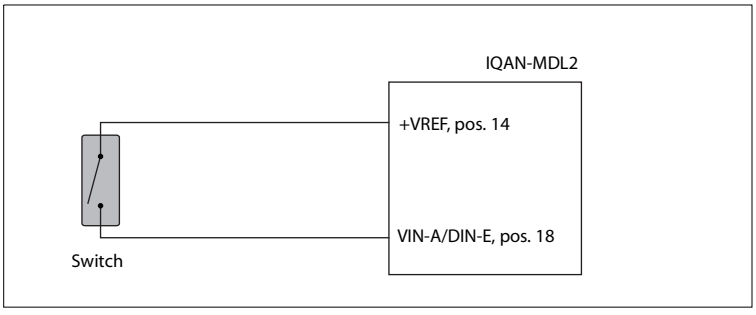
The pull up resistor value for a $R_{25}$=2000Ω, PTC sensor is 4,7 KΩ

### Connecting switches to the voltage inputs

Switches could be connected to the voltage inputs, to create a digital on/off signal. The switches should be connected to +VREF and VIN/DIN respectively for 5V signal. The current consumption for the input is negligible.

**EXAMPLE**

Connect the positive and negative terminals of the switch to +VREF, position 42, and VIN-A, position 18, respectively.



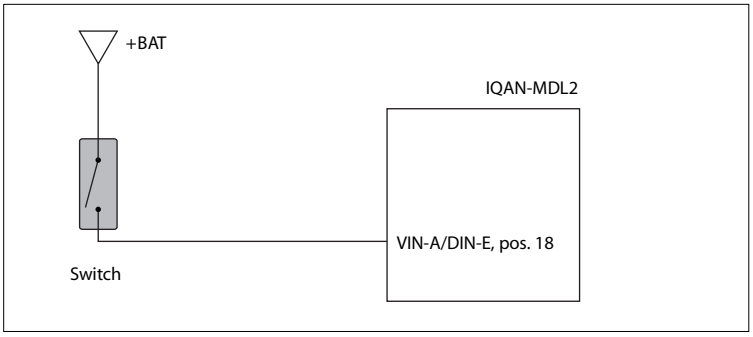

Connecting a switch to VIN-A and +VREF.

**NOTICE**

Maximum load for VREF position, see Appendix A, on page 31.

It is recommended to connect system voltage +BAT to the input through a switch in order to reserve 5Vdc VREF for sensors and potentiometers.

**EXAMPLE**
Connect the positive and negative terminals of the switch to supply or the unit's +BAT, position 28 and VIN-A/DIN-E, position 10, respectively.




Connecting a switch to VIN-A/DIN-E and +BAT.

# Digital inputs

### DIN-A to DIN-L

The digital inputs DIN-A to DIN-D have low impedance characteristics. DIN-E thru DIN-L share pins with VIN-A to VIN-H and have high impedance characteristics. The above connection examples will apply to any of these inputs. For impedance values, see Appendix A, on page 31.

### DIN-M to DIN-P

When connecting switches to the digital inputs DIN-M thru DIN-P, extra precautions should be taken.

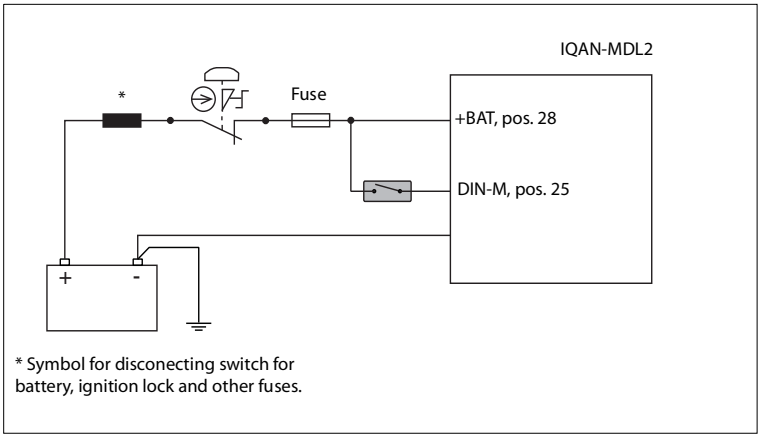
## Connecting switches to the digital inputs

**WARNING**
Risk of injury!

By sharing pins with the RET positions of the proportional outputs there is a possibilty of 'back-ending' the IQAN-MDL2 unit when flexibly using those pins as digital inputs. The internal circuitry has power clamping diodes between the RET pins and +BAT. This arrangement creates a risk of inadvertently supplying power to the unit by forward biasing the clamping diodes. There are two methods to avoid this:

1 The switch could be powered by the same source as the unit's +BAT.

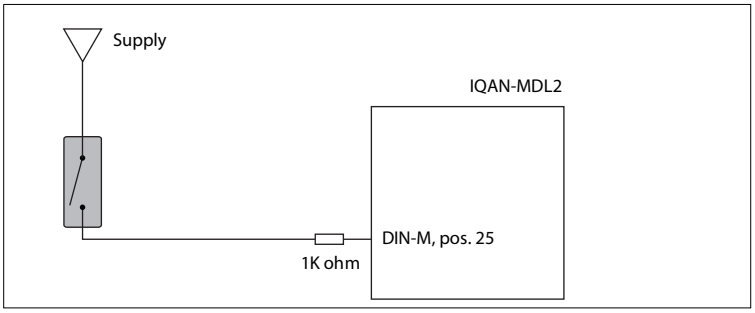
**EXAMPLE**
Connect the positive and negative terminals of the switch to +BAT, position 28 and DIN-M, position 25, respectively.




Connecting a switch to DIN-M and +BAT.

2 The switch could be connected to DIN through a 1K ohm resistor..

**EXAMPLE**
Connect the positive and negative terminals of the switch to supply and DIN-M through a 1K resistor, to position 25, respectively.




Connecting a switch to DIN-M and supply thru a resistor.

# Frequency / directional inputs

## Connecting sensors to the frequency inputs

Frequency inputs can operate in 2 modes. *Speed* which is frequency and *position* which is a pulse count. For the frequency ranges and trigger levels, see Appendix A, on page 31.

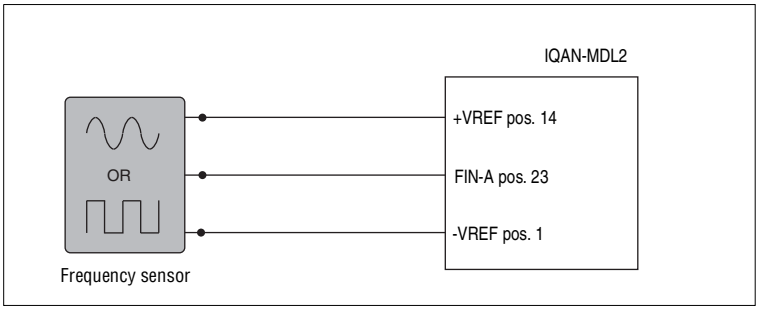
### Simple frequency sensor

The positive terminal of the frequency sensor is connected to the +VREF and the negative terminal to the -VREF respectively. The sensor signal is connected to the FIN position.

If the current consumption for the sensor exeeds the maximum load for the VREF, the sensor could be connected to the +BAT/-BAT positions.

**EXAMPLE**

Connect the positive and negative terminals of the frequency sensor to +VREF, position 14, and -VREF, position 1, respectively. Then connect the sensor signal to FIN-A, position 19.




Connecting of frequency sensor.

**NOTICE**

The negative terminal of the sensor must not be connected to the chassis.
Maximum load for VREF position, see Appendix A, on page 31.

## Connecting sensors to the directional inputs

Quadrature sensors are phase dependent. These sensors have two 90 degree out of phase "square wave" type signals for direction indication, and frequency.

Directional sensors are level dependent. These sensors have one "square wave" type signal for speed or position and one signal that is high or low to indicate the direction.

Quadrature and directional inputs can operate in 2 modes. *Speed* which is frequency with direction and *position* which is a pulse count with direction. For the frequency ranges and trigger levels, see Appendix A, on page 31.

### Quadrature sensor

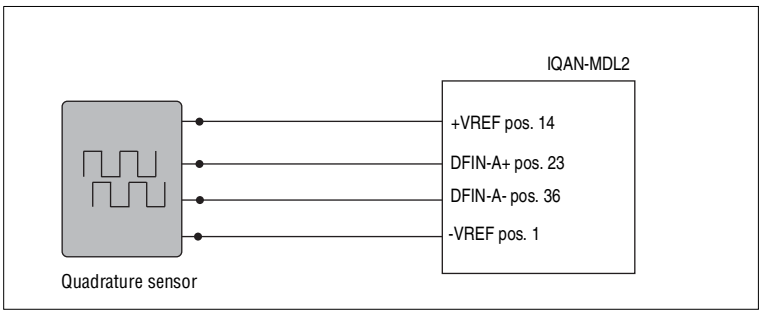
The positive terminal of the quadrature sensor is connected to the +VREF and the negative terminal to the -VREF respectively. The sensor's channel A is connected to DFIN-A+ and channel B to DFIN-A- positions.

### Directional frequency sensor

The positive terminal of the directional sensor is connected to the +VREF and the negative terminal to the -VREF respectively. The sensor output is connected to DFIN-A+ and the sensor direction signal to DFIN-A- position.

If the current consumption for the sensor exeeds the maximum load for the VREF, the sensor could be connected to the +BAT/-BAT positions.

**EXAMPLE**
Connect the positive and negative terminals of the quadrature sensor to +VREF, position 14, and -VREF, position 1, respectively. Then connect the sensor signals to DFIN-A+, position 23 and DFIN-A-, position 36.




Connecting of quadrature sensor.

**NOTICE**
The negative terminal of the sensor must not be connected to the chassis.
Maximum load for VREF position, see Appendix A, on page 31.

# Outputs

## Back-ending of module

**WARNING**
Risk of injury!

Digital outputs DOUT-A to DOUT-F and proportional outputs COUT-A to COUT-B have the potential risk to supply the unit backwards (back-ending) if connected to a voltage higher than 6V that is able to supply enough current to drive an external load.

The same type of situation is possible with flexibly configured digital inputs that share CRET pins, see section DIN-M to DIN-P, on page 22.

### Adjustable frequency

To obtain the best performance from proportional valves the control produces a current mode (closed loop) output signal or a PWM voltage (open loop) output signal. The type of output is selectable in IQAN software. The MDL2 unit has an adjustable frequency which can be changed using IQAN software.

The table below shows the MDL2 frequency possibilities. Any frequency may be entered in your application and is translated according to this table. The bold values are the actual frequencies in Hz output by the MDL2 for proportional valve control.

| Frequency (Hz) entered in appl. | Frequency (Hz) output by MDL2 | Frequency (Hz) entered in appl. | Frequency (Hz) output by MDL2 |
|---|---|---|---|
| 25 | **25** | 50-52 | **50** |
| 26 | **26** | 53-55 | **53** |
| 27 | **27** | 56-58 | **56** |
| 28 | **28** | 59-62 | **59** |
| 29 | **29** | 63-66 | **63** |
| 30 | **30** | 67-70 | **67** |
| 31 | **31** | 71-76 | **71** |
| 32 | **32** | 77-82 | **77** |
| 33 | **33** | 83-90 | **83** |
| 34-35 | **34** | 91-99 | **91** |
| 36 | **36** | 100-110 | **100** |
| 37 | **37** | 111-124 | **111** |
| 38-39 | **38** | 125-142 | **125** |
| 40-41 | **40** | 143-166 | **143** |
| 42 | **42** | 167-199 | **167** |
| 43-44 | **43** | 200-249 | **200** |
| 45-47 | **45** | 250-332 | **250** |
| 48-49 | **48** | 333+ | **333** |

## Connecting proportional valves and devices

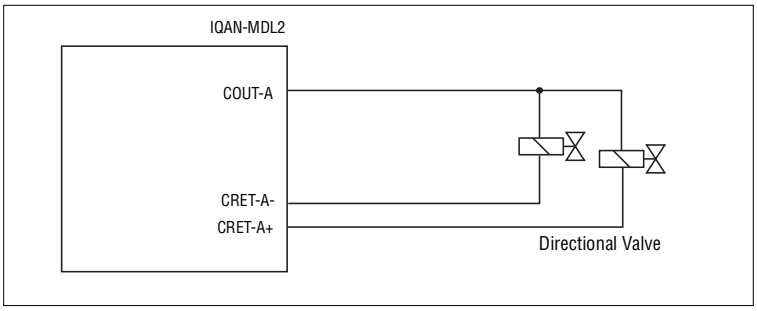
The current /PWM outputs control proportional valves and devices. For the current range and loads, see Appendix A, on page 31.

## Connecting loads to proportional outputs

Connecting a load, e.g. one proportional valve section, to the current mode or PWM mode outputs is done by using the COUT/CRET paired positions.

**EXAMPLE**

*Positive direction*:
Connect the proportional valve to the COUT-A, position 11 and the CRET-A+, position 25 respectively.
*Negative direction*:
Connect the proportional valve to the COUT-A, position 11 and the CRET-A- , position 39 respectively.




Connecting a load to a proportional output.

**NOTICE**

Do not install diodes across coils for Current or PWM output modes!

## Connecting control relays and on/off valves

The digital outputs control relays and on/off valves.

### Connecting loads to digital outputs

Connecting of loads to the digital outputs such as on/off valves is done by using the DOUT-A thru DOUT-F positions and chassis as ground.

### Protection against voltage transients

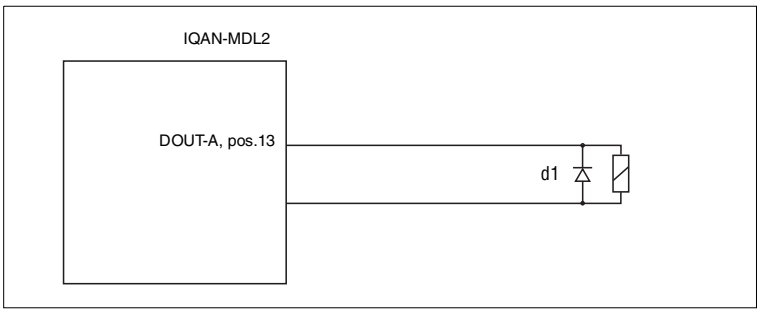
A clamping diode must be placed between the digital output and ground, as close to the load as possible. This protects the output against high voltage transients.

Use the diode: 1N5408 (3A/1000V) or others may be OK, depending on the load.

**EXAMPLE**

Connect the on/off valve to the digital output using the DOUT-A, position 13, and the chassis as ground.

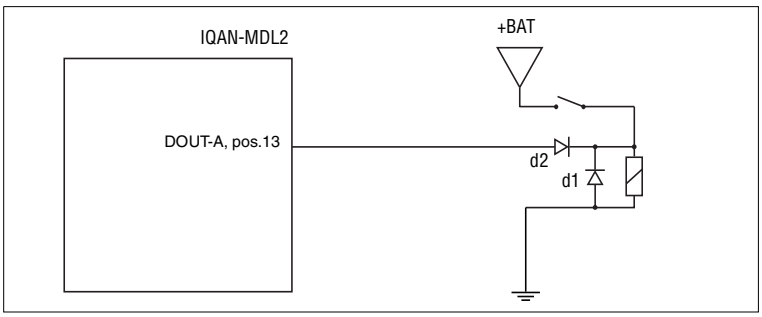
A clamping diode must be placed as close to the load as possible, see figure below.




Connecting a load to the digital output.

**NOTICE**

If the load is controlled in parallel with another system, the digital output must be protected with a diode.




Digital output protected with a diode.

**NOTICE**

For the maximum load per output see Appendix A, on page 31.

# 7 Start-up

## Start-up procedures

This chapter contains instructions for action to be taken in connection with the initial start.

**WARNING**
Risk of injury!
If the control system is not fitted properly, the machine could move uncontrollably. The machine's engine shall not be started before the control system is completely fitted and its signals are verified.

### Starting the control system

**Start the control system as follows:**

- Prior to start, all modules and cables are to be fitted correctly.
- Check fuses, i.e. make sure that the supply voltage to the modules is equipped with the correct fuse.
- Make sure that connections for supply voltage and return lines are correct in the cable's conductor joint.
- Make sure an emergency stop is installed.
  The emergency stop should disconnect the supply voltage to all modules. Alternatively, the emergency stop may also shut off the diesel engine or a dump valve, and with that, depressurize the hydraulic system.

### Prepare for system start

**WARNING**
Make sure no one is in dangerous proximity to the vehicle to avoid injuries when it starts.

**Prepare for the initial system start as follows:**

- The engine for the hydraulic system's pump shall be in off position.
- Make sure that all connectors are properly connected.
- Turn on the control system.
- Make sure that voltage is being supplied to all modules; the power/status diode shall be illuminated on all modules. Also, make sure that the master is in contact with all modules by reading the master's display.
- Make sure the emergency stop is functioning properly.

### Start the system

**Start the system as follows:**

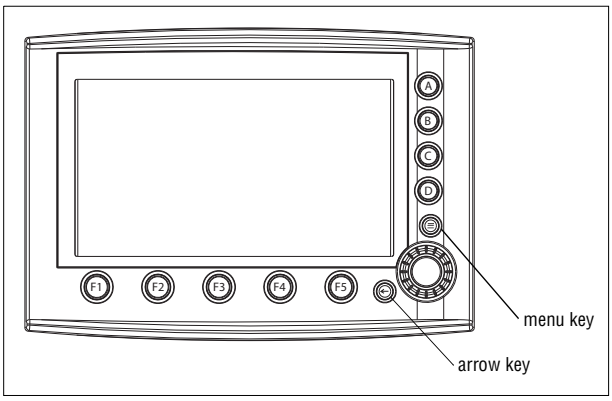
- Start the engine for the hydraulic system's pump, assuming that the above mentioned inspections have been carried out and shown correct values.

Calibrate and adjust input and output signals according to the instructions related to the master menu system and check each and every output function carefully.

# 8 System Diagnostics

## Diagnostic pages

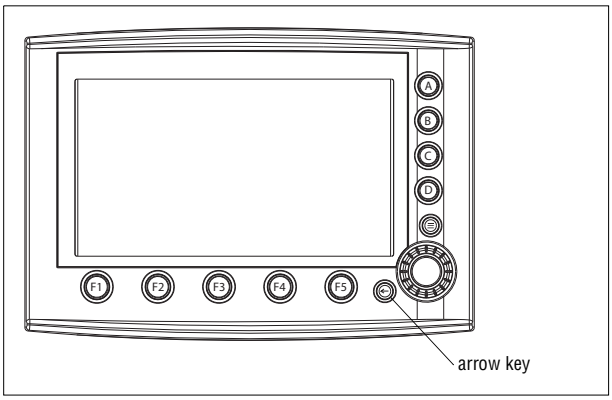
The MDL2 has two test pages for production diagnostics. These pages can be useful for obtaining system diagnostic information. To view the test pages press the menu and arrow keys simultaneously and hold during power up. To exit test mode, turn the unit off and power up normally.




Accessing the test pages.

## Safe mode

If necessary, the IQAN-MDL2 may be started in *safe mode*. When started in safe mode, no application is loaded and nothing is running. The screen shows a default background and a dialog box notifies the user that the module is in safe mode. This can be useful for installing an IQAN-MDL2 with an unknown application in memory, when retrofitting of new hydraulic components has occurred or if a user has somehow changed the application in an unacceptable way. To start in safe mode press the arrow key and hold during power up. In safe mode you can then download a new application to the IQAN-MDL2. To exit safe mode, turn the unit off and power up normally.




Starting in safe mode.

# Appendix A

## IQAN-MDL2 Technical Overview

### Absolute Maximum Ratings[a]

| Parameter | Limit values | | | Unit | Remark |
|---|---|---|---|---|---|
| | min. | typ. | max. | | |
| Ambient temperature, $T_{AOP}$ | – 30 | | +70 | °C | no external load, no backlight |
| Module Diagnostic temperature, $T_{MD}$ | – 30 | | +80 | °C | All operating conditions. Module Diagnostic signal |
| Storage temperature, $T_{AST}$ | – 40 | | +80 | °C | |
| Voltage supply on +BAT | 6.5 | | 36 | V | Reverse polarity protected with 20A fuse. |
| Voltage on any pin with respect to -BAT | | | 36 | V | Max voltage on USB signals D+ and D- is 3.5V. |
| Maximum current into -VREF | | | 2 | A | |
| Maximum current sourced by all outputs | | | 16 | A | |

a.The “Absolute Maximum Ratings” table lists the maximum limits to which the device can be subjected without damage. **This doesn´t imply that the device will function at these extreme conditions,** only that, when these conditions are removed and the device operated within the “Recommended Operating Conditions”, it will still be functional and its useful life won’t have been shortened.

### Environmental ratings

| Parameter | Remark |
|---|---|
| EMI<br>ISO 14982:1998, Radiated emission<br><br>EN 55025:2003, Conducted emission (CISPR 25)<br>ISO 11452-2:1998, Radiated Susceptilbility<br>ISO 11452-4:1998, Conducted Susceptibility<br>ISO 7637-2:2004, Conducted transient susceptibility on power<br>ISO 7637-3:2007, Conducted transient susceptibility on signal | <br>Bb: 30/75/400/1000MHz: 64/54/65/65 dBìV/m<br>Nb: 30/75/400/1000MHz: 54/44/55/55 dBìV/m<br>0.15-108 MHz, class 2<br>200-2000 MHz, 100V/m<br>1-200 MHz, 150mA<br>pulse 1,2a,2b,3a,3b,4: Level 3, pulse 5:+70V<br>Level 4 |
| ESD<br>ISO 10605:2001, ESD | <br>25 KV, air, front side of unit<br>15 KV, air, back side of unit<br>8 KV contact<br>8 KV contact, handling |
| Mechanical environment<br>IEC 60068-2-64:1993 Fh, Random vibration<br>IEC 60068-2-29:1987 Eb, Bump | <br>0.1 g2/Hz, 15- 250 Hz, 30 hours in each direction<br>40g, 6 ms,1000 in each direction |
| Climate environment<br>IEC 60529:2001, Enclosure protection<br>IEC 60068-2-1:1990 Ab, cold<br>IEC 60068-2-2:1974 Bb, heat<br>IEC 60068-2-30:1985 Db, Damp heat cyclic<br>IEC 60068-2-78:2001, Damp heat, steady state | <br>IPx3: 10 l/min, 5 min<br>-30°C, 16 hours<br>70°C, 72hours<br>55°C, 6 cycles<br>40°C, 93% RH, 21 days |
| Chemical environment<br>IEC 60068-2-52:1996 Kb, Salt mist | <br>3 days |

## Recommended Operating Conditions[a]

| Parameter | Limit values | | | Unit | Remark |
|---|---|---|---|---|---|
| | min. | typ. | max. | | |
| Module diagnostic temperature, $T_{MD}$ | – 30 | | +80 | °C | All operating conditions. Module Diagnostic signal Update time on LCD will be reduced below -10°C. |
| Voltage supply, $V_{BAT}$ | 11 | | 32 | V | |

a.Recommended operating conditions are given for maximum and minimum conditions where normal performance is still available from the device. Once the normal operating conditions are exceeded, the performance of the device may suffer.

## System

$T_A$ = +25 °C (unless otherwise specified)

| Parameter | Limit values | | | Unit | Remark |
|---|---|---|---|---|---|
| | min. | typ. | max. | | |
| Start-up delay | | 900 | | ms | Power to activated output |
| Dither frequency, DF | 25 | | 333 | Hz | |
| System cycle time | 10 | | 100 | ms | |
| Sample rate local I/O | 10 | | 100 | ms | |
| Output voltage on VREF | 4.9 | 5.0 | 5.1 | V | load < 40mA |
| Maximum load current on VREF<br>$V_{BAT}$ =11V to 32V | | | 40<br>100<br>150 | mA | $V_{drop}$ < 25mV (0.5%)<br>$V_{drop}$ < 50mV (1%)<br>$V_{drop}$ < 100mV (2%) |
| Current supply<br>Backlight = 100%<br>$V_{BAT}$ =14V<br>$V_{BAT}$ =28V<br><br>Backlight = 0%<br>$V_{BAT}$ =14V<br>$V_{BAT}$ =28V | | <br><br>580<br>320<br><br><br>300<br>175 | | <br><br>mA<br><br><br><br>mA | <br><br><br>outputs = off<br>fan=off<br>no load on VREF |
| Keypad operating life | | $1x10^5$ | | operations | 10N |
| Encoder operating life | | $1x10^5$<br>$1x10^5$ | | operations<br>rotations | 10N |
| TFT backlight operating life | | 10000 | | hours | $T_A$=+25°C<br>Brightness > 50% of original value |
| Fan operating life | | 10000 | | hours | $T_A$=+50°C |

## I/O

$T_A$ = +25 °C (unless otherwise specified)

| Parameter | Limit values | | | Unit | Remark |
|---|---|---|---|---|---|
| | min. | typ. | max. | | |
| VIN (Voltage input) | | | | | |
| Signal range low | | 0 | 0.05 | V | |
| Signal range high | 4.9 | 5.0 | 5.1 | V | |
| Input resistance | | 62 | | kΩ | |
| Signal resolution | | 5 | | mV | |
| Total unadjusted error | -35<br>-100 | | 35<br>100 | mV | VREF as source<br><40mA<br>External source |
| DIN (On/off input) | | | | | |
| Input low | | | 0.8 | V | |
| Input high | 4.0 | | | V | |
| Input hysteresis | | 1.0 | | V | DIN-E to DIN-L |
| Input resistance | | 5.6<br>62<br>5.6 | | kΩ | DIN-A to DIN-D<br>DIN-E to DIN-L<br>DIN-M to DIN-P |
| DFIN (Directional Frequency input) | | | | | |
| Input low | | | 0.8 | V | |
| Input high | 4.0 | | | V | |
| Input resistance | | 5.6 | | kΩ | |
| Input frequency low | 2<br>0 | | | Hz | speed mode<br>position mode |
| Input frequency high | | | 30.000 | Hz | |
| FIN (Frequency input) | | | | | |
| Input low | | | 0.8 | V | |
| Input high | 4.0 | | | V | |
| Input resistance | | 5.6 | | kΩ | |
| Input frequency low | 2<br>0 | | | Hz | speed mode<br>position mode |
| Input frequency high | | | 30.000 | Hz | |

## I/O

$T_A$ = +25 °C (unless otherwise specified)

| Parameter | Limit values | | | Unit | Remark |
|---|---|---|---|---|---|
| | min. | typ. | max. | | |
| COUT (closed-loop mode) | | | | | |
| Signal range | 100 | | 2000 | mA | |
| Load | 3.5 | | | Ω | |
| Voltage drop ($V_{BAT}$ -$V_{COUT}$)<br>load $I_L$ = 0.5A<br>load $I_L$ = 2A | | <br>0.2<br>0.8 | | V | |
| Off-State output current: | | | 1.8 | mA | |
| Short Circuit current limit | | 15 | | A | |
| Linearity error | | | 15 | mA | 100mA to 1500mA |
| Temperature error | | | 15 | mA | $T_A$= -40°C to 70°C<br>100mA to 1500mA |
| Power supply rejection<br>$V_{BAT}$= 11... 18V<br>$V_{BAT}$= 24... 32V | | <br>1<br>1 | | mA | $R_L$=6 Ω -25 Ω |
| Load regulation<br>$V_{BAT}$=14V, $R_L$=4... 9 Ω<br>$V_{BAT}$=28V, $R_L$=22... 34 Ω | | <br>1<br>1 | | mA | <br>Load=1000mA<br>Load=500mA |
| Dither frequency, DF | 25 | | 333 | Hz | |
| Resolution | | 0.1<br>0.8 | | mA<br>us | Dependent on load, power supply and dither frequency. |
| PWMOUT (open-loop mode) | | | | | |
| Signal range | 0 | | 95 | % MR | |
| Pulse width low | 63 | | | us | |
| Pulse width high | | | T-0.5 | ms | $T = \frac{1}{DF}$ |
| Error limits min (open load) | | 25 | | mA | Dependent on load, power supply and dither frequency. |
| Error limits max (over load) | | 2000 | | mA | Dependent on load, power supply and dither frequency. |
| Voltage drop ($V_{BAT}$ -$V_{PWMOUT}$)<br>load $I_L$ = 0.5A<br>load $I_L$ = 2A | | <br>0.2<br>0.8 | | V | |
| Off-State output current: | | | 1.8 | mA | |
| Short Circuit current limit | | 6 | | A | |
| Dither frequency, DF | 25 | | 333 | Hz | |
| Resolution | | 0.1 | | % MR | |

## I/O

$T_A$ = +25 °C (unless otherwise specified)

| Parameter | Limit values | | | Unit | Remark |
|---|---|---|---|---|---|
| | min. | typ. | max. | | |
| DOUT (on/off output) | | | | | |
| Load current | | | 2 | A | |
| Voltage drop ($V_{BAT}$ -$V_{DOUT}$)<br>load $I_L$ = 0.5A<br>load $I_L$ = 2A | | <br>0.2<br>0.8 | | V | |
| Off-State output current: | | | 10<br>1.8 | uA<br>mA | DOUT-A to DOUT-F<br>DOUT-G to DOUT-H |
| Max load inductance: | | | 200<br>1000 | mH | @ 2A<br>@ 1A |
| Short Circuit current limit | | 6 | | A | |

# Appendix B

## Error messages and actions

If an error is detected, a message will be presented on the display.

**WARNING**

An error message could indicate that a hazardous situation exists. If precautions are not taken, this could result in death, serious injury or major property damage.

## Failure Modes

The following tables contain information about the different possible failures that could occur for each module subsystem. In most cases when an error is detected, a message will be presented on the master display. In some cases, the master will turn off or at least shut down the outputs, to increase safety.

### Failure modes for FAN

| Failure mode | | Effect |
|---|---|---|
| 1 | +FAN Open | No forced cooling. May give high internal temp.<br>Error detected => FAN error |
| 2 | -FAN Open | No forced cooling. May give high internal temp.<br>Error detected => FAN error |
| 3 | +FAN Short-circuit to -FAN | No forced cooling. May give high internal temp.<br>If $t_{fa}$; Error detected => FAN error |
| 4 | +FAN Short-circuited to heatsink | No effect. |
| 5 | -FAN Short-circuited to heatsink | No effect. |
| 6 | FAN_SPEED Open | No effect. Error detected => FAN error |
| 7 | FAN_SPEED Short-circuit to -FAN | No effect. Error detected => FAN error |
| 8 | FAN_SPEED Short-circuit to +FAN | No effect. Error detected => FAN error |
| 9 | FAN_SPEED Short-circuited to heatsink | No effect. Error detected => FAN error |
| 10 | Fan jammed | No forced cooling. May give high internal temp.<br>Error detected => FAN error |
| 11 | High internal temp due to high ambient temperature. | Error detected => TEMP error |
| 12 | High internal temp due to jammed fan. | Error detected => FAN error + TEMP error |

## Failure modes for CAN interface

| Failure mode | | Effect |
|---|---|---|
| 1 | CAN-H to -BAT | No CAN communication. All output turned off. |
| 2 | CAN-L to -BAT | No CAN communication. All output turned off. |
| 3 | CAN-H to +BAT | No CAN communication. All output turned off. |
| 4 | CAN-L to +BAT | No CAN communication. All output turned off. |
| 5 | CAN-L open circuit | No CAN communication. All output turned off. |
| 6 | CAN-H open circuit | No CAN communication. All output turned off. |
| 7 | CAN-L to CAN-H | No CAN communication. All output turned off. |
| 8 | CAN-termination failure, termination on | No effect |
| 9 | CAN-termination failure, termination off | Dependent on CAN size and number of CAN nodes. |

## Failure modes for VREF

| Failure mode | | Effect |
|---|---|---|
| 1 | +VREF Open | VIN out of range, will create a VIN error => VIN=Predefined error value. |
| 2 | -VREF Open | VIN out of range, will create a VIN error => VIN=Predefined error value. |
| 3 | +VREF Short-circuit to -VREF | VREF error => VIN out of range, will create a VIN error => VIN=Predefined error value. |
| 4 | +VREF Short-circuited to +BAT | VREF error => VIN out of range, will create a VIN error => VIN=Predefined error value. |
| 5 | +VREF Short-circuited to -BAT | VREF error => VIN out of range, will create a VIN error => VIN=Predefined error value. |
| 6 | -VREF Short-circuited to +BAT | VREF error =>. May cause damage to VREF circuit. |
| 7 | -VREF Short-circuited to -BAT | Not detected. |

## Failure modes for VIN

| Failure mode | | Effect |
|---|---|---|
| 1 | VIN Open | VIN out of range, will create a VIN error => VIN=Predefined error value[a] |
| 2 | VIN Short-circuited to +BAT | VIN out of range, will create a VIN error => VIN=Predefined error value[a] |
| 3 | VIN Short-circuited to -BAT | VIN out of range, will create a VIN error => VIN=Predefined error value[a] |

a. Will require installation according to installation guidelines in chapter 6, see section Voltage inputs, on page 20.

## Failure modes for DIN

| Failure mode | | Effect |
|---|---|---|
| 1 | DIN Open | No effect on module, not detected |
| 2 | DIN Short-circuited to +BAT | No effect on module, not detected |
| 3 | DIN Short-circuited to -BAT | No effect on module, not detected |

## Failure modes for FIN

| Failure mode | | Effect |
|---|---|---|
| 1 | FIN Open | No effect on module, not detected |
| 2 | FIN Short-circuit to +BAT | No effect on module, not detected |
| 3 | FIN Short-circuit to -BAT | No effect on module, not detected |

## Failure modes for DFIN

| Failure mode | | Effect |
|---|---|---|
| 1 | DFIN Open | No effect on module, not detected |
| 2 | DFIN Short-circuit to +BAT | No effect on module, not detected |
| 3 | DFIN Short-circuit to -BAT | No effect on module, not detected |

## Failure modes in Current Mode

The table below presents failure modes and effects on I/O.

| Failure mode | | Effect |
|---|---|---|
| 1 | COUT Open | COUT error, output turned off |
| 2 | RET (active) Open | COUT error, output turned off |
| 3 | RET (passive) Open | Not detected, will not influence function |
| 4 | COUT Short-circuit to RET (active) | COUT error, output turned off |
| 5 | COUT Short-circuit to RET (passive) | Not detected, will not influence function |
| 6 | COUT Short-circuit to +BAT | COUT error, output turned off |
| 7 | COUT Short-circuit to - BAT | COUT error, output turned off |
| 8 | RET (active) Short-circuit to +BAT | COUT error, output turned off |
| 9 | RET (active) Short-circuit to - BAT | COUT error, output turned off |
| 10 | RET (passive) Short-circuit to +BAT | Not detected, will not influence function |
| 11 | RET (passive) Short-circuit to - BAT | COUT error, output turned off |
| 12 | COUT Short-circuit to 2:nd COUT (passive) | Not detected, will not influence function |
| 13 | COUT Short-circuit to 2:nd RET (active) | COUT error, output turned off |
| 14 | COUT Short-circuit to 2:nd RET (passive) | Not detected, will not influence function |
| 15 | RET Short-circuit to 2:nd RET (active) | COUT error, output turned off |
| 16 | RET Short-circuit to 2:nd RET (passive) | Not detected, will not influence function. |
| 17 | RET (active) Short-circuit to same channel RET (passive) | Not detected, will influence function. Valve will be powered on both solenoids, effects are valve dependent. |
| 18 | Insufficient Voltage | Detected, COUT saturated. If measured current is less than half of command, COUT error, output turned off |

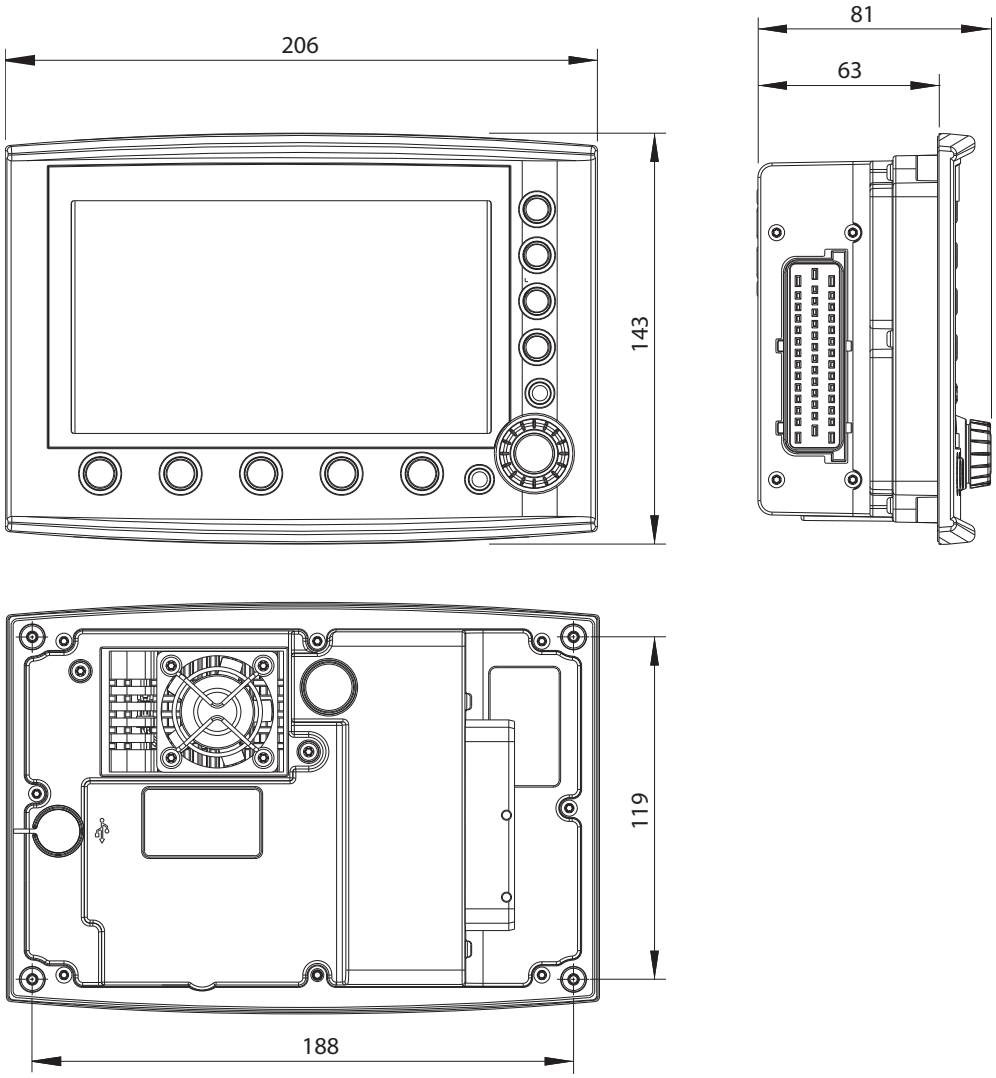
## Failure modes in PWM mode

Table below presents failure modes and effects on I/O.

| Failure mode | | Effect |
|---|---|---|
| 1 | H-side Open | PWMOUT error, output turned off |
| 2 | L-side (active) Open | PWMOUT error, output turned off |
| 3 | L-side (passive) Open | Not detected, will not influence function |
| 4 | H-side Short-circuit to L-side (active) | PWMOUT error, output turned off |
| 5 | H-side Short-circuit to L-side (passive) | Not detected, will not influence function |
| 6 | H-side Short-circuit to +BAT | PWMOUT error, output turned off |
| 7 | H-side Short-circuit to - BAT | PWMOUT error, output turned off |
| 8 | L-side (active) Short-circuit to +BAT | PWMOUT error, output turned off |
| 9 | L-side (active) Short-circuit to - BAT | Not detected, will not influence function |
| 10 | L-side (passive) Short-circuit to +BAT | Not detected, will not influence function |
| 11 | L-side (passive) Short-circuit to - BAT | Not detected, + and - direction activated without movement as result. |
| 12 | H-side Short-circuit to 2:nd L-side (active) | PWMOUT error, output turned off |
| 13 | H-side Short-circuit to 2:nd L-side (passive) | Not detected, will not influence function |
| 14 | L-side Short-circuit to 2:nd L-side (active) | Not detected, will not influence function |
| 15 | L-side Short-circuit to 2:nd L-side (passive) | Not detected, will not influence function |
| 16 | Insufficient Voltage | Not detected, lower max speed limit on function |

# Appendix C

## Dimensioning of the IQAN-MDL2 module




Unit = mm

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Information in this instructionbook is subject to change without notice

Publ no HY33-8401-IB/UK
Edition 2011/08/04

**Parker Hannifin**
Electronic Controls Division
SE-435 35 Mölnlycke
Sweden
Tel +46 31 750 44 00
Fax +46 31 750 44 21
www.parker.com

**Parker Hannifin**
Electronic Controls Division
1651 N. Main Street
Morton IL 61550
Tel +1 309 266 2200
Fax: +1 309 266 6674