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CrossFire IX

Technical manual

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1. Introduction

CrossFire IX is the 2nd product on CrossControl's new I/O Controller platform. It is a compact 32-bit I/O module, designed for advanced hydraulics control in Agricultural and Construction equipment. It offers 22 I/O channels, versatile and configurable in software. Fieldbus network capabilities include both CANopen and J1939 (planned). Wireless communication is offered as an option, making this module into a Smart connect interface in highly cost sensitive systems.

Business rationale:

- Smaller I/O module based upon the high-end Crossfire SX.
- Accuracy on inputs and outputs gives an outstanding performance in machine control.
- A smaller I/O count and a much lower price makes this product a perfect CANopen slave or J1939 device (planned) in a sub system or on machines where less I/O is needed.
- A strong companion with our displays when serious I/O capabilities are needed.
- Rich feature list. Can solve most tasks including hydraulic valve control, sensor inputs, button decoding, lamps and more.

Technical summary:

- CF IX is able to drive 4 proportional valves with current feedback and 4 on-off valves simultaneously. On-off outputs can be also used in PWM mode with limited current feedback which can be used for diagnostics. CrossFire IX contains 8 analog inputs, which can be configured individually to accept voltage (0-10V/0-32V) and 4-20mA current signals. In addition there are 6 dedicated digital inputs of which 2 can be configured for frequency input or to form a dual channel encoder input. All inputs (digital and analog) can be individually configured to have pull-up or pull-down resistor activated.

This technical manual provides important information regarding the device's hardware and its basic usage. For software, please see *chapter 1.5 Supporting documentation*.

1.1. Product models

Crossfire IX is based upon the CrossFire SX, a very flexible platform that easily can be adapted. Reduced complexity is a guiding principle in the design with the purpose to facilitate ease of: adaptability, testing, code readability and to further raise the quality.

CrossFire IX is built in three product variants that share the same hardware architecture, enclosure and connectors. The PCB is the same for all versions but is populated differently.

Part nr.	Product variant
C000141-40	Crossfire IX, wireless (customer branded)
C000141-50	Crossfire IX, CANopen slave
C000141-70	Crossfire IX, CANopen slave with data logger option

Feature	C000141-40	C000141-50	C000141-70
Analog inputs	8[1]	8[2]	8[2]
Digital inputs	4	4	4
Frequency inputs	-	2	2
Standard PWM	2	4	4
Advanced PWM	-	4	4
CAN	1	1	1
Protocol	CANopen	CANopen	CANopen
FRAM	2kbyte	8 kbyte	8 kbyte
FLASH	4 Mbyte	-	4 Mbyte
Wi-Fi	YES	-	YES
12V sensor supply	-	YES	YES
Status LED	-	YES	YES
Real Time Clock with battery	-	-	YES

[1] Voltage (0..10V), Current (4..20mA)

[2] Voltage (0..10/32V), Current (4..20mA), Pull up/down

1.1.1. Customized modules

The platform enables additional customization of hardware and software. Described herein are the features included using product models described above. Any additional feature will be described in model specific documentation.

1.2. Conventions and defines

The following definitions are used to separate model specific details within this document. The observe symbol is also used to highlight such difference.

The ‘observe’ symbol is used to highligt information regarding differences between product models and options.

The ‘exclamation’ symbol is used to highlight information that is especially important for the end-user.

Different text formats used in this document are described in the table below:

Format	Use
Italics	*Names, designations and references.*
Bolded	**Important information.**

1.3. Identification

Each device has a label with article number, serial number and revision which identify your unique device. Take note of these numbers. During service and other contact with the supplier it is important to be able to provide this information.

1.4. Maintenance and care

Handle the device with care and pay attention to the following handling directives:

- Disconnect all cables to the device during welding or when performing other service to the machine imposing a risk of damaging electronic devices.
- Service and repair to the device shall only be made by authorised personnel. If the device is opened by unauthorised personnel, its warranty will be voided.
- Avoid using alkaline, alcoholic or other chemicals for cleaning; doing so may damage the device. However, small amount isopropyl alcohol may be used for removing harsh stains.
- Avoid spray or apply water or alcohol directly to the device. Instead, dampen the cloth lightly before using it for cleaning the device.
- Never use high-pressure air, water or steam to clean the device.

1.5. Supporting documentation

This technical manual provides important information regarding the device's hardware, properties and basic usage. It's very important to read this manual before installation and usage of the unit.

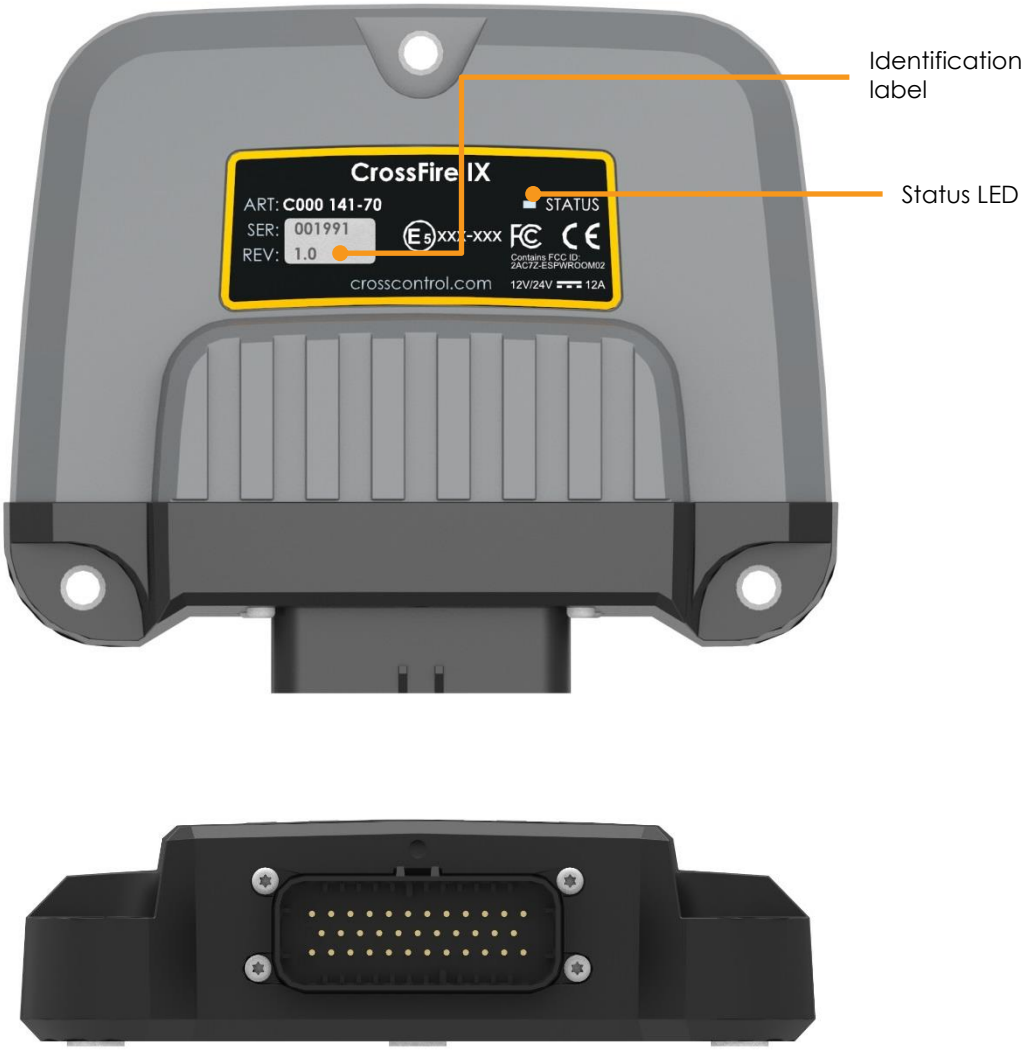
Not following the instructions around installation, and operation of the unit may lead to reduced safety of operators and machinery.

In addition to this document other supporting documents are available on our support site:

- CrossFire IX - CANopen Slave Developers Guide.docx
  - Describes the software specifics for the Crossfire IX, CANopen slave product

2. CrossFire IX device overview

The top side of *CrossFire IX* holds a label with information about product article number, serial number and revision. It also displays a status LED, see *chapter 7.12 Status LED indicator*.



On the connector side of the device there are one AMP 35-pin multi-pin connectors mounted holding the *CrossFire IX* I/O interface. More Information about connectors can be found in *chapter 4.1 - Connectors*

The enclosure is built in glass fibre reinforced nylon. For extreme moisture and condense protection, the unit is filled with a silicone gel. This potting also improves the shock and vibration resistance.

3. Mechanical installation

This chapter contains recommendations for mechanical installation of the *CrossFire IX* device.

3.1. Mounting

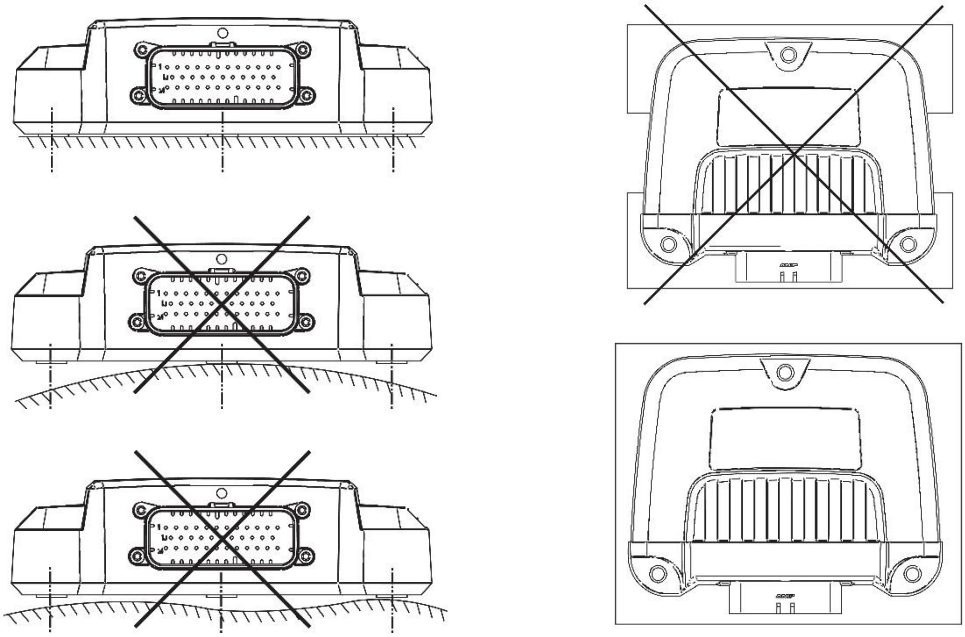
CrossFire IX is designed with a three pod mounting footprint that allows for flexible mounting. However, fastening the unit to an uneven surface may stress the enclosure, or possibly even flex the circuit board inside, leading to a premature failure.

Ensure the mounting bolts are of grade 8.8 or higher. The mounting holes have clearance for M6 bolts.

The recommended torque for the screws is 9.8Nm for a mounting plate in steel or when using a nut.

Note: recommended torque must be checked against mounting plate material.

Ensure there is adequate clearance to insert/remove all of the connectors.

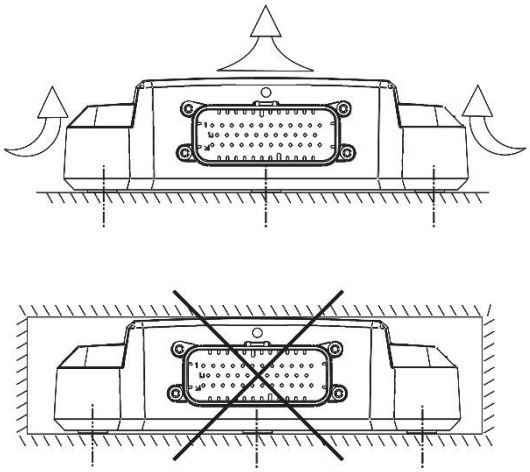


3.2. Installation position

Align *CrossFire IX* so that the cable entries of the connectors are not face upwards.

3.3. Heat dissipation

To enable sufficient cooling, the device must be installed to allow ambient air to circulate around it. A clearance of at least 50 mm around the device is recommended.



Ask CrossControl for recommendations about sandwich mounting.

3.4. Environmental considerations

To ensure proper and reliable operation of the device, follow the recommendations below:

- The device shall be placed in a way that prevents the unit from direct exposure to water or sunlight.
- To enable sufficient cooling, the device must be installed to allow ambient air to circulate around it. A clearance of at least 50 mm around the device is recommended.
- Avoid installing the device near hot air vents or in direct sunlight.
- To maintain the device's IP classification, the connector must be attached. Blind plugs for not connected signals/cables are also necessary.
- Loose mounting bolts are a common cause for excessive vibration. They may come loose due to improper mounting techniques such as omitting thread locker or lock washers, over- or under-tightening. Proper tightening requires clean dry bolts and a torque wrench.
- Install the device and its cables in such a way that they are not subject to excess vibrations or other mechanical stress.
- If the unit is exposed to chemicals, water, dirt, etc it's recommended to clean it according to *chapter 1.4 Maintenance and care* as soon as possible.
- Crossfire IX product C000141-70 and C000141-40 that includes a Wi-Fi module should be installed and operated with minimum distance of 20cm to your body to comply with radiation exposure limits for an uncontrolled environment.

4. Electrical installation

This chapter contains details and recommendations for electrical installation of the *CrossFire IX* device.

4.1. Connectors

The connector is accessible from the side of the *CrossFire IX* unit. The connector, an AMP 35-pin multi-pin connector, is marked 1(X1).

- X1 connector black, TE connectivity 1-776163-1 (Mating connector, e.g. 776164-1)

X1 connector

Use caution and avoid plugging/unplugging of connectors when the *CrossFire IX* unit is powered up. Always replace damaged cables.

4.1.1. Connector layout

Note that descriptions herein refer to the connectors located on the device and not the cable-side connectors which are attached to the device. Though, the pinout numbering and signal descriptions are the same.

1 AIN 1	2 AIN 2	3 AIN 3	4 DIN 1	5 DIN 2	6 UB	7 HS1	8 HS2	9 HS3	10 HS4	11 HS5	12 HS6
13 AIN 4	14 AIN 5	15 AIN 6	16 DIN 3	17 FIN 1	18 UB	19 IGN	20 12V	21 12V	22 12V	23 HS7	
24 AIN 7	25 AIN 8	26 GND	27 DIN 4	28 FIN 2	29 GND	30 GND	31 GND	32 CANH	33 CANL	34 CANS	35 HS8

HS x	High side output 1-4 (standard PWM)
HS x	High side output 5-8 (current controlled PWM)
GND	Ground
UB	Battery input
CAN_L	CAN bus x low
CAN_H	CAN bus x high
CAN_S	CAN bus x shield
AIN x	Analog input 1-8
DIN x	Digital input 1-4
FIN x	Frequency input 1-2
IGN	Ignition input
12V	12V sensor supply

Pin	Signals C000141-40	Signals C000141-50
1	Analog input 1	Analog input 1
2	Analog input 2	Analog input 2
3	Analog input 3	Analog input 3
4	Digital input 1	Digital input 1
5	Digital input 2	Digital input 2
6	Battery input	Battery input
7	High side output 1 (standard PWM)	High side output 1 (standard PWM)
8	High side output 2 (standard PWM)	High side output 2 (standard PWM)
9	[No signal]	High side output 3 (standard PWM)
10	[No signal]	High side output 4 (standard PWM)
11	[No signal]	High side output 5 (current controlled PWM)
12	[No signal]	High side output 6 (current controlled PWM)
13	Analog input 4	Analog input 4
14	Analog input 5	Analog input 5
15	Analog input 6	Analog input 6
16	Digital input 3	Digital input 3
17	[No signal]	Frequency input 1
18	Battery input	Battery input
19	Ignition input	Ignition input
20	Sensor supply 12 V	Sensor supply 12 V
21	Sensor supply 12 V	Sensor supply 12 V
22	Sensor supply 12 V	Sensor supply 12 V
23	[No signal]	High side output 7 (current controlled PWM)
24	Analog input 7	Analog input 7
25	Analog input 8	Analog input 8
26	Ground	Ground
27	Digital input 4	Digital input 4
28	[No signal]	Frequency input 2
29	Ground	Ground
30	Ground	Ground
31	Ground	Ground
32	CAN high	CAN high
33	CAN low	CAN low
34	CAN shield	CAN shield
35	[No signal]	High side output 8 (current controlled PWM)

4.1.2 Cable installation

Cables shall be installed in such a way that they don't run any risk of being damaged, pinched or worn.

- Avoid excessive bending and twisting of cables.
- Use strain-relief on cables near the device to minimize stress on cables and connectors.
- Properly snap the connectors to give good contact and avoid unnecessary strain.
- Shielded cables are recommended and in some cases necessary to ensure reliable communication and appliance with industrial EMC standards.

4.2. Power supply installation

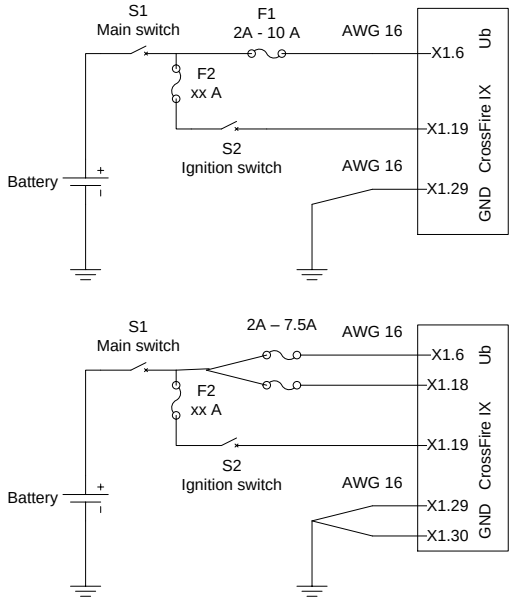
This chapter describes installation of *CrossFire IX* in vehicles or other machines. The principle is the same also for other types of installations.

For connector pinout, see *chapter 4.1 Connectors*.

Before installing the device into a vehicle or other machinery, carefully read through the instructions below:

- Wire gauge for the supply input shall be dimensioned with respect to cable length, supply voltage, maximum allowed voltage drop, start-up current and maximum current consumption of the device. As a guideline:
    - In applications which use several outputs at a time, with medium to high loads, the recommended power supply cable area is 1.31 mm² (AWG 16)
    - In applications which use many outputs at a time, with medium to high loads or long cable harness length, two power supply cables are recommended.
    - In applications which use none or few outputs at a time, with low loads, the power supply cable area might be 0.5 mm²

- When connecting the device to a vehicle's or machine's battery (or other power source with high current capability), always apply fusing to prevent cable fire in case of short circuit.
    - The fuse shall be located as close to the battery/power source as possible.
    - Fuse rating shall be dimensioned with respect to wire gauge maximum current rating and inrush current of the load.
    - As a guideline, a fuse with 2 A - 10 A current rating should be used depending on application, wiring and fuse characteristics.
- The device's external on/off control signal (connector X1, pin 19) should be connected to the positive supply line via the vehicles turnkey switch or a separate on/off switch (see "S2" in schematic below).
    - Remember to apply fusing also to the on/off control signal.
    - Several *CrossFire IX* devices may be controlled by the same external on/off switch by joining their external on/off control signals. The current drawn from this signal (when turned ON) is up to 3.0 mA for each device attached. The fuse rating and wire gauge shall be dimensioned for the total switch current.
    - It is possible to disable the handling of the ignition signal through object dictionary for the CANopen version.
- If the vehicle or machine has a main power switch (see "S1" in schematic below), the device's power supply and on/off signal shall be connected after this switch. Observe that this switch shall **not** be used for switching the device on/off during normal operation. It is only intended for disconnecting the battery to prevent draining of the battery during prolonged stalling intervals of the vehicle or machine.



Schematic examples for power supply installation of CrossFire IX in vehicles or other machines.

By connecting the power supply according to the illustration above, with the main switch S1 normally closed, the device will automatically start when the ignition switch S2 is turned on and shut down when the switch is turned off.

4.2.1. Precautions

It is not recommended to shut of power during storage of parameter data. If this is done, stored data might be corrupt and unit will return to default values.

Be advised that the device consumes a small amount of power (1.1 mA @ 24 V, 1.4 mA @ 12 V) from the main supply when shutdown (low level on the ignition signal). Therefore, if the device has been attached for a long period of time without the vehicle motor running, the battery may be drained, resulting in inability to start up the vehicle. A main switch for disconnecting the device's main supply is highly recommended in such situations.

5. Basic operations

This section covers basic operation of the device such as software and installation, start-up, shut-down and status notification. For additional information on device usage and operation also see the software user guides for the different product versions specified in *chapter 1.5 Supporting documentation*.

5.1. Software and installation

For the CANopen slave version, the unit comes with all software preinstalled. All IO needs to be configured with SDOs, as default all inputs and all outputs are disabled.

5.2. Starting up

Make sure that the instructions for mechanical and electrical installation described in *chapter 3 and 4* are followed before starting up the *CrossFire IX* unit the first time.

For information about CAN node id and baud rate, *see chapter 7.2.1 CAN*.

The *CrossFire IX* will start up when power is connected and active, and the voltage level on the ignition pin is above 4V.

For the CANopen slave version of CrossFire IX the status LED on the unit will indicate unit status according to the LED status table described in *chapter 7.12 Status LED indicator*.

During the startup, unit self-test and diagnostic are performed. If any error is detected the status LED will flash red, see *chapter 7.12 Status LED indicator*.

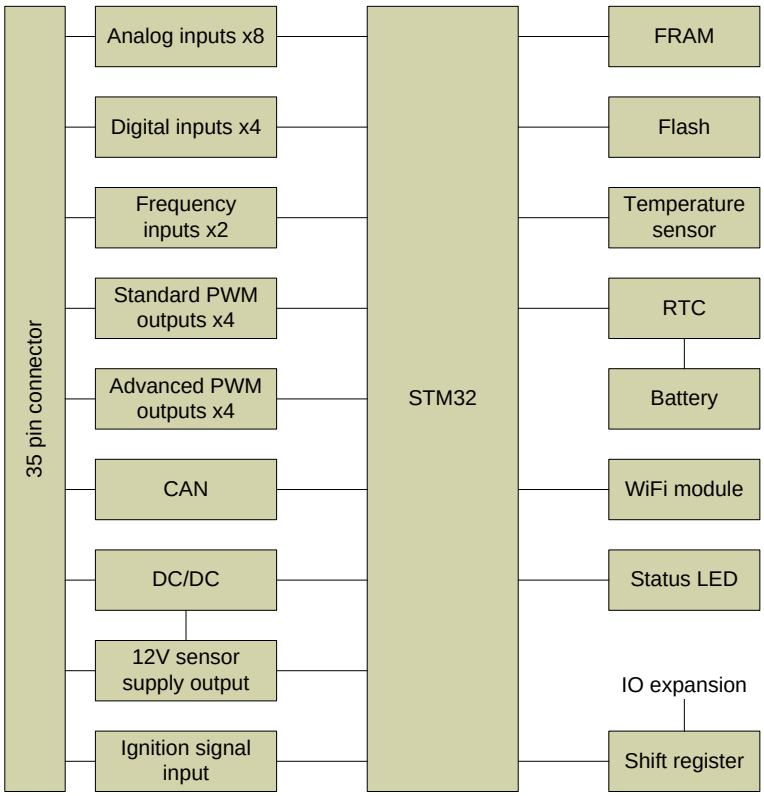
When the CANopen slave version of *CrossFire IX* is started up configuration can be done using SDO commands.

5.3. Shutting down

Removing power will shut down the Crossfire IX directly. CrossFire IX has no support for controlled shutdown when removing power. Setting the ignition signal low while keeping power will make the CrossFire IX shut down in a controlled fashion.

6. Interface overview

This section describes the overall various interfaces of the device.



7. Interface Characteristics

This section describes the basic interfaces on the *CrossFire IX* unit

7.1. Power interface

The *CrossFire IX* device is specified for a total of up to 12 A output current and special care must be taken with supplying power to the device. The device operates with a supply voltage of 8-32 VDC.

7.1.1. Supply pins

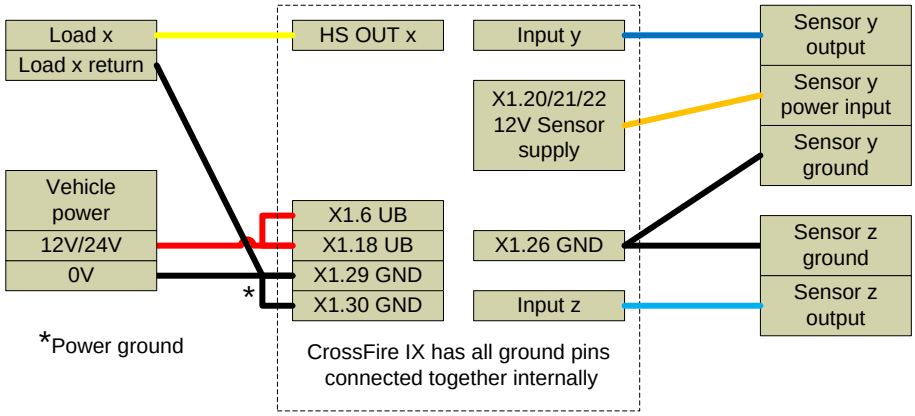
Each pin in the connector is rated for 17A and a maximum of AWG 16 (1.31 mm²) can be used. There are two pins, X1.6 and X1.18, for power input that are connected internally. In most cases it should be sufficient to use only one of these.

7.1.2. Ground pins

There are also 4 ground pins X1.26, X1.29, X1.30 and X1.31 that are connected internally together. The ground pins X1.29 and X1.30 in the connector close to the power pins are intended to be used for power ground when needed. Loads on high side outputs can be grounded directly to vehicle ground and cause almost no ground return current.

7.1.3. Recommended ground connection scheme

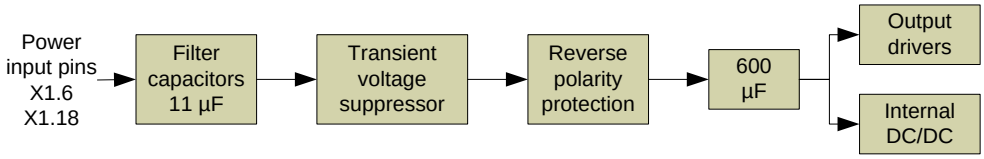
Note once more that all ground pins are connected internally and the connection scheme below is intended to facilitate the harness design and to minimize voltage drop on analog sensor returns due to ground currents.



Ground pin X1.26 is intended for sensor supply ground/analog input ground. Ground pin X1.31 is intended for CAN ground or additional ground for inputs.

7.1.4. Power filter and power architecture overview

An overview of the power filter and power architecture is shown below.



When connecting power to the unit the 11 µF of filter capacitors and 600 µF of bulk capacitors are charged causing a short initial current peak.

With power connected and the ignition signal low the device will consume typically 1.1 mA at 24V and 1.4 mA at 12V.

When the ignition signal is set high the DC/DC converters for the processing and logic are enabled and the unit will consume typically 0.03A at 24V with inputs and outputs not connected for the variant without Wi-Fi. The variant with Wi-Fi will consume typically 0.05A at 24V.

7.2. Communication interfaces

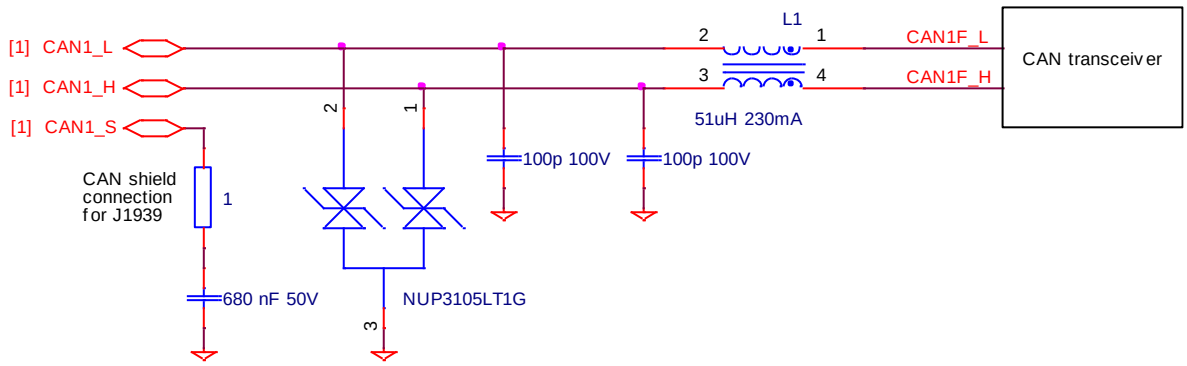
7.2.1. CAN

The *CrossFire IX* device contains one CAN port that meet the CAN ISO 11898 2.0B specification.

Supported CAN baud rates are 20 – 1000 Kbit/s. The device is optimized for baud rates up to 250 Kbit/s with a common mode input capacitance on CAN bus signals of approximately 150 pF. The usable baud rate depends on the CAN bus topology in terms of bus length, number of CAN nodes etc.

The CAN ports have short circuit protection allowing DC short circuit up to 32V without damage to the unit. There is no device-internal CAN bus termination. CAN bus termination must be provided for externally.

The unit has passed the electrical testing with standard CAN twisted pair cables, but it is advisable to use shielded cables for the CAN interfaces, especially when utilizing high bit rates and/or long cables. Each CAN port has its own CAN shield pin which is connected internally via a resistor and capacitor to ground as shown in the figure below. If shielded CAN cable is used the CAN cable shield shall be connected to ground at a single point to avoid ground loops.



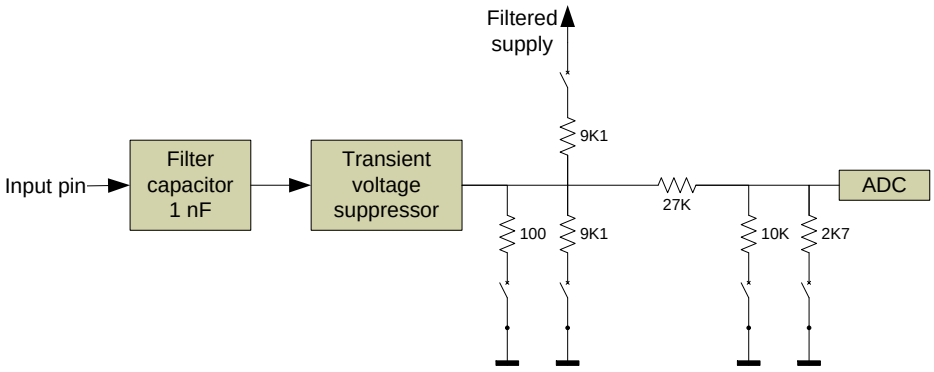
At first start up the CAN node id for CAN1 is 1. The device can be configured to use the digital inputs as node ID address pins (connector X1:4/5/16/27). If these address pins are used but unconnected (floating) the node id for CAN1 will be set to 16 as default. For information about how the pin pattern relates to node id, see *chapter 7.11 Digital inputs as ID interface*.

CAN node id can also be configured through software. CAN baud rate is set to 250kbit /s as default. To set the CAN baud rate and node id through software see the software user guides for the different product versions specified in *chapter 1.5 Supporting documentation*

7.3. Analog inputs 1-8

There are 8 configurable inputs that can be configured individually by software to accept different input ranges. A simplified schematic for the inputs is shown below. A 10 nF input capacitor and transient voltage suppressing diode handles ESD and other transients.

- A 100 Ohm sense resistor is used for 4-20 mA input range.
- Digital input modes are managed with a comparator and 9K1 pull-up or pull-down resistor can be enabled for sensor without push-pull outputs.
- Different voltage ranges are managed by enabling different resistor dividers.



All input ranges provides protection from short circuit and overload (0.. U_b).

Input type	Range	Accuracy Specification	Accuracy Typical	Impedance
Current input	4..20 mA	1 % ± 30 µA	<0.2% over temp	100 Ω
Voltage input	0..10V	1 % ± 10 mV	<0.4% over temp	37.0 KΩ
Voltage input	0..32V	1 % ± 30 mV	<0.2% over temp	29.7 KΩ

7.3.1. Analog inputs

For the analog voltage and current input modes the ADC operates with a resolution of 16-bits.

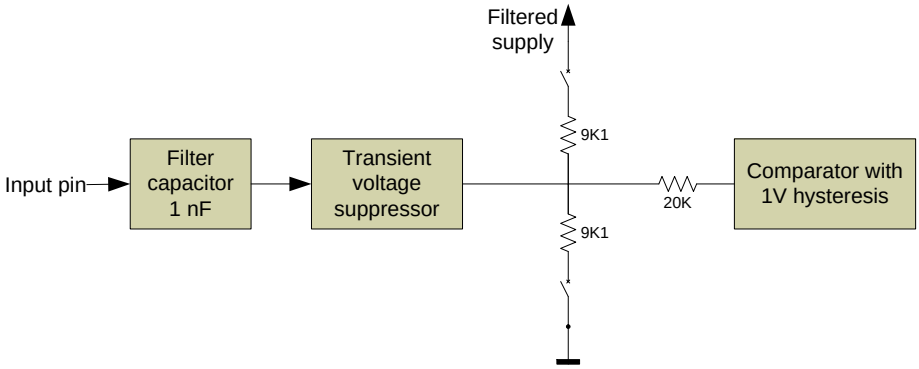
For the 4-20 mA current input range over current (over voltage) protection of the 100 Ohm sense resistor is implemented in software. If the input current is above 30 mA (equivalent to a voltage on the input above 3 V) for a certain time the 100 Ohm sense resistor will be disconnected for a time to allow the resistor to cool down before testing again for an over-current (over-voltage).

Each analog input have configurable pull-up and pull-down resistor for using the analog input with sensors other than analog ones such as for example switches and position sensors.

7.4. Digital inputs 1-4

There are 4 digital inputs with selectable pull-up or pull-down resistor. A comparator circuit with 1V of hysteresis is used to determine the input level.

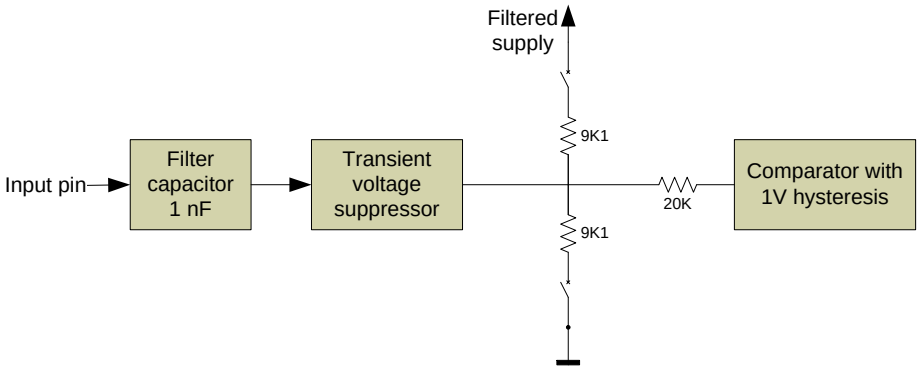
- For the input to change from high to low the input voltage must fall below ~2V.
- For the input to change from low to high the input voltage must rise above ~3V.



7.5. Frequency inputs 1-2

There are 2 frequency inputs with selectable pull-up or pull-down resistor. The frequency inputs A comparator circuit with 1V of hysteresis is used to determine the input level.

- For the input to change from high to low the input voltage must fall below ~2V.
- For the input to change from low to high the input voltage must rise above ~3V.



The 2 frequency inputs can either be used as independent frequency inputs or be combined in to an encoder input.

The bandwidth of the frequency input is more than 20 kHz for sensors with push-pull or open-drain with pull-up. When using sensors with high side output and pull-down resistor the bandwidth is 11-17 kHz depending on the supply voltage. The bandwidth difference for the modes is due to the 2-3 V threshold level.

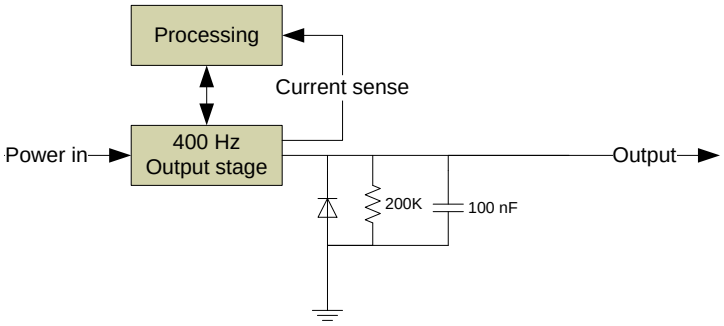
The time base for the timers in the microcontroller is better than 100 ppm over temperature.

7.6. Outputs 1-8

The 8 outputs (4 x Standard High-Side PWM + 4 x Advanced High-Side PWM) are individually and independently configurable through software. The total output current is specified to a maximum of 12A.

7.6.1. Standard High-Side PWM outputs 1-4

The block diagram for Standard High-Side output 1-4 which are rated for 2 A is shown below. The output stage has current limitation with approximately 9 A at 27V and room temperature. The current limit is higher at low temperature and lower at high temperatures. This output is capable of capacitive loads such as LED lamps and other units with high input capacitance on the input as well as inductive and resistive loads.



The current sense is not very accurate and mainly intended for diagnostics and open-load detection in on state. Off-state open load detection is done by connecting a 9K1 pull-up resistor to the output and check the voltage on the output.

In digital output mode when the output is enabled the output is allowed to be current limiting or have an output current above ~2.7A for up to 100 ms before turning off the output.

In PWM output mode when the PWM is enabled the output is **not** allowed to be current limiting or have an output current above ~2.7A in order to limit the number of activations into a short circuit.

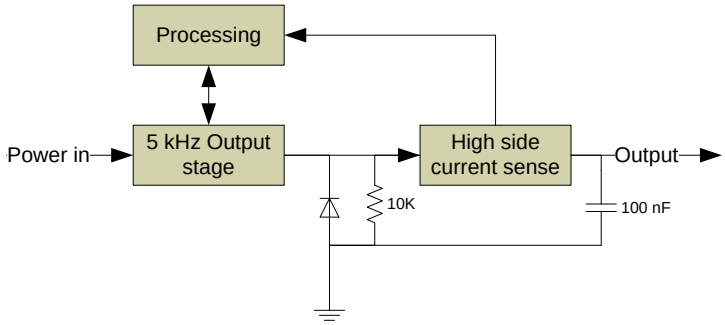
Common features	**Operating voltage range**	**8..32 V DC**
	Current per output	0...2000 mA
	All outputs can be used as an *ON/OFF outputs*	

PWM output	**Frequency**	**50…400 Hz**
	Duty cycle	0…100%, resolution 0,1%
	Loads	Inductive, resistive, capacitive
	Current Sense	±16% at 0.4A ±12% at 1.0A ±10% at 2.0A Accuracy is valid at 100% duty cycle
	Over current limit	~2.7A
	Open load detection	Off-state (yes/no) On-state (current sense)

7.6.2. Advanced High-Side PWM output 5-8

The block diagram for Advanced High-Side PWM output which is rated for 2 A is shown below.

The output stage is capable of fast switching for inductive and resistive loads.



Common features	Operating voltage range	8 V_{DC} to 32 V_{DC}
	Rated current per output	2 A
	Current sense range	0 to 2180 mA (min)
	Current over load limit	2180 mA (min) 2360 mA (max)

Current controlled output (PWMi)	Output frequency	Fixed high frequency, 5.2kHz
	Dither frequency range	25…400 Hz, adjustable in fixed steps
	Dither current	Adjustable up to 400 mA[1]
	Hardware output resolution	0.6 mA
	Software output resolution	1.0 mA
	Loads	Inductive, resistive
	Accuracy (design target)	ca ± 1% ± 10 mA
PWM output	Frequency	50…400 Hz
	Duty cycle	0…100%, resolution 0,1%
	Loads	Inductive, resistive
	Current Sense	ca ± 1% ± 5 mA

[1] The actual value is dependent many factors such as output current, dither frequency and solenoid type.

Protection from short circuit and overload (0..Ub).

7.6.3. PWM output

PWM outputs are adjustable individually for each output between 50-400Hz. Duty cycle is adjustable between 0-100% in 0.1% steps.

7.6.4. Digital output

All outputs might also be used in digital mode (on/off).

7.6.5. Current controlled output (PWMi)

PWMi mode is used to get a constant current through a solenoid. Because the resistance of the solenoid is affected by the temperature, the actual current is measured and the PWM duty cycle is automatically adjusted to get the desired current. In PWMi mode the desired current in mA is given directly as reference value.

PWMi outputs use a fixed high frequency PWM – 5.2kHz. This frequency is so high that the natural dither of the current will be very low. Instead an adjustable dither is superimposed on the PWM signal. The frequency and amplitude of this dither is adjustable. Also the parameter for the PID regulator used for current control can be adjusted if necessary. All PWMi settings are individually adjustable for all outputs.

7.7. Wi-Fi

The CrossFire IX product C000141-70 and C000141-40 includes a Wi-Fi module to facilitate wireless communication to and from the module.

The Wi-Fi module is based on the ESP8266 chip, UDP, TCP/IP network stacks and interfaces for communicating with STM32 are embedded in this module.

Wi-Fi chip protocol and communication specification:

Items	Specification
Radio certificates	CE, IC, FCC, KCC, NCC, SRRC, TELEC
Wi-Fi protocols	802.11 b/g/n
Frequency range	2.412 – 2.484 GHz
Temperature range	The Wi-Fi circuitry is operational in the CrossFire IX's full temperature range
Security	WPA2
Encryption	WEP/TKIP/AES
Output power at 72.2 Mbps	14 dBm
Output power in 11b mode	20 dBm

7.7.1. Radiation exposure statement

Crossfire IX product C000141-70 and C000141-40 that includes a Wi-Fi module should be installed and operated with minimum distance of 20cm to your body to comply with radiation exposure limits for an uncontrolled environment.

7.8. Sensor supply

The unit has a sensor supply output (connector X1.20/21/22) which provides a linear regulated output (typical 11.98V) for powering sensors or potentiometers. The output is current limited to typically 159 mA (+/- 10%) and withstands short to ground and short to 32V. There is voltage read back for diagnostics and application usage.

7.9. Ignition signal

The ignition pin (connector X1:19) controls the start-up and shutdown of the unit and is intended to be connected to the ignition switch. In installations without ignition switch the ignition signal can be connected to the power supply input pins and the unit will start-up when power is applied.

The ignition input has a 20 kΩ pull-down resistor. The threshold level for on/off is typically 3 V.

7.10. Firmware update

The CrossFire IX contains a CAN bootloader to allow for firmware upgrade over CAN. The CAN bootloader has to be activated through a CAN command before upgrade can be made. A specific PC tools needs to be used to perform the upgrade.

For more information about the firmware upgrade see supporting document *CrossFire IX – Firmware upgrade instructions.docx*.

7.11. Digital inputs as ID interface

For the CANopen version, the digital input pins X1:4/5/16/27 can alternatively be used as id pins setting the CANopen node id.

The table below show the CAN node id is set up by the digital input pins in connector X1:4/5/16/27

CANopen Node ID	D4	D3	D2	D1
1	0	0	0	0
2	0	0	0	1
3	0	0	1	0
4	0	0	1	1
….				
16	1	1	1	1

- Reading node id from digital pins needs to be activated in object dictionary.
- State 0 is reached by wiring corresponding pin to GND.
- State 1 is reached by leaving corresponding pin disconnected.
- It is possible to configure in software which of the digital inputs will affect the node id through the nod id pins mask in the object dictionary.

7.12. Status LED indicator

The table below describes the *default* behaviour of the status notification for different operational states.

Errors are signaled through the RED/GREEN led or through the CAN bus (application specific). During boot-up phase it is the boot loader that is responsible for controlling the LED. After the boot phase the application takes over the LED control. Read the respective application manual for more information.

7.12.1. Start up and normal operation indications

These tables present the status LED indication for the CANopen slave version during operation.

Run LED – Green

CANopen mode	State	Blinking Pattern
Operational	LED ON	Constantly ON
Pre-Operational Initializing	LED Blinking	Iso-phase on and off with a frequency of approximately 2,5 Hz: (ON 200ms, OFF 200ms)
Stopped	LED Single Flash	One short flash: (ON 200ms, OFF 1000ms)

Error LED – Red

CANopen mode	State	Blinking Pattern
CAN Bus-Off	LED ON	Constantly ON
CAN Bus Warning	LED Single Flash	One short flash: (ON 200ms, OFF 1000ms)
Output Port Error	LED Blinking	Iso-phase on and off with a frequency of approximately 2,5 Hz: (ON 200ms, OFF 200ms) The red error blinking is only shown during interleaving 2,5 seconds intervals.

7.12.2. Boot mode indications

These tables present the status LED indication if boot mode is activated.

Green LED – IX Boot mode LED

IX Boot mode	Blinking Pattern	Description
IDLE	LED Slow-Blinking	In boot mode and no upgrade in progress This state is usually an indication that a manual restart is needed after a firmware upgrade (ON 1000ms, OFF 44ms).
SW-UPGRADE	LED Fast-Triple-Blinking	Firmware upgrade in progress

Red LED – IX Boot Firmware error LED

IX Boot error	LED State	Description
NO-ERROR	LED-OFF	NO Firmware error
ERROR	LED-ON	Firmware error is present. Must be repaired with new firmware upgrade.
LOW SUPPLY VCC	LED-FLASHING	Low supply voltage. Supply voltage must exceed ~7.2 V otherwise SW start is blocked with the RED-LED-FLASHING

7.13. Memory

7.13.1. Flash

The main processor in CrossFire IX has 256 Kbyte of internal flash for firmware and application. The C000 141-70 variant has an additional serial Flash of 4Mbyte that can be used for data logging.

7.13.2. RAM

The main processor in CrossFire IX has 32 Kbyte of internal RAM for use by firmware and application.

7.13.3. FRAM

CrossFire IX has an 8 Kbyte FRAM memory for storage of persistent data. An FRAM memory is faster than an EEPROM and can handle much more write cycles.

7.14. RTC and back-up battery

The CrossFire IX product C000141-70 contains a real time clock circuit to store time and date information. The RTC is powered by an internal battery when the external power is not applied. The battery is a 3V 100mAh high operating temperature Poly-carbonmonofluoride Lithium battery. The expected life time of the battery is approximately 10 years and the battery is not replaceable.

7.15. Diagnostics

The CrossFire IX supports a number of different supervision functions. It is recommended to use as many as possible of these and perform appropriate actions. How this is done can be read in respective programming manual.

Please note that the diagnostics for the regular PWM and the advanced PWM outputs differ due to differences in the hardware.

7.15.1. Voltage supervision

There are four different supply voltages that are possible to read from software.

- External supply voltage
- Internal 5V rail
- Internal 3.3V rail
- The sensor supply output voltage

7.15.2. Temperature supervision

There is a temperature sensor on the board that is possible to read from software. It is recommended to keep the temperature below 115 degrees Celsius. There is no automatic shut off at high temperatures. There is also temperature supervision for the advanced PWM outputs that can be read as part of the port status. It is recommended to shut down outputs if over temperature is signalled.

7.15.3. Standard PWM output diagnostics

There are a number of diagnostics capabilities available for the standard PWM outputs:

- Open load detection in off-state.
- Open load detection in on-state by reading the output current.
- Current sense in on-state.
- Short to battery in off-state.
- Over current/short to ground/short to battery in on-state.

Note that most errors are signalled through a common error code.

7.15.4. Advanced PWM output diagnostics

There are a number of diagnostics capabilities available for the advanced PWM outputs:

- Open load detection in on-state by reading the output current.
- Current sense in on-state.
- Over current in on-state.
- Short to ground in on-state.
- Thermal warning/under voltage lockout (UVLO).

7.15.5. 4-20 mA input over current protection

The 4-20mA inputs are shut down individually in case the input current exceeds roughly 30 mA. In case this happens, an error flag is set that can be read from software. The input is automatically activated again after a short while.

8. Software overview

The *CrossFire IX* contains the following software parts.

Application	Purpose
Boot Loader	Makes it possible to upgrade the software over CAN
CANopen slave application	This application is written by CrossControl to allow the *CrossFire IX* to act as a CANopen slave. The application includes all need firmware to fully control interfaces and IO.

All software parts can be upgraded. It is important that all versions fit together. Only upgrade to combinations recommended by CrossControl. For more information about upgrade see supporting document *CrossFire IX – Firmware upgrade instructions.docx*.

For details about using the CANopen slave version, read the CrossFire IX - CANopen Slave Developers Guide.docx.

9. Specifications

9.1. Environmental specifications

The unit is tested towards the relevant segment tests as defined in:

- Earthmoving machines, ISO 13766:2006
- Agricultural and forestry machinery, EN ISO 14982:2009
- Construction Machinery, ISO 13309:2010

Environmental tests are performed at 24 VDC supply voltage unless otherwise required. The environmental tolerance may be affected by external factors like mounting, omitting the use of shielded cables etc.

Any changes or modifications to the device not expressly approved by CrossControl could void the environmental classification, warranty as well as user's authority to operate the equipment.

9.1.1. Electrical test

Environmental Test	Standard	Notes
EMC Transient	ISO 13766: 2006 ISO 7637-2: 2011	+24V system Pulse1 : -450V C Pulse2a : +37V A Pulse2b : +20V C Pulse3a : -150V A Pulse3b : +150V A Pulse4 : -12V A Pulse5 : +123V, 2Ω A +12V system Test level III Pulse1 : -75V C Pulse2a : +37V A Pulse2b : +10V C Pulse3a : -112V A Pulse3b : +75V A Pulse4 : -6V C Pulse5 : +65V, 1Ω A
EMC Immunity, ESD	ISO 13766: 2006 ISO/TR 10605: 2008	Test level IV, ±15 kV air, ±8kV contact
EMC RF Immunity, Radiated [1)]	ISO 13766: 2006 ISO11452-2: 2004	Radiated 200M-1GHz, 100V/m
EMC RF Immunity, Induced [1)]	ISO 11452-4: 2011	BCI 20-200MHz, 100mA
EMC Radiated Emission [1)]	ISO 13766: 2006	1 meter Narrowb. Broadb. MHz dBµV/m dBµV/m 30-75 54-44 64-54 75-400 44-55 64-54 400-1000 55 65

9.1.2. Climatic test

Environmental Test	Standard	Notes
Dry Heat	IEC 60068-2-2:2007	Functional during and after test, +85°C, 24 hours
Damp Heat	IEC 60068-2-30:2005	Functional during test, +25°C to +55°C >95% RH, 6x24h
Cold	IEC 60068-2-1:2007	Functional during and after test, -40°C, 24 hours
Change of temperature	IEC 60068-2-14:2009	Functional during test, -40°C to +85°C 5C/min 3h hold time, 20 cycles[1]

9.1.3. Mechanical test

Environmental Test	Standard	Notes
Vibration	IEC 60068-2-64:2008 IEC 60068-2-6: 2007	0,03 g2/Hz 5-200Hz, 0,01 g2/Hz 200-1000Hz, 3x3h 5g, 5-2000Hz, 1 octave/min, 20 cycles
Shock	IEC 60068-2-27:2009	30 g / 11ms 3x ±1000 bumps
Enclosure Ingress Protection	IEC 60529:2014	IP65, IP66 and IP67
Chemical compatible	ISO 16750-5: 2010	Window cleaner, Plasticizer, Soda, Windshield washer fluid, All Purpose Cleaner, Phosphate wash, Motor Oil, Gear Oil, Bearing grease, Hydraulic fluid, Power steering fluid, Antifreeze, Diesel Oil, Gasoline, Brake Fluid, Battery acid, Fertilizer (28% nitrogen with ammonium nitrate and urea at a pH of 5), Degreaser
Salt Spray	EN 60068-2-52: 2001	Severity level 3 (vehicle)
UV radiation	ISO 4892-3 cycle 6	500h

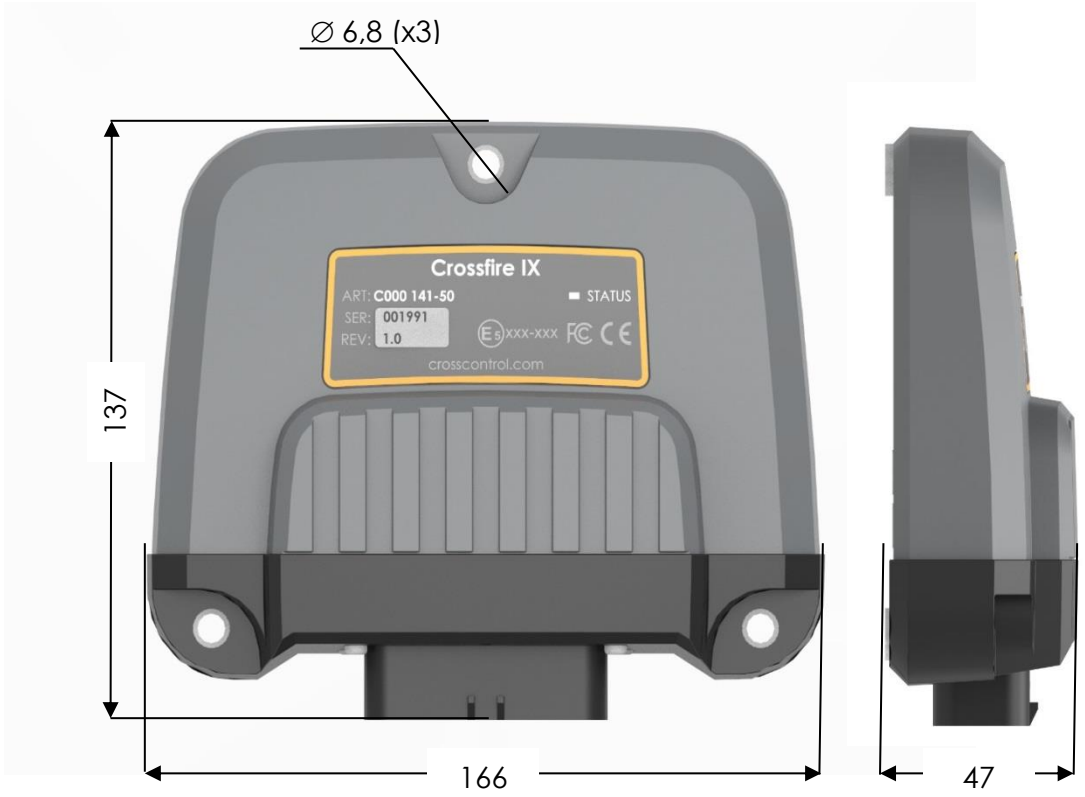
[1] Do not comply with requirement in 60950-22 regarding operating mode down to -50°C

9.2. Certifications

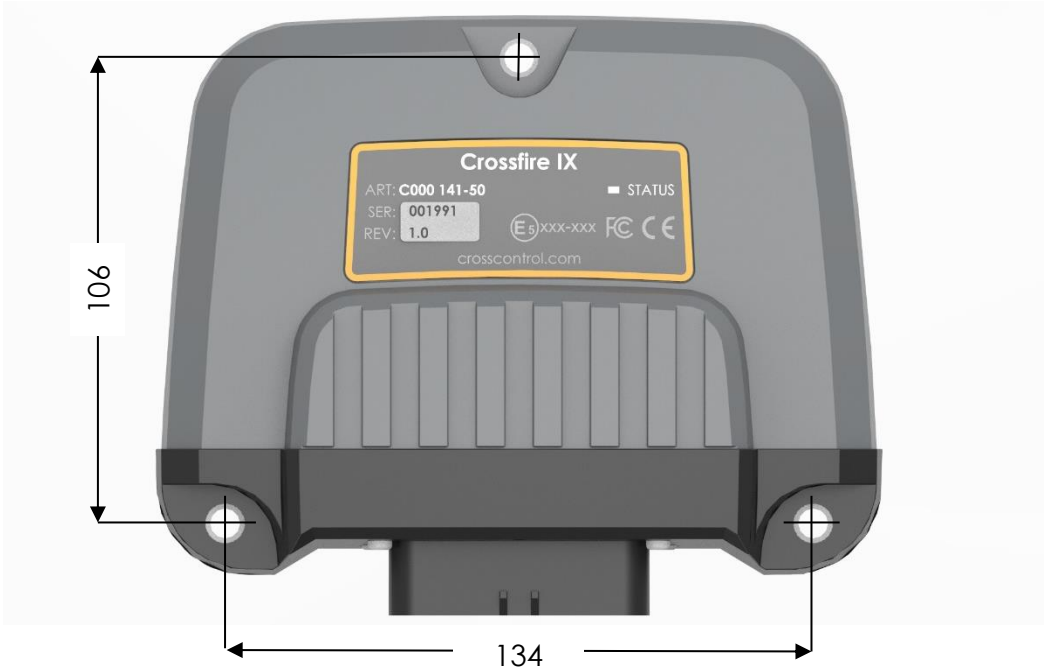
CE Marking, (93/68/EEC)
E-marking, (2004/104/EG)
FCC compliance, (FCC/15B)

9.3. Weight and dimensions

	Description	Comments
Dimensions	166 x 137 x 47 mm	(W x H x D)
Weight	0,64 Kg	




26,6


106
Crossfire IX
ART: C000 141-50
STATUS
SER: 001991
REV: 1.0
E5 xxx-xxx
crosscontrol.com
134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10. Technical Support

Contact your reseller or supplier for help with possible problems with your device. In order to get the best help, you should have your device in front of you and be prepared with the following information before you contact support.

- Part number and serial number of the unit, which you find on the brand label
- Date of purchase, which is found on the invoice
- Installed software versions
- The conditions and circumstances under which the problem arises
- LED indicator colors and blink patterns
- EMCY object error codes (if possible)
- Description of external equipment which is connected to the CrossFire™ IX
- Additional sources of information are available on the CrossControl support site https://crosscontrol.com/support/

11. Trademark, etc.

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