Revision: 1.0
2017-02-15

CrossFire SX

Technical manual

crosscontrol

www.crosscontrol.com

Contents

1. Introduction

The *CrossFire SX* - I/O module is a state of the art 32-bit I/O, optimized for use within the Construction and Agri segments and for special trucks. It offers 32 channels, (16 inputs and 16 outputs) fully versatile and configurable through software together with network capabilities through J1939 and CANopen. It also contains two full H-bridges with current limitation for motor control.

CrossFire SX is available in three product version, one CANopen slave, one freely programmable through CODESYS 3.5 and one certified for functional safety to performance level *PL (d)* and Integrity Level *SIL 2*.

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

This documentation is applicable for all *CrossFire SX* standard models. These models are:

Part nr.	Product variant	Comment	Configuration	SIL Certified
C000137-20	Crossfire SX, CODESYS	With full support for CANopen Master, CANopen Slave and J1939	Freely programmable through CODESYS 3.5	
C000137-30	Crossfire SX, Safety	SIL 2 certified	Freely programmable through CODESYS	Yes
C000137-40	Crossfire SX, CANopen Slave	CANopen slave according to CiA 401	EDS file available.	

All these models offer the same level of performance and connector interfaces.

Crossfire SX is a very flexible platform that easily can be adapted. Reduced complexity is a guiding principle in the design. All product variants share the same hardware architecture including PCB, enclosure and connectors. An open development board with JTAG header and without the enclosure is available on request.

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.

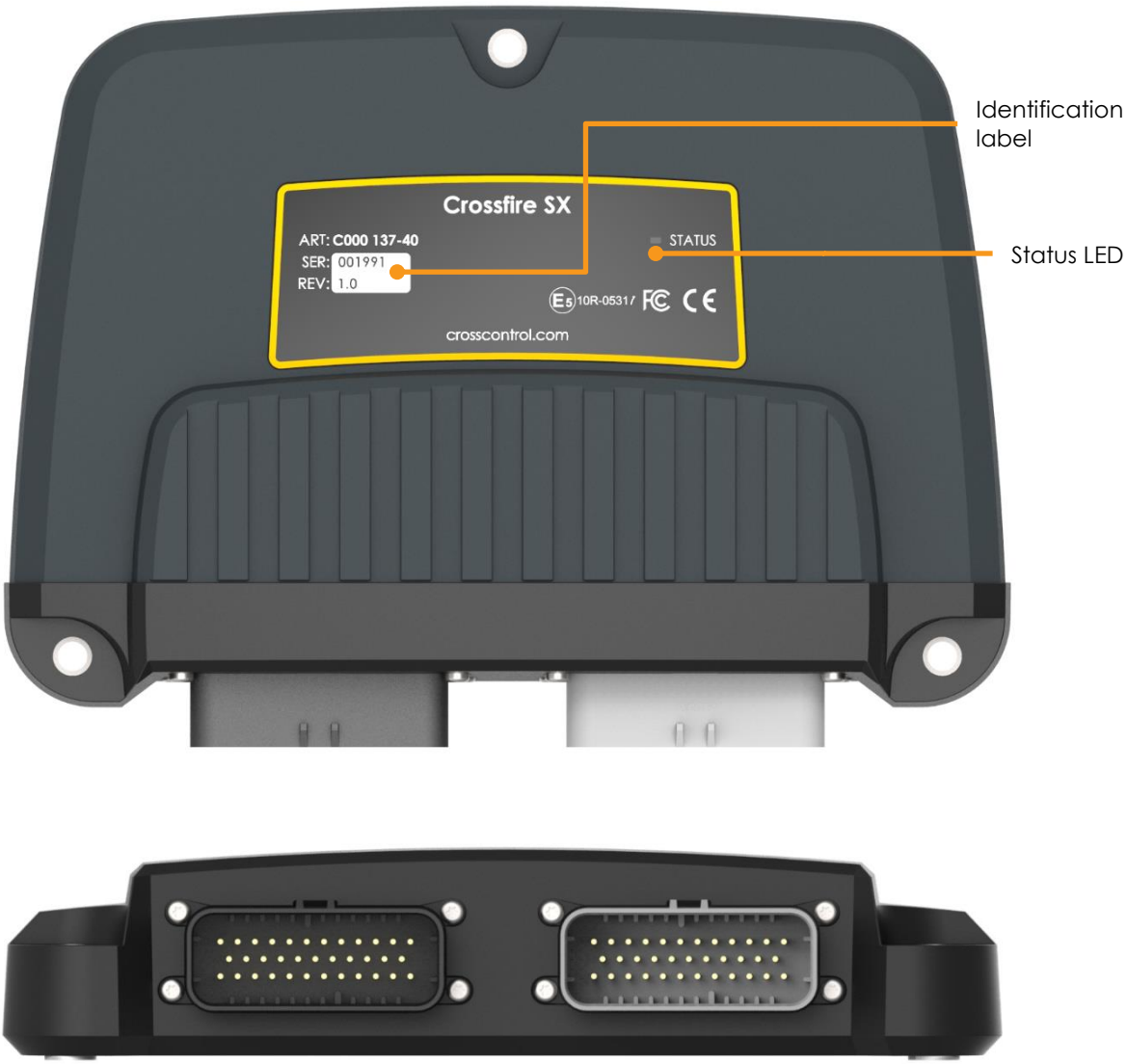
In addition to this document other supporting documents are available on our support site :

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

For specific or more detailed information around CODESYS IEC 61131-3 development software refer to https://www.codesys.com/

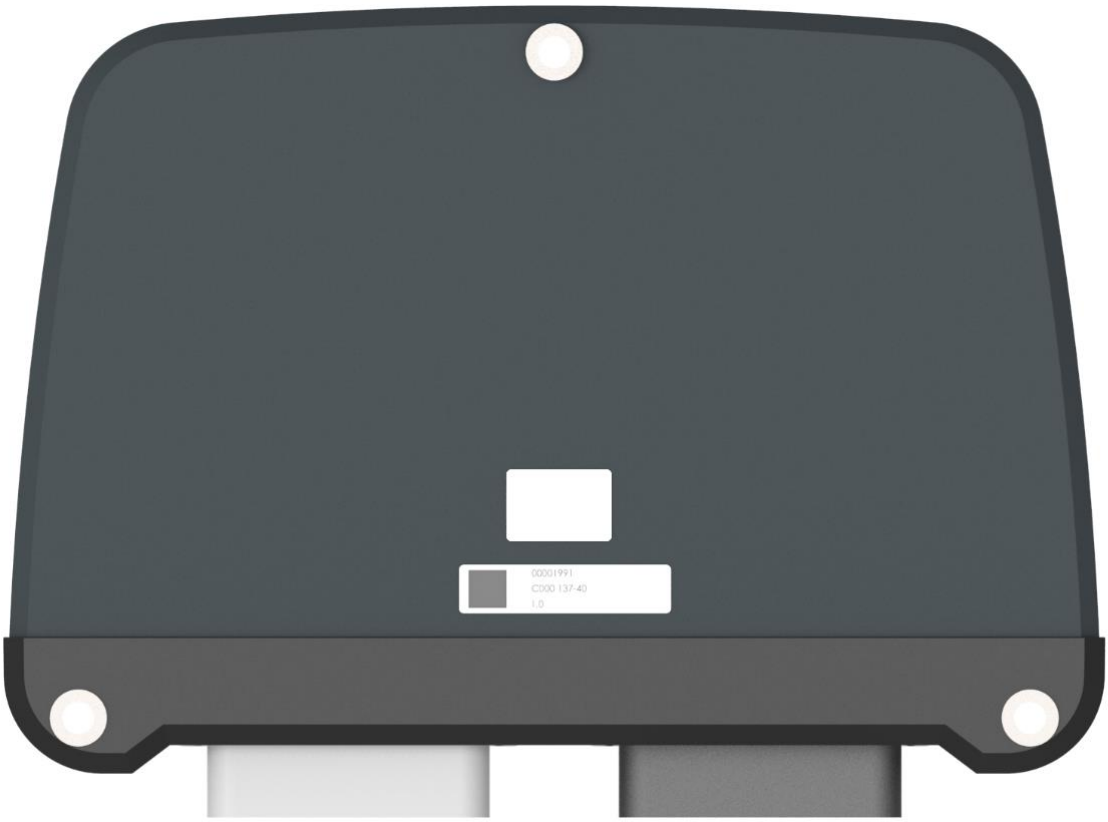
2. CrossFire SX device overview

The top side of *CrossFire SX* holds a label with information about product article number, serial number and revision. It also displays a status LED, see *chapter 7.10 Status LED indicator*.



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

The bottom side of the *CrossFire SX* unit holds two labels for identification information and CODESYS license.



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 SX* device.

3.1. Mounting

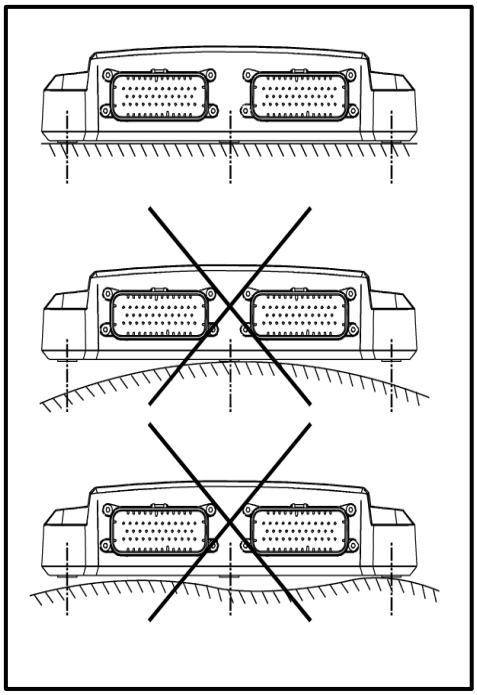
CrossFire SX is designed with a three pod mounting footprint that allows for flexible mounting. However, fastening the unit to an uneven surface may stress the enclosure, or possibly even flex the circuit board inside, leading to a premature failure.

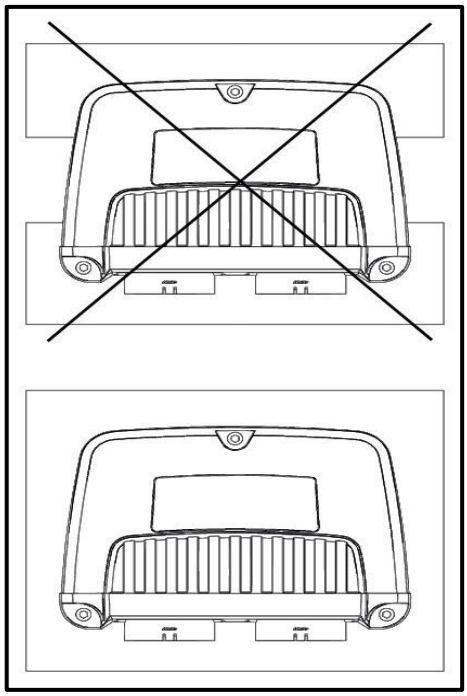
Ensure the mounting bolts are of grade 8.8 or higher. The mounting holes have clearance for M6 bolts.

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.



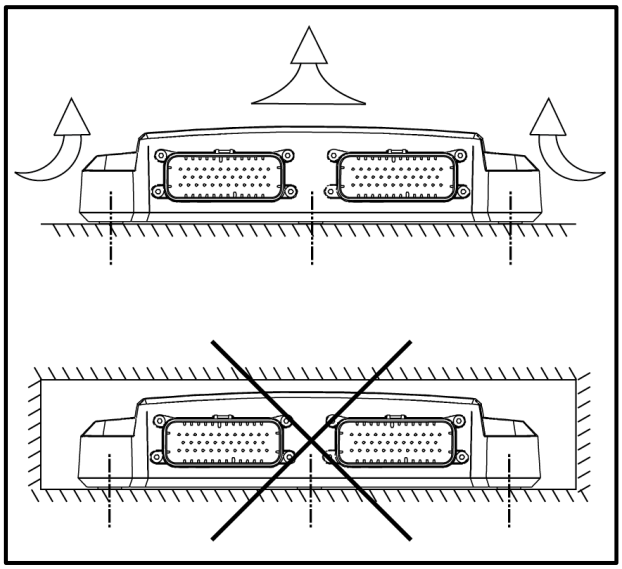


3.2. Installation position

Align *CrossFire SX* 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, both connectors 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.

4. Electrical installation

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

4.1. Connectors

All connectors are accessible from the side of the *CrossFire SX* unit. The connectors which are two AMP 35-pin multi-pin connectors are marked with a 1(X1) and a 2(X2).

- X1 connector black, TE connectivity 1-776163-1 (Mating connector, e.g. 776164-1)
- X2 connector white, TE connectivity 1-776163-4 (Mating connector, e.g. 776164-4)

Use caution and avoid plugging/unplugging of connectors when the *CrossFire SX* 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.

Connector pinning X1 (left)

1 HS 2A	2 HS 2A	3 HS 2A	4 HS 2A	5 HS 2A	6 HS 2A	7 HS 4A	8 HS 4A	9 GND	10 GND	11 UB	12 UB
13 CAN1_L	14 CAN1_H	15 CAN1_S	16 5V out	17 Input	18 Input	19 Input	20 Input	21 IGN	22 FW UP	23 UB	
24 CAN1_L	25 CAN1_H	26 CAN1_S	27 GND	28 Input	29 Input	30 Input	31 Input	32 A0	33 A1	34 A2	35 A3

Connector pinning X2 (right)

1 UB	2 UB	3 GND	4 GND	5 HS 4A	6 HS 4A	7 HS 2A	8 HS 2A	9 HS 2A	10 HS 2A	11 HS 2A	12 HS 2A
	13 HB A1	14 GND	15 RS-TX	16 Input	17 Input	18 Input	19 Input	20 Spare	21 CAN2_S	22 CAN2_H	23 CAN2_L
24 HB A2	25 HB B1	26 HB B2	27 RS-RX	28 Input	29 Input	30 Input	31 Input	32 GND	33 CAN3_S	34 CAN3_H	35 CAN3_L

HS 2A	High side output 2A
HS 4A	High side output 4A
GND	Ground
UB	Battery input
CANx_L	CAN bus x low
CANx_H	CAN bus x high
CANx_S	CAN bus x shield
5V out	5V sensor supply

Input	Configurable inputs
IGN	Ignition input
FW UP	Firmware upgrade enable
Ax	Slave address (0-15)
Spare	Spare pin for future use
RS-TX	RS-232 serial port transmit
RS-RX	RS-232 serial port receive
HB	H-bridge

Pin	Function X1	Pin	Function X2
X1-1	High side output 8, 2A, Group A	**X2-1**	Battery input
X1-2	High side output 7, 2A, Group A	**X2-2**	Battery input
X1-3	High side output 6, 2A, Group A	**X2-3**	Ground
X1-4	High side output 5, 2A, Group A	**X2-4**	Ground
X1-5	High side output 4, 2A, Group A	**X2-5**	High side output 9, 4A, Group B
X1-6	High side output 3, 2A, Group A	**X2-6**	High side output 10, 4A, Group B
X1-7	High side output 2, 4A, Group A	**X2-7**	High side output 11, 2A, Group B
X1-8	High side output 1, 4A, Group A	**X2-8**	High side output 12, 2A, Group B
X1-9	Ground	**X2-9**	High side output 13, 2A, Group B
X1-10	Ground	**X2-10**	High side output 14, 2A, Group B
X1-11	Battery input	**X2-11**	High side output 15, 2A, Group B
X1-12	Battery input	**X2-12**	High side output 16, 2A, Group B
X1-13	CAN 1 low	**X2-13**	H-bridge output A1, Group A
X1-14	CAN 1 high	**X2-14**	Ground
X1-15	CAN 1 shield	**X2-15**	RS-232 serial port transmit
X1-16	5V sensor supply	**X2-16**	Input 9
X1-17	Input 1	**X2-17**	Input 11
X1-18	Input 3	**X2-18**	Input 13
X1-19	Input 5	**X2-19**	Input 15
X1-20	Input 7	**X2-20**	Spare
X1-21	Ignition input	**X2-21**	CAN 2 shield
X1-22	Firmware upgrade pin	**X2-22**	CAN 2 high
X1-23	Battery input	**X2-23**	CAN 2 low
X1-24	CAN 1 low	**X2-24**	H-bridge output B1, Group B
X1-25	CAN 1 high	**X2-25**	H-bridge output B2, Group B
X1-26	CAN 1 shield	**X2-26**	H-bridge output A2, Group A
X1-27	Ground	**X2-27**	RS-232 serial port receive
X1-28	Input 2	**X2-28**	Input 10
X1-29	Input 4	**X2-29**	Input 12
X1-30	Input 6	**X2-30**	Input 14
X1-31	Input 8	**X2-31**	Input 16
X1-32	Slave address 0	**X2-32**	Ground
X1-33	Slave address 1	**X2-33**	CAN 3 shield
X1-34	Slave address 2	**X2-34**	CAN 3 high
X1-35	Slave address 3	**X2-35**	CAN 3 low

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 SX* in vehicles or other machines. The principle is the same also for other types of installations.

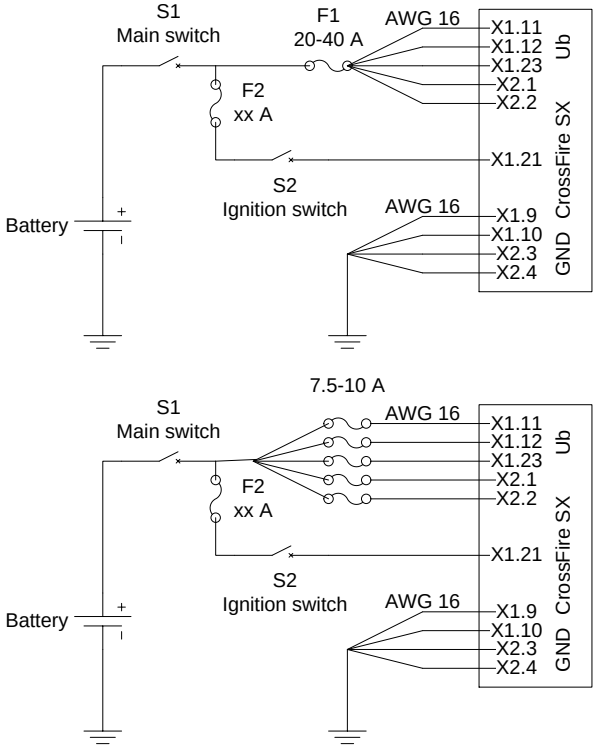
For connector pinout, see *chapter 4.1 Connectors*.

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, the recommended minimum power supply cable area is: 1.31 mm² (AWG 16)

- 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. Refer to *chapter 10.1 Technical data* for fuse rating details.
    - As a guideline, a fuse with 20 A -40 A current rating should be used depending on application and fuse characteristics.
    - As there are multiple power supply pins an alternative approach is to have a separate 7.5 A to 10 A fuse for each individual wire.
- The device's external on/off control signal (connector X1, pin 21) 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 SX* 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.

- 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 SX 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 turn off the device while sending configuration data to the device. The configuration data is double buffered in persistent memory and turning off the device while sending configuration data to the device might cause the old configuration to remain active.

Be advised that the device consumes a small amount of power (0.35 mA @ 24 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 inputs and outputs are disabled by default and needs to be configured with SDOs.

For the freely programmable CODESYS versions, the user needs to write a CODESYS application and download to the unit. However, at delivery an example application is preinstalled to simplify the first start up. All other software parts are preinstalled.

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 *CrossFires SX* unit the first time.

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

Make sure that the firmware pin is connected to ground or is floating before starting up. If this pin is active *CrossFire SX* will enter firmware update mode at start up.

The *CrossFire SX* will start up when the ignition pin gets active and power is connected.

For the CANOpen slave version of CrossFire SX the status LED on the unit will indicate unit status according to the LED status table described in *chapter 7.10 Status LED indicator*.

For the freely programmable CODESYS versions the status LED is controlled fully by the user/customer application.

During the startup, unit self-test and diagnostic are performed. If any error is detected the status LED will flash red, see *chapter 7.10 Status LED indicator*.

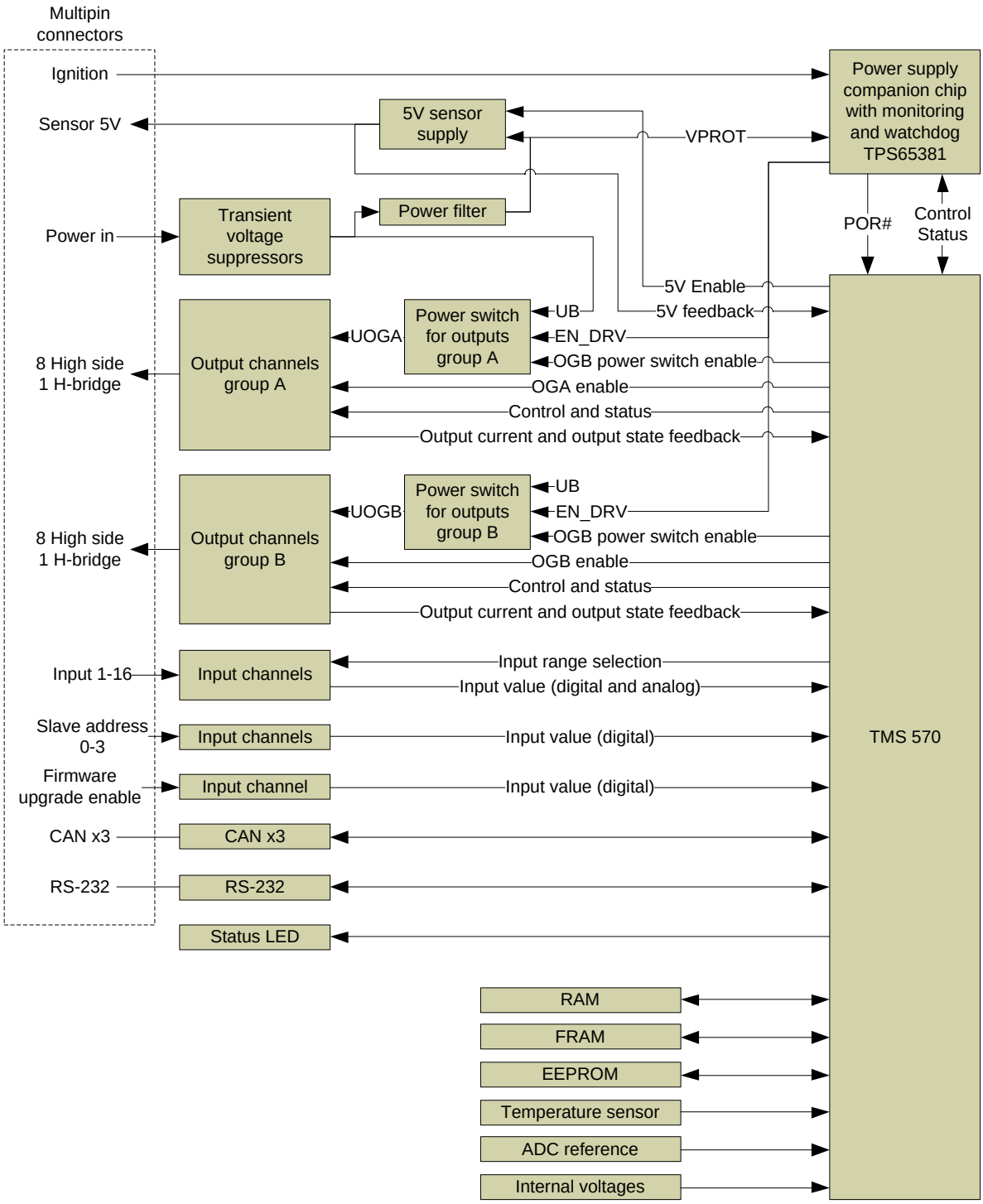
When the CANOpen slave version of *CrossFire SX* is started up configuration can be done using SDO commands.

5.3. Shutting down

Removing power or disconnecting the ignition signal shuts down the Crossfire SX directly. It is recommended to not remove power or ignition during configuration.

6. Interface overview

This section describes the overall various interfaces of the device. Main part of these interfaces can be accessed via software APIs.



7. Interface Characteristics

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

7.1. Power interface

The *CrossFire SX* device is specified for a total of up to 28 A output current and special care must be taken with supplying power to the device.

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. In order to handle the maximum current the *CrossFire SX* device uses multiple pins for power supply input. The device has 5 power inputs X1.11, X1.12, X1.23, X2.1 and X2.2 that are all connected together internally.

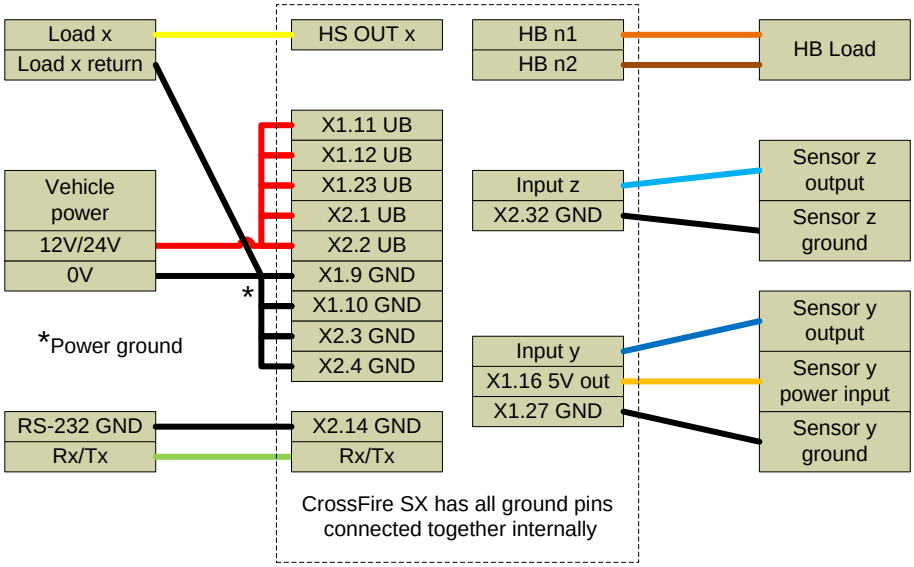
The minimum number of supply pins that must be connected depends on the maximum simultaneous output current, the start-up current and the allowed voltage drop of the cable.

7.1.2. Ground pins

There are also 7 ground pins X1.9, X1.10, X1.27, X2.3, X2.4, X2.14 and X2.32 that are connected internally together. The ground pins (X1.9, X1.10, X2.3 and X2.4) 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, but loads connected to the H-bridges have their return current through the ground pins of the device.

7.1.3. Recommended ground connection scheme

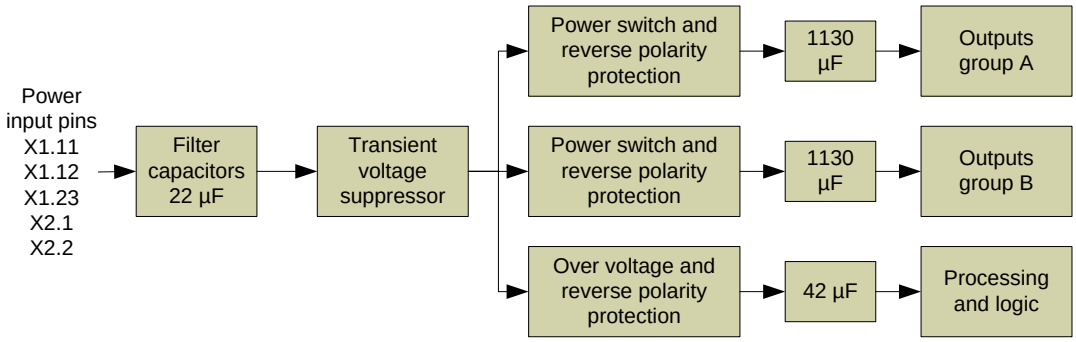
Note once more that all ground pins are connected internally and the connection scheme below is intended to facilitate the harness design and to minimize voltage drop on analog sensor returns due to ground currents.



Ground pin X1.27 is intended for sensor supply ground/analog input ground. Ground pin X2.14 is intended for RS-232 ground. Ground pin X2.32 is intended for analog input ground.

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 22 µF filter capacitors and 42 µF input capacitors to the DC/DC for the processing and logic are charged causing a short initial current peak.

With power connected and the ignition signal low the device will consume typically 0.35 mA at 24V.

When the ignition signal is set high the DC/DC converters for the processing and logic are enabled and the unit will consume typically 200mA at 24V with inputs and outputs not connected.

When the software enables the output groups A and B the internal capacitors for each output group are charged causing a short current peak of ~20A.

7.2. Communication interfaces

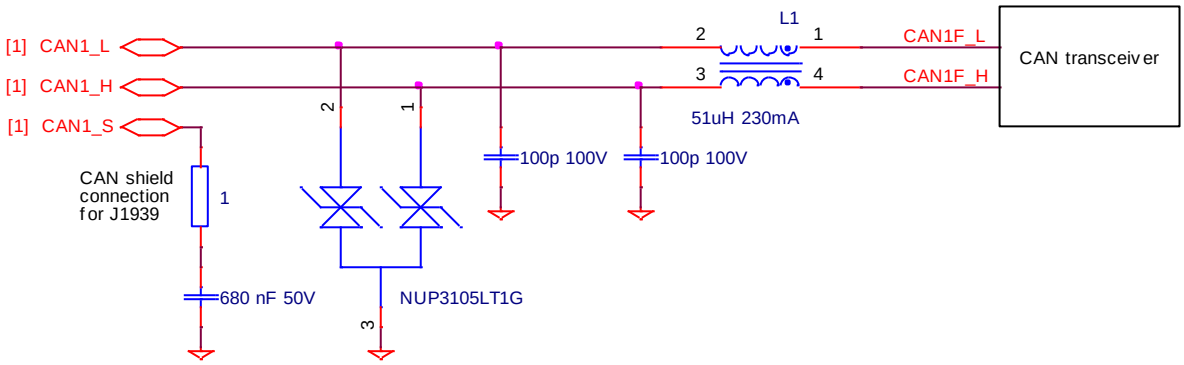
7.2.1. CAN

The *CrossFire SX* device contains three CAN ports 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.



CAN port 1 has a built in T-connection, i.e. for CAN port 1 each CAN bus signal is available in two pins (X1:13-16 and X1:24-26) to simplify cabling and termination.

At first start up the CAN node id for CAN1 is defined by the configuration of the address pins (connector X1:32-35). If these address pins are 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 7.9 ID interface*.

CAN node id can also be configured through software. CAN baud rate is set to 125kbit/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*

7.2.2. RS-232

The *CrossFire SX* device contains one RS-232 port with transmit and receive signals. The RS-232 signals have 1 nF input filter and support baud rates of up to 115200 bit/s.

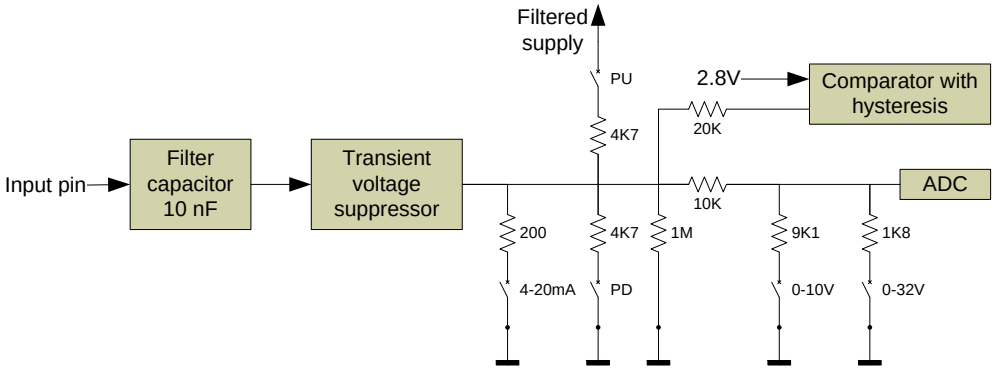
The RS-232 port has short circuit protection allowing DC short circuit up to 32V without damage to the unit.

The RS-232 port is considered to be a service port and is intended for CODESYS programing and debugging. Default baud rate is 115200bit/s. Being a service port the RS-232 port is not tested to comply with industrial surge and burst transients, see 10.2.1 *Electrical test*.

7.3. Inputs 1-16

There are 16 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 200 Ohm sense resistor is used for 4-20 mA input range.
- Digital input modes are managed with a comparator and 4K7 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**	**Impedance**
Inputs	Current input	4..20 mA	1 % ± 30 µA	200 Ω
	Voltage input	0..5 V	0,3 % ± 6 mV	>100 KΩ
	Voltage input	0..10V	1 % ± 15 mV	18,7 KΩ
	Voltage input	0..32V	1 % ± 50 mV	11,7 KΩ
	Frequency input	20 kHz Trigger level 2.3-2.9 V		
	Digital input	Trigger level 2.3-2.9 V		
	Encoder input	Available by pairing two frequency inputs.		

7.3.1. Analog inputs

For the analog voltage and current input modes the ADC operates with a resolution of 12-bits.

For the 4-20 mA current input range over current (over voltage) protection of the 200 Ohm sense resistor is implemented in software. If the input current is above 25 mA (equivalent to a voltage on the input above 5 V) for two readings in a row the 200 Ohm sense resistor will be disconnected for a time to allow to cool down before testing again for an over-current (over-voltage).

7.3.2. Digital inputs

The digital input mode utilizes a comparator with a hysteresis circuit. The input can be configured to enable pull-up or pull-down resistor. Add hysteresis and threshold levels.

7.3.3. Frequency inputs

The frequency input mode utilizes the digital input path and uses the timer functionality of the CPU to provide frequency measurements.

7.3.4. Encoder inputs

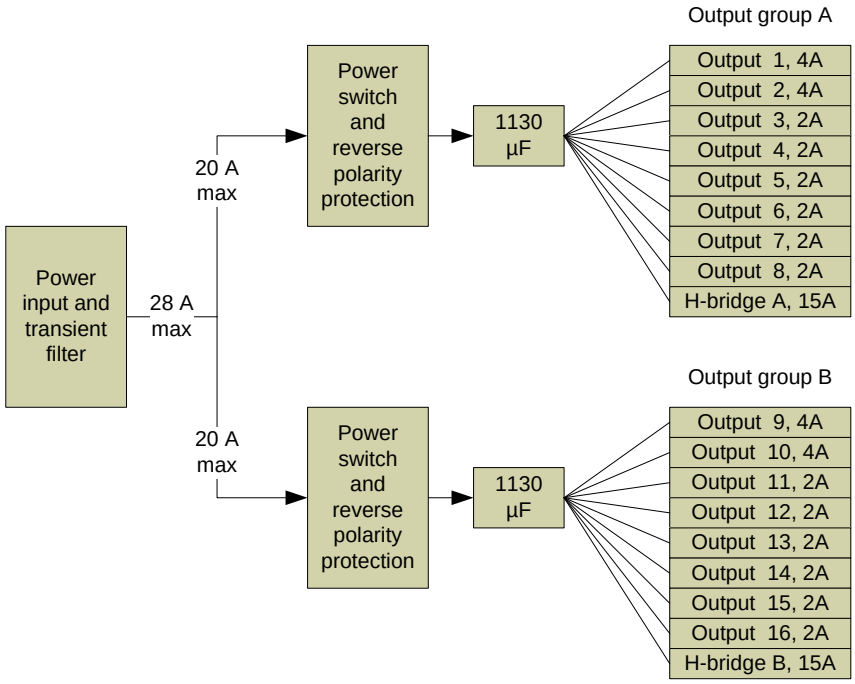
Two frequency inputs can be paired to an encoder input. The frequency input pairing is fixed; input 1 can be paired with input 2, input 3 can be paired with input 4 and so on up to input 15 which can be paired with input 16.

7.4. Outputs 1-16

The 16 outputs (4 x type A + 12 x type B) are individually and independently configurable through software.

7.4.1. Output groups

The 16 outputs and the two H-bridges are equally distributed on two output groups, see below.



For safety applications the power switch provides an additional means to shut down an output in case of malfunction. By partitioning the outputs in two groups one group can remain functional in case of malfunction of an output in the first group.

The voltage on each output group can be read via software.

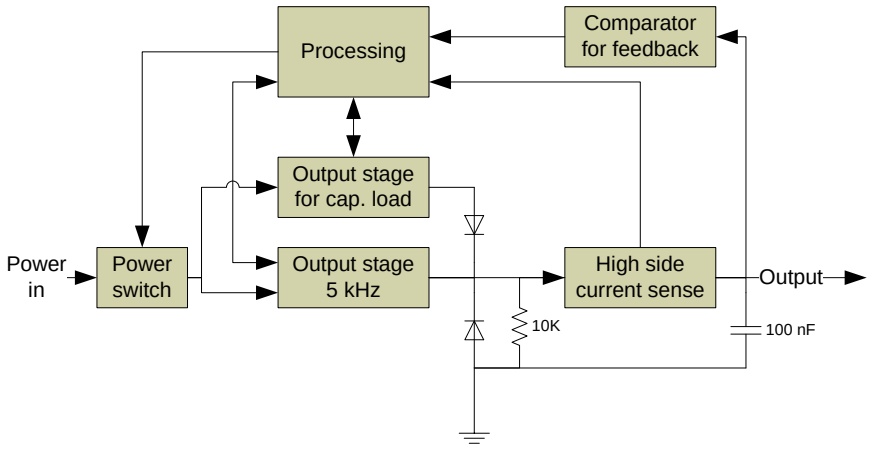
As shown in the block diagram above the total power for all active outputs in a single group are specified for a maximum of 20 A, but the total power for all active outputs together is limited to 28 A.

The output groups have individual power shut down. (Additional soft shutdown may be implemented in the application layer as described in the programmer's guide.) This function adds a third level of power control, beside shutting down the individual outputs and shutting down the complete unit.

7.4.2. Output type A (4 A)

The block diagram for outputs type A which is rated for 4 A is shown below. There are two different output stages in parallel. The first output stage is capable of fast switching for inductive and resistive loads. The second output stage has current limitation (peak approximately 30 A at 27V, higher peak current at 12V) and is used for starting-up capacitive loads such as LED lamps.

In the case of capacitive loads such as LED lamps the output stage for capacitive loads is used to start the output for up to 6 ms and then the 5 kHz output stage is turned on and finally the output stage for capacitive loads is turned off.



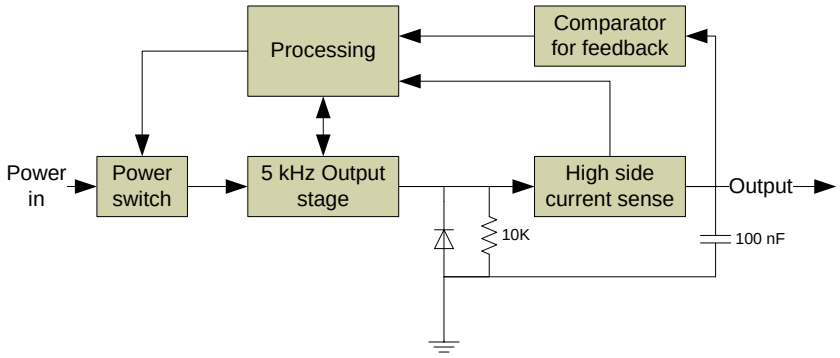
Common features	Operating voltage range	8 VDC to 32 VDC
	Rated current per output	4 A
	Current sense range	0 to 4800 mA (min)
	Current over load limit	4800 mA (min) 5200 mA (max)

PWM output	Frequency	50…400 Hz
	Duty cycle	0…100 %, resolution 0.1 %
On/off output		
Current controlled output (PWMi)	Output frequency	Fixed high frequency
	Dither frequency range	25…400 Hz, adjustable in fixed steps
	Dither current	Adjustable up to 400 mA
	Output resolution	1,2 mA
	Accuracy (design target)	± (ca 2 % + 25 mA)

7.4.3. Output type B (2 A)

The block diagram for outputs type B which is rated for 2 A is shown below.

For outputs type B there is only one output stage capable of fast switching for inductive and resistive loads. There is a soft-start mode with 40 kHz switching that can be used to start smaller capacitive loads, but that must be evaluated from case to case as the fast switching might affect other outputs with capacitive load.



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)

PWM output	Frequency	50…400 Hz
	Duty cycle	0…100%, resolution 0.1 %
On/off output		
Current controlled output (PWMi)	Output frequency	Fixed high frequency
	Dither frequency range	25…400 Hz, adjustable in fixed steps
	Dither current	Adjustable up to 400 mA
	Output resolution	0,6 mA
	Accuracy (design target)	± (ca 2 % + 10 mA)

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

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

7.4.4. PWM output

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

7.4.5. Digital output

Outputs in digital mode normally use the same output driver as outputs in PWM and PWMi mode. This driver is capable of driving inductive and resistive load.

In digital out mode a soft-start functionality can be activated to be able to drive capacitive load such as LED lamps. For outputs 1,2,8,9 (the 4A outputs), an additional driver can be activated when the output is turned on to handle the high inrush current of capacitive load. For the other outputs, a soft start in software can be performed. This soft-start mode uses a high frequency PWM (40 kHz) and ramps up the current to keep the current down.

To adjust the behavior for driving capacitive load two parameters, A and B are used. For the 4A outputs the A parameter adjusts the number of start attempts that will be made. Parameter B decides the current threshold level used to detect if a new start is needed or not. Maximum number of start attempts is 3. Recommended threshold level is 5. If A and B=0, the normal high-side switch designed for inductive and resistive load will be used. For the 4A outputs, it is not possible to toggle a digital out faster than 200ms when configured to drive capacitive load.

For the 2A outputs, the current is set according to the formula: $y = \frac{A}{1024} \cdot e^{\frac{B}{255}x}$. Recommended settings to drive capacitive load is A=5, B=5. If A=0, B=0, no soft start is performed.

If using the high frequency PWM (40 kHz) soft start mode, make sure that the high frequency PWM does not disturb anything else connected to the CrossFire SX.

7.4.6. Current controlled output (PWMi)

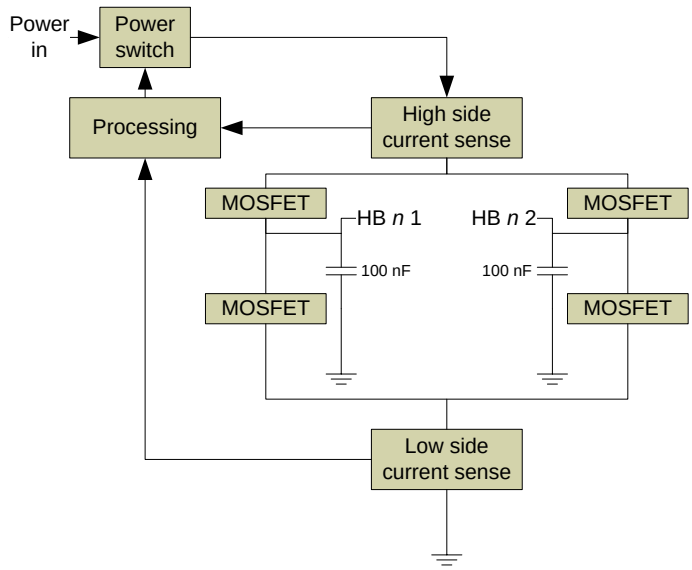
PWMi mode is used to get a constant current through a solenoid. Because the resistance of the solenoid is affected by the temperature, the actual current is measured and the PWM duty cycle is automatically adjusted to get the desired current. In PWMi mode the desired current in mA is given directly as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

Current control is performed in separate slave processor to not burden the main processor.

7.5. H-Bridge

The unit has two dedicated full H-bridges for electrical motor control. Targeted to 12-24 V bidirectional brushed DC motors and linear actuators, but can also be used to drive inductive load. The block diagram below shows the output stage, current sensing and 100 nF output filters.



Max load	15A continuous
Current limitation	Adjustable current limitation 0-20A limits output current by using a fixed time-off current chopping scheme
Current over load limit	The overcurrent limit is adjustable between 0-25A. When the current exceeds the set threshold the output is turned off.
Current sense range	0-24A current sense (min)
Control	Forward, Reverse, Brake, Coast
Speed control	0-100% duty cycle 20kHz PWM

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

One H-bridge uses two output pins. The H-bridge is used to control a DC motor in both directions in variable speed using PWM. In forward direction output 1 will be connected to VBAT and output 2 to GND. In backward direction this will be the opposite. There is also a brake command where both outputs will be connected to GND.

The H-bridges contains a configurable low side current limit (with automatic current regulation in hardware), a configurable high side current limit and also current feedback. If the low side current limit is exceeded, current regulation is performed in hardware to reduce the current. This limit is mainly used to reduce inrush current when the motor starts. The H-bridge also contains a high side current limit. If this limit is exceeded, the motor is shut off. This limit is used to protect against short circuit between high side output and ground.

Current feedback from the H-bridge is only accurate at full speed so it is mainly intended to be able to see if the motor is running or not.

7.6. Sensor supply

The unit has a sensor supply output (connector X1.16) which provides a precision 5V output for powering sensors or potentiometers. It's rated for max 300 mA (with read back on voltage) and protection for short circuit and overload (0 V to 32 V).

7.7. Ignition signal

The ignition pin (connector X1:21) 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 15 kΩ pull-down resistor and a 10 nF input capacitor. The threshold level for on/off is typically 2.5 V.

7.8. Firmware update

For normal operation shall the firmware pin (connector X1:22) be inactive i.e. connected to ground.

If the unit software needs to be upgraded (boot, STM32 or CODESYS run time) this pin must be activated i.e. connected to VBAT and the unit needs to be power cycled. At power on the unit will stay in boot mode and be ready to receive a program update. After a successful program update the unit needs to be power off and the pin deactivated.

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

The firmware update pin has a 10 nF input capacitor and pull-down resistor. Minimum input high level 6V. Current input high level is <3mA at 32V.

7.9. ID interface

The table below show the CAN node id is set up by the address pins in connector X2:32-35

CANopen Node ID	A3	A2	A1	A0
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

- State 0 is reached by wiring corresponding ID pin to GND.
- State 1 is reached by leaving corresponding ID pin disconnected.

The ID pins have 100 nF input capacitors and 10 kΩ pull-up resistors to internal 3.3V. For a high level the ID pin should be left open and for a low level the ID pin should be grounded. The ID pins sustain input voltages of -32 V to 32 V, but normal use is to leave open or to ground.

If the ID pins are not used for node ID, they can be used as 4 additional digital in.

7.10. 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.

7.10.1. Start up and normal operation indications

This table presents the status LED indication for the CANopen slave version during operation.

CANopen mode	Blinking Pattern
Operational	On
Pre-Operational	Blinking 2,5 Hz (ON 200ms, OFF 200ms)
Initializing	Blinking 2,5 Hz (ON 200ms, OFF 200ms)
Stopped	Single Flash (ON 200ms, OFF 1000ms)
Power Down	Single Flash (ON 200ms, OFF 1000ms)

7.10.2. Boot mode indications

This table presents the status LED indication if boot mode is activated.

LED Color (Amber, Red or Green)	Blinking Pattern	Description
Green	On	At start-up
Green	Blinking	Firmware upgrade in progress
Red	On	Error during or after firmware upgrade
Green	On	After successful firmware upgrade
Amber	On	Incompatible or no application loaded

7.11. Memory

7.11.1. Flash

The main processor in CrossFire SX holds a flash memory used for storage of firmware and application. The flash size is 3MB with ECC (Error correcting code). Available memory space for customer application is approx. 1,5MB.

7.11.2. RAM

The main processor in CrossFire SX holds a RAM used by firmware and application. RAM size is 256kb with ECC (Error correcting code). There are also options for additional RAM up to 2MB.

7.11.3. EEPROM

Only used internally by the firmware and not accessible for customer application.

7.11.4. FRAM

CrossFire SX has an 8Kb FRAM memory for storage of persistent data. An FRAM memory is faster than an EEPROM and can handle much more write cycles. A double buffering algorithm is used to handle sudden power loss. 640 bytes * 2 of the FRAM is used for retain memory for CODESYS.

7.12. Diagnostics

The CrossFire SX 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.

Voltage supervision

There are nine different supply voltages that are possible to read from software. Three of them are checked at start up (VOLTAGE_UOGA, VOLTAGE_UOGB and VOLTAGE_3V0). If anyone of them are outside the valid range the unit will not start but will show an error code on the LED. Five of the voltages are supervised during normal operation (VOLTAGE_3V0, VOLTAGE_VCOMP, VOLTAGE_2V8, VOLTAGE_5V14 and VOLTAGE_ADC_SENSOR_HIRES). If anyone of them are outside valid range, an error flag is set in the voltages supervision bit-mask.

VOLTAGE_UOGA	The voltage on output group A
VOLTAGE_UOGB	The voltage on output group B
VOLTAGE_VCOMP	The voltage supply for the comparators used by digital inputs.
VOLTAGE_3V0	3.0V reference voltage used for current regulation.
VOLTAGE_2V8	2.8V supply used as digital threshold level
VOLTAGE_6V5	6.5V supply used to power sensor supply voltage tracking regulator.
VOLTAGE_SENSORSUPPLY5V	Sensor supply output voltage 0-42.5V range.
VOLTAGE_5V14	5.14V supply for TMS570 AD-converter analog rail (this is not VREF)
VOLTAGE_ADC_SENSOR_HIRES	Sensor supply output voltage 0-8.33V range.

Temperature supervision

There are four different temperatures that are possible to read from software. If some temperature is outside valid range, outputs will be shut off and over temp flag will be set. It is possible to retry by issuing the restart-command. Over temperature is normally 125 degrees Celsius.

Output feedback

There are a number of different feedback values for the outputs available:

- For digital out there is a digital feedback.
- For PWM it is possible to read frequency and duty cycle.
- For PWMi it is possible to read the actual current.
- Digital feedback can also be used to detect short to battery. If digital feedback is high while output is off, there is probably a short to battery error.
- Current feedback can be compared with the expected current. Especially if current is close to 0 it expecting a higher current, there is probably an open load condition.
- Outputs do also have a status bitmask where short to ground, thermal warning, charge pump under-voltage lockout and over current is indicated.

The H-bridge contains an over current limitation measured on low-side. In case the current exceeds the adjustable over current, current is limited by hardware. This is very useful for reducing the inrush current during start-up of a motor. The H-bridge does also contain an over current detection on high-side. If the current exceeds this limit the H-bridge is shut down. It is recommended to set the over current shut-off level higher than the over current limitation level. By doing like this,

inrush current is limited without triggering the over current shut off. However, if high side is short circuit directly to GND, the h-bridge will be switched off.

Input feedback

The 4-20mA inputs are shut down individually in case current exceeds roughly 25mA. In case this happen, an error flag is set that can be read from software.

Other supervision

A hardware watchdog makes sure the application is running and if not the outputs are shut down.

The main processor is equipped with ECC checking of memories. It is also equipped with lock-step which means that there are actually two cores running in parallel. In case the result of one core differs from the result of the other core, the unit is shut down.

8. Software overview

The *CrossFire SX* contains the following software parts.

Application	Purpose
Boot Loader	Makes it possible to upgrade the software over CAN
CODESYS runtime	Runtime responsible for executing the CODESYS applications.
CODESYS application	The CODESYS application. This application is written by the user for the CODESYS programmable version or by CrossControl for the CANopen slave.
Current Control Software	Responsible for controlling the outputs of the unit including current control for PWMi. This software is running on two separate slave processors responsible for 8 outputs each. If upgrading this software, it is important to upgrade both slave processors.

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 SX – Firmware upgrade instructions.docx.*

For details about programming the CODESYS version, read the CrossFire SX - CODESYS Developers Guide.docx.

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

9. Functional safety

9.1. Certification

The Crossfire SX safety is certified according to the standards below:

Standard	Safety level	Comment
IEC 61508:2010	SIL CL 2	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems
ISO 13849:2008	PL(d)	Safety of machinery -- Safety-related parts of control systems
ISO 25119:2010	AgPL(d)	Tractors and machinery for agriculture and forestry -- Safety-related parts of control systems
ISO 15998:2008		Earth-moving machinery -- Machine-control systems (MCS) using electronic components

This means that the unit is certified, during normal operation, that it will compute the correct output. This holds up to the specified safety level, i.e. including systematic capability (including e.g. safety management, project management, and software development) as well as the target random hardware tolerable hazard rates specified by the standards.

10. Specifications

10.1. Technical data

Temperature specification	
Operating	-40 to +85 °C
Storage	-40 to +85 °C

Kernel	
Processor	32-bit safety CPU, Texas Instruments TMS570 ARM Cortex R4, 180 MHz
Flash memory	3MB
RAM memory	256 kB
Other memory	Internal: 3 MB Flash, 256 kB RAM, 64 kB Emulated EEPROM External: Up to 2 MB (optional), 2 kB FRAM, 64 kb EEPROM

Controller specifics	
Type	IEC 61131-3 soft PLC
Runtime software	CODESYS 3.5.x

CANopen slave specifics	
Type	CANopen slave CiA 401 profile
Node ID	ID keying in 127 positions through SW. Position 1-16 can also be set by 4 pins in the connector.
Node states	Pre-operational, operational and stopped
SDO	All settings configurable by SDO's
PDO	Supports all transmission types, event timer and inhibit time.
NMT	Heartbeat producer and consumer
Node	Node guarding also supported

Power Supply	
Supply Voltage	
Nominal	12 V_{DC} or 24 V_{DC}
Operational	8 V_{DC} to 30 V_{DC}
Over voltage protection	36 V_{DC}
Reverse polarity protection	32 V_{DC}
Load dump protection	+123 V 2 Ω for 24V systems +65 V for 12V systems
Current Consumption 24V (typical)	
Operational (no sensor supply)	0.2 A + external loads
Operational (max sensor supply)	0.4 A + external loads)
Shutdown	0.35 mA
Rated output current	
Max current per group	20 A
Max current unit total	28 A
Inrush current (typical)	
@ 24 V_{DC} input	30 A peak, 200 µs (tested with relay)
@ 12 V_{DC} input	15 A peak, 150 µs (tested with relay)
Input capacitance	64 µF
Power switch turn-on current (typical)	
@ 24 V_{DC} input	13 A for 3 ms
@ 12 V_{DC} input	8 A for 3 ms
External fuse recommendation	
Current rating	Requires external fuse rated for at least 20 A for low current applications and 30 A – 40 A (depending on fuse characteristics) for high current applications
Sensor supply output	
Voltage nominal	5 V
Voltage accuracy (no load)	1 mV typical @25C, 10 mV max
Voltage accuracy (300 mA)	4 mV typical @25C, 15 mV max
Voltage ripple (typical)	4 mVpp
Current capability (min)	300 mA
Current limit (typical)	450 mA
Current limit (max)	520 mA
Short circuit protection	0 V to 32 V
HMI	
Status LED	Freely programmable RG LED

Interfaces	
CAN	
Number of CAN	3
Easy CAN	Built in T-connection for CAN1 to simplify cabling and termination

Protocols	CAN ISO 11898-2, 2.0B, (High Speed CAN)
Type	SAE J1939 and CANopen stack
Driver	NXP TJA1051
Input capacitance	150 pF
Protection	-32 V_{DC} to 32V_{DC}
Baud Rate	Configurable 20 – 250 Kbit/s, optional up to 1 Mbit/s*
	* Internal CAN bus filters have a capacitance of 100pF (type) as stated in the J1939 standard. This puts limitations on the CAN bus topology considering bus length, number of CAN nodes etc., when running at high bit-rates (i.e. above 250kbit/s).
RS-232	
Number of ports	1
Baud Rate	Up to 115,2 kbps
Input capacitance	1 nF
Protection	-32 V_{DC} to 32 V_{DC}
Configurable inputs	
Number of inputs	16
Common features	
Analog resolution	12-bit
Analog bandwidth	>150 Hz 3dB
Protected input range	0-32V
Input capacitance	10 nF
Current input 4-20 mA	
Range	0-25 mA
Accuracy	Typical 0.2 % ± 30 µA,1 % ± 30 µA over temperature
Input impedance	200 Ω
Voltage input 0-5 V	
Range	0-5 V
Accuracy	Typical 0.1 % ± 6 mV, 0,3 % ± 6 mV over temperature
Input impedance	>100 kΩ
Voltage input 0-10 V	
Range	0-10 V
Accuracy	Typical 0.1 % ± 10 mV, 1 % ± 15 mV over temperature
Input impedance	18.7 kΩ
Voltage input 0-32 V	
Range	0-32V
Accuracy	Typical 0.1 % ± 20 mV, 1 % ± 50 mV over temperature
Input impedance	11.7 kΩ
Digital/Frequency input	
Input threshold low	2.33 V (typical)
Input threshold high	2.88 V (typical)
Input hysteresis	0.55 V (typical)
Input bandwidth	20 kHz with push-pull driver
Selectable pull-up	4.7 kΩ
Selectable pull-down	4.7 kΩ
Digital readings	100 readings per second
Frequency range	0-20 kHz
Encoder input	Available by pairing two frequency inputs.
Selectable pairs	1 and 2, 3 and 4, 5 and 6, 7 and 8, 9 and 10, 11and 12, 13 and14, 15 and16
Configurable outputs	
Voltage on output	0 Vto U_b
Type A (4 A)	
Number of outputs	4
Current rating	4 A
Current meas. range	0 to 4800 mA min, 0 to 5000 mA typical, 0 to 5200 mA max
Current meas. accuracy	1 % + 8 mA max
Current meas. resolution	12-bit
Short circuit limit to GND	5.1 A min, 14 A typical, 26 A max
Current overload limit	4.8 A min, 5 A typical, 5.2 A max.
Type B (2 A)	

Number of outputs	12
Current rating	2 A
Current meas. range	0 to 2180 mA min, 0 to 2270 mA typical, 0 to 2360 mA max
Current meas. accuracy	1 % + 4 mA max
Current meas. resolution	12-bit
Short circuit limit to GND	5.1 A min, 14 A typical, 26 A max
Current overload limit	2.18 A min, 2.27 A typical, 2.36 A max
Modes	PWM, PWMi and digital out.
PWM	
Frequency	50-400 Hz
Duty cycle	0 – 100 %, resolution 0.1 %
PWMi	
Frequency	Fixed high frequency (5.2 kHz)
Resolution (type A)	1,2 mA
Resolution (type B)	0,6 mA
Accuracy (type A)	± (ca 2 % + 25 mA)
Accuracy (type B)	± (ca 2 % + 10 mA)
Dither frequency	25 – 400 Hz, adjustable in fixed steps
Dither current	Adjustable up to 400 mA
H-Bridge	
Voltage on output	0 V to U_b
Number of H-Bridge	2
Max load	15 A continuous
Current limitation	Configurable in the range 0 A to 20 A
Over current protection	Configurable in the range 0 A to 25 A
Control	Forward, reverse, brake, coast.

10.2. 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
- Cargo, EN 61000-6-2 and EN 61000-6-4
- CISPR 25

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.

10.2.1. Electrical test

Environmental Test	Standard	Notes
EMC Transient	ISO 13766: 2006 ISO 7637-2: 2011	+24V system Pulse1 : -450V C Pulse2a : +37V B Pulse2b : +20V C Pulse3a : -150V A Pulse3b : +150V A Pulse4 : -12V B Pulse5 : +123V, 2Ω C +12V system Test level III Pulse1 : -75V C Pulse2 : +37V B Pulse3a : -112V A Pulse3b : +75V A Pulse4 : -6V B Pulse5 : +65V C
	EN 61000-4-4: 2012	Burst, ±2kV DC, ±1kV signal, no burst on RS232
	EN 61000-4-5: 2014	Surge, ±500V2Ω DC L-L, ±500V 12Ω DC L-E ±1kV signal Cable length limited to 30 m No surge on I/O and RS232
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
	EN 61000-4-3: 2006	80M-1GHz 10V/m 1,4G-2GHz 3V/m 2,0G-2,7GHz 1V/m
EMC RF Immunity, Induced [1]	ISO 11452-4: 2011	BCI 20-200MHz, 100mA
	EN 61000-6-4: 2014	Induced RF, 0.15-80MHz 10V
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
	EN 61000-6-4:2007	10 meter q-p MHz dBµV/m 30-230 40 230-1000 47 3 meter peak avg. GHz dBµV/m dBµV/m 1-2 76 56
	CISPR 25	150k-300kHz 41 dBµV/m 530k-2 MHz 35 dBµV/m 5.9-6.2 MHz 35 dBµV/m 30-54 MHz 35 dBµV/m

10.2.2. 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.

10.2.3. Mechanical test

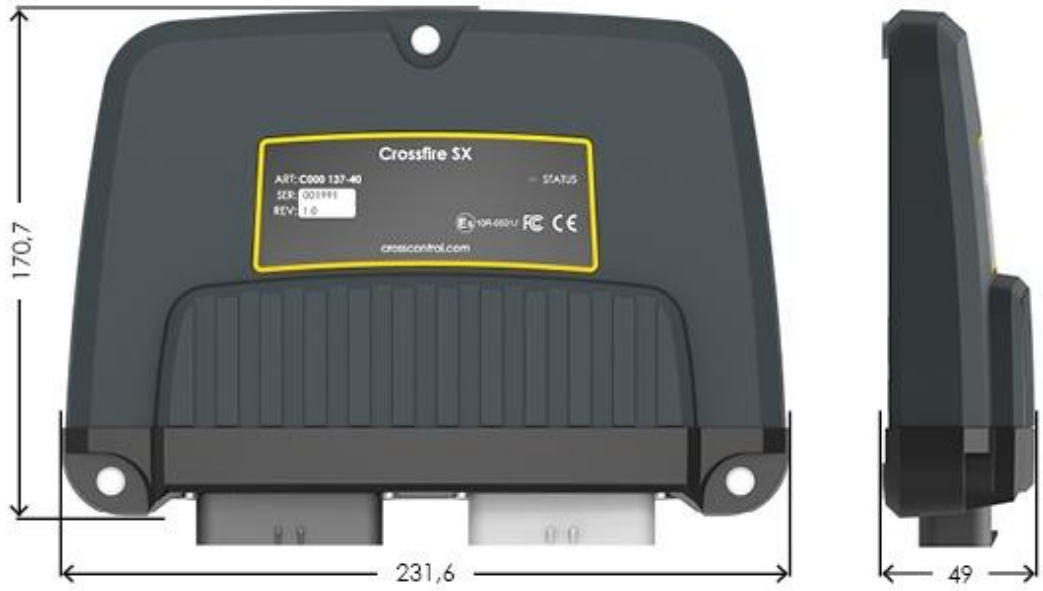
Environmental Test	Standard	Notes
Vibration	IEC 60068-2-64:2008 IEC 60068-2-6: 2007	0,03 g2/Hz 5-200Hz, 0,01 g2/Hz 200-1000Hz, 3x3h 5g, 5-2000Hz, 1 octave/min, 20 cycles
Shock	IEC 60068-2-27:2009	30 g / 11ms 3x ±1000 bumps
Enclosure Ingress Protection	IEC 60529:2014	IP66, IP66 and IP67
Chemical compatible	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

10.3. Certifications

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

10.4. Weight and dimensions

	Description	Comments
Dimensions	231,6 x 170,7 x 49 mm	(W x H x D)
Weight	0,45 Kg	




26,6
Crossfire SX
ART: C000 137-40
STATUS
140
200
23

11. 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™ SX
- Additional sources of information are available on the CrossControl support site http://support.crosscontrol.com

12. Trademark, etc.

All trademarks sighted in this document are the property of their respective owners.

CrossFire is a trademark which is the property of CrossControl AB.

Freescale is a registered trademark of Freescale Semiconductor Inc. ARM is a registered trademark of ARM Limited. Linux is a registered trademark of Linus Torvalds. Bluetooth is a trademark of Bluetooth SIG. CANopen is a registered trademark of CAN in Automation (CiA).

CrossControl is not responsible for editing errors, technical errors or for material which has been omitted in this document. CrossControl is not responsible for unintentional damage or for damage which occurs as a result of supplying, handling or using of this material including the devices and software referred to herein. The information in this handbook is supplied without any guarantees and can change without prior notification.

For CrossControl licensed software, CrossControl grants you a license, to under CrossControl intellectual property rights, to use, reproduce, distribute, market and sell the software, only as a part of or integrated within, the devices for which this documentation concerns. Any other usage, such as, but not limited to, reproduction, distribution, marketing, sales and reverse engineer of this documentation, licensed software source code or any other affiliated material may not be performed without written consent of CrossControl.

CrossControl respects the intellectual property of others, and we ask our users to do the same. Where software based on CrossControl software or products is distributed, the software may only be distributed in accordance with the terms and conditions provided by the reproduced licensors.

For end-user license agreements (EULAs), copyright notices, conditions, and disclaimers, regarding certain third-party components used in the device, refer to the copyright notices documentation.