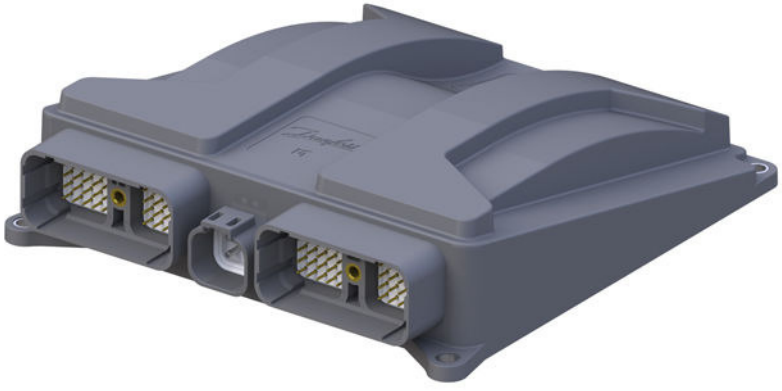
ENGINEERING
TOMORROW

Technical Information

PLUS+1® Controller
XL104-xxxx



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Revision history

Table of revisions

Date	Changed	Rev
August 2020	First edition	0101

Contents

XL 104-xxxx Controller Family literature references

Literature title	Document type	Literature ID
PLUS+1® XL104-XXXX Controller Family Technical Information	Technical Information	**BC320261740866**
PLUS+1® XL104-XXXX Data Sheet	Data Sheet	**AI318200103711**
PLUS+1® Controller *XL104-XXXX Functional Safety Implementation*	Safety Manual	**BH346381901208**
PLUS+1® GUIDE Software User Manual	Operation Guide	**AQ152886483724**

Technical Information (TI)

A TI references comprehensive information for engineering and service personnel.

Module product Data Sheet (DS)

A module product DS contains summarized information and parameters that are unique to an individual PLUS+1® module, including:

- Numbers and types of inputs and outputs
- Module connector pin assignments
- Module maximum current capacity
- Module sensor power supply (if present) current capacity
- Module installation drawing
- Module weights
- Product ordering information

API specifications (API)

Module API specifications contain detailed information about the module BIOS. PLUS+1® BIOS functionality is pin dependent. Pins are defined in module data sheets as C (connector number) p (pin number).

API specifications include:

- Variable name
- Variable data type
- Variable direction (read/write)
- Variable function and scaling

Module API specifications are the definitive source of information regarding PLUS+1® module pin characteristics.

PLUS+1 GUIDE User Manual

The Operation Manual (OM) details information regarding the PLUS+1® GUIDE tool used in building PLUS +1® applications. This OM covers the following broad topics:

- How to use the PLUS+1® GUIDE graphical application development tool to create machine applications
- How to configure module input and output parameters
- How to download PLUS+1® GUIDE applications to target PLUS+1® hardwaremodules
- How to upload and download tuning parameters
- How to use the PLUS+1® ServiceTool

User liability safety statements

OEM responsibility

The OEM of a machine or vehicle in which Danfoss products are installed has the full responsibility for all consequences that might occur. Danfoss has no responsibility for any consequences, direct or indirect, caused by failures or malfunctions.

- Danfoss has no responsibility for any accidents caused by incorrectly mounted or maintained equipment.
- Danfoss does not assume any responsibility for Danfoss products being incorrectly applied or the system being programmed in a manner that jeopardizes safety.
- All safety critical systems shall include an emergency stop to switch off the main supply voltage for the outputs of the electronic control system. All safety critical components shall be installed in such a way that the main supply voltage can be switched off at any time. The emergency stop must be easily accessible to the operator.

Overview

XL104-xxxx Controllers family

PLUS+1® Mobile Machine Modules are designed to provide flexible, expandable, powerful and cost effective total machine management systems for a wide variety of vehicle applications.

These modules communicate with one another and other intelligent systems over a machine Controller Area Network (CAN) data bus.

PLUS+1® controller products utilize modular designs wherever possible. This modularity extends to product housings, connectors and control circuitry.

PLUS+1® hardware products are designed to be equally effective in a distributed CAN system, with intelligence in every node, or as stand-alone control for smaller machine systems.

While targeted to single-machine controller applications unlike the PLUS+1® MC/SC controllers with an expanded moduce architecture, the PLUS+1® Compliant systems are incrementally expandable; Additional modules can be easily added to the machine CAN bus to increase system capabilities or computational power.

The XL104-xxxx comes in a standard 104 pin housing but is available in various depopulated variants.

Inputs/outputs types and specificatons

PLUS+1® modules have input or output pins that support multiple functions. Pins that support multiple input or output types are user-configurable using PLUS+1® GUIDE software. Refer to product data sheets for the input/output (I/O) content of individual modules.

Input types

- Digital (DIN)
- Digital or Analog (DIN/AIN)
- Multifunction: Digital or Analog or Frequency (DIN/AIN/FreqIN)
- Multifunction: Digital or Analog or Frequency or Resistance or 4-20 mA Current (DIN/AIN/FreqIN/ ResIN/CrntIN)
- Digital or Analog or CAN shield (DIN/AIN/CAN Shield)

Each PLUS+1® module input pin supports one of the above functional types. For pins with multiple functions, input configurations are user programmable using PLUS+1® GUIDE templates.

Each input type has been designed for different Functional Safety performance level. Refer to the PLUS +1® XL104-XXXX Safety Manual for more information.

General response time to input time

Description	Comment
Response to input below minimum voltage	Non-damaging, non-latching; reading saturates to the low limit.
Response to input above maximum voltage	Non-damaging, non-latching; reading saturates to the high limit.
Response to input open	Pin configuration dependent: No pull up/ no pull down = floating Pull up to 5 Vdc = 5 Vdc Pull down = 0 Vdc Pull up / pull down = 2.5 Vdc
Voltage working ranges	DIN: 0V to 5V DIN/AIN: Programmable (see specific data sheets for ranges). DIN/AIN/FreqIN: Programmable DIN/AIN/FreqIN/ResIN/CrntIN: Programmable

A/D refresh rate

Analog to digital (A/D) refresh rates for PLUS+1® family

PLUS+1®module	A/D refresh rate
XL104-XXXX	All: 1.00 ms

Digital Inputs (DIN)

Digital inputs (DIN) connected to PLUS+1® dedicated digital input pins are debounced in software. Digital input debounce is defined as an input being in a given state for three samples before a state change is reported. The sample time is a function of application loop time.

DIN inputs can be pulled to +5Vdc, pulled to ground or operated with no pull up/pull down.

Digital (DIN) Specifications

Description	Units	Minimum	Typical	Maximum	Comment
Input voltage range	V	0	—	36	
Rising threshold voltage	V	—	—	4.12	Guaranteed high voltage.
Falling threshold voltage	V	0.85	—	—	Guaranteed low voltage.

Inputs/outputs types and specificatons

Digital (DIN) Specifications (continued)

Description	Units	Minimum	Typical	Maximum	Comment
Input impedance	kΩ	230	233	236	No pull up or pull down with 0V to 5.7V input voltage.
Input impedance (5 V/GND)	kΩ	13.9	14.1	14.3	Pull up to +5 V or pull down to ground with 0V to 5.7V input voltage.

Digital/Analog Inputs (DIN/AIN)

Digital/Analog mode (DIN/AIN) general information

Multifunction pins that are configured to be Digital input (DIN) are subject to the same update rates as the Analog input (AIN) function for that pin. Debounce is not used, as hysteresis is built into the function. The time to recognize a transition is dependent on the timing of the switch activation and the sample rate.

These inputs can be pulled to +5Vdc, pulled to ground, pulled to +2.5Vdc, or operated with no pull up/ pull down.

Description	Comment
Response to input below minimum voltage	Non-damaging, non-latching; reading saturates to the low limit.
Response to input above maximum voltage	Non-damaging, non-latching; reading saturatesto the high limit.
Pull up/pull down configuration	No pull up / pull down is standard with pull up or pull down programmable; failure modes are detectable.

Digital/Analog mode (DIN/AIN) specifications

Description	Units	Minimum	Typical	Maximum	Comment
Allowed voltage at pin	V	0	–	36	
DIN mode					
Rising threshold voltage	V	–	–	Programmable	Guaranteed high voltage may be varied with the selected Analog range
Falling threshold voltage	V	Programmable	–	–	Guaranteed low voltage may be varied with the selected Analog range
AIN mode Low range (DAF and DAFRC only)					
Minimum discernible voltage	mV	–	–	13.1	
Maximum discernible voltage	V	5.14	–	5.37	
Precision	mV	–	1.3	–	
Worst case error	mV	–	–	120	Over the full temp range
Input imdedance	kΩ	230	233	236	No pull up or pull down
Input impedance (5 V/ GND)	kΩ	13.9	14.1	14.3	Pull up to +5 V or pull down to ground
Input impedance (2.5 V)	kΩ	7.1	7.3	7.4	Pull to +2.5 V

Inputs/outputs types and specificatons

Digital/Analog mode (DIN/AIN) specifications (continued)

Description	Units	Minimum	Typical	Maximum	Comment
AIN mode High range					
Minimum discernible voltage	mV	0	–	150	
Maximum discernible voltage	V	34.1	35.3	36.4	
Precision	mV	–	9	–	
Worst case error	V	–	–	1.1	Over the full temp range
Input impedance	kΩ	108	109	111	No pull up or pull down
Input impedance (5 V/ GND)	kΩ	13.0	13.2	13.4	Pull up to +5 V or pull down to ground
Input impedance (2.5 V)	kΩ	6.9	7.0	7.1	Pull to +2.5 V

Digital/Analog/Frequency (DIN/AIN/FreqIN)

Frequency mode (FreqIN) general information

Description	Comment
Expected measurement	Frequency (Hz)
	Period (0.1 µsec
	Channel to channel phase shift (paired inputs)(0.1 ms)
	PWM duty cycle (0.01%) – Duty cycle measurement only valid up to 5kHz
	Edge count
	Quadrature count (paired inputs driven from a quadrature encoder)

If the frequency goes to zero, the data will not decay over time. The data will be updated once a new pulse is seen or the measurement times out. It is possible to monitor the count of pulses to know when the frequency reading is updated.

Frequency mode (FreqIN) specifications

Description	Units	Minimum	Typical	Maximum	Comment
Frequency range	Hz	0	–	10,000	In steps of 1 Hz, max 0.1% error
Frequency range when input is used as a quadrature count or phase shift	Hz	0	–	5000	In steps of 1 Hz, max 0.1% error
PWM duty cycle	Hz	0	–	5000	Max 0.01% error
Low range					
Rising voltage threshold	V	0.11	–	0.30	Voltage required for frequency input to read high
Falling voltage threshold (low range)	V	0.04	–	0.22	Voltage required for frequency input to read low
Middle range					
Rising voltage threshold	V	1.78	–	3.92	Voltage required for frequency input to read high
Falling voltage threshold	V	0.84	–	2.79	Voltage required for frequency input to read low

Inputs/outputs types and specificatons

Frequency mode (FreqIN) specifications (continued)

Description	Units	Minimum	Typical	Maximum	Comment
High range					
Rising voltage threshold	V	11.8		–	Voltage required for frequency input to read high
Falling voltage threshold	V	5.6		–	Voltage required for frequency input to read low

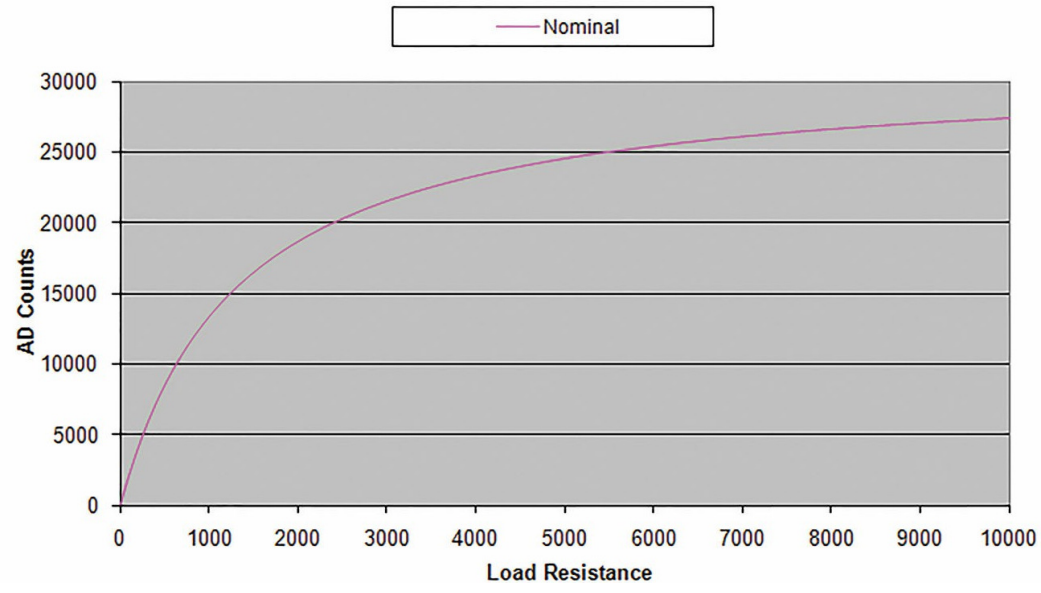
Digital/Analog/Frequency/Resistance/Current (DIN/AIN/FreqIN/ResIN/CrntIN)

Resistance mode (ResIN) general information

When configured as a resistance/rheostat/temp sensor input, the device will provide up to 3.76 mA current to an external load which can then be measured. The equation for calculating AD counts for a given load is: AD counts = (30996 x RL / (RL + 1322)). The following chart shows the relationship between AD counts and load.

High range mode, Low range mode and the pull up / pull down features are not available when the input is configured in Resistance mode.

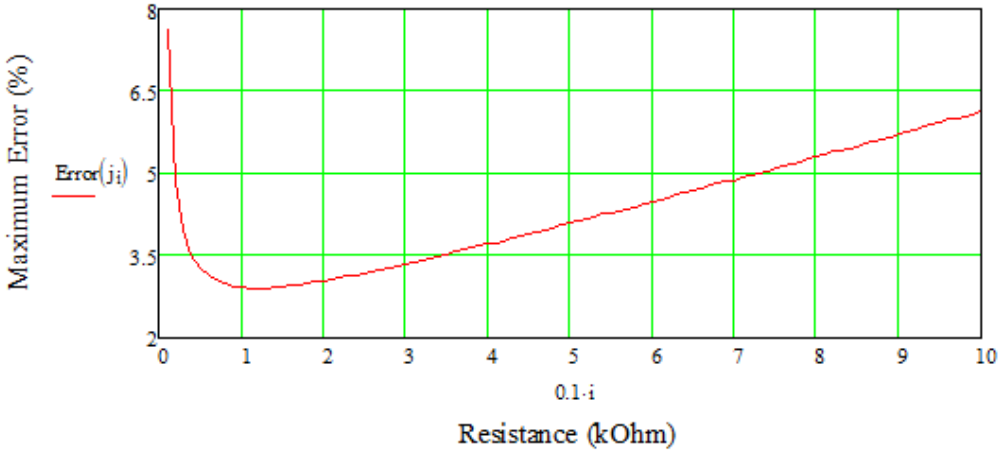
Load resistance versus ADC counts



The following chart shows the relationship between load resistance versus worst case error over the full operating temperature -40°C to 85°C (-40°F to 158°F).

Inputs/outputs types and specificatons

Load resistance vs worst case error



Resistance mode (ResIN) specifications

Description	Units	Minimum	Typical	Maximum	Comment
Allowed voltage at pin	V	0	—	36	
Measured resistance	Ω	0	–	10,000	

Current mode (CrntIN) general information

High range mode, Low range mode and the pull up / pull down features are not available when the input in configured in Current mode.

Current mode (CrntIN) specifications)

Description	Units	Minimum	Typical	Maximum	Comment
Allowed voltage at pin	V	–	5.0	7.0	
Minimum discernable current	mA	0	–	0.1	
Maximum discernible current	mA	25.3	–	27	
Precision	µA		–	6	
Worst case error	µA	–	–	868	Over the full temperature range -40°C to 85°C (-40°F to 185°F)
Input impedance	Ω	198.6	200	202.6	

Output types

- Digital (DOUT)
- Pulse width modulated (PWM/DOUT/PVGOUT)

Warning

Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. The module will be powered up if battery voltage is applied to the module's output pin. To protect against unintended movement, secure the machine.

Inputs/outputs types and specificatons

Caution

Warranty voids if module is damaged.

Caution

Avoid significant current driven back through an output pin.

DOUT

Digital (DOUT)

Digital outputs can source up to 3 or 4 A

- XL104-0000: C1p36, C1p46, C2p35, C2p36, C2p45 and C2p46 can source up to 4 A @module temperature up to 70˚ C [158˚ F]
- The XL104 controller is capable of sourcing a total of 40 A, and sinking a total of 20A, in ambient temperatures of -40 to +70°C, with no external cooling measures. At ambient temperatures from +70 to 85°C, the XL controller is capable of 20 A sourcing and 12 A sinking.

Caution

Driving an inductance with higher turn off energy than is safe may cause damage to the device. For safe levels, please see *Single pulse maximum demagnetization energy at 150° C* on page 13. Damage can be avoided by adding an external recirculation diode or driving with a PWM output.

General

Description	Comment
Configuration	Sourcing only.
Type	Linear switching.
Short circuit to ground protection	Non-damage, current/thermal limit with status indication; automatic latch off /resume.
Open circuit detection	Fault indication provided. The GUIDE Pin Status requires a load of 500 mA to be connected or an open fault will be declared.
Parallel operation	Digital outputs from the same module are capable of being connected together such that the net current rating is the sum of the individual ratings; timing is resolved by the operating system; diagnostic capability is maintained.
Shut off	Processor control Additional Safe Bank Shutoff on 4A outputs. Safe Banks are two outputs per bank. C1p36+C1p46, C2p35+C2p45, C2p36+C2p46
Overcurrent Protection	All DOUT include Thermal shutdown. 4A DOUT have Processor controlled Overcurrent limit of 6 A nominal (5.0A to 6.7A).

Description	Units	Minimum	Maximum	Comment
Allowed voltage at pin	V	0	36	See Caution statement below
Output voltage, energized state	V	Vbatt-1.0	Vbatt	Overall load conditions.
Output voltage, off state	V	0	0.1	At Rload=200 Ω
Output current range for a status bit to read OK	A	0.5	3	

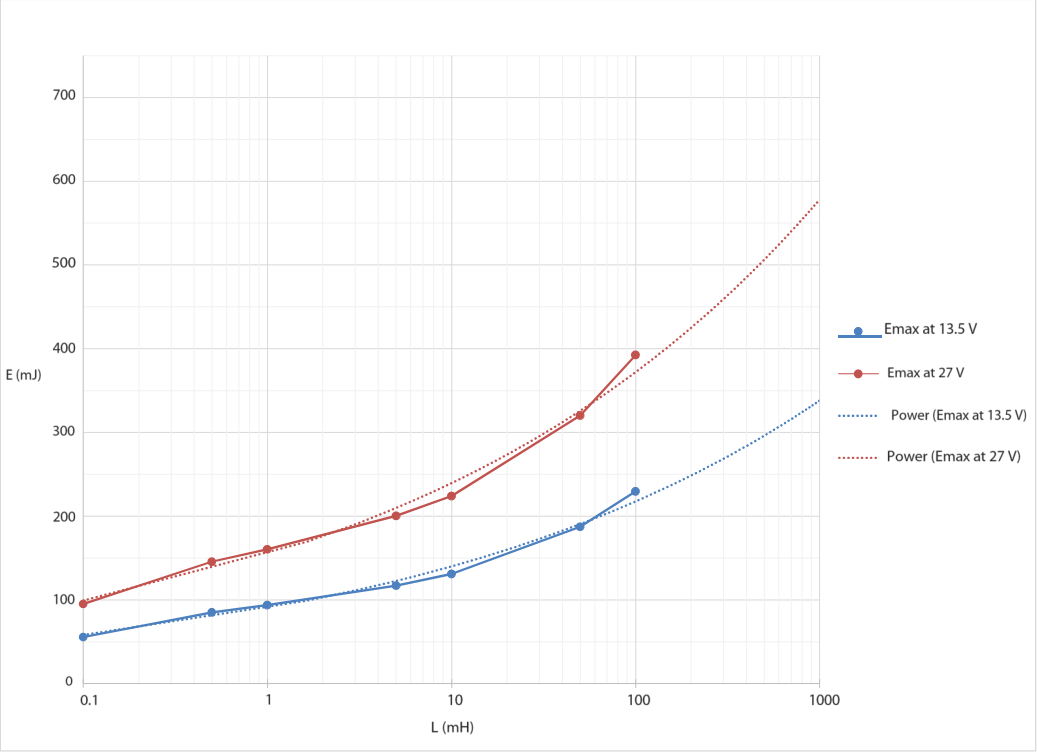
Caution

Do not connect a digital output to battery+ (back drive) without a series diode.

Inputs/outputs types and specificatons

Single pulse maximum demagnetization energy at 150° C

1. The high side driver (HSD) has a built in voltage clamp for fast demagnetization of inductive loads.
2. The turn off energy is absorbed by the HSD.
3. If the turn off energy is above the HSD maximums shown in following graph, there will be two options:
   - Use external clamping or a recirculating diode.
   - Use a PWM output that has built in recirculation/clamping.
4. Power trend lines were added to extend the graphs for inductances over 100 mH.



PWMOUT/DOUT/PVGOUT

All PLUS+1® module proportional outputs are Pulse Width Modulated (PWM). PWM frequency is software adjustable using PLUS+1® GUIDE. There are two modes of PWM operation: open loop and closed loop (current control).

In open loop mode, current can be sourced or sunk, but the output is a PWM duty cycle. Current feedback may be monitored in open loop mode, but the output is a constant voltage, not a constant current. The signal line of PVG valves can be driven with an open loop PWM. The PWM driving the control signal must be set to 0 at the same time as the digital output driving the PVE power pin is set to 0.

In closed loop mode, current is sourced and a constant current is maintained by the module's operating system using internal current feedback. Load impedance must not exceed 65 ohms.

In closed loop mode, the maximum current is limited by measuring the feedback current. There is no thermal protection. If the maximum current is exceeded, the controller kernel will shut down the output and latch it. The kernel also limits how quickly the output can be repowered (250 ms). The output cannot be reset until the command goes to 0 or False (if configured as a digital output).

Proportional outputs that are used as a digital sinking output have a potential for a leakage current of up to 5 mA when off.

PWM outputs are phase shifted to reduce input current ripple.

Inputs/outputs types and specificatons

Refer to individual module data sheets for the maximum allowable output current for each PLUS+1® module.

Description	Comment
Configuration	Sourcing or sinking
Type (Linear vs. PWM)	PWM
Operating modes	Programmable: closed loop current or open loop voltage (duty cycle)
Dual coil PCPs	Compensated for induced currents in a non-driven coil (closed loop mode)
Short circuit to ground	Output fully protected against damage and fault detected
Mode selection (current or voltage) and full scale current ranges	Programmable

Do not connect a digital output to battery+ (back drive) without a series diode.

PLUS+1® PWM output circuits are not designed to be used as inputs. Output current feedback readings should be used for fault checking only.

Warning

Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. The module will be powered up if battery voltage is applied to the module's output pin. To protect against unintended movement, secure the machine.

Caution

Warranty voids if module is damaged. Avoid significant current driven back through an output pin.

Description	Units	Minimum	Maximum	Comment
Full scale proportional current output	mA	10	3,000	The current may accidentally be exceeded in open loop mode. If the current exceeds the trip point, the output will be latched off.
Output voltage, 100% duty cycle	V	0	Vbatt	
Output resolution of 3 A	mA		0.25	
Repeatability of full range	% of full scale		0.5	
Absolute accuracy of full range	% of full scale		3	1% typical. Offsets removed when command is Ø.
Output settling time	ms		100	Depends on load characteristics.
PWM frequency	Hz	33	4,000/20,000	
Over-current trip point	A	7.3		There is over-current protection built into each output driver. If the instantaneous current exceeds the trip point, the driver is latched off. GUIDE application software can reset the latch and attempt to drive current again. A typical overcurrent protection will retry for 40 ms to allow higher outrush currents on capacitive loads

Controller Area Network (CAN)

CAN system design

All PLUS+1® modules have CAN ports that conform to CAN 2.0B specifications, including CAN shield.

All CAN ports on XL104-xxx controllers can be used to download PLUS+1® GUIDE application programs.

Specifications for terminating resistor

Each end of the main backbone of the CAN bus must be terminated with an appropriate resistance to provide correct termination of the CAN_H and CAN_L conductors. This termination resistance should be connected between the CAN_H and CAN_L conductors.

Description	Units	Minimum	Maximum	Nominal	Comment
Resistance	Ω	110	130	120	Minimum power dissipation 400 mW (assumes a short of 16 Vdc to CAN_H).
Inductance	µH		1		

Notes on CAN Bus installation

Total bus impedance should be 60 Ω.

The CAN transceiver will be damaged by any voltage outside of allowable range, (-27 to +36 Vdc), even with a very short pulse.

If using shielded cable, the shield must be grounded to the machine ground at one point only; preferably at the mid-point of the CAN bus. Each PLUS+1® module CAN shield pin must be connected to the cable shield.

Expansion module CAN Bus loading

System designers incorporating PLUS+1® expansion modules in their applications should be aware of PLUS+1® CAN bus loading and controller memory usage during system design. Each expansion module is associated with a PLUS+1® controller and uses part of the controller's memory resources for inter-module communications. The following table can be used to estimate system CAN bus loading and the memory impact of I/O modules on their associated controller.

Estimated usage of memory and communication resources

Description	IX012-010	IX024-010	OX012-010	OX024-010	IOX012-010	IOX024-20
Estimated module bus load (using default update and 250K bus speed)	4%	10%	11%	27%	11%	27%
Estimated module bus load (using 70 ms updates and 250K bus speed)	2%	5%	3%	8%	4%	8%
RAM usage on XL104-xxxx	TBD	TBD	TBD	TBD	TBD	TBD
ROM usage on XL104-xxxx	TBD	TBD	TBD	TBD	TBD	TBD

Product ratings

Power

Module supply voltage/maximum current ratings

PLUS+1® XL modules are designed to operate with a nominal 7 to 36 V dc power supply.

The modules will survive with full functionality if the supply voltage remains below 36 Vdc.

Specifications

Description	Units	Minimum	Maximum	Comment
Allowed voltage at pin	V	0	36	
Fuse rating	A	0	50	

Caution

PCB damage may occur. To prevent damage to the module all module power supply + pins must be connected to the vehicle power supply to support advertised module maximum output current capacity. DO NOT use module power supply + pins to supply power to other modules on a machine.

Sensor power supply ratings

PLUS+1® XL modules that support sensor inputs are provided with dedicated, software adjustable, regulated sensor power supply and ground pins. XL104-xxxx supports two external sensor power supplies, one fixed 5V supply and one variable supply 3 to 12V. Both are rated for 500mA at 5V.

General

Description	Comment
Short circuit to ground	Output is not damaged and fault is detected.
Short circuit to battery +	Output is not damaged and fault is detected.

Fixed 5V Sensor Supply

Description	Units	Minimum	Nominal	Maximum	Comment
Output voltage (actual)	V	4.90	5	5.1	Fixed 5V output
Output voltage (internally measured)	V	4.85	5	5.15	+/- 1% from actual
Output current	mA	-	-	500	
Output Load Capacitance	µF		-	10	

Variable sensor supply

Description	Units	Minimum	Nominal	Maximum	Comment
Output voltage (actual)	V	3	-	12	The voltage level is software adjustable
Output voltage (internally measured)	V	2.90	-	12.10	+/- 1% from actual
3V setting voltage	V	2.90	3.02	3.12	
5V setting voltage	V	4.89	4.99	5.10	
12V setting voltage	V	11.94	12.0	12.06	

Product ratings

Variable sensor supply (continued)

Description	Units	Minimum	Nominal	Maximum	Comment
Output current	mA	-	-	500	@5V, Limit to 2.5 watts for Vout greater than 5V
Output load capacitance	µF			10	

PVG valve power supply ratings

DOUT pins can provide the battery supply voltage required by Danfoss PVG valve electronics for those control strategies requiring application software control of the valve power source.

When enabled, the DOUT pin passes battery (reference) voltage to the PVG valve electronics. One DOUT pin can power up to 3 PVG valves.

Non-volatile memory read/write ratings

EEPROM write/erase ratings

To prevent unexpected memory writes, care must be taken to ensure memory with a high number of read/write cycles is either U32 or S32 data types.

Write/erase cycles

Description	Minimum	Maximum	Comment
EEPROM write/erase cycles	1 million		Minimum valid over entire operating temperature range.

EEPROM used in XL104-xxxx controllers is rated for 1 million read/write cycles per sector. Sector size is 32 bits. When a value is written to EEPROM, all 32 bits in a particular sector are always written, regardless of the size of the size of the saved value. If the value being saved in a sector is less than 32 bits (such as U8, S16, BOOL) adjacent bits in the same EEPROM sector are rewritten with their previous value.

The implication of this memory property is that if two values are being written to the same memory sector, the useful life of the sector is determined by the value being written most frequently. If that value exceeds 1 million read/write cycles, all values in the sector may be compromised if the useful life is exceeded.

Vault memory

Some XL104-xxxx variants have 64 Mbyte of serial flash vault memory (also referred to as *application logging memory*).

Application developers can use this memory to log machine event data and use the PLUS+1® Service Tool to extract the logged data. As there is no real time clock on PLUS+1® modules, vault memory is not time stamped.

Accessing non-volatile or application log memory can delay the service tool scan.

General ratings

XL controllers general ratings

Description	Units	Minimum	Maximum	Comment
Operating temperature	°C [°F]	-40 [-40]	70 [158]	@ 40 Amps sourcing
Operating temperature	°C [°F]	-40 [-40]	85 (185)	@ 20 Amps or less sourcing

Product ratings

XL controllers general ratings (continued)

Description	Units	Minimum	Maximum	Comment
Storage temperature	˚C [˚F]	-40 [-40]	85 [185]	
Allowable supply voltage	Vdc	7	36	
Sensor supply voltage	Vdc	4.9	5.1	Sensor voltage drops below the minimum value if module supply voltage < 7 Vdc. see *Sensor power supply ratings* on page 16.
Analog input voltage levels	Vdc		36	
Maximum allowable total sourcing output current	A		40/20	70/85°C [158/185°F]
Maximum allowable total sinking output current	A		20/12	70/85°C [158/185°F]
Ingress Protection (IP) rating*				IP 67
CE rating				CE compliant.

* The PLUS+1® modules IP67 rating is only valid when the module mating connector is in place and unused connector pin positions have sealing plugs installed.

Wake-up functions

Conditions to wake up XL104-xxxx

Either of two conditions will wake up the controller:

- The power supplies can be re-energized by cycling battery power.
- Generating a positive/rising edge on one of several inputs:

Eight of the DIN pins have K15 key switch wake capability. These are C2p11, C2p14, C2p15 and C2p20-p25. K15 key switch wake capability will enable the XL104's internal power supplies when a rising edge is detected on one of these inputs. This assumes that power on C1p02 and ground on C1p01 are continuously connected.

Environmental testing criteria

Climate environment

Description	Applicable standard	Comment
Storage temperature	IEC 60068-2-1, test Ab, IEC 60068-2-2 test Bb	
Operating temperature	IEC 60068-2-1, test Ab, IEC 60068-2-2 test Bd	
Thermal cycle	IEC 60068-2-2, test Na, IEC 60068-2-38 (partial)	
Humidity	IEC 60068-2-78, IEC 60068-2-30 test Db	Damp heat steady state and cyclic.
Degree of protection	IEC 60529	

Chemical environment

Description	Applicable standard	Comment
Salt mist	IEC 60068-2-58 test Kb	
Chemical resistance	ISO 16750-5	

Product ratings

Mechanical environment

Description	Applicable standard	Comment
Vibration	IEC 60068-2-6 test Fc, IEC 6008-2-64 test Fh	
Bump	IEC 60068-2-29 test Eb	
Shock	IEC 60068-2-27 test Ea	
Free fall	IEC 60068-2-32 test Ed	

Electrical/electromagnetic

Description	Applicable standard	Comment
EMC emission	ISO 13766, SAE J1113-13	Electromagnetic compatibility for earth moving machinery.
EMC immunity	ISO 13766	Electromagnetic compatibility for earth moving machinery.
Electrostatic discharge	EN 60-1 000-4-2	
Auto electrical transients	ISO 7637-2, ISO 7637-3	
Short circuit protection	Danfoss test	Inputs and outputs survive continuous short circuit. Normal function resumes when short is removed.
Reversed polarity protection	Danfoss test	Survives reverse polarity at supply voltage for at least five minutes.

Modules housing

PLUS+1® modules housing features a assembly that is tamper-proof. Once assembled at the factory, the housing cannot be opened for service.

Caution

Opening the device voids the warranty. Device is not field serviceable. Do not open the device.

Product installation and start-up

Connectors

PLUS+1® modules use DEUTSCH connectors. Danfoss assembles mating connector kits, referred to as 50p C1 and 50p C2 kits, and 4p Cp kit.

Mating connector bag assembly ordering information is found in module product data sheets.

DEUTSCH mating connector part information

Description	4 pin Connector CP	50 pin connector C1	50 pin connector C2
Crimp tool	HDT48-00 (solid contacts) (20 to 24 AWG)	HDT48-00 (solid contacts) (20 to 24 AWG)	HDT48-00(solid contacts) (20 to 24 AWG)
	DTT20-00 (stamped contacts) (16 to 20 AWG)	DTT20-00 (stamped contacts) (16 to 20 AWG)	DTT20-00 (stamped contacts) (16 to 20 AWG)
Contacts	Solid: 0462-203-12141 10, 12, 14 AWG	Solid: 0462-201-2031 (20 to 24 AWG)	Solid: 0462-201-2031 (20 to 24 AWG)
	Stamped: 1062-12-0166 10, 12, 14 AWG	Stamped: 1062-20-0144 (16 to 20 AWG)	Stamped: 1062-20-0144 (16 to 20 AWG)
Connector plug	Grey No-Key DTP06-4S	DRC26-50S01	DRC26-50S02
Wedge	WP-4S	Not required	Not required
Strip length	3.96 to 5.54 mm [0.156 to 0.218 in]	3.96 to 5.54 mm [0.156 to 0.218 in]	3.96 to 5.54 mm [0.156 to 0.218 in]
Real seal maximum insulation OD	3.4 mm to 4.95 mm [0.134 to 0.195 in]	2.41 mm [0.095 in]	2.41 mm [0.095 in]
Sealing plugs	114017	0413-204-2005	0413-204-2005
Mating connector bag assembly	11188220 (10 to 14 AWG)	10100946 (20 to 24 AWG)	
Mating connector bag assembly		10102024 (16 to 20 AWG)	11249153 (16 to 20 AWG)

Danfoss crimp extraction tool part information

Description	Part number
Crimp tool for 20 to 24 AWG	10100745
Crimp tool for 16 to 20 AWG	10102028
Extraction tool DEUTSCH 114010; 12 AWG	11068808
Extraction tool DEUTSCH 0411-240-2005; 16 to 20, 20 to 24 AWG	10100744

Mounting

Take care to position the module connector so that moisture drains away from the unit.

If the module is side mounted, provide a drip loop in the harness. If the module is mounted vertically, the connector should be on the bottom of the module.

Provide strain relief for mating connector wires.

Caution

Module damage may occur. Use caution when installing modules. Due to the size of the mating connector wire bundle, it is possible to damage the module if excessive pressure is applied during the installation of harness strain relief.

Product installation and start-up

Fasteners

Recommended outer diameter (OD)	Recommended torque
6.0 mm (0.25 in)	2.26 N•m (20 in•lbs)

Mating connectors

Recommended torque
2.26 N•m (20 in•lbs)

Machine diagnostic connector

It is recommended that a diagnostic connector be installed on machines that are controlled by PLUS+1® modules. The connector should be located in the operator's cabin or in the area where machine operations are controlled and should be easily accessible.

Communication (software uploads and downloads and service and diagnostic tool interaction) between PLUS+1® modules and personal computers is accomplished over the vehicle CAN network. The diagnostic connector should tee into the vehicle CAN bus and have the following elements:

- CAN +
- CAN -
- CAN shield

Grounding

Proper operation of any electronic control system requires that all control modules including displays, microcontrollers and expansion modules be connected to a common ground. A dedicated ground wire of appropriate size connected to the machine battery is recommended.

Hot plugging

Machine power should be off when connecting PLUS+1® modules to mating connectors.

Machine wiring guidelines

Warning

Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. Improperly protected power input lines against over current conditions may cause damage to the hardware. Properly protect all power input lines against over-current conditions. To protect against unintended movement, secure the machine.

Caution

Unused pins on mating connectors may cause intermittent product performance or premature failure. Plug all pins on mating connectors.

The following is recommended when wiring on a machine:

- Protect wires from mechanical abuse, run wires in flexible metal or plastic conduits.
- Use 85° C (185° F) wire with abrasion resistant insulation and 105° C (221° F) wire should be considered near hot surfaces.
- Use a wire size that is appropriate for the module connector.
- Separate high current wires such as solenoids, lights, alternators or fuel pumps from sensor and other noise-sensitive input wires.

Product installation and start-up

- Run wires along the inside of, or close to, metal machine surfaces where possible, this simulates a shield which will minimize the effects of EMI/RFI radiation.
- Do not run wires near sharp metal corners, consider running wires through a grommet when rounding a corner.
- Do not run wires near hot machine members.
- Provide strain relief for all wires.
- Avoid running wires near moving or vibrating components.
- Avoid long, unsupported wire spans.
- Ground electronic modules to a dedicated conductor of sufficient size that is connected to the battery (-).
- Power the sensors and valve drive circuits by their dedicated wired power sources and ground returns.
- Twist sensor lines about one turn every 10 cm (4 in).
- Use wire harness anchors that will allow wires to float with respect to the machine rather than rigid anchors.

Machine welding guidelines

Warning

High voltage from power and signal cables may cause fire or electrical shock, and cause an explosion if flammable gasses or chemicals are present. Disconnect all power and signal cables connected to the electronic component before performing any electrical welding on a machine.

The following is recommended when welding on a machine equipped with electronic components:

- Turn the engine off.
- Remove electronic components from the machine before any arc welding.
- Disconnect the negative battery cable from the battery.
- Do not use electrical components to ground the welder.
- Clamp the ground cable for the welder to the component that will be welded as close as possible to the weld.

PLUS+1® USB/CAN Gateway

Communication (software uploads and downloads and service and diagnostic tool interaction) between PLUS+1® modules and a personal computer (PC) is accomplished using the vehicle's PLUS+1® CAN network.

The PLUS+1® CG150-2 USB/CAN gateway provides the communication interface between a PC USB port and the vehicle CAN bus. When connected to a PC, the gateway acts as a USB slave. In this configuration, all required electrical power is supplied by the upstream PC host. No other power source is required.

Refer to the PLUS+1® *GUIDE Software User Manual*, **AQ152886483724**, for gateway set-up information. Refer to the *CG150-2 USB/CAN Gateway Data Sheet*, **AI00000190**, for electrical specifications and connector pin details.

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