ENGINEERING
TOMORROW

Technical Information

PLUS+1
High Current Controller Family



www.danfoss.com

Revision history

Table of revisions

Date	Changed	Rev
June 2019	Added new column for IXO018-130 in table Estimated usage of memory and communication resources under topic Expansion module CAN Bus loading	0201
June 2017	First edition	0101

Contents

High Current Controller Family literature references
Technical Information (TI) ... 4
Module product Data Sheet (DS) ... 4
API specifications (API) ... 4
PLUS+1® GUIDE User Manual ... 4

User liability and safety statements
OEM responsibility ... 5

Overview
High Current Controller Family ... 6

Inputs/outputs types and specifications
Input types ... 7
DIN/AIN, A/D Refresh Rates ... 7
DIN/AIN/FreqIN/Rheo ... 9
RheoIN ... 11
Output types ... 13
PWMOUT/DOUT ... 13
LEDs ... 14

Controller Area Network (CAN)
CAN system design ... 15
Specifications for terminating resistor ... 15
Notes on CAN Bus installation ... 15
Expansion module CAN Bus loading ... 16

Product ratings
Power ... 17
Module supply voltage/maximum current ratings ... 17
EEPROM write/erase ratings (High Current Controller) ... 17
High Current Controller general ratings ... 17
Environmental testing criteria ... 18
Modules housing ... 19

Product installation and start-up
Connectors ... 20
Mounting ... 20
Machine diagnostic connector ... 21
Grounding ... 21
Hot plugging ... 21
Machine wiring guidelines ... 21
Machine welding guidelines ... 22
PLUS+1® USB/CAN Gateway ... 22

High Current Controller Family literature references

Literature title	Document type	Literature ID
PLUS+1® High Current Controller Family Technical Information	User Guide	**BC00000381**
PLUS+1® MC018-130 Data Sheet	Data Sheet	**AI00000320**
PLUS+1® GUIDE Software User Manual	Operation Guide	**10100824**

Comprehensive technical literature is online at *www.danfoss.com*

Technical Information (TI)

A TI is comprehensive information for engineering and service personnel to reference.

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® hardware modules
- How to upload and download tuning parameters
- How to use the PLUS+1® Service Tool

User liability and 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

High Current Controller Family

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

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.

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.

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 PLUS+1® High Current controller employs a 32 bit Cortex-M3 Processor, providing the controller with extremely fast single cycle processing speed and 512K internal flash. It features high current capabilities for your machine control.

Inputs/outputs types and specifications

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 or Analog (DIN/AIN)
- Multifunctional Digital/Analog/Frequency/Rheostat (DIN/AIN/FreqIN/Rheo)

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.

DIN/AIN, A/D Refresh Rates

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.

General response 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 Pull up to 5 Vdc = 5 Vdc Pull down = 0 Vdc Pull up/ pull down = 2.5 Vdc
Voltage working ranges	Programmable (see specific data sheets for ranges).

DIN/AIN characteristics

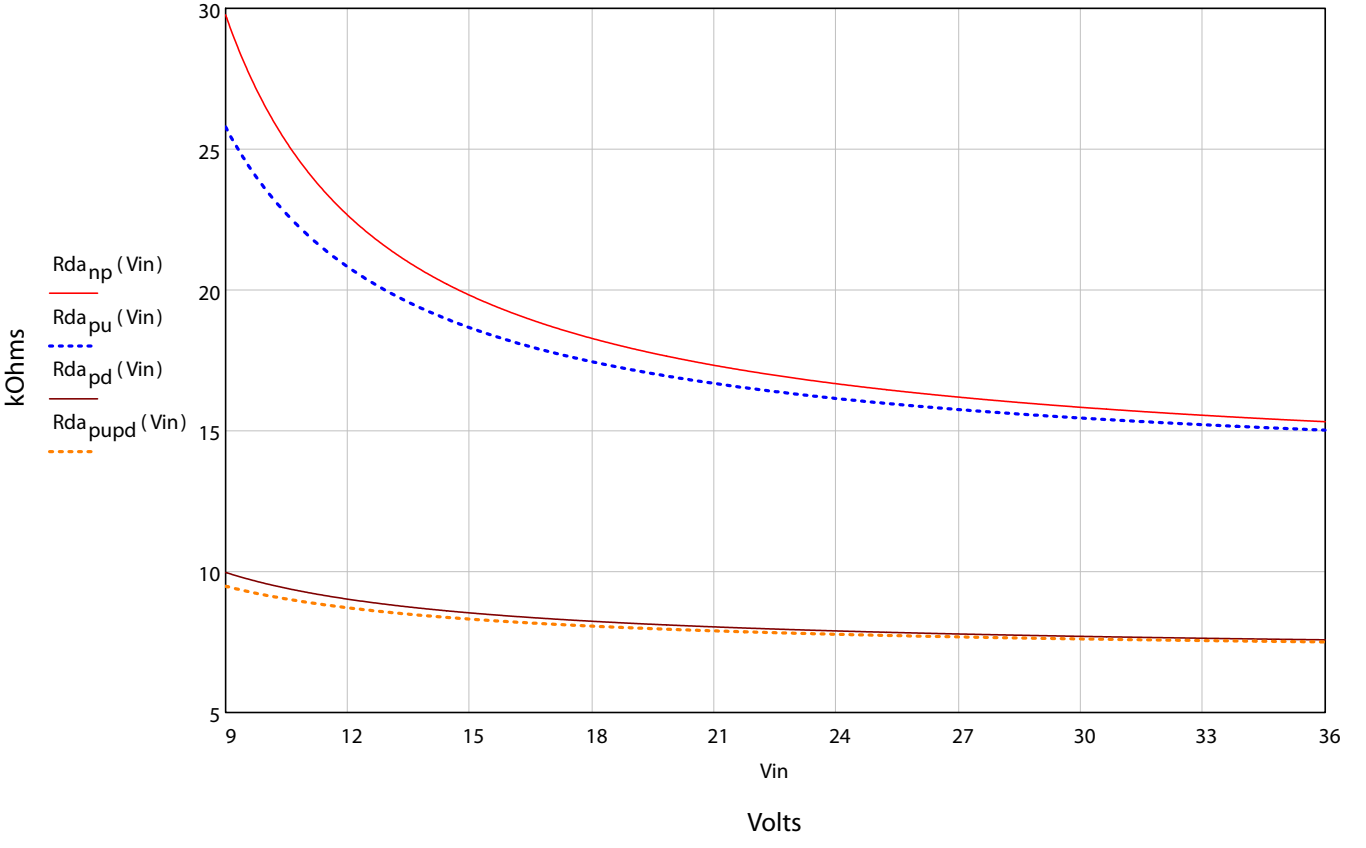
Description	Values			Unit	Comment
	Min.	Typ.	Max.		
General					
Input voltage range	0		36	V	Maximum Voltage at pin.
Low level digital input				V	Level adjustable in software.
High level digital input				V	Level adjustable in software Voltage >= Vin_{high}, Digital Input = True
Time to change state in response to step input		---		ms	Depends on application (OS.ExecTime)
Middle range					
Minimum discernible voltage			0.02	V	
Maximum discernible voltage	5.14	5.26	5.37	V	
Resolution		1.3		mV	
Worst case offset and gain error			±0.12	V	At $V_{Measure}$ = 5.26V
Non-linearity			± 3.8	mV	
Input impedance	230	233	236	kΩ	
Input impedance (5V/GND)	13.9	14.1	14.3	kΩ	Pull up or pull down (Vin < 5.7V)
Input impedance (2.5V)	7.1	7.3	7.4	kΩ	Pull up and pull down (Vin < 5.7V)
High range					
Minimum discernible voltage			0.13	V	

Inputs/outputs types and specifications

DIN/AIN characteristics (continued)

Description	Values			Unit	Comment
	Min.	Typ.	Max.		
Maximum discernible voltage	34.1	35.3	36.4	V	
Resolution		9		mV	
Worst case offset and gain error			1.1	V	At $V_{measure}$ = 35.3V
Non-linearity			±26	mV	
Input impedance	108.2	109.3	110.4	kΩ	No pull up or pull down (Vin < 5.7V)
Input impedance (5V/GND)	13.0	13.2	13.4	kΩ	Pull up or pull down (Vin < 5.7V)
Input impedance (2.5V)	6.9	7.0	7.1	kΩ	Pull up and pull down (Vin < 5.7V)
Input impedance (Vin > 5.75V)					See the following *High range input impedance for DA inputs* chart.

High range input impedance for DA inputs



In high range the input impedance decreases as the input voltage increases.

Inputs/outputs types and specifications

DIN/AIN/FreqIN/Rheo

The characteristics of Digital/Analog/Frequency/Rheostat (DIN/AIN/FreqIN/Rheo) pins are PLUS+1® GUIDE software controlled. The input can be digital, analog, frequency, or rheostat.

Inputs can be pulled to 5 Vdc, pulled to ground, pulled to 2.5 Vdc, or no pull-up/pull-down.

General response 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.
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 5 kHz (FreqIN).
	Edge count.
	Quadrature count (paired inputs driven from a quadrature encoder).
Pull up/pull down configuration	No pull down/ pull up is standard with pull up or pull down programmable; failure modes are detectable.
Maximum frequency	The controller may re-boot under some high frequency load conditions above 10 kHz.

DIN/AIN/FreqIN/Rheo characteristics

Description	Values			Unit	Comment
	Min.	Typ.	Max.		
Input voltage range	0		36	V	Maximum voltage at pin
Frequency range	0		10,000	Hz	
Quad count or Phase shift	0		5,000	Hz	
Low level digital input				V	Level adjustable in software
High level digital input				V	Level adjustable in software Voltage >= Vin_{high}, Digital Input = True
Time to change state in response to step input		---		ms	Depends on application (OS.ExecTime)
Low range					
Minimum discernible voltage			12.8	mV	
Maximum discernible voltage	344	368	391	mV	
Resolution		0.09		mV	
Worst case offset and gain error			±24	mV	At $V_{measure}$ = 368mV
Non-linearity			±0 .3	mV	
Rising Voltage Threshold			0.29	V	Voltage required for frequency input
Falling Voltage Threshold	0.04			V	Voltage required for frequency input
Input Impedance	232	233	234	kΩ	No pull up or pull down

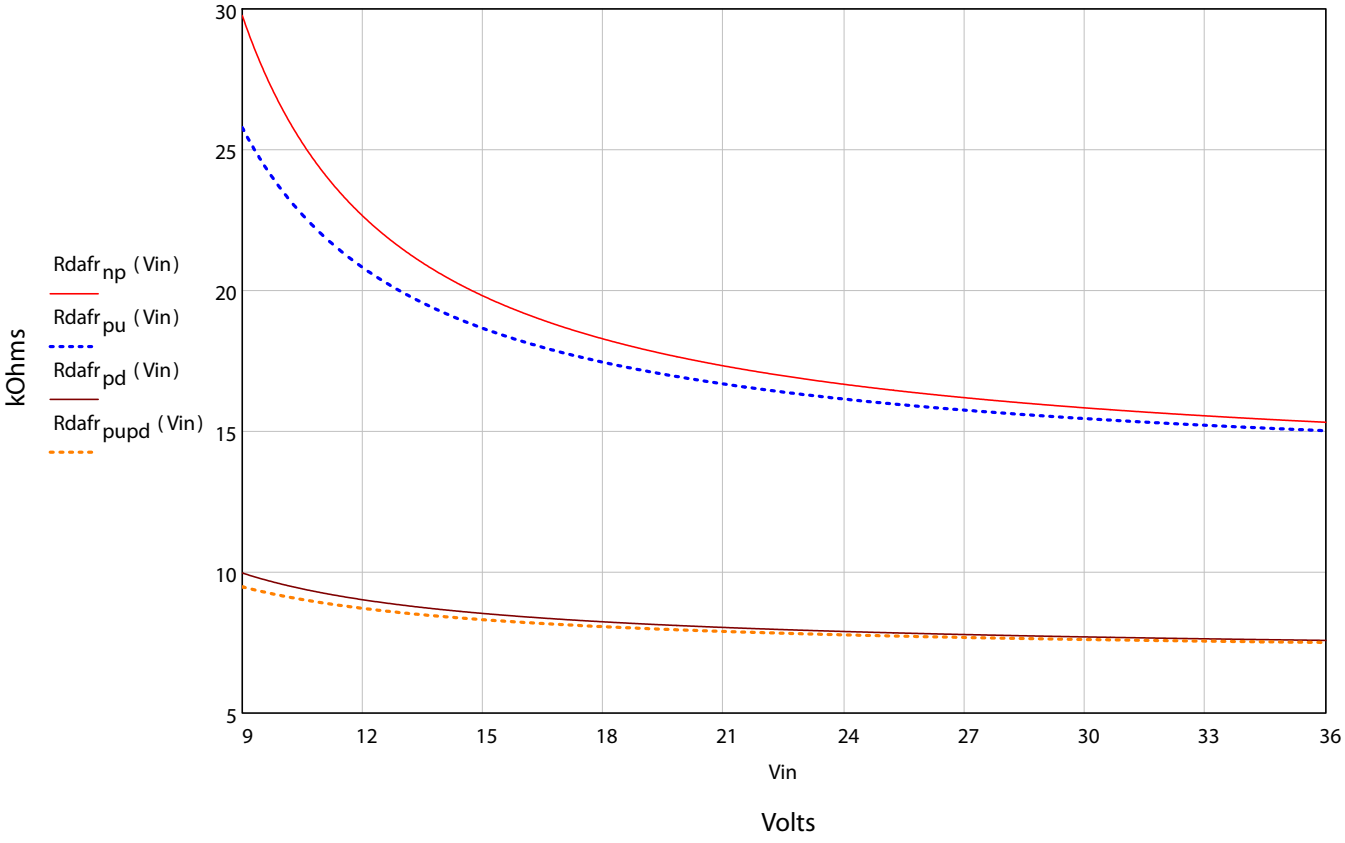
Inputs/outputs types and specifications

DIN/AIN/FreqIN/Rheo characteristics (continued)

Description	Values			Unit	Comment
	Min.	Typ.	Max.		
Input Impedance (5V/ GND)	13.9	14.1	14.3	kΩ	Pull up or pull down
Input Impedance (2.5V)	7.1	7.3	7.4	kΩ	Pull up and pull down
Middle range					
Minimum discernible voltage			0.02	V	
Maximum discernible voltage	5.18	5.26	5.33	V	
Resolution		1.3		mV	
Worst case offset and gain error			±0.07	V	At $V_{measure}$ = 5.26V
Non-linearity			± 3.8	mV	
Rising Voltage Threshold			3.89	V	Voltage required for frequency input
Falling Voltage Threshold	0.85			V	Voltage required for frequency input
Input Impedance	232	233	234	kΩ	No pull up or pull down
Input Impedance (5V/ GND)	13.9	14.1	14.3	kΩ	Pull up or pull down
Input Impedance (2.5V)	7.1	7.3	7.4	kΩ	Pull up and pull down
High range					
Minimum discernible voltage			0.13	V	
Maximum discernible voltage	34.4	35.3	36.1	V	
Resolution		9		mV	
Worst case offset and gain error			±0.78	V	At $V_{measure}$ = 35.3V
Non-linearity			±26	mV	
Rising Voltage Threshold			26.3	V	Voltage required for frequency input
Falling Voltage Threshold	5.6			V	Voltage required for frequency input
Input Impedance	109.1	109.3	119.5	kΩ	No pull up or pull down (Vin < 5.7V)
Input Impedance (5V/ GND)	13.0	13.2	13.4	kΩ	Pull up or pull down (Vin < 5.7V)
Input Impedance (2.5V)	6.9	7.0	7.1	kΩ	Pull up and pull down (Vin < 5.7V)
Input Impedance (Vin > 5.7V)					See chart below

Inputs/outputs types and specifications

High range input impedance for DAFR inputs



In high range the input impedance decreases as the input voltage increases.

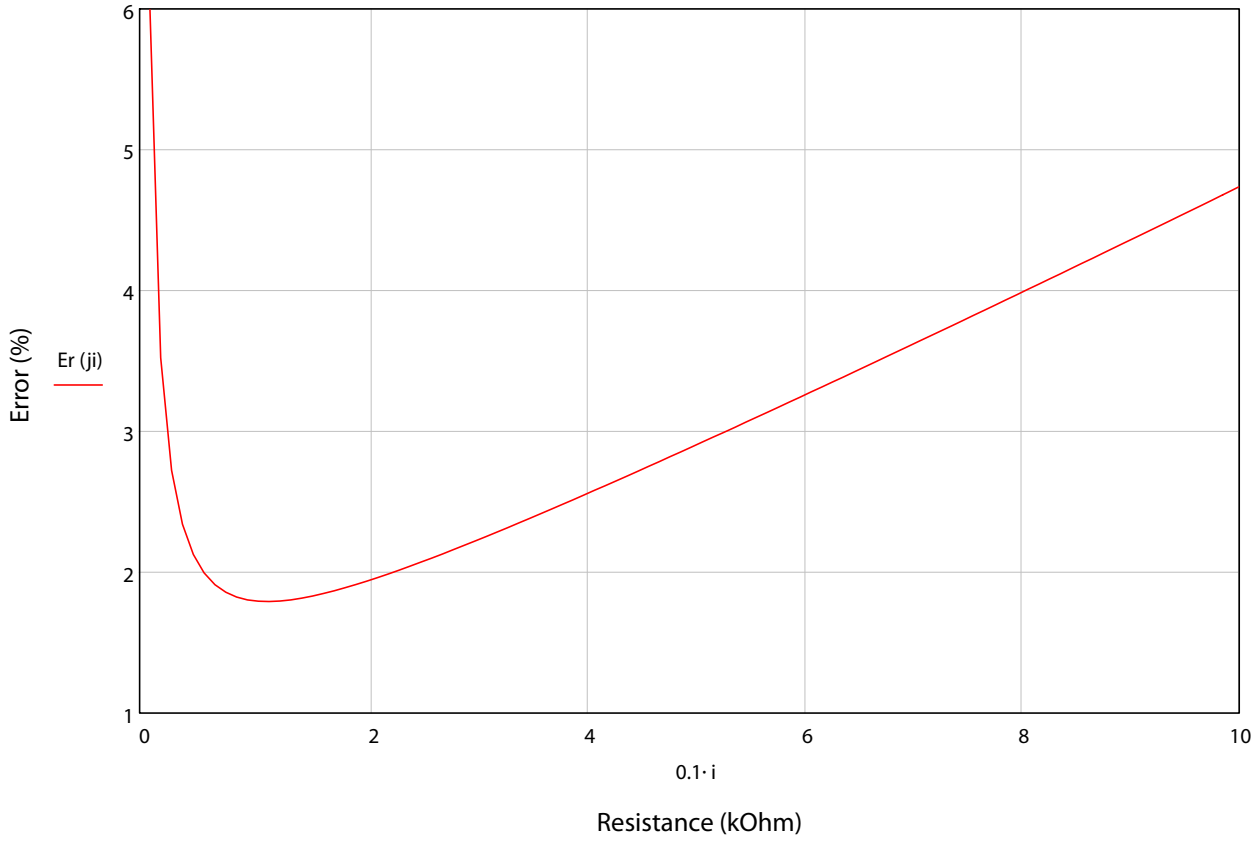
RheoIN

Rheostat Input (RheoIN) characteristics

Description	Values			Unit	Comment
	Min.	Typ.	Max.		
Input impedance	1.32	1.32	1.33	kΩ	
Minimum discernible resistance			6	Ω	
Maximum discernible resistance			10,000	Ω	
Measurement error			6	%	100Ω
Measurement error			1.8	%	1kΩ
Measurement error			4.7	%	10kΩ

Inputs/outputs types and specifications

Resistance versus maximum measurement error



Inputs/outputs types and specifications

Output types

- 15A Pulse Width Modulated (PWM/DOUT)
- 25A Pulse Width Modulated (PWM/DOUT)

PWMOUT/DOUT

All PLUS+1® module proportional outputs are Pulse Width Modulated (PWM). PWM frequency is software adjustable using PLUS+1® GUIDE. A low frequency dither may also be added with software to some outputs (see individual module API specifications for PWM outputs that support dither). 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.

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). There is built in thermal protection that will reduce the maximum current (closed loop) or the maximum duty cycle (open loop) if the internal temperature becomes too high.

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

General

Description	Comment
Configuration	Sourcing or sinking
Type (Linear vs. PWM)	PWM
Operating modes	Programmable: closed loop current or open loop voltage (duty cycle)
Short circuit to ground and battery	Output fully protected against damage and fault detected
Mode selection (current or voltage) and full scale current ranges	Programmable

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

Caution

Warranty will be voided if module is damaged.
Avoid significant current driven back through an output pin.

15A PWM

Description	Values			Unit	Comment
	Min.	Typ.	Max.		
Output	Vbattery - 0.3			V	Iout = 15A
Output current/ Duty cycle			15 100	A %	Internal temperature < 85°C (185°F)
			0 0	A %	Internal temperature > 105°C (221°F)
Measurable current range		33.3		A	
Resolution		2.1		mA	

Inputs/outputs types and specifications

15A PWM (continued)

Description	Values			Unit	Comment
	Min.	Typ.	Max.		
DC overcurrent trip point		31.7		A	Latching
PWM frequency	33		4000 and 20,000	Hz	Running at higher PWM frequencies increases the internal losses. This may reduce the available output current due to thermal limiting.

25A PWM

Description	Values			Unit	Comment
	Min.	Typ.	Max.		
Output	Vbattery - 0.5			V	Iout = 25A
Output current/ Duty cycle			25 100	A %	Internal temperature < 85°C (185°F)
			0 0	A %	Internal temperature > 105°C (221°F)
Measurable current range		50		A	
Resolution		3.1		mA	
DC overcurrent trip point		47.6		A	Latching
PWM frequency	33		4000 and 20,000	Hz	Running at higher PWM frequencies increases the internal losses. This may reduce the available output current due to thermal limiting.

The PWM output is linearly de-rated between 85° C (185° F) and 105° C (221° F).

Turn the output off for 250 mS to reset.

LEDs

There are two LEDs on every PLUS+1® module, one red and one green. Both are under application software control of the primary processor. Before the primary processor's application software starts running, the green LED will be on and the red LED will be off.

Controller Area Network (CAN)

There is one channel fully dedicated to CAN communications on the 18 pin hardware.

Baud rate	Up to 1 MBps
Termination	No internal termination

CAN system design

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

Warning

Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. Machine performance may be impaired if CAN communications are disrupted by electrical fields. To prevent potential unintended machine movement and to meet EMC requirements, a shielded CAN bus is recommended.

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.

Specifications

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.

Controller Area Network (CAN)

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	OX012-110	OX024-110	IOX012-110	IOX018-130	IOX024-120
Estimated module bus load (using default update and 250K bus speed)	4%	10%	11%	27%	11%	26%	27%
Estimated module bus load (using 70 ms updates and 250K bus speed)	2%	5%	3%	8%	4%	7%	8%
RAM usage on MC018-1XX, SC024-120/122	9%	12%	9%	14%	9%	3%	17%
ROM usage on MC018-1XX, SC024-120/122	8%	11%	12%	18%	10%	7%	20%
ROM usage on SC050-120/122	3%	4%	4%	6%	3%	7%	8%

Product ratings

Power

Battery power must be supplied to designated power-up digital inputs, since the controller's 3 to 12 Vdc regulated power supply is not available when the controller is in lower power mode.

Module supply voltage/maximum current ratings

PLUS+1® modules are designed to operate with a nominal 9 to 36 Vdc 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	
Allowed module current	A	0	120	

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.

EEPROM write/erase ratings (High Current Controller)

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.

FRAM used in the controller, is rated for 100 trillion read/write cycles per sector. Sector size is 32 bits. When a value is written to FRAM, all 32 bits in a particular sector are always written, regardless 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, etc) adjacent bits in the same FRAM 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 100 trillion read/write cycles, all values in the sector may be compromised if the useful life is exceeded.

Pins C3-P1 and C4-P1 were designed to be connected directly to battery power.

High Current Controller general ratings

Description	Values				Unit	Comment
	Min.	Typ.	Max.	Vin		
Average supply current			120		amps	External 125A fuse
Idle supply current (Logic Power = 0V)		0.1		9V	mA	MOV starts to conduct at 33V
		0.2		13.5V		
		0.4		27V		
		2.5		36V		

Product ratings

Description	Values				Unit	Comment
	Min.	Typ.	Max.	Vin		
Processor hold up time (Logic Power Input)		9		9V	mS	
		23		13.5V		
		77		27V		
		130		36V		
Turn-on-time		60	250		mS	Logic Power applied to application start

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
Chemical resistance	ISO 16750-5	

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	EN ISO 14982, ISO 13766	Electromagnetic compatibility for earth moving machinery.
EMC immunity	EN ISO 14982, 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: Reversed polarity logic power. Reversed polarity battery power.	Danfoss test	Logic power input survives reversed polarity at supply voltage for at least five minutes. Battery power input is protected by external fuse.

Product ratings

Modules housing

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

Caution

Warranty will be voided if device is opened.
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 a bag assembly.

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

Connectors and mating connectors

Name	Connector	Mating connector	Rating	Max. wire size
C1	DEUTSCH DT04-12PA	DEUTSCH DT06-12SA	13A at 125C	14 AWG
C2	DEUTSCH DTP04-4P	DEUTSCH DTP06-4S	25A at 125C	10 AWG
C3	6mm Stud with 125A fuse	6mm ring terminal	120A	NA
C4	6mm Stud	6mm ring terminal	120A	NA

DEUTSCH mating connector parts

Description	4 pin	12 pin
Shell	Gray No-Key DTP06-4S	Gray A-key DT06-12SA
Contact size	12	16
Insulation size	3.4 mm to 4.95 mm	2.24 mm to 3.68 mm
Wire size	10, 12, 14 gauge	14, 16, 18, 20 gauge
Wedgelock	WP-4S	W12S
Solid contacts	0462-203-12141	0462-201-1631
Stamped contacts	1062-12-0166	1062-16-0122
Sealing plug	114017	114017
Crimp specs	*https://www.laddinc.com/wp-content/uploads/2014/01/Crimp_Spec_and_Die_Ordering_Guide.pdf*	

Danfoss mating connectors bag assemblies and fuse part numbers

4 pin DEUTSCH mating connector bag assembly (10 to 14 AWG)	11188220
12 pin DEUTSCH mating connector bag assembly (14 to 20 AWG)	11188221
4 and 12 pin DEUTSCH mating connector bag assembly	11188232
125 Amp fuse	11188233

Danfoss module mating connectors may be mated 10 times.

Mounting

PLUS+1® High Current Controller should be mounted to metal heat sink that stays below 70° C for full output capabilities.

Care must be taken to insure that the module connector is positioned so that moisture drains away from the connector.

Provide strain relief for mating connector wires.

Fasteners

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

Product installation and start-up

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.

- 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.
- 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 (-).

Product installation and start-up

- 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

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*, **AQ00000026**, for gateway set-up information. Refer to the *CG150-2 USB/CAN Gateway Data Sheet*, **AI00000190**, for electrical specifications and connector pin details.

ENGINEERING
TOMORROW

Products we offer:

- DCV directional control valves
- Electric converters
- Electric machines
- Electric motors
- Hydrostatic motors
- Hydrostatic pumps
- Orbital motors
- PLUS+1® controllers
- PLUS+1® displays
- PLUS+1® joysticks and pedals
- PLUS+1® operator interfaces
- PLUS+1® sensors
- PLUS+1® software
- PLUS+1® software services, support and training
- Position controls and sensors
- PVG proportional valves
- Steering components and systems
- Telematics

Danfoss Power Solutions is a global manufacturer and supplier of high-quality hydraulic and electric components. We specialize in providing state-of-the-art technology and solutions that excel in the harsh operating conditions of the mobile off-highway market as well as the marine sector. Building on our extensive applications expertise, we work closely with you to ensure exceptional performance for a broad range of applications. We help you and other customers around the world speed up system development, reduce costs and bring vehicles and vessels to market faster.

Danfoss Power Solutions – your strongest partner in mobile hydraulics and mobile electrification.

Go to www.danfoss.com for further product information.

We offer you expert worldwide support for ensuring the best possible solutions for outstanding performance. And with an extensive network of Global Service Partners, we also provide you with comprehensive global service for all of our components.

Hydro-Gear
www.hydro-gear.com

Daikin-Sauer-Danfoss
www.daikin-sauer-danfoss.com

Local address:

Danfoss
Power Solutions (US) Company
2800 East 13th Street
Ames, IA 50010, USA
Phone: +1 515 239 6000

Danfoss
Power Solutions GmbH & Co. OHG
Krokamp 35
D-24539 Neumünster, Germany
Phone: +49 4321 871 0

Danfoss
Power Solutions ApS
Nordborgvej 81
DK-6430 Nordborg, Denmark
Phone: +45 7488 2222

Danfoss
Power Solutions Trading (Shanghai) Co., Ltd.
Building #22, No. 1000 Jin Hai Rd
Jin Qiao, Pudong New District
Shanghai, China 201206
Phone: +86 21 3418 5200

Danfoss can accept no responsibility for possible errors in catalogues, brochures and other printed material. Danfoss reserves the right to alter its products without notice. This also applies to products already on order provided that such alterations can be made without subsequent changes being necessary in specifications already agreed.
All trademarks in this material are property of the respective companies. Danfoss and the Danfoss logotype are trademarks of Danfoss A/S. All rights reserved.