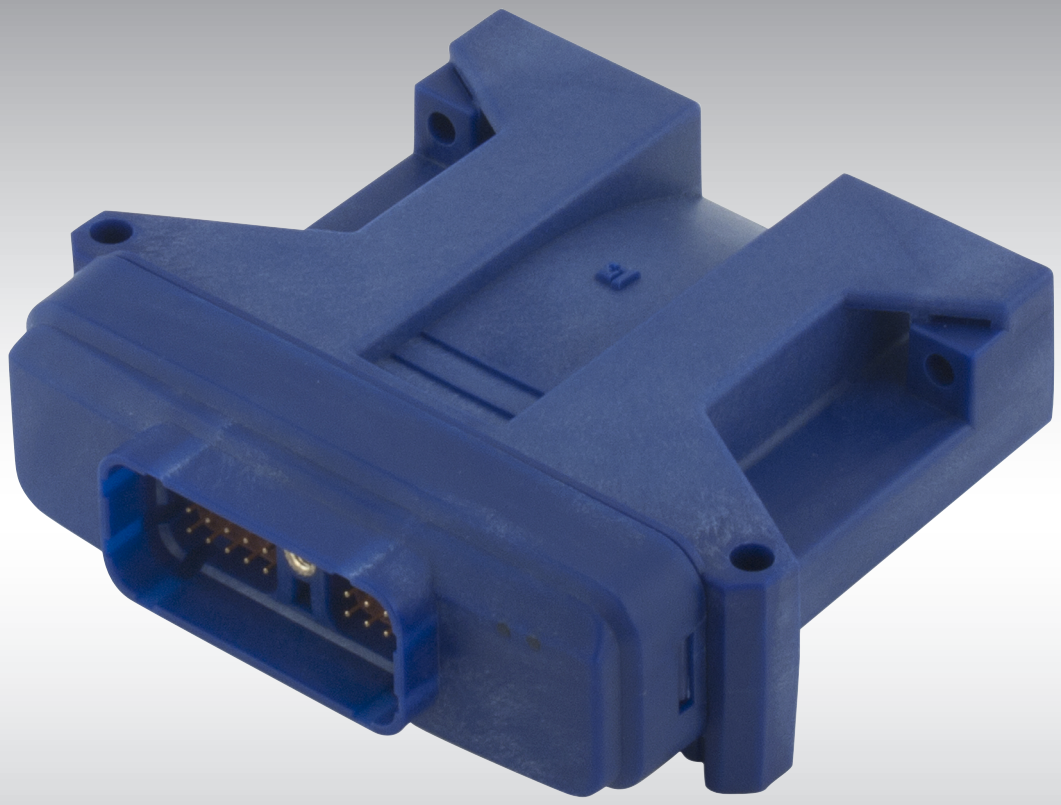
MAKING MODERN LIVING POSSIBLE

Technical Information

PLUS+1® SC
Controller Family



Revisions

Revision History

Table of Revisions

Date	Page	Changed	Rev.
17 Sep 2013	14, 16	Added LED information and secondary controller information	EA
17 Sep 2013	All	New layout	DA
11 Mar 2013	17	SC050-020 input condition	CA
06 Nov 2012	Various		BA
15 Jul 2012			AA

Contents

Product Overview

About This Manual 4
- PLUS+1® SC Controller Family Technical Information 4
- What information is in this manual? 4
- What information is in individual module product data sheets? 4
- What information is in individual module API specifications? 4
- What information is in the PLUS+1 GUIDE Software User Manual? 4
- What information is in the PLUS+1 SC Controller Family Safety Manual? 4

PLUS+1 SC Controller Family of Mobile Machine Management Products 5
User Liability and Safety Statements 5
- OEM Responsibility 5

Inputs/Outputs Types and Specifications

Inputs 6
- Input Types 6
- Digital/Analog (DIN/AIN), A/D Refresh Rates 7
- Digital/Analog/Frequency (DIN/AIN/FreqIN) 8
- Digital/Analog/Resistance/4-20 mA Current (DIN/AIN/ResIN/CrntIN) 10

Outputs 11
- Output Types 11
- Digital (DOUT) 12
- Pulse Width Modulated (PWMOUT/DOUT) 13
- LEDs 14

Controller Area Network Specifications

CAN (Controller Area Network) 15
CAN System Design 15
- Terminating Resistor 15
- CAN Bus Installation 15

Expansion Module CAN Bus Loading 16
Internal Micro-Micro Uart 16

Product Ratings

Power 17
- Module Supply Voltage/Maximum Current Ratings 17
- Lower Power Mode 17
- Sensor Power Supply Ratings 18

EEPROM Write/Erase Ratings 19
Environmental
Testing Criteria 19
- General Product Ratings 19
- PLUS+1 SC Controller Environmental Testing Criteria 20
- Modules Housing 20

Product Installation and Start-up

General Comments 21
- Mating Connectors 21

Product Installation 22
- Mounting 22
- Machine Diagnostic Connector 22
- Grounding 22
- Hot Plugging 22
- Recommended Machine Wiring Guidelines 23
- Recommended Machine Equipped with PLUS+1 Module Welding Procedures 23
- PLUS+1 USB/CAN Gateway 24

Product Overview

About This Manual

PLUS+1® SC Controller Family Technical Information
This technical information manual is designed to be a comprehensive PLUS+1® product family hardware module reference tool for vehicle OEM design, engineering, and service personnel. It is one of four sources of PLUS+1 product technical information. Other sources include individual module product data sheets, module specific Application Program Interface (API) specifications, the *PLUS+1 GUIDE Software User Manual,* literature number **10100824**, and the PLUS+1™ SC Controller Family Safety Manual, literature number **L1228981**.

What information is in this manual?
This manual describes unique characteristics and electrical details of PLUS+1 SC Controllers, including general specifications, input and output parameters, environmental ratings and installation details.

What information is in individual module product data sheets?
Parameters that are unique to an individual module are contained in the module product data sheet. Data sheets contain the following information:
- 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

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

What information is in individual module API specifications?
Detailed information about the module BIOS is contained in the module API specification. 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

What information is in the PLUS+1 GUIDE Software User Manual?
Detailed information regarding the PLUS+1 GUIDE software tool set that is used to build PLUS+1 machine management solutions is contained in the user manual. This manual covers the following broad topics:
- How to use the GUIDE graphical application development tool to create machine applications
- How to configure module input and output parameters
- How to download GUIDE applications to target PLUS+1 hardware modules
- How to upload and download tuning parameters
- How to use the PLUS+1 service tool

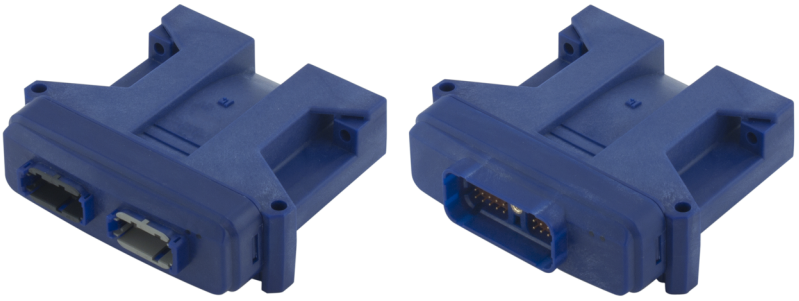
PLUS+1 product literature is available at: www.Danfoss.com

What information is in the PLUS+1 SC Controller Family Safety Manual?
Detailed information necessary to design, implement, verify and maintain a safety function utilizing the PLUS+1 SC050-020 Controller. This manual provides necessary requirements for meeting the IEC 61508 functional safety standard:
- Failure Modes, Effects, and Diagnostic Analysis (FMEDA) Summary
- Standards and references used

PLUS+1 SC Controller Family of Mobile Machine Management Products

24 and 50 Pin SC Controllers

Both modules come in the same sized blue housing.



PLUS+1 modules are designed to provide flexible, expandable, powerful, and cost effective total machine management systems for off-highway vehicles. These modules communicate with one another and other intelligent systems over a machine Controller Area Network (CAN) data bus. 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 systems are incrementally expandable: additional modules can be easily added to the machine CAN bus to increase system capabilities or computational power.

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

User Liability and Safety Statements

OEM Responsibility
The OEM of a machine or vehicle in which PLUS+1 electronic controls 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 PLUS+1 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.

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.

Inputs

Input Types

- Digital or Analog (DIN/AIN)
- Analog Input Offset
- A/D Refresh Rate
- Digital/Analog/Frequency (DIN/AIN/FreqIN)
- Digital/Analog/Resistance/4-20 mA Current (DIN/AIN/ResIN/CrntIN)
- Digital/Analog/1.6 Vdc Sensor Power (DIN/AIN/SnsrPwr1.6Vdc)
- Digital/Analog/3.6 Vdc Sensor Power (DIN/AIN/SnsrPwr3.6Vdc)

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.

Inputs (continued)

Digital/Analog (DIN/AIN), A/D Refresh Rates

Multifunction pins that are configured to be DIN are subject to the same update rates as the analog input 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

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	Programmable (see specific data sheets for ranges).

Specifications

Description	Units	Minimum	Maximum	Comment
Allowed voltage at pin	Vdc	0	36	— —
Maximum discernable voltage (high range)	Vdc	34.10	36.5	35.3 Vdc is typical.
Minimum discernable voltage (high range)	mV	0	130	— —
Maximum discernable voltage (middle range	Vdc	5.13	5.38	5.26 Vdc is typical.
Minimum discernable voltage (low range)	mV	0	20	— —
Precision (high range)	mV	— —	9	— —
Worst case error (high range)	Vdc	— —	1.16	— —
Precision (middle range)	mV	— —	1.3	— —
Worst case error (middle range)	mV	— —	120	— —
Input impedance (pulled up to 5 Vdc or ground, middle range)	kΩ	13.9	14.3	— —
Input impedance (pulled up to 2.5 Vdc middle range)	kΩ	7.2	7.4	— —
Input impedance (no pull ups, middle range)	kΩ	230	236	— —
Input impedance (pulled up to 5 Vdc or ground, high range)	kΩ	13.0	13.4	— —
Input impedance (pulled up to 2.5 Vdc high range)	kΩ	6.9	7.1	— —
Input impedance (no pull ups, high range)	kΩ	108	112	— —

A/D Refresh Rates for PLUS+1 SC Controllers

PLUS+1 SC Controller	A/D refresh rate
SC024-010/012	All: 1.0 ms
SC024-020/022	All: 1.0 ms
SC050-020/022	All: 1.0 ms

Inputs (continued)

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

The characteristics of Digital/Analog/Frequency pins are GUIDE software controlled. The input can be digital, analog or frequency. Inputs can be pulled to 5 Vdc, pulled to ground, pulled to 2.5 Vdc, or no pull-up/pull-down.

General

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.

Specifications

Description	Units	Minimum	Maximum	Comment
Allowed voltage at pin	Vdc	0	36	
Frequency range	Hz	0	10,000	In steps of 1 Hz.
Frequency input when used as quad count or phase shift	Hz	0	5000	In steps of 1 Hz.
Maximum discernable voltage (high range)	Vdc	34.1	36.5	35.3 Vdc is typical.
Minimum discernable voltage (high range)	mV	0	130	
Maximum discernable voltage (middle range)	Vdc	5.13	5.38	5.26 Vdc is typical.
Minimum discernable voltage (middle range)	mV	0	20	
Maximum discernable voltage (low range)	Vdc	0.341	0.395	0.368 Vdc is typical.
Minimum discernable voltage (low range)	mV	0	12.9	
Precision (high range)	mV	– –	9	
Worst case error (high range)	Vdc	– –	1.16	
Precision (middle range)	mV	– –	1.3	
Worst case error (middle range)	mV	– –	120	
Precision (low range)	µV	– –	90	
Worst case error (low range)	mV	– –	27	
Input impedance (pulled to 5 Vdc or ground, low range)	kΩ	13.9	14.3	
Input impedance (pulled to 2.5 Vdc, low range)	kΩ	7.2	7.4	
Input impedance (no pull ups, low range)	kΩ	230	236	
Input impedance (pulled to 5 Vdc or ground, middle range)	kΩ	13.9	14.3	
Input impedance (pulled to 2.5 Vdc middle range)	kΩ	7.2	7.4	
Input impedance (no pull ups, middle range)	kΩ	230	236	
Input impedance (pulled to 5 Vdc or ground, high range)	kΩ	13	13.4	
Input impedance (pulled to 2.5 Vdc high range)	kΩ	6.9	7.1	
Input impedance (no pull ups, high range)	kΩ	108	112	

Inputs (continued)

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

This table shows the rising and falling thresholds when the input is used as a frequency input.

Specifications

Description	Units	Minimum	Maximum	Comment
Rising voltage threshold (high range)	Vdc	11.83	26.55	Voltage required for frequency input to read high.
Falling voltage threshold (high range)	Vdc	5.61	18.89	Voltage required for frequency input to read low.
Rising voltage threshold (middle range)	Vdc	1.78	3.92	Voltage required for frequency input to read high.
Falling voltage threshold (middle range)	Vdc	0.84	2.79	Voltage required for frequency input to read low.
Rising voltage threshold (low range)	Vdc	0.11	0.30	Voltage required for frequency input to read high.
Falling voltage threshold (low range)	Vdc	0.04	0.22	Voltage required for frequency input to read low.

Potential for IX modules to not go online. If voltage is applied to an IX module input pin prior to the module being powered on, there is a possibility that the module CPU will not power up. The module is not damaged and will power up and operate normally once power is removed from the input pins. It is recommended that either the IX module's
5 Vdc sensor power be used to power sensors or that power is removed from the input pins until the module is powered up.

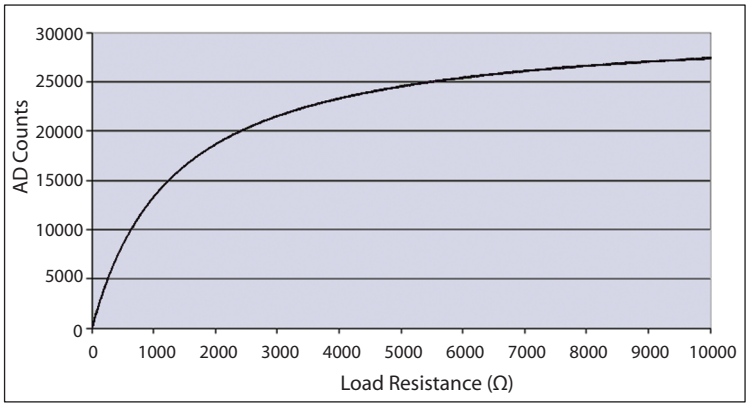
If the frequency goes to zero, the data will not decay over time, it will be updated once a new pulse is seen, or times out. It is possible to monitor the count of pulses to know when the frequency reading is updated.

Inputs (continued)

Digital/Analog/Resistance/4-20 mA Current (DIN/AIN/ResIN/CrntIN)

When a PLUS+1 SC Controller input pin is configured as a resistance/rheostat/temp sensor input, the device will provide up to 3.76 mA current to an external load (RL) which then can be measured. The equation for relating AD counts to a given load is: AD counts = (30996*RL) / (RL + 1322). This calculation is solved internally and the ohms value is available for the programmer. The following chart shows the relationship between AD counts and load resistance in ohms.

Rheostat Inputs



P200 083

Specifications

Description	Units	Minimum	Maximum	Comment
Allowed voltage at pin	Vdc	0	36	
Measured resistance	Ω	0	10,000	
Minimum discernable current	mA	0	0.1	
Maximum discernable 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	202.6	
Maximum over-current protection time	ms		250	
Recover time after over-current protection	s	5.4		
Maximum discernable voltage (high range)	Vdc	25.3		
Minimum discernable voltage (high range)	mV	0	130	
Precision (high range)	mV		9	
Worst case error (high range)	Vdc		1.16	Over the full temperature range -40°C to 85°C (-40°F to 185°F)
Maximum discernable voltage (middle range)	Vdc	5.13	5.38	
Minimum discernable voltage (middle range)	mV	0	20	
Precision (middle range)	mV		1.3	
Worst case error	mV		120	Over the full temperature range -40°C to 85°C (-40°F to 185°F)
Input impedance (pulled to 5 Vdc or ground high range)	KΩ	13.0	13.4	
Input impedance (pulled to 2.5 Vdc high range)	KΩ	6.9	7.1	
Input impedance (no pull ups high range)	KΩ	108	112	
Input impedance (pulled to 5 Vdc or ground middle range)	KΩ	13.9	14.3	
Input impedance (pulled to 2.5 Vdc middle range)	KΩ	7.2	7.4	
Input impedance (no pull ups middle range)	KΩ	230	236	

Outputs

Output Types

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

Output Pins Available on Individual PLUS+1 SC Controllers

PLUS+1 SC Controllers	DOUT (3 A)	PWMOUT/DOUT/(3 A)
SC024-010		4
SC024-020		8
SC050-020	6	8

PLUS+1 control modules feature user-configurable output pin parameters. Output pin parameters are configured using PLUS+1 GUIDE templates.

Refer to module data sheets for maximum output current ratings of individual modules. The total output current for any PLUS+1 module must not exceed the maximum allowable current specified in the module data sheet.

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

Outputs (continued)

Digital (DOUT)
Digital outputs can source up to 3 A.

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 0.22 A 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 with hardware WatchDog override.

Specifications

Description	Units	Minimum	Maximum	Comment
Output voltage, energized state	Vdc	Vbatt-1.0	Vbatt	Over all load conditions.
Output voltage, off state	Vdc	0	0.1	At Rload=200 Ω
Output current range for a status bit to read OK	A	0.22	3	See note regarding pair, above.

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

For each digital output there are two switches in series. One switch is controlled and monitored by the secondary controller, and one is controlled and monitored by the primary controller. The secondary controller can monitor the condition of the redundant switch under its control with a digital voltage feedback signal. Any output can be disconnected from its supply voltage at any time by the secondary controller with this redundant switch. When the redundant switch is disabled it must remain disabled by the kernel for 250 milliseconds before the secondary controller's application is allowed to re-enable the redundant switch. When the redundant switch controlled by the secondary controller is enabled then the digital outputs can be enabled/disabled as commanded by the primary controller. The primary controller can monitor the condition of its switch with a digital voltage feedback signal.

Outputs (continued)

Pulse Width Modulated (PWMOUT/DOUT)
All PLUS+1 module proportional outputs are Pulse Width Modulated (PWM). PWM frequency is software adjustable using 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 (all modules are limited to 8 amps sinking), 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. PVG valves may be driven with open loop PWM.

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).

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

Outputs (continued)

Pulse Width Modulated (PWMOUT/DOUT) (continued)

Specifications

Description	Units	Minimum	Maximum	Comment
Full scale proportional current output	mA	10	3000	The current may accidently be exceeded in open loop mode. If the current exceeds the trip point, the output will be latched off.
Output voltage, 100% duty cycle	Vdc	0	Vbatt-1	
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		0.3	
Output settling time	ms		100	Depends on load characteristics.
PWM frequency	Hz	33	4000 and 20,000	
Dither frequency	Hz	40	250	Increased in steps, see module API.
Dither amplitude	A	0	0.5	Increased in steps, see module API.
Over-current trip point	A	5	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.

For each PWM output there are two switches in series for sourcing current/voltage (the high-side of the half bridge has two switches). One switch is controlled and monitored by the secondary controller, and the other is controlled and monitored by the primary controller. The secondary controller can monitor the condition of the redundant switch under its control with a digital voltage feedback signal. Each sourcing PWM output can be disconnected from its supply voltage at any time by the secondary controller with this redundant switch. When the redundant switch is disabled it must remain disabled by the kernel for 250 ms before the secondary controller's application is allowed to re-enable the redundant switch. When the switch controlled by the secondary controller is enabled then the PWM outputs are allowed to source current as commanded by the primary controller. The primary controller can monitor the condition of its switch with the analog current feedback measurement.

LEDs

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

Each LED light pipe will have an alternate yellow color which the application software will not have access to. These alternate yellow colors will be used to indicate low-level software and/or hardware failures. The yellow LED shared with the green LED light pipe will be controlled by the primary controller, and the yellow LED shared with the red LED light pipe will be controlled by the secondary controller. When either yellow LED is enabled the signal will override its shared green or red LED.

Controller Area Network Specifications

CAN (Controller Area Network)

There are two channels fully dedicated to CAN communications on the 50 pin hardware. One channel routed to the primary processor only, and the other channel is routed to both the primary and secondary processors.

There is one channel fully dedicated to CAN communications on the 24 pin hardware. This channel is routed to both the primary and secondary processors.

Baud rate	Up to 1 M
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 in excess of 30 V/m between 20 and 30 MHz. To prevent potential unintended machine movement and to meet EMC requirements, a shielded CAN bus must be used to achieve 100 V/m immunity.

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		

CAN Bus Installation

Total bus impedance should be 60 Ω.

The CAN transceiver will be damaged by any voltage outside of allowable range, (-7 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.

CAN (Controller Area Network) continued

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 table below 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 SC024-010, SC024-020	9%	12%	9%	14%	9%	17%
RAM usage on SC050-020	1%	1%	1%	2%	1%	2%
ROM usage on SC024-010, SC024-020	8%	11%	12%	18%	10%	20%
ROM usage on SC050-020	3%	4%	4%	6%	3%	8%

Internal Micro-Micro Uart

There are two channels fully dedicated to diagnostic communication between processors. One channel is dedicated to processor diagnostics, and the other is dedicated to CAN_1 message send and receive diagnostics.

The hardware and low-level software provide a basic framework for communication on each channel, however the specific data structure is not predefined because the data to be transferred is application dependent.

Baud rate	Up to 7.5 M
Termination	N/A

The secondary controller:

- Has access to all inputs including sensor power and battery measurements, PWM output currents, as well as one external CAN channel.
- Can control and check all redundant sourcing output stages.
- Has access to a digital signal indicating that the internal power supplies are within acceptable limits.
- Can communicate application specific data through a dedicated serial bus.
- Has the ability to disable sourcing (disconnect high-side switch) of each output individually in the event that any of these signals indicates there is a fault condition as defined by the application.

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 7 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		Vdc	0	36	
Allowed module current		A	0		Consult module data sheets for maximum allowable current.
SR_{on}	Minimum voltage rise rate for power turn-on	V/ms	1	—	The voltage applied to the power pins must exceed this value to guarantee the device will power-up.
T_{on}	Turn-on time	ms	—	250	From applied battery power to application software start.

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.

Lower Power Mode

This feature gives OEM designers the ability to implement automotive-like features in their machine control system design. If the lower power mode feature is not implemented, this controller has the same operating characteristics as any other PLUS+1 controller.

When used as a lower power mode controller, supply power to the module is connected directly to the battery. Lower power mode initiation is defined by the controller's application software: PLUS+1 GUIDE programmers define the conditions under which the controller is to put into lower power mode. When in lower power mode, controller outputs are set to zero, sensor power supply is off and the controller consumes a small amount of current.

Controller Lower Power Mode Current Consumption

Supply voltage	Lower power mode current consumption
12 Vdc	20 mA
24 Vdc	20 mA

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:
  - SC024-010: C1p5, C1p6, C1p7, C1p10, C1p11, C1p12, C2p1, C2p7, C2p8
  - SC024-020: C1p5, C1p6, C1p7
  - SC050-020: C1p5, C1p6, C1p7, C1p18, C1p19, C1p23, C1p24, C1p25, C1p31, C1p32

Power (continued)

Module Supply Voltage/Maximum Current Ratings (continued)

Specifications

Description		Units	Minimum	Maximum	Comment
Power-up pin threshold		Vdc	2	36	To wake up by cycling input power.
Power-up pin threshold		Vdc	4.5	36	To wake up by digital input.
Power-up time delay		mSec	250	500	
SRon	Minimum voltage rise rate for power turn-on	V/ms	—	—	The voltage applied to the input pins must exceed this value to guarantee the device will power-up.
Toff	Turn-off time	ms	150	400	From software commanded shutdown to micro reset.

Sensor Power Supply Ratings

PLUS+1 modules that support sensor inputs are provided with dedicated, software adjustable, regulated sensor power supply and ground pins. Refer to individual product data sheets for sensor power supply current ratings.

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.

Specifications

Description	Units	Minimum	Maximum	Comment
Output short circuit voltage	Vdc		36	
Sensor output voltage	Vdc	3	12	
Output current	mA	0	500	The maximum power must be limited to 2.5 Watts for Vout greater than 5 Vdc.
Output Load Capacitance	µF		10	
Hold up time after power loss	ms	5	15	

SC Controllers feature two additional levels of regulated power: 1.6 Vdc and 3.3 Vdc. The PLUS+1 GUIDE application developer can detect open and short digital inputs, when these power supplies are used in conjunction with DIN/AIN inputs.

Specifications

Description	Units	Minimum	Maximum	Comment
Output short circuit voltage	Vdc		36	
Output voltage, sensors	Vdc	3	12	Sensor power supply drops below minimum if controller power supply is less than 7 Vdc.
Output voltage, DIN diagnostics	Vdc	1.58	1.76	Nominal 1.6
Output voltage, DIN diagnostics	Vdc	3.21	3.45	Nominal 3.3

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.

Specifications

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

EEPROM used in PLUS+1 controllers is rated for one 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, BOLL, etc) 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.

Environmental Testing Criteria

General Product Ratings

Description	Units	Minimum	Maximum	Comment
Operating temperature	˚C [˚F]	-40 [-40]	85 [185]	
Storage temperature	˚C [˚F]	-40 [-40]	85 [185]	
Allowable module supply voltage	Vdc	7	36	
Module sensor supply voltage	Vdc	3	12	Sensor voltage drops below the minimum value if module supply voltage < 7 Vdc. *Sensor Power Supply Ratings*, page 18.
Analog input voltage levels	Vdc		36	
Allowable output load current (per pin)	A			See individual module date sheets.
Module allowable total output current	A			See individual module data sheets.
All modules Ingress Protection (IP) rating*				IP 67
All modules CE rating				CE compliant.

* The PLUS+1 modules IP 67 rating is only valid when the module mating connector is in place and unused connector pin positions have sealing plugs installed.

Environmental Testing Criteria (continued)

PLUS+1 SC Controller 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	Danfoss test	Survives reverse polarity at supply voltage for at least five minutes.

Modules Housing

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

Opening the modules housing will void the factory warranty.

Product Installation and Start-up

General Comments

Mating Connectors

PLUS+1 SC Controllers use Deutsch® connectors. Danfoss has assembled a mating connector kit, referred to as a bag assembly, for the 24 and 50 pin module housings. Mating connector bag assembly ordering information is found in the product data sheet for each module.

Deutsch Mating Connector Part Information

Description	24 pin module	50 pin module
Crimp tool	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)
Contacts	Solid: 0462-201-2031 (20 to 24 AWG)	Solid: 0462-201-2031 (20 to 24 AWG)
	Stamped: 1062-20-0144 (16 to 20 AWG)	Stamped: 1062-20-0144 (16 to 20 AWG)
Connector plug	Gray A-Key DTM 06-12SA Black B-Key DTM 06-12SB	DRC26-50S01
Wedge	WM-12S	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]
Rear seal maximum insulation OD	3.05 mm [0.120 in]	2.41 mm [0.095 in]
Sealing plugs	0413-204-2005	0413-204-2005

Danfoss Mating Connector Part Information

Description	24 pin module	50 pin module
Mating connector bag assembly (20 to 24 AWG)	10100945	10100946
Mating connector bag assembly (16 to 20 AWG)	10102023	10102024

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 0144-240-2005; 16 to 20, 20 to 24 AWG	10100744

PLUS+1 module mating connectors may be mated 10 times.

Recommended torque for the Deutsch® mating connector retaining fastener on the 50 pin connector is 20 lb•in (2.26 N•m).

Product Installation

Mounting

PLUS+1 modules can be mounted in one of three ways:

- End (bulkhead) installation
- Up to 3 units stacked on one another
- Individually side mounted

In each case, care must be taken to insure that the module connector is positioned so that moisture drains away from the connector. If the module is side or stack 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 twist off the end cap of the module if excessive pressure is applied during the installation of harness strain relief.

Suggested Fasteners and Recommended Installation Torque

Mounting method	Recommended OD	Recommended torque
Bulkhead mount; multiple units stacked; single	6.0 mm (.25 in)	9.49 N•m (7 ft•lb)

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.

Product Installation (continued)

Recommended Machine Wiring Guidelines

1. All wires must be protected from mechanical abuse. Wires should be run in flexible metal or plastic conduits.
2. Use 85˚ C [185˚ F] wire with abrasion resistant insulation. 105˚ C [221˚ F] wire should be considered near hot surfaces.
3. Use a wire size that is appropriate for the module connector.
4. Separate high current wires such as solenoids, lights, alternators or fuel pumps from sensor and other noise-sensitive input wires.
5. 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.
6. Do not run wires near sharp metal corners. Consider running wires through a grommet when rounding a corner.
7. Do not run wires near hot machine members.
8. Provide strain relief for all wires.
9. Avoid running wires near moving or vibrating components.
10. Avoid long, unsupported wire spans.
11. All analog sensors should be powered by the sensor power source from the PLUS+1 controller and ground returned to the sensor ground pin on the PLUS+1 controller.
12. Sensor lines should be twisted about one turn every 10 cm [4 in].
13. It is better to use wire harness anchors that will allow wires to float with respect to the machine rather than rigid anchors.
14. Electronic modules should be grounded to a dedicated conductor of sufficient size that is connected to the battery (-).

Recommended Machine Equipped with PLUS+1 Module Welding Procedures

The following procedures are recommended when welding on a machine equipped with PLUS+1 modules:

- The engine should be off.
- 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 a possible to the weld.

Product Installation (continued)

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 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*, literature number **10100824**, for gateway set-up information. Refer to the *CG150 USB/CAN Gateway Data Sheet*, literature number **520L0945**, for electrical specifications and connector pin details.

Notes

Notes

Notes

Products we offer:

- Bent Axis Motors
- Closed Circuit Axial Piston Pumps and Motors
- Displays
- Electrohydraulic Power Steering
- Electrohydraulics
- Hydraulic Power Steering
- Integrated Systems
- Joysticks and Control Handles
- Microcontrollers and Software
- Open Circuit Axial Piston Pumps
- Orbital Motors
- PLUS+1® GUIDE
- Proportional Valves
- Sensors
- Steering
- Transit Mixer Drives

Danfoss Power Solutions is a global manufacturer and supplier of high-quality hydraulic and electronic 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. Building on our extensive applications expertise, we work closely with our customers to ensure exceptional performance for a broad range of off-highway vehicles.

We help OEMs around the world speed up system development, reduce costs and bring vehicles to market faster.
Danfoss – Your Strongest Partner in Mobile Hydraulics.

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

Wherever off-highway vehicles are at work, so is Danfoss.

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

Please contact the Danfoss Power Solution representative nearest you.

Comatrol
www.comatrol.com

Schwarzmüller-Inverter
www.schwarzmueller-inverter.com

Turolla
www.turollaocg.com

Valmova
www.valmova.com

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
22F, Block C, Yishan Rd
Shanghai 200233, China
Phone: +86 21 3418 5200

L1206334 • Rev DA • Sep 2013