SAUER DANFOSS

PLUS+1 Controller Family

Technical Information

PLUS+1™ by SAUER-DANFOSS

Version

Revisions

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21 Jul, 2008	Various	General content update	FA
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SAUER DANFOSS

PLUS+1 Controller Family Technical Information

Contents

About This Manual

PLUS+1 Controller Family Technical Information

This manual is designed to be a comprehensive PLUS+1™ product family hardware 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 and the *PLUS+1 GUIDE Software User Manual,* literature number **10100824**.

What information is in this manual?

This manual describes electrical details that are common to all PLUS+1 modules, 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 PLUS+1 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

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 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.

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 technical information 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.sauer-danfoss.com

PLUS+1 Family of Mobile Machine Management Products

12, 24, 50, and 88 Pin Models

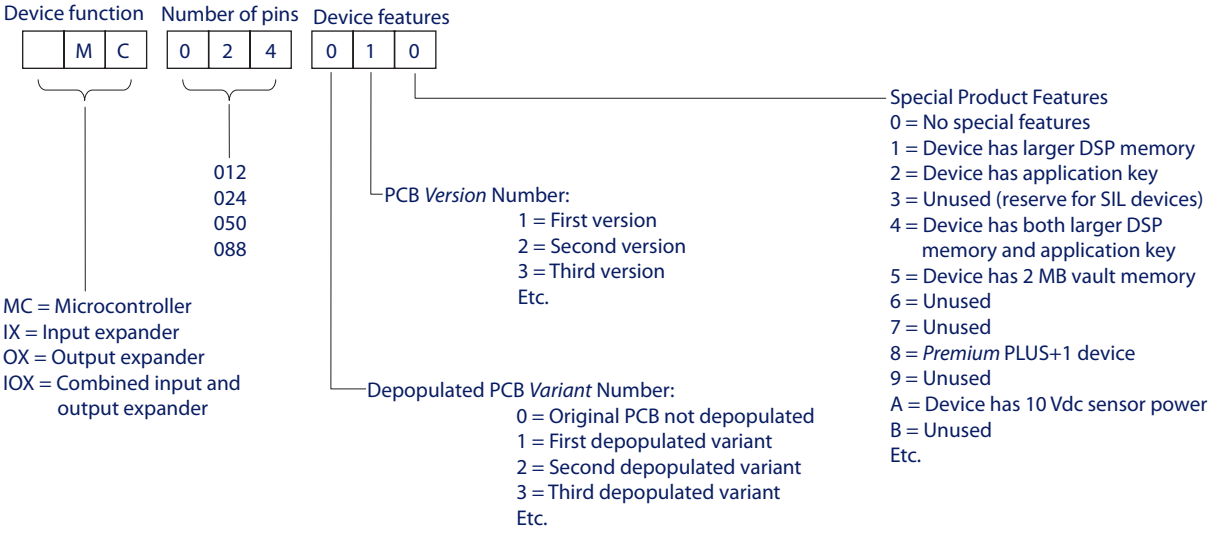
F101753

PLUS+1 controllers and input/output expansion 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 control products utilize modular designs wherever possible. This modularity extends to product housings, connectors and control circuitry. Four standard housings, 12, 24, 50, and 88 pin, cover the entire product line.

PLUS+1 Module Naming Convention

PLUS+1 Master Model Code (Example: MC 024 010)



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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. Sauer-Danfoss has no responsibility for any consequences, direct or indirect, caused by failures or malfunctions.

- Sauer-Danfoss has no responsibility for any accidents caused by incorrectly mounted or maintained equipment.
- Sauer-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.

Input/Output Types

Each PLUS+1 hardware module has 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.

This section provides technical information and specifications for each I/O type.

The following ratings apply to all PLUS+1 input and output types.

Absolute Rating for All PLUS+1 I/O

Description	Units	Minimum	Maximum	Comment
Input voltage	Vdc	0	36	Modules will survive with full functionality if input voltage does not exceed 36 Vdc

Inputs

A/D Refresh Rate

A/D refresh rates for individual PLUS+1 modules are as follows. CPU A/D channels are sampled at 25KHz and 64 samples are taken to build an average value. This results in a refresh rate of 2.56 ms for channels directly measured. All internal current feedback channels are refreshed at the 2.56 ms rate.

Some PLUS+1 module A/D CPU channels are shared. Each of the shared channels has eight multiplexed analog inputs. Each multiplexed input is serviced every 20.48 ms. Update rates for specific analog input pins are found below. Update rates for input expander modules are dependent on the CAN message frequency selected in the application program.

A/D Update Rates for PLUS+1 Modules

PLUS+1 module	A/D refresh rate
MC012-010	All: 2.56 ms
MC024-010	All: 2.56 ms
MC024-020	C1p10, C1p11, C1p12: 7.68 ms Remaining pins: 2.56 ms
MC024-500	All: 2.56 ms
MC050-010	C1p05, C1p08, C1p14, C1p15, C1p16, C1p17, C1p18, C1p19, C1p22, C1p23, C1p24, C1p25, C1p26, C1p27, C1p28, C1p29, C1p30, c1p34, C1p35, C1p36: 20.48 ms C1p02: 2.56 ms
MC050-020	C1p05, C1p22, C1p25, C1p26, C1p27, C1p28, C1p29, C1p30, C1p31, C1p32, C1p39, C1p40: 20.48 ms C1p02, C1p08, C1p18, C1p19, C1p23, C1p24: 2.56 ms
MC088-015, MC088-315	C1p05,C1p08, C1p22, C1p27, C1p28, C1p29, C1p30,, C1p14, C1p15, C1p16, C1p17, C1p18, C1p19, C1p23, C1p24, C1p25, C1p26, C1p34, C1p35, C1p36, C1p47, C1p48, C1p49, C1p50 , C2p09, C2p10, C2p11, C2p35, C2p36, C2p37, C2p38: 20.48 ms
IOX012-010	Refresh rate is a function of CAN message frequency
IX012-010	Refresh rate is a function of CAN message frequency
IX024-010	Refresh rate is a function of CAN message frequency

Inputs (continued)

Input Types

- Digital (DIN)
- Digital or Analog (DIN/AIN)
- Multifunction digital or Analog or Frequency (DIN/AIN/FreqIN)
- Analog or Temperature or Rheostat (AIN/Temp/Rheo)
- Fixed Range Analog or CAN shield (AIN/CAN shield)
- Digital or Analog or Current (DIN/AIN/4-20 mA IN)

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

Digital (DIN)

Digital inputs 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.

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.

Specifications

Description	Units	Minimum	Max	Comment
Allowed voltage at pin	Vdc	0	36	
Rising voltage threshold	Vdc	2.73	4.00	A digital input is guaranteed to be read as high if the voltage is greater than 4.00 Vdc
Falling voltage threshold	Vdc	0.97	2.68	A digital input is guaranteed to be read as low if the voltage is less than 0.97 Vdc
Time to change state in response to step input	ms		1.5	Input change from maximum to minimum - add to debounce time
Input impedance	kΩ	13.9	14.3	Depends on pin configuration

Inputs (continued)

Analog (AIN)

General

Feature	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	Vdc	5.18	5.33	5.26 is typical
Minimum discernable voltage	Vdc	0	0.08	
Precision	mV		1.28	
Input impedance	kΩ	230	236	Depends on pin configuration

* Maximum allowed voltage on fixed range analog input pins (CAN shield) is 25 Vdc.

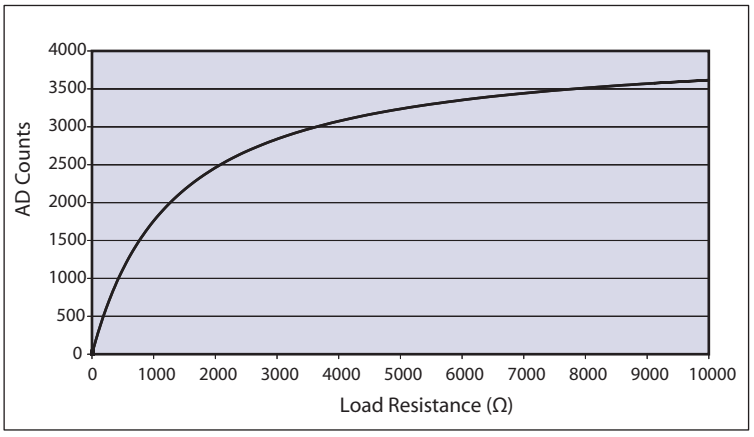
Module analog input offset error can be 80 counts out of 4096 (12 bit A/D resolution). Therefore, the minimum voltage that a module will read at the most common 0 to 5.25 Vdc range is 105 mV.

Inputs (continued)

Analog/Temperature/Rheostat (AIN/Temp/Rheo)

When a PLUS+1 module input pin is configured in the temperature/rheostat mode, the input has a 1.33 kΩ pull up resistor to +5 Vdc. It will source up to 3.75 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 = (4096*RL) / (RL + 1330). 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



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Specifications

Description	Units	Minimum	Maximum	Comment
Allowed voltage at pin	Vdc	0	36	

Inputs (continued)

Digital/Analog/Frequency (DIN/AIN/FreqIN) (all modules except IX012-010, IX024-010)

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

Feature	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%)
	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

As with analog input pins, values in the following table assume software compensation for AD converter offset errors.

Specifications

Description	Units	Minimum	Maximum	Comment
Allowed voltage at pin	Vdc	0	36	
Frequency range	Hz	0	10000	In steps of 1 Hz
Maximum discernable voltage (high range)	Vdc	35.2	35.4	35.3 Vdc is typical
Maximum discernable voltage (middle range)	Vdc	5.18	5.33	5.26 Vdc is typical
Maximum discernable voltage (low range)	Vdc	0.360	0.375	0.3675 Vdc is typical
Minimum discernable voltage	Vdc	0	0.08	For all ranges
Precision (high range)	mV	-	8.62	
Worst case error (high range)	mV	-	614	
Precision (middle range)	mV	-	1.28	
Worst case error (middle range)	mV	-	75	
Precision (low range)	µV	-	89.7	
Worst case error (low range)	mV	-	7.39	
Input impedance (pulled to 5 Vdc or ground, middle and low range)	kΩ	13.9	14.3	
Input impedance (pulled to 2.5 Vdc middle and low range)	kΩ	7.17	7.37	
Input impedance (no pull ups, middle and low range)	kΩ	230	236	
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	6.92	7.12	
Input impedance (no pull ups, high range)	kΩ	108	112	

Inputs (continued)

Digital/Analog/Frequency (DIN/AIN/FreqIN) (all modules except IX012-010, IX024-010) (continued)

Specifications (continued)

Description	Units	Minimum	Maximum	Comment
Rising voltage threshold (high range)	Vdc	18.9	27.6	It is inadvisable to use the high range option when configuring the input as a digital or frequency input.
Falling voltage threshold (high range)	Vdc	6.8	18.5	It is inadvisable to use the high range option when configuring the input as a digital or frequency input.
Rising voltage threshold (middle range)	Vdc	2.92	4.12	A digital input is guaranteed to be read as high if the voltage is greater than 3.99 Vdc. These numbers also apply to frequency.
Falling voltage threshold (middle range)	Vdc	1.02	2.75	A digital input is guaranteed to be read as low if the voltage is less than 0.96 Vdc. These numbers also apply to frequency.
Rising voltage threshold (low range)	Vdc	0.197	0.298	A digital input is guaranteed to be read as high if the voltage is greater than 0.28 Vdc.
Falling voltage threshold (low range)	Vdc	0.071	0.192	A digital input is guaranteed to be read as low if the voltage is greater than 0.067 Vdc.

Digital/Analog/Frequency (DIN/AIN/FreqIN) (IX012-010, IX024-010 modules)

The characteristics of Analog/Digital/Frequency pins are GUIDE software controlled. The input can be digital, analog or frequency. Inputs can be pulled to 5 Vdc, pulled to ground, or pulled to 2.5 Vdc.

As with analog input pins, values in the following table assume software compensation for the errors in the AD converter.

Specifications

Description	Units	Minimum	Maximum	Comment
Allowed voltage at pin	Vdc	0	36	
Frequency range	Hz	0	10000	In steps of 1 Hz
Maximum discernable voltage (high range)	Vdc	35.3	36	36 Vdc is typical
Maximum discernable voltage (middle range)	Vdc	5.67	5.83	5.75 Vdc is typical
Maximum discernable voltage (low range)	Vdc	0.440	0.456	0.448 Vdc is typical
Minimum discernable voltage	Vdc	0	0.08	
Precision (high range)	mV	-	36.5	
Worst case error (high range)	mV	-	614	
Precision (middle range)	mV	-	5.62	
Worst case error (middle range)	mV	-	75	
Precision (low range)	µV	-	438	
Worst case error (low range)	mV	-	7.39	
Input impedance (pulled to 5 Vdc or ground, middle and low range)	kΩ	13.9	14.3	

Inputs (continued)

Digital/Analog/Frequency (DIN/AIN/FreqIN) (IX012-010, IX024-010 modules) (continued)

Specifications (continued)

Description	Units	Minimum	Maximum	Comment
Input impedance (pulled to 2.5 Vdc middle and low range)	kΩ	7.17	7.37	
Input impedance (no pull ups, middle and low range)	kΩ	230	236	
Input impedance (pulled to 5 Vdc or ground, high range)	kΩ	10.3	10.7	
Input impedance (pulled to 2.5 Vdc high range)	kΩ	6.07	6.27	
Input impedance (no pull ups, high range)	kΩ	36.4	38.4	

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

Specifications

Description	Units	Minimum	Maximum	Comment
Rising voltage threshold (high range)	Vdc	-	-	It is inadvisable to use the high range option when configuring the input as a digital or frequency input.
Falling voltage threshold (high range)	Vdc	-	-	It is inadvisable to use the high range option when configuring the input as a digital or frequency input.
Rising voltage threshold (middle range)	Vdc	2.85	4.03	A digital input is guaranteed to be read as high if the voltage is greater than 4.03 Vdc. These numbers also apply to frequency.
Falling voltage threshold (middle range)	Vdc	1.15	2.59	A digital input is guaranteed to be read as low if the voltage is less than 1.15 Vdc. These numbers also apply to frequency.
Rising voltage threshold (low range)	Vdc	0.22	0.31	A digital input is guaranteed to be read as high if the voltage is greater than 0.31 Vdc.
Falling voltage threshold (low range)	Vdc	0.090	0.20	A digital input is guaranteed to be read as low if the voltage is greater than 0.090 Vdc.

Potential for IX modules to go offline. When battery voltage is applied to an input pin prior to the module CPU being powered on there is a possibility that the 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 CPU is powered up.

Inputs (continued)

Digital/Analog/4-20 mA (DIN/AIN/4-20 mA IN)

Refer to Analog/Digital/Frequency *Specifications* table, page 11, for input properties when pins are configured as digital, analog or frequency. If the pin is configured to read current, the table below applies. When interfacing with sensors that transmit a 4 to 20 mA current signal, the positive lead of the transmitter is connected to battery voltage and the negative lead is connected to the PLUS+1 module pin. The current measuring configuration relies on the application program to provide over current protection.

The current measuring configuration is only available on MC088-XXX modules.

Specifications

Description	Units	Minimum	Maximum	Comment
Allowed voltage at pin	Vdc	0	36	
Minimum input current	mA	3	4	
Maximum input current	mA	20	24	
Precision	µA		5.86	

Outputs

Output Types

PLUS+1 control modules feature user-configurable output circuits. Output parameters are configured using PLUS+1 GUIDE templates. Refer to module data sheets for maximum current ratings of individual modules and MC088-015 power planes. The following output types are supported:

- Digital (DOUT, DOUT/PVG Pwr)
- Proportional (PWMOUT/DOUT/PVGOUT)
- High current digital (HDOUT) —MC088-015 module

⚠ Warning

Potential uncommanded machine movement. DOUT and HDOUT digital outputs do not have an internal feedback to the PLUS+1 module kernel. If the application requires fault detection, an external feedback using an AIN configured pin must be used. External feedback is required if the actual output is to be read by the PLUS+1 Service Tool.

All other output types have internal feedback to the PLUS+1 module kernel that provide pin fault and status information that can be read directly by the application and the PLUS+1 Service Tool.

Digital (DOUT, DOUT/PVE Pwr)

Digital outputs can source up to 3 amps. However, the total output current for any PLUS+1 module must not exceed the maximum allowable current specified in the module data sheet. In the case of MCO88-XXX modules, the total output current for an individual power plane and the total output current for the module must not exceed the limits specified on the data sheet.

- Current outputs for MC050-010, MC050-020, MC088-015, and OX024-010 module DOUT and DOUT/PVG Pwr pins are pair limited and a function of temperature. Output per pair is
  6 A maximum at 25° C [77˚ F]. Output per pair is 4 A maximum at 70° C [158˚ F].
- MC050-010 pairs are C1P31 and C1P32, C1P33 and C1P34, C1P35 and C1P36.
- MC050-020 pairs are C1P33 and C1P34, C1P35 and C1P36, C1P37 and C1P38, C1P39 and C1P40.
- MC088-015 pairs are:
  Power plane C2p35: C1P31 and C1P32, C1P33 and C1P34
  Power plane C2p36: C1p35 and C1p36
  Power plane C2p37: C2p1 and C2p7, C2p2 and C2p3, C2p4 and C2p5, C2p30 and C2p33
  Power plane C2p38: C2p6 and C2p12
- OX024-010 pairs are C1P6 and C1P7, C1P8 and C1P9, C1P10 and C1P11.
- Example: At a module temperature of 70˚ C [158˚ F], if C1P31 is sourcing 2.5 A, the most current that can be sourced on its paired pin C1P32 is 1.5 A.

Outputs (continued)

Digital (DOUT, DOUT/PVE Pwr) (continued)

General

Feature	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 with hardware WatchDog override

Specifications

Description	Units	Minimum	Maximum	Comments
Allowed voltage at pin	Vdc	0	36	See caution statement below
Output voltage, energized state	Vdc	Vbatt-1.0	Vbatt	Over all load conditions
Output voltage, off state	Vdc	0	0.1	At Rload=200Ω
Output current range for a status bit to read OK	A	0.5	3	See pair note, above

High Current Outputs (HDOUT)

High current digital outputs can source up to 6 amps.

General

Feature	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	Status indication provided. The GUIDE pin status requires a load of 1000 mA to be connected or an open status 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 and diagnostic capability is maintained.
Shut off	Processor control with hardware Watchdog override

Specifications

Description	Units	Minimum	Maximum	Comments
Allowed voltage at pin	Vdc	0	36	See caution statement below
Output voltage, energized state	Vdc	Vbatt-1.0	Vbatt	Over all load conditions
Output voltage, off state	Vdc	0	0.1	At Rload=200Ω
Output current range for status bit to read OK	A	1	6	See pair comment above

Caution

Damage to the module outputs may occur. If battery voltage is applied to a module output pin the module will be powered up. If significant current is driven through an output pin, the module will be damaged.

Outputs (continued)

Proportional (PWMOUT/DOUT/PVGOUT)

All PLUS+1 Module proportional outputs are PWM. PWM frequency is software adjustable using GUIDE. A low frequency dither may also be added with software to any of the outputs. There are two modes of PWM operation: Open loop and closed loop.

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.

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.

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

General

Feature	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
Shut off	Shut off condition is either Tri-state drive output or power to PVG removed; processor control with hardware Watch Dog override
Mode selection (current or voltage) and full scale current ranges	Programmable

Outputs (continued)

Proportional (PWMOUT/DOUT/PVGOUT) (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		0.5	
Output settling time	ms		100	Depends on load characteristics
PWM frequency	Hz	33	4000	Some pins have a fixed frequency, consult module application program interface (API)
Dither frequency	Hz	33	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	5.25	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.

MC088-XXX Output Power Distribution

The power distribution design of the MC088 module is different from that of other PLUS+1 modules. MC088 controllers have four discrete power planes and a separate dedicated power supply for the microprocessor.

Each module output pin is associated with a specific power plane. See the module data sheet for a map of outputs, their associated power plane, and power plane fusing recommendations.

CAN (Controller Area Networks) Ports

System Design

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

The second (CAN1) port on MC050-010 and MC050-020 controllers may not interface with the PLUS+1 Service Tool, depending on the version of .hwd file used to build the application. MC050-010 .hwd files version 190 and higher allow communication with the PLUS+1 Service Tool. MC050-020 .hwd files version 150 and higher allow communication with the PLUS+1 Service Tool. Regardless of .hwd version, CAN1 port cannot be used to download GUIDE application programs.

⚠ Warning

Potential uncommanded machine movement. 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 uncommanded 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		

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-device 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

	Estimated device bus load (using default update and 250K bus speed	Estimated device bus load (using 70 ms updates and 250K bus speed	RAM usage on MCO24-XXX	RAM usage on MC050-XXX	Flash usage on MC024-XXX	Flash usage on MC050-XXX	Flash usage on MC088-XXX
IX012	4%	2%	9%	1%	8%	3%	3%
IX024	10%	5%	12%	1%	11%	4%	4%
OX012	11%	3%	9%	1%	12%	4%	4%
OX024	27%	8%	14%	2%	18%	6%	6%
IOX012	11%	4%	9%	1%	10%	3%	3%

Power

Module Supply Voltage/Maximum Current Ratings

PLUS+1 modules are designed to operate with a nominal 9 to 32 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

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 devices on a machine.

Sensor Power Supply Ratings

PLUS+1 modules that support sensor inputs are provided with dedicated regulated sensor power supply and ground pins. Refer to individual product data sheets for sensor power supply current ratings. The sensor power is nominally 5 Vdc, unless otherwise noted.

General

Feature	Comment
Short circuit to ground	Output is not damaged and fault is detected
Short circuit to battery +	Will not energize an otherwise un-powered controller; output is not damaged and fault is detected

Specifications

Description	Units	Minimum	Maximum	Comment
Output short circuit voltage	Vdc		36	
Output voltage	Vdc	4.88	5.12	
Ripple voltage	mVrms		5.0	
Output current	mA			Refer to individual data sheets for sensor power supply ratings
Output Load Capacitance	µF		10	
Hold up time after power loss	ms	5	15	

PVG Valve Power Supply

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

When enabled, the DOUT/PVG Pwr pin passes battery (reference) voltage to the PVG valve electronics. One DOUT/PVG Pwr pin can power up to 3 PVG valves. Refer to individual module API documents for PVG power pin characteristics.

EEPROM

EEPROM Write/Erase Ratings

Specifications

Description	Minimum	Maximum	Comment
EEPROM write/erase cycles (all modules except IX012-010, IX024-010)	1,000,000		Minimum valid over entire operating temperature range
EEPROM write/erase cycles (IX012-010, IX024-010)	10,000		Minimum valid over entire operating temperature range

Vault Memory

Some variants of PLUS+1 modules have 2 MB of 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.

General, Maximum, and Environmental

General Ratings

Description	Comments
Reversed polarity protection	Modules will withstand reversed polarity at supply voltage
Short circuit protection	All inputs and outputs will withstand continuous short circuit to any other leads; when the short circuit is removed, the module will return to normal function
Automotive electrical transients	ISO 7637/1 electrical disturbance by conduction part 1, 12 Vdc supply
	ISO 7637/2 electrical disturbance by conduction part 2, 24 Vdc supply
	ISO 7637/3 electrical disturbance by conduction and coupling part 3: electrical transient transmission by capacitive and inductive coupling via lines other than supply lines
EMC	Modules conform to 89/336/EEC Directive
	ISO 14982 Agricultural and forestry machinery
	ISO 13766 Earth moving machinery
EMC emission	Modules conform to EN 61000-6-3
	EMC generic standard for emission, residential and light-industrial environments
EMC immunity	Modules conform to EN 61000-6-2 and the following:
	HF immunity: 100 V/m including 1 kHz AM 80%
	14 kHz to 30 MHz: ISO 11 452 *stripline*
	30 MHz to 2.5 GHz: ISO 11452-2 *absorber lines chamber*
Electrostatic discharge	EN 61000-4-2 Electromagnetic compatibility—Electrostatic discharge immunity test: 8 kV air discharge, 8 kV contact

Absolute Minimum/ Maximum Ratings

Description	Units	Minimum	Maximum	Comment
Operating temperature	°C [°F]	-40 [-40]	70 [158]	
Storage temperature	°C [°F]	-40 [-40]	100 [212]	
Supply voltage	Vdc	9	36	
Sensor voltage	Vdc	4.8	5.2	
Analog input levels	Vdc		36	
Output load current (per pin)				See individual module date sheets
Module total output current				See individual module data sheets

All PLUS+1 modules are CE compliant

General Comments

PLUS+1 Modules Environmental Ratings

Environmental Ratings

EMI	ESD	Mechanical Environment	Climate Environment
ISO 11452-2	EN 61000-4-2 (External)	IEC 60068-2-64 (Random, 10-250 Hz)	IEC 60068-2-38 (Temperature and humidity)
		IEC 60068-2-27 (Shock, 11 ms)	IEC 60529 (Degrees of protection)
		IEC 60068-2-29B (Bump, 6 ms)	DIN 40050 (High pressure wash)
		IEC 60068-2-32 (Free fall, 1000 mm)	IEC 60068-2-11 test Ka (Salt mist)
			IEC 60068-2-1 tests Ab, Ad (Cold test)
			IEC 600-2-2 tests Bb, Bd (Dry heat)
			IEC 60068-2-30 test Db (Cyclic damp heat)
			IEC 60068-2-14 test Nb (Temp change)
			ISO/DIS 16750-5 (Chemical resistance)

The PLUS+1 module IP 67 rating is only valid when the module mating connector is in place.

Mating connectors must have proper sealing plugs on all unused connector pins.

Housings

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

General Comments (continued)

Mating Connectors

PLUS+1 modules use Deutsch® connectors. Sauer-Danfoss has assembled a mating connector kit, referred to as a bag assembly, for the 12, 24, 50, and 88 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	12 pin module	24 pin module	50 pin module	88 pin module	
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)	HDT48-00 (solid contacts) (20 to 24 AWG, 12 to 14 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: 0462-201-12031 (20 to 24 AWG)	Solid: 0462-201-12031 (20 to 24 AWG)	Solid: 0462-201-12031 (20 to 24 AWG)	Solid: 0462-201-12031 (20 to 24 AWG)	
	Stamped: 1062-20-0144 (16 to 20 AWG)	Stamped: 1062-20-0144 (16 to 20 AWG)	Stamped: 1062-20-0144 (16 to 20 AWG)	Solid: 0462-201-12141 (12 to 14 AWG)	
Connector plug	Gray A-Key DTM 06-12SA	Gray A-Key DTM 06-12SA Black B-Key DTM 06-12SB	DRC26-50S01	DRC26-50S01 DRC26-38S01-P017	
Wedge	WM-12S	WM-12S	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]	20 to 24 AWG	12 to 14 AWG
				3.96 to 5.54 mm [0.156 to 0.218 in]	6.43 to 0.79 mm [0.253 to 0.031 in]
Rear seal maximum insulation OD	3.05 mm [0.120 in]	3.05 mm [0.120 in]	2.41 mm [0.095 in]	20 to 24 AWG	12 to 14 AWG
				2.41 mm [0.095 in]	4.32 mm [0.17 in]
Sealing plugs	0413-204-2005	0413-204-2005	0413-204-2005	0413-204-2005, 114017	

Sauer-Danfoss Mating Connector Part Information

Description	12 pin module	24 pin module	50 pin module	88 pin module
Mating connector bag assembly (20 to 24 AWG)	10100944	10100945	10100946	10105649
Mating connector bag assembly (16 to 20 AWG)	10102025	10102023	10102024	

Sauer-Danfoss Crimp Tool Part Information

Description	Part number
Crimp tool for 20 to 24 AWG	10100745
Crimp tool for 16 to 20 AWG	10102028

The 50 pin module mating connector may be mated 10 times.

Recommended torque for the Deutsch® mating connector retaining fastener on 38 and 50 pin connectors is 20 lb•in (2.26 N•m).

Product Installation

Mounting

PLUS+1 12, 24, and 50 pin modules can be mounted in one of three ways:

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

MC088-XXX modules are designed for bulkhead mounting only.

In each case, care must be taken to insure that the module connector is positioned so that moisture drains away from the module. 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 MC050-XXX 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 devices 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.

Welding on a machine equipped with PLUS+1 modules

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.

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

Notes

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