Tech Note

CAN bus components

Introduction

HN.50.Y1.02 is new

Introduction

Danfoss has introduced a new remote control system with CAN bus components that will give customers greater flexibility as far as their particular application needs are concerned. In the new series, focus has been particularly concentrated on:

- Improved performance
- Lower installation costs
- Easier servicing
- Improved safety
- Flexibility

CAN components can be used together with PVG 32, PVG 120 and PVG 83.

What is CAN bus

The CAN (Controller Area Network) bus was originally designed for the automobile industry. It is a serial communication interface in which special emphasis is placed on the following parameters:

- Safety
- Reliability
- Real time control
- Costs (installation/service)

CAN communication

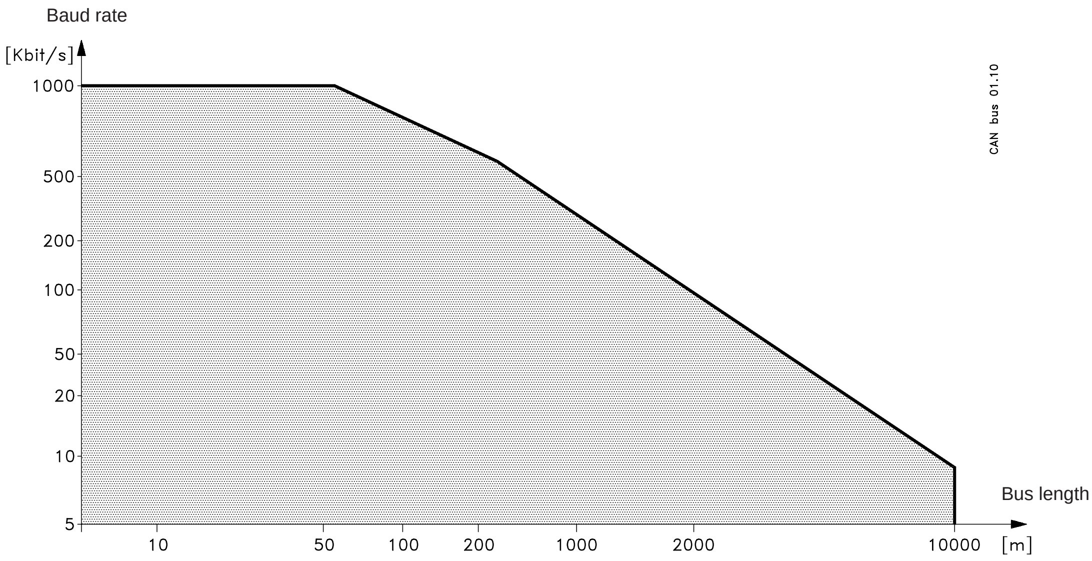
CAN communication is best understood in the following way:

Instead of sending a message from component A to unit B, it is broadcast. Each component, a PVG CIP for example, is then able to listen in and col-lect information relevant to it selv. The message format is designated COB (Communication Object), which applies to all messages.

A COB has an identification code (COB-ID) that makes it possible for a component, a PVG CIP for example, to sort and prioritise transmitted communication objects (COBs). The COB-ID clearly identifies the COB in a network.

CAN communication works on the prioritising of messages, thus CAN uses familiar and established methods such as CSMA/CA (Carrier Sense, Multiple Access with Collision Avoidance) with improved capability to avoid collision (non-destructive bit arbitration). This means that the message with the lowest identification code will have access to the bus before other messages, ensuring that the capacity of the bus can be utilised to the maximum.

The speed of the bus is limited by its length, see below.



CANopen

CAN components communicate using a protocol. A protocol can be compared to a language. The different protocols on the market are adapted to the applications in which they are used.
The CANopen protocol is particularly suitable for mobile applications. There are many suppliers on the market whose products work together with CANopen, therefore it is easy to put together a comprehensive CANopen system.

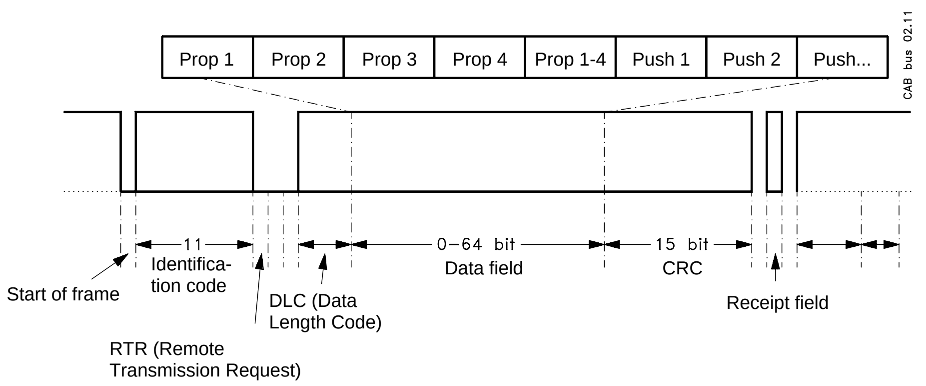
CANopen uses objects for communication. The most common are:

Service Data Object(SDO)
SDOs transfer large amounts of information that is not time-critical eg setting-up parameters.

Process Data Object (PDO)
PDOs are used to transfer data that are time-critical. For example, joysticks transfer signals via PDOs.

NMT is a special part that handles emergency situations and other network administration.
Via an emergency object, the individual nodes (components) are able to send a warning of emergency situations. In this way, other CANopen components are able to identify the node point from which the emergency call was sent.

CANopen specifies an Object Dictionary (OD) that describes all parameters in the product. This OD does not function solely as a specification file, but also as an interface with other CANopen devices. In other words, a description is given detailing which parameters are necessary to activate the different functions the product can perform.



The example above shows the structure of a joystick COB.

1. A COB is started by sending a 0 (start of frame).
2. An identification code (COB-ID) is sent and through bit arbitration the message having the lowest bit identification code is allowed to continue.
3. RTR (Remote Transmission Request) specifies whether the sender wishes to receive or send data to the message receiver.
4. DLC specifies the length of the data field.
5. The data field contains information on, for example, joystick data.
6. The CRC field is used as a safety control for finding bit error.
7. The receipt field is a position in which all other components acknowledge receiving a message.

Danfoss CAN concept

CAN components supplied by Danfoss can be identified from the abbreviation CIP (CAN Interfaced Product). We supply the following:

- PVG CIP
- Prof 1 CIP
- CIP Configuration Tool

Our objective is to supply CAN components which are not only capable of communicating with our own products, but also with other standard available components. There are many suppliers of CANopen components on the market and therefore it is simple, inexpensive and very flexible to set up a comprehensive system.

The CIP Configuration Tool is designed to guide hydraulic system designers/ service technicians through system setup.

Prof 1 CIP

The Prof 1 CIP joystick is available in many mechanical configurations. To simplify the way in which this information is shown in the COB, the maximum configuration possibilities are always built in. Depending on the actual configuration of the joystick, some of the fields for proportional or on/off signals contain no information. The joystick sends information on the first PDO (Process Data Object). As standard, it sends cyclically at T_c = 10 ms.
The Emergency Object is used if a fault arises in the joystick.

Prof 1 CIP can be ordered as described in Tech Note HN.50.Z3 Joystick Prof 1. New modules for Prof 1 CIP are shown in the table below.

Prof 1 CIP contains new functions often requested in hydraulic systems:

Joystick guide (x - y interlook)
This function ensures that only the first proportional signal activated from the control lever is sent (prop 1 or prop 2).

Memory function
This function makes it possible for the user to hold a proportional function by pressing a selected memory button (on/off) in the joystick. The associated proportional signal can be deactivated by pressing the memory button again or by activating the proportional function in the opposite direction.

Name	Code no. 162B....	Pos. no. in code no. list	Description
Cable	6100	6	Length 230 mm with AMP 282404-1, male plug AMP 282107-1, tab house
Main function module with electronics	5100	5	CAN electronics

PVG CIP

PVG CIP is designed to control up to eight sections equipped with PVEO, PVEM, PVEH or PVES, and versions with float position control.
PVG CIP is able to receive COBs sent in joystick format from four joysticks or other sources. The joystick signals are distributed to the PVEs in relation to the actual setup. The CAN signals are converted to proportional or on/off values on the output pins of the module.
PVG CIP contains functions often used in hydraulic systems:

- Two different ramps (principle 1 from EH boxes)
- Flow limitation
- Deadband compensation
- Gain
- Software tuning of spool characteristics
- Spool float position control
- Power saving
- Service and diagnosing
- Softwiring

PVG CIP must be ordered as a separate component with code number as follows.

Name	Code no. 155U....	Description
PVG CIP	5660	With AMP plug 1-967280-1, male plug

CIP Configuration Tool

The CIP Configuration Tool is a program developed for setting up systems consisting of PVG CIP and Prof 1 CIP.

Name	Code no. 155U....	Description
CIP Configuration Tool	5670	Product contents • CIP Configuration Tool • CIP Downloading Utility • CANview • CAN dongle • Documentation, examples, help files

Technical data

Common to PVG CIP & Prof 1 CIP

Power supply

Supply voltage	U_{dc}	10 - 30 V DC
Max. supply voltage		36 V DC
Max. pulsation (peak to peak)		5%

CAN interface - ISO 11898 ver. 2.0 B

Baud rate	10 Kbit/s - 1000 Kbit/s
Communication profile	CANopen ver. 3.0
Typical start-up time	< 500 ms
CAN	Full CAN

EMC - EMC Directive (89/336/ECC)

Emission	EN 50081-2
Immunity	EN 50082-2
HF immunity	ISO 14892 (60 V/m, 20 MHz - 1000 MHz)
	ISO 13766 (60 V/m, 20 MHz - 1000 MHz)

Environmental data

Ambient temperature	Storage temperature	-40°C to +90°C
	Operating temperature	-30°C to +70°C

Termination

A CAN bus must be terminated at both ends where CAN+ and CAN- are to be connected via a 120 Ω resistor.

Termination can be effected by connecting a jumper between the pins given below (a 120 Ω resistor is fitted in the component).

Prof 1 CIP	
CAN_TERM	Pin 1
CAN+	Pin 4

PVG CIP	
CAN_TERM	Pin 16
CAN+	Pin 3

References

ISO 11898	Vehicles, interchange of digital information - Controller Area Network (CAN) for high-speed communication
CANopen	CANopen communication profile for industrial systems, CiA standard draft 3.0 Revision 3.0
EMC Directive	89/336/ECC
ISO 14892	Agricultural and forestry machines - electromagnetic compatibility
ISO 13766	Earth-moving machinery - electromagnetic compatibility

Prof 1 CIP data format

The data format is independent of the mechanical configuration. It is manufactured so that a signal for an 8-bit processor can be extracted without signal manipulation. This gives 8-bit signal resolution, and in order to get full resolution (10 bit) signal manipulation is necessary. This is standard on PVG CIP. The data format is "twos complement" and is shown in the figure below.

1 byte	SIGN----MSB -----Prop1-----							
2 byte	SIGN----MSB -----Prop2-----							
3 byte	SIGN----MSB -----Prop3-----							
4 byte	SIGN----MSB -----Prop4-----							
5 byte	rest_Prop4 - LSB		rest_Prop3 - LSB		rest_Prop2 - LSB		rest_Prop1 - LSB	
6 byte	Push 8	Push 7	Push 6	Push 5	Push 4B	Push 4A	Push 3B	Push 3A
	8 bit	7 bit	6 bit	5 bit	4 bit	3 bit	2 bit	1 bit

SIGN = +/–
MSB = Most significant bit
LSB = Least significant bit

PVG CIP specification

Electrical

PVE outputs	8
PVE types that can be connected	PVEO, PVEM, PVEH, PVES incl. versions with float position
PVPX/PVPE outputs	1
Resolution	9 bit (-100% to +100%)
Plug type (Only part no. 1-967280-1 supplied with PVG)	AMP part no. 1-967280-1, PCB-connector
	AMP part no. 1-967281-1, Timer house
	AMP part 0-929937-1, junior contact
	AMP part 0-962876-2, micro contact
	AMP part no. 0-965643-1, cover
	Seals and plugs
CAN setting	Slave only

Plug connections

Pin number	Name	
1	PVPX out	
2	CAN+	
3	CAN+	
4	Alarm_1	
5	Alarm_2	
6	Gnd	
7	Alarm_3	
8	Alarm_4	
9	Alarm_5	
10	Gnd	
11	Alarm_6	
12	Alarm_7	
13	Alarm_8	
14	Gnd	
15	U_{dc}	
16	CAN_TERM	
17	Gnd	
18	PVE1_A ♣	PVE1 signal ∇
19	PVE2_A ♣	PVE2 signal ∇
20	PVE3_A ♣	PVE3 signal ∇
21	Gnd	

Pin number	Name	
22	PVE4_A ♣	PVE4 signal ∇
23	PVE5_A ♣	PVE5 signal ∇
24	PVE6_A ♣	PVE6 signal ∇
25	Gnd	
26	PVE7_A ♣	PVE7 signal ∇
27	PVE8_A ♣	PVE8 signal ∇
28	Gnd	
29	U_{dc}	
30	CAN-	
31	CAN-	
32	PVE1_B ♣	PVE1 U_{dc} ∇
33	PVE2_B ♣	PVE2 U_{dc} ∇
34	PVE3_B ♣	PVE3 U_{dc} ∇
35	Gnd	
36	PVE4_B ♣	PVE4 U_{dc} ∇
37	PVE5_B ♣	PVE5 U_{dc} ∇
38	PVE6_B ♣	PVE6 U_{dc} ∇
39	Gnd	
40	PVE7_B ♣	PVE7 U_{dc} ∇
41	PVE8_B ♣	PVE8 U_{dc} ∇
42	Gnd	

♣ When using PVEO
∇ When using PVEM/H/S

PVEM/H/S

Voltage, neutral position		50% of U_{dc}
Voltage, full flow port A		25% of U_{dc}
	Version with float position control	35% of U_{dc}
Voltage, full flow port B		75% of U_{dc}
	Version with float position control	65% of U_{dc}
Voltage, float position control	Version with float position control	80% of U_{dc}
Alarm input signals	Low	< 1,6 V
	High	> 85% of U_{dc}
Max. linearity deviation		3%
Max. pulsation content	(f > 2 kHz)	5%
Max. band width		10 Hz
Max. output current		± 1 mA

PVEO

Max. output current	1,2 A

PVPE/PVPX

Max. output current	3 A

Note: To ensure maximum safety, the normally open (NO) version of PVPE/PVPX is recommended.

Environmental data

IP classification	IP 66, IEC 529

Prof 1 CIP specification

Electrical

Proportional signals max.		4
Resolution		9 bit (-100% to +100%)
Operating buttons on/off max.		6
DIP switch settings	DIP no. 1	Open = CANopen min. master
		Closed = CANopen slave
DIP switch settings	DIP no. 2	Open = Default baudrate and Node id
		Closed = Baudrate and Node id acc. to OD
Plug type Only part no. 282404-1 and no. 282107-1 supplied		AMP part no. 282404-1, male plug
		AMP part no. 282403-1, female plug
		AMP 282107-1, tab house
		AMP 282089-1, plug house
		Seals and plugs

Plug connections

Pin number	Name
1	CAN_TERM
2	U_{dc}
3	Frame
4	CAN+
5	CAN-

Environmental/mechanical

As analog version

Safety aspects

Both PVG CIP and Prof 1 CIP are designed to give maximum safety. They both incorporate self-test functions, signal protection and 'watchdogs.

The self-test is performed when power is applied and before any of the PVE outputs are activated. The unit then goes to the operating function and a series of running tests are carried out. A list of these tests is given below.

Self-tests

PVG CIP

1. Internal RAM test
2. External RAM test
3. EE-PROM test
4. FLASH test
5. Test of feedback monitoring (tests all outputs for short-circuiting to earth and U_{dc})

Prof 1 CIP

1. Internal RAM test
2. EE-PROM test
3. FLASH test

Running tests

PVG CIP

1. Watchdog
2. PVEH alarms
3. Signal protection

Prof 1 CIP

1. Watchdog
2. Potentiometer control

To ensure optimum system function, two safety levels are used:

- Fail-safe condition
- Alarm condition

Fail-safe condition		Alarm condition
PVG CIP	Prof 1 CIP	PVG CIP
PVE forced to neutral position. Voltage supply to PVE cut off.	Neutral position signal sent from the joystick to all PVEs.	Alarm signal sent on bus so that a third unit is able to take appropriate action.
Alarm signal sent on bus so that a third unit is able to take appropriate action.	Alarm signal sent on bus so that a third unit is able to take appropriate action.	Depending on OD-index 2108 subindex 1, PVPX/PVPE dump valve dumps pressure in alarm condition. Because this is an NO valve (normally open) voltage must be cut off.

Fail-safe condition arises when faults of the following types occur:

PVG CIP

Fault code HEX	Description	PVEs that go into fail-safe condition
1000	Generic fault	All PVEs
5000	System hardware	All PVEs
5001	Self-test fault, internal RAM	All PVEs
5002	Self-test fault, external RAM	All PVEs
5003	Self-test fault, EE-PROM	All PVEs
5004	Self-test fault, FLASH	All PVEs
5005	Self-test fault, feedback test # 1	PVE 1
5006	Self-test fault, feedback test # 2	PVE 2
5007	Self-test fault, feedback test # 3	PVE 3
5008	Self-test fault, feedback test # 4	PVE 4
5009	Self-test fault, feedback test # 5	PVE 5
500A	Self-test fault, feedback test # 6	PVE 6
500B	Self-test fault, feedback test # 7	PVE 7
500C	Self-test fault, feedback test # 8	PVE 8
500D	Self-test fault, feedback test PVPX	All PVEs
5016	Watchdog fault	All PVEs
6300	Joystick data format nonconformance	All PVEs
8100	Communication fault	No PVEs
8101	Protection fault PDO1	PVE controlled by PD01
8102	Protection fault PDO2	PVE controlled by PD02
8103	Protection fault PDO3	PVE controlled by PD03
8104	Protection fault PDO4	PVE controlled by PD04

Prof 1 CIP

Fault code hex	Description
1000	Generic fault
5000	System hardware
5001	Self-test fault, internal RAM
5003	Self-test fault, EE-PROM
5004	Self-test fault, FLASH
5005	Proportional voltage outside range
5007	Proportional signal registered without corresponding direction change
500F	Watchdog fault

Alarm condition arises on faults of the following types:

Fault code HEX	Description
500E	PVEH alarm # 1, pin 3
500F	PVEH alarm # 2, pin 3
5010	PVEH alarm # 3, pin 3
5011	PVEH alarm # 4, pin 3
5012	PVEH alarm # 5, pin 3
5013	PVEH alarm # 6, pin 3
5014	PVEH alarm # 7, pin 3
5015	PVEH alarm # 8, pin 3

The table below shows at which settings PVPX/PVPE dumps in alarm condition.

OD-index 2018 subindex 9 HEX	Activation of PVPX/PVPE
0	No PVPX => must not dump in alarm condition
1	PVPX can be controlled from an external source => must not dump in alarm condition
2	PVPX controlled from an external source, or by alarm condition => must dump in alarm condition

Introduction to PVG CIP

This component is located near the valve and acts as the interface between PVG and CAN bus. The interface can control up to eight PVEs and 1 PVPX/PVPE.

System parameters can be set in the OD (see overview, page 25), either by using CIP Configuration Tool or with a normal CANopen Configuration Tool.

Setting up PVG CIP can be divided into four main parts:

1) Identification of components
   a) Identification of PVE
   b) Identification of PVPX/PVPE

2) Setting up connections
   a) To other components on bus (Prof 1 CIP)
   b) Between data (joystick signals) and PVE/PVPX

3) Setting system-related parameters
   a) Baudrate
   b) Node identification
   c) Softwiring

4) Setting hydraulic-related parameters
   a) Deadband compensation
   b) Signal gain
   c) Flow limitation
   d) Software tuning of spool characteristics
   e) Ramps (individual on each port, two different settings for each port)
   f) Float position control
   g) Power saving

These components also contain facilities for fault location, servicing and restoring factory setting.

Component identification

To be able to communicate with PVG CIP it is necessary to identify the system components:

- Identification of PVE type
- Identification of PVPX/PVPE type

Identification of PVE type

Type identification is used to specify how PVG CIP is to control the PVEs. The types used are specified as follows:

Units	0: Not accessible
	1: PVEO
	2: PVEM
	3: PVEH/S
	4: PVEM (float position control)
	5: PVEH (float position control)
Max.	5
Min.	0
Standard	3 (PVEH/S)
Precision	1
OD index	2018 HEX

PVG CIP output/input will be on the following PVE pins, depending on type

PVE pins	PVEH/S	PVEM	PVEO
1	+	+	Port A
2	Signal	Signal	Port B
3	Alarm	N/A	N/A
⏚	Frame	Frame	Frame

Identification of PVPX

PVPX is used as a safety device for the PVG and dumps to tanks LS pressure in dangerous situations. With PVG CIP it is possible to select whether PVPX is to dump the LS pressure if a fault occurs in PVEH/PVES (pin 3).

In all cases of fault from a PVE of type PVEH/S, PVG CIP will automatically send a fault message on the bus so that an external controller or similar unit is able to react to the information. Whether PVPX is present and whether it must be activated in the case of a PVEH/PVES fault can be determined from the following table.

Note: If an extra component for control of the PVPX is not mapped, it will automatically be actuated upon start-up.

Units	-
	PVPX can be set as follows: 0. PVPX N/A 1. PVPX present • Controlled by external source, e.g. joystick or controller input 2. PVPX present: • Controlled by alarm signal from PVEH/S • Controlled by external source, e.g. joystick or controller input
Max.	-
Min.	-
Standard	0
Precision	-
OD index	2018 subindex 9 HEX

Connections to other components on bus

To set up which joystick or other sources the PVG CIP is to listen to, the relevant COB-ID must be set in the following OD index.
PVG CIP is able to listen to a maximum of four different COB-IDs.

Units	-
Max.	-
Min.	-
Standard	0
Precision	-
OD-index	1400 subindex 1 HEX 1401 subindex 1 HEX 1402 subindex 1 HEX 1403 subindex 1 HEX

Note: If some COB-IDs are not used, they must be set to zero.

Connections between data (joystick signals) and PVE, PVPX/PVPE

To set up the system the joystick on/off and proportional functions must be directed to the correct PVEs and PVPX/PVPE. This can be done by connecting the PVEs to the correct position on the COB. See example on page 21.

Control of dump valves
To ensure that an external controller or a joystick is able to control the PVPX, an on/off signal can be mapped to control it. Because it is NO (normally open) a constant voltage must be applied to PVPX/PVPE so that it does not dump the LS pressure and thereby deactivate the PVG. During an alarm condition, voltage must therefore be removed. In other words, if a joystick is used, the button that is mapped for PVPE/PVPX acts as a deadman's button.

Units	-
Max.	-
Min.	-
Standard	0
Precision	-
OD index	2104 HEX

System-related parameters

To be able to set up and service PVG CIP some system-related parameters have to be set:

- Baudrate
- Node identification
- Softwiring

Baudrate

The speed of communication must be set. The baudrate becomes effective after system reboot.

Note: The baudrates 10 and 800 are not supported by CIP Configuration Tool v.1.00.

Units	[kbit/s]
Max.	1000
Min.	10
Standard	250
Precision	*
OD index	201A HEX

* 10, 20, 50, 100, 125, 250, 500, 800, 1000.

Node identification

Node identification specifies the address PVG CIP has for the other CAN components (applies after system reboot).

Units	-
Max.	127
Min.	1
Standard	101
Precision	1
OD index	100B HEX

Softwiring

With softwiring it is possible for any joystick signal to be sent to one or more PVEs. Softwiring is made via an SDO, making it possible to introduce changes during operation. See example on page 21.

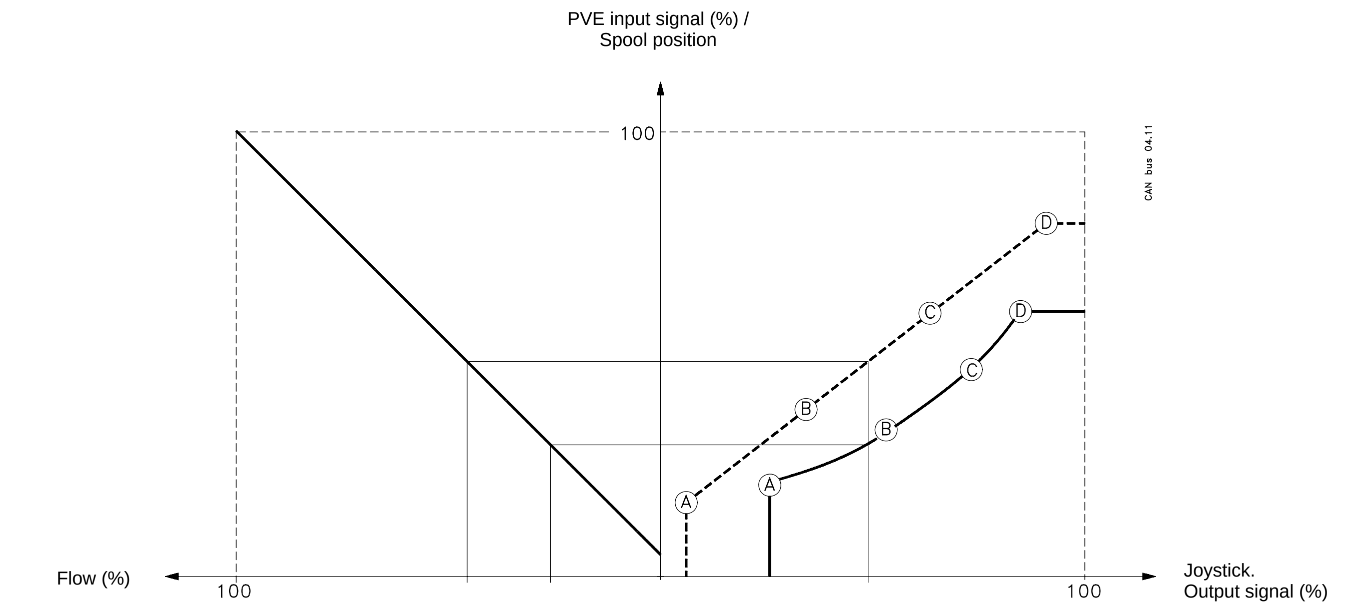
Note: On/off and proportional signals must not be mixed.

Hydraulic-related parameters

PVG CIP contains many parameters that can be adjusted to optimise the input signal before it is sent to a PVE.
These parameters are:

- Deadband compensation
- Signal gain
- Flow limitation
- Software tuning of spool characteristics
- Ramps (individual on each port and two different settings for each port)
- Float position control
- Power saving

The purpose of tuning spool characteristics is to allow software modification of the mechanical spool characteristics made available by the selected spool. See figure on next page. On a given joystick movement, the different software characteristics will give a different spool position and thereby produce another flow.



1. The diagram shows the signal condition for only one port (e.g. port A).
2. Circles indicate parameters that can be set.

The above diagram shows all functions in connection with one port, using four points A, B, C, and D. Points A and D define the limits of the graph and thus the range of the functions that transform a joystick signal to a PVE output in the PVG CIP which then controls the position of the spool in the valve accordingly.

A : Defines deadband compensation and initial flow.

B, C : Defines software tuning of the spool characteristics. Coordinates for B and C are specified to suit the graph and must be scaled every time A and D are changed. This means that seen from points B and C, A always corresponds to (0,0) and D always to (100,100).

D : Defines joystick gain and flow limitation.

Deadband compensation (point A)

This function compensates for the deadband in the PVG spool. The parameters specify a set of coordinates and linear interpolation is performed from (joystick signal, 0) to the function when the deadband compensation is worked out. The function cannot be used in connection with on/off signals.

Joystick signal, PVG CIP output signal

Units	[x, y]: [%,%]
Max.	(100, 100)
Min.	(0,0)
Standard	(0,0)
Precision	(1,1)
OD index	2000 HEX port A x-coordinate
	2001 HEX port A y-coordinate
	2002 HEX port B x-coordinate
	2003 HEX port B y-coordinate

Signal gain (value D_x)

The joystick signal can be scaled with this function. The function cannot be used in connection with on/off signals.

Note: 100% corresponds to normal amplification. Lower figures give larger amplification.

Units [%]	
Max.	100
Min.	25
Standard	100
Precision	1
OD index	2004 HEX port A
	2005 HEX port B

Flow limitation (value D_y)

This function limits the PVE output signal and thereby valve flow. The parameter is specified in percentage since the mechanical characteristics of the PVG CIP spool are not known. The function cannot be used in connection with on/off signals.

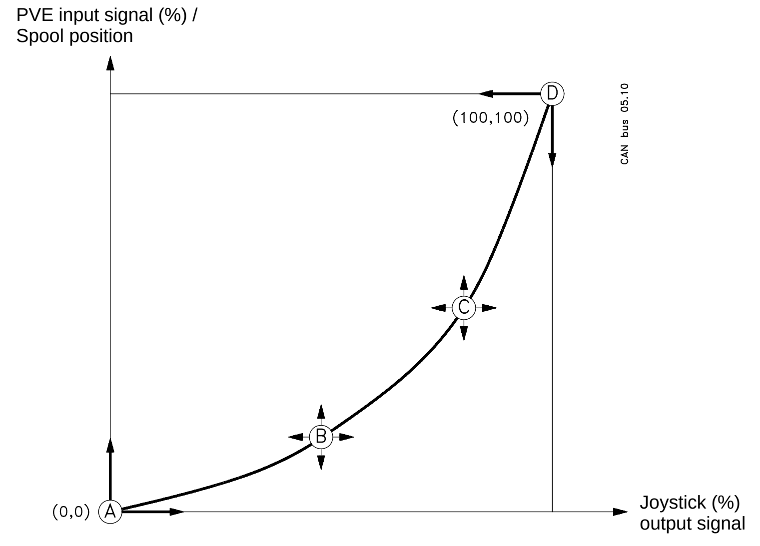
Units	[%]	
Max.	100	
Min.	Ay (from deadband compensation)	
Standard	100	
Precision	1	
OD index	2006 HEX port A	
	2007 HEX port B	

Software tuning of spool characteristics (points B, C)

Used to change spool characteristics. This means that the spool need not be changed when only minor changes are necessary. The spool characteristics obtained are limited by its physical characteristics. The function cannot be used in connection with on/off signals.

Note: Points B and C are specified to suit A and D which always represent (0,0) and (100,100) for this function.

On the basis of the two coordinate sets B and C, the best approximated curve through these points is drawn in. Depending on the position of the points, the curve is either a second-order or third-order polynomial.



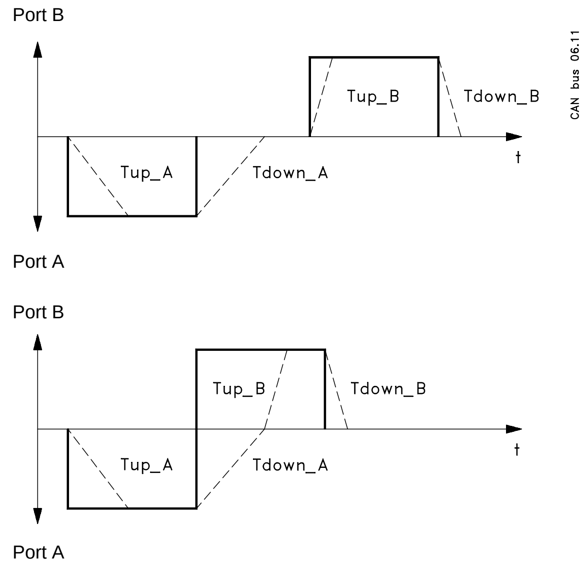
Units	1: (Bxx, Byy)
	2: (Cxx, Cyy)
Max.	(Bx, By) = (100, 100)
	(Cx, Cy) = (100, 100)
Min.	(Bx, By) = (0,0)
	(Cx, Cy) = (0,0)
Standard	1: (33,33)
	2: (66, 66)
OD index	2008 HEX (Bx_ port A)
	2009 HEX (By_ port B)
	200A HEX (Cx_ port A)
	200B HEX (Cy_ port A)
	200C HEX (Bx_ port B)
	200D HEX (By_ port B)
	200E HEX (Cx_ port B)
	200F HEX (Cy_ port B)

Ramps

After signal tuning of points A-D as specified in the previous figure, the signal follows the ramp that is specified here. Two sets of ramps are available for each PVE output (see figure below). Both work on ramp principle 1, familiar in the EHR modules. Fast operation can be obtained by setting Tdown_A and Tdown_B on zero. The function cannot be used in con-nec-tion with on/off signals.

Port A (Tup_A, Tdown_ A)
Port B (Tup_B, Tdown_ B)

Units	[ms]
Max.	(5000, 5000)
Min.	(0,0)
Standard	(0,0)
Precision	1
OD index	2010 HEX (Ramp1 Tup_port A)
	2011 HEX (Ramp1 Tdown_port A)
	2012 HEX (Ramp1 Tup_port B)
	2013 HEX (Ramp1 Tdown_port B)
	2014 HEX (Ramp2 Tup_port A)
	2015 HEX (Ramp2 Tdown_port A)
	2016 HEX (Ramp2 Tup_port B)
	2017 HEX (Ramp2 Tdown_port B)



Ramp switch

Used to select the active ramp setting for a PVG CIP output.

Units	-
	The ramp switch can be set in four ways: 0: No ramps 1: Ramp 1 used permanently 2: Ramp 2 used permanently [ ]: Switch between ramp 1 and ramp 2 using an on/off signal. If this is the case, the address of the on/off (OD index 2100-2103) must be entered in this field.
Max.	3 sec.
Min.	0
Standard	0
Precision	1
OD index	2019 HEX

Float position control function

The float position control function makes it possible to connect ports A and B to tank. This is performed mechanically by a specially designed spool. Two steps are necessary to activate the function:

1. The proportional function connected to the float position control function must be established.

OD index	2104 HEX

The signal for the float position PVE must be activated say more than x% in the direction of port B.

Units	[%]-
Max.	100
Min.	10
Standard	10
Precision	1
OD index	201D HEX

The function can be deactivated in two ways:

- If the joystick is moved towards port A by a signal of more than 10%.
- If the joystick is within 10% signal to both ports A and B and the button is activated.

2. The button used to activate the float position is mapped.

OD index	2105 HEX

Power save time

Defines the time delay from inactivity (PVE signal = neutral) until power to the PVEs is cut off (individually).

Units	[s]
Max.	20
Min.	0 (not connected)
Standard	0
Precision	1
OD index	201C HEX

Fault location/service parameters

The following functions are provided to enable servicing and fault location on PVG CIP:

- Activation of PVE
- Diagnosing
- Restoring factory settings

Enable PVE

This function is used for servicing. It activates or deactivates individual PVE signals, i.e. when the function is deactivated, a neutral signal is sent to the PVE irrespective of the received CAN message.

Units	-
Max.	1 (activated)
Min.	0 (deactivated)
Standard	1
Precision	1
OD index	201B HEX

Diagnosing

When diagnosing it is possible to see the last 25 faults and their types. See fault types under “Safety aspects”, page 9.

Note: The value 0 signifies no fault.

OD index	1003 HEX

Restoring factory settings

Factory settings of all accessible parameters are stored permanently in PVG CIP. This function is used to restore all parameter settings to “Factory standard” by overwriting the existing parameter settings.
Restoring can be performed at several levels by writing a signature “LOAD” in reverse order to the respective subindexes:

- All parameters
- Communication parameters
  - Node ID
  - Baudrate
- Functions
- Connection between Prof 1 CIP and PVG CIP

Units	-
DOAL	64616F6C HEX
Standard	-
Precision	1
OD index	1011 HEX

Introduction to Prof 1 CIP

This component is based on the Prof 1 joystick and can therefore be set up for many mechanical configurations. The joystick also contains other functions often used on the hydraulics market. The associated parameters can be set in the OD (see page 29) either using the CIP Configuration Tool or standard CANopen configuration tools.

Setting up Prof 1 CIP can be divided into four main parts:

1) Setting up the mechanical Prof 1 CIP

2) Setting up hydraulic-related parameters
   a) Guide function
   b) Memory

3) Setting system-related parameters
   a) Baudrate setting
   b) Node identification
   c) Cyclic trigger
   d) Node guarding

4) Fault location and servicing
   a) Restoring factory settings
   b) Diagnosing

Setting up the mechanical Prof 1 CIP

The Prof 1 joystick is available in many mechanical configurations. To simplify the way in which this can be represented in the COB, the maximum configuration is always sent. This means that four proportional and six on/off signals are packed in one COB. Depending on the actual configuration of the joystick, some of the fields for proportional and/or on/off signals carry no information. For the same reason it is not necessary to make any adjustments from joystick to joystick because of different mechanical setups.

Setting up hydraulic-related parameters

Prof 1 CIP also contains functions that are often used in hydraulic systems:

- Joystick guide function. This function prioritises the main axis in the joystick by giving first priority to the axis activated first.

Joystick gate function

Units	-
Max.	1 (function activated)
Min.	0 (function deactivated)
Standard	0
Precision	1
OD index	3002 HEX

- The memory function makes it possible for the user to set the joystick so that it trans fers a proportional signal to the bus even though the joystick is in neutral.
  The proportional signal can be maintained deleted from the memory by pressing a button. This button and the proportional function can be mapped in:

OD index	3007 HEX

The function can be activated/deactivated in:

Units	-
Max.	1 (function activated)
Min.	0 (function deactivated)
Standard	0
Precision	1
OD index	3004 HEX

System-related parameters

To be able to set up and service Prof 1 CIP, the following system-related parameters must be adjusted:

- Baudrate
- Node identification
- Cyclic trigger
- Node guarding

Baudrate

The communication speed must be set. The baudrate comes into effect after system reboot.

Note: The baudrates 10 and 800 are not supported by CIP Configuration Tool v.1.00.

Units	[kbit/s]
Max.	1000
Min.	10
Standard	250
Precision	*
OD index	3000 HEX

* 10, 20, 50, 100, 125, 250, 500, 800, 1000.

Node identification

Node identification specifies which address Prof 1 CIP has.

Units	-
Max.	127
Min.	1
Standard	100
Precision	1
OD index	100B HEX

Cyclic trigger

The joystick sends information on the first PDO (tx). As standard, the joystick transfers cyclically using T_c = 10 ms. NMT is used if a fault arises in the joystick. The NMT object is a standard emergency object in CANopen.

Units	[ms]
Max.	200
Min.	10
Standard	10
Precision	1
OD index	3005 HEX

Node guarding

Used in minimum systems where Prof 1 CIP is master. The function checks whether all components/nodes (max. 20) on the bus work. If they do not, the components involved receive a reset on their Node ID via the CAN bus.

Units	Node ID
Max.	127
Min.	0
Standard	0
Precision	1
OD index	3008 HEX subindex 1-20

Fault location/service parameters

The following functions are provided in Prof 1 CIP for servicing and fault location:

- Diagnosing
- Restoring factory settings

Diagnosing

Here, it is possible to see the last ten faults and their type (see page 9).

Note: The value 0 signifies no fault.

OD index	1003 HEX

Restoring factory settings

Factory settings of all accessible parameters are stored permanently in Prof 1 CIP. This function is used to re-establish all parameter settings to “Factory standard” by overwriting the existing parameter settings.
Re-establishment can be performed at several levels by writing a signature “LOAD” in reverse order to the respective subindexes:

- All parameters
- Communication parameters
  - Node ID
  - Baudrate
- Functions and connections between Prof 1 CIP and PVG CIP

Units	-
DOAL	64616F6C HEX
Min.	0 (deactivated)
Standard	-
Precision	1
OD index	1011 HEX

Introduction to CIP Configuration Tool

This program pack offers the user several different programs for meeting various requirements:

CIP Configuration Tool
Setting up a system consisting exclusively of PVG CIP and Prof 1 CIP via a graphical user interface. It takes the user through setting up a system in an easily understandable and instructive way. It cannot set up components from a third party. However, the hydraulic parameters in PVG CIP and Prof 1 CIP can be adjusted with advantage even though CAN components from a third party are involved.

CIP Downloading Utility
This program enables the adjustment of CANopen parameters on all CANopen components, direct in the OD (see example on page 21).

CANview
CANview is a program able to read the activity taking place on the bus. It is therefore a tool that can be used in servicing.

The program pack also contains a dongle (PEAK) which is the interface between the PC and CAN bus.

P.S. We recommend the use of PEAK's dongle in connection with our software.

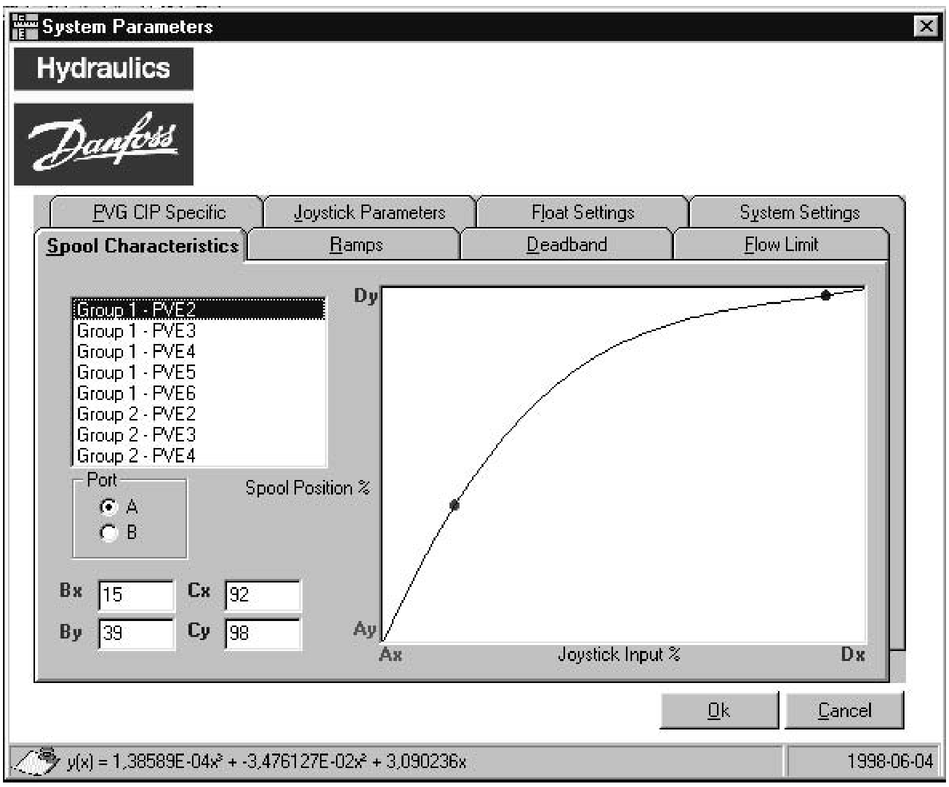
System requirements

- Windows 95 or higher
- Recommended Pentium microprocessor (or higher)
- 16 Mb RAM (recommended)
- PEAK dongle (CAN communication interface)
- PS/2 mouse port

Installation of CIP Configuration Tool

To install a CIP Configuration Tool:

1. Insert the CD-ROM in the CD-ROM drive.
2. From Start, select Run and write x:\setup.exe (where x is the CD-ROM drive).
3. Follow the displayed instructions.



Example of system setup via CIP Downloading Utility

This is an example of setting up the parameters in connecting a Prof 1 CIP joystick with a PVG CIP. The example is divided into steps:

Step 1: Connection of PDOs
Step 2: Setup of PVE types
Step 3: Connections between Prof 1 CIP and PVG CIP outputs

The example is based on the following requirements:

PVG group

Output	Type
1	PVEH
2	PVEO
3	PVEH float position control
4	N/A
5	N/A
6	N/A
7	N/A
8	N/A

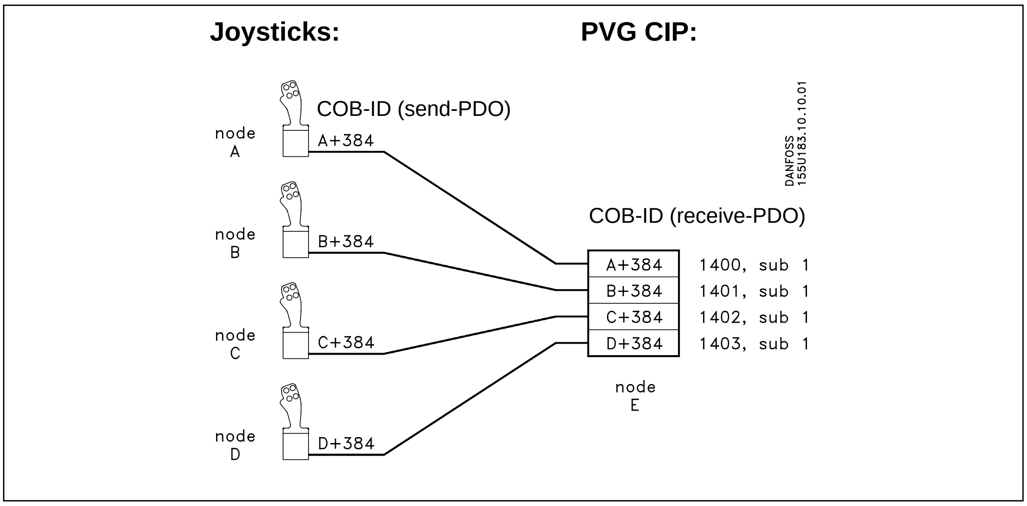
Connection

Prof 1 CIP	PVG CIP
Plug 1	PVE 1
Push 3A	PVE 2 port A
Push 4A	PVE 2 port B
Plug 2	PVE 3 (inverted)
Push 5	PVE 3 (float position (control activated)

Stage 1: Connection of PDOs

To be able to send information between Prof 1 CIP and PVG CIP components, the Prof 1 CIP send-PDO and PVG CIP receive-PDO match each other. Since both comply with the CAN-open standard, the connection must be established by the system designer.

There is a connection between the joystick node ID and the corresponding COB-ID. It is used to send and receive PDOs and is made up as follows:

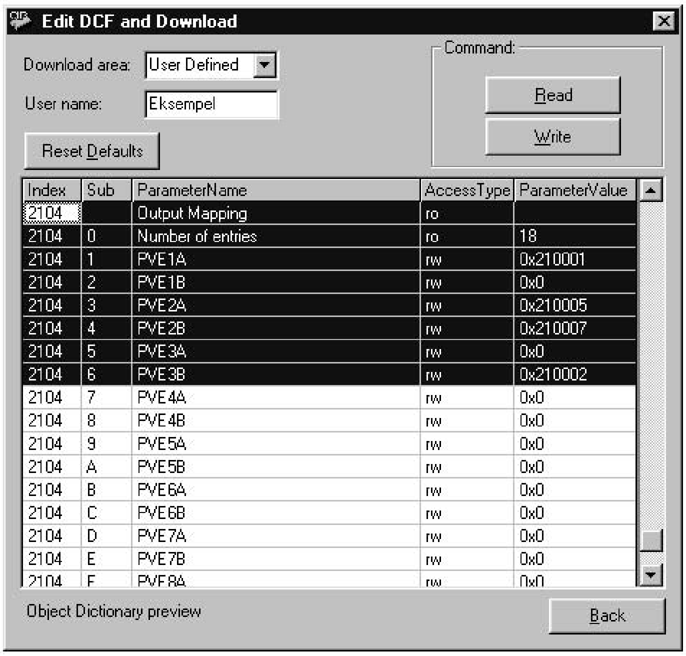


Since the standard ID of Prof 1 CIP is 100, the corresponding send-PDO uses COB-ID: 100+384d = 484d

To connect the PVG CIP to the COB-ID of a Prof 1 CIP it is also necessary to change the PVG CIP receive-PDO to 484d.

This is done by changing the index 1400 HEX, Subindex 1 = 484d, where d states that the figure is decimal.

1400, sub 1



Step 2:
Setting up PVE types

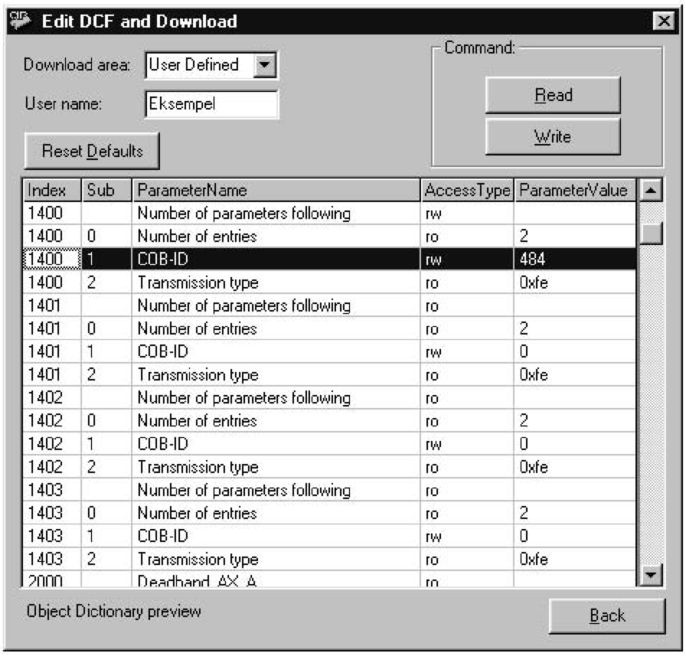
PVE (PVEM/H/S) types are used to select the PVG CIP control function. The types are defined in Index 2018, subindex 1-8 (see page 27).

Applicable PVE types:

Not accessible	0
PVEO	1
PVEM	2
PVEH/S	3
PVEM (float position control)	4
PVEH (float position control)	5

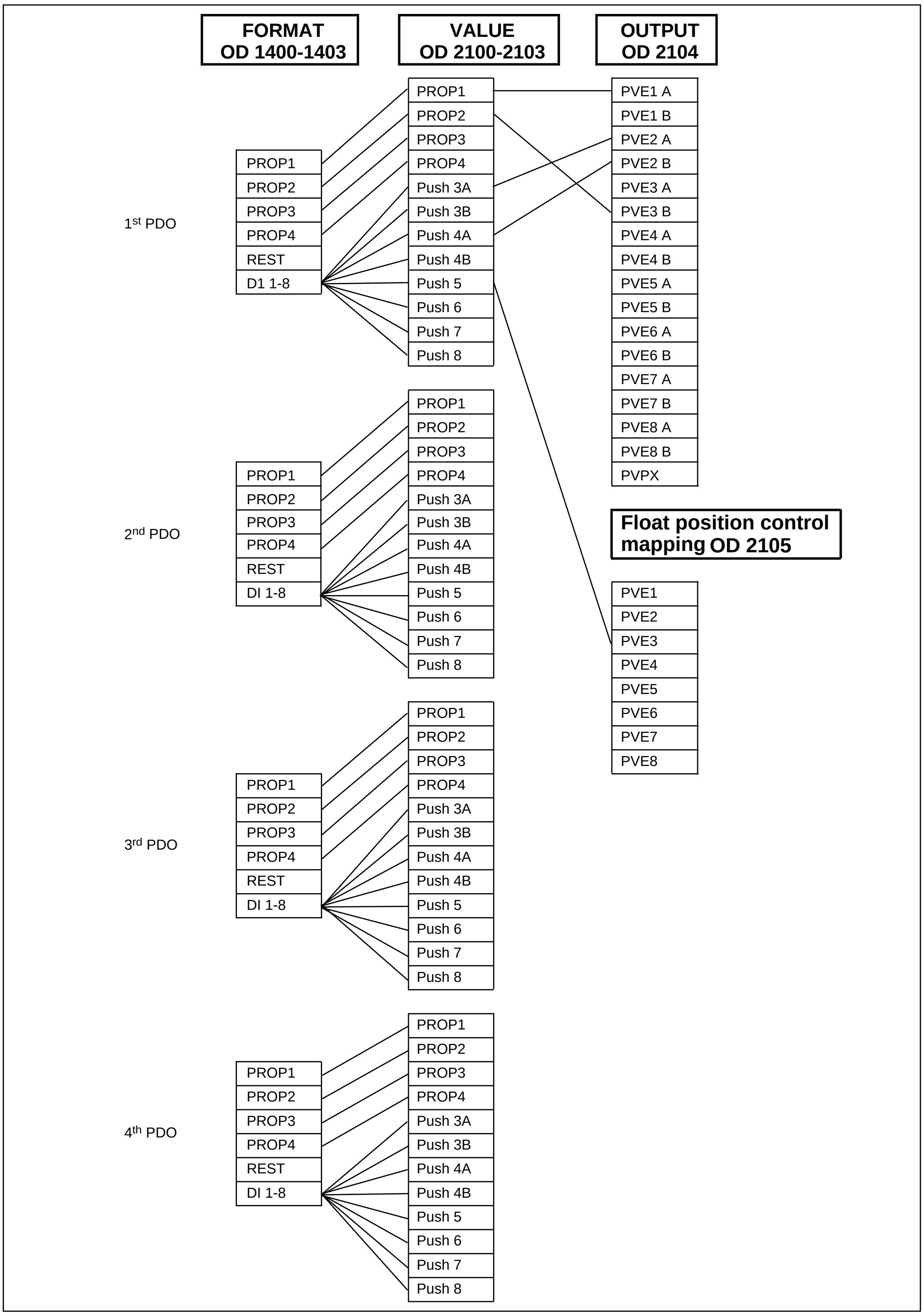
In this example the following changes have:

Screen dump of type setup



Step 3: Connecting joystick signals to PVE outputs

Connections between inputs and outputs in PVG CIP are made as follows:

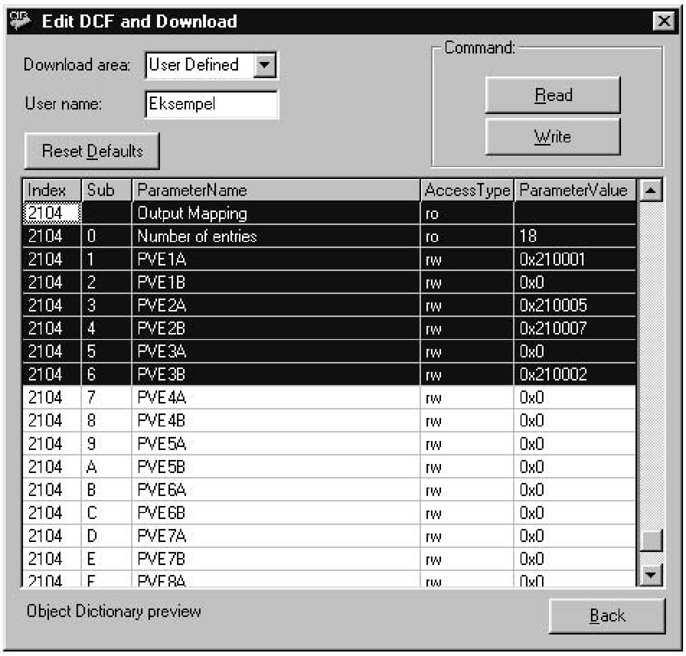


In the PVG CIP OD the inputs have indexes 1400-1403. In this OD range only the format of incoming message is shown, not the values. The values of incoming joystick signals can be read from the index range 2100-2103.

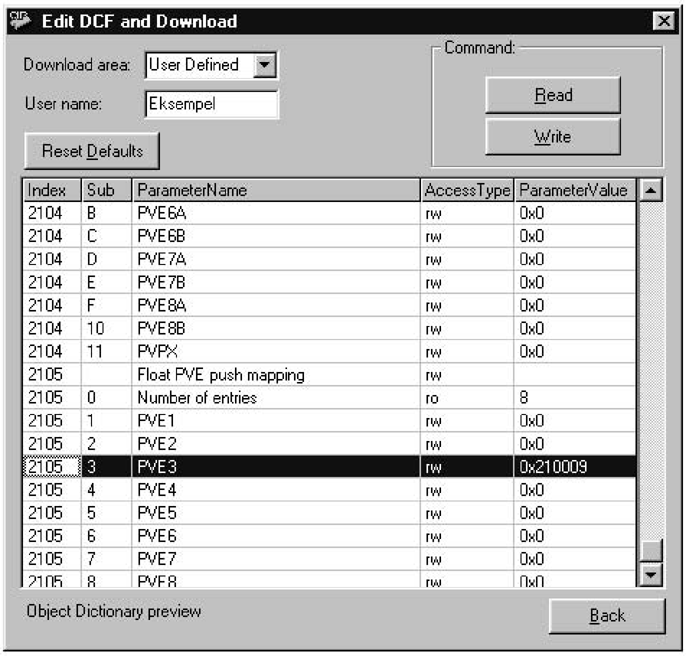
	Index for changing COB-ID, see step 1	Index from which values can be read
1st PDO	1400, sub 1	2100, sub 1-C
2nd PDO	1401, sub 1	2101, sub 1-C
3rd PDO	1402, sub 1	2102, sub 1-C
4th PDO	1403, sub 1	2103, sub 1-C

PVG CIP inputs can be connected with Prof 1 CIP outputs by writing the corresponding value index in the PVG CIP input mapping structure.

This means that in this example we must make the following connections in PVG CIP OD index 2104 HEX.



*)



***) Note:** If a proportional signal is connected to, for example, PVE 3 B instead of A, the signal becomes inverted.

Parameter list 1 of 5 for PVG CIP (shortened version of OD)

Index	Subindex	Parameter Name
1000		Device Type
1001		Error Register
1003		error field
1003	0	Number of errors
1003	1	Standard error code
1004		Number of PDOs supported
1004	0	Number of PDOs supported
1004	1	Number of synchronous PDOs
1004	2	Number of asynchronous PDOs
1008		Manufaturer Device Name
1009		Hardware Version
100A		Software Version
100B		Node-ID
100C		Guard Time
100D		Life time factor
100E		Node guarding ID
1011		Restore parameters
1011	0	Largest supported sub-index
1011	1	Restore all default parameters
1011	2	Restore communication default parameters
1011	4	Restore default function settings
1011	5	Restore default output mapping
1400		Number of parameters following
1400	0	Number of entries
1400	1	COB-ID
1400	2	Transmission type
1401		Number of parameters following
1401	0	Number of entries
1401	1	COB-ID
1401	2	Transmission type
1402		Number of parameters following
1402	0	Number of entries
1402	1	COB-ID
1402	2	Transmission type
1403		Number of parameters following
1403	0	Number of entries
1403	1	COB-ID
1403	2	Transmission type
1600		Input values PDO1 index 1600
1600	0	Number of entries
1600	1	Prop1
1600	2	Prop2
1600	3	Prop3
1600	4	Prop4
1600	5	Rest
1600	6	Push3A
1600	7	Push3B
1600	8	Push4A
1600	9	Push4B
1600	A	Push5
1600	B	Push6
1600	C	Push7
1600	D	Push8
1601		Input values PDO2 index 1601
1601	0	Number of entries
1601	1	Prop1
1601	2	Prop2

Index	Subindex	Parameter Name
1601	3	Prop3
1601	4	Prop4
1601	5	Rest
1601	6	Push3A
1601	7	Push3B
1601	8	Push4A
1601	9	Push4B
1601	A	Push5
1601	B	Push6
1601	C	Push7
1601	D	Push8
1602		Input values PDO3 index 1602
1602	0	Number of entries
1602	1	Prop1
1602	2	Prop2
1602	3	Prop3
1602	4	Prop4
1602	5	Rest
1602	6	Push3A
1602	7	Push3B
1602	8	Push4A
1602	9	Push4B
1602	A	Push5
1602	B	Push6
1602	C	Push7
1602	D	Push8
1603		Input values PDO4 index 1603
1603	0	Number of entries
1603	1	Prop1
1603	2	Prop2
1603	3	Prop3
1603	4	Prop4
1603	5	Rest
1603	6	Push3A
1603	7	Push3B
1603	8	Push4A
1603	9	Push4B
1603	A	Push5
1603	B	Push6
1603	C	Push7
1603	D	Push8
2000		Deadband_AX_A
2000	0	Number of PVEs
2000	1	DBC_1_AX_A
2000	2	DBC_2_AX_A
2000	3	DBC_3_AX_A
2000	4	DBC_4_AX_A
2000	5	DBC_5_AX_A
2000	6	DBC_6_AX_A
2000	7	DBC_7_AX_A
2000	8	DBC_8_AX_A
2001		Deadband_AY_A
2001	0	Number of PVEs
2001	1	DBC_1_AY_A
2001	2	DBC_2_AY_A
2001	3	DBC_3_AY_A
2001	4	DBC_4_AY_A
2001	5	DBC_5_AY_A

Parameter list 2 of 5 for PVG CIP (shortened version of OD)

Index	Subindex	Parameter Name
2001	6	DBC_6_AY_A
2001	7	DBC_7_AY_A
2001	8	DBC_8_AY_A
2002		Deadband_AX_B
2002	0	Number of PVEs
2002	1	DBC_1_AX_B
2002	2	DBC_2_AX_B
2002	3	DBC_3_AX_B
2002	4	DBC_4_AX_B
2002	5	DBC_5_AX_B
2002	6	DBC_6_AX_B
2002	7	DBC_7_AX_B
2002	8	DBC_8_AX_B
2003		Deadband_AY_B
2003	0	Number of PVEs
2003	1	DBC_1_AY_B
2003	2	DBC_2_AY_B
2003	3	DBC_3_AY_B
2003	4	DBC_4_AY_B
2003	5	DBC_5_AY_B
2003	6	DBC_6_AY_B
2003	7	DBC_7_AY_B
2003	8	DBC_8_AY_B
2004		GAIN
2004	0	Number of PVEs
2004	1	GAIN_1_DX_A
2004	2	GAIN_2_DX_A
2004	3	GAIN_3_DX_A
2004	4	GAIN_4_DX_A
2004	5	GAIN_5_DX_A
2004	6	GAIN_6_DX_A
2004	7	GAIN_7_DX_A
2004	8	GAIN_8_DX_A
2005		GAIN_DX_B
2005	0	Number of PVEs
2005	1	GAIN_1_DX_B
2005	2	GAIN_2_DX_B
2005	3	GAIN_3_DX_B
2005	4	GAIN_4_DX_B
2005	5	GAIN_5_DX_B
2005	6	GAIN_6_DX_B
2005	7	GAIN_7_DX_B
2005	8	GAIN_8_DX_B
2006		Flow Limit
2006	0	Number of PVEs
2006	1	FLOW LIMIT_1_DY_A
2006	2	FLOW LIMIT_2_DY_A
2006	3	FLOW LIMIT_3_DY_A
2006	4	FLOW LIMIT_4_DY_A
2006	5	FLOW LIMIT_5_DY_A
2006	6	FLOW LIMIT_6_DY_A
2006	7	FLOW LIMIT_7_DY_A
2006	8	FLOW LIMIT_8_DY_A
2007		FLOW LIMIT
2007	0	Number of PVEs
2007	1	FLOW LIMIT_1_DY_B
2007	2	FLOW LIMIT_2_DY_B
2007	3	FLOW LIMIT_3_DY_B

Index	Subindex	Parameter Name
2007	4	FLOW LIMIT_4_DY_B
2007	5	FLOW LIMIT_5_DY_B
2007	6	FLOW LIMIT_6_DY_B
2007	7	FLOW LIMIT_7_DY_B
2007	8	FLOW LIMIT_8_DY_B
2008		SW TUNE BX A
2008	0	Number of PVEs
2008	1	SW TUNE_1_BX_A
2008	2	SW TUNE_2_BX_A
2008	3	SW TUNE_3_BX_A
2008	4	SW TUNE_4_BX_A
2008	5	SW TUNE_5_BX_A
2008	6	SW TUNE_6_BX_A
2008	7	SW TUNE_7_BX_A
2008	8	SW TUNE_8_BX_A
2009		SW TUNE BY A
2009	0	Number of PVEs
2009	1	SW TUNE_1_BY_A
2009	2	SW TUNE_2_BY_A
2009	3	SW TUNE_3_BY_A
2009	4	SW TUNE_4_BY_A
2009	5	SW TUNE_5_BY_A
2009	6	SW TUNE_6_BY_A
2009	7	SW TUNE_7_BY_A
2009	8	SW TUNE_8_BY_A
200A		SW TUNE CX A
200A	0	Number of PVEs
200A	1	SW TUNE_1_CX_A
200A	2	SW TUNE_2_CX_A
200A	3	SW TUNE_3_CX_A
200A	4	SW TUNE_4_CX_A
200A	5	SW TUNE_5_CX_A
200A	6	SW TUNE_6_CX_A
200A	7	SW TUNE_7_CX_A
200A	8	SW TUNE_8_CX_A
200B		SW TUNE CY A
200B	0	Number of PVEs
200B	1	SW TUNE_1_CY_A
200B	2	SW TUNE_2_CY_A
200B	3	SW TUNE_3_CY_A
200B	4	SW TUNE_4_CY_A
200B	5	SW TUNE_5_CY_A
200B	6	SW TUNE_6_CY_A
200B	7	SW TUNE_7_CY_A
200B	8	SW TUNE_8_CY_A
200C		SW TUNE BX B
200C	0	Number of PVEs
200C	1	SW TUNE_1_BX_B
200C	2	SW TUNE_2_BX_B
200C	3	SW TUNE_3_BX_B
200C	4	SW TUNE_4_BX_B
200C	5	SW TUNE_5_BX_B
200C	6	SW TUNE_6_BX_B
200C	7	SW TUNE_7_BX_B
200C	8	SW TUNE_8_BX_B
200D		SW TUNE BY B
200D	0	Number of PVEs
200D	1	SW TUNE_1_BY_B

Parameter list 3 of 5 for PVG CIP (shortened version of OD)

Index	Subindex	Parameter Name
200D	2	SW TUNE_2_BY_B
200D	3	SW TUNE_3_BY_B
200D	4	SW TUNE_4_BY_B
200D	5	SW TUNE_5_BY_B
200D	6	SW TUNE_6_BY_B
200D	7	SW TUNE_7_BY_B
200D	8	SW TUNE_8_BY_B
200E		SW TUNE CX B
200E	0	Number of PVEs
200E	1	SW TUNE_1_CX_B
200E	2	SW TUNE_2_CX_B
200E	3	SW TUNE_3_CX_B
200E	4	SW TUNE_4_CX_B
200E	5	SW TUNE_5_CX_B
200E	6	SW TUNE_6_CX_B
200E	7	SW TUNE_7_CX_B
200E	8	SW TUNE_8_CX_B
200F		SW TUNE CY B
200F	0	Number of PVEs
200F	1	SW TUNE_1_CY_B
200F	2	SW TUNE_2_CY_B
200F	3	SW TUNE_3_CY_B
200F	4	SW TUNE_4_CY_B
200F	5	SW TUNE_5_CY_B
200F	6	SW TUNE_6_CY_B
200F	7	SW TUNE_7_CY_B
200F	8	SW TUNE_8_CY_B
2010		RAMP1_TUP_A
2010	0	Number of PVEs
2010	1	RAMP1_1_TUP_A
2010	2	RAMP1_2_TUP_A
2010	3	RAMP1_3_TUP_A
2010	4	RAMP1_4_TUP_A
2010	5	RAMP1_5_TUP_A
2010	6	RAMP1_6_TUP_A
2010	7	RAMP1_7_TUP_A
2010	8	RAMP1_8_TUP_A
2011		RAMP1 TDOWN A
2011	0	Number of PVEs
2011	1	RAMP1_1_TDOWN_A
2011	2	RAMP1_2_TDOWN_A
2011	3	RAMP1_3_TDOWN_A
2011	4	RAMP1_4_TDOWN_A
2011	5	RAMP1_5_TDOWN_A
2011	6	RAMP1_6_TDOWN_A
2011	7	RAMP1_7_TDOWN_A
2011	8	RAMP1_8_TDOWN_A
2012		RAMP1 TUP B
2012	0	Number of PVEs
2012	1	RAMP1_1_TUP_B
2012	2	RAMP1_2_TUP_B
2012	3	RAMP1_3_TUP_B
2012	4	RAMP1_4_TUP_B
2012	5	RAMP1_5_TUP_B
2012	6	RAMP1_6_TUP_B
2012	7	RAMP1_7_TUP_B
2012	8	RAMP1_8_TUP_B
2013		RAMP1 TDOWN B

Index	Subindex	Parameter Name
2013	0	Number of PVEs
2013	1	RAMP1_1_TDOWN_B
2013	2	RAMP1_2_TDOWN_B
2013	3	RAMP1_3_TDOWN_B
2013	4	RAMP1_4_TDOWN_B
2013	5	RAMP1_5_TDOWN_B
2013	6	RAMP1_6_TDOWN_B
2013	7	RAMP1_7_TDOWN_B
2013	8	RAMP1_8_TDOWN_B
2014		RAMP2 TUP A
2014	0	Number of PVE's
2014	1	RAMP2_1_TUP_A
2014	2	RAMP2_2_TUP_A
2014	3	RAMP2_3_TUP_A
2014	4	RAMP2_4_TUP_A
2014	5	RAMP2_5_TUP_A
2014	6	RAMP2_6_TUP_A
2014	7	RAMP2_7_TUP_A
2014	8	RAMP2_8_TUP_A
2015		RAMP2 TDOWN A
2015	0	Number of PVEs
2015	1	RAMP2_1_TDOWN_A
2015	2	RAMP2_2_TDOWN_A
2015	3	RAMP2_3_TDOWN_A
2015	4	RAMP2_4_TDOWN_A
2015	5	RAMP2_5_TDOWN_A
2015	6	RAMP2_6_TDOWN_A
2015	7	RAMP2_7_TDOWN_A
2015	8	RAMP2_8_TDOWN_A
2016		RAMP2 TUP B
2016	0	Number of PVEs
2016	1	RAMP2_1_TUP_B
2016	2	RAMP2_2_TUP_B
2016	3	RAMP2_3_TUP_B
2016	4	RAMP2_4_TUP_B
2016	5	RAMP2_5_TUP_B
2016	6	RAMP2_6_TUP_B
2016	7	RAMP2_7_TUP_B
2016	8	RAMP2_8_TUP_B
2017		RAMP2 TDOWN B
2017	0	Number of PVEs
2017	1	RAMP2_1_TDOWN_B
2017	2	RAMP2_2_TDOWN_B
2017	3	RAMP2_3_TDOWN_B
2017	4	RAMP2_4_TDOWN_B
2017	5	RAMP2_5_TDOWN_B
2017	6	RAMP2_6_TDOWN_B
2017	7	RAMP2_7_TDOWN_B
2017	8	RAMP2_8_TDOWN_B
2018		PVE Type Indicator
2018	0	Number of PVEs + PVPX
2018	1	TYPE_1
2018	2	TYPE_2
2018	3	TYPE_3
2018	4	TYPE_4
2018	5	TYPE_5
2018	6	TYPE_6
2018	7	TYPE_7

Parameter list 4 of 5 for PVG CIP (shortened version of OD)

Index	Subindex	Parameter Name
2018	8	TYPE_8
2018	9	PVPX AVAILABLE
2019		RAMP MODE
2019	0	Number of PVEs
2019	1	RAMP MODE_1
2019	2	RAMP MODE_2
2019	3	RAMP MODE_3
2019	4	RAMP MODE_4
2019	5	RAMP MODE_5
2019	6	RAMP MODE_6
2019	7	RAMP MODE_7
2019	8	RAMP MODE_8
201A		Baudrate
201B		ENABLE PVE OUTPUTS
201B	0	Number of PVEs
201B	1	ENABLE_1
201B	2	ENABLE_2
201B	3	ENABLE_3
201B	4	ENABLE_4
201B	5	ENABLE_5
201B	6	ENABLE_6
201B	7	ENABLE_7
201B	8	ENABLE_8
201C		Power saving time
201C	0	Number of PVEs
201C	1	POWER SAVING TIME_1
201C	2	POWER SAVING TIME_2
201C	3	POWER SAVING TIME_3
201C	4	POWER SAVING TIME_4
201C	5	POWER SAVING TIME_5
201C	6	POWER SAVING TIME_6
201C	7	POWER SAVING TIME_7
201C	8	POWER SAVING TIME_8
201D		FLOAT ACTIVATION LEVEL
201D	0	Number of PVEs
201D	1	FLOAT ACTIVATION LEVEL_1
201D	2	FLOAT ACTIVATION LEVEL_2
201D	3	FLOAT ACTIVATION LEVEL_3
201D	4	FLOAT ACTIVATION LEVEL_4
201D	5	FLOAT ACTIVATION LEVEL_5
201D	6	FLOAT ACTIVATION LEVEL_6
201D	7	FLOAT ACTIVATION LEVEL_7
201D	8	FLOAT ACTIVATION LEVEL_8
2100		Input values PDO 1
2100	0	Number of entries
2100	1	Prop1
2100	2	Prop2
2100	3	Prop3
2100	4	Prop4
2100	5	Push3A
2100	6	Push3B
2100	7	Push4A
2100	8	Push4B
2100	9	Push5
2100	A	Push6
2100	B	Push7
2100	C	Push8
2101		Input values PDO 2

Index	Subindex	Parameter Name
2101	0	Number of entries
2101	1	Prop1
2101	2	Prop2
2101	3	Prop3
2101	4	Prop4
2101	5	Push3A
2101	6	Push3B
2101	7	Push4A
2101	8	Push4B
2101	9	Push5
2101	A	Push6
2101	B	Push7
2101	C	Push8
2102		Input values PDO 3
2102	0	Number of entries
2102	1	Prop1
2102	2	Prop2
2102	3	Prop3
2102	4	Prop4
2102	5	Push3A
2102	6	Push3B
2102	7	Push4A
2102	8	Push4B
2102	9	Push5
2102	A	Push6
2102	B	Push7
2102	C	Push8
2103		Input values PDO 4
2103	0	Number of entries
2103	1	Prop1
2103	2	Prop2
2103	3	Prop3
2103	4	Prop4
2103	5	Push3A
2103	6	Push3B
2103	7	Push4A
2103	8	Push4B
2103	9	Push5
2103	A	Push6
2103	B	Push7
2103	C	Push8
2104		Output Mapping
2104	0	Number of entries
2104	1	PVE1A
2104	2	PVE1B
2104	3	PVE2A
2104	4	PVE2B
2104	5	PVE3A
2104	6	PVE3B
2104	7	PVE4A
2104	8	PVE4B
2104	9	PVE5A
2104	A	PVE5B
2104	B	PVE6A
2104	C	PVE6B
2104	D	PVE7A
2104	E	PVE7B
2104	F	PVE8A

Parameter list 5 of 5 for PVG CIP (shortened version of OD)

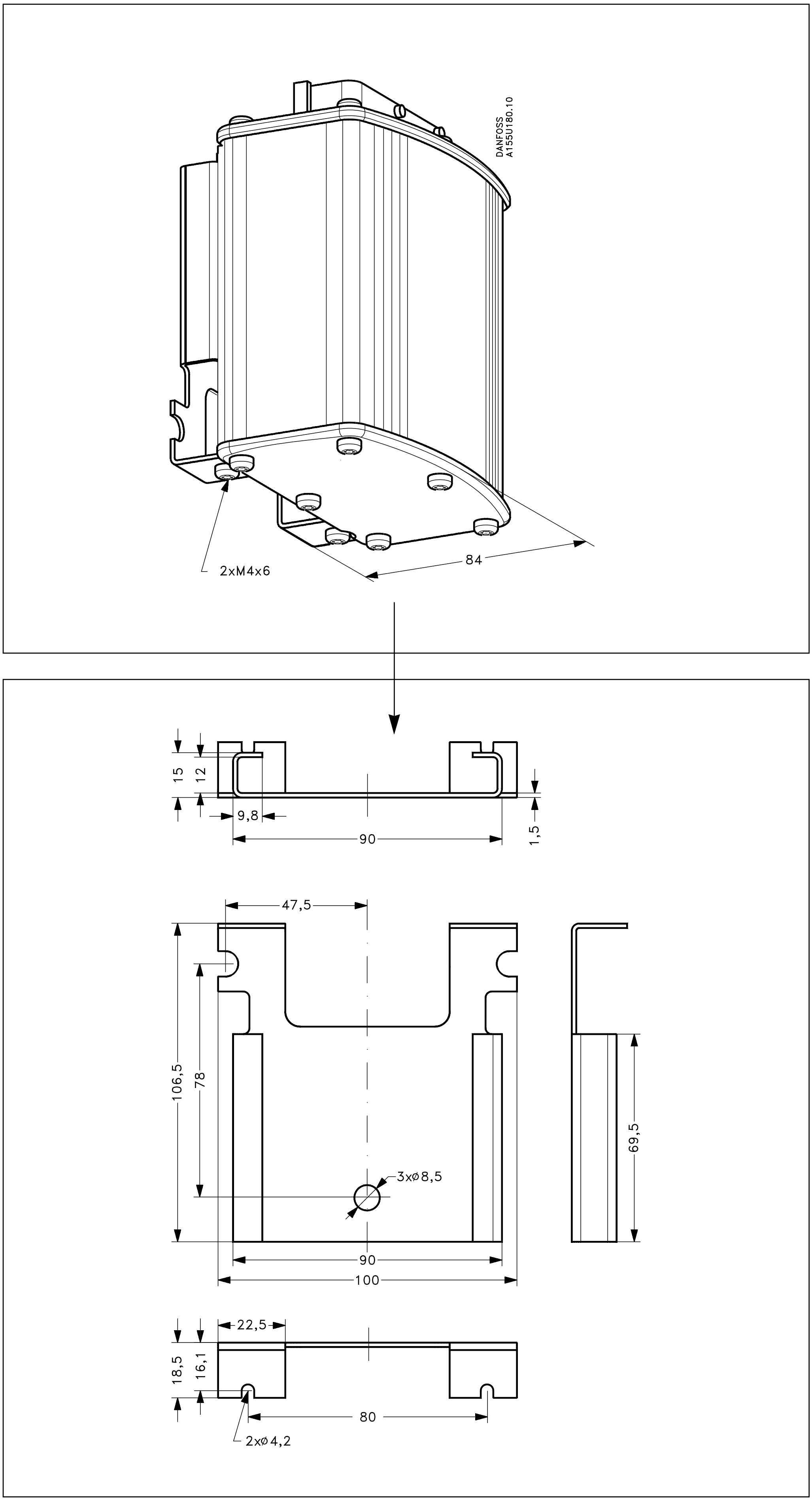
Index	Subindex	Parameter Name
2104	10	PVE8B
2104	11	PVPX
2105		Float PVE push mapping
2105	0	Number of entries
2105	1	PVE1
2105	2	PVE2
2105	3	PVE3
2105	4	PVE4
2105	5	PVE5
2105	6	PVE6
2105	7	PVE7
2105	8	PVE8

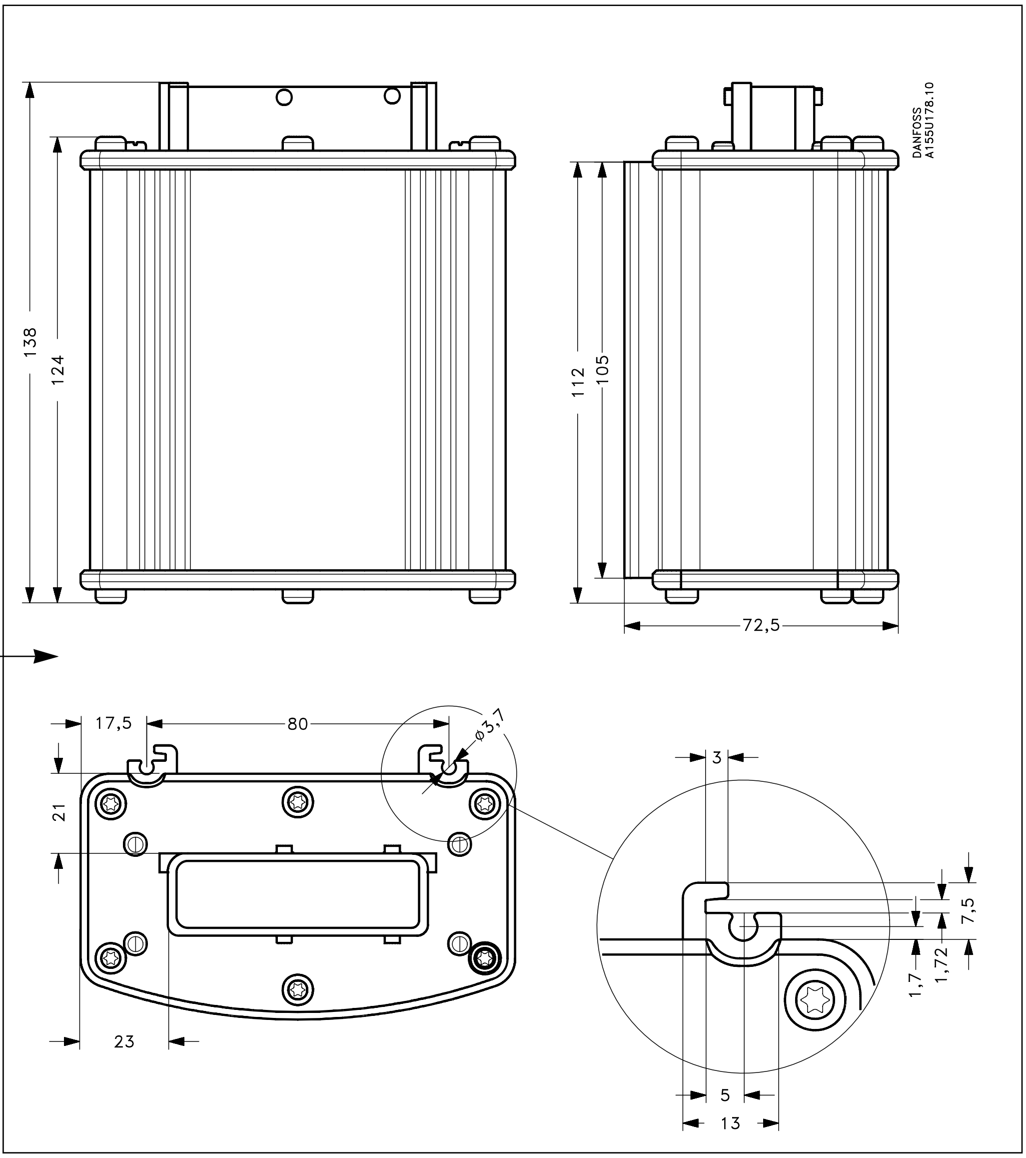
Parameterlist for Prof 1 CIP (shortened version of OD)

Index	Subindex	Parameter Name
1000		Device Type
1001		Error Register
1003		Pre-defined error field
1003	0	Number of Errors
1003	1	Last Error Occured
1004		Number of PDOs
1004	0	Number of PDOs supported
1004	1	Number of synchronous PDOs
1004	2	Number of asynchronous PDOs
1008		Device name
1009		Hardware Version
100A		Software Version
100B		Node-ID
100C		Guard Time
100D		Life time factor
100E		Node guarding ID
1011		Restore parameters
1011	0	Largest supported sub-index
1011	1	Restore all default parameters
1011	2	Restore communication default parameters
1011	4	Restore default function settings
1800		Number of parameters following
1800	0	Number of entries
1800	1	COB-ID used by PDO
1800	2	Transmission type
1A00		Transmit PDO mapping
1A00	0	Number of entries
1A00	1	Analog input 1
1A00	2	Analog input 2
1A00	3	Analog input 3
1A00	4	Analog input 4
1A00	5	Rest of Analog Inputs

Index	Subindex	Parameter Name
1A00	6	Digital input 1
3000		Baudrate
3002		Enable Guide function
3004		Enable Memory function
3005		Cyclic trigger
3006		Mapping structure
3006	0	Number of entries
3006	1	Prop 1
3006	2	Prop 2
3006	3	Prop 3
3006	4	Prop 4
3006	5	Push 3A
3006	6	Push 3B
3006	7	Push 4A
3006	8	Push 4B
3006	9	Push 5
3006	A	Push 6
3006	B	Push 7
3006	C	Push 8
3007		Memory function mapping
3007	0	Number of entries
3007	1	Proportional mapping
3007	2	Button used
6000		Digital input values
6000	0	Number of entries
6000	1	Read_8_Input_1H_8H
6401		Read_Analog_Input_16
6401	0	Number of entries
6401	1	Prop1
6401	2	Prop2
6401	3	Prop3
6401	4	Prop4

PVG CIP dimensions





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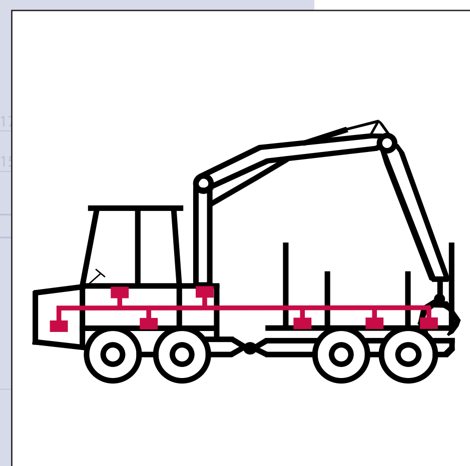
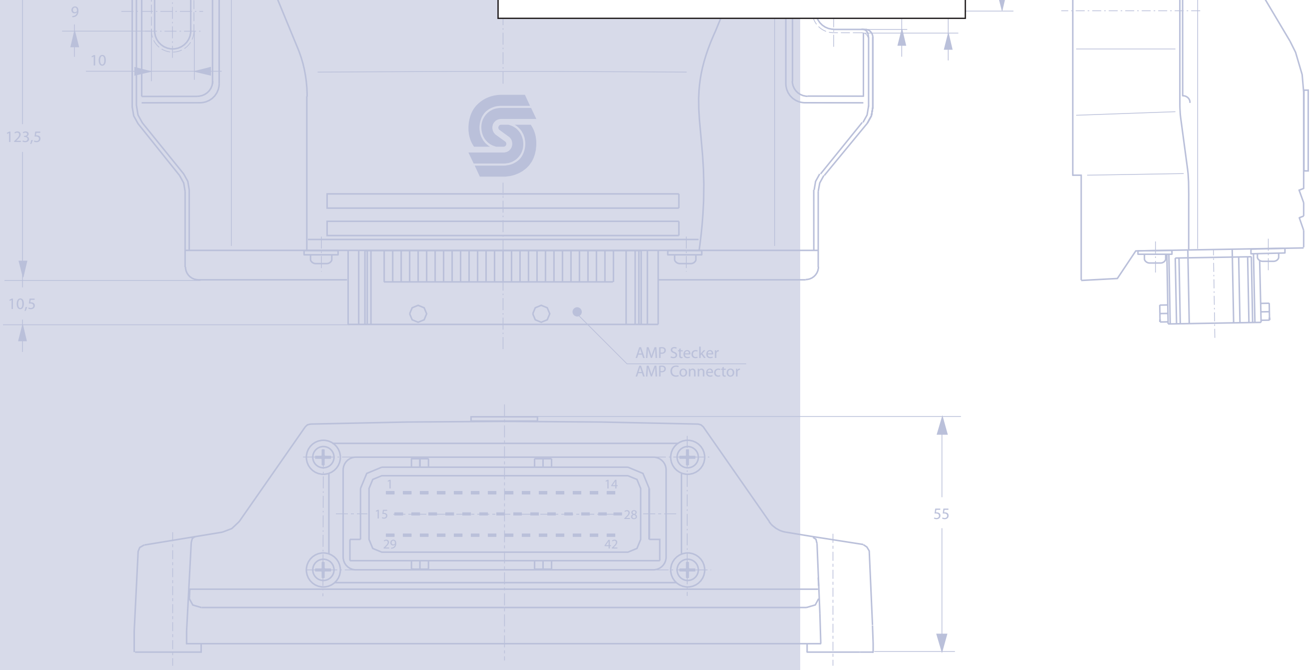
CAN Controller Area Network

Technical Information





HISTORY

Forced by the increasing number of distributed control systems in cars and the increasing wiring costs of electronics, the availability of a powerful and reliable data communication system for the exchange of information between the different control units was becoming urgent.
This was the starting point for BOSCH, a main provider of electronic car equipment to develop the CAN protocol and standardize it as an international standard in ISO 11898. 1989 the first protocol controller chip was provided by INTEL.

WHAT IS CAN

CAN is a serial bus system which is especially suited for connecting devices within a system or sub-system. These devices (nodes) can be intelligent devices as well as sensors and actuators.
CAN is a serial bus system with multi-master capabilities, that means that all CAN nodes are able to transmit data and several CAN nodes can request access to the bus simultaneously. A transmitter sends a message to all CAN nodes (broadcasting).
A CAN message can transmit from 0 up to 8 bytes of user information. Each CAN Message starts with a so called identifier followed by the data bytes. This identifier can be 11 Bit or 29 Bit wide. If the identifier is 11 bit wide, than it is a message in „standard format" (CAN specification 2.0 Part A). Otherwise it is a message in the „extended format" (CAN specification 2.0 Part B). Please be aware that not all CAN controller supports the extended format.
Each node decides on the basis of the identifier received whether it should process the message or not. The identifier also determines the priority that the message have in competition for bus access.
One of the outstanding features of the CAN bus is its high transmission reliability. The CAN protocol controller detects a stations error and evaluates it statistically in order to take appropriate actions. These may extend to disconnecting the CAN node producing the errors.

BENEFITS

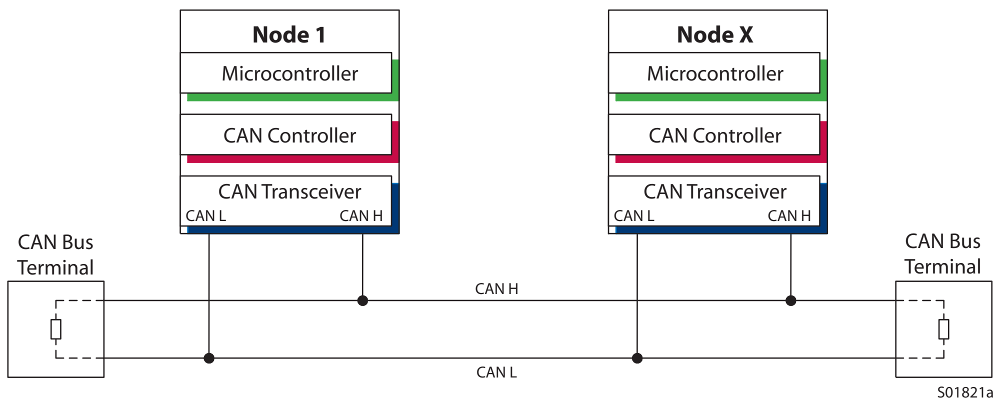
The use of a CAN system increases the flexibility of a system. One of the most obvious benefits is reduced wiring. A single two-wire bus is all that is needed to connect several CAN devices. This reduces costs, simplifies mechanical design, and makes it easier to insert additional devices into a system.
The key benefit of CAN, like any network, is that it makes it possible to share resources and information between devices. This means that one sensor can easily be shared between two or more controllers, or two controllers may share information about their respective subsystems. Instead of using point to point communications, any device on a CAN network can communicate with any other.
An additional benefit of this is that system diagnostics can be centralized and simplified. As a single device can access all of the devices on the CAN, it is possible to centralize diagnostic tools to a single access point.

BUS TOPOLOGY

According to ISO 11898 the CAN-Bus is realized by a cable with two lines. The bus cable is terminated at both ends by termination resistors (see figure 1).

Note: The stub cable, which is the cable from the bus cable to a node, is an unterminated cable and should be as short as possible.

Figure 1: CAN-Bus realization



BUS CABLES AND TERMINATION RESISTORS

The table below shows some standard values for CAN-networks according to ISO 11898 with less than 64 nodes and can be used as a kind of guideline. In addition, the cable should have following AC parameters:
- A 120 Ω impedance and a 5 ns/m specific line delay.

Bus length [m]	Bus cable		Termination resistance [Ω]	Baud rate [Kbit/s]
	Length related resistance [mΩ/m]	Cross section [mm²]		
0...40	70	0.25...0.34	120	1000 at 40 m
40...300	< 60	0.34...0.60	150 ... 300	> 500 at 100 m
300...600	< 40	0.50...0.60	150 ... 300	> 100 at 500 m
600...1000	< 26	0.75...0.80	150 ... 300	> 50 at 1 km

DATA EXCHANGE

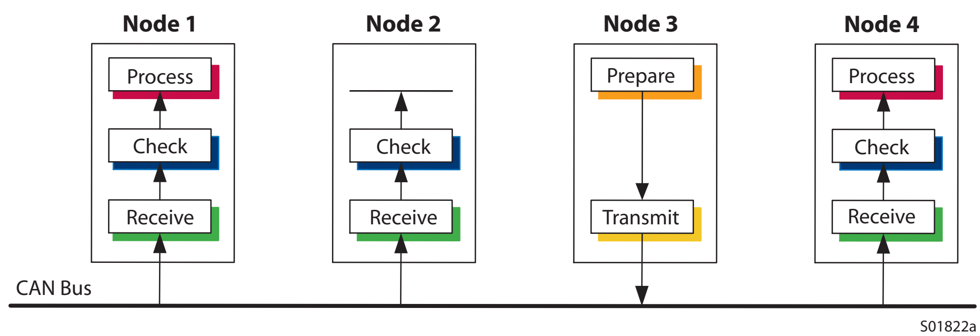
When data is transmitted through a CAN Network, no nodes are addressed, but instead, the content of the message (e.g. engine rpm or vehicle speed) is designated by an identifier that is unique throughout the network.

If the Microcontroller of a given node wishes to send a message to one or more nodes, it passes the data to be transmitted and their identifiers to the assigned CAN controller ("Prepare"). This is all the Microcontroller has to do: To initiate the data exchange. The message is constructed and transmitted by the CAN controller itself.

DATA EXCHANGE (continued)

As soon as the CAN controller receives bus access ("Transmit") all other nodes on the CAN network become receivers of this message ("Receive"). Each node in the CAN network, having received the message correctly, performs an acceptance test to determine whether the received data is relevant for that station ("Check"). If the data is of interest for the node it is processed ("Process"), otherwise ignored.

Figure 2: CAN network



HIGHER LEVEL PROTOCOLS

All the above mentioned specifications describes how data is physically transmitted through the CAN network but not what kind of data. This means that the CAN controller does not care with which identifier the engine RPM is transmitted.
This is the task of the system designer. He has to design what data is transmitted through the bus. Due to that application specific data exchange solutions have been implemented.

These so called „proprietary" protocols are mainly not compatible to each other because they are optimized for a specific application.

In this case optimized means:
- Bandwidth usage of the bus
- Memory allocation in the control unit
- Reaction time

For an open system approach several higher layer protocols have been envolved. Most popular protocols of that are:
- SAE J1939
- CANOpen
- CANKingdom

REFERENCES

- Robert Bosch GmbH:
  CAN specification 2.0 Part A+B (1991)
- CiA DS-102:
  CAN physical layer for industrial applications (1994)
- Konrad Etschberger (Hrsg.):
  Controller-Area-Network; Grundlagen, Protokolle, Bausteine, Anwendungen (2000)

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PLUS+1 Controller Family

Technical Information

Version

Revisions

Date	Page	Changed	Rev.
23 June, 2009	13, 23	Correction regarding IX modules; MC050-055 Specifications table	HB
16 June, 2009	3, 6, 15, 18, 20, 21	General; and updated Memory /Communication Resources table	HA
02 June, 2009	Various	MC038-010, MC050-55 modules added	GA
23 Oct, 2008	All	Literature order number corrected at bottom of pages	FB
21 Jul, 2008	Various	General content update	FA
25 Sep, 2007	21	Corrected typo	EB
24 Sep, 2007	Various	Specifications update, added 88 pin module	EA
24 Oct, 2006	14	Paragraph added re: maximum current; specifications	D
21 Sep, 2006	5, 7-22	Specifications	C
29 Jun, 2005		General content update	B
24 Mar, 2004		First edition	A

Front cover illustrations: F101877, F101878, F101787, F101879, F101880, F101425, P108014

Contents

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Product Installation and Start-up

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?

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

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?

PLUS+1 product literature is available at: www.sauer-danfoss.com

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 Family of Mobile Machine Management Products

12, 24, 38, 50, and 88 Pin Models

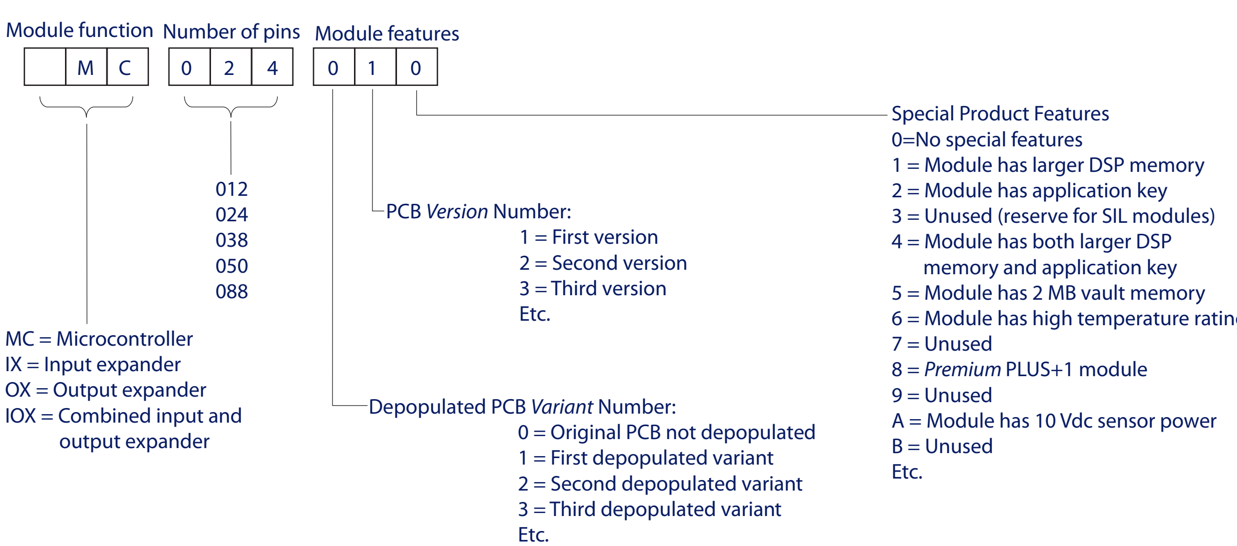
F101753

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. Five standard housings, 12, 24, 38, 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

Input Types

- Digital (DIN)
- Digital or Analog (DIN/AIN)
- Analog or Temperature or Rheostat (AIN/Temp/Rheo)
- Multifunction: Digital or Analog or Frequency (DIN/AIN/FreqIN)
- 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	2.80	4.15	A digital input is guaranteed to be read as high if the voltage is greater than 4.15 Vdc
Falling voltage threshold	Vdc	1.01	2.77	A digital input is guaranteed to be read as low if the voltage is less than 1.01 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	15.53	Depends on pin configuration

Inputs (continued)

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)

Analog (AIN)

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.

Specifications

Description	Units	Minimum	Maximum	Comment
Allowed voltage at pin *	Vdc	0	36	
0 to 5 Vdc range Maximum discernable voltage	Vdc	5.21	5.30	5.26 is typical
0 to 36 Vdc range Maximum discernable voltage	Vdc	34.62	35.91	35.26 is typical
Precision	mV		1.28	
Input impedance	kΩ	206	236	Depends on pin configuration

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

A/D Refresh Rate

A/D refresh rates for individual PLUS+1 modules are as follows. 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 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.

Inputs (continued)

A/D Refresh Rate (continued)

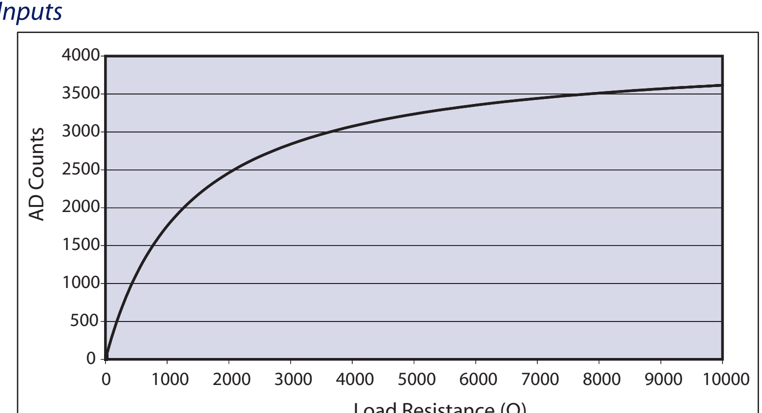
A/D Update Rates for PLUS+1 Modules

PLUS+1 module	A/D refresh rate
MC012-010	All: 2.56 ms
MC024-010	All: 2.56 ms
MC024-020	C1p10 to C1p12: 7.68 ms Remaining pins: 2.56 ms
MC024-500	All: 2.56 ms
MC038-010	C1p08, C1p14, C1p17 to C1p20, C1p24 to C1p27, C1p36 to C1p38: 20.48 ms C1p05, C1p10 to C1p12: 2.56 ms
MC050-010	C1p05, C1p08, C1p14 to C1p19, C1p22 to C1p30, C1p34 to C1p36: 20.48 ms C1p02: 2.56 ms
MC050-020	C1p05, C1p22, C1p25 to C1p32, C1p39, C1p40: 20.48 ms C1p02, C1p08, C1p18, C1p19, C1p23, C1p24: 2.56 ms
MC050-055	C1p05, C1p13 to C1p29, C1p31 to C1p39, C1p41 to C1p45: 20.48 ms C1p46 to C1p49: 2.56 ms
MC088-015, MC088-315	C1p05, C1p08, C1p14 to C1p19, C1p22 to C1p30, C1p34 to C1p36, C1p47 to C1p50 , C2p09 to C2p11, C2p35 to 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

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



P108013

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	34.62	35.91	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	0.368 Vdc is typical
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)

MC050-010
C1p26
should not be configured as a FreqIN.

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 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.

Inputs (continued)

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

Refer to Analog/Digital/Frequency *Specifications* table, page 12, 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 MC038-010 and MC088-015 power planes. The following output types are supported:

- Digital (DOUT, DOUT/PVG Pwr)
- Proportional (PWMOUT/DOUT/PVGOUT)
- High current digital (HDOUT) — MC038-010 and MC088-015 module
- High current proportional (HPWM/DOUT) — MC038-010 module

MC038-010, MC088-XXX Output Pin Power Supply

The controller DSP will be powered if power is supplied to any one of the controller's power planes.

The output pin power supply design of the MC038-010 and MC088-XXX controllers is different from that of other PLUS+1 modules. MC038-010 and MC088-XXX controllers have discrete power supply planes for output pins and a separate dedicated power supply for the DSP. Each output pin is associated with a specific power supply plane. Refer to the controller data sheets for a map of outputs and their associated power plane.

⚠ Warning

Potential uncommanded machine movement. If battery voltage is applied to a module output pin when the module is not powered the module will be powered up. If significant current is driven back through an output pin, the module will be damaged, and the warranty voided.

⚠ 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.

Outputs (continued)

Digital (DOUT, DOUT/PVE Pwr)

Digital outputs can source up to 3 A (exception: MC038-010 DOUT pins are limited to 2 A). 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

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	Comment
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=200 Ω
Output current range for a status bit to read OK	A	0.5	3	See pair note, above

Outputs (continued)

High Current Digital 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	Comment
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=200 Ω
Output current range for status bit to read OK	A	1	6	See pair comment above

⚠ Warning

Potential uncommanded machine movement. If battery voltage is applied to a module output pin when the module is not powered the module will be powered up. If significant current is driven back through an output pin, the module will be damaged, and the warranty voided.

Outputs (continued)

Proportional (PWMOUT/DOUT/PVGOUT)

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 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. Load impedance must not exceed 65 ohms.

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
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.

High Current Proportional (HPWM/DOUT)

High current proportional outputs are unique to the MCO38-010 controller. These outputs are PWM, with PWM frequency software adjustable using GUIDE.

All high current proportional outputs are operated as open loop. The controller kernel does, however, monitor current for circuit protection, but there is no current feedback to the application. The output is a constant voltage and not a constant current. PWM outputs are hardware protected from short or over current.

The MC038-010 has two types of PWM outputs: paired bi-directional PWMs (10 A) that can be configured as H bridges or independent outputs and sourcing only PWMs (6 A and 10 A). See the product data sheet and API documents for pair assignments.

Specifications

Description	Units	Minimum	Maximum	Comment
Over-current trip point, 6 A	A		12	Temperature dependent.
Over-current trip point, 10 A	A		18	Temperature dependent.
PWM frequency	Hz	33	4000	

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 and CAN2 port on MC050-055 controllers 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-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

	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 MC012-XXX	9%	12%	9%	14%	9%	17%
RAM usage on MC024-010	9%	12%	9%	14%	9%	17%
RAM usage on MC024-011	9%	12%	9%	14%	9%	17%
RAM usage on MC038-010	9%	12%	9%	18%	9%	26%
RAM usage on MC050-010, MC050-020	1%	1%	1%	2%	1%	2%
RAM usage on MC050-055	1%	1%	1%	2%	1%	0%
RAM usage on MC088-010	1%	1%	1%	2%	1%	2%
ROM usage on MC012-XXX	8%	11%	12%	18%	10%	19%
ROM usage on MC024-010	8%	11%	12%	18%	10%	20%
ROM usage on MC024-011	3%	4%	4%	6%	3%	7%
ROM usage on MC038-010	8%	11%	12%	18%	10%	21%
ROM usage on MC050-010, MC050-020	3%	4%	4%	6%	3%	8%
ROM usage on MC050-055	3%	4%	4%	6%	3%	8%
ROM usage on MC088-015	3%	4%	4%	6%	3%	7%

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 modules on a machine.

MC038-010 Power Supply

The MC038-010 controller's power supply design recommendations must be followed:

- Power supply to MC038-010 controller's output power planes (C1-p36 to C1-p38) must be wired directly to the vehicle battery and the wiring runs must be kept as short as possible.
- Power supply to the controller's DSP (C1-p2) must be wired separately from the power supply to the controller's output power planes.
- Do not connect any other PLUS+1 controllers to the power supply to MC038-010 controller's output power planes.

MC038-010 Sleep Mode

Sleep mode is unique to the MC038-010 controller. This feature gives OEM designers the ability to implement automotive-like features in their machine control system design. If the sleep mode feature is not implemented, this controller has the same operating characteristics as any other PLUS+1 controller.

When used as a sleep mode controller, supply power to the MC038-010 is connected directly to the battery. Sleep mode initiation is defined by the controller's application software: PLUS+1 GUIDE programmers define the conditions under which the controller is to put to sleep. When in sleep mode, controller outputs are set to zero, sensor power supply is off and the controller consumes a small amount of current.

Controller Sleep Mode Current Consumption

Supply voltage	Sleep mode current consumption
12 Vdc	0.14 mA
24 Vdc	0.28 mA

Power (continued)

Battery power must be supplied to designated wake-up digital inputs, since the controller's 5 Vdc regulated power supply is not available when the controller is in sleep mode.

MC038-010 Sleep Mode (continued)

Either of two conditions will wake up the controller:

- Switching of any of the designated (in the GUIDE application) wake-up digital inputs (DIN) to high.
- Cycling all input power to the controller.

The following input pins may be designated as wake-up digital inputs:

- DIN (C1p06, C1p07)
- DIN/AIN (C1p14, C1p17 to C1p20, C1p24 to C1p27

Specifications

Description	Units	Minimum	Maximum	Comment
Wake-up pin threshold	Vdc	2	36	To wake up by cycling input power
Wake-up pin threshold	Vdc	4.5	36	To wake up by digital input
Wake-up time delay	mSec	250	500	

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 on the product data sheet.

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 (all modules except MC050-055)

Description	Units	Minimum	Maximum	Comment
Output short circuit voltage	Vdc		36	
Output voltage	Vdc	4.88	5.12	
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	

The MC050-055 controller features 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 (MC050-055)

Description	Units	Minimum	Maximum	Comment
Output short circuit voltage	Vdc		36	
Output voltage, sensors	Vdc	4.88	5.12	Sensor power supply drops below minimum if controller power supply is less than 9 Vdc
Output voltage, DIN diagnostics	Vdc	1.54	1.66	Nominal 1.6
Output voltage, DIN diagnostics	Vdc	3.00	3.60	Nominal 3.3

Power (continued)

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 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

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.

EEPROM used in PLUS+1 controllers is rated for 1,000,000 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 (e. g. 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.

Vault Memory

Some variants of PLUS+1 modules have 2 MByte 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	Comment
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 7637/2 electrical transient conduction along supply lines
	ISO 7637/3 electrical transient transmission by capacitive and inductive coupling via lines other than supply lines
EMC	Modules conform to 2004/108/EC directive
	ISO 14982 agricultural and forestry machinery
	ISO 13766 earth moving machinery
Electrostatic discharge	EN 61000-4-2 electromagnetic compatibility—electrostatic discharge immunity test: 15 kV air discharge, 8 kV contact
	SAE J1113-13 8 kV pin direct contact discharge

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	Sensor voltage drops out if supply voltage < 9 Vdc. Exception for MC050-055, see *Sensor Power Supply Ratings*, page 22.
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

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.

PLUS+1 Modules Environmental Ratings

Environmental Ratings

Mechanical Environment	Climate Environment
IEC 60068-2-61, Test Fc (Random vibration, 10-250 Hz)	IEC 60068-2-38 (Temperature and humidity)
IEC 60068-2-27, Test Ea (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)

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	38 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)	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)	Stamped: 0462-203-12141 (10 to 14 AWG) 1062-20-0144 (16 to 20 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	DRC26-38S01-P017	DRC26-50S01	DRC26-50S01 DRC26-38S01-P017
Wedge	WM-12S	WM-12S	Not required	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]	6.43 to 0.79 mm [0.253 to 0.031 in]	3.96 to 5.54 mm [0.156 to 0.218 in]	20 to 24 AWG: 3.96 to 5.54 mm [0.156 to 0.218 in]
					12 to 14 AWG: 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]	4.32 mm [0.17 in]	2.41 mm [0.095 in]	20 to 24 AWG: 2.41 mm [0.095 in]
					12 to 14 AWG: 4.32 mm [0.17 in]
Sealing plugs	0413-204-2005	0413-204-2005	114017	0413-204-2005	0413-204-2005, 114017

Sauer-Danfoss Mating Connector Part Information

Description	12 pin module	24 pin module	38 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	11027919	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

PLUS+1 module mating connectors 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, 38, 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 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.

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.

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.

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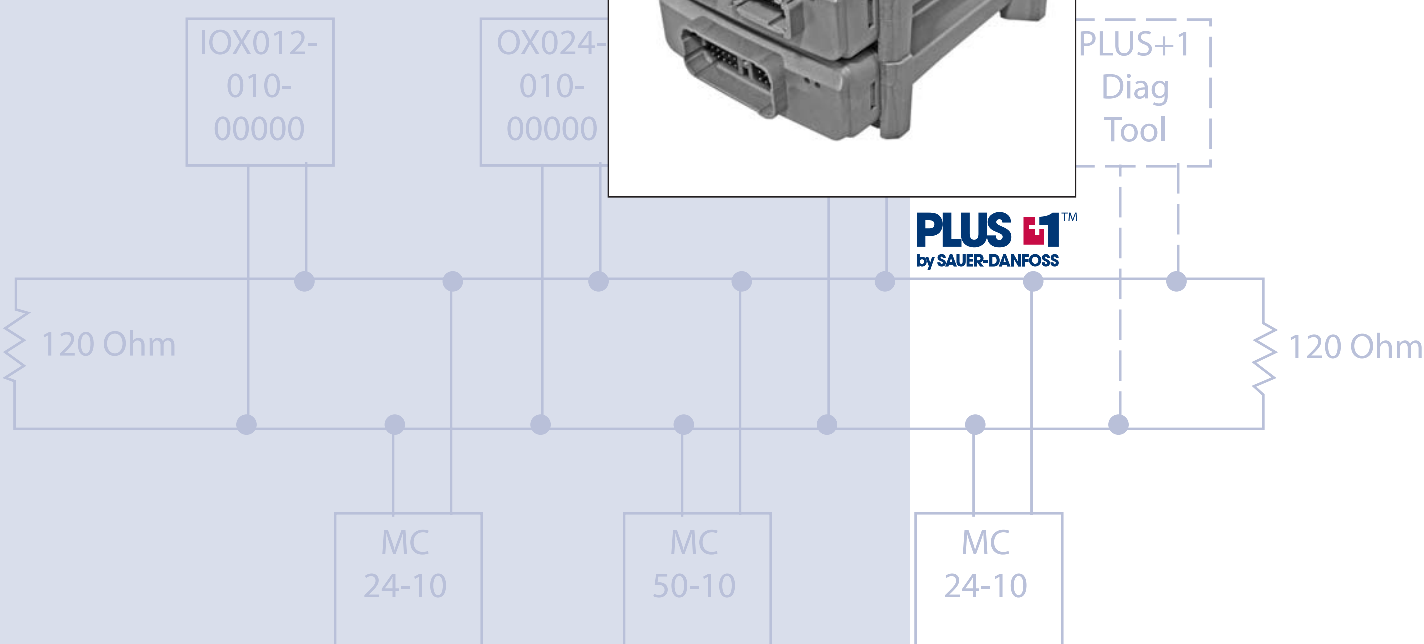
PLUS+1 CAN I/O Module Communications

Technical Information



Contents

Revision history

Revision date	Page	Change	Remarks
12/16/2005			Initial release

Front cover illustrations: F101421, F101422, F101423, F101425, 2326

ABOUT THIS MANUAL

This publication explains the protocol design of the PLUS+1 CAN I/O communication. It will show the necessary parts of the design and their interaction.

Applicable documents

DM	SPRS1741 (i)	TMS320F2810 TMS320F2812 - Digital Signal Processors Data Technical Information (Texas Instruments)

References

SFS	D-270405-1, 1.14	Smart Flash loader Specification (Smart GmbH)
DS301	DS301, 4.00	Application Layer and Communication Profile CiA (CAN in Automation)
2.0	CAN2spec, 2.00	CAN Specification (Bosch®)
J1939	Data Link Layer	Surface Vehicle Recommended Practice – J1939-21 (SAE)

Definitions and abbreviations

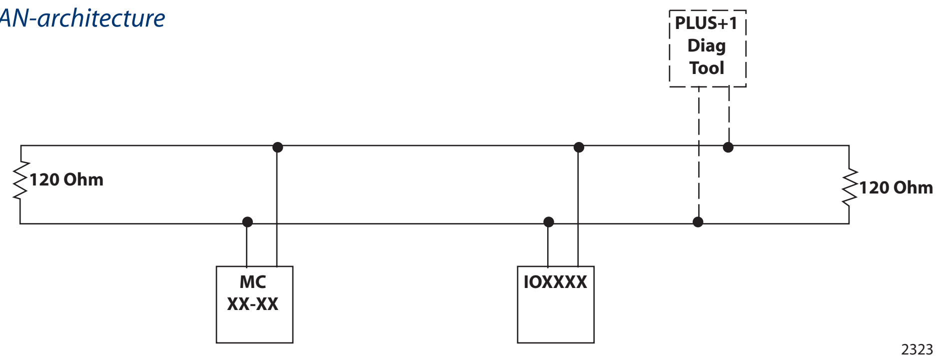
CAN	Controller Area Network
CRC	Cyclic Redundancy Check
CPU	Central Processing Unit
ECU	Electronic Control Unit
EEPROM	Electrically Erasable and Programmable Read Only Memory*
Kernel	Set of hardware dependant driver functions and operating system
OTP	One-Time Programmable
RAM	Random Access Memory
ROM	Read Only Memory
LSB	Least Significant Byte
MSB	Most Significant Byte
PDO	Process Data Object (CAN Open Terminology) [DS301]
Tx	Transmit
Rx	Receive
I/O	Input/Output
MC	Master Controller in the network (for example: MC024-010 or MC050-010)
0x	In front of a number defines a base 16 number (hexadecimal)
CAN-Bx	CAN Data Byte number X, counting of these bytes start from zero

* This phrase is still used, even if the selected device is re-programmable

SYSTEM OVERVIEW

Besides the programmable members of the microcontroller family like the MC024-010 and MC050-010, the PLUS+1 platform needs different I/O expander modules. There is always the chance that some additional requirements will need extra inputs or outputs to the system. If the controllers already in the system are out of I/O, it may make sense to add an inexpensive I/O module to the system rather than stepping up to a higher performance controller.

CAN-architecture



SYSTEM CONTEXT

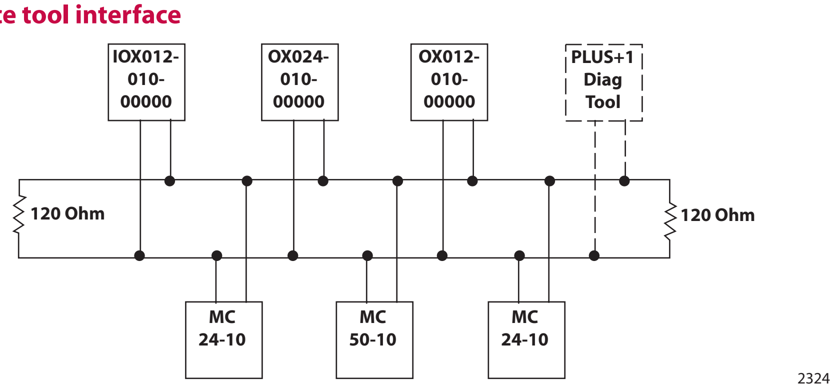
PLUS+1 family with five different I/O units

IX012-010-00000	12 pin input
IX024-010-00000	24 pin input
OX012-010-00000	12 pin output
OX024-010-00000	24 pin output
IOX012-10-00000	12 pin input/output

You can use more than one I/O device in the same network. It is also possible in *Sauer-Danfoss only networks** to replace one unit without additional service actions.

CAN-bus with several PLUS+1 MC and I/O Modules

Service tool interface



The I/O modules have a *bootloader* program. You can update the firmware using the PLUS+1 service and diagnostic tool. Use the *downloader* from the *service tool* to load a new .Ihx file.

**Sauer-Danfoss only network* means that only PLUS+1 compliant units are connected on the CAN-bus.

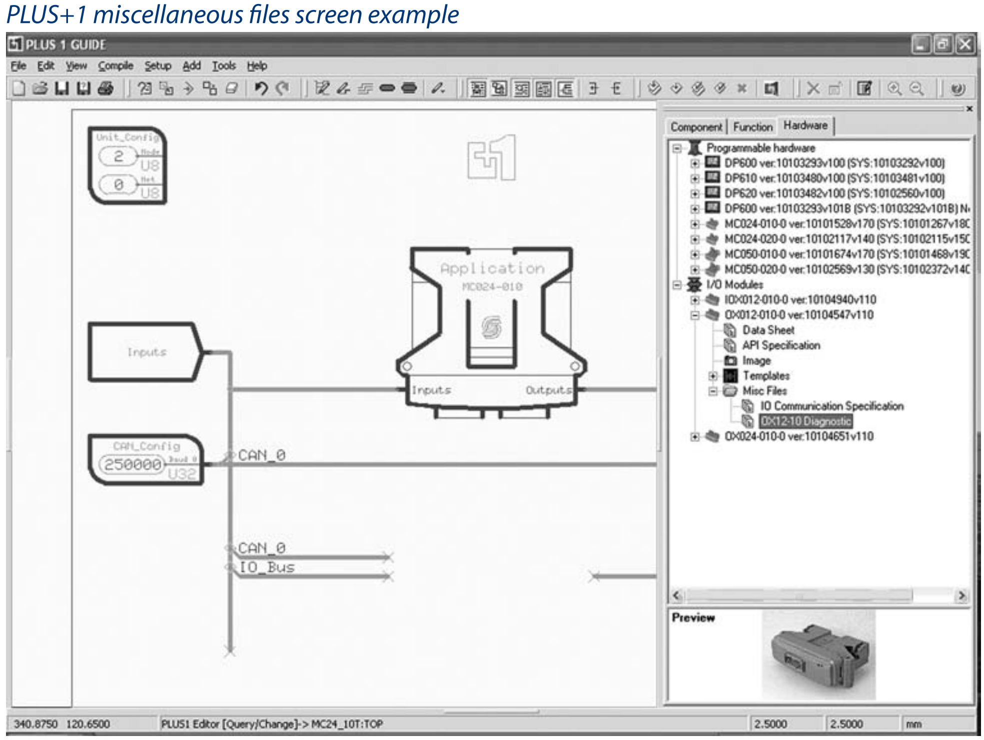
SYSTEM CONTEXT (CONTINUED)

Service tool interface (continued)

You can also use the service tool to change the default addressing mode of the I/O modules. This might be necessary in some circumstances. The service tool and the desired I/O module must be the only devices on the CAN-bus. You can also use the service tool to monitor the configuration and status of the outputs.

To use the service tool, you must first save the *diagnostic (.p1h) file* for the specific I/O module hardware that you are using. This file is available under the *misc files* in the *hardware tab* on the right side of the PLUS+1 GUIDE screen. Right click on the file and save it to your local hard drive.

PLUS+1 miscellaneous files screen example



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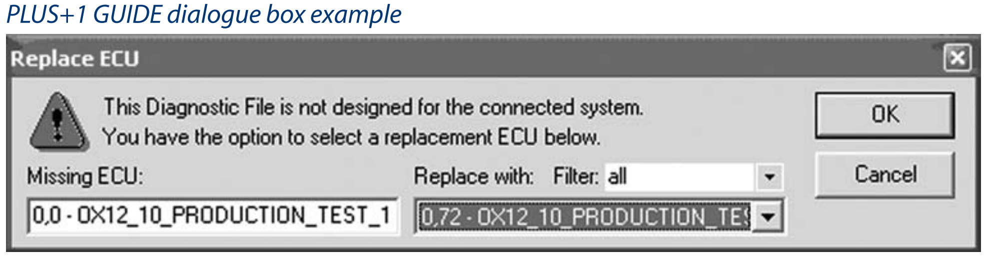
Now that the file is saved to the local hard drive, open it with the service tool.

Remember that it is a .p1h file, not a .p1d file. (.p1h indicates that it is associated with a particular hardware, not an application.)

When you open the .p1h file you may get the following dialog box.

PLUS+1 GUIDE dialogue box example



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SYSTEM CONTEXT (CONTINUED)

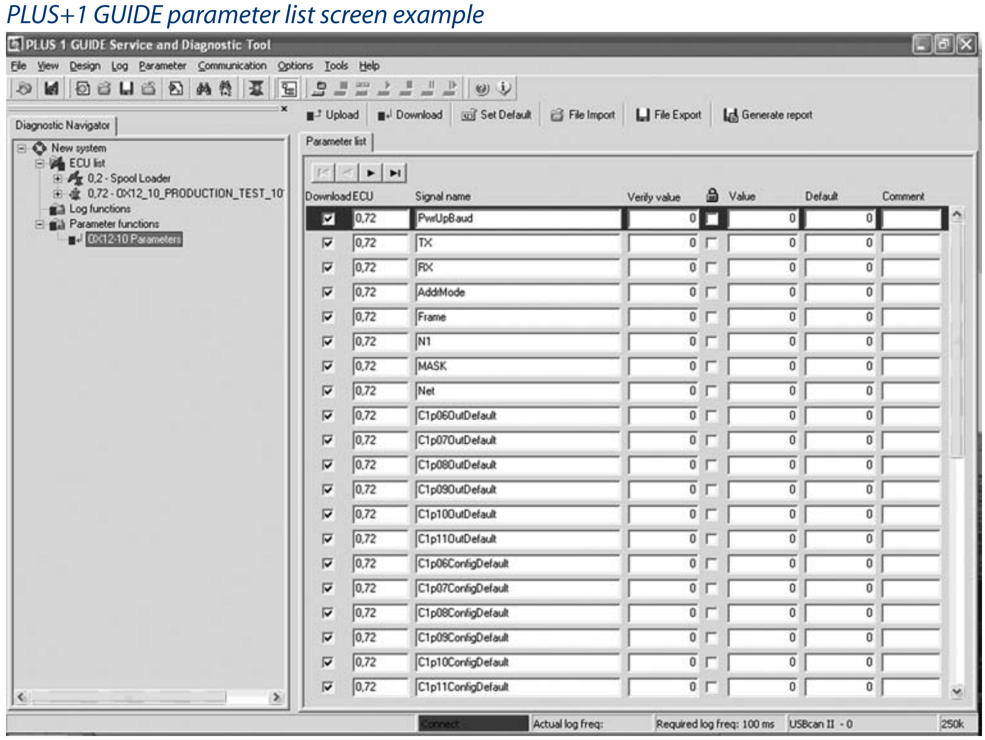
Service tool interface (continued)

Simply click the drop down box on the right and select the actual hardware that is in your system. The reason for this is that the CAN-ID of the numeral 0 (zero) on the left doesn't match the CAN-IDs that are in your system. You need to tell it where the I/O module that you are selecting is located.

Next, you can click on the Parameter function for your I/O module in the *diagnostic navigator*. This will bring up a parameter list for the I/O module.

This parameter screen will allow you to view and change all of the configuration data for the I/O module.

PLUS+1 GUIDE parameter list screen example



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Any change of the communication parameters requires a restart of the I/O device for the changes to take effect.

SYSTEM DESIGN

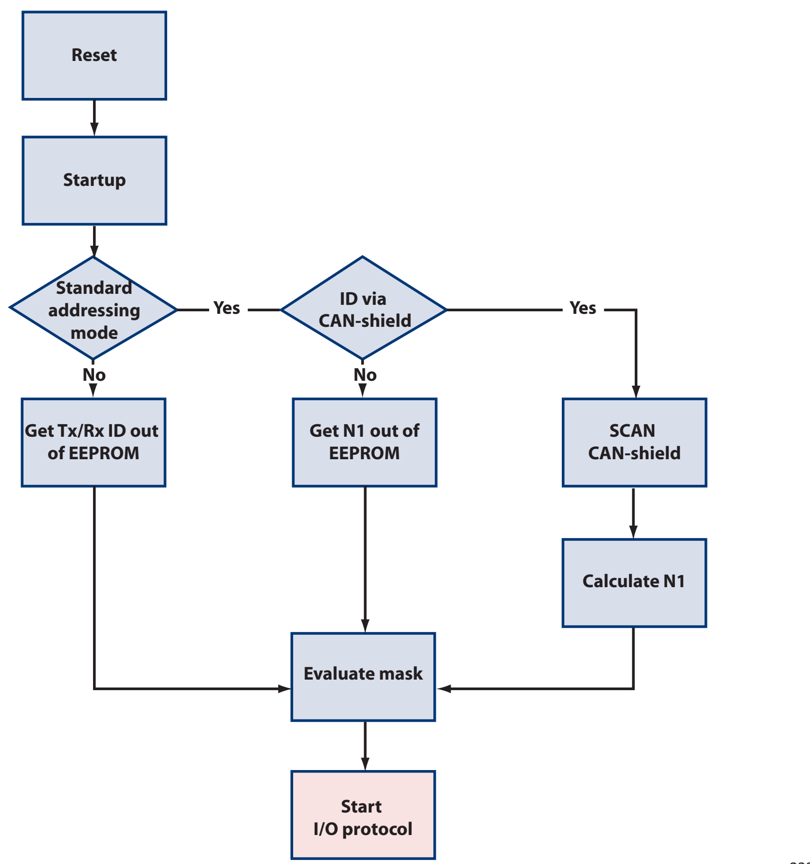
CAN-ID

To minimize the number of CAN identifiers (CAN-ID) used, each I/O device uses just one CAN-ID to transmit data.

To run several devices on one network, each needs a different CAN-ID. After production all units start with the same standard default addressing mode. In the default addressing mode the devices scan the CAN-shield pin at startup and measure the voltage level at this pin. The CAN-ID is set based on this voltage. The default startup configuration is designed to create no conflicts with existing higher layer protocols in regards to the CAN-ID usage.

The addressing mode can be changed with the service tool to a set of default identifiers.

Default configuration flow chart



DECOMPOSITION DESCRIPTION

The default startup configuration of I/O devices is designed to create as few conflicts as possible with existing higher layer protocols in regards to the CAN-ID usage. Due to the restricted CAN-ID range, the system will use the first data byte as a kind of sub-identifier.

Non time-critical messages and configuration messages use a special sub-identifier (0xFF) to enter a new page of commands. In this page the second data byte works as a sub-command.

CAN-ID USAGE

The I/O device can provide up to three different ways of using the CAN-ID.

Variable identifier usage define with CAN-shield

In the default configuration the system uses 11-bit identifiers according to CAN2.0 Part A. The usage of 11-bit identifiers means that the communication happens in the proprietary area of SAE J1939. To work in parallel on a CAN-open bus, the addressing scheme works on PDO (DS301).

The CAN-open default PDOs (CAN-IDs) are defined with a function code (bit 10...bit 7) and the node ID (bit 6...bit 0).

PDO CAN-ID

Most significant bit **Least significant bit**

10	9	8	7	6	5	4	3	2	1	0
P	P	P	P	N	N	N	N	N	N	N

P	4 bits – PDO
N	7 bits - node ID

PDOs defined

PDO1 Tx 0x180+node ID
PDO1 Rx 0x200+node ID
PDO2 Tx 0x280+node ID
PDO2 Rx 0x300+node ID
PDO3 Tx 0x380+node ID
PDO3 Rx 0x400+node ID
PDO4 Tx 0x480+node ID
PDO4 Rx 0x500+node ID

CAN-open allows the node ID to range from 1 to 127.

The I/O devices will use PDO1 Tx *to transmit* and PDO2 Rx *for receive*. This avoids collision if someone in a proprietary system uses a node ID larger than 127.

PDO Node ID usage

The node ID consists of 7 bits. The node ID is divided into two sections

a) to address the requirements of different devices on the same network
b) so that one device is able to listen to more than one MC

CAN-IDENTIFIER USAGE (CONTINUED)

PDO CAN-ID with divided node-id

Most significant bit — **Least significant bit**

10	9	8	7	6	5	4	3	2	1	0
P	P	P	P	N1	N1	N1	N1	N0	N0	N0

Bit definition

P	4 bits - PDO
N1	4 bits - node ID defined by voltage
N0	3 bits - node ID defined for multi MC receive communication

N0 definition

N0 is always set to zero for the PDO1 Tx message. N0 is also zero for the standard PDO2 Rx message, but it is possible to apply the mask value to receive all possible configurations for N0.

N0 usage in PDO

N0	Tx	Rx
0x00	Default, valid	Default, valid
0x01	Invalid	Only with masking
0x02	Invalid	Only with masking
0x03	Invalid	Only with masking
0x04	Invalid	Only with masking
0x05	Invalid	Only with masking
0x06	Invalid	Only with masking
0x07	Invalid	Only with masking

N1 definition

N1 is always assigned at start-up by scanning the analog/shield input. The input range is divided into 16 equal sections, each with a size of 300 mV, starting at 0 V. Any voltage higher than 4.5 Vdc will be interpreted as the highest input value.

N1 calculation

AD-Input low value (mV)	AD-Input high value (mV)	N1	N1 (hex)	N1 (hex pos)	Tx	Rx
0	299	0	0x00	0	0x0180	0x0300
300	599	1	0x01	0x08	0x0188	0x0308
600	899	2	0x02	0x10	0x0190	0x0310
900	1199	3	0x03	0x18	0x0198	0x0318
1200	1499	4	0x04	0x20	0x01A0	0x0320
1500	1799	5	0x05	0x28	0x01A8	0x0328
1800	2099	6	0x06	0x30	0x01B0	0x0330
2100	2399	7	0x07	0x38	0x01B8	0x0338
2400	2699	8	0x08	0x40	0x01C0	0x0340
2700	2999	9	0x09	0x48	0x01C8	0x0348
3000	3299	10	0x0A	0x50	0x01D0	0x0350
3300	3599	11	0x0B	0x58	0x01D8	0x0358
3600	3899	12	0x0C	0x60	0x01E0	0x0360
3900	4199	13	0x0D	0x68	0x01E8	0x0368
4200	4499	14	0x0E	0x70	0x01F0	0x0370
4500	—	15	0x0F	0x78	0x01F8	0x0378

CAN-IDENTIFIER USAGE (CONTINUED)

Predefined identifier usage with fixed N1

In this configuration the N1 portion of the CAN identifier is predefined by Sauer-Danfoss. It can be adjusted by the OEM with the PLUS+1 service and diagnostic tool.

Fixed identifier usage

This special configuration works only with fixed identifiers. These identifiers are configurable with the diagnostic tool. Also in this configuration it is possible to apply a mask for receiving messages. It is also possible to select between 11 bit and 29 bit identifiers.

KWP2000 NODE and NET ASSIGNMENTS

In addition to the I/O protocol the I/O devices also need to support the PLUS+1 service and diagnostic tool protocol. This is based on KeyWord Protocol 2000 (KWP2000.) Basic parameters for this are the *node* and *net* number. The following sections describe how these numbers are assigned.

KWP2000 node number

The node number is assigned by using N1 as the KWP2000 node number as shown below in variable identifier and predefined identifier addressing mode:

KWP2000 node number

Most significant bit … **Least significant bit**

7	6	5	4	3	2	1	0
X	N1	N1	N1	N1	X	X	X

X	Not used = 0
N1	4 bits - node ID defined by voltage or with fixed value

KWP2000 net number

The *net number* is stored as a parameter in the non-volatile memory and can be modified with the PLUS+1 service and diagnostic tool.

LED HANDLING

To simplify system diagnostics the I/O device will use its LEDs, if available, to indicate different status conditions.

Red LED

The red LED indicates outgoing message traffic from the I/O device. The LED toggles its state with every successfully transmitted frame.

If the device's CAN-bus goes into a *bus off* condition then the LED will be permanently on.

Green LED

The green LED indicates that the I/O device is seeing incoming message traffic. The LED toggles its state with every successfully received frame. If no messages are received for more than 10 seconds, then the LED starts to blink at a one Hertz rate.
Time critical messages and messages which have to be used all the time are implemented with a sub identifier which has a value from 0 to 0xFE.

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Cartridge valves

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