Original Programming Manual
CabinetController

ecomat100

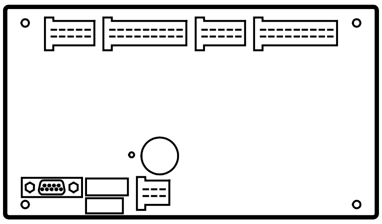
CR0302

Runtime system V05

CODESYS® ≥ V2.3.9.33 (< V 3.0)

English

7391084_01_UK 2016-04-22



Contents

1 About this manual

Contents

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1.1 Copyrightwww.

6088

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1.2 Overview: documentation modules for ecomatmobile devices

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The documentation for **ecomat*mobile*** devices consists of the following modules:

1.	Data sheet
Contents	Technical data in a table
Source	→ www.ifm.com > select your country > [Data sheet search] > CR0302 > [Technical data in PDF format]

2.	Installation instructions / operating instructions
Contents	Instructions for installation, electrical installation, (commissioning*), technical data
Source	The instructions are supplied with the device They are also found on ifm's homepage: → www.ifm.com > select your country > [Data sheet search] > CR0302 > [Operating instructions]

3.	Programming manual + online help
Contents	Description of the configuration and the functions of the device software
Source	→ www.ifm.com > select your country > [Data sheet search] > CR0302 > [Operating instructions]

4.	System manual "Know-how ecomatmobile"
Contents	Know-how about the following topics: • Overview Templates and demo programs • CAN, CANopen • Control outputs • User flash memory • Visualisations • Overview of the files and libraries used
Source	→ www.ifm.com > select your country > [Data sheet search] > CR0302 > [Operating instructions]

5.	System manual "The ISOBUS in the ifm controller"
Contents	Description of the configuration and the functions of the ISOBUS software in the device
Source	→ www.ifm.com > select your country > [Data sheet search] > CRnnnn > [Operating instructions] thereby "CRnnnn" stands for the articel numbers of the devices which are pre-installed with ISOBUS

*) The descriptions in brackets are only included in the instructions of certain devices.

1.3 CODESYS programming manual

17542

In the additional "Programming Manual for CODESYS V2.3" you obtain more details about the use of the programming system.
This manual can be downloaded free of charge from **ifm's** website:
→ www.ifm.com > Select your country > [Service] > [Download] > [Systems for mobile machines]
You also find manuals and online help for **ecomat*mobile*** at:
→ **ecomat*mobile*** DVD "Software, tools and documentation"

1.4 What do the symbols and formats mean?

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The following symbols or pictograms illustrate the notes in our instructions:

⚠ WARNING

Death or serious irreversible injuries may result.

⚠ CAUTION

Slight reversible injuries may result.

NOTICE

Property damage is to be expected or may result.

!	Important notes concerning malfunctions or disturbances
i	Other remarks
► ...	Request for action
> ...	Reaction, result
→ ...	"see"
abc	Cross-reference
123 0x123 0b010	Decimal number Hexadecimal number Binary number
[...]	Designation of pushbuttons, buttons or indications

1.5 How is this documentation structured?

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This documentation is a combination of different types of manuals. It is for beginners and also a reference for advanced users. This document is addressed to the programmers of the applications.

How to use this manual:

- Refer to the table of contents to select a specific subject.
- Using the index you can also quickly find a term you are looking for.
- At the beginning of a chapter we will give you a brief overview of its contents.
- Abbreviations and technical terms → Appendix.

In case of malfunctions or uncertainties please contact the manufacturer at:
→ www.ifm.com > Select your country > [Contact].

We want to become even better! Each separate section has an identification number in the top right corner. If you want to inform us about any inconsistencies, indicate this number with the title and the language of this documentation. Thank you very much for your support!

We reserve the right to make alterations which can result in a change of contents of the documentation. You can find the current version on **ifm's** website at:
→ www.ifm.com > Select country > [Data sheet search] > (Article no.) > [Operating instructions]

1.6 History of the instructions (CR030n)

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What has been changed in this manual? An overview:

Date	Theme	Change
2010-09-09	PID2 (FB)	parameters of the inputs corrected
2010-11-10	Terminating resistors	correction in topic 1244
2011-02-14	TIMER_READ_US (FB)	conversion of max. counter value corrected
2011-04-05	Memory POUs FRAMREAD, FRAMWRITE, FLASHREAD, FLASHWRITE	permitted values of the parameters SRC, LEN, DST
2011-04-13	CANopen overview	new: CANopen tables in the appendix
2011-04-14	CR0303 several corrections:	- device has an own hydraulic library - some system flags do not exist - IEC addresses of in- and outputs - configuration of the inputs - set the status LED in the application program
2011-05-24	CR0303: memory FBs FRAMREAD, FRAMWRITE	permitted values of the parameters SRC, DST corrected
2012-01-09	Memory modules FRAMREAD, FRAMWRITE	Swapped parameters SRC, DST in the table "Permissible values"
2012-10-04	diverse	corrections
2013-06-24	various	new document structure
2014-04-28	Various function blocks	More precise description of the function block input CHANNEL
2014-06-30	Name of the documentation	"System manual" renamed as "Programming manual"
2014-07-18	CR0303: Error flag	Wrong: ERROR_A_INx Correct: ERROR_Ix
2014-07-31	FB PHASE	Description of parameters of outputs C, ET corrected
2014-08-26	Description of inputs, outputs	highside / lowside replaced by positive / negative switching
2015-01-13	Structure of documentation for error codes, system flags	• error flags: now only in the appendix, chapter *System flags* • CAN / CANopen errors and error handling: now only in the system manual "Know-How" • error codes, EMCY codes: now in the appendix, chapter *Error tables*
2015-03-10	Available memory	Description improved
2015-05-26	FB J1939_x_GLOBAL_REQUEST	More precise description
2015-06-10	Various function blocks	Description of the FB input CHANNEL corrected

2 Safety instructions

Contents

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2.1 Please note!

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11212

No characteristics are warranted with the information, notes and examples provided in this manual. With the drawings, representations and examples given no responsibility for the system is assumed and no application-specific particularities are taken into account.

► The manufacturer of the machine/equipment is responsible for ensuring the safety of the machine/equipment.

► Follow the national and international regulations of the country in which the machine/installation is to be placed on the market!

⚠ **WARNING**

Non-observance of these instructions can lead to property damage or personal injury.
ifm electronic gmbh does not assume any liability in this regard.

► The acting person must have read and understood the safety instructions and the corresponding chapters in this manual before working on and with this device.

► The acting person must be authorised to work on the machine/equipment.

► The acting person must have the qualifications and training required to perform this work.

► Adhere to the technical data of the devices!
You can find the current data sheet on **ifm's** homepage at:
→ www.ifm.com > Select your country > [Data sheet search] > (article number.) > [Technical data in PDF format]

► Note the installation and wiring information as well as the functions and features of the devices!
→ supplied installation instructions or on **ifm's** homepage:
→ www.ifm.com > Select your country > [Data sheet search] > (article number.) > [Operating instructions]

► Please note the corrections and notes in the release notes for the existing documentation, available on the **ifm** website:
→ www.ifm.com > Select your country > [Data sheet search] > (article number.) > [Operating instructions]

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NOTICE

The driver module of the serial interface can be damaged!

Disconnecting or connecting the serial interface while live can cause undefined states which damage the driver module.

► Do not disconnect or connect the serial interface while live.

2.2 What previous knowledge is required?

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This document is intended for people with knowledge of control technology and PLC programming with IEC 61131-3.

To program the PLC, the people should also be familiar with the CODESYS software.

The document is intended for specialists. These specialists are people who are qualified by their training and their experience to see risks and to avoid possible hazards that may be caused during operation or maintenance of a product. The document contains information about the correct handling of the product.

Read this document before use to familiarise yourself with operating conditions, installation and operation. Keep the document during the entire duration of use of the device.

Adhere to the safety instructions.

2.3 Start-up behaviour of the controller

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15233
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⚠ **WARNING**

Danger due to unintentional and dangerous start of machine or plant sections!

► When creating the program, the programmer must ensure that no unintentional and dangerous start of machines or plant sections after a fault (e.g. e-stop) and the following fault elimination can occur!
⇨ Realise restart inhibit.

► In case of an error, set the outputs concerned to FALSE in the program!

A restart can, for example, be caused by:
- voltage restoration after power failure
- reset after watchdog response because of too long a cycle time
- error elimination after an E-stop

To ensure a safe behaviour of the controller:

► Monitor the voltage supply in the application program.

► In case of an error switch off all relevant outputs in the application program.

► Monitor actuators which can cause hazardous movements in the application program (feedback).

► Monitor relay contacts which can cause hazardous movements in the application program (feedback).

► If necessary, ensure that welded relay contacts in the application project cannot trigger or continue hazardous movements.

2.4 Notes: serial number

20780

- ► In the user's production facility, draw a diagram of the controller network in the machine. Enter the serial number of each controller installed into the network diagram.
- ► Before downloading a software component, read out this serial number and check the network diagram to make sure that you are accessing the right controller.

2.5 Notes: TEST inputs

20781

- ► The TEST inputs of all the controllers in the machine should be wired individually and marked clearly so that they can be properly allocated to the controllers.
- ► During a service access only activate the TEST input of the controller to be accessed.

3 System description

Contents

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3.1 Information about the device

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This manual describes of the **ecomat*mobile*** family for mobile machines of **ifm electronic gmbh**:

- CabinetController: CR0301, CR0302

3.2 Hardware description

Contents

14081

3.2.1 Hardware structure

Contents

15332

Conditions

19971

The device does not start until sufficient voltage is applied to the supply connection VBBs.
A voltage > 10 V is deemed sufficient.
Permissible operating voltage → data sheet

Prinziple block diagram

21005

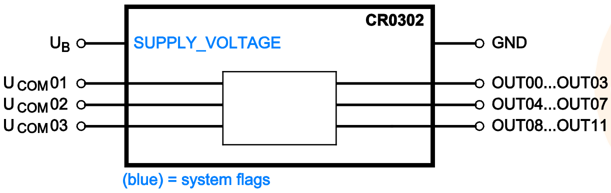

Figure: Block diagram of the supply

Available memory

13736

FLASH-Speicher

14024

FLASH memory (non-volatile, slow memory) overall existing in the device	512 kByte

Thereof the following memory areas are reserved for ...

maximum size of the application program	192 kByte
data other than the application program user can write data such as files, bitmaps, fonts	48 kByte
data other than the application program read data with *FLASHREAD* (→ page 166) or write data with *FLASHWRITE* (→ page 167) (files: 128 bytes less for header)	16 kByte

The remaining rest of the memory is reserved for system internal purposes.

SRAM

18705

SRAM (volatile, fast memory) overall existing in the device SRAM indicates here all kinds of volatile and fast memories.	256 kByte

Thereof the following memory areas are reserved for ...

data reserved by the application program	48 kByte

The remaining rest of the memory is reserved for system internal purposes.

EEPROM

3957

EEPROM (non-volatile, slow memory) overall existing in the device	4 kByte

Thereof the following memory areas are reserved for ...

variables in the application program, declared as VAR_RETAIN	256 Byte
remanent memory freely available to the user Access is made via *E2READ* (→ page 164) and *E2WRITE* (→ page 165)	3 840 Byte

3.2.2 Monitoring concept

19973

The controller monitors the supply voltages and the system error flags.
Depending on the status...

- the controller switches off completely
  - > the program stops
  - > the outputs become currentless and change to logic "0"
  - > the status LED goes out

Monitoring and securing mechanisms

Contents

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For the these devices the following monitoring activities are automatically carried out:

After application of the supply voltage

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After application of the supply voltage (controller is in the boot loader) the following tests are carried out in the device:

> RAM test (one-time)

> supply voltage

> system data consistency

> CRC of the boot loader

> if exists and is started: CRC of the runtime system

> if exists and is started: CRC of the application program

> memory error:
- If the test is running: flag ERROR_MEMORY = TRUE
  (can be evaluated as from the first cycle).
- If the test is not running: red LED is lit.

If runtime system / application is running

3928

then the following tests are cyclically carried out:

> Triggering of the watchdog (100 ms)
> Then continuous program check watchdog

> Continuous temperature check
> In case of a fault: system flag ERROR_TEMPERATURE = TRUE

> Continuous voltage monitoring
> In case of a fault: system flag ERROR_POWER = TRUE or ERROR_VBBR = TRUE

> Continuous CAN bus monitoring

> Continuous system data monitoring:
> - program loaded
> - operating mode RUN / STOP,
> - runtime system loaded,
> - node ID,
> - baud rate of CAN and RS232.

> In the operating mode RUN:
> Cyclical I/O diagnosis:
> - short circuit,
> - wire break,
> - overload (current) of the inputs and outputs,
> - cross fault (only for SafetyController).

If the TEST pin is not active

3929

> Write protection for system data in FRAM [1]), e.g.:
> • runtime system loaded,
> • calibration data.
> Implemented via hardware and software.

> Write protection for application program (in the flash memory)

> DEBUG mode

[1]) FRAM indicates here all kinds of non-volatile and fast memories.

One-time mechanisms

3930

> CRC monitoring during download or upload.

> It must be checked that the runtime system and the application are assigned to the same device.

3.2.3 Inputs (technology)

Contents

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Analogue inputs

2426

The analogue inputs can be configured via the application program. The measuring range can be set as follows:

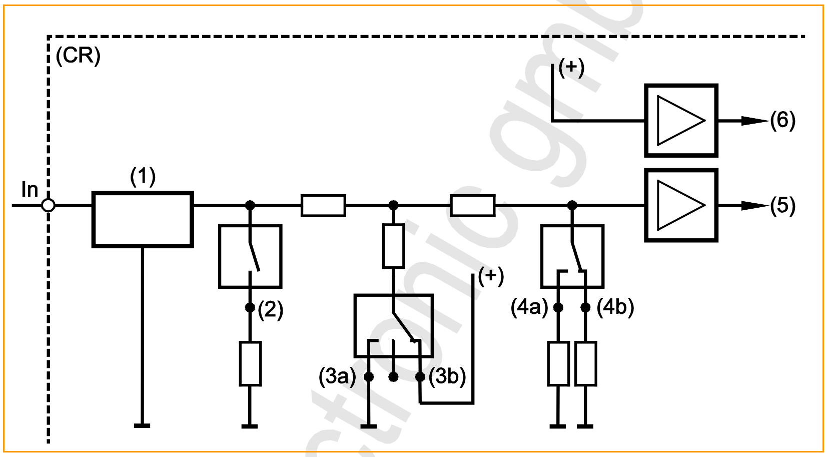
- current input 0...20 mA
- voltage input 0...10 V
- voltage input 0...32 V

The voltage measurement can also be carried out ratiometrically (0...1000 ‰, adjustable via function blocks). This means potentiometers or joysticks can be evaluated without additional reference voltage. A fluctuation of the supply voltage has no influence on this measured value.

As an alternative, an analogue channel can also be evaluated binarily.

> ! In case of ratiometric measurement the connected sensors should be supplied with VBBs of the device. So, faulty measurements caused by offset voltage are avoided.

8971



In = pin multifunction input n
(CR) = device
(1) = input filter
(2) = analogue current measuring
(3a) = binary-input plus switching
(3b) = binary-input minus switching
(4a) = analogue voltage measuring 0...10 V
(4b) = analogue voltage measuring 0...32 V
(5) = voltage
(6) = reference voltage

Figure: principle block diagram multifunction input

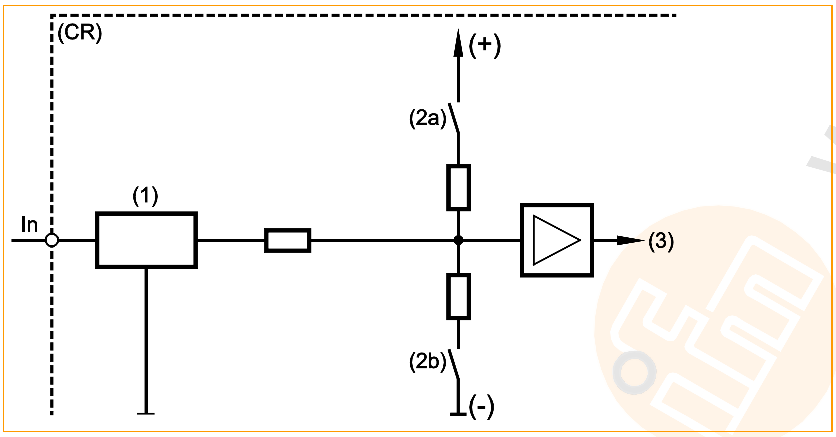
Binary inputs

1015 7345

The binary input can be operated in following modes:

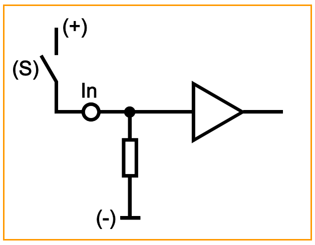
- binary input plus switching (BL) for positive sensor signal
- binary input minus switching (BH) for negative sensor signal

Depending on the device the binary inputs can configured differently. In addition to the protective mechanisms against interference, the binary inputs are internally evaluated via an analogue stage. This enables diagnosis of the input signals. But in the application software the switching signal is directly available as bit information



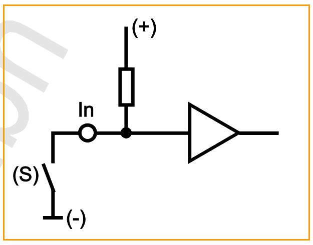
In = pin binary-input n
(CR) = device
(1) = input filter
(2a) = input minus switching
(2b) = input plus switching
(3) = voltage

Figure: basic circuit of binary input minus switching / plus switching for negative and positive sensor signals



In = pin binary input n
(S) = sensor

Basic circuit of binary input plus switching (BL)
for positive sensor signal:
Input = open ⇨ signal = low (GND)



In = pin binary input n
(S) = sensor

Basic circuit of binary input minus switching (BH)
for negative sensor signal:
Input = open ⇨ signal = high (supply)

For some of these inputs (→ data sheet) the potential can be selected to which it will be switched.

Input group ANALOG0...7

20856

These inputs are a group of multifunction channels.

These inputs can be used as follows (each input separately configurable):

- analogue input 0...20 mA
- analogue input 0...10 V
- analogue input 0...32 V
- voltage measurement ratiometric 0...1000 ‰ von 32 V
- binary input plus switching (BL) for positive sensor signal (with/without diagnosis)

→ chapter *Possible operating modes inputs/outputs* (→ page 186)

All inputs show the same behaviour concerning function and diagnosis.

► Configuration of each input is made via the application program:
- configuration byte ANALOGxy_MODE
- FB *INPUT_ANALOG* (→ page 122) > input MODE

If the analogue inputs are configured for current measurement, the device switches to the safe voltage measurement range (0...32V DC) and the corresponding error bit in the flag byte ERROR_A_INx is set when the final value (> 23 mA) is exceeded.

> When the value is again below the limit value, the input automatically switches back to the current measurement range.

Input group IN00...IN07

19976

These inputs are a group of multifunction channels.

These inputs can be used as follows (each input separately configurable):

- binary input plus switching (BL) for positive sensor signal (with/without diagnosis)

→ chapter *Possible operating modes inputs/outputs* (→ page 186)

► Configuration of each input is made via the application program:
- configuration byte INxx_MODE

Sensors with diagnostic capabilities to NAMUR can be evaluated.

Input group IN08...IN11 / FRQ00...FRQ03

19979

These inputs are a group of multifunction channels.

These inputs can be used as follows (each input separately configurable):

- binary input plus switching (BL) for positive sensor signal (with/without diagnosis)
- fast input for e.g. incremental encoders and frequency or interval measurement

→ chapter *Possible operating modes inputs/outputs* (→ page 186)

Sensors with diagnostic capabilities to NAMUR can be evaluated.

► Configuration of each input is made via the application program:
- configuration byte INxx_MODE
- Fast inputs with the following FBs:

FAST_COUNT (→ page 129)	Counter block for fast input pulses
FREQUENCY (→ page 130)	Measures the frequency of the signal arriving at the selected channel
INC_ENCODER (→ page 131)	Up/down counter function for the evaluation of encoders
PERIOD (→ page 133)	Measures the frequency and the cycle period (cycle time) in [µs] at the indicated channel
PERIOD_RATIO (→ page 135)	Measures the frequency and the cycle period (cycle time) in [µs] during the indicated periods at the indicated channel. In addition, the mark-to-space ratio is indicated in [‰].
PHASE (→ page 137)	Reads a pair of channels with fast inputs and compares the phase position of the signals

Input group IN12...IN15

20858

These inputs are a group of multifunction channels.

These inputs can be used as follows (each input separately configurable):
• binary input plus switching (BL) for positive sensor signal
• binary input minus switching (BH) for negative sensor signal
→ chapter *Possible operating modes inputs/outputs* (→ page 186)

Sensors with diagnostic capabilities to NAMUR can be evaluated.

All inputs show the same behaviour concerning function and diagnosis.

ℹ Detailed description → chapter *Address assignment inputs / outputs*

► Configuration of each input is made via the application program:
• inputs IN12+IN13 via configuration byte IN12_13_MODE
• inputs IN14+IN15 via configuration byte IN14_15_MODE

3.2.4 Outputs (technology)

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Binary outputs

19986

The following operating modes are possible for the device outputs (→ data sheet):

- binary output, plus switching (BH), short-circuit proof, overload protected

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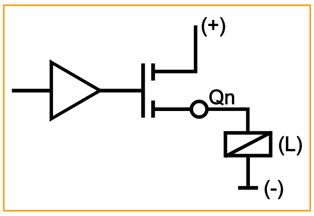


Qn = pin output n
(L) = load

Basic circuit of output plus switching (BH)
for positive output signal

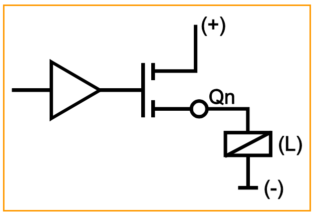
PWM outputs

14095

The following operating modes are possible for the device outputs (→ data sheet):

- PWM output, plus switching (BH) without diagnostic function

15451



Qn = pin output n
(L) = load

Basic circuit of output plus switching (BH)
for positive output signal

Output group OUT00...OUT03

20860

These outputs are a group of multifunction channels.

These outputs provide several function options (each output separately configurable):
- binary output, plus switching (BH), short-circuit proof, overload protected
- analogue output with Pulse Width Modulation (PWM)

→ chapter *Possible operating modes inputs/outputs* (→ page 186)

► Configuration of each output is made via the application program:
PWM outputs: selectively
→ FB *PWM* (→ page 140)
→ FB *PWM100* (→ page 144)
→ FB *PWM1000* (→ page 146)

► ⓘ For the limit values please make sure to adhere to the data sheet!

Output group OUT04...OUT07

20863

These outputs are a group of channels with a single specified function.

These outputs have the following fixed setting:
- binary output, plus switching (BH), short-circuit proof, overload protected

→ chapter *Possible operating modes inputs/outputs* (→ page 186)

► ⓘ For the limit values please make sure to adhere to the data sheet!

Output group OUT08...OUT11

21008

These outputs are a group of channels with a single specified function.

These outputs have the following fixed setting:
- binary output, plus switching (BH), short-circuit proof, overload protected

→ chapter *Possible operating modes inputs/outputs* (→ page 186)

► ⓘ For the limit values please make sure to adhere to the data sheet!

3.2.5 Note on wiring

1426

The wiring diagrams (→ installation instructions of the devices, chapter "Wiring") describe the standard device configurations. The wiring diagram helps allocate the input and output channels to the IEC addresses and the device terminals.

The individual abbreviations have the following meaning:

A	Analogue input
BH	Binary high side input: minus switching for negative sensor signal Binary high side output: plus switching for positive output signal
BL	Binary low side input: plus switching for positive sensor signal Binary low side output: minus switching for negative output signal
CYL	Input period measurement
ENC	Input encoder signals
FRQ	Frequency input
H bridge	Output with H-bridge function
PWM	**P**ulse-**w**idth **m**odulated signal
PWMi	PWM output with current measurement
IH	Pulse/counter input, high side: minus switching for negative sensor signal
IL	Pulse/counter input, low side: plus switching for positive sensor signal
R	Read back channel for one output

Allocation of the input/output channels: → Catalogue, mounting instructions or data sheet

3.2.6 Safety instructions about Reed relays

7348

For use of non-electronic switches please note the following:

> ❗ Contacts of Reed relays may be clogged (reversibly) if connected to the device inputs without series resistor.

- ► **Remedy:** Install a series resistor for the Reed relay:
  Series resistor = max. input voltage / permissible current in the Reed relay
  Example: 32 V / 500 mA = 64 Ohm
- ► The series resistor must not exceed 5 % of the input resistance RE of the device input (→ data sheet). Otherwise, the signal will not be detected as TRUE.
  Example:
  RE = 3 000 Ohm
  ⇒ max. series resistor = 150 Ohm

3.2.7 Status LED

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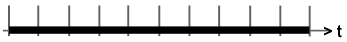
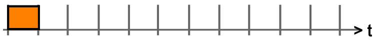
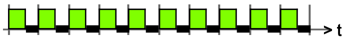
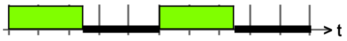
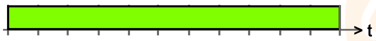
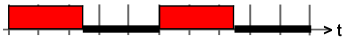
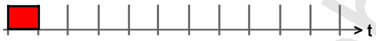
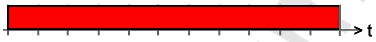
The operating states are indicated by the integrated status LED (default setting).

LED colour	Display	Description
Off	Permanently off	No operating voltage
		
Orange	Briefly on	Initialisation or reset checks
		(time frame = 200 ms)
Green	Flashing with 5 Hz	TEST=TRUE: no runtime system loaded
		(time frame = 200 ms)
Green	Flashing with 2 Hz	Application = RUN
		(time frame = 200 ms)
Green	Permanently on	Application = STOP
		
Red	Flashing with 2 Hz	Application = RUN with error
		(time frame = 200 ms)
Red	Briefly on	FATAL ERROR
		(time frame = 200 ms)

Red	Permanently on	TEST=TRUE: Application = STOP and FATAL ERROR
		TEST=FALSE: ERROR STOP / SYSTEM STOP

The status LED can be changed by the programming system for the operating states STOP and RUN. To do so, the following system variable is used:

LED_MODE	Flashing frequency from the data structure "LED_MODES" permissible: LED_2HZ, LED_1HZ, LED_05HZ, LED_0HZ (constant)

❗ If the flashing mode is changed in the application program, the default setting table is no longer valid.

3.3 Interface description

Contents

14098

3.3.1 Serial interface

14099

This device features a serial interface.

The serial interface can generally be used in combination with the following functions:
- program download
- debugging
- free use of the application

12998

NOTE

The serial interface is not available to the user by default, because it is used for program download and debugging.

The interface can be freely used if the user sets the system flag bit SERIAL_MODE=TRUE.
Debugging of the application program is then only possible via one of the 4 CAN interfaces.

Connections and data → data sheet

3.3.2 CAN interfaces

Contents

14101

Connections and data → data sheet

Available CAN interfaces and CAN protocols

20872

The following CAN interfaces and CAN protocols are available in this **ecomat*mobile*** device:

CAN interface	**CAN 1**	**CAN 2**	**CAN 3**	**CAN 4**
Default download ID	ID 127	ID 126	ID 125	ID 124
CAN protocols	CAN Layer 2	Interface does not exist	Interface does not exist	Interface does not exist
	CANopen			
	SAE J1939			

Standard baud rate = 125 kBit/s

3.4 Software description

Contents

14107

3.4.1 Software modules for the device

Contents

14110

The software in this device communicates with the hardware as below:

software module	Can user change the module?	By means of what tool?
Application program with libraries	yes	CODESYS, MaintenanceTool
Runtime system *)	Upgrade yes Downgrade yes	MaintenanceTool
Bootloader	no	---
(Hardware)	no	---

*) The runtime system version number must correspond to the target version number in the CODESYS target system setting.
→ chapter *Set up the target* (→ page 43)

Below we describe this software module:

Bootloader

14111

On delivery **ecomat*mobile*** controllers only contain the boot loader.
The boot loader is a start program that allows to reload the runtime system and the application program on the device.
The boot loader contains basic routines...

- for communication between hardware modules,
- for reloading the operating system.

The boot loader is the first software module to be saved on the device.

Runtime system

14112

Basic program in the device, establishes the connection between the hardware of the device and the application program.

On delivery, there is normally no runtime system loaded in the controller (LED flashes green at 5 Hz). Only the bootloader is active in this operating mode. It provides the minimum functions for loading the runtime system, among others support of the interfaces (e.g. CAN).

Normally it is necessary to download the runtime system only once. Then, the application program can be loaded into the controller (also repeatedly) without affecting the runtime system.

The runtime system is provided with this documentation on a separate data carrier. In addition, the current version can be downloaded from the website of **ifm electronic gmbh**:
→ www.ifm.com > Select your country > [Service] > [Download]

Application program

14118

Software specific to the application, implemented by the machine manufacturer, generally containing logic sequences, limits and expressions that control the appropriate inputs, outputs, calculations and decisions.

8340

⚠ **WARNING**

The user is responsible for the reliable function of the application programs he designed. If necessary, he must additionally carry out an approval test by corresponding supervisory and test organisations according to the national regulations.

Libraries

20880

ifm electronic offers several libraries (`*.LIB`) to match each device containing program modules for the application program. Examples:

Library	Usage
`ifm_CR0302_Vxxyyzz.LIB`	Device-specific library Must always be contained in the application program!
`ifm_CR0302_CANopenMaster_Vxxyyzz.LIB`	(optional) if the CAN interface of the device is to be operated as a CANopen master
`ifm_CR0302_CANopenSlave_Vxxyyzz.LIB`	(optional) if the CAN interface of the device is to be operated as a CANopen-Slave
`ifm_CAN1_EXT_Vxxyyzz.LIB`	(optional) if the CAN interface of the device is to operate on 29 bits
`ifm_CR0302_J1939_1_Vxxyyzz.LIB`	(optional) if theCAN interface of the device is to communicate with a motor control

Details: → chapter *ifm libraries for the device CR0302* (→ page 52)

3.4.2 Programming notes for CODESYS projects

Contents

7426

Here you receive tips how to program the device.

► See the notes in the CODESYS programming manual
→ www.ifm.com > select your country > [Data sheet search] > CR0302 > [Operating instructions]
→ **ecomat*mobile*** DVD "Software, tools and documentation".

FB, FUN, PRG in CODESYS

8473

In CODESYS we differentiate between the following types of function elements:

FB = function block

- An FB can have several inputs and several outputs.
- An FB may be called several times in a project.
- An instance must be declared for each call.
- Permitted: Call FB and FUN in FB.

FUN = function

- A function can have several inputs but only one output.
- The output is of the same data type as the function itself.

PRG = program

- A PRG can have several inputs and several outputs.
- A PRG may only be called once in a project.
- Permitted: Call PRG, FB and FUN in PRG.

NOTE

Function blocks must NOT be called in functions!
Otherwise: During execution the application program will crash.

All function elements must NOT be called recursively, nor indirectly!

An IEC application must contain max. 8,000 function elements!

Background:

All variables of functions...

- are initialised when called and
- become invalid after return to the caller.

Function blocks have 2 calls:

- an initialisation call and
- the actual call to do something.

Consequently that means for the FB call in a function:

- every time there is an additional initialisation call and
- the data of the last call gets lost.

Calculations and conversions in the application program

20779

NOTE

If the following elements are required in the application program:
- mathematical functions (e.g. ATAN),
- calculations,
- conversions (e.g. REAL_TO_BYTE),

then the following applies to the values at the inputs and outputs of the corresponding operators:

▶ Strictly observe the admissible value range in each individual case!

> Otherwise, this may cause an FPU error in the controller.

Examples:

20777

The value of the target format that can max. represented is exceeded.
Example:
REAL_TO_INT (12345678.3)
> INT is limited to -32768...+32767 (only integers)

20778

An existing real number is obviously in the value range of the target format.
In reality, however, the number is outside the target format (because of the internal representation of the real number).
Example:
DW := REAL_TO_DWORD (4294967295.0);
> The most accurate representation of 4294967295 in REAL is 4.294967296E9
> Therefore the value exceeds the max. permissible value of the target format by 1.
> DWORD is limited to 0...4294967295.

Note the cycle time!

8006

For the programmable devices from the controller family **ecomat*mobile*** numerous functions are available which enable use of the devices in a wide range of applications.

As these units use more or fewer system resources depending on their complexity it is not always possible to use all units at the same time and several times.

NOTICE

Risk that the device acts too slowly!
Cycle time must not become too long!

▶ When designing the application program the above-mentioned recommendations must be complied with and tested.

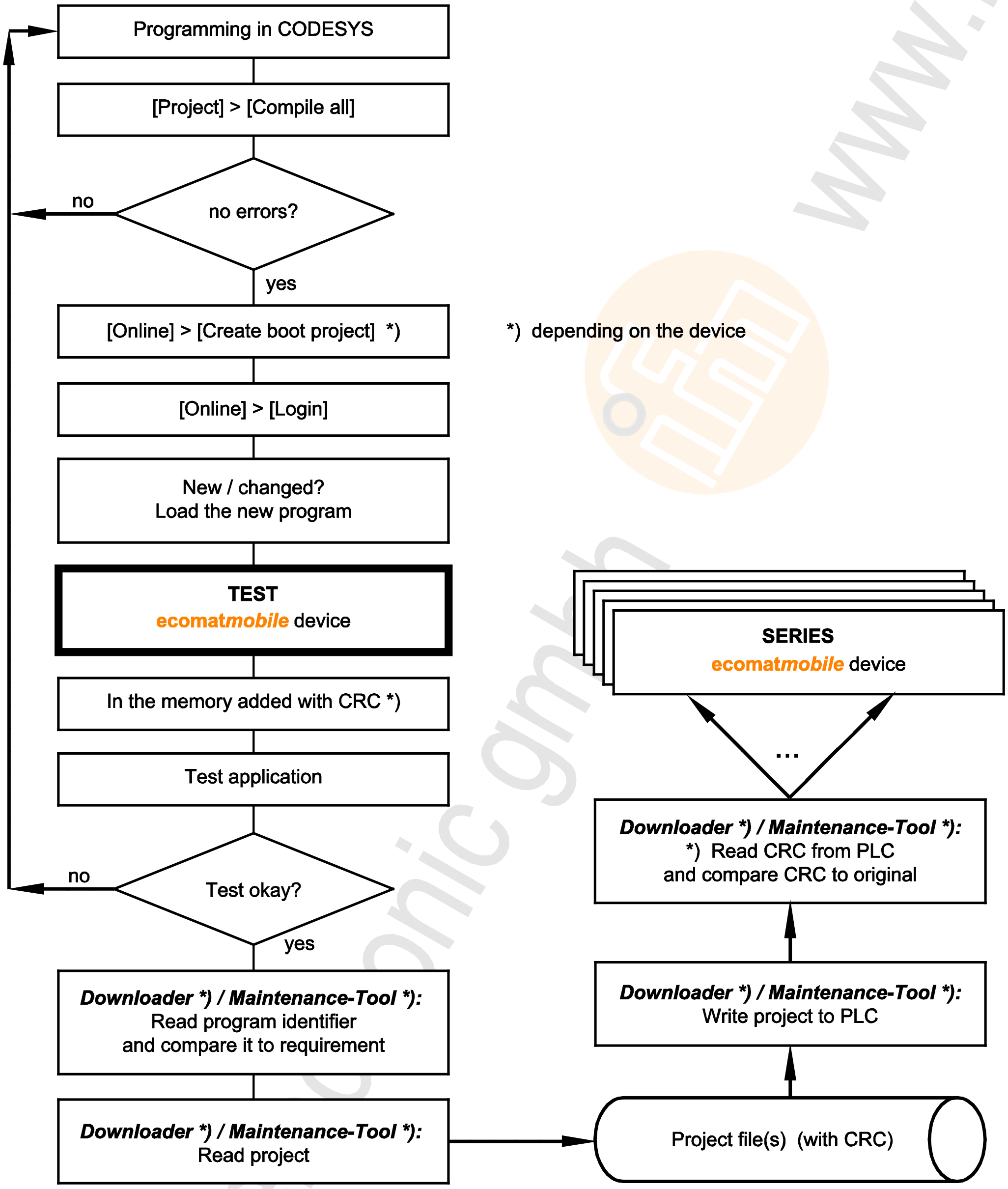
▶ If necessary, the cycle time must be optimised by restructuring the software and the system set-up.

Creating application program

8007

The application program is generated by the CODESYS programming system and loaded in the controller several times during the program development for testing:
In CODESYS: [Online] > [Login] > load the new program.

For each such download via CODESYS the source code is translated again. The result is that each time a new checksum is formed in the controller memory. This process is also permissible for safety controllers until the release of the software.


Programming in CODESYS
[Project] > [Compile all]
no errors?
no
yes
[Online] > [Create boot project] *)
*) depending on the device
[Online] > [Login]
New / changed?
Load the new program
TEST
ecomatmobile device
In the memory added with CRC *)
Test application
Test okay?
no
yes
Downloader *) / Maintenance-Tool *):
Read program identifier
and compare it to requirement
Downloader *) / Maintenance-Tool *):
Read project
Project file(s) (with CRC)
Downloader *) / Maintenance-Tool *):
Write project to PLC
Downloader *) / Maintenance-Tool *):
*) Read CRC from PLC
and compare CRC to original
...
SERIES
ecomatmobile device

Graphics: Creation and distribution of the software

Save boot project

7430

❗ Always save the related boot project together with your application project in the device. Only then will the application program be available after a power failure in the device.

❗ **NOTE**

Note: The boot project is slightly larger than the actual program.

However: Saving the boot project in the device will fail if the boot project is larger than the available IEC code memory range. After power-on the boot project is deleted or invalid.

► CODESYS menu [Online] > [Create boot project]
This is necessary after each change!

> After a reboot, the device starts with the boot project last saved.

> If NO boot project was saved:
• The device remains in the STOP operation after reboot.
• The application program is not (no longer) available.
• The LED lights green.

Using ifm downloader

8008

The **ifm** downloader serves for easy transfer of the program code from the programming station to the controller. As a matter of principle each application software can be copied to the controllers using the **ifm** downloader. Advantage: A programming system with CODESYS licence is not required.

Here you will find the current **ifm** downloader (min. V06.18.26):
ecomat*mobile* DVD "Software, tools and documentation" under the tab 'R360 tools [D/E]'

3.4.3 Operating states

Contents

14120

After power on the **ecomat*mobile*** device can be in one of five possible operating states:
- BOOTLOADER
- INIT
- STOP
- RUN
- SYSTEM STOP (after ERROR STOP)

Operating states: runtime system is not available

19217

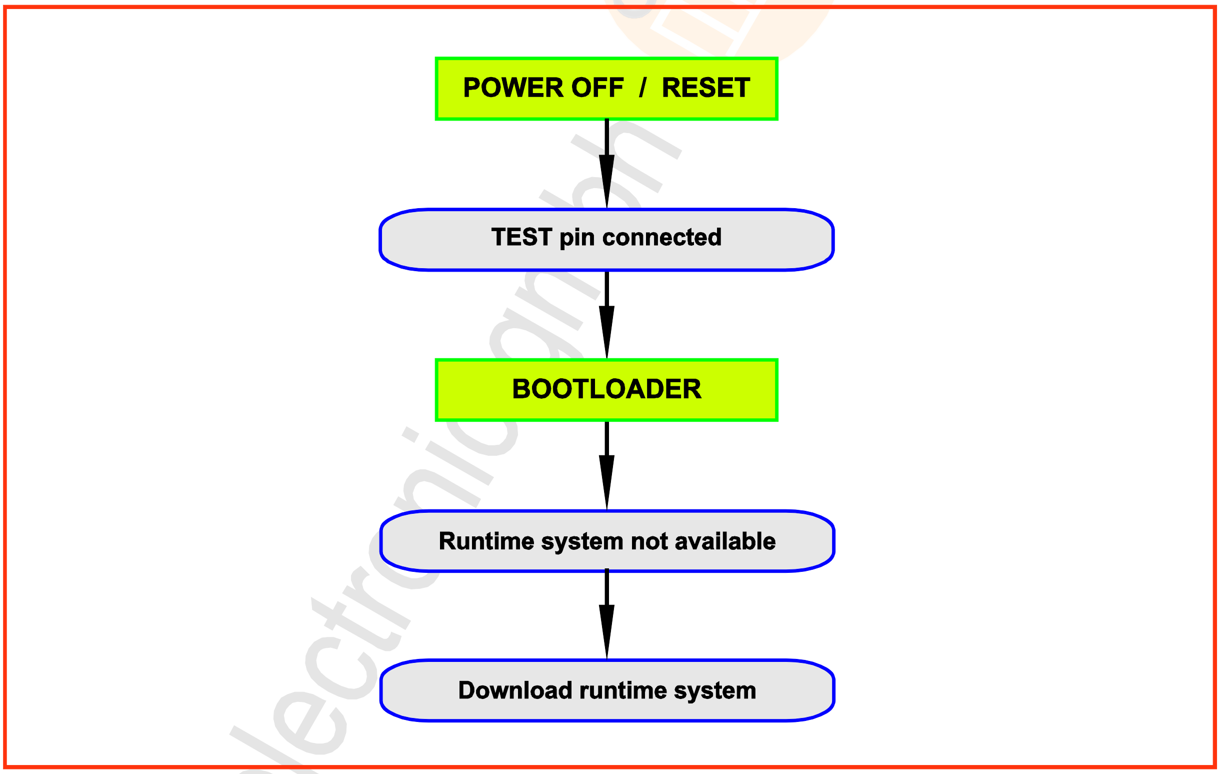


Figure: operating states (here: runtime system is not available)

Operating states: application program is not available

19218

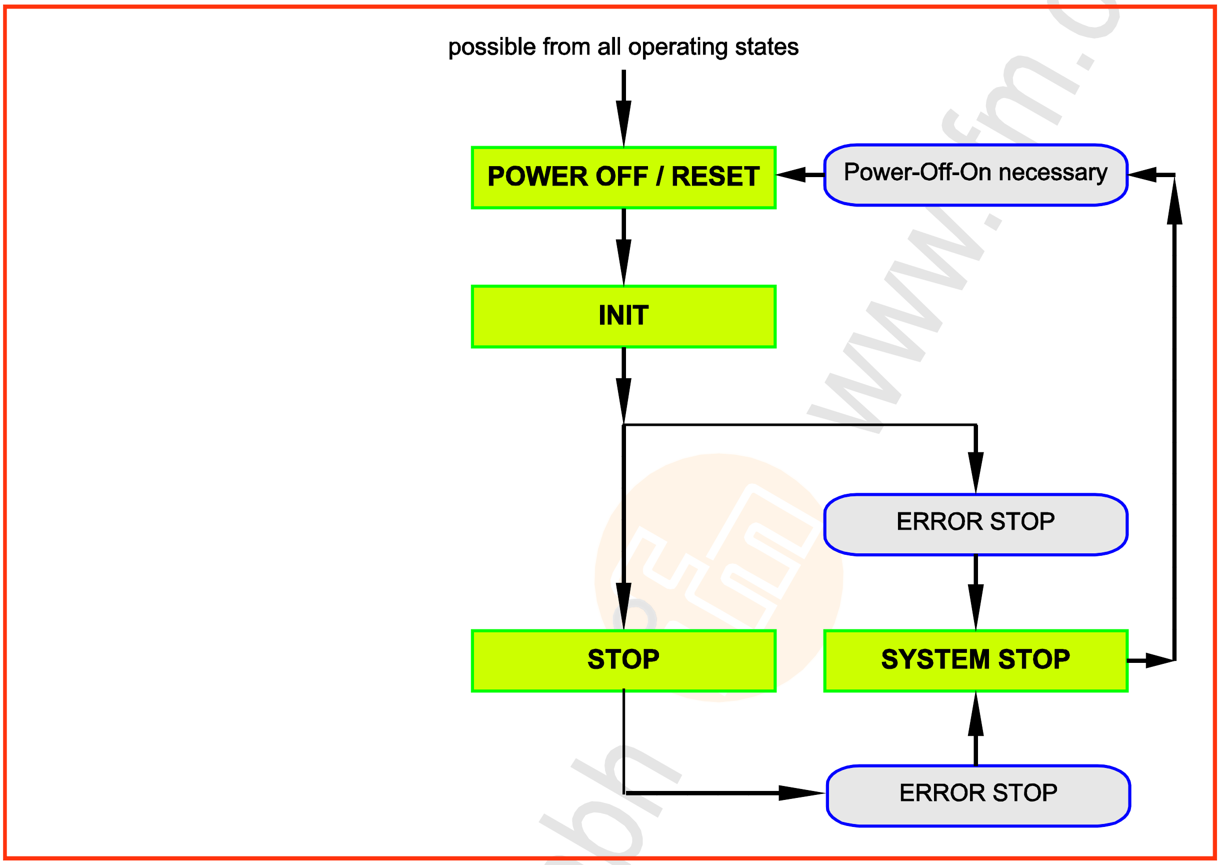


Figure: operating states (here: application program is not available)

Operating states: application program is available

19219

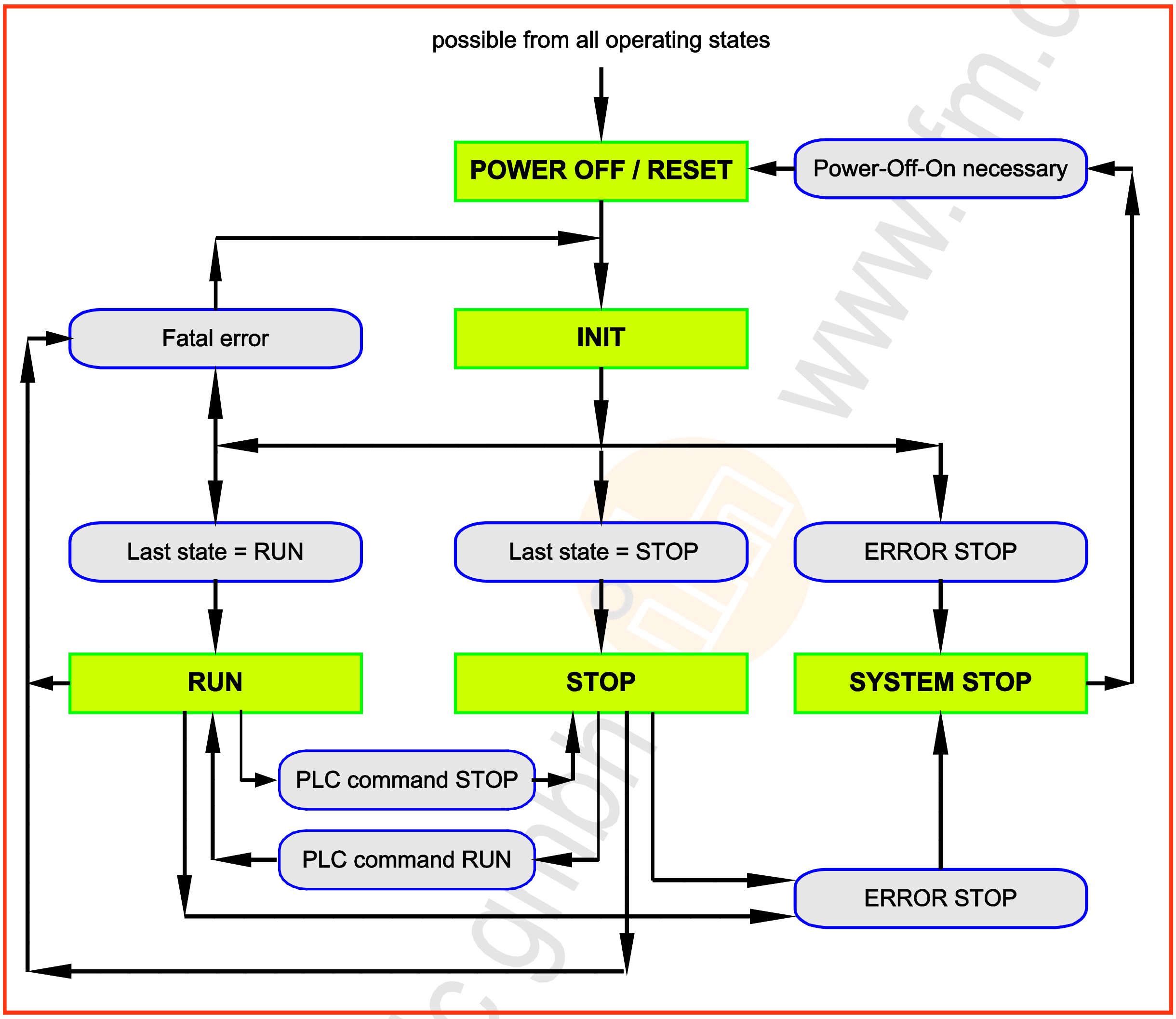


Figure: operating states (here: application program is available)

Bootloader state

1080

No runtime system was loaded. The **ecomat*mobile*** controller is in the boot loading state. Before loading the application software the runtime system must be downloaded.

> The LED flashes green (5 Hz).

INIT state (Reset)

1076

Premise: a valid runtime system is installed.

This state is passed through after every power on reset:

> The runtime system is initialised.

> Various checks are carried out, e.g. waiting for correctly power supply voltage.

> This temporary state is replaced by the RUN or STOP state.

> The LED lights yellow.

Change out of this state possible into one of the following states:
- RUN
- STOP

STOP state

1078

This state is reached in the following cases:

- From the RESET state if:
  - no program is loaded or
  - the last state before the RESET state was the STOP state
- From the RUN state by the STOP command
  - only for the operating mode = Test (→ chapter *TEST mode*)

> The LED lights green.

RUN state

1077

This state is reached in the following cases:

- From the RESET state if:
  - the last state before the RESET state was the RUN state
- From the STOP state by the RUN command
  - only for the operating mode = Test (→ chapter *TEST mode*)

> The LED flashes green (2 Hz).

SYSTEM STOP state

19222

The **ecomat*mobile*** controller goes to this state if a non tolerable error (ERROR STOP) was found. This state can only be left by a power-off-on reset.

> The LED lights red.

3.4.4 Operating modes

1083

Independent of the operating states the **ecomat*mobile*** controller can be operated in different modes.

TEST mode

20876

NOTICE

Loss of the stored software possible!

In the test mode there is no protection of the stored runtime system and application software.

14892

NOTE

> Connect the TEST connection to the supply voltage only AFTER you have connected the OPC client!

This operating mode is achieved by applying a high level (supply voltage) to the test input
(→ installation instructions, chapter "wiring").

The controller can now receive commands via one of the interfaces in the RUN or STOP mode and, for example, communicate with the programming system.

Only in the TEST mode, the software can be downloaded to the controller.

The state of the application program can be queried via the flag TEST.

Summary Test input is active:
- Programming mode is enabled
- Software download is possible
- Status of the application program can be queried
- Protection of stored software is not possible

NOTICE

Zerstörung des EEPROMs möglich!

Der Test-Eingang darf nicht permanent aktiviert werden, weil sonst die zulässigen Schreibzyklen im EEPROM überschritten werden.

Notes: TEST inputs

20781

- ► The TEST inputs of all the controllers in the machine should be wired individually and marked clearly so that they can be properly allocated to the controllers.
- ► During a service access only activate the TEST input of the controller to be accessed.

SERIAL_MODE

1085

The serial interface is available for the exchange of data in the application. Debugging the application software is then only possible via the CAN interface.

This function is switched off as standard (FALSE). Via the flag SERIAL_MODE the state can be controlled and queried via the application program or the programming system.

→ chapter *Function elements: serial interface* (→ page 109)

DEBUG mode

1086

If the input DEBUG of *SET_DEBUG* (→ page 173) is set to TRUE, the programming system or the downloader, for example, can communicate with the controller and execute some special system commands (e.g. for service functions via the GSM modem CANremote).

In this operating mode a software download is not possible because the test input (→ chapter *TEST mode*) is not connected to supply voltage.

3.4.5 Performance limits of the device

7358

❗ Note the limits of the device! → Data sheet

Above-average stress

20878

The following FBs, for example, utilise the system resources above average:

Function block	Above average load
FREQUENCY, PERIOD, PERIOD_RATIO, PHASE	Use of several measuring channels with a high input frequency
CAN interface	High baud rate (> 250 kbits) with a high bus load
PWM, PWM100, PWM1000	Many PWM channels at the same time. In particular the channels as from 4 are much more time critical
INC_ENCODER	Many encoder channels at the same time

The FBs listed above as examples trigger system interrupts. This means: each activation prolongs the cycle time of the application program.

1509

NOTICE

Risk that the controller works too slowly! Cycle time must not become too long!

► When the application program is designed the above-mentioned recommendations must be complied with and tested. If necessary, the cycle time must be optimised by restructuring the software and the system set-up.

Watchdog behaviour

1490

In this device, a watchdog monitors the program runtime of the CODESYS application.

If the maximum watchdog time (100...200 ms) is exceeded:
> the device performs a reset and reboots

4 Configurations

Contents

1016

The device configurations described in the corresponding installation instructions or in the *Appendix* (→ page 178) to this documentation are used for standard devices (stock items). They fulfil the requested specifications of most applications.

Depending on the customer requirements for series use it is, however, also possible to use other device configurations, e.g. with respect to the inputs/outputs and analogue channels.

4.1 Set up the runtime system

Contents

14091

4.1.1 Reinstall the runtime system

14092
2733

On delivery of the **ecomat*mobile*** device no runtime system is normally loaded (LED flashes green at 5 Hz). Only the bootloader is active in this operating mode. It provides the minimum functions for loading the runtime system (e.g. RS232, CAN).

Normally it is necessary to download the runtime system only once. The application program can then be loaded to the device (also several times) without influencing the runtime system.

The runtime system is provided with this documentation on a separate data carrier. In addition, the current version can be downloaded from the website of **ifm electronic gmbh** at:
→ www.ifm.com > Select your country > [Service] > [Download]

2689

NOTE

The software versions suitable for the selected target must always be used:
- runtime system (`ifm_CR0302_Vxxyyzz.H86`),
- PLC configuration (`ifm_CR0302_Vxx.CFG`),
- device library (`ifm_CR0302_Vxxyyzz.LIB`) and
- the further files.

V	version
xx: 00...99	target version number
yy: 00...99	release number
zz: 00...99	patch number

The basic file name (e.g. "`CR0302`") and the software version number "xx" (e.g. "`02`") must always have the same value! Otherwise the device goes to the STOP mode.

The values for "yy" (release number) and "zz" (patch number) do **not** have to match.

4368

The following files must also be loaded:
- the internal libraries (created in IEC 1131) required for the project,
- the configuration files (`*.CFG`) and
- the target files (`*.TRG`).

It may happen that the target system cannot or only partly be programmed with your currently installed version of CODESYS. In such a case, please contact the technical support department of **ifm electronic gmbh**.

The runtime system is transferred to the device using the separate program "**ifm** downloader". (The downloader is on the **ecomat*mobile*** DVD "Software, tools and documentation" or can be downloaded from **ifm's** website, if necessary): → www.ifm.com > Select your country > [Service] > [Download].

Normally the application program is loaded to the device via the programming system. But it can also be loaded using the **ifm** downloader if it was first read from the device (→ upload).

4.1.2 Update the runtime system

13269

An older runtime system is already installed on the device. Now, you would like to update the runtime system on the device?

14158

NOTICE

Risk of data loss!

When deleting or updating the runtime system all data and programs on the device are deleted.

► Save all required data and programs before deleting or updating the runtime system!

For this operation, the same instructions apply as in the previous chapter 'Reinstall the runtime system'.

4.1.3 Verify the installation

14512
14406

► After loading of the runtime system into the controller:
• check whether the runtime system was transmitted correctly!
• check whether the right runtime system is on the controller!

► 1st check:
use the **ifm** downloader or the maintenance tool to verify whether the correct version of the runtime system was loaded:
• read out the name, version and CRC of the runtime system in the device!
• Manually compare this information with the target data!

► 2nd check (optional):
verify in the application program whether the correct version of the runtime system was loaded:
• read out the name and version of the runtime system in the device!
• Compare this data with the specified values!
The following FB serves for reading the data:

GET_IDENTITY (→ page 172)	Reads the specific identifications stored in the device: • hardware name and hardware version of the device • name of the runtime system in the device • version and revision no. of the runtime system in the device • name of the application (has previously been saved by means of *SET_IDENTITY* (→ page 174))

► If the application detects an incorrect version of a runtime system:
bring all safety functions into the safe state.

4.2 Set up the programming system

Contents

3968

4.2.1 Set up the programming system manually

Contents

3963

Set up the target

2687
11379

When creating a new project in CODESYS the target file corresponding to the device must be loaded.

► Select the requested target file in the dialogue window [Target Settings] in the menu [Configuration].

> The target file constitutes the interface to the hardware for the programming system.

> At the same time, several important libraries and the PLC configuration are loaded when selecting the target.

► If necessary, in the window [Target settings] > tab [Network functionality] > activate [Support parameter manager] and / or activate [Support network variables].

► If necessary, remove the loaded (3S) libraries or complement them by further (ifm) libraries.

► Always complement the appropriate device library `ifm_CR0302_Vxxyyzz.LIB` manually!

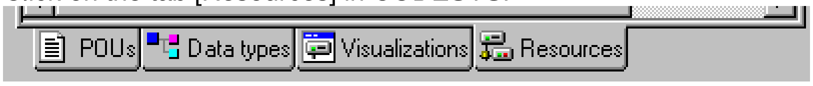
Activate the PLC configuration (e.g. CR0033)

15824

During the configuration of the programming system (→ previous section) the PLC configuration was also carried out automatically.

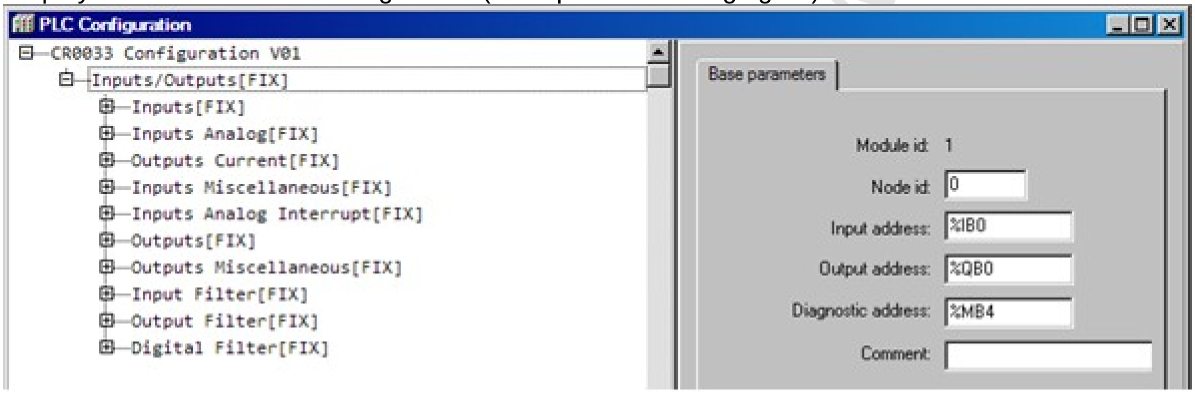
► The menu item [PLC Configuration] is reached via the tab [Resources].
Double-click on [PLC Configuration] to open the corresponding window.

► Click on the tab [Resources] in CODESYS:



► In the left column double-click on [PLC Configuration].

> Display of the current PLC configuration (example → following figure):

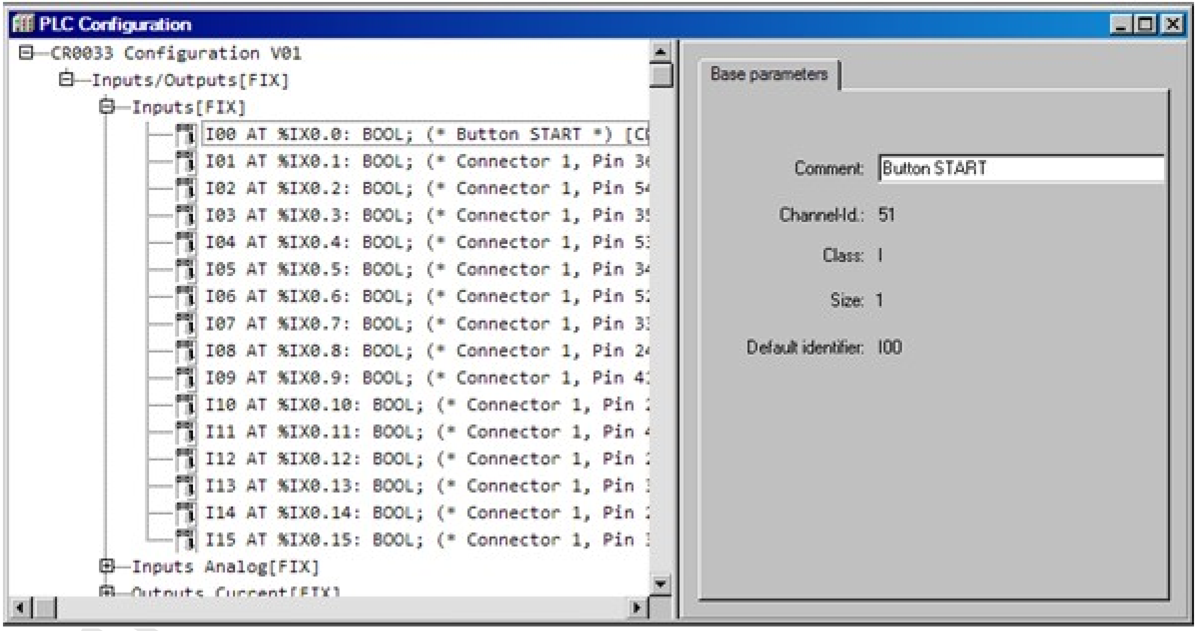


```
⊟—CR0033 Configuration V01
   ⊟—Inputs/Outputs[FIX]
      ⊞—Inputs[FIX]
      ⊞—Inputs Analog[FIX]
      ⊞—Outputs Current[FIX]
      ⊞—Inputs Miscellaneous[FIX]
      ⊞—Inputs Analog Interrupt[FIX]
      ⊞—Outputs[FIX]
      ⊞—Outputs Miscellaneous[FIX]
      ⊞—Input Filter[FIX]
      ⊞—Output Filter[FIX]
      ⊞—Digital Filter[FIX]
```

Module id: 1
Node id: 0
Input address: %IB0
Output address: %QB0
Diagnostic address: %MB4
Comment:

Based on the configuration the user can find the following in the program environment:

- all important system and error flags
Depending on the application and the application program, these flags must be processed and evaluated. Access is made via their symbolic names.
- The structure of the inputs and outputs
These can directly be designated symbolically (highly recommended!) in the window [PLC Configuration] (→ figure below) and are available in the whole project as [Global Variables].



```
⊟—CR0033 Configuration V01
   ⊟—Inputs/Outputs[FIX]
      ⊟—Inputs[FIX]
         ├—I00 AT %IX0.0: BOOL; (* Button START *) [C
         ├—I01 AT %IX0.1: BOOL; (* Connector 1, Pin 3
         ├—I02 AT %IX0.2: BOOL; (* Connector 1, Pin 5
         ├—I03 AT %IX0.3: BOOL; (* Connector 1, Pin 3
         ├—I04 AT %IX0.4: BOOL; (* Connector 1, Pin 5
         ├—I05 AT %IX0.5: BOOL; (* Connector 1, Pin 3
         ├—I06 AT %IX0.6: BOOL; (* Connector 1, Pin 5
         ├—I07 AT %IX0.7: BOOL; (* Connector 1, Pin 3
         ├—I08 AT %IX0.8: BOOL; (* Connector 1, Pin 2
         ├—I09 AT %IX0.9: BOOL; (* Connector 1, Pin 4
         ├—I10 AT %IX0.10: BOOL; (* Connector 1, Pin
         ├—I11 AT %IX0.11: BOOL; (* Connector 1, Pin
         ├—I12 AT %IX0.12: BOOL; (* Connector 1, Pin
         ├—I13 AT %IX0.13: BOOL; (* Connector 1, Pin
         ├—I14 AT %IX0.14: BOOL; (* Connector 1, Pin
         └—I15 AT %IX0.15: BOOL; (* Connector 1, Pin
      ⊞—Inputs Analog[FIX]
      ⊞—Outputs Current[FIX]
```

Comment: Button START
Channel-Id.: 51
Class: I
Size: 1
Default identifier: I00

4.2.2 Set up the programming system via templates

13745

ifm offers ready-to-use templates (program templates), by means of which the programming system can be set up quickly, easily and completely.

970

ℹ When installing the **ecomat*mobile*** DVD "Software, tools and documentation", projects with templates have been stored in the program directory of your PC:
`…\ifm electronic\CoDeSys V…\Projects\Template_DVD_V…`

► Open the requested template in CODESYS via:
[File] > [New from template…]

> CODESYS creates a new project which shows the basic program structure. It is strongly recommended to follow the shown procedure.

4.3 Function configuration of the inputs and outputs

Contents

1394

For some devices of the **ecomatmobile** controller family, additional diagnostic functions can be activated for the inputs and outputs. So, the corresponding input and output signal can be monitored and the application program can react in case of a fault.

Depending on the input and output, certain marginal conditions must be taken into account when using the diagnosis:

► It must be checked by means of the data sheet if the device used has the described input and output groups (→ data sheet).

- Constants are predefined (e.g. IN_DIGITAL_H) in the device libraries (`ifm_CR0302_Vxxyyzz.LIB`) for the configuration of the inputs and outputs.
  For details → *Possible operating modes inputs/outputs* (→ page 186).

4.3.1 Configure inputs

Contents

3973

Valid operating modes → chapter *Possible operating modes inputs/outputs* (→ page 186)

Safety instructions about Reed relays

7348

For use of non-electronic switches please note the following:

> ❗ Contacts of Reed relays may be clogged (reversibly) if connected to the device inputs without series resistor.

► **Remedy:** Install a series resistor for the Reed relay:
Series resistor = max. input voltage / permissible current in the Reed relay
Example: 32 V / 500 mA = 64 Ohm

► The series resistor must not exceed 5 % of the input resistance RE of the device input (→ data sheet). Otherwise, the signal will not be detected as TRUE.
Example:
RE = 3 000 Ohm
⇒ max. series resistor = 150 Ohm

Analogue inputs: configuration and diagnosis

20881

► Configuration can be carried out via the system variables ANALOGx_y_MODE (→ *Appendix* (→ page 178)) or, preferably, via *INPUT_ANALOG* (→ page 122) (input MODE). In principle, it is carried out in pairs:
- ANALOG0 and ANALOG4
- ANALOG1 and ANALOG5
- ANALOG2 and ANALOG6
- ANALOG3 and ANALOG7

If the analogue inputs are configured for current measurement, the device switches to the safe voltage measurement range (0...32V DC) and the corresponding error bit in the flag byte ERROR_A_INx is set when the final value (> 23 mA) is exceeded.

> When the value is again below the limit value, the input automatically switches back to the current measurement range.

> When the analogue input FBs are used, the diagnostic function is automatically activated.

> If for an input channel the limit value is exceeded, switching to the safe voltage range is also done in pairs:

Example:

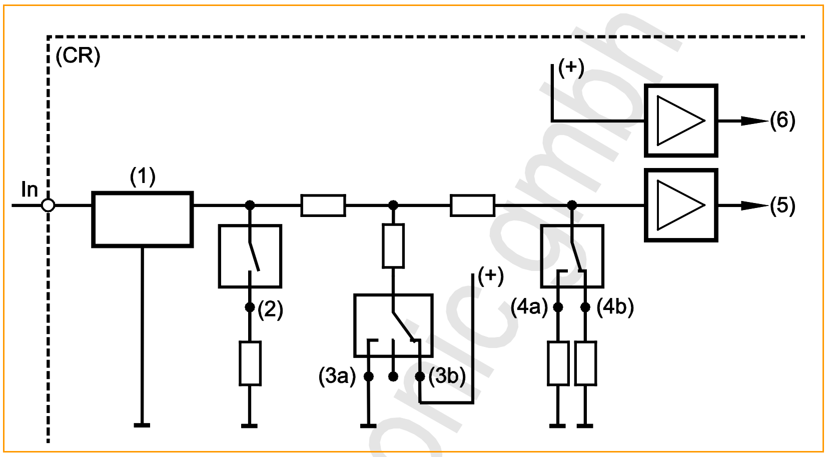
ANALOG0 > 23 mA

> ANALOG0 and ANALOG4 are switched to the safe range 0...32 V DC.

> The error bit is only set for the incorrect input value.

As an alternative, an analogue channel can also be evaluated binarily.

8971



In = pin multifunction input n
(CR) = device
(1) = input filter
(2) = analogue current measuring
(3a) = binary-input plus switching
(3b) = binary-input minus switching
(4a) = analogue voltage measuring 0...10 V
(4b) = analogue voltage measuring 0...32 V
(5) = voltage
(6) = reference voltage

Figure: principle block diagram multifunction input

Binary inputs: configuration and diagnosis

20001

► Configuration of each input is made via the application program:
• configuration byte INxx_MODE
→ chapter *Possible operating modes inputs/outputs* (→ page 186)

Fast inputs

20886

The devices dispose of fast counting/pulse inputs for an input frequency up to 30 kHz (→ data sheet).

If, for example, mechanical switches are connected to these inputs, there may be faulty signals in the controller due to contact bouncing.

Furthermore it has to be noted whether the pulse inputs are designed for frequency measurement (FRQx) and/or period measurement (CYLx) (→ data sheet).

Appropriate function blocks are e.g.:

On FRQx inputs:

FAST_COUNT (→ page 129)	Counter block for fast input pulses
FREQUENCY (→ page 130)	Measures the frequency of the signal arriving at the selected channel

On CYLx inputs:

PERIOD (→ page 133)	Measures the frequency and the cycle period (cycle time) in [µs] at the indicated channel
PERIOD_RATIO (→ page 135)	Measures the frequency and the cycle period (cycle time) in [µs] during the indicated periods at the indicated channel. In addition, the mark-to-space ratio is indicated in [‰].
PHASE (→ page 137)	Reads a pair of channels with fast inputs and compares the phase position of the signals

ℹ When using these units, the parameterised inputs and outputs are automatically configured, so the programmer of the application does not have to do this.

Use as binary inputs

3804

The permissible high input frequencies also ensure the detection of faulty signals, e.g. bouncing contacts of mechanical switches.

► If required, suppress the faulty signals in the application program!

4.3.2 Configure outputs

Contents

3976

Valid operating modes → chapter *Possible operating modes inputs/outputs* (→ page 186)

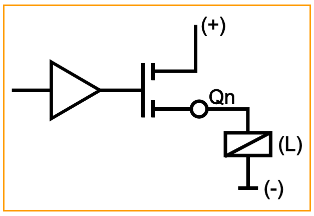
Binary outputs: configuration and diagnosis

20004

These outputs have the following fixed setting:

- binary output, plus switching (BH), short-circuit proof, overload protected

15451



Qn = pin output n
(L) = load

Basic circuit of output plus switching (BH) for positive output signal

13975

⚠ WARNING

Dangerous restart possible!
Risk of personal injury! Risk of material damage to the machine/plant!

If in case of a fault an output is switched off via the hardware, the logic state generated by the application program is not changed.

► Remedy:
- Reset the output logic in the application program!
- Remove the fault!
- Reset the outputs depending on the situation.

Binary outputs: configuration

20890

These outputs are a group of channels with a single specified function.
Permissible values → chapter *Possible operating modes inputs/outputs* (→ page 186)

Binary outputs: Diagnostics

20888

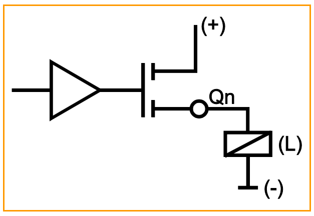
- These outputs are not able for diagnosis.

PWM outputs

14705

The following operating modes are possible for the device outputs (→ data sheet):
- PWM output, plus switching (BH) without diagnostic function

15451



Qn = pin output n
(L) = load

Basic circuit of output plus switching (BH) for positive output signal

15414

⚠ **WARNING**

Property damage or bodily injury possible due to malfunctions!

For outputs in PWM mode:
- there are no diagnostic functions
- the overload protection OUT_OVERLOAD_PROTECTION is NOT active

9980

NOTE

PWM outputs must NOT be operated in parallel, e.g. in order to increase the max. output current. The outputs do not operate synchronously.

Otherwise the entire load current could flow through only one output. The current measurement would no longer function.

Availability of PWM

20889

Device	Number of available PWM outputs	of which current-controlled (PWMi)	PWM frequency [Hz]
CabinetController: CR0301, CR0302	4	---	20...250

FBs for PWM functions

20891

The following function blocks are available for the PWM function of the outputs:

PWM (→ page 140)	Initialises and configures a PWM-capable output channel Definition of the PWM frequency via RELOAD
PWM100 (→ page 144)	Initialises and configures a PWM-capable output channel Indicate PWM frequency in [Hz] Indicate mark-to-space ratio in steps of 1 %
PWM1000 (→ page 146)	Initialises and configures a PWM-capable output channel the mark-to-space ratio can be indicated in steps of 1 ‰

4.4 Note on wiring

1426

The wiring diagrams (→ installation instructions of the devices, chapter "Wiring") describe the standard device configurations. The wiring diagram helps allocate the input and output channels to the IEC addresses and the device terminals.

The individual abbreviations have the following meaning:

A	Analogue input
BH	Binary high side input: minus switching for negative sensor signal Binary high side output: plus switching for positive output signal
BL	Binary low side input: plus switching for positive sensor signal Binary low side output: minus switching for negative output signal
CYL	Input period measurement
ENC	Input encoder signals
FRQ	Frequency input
H bridge	Output with H-bridge function
PWM	**P**ulse-**w**idth **m**odulated signal
PWMi	PWM output with current measurement
IH	Pulse/counter input, high side: minus switching for negative sensor signal
IL	Pulse/counter input, low side: plus switching for positive sensor signal
R	Read back channel for one output

Allocation of the input/output channels: → Catalogue, mounting instructions or data sheet

4.5 Safety instructions about Reed relays

7348

For use of non-electronic switches please note the following:

> ! Contacts of Reed relays may be clogged (reversibly) if connected to the device inputs without series resistor.

- ► **Remedy:** Install a series resistor for the Reed relay:
  Series resistor = max. input voltage / permissible current in the Reed relay
  Example: 32 V / 500 mA = 64 Ohm
- ► The series resistor must not exceed 5 % of the input resistance RE of the device input (→ data sheet). Otherwise, the signal will not be detected as TRUE.
  Example:
  RE = 3 000 Ohm
  ⇒ max. series resistor = 150 Ohm

5 ifm function elements

Contents

13586

All CODESYS function elements (FBs, PRGs, FUNs) are stored in libraries. Below you will find a list of all the **ifm** libraries you can use with this device.

This is followed by a description of the function elements, sorted by topic.

5.1 ifm libraries for the device CR0302

Contents

14235

5.1.1 Bibliothek ifm_CR0302_V05yyzz.LIB

21015

This is the device library. This **ifm** library contains the following function blocks:

Function element	Short description
CAN1_BAUDRATE (→ page 58)	Sets the transmission rate for the bus participant on CAN interface 1
CAN1_DOWNLOADID (→ page 59)	Sets the download identifier for CAN interface 1
CANx_ERRORHANDLER (→ page 67)	Executes a "manual" bus recovery on CAN interface x x = 1 = number of the CAN interface
CANx_RECEIVE (→ page 69)	CAN interface x: Configures a data receive object and reads out the receive buffer of the data object x = 1 = number of the CAN interface
CANx_RECEIVE_RANGE (→ page 71)	CAN interface x: Configures a sequence of data receive objects and reads out the receive buffer of the data objects x = 1 = number of the CAN interface
CANx_SDO_READ (→ page 93)	CAN interface x: reads the SDO with the indicated indices from the node x = 1 = number of the CAN interface
CANx_SDO_WRITE (→ page 95)	CAN interface x: writes the SDO with the indicated indices to the node x = 1 = number of the CAN interface
CANx_TRANSMIT (→ page 73)	Transfers a CAN data object (message) to the CAN interface x for transmission at each call x = 1 = number of the CAN interface
CHECK_DATA (→ page 170)	Generates a checksum (CRC) for a configurable memory area and checks the data of the memory area for undesired changes
DELAY (→ page 149)	Delays the output of the input value by the time T (dead-time element)
E2READ (→ page 164)	transfers different data types directly from the serial EEPROM to the RAM
E2WRITE (→ page 165)	writes different data types directly into the serial EEPROM
FAST_COUNT (→ page 129)	Counter block for fast input pulses
FLASHREAD (→ page 166)	transfers different data types directly from the flash memory to the RAM
FLASHWRITE (→ page 167)	writes different data types directly into the flash memory
FREQUENCY (→ page 130)	Measures the frequency of the signal arriving at the selected channel
GET_IDENTITY (→ page 172)	Reads the specific identifications stored in the device: • hardware name and hardware version of the device • name of the runtime system in the device • version and revision no. of the runtime system in the device • name of the application (has previously been saved by means of *SET_IDENTITY* (→ page 174))
GLR (→ page 150)	The synchro controller is a controller with PID characteristics
INC_ENCODER (→ page 131)	Up/down counter function for the evaluation of encoders
INPUT_ANALOG (→ page 122)	analogue input channel: alternatively measurement of ... • current • voltage
INPUT_CURRENT (→ page 123)	Current measurement on the analogue input channel
INPUT_VOLTAGE (→ page 124)	Voltage measurement on the analogue input channel
MEMCPY (→ page 168)	Writes and reads different data types directly in the memory
NORM (→ page 126)	Normalises a value [WORD] within defined limits to a value with new limits
PERIOD (→ page 133)	Measures the frequency and the cycle period (cycle time) in [µs] at the indicated channel
PERIOD_RATIO (→ page 135)	Measures the frequency and the cycle period (cycle time) in [µs] during the indicated periods at the indicated channel. In addition, the mark-to-space ratio is indicated in [‰].
PHASE (→ page 137)	Reads a pair of channels with fast inputs and compares the phase position of the signals
PID1 (→ page 152)	PID controller

Function element	Short description
PID2 (→ page 154)	PID controller
PT1 (→ page 156)	Controlled system with first-order delay
PWM (→ page 140)	Initialises and configures a PWM-capable output channel Definition of the PWM frequency via RELOAD
PWM100 (→ page 144)	Initialises and configures a PWM-capable output channel Indicate PWM frequency in [Hz] Indicate mark-to-space ratio in steps of 1 %
PWM1000 (→ page 146)	Initialises and configures a PWM-capable output channel the mark-to-space ratio can be indicated in steps of 1 ‰
SERIAL_PENDING (→ page 110)	Determines the number of data bytes stored in the serial receive buffer
SERIAL_RX (→ page 111)	Reads a received data byte from the serial receive buffer at each call
SERIAL_SETUP (→ page 112)	Initialises the serial RS232 interface
SERIAL_TX (→ page 113)	Transmits one data byte via the serial RS232 interface
SET_DEBUG (→ page 173)	organises the DEBUG mode or the monitoring mode (depending on the TEST input)
SET_IDENTITY (→ page 174)	Sets an application-specific program identification
SET_INTERRUPT_I (→ page 115)	Conditional execution of a program part after an interrupt request via a defined input channel
SET_INTERRUPT_XMS (→ page 118)	Conditional execution of a program part at an interval of x milliseconds
SET_PASSWORD (→ page 175)	Sets a user password for access control to program and memory upload
SOFTRESET (→ page 158)	leads to a complete reboot of the device
TIMER_READ (→ page 160)	Reads out the current system time in [ms] Max. value = 49d 17h 2min 47s 295ms
TIMER_READ_US (→ page 161)	Reads out the current system time in [µs] Max. value = 1h 11min 34s 967ms 295µs

5.1.2 Library ifm_CR0302_CANopenMaster_V04yynn.LIB

18714

This library contains the function blocks for operation of the device as a CANopen master.
The library is only permissible for the 1st CAN interface.

x = 1 = number of the CAN interface

This **ifm** library contains the following function blocks:

Function element	Short description
CANx_MASTER_EMCY_HANDLER (→ page 75)	Handles the device-specific error status of the CANopen master on CAN interface x x = 1 = number of the CAN interface
CANx_MASTER_SEND_EMERGENCY (→ page 76)	Sends application-specific error status of the CANopen master on CAN interface x x = 1 = number of the CAN interface
CANx_MASTER_STATUS (→ page 78)	Status indication on CAN interface x of the device used as CANopen master x = 1 = number of the CAN interface

5.1.3 Library ifm_CR0302_CANopenSlave_V04yynn.LIB

18719

This library contains the function blocks for operation of the device as a CANopen slave.
The library is only permissible for the 1st CAN interface.

x = 1 = number of the CAN interface

This **ifm** library contains the following function blocks:

Function element	Short description
CANx_SLAVE_EMCY_HANDLER (→ page 85)	Handles the device-specific error status of the CANopen slave on CAN interface x: • error register (index 0x1001) and • error field (index 0x1003) of the CANopen object directory x = 1 = number of the CAN interface
CANx_SLAVE_NODEID (→ page 86)	Enables setting of the node ID of a CANopen slave on CAN interface x at runtime of the application program x = 1 = number of the CAN interface
CANx_SLAVE_SEND_EMERGENCY (→ page 87)	Sends application-specific error status of the CANopen slave on CAN interface x x = 1 = number of the CAN interface
CANx_SLAVE_STATUS (→ page 89)	Shows the status of the device used as CANopen slave on CAN interface x x = 1 = number of the CAN interface

5.1.4 Library ifm_CAN1_EXT_Vxxyyzz.LIB

18732

This library contains the complementary POUs for engine control on the 1st CAN interface.
The library is only permissible for the 1st CAN interface.

This **ifm** library contains the following function blocks:

Function element	Short description
CAN1_EXT (→ page 60)	Initialises CAN interface 1 also for the exended mode Set the mode and baud rate
CAN1_EXT_ERRORHANDLER (→ page 61)	Executes a "manual" bus recovery on CAN interface 1
CAN1_EXT_RECEIVE (→ page 62)	CAN interface 1: Configures a data receive object and reads out the receive buffer of the data object
CANx_EXT_RECEIVE_ALL (→ page 64)	CAN interface x: Configures all data receive objects and reads out the receive buffer of the data objects x = 1 = number of the CAN interface
CAN1_EXT_TRANSMIT (→ page 66)	Transfers a CAN data object (message) to CAN interface 1 for transmission at each call

5.1.5 Bibliothek ifm_J1939_1_Vxxyyzz.LIB

20902

This library contains the function blocks for engine control.
x = 1 = number of the CAN interface

This **ifm** library contains the following function blocks:

Function element	Short description
J1939_x (→ page 98)	CAN interface x: protocol handler for the communication profile SAE J1939 x = 1 = number of the CAN interface
J1939_x_GLOBAL_REQUEST (→ page 99)	CAN interface x: handles global requesting and receipt of data from the J1939 network participants x = 1 = number of the CAN interface
J1939_x_RECEIVE (→ page 101)	CAN interface x: Receives a single message or a message block x = 1 = number of the CAN interface
J1939_x_RESPONSE (→ page 103)	CAN interface x: handles the automatic response to a request message x = 1 = number of the CAN interface
J1939_x_SPECIFIC_REQUEST (→ page 105)	CAN interface x: automatic requesting of individual messages from a specific J1939 network participant x = 1 = number of the CAN interface
J1939_x_TRANSMIT (→ page 107)	CAN interface x: sends individual messages or message blocks x = 1 = number of the CAN interface

5.2 ifm function elements for the device CR0302

Contents

13988
3826

Here you will find the description of the **ifm** function elements suitable for this device, sorted by topic.

5.2.1 Function elements: CAN layer 2

Contents

13754

Here, the CAN function blocks (layer 2) for use in the application program are described.

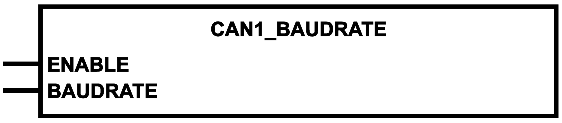
CAN1_BAUDRATE

651

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

654

CAN1_BAUDRATE sets the transmission rate for the bus participant.

► To do so, the corresponding value in kbits/s is entered at the input BAUDRATE.

NOTICE

Please note for CR250n, CR0301, CR0302 and CS0015:

The EEPROM memory module may be destroyed by the permanent use of this unit!

► Only carry out the unit **once** during initialisation in the first program cycle!

► Afterwards block the unit again with ENABLE = FALSE!

❗ The new baud rate will become effective on RESET (voltage OFF/ON or soft reset).

ExtendedController: In the slave module, the new baud rate will become effective after voltage OFF/ON.

Parameters of the inputs

655

Parameter	Data type	Description
ENABLE	BOOL	TRUE (in the 1st cycle): Adopt and activate parameters else: this function is not executed
BAUDRATE	WORD := 125	Baud rate [kbits/s] valid = 20, 50, 100, 125, 250, 500, 1000

CAN1_DOWNLOADID

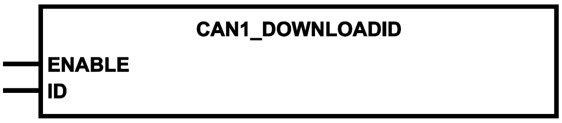
645

= CAN1 download ID

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

648

CAN1_DOWNLOADID sets the download identifier for the first CAN interface.

The function block can be used to set the communication identifier for program download and debugging. The new value is entered when the input ENABLE is set to TRUE.

! The new value will become effective on RESET (voltage OFF/ON or soft reset).

NOTICE

Note for CR250n, CR0301, CR0302 and CS0015:

The EEPROM memory module may be destroyed if this function is used permanently.

► Only execute this POU **once** during initialisation in the first program cycle!
Afterwards disable the POU again (ENABLE = "FALSE")!

Parameters of the inputs

649

Parameter	Data type	Description
ENABLE	BOOL	TRUE (in the 1st cycle): Adopt and activate parameters else: this function is not executed

ID	BYTE	Set download ID of CAN interface x
		x = 1...n = number of the CAN interface (depending on the device, → Data sheet)
		allowed = 1...127
		preset = 127 - (x-1)

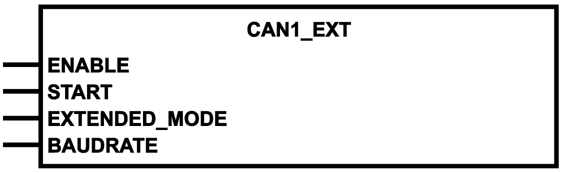
CAN1_EXT

4192

Unit type = function block (FB)

Unit is contained in the library `ifm_CAN1_EXT_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

4333

CAN1_EXT initialises the first CAN interface for the extended identifier (29 bits).

The FB has to be retrieved if the first CAN interface e.g. with the function libraries for *SAE J1939* is to be used.

A change of the baud rate will become effective after voltage OFF/ON.
The baud rates of CAN 1 and CAN 2 can be set differently.

The input START is only set for one cycle during reboot or restart of the interface.

> ❗ The FB must be executed **before** CAN1_EXT_... .

Parameters of the inputs

4334

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
START	BOOL	TRUE (in the 1st cycle): Start CAN protocol at CAN interface x FALSE: during further processing of the program
EXTENDED_MODE	BOOL := FALSE	TRUE: identifier of the CAN interface operates with 29 bits FALSE: identifier of the CAN interface operates with 11 bits
BAUDRATE	WORD := 125	Baud rate [Kbits/s] permissible = 50, 100, 125, 250, 500, 800, 1000

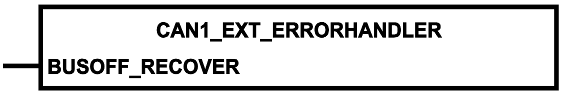
CAN1_EXT_ERRORHANDLER

4195

Unit type = function block (FB)

Unit is contained in the library `ifm_CAN1_EXT_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

4335

CAN1_EXT_ERRORHANDLER monitors the first CAN interface and evaluates the CAN errors. If a certain number of transmission errors occurs, the CAN participant becomes error passive. If the error frequency decreases, the participant becomes error active again (= normal condition).

If a participant already is error passive and still transmission errors occur, it is disconnected from the bus (= bus off) and the error bit CANx_BUSOFF is set. Returning to the bus is only possible if the "bus off" condition has been removed (signal BUSOFF_RECOVER).

Afterwards, the error bit CANx_BUSOFF must be reset in the application program.

! If the automatic bus recover function is to be used (default setting) CAN1_EXT_ERRORHANDLER must **not** be integrated and instanced in the program!

Parameters of the inputs

2177

Parameter	Data type	Description
BUSOFF_RECOVER	BOOL	TRUE (only 1 cycle): > remedy 'bus off' status > reboot of the CAN interfacex FALSE: function element is not executed

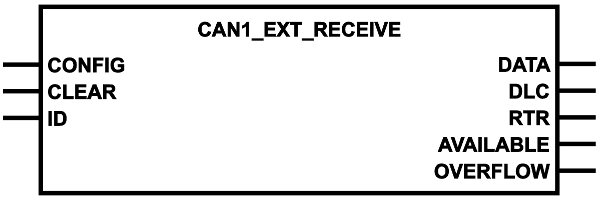
CAN1_EXT_RECEIVE

4302

Unit type = function block (FB)

Unit is contained in the library `ifm_CAN1_EXT_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

4336

CAN1_EXT_RECEIVE configures a data receive object and reads the receive buffer of the data object.

The FB must be called once for each data object during initialisation to inform the CAN controller about the identifiers of the data objects.

In the further program cycle CAN1_EXT_RECEIVE is called for reading the corresponding receive buffer, this is done several times in case of long program cycles The programmer must ensure by evaluating the byte AVAILABLE that newly received data objects are retrieved from the buffer and further processed.

Each call of the FB decrements the byte AVAILABLE by 1. If the value of AVAILABLE is 0, there is no data in the buffer.

By evaluating the output OVERFLOW, an overflow of the data buffer can be detected. If OVERFLOW = TRUE at least 1 data object has been lost.

If this unit is to be used, the 1st CAN interface must first be initialised for the extended ID with *CAN1_EXT* (→ page 60).

Parameters of the inputs

2172

Parameter	Data type	Description
CONFIG	BOOL	TRUE (in the 1st cycle): configure data object FALSE: during further processing of the program
CLEAR	BOOL	TRUE: delete receive buffer FALSE: function element is not executed
ID	DWORD	Number of the data object identifier: normal frame (2^{11} IDs): 0...2 047 = 0x0000 0000...0x0000 07FF extended Frame (2^{29} IDs): 0...536 870 911 = 0x0000 0000...0x1FFF FFFF

Parameters of the outputs

19810

Parameter	Data type	Description
DATA	ARRAY [0..7] OF BYTE	received data, (1...8 bytes)
DLC	BYTE	Number of the bytes of the CAN telegram read from the receive buffer allowed: 0...8
RTR	BOOL = FALSE	Received message was a Remote Transmission Request (wird hier nicht unterstützt)
AVAILABLE	BYTE	Number of the CAN telegrams received but not yet read from the receive buffer (before the FB is called). Possible values = 0...16 0 = no valid data available
OVERFLOW	BOOL	TRUE: Overflow of the data buffer ⇨ loss of data! FALSE: Data buffer is without data loss

CAN1_EXT_RECEIVE_ALL

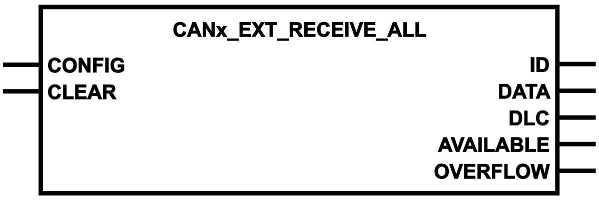
20913

x = 1 = number of the CAN interface

Unit type = function block (FB)

Unit is contained in the library `ifm_CAN1_EXT_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

4326

CANx_EXT_RECEIVE_ALL configures all data receive objects and reads the receive buffer of the data objects.

The FB must be called once during initialisation to inform the CAN controller about the identifiers of the data objects.

In the further program cycle CANx_EXT_RECEIVE_ALL is called for reading the corresponding receive buffer, also repeatedly in case of long program cycles. The programmer must ensure by evaluating the byte AVAILABLE that newly received data objects are retrieved from the buffer and further processed.

Each call of the FB decrements the byte AVAILABLE by 1. If the value of AVAILABLE is 0, there is no data in the buffer.

By evaluating the output OVERFLOW, an overflow of the data buffer can be detected. If OVERFLOW = TRUE at least 1 data object has been lost.

Receive buffer: max. 16 software buffers per identifier.

Parameters of the inputs

4329

Parameter	Data type	Description
CONFIG	BOOL	TRUE (in the 1st cycle): configure data object FALSE: during further processing of the program
CLEAR	BOOL	TRUE: delete receive buffer FALSE: function element is not executed

Parameters of the outputs

2292

Parameter	Data type	Description
ID	DWORD	Number of the data object identifier
DATA	ARRAY [0..7] OF BYTE	received data, (1...8 bytes)
DLC	BYTE	Number of bytes received in the DATA array with SRDO allowed: 0...8
AVAILABLE	BYTE	Number of the CAN telegrams received but not yet read from the receive buffer (before the FB is called). Possible values = 0...16 0 = no valid data available
OVERFLOW	BOOL	TRUE: Overflow of the data buffer ➩ loss of data! FALSE: Data buffer is without data loss

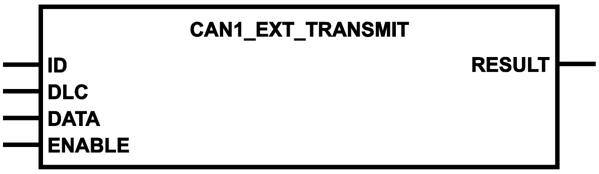
CAN1_EXT_TRANSMIT

4307

Unit type = function block (FB)

Unit is contained in the library `ifm_CAN1_EXT_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

4337

CAN1_EXT_TRANSMIT transfers a CAN data object (message) to the CAN controller for transmission.

The FB is called for each data object in the program cycle; this is done several times in case of long program cycles. The programmer must ensure by evaluating the output RESULT that his transmit order was accepted. To put it simply, at 125 kbits/s one transmit order can be executed per 1 ms.

The execution of the FB can be temporarily blocked via the input ENABLE = FALSE. This can, for example, prevent a bus overload.

Several data objects can be transmitted virtually at the same time if a flag is assigned to each data object and controls the execution of the FB via the ENABLE input.

> ❗ If this unit is to be used, the 1st CAN interface must first be initialised for the extended ID with *CAN1_EXT* (→ page 60).

Parameters of the inputs

4380

Parameter	Data type	Description
ID	DWORD	Number of the data object identifier: normal frame (2^{11} IDs): 0...2 047 = 0x0000 0000...0x0000 07FF extended Frame (2^{29} IDs): 0...536 870 911 = 0x0000 0000...0x1FFF FFFF
DLC	BYTE	Number of bytes to be transmitted from the DATA array allowed: 0...8
DATA	ARRAY [0..7] OF BYTE	data to be sent (1...8 bytes)
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified

Parameters of the outputs

614

Parameter	Data type	Description
RESULT	BOOL	TRUE (only for 1 cycle): Function block accepted transmit order FALSE: Transmit order was not accepted

CANx_ERRORHANDLER

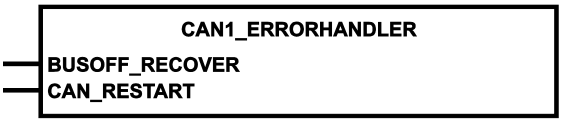
9344

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

636

Error routine for monitoring the CAN interfaces

CANx_ERRORHANDLER monitors the CAN interfaces and evaluates the CAN errors. If a certain number of transmission errors occurs, the CAN participant becomes error passive. If the error frequency decreases, the participant becomes error active again (= normal condition).

If a participant already is error passive and still transmission errors occur, it is disconnected from the bus (= bus off) and the error bit CANx_BUSOFF is set. Returning to the bus is only possible if the "bus off" condition has been removed (signal BUSOFF_RECOVER).

The input CAN_RESTART is used for rectifying other CAN errors. The CAN interface is reinitialised.

Afterwards, the error bit must be reset in the application program.

The procedures for the restart of the interfaces are different:

- For CAN interface 1 or devices with only one CAN interface:
  set the input CAN_RESTART = TRUE (only 1 cycle)
- For CAN interface 2:
  set the input START = TRUE (only 1 cycle) in *CAN2*

> **NOTE**
>
> In principle, CAN2 must be executed to initialise the second CAN interface, before FBs can be used for it.
>
> If the automatic bus recover function is to be used (default setting) CANx_ERRORHANDLER must **not** be integrated and instanced in the program!

Parameters of the inputs

637

Parameter	Data type	Description
BUSOFF_RECOVER	BOOL	TRUE (only 1 cycle): > remedy 'bus off' status > reboot of the CAN interfacex FALSE: function element is not executed
CAN_RESTART	BOOL	TRUE (only 1 cycle): completely reinitialise CAN interface FALSE: function element is not executed

CANx_RECEIVE

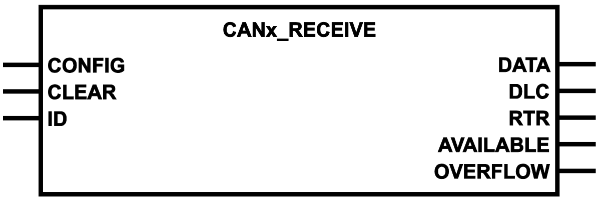
627

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

630

CANx_RECEIVE configures a data receive object and reads the receive buffer of the data object.

The FB must be called once for each data object during initialisation, in order to inform the CAN controller about the identifiers of the data objects.

In the further program cycle CANx_RECEIVE is called for reading the corresponding receive buffer, also repeatedly in case of long program cycles. The programmer must ensure by evaluating the byte AVAILABLE that newly received data objects are retrieved from the buffer and further processed.

Each call of the FB decrements the byte AVAILABLE by 1. If the value of AVAILABLE is 0, there is no data in the buffer.

By evaluating the output OVERFLOW, an overflow of the data buffer can be detected. If OVERFLOW = TRUE at least 1 data object has been lost.

> ! If CAN2_RECEIVE is to be used, the second CAN interface must be initialised first using *CAN2*.

Parameters of the inputs

631

Parameter	Data type	Description
CONFIG	BOOL	TRUE (in the 1st cycle): configure data object FALSE: during further processing of the program
CLEAR	BOOL	TRUE: delete receive buffer FALSE: function element is not executed
ID	WORD	number of the data object identifier permissible values = 0...2 047

Parameters of the outputs

19810

Parameter	Data type	Description
DATA	ARRAY [0..7] OF BYTE	received data, (1...8 bytes)
DLC	BYTE	Number of the bytes of the CAN telegram read from the receive buffer allowed: 0...8
RTR	BOOL = FALSE	Received message was a Remote Transmission Request (wird hier nicht unterstützt)
AVAILABLE	BYTE	Number of the CAN telegrams received but not yet read from the receive buffer (before the FB is called). Possible values = 0...16 0 = no valid data available
OVERFLOW	BOOL	TRUE: Overflow of the data buffer ⇨ loss of data! FALSE: Data buffer is without data loss

CANx_RECEIVE_RANGE

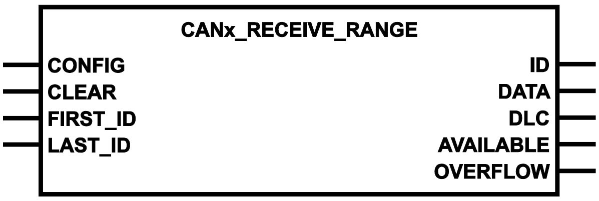
4179

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB` (xx ≥ 05)

Symbol in CODESYS:



Description

20914

CANx_RECEIVE_RANGE configures a sequence of data receive objects and reads the receive buffer of the data objects.

For the first CAN interface max. 2048 IDs per bit are possible.
To ensure that the watchdog does not react, the process should be distributed to several cycles in the case of bigger ranges(→ *Example: Initialisation of CANx_RECEIVE_RANGE in 4 cycles* (→ page 72)).

The FB must be called once for each sequence of data objects during initialisation to inform the CAN controller about the identifiers of the data objects.

The FB must NOT be mixed with *CANx_RECEIVE* (→ page 69) or CANx_RECEIVE_RANGE for the same IDs at the same CAN interfaces.

In the further program cycle CANx_RECEIVE_RANGE is called for reading the corresponding receive buffer, also repeatedly in case of long program cycles. The programmer has to ensure by evaluating the byte AVAILABLE that newly received data objects are retrieved from buffer SOFORT and are further processed as the data are only available for one cycle.

Each call of the FB decrements the byte AVAILABLE by 1. If the value of AVAILABLE is 0, there is no data in the buffer.

By evaluating the output OVERFLOW, an overflow of the data buffer can be detected. If OVERFLOW = TRUE, at least 1 data object has been lost.

Receive buffer: max. 16 software buffers per identifier.

Parameters of the inputs

20915

Parameter	Data type	Description
CONFIG	BOOL	TRUE (in the 1st cycle): configure data object FALSE: during further processing of the program
CLEAR	BOOL	TRUE: delete receive buffer FALSE: function element is not executed
FIRST_ID	WORD	Number of the first data object identifier of the sequence. permissible values normal frame: 0...2 047 (2^{11}) permissible values extended frame: 0...536 870 911 (2^{29})
LAST_ID	WORD	Number of the last data object identifier of the sequence. permissible values normal frame: 0...2 047 (2^{11}) permissible values extended frame: 0...536 870 911 (2^{29}) LAST_ID has to be higher than FIRST_ID.

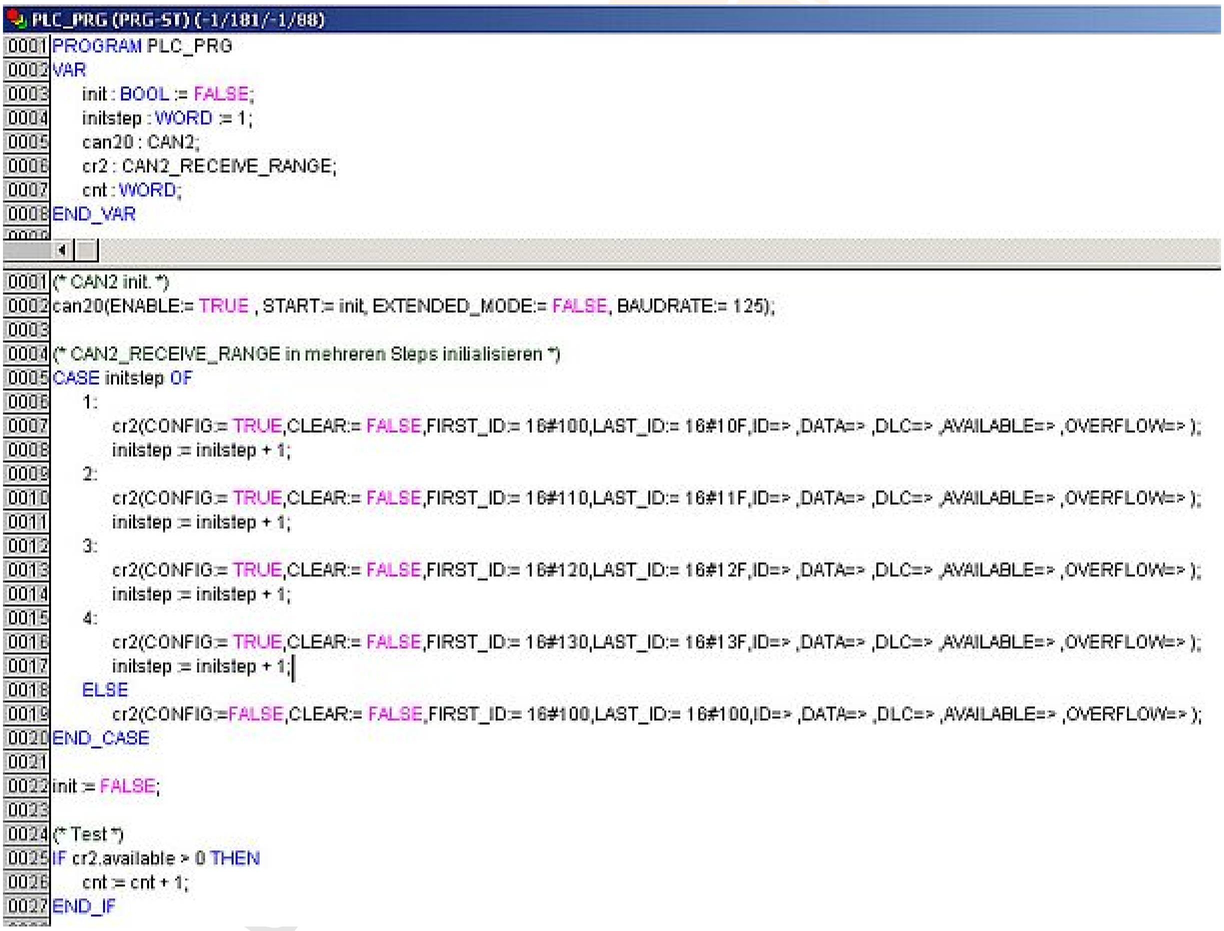
Parameters of the outputs

4381

Parameter	Data type	Description
ID	CAN1: WORD CAN2: DWORD	ID of the transmitted data object
DATA	ARRAY [0..7] OF BYTE	received data, (1...8 bytes)
DLC	BYTE	Number of the bytes of the CAN telegram read from the receive buffer allowed: 0...8
AVAILABLE	BYTE	Number of the CAN telegrams received but not yet read from the receive buffer (before the FB is called). Possible values = 0...16 0 = no valid data available
OVERFLOW	BOOL	TRUE: Overflow of the data buffer ➩ loss of data! FALSE: Data buffer is without data loss

Example: Initialisation of CANx_RECEIVE_RANGE in 4 cycles

2294



PLC_PRG (PRG-ST) (-1/181/-1/88)

```
PROGRAM PLC_PRG
VAR
    init : BOOL := FALSE;
    initstep : WORD := 1;
    can20 : CAN2;
    cr2 : CAN2_RECEIVE_RANGE;
    cnt : WORD;
END_VAR
```

```
(* CAN2 init. *)
can20(ENABLE:= TRUE , START:= init, EXTENDED_MODE:= FALSE, BAUDRATE:= 125);

(* CAN2_RECEIVE_RANGE in mehreren Steps initialisieren *)
CASE initstep OF
    1:
        cr2(CONFIG:= TRUE,CLEAR:= FALSE,FIRST_ID:= 16#100,LAST_ID:= 16#10F,ID=> ,DATA=> ,DLC=> ,AVAILABLE=> ,OVERFLOW=> );
        initstep := initstep + 1;
    2:
        cr2(CONFIG:= TRUE,CLEAR:= FALSE,FIRST_ID:= 16#110,LAST_ID:= 16#11F,ID=> ,DATA=> ,DLC=> ,AVAILABLE=> ,OVERFLOW=> );
        initstep := initstep + 1;
    3:
        cr2(CONFIG:= TRUE,CLEAR:= FALSE,FIRST_ID:= 16#120,LAST_ID:= 16#12F,ID=> ,DATA=> ,DLC=> ,AVAILABLE=> ,OVERFLOW=> );
        initstep := initstep + 1;
    4:
        cr2(CONFIG:= TRUE,CLEAR:= FALSE,FIRST_ID:= 16#130,LAST_ID:= 16#13F,ID=> ,DATA=> ,DLC=> ,AVAILABLE=> ,OVERFLOW=> );
        initstep := initstep + 1;
    ELSE
        cr2(CONFIG:=FALSE,CLEAR:= FALSE,FIRST_ID:= 16#100,LAST_ID:= 16#100,ID=> ,DATA=> ,DLC=> ,AVAILABLE=> ,OVERFLOW=> );
END_CASE

init := FALSE;

(* Test *)
IF cr2.available > 0 THEN
    cnt := cnt + 1;
END_IF
```

CANx_TRANSMIT

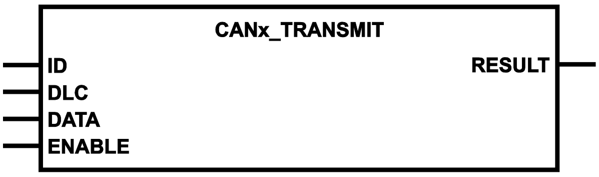
609

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

612

CANx_TRANSMIT transmits a CAN data object (message) to the CAN controller for transmission.

The FB is called for each data object in the program cycle, also repeatedly in case of long program cycles. The programmer must ensure by evaluating the FB output RESULT that his transmit order was accepted. Simplified it can be said that at 125 kbits/s one transmit order can be executed per ms.

The execution of the FB can be temporarily blocked (ENABLE = FALSE) via the input ENABLE. So, for example a bus overload can be prevented.

Several data objects can be transmitted virtually at the same time if a flag is assigned to each data object and controls the execution of the FB via the ENABLE input.

❗ If CAN2_TRANSMIT is to be used, the second CAN interface must be initialised first using *CAN2*.

Parameters of the inputs

613

Parameter	Data type	Description
ID	WORD	number of the data object identifier permissible values = 0...2 047
DLC	BYTE	Number of bytes to be transmitted from the DATA array allowed: 0...8
DATA	ARRAY [0..7] OF BYTE	data to be sent (1...8 bytes)
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified

Parameters of the outputs

614

Parameter	Data type	Description
RESULT	BOOL	TRUE (only for 1 cycle): Function block accepted transmit order FALSE: Transmit order was not accepted

5.2.2 Function elements: CANopen master

Contents

1870

ifm electronic provides a number of FBs for the CANopen master which will be explained below.

CANx_MASTER_EMCY_HANDLER

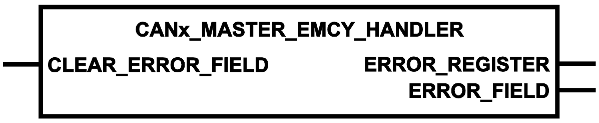
13192

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_CANopenMaster_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2009

CANx_MASTER_EMCY_HANDLER manages the device-specific error status of the master. The FB must be called in the following cases:

- the error status is to be transmitted to the network and
- the error messages of the application are to be stored in the object directory.

The current values from the error register (index 0x1001/01) and error field (index 0x1003/0-5) of the CANopen object directory can be read via the FB.

> ! If application-specific error messages are to be stored in the object directory, CANx_MASTER_EMCY_HANDLER must be called **after** (repeatedly) calling *CANx_MASTER_SEND_EMERGENCY* (→ page 76).

Parameters of the inputs

2010

Parameter	Data type	Description
CLEAR_ERROR_FIELD	BOOL	FALSE ⇨ TRUE (edge): • transmit content of ERROR_FIELD to function block output • delete content of ERROR_FIELD in object directory else: this function is not executed

Parameters of the outputs

2011

Parameter	Data type	Description
ERROR_REGISTER	BYTE	Shows content of OBV index 0x1001 (error register)
ERROR_FIELD	ARRAY [0..5] OF WORD	Shows the content of the OBV index 0x1003 (error field) ERROR_FIELD[0]: number of stored errors ERROR_FIELD[1...5]: Stored errors, the most recent error is shown on index [1]

CANx_MASTER_SEND_EMERGENCY

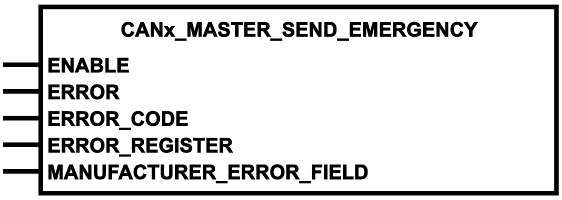
13195

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_CANopenMaster_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2015

CANx_MASTER_SEND_EMERGENCY transmits application-specific error states. The FB is called if the error status is to be transmitted to other devices in the network.

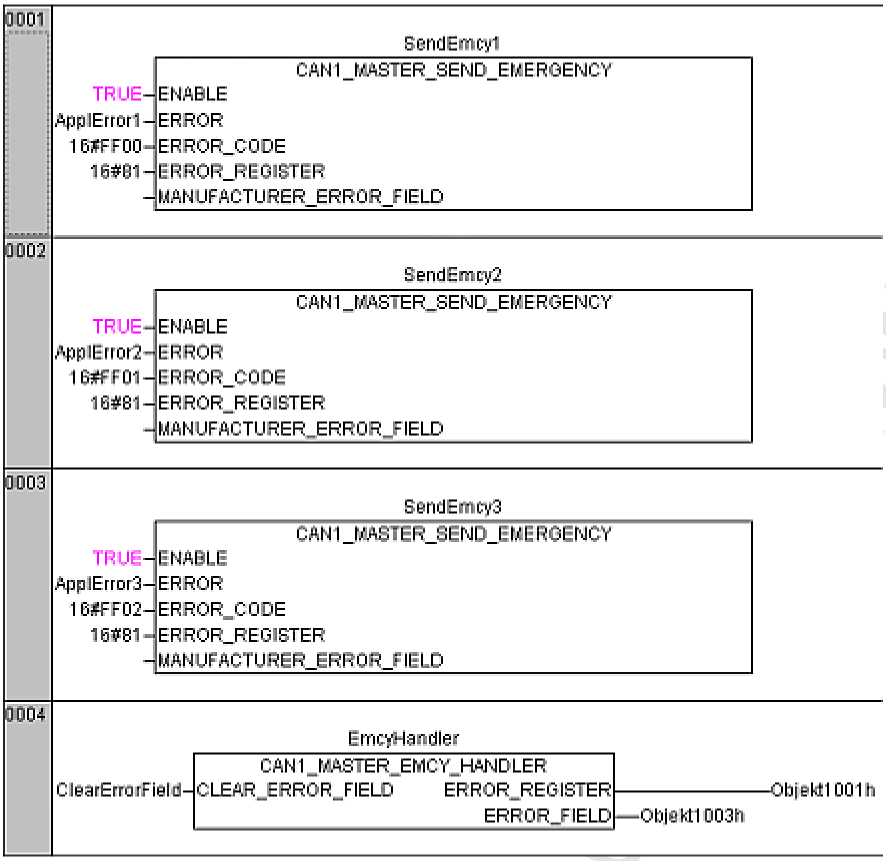
> ❗ If application-specific error messages are to be stored in the object directory, *CANx_MASTER_EMCY_HANDLER* (→ page 75) must be called **after** (repeatedly) calling CANx_MASTER_SEND_EMERGENCY.

Parameters of the inputs

2016

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
ERROR	BOOL	Using this input, the information whether the error associated to the configured error code is currently present is transmitted. FALSE ⇨ TRUE (edge): sends the next error code if input was not TRUE in the last second TRUE ⇨ FALSE (edge) AND the fault is no longer indicated: after a delay of approx. 1 s: > zero error message is sent else: this function is not executed
ERROR_CODE	WORD	The error code provides detailed information about the detected error. The values should be entered according to the CANopen specification.
ERROR_REGISTER	BYTE	ERROR_REGISTER indicates the error type. The value indicated here is linked by a bit-by-bit OR operation with all the other error messages that are currently active. The resulting value is written into the error register (index 1001_{16}/00) and transmitted with the EMCY message. The values should be entered according to the CANopen specification.
MANUFACTURER_ERROR_FIELD	ARRAY [0..4] OF BYTE	Here, up to 5 bytes of application-specific error information can be entered. The format can be freely selected.

Example: CANx_MASTER_SEND_EMERGENCY



In this example 3 error messages will be generated subsequently:

1. ApplError1, Code = 0xFF00 in the error register 0x81
2. ApplError2, Code = 0xFF01 in the error register 0x81
3. ApplError3, Code = 0xFF02 in the error register 0x81

CAN1_MASTER_EMCY_HANDLER sends the error messages to the error register "Object 0x1001" in the error array "Object 0x1003".

CANx_MASTER_STATUS

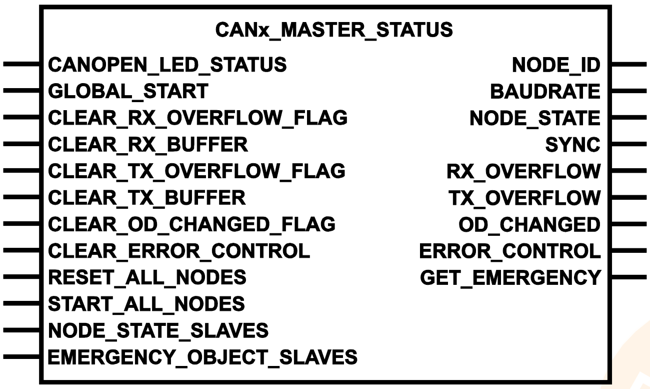
2021

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_CANopenMaster_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2024

Status indication of the device used with CANopen.

CANx_MASTER_STATUS shows the status of the device used as CANopen master. Further possibilities:

- monitoring the network status
- monitoring the status of the connected slaves
- resetting or starting the slaves in the network.

The FB simplifies the use of the CODESYS CANopen master libraries. We urgently recommend to carry out the evaluation of the network status and of the error messages via this FB.

Parameters of the inputs

Parameter	Data type	Description
CANOPEN_LED_STATUS	BOOL	(input not available for PDM devices) TRUE: the status LED of the controller is switched to the mode "CANopen": flashing frequency 0.5 Hz = PRE-OPERATIONAL flashing frequency 2.0 Hz = OPERATIONAL The other diagnostic LED signals are not changed by this operating mode.
GLOBAL_START	BOOL	TRUE: All connected network participants (slaves) are started simultaneously during network initialisation (⇨ state OPERATIONAL). FALSE: The connected network participants are started one after the other.
CLEAR_RX_OVERFLOW_FLAG	BOOL	FALSE ⇨ TRUE (edge): Clear error flag RX_OVERFLOW else: this function is not executed
CLEAR_RX_BUFFER	BOOL	FALSE ⇨ TRUE (edge): Delete data in the receive buffer else: this function is not executed
CLEAR_TX_OVERFLOW_FLAG	BOOL	FALSE ⇨ TRUE (edge): Clear error flag TX_OVERFLOW else: this function is not executed
CLEAR_TX_BUFFER	BOOL	FALSE ⇨ TRUE (edge): Delete data in the transmit buffer else: this function is not executed
CLEAR_OD_CHANGED_FLAG	BOOL	FALSE ⇨ TRUE (edge): Delete flag OD_CHANGED else: this function is not executed
CLEAR_ERROR_CONTROL	BOOL	FALSE ⇨ TRUE (edge): Delete the guard error list (ERROR_CONTROL) else: this function is not executed
RESET_ALL_NODES	BOOL	FALSE ⇨ TRUE (edge): All connected network participants (slaves) are reset via NMT command else: this function is not executed
START_ALL_NODES	BOOL	FALSE ⇨ TRUE (edge): All connected network participants (slaves) are started via NMT command else: this function is not executed
NODE_STATE_SLAVES	DWORD	Shows states of all network nodes. Example code → chapter *Example: CANx_MASTER_STATUS* (→ page 82)
EMERGENCY_OBJECT_SLAVES	DWORD	Shows the last error messages of all network nodes. ℹ → chapter *Access to the structures at runtime of the application* (→ page 83)

Parameters of the outputs

2029

Parameter	Data type	Description
NODE_ID	BYTE	current node ID of the CANopen master
BAUDRATE	WORD	current baudrate of the CANopen master in [kBaud]
NODE_STATE	INT	Current status of CANopen master
SYNC	BOOL	SYNC signal of the CANopen master TRUE: In the last cycle a SYNC signal was sent FALSE: In the last cycle no SYNC signal was sent
RX_OVERFLOW	BOOL	TRUE: Error: receive buffer overflow FALSE: no overflow
TX_OVERFLOW	BOOL	TRUE: Error: transmission buffer overflow FALSE: no overflow
OD_CHANGED	BOOL	TRUE: Data in the object directory of the CANopen master have been changed FALSE: no data change
ERROR_CONTROL	ARRAY [0..7] OF BYTE	The array contains the list (max. 8) of missing network nodes (guard or heartbeat error)
GET_EMERGENCY	STRUCT CANx_EMERGENY_MESSAGE	At the output the data for the structure CANx_EMERGENCY_MESSAGE are available. The last received EMCY message in the CANopen network is always displayed. To obtain a list of all occurred errors, the array EmergencyObjectSlavesArray must be evaluated!
NODE_ID	BYTE	node ID of the master
BAUDRATE	WORD	baud rate of the master
NODE_STATE	INT	current status of the master
SYNC	BOOL	SYNC signal of the master This is set in the *tab [CAN parameters]* of the master depending on the set time [Com. Cycle Period].
RX_OVERFLOW	BOOL	error flag "receive buffer overflow"

Parameters of internal structures

2030

Below are the structures of the arrays used in this FB.

Parameter	Data type	Description
CANx_EMERGENY_MESSAGE	STRUCT	NODE_ID: BYTE ERROR_CODE: WORD ERROR_REGISTER: BYTE MANUFACTURER_ERROR_FIELD: ARRAY[0...4] OF BYTE The structure is defined by the global variables of the library `ifm_CR0302_CANopenMaster_Vxxyyzz.LIB`.
CANx_NODE_STATE	STRUCT	NODE_ID: BYTE NODE_STATE: BYTE LAST_STATE: BYTE RESET_NODE: BOOL START_NODE: BOOL PREOP_NODE: BOOL SET_TIMEOUT_STATE: BOOL SET_NODE_STATE: BOOL The structure is defined by the global variables of the library `ifm_CR0302_CANopenMaster_Vxxyyzz.LIB`.

Using the controller CR0020 as an example the following code fragments show the use of the FB CANx_MASTER_STATUS.

Example: CANx_MASTER_STATUS

2031

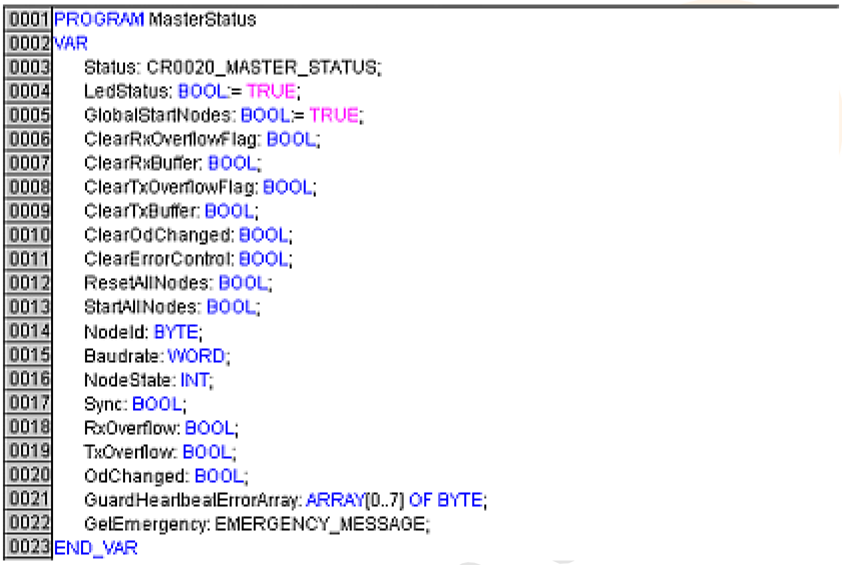
Slave information

2033

To be able to access the information of the individual CANopen nodes, an array for the corresponding structure must be generated. The structures are contained in the library. You can see them under "Data types" in the library manager.

The number of the array elements is determined by the global variable MAX_NODEINDEX which is automatically generated by the CANopen stack. It contains the number of the slaves minus 1 indicated in the network configurator.

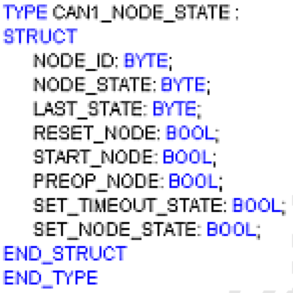
> ! The numbers of the array elements do **not** correspond to the node ID. The identifier can be read from the corresponding structure under NODE_ID.



```
PROGRAM MasterStatus
VAR
    Status: CR0020_MASTER_STATUS;
    LedStatus: BOOL:= TRUE;
    GlobalStartNodes: BOOL:= TRUE;
    ClearRxOverflowFlag: BOOL;
    ClearRxBuffer: BOOL;
    ClearTxOverflowFlag: BOOL;
    ClearTxBuffer: BOOL;
    ClearOdChanged: BOOL;
    ClearErrorControl: BOOL;
    ResetAllNodes: BOOL;
    StartAllNodes: BOOL;
    NodeId: BYTE;
    Baudrate: WORD;
    NodeState: INT;
    Sync: BOOL;
    RxOverflow: BOOL;
    TxOverflow: BOOL;
    OdChanged: BOOL;
    GuardHeartbeatErrorArray: ARRAY[0..7] OF BYTE;
    GetEmergency: EMERGENCY_MESSAGE;
END_VAR
```

Structure node status

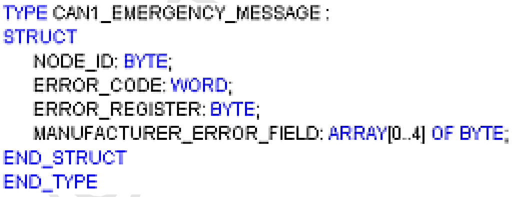
2034



```
TYPE CAN1_NODE_STATE :
STRUCT
    NODE_ID: BYTE;
    NODE_STATE: BYTE;
    LAST_STATE: BYTE;
    RESET_NODE: BOOL;
    START_NODE: BOOL;
    PREOP_NODE: BOOL;
    SET_TIMEOUT_STATE: BOOL;
    SET_NODE_STATE: BOOL;
END_STRUCT
END_TYPE
```

Structure Emergency_Message

2035

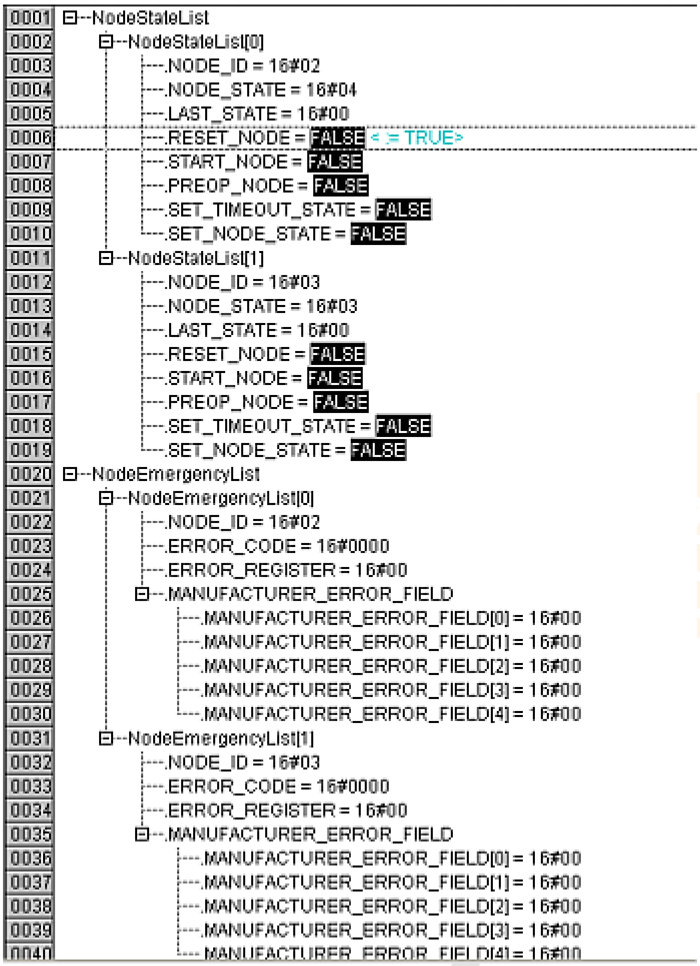


```
TYPE CAN1_EMERGENCY_MESSAGE :
STRUCT
    NODE_ID: BYTE;
    ERROR_CODE: WORD;
    ERROR_REGISTER: BYTE;
    MANUFACTURER_ERROR_FIELD: ARRAY[0..4] OF BYTE;
END_STRUCT
END_TYPE
```

Access to the structures at runtime of the application

2036

At runtime you can access the corresponding array element via the global variables of the library and therefore read the status or EMCY messages or reset the node.



```
⊟--NodeStateList
    ⊟--NodeStateList[0]
    |    |---.NODE_ID = 16#02
    |    |---.NODE_STATE = 16#04
    |    |---.LAST_STATE = 16#00
    |    |---.RESET_NODE = FALSE <:= TRUE>
    |    |---.START_NODE = FALSE
    |    |---.PREOP_NODE = FALSE
    |    |---.SET_TIMEOUT_STATE = FALSE
    |    └---.SET_NODE_STATE = FALSE
    ⊟--NodeStateList[1]
         |---.NODE_ID = 16#03
         |---.NODE_STATE = 16#03
         |---.LAST_STATE = 16#00
         |---.RESET_NODE = FALSE
         |---.START_NODE = FALSE
         |---.PREOP_NODE = FALSE
         |---.SET_TIMEOUT_STATE = FALSE
         └---.SET_NODE_STATE = FALSE
⊟--NodeEmergencyList
    ⊟--NodeEmergencyList[0]
    |    |---.NODE_ID = 16#02
    |    |---.ERROR_CODE = 16#0000
    |    |---.ERROR_REGISTER = 16#00
    |    ⊟--.MANUFACTURER_ERROR_FIELD
    |         |---.MANUFACTURER_ERROR_FIELD[0] = 16#00
    |         |---.MANUFACTURER_ERROR_FIELD[1] = 16#00
    |         |---.MANUFACTURER_ERROR_FIELD[2] = 16#00
    |         |---.MANUFACTURER_ERROR_FIELD[3] = 16#00
    |         └---.MANUFACTURER_ERROR_FIELD[4] = 16#00
    ⊟--NodeEmergencyList[1]
         |---.NODE_ID = 16#03
         |---.ERROR_CODE = 16#0000
         |---.ERROR_REGISTER = 16#00
         ⊟--.MANUFACTURER_ERROR_FIELD
              |---.MANUFACTURER_ERROR_FIELD[0] = 16#00
              |---.MANUFACTURER_ERROR_FIELD[1] = 16#00
              |---.MANUFACTURER_ERROR_FIELD[2] = 16#00
              |---.MANUFACTURER_ERROR_FIELD[3] = 16#00
              └---.MANUFACTURER_ERROR_FIELD[4] = 16#00
```

If ResetSingleNodeArray[0].RESET_NODE is set to TRUE for a short time in the example given above, the first node is reset in the configuration tree.

🛈 concerning the possible error codes → system manual "Know-How ecomat*mobile*"
→ chapter *CAN / CANopen: errors and error handling*.

5.2.3 Function elements: CANopen slave

Contents

1874

ifm electronic provides a number of FBs for the CANopen slave which will be explained below.

CANx_SLAVE_EMCY_HANDLER

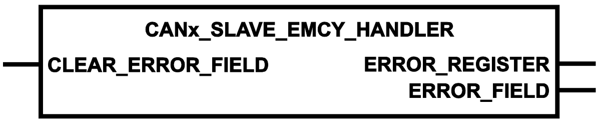
13199

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_CANopenSlave_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2053

CANx_SLAVE_EMCY_HANDLER handles the device-specific error status of the CANopen slave:

- error register (index 0x1001) and
- error field (index 0x1003) of the CANopen object directory.

► Call the function block in the following cases:

- the error status is to be transmitted to the CAN network and
- the error messages of the application program are to be stored in the object directory.

Do you want to store the error messages in the object directory?

► **After** (repeated) handling of *CANx_SLAVE_SEND_EMERGENCY* (→ page 87) call CANx_SLAVE_EMCY_HANDLER once!

Parameters of the inputs

2054

Parameter	Data type	Description
CLEAR_ERROR_FIELD	BOOL	FALSE ⇨ TRUE (edge): • transmit content of ERROR_FIELD to function block output • delete content of ERROR_FIELD in object directory else: this function is not executed

Parameters of the outputs

2055

Parameter	Data type	Description
ERROR_REGISTER	BYTE	Shows content of OBV index 0x1001 (error register)
ERROR_FIELD	ARRAY [0..5] OF WORD	Shows the content of the OBV index 0x1003 (error field) ERROR_FIELD[0]: number of stored errors ERROR_FIELD[1...5]: Stored errors, the most recent error is shown on index [1]

CANx_SLAVE_NODEID

13202

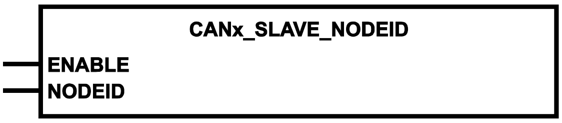
= CANx Slave Node-ID

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_CANopenSlave_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2049

CANx_SLAVE_NODEID enables the setting of the node ID of a CANopen slave at runtime of the application program.

Normally, the FB is called once during initialisation of the controller, in the first cycle. Afterwards, the input ENABLE is set to FALSE again.

Parameters of the inputs

2047

Parameter	Data type	Description
ENABLE	BOOL	FALSE ➪ TRUE (edge): Adopt and activate parameters else: this function is not executed
NODEID	BYTE	node ID = ID of the node permissible values = 1...127

CANx_SLAVE_SEND_EMERGENCY

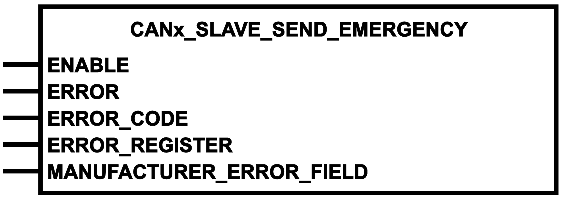
13205

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_CANopenSlave_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2059

CANx_SLAVE_SEND_EMERGENCY transmits application-specific error states. These are error messages which are to be sent in addition to the device-internal error messages (e.g. short circuit on the output).

► Call the FB if the error status is to be transmitted to other devices in the network.

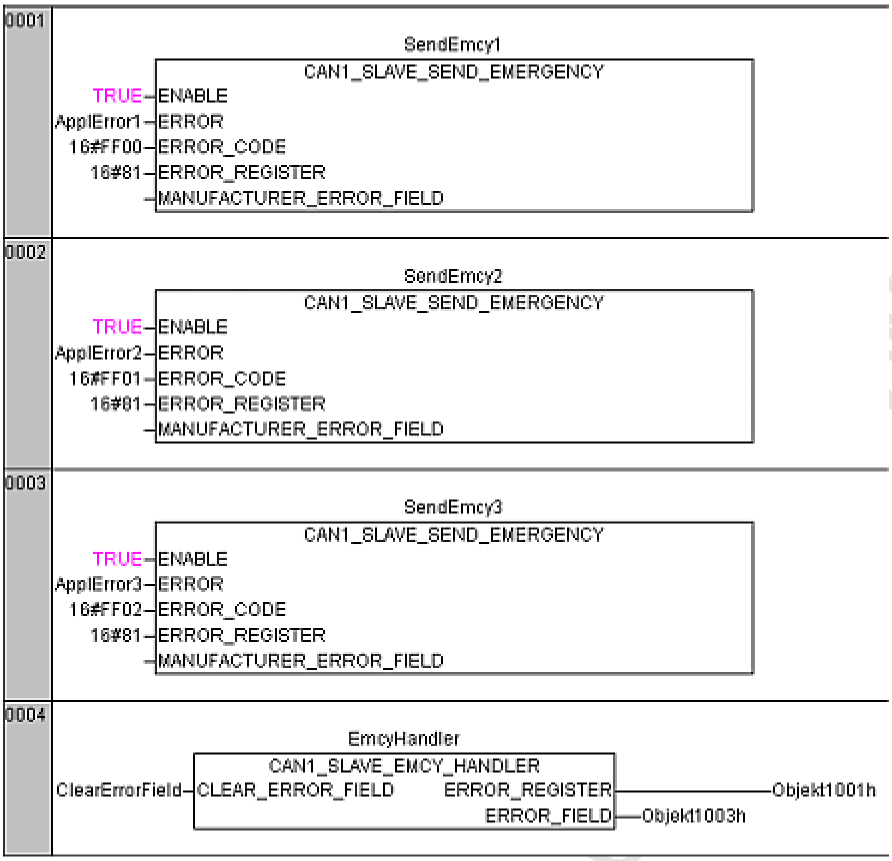
Parameters of the inputs

2060

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
ERROR	BOOL	Using this input, the information whether the error associated to the configured error code is currently present is transmitted. FALSE ⇨ TRUE (edge): sends the next error code if input was not TRUE in the last second TRUE ⇨ FALSE (edge) AND the fault is no longer indicated: after a delay of approx. 1 s: > zero error message is sent else: this function is not executed
ERROR_CODE	WORD	The error code provides detailed information about the detected error. The values should be entered according to the CANopen specification.
ERROR_REGISTER	BYTE	ERROR_REGISTER indicates the error type. The value indicated here is linked by a bit-by-bit OR operation with all the other error messages that are currently active. The resulting value is written into the error register (index 1001_{16}/00) and transmitted with the EMCY message. The values should be entered according to the CANopen specification.
MANUFACTURER_ERROR_FIELD	ARRAY [0..4] OF BYTE	Here, up to 5 bytes of application-specific error information can be entered. The format can be freely selected.

Example: CANx_SLAVE_SEND_EMERGENCY

2062



In this example 3 error messages will be generated subsequently:

1. ApplError1, Code = 0xFF00 in the error register 0x81
2. ApplError2, Code = 0xFF01 in the error register 0x81
3. ApplError3, Code = 0xFF02 in the error register 0x81

CAN1_SLAVE_EMCY_HANDLER sends the error messages to the error register "Object 0x1001" in the error array "Object 0x1003".

CANx_SLAVE_STATUS

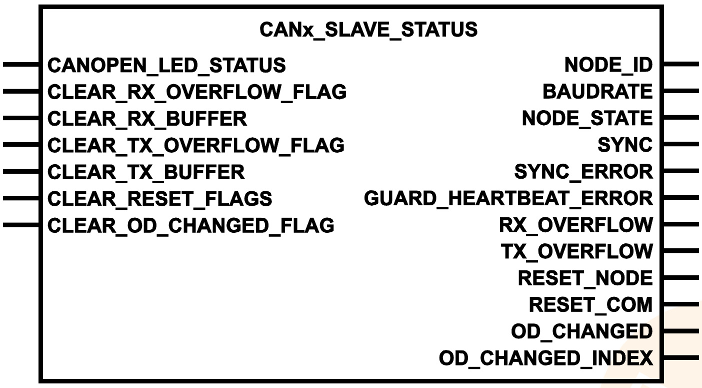
2063

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_CANopenSlave_Vxxyyzz.LIB`

Symbol in CODESYS:



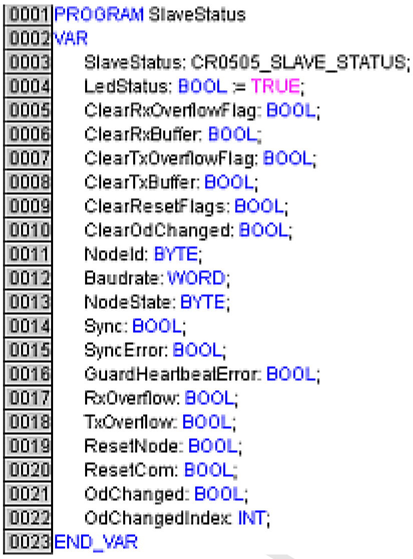
Description

2066

CANx_SLAVE_STATUS shows the status of the device used as CANopen slave. The FB simplifies the use of the CoDeSys CANopen slave libraries. We urgently recommend to carry out the evaluation of the network status via this FB.

At runtime you can then access the individual outputs of the block to obtain a status overview.

Example:



```
PROGRAM SlaveStatus
VAR
    SlaveStatus: CR0505_SLAVE_STATUS;
    LedStatus: BOOL := TRUE;
    ClearRxOverflowFlag: BOOL;
    ClearRxBuffer: BOOL;
    ClearTxOverflowFlag: BOOL;
    ClearTxBuffer: BOOL;
    ClearResetFlags: BOOL;
    ClearOdChanged: BOOL;
    NodeId: BYTE;
    Baudrate: WORD;
    NodeState: BYTE;
    Sync: BOOL;
    SyncError: BOOL;
    GuardHeartbeatError: BOOL;
    RxOverflow: BOOL;
    TxOverflow: BOOL;
    ResetNode: BOOL;
    ResetCom: BOOL;
    OdChanged: BOOL;
    OdChangedIndex: INT;
END_VAR
```

Parameters of the inputs

2067

Parameter	Data type	Description
CANOPEN_LED_STATUS	BOOL	(input not available for PDM devices) TRUE: the status LED of the controller is switched to the mode "CANopen": flashing frequency 0.5 Hz = PRE-OPERATIONAL flashing frequency 2.0 Hz = OPERATIONAL The other diagnostic LED signals are not changed by this operating mode.
GLOBAL_START	BOOL	TRUE: All connected network participants (slaves) are started simultaneously during network initialisation (⇨ state OPERATIONAL). FALSE: The connected network participants are started one after the other.
CLEAR_RX_OVERFLOW_FLAG	BOOL	FALSE ⇨ TRUE (edge): Clear error flag RX_OVERFLOW else: this function is not executed
CLEAR_RX_BUFFER	BOOL	FALSE ⇨ TRUE (edge): Delete data in the receive buffer else: this function is not executed
CLEAR_TX_OVERFLOW_FLAG	BOOL	FALSE ⇨ TRUE (edge): Clear error flag TX_OVERFLOW else: this function is not executed
CLEAR_TX_BUFFER	BOOL	FALSE ⇨ TRUE (edge): Delete data in the transmit buffer else: this function is not executed
CLEAR_RESET_FLAGS	BOOL	FALSE ⇨ TRUE (edge): Clear flag RESET_NODE Clear flag RESET_COM else: this function is not executed
CLEAR_OD_CHANGED_FLAGS	BOOL	FALSE ⇨ TRUE (edge): Clear flag OD_CHANGED Clear flag OD_CHANGED-_INDEX else: this function is not executed

Parameters of the outputs

2068

Parameter	Data type	Description
NODE_ID	BYTE	current node ID of the CANopen slave
BAUDRATE	WORD	current baudrate of the CANopen node in [kBaud]
NODE_STATE	BYTE	Current status of CANopen slave 0 = Bootup message sent 4 = CANopen slave in PRE-OPERATIONAL state and is configured via SDO access 5 = CANopen slave in OPERATIONAL state 127 = CANopen slave in PRE-OPERATIONAL state
SYNC	BOOL	SYNC signal of the CANopen master TRUE: In the last cycle a SYNC signal was received FALSE: In the last cycle no SYNC signal was received
SYNC_ERROR	BOOL	TRUE: Error: the SYNC signal of the master was not received or received too late (after expiration of ComCyclePeriod) FALSE: no SYNC error
GUARD_HEARTBEAT_ERROR	BOOL	TRUE: Error: the guarding or heartbeat signal of the master was not received or received too late FALSE: no guarding or heartbeat error
RX_OVERFLOW	BOOL	TRUE: Error: receive buffer overflow FALSE: no overflow
TX_OVERFLOW	BOOL	TRUE: Error: transmission buffer overflow FALSE: no overflow
RESET_NODE	BOOL	TRUE: the CANopen stack of the slave was reset by the master FALSE: the CANopen stack of the slave was not reset
RESET_COM	BOOL	TRUE: the communication interface of the CAN stack was reset by the master FALSE: the communication interface was not reset
OD_CHANGED	BOOL	TRUE: Data in the object directory of the CANopen master have been changed FALSE: no data change
OD_CHANGED_INDEX	INT	Index of the object directory entry changed last

5.2.4 Function elements: CANopen SDOs

Contents

2071

Here you will find **ifm** function elements for CANopen handling of Service Data Objects (SDOs).

CANx_SDO_READ

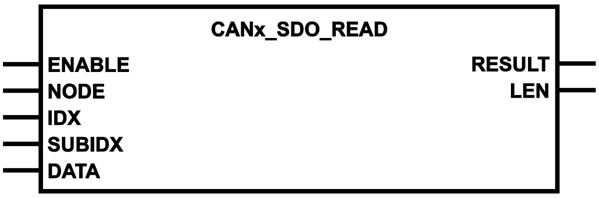
621

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

624

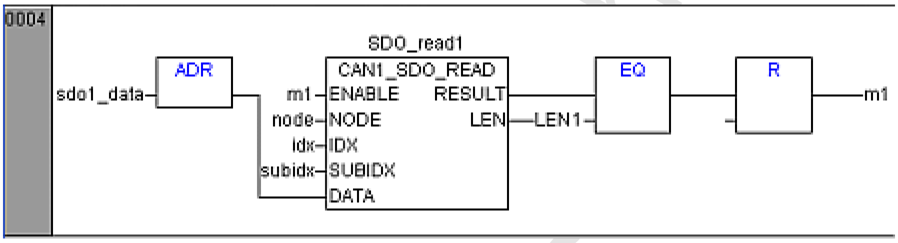
CANx_SDO_READ reads the →*SDO* (→ page 201) with the indicated indexes from the node.

Prerequisite: Node must be in the mode "PRE-OPERATIONAL" or "OPERATIONAL".

By means of these, the entries in the object directory can be read. So it is possible to selectively read the node parameters.

> ! Danger of data loss!
> Allocate enough memory space for the requested SDO!
> Otherwise the data following behind will be overwritten.

Example:



Parameters of the inputs

625

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
NODE	BYTE	ID of the node permissible values = 1...127 = 0x01...0x7F
IDX	WORD	index in object directory
SUBIDX	BYTE	sub-index referred to the index in the object directory
DATA	DWORD	Addresse of the receive data array valid length = 0...255 ! Determine the address by means of the operator ADR and assigne it to the FB!

Parameters of the outputs

626

Parameter	Data type	Description
RESULT	BYTE	feedback of the function block (possible messages → following table)
LEN	WORD	length of the entry in "number of bytes" The value for LEN must not be greater than the size of the receive array. Otherwise any data is overwritten in the application.

Possible results for RESULT:

Value dec | hex		Description
0	00	FB is inactive
1	01	FB execution completed without error – data is valid
2	02	function block is active (action not yet completed)
3	03	Error, no data received during monitoring time

CANx_SDO_WRITE

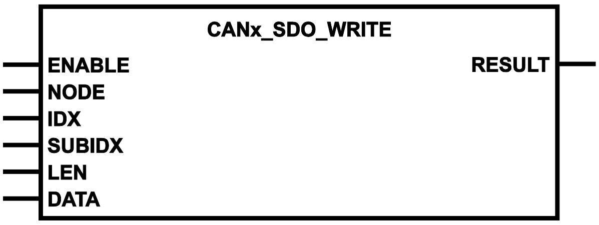
615

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

618

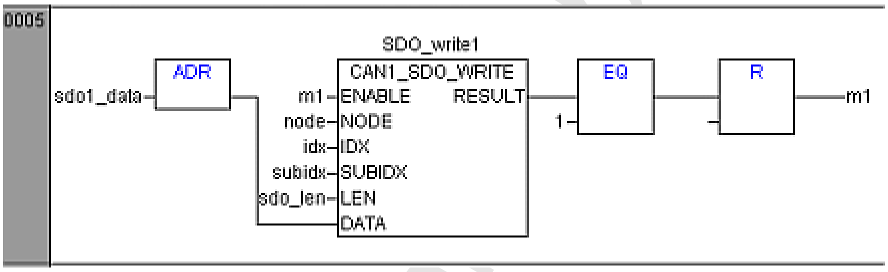
CANx_SDO_WRITE writes the →*SDO* (→ page 201) with the specified indexes to the node.

Prerequisite: the node must be in the state "PRE-OPERATIONAL" or "OPERATIONAL".

Using this FB, the entries can be written to the object directory. So it is possible to selectively set the node parameters.

> ❗ The value for LEN must be lower than the length of the transmit array. Otherwise, random data will be sent.

Example:



Parameters of the inputs

619

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
NODE	BYTE	ID of the node permissible values = 1...127 = 0x01...0x7F
IDX	WORD	index in object directory
SUBIDX	BYTE	sub-index referred to the index in the object directory
LEN	WORD	length of the entry in "number of bytes" The value for LEN must not be greater than the size of the transmit array. Otherwise any data is sent.
DATA	DWORD	Address of the transmit data array permissible length = 0...255 ❗ Determine the address by means of the operator ADR and assigne it to the FB!

Parameters of the outputs

620

Parameter	Data type	Description
RESULT	BYTE	feedback of the function block (possible messages → following table)

Possible results for RESULT:

Value dec	hex	Description
0	00	FB is inactive
1	01	FB execution completed without error – data is valid
2	02	function block is active (action not yet completed)
3	03	Error, data cannot be transmitted

5.2.5 Function elements: SAE J1939

Contents

2273

For SAE J1939, **ifm electronic** provides a number of function elements which will be explained in the following.

J1939_x

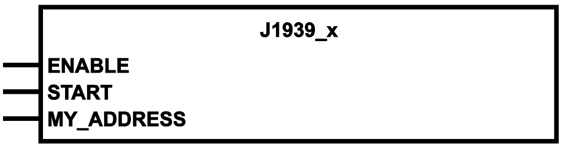
9375

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_J1939_x_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

4325

J1939_x serves as protocol handler for the communication profile SAE J1939.

4313

NOTE

(for RTS to v05 only)
J1939 communication via the 1st CAN interface:

- ► First initialise the interface via *CAN1_EXT* (→ page 60)!

J1939 communication via the 2nd CAN interface:

- ► First initialise the interface via *CAN2*!

To handle the communication, the protocol handler must be called in each program cycle. To do so, the input ENABLE is set to TRUE.

The protocol handler is started if the input START is set to TRUE for one cycle.

Using MY_ADDRESS, a device address is assigned to the controller. It must differ from the addresses of the other J1939 bus participants. It can then be read by other bus participants.

Parameters of the inputs

469

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
START	BOOL	TRUE (only for 1 cycle): Start J1939 protocol at CAN interface x FALSE: during further processing of the program
MY_ADDRESS	BYTE	J1939 address of the device

J1939_x_GLOBAL_REQUEST

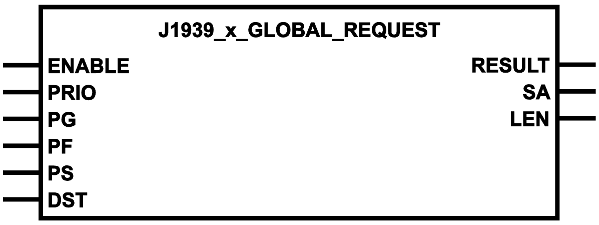
4315

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_J1939_x_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2301

J1939_x_GLOBAL_REQUEST is responsible for the automatic requesting of individual messages from all (global) active J1939 network participants. To do so, the parameters PG, PF, PS and the address of the array DST in which the received data is stored are assigned to the FB.

ⓘ **Info**

PGN = [Page] + [PF] + [PS]
PDU = [PRIO] + [PGN] + [J1939 address] + [data]

13790

NOTICE

Risk of inadmissible overwriting of data!

▶ Create a receiver array with a size of 1 785 bytes.
This is the maximum size of a J1939 message.

▶ Check the amount of received data:
the value must not exceed the size of the array created to receive data!

▶ For every requested message use an own instance of the FB!

▶ To the destination address DST applies:
❗ Determine the address by means of the operator ADR and assigne it to the FB!

▶ In addition, the priority (typically 3, 6 or 7) must be assigned.

▶ Given that the request of data can be handled via several control cycles, this process must be evaluated via the RESULT byte.

- RESULT = 2: the POU is waiting for data of the participants.
- RESULT = 1: data was received by a participant.
The output LEN indicates how many data bytes have been received.
Store / evaluate this new data immediately!
When a new message is received, the data in the memory address DST is overwritten.
- RESULT = 0: no participant on the bus sends a reply within 1.25 seconds.
The FB returns to the non-active state.
Only now may ENABLE be set again to FALSE!

▶ For the reception of data from several participants at short intervals:
call the POU several times in the same PLC cycle and evaluate it at once!

Parameters of the inputs

463

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
PRIO	BYTE	message priority (0…7)
PG	BYTE	Data page Value of defined PGN (Parameter Group Number) allowed = 0...1 (normally = 0)
PF	BYTE	PDU format byte Value of defined PGN (Parameter Group Number) PDU2 (global) = 240...255
PS	BYTE	PDU specific byte Value of defined PGN (Parameter Group Number) GE (Group Extension) = 0...255
DST	DWORD	destination address ❗ Determine the address by means of the operator ADR and assigne it to the FB!

Info

PGN = [Page] + [PF] + [PS]
PDU = [PRIO] + [PGN] + [J1939 address] + [data]

Parameters of the outputs

464

Parameter	Data type	Description
RESULT	BYTE	feedback of the function block (possible messages → following table)
SA	BYTE	J1939 address of the answering device
LEN	WORD	number of received bytes

Possible results for RESULT:

Value dec	hex	Description
0	00	FB is inactive
1	01	FB execution completed without error – data is valid
2	02	function block is active (action not yet completed)
3	03	Error

J1939_x_RECEIVE

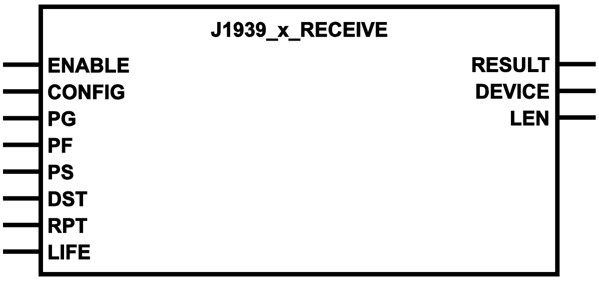
9393

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_J1939_x_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2288

J1939_x_RECEIVE serves for receiving one individual message or a block of messages.

To do so, the FB must be initialised for one cycle via the input CONFIG. During initialisation, the parameters PG, PF, PS, RPT, LIFE and the memory address of the data array DST are assigned.

> ❗ Once the following parameters have been configured they can no longer be modified in the running application program: PG, PF, PS, RPT, LIFE, DST.

13790

> **NOTICE**
>
> Risk of inadmissible overwriting of data!
>
> ► Create a receiver array with a size of 1 785 bytes.
> This is the maximum size of a J1939 message.
>
> ► Check the amount of received data:
> the value must not exceed the size of the array created to receive data!

► To the destination address DST applies:
❗ Determine the address by means of the operator ADR and assigne it to the FB!

❗ Once RPT has been set it can no longer be modified!

► The receipt of data must be evaluated via the RESULT byte. If RESULT = 1 the data can be read from the memory address assigned via DST and can be further processed.

> When a new message is received, the data in the memory address DST is overwritten.

> The number of received message bytes is indicated via the output LEN.

> If RESULT = 3, no valid messages have been received in the indicated time window (LIFE • RPT).

> ❗ This block must also be used if the messages are requested using the FBs J1939_..._REQUEST.

Parameters of the inputs

457

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
CONFIG	BOOL	TRUE (in the 1st cycle): configure data object FALSE: during further processing of the program
PG	BYTE	Data page Value of defined PGN (Parameter Group Number) allowed = 0...1 (normally = 0)
PF	BYTE	PDU format byte Value of defined PGN (Parameter Group Number) PDU1 (specific) = 0...239 PDU2 (global) = 240...255
PS	BYTE	PDU specific byte Value of defined PGN (Parameter Group Number) If PF = PDU1 ⇨ PS = DA (Destination Address) (DA = J1939 address of external device) If PF = PDU2 ⇨ PS = GE (Group Extension)
DST	DWORD	destination address ❗ Determine the address by means of the operator ADR and assigne it to the FB!
RPT	TIME	Monitoring time Within this time window the messages must be received cyclically. > Otherwise, there will be an error message. RPT = T#0s ⇨ no monitoring ❗ Once RPT has been set it can no longer be modified!
LIFE	BYTE	tolerated number of J1939 messages not received

Parameters of the outputs

458

Parameter	Data type	Description
RESULT	BYTE	feedback of the function block (possible messages → following table)
DEVICE	BYTE	J1939 address of the sender
LEN	WORD	number of received bytes

Possible results for RESULT:

Value dec | hex		Description
0	00	FB is inactive
1	01	FB execution completed without error – data is valid
3	03	Error, no data received during monitoring time

J1939_x_RESPONSE

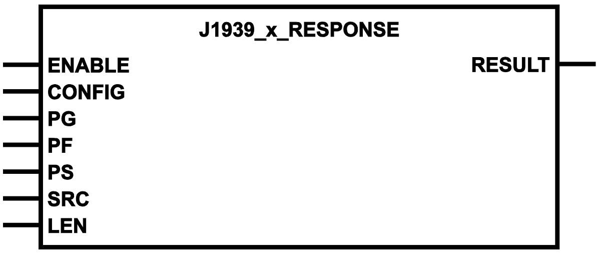
9399

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_J1939_x_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2299

J1939_x_RESPONSE handles the automatic response to a request message.

This FB is responsible for the automatic sending of messages to "Global Requests" and "Specific Requests". To do so, the FB must be initialised for one cycle via the input CONFIG.

The parameters PG, PF, PS, RPT and the address of the data array SRC are assigned to the FB.

- To the source address SRC applies:
  ❗ Determine the address by means of the operator ADR and assigne it to the FB!
- In addition, the number of data bytes to be transmitted is assigned.

Parameters of the inputs

451

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
CONFIG	BOOL	TRUE (in the 1st cycle): configure data object FALSE: during further processing of the program
PG	BYTE	Data page Value of defined PGN (Parameter Group Number) allowed = 0...1 (normally = 0)
PF	BYTE	PDU format byte Value of defined PGN (Parameter Group Number) PDU1 (specific) = 0...239 PDU2 (global) = 240...255
PS	BYTE	PDU specific byte Value of defined PGN (Parameter Group Number) If PF = PDU1 ⇨ PS = DA (Destination Address) (DA = J1939 address of external device) If PF = PDU2 ⇨ PS = GE (Group Extension)
SRC	DWORD	start address in source memory ❗ Determine the address by means of the operator ADR and assigne it to the FB!
LEN	WORD	number (≥ 1) of the data bytes to be transmitted

Parameters of the outputs

13993

Parameter	Data type	Description
RESULT	BYTE	feedback of the function block (possible messages → following table)

Possible results for RESULT:

Value dec | hex		Description
0	00	FB is inactive
1	01	Data transfer completed without errors
2	02	function block is active (action not yet completed)
3	03	Error, data cannot be transmitted

J1939_x_SPECIFIC_REQUEST

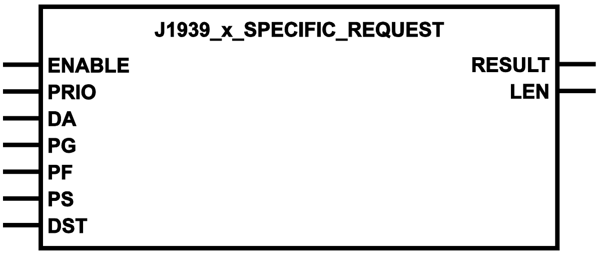
8884

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_J1939_x_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2300

J1939_x_SPECIFIC_REQUEST is responsible for the automatic requesting of individual messages from a specific J1939 network participant. To do so, the logical device address DA, the parameters PG, PF, PS and the address of the array DST in which the received data is stored are assigned to the FB.

ⓘ **Info**

PGN = [Page] + [PF] + [PS]
PDU = [PRIO] + [PGN] + [J1939 address] + [data]

13790

NOTICE

Risk of inadmissible overwriting of data!

- ► Create a receiver array with a size of 1 785 bytes.
  This is the maximum size of a J1939 message.
- ► Check the amount of received data:
  the value must not exceed the size of the array created to receive data!

- ► To the destination address DST applies:
  ❗ Determine the address by means of the operator ADR and assigne it to the FB!
- ► In addition, the priority (typically 3, 6 or 7) must be assigned.
- ► Given that the request of data can be handled via several control cycles, this process must be evaluated via the RESULT byte. All data has been received if RESULT = 1.

> The output LEN indicates how many data bytes have been received.

Parameters of the inputs

445

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
PRIO	BYTE	message priority (0…7)
DA	BYTE	J1939 address of the requested device
PG	BYTE	Data page Value of defined PGN (Parameter Group Number) allowed = 0...1 (normally = 0)
PF	BYTE	PDU format byte Value of defined PGN (Parameter Group Number) PDU1 (specific) = 0...239 PDU2 (global) = 240...255
PS	BYTE	PDU specific byte Value of defined PGN (Parameter Group Number) If PF = PDU1 ➩ PS = DA (Destination Address) (DA = J1939 address of external device) If PF = PDU2 ➩ PS = GE (Group Extension)
DST	DWORD	destination address ! Determine the address by means of the operator ADR and assigne it to the FB!

Info

PGN = [Page] + [PF] + [PS]
PDU = [PRIO] + [PGN] + [J1939 address] + [data]

Parameters of the outputs

446

Parameter	Data type	Description
RESULT	BYTE	feedback of the function block (possible messages → following table)
LEN	WORD	number of received bytes

Possible results for RESULT:

Value		Description
dec	hex	
0	00	FB is inactive
1	01	FB execution completed without error – data is valid
2	02	function block is active (action not yet completed)
3	03	Error

J1939_x_TRANSMIT

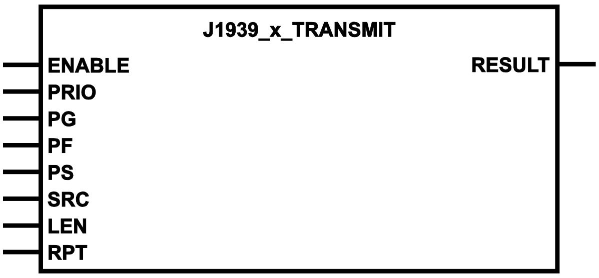
4322

x = 1...n = number of the CAN interface (depending on the device, → Data sheet)

Unit type = function block (FB)

Unit is contained in the library `ifm_J1939_x_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2298

J1939_x_TRANSMIT is responsible for transmitting individual messages or blocks of messages. To do so, the parameters PG, PF, PS, RPT and the address of the data array SRC are assigned to the FB.

> ⓘ **Info**
>
> PGN = [Page] + [PF] + [PS]
> PDU = [PRIO] + [PGN] + [J1939 address] + [data]

- To the source address SRC applies:
  ❗ Determine the address by means of the operator ADR and assigne it to the FB!
- In addition, the number of data bytes to be transmitted and the priority (typically 3, 6 or 7) must be assigned.
- Given that the transmission of data is processed via several control cycles, the process must be evaluated via the RESULT byte. All data has been transmitted if RESULT = 1.

ⓘ If more than 8 bytes are to be sent, a "multi package transfer" is carried out.

Parameters of the inputs

439

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
PRIO	BYTE	message priority (0…7)
PG	BYTE	Data page Value of defined PGN (Parameter Group Number) allowed = 0...1 (normally = 0)
PF	BYTE	PDU format byte Value of defined PGN (Parameter Group Number) PDU1 (specific) = 0...239 PDU2 (global) = 240...255
PS	BYTE	PDU specific byte Value of defined PGN (Parameter Group Number) If PF = PDU1 ➩ PS = DA (Destination Address) (DA = J1939 address of external device) If PF = PDU2 ➩ PS = GE (Group Extension)
SRC	DWORD	start address in source memory ! Determine the address by means of the operator ADR and assigne it to the FB!
LEN	WORD	number of data bytes to be transmitted allowed = 1...1 785 = 0x0001...0x06F9
RPT	TIME	Repeat time during which the data messages are to be transmitted cyclically RPT = T#0s ➩ sent only once

Info

PGN = [Page] + [PF] + [PS]
PDU = [PRIO] + [PGN] + [J1939 address] + [data]

Parameters of the outputs

440

Parameter	Data type	Description
RESULT	BYTE	feedback of the function block (possible messages → following table)

Possible results for RESULT:

Value dec	hex	Description
0	00	FB is inactive
1	01	FB execution completed without error – data is valid
2	02	function block is active (action not yet completed)
3	03	Error, data cannot be transmitted

5.2.6 Function elements: serial interface

Contents

1600

NOTE

In principle, the serial interface is not available for the user, because it is used for program download and debugging.

The interface can be freely used if the user sets the system flag bit SERIAL_MODE to TRUE. Then however, program download and debugging are only possible via the CAN interface.

The serial interface can be used in the application program by means of the following FBs.

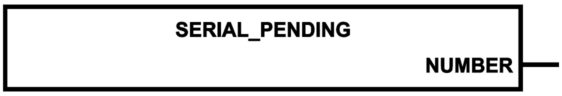
SERIAL_PENDING

314

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

317

SERIAL_PENDING determines the number of data bytes stored in the serial receive buffer.

In contrast to *SERIAL_RX* (→ page 111) the contents of the buffer remain unchanged after calling this FB.

The SERIAL FBs form the basis for the creation of an application-specific protocol for the serial interface.
To do so, set the system flag bit SERIAL_MODE=TRUE!

NOTE

In principle, the serial interface is not available for the user, because it is used for program download and debugging.

The interface can be freely used if the user sets the system flag bit SERIAL_MODE to TRUE. Then however, program download and debugging are only possible via the CAN interface.

Parameters of the outputs

319

Parameter	Data type	Description
NUMBER	WORD	Number of data bytes received

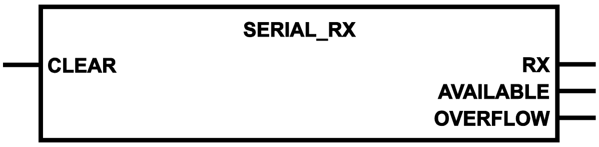
SERIAL_RX

308

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

311

SERIAL_RX reads a received data byte from the serial receive buffer at each call.

Then, the value of AVAILABLE is decremented by 1.

If more than 1000 data bytes are received, the buffer overflows and data is lost. This is indicated by the bit OVERFLOW.

If 7-bit data transmission is used, the 8th bit contains the parity and must be suppressed by the user if necessary.

The SERIAL FBs form the basis for the creation of an application-specific protocol for the serial interface.
To do so, set the system flag bit SERIAL_MODE=TRUE!

NOTE

In principle, the serial interface is not available for the user, because it is used for program download and debugging.

The interface can be freely used if the user sets the system flag bit SERIAL_MODE to TRUE. Then however, program download and debugging are only possible via the CAN interface.

Parameters of the inputs

312

Parameter	Data type	Description
CLEAR	BOOL	TRUE: delete receive buffer FALSE: function element is not executed

Parameters of the outputs

313

Parameter	Data type	Description
Rx	BYTE	Byte data received from the receive buffer
AVAILABLE	WORD	Number of remaining data bytes 0 = no valid data available
OVERFLOW	BOOL	TRUE: Overflow of the data buffer ⇨ loss of data! FALSE: Data buffer is without data loss

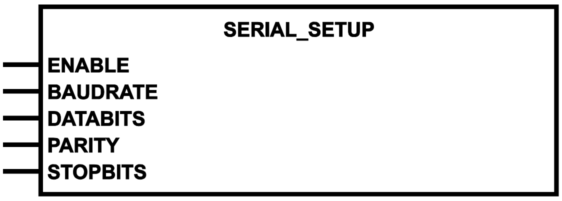
SERIAL_SETUP

302

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

305

SERIAL_SETUP initialises the serial RS232 interface.

The function block does not necessarily need to be executed in order to be able to use the serial interface. Without function block call the default settings below apply.

Using ENABLE=TRUE for one cycle, the function block sets the serial interface to the indicated parameters. The changes made with the help of the function block are saved non-volatily.

NOTE

In principle, the serial interface is not available for the user, because it is used for program download and debugging.

The interface can be freely used if the user sets the system flag bit SERIAL_MODE to TRUE. Then however, program download and debugging are only possible via the CAN interface.

5020

NOTICE

The driver module of the serial interface can be damaged!

Disconnecting or connecting the serial interface while live can cause undefined states which damage the driver module.

► Do not disconnect or connect the serial interface while live.

Parameters of the inputs

306

Parameter	Data type	Description
ENABLE	BOOL	TRUE (only for 1 cycle): Initialise interface FALSE: during further processing of the program
BAUD RATE	WORD	Baud rate permissible values → data sheet preset value → data sheet
DATABITS	BYTE := 8	Number of data bits allowed = 7 or 8
PARITY	BYTE := 0	Parity allowed: 0=none, 1=even, 2=odd
STOPBITS	BYTE := 1	Number of stop bits allowed = 1 or 2

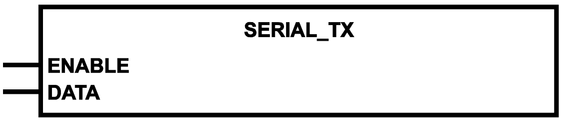
SERIAL_TX

296

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

299

SERIAL_TX transmits one data byte via the serial RS232 interface.

Using the input ENABLE the transmission can be enabled or blocked.

The SERIAL FBs form the basis for the creation of an application-specific protocol for the serial interface.
To do so, set the system flag bit SERIAL_MODE=TRUE!

> **NOTE**
>
> In principle, the serial interface is not available for the user, because it is used for program download and debugging.
>
> The interface can be freely used if the user sets the system flag bit SERIAL_MODE to TRUE. Then however, program download and debugging are only possible via the CAN interface.

Parameters of the inputs

300

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
DATA	BYTE	value to be transmitted

5.2.7 Function elements: Optimising the PLC cycle via processing interrupts

Contents

20965
8609

Here we show you functions to optimise the PLC cycle.

1599

The PLC cyclically processes the stored application program in its full length. The cycle time can vary due to program branchings which depend e.g. on external events (= conditional jumps). This can have negative effects on certain functions.

By means of systematic interrupts of the cyclic program it is possible to call time-critical processes independently of the cycle in fixed time periods or in case of certain events.

Since interrupt functions are principally not permitted for SafetyControllers, they are thus not available.

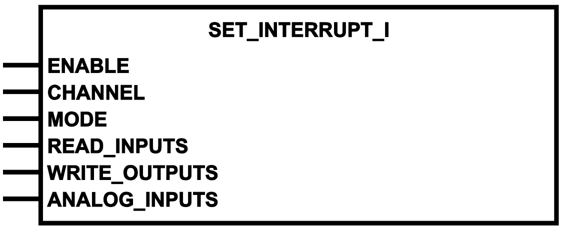
SET_INTERRUPT_I

2381

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

281
11573

SET_INTERRUPT_I handles the execution of a program part by an interrupt request via an input channel.

In the conventional PLC the cycle time is decisive for real-time monitoring. So the PLC is at a disadvantage as compared to customer-specific controllers. Even a "real-time operating system" does not change this fact when the whole application program runs in one single block which cannot be changed.

A possible solution would be to keep the cycle time as short as possible. This often leads to splitting the application up to several control cycles. This, however, makes programming complex and difficult.

Another possibility is to call a certain program part only upon request by an input pulse independently of the control cycle:

The time-critical part of the application is integrated by the user in a block of the type PROGRAM (PRG). This block is declared as the interrupt routine by calling SET_INTERRUPT_I once (during initialisation). As a consequence, this program block will always be executed if an edge is detected on the input CHANNEL. If inputs and outputs are used in this program part, these are also read and written in the interrupt routine, triggered by the input edge. Reading and writing can be stopped via the FB inputs READ_INPUTS, WRITE_OUTPUTS and ANALOG_INPUTS.

So in the program block all time-critical events can be processed by linking inputs or global variables and writing outputs. So FBs can only be executed if actually called by an input signal.

NOTE

The program block should be skipped in the cycle (except for the initialisation call) so that it is not cyclically called, too.

The input (CHANNEL) monitored for triggering the interrupt cannot be initialised and further processed in the interrupt routine.

The runtime of the main cycle plus the sum of the duration of all program parts called via interrupt must always be within the max. permissible cycle time!

The user is responsible for data consistency between the main program and the program parts running in the interrupt mode!

19866

Interrupt priorities:

- All program parts called via interrupt have the same priority of execution. Several simultaneous interrupts are processed sequentially in the order of their occurrence.
- If a further edge is detected on the same input during execution of the program part called via interrupt, the interrupt is listed for processing and the program is directly called again after completion. As an option, interfering multiple pulses can be filtered out by setting the glitch filter.
- The program running in the interrupt mode can be disrupted by interrupts with a higher priority (e.g. CAN).
- If several interrupts are present on the same channel, the last initialised FB (or the PRG) will be assigned the channel. The previously defined FB (or the PRG) is then no longer called and no longer provides data.

971

NOTE

The uniqueness of the inputs and outputs in the cycle is affected by the interrupt routine. Therefore only part of the inputs and outputs is serviced. If initialised in the interrupt program, the following inputs and outputs will be read or written.

Inputs, digital:

%IX0.0...%IX0.7 (Controller: CR0n3n, CR7n3n)
%IX0.12...%IX0.15, %IX1.4...%IX1.8 (all other ClassicController, ExtendedController, SafetyController)
%IX0.0, %IX0.8 (SmartController: CR250n)
IN08...IN11 (CabinetController: CR030n)
IN0...IN3 (PCB controller: CS0015)

Inputs, analogue:

%IX0.0...%IX0.7 (Controller: CR0n3n, CR7n3n)
All channels (selection bit-coded) (all other controller)

Outputs, digital:

%QX0.0...%QX0.7 (ClassicController, ExtendedController, SafetyController)
%QX0.0, %QX0.8 (SafetyController: CR7nnn)
OUT00...OUT03 (CabinetController: CR030n)
OUT0...OUT7 (PCB controller: CS0015)

Global variants, too, are no longer unique if they are accessed simultaneously in the cycle and by the interrupt routine. This problem applies in particular to larger data types (e.g. DINT).

All other inputs and outputs are processed once in the cycle, as usual.

Parameters of the inputs

20089

Parameter	Data type	Description
ENABLE	BOOL	TRUE (only for 1 cycle): initialisation of the function block FALSE: unit is not executed
CHANNEL	BYTE	Number of the interrupt input 0...3 for the inputs IN08...IN11
MODE	BYTE	Type of edge at the input CHANNEL which triggers the interrupt 1 = rising edge (standard value) 2 = falling edge 3 = rising and falling edge > 3 = standard value
READ_INPUTS	BOOL	TRUE: read the inputs 8...11 before calling the program and write to the input flags IN08...IN11 FALSE: only read the channel indicated under CHANNEL and write to the corresponding input flag INnn
WRITE_OUTPUTS	BOOL	TRUE: write the current values of the output flags Q00...Q03 to the outputs after completion of the program sequence FALSE: do not write outputs
ANALOG_INPUTS	BOOL	TRUE: read inputs 16...23 and write the unfiltered, uncalibrated analogue values to the flags ANALOG_IRQ16...23 FALSE: do not write the flags A_IN16...23

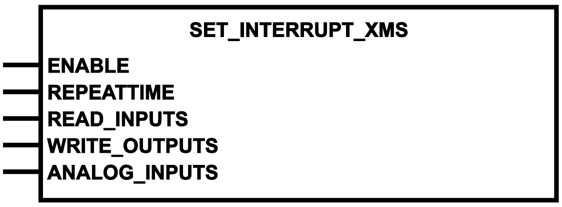
SET_INTERRUPT_XMS

272

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

275

SET_INTERRUPT_XMS handles the execution of a program part at an interval of x ms.

In the conventional PLC the cycle time is decisive for real-time monitoring. So, the PLC is at a disadvantage as compared to customer-specific controllers. Even a "real-time operating system" does not change this fact when the whole application program runs in one single block which cannot be changed.

A possible solution would be to keep the cycle time as short as possible. This often leads to splitting the application up to several control cycles. This, however, makes programming complex and difficult.

Another possibility is to call a certain program part at fixed intervals (every xAnother possibility is to call a certain program part at fixed intervals (every x ms) independently of the control cycle.

The time-critical part of the application is integrated by the user in a block of the type PROGRAM (PRG). This block is declared as the interrupt routine by calling SET_INTERRUPT_XMS once (during initialisation). As a consequence, this program block is always processed after the REPEATTIME has elapsed (every x ms). If inputs and outputs are used in this program part, they are also read and written in the defined cycle. Reading and writing can be stopped via the FB inputs READ_INPUTS, WRITE_OUTPUTS and ANALOG_INPUTS.

So, in the program block all time-critical events can be processed by linking inputs or global variables and writing outputs. So, timers can be monitored more precisely than in a "normal cycle".

NOTE

To avoid that the program block called by interrupt is additionally called cyclically, it should be skipped in the cycle (with the exception of the initialisation call).

Several timer interrupt blocks can be active. The time requirement of the interrupt functions must be calculated so that all called functions can be executed. This in particular applies to calculations, floating point arithmetic or controller functions.

The user is responsible for data consistency between the main program and the program parts running in the interrupt!

Please note: In case of a high CAN bus activity the set REPEATTIME may fluctuate.

971

❗ NOTE

The uniqueness of the inputs and outputs in the cycle is affected by the interrupt routine. Therefore only part of the inputs and outputs is serviced. If initialised in the interrupt program, the following inputs and outputs will be read or written.

Inputs, digital:

%IX0.0...%IX0.7 (Controller: CR0n3n, CR7n3n)
%IX0.12...%IX0.15, %IX1.4...%IX1.8 (all other ClassicController, ExtendedController, SafetyController)
%IX0.0, %IX0.8 (SmartController: CR250n)
IN08...IN11 (CabinetController: CR030n)
IN0...IN3 (PCB controller: CS0015)

Inputs, analogue:

%IX0.0...%IX0.7 (Controller: CR0n3n, CR7n3n)
All channels (selection bit-coded) (all other controller)

Outputs, digital:

%QX0.0...%QX0.7 (ClassicController, ExtendedController, SafetyController)
%QX0.0, %QX0.8 (SafetyController: CR7nnn)
OUT00...OUT03 (CabinetController: CR030n)
OUT0...OUT7 (PCB controller: CS0015)

Global variants, too, are no longer unique if they are accessed simultaneously in the cycle and by the interrupt routine. This problem applies in particular to larger data types (e.g. DINT).

All other inputs and outputs are processed once in the cycle, as usual.

Parameters of the inputs

20095

Parameter	Data type	Description
ENABLE	BOOL	TRUE (only for 1 cycle): initialisation of the function block FALSE: unit is not executed
REPEATTIME	TIME	Duration in [ms] between end of program and reboot The duration between two calls is determined as the sum of REPEATTIME and runtime of the program called via interrupt.
READ_INPUTS	BOOL	TRUE: read the inputs 8...11 before calling the program and write to the input flags IN08...IN11 FALSE: only read the channel indicated under CHANNEL and write to the corresponding input flag INnn
WRITE_OUTPUTS	BOOL	TRUE: write the current values of the output flags Q00...Q03 to the outputs after completion of the program sequence FALSE: do not write outputs
ANALOG_INPUTS	BOOL	TRUE: read inputs 16...23 and write the unfiltered, uncalibrated analogue values to the flags ANALOG_IRQ16...23 FALSE: do not write the flags A_IN16...23

5.2.8 Function elements: processing input values

Contents

1602
1302

In this chapter we show you **ifm** FBs which allow you to read and process the analogue or digital signals at the device input.

NOTE

The analogue raw values shown in the PLC configuration of CODESYS directly come from the ADC. They are not yet corrected!

Therefore different raw values can appear in the PLC configuration for identical devices.

Error correction and normalisation are only carried out by ifm function blocks. The function blocks provide the corrected value.

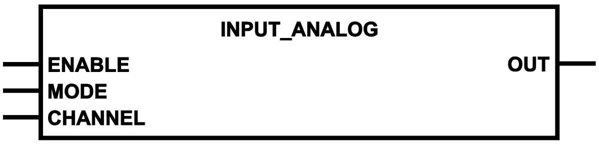
INPUT_ANALOG

519

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

522

INPUT_ANALOG enables current and voltage measurements at the analogue channels.

The FB provides the current analogue value at the selected analogue channel. The measurement and the output value result from the operating mode specified via MODE.

MODE	Input operating mode	Output OUT	Unit
IN_DIGITAL_H	digital input	0 / 1	---
IN_CURRENT	current input	0...20 000	µA
IN_VOLTAGE10	voltage input	0...10 000	mV
IN_VOLTAGE30	voltage input	0...32 000	mV
IN_RATIO	voltage input ratiometric	0...1 000	‰

For parameter setting of the operating mode, the indicated global system variables should be used.
The analogue values are provided as standardised values.

> ❗ When using this FB you must set the system variable RELAIS *).
> Otherwise the internal reference voltages are missed for the current measurement.

*) Relay exists only in the following devices: CR0020, CRnn32, CRnn33, CR0200, CR0505, CR7nnn

Parameters of the inputs

523

Parameter	Data type	Description		
ENABLE	BOOL	TRUE: FALSE:	execute this function element unit is not executed > Function block inputs are not active > Function block outputs are not specified	
MODE	BYTE	IN_DIGITAL_H IN_CURRENT IN_VOLTAGE10 IN_VOLTAGE30 IN_RATIO	Digital input Current input Voltage input Voltage input ratiometric analogue input	 0...20 000 µA 0...10 000 mV 0...32 000 mV
INPUT_CHANNEL	BYTE	Number of input channel allowed = 0...7		

Parameters of the outputs

524

Parameter	Data type	Description
OUT	WORD	Output value according to MODE in case of an invalid setting: OUT = "0"

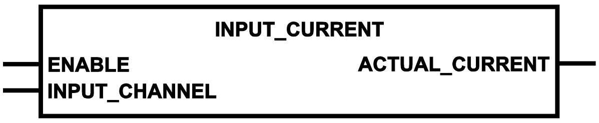
INPUT_CURRENT

513

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

516

INPUT_CURRENT returns the actual input current in [µA] at the analogue current inputs.

ℹ Info

INPUT_CURRENT is a compatibility FB for older programs. In new programs, the more powerful *INPUT_ANALOG* (→ page 122) should be used.

Parameters of the inputs

517

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
INPUT_CHANNEL	BYTE	Number of input channel allowed = 0...7

Parameters of the outputs

518

Parameter	Data type	Description
ACTUAL_CURRENT	WORD	input current in [µA]

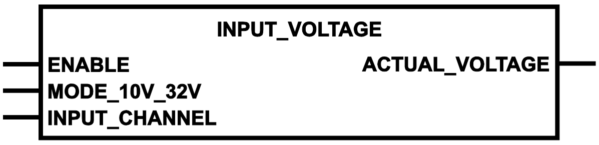
INPUT_VOLTAGE

507

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

510

INPUT_VOLTAGE processes analogue voltages measured on the analogue channels.

> The FB returns the current input voltage in [mV] on the selected analogue channel. The measurement refers to the voltage range defined via MODE_10V_32V (10 000 mV or 32 000 mV).

Info

INPUT_VOLTAGE is a compatibility FB for older programs. In new programs, the more powerful *INPUT_ANALOG* (→ page 122) should be used.

Parameters of the inputs

511

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
MODE_10V_32V	BOOL	TRUE: voltage range 0...32 V FALSE: voltage range 0...10 V
INPUT_CHANNEL	BYTE	Number of input channel allowed = 0...7

Parameters of the outputs

512

Parameter	Data type	Description
ACTUAL_VOLTAGE	WORD	input voltage in [mV]

5.2.9 Function elements: adapting analogue values

Contents

1603

If the values of analogue inputs or the results of analogue functions must be adapted, the following FBs will help you.

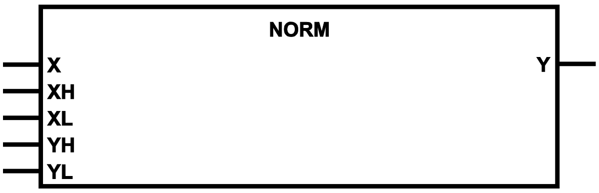
NORM

401

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

404

NORM normalises a value within defined limits to a value with new limits.

The FB normalises a value of type WORD within the limits of XH and XL to an output value within the limits of YH and YL. This FB is for example used for generating PWM values from analogue input values.

NOTE

► The value for X must be in the defined input range between XL and XH!
There is no internal plausibility check of the value X.

> Due to rounding errors the normalised value can deviate by 1.

> If the limits (XH/XL or YH/YL) are defined in an inverted manner, normalisation is also done in an inverted manner.

Parameters of the inputs

405

Parameter	Data type	Description
X	WORD	input value
XH	WORD	Upper limit of input value range [increments]
XL	WORD	Lower limit of input value range [increments]
YH	WORD	Upper limit of output value range
YL	WORD	Lower limit of output value range

Parameters of the outputs

406

Parameter	Data type	Description
Y	WORD	output value

Example: NORM (1)

407

lower limit value input	0	XL
upper limit value input	100	XH
lower limit value output	0	YL
upper limit value output	2000	YH

then the FB converts the input signal for example as follows:

from X =	50	0	100	75
	↓	↓	↓	↓
to Y =	1000	0	2000	1500

Example: NORM (2)

408

lower limit value input	2000	XL
upper limit value input	0	XH
lower limit value output	0	YL
upper limit value output	100	YH

then the FB converts the input signal for example as follows:

from X =	1000	0	2000	1500
	↓	↓	↓	↓
to Y =	50	100	0	25

5.2.10 Function elements: counter functions for frequency and period measurement

Contents

18818

The controllers support up to 4 fast inputs which can process input frequencies of up to 30 kHz. In addition to frequency measurement, the FRQ inputs can also be used for the evaluation of incremental encoders (counter function).

Due to the different measuring methods errors can occur when the frequency is determined.

The following FBs are available for easy evaluation:

Function element	Permissible values	Explanation
FAST_COUNT	0...30 000 Hz	Counting of fast pulses
FREQUENCY	0.1...30 000 Hz	Measurement of the frequency on the indicated channel. Measurement error is reduced in case of high frequencies
INC_ENCODER	0...30 000 Hz	Up/down counter function for the evaluation of encoders
PERIOD	0...5 000 Hz	Measurement of frequency and period duration (cycle time) on the indicated channel
PERIOD_RATIO	0...5 000 Hz	Measurement of frequency and period duration (cycle time) as well as mark-to-space ratio [‰] on the indicated channel
PHASE	0...5 000 Hz	Reading of a channel pair and comparison of the phase position of the signals

! Important when using the fast inputs as "normal" digital inputs:

► The increased sensitivity to noise pulses must be taken into account (e.g. contact bouncing for mechanical contacts).

- The standard digital input can evaluate signals up to 50 Hz.

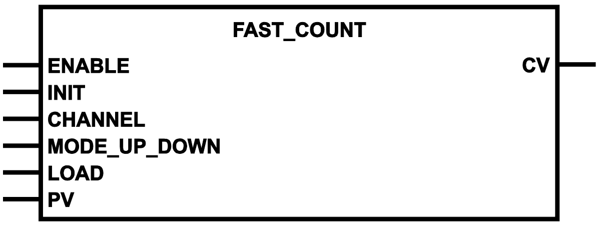
FAST_COUNT

20430

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

570

FAST_COUNT operates as counter block for fast input pulses.

This FB detects fast pulses at the FRQ input channels 0...3. With the FRQ input channel 0 FAST_COUNT operates like the block CTU. Maximum input frequency → data sheet.

❗ Due to the technical design, for the **ecomat*mobile*** controllers channel 0 can only be used as up counter. The channels 1...3 can be used as up and down counters.

Parameters of the inputs

17812

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > counter stopped
INIT	BOOL	FALSE ⇨ TRUE (edge): unit is initialised FALSE: during further processing of the program
CHANNEL	BYTE	Number of the fast input channel 0...3 for the inputs IN08...IN11
MODE_UP_DOWN	BOOL	TRUE: counter counts downwards FALSE: counter counts upwards
LOAD	BOOL	TRUE: start value PV is loaded in CV FALSE: function element is not executed
PV	DWORD	Start value (preset value) for the counter

Parameters of the outputs

572

Parameter	Data type	Description
CV	DWORD	current counter value Behaviour in case of overflow: • the counter stops at 0 when counting downwards • there is an overflow when counting upwards

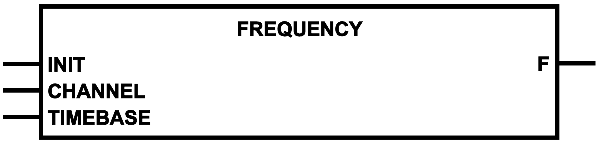
FREQUENCY

20604

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

540

FREQUENCY measures the signal frequency at the indicated channel. Maximum input frequency → data sheet.

This FB measures the frequency of the signal at the selected CHANNEL. To do so, the positive edge is evaluated. Depending on the TIMEBASE, frequency measurements can be carried out in a wide value range. High frequencies require a short time base, low frequencies a correspondingly longer time base. The frequency is provided directly in [Hz].

! For FREQUENCY only the inputs FRQ0...FRQ3 can be used.

Parameters of the inputs

17814

Parameter	Data type	Description
INIT	BOOL	FALSE ⇨ TRUE (edge): unit is initialised FALSE: during further processing of the program
CHANNEL	BYTE	Number of the fast input channel 0...3 for the inputs IN08...IN11
TIMEBASE	TIME	Time basis for frequency measurement (max. 57 s)

8406

! The FB may provide wrong values before initialisation.

► Do not evaluate the output before the FB has been initialised.

We urgently recommend to program an own instance of this FB for each channel to be evaluated. Otherwise, wrong values may be provided.

Parameters of the outputs

542

Parameter	Data type	Description
F	REAL	frequency of the input signal in [Hz]

INC_ENCODER

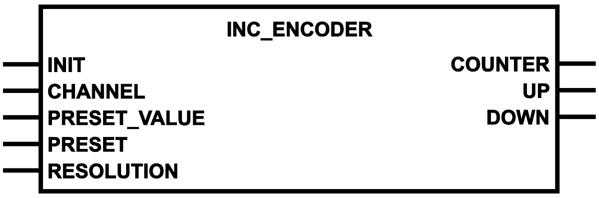
20432

= Incremental Encoder

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

4330

INC_ENCODER offers up/down counter functions for the evaluation of encoders.

Each input pair to be evaluated by means of the function block is formed by two frequency inputs.

Limit frequency = 30 kHz
max. number of units to be connected: 4 encoders (ExtendedController: max. 8 encoders)

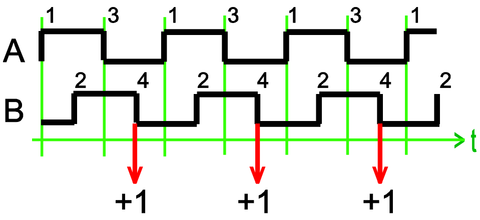
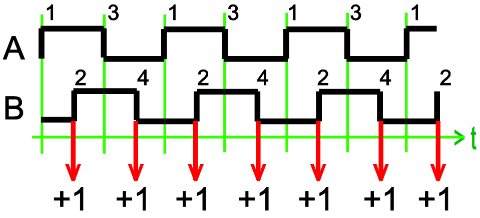
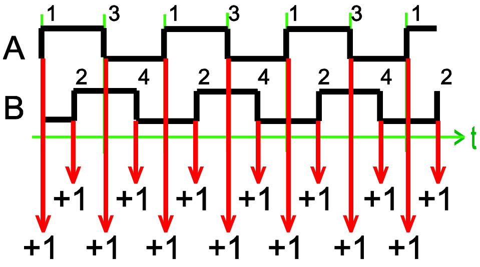
Set preset value:
1. Enter value in PRESET_VALUE
2. Set PRESET to TRUE for one cycle
3. Reset PRESET to FALSE

The function block counts the pulses at the inputs as long as INIT=FALSE and PRESET=FALSE.
The current counter value is available at the output COUNTER.

The outputs UP and DOWN indicate the current counting direction of the counter. The outputs are TRUE if the counter has counted in the corresponding direction in the preceding program cycle. If the counter stops, the direction output in the following program cycle is also reset.

! Do **not** use this function block on one input together with one of the following function blocks!
- *FAST_COUNT* (→ page 129)
- *FREQUENCY* (→ page 130)
- *PERIOD* (→ page 133)
- *PERIOD_RATIO* (→ page 135)
- *PHASE* (→ page 137)

On input RESOLUTION the resolution of the encoder can be evaluated in multiples:
1 = normal resolution (identical with the resolution of the encoder),
2 = double evaluation of the resolution,
4 = 4-fold evaluation of the resolution.
All other values on this input mean normal resolution.

	RESOLUTION = 1 In the case of normal resolution only the falling edge of the B-signal is evaluated.
 A B 1 3 1 3 1 3 1 2 4 2 4 2 4 2 t +1 +1 +1 +1 +1 +1 +1	RESOLUTION = 2 In the case of double resolution the falling and the rising edges of the B-signal are evaluated.
 A B 1 3 1 3 1 3 1 2 4 2 4 2 4 2 t +1 +1 +1 +1 +1 +1 +1 +1 +1 +1 +1 +1 +1 +1	RESOLUTION = 4 In the case of 4-fold resolution the falling and the rising edges of the A-signal and the B-signal are evaluated.

Parameters of the inputs

17822

Parameter	Data type	Description
INIT	BOOL	TRUE (only for 1 cycle): Function block is initialised FALSE: during further processing of the program
CHANNEL	BYTE	Number of the input channel pair 0 = channel pair 0 = inputs IN08 + IN09 1 = channel pair 1 = inputs IN10 + IN11
PRESET_VALUE	DINT	counter start value
PRESET	BOOL	FALSE ⇨ TRUE (edge): PRESET_VALUE is loaded to COUNTER TRUE: Counter ignores the input pulses FALSE: Counter counts the input pulses
RESOLUTION	BYTE	evaluation of the encoder resolution: 01 = counts for every fourth edge (= resolution of the encoder) 02 = counts for every second edge 04 = counts for every rising and falling edge All other values count as "01".

Parameters of the outputs

530

Parameter	Data type	Description
COUNTER	DINT	Current counter value
UP	BOOL	TRUE: counter counts upwards in the last cycle FALSE: counter counts not upwards in the last cycle
DOWN	BOOL	TRUE: counter counts downwards in the last cycle FALSE: counter counts not downwards in the last cycle

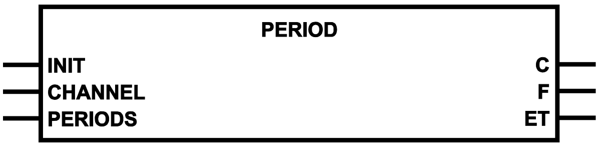
PERIOD

20606

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

373

PERIOD measures the frequency and the cycle period (cycle time) in [µs] at the indicated channel. Maximum input frequency → data sheet.

This FB measures the frequency and the cycle time of the signal at the selected CHANNEL. To calculate, all positive edges are evaluated and the average value is determined by means of the number of indicated PERIODS.

In case of low frequencies there will be inaccuracies when using FREQUENCY. To avoid this, PERIOD can be used. The cycle time is directly indicated in [µs].

The maximum measuring range is approx. 71 min.

NOTE

For PERIOD only the inputs CYL0...CYL3 can be used.
For PDM360smart: CR1071: all inputs.

Frequencies < 0.5 Hz are no longer clearly indicated!

Parameters of the inputs

17818

Parameter	Data type	Description
INIT	BOOL	FALSE ⇨ TRUE (edge): unit is initialised FALSE: during further processing of the program
CHANNEL	BYTE	Number of the fast input channel 0...3 for the inputs IN08...IN11
PERIODS	BYTE	Number of periods to be compared

8406

The FB may provide wrong values before initialisation.

► Do not evaluate the output before the FB has been initialised.

We urgently recommend to program an own instance of this FB for each channel to be evaluated. Otherwise, wrong values may be provided.

Parameters of the outputs

375

Parameter	Data type	Description
C	DWORD	Cycle time of the detected periods in [µs] allowed = 200...10 000 000 = 0xC8...0x989680 (= 10 seconds)
F	REAL	frequency of the input signal in [Hz]
ET	TIME	time elapsed since the last rising edge on the input (can be used for very slow signals)

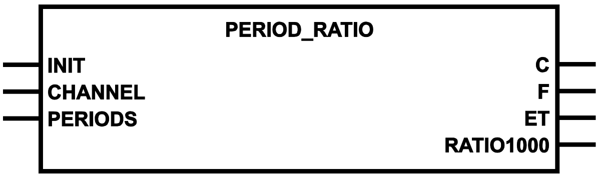
PERIOD_RATIO

20441

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

367

PERIOD_RATIO measures the frequency and the cycle period (cycle time) in [µs] during the indicated periods at the indicated channel. In addition, the mark-to-period ratio is indicated in [‰]. Maximum input frequency → data sheet.

This FB measures the frequency and the cycle time of the signal at the selected CHANNEL. To calculate, all positive edges are evaluated and the average value is determined by means of the number of indicated PERIODS. In addition, the mark-to-period ratio is indicated in [‰].

For example: In case of a signal ratio of 25 ms high level and 75 ms low level the value RATIO1000 is provided as 250 ‰.

In case of low frequencies there will be inaccuracies when using FREQUENCY. To avoid this, PERIOD_RATIO can be used. The cycle time is directly indicated in [µs].

The maximum measuring range is approx. 71 min.

NOTE

For PERIOD_RATIO only the inputs CYL0...CYL3 can be used.
For PDM360smart: CR1071: all inputs.

The output RATIO1000 provides the value 0 for a mark-to-period ratio of 100 % (input signal permanently at supply voltage).

Frequencies < 0.05 Hz are no longer clearly indicated!

Parameters of the inputs

17820

Parameter	Data type	Description
INIT	BOOL	FALSE ⇨ TRUE (edge): unit is initialised FALSE: during further processing of the program
CHANNEL	BYTE	Number of the fast input channel 0...3 for the inputs IN08...IN11
PERIODS	BYTE	Number of periods to be compared

8406

The FB may provide wrong values before initialisation.

► Do not evaluate the output before the FB has been initialised.

We urgently recommend to program an own instance of this FB for each channel to be evaluated. Otherwise, wrong values may be provided.

Parameters of the outputs

369

Parameter	Data type	Description
C	DWORD	Cycle time of the detected periods in [µs] allowed = 200...10 000 000 = 0xC8...0x989680 (= 10 seconds)
F	REAL	frequency of the input signal in [Hz]
ET	TIME	Time passed since the last change of state on the input (can be used in case of very slow signals)
RATIO1000	WORD	Mark-to-space ratio in [‰] permissible = 1...999 = 0x1...0x3E7 Preconditions: • for measuring the interval • pulse duration ≥ 100 µs • frequency < 5 kHz

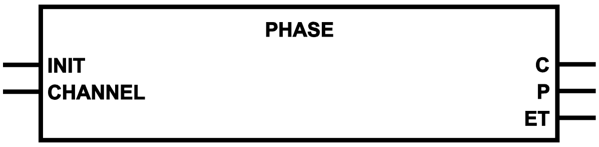
PHASE

20443

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

361

PHASE reads a pair of channels with fast inputs and compares the phase position of the signals.
Maximum input frequency → data sheet.

This FB compares a pair of channels with fast inputs so that the phase position of two signals towards each other can be evaluated. An evaluation of the cycle period is possible even in the range of seconds.

> ! For frequencies lower than 15 Hz a cycle period or phase shift of 0 is indicated.

Parameters of the inputs

528

Parameter	Data type	Description
INIT	BOOL	FALSE ⇨ TRUE (edge): unit is initialised FALSE: during further processing of the program
CHANNEL	BYTE	Number of the input channel pair 0 = channel pair 0 = inputs IN08 + IN09 1 = channel pair 1 = inputs IN10 + IN11

8406

> ! The FB may provide wrong values before initialisation.
>
> ► Do not evaluate the output before the FB has been initialised.
>
> We urgently recommend to program an own instance of this FB for each channel to be evaluated. Otherwise, wrong values may be provided.

Parameters of the outputs

363

Parameter	Data type	Description
C	DWORD	period duration of the first input's signal of the channel pair in [µs]
P	INT	angle of the phase shaft valid measurement: 1...358 °
ET	TIME	Time elapsed since the last positive edge at the second pulse input of the channel pair

5.2.11 Function elements: PWM functions

Contents

13758

Here, you will find **ifm** function blocks that allow you to operate the outputs with Pulse-Width Modulation (PWM).

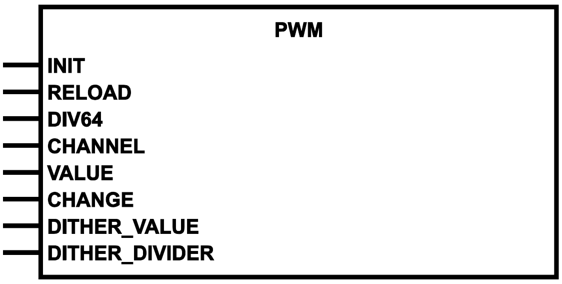
PWM

20457

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

20973

PWM is used for initialisation and parameter setting of the PWM outputs.

PWM has a more technical background. Due to their structure, PWM values can be very finely graded. So, this FB is suitable for use in controllers.

PWM is called once for each channel during initialisation of the application program. When doing so, input INIT must be set to TRUE. During initialisation, the parameter RELOAD is also assigned.

NOTE

The value RELOAD must be identical for all PWM channels.

For these channels, PWM and *PWM100* (→ page 144) and *PWM1000* (→ page 146) must not be mixed.

The PWM frequency (and so the RELOAD value) is internally limited to 5 kHz.

Depending on whether a high or a low PWM frequency is required, the input DIV64 must be set to FALSE (0) or TRUE (1).

During cyclical processing of the program INIT is set to FALSE. The FB is called and the new PWM value is assigned. The value is adopted if the input CHANGE = TRUE.

A current measurement for the initialised PWM channel can be implemented:

- for example using the **ifm** unit EC2049 (series element for current measurement).

PWM_Dither is called once for each channel during initialisation of the application program. When doing so, input INIT must be set to TRUE. During initialisation, the DIVIDER for the determination of the dither frequency and the VALUE are assigned.

The parameters DITHER_FREQUENCY and DITHER_VALUE can be individually set for each channel.

Parameters of the inputs

20969

Parameter	Data type	Description
INIT	BOOL	FALSE ⇨ TRUE (edge): unit is initialised FALSE: during further processing of the program
RELOAD	WORD	Value for the determination of the PWM frequency (→ chapter *Calculation of the RELOAD value* (→ page 142))
DIV64	BOOL	CPU cycle / 64
CHANNEL	BYTE	Number of the PWM output channel 0...3 for the outputs OUT00...OUT03

VALUE	WORD	Current PWM value
		permissible = 0...RELOAD
		0 = switch-on time 100 %
		RELOAD = switch-on time 0 %

CHANGE	BOOL	TRUE: Adopting new value from ... • VALUE: after the current PMW period • DITHER_VALUE: after the current Dither period FALSE: the changed PWM value has no influence on the output
DITHER_VALUE	WORD	peak-to-peak value of the dither in [‰] permissible values = 0...1 000 = 0000...03E8
DITHER_DIVIDER	WORD	Dither frequency = PWM frequency / DIVIDER * 2

PWM frequency

1529

Depending on the valve type, a corresponding PWM frequency is required. For the PWM function the PWM frequency is transmitted via the reload value (PWM) or directly as a numerical value in [Hz] (PWM1000). Depending on the controller, the PWM outputs differ in their operating principle but the effect is the same.

The PWM frequency is implemented by means of an internally running counter, derived from the CPU pulse. This counter is started with the initialisation of the PWM. Depending on the PWM output group (0...3 and / or 4...7 or 4...11), it counts from 0xFFFF backwards or from 0x0000 forwards. If a transmitted comparison value (VALUE) is reached, the output is set. In case of an overflow of the counter (change of the counter reading from 0x0000 to 0xFFFF or from 0xFFFF to 0x0000), the output is reset and the operation restarts.

If this internal counter shall not operate between 0x0000 and 0xFFFF, another preset value (RELOAD) can be transmitted for the internal counter. In doing so, the PWM frequency increases. The comparison value must be within the now specified range.

Calculation of the RELOAD value

1531

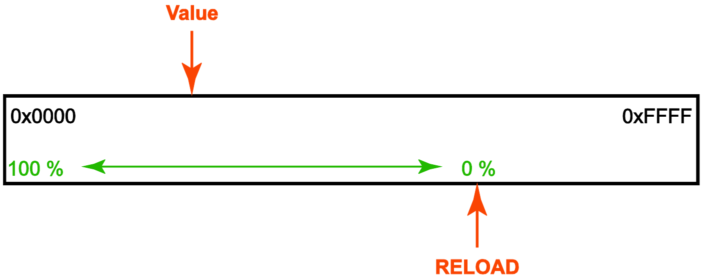


Figure: RELOAD value for the PWM channels 0...3

The RELOAD value of the internal PWM counter is calculated on the basis of the parameter DIV64 and the CPU frequency as follows:

	• CabinetController: CR0303 • ClassicController: CR0020, CR0505 • ExtendedController: CR0200 • SafetyController: CR7020, CR7021, CR7200, CR7201, CR7505, CR7506	• CabinetController: CR0301, CR0302 • SmartController: CR250n • PCB controller: CS0015 • PDM360smart: CR1071
DIV64 = 0	RELOAD = 20 MHz / f_{PWM}	RELOAD = 10 MHz / f_{PWM}
DIV64 = 1	RELOAD = 312.5 kHz / f_{PWM}	RELOAD = 156.25 kHz / f_{PWM}

Depending on whether a high or a low PWM frequency is required, the input DIV64 must be set to FALSE (0) or TRUE (1). In case of frequencies below 305 Hz respectively 152 Hz (according to the controller), DIV64 must be set to "1" to ensure that the RELOAD value is not greater than 0xFFFF.

Calculation examples RELOAD value

1532

• CabinetController: CR0303 • ClassicController: CR0020, CR0505 • ExtendedController: CR0200 • SafetyController: CR7020, CR7021, CR7200, CR7201, CR7505, CR7506		• CabinetController: CR0301, CR0302 • SmartController: CR250n • PCB controller: CS0015 • PDM360smart: CR1071
The PWM frequency shall be 400 Hz. $\frac{20 \text{ MHz}}{400 \text{ Hz}}$ = 50 000 = 0xC350 = RELOAD		The PWM frequency shall be 200 Hz. $\frac{10 \text{ MHz}}{200 \text{ Hz}}$ = 50 000 = 0xC350 = RELOAD
Thus the permissible range of the PWM value is the range from 0x0000...0xC350. The comparison value at which the output switches must then be between 0x0000 and 0xC350.		

This results in the following mark-to-space ratios:

Mark-to-space ratio	Switch-on time	Value for mark-to-space ratio
Minimum	0 %	50 000 = 0xC350
Maximum	100 %	0 = 0x0000

Between minimum and maximum triggering 50 000 intermediate values (PWM values) are possible.

PWM dither

1534

For certain hydraulic valve types a so-called dither frequency must additionally be superimposed on the PWM frequency. If valves were triggered over a longer period by a constant PWM value, they could block due to the high system temperatures.

To prevent this, the PWM value is increased or reduced on the basis of the dither frequency by a defined value (DITHER_VALUE). As a consequence a vibration with the dither frequency and the amplitude DITHER_VALUE is superimposed on the constant PWM value. The dither frequency is indicated as the ratio (divider, DITHER_DIVIDER • 2) of the PWM frequency.

Ramp function

1535

In order to prevent abrupt changes from one PWM value to the next, e.g. from 15 % ON to 70 % ON, it is possible to delay the increase by using *PT1* (→ page 156). The ramp function used for PWM is based on the CODESYS library `UTIL.LIB`. This allows a smooth start e.g. for hydraulic systems.

964

NOTE

When installing the **ecomat*mobile*** DVD "Software, tools and documentation", projects with examples have been stored in the program directory of your PC:
`…\ifm electronic\CoDeSys V…\Projects\DEMO_PLC_DVD_V…` (for controllers) or
`…\ifm electronic\CoDeSys V…\Projects\DEMO_PDM_DVD_V…` (for PDMs).

There you also find projects with examples regarding this subject. It is strongly recommended to follow the shown procedure.

The PWM function of the controller is a hardware function provided by the processor. The PWM function remains set until a hardware reset (power off and on) has been carried out on the controller.

PWM100

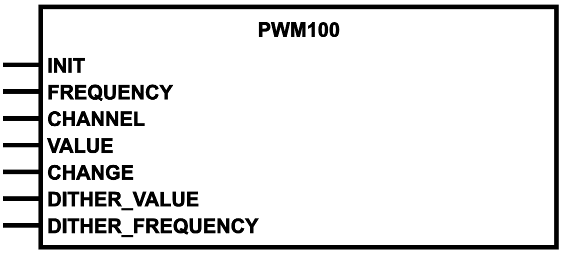
20461

Unit type = function block (FB)

New **ecomat*mobile*** controllers only support *PWM1000* (→ page 146).

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

20970

PWM100 handles the initialisation and parameter setting of the PWM outputs.

The FB enables a simple application of the PWM FB in the **ecomat*mobile*** controller. The PWM frequency can be directly indicated in [Hz] and the mark-to-space ratio in steps of 1 %. This FB is **not** suited for use in controllers, due to the relatively coarse grading.

The FB is called once for each channel in the initialisation of the application program. For this, the input INIT must be set to TRUE. During initialisation, the parameter FREQUENCY is also assigned.

> **NOTE**
>
> The value FREQUENCY must be identical for all PWM channels.
>
> For these channels, *PWM* (→ page 140) and PWM100 and *PWM1000* (→ page 146) must not be mixed.
>
> The PWM frequency is limited to 5 kHz internally.

During cyclical processing of the program INIT is set to FALSE. The FB is called and the new PWM value is assigned. The value is adopted if the input CHANGE = TRUE.

A current measurement for the initialised PWM channel can be implemented:

- for example using the **ifm** unit EC2049 (series element for current measurement).

DITHER is called once for each channel during initialisation of the application program. When doing so, input INIT must be set to TRUE. During initialisation, the value FREQUENCY for determining the dither frequency and the dither value (VALUE) are transmitted

> The parameters DITHER_FREQUENCY and DITHER_VALUE can be individually set for each channel.

Parameters of the inputs

20971

Parameter	Data type	Description
INIT	BOOL	FALSE ⇨ TRUE (edge): unit is initialised FALSE: during further processing of the program
FREQUENCY	WORD	PWM frequency in [Hz] allowed = 20...250 = 0x0014...0x00FA
CHANNEL	BYTE	Number of the PWM output channel 0...3 for the outputs OUT00...OUT03
VALUE	BYTE	current PWM value
CHANGE	BOOL	TRUE: Adopting new value from ... • VALUE: after the current PMW period • DITHER_VALUE: after the current Dither period FALSE: the changed PWM value has no influence on the output
DITHER_VALUE	BYTE	peak-to-peak value of the dither in [%] permissible values = 0...100 = 0x00...0x64
DITHER_FREQUENCY	WORD	dither frequency in [Hz] value range = 0...FREQUENCY / 2 FREQUENCY / DITHER_FREQUENCY must be even-numbered! The FB increases all other values to the next matching value.

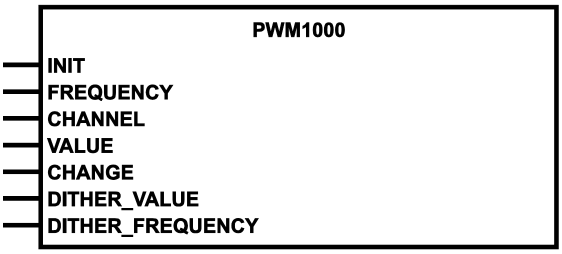
PWM1000

20465

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

20972

PWM1000 handles the initialisation and parameter setting of the PWM outputs.

The FB enables a simple use of the PWM FB in the **ecomat*mobile*** device. The PWM frequency can be directly indicated in [Hz] and the mark-to-space ratio in steps of 1 ‰.

The FB is called once for each channel during initialisation of the application program. When doing so, input INIT must be set to TRUE. During initialisation, the parameter FREQUENCY is also assigned.

NOTE

The value FREQUENCY must be identical for all PWM channels.

For these channels, *PWM* (→ page 140) and *PWM100* (→ page 144) and PWM1000 must not be mixed.

Die PWM-Frequenz ist intern auf 5 kHz begrenzt.

During cyclical processing of the program INIT is set to FALSE. The FB is called and the new PWM value is assigned. The value is adopted if the input CHANGE = TRUE.

A current measurement for the initialised PWM channel can be implemented:

- for example using the **ifm** module EC2049 (series element for current measurement).

DITHER is called once for each channel during initialisation of the application program. When doing so, input INIT must be set to TRUE. During initialisation, the value FREQUENCY for determining the dither frequency and the dither value (VALUE) are transmitted.

The parameters DITHER_FREQUENCY and DITHER_VALUE can be individually set for each channel.

Parameters of the inputs

17877

Parameter	Data type	Description
INIT	BOOL	FALSE ⇨ TRUE (edge): unit is initialised FALSE: during further processing of the program
FREQUENCY	WORD	PWM frequency in [Hz] allowed = 20...250 = 0x0014...0x00FA
CHANNEL	BYTE	Number of the PWM output channel 0...3 for the outputs OUT00...OUT03
VALUE	WORD	PWM value (mark-to-space ratio) in [‰] allowed = 0...1 000 = 0x0000...0x03E8 Values > 1 000 are regarded as = 1 000
CHANGE	BOOL	TRUE: adoption of the new value of ... • FREQUENCY: after the current PWM period • VALUE: after the current PWM period • DITHER_VALUE: after the current dither period • DITHER_FREQUENCY: after the current dither period FALSE: the changed PWM value has no influence on the output
DITHER_VALUE	WORD	peak-to-peak value of the dither in [‰] permissible values = 0...1 000 = 0000...03E8
DITHER_FREQUENCY	WORD	dither frequency in [Hz] value range = 0...FREQUENCY / 2 FREQUENCY / DITHER_FREQUENCY must be even-numbered! The FB increases all other values to the next matching value.

5.2.12 Function elements: controllers

Contents

1634

The section below describes in detail the units that are provided for set-up by software controllers in the ***ecomatmobile*** device. The units can also be used as basis for the development of your own control functions.

Setting rule for a controller

1627

For controlled systems, whose time constants are unknown the setting procedure to Ziegler and Nickols in a closed control loop is of advantage.

Setting control

1628

At the beginning the controlling system is operated as a purely P-controlling system. In this respect the derivative time T_V is set to 0 and the reset time T_N to a very high value (ideally to ∞) for a slow system. For a fast controlled system a small T_N should be selected.

Afterwards the gain KP is increased until the control deviation and the adjustment deviation perform steady oscillation at a constant amplitude at KP = $KP_{critical}$. Then the stability limit has been reached.

Then the time period $T_{critical}$ of the steady oscillation has to be determined.

Add a differential component only if necessary.

T_V should be approx. 2...10 times smaller than T_N.

KP should be equal to KD.

Idealised setting of the controlled system:

Control unit	KP = KD	TN	TV
P	2.0 • $KP_{critical}$	—	—
PI	2.2 • $KP_{critical}$	0.83 • $T_{critical}$	—
PID	1.7 • $KP_{critical}$	0.50 • $T_{critical}$	0.125 • $T_{critical}$

❗ For this setting process it has to be noted that the controlled system is not harmed by the oscillation generated. For sensitive controlled systems KP must only be increased to a value at which no oscillation occurs.

Damping of overshoot

1629

To dampen overshoot *PT1* (→ page 156) (low pass) can be used. In this respect the preset value XS is damped by the PT1 link before it is supplied to the controller function.

The setting variable T1 should be approx. 4...5 times greater than TN of the controller.

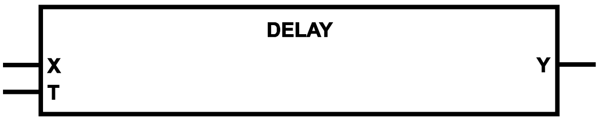
DELAY

585

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

588

DELAY delays the output of the input value by the time T (dead-time element).

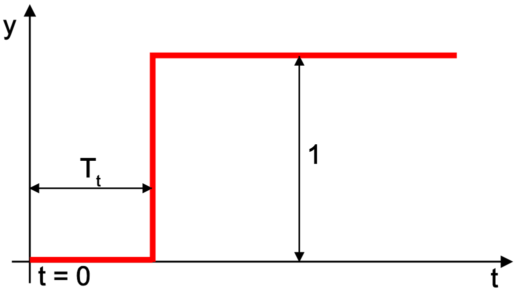


Figure: Time characteristics of DELAY

The dead time is influenced by the duration of the PLC cycle.
The dead time my not exceed 100 • PLC cycle time (memory limit!).
In case a longer delay is set, the resolution of the values at the output of the FB will be poorer, which may cause that short value changes will be lost.

> ❗ To ensure that the FB works correctly: FB must be called in each cycle.

Parameters of the inputs

589

Parameter	Data type	Description
X	WORD	input value
T	TIME	Delay time (dead time) allowed: 0...100 • cycle time

Parameters of the outputs

590

Parameter	Data type	Description
Y	WORD	input value, delayed by the time T

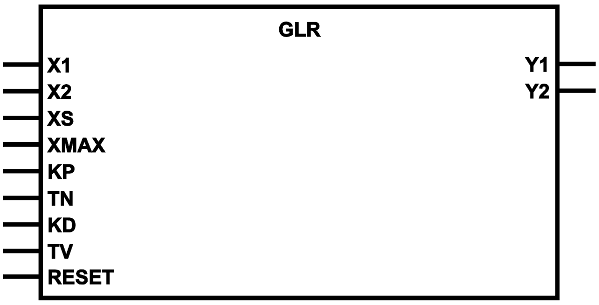
GLR

531

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

534

GLR handles a synchro controller.

The synchro controller is a controller with PID characteristics.

The values entered at the inputs KP and KD are internally divided by 10. So, a finer grading can be obtained (e.g.: KP = 17, which corresponds to 1.7).

The manipulated variable referred to the greater actual value is increased accordingly.
The manipulated variable referred to the smaller actual value corresponds to the reference variable.
Reference variable = 65 536 – (XS / XMAX * 65 536).

NOTE

The manipulated variables Y1 and Y2 are already standardised to the PWM FB
(RELOAD value = 65 535). Note the reverse logic:
65 535 = minimum value
0 = maximum value.

Note that the input value KD depends on the cycle time. To obtain stable, repeatable control characteristics, the FB should be called in a time-controlled manner.

Parameters of the inputs

535

Parameter	Data type	Description
X1	WORD	actual value channel 1
X2	WORD	actual value channel 2
XS	WORD	preset value
XMAX	WORD	maximum preset value
KP	Byte	constant of the proportional component (/10) (positive values only!)
TN	TIME	integral action time (integral component)
KD	BYTE	differential component (/10) (positive values only!)
TV	TIME	derivative action time (differential component)
RESET	BOOL	TRUE: reset the function element FALSE: function element is not executed

Parameters of the outputs

536

Parameter	Data type	Description
Y1	WORD	manipulated variable channel 1
Y2	WORD	manipulated variable channel 2

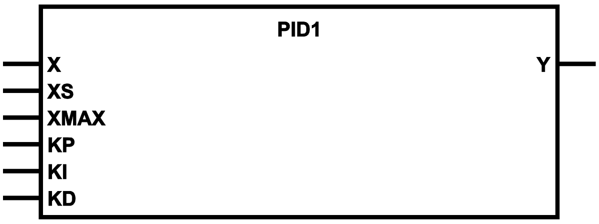
PID1

351

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

354

PID1 handles a PID controller.

The change of the manipulated variable of a PID controller has a **p**roportional, **i**ntegral and **d**ifferential component. The manipulated variable changes first by an amount which depends on the rate of change of the input value (D component). After the end of the derivative action time the manipulated variable returns to the value corresponding to the proportional range and changes in accordance with the reset time.

NOTE

The manipulated variable Y is already standardised to the PWM FB (RELOAD value = 65,535). Note the reverse logic:
65,535 = minimum value
0 = maximum value.

Note that the input values KI and KD depend on the cycle time. To obtain stable, repeatable control characteristics, the FB should be called in a time-controlled manner.

If X > XS, the manipulated variable is increased.
If X < XS, the manipulated variable is reduced.

The manipulated variable Y has the following time characteristics:

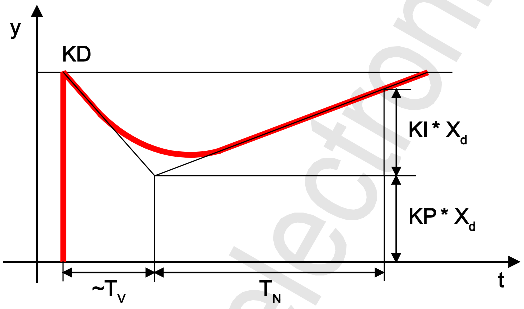


Figure: Typical step response of a PID controller

Parameters of the inputs

355

Parameter	Data type	Description
X	WORD	input value
XS	WORD	preset value
XMAX	WORD	maximum preset value
KP	BYTE	proportional component of the output signal
KI	BYTE	integral component of the output signal
KD	BYTE	differential component of the output signal

Parameters of the outputs

356

Parameter	Data type	Description
Y	WORD	Manipulated variable (0...1000 ‰)

Recommended settings

357

KP = 50
KI = 30
KD = 5

With the values indicated above the controller operates very quickly and in a stable way. The controller does not fluctuate with this setting.

► To optimise the controller, the values can be gradually changed afterwards.

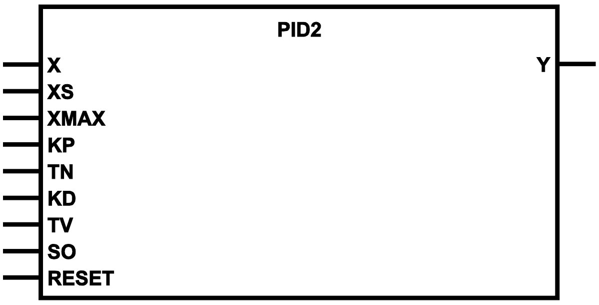
PID2

9167

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

347

PID2 handles a PID controller with self optimisation.

The change of the manipulated variable of a PID controller has a **p**roportional, **i**ntegral and **d**ifferential component. The manipulated variable changes first by an amount which depends on the rate of change of the input value (D component). After the end of the derivative action time TV the manipulated variable returns to the value corresponding to the proportional component and changes in accordance with the reset time TN.

The values entered at the inputs KP and KD are internally divided by 10. So, a finer grading can be obtained (e.g.: KP = 17, which corresponds to 1.7).

NOTE

The manipulated variable Y is already standardised to the PWM FB (RELOAD value = 65,535). Note the reverse logic:
65,535 = minimum value
0 = maximum value.

Note that the input value KD depends on the cycle time. To obtain stable, repeatable control characteristics, the FB should be called in a time-controlled manner.

If X > XS, the manipulated variable is increased.
If X < XS, the manipulated variable is reduced.

A reference variable is internally added to the manipulated variable.
Y = Y + 65,536 – (XS / XMAX * 65,536).

The manipulated variable Y has the following time characteristics.

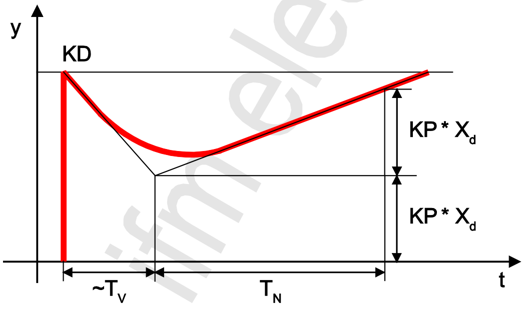


Figure: Typical step response of a PID controller

Parameters of the inputs

348

Parameter	Data type	Description
X	WORD	input value
XS	WORD	preset value
XMAX	WORD	maximum preset value
KP	Byte	constant of the proportional component (/10) (positive values only!)
TN	TIME	integral action time (integral component)
KD	BYTE	differential component (/10) (positive values only!)
TV	TIME	derivative action time (differential component)
SO	BOOL	TRUE: self-optimisation active FALSE: self-optimisation not active
RESET	BOOL	TRUE: reset the function element FALSE: function element is not executed

Parameters of the outputs

349

Parameter	Data type	Description
Y	WORD	Manipulated variable (0...1000 ‰)

Recommended setting

9127
350

- ► Select TN according to the time characteristics of the system:
  fast system = small TN
  slow system = large TN
- ► Slowly increment KP gradually, up to a value at which still definitely no fluctuation will occur.
- ► Readjust TN if necessary.
- ► Add **d**ifferential component only if necessary:
  Select a TV value approx. 2...10 times smaller than TN.
  Select a KD value more or less similar to KP.

Note that the maximum control deviation is + 127. For good control characteristics this range should not be exceeded, but it should be exploited to the best possible extent.

Function input SO (self-optimisation) clearly improves the control performance. A precondition for achieving the desired characteristics:

- The controller is operated with I component (TN ≥ 50 ms)
- Parameters KP and especially TN are already well adjusted to the actual controlled system.
- The control range (X – XS) of ± 127 is utilised (if necessary, increase the control range by multiplying X, XS and XMAX).

► When you have finished setting the parameters, you can set SO = TRUE.

> This will significantly improve the control performance, especially reducing overshoot.

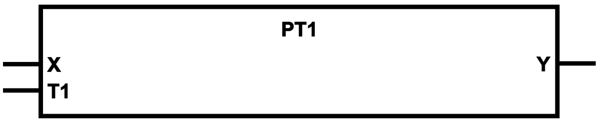
PT1

338

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

341

PT1 handles a controlled system with a first-order time delay.

This FB is a proportional controlled system with a time delay. It is for example used for generating ramps when using the PWM FBs.

> ❗ The output of the FB can become instable if T1 is shorter than the SPS cycle time.

The output variable Y of the low-pass filter has the following time characteristics (unit step):

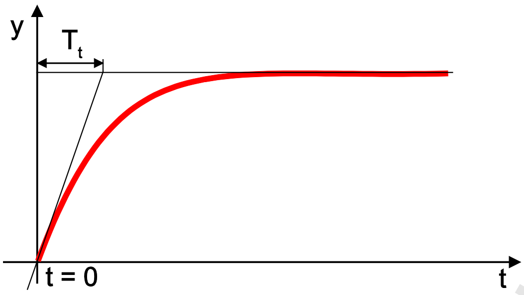


Figure: Time characteristics of PT1

Parameters of the inputs

342

Parameter	Data type	Description
X	INT	Input value [increments]
T1	TIME	Delay time (time constant)

Parameters of the outputs

343

Parameter	Data type	Description
Y	INT	output value

5.2.13 Function elements: software reset

Contents

1594

Using this FB the control can be restarted via an order in the application program.

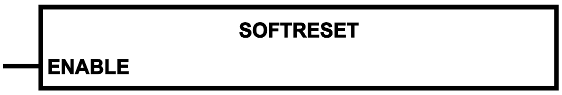
SOFTRESET

260

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

263

SOFTRESET leads to a complete reboot of the device.

The FB can for example be used in conjunction with CANopen if a node reset is to be carried out. FB SOFTRESET executes an immediate reboot of the controller. The current cycle is not completed.

Before reboot, the retain variables are stored.
The reboot is logged in the error memory.

> ❗ In case of active communication: the long reset period must be taken into account because otherwise guarding errors will be signalled.

Parameters of the inputs

264

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified

5.2.14 Function elements: measuring / setting of time

Contents

1601

Using the following function blocks of **ifm electronic** you can...
- measure time and evaluate it in the application program,
- change time values, if required.

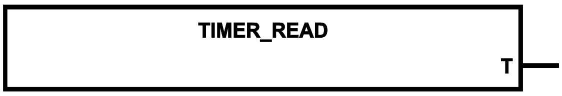
TIMER_READ

236

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

239

TIMER_READ reads the current system time.

When the supply voltage is applied, the device generates a clock pulse which is counted upwards in a register. This register can be read using the FB call and can for example be used for time measurement.

> ❗ The system timer goes up to 0xFFFF FFFF at the maximum (corresponds to 49d 17h 2min 47s 295ms) and then starts again from 0.

Parameters of the outputs

241

Parameter	Data type	Description
T	TIME	Current system time [ms]

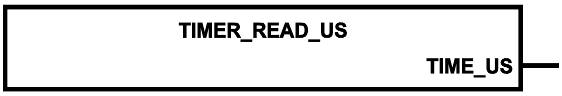
TIMER_READ_US

657

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

660

TIMER_READ_US reads the current system time in [µs].

When the supply voltage is applied, the device generates a clock pulse which is counted upwards in a register. This register can be read by means of the FB call and can for example be used for time measurement.

Info

The system timer runs up to the counter value 4 294 967 295 µs at the maximum and then starts again from 0.

4 294 967 295 µs = 1h 11min 34s 967ms 295µs

Parameters of the outputs

662

Parameter	Data type	Description
TIME_US	DWORD	current system time [µs]

5.2.15 Function elements: saving, reading and converting data in the memory

Contents

13795

Storage types for data backup

13805

The device provides the following memory types:

EEPROM memory

13807

Features:

- slow writing / reading
- limited writing / reading frequency
- any memory area can be selected
- saving data with E2WRITE
- reading data with E2READ

Flash memory

13803

Properties:

- non-volatile memory
- writing is relatively slow and only block by block
- before re-writing, memory content must be deleted
- fast reading
- limited writing and reading frequency
- really useful only for storing large data quantities
- saving data with FLASHWRITE
- reading data with FLASHREAD

Manual data storage

Contents

13801

Besides the possibility to store data automatically, user data can be stored manually, via function block calls, in integrated memories from where they can also be read.

ℹ By means of the storage partitioning (→ chapter *Available memory* (→ page 14)) the programmer can find out which memory area is available.

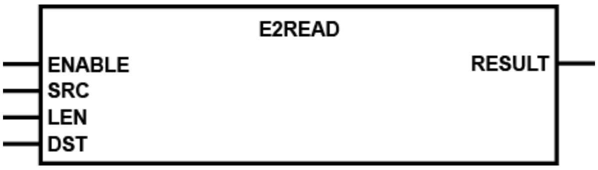
E2READ

579

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

582

E2READ enables reading of different data from the serial EEPROM.

The FB reads the contents as from the address of SRC from the serial EEPROM.

- ► ❗ Determine the address by means of the operator ADR and assigne it to the FB!
- ► Given that the processing of the FB takes some time it must be monitored via the output RESULT. If RESULT = 1 , the input ENABLE must be set to FALSE again.

Parameters of the inputs

583

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
SRC	INT	Source start address in the memory permissible = 0...767 = 0x0000...0x02FF and: 832...EEPROM size = 0x0340...EEPROM size
LEN	INT	Number of data bytes to be transmitted
DST	DINT	Start address of the target variables ❗ Determine the address by means of the operator ADR and assigne it to the FB!

Parameters of the outputs

584

Parameter	Data type	Description
RESULT	BYTE	feedback of the function block (possible messages → following table)

Possible results for RESULT:

Value		Description
dec	hex	
0	00	FB is inactive
1	01	Data transfer completed without errors
2	02	function block is active (action not yet completed)

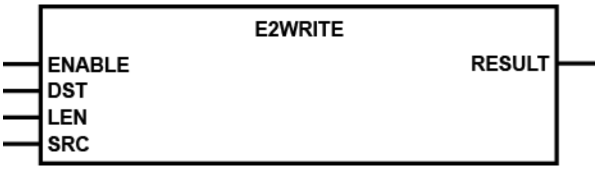
E2WRITE

573

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

576

E2WRITE enables writing of different data types directly to the serial EEPROM.

The FB writes the contents as from the address of SRC to the serial EEPROM.

- ► ❗ Determine the address by means of the operator ADR and assigne it to the FB!
- ► The execution of the FB takes some time, therefore it must be monitored via the output RESULT. If RESULT = 1 , the input ENABLE must be set to FALSE again.

Parameters of the inputs

577

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
DST	INT	Target start address in the memory permissible = 0...767 = 0x0000...0x02FF
LEN	INT	Number of data bytes to be transmitted
SRC	DINT	start address of the source variables ❗ Determine the address by means of the operator ADR and assigne it to the FB!

Parameters of the outputs

578

Parameter	Data type	Description
RESULT	BYTE	feedback of the function block (possible messages → following table)

Possible results for RESULT:

Value dec | hex		Description
0	00	FB is inactive
1	01	Data transfer completed without errors
2	02	function block is active (action not yet completed)

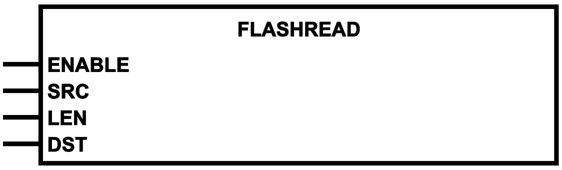
FLASHREAD

561

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

564

FLASHREAD enables reading of different types of data directly from the flash memory.

> The FB reads the contents as from the address of SRC from the flash memory. In doing so, as many bytes as indicated under LEN are transmitted.

> The contents are read completely during the cycle in which the FB is called up.

► Please make sure that the target memory area in the RAM is sufficient.

► To the destination address DST applies:
❗ Determine the address by means of the operator ADR and assigne it to the FB!

Parameters of the inputs

20054

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
SRC	INT	relative source start address in the memory permissible = 0...16 383 = 0x0000...0x3FFF
LEN	INT	number of data bytes permissible = 0...16 383 = 0x0000...0x3FFF
DST	DINT	Start address of the target variables ❗ Determine the address by means of the operator ADR and assigne it to the FB!

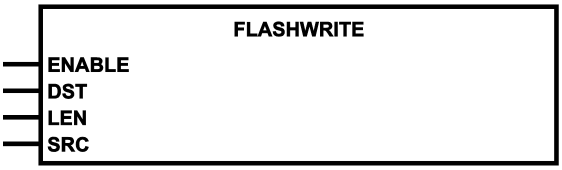
FLASHWRITE

555

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

558

⚠ WARNING

Danger due to uncontrollable process operations!

The status of the inputs/outputs is "frozen" during execution of FLASHWRITE.

► Do not execute this FB when the machine is running!

FLASHWRITE enables writing of different data types directly into the flash memory.

Using this FB, large data volumes are to be stored during set-up, to which there is only read access in the process.

► If a page has already been written (even if only partly), the entire flash memory area needs to be deleted before new write access to this page. This is done by write access to the address 0.

► Never write to a page several times! Always delete everything first!
Otherwise, traps or watchdog errors occur.

► ❗ Do not delete the flash memory area more often than 100 times. Otherwise, the data consistency in other flash memory areas is no longer guaranteed.

► During each SPS cycle, FLASHWRITE may only be started <u>once</u>!

► To the source start address SRC applies:
❗ Determine the address by means of the operator ADR and assigne it to the FB!

> The FB writes the contents of the address SRC into the flash memory. In doing so, as many bytes as indicated under LEN are transmitted.

❗ If destination start address DST is outside the permissible range: no data transfer!

Parameters of the inputs

20061

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
DST	INT	relative destination start address in memory permissible = 0...16 383 = 0x0000...0x3FFF
LEN	INT	number of data bytes permissible = 0...16 383 = 0x0000...0x3FFF
SRC	DINT	start address of the source variables ❗ Determine the address by means of the operator ADR and assigne it to the FB!

MEMCPY

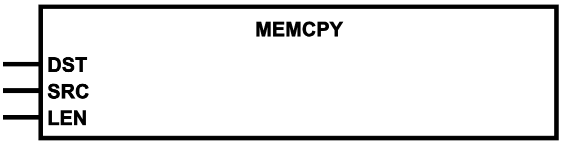
409

= memory copy

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

412

MEMCPY enables writing and reading different types of data directly in the memory.

The FB writes the contents of the address of SRC to the address DST.

► To the addresses SRC and DST apply:
❗ Determine the address by means of the operator ADR and assigne it to the FB!

> In doing so, as many bytes as indicated under LEN are transmitted. So it is also possible to transmit exactly one byte of a word variable.

Parameters of the inputs

413

Parameter	Data type	Description
DST	DWORD	destination address ❗ Determine the address by means of the operator ADR and assigne it to the FB!
SRC	DWORD	start address in source memory ❗ Determine the address by means of the operator ADR and assigne it to the FB!
LEN	WORD	number (≥ 1) of the data bytes to be transmitted

5.2.16 Function elements: data access and data check

Contents

1598

The FBs described in this chapter control the data access and enable a data check.

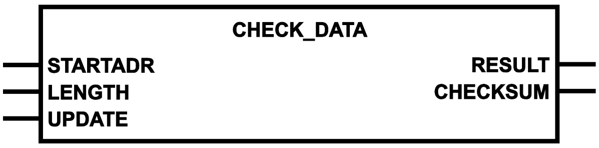
CHECK_DATA

603

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

606

CHECK_DATA generates a checksum (CRC) for a configurable memory area and checks the data of the memory area for undesired changes.

► Create a separate instance of the function block for each memory area to be monitored.

► ❗ Determine the address by means of the operator ADR and assigne it to the FB!

► In addition, indicate the number of data bytes LENGTH (length from the STARTADR).

Undesired change: Error!
If input UPDATE = FALSE and data in the memory is changed inadvertently, then RESULT = FALSE. The result can then be used for further actions (e.g. deactivation of the outputs).

Desired change:
Data changes in the memory (e.g. of the application program or **ecomat*mobile*** device) are only permitted if the output UPDATE is set to TRUE. The value of the checksum is then recalculated. The output RESULT is permanently TRUE again.

Parameters of the inputs

607

Parameter	Data type	Description
STARTADR	DINT	start address of the monitored data memory (WORD address as from %MW0) ❗ Determine the address by means of the operator ADR and assigne it to the FB!
LENGTH	WORD	length of the monitored data memory in [byte]
UPDATE	BOOL	TRUE: changes to data permissible FALSE: changes to data not permitted

Parameters of the outputs

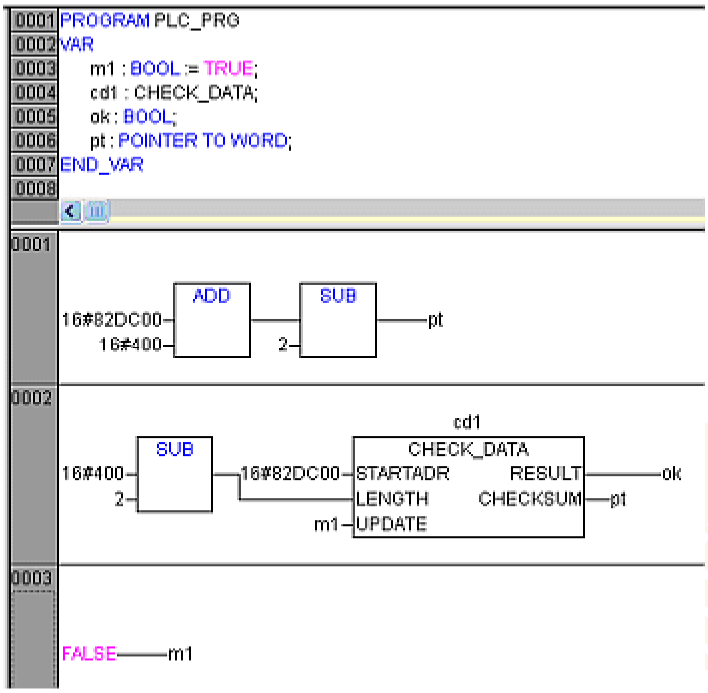
608

Parameter	Data type	Description
RESULT	BOOL	TRUE: CRC checksum ok FALSE: CRC checksum faulty (data modified)
CHECKSUM	DWORD	current CRC checksum

Example: CHECK_DATA

4168

In the following example the program determines the checksum and stores it in the RAM via pointer pt:



```
PROGRAM PLC_PRG
VAR
    m1 : BOOL := TRUE;
    cd1 : CHECK_DATA;
    ok : BOOL;
    pt : POINTER TO WORD;
END_VAR
```

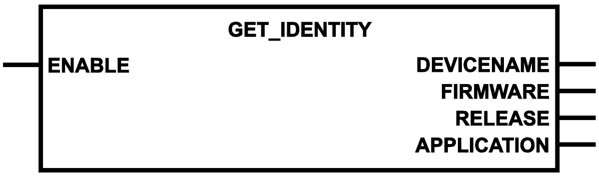
GET_IDENTITY

2212

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

2344

GET_IDENTITY reads the specific identifications stored in the device:

- hardware name and hardware version of the device
- name of the runtime system in the device
- version and revision no. of the runtime system in the device
- name of the application (has previously been saved by means of *SET_IDENTITY* (→ page 174))

Parameters of the inputs

2609

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified

Parameters of the outputs

2610

Parameter	Data type	Description
DEVICENAME	STRING(31)	hardware name as a string of max. 31 characters, e.g.: "CR0403"
FIRMWARE	STRING(31)	Name of the runtime system in the device as character string of max. 31 characters e.g.: "CR0403"
RELEASE	STRING(31)	software version as a character string of max. 31 characters
APPLICATION	STRING(79)	Name of the application as a string of max. 79 characters e.g.: "Crane1704"

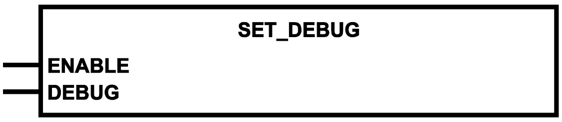
SET_DEBUG

290

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

293

SET_DEBUG handles the DEBUG mode without active test input (→ chapter *TEST mode*).

If the input DEBUG of the FB is set to TRUE, the programming system or the downloader, for example, can communicate with the device and execute some special system commands (e.g. for service functions via the GSM modem CANremote).

❗ In this operating mode a software download is not possible because the test input is not connected to supply voltage. Only read access is possible.

Parameters of the inputs

294

Parameter	Data type	Description
ENABLE	BOOL	TRUE: execute this function element FALSE: unit is not executed > Function block inputs are not active > Function block outputs are not specified
DEBUG	BOOL	TRUE: debugging via the interfaces possible FALSE: debugging via the interfaces not possible

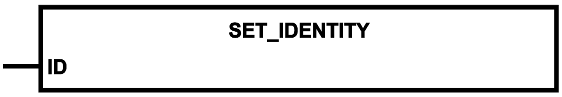
SET_IDENTITY

284

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



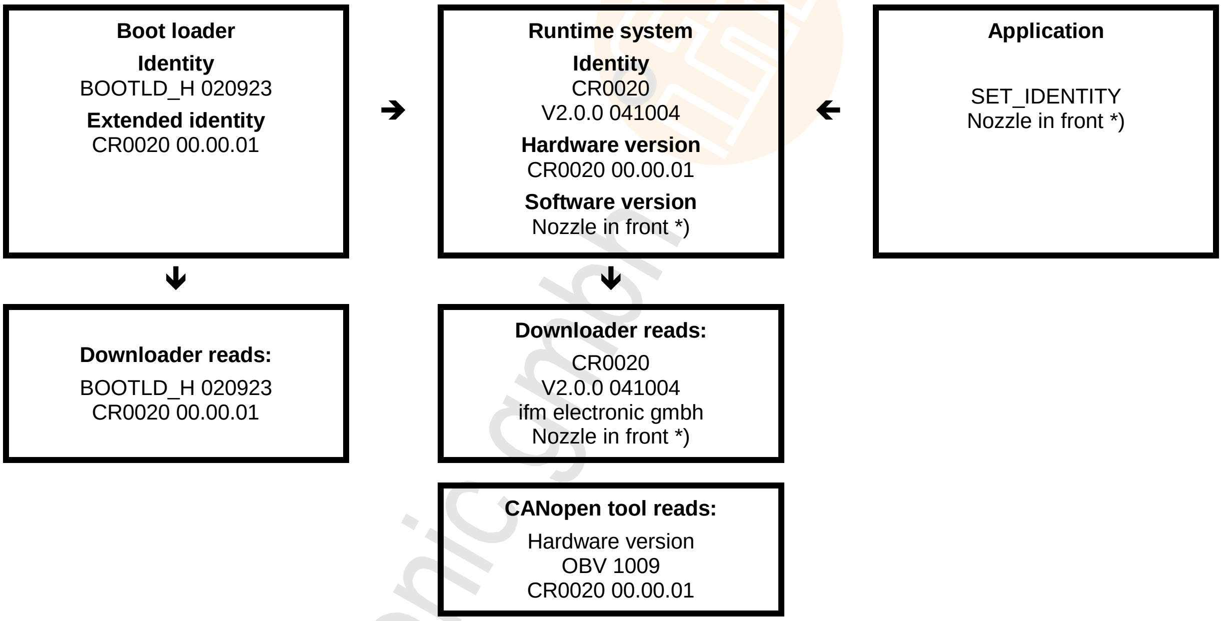
Description

287

SET_IDENTITY sets an application-specific program identification.

Using this FB, a program identification can be created by the application program. This identification (i.e. the software version) can be read via the software tool DOWNLOADER.EXE in order to identify the loaded program.

The following figure shows the correlations of the different identifications as indicated by the different software tools. (Example: ClassicController CR0020):



Boot loader
Identity
BOOTLD_H 020923
Extended identity
CR0020 00.00.01

Runtime system
Identity
CR0020
V2.0.0 041004
Hardware version
CR0020 00.00.01
Software version
Nozzle in front *)

Application
SET_IDENTITY
Nozzle in front *)

Downloader reads:
BOOTLD_H 020923
CR0020 00.00.01

Downloader reads:
CR0020
V2.0.0 041004
ifm electronic gmbh
Nozzle in front *)

CANopen tool reads:
Hardware version
OBV 1009
CR0020 00.00.01

*) ℹ 'Nozzle in front' is substitutionally here for a customised text.

Parameters of the inputs

288

Parameter	Data type	Description
ID	STRING(80)	Any text with a maximum length of 80 characters

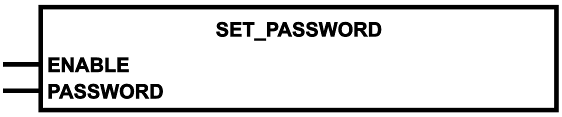
SET_PASSWORD

266

Unit type = function block (FB)

Unit is contained in the library `ifm_CR0302_Vxxyyzz.LIB`

Symbol in CODESYS:



Description

13038

NOTICE

Please note for CR250n, CR0301, CR0302 and CS0015:

The EEPROM memory module may be destroyed by the permanent use of this unit!

- ► Only carry out the unit **once** during initialisation in the first program cycle!
- ► Afterwards block the unit again with ENABLE = FALSE!

269

SET_PASSWORD sets a user password for the program and memory upload with the DOWNLOADER.

If the password is activated, reading of the application program or the data memory with the software tool DOWNLOADER is only possible if the correct password has been entered.

If an empty string (default condition) is assigned to the input PASSWORD, an upload of the application software or of the data memory is possible at any time.

A new password can be set only after resetting the previous password.

! The password is reset when loading a new application program as boot project.

Parameters of the inputs

270

Parameter	Data type	Description
ENABLE	BOOL	TRUE (nur 1 Zyklus lang): use new Parameter FALSE: unit is not executed
PASSWORD	STRING(16)	password If PASSWORD = "", than access is possible without enter of a password

6 Diagnosis and error handling

Contents

19598

The runtime-system (RTS) checks the device by internal error checks:

- during the boot phase (reset phase)
- during executing the application program

→ chapter ***Operating states*** (→ page 33)

In so doing a high operating reliability is provided, as much as possible.

6.1 Diagnosis

19601

During the diagnosis, the "state of health" of the device is checked. It is to be found out if and what →faults are given in the device.

Depending on the device, the inputs and outputs can also be monitored for their correct function.
- wire break,
- short circuit,
- value outside range.

For diagnosis, configuration and log data can be used, created during the "normal" operation of the device.
The correct start of the system components is monitored during the initialisation and start phase.
Errors are recorded in the log file.
For further diagnosis, self-tests can also be carried out.

6.2 Fault

19602

A fault is the state of an item characterized by the inability to perform the requested function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources.
A fault is often the result of a failure of the item itself, but may exist without prior failure.
In →ISO 13849-1 "fault" means "random fault".

6.3 Reaction in case of an error

19653

When errors are detected the system flag ERROR can also be set in the application program. Thus, in case of a fault, the controller reacts as follows:

> the operation LED lights red,

ⓘ Complete list of the device-specific error codes and diagnostic messages
→ chapter *System flags* (→ page 178).

6.4 Reaction in case of a system error

19654

> ❗The programmer has the sole responsibility for the safe processing of data in the application software.

► Process the specific error flags in the application program!
An error description is provided via the error flag.
These error flags can be further processed if necessary.

In case of serious errors, the system sets the flag bit ERROR.
At the same time, ERROR = TRUE leads to the following:

- set all relevant outputs to FALSE via the application program,
- the operation LED lights red,
- the ERROR output is set to FALSE.

After analysis and elimination of the error cause:

► As a general rule, reset all error flags via the application program.
Without explicit reset of the error flags the flags remain set with the corresponding effect on the application program.

6.5 CAN / CANopen: errors and error handling

19604

→ System manual "Know-How ecomat*mobile*"
→ chapter *CAN / CANopen: errors and error handling*

7 Appendix

Contents

1664

Additionally to the indications in the data sheets you find summary tables in the appendix.

7.1 System flags

Contents

12167

❗ The addresses of the system flags can change if the PLC configuration is extended.

► While programming only use the symbol names of the system flags!

→ System manual "Know-How ecomat*mobile*"
→ chapter *Error codes and diagnostic information*

7.1.1 System flags: CAN

20979

<table>
<tr><th>System flags (symbol name)</th><th>Type</th><th colspan="2">Description</th></tr>
<tr><td>CANx_BAUDRATE</td><td>WORD</td><td colspan="2">CAN interface x: set baud rate in [kBaud]</td></tr>
<tr><td>CANx_BUSOFF</td><td>BOOL</td><td colspan="2">CAN interface x: Error "CAN-Bus off"
ℹ Reset of the error code alse resets the flag</td></tr>
<tr><td rowspan="8">CANx_LASTERROR</td><td rowspan="8">BYTE</td><td colspan="2">CAN interface x:
Error number of the last CAN transmission:</td></tr>
<tr><td>0 = no error</td><td>Initial value</td></tr>
<tr><td>1 = stuff error</td><td>more than 5 identical bits in series on the bus</td></tr>
<tr><td>2 = form error</td><td>received message had wrong format</td></tr>
<tr><td>3 = ack error</td><td>sent message was not confirmed</td></tr>
<tr><td>4 = bit1 error</td><td>a recessive bit was sent outside the arbitration area, but a dominant bit was read on the bus</td></tr>
<tr><td>5 = bit0 error</td><td>it was tried to send a dominant bit, but a recessive level was read
OR: a sequence of 11 recessive bits was read during bus-off recovery</td></tr>
<tr><td>6 = CRC error</td><td>checksum of the received message was wrong</td></tr>
<tr><td>CANx_WARNING</td><td>BOOL</td><td colspan="2">CAN interface x: warning threshold reached (≥ 96)
ℹ A reset of the flag is possible via write access</td></tr>
<tr><td>DOWNLOADID</td><td>WORD</td><td colspan="2">CAN interface x: set download identifier</td></tr>
</table>

x = 1 = number of the CAN interface

7.1.2 System flags: error flags

21016

System flags (symbol name)	Type	Description
ERROR	BOOL	TRUE: safe state assumed all outputs = OFF all relays de-energised (e.g. fatal error / error stop) FALSE: no serious error occurred
ERROR_A_INx	BOOL	Overcurrent error on analogue input ANALOGx (0...7) Controller switches to voltage measurement
ERROR_IO	BOOL	Group error message input / output error TRUE: Error FALSE: No error
ERROR_MEMORY	BOOL	memory error
ERROR_POWER	BOOL	Voltage error for VBBS / clamp 15: TRUE: Value out of range or: difference (VBB15 - VBBS) too great > general error FALSE: Value OK
ERROR_TEMPERATURE	BOOL	Temperature error TRUE: Value out of range > general error FALSE: Value OK

7.1.3 System flags: status LED

20984

System flags (symbol name)	Type	Description
LED_MODE	WORD	LED flashing frequency: 0x0000 = LED_2HZ (flashes at 2 Hz; preset) 0x0001 = LED_1HZ (flashes at 1 Hz) 0x0002 = LED_05HZ (flashes at 0.5 Hz) 0x0003 = LED_0HZ (lights permanently with value in LED)

7.1.4 System flags: voltages

20985

System flags (symbol name)	Type	Description
SERIAL_MODE	BOOL	Activate serial interface (RS232) for use in the application TRUE: The RS232 interface can be used in the application, but no longer for programming, debugging or monitoring of the device. FALSE: The RS232 interface cannot be used in the application. Programming, debugging or monitoring of the device is possible.
SERIAL_BAUDRATE	WORD	Baud rate of the RS232 interface
SUPPLY_VOLTAGE	WORD	Value • 0.1 = supply voltage on VBBs in [V]
TEST	BOOL	TRUE: Test input is active: • Programming mode is enabled • Software download is possible • Status of the application program can be queried • Protection of stored software is not possible FALSE: application is in operation

7.1.5 System flags: inputs and outputs

21017

System flags (symbol name)	Type	Description
ANALOGx x = 0...7	WORD	Analogue input xx: filtered A/D converter raw value (12 bits) without calibration or standardisation
ANALOGx x = 8...23	WORD	Binary input INxx, analogue evaluation: ANALOG8 for IN00 ... ANALOG23 for IN15 filtered A/D converter raw value (10 bits) without calibration or standardisation
ANALOGx x = 24...31	WORD	Binary input DIPx, analogue evaluation: ANALOG24 for DIP0 ... ANALOG31 for DIP7 filtered A/D converter raw value (10 bits) without calibration or standardisation

ANALOGxy_MODE	BYTE	Operating mode of the analogue input pair:
		xy = 0_4 = inputs ANALOG0 + ANALOG4
		xy = 1_5 = inputs ANALOG1 + ANALOG5
		xy = 2_6 = inputs ANALOG2 + ANALOG6
		xy = 3_7 = inputs ANALOG3 + ANALOG7
		→ chapter *Possible operating modes inputs/outputs* (→ page 186)

INxx xx = 00...15	BOOL	Status on binary input xx Requirement: input configured as binary input (MODE = IN_DIGITAL_H or IN_DIGITAL_L) TRUE: Voltage on binary input > 70 % of VBBs FALSE: Voltage on binary input < 30 % of VBBs or: not configured as binary input or: not correctly configured
INxx_MODE xx = 08...11	BYTE	Operating mode of the input INxx → chapter *Possible operating modes inputs/outputs* (→ page 186)

INxy_MODE	BYTE	Operating mode of the input pair xy:
		xy = 12_13 = inputs IN12 + IN13
		xy = 14_15 = inputs IN14 + IN15
		→ chapter *Possible operating modes inputs/outputs* (→ page 186)

LEDnn	BOOL	Status on LED output nn: TRUE:LED activated FALSE:LED deactivated
OUTxx xx = 00...11	BOOL	Status on binary output xx: TRUE: output activated FALSE: output deactivated

7.1.6 System flags: system

20992

System flags (symbol name)	Type	Description
DIPx x = 0...7	BOOL	Status of the DIP switch x

7.2 Address assignment and I/O operating modes

Contents

1656

→ also data sheet

7.2.1 Addresses / variables of the I/Os

Contents

2376

Inputs: addresses and variables

20996

IEC address	I/O variable	Remark
%IB0	--	Input byte 0 (%IX0.0...%IX0.7)
%IB1	--	Input byte 1 (%IX0.8...%IX0.15)
%IX0.0	IN00	Binary input 00
%IX0.1	IN01	Binary input 01
%IX0.2	IN02	Binary input 02
%IX0.3	IN03	Binary input 03
%IX0.4	IN04	Binary input 04
%IX0.5	IN05	Binary input 05
%IX0.6	IN06	Binary input 06
%IX0.7	IN07	Binary input 07
%IX0.8	IN08	Binary input 08
%IX0.9	IN09	Binary input 09
%IX0.10	IN10	Binary input 10
%IX0.11	IN11	Binary input 11
%IX0.12	IN12	Binary input 12
%IX0.13	IN13	Binary input 13
%IX0.14	IN14	Binary input 14
%IX0.15	IN15	Binary input 15
%IX1.0	DIP0	Status DIP switch 0
%IX1.1	DIP1	Status DIP switch 1
%IX1.2	DIP2	Status DIP switch 2
%IX1.3	DIP3	Status DIP switch 3
%IX1.4	DIP4	Status DIP switch 4
%IX1.5	DIP5	Status DIP switch 5
%IX1.6	DIP6	Status DIP switch 6
%IX1.7	DIP7	Status DIP switch 7
%IW2	ANALOG0	Analogue input 0
%IW3	ANALOG1	Analogue input 1
%IW4	ANALOG2	Analogue input 2
%IW5	ANALOG3	Analogue input 3
%IW6	ANALOG4	Analogue input 4
%IW7	ANALOG5	Analogue input 5
%IW8	ANALOG6	Analogue input 6
%IW9	ANALOG7	Analogue input 7
%IW10	ANALOG8	Binary input IN00, analogue evaluation
%IW11	ANALOG9	Binary input IN01, analogue evaluation
%IW12	ANALOG10	Binary input IN02, analogue evaluation
%IW13	ANALOG11	Binary input IN03, analogue evaluation
%IW14	ANALOG12	Binary input IN04, analogue evaluation

IEC address	I/O variable	Remark
%IW15	ANALOG13	Binary input IN05, analogue evaluation
%IW16	ANALOG14	Binary input IN06, analogue evaluation
%IW17	ANALOG15	Binary input IN07, analogue evaluation
%IW18	ANALOG16	Binary input IN08, analogue evaluation
%IW19	ANALOG17	Binary input IN09, analogue evaluation
%IW20	ANALOG18	Binary input IN10, analogue evaluation
%IW21	ANALOG19	Binary input IN11, analogue evaluation
%IW22	ANALOG20	Binary input IN12, analogue evaluation
%IW23	ANALOG21	Binary input IN13, analogue evaluation
%IW24	ANALOG22	Binary input IN14, analogue evaluation
%IW25	ANALOG23	Binary input IN15, analogue evaluation
%IW26	ANALOG24	DIP switch 0, analogue evaluation
%IW27	ANALOG25	DIP switch 1, analogue evaluation
%IW28	ANALOG26	DIP switch 2, analogue evaluation
%IW29	ANALOG27	DIP switch 3, analogue evaluation
%IW30	ANALOG28	DIP switch 4, analogue evaluation
%IW31	ANALOG29	DIP switch 5, analogue evaluation
%IW32	ANALOG30	DIP switch 6, analogue evaluation
%IW33	ANALOG31	DIP switch 7, analogue evaluation
%IW34	SUPPLY_VOLTAGE	Supply voltage in [mV]

Outputs: addresses and variables

21020

IEC address	I/O variable	Remark
%QX0.0	OUT00	Binary output / PWM output channel 0
%QX0.1	OUT01	Binary output / PWM output channel 1
%QX0.2	OUT02	Binary output / PWM output channel 2
%QX0.3	OUT03	Binary output / PWM output channel 3
%QX0.4	OUT04	Binary output channel 4
%QX0.5	OUT05	Binary output channel 5
%QX0.6	OUT06	Binary output channel 6
%QX0.7	OUT07	Binary output channel 7
%QX0.8	OUT08	Binary output channel 8
%QX0.9	OUT09	Binary output channel 9
%QX0.10	OUT10	Binary output channel 10
%QX0.11	OUT11	Binary output channel 11
%QX2.0	LED0	Status LED output 0
%QX2.1	LED1	Status LED output 1
%QX2.2	LED2	Status LED output 2
%QX2.3	LED3	Status LED output 3
%QX2.4	LED4	Status LED output 4
%QX2.5	LED5	Status LED output 5
%QX2.6	LED6	Status LED output 6
%QX2.7	LED7	Status LED output 7
%QX2.8	LED8	Status LED output 8
%QX2.9	LED9	Status LED output 9
%QB6	IN08_MODE	Configuration byte for %IX0.8
%QB7	IN09_MODE	Configuration byte for %IX0.9
%QB8	IN10_MODE	Configuration byte for %IX0.10
%QB9	IN11_MODE	Configuration byte for %IX0.11
%QB10	IN12_13_MODE	Configuration byte for %IX0.12 and %IX0.13
%QB11	IN14_15_MODE	Configuration byte for %IX0.14 and %IX0.15
%QB12	ANALOG0_4_MODE	Configuration byte for %IW2 and %IW6
%QB13	ANALOG1_5_MODE	Configuration byte for %IW3 and %IW7
%QB14	ANALOG2_6_MODE	Configuration byte for %IW4 and %IW8
%QB15	ANALOG3_7_MODE	Configuration byte for %IW5 and %IW9

7.2.2 Possible operating modes inputs/outputs

Contents

2386

Inputs: operating modes

21001

Possible configuration combinations (where permissible) are created by adding the configuration values.

🟩 = this configuration value is default

Inputs	Possible operating mode		Set with ...	FB input	Value	
					dec	hex
ANALOG0...7	IN_DIGITAL_H	plus		--	1	01
	IN_CURRENT	0...20 000 µA	ANALOG0_4_MODE	--	4	04
	IN_VOLTAGE10	0...10 000 mV	ANALOG1_5_MODE	--	8	08
	IN_VOLTAGE32	0...32 000 mV	ANALOG2_6_MODE	--	16	10
	IN_RATIO32	0...1 000 ‰	ANALOG3_7_MODE	--	32	20
	IN_DIAGNOSTIC	with IN_DIGITAL_H		--	64	40
IN00...07	IN_DIGITAL_H	plus	INxx_MODE	--	1	01
	IN_DIAGNOSTIC	with IN_DIGITAL_H	INxx_MODE	--	64	40
IN08...11	IN_DIGITAL_H	plus	INxx_MODE	--	1	01
	IN_DIAGNOSTIC	with IN_DIGITAL_H	INxx_MODE	--	64	40
	IN_FAST	for interrupt FBs	INxx_MODE	--	128	80
	Frequency measurement	0...30 000 Hz	FB FREQUENCY	→ FB description		
	Period measurement	0.1...5 000 Hz	FB PERIOD	→ FB description		
	Period duration and ratio measurement	0.1...5 000 Hz	FB PERIOD_RATIO	→ FB description		
	Counter	0...50 Hz	FB FAST_COUNT	→ FB description		
	Detect encoder values	0...30 000 Hz	FB INC_ENCODER	→ FB description		
IN12...15	IN_DIGITAL_H	plus	INxx_MODE	--	1	01
	IN_DIGITAL_L	minus	INxx_MODE	--	2	02
	IN_DIAGNOSTIC	with IN_DIGITAL_H	INxx_MODE	--	64	40

Set operating modes with the following function block:

FAST_COUNT (→ page 129)	Counter block for fast input pulses
FREQUENCY (→ page 130)	Measures the frequency of the signal arriving at the selected channel
INC_ENCODER (→ page 131)	Up/down counter function for the evaluation of encoders
PERIOD (→ page 133)	Measures the frequency and the cycle period (cycle time) in [µs] at the indicated channel
PERIOD_RATIO (→ page 135)	Measures the frequency and the cycle period (cycle time) in [µs] during the indicated periods at the indicated channel. In addition, the mark-to-space ratio is indicated in [‰].

Outputs: operating modes

21022

🟩 = this configuration value is default

Outputs	Possible operating mode		Set with ...	FB input	Value	
					dec	hex
OUT00...03	binary output	plus-switching	--	--	--	--
	analogue output with pulse-width modulation		PWM PWM100 PWM1000			
OUT04...07	binary output	plus-switching	--	--	--	--
OUT08...11	binary output	plus-switching	--	--	--	--

Details→ chapter *Outputs OUT00...OUT11: permitted operating modes* (→ page 188)

Set operating modes with the following function block:

PWM (→ page 140)	Initialises and configures a PWM-capable output channel Definition of the PWM frequency via RELOAD
PWM100 (→ page 144)	Initialises and configures a PWM-capable output channel Indicate PWM frequency in [Hz] Indicate mark-to-space ratio in steps of 1 %
PWM1000 (→ page 146)	Initialises and configures a PWM-capable output channel the mark-to-space ratio can be indicated in steps of 1 ‰

Outputs OUT00...OUT11: permitted operating modes

21023

Operating mode		OUT00	OUT01	OUT02	OUT03	OUT04	OUT05	OUT06	OUT07
OUT_DIGITAL_H	plus	X	X	X	X	X	X	X	X
OUT_CURRENT_RANGE	2 A	X	X	X	X	X	X	X	X
PWM		X	X	X	X	--	--	--	--
OUT_OVERLOAD_PROTECTION		X	X	X	X	X	X	X	X
Operating mode		OUT08	OUT09	OUT10	OUT11	--	--	--	--
OUT_DIGITAL_H	plus	X	X	X	X	--	--	--	--
OUT_CURRENT_RANGE	2 A	X	X	X	X	--	--	--	--
OUT_OVERLOAD_PROTECTION		X	X	X	X	--	--	--	--

7.3 Error tables

19606

7.3.1 Error flags

19608

→ chapter *System flags* (→ page 178)

7.3.2 Errors: CAN / CANopen

19610
19604

→ System manual "Know-How ecomat*mobile*"
→ chapter *CAN / CANopen: errors and error handling*

EMCY codes: CANx

13094

ℹ The indications for CANx also apply to each of the CAN interfaces.

EMCY code object 0x1003		Object 0x1001	Manufactor specific information					
Byte 0 [hex]	Byte 1 [hex]	Byte 2 [hex]	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Description
00	80	11	--	--	--	--	--	CANx monitoring SYNC error (only slave)
00	81	11	--	--	--	--	--	CANx warning threshold (> 96)
10	81	11	--	--	--	--	--	CANx receive buffer overrun
11	81	11	--	--	--	--	--	CANx transmit buffer overrun
30	81	11	--	--	--	--	--	CANx guard/heartbeat error (only slave)

EMCY codes: I/Os, system

2671

The following EMCY messages are sent automatically in the following cases:

- as CANopen master: if *CANx_MASTER_EMCY_HANDLER* (→ page 75) is called cyclically
- as CANopen slave: if *CANx_SLAVE_EMCY_HANDLER* (→ page 85) is called cyclically

EMCY code object 0x1003		Object 0x1001	Manufactor specific information					
Byte 0 [hex]	Byte 1 [hex]	Byte 2 [hex]	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Description
00	21	03	I0					Diagnosis analogue current inputs
00	31	05						Terminal voltage VBBo/VBBs
00	61	11						Memory error

8 Glossary of Terms

A

Address

This is the "name" of the bus participant. All participants need a unique address so that the signals can be exchanged without problem.

Application software

Software specific to the application, implemented by the machine manufacturer, generally containing logic sequences, limits and expressions that control the appropriate inputs, outputs, calculations and decisions.

Architecture

Specific configuration of hardware and/or software elements in a system.

B

Baud

Baud, abbrev.: Bd = unit for the data transmission speed. Do not confuse baud with "bits per second" (bps, bits/s). Baud indicates the number of changes of state (steps, cycles) per second over a transmission length. But it is not defined how many bits per step are transmitted. The name baud can be traced back to the French inventor J. M. Baudot whose code was used for telex machines.
1 MBd = 1024 x 1024 Bd = 1 048 576 Bd

Boot loader

On delivery **ecomat*mobile*** controllers only contain the boot loader.
The boot loader is a start program that allows to reload the runtime system and the application program on the device.
The boot loader contains basic routines...

- for communication between hardware modules,
- for reloading the operating system.

The boot loader is the first software module to be saved on the device.

Bus

Serial data transmission of several participants on the same cable.

C

CAN

CAN = **C**ontroller **A**rea **N**etwork
CAN is a priority-controlled fieldbus system for large data volumes. There are several higher-level protocols that are based on CAN, e.g. 'CANopen' or 'J1939'.

CAN stack

CAN stack = software component that deals with processing CAN messages.

CiA

CiA = CAN in Automation e.V.
User and manufacturer organisation in Germany / Erlangen. Definition and control body for CAN and CAN-based network protocols.
Homepage → www.can-cia.org

CiA DS 304

DS = **D**raft **S**tandard
CANopen device profile for safety communication

CiA DS 401

DS = **D**raft **S**tandard
CANopen device profile for binary and analogue I/O modules

CiA DS 402

DS = **D**raft **S**tandard
CANopen device profile for drives

CiA DS 403

DS = **D**raft **S**tandard
CANopen device profile for HMI

CiA DS 404

DS = **D**raft **S**tandard
CANopen device profile for measurement and control technology

CiA DS 405

DS = **D**raft **S**tandard
CANopen specification of the interface to programmable controllers (IEC 61131-3)

CiA DS 406

DS = **D**raft **S**tandard
CANopen device profile for encoders

CiA DS 407

DS = **D**raft **S**tandard
CANopen application profile for local public transport

Clamp 15

In vehicles clamp 15 is the plus cable switched by the ignition lock.

COB ID

COB = **C**ommunication **Ob**ject
ID = **Id**entifier
ID of a CANopen communication object
Corresponds to the identifier of the CAN message with which the communication project is sent via the CAN bus.

CODESYS

CODESYS® is a registered trademark of 3S – Smart Software Solutions GmbH, Germany.
'CODESYS for Automation Alliance' associates companies of the automation industry whose hardware devices are all programmed with the widely used IEC 61131-3 development tool CODESYS®.
Homepage → www.codesys.com

CSV file

CSV = **C**omma **S**eparated **V**alues (also: **C**haracter **S**eparated **V**alues)
A CSV file is a text file for storing or exchanging simply structured data.
The file extension is `.csv`.

Example: Source table with numerical values:

value 1.0	value 1.1	value 1.2	value 1.3
value 2.0	value 2.1	value 2.2	value 2.3
value 3.0	value 3.1	value 3.2	value 3.3

This results in the following CSV file:

```
value 1.0;value 1.1;value 1.2;value 1.3
value 2.0;value 2.1;value 2.2;value 2.3
value 3.0;value 3.1;value 3.2;value 3.3
```

Cycle time

This is the time for a cycle. The PLC program performs one complete run.

Depending on event-controlled branchings in the program this can take longer or shorter.

D

Data type

Depending on the data type, values of different sizes can be stored.

Data type	min. value	max. value	size in the memory
BOOL	FALSE	TRUE	8 bits = 1 byte
BYTE	0	255	8 bits = 1 byte
WORD	0	65 535	16 bits = 2 bytes
DWORD	0	4 294 967 295	32 bits = 4 bytes
SINT	-128	127	8 bits = 1 byte
USINT	0	255	8 bits = 1 byte
INT	-32 768	32 767	16 bits = 2 bytes
UINT	0	65 535	16 bits = 2 bytes
DINT	-2 147 483 648	2 147 483 647	32 bits = 4 bytes
UDINT	0	4 294 967 295	32 bits = 4 bytes
REAL	$-3.402823466 \bullet 10^{38}$	$3.402823466 \bullet 10^{38}$	32 bits = 4 bytes
ULINT	0	18 446 744 073 709 551 615	64 Bit = 8 Bytes
STRING			number of char. + 1

DC

Direct **C**urrent

Diagnosis

During the diagnosis, the "state of health" of the device is checked. It is to be found out if and what →faults are given in the device.

Depending on the device, the inputs and outputs can also be monitored for their correct function.
- wire break,
- short circuit,
- value outside range.

For diagnosis, configuration and log data can be used, created during the "normal" operation of the device.
The correct start of the system components is monitored during the initialisation and start phase.
Errors are recorded in the log file.
For further diagnosis, self-tests can also be carried out.

Dither

Dither is a component of the →PWM signals to control hydraulic valves. It has shown for electromagnetic drives of hydraulic valves that it is much easier for controlling the valves if the control signal (PWM pulse) is superimposed by a certain frequency of the PWM frequency. This dither frequency must be an integer part of the PWM frequency.

DLC

Data **L**ength **C**ode = in CANopen the number of the data bytes in a message.
For →SDO: DLC = 8

DRAM

DRAM = **D**ynamic **R**andom **A**ccess **M**emory.
Technology for an electronic memory module with random access (Random Access Memory, RAM). The memory element is a capacitor which is either charged or discharged. It becomes accessible via a switching transistor and is either read or overwritten with new contents. The memory contents are volatile: the stored information is lost in case of lacking operating voltage or too late restart.

DTC

DTC = **D**iagnostic **T**rouble **C**ode = error code
In the protocol J1939 faults and errors well be managed and reported via assigned numbers – the DTCs.

E

ECU

(1) **E**lectronic **C**ontrol **U**nit = control unit or microcontroller
(2) **E**ngine **C**ontrol **U**nit = control device of a engine

EDS-file

EDS = **E**lectronic **D**ata **S**heet, e.g. for:
- File for the object directory in the CANopen master,
- CANopen device descriptions.

Via EDS devices and programs can exchange their specifications and consider them in a simplified way.

Embedded software

System software, basic program in the device, virtually the →runtime system.
The firmware establishes the connection between the hardware of the device and the application program. The firmware is provided by the manufacturer of the controller as a part of the system and cannot be changed by the user.

EMC

EMC = **E**lectro **M**agnetic **C**ompatibility.
According to the EC directive (2004/108/EEC) concerning electromagnetic compatibility (in short EMC directive) requirements are made for electrical and electronic apparatus, equipment, systems or components to operate satisfactorily in the existing electromagnetic environment. The devices must not interfere with their environment and must not be adversely influenced by external electromagnetic interference.

EMCY

abbreviation for emergency
Message in the CANopen protocol with which errors are signalled.

Ethernet

Ethernet is a widely used, manufacturer-independent technology which enables data transmission in the network at a speed of 10...10 000 million bits per second (Mbps). Ethernet belongs to the family of so-called "optimum data transmission" on a non exclusive transmission medium. The concept was developed in 1972 and specified as IEEE 802.3 in 1985.

EUC

EUC = **E**quipment **U**nder **C**ontrol.
EUC is equipment, machinery, apparatus or plant used for manufacturing, process, transportation, medical or other activities (→ IEC 61508-4, section 3.2.3). Therefore, the EUC is the set of all equipment, machinery, apparatus or plant that gives rise to hazards for which the safety-related system is required.
If any reasonably foreseeable action or inaction leads to →hazards with an intolerable risk arising from the EUC, then safety functions are necessary to achieve or maintain a safe state for the EUC. These safety functions are performed by one or more safety-related systems.

F

FiFo

FIFO (**F**irst **I**n, **F**irst **O**ut) = Operating principle of the stack memory: The data packet that was written into the stack memory first, will also be read first. Each identifier has such a buffer (queue).

Flash memory

Flash ROM (or flash EPROM or flash memory) combines the advantages of semiconductor memory and hard disks. Similar to a hard disk, the data are however written and deleted blockwise in data blocks up to 64, 128, 256, 1024, ... bytes at the same time.

Advantages of flash memories

- The stored data are maintained even if there is no supply voltage.
- Due to the absence of moving parts, flash is noiseless and insensitive to shocks and magnetic fields.

Disadvantages of flash memories

- A storage cell can tolerate a limited number of write and delete processes:
  • Multi-level cells: typ. 10 000 cycles
  • Single level cells: typ. 100 000 cycles
- Given that a write process writes memory blocks of between 16 and 128 Kbytes at the same time, memory cells which require no change are used as well.

FRAM

FRAM, or also FeRAM, means **Fe**rroelectric **R**andom **A**ccess **M**emory**.** The storage operation and erasing operation is carried out by a polarisation change in a ferroelectric layer.
Advantages of FRAM as compared to conventional read-only memories:
• non-volatile,
• compatible with common EEPROMs, but:
• access time approx. 100 ns,
• nearly unlimited access cycles possible.

H

Heartbeat

The participants regularly send short signals. In this way the other participants can verify if a participant has failed.

HMI

HMI = **H**uman **M**achine **I**nterface

I

ID

ID = **Id**entifier

Name to differentiate the devices / participants connected to a system or the message packets transmitted between the participants.

IEC 61131

Standard: Basics of programmable logic controllers
• Part 1: General information
• Part 2: Production equipment requirements and tests
• Part 3: Programming languages
• Part 5: Communication
• Part 7: Fuzzy Control Programming

IEC user cycle

IEC user cycle = PLC cycle in the CODESYS application program.

Instructions

Superordinate word for one of the following terms:
installation instructions, data sheet, user information, operating instructions, device manual, installation information, online help, system manual, programming manual, etc.

Intended use

Use of a product in accordance with the information provided in the instructions for use.

IP address

IP = **I**nternet **P**rotocol.
The IP address is a number which is necessary to clearly identify an internet participant. For the sake of clarity the number is written in 4 decimal values, e.g. 127.215.205.156.

ISO 11898

Standard: Road vehicles – Controller area network

- Part 1: Data link layer and physical signalling
- Part 2: High-speed medium access unit
- Part 3: Low-speed, fault-tolerant, medium dependent interface
- Part 4: Time-triggered communication
- Part 5: High-speed medium access unit with low-power mode

ISO 11992

Standard: Interchange of digital information on electrical connections between towing and towed vehicles

- Part 1: Physical and data-link layers
- Part 2: Application layer for brakes and running gear
- Part 3: Application layer for equipment other than brakes and running gear
- Part 4: Diagnostics

ISO 16845

Standard: Road vehicles – Controller area network (CAN) – Conformance test plan

J

J1939

→ SAE J1939

L

LED

LED = **L**ight **E**mitting **D**iode.
Light emitting diode, also called luminescent diode, an electronic element of high coloured luminosity at small volume with negligible power loss.

Link

A link is a cross-reference to another part in the document or to an external document.

LSB

Least **S**ignificant **B**it/Byte

M

MAC-ID

MAC = **M**anufacturer's **A**ddress **C**ode
= manufacturer's serial number.
→ID = **Id**entifier
Every network card has a MAC address, a clearly defined worldwide unique numerical code, more or less a kind of serial number. Such a MAC address is a sequence of 6 hexadecimal numbers, e.g. "00-0C-6E-D0-02-3F".

Master

Handles the complete organisation on the bus. The master decides on the bus access time and polls the →slaves cyclically.

Misuse

The use of a product in a way not intended by the designer.
The manufacturer of the product has to warn against readily predictable misuse in his user information.

MMI

→ *HMI* (→ page 195)

MRAM

MRAM = **M**agnetoresistive **R**andom **A**ccess **M**emory
The information is stored by means of magnetic storage elements. The property of certain materials is used to change their electrical resistance when exposed to magnetic fields.
Advantages of MRAM as compared to conventional RAM memories:

- non volatile (like FRAM), but:
- access time only approx. 35 ns,
- unlimited number of access cycles possible.

MSB

Most **S**ignificant **B**it/Byte

N

NMT

NMT = **N**etwork **M**anagemen**t** = (here: in the CANopen protocol).
The NMT master controls the operating states of the NMT slaves.

Node

This means a participant in the network.

Node Guarding

Node = here: network participant
Configurable cyclic monitoring of each →slave configured accordingly. The →master verfies if the slaves reply in time. The slaves verify if the master regularly sends requests. In this way failed network participants can be quickly identified and reported.

O

Obj / object

Term for data / messages which can be exchanged in the CANopen network.

Object directory

Contains all CANopen communication parameters of a device as well as device-specific parameters and data.

OBV

Contains all CANopen communication parameters of a device as well as device-specific parameters and data.

OPC

OPC = **O**LE for **P**rocess **C**ontrol
Standardised software interface for manufacturer-independent communication in automation technology
OPC client (e.g. device for parameter setting or programming) automatically logs on to OPC server (e.g. automation device) when connected and communicates with it.

Operational

Operating state of a CANopen participant. In this mode →SDOs, →NMT commands and →PDOs can be transferred.

P

PC card

→PCMCIA card

PCMCIA card

PCMCIA = Personal Computer Memory Card International Association, a standard for expansion cards of mobile computers.
Since the introduction of the cardbus standard in 1995 PCMCIA cards have also been called PC card.

PDM

PDM = **P**rocess and **D**ialogue **M**odule.
Device for communication of the operator with the machine / plant.

PDO

PDO = **P**rocess **D**ata **O**bject.
The time-critical process data is transferred by means of the "process data objects" (PDOs). The PDOs can be freely exchanged between the individual nodes (PDO linking). In addition it is defined whether data exchange is to be event-controlled (asynchronous) or synchronised. Depending on the type of data to be transferred the correct selection of the type of transmission can lead to considerable relief for the →CAN bus.
According to the protocol, these services are unconfirmed data transmission: it is not checked whether the receiver receives the message. Exchange of network variables corresponds to a "1 to n connection" (1 transmitter to n receivers).

PDU

PDU = **P**rotocol **D**ata **U**nit.
The PDU is an item of the →CAN protocol →SAE J1939. PDU indicates a part of the destination or source address.

PES

Programmable **E**lectronic **S**ystem ...
- for control, protection or monitoring,
- dependent for its operation on one or more programmable electronic devices,
- including all elements of the system such as input and output devices.

PGN

PGN = **P**arameter **G**roup **N**umber
PGN = PDU format (PF) + PDU source (PS)
The parameter group number is an item of the →CAN protocol →SAE J1939. PGN collects the address parts PF and PS.

Pictogram

Pictograms are figurative symbols which convey information by a simplified graphic representation.
(→ chapter *What do the symbols and formats mean?* (→ page 6))

PID controller

The PID controller (proportional–integral–derivative controller) consists of the following parts:
- P = proportional part
- I = integral part
- D = differential part (but not for the controller CR04nn, CR253n).

PLC configuration

Part of the CODESYS user interface.

► The programmer tells the programming system which hardware is to be programmed.

> CODESYS loads the corresponding libraries.

> Reading and writing the periphery states (inputs/outputs) is possible.

Pre-Op

Pre-Op = PRE-OPERATIONAL mode.
Operating status of a CANopen participant. After application of the supply voltage each participant automatically passes into this state. In the CANopen network only →SDOs and →NMT commands can be transferred in this mode but no process data.

Process image

Process image is the status of the inputs and outputs the PLC operates with within one →cycle.

- At the beginning of the cycle the PLC reads the conditions of all inputs into the process image. During the cycle the PLC cannot detect changes to the inputs.
- During the cycle the outputs are only changed virtually (in the process image).
- At the end of the cycle the PLC writes the virtual output states to the real outputs.

PWM

PWM = pulse width modulation
The PWM output signal is a pulsed signal between GND and supply voltage.
Within a defined period (PWM frequency) the mark-to-space ratio is varied. Depending on the mark-to-space ratio, the connected load determines the corresponding RMS current.

R

ratiometric

Measurements can also be performed ratiometrically. If the output signal of a sensor is proportional to its suppy voltage then via ratiometric measurement (= measurement proportional to the supply) the influence of the supply's fluctuation can be reduced, in ideal case it can be eliminated.
→ analogue input

RAW-CAN

RAW-CAN means the pure CAN protocol which works without an additional communication protocol on the CAN bus (on ISO/OSI layer 2). The CAN protocol is international defined according to ISO 11898-1 and garantees in ISO 16845 the interchangeability of CAN chips in addition.

remanent

Remanent data is protected against data loss in case of power failure.
The →runtime system for example automatically copies the remanent data to a →flash memory as soon as the voltage supply falls below a critical value. If the voltage supply is available again, the runtime system loads the remanent data back to the RAM memory.
The data in the RAM memory of a controller, however, is volatile and normally lost in case of power failure.

ro

RO = read only for reading only
Unidirectional data transmission: Data can only be read and not changed.

RTC

RTC = **R**eal **T**ime **C**lock
Provides (batter-backed) the current date and time. Frequent use for the storage of error message protocols.

Runtime system

Basic program in the device, establishes the connection between the hardware of the device and the application program.

rw

RW = read/ write
Bidirectional data transmission: Data can be read and also changed.

S

SAE J1939

The network protocol SAE J1939 describes the communication on a →CAN bus in commercial vehicles for transmission of diagnosis data (e.g.engine speed, temperature) and control information.
Standard: Recommended Practice for a Serial Control and Communications Vehicle Network

- Part 2: Agricultural and Forestry Off-Road Machinery Control and Communication Network
- Part 3: On Board Diagnostics Implementation Guide
- Part 5: Marine Stern Drive and Inboard Spark-Ignition Engine On-Board Diagnostics Implementation Guide
- Part 11: Physical Layer – 250 kBits/s, Shielded Twisted Pair
- Part 13: Off-Board Diagnostic Connector
- Part 15: Reduced Physical Layer, 250 kBits/s, Un-Shielded Twisted Pair (UTP)
- Part 21: Data Link Layer
- Part 31: Network Layer
- Part 71: Vehicle Application Layer
- Part 73: Application Layer – Diagnostics
- Part 81: Network Management Protocol

SD card

An SD memory card (short for **S**ecure **D**igital Memory Card) is a digital storage medium that operates to the principle of →flash storage.

SDO

SDO = **S**ervice **D**ata **O**bject.
The SDO is used for access to objects in the CANopen object directory. 'Clients' ask for the requested data from 'servers'. The SDOs always consist of 8 bytes.

Examples:

- Automatic configuration of all slaves via →SDOs at the system start,
- reading error messages from the →object directory.

Every SDO is monitored for a response and repeated if the slave does not respond within the monitoring time.

Self-test

Test program that actively tests components or devices. The program is started by the user and takes a certain time. The result is a test protocol (log file) which shows what was tested and if the result is positive or negative.

Slave

Passive participant on the bus, only replies on request of the →master. Slaves have a clearly defined and unique →address in the bus.

stopped

Operating status of a CANopen participant. In this mode only →NMT commands are transferred.

Symbols

Pictograms are figurative symbols which convey information by a simplified graphic representation.
(→ chapter *What do the symbols and formats mean?* (→ page 6))

System variable

Variable to which access can be made via IEC address or symbol name from the PLC.

T

Target

The target contains the hardware description of the target device for CODESYS, e.g.: inputs and outputs, memory, file locations.
Corresponds to an electronic data sheet.

TCP

The **T**ransmission **C**ontrol **P**rotocol is part of the TCP/IP protocol family. Each TCP/IP data connection has a transmitter and a receiver. This principle is a connection-oriented data transmission. In the TCP/IP protocol family the TCP as the connection-oriented protocol assumes the task of data protection, data flow control and takes measures in the event of data loss. (compare: →UDP)

Template

A template can be filled with content.
Here: A structure of pre-configured software elements as basis for an application program.

U

UDP

UDP (**U**ser **D**atagram **P**rotocol) is a minimal connectionless network protocol which belongs to the transport layer of the internet protocol family. The task of UDP is to ensure that data which is transmitted via the internet is passed to the right application.
At present network variables based on →CAN and UDP are implemented. The values of the variables are automatically exchanged on the basis of broadcast messages. In UDP they are implemented as broadcast messages, in CAN as →PDOs.
According to the protocol, these services are unconfirmed data transmission: it is not checked whether the receiver receives the message. Exchange of network variables corresponds to a "1 to n connection" (1 transmitter to n receivers).

Use, intended

Use of a product in accordance with the information provided in the instructions for use.

W

Watchdog

In general the term watchdog is used for a component of a system which watches the function of other components. If a possible malfunction is detected, this is either signalled or suitable program branchings are activated. The signal or branchings serve as a trigger for other co-operating system components to solve the problem.

wo

WO = write only
Unidirectional data transmission: Data can only be changed and not read.

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