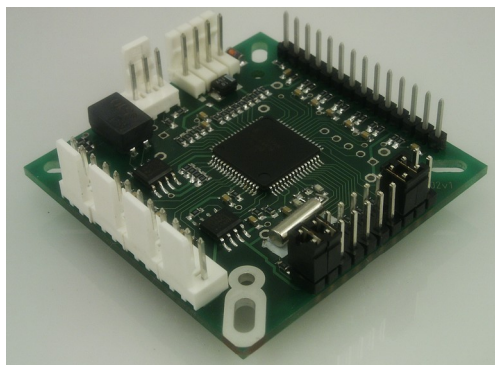# MCB-402
CANOPEN Controller
for joystick

version 1.0

MEGATRON

1. Specifications.

- Compatible with CANOPEN DS401 2.0 DS301 4.0
- 2 TRANSMIT PDO
- 1 RECEIVE PDO
- All canopen specific PDO transmission types supported :
  synchronous, asynchronous, event driven, cyclic, acyclic and remote
  frame dependant.
- Event timer for all transmit PDO
- Node guarding, life guarding, hearbeat
- 20,50,125,250,500 kBaud
- Adress selectable by jumpers 1 to 0x7F
- 4 axis 0 to 5VDC, 10 bits scalled to signed 16 bits. Neutral zone.
- 7 pushbuttons
- 4 outputs for leds
- Power supply 5VDC 50 mA

2. Connexion

CN6 Buttons inputs (short to GND) (Molex KK 14 pins 2.54)	
1	BP7
3	BP6
5	BP5
7	BP4
9	BP3
11	BP2
13	BP1
2,4,6,8,10,12,14	GND

Axis analog input (Molex KK 3 pins 2.54)				
	CN5	CN9	CN7	CN8
1	5 VDC	5 VDC	5 VDC	5 VDC
2	X axis input	Y axis input	Z axis input	T axis input
3	GND	GND	GND	GND

CN1 CAN interface (Molex KK 3 pins 2.54)	
1	CAN H
2	CAN L
3	GND

CN2 power supply (Molex KK 4 pins 2.54)	
1,2	+5VDC, 50mA + current for joystick
3,4	GND

CN10 LED output **(Molex KK 5 pins 2.54)** max sink 4mA, not short circuit protected	
1	+5VDC
2	OUT0
3	OUT1
4	OUT2
5	OUT3

3. Configuration

CN3 CAN settings (short with jumpers)											
20	18	16	K Baud	14	12	10	8	6	4	2	CAN address
1	0	1	500	1	1	1	1	1	1	0	0x1
1	0	0	250	1	1	1	1	1	0	1	0x2
0	1	1	125	1	1	1	1	1	0	0	0x3
0	1	0	50	...	...	...	...	...	...	...	
0	0	1	20	0	0	0	0	0	0	0	0x7F
2,4,6,8,10,12,14,16,18,20			Inputs (with +5V pullup)								
1,3,5,7,9,11,13,15,17,19,21			GND								

4. Using in a non CANOPEN network.

The MCB402 uses CAN 11 bits format, which is based on an identifier (11 bits) and up to 8 bytes of datas. Words are made from 2 bytes arranged according to little endian. That means that the word 0x1234 is transmitted with 0x34 in first position.
It is possible to use the MCB402 in a non Canopen network by configuring it with the following sequences. The board will write on the bus a message each time a push button is pressed or relaxed. It will write a message containing the values of the 4 axis (X Y Z T) according to a programmable delay.
Be aware that you can not write on the bus some other messages that can be interpreted by the CANOPEn stack of MCB402. Avoid messages with identifiers between 0 and 0x180 and all identifiers ending with the address of the MCB402. For example, if the adress of the board is 0x03, do not write on the bus messages ID like 0x503. You can use 0X502 for example because it will not be processed by the board.

In the following examples the MCB402 is configured at address 0x03
The format is ID followed by data. 703 = 700 + address.

At the power on, MCB402 writes on the bus :

703 00   Tells connected but inactive

083 00 81 11 00 00 00 00 00 SYNC sequence with other canopen
                                                     equipments. (do not care)

Write on bus :
000 01 03   Starts MCB402 at address 0x03

MCB writes :
183 00 00 cc 00   Levels of the push buttons inputs. When
                                                     pressed, the corresponding bit is set to 1

Bit of cc	7	6	5	4	3	2	1	0
N° BP	.	7	6	5	4	3	2	1

283 aa bb cc dd ee ff gg hh Axis X Y Z T (signed 16 bits). When the handle is on neutral position at 2.5V the output value is 0x0000. When pushed to 5V, the value is 0x7FFF. When pulled to 0V, 0x8000. The word for X axis is 0xbbaa.

If a swich is pressed, as a change of state occurs, MCB402 returns :

183 aa bb cc dd   0x183 = 0x180 + address, here 0x03.

We now set the timer events so that the MCB402 sent at regular intervals the value of the axis.
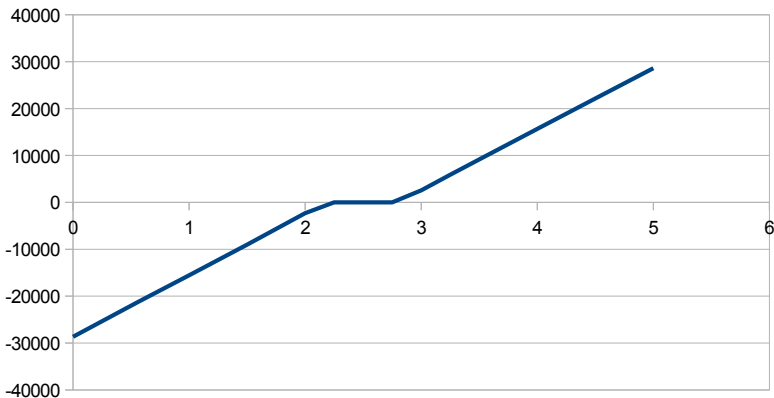
Write :
603 22 01 18 05 aa bb 00 00 0xbbaa = duration in ms.

The MCB402 returns now the values of axis each 0xbbaa ms :

283 aa bb cc dd ee ff gg hh

The voltage output is as follows. There is a central zone. This zone is adjustable, contact us.

5. CANOPEN object dictionary

The CO4013 Single Chip CANopen Controller implements a complex object dictionary for CANopen I/O devices.

For detailed information about CANopen objects see additional brochure "Introduction to CANopen"

For the Object tables all values are shown in hexa-decimal way.
For access type the following settings are valid
ro   read only
wo   write only
rw   read and write access enabled

DS301: global Objects

Index	Sub-Index	Name	Acc.
0005	-	Dummy 8	ro
0006	-	Dummy 16	ro
0007	-	Dummy 32	ro
1000	-	Device Type	ro
1001	-	Error Register	ro
1002	-	Manufacturer Status Register	ro
1005	-	COB-ID Sync Identifier Sync Object	rw
1008	-	Device Name	ro
1009	-	Hardware Version	ro
100C	-	Guard Time	rw
100D	-	Life Time Factor	rw
100E	-	COB-ID Guard	rw
1010	-	Store Parameters *2)	rw
1011	-	Reload Default Parameter *2)	rw
1014	-	COB ID Emergency	rw
1015	-	Inhibit Time Emergency	rw
1017	-	Producer Heartbeat Time	rw
1018	0	Identity Object	ro
	1	Vendor ID	ro
	2	Product Code	ro
	3	Revision Number	ro
2000	-	Device Manufacturer *1)	ro
2101	-	System Configuration	ro
2180	-	CAN Restart Time	rw

Notes:
*1) This Objects shows "Frenzel + Berg" as visible string data type.
*2) This object cannot be written to in operational device state.
Only use this command in preoperational device state, otherwise the CO4012 will answer requests with SDO abort telegrams.

The data type entries Index 0005 to 0007 are implemented for compatibility reasons. They may be mapped to PDOs in order to define the appropriate space in the PDO.

DS301: PDO Parameter Objects

Description of PDO Parameter objects:
These Objects enable dynamic PDO mapping, variable identifier distribution for PDOs and setting of the transmission mode, inhibit and event times.
For the CO4013 setting of all parameters may be done in the device state "operational" as well as in "preoperational" state.

Index	Sub-Index	Name	Acc.
1400	0	Receive PDO1 Communication Parameter	ro
	1	COB-ID	rw
	2	Transmission Type	rw
	3	Inhibit Time (not used)	rw
	4	Reserved	rw
	5	Event Time	rw
1401 ... 1403		Receive PDO2 to RPDO4 Communication Parameter same as 1400.00 .. 1400.05	rw
1600	0	Receive PDO1: Parameter mapping	rw
	1 to n	Mapped Object (max. 8 objects mappable)	rw
1601 ... 1603		Receive PDO2 to RPDO4 Parameter mapping Same as 1600	rw
1800	0	Transmit PDO1 Communication Parameter	ro
	1	COB-ID	rw
	2	Transmission Type	rw
	3	Inhibit Time	rw
	4	Reserved	rw
	5	Event Timer	rw
1801 ... 1803		Transmit PDO2 to TPDO4 Communication Parameter same as 1800.00 .. 1800.05	rw
1A00	0	Transmit PDO1 Parameter mapping	rw
	1 to n	Mapped Object (max. 8 objects mappable)	rw
1A01 ... 1A03		Transmit PDO2 to TPDO4 Parameter mapping Same as 1A00	rw

Note:
The CO4013A supports a maximum of 1 receive and 2 transmit PDOs. (according to configuration). All other Objects for higher PDO numbers are not implemented.

Note:
For detailed information about CANopen objects see additional brochure "Introduction to CANopen"

DS401: Digital Input Objects

Index	Sub-Index	Name	Acc.
5003	0 to n	Debounce (Filter) time for each digital input	rw
6000	0 to n	Read digital input 8 bit	ro
6002	0 to n	Polarity input 8-bit	rw
6005		Global interrupt enable	rw
6006	0 to n	Interrupt mask: any change	rw
6007	0 to n	Interrupt mask rising edge	rw
6008	0 to n	Interrupt mask falling edge	rw

The objects 5001 and 5002 are implemented for debug purposes, because the CANopen object 6000 does not allow write access to an input line. With objects 5001 and 5002 a debug environment may simulate setting or resetting of input lines. The CO4013 first scans the physical input lines and then processes the scanned values with the debug parameters.

With object 5003 an individual filter constant (value in msec) may be assigned to each input line. This gives great flexibility to prevent inputs from distortion. The default value for filter constant is 20 msec. The filter time is used for debouncing all input lines. Set value to 0 to disable debouncing of input lines.

DS401: Digital Output Objects

Index	Sub-Index	Name	Acc.
6200	0 to n	Write Output 8 Bit	rw
6202	0 to n	Change Polarity Output 8 bit	rw
6206	0 to n	Error Mode Output	rw
6207	0 to n	Error State Output	rw

DS401: Analog Input Objects

Index	Sub-Index	Name	Acc.
5401	0 to n	Zero Point Enlargement	rw
6401	0 to n	Read Analog Input 16 Bit Axis proportional values	ro
6421	0 to n	Analog Input Interrupt Trigger	rw
6423		Analog Input global Interrupt Enable	rw
6424	0 to n	Analog Input Upper Limit	rw
6425	0 to n	Analog Input Lower Limit	rw
6426	0 to n	Analog Input Interrupt Delta	rw
6427	0 to n	Analog Input Interrupt Negative Delta	rw
6428	0 to n	Analog input interrupt positive delta	rw
6431	0 to n	Analog input offset integer	rw

The following list gives da short description of all dictionary entries.

Index 0005

This object is implemented to enable reservation of data space in PDOs by mapping dummy entries.

Index	0005
Name	Dummy 8
Description	-
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	Yes
Value Range	-
Default Value	0

Index 0006

This object is implemented to enable reservation of data space in PDOs by mapping dummy entries.

Index	0006
Name	Dummy 16
Description	-
Data Type	Unsigned 16
Access modes	RO
PDO Mapping	Yes
Value Range	-
Default Value	0

Index 0007

This object is implemented to enable reservation of data space in PDOs by mapping dummy entries.

Index	0007
Name	Dummy 32
Description	-
Data Type	Unsigned 32
Access modes	RO
PDO Mapping	Yes
Value Range	-
Default Value	0

Index 1000 : Device Type

Description of the device type. The Object gives the CiA device profile number and additionally the functionality of the device.

Index	1000h	
Name	Device Type	
Description	-	
Data Type	Unsigned 32	
Access modes	RO	
PDO Mapping	No	
Value Range	-	
Default Value	Operation Mode	Value of Index
	CO4013A0	0105 0191 h
	CO4013A1	0105 0191 h
	CO4013A2	0107 0191 h
	CO4013A3	0107 0191 h
	CO4013A4	0107 0191 h

Index 1001 : Error Register

This object holds an error of the device.

Index	1001h
Name	Error Register
Description	-
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	Yes
Value Range	-
Default Value	-

The error register has the following structure

Bit	Meaning
0	Generic error. This bit is set, if any error is active
1	0
2	0
3	0
4	CAN bus or communication error
5	0
6	0
7	Device Error

Index 1002 : Status Register

This object gives additional information for the device

Index	1002h
Name	Status Register
Description	-
Data Type	Unsigned 32
Access modes	RO
PDO Mapping	Yes
Value Range	-
Default Value	-

The status register bits have the following meaning

Bit	Meaning
31	The device is in operational state
30	Node guarding error

Index 1005 : COB-ID Sync

Identifier of Can Object for the Synchronisation message. The CO4013 may only operate in Sync consumer mode. Generating of Sync messages is not possible. Nevertheless is the Identifier for the Sync message programmable.

Index	1005h
Name	COB-ID Sync
Description	-
Data Type	Unsigned 32
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	-

Index 1008 : Device Name

This object shows the name of the device as visible string.

Index	1008h
Name	Device Name
Description	-
Data Type	Visible String
Access modes	RO
PDO Mapping	No
Value Range	The maximum string length is 20 characters
Default Value	CO4013A

Index 1009 : Hardware Version

This object shows the name of the device as visible string.

Index	1009h
Name	Hardware Version
Description	-
Data Type	Visible String
Access modes	RO
PDO Mapping	No
Value Range	The maximum string length is 20 characters
Default Value	-

Index 100C : Guard Time

The objects at index 100Ch (Guard Time in milli-seconds) and 100Dh (Life Time Factor) are used to implement the life guarding protocol. The Guard Time multiplied with the Life Time Factor gives the Life Time in milliseconds.
It is 0 (zero) if not used.

Index	100Ch
Name	Guard Time
Description	-
Data Type	Unsigned 16
Access modes	RW
PDO Mapping	No
Value Range	
Default Value	0

Index 100D : Life Time Factor

The objects at index 100Ch (Guard Time in milli-seconds) and 100Dh (Life Time Factor) are used to implement the life guarding protocol. The Guard Time multiplied with the Life Time Factor gives the Life Time in milliseconds.
It is 0 (zero) if not used.

Index	100Dh
Name	Life Time Factor
Description	-
Data Type	Unsigned 16
Access modes	RW
PDO Mapping	No
Value Range	
Default Value	0

Index 100E : COB-ID Guard

Identifier of Can Object for the Node Guarding or Heartbeat protocol.

Index	100Eh
Name	COB-ID Guard
Description	-
Data Type	Unsigned 32
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	700h + Node-ID

Index 1010 : Store Parameters

This object supports the saving of parameters in 22non-volatile memory. By read access the device provides information about its saving capabilities. Several parameter groups are distinguished:
Sub-Index 0 contains the largest Sub-Index that is supported.
Writing to Sub-Index 1 means that all parameters shall be stored on the device.
In order to avoid storage of parameters by mistake, storage is only executed when a specific signature is written to the appropriate Sub-Index. (This means that the signature is transferred as data bytes 4 to 7 in the CAN message of the corresponding SDO protocol.

The signature is "save".

MSB			LSB
e	v	a	s
65h	76h	61h	73h

On reception of the correct signature on sub-index 1 the device stores the parameters and then confirms the SDO transmission (initiate download response). If the storing failed, the device responds with an Abort SDO Transfer (abort code: 0606 0000 h). If a wrong signature is written, the device refuses to store and responds with Abort SDO Transfer (Abort code: 0800 002x h).

Index	1010h
Name	Store Parameters
Description	-
Data Type	Structure

Index	1010h Subindex 0
Name	Largest SubIndex supported
Description	-
Data Type	Unsigned char
Access modes	RO
PDO Mapping	No
Value Range	1
Default Value	1

Index	1010h Subindex 1
Name	Store All Parameters
Description	Writing to this object stores the dictionary to non-volatile memory.
Data Type	Unsigned 32
Access modes	RW
PDO Mapping	No
Value Range	Signature "save"
Default Value	-

By read access to object 1010h Subindex 1, the device responds with SDO data 00000001h indi-cating that storing of data is only done on command.

Note:
Writing to this objected is only allowed in pre-operational mode.

Index 1011 : Restore Default Parameters

With this object the default values of parameters according to the communication or device profile are restored. By read access the device provides information about its capabilities to restore these values.
Several parameter groups are distinguished:
Sub-Index 0 contains the largest Sub-Index that is supported.
Writing to Sub-Index 1 restores all parameters that can be restored.
In order to avoid the restoring of default parameters by mistake, restoring is only executed when a specific signature is written to the appropriate sub-index. (This means that the signature is transferred as data bytes 4 to 7 in the CAN message of the corresponding SDO protocol.

The signature is "load".

MSB			LSB
d	a	o	l
64h	61h	6Fh	6Ch

On reception of the correct signature on sub-index 1 the device prepares restoring of the parameters at the next "reset node" command or on the next power on cycle and then confirms the SDO transmission (initiate download response). If failed, the device responds with an abort SDO transfer (abort code: 0606 0000h).
If a wrong signature is written, the device refuses to store and responds with Abort SDO Transfer (Abort code: 0800 002x h).
The default values are set valid after the device is reset (reset node) or power cycled. If the device requires storing on command (see Object 1010h), the appropriate command has to be executed after the reset if the default parameters are to be stored permanently.

Index	1011h
Name	Restore Default Parameters
Description	-
Data Type	Structure

Index	1011h Subindex 0
Name	Largest SubIndex supported
Description	-
Data Type	Unsigned char
Access modes	RO
PDO Mapping	No
Value Range	1
Default Value	1

Index	1011h Subindex 1
Name	Restore All Parameters
Description	Writing to this object prepares restoring of the default values to the dictionary at the next power cycle or "reset node" NMT.
Data Type	Unsigned 32
Access modes	RW
PDO Mapping	No
Value Range	Signature "load"
Default Value	-

By read access to object 1011h Subindex 1, the device responds with SDO data 00000001h indicating that restoring of default data is available.

Note:
Writing to this objected is only allowed in pre-operational mode.

Index 1014 : COB-ID Emergency

Identifier of Can Object for the emergency messages.

Index	1014h
Name	COB-ID Emergency
Description	-
Data Type	Unsigned 32
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	80h + Node-ID

Index 1015 : Inhibit Time Emergency

Inhibit Time for emergency messages. If the Inhibit Time is set to 0, inhibit delay is disabled. The Inhibit Time is a multiple of 100usec, but the CO4013A offers a maximum resolution of 1 millisecond.

Index	1015h
Name	Inhibit Time Emergency
Description	-
Data Type	Unsigned 16
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0

Index 1017 : Producer Heartbeat Time

The producer heartbeat time defines the cycle time of the heartbeat. The producer heartbeat time is 0 if it not used. The time has to be a multiple of 1ms.

Index	1017h
Name	Producer Heartbeat Time
Description	-
Data Type	Unsigned 16
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0

Either Heartbeat or node guarding may be allowed at the same time. Do not use both protocols at the same time.
See additional brochure for further information.

Index 1018 : Identity Object

The object at index 1018h contains general information about the device and the manufacturer frenzel + berg elektronik. It cannot be modified.

Index	1018h
Name	Identity Object
Description	-
Data Type	Structure

Index	1018h Subindex 0
Name	Largest SubIndex supported
Description	-
Data Type	Unsigned char
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	3

Index	1018h Subindex 1
Name	Vendor ID
Description	Registration Code of frenzel + berg elektronik at the CiA
Data Type	Unsigned 32
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	58h

Index	1018h Subindex 2
Name	Product Code
Description	Internal Product Code for CO4013A at frenzel + berg elektronik
Data Type	Unsigned 32
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	0104 0131 h

Index	1018h Subindex 3
Name	Revision Code
Description	
Data Type	Unsigned 32
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	Revision of the device

This Object shows "Frenzel + Berg" as visible string.

Index	2000h
Name	Device Manufacturer
Description	-
Data Type	Visible String
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	"Frenzel + Berg"

Index 2101 : System Configuration

This Object returns the operation mode of the CO4013A. It represents the inverted Setting of the configuration input bits CFG0 to CFG3.

Index	2101h
Name	System Configuration
Description	-
Data Type	Unsigned 32
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	Depends on CFG0 to CFG3

Index 2180 : CAN Restart Time

This Object provides the restart time out for the CAN communication layer in case of bus off errors in milliseconds.
If the restart time is set to 0 automatic restart of the device in case of bus off is prohibited.

Index	2180h
Name	CAN Restart Time
Description	-
Data Type	Unsigned 16
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0 (restart disabled)

DS301: PDO Parameter Objects

Communication Parameter Objects

The following table shows the communication parameter objects for Index 140x (Receive PDOs) and Index 180x (Transmit PDOs). The tables show Index 1400 as an example for all PDOs

The transmission type (sub-index 2) defines the mode for transmission / reception of the PDO. See table for detailed description of this entry.

Description of transmission type:

Type	PDO transmission				
	cyclic	acyclic	Sync related	Async.	Only on remote
0		X	X		
1-240	X		X		
241-251	Reserved				
252			X		X
253				X	X
254				X	
255				X	

Synchronous (transmission types 0-240 and 252) means that the transmission of the PDO shall be related to the SYNC object. Asynchronous means that the transmission of the PDO is not related to the SYNC object.
A transmission type of zero means that the message shall be transmitted synchronously with the SYNC object but not periodically but only in case of data change.
A value between 1 and 240 means that the PDO is transferred synchronously and cyclically, the transmission type indicating the number of SYNC signals, which are necessary to trigger PDO transmissions or receptions.

The transmission types 252 and 253 mean that the PDO is only transmitted on reception of a remote frame. At transmission type 252, the data is updated (but not sent) immediately after reception of the SYNC object. At transmission type 253 the data is updated at the reception of the remote frame. These values are only possible for transmit PDOs.

Transmission type 254 selects the CanEASY mode. Transmission type 255 means, the application event is defined in the device profile. For receive PDOs the reception of a PDO will update the mapped data (normally the analog or digital outputs).

Sub-index 3h contains the inhibit time. This time is a minimum interval for PDO transmission. The value is defined as multiple of 100ms.
Sub-index 4h is reserved.
In mode 254/255 additionally an event time can be used for TPDO. If an event timer exists for a TPDO (value not equal to 0) the elapsed timer is considered to be an event. The event time is a multiple of 1 ms. This event will cause the transmission of this TPDO in addition to otherwise defined events.

Index	1400h
Name	Receive PDO1 Communication Parameters
Description	-
Data Type	Structure

Index	1400h Subindex 0
Name	Largest SubIndex supported
Description	-
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	5

Index	1400h Subindex 1
Name	COB-ID
Description	Identifier for CAN-Object for PDO1
Data Type	Unsigned 32
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	200h + Node-Id

Index	1400h Subindex 2
Name	Transmission Type
Description	-
Data Type	Unsigned 8
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0FFh

Index	1400h Subindex 3
Name	Inhibit Time
Description	-
Data Type	Unsigned 16
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0

Index	1400h Subindex 4
Name	Reserved
Description	-
Data Type	-
Access modes	-
PDO Mapping	No
Value Range	-
Default Value	-

Index	1400h Subindex 5
Name	Event Time
Description	-
Data Type	Unsigned 16
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0

The PDO communication parameter objects have the same structure for all PDOs. The following Objects are used.

Index	PDO
1400h	Receive PDO1 (digital output)
1401h	Receive PDO2 (analog output) Not implemented in CO4013A
1800h	Transmit PDO1 (digital input)
1801h	Transmit PDO2 (analog input)

The following table shows the PDO Mapping Objects. The principle of PDO mapping is the same for all PDOs. The PDO Mapping table is the cross reference between the Object dictionary entries (for example the data of an digital output byte) and the data field inside an PDO data field (position in the data field of a CAN message for PDO transfer).

Subindex 0 determines the valid number of objects that have been mapped. The CO4013 allows a maximum of 8 mapped objects for each PDO. For changing the PDO mapping first subindex 0 must be set to 0 (mapping is deactivated). Then the objects can be remapped. When a new object is mapped by writing a subindex between 1 and 8, the device may check whether the object specified by index /subindex exists. If the object does not exist or the object cannot be mapped, the SDO transfer will be aborted.
If the special CAN features are enabled (CFG3=0), the CO4013 allows adding of additional mapping entries without resetting subindex 0. In this case the device calculates the number of mapped objects by itself and modifies subindex 0 respectively.

Subindexes 1 to 8 keep the pointers of the mapped objects as unsigned 32 values. The value is 0 if there is no mapped object. The structure for these pointers is as follows.

MSB			LSB
Byte3	Byte2	Byte1	Byte0
Mapped index		Subindex	Length

Mapped Index and Subindex together are the Pointer to the Object dictionary data to be mapped at this location.
Length gives the length of the mapped object in bits.

The PDO mapping objects have the same structure for all PDOs. The following Objects are used.

Index	PDO
1600h	Receive PDO1 (digital output) Only valid if general purpose output pins are supported
1601h	Receive PDO2 (analog output) Not implemented in CO4013A
1A00h	Transmit PDO1 (digital input lines)
1A01h	Transmit PDO2 (analog input) Representing the axis values of the joystick potentiometers

The following mapping object uses index 1600 as an example for all mapping objects.

Index	1600h
Name	Receive PDO1 Mapping Parameters
Description	-
Data Type	Array

Index	1600h Subindex 0
Name	Largest SubIndex supported
Description	Number of mapped objects
Data Type	Unsigned 8
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	According to operation mode

Index	1600h Subindex 1 to 8
Name	Mapped object
Description	
Data Type	Unsigned 32
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	According to operation mode

Example:
As an example for PDO mapping, the following table shows the default mapping for transmit PDO1 in operation mode 0 (Push button memory keys).

Index	Entry	Explanation
1A00.00	3	There are 3 mapped objects in transmit PDO1
1A00.01	60000108h	First mapped object: Input Byte0 including state of push button flip-flop
1A00.02	60000208h	First mapped object: Input Byte1 including state of direction control input lines X-POSITIVE..W-NEGATIVE
1A00.03	60000308h	First mapped object: Input Byte2 including general-purpose input pins IN0 .. IN7

The data of the transmit PDO1 for this example will be three bytes.
All objects with PDO mapping capabilities (not only digital or analog I/O) may be mapped to one of the PDOs.

The following objects are describing the functionality of the digital input lines of the CO4013A

Index 5003 : Debounce Time Digital Input

The CO4013A offers noise filtering for each digital input line. With object 5003 an individual filter time may be assigned to each input line. This allows direct connection of switches and push buttons without any external filter requirements.

The filter time is set in milliseconds. A value of 0 disables the filtering function.

Index	5003h
Name	Filter Time Digital Input
Description	-
Data Type	Array

Index	Subindex 0
Name	Nr of Subobjects
Description	
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	Number of digital input lines

Index	Subindex 1 to Nr of input lines
Name	Filter Time
Description	There is a individual Time for each input line.
Data Type	Unsigned 8
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	40

This object represents the digital input bytes. The value of the input lines is written to this object.
If pushbutton support for memory function is supported, the corresponding input bit represents the state of the internal flip-flop.

The number of digital input bytes depends on the selected operation mode.
The mapping of the I/O lines to object 6000 is explained in chapter "Mapping I/O to Object Dictionary"

Index	6000h
Name	Digital Input 8 Bit
Description	-
Data Type	Array

Index	Subindex 0
Name	Nr of Subobjects
Description	
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	Depending on operation mode

Index	Subindex 1
Name	Digital Input 8 Bit Byte 0
Description	Memory function for axis values One bit for each axis
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	Yes
Value Range	-
Default Value	Bitx = 0 : values are saved *1) Bitx = 1 : released

*1) If there is a mode with internal analog input freezing feature, the analog input value (axis proportional value) is not changed, even if analog input voltage changes.
In operation modes without internal analog input freezing feature, the analog input value (axis proportional value) will change in the same way the input voltage changes. In this case the Bits only represent the state of the memory switches or push button flip-flops. The freezing of axis value must be done by the application in this case.
In configuration modes without any memory support (pins X-MEM to W-MEM are general purpose input pins IN8 to IN11) the default value for SubIndex1 is 0FFh.

Index	Subindex 2
Name	Digital Input 8 Bit Byte 1
Description	State of Direction input bits (inverted level because active low)
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	Yes
Value Range	-
Default Value	Bit 0: X-POSITIVE Bit 1: X-NEGATIVE Bit 2: Y-POSITIVE Bit 3: Y-NEGATIVE Bit 4: Z-POSITIVE Bit 5: Z-NEGATIVE Bit 6: W-POSITIVE Bit 7: W-NEGATIVE

There is no special function associated with the direction input bits, so they may be used for general-purpose input lines.

Index	Subindex 3
Name	Digital Input 8 Bit Byte 2
Description	State of general purpose input bits Byte IN7.. IN0 (inverted level because active low)
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	Yes
Value Range	-
Default Value	

Index	Subindex 4
Name	Digital Input 8 Bit Byte 3
Description	State of general purpose input bits Byte IN11 .. IN8 (inverted level because active low)
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	Yes
Value Range	-
Default Value	

If there is an operation mode with memory function selected, Subindex 4 is not implemented, because the corresponding pins are already mapped to Subindex 1.

Index 6002 : Polarity Input 8 Bit

With this object, the digital inputs may be inverted. See also Index 6000 for additional information. The number of digital input bytes depends on the selected operation mode.

Index	6002h
Name	Polarity Input 8 Bit
Description	-
Data Type	Array

Index	Subindex 0
Name	Nr of Subobjects
Description	
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	Number of digital input bytes

Index	Subindex 1 to Nr of input bytes
Name	Polarity Input 8 Bit Byte n
Description	
Data Type	Unsigned 8
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0

Index 6005 : Global Interrupt Enable

This object enables or disables globally the interrupt behaviour without changing the interrupt masks. In event-driven mode the device transmits the input values depending on the interrupt masks in objects 6006h, 6007h, and 6008h and the PDO transmission type.
TRUE (1)= global interrupt enabled
FALSE (0)= global interrupt disabled

Index	6005h
Name	Global Interrupt Enable
Description	-
Data Type	Boolean
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	TRUE

Index 6006 : Interrupt Mask Any Change

This object determines, which input lines shall activate an interrupt by any change of the input line. Both negative and positive edge will cause an interrupt, if enabled.
An interrupt will cause a PDO transmission in case of event driven transmission mode.
1 = interrupt enabled
0 = interrupt disabled

Index	6006h
Name	Interrupt Mask any change
Description	-
Data Type	Array

Index	Subindex 0
Name	Nr of Subobjects
Description	
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	Number of digital input bytes

Index	Subindex 1 to Nr of input bytes
Name	Interrupt Mask any change
Description	
Data Type	Unsigned 8
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0FFh (interrupt enabled)

Index 6007/8 : Interrupt Mask on Edge

Object 6007 has the same structure and behaviour as object 6006h but will cause interrupts only on rising edge of object index 6000. Note that input lines are active low, so rising edge of input data (object 6000) means falling edge of input port line.
Default value is 0.

Object 6008 has the same structure and behaviour as object 6006h but will cause interrupts only on falling edge of object index 6000. Note that input lines are active low, so falling edge of input data (object 6000) means rising edge of input port line.
Default value is 0.

DS401: Digital Output Objects

The following objects are describing the functionality of the digital output lines of the CO4013A. The CO4013A supports only 8bit access. The objects are only implemented, if an operation mode with general purpose output pins is selected.

The number of digital output bytes depends on the selected operation mode.

Index 6200 : Write to Digital Output

With object 6200, the digital outputs of the CO4013A can be written to. Before writing to the output ports, the value of the bitmap of object 6200 is processed with object 6202 (Change polarity output 8 bit) and the inverted. (Output port bits of the CO4013A device are active low)

The mapping of the I/O lines to object 6200 is explained in chapter "Mapping I/O to Object Dictionary"

Index	6200h
Name	Write to digital output
Description	-
Data Type	Array

Index	Subindex 0
Name	
Description	Number of mapped objects
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	NO
Value Range	-
Default Value	1

Index	Subindex 1 to Nr of output bytes
Name	Write to digital output
Description	
Data Type	Unsigned 8
Access modes	WO
PDO Mapping	YES
Value Range	-
Default Value	0

Index 6202 : Polarity Output 8 Bit

With this object, the digital outputs may be inverted. See also Index 6200 for additional information.

Index	6202h
Name	Polarity Output 8 Bit
Description	-
Data Type	Array

Index	Subindex 0
Name	Nr of Subobjects
Description	
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	Number of digital output bytes

Index	Subindex 1 to Nr of input bytes
Name	Polarity Output 8 Bit Byte n
Description	
Data Type	Unsigned 8
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0

Index 6206 : Error Mode Output 8 Bit

This object indicates, whether an output is forced to a predefined value (given in object 6207) in case of a device error.
1 = Output will be forced to the value selected in object 6207
0 = Output will be unchanged even in case of an error condition.

Index	6206h
Name	Error Mode Output 8 Bit
Description	-
Data Type	Array

Index	Subindex 0
Name	Nr of Subobjects
Description	
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	Number of digital output bytes

Index	Subindex 1 to Nr of input bytes
Name	Error Mode Output 8 Bit Byte n
Description	
Data Type	Unsigned 8
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0FFh (Take error condition from object 6207)

This object selects the level the outputs are forced to in case of device error mode if the error mode (object 6206 is enabled)
1 = Output will be forced to active state
0 = Output will be forced to inactive state.
Note: Outputs of CO4013 are active low.

Index	6207h
Name	Error Value Output 8 Bit
Description	-
Data Type	Array

Index	Subindex 0
Name	Nr of Subobjects
Description	
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	No
Value Range	-
Default Value	Number of digital output bytes

Index	Subindex 1 to Nr of input bytes
Name	Error Value Output 8 Bit Byte n
Description	
Data Type	Unsigned 8
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0 (Inactive, high level)

The following objects are describing the functionality of the analog input lines of the CO4013A.

The number of analog input bytes depends on the number of supported axis.

Index 5401 : Axis Zero Point Enlargement

With Object 5401, the zero area of the joystick may be enlarged. The Axis Value will be forced to zero, if the analog input voltage from the axis potentiometer is less than Object 5401. In this case the Joystick may be moved in the zero position without setting an input voltage.
The axis position value (object 6401) will be calculated as follows:
If 6401 > 5401 then 6401= 6401 - 5401
Else if 6401 < -5401 then 6401= 6401 + 5401
Else 6401= 0

Index	5401h
Name	Axis zero position enlargement
Description	-
Data Type	Array

Index	Subindex 0
Name	
Description	Number of mapped objects
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	NO
Value Range	-
Default Value	Number of axis

Index	Subindex 1 to Nr of input lines
Name	Axis zero position enlargement
Description	See above
Data Type	unsigned 16
Access modes	RW
PDO Mapping	NO
Value Range	-
Default Value	1000h

Index 6401 : Joystick Position 16 Bit

Object 6401, represent the values of the axis potentiometers. The position of the joystick potentiometer is coded as a 16 bit conversion result of the analog input voltage in a signed value. Therefore voltages less then 2.5V are read as negative input voltage. An input of 2.5V is read as 0 (zero position of joystick axis) and an input voltage higher than 2.5V is converted into positive values.
If the application requires reading of the analog input voltage as unsigned values, the object 6431 may be used for adding an offset to the conversion result.

The mapping of the I/O lines to object 6401 is explained in chapter "Mapping I/O to Object Dictionary"

Index	6401h
Name	Read Analog Input
Description	-
Data Type	Array

Index	Subindex 0
Name	
Description	Number of mapped objects
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	NO
Value Range	-
Default Value	Number of axis

Index	Subindex 1 to Nr of input lines
Name	Read Analog Input
Description	Proportional axis input
Data Type	Signed 16
Access modes	RO
PDO Mapping	YES
Value Range	-
Default Value	-

Index 6421 : Analog Input Interrupt Trigger

Object 6421 selects the event that shall cause a transmission interrupt for the selected analog channel.

There is one Subindex for each channel to enable individual setting according to application requirements.

Table of possible Trigger Conditions:

Bit Nr	Interrupt Trigger Selection
0	Input voltage greater than Upper Limit
1	Input voltage less than Lower Limit
2	Input changed by more than Delta
3	Input reduced more than Negative Delta
4	Input increased more than Positive Delta
5 to 7	Reserved (must be forced to zero)

Index	6421h
Name	Analog Input Interrupt Trigger
Description	-
Data Type	Array

Index	Subindex 0
Name	
Description	Number of mapped objects
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	NO
Value Range	-
Default Value	Number of analog input lines

Index	Subindex 1 to Nr of input lines
Name	Analog Input Interrupt Trigger
Description	Selects trigger condition
Data Type	Unsigned 8 (See Table of Trigger Conditions)
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	7

Index 6423 : Analog Input Interrupt Enable

This object enables or disables globally the interrupt behaviour without changing the interrupt masks.
The interrupt is disabled by default, in order to avoid transmission of analog input values.

TRUE (1)= global interrupt enabled
FALSE (0)= global interrupt disabled

Index	6423h
Name	Analog Input Interrupt Enable
Description	-
Data Type	Boolean
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	FALSE

These objects give the Limit for generation of interrupts. All objects have the same structure.
The function of the interrupt limit is only enabled, if the corresponding bit of object 6421 is set.
All values of limit parameters are signed 32. So the user must take care not to exceed the range of the input data objects.

Table of Limit Function

Object	Object Name and Function
6424	Analog Input Upper Limit Generate interrupt if input voltage is greater than Upper Limit (6424)
6425	Analog Input Lower Limit Generate interrupt if input voltage is less than Lower Limit (6425)
6426	Analog Input Interrupt Delta Generate interrupt if input voltage changed by more than Interrupt Delta
6427	Analog Input Negative Delta Generate interrupt if input voltage reduced by more than Negative Delta
6428	Analog Input Positive Delta Generate interrupt if input voltage increased by more than Positive Delta

Index	6424/5/6/7/8/9
Name	See table above
Description	-
Data Type	Array

Index	Subindex 0
Name	
Description	Number of mapped objects
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	NO
Value Range	-
Default Value	Number of analog input lines

Index	Subindex 1 to Nr of input lines
Name	See table above
Description	
Data Type	Integer 32
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0

Object 6431 adds an offset value to the analog input data object (6400 / 6401).
The normal input scaling for analog data objects 6400 and 6401 considers conversion of negative input voltages (input amplifier must shift to positive voltages because input port pin is 0 to 5V only) by placing the zero point (of data) to 2.5V. (middle of input voltage range)
If application requires only positive input values an offset may be add with object 6431, in order to adjust the zero point for data to an input voltage of 0V. For 8 Bit analog conversion (object 6400) the offset value (object 6431) must be 80h. For 16 Bit analog conversion (object 6401) the offset value must be set to 8000h.

Index	6431h
Name	Analog Input Offset
Description	-
Data Type	Array

Index	Subindex 0
Name	
Description	Number of mapped objects
Data Type	Unsigned 8
Access modes	RO
PDO Mapping	NO
Value Range	-
Default Value	Number of analog input lines

Index	Subindex 1 to Nr of input lines
Name	Analog Input Offset
Description	
Data Type	Signed 32
Access modes	RW
PDO Mapping	No
Value Range	-
Default Value	0

The CO4013 supports several emergency messages. For all emergencies the same structure is used:

Byte							
0	1	2	3	4	5	6	7
EMY-Code		1001	0	CO4011-Code			

EMY-Code: Emergency-Error-Code according to DS301
1001: Content of Object 1001
CO4011-Code: Emergency-Error-Code for CO4011 as unsigned 32 value

CO4013-Code (hex)	May change NMT	I/O	Description
8000 0000	X	X	CAN bus is bus off
4000 0000			CAN bus in error warning state
3000 0000	X	X	Life guarding error

If more than one error is active at the same time, the bitmap of the CO4013-Codes for all active errors are combined with a logical or conjunction.

Some of the emergencies may cause a NMT state change and/or may force the output pins to the error state.

The ID for emergency transmission is fixed to:
0x80 + $NodeID.

List of emergency messages:

Life-Guarding Error							
30	81	11	00	00	00	00	00

This error occurs, if the masters fails to transmit the guarding remote frame within the specified Life Time (Guard Time object 100C multiplied with Life Time Factor object 100D)

CAN Bus in Error Warning state							
00	81	11	00	00	00	00	00

This error occurs, if the chips internal CAN module is in error warning state.

Return from CAN Bus OFF							
40	81	11	00	00	00	00	00

This message indicates a return from Bus OFF state.

cable break detection							
20	31	81	00	8x	00	00	00
Error bits				bit0	x-axis		
				bit1	y-axis		
				bit2	z-axis		
				bit3	w-axis		

This error occurs, if the axis is active and a cable isn't connected or broken.

The mapping of the I/O channels depends on the setting of configuration bits CFG0 to CFG3.
All possible configurations are shown in individual tables. Select the table for your application according to your joystick I/O requirements.

Note for A/D converter the resolution is fixed with 10 bit. Tables that show analog input with 16-bit mean, that dictionary entry is made as signed integer (16 bit wide).

The following tables are describing the Mapping of the I/O to the dictionary considering there is a 4 axis joystick connected. If there are less then 4 axis, the objects for deactivated axis are not implemented.

See chapter "Device Configuration" for more information how to disable any axis.

Costumer specific configurations are available on request.

The following table shows a summary of possible operation modes.

CFG				Mode	Description
3	2	1	0		
1	1	1	1	0	Memory function with push button internal analog value freeze
1	1	1	0	1	Memory function with push button no internal analog value freeze
1	1	0	1	2	Memory function with switches internal analog value freeze
1	1	0	0	3	Memory function with switches no internal analog value freeze
1	0	1	1	4	No memory function
1	0	1	0	5	reserved *1)
1	0	0	1	6	reserved *1)
1	0	0	0	7	reserved *1)
0	x	x	X		reserved *1)

*1) These modes are reserved for future use and must not be set. Selecting the reserved modes may cause improper operation of the device.

See chapters "Device Configuration" and "Operation Mode: Memory Function and I/O" for further information about the operation modes.

The selected operation mode may be read via object 2101h from the object dictionary.

<u>Note:</u>
Setting of configuration must be fixed. The CO4013 scans the setting of CFG0 to CFG3 only during reset. Changing of configuration on the fly is not allowed and may cause improper operation of the device.
<u>Note:</u>
CFGx are input pins during start up and output pins in normal operation mode. In order to prevent short circuit overload, a series resistor between CFGx and configuration device (example DIP switch) should be used. See also "typical application" for details.

No Memory function

Operation mode 4								
CFG 3 = 1 CFG 2 = 0 CFG1 = 1 CFG0 = 1								
EDS-file: CO4013A4.EDS								
No Memory function								
20 direction- and general purpose digital input lines								
4 general purpose output lines								
Data Mapping to Dictionary								
Index. SubIndex	Mapped I/O Signal bit/value							
	7	6	5	4	3	2	1	0
6000.01 MEMORY- Input Or -Flip-Flop	0	0	0	0	0	0	0	0
	All Memory flags forced to 0							
6000.02 Direction-Input	W-N	W-P	Z-N	Z-P	Y-N	Y-P	X-N	X-P
	P POSITIVE input N NEGATIVE input *1)							
6000.03 General- Purpose Input	IN7 .. IN0 *1)							
6000.04 General- Purpose Input	0	0	0	0	IN11 .. IN8 *1)			
6200.01 General- Purpose Output	-	-	-	-	OUT3 .. OUT0 *1)			
6401.01	X-Axis proportional value (16 bit)							
6401.02	Y-Axis proportional value (16 bit)							
6401.03	Z-Axis proportional value (16 bit)							
6401.04	W-Axis proportional value (16 bit)							
Default PDO Mapping								
PDO	Mapped Data							
RPDO1	6200.01 General-Purpose Output							
TPDO1	6000.01 Memory Input (forced to 0) 6000.02 Direction Input 6000.03 General-Purpose Input 6000.04 General-Purpose Input							
TPDO2	6401.01 X-Axis proportional value 6401.02 Y-Axis proportional value 6401.03 Z-Axis proportional value 6401.04 W-Axis proportional value							

*1) Note: The CO4013 has inverted input/output pin polarity.

The MCB402 is configured in this mode.

6. Dimensions.