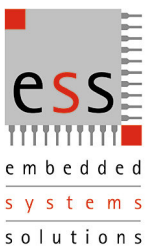
User Manual

No. 1



September 2003

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Contents

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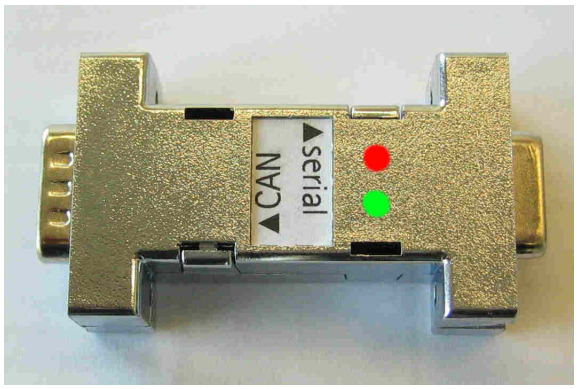
1. Introduction

Thank you for choosing a product of our CANgine product family. The CANgine family is based on high performance 8 bit microcontrollers with integrated full CAN interface and flash memory. With these products you are able to build extermely small but powerful CAN units.



CANgine No. 1 is powered via the CAN connector. The serial link "speeks" pure ASCII code. Therefore CANgine No. 1 can be used on nearly any device with a serial link to which you have access. So the connection to CAN bus is possible for nearly all automation devices even for older ones.

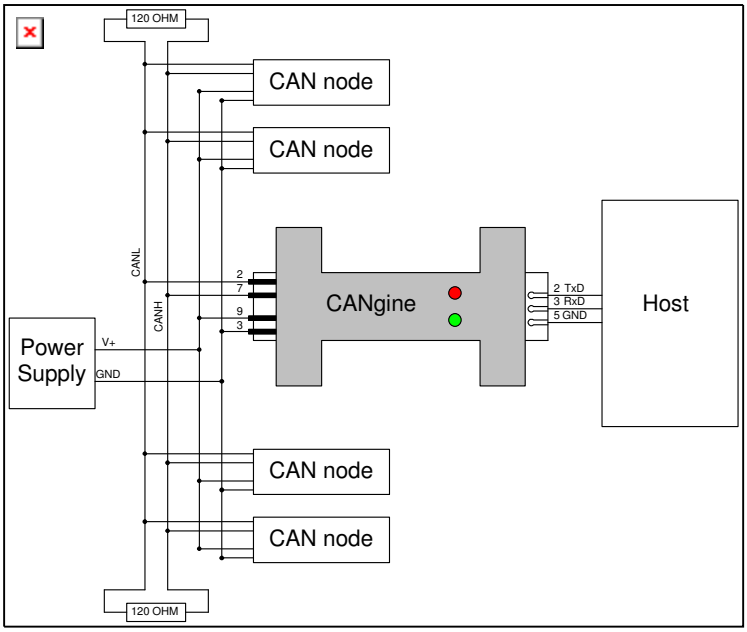
In it's standard case, CANgine No. 1 only measures 53 x 34 x 16 mm³. If this does not fit for some applications CANgine can be delivered in other cases or without case in customer specific variants. Due to the modular concept of CANgine in hardware and software this is possible even at lower production volumes. Email or call our sales departement if you have special requirements.

The serial link of CANgine No. 1 runs with baud rates from 1200 up to 115200. The CAN bus supports all CiA (CAN in Automation) recommended bit rates between 10 kBaud and 1 Mbaud. Installation and diagnostics are supported by two LEDs.

Updating the software or loading customer specific software is easy due to the in system programmability of the internal microcontroller. You don't even have to open the case to load a new firmware.

2. Installation

The picture shows how to connect CANgine to a CAN network. Power supply is connected via pin 9 (+) and pin 3 (GND) of the CAN connector as proposed by CiA. The maximum supply voltage is 30 V. Applying higher voltages will lead to damages. Pay attention to the terminating resistors (120 Ohm) at both ends of the CAN bus.



After applying the supply voltage the green LED blinks. The blink-

ing code shows the baud rate of the serial link:

Pulses	Baudrate
2	115200
3	57600
4	38400
5	19200
6	9600
7	4800
8	2400

Blinking stops if the CAN bus is activated with the O command. Starting with that command the green LED signals the state of the CAN bus.

CANgine No. 1 now is in working state and executes commands coming via serial link.

To make first tests with CANgine we recommend to use a PC with a terminal program. You should use the following settings:

- baud rate according to CANgine setup
- 8 data bit
- no parity
- one stop bit
- no protocol
- Inserting of newline char (0x0A) on receiving carriage return (0x0D)
- local echo

3. Initializing procedure

On power on some internal checks are run to guarantee a good operation of CANgine. One of these is checking the program memory with a checksum. To visualize these checks the red LED is switched on immediately after applying power. If all checks are run successfully the red LED is switched off. If a program checksum failure is detected, the red LED blinks with a blinking code of seven.

If the internal checks are completed successfully the peripheral devices (RS232 and CAN) are initialized and the red LED is switched off. The green LED blinks with a blinking code signalling the serial baud rate (see table above). Blinking stops if the CAN is activated. Srtiung at this moment the green LED shows if CAN is active or inactive (due to command C or any bus errors).

4. Instruction Execution

As soon as a complete command line (terminated with CR character) is detected the command line is translated and executed. Each command line is answered with a positive (e.g. CR character) or negative (BELL charactwer 0x07) acknowledge. Before sending the acknowledge character no other command lines will be accepted.

Both the serial link and the CAN bus are serviced with interrupts. Therefore reception of CAN messages has a higher priority than executing commands.

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5. CAN Transmit and Receive Buffer

CANgine has two circular buffers (queues). One is used for reception the other for transmission of CAN messages. Each queue can hold up to 30 messages.

The bottleneck on receiving CAN messages is the serial link. At 115200 kbaud the maximum rate is 350 standard or 250 extended CAN frames per second. These values were measured with 8 data bytes. If the messages has less data bytes the values will be slightly higher. If you have heavy CAN load you have to set the acceptance filters to adapt CANgine in a ideal manner to your application and optimize the message throughput.

To help you optimize the throughput CANgine implements two counters. The first counts the number of messages which are correctly entered in the receive queue. The second counts the number of messages which were discarded due to a full receive queue. The counters has 32 bit and therefore counts from 0 to 4,294,967,295. On overflow theses counters restart counting at 0. Reading these counters is done with the X command. Both counters are reset with the F command (reading the error information).

6. Error Handling and Signaling

The following errors are detected and saved in an error marker:

Error	Bit of error marker
CAN receive queue overflow	0
CAN transmit queue overflow	1
CAN "error passive" detected	5
CAN "bus error" detected	7

Additionaly these errors are signaled by the LED ERR with different blinking codes.

ERR (blink code)	Meaning
8	CAN bus error (bus off)
7	reserviert
6	CAN error passive state
5	reserviert
4	reserviert
3	reserviert
2	CAN transmit queue full
1	CAN receive queue full

With the F command the error marker is read and reset.

The LED ERR only shows the error with the highest error code. The error marker shows all errors detected since startup or last reading of error marker. Reading the error marker not only resets it but also switches the LED ERR off. Consider that the red LED will not switch off if the error still is active (e.g. CAN bus state error passive). In this case you first have to correct the error reason (often wrong baudrate on some CAN node) before resetting the CANgine error situation with the F command.

Another special situation is a CAN bus error when executing the F command. A CAN bus error situation in the internal CAN controller can only be reset by a complete re-initialization

of the CAN controller. This is done if the F command is executed while a CAN bus error is detected.

7. Commands

7.1 Overview

A[CR]	send all received CAN frames to serial link
C[CR]	close CAN
F[CR]	send error information to serial link
mxxxxxxxx[CR]	set acceptance mask register
Mxxxxxxxx[CR]	set acceptance tag register
O[CR]	open CAN channel
P[CR]	send one received CAN frame to serial link
Sn[CR]	set CAN baud rate to n = 0..8 (0 = 10 kbit, 8 = 1Mbit)
saabcde[CR]	set CAN baud rate via internal controller register
tiiildd..[CR]	send a CAN frame in standard format (11 bit ID)
Tiiiiiiiildd..[CR]	send a CAN frame in extended format (29 bit ID)
Un[CR]	set RS232 baud rate to n = 1..8 (1 = 115200 baud, 8 = 1200 baud)
V[CR]	send version information to serial link
X[CR]	send CAN frame counter information to serial link
Zn[CR]	set serial link output to continuous or single frames

7.2 A Command

Send all CAN frames from receive queue to serial link. The output format complies with the format for the T or t command. After each frame a CR character is send, after the last frame an additional A character with a CR character is send.

Format:

A[CR]

Answer:

All received frames, followed by A[CR]
A[CR] if no frames are available
[BELL] if CAN is inactive or if the command line format is invalid

7.3 C Command

Closes the CAN channel. After executing this command CANgine does not influence the CAN bus in any way. No more ACK bits are send on receiving frames. The green LED RUN switches off.

Format:

C[CR]

Answer:

[CR] if command was executed
[BELL] if CAN is inactive or the command line format is invalid

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7.4 F Command

Sends error information to th eserial link and resets error marker and the red error LED

Format:
F[CR]

Answer:
Fxx[CR]
[BELL] if command line format is invalid

F is a hexadecimal value with two digits:

7	6	5	4	3	2	1	0
CAN Bus Off	res	CAN error passive	res	res	res	Transmit queue overflw	Receive queue overflw

7.5 M Command

Sets the 32 Bit acceptance tag register for filtering of receive frames. This command is only valid if CAN is deactivated.

Format:
Mcccccccc[CR]
cccccccc acceptance tag register (8 hexadecimal digits)

Answer:
[CR] on successful execution
[BELL] if CAN is active or command line format is invalid

See chapter acceptance filtering for meaning of the parameter.

7.6 m Command

Sets the 32 Bit acceptance mask register for filtering of receive frames. This command is only valid if CAN is deactivated.

Format:
mcccccccc[CR]
cccccccc acceptance mask register (8 hexadecimal digits)

Answer:
[CR] on successful execution
[BELL] if CAN is active or command line format is invalid

See chapter acceptance filtering for meaning of the parameter.

7.7 O Command

Opens the CAN channel and activates the CAN controller. After executing zthis command the CAN controller connects to the CAN bus and receives messages according to the acceptance filter settings. The green LED RUN switches on.

Format:
O[CR]

Answer:
[CR] on successful execution
[BELL] if CAN was already active or if command line format is invalid

7.8 P Command

Sends one CAN frame from the receive queue to the serial link. If more than one frames are in the queue the oldest frame is sent.

Format:
P[CR]

Answer:
One CAN frame in the same format as described at the t or T command. The frame is terminated with [CR]
[CR] without any other preceding characters if no frames are available in the receive queue
[BELL] if CAN is inactive or if command line format is invalid

7.9 S Command

Sets the CAN baud rate to one of the CiA recommended values. The Command can only be executed if CAN is inactive.

Format:
Sn[CR]

S0	10 kBit
S1	20 kBit
S2	50 kBit
S3	100 kBit
S4	125 kBit
S5	250 kBit
S6	500 kBit
S7	800 kBit
S8	1 MBit

Answer:
[CR] on successful execution
[BELL] if CAN is active or if command line format invalid

Answer: [CR] command executed successfully
[BELL] invalid value for n or CAN is active

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7.10 s Command

Sets the bus timing registers of the internal CAN controller. This command can be used where the standard baud rate settings do not fit because special bus topologies are used. To get the right values see the data sheet of Atmels T89C51CC01.

Format:

saabcde[CR]

aa X2 Bit and BTR register in two hexadecimal digits (00..7F)

7	6	5	4	3	2	1	0
0	X2 Bit	BTR					

b PRS register (0..7)
c PHS1 register (0..7)
d PHS2 register (0..7)
e SJW register (0..3)

Answer:

[CR] on successful execution
[BELL] if CAN is active or if command line format invalid

7.11 t Command

Puts a standard (11 bit identifier) CAN frame in the transmission queue. The transmission queue is scanned continuously and if the CAN transmitter is available the next frame is read from transmission queue and sent to the CAN bus. If more than one entry is found in the queue the oldest entry is transmitted first.

Format:

tiiildd…[CR]

t command character
iii CAN identifier with fixed length (3 hexadecimal digits {000..7FF})
l number of data bytes in the message (1 digit {0...8})
dd… data bytes (hexadecimal digit count is 2 x l, no separation character)

Answer:

[CR] if frame was entered in the transmission queue
[BELL] if CAN is inactive, transmission queue full or command line format invalid

7.12 T Command

Puts an extended (29 bit identifier) CAN frame in the transmission queue. The transmission queue is scanned continuously and if the CAN transmitter is available the next frame is read from transmission queue and sent to the CAN bus. If more than one entry is found in the queue the oldest entry is transmitted first.

Format:

Tiiiiiiiildd…[CR]

T command character

iiiiiiii	CAN identifier with fixed length (8 hexadecimal digits {00000000..1FFFFFFF})
l	number of data bytes in the message (1 digit {0...8})
dd…	data bytes (hexadecimal digit count is 2 x l, no separation character)

Answer:

[CR] if frame was entered in the transmission queue
[BELL] if CAN is inactive, transmission queue full or command line format invalid

7.13 U Command

Sets the baud rate of the serial link. The answer to the command is given with the old baud rate then the baud rate is switched.

U1	115200
U2	57600
U3	38400
U4	19200
U5	9600
U6	4800
U7	2400

Format:

Un[CR]

Answer:

[CR] on successful execution
[BELL] if command line format is invalid

7.14 V Command

Sends hardware and software version information to the serial link

Format:

V[CR]

Answer:

Vhhss[CR]
hh = hardware version
ss = software version
[BELL] if command line format is invalid

7.15 X Command

Sends the actual values of the CAN frame counters to the serial link. First the counter value for successfully processed frames is sent, than a [CR] character followed by the counter value for the discarded frames is sent. The answer is terminated by a [CR] character.

Format:

X[CR]

Answer:

s..s[CR]f..f[CR]

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s..s = {0.. 4294967295}
f..f = {0.. 4294967295}

[BELL] if command line format is invalid

The frame counter are reset by reading the error information with the F command.

7.16 Z Command

The Z command serves to control the CANgine behaviour on receiving CAN frames. CANgine can collect the frames in th ereceive queue and wait until a P or A command is given or it can send a received frame immediately to the serial link. The command is only valid if the CAN channel is closed.

Format:
Za[CR]
a=1 continuous output on
a=0 continuous output off

Answer:
[CR] on successful execution
[BELL] if CAN is active or Z state is already given or if command line format is invalid

8. Receiving CAN Frames

Messages received from CAN must successfully pass acceptance filtering (chapter 8.2) before being inserted into the receive queue. Depending on settings for handling of received frames a message is send to the serial link upon request (P or A command) or immediately (Z1 command) after receiving the CAN frame.

8.1 Output Format

The output format is compliant to the format of the transmit command (T or t). The only difference is that received massages are preceded with a 'r' (standard format – 11 bit identifier) or 'R' (extended format – 29 bit identifier) character.

8.1.1 Standard Frame

riiildd…[CR]

r	marks a standard frame (11 bit identifier)
iii	CAN identifier with fixed length (3 hexadecimal digits {000..7FF})
l	number of data bytes in the message (1 digit {0...8})
dd…	data bytes (hexadecimal digit count is 2 x l, no separation character)

8.1.2 Extended Frame

Riiiiiiiildd…[CR]

R	marks an extended frame (29 bit identifier)
iiiiiiii	CAN identifier with fixed length (8 hexadecimal digits {00000000..1FFFFFFF})
l	number of data bytes in the message (1 digit {0...8})
dd…	data bytes (hexadecimal digit count is 2 x l, no separation character)

8.2 CAN Acceptance Filtering

The acceptance filtering permits to receive only these CAN frames which are relevant for the connected application. Acceptance filtering relieves the processor from processing unnecessary CAN frames which is particularly important at high bus loads and / or high baud rates.

CANgine uses two registers for acceptance filtering:

- acceptance tag register
- acceptance mask register

The acceptance tag register holds the bits which has to be one or zero in the message identifiers. The mask register marks the bit positions for filtering with a one.

Example for standard (11 bit) identifier
You wish to receive all messages with identifier between 0x100 and 0x1FF, all other messages should be filtered and disregarded. Set bits 10..8 in the acceptance mask register to one and in the acceptance tag register to 0x001.

Bit	10	9	8	7	6	5	4	3	2	1	0
Tag	0	0	1	x	x	x	x	x	x	x	x
Mask	1	1	1	0	0	0	0	0	0	0	0

So tag register = 0x100, mask register = 0x700.

CANgine allows with two additional bits to filter also the IDE bit which distinguish between standard and extended frames and the RTR bit which marks RTR messages.

With this you are able to decide if you want to receive only standard or only extended frames or both. You can also filter on RTR messages. The CANgine acceptance filter register are both 32 bit wide. The identifier bits are shifted to bit position 31 (counting from 0) and the bit position 2 marks RTR and bit position 0 DIE. The table shows the relation between bit positions in the both formats (standard and extended) and the bit positions in CANgine.

S	10	9	8	7	6	5	4	3	2	1	0	-	-	-	-	-
Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13

S	-	-	-	-	-	-	-	-	-	-	-	-	-	RTR	-	IDE
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E	12	11	10	9	8	7	6	5	4	3	2	1	0	RTR	-	IDE

Bit 0 in the tag and mask registers decides which format is received and which discarded:

M[0]	**m[0]**	**Verhalten**
0	0	receives both frame types
0	1	receives only standard frames
1	0	receives both frame types
1	1	receives only extended frames

Example:
To only receive standard frames with identifier between 0x100 and 0x1FF set the registers to:
acceptance tag register (M): $0x100 * 2^{21} + 0 = 0x20000000$

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acceptance mask register (m): 0x700 * 2^{21} + 1 = 0xE0000001

To only receive extended frames with identifier between 0x100 and 0x1FF set the registers to:

acceptance tag register (M): 0x100 * 2^{3} + 1 = 0x00000801
acceptance mask register (m): 0x700 * 2^{3} + 1 = 0x00003801

9. Initial Operation and Test with a PC

Connect CANgine to the RS232 port you will use in the terminal program. Connect a CAN cable to CANgine and support DC power (7..30VDC) on pins 3 (GND) and 9 (+).

Check the baud rate on the serial link with the blink count of the green LED. Start your preferred terminal program and set the baud rate accordingly. Other settings: 8 data bits, no parity, 1 stop bit, no hardware protocol, no software protocol. We also recommend: local echo, Insert of [LF] (0x0A) on [CR] (0x0D), as CANgine does not echo received characters and only sends [CR] as line terminator.

Type 'V' (CANgine is case sensitive) followed by the enter key. CANgine answers with Vhhff, where hh is the hardware version (e.g. 20) and ff is the firmware version (e.g. 21).

Now set the CAN baud rate according to your CAN bus with the S command. The default value is 125 kbaud. Then type Z1[CR] to set CANgine to the continuous output mode. Finally type O[CR] to open the CAN channel and to receive messages.

You now see all received CAN messages (standard and extended frames) on your terminal program. Watch the red LED ERR to see if all frames could be received or if the serial baud rate is too slow for your CAN bus load or baud rate.

10. Connector Pinout

10.1 Serial Link

Pin	Signal	Pin	Signal
1	nc	6	nc
2	TxD	7	nc
3	RxD	8	nc
4	nc	9	nc
5	GND		

10.2 CAN

Pin	Signal	Pin	Signal
1	nc	6	GND
2	CANL	7	CANH
3	GND	8	nc
4	nc	9	+Vcc
5	nc		

11. Technical Data

Power Supply	7 .. 30	VDC
Supply Current	35 (typ.)	mA
Internal Microcontroller	internal clock: 40 Full CAN 2.0B interface	MHz
CAN Transceiver	82C251	
CAN Connector	Sub-D 9 pin male	
CAN Baudrate	10 .. 1.000	kBit
Serial Connector	Sub-D 9 pin female	
Serial Baudrate	2.400 .. 115.200	baud
Display	LED RUN (green) LED ERR (red)	
Size	53 x 54 x 16 2.08 x 1.32 x 0.62	mm^3 $inch^3$
Weight	22	g
Operating Temperature	-40 .. +80	℃

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