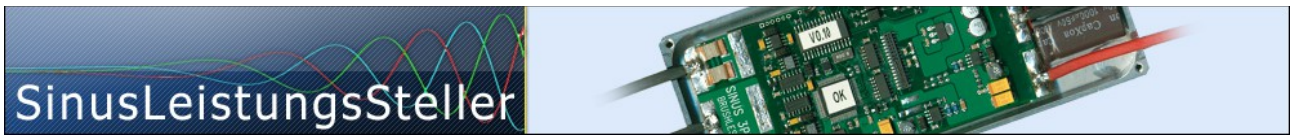


CAN-Bus - Protocol - SLR

Low-level documentation
needed for implementation
of own host software.

based on Firmware V0.750, released 06. October 2022
(Document status 06. October 2022)

Ing.-Büro Zimmermann - Industriestraße 7 - D-97297 Waldbüttelbrunn
Tel.: +49 (0) 931/78011030 - www.SinusLeistungsSteller.de - info@SinusLeistungsSteller.de

Inhaltsverzeichnis

1 General Structure

All messages sent via CAN-Bus are using same frame-structure with 11-Bit-Identifier followed by up to 8 Bytes of payload-data.

ID: 11 Bits		DATA: up to 8 Bytes
4 Bits	7 Bits	
MSG	NODE	

ID: The ID consists of 4 bits for the MSG-number and 7 bits for the NODE-address.
MSG-numbers 0 to 7 are for **sending commands** to the SLR (see 3.1 - 3.8).
MSG-numbers 8 to 15 are for **receiving information** from the SLR (see 4.1 - 4.8).

DATA: 0 to 8 bytes of this frame are transferred.
Unused transmitted payload-data are random.

2 Used Dataformats

2.1 Float32

A float in IEEE 754 format is used.

Byte 0		Byte 1	Byte 2	Byte 3
S	exponent		mantissa	

S: Sign-bit

e**xponent:** 8 bit exponent

mantissa: 23 bit mantissa

2.2 Int32

Byte 0	Byte 1	Byte 2	Byte 3
High-Word		Low-Word	
High-Byte	Low-Byte	High-Byte	Low-Byte

2.3 Int16

Byte 0	Byte 1
High-Byte	Low-Byte

2.4 Bits in Byte

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

2.5 Address

Byte 0	Byte 1
Address_H	Address_L

Address: The address of the payload parameter, range: 0x0000 .. 0xFFFF

3 Command

3.1 Broadcast

A broadcast message will be received **simultaneously** by all nodes.

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0	Node	--	--	--	--	--	--	--	--

Broadcast with Node=0 is for everyone. Each SLR connected to the CAN-Bus sends a acknowledge. By this, a host can scan the CAN-Bus segment for active nodes.

To test if a single CAN-Bus node is still active, its node-address must be set. Only the addressed controller will send an acknowledge.

3.2 ECU-Control

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
1	Node	Control	--	--	--	--	--	--	--

Control:

Bit 7-0

W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0
--	--	brake		reset		source	

Bit 7 free_7 reserved, no function yet, set to 0

Bit 6 free_6 reserved, no function yet, set to 0

Bit 5-4 **brake:** 00 no brake
01 speed brake: the motor brakes by short circuit of the 3 phases
10 torque brake: a brake current is applied
11 reserved

Bit 3-2 **reset:** 00 no action
01 **Clear:** all errors are cleared (no reset/reboot)
10 **Reboot:** complete software will be restarted (via reset vector)
11 reserved

Set to "no action" for normal motor operation.
Only when the motor is stopped (no active rotating and no brakes enabled), the reset will be carried out. With firmware V0.690 the resets are transparent to the mode selection.

Bit 1-0 **source:** 00 no reference via CAN-Bus
01 reference by ServoSignal (like ServoSimulation)
10 reference by RPM/current (like ControlPanel)
11 reserved

3.3 Signal reference value

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
2	Node	Signal		--	--	--	--	--	--

Signal : **S**ignal reference value [µs], range: 800 .. 2200 µs, int16

3.4 Speed reference value

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
3	Node	Speed				--	--	--	--

Speed : Speed reference value [rpm], range: -CCW .. 0 .. +CW the maximum speed is limited to the values in the parameters.
Default value after reset 0,0 rpm. float32

3.5 Current reference value

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
4	Node	Imot				Igen			

Imot : motor current specification [Aac], range: 0.. I_Mot, the maximum Current is limited to the values in the parameters.
Default value after reset 0,0 Aac. float32

Igen : generator current specification [Aac], range: 0 .. I_Gen, the maximum Current is limited to the values in the parameters.
Default value after reset 0,0 Aac. float32

3.6 Ramps

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
5	Node	accel				decel			

accel: acceleration rate, range: 0.. accel, the maximum acceleration rate is limited to the values in the parameters [rad/sec²].
Default value after reset 1,0 rad/sec². float32

decel: deceleration rate, range: 0.. decel, the maximum deceleration rate is limited to the values in the parameters [rad/sec²].
Default value after reset 1,0 rad/sec². float32

3.7 Command with Address

Address: The address of the payload parameter, range: 0x0000 .. 0xFFFF

Payload: There are different types of payload described in the next sections.

3.7.1 Command with **float32** as payload

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
6	Node	Address		Payload					

3.7.2 Command with **int32** as payload

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
6	Node	Address		Payload					

3.7.3 Command with **int16** as payload

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
6	Node	Address		Payload		--	--	--	--

3.7.4 Command with **byte** as payload

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
6	Node	Address		Payload	--	--	--	--	--

A table of the used addresses can be found in chapter 5 at the end of the document!

3.8 Update

3.8.1 Parameter update

Parameter update is only available if either the "Expert" or "Motor parameters" option is enabled.

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7	Node	0x00	0x00	Block number		Data 0	Data 1	Data 2	Data 3

The parameter file contains 256 bytes, split into 64 blocks of 4 bytes each for transmission.

With block 0, bytes 0 to 3 are transmitted,
With block 1, bytes 4 to 7 are transmitted, etc.
The last block (block 63) contains the last bytes 252 to 255 of the file.

The file name (up to 16 characters) occupies 4 additional blocks sent directly afterwards (block 64...67).

When all blocks have been transferred, the paramters are checked by SLR-Firmware. Only if this check is successful, the parameters will be activated.

A final message is send by the SLR with result of Parameter update containing value of address 0x8F00.

0x8F00: 0x01 => Parameter update successful

0x8F00: 0xFE => Parameter update denied because Password is set

0x8F00: 0xFF => Parameter update denied because of transmission error

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
14	Node	0x8F00		Payload	--	--	--	--	--

Please note:

Transfer of new Parameters can be done even while motor is active rotating or brakes are active.

But switching to new Parameter will exclusively performed while motor is stopped (no active rotating and no brakes enabled)!

Parameter update protocol is started with sending block 0. Further blocks can be sent in random order. If a block is sent more than once, only the first copy is valid, others copies of this block will be ignored.
Parameter update protocol is finished when all blocks are transmitted.

Each successful Parameters update will force an erase of internal TraceMemory as soon as these Parameters are activated.

3.8.2 Firmware update

(do be defined)

4 Feedback

4.1 Identifier

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
8	Node	Project	Hardware	Firmware		SN	

Project: project-ID (=5 for all SLR), byte
Hardware: hardware-ID, byte
Firmware: firmware-version (hexadecimal, eg. 0x0635 is V0.635), int16
SN: serial number of the SLR, int16

4.2 RPM and ServoSignal

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
9	Node	RPM				Signal		D_IN

RPM: speed [rpm], float32

Signal_L, Signal_H: ServoSignal [µs], the uppermost 4 bits must be masked (12-bit value), int16
If the timeout has triggered, the µs value read back value is invalid (0).

D_IN (Digital Input):

Bit 7-0

R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
HS_Stop	--	--	--	Din4	Din3	Din2	Din1

Bit 7 **HS_Stop** (HallSensorStop)**:** 1 if parking was successful, otherwise 0
Bit 6-4 **unimplemented:** read as '0'
Bit 3 **Din4:** direct value read in at the digital input 4
Bit 2 **Din3:** direct value read in at the digital input 3
Bit 1 **Din2:** direct value read in at the digital input 2
Bit 0 **Din1:** direct value read in at the digital input 1

4.3 Current

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
10	Node	IQ				ID			

IQ: current IQ [Aac], float32

ID: current ID [Aac], float32

4.4 Voltage

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
11	Node	Ubatt				UZK			

UBatt: battery voltage [V], float32

UZK: intermediate circuit voltage [V], float32

4.5 Temperature

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
12	Node	TP		TExt		Idc			

TP (Powermodule-Temperature): int16
There are two different types of temperature sensors:

Type 1a (KTY (R25=2k0 + 2k0)): conversion to °C:

$$T = -178{,}4 + \left(249 * \sqrt{\frac{3416}{4095 - TP} - 1}\right)$$

Type 1b (KTY (R25=2k0 + 4k7)): conversion to °C:

$$T = -185{,}1 + \left(367 * \sqrt{\frac{3816}{4095 - TP} - 1}\right)$$

Type 2 (NTC): Conversion to °C:

$$T = \frac{Beta}{\ln\left(\frac{TP * 4700}{(4095 - TP) * R25}\right) + \left(\frac{Beta}{298}\right)} - 273$$

The Beta value and the resistance value R25 can be found and configured in the WMon under Extras / NTC_Config.

If the Beta value is set to 0 then this is a Type1a sensor (KTY (R25=2k0 + 2k0)).
If the Beta value is set to 1 then this is a Type1b sensor (KTY (R25=2k0 + 4k7)).

TExt (external Temperature, only by some SLR): Conversion to °C: see TP, int16

Idc: current from the battery [Adc], float32
(not available on each SLR)

4.6 Faults and derate

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
13	Node	T_F	U_F	C_F	Any _DR	T1 _DR	T2 _DR	Umax _DR	Umin _DR

T_F (over-temperature fault):

Bit 7-0

R-0	R-0	R-0	U-0	U-0	U-0	U-0	U-0
SO_T	CMT	LMT	--	--	--	--	--

The value in curly brackets {} can be found in the Windows Monitor >Parameter > Limits!

Bit 7 **SO_T:** SwitchOff OverTemp (TP > 100°C) =>Failsafe (SLR stopped)
Bit 6 **CMT:** CutOff MaxTemp (TP > 90°C, TExt > {T2_upper Lim})
Bit 5 **LMT:** Limit MaxTemp(TP > {T1_lower Lim}, TExt > {T2_lower Lim})
Bit 4-0 **unimplemented:** read as '0'

U_F (over- /under-voltage fault):

Bit 7-0

R-0	R-0	R-0	U-0	R-0	R-0	R-0	U-0
SO_OV	CMV	LMV	--	SO_UV	CUV	LUV	--

The value in curly brackets {} can be found in the Windows Monitor >Parameter > Limits!

Bit 7 **SO_OV:** SwitchOff OverVolt (mSLR-28-xx: Udc > 29V
mSLR-36-xx: Udc > 37V
mSLR-60-xxx: Udc > 61V
SLRi-60-xxx: Udc > 61V)
Bit 6 **CMV:** CutOff MaxVolt (U > {Udc_upper Lim})
Bit 5 **LMV:** Limit_MaxVolt (U > {Udc_lower Lim})
Bit 4 **unimplemented:** read as '0'
Bit 3 **SO_UV:** SwitchOff UnderVolt (mSLR-28-xx: Udc < 4,8V
mSLR-36-xx: Udc < 7,8V
mSLR-36-55: Udc < 9,7V
mSLR-60-xxx: Udc < 15V
SLRi-60-xxx: Udc < 15V)
Bit 2 **CUV:** CutOff_MinVolt (U <{Udc_lower Lim})
Bit 1 **LUV:** Limit_MinVolt (U < {Udc_upper Lim})
Bit 0 **unimplemented:** read as '0'

C_F (Error of the internal control):

Bit 7-0

R-0	U-0	R-0	R-0	R-0	R-0	R-0	R-0
PL_F	HW_F	ZS_F	I_F	OS_F	LL_F	2PH	FS

Bit 7 **PL_F:** PhaseLoss_Flt -> stop+retry
Bit 6 **HW_F:** HW-Overcurrent_Flt-> stop+retry
Bit 5 **ZS_F:** ZeroSpd_Flt -> stop+retry
Bit 4 **I_F:** I_Offset_Flt -> stop+retry
Bit 3 **OS_F:** OvrSpd_Flt -> stop+retry
Bit 2 **LL_F:** Loadless_Fault -> stop+retry
Bit 1 **2PH:** 2-Phase-PWM
Bit 0 **FS:** Failsafe_STOP (SLR stopped) -> check -> clear Error

Any_DR(above all derate Register):
T1_DR (Temp1 Max derate Register)**:**
T2_DR (Temp2 Max derate Register)**:**
Umax_DR (Overvoltage derate Register)**:**
Umin_DR (Undervoltage derate Register)**:** These 5 registers give more detail on how far is down regulated.
Value ranges for the 5 Derate registers:
0xFF (it is not yet regulated) until
0x00 (controller switches off)

4.7 Feedback with Address

Address: The address of the payload parameter, range: 0x0000 .. 0xFFFF

Payload: There are different types of payload described in the next sections.

4.7.1 Feedback with **float32** as payload

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
14	Node	Address		Payload			

4.7.2 Feedback with **int32** as payload

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
14	Node	Address		Payload			

4.7.3 Feedback with **int16** as payload

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
14	Node	Address		Payload		--	--

4.7.4 Feedback with **byte** as payload

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
14	Node	Address		Payload	--	--	--

A table of the used addresses can be found in chapter 5 at the end of the document!

5 Table of used Addresses

Address Read	Address Write	Payload	Format
0x8200	0x0200	**MSGBox:** to activate a MSGBox, the associated bit must be set. (default: 0x3F) **Bit0:** The identifier MSGBox (Telegram-number: 8) is activated if this bit is set, otherwise it is deactivated. **Bit1:** The RPM and µs Signal MSGBox (Telegram-number: 9) is activated if this bit is set, otherwise it is deactivated. **Bit2:** The current MSGBox (Telegram-number: 10) is activated if this bit is set, otherwise it is deactivated. **Bit3:** The voltage MSGBox (Telegram-number: 11) is activated if this bit is set, otherwise it is deactivated. **Bit4:** The temperature MSGBox (Telegram-number: 12) is activated if this bit is set, otherwise it is deactivated. **Bit5:** The fault and derate MSGBox (Telegram-number: 13) is activated if this bit is set, otherwise it is deactivated. **Bit6:** The answer with sub ID MSGBox (Telegram-number: 14) is activated if this bit is set, otherwise it is deactivated. **Bit7:** This MSGBox (Telegram-number: 15) is not used yet.	byte
0x8201	0x0201	**delay:** Time gap to next transmission in steps of ms, range: 0 .. 32767 ms (default: 500ms, up to version 0.674 the value was 20ms)	int16
0x8202	0x0202	**I_FieldWeak:** Field weakening current specification [Aac], range: 0.. I_FieldWeak, the maximum Current is limited to the values in the parameters, float32 (Node 2)	float32
0x8203	N/A	**NTC BETA onboard:** BETA value of the internal NTC (if T1 was measured with NTC, if a KTY13 is installed, this value is 0)	int16
0x8204	N/A	**NTC2/ext BETA(25/80):** BETA-value of the NTC for the temperature range 25/80	int16
0x8205	N/A	**NTC2/ext R25:** resistance of the NTC at 25 ° C	int16
0x8206	0x0206	**timeout:** maximum time until a new CAN-message must be received, otherwise the engine will stop. range: 1 .. 32767 ms, 0 = not timeout (default) the timeout has triggered, the µs value read back value is invalid (0).	int16
0x8207	N/A	**MaxRPM:** the maximum speed that can be enabled in the parameter set [rpm]	int32
0x8240	N/A	**projectnumber:** project number internal hardware number	int32
0x8241	N/A	**ECU-voltage:** rated voltage [V]	int16
0x8242	N/A	**ECU-Current:** rated current [Aac]	float32
0x8243	N/A	**firmwareversion:** the firmware currently installed on the controller	int16
0x8320	N/A	**ECU-CONTROL:** the mirrored value from 3.2	byte
0x8340	N/A	**Speed reference value:** the mirrored value from 3.4	float32
0x8350	N/A	**Imot reference value:** the mirrored value from 3.5	float32
0x8351	N/A	**Igen reference value:** the mirrored value from 3.5	float32
0x8360	N/A	**accel :** the mirrored value from 3.6	float32

0x8361	N/A	**decel:** the mirrored value from 3.6	float32
0x8400	0x0400	R (Node 1)	float32
0x8401	0x0401	Lq (Node 1)	float32
0x8402	0x0402	Ld (Node 1)	float32
0x8403	0x0403	ke (Node 1)	float32
0x8404	0x0404	PP (Node 1)	int16
0x8405	0x0405	KP_w (Node 1)	float32
0x8406	0x0406	KI_w (Node 1)	float32
0x8407	0x0407	KD_w (Node 1)	float32
0x8408	0x0408	KP_iq (Node 1)	float32
0x8409	0x0409	KI_iq (Node 1)	float32
0x840A	0x040A	KD_iq (Node 1)	float32
0x840B	0x040B	KP_id (Node 1)	float32
0x840C	0x040C	KI_id (Node 1)	float32
0x840D	0x040D	KD_id (Node 1)	float32
0x840E	0x040E	KP_pll (Node 1)	float32
0x840F	0x040F	KI_pll (Node 1)	float32
0x8410	0x0410	KD_pll (Node 1)	float32
0x8F00	0x0F00	Update Parameter status (internally used)	byte
0x8F01	0x0F01	Update Firmware status (internally used)	byte

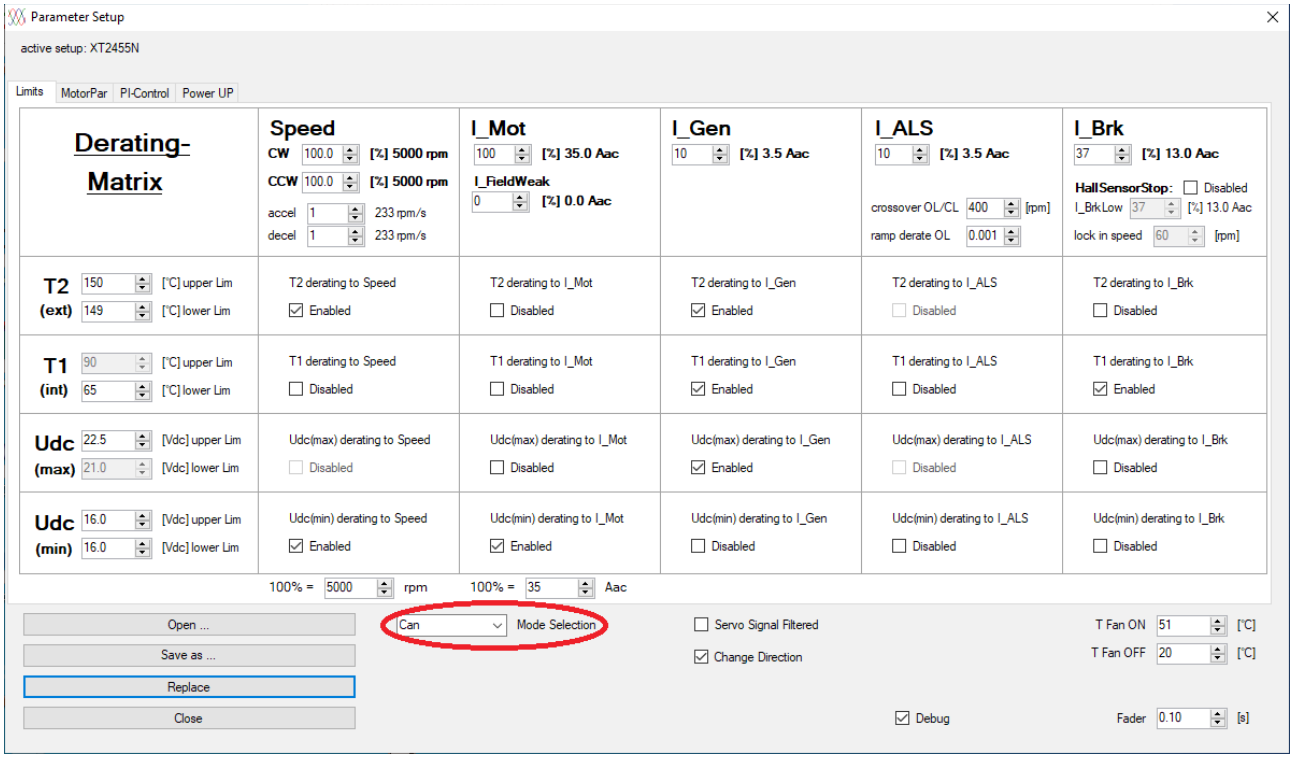
At the moment only few addresses are used.
Future SLR-firmware-versions might map further parameters into the available address-range as needed.

(Node 1) In order to be able to write these parameters, either the "Expert" or "Motor parameters" option is required.
(Node 2) In order to be able to write these parameter, the "field weakening” option is required.

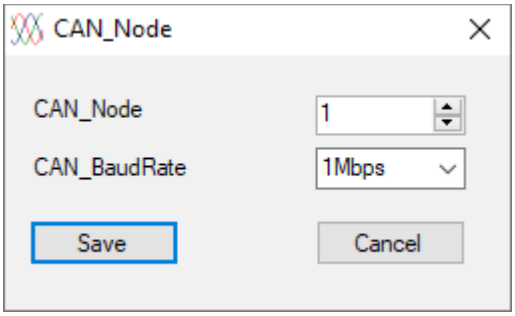
6 Getting startet with CAN

6.1 Check settings in parameter

The first thing to do is to ensure that the Windows-Monitor has been switched to CAN-mode. In Parameters/Limits, the mode must be set to CAN.



The next step is to set the CAN_BaudRate and the CAN_node in Extras/CAN



6.2 Check for connected SLR and verify communication

Next is to check if the communication is working and all connections are done correctly. The easiest way for this is to send a broadcast (see chapter 3.1). Every connected and correctly configured SLR then answers with its ID.

In the simplest broadcast, the identifier is 0 followed by 0 data bytes.

4 Bits	7 Bits
0x0	0x00
0x000	
11 Bit ID	

All correctly connected SLR answer with their ID and 6 DataBytes. (See chapter 4.1)

e.g. SLR with node = 1 will answer:

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
0x8	0x01	5	6	0x0640		111	
0x401							
11 Bit ID							

6.3 Getting status information and activate MessageBoxes for answers

As a default (after powerup or reset), the SLR sends 6 feedbacks every 500 ms, see Chapters 4.1 to 4.6

e.g.:

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
0x9	0x01	Rpm = 0				Signal = 1500	
0x481							
11 Bit ID							

Settings that are rarely required can be made using "command with address".

To configure the feedback of the SLR, the following must be sent:

4 Bits	7 Bits	Byte 0	Byte 1	Byte 2
0x6	0x01	0x0200		0x02
0x301				
11 Bit ID				

Byte 2 = 0x02 (only the RPM and µs Signal MSGBox is activated)

6.4 Active motor control with reference values

If active control via CAN is needed, you have to decide, if reference values are transmitted as:

- µs-values (interpreted by the SLR via SignalCurve-LUT)

or

- as real physically values for speed[RPM], currents[A], etc.

Via ECU Control (See chapter 3.2) you can specify this source of reference signal. We are assuming a µs specification here:

4 Bits	7 Bits	Byte 0
0x1	0x01	0x01
0x081		
11 Bit ID		

Next, the µs value must be specified. (See chapter 3.3)

4 Bits	7 Bits	Byte 0	Byte 1
0x2	0x01	1500	
0x101			
11 Bit ID			

Range for Signal (Byte 0,1) is 800 .. 2200µs

Reminder:

- Reference signals (µs-values or physically values) must be sent frequently to avoid a timeout trigger event!

- All physically reference values will be clipped to the parameter´s max. values. Speed reference value(ch. 3.4) will be clipped to maxCW/maxCCW, the same applies for Currents reference values (Ch. 3.5) and Ramps (Ch. 3.6)