BRUSA

SOFTWARE

STATE MACHINE

On-board Fast Charger

NLG66X-U0

Translation of the original German operating instructions

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LEGAL NOTICE

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Updates	In light of the further technical development of our products, we reserve the right to make technical changes. Any changes will be disclosed in the relevant manuals through the replacement of the relevant pages and/or a revision of the electronic data storage device.
Writer/Author	Manuel Tschumper

REVISIONS

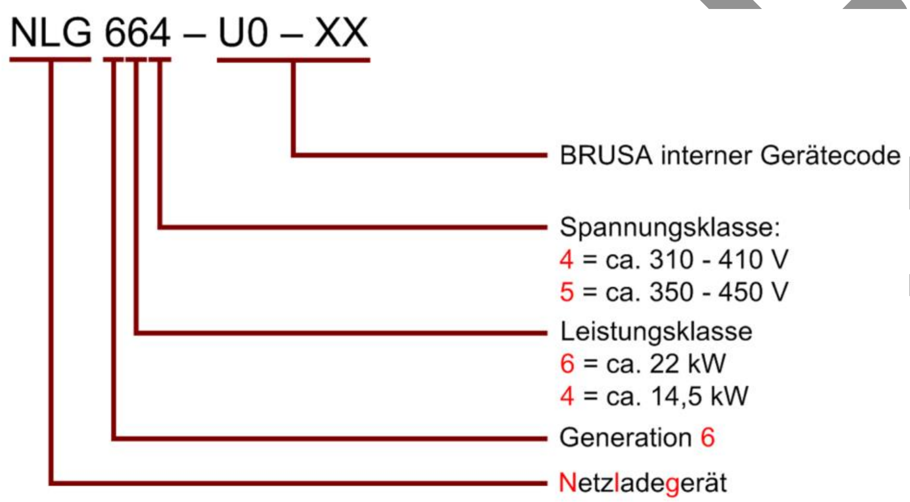
REVISION	DATE	NAME	CHANGE
Rev01	17th Sept. 2013	M.Tschumper	Creation of the document.
Rev01.1	30th Sept. 2013	L.Böhler	Extension 5.3.1 => Cyclical WakeUp option
Rev02	1st May 2014	B.Graf	Removed NLG665, and general revision

VALIDITY

This manual is only valid for the devices listed in the following table:

NLG664 – UO – XX*****

The decoding of the device designation is as follows



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1 Foreword

Dear customer!

With the BRUSA NLG6 Charger, you have purchased a very high performance and versatile product. Since the present device is a power electronics product which uses dangerous voltages and currents, special expertise with respect to handling and operation is required!

Before installing the NLG6 Charger or carrying out any other work on it, read this manual thoroughly, in particular chapter 3 *Safety and warning instructions!*

2 List of abbreviations

Throughout this manual, some specific technical abbreviations are used. The following table provides an overview of these abbreviations and their meaning:

ABBR.	MEANING	ABBR.	MEANING
CAN	**C**ontroller **A**rea **N**etwork	**PI**	**P**ower **I**ndicator
CP	**C**ontrol **P**ilot	**VCU**	**V**ehicle **C**ontrol **U**nit
NLG	Mains charger (**N**etz**l**ade**g**erät)	**PON**	**P**ower **ON**
EVSE	**E**lectric **V**ehicle **S**upply **E**quipment	**PP**	**P**roximity Resistance
NMT	**N**etwork **M**anagement	**PWM**	**P**ulse **W**idth **M**odulation
I_N	Mains input current (I_{L1},I_{L2},I_{L3})	**µP**	Microprocessor

3 Safety and warning instructions

This chapter contains safety instructions applying to this device. These instructions refer to the assembly, start-up and running operation in the vehicle. Always read and observe these instructions in order to ensure personal safety and to avoid damage to the device!

3.1 Symbols and their meaning

Throughout this manual, some specific technical symbols are used. For an overview of symbols as well as their meaning, refer to the following table:

PROHIBITION SYMBOLS

SYMBOL	MEANING	SYMBOL	MEANING
	General prohibition		Warning! High voltage! Do not touch!
	Do not switch!		

WARNING SYMBOLS

SYMBOL	MEANING	SYMBOL	MEANING
	General hazard warning		Electromagnetic field warning
	Warning! Explosion hazard area. t		Warning! Danger caused by batteries!
	Warning! Hot surface!		Warning! High voltage!
	Warning! High pressure/fluid ejection!		Warning! Fire hazard!

MANDATORY SIGNS

SYMBOL	MEANING	SYMBOL	MEANING
	Disconnect device from electric power		Disconnect device from mains

INFORMATION SIGNS

SYMBOL	MEANING	SYMBOL	MEANING
	Important information to avoid possible damage to property		Important information

3.2 Safety instructions and danger levels

DANGER
This instruction warns against serious, irreversible risks of personal injury with possibly fatal consequences! Avoid these risks by observing these instructions!

WARNING
This instruction warns against serious but reversible risks of injury! Avoid these risks by observing these instructions!

CAUTION
This instruction warns against a minor risk of injury! Avoid these risks by observing these instructions!

NOTICE
This instruction warns against possible damages to property if the following instructions and work procedures are not observed.

INFORMATION
This type of instruction discloses important information to the reader.

4 General

4.1 Content and scope of this manual

This documentation contains a description of the function and operation of the unit, a description of the state machine, and the individual CAN messages and signals, as well as a few other signals.

4.2 Scope of the entire documentation

NOTICE
In order to successfully operate the charger, the user's manual and possibly some additional software is required. BRUSA will be happy to provide them in appropriate form.

4.3 Contact information of the manufacturer

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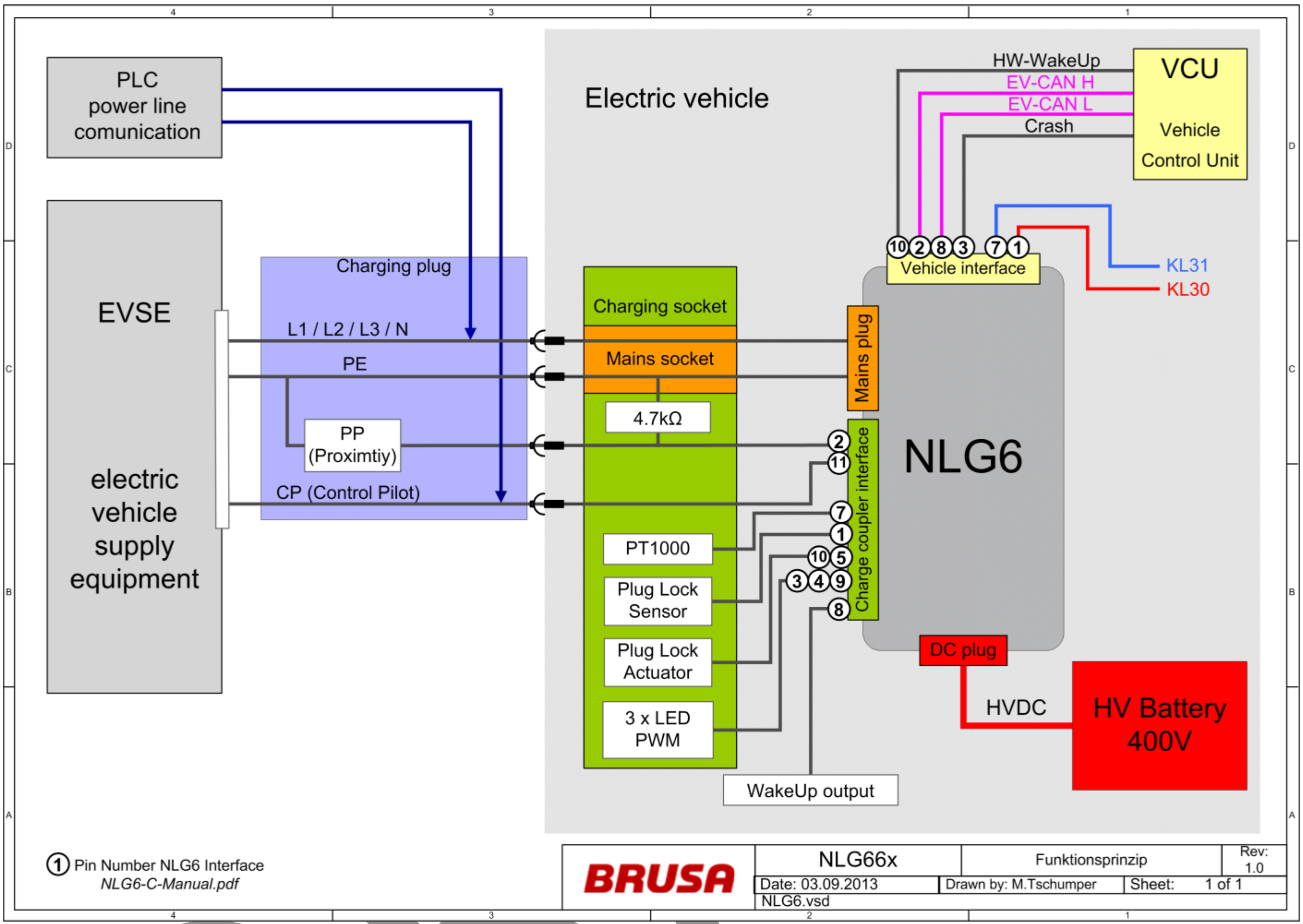
5 NLG6 - Functionality and Interfaces



CHARGE COUPLER PIN	DESCRIPTION	VEHICLE INTERFACE PIN	DESCRIPTION
1	Plug locking feedback signal	1	+12 V (Aux net positive)
2	Proximity Detection Resistor	2	EV CAN high
3	Output LED green	3	Kl30 Crash
4	Output LED blue	4	HV interlock loop output
5	Plug locking	5	not connected
6	not connected	6	not connected
7	PT1000 temperature sensor	7	Earth (Aux net negative)
8	Vehicle WakeUp output	8	EV CAN low
9	Output LED red	9	HV interlock loop input
10	Plug unlocking	10	Hardware WakeUp (input)
11	Control Pilot	11	Debug_CAN_H
12	Earth output LED	12	Debug_CAN_L

5.1 Charging modes

The NLG6 communicates with the infrastructure according to IEC61851, operating in charging mode 1…3. In mode2 and mode3, the proximity resistor tells the maximum allowed current of the mains cable, and the control pilot signal (CP) communicates with the EVSE. The EVSE tells the charger via CP signal the maximum available charging current, and the charger signals back its state (communication ready, ready for charging, etc.).
In mode1 (charging from domestic socket) there is no control pilot signal, and the current in the mains line is not monitored. On delivery, mains current I_N is limited to max. 10 A for mode 1 charging, thus it's in the same range as common household appliances. The PARAM Tool can be used to change the current limit, or to deactivate mode1 charging. (Chapter 12 *PARAM Functions*)

5.2 1-phase charging

NOTICE
For 1-phase charging, L1 needs to be connected. L2 and L3 can only be used in conjunction with L1, to supply the charger in 3-phase charging mode

5.3 Charging process

In order to charge with the NLG6, at least the following two CAN messages are required:

RX NLG_DEM_LIM: These signals control the NLG6.

- NLG_StateDem
- NLG_DcHvVoltLimMax
- NLG_DcHvCurrLimMax
- NLG_AcCurrLimMax
- NLG_C_UnlockConRq
- NLG_LedDem
- NLG_C_VentiRq
- NLG_C_ClrError

TX NLG_ACT_LIM: Sends the following (most important) live data signals to the car or control unit.

- NLG_StateAct
- NLG_DcHvVoltAct
- NLG_DcHvCurrAct
- NLG_AcCurrMaxAct
- NLG_S_ConLocked
- NLG_S_Err
- Additional state bits

5.3.1 Switching on/WakeUp

If the charger is asleep, it can be woken up either by the vehicle (1) , or by the infrastructure (2).

(1) The NLG6 can be woken up by the vehicle via the following inputs and signals:

a) HW WakeUp input (Pin10 of the vehicle interface connector)

b) CAN communication
As soon as the CAN bus carries messages, the NLG6 wakes up. It does not send CAN messages itself though before the message *NLG_DEM_LIM* is received, the *control pilot* is recognized or mains power is detected at the *AC* input.

NOTICE
Any CAN message wakes up the NLG6, even messages that are not relevant for it. So the charger will start to transmit its won CAN messages, which might lead to a WakeUp loop. For this reason, BRUSA recommends to stop all CAN communication 3s after transmitting the last *NLG_DEM_LIM* (0x711) message.

(2) The infrastructure / EVSE / Charge Coupler can trigger the following WakeUp mechanisms:

a) AC voltage

b) Proximity (PP)

c) Control pilot (CP)

d) Optional: By means of a Software Change, a cyclical WakeUp can be realized

e) Optional: If PLC communication is implemented, the NLG6 can be woken up via PLC

The NLG6 can be operated with or without using the HW WakeUp input.

1) Operation without HW WakeUp input *(pin 10 of vehicle interface connector):*
The NLG6 sends CAN messages as long as the *NLG_DEM_LIM* message is received periodically and *Sleep* is not requested via *NLG_DEM_LIM:NLG_StateDem.* The HW WakeUp pin is not connected (or Low/KL31).

2) Operation with HW WakeUp input *(pin 10 of vehicle interface connector):*
The NLG6 sends CAN messages as long as the *NLG_DEM_LIM* message is received periodically and *Sleep* is not requested via *NLG_DEM_LIM:NLG_StateDem,* OR the HW WakeUp pin is *high* (e.g. KL15).

5.3.2 HW WakeUp output

The purpose of the WakeUp output is to wake up control units in the vehicle as soon as the operator plugs in the charging cable. As soon as the cable's proximity resistor is detected, the WakeUp output provides a pulse with KL30 potential (12-14V) for 3 to 5 seconds.

The WakeUp output provides KL30 potential permanently, as long as the NLG6 is communicating on CAN and the proximity resistor is detected.

5.3.3 Start charging

5.3.3.1 Drive mode (charging plug not inserted)

If no PP, CP and AC are detected and the NLG6 is awake, it is in standby mode.

5.3.3.2 Charging preparation

If a charging cable is plugged in, the NLG6 detects its PP resistor and communicates this to the CAN bus via the *NLG_S_ProximityDet* signal. Now, the charging plug can be locked via the *NLG_C_UnlockConRq* CAN signal. Successful locking is indicated by the *NLG_S_ConLocked* CAN signal.

In the following, we distinguish between charging in mode1 and charging in mode2/3, as outlined in IEC61851. Mode1 refers to charging from a common household outlet without any control signals, while mode2/3 is a charging situation where PP and CP signals are used for charging.

Mode 2/3

As soon as a connection is established between EVSE and NLG6, the control pilot changes to [State B *NLG_StateCtrlPilot*] (according to IEC61851). If no errors are present and the charge plug is locked, the CP signal changes to [State C *NLG_StateCtrlPilot*]. The CAN signal *NLG_StateAct* now reports the state *Ready2Charge* (see Chapter 6 *State Machine*) (Chapter 8.1.3 *NLG_ACT_LIM message*)

Mode 1

If AC is detected without CP, but with PP, it is assumed that mode1 charging is intended. If no errors are present and the charge plug is locked, the CAN signal *NLG_StateAct* now reports the state *Ready2Charge.*

5.3.3.3 Charging mode

The power of the NLG6 can be limited by the following parameters of the *NLG_DEM_LIM* message:

NLG_DcHvVoltLimMax:	Desired maximum battery voltage
NLG_DcHvCurrLimMax:	Desired maximum DC current
NLG_AcCurrLimMax:	Desired maximum AC current

After proper values have been assigned to the signals and as soon as the NLG6 is in *Ready2Charge* state, the charging command (*Charge*) can be provided via the *NLG_StateDem* CAN signal. The *NLG_StateAct* CAN signal changes to state *Charge* then. Now the NLG6 will slowly increase its power until desired values are met, or a limit applies. For example, if a vehicle requests a maximum charging current of 32 A_{AC} on the AC side and the proximity resistor only allows a maximum of 16 A_{AC}, the NLG6 will automatically only charge with a maximum of 16 A_{AC}. If the charger independently terminates charging (refer to the *Charge* → *Standby* state change, chapter 6 *State Machine*), the status *Standby* is returned via the *NLG_StateAct* CAN signal.

5.3.4 Stop charging

Charging is immediately terminated if the *Standby* command is sent via the *NLG_StateDem* CAN signal. The NLG6 transitions through *Shutdown* state to *Ready2Charge* state, and is then ready for the next charging cycle.

Internal relays are kept closed for a few seconds, in case charging is restarted within short time. This way, switching cycles can be minimised in order to improve service life. In this state, only reactive power is drawn from the MAINS. These relays are opened after idling for 5 s.

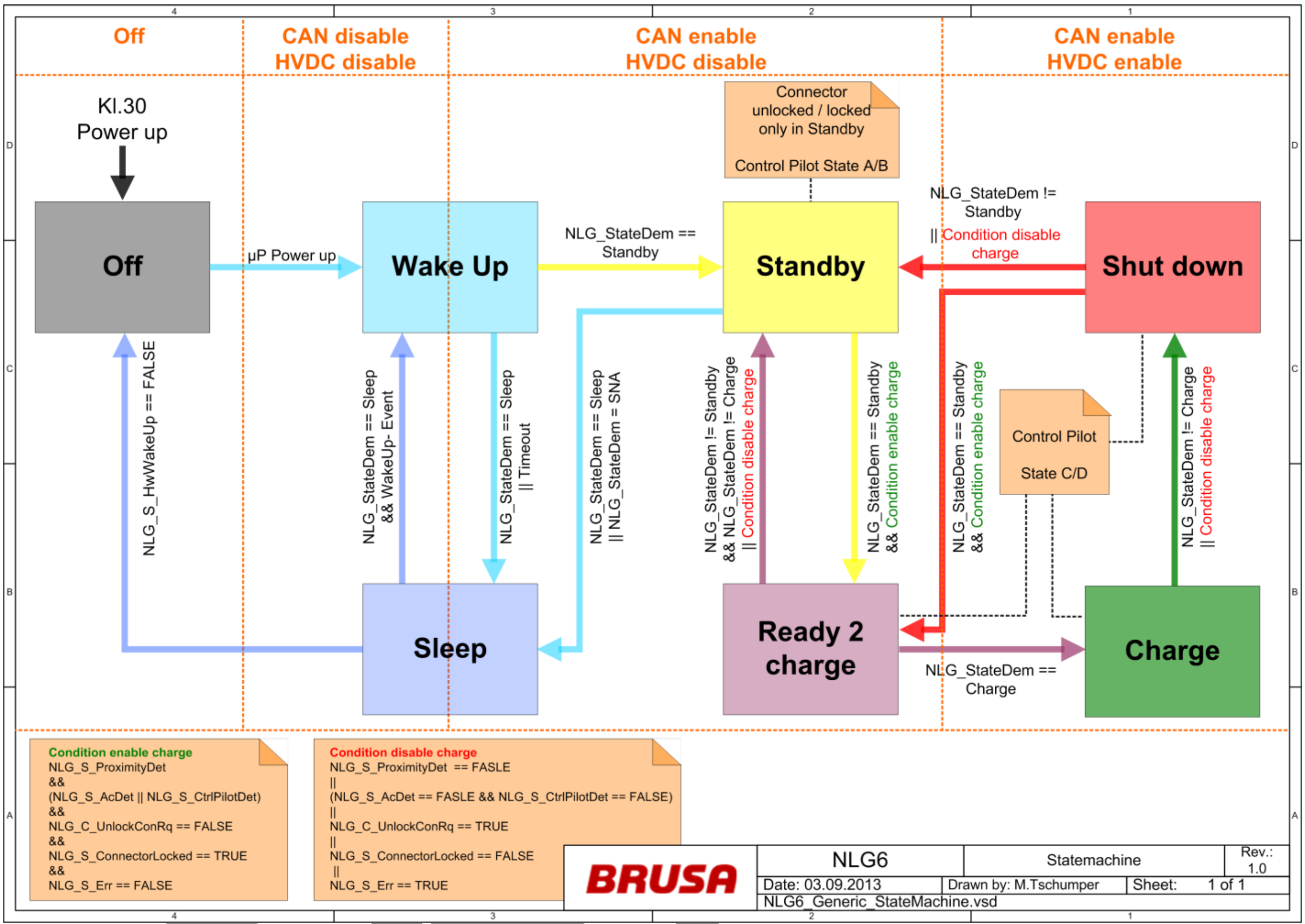
Now, the charging plug can be unlocked via the *NLG_C_UnlockConRq* CAN signal. For this purpose, the NLG6 switches to *NLG_StateAct Standby*, opens the internal relays and indicates subsequent unlocking via the *NLG_S_ConLocked* CAN signal. Afterwards, the user can disconnect the charging plug which is indicated by the *NLG_S_ProximityDet* CAN signal.

5.3.5 Switching off/sleep

It may make sense to keep the charging plug locked (e.g. as theft protection) even if the system is completely shut down.. Due to this, the NLG6 can be set to *Sleep* mode via the *NLG_StateDem* CAN signal, whether or not the charging plug is locked.

As soon as the *Sleep* state is commanded via the *NLG_StateDem* CAN signal and the HW WakeUp input is set to *low* / KL31, the NLG6 opens the internal relays and terminates CAN communication.

6 State Machine



6.1 Basic principle

The NLG6 can be woken up by various sources and set to [State *WakeUp*]. As soon as the CAN communication is enabled and NLG_StateDem == *Standby* is requested, the device is ready for operation and in [State *Standby*]. In [State *Standby*], the NLG6 checks the charging infrastructure. If it is ready for charging and the plug is locked, the device changes to [State *Ready2charge*]. Afterwards, the NLG6 activates the AC voltage via charging column (EVSE) by closing the power contactor in the EVSE through CP signalling. After requesting NLG_StateDem == *charge,* the device switches to [State *Charge*]. However, charging is not initiated before AC (mains) and DC (battery) voltage are detected by the charger. Via NLG_StateDem == *standby,* charging can be interrupted and the device switches to [State *ShutDown*] and eventually to [State *Ready2charge*]. If the EVSE is no longer ready for operation or if the plug is unlocked, the device switches to [State *Standby*].

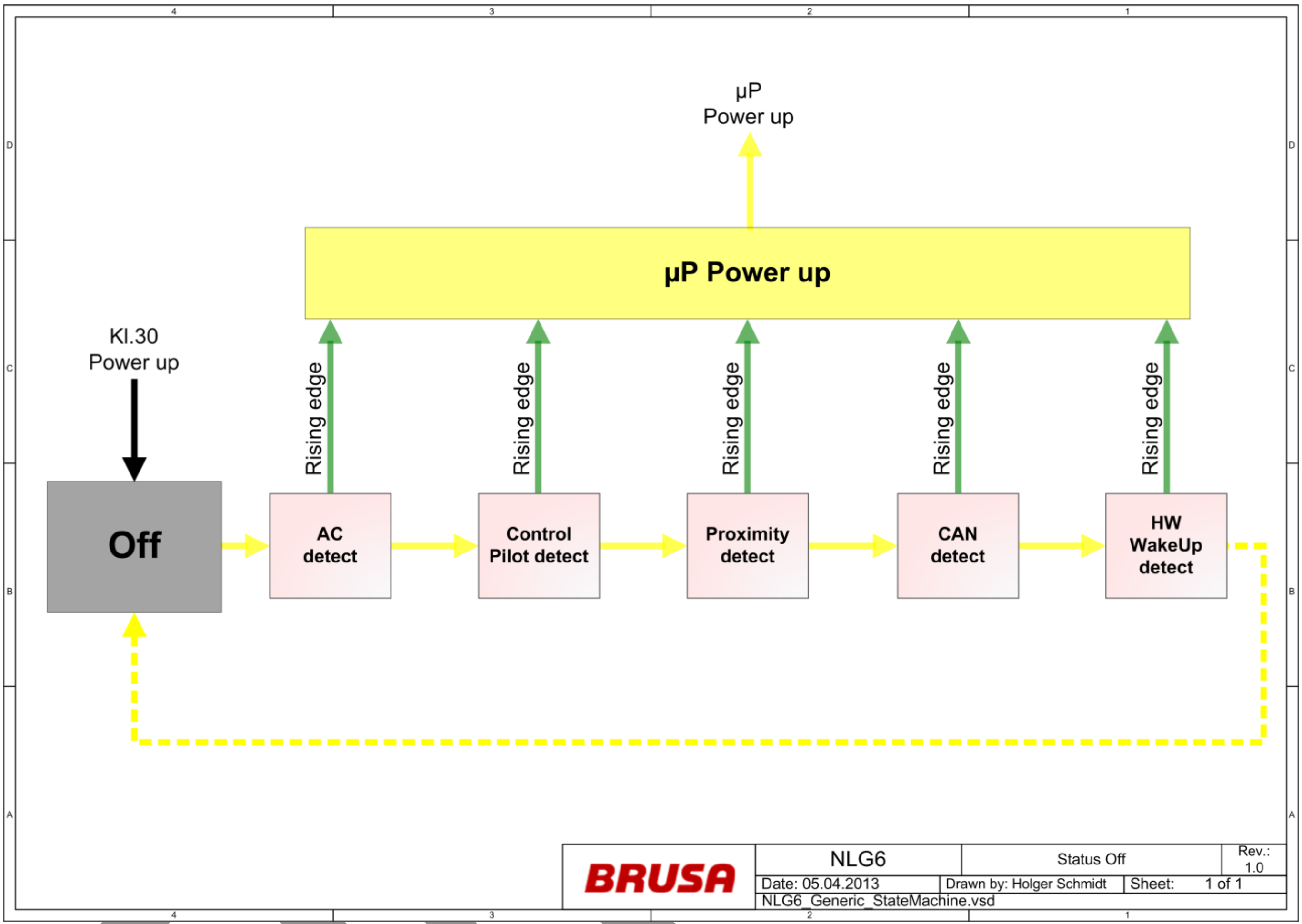
If the device is switched off in [State *Standby*], it transitions to [State *Sleep*] and eventually to [State *Off*].

INFORMATION

To ensure that the runtime data is properly recorded, the charger has to be shut down via NLG_StateDem = *sleep*.

6.2 States

6.2.1 State Off



In [State Off], the NLG6 draws only standby current via KL30/31. The hardware monitors the following WakeUp sources:

- Proximity
- Control pilot (only from state A)
- AC voltage (relevant for mode 1)
- CAN
- HW WakeUp
- Optionally, a cyclical WakeUp is possible (relevant for CP load management)

If a WakeUp source is detected, the µP of the NLG6 is woken up and the power consumption from KL30/31 increases.

6.2.1.1 State change to [WakeUp]

On wakeup of the Microprocessor, the unit changes to [State WakeUp]. (Chapter 6 *State Machine:* µP power up)

6.2.2 State WakeUp

If in State [WakeUp] the signal NLG_StateDem == *standby* is received, the CAN transmission is started immediately (within 250 ms) in order to wake up the vehicle via CAN. Otherwise, the CAN communication to wake the vehicle is not started until CP (for mode 2/3) or AC (for mode 1) is detected

If in State [WakeUp] only PP is detected, then the WakeUp output is activated for at least 2s and a maximum of 5s. So plugging in the charging cable with PP resistor on vehicle side is sufficient to wake up the vehicle.

6.2.2.1 State change to [Standby]

If in state [WakeUp] the signal NLG_StateDem == *standby* is received, then the state is changed to [Standby]

6.2.2.2 State change to [Sleep]

If in state [WakeUp] the signal NLG_StateDem == *sleep* is received, or if the signal NLG_StateDem == *standby* is not received within one minute, then the state is changed to [Sleep].

6.2.3 State Standby

The locking mechanism of the charging plug is requested via NLG_C_UnlockConRq. It can only be controlled in State [Standby],

In state [Standby], the state of the CP is always A or B.

6.2.3.1 State change to [Ready2Charge]

The State changes to [Ready2Charge] as soon as **ALL** of the following conditions are fulfilled:

NLG_StateDem == *standby*	
NLG_C_UnlockConRq == FALSE	
Proximity detected	(NLG_S_ProximityDet)
AC detected or CP detected	(NLG_S_AcDet || NLG_S_CtrlPilotDet)
Plug locked	(NLG_S_ConnectorLocked)
No detected errors active	(NLG_S_Err)

6.2.3.2 State change to [Sleep]

The device changes to State [Sleep] if this is requested by the signal NLG_StateDem == *sleep,* or if the signal is not received for 750 ms.

6.2.4 State Ready2charge

In State [Ready2Charge], the switch S2 (signal switch acc. to IEC61851) of the CP is applied, in order to signal CP state C or D (depending on NLG_C_VentiRq) to the EVSE and thus request to close the AC contactors in the EVSE.

In this state the latest, the HV battery must be firmly connected to the charger, and correct values must be assigned to the CAN control signals (set values).

NLG_DcHvVoltLimMax:	Desired maximum battery voltage
NLG_DcHvCurrLimMax:	Desired maximum DC current
NLG_AcCurrLimMax:	Desired maximum AC current

6.2.4.1 State change to [Charge]

As soon as NLG_StateDem == *charge* is requested, the device changes to [State Charge]

6.2.4.2 State change to [Standby]

If at least **ONE** of the following conditions is fulfilled, the state changes to [Standby]

NLG_StateDem != *charge* and NLG_StateDem != *standby*
NLG_C_UnlockConRq == TRUE

Proximity not detected	(NLG_S_ProximityDet)
AC and CP not detected	(NLG_S_AcDet & NLG_S_CtrlPilotDet)
Plug unlocked	(NLG_S_ConnectorLocked)
Error detected	(NLG_S_Err)

6.2.5 State Charge

In State [Charge], the energy flow is started according to the values requested by CAN as soon as AC voltage and DC voltage are applied. The charging current slope is limited by the charger on the software side. This prevents immediate load changes on the mains (AC supply).

The NLG6 can select the optimum charging mode (1- or 3-phase charging) according to the available and required mains and DC voltage. The currently implemented software only supports 1-phase and 3-phase charging. However, the hardware of the NLG6 also supports 2-phase charging.

3-phase charging generally requires a device-specific minimum voltage:

NLG664 > 308 V_{DC}

Below this voltage limit, the NLG6 always charges in 1-phase mode. If the voltage limit is reached, the NLG6 automatically switches to 3-phase charging. As there is a potential DC voltage drop during this switching process, a hysteresis of 7 V has been implemented. This voltage limit could also be reduced. For this purpose, however, BRUSA Elektronik AG has to be specifically consulted.

During the switching process, loads in the DC circuit and high battery impedances may cause that the DC voltage drops below the minimum voltage limit for 3-phase mode. If this is the case, the device switches to 1-phase charging after a defined delay of 30 s and the switching threshold is increased by 2 V, thereby forcing a higher margin for switching.

The currently active charging mode is indicated by the charging voltages. If the charger is in 1-phase mode, 0 V is always displayed for U_L2_EFF (NLG6_AcVoltL2Act) and U_L3_EFF (NLG6_AcVoltL3Act). This applies even if all three phases are connected physically, as long as the charger is in 1-phase mode.

The charging currents of L2 and L3 are not 0 A in 1-phase mode. The displayed currents L2 and L3 actually flow inside the unit, they indicate the correct function of power ripple compensation (PRC).

The signal sequences are described under chapter 11 *Important to know*, charging power.

If a set current of 0 A is requested, the charger interrupts the power flow by deactivating the internal power stages. Internal relays are kept closed for a few seconds, in case charging is restarted within short time. This way, switching cycles can be minimised in order to improve service life. In this state, only reactive power is drawn from the MAINS. These relays are opened after idling for 5 s.

If 0 V is specified as maximum output voltage, the NLG6 returns an HV range error.

In case of a load dump (HDVC battery is disconnected during charging), the voltage at the NLG6 output quickly increases and triggers an emergency shutdown due to overvoltage. This does not destroy the charger.

For information on power limiting, refer to chapter 11.3 *Charging power calculation*).

6.2.5.1 State change to [ShutDown]

The device changes to State [Standby] if at least **ONE** of the following conditions is fulfilled:

NLG_StateDem != *charge*	
NLG_C_UnlockConRq == TRUE	
Proximity not detected	(NLG_S_ProximityDet)
AC and CP not detected	(NLG_S_AcDet & NLG_S_CtrlPilotDet)
Plug unlocked	(NLG_S_ConnectorLocked)
Error detected	(NLG_S_Err)

6.2.6 State ShutDown

In State [ShutDown] the power is ramped down to zero.

> **NOTICE**
>
> The shutdown phase has to be completed before NLG_StateDem=*charge* can be requested again. This way uncontrolled switching on/off is prevented. So after a shutdown, NLG_StateDem=*standby* must be requested first before the next charging process can be initiated.

In this state, the AC and DC kWh meters are written to the non-volatile memory.

6.2.6.1 State change to [Ready2Charge]

The device changes to State [Ready2Charge] as soon as NLG_StateDem=*standby* is requested and **ALL** of the following conditions are fulfilled:

NLG_C_UnlockConRq == FALSE	
Proximity detected	(NLG_S_ProximityDet)
AC detected or CP detected	(NLG_S_AcDet || NLG_S_CtrlPilotDet)
Plug locked	(NLG_S_ConnectorLocked)
No detected errors active	(NLG_S_Err)

6.2.6.2 State change to [Standby]

The device changes to [State Standby] if at least **ONE** of the following conditions is fulfilled:

NLG_StateDem != *standby*	
NLG_C_UnlockConRq ==TRUE	
Proximity not detected	(NLG_S_ProximityDet)
AC and CP not detected	(NLG_S_AcDet & NLG_S_CtrlPilotDet)
Plug unlocked	(NLG_S_ConnectorLocked)
Error detected	(NLG_S_Err)

6.2.7 State Sleep

In State [Sleep], the device waits until the HW-WakeUp signal is not present any more. As soon as the signal disappears, CAN communication is terminated and the µP of the charger is shut down.

6.2.7.1 State change to [Off]

If NLG_S_HwWakeUp == FALSE, and when the µP has been shut down and the current consumption of KL30/31 has dropped to standby current thus, the device changes to State [Off].

6.2.7.2 State change to [WakeUp]

The device changes to [State WakeUp], if NLG_StateDem != *sleep* is requested or a new WakeUp event occurs.

7 Limits

7.1 Requested limits

The power can be limited by the vehicle by means of the following demand values:

U_A_MAX	(NLG_DcHvVoltLimMax)
I_A_MAX	(NLG_DcHvCurrLimMax)
I_IN_MAX	(NLG_AcCurrLimMax)

If the battery reaches the U_A_MAX threshold, the NLG6 reduces its power automatically in order not to exceed the voltage limit

CAUTION

The NLG6 never cuts off the charging current completely due to the U_A_MAX threshold. For this reason, it is recommended to switch off the charger at a charging cut-off current of e.g. 2A DC (NLG6_DcHvCurrAct).

If the U_A_MAX threshold is exceeded by a value of 6 V, the NLG6 immediately switches off (*NLG6_E_DcHvVoltRange* DC range error).

7.2 External limits

7.2.1 Mains undervoltage

If a phase (L1, L2 or L3) drops below 182 V_{ACeff}, this is considered a "brown out" and charging is immediately interrupted. Simultaneously, *AC detected* (*NLG6_AcDet)* is set to 0. The charging process is continued as soon as the AC voltage returns to the nominal range again.

7.2.2 Mains overvoltage

In case of overvoltage at one of the phases (L1, L2 or L3), the charging process is immediately interrupted and *AC detected* (NLG6_AcDet) is set to 0. The charging process is continued as soon as the voltage returns to the nominal range again.

7.2.3 Mains voltage dips

Before the NLG6 draws energy from the mains, the voltages L1, L2 and L3 are measured and the values saved. The charger automatically reduces its power if the mains voltage drops more than 15 % below these values.

7.2.4 Fuse triggered

If an (external) fuse on L2 and/or L3 is triggered during charging, the charger automatically switches to 1-phase charging. After the fuse is re-engaged, the NLG6 remains in 1-phase mode. The device must be switched off/on to return to 3-phase charging. If the L1 fuse is triggered, charging stops.

7.2.5 Mains disturbances

The NLG6 draws a sinusoidal current with a CosPhi of approx. 1. In combination with the sinusoidal current, distorted mains voltage creates a power ripple that results in a ripple current at the device output. For this reason, the power is slightly reduced at highly distorted mains voltage and and low battery voltage in 3-phase mode, in order to increase the stability of the charger.

7.2.6 1-phase charging

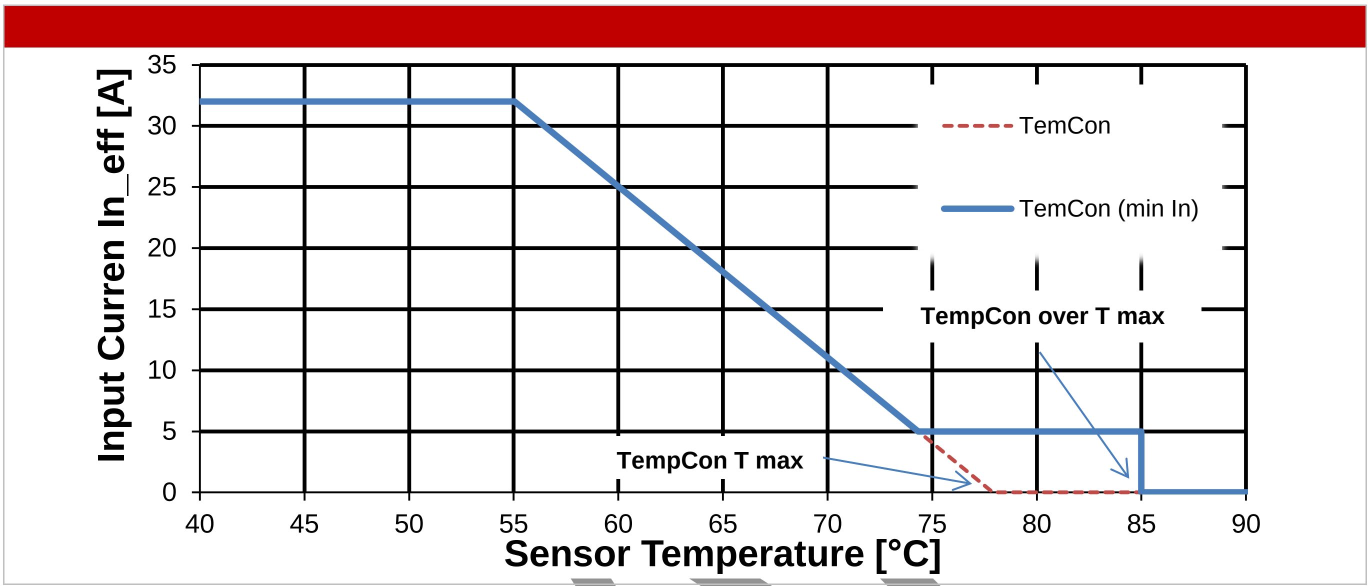
In Germany and other European countries, a maximum asymmetric load of 20 A is permitted. For this reason, a maximum of 16 A is applied for charging in 1-phase mode. This limit can be adjusted by modifying the corresponding software parameter. (Chapter 12 *PARAM Functions*)

7.2.7 EVSE and charging cable limits [proximity detection, control pilot]

The EVSE and charging cable limits are automatically considered by the charger.

7.2.8 Connector temperature derating

In order to prevent overheating of the charging plug, a PT1000 temperature sensor can be connected to the device. Derating takes place according to the following characteristic curve (adjustable by corresponding software parameters, see chapter 12 *PARAM Functions*):

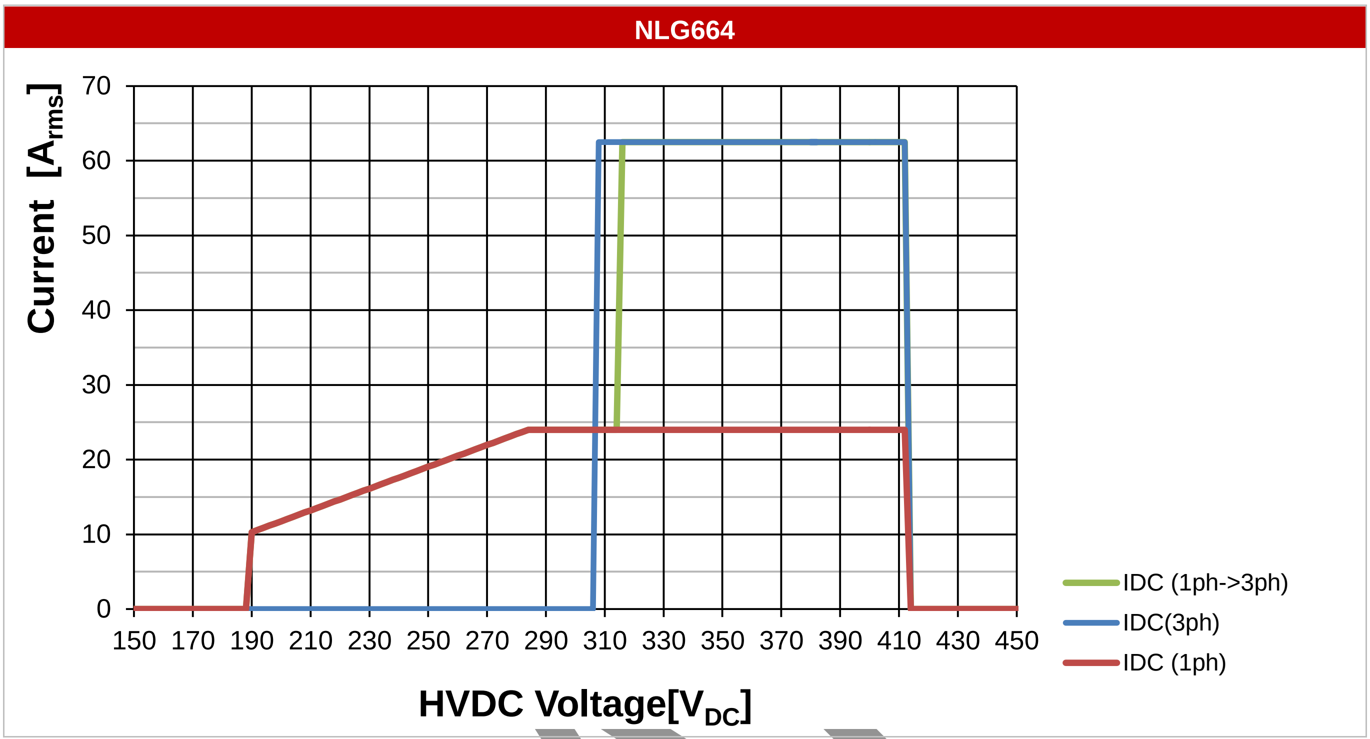


7.3 Device limits

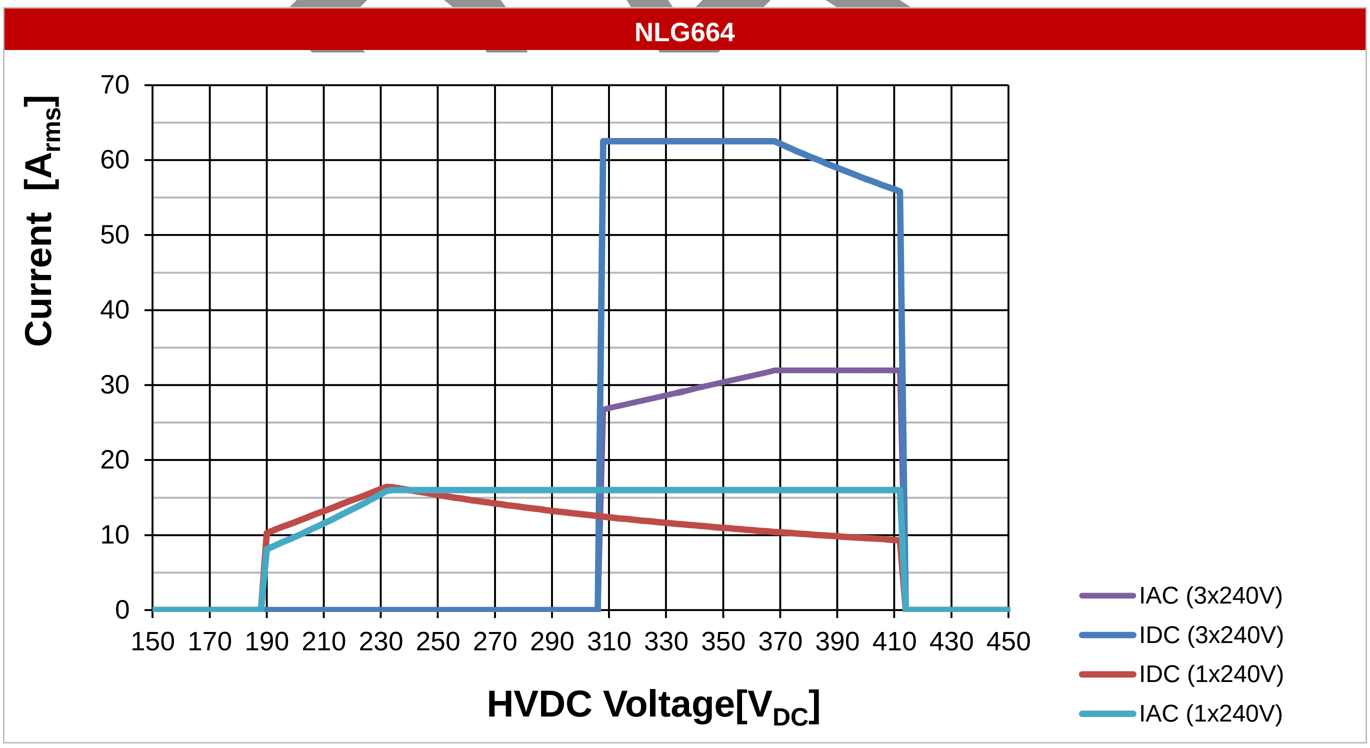
7.3.1 Thermal limits

The NLG6 protects itself against overheating and overload. Inside the device, ten temperature sensors continuously measure specific temperatures and reduce the power throughput if critical temperature thresholds are reached. The power is adapted to the remaining cooling capability of the system then. A potential power reduction due to temperature limits is indicated by the *NLG6_S_IntTempLim* signal.

7.3.2 Max. output current vs. output voltage for 1- and 3-phase charging



7.3.3 Input and output currents vs. output voltage at 240 Vrms input voltage



8 CAN Signals

8.1 TX messages

These are signals that the charger sends to the vehicle as a feedback.

8.1.1 NLG_ACT_AC message

NLG_AcVoltL1Act; NLG_AcVoltL2Act; NLG_AcVoltL3Act
These signals tell the RMS value of the actual AC voltage at phases L1, L2 and L3. During 1-phase operation, 0 V is constantly signalled for L2 and L3. This indicates that the charger is in 1-phase mode.

NLG_S_AcPhaseRot
This signal indicates whether a clockwise (CW => ClockWise) or counter clockwise (CCW => counter clock wise) rotating field is applied at AC input the NLG6. The charger supports both systems without restrictions. Thus, this bit has an informative character and no reaction is required.

NLG_AcFreqAct
This signal tells the actual AC frequency. The NLG6 is designed for 50 Hz systems; outside of the range 49.5 Hz to 50.5 Hz the charger signals an *NLG_W_AcFrequency* warning. Outside the frequency range of 45 Hz to 55 Hz, the charger shuts down and returns the error code: “ AC frequency out of specs”.

NLG_AcCurrL1Act; NLG_AcCurrL2Act; NLG_AcCurrL3Act
These signals tell the RMS value of the currents at the phases L1, L2 and L3 when doing 3-phase charging. In 1-phase mode, NLG_AcCurrL2Act and NLG_AcCurrL3Act are non-zero, although only L1 is supplied from mains. In this case, the currents indicate proper function of the power ripple compensation (PRC), which makes use of the L2 and L3 circuitry.

NLG_AcPowTotAct
This signal tells the power that the charger currently draws from AC mains.

8.1.2 NLG_ACT_INT message

NLG_AcWhAct; NLG_DcHvWhAct
These signals tell the total amount of energy drawn from the mains, and the energy provided to the DC output respectively, which ocurred during the total service life of the NLG6 up till now.

NLG_DcHvAhAct
The signal tells the total amp hours delivered to the battery during the service life of the NLG6.

INFORMATION
The Wh/Ah power meters are reset if the proximity resistor is not detected.

NLG_MaxTempAct
This signal tells the highest actual temperature inside the charger.

NLG_TempCon
Via this signal, the temperature of the temperature sensor connected to the PT1000 input can be read out. The derating characteristic can be parametrised via PARAM. For the default derating characteristic recommended by BRUSA Elektronik AG, refer to chapter 7.8.2 *Connector temperature derating*

8.1.3 NLG_ACT_LIM message

NLG_StateCtrlPilot
Via this signal, the current state of the control pilot (CP) can be read out.

NLG_StateCtrlPilot	DESCRIPTION
State A (12 VDC):	State A of the CP is active if no charger is connected to the EVSE.
State B (9 Vp with PWM):	In this state, the communication with the EVSE is build up, however, the AC contactors in the EVSE are still closed.
State C (6 Vp with PWM):	In this state, the AC contactors in the EVSE are closed.
State D (3 Vp with PWM):	In this state, the AC contactors in the EVSE are closed provided ventilation is available for the parking field.

For a detailed description of the CP signal, please refer to IEC61851.

NLG_DcHvVoltAct
This signal specifies the DC voltage measured by the NLG6.

NLG_DcHvCurrAct
This signal specifies the current output current on the DC side.

NLG_StateAct
Via this signal, the current state of the state machine described in chapter 6 *State Machine* can be read out.

NLG_S_DcHvCurrLim; NLG_S_DcHvVoltLim; NLG_S_ProximityLim; NLG_S_ConTempLim; NLG_S_IntTempLim; NLG_S_CtrlPilotLim; NLG_S_IntTempLim; NLG_S_AcCurrLim
The power of the NLG6 is always limited by a parameter. These state bits specify the currently limiting factor.

NLG_S_DcHvCurrLim: Power limited by a predefined maximum current on the DC side
NLG_S_DcHvVoltLim: Power limited by a predefined maximum voltage on the DC side
NLG_S_ProximityLim: Power limited by a proximity value
NLG_S_ConTempLim: Power limited by connector temperature
NLG_S_CtrlPilotLim: Power limited by CP value
NLG_S_IntTempLim: Power limited by high internal temperatures
NLG_S_AcCurrLim: Power limited by a predefined maximum current on the AC side

For a detailed description, refer to chapter 7 *Limits*.

NLG_AcCurrMaxAct
This signal returns the effective value of the phase with the currently highest current flow.
NLG_AcCurrMaxAct=max(*NLG_AcVoltL1Act*; *NLG_AcVoltL2Act*; *NLG_AcVoltL3Act*)

NLG_AcCurrHwAvl
This signal returns the currently available maximum AC current with respect to all limiting factors. For a detailed functional description, refer to chapter 11.3 *Charging power calculation*.

NLG_S_ConLocked
This bit specifies whether the charging plug is locked.

- If <0.5 V is applied at pin 1 of the code B plug, the locking mechanism is regarded as open.
- If >5 V is applied at pin 1 of the code B plug, the locking mechanism is regarded as closed.

If the charging plug is not connected, the locking mechanism is regarded as closed as the NLG6 is equipped with a pull-up resistor. Whether the charging plug is missing can be detected via *NLG_C_UnlockConRq=TRUE.*

NLG_S_ProximityDet
This bit specifies whether proximity is detected.

NLG_S_CtrlPilotDet
This bit specifies whether CP is detected.

NLG_S_AcDet
This bit specifies whether AC voltage is detected.

NLG_S_HwWakeup
This bit specifies whether “high” or “low” is detected at the HW WakeUp input.

NLG_S_HwEnable
This bit specifies that the power component is released.

NLG_S_Err
This bit indicates whether charging is not permitted due to an active error. The reaction to errors is described in chapter 9 *Reaction to Errors*).

NLG_S_War
This bit indicates whether a warning is active.

8.1.4 NLG_PARAM_RP

This message is used for the PARAM Tool for NLG6 parametrization.

INFORMATION
For further information, refer to chapter 12 *PARAM Functions* and the *PARAM_Manual.pdf*

8.1.5 NLG_ACT_ERR

NLG_ACT_ERR bit	Description
NLG_E_OsTrap	Error – internal error OS trap encountered
NLG_E_Flash	Error - Flash memory checksum failure
NLG_E_NVS_Ram	Error - NVSRAM check sum failure
NLG_E_FpgaInit	Error – internal error FPGA Initialization
NLG_E_WrongFPGA	Error – internal error wrong FPGA (doesn't match SW)
NLG_E_WrogHW	Error - wrong Hardware (doesn't match SW)
NLG_E_IntSupply	Error – intern supply fault
NLG_E_DcHvVoltRed	Error – HV voltage redundant value different from main value
NLG_E_TempInt	Error –internal temperature wrong
NLG_E_Internal	Error - Internal error
NLG_E_HvIsoNeg	reserved
NLG_E_HvIsoPos	reserved
NLG_E_Crash	Error - Crash detected
NLG_E_Interlock	reserved
NLG_E_ConLocked	Error - Connector can not be locked
NLG_E_TempCon	Error - Connector temperature
NLG_E_DCHvVoltRange	Error - HVDC voltage out of range
NLG_E_AcInterruption	Error-AC Interruption
NLG_E_CanValue	Error - Commanded value is out of specified range
NLG_E_CanMsgLost	Error - CAN timeout, no control message received
NLG_E_OverTemp	Error - Over temperature (charge coupler or internal)
NLG_E_LatchFPGA	Error-AC Interruption
NLG_E_UZK	Error - DC voltage to low
NLG_E_TPON	Error - Serial relay has not been switched
NLG_E_BURST	Error - Output voltage to low
NLG_E_PRELOAD	Error - DC-Link (Mains!) not preloaded
NLG_W_Watchdog	Warning - Internal Watchdog Timeout
NLG_W_TempInt	Warning - Power reduction due to internal temperature
NLG_W_PowRed	Warning - Power reduction due to internal conditions
NLG_W_ConLocked	Warning - Connector not locked at first attempt
NLG_W_CanTx	Warning - CAN transmit error counter > 127
NLG_W_CanRx	Warning - CAN receive error counter > 127
NLG_W_CanOff	Warning - CAN receive error counter > 127
NLG_W_CanTimeout	Warning - Some CAN messages lost
NLG_W_PRELOAD	Warning - Too many preloaded
NLG_W_AcFrequency	Warning - AC frequency out of specs
NLG_W_AcVoltage	Warning - AC voltage out of specs
NLG_W_FPGA	Warning - FPGA shutdown

8.2 RX Messages

8.2.1 NLG_DEM_LIM

NLG_C_ClrError
With this command, a stored error can be deleted. The reaction to errors is described in chapter 9 Reaction *to Errors*).

NLG_C_UnlockConRq
With this command, the locking mechanism of the charging plug can be controlled. For a detailed description of this function, refer to chapter 10.1 *Locking*).

NLG_C_VentiRq
For safety reasons, particular battery types require a ventilated area during charging. If the ventilation request is activated via the respective command, the NLG6 sets the CP state to D. Thus, charging is only released by the EVSE if the vehicle is in a ventilated area.

NLG_DcHvVoltLimMax
If the DC voltage of the charger exceeds the limit set via this signal, the voltage control mode is activated. This means that the charging current is controlled to prevent the DC voltage from exceeding the set value. The mode is indicated by the *NLG_S_DcHvVoltLim=TRUE* signal.

NOTICE
The NLG6 never reduces the current to zero Ampere. This may overcharge the battery. For this reason, charging is to be stopped under 2A DC.

NLG_LedDem
The device is equipped with 3 LED outputs. These can be controlled via the *NLG_LedDem* signal. For a detailed description of this function, refer to chapter 10.2 *LED*).

NLG_AcCurrLimMax
Via this signal, the maximum admissible AC current can be requested.

NLG_C_EnPhaseShift
With this command, reactive power compensation can be requested. This function is not implemented in the current software version. Refer to: Chapter 13 *Interface functions*

On delivery, all functions are activated. The following functions can be deactivated using the PARAM Tool (Chapter 12 *PARAM Functions*).

- Proximity evaluation (a parallel [PP-PE] 4.7 kΩ resistor is expected in the charging plug/Charge Coupler)

  The proximity resistor in the charging cable plug codes (refer to IEC61851) the maximum admissible current capacity of the charging cable. This limits the maximum current I_N.

- Control Pilot communication

  The Control Pilot (CP) is a bidirectional communication system (refer to IEC61851).

  By means of the PWM signal, the EVSE can define the maximum input current I_N that is to be applied for charging to ensure that the system is not overloaded.

  The EVSE is equipped with power contactors that have to be closed by communicating with the charger. (Chapter 8.1.2 *NLG_ACT_LIM message*)

- PT1000 evaluation

  A PT1000 is a standard temperature sensor. This temperature monitoring system prevents overheating of the charging plug (Charge Coupler). The measured temperature leads to derating of the I_N input current. (Chapter 7.2.8 *Connector temperature derating*)

- Plug Lock

  Engaging the lock on the plug ensures that the charging cable cannot be disengaged during charging and serves as theft protection. (Chapter 10.1 *Locking*)

- LED control

  Three LEDs can be controlled by means of a PWM signal. These serve as feedback to inform the user on the state of charging. (Chapter 10.2 *LED*)

Specific Software Adjustment Options

NLG_AcPhaseShift
With this parameter, cosϕ can be set for reactive power compensation. This function is not implemented in the current software version. Refer to: Chapter 13 *Interface functions*
On delivery, all functions are activated. The following functions can be deactivated using the PARAM Tool (Chapter 12 *PARAM Functions*).

- Proximity evaluation (a parallel [PP-PE] 4.7 kΩ resistor is expected in the charging plug/Charge Coupler)

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  The Control Pilot (CP) is a bidirectional communication system (refer to IEC61851).

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  The EVSE is equipped with power contactors that have to be closed by communicating with the charger. (Chapter 8.1.2 *NLG_ACT_LIM message*)

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  A PT1000 is a standard temperature sensor. This temperature monitoring system prevents overheating of the charging plug (Charge Coupler). The measured temperature leads to derating of the I_N input current. (Chapter 7.2.8 *Connector temperature derating*)

- Plug Lock

  Engaging the lock on the plug ensures that the charging cable cannot be disengaged during charging and serves as theft protection. (Chapter 10.1 *Locking*)

- LED control

  Three LEDs can be controlled by means of a PWM signal. These serve as feedback to inform the user on the state of charging. (Chapter 10.2 *LED*)

8.2.2 NLG_PARAM_RQ

This message is used for the PARAM Tool for NLG6 parametrization.

INFORMATION
For further information, refer to chapter 12 *PARAM Functions* and the *PARAM_Manual.pdf*

9 Reaction to Errors

In case of an error, the *NLG_S_Err* CAN signal is set and the device switches to *standby.* The charger is now in a safe state in which the contactors of the EVSE and all internal relays are open and the power stage is switched off.

The following procedure is recommended:

NLG_StateDem → standby
Error analysis according to the CAN message: NLG_ACT_ERR (chapter 8.1.5 *NLG_ACT_ERR)*
Deleting the error by means of a pulse on *NLG_C_ClrError* (recommended is 1 s or at least 200 ms)
Restart by *NLG_StateDem* => charge

NOTICE
Deleting an error via *NLG_C_ClrError* resets the cycle protection of internal relays (chapter 11.1 *Cycle protection relay*). On the vehicle, no unlimited deleting process may be carried out. This may damage the charger.

10 Actuators

10.1 Locking

Locking is based on impulse control. This means that a locking drive is activated for 300 ms. Via the return line, a position limit switch can be read out. If locking was not successful, 5 attempts are made before the *NLG_E_ConLocked* error bit is set (On/Off = 300 ms/500 ms).

NOTICE
Cycle protection is not implemented in the NLG6 software. Cycle protection has to be realized in the VCU. Via CAN, the VCU controls the locking drive that is simply connected to the NLG6. The feedback of the locking drive is also connected to the NLG6 and accesses the VCU via CAN.

10.2 LED

The LEDs can be controlled via the *NLG_LedDem* CAN signal according to the following table of values:

NLG_LedDem	DESCRIPTION	NLG_LedDem	DESCRIPTION
0x00	All LEDs off	0x08	BLUE LED on only
0x01	RED pulsating, 0.5 Hz	0x09	BLUE, RED pulsating, 0.5 Hz
0x02	Constant RED	0x0A	BLUE, constant RED
0x03	GREEN pulsating, 0.5 Hz	0x0B	BLUE, GREEN pulsating, 0.5 Hz
0x04	Constant GREEN	0x0C	BLUE, constant GREEN
0x05	YELLOW pulsating, 0.5 Hz	0x0D	BLUE, YELLOW pulsating, 0.5 Hz
0x06	Constant YELLOW	0x0E	BLUE, constant YELLOW
0x07	All LEDs off	0x0F	BLUE LED on only

10.3 WakeUp output

If only PP is detected in [State WakeUp], the WakeUp output is activated for at least 2 s and a maximum of 5 s. Via this function, the vehicle can be woken up if the charging cable is only plugged in on the vehicle side.

As long as the charger is communicating on the CAN and the proximity resistor is detected, the WakeUp output is permanently activated.

11 Important to know

11.1 Cycle protection relay

The NLG6 is equipped with internal relays for switching from 1-phase to 3-phase operation as well as for pre-charging. To protect the relays in a misuse case against premature wear, a cycle protection unit has been implemented. This unit doubles the delay between the relay switching processes in every switching cycle. This time can be reset by setting the *Sleep or Unlock Request* and is indicated by the preload warning. (NLG_W_PRELOAD / Warning - too many preloaded)

11.2 Keeping the internal relays closed

If the charger is set to *Standby* mode after charging, the internal relays remain closed for 5 s. This way, the device can be switched on and off repeatedly on charging cut-off without increasing wear or tripping the cycle protection provided a cycle is shorter than 5 s.

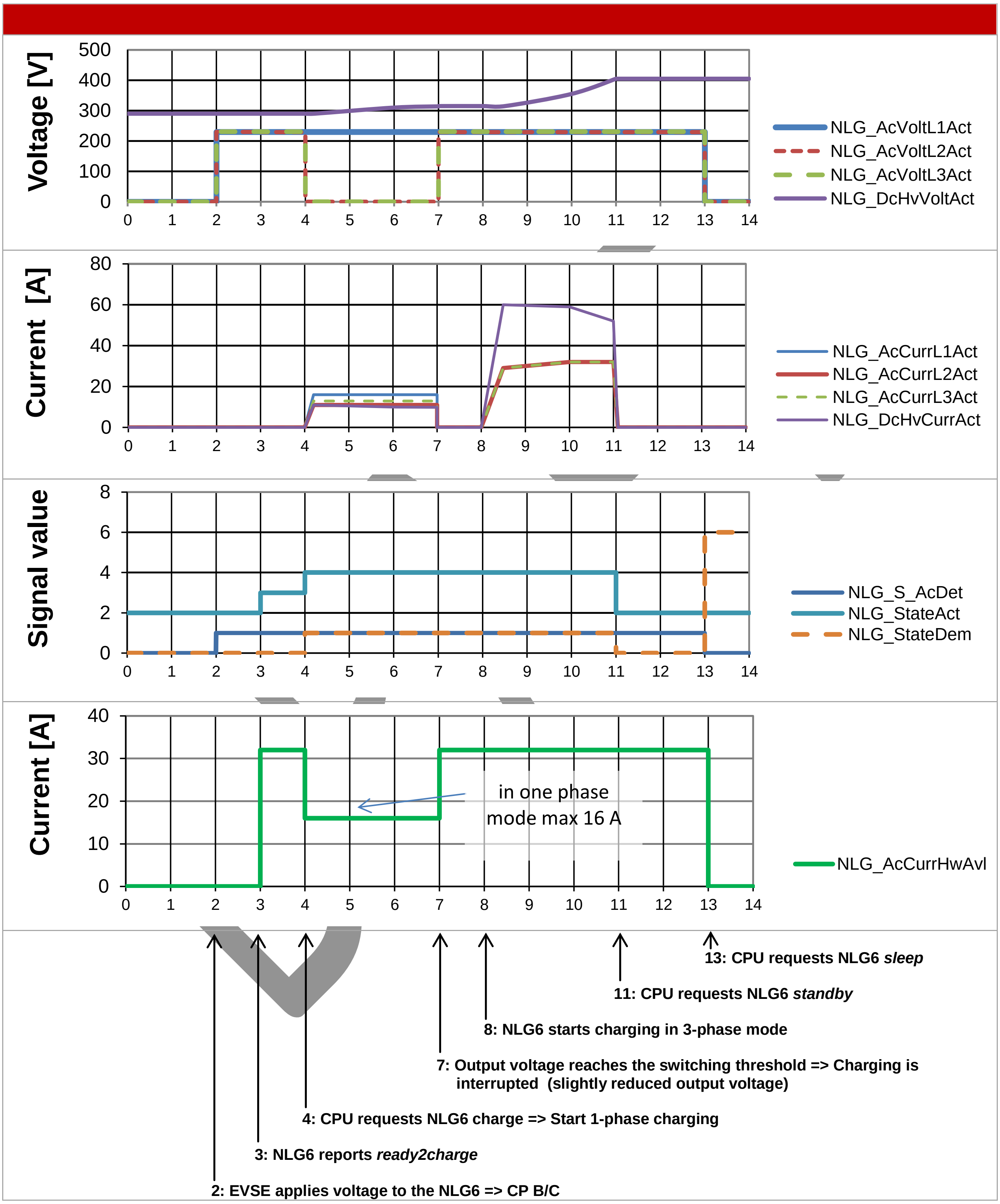
11.3 Charging power calculation

As soon as the NLG6 is connected to an EVSE and "awake", communication is automatically initialised. After the EVSE activates the mains AC voltage supply to the charger, the maximum charging current per phase (*NLG_AcCurrHwAvl*) can be calculated by means of the following parameters:

Proximity resistor
Control pilot signal
Number of detected phases
Device limits

In this state, the actually available charging power for the vehicle can be calculated as follows: *P_MAX = NLG_AcCurrHwAvl *(NLG_AcVoltL1Act + NLG_AcVoltL2Act + NLG_AcVoltL3Act)*

11.4 Signal sequences of a charging cycle

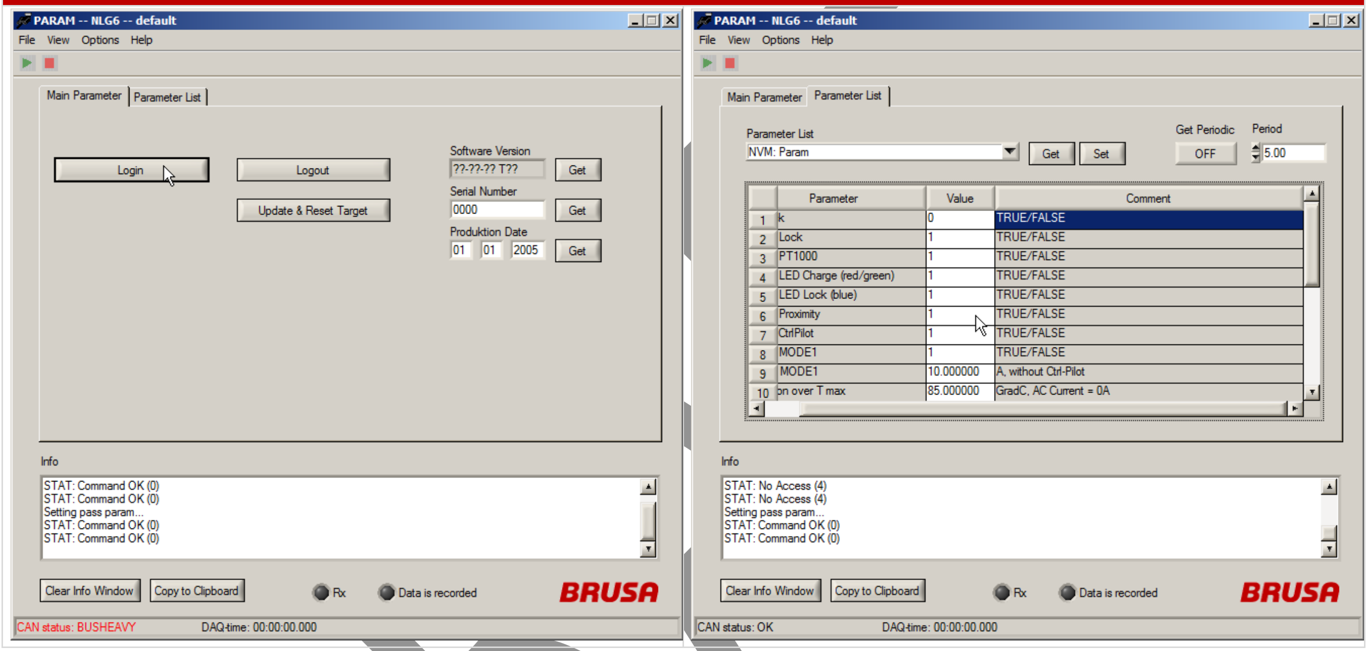


12 PARAM Functions

The PARAM software provided by BRUSA provides access to various parameters and functions of the NLG6. Parameters and functions or their addresses may deviate for various software versions. For this reason, it is crucial to always use the latest firmware XML file!

With the password *monitor*, the customer can log into PARAM or the NLG6.
Changes can be applied to the non-volatile memory of the NLG6 by pressing *Update & Reset Target.*

PARAM



INFORMATION

For further information on the PARAM Tool, refer to the *PARAM_Manual.pdf*
For customer support with regard to the PARAM Tool, a support package has to be ordered at BRUSA Elektronik AG.
Support in connection with the PARAM Tool is only to be requested after purchasing this support package. (*Contact information of the manufacturer*)

12.1 List of parameters

READ ONLY	
NLG6: IDENT	For Support questions, this data has to be provided to BRUSA Elektronik AG
NLG6: AppData / Counter	Summation of life cycle charging time and kWh
NLG6: States	Internal states
NLG6: Digital input	Digital input states
NLG6: Internal temperature	Internal temperatures
NLG6: Analog input	Analog input states
NLG6: VehicleCan value	Received and interpreted CAN values
Connector: Control pilot	Control pilot information
Connector: Proximity detection	Proximity information
Connector: Temp	Connector temperature (PT1000) information

CONFIGURATION		
DIAG: LED	Red	PWM Value
	Green	PWM Value
	Blue	PWM Value
	Red DC Max Act	---
	Green DC Max Act	---
	Blue DC Max Act	---
DIAG: CCLOCK	Diag: CCLOCK	---
	State: CCLOCK	---
NVM: Param	HV Lock	If HV Lock is enabled, the charger behaves as if charging is possible, but the power drivers are disabled => no power flow possible
	Enable Lock	Charge Coupler lock mechanism
	Enable PT1000	PT1000 derating
	Enable LED Charge (red/green)	
	Enable LED Lock (blue)	
	Enable Proximity	Enable/disable Proximity functionality
	Enable CtrlPilot	Enable/disable ControlPilot functionality
	Enable MODE1	Enable/disable MODE1 charging => Charging without Control Pilot
	Current MODE1	Maximum Current in MODE1
	TempCon over T max	PT1000 over temperature threshold
	TempCon T max	PT1000 maximum point of derating slope
	TempCon current slope	PT1000 derating slope
	TempCon current min	PT1000 minimal current
	LED Red DC Max	
	LED Green DC Max	
	LED Blue DC Max	
	CCLOCK Puls delay	
	CCLOCK Puls on	
	CCLOCK Confirm locked retry	
	CCLOCK Locked retry delay	
	CCLOCK Indicator delay	

12.2 Interface functions

On delivery, all functions are activated. The following functions can be deactivated using the PARAM Tool (Chapter 12 *PARAM Functions*).

- Proximity evaluation (a parallel [PP-PE] 4.7 kΩ resistor is expected in the charging plug/Charge Coupler)

  The proximity resistor in the charging cable plug codes (refer to IEC61851) the maximum admissible current capacity of the charging cable. This limits the maximum current I_N.

- Control Pilot communication

  The Control Pilot (CP) is a bidirectional communication system (refer to IEC61851).

  By means of the PWM signal, the EVSE can define the maximum input current I_N that is to be applied for charging to ensure that the system is not overloaded.

  The EVSE is equipped with power contactors that have to be closed by communicating with the charger. (Chapter 8.1.2 *NLG_ACT_LIM message*)

- PT1000 evaluation

  A PT1000 is a standard temperature sensor. This temperature monitoring system prevents overheating of the charging plug (Charge Coupler). The measured temperature leads to derating of the I_N input current. (Chapter 7.2.8 *Connector temperature derating*)

- Plug Lock

  Engaging the lock on the plug ensures that the charging cable cannot be disengaged during charging and serves as theft protection. (Chapter 10.1 *Locking*)

- LED control

  Three LEDs can be controlled by means of a PWM signal. These serve as feedback to inform the user on the state of charging. (Chapter 10.2 *LED*)

13 Specific Software Adjustment Options

By means of a specific software adjustment, the PRC function can be deactivated in 1-phase operation. This adjustment would have a very positive impact on the efficiency of the NLG6. Without the PRC function, a ripple current with 100 Hz (2*mains frequency) occurs at the device output. In the software implemented by default, PRC is always activated which leads to a DC current at the device output.

The 1-phase efficiency of the charger on charging cut-off can also be further increased by a specific software adjustment, also with PRC function.

The hardware of the NLG6 is designed for and supports 1-phase charging at 30 A. As in some countries only 20 A are permitted due to asymmetric load, the 1-phase charging power was limited to 3.6 kW. For this reason, the 1-phase charging power could be increased by means of a software adjustment.

The NLG6 is electrically capable of compensating capacitive as well as inductive reactive power. For this, further software adjustments have to be made.

For a specific software adjustment, please contact the BRUSA support team.

Refer to: Chapter *4.3 Contact information of the manufacturer*

14 Warranty and Guarantee

The company BRUSA Elektronik AG provides a guarantee period of 24 months after the date of purchase in the case of clear and verifiable material and workmanship defects.

The guarantee will immediately become null and void if the seal on the housing is damaged through unauthorised opening or if it is missing entirely.

Furthermore, BRUSA Elektronik AG shall not assume any liability for damage resulting from incorrect or improper handling of the device!

In the event of personal injury resulting from the non-observance of the general and product-specific safety guidelines, no liability claims shall be asserted against BRUSA Elektronik AG!

For damage to peripheries which results in connection with this device, BRUSA Elektronik AG shall not accept any liability! If you have any further questions regarding the operation of this product, please contact our support team BEFORE you start the installation!

Refer to: Chapter 4.3 Contact information of the manufacturer

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