# HC heating controller

function, installation and set into operation



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IIH24_E.DOCc

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# List of Contents

# 1 Introduction

## *1.1 Available documentation*

This manual was written to give a detailed information about all features and functions of the HC.
In addition it describes the principal function of the HC-HMIs and they way to connect the HC-HMIs to the HC-blocs.
This manual is also available in Italian and German language.
For the programming of the HC-HMI we refer to the „complementary programming manual HC-HMIs“ (order no.: AF/PBD_PH-E / English; AF/PBD_PH-D / German).

This manual was written for programmers and/or planners with a good background in the automation field. It’s a guide for the integration of the HC-blocs in an automation concept.

## *1.2 Symbols*

information

important hint

warning (DANGER)

# 2 Application of the HC

HC stands for Heating Controller, although it is simply a regulator.

The main application of the HC is where the level of output power (= heat) of ohmic (not inductive) resistance has to be varied.

This is achieved by varying the voltage sent to the electrical heaters (consumers) by the means of cutting full half-waves from the supply voltage of the consumers.

The most common application is the regulation of the power (= heat) of heating elements in vacuum thermoforming machines. But the HC is also used for (tunnel) oven control as well as to control the heat in the hardening process of resins.

# 3 HC system concept

The HC heating controller is a modular system. The smallest unit of a HC-system are so called HC-blocs.
Each HC-bloc has:

- HC200: 24 power outputs (channels)
- HC400: 24 SSR-control-outputs (channels)

Each channel can control power between 0 and 100% in steps of 1%.

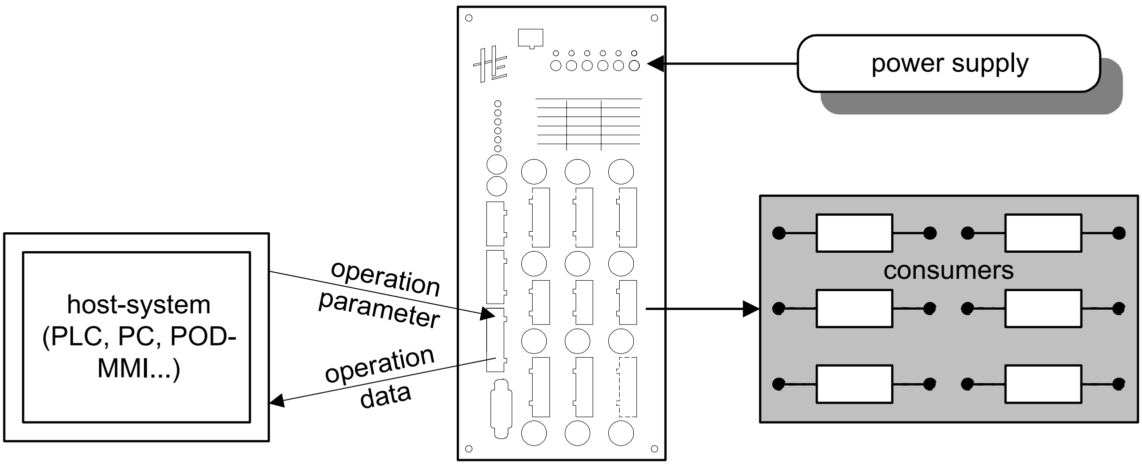
A HC200 HC-bloc has internal power switches (triacs) to control loads between 100 and 2.000 Watts each.
The HC400 HC-bloc has SSR-control-outputs to control external SSRs (solid-state-relays).

24 channels is not equivalent to 24 consumers. At each channel more than 1 consumers can be connected in parallel to other consumers.
The HC is detecting the failure of a single consumer.
With this feature the classical statement „1 consumer per channel“ is obsolete.

Each HC-bloc has its own CPU to calculate the required output power and to keep check of the power circle for occurring errors.

For operation the HC-bloc needs a number of operation-parameters. Those operation-parameters must be provided by a host-system

The host-system itself gets back from the HC-bloc a number of operation-data.
*(refer to chapter 10“ Operation* data and operation-parameters*“ page 32 ff.).*




In the automation field the most often used host-systems are PLCs (programmable logic controllers). But also PCs, mainframes or even the HC-HMIs *(refer to chapter 15 “HC-HMI” page 86)* can assume the function of the host-system.

Using the host-system several HC-blocs can be networked together.

# 4 Design / HC-bloc versions / mounting

## *4.1 HC2xx*

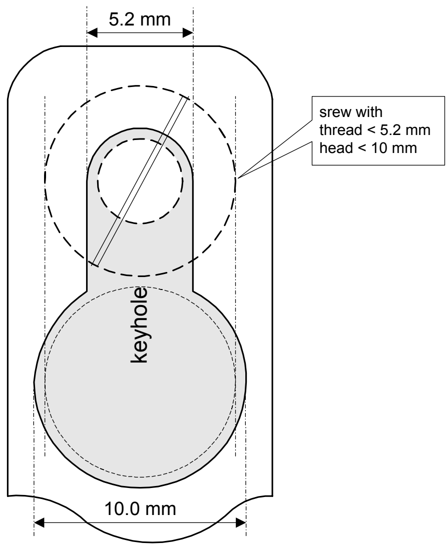
The case has a dimension of 240 (270 with mounting fishplate) x 110 x 160 (185 with connector blocs) mm (H x W x D).
The case is held in 1,5 mm sheet steel, the front panel in aluminum.
The case is zinc galvanized the front panel powder coated.

| product name | HC200-HN-12 | HC200-HN-12-DI | HC200-HN-12-N |
|---|---|---|---|
| order no. | 200 102 | 200 302 | 200 502 |
| power outputs | 24 | | |
| no. of fuses | 12 | | |
| max. load | 1.000 Watt<br>using only every second power output = 2.000 Watt | | |
| relay status outputs | no | | yes |
| digital control inputs | no | | yes |
| neuural connector blocs | no | no | yes |
| soft start | no | | |

| product name | HC205-HN-12 | HC205-HN-12-DI | HC205-HN-12-N |
|---|---|---|---|
| order no. | 205 102 | 205 302 | 205 502 |
| power outputs | 24 | | |
| no. of fuses | 12 | | |
| max. load | 1.000 Watt<br>using only every second power output = 1.500 Watt | | |
| relay status outputs | no | | yes |
| digital control inputs | no | | yes |
| neuural connector blocs | no | no | yes |
| soft start | yes | | |

| product name | HC200-HN-24 |
|---|---|
| order no. | 200 111 |
| power outputs | 24 |
| no. of fuses | 24 |
| max. load | 1.200 Watt (max. 8.400 Watt je Phase) |
| relay status outputs | no |
| digital control inputs | no |
| neuural connector blocs | no |
| soft start | yes |

The HC-bloc will be fixed (for example to a mounting plate of an electric cabinet) by means of 4 fishplates:




It is not required that the case is in an electrical contact to the mounting plate. But In any case the protective conductor must be connected to the case (by means of the screw terminal clamping point for the protective conductor - connector bloc for power supply voltage).

The case contains 3 power-output circuit boards (1 for each phase) with 8 channels (power outputs = trics) each. Aluminum heat sink of generous proportions are mounted directly to these power-output circuit boards.

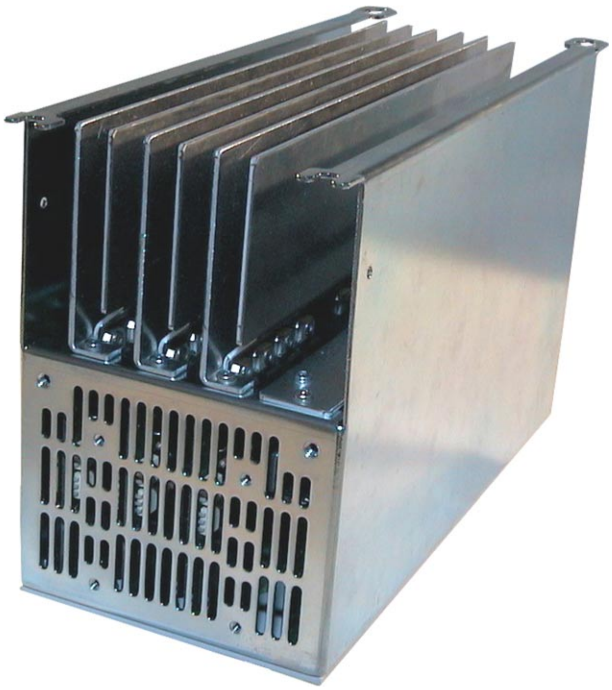
Furthermore each case contains a CPU board and another circuit board for the generation of the supply voltage for the HC-CPU as well as the measurement devices for current and voltage.

However the HC-bloc is a closed unit. Single circuit boards can (should) only be changed by us or an authorized dealer.

A HC-bloc is a closed unit. When opening the enclosure the warranty expire.

### 4.1.1 Convection cooling and forced ventilation

The heat sinks are located at the back of the HC-bloc.



Because of the required air confection over the heat sinks, the HC-blocs must be mount vertically

When fired, each power switch (triac) has an electrical resistance.
The loss voltage at its resistance is depending on the amp flow through it - typically 1,5 Volts.
The amp trough a 1.000 Watt load at 230 Volts is (1.000 W / 230 V =) 4,35 Amps.
The stray power generated of the power switch is (4,35 A * 1,5 V =) approximately 6,5 Watts.
With 24 triacs each HC-bloc an amount of 150 Watts heat is generated.
The power switches are mount to heat sinks to release the heat to the air.

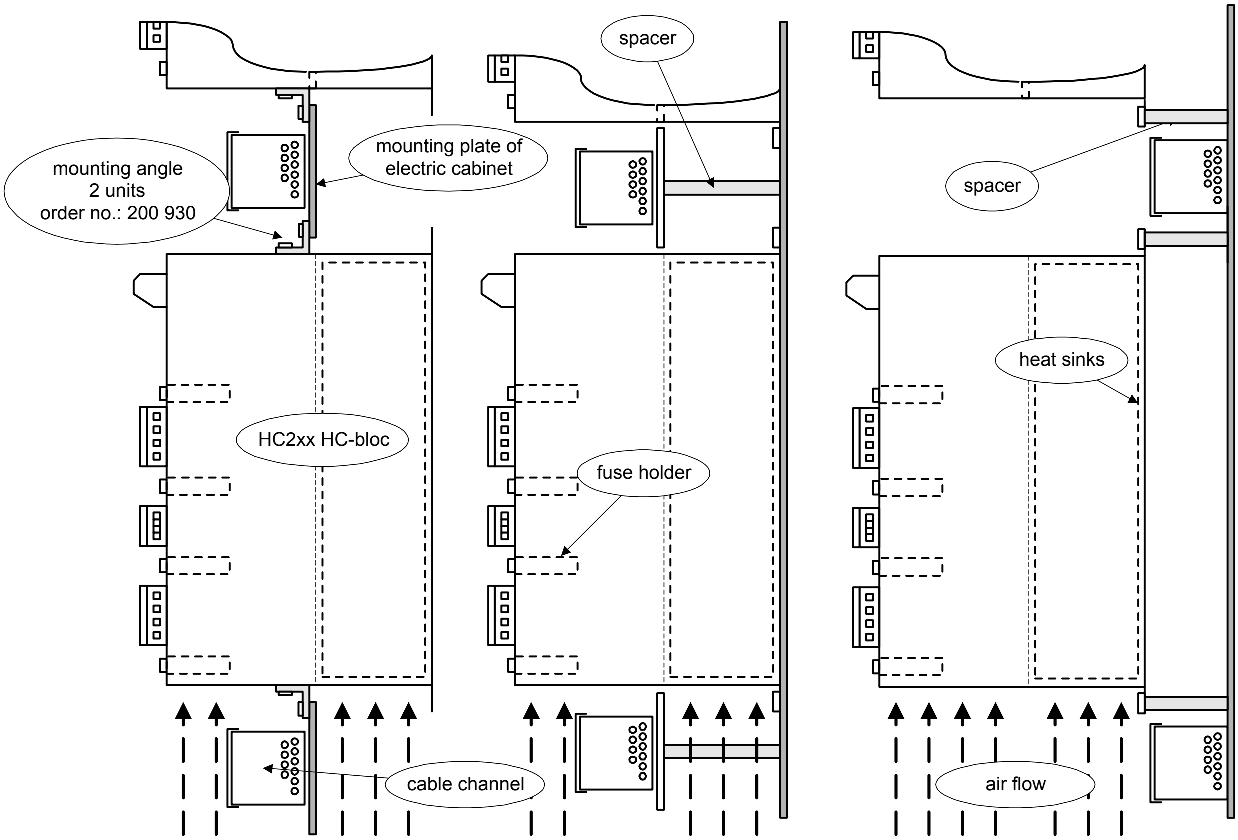
The max. control power of a HC-bloc depends on

- the HC-bloc type (12 or 24 fuses),
- the ambient temperature and
- the measurements taken for cooling respectively the mounting.

At 35 degrees Celsius (°C) the following directives must be taken into consideration:

| | HC2xx HC-bloc with 12 fuses | HC2xx HC-bloc with 24 fuses |
|---|---|---|
| convection cooling only | 600 Watts / power output | 750 Watts / power output |
| forced ventilation | 1.000 Watts / power output (if only every second power output is used: HC200 = 2.000 Watts HC205 = 1.500 Watts) | 1.200 Watts / power output (8.400 Watts / phase) |

Mounting possibilities of HC-blocs without forced ventilation (convection only).




It must be respect that the natural air flow (due to convection) over the heat sinks **and** <u>fuses</u> is not hindered, for example with cable channels.

Fundamental is.
A HC-bloc is working properly to an electronic temperature of 70 °C.
(The electronic temperature can be read from each HC-bloc.)

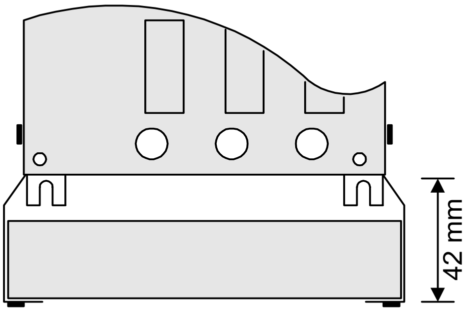
But for a long lasting trouble free operation you should be able to touch the heat sinks, without „burning“ your fingers.
< 40 °C is the ideal operation temperature of a HC-bloc.

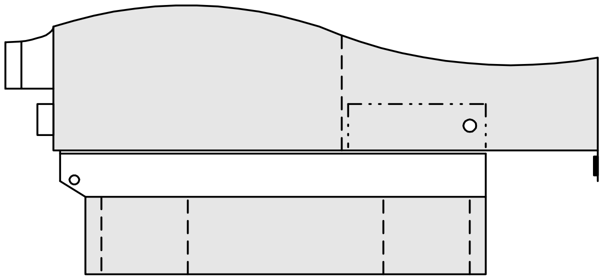
Cooler the HC-bloc is operated longer is its lifetime.

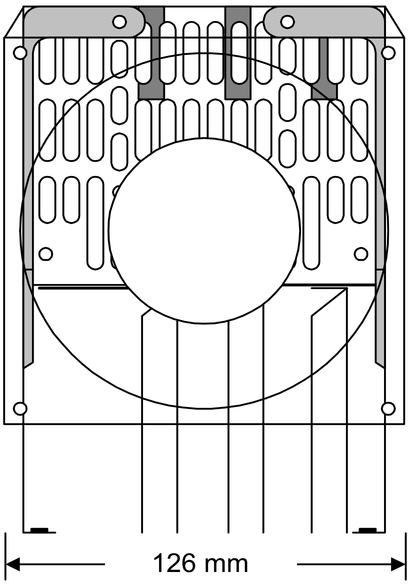
For heavy loads and high ambient temperatures, the heat sinks <u>and fuse holders</u> must be cooled with a forced airflow.

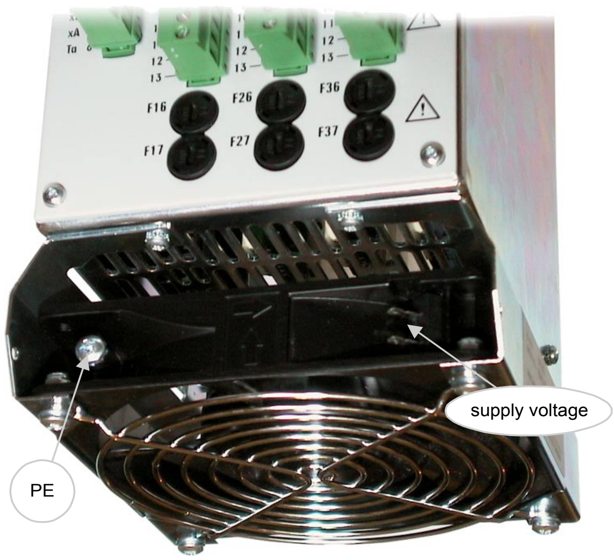
There are various possibilities to cool the heat sinks and <u>fuse holders</u>.

We offer a fan unit that can be mount directly under the HC-blocs.






| | |
|---|---|
| product code | HC200-FU-220 |
| supply voltage | 220 V ac |
| clamping points | Two 2,8 x 0,5 mm flat plate pins for standard flat plate connectors |
| ventilator diameter | 120 mm |
| MTBF at 40 °C | 50.000 hours |

| | at 50 Hz | at 60 Hz |
|---|---|---|
| power | 14 Watt | 11 Watt |
| amp | 100 mA | 90 mA |
| rpm | 2300 1/min | 2700 1/min |
| air volume | 1,8 $m^3$/min | 2,0 $m^3$/min |

For own designed cooling devices, it must respect that the airflow over the heat sinks and fuse holders is not hindered.

It is recommended, that HC-blocs mounted vertically (one over another) should keep a distance of minimum 20 cm.
When mounting HC-blocs horizontal (one next to another) no distance is required.

- Because of the required air-flow over the heat sinks HC-bloc are only allowed to be mounted vertically.
- When HC-blocs are mounted one over another, a minimum distance of 20 cm must be respected.
- Horizontal HC-blocs can be mount one beside another without any distance

## *4.2 HC400*

A HC400 HC-bloc is composed of 3 single components:

- controller unit (HC400-CU)
- measurement-unit (HC400-MU)
- junction cable (HC400-JC)

- CPU-units (CU)

| product name | HC400-CU-HN-24 | HC400-CU-HN-24-LED | HC400-CU-HN-24-LED-DI |
|---|---|---|---|
| order no. | 400 101 | 400 201 | 400 401 |
| no. of SSR-control-outputs | 24 | | |
| relay status outputs | no | | yes |
| digital control inputs | no | | yes |
| output LEDs | no | yes | |

- measurement unit (MU)

| product name | HC400-MU-480-400 |
|---|---|
| order no. | 400 501 |
| max phase voltage | 480 Volt |
| max phase amp | 400 amps |

- junction cable between CPU-unit and measurement unit (JC)

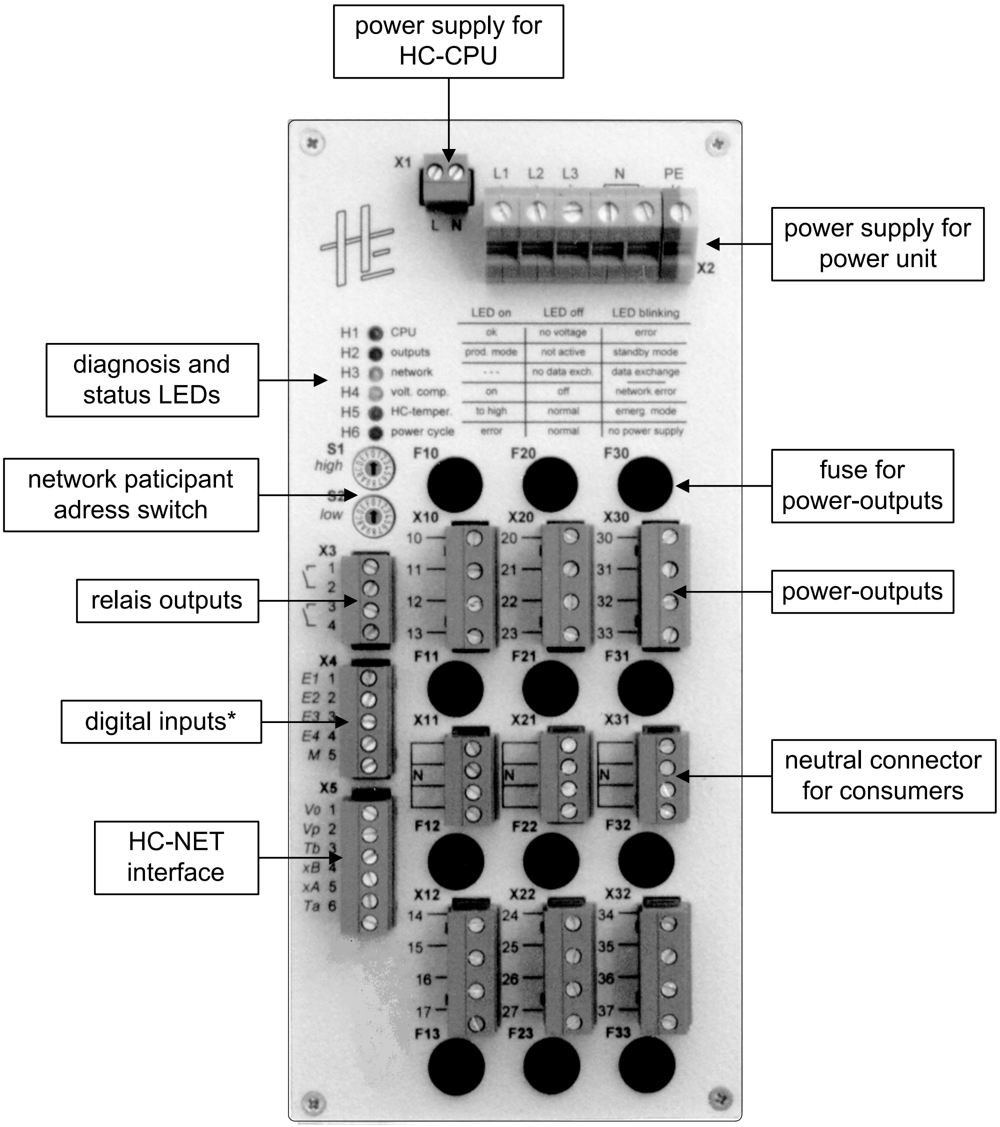
| product name | HC400-JC-75 |
|---|---|
| order no. | 400 607 |
| cable lenth | 75 cm |

# 5 Contact points / network address switches / LEDs

## *5.1 HC200 contact points*

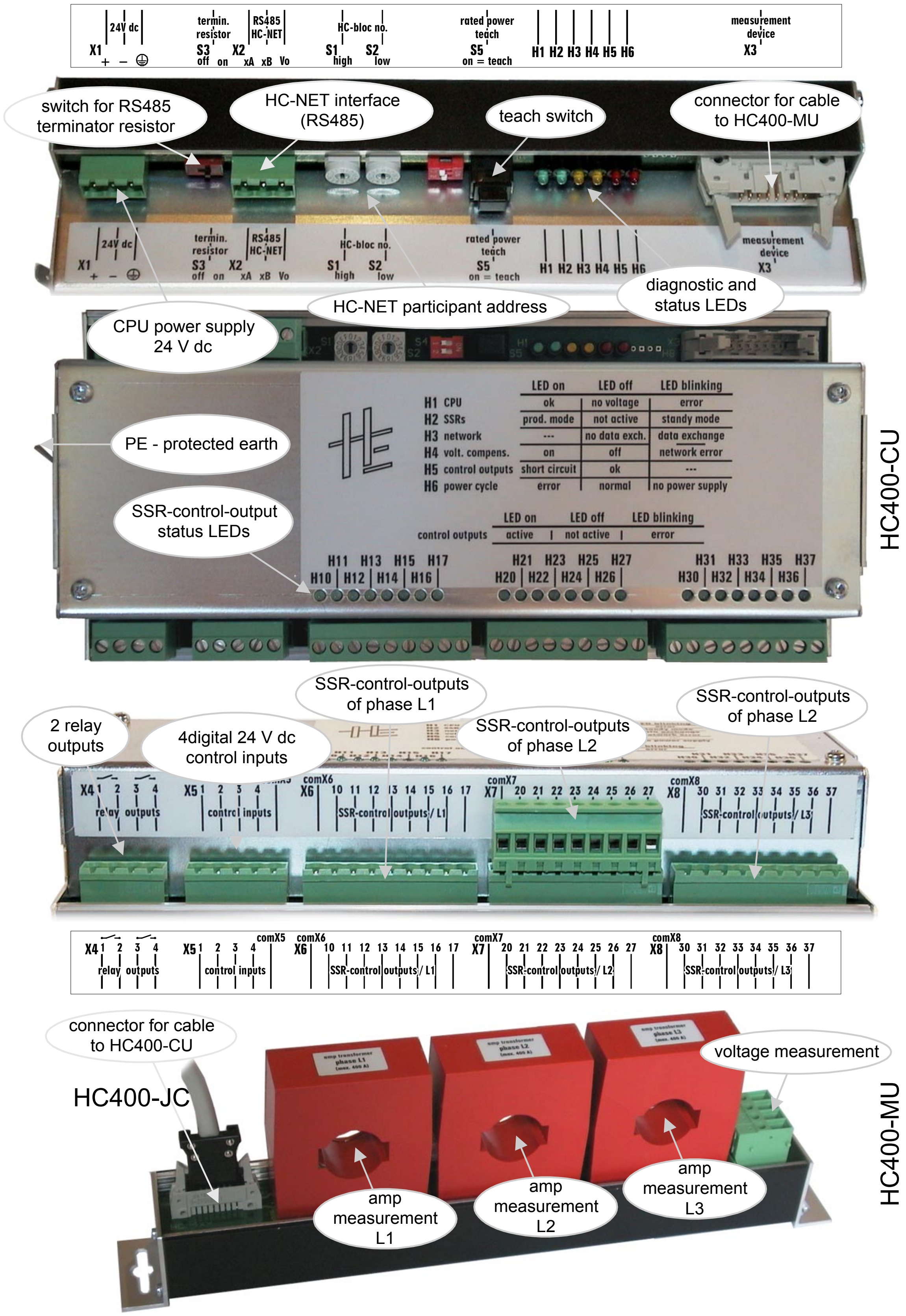
All contact points of the HC200 HC-bloc are realized with screwable plug-type connectors accessible at the front. An exception are only the 5 screw terminal clamping points for the power supply. These are because of security regulations (EDV) not plugable.

So to change a bloc is quite easy.




* only with HC200-DI (digital input model).

## 5.2 HC400 contact points



## 5.3 Power unit

The frequency of the supply voltage for the power unit must be

- 50 Hz or
- 60 Hz .

All HC-bloc need a three phase supply voltage.
A single phase operation is not possible.

### 5.3.1 Power-outputs HC200

Each HC-bloc has 24 power-outputs (triacs) to connect the ohmic consumers.
The range of power of each channel can vary with a rated voltage of 230 volts, from 100 to 1000 Watts (2.000 Watts if every second power-output is used).

The triacs are protected with a fast type fine wire fuse (FF fuse).

- HC-bloc with 12 fuses = 10,0 amps
- HC-bloc with 24 fuses = 6,3 amps

A fuse can be easily accessed with a fuse holder (screwable) at the front of the HC-bloc.

Before changing a fuse power output of the respective HC-bloc must be disabled.

### 5.3.2 HC200 power circle

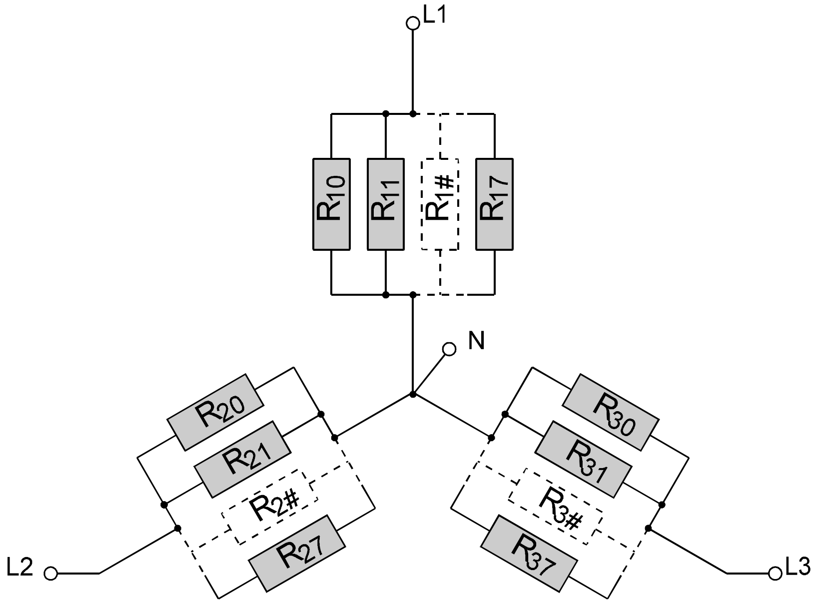
For the power unit each HC200 HC-bloc must be connected to the three phases (L1, L2, L3) and the neutral (N) of a three-phase four-wire (= the neutral must be supplied and connected / three-phase 3 wire connection is not allowed) network with 400/230 V dc.

The power unit of the HC-bloc **must** be connected with **L1, L2, L3, N and PE** of X2 to the supply network. IMPORTANT: N must be connected.

8 channels (power-outputs) at a time are supplied with one phase of the three-phase four-wire 400/230 V network.

The fuse protection for the power unit of each HC-bloc has to be done externally with a 40 A fuse for each phase.

Because all consumers are connected between one phase an neutral (star connection) the three-phase four-wire network must be suitable and qualified for an unsymmetrical load!




The three-phase four-wire network must be suitable and qualified for an unsymmetrical load.

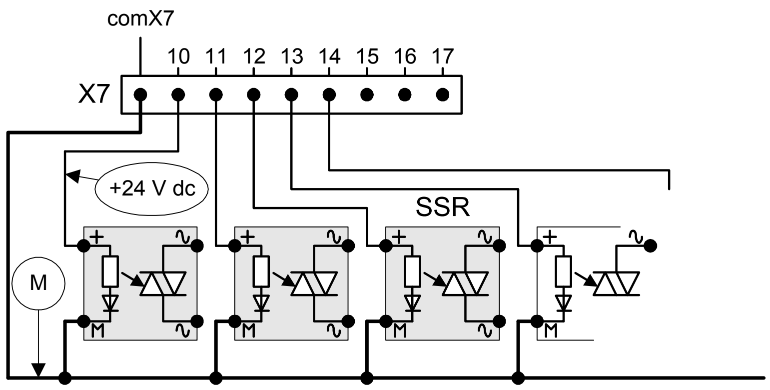
### 5.3.3 HC400 SSR-control-outputs

The HC400 HC-blocs have in comparison to the HC200 HC-blocs no internal power switches (triacs) but control the power of external SSRs (solid state relays).

Each HC-bloc has 24 digital outputs (24 Vdc) to control the SSRs (called SSR-control-outputs).

| | |
|---|---|
| SSR control voltage | 24 V dc |
| max. amp each SSR-control-output | 60 mA |

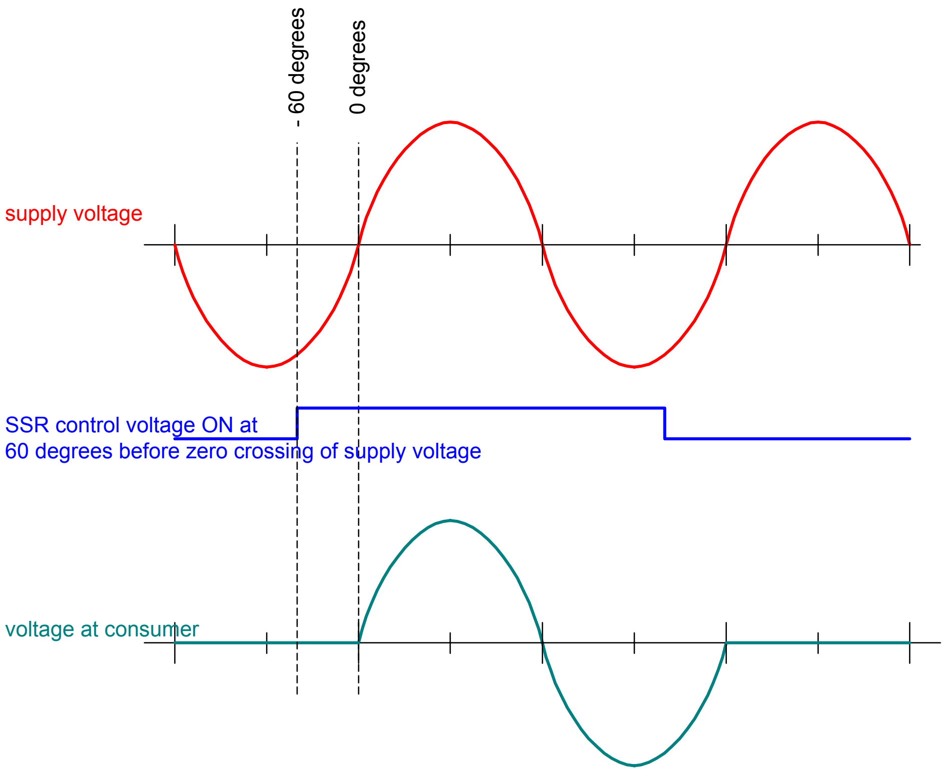
The zero (M) of all SSRs, belonging to one phase of the supply voltage must be connected to the respective claming point named comX*.
The zero (M) of the 24 V dc SSR-control-outputs is different from the zero (M) of the 24 V dc supply voltage of the HC400-CU
Do not connect the zero (M) to the zero (M) of the supply voltage.



#### *5.3.3.1 SSRs that can be used*

2 types of SSRs are available on the market
- SSR with zero crossing switches
- SSR without zero crossing switches

Zero crossing switch will mean, that an SSR can fired only at zero crossing of the supply voltage but not at the moment the control voltage is going to on.




| |
|---|
| It is not allowed to use SSRs without zero crossing because the SSRs would be operate in phase-control. |

### 5.3.4 HC400 power circle

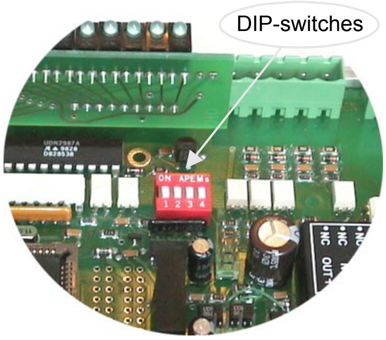
The supply voltage and amp is measured with a so called HC400 measurement unit (HC400-MU).

Max. amp of all SSRs of each phase: 400 A
Max. phase voltage: 480 V

The consumers can be connected

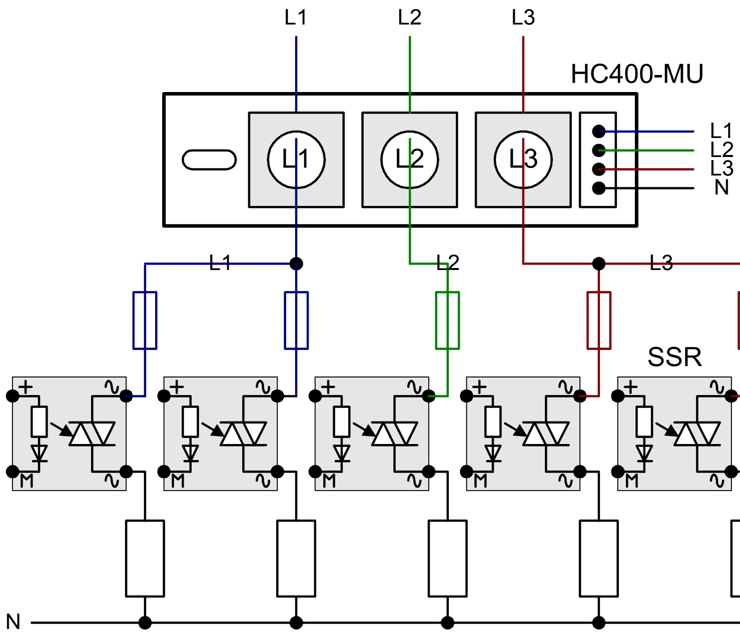
- between phase and neutral [L1-N; L2-N; L3-N] (Y-operation) or
- between two phases (Δ-operation) [L1-L2; L2-L3; L3-L1] (Δ-operation)

| DIP switch 2 | operation mode |
|---|---|
| OFF (default) | Y-operation |
| ON | Δ-operation |

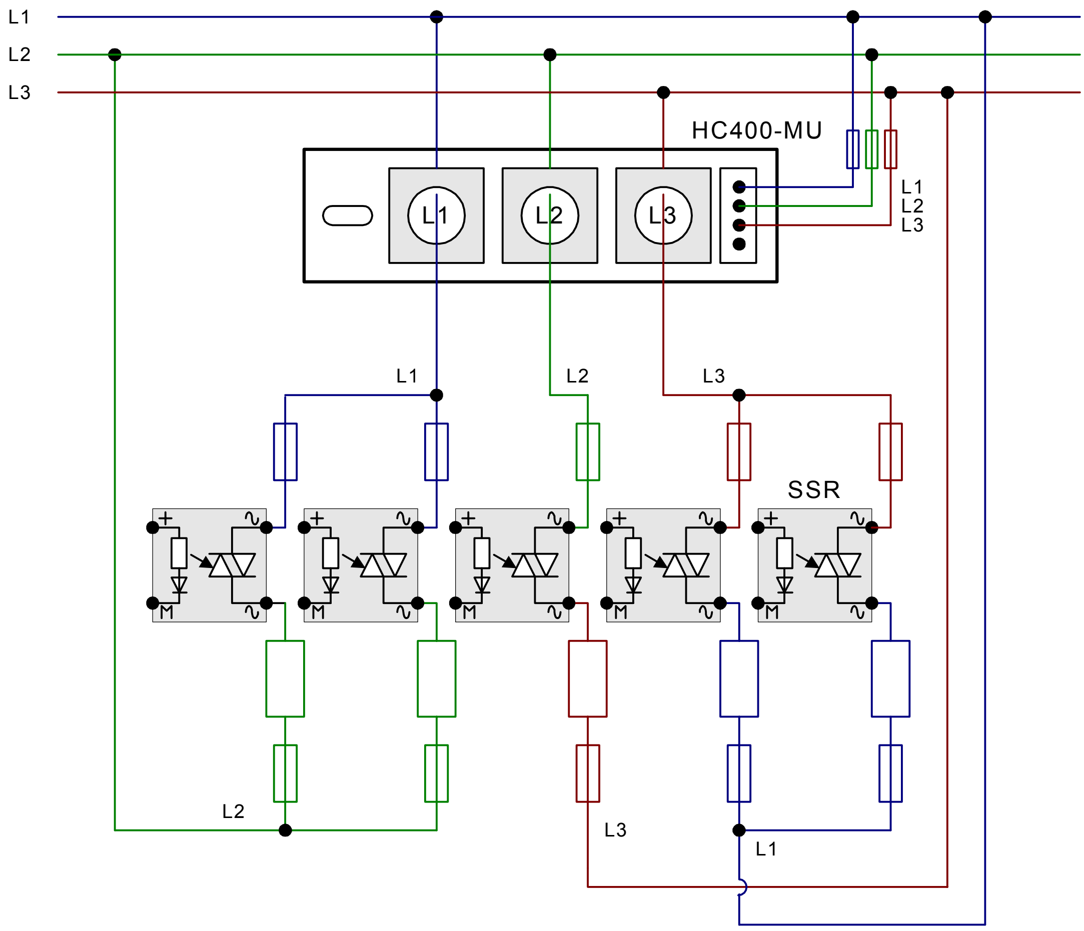



At wrong setting the error control of the power circles is not function properly.

Y-operation (default):



Δ-operation:




The following wiring of the consumers must be respected:

consumer between

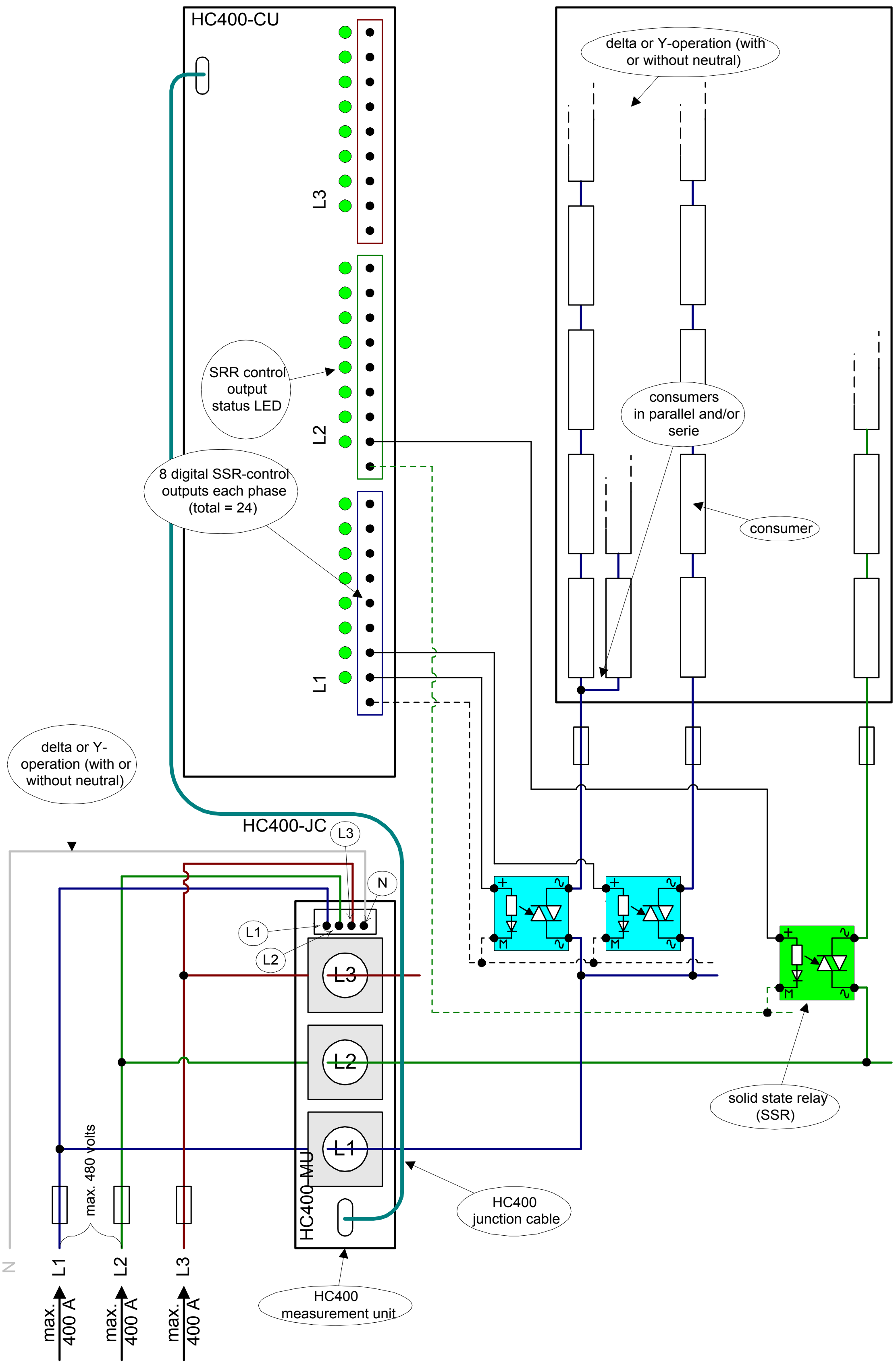
| phase |
|---|
| L1 |
| L2 |
| L3 |

and

| versus phase |
|---|
| L2 |
| L3 |
| L1 |

At  wrong cabling the error control of the power circles is not function properly.

### 5.3.5 Wiring of HC400 control and power circle



## 5.4 HC-CPUs

| HC-bloc | supply voltage | amp consumption |
|---|---|---|
| HC200 | 230 V ac | < 20 mA |
| HC400-CU | 24 V dc | CPU = 150 mA<br>+ amp consumption of SSRs |

The HC-CPUs must be protected with an external fuse.

## 5.5 HC-NET interface

By means of this interface single HC-bloc can be networked with a host-system (PLC, PC, etc.).
*Please refer to chapter 9 „*Maximum system expansion / networking*“ page 31.*

## 5.6 Digital inputs

To control the most important functions (ON/OFF, standby/production...)
we offer HC-blocs with digital inputs.
Of course the functions can also be controlled over the HC-NET network.
The digital inputs are only available with HC-blocs with the code „-DI“ *(refer to chapter 6 „Digital control inputs* (-DI)*“ page 26 ff.)*.

## 5.7 Relay outputs

Under certain circumstances it could be difficult to locate a defective HC-bloc in a decentralized HC-system, especially in very extensive machines or plants or when service technicians do not have any general plan with the location of the single HC-blocs.
For this reason HC-blocs coded „-DI“ have 2 relay outputs that can be used to connect signal lamps which can be mounted clearly visible.
Another application for the relay is the use as ready for work relay.
*(Refer to chapter 12.3.1 „Application example for relay outputs“ page 57 ff..)*

## 5.8 Network address switch

To distinguish single HC-blocs in a HC-Network, it is necessary to give each participant (HC-bloc) in the HC-network a unique address. This must be done with two address switches located on the front panel of the HC-bloc.

## 5.9 Status LEDs

With the 6 status LEDs, the service technicians have a tool for a simple and fast system diagnosis of each single HC-bloc *(refer to chapter 12.1 „Diagnosis with status LEDs“ page 54)*.

## 5.10 Summary HC200

| designation | destination | execution |
|---|---|---|
| X2 | power supply to power unit<br>L1, L2, L3, N, PE | 5 x 1 pin screw terminal clamping point<br>(VDE-approved for max. 400 V ac, $I_{max}$ = 40 A)<br>∅: solid 6 mm² / flexible 4 mm² (with clamp type socket 6 mm²)<br>*(N internal connected with consumer neutral X11, X21 and X31)* |
| X10, X12<br>X20, X22<br>X30, X32 | power-outputs (connection to consumers) | 4 pin scewable plug-type connector block<br>6 connector blocks total<br>(VDE-approved for max. 400 V ac, $I_{max}$ = 12 A)<br>∅: 0,5 ... 2,5 mm² |
| X11<br>X21<br>X31 | consumer neutral (N cable of consumers) | 4 pin scewable plug-type connector block each<br>3 connector blocks total<br>1 screw terminal clamping point for 2 N cables<br>∅: 0,5 ... 2,5 mm²<br>*(N internal connected with N of X2)* |
| F11/12/13<br>F21/22/23<br>F30/31/33 | fuse | fine wire fuse 10 A FF (superfast type) in fuse holder (screwable) for protection of 2 power-outputs. |
| X5 | serial system-network interface, RS485 | 6 pin scewable plug-type connector block |
| S1<br>S2 | address switches | setup of network participant address |
| X1 | power supply to HC-CPU | 2 pin, scewable plug-type connector block<br>∅: 0,5 ... 2,5 mm² |
| X3 | - ready for work relay<br>- error indication relay | 2 relay (breaking capacity 6 A with 24 V dc / 230 V ac)<br>4 pin scewable plug-type connector block<br>∅: 0,5 ... 2,5 mm² |
| X4 | - HC-system start/ stop<br>- supply voltage compensation<br>- production-/standby-cycle | 4 pin, scewable plug-type connector block<br>digital 24 V dc input with common neutral.<br>230 V ac on request<br>∅: 0,5 ... 2,5 mm² |

## 5.11 Summary HC400

# 6 Digital control inputs (-DI)

HC200 and HC400

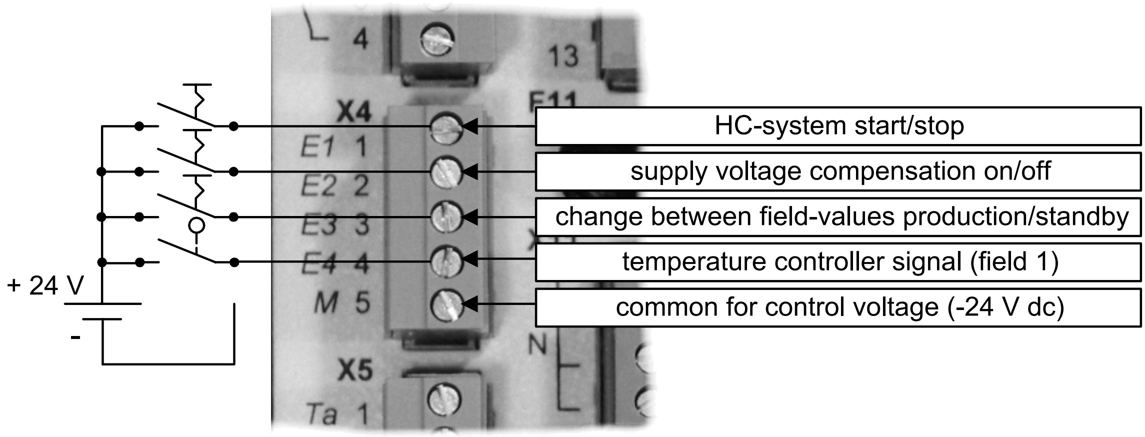
The must important HC-functions

- HC-system start/stop (E1)
- supply voltage compensation on/off (E2)
- change between field-values production and field-values/standby (E4)

can not only be controlled with HC-NET but also with 4 digital 24 V dc inputs.

The HC-bloc can calculate the field-value production of field no. 1 with a pulse/pause ratio read with the digital input E4 (optional).
By means of this input and a temperature controller a temperature regulation for field no. 1 can be obtained.

## 6.1 Pinout of digital inputs




| | input 0 V dc | input 24 V dc |
|---|---|---|
| E1 | HC-system stop | HC-system start |
| E2 | production mode | standby mode |
| E3 | supply voltage compensation OFF | supply voltage compensation ON |
| E4 | if period time < 1 second 24 V dc then:<br>field-value-production of field 1 = 0% | if period time > 10 seconds 24 V dc then:<br>field-value-production of field 1 = 100% |

These 4 functions can of course also be controlled over the HC-NET network.

The following cross linkage applies:

| | | | |
|---|---|---|---|
| HC-system stop | SCB Bit 0 = „0“ | **AND** | E1 = 0 V |
| HC-system start | SCB Bit 0 = „1“ | **OR** | E1 = 24 V dc |

| | | | |
|---|---|---|---|
| supply voltage compensation ON | SCB Bit 1 = „0“ | **AND** | E2 = 0 V |
| Supply voltage compensation OFF | SCB Bit 1 = „1“ | **OR** | E2 = 24 V dc |

| | | | |
|---|---|---|---|
| production mode | SCB Bit 2 = „0“ | **AND** | E3 = 0 V |
| standby mode | SCB Bit 2 = „1“ | **OR** | E3 = 24 V dc |

## *6.2 Function of E4 (temperature control signal input)*

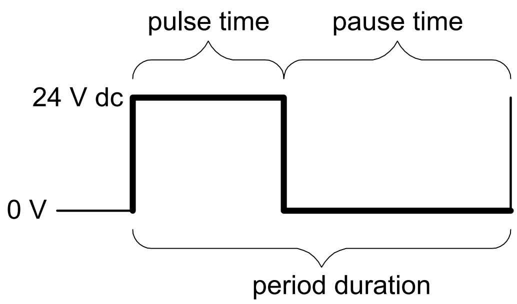
Over the pulse/pause ratio the HC-CPU is calculating the field-value of field no. 1 ($FP\%_1$).

$$\boxed{\text{field-value } (FP\%_1) = (\text{pulse time/period duration}) * 100}$$

**Example:**
Input E4 is for 0,8 seconds ON and for 1,2 seconds OFF.

| | |
|---|---|
| pulse time = | 0,8 s |
| period duration = pulse time + pause time = 0,8 s + 1,2 s = | 2,0 s |

Therefore:
$FP\%_1$ = (0,8/2,0) * 100 = 40%




- The function of E4 will be activated, when E4 is detecting within 10 seconds 2 positive 24 Vdc flanks.
- Once enabled the function of E4 the function can only be disabled when cutting the HC-CPU supply voltage.
- If you send to a HC-bloc, having the function of E4 enabled, a field value production of field 1 the value sent will be ignored.

At active function of E4:
- If pulse time > 10 seconds then field value 1 = 100%
- If pulse time < 1 second then field value 1 = 0%
- the period duration
  ⇒ must not be constant
  ⇒ is not allowed to exceed 10 seconds
  ⇒ should not drop below 2 seconds
  ⇒ is depending on the speed of the controlled member

## *6.3 Hints for temperature regulators*

Each temperature regulator is generating a „controller-output-value“ depending on the actual temperature, the set point temperature and its proper controller algorithm. Internally the „controller output value“ is a value between 0 and 100%.
To use the temperature controller with the digital input E4, you need a temperature regulator generating a 24 Vdc pulse/pause signal.

The period duration of the pulse/pause signal must be a variable that can be set individually. A typical period duration for ceramic heating elements is 2...5 seconds.

Let’s suppose the period duration was set to 3 seconds and a cold heating element must be controlled to reach the desired set point temperature above the actual temperature of the heating element.
After power on, the heating controller is calculating a controller-output-value of 100% and output a 24 V signal with a pulse time of 3 seconds and a pause time of 0 seconds.
Consequently the HC-bloc is reading a constant 24 Vdc signal at input E4. This means that the HC-bloc will not enable the function assigned to E4 (missing of 2 positive 24 Vdc flanks within 10 seconds).

The 24V signal must alternate (according to the conditions above) in order to be able to calculate the controller-output-value = field value of field 1.

This is possible, defining limits (a range) for the controller-output-values.

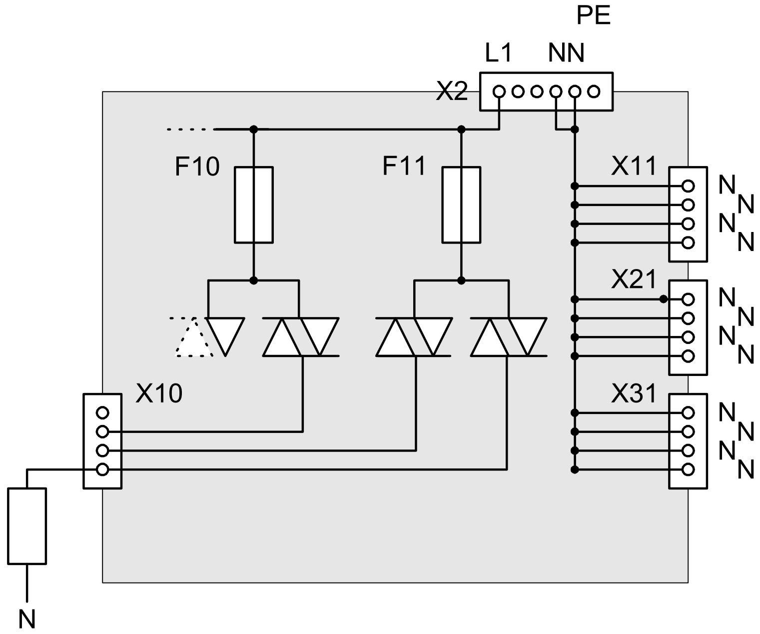
> For a proper function of E4, it is necessary to limit the max. and min. controller-output-value to 1% respectively 99%.

| | |
|---|---|
| internal controller-output-values = 0% | generated controller-output-value = 1% |
| internal controller-output-values = 100% | generated controller-output-value = 99% |

This means for our example: E4 gets in 3 seconds 2,97 seconds 24V and for 0,03 seconds no voltage. Once the function of E4 is activated the HC-bloc is calculating 99% for field value of field no. 1, even if the internal controller-output-value is 100% (or 0%).

# 7 Neutral clamping points (-N)

The HC-blocs HC200-HN-12-N and HC205-HN-12-N make at disposal for 2 power-outputs, 1 screw terminal clamping point for the neutral. Because of this neutral connector an external connector block for the neutral is not required.




But it is **not** necessary that X11, X21 und X31 must be connected to the neutral (N) of the consumers.

# 8 Softstart

HC205 only

Since some years thermoforming machine builders are using halogen lamps in their machines. The halogen lamps have a 15 times smaller cold resistance than hot resistance.
Starting such a heating element the current in the first half waves of the supply voltage is 15 times higher than the rated amp during normal operation.
This amp peak will blow the fuse which has to protect the triacs against short circuit.
15 times the rated amp means short circuit.

The HC-CPU has to take care for 24 power outputs only - this means the HC-CPU has a lot of CPU power for each power output.
The HC-blocs does not have simple zero crossing triacs but those without a zero crossing feature being fired exactly at the moment when amp and voltage are crossing zero.
So the HC-CPU is giving full half waves to the consumers.

The supply voltage companies allows to run electric consumers for a defined time in a so called phase control mode cutting the half waves of the supply voltage.

The HC-CPU is programmed to startup halogen lamps running the first halfwaves after power ON in a phase control mode. The result is, that the startup amp will remain under the rated amp of the halogen lamp and the fuses will not blow.

All consumers will be startup in a sequence one by one bringing them to their normal operation temperature without exceeding the rated amp.
During operation the HC-bloc will automatically hold a minimum output value (OV%) in order not to exceed the minimum temperature of halogen lamps.

# 9 Maximum system expansion / networking

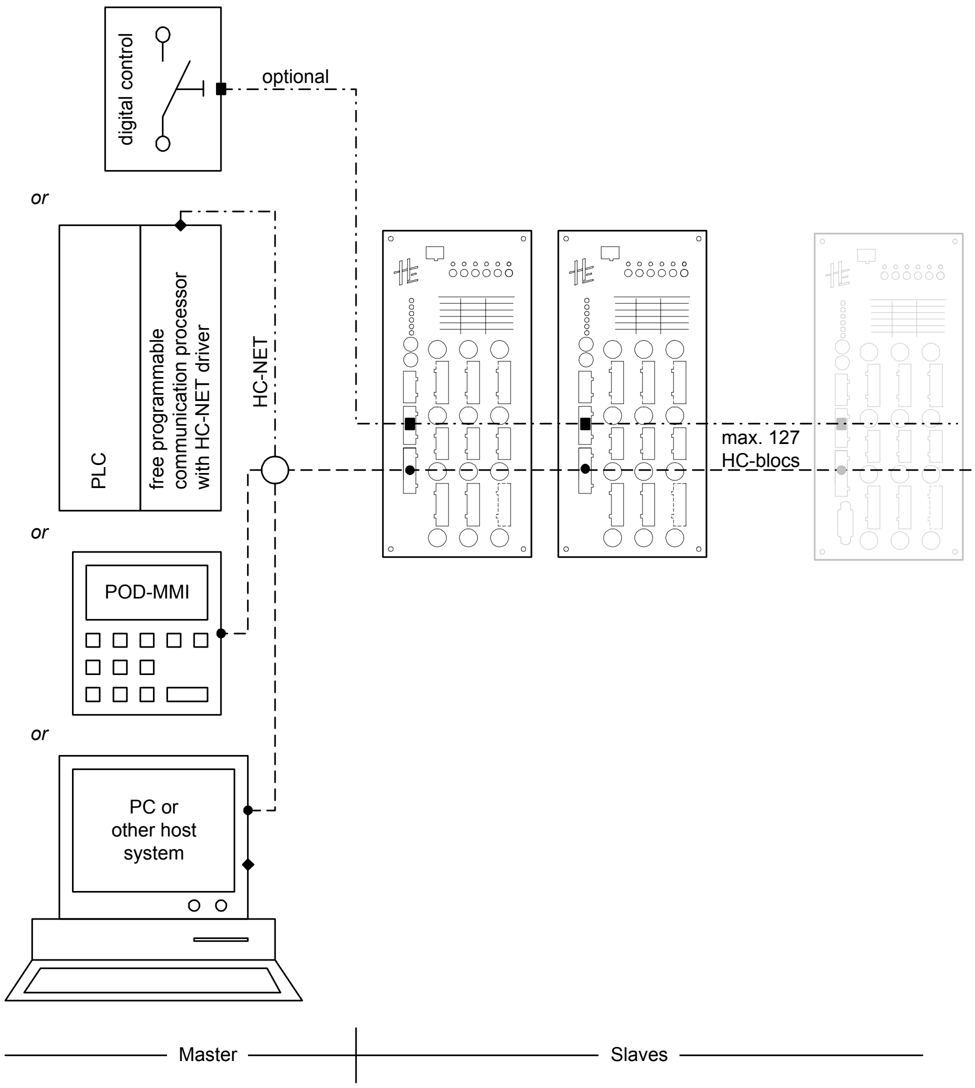
With 24 channels of each HC-bloc and a maximum of

- 127 HC-blocs in 1 HC-network or

the number of channels per system equals to 3.048 channels.

If there is an application need for more than 3.048 channels, it's possible with an appropriate programming of the host-system, to link single HC-systems. Therefore there is theoretically no limit for the maximum numbers of channels operated by a single host-system.

As already mentioned, each HC-bloc has its own microprocessor (HC-CPU) with which it sets and controls the required output power of its 24 channels independent of other HC-blocs connected in the same HC-network.
Therefore the absolutely maximum of channels used with an single HC-system depends only of the programming of the host-system and not at all from the single HC-blocs.



# 10 Operation data and operation-parameters

## *10.1 Data exchange between HC-bloc and host-system*

Like already mentioned in chapter 3 „HC system concept“ at page 7 the host-system send data to and receive (on request) data from the HC-blocs.

- host-system ⇒ HC-bloc = operation-parameters
- HC-bloc ⇒ host-system = operation-data

To drive and error check its outputs, the HC-bloc needs to get send from the HC-bloc various **operation-parameters**.
The HC-blocs will send on request from the host-system its **operation-data**.

In a HC-network the host-system is always master. It
- send operation-parameters (which can be modified in the HC-bloc) or
- receive operation-data (which can be read from the HC-bloc).

In a HC-network the HC-blocs are always slaves.

HC-blocs in a HC-network are always salves.

A part of the operation-parameters and operation-data must be refreshed
- cyclically

on the other hand there are data and parameters which will only be exchanged
- on request.

# *10.2 Short description of HC-operation-parameters*

| designation | description |
|---|---|
| channel-values | Output-value for each power-output in [%] of maximum power (max. power = 100%). |
| channel-field-index | With help of this index each channel can be assigned to a field. There are 64 fields in a HC-system available (field 0 ... field 63).<br>If a channel is assigned to field „0“ this channel is deactivated (no drive of channel and no error control). |
| lowest to expect supply voltage | The value in [V] indicates the lowest to expect supply voltage for the power circle. It is the reference value for the supply voltage compensation. |
| rated voltage of consumers | Indicates the voltage in [V] at which the consumers give up their rated power.<br>This value is needed to error control more than one consumer connected to a channel in parallel. |
| rated power of consumers | The total power in [W] of all consumers connected to a single power-output.<br>This value is needed to error control more than one consumer connected to a channel in parallel. |
| field-values-production | Field-values in [%]. Each field (field 1 to 63; not field 0) for the production-cycle contains a field-value from 0-100%. |
| field-values-standby | Field-values in [%]. Each field (field 1 to 63; not field 0) for the standby-cycle contains a field-value from 0-100%. |
| Error status power circle | Detailed error status about each single power-output and the connected consumers. |
| actual phase voltage | $U_{eff}$ (average voltage) of phase L1, L2 and L3 from supply voltage of power unit. |
| actual current/phase | $I_{eff}$ (average current) of phase L1, L2 and L3 from supply voltage of power unit. |
| HC-electronic temperature | Temperature of the HC200 electronic. |
| actual current/channel | $I_{eff}$ (average current) of each single channel. |
| output-value | Output-value in [%]. The absolute %-value of each single power-output. |
| HC-bloc-status | Status information about the HC-bloc and global error status about the power outputs. |
| HC-system-control-byte | By means of the bits of this byte the host-system can control those functions which are the same for all HC-blocs in a HC-network.<br>• HC-system start/stop<br>• supply voltage compensation on/off<br>• switch between standby and production mode |
| HC-bloc-control-byte | By means of the bits of this byte the host-system can control those functions which are valid only for a single HC-bloc.<br>• HC-bloc-enabling<br>• „normal/emergency-operation temperature“ |

## *10.3 Difference of HC-parameters/data according to read and write data*

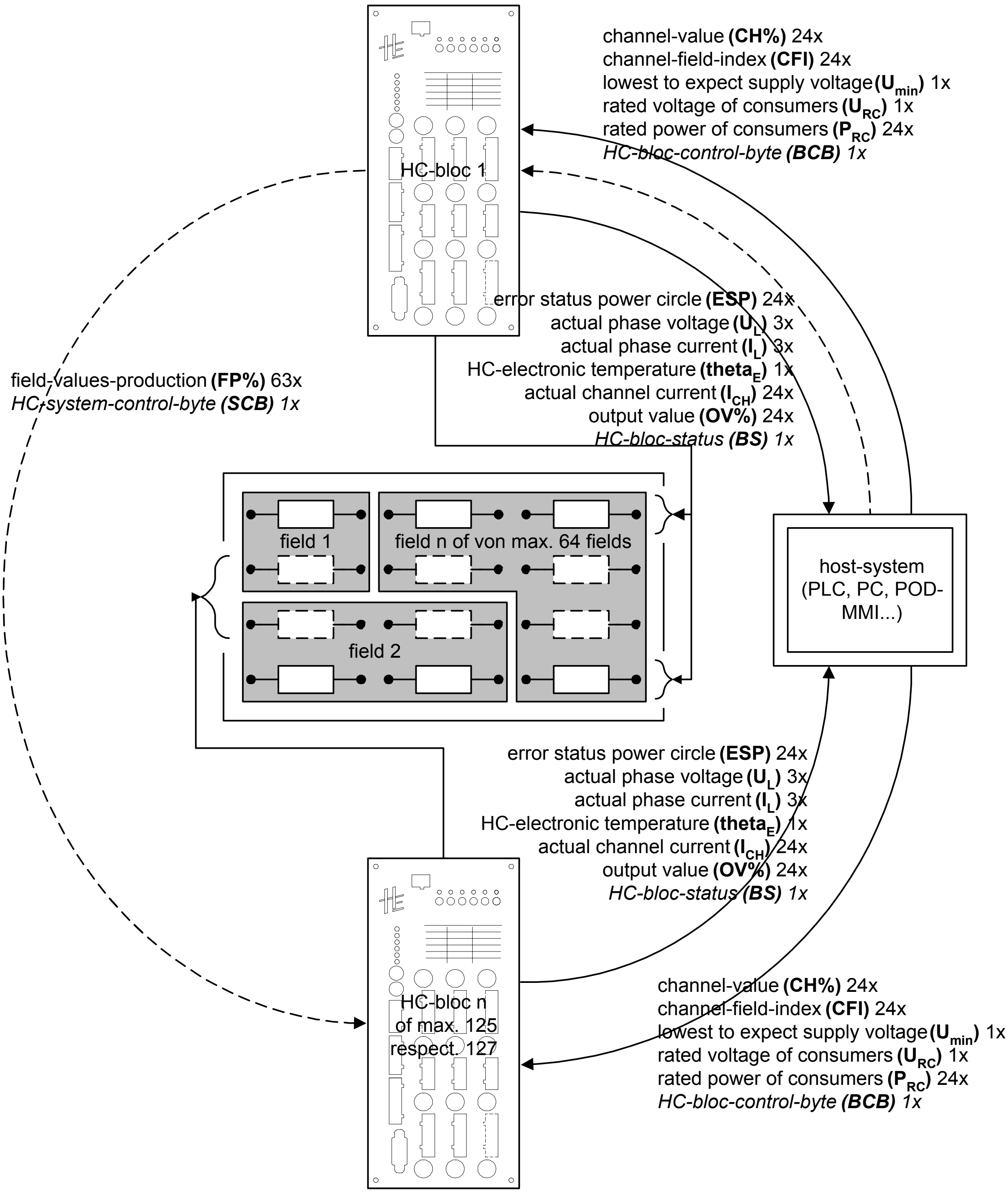
All operation-data can be read from a host-system at will. Logically they can not be modified by the host-system.
Theoretically one could try to write above the operation-data in the HC-bloc. In this case the HC-bloc will not accept the sent data from the host-system.

Operation-parameters will be send to the HC-bloc from the host-system.
It is also possible that a host-system can read the actual operation-parameters from a HC-bloc.

In case of a switch off of the HC-CPU supply voltage, all operation-parameters will get lost.

The operation-parameters get lost when the HC-CPU supply voltage will be switched off.

| operation-parameters / -data | can be read from host-system | can be modified by host-system |
|---|---|---|
| channel-value | X | X |
| channel-field-index | X | X |
| lowest to expect supply voltage | X | X |
| rated voltage of consumers | X | X |
| rated power of consumers | X | X |
| field-values-production | X | X |
| field-values-standby | X | X |
| error status power circle | X | |
| actual phase voltage | X | |
| actual phase current | X | |
| HC-electronic temperature | X | |
| actual channel current | X | |
| output-value | X | |
| HC-bloc-status | X | |
| HC-system-control-byte | | X |
| HC-bloc-control-byte | | X |


channel-value (CH%) 24x
channel-field-index (CFI) 24x
lowest to expect supply voltage ($U_{min}$) 1x
rated voltage of consumers ($U_{RC}$) 1x
rated power of consumers ($P_{RC}$) 24x
HC-bloc-control-byte (BCB) 1x
HC-bloc 1
error status power circle (ESP) 24x
actual phase voltage ($U_L$) 3x
actual phase current ($I_L$) 3x
HC-electronic temperature ($theta_E$) 1x
actual channel current ($I_{CH}$) 24x
output value (OV%) 24x
HC-bloc-status (BS) 1x
field-values-production (FP%) 63x
HC-system-control-byte (SCB) 1x
field 1
field n of von max. 64 fields
field 2
host-system
(PLC, PC, POD-MMI...)
error status power circle (ESP) 24x
actual phase voltage ($U_L$) 3x
actual phase current ($I_L$) 3x
HC-electronic temperature ($theta_E$) 1x
actual channel current ($I_{CH}$) 24x
output value (OV%) 24x
HC-bloc-status (BS) 1x
HC-bloc n
of max. 125
respect. 127
channel-value (CH%) 24x
channel-field-index (CFI) 24x
lowest to expect supply voltage ($U_{min}$) 1x
rated voltage of consumers ($U_{RC}$) 1x
rated power of consumers ($P_{RC}$) 24x
HC-bloc-control-byte (BCB) 1x

## *10.4 Shorthand expressions, occurrence, range of values and data type of HC-parameters/data*

| operation parameters / data | short | occurrence per HC-bloc | occurrence in a HC-system with n HC-blocs | range of values [dec]<br>values are exchanged in [hex] |
|---|---|---|---|---|
| channel-value | CH% | 24 | n x 24 | 0...100 % |
| channel-field-index | CFI | 24 | n x 24 | 0...63<br>0 = field inactive |
| lowest to expect supply voltage | $U_{min}$ | 1 | 1 | default = 207 volts<br>*HC200:* 170...240 volts<br>*HC400:* 170...500 volts |
| rated voltage of consumers | $U_{RC}$ | 1 | 1 | default = 230 V<br>*HC200:* 190...240 volts<br>*HC400:* 190...500 volts |
| rated power of consumers | $P_{RC}$ | 24 | n x 24 | default = not active<br>*HC200:* 100...2.000<br>*HC400:* 300...65.000 watts |
| field-values-production | FP% | 63 | 63 | 0...100 % |
| field-values-standby | FS% | 63 | 63 | 0...100 % |
| *HC400 only* | | | | |
| shut-down-voltage | $U_{SD}$ | 1 | n x 1 | default = 170 volts<br>140...500 volts |
| overcurrent | $I_{OC}$ | 1 | n x 1 | default = 50 ampere<br>3...4.000<br>3....400 amps |
| allowed rated-power-tolerance % | $P_{RCT}$% | 1 | n x 1 | 4...100 % |
| allowed rated-power-tolerance Watt | $P_{RCT}$W | 24 | n x 24 | 200...65.000 watts |
| error status power circle | ESP | 24 | n x 24 | bit code |
| actual phase voltage | $U_L$ | 3 | n x 3 | *HC200:* 0...278 volts<br>*HC400:* 0...578 volts |
| actual phase current | $I_L$ | 3 | n x 3 | *HC200*<br>0...400 = 0..40 amps<br>*HC400*<br>0...4.000 = 0...400 A |
| *HC400 only* | | | | |
| HC-electronic temperature | $\vartheta_E$ | 1 | n | 100...170 = 0...70 C° |
| actual channel current | $I_{CH}$ | 24 | n x 24 | *HC200*<br>0...400 = 0..40 amps<br>*HC400*<br>0...4.000 = 0...400 A |
| output-value | OV% | 24 | n x 24 | 0...100 % |
| *HC400 only* | | | | |
| rated power of cosumers measured | $P_{RCM}$ | 24 | n x 24 | 200...**???** watts |
| HC-bloc-status | BS | 1 | n | bit code |
| HC-system-control-byte | SCB | 1 | 1 | bit code |
| HC-bloc-control-byte | BCB | 1 | n | bit code |

## *10.5 Detailed description of the HC-data*

### 10.5.1 Channel-value (CH%)

To know the desired height of power generated at the consumers connected to a single power-output (channel) the HC-bloc need for each channel a so called „channel-value". The channel-value must be input in %. 100% will mean, that all sinus half waves will be switched to the consumer(s) whereas 30% will mean that only 30 of 100 halfwaves will be switched to the consumer.

### 10.5.2 Channel-field-index (CFI)

By means of the CFI, each power-output (channel) can be assigned to a field. By assigning different channels to the same field, single channels can be combined in groups.

The CFIs are the same for all HC-blocs in a HC-system. That means, that a field can be grouped with channels from different HC-blocs.

Channels can be assigned individually to CFIs from „0" to „63" (64 CFIs total).

Assigning a channel to CFI = „0" will mean, that the cannel is deactivated (no drive of output, independent of the value in CH%) and that the channel will not be taken in consideration for error control.

| CFI = „0" will mean that the corresponding channel is deactivated. |
|---|

### 10.5.3 Lowest to expect supply voltage ($U_{min}$)

$U_{min}$ is needed for the supply voltage compensation *(refer to chapter „Supply voltage compensation" page 87 ff.)*.
This value is unique in the HC-network. I.e. $U_{min}$ is valid for all HC-blocs likewise.

### 10.5.4 Rated voltage ($U_{RC}$) and rated power ($P_{RC}$) of consumers

Rated voltage of consumers ($U_{RC}$) and rated power of consumers ($P_{RC}$) are needed for the extended error control of the consumers (overload / one of many consumers broken = Bit 3 and 4 of the error-status power circle (ESP)).
$P_{RC}$ can (not a must) be input for each channel individually. $P_{RC}$ stands for the total rated power of all consumers connected to a single power-output.
A consumer generate at its specific nominal voltage (usually specified by the manufacturer and stamped on the consumer) its rated power.
The rated voltage of consumers ($U_{RC}$) is valid for all consumers operate with the same HC-bloc.

Consequently all consumers operate with the same HC-bloc should have the same rated voltage of consumers ($U_{RC}$).

For a correct function of the extended consumer error control, all consumers of a HC-bloc should have the same rated voltage of consumers ($U_{RC}$).

HC400 only:
The HC400 HC-blocs have at disposal a so called teach-mode.
In the teach mode they measure the voltage an amps of all consumers and calculate with the information of the rated voltage of consumers (URC) the rated power of consumers (PRC)
*(Refer to chapter* ***Fehler! Verweisquelle konnte nicht gefunden werden.****" **Fehler! Verweisquelle konnte nicht gefunden werden.**" at page* ***Fehler! Textmarke nicht definiert.****.)*

### 10.5.5 Field-values-production (FP%)

Only because, like mentioned above, single power-outputs can be grouped as fields, it is possible to set the level of output power by variation of a single value, the field-value.

With 64 possible fields 63 field-values-production can be input (field 0 is reserved to deactivate channels and therefor do not need a field-value).
Field-values are input in % (1 ... 100%).

The output-value (the output power) is calculated according to the following formula.

output-value [%] = channel-value [%] x belonging field-value [%]
OV% = CH% x FP% (resp. FS%)

For the temperature regulation *(refer to chapter 18 „Concept of temperature control" page 90)* it is absolutely necessary to have a fast influence on the output-power of <u>all</u> consumers and especially at the same time (variation of set point values for all consumer).
Consequently for a temperature regulation the field-values-production (FP%) and not all single channel-value (CH%) should be influenced.
For this the 63 field-values-production will be send at the same time to all HC-blocs in a HC-network by a special network service *(refer to chapter 13.7.4 „Service 4 / broadcast" on page 76)*.

### 10.5.6 Field-values-standby (FS%)

Next to the 63 field-values for the production-cycle another 63 field-values for the standby-cycle.

The field-values standby are available with each HC-bloc but practically make sense when being used with the HC-HMIs.

Like already explained in the previous chapter field-values-production can be influenced very fast with a special network service *(refer to chapter 13.7.4 „Service 4 / broadcast“ on page 76)*.
Already with this feature the machine builder is enabled to reduce the output power of the single channels belonging to (for example used with thermoforming machines while the foil is deep-drawing and the heating, to reduce energy cost, in standby).

### 10.5.7 Shut-down-voltage ($U_{SD}$)

*HC400 only*
A HC200 HC-blocs disables its power outputs 300 milliseconds after the voltage (between phase and neutral) has dropped below 170 Volts.
Duration of shut down = the time the voltage is below 170 Volts.

The HC400 HC-bloc can be operate in a supply voltage network with neutral (consumers between phase and neutral = Y-operation) as well as those without neutral (consumers between two phases = ∆-operation).
The max. phase voltage can be 480 volts.

As a standard the HC400 HC-bloc is also disabling its SSR-control-outputs as long as the supply voltage drops below 170 Volts for longer then 300 ms.

Because a HC400 HC-bloc can be operate at various supply voltages, the voltage at which the HC-bloc is going to disable its outputs can be set, using the HC-parameter shut-down-voltage ($U_{SD}$)“.

| | **HC200** | **HC400** |
|---|---|---|
| **default** | 170 V | 170 V |
| **range** | --- | 140...500 V |

### 10.5.8 Overcurrent ($I_{OC}$)

HC400 only:
In case the HC-parameter „rated power of consumers is ($P_{RC}$)" has not been transferred to a HC-bloc, the HC200 HC-bloc (not HC205) indicate an alarm, when the channel current exceed 5 amps.
*(Refer to chapter 10.5.11 „Error status power circle (ESP)" at page 44.)*

A HC400 HC-bloc can control by means of SSRs a max. current of 400 amps.
In case the HC-parameter „rated power of consumers is ($P_{RC}$)" has not been transferred to a HC-bloc, the HC400 HC-bloc indicate an alarm, when the channel current exceed 60 amps.

The HC200 current limit is depending on the max. amp of the internal power switch (triac). The HC400 has no amp restrictions of internal triacs because of external SSRs. SSRs with a max. of 400 amps can be used.

For this reason the amp at which the HC400 HC-bloc will indicate an error is a variable („overcurrent ($I_{OC}$)") that can be set individually.

| | HC200 | HC400 |
|---|---|---|
| default | 5 A | 50 A |
| range | can not be edit | 4...400 A |

### 10.5.9 Allowed rated power tolerance % ($P_{RCT}$%)

*HC400 only*
The HC200 (not HC205) indicates an alarm if the „rated power of consumers % ($P_{RC}$)" has been transferred to the HC-bloc and the measured power is 20% (or above) below the „rated power of consumers ($P_{RC}$)".

To detect a difference between expected and measured power at least 1 value for „rated power of consumers ($P_{RC}$)" must be transmit to the HC-bloc.

Transmitting the „rated power of consumers ($P_{RC}$)" to the HC-bloc, the HC-bloc can detect that one of 2 or 3 heaters operate at the same power output break.

At HC400 controlled SSRs many heaters (we recommend a max. of 12...15 heating elements) can be controlled in parallel.

The power of 1 heating element could be less then 20% of the power of all heating element at an SSR.
In this case one heater could break without an error indication of the HC400

*Example:*
„rated power of consumers ($P_{RC}$)" at one SSR = 9 x 1.000 watts = 9.000 watts.
20 % of 9.000 watts = 1.800 watts.

At a difference of 1.800 watts (or above) the HC400 would indicate an error. The break of a heater with 1.000 Watt is not detected.

For this reason the „allowed rated power tolerance % ($P_{RCT}$%)“ between nominal power (=„rated power of consumers ($P_{RC}$)“) and measured power can be input as a % value of the „rated power of consumers ($P_{RC}$)“.

The „allowed rated power tolerance % ($P_{RCT}$%)“ is valid for all channels of the HC400.

| | HC200 | HC400 |
|---|---|---|
| default | 20% | 20% |
| range | --- | 4...100% |

Setting $P_{RCT}$% to 1, 2 or 3% will be changed by the HC400 to 4 %
Setting $P_{RCT}$% above 100% will be changed by the HC400 to 100%.

The amp resolution of the HC400 is 2* 0,7 amps.
It is guaranteed that the HC400 will detect the break of

- a 600 watt heater at 230 volts (> 2 * 0,7 A * 230 volts = 322 watts) and
- a 1000 watt heater at 480 volts (> 0,7 A * 480 volts = 672 watts)

Controlling two 400 $Watt_{230V}$ heaters at an SSRs and inputting for „allowed rated power tolerance % ($P_{RCT}$%)“ a value of 4%, does not mean that at a difference of 32 watts but only at a difference of approx. 2 * 0,7 A x 230 Volt = 322 watts (guaranteed 600 watts) the load break of one heater is indicated !

### 10.5.10 Allowed rated power tolerance Watt ($P_{RCT}$W)

The „allowed rated power tolerance % ($P_{RCT}$%)“ is valid for all channels of the HC400. Controlling a the SSRs different quantities of heating elements, the HC400 could in certain cases not detect the break of a single heating element.

*Example:*

- channel A = 2 x 300 watts; total = 600 watts
  „rated power of consumer ($P_{RC}$)“ = 600 watts
- channel B = 15 x 750 watts; total = 11.250 watts
  „rated power of consumer ($P_{RC}$)“ = 11.250 Watt

To detect the break of a single heating element „rated power of consumer ($P_{RC}$)“ must be set for

- channel A to approx. 33% (33% of 600 watts = approx. 200 watts) but for
- channel B to approx. 5 % (5% of 11.250 Watt = approx. 560 watts).

For such a case the „allowed rated power tolerance Watt ($P_{RCT}W$)“ can be input for each channel individually“.

| | HC200 | HC400 |
|---|---|---|
| default | --- | --- |
| range | --- | 200...65.000 Watt |

To enable the function of „allowed rated power tolerance Watt ($P_{RCT}W$)“ at least 1 value for „rated power of consumers ($P_{RC}$)“ must be transmit to the HC-bloc.

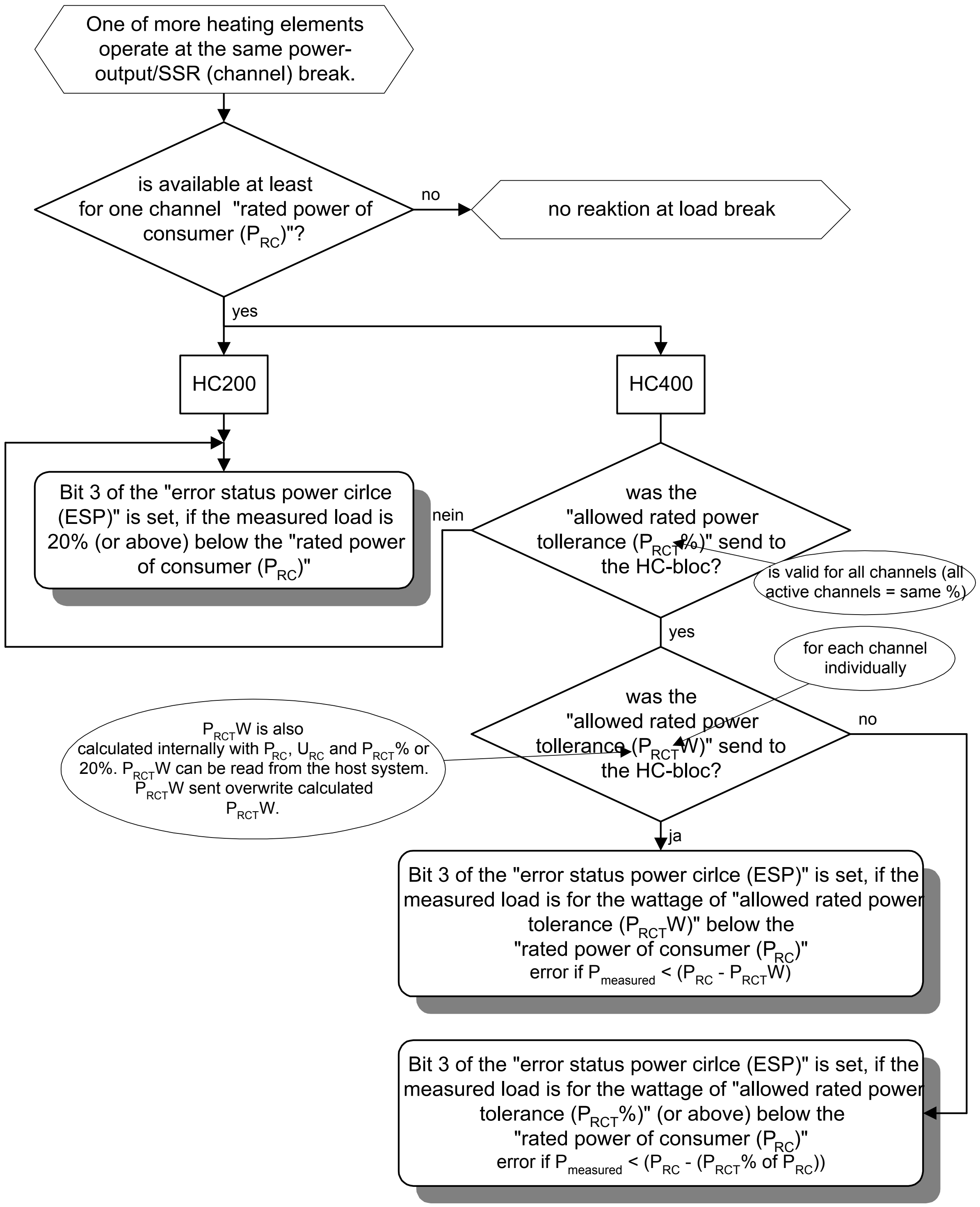
The „allowed rated power tolerance Watt ($P_{RCT}W$)“ is valid at the „rated voltage of consumer ($U_{RC}$)“.

It is not essential to input the „allowed rated power tolerance Watt ($P_{RCT}W$)“ for all channels.

For those channels not having at disposal a value for „allowed rated power tolerance Watt ($P_{RCT}W$)“ the HC400 is calculating this wattage with

- „rated power of consumers ($P_{RC}$)“,
- „rated voltage of consumers ($U_{RC}$)“,
- „actual phase voltage ($U_L$)“ and
- 20% respectively „allowed rated power tolerance % ($P_{RCT}$%)“

The calculated resp. input value (input value overwrite calculated value) of the „allowed rated power tolerance Watt ($P_{RCT}W$)“ can be read with the host system.


One of more heating elements operate at the same power-output/SSR (channel) break.
is available at least for one channel "rated power of consumer ($P_{RC}$)"?
no
no reaktion at load break
yes
HC200
HC400
Bit 3 of the "error status power cirlce (ESP)" is set, if the measured load is 20% (or above) below the "rated power of consumer ($P_{RC}$)"
nein
was the "allowed rated power tollerance ($P_{RCT}$%)" send to the HC-bloc?
is valid for all channels (all active channels = same %)
yes
for each channel individually
was the "allowed rated power tollerance ($P_{RCT}$W)" send to the HC-bloc?
no
$P_{RCT}$W is also calculated internally with $P_{RC}$, $U_{RC}$ and $P_{RCT}$% or 20%. $P_{RCT}$W can be read from the host system. $P_{RCT}$W sent overwrite calculated $P_{RCT}$W.
ja
Bit 3 of the "error status power cirlce (ESP)" is set, if the measured load is for the wattage of "allowed rated power tolerance ($P_{RCT}$W)" below the "rated power of consumer ($P_{RC}$)"
error if $P_{measured} < (P_{RC} - P_{RCT}W)$
Bit 3 of the "error status power cirlce (ESP)" is set, if the measured load is for the wattage of "allowed rated power tolerance ($P_{RCT}$%)" (or above) below the "rated power of consumer ($P_{RC}$)"
error if $P_{measured} < (P_{RC} - (P_{RCT}\% \text{ of } P_{RC}))$

### 10.5.11 Error status power circle (ESP)

By means of 24 datawords (1 dataword per power-output) the host-system can request a detailed error status of all 24 power circle of a single HC-bloc.

If one ore more bits are set to 1, an error in the corresponding power circle is present.

The error status power circle is available for each channel

| bit | Bit = 1 if | possible reason for error | with soft start | with rated power of consum-ers |
|---|---|---|---|---|
| 0 | current limit value remain under<br>*HC200:* 0,1 A<br>*HC400:* 0,7 A | fuse blown or<br>load or wire broken;<br>HC400 only: SSR defective | x | x |
| 1 | the amp limit is exceeding<br>• HC200: 5 A<br>• HC400: HC-Parameter $I_{OC}$ | overload | ---- | --- |
| 2 | power-output can not be switch off | triac or SSR defective (shorted) | x | x |
| 3* | actual power<br>• HC200 = 20%<br>• HC400 = HC-Parameter $P_{RCT}$% or $P_{RCT}$W<br>below rated power | One ore more consumer at the power-output / SSR are defective or failed. | --- | x |
| 4* | actual power<br>• HC200 = 20%<br>• HC400 = HC-Parameter $P_{RCT}$% or $P_{RCT}$W<br>above rated power | One ore more consumer at the power-output / SSR are defective | --- | x |
| 5 | supply voltage of L1, L2 or L3 = 0V or<br>• HC200: <170 Volt<br>• HC400: < HC-Parameter $U_{SD}$ | Circuit breaker or contactor for power supply defective. Supply voltage not available. | x | x |
| HC400 only: | | | | |
| 6** | amp of SSR-control output above 60 mA | short circuit at SSR-control-output | x | x |
| 7 ...15 | reserved (all times 0) | | | |

* Bit 3 and 4 are only taken into consideration (will only be set in case of an error) if the HC-bloc has the information about the rated power of consumers ($P_{RC}$) and rated voltage of consumers ($U_{RC}$).

HC400 only:

** If more then one bit 6 is set (= „1“) the respective bits 0 will be set also. In this case, the HC can not detect which channels have a short circuit SSR-control-output and which a blown fuse / broken load / broken cable / shorted SSR.

### 10.5.12 Actual phase voltage ($U_L$), actual phase current ($I_L$)

From each HC-bloc the host-system can request the values of the actual voltage ($U_{L1}$, $U_{L2}$ and $U_{L3}$) and the actual current ($I_{L1}$, $I_{L2}$ and $I_{L3}$) from phase L1, L2 und L3.
With these values a machine builder can calculate the actual power consumption of the whole HC-system or just of a single HC bloc.

The voltage and current values are refreshed every 5 seconds.

### 10.5.13 Electronic temperature($\vartheta_E$)

*only HC200*
The host-system can request by means of this operation-data the actual HC200-electronic temperature.
The measuring range goes from 0 to 70°C.
The value 100 stands for 0°C, the value 170 stand for 70°C.

### 10.5.14 Actual channel current ($I_{CH}$)

In each of the 24 HC-data called „actual phase current“ ($I_{CH10}$, $I_{CH11}$, $I_{CH12}$ ... $I_{CH17}$, $I_{CH20}$ ... $I_{CH27}$ and $I_{CH30}$ ... $I_{CH37}$) the HC-bloc makes at disposal the nominal amp of the load connected to the respective power outputs.
I.e.: The HC-bloc measures the effective amp that a load would consume at 100% output value.
Only the $I_{CH}$ of active channels (channels that are assigned to field 1 ... 63 and not to field 0) are measured.
$I_{CH}$ of each channel will be refreshed with the start of the heating (setting bit 0 of the HC-system-control-byte (SCB) to „1“) and all 4 minutes with the HC200 in operation (heating = started).

### 10.5.15 Output-values (OV%)

The output-value [in %] of each channel is a result of

- channel-value (CH%) *
- field-value production or standby (FP% or FS%) of the respective channel *
- supply voltage compensation value.

The advantage of the OV% is that the output-value of all 24 channels of a HC-bloc are available as an actual operation-data in the HC-bloc and must not be calculated in the host system (what you see is what you get).

The OV% will even be shown if the heating is off (offline information).

### 10.5.16 Rated power measured ($P_{RCM}$)

*HC400 only*

The HC-bloc is calculating for each channel with

- the measured „actual channel current“,
- the „rated voltage of consumers ($U_{RC}$)“ and
- the „actual phase voltage ($U_L$)“

the „rated power of consumers measured ($P_{RCM}$)“.

„Rated power of consumers measured ($P_{RCM}$)“ but not the wattage indicated on the heating elements should be input for „rated power of consumers ($P_{RC}$)“.

Reason: The power indicated on the heating elements differ sometimes considerable with the measured rated power.

### 10.5.17 HC-bloc-status (BS)

Each HC-bloc send on request of the host-system its status (the HC-bloc-status). The HC-bloc-status contain the 4 most important information about the operation status of the HC-bloc *(refer to chapter 13.7.1 „Service 1 /* start-communication*" on page 71)*.
It is obvious that the HC-bloc-status can only be requested if the host-system succeed to communicate via the HC-network with the appropriate HC-bloc.
If a communication is not possible the HC-bloc or the HC-network are defective or in the HC-network transmission errors occur.

| function | Bit | Bit = 0 | Bit = 1 |
|---|---|---|---|
| HC-CPU-status | 0 | HC-CPU is defective | HC-CPU is operating normally |
| power circle | 1 | OK | error |
| temperature monitoring of HC-electronic | 2 | no response | respond |
| HC-NET communication error | 3 | OK | last communication failed |

<u>HC-CPU-status</u>
When this error occurs, the HC-CPU recognize an error at itself. For security reasons all power outputs of the HC-bloc will be switched off, regardless weather the host system are enabled the HC-bloc or started the HC-system *(refer also to chapter 12.4.1* „Special case HC-HMI / reaction at error*" page 59 ff. .)*

If the HC-CPU recognize any error at itself (or on the CPU circuit board), all power outputs of the HC-bloc will be switched off (if possible).

<u>power circle</u>
If this bit is set to „1" some error is present in the power circle of the respective HC-bloc. A detailed error status about he power circle can be obtained by means of the operation-data „error status power circle" *(refer to chapter 10.5.11* „Error status power circle (ESP)*" on page 44)*.

If one ore more errors in the power circle are present, the power-outputs of the respective HC-bloc will <u>not</u> be switched off. Exception: If one ore more phases are missing all power-outputs will be switches off automatically.

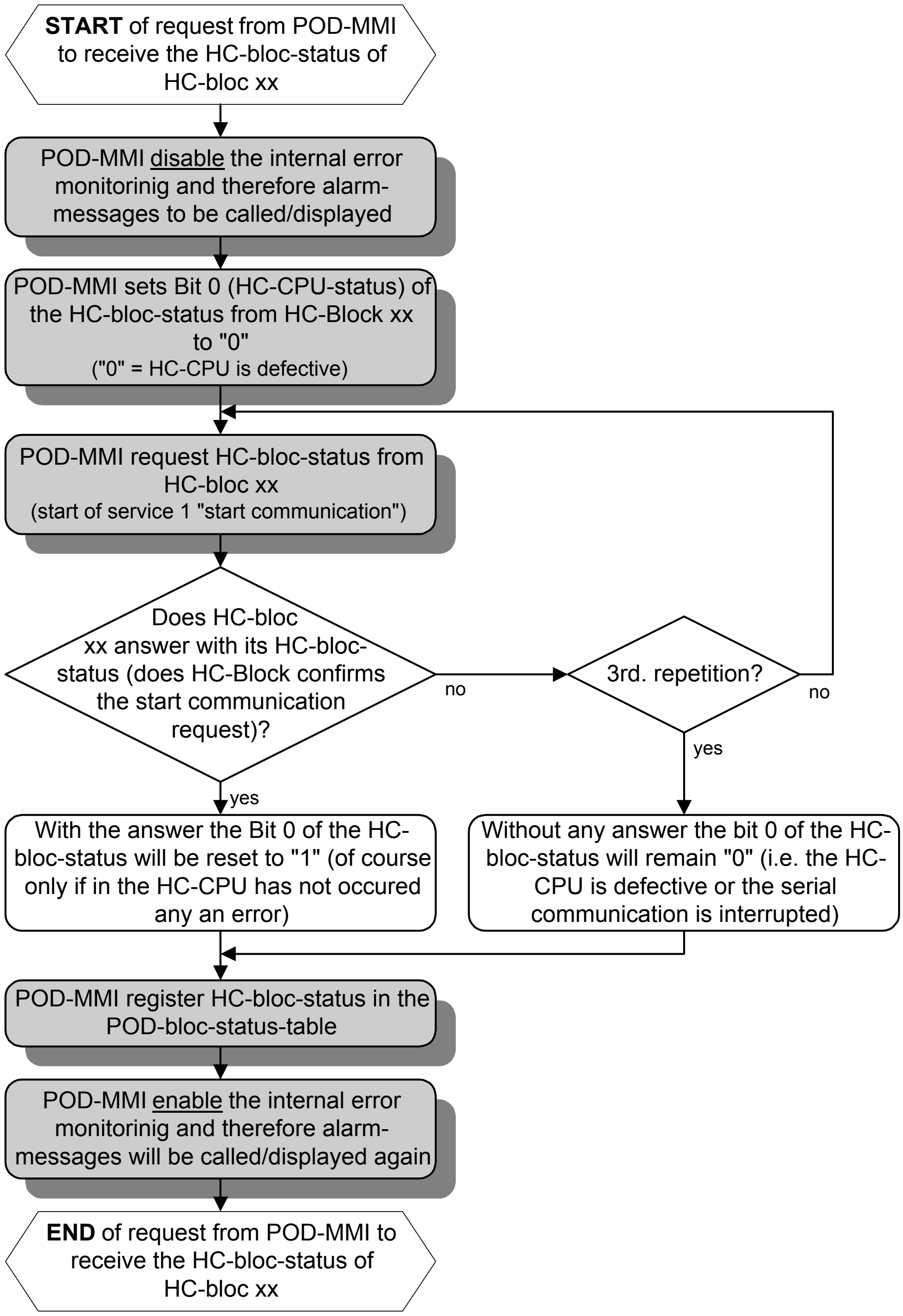
<u>temperature monitoring of HC-electronic</u>
By means of this Bit the HC-bloc indicates that the HC-electronic temperature has exceed a limit to high to enable a secure operation of the HC-bloc.
*(The reaction in case of this failure are explained in chapter 11 „Error* mode - temperature exceed*" page 53 ff. .)*

HC-network communication error

If during transmission of data/parameters from the host-system an error occurs (checksum, parity...) the error will be reported to the host-system by means of this bit. *(Refer also to chapter 12.4 „*Behavior at error*“ on page 58 and chapter 13.8.3 “*Reaction at checksum error*“ on page 80“.)*

### *10.5.17.1 Special case HC-HMI / HC-bloc-status*

Die HC-HMI request cyclically (with a fixed polling time) the HC-bloc-status of each HC-bloc in a HC-network. The HC-bloc-status will be written form the HC-HMI in the POD-bloc-status-table. If an error is reported, the HC-HMI react in different ways *(refer to chapter 12.4 „Behavior at error“ page 58 ff.)*.



### 10.5.18 HC-bloc-control-byte (BCB)

By means of the bits of the HC-bloc-control-bytes (BCB) the HC-functions for each single HC-bloc can be controlled separately *(refer to chapter 13.7.1 „Service 1 /* start-communication*“ on page 71)*.
(Compare to HC-system-control-byte - this byte controls only those functions valid for all HC-blocs in a HC-network.)

| HC-function | Bit | Bit = 0 | Bit = 1 |
|---|---|---|---|
| HC-bloc-enabling | 0 | locked | released |
| normal/emergency-operation temperature | 1 | normal operation | emergency operation |
| reserved | 2 | | |
| reserved | 3 | | |

HC-bloc-enabling
By means of the Bit 0 the host-system can enable a single HC-bloc for HC-bloc enabling.
But before power can be output at a power-output of the HC-bloc, still some other conditions must be fulfilled *(refer to the flow chart in the following chapter)*.

emergency operation temperature
If the bit 1 is set to „1“ the HC-bloc will not disable its power outputs as soon as a to high temperature of the HC-electronic is detected.
*(refer to chapter 11 „*Error mode - temperature exceed*“ on page 53)*.

### 10.5.19 HC-system-control-byte (SCB)

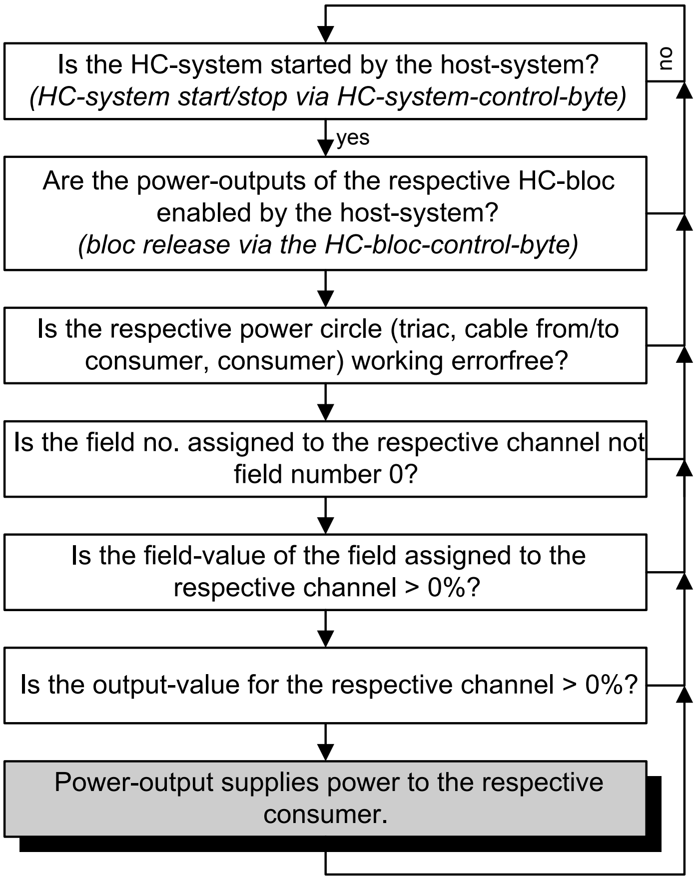
With the HC-system-control-byte the host-system can control those HC-functions that applies to all HC-blocs in a HC-network *(refer to chapter 13.7.4 „Service 4 / broadcast“ on page 76)*.
(Compare to HC-bloc-control-byte - this byte controls only those functions valid for one single HC-blocs in a HC-network.)

| HC-function | Bit | Bit = 0 | Bit = 1 |
|---|---|---|---|
| HC-system start/stop | 0 | stopped | started |
| supply voltage compensation | 1 | off | on |
| standby-mode | 2 | off | on |
| reserved | 3 ... 15 | | |

HC-system start/stop
By means of this Bit 0 all power-outputs are enabled to output power if in addition the following conditions are fulfilled:

- The HC-bloc-enabling for the respective HC-bloc in the HC-network must be enabled (released) from the host-system,
- the field assigned to the channel must have a field number from 1 to 63 (not 0)
- channel-value und field-value for the respective power-output must be > as 0% and
- the HC-bloc as well as the respective power-output must operate error free.

The simplified flow chart on the next page will show the context:




Supply-voltage-compensation
The supply-voltage-compensation can be activated/deactivated for all HC-blocs in a HC-system by means of bit 2 of the HC-system-control-byte *(refer to chapter 16* „Supply voltage compensation*“ at page 87 ff.)*.

Standby-mode
The standby-Mode can be activated/deactivated for all HC-blocs in a HC-system by means of Bit 3 of the HC-system-control-byte.

## *10.6 HC-addresses of HC-data in HC-bloc*

For each HC-bloc the following HC-data are available.
These HC-data differ according to its origin:

- HC-data which will be send/(edit) from the host-system (operation-parameters) and
- HC-data which can be read from the host-system (operation-data).

| HC-data | short | from HC-address (dez/hex) | to HC-address (dez/hex) | no. of data | host-system receive (can be read from host-system) | host-system send (can be edit from host-system) |
|---|---|---|---|---|---|---|
| channel-value | CH% | 0/0 | 23/17 | 24 | X | X |
| channel-field-index | CFI | 24/18 | 47/2F | 24 | X | X |
| lowest to expect supply voltage | $U_{min}$ | 48/30 | 48/30 | 1 | X | X |
| rated voltage of consum. | $U_{RC}$ | 49/31 | 49/31 | 1 | X | X |
| rated power of consumers | $P_{RC}$ | 50/32 | 73/49 | 24 | X | X |
| field-values-production | FP% | 74/4A | 136/88 | 63 | X | X |
| field-values-standby | FS% | 137/89 * | 199/C7 * | 63 * | X | X |
| *HC400 only* | | | | | | |
| shut down voltage | $U_{SD}$ | 200/C8 | --- | 1 | X | X |
| overcurrent | $I_{OC}$ | 201/C9 | --- | 1 | X | X |
| allowed rated power tolerance % | $P_{RCT}$% | 202/CA | --- | 1 | X | X |
| allowed rated power tolerance Watt | $P_{RCT}$W | 203/CB | 226/E2 | 24 | X | X |
| *reserved (not used)* | | *227/E3* | *255/FF* | | | |
| error status power circle | ESP | 256/100 | 279/117 | 24 | X | |
| actual phase voltage | $U_L$ | 280/118 | 282/11A | 3 | X | |
| actual phase current | $I_L$ | 283/11B | 285/11D | 3 | X | |
| *HC200 only* | | | | | | |
| HC-electronic temperature | $\vartheta_E$ | 286/11E | 286/11E | 1 | X | |
| actual channel current | $I_{CH}$ | 287/11F | 310/136 | 24 | X | |
| output-value | OV% | 311/137 | 334/14E | 24 | X | |
| *HC400 only* | | | | | | |
| rated power of cosumers measured | $P_{RCM}$ | 335/14F | 358/166 | 24 | X | |
| HC-bloc-status | BS | ** | ** | 1 | X | |
| HC-system-control-byte | SCB | *** | *** | 1 | | X |
| HC-bloc-control-byte | BCB | **** | **** | 1 | | X |

** The HC-bloc-status is an operand (in the first answer command/data-sentence) send from the HC-bloc after a start-communication-request of the host-system *(refer to chapter 13.7.1 „Service 1 / start-communication“ on page 71)*.
That’s the reason why the HC-bloc-status has no direct address in the HC-bloc.

*** The HC-bloc-control-byte is an operand (in the first command/data-sentence) of the start-communication-request send from the host-system to the HC-bloc *(refer to chapter 13.7.1 „Service 1 / start-communication“ on page 71).*
That’s the reason why the HC-bloc-control-byte has no direct address in the HC-bloc.

**** The HC-system-control-byte is an operand (in the second command/data-sentence) send from the host-system to all HC-blocs *(refer to chapter 13.7.4 „Service 4 / broadcast“ on page 76).*
That’s the reason why the HC-system-control-byte has no direct address in the HC-bloc.

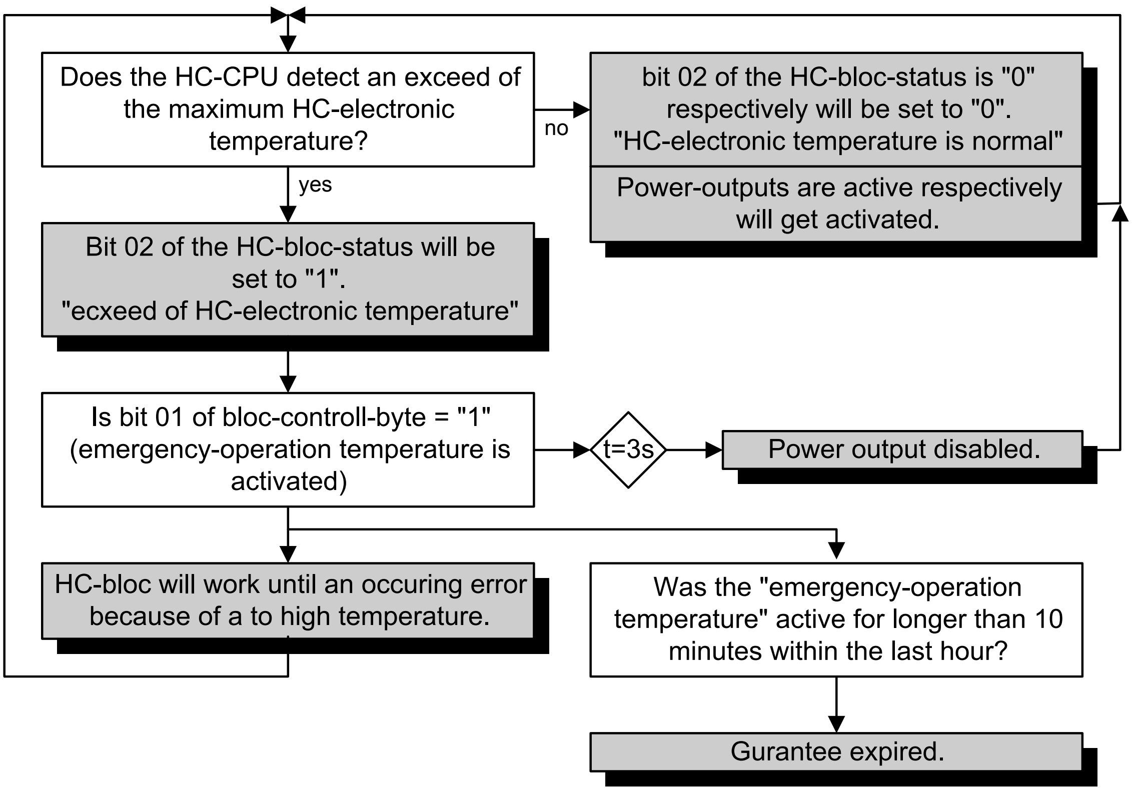
# 11 Error mode - temperature exceed

If the HC-CPU detect during operation, that the HC-electronic is to hot, the HC-CPU disable the power output (power = 0%) of all channels after a delay of 3 seconds.

But its also possible to disable this security function and to give power to the outputs even if the HC-electronic has become to hot.
That makes sense only to finish a started production-cycle and not for standard operation.
The automatic switch off of the output power because of a temperature exceed of the HC-temperature can be suppressed by means of Bit 1 of the HC-bloc-control-byte „emergency-operation temperature“.

Should the „emergency-operation temperature“ be activated for more than 10 minutes within a period of 1 hour, the guarantee is expired automatically.

The following flow chart illustrates the context of the „emergency-operation temperature“.



# 12 Error diagnosis / reaction at error

Each HC-bloc is diagnosable through

- its status-LEDs or
- the HC-bloc-status respectively the „error status power cycle“ over the HC-network.

In addition its possible to indicate the operation status of each HC-bloc by means of 2 relay (make contact type).

## *12.1 Diagnosis with status LEDs*

The LEDs can have the following conditions: on, off and blinking.
Already on the front panel a inscription describes the meaning of the condition of each single LED (in English language).

| | **LED on** | **LED off** | **LED blinking** |
|---|---|---|---|
| **H1 / CPU** | ok | no voltage | error |
| **H2 / outputs** | prod. mode | not active | standby mode |
| **H3 / network** | --- | no data exch. | data exchange |
| **H4 / voltage.** | on | off | network error |
| *HC200 =* | | | |
| **H5 / HC-temper.** | to high | normal | emerg. mode |
| *HC400 =* | | | |
| **H5 / SSR-crt out** | error | ok | --- |
| **H6 / power cicle** | error | normal | no power supply |

| LED | meaning | color | LED on | LED off | LED blinking |
|---|---|---|---|---|---|
| H1 | HC-CPU | green | supply voltage available and HC-CPU OK | no supply voltage for HC-CPU | error in HC-CPU |
| H2 | power-outputs | green | active in production cycle | not active | active in standby cycle |
| H3 | HC-network | yellow | | non data exchange | data exchange |
| H4 | supply voltage compensation | yellow | supply-voltage-compensation on | supply-voltage-compensation off | error in network (usually missing network or host-system) |
| HC200 only: | | | | | |
| H5 | monitoring of HC-electronic temp-erature | red | exceed of HC-electr. temperature | HC-electronic temperature normal | emergency-operation temperature |
| HC400 only: | | | | | |
| H5 | SSR-control-outputs | red | one ore more short circuit | normal operation | |
| H6 | - power circle<br>- load supply | red | error in HC-power circle | normal operation of power circle | supply voltage of min. 1 phase missing |

HC400 only:
In case of a short circuit of one ore more SSR-control-outputs, LED 5 will be set to ON.
In case of one ore more short circuit SSR-control outputs and one ore more power circles have a problem (fuse blown, load broken, defective triac ..) the HC-bloc can not detect what channel has what type of problem.
In this case LED 5 and LED 6 will be set to ON.

## *12.2 Diagnosis with HC-bloc-request from host-system*

By means of the HC-bloc-status (BS) a host-system can obtain a global (compressed) error status about

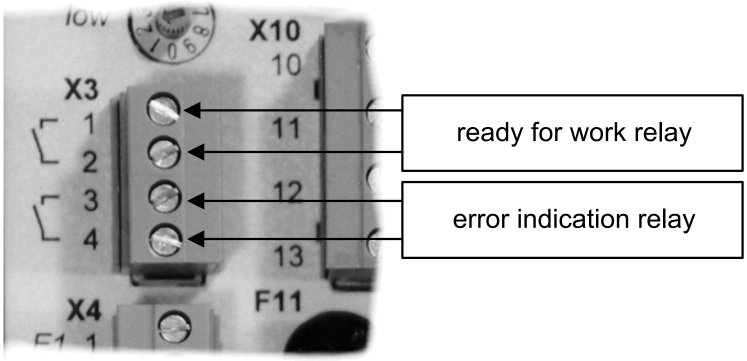
- the HC-CPU
- the power circles
- HC400 only: the SSR control outputs and SSRs
- HC200 only: the HC200-electronic temperature and
- the HC-NET network

*(For detailed information refer to chapter 10.5.17 "HC-bloc-status* (BS)" *page 47ff. .)*

For more detailed information about the status of each power-output the host-system can request the „error status power circle" for each single HC-bloc.
(refer to chapter *10.5.11 „*Error status power circle (ESP)*" on page 44)*.

## *12.3 Operation status with relay outputs*

The easiest way to get an information about the operation status of a HC-bloc is to use the relay outputs.
2 relay with one make contact for 230 V dc / 6 A resp. 24 V ac / 6 A are available as an optional on each HC-bloc.
One relay is related to the status of the HC-CPU / HC-network, the other to the HC-power unit / power circle.




At the presence of the following errors

- HC-CPU supply voltage not available and/or
- HC-CPU error and/or
- HC-NET network transmission error

the **ready for work relay** will open (resp. do not pick up). Then the relay is in neutral position (contact opened).

At the presence of the following errors

- load or wire breaking or defective power switch of one or more channels and/or
- HC200 only: HC200-electronic temperature to high and/or
- HC400 only: short circuit of one ore more SSR control outputs and/or
- supply voltage for power unit (of one or more phase) failed or not available

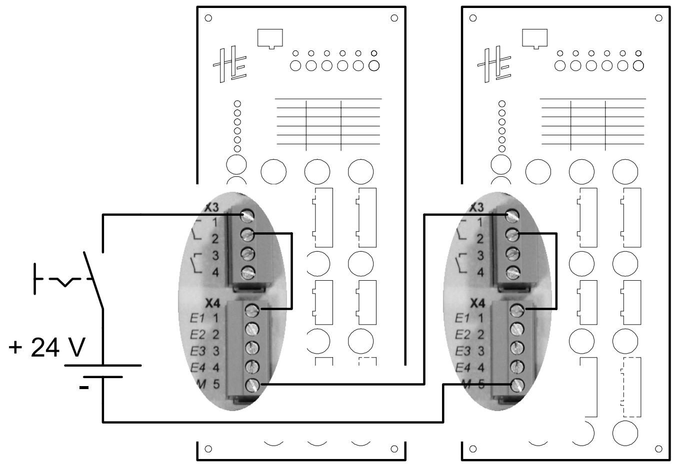
the **error indication relay** will pick up. Then the contacts are closed.

The error indication relay is only active when then ready for work relais has picked up.

| | relay picked up | relay not picked up |
|---|---|---|
| ready for work relay (1 x make contact type) | | |
| HC-CPU supply voltage | available | error |
| HC-CPU | in normal operation | error |
| HC-NET network data communication | ok | error |
| error indication relais (1 x make contact type) | | |
| load or wire breaking, or short circuit at one or more power outputs | error | ok |
| HC200 only: HC200-electronic | to hot | ok |
| HC400 only: SSR control output(s) | short circuit | ok |
| supply voltage for power unit | missing | available |

### 12.3.1 Application example for relay outputs

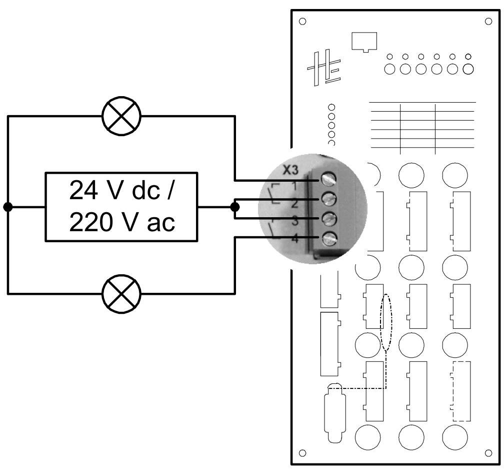
With the ready for work relay an shutdown chain can be realized.




If you network HC-blocs with a HC-network you should program the shutdown function in the host system *(refer to chapter 12.4.1 „Special case HC-HMI / reaction at error“ page 59 ff.).*

It could be difficult for service technicians to find in large extended machines with a decentralized system configurations HC-blocs.

To simplify the location of the HC-blocs indication lamps controlled by the relais outputs could be mounted clearly visible near the HC-bloc.



## *12.4 Behavior at error*

According to the kind of error occurred, the HC200 will either switch off only the concerned power-output or will switch off all power outputs of the HC-bloc.

If the HC-CPU detects an error in the
- HC-CPU itself or
- an exceed of the temperature of the HC-electronic

**all** power-outputs will be switched of to prevent life and material from danger.

In case of a
- HC-CPU error
- or exceed of the temperature of the HC-electronic,

the HC-bloc will switch of its power-outputs, independent of the bits set for HC-bloc-enabling and HC-system Start/stop.

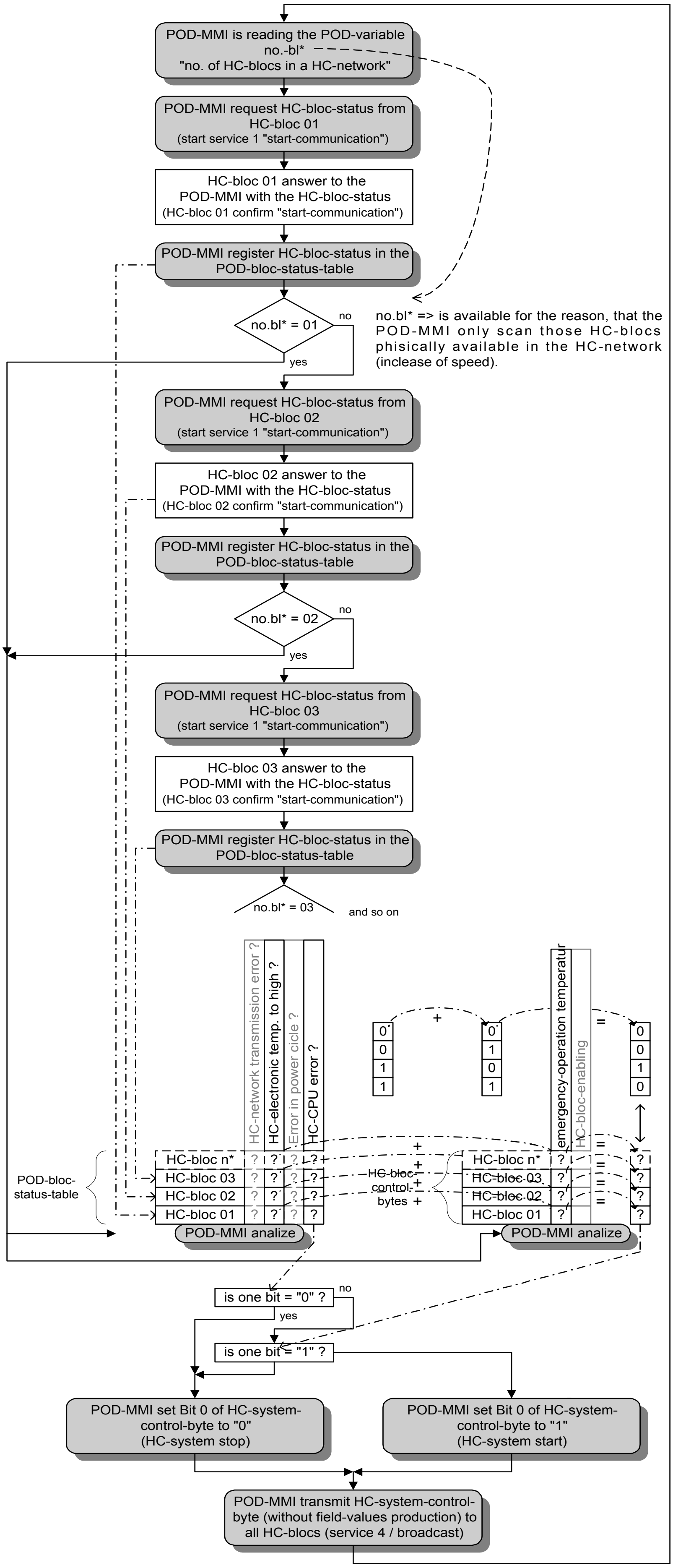
*(For a more detailed information about the reaction at an exceed of the temperature of the HC-electronic refer to chapter 11 „Error* mode - temperature exceed*“ on page 53.)*

For the utmost security of life and material we recommend to program your host-system according to the functionality of the HC-HMI.

### 12.4.1 Special case HC-HMI / reaction at error

The HC-HMI is considered a host-system for the HC-blocs. The HC-HMI-firmware was programmed that way, that all HC-blocs connected to the host-system are cyclically requested to send its HC-bloc-status to the host-system.
In case the HC-HMI gets reported an error, different actions will get started.

The following flow chart allows a closer look to the context.



POD-MMI is reading the POD-variable no.-bl* "no. of HC-blocs in a HC-network"
POD-MMI request HC-bloc-status from HC-bloc 01 (start service 1 "start-communication")
HC-bloc 01 answer to the POD-MMI with the HC-bloc-status (HC-bloc 01 confirm "start-communication")
POD-MMI register HC-bloc-status in the POD-bloc-status-table
no.bl* = 01
no
yes
no.bl* => is available for the reason, that the POD-MMI only scan those HC-blocs phisically available in the HC-network (inclease of speed).
POD-MMI request HC-bloc-status from HC-bloc 02 (start service 1 "start-communication")
HC-bloc 02 answer to the POD-MMI with the HC-bloc-status (HC-bloc 02 confirm "start-communication")
POD-MMI register HC-bloc-status in the POD-bloc-status-table
no.bl* = 02
POD-MMI request HC-bloc-status from HC-bloc 03 (start service 1 "start-communication")
HC-bloc 03 answer to the POD-MMI with the HC-bloc-status (HC-bloc 03 confirm "start-communication")
POD-MMI register HC-bloc-status in the POD-bloc-status-table
no.bl* = 03
and so on
HC-network transmission error ?
HC-electronic temp. to high ?
Error in power cicle ?
HC-CPU error ?
emergency-operation temperatur
HC-bloc-enabling
POD-bloc-status-table
HC-bloc n*
HC-bloc 03
HC-bloc 02
HC-bloc 01
HC-bloc-control-bytes
POD-MMI analize
is one bit = "0" ?
is one bit = "1" ?
POD-MMI set Bit 0 of HC-system-control-byte to "0" (HC-system stop)
POD-MMI set Bit 0 of HC-system-control-byte to "1" (HC-system start)
POD-MMI transmit HC-system-control-byte (without field-values production) to all HC-blocs (service 4 / broadcast)

# 13 Data protocol HC-NET

HC-NET is a HC200 specific data protocol to exchange data (operation-parameters and operation-data) between the HC-bloc(s) and one host-system (in a language both can understand).

In the following this data protocol is described to support the implementation in any host-system.

## *13.1 Physical layer / data line*

For the data exchange the RS 485-technology is used. This technology has widely proofed to be stable against interference at low costs. Simply a 2 wire copper cable can be used for the BUS.

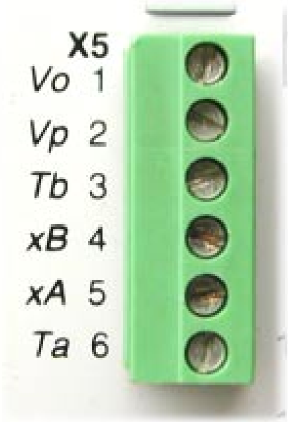
We recommend a twisted and shielded cable with

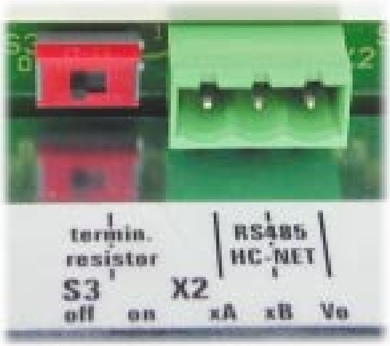
- a resistance??? of 100 to 120 Ω,
- dimension of cross section of > 0,22 $mm^2$
- cable capacity of < 60 pF/m

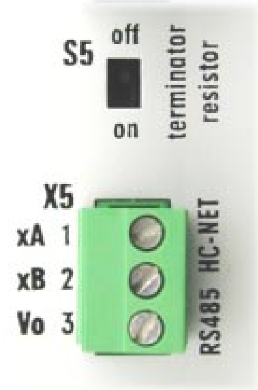
From these specifications depends in the first place the maximal length of the data cable. With 19,2 kBaud of transmission a total length of 1,2 km should be possible.

A maximum of 128 network participants can be used in a single HC-NET network. That corresponds to 1 host-system and 127 HC-bloc.

## 13.2 Pinout of HC-NET interface




| pin | description | HC-block model |
|---|---|---|
| Vo | shield | all |
| Vp | + 5Vdc (not used) | HC200 |
| Tb | connected to xB to make active the RS485 terminator resistor | HC200 |
| xB | data wire | all |
| xA | data wire | all |
| Ta | connected to xA to make active the RS485 terminator resistor | HC200 |

## 13.3 Wiring of HC-NET network / network-topology

The HC-NET network must be configured to a bus-net (not ring- star or tree-network) I.e.: all network participants must be connected with xA und xB parallel to the data litz. It is not of importance at what position the single network participants are connected to the bus (network)

To avoid refexion on the data litz, the end of both data litz must be bridged (shorten) with a terminator resistor of 100 to 120 Ω.

Both HC-NET network litz must be bridged before the first (beginning) and after the last (end) network participant with a terminator resistor of 100 to 120 Ω.

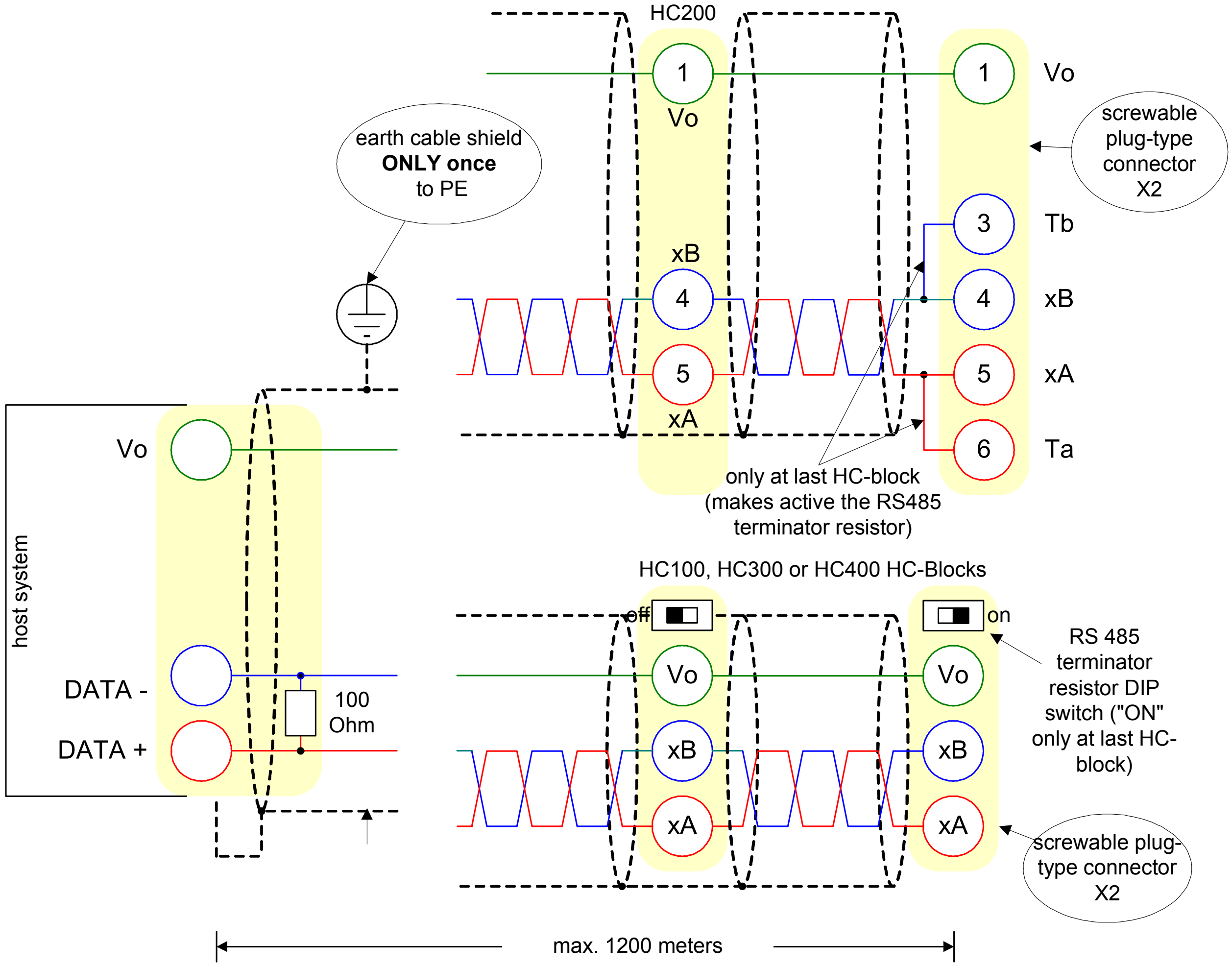
Each HC-block has a build in terminator resistor. To make active the terminator resistor simply short „Ta with xA“ and „Tb with xB“ (HC200) or set the dip switch.

HINT: Build your network with a HC-block each on each end of the cable. Not having the host system at one end of the network cable you do not need to solder a terminator resistor to the end where the host system is.

All Vo (Pin 1) must be connected together and must be connected to the electronic earth of the serial interface of the host system.
Only if the electronic earth of the host system is galvanically isolated, the Vo connection has to be connected to the machine earth (PE) once.

All cable shields of all single network cables has to be connected together and must be connected to the machine earth (PE) once.

Vp (Pin 5) is not used.




HC100, HC200, HC300 and HC400 HC-blocks can be networked in the same network.

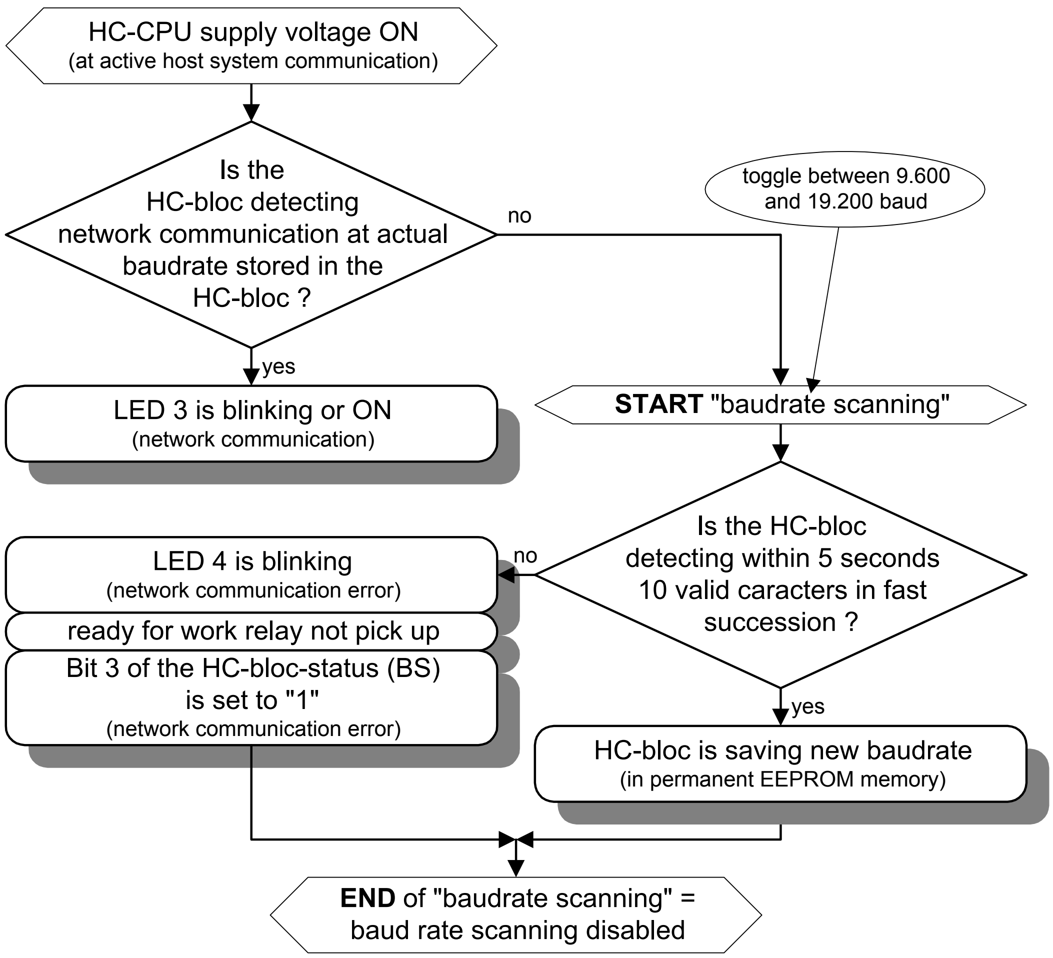
## *13.4 Transmission parameters of HC-NET*

Data will are transmitted in a HC-NET network

- asynchronous
- in half duplex mode
- bi-directional

start bit = 1
data bits = 7
parity bit = 1
stop bit = 1
parity = even

Data transmission speed (baudrate) = 9.600 or 19.200 baud. Automatic detection.



Ältere Firmwareversionen brechen eine nicht erfolgreiche Baudratensuch, 5 Sekunden nach Anlegen der HC-CPU Versorgungsspannung ab.

Die aktuellen HC-Blöcke scannen so lange bis eine gültige Baudrate gefunden wurde. Das Scannen wird über ein 30 ms aus / 970 ms aus blinken der LED H1 angezeigt. Sobald die LED H1 dauerhaft brennt, hat der HC-Block sich auf die Baudrate des Leitsystems eingestellt.

## *13.5 Control of access to HC-NET*

In a HC-NET network the host-system is always master and all HC-blocs are always slaves.

| In a HC-NET network only the host-system has master functionality. |
|---|

Die HC-HMI is also a master in a HC-NET network.

Because the HC-blocs are only slaves, they can only send information (data) to the host-system on the request of the host-system.

Because all HC-NET network participants are connected to the same bus (to the same 2 lize) only one participant can be active at the same time whereas al other participants listen passive all communication on the network.

Only the host-system (master) can give permission to single HC-blocs (slaves) to send data.

If a HC-bloc (slave) is request from the host-system (master) to send data, the HC-bloc will be active at the bus just for the time he needs to send the data to the host-system. After the transmission immediately the host-system will get active again.

A direct communication between HC-blocs is not possible, neither without nor with host-system.

The HC-NET participant-address 0 is reserved for the host-system.
The HC-blocs have the HC-network-address from $1_{dez}$ ...$127_{dez}$ to $1_{dez}$ ... $7F_{HEX}$.

All HC-blocs all times „listen“ all communication on the HC-NET network. A HC-bloc can be reached with its HC-network-address.

The HC-network-address can be setup by means of 2 HEX-switches on the front panel of the HC-bloc.

It must be taken in consideration, that a single address can be assigned only once in a HC-NET network.

| In a HC-NET network the network-address of each HC-bloc must differ from all other HC-blocs. |
|---|

### 13.5.1 Security shut down of power outputs

To avoid the uncontrolled function of a HC-bloc after an error of the network (interruption) or a failure of the host-system (failure or error in the host-system program) the HC-blocs have a security function to switch off its power outputs.

In case

- a HC-bloc can not detect within 5 seconds any communication on the network or
- a HC-bloc is not asked each 30 seconds from the host-system with service 1 *(refer to chapter 13.7.1 „Service 1 / start-communication“ page 71 ff.)*

the respective HC-bloc will switch off all its power outputs.
This is obtained be the independent setting (from the HC-bloc itself) of Bit 0 of the HC-bloc-control byte to „0“ (HC-Bloc-enabling locked).

In addition the respective HC-bloc will set bit 3 of the HC-bloc-status to „1“ (HC-network communication error).

> In case
> - a HC-bloc is not recognizing any communication on the HC-network for more than 2 seconds or
> - a HC-bloc is not asked within 30 seconds from the host-system with service 1, the HC-bloc will diable its power outputs.

For this reason you have to program your host-system to get in communication with each single HC-bloc within a period of at least 5 seconds.

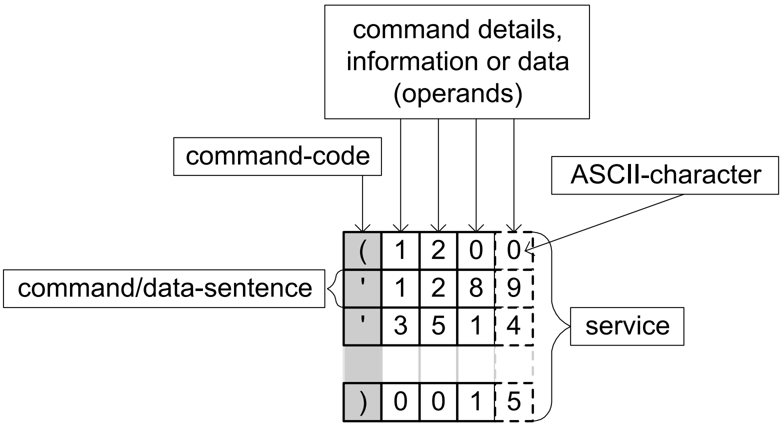
The scantime per HC-bloc of the HC-HMI is a variable to define in the HC-HMI Project. *(Refer also to chapter 12.4.1 “Special case HC-HMI /* reaction at error*“ page 59 ff.)*.

## 13.6 HC-NET data protocol description

HC-NET has 10 different commands (command-codes).

A command/data-sentence is made of a command-code (ASCII-character) and 3 resp. 4 other (ASCII-)characters for the command details, transmission of information and data (generally called operand).

A service is made of 2 to max. 259 command/data-sentences (exception: service broadcast = maximum 66 command/data-sentences; *refer to the following*).




Only the ASCII characters from $0_{ASCII}...9_{ASCII}$ and $A_{ASCII}...F_{ASCII}$ are allowed (and logic) for the operands.

The ASCII characters $-_{ASCII}$, $+_{ASCII}$ , $>_{ASCII}$, $?_{ASCII}$, $<_{ASCII}$, $=_{ASCII}$, $(_{ASCII}$, $‘_{ASCII}$, $)_{ASCII}$, $*_{ASCII}$ und $/_{ASCII}$ are reserved for the command-codes. It is not at all allowed to use those ASCII characters for the operands.

Because only printable ASCII characters are used for the command-codes and the operands the protocol can be easily printed.

### 13.6.1 Command-codes

| ASCII | direction | meaning |
|---|---|---|
| - | host-system ⇒ HC-bloc | • host-system request start-communication and<br>• host-system sends HC-bloc-control-byte |
| + | HC-bloc ⇒ host-system | • HC-bloc confirms start-communication request and<br>• HC-bloc sends HC-bloc-status |
| > | host-system ⇒ HC-bloc | start address for HC-data to send |
| ? | host-system ⇒ HC-bloc | end address for HC-data to send |
| < | host-system ⇒ HC-bloc | start address for requested HC-data |
| = | host-system ⇒ HC-bloc | end address for requested HC-data |
| ( | host-system ⇔ HC-bloc | first HC-data |
| ' | host-system ⇔ HC-bloc | next HC-data |
| ) | host-system ⇔ HC-bloc | last HC-data |
| * | host-system ⇔ HC-bloc | checksum |
| / | host-system ⇒ HC-blocs | • host-system starts broadcast and<br>• host-system sends HC-system-control-byte |

## 13.7 The possible services of the host-system

With the already mentioned command-codes 4 different services are possible.

**service 1 / start-communication**
- host-system sends HC-bloc-control-byte to a defined HC-bloc
- host-system receives HC-bloc-status from the respective HC-bloc

**service 2 / sending**
- host-system sends data (operation-parameters) to a defined HC-bloc

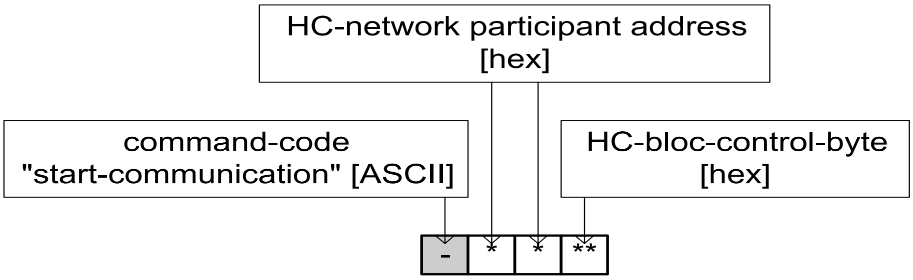
**service 3 / receiving**
- host-system receives data (operation-data) from a defined HC-bloc

**service 4 / broadcast**
- host-system sends the HC-system-control-byte to all HC-blocs
- host-system sends the field-values-production to all HC-blocs

### 13.7.1 Service 1 / start-communication

Before the host-system is enabled to send data to a specific HC-bloc (service 1 and 2 but not service 4) the host-system must start the communication to this HC-bloc.

To request the start-communication the host-systems sends the following command/data-word in the HC-NET network:

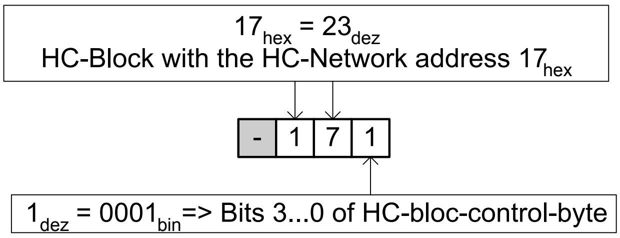



* Die **HC-NET participant address** has 2 digits (2 hex characters)
$00_{hex}$ = not allowed (first possible address for a HC-bloc = 01)
$01_{hex}$ = HC-bloc with HC-NET participant address $01_{dez}$
$02_{hex}$ = HC-bloc with HC-NET participant address $02_{dez}$
...
$7F_{hex}$ = HC-bloc with HC-NET participant address $127_{dez}$

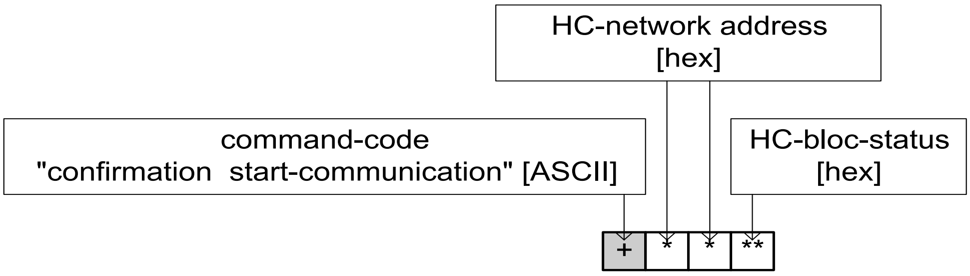
The HC-NET participant address will be setup by means of the HEX switch on the respective HC-bloc.

** Together with the host-system request „start-communication“ the host-system send also the **HC-bloc-control-byte** for the respective HC-bloc.
*(A detailed description about the HC-bloc-control-byte can be find in chapter* 10.5.18 „HC-bloc-control-byte *(BCB)*“ *page 49 ff. .)*
From the HC-bloc-control-byte only the first 4 bits are used (Bit 0 ... Bit 3) and will therefore only be transmitted.
Before sending, the binary code of the HC-bloc-control-byte has to be converted into a hex code.
$0000_{BIN}$ of HC-bloc-control-bytes = $0_{hex}$
$0001_{BIN}$ of HC-bloc-control-bytes = $1_{hex}$
...
$1111_{BIN}$ of HC-bloc-control-bytes = $F_{hex}$

**example:**




If HC-bloc recognize the request „start-communication“ from the host-system, the HC-bloc will answer with:




* *see above*

** Together with the confirmation of the „start-communication“ the respective HC-bloc send its **HC-bloc-status**.
*(For a detailed description about the HC-bloc-status refer to chapter 10.5.17 „*HC-bloc-status (BS)*“ page 47 ff. .)*
The HC-bloc-status will be send from the HC-bloc as HEX code.
For an easy interpretation, the HEX code should be transformed after receive from the HC-bloc from the host-system into a 4 digit binary code.
$0_{hex}$ of the HC-bloc-status = $0000_{BIN}$
$1_{hex}$ of the HC-bloc-status = $0001_{BIN}$
...
$F_{hex}$ of the HC-bloc-status = $1111_{BIN}$

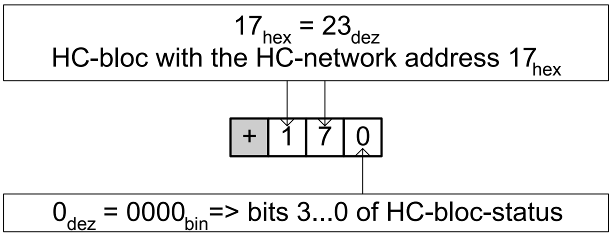
After the confirmation of the HC-bloc to a „start-communication“ request of the host-system, the HC-bloc is ready to receive data (production-parameters) or to send data (production-data) to the host-system.

But after this confirmation, the host-system can go on to request a „start-communication“ with another HC-bloc. In this case the existing communication to the actual HC-bloc will be brake off (the respective HC-bloc is not longer ready to send and to receive data).

That’s the same if the host-system executes service 4 „broadcast“.

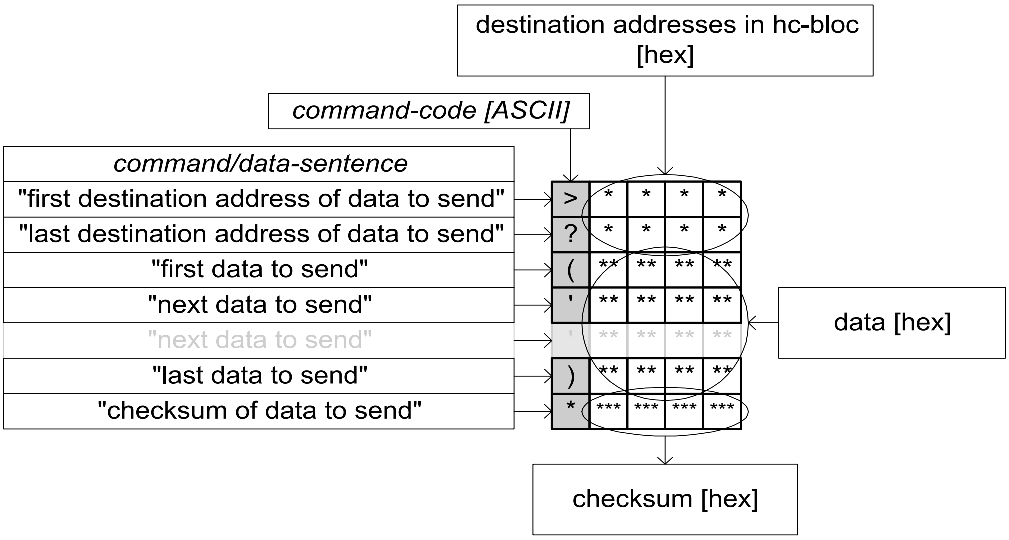
- The service 1 „start-communication“ must always be executed before service 2 („sending“) and/or service 3 („receiving“) can be started.
- For service 4 („broadcast“; host-system is sending data to all HC-blocs) no initial „start-communication“ is necessary.
- With the request for „start-communication the host-systems the HC-bloc-control-byte is send to the respective HC-bloc.
- With the confirmation of the HC-bloc to a „start-communication“ request from the host-system, the HC-bloc send its HC-bloc-status to the host-system.

**example:**



### 13.7.2 Service 2 / sending

To start the service 2 „sending“, it is absolutely necessary that a communication between the host-system an a specific HC-bloc exist (refer to *service 1 „start-communication“)*.
To this HC-bloc the host-system can send according to the following syntax data (production parameters).

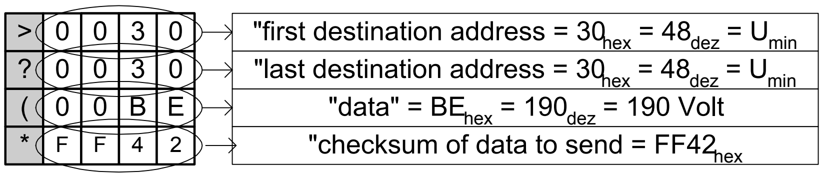



* The „first destination address“ and the „last destination address“ defines the address range in which the data will be written in the HC-bloc
Each character occupies 1 digit.
E.g.: The HC-address $60_{dez}$ = $3C_{hex}$ has to be send as $0_{hex}$ $0_{hex}$ $3_{hex}$ $C_{hex}$.

** Data can have values between 0 and 9999. (The greatest value of a HC-data is 1000 [watts]).
E.g.: The value $600_{dez}$ = $258_{hex}$ has to be send as $0_{hex}$ $2_{hex}$ $5_{hex}$ $8_{hex}$.

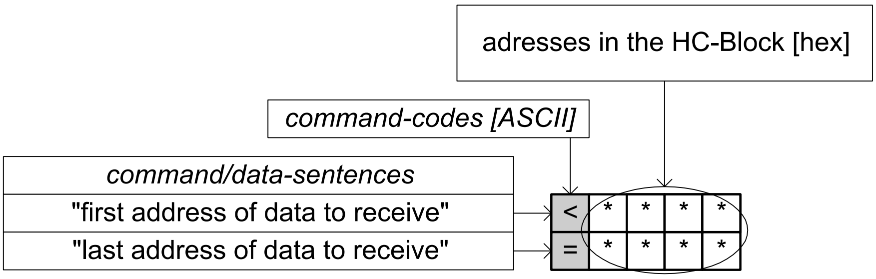
*** *For the checksum calculation refer to chapter 13.8.1 „Calculation* of checksum*“ page 78 ff. .*

**example:** Sending of $U_{min}$ = 190 volts (lowest to expect supply voltage)



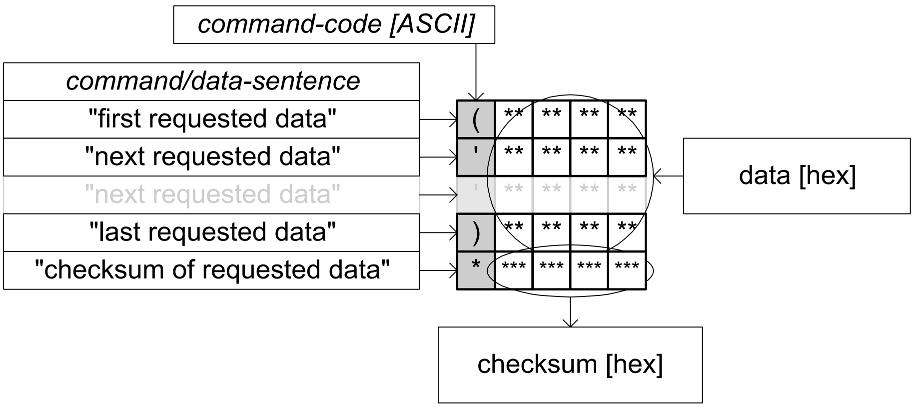
### 13.7.3 Service 3 / receiving

To start the service 3 „receiving“, it is absolutely necessary that a communication between the host-system an a specific HC-bloc exist (refer to *service 1 „start-communication“)*.
From this HC-bloc the host-system can request data according to the following syntax.




* *see above*

After receiving the request, the respective HC-bloc will send the requested data according to the following syntax.




** *see above*
*** *see above*

**example:**

Host-system request "actual current/phase" values $I_L$ from HC-bloc.

| | | | | | |
|---|---|---|---|---|---|
| < | 0 | 1 | 1 | B | "first address of data to receive" = $11B_{hex}$ = $283_{dez}$ = $I_{L1}$ |
| = | 0 | 1 | 1 | D | "last address of data to receive" = $11D_{hex}$ = $285_{dez}$ = $I_{L3}$ |

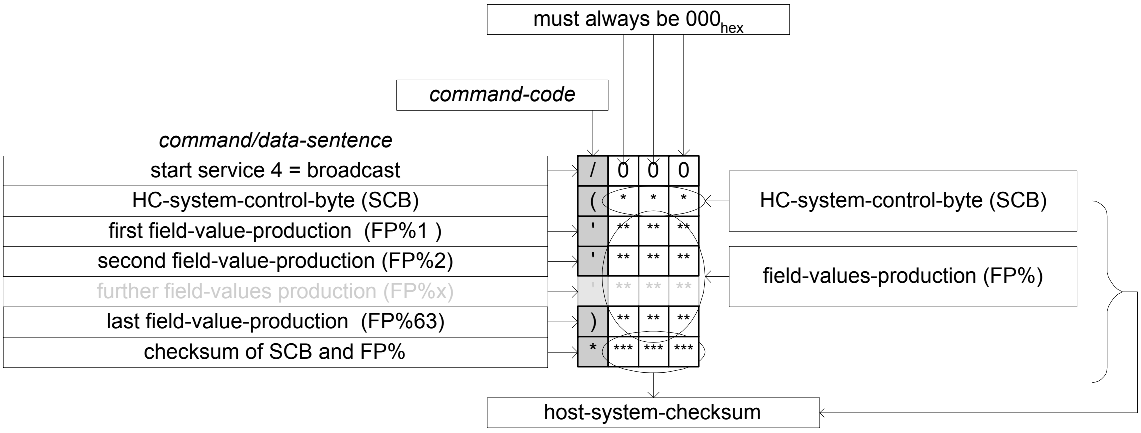
HC-bloc is sending the requested "actual current/phase" values $I_L$ .

| | | | | | |
|---|---|---|---|---|---|
| ( | 0 | 0 | E | 1 | "requested data" = $E1_{hex}$ = $225_{dez}$ = 22,5 ampere = $I_{L3}$ |
| ' | 0 | 0 | B | A | "requested data" = $BA_{hex}$ = $186_{dez}$ = 18,6 ampere = $I_{L2}$ |
| ) | 0 | 0 | E | E | "requested data" = $EE_{hex}$ = $238_{dez}$ = 23,8 ampere = $I_{L3}$ |
| * | F | D | 7 | 7 | "checksum of requested data" = $FD77_{hex}$ |

### 13.7.4 Service 4 / broadcast

Often the power outputs of all HC-blocs in a HC-NET network must be started and stopped at the same moment
Also field-values (remember, field-values are the same for all HC-blocs in a HC-network) must become valid for all HC-blocs at the same moment.
But with the described service 2 / sending a fast reaction of all HC-blocs at the same moment is not possible.
So fare only 1 HC-bloc can be in communication with the host-system.

For this reason the HC-system-control-byte (SCB) and the field-values-production (FP%) can be sent to all HC-blocs with service 4 / broadcast.




* With the second command/data-sentence the host-system transmits the **HC-system-control-byte (BSC)** to all HC-blocs.
*(For a more detailed information about the HC-system-control-byte refer to chapter 10.5.19 „HC-system-control-byte (SCB)“ on page 50.)*
From the HC-system-control-byte only the first 4 bits are used (Bit 0 ... Bit 3) and will therefore only be transmitted.
Before sending, the binary code of the HC-system-control-byte has to be converted into a hex code.
E.g.: The value $11010_{bin}$ has to be send as $01A_{hex}$.

** The **field-values-production (FP%)** can have values from 0 to 100 (0 ... 100%).
E.g.: The value $025_{dez}$ has to be send as $025_{hex}$.

*** *see above*

With service 4 not all 63 field-values-production (FP%) must be send.
It is possible to send only the HC-system-control-byte (SCB) and no or only some field-values-production (FP%).

## *13.8 Checksum over data*

The checksum of the data to send/to transmit (HC-parameters resp. HC-data) will be transmitted always after the last HC-parameter/data.
Die checksum will be calculated with the HC-parameter/data to send or the received .

The checksum will be calculated with the HC-parameter/data of service 2 („sending“), service 3 („receiving“) and service 4 („broadcast“) . Start und end addresses are not taken into consideration with the checksum.
With service 1 („start-communication“) non checksum will be calculated.

After receiving data, the HC-bloc is automatically calculating a checksum over the received data. Then automatically the HC-bloc compares its calculated checksum with the checksum calculated by and transmitted from the host-system.
I.e.: The host-system must calculate and transmit a checksum!

In case the host-system receives data from a HC-bloc, a comparison of the checksum is not required but recommended.
The HC-HMI is taking into consideration the checksum of received data.

### 13.8.1 Calculation of checksum

For a better understanding we distinguish between 2 checksums:

- host-system-checksum — for HC-parameters send from the host-system to the HC-blocs.
- HC-checksum — for HC-parameters/data send from the HC-bloc and received from the host-system.

#### *13.8.1.1 host-system checksum*

- Over all HC-parameters to send from the host-system to the HC-blocs, the host-system must calculate the total.
- Next the host-system must calculate the complement ( = NOT) of the total.
- To the complement the host-system must ad $1_{hex}$.

The complement of $0_{hex} = F_{hex}$
$1_{hex} = E_{hex}$
$2_{hex} = D_{hex}$
$3_{hex} = C_{hex}$
$4_{hex} = B_{hex}$
...

**example:**
Over the „lowest to expect supply voltage“ $U_{min}$ and the „rated voltage of consumers“ $U_{RC}$ the host-system must calcultate the host-system-checksum.
$U_{RC}$ = 220 V = $220_{dez}$ = $00DC_{hex}$
$U_{min}$ = 190 V = $190_{dez}$ = $00BE_{hex}$

total over the data (HC-parameters) to send: $00DC_{hex}$ + $00BE_{hex}$ = $019A_{hex}$
complement ( = NOT) of the total: NOT 019Ahex = FE65
adding of $+1_{hex}$ = $FE66_{hex}$ = host-system-checksum

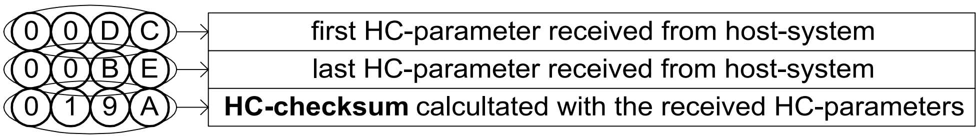
| | | | | | |
|---|---|---|---|---|---|
| ( | 0 | 0 | D | C | first HC-parameter to send from host-system |
| ) | 0 | 0 | B | E | last HC-parameter to send from host-system |
| * | F | E | 6 | 6 | **host-system-checksum** over HC-parameters to send |

#### *13.8.1.2 HC-checksum*

Over all received data and all data to send, the HC-bloc automatically calculates the total. The total is the HC-checksum.

**Continuation of example:**
Calculation of total over received HC-parameters:

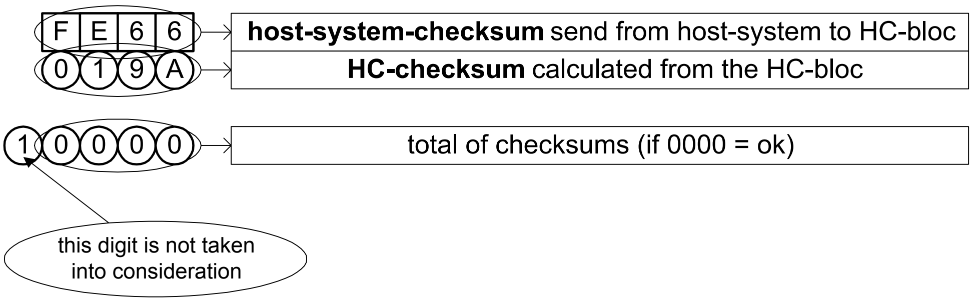
$00DC_{hex} + 00BE_{hex} = 019A_{hex}$




### 13.8.2 Comparison of checksum

The from the HC-bloc calculated HC-checksum will be compared automatically with the received host-system-checksum by adding both checksums. If the last 4 digits are $0_{hex}$ the data have been arrived correctly.

**Continuation of :**
received host-system-checksum = $FE66_{hex}$
calculated HC-checksum = $019A_{hex}$
total of checksums = $FE66_{hex} + 019A_{hex} = 10000_{hex}$



### 13.8.3 Reaction at checksum error

If during data exchange between host-system ⇔ HC-bloc with **service 2 / sending**, **service 3 / receiving** and **service 4 / Broadcast** a checksum error is detected,

- the HC-bloc will set Bit 3 of the HC-bloc-status (refer to chapter 10.5.17 „HC-bloc-status (BS)“ page 47 ff.) to „1“. With the next answer to the start-communication request (service 1) from the host-system the HC-bloc will inform the host-system that during the last data transfer a checksum error occurred
- and all data will be refused, i.e. the active data will not be updated.

With the Bit 3 of the HC-bloc status set to „1“ the host-system can start a procedure to resent the data.

Die HC-HMI is reacting according to the description in the next chapter.

We recommend, to implement this functionality to your host-system as well.

The same reaction as a checksum error are caused by parity errors, stop bit errors and baudrate errors. Because these errors are already handled by the interface controller of the host-system no detailed description is given in this manual.

#### *13.8.3.1 Special case HC-HMI / Reaction at checksum error*

In the firmware of the HC-HMI the following reaction at a checksum error was programmed.

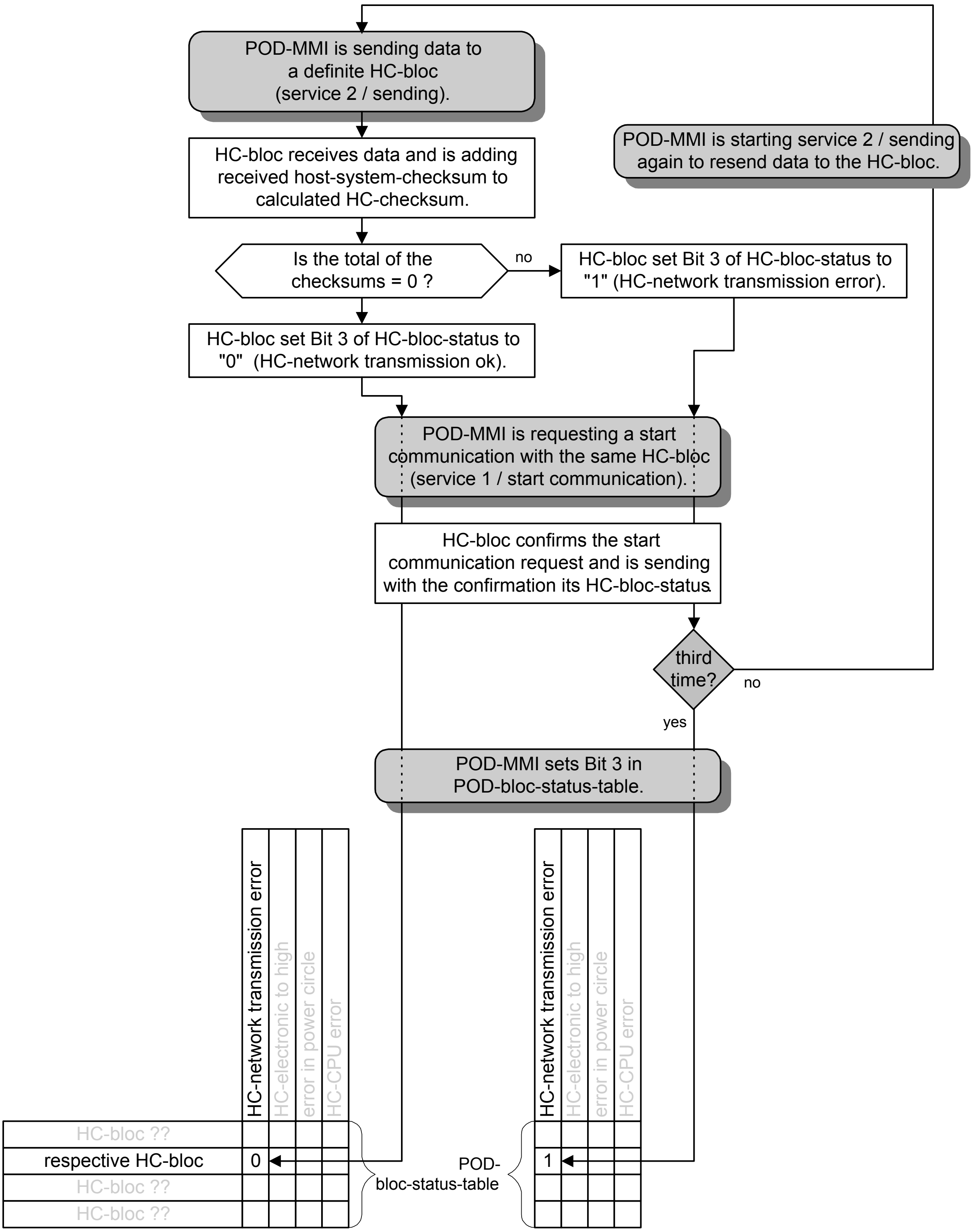
We distinguish between three cases.

**A.)** The HC-HMI is reacting at an checksum error detected from the HC-bloc.
(**Service 2 / sending** = HC-HMI is sending data to a definite HC-bloc.)

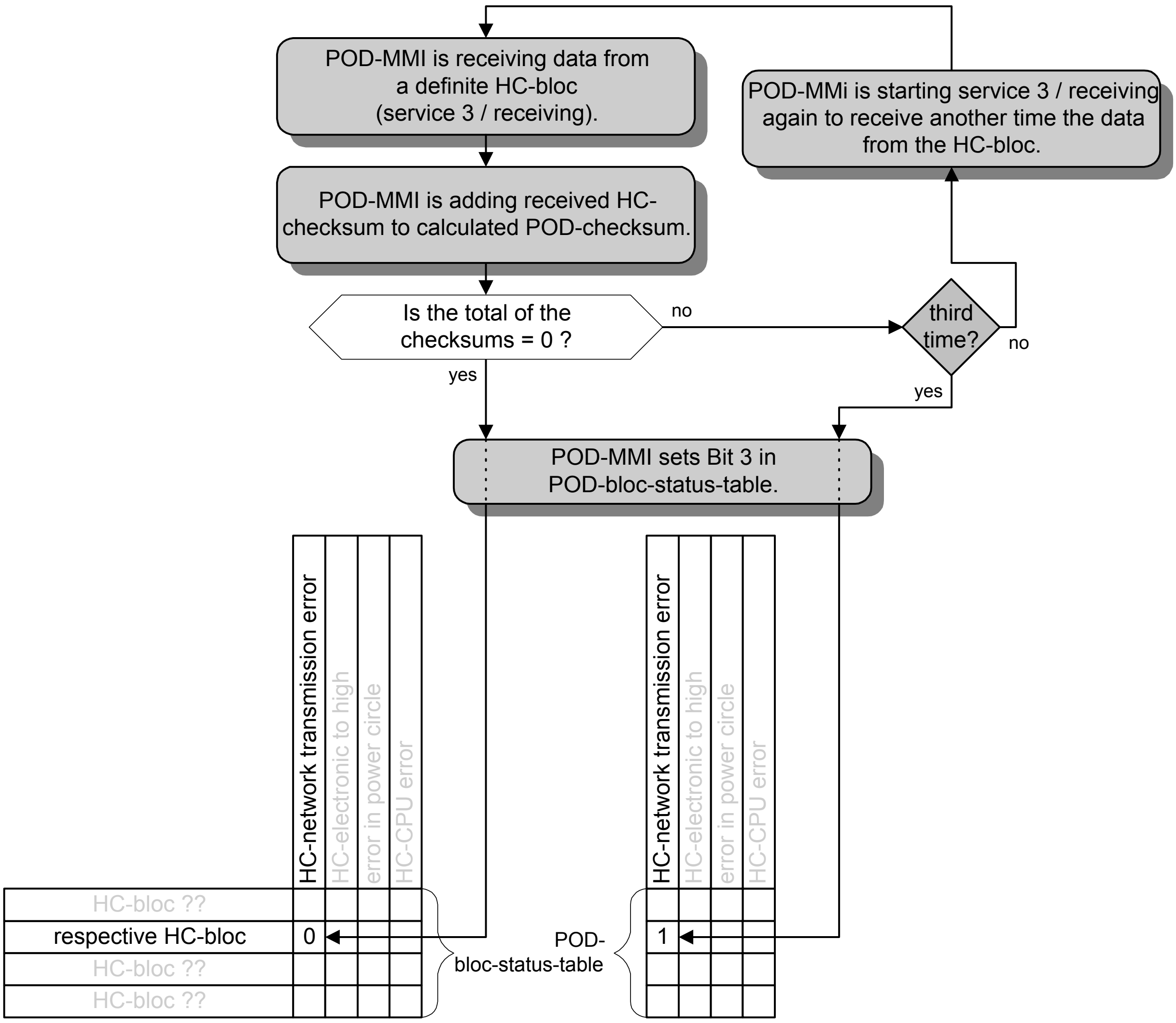
**B.)** The HC-HMI is reacting at a checksum error detected by itself.
(**Service 3 / receiving** = HC-HMI is receiving data from a definite HC-bloc.)

**C.)** The HC-HMI is reacting at an checksum error detected from a HC-bloc.
(**Service 4 / broadcast** = HC-HMI is sending data to all HC-blocs.)

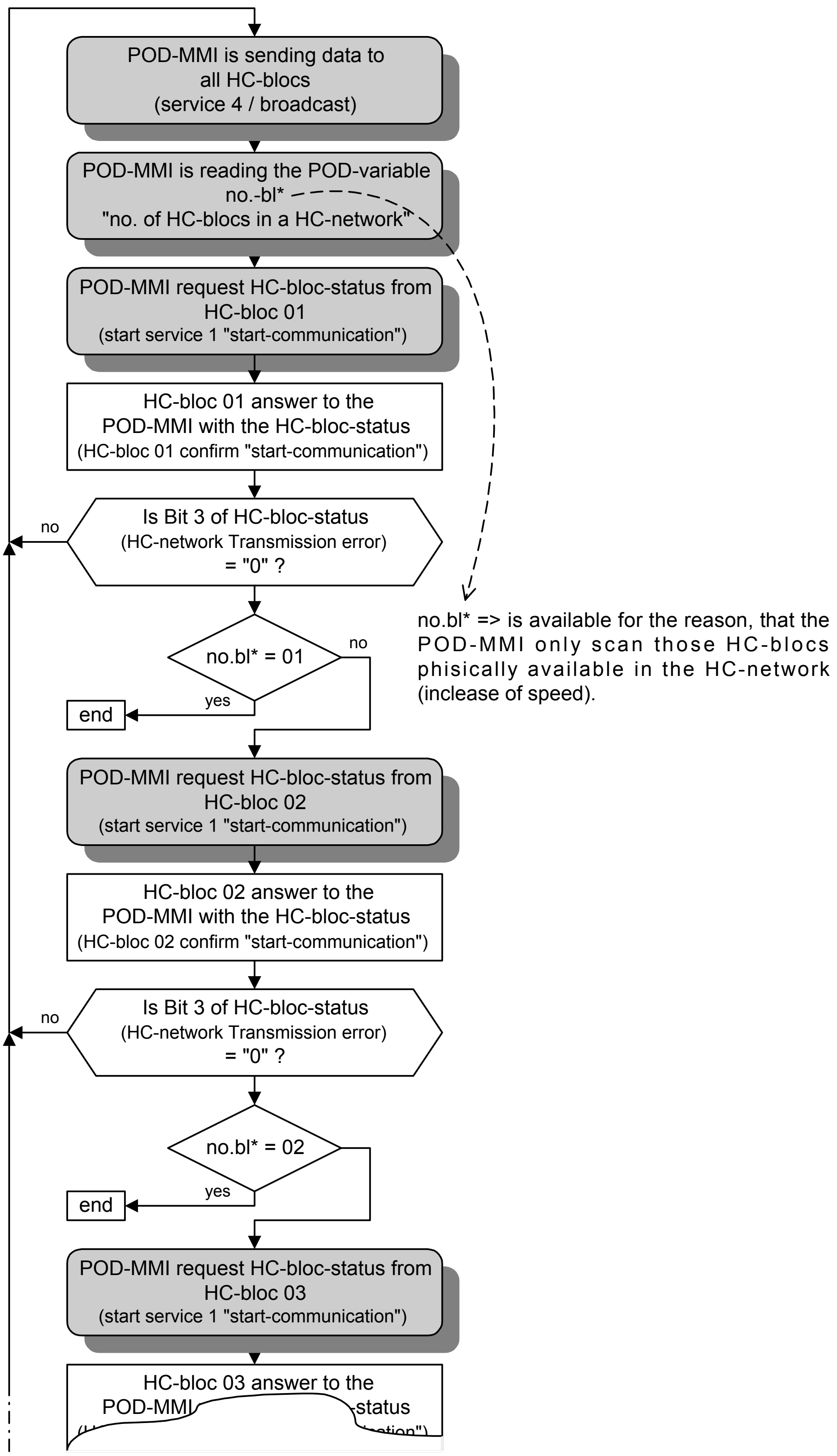
Flow chart to **A.)**



Flow chart to B.)



Flow chart to **C.)**



# 14 Compatibility to SCHLEICHER PD-NET

The data protocol HC-NET is partially compatible with the SCHLEICHER data protocol PD-NET. PD-NET supports all HC-NET functions.
Therefore it is possible to use the SCHLEICHER PDPS, P03, P02V, P02, PROMODUL-U and PROMODUL-F CPUs as host-systems without being forced to program a protocol handler for HC-NET.

## *14.1 Schleicher P03-CPUs*

For the PO3-CPUs the SCHLEICHER protocol PD-NET is available over the serial interface COM2 (attention: use the RS485 not the RS232 version). For this it is necessary to call with the programming software PRODOC5 the library module PD-NET master as well as to initialize the interface COM2 in a so called initialization program.

In order to communicate between the PLC and the HC-bloc the programmer must pay attention to some special features.
To avoid already at the beginning problems with the PLC programming we made available a PLC example program.
This PLC program should be your basis to enable communication between the P03-CPU and the HC-blocs.

| Ask for our SCHLEICHER PLC program. |
|---|

## *14.2 Restriction*

- The SCHLEICHER library module for PD-NET Master allows today only to communicate to a maximum of 31 HC-blocs.
- The service 4 / broadcast is supported be SCHLEICHER at present with maximum 34 command/data-sentences. Therefore its only possible to control 31 instead of 63 field-values (32 instead of 64 fields).

# 15 HC-HMI

The HC-HMI (HMI stands for **H**uman **M**achine **I**nterface) is a HC host-system very similar to an HMI for a PLCs.
Only the firmware of the HC-HMI was modified to communicate with the HC-blocs with the HC-NET data protocol. The HC-HMIs are master in the HC-NET network.

With the HC-HMI one can
- parametrize (input and sending of operation-parameter),
- operate (activate/deactivate system functions, display of operation-data) and
- diagnose (display of the status of the system, error diagnostic...).

The HC-HMI will be connected to the HC-NET interface and therefore support the data protocol HC-NET. In the HC-NET network they HC-HMI is always master.

The functionality of the H200 related features of the HC-HMIs is described in the respective chapters of these manual.

The user related part of the HC-HMI can be programmed according to the machine builders needs with the programming software UNIOP-Designer. With UNIOP-Designer the programmer can create its own project including customer specific display pages with text, graphics and data.
It is possible for example to create input display pages for HC-parameters, pages to show the status of each HC-bloc or even the storage of HC-parameters in the receipt memory of the HC-HMI.

The HC-HMI therefore is host-system and MMI at the same time.

We refer to the
**HC-HMI manual** (order no.: EX/PBD-IIH_D / German; EX/PBD-IIH_E / English and EX/PBD-IIH_I / Italian).

# 16 Supply voltage compensation

The power-output of an ohmic consumer depends quadratically on the voltage.
With an allowable tolerance from the supply voltage of +6%/- 10% the power-output of an ohmic consumer has a tolerance of +12,4%/-19%.

The HC200 offers a feature called „supply voltage compensation“ that keeps constant the power-output while the supply voltage is floating.

Each single HC-bloc is calculating with the permanently measured supply voltage ($U_{absolute}$) and the lowest expected supply voltage ($U_{min}$) a so called „supply voltage compensation value“.

$$\boxed{\text{supply voltage compensation value} = U_{min}^2 / U_{absolute}^2}$$

As you can see from the formula, the supply voltage compensation value will be practically always < 1.

The compensated output-value [%] is calculated from:

$$\boxed{\text{output-value}_{compensated}\ [\%] = \text{output-value}\ [\%] \times \text{supply voltage compensation value}}$$

The user or OEM specifies with $U_{min}$ the lowest to expect supply voltage value and herewith also the maximum of output power to get form the consumers with 100% output-value.
With $R = U^2 / P$ = constant follows: $P_{max} = P_{RC} \times (U_{min}^2 / U_{RC}^2)$.

**Example:** Rated output power of consumer (= $P_{RC}$) at 230 V (= $U_{RC}$) is 600 W.
The lowest voltage to expect = 210 V (= $U_{min}$)
With $P_{max}$ = 600 W x ($210^2$ $V^2$ / $230^2$ $V^2$) follows, that the with 100% output-value the consumer supplies only a maximum of 500,2 W.

The worse the quality of the supply voltage network (the bigger the tolerances) the bigger have to be the consumers chosen by the OEM and the more expensive is the machine.

The function „supply voltage compensation“ can be activated for all HC-network participants over the bit 1 of the HC-system-control-byte and the service 4 / broadcast.
*(Refer to chapter 13.7.4 „Service 4 / broadcast“ page 76 ff..)*

The function „Supply-voltage-compensation“ can also be controlled over the digital input *E2* *(refer to chapter 6.1 „Pinout of digital inputs“ page 26*).

# 17 Symmetrical load of phases

8 channels each of a HC-bloc are supplied with one phase of the supply network.

The HC-CPU takes care of a mostly linear power consumption over the time of a single phase.

A symmetrical load among the 3 phases can not be obtained by the HC intelligence but only with a symmetric load distribution among the 3 phases .

## *17.1 Definition of pulse effect*

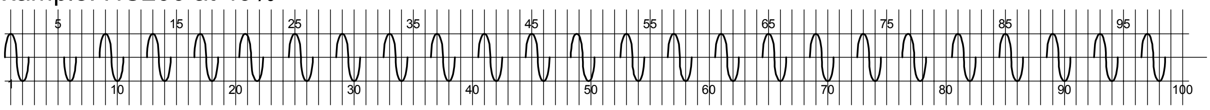
according to the data of

- channel-value,
- field-value and
- supply voltage compensation value

only a view of 100 half/full-waves will we switched on the power-outputs/SSRs.

1 switched half/full-wave is corresponding to 1% of the maximum output power, a 2 switched half/full-wave = 2% and 100 half/full-waves =100%

example: HC200 at 49%

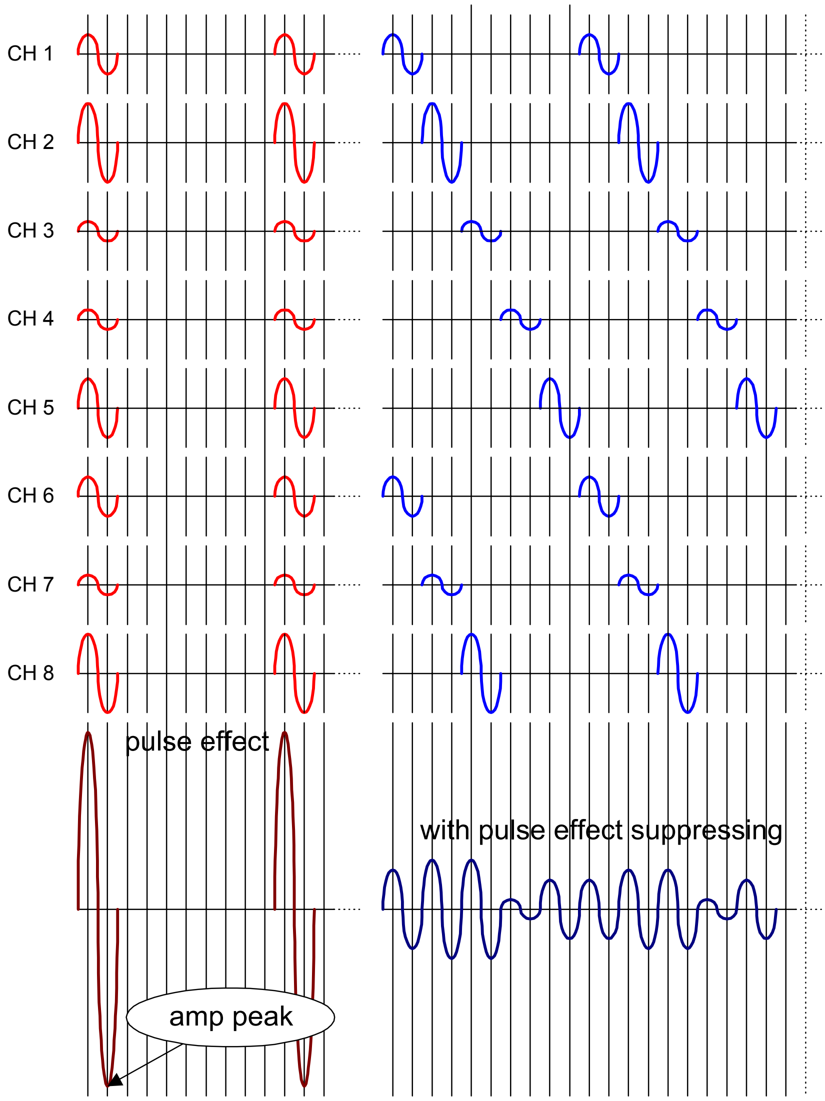



In the event that all channels of a HC-system are fired at the same time and erased after less then 100 half/full-waves, the effect would be, that the power need wouldn’t be constant over the time but cause a pulse effect to the power supply.
The most drastically pulse effect would be if all channels were erased after the same amount of half/full-waves (all channels at x%).

The pulse-effect would produce peak loads, which soil the power supply network and would have to be paid at high cost to the electric supply company.

## 17.2 *Pulse effect suppressing*

To avoid the pulse effect, the HC is calculating (no random function!) a symmetrical load distribution over the time and therefore time lagged firing between all channels of one phase.
This function is called „pulse effect suppressing“.



# 18 Concept of temperature control

Since each machine builder has its own philosophy and concepts for the regulation of the actual temperature of the consumers or even of the temperature of the workpiece itself, the HC has not an integrated temperature regulation feature.
From our point of view the temperature regulation would only be an unsatisfactory compromise between the different needs.

For this reason we expect the machine builder to integrate the temperature regulation in the host-system.

The HC2 is consciously only a regulator and not a controller in a control circuit.

In practice temperatures of single consumers very seldom are measured by themselves. Single consumers are grouped to fields and field temperatures (actual values) are measured . This saves costs for expensive heat detectors (thermo-elements).

The HC includes the feature of grouping single channels to fields. The value of a field can be influenced by changing the data of the field-value which is known as nominal data in the close loop control circuit theory.
*(Refer to chapter 10.5.5* „Field-values-production (FP%) *page 38.)*

# 19 Summary of features

- Stand alone operating regulator system for ohmic consumers.
- Cost efficient use for applications with < 24 up to several 1000 channels.
- Compact bloc building size with 24 power or SSR control outputs each.
- Adjustable output power for each channel from 0 to 100% in 1% steps.
- With 1 CPU for each HC-bloc possibility for decentral as well as central system configurations.
- Interference resistant RS485 network: HC-NET (ASCII protocol) with 9.600/19.200 Baud
- Networking of a maximum of 127 blocs.
- Each channel can be assigned to one of (2x) 63 fields.
- 63 field-values for production-cycle and 63 for standby-cycle (useful for stand alone operation).
- Fast update/modification of field-values for all networked HC-blocs with broadcast service (important for temperature regulation).
- Switches for regulation of output power single/full half waves at zero crossing of supply voltage (processor controlled, no simple no-voltage switch).
- Constant power consumption (over the time) in each phase with CPU calculated fire of triacs (no pulse effect on supply network).
- Supply voltage compensation for constant output power independent of variation of supply network voltage.
- Acquisition of power consumption for each channel (integrated voltage and ampere measuring device).
- Detection of fuse blowing, load or wire (consumer) breaking.
- Error detection each single consumer connected parallel to other consumers at the same power-output.
- Detection of faulty triacs or SSRs.
- Integrated temperature measuring device with automatic damage protection features (controlled shut down of system).
- Easy system diagnosis with 6 status LEDs on each single HC-bloc.
- Can be operated without any PLC because of available HC-HMIs (user-panels with host-system functionality).
- Softstart-function to power up halogen lamps without exceeding the nominal amp.

# 20 technical data

| | |
|---|---|
| power outputs (HC200) resp.<br>SSR-control outputs (HC400) each HC-bloc | 24 |
| digital inputs | 4 with 24 V dc<br>*(„-DI“ HC-blocs only)* |
| relay outputs | 2 (6 A 24 V dc / 230 V ac, make contact type)<br>*(„-DI“ HC-blocs only)* |
| system of protection | IP20 |
| frequency of power supply | 50 or 60 Hz (autodetect) |
| cable connections | all but HC200 power supply connector<br>screwable plug type |
| interface | RS485; 9.600 / 19.200 Baud (autodetect) |
| data protocol | HC-NET (ASCII) |
| HC-bloc each HC-NET network | depending on host system; max. 127 |

## *20.1 HC200*

| | |
|---|---|
| supply of HC-CPU | 230 V ac / < 20 mA |
| supply protection of HC-CPU | external |
| power supply of power unit | 400/230 V suitable for non symmetrical loads<br>3-phase-4-wire (L1, L2; L3, N, PE) |
| power supply protection | extern with max. 40 A each phase |
| consumer | between phase and neutral = Y-operation |
| protection of power outputs against short circuit | |
| • HC-blocs with 12 fuses | fine wire fuse 10,0 A FF (super fast) |
| • HC-blocs with 24 fuses | fine wire fuse 6,3 A FF (super fast |
| min. load each power output | 100 Watts |
| max. load each power output | |
| HC200 HC-blocs with 12 fuses | |
| • without forced ventilation | 600 Watts |
| • with forced ventilation | 1.000 Watt (2.000 Watts if every second output used) |
| HC205 HC-blocs | |
| • without forced ventilation | 600 Watts |
| • with forced ventilation | 1.000 Watt (1.500 Watt if every second output used) |
| HC200 HC-blocs with 24 fuses | |
| • without forced ventilation | 750 Watts |
| • with forced ventilation | 1.200 Watt (8.400 Watts each phase = 8 outputs) |
| max. power consumption each HC-bloc | |
| • HC-blocs with 12 fuses | 24,0 kWatts |
| • HC-blocs with 24 fuses | 25,2 kWatts |

| | |
|---|---|
| dimension | 240(270*) / 110 / 160(185*) mm (H/W/D)<br>* = with mounting fish plate |
| weight | approx. 3.000 g |
| case design | - case 1,5 mm sheet steel / zinc coated<br>- front panel 2,5 mm aluminum / powder coated |

## *20.2 HC400*

| | |
|---|---|
| supply of HC-CPU | 24V dc / 150 mA + amp consumption of SSRs |
| supply protection of HC-CPU | external |
| measurement unit | - max. phase voltage = 480 V<br>- max. phase amp = 400 A<br>- measurement resolution 0,75 A |
| SSR-control outputs isolated | for each phase (= 8 outputs) electrically<br>short circuit proof |
| max. amp each SSR-control output | 60 mA |
| SSR control voltage | 24 V dc |
| SSRs | with or without zero crossing switch |
| load | - between phase and neutral = Y-operation<br>- between two phases = $\Delta$-operation |
| min. amp each SSR | 1,0 A |
| max. load amp each SSR | 400 A (400 A each phase = 8 SSRs) |
| dimension | mm (H/B/T) * = with kickover spring |
| • CPU-unit | 106 / 230 / (80*) |
| • measurement unit | 50(58*) / 310(340*) / (118*) |
| weight | |
| • CPU-unit | approx. 1.000 g |
| • measurement unit | approx. 1.600 g |
| case design | |
| CPU-unit | - bottom = aluminum profile<br>- cover = sheet steel / zinc coated |
| measurement unit | aluminum profile |