HC500 Heater **C**ontroller

Function description - basics

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1 Table of contents

2 Important safety information (read before using products)

To read and fully understand this document is a prerequisite to ensure correct and safe operation of this equipment.

In general
- proper shipping
- proper handling,
- professional installation by qualified personnel,
- professional master programming by qualified personnel,
- professional service and maintenance by qualified personnel

are necessary for the correct and safe operation of this equipment.

The use of these products must be limited to technically qualified personnel with the proper education and experience to design, install, and maintain complex high voltage (and/or high current) automated control systems.

Technically qualified personnel are, for example:
- project and design personnel for electrical control panels and cabinets
- high voltage automated control system engineers or programmers
- electricians and electric control panel builders
- service technicians,

all who know the applicable electrical codes and regulations and can properly apply this knowledge in the design of complex high voltage (and/or high current) automated control systems.

Unqualified personnel <u>do not</u> possess the ability to properly interpret the handling and installation information in the product documentation and therefore must not be responsible for the installation or use of these products.

These products operate under high voltage. Improper handling of these products may result in death, series injury, and/or the loss of property.

For each specific installation of this product all applicable safety regulations and industry “best practices” must be observed.

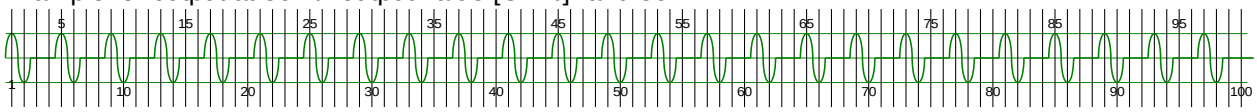
(230504)

3 Introduction

This manual describes the basic functionality of the **HC**500 **H**eater **C**ontroller using a CPU-unit (CU) with firmware v1.15 or newer.

The HC500 is a multi-channel power controller to setup the heat level of resistors (infrared heaters, infrared lamps, cartridge heaters, ...) while switching full sinusoid waves of the ac power voltage.

Example for output at 50 % "output value [OV%]" and 50 Hz



A HC500 system consist of
- one CPU-unit (CU)

and
- one or more output-cards (OC) in
- one or more fan cooled rack's (RK)

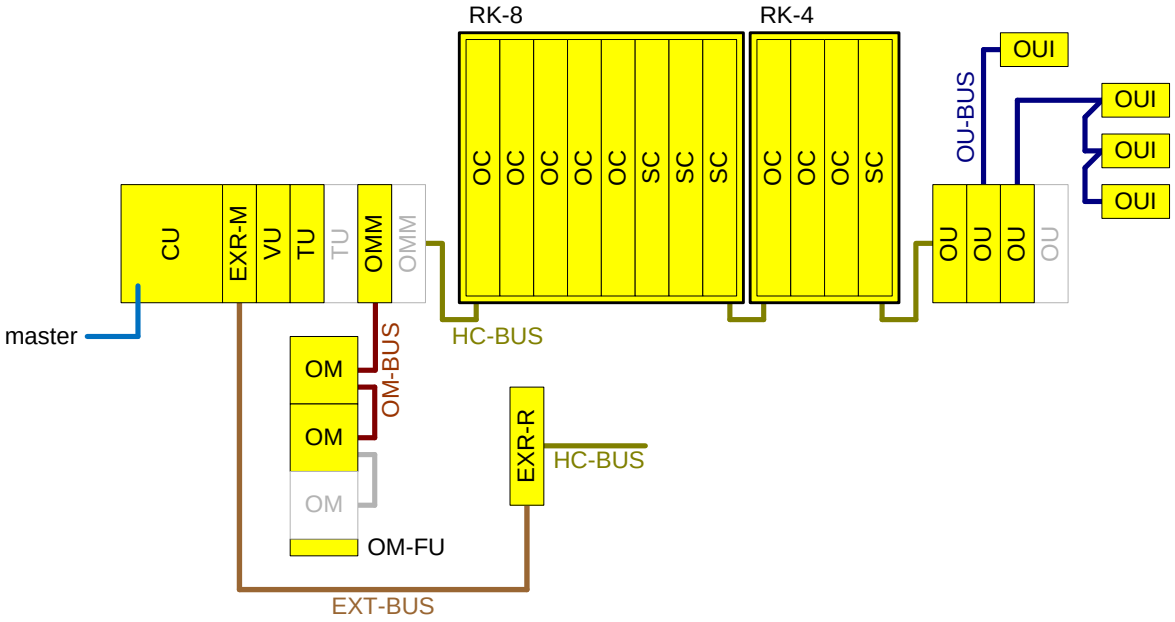
and eventually
- one or more empty slot covers (SC) for not used slots in the rack/s (RK)

and /or
- one or more output-module-masters (OMM) with output-module/s (OM)

and / or
- one or more output-units (OU) with optional output-unit-ampmeter (OUI)

and optional
- one voltage-unit (VU)

and optional
- one or more temperature-units (TU)



One HC500 system is one slave. The slave must be interfaced with a master.
Typical masters are PLCs or PCs.

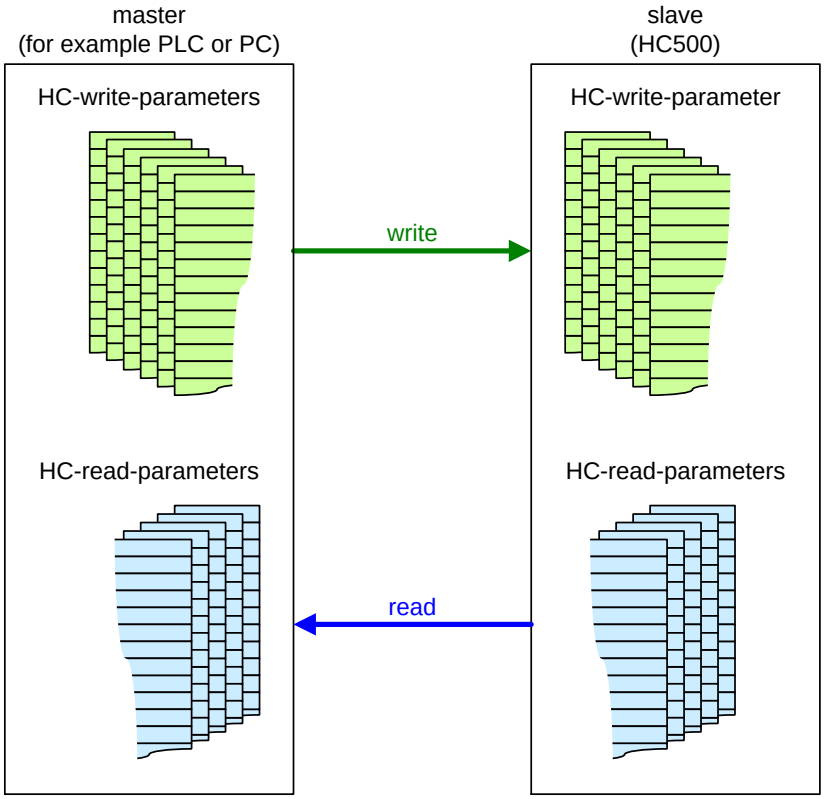
Data exchange between the master and the HC500 is handled via PROFINET, PROFIBUS-DP, EtherCAT, EtherNet/IP or a serial interface (RS232 or RS485) and the HC specific ASCI protocols HC-COM or HC-NET.

For the voltage-unit (VU) that keeps constant the heat if the phase voltages fluctuate please refer to the document *HC500 function description - voltage-unit (VU)*.

For the temperature-units (TU) to measure and optional PID/PI control temperatures please refer to the document *HC500 function description - temperature-units (TU)*.

4 Data appearance

In order to allow an output-card (OC) to control its outputs and to error-monitor its power-circles a master must send **HC-write-parameters** to the HC500 (slave).
The master read **HC-read-parameters** from the HC500.



4.1 HC-write-parameters

HC-parameters	short	occurrence	*reference*
system-control	SC	1 x each HC500	*chapter 7, page 12*
output-card-control	OCC	1 x each output-card	*chapter 8.1, page 15*
channel-values	CH%	1 x each channel	*chapter 6.1, page 11*
channel-field-index	CFI	1 x each channel	*chapter 6.2, page 11*
field-values	FP%	1 to 265* x each HC500	*chapter 6.3, page 11*

* H500 first generation = 63

4.2 HC-read-parameters

HC-parameters	short	occurrence	reference
system-status	SS	1 x each HC500	chapter,7.1 page 12
output-card-status	OCS	1 x each output-card	chapter 8.2, page 16
error-status-power-circle	ESP	1 x each channel	chapter 9, page 17
electronic-temperature	TE	1 x each output-card	chapter 12 , page 21
output-values	OV%	1 x each channel	chapter 6.1, page 11
frequency-maximal	FREQmax	1 x each HC500	chapter 10, page 19
frequency-minimal	FREQmin	1 x each HC500	

5 Heating-ON / heating-ONsoft

Heating-ON means that the outputs of OCs without softSTARTlight (-SL) and softSTART (-S) are turned ON

Heating-ONsoft means that the outputs of OCs with softSTARTlight (-SL) and softSTART (-S) outputs are turned ON

Either separately via two different bits in the system-control [SC] or together via the digital input E1 on the CPU-unit (CU).

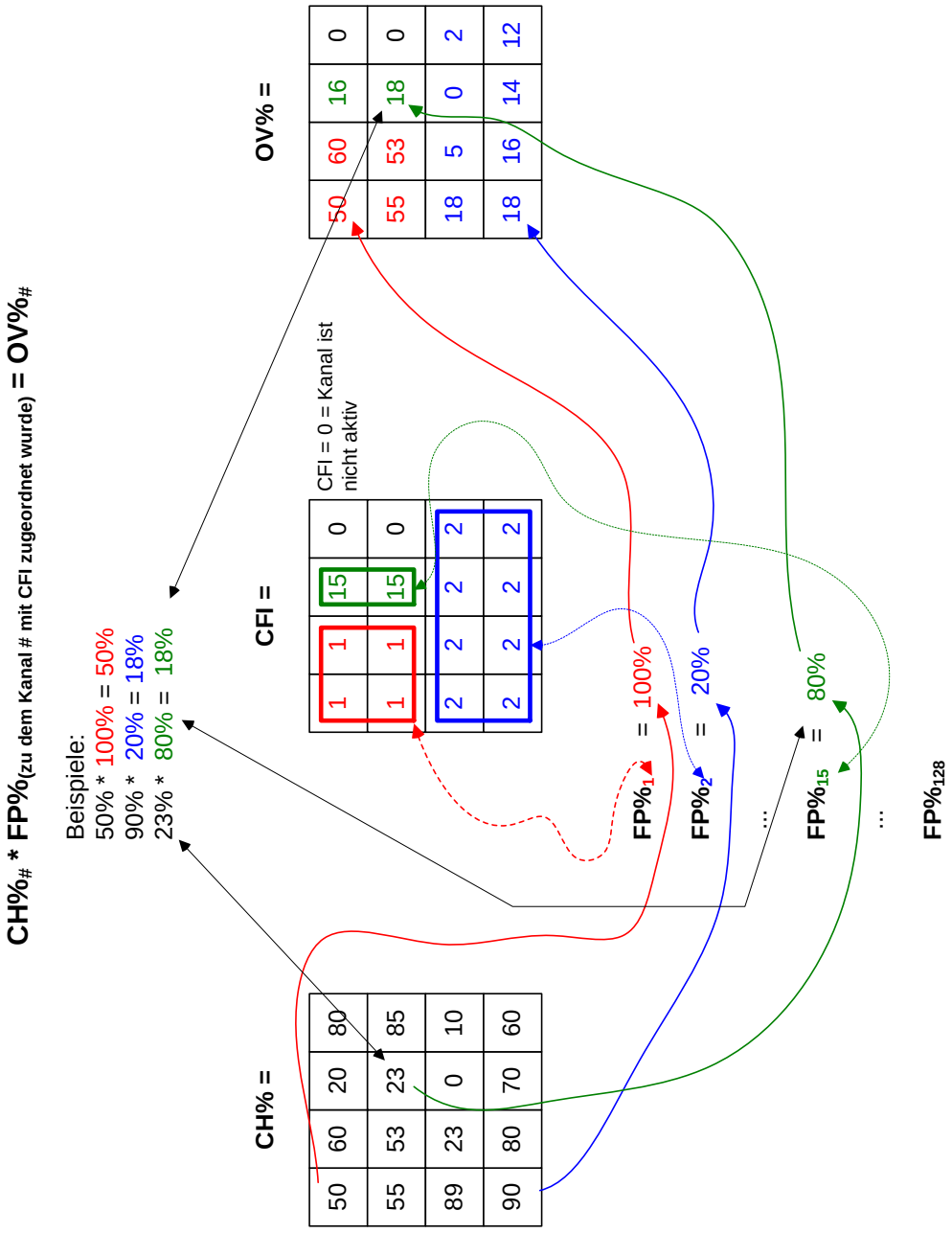
For the outputs to switch ON, further conditions must be fulfilled:

condition
H1 on the CU must not blink = HC500 system without failure
The power voltage/s for the output-cards (OC) must be available and error free.
The load, the wire to the load, the fuse and the power switch (triac) must not be defective.
The channel-value [CH%] of the respective channel must be > 0 %.
The channel-field-index [CFI] of the respective channel must be 1, 2, ... 255 (63 for first HC500 generation) but not 0.
The field-value-production [FP%] of the field, the channel was assigned to with CFI, must be > 0%.
The outputs of the output-card (OC) must be enabled via bit 0 = "1" of the output-card-control [OCC].

6 [CH%], [CFI], [FP%] and [OV%]

When heating-ON, each power output work at a %age value (= output-value [OV%]), that arise from

- its channel-value [CH%],
- its channel-field-index [CFI] and
- the assigned field-value-production [FP%]



Please ask for this EXCEL file, that illustrates the correlation:

channel-values [CH%]

100	100	100	69	67	67	69	73	79	88
100	100	100	65	62	62	65	68	72	79
100	100	100	60	59	59	60	63	68	73
100	100	100	58	56	56	58	60	65	69
100	100	100	56	54	54	56	59	62	67
100	100	100	56	54	54	56	59	62	67
100	100	100	58	56	56	58	60	65	69
100	100	100	60	59	59	60	63	68	73
100	100	100	65	62	62	65	68	72	79
100	100	100	69	67	67	69	73	79	88

%

channel-field-index [CFI]

Assignment of each channel to one of 128 fields
(in this example only to one of 3 fields).

1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	3	3	3	3	3	3	1	1
1	1	3	3	3	3	3	3	1	1
1	1	3	3	2	2	3	3	1	1
1	1	3	3	2	2	3	3	1	1
1	1	3	3	3	3	3	3	1	1
1	1	3	3	3	3	3	3	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1

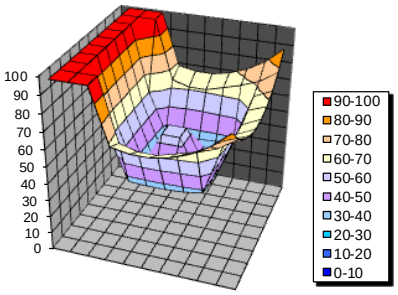
field-values [FP%]

field 1	$FP\%_1$ =	99	%
field 2	$FP\%_2$ =	100	%
field 3	$FP\%_3$ =	60	%
field 4	$FP\%_4$ =		%
field 5	$FP\%_5$ =		%
field 6	$FP\%_6$ =		%
field 7	$FP\%_7$ =		%
field 8	$FP\%_8$ =		%
etc …			
field 64	$FP\%_{128}$ =		%

output-values [OV%]

99	99	99	68	66	66	68	72	78	87
99	99	99	64	61	61	64	67	71	78
99	99	60	36	35	35	36	38	67	72
99	99	60	35	34	34	35	36	64	68
99	99	60	34	54	54	34	35	61	66
99	99	60	34	54	54	34	35	61	66
99	99	60	35	34	34	35	36	64	68
99	99	60	36	35	35	36	38	67	72
99	99	99	64	61	61	64	67	71	78
99	99	99	68	66	66	68	72	78	87

%



6.1 Channel-value [CH%]

By means of the CH%, the max. power output of the load or loads controlled at its output is setup.

Range: 0 to 100% in 1% steps.

Example:
In case the channel-value of a channel is set to 60 %, a 1'000 Watts heater emitter 600 Watts (60 % of 1'000 Watts).

6.2 Channel-field-Index [CFI]

Each channel must be assigned to one of 256 fields (63 for first HC500 generation).

If CFI = "0", the output is disabled.
I.e., the output can not be controlled and is not monitoring the power circle for errors (only triac).

6.3 Field-value-production [FP%]

By means of the field-value [FP%] all channels that belong to the respective field, are influenced at once.
This allows a fast change of many output-values [OV%] with one value only.

Range: 0 to 100% in 1% steps

6.4 Output-value [OV%]

By means of the output-values [OV%] the master can receive the information at what value each outputs is controlled.

OV% is not "0" at heating-OFF !
I.e. OV% can show values above "0" despite the output is OFF.
(What you see is what you get at heating-ON.)

OV% of OC with softSTART (-S) or softSTARTlight (-SL) is limited to 0 % and 10...100 %.

7 [SC] and [SS]

7.1 System-control [SC]

The most important functions of the HC500 system are controlled with the system-control [SC]:

function	bit	bit = 0	bit = 1
heating-ON/OFF for all OCs without softSTARTlight (-SL) and without softSTART (-S)	0	OFF	ON
power voltage fluctuation compensation	1	OFF	ON
ESPscan	2	END	START
heating-ONsoft/OFF for all OCs with softSTARTlight (-SL) and with softSTART (-S)	3	ON	OFF
channel-values alternation	4	[CH%]	[CH%2]
not used	5 ... 7	---	---
fast FP% refresh (fastFPrefresh)	8	not active	active

heating-ON/OFF with normalSTART or softSTARTlight
chapter 5, page 8

Power voltage fluctuation-compensation
HC500 Function description - voltage-unit (VU)

ESPscan
HC500 Function description - amp measurement (-I)
HC500 Function description - ESPscan

channel-values alternation
HC500 Function description - channel-values2

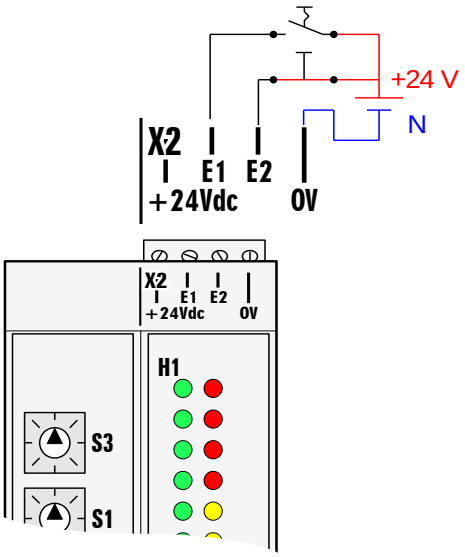
fast FP% refresh (fastFPrefresh)
HC500 Function description - fast FP refresh (fastFPrefresh)

7.1.1 Digital inputs

The must important HC-functions

- Heating-ON/OFF (E1)
- power voltage fluctuation compensation ON/OFF (E2)

can not only be controlled with network protocol but also with digital inputs.



	input 0 Vdc	input 24 Vdc
E1	heating-OFF	heating-ON
E2	power voltage fluctuation compensation = OFF	power voltage fluctuation compensation = ON

The outputs of all OCs of an HC500 system are switched.
I.E. OCs with and without softSTARTlight (-SL) / softSTART (-S) cannot be turned ON independently.
This is only possible via the system-control [SC].

7.2 System-status [SS]

SS delivers compressed information about the total HC500 system.

function	bit	bit = 0	bit = 1
output-cards (OC)	0	all present	one or more missing
output-cards (OC): phase voltage/s	1	all ok	one or more missing
output-cards (OC): power-circles	2	all ok	one or more with error (not all ESP = "0")
output-cards (OC): electronic temperatures	3	all ok	one ore more above 60 °C
voltage-unit (VU)	4	OFF	ON, but VU not present
voltage-unit (VU): phase voltages and power voltage fluctuation compensation	5	all phases present	one or more phase missing **or** not three different phases **or** overcompensation
temperature-units (TU)	6	all present	one or more missing
temperature-unit (TU): channels	7	all ok	one or more with error
not used	8 and 9	---	---
OCmode	10	known and accepted / executed	cannot be executed by at least one OC (at least one OC does not support the OCmode)
not HC-BUS2	11	all HC500 devices HC-BUS2 capable (HC-BUS2 is active)	at least one HC500 device not HC-BUS2 capable (HC-BUS is active) **and** OCmode not "0" **and/or** TUQ > 8 **and/or** CFI > 63
ESPscan Status	12	ESPscan = "1" -> "0"	ESPscan FINISHED, master has read the ESPs
temperature algorithm parameters [TALP]	13	no changes	changed with auto tuning
H-COM communication*	14	last communication ok	last communication failed
master	15	host system (e.g. PLC o PC)	HC500-DIAG** or HC-DIAG2***

* only CUs with HC-COM interface (-HCOM)
** HC-DIAG for CUs with firmware v1.15 to v1.19
*** HC-DIAG2 (successor of HC500-DIAG2) for CUs with firmware v2.0 or higher and all CU2s

8 OCC and OCS

8.1 Output-card-control [OCC]

By means of OCC functions can be controlled for each output-card (OC) individually.

function	bit	bit = "0"	bit = "1"
outputs	0	locked	enabled
emergency mode - electronic-temperature	1	disabled	enabled
channel-amp correction	2	ON (active)	OFF
not used	3	---	---

output-card (OC) enabling

The normal application case is that bit 0 is set continuously to "1".
I.e. outputs are enabled and are turned ON with heating-ON (SC bit 0 and/or bit 3 = "1").

HINT:
If bit 0 of the system-control [SC] is permanently set to "1" the outputs of each output-card (OC) can be turned ON/OFF individually by means of the output-card-control [OCC] bit 0.

Emergency-mode - electronic-temperature
Chapter 12.1, page 21.12.1

channel-amp correction
HC500 Function description – amp measurement (-)

8.2 Output-card-status [OCS]

Via the output-card-status [OCS], the CPU-unit (CU) informs the master in a compressed form about the operation status of the output-cards (OC).

function	bit	bit = "0"	bit = "1"
output-card (OC)	0	defective or missing	ok
power-circles	1	ok	error
electronic-temperature	2	ok	to high (above 60 °C)

output-card (OC)
"1" =
output card (OC) is supplied with voltage (via the HC-BUS) and is working error free.
"0" =

- output-card (OC) is defective or
- output-card (OC) is not supplied with 24 Vdc via the HC-BUS or
- wrong HEX-switch S1 and S2 (no. of OCs) setting on CPU-unit (CU) or
- wrong HEX-switch setting in one or more racks (RK) = address failure

power-circles
"1" =

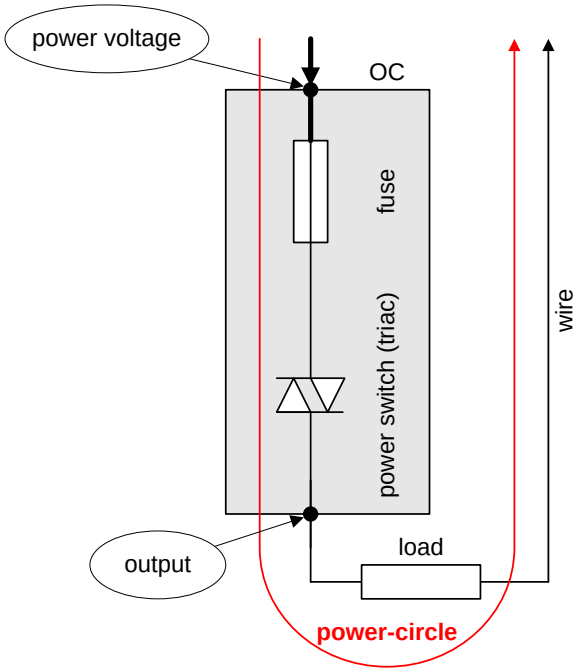
- one or more power-circle errors (ESP is not “0”) or
- power voltage problem.

Detailed failure information of each power-circle can be obtained via the error-status-power-circle [ESP]. *Chapter 9, page 17.*

electronic-temperature
"1" = electronic-temperature is to hot (above 60 °C). *Chapter 12, page 21.*

9 Error-status-power-circle [ESP]

The error-status-power-circle [ESP] delivers detailed information about each power-circle of each output-card (OC)



(schematic simplified),

There is one ESP for each power-circle.
The first four ESP bits are related to the load/cable, fuse and triac failures.
Bits 5 and 7 indicate a problem with the power voltage.

In case of a failure,

- bit 1 of the output-card-status [OCS] is "1" and
- the corresponding bit of the error-status-power-circle [ESP] is "1" and
- LED H9 (power voltage) respectively H10 (load/able, fuse, triac) is ON.

bit	bit = "1" if
0	load/wire broken
1	fuse blown
2	power switch (triac) cannot be turned OFF = shorted triac
3	amp to low (channel-amp [Ich] is lower than lowest expected channel-amp [Ichmin])
4	---
5	one or more phases are missing
6	***
7	not 49...51 or 59...61 Hz

In case of a problem with the power voltage, the related bits (bit 5 or bit 7) of all channels of the respective output-card (OC) are "1".

For OCs with -I (amp measurement) in the product name, all channels of a phase indicate a triac error, even if only one triac is defective.

For detailed information about the failure detection via amp measurement, refer to *"HC500 Function description - amp measurement (-I)"*.

In case a heater is not getting warm despite
- H1 on the CPU-unit (CU) is ON = HC500 system without failure and
- output-value [OV%] is different than 0% and
- heating-ON resp. heating-ONsoft (LED H5 = ON; for CU first generation H5 resp. H6 = ON)

there is more than one possible reason:

- no power voltage
- frequency not 49…51 or 59…61 Hz
- load broken
- cable broken
- fuse blown
- defective power switch (triac)
- connector defective

If the heater is getting warm, despite the output-value is 0%, there is only one possible reason:
- power switch (triac) is short circuit.

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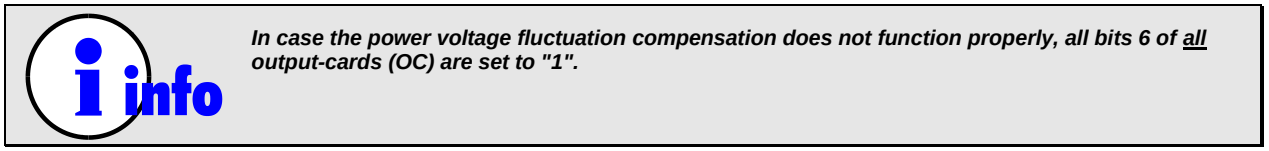
**** from Firmware v1.15 only for CPU-unit (CU) HC500-VU-HN*

Bit	*Bit = "1" wenn*
6	*power voltage fluctuation compensation does not operate properly*



In case the power voltage fluctuation compensation does not function properly, all bits 6 of all output-cards (OC) are set to "1".

9.1 Wrong wiring of output-unit-ampmeter (OUI)

If the OUI is wired incorrect (= phases of an OUI are not identical), bits 2, 3 and 5 are "1".

10 Frequency [FREQ]

All output-cards (OC) operate with 50 ± 1 Hz or 60 ± 1 Hz ac power voltage.
The 50 or 60 frequency is detected automatically = must not be setup.

The maximum and minimum measured frequency is measured and can be read from the master (FREQmax and FREQmin).

11 Automatic heating-OFF

To avoid that a HC500 system continue to fire the outputs in case the network cable is broken o in case of master communication problems, the HC500 has an automatic “heating-OFF” function.

In case
- the CPU-unit (CU) does not detect any communication of the host system for longer then 5 seconds **and**
- the master does not send any 30 seconds heating-ON [via SC]

all outputs are turned OFF automatically.

Loss of communication with the master is indicated on the CPU-unit (CU).
Information in respective *H500 Hardware description - CPU-Unit #* .

This security feature does not engage, in case heating is turned ON with the digital input E1. *Chapter 7.1.1 page 13*

12 Electronic-temperature [TE]

The electronic-temperature [TE] of each output-card (OC) is measured.

If the electronic-temperature of an OC exceed 60 °C,
- bit 2 of the output-card-status [OCS] is set to "1",
- ERROR C3 on LCD-display (CU first generation: LED H11 is ON)
- the OC turn OFF its power outputs.

If the electronic-temperature [TE] drop again below 57 °C, the OC control its outputs again.

Power output continue to fire again if the electronic-temperature [TE] drop to below 57 °C.

12.1 Emergency mode - electronic-temperature

It is possible to continue to operate the outputs even if the electronic-temperature of an output-card (OC) is above 60 °C. This makes sense eventually to finish a started production-cycle.
The automatic output OFF function can be disabled setting bit 1 of output-card-control [OCC] = „emergency mode - electronic-temperature to "1".

If the output-card (OC) electronic is getting to warm the OC can be damaged.

If the „emergency mode - electronic-temperature is active for more than 10 minutes within a period of one hour, the guarantee expire.