Laser Diode Controller
Series CS400

Generation V

AMTRON

Manual

Amtron GmbH
Am Weiweg 8
52146 Wuerselen, Germany
Fax: +49 (0)2405 42397 66
mail: info@amtron.net

www.amtron.net

Contents

1 Introduction 5
2 Design principles 6
Complex interface management 6
Process management 6
Multi-current systems 6
Operating modes 7
1. CW mode without gate 7
2. CW mode with gate 7
3. Trigger mode 8
4. Timer mode 8
5. Gated timer mode 9
Bias current 9
Profile 10
Control System 11
1. Temperature control 11
2. Speed control 11
Parameterization with registers 12
3 Views 13
CS401, CS402, CS404P 13
CS411, CS412, CU411 14
4 Control and display elements 15
Overview 15
Setting parameters 16
1. Fast access per *Direct/FlexMenu* 16
2. Fast access to special functions 17
3. General access to parameters 18
Error and warning messages 20
1. Warning messages 20
2. Error messages 20
5 Interfaces 21
Emergency-off external 22
Interlock external 22
Warning lights 23
Laser head (DSub 15) 23
SPI (DSub 15) 24
Port 0 (DSub 15) 24
Port 0 (DSub 15) 25
PLC (DSub 25) 26
RS232 (DSub 9) 27
CAN-Bus (DSub 9) 28
Link (2x RJ45) 28
Cooler (DSub 9) 29
6 Safety 30
7 History 31
8 Appendix 32
Register list 32
1. Overview 32
2. Main 33
3. Profile 35
4. Control 36
5. Laser 38
6. Interface 39
7. Cooler 41
8. Power unit 1 42

9. Power unit 2 43
10. Power unit 3 44
11. Power unit 4 45
Error/warning list 46
1. Full register (all errors/warnings) 46
2. Errors/warnings from Main (0) 47
3. Errors/warnings from Laser (5) 48
4. Errors/warnings from Interface (6) 49
5. Errors/warnings from Cooler (7) 50
6. Errors/warnings from power units (A to D) 51

1 Introduction

Congratulations on selecting the new digital laser diode controller from AMTRON. To ensure that you make full use of the different functions of your new device, we strongly recommend that you read this manual carefully and in full, and that you store it somewhere safe for later reference.

This manual describes the functions of the AMTRON CS400 series of devices, available in different versions with regard to performance, control elements and interfaces.

The following devices were available at the time of publication:

AMTRON CS401	digital laser diode controller, standard version, air or water-cooled
AMTRON CS402	digital laser diode controller. As the CS401 but with extended interface functionality
AMTRON CS404P	digital laser diode controller for pulse mode only. As the CS401 but with extended interface functionality and integrated high-tension power supply.
AMTRON CS411	digital laser diode controller. As the CS401 but with additional control elements and display unit.
AMTRON CS412	digital laser diode controller. As the CS401 but with extended interface functionality, additional control elements and display unit.
AMTRON CS442	digital laser diode controller. As the CS412 but with compact OEM housing instead of the 19” format
AMTRON CU411	digital laser diode controller. As the CS411 but without integrated power unit
AMTRON CU412	digital laser diode controller. As the CS412 but without integrated power unit
AMTRON LS403	digital laser-diode compact system. As the CS401 but with integrated, air-cooled laser source and extended interface functionality
AMTRON LS413	digital laser-diode compact system. As the CS401 but with integrated, air-cooled laser source, extended interface functionality, additional control elements and display unit.
AMTRON LS453	digital laser-diode compact system. As the LS413 but with compact OEM housing instead of the 19” format

The model’s name indicates the power output and type of cooling:
For example, the CS401 13L80 is an air-cooled 13V/80A version.

For simplicity’s sake this manual refers to all models as CS400.
Please observe that your particular device may not have all of the functions listed in this manual and that your model may look different to those illustrated.
In addition to the protective measures outlined in this manual, the devices of the LS 400 series—laser-diode compact systems—are to be operated while observing the protective measures for lasers (see separate documentation).

This manual refers to the device firmware version 5.044.

2 Design principles

The AMTRON digital laser-diode controllers of the CS400 series enable applications and configurations that far exceed the functions of a simple power supply.
In particular the differences to the classical analog solutions (even those with digital extensions) offer new perspectives in operations.
The following describes the outstanding features, the parameters for device configuration, the available operating modes, and the behavior under certain circumstances (e.g. interlock).

Complex interface management

The operation of high-power laser diodes should be subject to close monitoring in many respects: This includes not only operational safety aspects such as interlocks, the emergency-stop and warning lights, but also the permissible working tolerances of the diodes.
The CS400 manages all of these aspects, either as a fixed component or configurable:

- Most of the interlock inputs are designed with redundancy and prevent the activation of the laser power supply.
- The emergency-stop circuit also has a redundant layout and directly interrupts the internal power feed.
- An infringement of the above redundancies will be detected.
- Warning-light outputs are activated with the laser current and, on request, their function can be monitored.
- Short-circuits and circuit breakage at the diodes can be monitored, on request.
- Analog measurements such as fiber resistance, temperature, humidity or power can be monitored, on request.
- The integrated high-speed bus additionally enables the realization of complex interface functions (e.g. in the laser head) via a simple Ethernet cable.

Further configuration options include additional in- and outputs that allow simple communications with the status lines and analog values.
All these interfaces enable the convenience of full monitoring by micro-processors.

Process management

Many processes demand far more than the simple definition of a fixed current. The CS400 offers the following extensions:

- Definition of current values and, alternatively, laser power.
- A control range can be defined, to which the output current will be limited even if external requests exceed this range.
- In combination with the AMTRON Pyrometer SE242, the process temperature can be controlled with the simultaneous monitoring of power output.

Multi-current systems

The setting and regulation systems mentioned above normally act on *one* amplifier and *one* connected laser unit.
In some situations, the parallel operation of multiple amplifiers and/or lasers may be suitable. This increases redundancy and the work rate.
The CS400 supports these multiple systems:
The integrated high-speed bus can be used to connect up to four PU400 digital amplifiers. The settings for current, power, or process regulation remain unchanged; the only variable is the split factor between the individual amplifiers.
This method provides scalable total power combined with a consistent interface to an upstream controller, and enables operation via the control unit.

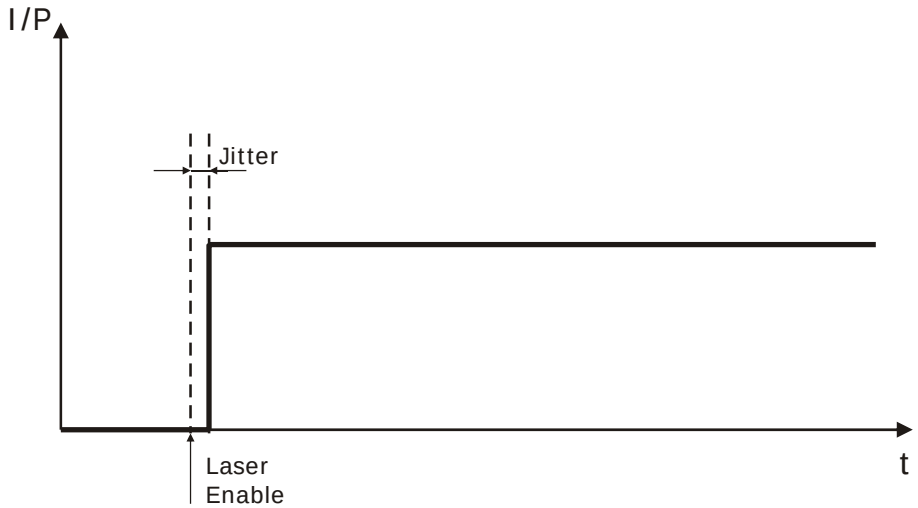
Similar to the CS400, the PU400 amplifiers are available in versions with various power capacities and features.

Operating modes

The operating modes of the CS400 are suited to a variety of applications:

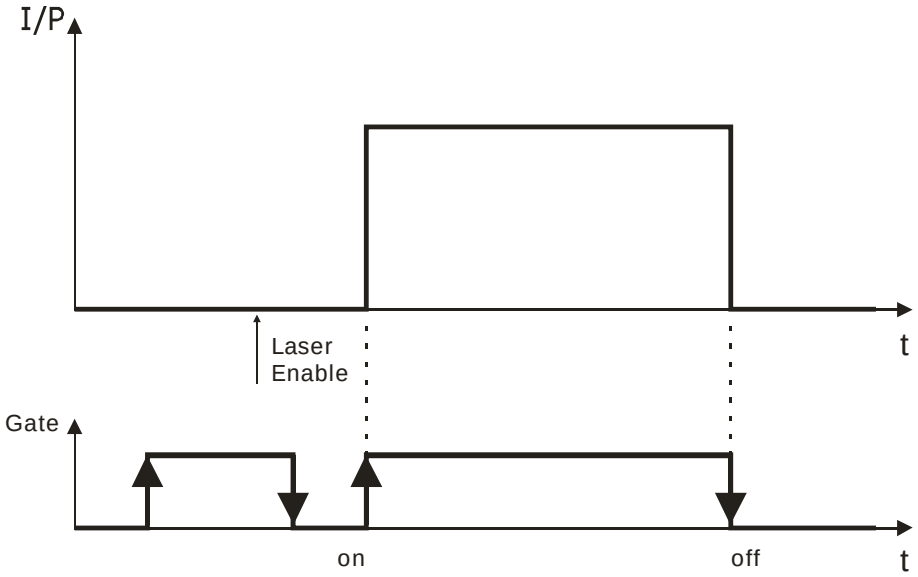
1. CW mode without gate

The standard operating mode that enables current modulation at up to approx. 1kHz. The edge gradient of the current is limited to approx. 100A/ms to protect the laser diodes.
When the laser current is enabled (via control elements or interface) the nominal current is switched on immediately. The current is switched on and off with a 0-20ms time delay.



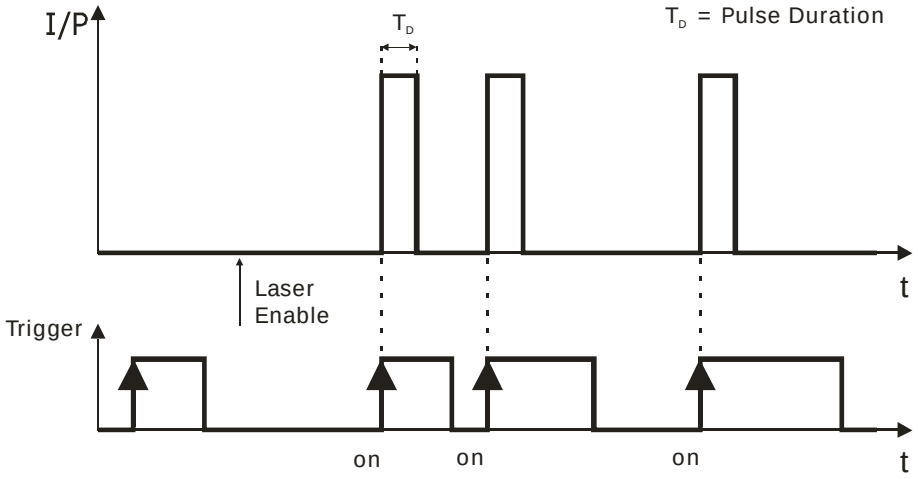
2. CW mode with gate

Like operating mode 1 “CW mode without gate” except that the gate can activate the current almost jitter-free and with a minimal time delay (approx. 30µs). A condition is that the laser current is already enabled. In addition to the “no current – nominal current” switch, a “bias current – nominal current” switch is also possible.



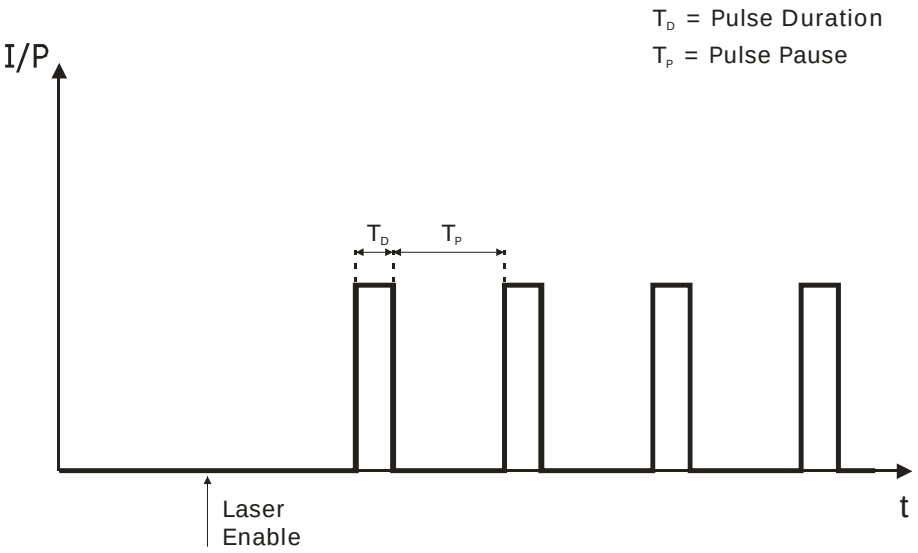
3. Trigger mode

Short-pulse operation with pulse widths from 32ms down to 100µs, depending on the device specification. A pulse edge arriving at the gate releases a current pulse of pre-defined width. The edge gradient is not limited in this case and is typically below 30µs.
Important for pump applications: The pulse start and pulse width are fully jitter free. Additionally, a trigger signal at the pulse end can be produced for external purposes.



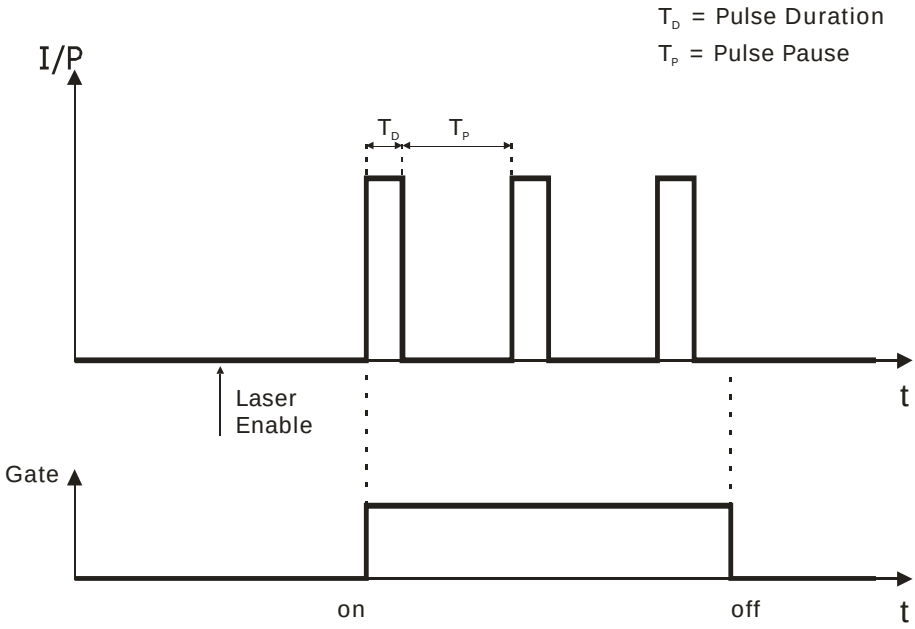
4. Timer mode

Like operating mode 3 “Trigger mode”, but with a free-running trigger, controlled by internal timers. Additional to the pulse width, a pulse pause is also defined, after which a new pulse is produced. When the laser current is enabled (via control elements or interface) the nominal current is switched on immediately.



5. Gated timer mode

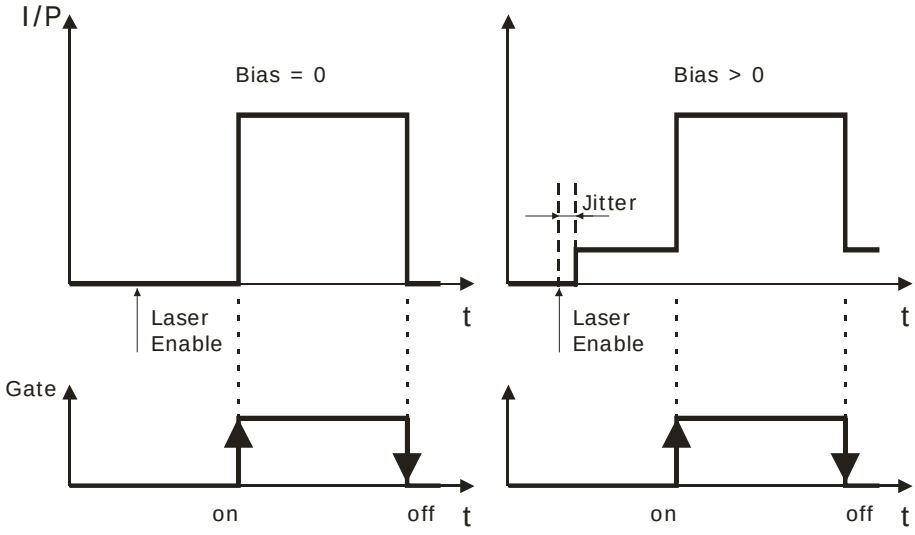
Like operating mode 4 “Timer mode”, but with an additional linking of the gate signal. Pulse pause and pulse duration are also set by the internal triggers. Once the laser is enabled (via control elements or interface), the gate enables the timer pulse (timer sequence).
Notice: Available as of firmware version 4.067.



The main factor in selecting one of the five operating modes is the time characteristic required of the current.
Use the trigger or (gated) timer modes for steep, absolutely jitter-free pulses (<10ms pulse width), required for pumping a solid-state laser, for example.
For longer pulses (>10ms pulse width) or modulated signals on a CW (continuous wave) up to 1kHz, one of the two CW modes should be used.

Bias current

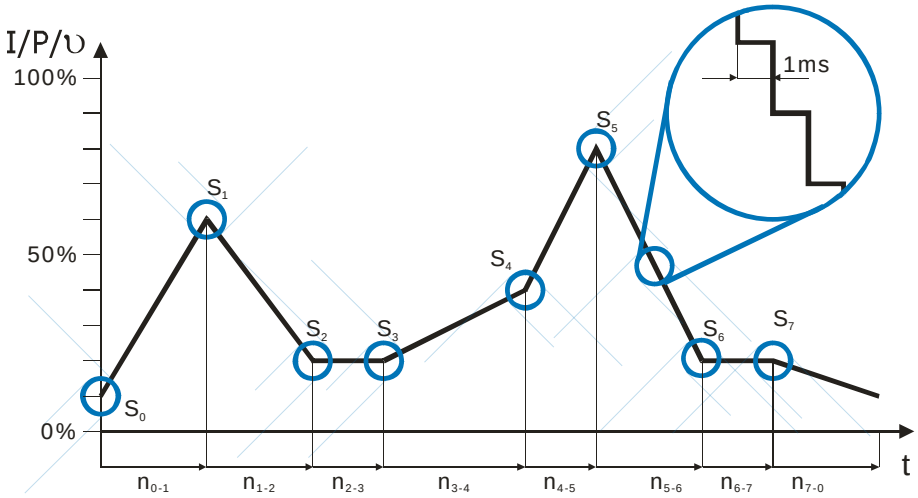
To save load on the high-power laser diodes and to take advantage of thermal effects, a bias current can be used in all operating modes. This means that the output current of the CS400 does not fall back to zero, but to a defined value which is below that of the nominal current.



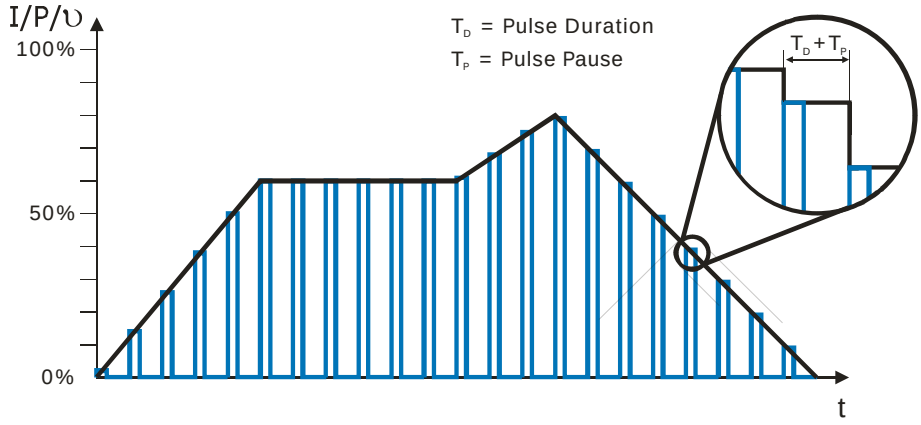
Profile

The operating modes CW, gate and timer can be combined with the profile mode. This involves the modulation of the laser current or laser power according to a predefined profile. A processing profile can consist of 8 reference values. Interpolation between the reference points is linear. Each reference point is defined by the following two values:

- A percentage value for the modulation (current, laser power, temperature…) in 0.1%
- A time value until the next reference point is reached, in ms



In the “Timer” operating mode, the processing profile is determined by the envelope of the timer sequence. Other than in the CW and gate modes, the unit of time is not 1 ms but the period of the timer cycle.



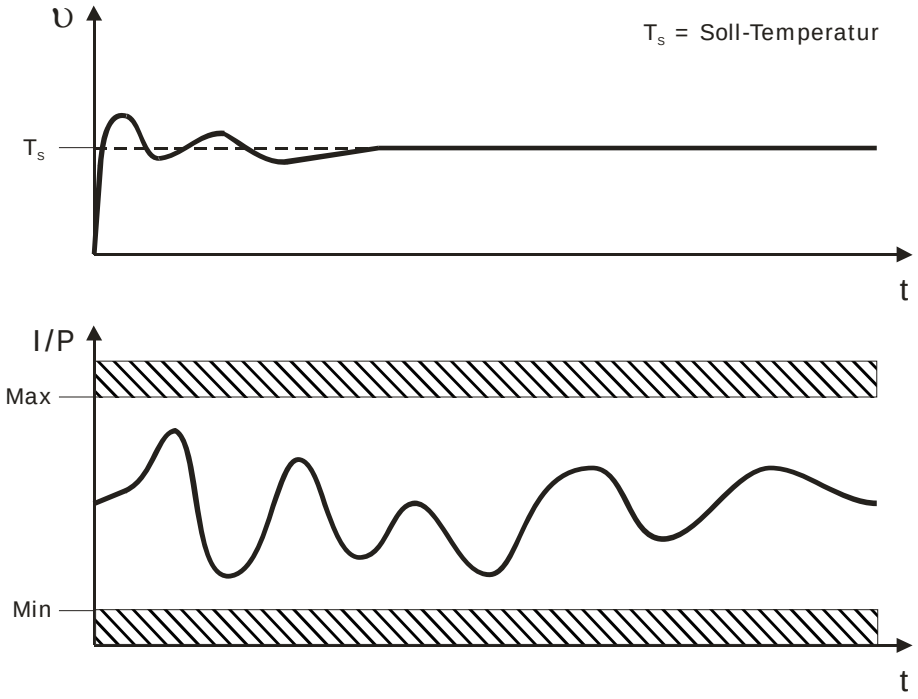
Notice: Timer profile mode available as of firmware 4.067.

Control System

Along with direct settings for current or laser power, the CS400 can also carry out controlling based on process values.

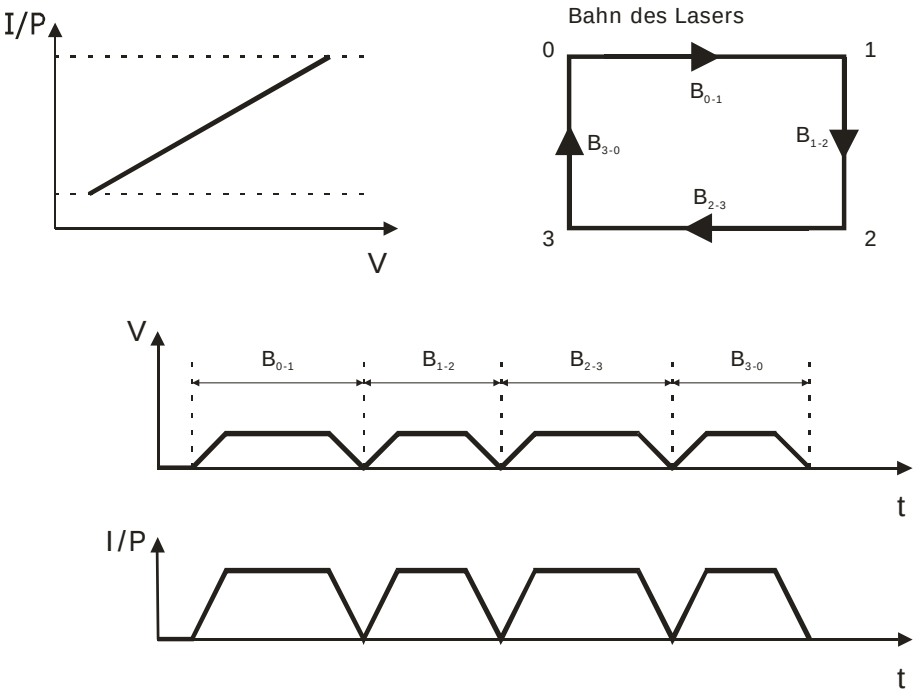
1. Temperature control

In combination with the AMTRON SE200 digital pyrometers, the CS400 can operate by directly and precisely controlling process temperatures. The laser power is tracked according to a preset required temperature, control parameters, and limiting values.



2. Speed control

The CS400 can adjust laser power to feed rate if an external speed signal is supplied. An analogue input and a PWM input are available for this purpose. Power is adjusted to the current feed rate according to the parameter and limit settings.



Parameterization with registers

Communication with the CS400 takes place on the lowest level with registers.
Even though the registers are rarely required in the day-to-day operation of the CS400's operating/display unit (chapter 4), they offer the only access to certain basic settings and extended features.

Each register has a three-figure hexadecimal identifier, e.g. 208 or A05. This register number can be directly accessed by RS232 or CAN bus.
The available registers, their meaning and their content can be found in the appendix of this manual or interrogated with the RS232 command `:p` (settings: 19,200 baud, 8N1, no echo). The commands
`:r <register> and`
`:w <register> <16-bit integer value>`
can also be used to query and set values. Further details are available in the Technical Manual.

For clarity, the registers are divided into logical groups: The first figure of the three-figure identifier indicates the group that it belongs to.

Currently the following groups are defined:

Group	Name	Meaning
0	Main	Register with higher-ranking device function
1	Profile	Register for setting a (current) profile
2	Control	Parameters, limit values and modes for control and regulation of the power flow
5	Laser	Register relating directly to the laser
6	Interface	Configuration and status of the digital/analog interfaces
7	Cooler	Cooler-specific register (when using the AMTRON cooler controller CM102)
A	Power A	Power-unit parameter for the internal or external Power 1
B	Power B	Power-unit parameter for the external Power 2
C	Power C	Power-unit parameter for the external Power 3
D	Power D	Power-unit parameter for the external Power 4

3 Views

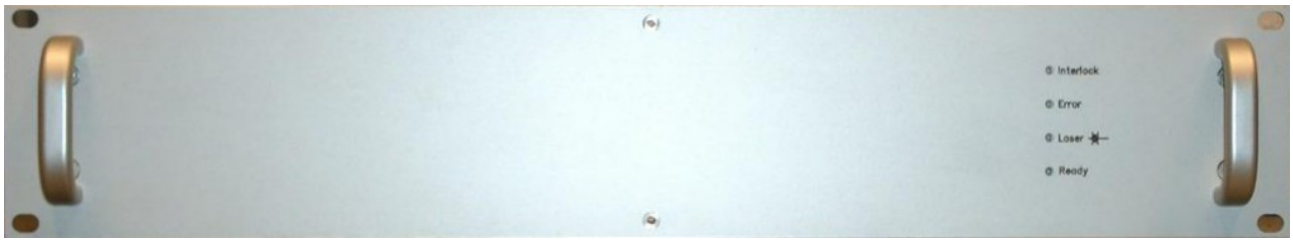
In the following, the front and rear views of different 19” models are shown. All models have 19” mounts and front-mounted handles.
Depending on the power and cooling versions, some models have front-to-back blowing air ducts or water connectors on the housing.

Notice

Ensure that air-cooled models have unobstructed air intakes and outlets. For example, cables should not obstruct the rear exit ducts. An obstruction to the airflow can lead to a temperature rise and cause the amplifier to be shut down.

CS401, CS402, CS404P

The models CS401, CS402 and CS404P are solely for control by external components such as personal computers, PDAs, programmable logic controllers (PLC) or even the AMTRON remote terminal RT400.
Consequently, the front panel features only the four status displays for Interlock, Error, Laser (enabled) and Ready.
The layout of the rear panel differs from version to version.

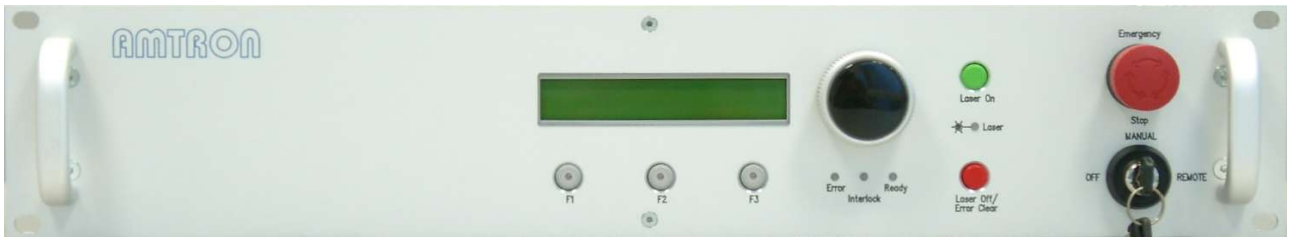


Front panel CS401 / CS402 / CS404P water-cooled

Rear panel CS401 water-cooled, power connector via MC circular connector

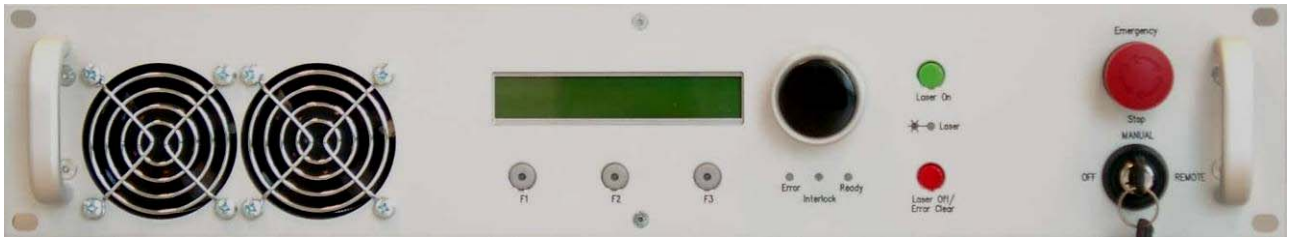
CS411, CS412, CU411

The devices CS411, CS412 and CU411 can be fully self-sufficiently operated via their control elements. There are also buttons for “Laser on” and “Laser off” and an alphanumeric display for parameter selection and status display. All settings can be adjusted with the non-wear rotating wheel and three illuminating function keys.
A key switch controls the power on/off and selects operation via keyboard or external interface.
The integrated emergency-stop button cuts the internal power supply in all operating modes.



Front panel CS411 water-cooled

Rear panel CS411 water-cooled, power connector via industrial connector



Front panel CS412 air-cooled

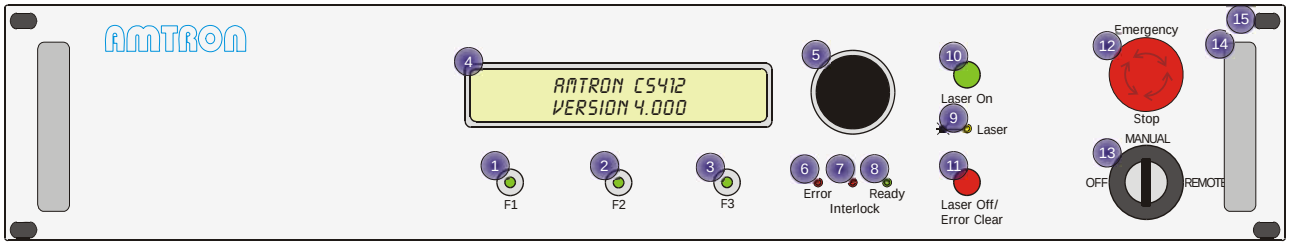
Rear panel CS412 air-cooled, power connector via industrial connector

4 Control and display elements

The control and display elements of the CS400 series are limited to a small number of clearly arranged units to facilitate their easy operation.
The alphanumeric display combined with three function keys and a useful rotating control wheel facilitate a quick adjustment even of complex settings. An operating menu is structured according to the individual functions.

Overview

Illustrated is the control unit of the CS411 (water-cooled). The elements of the devices CS412, CU411 and the remote terminal RT400 are identical.



1 Menu key “Select”
Selects parameters or executes special functions.

2 Menu key “Back”
Returns to higher menus or cancels entered values.

3 Menu key “Menu/Enter”
Enters lower menus or confirms entered values.

4 These three function keys are fitted with lights and illuminate according to their designated function in the current menu.*

5 Alphanumeric display. The color and illumination vary between models.

6 Rotating wheel with non-wearing, optical encoder for menu navigation and value/ parameter entry.

7 Error/warning signal (red)
Blinking: A system warning is activated that does not require the laser current to be interrupted, or that prevents it being switched on.
Permanent: An error has occurred and must be cleared. Attempting to clear the error will demonstrate if the error is still current. The laser current cannot be enabled.

8 Interlock signal (red)*
An external signal state prevents the laser current from being enabled. Once this state is no longer present, the laser current can be activated immediately without acknowledgement.

9 Ready signal (green)
The CS400 is ready for the laser current to be enabled. Apart from errors and interlock, the current-enable with the CS400 is prevented when powering up and in the standby mode. The Ready signal for devices without control elements (CS401, CS402, CS404P) is never switched off, and blinks as soon as it has mains power.

10 Laser signal (yellow)
The laser current is enabled. Depending on the operating mode, external and internal parameters, current is present and the laser is emitting.

* Depending on model

11 Laser On key (green)
The laser current will be enabled on the condition that the device is operational, the manual mode is activated with the key switch (13) and there are no interlocks or error messages. Depending on the operating mode, external and internal parameters, current is present and the laser is emitting.

12 Laser Off/Clear Error key (red)
Current will be cut immediately if the laser current is enabled and the manual mode is activated with the key switch (13).
If there is an error message to be cleared and the manual mode is activated with the key switch (13), then an attempt will be made to reset the error. If an error is still present, the equipment will remain inactive.

13 Emergency-Stop button
Pressing the Emergency-Stop button immediately cuts all internal power circuits and their supplies, and displays an error that must be cleared. Turning the button will release the Emergency-Stop function.
Where the AMTRON remote terminal RT400 is in use, interrupting the cable connection between CS400 and RT400 prompts the same Emergency-Stop effect.

14 Key switch
The key switch has two functions: One is to switch the CS400 between Ready (on) and Standby. The other function is determined by the key setting “manual” or “remote”, allowing operation either via the control elements or via the interfaces (such as PLC, RS232, CAN bus).

15 Handles for the convenient removal of the device from switch cabinets.

16 19“ mounting holes

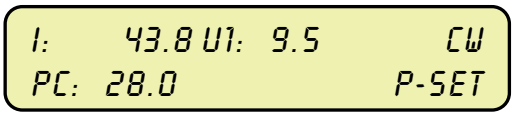
Setting parameters

Various device parameters can be displayed and set with the control and display elements on the CS400-series devices. The supplier of your system has defined which of these parameters are accessible in each display mode. The following description thus outlines example parameters which may not necessarily agree with the device configuration that is available to you. Please ask your system supplier for details.

Concerning the access to parameters and functions, the system differentiates between those required on a daily basis (e.g. required current, true power, operating mode, etc.) and those used less often (e.g. operating hours, configurations, etc.):

1. Fast access per *Direct/FlexMenu*

In the basic state, an operational device’s display shows important parameters in the left/middle portion and the main operating modes in the right-hand portion.



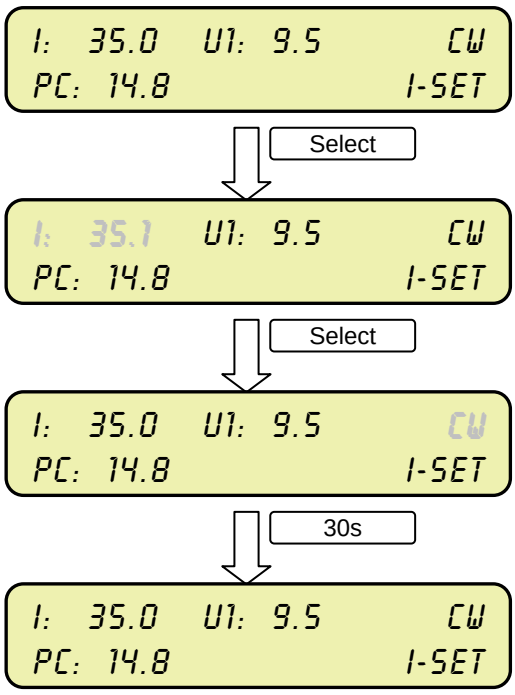
In the example (right figure) these are: I – momentary overall current, U1 – momentary laser-diode voltage on channel 1, PC – momentary, calculated overall power, CW mode, power setting.

All of the variable values displayed in this menu can be accessed with key 1 “Select”.
Assuming that the operating mode is manual (see key switch), a variable value can be selected as set by rotating the control wheel.

A parameter selected in this way starts to blink (shown in the figure shaded in gray). In the process, it changes from the true value to the required value, i.e. from true current to required current in this example.

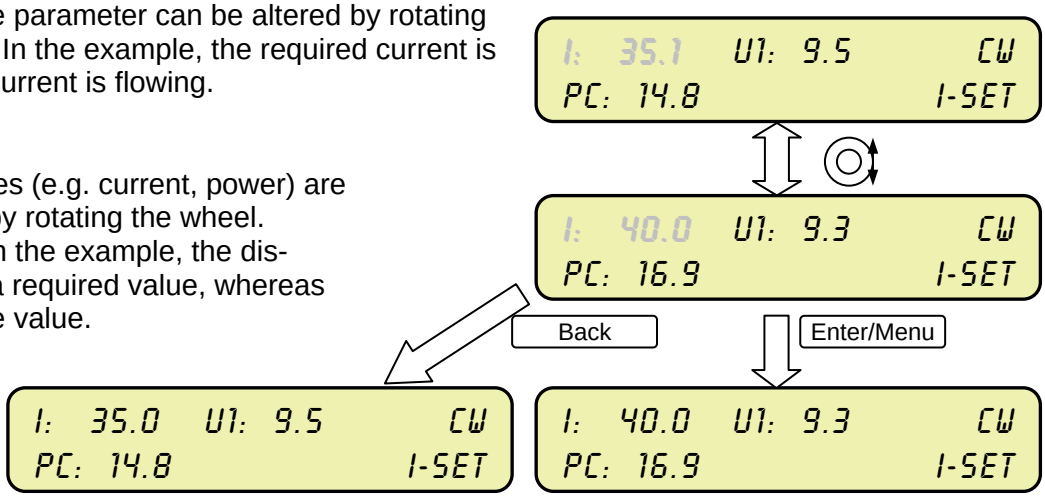
Pressing the “Select” key again will select a further variable parameter.
Which parameters are variable depends on the momentary operating mode and the access rights.

The display returns to its basic state after a short time (ca. 30s) if the user takes no further action (key press, wheel rotation). This happens immediately when key 2 “Back” is pressed. This behavior also applies to most of the menus described below.



When blinking, the parameter can be altered by rotating the control wheel. In the example, the required current is altered while the current is flowing.

The required values (e.g. current, power) are directly changed by rotating the wheel.
Please observe: In the example, the displayed current is a required value, whereas the power is a true value.



New value
settings are accepted by pressing key 3 “Enter/Menu” or by switching to another parameter by pressing “Select”.
To return to the previous value, simply press the “Back” key.

2. Fast access to special functions

Some special functions are immediately accessible from the operational device’s basic state. These are:

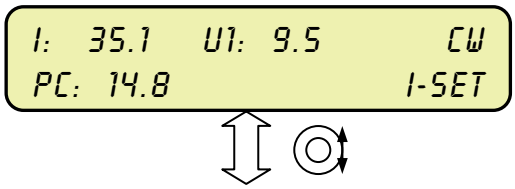
- Switch pilot laser
- Set display contrast*
- Save the settings

* Depending on model

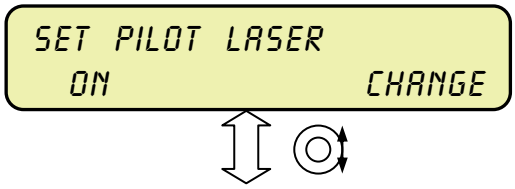
The menus for the above functions can be access simply by rotating the control wheel either clockwise or anticlockwise. All necessary actions within the menus can be carried out with the “Back” and “Enter/Menu” keys and with the control wheel.

The following diagrams illustrate the menu sequence:

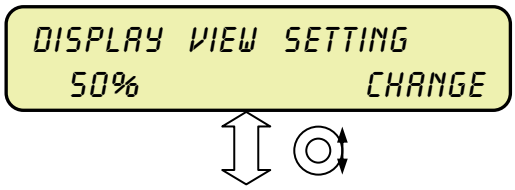
Basic state *Direct/FlexMenu*



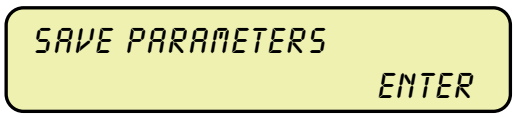
Pilot laser on/off menu
The pilot laser can be switched between the two states by using the “Enter/Menu” key.



Display contrast menu*
After pressing the “Enter/Menu” key, the display contrast can be set with the control wheel.

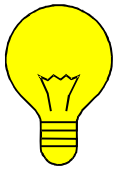


Save menu
The current device configuration (except laser-on) is saved to the device's nonvolatile memory and remains available even after switching the device off.



Tip

With the CS400, the pilot laser can not only be operated fully manually; it can also be automatically deactivated when the (main) laser current is switched on. The “Pilot Laser” setting is always "ON“ in this case. A configuration register can be used to activate this behavior when required.



Apart from moving between the menus with the control wheel, the “Back” key can be used in any menu to return to the basic state, the *Direct/FlexMenu*.
This also takes place automatically after a short wait in most menus if the user takes no further action (key press, wheel rotation).

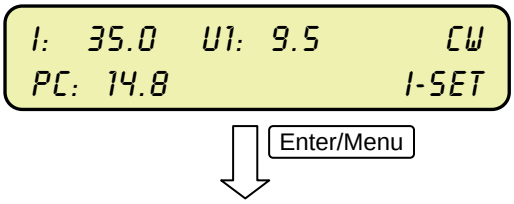
3. General access to parameters

Relevant parameters other than those that are accessible as described above can be found in a dedicated parameter menu, the parameter tree.
Accessing the parameters here is structured according to individual parameter groups. Within these groups, parameters can be called or changed, as applicable.
Here too, all necessary actions can be carried out with the “Back” and “Enter/Menu” keys and with the control wheel.

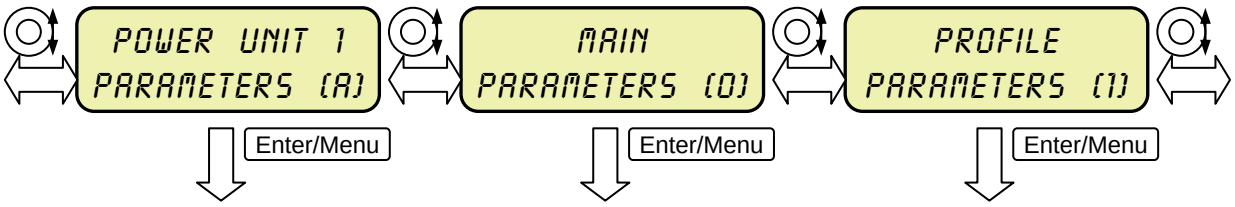
* Depending on model

An example of a menu sequence is as follows:

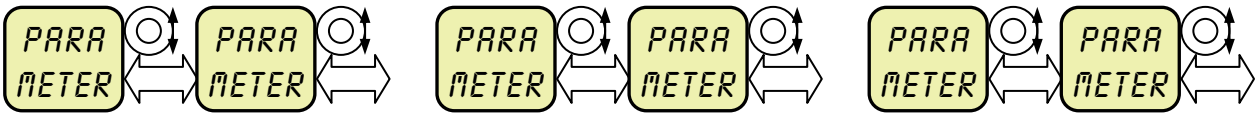
Basic state
Direct/FlexMenu



Group selection



Parameter selection



Pressing the “Enter/Menu” key takes the user into the parameter tree one level “deeper” at a time. Similarly, the “Back” key takes the user one level “higher” until reaching the basic state.

A parameter may be displayed as follows:

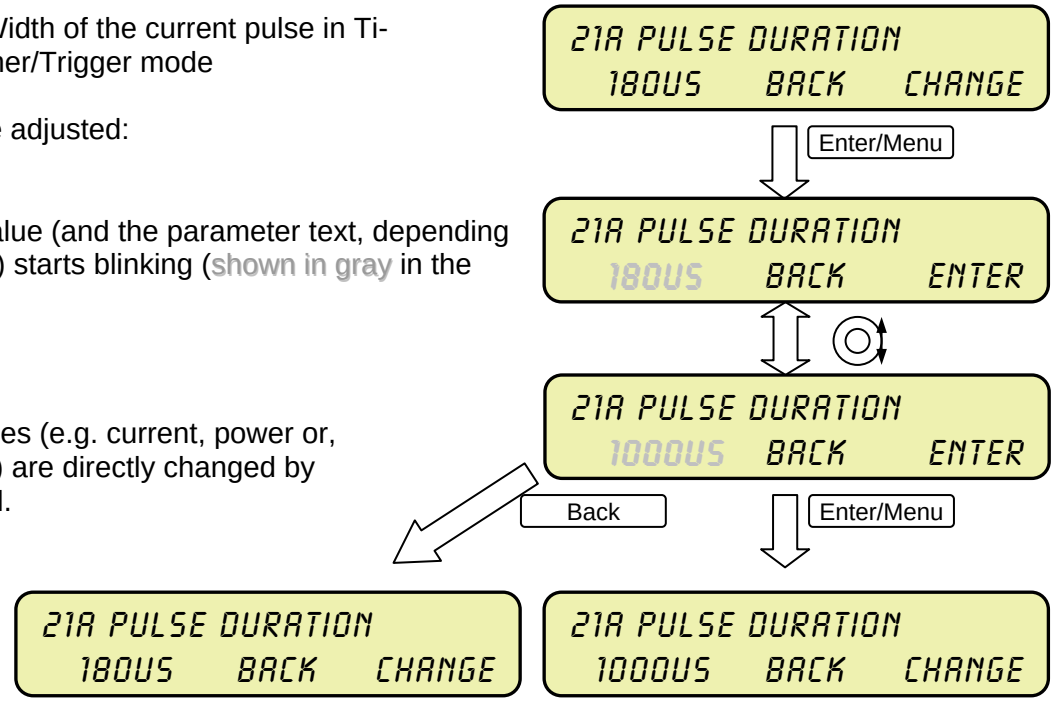
Parameter 509: Operating time of the laser in hours
This value cannot be altered and only the “Back” key can be pressed.

Parameter 21a: Width of the current pulse in Timer/Trigger mode

This value can be adjusted:

The parameter value (and the parameter text, depending on the parameter) starts blinking (shown in gray in the figure).

The required values (e.g. current, power or, here, pulse width) are directly changed by rotating the wheel.



New value settings are accepted by pressing the key “Enter/Menu”. To return to the previous value, simply press the “Back” key.

Error and warning messages

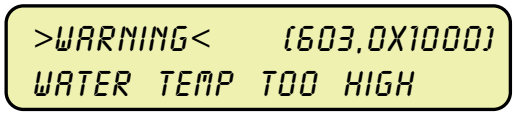
During operation of the CS400, extraordinary statuses, errors and warnings may arise. These are shown not only by the red “Error” and “Interlock” warning lamps, but by plain text in the display as well.

1. Warning messages

Warning messages indicate a critical but not (yet) erroneous status.

For example:
Warning-lamp failure, service interval, approach to a critical temperature, or the activation of the external interlock in the “laser disabled” state.

Should the warning status actually occur, then the signal lamp “Error” will start to blink and the display changes briefly (2 seconds) to show the appropriate plain-text message. Should multiple warning states arise, the display will continuously cycle between the various warning messages.



A diagnosis code is displayed in brackets along with the warning message and serves to assist you in communications with the responsible service technicians.
Please keep this code at hand.

Barring a small number of exceptions, warnings and the displayed warning messages cannot be manually deleted or suppressed. A warning will only be cancelled if the cause of the warning ceases to exist.

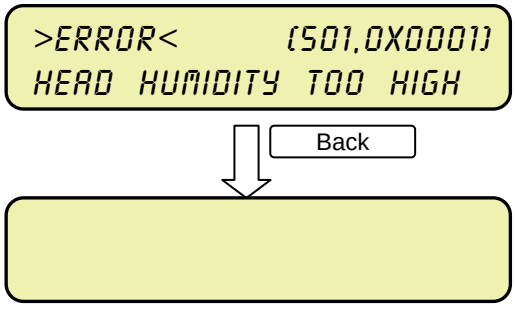
Some warnings act like an interlock, i.e. they prevent the laser current from being switched on. In such cases, the warning messages are similarly displayed, but the interlock signal lamp illuminates in addition (7).

2. Error messages

Unlike warnings, errors cause the device’s amplifier to be shut down and are subject to an obligatory acknowledgement.

For example:
Short-circuit at the laser output, excessively high laser temperatures, actuation of an emergency-stop circuit or even an internal device error.

In the case of an error, the “error” warning lamp illuminates and the display shows a blinking plain text error message. If multiple errors should arise simultaneously, these will be displayed briefly one after the other.

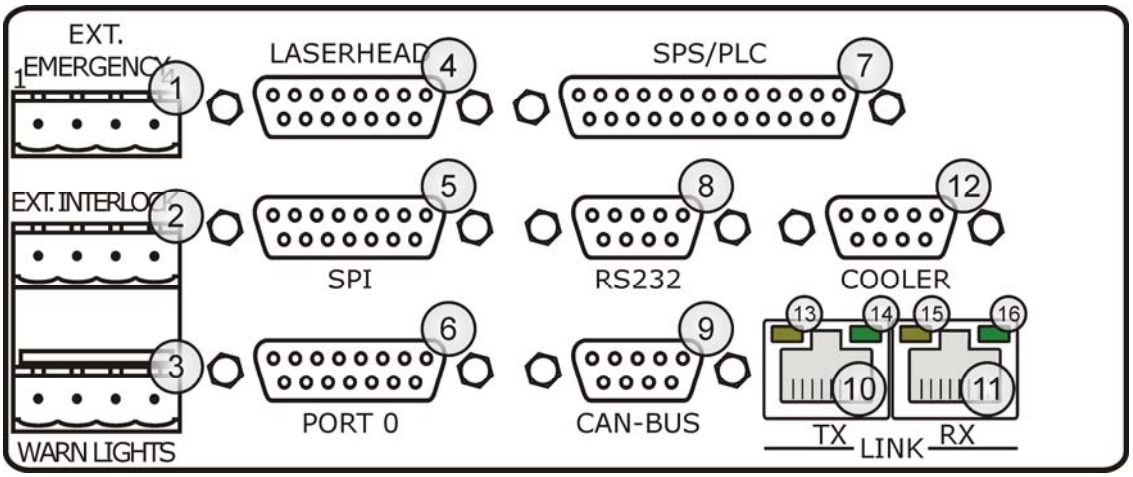


Pressing the “Back” key temporarily takes the user back to the previous display. If the user takes no further action (key press, wheel rotation) then the display reverts to the error message after a short period (ca. 30s).

All errors are cleared with the key “Laser Off / Error Clear” (11). If there are no (further) errors, the amplifier will be restarted and the display reverts to its former status. In every situation of this type, the laser current is only reactivated after being explicitly enabled.

5 Interfaces

The rear of the device accommodates the connectors for power, laser and water (if applicable), and the central interface panel:



1 Emergency off external* (page 22)

2 Interlock external (page 22)

3 Laser warning light (page 23)

4 Laser head interface*, for example fiber monitoring, camera voltage, interlock (page 23)

5 Extension bus for medium speed add-on components such as the AMTRON remote terminal RT400 (page 24)

6 Basic analog/digital interface, for example gate, analog definition (page 25)

7 PLC interface *, for example switching input, status output (page 26))

8 Serial RS232 interface for slow device communication (page 27)

9 CAN bus for fast process communication (page 28)

High-speed Ethernet bus for real-time capable add-on components, such as AMTRON Pyrometer series SE200 or AMTRON Power Units series PU400 (page 28):

10 Bus transmit line (Tx) with ring configurations or send/receive line (Tx/Rx) with single-cable configurations

11 Bus receive line (Rx) with single-cable configuration

12 Cooler interface for direct connection of the system cooler, for example with temperature or flow interlock (page 29)

13 "Controller active" display

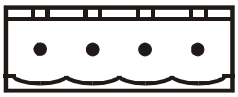
14 "Link communication active" display

15 "Link receiver active" display

16 "Link sender active" display

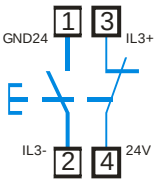
The interfaces of the CS400 will be described in detail in the following chapters.

* on devices with extended interface



Emergency-off external*

The “Emergency-off external” interface allows an external device to supply an emergency-off signal. The contacts IL3+ and IL3- satisfy the legal requirements for the redundant layout of the breaker and maker circuit.
The emergency-off is triggered if:



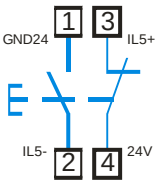
- the break circuit is broken
or - the make circuit is closed.

In normal operation, the terminals 3 and 4 should be closed, whereas in case of an error, the terminals 1 and 2 should be closed.

In the case of an emergency-off, the CS400 immediately cuts the power to its amplifiers and an error message that must be cleared is sent to all interfaces.

Interlock external

Like the Emergency-off input, the Interlock input has a redundant layout with four contacts: Two each for the break circuit and two for the make circuit.
The interlock is triggered if:



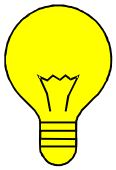
- the break circuit (closed current) is broken
or - the make circuit is closed.

In normal operation, the terminals 3 and 4 should be closed, whereas in the case of an interlock, the terminals 1 and 2 should be closed.

In the case of an interlock, the CS400 immediately switches its amplifiers off and sends an interlock warning message to all interfaces.
If an interlock occurs during a “laser enabled” phase, the power supply to the amplifiers is cut and an error message that must be cleared will be generated.

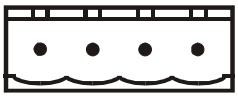
Tip

With the maker / breaker contacts in use, the CS400 can monitor the plausibility of the interlock- and emergency-off contacts. Future firmware versions will be able to issue a warning or error message. Use a maker / breaker combination wherever possible.

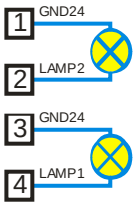


Breaker	Maker	Interlock / emergency stop	Error
closed	open	No	No
open	closed	Yes	No
open	open	Yes	Yes
closed	closed	Yes	Yes

* on devices with extended interface



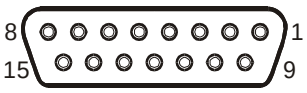
Warning lights



The CS400 can be fitted with two 24V-warning lights that illuminate when the current to the laser is enabled. Terminals 1 and 2 are assigned to warning light 1 and terminals 3 and 2 to warning light 2. The maximum overall load capacity is 10W.

Tip

The CS400 can monitor the function of the laser warning lights when switched on. A configuration register allows you to set up different reactions according to the failure of one or both lights.



Laser head (DSub 15)*

The laser-head connector provides signals directly relevant to outcouplers for fiber optics.
All input and output signals can be freely configured, except for the interlock.
Depending on the device type and customized models, where applicable, some of the signals may be different from one another.

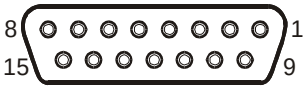
Pin	Signal name	Type	Meaning	Remarks
1	Temp-	Input	Laser head temperature measurement, PT-100	Related to pin 11
9	12V	Output	Supply voltage	Load capacity: max. 250mA
2	Pilot1+	Output	Pilot laser control, 5V	Switchable, Load capacity: max. 200mA
10	GND24	GND	Reference ground	Optional control signal for pilot laser intensity
3	DIn2	Input	Unplugged fibre detection, 24V	Configurable, related to GND24
11	Temp+	Input	Laser head temperature measurement, PT-100	Related to pin 1
4	Power	Input	Laser head power measurement	Configurable, depending on model 0-200mV or 0-5V
12	AGND			
5	Fiber	Input	Fiber monitoring 50Ω-10kΩ	Configurable
13	AGND			
6	Humid		Humidity monitoring, 0-5V	Configurable
14	ILH+	Input	Interlock breaker	Functions as IL5+
7	24V	Output	Supply voltage	
15	ILH-	Input	Interlock maker	Functions as IL5-
8	GND24	GND-24V	GND to 5V,12V,24V signals	

* on devices with extended interface

Notice

If you operate your CS400 with an extended interface but without a laser-head interlock connected, be sure to bridge the interface between pins 14 and 7.

SPI (DSub 15)



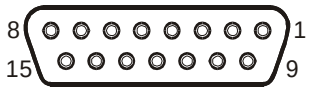
Extension bus for medium-speed AMTRON add-on components. For example, the AMTRON Remote Terminal RT400 for remote control can be connected using “Plug’n’Play”. The removal of components during operation will always cause an error that has to be cleared. Detailed descriptions are available in the relevant operating manuals.
For devices not fitted with an emergency-stop function (no control unit or extended interface), the pins 1 and 9 must be externally bridged if the SPI port remains unused.
Not suitable for use of external signals.

Pin	Signal name	Type	Meaning	Remarks
1	24V	Output	Supply voltage	
9	IL3 +	Input	Emergency-stop breaker	Possible bridge to pin 1 (see text)
2	GND24	GND-24V	GND to 24V signals	
10	IL3 -	Input	Emergency-stop maker	
3	DataIn+	Input	Data bus	
11	DataIn-			
4	DataOut+	Output	Data bus	
12	DataOut-			
5	Load+	Output	Data bus	
13	Load-			
6	Clock+	Output	Data bus	
13	Clock-			
7	Trigger+	Output	Trigger, 5V	Reserved
15	Trigger-			
8	5V	Output	Supply voltage	

Notice

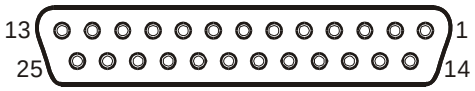
If you operate your CS400 without extension components connected to the SPI plug, be sure to bridge the interface between pins 1 and 9.

Port 0 (DSub 15)



Port 0 is the basic I/O interface for simple operation and control functions.
The analog input AIn0 is particularly suitable for the simple definition of current, power or process temperature (in combination with the AMTRON Pyrometer SE242). The gate enables very fast current switching with a reaction time of <30µs.
For current to flow, it must first be enabled via the control panel, RS232, CAN bus or PLC interface.

Pin	Signal name	Type	Meaning	Remarks
1	AIn0	Input	Analog input, 0-5V max. sampling rate: 1kHz	For example, for analog setting of power or current
9	AGND			
2	AOut0	Output	Analog output, 0-5V	Reserved
10	GND24			
3	Trigger out	Output	Trigger output 5V	Supplies a signal depending on a generated current pulse
11	GND24			
4	PWMIn+	Input	PWM input, 5-24V, Range: 500kHz-1MHz	Reserved
12	PWMIn-			
5	Gate+	Input	Laser triggering / Laser gate, 5-24V	Variable high-tension level
13	Gate -			
6	DOut1	Output	Signal output, 24V	For any use
14	GND24			
7	DOut2		Signal output, 24V	For any use
15	Pilot0	Output	Signal output 5V	reserved, Load capacity: max. 250mA
8	GND			



PLC (DSub 25)*

The PLC interface unites all of the signal wires that are required for remote operation without the RS232/CAN protocol or the control unit.
The input signals help with the realization of laser-enable, gate, definition, and error clear. The output signals include all status information such as “laser enabled”, “error” or “standby” and also a current monitor.
Depending on the device type and customized models, where applicable, some of the outputs may be different from one another.
The inputs Gate and Ain1 at the PLC port have the same function as Gate+/- and Ain0 at Port0. The port to be used is defined in the configuration registers. For fast processing (<20ms) the gate input at Port0 is preferable.

Standard model:

Pin	Signal name	Type	Meaning	Remarks
1	AIn1	Input	Analog input, 0-10V max. sampling rate: 10kHz	For example, for analog setting of power or current
14	AGND			
2	LasEnIn+	Input	Enable laser current, 24V	Edge controlled, floating output
15	LasEnIn-			
3	ErrClr+	Input	Clear error messages, 24V	Edge controlled, floating output
16	ErrClr-			
4		Output		Reserved
17	Error	Output	Collective error message for all errors, 24V	
5		Output		Reserved
18	LasEnOut	Output	Laser current is enabled, 24V	
6		Output		Reserved
19	Remote	Output	Control via interfaces is enabled, 24V	
7	IMon	Output	Current monitor, 0-10V max. resolution: 1ms	For devices manufactured in 2004
20	AGND			
8	Gate	Input	Laser current gate, 24V Reaction time <10ms	Edge controlled
21		Output		Reserved
9	Ready	Output	System is ready to enable laser current, 24V	“Laser enable” is not possible without Ready
22		Input		Reserved
10	DOut1	Output	Signal output, 24V	For any use, “collective warning” function is configurable
23	GND24	GND	Signal ground	
11	DOut2	Output	Signal output, 24V	For any use, “shutter opened” function is configurable
24	GND24	GND	Signal ground	
12	AIn2	Input	Analog input, 0-5V	Reserved
25	AGND			
13	24V	Output	Supply voltage	

* on devices with extended interface

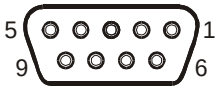
The device CS404P has a slightly different interface configuration as it provides a TTL trigger signal

Pin	Signal name	Type	Meaning	Remarks
6	5V	Output	Trigger output pulse end	For example, for Pockels cell
19	TriggerOut			

Upon request we can implement the three outputs “Error”, “Laser enabled” and “Remote” as floating outputs. In this case, each must be externally supplied with the positive reference voltage.

Pin	Signal name	Type	Meaning	Remarks
4	Ref-Error	Input	Collective error message for all errors, max. 24V	
17	Error	Output		
5	Ref-LasEnOut	Input	Laser current is enabled, max. 24V	
18	LasEnOut	Output		
6	Ref-Remote	Input	Control via interfaces is enabled, max. 24V	
19	Remote	Output		

RS232 (DSub 9)



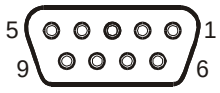
The serial interface (RS232) is for device configuration, service, or slow control functions.
Its parameters are: 19,200 baud, 8 data bits, no parity, 1 stop bit (8N1),
no flow control (XON/XOFF and RTS/CTS deactivated).

Pin	Signal name	Type	Meaning	Remarks
1				
6	DSR	Output	RS232 Data Set Ready	Handshake, reserved
2	Tx	Output	RS232 transmit line	Connection to PC port pin 2
7	RTS	Input	RS232 Request to Send	Handshake, reserved
3	Rx	Input	RS232 receive line	Connection to PC port pin 3
8	CTS	Output	RS232 Clear to Send	Handshake, reserved
4	DTR	Input	RS232 Data Terminal Ready	Handshake, reserved
9	RI	Input	RS232 Ring Indicator	Reserved
5	GND	GND	GND	Connection to PC port pin 5

Tip

The CS400 is configured as *Data Communication Equipment* (DCE), i.e. it can be connected to a PC (*Data Terminal Equipment*, DTE) with a normal 1:1 cable. If communication to different DCE is required, e.g. a PDA, then a *null-modem cable* will be required, whereby the wires 2 and 3 are swapped.

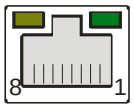
CAN-Bus (DSub 9)



The CAN interface is ideally suited to fast process data communication via CANopen. The transfer rate can be configured in steps up to a maximum of 1Mbps (factory: 500 kbps). The Device ID can also be configured in the range 1-127 (factory: 15). The CS400 does not have an internal terminator.

Pin	Signal name	Type	Meaning	Remarks
1				
6	GND	GND	GND	
2	CanL	Bus	CAN bus low signal line:	No terminator
7	CanH	Bus	CAN bus high signal line	No terminator
3	GND	GND	GND	
8				
4				
9				
5				

Link (2x RJ45)



High-speed bus with 100Mbps transfer rates for connecting fast extension units such as the AMTRON Pyrometer/Laser-head Interface SE242. Detailed descriptions are available in the relevant operating manuals.
Not suitable for using external signals.

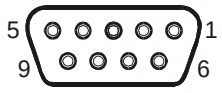
Link Tx

Pin	Signal name	Type	Meaning	Remarks
1	Tx+	Output	Transmit line	
2	Tx -			
3	Rx+_2	Input	Receive line	With single-cable configuration only
6	Rx-_2			
4	IL1+_OUT	Output	Interlock breaker	Input with single-cable configuration
5	IL1-_OUT	Output	Interlock maker	Input with single-cable configuration
7	24V	Output	Supply voltage	
8	GND24	GND-24V	GND to 24V signals	
	Shield	Shield	Housing ground	

Link Rx

Pin	Signal name	Type	Meaning	Remarks
1	Rx+	Input	Receive line	
2	Rx -			
3	Rx+_2	Output	Transmit line	For connection with pin 1/2
6	Rx-_2			
4	IL1+_IN	Input	Interlock breaker	
5	IL1-_IN	Input	Interlock maker	
7	24V	Output	Supply voltage	
8	GND24	GND-24V	GND to 24V signals	
	Shield	Shield	Housing ground	

Cooler (DSub 9)



The cooler connector enables the direct connection to a water cooler.
The coolers common to most systems offer flow and temperature monitoring signals as a safety feature. As a cooling failure can quickly lead to the destruction of the laser diodes, the CS400 only allows the activation of the laser power if the maker contacts on the nTempOK and nFlowOK inputs are confirmed against GND24.

Where a water-cooled CS400 is within the laser cooling circulation, low coolant temperatures within the device can lead to condensation problems. Optionally, the TempOut output can be used to control the water flow through the CS400 in relation to the surrounding temperature to ensure that a minimum temperature is not exceeded.

Pin	Signal name	Type	Meaning	Remarks
1	GND24	GND-24V	GND to 24V signals	
6	CoolIn1	Input	24V input	Reserved
2	nTempOK	Input	Temperature interlock	OK on contact to GND24
7	CoolIn2	Input	24V input	Reserved
3	GND24	GND-24V	GND to 24V signals	
8	TempOut	Output	24V switching signal for CS400 water flow	Supplies a temperature-dependent switching signal
4	nFlowOK	Input	Flow interlock	OK on contact to GND24
9	CoolerOn	Output	Cooler remote start signal 24V	Optionally switchable
5	GND24	GND-24V	GND to 24V signals	

Notice

If you operate your CS400 without water-cooling or without temperature/flow monitoring, be sure to bridge the cooler interface between pins 2 and 3 and between pins 4 and 5.

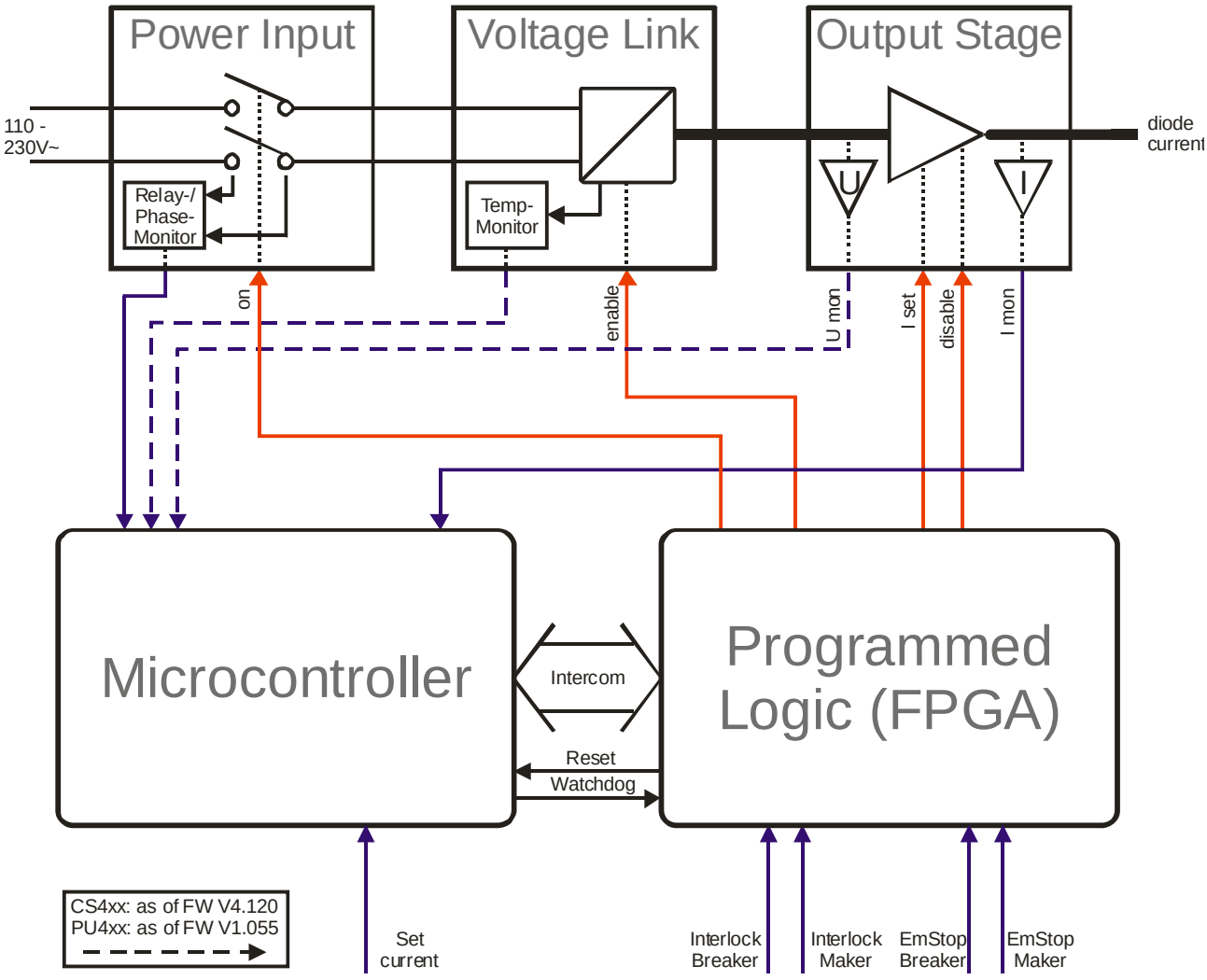
Tip

Many coolers can be remotely activated via 24V signal. If you are using the 24V output (pin 9) of the cooler connector to this end, then the cooler will automatically start after switching the CS400 on. You can use the configuration to define the time required for your cooler to reach its operating temperature and flow. Only after this time period has been exceeded will an error message be generated (and the laser power cannot be activated).

6 Safety

The power for the CS400 flows via the components of the power input, the intermediate circuit, and the power amplifier. These three components are directly regulated by a programmed logical device (FPGA). A microcontroller equipped with non-volatile memory contains the algorithms which handle the monitoring and regulation in communication with the FPGA over a bus interface. This bus communication itself is protected by a watchdog which immediately initiates a system re-start in the event that accessing is missed for a cycle.

As a safety feature, the inputs “Interlock external”, “Emergency stop”, and the interlock of the high-speed bus “Link 1” are directly connected to the FPGA.
In case of an “Interlock external”, the FPGA deactivates the power amplifier and the intermediate circuit independent of the microcontroller. In the event of an emergency stop (emergency-stop button or “emergency stop external”), the FPGA is additionally cut off from the power input.



The microcontroller permanently monitors all states of the power flow. The entire unit is deactivated upon recognition of an error state.

Example:
Monitoring the output current of the power amplifier.

- The setting for nominal current may not be exceeded by >3A for more than 2s.
- The setting for limiting current may not be exceeded by >3A for more than 10ms.
- The setting for null/bias current may not be exceeded by >3A for more than 500ms.
- In the “laser disabled” state, a current flow of >2A may not exceed 50ms.

7 History

Version	Date	Change
4.09	25.10.2006	Adaptations according to new/changed registers in firmware v4.104
		Removal of description of Port 1
		Revision of terminal pin assignments of Laser head, Port 0 und Cooler-connectors
		Extension of Bit descriptions of error registers (appendix)
5.10	30.08.2007	Adaptation for G5 hardware/firmware

8 Appendix

Register list

Register list status: Firmware version 5.044.

Please note:
This list can contain registers and functions that may differ from those in your firmware version.
Please contact us per e-mail for a table that conforms to your firmware version.

1. Overview

RS232 index	CAN index	Name	function
0xx	0x2000	Main	main registers with superordinated functions
1xx	0x2100	Profile	sampling points for profile mode
2xx	0x2200	Control	parameters, limits and operating modes of the power control system
5xx	0x2500	Laser	laser's measure and calibration values
6xx	0x2600	Interface	interface configurations and states
7xx	0x2700	Cooler	Cooler Controller specific registers (e.g. with cooler controller CM102/CM112)
Axx	0x2A00	Power A	Power Unit A (internal or external)
Bxx	0x2B00	Power B	Power Unit B (external, e.g. with power unit PU400)
Cxx	0x2C00	Power C	Power Unit B (external, e.g. with power unit PU400)
Dxx	0x2D00	Power D	Power Unit B (external, e.g. with power unit PU400)

All registers can be addressed via CAN bus with CAN-Subindex=xx.
Example: RS232 index 612 can be accessed per CAN index 0x2600, subindex 0x12.

Registers that can be addressed per CAN PDO are indicated in the “PDO” column.
In the “access” column, the access rights for each register are defined:
R1 – read-only access
RW1 – read and write access
RW2 – read access, write access in OEM mode only

2. Main

register	name	description	unit	access	PDO	view mode	min	max	default	remark
001	ERR0	errors group 0	1	R1	x	hexadecimal	0	0xffff	0	errors in group 0 (e.g. timeout, ...)
002	RES01	reserved 01	1	R1		not displayed	0	0	0	not defined yet
003	WRN0	warnings group 0	1	R1	x	hexadecimal	0	0xffff	0	warnings in group 0 (e.g. startup delay, ...)
004	RES02	reserved 03	1	R1		not displayed	0	0	0	not defined yet
005	MCNF1	main conf	1	RW1		hexadecimal	0	0x8001	0	Bit 0 (0x0001): automatically go to 'power on' on power up Bit 1 (0x0002): device fans/water flow always on (rather than temperature controlled) Bit 2 (0x0004): laser on timeout does not issue an error Bit 15 (0x8000): enable RS232 debug prints (only for temporary usage!)
006	MCNF2	main conf OEM	1	RW2		hexadecimal	0	0x0000	0	not defined yet
007	FVER	firmware version	0,001	R1	x	unsigned integer	0	65535	-	Firmware version
008	SERHI	serial number high	1	R1	x	unsigned integer	0	9999	1234	upper 4 digits of device serial number
009	SERLO	serial number low	1	R1	x	unsigned integer	0	9999	5678	lower 4 digits of device serial number
00a	OMODE	operational mode	1	RW1		unsigned integer	0	4	0	0-CW (gateless) mode 1-CW (gated) mode 2-pulse trigger mode 3-pulse timer mode 4-gated pulse timer mode
00b	GATE	gate	1	RW1	x	hexadecimal	0	0xffff	0	laser on if magic number (0x8B6C) is in register
00c	SMODE	source mode	1	RW1		unsigned integer	0	1	0	0=digital input (via register access) 1=analog input (via analog ports)
00d	CMD	command	1	RW1		unsigned integer	0	24	0	0-Command ready (automatically set after execution) 1-clear errors 2-power off, 3-power on/laser disabled 4-laser enabled 7-save all parameters (according to access level) 10- restore all parameters (according to access level) 13-factory default all parameters (according to access level) 14-upload new F/W (act. only via RS232) 18-set new CAN ID via DATA1(new ID), DATA2 (serial number low word SERLO) 22-write parameter via DATA1,DATA2 23-read parameter via DATA1,DATA2 24-save external parameters via DATA1,DATA2

register	name	description	unit	access	PDO	view mode	min	max	default	remark
00e	DEVSTATE	device state	1	R1	x	hexadecimal	0	0xffff	0	bit 0 (0x0001): READY bit 1 (0x0002): LASER ENABLED bit 2 (0x0004): GATE ON bit 3 (0x0008): WARN LIGHTS ON bit 4 (0x0010): WARNING PRESENT bit 5 (0x0020): ERROR PRESENT bit 6 (0x0040): INTERLOCK ON bit 7 (0x0080): ON (not in Stand by) bit 8 (0x0100): REMOTE MODE bit 9 (0x0200): SHUTTER OPEN bit 12 (0x1000): BIAS MODE bit 15 (0x8000): COMMAND IS BEING PROCESSED (BUSY)
00f	RES05	reserved 05	1	R1		not displayed	0	0	0	not defined yet
010	DATA1	data 1	1	RW1		hexadecimal	0	0xffff	0	access to extended registers and special functions
011	DATA2	data 2	1	RW1		hexadecimal	0	0xffff	0	access to extended registers and special functions
012	ERRT	errors total	1	R1	x	hexadecimal	0	0xffff	0	all errors over groups 0-D
013	WRNT	warnings total	1	R1	x	hexadecimal	0	0xffff	0	all warnings over groups 0-D
014	TIMEOUT	timeout laser on	0,1s	RW1		unsigned integer	0	3000	0	retrigger via gate pin or laser on command
015	TSTART		1s	RW2		unsigned integer	0	300	0	delay to startup
016	TNOERR	startup error delay	1s	RW2		unsigned integer	0	300	0	delay to external error handling (only cooler flow/temp)
017	CANID	CAN device ID	1	RW1		unsigned integer	1	127	15	unique CAN device ID
018	CANBD	CAN baud rate	1	RW1		unsigned integer	0	7	2	0 = 1Mbit/s, 1 = 800kBit/s, 2 = 500kBit/s, 3 = 250kBit/s, 4 = 125kBit/s, 5 = 100kBit/s, 6 = 50kBit/s, 7 = 20kBit/s
019	RES06	reserved 06	1	R1		not displayed	0	0	0	not defined yet
01a	TIOPR	operation time	1h	RW2		unsigned integer	0	32767	0	operation timer, internally in 1 min. steps

3. Profile

register	name	description	unit	access	PDO	view mode	min	max	default	remark
101	PMODE	profile mode	1	RW1		unsigned integer	0	2	0	0-no profile (profile mode off) 1-single profile (profile is driven only one time after Gate is issued) 2-multi profile (profile is repeated automatically)
102	PR0A	point 0 amplitude	0,1%	RW1		unsigned integer	0	1000	0	relative amplitude, 100%=maximum
103	PR01T	point 0 to point 1 time	1ms	RW1		integer	0	10000	0	time between two profile points
104	PR1A	point 1 amplitude	0,1%	RW1		unsigned integer	0	1000	0	relative amplitude, 100%=maximum
105	PR12T	point 1 to point 2 time	1ms	RW1		integer	0	10000	0	time between two profile points
106	PR2A	point 2 amplitude	0,1%	RW1		unsigned integer	0	1000	0	relative amplitude, 100%=maximum
107	PR23T	point 2 to point 3 time	1ms	RW1		integer	0	10000	0	time between two profile points
108	PR3A	point 3 amplitude	0,1%	RW1		unsigned integer	0	1000	0	relative amplitude, 100%=maximum
109	PR34T	point 3 to point 4 time	1ms	RW1		integer	0	10000	0	time between two profile points
10a	PR4A	point 4 amplitude	0,1%	RW1		unsigned integer	0	1000	0	relative amplitude, 100%=maximum
10b	PR45T	point 4 to point 5 time	1ms	RW1		integer	0	10000	0	time between two profile points
10c	PR5A	point 5 amplitude	0,1%	RW1		unsigned integer	0	1000	0	relative amplitude, 100%=maximum
10d	PR5T	point 5 to point 6 time	1ms	RW1		integer	0	10000	0	time between two profile points
10e	PR6A	point 6 amplitude	0,1%	RW1		unsigned integer	0	1000	0	relative amplitude, 100%=maximum
10f	PR67T	point 6 to point 7 time	1ms	RW1		integer	0	10000	0	time between two profile points
110	PR7A	point 7 amplitude	0,1%	RW1		unsigned integer	0	1000	0	relative amplitude, 100%=maximum
111	PR70T	point 7 to point 0 time	1ms	RW1		integer	0	10000	0	time between two profile points

In timer modes (OMODE=3 or OMODE=4), time interval values between two profile points reflect the timer pulse period, rather than milli-seconds.

4. Control

register	name	description	Unit	access	PDO	view mode	min	max	default	remark
201	RES21	reserved 21	1	R1		not displayed	0	0	0	not defined yet
202	RES22	reserved 22	1	R1		not displayed	0	0	0	not defined yet
203	RES23	reserved 23	1	R1		not displayed	0	0	0	not defined yet
204	RMODE	control mode	1	RW1		unsigned integer	1	4	1	0=not defined yet 1=current control 2=power control 3=power regulation 4=temperature regulation
205	ISETT	set current total	0,1A	RW1	x	unsigned integer	0	3200	10	total current over all power units (apportionment to each unit is calculated via power factor)
206	IACTT	act current total	0,1A	R1	x	unsigned integer	0	3200	0	total actual current
207	PSETT	set power total	0,1W	RW1	x	unsigned integer	0	40000	0	total power over all power units (apportionment to each unit is calculated via power factor)
208	PACTTM	act meas power total	0,1W	R1	x	unsigned integer	0	40000	0	total actual power (measured via power meter)
209	RES24	reserved 24	1	R1		not displayed	0	0	0	not defined yet
20a	PACTTC	act calc power total	0,1W	R1	x	unsigned integer	0	40000	0	total actual power (calculated via current)
20b	RES25	reserved 25	1	R1		not displayed	0	0	0	not defined yet
20c	TSET	set temperature	1C	RW1	x	unsigned integer	0	2000	200	set temperature
20d	TACT	act temperature	1C	R1	x	unsigned integer	0	2000	0	actual measured temperature
20e	RES26	reserved 26	1	R1		not displayed	0	0	0	not defined yet
20f	PMAXT	max power total	0,1W	RW2		unsigned integer	0	40000	1000	maximum power
210	PMAXTA	max power total avg	0,1W	RW2		not displayed	0	40000	1000	maximum mean power (for pulse applications, not yet implemented!)
214	RIMAX	reglt max current	0,1A	RW1		unsigned integer	0	3200	3200	upper margin for control
215	RIMIN	reglt min current	0,1A	RW1		unsigned integer	0	3200	0	lower margin for control
216	RP	reglt P-term	1	RW1		unsigned integer	0	65535	100	P-term for PID-control
217	RI	reglt I-term	1	RW1		unsigned integer	0	65535	100	I-term for PID-control
218	RD	reglt D-term	1	RW1		unsigned integer	0	65535	0	D-term for PID-control
21a	TPDUR	pulse duration	1us	RW1		unsigned integer	10	65000	250	timer pulse duration, min. 100µs on external power units
21b	TPPSE	pulse pause	1us	RW1		unsigned integer	0	65000	750	timer pulse pause, min. 100µs on external power units
21c	PCORRA	power correct analog	0,1%	RW2		unsigned integer	0	2000	1000	correction factor for analog input
21d	MAXDUTY	max pulse duty cycle	0,1%	RW2		unsigned integer	10	950	500	maximum duty cycle in pulse modes (trigger, timer)
21e	TPCOPSE	Pulse pause coarse	0,01s	RW1		unsigned integer	0	12000	0	timer pulse pause coarse value

register	name	description	Unit	access	PDO	view mode	min	max	default	remark
21f	PCNT	pulses counted	1	R1	x	unsigned integer	0	65535	0	pulse counter (with overflow), resetted with laser enable
220	MINDUTY	Min pulse duty cycle	0,1%	RW1		unsigned integer	0	950	1	Minimum duty cycle in pulse modes (trigger, timer)

5. Laser

register	name	description	Unit	access	PDO	view mode	min	max	default	remark
501	ERR5	errors group 5	1	R1	x	hexadecimal	0	0xffff	0	errors in group 5
502	RES51	reserved 51	1	R1		not displayed	0	0	0	not defined yet
503	WRN5	warnings group 5	1	R1	x	hexadecimal	0	0xffff	0	warnings in group 5
504	RES52	reserved 52	1	R1		not displayed	0	0	0	not defined yet
505	LCNF1	laser config	1	RW1		hexadecimal	0	0xffff	0	Bit 11 (0x0800): enable laser power monitoring
506	LCNF2	laser config OEM	1	RW2		hexadecimal	0	0xffff	0	Bit 0 (0x0001): enable fiber monitoring Bit 1 (0x0002): enable humidity monitoring Bit 2 (0x0004): enable fiber plug monitoring Bit 3 (0x0008): enable shutter control Bit 4 (0x0010): enable shutter monitoring Bit 8 (0x0100): enable laser service timer Bit 9 (0x0200): enable laser TEC control Bit 10 (0x0400): enable laser temperature monitoring Bit 15 (0x8000): force presence of laser head interface/contrl.
507	HSERHI	laser ser num high	1	RW2		unsigned integer	0	65535	0	high word for laser serial number
508	HSERLO	laser ser num low	1	RW2		unsigned integer	0	65535	0	low word for laser serial number
509	TILON	laser on time	1h	RW2		unsigned integer	0	32767	0	see TIOPR
50a	TILONSW	laser serv interval	1h	RW2		unsigned integer	0	32767	0	see TIOPRSW, counts down
50b	TLSET	set laser temp	0,1C	RW2		unsigned integer	100	400	220	set temperature for laser
50c	TLACT	act laser temp	0,1C	R1	x	unsigned integer	0	500	0	actual laser temperature
50d	PLACT	act laser power	0,1W	R1	x	unsigned integer	0	40000	0	actual laser monitor power
50e	FIBACT	act fiber value	1	R1	x	unsigned integer	0	65535	0	actual fiber monitoring value
50f	HUMACT	act head humidity	0,1%	R1	x	unsigned integer	0	1000	0	actual laser head humidity
510	TLUDW	maxdev laser temp wn	0,1C	RW2		unsigned integer	0	200	15	maximum laser temp deviation before warning
511	TLUDE	maxdev laser temp er	0,1C	RW2		unsigned integer	0	200	40	maximum laser temp deviation before error
512	FIBUE	max fiber value	1	RW2		unsigned integer	0	65535	5600	maximum fiber value
513	FIBLE	min fiber value	1	RW2		unsigned integer	0	65535	180	minimum fiber value
514	HUMUW	max head humidity wn	0,1%	RW2		unsigned integer	0	1000	400	maximum laser humidity before warning
515	HUMUE	max head humidity er	0,1%	RW2		unsigned integer	0	1000	450	maximum laser humidity before error
516	PLUDW	Maxdev laser pwr wn	0,1W	RW2		unsigned integer	0	32000	30	maximum laser power before warning
517	PLUDE	Maxdev laser pwr er	0,1W	RW2		unsigned integer	0	32000	50	maximum laser power before error
518	PPUDW	Maxdev process pwr wn	0,1W	RW2		unsigned integer	0	32000	30	maximum process power before warning
519	PPUDE	Maxdev process pwr er	0,1W	RW2		unsigned integer	0	32000	50	maximum process power before error

6. Interface

register	name	description	unit	access	PDO	view mode	min	max	default	remark
601	ERR6	errors group 6	1	R1	x	hexadecimal	0	0xffff	0	errors in group 6
602	RES61	reserved 61	1	R1		not displayed	0	0	0	not defined yet
603	WRN6	warnings group 6	1	R1	x	hexadecimal	0	0xffff	0	warnings in group 6
604	RES62	reserved 62	1	R1		not displayed	0	0	0	not defined yet
605	ICNF1	I/O config	1	RW1		hexadecimal	0	0xffff	6	bit 0 (0x0001): warning lights follow gate signal in gated mode bit 1 (0x0002): enable warn lights monitoring with warning bit 2 (0x0004): enable warn lights monitoring with error bit 4 (0x0010): trigger on negative edge of gate signal in trigger mode bit 5 (0x0020): pilot laser only on during laser disabled state
606	ICNF2	I/O config OEM	1	RW2		hexadecimal	0	0xffff	0	bit 0 (0x0001): lock warn lights configuration in ICNF1 bit 1 (0x0002): use SPS/PLC port DOUT1 as warning output bit 2 (0x0004): use SPS/PLC port DOUT2 as shutter opened output signal bit 3 (0x0010): SPS/PLC gate port is shutter input bit 5 (0x0020): gate via SPS/PLC port instead of Port0 bit 6 (0x0040): analog control via SPS/PLC port instead of Port0 bit 12 (0x1000): cooler temp interlock issues always an error bit 13 (0x2000): cooler flow interlock issues always an error
607	IOSTAT	I/O state	1	R1	x	hexadecimal	0	0xffff	0	not defined yet
608	RES63	reserved 63	1	R1		not displayed	0	0	0	not defined yet
609	IDIN1	I/O digital in	1	R1	x	hexadecimal	0	0xffff	0	not defined yet
60a	IDOUT1	I/O digital out	1	RW1	x	hexadecimal	0	0xffff	0	bit 0 (0x0001): Port 0 Dout1 bit 1 (0x0002): Port 0 Dout2 bit 2 (0x0004): SPS Dout1 (only can be set/reset, if ICNF2, Bit1 isn't set) bit 3 (0x0008): SPS Dout2 bit 4 (0x0010): Pilot laser (can be influenced by display pilot laser setting)
60b	PILOTI	Pilot beam intensity	1	RW1		unsigned integer	1	10	1	intensity of the pilot laser beam, if applicable
60c	PWMA	PWMin offset	1	RW2		signed integer	-10000	10000	0	PWM Input
60d	PWMB	PWMin slope	1	RW2		unsigned integer	0	8000	1000	PWM Input
60e	AIN0A	Ain 0 offset	1	RW2		signed integer	-10	10	-5	analog control, Port 0
60f	AIN0B	Ain 0 slope	1	RW2		unsigned integer	0	1000	407	analog control, Port 0
610	AIN1A	SPS/PLC Iset offset	1	RW2		signed integer	-10	10	0	analog control, SPS Port
611	AIN1B	SPS/PLC Iset slope	1	RW2		unsigned integer	0	1000	241	analog control, SPS Port

register	name	description	unit	access	PDO	view mode	min	max	default	remark
612	RES65	reserved 65	1	R1		not displayed	-10000	10000	0	not defined yet
613	RES66	reserved 66	1	R1		not displayed	0	2000	1000	not defined yet
614	HUMINA	humid sensor offset	1	RW2		signed integer	-10000	10000	-170	Laser head Humidity
615	HUMINB	humid sensor slope	1	RW2		unsigned integer	0	2000	1000	Laser head Humidity
616	FIBINA	fiber sensor offset	1	RW2		signed integer	-10000	10000	-516	Laser head Fiber
617	FIBINB	fiber sensor slope	1	RW2		unsigned integer	0	8000	4548	Laser head Fiber
618	POWINA	power sensor offset	1	RW2		signed integer	-4000	500	0	Laser head Power meter
619	POWINB	power sensor slope	1	RW2		signed integer	-8000	8000	4096	Laser head Power meter
61a	TEMPINA	temp sensor offset	1	RW2		signed integer	-500	500	0	Laser head PT-100 input (not on all hardware designs)
61b	TEMPINB	temp sensor slope	1	RW2		unsigned integer	0	8000	437	Laser head PT-100 input (not on all hardware designs)
61c	RES67	reserved 67	1	R1		not displayed	0	0	0	not defined yet
61d	RES68	reserved 68	1	R1		not displayed	0	0	0	not defined yet
622	AOUT2A	SPS/PLC Imon offset	1	RW2		signed integer	-100	100	0	SPS Port current monitor, resolution: 1ms
623	AOUT2B	SPS/PLC Imon slope	1	RW2		unsigned integer	0	1000	235	SPS Port current monitor, resolution: 1ms

7. Cooler

register	name	description	unit	access	PDO	view mode	min	max	default	remark
701	ERR71	cooler errors 1	1	R1	x	hexadecimal	0	0xffff	0	errors 1 in group 7
702	ERR72	cooler errors 2	1	R1	x	hexadecimal	0	0xffff	0	errors 2 in group 7
703	WRN7	cooler warnings	1	R1	x	hexadecimal	0	0xffff	0	warnings in group 7
704	RES71	reserved 71	1	R1		not displayed	0	0	0	not defined yet
705	CCCNF1	cooler config	1	RW1		hexadecimal	0	0	0	not defined yet
706	CCCNF2	cooler config OEM	1	RW2		hexadecimal	0	0xffff	0	bit 15 (0x8000): force presence of cooler controller
707	CCCOND	water conductivity	0,1uS	R1	x	unsigned integer	0	1000	0	cooler water conductivity
708	CCFLOW	water flow	1l/h	R1	x	unsigned integer	0	3000	0	cooler water flow
709	CCPRESF	filter pressure	0,01bar	R1	x	unsigned integer	0	1000	0	cooler water filter pressure
70a	CCTEMP	water temperature	0,1C	R1	x	unsigned integer	0	2000	0	cooler water temperature
70b	CCCONDHW	max water cond wrn	0,1uS	RW2		unsigned integer	0	1000	50	maximum level for warning
70c	CCCONDHE	max water cond err	0,1uS	RW2		unsigned integer	0	1000	80	maximum level for error
70d	CCFLOWLW	min water flow wrn	1l/h	RW2		unsigned integer	0	3000	60	minimum level for warning
70e	CCFLOWLE	min water flow err	1l/h	RW2		unsigned integer	0	3000	50	minimum level for error
70f	CCFLOWHW	max water flow wrn	1l/h	RW2		unsigned integer	0	3000	3000	maximum level for warning
710	CCFLOWHE	max water flow err	1l/h	RW2		unsigned integer	0	3000	3000	maximum level for error
711	CCTEMPLW	min water temp wrn	0,1C	RW2		unsigned integer	0	2000	190	maximum level for warning
712	CCTEMPLE	min water temp err	0,1C	RW2		unsigned integer	0	2000	180	maximum level for error
713	CCTEMPHW	max water temp wrn	0,1C	RW2		unsigned integer	0	2000	260	maximum level for error
714	CCTEMPHE	max water temp err	0,1C	RW2		unsigned integer	0	2000	310	maximum level for error
715	CCTEMPSET	set water temp	0,1C	RW2		unsigned integer	0	2000	220	water temperature set value

8. Power unit 1

register	name	description	unit	access	PDO	view mode	min	max	default	remark
a01	PMODE	PU1 errors 1	1	R1	x	hexadecimal	0	0xffff	0	errors 1 in group A
a02	ERRA2	PU1 errors 2	1	R1	x	hexadecimal	0	0xffff	0	errors 2 in group A
a03	WRNA	PU1 warnings	1	R1	x	hexadecimal	0	0xffff	0	warnings in group A
a04	RESA2	reserved A2	1	R1		not displayed	0	0	0	not defined yet
a05	PUCNFA1	PU1 config	1	RW1		hexadecimal	0	0xffff	0	bit 0 (0x0001): activate connected powermeter
a06	PUCNFA2	PU1 config OEM	1	RW2		hexadecimal	0	0xffff	0	0-select current edge limitation automatically 1-4:select current edge limitation manually (1= weak, 4=strong) 8-current edge limitation off bit 15 (0x8000): force presence of external PU
a07	RESA3	reserved A3	1	R1		not displayed	0	0	0	not defined yet
a08	ISET1C	PU1 calculated set current	0,1A	R1	x	unsigned integer	0	2000	0	calculated current as result of any reference (digital, analog, current, power, etc.)
a09	IBIAS1	PU1 bias current	0,1A	RW1		unsigned integer	0	2000	0	bias current
a0a	IACT1	PU1 act current	0,1A	R1	x	unsigned integer	0	2000	0	actual output current
a0b	UACT1	PU1 act voltage	0,01V	R1	x	unsigned integer	0	10000	0	actual output voltage
a0c	PACT1	PU1 act power	0,1W	R1	x	unsigned integer	0	10000	0	actual output power based on current
a0d	PTOPT1	PU1 power factor	0,1%	RW1		unsigned integer	0	1000	1000	fraction of total power
a0e	IMAX1	PU1 max current	0,1A	RW2		unsigned integer	0	2000	1000	maximum current (for diode protection)
a0f	UMIN1	PU1 min voltage	0,01V	RW2		unsigned integer	0	10000	150	minimum voltage (for short circuit detection)
a10	UMAX1	PU1 max voltage	0,01V	RW2		unsigned integer	0	10000	400	maximum voltage (for open circuit detection)
a11	ILMAX1	PU1 max current lin	0,1A	RW2		unsigned integer	0	2000	800	for P/I calculation
a12	PLMAX1	PU1 max power lin	0,1W	RW2		unsigned integer	10	10000	1000	for P/I calculation
a13	ITHRES1	PU1 thres current	0,1A	RW2		unsigned integer	0	2000	150	laser threshold, for IBIASmax P/I calculation
a14	PTHRES1	PU1 thres power	0,1W	RW2		unsigned integer	0	50	0	below is I=0
a15	IMAX1EOL	PU1 max current EOL	0,1A	RW2		unsigned integer	0	2000	1000	maximum current at end of life (for diode degradation)
a16	IACTB1	PU1 act bias current	0,1A	RW1	x	unsigned integer	0	2000	0	actual output bias current (not on all hardware designs)

9. Power unit 2

register	name	description	unit	access	PDO	view mode	min	max	default	remark
b01	ERRB1	PU2 errors 1	1	R1	x	hexadecimal	0	0xffff	0	errors 1 in group B
b02	ERRB2	PU2 errors 2	1	R1	x	hexadecimal	0	0xffff	0	errors 2 in group B
b03	WRNB	PU2 warnings	1	R1	x	hexadecimal	0	0xffff	0	warnings in group B
b04	RESB2	reserved B2	1	R1		not displayed	0	0	0	not defined yet
b05	PUCNFB1	PU2 config	1	RW1		hexadecimal	0	0xffff	0	bit 0 (0x0001): activate connected power meter
b06	PUCNFB2	PU2 config OEM	1	RW2		hexadecimal	0	0xffff	0	0-select current edge limitation automatically 1-4:select current edge limitation manually (1= weak, 4=strong) 8-current edge limitation off bit 15 (0x8000): force presence of external PU
b07	RESB3	reserved B3	1	R1		not displayed	0	0	0	not defined yet
b08	ISET2C	PU2 calculated set current	0,1A	R1	x	unsigned integer	0	2000	0	calculated current as result of any reference (digital, analog, current, power, etc.)
b09	IBIAS2	PU2 bias current	0,1A	RW1		unsigned integer	0	2000	0	bias current
b0a	IACT2	PU2 act current	0,1A	R1	x	unsigned integer	0	2000	0	actual output current
b0b	UACT2	PU2 act voltage	0,01V	R1	x	unsigned integer	0	10000	0	actual output voltage
b0c	PACT2	PU2 act power	0,1W	R1	x	unsigned integer	0	10000	0	actual output power based on current
b0d	PTOPT2	PU2 power factor	0,1%	RW1		unsigned integer	0	1000	1000	fraction of total power
b0e	IMAX2	PU2 max current	0,1A	RW2		unsigned integer	0	2000	1000	maximum current (for diode protection)
b0f	UMIN2	PU2 min voltage	0,01V	RW2		unsigned integer	0	10000	150	minimum voltage (for short circuit detection)
b10	UMAX2	PU2 max voltage	0,01V	RW2		unsigned integer	0	10000	400	maximum voltage (for open circuit detection)
b11	ILMAX2	PU2 max current lin	0,1A	RW2		unsigned integer	0	2000	800	for P/I calculation
b12	PLMAX2	PU2 max power lin	0,1W	RW2		unsigned integer	10	10000	1000	for P/I calculation
b13	ITHRES2	PU2 thres current	0,1A	RW2		unsigned integer	0	2000	150	laser threshold, for IBIASmax P/I calculation
b14	PTHRES2	PU2 thres power	0,1W	RW2		unsigned integer	0	50	0	below is I=0
b15	IMAX2EOL	PU2 max current EOL	0,1A	RW2		unsigned integer	0	2000	1000	maximum current at end of life (for diode degradation)
b16	IACTB2	PU2 act bias current	0,1A	RW1	x	unsigned integer	0	2000	0	actual output bias current (not on all hardware designs)

10. Power unit 3

register	name	description	unit	access	PDO	view mode	min	max	default	remark
c01	ERRC1	PU3 errors 1	1	R1	x	hexadecimal	0	0xffff	0	errors 1 in group C
c02	ERRC2	PU3 errors 2	1	R1	x	hexadecimal	0	0xffff	0	errors 2 in group C
c03	WRNC	PU3 warnings	1	R1	x	hexadecimal	0	0xffff	0	warnings in group C
c04	RESC2	reserved C2	1	R1		not displayed	0	0	0	not defined yet
c05	PUCNFC1	PU3 config	1	RW1		hexadecimal	0	0xffff	0	bit 0 (0x0001): activate connected power meter
c06	PUCNFC2	PU3 config OEM	1	RW2		hexadecimal	0	0xffff	0	0-select current edge limitation automatically 1-4:select current edge limitation manually (1= weak, 4=strong) 8-current edge limitation off bit 15 (0x8000): force presence of external PU
c07	RESC3	reserved C3	1	R1		not displayed	0	0	0	not defined yet
c08	ISET3C	PU3 calculated set current	0,1A	R1	x	unsigned integer	0	2000	0	calculated current as result of any reference (digital, analog, current, power, etc.)
c09	IBIAS3	PU3 bias current	0,1A	RW1		unsigned integer	0	2000	0	bias current
c0a	IACT3	PU3 act current	0,1A	R1	x	unsigned integer	0	2000	0	actual output current
c0b	UACT3	PU3 act voltage	0,01V	R1	x	unsigned integer	0	10000	0	actual output voltage
c0c	PACT3	PU3 act power	0,1W	R1	x	unsigned integer	0	10000	0	actual output power based on current
c0d	PTOPT3	PU3 power factor	0,1%	RW1		unsigned integer	0	1000	1000	fraction of total power
c0e	IMAX3	PU3 max current	0,1A	RW2		unsigned integer	0	2000	1000	maximum current (for diode protection)
c0f	UMIN3	PU3 min voltage	0,01V	RW2		unsigned integer	0	10000	150	minimum voltage (for short circuit detection)
c10	UMAX3	PU3 max voltage	0,01V	RW2		unsigned integer	0	10000	400	maximum voltage (for open circuit detection)
c11	ILMAX3	PU3 max current lin	0,1A	RW2		unsigned integer	0	2000	800	for P/I calculation
c12	PLMAX3	PU3 max power lin	0,1W	RW2		unsigned integer	10	10000	1000	for P/I calculation
c13	ITHRES3	PU3 thres current	0,1A	RW2		unsigned integer	0	2000	150	laser threshold, for IBIASmax P/I calculation
c14	PTHRES3	PU3 thres power	0,1W	RW2		unsigned integer	0	50	0	below is I=0
c15	IMAX3EOL	PU3 max current EOL	0,1A	RW2		unsigned integer	0	2000	1000	maximum current at end of life (for diode degradation)
c16	IACTB3	PU3 act bias current	0,1A	RW1	x	unsigned integer	0	2000	0	actual output bias current (not on all hardware designs)

11. Power unit 4

register	name	description	unit	access	PDO	view mode	min	max	default	remark
d01	ERRD1	PU4 errors 1	1	R1	x	hexadecimal	0	0xffff	0	errors 1 in group D
d02	ERRD2	PU4 errors 2	1	R1	x	hexadecimal	0	0xffff	0	errors 2 in group D
d03	WRND	PU4 warnings	1	R1	x	hexadecimal	0	0xffff	0	warnings in group D
d04	RESD2	reserved D2	1	R1		not displayed	0	0	0	not defined yet
d05	PUCNFD1	PU4 config	1	RW1		hexadecimal	0	0xffff	0	bit 0 (0x0001): activate connected power meter
d06	PUCNFD2	PU4 config OEM	1	RW2		hexadecimal	0	0xffff	0	0-select current edge limitation automatically 1-4:select current edge limitation manually (1= weak, 4=strong) 8-current edge limitation off bit 15 (0x8000): force presence of external PU
d07	RESD3	reserved D3	1	R1		not displayed	0	0	0	not defined yet
d08	ISET4C	PU4 calculated set current	0,1A	R1	x	unsigned integer	0	2000	0	calculated current as result of any reference (digital, analog, current, power, etc.)
d09	IBIAS4	PU4 bias current	0,1A	RW1		unsigned integer	0	2000	0	bias current
d0a	IACT4	PU4 act current	0,1A	R1	x	unsigned integer	0	2000	0	actual output current
d0b	UACT4	PU4 act voltage	0,01V	R1	x	unsigned integer	0	10000	0	actual output voltage
d0c	PACT4	PU4 act power	0,1W	R1	x	unsigned integer	0	10000	0	actual output power based on current
d0d	PTOPT4	PU4 power factor	0,1%	RW1		unsigned integer	0	1000	1000	fraction of total power
d0e	IMAX4	PU4 max current	0,1A	RW2		unsigned integer	0	2000	1000	maximum current (for diode protection)
d0f	UMIN4	PU4 min voltage	0,01V	RW2		unsigned integer	0	10000	150	minimum voltage (for short circuit detection)
d10	UMAX4	PU4 max voltage	0,01V	RW2		unsigned integer	0	10000	400	maximum voltage (for open circuit detection)
d11	ILMAX4	PU4 max current lin	0,1A	RW2		unsigned integer	0	2000	800	for P/I calculation
d12	PLMAX4	PU4 max power lin	0,1W	RW2		unsigned integer	10	10000	1000	for P/I calculation
d13	ITHRES4	PU4 thres current	0,1A	RW2		unsigned integer	0	2000	150	laser threshold, for IBIASmax P/I calculation
d14	PTHRES4	PU4 thres power	0,1W	RW2		unsigned integer	0	50	0	below is I=0
d15	IMAX4EOL	PU4 max current EOL	0,1A	RW2		unsigned integer	0	2000	1000	maximum current at end of life (for diode degradation)
d16	IACTB4	PU4 act bias current	0,1A	RW1	x	unsigned integer	0	2000	0	actual output bias current (not on all hardware designs)

Error/warning list

1. Full register (all errors/warnings)

ERRT (012)	bit	function
	0 (0x0001)	Errors Group 0
	1 (0x0002)	n.def.
	2 (0x0004)	n.def.
	3 (0x0008)	n.def.
	4 (0x0010)	n.def.
	5 (0x0020)	Errors Group 5
	6 (0x0040)	Errors Group 6
	7 (0x0080)	Errors Group 7
	8 (0x0100)	n.def.
	9 (0x0200)	n.def.
	10 (0x0400)	Errors Group A
	11 (0x0800)	Errors Group B
	12 (0x1000)	Errors Group C
	13 (0x2000)	Errors Group D
	14 (0x4000)	n.def.
	15 (0x8000)	n.def.

WRNT (013)	bit	function
	0 (0x0001)	Warnings Group 0
	1 (0x0002)	n.def.
	2 (0x0004)	n.def.
	3 (0x0008)	n.def.
	4 (0x0010)	n.def.
	5 (0x0020)	Warnings Group 5
	6 (0x0040)	Warnings Group 6
	7 (0x0080)	Warnings Group 7
	8 (0x0100)	n.def.
	9 (0x0200)	n.def.
	10 (0x0400)	Warnings Group A
	11 (0x0800)	Warnings Group B
	12 (0x1000)	Warnings Group C
	13 (0x2000)	Warnings Group D
	14 (0x4000)	n.def.
	15 (0x8000)	n.def.

2. Errors/warnings from Main (0)

ERR0 (001)	bit	function
	0 (0x0001)	n.def.
	1 (0x0002)	n.def.
	2 (0x0004)	n.def.
	3 (0x0008)	n.def.
	4 (0x0010)	n.def.
	5 (0x0020)	n.def.
	6 (0x0040)	n.def.
	7 (0x0080)	CAN guarding timeout
	8 (0x0100)	laser on timeout
	9 (0x0200)	firmware config
	10 (0x0400)	hardware config
	11 (0x0800)	initialisation failure
	12 (0x1000)	device overtemp
	13 (0x2000)	n.def.
	14 (0x4000)	n.def.
	15 (0x8000)	wrong command

WRN0 (003)	bit	function
	0 (0x0001)	n.def.
	1 (0x0002)	n.def.
	2 (0x0004)	n.def.
	3 (0x0008)	n.def.
	4 (0x0010)	n.def.
	5 (0x0020)	n.def.
	6 (0x0040)	n.def.
	7 (0x0080)	startup is delayed
	8 (0x0100)	n.def.
	9 (0x0200)	n.def.
	10 (0x0400)	n.def.
	11 (0x0800)	n.def.
	12 (0x1000)	n.def.
	13 (0x2000)	n.def.
	14 (0x4000)	n.def.
	15 (0x8000)	n.def.

3. Errors/warnings from Laser (5)

ERR5 (501)	bit	function
	0 (0x0001)	head humidity too high
	1 (0x0002)	laser fiber broken
	2 (0x0004)	laser fiber shortened
	3 (0x0008)	shutter error
	4 (0x0010)	fiber not plugged
	5 (0x0020)	n.def.
	6 (0x0040)	interlock head on
	7 (0x0080)	interlock head wire
	8 (0x0100)	n.def.
	9 (0x0200)	n.def.
	10 (0x0400)	config hardware error
	11 (0x0800)	laser temp too high
	12 (0x1000)	laser power dev too high
	13 (0x2000)	n.def.
	14 (0x4000)	n.def.
	15 (0x8000)	n.def.

WRN5 (503)	bit	function
	0 (0x0001)	head humid pretty high
	1 (0x0002)	n.def.
	2 (0x0004)	n.def.
	3 (0x0008)	n.def.
	4 (0x0010)	n.def.
	5 (0x0020)	n.def.
	6 (0x0040)	interlock head on
	7 (0x0080)	n.def.
	8 (0x0100)	laser service interval
	9 (0x0200)	laser temp too low
	10 (0x0400)	laser temp pretty high
	11 (0x0800)	laser temp too high
	12 (0x1000)	n.def.
	13 (0x2000)	n.def.
	14 (0x4000)	n.def.
	15 (0x8000)	n.def.

4. Errors/warnings from Interface (6)

ERR6 (601)	bit	function
	0 (0x0001)	emergency stop
	1 (0x0002)	emergency stop wire
	2 (0x0004)	emergency stop remote terminal
	3 (0x0008)	emergency wire remote terminal
	4 (0x0010)	emergency stop external
	5 (0x0020)	emergency stop external wire
	6 (0x0040)	interlock external
	7 (0x0080)	interlock external wire
	8 (0x0100)	link error
	9 (0x0200)	emergency stop SPI
	10 (0x0400)	warn light(s) error
	11 (0x0800)	n.def.
	12 (0x1000)	cooler temp
	13 (0x2000)	cooler flow
	14 (0x4000)	n.def.
	15 (0x8000)	n.def.

WRN6 (603)	bit	function
	0 (0x0001)	n.def.
	1 (0x0002)	n.def.
	2 (0x0004)	n.def.
	3 (0x0008)	n.def.
	4 (0x0010)	n.def.
	5 (0x0020)	n.def.
	6 (0x0040)	interlock external
	7 (0x0080)	n.def.
	8 (0x0100)	n.def.
	9 (0x0200)	n.def.
	10 (0x0400)	warn light(s) warning
	11 (0x0800)	n.def.
	12 (0x1000)	cooler temp
	13 (0x2000)	cooler flow
	14 (0x4000)	n.def.
	15 (0x8000)	n.def.

5. Errors/warnings from Cooler (7)

ERR71 (701)	bit	function
	0 (0x0001)	interlock
	1 (0x0002)	filter press. too high
	2 (0x0004)	n.def.
	3 (0x0008)	n.def.
	4 (0x0010)	water temp too low
	5 (0x0020)	water temp too high
	6 (0x0040)	link error
	7 (0x0080)	water conduct too high
	8 (0x0100)	water flow 1 too low
	9 (0x0200)	water flow 1 too high
	10 (0x0400)	cooler water level low
	11 (0x0800)	water flow 2 too low
	12 (0x1000)	water flow 2 too high
	13 (0x2000)	cooler internal error
	14 (0x4000)	see error 2
	15 (0x8000)	cooler command error

ERR72 (702)	bit	function
	0 (0x0001)	n.def.
	1 (0x0002)	n.def.
	2 (0x0004)	n.def.
	3 (0x0008)	cooler internal-nosync
	4 (0x0010)	cooler internal-nocom1
	5 (0x0020)	cooler internal-nocom2
	6 (0x0040)	cooler internal-nocom3
	7 (0x0080)	n.def.
	8 (0x0100)	n.def.
	9 (0x0200)	cooler firmware config
	10 (0x0400)	cooler hardware config
	11 (0x0800)	cooler init failure
	12 (0x1000)	n.def.
	13 (0x2000)	n.def.
	14 (0x4000)	n.def.
	15 (0x8000)	n.def.

WRN7 (703)	bit	function
	0 (0x0001)	interlock
	1 (0x0002)	filter press. pretty high
	2 (0x0004)	n.def.
	3 (0x0008)	n.def.
	4 (0x0010)	water temp pretty low
	5 (0x0020)	water temp pretty high
	6 (0x0040)	cooler link missing
	7 (0x0080)	water conduct pretty high
	8 (0x0100)	water flow 1 pretty low
	9 (0x0200)	water flow 1 pretty high
	10 (0x0400)	n.def.
	11 (0x0800)	water flow 2 pretty low
	12 (0x1000)	water flow 2 pretty high
	13 (0x2000)	n.def.
	14 (0x4000)	n.def.
	15 (0x8000)	cooler wrong command

6. Errors/warnings from power units (A to D)

ERRx1 (x01)	bit	function
	0 (0x0001)	interlock
	1 (0x0002)	no prim voltage
	2 (0x0004)	no output voltage
	3 (0x0008)	internal-malvoltage
	4 (0x0010)	internal-relay open
	5 (0x0020)	internal-relay short
	6 (0x0040)	link failure
	7 (0x0080)	DC overtemp
	8 (0x0100)	internal-dcmal
	9 (0x0200)	overcurrent
	10 (0x0400)	internal-overpower
	11 (0x0800)	internal-malcurrent
	12 (0x1000)	PA overtemp
	13 (0x2000)	internal error
	14 (0x4000)	see error 2
	15 (0x8000)	command error

ERRx2 (x02)	bit	function
	0 (0x0001)	open circuit
	1 (0x0002)	short circuit
	2 (0x0004)	n.def.
	3 (0x0008)	internal-nosync
	4 (0x0010)	internal-nocom1
	5 (0x0020)	internal-nocom2
	6 (0x0040)	internal-nocom3
	7 (0x0080)	n.def.
	8 (0x0100)	n.def.
	9 (0x0200)	firmware config
	10 (0x0400)	hardware config
	11 (0x0800)	initialisation error
	12 (0x1000)	power calibration error
	13 (0x2000)	n.def.
	14 (0x4000)	n.def.
	15 (0x8000)	n.def.

WRNx (x03)	bit	function
	0 (0x0001)	interlock
	1 (0x0002)	no primary voltage
	2 (0x0004)	n.def.
	3 (0x0008)	n.def.
	4 (0x0010)	n.def.
	5 (0x0020)	n.def.
	6 (0x0040)	link missing
	7 (0x0080)	DC/DC temp pretty high
	8 (0x0100)	internal-dcmal
	9 (0x0200)	n.def.
	10 (0x0400)	n.def.
	11 (0x0800)	n.def.
	12 (0x1000)	PA temp high
	13 (0x2000)	n.def.
	14 (0x4000)	n.def.
	15 (0x8000)	internal-wrong cmd