**INTERFACING MANUAL COMPex***Pro***® (RoHS)**

**LASER CONTROL SOFTWARE LCS V2.29**

**02/2008**

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VIII Interfacing Manual COMPex*Pro* ®

The Interfacing Manual

**1 INTRODUCTION**

This COMPex*Pro* designed Interfacing to familiarize ® excimer Manual the laser is part user device. of with the the instruction The COMPex*Pro* instruction manual manual excimer for the is

laser device and its designated use. It contains important information on how to install, operate and service the laser device safely, properly and most efficiently. Observing these instructions helps to avoid danger, reduce repair costs and downtimes and increase the reliability and lifetime of the laser device. The COMPex*Pro* excimer laser device is intended for use as a subsystem within a laser system (laser assembly or laser unit as defined in ISO 11145). Consequently, the instruction manual is to be used in conjunction with other instruction manuals that describe the complete system or further system elements. In addition, it is to be supplemented by the respective national rules and regulations for accident prevention and environmental protection. The instruction manual for the COMPex*Pro* laser device is subdivided into the following self-contained manuals:

– User Manual

– Service Manual

– Interfacing Manual

– Site Preparation Manual.

Each manual has been prepared for a specific target audience and will be made available to this audience by Coherent, their authorized representative or the laser unit manufacturer (system integrator).

**1.1 The Interfacing Manual**

This commands manual required describes for the communication interfaces, message with the formats COMPex*Pro*

and

controller. This information is required when preparing a program to operate the laser device from an external (remote) computer control system.

The LCS laser control software (version 2.29) is based on a source software that is used with various excimer laser device configurations. Therefore, specifically some apply commands for the COMPex*Pro* available laser in the device software and may are,

not

consequently, not described in this manual.

For further information about the software control structure or hand- held keypad controlled laser operation, please refer to the separate User Manual.

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INTRODUCTION

**1.1.1 Intended Audience**

The the installation Interfacing of Manual the COMPex*Pro* is intended laser for all device, persons integrate that are the to prepare

laser device into a laser processing system or prepare a program to operate the laser device from an external (remote) control system.

**1.1.2 Availability and Use**

The are assigned Interfacing with Manual the installation should be or made integration available of the to all COMPex*Pro*

persons that

laser device and particularly persons that are to prepare a communication link with the laser device.

**1.1.3 Numbering of Chapters, Pages and Instructions**

The pages of this manual are numbered continuously. The page number appears in the lower outside corner of every page.

The chapters are numbered continuously. The name of the chapter appears in the upper outside corner of every even page. Each chapter ends with an even page number. Consequently, certain even pages at the ends of chapters will be intentionally left blank.

Each step within a procedure is sequentially numbered. Each procedure starts with the step number one.

**1.1.4 Typographic Conventions**

The button description <ENTER> is used to describe the keyboard button marked or referred to as ENTER, ↵, RETURN, CR or CARRIAGE RETURN.

Commands to be entered through a keyboard are written in non- proportional lower-case letters.

– Example: Type cd lambda.

Programming commands for remote communication to be used literally are written in upper-case letters.

– Example: OPMODE=

Placeholders in commands or messages are written in italic letters.

– Example: OPMODE=*operating mode*

A permitted command is to be used instead of the words operating mode.

Examples are written in non-proportional, upper-case letters to simulate the appearance of monitor displays or printer output.

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The Interfacing Manual

**1.1.5 Trademarks**

The trademarks used in this manual are the properties of their respective owners and are used for identification purposes only:

– Coherent and the Coherent Logo are registered trademarks of

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In the following sections of this manual, no mention is made of patents, trademark rights or other proprietary rights which may attach to certain words. The absence of such mention, however, in no way implies that the words in question are exempt from such rights.

**1.1.6 Cited Standards**

Unless otherwise stated, all technical standards cited in this manual relate to the latest version of the standard that is applicable at the date of the publication of this manual.

In many cases, cited international standards (ISO and IEC standards) have been adopted wholly or in part by national or regional standards authorities and are often known locally under the appropriate local designation. For instance, IEC 60825-1 (Safety of Laser Products) has been adopted by the European Committee for Standardization as EN 60825-1 and, in turn, by various national standards authorities as, for example, DIN EN 60825 (Germany) and BS EN 60825 (United Kingdom). The exact content, number and revision date of a national standard may, however, vary from that of the corresponding international standard. For further information, please contact the publisher of the respective national standard.

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INTRODUCTION

**1.2 Safety**

**1.2.1 Laser Safety Classification**

IEC-60825-1, FDA 21 CFR 1040.10 and 1040.11 and ANSI Z-136.1 indicate the requirements and procedures that are to be followed to ensure the safe use of laser products. These standards and regulations classify each laser product according to the potential hazards arising in its use. In each case, the Laser Class indicates the accessible emission limit (AEL), i.e. the maximum emission level that humans can access.

The lowest Laser Class is Class 1 and the highest is Class 4:

– Class 1 laser products are laser products that are safe under

reasonably foreseeable conditions of operation.

– Class 4 laser products are laser products that permit human

access to emission levels that represent an acute hazard to the eyes and skin from direct and scattered radiation. **Within this classification, the COMPex***Pro***, as a stand-alone laser device, is a Class 4 laser product. It must, consequently, be regarded as a potential hazard to the human operator.**

The laser beam must also be regarded as a potential fire hazard.

**1.2.2 Safety Information**

The Safety Chapter of the separate User Manual describes the physical hazards related to the excimer laser device, the means of protection against these hazards and the safety features incorporated in the design of the laser device. This chapter must be read by all persons entrusted with any sort of work on the laser device.

**Never start to work on or with the laser device unless you have read and fully understood the information in the Safety Chapter!**

**1.2.3 Signal Words and Symbols in this Manual**

The COMPex*Pro* documentation may contain sections in which particular hazards are defined or special attention is drawn to particular conditions. These sections are indicated with signal words in accordance with ANSI Z-535.2-2002 and ISO 3864-2:2004 and safety symbols (pictorial hazard alerts) in accordance with ANSI Z-535.3- 2002 and ISO 7010:2003.

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Laser Terminology

**1.2.3.1 Signal Words**

Four signal words are used in the COMPex*Pro* documentation: DANGER, WARNING, CAUTION and NOTICE.

In this document, only the signal word “NOTICE” may be used. This indicates that there is the risk of property damage:

***NOTICE*** Addresses practices not related to personal injury.

**1.2.3.2 Symbols**

The signal words **DANGER**, **WARNING**, and **CAUTION** are always emphasized with a safety symbol that indicates a special hazard, regardless of the hazard level. As only the signal word “NOTICE” may occur in this manual, no safety symbols are used.

**1.3 Laser Terminology**

ISO 11145 (“Optics and Optical Instruments - Lasers and Laser Related Equipment - Vocabulary and Symbols”) contains a list of laser terminology (for more information, see the User Manual):

– Laser

Consists of an amplifying medium capable of emitting coherent radiation with wavelengths up to 1 mm by means of stimulated emission.

– Laser Device

A laser, where the radiation is generated, together with essential additional facilities that are necessary to operate the laser, e.g. cooling, power and gas supply. To prevent misunderstandings, the COMPex*Pro* documentation strictly differentiates between “laser” and “laser device”. Thus “start laser device” means that the power is off and shall be turned on. To “start the laser” means to switch on the laser beam and start laser operation.

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INTRODUCTION

**1.4 Conversion Table**

Listed below are the units of measure used in this manual and their equivalents according to the SI standard:

1 meter (m) = 39.37 inches (in) 1 meter (m) = 3.28 feet (ft) 1 centimeter (cm) = 0.3937 inch (in) 1 bar = 100,000 Pascal (Pa) 100,000 Pascal (Pa) = 14.50 pounds force per square inch (lbf/in2)

**1.5 Feedback Regarding Documentation**

If you have any comments regarding the documentation provided to you, please contact us.

When you contact us, please provide us with:

– the document code,

– the date of issue,

– the page number, section number and, where applicable, the

procedure step number,

– a description of any errors,

– a proposal for improvements.

**Feedback Address**

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**2 CONTROL STRUCTURE**

The COMPex*Pro* (see Figure 1, A) is controlled through a central laser control board (C) that directly communicates with the system’s various controllable modules and components (B) such as the HV power supply, energy monitor, trigger board, solenoid valves and ventilators. Depending on the address, communication occurs through 24 V control signals or optically through fiber optic lightwave guides.

***Figure 1:*** *External interfaces and control structure*

*Key to Figure 1*

A Laser device E Computer control system B Controlled module/ component F Handheld keypad C Laser control board (LCB) G Synchronization device D Diagnostics computer H Trigger generator

The user interface to the LCB (C) is either the handheld keypad (F) or a remote computer control system (E). Two serial interface (RS232) ports are provided so that two user interface devices can be connected at the same time. To prevent the input of conflicting commands, one of the ports (COM1) can be deactivated by the user. Alternatively, this port can be switched by the user to allow the connection of a diagnostics computer (D) or a control system designed for an earlier version of the laser device (backward compatibility).

In addition to the serial interfaces, the laser device is equipped with dedicated ports that allow trigger signals from an external trigger generator (H) to be input and synchronization pulses to be output to an external device (G) that synchronizes the laser pulses with other operating sequences.

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CONTROL STRUCTURE

**Serial Interfaces**

All operating modes and laser parameters are set and/or requested through either of the serial interfaces. The laser device requests a special handshake with the user or the control program in the following cases:

– PGR request

Partial gas replacement (PGR) requests are indicated by status code 104. When a request occurs, the user has to activate the HI/PGR mode (see Section 4.3.2.6 on page 27) so that the gas action can be performed. If the gas action is not carried out within a predefined timeout period, a corresponding interlock will be activated and laser operation is stopped.

– Interlocks and warnings

A list of possible laser status codes is indicated in Section 4.3.3 on page 35. If an interlock or warning occurs, solve the problem (see “Basic Troubleshooting” in the User Manual) and clear the message by sending the opmode OFF (see Section 4.3.2.1 on page 24).

**Handheld Keypad**

The handheld keypad is a dedicated control device that is supplied as standard with the laser device. It communicates with the laser device through the corresponding serial interface port.

For more information about controlling the laser device through the hand-held keypad, please refer to the laser device’s User Manual.

**External Triggering**

The external trigger (Trig. In) port is only active in one of the external triggering modes, i.e. when the laser device expects external signals. The signals received through the Ext. Trigger port can either be trigger signals for externally triggered laser operation or gate signals for operation in the internal gated trigger mode (for more information, see Section 4.4.4 on page 45).

**Synchronization Pulses**

Synchronization pulses (Sync. Out) are generated when the system controller recognizes a trigger signal, regardless of whether the signal is internally or externally generated. These pulse signals inform an external device that a trigger signal has been received. This enables the triggering of the laser device to be synchronized with external operating sequences.

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**Software Communication** The structure of the COMPex*Pro* laser control software and communication between the various modules is shown in Figure 2.

***Figure 2:*** *Software communication*

• The LCS software consists of various modules that control all operations of the laser device:

– COMPEX.RTB is the primary laser control program. – USEREXEC.BAT and RTTBOOT.COM are execution and boot

programs for the primary laser control program. – PLD\_V302.JBC is the configuration file for the PLD

(programmable logic device). The PLD controls access to the periphery devices in the laser device such as pumps and fans. – PORTTEST.EXE and LPJAM.EXE are setup and service tools.

The LCS software is stored on the LCB on a flash drive. Necessary software upgrades can be carried out by authorized Coherent field service engineers.

• The CTERM software controls the operation of the hand-held keypad that is supplied as standard with the laser device. This software is stored on an EPROM in the hand-held keypad.

• LCSMON (CMPX\_MON.EXE) is a service software package that is exclusively available to authorized Coherent service engineers. It is installed on an external computer (usually a laptop PC) that has to be connected to COM1 on the laser device. LCSMON enables operations such as debugging and modification of operating parameters in the LCS software modules.

• The host PC software is the software written by the customer or system integrator that allows the laser device to be operated through a remote computer control system. The syntax and necessary laser control commands to write this software are

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described in Section 4 of this manual. If the host PC software was orginally written for an earlier Coherent or Lambda Physik excimer laser device (backward compatibility), take into account the fundamental changes that affect interaction with the external software described in Section 6 of this manual.

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Location of Connections

**3 INTERFACE SPECIFICATIONS**

**3.1 Location of Connections**

The connections for all signal and control lines are located on the connector panel which is situated on the connection side of the laser device. The exact location of the connector panel is indicated in Figure 3, A.

***Figure 3:*** *Location of signal and control line connector panel*

The location of the respective connections on the connector panel is indicated in Section 3.2.

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**3.2 Overview of Connections**

Figure 4 shows the layout of the connections on the connector panel.

***Figure 4:*** *Layout of connector panel*

The table below contains a key to Figure 4 and provides an overview of the configuration of the control and signal connections. The gender of the connector (where indicated) relates to the chassis part on the laser device and not the connector on the cable. The cables have to be provided with the corresponding plugs.

**Pos. Designation Type Purpose Further**

**information** A Remote 15 pin Harting,

female

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Safety connections (category 3 remote interlock, external laser radiation warning lamp, external gas error etc.)

Section 3.5

B COM 1 9 pin sub D,

male

Serial interface for input/output of operating modes and parameters

Section 3.3.1

C COM 2

(TERMINAL)

25 pin sub D, female

Serial interface (handheld keypad configuration) for input/output of operating modes and parameters

Section 3.3.2

D SYNC. OUT BNC Output of synchronization signal Section 3.4.2 E TRIG. IN BNC Input of external trigger signal Section 3.4.1

Serial Interfaces

**3.3 Serial Interfaces**

The laser device is equipped with two RS232 serial interfaces, designated as COM 1 and COM 2. Both ports enable operating modes (opmodes) and parameters to be set or read and status codes to be read.

All signals are compatible to standard RS232 levels: +5 to +15V for SPACE and -5 to -15V for MARK.

**Communication Protocol**

Baud rate 9600 bps Number of data bits 8 Number of start bits 1 Number of stop bits 1 Parity none Handshake none Message format uppercase and lowercase ASCII characters

using clear text full word commands

**Communication Syntax**

Both ports use an identical communication syntax. The communication syntax is described in Chapter 4 on page 19.

**3.3.1 COM 1**

COM 1 can be switched by the user through a pushbutton on the handheld keypad to enable the connection of one of the following:

– a diagnostics computer,

– an external computer control system (remote computer) that uses

the current protocol (see Section 4 on page 19),

–a control COMPex*Pro* system or designed LPX series for an laser earlier device version (backward of the COMPex,

compatibility). With this setting, not all commands offered by the current laser control software will be supported. In addition, as the status code table has changed, status codes sent by the laser device may not be recognized or correctly interpreted by the external control system. A list of the currently applicable status codes is contained in Section 4.3.3 on page 35.

Alternatively, this port can be deactivated by the user to prevent the input of conflicting commands.

For further information about switching the COM 1 port, please refer to the separate User Manual

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**Specifications**

Device 9 pin Sub-D Type RS232C Gender male Galvanic isolation TBS Locking size 4-40 UNC

**Pin Assignment**

**Signal Pin Type Purpose** RxD 2 Input Receive RS 232 data TxD 3 Output Transmit RS 232 data GND 5 Output RS232 ground n.c. 1, 4, 6 to 9 not connected

**3.3.2 COM 2 (Terminal)**

COM 2 is configured for the connection of the handheld keypad that is supplied as standard with the laser device. If required, an external control computer (remote computer) can be connected to this terminal instead of the handheld keypad. This computer has to use the same protocol as the handheld keypad (see Section 4 on page 19).

**Specifications**

Device 25 pin Sub-D Type RS232C Gender female Galvanic isolation TBS Locking size 4-40 UNC

**Pin Assignment**

**Signal Pin Type Purpose** RxD 3 Input Receive RS 232 data TxD 2 Output Transmit RS 232 data GND 7 Output RS232 ground 15 V 9 Output +15 V DC n.c. 1, 4 to 6 and

10 to 25

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not connected

Synchronization Signals

**3.4 Synchronization Signals**

**3.4.1 Trigger In**

The laser can be triggered from an external source (trigger generator). This source is to be connected to the TRIG. IN socket.

**Specifications**

Port on laser device Trig. In Device BNC, galvanic isolation through optocoupler Signal level 3.3 VDC to 5 VDC, TTL Pulse duration 10 ms to 100 ms Trigger edge positive slope Delay ext. trigger to light pulse:a - without COD 2 ms - 50 / 110 with COD 9500 ms - 102 with COD 12500 ms - 201 / 205 with COD 18000 ms Delay, drift < 200 ns Jitter ext. trigger to light pulse < ± 10 ns (pulse-to-pulse)

a. For further information, see Section 3.4.3 on page 16

**3.4.2 Sync. Out**

The Sync. Out signal informs external devices that a trigger signal has just been sent to the discharge capacitors..

**Specifications**

Port on laser device Sync. Out Device BNC, galvanic isolation through optocoupler Signal level 3.3 VDC to 5 VDC, TTL Pulse duration 50 ms Delay to light sync. pulseout

a 0.5 ms

a. For further information, see Section 3.4.3 on page 16

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INTERFACE SPECIFICATIONS

**3.4.3 Timing Diagrams**

The diagrams in this section indicate the time delay between:

– the trigger-in signal (signal A in each diagram),

– the laser light pulse (B) and

– the sync out. signal (C).

There is a fundamental difference in delay times for laser operation with and without charge on demand (COD).

**Operation With COD**

In the COD mode, capacitor charging is specifically triggered by the demand for a laser pulse rather than occurring automatically after the previous discharge. This maximizes the lifetime of the components in the high voltage (HV) circuit and prevents the laser firing a light pulse without receiving a trigger pulse (self-firing). The trade-off of COD is a long delay between the trigger-in signal and the laser light pulse. The exact length of this delay differs depending on the version of the laser device (see Figures 5 to 7).

***Figure 5:*** *Delay, COMPexPro 50 and 110 with COD*

In the case of the COMPex*Pro* 110, there is an exception to the delay times indicated in Figure 5. Interacting parameters such as the signal- to-light delay and the maximum permissible HV are normally set to enable operation at the maximum permissible repetition rate (100 Hz). However, when operating in the HV constant mode at repetition rates below 10 Hz, the HV setpoint can be increased to a value above the usually applicable maximum. To compensate for the necessary additional automatically capacitor increased charging to the time, value the specified signal-to-light for the COMPex*Pro* delay is

102 (see Figure 6).

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Synchronization Signals

***Figure 6:*** *Delay, COMPexPro 102 with COD*

***Figure 7:*** *Delay, COMPexPro 200 Series with COD*

If the delay is unacceptable for the effective coordination of the laser with other operations, COD can be switched off through a dedicated software command.

**Operation Without COD**

Without COD (see Figure 8), the delay is the same for all versions of the laser device.

***Figure 8:*** *Delay, all versions without COD*

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INTERFACE SPECIFICATIONS

**3.5 Remote Connector**

The remote connector enables the laser device to be connected to external safety circuits that, for instance, disable the laser until a protective door is closed, indicate that laser radiation is being emitted or indicate an external halogen leak.

**Specifications**

Port on laser device Remote Device 15 pin connector Type Harting HAN 15D Gender female

**Pin Assignment and Connections**

***Figure 9:*** *Remote connector pin assignment and connections*

**Signal Pins Type Purpose Specifications** Laser radiation warning lamp

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A1 + A2 Output External warning lamp that lights

when laser radiation is being emitted

24 V DC

Remote interlock B1 + B2 Input EN 954-1 safety category 3

connection. B3 and B4 have to be open and B1 and B2 have to be closed to enable the emission of laser radiation

Potential-free B3 + B4 Input contacts External gas error C3 + C4 Input Contact has to be closed if there is

no external gas error (e.g. leak)

Communication Syntax

**4 REMOTE COMMUNICATION**

The serial interface is used to set and request all operating modes and parameters and to indicate the laser status. Activities requiring a handshake wit h the user or the remote controller, like PGRs, indication of interlocks and warnings as well as maintenance activities, are also handled via this interface.

**4.1 Communication Syntax**

All commands are case insensitive text commands. Each command is terminated with the <CR> (Carriage Return) character.

Two fundamental types of commands are used:

– Setting commands:

are used to set laser operating modes or values of configurables.

– Polling commands:

are used to request the current laser status or configurable setting.

The laser confirms commands, returns requested parameter settings or sends an error code as a reply message.

**Setting Commands**

Command syntax: *name*=*setting*<CR> Reply syntax: *reply code*<CR> Example: The command

OPMODE=OFF<CR> has to be sent to the system controller to switch off the laser. To indicate that the command is permitted and has been accepted, the system controller re-sends 0<CR>

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REMOTE COMMUNICATION

**Polling Commands**

Command syntax: *name?*<CR> The syntax of the reply will depend on whether an operating mode (see Section 4.3 on page 22) or operating parameter (see Section 4.4.2 on page 39) is being polled: Reply syntax for operating modes:

**Syntax Description**

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OPMODE=*setting,status*<CR> orOPMODE=*setting,status,status*<CR> or *reply code*<CR> Reply syntax for operating parameters:

*name*=*setting*<CR> or*name*=*setting,setting*<CR> or *reply code*<CR> Example: The command

OPMODE?<CR> has to be sent to the system controller to request the current operating mode. If the laser is ready for operation but at present switched off, the system controller will re-send OPMODE=OFF,0<CR>. If the reply 2<CR> is received, the entered polling command is unknown to the system controller and, consequently, cannot be processed.

*name* The name OPMODE (to indicate an operating mode) or

one of the parameter names listed in Section 4.4 on page 37. The name occurs both in setting and polling commands. *setting* A word or numerical value that defines an operating mode

or parameter setting. With numerical values, the character X in the descriptions in this chapter indicates each permitted place in the value (i.e. each digit between 0 and 9). Less positions or leading zeros are permitted. If the value has to be within a permitted range of values, this range is indicated in the respective command description. When a numerical value is to contain a special character (e.g. colon or decimal point), this is also indicated in the respective command description. Where more than one word or numerical value is required, the information separator is a comma. *reply code* One of the reply codes listed in Section 4.2 on page 21. *status* One of the status codes listed in Section 4.3.3 on page 35.

Reply Codes

= Equals sign. This is always written between the name and

setting in both setting commands and replies to polling commands. ? Question mark. This is always written at the end of a

polling command. , Comma. This is written as information separator when a

setting consists of more than one word or numerical value. <CR> Carriage Return character. This is always inserted after

each polling command, setting command or reply to terminate the command. The insertion of this character is assumed in the command syntax descriptions in the remainder of this chapter.

Do not insert a blank before or after an equals sign, question mark, comma or CR character. If a blank is required within a command, this is indicated in the syntax of the individual command description.

**4.2 Reply Codes**

The respective meaning of the possible reply codes together with any necessary corrective action is listed in the table below. The reply codes apply to both laser operating modes and laser parameter commands.

**No. Description Action**

0 Command/parameter

— accepted 1 Command/parameter not

Change operating mode and send accepted in current mode

the command/ parameter again 2 Command/parameter

Send correct command/ unknown

parameter name 3 Parameter value out of

range or input/output error

One of the above reply codes will always be sent as response to a setting command.

No reply code is sent when a valid polling command is received. In this case, acceptance of the command is indicated by the reply to the polling command. The reply code 2 will be sent as response to an invalid command.

The means of clearing by changing the operating mode indicates that a valid opmode command has to be sent. Take into account that not all operating mode transitions are possible (see Section 4.3.1.).

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Send any value inside valid range

REMOTE COMMUNICATION

**4.3 Laser Operating Mode Commands**

The operating modes of the COMPex*Pro* are changed and called through OPMODE commands (abbreviation for “OPerating MODE“). In most cases, a change of operating mode will not influence the settings of the parameters.

Operating modes are changed by the “OPMODE=” command.

The current operating mode can be requested through the polling command “OPMODE?”. The reply contains the operating mode, followed by one or more status codes (see Section 4.3.3 on page 35).

**4.3.1 Overview of Operating Modes**

The available operating modes are listed alphabetically in the following table. The access “r” (read) indicates operating modes that will be received from the laser controller after sending the OPMODE? polling command. The access “s” (send) indicates commands that are to be sent to the laser controller to enter the corresponding operating mode.

**OPMODE= Access Meaning / Function Accepted Description** CONT s Continue the flushing procedure

with a leak test

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FLUSHING CONT active

Section 4.3.2.14

ENERGY CAL r/s Routine for calibrating the

energy monitor

always Section 4.3.2.18

ENERGY CAL CONT r Calibration value ready - FLUSH <xy> LINE r/s Evacuate the <xy> gas line for

two seconds

OFF mode onlya Section 4.3.2.15

FLUSHING r/s Evacuate the laser tube and fill it

with an inert gas to enable the optics to be exchanged

OFF mode onlya Section 4.3.2.13

FLUSHING CONT r Flushing action waiting for

OPMODE=CONT after window exchange

-

FLUSHING LEAKTEST r Leak test being performed during

a flushing action

-

HI r/s Inject gas into the laser tube

(HI, RI)

always Section 4.3.2.4

HI/PGR s Execute a requested gas action gas action

request exists

Section 4.3.2.6

LL OFF s Deactivate the low light function always Section 4.3.2.17 MANUAL FILL INERT r/s Fill the laser tube for 10 seconds

with inert gas

OFF mode onlya Section 4.3.2.12

*(Sheet 1 of 2)*

Laser Operating Mode Commands

**OPMODE= Access Meaning / Function Accepted Description** NEW FILL s Evacuate the laser tube and fill it

OFF mode onlya Section 4.3.2.7 with fresh laser gas NEW FILL,EVAC r New fill in progress, gas

- evacuation phase NEW FILL,FILL r New fill in progress, new gas fill

phase

*(Sheet 2 of 2)*

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-

OFF r/s Switch the laser off always Section 4.3.2.1 OFF,WAIT r Laser is switching to the ON

state

-

ON r/s Switch the laser on to run with the

currently active operating parameters

OFF modeb Section 4.3.2.2

PASSIVATION FILL r/s Evacuate the laser tube and fill it

with a gas mixture for tube re- passivation (Halogen / Buffer)

OFF mode onlya Section 4.3.2.8

PGR r/s Exchange part of the laser gas

(PGR, macro PGR)

alwaysc Section 4.3.2.5

PURGE <xy> LINE r/s Evacuate the <xy> gas line for 5

seconds and fill it with inert gas

OFF mode onlya Section 4.3.2.16

PURGE RESERVOIR r/s Evacuate the laser tube and fill it

with inert gas for purging

OFF mode onlya Section 4.3.2.9

SAFETY FILL r/s Fill the laser tube with inert gas in

case of a leak

OFF mode onlya Section 4.3.2.10

SKIP s Interrupt the warm-up phase alwaysd Section 4.3.2.3 TRANSPORT FILL r/s Evacuate the laser tube and fill it

with buffer gas (Neon) for transport

OFF mode onlya Section 4.3.2.11

a. Ignored if any other gas action is already in progress b. Ignored if an interlock condition is pending or a gas action is in progress c. If OPMODE=ON is active, pulse triggering is switched off for the duration of the action d. Ignored if the laser is not in the warm up period

REMOTE COMMUNICATION

**4.3.2 Description of Operating Modes**

This chapter describes the various operating modes as well as the commands that are to be used to change the mode and poll the current status.

**4.3.2.1 OPMOFE=OFF**

Syntax:

Setting: OPMODE=OFF Polling: OPMODE? Reply: OPMODE=OFF,aa

OPMODE=OFF,WAIT,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35) WAIT During laser start-up: the laser waits for power supply

standby and the gas circulation fan to start (duration: approx. 5 seconds)

In this mode the laser device is switched on and the laser controller is active. The high voltage power supply and pulse triggering is off. No gas action is in progress.

OPMODE=OFF is activated:

– automatically after switching on the laser device,

– from OPMODE=ON, when OPMODE=OFF is sent to switch off the

laser,

– automatically after an interlock.

When OPMODE=OFF is active, laser operation can be started and maintenance actions can be executed.

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Laser Operating Mode Commands

**4.3.2.2 OPMODE=ON**

Syntax:

Setting: OPMODE=ON Polling: OPMODE? Reply: OPMODE=ON,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35)

In this mode the laser is switched on. Light pulses will be generated and emitted according to the currently active laser parameters.

OPMODE=ON will be accepted in any mode. It will, however, be ignored if an interlock condition is pending or a gas action is in progress.

**4.3.2.3 OPMODE=SKIP**

Syntax:

Setting: OPMODE=SKIP

After initially switching on the laser device (mains on), the laser enters a warm-up period that normally has to elapse before laser emission can be started. OPMODE=SKIP terminates the warm-up period. If, however, the warm-up period is skipped, the laser will not optimally perform (missing pulses or no pulses!).

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**4.3.2.4 OPMODE=HI**

Syntax:

Setting: OPMODE=HI Polling: OPMODE? Reply: OPMODE=HI,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35)

In this mode a HI (*H*alogen *I*njection), RI (*R*are *I*njection) or MHI (*m*acro *H*alogen *I*njection) is carried out to refreshen the laser gas. The partial pressure of the gas to be injected is indicated in the gas menu. OPMODE=HI will be accepted in any mode. The command will, however, not be executed if an interlock inhibits gas actions.

**4.3.2.5 OPMODE=PGR**

Syntax:

Setting: OPMODE=PGR Polling: OPMODE? Reply: OPMODE=PGR,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35)

The software LCS 2.29 does not support this operating mode!

In this mode a PGR (*P*artial *G*as *R*eplacement) is carried out to refreshen the laser gas. A portion of the gas in the laser tube is replaced by fresh gas. The partial pressure of the gases to be filled is indicated in the gas menu.

OPMODE=PGR will be accepted in any mode. The command will, however, not be executed if an interlock inhibits gas actions. If OPMODE=ON is active, triggering will be suspended and the HV power supply will be switched off before starting the PGR. When the PGR has been completed, the HV power supply will be switched on again and triggering will resume.

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Laser Operating Mode Commands

**4.3.2.6 OPMODE=HI/PGR**

Syntax:

Setting: OPMODE=HI/PGR

The software LCS 2.29 does not support this operating mode!

This mode will execute the required gas action (PGR or macro PGR) when the corresponding gas action request is received (the currently active operating mode is appended by status code 104). The gas action request occurs according to the algorithms specified in the laser control software.

Depending on the laser control software setting, gas actions will either be carried out automatically or a request for a gas action will be output:

– If the HI/PGR entry is set to AUTO, the required gas action will be carried out automatically and immediately. The user does not have to send OPMODE=HI/PGR. This choice may, however, cause unwanted interruptions in automated laser processing sequences as no laser pulses can be triggered when the PGR or macro PGR is in progress.

– If the HI/PGR entry is set to REQUEST (default setting), the user

can choose the exact timing of the gas action. OPMODE=HI/PGR has to be sent within a specified period of time of the request to perform the required gas action (status code 104). When the setting command is not sent within the specified period, the “PGR request timeout” interlock is triggered (OPMODE=OFF,63). The default setting for the maximum period that can elapse between the HI/PGR request and the command to trigger the HI/PGR is 10 minutes. This period can be amended by changing the corresponding setting in the gas action table. Alternatively, the “HI/ PGR request timeout” interlock can be completely deactivated by setting the “PGR action” parameter in the gas setting table to DISABLE. In this case, the laser will only perform remotely triggered PGRs.

OPMODE=HI/PGR will only be accepted if a PGR request or macro PGR request is present. If OPMODE=ON is active, sending OPMODE=HI/PGR will suspend triggering and switch off the HV power supply before starting the PGR or macro PGR. When the PGR or macro PGR has been completed, the HV power supply will be switched on again and triggering will resume.

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**4.3.2.7 OPMODE=NEW FILL**

Syntax:

Setting: OPMODE=NEW FILL Polling: OPMODE? Reply: OPMODE=NEW FILL,EVAC,aa

OPMODE=NEW FILL,FILL,aa

Syntax Description:

EVAC Laser tube is being evacuated FILL Laser tube is being filled with fresh gas aa Status code (see Section 4.3.3 on page 35)

In this mode the laser tube is evacuated and filled with fresh laser gases.

OPMODE=NEW FILL is only accepted when OPMODE=OFF is active. It will be ignored if any other gas action is already in progress.

**4.3.2.8 OPMODE=PASSIVATION FILL**

This function fills the laser tube with up to ten times the usual concentration of halogen gas. For safety reasons, only authorized and correspondingly trained service personnel shall have access to this function (please refer to the Service Manual for further information).

Syntax:

Setting: OPMODE=PASSIVATION FILL Polling: OPMODE? Reply: OPMODE=PASSIVATION FILL,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35)

In this mode the laser tube is evacuated and filled with halogen and buffer gas so that the tube can be re-passivated.

OPMODE=PASSIVATION FILL is only accepted when OPMODE=OFF is active. It will be ignored if any other gas action is already in progress.

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Laser Operating Mode Commands

**4.3.2.9 OPMODE=PURGE RESERVOIR**

Syntax:

Setting: OPMODE=PURGE RESERVOIR Polling: OPMODE? Reply: OPMODE=PURGE RESERVOIR,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35)

In this mode the laser tube is evacuated and filled (purged) with inert gas.

OPMODE=PURGE RESERVOIR is only accepted when OPMODE=OFF is active. It will be ignored if any other gas action is already in progress.

**4.3.2.10 OPMODE=SAFETY FILL**

Syntax:

Setting: OPMODE=SAFETY FILL Polling: OPMODE? Reply: OPMODE=SAFETY FILL,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35)

This mode is started automatically by the laser controller when the permissible period for the evacuation of the laser tube is exceeded (30 mbar is not reached within 11.5 minutes). The laser tube is filled to 1050 mbar with the gas connected to the ”Buffer“ connection (Neon).

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**4.3.2.11 OPMODE=TRANSPORT FILL**

Syntax:

Setting: OPMODE=TRANSPORT FILL Polling: OPMODE? Reply: OPMODE=TRANSPORT FILL,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35)

In this mode the laser tube is evacuated and filled for transport or storage to 1050 mbar with the gas connected to the ”Buffer“ connection (Neon). If no gas is connected to the ”Buffer“ connection, the laser tube will be automatically filled with the gas connected to the “Inert” connection.

OPMODE=TRANSPORT FILL is only accepted when OPMODE=OFF is active. It will be ignored if any other gas action is already in progress.

**4.3.2.12 OPMODE=MANUAL FILL INERT**

Syntax:

Setting: OPMODE=MANUAL FILL INERT Polling: OPMODE? Reply: OPMODE=MANUAL FILL INERT, aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35)

In this mode inert gas will be filled into the laser tube for 10 seconds. This is only possible up to a tube pressure of 3000 mbar.

OPMODE=MANUAL FILL INERT is only accepted when OPMODE=OFF is active. It will be ignored if any other gas action is already in progress.

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Laser Operating Mode Commands

**4.3.2.13 OPMODE=FLUSHING**

Syntax:

Setting: OPMODE=FLUSHING Polling: OPMODE? Reply: OPMODE=FLUSHING,aa

OPMODE=FLUSHING CONT,aa OPMODE=FLUSHING LEAKTEST,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35) CONT The flushing routine has been stopped to allow the optics

to be exchanged. The routine is continued by sending OPMODE=CONT (see Section 4.3.2.14) LEAKTEST Leak test being performed after exchanging the windows

This routine is required to exchange the tube optics. The laser tube is evacuated and filled to 1050 mbar with inert gas. After exchanging the optics, a leak test is carried out and the laser tube is then filled with fresh laser gas.

OPMODE=FLUSHING is only accepted when OPMODE=OFF is active. It will be ignored if any other gas action is already in progress.

**4.3.2.14 OPMODE=CONT**

Syntax:

Setting: OPMODE=CONT

The flushing routine automatically stops whenever user intervention is required (see Section 4.3.2.13). OPMODE=CONT continues the flushing routine after exchanging the optics and successfully completing the leak test. OPMODE=CONT is only accepted when OPMODE=FLUSHING CONT is active.

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**4.3.2.15 OPMODE=FLUSH <XY> LINE**

Syntax:

Setting: OPMODE=FLUSH <XY> LINE Polling: OPMODE? Reply: OPMODE=FLUSH <XY> LINE,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35) <XY> Name of a gas line (BUFFER, HALOGEN, INERT or

RARE)

In this mode the selected gas line will be evacuated for two seconds.

OPMODE=FLUSH <XY> LINE is only accepted when OPMODE=OFF is active. It will be ignored if any other gas action is already in progress.

Example: Evacuating the halogen gas line

OPMODE=FLUSH HALOGEN LINE<CR> OPMODE?<CR> OPMODE=FLUSH HALOGEN LINE,0<CR>

**4.3.2.16 OPMODE=PURGE <XY> LINE**

**Syntax:**

Setting: OPMODE=PURGE <XY> LINE Polling: OPMODE? Reply: PURGE <XY> LINE,aa

**Syntax Description:**

aa Status code (see Section 4.3.3 on page 35) <XY> Name of a gas line (BUFFER, HALOGEN, INERT or

RARE)

In this mode the selected gas line will be evacuated for five seconds and then filled for two seconds with inert gas.

OPMODE=PURGE <XY> LINE is only accepted when OPMODE=OFF is active. It will be ignored if any other gas action is already in progress.

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Example: Purging the halogen gas line

OPMODE=PURGE HALOGEN LINE<CR> OPMODE?<CR> OPMODE=PURGE HALOGEN LINE,0<CR>

**4.3.2.17 OPMODE=LL OFF**

Syntax:

Setting: OPMODE=LL OFF

This mode deactivates the Low Light function. When the Low Light function is active (default choice), laser operation is interrupted when more than 30% of laser pulses are missing within a 10 second period. The Low Light OFF function (OPMODE=LL OFF) will not interrupt laser operation when there are missing pulses and should, therefore, only be used for diagnostic purposes.

OPMODE=LL OFF is a one shot command. After setting LL OFF, the Low Light function will be deactivated for the next laser operation started through OPMODE=ON. When this laser operation is terminated through OPMODE=OFF, OPMODE=LL OFF will be automatically cancelled. The Low Light function (default choice) will be automatically active for the following laser operation started through OPMODE=ON.

**4.3.2.18 OPMODE=ENERGY CAL**

Syntax:

Setting: OPMODE=ENERGY CAL Polling: OPMODE? Reply: OPMODE=ENERGY CAL,aa

OPMODE=ENERGY CAL CONT,aa

Syntax Description:

aa Status code (see Section 4.3.3 on page 35) CONT The routine waits for the input of a reference energy

through the command ”EGY=“ (see Section 4.4.3.2) or „EGY SET=“ (see Section 4.4.3.3)

This mode controls the internal energy monitor calibration routine.

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The functional sequence of the routine when controlling the laser device through an external PC is indicated in Figure 10. The steps are indicated in the rectangles, the necessary commands are written in capital letters next to the corresponding steps.

OPMODE=ENERGY CAL will be accepted in any mode. It will, however, be ignored if an interlock condition is pending or a gas action is in progress.

***Figure 10:*** *Calibrating the energy monitor*

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Laser Operating Mode Commands

**4.3.3 Status Codes**

One or more of the status codes indicated in this section will always be sent as attachment to an operating mode returned to the OPMODE? polling command. Status codes are values with up to three digits.

The table below lists the available status codes. Depending on the configuration of the laser device, some of the listed codes may not apply. Missing status code numbers are reserved for other laser devices or future use.

Interlocks will only be cleared when sending a valid operating mode, e.g. OFF. Warnings will automatically be cleared when the checked parameter is within its limit or the corresponding signal is detected. **PStatus Code**

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**Typea Meaning**

0 -- No message, warning or interlock active 2 Interlock (sw) Preset energy too high 6 Interlock (sw) Tube pressure out of range 10 Interlock (hw) Tube temperature too high 11 Interlock (hw) Ventilation motor failed 16 Interlock (hw) Remote interlock switch is open 18 Interlock (hw) HV power supply error 21 Warning Thyratron warm-up 23 Warning No gas flow 25 Warning Preset energy too low 26 Interlock (sw) Low light 27 Interlock (sw) No gas flow 30 Interlock (sw) Configuration error detected (no valid set of

parameters can be loaded from FRAM) 31 Interlock (sw) Reboot required (after tube temperature or

pulser temperature interlock) 32 Warning No vacuum (set time period to evacuate laser

tube to set point pressure exceeded) 42 Interlock (hw) Service panel (cover 1) open 46 Interlock (hw) Liquid leak detected 49 Interlock (hw) HV power supply temperature too high 51 Warning Internal gas purifier error 54 Interlock (sw) No external trigger signal detected (time out,

set time between two successive external trigger pulses exceeded) 62 Interlock (sw) Halogen filter exchange required (halogen filter

filling capacity has been exceeded) 63 Interlock (sw) HI/PGR request time outb 64 Warning Tube temperature too high 69 Warning Check safety relay

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**Status**

**Typea Meaning Code**

89 Warning Preset energy too high 95 Interlock (sw) Max. power (calculated power exceeds max.

power parameter) 103 Warning Halogen filter exchange required soon 104 Warning HI/PGR request (the gas action algorithm

indicates that a gas action is required)b 106 Interlock (hw) Pulser temperature too high 120 Interlock (hw) Front mirror access panel (cover 2) open 121 Interlock (hw) Rear mirror access panel (cover 3) open 122 Interlock (hw) Safety control module off 123 Warning Tube pressure too high 124 Warning Tube pressure too low 125 Interlock (sw) Tube temperature too high 126 Warning Leak test failed 127 Interlock (sw) Communication time out (no communication

through serial interface within set time period) 128 Interlock (sw) Tube pressure sensor failed (reading outside of

the parameter range) 130 Interlock (sw) Tube temperature sensor failed (reading

outside of the parameter range) 131 Warning HV power supply temperature 157 Interlock (sw) Gas action time out (gas action not completed

within set time period) 182 Interlock (sw) Gas mismatch (gas mixture does not

correspond with current menu or tube flushing, transport fill, safety fill or passivation fill has been carried out) 220 Interlock (sw) Watchdog error (fatal error) 221 Interlock (sw) External gas failure 223 Warning Tube pressure max. 224 Interlock (sw) Tube pressure max.

*(Sheet 2 of 2)* a. hw = hardware, sw = software b. LCS version 2.29 does not support HIs/PGRs

**Status After Warnings and Interlocks:**

A *Warning* generally indicates a condition that will cause an interlock if no corrective measures are taken. The status of the currently active operating mode is not changed.

A *Software Interlock* will always change the operating mode to OPMODE=OFF. In most cases, started gas actions will be aborted.

A *Hardware Interlock* will always change the operating mode to OPMODE=OFF. In most cases, the HV power supply will also be shut down and started gas actions will be aborted.

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Parameter Commands

**4.4 Parameter Commands**

To set or change laser operating parameters, parameter commands are used.

Parameter settings are changed by the “*name*=” command (with *name* as the parameter name). The available parameter setting commands are listed in the overview in Section 4.4.1. Each command is described in more detail in the corresponding section indicated in the right column of the table.

The current parameter setting can be requested at any time through the polling command “*name*?”. The reply contains the parameter name, followed by one or more settings. The available parameter setting commands are listed in the overview in Section 4.4.2. Each command is described in more detail in the corresponding section indicated in the right column of the table.

**4.4.1 Overview of Setting Commands**

**Command Name Command Setting Unit Further Information**

BSTPAUSE= XXXXX ms Section 4.4.4.4

BSTPULSES= XXXXX pulses Section 4.4.4.3

BUFFER= XXXX mbar Section 4.4.5.2

COD= ON - Section 4.4.6.1

OFF -

COUNTER= RESET - Section 4.4.7.1

COUNTER E3= RESET - Section 4.4.7.2

COUNTERMAINT.= RESET - Section 4.4.7.3

COUNTS= XXXXXXX pulses Section 4.4.4.7

EGY= XX.XX mJ Section 4.4.3.2

EGYSET= XX.XX mJ Section 4.4.3.3

FANCTRL= ON - Section 4.4.6.2

OFF -

FILTER= XX 1/10 second Section 4.4.8.1

FILTERCONTAMINATION= RESET - Section 4.4.8.2

HALOGEN= XXXX mbar Section 4.4.5.3

HV= XX.XX kV Section 4.4.3.4

INERT= XXXX mbar Section 4.4.5.4

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**Command Name Command Setting Unit Further Information**

MENU= RESET - Section 4.4.5.1

X -

MODE= EGY NGR - Section 4.4.3.1

EGY PGR -

EGYBURST NGR -

EGYBURST PGR -

HV NGR -

HV PGR -

RARE= XXXX mbar Section 4.4.5.5

REPRATE= XXX Hz Section 4.4.4.2

SEQBST= XXXXX bursts Section 4.4.4.5

SEQPAUSE= XXXXX ms Section 4.4.4.6

SYSDATE= XX.XX.XX - Section 4.4.9.1

SYSTIME= XX:XX:XX - Section 4.4.9.2

TEMP CONTROL ON - Section 4.4.6.3

OFF -

TIMEOUT ON - Section 4.4.6.4

OFF -

TRIGGER= EXT - Section 4.4.4.1

EXT COUNTS -

INT -

INTB -

INT COUNTS -

INTG -

*(Sheet 2 of 2)*

Except for HV=XX.XX, parameter setting commands are accepted in all operating modes and with any other parameter active. HV=XX.XX is only accepted if MODE=HV NGR or MODE=HV PGR is active.

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**4.4.2 Overview of Polling Commands**

**Polling Command Possible Replies Unit Further Information**

BSTPAUSE? BSTPAUSE=XXXXX ms Section 4.4.4.4

BSTPULSES? BSTPULSES=XXXXX pulses Section 4.4.4.3

BUFFER? BUFFER=XXXX mbar Section 4.4.5.2

COD? COD=ON - Section 4.4.6.1

COD=OFF -

COUNTER? COUNTER=XXXXXXXXX pulses Section 4.4.7.1 COUNTER E3? COUNTER=XXXXXXXXX 103 pulses Section 4.4.7.2

COUNTERMAINT.? COUNTERMAINT=XXXXXXXXX pulses Section 4.4.7.3

COUNTER NEW FILL? COUNTER NEW FILL=XXXXXXXXX pulses Section 4.4.7.8

COUNTER TOTAL? COUNTER TOTAL=XXXXXXXXX pulses Section 4.4.7.4 COUNTER TOTAL E3? COUNTER TOTAL E3=XXXXXXXXX 103 pulses Section 4.4.7.5

COUNT NEW FILL? COUNT NEW FILL=XXXXXXXXX pulses Section 4.4.7.8

COUNTS? COUNTS=XXXXXXX pulses Section 4.4.4.7

EGY? EGY=XX.XX mJ Section 4.4.3.2

EGYSET? EGYSET=XX.XX mJ Section 4.4.3.3

FANCTRL? FANCTRL=ON - Section 4.4.6.2

FANCTRL=OFF -

FILTER? FILTER=XX 1/10 second Section 4.4.8.1

FILTERCONTAMINATION? FILTERCONTAMINATION=XXX % Section 4.4.8.2

HALOGEN? HALOGEN=XXXX mbar Section 4.4.5.3

HICOUNT? HICOUNT=XXXXX actions Section 4.4.7.6

HV? HV=XX.XX kV Section 4.4.3.4

ID ID=L,text,XX.XX,XX.XX,text - Section 4.4.9.3

INERT? INERT=XXXX mbar Section 4.4.5.4

INTERLOCK? INTERLOCK=NONE - Section 4.4.8.3

INTERLOCK=XXX -

MAINTENANCE? MAINTENANCE=X - Section 4.4.8.4

MENU? MENU=X,text - Section 4.4.5.1

*(Sheet 1 of 2)*

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**Polling Command Possible Replies Unit Further Information**

MODE? MODE=EGY NGR - Section 4.4.3.1

MODE=EGY PGR -

MODE=EGYBURST NGR -

MODE=EGYBURST PGR -

MODE=HV NGR -

MODE=HV PGR -

NF COUNT? COUNTER NEW FILL=XXXXXXXXX pulses Section 4.4.7.8

OPMODE? See Section 4.3 on page 22

PGR COUNT? PGR COUNT=XXXXX actions Section 4.4.7.7

PRESSURE? PRESSURE=XXXX mbar Section 4.4.8.6

RARE? RARE=XXXX mbar Section 4.4.5.5

RESERVOIR TEMP? RESERVOIR TEMP=XX.X °C Section 4.4.8.5

REPRATE? REPRATE=XXX Hz Section 4.4.4.2

SEQBST? SEQBST=XXXXX bursts Section 4.4.4.5

SEQPAUSE? SEQPAUSE=XXXXX ms Section 4.4.4.6

SERIALNUMBER? SERIALNUMBER=text - Section 4.4.9.4

SYSDATE? SYSDATE=XX.XX.XX - Section 4.4.9.1

SYSTIME? SYSTIME=XX:XX:XX - Section 4.4.9.2

TEMP CONTROL? TEMP CONTROL=ON - Section 4.4.6.3

TEMP CONTROL=OFF -

TIME? TIME=0 - Section 4.4.8.7

TIME=XXX secs.

TIMEOUT? TIMEOUT=ON - Section 4.4.6.4

TIMEOUT=OFF -

TOTAL COUNTER? TOTAL COUNTER=XXXXXXXXX pulses Section 4.4.7.4

TRIGGER? TRIGGER=EXT - Section 4.4.4.1

TRIGGER=EXT COUNTS

TRIGGER=INT -

TRIGGER=INTB -

TRIGGER=INT COUNTS -

TRIGGER=INTG -

TUBETEMP? TUBE TEMP=XX.X °C Section 4.4.8.5

TYPEOFLASER? TYPEOFLASER=text - Section 4.4.9.5

VERSION? VERSION=X.XX - Section 4.4.9.6

*(Sheet 2 of 2)*

All polling commands are accepted at all times.

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**4.4.3 Energy Management Parameters**

For additional information about fundamental energy management of the excimer laser device, please refer to the “Fundamentals” chapter of the User Manual.

**4.4.3.1 MODE**

Syntax:

Setting: MODE=*mode* Polling: MODE? Reply: MODE=*mode*

Syntax Description:

*mode* EGY NGR, EGY PGR, EGYBURST NGR,

EGYBURST PGR, HV NGR or HV PGR

This parameter specifies the laser running mode:

– EGY NGR indicates laser operation in the constant energy mode

without gas actions (constant *E*ner*GY*, *N*o *G*as *R*eplacements).

When MODE=EGY NGR is active, the laser runs at the pulse output energy specified through the parameter EGY (see Section 4.4.3.2). To compensate for the deterioration in the excimer laser gas, the HV is continuously increased. When the HV has reached a given level, a message appears indicating that the gas in the laser tube requires replacing.

– EGY PGR indicates laser operation in the constant energy mode

with gas actions (constant *E*ner*GY*, *P*artial *G*as *R*eplacements).

When MODE=EGY PGR is active, the laser runs at the pulse output energy specified through the parameter EGY (see Section 4.4.3.2). To compensate for the deterioration in the excimer laser gas, the HV is continuously increased. When the HV reaches a preset replacement value, the gas in the laser tube is replenished and the HV value is correspondingly reduced.

The gas replenishment action (Halogen Injection, macro Halogen Injection, Rare Injection, Partial Gas Replacement or Macro Partial Gas Replacement) occurs according to the gas replenishment algorithms defined in the laser control software. Depending on the HI/PGR entry in the configuration file, the gas replenishment action will either occur immediately (AUTO setting) or the laser control software will request that the gas action is performed within a preset time period (REQUEST setting). In case of a request, the command OPMODE=HI/PGR will cause the gas action to be performed (see Section 4.3.2.6 on page 27).

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– EGYBURST NGR indicates operation in the energy burst mode

without gas replenishment actions (constant *E*ner*GY BURST*, *N*o *G*as *R*eplacements). This function is only available if the laser device is equipped with the optional POWERLOK function.

The energy burst mode without gas actions operates similarly to the constant energy mode without gas actions (see EGY NGR above). Additionally, the optional POWERLOK function is activated to minimize power overshoots at the beginning of each burst of laser pulses.

– EGYBURST PGR indicates operation in the energy burst mode

with gas replenishment actions (constant *E*ner*GY BURST*, *P*artial *G*as *R*eplacements).This function is only available if the laser device is equipped with the optional POWERLOK function.

The energy burst mode with gas actions operates similarly to the constant energy mode with gas actions (see EGY PGR above). Additionally, the optional POWERLOK function is activated to minimize power overshoots at the beginning of each burst of laser pulses.

– HV NGR indicates laser operation in the constant high voltage (HV)

mode without gas actions (constant *HV*, *N*o *G*as *R*eplacements).

When MODE=HV NGR is active, the high voltage remains constant at the value specified through the parameter HV (see Section 4.4.3.4). In the constant HV mode the pulse energy will decrease as the excimer laser gas deteriorates. When the energy has dropped to a given level, a message appears indicating that the gas in the laser tube requires replacing.

– HV PGR indicates laser operation in the constant high voltage (HV)

mode with gas actions (constant *HV*, *P*artial *G*as *R*eplacements).

When MODE=HV PGR is active, the high voltage remains constant at the value specified through the parameter HV (see Section 4.4.3.4). In the constant HV mode the pulse energy will decrease as the excimer laser gas deteriorates. To compensate for the decreases in energy, pulse counter controlled and/or timer controlled gas actions are performed.

The gas replenishment action (Halogen Injection, macro Halogen Injection, Rare Injection, Partial Gas Replacement or Macro Partial Gas Replacement) occurs according to the gas replenishment algorithms defined in the laser control software. Depending on the HI/PGR entry in the configuration file, the gas replenishment action will either occur immediately (AUTO setting) or the laser control software will request that the gas action is performed within a preset time period (REQUEST setting). In case of a request, the command OPMODE=HI/PGR will cause the gas action to be performed (see Section 4.3.2.6 on page 27).

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**4.4.3.2 EGY**

Syntax:

Setting: EGY=XXX.XX Polling: EGY? Reply: EGY=XXX.XX

Syntax Description:

Variable decimal, max. 3 places before and 2 places after decimal

point Unit mJ Range *For energy set point*:

≥ 0.1 × [max. energy set point] ≤ [max. energy set point] *For calibration value*: ≥ 0.2 × [max. energy set point] ≤ 2 × [max. energy set point] Increment 0.01 mJ

The exact function and meaning of this parameter depends on the currently active operating mode:

– In all modes except OPMODE=ENERGY CAL, the setting

command EGY=XXX.XX specifies the pulse energy set point, i.e. the energy of each pulse at which the laser is to be stabilized. The value defined through EGY=XXX.XX is effective in conjunction with the energy constant modes (MODE=EGY NGR or MODE=EGY PGR) and burst modes (MODE=EGYBURST NGR or MODE=EGYBURST PGR).

– In OPMODE=ON, the polling command reply EGY=XXX.XX

indicates the current average energy value.

– In OPMODE=OFF, the polling command reply EGY=XXX.XX indicates the current energy set point for the constant energy mode.

– In OPMODE=ENERGY CAL, the setting command EGY=XXX.XX

specifies the energy value for calibration. If the value is accepted (within range), the laser switches to OPMODE=OFF and the calibration value is saved.

– In OPMODE=ENERGY CAL, the polling command reply

EGY=XXX.XX indicates the raw average value of the energy sensor.

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**4.4.3.3 EGYSET**

Syntax:

Setting: EGYSET=XXX.XX Polling: EGYSET? Reply: EGYSET=XXX.XX

Syntax Description:

Variable decimal, max. 3 places before and 2 places after decimal

point Unit mJ Range ≥ 0.1 × [max. energy set point]

≤ [max. energy set point] Increment 0.01 mJ

This parameter indicates the pulse energy set point, i.e. the energy of each pulse at which the laser is to be stabilized. It is similar to EGY except that the function of EGYSET does not change according to the currently active operating mode.

**4.4.3.4 HV**Syntax:

Setting: HV=XX.XX Polling: HV? Reply: HV=XX.XX

Syntax Description:

Variable decimal, max. 2 places before and after decimal point Unit kV Range ≥ [HV minimum] for HV constant mode

≤ [HV maximum] for HV constant mode Increment 0.01 kV

This parameter specifies the charging voltage (HV power supply module). The setting command HV=XX.XX is only effective in conjunction with the HV constant modes (MODE=HV NGR or MODE=HV PGR).

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**4.4.4 Pulse Trigger Parameters**

For additional information about the fundamental laser triggering modes, please refer to the “Fundamentals” chapter of the User Manual.

**4.4.4.1 TRIGGER**

Syntax:

Setting: TRIGGER=*mode* Polling: TRIGGER? Reply: TRIGGER=*mode*

Syntax Description:

*mode* name of one of the triggering modes:

EXT, EXT COUNTS, INT, INTB, INT COUNTS, INTG

This parameter specifies the trigger source and mode. For additional information about the fundamental laser triggering modes, please refer to the “Fundamentals” chapter of the User Manual.

– EXT indicates external triggering, i.e. the laser pulses are triggered from an external trigger generator connected to the trigger interface on the laser device.

– INT indicates internal triggering, i.e. the laser pulses are triggered by the laser device’s internal trigger generator at the repetition rate specified through the parameter REPRATE (see Section 4.5.2.5).

The internal trigger generator will trigger a series of pulses without a break. If bursts of pulses are required, activate either

– TRIGGER=INTB and set the burst generator through the

dedicated burst generator functions or – TRIGGER=EXT and use an external trigger generator.

– INTG indicates internal gated triggering, i.e. the laser pulses are

triggered by the laser device’s internal trigger generator at the repetition rate specified through the parameter REPRATE (see Section 4.4.4.2) when a gate signal is received through the external trigger socket on the laser device.

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– INTB indicates triggering with the internal burst generator

according to a predefined burst pattern (see Figure 11).

***Figure 11:*** *Burst pattern*

*Key to Figure 11:*

A Burst length in pulses B Burst pause in milliseconds C Sequence length in bursts D Sequence pause in milliseconds

Before sending TRIGGER=INTB to start internal triggering in the burst mode, always check and, where necessary, change the repetition rate (see Section 4.4.4.2) and set the burst pattern through the following functions:

– BSTPULSES (see Section 4.4.4.3) – BSTPAUSE (see Section 4.4.4.4) – SEQBST (see Section 4.4.4.5) – SEQPAUSE (see Section 4.4.4.6)

– EXT COUNTS indicates external triggering of the amount of trigger

pulses set through the command COUNTS=XXXXXXX (see Section 4.4.4.7).

– INT COUNTS indicates internal triggering of the amount of trigger

pulses set through the command COUNTS=XXXXXXX (see Section 4.4.4.7).

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**4.4.4.2 REPRATE**

Syntax:

Setting: REPRATE=XXX Polling: REPRATE? Reply: REPRATE=XXX

Syntax Description:

Variable integer, max. 3 places Unit Hz Range ≥ 1

≤ 200 Increment 1 Hz

This parameter indicates the repetition rate (rep. rate) at which the laser is running with internal triggering.

When TRIGGER=INT is active, REPRATE=XXX will become active immediately. When TRIGGER=EXT is active, REPRATE=XXX will become immediately active when TRIGGER=INT is next activated.

**4.4.4.3 BSTPULSES**

Syntax:

Setting: BSTPULSES=XXXXX Polling: BSTPULSES? Reply: BSTPULSES=XXXXX

Syntax Description:

Variable integer, max. 5 places Unit pulses Range ≥ 1

≤ 10000 Increment 1 pulse

This parameter indicates the amount of laser pulses in a burst (see Figure 11, A on page 46). The rate at which the pulses are emitted is set through REPRATE (see Section 4.4.4.2). The break between the pauses is set through BSTPAUSE (see Section 4.4.4.4).

The BSTPULSES value will become active when TRIGGER=INTB (see Section 4.4.4.1) is activated.

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**4.4.4.4 BSTPAUSE**

Syntax:

Setting: BSTPAUSE=XXXXX Polling: BSTPAUSE? Reply: BSTPAUSE=XXXXX

Syntax Description:

Variable integer, max. 5 places Unit milliseconds Range ≥ 1

≤ 10000 Increment 1 millisecond

This parameter indicates the length of the break between two bursts of laser pulses (see Figure 11, B on page 46). The amount and frequency of the laser pulses in the burst is defined through BSTPULSES (see Section 4.4.4.3) and REPRATE (see Section 4.4.4.2).

The BSTPAUSE value will become active when TRIGGER=INTB (see Section 4.4.4.1) is activated.

If one of the energy burst modes (EGYBURST NGR, EGYBURST PGR; see Section 4.4.3.1) is active, the optional POWERLOK algorithm may be activated to minimize the inherent power overshoot at the beginning of the each burst.

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**4.4.4.5 SEQBST**

Syntax:

Setting: SEQBST=XXXXX Polling: SEQBST? Reply: SEQBST=XXXXX

Syntax Description:

Variable integer, max. 5 places Unit bursts Range ≥ 1

≤ 10000 Increment 1 burst

This parameter indicates the amount of pulse bursts in a sequence of bursts (see Figure 11, C on page 46). The burst is defined through BSTPULSES (see Section 4.4.4.3), REPRATE (Section 4.4.4.2) and BSTPAUSE (Section 4.4.4.4).

The SEQBST value will become active when TRIGGER=INTB (see Section 4.4.4.1) is activated.

**4.4.4.6 SEQPAUSE**

Syntax:

Setting: SEQPAUSE=XXXXX Polling: SEQPAUSE? Reply: SEQPAUSE=XXXXX

Syntax Description:

Variable integer, max. 5 places Unit milliseconds Range ≥ 1

≤ 10000 Increment 1 millisecond

This parameter indicates the length of the break between two sequences of pulse bursts (see Figure 11, D on page 46). The amount of pulse bursts in a sequence is defined through SEQBST (see Section 4.4.4.5).

The SEQPAUSE value will become active when TRIGGER=INTB (see Section 4.4.4.1) is activated.

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**4.4.4.7 COUNTS**

Syntax:

Setting: COUNTS=XXXXXXX Polling: COUNTS? Reply: COUNTS=XXXXXXX

Syntax Description:

Variable integer, max. 7 places Unit pulses Range ≥ 1

≤ 1000000 Increment 1 pulse

This parameter indicates the value of the reload counter for countdown triggering of the laser.

Countdown triggering is only available when one of the commands TRIGGER=EXT COUNTS or TRIGGER=INT COUNTS is active. COUNTS=XXXXXXX sets the laser to generate a preset number of laser pulses. Trigger pulses will only be accepted until the indicated amount of counts is reached. Following this, the laser will switch to OPMODE=OFF and COUNTS will be reloaded. When OPMODE=ON is reselected, the set number of pulses will be triggered again.

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**4.4.5 Gas Parameters**

**4.4.5.1 MENU**

Syntax:

Setting: MENU=X or MENU=RESET Polling: MENU? Reply: MENU=X,text

Syntax Description:

Variable integer, 1 place Unit – Range ≥ 1 ≤ 6 Increment 1 text text string indicating gas type and gas supply mode

This parameter selects the required gas menu. This menu contains the pressure set points for the individual gases that are to be filled into the laser tube. The six gas menus are factory set according to the version of the laser device (F or Cl) and, consequently, the gas mixtures that the laser can be operated with. The gas menu has to be changed when, for instance, the gas supply mode is changed from single gases to a premix gas. Generally, the menus 1 to 3 are for single gases and the menus 4 to 6 are for premix gases. The F-version has single gas and premix gas menus for ArF, KrF and XeF (six menus). The Cl- version has single gas and premix gas menus for XeCl (two menus).

The reply MENU=X,TTT indicates the currently selected gas menu. The value in front of the comma is the gas menu number and the string after the comma is a description of the gas menu. For example, MENU=2,KrF Single indicates gas menu number 2 for Krypton fluoride operation (248 nm) supplied from single gas cylinders.

If the partial gas pressures have been changed (see Sections 4.4.5.2 to 4.4.5.5), the command MENU=RESET resets the gas pressure set points to the factory settings.

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**4.4.5.2 BUFFER**

Syntax:

Setting: BUFFER=XXXX Polling: BUFFER? Reply: BUFFER=XXXX

Syntax Description:

Variable integer, max. 4 places Unit mbar Range ≥ [min. set point buffer]

≥ [min. total pressure] – ([set point halogen] + [set point rare] + [set point inert]) ≤ [max set point buffer] ≤ [max total pressure] – ([set point halogen] + [set point rare] + [set point inert]) Increment 1 mbar

This parameter indicates the set point in the currently active gas menu for the gas connected to the buffer line.

**4.4.5.3 HALOGEN**

Syntax:

Setting: HALOGEN=XXXX Polling: HALOGEN? Reply: HALOGEN=XXXX

Syntax Description:

Variable integer, max. 4 places Unit mbar Range ≥ [min. set point halogen]

≥ [min. total pressure] – ([set point buffer] + [set point rare] + [set point inert]) ≤ [max set point halogen] ≤ [max total pressure] – ([set point buffer] + [set point rare] + [set point inert]) Increment 1 mbar

This parameter indicates the set point in the currently active gas menu for the gas connected to the halogen line.

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**4.4.5.4 INERT**

Syntax:

Setting: INERT=XXXX Polling: INERT? Reply: INERT=XXXX

Syntax Description:

Variable integer, max. 4 places Unit mbar Range ≥ [min. set point inert]

≥ [min. total pressure] – ([set point buffer] + [set point halogen] + [set point rare]) ≤ [max set point inert] ≤ [max total pressure] – ([set point buffer] + [set point halogen] + [set point rare]) Increment 1 mbar

This parameter indicates the set point in the currently active gas menu for the gas connected to the inert line.

**4.4.5.5 RARE**

Syntax:

Setting: RARE=XXXX Polling: RARE? Reply: RARE=XXXX

Syntax Description:

Variable integer, max. 4 places Unit mbar Range ≥ [min. set point rare]

≥ [min. total pressure] – ([set point buffer] + [set point halogen] + [set point inert]) ≤ [max set point rare] ≤ [max total pressure] – ([set point buffer] + [set point halogen] + [set point inert]) Increment 1 mbar

This parameter indicates the set point in the currently active gas menu for the gas connected to the rare line.

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**4.4.6 Miscellaneous Switching Commands**

**4.4.6.1 COD**

Syntax:

Setting: COD=XXX Polling: COD? Reply: COD=XXX

Syntax Description:

Variable ON or OFF

This parameter defines the status of the Charge on demand (COD) function.

– ON indicates that the COD function is active.

COD=ON is a setting command or reply to the polling command COD? Capacitor charging is specifically triggered by the demand for a laser pulse. In other words, as long as there is no pulse trigger signal, the HV is switched off and the capacitors remain uncharged. When a laser pulse is needed, a trigger signal enables the power supply to charge the storage capacitors. When the storage capacitors have been charged, the thyratron is triggered, the laser emits a single pulse and the HV is switched off again. This prevents laser pulses being emitted without the input of a trigger signal (self- firing).

When the laser is operating in the COD mode, the delay between the trigger signal and the laser pulse is significantly increased (see Section 3.4.3 on page 16). With certain laser device versions, this delay will vary depending on the currently active running mode and repetition rate.

To prevent malfunctioning, a COD status change (e.g. COD=OFF to COD=ON) will only be accepted when OPMODE=OFF is active.

– OFF indicates that the COD function is inactive.

The capacitors are automatically charged after the previous discharge. Without COD, the delay between the trigger pulse and laser pulse is minimized. There is, however, an increased risk of self-firing.

To prevent malfunctioning, a COD status change (e.g. COD=ON to COD=OFF) will only be accepted when OPMODE=OFF is active.

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**4.4.6.2 FANCTRL**

Syntax:

Setting: FANCTRL=XXX Polling: FANCTRL? Reply: FANCTRL=XXX

Syntax Description:

Variable ON or OFF

This parameter defines the status of the gas circulation fan when OPMODE=OFF is active.

– ON indicates that the gas circulation fan is to stay on when

OPMODE=OFF is active.

– OFF indicates that the gas circulation fan is to be switched off when

OPMODE=OFF is active.

**4.4.6.3 TEMP CONTROL**

Syntax:

Setting: TEMP CONTROL=XXX Polling: TEMP CONTROL? Reply: TEMP CONTROL=XXX

Syntax Description:

Variable ON or OFF

This function only applies if the laser device is equipped with the automatic temperature regulation option. It defines the status of the tube temperature measurement function.

– ON indicates that the tube temperature measurement function is

enabled. TEMP CONTROL=ON is the default choice when the laser device is initially powered up.

– OFF indicates that the tube temperature measurement function is

disabled.

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**4.4.6.4 TIMEOUT**

Syntax:

Setting: TIMEOUT=XXX Polling: TIMEOUT? Reply: TIMEOUT=XXX

Syntax Description:

Variable ON or OFF

This parameter defines the status of the serial interface time out function.

– ON indicates that the serial interface time out function is active.

This monitors the flow of data through the serial interface to detect any interruptions in the communication between the laser device and handheld keypad or remote control computer system. If no communication occurs through the serial interface for a specific period of time, an interlock (status code 127) will shut down the laser.

When TIMEOUT=ON is active, there should be continuous communication through the RS232 interface. Where necessary, program the remote computer system with continuous requests to ensure that communication with the laser device is not interrupted resulting in the laser device being unexpectedly switched off.

– OFF indicates that the serial interface time out function is not

active. TIMEOUT=OFF is the default choice when the laser device is initially powered up.

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Parameter Commands

**4.4.7 Counters**

To allow scheduled gas actions and maintenance activities to be effectively coordinated with fabrication cycles, various counters and timers are incorporated into the laser control software. These either count a number of pulses or events or count a period of time to or from a particular event. One of the pulse counters is user-resettable.

**4.4.7.1 COUNTER**

Syntax:

Setting: COUNTER=RESET Polling: COUNTER? Reply: COUNTER=XXXXXXXXX

Syntax Description:

Variable integer, max. 9 places Unit pulses Range 0 to 232 Increment 1 pulse

This parameter indicates the momentary reading of the user-resettable pulse counter. This counts the number of individual pulses that have been emitted since the counter was last reset through COUNTER=RESET.

**4.4.7.2 COUNTER E3**

Syntax:

Setting: – Polling: COUNTER E3? Reply: COUNTER E3=XXXXXXXXX

Syntax Description:

Variable integer, max. 9 places Unit 103 pulses Range 0 to 232 Increment 103 pulses

This parameter has the same purpose and syntax as COUNTER except that it counts 103 pulses. Due to the limitation of the counters to 232 (4,294,967,296) pulses, higher readings will not be correctly indicated. COUNTER E3 enlarges the number of countable pulses but reduces accuracy as it is not possible to break-down the reading to one individual pulse. COUNTER E3 is reset together with COUNTER.

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**4.4.7.3 COUNTERMAINT.**

Syntax:

Setting: COUNTERMAINT.=RESET Polling: COUNTERMAINT.? Reply: COUNTERMAINT.=XXXXXXXXX

Syntax Description:

Variable integer, max. 9 places Unit pulses Range 0 to 232 Increment 1 pulse

This parameter indicates the momentary reading of the maintenance counter. This counts the number of individual pulses that have been emitted since the counter was last reset through COUNTERMAINT.=RESET.

**4.4.7.4 COUNTER TOTAL**

Syntax:

Setting: – Polling: COUNTER TOTAL? Reply: COUNTER TOTAL=XXXXXXXXX

Syntax Description:

Variable integer, max. 9 places Unit pulses Range 0 to 232 Increment 1 pulse

This parameter indicates the momentary reading of the non-resettable pulse counter. This counter counts the number of individual pulses that have been emitted since the laser was initially commissioned.

The polling command TOTAL COUNTER? has same purpose and reply syntax as COUNTER TOTAL?

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**4.4.7.5 COUNTER TOTAL E3**

Syntax:

Setting: – Polling: COUNTER TOTAL E3? Reply: COUNTER TOTAL E3=XXXXXXXXX

Syntax Description:

Variable integer, max. 9 places Unit 103 pulses Range 0 to 232 Increment 103 pulses

This parameter has the same purpose and syntax as COUNTER TOTAL except that it counts 103 pulses. Due to the limitation of the counters to 232 (4,294,967,296) pulses, higher readings will not be correctly indicated. COUNTER TOTAL E3 enlarges the number of countable pulses but reduces accuracy as it is not possible to break- down the reading to one individual pulse.

**4.4.7.6 HICOUNT**

Syntax:

Setting: – Polling: HICOUNT? Reply: HICOUNT=XXXXXXXXX

Syntax Description:

Variable integer, max. 5 places Unit HI / RI actions Range 0 to 232 Increment 1 HI or RI

This parameter indicates the reading of a counter that counts the number of HI and RI actions that have been carried out since the last new fill. This counter is automatically reset to zero by the laser control software when OPMODE=NEW FILL is received.

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**4.4.7.7 PGR COUNT**

Syntax:

Setting: – Polling: PGR COUNT? Reply: PGR COUNT=XXXXXXXXX

Syntax Description:

Variable integer, max. 5 places Unit Macro HI / PGR / Macro PGR actions Range 0 to 232 Increment 1 Macro HI, PGR or Macro PGR

This parameter indicates the reading of a counter that counts the number of macro gas actions (Macro HIs, PGRs and Macro PGRs) that have been carried out since the last new fill. This counter is automatically reset to zero by the laser control software when OPMODE=NEW FILL is received.

**4.4.7.8 COUNTER NEW FILL**

Syntax:

Setting: – Polling: COUNTER NEW FILL? Reply: COUNTER NEW FILL=XXXXXXXXX

Syntax Description:

Variable integer, max. 9 places Unit pulses Range 0 to 232 Increment 1 pulse

This parameter indicates the reading of a counter that counts the number of individual pulses that have been emitted since the excimer laser gas in the laser tube was last exchanged. This counter is automatically reset to zero by the laser control software when OPMODE=NEW FILL is received.

The polling commands COUNT NEW FILL? and NF COUNT? have the same purpose and reply syntax as COUNTER NEW FILL?

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Parameter Commands

**4.4.8 System Status Parameters**

**4.4.8.1 FILTER**

Syntax:

Setting: FILTER=XX Polling: FILTER? Reply: FILTER=XX

Syntax Description:

Variable integer, max. 2 places Unit 1/10 second Range 00 and

≥ 01 ≤ 99 Increment 1/10 second

This parameter indicates the time period during which the average energy is to be calculated. For instance, FILTER=50 indicates that the average energy is to be calculated over a period of 5 seconds. The default is FILTER=10 (1 second). If no filter is required, FILTER=00 has to be set.

**4.4.8.2 FILTERCONTAMINATION**

Syntax:

Setting: FILTERCONTAMINATION=RESET Polling: FILTERCONTAMINATION? Reply: FILTERCONTAMINATION=XXX

Syntax Description:

Variable integer, max. 3 places Unit % Range ≥ 0

≤ 100 Increment 1 %

This parameter indicates the filling level of the halogen filter. The setting command FILTERCONTAMINATION=RESET resets the halogen filter saturation indicator to 0.

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**4.4.8.3 INTERLOCK**

Syntax:

Setting: – Polling: INTERLOCK? Reply: INTERLOCK=NONE or INTERLOCK=XXX[,XXX,...]

Syntax Description:

Variable integer, max. 3 places Unit – Range see Section 4.3.3 on page 35

This parameter indicates the codes of the currently active interlocks. If more than one interlock is active, the individual codes are separated by a comma. The meaning of each code is indicated in Section 4.3.3.

If no interlocks are active, the reply INTERLOCK=NONE is returned.

**4.4.8.4 MAINTENANCE**

Syntax:

Setting: – Polling: MAINTENANCE? Reply: MAINTENANCE=X[,X,...]

Syntax Description:

Variable integer, max. 1 place Unit – Range 0 to 4

This parameter indicates the currently active maintenance status code(s). If more than one maintenance status code is active, the individual codes are separated by a comma.

The individual maintenance status codes have the following meaning:

0 No maintenance action required 1 New fill required 2 Maintenance action required 3 Halogen filter contamination counter exceeds 80 % 4 HI/PGR request active

Example: The reply MAINTENANCE=1,3 indicates that the halogen filter contamination exceeds 80% and a new fill is required.

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**4.4.8.5 TUBETEMP**

Syntax:

Setting: – Polling: TUBETEMP? Reply: TUBETEMP=XX.X

Syntax Description:

Variable decimal, max. 1 place after decimal point Unit °C Increment 0.1 °C

This parameter indicates the temperature of the excimer laser gas in the laser tube.

The polling command RESERVOIR TEMP? has same purpose and reply syntax as TUBETEMP?

**4.4.8.6 PRESSURE**

Syntax:

Setting: – Polling: PRESSURE? Reply: PRESSURE=XXXX

Syntax Description:

Variable integer, max. 4 places Unit mbar Increment 1 mbar

This parameter indicates the pressure of the excimer laser gas in the laser tube.

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**4.4.8.7 TIME**

Syntax:

Setting: – Polling: TIME? Reply: TIME=XXX or TIME=0

Syntax Description:

Variable integer, max. 3 places Unit seconds Decrement 1 second

This parameter indicates the remaining time period of the flushing leak test (see Section 4.3.2.13 on page 31). If the command TIME? is sent when the flushing leak test is not in progress, the reply TIME=0 is returned.

**4.4.9 General Information**

**4.4.9.1 SYSDATE**

Syntax:

Setting: SYSDATE=dd.mm.yy Polling: SYSDATE? Reply: SYSDATE=dd.mm.yy

Syntax Description:

Variable 3 x integer with 2 places each, separated by a dot

This parameter indicates the system date setting. This setting will be displayed on the hand-held keypad and entered into system logbook files written by the laser device’s controller.

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**4.4.9.2 SYSTIME**

Syntax:

Setting: SYSTIME=hh:mm:ss Polling: SYSTIME? Reply: SYSTIME=hh:mm:ss

Syntax Description:

Variable 3 x integer with 2 places each, separated by a colon

This parameter indicates the system time setting. This setting will be displayed on the hand-held keypad and entered into system logbook files written by the laser device’s controller.

**4.4.9.3 ID**Syntax:

Setting: – Polling: ID? Reply: ID=L,text,XX.XX,XX.XX,text

Syntax Description:

Variable text string in four main blocks, separated by commas

This parameter describes the laser device.

The first text block (L,text) is a plain language description of the laser device. This is followed by the software version of the laser control software (XX.XX) and the version of the PLD (programmable logical devcice) software (XX.XX). The last text block indicates the serial number of the laser device.

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**4.4.9.4 SERIALNUMBER**

Syntax:

Setting: – Polling: SERIALNUMBER? Reply: SERIALNUMBER=text

Syntax Description:

Variable text string

This parameter indicates the serial number of the laser device. The currently applicable serial number format is GEP.XXXXXXX.XXXXX. (three letter code, followed by seven digit device part number and a five digit running number).

**4.4.9.5 TYPEOFLASER**

Syntax:

Setting: – Polling: TYPEOFLASER? Reply: TYPEOFLASER=text

Syntax Description:

Variable text string

This parameter indicates the model of the laser device.

**4.4.9.6 VERSION**

Syntax:

Setting: – Polling: VERSION? Reply: VERSION=X.XX

Syntax Description:

Variable decimal, 2 places after decimal point

This parameter indicates the version number of the laser control software. The string is always written with two decimal places.

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Laser Device Start-Up

**5 OPERATING ROUTINES**

This section provides examples for remote commands which are to be sent to check or perform routines such as

– Laser device start-up (Section 5.1)

– Laser operation (Section 5.2)

– Laser maintenance and upkeep (Section 5.3)

**5.1 Laser Device Start-Up**

After switching on the laser device, the controller waits for the thyratron to warm up, the power supply to enter the standby mode and the gas circulation fan to start. During this period (approx. 8 minutes) laser operation is inhibited.

⇨ ⇦ OPMODE? OPMODE=OFF,WAIT,0

When the gas circulation fan is running and the HV power supply is ready to operate, the WAIT message disappears.

⇨ ⇦ OPMODE? OPMODE=OFF,0

Laser operation should not be started until the gas in the laser tube has reached operating temperature. For a feedback of the temperature in the laser tube, the temperature value can be requested in a loop and displayed for the user:

⇨ ⇦ TUBETEMP? TUBETEMP=38.2

After initially powering up the laser device, the fan control mode is active. This means that once the laser gas has been warmed-up, the gas circulation fan is switched off and only switched on again in order to maintain the gas at the operating temperature. If the gas circulation fan is to remain permanently switched off in the OFF mode, the parameter FANCTRL=OFF has to be set.

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**5.2 Laser Operation**

**5.2.1 Set Laser Operating Parameters**

For production sequences, the laser device can be operated with internal or external triggering.

In the following example, the laser is to be set for internal triggering at a repetition rate of 10 Hz and operation in the energy constant mode with a pulse energy of 10 mJ.

1. Set the operating parameters.

⇨ ⇦ TRIGGER=INT 0

⇨ ⇦ MODE=EGY 0

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PGR ⇨ ⇦ REPRATE=10 0

⇨ ⇦ EGY=10.00 0

2. The current settings can be polled using the following commands:

⇨ ⇦ TRIGGER? TRIGGER=INT

⇨ ⇦ MODE? MODE=EGY PGR

⇨ ⇦ REPRATE? REPRATE=10

⇨ ⇦ EGY? EGY=10.00

Laser Operation

**5.2.2 Start and Stop Laser**

1. Set the Opmode to ON to start laser operation:

⇨ ⇦ OPMODE=ON 0

The HV power supply module and gas circulation fan are switched on and the trigger mode is set. The laser then enters the On state: laser pulses are generated with the preset parameters: ⇨ ⇦ OPMODE? OPMODE=ON,0

2. Check the operating parameters (see step 2 on page 68) and

change if necessary (see step 1 on page 68). 3. After finishing the work, the laser is to be set to the OFF mode:

⇨ ⇦ OPMODE=OFF 0

**5.2.3 Start Internal Burst Operation**

The laser is to emit a sequence of 20 bursts of 300 pulses each at a repetition rate of 10 Hz. Between each burst there is to be a pause of half a second. The pause between each sequence of bursts is to be two seconds.

1. Make sure that the laser is in the OFF mode.

⇨ ⇦ OPMODE? OPMODE=OFF

2. Set the repetition rate and internal burst generator

⇨ ⇦ REPRATE=10 0

⇨ ⇦ BSTPULSES=300 0

⇨ ⇦ BSTPAUSE=500 0

⇨ ⇦ SEQBST=20 0

⇨ ⇦ SEQPAUSE=2000 0

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OPERATING ROUTINES

3. Change the trigger mode to internal burst.

⇨ ⇦ TRIGGER=INTB 0

4. Start laser operation in the internal burst mode.

⇨ ⇦ OPMODE=ON 0

Laser operation will start with the set burst pattern in the currently active running mode. It will continue according to the burst pattern until OPMODE=OFF is sent.

**5.2.4 External Countdown Operation**

The laser is to emit 2500 pulses at specific positions on a workpiece with a repetition rate and burst pattern defined by an external trigger generator.

1. Make sure that the laser is in the OFF mode.

⇨ ⇦ OPMODE? OPMODE=OFF

2. Set the trigger mode and pulse counter.

⇨ ⇦ TRIGGER=EXT 0

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COUNTS ⇨ ⇦ COUNTS=2500 0

3. Move the workpiece to the first position and start laser operation.

⇨ ⇦ OPMODE=ON 0

2500 pulses will be emitted in the currently active running mode according to the pulse pattern set by the external trigger generator. 4. After making sure that the laser is OFF, move the workpiece to the

next position. ⇨ ⇦ OPMODE? OPMODE=OFF

5. Start laser operation.

⇨ ⇦ OPMODE=ON 0

6. Repeat steps 4 and 5 until all positions have been processed.

Laser Maintenance and Upkeep

**5.3 Laser Maintenance and Upkeep**

**5.3.1 New Fill**

After a series of gas actions have been performed (see Section 5.3 on page 71), a New Fill is to be performed to completely exchange the exhausted gas in the laser tube with fresh gas.

The gas lifetime is monitored by an internal new fill maintenance counter. When this indicates that a new fill is required, the maintenance status code 1 is indicated. This status code is called through the MAINTENANCE? polling command:

⇨ ⇦ MAINTENANCE? MAINTENANCE=1

To determine the number of pulses that have been fired since a new fill was last carried out, use one of the new fill counter functions (see Section 4.4.7.8 on page 60).

At the end of the gas lifetime, the HV power supply may not be able to be adjusted to a value that provides the preset beam energy output. In this case, the “Preset energy too high” warning will be generated,e.g.

⇨ ⇦ OPMODE? OPMODE=ON,0

changes to

⇨ ⇦ OPMODE? OPMODE=ON,89

After 8 minutes warning time, the laser is switched off with the “Preset energy too high” interlock. The status code changes:

⇨ ⇦ OPMODE? OPMODE=OFF,2

**Performing a New Fill**

1. If the laser is not in the OFF mode, stop laser operation by

switching to the OFF mode: ⇨ ⇦ OPMODE=OFF 0

⇨ ⇦ OPMODE? OPMODE=OFF,0

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2. Set the Opmode to NEW FILL to start the New Fill:

⇨ ⇦ OPMODE=NEW 0

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FILL ⇨ ⇦ OPMODE? OPMODE=NEW FILL,0

If OPMODE=NEW FILL,23 or OPMODE=OFF,27 is returned, there is insufficient or no gas flow. In this case, check that the gas cylinder valves are open and that the pressure regulators in the external gas lines are correctly set. 3. When the New Fill has been completed, the Opmode changes

automatically to OFF: ⇨ ⇦ OPMODE? OPMODE=OFF,0

4. Restart laser operation (see Section 5.2 on page 68).