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二极管激光器系统DL 100
(光栅稳定二极管激光器DL 100)

Diode Laser System DL 100 (Grating Stabilized Diode Laser DL 100)

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Manual Grating Stabilized Diode Laser PL 100 Page 3 1 1. The Grating Stabilized Diode Laser DL 100 A OB © § V < 11,4cm > Figure 1: Schematic diagram ot the Diode Laser DL 100 1.1 Operating principle Free-running laser diodes have a linewidth of almost 100 MHz. Their basic frequency can be fine-tuned by adjusting ,durrent and temperature of the pn-junction. If the laser diode is tuned by adjusting current at an constant temperature, mode hops occur, i.e. a hop over a large wavelength interval will occur after a short continual dependence of the basic wavelenth on current. These mode points can be shifted by adjusting the temperature. But repeatedly it is the case that the desired wavelength can not

be adjusted by current and temperature. Even if the required wavelength is found, problems might occur due to aging of the laser diode. In the /]\ OB © V

Manual Grating Stabilized Diode Laser DL 100 Page 4 past the laser diode was simply replaced and other laser diodes tried out. This, however, makes its application in spectroscopy problematic. The Diode Laser DL 100 solves these problems. The light emitted from the front facet of the laser diode is collimated by a multi-element lens with a very short focal length (diffraction-limited) and then hits a reflection grating. The grating is adjusted in the "Littrow" set-up, i.e., the first diffraction order of the grating is reflected back into the laser diode. The light then passes through the collimator again and is focussed back into the laser diode resonator being ideally adapted to the laser diode resonator mode. As the feedback of the grating is considerably higher than the feedback from the front facet, the laser resonator, consisting of rear facet and backlash grating, starts oscillating. The free spectral range of this new resonator with a length of only a few centimeters is substantially smaller than the one of the laser diode of some 100 micrometers and it has a higher finesse. The linewidth, therefore, is reduced to a typical value of 1 MHz (measured in a millisecond.) 1.2 Design of the Diode Laser DL 100 The grating-stabilized Diode Laser DL 100 has a modular and user-friendly design. A thermo-electric element (TEC) is located on the solid, water-cooled base block (heat reservoir). On the TEC, in turn, one finds the laser base plate, which is connected to the base block by plastic screws. In this way an electrical insulation of the base block from the laser base plate is achieved. The laser, collimator and grating holder are fastened and centered onto the laser base plate by metal screws. Furthermore, an AD590 temperature sensor is cemented into the laser base plate. The laser diode is inserted into a hole provided in the laser and collimator holder, prealigned by a ring and fixed by means of two M2 screws. When

installing, it is necessary to insure the correct polarizing direction of the laser irradiation, i.e. the correct installation of the laser diode. In most cased, the long axis of the elliptical beam section should be perpendicular to the grating lines and therefore parallel to the laser base plate, in order to illuminate it as broadly as possible. The emitted light is then polarized perpendicular to its long axis and thus also with respect to the base block (s-polarization). For subsequent beam shaping, we recommend the mounted anamorphotic prism pair (available from TUI Laser) which only widens the small axis or compresses the long axis of the collimated laser beam. (Note: for adjusting the polarization to the Brewster surfaces, a X/2 platelet must be inserted in front of the prism pair, when the beam shape has to be compressed.) The output beam can now be coupled with high efficiency for example into a glass fibre. The Diode Laser DL 100 can be assembled using either the M6 or M8 threads located on the base block or the miling groove at the base block. A higher acoustic and thermal stability can be achieved by assembling the Diode Laser directly on a large

Manual Grating Stabilized Diode Laser PL 100 Page 5 metal plate such as an optical table. The careful installation (using as short cables as possible) is necessary to insure that no mechanical vibrations disturb the Diode Laser. For transport safety, the Diode Laser DL 100 has a short-circuit relay to protect the laser diode from transient voltage peaks which might occur during careless disconnection of cables or during transport. This fuse circuit will be opened automatically after switching on the Current Controler DCC 100. 1.2.1 Safety instructions and warnings Warning! Using powerful lasers: Very powerful lasers (up to class 3b) can be used in the Diode Laser DL 100. Therefore, it is imperative that great care and regulation warning markers are used with the unit. In order to set up a door-interlock, the Diode Laser Current Controller DCC 100) has a safety plug on the back side. By using the appropriate door switch, the energy

can be cut, and thus the Diode Laser can be turned off. Warning! When using the Diode Laser, it is necessary to prevent any inadvertent electrical short-circuits of the Diode Laser and to avoid contact with current-carrying parts. The laser diode is particularly sensitive to voltage peaks. These might considerably affect the service life of the laser diode, even if a disturbance is not immediately noticeable. To achieve good thermal contact make sure that the laser diode is connected electrically to the laser base plate by its housing. When making adjustments be sure to wear a high-impedance grounding strip around the wrist at all times. Warning! When adjusting the laser diode, the reflection of the zero order (specular reflection) must under no circumstances be coupled back into the laser diode, as this may destroy diode. In the case of coarse adjustments it is advisable to reduce the laser diode current to the threshold value. Warning! At all costs avoid high uncontrolled optical feedback into the laser diode, as this may damage or even destroy the laser diode. When making adjustments to the laser diode during operation, the controller current has to be reduced to the losing threshold. Only weakly reflecting objects may be allowed into the laser beam. Warning! For a better thermal coupling the thermo-electric-element (TEC) and other important heat transmission elements are treated with a heat-conducting paste before they leave the company. If individual parts are replaced or repositioned, please replenish the paste, if needed.

Manual Grating Stabilized Diode Laser DL 100 Page 6 Warning! It is essential to check the adjusted parameters of the supply units before connecting the supply cables! In particular pay attention to the lmax-limitation of the Current Controller Unit DCC 100. Before connecting the cables be sure to switch off the appliances, so that the laser diode is short-circuited by the relay integrated in the Diode Laser DL 100. Warning! The Diode Laser DL 100 is an appliance for the operation of laser diodes and thus cannot be regarded as

a separate laser device at the time of delivery .Therefore, the user is responsible for carrying out the legally specified protective measures for lasers (details of the laser safety class, markings on the Diode Laser and on site, laser warning systems during operation, instruction of the operating personnel, etc.). Warning! The user must not open the appliance during operation. Internal tuning as well as the replacing of components may only be carried out by authorized and specially trained service personnel. Under certain circumstances there may be dangerous voltages, even if the device is disconnected from the mains. Achtung! Special precautions are necessary, if the Diode Laser is to be operated in surroundings of high electro-magnetic radiation such as close to a plasma discharge. Please refer to TUI Laser for technical support. Warning! If the user wishes a direct modulation of the laser diode current over a high- frequency radiation source (HF-option), he has to guarantee necessary shielding against leakage radiation from the Diode Laser, in order to protect the electric devices close to it against radio interferences. 1.2.2 Collimator The collimator can be coarsely adjusted after loosening the collimater locking screw. The good parallel collimation of the laser light is controlled by coupling out the laser light from the Diode Laser housing either using a mirror or by removing the grating,the micrometer screw and rear housing cover. At a large distance from the laser, using a detector suitable for the specific wavelength the beam shape should be monitored for proper collimation. We recommend the use of an inexpensive CCD-camera, particularly for infrared wavelengths (available from TUI Laser as an additional option). The collimator lens can be fine-tuned using the flexure joint on the laser- and collimator holder. For setting the joint you will find locking screws on the right and left side of the micrometer screw.

Specifications of the collimator • diffraction-limited

projection operation • numerical aperture: 0.476 • free diameter: 4.3 mm 1.2.3 Grating The grating is mounted in the Littrow set-up. The Littrow angle a is determined by the equation: sina= kXlld. where the angle a is given with reference to the grating normal; k is the diffraction order, in our case k= 1. A grating groove density widely used is 1800 l/mm, i.e. a ? grating constant dˆAJZJ&ˆnvˆ At 780nm, this leads to a refraction angle 2a of about 90° for the output beam. For other wavelengths it may be advisable to use different gratings (see table 1). The Diode Laser system DL 100 allows immediate access to the grating and thus the grating can be replaced within a few minutes. Spare gratings can be ordered from TUI Laser. Wavelength [nm] 630 670 780 810 850 815 850 915 915 980 1010 980 1060 1300 1500 1600 Line density [1/mm] 2400 1800 1600 1400 1200 1000 800 Grating constant 2d f10-7mml 8,34 11,10 12,50 14,29 16,66 20 25 I deflection angle [°] 98.1 74,25 89,29 93,73 99,95 80,78 85,69 94,11 79,63 86,60 89,95 72,06 79,03 102,6 97,18 79,58 | TABLE 1 : Gratings for the different wavelengths in the near infrared spectral range.

Manual Grating Stabilized Diode Laser DL 100 Page 8 Detraction angles ranging from 72° to 100° are acceptable for the output aperture in the housing cover. The output beam has an elliptical cross-section (usually 3:1) and is collimated. In order to achieve a circular beam shape,we recommend the use of an anamor- photic prism pair (available as an extra to the Diode Laser DL 100). 1.2.4 TEC and Temperatur Sensor The TEC has a maximum electrical power consumption of 67 W. The maximum permissable current is 14 A and the maximum voltage 8.6 V. These values will not be exceeded if you use the DTC 100 as a temperature regulator. An AD 590- temperature sensor, located on the laser base plate, measures the actual temperature. The sensitivity of this sensor is 1 |jA/K. ground,can AD 590 (bottom view) Figure 2: Pin assignment of the AD590. 1.2.5 Piezo tuning The staple piezo acuator integrated in the grating holder is

provided with low- voltage piezoelectric crystals which may be controlled with a maximum voltage of - 30 to +200V. The staple has a typical maximum linear extension of more than 5 pm, i.e. 33 nm/V. The typical resonance frequency is 50 kHz, if restraint is one-sided and if there is no further mechanical load. The piezo actuator is controlled by an insulated BNC-socket on the Diode Laser DL 100. The control voltage, which is availabe for example via the ramp generator RG 100 amounts to +/-12 V and is sufficient for a 10- GHz-shift for the initial frequency. If the piezo actuator is operated at 1 kHz and a shift of 10 GHz, typical tuning rates of 10 GHz/ms are achieved.

Manual Grating Stabilized Diode Laser PL 100 Page? Specifications of the piezo actuator • overall length 12 mm • capacity 400 nF • compressive stiffness 30 N/pm • polarity: red/long: +; black/short: -, (with correctly chosen polarity there is a linear extension for positive voltages) • thermal operative range -40 to +80° C • thermal expansion coefficient less than < 10″ˆ 1.3 Connection of the Supply Cables to the DL 100 Warning! Before connecting the supply cables be sure to check the adjusted parameters of the supply units! In particular pay attention to the lmax-limitation of the Current Controller DCC 100. Before plugging in the cables, make sure that the devices are switched off to guarantee that the laser diode remains short-circuited by the relay integrated in the Diode Laser DL 100. In- and Outputs • SubD9-socket for laser and photo diode • SubD9-plug for TEC and temperature sensor • BNC-socket for grating control In order not to use the wrong cable, the supply cables for the Current Controller DCC 100 are exclusively provided with ..female″ sockets, and the ones for the Temperature Controller DTC 100 with ..male″ plugs. The cables have been specially developed for the control of the Diode Laser DL 100. Two leads of each are twisted pairs in order to prevent control currents reaching the sensor lines. The correct connection of the supply cables is controlled by a control

display. Whereas the green LED indicates the supply of sensor and TEC, the red LED indicates the supply of the Diode Laser and thus its operating state, i. e. the red LED also acts as a laser warning light. To achieve good results, the supply cables should not be replaced by other cables of lower specifications. Poor control cables may cause electrical interferences of the control units, poor modulation properties of the Diode Laser DL 100 as well as high temperatures when the maximum control currents of up to 6 A are reached.

Manual Grating Stabilized Diode Laser DL 100 Page 10 1.4 Options TUI Laser offers the following extras for the Diode Laser DL 100: • SMC-socket for external, fast current modulation via Bias-T (100 kHz to more than 500 kHz). Be sure to guarantee for HF-shielding! • anamorphotic prism pair for circular beam shaping such as coupling in fibres, mode matching in frequency doubling resonators etc. • fibre coupling

Manual Grating Stabilized Diode Laser PL 100 Page 11 2 Adjusting the Diode Laser DL 100 In general, the Diode Laser DL 100 is delivered with the laser diode mounted in the laser and collimator holder. The external resonator will have already been coarsely adjusted to the specific wavelength. If the customer, however, wishes to adjust the Diode Laser himself, the necessary instructions are provided on the following pages. For the assembly of the laser diode please follow the safety notes and the instructions in the appendix (see chapter: "Replacement of the laser diode"). 2.1 Coarse Adjustment 2.1.1 First Lighting After switching on the mains supply and after checking the laser parameters to protect the laser diode, the precision trimmer CURRENT FINE, which regulates the control current of the laser diode, must be opened carefully. The set and actual drive current can be monitored on the Monitor Unit of the DC 100 under "lsef and "lacf. If the display does not indicate any change or if a

warning lamp lights up at the driver units, all adjustments and connections should be checked again in order to avoid any damage to the laser diode. At first, the laser diode will only dim weakly. When the laser threshold has been reached, the initial intensity will increase rapidly, resulting in a flashlike behaviour. 2.1.2 Localization of Feedback The main criterium for the quality of adjustment of the resonator is the degree of reduction of the laser threshold. Therefore, the current threshold value during free- running operation should be noted down first. The grating reflection of the first order can be localized on the emersion side of the laser- and collimator holder (a CCD-camera and IR-viewer are very useful!), and the grating tilted coarsely in such a way that the feedback hits the lens of the collimator again. In the output beam a weak reflection can soon be recognised beside the beam of the zero order reflected and decoupled from the grating. By moving the flexure joints, this reflection is "placed over" the beam of the zero order.

Manual Grating Stabilized Diode Laser PL 100 Page 12 Warning! When adjusting the Diode Laser, make sure that the reflection of the zero order (specular reflection) under no circumstances is coupled back into the laser diode, as this may destroy the laser diode. In the case of coarse adjustments, it is advisable to reduce the laser diode current to the threshold value. The reason for this weak reflection is the backcoupled light of the first diffraction order of the grating which is thrown back by the lens and the laser diode holder. By turning the micrometer screws on the laser plate to set the vertical height and the micrometer screw on the grating holder, an attempt is made to bring the two reflections" in a congruent position". The current of the laser diode is set to just under the laser threshold level. When a satisfactory state of feedback is reached, the intensity of the new grating laser resonator is increased. Then the laser threshold is successively decreased through fine-tuning. In the case of a good adjustment the beam

emitted can be caused to "flash" briefly several times by manual turning of the micrometer screw of the grating. If the current of the laser diode is modulated, the reduction of the laser threshold can clearly be observed on an oscilloscope by means of a photo diode as a function of the initial current positioned in the optical output beam. 2.1.3 Manual Coarse Tuning of the Wavelength The grating can be coarsely adjusted by a micrometer screw to tune the wavelength of the emitted beam laser power to a typical value of up to 7 nm above or below the free-running wavelength. Then, the lowering of the threshold should be controlled again and the value noted down for future comparison. 2.1.4 Electrical Tuning of the Wavelength The piezo element integrated in the grating holder is a low-voltage piezo actuator which can be controlled wjth,_gjnaximum of 200 V. It has a typical linear extension of 5 |jm/150V and can be controlled by an insulated BNC-socket on the side wall of the the Diode Laser DL 100. The control voltage of the Ramp Generator RG 100 amounts to +/-12V which leads to a shift of more than 10 GHz. 2.2 Continous Operation of the Diode Laser DL 100 The typical service life of commercial laser diodes nowadays amounts to several thousands of hours, but may vary depending on the particular laser diode. Increasing the driving current above the recommended value lmax as well as the operation of the laser diode at high temperatures may result in a shortened service life. It is advisable to avoid any voltage peaks whatsoever. Even if this does not lead

 to noticable damage, the service life of the laser diode may be reduced. For this reason it is essential to follow the instructions given by the laser diode manufacturer. To guarantee continuous operation and temperature stability, the cover of the housing should be replaced after successful adjustment of the Diode Laser DL 100. The beam output window can be adjusted by loosening the clamping screws. If the Diode Laser DL 100 is to be operated in a room with high

temperature variations, it is recommended to connect the water- cooling system to the rapid action hose- couplings (6 x 1 mm hose). The same applies if a very low operating temperature is chosen and thus the base block is considerably heated up. To achieve a continuous operation with high reproductivity, we advise you to keep the temperature control system switched on. At the end of each measurement only the Current Controller DCC 100 is switched off and the Temperature Controller DTC 100 remains on. In this way the warming up procedure for the control units and the Diode Laser itself can be avoided and a more stable operation is achieved.

Manual Grating Stabilized Diode Laser PL 100 Page 14 3 Warranty The delivered Diode Laser DL 100 has been produced with utmost care and using high-quality components. The device went through extensive testing before delivery. The results obtained in these tests can be seen in the data sheet enclosed. In case of a malfunction or damage, although all operating instructions and -rules in the user's manual have been followed, we will do our best to resolve these problems as soon as possible. For this, the following conditions of guarantee apply: TUI Lasertechnik und Laserintegration GmbH grants a 12-month-guarantee from the date of delivery to the finish and functioning of the Diode Laser DL 100. The guarantee includes either free repair or free replacement of defective devices sent to us. There is a guarantee of three months on all parts replaced or repaired. Any device or individual component are sent in at the client's own risk. The client also has to bear all transport or insurance costs. TUI Laser will send back all components which fall under the guarantee free of charge. The guarantee is not applicable if malfunctions or damage • are not due to material defects • caused by faulty handling - whether deliberate, negligent or inadvertent • caused by unauthorized usage. No liability is taken for built-in laser diodes. These fall under the guarantee of the original manufacturer. In addition, refer to

conditions under "6. liability for defects during transport" as laid down in the General Sales and Business Terms of TUI Laser Inc..

Manual Grating Stabilized Diode Laser PL 100 Page 15 4 Appendices 4.1 Appendix A: Specifications of the DL 100 tuneable grating stabilized Diode Laser DL 100 in Littrow mounting tuneability more than +/- 7 nm depending on the implemented laser diode any wavelength within the tuning range is selectable (no spectral gaps) single mode operation also for many multi mode laser diodes due to the grating set-up construction made from high quality, heat conducting, flexible metal material excellent passive temperature stability, active temperature control by thermoelectric element massive base block acts as heat reservoir (water cooling also possible, when needed) flexure joints for elasticity by good mechanical stability at the same time precision adjustment screw for prealignment laser diode can be chosen from a broad range of commercial suppliers. ! no need for expensive anti reflection coating of the laser diode facet! laser diode potential is floating, no common noise relay short-circuit for laser diode protection during transport Specifications Plezo mechanical wavelength tuning with a low voltage piezo actuator +/-15 V sufficient wavelength selection by tilting the grating grating groove density (depending on the laser wavelength) 1200/1800/2400 l/mm short term linewidth of the laser < 1 MHz tuning range (depending on the gain range of the particular laser diode) typ. > +/- 7 nm tuning range without mode hop typ. 10 GHz spectral sweep rates 5 GHz/ms laser beam characteristics collimated; elliptic numerical aperture of the standard collimator (diffraction limited) 0,476 typical diameter of the collimated beam 1 x 3 mm integrated absolute temperature sensor (AD 590) 1 uA/K thermoelectric cooler/heater for temperature stabilisation Imax = 6A, Umax = 8,6V, Qmax = 28 W laser-on indicator (red LED) In/Outputs SubD9-female connector for laser and photodiode SubD9-male connector for

thermoelectric element and temperature sensor AD 590 BNC-socket for grating control

Manual Grating Stabilized Diode Laser DL 100 Page 16 4.2 Appendix B: Pin Assignment at the DL 100 Pin Assignment of the Current Controller SubD9-female Pin 1 LED MLD on" (anode) Pin 2 Photo diode cathode Pin 3 Laser diode ground Pin 4 Photo diode ground Pin 5 LED ground (cathode) Pin 6 Laser diode ground for ULd sense Pin 7 Laser diode cathode Pin 8 Laser diode anode Pin 9 Pin for ULd sense Pin Assignment of the Temperature Control SubD9-male 5 4 3 2 1 o[\\\vJo 9 8 7 6 Pin 1 LED "TEC on" (anode) Pin 2 n. c. Pin 3 n. c. Pin 4 TEC + Pin 5 TEC -, LED ground Pin 6 n. c. Pin 7 AD 590 - Pin 8 n. c. Pin 9 AD 590 +

Manual Grating Stabilized Diode Laser DL 100 Page 17 4.3 Appendix C: Safety-Circuit-Board in the DL 100 Including the Bias-T (Appendix E):

Manual Grating Stabilized Diode Laser DL 100 Page 18 4.4 Appendix D: Replacement of the Laser Diode If the laser diode has to be replaced, e.g. because the Diode Laser DL 100 has to be adjusted to another wavelength, a flat rate for conversion and reoperation will be charged byTUI Laser. TUI Laser also offers various collimator and grating holders for an easy replacement of the laser diode. Warning! The client is free to change the laser diode in the Diode Laser DL 100 himself, but at his own risk! To reposition a laser diode, it needs to be unsoldered. It is recommended to first short-circuit the laser diode pins before removing (short circuit by the integrated relay on the safety circuit board or by soldering a wire across the pins of the laser diode. Then, the laser diode can be taken out of the holder by loosening the retaining ring and unsoldering. When installing the new laser diode, it is essential to follow the laser diode manufacturer's installation instructions! A grounded metal plate should be placed under the workplace and the soldering

iron should have a high-impedace grounding. Moreover, it is recommended to wear a grounding wrist strip. When a new laser diode is installed, pay attention to the correct pin assignment! The current flow of the drive current is determined by the Jumper J1 on the safety circuit board. In the case of cathode-grounded laser diodes, the Jumper J1 must be plugged into the lower position; in the case of anode-grounded laser diodes it must be plugged into the upper position.

Manual Grating Stabilized Diode Laser DL 100 Page 19 4.5 Appendix E: High Frequency Modulation of DL 100 via Bias-T Important! This option is only for the experienced user in the scientific laboratory and still in the experimental stage. The chance for high frequency modulation also opens up new risks for the destruction of the laser diode itself, because slower safety electronic precautions have to be circumvented. Besides problems associated with microwave heating of the laser diode itself, there is also the risk of strong emission of rf power into the room. The metal housing of the DL 100 laser head is therefore grounded via the cable of the high frequency synthesizer. Consequently also one of the connecting wires of the laser diode is directly grounded. The laser user is asked to take precautious action to prevent problems of the laser performance by disturbances on the ground leads. It is recommended to mount the laser head electrically seperated, e.g. by a sheet of paper etc. The Diode Laser DL 100 can be equipped with an optional high frequency modulation. To this purpose, a commercially available Bias-T (50 Ohm impedance) is integrated into the laser head. Onto the driving current a high frequency modulation is introduced via an additional SMC socket in the DL 100 laser head. Important points to be observed: • proper impedance matching of the drivers • radio frequency termination of the diode laser head to prevent rf emission into the laboratory by electrically conducting laser head mounts and screws, coaxial leads etc. Attention! The exact

frequency and amplitude modulation behaviour of the modulated optical carrier frequency and its side bands are a very sensitive function of the chosen working point of the DL 100 and should be supervised, for example by an external Fabry-Perot-lnterferometer. In the factory a modulation up to 1 GHz for a 20 dBm modulation amplitude (the upper limit of the synthesizer) was applied. While at lower frequencies around 100 MHz a complete modulation (vanishing of the carrier frequency; note that the optical lock mechanism of the diode laser fails) could be achieved, for 1 GHz the carrier-to-side band ratio was 20:1. Besides the generation of sidebands of the optical carrier frequency small amplitude modulation effects are detectable!

Manual Grating Stabilized Diode Laser DL 100 Page 20 4.6 Appendix F: How to get started quickly? After having studied the full manual shipped with the Diode Laser DL 100, this short list of commands will help the experienced user to produce laser light more quickly. When, and only when, the DL 100 has been purchased by the customer as a complete system, TUI Laser has standardly performed extensive outlet testing with the device and has preset all values to the requested position. The driving electronics is assembled and adapted to the particular laser diode implemented by TUI Laser. Only then, this fast routine for operation given here is applicable at all. In all other cases, refer to the full manual to preset the electronic drivers correctly and to prevent damage to the laser diode. Of course, all rules for laser safety have to be obeyed all the times. 1. Make sure all modules in the rack are switched off. And a proper interlock is set using the safety interlock plug at the backplane of the Diode Control rack DC 100. 2. Connect the special cables for the electronic controlers between laser head DL 100 and the DC 100 rack and fasten them securely by tightening the locking screws. 3. Put the wall plug into the socket and start the DC 100 by turning the key switch. The monitor unit will be showing the preset and the actual

parameters. 4. Switch on the DTC 100 Temperature Control and watch the green control LED on the laser head DL 100. The actual temperature will be approaching the set temperature within a few minutes. In case a high start current is needed (significant difference between set and actual temperature), the red Lax LED will glow for a short while, but it should turn off as soon the system is in balance again. 5. Then switch the DCC 100 Current Control into life using the CURRENT stabilisation mode. The red LED at the laser head will start to glow. Slowly turn up the current by the precision potentiometer CURRENT/INTENSITY and watch the actual current. After a while the optical output from the DL 100 through the outcoupling hole will increase. Notify when the laser reaches threshold and adjust further to the power level of your choice. Then you are readily set for your first measurements. 6. The DL 100 can be switched off by the ON/OFF switch at the Current Control DCC 100 without turning the potentiometer CURRENT/INTENSITY down again. This allows the user to exactly come back to the old settings the next time the laser is switched on again. 7. Next switch off the Temperature Control DTC 100 and turn the key switch to fully stop operation. Reading the full manual you will find out quickly about all other options to take advantage of the Diode Laser DL 100 in your applications.

Diode Laser System DL 100 Manual Controller Unit DC 100 with Monitor Article Number: 32lx und 32103x Serial Number:. © TUI Lasertechnik und Lasenntegration GmbH LochhamerSchlag 19 82166 Graf elf ing Tel.: 089/89 81 69-0 Fax: 089 7 8 54 56 10 (Status: March 1996, Changes possible without notice)

Manual Diode Laser Controller Unit DC 100 with Monitor Page 2 1. Contents 1. Contents 2 2. Important Security Guidelines and Helpful Hints 3 3. The Diode Laser Controller Unit DC 100 5 3.1. Power Supplies 5 3.2. High Voltage Supply (Option) 7 3.3. The Monitor Unit of the Diode Laser Controller Unit 7 3.3.1. Operator Panel 7 3.3.2. Start of the Diode Laser

Controller Unit DC 100 8 3.3.3. The choice of Displaying Channel 8 3.3.4. Indicated Parameters 9 3.3.5. Supply sockets 9 4. Warranty 10 5. Appendices 11 5.1. Appendix A: Backplane Connector 11 Attention! Prior to using the Diode Laser Controller Unit, the manual should be studied in order to prevent damage to the Controller and connected laser diodes or to people. The given security guide lines must be followed at all times.

Manual Diode Laser Controller Unit DC 100 with Monitor Page 3 2. Important Security Guidelines and Helpful Hints To avoid the risk of electricshock, do not remove the casing or open the back. There are no user-servicable parts inside. Leave servicing to the the experts! To prevent fire or the ristk of electric shock, keep this unit out of the rain and away from moisture. The lightning symbol with the arrow head inside an equilateral triangle means that there are live, uninsulated parts inside this unit, that may give you a dangerous electric shock if touched. 1. Instructions: Before operating the Controller Unit DC 100, you should read this manual carefully, to prevent damage to the apparatus or connected diode lasers or even to persons. 2. These safety instructions given herein must be followed at all times. Read all the safety instructions and all the operating instructions thoroughly before using the unit for the first time. Keep these safety instructions and operating instructions somewhere safe in case you need to refer to them again in the future. 3. Safety warnings: In your own interest pay heed to all the safety warnings on the unit and in the operating instructions. Follow the instructions on operation and use of the unit in every respect. 4. Water and moisture: Never use the unit near water, for example near a bathtub, a washbasin, a sink, a washing machine, in a damp cellar or near a swimming pool. 5. Ventilation: Wherever you put the unit, always ensure there is sufficient ventilation. Never put the unit on a bed, for example, or a sofa, a carpet or similar surface that might block the vents. Do not build it into

furniture either, such as a bookcase or a cupboard. 6. Effect of heat: Do not put the unit anywhere near sources of heat, such as radiators, hot-air shafts, ovens, etc. 7. Power source: Connect the unit only to the power source indicated in the operating instructions or on the unit. 8. Protecting the flex: Run the flex so that no one can step on it and nothing can rest on or against it. The flex is particularly at risk in the area of the plug, the socket and where it comes out of the unit. 9. Cleaning: Follow the manufacturer's recommendations for cleaning the unit. 10.Unit not in use: If you are not going to use the unit for some time, remove the plug from the socket. 11.Foreign bodies: Take great care to ensure that no liquids or other foreign bodies can find their way inside the unit through the openings in the casing.

Manual Diode Laser Controller Unit DC 100 with Monitor Page 4 12.Repair in the event of damage: The unit should only be repaired by qualified personnel. Never try to do more in the way of maintenance to your unit than the operating instructions allow. Beyond that, always consult an expert for repair work. 13.Fixing to wall or ceiling: The unit may only be fixed to a wall or ceiling in the manner specified by the manufacturer. 14.Dealing with laser diodes: Do not look into the beam from the laser diode under conditions with exceed the limits specified by the United States Food and Drug Administration, Department of Health and Human Services, Center for Devices and Radiological Health, 21 CFR 1040.10 and 2 CFR 1040.11 as applicable. Take precautions to eliminate exposure to a direct or reflected beam. When working with the Diode Laser DL 100 always take care not cause unwanted electrical shortings. The laser diodes are extremely charge sensitive! Also when their is no directly evident damage the life time of the laser diode can be significantly be reduced. LASER SAFETY INTERLOCK The DC 100 provides the user with an interlock switch situated at the back of the rack. Only when the interlock plug is configured as shown in the figure, the DC 100 can be started. The user

of the device is asked to take care of the requested safety measures applicable in his working environment. p Tur/Door Schalter/Switch Interlockstecker / plug

Manual Diode Laser Controller Unit DC 100 with Monitor Page 5 3. The Diode Laser Controller Unit DC 100 Figure: Diode Laser Controller Unit DC 100 (19 inch version) fully stacked with high voltage option (HV) The above figure shows the Diode Laser Controller Unit DC 100 shows the obligatory Monitor Unit with a Diode Laser Controller pair for temperature (DTC 100) and current (DCC 100), a Ramp Generator (RG 100) to operate a Diode Laser DL 100, while the Ramp Generator RG 100 controls the grating position of the DL 100 for frequency tuning. On the right side a PID 100/HV controller with an additional RG 100 is positioned which can serve to control a high voltage piezo actuator, as used for stabilisation of a laser resonator. The DC 100 equipped as shown above can be used for frequency doubling of a diode laser. In this manual the functions of the Diode Laser Controller Unit DC 100 with the monitor is described. 3.1. Power Supplies The DC 100 Diode Laser Controller Unit is equipped with a linearly regulated power supply with +/-15V and 5 V. The supplies are short-circuit protected and temperature monitored. Transformer and printed circuit board are situated on the back of the rack, therefore providing ample space in the rack for the modular controller units of the DL 100 system. A backplane bus connects the units with each other. The single units are fixed in the DC 100 and connected by VG64ac-connector to the backplane bus. All modules must be firmly attached by the four front screws to the rack when operated, to prevent damage to the connected devices. The standard mains voltage for operation within Europe is preselected for 230 V and for delivery to the United States is 115 V. The mains supply is protected by a 1 A fuse which is accessible from the back of the DC 100.

Manual Diode Laser Controller Unit DC 100 with Monitor Page 6 Attention! Before exchanging the fuse make sure to disconnect the device from the mains line! Specifications • linearly regulated, low noise power supply, thermally protected, +/-15 V, 3 A; +5 V, 6 A • voltage and power compensation: < 0.01 % • very low noise transformers • all supply voltages short circuit protected • mains supply with mains filtering: 115/230 V, 60/50 Hz • interlock socket Display Module (20HP) • two LED display units, 3 1 /2 digits • switch for display selection of operating parameters of two diode lasers • temperature display in ° C (Tset, Tact), current is indicated in mA • safety key switch with operational indicating LED • 2 mm sockets with the supply voltages +/- 15 V, +5 V for small external devices such as photo diodes, preamplifiers etc. Options Rack DC 100 as 10 Inch Desktop 10″-Rack (50 HP, 3 U) with two free slots a 12 HP (e.g. for 1 pair of Current/Temperature Control) + Computer Interface (5 HP) Rack DC 100 as 19 Inch Desktop 19″-Rack (85 HP, 3 U) with 5 slots a 12 HP (e.g. for 2 pairs of Current/Temperature Control + Ramp Generator RG 100) Rack DC 100 as 19 Inch Desktop with High Voltage Supply • in addition to the mentioned supply voltages a high voltage of 300 V/100 mA is available from the rack • up to two modules of the type HV 300-2 can be inserted into the DC 100/HV Rack DC 100 as 19 Inch Plug-in Unit

Manual Diode Laser Controller Unit DC 100 with Monitor Page 7 3.2. High Voltage Supply (Option) 3.3. The Monitor Unit ot the Diode Laser Controller Unit Figure of the front plate: 3.3.1. Operator Panel Monitor Unit (20 HP) (1), (2): Safety key switch with indicating operation LED (3), (4): Switch for displaying the operating parameters for two laser diodes (temperature and current) (5), (6): Two LED-display units, each 3 1/2 digits current displays in mA , temperature displays in ° C (Tset, Tact) (7): Channel Switch (8): 2 mm sockets with the supply voltages for small external devices such as photo diodes, preamplifiers etc. acoustic warning signal when the adjustable operation limits of the laser

diodes are reached Options Diode Laser Controller DC 100/10″ in a 10 inch desktop frame • 10″-frame (50 HP, 3 U) with 2 slots at 12 HP (e.g. for 1 pair of current/temperature controller + computer interface)

Manual Diode Laser Controller Unit DC 100 with Monitor Page 8 Diode Laser Controller DC 100/19″ in a 19 inch desktop frame 19″-frame (85 HP, 3 U) with 5 slots at 12 HP (e.g. for 2 pairs of current/temperature controller + ramp generator) Diode Laser Controller DC 100/19″ in a 19 inch desktop frame with High Voltage Supply • In addition to the abovementioned supply voltages, a high voltage of 300 V/100 mA can be used for high voltage modules • up to 2 modules of the type HV 300-2 can be inserted into the DC 100/197HV Diode Laser Controller DC 100/19″ in a 19 inch rack to be mounted in a full frame system 3.3.2. Start of the Diode Laser Controller Unit DC 100 Operation of the Diode Laser Controller Unit DC 100 is started by turning the safety key on the operator panel. The Diode Laser Controller Unit has a Power-Up-Automatic, which is in charge of slow start and stop ramps. This prevents damage to interconnected laser diodes even when operated with large currents. The operating conditions of the laser diode are preset with the particular controller module and can be checked on the monitor unit by displaying the function in question. In case the preset values do not vary within the preadjusted safety limit for the corresponding laser diode, an acoustic signal together with a red warning light will alert the operator. 3.3.3. The choice of Displaying Channel The choice of the displaying channel on the front plate must correspond to the controller module of interest. The red color is strictly used for current related parameters and green for the temperature related parameters. The following parameters can be monitored:

Manual Diode Laser Controller Unit DC 100 with Monitor Page? 3.3.4. Indicated Parameters red display: 'act [mA]- 'set [mAl< ■max [mA], lPD [mA], Umax [V] green display: ■act

[° C], Tset [° C], Tmin rC], ■max rci. 'max [mA] Before changing the preset values, check with the operator manual of the corresponding controller module and also with the data sheet of the laser diode supplied with the system. 3.3.5. Supply sockets For many every-days situations in the laboratory it is handy to have a low voltage supply readily available. Therefore the DC 100 allows access to its internal stabilised DC voltages (+/-15 V und 5 V) by 2 mm-banana sockets at the front panel (8). Attention! The low voltages accessible from the front panel are only for small loads, such as photo diodes, preamplifiers etc.

Manual Diode Laser Controller Unit DC 100 with Monitor Page 10 4. Warranty The delivered Diode Laser Current Controller DCC 100 has been produced with utmost care and using high-quality components. The device went through extensive testing before delivery. The results obtained in these tests can be seen in the data sheet enclosed. In case of a malfunction or damage, although all operating instructions and -rules in the user's manual have been followed, we will do our best to resolve these problems as soon as possible. For this, the following conditions of guarantee apply: TUI Lasertechnik und Laserintegration GmbH grants a 12-month-guarantee from the date of delivery to the finish and functioning of the diode laser DL 100. The guarantee includes either free repair or free replacement of defective devices sent to us. There is a guarantee of three months on all parts replaced or repaired. Any device or individual component are sent in at the client's own risk. The client also has to bear all transport or insurance costs. TUI Laser will send back all components which fall under the guarantee free of charge. The guarantee is not applicable if malfunctions or damage • are not due to material defects • caused by faulty handling - whether deliberate, negligent or inadvertent • caused by unauthorized usage. No liability is taken for built-in laser diodes. These fall under the guarantee of the original manufacturer. In addition, refer to conditions under "6. liability for defects

during transport" as laid down in the General Sales and Business Terms of TUI Laser Inc.

Manual Diode Laser Controller Unit DC 100 with Monitor Page 11 5. Appendices 5.1. Appendix A: Backplane Connector (VG-64-a/c standard connector according DIN 4161 2) I general digital GND I 1a | = | 1c I (brown) | Supply voltages I free 230 V Phase in (red) 230 V Phase out (yellow) I free 2a 3a 4a 5a 2c 3c 4c 5c free I Null in (brown) Null out (orange) free | Analog Signals |RG 100 out Channel 1 Photo diode Channel I I Umay Channel 1 6a 7a 8a 9a 6c 7c 8C 9c RG 100 out Channel 21 Photo diode Channel 2 UmflY Channel 21 Adress Lines Photo Diode Channel 1 I Umav Channel 1 10a 11a 12a 13a 14a 10c 11c 12c 13c 14c Photo Diode Channel 2 Umav Channel 21 Indicated Parameter I l(T)mav Channel 1 I Tmav Channel 1 ■may Channel 1 Tmin Channel 1 Uet Channel 1 T«;pt Channel 1 I art Channel 1 Tart Channel 1 HV-Supply HV + Supply Error Analog GND Iurpf(+5V) 15a 16a 17a 18a 19a 20a 21a 22a 23a 24a 25a 26a 27a 28a 29a = = 15c 16c 17c 18c 19c 20c 21c 22c 23c 24c 25c 26c 27c 28c 29c l(T)maY Channel 21 TmflY Channel 2 Imav Channel 2 Tmin Channell 2 lQPt Channel 2 TQPt Channel 2 lart Channel 2 Tarn Channel 2 Blink Power up -IW(-5V)I gen. Supply Lines I -15 V stabilised 1+15 V stabilised I +5 V stabilised 30a 31a 32a = = = I 30c 31c 32c (yellow) I (orange) (rediJ

Diode Laser System DL 100 Manual Current Controller DCC 100 Article number: 32104x Serial number:. © TUI Lasertechnik und Lasenntegration GmbH LochhamerSchlag 19 82166Grafelfing Tel.: 089/89 81 69-0 Fax: 089 7 8 54 56 10 (Stand: March 1996, changes possible without notice)

Manual Diode Laser Current Controller DCC 100 Page 2 1. Contents 1. Contents 2 2. Safety Instructions 3 3. Current Stabilisation with the DCC 100 4 3.1. Operator Panel 4 3.1.1. Switch ON/OFF 5 3.1.2. Choice of the Laser Diode Type POS/NEG 5 3.1.2.1. Anode-Grounded Laser diodes 5 3.1.2.2. Cathode-Grounded Laser Diodes 5 3.1.3. Setting of Voltage Limit Umax

 2. Safety Instructions Attention! Before operating the unit please read this manual carefully to prevent damage of the device, connected diode lasers or even personal damage. The herein given security instructions have to be obeyed all the time. Attention! For safe operation please use the supplied mains lead only to get proper grounding. Bad or missing grounding can lead to serious personal damage. Attention! The unit should not be operated in a hazardous environment. Attention! The cassette of the DCC 100 should only be opened by trained personal. Before opening the DCC 100 the unit has to be disconnected from the mains suppy. Attention! When working with the Diode Laser DL 100 always take care not to cause unwanted electrical shortings. The laser diodes are extremely charge sensitive! Also when their is no directly evident damage the life time of the laser diode can be significantly be reduced. Attention! Do not look into the beam from the laser diode under conditions with exceed the limits specified by the United States Food and Drug Administration, Department of Health and Human Services, Center for Devices and Radiological Health, 21 CFR 1040.10 and 2 CFR 1040.11 as applicable. Take precautions to eliminate exposure to a direct or reflected beam. Attention!

The user should not open the device under operating conditions. Internal trimming or exchange of parts should only be performed by trained personnel. The device has to be disconnected from the mains supply!

Manual Diode Laser Current Controller DCC 100 Page 4 3. Current Stabilisation with the DCC 100 The operation of a laser diode for spectroscopic applications demands a highly stable current controller and an active laser diode temperature controller. The Diode Laser Current Controller DCC 100 is a plug-in module for the Diode Laser Controller Unit DC 100. Figure: Front panel of the Diode Laser Current Controller DCC 100 3.1. Operator Panel The plug-in module DCC 100 (Diode Laser Current Controller) offers the opportunity to change the display channel by switching five miniature switches which are

Manual Diode Laser Current Controller DCC 100 Page 5 accessible with a screw driver from the side of the cassette. To do so the HF-tight cassette has to be removed from the main frame DC 100. Either all switches have to be set towards the supply socket (Channel 1) or all switches are set to the opposite side (Channel 2). Correspondingly the Monitor Unit has to be set for monitoring the parameters. Usually the channels are preset accordingly when a complete DL 100 system is shipped. 3.1.1. Switch ON/OFF The black switch (1) controls the power output of the DTC 100. The soft start/stop automatic can be surveilled acoustically and optically by the time delayed response of the relais and the green indicator LED. All operating parameters can be set already. Then the Current Controller output can be activated by the switch. The indicated set current lsef should always be equal to the indicated actual value when the laser diode is connected correctly to the DL 100. As soon as a red indicator LED Umax is lit, high ohmic resistor will be present at the output port or the laser diode is disconnected (lacf = 0 mA). The DCC 100 has increased the output voltage until the preset

limit is reached. The second alert LED lmax will be active when the preset current maximum has been reached. The warning is also acoustically present to attract the attention of the user. 3.1.2. Choice of the Laser Diode Type POS/NEG The laser diode is always connected to the internal laser diode ground (Pin 3 at the subD9-socket). Depending on the particular laser diode (anode or cathode grounded) a driving current between Pin 7 and Pin 3 (Position NEG) or Pin 8 and Pin 3 (Position POS) is applied. When the laser diode is mounted into the grating stabilised DL 100 the Pin connection is fixed. Please find the data in the appendix. 3.1.2.1. Anode-Grounded Laser diodes In this case the switch (7) at the front panel of the DCC 100 is in the position NEG. The driving current is shown with a negative sign and is flowing from Pin 7 and Pin 3 at the socket. 3.1.2.2. Cathode-Grounded Laser Diodes In this case the switch (7) at the front panel of the DCC 100 is in the position POS. The driving current is shown with no sign and is flowing from Pin 8 and Pin 3 at the socket.

Manual Diode Laser Current Controller DCC 100 Page 6 3.1.3. Setting of Voltage Limit Uˆx An inportant way of protecting the laser diode is the preset maximum voltage Umax (< 5V) at the output port of the Controller. From the data sheet of the particular laser diode this value can be extracted and with the help of an small screw driver preset at the trimming potentiometer (2) at the front panel. Voltage spikes can be eliminated. In case the output is open, the controller is not increasing the output voltage unlimitedly. This protection-circuit is also helpful when the laser diode was accidently mounted reversely. A red LED at the front panel indicates that the limit is reached. Also an acoustic warning signal will occur. Attention! When adjusting off! the Controller Limits make sure that the Controller is switched 3.1.4. Setting of the Current Limit lˆx In order to prevent accidental damage by increasing the laser diode current beyond the maximum limit of the laser diode, the DCC 100 has

a current limit protection which can be set to value lmax< 500 mA. A precision potentiometer in the front panel can be set by using a small screw driver. Therefore the Moinitor Unit is switched to show lmax at the display. A warning LED at the front panel is lit as soon the current limit is reached together with an acoustic warning. Warning! When changing the limit settings the device has to be switched off in order to prevent damage to the laser diode. 3.1.5. Calibration of the Internal Photodiode As an option the internal photo diode can be calibrated to show not only relative but absolute values. 3.1.6. Choice of the Operational Modus 3.1.6.1. Operation as Current Stabilisation CURRENT In most cases the Controller DCC 100 is used to stabilize the laser diode current. This choice is preset (Position Current) when the device is shipped.

Manual Diode Laser Current Controller DCC 100 Page 7 3.1.6.2. Operation as Power Stabilisation LIGHT Alternatively the Controller can stabilise the optical output power of the laser diode by feedback of the internal photo diode. The switch (5) is set to the position LIGHT. The light power is selected again by the potentiometer (10) at the front panel. With the precision potentiometer (4) a photo current light power adjustment can be performed. The current limit protection lmax ’s f° r safety reasons still active, as soon the optical power chosen requires more current than preselected. 3.1.7. Setting of the Turning Switch RANGE With the Turning Switch (6) a coarse setting of the current range can be selected. The different settings are as follows (indicated by the arrow) bedeuten: Position Current Range Starting Position 1 \+l- mAI 0 0 1 50 2 100 3 150 4 200 5 250 6 300 7 350 8 400 9 450 Any range has 100 mA fine tune, selectable by the precision potentiometer. The prefix of the indicated current is given by the driving current and can be changed by the switch POS/NEG. 3.1.8. Setting of the Driver Current CURRENT/INTENSITY FINE The setting of the driver current lsef or the optical power is done by the 10-turn

Potentiometer (10) at the front panel. After adjustung the required current level the potentiometer can be mechanically fixed. Due to the soft start/stop function of the DCC Module the current does not need to be turned down after an experiment before switching off the laser diode. This is performed automatically by the controller. This option allows to keep the settings for the next session.

Manual Diode Laser Current Controller DCC 100 Page 8 3.1.9. Connecting the Laser Diode LASER OUTPUT Using the cable K 100 the Diode Laser DL 100 is connected to the DCC 100 Current Controller. The SubD9-connectors and the electrical definitions are given in the appendix. 3.1.10. Modulation of the Laser Diode MODULATION OUTPUT By means of the BNC analogue input (11) the output current of the DCC 100 can be externally modulated. The bandwidth of the controller allows an output modulation of the driving current from DC up to 100 kHz. 3.1.11. Monitoring the Controller by MON. OUT The BNC-Monitor Socket (9) offers the chance to monitor the regulator error with an oscilloscope. An output voltage of IV corresponds to an error of 100 mA.

Manual Diode Laser Current Controller DCC 100 Page? 4. Warranty The delivered Diode Laser Current Controller DCC 100 has been produced with utmost care and using high-quality components. The device went through extensive testing before delivery. The results obtained in these tests can be seen in the data sheet enclosed. In case of a malfunction or damage, although all operating instructions and -rules in the user's manual have been followed, we will do our best to resolve these problems as soon as possible. For this, the following conditions of guarantee apply: TUI Lasertechnik und Laserintegration GmbH grants a 12-month-guarantee from the date of delivery to the finish and functioning of the diode laser DL 100. The guarantee includes either free repair or free replacement of defective devices sent to us. There is a guarantee of three months on all parts replaced or repaired.

Any device or individual component are sent in at the client's own risk. The client also has to bear all transport or insurance costs. TUI Laser will send back all components which fall under the guarantee free of charge. The guarantee is not applicable if malfunctions or damage • are not due to material defects • caused by faulty handling - whether deliberate, negligent or inadvertent • caused by unauthorized usage. No liability is taken for built-in laser diodes. These fall under the guarantee of the original manufacturer. In addition, refer to conditions under "6. liability for defects during transport" as laid down in the General Sales and Business Terms of TUI Laser Inc..

Manual Diode Laser Current Controller DCC 100 Page 10 5. Appendices 5.1. Appendix A: Specifications of the DCC 100 (Stand 1.9.95) Plug-in Module for Diode Laser Supply and Monitor Unit DC 100 • output current range 0...+/- 500 mA, • optional +/- 1 A or +/- 2 A • stabilisation of constant output current • coarse switch for range selection of output current in steps of 50 mA • fine tuning of output current or optical power by precision trimmers • operation of laser diodes / photo diodes in any combination of polarity • external modulation of output current up to 100 kHz • low noise (DC to 1 MHz): < 10 mA width: 12 HP (60 mm) • Controller optimised for operation of the grating stabilised Diode Laser DL 100 Numerous protection circuits for the laser diodes • low noise linearly regulated power supplies, mains filtering within the power supply DC 100 • double shielding of the case reduces pick-up of transients significantly • fast active protection circuits omit the surpassing of the adjustable limits for output current and voltage, monitoring by LEDs (and error warning to a computer controlled system) in case limits are reached • operation indicators (LEDs) at the Control Module and at the Diode Laser DL 100 • soft start/stop function is steering the laser diode current in ramp within 100 ms when the module is switched on or off • power-up/down function leads to controlled operation of the

system even by failure of the mains supply • relay protection of the laser diode after the module is switched off (pin short circuit prevents damage when connector cable slip or during transport)

Manual Diode Laser Current Controller DCC 100 Page 11 In/Outputs • SubD9 socket for laser and photodiode • BNC socket for external modulation (DC to 100 kHz, HF coupling directly to the laser diode up to 2 GHz is possible) • BNC monitor socket for supervising the Control Module • output of relevant data to a computer-controlled system: 'act' 'set' 'max' '-'max' TD 5.2. Appendix B: SubD9-Socket (female) at the Output Port Pin Assignment of the Current Controller SubD9-female Pin 1 LED TD onH (anode) Pin 2 Photo diode cathode Pin 3 Laser diode ground Pin 4 Photo diode ground Pin 5 LED ground (cathode) Pin 6 Laser diode ground for ULd sense Pin 7 Laser diode cathode Pin 8 Laser diode anode Pin 9 Pin for ULd sense

Manual Diode Laser Current Controller DCC 100 Page 12 5.3. Appendix C: Backplane Bus (VG-64-a/c standard connector according DIN 41612) I general digital GND 1a 1c (brown) | Supply voltages I free 230 V Phase in (red) 230 V Phase out (yellow) | free 2a 3a 4a 5a 2c 3c 4c 5c free I Null in (brown) Null out (orange) free| Analog Signals |RG 100 out Channel 1 Photo diode Channel 1 I Umav Channel 1 6a 7a 8a 9a 6c 7c 8c 9c RG 100 out Channel 21 Photo diode Channel 2 UmaY Channel 21 Adress Lines Photo Diode Channel 1 I Umax Channel 1 10a 11a 12a 13a 14a 10c 11c 12c 13c 14c Photo Diode Channel 2 Um3Y Channel 21 Indicated Parameter I IfOmav Channel 1 Tmav Channel 1 lmav Channel 1 I Tmin Channel 1 l«At Channel 1 Toot Channel 1 I art Channel 1 Tar» Channel 1 HV • Supply HV + Supply Error Analog GND |urftf(+5V) 15a 16a 17a 18a 19a 20a 21a 22a 23a 24a 25a 26a 27a 28a 29a = = 15c 16c 17c 18c 19c 20c 21c 22c 23c 24c 25c 26c 27c 28c 29c IfOmAv Channel 21 Tmav Channel 2 lmav Channel 2 Tmin Channell 2 Upt Channel 2 T<u>t Channel 2 ■art Channel 2 Tartt Channel 2 Blink Power

up -Ur»f(-5V)| gen. Supply Lines 1-15 V stabilised +15 V stabilised I +5 V stabilised 30a 31a 32a = = = 30c 31c 32c (yellow) I (orange) (redj

Manual Diode Laser Current Controller DCC 100 Page 13 5.4. Appendix D: Schematic Controller Set-Up 1 co u 2 £ ″fc. 1 6S -£>J Lˆ e ool ˆ7 ˆ7 -5? 8 j a w ! J11 6 J. w— tJ S em p. Dete emp. Dete 4>| ’ pply Curr CO e a r- H a a & w> &J2 3 S 8 o »e S«. on o CO a. S H co X; 161 I A I A I I A I i SI c X CO if! J lllii III 111 S5i5 F-!£ 8 Q .2 CO 3 #11

Diode Laser System DL 100 Manual Temperature Controller DTC 100 Article Number: 32105x Serial Number:. © TUI Lasertechnik und Laserintegration GmbH LochhamerSchlag 19 82166Grafelfing Tel.: 089 / 89 81 69 - 0 Fax: 089/8 54 56 10 (Status: October 1996, Subject to alterations without notice)

Manual Diode Laser Temperature Controller DTC 100 Page 2 Content 1. Temperature Stabilisation with the DTC 100 4 1.1. The Choice of the Display Channel 4 1.2. Operator Panel 4 1.2.1. Unit Switch ON/OFF 5 1.2.2. Choice of Temperature Sensor: AD 590 or Rfh 5 1.2.3. Switch POS/NEG 5 1.2.4. Limiting the Laser Diode Current lmax 5 1.2.5. Setting the temperature window Tmax and Tmjn 6 1.2.6. Setting of the Turning Switch RANGE 6 1.2.7. Setting of the Controller Parameter TEMPERATURE FINE 6 1.2.8. Connecting the DTC TEC OUTPUT 6 1.2.9. Surveying the Controller via MON. OUT 6 1.3. Calibration of the DTC 100 7 2. Warranty 8 3. Appendices 9 3.1. Appendix A: Specifications of the DTC 100 9 3.2. Appendix B: Output Socket at the DTC 100 10 3.3. Appendix C: The Backplane Bus 11 3.4. Appendix D: Schematic Controller Working Principle 12

Manual Diode Laser Temperature Controller DTC 100 Page 3 Safety and Security Guide Lines Attention! Before operating the unit please read this manual carefully to prevent damage of the device or interconnected diode lasers or even personal damage. The herein given security instructions have to be

obeyed all the time. Attention! For safe operation please use the supplied mains lead only to get proper grounding. Bad or missing grounding can lead to serious personal damage. Attention! The unit should not be operated in a hazardous environment. Attention! The cassette of the DTC 100 should only be opened by trained personel. Before opening the DTC 100 the unit has to be disconnected from the mains supply. Attention! When working with the Diode Laser DL 100 always take care not cause unwanted electrical shortings. The laser diodes are extremely charge sensitive! Also when their is no directly evident damage the life time of the laser diode can be reduced significantly. Attention! Do not look into the beam from the laser diode under conditions with exceed the limits specified by the United States Food and Drug Administration, Department of Health and Human Services, Center for Devices and Radiological Health, 21 CFR 1040.10 and 2 CFR 1040.11 as applicable. Take precautions to eliminate exposure to a direct or reflected beam. Attention! The user should not open the device under operating conditions. Internal trimming or exchange of parts should only be performed by trained personnel. The device has to be disconnected from the mains supply!

Manual Diode Laser Temperature Controller DTC 100 Page 4 1. Temperature Stabilisation with the DTC 100 Figure of the front plate The operation of a laser diode for spectroscopic applications demands a highly stable current controller and an active laser diode temperature controller. The Diode Laser Temperature Controller DTC 100 is a plug-in module for the Diode Laser Controller Unit DC 100. For displaying the controller parameters of the controller (set, actual and safety values) at the Monitor Unit of the DC 100 the display channel has to be set by the user with the help of dip switches on the side of the cassette of the DTC 100. 1.1. The Choice of the Display Channel The plug-in module DTC 100 (Diode Laser Temperature Controller) offers the opportunity to change the display channel by switching five miniature

switches which are accessible with a screw driver from the side of the cassette. To do so the HF-tight cassette has to be removed from the main frame DC 100. Either all switches have to be set towards the supply socket (Channel 1) or all switches are set to the opposite side (Channel 2). Correspondingly the Monitor Unit has to be set for surveying the parameters. Usually the channels are preset accordingly when a complete DL 100 system is shipped. 1.2. Operator Panel The Temperature Controller DTC 100 is automatically switched on as soon as the DC 100 is started by the safety key on the Monitor Unit of the DC 100. The controller parameters can be displayed and changed now. However the DTC 100 output is only active when the black switch on the front panel (ON/OFF) is switched to the position ON.

Manual Diode Laser Temperature Controller DTC 100 Page 5 1.2.1. Unit Switch ON/OFF The black switch (1) controls the power out put of the DTC 100 unit. The electronic soft start/stop feature can be surveilled acoustically and optically by the time delayed response of the relay and the indicator LED. When started, the controller needs a few minutes to heat or cool the Diode Laser DL 100 to the preset temperature. In case, the actual and set temperature differ by more than a few degrees the regulator will reach its current limit protection which is indicated by the red warning LED. There will be a slight overshooting before the regulation approaches the set temperature in an exponential decay. 1.2.2. Choice of Temperature Sensor: AD 590 or Rfh The Diode Laser DL 100 is equipped with a AD 590 as temperature sensing element. Therefore the switch (5) at the front panel is preset to this position. Optional a change of the electronics to operate a thermistor Rfˆ as temperature sensor is possible and can be done at TUI Laser. 1.2.3. Switch POS/NEG The switch POS/NEG (7) enables the user to invert the feed back sign of the DTC 100. The default setting for the Diode Laser DL 100 is the position POS. In case other heating or cooling elements are used the setting can be changed by

using a small screw driver. When first connecting the power element to the controller the temperature change should be monitored. In case the switch is set wrongly a positive feed back will lead to a unlimited change of the temperature away from the set value. 1.2.4. Limiting the Laser Diode Current lmax By a precision trimming element (2) the maximum Peltier current lmax can ˆe limited to a value below 5 A using a small screw driver. The setting should be controlled at the Monitor Unit of the DC 100. Although the DTC 100 will not be harmed when the current limit protection is used, one should be aware that the Controller is not corresponding linearly anymore and the overshooting can be more significant. For most cases a setting of 2 A is sufficient to reach temperatures close to room temperature and should be used. In case two or more Temperature Controller DTC 100 are operated in one rack of the type DC 100, please make sure that the sum of the maximum currents ’max ° f ˆe s’ng’e units does not overcome the allowed total 6 A for the DC 100. Unwanted feed back and couplings could result.

Manual Diode Laser Temperature Controller PTC 100 Page 6 1.2.5. Setting the temperature window Tmax and Tmjn By two precision trimmers (3 and 4) a window of allowed set-temperatures (minimum and maximum temperature) can be adjusted, again using a small screw driver. The setting should be checked by displaying Tmax and Tmjn at the Monitor Unit. For the standard controller the two temperatures can be chosen between 0° and 50° C, with Tmjn smaller as lmax- 1.2.6. Setting of the Turning Switch RANGE With the help of the switch (6) the starting set value can be chosen. The following settings are available: Position |Temp.-range [° C] 1 0 2 5 3 10 4 15 5 20 6 25 7 30 8 35 9 40 ol 45 | 1.2.7. Setting of the Controller Parameter TEMPERATURE FINE The set-temperature can be set fine by a 10-tum-potentiometer at the front panel. The value can only be chosen inbetween the selected temperature window. As soon the limit is reached a red LED together with an acoustic warning sign will appear.

1.2.8. Connecting the DTC TEC OUTPUT Using the cable K 100 the Diode Laser DL 100 is connected to the DTC 100 Temperature Controller. The SubD9-connectors and the electrical definitions are given in the appendix. 1.2.9. Surveilling the Controller via MON. OUT A BNC-Monitor Socket (9) allows the user to surveil the Controller during operation. A voltage difference of 1 V corresponds to a regulator error of 10° C between set and actual temperature.

Manual Diode Laser Temperature Controller PTC 100 Page 7 1.3. Calibration of the DTC 100 Attention! For calibration of the Controller the HF-tight cassette has to be opened. The company TUI Laser can now not longer provide any warranty for the controller. To avoid this risk you might consider to send the controller back to the manufacturer for calibration. In case an excellent absolute temperature measurement is needed, on the printed circuit board (PCB) of the DTC a trimm potentiometer is available for offset calibration of the controller for the specific temperature sensor. Under standard conditions, an error of the absolute temperature reading by the sensor AD 590 is +/- 0.5 ° C. It is extremely important to adapt the controlling parameters of the PID-controller according to the "thermal mass" of the object to be cooled. At the factory the DTC 100 is optimised to the conditions of the Diode Laser Head DL 100. By means of a stacked resistor (coarse) and a potentiometer (fine) the proportional part and a capacitor (integrational part) the settings can be changed easily. However, any change should be carried out carefully, because some experience is needed. Important and interesting hints are given in an article by CD. Knighton und G. Estep: Optimize thermoelectric coolers to improve system performance in Laser Focus World, May 1995, page 205 ff.

Manual Diode Laser Temperature Controller DTC 100 Page 8 2. Warranty The delivered Diode Laser Temperature Controller DTC 100 has been produced with utmost care and using high-quality

components. The device went through extensive testing before delivery. The results obtained in these tests can be seen in the data sheet enclosed. In case of a malfunction or damage, although all operating instructions and -rules in the user's manual have been followed, we will do our best to resolve these problems as soon as possible. For this, the following conditions of guarantee apply: TUI Lasertechnik und Laserintegration GmbH grants a 12-month-guarantee from the date of delivery to the finish and functioning of the diode laser DL 100. The guarantee includes either free repair or free replacement of defective devices sent to us. There is a guarantee of three months on all parts replaced or repaired. Any device or individual component are sent in at the client's own risk. The client also has to bear all transport or insurance costs. TUI Laser will send back all components which fall under the guarantee free of charge. The guarantee is not applicable if malfunctions or damage • are not due to material defects • caused by faulty handling - whether deliberate, negligent or inadvertent • caused by unauthorized usage. No liability is taken for built-in laser diodes. These fall under the guarantee of the original manufacturer. In addition, refer to conditions under "6. liability for defects during transport" as laid down in the General Sales and Business Terms of TUI Laser Inc.

Manual Diode Laser Temperature Controller PTC 100 Page? 3. Appendices 3.1. Appendix A: Specifications of the DTC 100 Plug-in Module for Diode Laser Supply and Monitor Unit DC 100 max. output current: 0... 6 A max. output power: 30 W bipolar control (heating/cooling) allows fast and ultra stable controlling, even at conditions close to room temperature setting of the limits for minimum and maximum temperature and the maximally allowed output current by precision trimmers indication of operation by LEDs at the module and the DL 100 usage of different temperature senosors possible: AD 590, thermistor etc. temperature selection range: -50 ° C to 50 ° C stability/long term drift: < 5 mK coarse/fine tuning by

range switches and precision trimmers width: 12 HP (60 mm) Module optimised for operation of the grating stabilised Diode Laser DL 100 In/Outputs • SubD9-sockets for connection to TEC and temperature sensor • BNC-socket for surveying the active control • relevant data for monitor unit are available as analog signals: 'act' ″set' 'miir 'max' 'max

Manual Diode Laser Temperature Controller DTC 100 Page 10 3.2. Appendix B: Output Socket at the DTC 100 SubD9-socket at the output port of the Diode Laser Temperature Controller DTC 100. Pin Assignment of the Temperature Control SubD9-male 5 4 3 2 1 9 8 7 6 Pin 1 LED ″TEC on″ (anode) Pin 2 n. c. Pin 3 n. c. Pin 4 TEC + Pin 5 TEC -, LED ground Pin 6 n. c. Pin 7 AD 590 - Pin 8 n. c. Pin 9 AD 590 +

Manual Diode Laser Temperature Controller DTC 100 Page 11 3.3. Appendix C: The Backplane Bus (VG-64-a/c standard connector according DIN 41612) | general digital GND Supply voltages Ifree 230 V Phase in (red) 230 V Phase out (yellow) |free Analog Signals |RG 100 out Channel 1 Photo diode Channel 1 I Umay Channel 1 Adress Lines Photo Diode Channel 1 I UmflY Channel 1 Indicated Parameter 11 CO ma* Channel 1 TmflY Channel 1 11 ma* Channel 1 I Tmin Channel 1 lSAt Channel 1 I TSflt Channel 1 Ur* Channel 1 Tant Channel 1 HV - Supply HV + Supply Error Analog GND |Urftf(+5V) gen. Supply Lines I-15 V stabilised 1+15 V stabilised | +5 V stabilised 1a | = | 1c 2a 3a 4a 5a 2C 3c 4C 5C 6a 7a 8a 9a 6c 7c 8c 9c 10a 11a 12a 13a 14a 10c 11c 12c 13c 14c 15a 16a 17a 18a 19a 20a 21a 22a 23a 24a 25a 26a 27a 28a 29a = = 15c 16c 17c 18c 19c 20c 21c 22c 23c 24C 25c 26c 27c 28c 29c 30a 31a 32a =] = = 30C 31c 32c (brown) | free I Null in (brown) I Null out (orange) free | RG 100 out Channel 21 Photo diode Channel 2 Umfly Channel 21 Photo Diode Channel 2 UmflV Channel 21 1(T)may Channel 21 Tm«y Channel 2 I may Channel 2 Tmin Channell 2 I sat Channel 21 TSat Channel 2 lart Channel 2 Tantt Channel 2 Blink Power up -Ur«f(-5V)I (yellow) I (orange) (red) |

Manual Diode Laser Temperature Controller DTC 100 Page 12 3.4. Appendix D: Schematic Controller Working Principle Voltage Re 5pp«/K 1Ofc zm Modulation Input fdOOkHz 2″ w Modulation froi DA Soft Start/Stop LD-Save Up .Set Reference, M Safety Clrcnlt 1 f* to Monitor Unit >| Actual Value ■n Tj Output oltage/Curren Detect Safety Circuit 2 Error Detect egral Differ Error to Monitor Unit Temp. Scaling act scaled Tempj _J£k oto-Dk> Amp act opt Power; DL 100 Laser Mode Connector Socket Photodlode Current A I Laser Diode Supply Currei Safety Relay **-4-\ TEC/Peltier Socket DL 100 TeniD. Detect DL 100 Temp. Detect ″ˆ˜** ■:'ˆ˜˜i i Peltier Su,pp|yCgrregt DL100 Module Connector Socket 4SKim.SOL-

Manual Diode Laser Temperature Controller DTC 100 Page 13 4.5. Appendix E: Top View of the Printed Circuit Board a*sie>oe f? gn 3 O o u u a o ' f ' •″ • !ˆZ>X! • ˆ ii»-«: -!i..«o: v--»˜ ˜ -X/g: ˆ-.i i i i i i i sˆHˆJD-ˆns h 59ˆ t]= hˆod3p- \E\tL »' u'J £″ *tt″ i ir. * ˆOdOl z> z> I. I: — z m ■sisCpjzˆ-* Hf- l˜t' ' ' '■■• i t »rLi t i ills″ s i©-OˆD* I . z .v rE 5 ˆ * o \ X OJ --. Q -Q qn oj 2 £ £ a ˆ, J £| ' ' ox ˆ D O O N C ˆ O W W JD (b D W U U Of c

Diode Laser System DL 100 Manual Ramp Generator RG 100 Article number: 32106x Serial number:. © TUI Lasertechnik und Laserintegration GmbH Lochhamer Schlag 19 82166 Graf effing Tel.: + 89 / 89 81 69 - 0 Fax:+ 89/8 54 56 10 email: tui.laser@t-online.de (Status: October 1996, subject to alterations without notice)

Manual Diode Laser Ramp Generator RG 100 Page 2 Content 1 DESIGN OF THE RAMP GENERATOR RG 100 3 1.1 Safety Instructions 4 1.2 Switch ON/OFF 5 1.3 Choice of Frequency 5 1.3.1 Coarse Tuning FREQUENCY RANGE 5 1.3.2 Fine Tuning FREQUENCY 5 1.4 Setting the Output Amplitude AMPLITUDE 5 1.5 Using the Trigger TRIGGER OUT 6 1.5.1 Setting the Trigger TRIG. DELAY 6 1.6 Setting the Output Offset - OFFSET 6 1.6.1 Turning Off the Output Offset - OFFSET OFF 6 1.7 Asymmetrical Ramps 6

Manual Diode Laser Ramp Generator RG 100 Page 3 1 Design of the Ramp Generator RG 100 Figure of the front plate: Plug-in module for Diode Laser-Controller Unit DC 100 (1) Switch ON/OFF, Operation-LED (green) (7) Frequency-band Switch (coarse, 10 positions) (3) Variable fine tuning with trimming potentiometer (12) Variable amplitude tuning with FINE/PRECISION potentiometer (4) Feed forward-trimming potentiometer for independent fine tuning of the amplitude of the output signal on the backplane bus Symmetrical and asymmetrical triangular sawtooth ramps (8) Variable asymmetry degree of the sawtooth, switch off; amplitude: +/-14 V or +/-30 V (6,11) Offset switch OFF, tuning at the front plate with a precision potentiometer (2) Trigger-LED (5) Trigger-Delay, variable delay PLUGS AND SOCKETS (9) BNC-SOCKET to drive 50 Ohm loads (10) BNC-TTL-Trigger

Manual Diode Laser Ramp Generator RG 100 Page 4 The RG 100 ramp generator was designed as a plug-in module for the Diode Laser System DL 100. The performance has been optimized for driving the Grating Stabilised Diode Laser DL 100 or for use with the general Regulator PID 100, which can be used for stabilizing to an atomic resonance or for regulating the length of a frequency doubling resonator, for example. 1.1 Safety Instructions Attention! Before operating the unit please read this manual carefully to prevent damage to the device, connected diode lasers and injury to persons. The following security instructions must be followed at all times. Attention! For safe operation, please use the supplied mains lead only to get proper grounding. Improper or missing grounding can lead to serious injury. Attention! The electrical units should not be operated in a hazardous

environment. Attention! The cassette of the RG 100 should only be opened by trained personnel. Before opening the RG 100, the unit must be disconnected from the mains supply. Attention! When working with the Diode Laser DL 100, always take care not to cause unwanted electrical shortings. The laser diodes are extremely charge sensitive! Even when there is no immediate damage evident, the life time of the laser diode can be significantly reduced. Attention! Do not look into the beam from the laser diode under conditions with exceed the limits specified by the United States Food and Drug Administration, Department of Health and Human Services, Center for Devices and Radiological Health, 21 CFR 1040.10 and 2 CFR 1040.11. Take precautions to eliminate exposure to a direct or reflected beam. Attention! The user should not open the device under operating conditions. Internal trimming or exchange of parts should only be performed by trained personnel. The device must be disconnected from the mains supply!

Manual Diode Laser Ramp Generator RG 100 Page 5 1.2 Switch ON/OFF This switch (1) sets the ramp generator RG 100 in operation and an output voltage is available at the output sockets (BNC sockets 9 and 10). In order to become acquainted with the operation parameters of the RG 100, an oscillocope may be hooked up. At the same time, the OUTPUT signal will made available to the other plug-in modules via the backplane bus of the diode laser control unit DC 100. If necessary, the amplitude of the signal for the backplane bus can be additionally limited with a front plate trimming potentiometer. The amplitude is, at the most, 1/5 of the amplitude of the output signal of the BNC socket (9). For example, when using the proportional intergral regulator PID 100, the RG 100 ramp can be used as the modulation source. 1.3 Choice of Frequency 1.3.1 Coarse Tuning FREQUENCY RANGE Coarse tuning of the output frequency can be set using the 10 positions of the Frequency Range switch (7). The coarse settings are given in the table below. Position Frequency

IHz] 0 10000 1 4400 2 2700 3 2000 4 1000 5 850 6 780 7 700 8 300 9 280 1.3.2 Fine Tuning FREQUENCY Precise setting of the output frequency in the choice COARSE frequency range can be made with the front plate trimming potentiometer (3). It has logarithmic sensitivity. The frequencies given above are valid for the trimming potentiometer at the far right position. 1A Setting the Output Amplitude AMPLITUDE The output amplitude can be set continuously using the FINE/PRECISION potentiometer (12) found on the front plate.

Manual Diode Laser Ramp Generator RG 100 Page 6 1.5 Using the Trigger TRIGGER OUT The ramp generator RG 100 has a trigger output for synchronizing the oscilloscope. As a standard TTL signal it is available at the BNC socket (10). The positive rising edge of the output signal is indicated by the lit red Trigger- LED (2). 1.5.1 Setting the Trigger TRIG. DELAY The ramp generator RG 100 offers the possibility to delay the TTI Trigger in relation to the output signal. This can be an important option in some applications such as driving piezo crystals. This setting is made via the trimming potentiometer set in the front plate (5). 1.6 Setting the Output Offset - OFFSET There is a 10 turn precision potentiometer on the front plate (11), which offers variable settings of the output offset between the maximum output values (+/-12 V or +/-40 V). When the offset switch is on, the output amplitude is 12 or 40 V peak-peak as maximum. 1.6.1 Turning Off the Output Offset - OFFSET OFF The input offset can be turned off with switch (6). Note, that this causes the previously set output amplitude to be doubled. 1.7 Asymmetrical Ramps 1.7.1 Turning the Asymmetrie On and Off SYM./ASYM. The ramp generator RG 100 also offers the option of simple generation of asymmetrical ramps (sawtooth), which are useful for many control tasks. The switch (7) changes the defined symmetrical output of the ramp generator to an adjustable sawtooth form. 1.7.2 Setting the Sawtooth Signal ASYM. The trimming potentiometer (7) on the front plate allows the degree of asymmetry to be variably adjusted.

Manual Diode Laser Ramp Generator RG 100 Page 7 1.8 Feed Forward Setting Standardly the RG 100 will be used in conjunction with the tunable Diode Laser DL 100. The DL 100 is, as mentioned before, tuned by tilting the external grating in the diode laser set-up of the DL 100. For improvement of the mode-hop free tuning range an simultaneous additional modulation of the laser diode current using the same ramp pˆn can be used. However, the tuning behaviour improves at the expense of a more pronounced amplitude modulation. The Diode Laser System DL 100 has this feature already implemented and prepared for the ease of the user. A potentiometer screw on the frontpanel (4) adjusts the output power level of the ramp that is brought to the laser diode using the backplane bus to the DCC 100. For setting this control it is advised to turn the screw anticlockwise until one can hear faint clicks indicating that the lower limit of the setting range is reached, which means the current modulation is zero now. While observing the output mode spectrum of the laser with a Fabry-Perot resonator, the potentiometer screw is now turned clockwise until a satifsfactory modal behaviour is observed.

Manual Diode Laser Ramp Generator RG 100 Page 8 2 Warranty The delivered ramp generator RG 100 has been produced with utmost care and using high-quality components. The device went through extensive testing before delivery. The results obtained in these tests can be seen in the data sheet enclosed. In case of a malfunction or damage, although all operating instructions and -rules in the user's manual have been followed, we will do our best to resolve these problems as soon as possible. For this, the following conditions of guarantee apply: TUI Lasertechnik und Laserintegration GmbH grants a 12-month-guarantee from the date of delivery to the finish and functioning of the ramp generator RG 100 . The guarantee includes either free repair or free replacement of defective devices sent to us. There is a guarantee of three months on all parts replaced or repaired. Any device or

individual component are sent in at the client's own risk. The client also has to bear all transport or insurance costs. TUI Laser will send back all components which fall under the guarantee free of charge. The guarantee is not applicable if malfunctions or damage • are not due to material defects • caused by faulty handling - whether deliberate, negligent or inadvertent • caused by unauthorized usage. No liability is taken for built-in laser diodes. These fall under the guarantee of the original manufacturer. In addition, refer to conditions under "6. liability for defects during transport" as laid down in the General Sales and Business Terms of TUI Laser Inc.

Manual Diode Laser Ramp Generator RG 100 Page? 3 Appendices 3.1 Appendix A: Specifications of the Ramp Generator RG 100 Plug-in Module for the Diode Laser Control Unit DC 100 • Frequency: 0.1 Hz to about 10 kHz • Frequency-range switch (coarse, 10 positions) and continuous fine tuning • Symmetrical and asymmetrical triangular and sawtooth ramps • Variable degree of asymmetry of the sawtooth, can be completely switched off • Amplitude: +/-12 V or +/-40 V • Offset: setting with a high precision trimming potentiometer from the front (+/-12 V or +/-40 V; can be completely switched off) • Trigger-Delay adjustable • Optimised to work in conjunction with the grating-stabilized Diode Laser DL 100

Manual Diode Laser Ramp Generator RG 100 Page 10 3.2 Appendix B: Backplane Bus (VG-64-a/c standard connector according DIN 41612) | general digital GND Supply voltages Ifree 230 V Phase in (red) 230 V Phase out (yellow) |free Analog Signals |RG 100 out Channel 1 Photo diode Channel 1 I Umay Channel 1 Adress Lines I Photo Diode Channel 1 I Umay Channel 1 Indicated Parameter I l(T)mav Channel 1 I Tmay Channel 1 lm«iY Channel 1 I Tmjn Channel 1 lSAt Channel 1 Tfint Channel 1 lflrt Channel 1 Tflrt Channel 1 HV - Supply HV + Supply Error Analog GND |urof(+5V) gen. Supply Lines I-15 V stabilised I+15 V stabilised | +5 V stabilised [1a | - | 1c

2a 3a 4a 5a 2c 3c 4C 5C 6a 7a 8a 9a 6C 7C 8C 9C 10a 11a 12a 13a 14a 10c 11c 12c 13c 14c 15a 16a 17a 18a 19a 20a 21a 22a 23a 24a 25a 26a 27a 28a 29a = = 15c 16c 17c 18c 19c 20c 21c 22c 23c 24c 25c 26c 27c 28c 29c 30a 31a 32a = = | = 30c 31C 32c (brown) | free I Null in (brown) Null out (orange) free | RG 100 out Channel 21 Photo diode Channel 2 Umav Channel 21 Photo Diode Channel 2 Umay Channel 21 l(T)mflY Channel 21 Tmay Channel 21 lmfly Channel 2 Tmjn Channell 21 lSAt Channel 2 TsAt Channel 2 la,* Channel 2 Tarn Channel 2 Blink Power up -Urof(-5V)l (yellow) I (orange) (rMJ