PRIOR
Scientific

LF210

Laser Autofocus
Manual Version 2.1

bsi. ISO 9001 Quality Management
FM 61600

Worldwide distribution

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IMPORTANT SAFETY INFORMATION
SECTION 1

Use only as specified by the operating instructions or the intrinsic protection may be impaired. The below symbol means that there is a potential hazard that means you should take extra care.

Before using the system, please follow and adhere to all warnings, safety and operating instructions located either on the product or in this User's Manual.

- Do not expose the product to water or moisture.
- Do not expose the product to extreme hot or cold temperatures.
- Do not expose the product to open flames.
- Do not allow objects to fall on or liquids to spill on the product.
- Do not touch the glass plate fitted between the circular dovetail and the top plate. Any dust, dirt, fingerprints will cause degradation of image quality
- Do not poke inside the open aperture in the base plate of the unit. There are delicate optical components which are easily damaged if touched.
- **WARNING**. This unit emits visible laser light from the aperture in the base plate of the unit. The total continuous power does not exceed 1mW thus it falls into a CLASS 1 Laser Product. As such the user should not stare directly into the laser beam although the normal eye reflex response will offer protection. The laser power is less than most commercially available laser pointers sold in novelty shops.

- **DANGER**. Under no circumstances unscrew the lid off the unit. The unit contains a CLASS 3B visible laser diode with a maximum continuous power of 35mW. This laser power is only accessible with the unit dismantled and should only be performed by Authorised Service Centres. Disassembly of the unit will void the warranty. This product does not contain consumer serviceable components.

- Use only the proper type of power supply cord set (provided with the system) for this unit. Failure to do so could instantly destroy the electronics and laser diode. The unit requires **+5VDC** at **3 Amperes**.

- Always switch off the unit using the on/off rocker switch **SW1** or unplug the PSU (CON3) when plugging/unplugging the stepper motor (CON4) or DIGIPOT (CON2). It is safe to plug/unplug the RS232 connector (CON1) with the unit powered.

Keep this manual in a safe place as it contains important safety information and operating instructions.

PRODUCT DESCRIPTION SECTION 2

2.1 Product Description.

The Prior Scientific Laser Auto Focus Module model LF210 is an advanced, integrated unit which combines a visible laser diode, associated optical components, detectors, and electronics with on-board micro controller. The controller can output analogue and digital signals suitable for controlling piezo or motor focus drives. The analogue output voltage is compatible with the Prior NanoScanZ piezo Z stage. When using the unit with the Prior Stepper motor, the Prior keypad (LF100K) with integral stepper motor drive unit is required.

It is a simple procedure to install the unit into the optical path of many of the popular laboratory microscopes using infinity corrected optics. Simply install the laser focus unit (LF210), then the Prior focus motor (PS3H122R) to the fine focus knob of the microscope and connect both to the LF100K.

The laser beam passes through the microscope objective on to the sample. The detection circuitry in the Module monitors the spot position on the sample and continuously servos the focus motor or piezo stage to keep the spot position static. Optimum visual focus is maintained.

The LF210 is best suited to metallurgical and semiconductor examination using incident illumination where the sample has a reasonably flat, reflective surface.

Using the LF100K keypad allows fully stand alone operation. The Micro Controller built into LF210 allows the unit to act as an intelligent motorised focus controller in addition to its primary task of automatic focus control. The closed loop action can be disabled, manual focus achieved using the integral rotary digipot and remote focus control can be implemented by connecting the RS232 communication port of the unit to a host p.c.

2.2 Important Information

There are two essential requirements required for correct operation of LF210:

Microscope must have infinity corrected optics (Infinity corrected objectives used in conjunction with tube lens.

It must be possible to insert LF210 in the collimated region of the microscope optics. This is the region between the objectives and the tube lens.

The LF210 system will not function correctly using DIC optics.

UNPACKING THE SYSTEM
SECTION 3

Each Laser Focus system should consist of the following:-

Part	**To fit microscope**
A	LF20 Laser Autofocus 
B	Appropriate flanges for microscope
C	LF100K Control Pad 
D	H407 desktop PSU +24V at 60VA. This plugs into the LF100K and provides power for the stepper motor.
E	PS3H122R Focus Drive
F	Mitutoyo

Dovetail flanges come as a pair and will be factory fitted to the top/bottom halves of the LF210 unit to fit the correct microscope manufacturer/model number. The part numbers are as follows:-

Flange Part Number	**To fit microscope**
LF310	Leica
LF320	Nikon
LF330	Olympus BH
LF335	Olympus BX
LF340	Zeiss
LF350	Mitutoyo

Flanges for other microscopes are available. Please contact Prior Scientific Instruments for details.

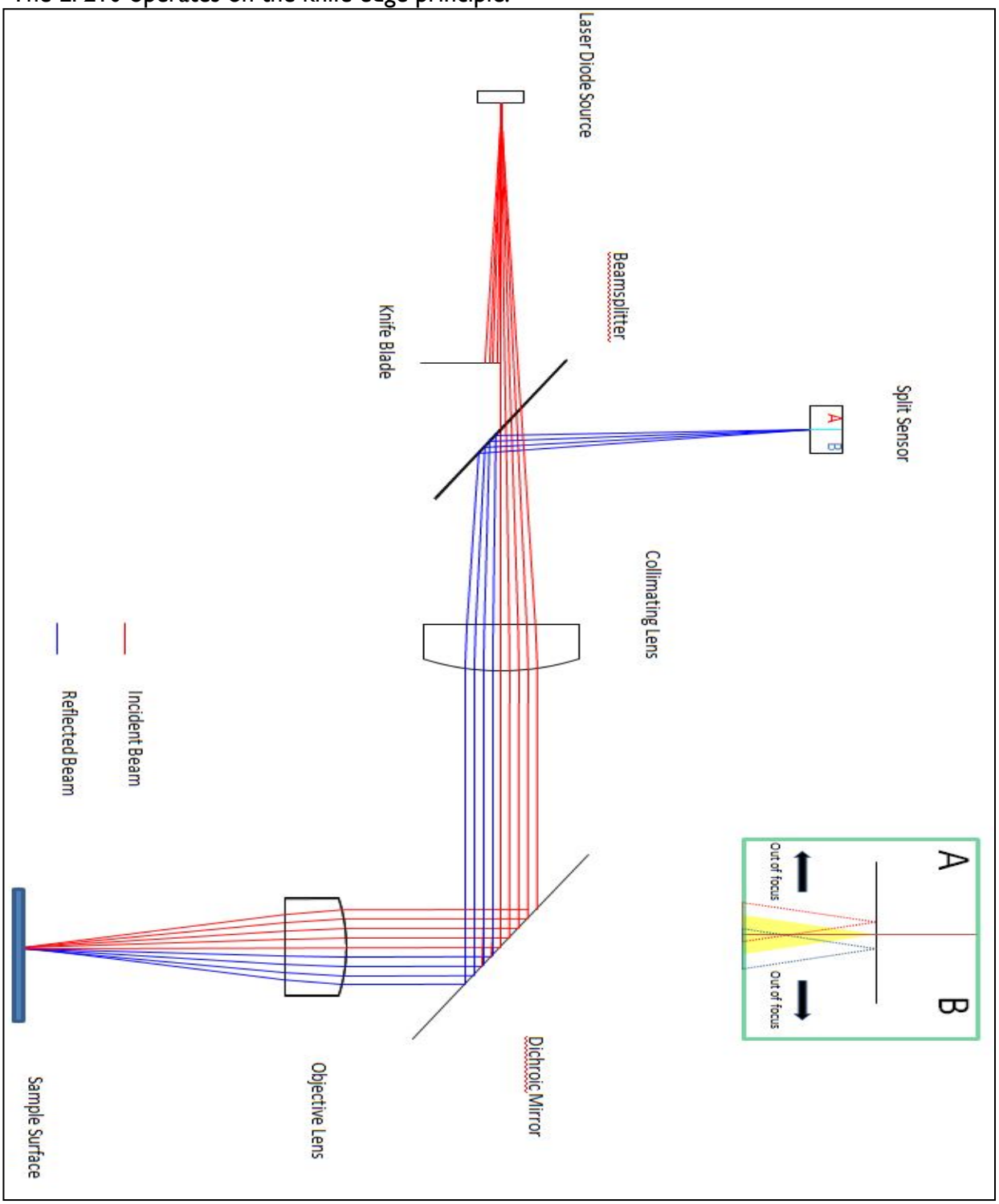
Note: Make sure that all of the components that should be included with your LF210 system have been supplied. If parts are missing please contact your local Prior Dealer.

Take great care when unpacking the LF210 Unit.

In particular do not touch the glass plate in the lid of the unit or poke any object up the aperture in the base. This could cause significant loss of performance or failure of the unit.

PRINCIPLES OF OPERATION
SECTION 4

The LF210 operates on the knife edge principle.



Half the aperture of the collimated light is blocked. The diagram below shows how this spoils the symmetry of the optical system about the optical axis. The collimation of the laser beam is adjusted to be the same as the objective lenses so that the best visual focus and the laser focus coincide. Moving the focus either side of focus not only defocuses the laser spot but moves it laterally on the sample surface.

The reflected light retraces the path of the incident beam, 50% reflecting off a beam splitter through a focussing lens onto a duo lateral silicon position sensor. The image falling on the position sensor is effectively the same as seen by the camera viewing the sample.

The position sensor has 2 electrodes. The spot generates a current from each electrode A and B. If the spot is in the centre of the sensor then current A equal current B.

The sum (A+B) is proportional to light intensity. If for example the spot moves to the right current B increases and current A decreases. We can use this to calculate spot position and over light intensity.

Spot position = K(A-B)/(A+B)

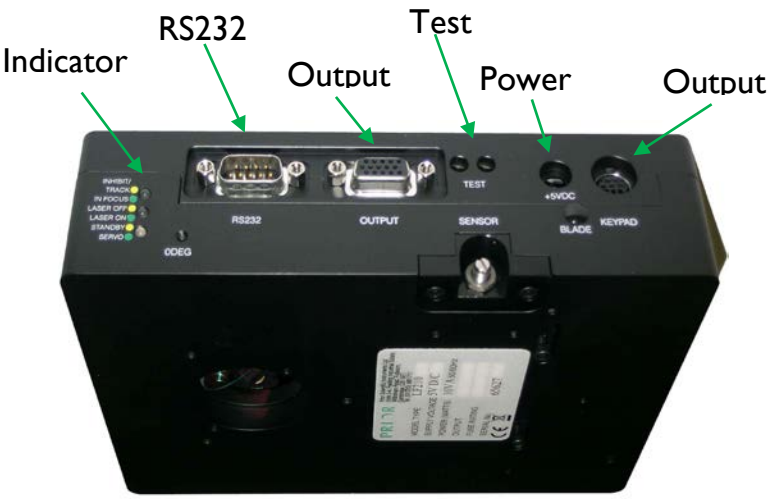
Light intensity = C(A+B)

Where K and C are proportionality constants.

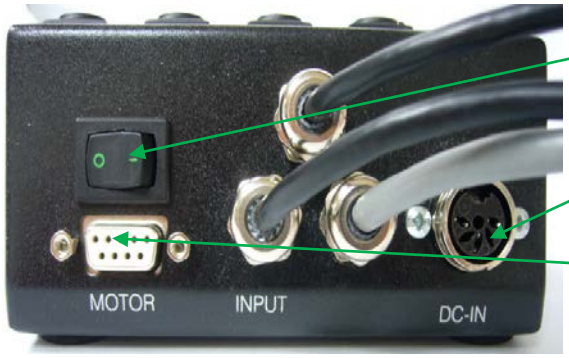
By setting target positions for each objective we can use the LF210 to adjust the focus when the focus position moves from the target position.

INSTALLATION SECTION 5

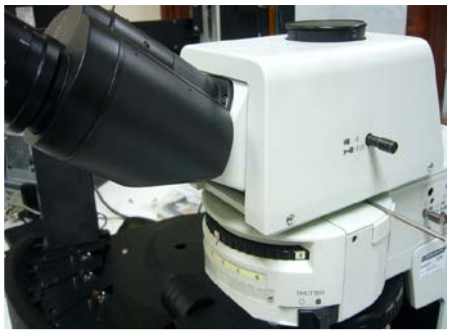
5.1 Diagrams



LF100K, Keypad and digipot control.



5.2 Installation of LF210



Remove the tri/binocular head from the nosepiece using the hex key provided by the microscope manufacturer and place it to one side.

Fit male microscope adapter to the bottom of the LF210

Fit the LF210 laser module to the microscope. Connect cables to LF210 and switch on LF100K and the LF210 units.

In most cases the factory alignment LF210 is of sufficient quality that the unit can be fitted without any adjustment of the optics. To make sure that the laser is on axis use the Prior alignment objective to visualise and centre the LF210 laser.

focus

There are two configurations for the LF210 laser beam shape, spot and line. Laser alignment requires the laser beam shape to be a spot changing from spot to line involves sliding a cylindrical lens in and out of the beam path. There are two cap screw on the LF210, loosen these screw and slide the screws to the opposite position.

To access these cap screw loosen the grub screw attaching the LF210 to the microscope and rotate the LF210 to exposes the cap screws. The spot shape will show a semi-circular beam displayed on the surface of the Prior alignment objective

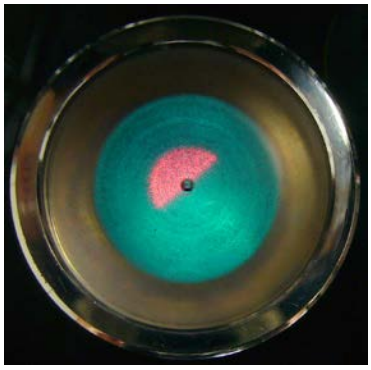


Image of the LF210 laser showing how it looks after alignment

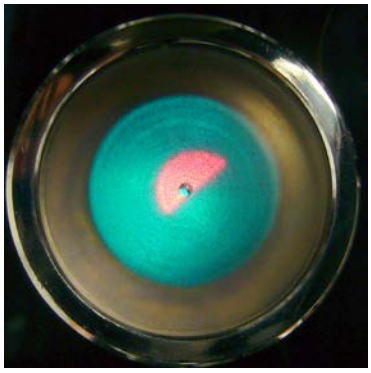


Image of the LF210 laser showing how it may look if the laser is mis-aligned.

If the laser requires alignment:
The laser can be alignment by moving the 45 deg mirror. To access this port requires removal of the binocular head and the microscope adapter. This will move the laser image North and South through the optical axis

To move the laser West and East use the 0 deg port

Change the position of the cylindrical mirror to appropriate spot or line shape as required.
Fit the Female microscope adapter to the top surface of the LF210 using the screws provided and fit the trinocular/binocular head

LF210 and the Focus motor fitted to the microscope.
Connect your computer (running MS Windows): Plug the RS232 cable into RS232 socket on the computer and LF210. Use an RS232 to USB adapter if your computer does not have an RS232 port.

Select x50 objective and achieve a best focus on a typical sample surface in the usual manner. (Use coarse focus knob for large adjustments).

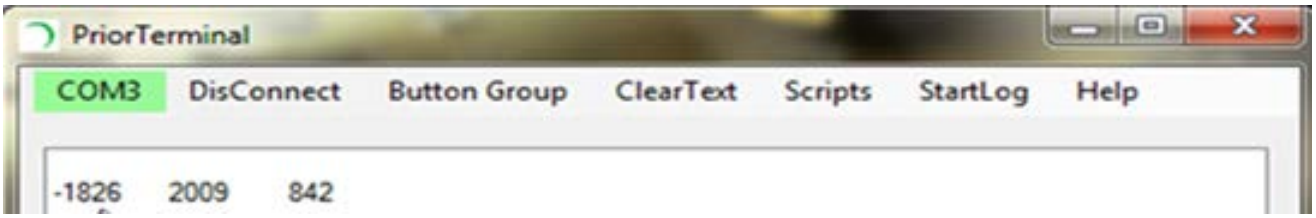
The PS3H122R focus motor should now be attached

Move the sample into focus, and then move the sample in and out of focus, the laser beam (red) should move from one side to the other as the sample moves in and out of focus. Move the sample back into focus.
Initial setup is now complete

Select x50 objective and achieve a best focus on a typical sample surface in the usual manner. (Use coarse focus knob for large adjustments). Use the digipot on the LF100K for fine focus

Run Prior Terminal (Installing and Using Prior Terminal and Prior Demo Controller http://www.prior-scientific.co.uk/Customer-Support/Download-Centre/).

- Successful communication between LF210 and computer has been achieved when pressing the Enter key "<cr>" returns 3 numbers.



GETTING STARTED
SECTION 6

6.1 Using the KeyPad (LF100K)

The LF100K allows standalone operation of the system and also incorporates stepper motor drive circuitry to allow the LF210 to drive Prior PS3H122R focus motor. The Rotary digipot allows remote motorised operation of the fine focus of the microscope. (Only available when SERVO key is not active.) The servo mode allows optimum servo response for each objective magnification.

The five keys number 1 to 5 can be configured for 5 different objective magnifications. The buttons have clear plastic snap in tops with white inserts. Remove the white insert and write on the magnification before replacing the white insert. It is suggested that the lowest magnification is the lowest number button e.g., x5 x10, x20, x50, x100 are buttons 1,2,3,4 and 5 respectively.

Select x50 objective on the microscope. Press the key corresponding to this magnification. This now will associate all subsequent settings to this objective. Focus the microscope using the digipot on the LF100K. Once in focus press the TARGET button. This establishes the target focus position for the objective and the position that the LF210 will servo to. *Note: This TARGET position is not a target Z position as this will change with stage movement and for a sample with differing height or with tilt.*. The initial set up for objective 4 is now complete. To test the autofocus action, use the rotary digipot to move the focus slightly away from best focus. *Warning: Be prepared to turn* ***SERVO*** *off by pressing the* ***SERVO*** *button again.* Press the SERVO key. The STANDBY/SERVO led on the side of LF210 will change from yellow to green and the focus motor will rotate a small amount to bring the image back to best focus and then stop.

If the motor continues to turn and does not stop at best focus, turn SERVO off by pressing the SERVO button a second time. It is possible for the focus motor to drive continuously or oscillate. If the focus motor turns continuously, reverse the sign of KP using Prior Terminal. If the focus motor oscillates, reduce the magnitude of KP

Use Prior Terminal to change values. The value of KP needs to be adjusted so that the response is quick but not liable to oscillate. Start with small value of KP and increase in increments.

Remember to use SAVE command to store the optimum value of KP to non-volatile memory otherwise the new value will be lost on power down. Example of KP values for different objectives are as follows:

Parameter	Default	X 5	X 10	X 20	X 50	X 100
KP	100	2000	1000	1000	100	25

Advanced configuration (electrical servo gain "KP" and damping "KD") are completed by using Prior Terminal. ffor further details of fine tuning parameters see Section 9

6.2 LF100K Kepad Functions

The table below describes the function of each key.

Note that **FUNCTION+KEY** works as follows:-

Press FUNCTION key. LED will flash indicating it's active.

Release FUNCTION key then press appropriate key.

This completes the action. Note that the FUNCTION key then becomes inactive (indicated by its led going out)

The exception to this operation of FUNCTION/UP and FUNCTION/DOWN which increases/decreases buzzer volume respectively. Here FUNCTION key is kept pressed whilst repetitively pressing UP/DOWN key **FUNCTION** key is cancelled afterwards by pressing it again.

Key	Operation
1 to 5	Selects the optimum parameters for the particular objective. The following parameters are associated with each objective and are normally pre set using the RS232 communication with computer and/or using keystrokes with the FUNCTION key (see below). The pre set parameters for each objective are TARGET,KP,KD(see RS232 Commands)
SERVO	Switches on and off the SERVO or Auto Focus function. STANDY / SERVO goes green when SERVO is active. Switching SERVO off enables the Digipot. The LF210 will also then function as an intelligent motorised focus drive controlled using commands sent along the RS232 connection (if fitted to a computer) SERVO/STANDBY mode of LF210 is also indicated by the LEDs on the front of LF200
UP	With unit in STANDBY holding UP button will cause focus to move up continuously at a speed set by the SPEED button.
DOWN	With unit in STANDBY holding DOWN button will cause focus to move down continuously at a speed set by the SPEED button.
SPEED	With unit in STANDBY each successive momentary depression of this button will cycle the speed at which the focus moves using UP/DOWN buttons or Digipot through 100%/25%/50% The preferred setting is stored even through a power cycle. This button will change the speed setting whether motor is moving or stationary. The unit must however be in STANDBY.
HOME	Moves stage to a preset HOME position.

Key	Operation
HOME / FUNCTION	Set the current focus position as the HOME position. Future use of the HOME key on its own will move the focus to this position.
TARGET	Use the digipot to establish best visual focus. Pressing this key will set this as the focus which will be maintained during SERVO action for the current objective.
FUNCTION / UP	Keeping FUNCTION key pressed whilst repetitively pressing UP key increases volume of buzzer. Note that a maximum volume will be reached such that further presses of the UP key has no effect.
FUNCTION / DOWN	Keeping FUNCTION key pressed whilst repetitively pressing DOWN key increases volume of buzzer. Note that minimum volume is the buzzer switched off.

RS232 COMMANDS

SECTION 7

LF210 Module can accept commands from a host computer (running Application Software or Prior Terminal Programme) using the RS232 serial port. The port need to be set to a baud rate of 115kB (settings 115200,n,8,1))

All commands are terminated with a Carriage Return <cr>

Commands are separated from arguments by one or more of the following delimiters.

COMMA

SPACE

TAB

EQUALS

SEMICOLON

COLON

Thus to move the focus UP by 100 steps the user could enter any of the following

U,100<cr>

U 100<cr>

U:100<cr>

U;100<cr>

U100<cr>

Proof of successful acceptance of any command sent to LF210 is the response '0'<cr> The response is immediate i.e. it does not wait for the command to be completed.

Commands can be stacked (queued) although they are not necessarily acted upon immediately. e.g. sending a move command U,1000 immediately followed by PZ,0 will zero the Z position after the Up move has finished.

If a command is not valid a response of "E,n" is returned. The n specifies an error type as listed below. The error codes are the same as for Prior Scientific's other motor controllers (ProScan and OptiScan)

Error Code	Error Description	Error Code	Error Description
2	Not Idle	**9**	ARG1 out of range
3	-	**10**	ARG2 out of range
4	String Parse	**11**	ARG3 out of range
5	Command Not Found	**12**	Arg3 out of range
6	-	**13**	Arg4 out of range
7	-	**14**	Arg5 out of range
8	Value out of range	**15**	Arg6 out of range

Commands specific to LF210 operating as Auto Focus unit.

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
CONFIG	None	K,S,N	Reports configuration mode where: K = default gain settings for OEM piezo without internal PID loop N = gain settings for Prior NanoScanZ stage with closed loop integral height sensor S= gain setting for Prior stepper motor control.
CONFIG	n(K,N,S)	0	Sets 50X objective default values for Gain Settings: KP,DK,KI,Delay,DelayD,Rate where: K = default settings for OEM piezo without internal PID loop N = setting for Prior NanoScanZ stage with closed loop integral height sensor S - gain setting for Prior stepper motor control.
KP	none	p	Reports the proportional gain setting
KP	P-gain(-2000 to 2000)	0	Sets the Proportional gain. The proportional gain regulates the speed the system responds to a focus error. The proportional gain is the error signal multiplied by a gain constant which controls the drive. Decrease this value for better stability but slower response. Typical value are between 20-200. If the unit makes the focus drive continuously away from Target then it is likely that the loop is negative, not positive feedback and so negative values should be used.

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
CONFIG	None	K,S,N	Reports configuration mode where: K = default gain settings for OEM piezo without internal PID loop N = gain settings for Prior NanoScanZ stage with closed loop integral height sensor S= gain setting for Prior stepper motor control.
CONFIG	n(K,N,S)	0	Sets 50X objective default values for Gain Settings: KP,DK,KI,Delay,DelayD,Rate where: K = default settings for OEM piezo without internal PID loop N = setting for Prior NanoScanZ stage with closed loop integral height sensor S - gain setting for Prior stepper motor control.
KP	none	p	Reports the proportional gain setting
KP	P-gain(-2000 to 2000)	0	Sets the Proportional gain. The proportional gain regulates the speed the system responds to a focus error. The proportional gain is the error signal multiplied by a gain constant which controls the drive. Decrease this value for better stability but slower response. Typical value are between 20-200. If the unit makes the focus drive continuously away from Target then it is likely that the loop is negative, not positive feedback and so negative values should be used.
KD	none	d	Reports the differential gain setting.

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
KD	D-gain (-10000 to +10000)	0	The differential gain parameter reduces any oscillations the system caused by the external drive overshooting the optimum position. A differential controller is used to stabilize the output signal, it predicts the future state of the system using the current rate of change of measure values. By analysing the rate of change it is possible to calculate how much the drive system will go past the optimum position and change the rate of change to compensate for this. The differential value is multiplied by the KD constant value. Increasing this value from zero will reduce the overshoot as the focus approaches best focus. If the opposite happens then enter negative values. It is found that using LF210 to control PS3H122R stepper motor or Prior NanoScanZ piezo stage the default value of zero is optimal.
KI	none	I	Reports the integral gain setting.
KI	I-gain(-1000 to +1000)	0	Sets the Integral Gain Value (I). Integral gain is the sum of all previous error signals multiplied by a gain constant and fed out to the drive. The integral term becomes very large and so it is multiplied by small numbers for use in the LF210. This command is used to set and read the gain constant, which gets divided by 65000 for use in the system. In most instances KI is ignored and set to zero. The default value is zero.
Rate	none	r	Reports slew rate (r) of the digital to analog converter
Rate	bits (1 to 100)	0	The Slew rate is a second parameter which can be used to reduce any oscillations the system caused by the external drive overshooting the optimum position. The Slew rate of the Digital to Analogue Converter (DAC) that is used for output to the NanoScanZ can be controlled. The rate of change of the output can be controlled via this parameter, a value of 1 means that each subsequent DAC output can only change from the previous value by a maximum of 1. The DAC outputs a value every 1msec.

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
KD	D-gain (-10000 to +10000)	0	The differential gain parameter reduces any oscillations the system caused by the external drive overshooting the optimum position. A differential controller is used to stabilize the output signal, it predicts the future state of the system using the current rate of change of measure values. By analysing the rate of change it is possible to calculate how much the drive system will go past the optimum position and change the rate of change to compensate for this. The differential value is multiplied by the KD constant value. Increasing this value from zero will reduce the overshoot as the focus approaches best focus. If the opposite happens then enter negative values. It is found that using LF210 to control PS3H122R stepper motor or Prior NanoScanZ piezo stage the default value of zero is optimal.
KI	none	I	Reports the integral gain setting.
KI	I-gain(-1000 to +1000)	0	Sets the Integral Gain Value (I). Integral gain is the sum of all previous error signals multiplied by a gain constant and fed out to the drive. The integral term becomes very large and so it is multiplied by small numbers for use in the LF210. This command is used to set and read the gain constant, which gets divided by 65000 for use in the system. In most instances KI is ignored and set to zero. The default value is zero.
Rate	none	r	Reports slew rate (r) of the digital to analog converter
Rate	bits (1 to 100)	0	The Slew rate is a second parameter which can be used to reduce any oscillations the system caused by the external drive overshooting the optimum position. The Slew rate of the Digital to Analogue Converter (DAC) that is used for output to the NanoScanZ can be controlled. The rate of change of the output can be controlled via this parameter, a value of 1 means that each subsequent DAC output can only change from the previous value by a maximum of 1. The DAC outputs a value every 1msec.
Delay	none	D	Reports the Servo Delay Setting (D).

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
Delay	D(TBD)		Sets the Servo Delay Setting (D) The servo loop is run every 1ms. This command will reduce the run rate of the loop if required. The default value is zero. This command will only need to be used if the piezo focus drive being used to move the focus position is slow to respond. The standard loop time is 1ms. Each unit of delay increases the loop time by 0.1ms. In most cases this should be set to zero.
DelayD	none	D	Reports the Dynamic Delay Setting (D)
DelayD	D(TBD)	0	Sets the Dynamic Delay (D). This is an additional delay setting. Dynamic Delay is utilized in lieu of (Delay) when the (Delta) error is greater than 40,000 or less than -40000. In most cases this should be set to zero. Default is zero.
Target	none	0	Sets the Target position for a particular objective.
Target	?	t	Reports the value for the target position stored during the (Target) command.
Target	pos	0	Sets the laser target position to a known value. Should a sample have 2 or more known heights the target value can be changed for each height. Where surfaces at different heights have significantly different reflectivities, the (ADC) command can be used to determine when to switch between target positions.

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
Target	B	0	There are some extreme situations where the surface characteristics vary wildly, so much so that the laser spot/line shape is different on each surface even though the surfaces are at the same height and therefore stay in best visual focus. One such example is chrome on glass. If the glass substrate is thin then the laser reflection off bottom surface upsets the laser light distribution. The reflectance of the top surface is also dramatically different. Move one type of sample surface under the laser beam, achieve best visual focus and type TARGET,W (white), move to other type of surface (refocusing if necessary) and type TARGET,B (black), type MODE,1 and best visual focus is maintained on either surface. Use TEST,4 to confirm correct operation. The LF210 uses the Reflectance to calculate a Target Spot Position. It assumes a linear behaviour for any surface which has Reflectance different from the 2 used to do this calibration. It is advisable to mechanically adjust the sensor so that (A-B) for the 2 surfaces at best focus lie approximately either side of zero e.g, it is better to have A-B +/-700 and not 0 and 1400
			IMPORTANT TARGET,W TARGET,B calculates a REFLECT number which is proportional to slope of Target Spot Position vs Reflectivity. Reverting to a single target set using TARGET,s will cancel this feature and RELECT will be set back to zero. Alternatively typing REFLECT,0 will cancel. LIST will confirm that this feature is cancelled by returning REFLECT,0 in the list.
Target	W	0	See above.
INHREF	none	min,max	Reports the minimum and maximum reflectivity setting between which the LF210 will continue to servo i.e... Mode 1.

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
INHREF	min(0-49000),max(1-50000)	0	Allows the LF210 to toggle between Mode 1 and Mode 2 when scanning across surfaces such as chrome and glass where glass would cause an undesirable focus shift. Any reflectivity less than the minimum or greater than the maximum will switch the LF210 into Mode 2(standby), moving back into the reflectivity range automatically returns the unit to servo mode 1.Any Reflectivity number >50000 is considered as a fault condition and will put the unit into MODE,2 (standby) Use ADC or TEST,4 to observe the reflectance of the surfaces Default max is 50000, Default min is 0 Second parameter (max) is optional INHREF,0 will set min to 0 and max to 50000 INHREF,500 will set min to 500 and max stays at 50000 INHREF,500,2000 sets min to 500 and max to 2000.
Delta	none	error	Reports the error between the target laser spot position and the measured laser spot position. (TARGET) will set this to zero.
Laser	none	intensity	Reports the current laser intensity.
Laser	I(1-4095)	0	Sets the laser intensity. Less reflective samples require higher laser intensity for optimal performance Default value is 2000.
Laser	D	0	Disables the laser. Command can be used to capture an image without the laser visible.
Laser	E	0	Enables the laser. Note simply changing the laser intensity does not turn the laser back on.
Obj	none	O	Reports the objective currently selected.
OBJ	O(1-6)	0	Selects the current objective and all settings associated with it.
OBJ	O(1-6),M(4-200)	0	Sets objective magnification and associated KP value equal to 25000 divided by M OBJ,1,50 sets KP to 50.
Piezo	none	piezo position	Reports piezo control voltage in DAC counts (0-4095) as specified by (OUTPUT).

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
Piezo	n(+4095 to -4095)		This command should only be used in Mode 2 Changes the analog voltage on pin 3 of the 15 way socket to control piezo position. From the midway voltage defined by the (OUTPUT) command Piezo,2047 increases the output to maximum voltage and Piezo,-2047 will bring you to the minimum voltage when starting from the middle of the voltage range. Example: Output ,0,4000 sets piezo range from 0-4V with starting voltage at the midpoint = 2V Piezo Returns 0 = 2V starting point Piezo,2047 Sets piezo voltage to maximum of 4V Piezo Returns 2047 Piezo,-4095 Sets piezo voltage to minimum of 0V Piezo Returns -2047 Piezo,2047 Sets piezo voltage to midpoint = 2V Piezo Returns 0 It is important to note the following:- Do not connect PIEZO voltage output to the device which is to be driven until it is established that the voltage range is limited to the voltage range for the device. Failure to do this could damage the piezo drive circuitry. Output voltage is generated from a 12 bit DAC therefore full voltage range is 4095 steps. Thus for OUTPUT,0,10000 gives 2.44mV per step. Reading PIEZO returns an absolute position (+/-2047). PIEZO,n is a relative step move. In MODE,2 only PIEZO,n command or moving digipot will change PIEZO voltage. Absolute range is +/-2047. Any attempt to go outside this range using PIEZO,n will be truncated . to keep absolute position to within +/-2047.

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
Infocus	none	0 or 1	Reports whether the sample is in focus. 0 = out of focus, 1 = in focus Sample is in focus when (Delta) is within +/- (FOCUS) value, see (FOCUS) Command Note: When Infocus = 1, InFocus LED will go green and InFocus TTL will go low When Infocus = 0 LED will flash yellow.
Focus	none	n	Reports the range (n) that the sample can drift from the target position before triggering a servo move LF210 will servo until (Delta)<0.5n. Servo will re-activate once (Delta)>+/-n.
Inhibit	none	N	Returns Inhibit status. 0 = normal operation, 1 = in inhibit mode.
Inhibit	N(minimum = 1)	0	N is the value of (A+B) visible light on the sensor below which the calculated error will be forced to zero. In mode 1 this would freeze the output voltage, or stop output pulses to the stepper In mode 0 voltage would fall to zero. The InFocus LED will switch to Red and the Infocus TTL will go low when (A+B) falls below this value. Default value is 250.
Mode	none	0-2	Reports the Operating Mode
Mode	0-2	0	Sets the Operating Mode of the LF210 Mode,1 = Servo Mode Mode,2 = Stand by/Open Loop Mode Mode,0 = Height Sensor Mode - open loop - not recommended.
Output	none	Vmin,Vmax	Reports the minimum and maximum output mV for piezo control (pin 3 of 15 way socket) - Mode 1 and 2 Reports the minimum and maximum output mV for error signal (pin 3 of 15 way socket) - Mode 0 e.g. Output,-4000,4000 sets voltage to +/- 4V Output ,0,10000 sets output voltage to 0-10V Note that this range cannot be set unipolar and negative, for example Output,-4000,0 is not valid.

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
Output	Vmin,Vmax	0	Sets the minimum and maximum output voltage for piezo control, Mode 1 and 2 Sets the minimum and maximum output voltage for error signal, Mode 0.
Pos	none	pos	Reports the spot position on the sensor. The spot position is calculated as 65535*(A-B)/(A+B).
Save	none	0	Saves parameters from volatile memory into non-volatile memory. Any changes between saves will be lost with a power cycle.
Load	none	0	Loads the parameters saved in non-volatile memory back into working memory.
List	none	see description	Lists all user settable values associated with the current objective. List ends with END which should be used to identify end of LIST (so additional lines can be added) Note that this command should be preceded by the correct objective required using OBJ,n e.g. VERSION 027 OBJ 4 KP 100 KD 500 KI 0 RATE,1 DELAY 200 DELAYD 0 LAG,1 LASER 2000 INHIBIT 250 FOCUS 5000 OFFSET 0 0 MODE 2 REFLECT 0 END

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
Version	none	software version	Returns 3 digit software version number.
Date	none		Returns date of software compilation and build number.
ADC	none	(a-b), reflectance,(a+b)	Useful when setting INHREF command.
S	none	pos,(a+b),delta	This command may be useful to the user for diagnostic purposes For instance the user can carry out the following sequence:- MODE,2 (allows manual movement to best visual focus) TARGET (sets current spot position to Target) PIEZO,-1000 (moves stage down by 1000 steps) S (outputs (a-b), spot position, (a+b) PIEZO,1 (moves stage up by 1 count) S (outputs (a-b), spot position, (a+b) loop 2 steps above. User has (A+B) and DELTA which can be plotted against height(PIEZO) A note of warning. The user should be aware that PIEZO,n changes the voltage input to the piezo stage. Prior NanoScanZ piezo stage has its own integral height sensor and operates in closed loop mode such that input voltage (0-10V) and mechanical position are accurately related. If the LF210 is inputted to a piezo stage which has no internal feedback the relationship of voltage input to mechanical position will be inaccurate and show substantial hysteresis therefore PIEZO voltage will not represent the accurate mechanical position.
Keypad	"0" or "1"	0	Zero will disable the LF100K keypad, one will enable the keypad. Use the "save" command to save this setting

COMMAND	ARGUMENT/RANGE	RESPONSE	DESCRIPTION
TTL	0 or "1"	0	One will enable TTL outputs, zero will disable TTL outputs. Outputs are disabled automatically upon every start-up
			See section 7 for definition of TTL inputs.
Reset	none	0	Resets to factory defaults. Note that all variables saved to non-volatile memory will be lost.
Test,1	t	see description	Test,1 will display (a-b), spot position, (a+b) every 100 ms. The argument t can be omitted for
			100 ms intervals or changed for more or less frequent intervals. Useful for diagnostic purposes.

Commands specific to LF210 operating as motorised focus controller

Note SERVO must be disabled (i.e. be in MODE0 or MODE1) for LF210 to operate as an intelligent motor controller responding to commands sent along the RS232 port.

Command	Argument(range)	Response	Description
Z			Sets absolute motor position to 0
GZ			Moves motor to Absolute Position n.
PZ			Returns motor position
C	n		Sets the step size when using U and D commands.
U	n		Moves the motor position Up by n counts. Convention is that Up will increase motor position. If n is omitted the step size is defined by C command.
D	n		Moves the motor position Down by n counts. Convention is that Down will decrease motor position. If n is omitted the step size is defined by C command.
ZD	n		Reverses the direction of the motor when instructed to go to position P from zero position. n=+1 or -1 Default ZD=1
SMZ	n		Sets the maximum rotational velocity of motor to n. Units are % Range 0-100% Default 50%

I/O CONNECTORS
SECTION 8

OUTPUT connector is High Density (3 Row) D type socket.

Pin number	Signal Type	Input/Output	Range/comments
1	GND	-	-
2	Sum	output voltage	0-10V
3	Piezo pos/error	output voltage	Defaults to 0V-4VDC (OUTPUT,0,4000) but can be changed using OUTPUT command. In MODE,2 the output voltage is midway between Vmin and Vmax at power-up and can be altered using the PIEZO,n command.
4	Position	output voltage	Proportional to Calculated spot position. Range is +/-5V
5	GND	-	-
6	Pulse	TTL Output	Outputs pulses at a rate proportional to ERROR. Used to control stepper motor drive in LF100K
7	n/c	-	-
8	n/c	-	-
9	n/c	-	-
10	Dir	TTL output	Used with Pulse to determine direction of drive for stepper motor.
11	n/c	-	-
12	n/c	-	-
13	+5V output	-	-
14	In Focus(L)	TTL Output	InFocus flag (see INFOCUS command)
15	Inhib(L)	TTL Output	Inhibit flag (See INHIB command)

Notes

2) Intensity. This is (A+B) and is a purely analogue signal (A and B are rectified and added) i.e. it does not go through any ADC/DAC conversion

3) Mode 1/Mode2 this is piezo output voltage .Mode 0 converts voltage to Error Voltage proportional to Spot position error). Output voltage range set using Output command.

6) Pulse output. MODE,1/MODE,2 should be used for this. e.g., if OUTPUT,0,4000 then piezo voltage sits at 2.000V. However setting TARGET and then MODE,1 will output up/down pulses to maintain spot position at Target position.

Note that the pulse rate will be affected by the KP,KD,KI values in the same way as the analogue output voltage on pin 3

TTL inputs.

Unit has 4 TTL inputs using the 8 way Min-Din socket. The contact assignment is as follows:-

Any user wishing to use these TTL inputs can obtain a suitable cable from Prior Scientific (Prior part number W1867)

These inputs are inactive by default.

Use command TTL,1 to activate these inputs

Use SAVE to ensure that they are active for all subsequent power ups

These inputs allow control of LF210 without needing to use the RS232. The response to these inputs will be faster than sending the same commands via RS232.

Contact	**Cable wire colour**	**TTL numbering.**	
1	black	TTL2	
2	white	+5Vout	
3	red	TTL4	MODE 1(H)/MODE 2(L)
4	yellow	A(encoder 0Deg)	
5	purple	TTL1	
6	blue	0V	
7	green	TTL3	LaserOn(H)/Off (L)
8	brown	B(encoder 90Deg)	

TTL1 and TTL2 select the objective as below.

TTL1	TTL2	OBJ
0	0	1
0	1	2
1	0	3
1	1	4

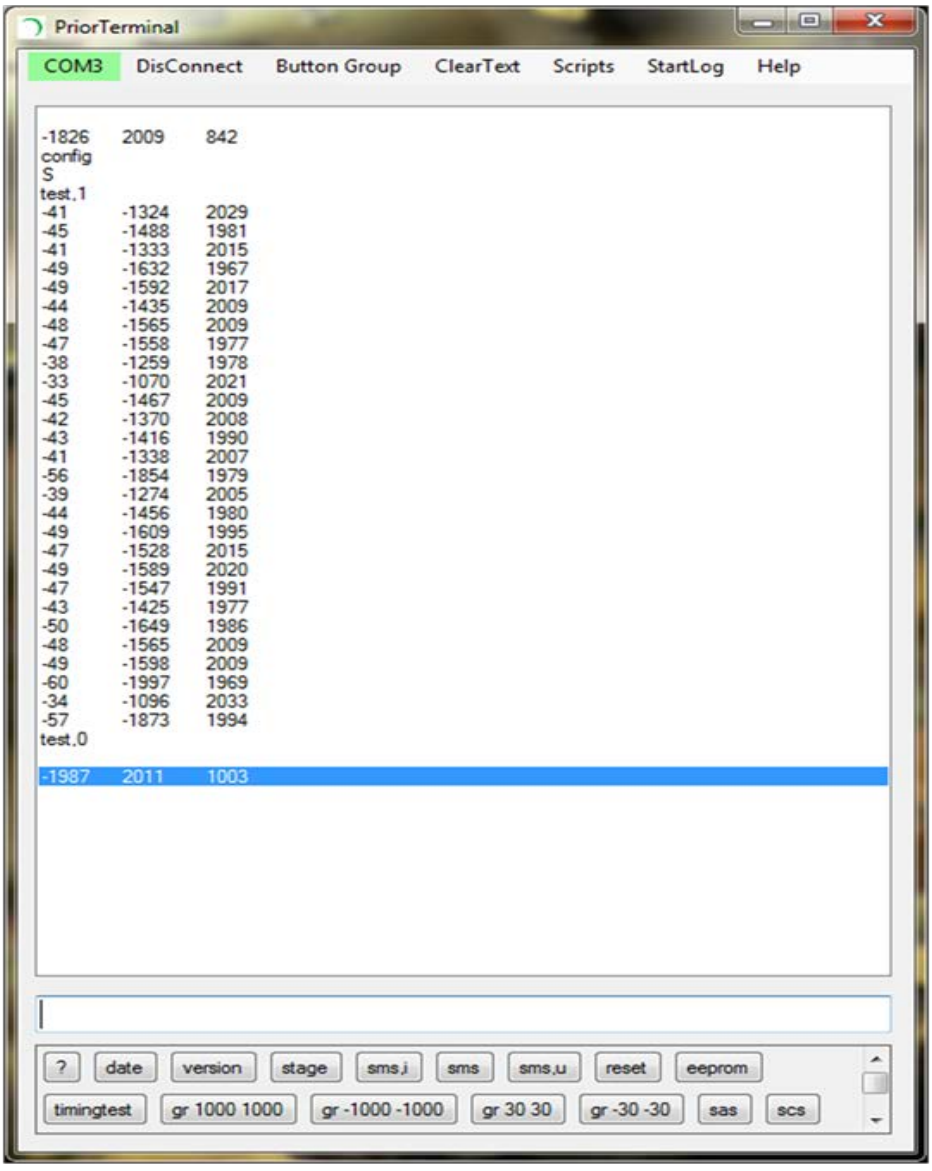
SUGGESTED SETTINGS FOR TUNING SECTION 9

The user should first configure LF210 for the type of drive connected to the 15 way output socket using the CONFIG command. This sets parameters which should be most suited to x50 objective and should work for lower power objectives but at low response speed. The parameters are initiated to be the same for all Objectives (see OBJ command)

Servo Response:

Tuning the LF210 Sensor for optimal use

In MODE,2 (open loop, no servo) run TEST,1 with image at best focus. Confirm (A-B)=<+/-50. Use mechanical adjustment of sensor to achieve this. Type TEST,0 to stop test.



LF210 fails to focus

If the LF210 does not focus but continues to move the focus knob of the microscope it is likely that KP needs to be reverse sign (positive feedback)

Adjusting response of the LF210

If focus oscillates then reduce KP

Adjust KP,KD, RATE, DELAY to achieve fastest response without flicker or oscillation. This can be tested by either pushing down on the stage or manually adjusting the coarse focus whilst looking at the image. At best the LF210 will respond quick enough for the image not to go out of focus. Be aware that Prior NanoScanZ has limited travel (+/-100 microns NZ100 or +/-400 microns NZ400) so focus correction can only be within this range.

Parameters for LF100K and PS3H122R Stepper motor focus

Prior Terminal must be set to the correct configuration to enable parameters to be changed. When using the PS3H122R motor focus CONFIG,S must be used. Type CONFIG <cr> to check configuration. If S is returned the configuration is correct. To change the configuration to S, type CONFIG,S <cr>.

Use the obj command or the keypad to select objective the use the LIST command to obtain the settings for each objective. The table below shows the default settings and suggested settings for each objective

High values of KP will show oscillation, small values will show slow response. As a rule of thumb use ratios for KP which are the inverse of square of the ratio of magnifications i.e.
KP(x50)=4*kp(x100)

FOCUS value determines how far from best focus before servo action is initiated. It is a deadband either side of best focus. Too small a value will show constant corrections which will be seen as a flicker of the image. Too large a value will result in the image being able to go too far out of best focus before corrective action.

Parameters shown in italics should be left alone and will have no effect on servo behaviour.

Parameter	default	x5	x10	x20	x50	x100
kp	50	4000	4000	1000	500	200
kd	0					
ki	0					
rate	*1*					
delay	*0*					
delayd	*0*					
lag	*1*					
laser	*2000*					
inhibit	500					
focus	8000	1000	2000	3000	8000	8000
offset	*0,0*					
mode	2					
reflect	*0*					

Remember to type SAVE so that LF210 will power up in the configuration.

Parameters for LF100K and Piezo focus

Prior Terminal must be set to the correct configuration to enable parameters to be changed. When using a piezo focus CONFIG,N must be used. Type CONFIG <cr> to check configuration. If N is returned the configuration is correct. To change the configuration to N, type CONFIG,N<cr>.
The table shows the parameters for pin 3 of 15 way output socket (Piezo Output) connected to 0-10V voltage input of Prior NanoScanZ

High values of KP will show oscillation, small values will show slow response. As a rule of thumb use ratios for KP which are the inverse of square of the ratio of magnifications i.e. KP(x50)=4*kp(x100)

Rate determines how quickly the Output voltage can change. Since the depth of field of low power objectives is high the Rate needs to be higher for the servo action to correct for large focus shifts.

Delay is set to zero for high power objectives otherwise the user can observe the delay due to the small depth of field.

FOCUS value determines how far from best focus before servo action is initiated. It is a deadband either side of best focus. Too small a value will show constant corrections which will be seen as a flicker of the image. Too large a value will result in the image being able to go too far out of best focus before corrective action.Parameters shown in italics should be left alone and will have no effect on servo behaviour.
Looking at the graphs below showing the sensitivity of the LF210 for different objectives it is clear that it is most sensitive for high magnifications therefore kp can be reduced.

Parameter	default	x5	x10	x20	x50	x100
kp	100	2000	1000	1000	100	25
kd	500					
ki	0					
rate	5	200	100	50	5	5
delay	0	200	200	200	0	0
delayd	0					
lag	1					
laser	2000					
inhibit	500					
focus	8000	1000	2000	3000	8000	8000
offset	0,0					
mode	2					
reflect	0					

Depth of field

Prior NanoScanZ is a very sensitive Z stage and can be used as an accurate Z positioner when used with LF210 in MODE,2 (open loop)

OUTPUT,0,10000 will set Piezo voltage range of LF210 0V-10V which is 0-100 micron travel of NanoScanZ

PIEZO command can be used to move the NanoScanZ with an absolute position range 0-4095, thus having a theoretical resolution of 0.025microns.

PIEZO command can be used to step the sample position until the observer sees the image just going out of focus.

The DOF is the +/- range within which the image is not observed to be going out of focus.

FOCUS value is typically half the value at which INFOCUS flag stops toggling. Thus the FOCUS value will ensure that the image stays well within the DOF in MODE,1

	x5	x10	x20	x50	x100
NA	0.1	0.25	0.4	0.75	0.9
DOF(+/- microns)	12	2.5	1.25	0.4	0.1
FOCUS	1000	2000	3000	8000	8000

TROUBLESHOOTING SECTION 10

Problem:

LF210 is totally inactive when switched on using the rocker switch. The green led of the power supply is not lit

Suggestions:

Check that the mains socket used by the PSU is live (plug in another electrical appliance). Check the fuse in the mains plug (if present), or alternatively replace mains cable with another which is known to work with another appliance. Pull out the 2.5mm socket from (LF210) to see if unit is shorting out the output of the PSU. If the led on the PSU remains off then it is likely that PSU is faulty and needs replacement.

WARNING

Replace +5V 35W PSU with genuine Prior replacement (Prior part number W?) otherwise permanent damage can be done to LF210

Problem:

The unit is totally inactive when switched on using the rocker switch. The green led of PSU is on.

Suggestions:

The digipot LED should be on when power is applied to the unit. If no LED is lit then the unit has no power. Although the green led of PSU is on it may be that the PSU is still faulty. Switch PSU off by removing the mains. Reapply mains power to PSU. If fault persists then return complete system back to Prior,

SYSTEM SPECIFICATIONS
SECTION 11

Power

Universal integral power supply (for LF210 LaserFocus unit)

Input: 90 - 265V 110 - 240V, 50/60Hz 15VA

Output: 5VDC 20VA

Universal integral power supply (for LF100K Keypad with integral stepper motor drive)

Input: 90 - 265V 110 - 240V, 50/60Hz 15VA

Output: 24VDC 60VA

Part	Unit	Dimensions (L x W x D mm)	Weight (Kg)
LF210	Autofocus	175 x 130 x 47	1.5
LF100K	Keypad	154 x 124 x 57	1

Specifications subject to change without notice.

GLOSSARY OF TERMS
SECTION 12

Aperture - The area which is available for the passage of light

Autofocus - The ability of a Z focus system to automatically find the correct focus

Coarse Focus Knob - The large knob on the side of a microscope that moves the stage up and down relatively large distances with relatively small motion.

Controller - The device which provides positional control to the stage, focus drive, filter wheel, or shutter.

Digipot - A circular device/encoder, typically mounted on a joystick used to manually rotate the fine focus knob. The digipot rotates the focus knob at an angle relative to the angular movement of the rotation of the digipot.

Encoder - A feedback device which provides positional information for either an XY stage or the focus drive assembly. Encoders can either be rotary or linear.

Fine Focus Knob - The small knob on the side of the microscope that moves the stage up and down relatively small amounts with relatively large movements. Typically 100 microns per revolution of the fine focus knob.

Flash Memory Capability - The ability of the Prior controller to download new software without requiring an EPROM change. This ability is analogous to that of a solid state hard drive.

Focus Drive - A motor and adapter assembly that typically mounts to the coarse focus knob of a microscope and drives the fine focus knob.

Incident Illumination - Light which falls on the object from the same direction as viewing.

Inverted Microscope - A microscope that views the object from below. The objectives are underneath the stage.

Open Loop System - A control system that has no means of comparing the output with the input for control purposes. Open loop stage systems rely on the controller to send the proper amount of pulses to the motor to achieve the required movement.

RS-232 - A communication standard which specifies electrical, mechanical and functional characteristics for serial binary communication circuits in a point to point link. Commands from a computer's COM port travel to the controller via RS-232.

Serial Control - A type of information transfer where the bits are handled sequentially

Stepper Motor - A motor which when current is applied generates a holding torque. The motor is rotated by switching the coils on and off. The step motors in Prior stages and focus motors generally have 200 steps per revolution, which is then microstepped to 50,000 microsteps per revolution.

TTL - Transistor-Transistor Logic. An integrated circuit with its inputs and outputs directly tied to transistors. Inputs and outputs are low voltage (<1 VDC) and high voltage (>3 VDC).

Transmitted Illumination - Light which passes through the object

Upright Microscope - A microscope that views the object from above

XYZ - The term used to describe the axes of a microscope that move left/right(X), front/back(Y) and up/down(Z)

SECTION 13
RETURNS AND REPAIRS

Should you experience problems with your Plate Loading System and want to send it back for service, warranty or otherwise, a Return Material Authorisation (RMA) number must be obtained from the appropriate Prior Scientific office before returning any equipment. For North and South America contact Prior Scientific Inc. and for the rest of the world call Prior Scientific Instrument

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