Litron Lasers Ltd.

8 Consul Road

Rugby

Warwickshire CV21 1PB

England

Tel (0)1788 574444

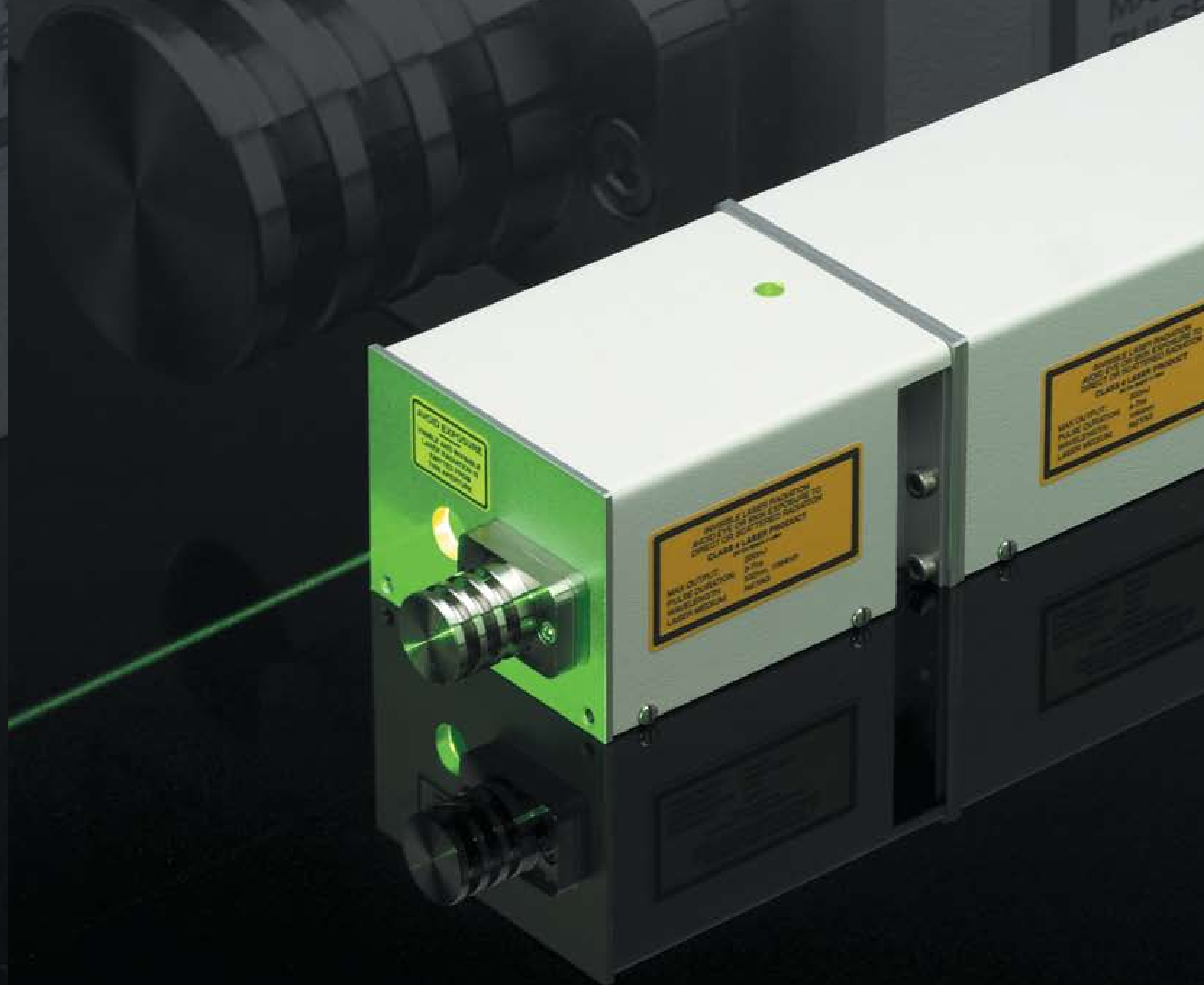
Fax (0)1788 574888

Email sales@litron.co.uk

www.litronlasers.com

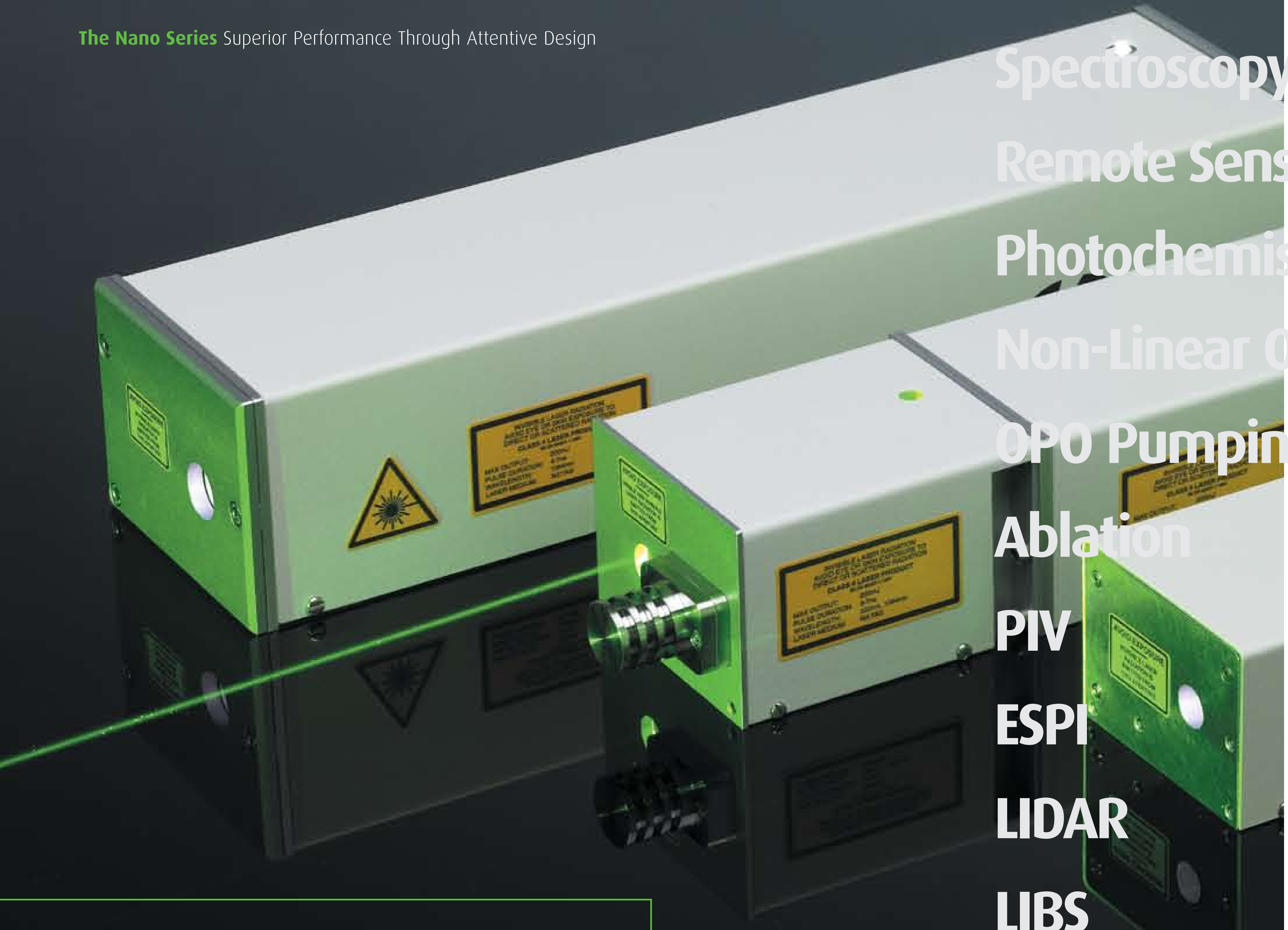
Litron Lasers

Nano Series Ultra Compact Pulsed Nd:YAG Lasers



Litron Lasers

The Nano Series Superior Performance Through Attentive Design



Spectroscopy

Remote Sensing

Photochemistry

Non-Linear Optics

OPO Pumping

Ablation

PIV

ESPI

LIDAR

LIBS

LIF

The Nano series of pulsed Q-switched Nd:YAG lasers have been designed to satisfy the demands of customers today. With industry leading performance in every respect, and unsurpassed design and build quality, the Nano series sets the new benchmark for laser systems today.

World class performance results only from world class design. During the design process every aspect of the Nano range of laser systems has been attended to in great detail, leading to a range of laser systems that are rugged, reliable, and which perform optimally with little need for maintenance. Heed has been paid to comments from customers and service engineers, and design features resulting in useable and serviceable systems have been incorporated wherever possible. For example, simple flashlamp change without the need for either complete removal of the pumping chamber or optical realignment, easily removable and cleanable optics, an electronic intra-cavity safety shutter and a latched interlock suite are but a few of the features which set Litron's Nano series apart from the competition.

As with any piece of equipment it is the performance of the device, both in terms of reliability and in terms of specification, which define its suitability for an application. Nowadays, applications for laser systems are extremely varied, and as such a 'one system suits all' approach is rarely acceptable. On this basis the Nano range comprises four laser head models and three power supplies allowing Q-switched outputs from 10mJ per pulse to 500mJ per pulse at repetition rates of up to 100Hz. This allows us to provide our customers with a solution tailored to their specific need, saving both time and expense.

Engineering Excellence

MECHANICAL

Implicit in good design is good engineering. When considering the important mechanical aspects of a laser system, mechanical and thermal stability and insensitivity to misalignment coupled with ease of maintenance come first. The Nano series laser heads are machined from solid aluminium, and the optical resonator is an integral part of the aluminium body. This results in a mechanically rigid and rugged design, whose thermal stability is as good as a self supporting invar structure.

The pumping chamber is machined from 316 surgical grade stainless steel, and houses a pair of close coupled ceramic reflectors. The pumping chamber is thermally decoupled from the resonator resulting in good thermal stability even at high flashlamp power loadings. The ceramic reflectors allow very uniform pumping of the laser rod, and as a direct consequence exceptional output beam quality. Other aspects of beam quality, such as pointing stability, are affected by the efficiency with which the laser rod is cooled. By ensuring the laser rod is cooled before the flashlamp, and by ensuring a large turbulent flow over the laser rod, the pulse to pulse stability and the pointing stability of the Nano series are amongst the best available. Also the serial flow ensures very uniform cooling of the laser rod and flashlamp, leading to a longer flashlamp life. This is because there are no voids in the cooling as are commonly seen in parallel flow arrangements, where flashlamps may even distort due to extreme localised heating.

De-ionised water is corrosive: the cooling system therefore comprises entirely of hard plastic or stainless steel parts which are totally inert to de-ionised water. As a result there is no risk of contamination from the cooling system compromising laser performance, and further there is no need to worry about draining or running the laser system should it stand idle for protracted periods of time. An easily changeable de-ioniser cartridge is standard on all power supplies. The cooling system in all of the power supplies is a closed loop with a water to air heat exchanger. This means that the entire laser system is totally self contained with no need for an external coolant supply.

OPTICAL

Optically the KD*P Pockels cell is mounted in a fully sealed housing, eliminating any possibility of crystal damage due to moisture or dirt. All optics are coated with hard dielectric coatings that have extremely high damage thresholds. The diffuse cavity reflectors are arranged to give the highest pump uniformity of the laser rod, and therefore the best beam quality.

In any optical system, the need may arise to clean the optics. To this end, all optics are fully demountable for cleaning. Alignment of the laser system is by two adjustable mirror mounts that can be firmly locked in place. Whilst cleaning of the optics and system alignment should not normally be necessary, the design of the system allows the customer to undertake such procedures quickly and easily, without the need for any expensive service visits or protracted periods of down time.

The Nano Range – A solution for every problem

There are three ‘end user’ laser heads in the Nano series, the Nano S, the Nano L and the Nano T. All three laser heads are fundamentally the same in terms of construction: they are all machined from a solid block of aluminium, have electronic intra-cavity safety shutters, fully sealed Pockels cells, stainless steel close coupled pumping chambers and easily adjustable and cleanable mirrors and optics.

The design of the Nano range facilitates the connection of any power supply to any head. This benefits the customer both in terms of size and cost of the laser system, as the system provided will be optimally tailored to the requirements of the customer.

130mJ

THE NANO S

The Nano S is one of the smallest ‘end user’ laser systems of its type in the world. Its footprint is just 272mm x 82mm x 62mm. It offers the user energies of up to 130mJ per pulse and repetition rates of up to 50Hz. It is supplied with a conventional stable resonator, and can be configured to give TEM_{00} if required, by the inclusion of an intra-cavity aperture.

350mJ

THE NANO L

The Nano L has a footprint of only 360mm x 96mm x 74mm. Output energies of up to 350mJ and repetition rates of up to 100Hz are available. It can be supplied with either a stable resonator or with Gaussian optics. If required an intra-cavity aperture can be fitted to give a TEM_{00} output.

500mJ

THE NANO T

The Nano T has a footprint of 500mm x 96mm x 74mm. Output energies of up to 500mJ and repetition rates of up to 100Hz are available. The Nano T can be configured with a stable, telescopic or Gaussian resonator, and can be fitted with an intra-cavity aperture to give a TEM_{00} output.

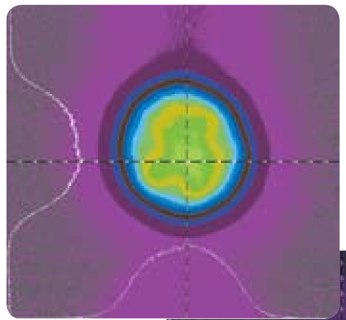
STABLE RESONATOR

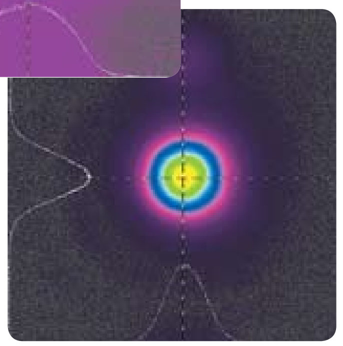
A stable resonator provides the greatest flexibility in terms of output energy and repetition rate, as both parameters can be varied with minimal effect upon the alignment of the system. In general, the output of such systems is multi-mode. With the addition of an intra-cavity aperture, a TEM_{00} output can easily be realised, but at the expense of overall efficiency.

GAUSSIAN RESONATOR

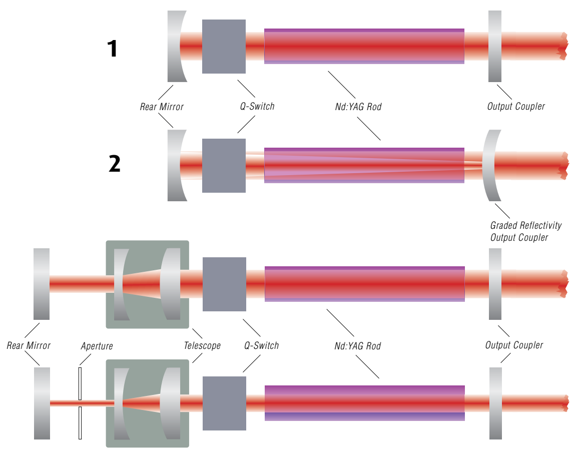
In a Gaussian system, graded reflectivity mirrors are used, and form part of an unstable resonator. Such systems give a high energy single transverse mode with a low beam divergence. However this optical configuration does have drawbacks. The thermal lens formed by the laser rod is part of the optical arrangement. Such systems will therefore only work properly at one repetition rate, when the thermal loading on the laser rod is constant. As a direct result of this, the laser is factory set at one pulse repetition frequency and output energy. To overcome these limitations, which are governed by the physics of the system, Litron offers two options. The first option, the pulse repetition rate divider, allows the user to divide the set repetition rate by 2, 4, 8 or 16. This works by allowing the flashlamp to pulse at a set frequency, thus maintaining almost the same thermal lens on the laser rod, but only switching the Pockels cell on the desired pulses (i.e. every other pulse for divide by two operation). The second option is a motorised variable optical attenuator. By the use of an extra-cavity polariser and half-wave plate, the output energy of the laser can be attenuated, whilst maintaining the beam quality and divergences required.

Near field beam profile of Nano S with stable resonator at 1064nm.





Near field profile of Nano L running TEM_{00} at 1064nm.

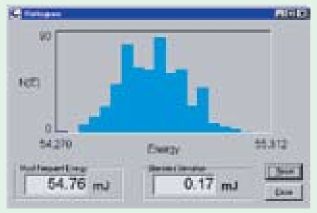


Schematics showing oscillator design.
1) Stable
2) Gaussian
3) Telescopic Multimode
4) Telescopic TEM_{00}

In a system fitted with Gaussian optics, the pulse length tends to be shorter than in a conventional stable resonator. This increases the peak power density that is seen by the resonator optics and subsequently by any beam handling optics that may be used.

TELESCOPIC RESONATOR

To obtain high energy low divergence beams, the preferred method is the use of a telescopic resonator. In this configuration, an intra-cavity telescope is used to reduce the beam diameter in the rear leg of the resonator. This has the effect of making the resonator appear longer, increasing the losses in the higher order modes, leading to a superior output beam with very low divergence. With no optical adjustment at all, the laser can be varied over a wide range of pulse energies and repetition rates, whilst maintaining a high quality, low divergence beam. With slight adjustment to the telescope (a simple procedure) the full range of energies and repetition rates from single pulse to the maximum can be achieved. For high energy TEM_{00} beams, an intra-cavity aperture can be fitted behind the telescope. Varying the sizes of these apertures allows output beams that are to within 15% of the diffraction limit to about 2.5 times the diffraction limit. That is from an almost pure Gaussian TEM_{00} to full energy in a uniform spatial profile. The output from a telescopic resonator is longer and smoother temporally, making it the system of choice for pumping dye lasers or optical parametric oscillators. Such arrangements, by virtue of the longer pulse length, are much less prone to optical damage than Gaussian systems.



Distribution of the output energy per pulse for 500 consecutive shots. Range of histogram ± 1% ofmean value. Standard devitaion ~0.3%.

OSCILLATOR AMPLIFIER SYSTEMS

In order to generate high energy laser outputs, or to generate medium energy outputs at very high repetition rates, the use of an amplifier stage is often beneficial. An oscillator amplifier is advantageous over a single high energy oscillator for several reasons. In an oscillator, the energy that can be extracted is governed by the Q-switch hold off, parasitic oscillations and amplified spontaneous emission. In an amplified system, the oscillator is not usually run at its maximum output (as dictated by the maximum stored energy of the laser rod), therefore the peak powers are lower through the cavity optics and Pockels cell, leading to longer life and more reliable service. When using an oscillator and amplifier to obtain output energies greater than about 500mJ, the near field spatial profile is usually better, containing less structure than an equivalent single oscillator yielding the same output.

A range of amplifiers can be fitted to the Nano series, in an oscillator amplifier arrangement, the oscillator is typically one of the standard Nano range. The output is then folded to pass through the amplifier rod. The amplifier design uses a single lamp pumped rod housing, of the same design as those used in the oscillators. With the use of a suitable amplifier stage, outputs of >1200mJ are available from the Nano series.

HARMONIC GENERATION

Litron offers a full range of harmonic generation and separation modules, giving the customer access to 532nm, 355nm, 266nm and 213nm. There are two types of harmonic housing available: a short form housing and a long form housing. These can be added and removed as required and can usually be retrofitted. The short housing is ideal for applications which require only 532nm, this contains a frequency doubling crystal and dichroic separation mirrors. The long harmonic housing can hold a frequency doubler, or a frequency doubler and tripler, or a frequency doubler and quadrupler, and dichroic separation mirrors. Typically KTP or LBO are used as frequency doublers, LBO or BBO are used as frequency triplers and BBO is used as a frequency quadrupler. Temperature stabilisation of the crystals is available.

5 QUARTER-WAVE PLATE AND POLARISER

Hold-off is achieved by means of a polariser and a quarter-wave plate. Light passes through the polariser and is horizontally polarised, it passes through the Pockels cell, which with no bias voltage applied does not affect the polarisation. As it passes through the quarter-wave plate it is resolved into two polarisations, one of which undergoes a 90˚ phase shift with respect to the other. The light leaving the quarter-wave plate is thus circularly polarised. Upon reflection from the rear mirror, the light once again passes through the quarter-wave plate and again one polarisation undergoes a further 90˚ phase shift, leading to vertically polarised light exiting the quarter-wave plate. This light passes back through the Pockels cell and is reflected out of the cavity by the polariser, preventing any pulse build up. When bias volts are applied to the Pockels cell, an additional 90˚ phase shift in one polarisation is added in each pass, this leads to a total phase shift of 360˚ or 0˚, and therefore horizontally polarised light is returned and passes through the polariser allowing the laser pulse to build up. An advantage of this method, over using the Pockels cell itself as a quarter-wave plate (by biasing it and then removing the voltage at the peak inversion), is that there is no chance of post-lasing as the bias voltage is applied to the Pockels cell for only long enough for the Q-switched pulse to emerge.

4 MIRROR MOUNTS

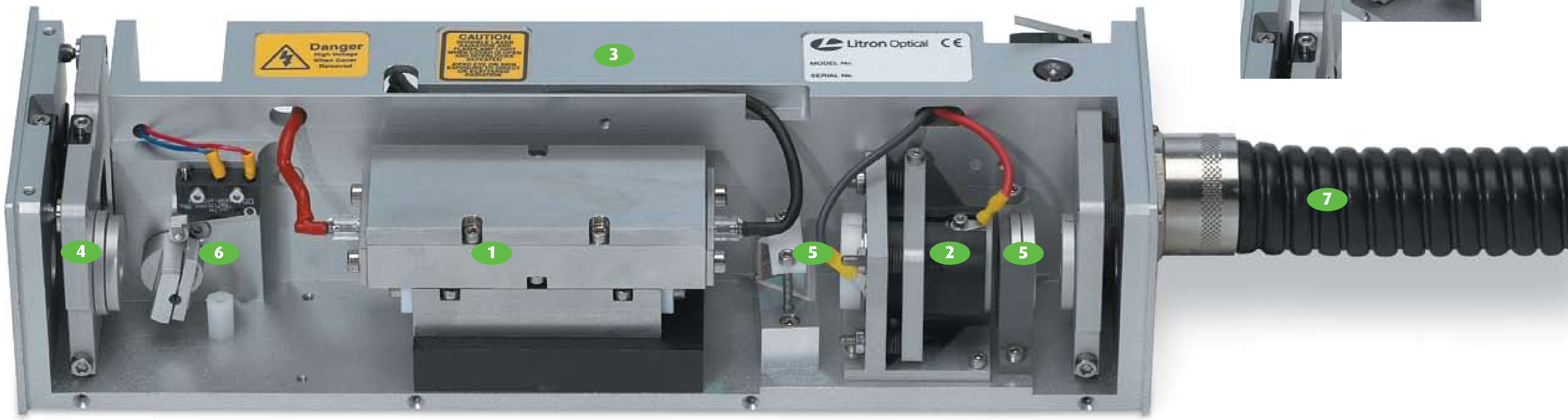
The mirrors are held in aluminium mounts connected to the laser body by high tension steel springs. Adjustment is made by two fine-pitch ball-ended screws giving independent horizontal and vertical adjustment, making alignment very easy. The mirrors can be firmly locked in position, eliminating any risk of the alignment changing. For Gaussian optics the graded reflectivity output coupler is mounted in a precision x – y mount.

6 ELECTRONIC SAFETY SHUTTER

All Nano models (with the exception of the Nano O) come with a solenoid driven safety shutter. This shutter automatically closes when the laser turns off; therefore when the laser is started the shutter will be closed. This makes the laser safer when used in a laboratory. As a further safety measure, the position of the shutter is monitored by the system control. Should the actual position of the shutter and the required position of the shutter not be in agreement the laser will automatically turn off.

7 RUGGED STEEL CLAD UMBILICAL

All of the Nano range are fitted with rugged PVC covered steel clad umbilicals to carry the necessary services to the laser head. The umbilical diameter on the Nano O and Nano S heads is 25mm and on the Nano L and Nano T heads is 33mm.



1 PUMPING CHAMBER

The most important requirement for high beam quality, both in terms of spatial profile and pointing stability, is that the pumping chamber is designed properly. Litron's pumping chambers are machined from solid 316 grade stainless steel. They contain two extremely close coupled diffuse ceramic reflectors, which give rise to a highly uniform pumping of the laser rod, something not achieved with elliptical specular reflectors. The laser rod and the flashlamp are separated by a tough ionic glass filter that totally absorbs all of the UV radiation emitted by the flashlamp. Such radiation is of no use in pumping the laser rod, but can damage the rod over a period of time. The result of such a design is a system that will work reliably for many years with no problems. The flashlamp can be removed and replaced within 5 minutes, with no need for optical realignment at all.

2 POCKELS CELL

The Q-switch in the Nano S is KD*P. The crystal is totally sealed within a rugged housing and immersed in an index matching fluid. Such a design of Pockels cell is well proven and it has the added benefit of protecting the hygroscopic KD*P from any moisture that it may encounter during the flashlamp change procedure, or if the laser head is uncovered in a humid laboratory. Avalanche transistors are used to switch the necessary quarter-wave voltage onto the crystal, and this can be achieved at repetition rates of up to 1kHz with electronic jitter of <500ps with respect to the direct access trigger input.

3 RESONATOR HOUSING

The laser body is machined from a solid piece of aluminium. Its rigid design, approximating to an I-section with ends gives exceptional mechanical rigidity, and a thermal stability as good as that of a self supporting invar structure.

Applications

APPLICATIONS INCLUDE

- SPECTROSCOPY
- REMOTE SENSING
- PHOTOCHEMISTRY
- NON-LINEAR OPTICS
- OPO PUMPING
- ABLATION
- PIV
- ESPI
- LIDAR
- LIBS
- LIF

PARTICLE IMAGE VELOCIMETRY (PIV)

PIV has over the last few years become a commonplace technique, both industrially and in research establishments. A full range of PIV laser systems is available with outputs from 20 – 100mJ per pulse, and adjustable pulse separations of sub microsecond to milliseconds. PIV laser systems use two laser oscillators with orthogonal polarizations, the beams are combined with dielectric polarisers and then frequency doubled.

CUSTOM LASER SYSTEMS

Due to the pseudo modular design of the Nano range of laser systems, custom laser systems are often configurable from existing parts. For this reason, along with our experience in the manufacture of laser systems, if a product does not exactly meet your required specification, we will gladly discuss providing you with one that does. This is often achievable with little or no extra cost.

Other laser media such as erbium glass (1.5µm), erbium YAG (2.94µm), holmium YAG (2.01µm), ruby (694nm), and neodymium glass laser systems are also available upon request.

SAFETY

Perhaps the single most important aspect of any equipment is its safety. Litron's laser systems have been designed with safety as one of the prime constraints. All covers are interlocked, so that the laser cannot be run if any cover is removed. This reduces the risk of stray radiation from within the device causing damage. All high voltages are covered with insulating covers, within an interlocked case. The system cannot be run when any high voltages are exposed to the user. An electronic safety shutter with additional verification is standard on all 'end user' systems, so when the laser is started it will not emit any radiation. An external interlock is standard and can be connected to a laboratory door, so that the laser system will switch off should the door be opened. This interlock can be overridden in situations when an external interlock is not a requirement.

Litron's laser systems are designed to comply with BS EN 60825-1 (Safety of Laser Products – Equipment Classification, Requirements and User's Guide) and BS EN 60101-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use).

Power Supplies

Litron offers a complete range of fully featured power supplies, with output powers from 200W up to 2kW from a single charger. All power supplies utilize the latest resonant IGBT switching technology for maximum efficiency. The flashlamps in all systems are fully simmered and the Pockels cell is driven using avalanche transistors. The system control contains a suite of latched interlocks, allowing quick and easy fault diagnosis.

LPU500 integrated power supply and cooler.

The smallest power supply in the range, the LPU250, measures only 202mm (wide) x 320mm (high) x 382mm (long) and contains a 250W capacitor charger, simmer, Q-switch driver, all system control and an integral water to air heat exchanger. The LPU250 is fully power factor corrected and will run off any mains input between 90 and 260V.

Control of the laser is via a remote control box, which allows control of all of the system features, these are: laser start and stop, pump on and off, pulse repetition rate, output energy and shutter position. Standard TTL controls give access to Q-switch and lamp synchronisation and triggering, allowing quick and easy integration into almost any set up. An optional RS232 interface and computer software suite gives complete system control from a PC.

LPU250 integrated power supply and cooler.

The LPU500 has all of the features of the LPU250 but contains a 500W capacitor charger and a more powerful cooler.

The LPU1000 is again a fully featured power supply containing a 1kW capacitor charger. This power supply has been designed such that slave charger units can be added to increase the power capability of the unit. This allows very high energy or high repetition rate systems to be constructed with ease.

OEM power supplies are supplied in standard 19" rack mount modules. The smallest of these is a 200W complete power supply which includes a full closed loop cooling system, all contained in a unit that is just 3U (133mm) high.

All power supplies (up to 1kW) can be supplied to optionally run off DC inputs of 24 – 100VDC, making them ideally suited to airborne applications or field use, where a DC supply from batteries is available.

For custom systems, the power supplies can easily be modified to give higher capacitor charge rates or specific system control requirements.

VARIABLE OPTICAL ATTENUATION

In certain circumstances where the pump energy and repetition rate of the laser system are fixed (e.g. in a Gaussian resonator), adjustment of the laser output energy may be necessary. For this reason a variable optical attenuator is offered as an option on all of our laser systems. By the use of a half-wave plate and polariser, the axial beam energy can be varied. The residual energy can either be dumped safely or utilized in some way.

Additionally a variable optical attenuator is useful if the temporal profile of the pulse needs to be maintained at different output energies. As the pump intensity is reduced, the gain of the laser rod decreases, this leads to a longer Q-switched pulse at lower energies. By keeping the output at a given level, and using a variable optical attenuator, all pulses will be temporally of similar length.

MECHANICAL AND OPTICAL MOUNTS

A range of mechanical mounts to attach the laser to an optical table and optical mounts such as steering mirror mounts are available, giving the user maximum flexibility in handling and using the laser output. All accessories are designed to interface with standard optical tables. Optical breadboards of up to 600mm x 600mm with M6 holes on a 25mm pitch, along with a complete range of optical mounts to facilitate the user's experimental set-up, can be purchased from Litron either with a laser system or as accessories.

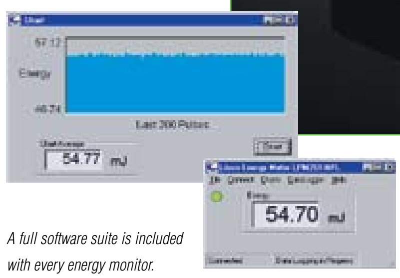
OPTIONAL FAST PHOTODIODE

A fast 50Ω terminated photodiode is available as an option on all of the laser heads in the range. This allows monitoring of the temporal profile of the Q-switched laser output when used in conjunction with a suitable oscilloscope.

CO-AXIAL DIODE LASER

An optional diode laser can be fitted behind the rear mirror of the laser to provide a visible aiming beam for the laser output.

LPM530 Transfer energy monitors allow accurate in-line energy monitoring of system performance.



A full software suite is included with every energy monitor.

ENERGY MONITORING

Litron manufactures a comprehensive range of laser energy monitors. These are photodiode based instruments and allow extremely accurate analysis and measurement of laser performance.
Unlike conventional energy measurement devices, Litron's range of monitors can measure every pulse from the laser system, rather than averaging the energy as many calorimetric devices do. This leads to unrivalled accuracy and flexibility of measurements. Typically the pulse to pulse measurement repeatability of these devices is better than 0.2%. The damage threshold of these energy monitors is extremely high, as the optics train scatters rather than absorbs the light. The input optic is ground fused silica, and is arranged such that easy removal is possible should it be damaged for any reason.

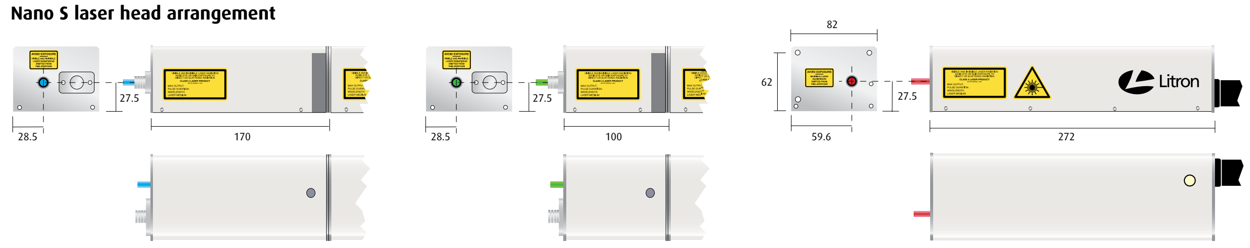
All energy monitors feature a bright 4 digit display and an RS232 output, which allows data-logging of the laser performance. A comprehensive software suite is provided as standard. For further information on Litron's range of energy monitors please refer to the specific data sheets.

Litron's range of photodiode laser energy monitors, with 30mm and 50mm input apertures allow accurate measurement of laser performance.

The Nano Range

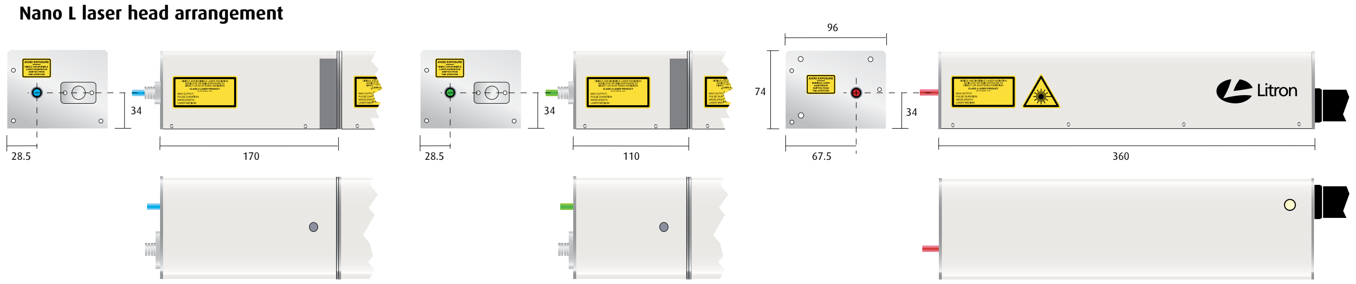
All dimensions in mm.

Nano S laser head arrangement



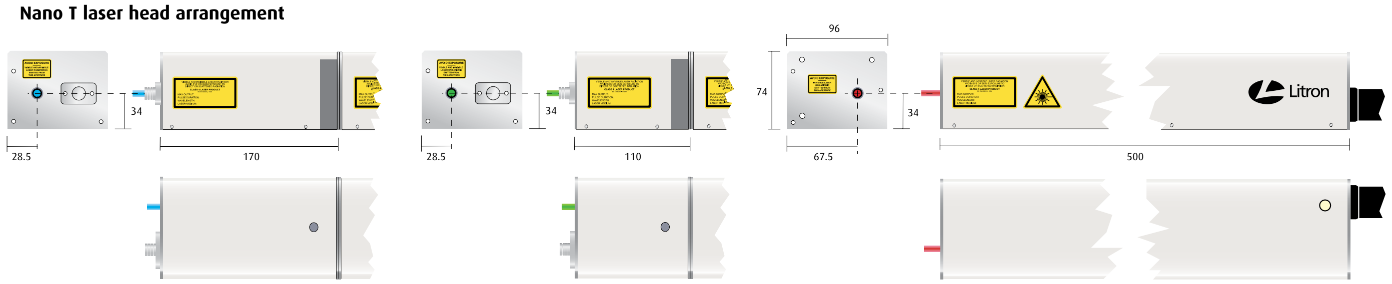
Long harmonic housing — Short doubler housing — Laser head

Nano L laser head arrangement



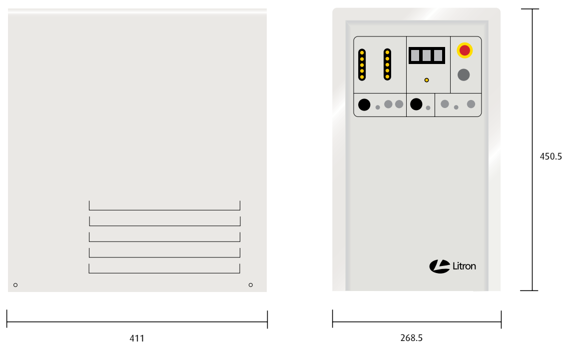
Long harmonic housing — Short doubler housing — Laser head

Nano T laser head arrangement

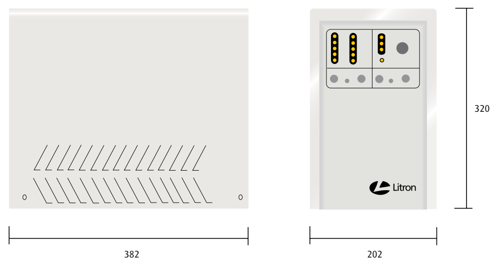


Long harmonic housing — Short doubler housing — Laser head

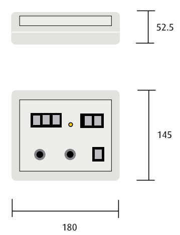
LPU500 power supply unit



LPU250 power supply unit



Remote control unit



MODEL SELECTION GUIDE

Model	Output Energy at 1064nm (1)	Resonator Types (2)	Harmonics Available (3)	Maximum Repetition Rate (1)	Standard Electronic Shutter
Nano S	130mJ	S, TEM_{00}	2,3,4,5	50Hz	Yes
Nano L	350mJ	S,G,TEM_{00}	2,3,4,5	100Hz	Yes
Nano T	500mJ	S,G,T,TEM_{00}	2,3,4,5	100Hz	Yes
Nano T +Amplifier Stage	1200mJ	S,G,T,TEM_{00}	2,3,4,5	100Hz	Yes

1 The maximum output energy is dependent upon the maximum repetition rate. The output energy for a given repetition rate is determined by the mean flashlamp power. Please contact Litron for further details.

2 S means stable resonator, G means Gaussian resonator, T means telescopic resonator, and TEM_{00} means that a TEM_{00} output option is available.

3 Harmonics are optional.

Our policy is to improve the design and specification of our products. The details given in this brochure are not to be regarded as binding.

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光と人をつなぐ

Rayture Systems

レイチャーシステムズ株式会社

〒160-0006 東京都新宿区舟町７ ロクサンビル７Ｆ

TEL : 03-3351-0717 FAX : 03-3351-6771

URL : http://www.rayture-sys.co.jp

E-mail : laser@rayture-sys.co.jp