Real-Time™ Energy Control Stable Laser Output

Since the advent of argon lasers, surgeons have been using green laser light for photocoagulation. Despite the many advantages of argon technology, the higher reliability of solid-state lasers and the small footprint have made them the preferred choice of surgeons today. Even so, argon technology has retained one key advantage over solid-state: more consistent and stable energy output. Ellex has addressed this by incorporating Real-Time™ Energy Control technology into all its photocoagulator systems. Real-Time Energy Control enables Ellex photocoagulators to monitor major system parameters and actively adjust the laser cavity output in real-time, which ensures stable power delivery at all times. As a result, the system delivers predictable and consistent retinal burns with every pulse.

Background

Ophthalmic photocoagulator devices utilizing green laser light have been in use for several decades[1]. Although argon gas lasers were the laser systems of choice[2] for many years, several disadvantages have been associated with this technology.

First and foremost, argon lasers were bulky, heavy and energy consuming. Second, the cooling necessary either caused strong air flow in the room or required tap water. Finally, the devices required frequent maintenance and optics cleaning. All of this was necessary to provide a stable laser output in the required optimal power range, with a true continuous-wave (CW), and without power drifts. Despite the technical disadvantages, most argon lasers delivered good quality power output.

Over the past few years, argon gas lasers have slowly been replaced by solid-state lasers, which use a physical method called "frequency doubling" to generate green laser light of 532 nm out of an infrared 1064 nm YAG solid-state laser. Among the advantages of solid-state lasers are a very small footprint, reduced power consumption, less noise and fewer service requirements. However, solid-state lasers came with one major disadvantage: the coagulation spot quality did not match that achieved by CW argon lasers.

In fact, the first commercially available green solid-state laser photocoagulators could not provide CW output at all. (A pure CW output is mandatory to avoid under- or overdoses, which can cause retinal damage such as burning or bleeding.) Their power output consisted of a series of spikes that provided an average programmed power over the chosen pulse duration. Though the peak power of each spike was relatively high, the average power output was quite stable. Nonetheless, this technology did not prove successful in clinical use, as surgeons witnessed "pop" effects on the irradiated retina, comparable to heavy overdosing.[3] These effects were directly related to the high power spikes.

Although researchers eventually resolved the spiking issue, they were unable to create a true CW laser that would ensure stable, reliable coagulation effects over the full range of pulse parameters. In this aspect, most true CW green solid-state lasers still do not reach the quality of argon lasers.

Ellex met this challenge by developing "Real-Time Energy Control" technology that allows high precision in retinal photocoagulation with highly stable, true CW laser power. Not only is this technology superior to other frequency-doubled Neodymium-YAG (Nd:YAG) lasers, but it also performs similar to, if not better than, argon laser systems.

The practical advantages of the Ellex system are:

- Highly reproducibe coagulation spots on the retina
- No "pop" effects
- Low maintenance costs
- Long lifetime
- Small footprint
- Low electric power consumption

Stabilizing Power Output

All laser systems require a method to internally monitor laser output delivery. Simple controls merely take the power measurement and feed it into the internal computer controls. The computer then determines deviations from the target and compensates for them by changing the drive current of the laser source. But such simple computer controls cannot provide high-quality CW power output in all treatment situations.

Power variations originate from many sources, including changing ambient conditions in the operating room, stress on the laser cavity and other environmental factors. The challenge of frequency-doubled, solid-state CW lasers is that the compensation often takes effect too late after a power change has occurred. The solution is a real-time energy control system consisting of multiple sensors and very fast hardware and software designed to swiftly and efficiently react to any of these changing operating conditions.

What is Real-Time Energy Control?

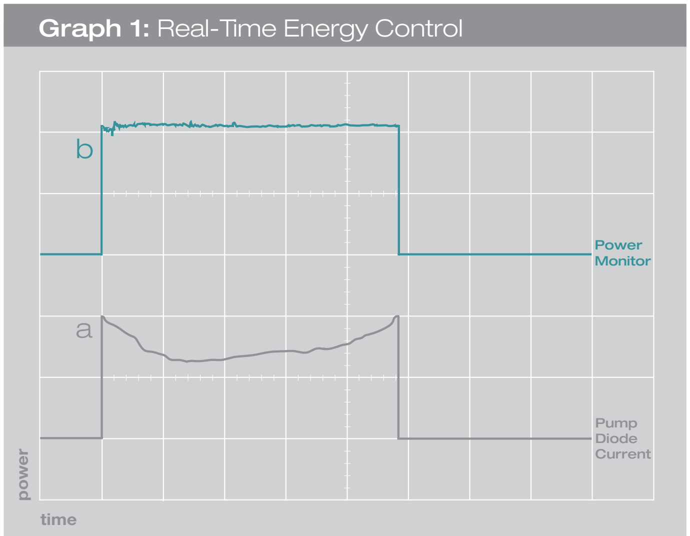
The Ellex Real-Time Energy Control technology is a unique, state-of-the-art hardware and software design that accurately provides and maintains the programmed power and pulse durations of the laser. This design actively monitors and controls laser power, component temperature and drive current at a precise level in real time.

"Real-Time" means that all sensing information is processed at the highest possible speed. Real-Time Energy Control features an implemented digital signal processing (DSP) microcontroller and software that perform control operations at a magnitude faster than state-of-the-art personal computers. This system provides the highest-quality output power and pulse duration available – all delivered with a better than 10 percent accuracy for consistent treatment results. This is demonstrated by the perfectly rectangular pulse shape in the laser pulse diagram (see Figure 1, Graph 2). Inherent in the system are thermo-electric coolers (TEC) that maintain very accurate temperature control (±0.5°C) of the laser components.

The digital signal processing microcontroller provides full, active, real-time control over the drive current to the cavity, as well as to the temperature controller via the TEC modules – all based on the signal received from the laser output power monitor.

Performance Outcome

The laser beam output has been life-tested under varying conditions using the Real-Time Energy Control system. This design technology has allowed for an almost ideal outcome, with very accurate results and an even, rectangular pulse shape output. Figure one illustrates the significant improvement achieved with the Ellex design compared to conventional control designs.



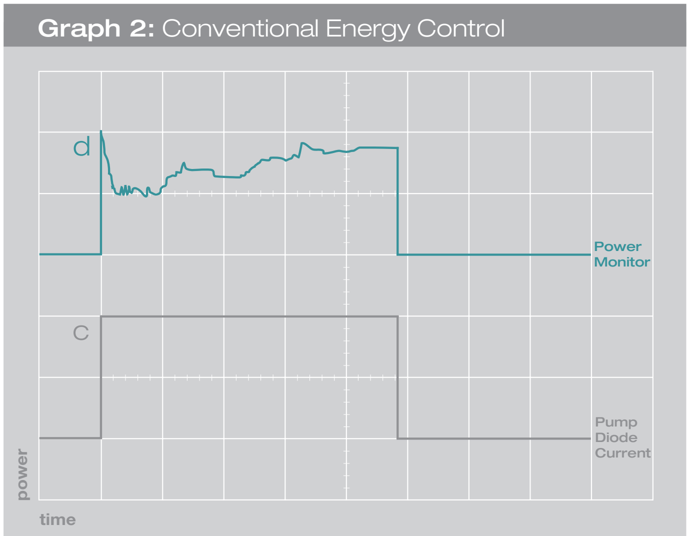


Figure 1: Output Comparison between Real-Time Energy Control and Conventional Energy Control.

The Ellex Real-Time Energy Control design measures the actual laser output power from the cavity at a very high sampling rate of more than 50KHz. In addition, it monitors parameters of the pump diode and the temperature control circuit at 10 Hz. The system then uses this information to continuously adjust the laser cavity (a) so that stable and consistent energy output is achieved (b). Conventional control systems, in contrast, only monitor the pump diode current. This results in inaccurate control of the laser cavity (c), which in turn leads to fluctuating, unstable laser power output (d).

Conclusion:

Ellex photocoagulators with Real-Time Energy Control combine the advantages of solid-state technology with the reliability of argon laser systems. Surgeons can rely on consistent and predictable retinal burns throughout the treatment, as well as safer, more precise results.

References

1 L'Esperance FA Jr. Clinical photocoagulation with the frequency-doubled neodymium yttrium-aluminum-garnet laser. Am J Ophthalmol. 1971 Mar;71(3):631-8.

2 Zweng HC, Little HL, Peabody RR. Argon laser photocoagulation of diabetic retinopathy. Arch Ophthalmol. 1971 Oct;86(4):395-400.

3 Roider J, Schiller M, El Hifnawi ES, Birngruber R. Retinal photocoagulation with a pulsed, frequency-doubled Nd:YAG laser (532 nm) Ophthalmologe. 1994 Dec;91(6):777-82.

ellex.com

Worldwide
82 Gilbert Street
Adelaide, SA
5000 AUSTRALIA
+61 8 8104 5200

USA
7138 Shady Oak Road
Minneapolis, MN
55344 USA
1 800 824 7444

Japan
4-3-7 Miyahara 4F
Yodogawa-ku Osaka
532-0003 JAPAN
+81 6 6396 2250