Driving Diode Lasers Is Straightforward

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Observing the basic principles and understanding the physical behaviour of diode lasers helps users operate them correctly and safely.

Ansteuerung von Diodenlasern ist unkompliziert
Die Beachtung ihrer grundsätzlichen Prinzipien sowie das Verständnis des physikalischen Verhaltens von Diodenlasern helfen dem Anwender, diese korrekt und sicher zu betreiben.

La "conduite" des diodes laser
L'observation des principes élémentaires et la compréhension du comportement physique des diodes laser aident les opérateurs à les utiliser correctement et sans danger.

Alimentare i diodi laser? E' facilissimo!
Osservare alcuni princìpi base e capire il comportamento fisico dei diodi laser aiuta gli utilizzatori a farli funzionare correttamente e senza rischi.

Driving diode lasers loses much of its mystery if you observe a few simple rules based on their properties. Below its threshold current, a diode laser emits LED light with spontaneous emission only. At the threshold current and above, it begins to generate laser light, and the optical output power rises steeply with increasing diode operating current. The correlation between the optical output power and the diode current is linear up to the maximum power, called differential efficiency (Figure 1).

One crucial factor often overlooked in handling diode lasers is the influence of temperature on the relationship between the optical output power and the operating current. The threshold current rises with temperature, but the optical output power and differential efficiency decrease. The driver circuit thus should have a safety feature so that a significant temperature increase will not destroy the laser.

Any driver circuit for diode lasers should include a well-filtered power supply that, as efficiently as possible, blocks inductive loads and other sources of interference. Battery operation circumvents the problem but is not an option in many industrial applications. Keeping the connections between the diode laser and the driver circuit short generally will help reduce interference.

Integrated driver circuits offer a variety of functions and safety measures, and they require few additional components. A simple resistor trimmer can usually set the operating point. It is important that diode lasers always have a regulated driver in either automatic current control or automatic power control operation. A standard laboratory power supply is not suitable for driving them directly.

The diode laser's wavelength varies with temperature. For a typical GaAlAs diode, this is about 0.25 nm/°C, gradually combined with sudden steplike jumps (mode hopping).

In automatic current control operation, precise temperature control of the diode laser yields the best stability of its optical output power. Because of the diodes' temperature dependency, the temperature must be regulated to maintain constant output so that it does not exceed critical values.

In industrial applications — such as light barriers and

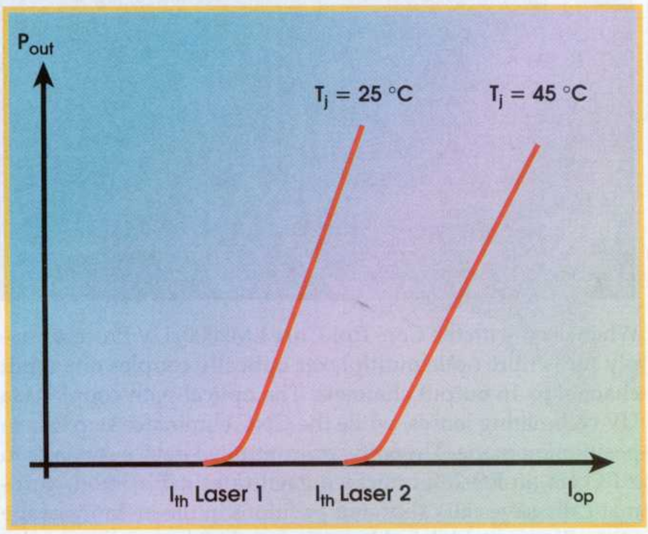

Figure 1. The output power of a diode laser is a function of the operating current. P_{out} = output power; I = current; th = threshold; T = temperature; j = junction (the place where laser radiation originates in the laser chip); I_{op} = operating current driving the diode laser.

distance-measuring sensors where the ambient temperature varies — automatic power control systems typically offer simplicity of operation. Conventional automatic power control driver circuits also have soft-start circuits, filter spikes, overvoltage and other transients.

The power regulator guarantees a constant output. When the temperature remains unregulated, however, wavelengths can shift and mode hopping can occur. Even in applications where this does not pose a problem, there should be sufficient thermal dissipation because, without it, rising temperature — through self-heating, for example — will cause a decrease in the efficiency of the diode laser. The regulator circuit compensates for this with an ever-increasing laser current in an attempt to keep the output power constant. Without a current limiter or safety shutdown circuit, the diode could be damaged or even destroyed.

Automatic power control uses a monitor diode integrated into the laser package for feedback. Lasers with integrated monitor diodes are available in three configurations, all with the common terminal connected to their housing, which is often electrically connected to ground. The output from an integrated monitor diode is not suitable for calibration. At a given output power, the monitor current may vary by a factor of 10 from laser to laser.

The laser configurations must be taken into account when selecting a driver circuit because each type requires different driver principles (Figure 2). The N-type diode needs an output driver from a negative supply voltage and a minus-referenced monitor current input. P-type diodes require an output driver from a positive supply voltage with a monitor input connected to plus. An M-type diode must have a dual supply with a driver output from plus and a minus-referenced monitor current input. Each of these three variants needs its own optimized driver configuration. Some driver devices include connections for two or even all three variants. The one limitation, however, is that the laser diode package cannot always be connected to ground, as it is in this illustration.

Keeping cool

In most applications, and in continuous-wave operation in particular, a heat sink is essential to prevent an excessive rise in chip temperature and thus damage to or destruction of the diode laser. A low operating temperature generally lengthens the life expectancy of the diode. Statistically, a reduction of 10 °C in the operating temperature doubles the lifetime.

Even if the diode laser is driven by a suitable integrated driver, the assembly of the setup requires great care. A driver device that doesn't have a safety shutdown circuit or current limiter can cause damage from overcurrent, when a line interruption in the monitor path is taking place. One should never disconnect the driver and the diode laser via a switch or relay. The various driver devices have respective functions for spike-free power up and power down and for pulsing of the laser diode.

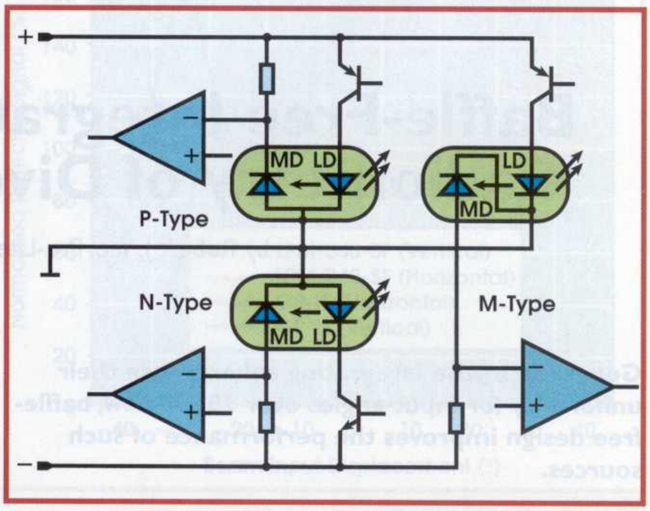

Figure 2. The three available diode laser configurations, P-, N- and M-type, require different driver principles. MD = monitor diode; LD = laser diode.

Either an automatic current control circuit combined with a temperature regulator or an automatic power control unit is required to guarantee maximum lifetime and stable operation. It is important to remember that even tiny increases above the threshold current can result in a considerable increase in output power and, thus, a rapid overshoot of the optical output power critical value. Cooling measures in both automatic current and power control setups are imperative for stable operation and long laser diode lifetimes.

IC-Haus GmbH is designing and manufacturing integrated circuits for diode laser drivers. Its latest device, the SO-8-packaged iC-WKM laser saver, drives blue diode lasers and enables continuous-wave operation at up to 350 mA from a single supply of up to 15 V. The chip offers rapid soft-start of the diode laser after power-on, with integrated reverse polarity protection for the integrated circuit and the laser as well as strong suppression of transients. A simple external resistor enables power adjustment.

Two feedback inputs accept all diode laser types with M, P or N configurations and with monitor current ranging from 2.5 μA to 6.25 mA. They also allow modulation of the laser output. The control loop accuracy maintains at better than 3 per cent with changes in temperature, supply voltage and load current. A protection circuit shuts down the laser permanently upon detecting excessive temperature or overcurrent. □

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