FL500

500 mA laser diode driver or two 250 mA drivers in a small SMT package that is reflow process compatible.

GENERAL DESCRIPTION:
The FL500 is ideal for driving low power laser diodes. It operates from 3 to 12 V, so is compatible with Li+ battery operation. It can be configured as two totally independent 250 mA drivers or a single 500 mA driver. Compatible with Type A or B laser diodes.

The FL500 allows for quick and easy operation in Constant Current (CC) mode. For simple CC mode operation the only components that are required are a power supply, an analog control voltage, your laser and optional filtering circuitry.

For additional features, including current limit and photodiode feedback for Constant Power operation, the FL500 can be used with the FL591 evaluation board.

FEATURES:
• Small Package (0.75” x 0.45” x 0.255”)
• Low Cost
• Brownout Protection
• 12-pin, SMT package, Reflow Compatible
• Slow Start Laser Diode Protection
• Drive Up to 500 mA Output Current
• Can be configured as two 250 mA drivers
• Voltage Controlled Setpoint
• TTL Compatible Shutdown Pin
• Adjustable Current Limit on Eval boards
• Adjustable Current Range Output
• 500 kHz sinewave Constant Current Bandwidth (100 kHz square wave)

Figure 1
Top View Pin Layout

TOP VIEW *

Figure 2
Connection Diagrams for FL500: Top - Dual Configuration, Bottom - Single Operation

*See complete pin descriptions, Page 4

* For Details See Page 6
BLOCK DIAGRAM

VDD GND
RESET (Active Low, TTL compatible)

V_{SET 1}
(V_{SET 1} (Impedance: 2k\Omega per driver, 1k\Omega when paralleled))

GND (for V_{SET})

SUPPORTS A & B LASER DIODE PACKAGE STYLES

Type A Laser Diode

Type B Laser Diode

* Contact factory for common cathode configuration
### ELECTRICAL AND OPERATING SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>RATING</th>
<th>SYMBOL</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (Voltage on Pin 1)</td>
<td>$V_{DD}$</td>
<td>+3 to +12 **</td>
<td>Volts DC</td>
</tr>
<tr>
<td>Output Current (See SOA Chart)</td>
<td>$I_{OUT}$</td>
<td>500</td>
<td>mA</td>
</tr>
<tr>
<td>Power Dissipation, $T_{AMBIENT} = +25°C$ [1]</td>
<td>$P_{MAX}$</td>
<td>2</td>
<td>Watts</td>
</tr>
<tr>
<td>Operating Temperature, case</td>
<td>$T_{OPR}$</td>
<td>- 40 to + 85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>$T_{STG}$</td>
<td>- 55 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>Weight</td>
<td>FL500</td>
<td>0.08</td>
<td>oz</td>
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#### PARAMETERS

<table>
<thead>
<tr>
<th>CONSTANT CURRENT CONTROL</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short Term Stability, 1 hour</td>
<td>$T_{AMBIENT} = 25°C$</td>
<td>35</td>
<td>40</td>
<td>ppm</td>
<td></td>
</tr>
<tr>
<td>Long Term Stability, 24 hours</td>
<td>$T_{AMBIENT} = 25°C$</td>
<td>50</td>
<td>75</td>
<td>ppm</td>
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#### CONSTANT POWER CONTROL

<table>
<thead>
<tr>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short Term Stability, 1 hour [3]</td>
<td>0.019</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long Term Stability, 24 hours [3]</td>
<td>0.011</td>
<td>%</td>
<td></td>
<td></td>
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#### OUTPUT [2]

| Current, peak, see SOA chart | Per channel | 245 | 250 | 252 | mA |
| Current, peak, see SOA chart | Two channels operated in parallel | 495 | 500 | 505 | mA |
| Compliance Voltage, Laser Diode Load | Full Temp. Range, $I_{OUT} = 500$ mA | $V_{DC}$ | 0.5 x $V_{set}$ | Volts |
| Rise Time | $I_{OUT}= 500$ mA | 300 | nsec |
| Fall Time | $I_{OUT}= 500$ mA | 300 | nsec |
| Bandwidth | Constant Current, Sine Wave | 500 | kHz |
| Bandwidth | Constant Current, Square Wave | 100 | kHz |
| Delayed start | | 100 | msec |
| Slow Start ramp rate | | 15 | mA / msec |
| Depth of Modulation | 100 kHz sine wave | 99 | % |
| Transfer Function - $V_{SET}$ to $I_{OUT}$ Configured as two 250 mA drivers | 0.125 | A / V |
| Transfer Function - $V_{SET}$ to $I_{OUT}$ Configured as one 500 mA driver | 0.25 | A / V |

#### POWER SUPPLY

| Voltage, $V_{DD}$ | 3 | 12** | Volts |
| Current, $V_{DD}$ supply, quiescent | 2.2 | 2.7 | 4.6 | mA |
| $V_S$, Maximum to LD Anode | 20** | Volts |

#### INPUT

| Offset Voltage, initial, $I_{mon}$ | Pin 2, $T_{AMBIENT} = 25°C$, $V_{CM} = 0$ V | 2 | mV |
| Bias Current (based on input Res of op amp) | Pin 2, $T_{AMBIENT} = 25°C$, $V_{CM} = 0$ V | 10 | 15 | nA |
| Common Mode Range | Pin 2, Full Temp. Range | 0 | $V_{DD}$ | V |
| Common Mode Rejection, Set point | Full Temperature Range | -16 | 64 | dB |
| Power Supply Rejection | Full Temperature Range | 60 | dB |

#### THERMAL

| Heatspreader Temperature Rise | $T_{AMBIENT} = 25°C$ | 43 | °C / W |
| Pin Solderability | Solder temp @260°C | 10 | Sec |

#### NOISE

| Noise & Ripple (Rms) | $I_{OUT} = 100$ mA, 100 kHz bandwidth | 3 | μA |
| Leakage Current | $V_{set} = 0$, Reset = 0 | 1 | mA |
| | $V_{set} = 0$, Reset = 1 | 0.2 | mA |
| | $V_{set} = 2$, Reset = 1 | 0.3 | mA |

**The FL591 Evaluation Board revision A or B limits the input voltage to 9 V. Revision C allows full range operation from +3 V to +12 V.**
### PIN DESCRIPTIONS

<table>
<thead>
<tr>
<th>Pin</th>
<th>Pin #</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD</td>
<td>1</td>
<td>Control Electronics Power</td>
<td>Power supply input for the FL500’s internal control electronics. Supply range input for this pin is +3 to +12 Volts DC. It is compatible with Li+ batteries.</td>
</tr>
<tr>
<td>GND</td>
<td>2</td>
<td>Control Electronics Ground</td>
<td>Return path for control electronics. Connect ground for VDD power supply here. Do not use for high current ground return.</td>
</tr>
<tr>
<td>RESET</td>
<td>3</td>
<td>Enable / RESET Control</td>
<td>TTL compatible. LO = laser diode current on FLOAT or HI = laser diode current attenuated to ~10 µA (~20 µA if drivers are paralleled to produce 500 mA)</td>
</tr>
<tr>
<td>VSET1</td>
<td>4</td>
<td>Setpoint for LDC1 control</td>
<td>2 kΩ input impedance. 0 to 2 V range. There is no internal clamping, so higher voltage here will produce more current through the laser diode. <strong>Not recommended above 2 V.</strong></td>
</tr>
<tr>
<td>GND</td>
<td>5</td>
<td>Ground for setpoint inputs</td>
<td>Low Current, Low Noise ground for use with VSET1 &amp; VSET2.</td>
</tr>
<tr>
<td>VSET2</td>
<td>6</td>
<td>Setpoint for LDC2 control</td>
<td>2 kΩ input impedance. 0 to 2 V range. There is no internal clamping, so higher voltage here will produce more current through the laser diode. <strong>Not recommended above 2 V.</strong></td>
</tr>
<tr>
<td>LDC2</td>
<td>7</td>
<td>Laser Diode Cathode, Driver 2</td>
<td>Tie to laser diode cathode for individual drive operation (250 mA max). Tie to LDC1 for parallel operation up to 500 mA. Tie to pin 8 (also LDC2) if laser diode current exceeds 125 mA. Actual pin capacity is greater, but higher current produces offsets and higher noise.</td>
</tr>
<tr>
<td>LDC2</td>
<td>8</td>
<td>Laser Diode Cathode, Driver 2</td>
<td>Tie to laser diode cathode for individual drive operation (250 mA max). Tie to LDC2 for parallel operation up to 500 mA. Tie to pin 12 (also LDC1) if laser diode current exceeds 125 mA. Actual pin capacity is greater, but higher current produces offsets and higher noise.</td>
</tr>
<tr>
<td>PGND</td>
<td>9</td>
<td>Power Ground for VS connection</td>
<td>Use for ground connection of VS power supply. Tie to pin 10 (also PGND) if laser diode current exceeds 125 mA.</td>
</tr>
<tr>
<td>PGND</td>
<td>10</td>
<td>Power Ground for VS connection</td>
<td>Use for ground connection of VS power supply. Tie to pin 10 (also PGND) if laser diode current exceeds 125 mA.</td>
</tr>
<tr>
<td>LDC1</td>
<td>11</td>
<td>Laser Diode Cathode, Driver 1</td>
<td>Tie to laser diode cathode for individual drive operation (250 mA max). Tie to LDC2 for parallel operation up to 500 mA. Tie to pin 12 (also LDC1) if laser diode current exceeds 125 mA. Actual pin capacity is greater, but higher current produces offsets and higher noise.</td>
</tr>
<tr>
<td>LDC1</td>
<td>12</td>
<td>Laser Diode Cathode, Driver 1</td>
<td>Tie to laser diode cathode for individual drive operation (250 mA max). Tie to LDC2 for parallel operation up to 500 mA. Tie to pin 12 (also LDC1) if laser diode current exceeds 125 mA. Actual pin capacity is greater, but higher current produces offsets and higher noise.</td>
</tr>
</tbody>
</table>

Note [1]. Maximum Power Dissipation is 1 Watt per channel. When configured as one driver, maximum power dissipation is 2 W.

Note [2]. Limit is fixed at 500 mA (250 mA per channel). The Evaluation Board circuitry adds a variable limit circuit.

Note [3]. Constant Power Control is available when the FL500 is used with FL591 and FL593 as well as the LDTC0520/1020 combination boards.
OPERATION

1. RESET / ENABLE FUNCTION
This control pin is common to both sources. When active, this pin attenuates the output current amplitude to near zero (~10 μA when configured for 250 mA max.) Current still flows through the laser diode. The pin is active LO. LO = LD current flowing to setpoint. FLOAT or HI = LD current attenuated. The input is TTL compatible.

2. DELAYED / SLOW START
Once power is applied, current at the attenuated level will flow (~10 μA when configured for 250 mA max). After 100 msec, current will rise to the level dictated by the setpoint voltage at the rate of about 15 mA / msec. This delay ensures that all control electronics are functioning before significant current flows to the laser diode. The delay time is set with internal components. [It can be increased - please request a custom modification through Sales.] Refer to Figure 3 for a typical sequence.

3. BROWN OUT PROTECTION
If VDD drops below 2.7 V, the RESET circuit is triggered immediately (on the order of 100 μsec), reducing current through the laser diode to attenuated levels (~10 μA).

4. VS & VDD
VDD powers the control electronics. VS powers the laser diode current source.
   a. To power the laser diode from VDD, connect VDD where VS is shown. For lower noise operation, separate VDD from VS.
   b. VS can be up to 20 V. At this level, however, too much power can be dissipated in the FL500 causing permanent damage. Calculate the power dissipated in the FL500 using the Safe Operating Area (SOA) Calculator online prior to using a VS more than 2 V greater than the voltage dropped over the laser diode.
   A maximum power dissipation of 1 W per source (2 W for paralleled operation) must not be exceeded.
   c. The minimum VS is determined by the voltage drop across the laser diode and half the setpoint voltage. VSMIN = VLD + VSET/2 + 25 mV (across FET). Ground this power supply at pins 9 and 10 (PGND). Using pin 2 could damage the FL500.

Example VSMIN:
VLD = 1.2 V
VSET = 1.5 V
VSMIN = 1.2V + (1.5 /2) + 0.025 = 1.975 V
5. OPERATION AS TWO INDEPENDENT DRIVERS

The FL500 contains circuitry for two 250 mA drivers. VS1 does not need to be tied to VS2. The transfer function for VSET is 0.125 A / V, the RESET minimum current is 10 μA, and leakage current is less than 1 mA. The FL500 has a known leakage current when disabled equal to the following magnitude:

\[ I_{OUT(LEAK)} = \frac{V_{IN}}{20 \, k\Omega} \]

This is well below 1 mA, and usual leakage expected is 100 μA.

See Figure 4 for typical operating schematic.

6. OPERATION IN PARALLEL AS ONE DRIVER.

The FL500 contains circuitry for two 250 mA drivers. They can be run in parallel to deliver 500 mA to one laser diode. Tie LDC1 & LDC2 together. VSET1 and VSET2 can be tied together or one can be used to set a DC bias while the other is used for an additive modulation signal. Only one VS can be used. The transfer function for tied VSETs is 0.25 A / V. The transfer function for independent VSETs is 0.125 A / V. The RESET minimum current is 20 μA, and leakage current is 2 mA. Note that if VSETs are tied together, input impedance becomes two 2 kΩ in parallel or 1 kΩ. The FL500 has a known leakage current when disabled equal to the following magnitude:

\[ I_{OUT(LEAK)} = \frac{V_{IN}}{20 \, k\Omega} \]

This is well below 1 mA, and usual leakage expected is 100 μA.

See Figure 5 for typical operating schematic.
7. MULTIPLE FL500s IN PARALLEL
Multiple FL500s can be used in parallel for 1 A, 1.5 A, etc. operation: Note input impedance on VSET drops. For two FL500s configured for 500 mA each and used in parallel, the input impedance drops to 500 Ω. See Figure 6 for typical operating schematic.

Figure 6
Multiple units in parallel
Caution:
Do not exceed the Safe Operating Area (SOA). Exceeding the SOA voids the warranty.

To determine if the operating parameters fall within the SOA of the device, the maximum voltage drop across the driver and the maximum current must be plotted on the SOA curves. These values are used for the example SOA determination:

\[
\begin{align*}
V_s &= 5 \text{ volts} \\
V_{\text{Load}} &= 2.5 \text{ volts} \\
I_{\text{Load}} &= 100 \text{ mA} \\
\end{align*}
\]

These values are determined from the specifications of the laser diode.

Follow these steps:

1. Determine the maximum voltage drop across the driver, \(V_s - V_{\text{Load}}\), and mark on the X axis. Example: 5 volts - 2.5 volts = 2.5 volts, Point A.
2. Determine the maximum current, \(I_{\text{Load}}\), through the driver and mark on the Y axis: (100 mA, Point B).
3. Draw a horizontal line through Point B across the chart. (Line BB)
4. Draw a vertical line from Point A to the maximum current line indicated by Line BB.
5. Mark \(V_s\) on the X axis. (Point C)
6. Draw the Load Line from where the vertical line from point A intersects Line BB down to Point C.

Refer to the chart shown below and note that the Load Line is in the Safe Operating Area. Note the first chart is for the independent channels. The second, on the following page, is for dual channels configured as a single 500 mA driver.

An online tool for calculating your load line is at http://www.teamwavelength.com/support/calculator/soa/soald.php.

Graphs assume:
- 25°C Ambient
- 35°C Case

FL500 Safe Operating Area
Independent Channels 1 W, 250 mA max

![FL500 Safe Operating Area Graph](image-url)
TYPICAL PERFORMANCE GRAPH FOR 2 WATT, 500 mA

Caution:
Do not exceed the Safe Operating Area (SOA). Exceeding the SOA voids the warranty.

To determine if the operating parameters fall within the SOA of the device, the maximum voltage drop across the driver and the maximum current must be plotted on the SOA curves. These values are used for the example SOA determination:

\[
\begin{align*}
V_s &= 3 \text{ volts} \\
V_{\text{Load}} &= 2 \text{ volts} \\
I_{\text{Load}} &= 400 \text{ mA}
\end{align*}
\]

These values are determined from the specifications of the laser diode.

Follow these steps:

1. Determine the maximum voltage drop across the driver; \(V_s - V_{\text{Load}}\), and mark on the X axis. Example: 3 volts - 2 volts = 1 volts, Point A)
2. Determine the maximum current, \(I_{\text{Load}}\), through the driver and mark on the Y axis: (400 mA, Point B)
3. Draw a horizontal line through Point B across the chart. (Line BB)
4. Draw a vertical line from Point A to the maximum current line indicated by Line BB.
5. Mark \(V_s\) on the X axis. (Point C)
6. Draw the Load Line from where the vertical line from point A intersects Line BB down to Point C.

Refer to the chart shown below and note that the Load Line is in the Safe Operating Area. Note this chart is for dual channels configured as a single 500 mA driver. The first, on the previous page, is for independent channels configured for 250 mA max.


Graphs assume:
- 25°C Ambient
- 35°C Case

[Diagram of FL500 Safe Operating Area]

- 1: \(P_{\text{in}} < 2\text{ W} \cdot \text{safe}\)
- 2: \(P_{\text{in}} > 2\text{ W} \cdot \text{un-safe}\)

\(P_{\text{in}}\) = Power internally dissipated in the FL500
MECHANICAL SPECIFICATIONS
FL500 is reflow process compatible.

PCB FOOTPRINT

All dimension tolerances are ±5%.
CERTIFICATION AND WARRANTY

CERTIFICATION:
Wavelength Electronics (Wavelength) certifies that this product met its published specifications at the time of shipment. Wavelength further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by that organization’s calibration facilities, and to the calibration facilities of other International Standards Organization members.

WARRANTY:
This Wavelength product is warranted against defects in materials and workmanship for a period of one (1) year from date of shipment. During the warranty period, Wavelength will, at its option, either repair or replace products which prove to be defective.

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For warranty service or repair, this product must be returned to the factory. An RMA is required for products returned to Wavelength for warranty service. The Buyer shall prepay shipping charges to Wavelength and Wavelength shall pay shipping charges to return the product to the Buyer upon determination of defective materials or workmanship. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Wavelength from another country.

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REVISION HISTORY

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<tr>
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<th>DATE</th>
<th>NOTES</th>
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</thead>
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<tr>
<td>REV. F</td>
<td>24-Feb-09</td>
<td>Updated to include FL500 Reflow Oven compatibility</td>
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<tr>
<td>REV. G</td>
<td>25-Sep-09</td>
<td>Updated to reflect RoHS Status</td>
</tr>
<tr>
<td>REV. H</td>
<td>6-June-13</td>
<td>Updated Noise &amp; Ripple specification</td>
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<tr>
<td>REV. I</td>
<td>26-Mar-14</td>
<td>Clarified reflow compatibility</td>
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<tr>
<td>REV. J</td>
<td>15-Dec-14</td>
<td>Updated to fully reflow compatible</td>
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