



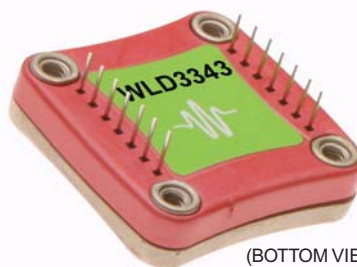
WAVELENGTH
ELECTRONICS

April, 2007

WLD3343 HB

General Purpose Driver for Laser Diodes

Warning: This is a Low Voltage Device



(BOTTOM VIEW)

GENERAL DESCRIPTION:

The WLD3343 is an easy-to-use analog circuit for space constrained laser diode applications. The WLD3343 maintains precision laser diode current (constant current mode) or stable photodiode current (constant power mode) regulation using electronics that are compatible with any laser diode type. Safely supply up to 2.2 Amps of current to your laser diode. The HB version of WLD 3343 offers low voltage operation for use with a **Lithium Ion Battery** or other low voltage power supplies.

Note: Contact factory for higher currents using Master/Slave configurations.

FEATURES:

- Low Cost
- Slow Start Laser Diode Protection
- Drive Up to 2.2 Amps Output Current
- Constant Current or Power Operation
- Compatible With Any Laser Diode Type
- Small Package Size (1.30" X 1.26" X 0.313")
- Voltage Controlled Setpoint
- Adjustable Current Limit
- Adjustable Current Range
- 2 MHz Constant Current Bandwidth
- Over Temperature Shutdown

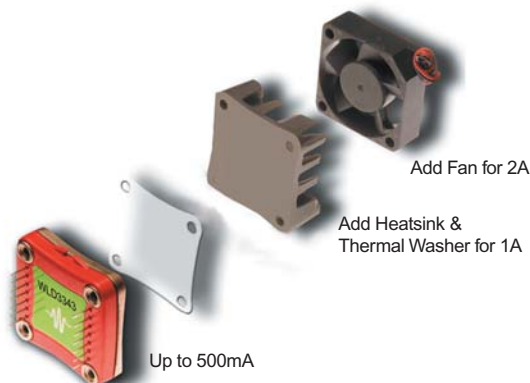
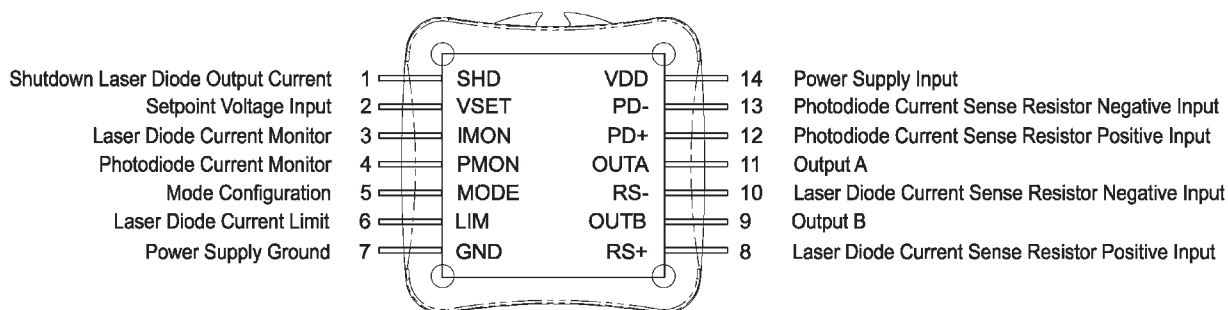


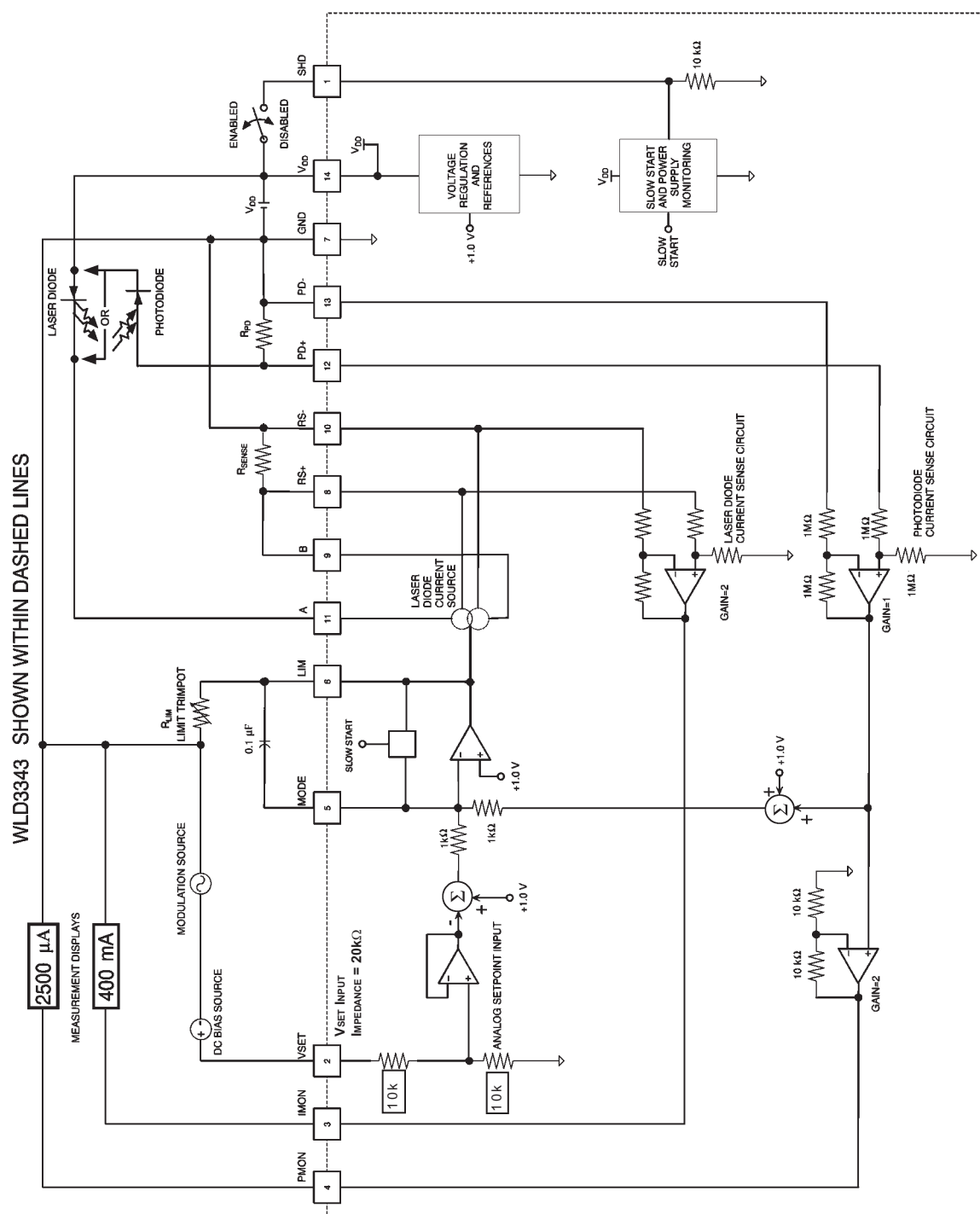
Figure 1

Top View Pin Layout
and Descriptions

TOP VIEW



External Connections For Type A/B Laser Diodes Operated in Constant Power Mode



ELECTRICAL AND OPERATING
SPECIFICATIONS

PAGE 3

ABSOLUTE MAXIMUM RATINGS						
RATING	SYMBOL	VALUE	UNIT			
Supply Voltage (Voltage on Pin 14)	V _{DD}	+3.3 to +6	Volts DC			
Output Current (See SOA Chart)	I _{LD}	2.2	Amperes			
Power Dissipation, T _{AMBIENT} = +25°C	P _{MAX}	9	Watts			
Operating Temperature, case [1]	T _{OPR}	- 40 to + 85	°C			
Storage Temperature	T _{STG}	- 65 to +150	°C			
Weight	WLD3343	0.576	oz			
PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNITS
CONSTANT CURRENT CONTROL						
Short Term Stability, 1 hour	T _{AMBIENT} = 25°C			25	50	ppm
Long Term Stability, 24 hours	T _{AMBIENT} = 25°C			50	75	ppm
CONSTANT POWER CONTROL						
Short Term Stability, 1 hour	T _{AMBIENT} = 25°C		0.005		0.01	%
Long Term Stability, 24 hours	T _{AMBIENT} = 25°C		0.02		0.05	%
OUTPUT						
Current, peak, see SOA chart			1.8	2.0	2.2	Amps
Compliance Voltage, Laser Diode Load	Full Temp. Range, I _{LD} = 100 mA, 5V		3.6			Volts
Compliance Voltage, Laser Diode Load	Full Temp. Range, I _{LD} = 1 Amp, 5V		3.5			Volts
Compliance Voltage, Laser Diode Load	Full Temp. Range, I _{LD} = 2.0 Amps, 5V		3.0			Volts
Compliance Voltage, Laser Diode Load	Full Temp. Range, I _{LD} = 100 mA,12V		10.6			Volts
Compliance Voltage, Laser Diode Load	Full Temp. Range, I _{LD} = 1 Amp,12V		10.4			Volts
Compliance Voltage, Laser Diode Load	Full Temp. Range, I _{LD} = 2.0 Amp,12V		10.1			Volts
Rise Time	I _{LD} = 2 Amps			160		nsec
Fall Time	I _{LD} = 2 Amps			320		nsec
Bandwidth	Constant Current, Sine Wave			2.0		MHz
Bandwidth	Constant Power (Depends on PD BW)					Seconds
Slow Start - Delay				0.24		Seconds
Slow Start - Ramp				.01		Seconds
Leakage Current [2]				.5		%
POWER SUPPLY						
Voltage, V _{DD}			3.3		6	Volts
Current, V _{DD} supply, quiescent			5	10	15	mA

Notes:

[1]. With Revision D of the WLD3343, an internal thermostat has been added to activate Shutdown (SHD) when the internal temperature exceeds 105°C. The output will be re-enabled after a 250 to 300 msec slow-start once the internal temperature drops below 95°C.

[2]. Leakage current specification is based on full current set by Rsense. See page 8 for information on setting the current range. Because of the relatively high leakage current of this device, the WLD is not recommended for use with VCELS

ELECTRICAL AND OPERATING
SPECIFICATIONS - Continued

PAGE 4

INPUT					
Offset Voltage, initial, I_{mon}	Pin 2, $T_{AMBIENT} = 25^{\circ}\text{C}$, $V_{CM} = 0\text{V}$		1	5	mV
Bias Current (based on input Res of op amp)	Pin 2, $T_{AMBIENT} = 25^{\circ}\text{C}$, $V_{CM} = 0\text{V}$		20	50	nA
Common Mode Range	Pin 2, Full Temp. Range	0		V_{DD}	V
Common Mode Rejection, Set point	Full Temperature Range	60	85		dB
Power Supply Rejection	Full Temperature Range	60	80		dB
THERMAL					
Heatspreader Temperature Rise	$T_{AMBIENT} = 25^{\circ}\text{C}$	28	30	33	$^{\circ}\text{C/W}$
Heatspreader Temperature Rise	With WHS302 Heat sink, WTW002 Thermal Washer	18	21.5	25	$^{\circ}\text{C/W}$
Heatspreader Temperature Rise	With WHS302 Heat sink, WTW002 Thermal Washer and 3.5 CFM fan	3.1	3.4	3.9	$^{\circ}\text{C/W}$
Pin Solderability	Solder temp @260°C		10		Sec

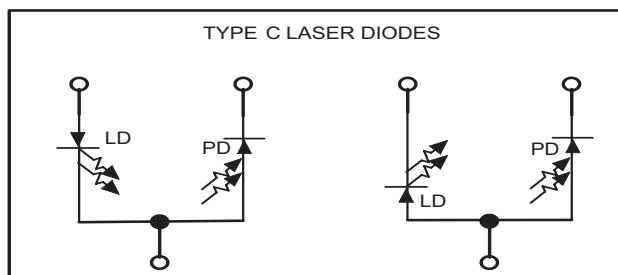
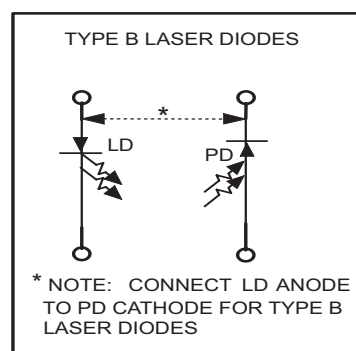
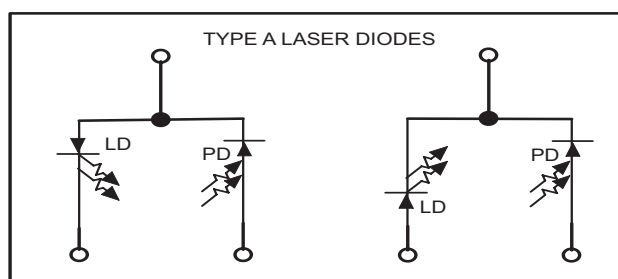
PIN DESCRIPTIONS

Pin	Pin #	Name	Function
SHD	1	Shutdown Laser Diode Output Current	Float or connect a zero Volt signal to Pin 1 (SHD) to ENABLE the output current to the laser diode. Connect a +3 Volt or greater signal to Pin 1 (SHD) to DISABLE the output current to the laser diode. Do Not Exceed Vdd!
VSET	2	Setpoint Voltage Input or Modulation Input	Connect a voltage source between Pin 2 (VSET) and Pin 7 (GND) to control either the laser diode current in constant current mode or laser diode power in constant power mode. Range is 0-2.0 volt full scale. Input impedance is 20K. The offset voltage is 0.5V when open(applies to Revision D forward).
IMON	3	Laser Diode Current Monitor	Monitor the laser diode forward current using Pin 3 (IMON). The Laser Diode Current Monitor produces a voltage proportional to the current flowing through the laser diode.
PMON	4	Photodiode Current Monitor	Monitor the laser diode power using Pin 4 (PMON). The Photodiode Current Monitor produces a voltage proportional to the current produced by the laser diode monitor photodiode.
MODE	5	Mode Configuration	CONSTANT CURRENT OPERATION: A 1k Ω resistor between Pin 5 (MODE) and Pin 6 (LIM) configures the WLD3343 to regulate the laser diode's forward current. CONSTANT POWER OPERATION: A 0.1 μ F capacitor between Pin 5 (MODE) and Pin 6 (LIM) configures the WLD3343 to regulate the laser diode's output power.
LIM	6	Laser Diode Current Limit	A resistor connected between Pin 6 (LIM) and Pin 7 (GND) limits the maximum amount of forward current through the laser diode
GND	7	Power Supply Ground	Connect the VDD power supply ground connection to Pin 7 (GND).
RS+	8	Laser Diode Current Sense Resistor Positive Input	Connect Pin 8 (RS+) directly to the positive side of the laser diode current sense resistor. The resistance value of R _{SENSE} determines the range of forward current through the laser diode.
OUTB	9	Output B	Connect Pin 9 (OUTB) to the positive side of R _{SENSE} .
RS-	10	Laser Diode Current Sense Resistor Negative Input	Connect Pin 10 (RS-) directly to the negative side of the laser diode current sense resistor. The resistance value of R _{SENSE} determines the range of forward current through the laser diode.

PIN DESCRIPTIONS

Output A

Pin	Pin #	Name	Function
OUTA	11	Output A	<p>TYPE A/B LASER DIODES: Connect Pin 11 (OUTA) to the cathode connection of the laser diode for type A/B laser diode operation.</p> <p>TYPE C LASER DIODES: Connect Pin 11 (OUTA) to Pin 14 (VDD) for type C laser diode operation.</p>
PD+	12	Photodiode Current Sense Resistor Positive Input	<p>TYPE A/B LASER DIODE OPERATION: CC: Connect Pin 12 (PD+) and Pin 13 (PD-) to Pin 7 (GND). CP: Connect Pin 12 (PD+) to the anode of the photodiode.</p> <p>TYPE C LASER DIODE OPERATION: CC: Connect Pin 12 (PD+) and Pin 13 (PD-) to Pin 7 (GND). CP: Connect Pin 12 (PD+) to Pin 14 (VDD).</p>
PD-	13	Photodiode Current Sense Resistor Negative Input	<p>TYPE A/B LASER DIODE OPERATION: CC: Connect Pin 12 (PD+) and Pin 13 (PD-) to Pin 7 (GND). CP: Connect Pin 13 (PD-) to Pin 7 (GND).</p> <p>TYPE C LASER DIODE OPERATION: CC: Connect Pin 12 (PD+) and Pin 13 (PD-) to Pin 7 (GND). CP: Connect Pin 13 (PD-) to the cathode of the photodiode.</p>
VDD	14	Power Supply Input	Power supply input for the WLD3343's internal control electronics. Supply range input for this pin is +3.3 to +6 Volts DC.

LASER DIODE PACKAGE STYLES

TYPICAL PERFORMANCE GRAPHS

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 controller and the maximum current must be plotted on the SOA curves.

These values are used for the example SOA determination:

$V_s = 5$ volts

$V_{load} = 1.5$ volts

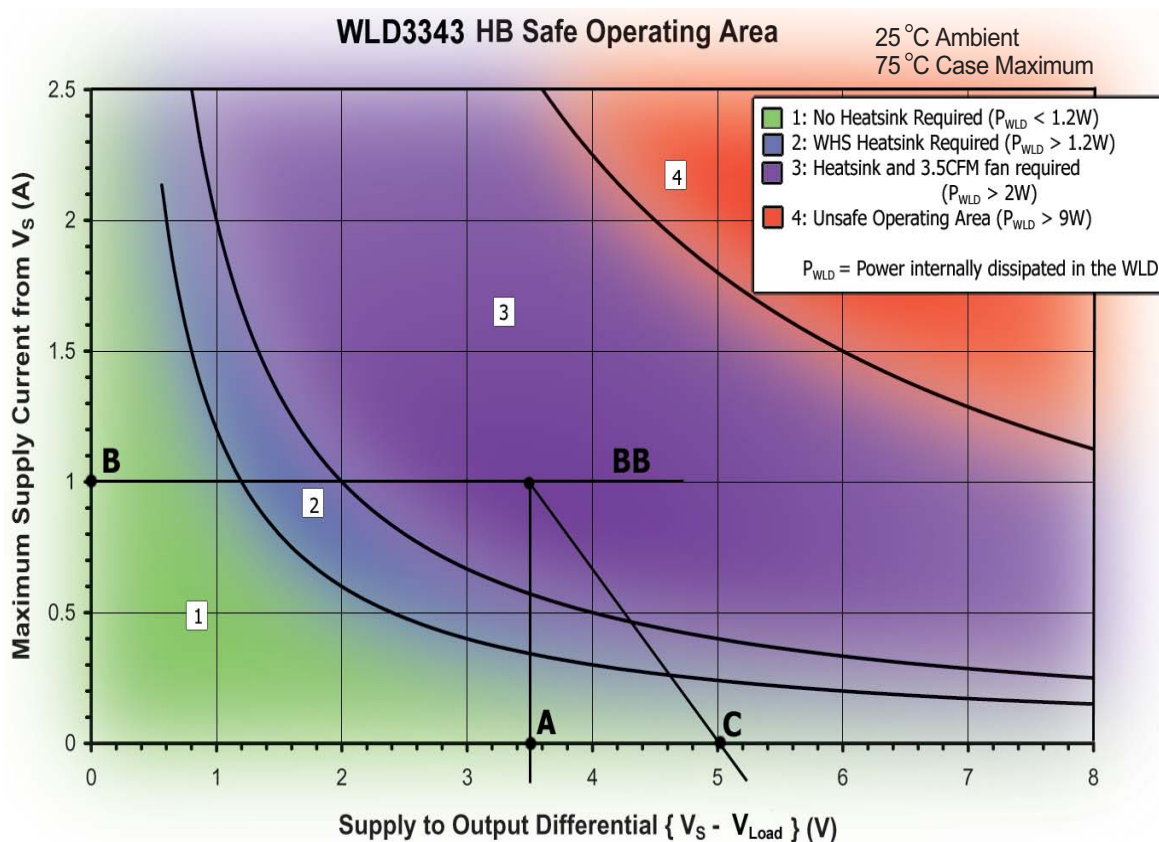
$I_{load} = 1$ amp

} These values are determined from the specifications of the Laser Diode.

Follow these steps:

1. Determine the maximum voltage drop across the controller, $V_s - V_{load}$, and mark on the X axis. (5volts - 1.5 volts = 3.5 volts, Point A)
2. Determine the maximum current, I_{load} , through the controller and mark on the Y axis: (1 amp, 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 Unsafe Operating Areas for use with no heatsink (1) or the heatsink alone (2), but is outside of the Unsafe Operating Area for use with heatsink and Fan (3).



OPERATION

1. SELECTING THE LASER DIODE OUTPUT CURRENT RANGE

The output current range of the WLD3343 depends on the selection of resistor R_{SENSE} placed between Pin 8 (RS+) and Pin 10 (RS-) as shown in Figure 1.

Equation 1 calculates R_{SENSE} for a maximum desired laser diode current, I_{LDMAX} . Refer to Table 1 to select R_{SENSE} for common laser diode current ranges.

Table 1

Laser Diode Current Sense Resistor R_{SENSE} vs Maximum Laser Diode Current I_{LDMAX}

Maximum Output Current I_{LDMAX}	Constant Power Current Sense Resistor, R_{SENSE}	Constant Current Current Sense Resistor, R_{SENSE}
50 mA	25.00 Ω	20.00 Ω
125 mA	10.00 Ω	8.00 Ω
250 mA	5.00 Ω	4.00 Ω
500 mA	2.50 Ω	2.00 Ω
1.25 Amps	1.00 Ω	0.80 Ω
2.2 Amps	0.57 Ω	0.45 Ω

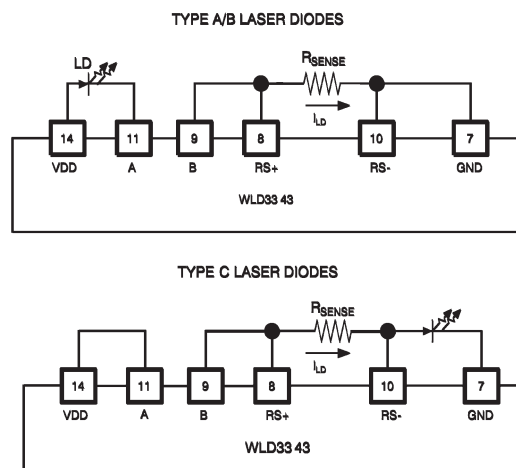
2. HELPFUL HINTS FOR CHOOSING R_{SENSE}

- Never use a carbon film resistor for R_{SENSE} .
- Avoid resistors with high parasitic inductance.
- Select a resistor with a low temperature coefficient (1% 100ppm/°C).
- Place R_{SENSE} as close to Pins 8 (RS+) and 10 (RS-) on the WLD3343 as possible to avoid parasitic resistance effects from the PCB layout.
- Use Equation 2 for determining the power rating of R_{SENSE} .

Note: Wavelength Electronics recommends a conservative power rating of 2 times normal maximum for R_{SENSE} . Equation 2 incorporates this recommendation.

Figure 1

Connecting R_{SENSE}



Equation 1

Calculating R_{SENSE}

Constant Power Mode

$$R_{\text{SENSE}} = \frac{1.25}{I_{\text{LDMAX}}}$$

Constant Current Mode

$$R_{\text{SENSE}} = \frac{1.00}{I_{\text{LDMAX}}}$$

Equation 2

Calculating The Power Rating For R_{SENSE}

$$\text{RATING} = 2 * I_{\text{LDMAX}}^2 * R_{\text{SENSE}}$$

OPERATION

3. CONFIGURING THE LASER DIODE CURRENT LIMIT

The WLD3343 allows a customized current range for a specific application. An optimized set point resolution while minimizing output noise are the benefits of configuring a customized current range. Table 2 lists the scaling factors for different current limiting (R_{LIM}).

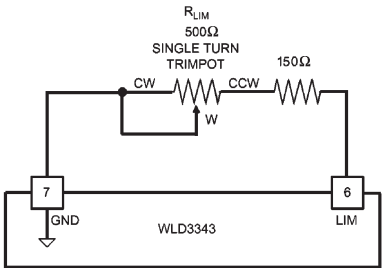
To select an appropriate resistance value for the limit resistor (R_{LIM}), the laser diode type and mode of operation, divide the maximum laser diode current (determined in Section 1) into the desired maximum operating current for the laser diode. This result is the Normalized Maximum Output Current. Choose the resistance value of the current limit set resistor (R_{LIM}) shown next to the calculated Normalized Maximum Output Current.

Use Equation 3 to calculate a precise value for R_{LIM} .

Setting Current Limits Using Trimpots

Connect a 500 Ω trimpot and a 150 Ω resistor as shown in Figure 2 to make the maximum current limit adjustable.

Figure 2
Adjustable Current Limits



Example 1
Choosing R_{LIM} for a Type A/B Laser Diode with a 1.5 AMP Maximum Forward Current in Constant Current Mode.

Configure the WLD3343 so that I_{LDMAX} is 2.2 Amps by selecting R_{SENSE} equal to 0.45 Ω . The Normalized Maximum Output Current then equals:

$$= \frac{1.5 \text{ Amps}}{2.2 \text{ Amps}} = 0.68$$

A Normalized Output Current of 0.68 (68%) corresponds to a current limit set resistor R_{LIM} of 405 Ω .

Equation 3
Calculating R_{LIM}

$$R_{LIM} = \frac{\alpha \left(\frac{I_{LDLIM} R_{SENSE} + 1}{\beta} \right)}{\left[1 - \left(\frac{I_{LDLIM} R_{SENSE} + 1}{\beta} \right) \right]}$$

Laser Diode Type / Mode	α	β
Type A/B - CC	282	2.85
Type A/B - CP	350	3.35
Type C - CC	290	2.93
Type C - CP	385	3.57

Table 2

**Current Limit Set Resistor R_{LIM} vs
Normalized Maximum Output Current**

Normalized Maximum Output Current	Type A/B Laser Diode Constant Current Limit Set Resistor R_{LIM} (Ω)	Type A/B Laser Diode Constant Power Limit Set Resistor R_{LIM} (Ω)	Type C Laser Diode Constant Current Limit Set Resistor R_{LIM} (Ω)	Type C Laser Diode Constant Power Limit Set Resistor R_{LIM} (Ω)
0.00 (0%)	152	149	150	150
0.04 (4%)	162	160	160	160
0.08 (8%)	172	171	169	171
0.12 (12%)	183	183	179	183
0.16 (16%)	194	195	190	195
0.20 (20%)	205	208	201	207
0.24 (24%)	217	222	213	220
0.28 (28%)	230	236	225	234
0.32 (32%)	243	251	238	248
0.36 (36%)	257	267	251	263
0.40 (40%)	272	284	265	279
0.44 (44%)	288	301	280	295
0.48 (48%)	305	320	296	313
0.52 (52%)	322	340	313	331
0.56 (56%)	341	361	330	350
0.60 (60%)	361	383	349	370
0.64 (64%)	382	406	369	392
0.68 (68%)	405	432	390	414
0.72 (72%)	429	459	412	438
0.76 (76%)	455	488	436	463
0.80 (80%)	483	519	462	490
0.84 (84%)	514	552	490	519
0.88 (88%)	547	588	519	550
0.92 (92%)	582	627	551	583
0.96 (96%)	621	670	586	618
1.00 (100%)	664	716	624	656

4. SELECTING THE MONITOR PHOTODIODE CURRENT RANGE

The monitor photodiode current range determines the selection of the resistor R_{PD} . Equation 4 calculates R_{PD} for a maximum desired photodiode current, I_{PDMAX} . Refer the Table 3 to select R_{PD} for common photodiode current ranges.

In constant power mode, the photodiode is used to control laser output and R_{PD} is connected across Pin 12 (PD+) and Pin 13 (PD-). In constant current mode, the photodiode is excluded from the control circuit and Pin 12 (PD+) and Pin 13 (PD-) are shorted together. The photodiode current can still be monitored in constant current mode with R_{PD} . Refer to Figure 3 for photodiode resistor connections.

Equation 4

Calculating R_{PD}

$$R_{PD} = \frac{1}{I_{PDMAX}}$$

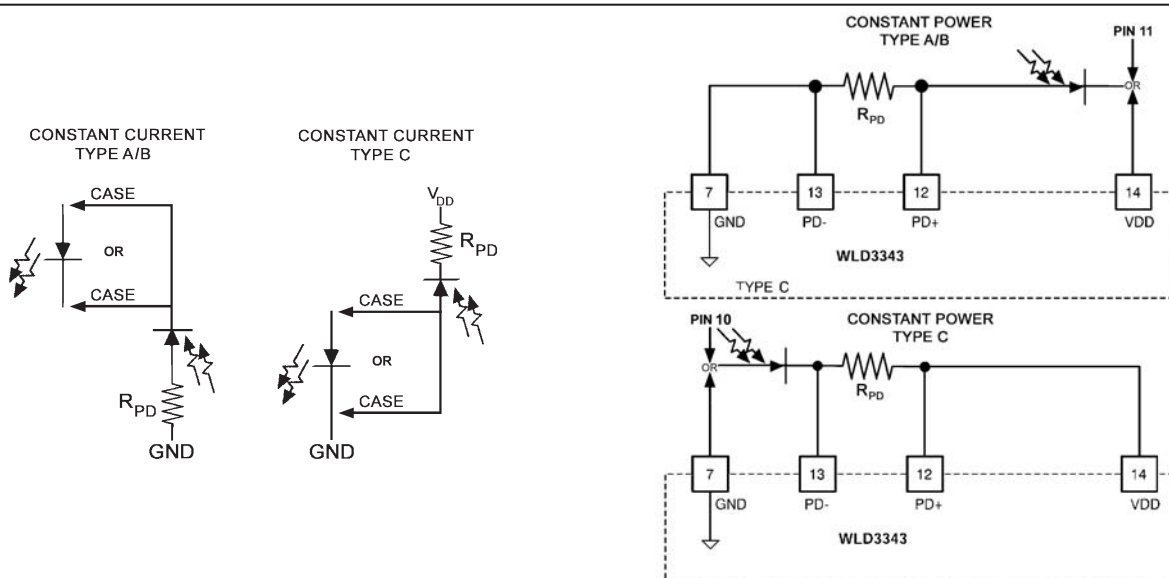
Table 3

Monitor Photodiode Sense Resistor R_{PD} vs Maximum Photodiode Current I_{PDMAX}

Maximum Photodiode Current, I_{PDMAX}	Monitor Photodiode Current Sense Resistor, R_{PD}
20 μ A	50k Ω
200 μ A	5k Ω
2mA	500 Ω
20mA	50 Ω

Figure 3

Connecting R_{PD}



5. HELPFUL HINTS FOR CHOOSING R_{PD}

- Never use a carbon film resistor for R_{PD} .
- Select a resistor with a low temperature coefficient (ppm/ $^{\circ}$ C).
- Place R_{PD} as close to Pins 12 (PD+) and 13 (PD-) on the WLD3343 as possible to avoid parasitic resistance effects from the PCB layout when in constant power mode.

OPERATION

6.DISABLING THE OUTPUT CURRENT

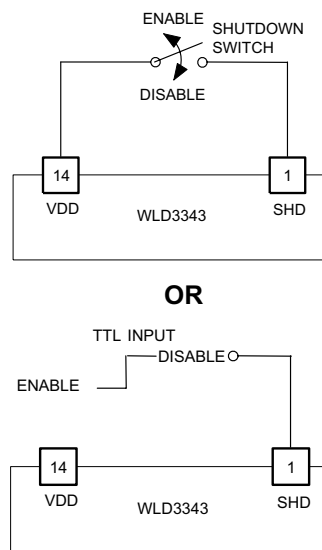
The output current can be enabled and disabled as shown in Figure 4 using a SPST (Single-Pole Single-Throw) switch or a TTL signal.

NOTE:

Do not insert or remove the laser diode from the WLD3343 circuit with power applied to the unit.

Figure 4

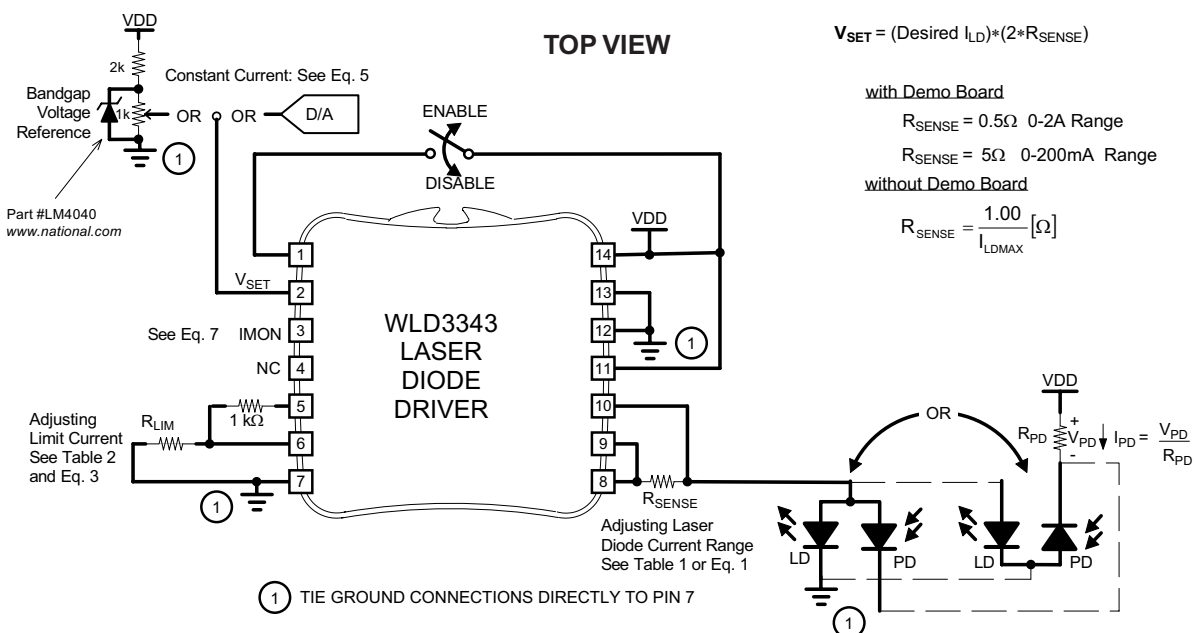
Disabling Output Current



8. OPERATING a C type laser diode

Figure 7

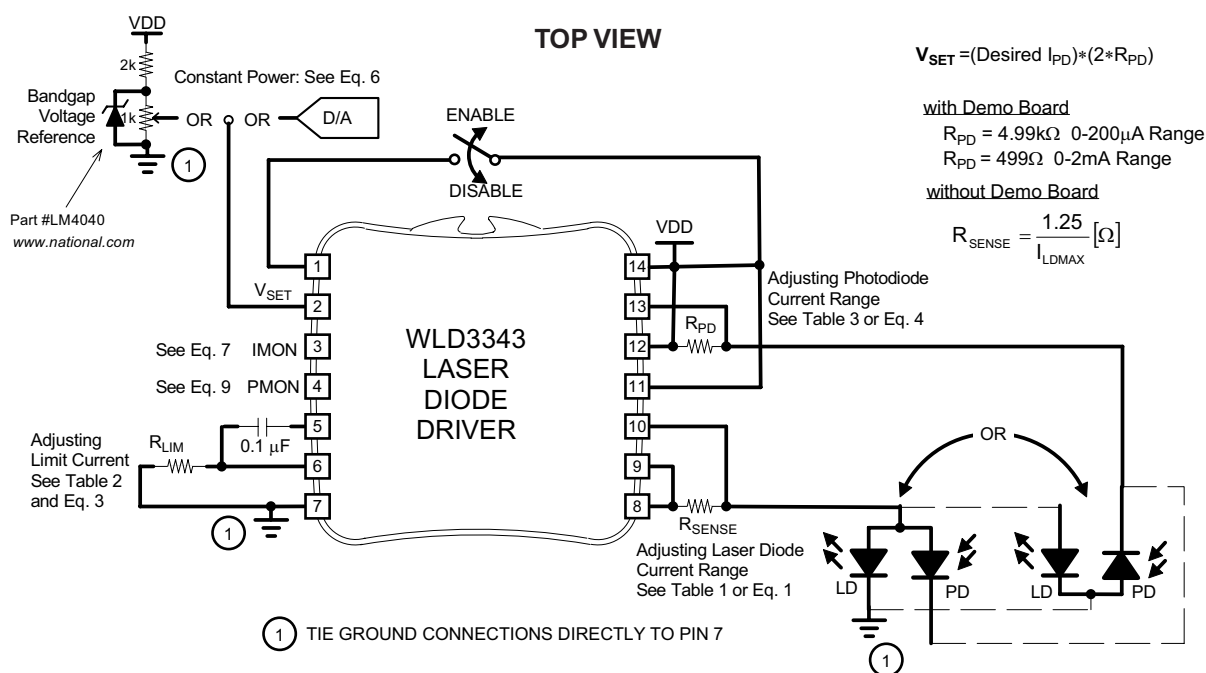
Type C Laser Diode Constant Current Operation



Free Design Calculator: www.teamwavelength.com/tools/tools.asp

Figure 8

Type C Laser Diode Constant Power Operation



Free Design Calculator: www.teamwavelength.com/tools/tools.asp

OPERATION

9. CONTROLLING THE LASER DIODE FORWARD CURRENT IN CONSTANT CURRENT MODE

Equation 5 calculates the laser diode forward current produced by applying a voltage at Pin 2 (V_{SET}) in constant current mode.

10. CONTROLLING THE MONITOR PHOTODIODE CURRENT IN CONSTANT POWER MODE

Equation 6 calculates the monitor photodiode current produced by applying a voltage at Pin 2 (V_{SET}) in constant power mode.

11. TYPICAL OPERATION OF THE VOLTAGE CONTROL INPUT

Figure 9 illustrates a typical configuration of the WLD3343 voltage input.

CAUTION: CONNECTING VOLTAGES OUTSIDE THE RANGE OF V_{DD} TO GND TO THE VOLTAGE SETPOINT INPUT ON PIN 2 (V_{SET}) CAN RESULT IN DAMAGE TO THE WLD3343 OR YOUR LASER DIODE.

12. MEASURING LASER DIODE FORWARD CURRENT USING THE CURRENT MONITOR OUTPUT

Equation 7 provides a transfer function for converting the voltage output of Pin 3 (I_{MON}) to the amount of forward current flowing through the laser diode.

13. MEASURING MONITOR PHOTODIODE CURRENT IN CONSTANT CURRENT MODE

Equation 8 provides a transfer function for converting the voltage across R_{PD} to the amount of current flowing through the monitor photodiode in constant current mode.

14. MEASURING MONITOR PHOTODIODE CURRENT IN CONSTANT POWER MODE USING THE POWER MONITOR OUTPUT

Equation 9 provides a transfer function for converting the voltage output of Pin 4 (P_{MON}) to the amount of current flowing through the monitor photodiode in constant power mode.

Equation 5

Constant Current Control

$$I_{LD} = \frac{V_{PIN2}}{2 \cdot R_{SENSE}} \quad [\text{AMPS}]$$

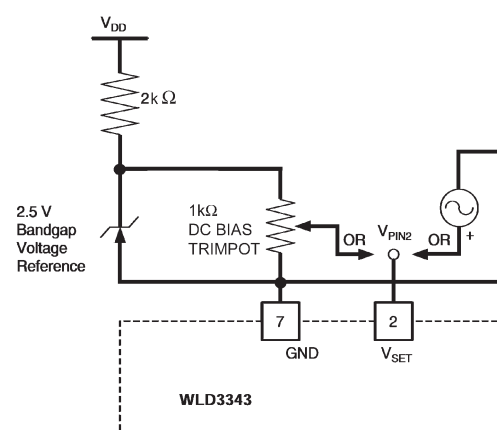
Equation 6

Constant Power Control

$$I_{PD} = \frac{V_{PIN2}}{2 \cdot R_{PD}} \quad [\text{AMPS}]$$

Figure 9

Configuring The Voltage Input



Equation 7

Laser Diode Forward Current Measurement

$$I_{LD} = \frac{V_{PIN3}}{2 \cdot R_{SENSE}} \quad [\text{AMPS}]$$

Equation 8

Monitor Photodiode Current Measurement in Constant Current Mode

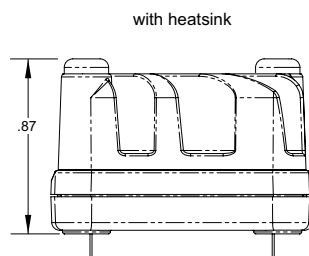
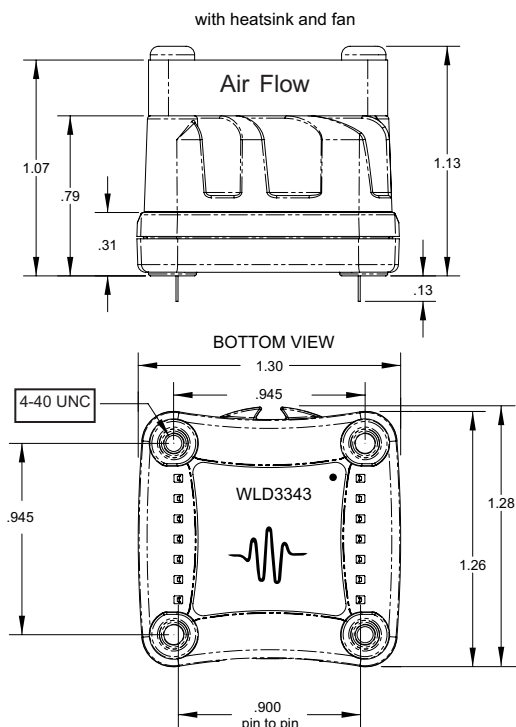
$$I_{PD} = \frac{V_{R_{PD}}}{R_{PD}} \quad [\text{AMPS}]$$

Equation 9

Monitor Photodiode Current Measurement in Constant Power Mode

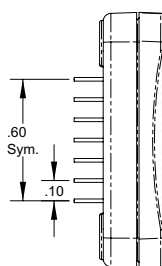
$$I_{PD} = \frac{V_{PIN4}}{2 \cdot R_{PD}} \quad [\text{AMPS}]$$

MECHANICAL SPECIFICATIONS



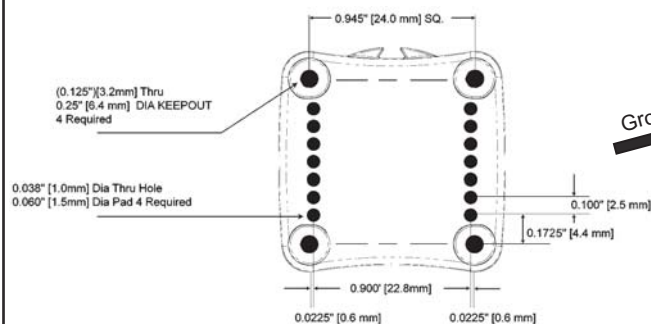
Weights

WLD3343	.576 oz
WHS302 Heatsink	.512 oz
WXC303/4 Fan	.288 oz

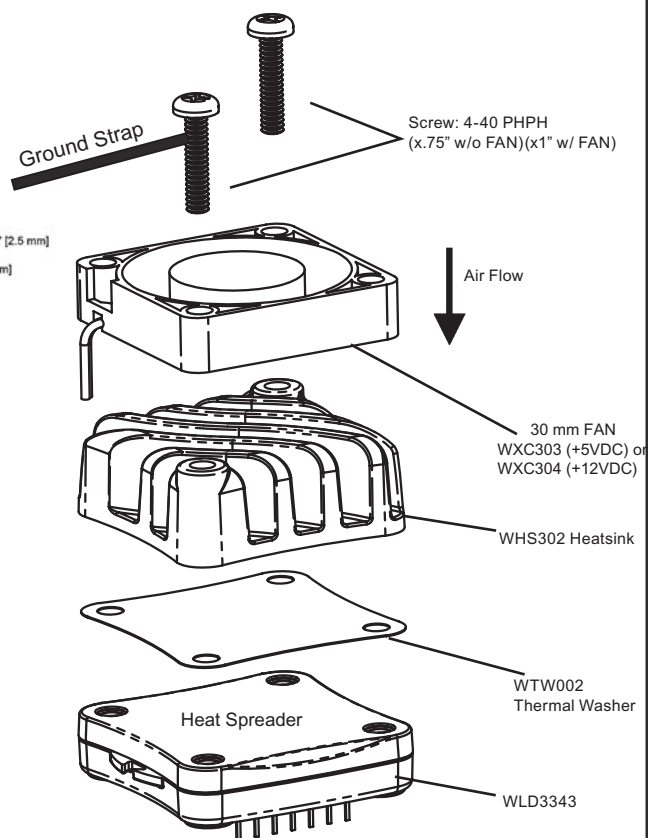
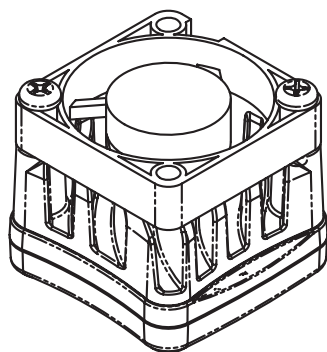


PIN DIAMETER: 0.028"
 PIN LENGTH: 0.126"
 PIN MATERIAL: Nickel Plated Steel
 HEAT SPREADER: Nickel Plated Aluminum
 PLASTIC COVER: LCP Plastic
 ISOLATION: 1200 VDC any pin to case
 THERMAL WASHER: WTW002
 HEATSINK: WHS320
 FANS: WXC303 (+5VDC)
 or WXC304 (+12VDC)

PCB FOOTPRINT



WLD3343 ASSEMBLED WITH HEATSINK & FAN



Noise Reduction: Grounding the heatspreader(metal plate on top of the driver) will reduce noise. In the case where a heatsink or fan is attached, connect the strap on top of the unit with the connecting screws.

CERTIFICATION AND WARRANTY

CERTIFICATION:

Wavelength Electronics (WEI) 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 Standard 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 90 days from date of shipment. During the warranty period, Wavelength will, at its option either repair or replace products which prove to be defective.

WARRANTY SERVICE:

For warranty service or repair, this product must be returned to the factory. 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. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Wavelength from another country.

LIMITATIONS OF WARRANTY:

The warranty shall not apply to defects resulting from improper use or misuse of the instrument or operation outside published specifications.

No other warranty is expressed or implied. Wavelength specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

EXCLUSIVE REMEDIES:

The remedies provided herein are the Buyer's sole and exclusive remedies. Wavelength shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any other legal theory.

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SAFETY:

There are no user serviceable parts inside this product. Return the product to Wavelength Electronics for service and repair to assure that safety features are maintained.

LIFE SUPPORT POLICY:

As a general policy, Wavelength Electronics, Inc. does not recommend the use of any of its products in life support applications where the failure or malfunction of the Wavelength Electronics, Inc. product can be reasonably expected to cause failure of the life support device or to significantly affect its safety or effectiveness. Wavelength Electronics, Inc. will not knowingly sell its products for use in such applications unless it receives written assurances satisfactory to Wavelength Electronics, Inc. that the risks of injury or damage have been minimized, the customer assumes all such risks, and there is no product liability for Wavelength Electronics, Inc. Examples or devices considered to be life support devices are neonatal oxygen analyzers, nerve stimulators (for any use), auto transfusion devices, blood pumps, defibrillators, arrhythmia detectors and alarms, pacemakers, hemodialysis systems, peritoneal dialysis systems, ventilators of all types, and infusion pumps as well as other devices designated as "critical" by the FDA. The above are representative examples only and are not intended to be conclusive or exclusive of any other life support device.

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