RedWave Labs

Operating manual

Laser Controller
C158

Contents

Introduction

Redwave Labs Laser Controller C158 comes with integrated temperature driver and laser driver in one package. Temperature control is fully linear and has capability to use separate power supply for laser TEC. TEC control can be done via built-in PI loop or external signal. Laser driver has analog bandwidth of 250 kHz and separate fast TTL compatible switching provided via SMB connector. Laser current has a hardware limit of 250 mA which cannot be exceeded in any case.

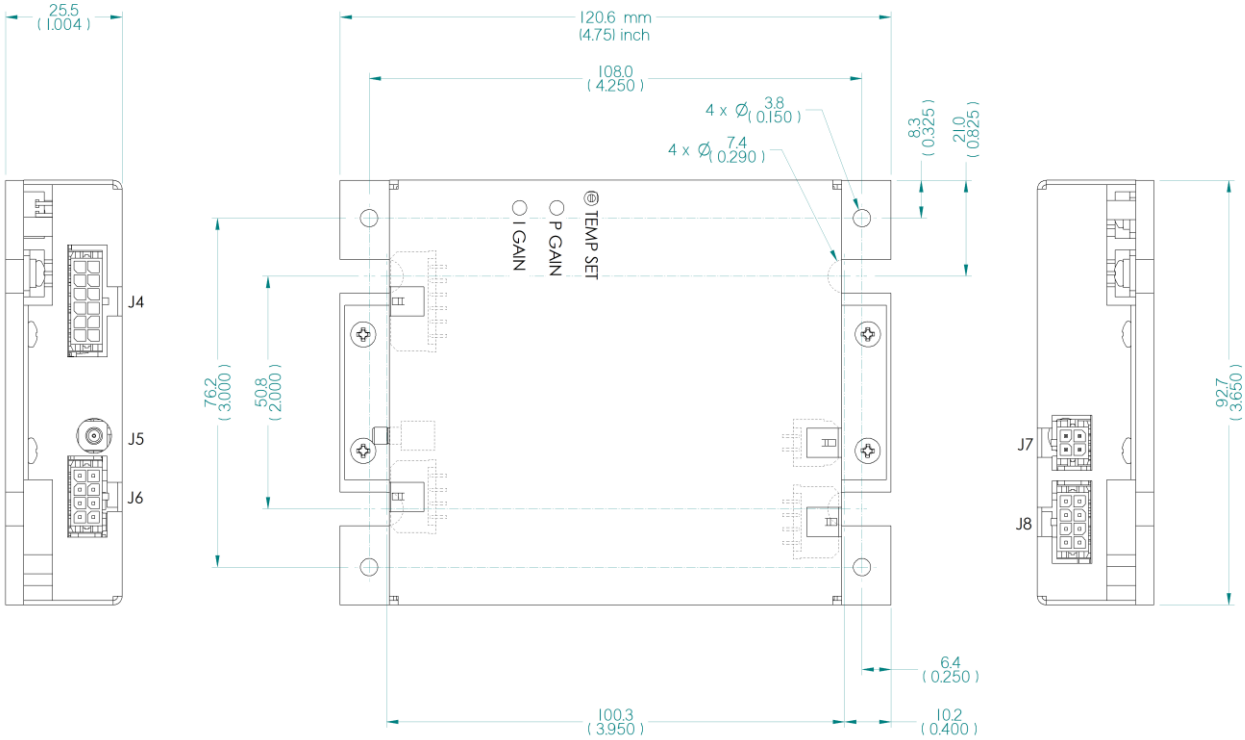
Features	Laser Controller C158 provides full control for semiconductor laser including laser diode control and integrated temperature control.	
Applications	Spectroscopy, Laser, Precision Instrument, OEM applications	
Specifications	Parameter	Value
Power	Dual	Option 1: +12 V, 2 A or +12 V/0.5A Option 2: +5V/1.5A; -12 V, 0.5 A
Laser Current Control	Laser current	0 - 250 mA. Hardware limit. Can be modified for customized versions
	Compliance voltage	> 4.0 V
	Setting accuracy	2 % fs
	Noise (RMS)	< 2μA
	Drift	< 20 μA
	Temperature coefficient	50 ppm/C
	Current limit	250 mA
	Setting accuracy of current limit	2 % fs
Laser External Control	Voltage range	0 to 10 V
	Input impedance	10 kOhm
	Modulation coefficient (I const)	20 mA/V
	3dB Bandwidth	DC … 250 kHz
	TTL modulation, rise / fall-time	250 ns
	Interlock	Yes
TEC control	TEC current	0 … +- 1.0 A /1.5A
	TEC voltage	> 8.0 V
	Max output power	12 W
	Current limit	1A or 1.5 A
	Input sensor	Thermistor 10 kOhm or 100 kOhm at 25 C
	PID control	Internal PI control or External direct TEC current control
Connectors	Laser	Integrated Azimuth Electronics 14 pin connector with heat sink. NEL DFB laser pinout. Can be replaced with optional DB15 connector.
	Power	Molex MicroFit 8 pin.
	Control	Molex MicroFit 12 pin.
Dimensions (WxHxD)		120 x 92 x 30 mm
Weight		350 g
Storage Temp		-55 to 100 C
Operating Temp		-40 to 85 C

RedWave Labs Ltd keeps improving its products and therefore some specifications can vary.

Absolute Maximum Ratings

Symbol	Parameter	Ratings	Unit
V_{dd1}	Supply positive voltage / Laser driver and TEC	+12±10%	Volt
V_{dd2}	Supply positive voltage / Separate TEC rail	+5;+10%;-0%	Volt
V_{ee}	Supply negative voltage / Laser driver and TEC	-12±10%	Volt
T_{op}	Operational Temperature	-40 to 85	Deg C
T_{st}	Storage Temperature	-55 to 100	Deg C

Mechanical Information



Parameter	**Value**	**Unit**
Length	4.75 (120.65)	Inch (mm)
Width	3.65 (92.7)	Inch (mm)
Height	1.01 (25.1)	Inch (mm)
Weight	350	gram

Electrical Characteristics

Parameter	Comments	Value	Unit
POWER			
Supply positive voltage V_{dd1} / Laser driver and TEC	Positive supply voltage for laser driver, all control circuits and TEC. 2 A minimum is required for single positive power supply	12 ± 10%	V
Supply positive voltage V_{dd2} / Separate TEC Power	Positive supply voltage for TEC only. 2 A minimum capabilities is required. Designed to use 5 V rail to minimize overall power consumption and heat dissipation	5 V; +10%;-0%	V
Negative supply voltage V_{ee}	Negative supply voltage for laser driver, all control circuits and TEC	-12 ± 10 %	V
LASER DIODE CONTROL AND MONITOR			
Laser current I_{ld} limit	Hardware laser limit. Can be modified for customized versions	250	mA
Laser Compliance voltage V_{comp}	Minimum voltage across laser diode. Can be change for customized versions.	4	V
Noise (RMS)	Integrated noise (DC-250kHz)	2	μA
Laser current drift	Laser current drift at constant temperature	20	μA
Laser current temperature coefficient	Temperature drift of the reference	50	Ppm / deg C
Laser current range	Laser current maximum current	250 (for custom version can be less; mentioned in the part number C154-70 – 70 mA, for example)	mA
Laser current setting accuracy	Set by components tolerance	2	% of full scale
Laser current set voltage	External transfer function ranges	0-10 (for custom version less than 10V depending on the version)	V
Laser current set voltage impedance		10	kOhm
Laser current modulation coefficient	Transfer function for laser current modulation	20	mA/V
Laser current modulation bandwidth	-3 dB	250	kHz

Parameter	Comments	Value	Unit
Laser current TTL modulation rise/fall time	Additional modulation capabilities on top of the analog modulation. Fast ON/OFF switches	250	nS
Laser current monitor	Monitor averaged laser current	0-10 (for custom version less than 10V depending on the version)	V
Laser current interlock	Available laser interlock. Can be overridden with DIP-switch		
TEC CONTROL AND MONITOR			
TEC control type	Linear bipolar		
TEC current range	Maximum range can be change with DIP switch S1	0…±1; 0…±1.4	Amp
TEC power supply	TEC power supply can be selected from +12V and +5V. +5V allow to improve power efficiency for TEC with 1 Ohm and maximum current of 1.5 A.	+5 ; +12	V
TEC compliance voltage	Voltage across TEC element	Vdd-3	V
Maximum TEC power	Maximum power for 12 V power supply	12	W
TEC current limit	Selected with DIP switch S1	1 of 1.4	Amp
Input sensor	TEC input sensor. Selected with S1 DIP switch. Configured in bridge mode.	100 or 10	kOhm
PI control	PI analog control loop (internal mode) or external loop though J2 connector (pin 3).Selected with S1 DIP-switch.	External or Internal	
TEC current external transfer function	Direct control of TEC. Input range –10 to+10 V	200	mA/V
TEC current monitor	Independent TEC current monitor at pin 4 of J4 connector	5.0	V/A
TEC disable	TEC current disable function: DIP-Switch S1.		
CONNECTORS			
Power J6	Molex 8 pin Micro Fit connector p/n 43045-0800		
Control and monitors J4	Molex 12 pin Micro Fit connector p/n 43045-1200		

Parameter	Comments	Value	Unit
Laser connector	Integrated Azimuth Electronics 14 pin connector with heat sink. NEL DFB laser pinout. Can be replaced with optional DB15 connector.		
Test connector J1	Test connector: can be used for remote control of the driver. Molex p/n 87831-1620		

Power Connector J6

PIN#	Abbreviation	Name	Description
1	V_{dd1}	Positive power +12 V	Electrically connected to Pin 5.
2	GND Main	Ground for V_{dd1}	Ground for the +12/-12 power supplies
3	V_{dd2}	TEC Power	Positive power for separate TEC power: +5 V. Electrically connected to pin 7
4	V_{ee}	Negative power – 12 V	Electrically connected to Pin 8.
5	V_{dd1}	Positive power +12 V	Electrically connected to Pin 1.
6	GND TEC	Ground for V_{dd2}	Ground for the +5 power supply. Connected to GND Main with 1 Ohm resistor at connector.
7	V_{dd2}	TEC Power	Positive power for separate TEC power: +5 V. Electrically connected to pin 3
8	V_{ee}	Negaive power – 12 V	Electrically connected to Pin 4.

Power connector J6 (pin assignment is on left) is Molex Micro-Fit p/n 43045-0800. Mating connector is Molex Micro-Fit p/n 43025-0800 with crimp pins Molex p/n 43030-0009. Mating connector and necessary number of crimp pins are included with C151 Laser controller. Molex suggested crimping tool p/n 63819-0000 which can be purchased from Digikey Inc (www.digikey.com)

Laser TEC Connector J7

PIN#	Abbreviation	Name	Description
1	TEC+	Laser package TEC Positive connection	Connected to J1-15
2	TH+	Laser package Thermistor Positive connection	Connected to J1-12
3	TEC-	Laser package TEC Negative connection	Connected to J1-16
4	TH-	Laser package Thermistor Positive connection	Connected to J1-11

Power connector J7 (pin assignment is on left) is Molex Micro-Fit p/n 43045-0400. Mating connector is Molex Micro-Fit p/n 43025-0400 with crimp pins Molex p/n 43030-0009. Mating connector and necessary number of crimp pins are included with C158 Laser controller. Molex suggested crimping tool p/n 63819-0000 which can be purchased from Digikey Inc (www.digikey.com)

Laser Connector J8

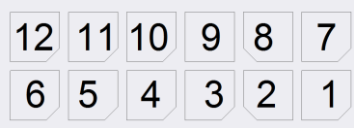
PIN#	Abbreviation	Name	Description
1	LD+	Laser Diode Positive Connection	Directly connected to the J1 -1
2	LD+	Laser Diode Positive Connection	Directly connected to the J1 -1
3	GND	Ground	
4	PD+	Positive Photodiode	
5	LD-	Laser Diode Negative Connection	Directly connected to the J1 -2
6	reserved		
7	GND	Ground	
8	PD-	Negative Photodiode	

Power connector J6 (pin assignment is on left) is Molex Micro-Fit p/n 43045-0800. Mating connector is Molex Micro-Fit p/n 43025-0800 with crimp pins Molex p/n 43030-0009. Mating connector and necessary number of crimp pins are included with C158 Laser controller. Molex suggested crimping tool p/n 63819-0000 which can be purchased from Digikey Inc (www.digikey.com)

Control and Monitor Connector J4

PIN#	Abbreviation	Name	Description
1	LD_I_CTRL	Laser current Control	Control laser diode current with transfer function of 20 mA/V
2	LD_ON_OFF	TTL control of laser current	Switches laser current ON/OFF with TTL level (5V) external signal. Electrically connected to J5 (SMB). 0V-LD_ON; 5V – LD_OFF.
3	TEC_I_CTRL_EXT	External control of TEC current	Controls TEC current directly with transfer function of 200 mA/V. Switch S1-3 must be in EXT position. Bandwidth of TEC control is limited to approximately 50 Hz.
4	TEC_I_MON	TEC current monitor	Shows current of the laser TEC with transfer function V_{mon}=Itec * 5.0 V/A.
5	GND	Ground	Control and Monitor Ground connection. Must not be used for power ground.
6	INTERLOCK-	Negative Interlock	Negative interlock connection. Connected to Ground directly
7	T_SET_EXTERNAL	External temperature set point	External temperature set point can be selected with switch S1-4. Transfer function can be calculated as R_{set} = (Vo+0.3119*V_{set})/(Vo-0.3119*V_{set}) * R_0 ; R_0 =10K or 100K , Vo=5.000V and $1/T_{set} = A + B * \ln(R_{set}) + C * (\ln(R_{set}))^3$. Typical values: A= 1.1280e-03; B=2.3450e-04;C=8.73e-08.
8	LD_I_MON	Laser diode monitor	Monitor average laser diode current with transfer function 50 V/A and bandwidth of approximately 25 kHz.

PIN#	Abbreviation	Name	Description
9	LIMIT_I_FAULT	TEC current limit error	0V – normal operation; +5V if current limit (any side) is reached.
10	GND	Ground	Control and Monitor Ground connection. Must not be used for power ground.
11	T_ACTUAL_MON	Actual temperature monitor	Buffered output of the voltage across the thermistor.
12	INTERLOCK+	Positive Interlock	Positive interlock connection. Can be overridden with S1-6.



Control and monitor connector J4 (pin assignment is on left) is Molex Micro-Fit p/n 43045-1200. Mating connector is Molex Micro-Fit p/n 43025-1200 with crimp pins Molex p/n 43030-0009 . Mating connector and necessary number of crimp pins are included with C151 Laser controller. Molex suggested crimping tool p/n 63819-0000 which can be purchased from Digikey Inc (www.digikey.com)

Control and Monitor Connector J5 (SMB)

PIN#	Abbreviation	Name	Description
1	LD_ON_OFF	TTL control of laser current	Switches laser current ON/OFF with TTL (5V) level external signal. Electrically connected to J4 Pin 2. 0V-LD_ON; 5V – LD_OFF.

Laser On/Off connector J5 is standard SMB connector for easy direct connection of laser current fast ON/OFF signal.

Test Connector J1

PIN#	Abbreviation	Name	Description
1	LD+	Laser Diode Positive Connection	Directly connected to the Azimuth connector J2 Pins 11 and 13
2	LD-	Laser Diode Positive Connection	Directly connected to the Azimuth connector J2 Pin 12
3	RESERVED		
4	RESERVED		
5	TEC_DISABLE	Laser TEC remote disable	Remote control of Switch S1-1: 0V – TEC Enable; 5V – TEC disable. Remote control overrides S1.
6	THERMISTOR_TYPE_CONTROL	10K/100K remote thermistor selection	Remote control of Switch S1-2: 0V – 100K; 5V – 10K. Remote control overrides S1.
7	PID_CONTROL	Remote PID control	Remote control of PID loop (S1-3): 0V – External; 5V – Internal (Analog PI loop). Remote control overrides S1.
8	T_SET_CONTROL	Remote control of set temperature	Remote control of S1-4: 0V – Internal; 5V – External. Remote control overrides S1.
9	TEC_I_LIMIT_CONTROL	Remote control of TEC current limit	Remote control of S1-5: 0V – 1A; 5V – 1.4A. Remote control overrides S1.

PIN#	Abbreviation	Name	Description
10	INTERLOCK_CONTROL	Remote control of Interlock function	Remote control of S1-6: 0V – Enable; 5V – Disable (Overridden). Remote control overrides S1.
11	TH-	Laser package Thermistor Negative connection	Directly connected to the Azimuth connector J2 Pin 2
12	TH+	Laser package Thermistor Positive connection	Directly connected to the Azimuth connector J2 Pin 1
13	RESERVED		
14	RESERVED		
15	TEC+	TEC_POWER_CONTROL	Directly connected to the Azimuth connector J2 Pin 6
16	TEC-	Laser package TEC Negative connection	Directly connected to the Azimuth connector J2 Pin 7

Test connector J1 (pin assignment is on left) is Molex Milli-Grid p/n 87831-1620. Mating connector is Molex Milli-Grid p/n 87568-1694 for ribbon cable. C158 comes without Milli-Grid mating connector. Customized connector arrangement can be used for the remote control of the switch S1. RedWave Labs can advised on the specific applications when required.

DIP SwitchS1

S1 can be remotely controlled through J1 except for the TEC power selection (POSITION 8 in table below). This remote control functionality can be used for integration inside spectrometers or other instruments.

PIN#	Abbreviation	Name	Description
1	TEC_DISABLE	Laser TEC disable	0V (0) – TEC Enable; 5V (1) – TEC disable.
2	THERMISTOR_TYPE_CONTROL	10K/100K thermistor selection	0V (0) – 100K; 5V (1) – 10K
3	PID_CONTROL	PID control	0V (0) – External; 5V (1) – Internal (Analog PI loop).
4	T_SET_CONTROL	Control of set temperature	0V (0)– Internal; 5V (1) – External
5	TEC_I_LIMIT_CONTROL	Control of TEC current limit	0V (0)– 1A; 5V (1) – 1.4A
6	INTERLOCK_CONTROL	Control of Interlock function	0V (0) – Enable; 5V (1) – Disable (Overridden)
7	RESERVED		
8	TEC_POWER_CONTROL	Control of TEC Power	0V (0) – 5 V Power supply; 5V (1) – 12 V Power Supply

Status LED

Status LEDs are used for fast visual assessment of the C158 status. LEDs are located close to test connector J1. Default LED color is red; this can varied in customized versions.

LED #	Abbreviation	Name	Description
1 (Top)	+12 V (Top)	V_{dd1}	Supply positive voltage V_{dd1} / Laser driver and TEC is ON.

2	+ 5 V	V_{dd2}	Supply positive voltage V_{dd2} / Separate TEC Power is ON
3	- 12 V	V_{ee}	Negative supply voltage V_{ee} is ON
4	TEC I LIM	TEC Current Limit reached	ON: TEC current limit reached. IF LED 4 is ON longer than 10 seconds then laser temperature might be too high or too low to achieve adequate stabilization
5 (Bottom)	INLK OFF (Bottom)	Laser interlock OFF	ON: Laser Interlock is overridden and will not switch the laser off when activated.

Temperature Set Point

C158 has 2 options to control temperature set point. These options are:i) internal set point with the 11-turn potentiometer located on the opposite side of laser connector ; ii) external voltage applied to the Pin 7 of the J4 connector.

Type	Selection	Position	Description
Internal (11-turn potentiometer)	S1	4 (0)	Internal set point: 0.9 to 4.2V set by 11 turn potentiometer located on the edge opposite to the laser connector. Voltage is increased in clockwise direction. With 10K thermistor this range cover from -5C to +60C.
External	S1	4 – (1)	External set point:-10V to +10V applied to Pin7 of J4 connector. Transfer function can be calculated as $R_{set} = (Vo+0.3119*V_{set})/(Vo-0.3119*V_{set}) * R_0$; R_0 =10K or 100K , Vo=5.000V and $1/T_{set} = A + B * \ln(R_{set}) + C * (\ln(R_{set}))^3$. Typical values: A= 1.1280e-03; B=2.3450e-04;C=8.73e-08. Application of the V_{set} values outside –10 to +10 V could result in board damage.

Temperature Measurements

Laser Controller C158 has two modes of temperature measurements. Temperature can be measured using the 10K or 100K thermistor. Selection between modes is made through switch S1-2. C158 uses a high stability voltage reference (V_0 = 5.00 V) on the board and measures the voltage across the thermistor using a bridge scheme. Thermistor voltage can be monitored between pins 11 and 12 of J1.
Temperature can be derived from the voltage across the thermistor using the following formula:

$$1/T = A + B * \ln(R_t) + C * (\ln(R_t))^3$$

$$R_t = V_t / (V_0 - V_t) * R_0$$

Where R_0 = 10.0kOhm for the 10K thermistor and R_0=100K for the 100K thermistor. V_t is the voltage across the thermistor. The 10 μA value of constants A, B and C (A= 1.1280e-03; B=2.3450e-04;C=8.73e-08) should be used to calculate the correct temperature. For example V_t=2.500 V for T=25 C using 10K thermistor settings and using the 10K thermistor as the temperature measurement element.

Note: This voltage is different from T_{set} voltage (see above Temperature Set Point).

PI Control

C158 has 2 options to control the temperature feedback loop: Internal and External. Internal PI control covers the vast majority of systems and the P and I control potentiometers can be adjusted to obtain the optimal PI. External PI control can be used if the user has a digital PID implementation elsewhere and connected to the Pin 3 of J4. Selection between internal and external control modes is done via S1-3.

Control	Selection	Position	Description
Internal Proportional	S1	3 – (1)	Internal Proportional Gain setting 2-100 A/V with ¾ turn linear potentiometer. Gain is increased in CW direction. Shipped with Proportional Gain=100 A/V.
Internal Integral	S1	3 – (1)	Internal Integral Gain setting 0.55-5 A/(*sec)V with ¾ turn linear potentiometer. Gain is increased in CW direction. Shipped with Integral Gain=5.0 A/(V*sec)
External	S1	3 – (0)	External control of TEC/heater current through Pin 4 of the J4. Transfer function 200 mA/V. Maximum current is limited by the current limit setting (1.0A or 1.5A).

Proportional and Integral gains can be measured using 3 test points (Common 'C', Proportional 'P', and Integral 'I') just under of P and I potentiometers. The Proportional gain (A/V) can be calculated using the value of the resistance between 'C' and 'P' test points and expressed in kOhm:

$$G_{prop} = \frac{400 - 2 * R_m}{4 + 1.98 * R_m}$$

where R_m is the measured resistance.

The Integral gain (A/(V*sec)) can be calculated using the same approach:

$$G_{in} = 0.5 + \frac{4.5}{1 + R_m}$$

Integral heat sink

C151 has two options for the laser integrated heat sink ('Low' and 'High').
'Low' heatsink is level with Printed circuit Board (PCB) and allows mount of customers' designed laser package enclosure. This option is used when an additional thermal isolation for DFB butterfly package is required.
'High' heatsink is about 2.5 mm higher than PCB and typically used for direct mounting of butterfly packages. 2.5 mm elevation provides minimum stress for package pins.
'Low' and 'High' option are easy interchangeable and relevant heat sinks can purchased independently.

Power dissipation

C151 laser controllers have been designed to 25 Watt power dissipation without heat sink at normal atmospheric conditions. 25 W dissipated heat is the maximum dissipated power. Most common regime would result in about 15 W heat dissipation. C151 does not require external heatsink.

External connections and cables

C151 laser controller comes with mating connectors and crimp kit for J4 and J6. Cables for J1, J4 and J6 can be purchased separately.

Installation

We recommend a first time use of the C151 with a high power load resistor (at least 10W rating) as TEC load and Laser Diode load. These load should connected to the corresponding pins of J1. Such a set-up will enable a system check before connecting to the laser temperature controller system and risking potential damages.

Certification

RedWave Labs Ltd certifies that: i) the parts and/or materials were produced in conformance with all contractually applicable Government and/or Buyer's specification as referenced in, or furnished with, the above purchase order and ii) all processes required in the production of these parts and/or materials are listed and were performed by a facility or by personnel specifically approved or certified by the seller's cognizant government quality control agency when such approval or certification is required by an applicable specification. RedWave Labs products are not authorized for use in safety-critical applications (such as life support) where a failure of the product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use of the products.

Warranty and returns

C151 Laser Controllers are warranted against defects in materials and workmanship for a period of 180 days from date of shipment. During the warranty period RedWave Labs Ltd will replace or repair products which prove to be defective or damaged. Our warranty shall not apply to defects or damages resulting from: i) misuse of the product or ii) operation beyond specifications detailed in the current manual.

Return procedure

Customer must obtain a valid RMA number by contacting RedWave Labs prior to the return. In all cases the customer is responsible for duty fees incurred on all received shipments and on all international returns for both warranty and non-warranty items; the customer is responsible for any duties, brokers fees or freight charges deemed chargeable to RedWave Labs Ltd.

Revisions

Revision 1: Original revision