

# Specifications

## WLS-TEMP



**MEASUREMENT  
COMPUTING™**

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# Specifications

Typical for 25 °C unless otherwise specified.

Specifications in *italic text* are guaranteed by design.

## Analog input

Table 1. Generic analog input specifications

Parameter	Conditions	Specification
A/D converters		Four dual 24-bit, Sigma-Delta type
Number of channels		8 differential
<i>Input isolation</i>		<i>500 VDC minimum between field wiring and USB interface</i>
Channel configuration		Software programmable to match sensor type
Differential input voltage range for the various sensor categories	Thermocouple	±0.080 V
	RTD	0 to 0.5 V
	Thermistor	0 to 2 V
	Semiconductor sensor	0 to 2.5 V
<i>Absolute maximum input voltage</i>	<i>±C0x through ±C7x relative to GND (pins 9, 19, 28, 38)</i>	<i>±25 V power on, ±40 V power off.</i>
Input impedance		5 Gigohm, min.
Input leakage current	Open thermocouple detect disabled	30 nA max.
	Open thermocouple detect enabled	105 nA max.
<i>Normal mode rejection ratio</i>	<i>f<sub>IN</sub> = 60 Hz</i>	<i>90 dB min.</i>
<i>Common mode rejection ratio</i>	<i>f<sub>IN</sub> = 50 Hz/60 Hz</i>	<i>100 dB min.</i>
Resolution		24 bits
<i>No missing codes</i>		<i>24 bits</i>
Input coupling		DC
Warm-up time		30 minutes min.
Open thermocouple detect		Automatically enabled when the channel pair is configured for thermocouple sensor. The maximum open detection time is 3 seconds.
<i>CJC sensor accuracy</i>	<i>15 °C to 35 °C</i>	<i>±0.25 °C typ., ±0.5 °C max.</i>
	<i>0 °C to 70 °C</i>	<i>-1.0 to +0.5 °C max</i>

## Channel configurations

Table 2. Channel configuration specifications

Sensor Category	Conditions	Max number of sensors (all channels configured alike)
Disabled		
Thermocouple	J, K, S, R, B, E, T, or N	8 differential channels
Semiconductor sensor		8 differential channels
RTD and thermistor	2-wire input configuration with a single sensor per channel pair	4 differential channels
	2-wire input configuration with two sensors per channel pair	8 differential channels
	3-wire configuration with a single sensor per channel pair	4 differential channels
	4-wire input configuration with a single sensor per channel pair	4 differential channels
	4-wire input configuration with two sensors per channel pair	8 differential channels

**Note 1:** Internally, the device has four dual-channel, fully differential A/Ds providing a total of eight differential channels. The analog input channels are therefore configured in four channel pairs with CH0/CH1 sensor inputs, CH2/CH3 sensor inputs, CH4/CH5 sensor inputs, and CH6/CH7 sensor inputs paired together. This "channel-pairing" requires the analog input channel pairs be configured to monitor the same category of temperature sensor. Mixing different sensor types of the same category (such as a type J thermocouple on channel 0 and a type T thermocouple on channel 1) is valid.

**Note 2:** Channel configuration information is stored in the EEPROM of the isolated microcontroller by the firmware whenever any item is modified. Modification is performed by commands issued over USB or wireless from an external application, and the configuration is made non-volatile through the use of the EEPROM.

**Note 3:** The factory default configuration is *Disabled*. The Disabled mode will disconnect the analog inputs from the terminal blocks and internally ground all of the A/D inputs. This mode also disables each of the current excitation sources.

## Compatible sensors

Table 3. Compatible sensor type specifications

Parameter	Conditions
Thermocouple	J: -210 °C to 1200 °C
	K: -270 °C to 1372 °C
	R: -50 °C to 1768 °C
	S: -50 °C to 1768 °C
	T: -270 °C to 400 °C
	N: -270 °C to 1300 °C
	E: -270 °C to 1000 °C
B: 0 °C to 1820 °C	
RTD	100 ohm PT (DIN 43760: 0.00385 ohms/ohm/°C)
	100 ohm PT (SAMA: 0.003911 ohms/ohm/°C)
	100 ohm PT (ITS-90/IEC751:0.0038505 ohms/ohm/°C)
Thermistor	Standard 2,252 ohm through 30,000 ohm
Semiconductor / IC	TMP36 or equivalent

## Accuracy

### Thermocouple measurement accuracy

Table 4. Thermocouple accuracy specifications, including CJC measurement error

Sensor Type	Maximum error	Typical error	Temperature range
J	±1.499 °C	±0.507 °C	-210 to 0 °C
	±0.643 °C	±0.312 °C	0 to 1200 °C
K	±1.761 °C	±0.538 °C	-210 to 0 °C
	±0.691 °C	±0.345 °C	0 to 1372 °C
S	±2.491 °C	±0.648 °C	-50 to 250 °C
	±1.841 °C	±0.399 °C	250 to 1768.1 °C
R	±2.653 °C	±0.650 °C	-50 to 250 °C
	±1.070 °C	±0.358 °C	250 to 1768.1 °C
B	±1.779 °C	±0.581 °C	250 to 700 °C
	±0.912 °C	±0.369 °C	700 to 1820 °C
E	±1.471 °C	±0.462 °C	-200 to 0 °C
	±0.639 °C	±0.245 °C	0 to 1000 °C
T	±1.717 °C	±0.514 °C	-200 to 0 °C
	±0.713 °C	±0.256 °C	0 to 600 °C
N	±1.969 °C	±0.502 °C	-200 to 0 °C
	±0.769 °C	±0.272 °C	0 to 1300 °C

**Note 4:** Thermocouple measurement accuracy specifications include linearization, cold-junction compensation and system noise. These specs are for one year, or 3000 operating hours, whichever comes first, and for operation of the device between 15 °C and 35 °C. For measurements outside this range, add ±0.5 degree to the maximum error shown. There are CJC sensors on each side of the module. The accuracy listed above assumes the screw terminals are at the same temperature as the CJC sensor. Errors shown do not include inherent thermocouple error. Please contact your thermocouple supplier for details on the actual thermocouple error.

**Note 5:** Thermocouples must be connected to the device such that they are floating with respect to GND (pins 9, 19, 28, 38). The device GND pins are isolated from earth ground, so connecting thermocouple sensors to voltages referenced to earth ground is permissible as long as the isolation between the GND pins and earth ground is maintained.

**Note 6:** When thermocouples are attached to conductive surfaces, the voltage differential between multiple thermocouples must remain within ±1.4 V. For best results we recommend the use of insulated or ungrounded thermocouples when possible.

### Semiconductor sensor measurement accuracy

Table 5. Semiconductor sensor accuracy specifications

Sensor Type	Temperature Range (°C)	Maximum Accuracy Error
TMP36 or equivalent	-40 to 150 °C	±0.50 °C

**Note 7:** Error shown does not include errors of the sensor itself. These specs are for one year while operation of the device is between 15 °C and 35 °C. Please contact your sensor supplier for details on the actual sensor error limitations.

## RTD measurement accuracy

Table 6. RTD measurement accuracy specifications

RTD	Sensor Temperature	Maximum Accuracy Error (°C) $I_{x+} = 210 \mu\text{A}$	Typical Accuracy Error (°C) $I_{x+} = 210 \mu\text{A}$
PT100, DIN, US or ITS-90	-200 °C to -150 °C	±2.85	±2.59
	-150 °C to -100 °C	±1.24	±0.97
	-100 °C to 0 °C	±0.58	±0.31
	0 °C to 100 °C	±0.38	±0.11
	100 °C to 300 °C	±0.39	±0.12
	300 °C to 600 °C	±0.40	±0.12

**Note 8:** Error shown does not include errors of the sensor itself. The sensor linearization is performed using a Callendar-Van Dusen linearization algorithm. These specs are for one year while operation of the device is between 15 °C and 35 °C. The specification does not include lead resistance errors for 2-wire RTD connections. Please contact your sensor supplier for details on the actual sensor error limitations.

**Note 9:** Resistance values greater than 660  $\Omega$  cannot be measured by the device in the RTD mode. The 660  $\Omega$  resistance limit includes the total resistance across the current excitation ( $\pm I_x$ ) pins, which is the sum of the RTD resistance and the lead resistances.

**Note 10:** For accurate three wire compensation, the individual lead resistances connected to the  $\pm I_x$  pins must be of equal value.

## Thermistor measurement accuracy

Table 7. Thermistor measurement accuracy specifications

Thermistor	Temperature Range	Maximum Accuracy Error (°C) $I_{x+} = 10 \mu\text{A}$
2252 $\Omega$	-40 to 120 °C	±0.05
3000 $\Omega$	-40 to 120 °C	±0.05
5000 $\Omega$	-35 to 120 °C	±0.05
10000 $\Omega$	-25 to 120 °C	±0.05
30000 $\Omega$	-10 to 120 °C	±0.05

**Note 11:** Error shown does not include errors of the sensor itself. The sensor linearization is performed using a Steinhart-Hart linearization algorithm. These specs are for one year while operation of the device is between 15 °C and 35 °C. The specification does not include lead resistance errors for 2-wire thermistor connections. Please contact your sensor supplier for details on the actual sensor error limitations. Total thermistor resistance on any given channel pair must not exceed 180 k  $\Omega$ . Typical resistance values at various temperatures for supported thermistors are shown in Table 8.

Table 8. Typical thermistor resistance specifications

Temp	2252 $\Omega$ thermistor	3000 $\Omega$ thermistor	5 k $\Omega$ thermistor	10 k $\Omega$ thermistor	30 k $\Omega$ thermistor
-40 °C	76 k $\Omega$	101 k $\Omega$	168 k $\Omega$	240 k $\Omega$ (Note 12)	885 k $\Omega$ (Note 12)
-35 °C	55 k $\Omega$	73 k $\Omega$	121 k $\Omega$	179 k $\Omega$	649 k $\Omega$ (Note 12)
-30 °C	40 k $\Omega$	53 k $\Omega$	88 k $\Omega$	135 k $\Omega$	481 k $\Omega$ (Note 12)
-25 °C	29 k $\Omega$	39 k $\Omega$	65 k $\Omega$	103 k $\Omega$	360 k $\Omega$ (Note 12)
-20 °C	22 k $\Omega$	29 k $\Omega$	49 k $\Omega$	79 k $\Omega$	271 k $\Omega$ (Note 12)
-15 °C	16 k $\Omega$	22 k $\Omega$	36 k $\Omega$	61 k $\Omega$	206 k $\Omega$ (Note 12)
-10 °C	12 k $\Omega$	17 k $\Omega$	28 k $\Omega$	48 k $\Omega$	158 k $\Omega$
-5 °C	9.5 k $\Omega$	13 k $\Omega$	21 k $\Omega$	37 k $\Omega$	122 k $\Omega$
0 °C	7.4 k $\Omega$	9.8 k $\Omega$	16 k $\Omega$	29 k $\Omega$	95 k $\Omega$

**Note 12:** Resistance values greater than 180 k $\Omega$  cannot be measured by the device in the thermistor mode. The 180 k $\Omega$  resistance limit includes the total resistance across the current excitation ( $\pm I_x$ ) pins, which is the sum of the thermistor resistance and the lead resistances.

**Note 13:** For accurate three wire compensation, the individual lead resistances connected to the  $\pm I_x$  pins must be of equal value.

## Throughput rate to PC (USB or wireless)

Table 9. Throughput rate specifications

Number of Input Channels	Maximum Throughput
1	2 Samples/second
2	2 S/s on each channel, 4 S/s total
3	2 S/s on each channel, 6 S/s total
4	2 S/s on each channel, 8 S/s total
5	2 S/s on each channel, 10 S/s total
6	2 S/s on each channel, 12 S/s total
7	2 S/s on each channel, 14 S/s total
8	2 S/s on each channel, 16 S/s total

**Note 14:** The analog inputs are configured to run continuously. Each channel is sampled twice per second. The maximum latency between when a sample is acquired and the temperature data is provided by the device is approximately 0.5 seconds

## Digital input/output

Table 10. Digital input/output specifications

Digital type	CMOS
Number of I/O	8 (DIO0 through DIO7)
Configuration	Independently configured for input or output. Power on reset is input mode unless bit is configured for alarm.
Pull up/pull-down configuration	All pins pulled up to +5 V via 47 K k $\Omega$ resistors (default). Pull down to ground (GND) also available.
Digital I/O transfer rate (software paced)	<ul style="list-style-type: none"> <li>▪ Digital input – 50 port reads or single bit reads per second typ.</li> <li>▪ Digital output – 100 port writes or single bit writes per second typ.</li> </ul>
Input high voltage	2.0 V min., 5.5 V absolute max.
Input low voltage	0.8 V max., -0.5 V absolute min.
Output low voltage (IOL = 2.5 mA)	0.7 V max
Output high voltage (IOH = -2.5 mA)	3.8 V min.

**Note 15:** All ground pins on the device (pins 9, 19, 28, 38) are common and are isolated from earth ground. If a connection is made to earth ground when using digital I/O and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground.

## Temperature alarms

Table 11. Temperature alarm specifications

Number of alarms	8 (one per digital I/O line)
Alarm functionality	Each alarm controls its associated digital I/O line as an alarm output. The input to each alarm may be any of the analog temperature input channels. When an alarm is enabled, its associated I/O line is set to output (after the device is reset) and driven to the appropriate state determined by the alarm options and input temperature. The alarm configurations are stored in non-volatile memory and are loaded at power on. Alarms will function both in wireless mode and while attached to USB.
Alarm input modes	<ul style="list-style-type: none"> <li>▪ Alarm when input temperature &gt; T1</li> <li>▪ Alarm when input temperature &gt; T1, reset alarm when input temperature goes below T2</li> <li>▪ Alarm when input temperature &lt; T1</li> <li>▪ Alarm when input temperature &lt; T1, reset alarm when input temperature goes above T2</li> <li>▪ Alarm when input temperature is &lt; T1 or &gt; T2</li> </ul> <p><b>Note:</b> T1 and T2 may be independently set for each alarm.</p>
Alarm output modes	<ul style="list-style-type: none"> <li>▪ Disabled, digital I/O line may be used for normal operation</li> <li>▪ Enabled, active high output (digital I/O line goes high when alarm conditions met)</li> <li>▪ Enabled, active low output (digital I/O line goes low when alarm conditions met)</li> </ul>
Alarm update rate	1 second

## Memory

Table 12. Memory specifications

EEPROM	1,024 bytes isolated micro reserved for sensor configuration 256 bytes USB micro for external application use
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## Microcontroller

Table 13. Microcontroller specifications

Type	Three high performance 8-bit RISC microcontrollers
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## Wireless communications

Table 14. Wireless Communications specifications

<i>Communication standard</i>	<i>IEEE 802.15.4, ISM 2.4GHz frequency band, non-beacon, point-to-point</i>
Range	Indoor/urban: Up to 150' (50 m) Outdoor RF line-of-sight: Up to 1/2 mile (750 m)
Transmit power output	10 mW (10 dBm)
<i>Receiver sensitivity</i>	<i>-100 dBm (1% packet error rate)</i>
<i>RF channels</i>	<i>12 direct sequence channels available, channels 12 – 23 (2.410 – 2.465 GHz) (software selectable)</i>
Addressing	16-bit PAN (personal area network) IDs per channel (software selectable) 64-bit device address
<i>Encryption</i>	<i>128-bit AES (software selectable)</i>

**Note 16:** Contains FCC ID: OUR-XBEEPRO. The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i.) this device may not cause harmful interference and (ii.) this device must accept any interference received, including interference that may cause undesired operation.

**Note 17:** Canada: Contains Model XBee Radio, IC: 4214A-XBEEPRO

**Caution!** To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

## USB +5V voltage

Table 15. USB +5V voltage specifications

Parameter	Conditions	Specification
USB +5V (VBUS) input voltage range		4.75 V min. to 5.25 V max.



## Power

Table 16. Power specifications

Parameter	Conditions	Specification
<b>Connected to USB</b>		
Supply current		500 mA max.
User +5V output voltage range (terminal block pin 21 and 47)	Connected to a self-powered hub. (Note 18)	4.75 V min. to 5.25 V max.
User +5V output current (terminal block pin 21 and pin 47)	Connected to a self-powered hub. (Note 18)	10 mA max.
Isolation	Measurement system to PC	500 VDC min.
<b>Wireless Communications operation</b>		
Supply current		500 mA max.
<b>AC Adapter Power Supply (used for remote wireless communications operation)</b>		
Standalone power supply		USB power adapter 2.5 Watt USB adapter with interchangeable plugs (Includes plug for USA)
Output voltage		5 V $\pm$ 5%
Output wattage		2.5 W
Input voltage		100 – 240 VAC 50 – 60 Hz
Input current		0.2 A

**Note 18:** Self-Powered Hub refers to a USB hub with an external power supply. Self-powered hubs allow a connected USB device to draw up to 500 mA. This device may not be used with bus-powered hubs due to the power supply requirements.

Root Port Hubs reside in the PC's USB Host Controller. The USB port(s) on your PC are root port hubs. All externally powered root port hubs (desktop PC's) provide up to 500 mA of current for a USB device. Battery-powered root port hubs provide 100 mA or 500 mA, depending upon the manufacturer. A laptop PC that is not connected to an external power adapter is an example of a battery-powered root port hub.

## USB specifications

Table 17. USB specifications

USB device type	USB 2.0 (full-speed)
Device compatibility	USB 1.1, USB 2.0
	Bus powered, 500 mA consumption max
USB cable type	A-B cable, UL type AWM 2725 or equivalent. (min 24 AWG VBUS/GND, min 28 AWG D+/D-)
USB cable length	3 meters max.

## Current excitation outputs (Ix+)

Table 18. Current excitation output specifications

Parameter	Conditions	Specification
Configuration		4 dedicated pairs: ±I1 - CH0/CH1 ±I2 - CH2/CH3 ±I3 - CH4/CH5 ±I4 - CH6/CH7
Current excitation output ranges	Thermistor	10 $\mu$ A typ.
	RTD	210 $\mu$ A typ.
Tolerance		±5% typ.
Drift		200 ppm/°C
Line regulation		2.1 ppm/V max.
Load regulation		0.3 ppm/V typ.
Output compliance voltage (relative to GND pins 9, 19, 28, 38)		3.90 V max. -0.03 V min.

**Note 19:** The device has four current excitation outputs, with ±I1 dedicated to the CH0/CH1 analog inputs, ±I2 dedicated to CH2/CH3, ±I3 dedicated to CH4/CH5, and ±I4 dedicated to CH6/CH7. The excitation output currents should always be used in this dedicated configuration.

**Note 20:** The current excitation outputs are automatically configured based on the sensor (thermistor or RTD) selected.

## Environmental

Table 19. Environmental specifications

Operating temperature range	0 to 70 °C
Storage temperature range	-40 to 85 °C
Humidity	0 to 90% non-condensing

## Mechanical

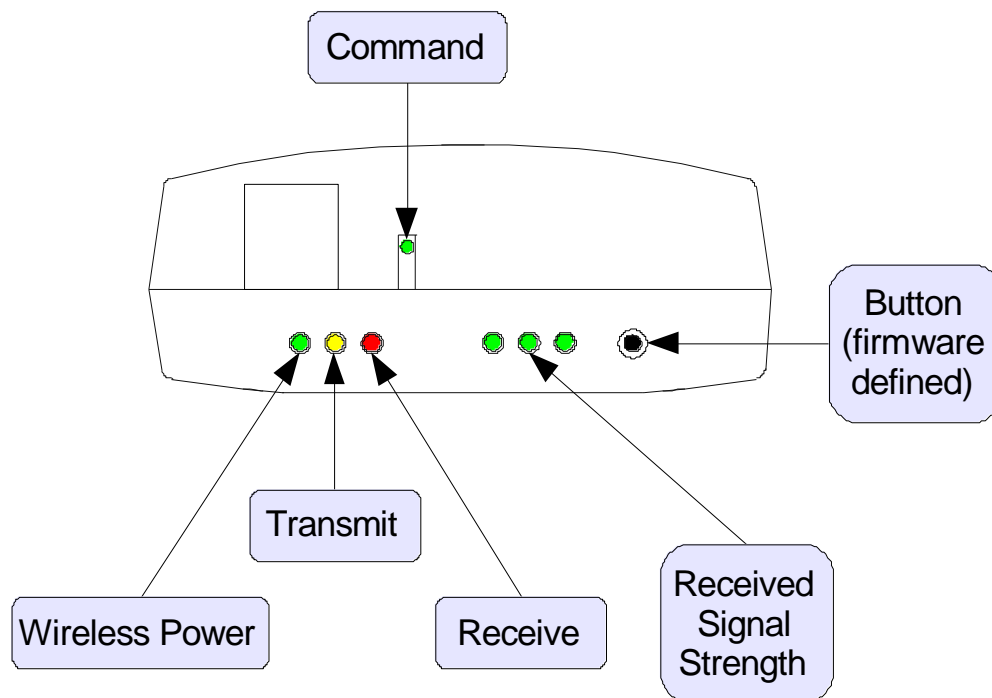
Table 20. Mechanical specifications

Dimensions	127 mm (L) x 88.9 mm (W) x 35.56 (H)
User connection length	3 meters max.

## LED / button configuration

Table 21. LED configuration

Command LED	Green LED – indicates a command was received by the device (either USB or wireless)
Received Signal Strength Indicator (RSSI) LEDs	Three green LED bar graph. LEDs will turn on when receiving a wireless message and stay on for approximately 1 second after the end of the message. They indicate the amount of fade margin present in an active wireless link. Fade margin is defined as the difference between the incoming signal strength and the device's receiver sensitivity. <ul style="list-style-type: none"> <li>▪ 3 LEDs on: Very strong signal (&gt; 30 dB fade margin)</li> <li>▪ 2 LEDs on: Strong signal (&gt; 20 dB fade margin)</li> <li>▪ 1 LED on: Moderate signal (&gt; 10 dB fade margin)</li> <li>▪ 0 LED on: Weak signal (&lt; 10 dB fade margin)</li> </ul>
Wireless Power LED	Green LED – indicates that the internal RF module is powered.
Transmit LED	Yellow LED – indicates transmitting data over the wireless link.
Receive LED	Red LED – indicates receiving data over the wireless link.
Button	Firmware defined; this revision executes an LED test.



## Screw terminal connector type and pin out

Table 22. Screw terminal connector specifications

Connector type	Screw terminal
Wire gauge range	16 AWG to 30 AWG

Table 23. Screw terminal pin out

Pin	Signal Name	Pin Description	Pin	Signal Name	Pin Description
1	I1+	CH0/CH1 current excitation source	27	I4-	CH6/CH7 current excitation return
2	NC		28	GND	
3	C0H	CH0 sensor input (+)	29	C7L	CH7 sensor input (-)
4	C0L	CH0 sensor input (-)	30	C7H	CH7 sensor input (+)
5	4W01	CH0/CH1 4-wire, 2 sensor common	31	IC67	CH6/CH7 2 sensor common
6	IC01	CH0/CH1 2-sensor common	32	4W67	CH6/CH7 4-wire, 2 sensor common
7	C1H	CH1 sensor input (+)	33	C6L	CH6 sensor input (-)
8	C1L	CH1 sensor input (-)	34	C6H	CH6 sensor input (+)
9	GND		35	NC	
10	I1-	CH0/CH1 current excitation return	36	I4+	CH6/CH7 current excitation source
	CJC sensor			CJC sensor	
11	I2+	CH2/CH3 current excitation source	37	I3-	CH4/CH5 current excitation return
12	NC		38	GND	
13	C2H	CH2 sensor input (+)	39	C5L	CH5 sensor input (-)
14	C2L	CH2 sensor input (-)	40	C5H	CH5 sensor input (+)
15	4W23	CH2/CH3 4-wire, 2 sensor common	41	IC45	CH4/CH5 2 sensor common
16	IC23	CH2/CH3 2 sensor common	42	4W45	CH4/CH5 4-wire, 2 sensor common
17	C3H	CH3 sensor input (+)	43	C4L	CH4 sensor input (-)
18	C3L	CH3 sensor input (-)	44	C4H	CH4 sensor input (+)
19	GND		45	NC	
20	I2-	CH2/CH3 current excitation return	46	I3+	CH4/CH5 current excitation source
21	+5V	+5V output	47	+5V	+5V output
22	GND		48	GND	
23	DIO0	Digital Input/Output	49	DIO7	Digital Input/Output
24	DIO1	Digital Input/Output	50	DIO6	Digital Input/Output
25	DIO2	Digital Input/Output	51	DIO5	Digital Input/Output
26	DIO3	Digital Input/Output	52	DIO4	Digital Input/Output

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