AtlasScientific
Biology•Technology

Dissolved Oxygen Circuit

V 4.0

Micro footprint D.O. monitoring subsystem

Features

- Full range D.O. readings +/- 0.1
- Accuracy within two significant figures (XX.XX Mg/L)
- Temperature dependent or temperature independent readings
- Fresh water/Saltwater/Brackish water readings
- Conductivity dependent or conductivity independent readings
- Simple 5 second calibration
- Data output is in Mg/L
- Single reading or continuous reading modes
- Simple RS-232 connectivity
- Simple instruction set consisting of only eight commands
- Micro footprint circuitry
- Debugging LED's
- Male BNC connector included
- 2.5V to 5.5V operational voltage
- Low power consumption

1.6 mA at 3.3V in active mode*
0.7 mA at 3.3V in quiescent mode*
*LED's off

Description

The D.O. Circuit is a highly compact D.O. monitoring system that fits into any breadboard. This design configuration allows the user to accurately monitor D.O. without having to add any additional circuitry or components to your design. Communication with the D.O. Circuit is done using only eight simple commands. TD.O. Circuit provides scientific grade readings to any embedded system that has an RS232 connection interface.

Contents

System Overview

Standard D.O. circuitry can be bulky and complex, often operating at voltages outside of the typical logic-level realm. Atlas Scientific has reinvented the way D.O. monitoring is done. The D.O. Circuit is an embedded solution designed to output quick, scientific grade D.O. readings in a simple RS-232 data transmission. From a single "as needed" D.O. reading to an infinite number of readings, the D.O. Circuit will deliver an accurate reading in just 510 milliseconds.

Pin Out

GND Return for the DC power supply. GND (& Vcc) must be ripple and noise free for best operation.

Vcc Operates on 2.5V – 5.5V

TX TX output delivers asynchronous serial data in RS232 format, except voltages are 0-Vcc. The output is (up to five) ASCII digits representing the D.O. in **mg/L** and ending with a carriage return (ASCII 13).

Example

4.60<CR>

The baud rate is: **38400, 8 bits, no parity, with one stop bit.**
If standard voltage level RS232 is desired, connect an RS232 converter such as a MAX232.

RX RS-232 receive pin

BNC D.O. probe connection
**For best results use an Atlas Scientific D.O. probe*

Absolute Maximum Ratings*

Parameter	MIN	TYP	MAX	Units
Storage temperature (D.O. Circuit)	-40		125	C°
Storage temperature (D.O. probe)	1	25	99	C°
VCC	2.5	3.3	5.5	V

***Note:** Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to maximum rating conditions for extended periods may affect device reliability

Device operation

When the D.O. Circuit is connected to a power supply (2.5v to 5.5v) the **red** "power on" indicator LED will be lit. The device will immediately enter standby mode and wait for a command.

A typical D.O. probe takes approximately 5 minutes to fully respond to a change in its environment. A small amount of fluctuation in the readings is normal.

There are a total of eight different commands that can be given to the Micro-D.O. system.
All commands must be followed by a carriage return <CR>.
Commands are not case sensitive.

Command list Quick reference

Command	Function	Default state
L1	Enables debugging LEDs	Enabled
L0	Disables debugging LEDs	Disabled
R	Returns a basic D.O. reading. Where the temperatureis 20 ° Celsius and the conductivity is 0	20,0 (This is good for a basic fresh water reading)
TT.TT, CCCCC	Returns a temperature/ conductivity compensated D.O. reading (conductivity can be 0 if in fresh water)	N/A
TT.TT,B; TT.TT,S	Returns a temperature/ conductivity compensated D.O. reading. Where "s" is salt water or "b" is brackish water	N/A S= 54,000µs B=19,900 µs
C	Returns continues readings Q 500ms at the temperature / conductivity previously used.	N/A
E	Stops all readings. Enter standby/quiescent mode.	N/A
X	Calibrates the D.O.	PO2 at *sea level = .21*

Command Definitions

L1 This will enable both debugging LED's.

The D.O. Circuit has two LED's
Green LED ....Power indicator
Red LED ....Instruction received/pH transmit

By default, the LED's are enabled.
These LED's are designed to help the user determine
that the D.O. Circuit is operating properly.

Changes to this setting are written to EEPROM memory
and therefore will be retained even if the power is cut.

Keeping the LEDs on will consume an additional 30 mA

Full proper syntax: l1<cr> or L1<CR>

L0 This will disable both debugging LED's.

Changes to this setting are written to EEPROM memory and therefore
will be retained even if the power is cut.

Full proper syntax: l0<cr> or L0<CR>

R Instructs the D.O. Circuit to return a single D.O. reading.

*This instruction takes 610 milliseconds to complete
(510 milliseconds with the LED's off)

When using the "R" command the temperature is set at 20° C and the conductivity is set to 0.

*A conductivity of 0 may not seem realistic however; the conductivity is converted into salinity
using the practical salinity scale. A salinity of < 2 is considered insignificant. Therefore the conductivity
is set to 0 because; in freshwater it is irrelevant.

Full proper syntax: r<cr> or R<CR>

The D.O. Circuit will respond: XX.XX<CR>
Where XX.XX is D.O. in mg/L

TT.TT,CCCCC
TT.TT,S
TT.TT,B

Instructs the D.O. Circuit to return a single D.O. reading where temperature and/or conductivity are accounted for.

- Temperature is always in Celsius.
- Conductivity is always in Microsiemens
- "S" is a short hand way of setting the conductivity to that of salt water: 54,000 μs
- "B" is a short hand way of setting the conductivity to that of brackish water: 19,900 μs

Adding the Microsiemens (the conductivity) will have no positive effect on the readings **IN FRESH WATER** AND SHOULD BE OMITED. ADDING CONDUCTIVITY IN FRESH WATER MAY LEAD TO INACURATE READINGS.

If you are taking a reading in fresh water simply set the conductivity to zero.

Example:

Temperature compensated reading in freshwater:
19,0<CR>

Else
19,1200<CR> Here we take a temperature reading at 19 °C and at a conductivity of 1200 μs.

Or

19,b<CR> Here we take a temperature reading at 19 °C and at a conductivity of brackish water 19,900 μs

Or

19,b<CR> (here we take a temperature reading at 19 °C and at a conductivity of brackish water 19,900 μs

Or

19,80123 <CR> Here we take a temperature reading at 19 °C and at a conductivity of very salty water 80123 μs

*The conductivity can be set as high as 99,999 or as low as 0
*The temperature can be set as high as 99 or as low as 0

C Instructs the D.O. Circuit to take continues reading at the parameters previously set

E Instructs the D.O. Circuit to cease continuous mode and enter its standby/quiescent mode.

Delivering this instruction when not in continuous mode will have no effect on the D.O. Circuit

Full proper syntax: e<cr> or E<CR>

The D.O. Circuit will respond by ceasing data transmission.
There is no ASCII response to this instruction.

X Instructs the D.O. Circuit to take a calibration reading.

Calibration should be done the first time the stamp is used. Dip your probe in water, just to get it wet. Let it sit in the air for 5 minutes. Do not leave it in water, it must calibrate to the oxygen level in the surrounding atmosphere. After 5 minutes, transmit the "x" command to calibrate.

After transmitting the 'X' command both LEDs will slowly blink twice. Take your D.O. probe and wave it in the air. The D.O. Circuit will need to read the atmospheric oxygen partial pressure.

After 1 to 2 seconds the D.O. Circuit will then transmit: "calibration set: nn" Where nn is the atmospheric oxygen partial pressure. D.O. Circuit will then return to standby mode. The calibration data will be stored in eeprom and will be used as the bases for all future readings. This data will not be lost due to power failure.

Full proper syntax: x<cr> or X<CR>

Calculating D.O. is a complex matter. Currently there is only one method used to derive D.O. in water which is considered scientifically accurate.

Weiss, R. (1970). "The solubility of nitrogen, oxygen, and argon in water and seawater". *Deep-Sea Res.* 17: 721–35.

$$\ln(DO) = A1 + A2 * 100 / T + A3 * \ln(T / 100) + A4 * T / 100 + S * [B1 + B2 * T / 100 + B3 * (T / 100)^2]$$

Salinity is derived using: The Practical Salinity Scale 1978 (PSS-78)

$$S = a_0 + a_1 R_T^{1/2} + a_2 R_T + a_3 R_T^{3/2} + a_4 R_T^2 + a_5 R_T^{5/2} + \frac{(T-15)}{1+k(T-15)} \left\{ b_0 + b_1 R_T^{1/2} + b_2 R_T + b_3 R_T^{3/2} + b_4 R_T^2 + b_5 R_T^{5/2} \right\}$$

Where:

$$R = \frac{C(S, T_{68}, P)}{C(35, 15_{68}, 0)}$$

Where:

$$R_T = \frac{R}{r_T R_P}$$

Where:

$$Rp = 1 + \frac{A_1 p + A_2 p^2 + A_3 p^3}{1 + B_1 T + B_2 T^2 + B_3 R + B_4 TR}$$

*** A typical D.O. probe should be considered inaccurate if it has been frozen**
*** A typical D.O. probe should be considered inaccurate if it has been boiled**

*The Wire length from the D.O. probe to the D.O. Circuit should be as short as possible to reduce noise.

Do not use this type of connection