AtlasScientific
Biology•Technology

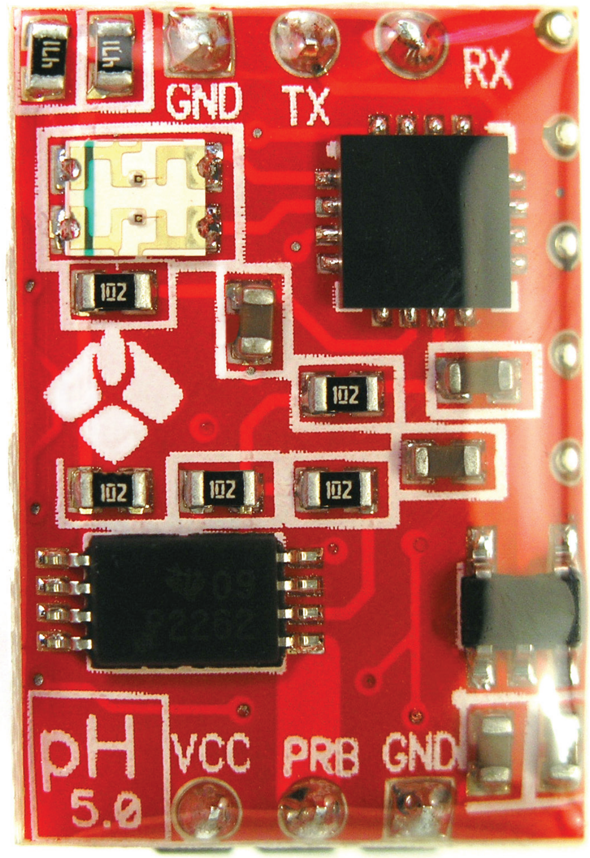
pH Circuit

Hardware V5.0
Firmware V5.0

Micro footprint pH monitoring subsystem

Features

- Full range pH reading from .01 to 14.00
- Accuracy within two significant figures (XX.XX)
- Single reading or continuous reading modes
- **Temperature dependent or independent readings**
- Simple calibration protocol
- Simple asynchronous serial connectivity **(voltage swing 0-VCC)**
- Simple asynchronous serial connectivity with 8 different baud rates
- Automatic baud rate detection
- Simple instruction set consisting of only 14 commands
- Debugging LED's
- 3.3V to 5.5V operational voltage
- Low power consumption
- ROHS compliant



2 mA at 3.3V in active mode*
1.89 mA at 3.3V in quiescent mode*
*LED's off

Description

The pH Circuit is a highly compact pH monitoring system that fits into any breadboard. This design configuration allows the user to accurately monitor pH without having to add any additional circuitry or components to your design. Communication with the pH Circuit is done using only 14 simple one character ASCII commands. The pH Circuit provides scientific grade readings to any embedded system that has an asynchronous serial connection interface (voltage swing 0-VCC, not +/- 12 volts).

Contents

System Overview

Standard pH circuitry can be bulky and complex, often operating at voltages outside of the typical logic level realm. Atlas Scientific has reinvented the way pH monitoring is done. The pH Circuit is an embedded solution designed to output quick, calibration free, scientific grade pH readings in a simple asynchronous serial data transmission. From a single "as needed" pH reading to an infinite number of readings, the pH Circuit will deliver an accurate reading in just 378 milliseconds.

It is important to keep in mind that only temperature dependent readings can be considered scientific grade pH readings. Without adding temperature information to your reading request the pH Circuit will use a default temperature of 25 C°.
See page 7 for more information.

Pin Out

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

Vcc Operates on 3.3V – 5.5V

TX TX output delivers asynchronous serial data in a TTL RS-232 format, except voltages are 0-Vcc. The output is (up to twelve) ASCII characters representing the pH or status messages; all ending with a carriage return (ASCII 13).

Example

4.60<CR>

The default baud rate is: **38400, 8 bits, no parity, with one stop bit.**
The voltage swing 0-VCC, not +/- 12 volts
If standard voltage level RS232 is desired, connect an RS232 converter such as a MAX232.

RX TTL RS-232 receive pin

PRB pH Sensor connection
**For best results use an Atlas Scientific pH Sensor*

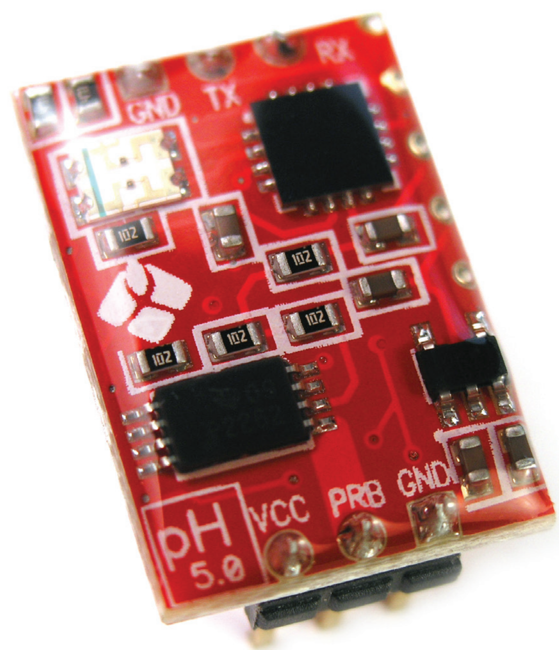
Absolute Maximum Ratings*

Parameter	MIN	TYP	MAX	Units
Storage temperature (pH Circuit)	-40		125	C°
Storage temperature (pH probe)	1	25	35	C°
VCC	3.3	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

Power Consumption

Parameter	5V	3.3V
LED on (Active)	14 mA	4 mA
LED off (Active)	2.3 mA	2 mA
LED on (Quiescent)	7.6 mA	3.6 mA
LED off (Quiescent)	2 mA	1.89 mA



Device operation

When the pH Circuit is connected to a power supply (3.3v to 5.5v) the **green** "Active Mode" indicator LED will begin blinking with transmission. The device will immediately enter continuous mode and begin transmitting pH data.

There are a total of 14 different commands that can be given to the pH Circuit.
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	Takes one pH reading	N/A
C	Takes continuous pH readings every 378 Milliseconds.	N/A
TT.TT	Take temperature dependent reading.	25 C°
E	Stops all readings. Enter standby/quiescent mode.	N/A
S	Calibration at pH Seven	N/A
F	Calibration at pH Four	N/A
T	Calibration at pH Ten	N/A
X	Return Circuit to factory settings	N/A
I	Information: Type of Circuit • firmware version • firmware creation date	N/A
# (xxxx, !, ?)	Set Device ID	No ID Set
Z0	Change baud rate	38,400 bps
Z(1-8)	Set fixed baud rate	Z6 (38,400 bps)

Command Definitions

L1 This will enable both debugging LED's.

The pH Circuit has two LED's
Green LED ....Data TX
Red LED ....Unknown instruction received

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

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

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 pH Circuit to return a single pH reading.

*This instruction takes 378 milliseconds to complete

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

The pH Circuit will respond: XX.XX<CR>

If the pH Circuit reads a pH that is out of range (i.e. a pH of 76.2)
The pH Circuit will respond with the error message "check probe"

check probe <CR>

C The pH-Circuit will operate in continuous mode and deliver a pH reading every 378 milliseconds until the "e" command is transmitted.

Full proper syntax: c<cr> or C<CR>

The pH Circuit will respond: pH.pH (where pH.pH represents a pH reading)

pH.pH<CR> (378 milliseconds)
pH.pH<CR> (756 milliseconds)
pH.pH<CR> (1134 milliseconds)
pH.pH<CR> (n+ 378 milliseconds)

If pH Circuit detects that a pH sensor is not connected or damaged it will not transmit a pH reading. Instead it will respond with the error message "check probe"

check probe <CR>

tt.tt (where "t" is temperature in °C) By transmitting a temperature to the pH Circuit a temperature compensated pH reading will be returned. The temperature entered will now be the new default temperature. Therefore it is not necessary to transmit a temperature each time a reading is taken.

Temperature data will be lost if Circuit is powered off. When the pH Circuit is powered on again temperature will go back to its default of 25°C

Full proper syntax: 35<CR> or 35.67<CR>

E This instructs the pH Circuit to end continuous mode and enter its standby/quiescent mode.

Delivering the "E" (END) instruction when not in continuous mode will have no effect on the pH Circuit.

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

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

X Instructs the pH Circuit to return to its original factory settings.

Transmitting this command will:

Reset calibration off set back to 0.
Reset default temperature back to 25°C
Set debugging LED to on.

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

The pH Circuit will respond: **reset<CR>**

I Instructs the pH Circuit to transmit it version number.

A comma separated string will be transmitted that will contain 3 values.

1. The type of device:	"P" (for pH)
2. The firmware version number:	"V5.0"
3. The firmware version date:	"5/13" (May / 2013)

Full proper syntax: i<cr> or I<CR>

The pH Circuit will respond: **P,V5.0,5/13<CR>**

S This instructs the pH Circuit to calibrate itself to a pH7 solution.

Full proper syntax: s<CR> or S<CR>

The pH Circuit will respond with a calibrated pH reading:

7.00<CR>

Sending the S command when the pH sensor is not immersed in a pH 7 solution will calibrate the pH Circuit to see that whatever it was reading to now be a pH 7 and could lead to significant errors. **Do not do this.**

F This instructs the pH Circuit to calibrate itself to a pH4 solution.

Full proper syntax: f<CR> or F<CR>

The pH Circuit will respond with a calibrated pH reading:

4.00<CR>

Sending the S command when the pH sensor is not immersed in a pH 4 solution will calibrate the pH Circuit to see that whatever it was reading to now be a pH 4 and could lead to significant errors. **Do not do this.**

T This instructs the pH Circuit to calibrate itself to a pH10 solution.

Full proper syntax: t<CR> or T<CR>

The pH Circuit will respond with a calibrated pH reading:

10.00<CR>

Sending the S command when the pH sensor is not immersed in a pH 10 solution will calibrate the pH Circuit to see that whatever it was reading to now be a pH 10 and could lead to significant errors. **Do not do this.**

#nnnn Set 4 digit programmable ID number

Where nnnn is an ID number consisting of numbers 0-9 and letters A-Z.

Setting the pH Circuit ID number is done by issuing the # command
followed by any combination of 4 ASCII letters or numbers.
The ID does not come set. A factory reset will **NOT** clear the ID number.

Full proper syntax: #nnnn<cr>

Example:

Setting the device ID number to "12AB"
#12AB<cr>

The pH Circuit will respond:
Set 12AB<cr>

#! Reset ID number

Full proper syntax
#!<cr>

The pH Circuit will respond:
clr<cr>

#? Query ID number

Full proper syntax
#?<cr>

The pH Circuit will respond with the ID number that it has been given.
nnnn<cr>

If the ID number has not been set the pH Circuit will respond
No ID set<cr>

Setting baud rate

The Atlas Scientific pH circuit is set to a default rate of 38,400 bps. This baud rare can be changed to one of eight possible different baud rates.

1: 300 baud
2: 1200 baud
3: 2400 baud
4: 9600 baud
5: 19.2k baud
6: 38.4k baud
7: 57.6k baud
8: 115.2k baud

Z0 Set the auto baud rate

Transmitting the "Z0<cr>" command will set the pH Circuit to auto baud detection mode. The red/green LEDs will rapidly blink, the pH Circuit will be waiting to receive the letter "U" (Ascii 85) followed by a <cr> at one of the eight possible baud rates.

Example

(at default baud rate 38.4k bps)
Z0<CR> or z0<cr>
The pH circuit will now begin rapid red/green LED blinking

Change your TX baud rate to your desired setting - i.e. 9600 baud and send the "U" command
U<CR>

The pH Circuit will now operate at 9600 baud

*** By using the Z0 command the pH circuit will enter baud rate detection mode each time it is powered up. If this is not desired simply use the Z(1-8) command**

Z(1-8) Set fixed baud rate

Sending the Z(1-8) command will instantly set the pH Circuit to a new baud rate.
This new baud rate will be stored to EEPROM and will be retained even if the pH Circuit is powered off.

Example

(at default baud rate 38.4k bps)

z4<cr> OR Z4<CR>

The pH Circuit baud rate has now been changed from 38.4k bps to 9600 bps
The baud rate can be changed at any time, and as many times as you like.

Calibration Instructions

The pH Circuit must be calibrated in the following order:

pH 7

pH 4

pH 10

1. First place you pH Sensor in the yellow pH 7 calibration solution.
2. Instruct the circuit to go into continues mode.
3. Wait 1 to 2 minutes.
4. TX the S command. Your pH Circuit is now calibrated for pH7.
5. Rinse off pH sensor, dry with paper towel.
6. Place pH sensor in the red pH 4 calibration solution.
7. Wait 1 to 2 minutes (Circuit should still be in continues mode).
8. TX the F command.
   Your pH Circuit is now calibrated for pH4.
9. Rinse off pH sensor, dry with paper towel.
10. Place pH sensor in the blue pH 10 calibration solution.
11. Wait 1 to 2 minutes (Circuit should still be in continues mode).
12. TX the T command. Your pH Circuit is now calibrated for pH10.
13. Transmit the E command.
14. The pH Circuit is now calibrated. The calibration data is stored in the EEPROM
    and will be retained even if the Circuit is powered off.

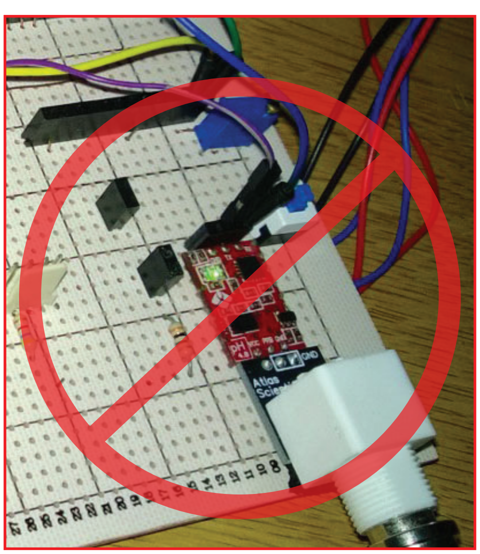
REMEMBER **ALL** TRANSMITION ARE TERMANATED WITH A <CR>.
THEY ARE NOT TERMANATED WITH A <CR><LF>.
MAKE SURE YOUR CODE DOES NOT INADVERTENTLY SEND <CR><LF>
AT THE END OF A TRANSMITION.

OK= I<CR> **NOT OK = I<CR><LF>**

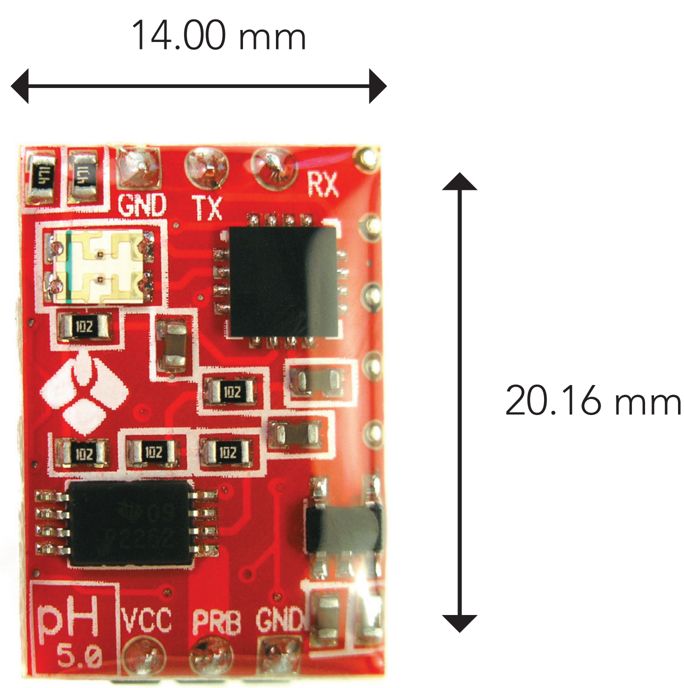
***A pH sensor will typically last between three and four years**
***A pH sensor should be considered inaccurate if it has been frozen**
***A pH sensor should be considered inaccurate if it has been allowed to dry**
***A pH sensor should be considered inaccurate if it has been boiled**

*The Wire length from the pH sensor to the pH Circuit should be as short as possible to reduce noise.

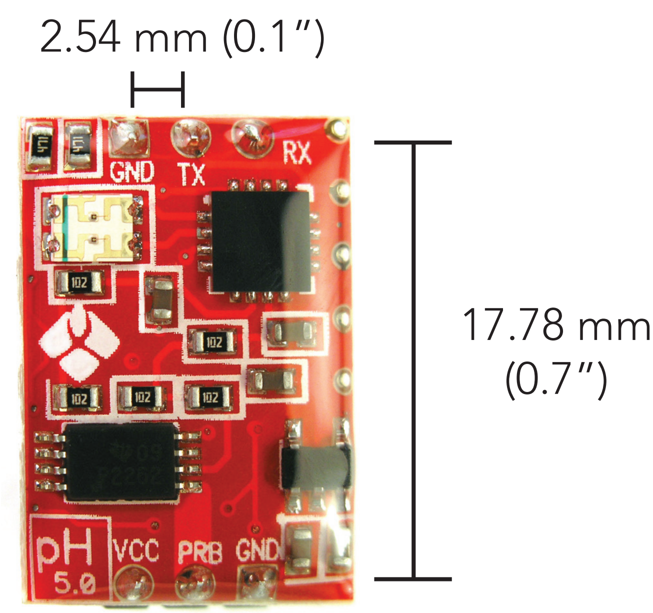
Do not use this type of connection



Do not use protoboard

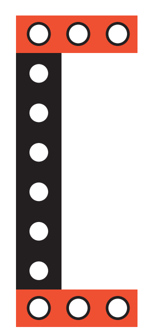


How to make a Footprint for the Atlas Scientific pH Circuit

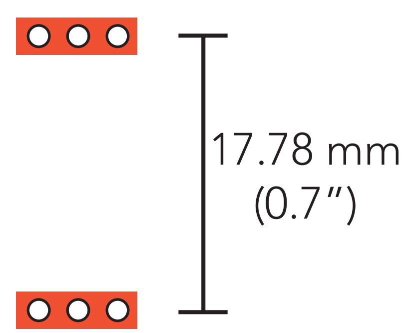


1. In your CAD software place an 8 position header.

2. Place a 3 position header at both top and bottom of the 8 position header as shown.



3. Once this is done you can delete the 8 position header. Make sure that the two 3 position headers are 17.78mm (0.7″) apart from each other.



Known Issues

During calibration; rapidly switching the pH sensor from a pH 4 to a pH 10 when the pH Circuit is in continues mode can cause a device reset. This will **NOT** damage the pH Circuit. Simply re-send the "c" command and continue with calibration.

Touching the pH Circuit can cause false readings; these readings can last as long as 5 minutes. As the pH Circuit returns to normal operation the pH readings will progressively return to normal.

Uneven heating can cause the pH Circuit to return false readings. Thermal stability should be considered when using this product.

Warranty

Atlas Scientific warranty's the pH Circuit to be free of defect during the debugging phase of device implementation, or 30 days after receiving the pH Circuit (which ever comes first).

The debugging phase

The debugging phase is defined by Atlas Scientific as the time period when the pH Circuit is inserted into a bread board or shield and is connected to a microcontroller according to this wiring diagram. Reference this wiring diagram for a connection to USB debugging device, or if a shield is being used, when it is connected to its carrier board.

If the pH Circuit is being debugged in a bread board, the bread board must be devoid of other components. If the pH Circuit is being connected to a microcontroller, the microcontroller must be running code that has been designed to drive the pH Circuit exclusively and output the pH Circuit's data as a serial string.

It is important for the embedded systems engineer to keep in mind that the following activities will void the pH Circuit's warranty:

- **Soldering any part of the pH Circuit**
- **Running any code that does not exclusively drive the pH Circuit and output its data in a serial string**
- **Embedding the pH Circuit into a custom made device**
- **Removing any potting compound**

Reasoning behind this warranty

Because Atlas Scientific does not sell consumer electronics; once the device has been embedded into a custom made system, Atlas Scientific cannot possibly warranty the pH Circuit against the thousands of possible variables that may cause the pH Circuit to no longer function properly.

Please keep this in mind:

1. **All Atlas Scientific devices have been designed to be embedded into a custom made system by you, the embedded systems engineer.**
2. **All Atlas Scientific devices have been designed to run indefinitely without failure in the field.**
3. **All Atlas Scientific devices can be soldered into place.**

*Atlas Scientific is simply stating that once the device is being used in your application, Atlas Scientific can no longer take responsibility for the pH Circuit continued operation. This is because that would be equivalent to Atlas Scientific taking responsibility over the correct operation of your entire device.