pH Meter Manual

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Modified from Tran, N. and Smith, E. T., Chem. Ed., 21, 143-145 (2016).

Part 1. Circuit Description

A pH meter measures a voltage across a high resistance glass membrane without current flow. To measure a potential under these conditions, a special but simple circuit is required (A voltage meter cannot be used to measure pH). The circuit is shown Figure 1. It consists of a microcontroller (not shown in diagram), power supply (a), BNC connector for the pH probe (b), operational amplifier (c), resistors (d), capacitor (e), and transistor (f). The circuit diagram illustrated in Fig. 1 is complicated to the uninitiated, but it provides sufficient information to allow other scientists to build it.

The device described here requires a *microcontroller*. A microcontroller is a computer on a chip, an integrated circuit with a processor core, memory, and programmable input/output peripherals. These devices are found in many modern devices (microwave ovens, automobiles, etc.). The *mbed LPC 1768* microcontroller is used in this application to convert a signal to a digital form, communicate this information to a computer, and power the data logger. Specifications and pin diagram are found at https://developer.mbed.org/platforms/mbed-LPC1768.
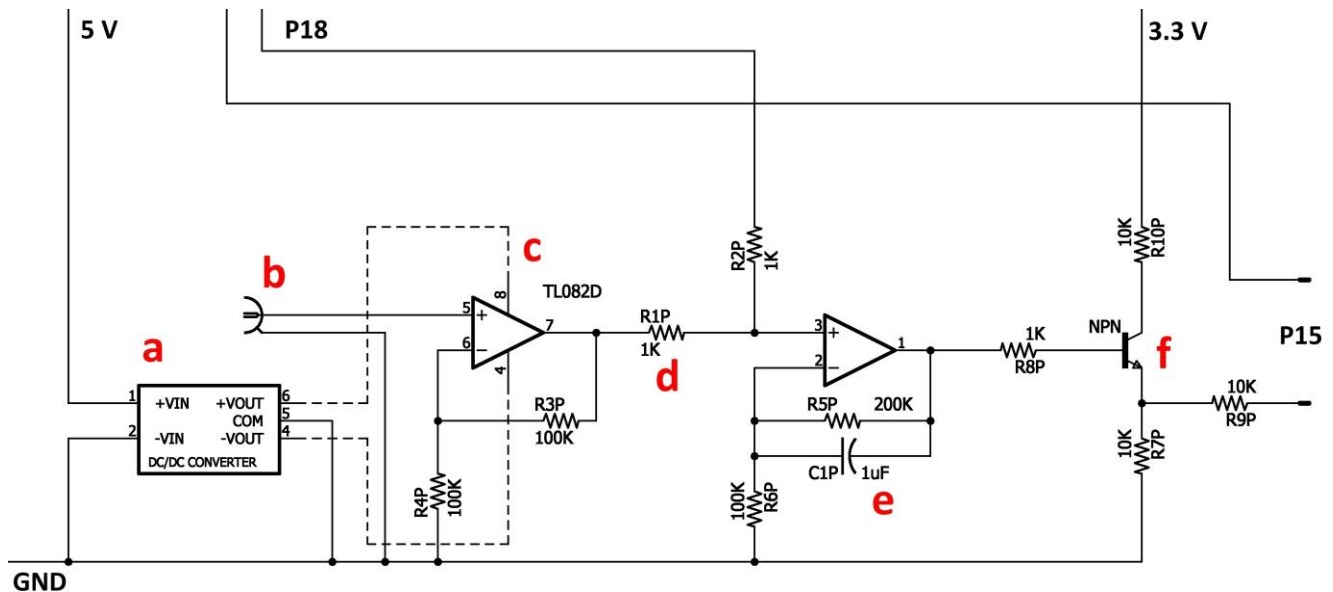

Fig. 1. Circuit diagram for a pH-meter illustrating the (a) power supply, (b) BNC connector, (c) op amp, (d) resistor, (e) capacitor, and (f) transistor.

Part 2. Board Assembly

Instruments and materials needed to assemble a printed circuit board (PCB) are listed in Table 1 (see next page). A fine tipped solder pen is needed to attach components to the PCB. A reflow oven (model T-962, Puhui Technology), which is a temperature-controlled infrared heater, is optional for board assembly. The surface mount components, listed in Table 2, can be obtained from DigiKey or Mouser. Fine tipped tweezers facilitate placement of components on the PCB board.

Instructions for assembling and troubleshooting the board are found in the instructional videos (www.kissinstruments.com). Ensure that IC's are positioned in the correct orientation. Pin 1 is to the upper left of the line on the integrated circuit as illustrated in Fig.

Fig. 2. Op amp with stripe used in identifying pin numbers

2. Alternatively, a white dot on the IC indicates pin 1. Utilize the diagram in Fig. 3 to properly place components on the printed circuit board (PCB) for the data logger. Apply solder paste sparingly to the PCB, and then add the appropriate components to the board. Keep circuit board free of fingerprints, especially around IC1 pins 5 and 6.

If a reflow oven is used, set the board in the oven and run the correct temperature program for the solder paste (refer to solder paste specification sheet). After the board is cool, visually inspect board to ensure that the components are attached correctly and that there are no solder bridges (see instructional videos on www.kissinstruments.com). The remaining components, power supply, header, and BNC connector are hand soldered to the board.

Troubleshooting. A multimeter is needed to check resistances and voltages on the PCB board. A digital oscilloscope, which is optional, is useful in trouble shooting boards. Use the USB cable supplied with microcontroller to power the board. Check that voltages supplied to the IC's as listed in Table 3.

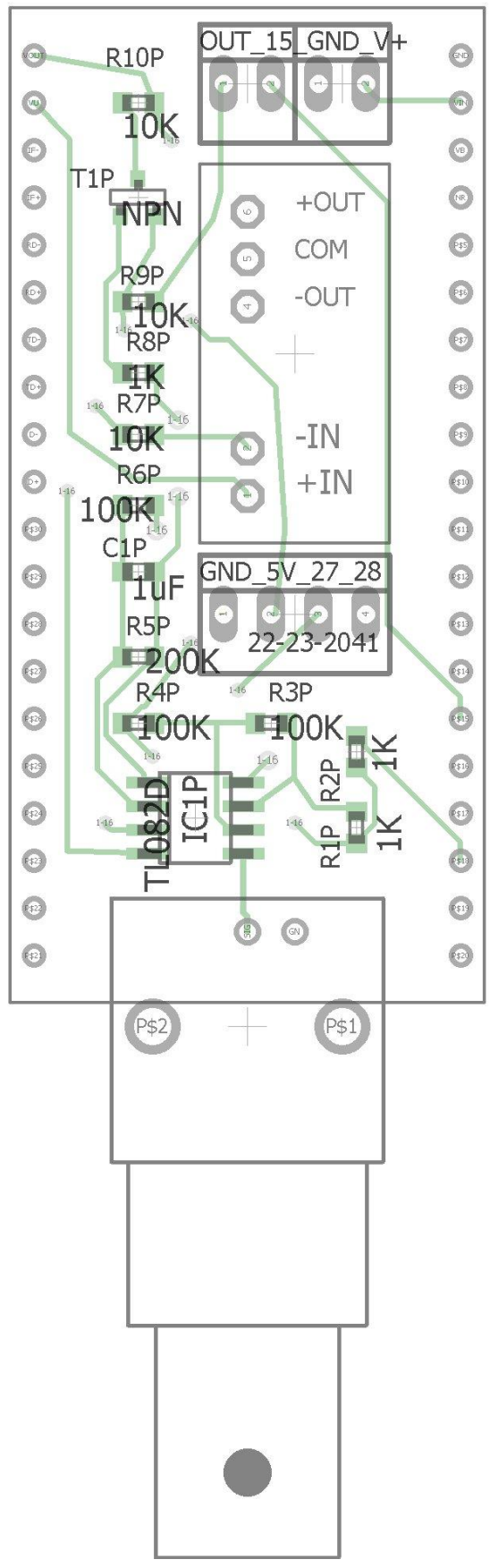**Table 3. IC power inputs indicating pin number and voltage value**

IC	Pin/(Voltage)	Pin/(Voltage)
1	8/(12V)	4/(−12V)

Additional Hardware. Any combination pH electrode with a BNC fitting should work with this PCB board. The *Excel* template has an offset to compensate for differences in the resistance across the pH glass membrane.

Table 1. Instruments and materials needed to assemble PCB			
Instrument	**Part**	**Type**	**Source**
Solder station	YiHua 968 DB	YiHua	Amazon.com
Infrared IC heater	T-962	Puhui Technology (Taian)	www.tech168.cn
Solder paste	SAC 305	ChipQuik	www.chipquik.com
Multimeter	Any type/model will suffice		

Table 2. Components needed for PCB				
Component	**Type**	**Part**	**Source**	**Quantity**
Circuit Board	See supplemental material		Sunstone	1
Microcontroller	Mbed LPC1768	OM11043	DigiKey	1
Power Supply	Murata	580-MEJ1D0512SC	DigiKey	1
Op Amp	TL082	497-2212-1-ND	DigiKey	1
Resistor	200K	CR0603-JW-204GLFCT-ND	DigiKey	1
Resistor	100K	CR0603-JW-104GLFCT-ND	DigiKey	4
Resistor	10	CR0603-JW-103GLFCT-ND	DigiKey	2
Resistor	1	CR0603-JW-102GLFCT-ND	DigiKey	4
Transistor	NPN	MMBT2222A-FDICT-ND	DigiKey	1
Capacitor	1uF	490-1543-1-ND	DigiKey	1
BNC	Molex	WM5514-ND	DigiKey	1
Cable/Headers	3" female cables	920-0005-01	SchmartBoard	1

**Fig. 3.
Component
placement on
circuit board**

OUT_15_GND_V+

R10P

10K

T1P

NPN

+OUT

COM

-OUT

R9P

10K

R8P

1K

R7P

10K

-IN

R6P

+IN

100K

C1P

1uF

GND_5V_27_28

R5P

200K

22-23-2041

R4P   R3P

100K   100K

1K

R2P

TL082D   IC1P

R1P   1K

P$2   P$1

Part 3. Software

A USB driver is available at https://developer.mbed.org/handbook/Windows-serial-configuration. Additionally, two files (an *Excel* template and microcontroller program), are necessary and links are found under products at www.kissinstruments.com. These files include (A) an *Excel* template for collecting data (DL-v500.xls) and (B) a compiled *mbed* program (DL-v100_LPC1768.bin

Install programs.

1. Install USB driver. The driver is available at https://developer.mbed.org/handbook/Windows-serial-configuration. Run *mbedWinSerial_16466.exe* and follow prompts. This program installs a serial communications program on the microcontroller so data can be collected through the USB cable.
2. Copy DL-program (DL-v100_LPC1768.bin) onto microcontroller. This program runs on the microcontroller. Using the Control Panel, Device Manager, identify the serial port used by the microcontroller.
3. Open the *Excel* template, *DL-v100.xls*. This template is used to communicate with the microcontroller. *Do not copy this template onto the microcontroller*.
4. Set communication ports. The COM port used by the microcontroller and spreadsheet need to be the same. In *Excel*, under the spreadsheet tab labelled "Parameters" change the COM port value as appropriate. The COM port value must be between 1–4. In the *Windows Device Manager*, set the COM port to the appropriate value (see Fig. 4).
5. Using the *Excel* template, record data by clicking on start/stop as necessary.

Scale Adjustment. On the *Parameter* tab of the spreadsheet template (see adjacent figure), a pull down menu allows the user to control the offset. The offset may be sensitive to the type of pH combination electrode.
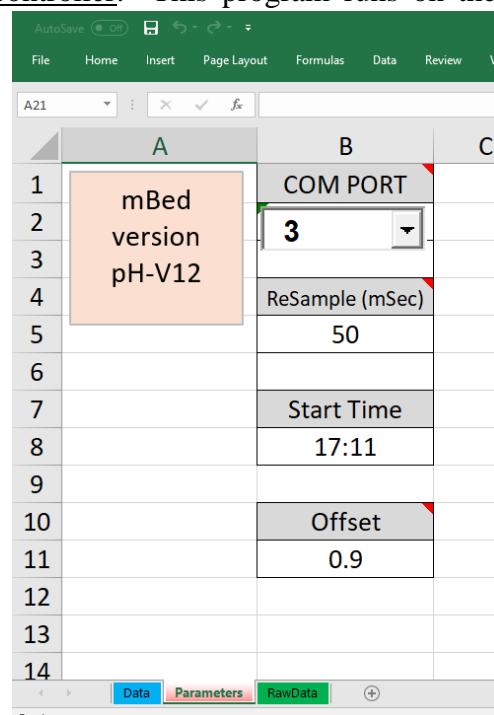
Fig. 4. Worksheet utilized to establish communication and offset to pH meter.