Auto-titrating pH Meter

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http://www.techneusa.com/ph/3510.jpg

Outline

- Objective
- Approach
  - Mechanical design
  - Electrical components
  - Flow chart of our program
- Results
- Cost Estimate
- Conclusion
  - Failure/success
  - Suggestions

Objective

- What is pH?
  - pH = -log [H+]
  - How is this important?
- Design a cost-effective pH meter (using BS2 as our microcontroller)
- Continuously check pH of solution
- Be able to create solution of desired pH
  - based on user's input

Approach : Mechanical Design

- Initial Design

- Final Design

Circuit : Electrical Components

- Materials needed :

10K Potentiometer

TL082 Dual BiFET OP Amp

ADC0831 A/D converter

Three continuous servo motors

pH probe sensor

9V snap connectors

Various resistors

Various jump wires

3 Normally Open Push-button switches

Electrical Basis of Project

- Measuring small voltages = .060 V per pH unit change
- Our pH range : pH 1- pH 7
- Neutral pH 7 : 0.0 V

As we move down pH : pH 7 → pH 6, increase in voltage by 0.060 V

e.g. At pH 4, 3 units from neutral pH

0.060 V/pH unit x 3 pH units from neutral pH = .180 V or 180 mV reading

pH Probe

pH probe model number 03847K : $ 60

High source impedance : glass membrane

Voltages cannot simply be measured with a DMM

In addition, voltages are very low (0-0.360V)

How to interface with BS2?

Operational Amplifier

Originally used an LM358 op-amp included in the BS2 kit

However, all op-amps are not ideal :

Golden Law of op-amp circuitry : input current into terminals should be zero. In reality, this is not the case

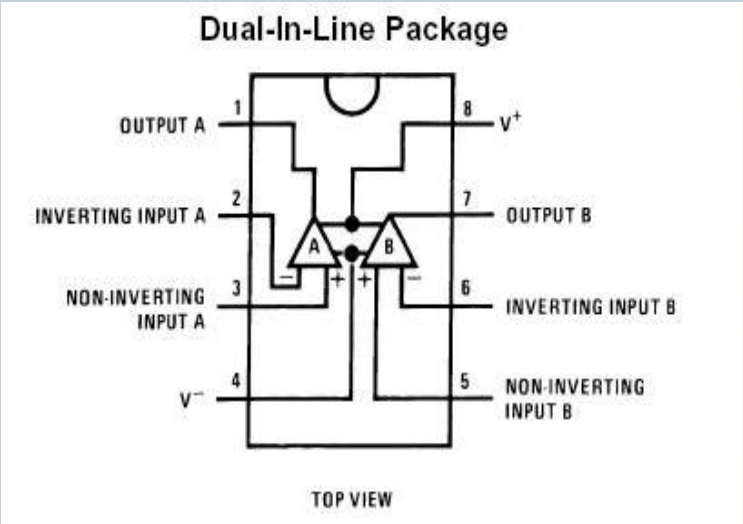
Small current converted into small voltage and also gets amplified!!

Results in output error in calculations

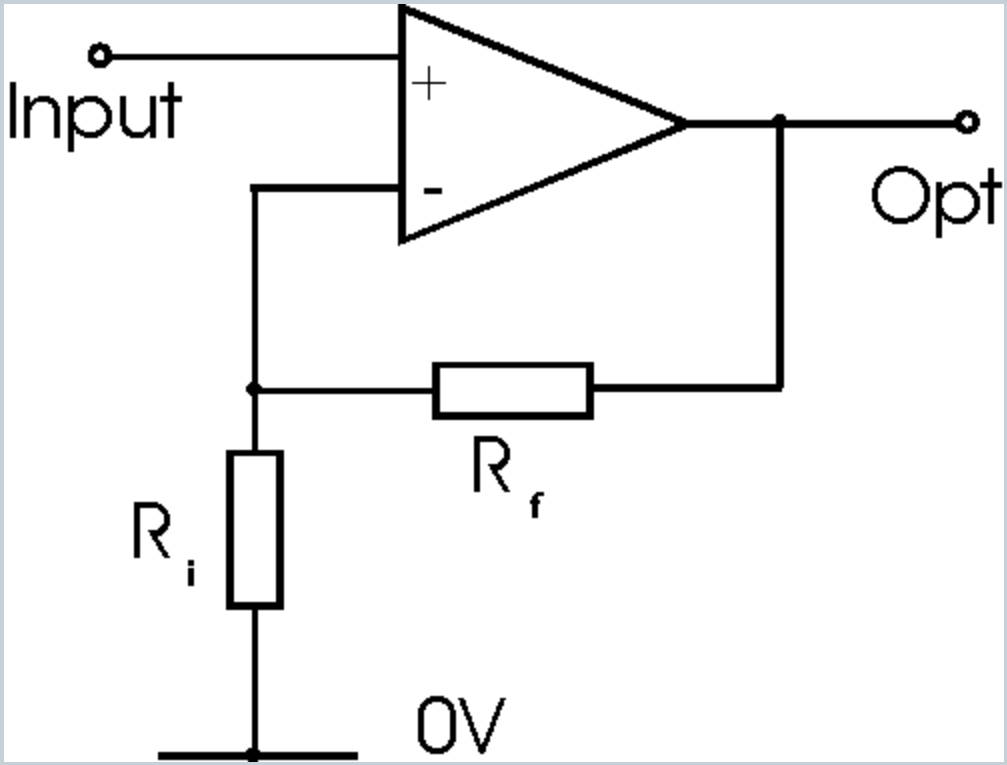
LM358 op-amp did not work with our setup

TL082

- High input impedance, available at local RadioShack : $2
- Powered using 2 9V batteries : $10
- Results using TL082 : Priceless



Non-Inverting Amplifier Circuit



$V_{out} = V_{in} (1+R_f/R_i)$

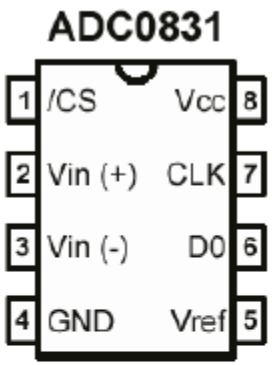
Gain : Amplification Factor
$(1+R_{f/} R_i)$

$R_f = 10\ k\Omega$
$R_i = 1\ k\Omega$

Gain = 11

Amplified Signal
.035 V- 4.03

Digitization



Vin (+) : input analog signal from pH probe needed to be digitized

Vin (-) : offset , 0V

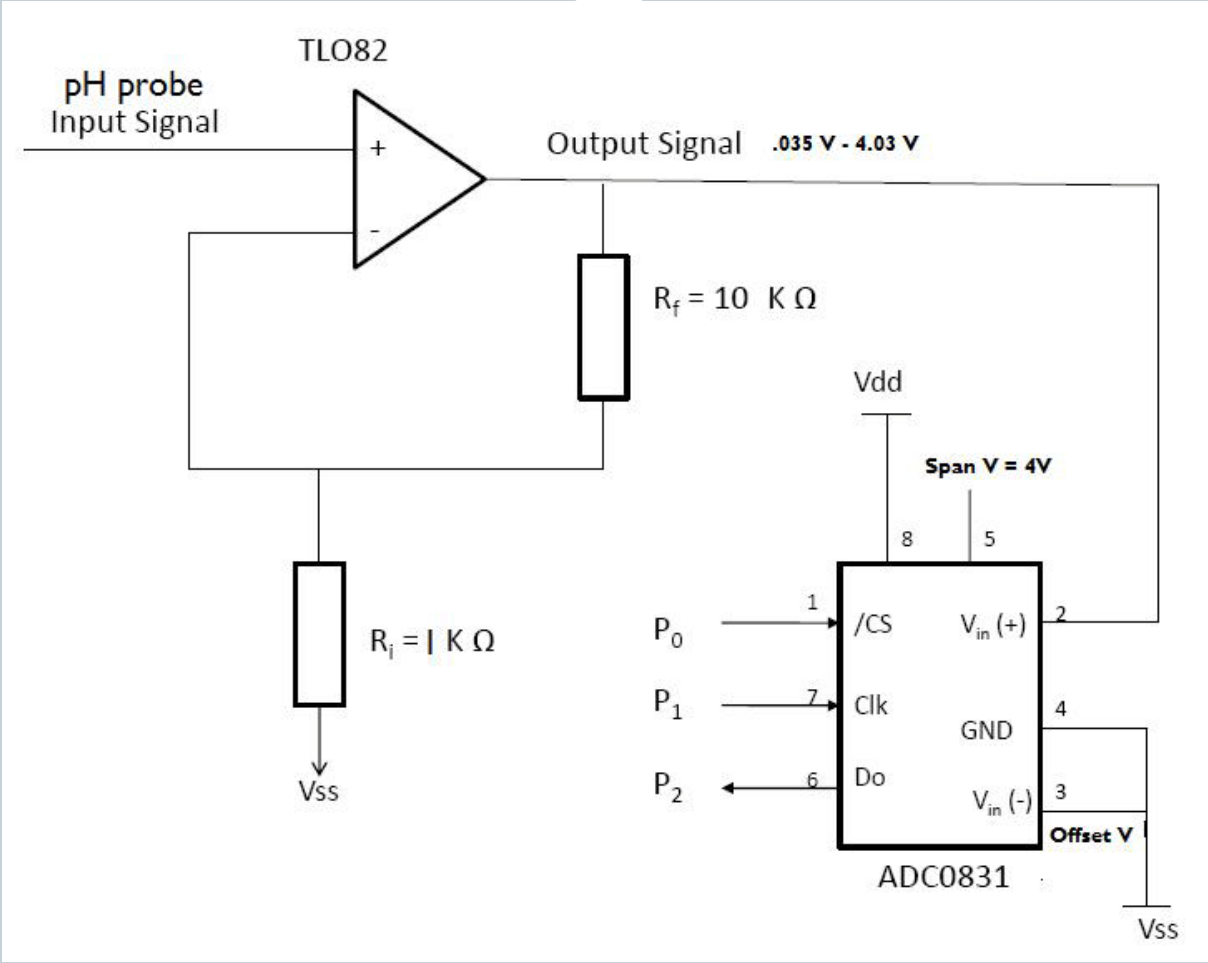
Vref : Set to 4V

Span = 4.03 V - .035 V = about 4.0 V

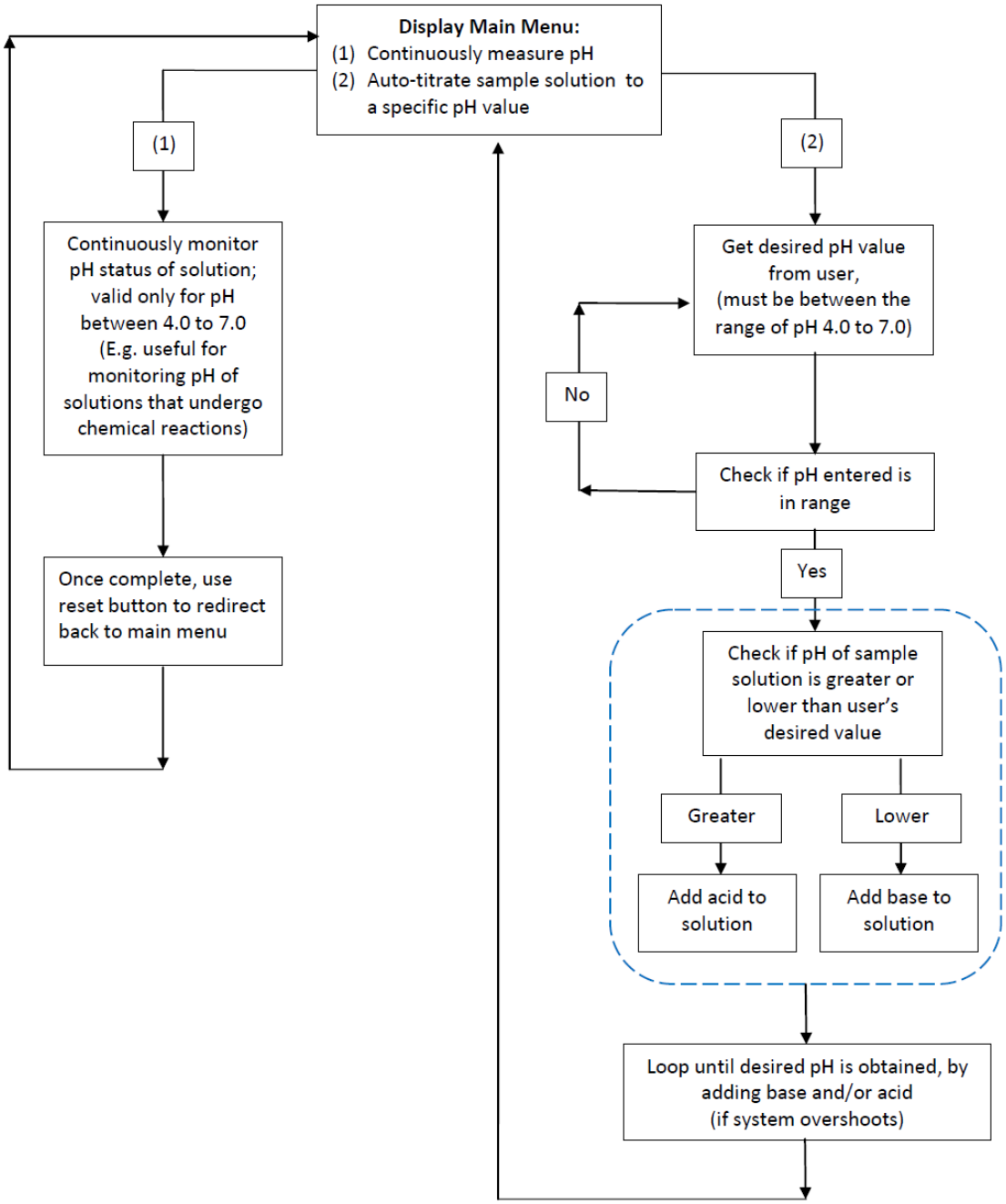
Quantization : (4.03 V - .035)/256 = ~ 16 mV per step

After ampification each pH unit 60 * 11 = 660 mv per pH unit ~ 42 steps per unit pH change

Circuit Diagram



Program Flow Chart:



Cost Estimate

Materials		Estimated Cost
10K Potentiometer		*
ADC0831 A/D convertor		*
Three continuous servo motors		*
Various resistors		*
Various jump wires		*
3 Normally Open Push-button switches		*
BS2 kit		$200.00
TL082 Dual BiFET OP Amp x 3		$6.00
pH probe sensor		$60.00
9V snap connectors		$3.00
Ring clamps x 2		$20.00
9V Battery x 2		$10.00
Tools/ misc		$20.00
* = included in BS2 kit	Total Cost	$319.00

Problems Encountered

- Initial design failures/flaws
  - Leakage
  - Stability
- BS2's EEPROM
  - Used maximum amount of space available
    - Not able to incorporate programming codes for keeping pH within desired range (i.e. not only go to desired pH value)
- Fluctuations of probe readings
  - Need to use the shortest lead possible
- Limited pH range (i.e. 4.0 to 7.0) ???
  - Pro: better resolution
  - Con: inability to detect basic pH (from 8.0 to 14.0)

Results (to be shown in demonstration)

Buffer	Salt	pH	mV Start	mV 3 min
50 mM NaPho	500 mM	7.0	49 mV	63 mV
50 mM NaPho	0 mM	7.0	37 mV	53 mV
50 mM Tris	500 mM	7.0	5 mV	10 mV
50 mM Tris	0 mM	7.0	18 mV	55 mV
100 mM NaPho	500 mM	7.0	48 mV	47 mV
100 mM NaPho	0 mM	7.0	46 mV	43 mV

Thank you!

Prof. Kapila, Chandresh, Alex,

& all of our classmates for your valuable advice

Now … *drum rolls*

DEMONSTRATION TIME

cross your fingers