CONDUCTIVITY MEASUREMENT 4 CELL

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A thesis submitted in fulfillment of the

requirements for the award of the degree of

Master of Engineering (Electrical - Electronics and Telecommunication)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

NOVEMBER 2005

To my almighty Sri Sathya SaiBaba

ACKNOWLEDGEMENT

In preparing this thesis, In particular, I wish to express my sincere appreciation to my main thesis supervisor, Professor Dr.Ruzairi Bin Abdul Rahim, for encouragement, Guidance, critics and friendship. I am also very thankful to all colleagues in particular Mr.K.Muralideran R& D Engineer Eutech Instruments Singapore for his guidance, and support in preparation of electronics circuit design.

I would also wish to acknowledge my beloved wife Ms.V.Deepa for her continuous support throughout the course and preparation of this Thesis.

ABSTRACT

Conductivity measurement is one of the most important and widely used to measure the quality of water in all spread of industries, labs & institutions. The Conductivity or specifically electrolytic conductivity is defined as the ability of a substance to conduct electric current. AC current is passed through two plate and voltage are measured across the plates, the resistance is offered by the liquid is measured in terms of voltage using ohms law principle.

The conductivity measurement's heart is the cell, among them 2 cell is most commonly used but it has few problem such as polarization, field effects, less measurement range etc, answer to solve this problem is 4 cell, this cell has 4 cells it can be of different forms – rings, pins, rectangular and square shaped etc.

The 4 cell concept helps to totally remove the field effect, polarization problems, cell constant is the key factor, there are different types of cell constant K=0.01, K=0.1, K= 1.0 and K= 10.0. The cell constant is chosen based on the ranges, cell constant 0.01 is used of low conductance measurement such as ultra pure water. As the conductivity goes higher cell constant will also chosen higher. Frequency - lower the conductivity measurement lower is the frequency (32 Hz) as the measurement value goes up the frequency should also go up to get optimum results.

The electronics has oscillator which generate required frequency, then high impedance op-amp and frequency dividers are used to measure conductivity.

Application of conductivity measurement such as concentration, salinity, resistivity, Total dissolved solids (TDS). All most all industries need this instrument even the drinking water, swimming pool also need this measurement.

ABSTRAK

Pengukuran konduktiviti merupakan satu pengukuran yang amat penting dan digunakan dengan meluas untuk mengukur kualiti air dalam kebanayakan industri, makmal dan institusi. “Contucivity” ataupun secara khusus conduktiviti elektrolitik di definasikan sebagfai kebolehan sesuatu “substance” untuk mengkonduksikan arus elektrik. Arus ulang-alik dilalukan melalui 2 plat dan voltan diukur melintasi plat, cecair menyumbang kepada kerintangan dan diukur dalam voltan menggunakan prinsip Hukum Ohm. Cell merupakan elemen paling penting dalam pengukuran konduktiviti, 2 sel biasanya digunakan tetapi mempunyai masalah-masalah seperti polarisasi, field effect(kesan medan)kekurangan julat ukuran dan lain-lain, jawapan untuk menyelesaikan masalah ini adalah dengan menggunakan 4 cell, cell jenis ini mempunyai 4 cell bentuknya boleh beraneka-cincin, pin, segiempat tepat dan segiempat dan lain-lain. Konsep 4 cell ini boleh mengahpuskan kesan medan, masalah polarisasi, konstan cell merupakan factor utama, terdapat pelbagai jenis konstan untuk cell k=0.01, k=0.1, k=1.0 dan k = 10.0 konstan. Untuk cell dipilih berdasarkan julat konstan 0.01 digunakan untuk pengukuran konduksi rendah seperti air semulajadi ultra. Sekiranya konduktiviti bertambah tinggi konstan cell yang dipilih juga tinggi. Frekuensi – sekiranya pengukuran konduktiviti adalah rendah frekuensinya juga turut rendah (32Hz). Andainya nilai pengukuran bertambah frekuensi juga harus bertambah untuk memperolehi kesan optimum. Elektronik ini mempunyai oscillator (pengayun)yang menjana frekuensi seperti yang dikehendaki, op-amp berimpidan tinggi dan pembahagi frekuensi digunakan untuk mengukur konduktiviti. Pengukuran konduktiviti di aplikasikan dalam kepekatan. Kepadatan rintangan (TDS). Kebanyakan industri memerlukan peralatan ini memandangkan air yang diminum, air kolam mandi juga memerlukan penukuran ini.

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LIST OF SYMBOLS

A, a	-	Area
AC	-	Alternating current
C	-	Conductivity
D.d	-	Distance
E	-	Volts
G	-	Conductance
HCL	-	Hydrochloric acid
H^+	-	Hydrogen ions
I	-	Current
K	-	Cell constant
KCL	-	Potassium chloride
mV	-	Milli volts
mg	-	Milligram
NACL	-	Sodium Chloride
NAOH	-	Sodium Hydroxide
ppm	-	Parts per million
ppt	-	Parts per thousand
R0	-	Reverse Osmosis
S	-	Siemens
SS	-	Stainless Steel
T	-	Temperature
T_r	-	Reference Temperature
TDS	-	Total dissolved solids
µS	-	Micro Siemens
α	-	Temperature Co-efficient

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CHAPTER 1

INTRODUCTION

Conductivity measurement is one of the most important and widely used to measure the quality of water/solutions in all spread of industries, labs & institutions; for examples drinking water quality in RO plant, feed water for boilers from Demineralization plants.

The possibility of using conductance to locate end points in titrations was also recognized early in the development of instrumental methods. Changes in slope of conductance versus titrant volume occur because ionic mobility's vary and also because of the formation of insoluble or non-ionized materials, accordingly conductometric titration was developed in recent years, high frequencies conductometric titration was developed in recent years. High frequency measurements permit the determination of changes in conductance or dielectric constant with out the introduction of electrodes into direct contact with the solution.[4]

Materials in which current is conducted by ions rather than electrons (as in metal conductors) are called electrolytes. These are divided into two groups strong and weak electrolytes according to their dissociation behavior, i.e. the property of the chemical compounds dissolved in a liquid to totally or partially split into separate

groups of ions. The group of strong electrolytes includes all strong acids and bases (e.g., HCL, NaOH). Water is an example of a weak electrolyte. The following applies to conduction in electrolytes: In solutions current is conducted by ions. All ions take part in this process but weak electrolytes only dissociate into ions.

In this project we are addressing 4 cell concepts of design, measurement and applications. The 2 cell in general has problems of polarization, geometry, field-effects etc, some this major problem can be overcome with the 4 cell concept.

and available easily, micro controller can be used to generate the frequency.

- This circuit uses high impedance op amp to prevent loss in the signals, The AD822 is a dual precision, low power FET input op amp
- that can operate from a single supply of 3.0 V to 36 V or dual
- supplies of ±1.5 V to ±18 V.
- For a multiplexer used
    i. Fast Switching and Propagation Speeds
    ii. Low Crosstalk Between Switches
    iii. Diode Protection on All Inputs/Outputs
    iv. Analog Power Supply Range (VCC – VEE) = 2.0 to 12.0 V
    v. Digital (Control) Power Supply Range (VCC – GND) = 2.0 to 6.0 V
    vi. Improved Linearity and Lower ON Resistance Than Metal–Gate

CHAPTER 14

FUTURE WORK

(i) Micro controller shall be used for oscillator, auto ranging and also table store based of Temperature co-efficient auto correction can be done automatic.

(ii) Different cell constant design.

(iii) Different materials like platinum, silver, copper and other material can be used and tried for better results.

(iv) ADC signal can further designed for Transmission purpose for 4-20mA for on-line applications.

(v) The sensor can be practical check with different applications.

REFERENCES

1. Conductivity Theory and Practice – Radio meter Analytical
2. Endresss + Hauser user manual
3. Eutech Instruments Web site
4. Instrumental Methods of Analysis – Willard Merritt & Dean Settle
5. Transducers in mechanical and electronic design – Harry L.Trietley
6. On-Line conductivity measurement -www.WTW.com
7. http://www.wonhitech.co.kr/product04_11.asp
8. Manual of Electrochemical Analysis, Part 3, electric conductivity – Sartorius
9. Application20% -from Internet
10. Sensorex technical education web site
11. Salinity - Dissolved Salts, Measuring Salinity - http://www.windows.ucar.edu/ at the University Corporation for Atmospheric Research (UCAR). ©1995-1999, 2000
12. Frequency Management - **www.fmi-inc.com**
13. Analog devices –AD822 data sheet www.analog.com
14. MC74HC4051 data sheet on semiconductor - http://onsemi.com
15. conductivities of materials, Microwave Engineering David M.Pozar 1998.