Automatic Bridge Balance and Measurement of Resistance Using Microcontroller

Saubhik Panda, Anirban Kar, Bivash Mondal

Electrical Engineering, Heritage Institute of Technology, Kolkata

***Abstract*— Automatic Bridge Balance and Measurement of Resistance using Microcontroller (ABBMRM) is implemented effectively for balancing the Wheatstone bridge using the Microcontroller (8051) with higher accuracy.**

***Keywords*— Microcontroller, Automatic, Bridge Balance, Resistance Measurement, Accuracy.**

I. INTRODUCTION

The paper [1] Dutta et.al has suggested the stochastic gradient algorithm for automatic balancing of AC bridge. The paper [2] L.Callegaro suggested PC controller by root finding strategies. There is also an automatic bridge balancing method based on the digital control signal platform where by using some standard operational amplifiers a linear bridge circuit output is obtained[3]. A microprocessor-controlled high-voltage current-comparator-based capacitance bridge is also existing and automatic balancing feature facilitates the use of the bridge for accurate load loss measurement of large high-voltage inductive loads[4]. This paper presents the balancing of Wheatstone bridge automatically by a microcontroller using a very simple algorithm and the measurement of unknown resistance with better accuracy.

The Wheatstone bridge is used for the measurement of medium resistance ranging from 1 ohm to 100 kilo ohms. A variable resistance being an arm of the bridge is varied till the null detector shows zero.

Normally a Wheatstone bridge is balanced by varying a resistor and balance condition is obtained through a null detector, a galvanometer. Sometimes it becomes very difficult to reach the balance condition due to the sensitivity of galvanometer and the accuracy of the variable resistor. This proposed method improves the sensitivity by employing an amplifier which receives the unbalanced voltage and the resolution of the potentiometer used as variable resistance. The Microcontroller, being a power efficient programmable digital device, receives the unbalanced equivalent digital value and generates signal to rotate the stepper motor in proper direction for balance condition in a minimum time.

A. Wheatstone Bridge

The Wheatstone bridge consists of a dc voltage source, four resistors and a detector being a galvanometer. The condition for balancing the bridge is: $\frac{R1}{R2} = \frac{R3}{R4}$, where R4 is an unknown resistance, R_3 is variable resistance and R_1,R_2 are the ratio resistance. This is shown in fig1.

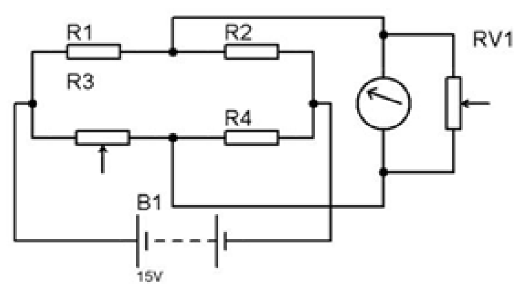

Fig1: Wheatstone bridge

B. Block Diagram of the Circuit Implementation

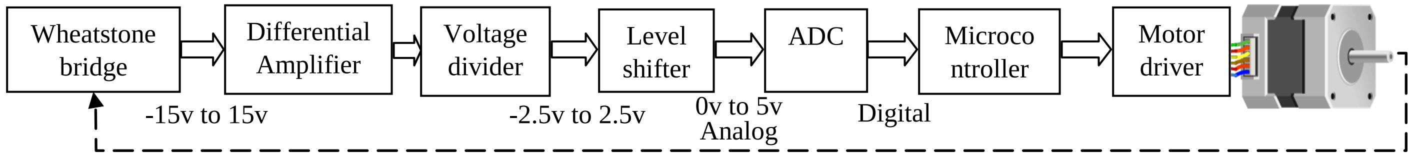

Fig2: Functional block diagram of ABBMRM

C. Circuit Illustration

The functional block diagram of ABBMRM is shown in fig-2. The block Wheatstone bridge, capable of generating maximum +15v to -15v output voltage feeds to the differential amplifier to improve the sensitivity of the difference voltage. The amplifier output voltage is passed through the voltage divider and level shifter converted to the range of voltage 0-5v for the input of Analog to Digital Converter (ADC). This digital output is fed to the port of microcontroller (AT89S52). Another port of the microcontroller is connected to the stepper motor via motor driver circuit. The shaft of the stepper motor is coupled with the shaft of variable resistor of the Wheatstone bridge.

D. Working Principle of ABBMRM

1) Initially the stepper motor coupled with the potentiometer is placed at extreme left position and supply applied to the bridge.
2) The range of unbalanced voltage is from $-V_{cc}$ to $+V_{cc}$.
3) A level shifter changes from 0 to +5 voltages being the input requirement of 16 bit ADC.
4) ADC generates the digital data for the Microcontroller.
5) Microcontroller checks the generated digital data and decides to rotate the stepper motor in clockwise or anti-clockwise.
6) The process continues till the motor stops rotating and the bridge becomes balanced.
7) After reaching balanced condition, the microcontroller calculates the value of the unknown resistance and displays the value.

E. Calculation of Unknown Resistance

Let resistance of the potentiometer is R and N is the total number of revolution. The shaft of a potentiometer is rotated by a stepper motor with a step angle 1.8 degree. When the balance condition is achieved the numbers of complete rotation store in register B and additional steps in register A. The change in resistance of the potentiometer in a complete revolution is R/N and that in a step is $(Rx1.8^0/Nx360^0)$.

Here a 100 ohm, 100 turns potentiometer has been used. So for one revolution change of resistance is 1 ohm and for one step change of resistance is 0.005 ohm. So the value of unknown resistance will be

R= (No of revolution × 1) + (No of step size × 0.005)

No of revolution is stored in register B and no of step size is stored in register A. By doing this type of arrangement the system can measure up to 3decimal places, which is more accurate than manual measurement.

F. Flow Chart

The flow chart for the assembly level program forAT89S52 as shown in fig-3 is self-explanatory.

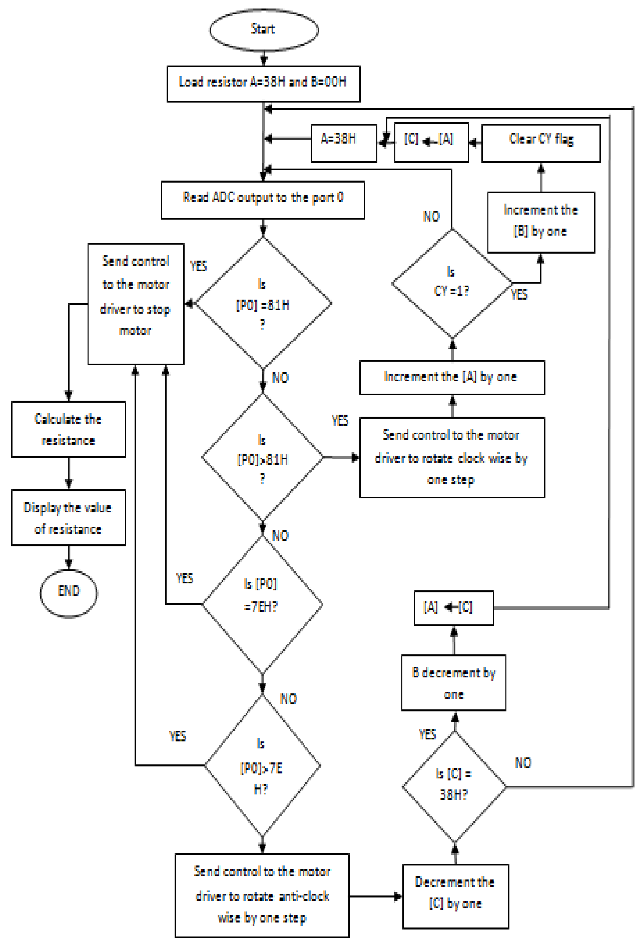

Fig3: Flow Chart of the program

G. Data Table and Observation

TABLE I

Unknown Resistance (ohms)	Theoretical Value (ohms)	Measured Value (ohms)	POT Resistance Error
1	1	1.005	0.5%
10	10	10.01	0.1%
20	20	20.01	0.05%
50	50	50.015	0.03%
70	70	69.995	0.007%

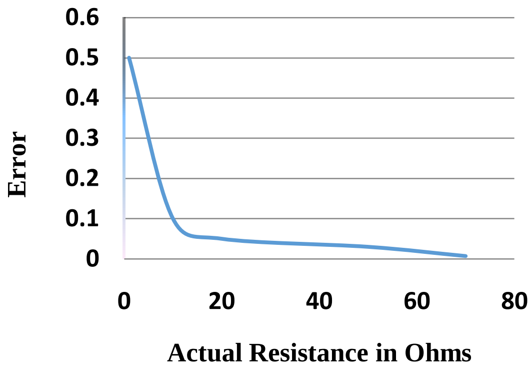

Fig 4 Error vs Actual Resistances in Ohms

The data given in Table-I shown the percentage error for different values and the fig-4 shows the plot of %errors against resistance values. It ensures the better measurement as deviation is 0.05%.

II. Conclusion And Scope Of Future Work

The ABBMRM has been implemented and tested in laboratory. The following are advantages achieved through this technique.

- Measurement of resistance with higher accuracy.
- Feature of programmability embedded.
- Automatic balance of Wheatstone bridge is achieved.

This technique may be extended to other a.c. bridges with modified algorithm and hardware.

Acknowledgment

The authors express sincere thanks to the Department of Electrical Engineering for extending the facility of Microcontroller and Microprocessor laboratory provided to test the circuit and Dr. Satadal Mal, HOD, EE for constant inspiration, advice and permission.

References

[1] M.Dutta, A.Rakshit, S.N.Bhattacharyya,"Development and study of an automatic AC bridge for impedance measurement."IEEE Transactions on Instrumentation and Measurement.Volume 50,Issue 5,Year 2001.

[2] L.Callegaro,"On strategies for automatic bridge balancing." IEEE Transactions on Instrumentation and Measurement. Volume 54,Issue 2,Year 2005.

[3] P.Holmberg,"Automatic balancing of linear AC bridge circuits for capacitive sensor elements." IEEE Transactions on Instrumentation and Measurement. Volume 44,Issue 3,Year 1995.

[4] E.So,"A microprocessor-controlled high-voltage current-comparator-based capacitance bridge."IEEE Transactions on Power Delivery. Volume 5,Issue 2,Year 1990.

[5] KENNETH J. AYALA, (1996), The 8051 Micro-controller Architecture, Programming and Applications, INDIA.3rd Edition.

[6] MUHAMMAD ALI MAZIDI, JANICE GILLISPIE MAZIDI, (1999), The 8051 Micro-controller and Embedded, 2nd Edition. Systems, Prentice Hall, USA.

[7] B. RAM, Fundamentals of Microprocessors and Microcontrollers, 8th Edition.

[8] R. P. JAIN, Modern Digital Electronics, 4th Edition.