A modified version of potentiometer

R N Pathak* & Archana Maurya
Department of Chemistry, University of Lucknow, Lucknow 226 007, India

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The simple potentiometer circuit for emf measurements based on poggendorf’s compensation principle has been successfully modified by introducing four Push Buttons (each containing six-base pins) in place of simple on/off keys. The modified circuit enables one to compare the emf of 1:1 or 1:2 cells putting them parallel to meter wire without the botheration of connecting and disconnecting several electrical wires. In fact, it is the circuit which is a resultant obtained by coupling different stages of measurements into one circuit. Just press a button and the circuit changes to another one.

The idea of modification of the circuit, based on poggendorf’s compensation principle\textsuperscript{1,2}, came from the problems and difficulties which most of the students were facing during their experiments in emf measurements. Such as; (i) cadmium standard cell, though it is new, is not giving reading on the meter wire; (ii) only one sided deflection is coming with the experimental cell, though it was prepared with utmost attention and great accuracy, (iii) inability to judge whether the experimental cell is weak enough to give null point when it is put alone in the circuit; (iv) difficulty in checking previous reading with standard cell as they have to disconnect and reconnect several wires leading to loosening of contact-end of the potentiometer wire which lands them upon a defective circuit; (v) difficulty in handling the standard cell with great care, i.e., to keep it always in upright and vertical position. The modification in the circuit has eliminated almost all the above problems and difficulties encountered by the students.

Experimental

Description of the Push Buttons used in the modified circuit

Two types of Push Buttons have been used in new circuit (i) Single Push Button: This type of Push Button is shown in Fig. 1 and has been used at two places in the circuit. In the main circuit if it is pressed once it makes the circuit on. If it is pressed second time it makes the circuit off. Same thing happens in the experimental cell-circuit. This Button enables us to put the experimental cell ‘in’ or ‘out’ circuit. (ii) Double Push Button: This type of Push Button is shown in Fig. 2 and has been used at one place, constituting the central part of the circuit. It is a pair of two Push Buttons which are mechanically linked with each other. If one button is pressed down, other button comes up automatically and vice versa.

*For correspondence (E-mail: rn_pathak_1953@sify.com)
Brief description of the modified circuit

The old circuits of emf measurement, based on Poggendorf’s compensation principle\textsuperscript{1,2}, as shown in Figs 3 and 4, have been modified by the use of above Push Buttons, to give a combined circuit whose different stages of observations are shown in Figs 3 and 4. Basically Figs 3 and 4 are nothing but only one circuit which enables us to give the observations of emf measurements in all possibilities of cell combinations. This gives the minimum error and botheration and reduces the time of observations for an observer.

Referring to the modified circuit, which has been shown in four different stages, includes two-simple type Push Buttons, one with the battery (main circuit) and other with the experimental cell (auxiliary circuit). In the central part of the circuit one-double Push Button has been attached. The middle pin of LHS Push Button is connected to point A and of RHS Push Button to Jockey through galvanometer. The standard cell is attached between the upper two pins of LHS Push Button. One of the ends of experimental cell (i.e. positive end) is connected to A and the other end (i.e. negative end) to the lowest right pin of single Push Button. The other internal connections of central part of circuit have been done as shown in the modified diagram. Fig. 3 (a, b) shows the connections of the mechanically linked double Push Button in P and Q positions while Fig. 4 (a, b) shows the connections, in R and S positions of this Button.

The Fig. 3a differs with Fig. 3b or the Fig. 4a differs with Fig. 4b only in lower Push Button positions, i.e., \( K_1 \) changes to \( K_2 \); other things remaining the same.

Procedure

When the emf of a constructed cell (i.e. experimental cell) is to be measured, there may be two possibilities —

Case 1: When the experimental cell \( C_2 \) is strong enough to give reading, independently, on wire AB for which the emf is calculated by:

\[
\text{Emf of } C_2 = \frac{l_2}{l_1} \times \text{emf of } C_1
\]

Case 2: When the experimental cell \( C_2 \) is too weak to give reading on the wire AB, it is added in series, with standard cell \( C_1 \); the emf of \( C_2 \) is calculated by:

\[
\text{Emf of } C_2 = \frac{l_2 - l_1}{l_1} \times \text{emf of } C_1
\]

These two cases have been shown in Figs 3 and 4. Both the above possibilities have been coupled to give one circuit whose different stages of readings are shown in Figs 3 (a, b) and 4(a, b).

Method of observations

When the experimental cell is strong —Referring Figs 3a and 3b the double Push Button is kept at position P

\[\text{Fig. 3 — Old circuit which generally used in laboratories: (a,b)—Introducing 3 push buttons in auxiliary circuit: The two push buttons which are paired (shown in the middle of each circuit) are mechanically linked with each other. If LHS button pushed in, i.e., it is in ‘P’ position, the RHS button moves up, i.e., it comes in ‘Q’ position automatically.}\]
and Q, the reading $I_1$ of standard cell $C_1$ is taken at $K_1$ position and the reading $I_2$ of experimental cell $C_2$ is taken at $K_2$ position of single Push Button shown at the lower part of the circuit.

When the experimental cell is weak—Referring Figs 4a and 4b; the double Push Button is changed to position R and S by pressing RHS-Button; the reading $I_1$, of standard cell $C_1$ is taken at $K_1$ position and the reading, $I_1+I_2$, of combined cells (standard cell and experimental cell, both in series) is taken at $K_2$ position of single Push Button as before.

The speciality of this modified circuit is that just press a Button and the circuit changes over to another one, without disassembling of anything.

Discussion

So many problems based on emf measurements such as effect of dilution on electrode potential, emf of different types of concentration cells, pH of buffer solutions by quinhydrone and calomel electrodes and solubility of sparingly soluble salts have been successfully studied by this modified circuit.

Now the new circuit can answer the problems mentioned earlier.

(i) Cadmium standard cell, though it is new, discharges immediately if it is short-circuited by mistake. The user wonders over this type of damage when he learns about it by a multimeter. This does not happen with electrically operated standard cell.

(ii) The experimental cell is all-right still there is one sided deflection on the meter wire. The reason is that the main circuit is not working at the time of taking observations with experimental cell. The modified circuit checks this error immediately. One can go to previous reading with standard cell only by pressing Button. If same error is there, that means the main circuit is defective.

(iii) Sometime weak cells give null point position at the extreme LHS of the meter wire and the reading is too small to be noticeable. The problem is rectified within a fraction of a second by switching on the circuit to the next possibility of cell combination by pressing a Push Button.

(iv) As mentioned above the one circuit can be changed to another circuit only by pressing a Button, the reading of standard cell can be checked anytime when we need it.

(v) Since electrically operated standard cell is used in the circuit, there is no fear of handling the cell with great care.

This circuit has got several advantages over the old circuit. Few of them are listed below:

Advantages of modified circuit over the old circuit

(i) In the old emf measurement circuit, one has to face botheration of connecting and disconnecting several wires each time when the observations are taken but in our modified circuit, the
make and break of circuit are achieved only by the use of Push Buttons.

(ii) Our modified circuit helps, even an ignorant student, to ascertain whether the experiment cell has sufficient power to give the observations on the meter wire or it needs the help of standard cell too, in the circuit. This, one can find out merely, by the use of Push Buttons. By pressing one Push Button, the circuit automatically includes the standard cell with the experimental cell while by pressing the other adjacent Push Button, the standard cell excludes the circuit of experimental cell.

(iii) By this circuit, it is possible to verify the old reading of standard cell anytime if we desire so, within fraction of a second and again we can shift to the current observation being taken, immediately which minimizes the possibility of error due to voltage fluctuations if any.

(iv) In our modified circuit, the battery in the main circuit is immediately thrown out of circuit leaving both the ends of battery electrodes completely free leading to no possibility of leakage of battery whereas in the old circuit only one lead of the battery is disconnected resulting in a little possibility of leakage of battery if the observer makes a mistake or the key ‘K3’ is short circuited.

(v) Old circuit used cadmium standard cell which needed special precaution in handling while electrically operated standard cell is very easy to handle.

(vi) Cadmium standard cell immediately gets damaged by short circuiting of the electrodes by little mistake or negligence. It is difficult to change it frequently due to its high cost while there is no such recurring loss in the electrically operated standard cell.

(vii) This modified circuit is best suited for many scientific and research laboratories for young students at college levels and scientists working in such laboratories where there is no much facility of instrumentation.

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References