

One-chip conductivity meter monitors salt concentration

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Using a single quad operational amplifier, this inexpensive circuit measures the relative change in the concentration of a solution by checking its conductance. It automatically monitors the long-term variations in the electrical conductance of any ionized fluid—or more precisely, any solution of a salt.

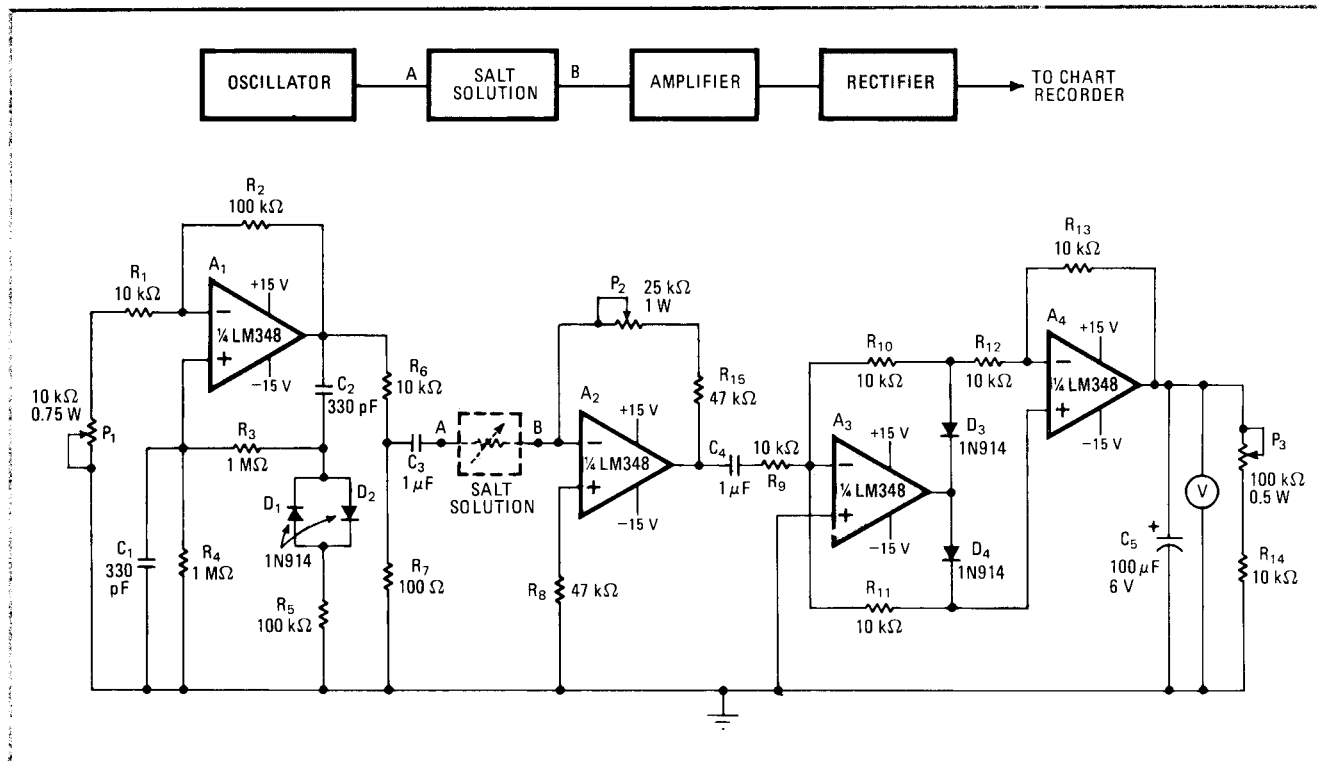
The circuit derives its long-term accuracy by passing an alternating current, rather than a direct current, through the solution, thereby eliminating the electrolysis effect which often causes large errors in measurement. Use of an op amp rather than a bridge circuit eliminates periodic manual adjustments and most nonlinearity. This permits continuous and unattended monitoring at an accuracy acceptable for most industrial applications.

Like metallic conductors, solutions of salts conduct electricity and obey Ohm's law, but a transfer of ions in the fluid, rather than electrons in a solid, takes place between the electrodes. Passing a direct current through the solution causes ions of like charge to cluster around the electrodes (the electrolysis effect), and this often acts to reduce current flow, causing errors when measuring solution concentration. To overcome this, an alternating current is sent through the solution as shown in Fig. 1.

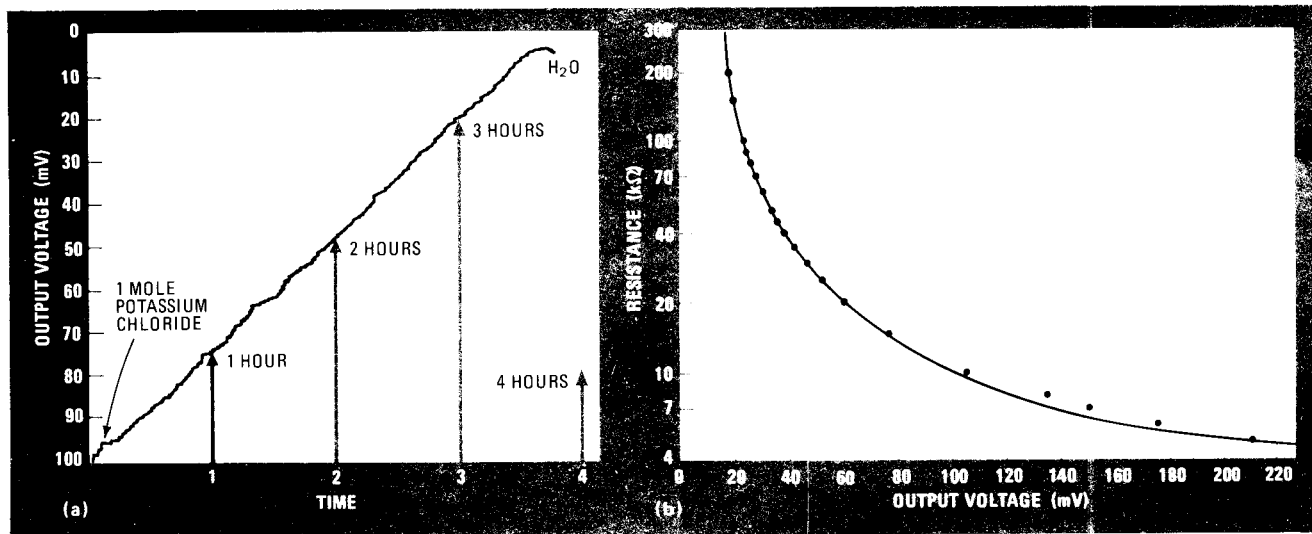
The salt solution may be characterized by a variable resistance. The voltage appearing at point B rises as the salt solution's concentration increases and is amplified and rectified in order to drive a chart recorder or a dc voltmeter.

A Wien bridge oscillator, having R_4C_1 and R_2R_3 as the arms of the bridge, generates a signal of about 1 kilocycle to drive amplifier A_2 through the salt solution. Potentiometer P_1 controls the oscillator's amplitude but has a small effect on oscillator frequency. P_2 adjusts the gain of stage A_2 as required.

The output of A_2 drives a precision rectifier composed of A_3 and A_4 , producing an output voltage equal to the absolute value of the input voltage. The rectified signal is



1. Conductivity checker. Meter uses one integrated circuit to measure relative change in concentration of salt solution by monitoring its electrical conductivity. It checks solution automatically and has good long-term accuracy, achieved by passing alternating current through solution, in lieu of direct current which causes electrolysis effect and measurement inaccuracies.



2. In action. One mole of potassium chloride is diluted over almost a 4-hour period (a). Output voltage is proportional to the salt concentration; the exact shape of the curve is dependent upon the salt tested. A curve showing relation of output voltage to solution "resistance" may be constructed (b). Alternatively, the ordinate may be calibrated in moles per cubic centimeter.

tered, or smoothed, by C_5 for the dc instrument. P_3 controls system calibration.

Figure 2a shows a typical test result obtained from the dilution of a solution of 1 mole of potassium chloride over almost a 4-hour period. The output voltage of the circuit is set at 100 millivolts at the start, and the KCl is gradually diluted by water introduced to the solution by gravity feed. The instrument probes are connected to the opposite ends of the beaker holding the salt solution.

Naturally, the shape of the curve depends upon the salt used and the test conditions. It should be noted that it is not unusual to perform tests that may require days to complete.

The instrument is not intended to measure the absolute value of the number of free ions in the solution or even the value of its electrical conductivity. Rather it

uses them only as an indicator of the relative change in fluid concentration. The exact number of free ions is difficult to determine accurately. In addition, determining the "conductivity" or "resistance" of a solution is meaningless in most applications.

If necessary, however, a curve of output voltage vs solution resistance or absolute concentration can be made for special applications, providing a quantitative measurement that is reasonably accurate. Simply substitute a resistance decade box for the salt solution and measure output voltage versus resistance as shown in Fig. 2b. Later, correlate the output voltage of the measured salt curve to resistance. Of course, the vertical scale in Fig. 2b can be calibrated in moles per cubic centimeter, which is the concentration, if the initial concentration of the fluid is known. □