A COMPACT, LOW-COST CIRCUIT FOR READING FOUR-ELECTRODE SALINITY SENSORS

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Abstract

An electrical circuit is described that uses a minimal number of components to measure soil electrical conductivity using the four-electrode salinity sensor. The portable circuit is compact, inexpensive, reliable, and easy to construct.

Additional Index Words: **soil salinity, soil electrical conductivity, soil electrical resistance, measuring salinity.**

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IN THE PAST, commercially available instruments for measuring soil electrical resistance by the four-electrode method were designed for geophysical purposes and were relatively large and expensive. In this manuscript, we describe an alternative circuit designed to be compatible with the "soil salinity probe" (Rhoades and van Schilfgaarde, 1976).[3,4] The small, easily operated circuit is convenient for making field salinity appraisals. The component's cost is less than $100.

Soil resistance is measured using four electrodes arranged with a fixed distance between them. A current is passed through the outside pair, and the voltage across the inside pair is measured. Since the current and voltage are known, the conductivity of the soil can be determined. The electrode tips may be inserted into the soil from above ground (Rhoades and Ingvalson, 1971) or the whole electrode assembly (the "soil salinity probe") may be inserted into the soil (Fig. 1).

Circuit Description

The circuit is shown in Fig. 2 and 3. A square wave is generated by the operational amplifier A1 (Texas Instruments TL081) and can be adjusted from 120 to 1,000 Hz by the frequency adjustment potentiometer. The two amplifiers A2 and A3 (National Semiconductor LM201) amplify the square wave to produce an alternating current that is passed through a 100-Ω null adjustment potentiometer and a four-electrode salinity sensor. (Note that the four-electrode salinity sensor is shown as three resistors between four electrodes. In this simplified representation the resistors represent the electrical resistance of the soil between the electrodes. The center resistor is the

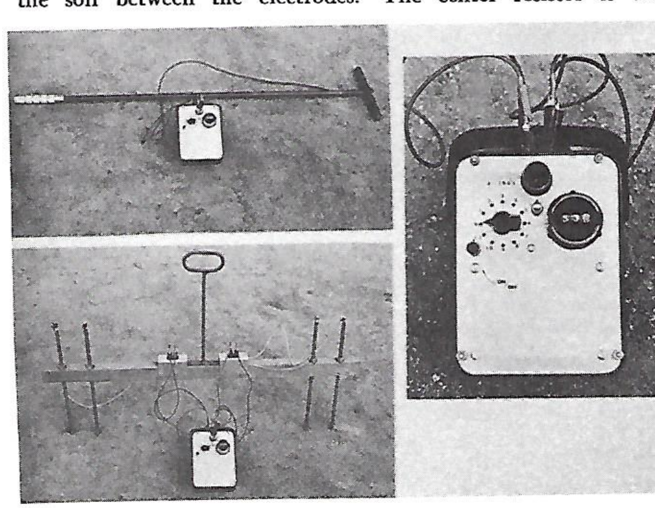

Fig. 1—New meter, shown with soil salinity probe, and horizontal array configuration of four electrodes.

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[3] Since this circuit was developed, a similar, commercial unit is now manufactured by Martek Instruments, Inc., Irvine, Calif., using different circuitry which reads out directly in conductivity instead of resistance, and includes temperature compensation.

[4] Mention of a particular product or company is for the convenience of the reader and does not imply any particular endorsement, guarantee, or preferential treatment by the USDA or its agents.

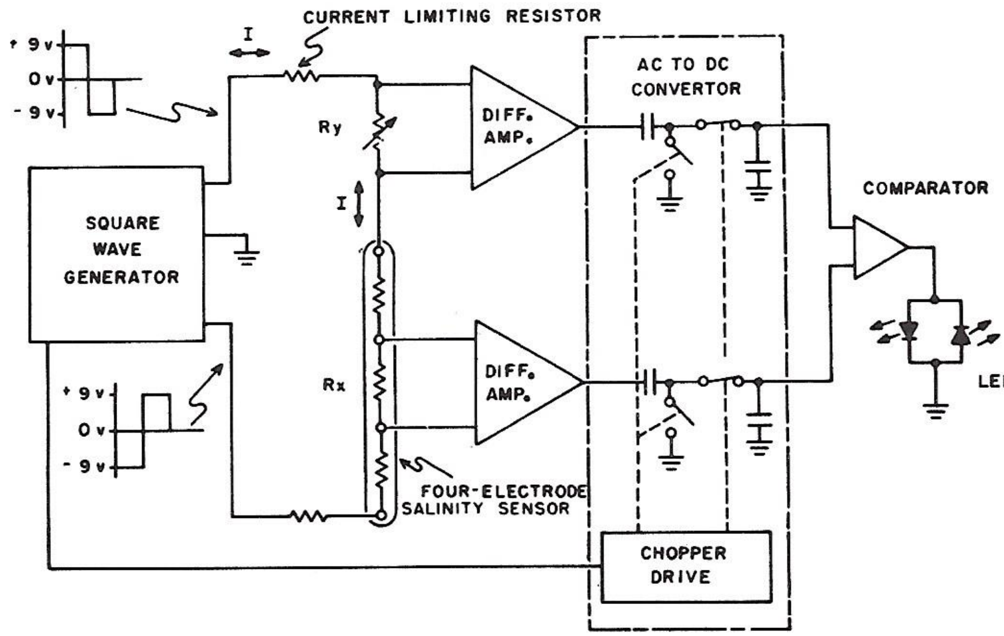

Fig. 2—Simplified diagram of the circuit. R_y, the resistance of the null adjustment potentiometer, is adjusted to equal R_x, the resistance of the salinity sensor.

resistance to be measured.) The differential amplifier A5 (National Semiconductor LF352) amplifies the voltage across the resistance between the two central electrodes of the probe and likewise A4 amplifies the voltage across the null adjustment potentiometer. The outputs from A4 and A5 are converted from alternating current (AC) to direct current (DC) by an analog switch (National Semiconductor LF13333) which is used as a chopper. The two converted voltages are then compared by A6 which lights an LED lamp corresponding to the higher voltage. When the null adjustment potentiometer is adjusted so that neither LED is lit, the resistance of the null adjustment potentiometer and the resistance of the sensor are equal. The sensor resistance is then read from the dial of the null potentiometer. The dial is a three-digital readout type from 00.0 to 99.9 Ω. Switch S1 is used to read resistances higher than 100 Ω by switching in 100-Ω resistors in series with the 100-Ω nul adjustment potentiometer and by switching in 1K Ω current limiting resistors to keep the signals to A4 and A5 within range. The four diodes on the input to A5 and the two on the input to the chopper are clamping diodes to protect the circuit. Since the gain of A4 and A5 must be the same, the 10K-Ω potentiometer of A4, pin 4, is used to match them. This

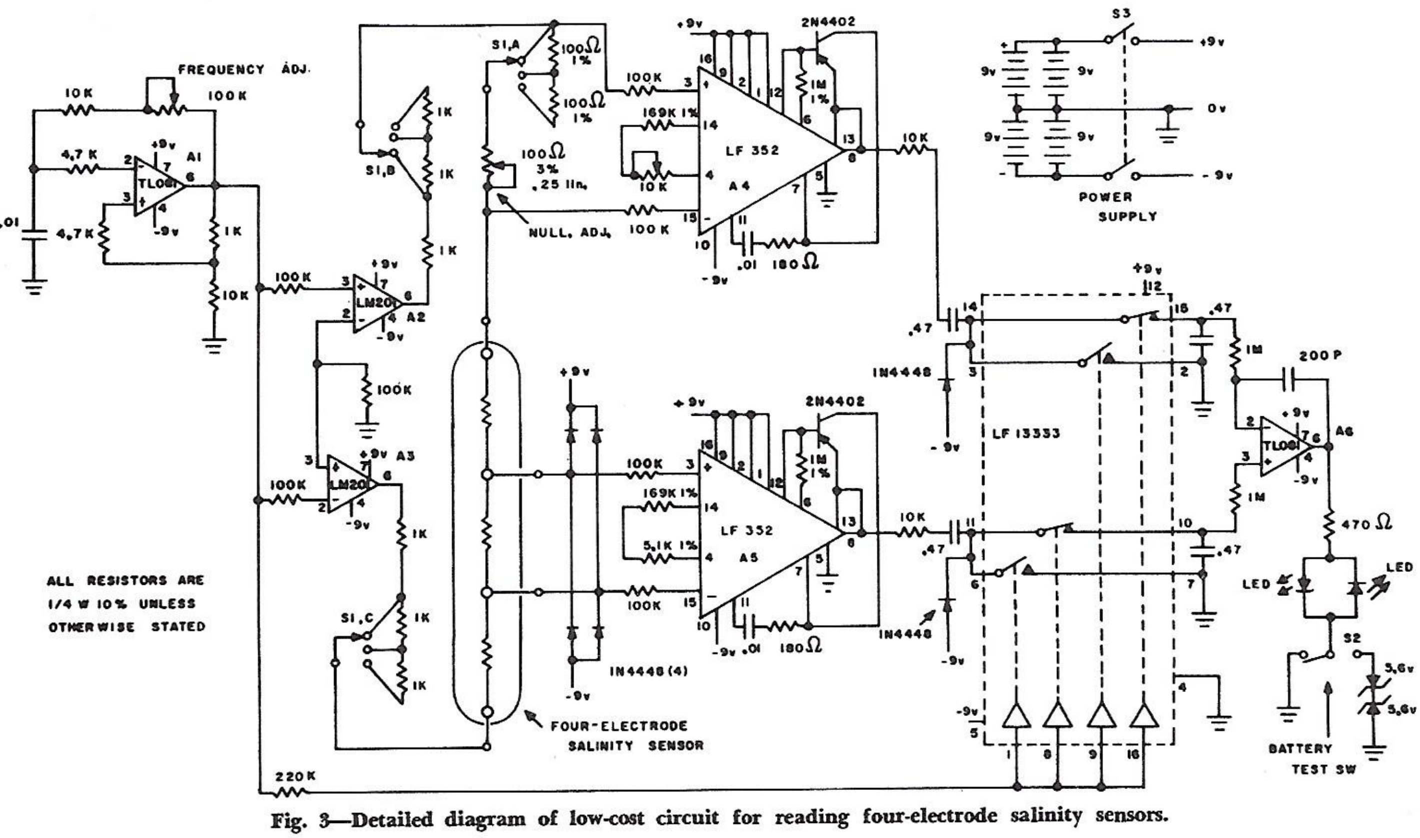

Fig. 3—Detailed diagram of low-cost circuit for reading four-electrode salinity sensors.

can be accomplished by adjusting the 10K-Ω potentiometer for a correct reading when known resistors are connected to the circuit in place of the four-electrode salinity sensor. Switch S2 allows the battery to be tested while taking a reading by simply switching in the zener diodes to see if each of the LED's will still light. Nine-V batteries were used because they are inexpensive and readily available; however, a plus and minus supply as high as ± 15V could be used. A pushbutton power switch is used to conserve battery life. At ± 15V the current drain is about 28 mA. Using the "heavy-duty" carbon-zinc type batteries (Eveready no. 1222), the expected battery life is 22 hours. Using the alkaline type batteries (Eveready no. 522), the expected life is 28 hours. A light shield was put around the LED lamps, so they could be easily seen even in direct sunlight.

Circuit Performance

Performance of the developed circuit was evaluated by measuring known resistors and also by comparing soil resistances with those obtained from a commercial geophysical earth resistivity meter (Bison Model 2350A). Compared to known resistors, the accuracy of the circuit was better than ± 0.3 Ω from 0 to 100 Ω, ± 2 Ω from 100 to 200 Ω, and ± 4 Ω from 200 to 300 Ω (or 2% of range). Soil resistances determined with the new meter agreed to within 2% of values determined with the commercial meter.

Literature Cited

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