Single Coax Carries Power and Signal for Remote pH Measurement

The system of **Figure 1** measures *pH* (*p*otential of *H*ydrogen), i.e., the acidity/alkalinity factor for a solution. The pH factor ranges from zero (most acidic) through 7 (neutral) to fourteen (most alkaline). By conditioning and amplifying the output of a special probe, the circuit produces an output voltage numerically equal to pH/10. It economizes on power as well as cabling—the remote op amp (IC_1) draws a quiescent current of only 1.2µA max.

System power is 15V. The precision reference (IC_2) delivers 10V power to the remote transmitter, which in turn delivers a signal current representing pH back along the same coaxial cable. Flowing through R_5, this signal current develops a voltage that is amplified by the differential amplifier (IC_{3A}), producing a single-ended output voltage of 0 to 1.4V. Capacitors C_1, C_3, and C_5 attenuate 60Hz noise.

The probe generates approximately 0mV for a neutral (pH7) solution. A voltage divider is therefore included (R_1/R_2) to offset the probe signal so V_{OUT} reads approximately the desired 700mV for this case. R_{13} lets you trim V_{OUT}, which includes the net effect of all other offsets in the circuit, to exactly 700mV while measuring a pH7 solution.

Typical probes generate 60mV/pH, so the nominal offset required at R_1/R_2 is 7 x 60mV, or 0.42V. But R_{13} can only decrease V_{OUT}. To ensure a useful adjustment range at R_{13}, the R_1/R_2 offset must equal 0.42V plus all additional (positive) offsets the probe and circuit can produce. For the circuit alone, a temperature change of 25 to 70°C causes a worst-case output error of only 21mV (one-fifth of a pH), assuming a 300MΩ output impedance for the probe. A key to this low level of error is the small change in IC_1's supply current—only 0.8µA (0.8 to 1.6µA) over the range 25 to 70°C.

Temperature also affects the slope of probe output vs. pH, causing the probe to contribute larger errors over temperature than does the circuit. To calibrate the system at a given temperature, set R_3 to midrange and place the probe in an acidic solution (typically pH4). Adjust R_{13} for an output of 400mV, then go to pH7 and adjust R_3 for an output of 700mV. R_3 and R_{13} adjustments interact, so you return to pH4, readjust R_{13} for V_{OUT} = 400mV, recheck the R_3 setting at pH7, and iterate as necessary until the calibration is satisfactory (±1% resistors will minimize these iterations). A probe output of 60mV/pH, for instance, requires 10.06Ω for the $R_3/R_4/R_5$ network.

(Circle 2)

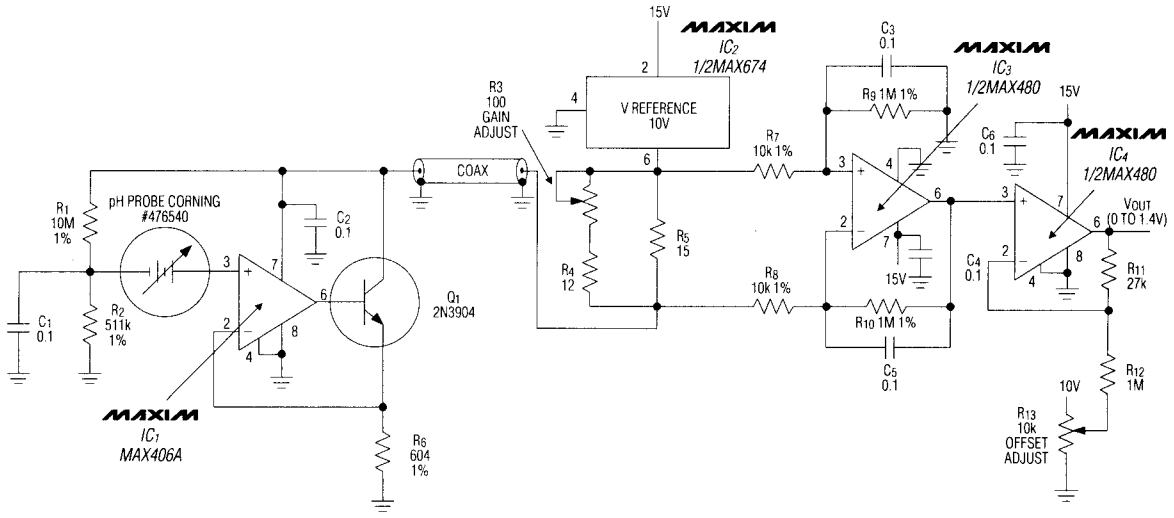

Figure 1. *This circuit lets you measure pH at a remote location, connected only by two wires or a coaxial cable.*