

and on the accuracy of the R6/R11 ratio. Q1 and Q2 should be of the same type (i.e., 2N3904). They were chosen as different types only for a more convenient simulation in PSpice.

For most applications, the V_{OUT}

accuracy is good enough. Higher accuracy is achievable by replacing the Q1-Q2 differential stage with an ultra-low-voltage op amp. In such a case, special attention should be paid to its “power-on” behavior.

ED Online 9136

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Simple Circuit Maintains Water Level Between Two Preset Limits

Ejaz ur Rehman

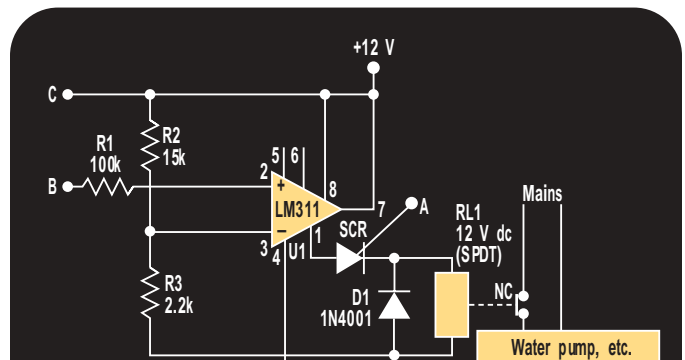
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There's an extremely simple water-level maintainer that keeps the water level between two predefined levels (see the figure). Due to the high input impedance of the LM311 IC (U1), practically no electrolysis of the metal is observed, and any non-toxic metal could successfully be used as sensors without any deterioration.

The circuit finds use in a variety of places. It can be successfully incorporated in all appliances where water levels are critical, such as chillers, boilers, and radiators. For those industries that must constantly monitor solvents and mixtures for their levels, this circuit can replace monitoring personnel. I tested this circuit for 15 days constantly. It worked perfectly, and the sensors weren't at all electrolyzed in water.

The LM311 was chosen for this circuit because it contains a built-in npn transistor at the output. The user sets the inverting input (pin 3), which is kept at a voltage level determined by the R2-R3 voltage divider. The noninverting input (pin 2) is connected to sensor B through R1 for lower-level detection of the



Note: Relay should be selected according to the current drawn by the load.
SCR = D106 or any general purpose

Because of U1's high input impedance, hardly any electrolysis takes place on the water-level sensors. Therefore, any non-toxic metal could be used for sensors A, B, and C.

water. The open collector of the built-in transistor (pin 7) is connected to the +12-V terminal. Also, the emitter of the built-in transistor (pin 1) is fed to the SCR's anode. And, the SCR's trigger is connected to sensor A for detecting the water's upper level. The anode, C, which is connected to the +12-V supply, is kept at the lowest water level, below B.

Assume you're starting with a full tank. Sensors A and B and anode C are covered. As sensor B gets a positive potential from anode C through hydrolysis in the water, the noninverting input of U1 is more positive than pin 3. Thus, the output state of the IC is high, and the SCR is

also triggered because its gate (connected to sensor A) gets positive potential from anode C through hydrolysis and is in a conducting state. Relay RL1 is energized, and its contacts are open. Therefore, no current flows to the water pump.

Now suppose the water is used and its level drops below sensor A (upper-level sensor). The SCR continues conducting because the lower-level sensor B is still in the water and the IC output is high. As soon as the water level drops below sensor B (lower-level sensor), the output state of the IC changes to low, thereby turning the SCR off. As a result, the relay is de-energized and the water pump is turned on to

fill water in the tank.

While the tank is filling with water, sensor B is covered first, which in turn changes the IC's output state to high. But the relay isn't energized because the SCR's gate (connected to the upper-level sensor A) isn't triggered yet. When the water touches the upper sensor A, the SCR is triggered, the relay is energized, the water pump is turned off, and the cycle repeats continuously. **ED Online 9137**

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Single-Supply Circuit Handles Bipolar Sensor Signals

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I recently had the task of designing an analog front-end circuit for a microcontroller application. A full-bridge sensor in a standard configuration produced the input signal.

An instrumentation amplifier then amplified the low-level signal and fed it to an analog-to-digital converter (ADC). After that, a microcontroller read and processed the data.

Due to the nature of the sensor and the apparatus to which it was connected, the sensor's output voltage was bipolar. I had to amplify and digitize that signal, but I couldn't find a single-supply op amp able to handle a bipolar input. Even worse, none of the single-supply ADCs that I found could handle a bipolar input.

After struggling for two days, I found parts that would do the job or create a decent alternative solution. Talking to engineers from major IC manufacturers didn't help either.

Suddenly, the light bulb went on and revealed an interesting solution. I used

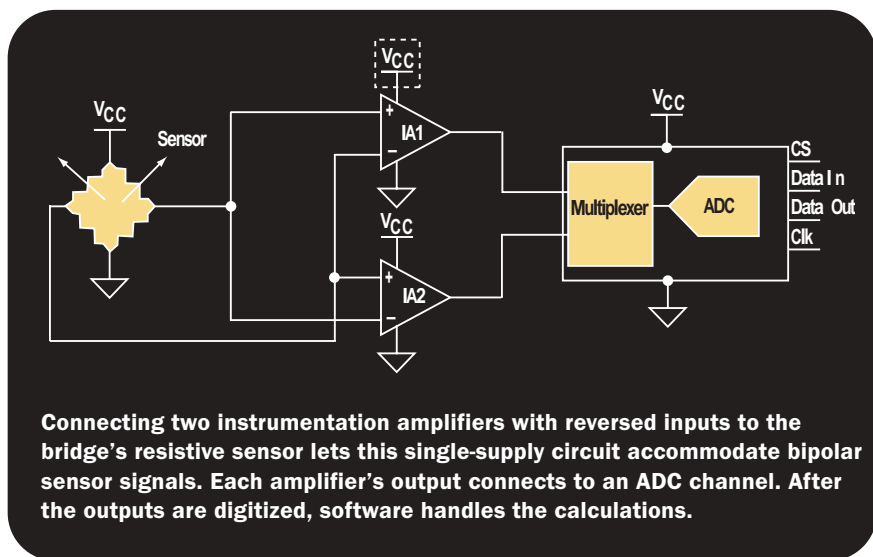
two instrumentation amplifiers (IA1 and IA2) with reversed inputs connected to the bridge's resistive sensor (see the figure). The output of each IA drove one of the ADC channels. (You need at least two available channels for this trick.)

Software handled the rest of the task. By monitoring the voltages on the two channels, I was able to predict the direction and measure the magnitude of the signal produced by the sensor.

The original circuit used an INA122

instrumentation amplifier and an LTC1594 four-channel ADC. Adding an extra INA122 chip and some code modifications eliminated the need for a bipolar power supply, all new op amps, and a different ADC. **ED Online 9138**

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Op Amp Idles To Save Power In Smoke Detectors, Other Sensors

With its power-saving mode, the LMV422 operational amplifier lets designers reduce power consumption while maintaining an active circuit. Thus, there's faster turn-on times in smoke detectors and other sensor interface applications where reaction time is critical. This dual rail-to-rail op amp can be switched between its nor-



mal 400- μ A/channel, 8-MHz mode to an economical 2- μ A/channel, 27-kHz mode via an external control pin. Running the amp in its low-power operational mode reduces overall power consumption while maintaining necessary charges on coupling capacitors. It also shortens the time needed to stabilize the signal after switching to high-power mode. The chip has a 5-pA input bias and runs off supplies from 2.7 to 5 V. Its common-mode rejection ratio is 85 dB. The LMV422 costs \$1.20 in 1000-unit quantities.

ED Online 9139
National Semiconductor Corp.
www.national.com

Smart Dual-Channel DC Motor Controller Drives Mobile Robots

It's now possible to directly drive up to 60 continuous amps on each channel of a dual-channel dc motor controller at up to 40 V. The microcomputer-based AX3500 provides optical-encoder input for automatic guided vehicles, underwater remotely operated vehicles, and mobile robots for exploration, hazardous material handling, and military and surveillance applications. The 4.2- by 6.75-in. device accepts commands from either a standard R/C radio or a serial-port interface that allows it to be connected to single-board computers, wireless modems, or wireless local-area network adapters in fully autonomous or semi-autonomous robots. It has inputs for two quadrature encoders up to 250 kHz and four limit switches. The two channels can be operated independently or combined for differential steering. The AX3500 is available for \$395 in single quantities, complete with cable and PC-based configuration software.



ED Online 9140
Roboteq
www.roboteq.com

Power Supplies Kick Out Rated Power Times Two For 10-Second Bursts

Where 24-V peak-current demand is needed for a short duration, the 5- and 24-V ZWD family of dual-output power supplies can deliver 200% of the nominal current rating for up to 10 seconds. These supplies are available with a 5-V, 5-A output for powering logic and auxiliary power circuits, as well as a 24-V output that can deliver a peak current of up to 18 A. Cooled at 50°C, the ZWD100PAF offers continuous 100-W convection and 196-W peak, the ZWD150PAF yields 150-W convection and 294 W peak, and the ZWD225PAF delivers 225-W convection with a peak of 440 W. All three accept input voltages from 85 to 265 V ac and contain active power-factor-correction (PFC) circuitry to meet EN61000-3-2 standards.



They also meet EN61000-4-X immunity and Class B electromagnetic interference standards. In addition, they're safety-approved to UL60950, CSA60950, EN60950, and EN50178 specifications, plus they're CE-marked. Prices start at \$94 in single-unit quantities.

ED Online 9141
Lambda Power
www.lambdapower.com

Fan-Free 1U Supply Reaches 400 W

The Series 1720 1U-high rackmount dc-dc converters provide 400 W without the need for fans. Input voltages include 24, 48, and 130 V dc. Standard isolated and regulat-



ed output voltages are 12, 24, and 48 V dc. Other combinations are available. The converters can be paralleled for additional power and/or redundancy. Single-piece pricing is \$574.

ED Online 9143
Wilmore Electronics
www.wilmoreelectronics.com

Two- And Four-Channel Audio ADCs Target Professional Production Gear

Professional and broadcast audio boards, which typically process many audio channels, are the target application for two high-performance, 24-bit audio analog-to-digital converters (ADCs). The PCM4202 and PCM4204 offer a 118-dB dynamic range, -105-dB total harmonic distortion, and sampling rates up to 216 kHz. Perhaps their most important attribute in audio gear is their low

150-mW per channel power consumption. The two-channel PCM4202 and four-channel PCM4204 include a 3.3-V logic-interface audio serial port that supports both standard pulse-code-modulated and time-division-multiplexing data. Both devices operate from a +5-V analog supply and a +3.3-V digital supply. The PCM4204 comes in a HTQFP-64 PowerPAD, and the PCM4202 is housed in a SSOP-28. Pricing is \$7.95 each in thousand-unit lots.

ED Online 9144
Texas Instruments Inc.
www.ti.com



Pin-Strapping Selects Internal Resistors To Set Gain

While traditional amplifiers use external resistors to set gain, a new amplifier family integrates on-board thin-film precision resistors that can be selected by pin-strapping. Users can configure the LT1991 and LT1995 as difference, summing, inverting, or non-inverting amplifiers with various gain options without using any external components. The precision LT1991 has a 560-kHz gain-bandwidth product. As a difference amp, gain is programmable from 1 to 13; as a non-inverting amp, from 0.07 to 14; and as an inverting amp, from -0.08 to -13, all with a guaranteed maximum gain accuracy of 0.04%. It has less than 50-mV input offset with a 50-pA input offset current. Offset voltage drift is 1 $\mu\text{V}/^\circ\text{C}$, and gain drift is less than 3 ppm/ $^\circ\text{C}$. The amp has rail-to-rail output

and operates on supplies from 2.7 to 36 V, drawing less than 110 mA from a single 5-V supply. The high-speed LT1995 offers a 32-MHz gain-bandwidth product. As a difference amp, gain is programmable from 1 to 7; as a non-inverting amp, from 1 to 8; and as an inverting amp, from -1 to -7, with a guaranteed maximum gain accuracy of 0.2%. It has less than 2.5-mV input offset. The LT1995 can slew at 1000 V/ μs and settles to 0.1% in 100 ns. It operates on supplies from ± 2.5 to ± 15 V, drawing less than 9 mA. Thousand-piece pricing starts at \$1.39 each for the LT1991 and \$1.89 each for the LT1995.

ED Online 9145
Linear Technology Corp.
www.linear.com

Temperature-Sensor IC Monitors Seven Channels Simultaneously

A small-footprint (8.5 by 6 mm), seven-channel temperature-sensor IC reads thermal diodes or thermistors to 1 $^\circ\text{C}$ accuracy. The MAX6697 measures its own temperature as well as the temperature of up to six external locations, such as CPUs, GPUs, or memory devices. For industrial applications, the MAX6698 can measure three thermistors and three remote diodes. Both chips communicate through an SMBus interface and operate from a 3- to 5-V supply. Operating current is 500 μA , while standby is 3 μA . Prices start at \$3.75 each in lots of 2500 and up.

ED Online 9146
Maxim Integrated Products
www.maxim-ic.com