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Featured Products

Sub-1 μ A 12V Op Amp with Rail-to-Rail Inputs

The LPV511 is a unity gain stable micropower operational amplifier that operates from a voltage supply range as wide as 2.7V to 12V, with guaranteed specifications at 3V, 5V, and 12V. The excellent speed-to-power ratio draws only 880 nA of supply current with a unity gain bandwidth of 27 kHz. The LPV511 has an input range that includes both supply rails for ground and high-side battery-sensing applications. The output swings within 100 mV of either rail to maximize the signal dynamic range in low supply applications.

Features

- High supply voltage range of 2.7V to 12V
- Supply current less than 900 nA
- Output voltage swing of 100 mV from rails
- Rail-to-rail inputs and outputs
- High PSRR (84 dB) ensures higher accuracy in battery applications
- Unity gain stable with 50 pF load



The LPV511 is ideal for applications including battery-powered systems, security systems, solar-powered systems, and remote sensor amplifiers. The LPV511 is available in the space-saving SC70-5 package, and is built on the advanced VIP50 process technology.

www.national.com/pf/LP/LPV511.html

www.national.com/see/VIP50



DESIGN | *idea:* Solar Cell Remote Sensors ►►►



Ultra Low-Power, 600 nA Comparator with 6.6 μ s Propagation Delay

The LPV7215 comparator with guaranteed 645 nA supply current operates down to 1.8V. Maximum operating voltage is 5.5V. It features CMOS rail-to-rail input voltages and a push-pull output stage, allowing operation with the absolute minimum amount of power consumption while driving resistive loads. The LPV7215 comparator is optimized for low power, 580 nA (typ), single supply operation while still providing a fast propagation delay of 6.6 μ s. This makes the LPV7215 more than twice as fast as other SC-70 comparators offered in the industry.

Features

- Ultra-low power consumption 580 nA
- Propagation delay 6.6 μ s
- Wide supply voltage range 1.8V to 5V
- Rail-to-rail inputs and outputs

The LPV7215 is ideal for applications including mobile phones, PDAs, notebook computers, and window comparators for voltage detection. The LPV7215 is available in space-saving SC70-5 and SOT23-5 packages, and is built on the advanced VIP50 process technology.

www.national.com/pf/LP/LPV7215.html

www.national.com/see/VIP50

Energy Scavenging for Remote Sensors

A recent concept being implemented to power circuits is using energy scavenging. This makes use of energy collection through solar cells, piezoelectric generators, or other energy conversion devices. These devices collect energy from diffuse sources, convert it to electricity, and typically store it in a capacitor until it is required. In many situations, the sensor circuitry is not required to operate continuously and the energy storage is replenished during the sensor off periods. In this example, a solar cell and a one-farad capacitor are used to power a remote motion-detector that uses an RF link to transmit the occurrence of any moment to a central monitor. This type of sensor is advantageous because wiring is not required and battery replacement is eliminated.

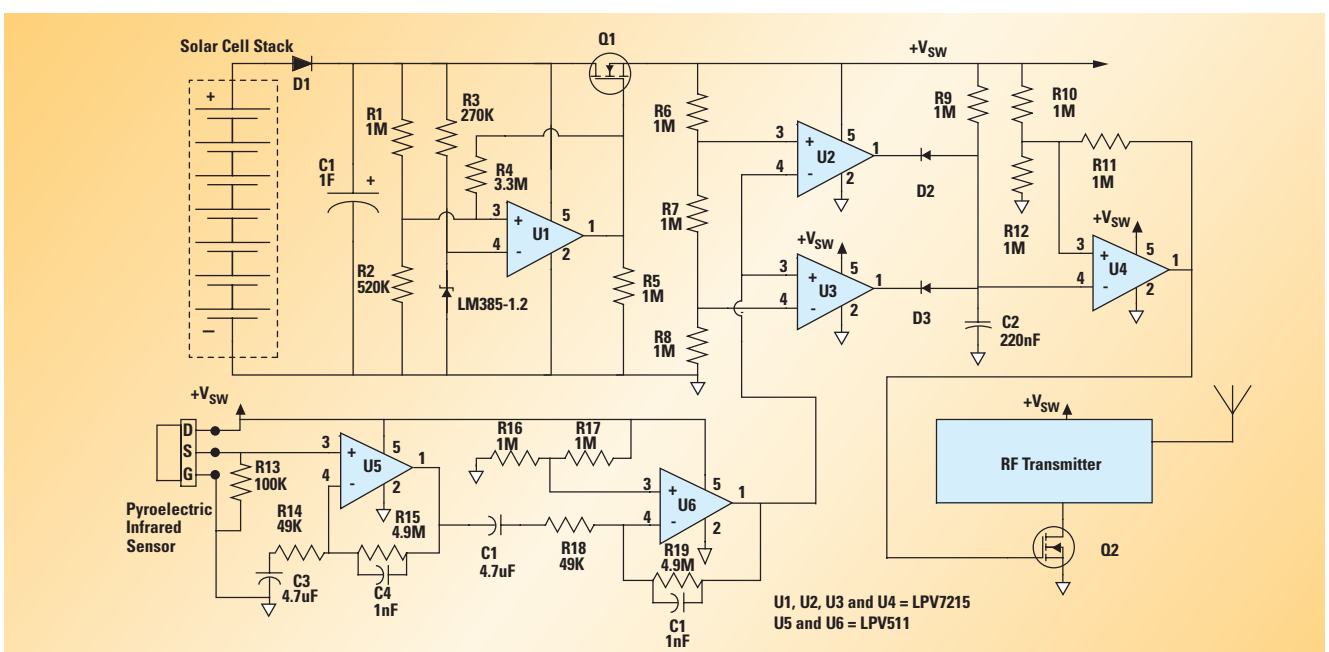
Some circuitry is required to monitor the voltage on the capacitor and to signal other circuits that there is enough voltage to turn on and perform some processing. When the capacitor voltage drops below a predetermined voltage, the circuitry is disabled. In conjunction with the capacitance, the voltage on the capacitor is a measure of how much energy is available to power the external circuits. Typically, the energy scavenging transducers cannot supply enough energy to power the circuitry continuously. The capacitor is used to accumulate enough energy to power the circuitry for a period of time.

In this example (Figure 1), amorphous silicon photovoltaic cells are used, which are low-cost devices that can power circuits from ambient indoor lighting as well as outdoor lighting. Trade offs can

be made in the size of the cells, size of the storage capacitor, and how often the circuitry must operate. The voltage monitoring circuit is used to isolate the load circuitry from the energy scavenging components until enough energy is available for the circuitry to complete a task. The solar cell stack (D1 and C1) is the energy collection and storage component.

The monitoring circuitry must be very low power and operate over a wide supply voltage range. The circuit in Figure 1 uses the LPV7215 comparator, which has a typical operating current of 580nA for the monitor function. The LPV7215 is used with the threshold and hysteresis setting resistors R1, R2, and R3, and the LM385-1.2 voltage reference to control a FET switch, Q1,

Figure 1. Solar Powered Motion Detector with an RF Link



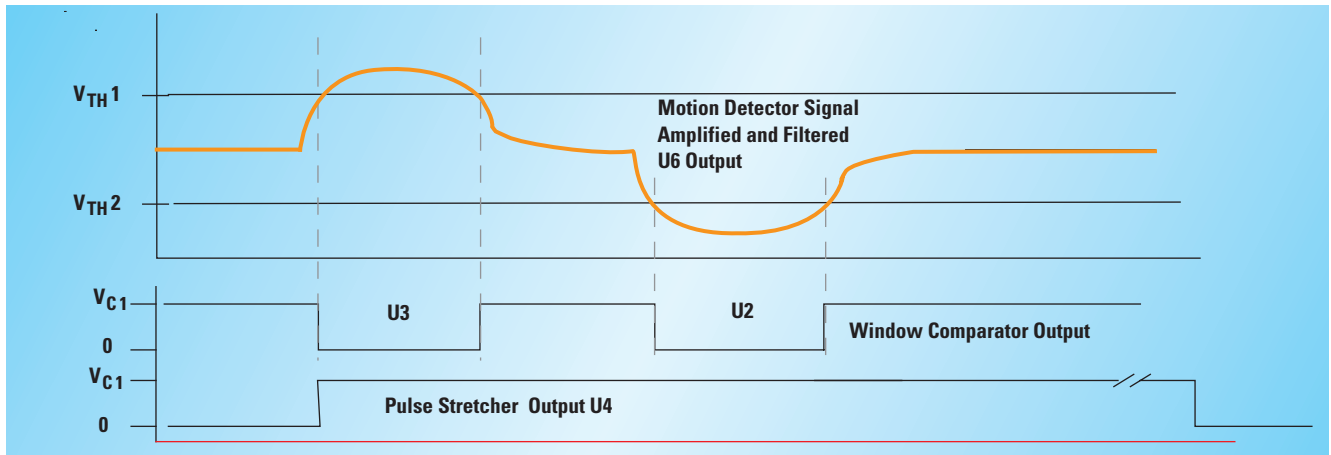


Figure 2. Motion Detector Signals

to turn on power to the motion detection circuitry. The FET is on when the voltage on C1 is greater than 4V and off when the voltage on C1 is less than 3V.

The motion detection circuitry uses a pyroelectric sensor followed by a high-gain band pass filter. The amplifiers U5 and U6 are LPV511 and have a typical operating current of only 880 nA while maintaining a 27 kHz gain bandwidth. The complete motion detection circuit only requires about 4 μA total. *Figure 2* shows the output of amplifier U6 when a warm body moves across the field of vision of the pyroelectric sensor in addition to the window comparator and pulse stretcher signals.

The output of U6 is the input of a window comparator made from two LPV7215 comparators, U2 and U3, and resistors R6, R7, and R8. The threshold voltages are set at 1/3 and 2/3 of the switched voltage, +V_{sw}. The comparator's output switches low when the motion detector signal swings above or below the threshold values. The outputs of the comparators are OR'ed together into a pulse stretcher through diodes D2 and D3. The pulse stretcher, which is composed of U4, an LPV7215 comparator, and C2, R9, R10, R11, and R12, generates about a 0.5 second pulse that turns on the RF transmitter through Q2. The RF transmitter requires about

25 mA while the detection and monitoring circuitry requires only about 20 μA.

Calculating the capacitor size for energy storage requires an estimate of the current flow in the circuitry, what is the voltage change on the capacitor and how much time is required complete a task. For example, when the transmitter is active, the circuitry of *Figure 1* requires about 25 mA for operation. The solar cell selected can supply about 5.5V at 10 mA and can charge C1 to about 4.9V. (Solar cell voltage minus the diode, D1, equals voltage drop of about 0.6V.) The time the circuitry can operate for a change in C1 capacitor's voltage from 4.9V to 3.0V is calculated from:

$$t = \frac{CdV}{i} = \frac{1F \cdot 1.9V}{0.025A} = 76 \text{ secs}$$

The transmitter is turned on for 0.5 seconds for each transmission so the motion detector can transmit about 156 times (76/0.5), without any recharging, before the capacitor is drained below the turn-off voltage of 3V. During normal operation, the solar cell is constantly recharging C1 when light is available.

The second area of concern for the energy storage is how long the motion detection circuit can operate without the capacitor being recharged. Using the equation above, calculate the operation

time for the motion detection and voltage monitoring circuits using an estimated current of 20 μA and a change in capacitor voltage from 4.9V to 3.0V:

$$t = \frac{CdV}{i} = \frac{1F \cdot 1.9V}{0.000020A} = 95000 \text{ secs} = 1.1 \text{ days}$$

A final concern is when this circuitry is first installed. It will take some time to charge C1 to the circuit's operating voltage. This can be estimated by the following calculation:

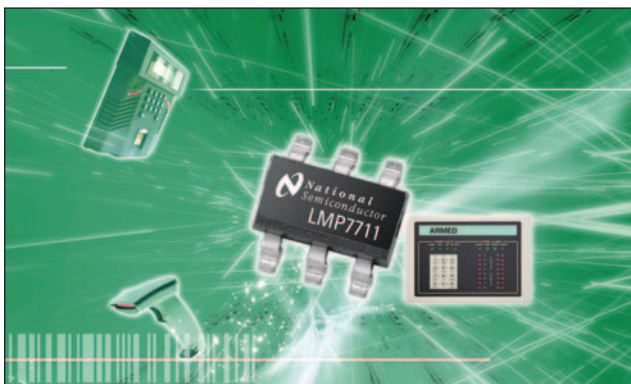
$$t = \frac{CdV}{i} = \frac{1F \cdot 3.0V}{0.010A} = 300 \text{ secs}$$

An alternative to waiting for the solar cell to charge C1 is to connect C1 to a 5V source and charge it just before installation.

This example demonstrates the use of very low-power amplifiers and comparators to implement remote wireless self-powered sensors. The motion detector circuitry shown here can be replaced with many other types of sensors such as temperature, humidity, and leak detectors. ■

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Featured Products



17 MHz, Rail-to-Rail Output, Low-Noise, Low-Power Amp

The LMP7711 is a low-noise, low-voltage, low-power amplifier with a very low offset. The unity-gain bandwidth is 17 MHz with a low-input voltage-noise density of $5.8\text{nV}/\sqrt{\text{Hz}}$, and a quiescent current of 1.4 mA (max). It provides rail-to-rail output swing into heavy resistive or capacitive loads. The LMP7711 has a built-in enable feature minimizing current consumption to 140 nA. The maximum input offset voltage is only 150 μV . The operating voltage range of this amplifier varies from 1.8V to 5.5V.

Features

(Typical 5V supply, unless otherwise noted)

- Guaranteed 1.8V and 5.0V performance
- Low 1/f noise $5.8\text{nV}/\sqrt{\text{Hz}}$ at 400 Hz
- Supply current: 1.15 mA
- Input bias current: 100 fA
- High PSRR (100 dB) ensures higher accuracy with noisy supplies
- High CMRR (100 dB) ensures high accuracy over a wide input range

The LMP7711 is ideal for applications including high-impedance sensor interfaces, battery-powered instrumentation, high-gain amplifiers, active filters, pH electrode buffers, and audio front-end buffers. The LMP7711 is available in thinSOT23-6 packaging and is built on National's advanced VIP50 process technology.

www.national.com/pf/LM/LMP7711.html
www.national.com/see/VIP50

High Common-Mode, Bidirectional Precision Voltage Difference Amp

The LMP8271 is a fixed-gain differential amplifier with a -2V to 27V input common-mode voltage range and a supply voltage range of 4.75V to 5.5V. This precision amplifier will detect, amplify, and filter small differential signals in the presence of high common-mode voltages. The LMP8271 also can operate over an extended voltage range of -2V to 36V with reduced specifications. This feature makes the device suitable for applications with load dump in automotive systems. The mid-rail offset adjustment pin enables this device to be used for bidirectional current sensing.



Features

(Typical Values, $T_A = 25^\circ\text{C}$)

- Bidirectional current sense capability
- Internal set gain of 20V/V with filter network feature
- Input offset voltage: $\pm 1\text{ mV}$ max
- TC V_{os} $\pm 15\ \mu\text{V}/^\circ\text{C}$ max
- CMRR: 80 dB min
- Extended CMVR -2V to 36V
- Output voltage swing Rail-to-Rail
- Bandwidth: 80 kHz
- Supply voltage: 4.75V to 5.5V
- Supply current: 1 mA

The LMP8271 is ideal for applications including fuel injection controls, high- and low-side driver configuration current sensing, and power management systems. The LMP8271 is available in SOIC-8 packaging.

www.national.com/pf/LM/LMP8271.html