Low Power Comparator for Signal Processing and Wake-Up Circuit in Smart Meters

Infrared (IR) communication is inherently immune to RF interference as long as there is a line-of-sight path between the transmitter and the receiver. It is also one of the lowest cost communication schemes. This makes it a good choice for implementing wireless communications in applications such as utility metering. These smart utility meters are hermetically sealed and use a combination of batteries and solar cells to power the system.

Maintenance in the field can be costly, so minimizing system power consumption to extend battery life is desired. A common system topology to extend battery life is to use a power efficient IR receiver analog front end (AFE) that is always on and wakes up the host only when there is a valid IR signal detected as shown in Figure 1. Power efficient comparators such as the TLV7031 can be used in the IR receiver AFE to increase battery life.

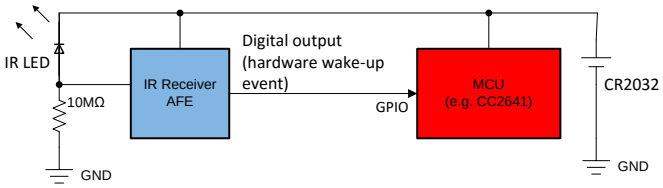

Figure 1. Coin Cell Battery Powered IR Receiver

The TLV7031 device is responsible for two major tasks:

1. IR signal conditioning
2. Host system wake-up.

The benefits of TLV7031 for this application include the following:

1. Nano quiescent supply current (335 nA)
2. Low input bias current (2 pA) which allows a greater load resistor value

TLV7031 is constantly powered to always be ready to receive IR signals and wake up the host microcontroller (MCU) when data is received. The short working distance (approximately 5 cm) is suitable for a virtual-contact operation where the IR transmitter and receiver are closely placed with an optional mechanical alignment guide.

Figure 1 shows the IR receiver system block diagram. The host MCU is normally in the shutdown mode (during which the quiescent current is less than 1 µA) except when data is being transferred.

Figure 2 shows the detailed circuit design. The circuit establishes a threshold through R2 and C1 which automatically adapts to the ambient light level. To further reduce BOM cost, this example uses an IR LED as the IR receiver. The IR LED is reverse-biased to function as a photodiode (but at a reduced sensitivity).

The low input bias current allows a greater load resistor value (R1) without sacrificing linearity, which in turn helps reduce the always-on supply current.

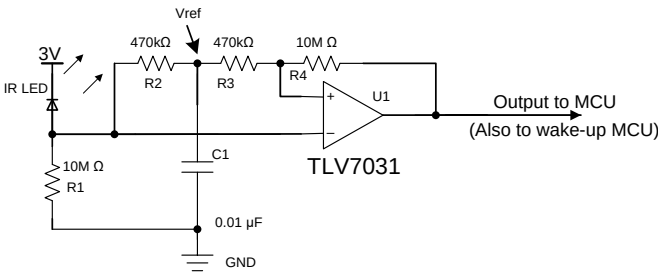

Figure 2. IR Receiver AFE Using TLV7031 (Push-Pull Output)

The load resistor R1 converts the IR light induced current into a voltage fed into the inverting input of the comparator. Figure 3 shows a scope capture of the load signal across R1 vs. comparator output. R2 and C1 establish a reference voltage Vref which tracks the mean amplitude of the IR signal. The noninverting input is connected to Vref through R3. And finally R3 and R4 are used to introduce additional hysteresis to keep the output free of spurious toggles.

Copyright © 2017, Texas Instruments Incorporated

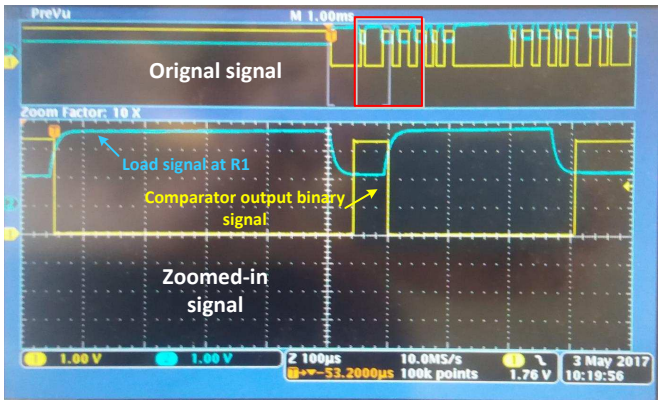

Figure 3. Scope Capture of the Load Signal vs. Comparator Output

To achieve years of operation running on a single coin cell battery, the host MCU must be put in the shutdown power state. Most TI MCUs like the CC2640 and MSP-430 consume under 100 nA when placed in the shutdown state. The MCU wakes up when data is received. After the data transmission is complete, the MCU reverts to the shutdown state and the overall supply current drops back to the micro amps level.

Table 1 shows a power budget based on the following assumptions:

1. The aggregated always-on quiescent current is estimated as 2 µA, which includes the TLV7031 quiescent current, divider network current, and the MCU and supporting devices current in the shutdown state.
2. Peak current during active data transmission and RF radio operation is estimated as 30 mA.
3. Each active session last for 30 seconds or less for every 30 days or longer.
4. The coin cell is based on an Energizer CR 2032, which is specified at 240 mAh and includes a 1% annual self-discharge rate. For further details on current drain impact on the capacity, refer to reference 1 in Section 1.

Table 1. CR2032 Coin Cell Battery Lifespan

PARAMETER	
Aggregated always-on Current	2 µA
Peak Current (Wireless Radio + IR LED)	30 mA
Active Duration/Frequency	30 sec/30 days
CR 2032 Coin Cell Battery Capacity	240 mAh
CR 2032 Lifespan (minimum)	5 years

Table 2. Alternative Device Recommendations

Device	Optimized Parameters	Performance Trade-Off
TLV3691	75nA IQ, Package: SC70-5, QFN-6	Slower rate of communication
TLV3701	16V VS (Max), Package: SOT-23, SOIC, PDIP	Slower rate of communication

1 Related Documentation

1. Texas Instruments White Paper, 2010, *Coin Cells and Peak Current Draw* (SWRA349)

1.1 Trademarks

All trademarks are the property of their respective owners.

Copyright © 2017, Texas Instruments Incorporated

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ('TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products http://www.ti.com/sc/docs/stdterms.htm), evaluation modules, and samples (http://www.ti.com/sc/docs/sampterms.htm).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated