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.

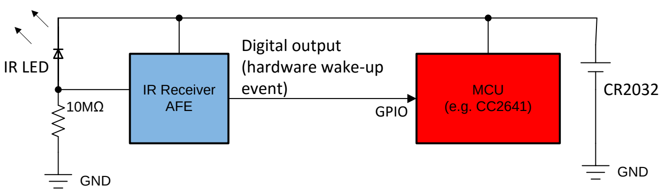

Figure 1. Coin Cell Battery Powered IR Receiver

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.

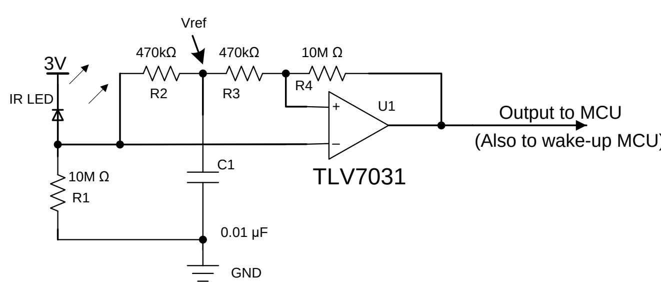

Figure 2. IR Receiver AFE Using TLV7031 (Push-Pull Output)

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.

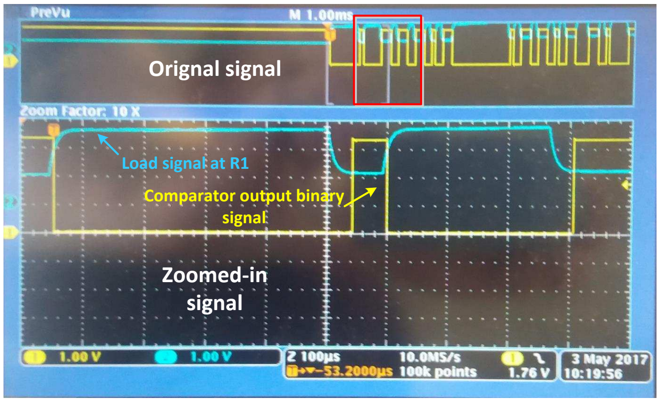

Figure 3. Scope Capture of the Load Signal vs. Comparator Output

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)

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