

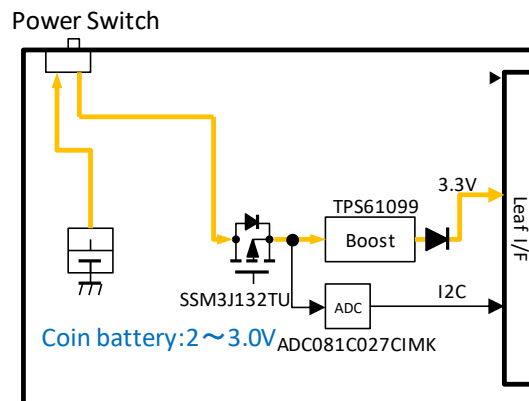
AV02 CR2450

1. Description

CR2450 This is a leaf provides 3.3V to every leaf. This has coin battery holder, converts source voltage 3V to 3.3 by using the power boosting circuit and has a switch to turn on and off the 3.3V. Also, this leaf has AD converter to monitor power voltage.

2. Leaf specification

2-1. Block diagram



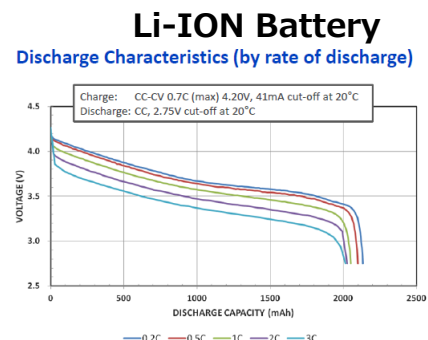
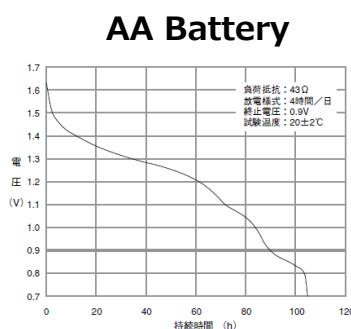
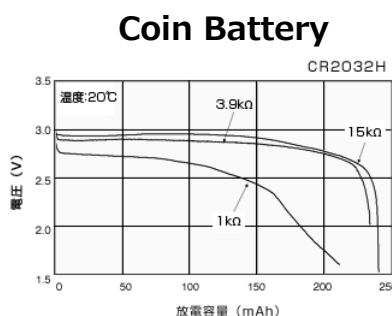
2-2. Power supply specification

| Symbol | Parameter | Condition | Min. | Typ. | Max. |
|--------|-----------------|-----------|-------|------|-------|
| Vbatt | Battery Voltage | — | 0.7V | - | 3.8V |
| Vout | Output Voltage | — | 3.23V | 3.3V | 3.37V |
| Ilim | Current limit | — | 0.8A | 1A | 1.25A |

2-3. Battery voltage monitoring function

Battery leaf has 8bit AD converter and has a function that monitors power voltage by using I2C. AD converter's reference voltage is 3.3V in 8bit resolution and cuts the voltage to half in AD converter's input. Therefore $3.3V/2^8 \times 2 = 26mV$ is 1LSV of the reading value of AD converter.

Typical characteristic of discharge by types of batteries are in below. Notice that the power voltage will decrease when there is load compared to when there isn't.



Reference

- ① http://biz.maxell.com/ja/primary_batteries/images/i_lineup00108.gif
- ② <https://industrial.panasonic.com/cdbs/www-data/pdf2/AAC4000/AAC4000CJ31.pdf>
- ③ <https://industrial.panasonic.com/cdbs/www-data/pdf2/ACA4000/ACA4000CJ284.pdf>

2-4. Practice of battery voltage measurement by tester in term of physics

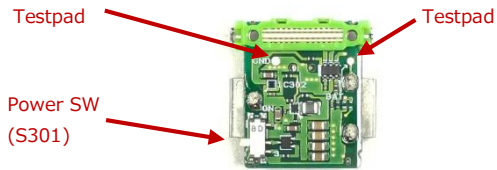
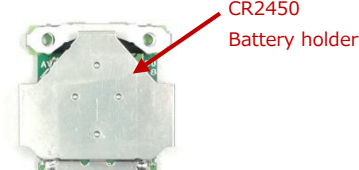
It is possible to measure directly by tester, because that the pad measures battery voltage is set on every battery leaf like the figure below.

2-5. Main parts

| Reference No. | Part name | Part number | Vendor name | note |
|---------------|------------------|----------------|-------------------|---|
| IC281 | Boost voltage IC | TPS61099YFFR | Texas Instruments | — |
| IC283 | AD Converter | ADC081C027CIMK | Texas Instruments | I2C address for battery voltage monitoring : 0x50(It is possible to alter to 0x51 or 0x52 by changing the chip) |

※I2C address is listed in 7bit

2-6. Appearance

| Top Side | Back Side |
|---|---|
|  |  |

2-7. Pinout

| Name | Function |
|------|-------------------------|
| SCL | I2C communication clock |
| SDA | I2C communication data |
| 3V3 | 3.3V output |
| GND | GND |

3. Boost voltage IC(TPS61099YFFR) Specifications

3-1. Description

| Item | 内容 |
|------------------------|---|
| Controlling method | PWM/PFM automatic switching control |
| Maximum output current | 300mA @3.3V to 5V |
| Protection circuit | Limitation of over current / thermal shutdown |

3-2. Electrical characteristics

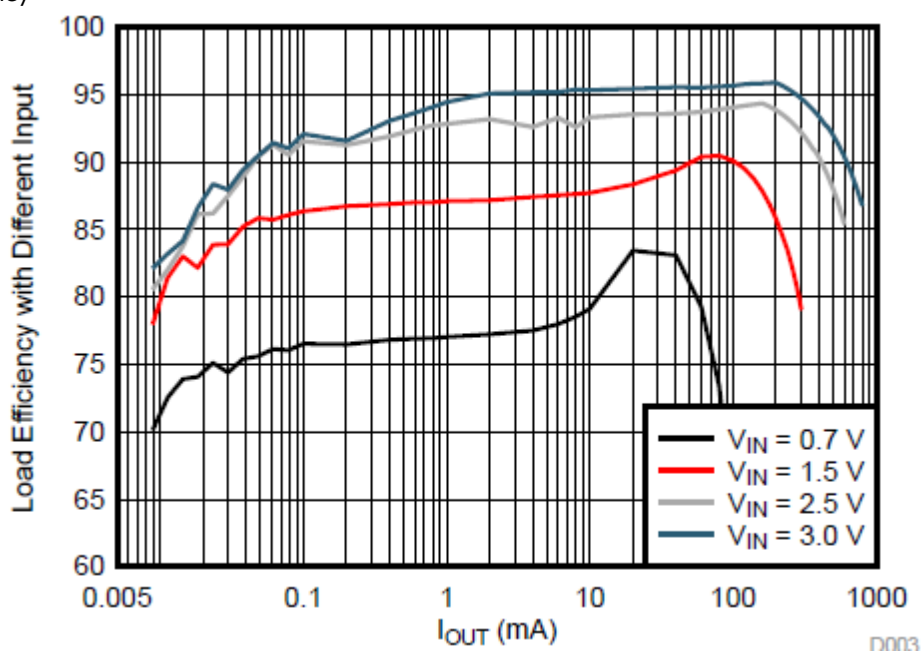
3-2-1. Absolute Maximum Ratings

| Parameter | Value |
|---------------------------|-----------------|
| Operating Temperature | -40°C to +150°C |
| Maximum Operation Voltage | Vin 6.0V |

3-2-2. Rated Value

| Symbol | Parameter | Condition | Min. | Typ. | Max. |
|--------|-------------------|---|------|-------|-------|
| Vin | Operating Voltage | — | 0.7V | - | 5.5V |
| Vout | Output Voltage | Iout =30mA | 1.8V | - | 5.5V |
| Iq | Quiescent Current | IC enabled, no Load, no Switching, Tj=-40°C to 85°C | - | 0.6uA | 1.5uA |
| Isd | Shutdown current | IC disabled, Vin=3.7V, Vout=0V | - | 0.5uA | 1.6uA |
| Ttso | Thermal Shutdown | — | - | 150°C | - |
| Ilim | Current Limit | — | 0.8A | 1A | 1.25A |

3-3. Efficiency



Reference : <http://www.ti.com/jp/lit/gpn/tps61099>

3-4. Link destination of data sheet

<http://www.tij.co.jp/product/jp/TPS61099/>

4. AD converter (ADC081C027CIMK) Specifications

4-1. Description

| Item | 内容 |
|---------------------|-----------|
| Resolution | 8bit |
| Reference voltage | Vdd(3.3V) |
| Maximum Sample Rate | 188.9kSPS |

| | |
|------------|-----|
| Interfaces | I2C |
|------------|-----|

4-2. Electrical characteristics

4-2-1. Absolute Maximum Ratings

| Parameter | Value |
|---------------------------|-----------------|
| Operating Temperature | -40°C to +105°C |
| Maximum Operation Voltage | 6.5V |

4-2-2. Rated value

| Symbol | Parameter | Condition | Min. | Typ. | Max. |
|--------|---------------------------|---------------------|------|--------|--------|
| Vdd | supply voltage | Internal Oscillator | 2.7V | - | 5.5V |
| Idd | Automatic Conversion Mode | Vdd=2.7V to 3.6V | - | 0.41mA | 0.59mA |
| | Power down mode | PD1 | - | 0.1uA | 0.2uA |
| | | PD2, fsc1=400kHz | - | 13uA | 45uA |

4-3. Link destination of data sheet

<http://www.tij.co.jp/product/jp/adc081c027>

4-4. Register

| Name | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----------------|----|----|----|----|----|-----------------|----|----|
| Address Pointer | 0 | 0 | 0 | 0 | 0 | Register Select | | |

Address Pointer Field Descriptions

| D2 | D1 | D0 | REGISTER |
|----|----|----|---------------------------------|
| 0 | 0 | 0 | Conversion Result (read only) |
| 0 | 0 | 1 | Alert Status (read/write) |
| 0 | 1 | 0 | Configuration (read/write) |
| 0 | 1 | 1 | Low Limit (read/write) |
| 1 | 0 | 0 | High Limit (read/write) |
| 1 | 0 | 1 | Hysteresis (read/write) |
| 1 | 1 | 0 | Lowest Conversion (read/write) |
| 1 | 1 | 1 | Highest Conversion (read/write) |

| Name | Pointer | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 |
|-------------------|---------|-------------------------|----------|-----|-----|-------------------------|-----|----|----|
| Conversion Result | 00h | Alert Flag | Reserved | | | Conversion Result [7:4] | | | |
| | | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| | | Conversion Result [3:0] | | | | Reserved | | | |

Conversion Result Register Field Descriptions

| Field | Description |
|-------|---|
| D15 | Alert Flag. This bit indicates when an alert condition has occurred. When the Alert Bit Enable is set in the Configuration Register, this bit will be high if either alert flag is set in the Alert Status Register. Otherwise, this bit is a zero. The I2C controller will typically read the Alert |

| | |
|----------|--|
| | Status register and other data registers to determine the source of the alert. |
| D[14:12] | Reserved. Always reads zeros. |
| D[11:4] | Conversion Result. The Analog-to-Digital conversion result. The Conversion result data is a 8-bit data word in straight binary format. The MSB is D11. |
| D[3:0] | Reserved. Always reads zeros. |

| Name | Pointer | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|--------------|---------|----------|----|----|----|----|----|------------|-------------|
| Alert Status | 01h | Reserved | | | | | | Over Range | Under Range |

Alert Status Register Field Descriptions

| Field | Description |
|--------|---|
| D[7:2] | Reserved. Always reads zeros. Zeros must be written to these bits. |
| D1 | Over Range Alert Flag. Bit is set to 1 when the measured voltage exceeds the VHIG ^H limit stored in the programmable VHIG ^H limit register. Flag is reset to 0 when one of the following two conditions is met: (1) The controller writes a one to this bit. (2) The measured voltage decreases below the programmed VHIG ^H limit minus the programmed VHYS ^T value . The alert will only self-clear if the Alert Hold bit is cleared in the Configuration register. If the Alert Hold bit is set, the only way to clear an over range alert is to write a one to this bit. |
| D0 | Under Range Alert Flag. Bit is set to 1 when the measured voltage falls below the VLOW limit stored in the programmable VLOW limit register. Flag is reset to 0 when one of the following two conditions is met: (1) The controller writes a one to this bit. (2) The measured voltage increases above the programmed VLOW limit plus the programmed VHYS ^T value. The alert will only self-clear if the Alert Hold bit is cleared in the Configuration register. If the Alert Hold bit is set, the only way to clear an under range alert is to write a one to this bit. |

| Name | Pointer | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---------------|---------|------------------|----|----|------------|-------------------|------------------|----|----------|
| Configuration | 02h | Cycle Time [2:0] | | | Alert Hold | Alert Flag Enable | Alert Pin Enable | 0 | Polarity |

Configuration Register Field Descriptions

| Field | Description |
|--------|--|
| D[7:5] | Cycle Time. Configures Automatic Conversion mode. When these bits are set to zeros, the automatic conversion mode is disabled. This is the case at power-up. When these bits are set to a non-zero value, the ADC will begin operating in automatic conversion mode. The Cycle Time table shows how different values provide various conversion intervals. |
| D4 | Alert Hold. 0: Alerts will self-clear when the measured voltage moves within the limits by more than the hysteresis register value. 1: Alerts will not self-clear and are only cleared when a one is written to the alert high flag or the alert low flag in the Alert Status register. |
| D3 | Alert Flag Enable. 0: Disables alert status bit [D15] in the Conversion Result register. 1: Enables alert status bit [D15] in the Conversion Result register. |
| D2 | Alert Pin Enable. *This bit does not apply to the ADC081C027. |
| D1 | Reserved. Always reads zeros. Zeros must be written to these bits. |
| D0 | Polarity. *This bit does not apply to the ADC081C027. |

Cycle Time Field Descriptions

| D7 | D6 | D5 | Conversion Interval | Typical fconvert[kcps] |
|----|----|----|---------------------|------------------------|
| 0 | 0 | 0 | Mode Disabled | 0 |
| 0 | 0 | 1 | Tconvert x 32 | 27 |
| 0 | 1 | 0 | Tconvert x 64 | 13.5 |
| 0 | 1 | 1 | Tconvert x 128 | 6.7 |
| 1 | 0 | 0 | Tconvert x 256 | 3.4 |
| 1 | 0 | 1 | Tconvert x 512 | 1.7 |
| 1 | 1 | 0 | Tconvert x 1024 | 0.9 |
| 1 | 1 | 1 | Tconvert x 2048 | 0.4 |

4-5. Power saving control

This system uses the power IC which has comparatively high efficiency on low load.

About the AD converter (ADC081C027CIMK), It is easier to achieve low power consumption by not using the active mode (Automatic operation mode). In normal mode, it can lower the power consumption because it automatically migrates to power-down mode after measurement. Migration of Automatic operation mode to Power-down is possible by disabling the auto converting mode. (Address : 02h D7-D5 : 000). Auto converting mode is disabled when the power is turned on.