AV04 2V～4.5V

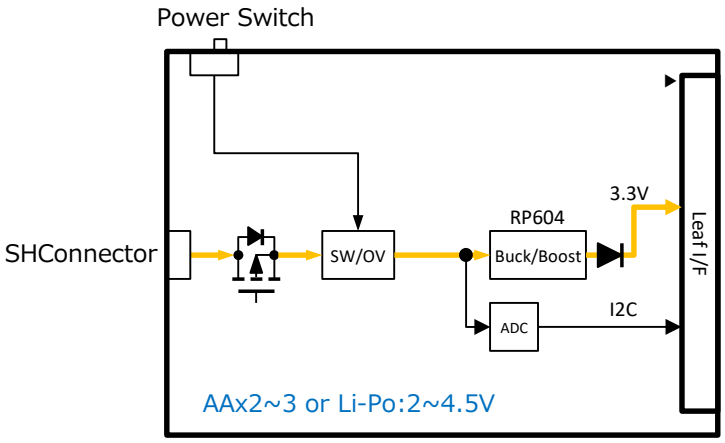
1. Description

This is a leaf provides 3.3V to every leaf.　This has SH connector, converts source voltage 1.5V to 3.3 by using the power boosting ciurcut and has a switch to turn on and off the 3.3V. Also, this leaf has AD converter to monitor power voltage.

The types of batteries able to connect to SH connectors are assumed as two to three regular batteries, Li-Po battery or Li-ION battery.

2. Leaf specification

2-1. Block diagram



2-2. Power supply specification しゆ

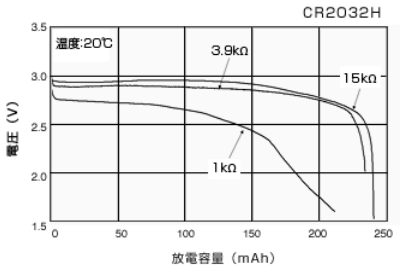
Symbol	Parameter	Condition	Min.	Typ.	Max.
Vbatt	Battery Voltage	–	1.8V	-	5.5V
Vout	Output Voltage	–	3.25V	3.3V	3.35V
Ilim	Current limit	–	0.6A	0.9A	-

2-3. Battery Voltage Check Function

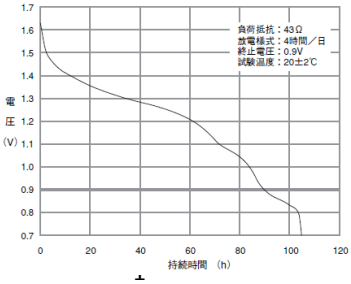
Battery leaf has 8bit AD converter （ADC081C027CIMK） and has a function that monitors power voltage by using I2C. AD cionverter's reference voltage is 3.3V in 8bit resolution and cuts the voltage to half in AD converter's input.Therefore 3.3V/2^8*2=26mV is 1LSV of the reading value of AD converter.

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

Coin Battery

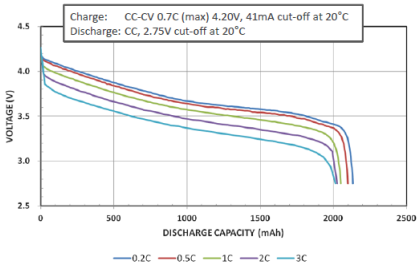


AA Battery



Li-IONBattery

Discharge Characteristics (by rate of discharge)



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

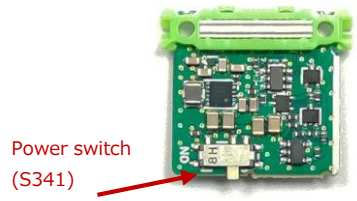
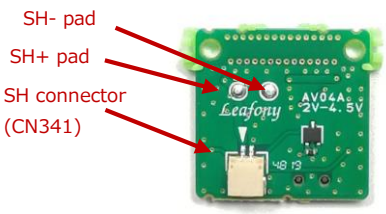
It is possible to measure directy by tester, because that the pad measures battery voltage is set on every battery leaf like the figure bellow.

2-5. Main parts

Reference No.	Part name	Part number	Vendor name	note
IC281	Step down and up voltage IC	RP604K331B	RICOH	–
IC343	AD Converter	ADC081C027CIMK	Texas Instruments	I2C address for battery voltage monitoring : 0x50(It is possible to alter to0x51 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. Step down and up power IC(RP604K331B) Specifications

3-1. Description

Item	内容
Controlling method	PWM/PFM automatic switching control
Maximum output current	300mA (when step down)

Protection circuit	Limitation of over current / thermal shutdown

3-2. Electrical characteristics

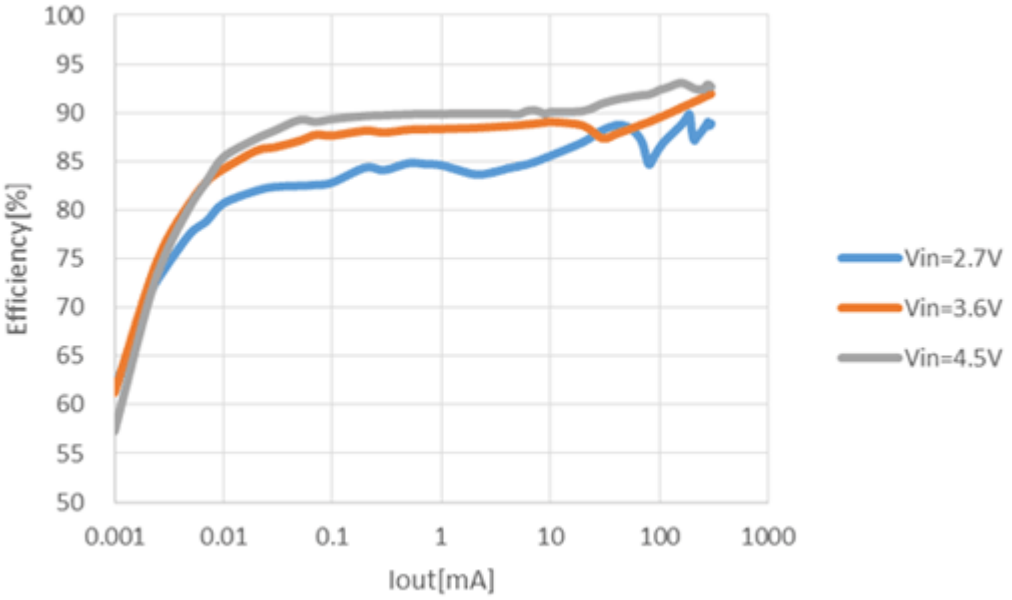
3-2-1. Absolute Maximum Ratings

Parameter	Value
Operating Temperature	-40℃ to +85℃
Maximum Operation Voltage	Vin 6.5V

3-2-2. Rated values

Symbol	Parameter	Condition	Min.	Typ.	Max.
Vin	Operating Voltage	–	1.8V	-	5.5V
Vout	Output Voltage	Iout =30mA	1.6V	-	5.2V
Iq	Quiescent Current	VIN = VCE = VOUT = 3.6 V,VSET = 3.3V Quiescent	-	0.3uA	-
Isd	Standby current	VIN = 5.5 V, VCE = 0 V	-	0.01uA	1uA
Ttso	Thermal Shutdown	–	-	140℃	-
Ilim	Current Limit	–	0.6A	0.9A	-

3-3. Efficiency



Reference : https://www.e-devices.ricoh.co.jp/ja/products/power/dcdc/rp604/

3-4. Link destination of data sheet

https://www.e-devices.ricoh.co.jp/ja/products/power/dcdc/rp604/

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℃ to +105℃
Maximum Operation Voltage	6.5V

4-2-2. Electrical characteristics

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, fscl=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 VHIGH limit stored in the programmable VHIGH 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 VHIGH limit minus the programmed VHYST 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 VHYST 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[ksps]
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 (RP604K331B) which has very 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 automanically 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.

5. Revision history

Rev A1.0: First edition, January 2020