Industrial Application
Battery Monitoring IC

KA49702A
Product Standards

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■ IMPORTANT NOTICE

Regarding the specifications of this product, it is considered that you have agreed to the quality level and disclaimer described below.

Support for industry standards and quality standards

Functional safety standards for automobiles ISO26262	**No**
AECQ-100	**No**
Market failure rate	**50Fit**

Disclaimer

1. When the application system is designed using this IC, please design the system at your own risk. Please read, consider, and apply appropriate usage notes and description in this standard.

2. When designing your application system, please take into the consideration of break down and failure mode occurrence and possibility in semiconductor products. Measures on the systems such as, but not limited to, redundant design, mitigating the spread of fire, or preventing glitch, are recommended in order to prevent physical injury, fire, social damages, etc. in using the Nuvoton Technology Japan Corporation (hereinafter referred to as NTCJ) products.

3. When using this IC, for each actual application systems, verify the systems and the all functionality of this IC as intended in application systems and the safety including the long-term reliability at your own risk

4. Please use this IC in compliance with all applicable laws, regulations and safety-related requirements that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. NTCJ shall not be held responsible for any damage incurred as a result of this IC being used not in compliance with the applicable laws, regulations and safety-related requirements.

5. This IC does not have any security functions using cryptographic algorithms, such as authentication, encryption, tampering detection.

6. Unless this IC is indicated by NTCJ to be used in applications as meeting the requirements of a particular industry standard (e.g., ISO 9001, IATF 16949, ISO 26262, etc.), this IC is neither designed nor intended for use in such environments for that applications. NTCJ shall not be held responsible for not meeting the requirements of a particular industry standard.

7. Using IC that have been indicated as compliant with industry functional safety standards does not warrant that the application meets the requirements of industry functional safety standards. NTCJ shall not be held responsible for the application compliance with requirements of the particular industry functional safety standard.

8. Unless this IC is indicated by NTCJ to be used in applications as meeting the requirements of a particular quality standard (e.g., AECQ-100, etc.), this IC is neither designed nor intended for use in such the environments for that applications. NTCJ shall not be held responsible for not meeting the requirements of a particular quality standard.

9. In case of damages, costs, losses, and/or liabilities incurred by NTCJ arising from customer's non-compliance with above from 1 to 8, customer will indemnify NTCJ against every damages, costs, losses and responsibility.

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Characteristics

- Maximum support 17 battery cells in series
- 2.9mV measurement accuracy with 14 bits voltage ADC for cell voltage, and 6 channels analog input measurement for Thermistor
- Built-in 16 bits Current measurement ADC (Coulomb Counter)
- Low–side Sense resistor Current measurement and monitoring
- Operation mode - Active, Standby/Low power; Sleep and Shutdown
- SPI serial communication interface up to 1MHz clock with CRC code correction and watchdog timer
- Built-in ALARM pins for overvoltage, undervoltage, overcurrent and short circuit detection and protection feature
- Support external cell balance MOSFET operation as well
- 2 channels General GPIO Interrupt signal provision for MCU to notify state of operation as well as measurement cycle indication at the available GPIO pins
- N-MOSFET driver: Charge (CHG) & Discharge (DIS) with built-in regulator and FETOFF control pin
- Built in controllable Fuse driver for cells Over-voltage, Over-current and Over-temperature monitoring algorithm to serve as secondary protection system
- Regulator (REGEXT) for external circuit power provision with selectable output setting 3.3V/**Hi-z**, and 50mA drive ability
- Package : TQFP 48L (**7x7**x1mm^3, Lead Pitch 0.5mm)

Overview

KA49702A is a battery monitoring IC with protection function. With high resolution ADC built-in, this IC is capable to measure battery cell voltage and current level accurately.

Through SPI serial interface, microcontroller unit (MCU) is able to read the status and measured result by this IC.

The ALARM pins alert the MCU with the abnormal condition such as over voltage (OV), under voltage (UV),

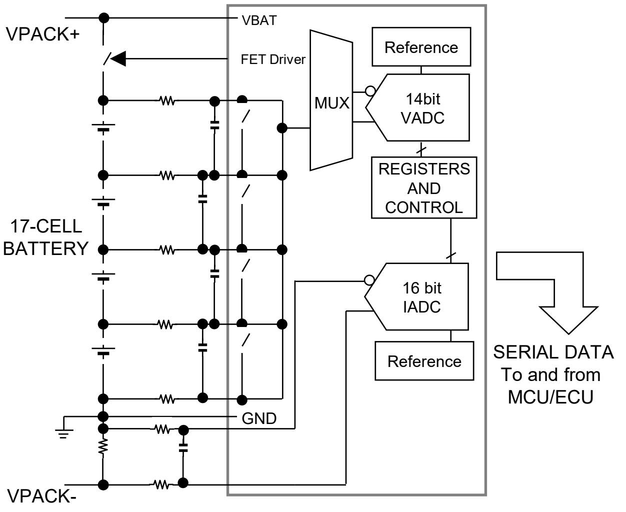
over current (OC), short circuit (SC), over temperature (OT) and under temperature (UT).

KA49702A can support an application with up to 17 batteries cells in series or a maximum voltage of 85V, it is suitable for application with high input voltage such as E-bike, UPS etc.

Applications

- Pedelec, e-Bike, UPS, Server Backup System, Power Tool, Energy Storage Systems etc

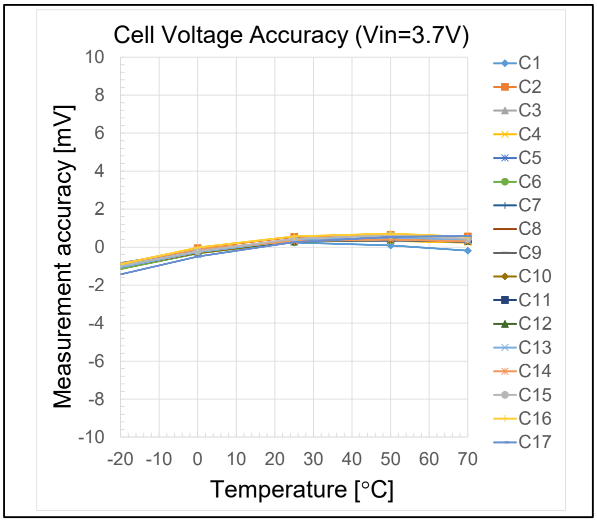
System Block Diagram



Notes: This is just an example of a circuit set: it is not guaranteed to function identically to the final production version. When designing a set for production, make sure to carefully evaluate and verify the circuitry.

Representation Characteristics

Measurement accuracy



Application circuit example (17cells connection), VBAT=62.9V, cell voltage ΔCn (C_n-C_{n-1}) = 3.7V, with averaging filter activated (ADV_AVE=10)

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Absolute Maximum Ratings

Parameter	Symbol *1	Rating	Unit	Notes
Supply voltage	V_{VBAT} to GND	-0.3 to 90	V	*4
	V_{Vpack} to GND	-0.3 to 90	V	
	V_{VDD50} to GND	-0.3 to 5.8	V	*2
	V_{VDD15} to GND	-0.3 to 2.0	V	*2
	V_{REGEXT} to GND	-0.3 to min(V_{VDD50} + 0.3, 5.8)	V	*2
Input Voltage Range	Cn (n=0 ～17)	-0.3 to V_{VBAT} + 0.3	V	
	SEN, SCL, SDI, FETOFF, GPIOn (n=1～4)	-0.3 to V_{REGEXT}+0.3	V	
	TMONIn (n=1～6)	–0.3 to V_{VDD50}+0.3	V	
	SRP.SRN	-0.5 to 2.0	V	
	VPC	-0.3 to 90	V	
	SHDN	-0.3 to 6.0	V	
Output Voltage Range	ALARM1,SDO	-0.3 to V_{REGEXT}+0.3	V	
	GPIOHn (n=1～2) CP1, CN1,CHG, DIS	-0.3 to 90	V	
	REGB	-0.3 to 14	V	
Output Current Range	ALARM1,SDO GPIOn (n=1～4)	-6.0 to +6.0 (-12.0 to +12.0)	mA	*3
	REGB	-5.0 to 0.1	mA	*3
	REGEXT	-50.0 to 0	mA	*5
Allowable Voltage Between Pins	C_n - C_{n-1} (n=1～17)	-0.3 to 15	V	
Operating junction temperature	T_j	-40 to 125	°C	
Storage temperature	T_{stg}	-55 to 125	°C	

Notes: Stresses that exceed the absolute maximum ratings may cause fatal damage to the product.
This specifies the maximum rating for stress.
It is NOT a guaranteed operating region because it exceeds the recommended operating conditions.
The reliability of the IC may be affected if it is kept under absolute maximum rating conditions for long periods.
Applied external current and voltage to pins should also not exceed the absolute maximum ratings listed here.

*1: GND is the voltage of pins GND and AVSS which are connected inside the device.
Connect these pins on the board and apply the same voltage.

*2: The maximum ratings are allowable unless the power consumption exceeds the power dissipation ratings.

*3: + Polarity is the direction in which current flows into the IC pins.
– Polarity is the direction in which current flows out from the IC pins.

*4: V_{VBAT} is the voltage of VBAT. It should not exceed the rated 90V.

*5: The output circuit consists of both external components and internal circuitry. Refer to the application circuit diagram.

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Power Dissipation Ratings

Package	θj-a	θj-c	P_D (Ta = 25°C)	P_D (Ta=105°C)	Note
TQFP 48 (7x7x1mm^3, Lead Pitch 0.5mm)	73.0 °C/W	7.8 °C/W	1.37 W	0.273 W	*1

Notes: These characteristics are the reference values for design.
Refer to the PD-Ta characteristics diagram in the package specifications. Thermal design with a sufficient margin is recommended based on the conditions of supply voltage, load, and ambient temperature.

*1: Mounting board: Glass epoxy 4-layer board without soldered heat spreader measuring 50 mm x 50 mm x 0.8 mm
Wiring layer thickness: all layers 0.035 mm, proportion of copper foil: 57% / 100% / 100% / 57%

Recommended Operating Conditions

Below items must be within the range of Recommended Operating Conditions.

Parameter	Symbol *1	Min.	Typ.	Max.	Unit	Note
Supply voltage range	V_{VBAT}	12.5	62.9	85	V	*1
	V_{VPACK}	(12.5)	62.9	85	V	*4
	V_{REGEXT}	3.0	5.0	5.5	V	*3
Input Voltage Range	C_n - C_{n-1} (n=1～17)	1.0	—	4.8	V	*2
	SEN, SCL, SDI	0	—	V_{REGEXT}	V	
	TMONIn (n=1～6)	0	—	V_{VDD50}	V	
	GPIOn (n=1～4)	0	—	V_{REGEXT}	V	
	GPIOHn (n=1～2)	0	—	85	V	
	SRP,SRN	-0.18	—	0.18	V	
	VPC	0	—	85	V	
	SHDN	0	—	V_{VDD50}	V	
Operating Ambient Temperature	Ta_{opr}	–40	25	105	℃	

*1 : The recommended operating supply range varies due to the characteristics of the external NPN BJT connected to VDD50. Use the parts described in the recommended circuit.

*2: The C_n - C_{n-1} voltage measurement accuracy is not guaranteed if input is less than 2.0 V or more than 4.3 V. Moreover, the measurement accuracy is not guaranteed unless the following conditions are fulfilled.
C2 > 2.0 V, C17 > 12 V, VBAT – C17 > –2 V, VBAT - C16 > 1 V
* Cn (n = 1 to 17) and VBAT voltage in this conditions are in reference to GND.

*3: The V_{REGEXT} is used in common with the digital IO power supply.

*4: When Vvpack pin operate as supply input, minimum voltage is 12.5V

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Electrical Characteristics

Unless otherwise noted, the characteristics are specified under the recommended operating condition:
VBAT = 62.9 V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
SUPPLY CURRENT*1							
VBAT Active Mode	I_{BAT1}	250ms intermittent mode ADV_AVE=00	—	260	—	μA	*1
VBAT Low Power Mode	I_{BAT2}	4s intermittent mode REGEXT=off Coulomb Counter=off FDRV=off Communication=off ADV_AVE=00	—	60	—	μA	*1
VBAT Sleep Mode	I_{BAT3}	REGEXT=off, Communication=off	—	13	—	μA	*1
VBAT Shutdown Mode	I_{BAT4}		—	0	1	μA	*1
VDD50							
VDD50 Output Voltage	V_{VDD50}		4.75	5.0	5.25	V	
VDD50 Base Current1	IB_{VDD501}	Temp=25ºC; VBAT=62.9V	2.6	3.3	4.0	mA	
REGEXT							
REGEXT Output Voltage1	V_{EXT1}		VDD50 input			V	
REGEXT Output Voltage2	V_{EXT2}	0mA ~ 50mA	3.05	3.3	3.55	V	
REGEXT Output Current1	I_{EXT1}	Normal mode	0	—	50	mA	
VDD15							
VDD15 output Voltage1	V_{VDD15_V1}	Active mode No load condition	1.45	1.50	1.55	V	
VDD15 output Voltage2	V_{VDD15_V2}	Sleep mode No load condition	1.40	1.50	1.60	V	

*1 : Current consumption is based on the following settings.
- Consumption current is measured based total current from VBAT pin and VDD50 pin.
- All pins no load ;SEN, SCL, and SDI = Low
- Unless otherwise specified, all registers are in the default setting.
  If VDD50 and REGEXT are supplying an external load, this extra current should be included additionally.

*2 : Design reference value not tested during final production inspection.

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Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:
VBAT = 62.9 V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits Min	Limits Typ	Limits Max	Unit	Note
CELL VOLTAGE MONITOR							
Input Voltage Range	V_{IN1}	C_n - C_{n-1} (n=1～17)	0	—	5	V	*3
Voltage Resolution	V_{RES1}	14bits V_{RES1} = 5 / 2^{14}	—	0.3	—	mV	*3
Voltage Accuracy0	V_{ACC_VC0}	ΔCn = 3.7V ADV_AVE=10	–2.9	—	2.9	mV	*3
Voltage Accuracy1	V_{ACC_VC1}	ΔCn = 2.0V ～ 4.3 V ADV_AVE=10	–3	—	3	mV	*1 *2
Voltage Accuracy2	V_{ACC_VC2}	ΔCn = 2.0V ～ 4.3 V Ta = –20℃ ～ 65℃ ADV_AVE=10	–5	—	5	mV	*3
Voltage Accuracy3	V_{ACC_VC3}	ΔCn = 2.0V ～ 4.3 V Ta = –30℃ ～ 85℃ ADV_AVE=10	–8	—	8	mV	*3
Cell Measurement Input Current	I_{IN}	Active mode	–5	—	5	μA	
Input Leakage Current	I_{LK}	Shutdown mode	–1	—	1	μA	
OVER / UNDER VOLTAGE DETECTOR (OV / UV)							
OV detection threshold step	V_{ACC_OV}	2.0～4.5V@6bit	—	50	—	mV	*4
UV detection threshold step	V_{ACC_UV}	0.5～3.0V@6bit	—	50	—	mV	*4
VPACK,GPIOH1,GPIOH2 VOLTAGE MONITOR							
Input Voltage Range	V_{IN2}		0	—	85	V	*4
Voltage Resolution	V_{RES2}	14bits	—	7.63	—	mV	*4
Voltage Accuracy1	V_{ACC_VPACK1}	V_{VPACK} = 12.5V ～ 76.5V	–0.2	—	0.2	V	*1 *2
Voltage Accuracy2	V_{ACC_VPACK2}	V_{VPACK} = 12.5V ～ 76.5V Ta = –30℃ ～ 85℃	–0.5	—	0.5	V	*3
Input Leakage Current	I_{HV_LK}	Shutdown mode	–1	—	1	μA	

*1 : The C_n - C_{n-1} voltage measurement accuracy is not guaranteed if input is less than 2.0 V or more than 4.3 V. Moreover, the measurement accuracy is not guaranteed unless the following conditions are fulfilled.
C2 > 2.0 V, C17 > 12 V, VBAT – C17 > –2 V, VBAT - C16 >1 V
* Cn (n = 1 to 17) and VBAT voltage in this conditions are in reference to GND.

*2 : Measurement accuracy value including consideration of input average current and input leakage current.

*3 : Design reference value not tested during final production inspection.

*4 : Voltage resolution Typ. value is an approximate value derived from the Input voltage range Max. value and the number of bits.
Cell (Monitoring) voltage resolution, V_{RES1} = V_{IN1} / 2^{14} = 5 / 2^{14} = 0.3mV approx.
Vpack voltage resolution, V_{RES2} = 85.0V / 11141 = 7.63mV approx.

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Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:
VBAT = 62.9 V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
TMONI1-6/ GPIO 1-4 VOLTAGE MONITOR							
Input Voltage Range	V_{IN3}		0	—	5	V	*1
Voltage Resolution	V_{RES3}	14bits	—	0.3	—	mV	*1
Voltage Accuracy1	V_{ACC_TMONI1}	VIN = 0.4V～4.7V Not use Pull-up Resistance	–10	—	10	mV	*2 to *3
Voltage Accuracy2	V_{ACC_TMONI2}	VIN = 0.4V～4.7V Not use Pull-up Resistance T_a = –30℃ ～ 75℃	–10	—	10	mV	*1
Voltage Accuracy3	V_{ACC_TMONI3}	VIN = 0.4V～4.7V Not use Pull-up Resistance T_a = –40℃ ～ 85℃	–15	—	15	mV	*1
Input Pull-up Resistance	R_{PU}		7	10	13	kΩ	*4
Input Pull-up Resistance Temperature coefficient	RT_{PU}	T_a = –30℃ ～ 75℃ (with reference to 25℃)	–1.0	—	1.0	%	*1/ *4

*1 : Design reference value not tested during final production inspection.
Voltage resolution Typ. value is an approximate value derived from the Input voltage range Max. value and the number of bits.
TMONI voltage resolution, $V_{RES3} = V_{IN3}(Max.) / 2^{14} = 5 / 2^{14} = 0.3mV$ approx.
*2 : This is the final inspection value before shipping out. The value does not include variations caused by stress applied during board mounting or after board mounting.
*3 : Measurement accuracy value including consideration of input average current and input leakage current.
*4 : When GPIO1 to GPIO4 are used as voltage monitor input, the internal Pull-up resistance need not be turn on.

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Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:
VBAT = 62.9 V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
VDD50 VOLTAGE MONITOR							
Input Voltage Range	V_{IN5}		0	—	7.5	V	*1
Voltage Resolution	V_{RES5}	14bits	—	0.5	—	mV	*1
Voltage Accuracy1	V_{ACC_VDD501}	VIN = 5.0V	–10	—	10	mV	*2 to *3
Voltage Accuracy2	V_{ACC_VDD502}	VIN = 5.0V T_a = –30℃ ~ 75℃	–15	—	15	mV	*1
Voltage Accuracy3	V_{ACC_VDD503}	VIN = 5.0V T_a = –40℃ ~ 85℃	–20	—	20	mV	*1
REGEXT VOLTAGE MONITOR							
Input Voltage Range	V_{IN6}		0	—	7.5	V	*1
Voltage Resolution	V_{RES6}	14bits	—	0.5	—	mV	*1
Voltage Accuracy1	$V_{ACC\_REGEXT1}$	VIN = 5.0V	–10	—	10	mV	*2 to *3
Voltage Accuracy2	$V_{ACC\_REGEXT2}$	VIN = 5.0V T_a = –30℃ ~ 75℃	–15	—	15	mV	*1
Voltage Accuracy3	$V_{ACC\_REGEXT3}$	VIN = 5.0V T_a = –40℃ ~ 85℃	–20	—	20	mV	*1

*1 : Design reference value not tested during final production inspection.
Voltage resolution Typ. value is an approximate value derived from the Input voltage range Max. value and the number of bits.
VDD50 voltage resolution, $V_{RES5} = V_{IN5}(Max.) / 2^{14} = 7.5 / 2^{14}$ = 0.5mV approx.
REGEXT voltage resolution, $V_{RES6} = V_{IN6}(Max.) / 2^{14} = 7.5 / 2^{14}$ = 0.5mV approx.
*2 : This is the final inspection value before shipping out. The value does not include variations caused by stress applied during board mounting or after board mounting.
*3 : Measurement accuracy value including consideration of input average current and input leakage current.

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Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:
VBAT = 62.9 V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
VDD15 VOLTAGE MONITOR							
Input Voltage Range	V_{IN7}		0	—	5	V	*1
Voltage Resolution	V_{RES7}	14bits	—	0.3	—	mV	*1
Voltage Accuracy1	V_{ACC_VDD151}	VIN = 1.50V	–10	—	10	mV	*2 to *3
Voltage Accuracy2	V_{ACC_VDD152}	VIN = 1.50V T_a = –30℃ ~ 75℃	–15	—	15	mV	*1
Voltage Accuracy3	V_{ACC_VDD153}	VIN = 1.50V T_a = –40℃ ~ 85℃	–20	—	20	mV	*1
THERMAL SHUTDOWN							
Shutdown Threshold	T_{SD2}	Tj	130	155	180	°C	*1

*1 :Design reference value not tested during final production inspection.
Voltage resolution Typ. value is an approximate value derived from the Input voltage range Max. value and the number of bits.
VDD15 voltage resolution, $V_{RES7} = V_{IN7}(Max.) / 2^{14}$ = $5 / 2^{14}$ = 0.3mV approx.
*2 :This is the final inspection value before shipping out. The value does not include variations caused by stress applied during board mounting or after board mounting.
*3 :Measurement accuracy value including consideration of input average current and input leakage current.

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Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:
VBAT = 62.9 V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
CURRENT MONITOR (SRP,SRN)							
Input Voltage Range	V_{IN4}		-180	—	180	mV	*1
Voltage Resolution	V_{RES4}	16bits	—	5.493	—	µV	*1
Voltage Accuracy1	V_{ACC_IMONI1}	VIN = 100mV ADIL_SEL=00	-1000	—	1000	µV	*2
Voltage Accuracy2	V_{ACC_IMONI2}	VIN = 10mV ADIL_SEL=00	-150	—	150	µV	*1
Voltage Accuracy3	V_{ACC_IMONI3}	VIN = 1mV ADIL_SEL=00	-25	—	25	µV	*1
Wake-up/CHG/DIS CURRENT MONITOR (SRP,SRN)							
Voltage Accuracy1	V_{ACC_IWCD1}	VIN < ±10 mV	-300	—	300	µV	*3
Voltage Accuracy2	V_{ACC_IWCD2}	VIN ≥ ±10 mV.	-3	—	3	%	*3
CURRENT PROTECTION (SRP,SRN)							
Over Current in Charge Detection Accuracy1	V_{CP_OCC1}	Detection Threshold 5mV & 10mV	-4	—	4	mV	*1
Over Current in Charge Detection Accuracy2	V_{CP_OCC2}	Detection Threshold from 15mV to 120mV	–10	—	10	mV	*1
Over Current in Discharge Detection Accuracy1	V_{CP_OCD1}	Detection Threshold from 10mV to 100mV	–10	—	10	mV	*1
Over Current in Discharge Detection Accuracy2	V_{CP_OCD2}	Detection Threshold from 100mV to 320mV	–10	—	10	%	*1
Short Circuit in Discharge Detection Accuracy1	V_{CP_SCD1}	Detection Threshold from 20mV to 100mV	–10	—	10	mV	*1
Short Circuit in Discharge Detection Accuracy2	V_{CP_SCD2}	Detection Threshold from 100mV to 500mV	–10	—	10	%	*1

*1 : Design reference value not tested during final production inspection.
Voltage resolution Typ. value is an approximate value derived from the Input voltage range Max. value and the number of bits.
$V_{RES8} = V_{IN8}$(max.) / 2^{16} = 360mV / 2^{16} = 5.493µV approx. ; $V_{RES9} = V_{IN9}$(max.) / 2^{15} = 360mV / 2^{15} = 10.99µV approx.

*2 : This is the final inspection value before shipping out. The value does not include variations caused by stress applied during board mounting or after board mounting.

*3 : T_a = 25℃, VIN = VSRP – VSRN. ADIL_SEL=2'bx1 (Coulomb counter conversion period 31.25ms)
INTM_TIM3=2'b01(WAKEUP measurement cycle 31.25ms)

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Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:
VBAT = 62.9 V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits Min	Limits Typ	Limits Max	Unit	Note
GENERAL PURPOSE INPUT/OUTPUT (GPIO1～2)							
Output Voltage "H"	V_{OH1}	I_{OH} = –1mA When REGEXT=VDD50	V_{REGEXT} –0.6	—	V_{REGEXT} +0.3	V	
Output Voltage "L"	V_{OL1}	I_{OL} = +1mA	–0.3	—	0.4	V	
GENERAL PURPOSE INPUT/OUTPUT (GPIO3～4)							
Input Voltage "H"	V_{IH1}		V_{REGEXT} × 0.8	—	V_{REGEXT}	V	
Input Voltage "L"	V_{IL1}		0	—	V_{REGEXT} × 0.2	V	
Output Voltage "H"	V_{OH1}	I_{OH} = –1mA When REGEXT=VDD50	V_{REGEXT} –0.6	—	V_{REGEXT} +0.3	V	
Output Voltage "L"	V_{OL1}	I_{OL} = +1mA	–0.3	—	0.4	V	
DIGITAL INPUT(1) VPC							
Input Voltage "H"	V_{IH2}		2.0	—	—	V	
Input Voltage "L"	V_{IL2}		—	—	0.5	V	
Pull-down resistance	R_{IL2}		20	40	80	MΩ	
DIGITAL INPUT(3) SHDN							
Input Voltage "H"	V_{IH4}		2.0	—	—	V	
Input Voltage "L"	V_{IL4}		—	—	0.1	V	
Pull-down resistance	R_{IL4}		200	820	1500	kΩ	
DIGITAL INPUT(4) SDI,SCL,SEN & FETOFF							
Input Voltage "H"	V_{IH5}		V_{REGEXT} × 0.8	—	V_{REGEXT}	V	
Input Voltage "L"	V_{IL5}		0	—	V_{REGEXT} × 0.2	V	
Input Leakage Current	I_{LK5}		-1	0	1	µA	
DIGITAL OUTPUT(1) ALARM1 & SDO							
Output Voltage "H"	V_{OH7}	I_{OH} = –1mA	V_{REGEXT} –0.6	—	V_{REGEXT} +0.3	V	
Output Voltage "L"	V_{OL7}	I_{OL} = +1mA	–0.3	—	0.4	V	

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Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:
VBAT = 62.9 V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
REGEXT UVLO							
UV detection voltage	V_{IL_UV1}		—	2.65	—	V	*1
UV release voltage	V_{IH_UV1}		—	2.80	—	V	*1
VDD50 UVLO							
UVLO detection voltage	V_{IL_UV2}		—	4.0	—	V	*1
UVLO release voltage	V_{IH_UV2}		—	4.2	—	V	*1
Nch. FET DRIVER							
Drive voltage (DIS=“H”)	V_{ON_DIS}	$V_{ON\_DIS} = V_{DIS} – V_{VPACK}$ VGS connect 10MΩ	9	11	13	V	
Drive voltage (CHG="H”)	V_{ON_CHG}	$V_{ON\_CHG} = V_{CHG} – V_{VBAT}$ VGS connect 10MΩ	9	11	13	V	
Drive voltage (DIS=“L”)	V_{OFF_DIS}	$V_{OFF\_DIS} = V_{DIS} – V_{VPACK}$ VGS connect 10MΩ	—	—	0.2	V	
Drive voltage (CHG=“L”)	V_{OFF_CHG}	$V_{OFF\_CHG} = V_{CHG} – V_{VBAT}$ VGS connect 10MΩ	—	—	0.2	V	
Rise time (DIS=“L” to ”H”)	Tr_{DIS}	V_{DIS} = 0 to 4V C_L = 20nF	—	20	50	µs	*1
Rise time (CHG=“L” to ”H”)	Tr_{CHG}	V_{CHG} = 0 to 4V C_L = 20nF	—	20	50	µs	*1
Fall time (DIS =“H” to ”L”)	Tf_{DIS}	V_{DIS} = 90% to 10% C_L = 20nF	—	20	30	µs	*1
Fall time (CHG=“H” to ”L”)	Tf_{CHG}	V_{CHG} = 90% to 10% C_L = 20nF	—	20	30	µs	*1

*1 :Design reference value not tested during final production inspection.

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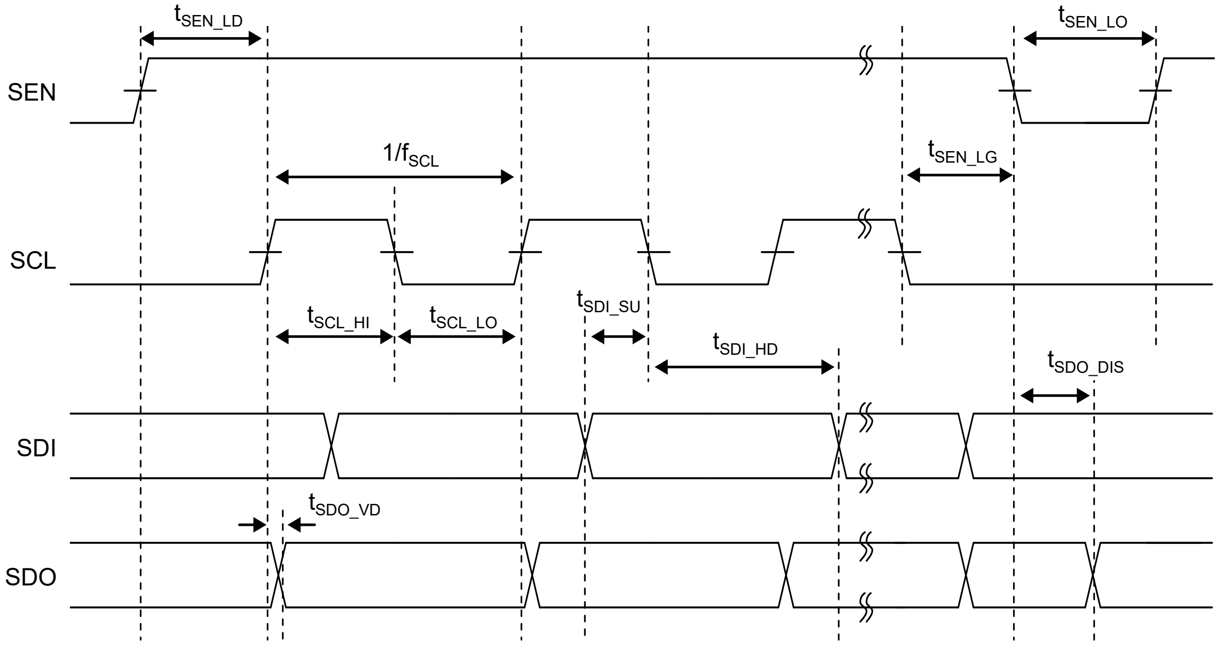
Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:
VBAT = 62.9 V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
SPI Interface Timing (SEN, SDI, SCL, SDO)							
SCL Frequency	f_{SCL}	—	—	—	1	MHz	
SCL Duty Cycle	t_{DUTY}	—	45	50	55	%	
SEN Rising to SCL Rising	t_{SEN_LD}	—	100	—	—	ns	
SCL Falling to SEN Falling	t_{SEN_LG}	—	100	—	—	ns	
SEN "L" Width	t_{SEN_LO}	—	500	—	—	ns	
SDI Setup Time	t_{SDI_SU}	SDI valid to SCL falling	100	—	—	ns	
SDI Hold Time	t_{SDI_HD}	SCL falling to SDI valid	100	—	—	ns	
SDO Valid Time	t_{SDO_VD}	SCL rising to SDO valid $C_L \leqq 50$ pF	—	—	400	ns	
SDO Disable Time	t_{SDO_DIS}	SEN falling to SDO disable	—	—	400	ns	



SPI Timing

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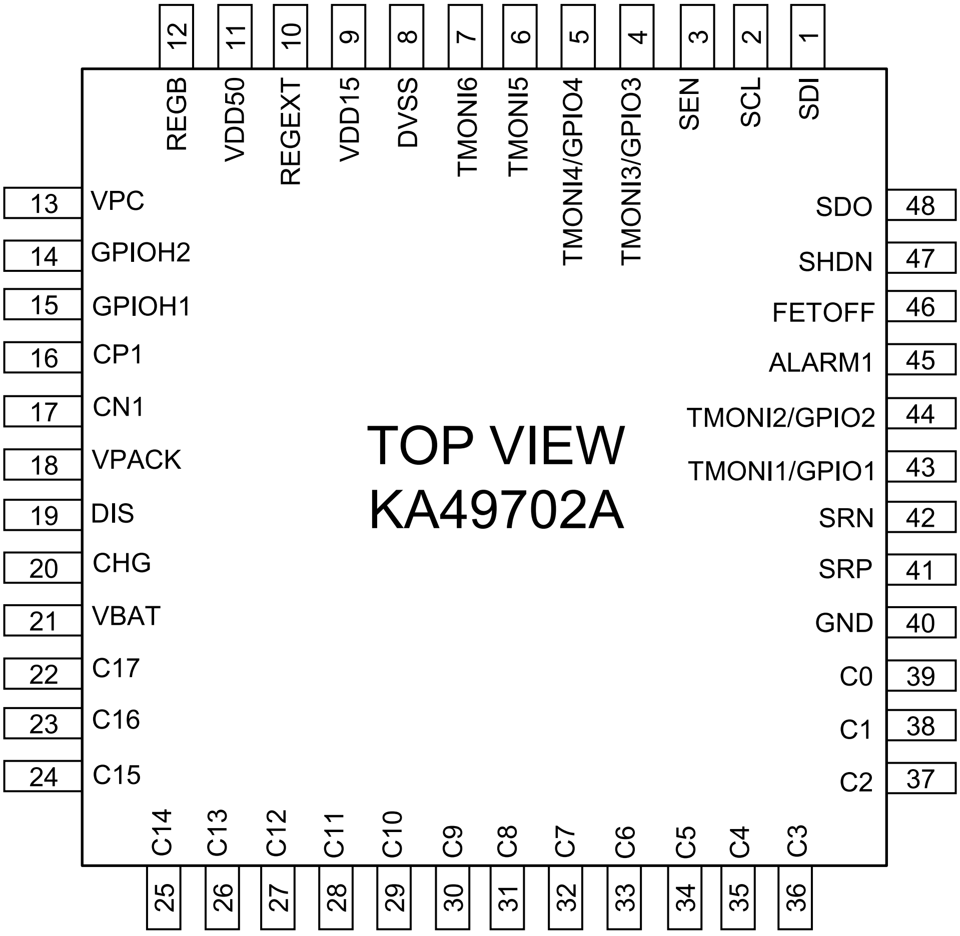
Pin Assignment



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Pin Description

Pin	Pin name	Type	Description
1	SDI	I	SPI Interface Pin – Data In *1
2	SCL	I	SPI Interface Pin – Clock *1
3	SEN	I	SPI Interface Pin – Enable *1
4	GPIO3/ TMONI3	I	General Purpose I/O Pin 3 / Analog Input Pin
5	GPIO4/ TMONI4	I	General Purpose I/O Pin 4 / Analog Input Pin
6	TMONI5	I	Analog Input Pin
7	TMONI6	I	Analog Input Pin
8	DVSS	GND	Digital Ground
9	VDD15	O	1.5V LDO Output Pin for Internal Use
10	REGEXT	O	External 3.3V LDO Output Pin
11	VDD50	O	5V Regulator Output Pin
12	REGB	O	Base Pin for 5V Pre-regulator
13	VPC	I	Wake Up Signal Pin - “L” Active / “H” Wake Up. Also for Charger Detect.
14	GPIOH2	I/O	High Voltage General Purpose I/O Pin
15	GPIOH1	I/O	High Voltage General Purpose I/O Pin
16	CP	O	Charge Pump Capacitor Pin
17	CN	O	Charge Pump Capacitor Pin
18	VPACK	I	Positive Terminal of Battery Pack to load or charger.
19	DIS	O	Discharge NMOSFET Gate Drive Pin
20	CHG	O	Charge NMOSFET Gate Drive Pin
21	VBAT	I	Stacked Cells Highest Voltage Pin
22	C17	I	Cell 17 Input Pin (+ve)
23	C16	I	Cell 16 Input Pin (+ve) / Cell 17 Input Pin (-ve)
24	C15	I	Cell 15 Input Pin (+ve) / Cell 16 Input Pin (-ve)

*1: An external capacitor may be required near the unused open pin to increase noise immunity.

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Pin Description (continued)

Pin	Pin name	Type	Description
25	C14	I	Cell 14 Input Pin (+ve) / Cell 15 Input Pin (-ve)
26	C13	I	Cell 13 Input Pin (+ve) / Cell 14 Input Pin (-ve)
27	C12	I	Cell 12 Input Pin (+ve) / Cell 13 Input Pin (-ve)
28	C11	I	Cell 11 Input Pin (+ve) / Cell 12 Input Pin (-ve)
29	C10	I	Cell 10 Input Pin (+ve) / Cell 11 Input Pin (-ve)
30	C9	I	Cell 9 Input Pin (+ve) / Cell 10 Input Pin (-ve)
31	C8	I	Cell 8 Input Pin (+ve) / Cell 9 Input Pin (-ve)
32	C7	I	Cell 7 Input Pin (+ve) / Cell 8 Input Pin (-ve)
33	C6	I	Cell 6 Input Pin (+ve) / Cell 7 Input Pin (-ve)
34	C5	I	Cell 5 Input Pin (+ve) / Cell 6 Input Pin (-ve)
35	C4	I	Cell 4 Input Pin (+ve) / Cell 5 Input Pin (-ve)
36	C3	I	Cell 3 Input Pin (+ve) / Cell 4 Input Pin (-ve)
37	C2	I	Cell 2 Input Pin (+ve) / Cell 3 Input Pin (-ve)
38	C1	I	Cell 1 Input Pin (+ve) / Cell 2 Input Pin (-ve)
39	C0	I	Cell 1 Input Pin (-ve)
40	GND	GND	Analog Ground
41	SRP	I	Shunt Resistor Positive Pin
42	SRN	I	Shunt Resistor Negative Pin
43	GPIO1/ TMONI1	I/O	General Purpose I/O Pin 1 / Analog Input Pin
44	GPIO2/ TMONI2	I/O	General Purpose I/O Pin 2 / Analog Input Pin
45	ALARM1	O	ALARM1 Pin
46	FETOFF	I	CHG/DIS FET Control Pin - “L” Normal / “H” FET Forced OFF
47	SHDN	I	Shutdown Control “L”: Active / “H”: Shutdown
48	SDO	O	SPI Interface Pin – Data Out *1

*1: An external capacitor may be required near the unused open pin to increase noise immunity.

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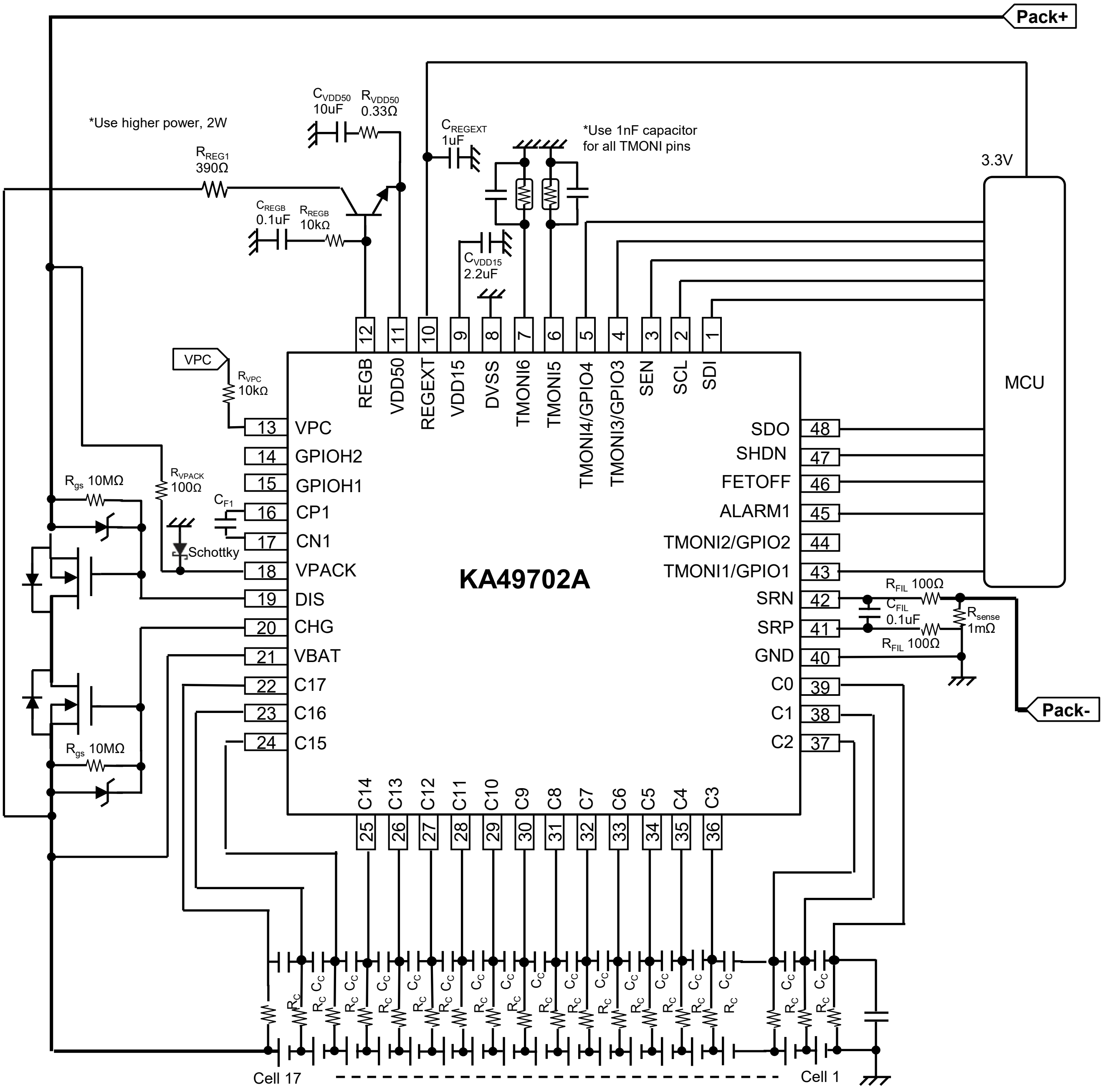
Application Circuit Example



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Recommended Constant of External Component

Item	Symbol	Constant				Note
		Min.	Typ.	Max.	Unit	
Constant of components connected to pins	C_{REGB}	—	0.1	—	uF	*1, *2
	R_{REGB}	—	10	—	kΩ	*2
	C_{VDD50}	—	10	—	μF	*1, *2
	R_{VDD50}	—	0.33	—	Ω	*2
	R_{REG1}	—	390	—	Ω	*2
	C_{VDD15}	—	2.2	—	μF	*1
	C_{REGEXT}	—	1	—	μF	*1,*3
	R_{GS}	—	10	—	MΩ	*2
	C_{F1}	—	0.68	—	μF	*1
	R_C	—	1	—	kΩ	*5
	C_C	—	1	—	μF	*1,*4
	R_{sense}	—	100	—	mΩ	*6
	R_{VPC}	—	10	—	kΩ	
	R_{VPACK}	—	100	—	Ω	
	R_{FIL}	—	100	—	Ω	
	C_{FIL}	—	0.1	—	μF	*1

*1: Use of a ceramic capacitor is recommended.

*2: The parameters are applicable for system using an external NPN BJT (Diodes Inc FZT458TA), as shown in the recommended circuit.

*3: REGEXT can be used for as power supply for external circuit. 1uF capacitor (C_{REGEXT}) is necessary at REGEXT output. It is recommended to connect a maximum of 1uF capacitor for external circuit, which is compatible with default C_{VDD50} and VDD50 NPN device (Diodes Inc FZT458TA)
If it is necessary to increase these total capacitor value, the capacitor C_{VDD50} must be increased proportionally with about 5 times ratio to ensure stability. Please note start-up time of VDD50 and REGEXT would increase proportionally by doing this.

*4: Usage of C_n pin input filter Capacitor or Resistor of different value other than the recommended values, or, RC filter connection other than the 17 cells testing circuitry indicated in the Electrical Characteristics, will cause a shift in voltage accuracy.

*5: R_C can be selected based on the required internal MOS Cell Balance function.
It is important to maintain the current below its rated value.

*6: R_{sense} resistor design is based on actual load current needed. This value should not cause SRP and SRN pin to generate voltage out of the sensing range which will affect measurement accuracy.

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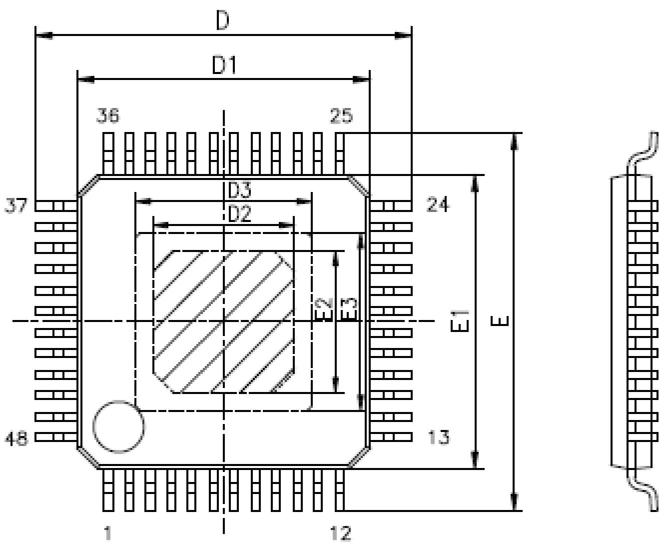
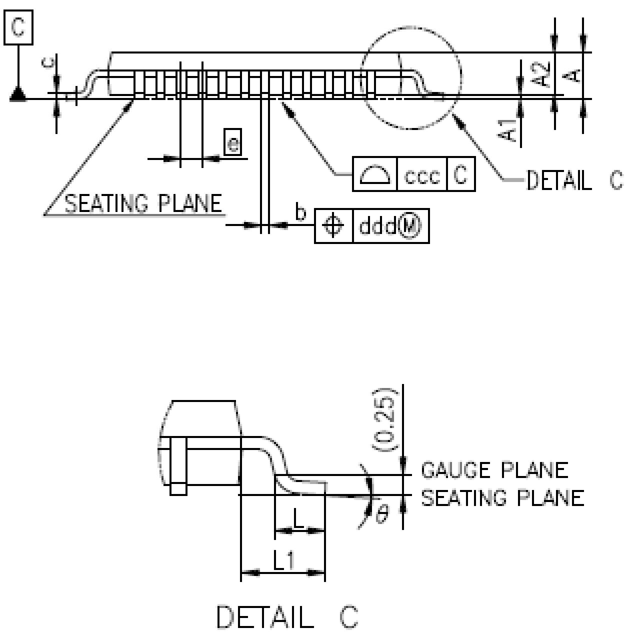
Dimensions

TQFP48L 7x7mm^2, Thickness 1.00mm, Lead_Pitch 0.50mm,
Lead_Length 1.00mm, EP Size 3.15x3.15mm^2

Unit: mm





VARIATIONS (ALL DIMENSIONS SHOWN IN MM)

SYMBOLS	MIN.	NOM.	MAX.
A	–	–	1.20
A1	0.05	0.10	0.20
A2	1.00REF		
D	8.80	9.00	9.20
D1	6.90	7.00	7.10
D2	3.15	–	–
D3	–	–	4.60
E	8.80	9.00	9.20
E1	6.90	7.00	7.10
E2	3.15	–	–
E3	–	–	4.60
L	0.45	0.60	0.75
L1	1.00REF		
b	0.15	0.20	0.25
c	0.10	0.15	0.20
e	0.50BSC		
ccc	0.10		
ddd	0.10		
θ	0.0°	–	8.0°

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Usage Notes

1. When using the IC for new models, verify the safety including the long-term reliability for each product.
2. When the application system is designed by using this IC, please confirm the notes in this book.
   Please read the notes to descriptions and the usage notes in the book.
3. This IC is intended to be used for measuring battery cell voltage in automotive application.
   Consult our sales staff in advance for information on the following applications: Special applications in which exceptional quality and reliability are required, or if the failure or malfunction of this IC may directly jeopardize life or harm the human body.
   Any applications other than the standard applications intended.
   (1) Space appliance (such as artificial satellite, and rocket)
   (2) Traffic control equipment (such as for automotive, airplane, train, and ship)
   (3) Medical equipment for life support
   (4) Submarine transponder
   (5) Control equipment for power plant
   (6) Disaster prevention and security device
   (7) Weapon
   (8) Others : Applications of which reliability equivalent to (1) to (7) is required
   Our company shall not be held responsible for any damage incurred as a result of or in connection with the IC being used for any special application, unless our company agrees to the use of such special application.
   However, for the IC which we designate as products for automotive use, it is possible to be used for automotive.
4. This IC is neither designed nor intended for use in automotive applications or environments unless the IC is designated by our company to be used in automotive applications.
   Our company shall not be held responsible for any damage incurred by customers or any third party as a result of or in connection with the IC being used in automotive application, unless our company agrees to such application in this book.
5. Please use this IC in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Our company shall not be held responsible for any damage incurred as a result of our IC being used by our customers, not complying with the applicable laws and regulations.
6. Pay attention to the direction of the IC. When mounting it in the wrong direction onto the PCB (printed-circuit-board), it might be damaged.
7. Pay attention in the PCB (printed-circuit-board) pattern layout in order to prevent damage due to short circuit between pins. In addition, refer to the Pin Description for the pin configuration.
8. Perform visual inspection on the PCB before applying power, otherwise damage might happen due to problems such as solder-bridge between the pins of the IC. Also, perform full technical verification on the assembly quality, because the same damage possibly can happen due to conductive substances, such as solder ball, that adhere to the IC during transportation.
9. Take notice in the use of this IC that it might be damaged when an abnormal state occurs such as output pin - VBAT short, output pin – CVDD fault (Power supply fault), output pin-GND short (Ground fault), output-to-output-pin short (load short), or leakage current between pins. Safety measures such as installation of fuses are recommended because the extent of the above-mentioned damage will depend on the current capability of the power supply.
10. The protection circuit is for maintaining safety against abnormal operation. Therefore, the protection circuit should not work during normal operation.
    Especially for the thermal protection circuit, if the area of safe operation or the absolute maximum rating is momentarily exceeded due to output pin to VBAT short, output pin to CVDD short (Power supply fault), or output pin to GND short (Ground fault), the IC might be damaged before the thermal protection circuit could operate.
11. Verify the risks which might be caused by the malfunctions of external components.

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