

## Industrial Application Battery Monitoring IC

# KA49522A Data Sheets

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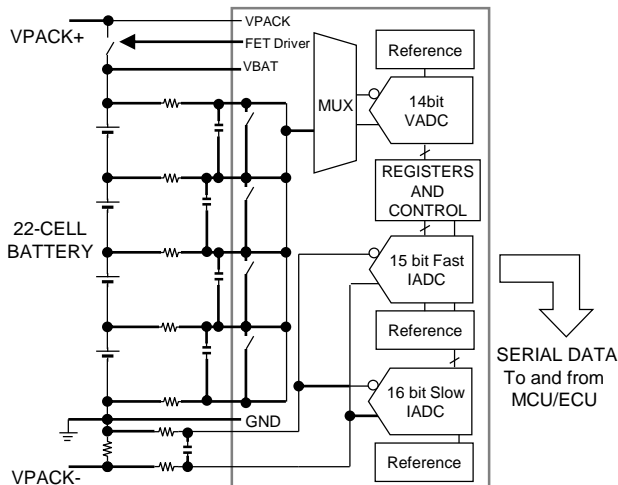
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## Characteristics

- Maximum support 22 battery cells in series
- 10mV measurement accuracy with 14 bits voltage ADC for cell voltage, and 5 channels analog input measurement for Thermistor
- Built-in 16 bits Low speed Current measurement ADC (Coulomb Counter) and 15 bits High speed Current measurement ADC
- 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
- Built-in cell balancing MOSFET, support external cell balance MOSFET operation as well
- 3 channels General GPIO and 2 channels high voltage output GPOH
- Interrupt signal provision for MCU to notify state of operation as well as measurement cycle indication at the available GPIO pins
- High-side N-MOSFET driver: Charge (CHG) & Discharge (DIS) with built-in charge pump and FETOFF control pin
- Built in controllable fuse driver for cell OV and overcurrent monitoring algorithm to serve as secondary protection system
- Regulator (REG\_EXT) for external circuit power provision with selectable output setting 5V/3.3V/2.5V, and 50mA drive ability
- Safety Diagnostic function for measurement related check and FET driver check to enhance the total diagnostic coverage of the chip
- Package : TQFP 64L (10x10x1mm<sup>3</sup>, Lead Pitch 0.5mm)

## 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.

## Overview

KA49522A is a battery monitoring IC with protection function. With high resolution ADC built-in, KA49522A 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 KA49522A.

The ALARM pins alert the MCU with the abnormal condition such as over voltage (OV), under voltage (UV), over current (OC) and short circuit (SC).

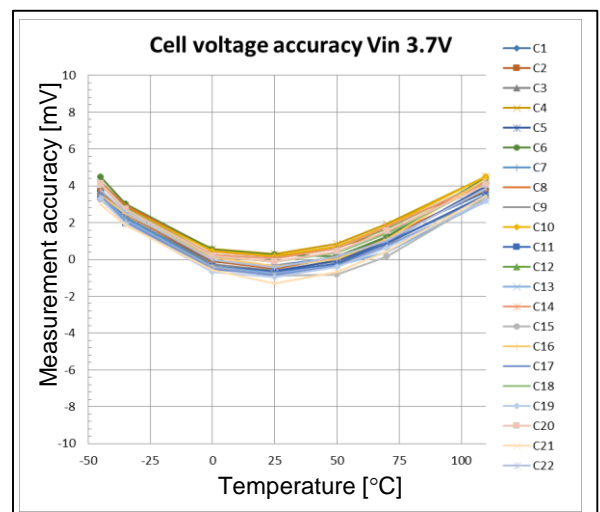
KA49522A can support an application with up to 22 batteries cells in series or a maximum voltage of 110V, it is suitable for application with high input voltage such as E-bike, UPS etc.

## Applications

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

## Representation Characteristics

### Measurement accuracy



Application circuit example (22cells connection), VBAT=81.4V , cell voltage  $\Delta C_n$  ( $C_n - C_{n-1}$ ) = 3.7V

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## Absolute Maximum Ratings

Parameter	Symbol *1	Rating	Unit	Notes
Supply voltage	$V_{VBAT}$ to GND	-0.3 to 130	V	*5
	$V_{CVDD}$ to GND	-0.3 to 6.4	V	*2
	$V_{VDD55}$ to GND	-0.3 to 6.4	V	*2
	$V_{VDD18}$ to GND	-0.3 to 2.3	V	*2
	$V_{REEXT}$ to GND	-0.3 to 6.4	V	*2
Input Voltage Range	$C_n$ (n=10 ~22)	-0.3 to $V_{VBAT}$	V	
	$C_n$ (n=1 ~9)	-0.3 to 38 + 11*(N-1)	V	
	C0	-0.3 to 38	V	
	SEN, SCL, SDI, FETOFF, GPIOn (n=1 ~3)	-0.3 to $V_{CVDD}+0.3$	V	*3
	TMONIn (n=1 ~5), REEXT_SEL	-0.3 to $V_{VDD55}+0.3$	V	*3
	SRP.SRN	-0.5 to 2.0	V	
	VPC	-0.3 to 130	V	
	LDM	-0.3 to 130	V	
	SHDN	-0.3 to 6.4	V	
Output Voltage Range	ALARM1,SDO,NRST	-0.3 to $V_{CVDD}+0.3$	V	
	GPOHn (n=1 ~2)	-0.3 to 130	V	
	REGB	-0.3 to 14	V	
Output Current Range	ALARM1,SDO,NRST GPIOn (n=1 ~3)	-6.0 to +6.0 (-12.0 to +12.0)	mA	*4
	REGB	-3.5 to 3.5	mA	
	REEXT	-50.0 to 0	mA	*6
Allowable Voltage Between Pins	$C_n - C_{n-1}$ (n=1 ~22)	-0.3 to 11	V	
Operating junction temperature	$T_j$	-40 to 125	°C	*2
Storage temperature	$T_{stg}$	-55 to 125	°C	*2

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 GND1, GND2, and GND3 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:  $V_{CVDD}$  is the voltage of CVDD.  $V_{VDD55}$  is the voltage of VDD55. It should not exceed the rated 6.4 V.

\*4: + 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.

\*5:  $V_{VBAT}$  is the voltage of VBAT. It should not exceed the rated 130V.

\*6: The output circuit consists of both external components and internal circuitry. Refer to the application circuit diagram.

## Power Dissipation Ratings

Package	$\theta_{j-a}$	$\theta_{j-c}$	$P_D$ ( $T_a = 25^\circ\text{C}$ )	$P_D$ ( $T_a = 125^\circ\text{C}$ )	Note
TQFP 64L (10x10x1mm <sup>3</sup> , Lead Pitch 0.5mm)	38.6 $^\circ\text{C/W}$	7.2 $^\circ\text{C/W}$ (TBD)	1.80 W (TBD)	0.36 W (TBD)	*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	81.4	110	V	*2
	$V_{CVDD}$	3.0	5.0	5.5	V	
Input Voltage Range	$C_n - C_{n-1}$ ( $n=1 \sim 22$ )	1.0	—	4.8	V	*3
	SEN, SCL, SDI	0	—	$V_{CVDD}$	V	
	TMONIn ( $n=1 \sim 5$ )	0	—	$V_{VDD55}$	V	
	GPION ( $n=1 \sim 3$ )	0	—	$V_{CVDD}$	V	
	REGSEL	0	—	$V_{VDD55}$	V	
	SRP, SRN	-0.18	—	0.18	V	
	VPC	0	—	110	V	
	LDM	0	—	110	V	
	SHDN	0	—	$V_{VDD55}$	V	
Operating Ambient Temperature	$T_{aopr}$	-40	25	85	$^\circ\text{C}$	

\*1: GND is the voltage of pins GND1, GND2, and GND3, which are connected inside the device.

Connect these pins on the board and apply the same voltage.

\*2: The recommended operating supply range varies due to the characteristics of the external Nch BJT connected to VDD55. Use the parts described in the recommended circuit.

\*3: 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.

$C2 > 2.0 \text{ V}$ ,  $C22 > 12 \text{ V}$ ,  $V_{BAT} - C22 > -2 \text{ V}$ ,  $V_{BAT} - C21 > 1 \text{ V}$

\*  $C_n$  ( $n = 1$  to 22) and VBAT voltage in this conditions are in reference to GND.

\* Similarly for the monitoring system, replace the above condition  $C_n$  ( $n = 1$  to 22) with  $CB_n$  ( $n = 1$  to 22).

**Electrical Characteristics (continued)**

Unless otherwise noted, the characteristics are specified under the recommended operating condition:

VBAT = 81.4 V, CVDD = 5.0V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
SUPPLY CURRENT*1							
VBAT Active Mode	I <sub>BAT1</sub>		—	3.6	4.5 (TBD)	mA	
VBAT Low Power Mode	I <sub>BAT2</sub>	INTMSEL=10 20ms intermittent mode	—	1.35	1.75 (TBD)	mA	*2
VBAT Standby Mode	I <sub>BAT3</sub>	VDD55=Low Power, REGEXT=Low Power Coulomb Counter=off FDRV=Intermittent INTMSEL=00 Communication=off	—	0.22	0.30 (TBD)	mA	
VBAT Sleep Mode	I <sub>BAT4</sub>	VDD55=Low Power, REG18=Low Power, REGEXT=off, Communication=off	—	80	130 (TBD)	μA	
VBAT Shutdown Mode	I <sub>BAT5</sub>		0	—	1	μA	
VDD55							
VDD55 Output Voltage	V <sub>VDD55</sub>		5.3	5.5	5.8	V	
VDD55 Base Current1	IB <sub>VDD551</sub>	High Power mode; Temp=25°C; VBAT=81.4V	0.7	0.95	1.2	mA	
VDD55 Base Current2	IB <sub>VDD552</sub>	Low Power mode; Temp=25°C; VBAT=81.4V	0.4	0.65	0.9	mA	
REGEXT							
REGEXT Output Voltage1	V <sub>EXT1</sub>	REGSEL pin=L	4.75	5	5.25	V	
REGEXT Output Voltage2	V <sub>EXT2</sub>	REGSEL pin=H	3.05	3.3	3.55	V	
REGEXT Output Voltage3	V <sub>EXT3</sub>	REGSEL pin=Float	2.3	2.5	2.7	V	
REGEXT Output Current1	I <sub>EXT1</sub>	Normal mode	0	—	50	mA	
REGEXT Output Current2	I <sub>EXT2</sub>	Low Power mode	0	—	10	mA	
REG18							
REG18 output Voltage	V <sub>REG18</sub>	No load condition	1.78 (TBD)	1.85	1.92 (TBD)	V	

\*1 : Current consumption is based on the following settings.

- Consumption current is measured based total current from VBAT pin (pin 14) and VDD55 pin (pin 28).
- LDM pin is HIZ condition unless specified ;All pins no load ;SEN, SCL, and SDI = Low
- Unless otherwise specified, all registers are in the default setting.

If VDD55 and CVDD are supplying an external load, this extra current should be included additionally .

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

## Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:

VBAT = 81.4 V, CVDD = 5.0V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
CELL VOLTAGE MONITOR							
Input Voltage Range	V <sub>IN1</sub>	C <sub>n</sub> - C <sub>n-1</sub> (n=1~22)	0	—	5	V	*4
Voltage Resolution	V <sub>RES1</sub>	14bits V <sub>RES1</sub> = 5 / 2 <sup>14</sup>	—	0.3	—	mV	*4
Voltage Accuracy1	V <sub>ACC_VC1</sub>	ΔCn = 2.0V ~ 4.3 V Ta = -30°C ~ 75°C	-10	—	10	mV	*4
Voltage Accuracy2	V <sub>ACC_VC2</sub>	ΔCn = 2.0V ~ 4.3 V Ta = -40°C ~ 85°C	-15	—	15	mV	*4
Conversion Time	t <sub>conv</sub>	time/cell	—	50	—	μs	*4
Cell Measurement Input Current	I <sub>IN</sub>	Active mode	-5	—	5	μA	
Input Leakage Current	I <sub>LK</sub>	Shutdown mode	-1	—	1	μA	
OVER / UNDER VOLTAGE DETECTOR (OV / UV)							
OV detection threshold step	V <sub>ACC_OV</sub>	2.0~4.5V@6bit	—	50	—	mV	*4
UV detection threshold step	V <sub>ACC_UV</sub>	0.5~3.0V@6bit	—	50	—	mV	*4
VPACK CELL VOLTAGE MONITOR							
Input Voltage Range	V <sub>IN2</sub>		0	—	110	V	*4
Voltage Resolution	V <sub>RES2</sub>	14bits	—	6.7	—	mV	*4
Voltage Accuracy1	V <sub>ACC_VPACK1</sub>	V <sub>VPACK</sub> = 12.5V ~ 99.0V	-1	—	1	V	*1 to *3
Voltage Accuracy2	V <sub>ACC_VPACK2</sub>	V <sub>VPACK</sub> = 12.5V ~ 99.0V T <sub>a</sub> = -30°C ~ 75°C	-1	—	1	V	*4

\*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.

$C2 > 2.0 V$ ,  $C22 > 12 V$ ,  $VBAT - C22 > -2 V$ ,  $VBAT - C21 > 1 V$

\*  $Cn$  ( $n = 1$  to 22) and VBAT voltage in this conditions are in reference to GND.

\*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. The value in the parenthesis is the accuracy after soldering and aging.

\*3 : Measurement accuracy value including consideration of input average current and input leakage current.

\*4 : Design reference value not tested during final production inspection.

\*5 : 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,  $V_{RES2} = V_{IN2} / 2^{14} = 110 / 2^{14} = 6.7mV$  approx

## Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:

VBAT = 81.4 V, CVDD = 5.0V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
TMONI1-5 VOLTAGE MONITOR							
Input Voltage Range	V <sub>IN3</sub>		0	—	5	V	*1
Voltage Resolution	V <sub>RES3</sub>	14bits	—	0.3	—	mV	*1
Voltage Accuracy1	V <sub>ACC_</sub> TMONI1	VIN = 0.4V~4.7V Not use Pull-up Resistance	−10	—	10	mV	*2 to *3
Voltage Accuracy2	V <sub>ACC_</sub> TMONI2	VIN = 0.4V~4.7V Not use Pull-up Resistance T <sub>a</sub> = −30°C ~ 75°C	−10	—	10	mV	*1
Voltage Accuracy3	V <sub>ACC_</sub> TMONI3	VIN = 0.4V~4.7V Not use Pull-up Resistance T <sub>a</sub> = −40°C ~ 85°C	−15	—	15	mV	*1
Input Pull-up Resistance	R <sub>PU</sub>		7	10	13	kΩ	
Input Pull-up Resistance Temperature coefficient	RT <sub>PU</sub>	T <sub>a</sub> = −30°C ~ 75°C (with reference to 25°C)	−1.0	—	1.0	%	*1
GPIO1-2 VOLTAGE MONITOR							
Input Voltage Range	V <sub>IN4</sub>		0	—	5	V	*1
Voltage Resolution	V <sub>RES4</sub>	14bits	—	0.3	—	mV	*1
Voltage Accuracy1	V <sub>ACC_</sub> GPIO1	VIN = 0.4V~4.7V	−10	—	10	mV	*2 to *3
Voltage Accuracy2	V <sub>ACC_</sub> GPIO2	VIN = 0.4V~4.7V T <sub>a</sub> = −30°C ~ 75°C	−15	—	15	mV	*1
Voltage Accuracy3	V <sub>ACC_</sub> GPIO3	VIN = 0.4V~4.7V T <sub>a</sub> = −40°C ~ 85°C	−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.

TMONI voltage resolution,  $V_{RES3} = V_{IN3}(\text{Max.}) / 2^{14} = 5 / 2^{14} = 0.3\text{mV approx.}$

GPIO voltage resolution,  $V_{RES4} = V_{IN4}(\text{Max.}) / 2^{14} = 5 / 2^{14} = 0.3\text{mV approx.}$

\*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.



## Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:

VBAT = 81.4 V, CVDD = 5.0V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
VDD55 VOLTAGE MONITOR							
Input Voltage Range	V <sub>IN5</sub>		0	—	7.5	V	*1
Voltage Resolution	V <sub>RES5</sub>	14bits	—	0.5	—	mV	*1
Voltage Accuracy1	V <sub>ACC_ VDD551</sub>	VIN = 5.5V	−10	—	10	mV	*2 to *3
Voltage Accuracy2	V <sub>ACC_ VDD552</sub>	VIN = 5.5V T <sub>a</sub> = −30°C ~ 75°C	−15	—	15	mV	*1
Voltage Accuracy3	V <sub>ACC_ VDD553</sub>	VIN = 5.5V T <sub>a</sub> = −40°C ~ 85°C	−20	—	20	mV	*1
REGEXT VOLTAGE MONITOR							
Input Voltage Range	V <sub>IN6</sub>		0	—	7.5	V	*1
Voltage Resolution	V <sub>RES6</sub>	14bits	—	0.5	—	mV	*1
Voltage Accuracy1	V <sub>ACC_ REGEXT1</sub>	VIN = 5V	−10	—	10	mV	*2 to *3
Voltage Accuracy2	V <sub>ACC_ REGEXT2</sub>	VIN = 5V T <sub>a</sub> = −30°C ~ 75°C	−15	—	15	mV	*1
Voltage Accuracy3	V <sub>ACC_ REGEXT3</sub>	VIN = 5V T <sub>a</sub> = −40°C ~ 85°C	−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.

VDD55 voltage resolution,  $V_{RES5} = V_{IN4}(\text{Max.}) / 2^{14} = 7.5 / 2^{14} = 0.5\text{mV approx.}$

REGEXT voltage resolution,  $V_{RES6} = V_{IN5}(\text{Max.}) / 2^{14} = 7.5 / 2^{14} = 0.5\text{mV approx.}$

\*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.

## Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:

VBAT = 81.4 V, CVDD = 5.0V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
VDD18 VOLTAGE MONITOR							
Input Voltage Range	V <sub>IN7</sub>		0	—	5	V	*1
Voltage Resolution	V <sub>RES7</sub>	14bits	—	0.3	—	mV	*1
Voltage Accuracy1	V <sub>ACC_</sub> VDD181	VIN = 1.85V	−10	—	10	mV	*2 to *3
Voltage Accuracy2	V <sub>ACC_</sub> VDD182	VIN = 1.85V T <sub>a</sub> = −30°C ~ 75°C	−15	—	15	mV	*1
Voltage Accuracy3	V <sub>ACC_</sub> VDD183	VIN = 1.85V T <sub>a</sub> = −40°C ~ 85°C	−20	—	20	mV	*1
CELL BALANCING CONTROL OUTPUT (CBn)							
Output Impedance	Z <sub>CB</sub>	ΔCn = 3.0V ~ 5.0V	—	12.5	20	Ω	
THERMAL SHUTDOWN							
Shutdown Threshold	T <sub>SD2</sub>	T <sub>j</sub>	150	175	200	°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.

VDD18 voltage resolution,  $V_{RES7} = V_{IN7}(\text{Max.}) / 2^{14} = 5 / 2^{14} = 0.3\text{mV}$  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.

## Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:

VBAT = 81.4 V, CVDD = 5.0V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
LOW SPEED CURRENT MONITOR (SRP,SRN)							
Input Voltage Range	V <sub>IN8</sub>		-180	—	180	mV	*1
Voltage Resolution	V <sub>RES8</sub>	16bits	—	5.493	—	μV	
Voltage Accuracy1	V <sub>ACC_</sub> IMONI	VIN = 100mV	-1000	—	1000	μV	*2
Voltage Accuracy2	V <sub>ACC_</sub> IMONI	VIN = 10mV	-150	—	150	μV	*1
Voltage Accuracy3	V <sub>ACC_</sub> IMONI	VIN = 1mV	-25	—	25	μV	
HIGH SPEED CURRENT MONITOR (SRP,SRN)							
Input Voltage Range	V <sub>IN9</sub>		-180	—	180	mV	*1
Voltage Resolution	V <sub>RES9</sub>	15bits	—	10.99	—	μV	*3
Voltage Accuracy1	V <sub>ACC_</sub> IMONI	VIN = 100mV	-1000	—	1000	μV	*2 *3
Voltage Accuracy2	V <sub>ACC_</sub> IMONI	VIN = 10mV	-150	—	150	μV	*1
Voltage Accuracy3	V <sub>ACC_</sub> IMONI	VIN = 1mV	-50	—	50	μV	*3
CURRENT PROTECTION (SRP,SRN)							
Over Current in Charge Detection Accuracy1	V <sub>CP_OCC</sub>	Detection Threshold 5mV & 10mV	-4 (TBD)	—	4 (TBD)	mV	*1
Over Current in Charge Detection Accuracy2	V <sub>CP_OCC</sub>	Detection Threshold from 15mV to 120mV	−10	—	10	mV	
Over Current in Discharge Detection Accuracy1	V <sub>CP_OCD</sub>	Detection Threshold from 10mV to 100mV	−10	—	10	mV	
Over Current in Discharge Detection Accuracy2	V <sub>CP_OCD</sub>	Detection Threshold from 100mV to 320mV	−10	—	10	%	
Short Circuit in Discharge Detection Accuracy1	V <sub>CP_SCD</sub>	Detection Threshold from 20mV to 100mV	−10	—	10	mV	
Short Circuit in Discharge Detection Accuracy2	V <sub>CP_SCD</sub>	Detection Threshold from 100mV to 640mV	−10	—	10	%	

\*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.

$V_{RES8} = V_{IN8}(\text{max.}) / 2^{16} = 360\text{mV} / 2^{16} = 5.493\mu\text{V}$  approx. ;  $V_{RES9} = V_{IN9}(\text{max.}) / 2^{15} = 360\text{mV} / 2^{15} = 10.99\mu\text{V}$  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 : Values are for normal measurement mode only (not in V-I sync mode)

## Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:

VBAT = 81.4 V, CVDD = 5.0V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
GENERAL PURPOSE INPUT/OUTPUT (GPIO)							
Input Voltage “H”	V <sub>IH1</sub>		V <sub>CVDD</sub> × 0.8	—	V <sub>CVDD</sub>	V	
Input Voltage “L ”	V <sub>IL1</sub>		0	—	V <sub>CVDD</sub> × 0.2	V	
Output Voltage “H”	V <sub>OH1</sub>	I <sub>OH</sub> = −1mA	V <sub>CVDD</sub> −0.6	—	V <sub>CVDD</sub> +0.3	V	
Output Voltage “L ”	V <sub>OL1</sub>	I <sub>OL</sub> = +1mA	−0.3	—	0.4	V	
GENERAL PURPOSE HV OUTPUT (GPO)							
Output Voltage “L”	V <sub>HVOL1</sub>	I <sub>OL</sub> = +1mA	−0.3	—	7.0	V	
DIGITAL INPUT(1) VPC							
Input Voltage “H”	V <sub>IH2</sub>		4.0	—	—	V	
Input Voltage “L ”	V <sub>IL2</sub>		—	—	0.3	V	
Pull-down resistance	R <sub>IL2</sub>		6	28	55	MΩ	
DIGITAL INPUT(2) LDM							
Input Voltage “H”	V <sub>IH3</sub>	LDM pin voltage rising for load release detection	—	2.2	2.3 (TBD)	V	
Input Voltage “L ”	V <sub>IL3</sub>	LDM pin voltage falling for load current detection	1.9 (TBD)	2	—	V	
Pull-Up current source 1	I <sub>IL3_1</sub>	LDM pin=2V ILDM setting=50uA	30 (TBD)	50	70 (TBD)	μA	
Pull-Up current source 2	I <sub>IL3_2</sub>	LDM pin=2.2V ILDM setting =400uA	200 (TBD)	400	600 (TBD)	μA	
DIGITAL INPUT(3) SHDN							
Input Voltage “H”	V <sub>IH4</sub>		3.0	—	—	V	
Input Voltage “L ”	V <sub>IL4</sub>		—	—	0.1	V	
Pull-down resistance	R <sub>IL4</sub>		200	820	1500	kΩ	

## Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:

VBAT = 81.4 V, CVDD = 5.0V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
DIGITAL INPUT(4) SDI,SCL,SEN,FETOFF							
Input Voltage “H”	V <sub>IH5</sub>		V <sub>CVDD</sub> × 0.8	—	V <sub>CVDD</sub>	V	
Input Voltage “L ”	V <sub>IL5</sub>		0	—	V <sub>CVDD</sub> × 0.2	V	
Input Leakage Current	I <sub>LK5</sub>		-1	0	1	μA	
DIGITAL INPUT(5) REGSEL							
Input Voltage “H”	V <sub>IH6</sub>	REGSEL pin=H For REGEXT=3.3V output settings	V <sub>VDD55</sub> −0.3	—	—	V	
Input Voltage “L ”	V <sub>IL6</sub>	REGSEL pin=L For REGEXT=5V output settings	—	—	0.3	V	
Input Voltage Float	V <sub>FLT6</sub>	REGSEL pin=Float For REGEXT=2.5V output settings	2	2.75	3.5	V	
DIGITAL OUTPUT(1) ALARM1,SDO							
Output Voltage “H”	V <sub>OH7</sub>	I <sub>OH</sub> = −1mA	V <sub>CVDD</sub> −0.6	—	V <sub>CVDD</sub> +0.3	V	
Output Voltage “L ”	V <sub>OL7</sub>	I <sub>OL</sub> = +1mA	−0.3	—	0.4	V	
DIGITAL OUTPUT(2) NRST							
Output voltage “L ”	V <sub>OL8</sub>	I <sub>OL</sub> = 0 mA	−0.3	—	0.5	V	
Pull-up resistance	R <sub>IL8</sub>	—	50	100	200	kΩ	

## Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:

VBAT = 81.4 V, CVDD = 5.0V, ambient temperature and test circuit reference.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
REGEXT UVLO							
UV detection voltage	V <sub>IL_UV1</sub>	REGEXT_SEL pin=L	—	4	—	V	*1
UV release voltage	V <sub>IH_UV1</sub>	REGEXT_SEL pin=L	—	4.2	—	V	*1
VDD55 UVLO							
UVLO detection voltage	V <sub>IL_UV2</sub>		—	4.5	—	V	*1
UVLO release voltage	V <sub>IH_UV2</sub>		—	4.75	—	V	*1
Nch. FET DRIVER							
Drive voltage (DIS="H")	V <sub>ON_DIS</sub>	V <sub>ON_DIS</sub> = V <sub>DIS</sub> – V <sub>VPACK</sub> VGS connect 10MΩ	9	11	13	V	
Drive voltage (CHG="H")	V <sub>ON_CHG</sub>	V <sub>ON_CHG</sub> = V <sub>CHG</sub> – V <sub>VBAT</sub> VGS connect 10MΩ	9	11	13	V	
Drive voltage (DIS="L")	V <sub>OFF_DIS</sub>	V <sub>OFF_DIS</sub> = V <sub>DIS</sub> – V <sub>VPACK</sub> VGS connect 10MΩ	—	—	0.2	V	
Drive voltage (CHG="L")	V <sub>OFF_CHG</sub>	V <sub>OFF_CHG</sub> = V <sub>CHG</sub> – V <sub>VBAT</sub> VGS connect 10MΩ	—	—	0.2	V	
Rise time (DIS="L" to "H")	tr	V <sub>DIS</sub> = 0 to 4V C <sub>L</sub> = 20nF	—	20	50	μs	*1
Rise time (CHG="L" to "H")	tr	V <sub>CHG</sub> = 0 to 4V C <sub>L</sub> = 20nF	—	20	50	μs	*1
Fall time (DIS="H" to "L")	tf	V <sub>DIS</sub> = 90% to 10% C <sub>L</sub> = 20nF	—	20	30	μs	*1
Fall time (CHG="H" to "L")	tf	V <sub>CHG</sub> = 90% to 10% C <sub>L</sub> = 20nF	—	20	30	μs	*1

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

## Electrical Characteristics (continued)

Unless otherwise noted, the characteristics are specified under the recommended operating condition:

VBAT = 81.4 V, CVDD = 5.0V, 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 <sub>SCL</sub>	—	—	—	1	MHz	
SCL Duty Cycle	t <sub>DUTY</sub>	—	45	50	55	%	
SEN Rising to SCL Rising	t <sub>SEN_LD</sub>	—	100	—	—	ns	
SCL Falling to SEN Falling	t <sub>SEN_LG</sub>	—	100	—	—	ns	
SEN "L" Width	t <sub>SEN_LO</sub>	—	500	—	—	ns	
SDI Setup Time	t <sub>SDI_SU</sub>	SDI valid to SCL falling	100	—	—	ns	
SDI Hold Time	t <sub>SDI_HD</sub>	SCL falling to SDI valid	100	—	—	ns	
SDO Valid Time	t <sub>SDO_VD</sub>	SCL rising to SDO valid C <sub>L</sub> ≤ 50 pF	—	—	400	ns	
SDO Disable Time	t <sub>SDO_DIS</sub>	SEN falling to SDO disable	—	—	400	ns	

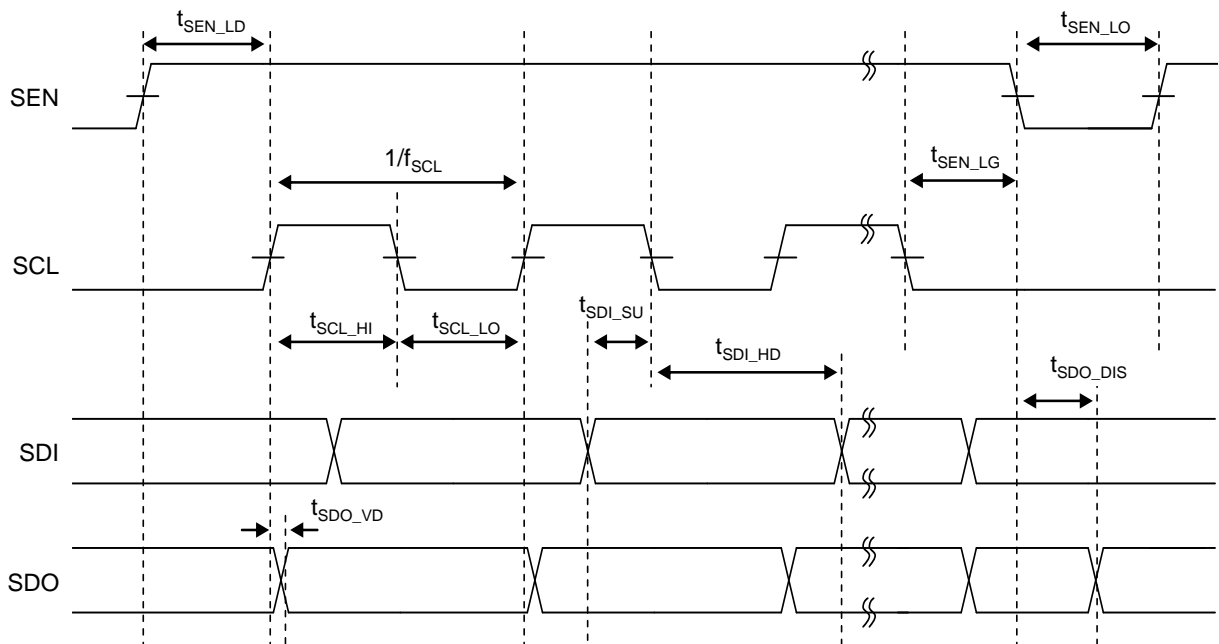
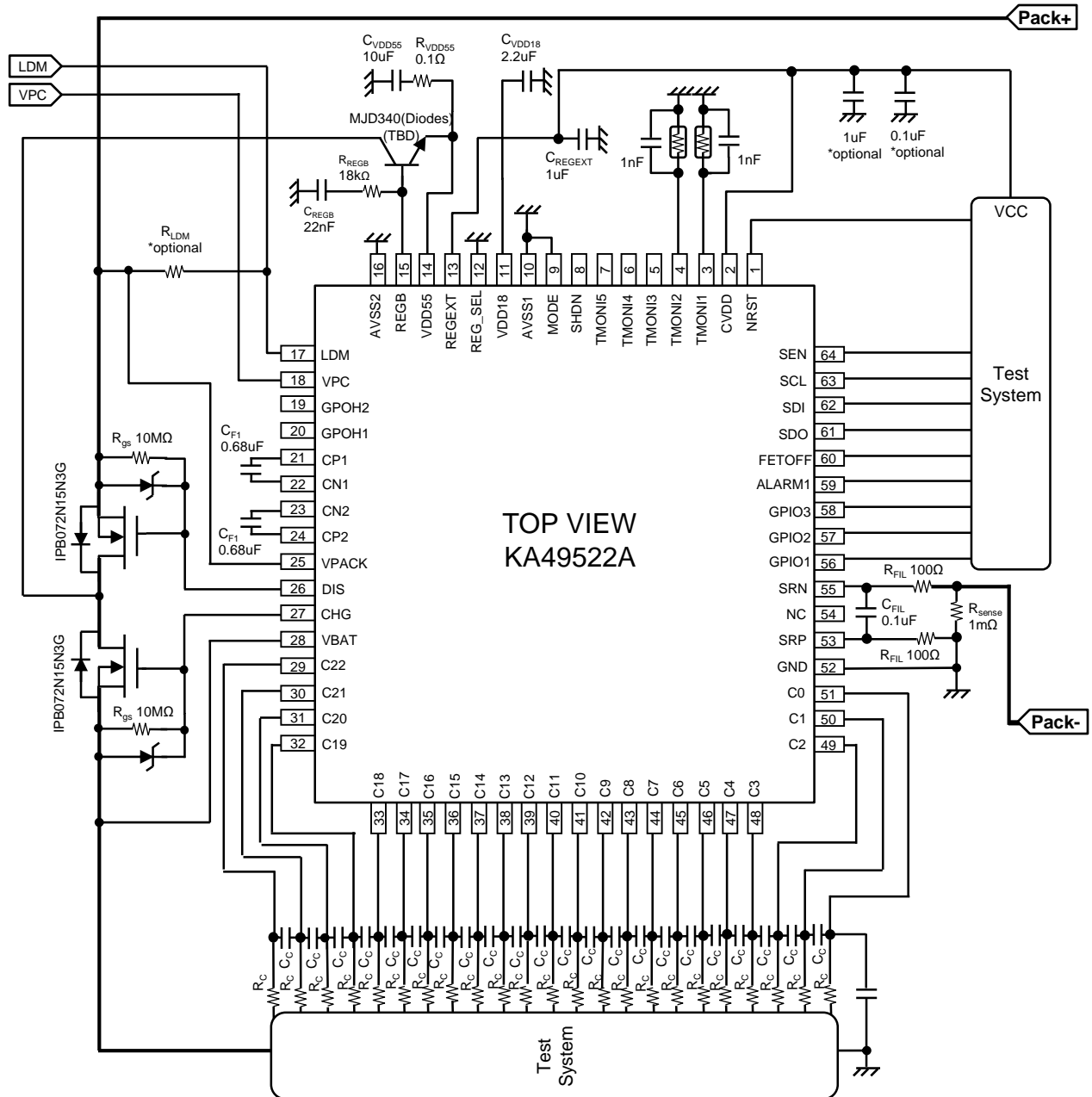


Fig.2.4.1 SPI Timing

## Electrical Characteristics (continued)

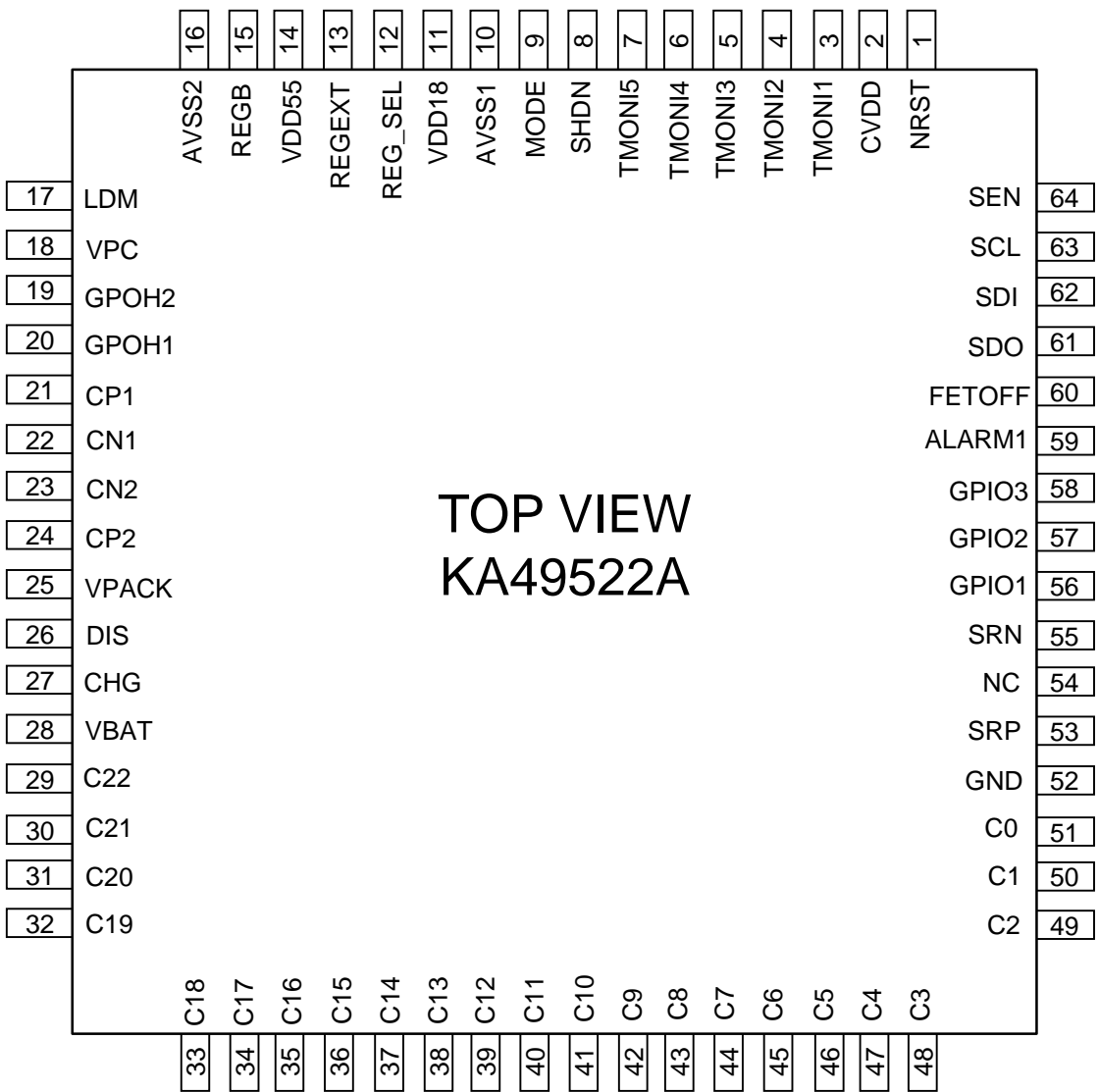
## ■ Test Circuit

Electrical characteristics are tested under our recommended 22cell RC filter condition below.



\*1: There is a requirement for the usage of REGEXT and CVDD total capacitor value.  
Please refer to page 23 bottom note (\*3) for more detail.





## Pin Description

Pin	Pin name	Type	Description
1	NRST	O	Power Reset Output Pin (Open Drain)
2	CVDD	I (Supply)	Digital Voltage Supply
3	TMONI1	I	Analog Input Pin
4	TMONI2	I	Analog Input Pin
5	TMONI3	I	Analog Input Pin
6	TMONI4	I	Analog Input Pin
7	TMONI5	I	Analog Input Pin
8	SHDN	I	Shutdown Control “L”: Active / “H”: Shutdown
9	MODE	I	Test Mode pin for Manufacturer Use Only (Connect to DVSS always) *1
10	AVSS1	GND	Analog Ground
11	VDD18	O	1.85V LDO Output Pin for Internal Use
12	REGSEL	I	External 5V/3.3V/2.5V REGEXT output selection Pin
13	REGEXT	O	External 5V/3.3V/2.5V LDO Output Pin
14	VDD55	O	5.5V Regulator Output Pin
15	REGB	O	Base Pin for 5.5V Pre-regulator
16	AVSS2	GND	Analog Ground
17	LDM	I	Load Detect Pin
18	VPC	I	Wake Up Signal Pin - “L” Active / “H” Wake Up. Also for Charger Detect.
19	GPOH2	O	High Voltage General Purpose Output Pin 2 (Open Drain)
20	GPOH1	O	High Voltage General Purpose Output Pin 1 (Open Drain)

\*1 An external pull-down resistor should be connected to MODE pin and it is internally connected to GND through a 1 kΩ resistor.

## Pin Description (continued)

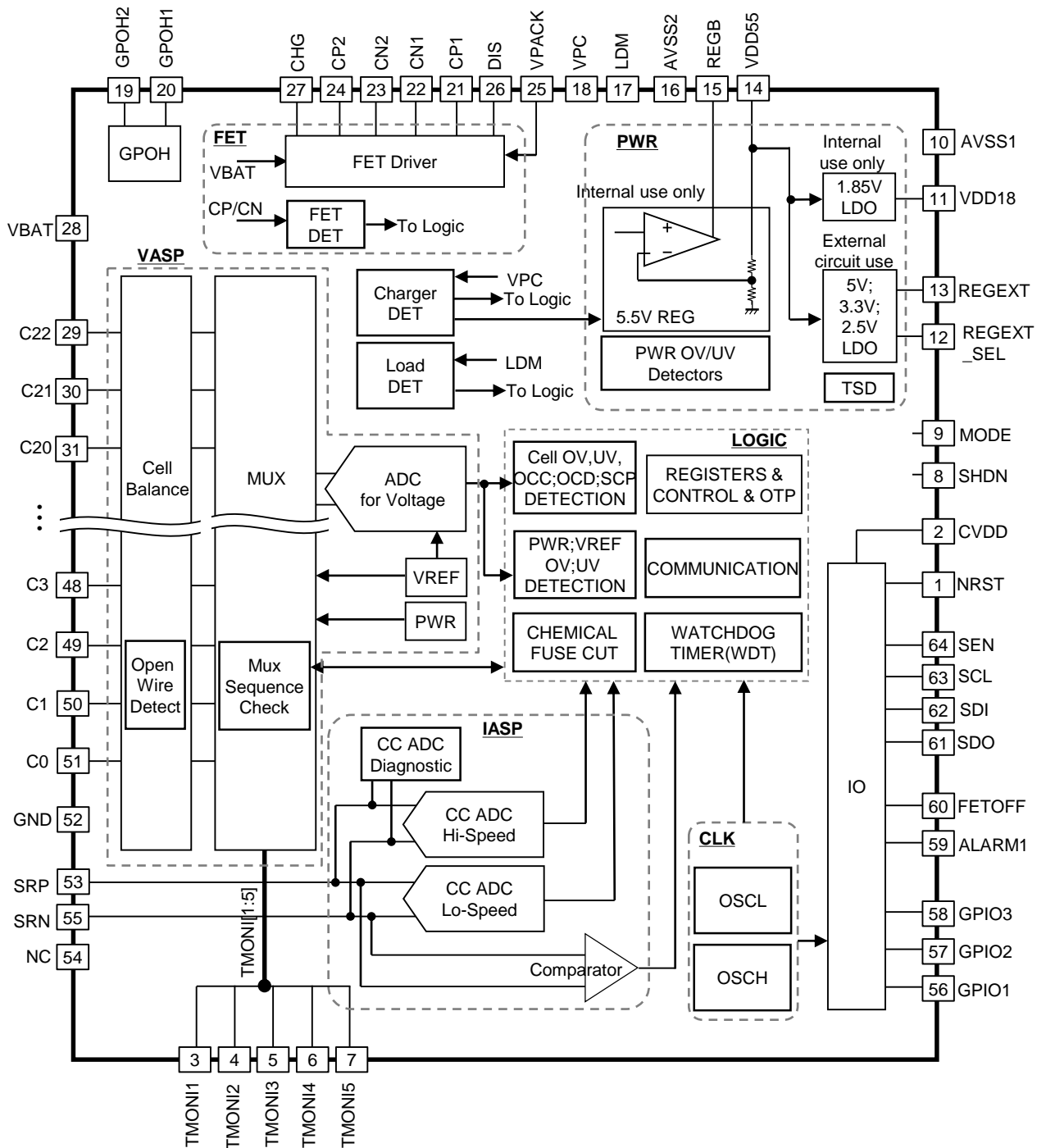
Pin	Pin name	Type	Description
21	CP1	O	Charge Pump Capacitor Pin (Positive Terminal for VPACK)
22	CN1	O	Charge Pump Capacitor Pin (Negative Terminal for VPACK)
23	CN2	O	Charge Pump Capacitor Pin (Negative Terminal for VBAT)
24	CP2	O	Charge Pump Capacitor Pin (Positive Terminal for VBAT)
25	VPACK	I (Supply)	Positive Terminal of Battery Pack to load or charger.
26	DIS	O	Discharge NMOSFET Gate Drive Pin
27	CHG	O	Charge NMOSFET Gate Drive Pin
28	VBAT	I (Supply)	Stacked Cells Highest Voltage Pin
29	C22	I	Cell 22 Input Pin (+ve)
30	C21	I	Cell 21 Input Pin (+ve) / Cell 22 Input Pin (-ve)
31	C20	I	Cell 20 Input Pin (+ve) / Cell 21 Input Pin (-ve)
32	C19	I	Cell 19 Input Pin (+ve) / Cell 20 Input Pin (-ve)
33	C18	I	Cell 18 Input Pin (+ve) / Cell 19 Input Pin (-ve)
34	C17	I	Cell 17 Input Pin (+ve) / Cell 18 Input Pin (-ve)
35	C16	I	Cell 16 Input Pin (+ve) / Cell 17 Input Pin (-ve)
36	C15	I	Cell 15 Input Pin (+ve) / Cell 16 Input Pin (-ve)
37	C14	I	Cell 14 Input Pin (+ve) / Cell 15 Input Pin (-ve)
38	C13	I	Cell 13 Input Pin (+ve) / Cell 14 Input Pin (-ve)
39	C12	I	Cell 12 Input Pin (+ve) / Cell 13 Input Pin (-ve)
40	C11	I	Cell 11 Input Pin (+ve) / Cell 12 Input Pin (-ve)

## Pin Description (continued)

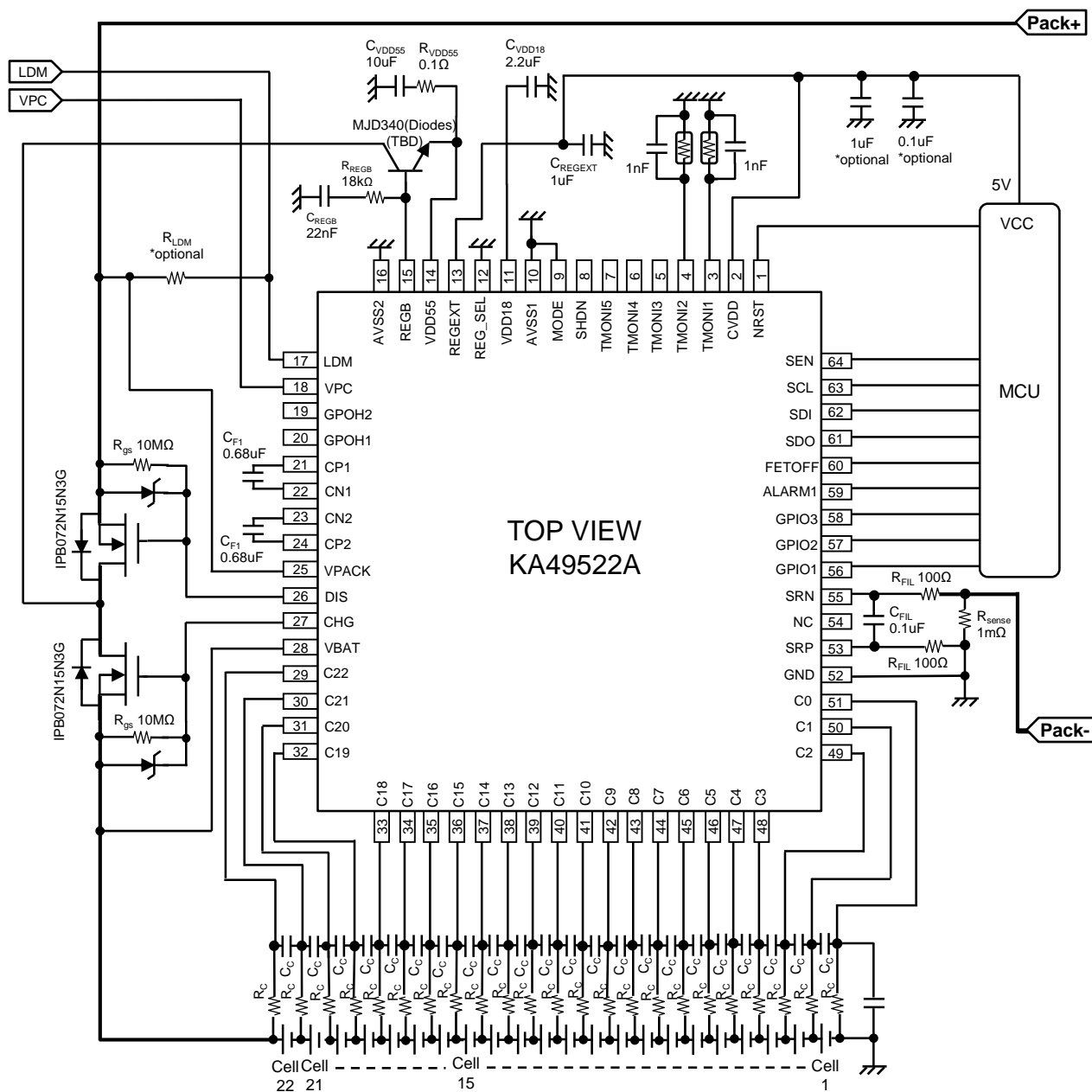
Pin	Pin name	Type	Description
41	C10	I	Cell 10 Input Pin (+ve) / Cell 11 Input Pin (-ve)
42	C9	I	Cell 9 Input Pin (+ve) / Cell 10 Input Pin (-ve)
43	C8	I	Cell 8 Input Pin (+ve) / Cell 9 Input Pin (-ve)
44	C7	I	Cell 7 Input Pin (+ve) / Cell 8 Input Pin (-ve)
45	C6	I	Cell 6 Input Pin (+ve) / Cell 7 Input Pin (-ve)
46	C5	I	Cell 5 Input Pin (+ve) / Cell 6 Input Pin (-ve)
47	C4	I	Cell 4 Input Pin (+ve) / Cell 5 Input Pin (-ve)
48	C3	I	Cell 3 Input Pin (+ve) / Cell 4 Input Pin (-ve)
49	C2	I	Cell 2 Input Pin (+ve) / Cell 3 Input Pin (-ve)
50	C1	I	Cell 1 Input Pin (+ve) / Cell 2 Input Pin (-ve)
51	C0	I	Cell 1 Input Pin (-ve)
52	GND	GND	Analog Ground
53	SRP	I	Shunt Resistor Positive Pin
54	NC	-	N.C. Pin
55	SRN	I	Shunt Resistor Negative Pin
56	GPIO1	I/O	General Purpose I/O Pin 1
57	GPIO2	I/O	General Purpose I/O Pin 2
58	GPIO3	I/O	General Purpose I/O Pin 3
59	ALARM1	O	ALARM1 Pin
60	FETOFF	I	CHG/DIS FET Control Pin - "L" Normal / "H" FET Forced OFF
61	SDO	O	SPI Interface Pin – Data Out *1
62	SDI	I	SPI Interface Pin – Data In *1
63	SCL	I	SPI Interface Pin – Clock *1
64	SEN	I	SPI Interface Pin – Enable *1

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

## Block Diagram



## B. Application Circuit Example



\*1: There is a requirement for the usage of REGEXT and CVDD total capacitor value.  
Please refer to page 23 bottom note (\*3) for more detail.

## Recommended Constant of External Component

Item	Symbol	Constant				Note
		Min.	Typ.	Max.	Unit	
Constant of components connected to pins	$C_{REGB}$	—	22	—	nF	*1, *2
	$R_{REGB}$	—	18	—	k $\Omega$	*2
	$C_{VDD55}$	—	10	—	$\mu$ F	*1, *2
	$R_{VDD55}$	—	0.1	—	$\Omega$	*2
	$C_{VDD18}$	—	2.2	—	$\mu$ F	*1
	$C_{REGEXT}$	—	1	—	$\mu$ F	*1,*3
	$R_{GS}$	—	10	—	M $\Omega$	*2
	$C_{F1}$	—	0.68	—	$\mu$ F	*1
	$C_{F2}$	—	0.68	—	$\mu$ F	*1
	$R_C$	—	1	—	k $\Omega$	*5
	$C_C$	—	1	—	$\mu$ F	*1,*4
	$R_{sense}$	—	100	—	m $\Omega$	*6
	$R_{FIL}$	—	100	—	$\Omega$	
	$C_{FIL}$	—	0.1	—	$\mu$ F	*1
	$R_{LDM}$	—	32.4	—	k $\Omega$	*7

\*1: Use of a ceramic capacitor is recommended.

\*2: The parameters are applicable for system using an external NPN BJT (Diodes Inc MJD340), as shown in the recommended circuit.

\*3: REGEXT can be used for as power supply for CVDD pin and external circuit. 1 $\mu$ F capacitor (CREGEXT) is necessary at REGEXT output. It is recommended to connect a maximum of 1 $\mu$ F capacitor for CVDD pin and external circuit, which is compatible with default CVDD55 and VDD55 NPN device (Diodes Inc MJD340). If it is necessary to increase these total capacitor value, the capacitor CVDD55 must be increased proportionally with about 5 times ratio to ensure stability. Please note start-up time of VDD55 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 22 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.

\*7:  $R_{LDM}$  allow user to adjust Load detector threshold based on system requirement. By using  $R_{LDM}$  of 32.4k, it is possible to detect LDM threshold of 0.4V when load current of minimum 70 $\mu$ A is drawn at the pin in the case FET is open case.

## Description of Functions

### 1. Battery Connection

The minimum required VBAT pin voltage is 12.5V to guarantee normal operation.

For application using less than 22 cells, all unused cells Cn pins should be connected as shown in figure below, user shall use cells connect to C22, C21, C1 and C2 pins first and followed by battery from lower cell. Battery cells connection sequence:

Connect the GND pin followed by VBAT pin. After that, it should be connected from the lower cell in turn.  
GND → VBAT → Cell between C0-C1 → Cell between C1-C2 → incrementally

Figures below are some system example. Minimum VBAT for 4 cells system must be higher than 12.5V.

Fig.1.1.1  
Example of  
20 Cell System

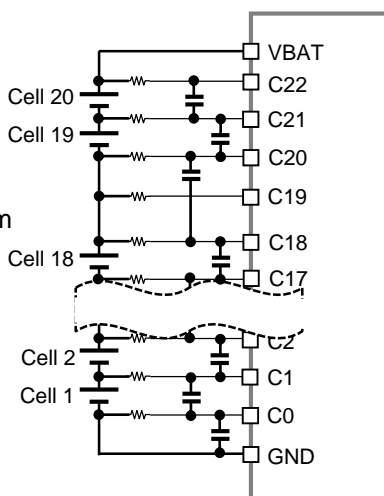


Fig.1.1.2  
Example of  
18 Cell System

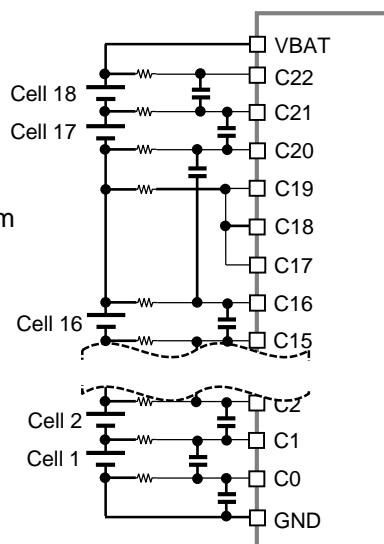


Fig.1.1.3  
Example of  
16 Cell System

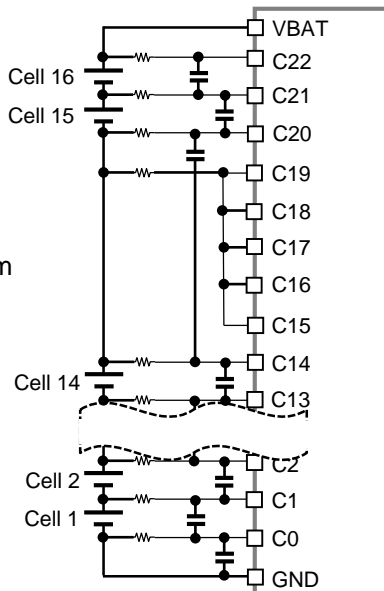
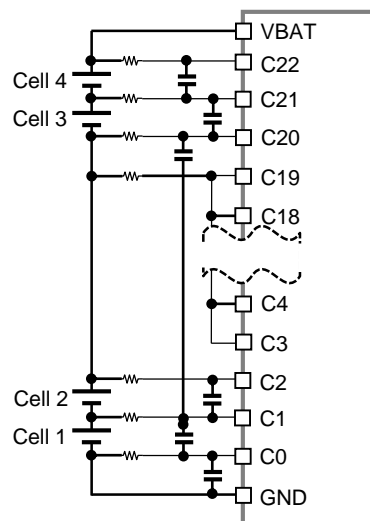


Fig.1.1.4  
Example of  
4 Cell System

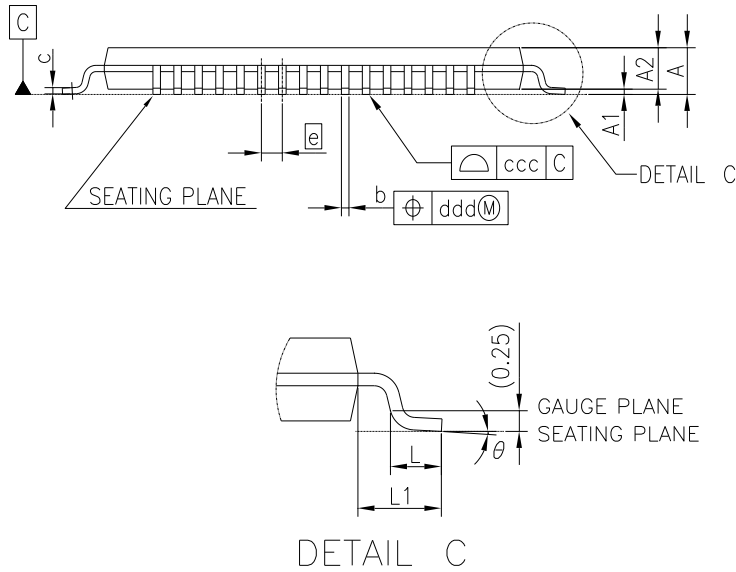
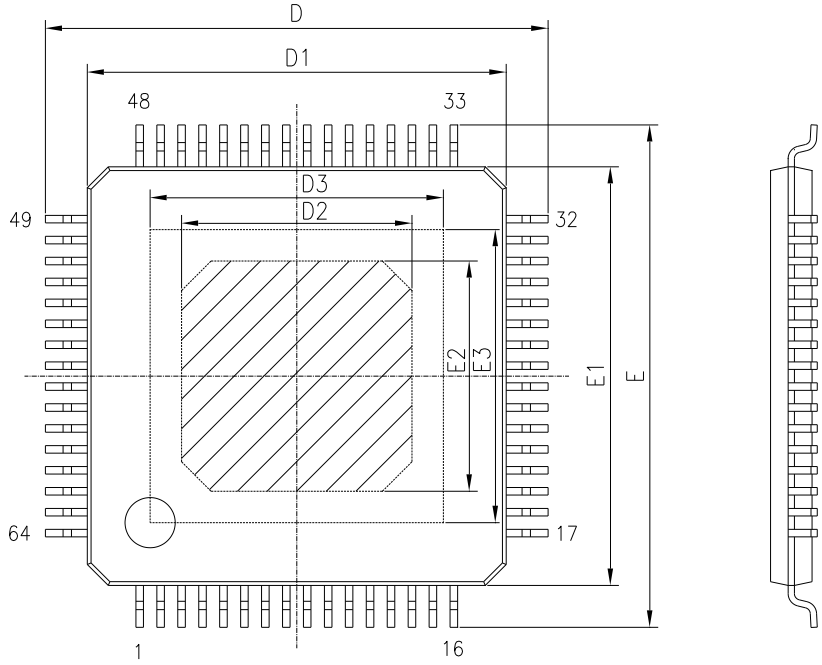




# Dimensions

- TQFP 64L 10x10mm<sup>2</sup>, Thickness 1mm, Lead Pitch 0.5mm, Lead Length 1mm, EP Size 5.5x5.5mm

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	11.80	12.00	12.20
D1	9.90	10.00	10.10
D2	5.50	—	—
D3	—	—	7.00
E	11.80	12.00	12.20
E1	9.90	10.00	10.10
E2	5.50	—	—
E3	—	—	7.00
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		
ddd	0.10		
ccc	0.10		
θ	0.0°	—	8.0°

## IMPORTANT NOTICE

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.

Revision History

Control Number 2101EL-01

Date	Page	Item	Before	After
28 Jan 2021	—	Initial Release	—	—

## Important Notice

Nuvoton Products are neither intended nor warranted for usage in systems or equipment, any malfunction or failure of which may cause loss of human life, bodily injury or severe property damage. Such applications are deemed, "Insecure Usage".

Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.

All Insecure Usage shall be made at customer's risk, and in the event that third parties lay claims to Nuvoton as a result of customer's Insecure Usage, customer shall indemnify the damages and liabilities thus incurred by Nuvoton.

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