TG28-ESP Single Cell NVDC PMU with E-gauge For AIOT

1 Features

- 3.9V – 5.5V Input Operating Range and Support single Cell Battery
- Battery fuel gauge: E gauge 3.0
- Support TWSI(Two Wire Serial Interface)
- Support high efficiency 1uH inductor buck mode switch charger, 85%@5V-3.8V-1A, Ichg can be up to 1.5A
- Single input to support USB input
- High battery discharge efficiency with 50 mOhm
- High integration includes all MOSFETS, current sensing and loop compensation
- Power off current <40uA（BATFET off，RTCLDO output on）
- 4 DCDCs

  DCDC1:1.5~3.4V, IMAX=2A,default=3.3V

  DCDC2: 0.5~1.2V, 1.22~1.54V, IMAX=2A,default=OFF

  DCDC3: 0.5~1.2V, 1.22~1.54V, IMAX=2A,default=OFF

  DCDC4: 0.5~1.2V, 1.22~1.84V, IMAX=1.5A,default=1.8V
- 8 LDOs ,2 Switchs

  RTCLDO1: 3V, 30mA;

  Support RTCLDO1 supplied by backup battery (button battery)

  ALDO1~4: analog LDO, 0.5~3.5V, 0.1V/step, IMAX=300mA,default=OFF

  BLDO1/2: analog LDO,0.5~3.5V, 0.1V/step, IMAX=300mA,default=OFF

  CPUSLDO: for CPUs, 0.5~1.4V, IMAX=30mA,default=OFF

  DLDO1/DC1SW: power switch ,input is DCDC1,IMAX=300mA,default=OFF

  DLDO2/DC4SW: power switch ,input is DCDC4,IMAX=300mA,default=OFF
- Protection

  Input Over-Voltage Protection

  Battery Thermistor Sense Hot/Cold to suspend Charging

  Programmable Safety Timer for Charger

  Die Thermal Balance for Charger

  Thermal Shutdown

  DCDC Over-Voltage/Under-Voltage Protection

2 Applications

- Wireless MCU,AIOT, etc.

3 Description

TG28 is a highly integrated power management IC (PMIC) targeting at single cell Li-battery (Li-ion or Li-polymer) applications that require multi-channel power outputs. It provides an easy and flexible power management solution for multi-core processors to meet the complex and accurate requirements of power control.

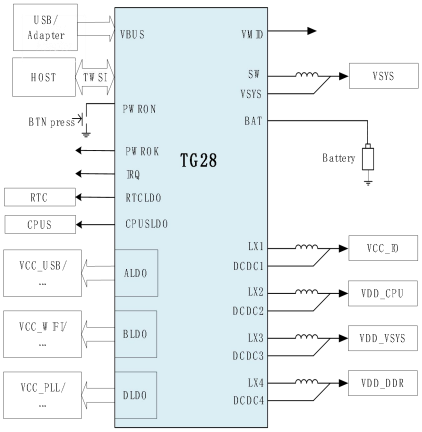
TG28 supports switch charge .Besides, it supports 14 channel power outputs which include 4 channel DCDCs ,8 channel LDOs,2 channel switchs. To ensure the security and stability of the system, TG28 provides multiple channels 14-bit ADC for voltage/temperature monitor and integrates protection circuits such as over-voltage protection (OVP), over-current protection (OCP) and over-temperature protection (OTP). Moreover, TG28 features a unique E-Gauge™ (Fuel Gauge) system, making power gauge easy and exact.

TG28 supports TWSI for system to dynamically adjust output voltages, charge current and configure interrupt condition.

Device Information

Part Number	Package	Body Size
TG28	QFN-40	5mm * 5mm

Simplified Application Diagram



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Revision History

Revision	Date	Author	Description
1.0	May 27, 2024	AWA 1017	Initial version

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Contents

1 Features 1
2 Applications 1
3 Description 1
Revision History 2
Contents 3
Figures 5
Tables 6
4 Pin Configuration and Functions 7
5 Specifications 9
5.1 Absolute Maximum Ratings (1) 9
5.2 ESD Ratings 9
5.3 Recommended Operating Conditions 9
5.4 Thermal Information 9
5.5 Electrical Characteristics 10
6 Detail Description 13
6.1 Overview 13
6.2 Function Block Diagram 14
6.3 TWSI Communication 15
6.4 Power Path 16
6.5 Power On/Off and reset 16
6.5.1 Power on reset(POR) 16
6.5.2 Power up from BAT 16
6.5.3 Power up from VBUS 16
6.5.4 System power on/off management 17
6.6 Multi-Power Outputs 19
6.7 Charger 19
6.7.1 Characteristics 19
6.7.2 Charging condition 20
6.7.3 Charging process 20
6.7.4 Charging protection 21
6.7.5 Charging indication 22
6.8 BATFET 23
6.9 RBFET 23
6.10 ADC 23
6.11 E-Gauge 23
6.12 IRQ /BACKUP 23

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6.12.1 IRQ 23
6.12.2 BACKUP 24
6.13 Register 24
6.13.1 Register List 24
6.13.2 Register Description 25
7 Application Information 45
7.1 Typical Application 45
8 Package, Carrier, Storage and Baking Information 46
8.1 Package 46
8.2 Carrier 46
8.3 Storage 47
8.3.1 Moisture Sensitivity Level(MSL) 47
8.3.2 Bagged Storage Conditions 48
8.3.3 Out-of-bag Duration 48
8.4 Baking 48
9 Reflow Profile 49

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Figures

Figure 4-1 Pin Map 7
Figure 6-1 Function Block Diagram 14
Figure 6-2 Waveform of TWSI 15
Figure 6-3 Timing of TWSI 15
Figure 6-4 Sleep and Wakeup 18
Figure 7-1 Typical Application 45
Figure 8-1 Package Information 46
Figure 8-2 TG28 marking 46
Figure 8-3 TG28 Tray Dimension Drawing 47
Figure 9-1 TG28 Typical Reflow Profile 49

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Tables

Table 4-1 Pin Description 7
Table 5-1 Absolute Maximum Ratings 9
Table 5-2 ESD Ratings 9
Table 5-3 Recommended Operating Conditions 9
Table 5-4 Thermal Metric 9
Table 5-5 Electrical Characteristics 10
Table 6-1 Read and write address of TWSI 15
Table 6-2 Timing constants 15
Table 6-3 Features of Multi-Power Outputs 19
Table 6-4 Charging Parameters 20
Table 6-5 Relationship among temperature, equivalent resistance, detected voltage and ADC data 22
Table 6-6 CHGLED Function Control 22
Table 6-7 ADC Channel and Data 23
Table 8-1 TG28 Marking Definitions 46
Table 8-2 TG28 Tray Carrier Information 46
Table 8-3 TG28 Packing Quantity Information 47
Table 8-4 MSL Summary 47
Table 8-5 Bagged Storage Conditions 48
Table 8-6 Out-of-bag Duration 48
Table 8-7 Baking Conditions 48
Table 9-1 TG28 Reflow Profile Conditions 49

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4 Pin Configuration and Functions

Figure 4-1 Pin Map

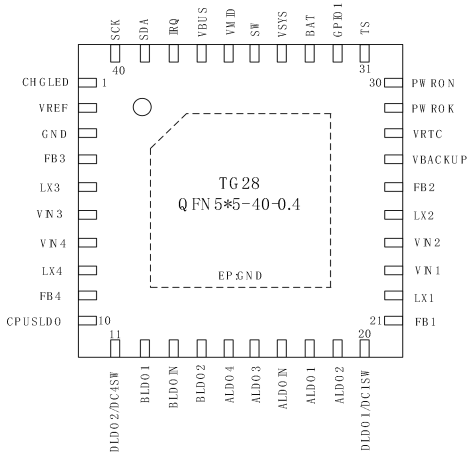


Table 4-1 Pin Description

NO.	Pin Name	Type	Description
1	CHGLED	AO	Charge status output to indicate various charger operation.
2	VREF	P	Internal reference voltage
3	GND	AI	Analog ground for interrupt analog and digital circuits.
4	FB3	P	DCDC3 feedback pin
5	LX3	P	Inductor pin for DCDC3
6	VIN3	P	DCDC3 input source
7	VIN4	P	DCDC4 input source
8	LX4	P	Inductor pin for DCDC4
9	FB4	P	DCDC4 feedback pin and Switch input source
10	CPUSLDO	P	Output pin of CPUSLDO
11	DLDO2/DC4SW	DO	Output pin of configured as the Output pin of DC4SW,input is DCDC4
12	BLDO1	P	Output pin of BLDO1
13	BLDOIN	P	BLDO input source
14	BLDO2	P	Output pin of BLDO2
15	ALDO4	P	Output pin of ALDO4
16	ALDO3	P	Output pin of ALDO3
17	ALDOIN	P	ALDO input source, should be connected to VSYS pin
18	ALDO1	P	Output pin of ALDO1
19	ALDO2	P	Output pin of ALDO2
20	DLDO1/DC1SW	P	Output pin of configured as the Output pin of DC1SW,input is DCDC1
21	FB1	P	DCDC1 feedback pin
22	LX1	P	Inductor pin for DCDC1
23	VIN1	P	DCDC1 input source
24	VIN2	P	DCDC2 input source
25	LX2	P	Inductor pin for DCDC2
26	FB2	AI	DCDC2 feedback pin
27	VBACKUP	P	Input pin of backup battery
28	VRTC	P	RTC power output
29	PWROK	DIO	Power good indication output
30	PWRON	DIO	Power On-Off key input, Internal 100k pull up to VINT.

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31	TS	AI	Temperature qualification voltage input. Connect a negative temperature coefficient thermistor from TS to GND. A current source is injected to TS pin and convert TS voltage to a digital code. Charging suspends when TS pin is out of range. Besides, TS can be connected to external input signal.
32	GPIO1	DIO	Output pin of GPIO1(open drain)
33	BAT	P	Battery connection point. The internal BATFET is connected between BAT and SYS. Connect a 1uF capacitor closely to the BAT pin.
34	VSYS	P	System connection point. The internal BATFET is connected between BAT and SYS. Connect two 22uF capacitors closely to the SYS pin.
35	SW	P	Inductor pin for Buck
36	VMID	P	VMID Power output
37	VBUS	P	VBUS input
38	IRQ	DIO	Open-drain interrupt Output. Connect the IRQ to a logic rail via a 4.7kΩ resistor. The IRQ pin sends a low level signal to host to report charger device status and fault.
39	SDA	DIO	Data pin for serial interface, needs a 2.2kΩ Pull High.
40	SCK	DI	SCK pin for serial interface, needs a 2.2kΩ Pull High.
EP	EP	GND	Exposed Pad, needs to be connected to system ground

(1)**O** for output, **I** for input, **IO** for input/output, **D** for digital, **A** for analog, **P** for power, and **G** for ground.

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5 Specifications

5.1 Absolute Maximum Ratings (1)

Table 5-1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)

SYMBOL	DESCRIPTION	MIN	MAX	UNIT
VBUS	Voltage range(with respect to GND)	-0.3	12	V
Others pin (exp VBUS, PGND, GND)		-0.3	7	V
		-0.3	7	V
PGND to GND		-0.3	0.3	V
Ta	Operating Temperature Range	-40	85	℃
TJ	Junction Temperature Range	-40	125	℃
Ts	Storage Temperature Range	-65	150	℃
TLEAD	Maximum Soldering Temperature (at leads，10sec)		300	℃

(1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

5.2 ESD Ratings

Table 5-2 ESD Ratings

		VALUE	UNIT
VESD	Human body model(HBM)(1)	±4000	V
	Charged device model(CDM)(2)	±750	V

(1) Reference: ESDA/JEDEC JS-001-2017.

(2) Reference: ESDA/JEDEC JS-002-2018.

5.3 Recommended Operating Conditions

Table 5-3 Recommended Operating Conditions

SYMBOL	DESCRIPTION	MIN	MAX	UNIT
VIN	Input voltage(VBUS)	3.9	5.5	V
IIN	Input current(VBUS)		2	A
ISYS	Output current		2	A
VBAT	Battery voltage		4.4	V
IBAT	charging current		1.5	A

5.4 Thermal Information

Table 5-4 Thermal Metric

Thermal Metric(1)		VALUE	UNIT
θ_{JA}	Junction-to-ambient thermal resistance	30	℃/W
θ_{JB}	Junction-to-board thermal resistance	10.8	
θ_{JC}	Junction-to-case(top) thermal resistance	22.8	

(1)Thermal metrics are calculated refer to JEDEC document JESD51.

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5.5 Electrical Characteristics

Table 5-5 Electrical Characteristics

Symbol	Parameters	Test Conditions	MIN	TYP	MAX	UNIT
QUIESCENT CURRENTS						
I_{BAT}	Battery discharge current	no VBUS, BATFET Disabled, with only RTCLDO on		40		uA
VBUS/BAT POWER UP						
V_{VBUS}	VBUS operating range		3.9		5.5	V
V_{VBUS_UVLOZ}	VBUS under voltage threshold			3.75		V
V_{VBUS_OV}	VBUS over-voltage rising threshold			7		V
V_{SLEEPZ}	Sleep mode rising threshold (VBUS-VBAT)			150		mV
V_{BAT}	V_{BAT} operating range		2.5		4.4	V
V_{BAT_UVLOZ}	VBAT under voltage threshold			2.4		V
V_{BAT_DPLZ}	VBAT depletion threshold			2.5		V
Battery Charger						
V_{BATREG_RANGE}	Typical Charge voltage range	V_{BATREG}= 4.0/ 4.1/ 4.2/ 4.35/ 4.4V	4.0		4.4	V
V_{BATREG}	Charge voltage resolution accuracy	V_{BAT} = 4.2V, TJ = 25˚C	-0.50%		0.50%	
$I_{CHG_REG_RANGE}$	Typical Fast charge current regulation range	V_{BATREG}= 4.0/4.1V	0		1500	mA
		V_{BATREG}= 4.2V	0		1400	
		V_{BATREG}= 4.35V	0		1100	
		V_{BATREG}= 4.4V	0		1000	
$I_{CHG_REG_ACC}$	Fast charge current regulation accuracy	I_{CHG}=800mA,T_J = 25˚C	-20%		20%	
$V_{BATLOWV}$	Battery low voltage threshold	Fast charge to precharge		3		V
I_{PRECHG_RANGE}	Precharge current range		0		200	mA
I_{PRECHG_ACC}	Precharge current accuracy	I_{PRECHG} = 200mA,T_J = 25˚C	-50%		50%	
I_{TERM_RANGE}	Termination current range		0		200	mA
V_{TRICHG}	Battery trickle charge threshold	V_{BAT} falling		2		V
I_{TRICHG}	Battery trickle charge current	V_{BAT} < 2 V		10		mA
V_{RECHG}	Recharge Threshold below VBATREG	V_{BAT} falling		100		mV
Input Voltage / Current Regulation						
V_{INDPM_RANGE}	Typical Input voltage regulation range		3.88		5.08	V
V_{INDPM_ACC}	Input voltage regulation accuracy	V_{INDPM}=4.36V	-3%		3%	
I_{INLIM_RANGE}	Input current regulation range		100		2000	mA
I_{INDPM_ACC}	Input current regulation accuracy	I_{INLIM} =500mA	350		500	mA

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Symbol	Parameters	Test Conditions	MIN	TYP	MAX	UNIT
DCDC						
DCDC1/2/3/4						
V_{IN}	Input Voltage		2.6		5.5	V
UVP				85%		
OVP				130%		
Accuracy	Output Accuracy	Accuracy, PWM mode, V_{OUT}<1V	-30		30	mV
		Accuracy, PWM mode, V_{OUT}>1V	-3.00%		3.00%	
DCDC1						
V_{OUT}	Output Voltage	Output Range	1.5		3.4	V
		Step Size		100		mV
I_{OUT}	Output Load Current			2		A
DCDC2						
V_{OUT}	Output Voltage	Output Range	0.5		1.54	V
		Step Size, V_{OUT}=0.5V~1.2V		10		mV
		Step Size, V_{OUT}=1.22V~1.54V		20		mV
I_{OUT}	Output Load Current			2		A
DCDC3						
V_{OUT}	Output Voltage	Output Range	0.5		1.54	V
		Step Size, V_{OUT}=0.5V~1.2V		10		mV
		Step Size, V_{OUT}=1.22V~1.54V		20		mV
I_{OUT}	Output Load Current			2		A
DCDC4						
V_{OUT}	Output Voltage	Output Range	0.5		1.84	V
		Step Size, V_{OUT}=0.5V~1.2V		10		mV
		Step Size, V_{OUT}=1.22V~1.84V		20		mV
I_{OUT}	Output Load Current			1.5		A
LDO						
RTCLDO1						
V_{OUT}	Output Voltage	V_{OUT}=1.8/ 2.5/ 3/ 3.3V	1.8		3.3	V
	Output voltage accuracy		-10%		+10%	
I_{OUT}	Output Load Current			30		mA
CPUSLDO						
VIN	Input Voltage	Input is DCDC4	0.8		1.84	V
V_{OUT}	Output Voltage	Output Range	0.5		1.4	V
		Step size		50		mV
	Output voltage accuracy	Accuracy,VIN=0.8V~1.84V, V_{OUT}<1V, I_{load}=10mA	-30		30	mV
		Accuracy,VIN=0.8V~1.84V, V_{OUT}>1V, I_{load}=10mA	-3%		3%	
V_{Drop}	Dropout			300		mV
I_{OUT}	Output Load Current			30		mA
ILIM	Current Limit			300		mA

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Symbol	Parameters	Test Conditions	MIN	TYP	MAX	UNIT
ALDO1~4/BLDO1~2						
VIN	Input Voltage		2.6		5.5	V
V_{OUT}	Output Voltage	Output Range	0.5		3.5	V
		Step size		100		mV
	Output voltage accuracy	Accuracy, V_{OUT}<1V, I_{load}=10mA	-30		30	mV
		Accuracy, V_{OUT}>1V, I_{load}=10mA	-3%		3%	
V_{Drop}	Dropout			300		mV
I_{OUT}	Output Load Current			300		mA
ILIM	Current Limit			500		mA
DLDO1(DC1SW)						
VIN	Input Voltage	Input is DCDC1	1.8		3.4	V
V_{OUT}	Output Voltage	Output Range	0.5		3.3	V
		Step size		100		mV
	Output voltage accuracy	Accuracy, V_{OUT}<1V, I_{load}=10mA	-30		30	mV
		Accuracy, V_{OUT}>1V, I_{load}=10mA	-3%		3%	
V_{Drop}	Dropout	As LDO		300		mV
I_{OUT}	Output Load Current			300		mA
ILIM	Current Limit			500		mA
DLDO2(DC4SW)						
VIN	Input Voltage	Input is DCDC4	1.5		1.8	V
V_{OUT}	Output Voltage	Output Range	0.5		1.4	V
		Step size		100		mV
	Output voltage accuracy	Accuracy, V_{OUT}<1V, I_{load}=10mA	-30		30	mV
		Accuracy, V_{OUT}>1V, I_{load}=10mA	-3%		3%	
V_{Drop}	Dropout	As LDO		300		mV
I_{OUT}	Output Load Current			300		mA
ILIM	Current Limit			500		mA
TWI&IO						
TWI INTERFACE (SCL, SDA)						
VIH	Input high threshold level, SCL and SDA		1.3			V
VIL	Input low threshold level				0.8	V
VOL	Output low threshold level	Sink Current = 5mA, sink current			0.4	V
Logic I/O pin Characteristics (IRQ/PWRON/PWROK)						
VIH	Input high threshold level		1.3			V
VIL	Input low threshold level				0.8	V

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6 Detail Description

6.1 Overview

TG28 is a highly integrated power management IC (PMIC) targeting at single cell Li-battery (Li-ion or Li-polymer) applications that require multi-channel power outputs. It provides an easy and flexible power management solution for multi-core processors to meet the complex and accurate requirements of power control.

TG28 supports switch charge . Besides, it supports 14 channel power outputs which include 4 channel DCDCs ,8 channel LDOs and 2 channel switchs . To ensure the security and stability of the system, TG28 provides multiple channels 14-bit ADC for voltage/temperature monitor and integrates protection circuits such as over-voltage protection (OVP), over-current protection (OCP) and over-temperature protection (OTP). Moreover, TG28 features a unique E-Gauge™ (Fuel Gauge) system, making power gauge easy and exact.

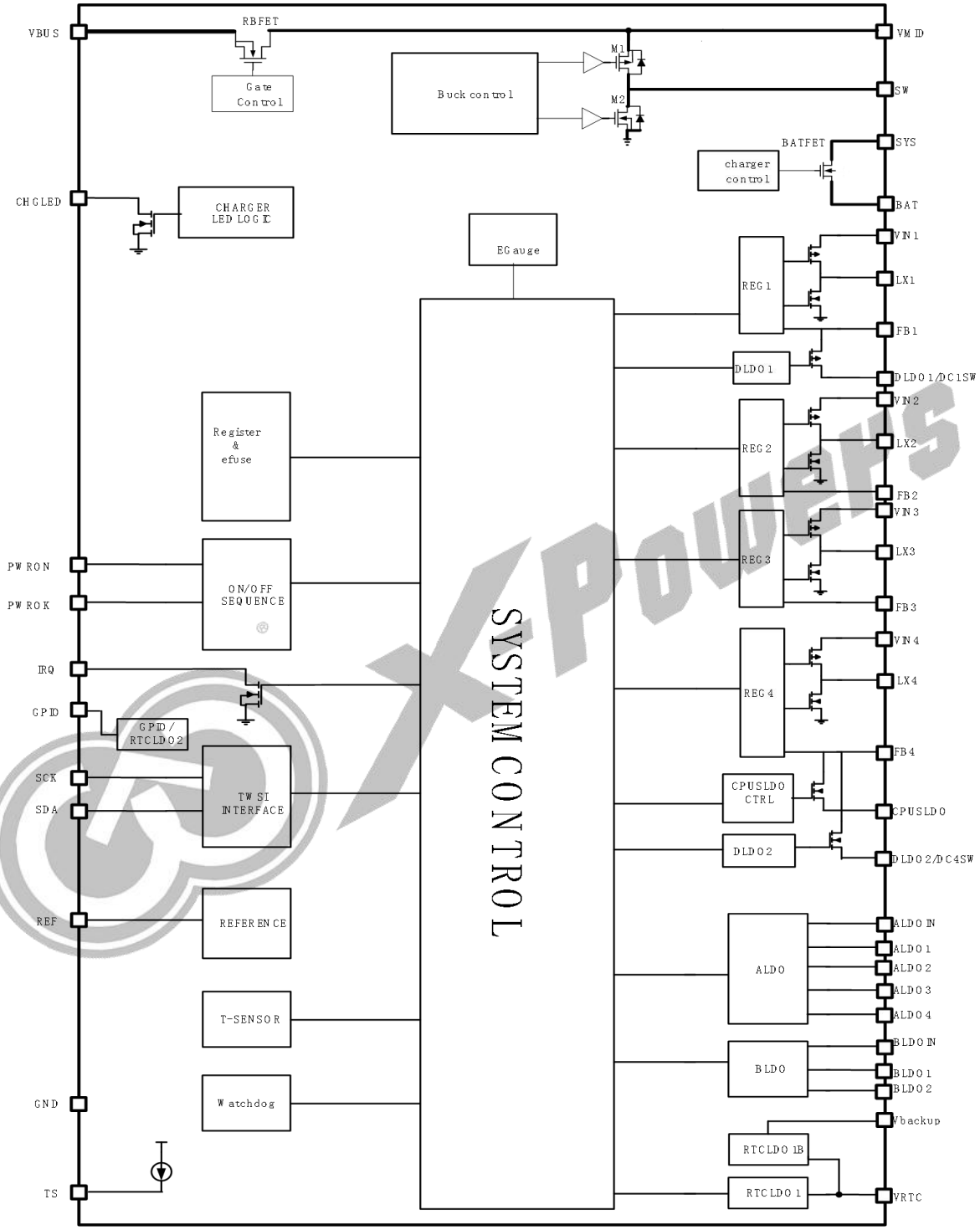
TG28 supports TWSI for system to dynamically adjust output voltages, charge current and configure interrupt condition.

TG28 is available in 5mm x 5mm 40-pin QFN package.

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6.2 Function Block Diagram

Figure 6-1 Function Block Diagram



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6.3 TWSI Communication

TG28 supports TWSI protocol and performs as a TWSI slave device with default address 0x68/0x69. When TG28 powers on, SCK/SDA pin of TWSI will be pulled up to IO Power and then Host can adjust and monitor TG28 with rich feedback information.

Note: "Host" here refers to system processor.

Figure 6-2 Waveform of TWSI

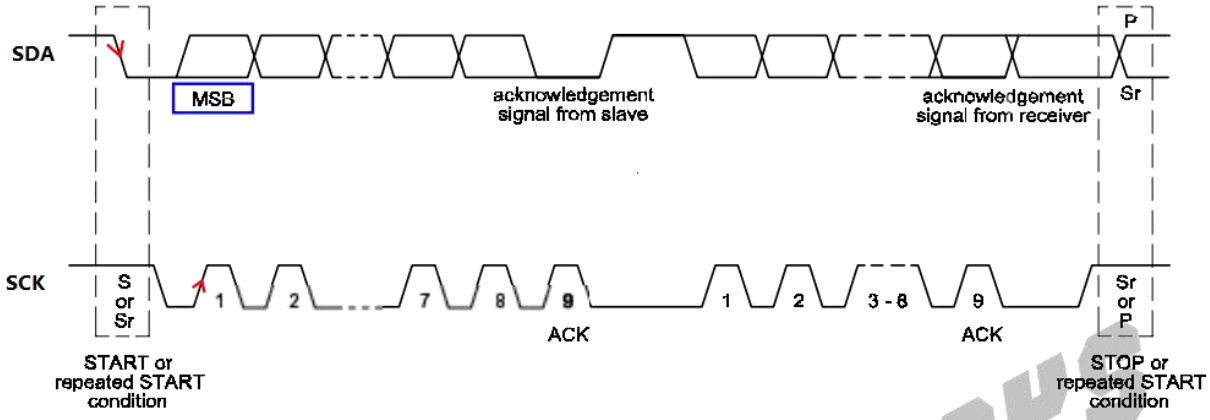


Table 6-1 Read and write address of TWSI

BYTE	BIT							
	MSB	6	5	4	3	2	1	0
WRITE	0	1	1	0	1	0	0	0
READ	0	1	1	0	1	0	0	1

Figure 6-3 Timing of TWSI

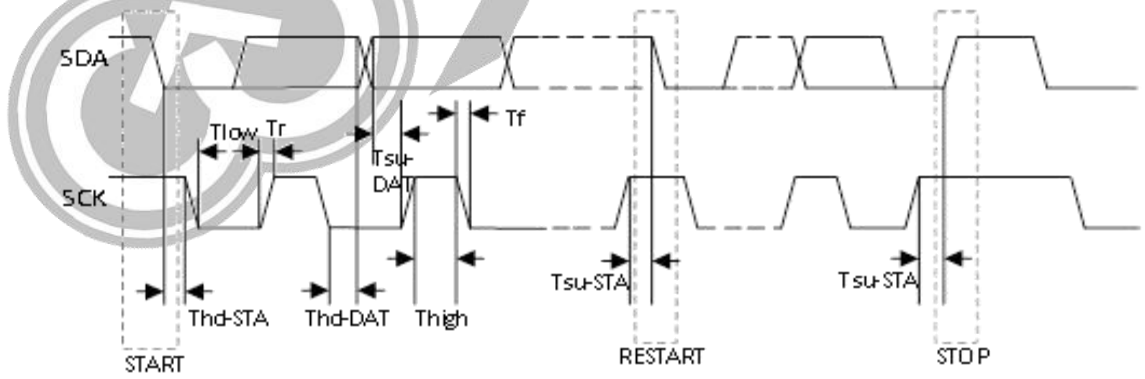


Table 6-2 Timing constants

Parameter	Symbol	Stander mode			Fast mode			Unit
		MIN	TYP	MAX	MIN	TYP	MAX	
SCK clock frequency	Fsck	0	-	100	0	-	400	kHz
Setup time in START	Tsu-STA	4.7	-	-	0.6	-	-	us
Hold time in START	Thd-STA	4.0	-	-	0.6	-	-	us
Setup time in Data	Tsu-DAT	250	-	-	100	-	-	ns
Hold time in Data	Thd-DAT	0	-	-	0	-	0.9	us
Setup time in STOP	Tsu-STO	4.0	-	-	0.6	-	-	us
SCK low level time	Tlow	4.7	-	-	1.3	-	-	us
SCK high level time	Thigh	4.0	-	-	0.6	-	-	us

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Parameter	Symbol	Stander mode			Fast mode			Unit
		MIN	TYP	MAX	MIN	TYP	MAX	
SDA/SCK falling time	Tf	-	-	300	20	-	300	ns
SDA/SCK rising time	Tr	-	-	1000	20	-	300	ns

6.4 Power Path

VBUS as the charger input, connecting to VSYS pin through a buck mode switch charger, provides power to system and charges battery through BATFET. Charge current can be adjusted automatically according to the feedback current which is detected with an internal resistor. When system current (I_{SYS}) changes, the detected current will change, and then the current change signal will feed back to charge loop to adjust the charge current to the setting value.

When battery voltage is above V_{SYS}, BATFET is turned on and PMU enters supplement mode. When in supplement mode, if the discharge current is lower than 1A, PMU controls the voltage(V_{DS}) between system and battery and keeps V_{DS} at 30mV to avoid entering and exiting supplement mode repeatedly. As discharge current increases, PMU adjusts BATFET to be fully on and V_{DS} increases linearly. If an adapter is not inserted, system current is provided only by battery. At this time, BATFET is at fully on state.

6.5 Power On/Off and reset

6.5.1 Power on reset(POR)

TG28 is powered from the higher voltage between VBUS and BAT. When VBUS voltage(V_{VBUS}) is higher than V_{VBUS_UVLOZ} or BAT voltage(V_{BAT}) is higher than V_{BAT_UVLOZ}, the sleep comparator, battery depletion comparator and BATFET driver are be activated. All registers are reset to the default value. TWSI communication is active and Host can communicate with PMU.

6.5.2 Power up from BAT

If only battery is present and V_{BAT} is higher than depletion threshold (V_{BAT_DPLZ}), BATFET, connecting battery to system, is off by default and need to be turned on by pressing the PWRON key or inserting an adapter.

6.5.3 Power up from VBUS

When VBUS is inserted, PMU detects the input voltage to start up the reference voltage and the bias circuit. When V_{VBUS} is higher than V_{VBUS_UVLOZ}, the VBUS insertion IRQ is sent and the register bit reg49H[7] is set to 1 to indicate VBUS is inserted. Then PMU detects the input source whether it is good or not. If VBUS is good, the RBFET is open and Vsys is working.

6.5.3.1 Good source condition

PMU needs to check the current capability of the input source. Only when the input source meets the following requirements can it start the buck converter.

a. VBUS voltage is lower than V_{ACOV}

b. VBUS voltage is higher than $V_{VBUSMIN}$ when pulling I_{BADBUS}(typical 30mA)

Once the input source meets the requirements above,the register bit reg00H[5](VBUS_GOOD) is set to 1 to indicate the input source is good.

6.5.3.2 Set input voltage limit(VINDPM)

TG28 supports wide range of input voltage(3.9V~5.5V). V_{INDPM} can be set through reg15H[3:0]. The range of V_{INDPM} is from 3.88V to 5.08V and the step is 80mV.

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When VBUS voltage reaches V_{INDPM}, the charge current will decrease automatically until the current is zero. If I_{SYS} is over the input power supply capability, V_{SYS} will drop. If V_{BAT} is above V_{SYS}, PMU will enter the supplement mode.

6.5.3.3 Set input current limit(IINLIM)

TG28 supports input current limit to avoid adaptor overload. I_{INLIM} can be set as 100mA, 500mA, 900mA, 1A, 1.5A and 2A through reg16H[2:0].

6.5.4 System power on/off management

PMU has power off and power on status. When at off state, all voltage outputs are turned off except RTCLDO . At this time, if only battery is present, the total power consumption is typically 40uA.

6.5.4.1 Power on-off Key (POK)

EN/PWRON pin can be configured as PWRON pin or EN pin by customization. The default is PWRON pin. The Power on-off Key (POK) can be connected between PWRON pin and GND of TG28. TG28 can automatically identify the four status (Long-press, Short-press, Negative edge, Positive edge) and then correspond respectively.

6.5.4.2 Power on

1. When EN/PWRON pin is configured as PWRON pin, power on sources include:

1) POK. TG28 can be powered on by pressing and holding POK for a period of time that longer than "ONLEVEL".

2) VBUS low go high. The function can be configured by customization.

3) VBAT low go high. The function can be configured by customization.

4) IRQ Low level. IRQ pin is low level for more than 16ms, TG28 will be powered on.The function can be configured by customization.

5) Battery is charged to normal (Vbat>3.3V and is charging). The function can be configured by customization.

2. When EN/PWRON pin is customized as EN pin, TG28 can be powered on by EN pin from low to high(0.6V).

After power on, DCDC and LDO will be soft booted in preset timing sequence. When IRQ low level power on, TG28 can be configured for fast power on by REG2B, and the DCDCs/LDOs start sequence can be configured by REG28H~REG2BH.

6.5.4.3 Power Off

1. When EN/PWRON pin is configured as PWRON pin, power off sources include:

1) POK. TG28 can be powered off by pressing and holding POK for a period of time that longer than "OFFLEVEL". The function can be configured by REG22H[1] and REG22H[3:2] decides whether the PMU auto turns on or not when it shuts down after OFFLEVEL POK.

2) Write "1" to REG10H[0].

3) VSYSGOOD high go low. When VSYS<VOFF or VBUS>7V, TG28 will be powered off. The default of VOFF is 2.6V which can be configured by REG24H[2:0].

4) The output voltage of DCDC is 15% lower than the setting value. The function can be configured by REG23H[4:0].

5) The output voltage of DCDC is much larger than their setting. The function can be configured by REG23H[5].

6) Die temperature is over the warning level2(145°C). The function can be configured by REG22H[2].

2. When EN/PWRON pin is customized as EN pin, TG28 can be powered off by EN pin from high to low.

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6.5.4.4 Sleep and wakeup

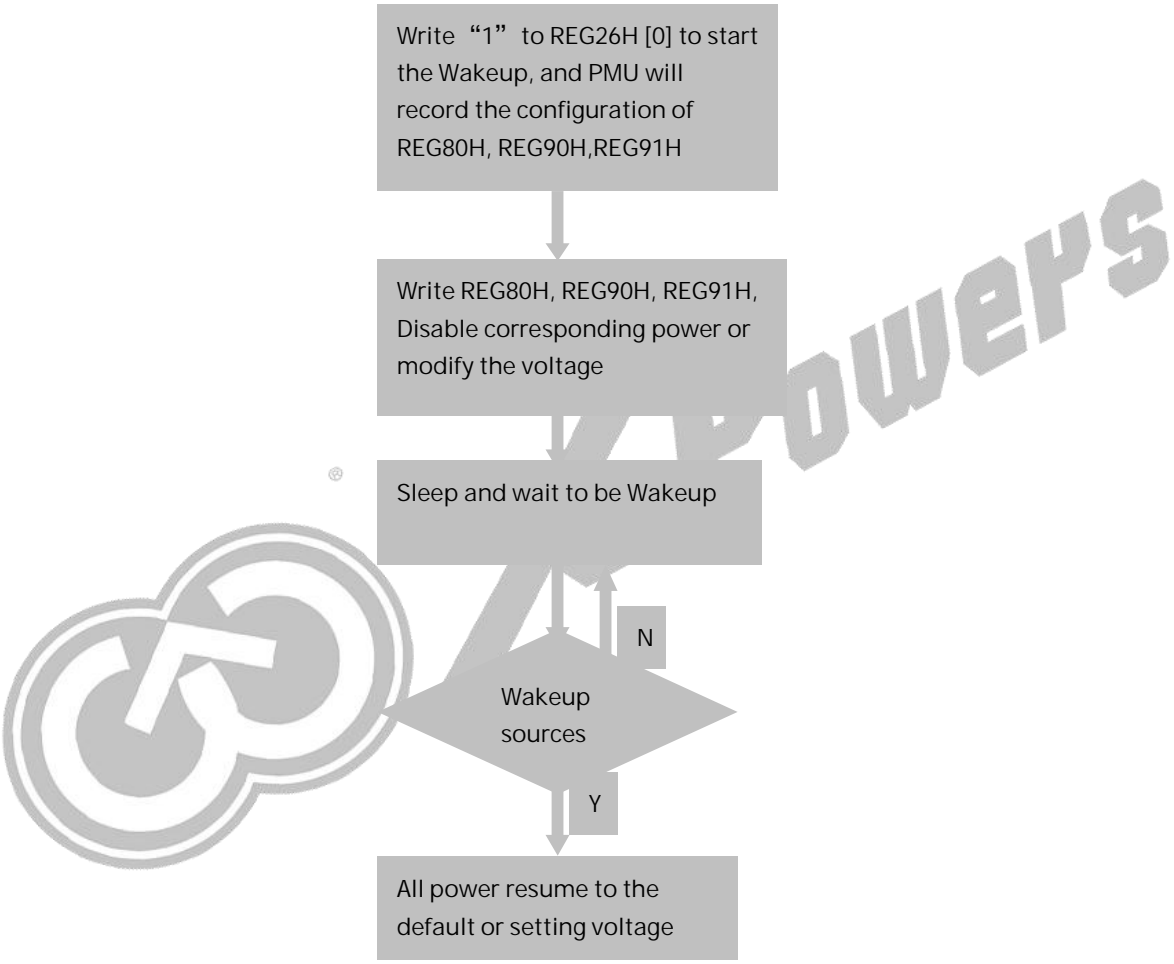
When the running system needs to enter Sleep mode, Maybe one or several power outputs should be disabled or changed to other voltage. Wakeup can be initiated by the following sources:

1. Software wakeup (REG26H[1] is set to 1)
2. IRQ pin wakeup (REG 26H[4] =1 and IRQ pin is low level for more than 16ms)

These sources will make the all the PMU power outputs resume to the default voltage or the setting voltage, which is configured by REG26H[2], and all shutdown powers will resume by the startup sequence.

See the control process under sleep and wakeup modes as below.

Figure 6-4 Sleep and Wakeup



6.5.4.5 Reset

The PMU has system reset and power on reset.

- System reset

System reset means the registers will be reset when PMU is powered on. at system reset state, all voltage outputs are turned off except RTCLDO and VREF. There are three ways of system reset.

PWROK drive low.

The PWROK pin can be used as the reset signal of application system. During TG28 startup, PWROK outputs low level, which will be pulled up to startup the system after output voltage reaches the regulated value.

When application system works normally, If the PWROK pin is driven low by external key or other reasons, the PMU will be restarted. The function can be configured by REG10H[3].

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1. Write “1” to REG10H[1] to restart the PMU.
2. Watchdog timeout. The function can be configured by REG18H[0] and REG19H[5:4]

- Power on reset

Power on reset means the registers will be reset when PMU is powered up. at power on reset state, all voltage outputs are turned off including RTCLDO and VREF.

6.6 Multi-Power Outputs

The following table has listed the multi-power outputs and their functions of TG28-ESP.If you need to customize other default outputs, please contact the business personnel for communication

Table 6-3 Features of Multi-Power Outputs of TG28-ESP.

Output Path	Type	Default Voltage	Load Capacity(Max)
DCDC1	BUCK	3.3V	2000mA
DCDC2	BUCK	OFF	2000mA
DCDC3	BUCK	OFF	2000mA
DCDC4	BUCK	1.8V	1500mA
ALDO1	LDO	OFF	300mA
ALDO2	LDO	OFF	300mA
ALDO3	LDO	OFF	300mA
ALDO4	LDO	OFF	300mA
BLDO1	LDO	OFF	300mA
BLDO2	LDO	OFF	300mA
DC1SW/DLDO1	Switch	OFF	300mA
DC4SW/DLDO2	Switch	OFF	300mA
CPUSLDO	LDO	OFF	30mA
RTC-LDO1	LDO	3V	30mA

TG28 includes 4 synchronous step-down DCDCs and 8 LDOs. The type of DLDO1/DC1SW and DLDO2/DC4SW is switch . The input of DLDO1/DC1SW is DCDC1. The input of DLDO2/DC4SW and CPUSLDO is DCDC4. The work frequency of DCDC1/4 is 3MHz and DCDC2/3 is 1.5MHz. External small inductors and capacitors can be connected. In addition, DCDC1/2/3/4 can be set in fixed PWM mode or auto mode (automatically switchable according to the load). See register REG81H.

DCDC2/3 has DVM enable option. In DVM mode, when there is a change in the output voltage, DCDC will change to the new targeted value step by step. It supports two kinds of DVM slope: 1 step/15.625us and 1step/31.250us. The slope can be chosen by REG80H[5].

Note: The input of ALDOIN must be VSYS.

6.7 Charger

6.7.1 Characteristics

- Range of input voltage:3.9V~5.5V, PWM charger, supports single cell Li-battery
- Precharge current settable (IPRECHG, reg61H[3:0]), default:125mA, range: 0mA~200mA,step:25mA
- Fast charge current settable (ICHG, reg62H[4:0]), default:300mA, range: 0mA~200mA, step:25mA, 200~1500mA, step:100mA
- Target charge voltage settable (VREG, reg64H[2:0]), default:4.2V, range: 4.0V/4.1V/4.2V/4.35V/4.4V
- Accuracy of target voltage:±0.5%(testing ambient temperature:25℃,target voltage:4.2V)

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6.7.2 Charging condition

- VBUS is present and available, VBUS>VBAT+VSLEEPZ
- Input source detection is finished (reg00H[5] =1)
- Charging is enabled (reg18H[1] =1)
- Die temperature is lower than the warning level2(145℃)
- When TS pin is used to detect battery temperature, battery temperature is within the chargeable range
- VBAT is lower than VBAT_OVP
- No charger safety timer fault

6.7.3 Charging process

When PMU meets all charging conditions, it can complete the whole charging process without the participation of Host. The charging status can be known from the register bits reg01H[2:0]. The default values of charging parameters are shown as following. Host can modify registers to optimize the values through TWSI.

Table 6-4 Charging Parameters

Parameter	Default value
Charging voltage	4.2V
Charging current	300mA
Pre-charging current	125mA
Termination current	125mA
Temperature profile	Cold/hot
Safety timer	12hours

6.7.3.1 Pre-charge

When V_{BAT} is lower than $V_{BATLOWV}$(3V), the charger is under pre-charge mode where charging current is limited to a value of $I_{PRE-CHG}$. Safety time is set through reg67H[1:0] and its default value is 50 minutes. If pre-charge process times out, PMU will stop charging and send a corresponding IRQ to Host. The function of safety timer can be disabled through reg67H[2].

6.7.3.2 Constant current charge

Once V_{BAT} is higher than $V_{BATLOWV}$ and lower than V_{REG}, the charger is under constant current charge mode. It will charge with constant current I_{CHG}.

6.7.3.3 Constant voltage charge

When V_{BAT} reaches target voltage (V_{REG}), the charger enters constant voltage charge mode. In this stage, the charger keeps the output voltage constant and step down charging current gradually, in order to fully charge battery.

When V_{BAT} is above V_{RECHG} and the charging current reduces under termination current (I_{TERM}), TG28 reports charger done, stops charging (charger enable bit is still 1) and turns off BATFET. Meanwhile, IRQ is sent to Host.

When TG28 is in regulation of input current, input voltage or temperature, the function of charging termination configured through reg63H[4] is temporarily disabled and the speed of safety timer slows down. Whether to set safety timer during DPM or thermal regulation depends on reg67H[7].

6.7.3.4 Re-charge

After charge done, if V_{BAT} falls below V_{RECHG}, PMU will automatically enable charger without reinserting adapter.

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No matter whether V_{BAT} is above V_{RECHG} or not, the charger is enabled when an adapter is inserted.

6.7.3.5 Battery detection

As long as an adapter is present and usable, battery detection will be enabled to detect whether battery is connected. Battery detection function is enabled by default and can be disabled through reg68H[0]. If the function is disabled, PMU considers that battery is always present. The detection result is saved in reg00H[3]

6.7.4 Charging protection

6.7.4.1 charger safety timer

Once starting pre-charge mode, PMU will enable timer1. If PMU cannot enter constant current charge mode from pre-charge within 50min (set through reg67H[1:0]), PMU will enter battery safe mode and send IRQ to indicate the battery may be damaged.

When the charger enters into constant current charge mode, PMU will enable timer2. If PMU cannot finish the whole charge cycle within 12 hours (set through reg67H[5:4]), PMU will enter battery safe mode and send IRQ to indicate the battery may be damaged.

If the actual current is lower than the setting value due to the VBUS DPM and thermal regulation, the timing speed of timer1 and timer2 will be halved.

6.7.4.2 Battery safe mode

In battery safe mode, the charger always charges with 10mA current. PMU can quit battery safe mode with one of the following methods:

- VBAT>VRECHG
- Adapter removal
- Charger enable bit (reg18H[1]) is reset to 1
- Safety timer1 enable bit or safety timer2 enable bit is reset to 1

6.7.4.3 PMU die temperature protection

TG28 has built-in temperature protection function through ADC to monitor internal temperature.

Under charging mode, the temperature point of thermal regulation can be set through reg65H[1:0]. When die temperature rises up to the setting point, the charging current will be decreased to decrease heat. When thermal regulation works, actual charge current is lower than the setting value and thermal regulation status(reg00H[1]) is set to 1. If die temperature rises up to T_{SHUT} (145℃), IRQ is sent, PMU is poweroff. When die temperature falls below hysteretic threshold (120℃), PMU is not poweron automatically.

6.7.4.4 Battery temperature protection

TG28 can monitor battery temperature and affect the charger(reg50H[4]=0), when TS pin is used to detect battery temperature. The battery temperature sensitive resistor is connected between TS pin and GND. The suggestion resistance should be 10Kohm at 25℃ ambient temperature. Through TS pin, PMU outputs constant current which can set through reg50H[1:0] to adapt different resistance. When the resistance is 10Kohm, the current should be set to 50uA. The enable bit of TS current source is configured through reg50H[3:2]. When current passes through the temperature sensitive resistor, PMU gets a detected voltage and calculates its value through ADC circuit. Take for example, TH11-3H103F temperature sensitive resistor of Mitsubishi Company. Using 50uA current source, the relationship among temperature, equivalent resistance, detected voltage and ADC data is as following.

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Table 6-5 Relationship among temperature, equivalent resistance, detected voltage and ADC data

Temperature	equivalent resistance	detected voltage	ADC DATA
-20℃	63.00Kohm	3.150V	189Ch
-15℃	50.15Kohm	2.508V	1398h
-10℃	40.26Kohm	2.013V	FBAh
-5℃	32.55Kohm	1.628V	CB8h
0℃	26.49Kohm	1.325V	A5Ah
5℃	21.68Kohm	1.084V	878h
10℃	17.78Kohm	0.889V	6F2h
15℃	14.63Kohm	0.732V	5B8h
20℃	12.07Kohm	0.604V	4B8h
25℃	10.00Kohm	0.500V	3E8h
30℃	8.320Kohm	0.416V	340h
35℃	6.954Kohm	0.348V	2B8h
40℃	5.839Kohm	0.292V	248h
45℃	4.924Kohm	0.246V	1ECh
50℃	4.171Kohm	0.209V	1A2h
55℃	3.549Kohm	0.177V	162h
60℃	3.032Kohm	0.152V	130h

During battery charging process, if TS pin voltage is lower than VHTF-CHG or higher than VLTF-CHG (VHTF-CHG and VLTF-CHG can be set through reg55H and reg54H. The default value of VLTF-CHG is set around 0℃ and VHTF-CHG around 45℃), which indicates battery temperature is too high or too low, then the charger is paused and IRQ is sent to notify Host. When battery temperature is back to the normal range, the charger will recovery automatically.

During battery discharging mode, if TS pin voltage is lower than VHTF-WORK or higher than VLTF-WORK (VHTF-WORK and VLTF-WORK can be set through reg57H and reg56H. The default value of VLTF-WORK is set around -10℃ and VHTF-WORK around 55℃), which indicates battery temperature is too high or too low, then the boost is paused and IRQ is sent to notify Host. When battery temperature is back to the normal range, the boost will recovery automatically.

High temperature protection threshold hysteresis for VHTF-CHG and VHTF-WORK can be set through reg53H. Low temperature protection threshold hysteresis for VLTF-CHG and VLTF-WORK can be set through reg52H. The range of temperature detection can be expanded by adding more resistors.

Some battery may have no temperature sensitive resistor. Under this situation, TS pin can be connected to GND with a 10Kohm resistor externally or set as external input of ADC through register.

6.7.5 Charging indication

CHGLED pin uses open-drain/push-pull output method. It is internally pulled up to LDO. Its output drive capability is above 10mA. Detail function is shown as the following table.

Table 6-6 CHGLED Function Control

REG69H[2:1] = 00 (Type A CHGLED) Open Drain	Hi-Z	No charging(conditions are not met or battery charged)
	25% 1Hz pull low/Hi-Z jump	Charger internal abnormal alarm(including timer out、die temperature over temperature、battery temperature out of charging range)
	25% 4Hz pull low/Hi-Z jump	Input source or battery over voltage

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	Pull low	Charging
REG69H[2:1] = 01 (Type B CHGLED) Open Drain	Hi-Z	No VBUS, and power supply by battery
	25% 1Hz pull low/Hi-Z jump	Charging
	25% 4Hz pull low/Hi-Z jump	Alarm, including input source or battery over voltage, battery temperature out of charging range, timer out ,die temperature over temperature
	Pull low	No battery or charge finished, and power supply by VBUS
REG69H[2:1]=10 Cfg chgled	The output status is controlled by REG69H[5:4]	

Note: LED is on when CHGLED is low.

6.8 BATFET

BATFET connects system and battery. The on-resistance is low to 50mohm (point to point).

6.9 RBFET

RBFET connects VMID and VBUS. The on-resistance is low to 100mOhm (point to point). It supports input and output current limit function. In charger mode, the input current limit value of RBFET is set through reg16H[2:0].

6.10 ADC

TG28 has a low speed 14 Bits SAR ADC for measuring BAT voltage, Vbus voltage, Vsys voltage, TS voltage and die temperature.

Table 6-7 ADC Channel and Data

No.	Channel function	0000H	0001H	0002H	···	1FFFH
0	VBAT voltage	0mV	1mV	2mV	···	8.191V
1	VBUS voltage	0mV	1mV	2mV	···	8.191V
2	VSYS voltage	0mV	1mV	2mV	···	8.191V
3	TS voltage	0mV	0.5mV	1mV	···	4.0955V
4	die temperature	0mV	0.1mV	0.2mV	···	0.8191V

Note: ADC data is 14 bits. In order to get the complete data, TWSI must read the high 6 bits firstly and then the low 8 bits.

6.11 E-Gauge

The Fuel Gauge system is able to export information about battery capacity percentage (regA4H) and Battery Voltage (reg34H, reg35H). The Fuel Gauge can be enabled or disabled through reg18H[3]. The Battery low warning level can be set through reg1AH, and IRQ will be sent out to alert the platform when the battery capacity percentage is lower than the warning level set through reg1AH.

Once a default battery is selected for a particular design, it is highly recommended to program the battery module to achieve better Fuel Gauge accuracy. Once the battery module data are available, user can write these information to battery parameter (REGA1H) after brom is enabled on each boot. Additionally, the Fuel Gauge system is capable to learn the battery characteristic automatically.

6.12 IRQ /BACKUP

6.12.1 IRQ

TG28 has an IRQ pin which is used to indicate whether there interrupt events occur.

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PMU Interrupt Controller monitors the trigger events such as over voltage, over current, PWRON pin signal, over temperature and so on. When the events occur and their IRQ enabled bits are set to 1 (Refer to registers reg40H/41H/42H), corresponding IRQ status will be set to 1 (Refer to registers reg48H/49H/4AH), and IRQ pin will be pulled down. When Host detects triggered IRQ signal, Host will scan through the IRQ Status registers and respond accordingly. Meanwhile, Host will reset the IRQ status by writing "1" to status bit.

6.12.2 BACKUP

TG28 has a backup pin which is used to connect backup battery. It is the source of RTCLDO1 when pmu has only backup battery.

When PMU is power on, the backup battery also can be charged by configuring reg18H[2] . The charger is working under linear mode with 100uA charge current and the termination voltage can be configured by reg6AH in range from 2.6V to 3.3V (default 2.9V).

The backup pin can also be configured for the RTCLDO2 by customization.

6.13 Register

6.13.1 Register List

Address	Description	R/W
0X00	PMU status1	R
0X01	PMU status2	R
0X04-0X07	DATA BUFFER	RW
0X10	PMU common configure	RW
0X12	BATFET control	RW
0X13	Die temperature control	RW
0X14	Minimum system voltage control	RW
0X15	Input voltage limit control	RW
0X16	Input current limit control	RW
0X17	Reset the fuel gauge	RW
0X18	Charger, fuel gauge , watchdog on/off control	RW
0X19	Watchdog control	RW
0X1A	Low Battery warning threshold setting	RW
0X1B	GPIO1 output configure	RW
0X20	PWRON status	R
0X21	PWROFF status	R
0X22	PWROFF_EN	RW
0X23	PWROFF of DCDC OVP/UVP control	RW
0X24	Vsys voltage for PWROFF threshold setting	RW
0X25	PWROK setting and PWROFF sequence control	RW
0X26	Sleep and wakeup control	RW
0X27	IRQLEVEL/OFFLEVEL/ONLEVEL setting	RW
0X28	Fast pwron setting 0	RW
0X29	Fast pwron setting 1	RW
0X2A	Fast pwron setting 2	RW
0X2B	Fast pwron setting 3	RW
0X30	ADC Channel enable control	RW
0X34-3D	ADC data	RW
0X40-0X42	IRQ Enable	RW
0X48-0X4A	IRQ Status	RW
0X50	TS pin control	RW

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Address	Description	R/W
0X52	TS_HYSL2H setting	RW
0X53	TS_HYSH2L setting	RW
0X54	VLTF_CHG setting	RW
0X55	VHTF_CHG setting	RW
0X56	VLTF_WORK setting	RW
0X57	VHTF_WORK setting	RW
0X58	JIETA standard enable control	RW
0x59-0X5B	JIETA standard setting	RW
0X61	Iprechg charger setting	RW
0X62	ICC charger setting	RW
0X63	Iterm charger setting and control	RW
0X64	CV charger voltage setting	RW
0X65	Thermal regulation threshold setting	RW
0X67	Charger timeout setting and control	RW
0X68	Battery detection control	RW
0X69	CHGLED setting and control	RW
0X6A	Button battery charge termination voltage setting	RW
0X80	DCDC ON/OFF and DVM control	RW
0X81	DCDC force PWM control	RW
0X82-0X86	DCDC voltage setting	RW
0X90-0X91	LDO ON/OFF control	RW
0X92-0X9A	LDO voltage setting	RW
0XA1	Battery parameter	RW
0XA2	Fuel gauge control	RW
0XA4	Battery percentage data	R

6.13.2 Register Description

6.13.2.1 REG 00: PMU status1

Bit	Description	R/W	Reset	Default
7:6		RO	/	0
5	VBUS good indication 0: not good 1: good	RO	POR	0
4	BATFET state 0: close 1: open	RO	POR	0
3	Battery present state 0: absent 1: present	RO	POR	0
2	Battery in Active Mode 0: in Normal 1: in Active Mode	RO	POR	0
1	Thermal regulation status 0: normal 1: in thermal regulation	RO	POR	0
0	Current Limit state 0: not in current limit state 1: in current limit state	RO	POR	0

6.13.2.2 REG 01: PMU status2

Bit	Description	R/W	Reset	Default
7		RO	/	0
6:5	Battery Current Direction 00: Standby 01: charge	RO	POR	0

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	10: discharge 11: reserved			
4	System status indication 0: System is power off. 1: System is power on.	RO	POR	0
3	VINDPM status 0: not in VINDPM 1: VINDPM	RO	POR	0
2:0	charging status 000: tri_charge 001: pre_charge 010: constant charge(CC) 011: constant voltage(CV) 100: charge done 101: not charging 11X: reserved	RO	POR	0

6.13.2.3 REG 04: DATA_BUFFER 0

Bit	Description	R/W	Reset	Default
7:0	data buffer	RW	POR	00h

6.13.2.4 REG 05: DATA_BUFFER 1

Bit	Description	R/W	Reset	Default
7:0	data buffer	RW	POR	00h

6.13.2.5 REG 06: DATA_BUFFER 2

Bit	Description	R/W	Reset	Default
7:0	data buffer	RW	POR	00h

6.13.2.6 REG 07: DATA_BUFFER 3

Bit	Description	R/W	Reset	Default
7:0	data buffer	RW	POR	00h

6.13.2.7 REG 10: PMU common configuration

Bit	Description	R/W	Reset	Default
7:6		RW	/	0b
5	Internal off-discharge enable for DCDC & LDO & SWITCH 0: disable 1: enable	RW	POR	1b
4		RW	/	1b
3	PWROK PIN pull low to Restart the System 0: disable 1: enable	RW	POR	0b
2	PWRON 16s to shut the PMIC enable 0: disable 1: enable	RW	POR	0b
1	Restart the SoC System, POWOFF/POWON and reset the related registers 0: normal 1: reset	RWAC	POR	0b
0	Soft PWROFF 0: Normal 1: PWROFF	RWAC	POR	0b

6.13.2.8 REG 12: BATFET control

Bit	Description	R/W	Reset	Default
7:4		RO	/	0
3	BATFET enable when POWEROFF and Battery only	RW	POR	0

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	0: BATFET disable 1: BATFET enable			
2:0		RO	/	0

6.13.2.9 REG 13: Die temperature control

Bit	Description	R/W	Reset	Default
7:3		RO	/	0
2:1	DIE Over Temperature Protection Level1 Configuration 00: 115deg 01: 125deg 10: 135deg 11: reserved	RW	POR	01b
0	DIE Temperature Detect Enable 0: disable 1: enable	RW	POR	1b

6.13.2.10 REG 14：Minimum system voltage control

Bit	Description	R/W	Reset	Default
7:3		RO	/	0
2:0	Switch Charger minimum system voltage limit 3.2+N*0.1 V 000: 3.2V 001: 3.3V 010: 3.4V 011: 3.5V 100: 3.6V 101: 3.7V 110: 3.8V 111: 3.9V	RW	POR	101b

6.13.2.11 REG 15: Input voltage limit control

Bit	Description	R/W	Reset	Default
7:4		RO	/	
3:0	VINDPM configuration: 3.88+N*0.08 V 0000: 3.88V 0001: 3.96V 0010: 4.04V 0011: 4.12V 0100: 4.20V 0101: 4.28V 0110: 4.36V 0111: 4.44V 1000: 4.52V 1001: 4.60V 1010: 4.68V 1011: 4.76V 1100: 4.84V 1101: 4.92V 1110: 5.00V 1111: 5.08V	RW	POR	0110b

6.13.2.12 REG 16: Input current limit control

Bit	Description	R/W	Reset	Default
7:3		RO	/	
2:0	Input current limit 000: 100mA 001: 500mA 010: 900mA 011: 1000mA 100: 1500mA 101: 2000mA 110-111: reserved	RW	POR	100b

6.13.2.13 REG 17: Reset the fuel gauge

Bit	Description	R/W	Reset	Default
7:4		RO	/	0
3	reset the gauge 0: normal 1: reset	RWAC	POR	0b
2	reset the gauge besides registers	RW	POR	0b

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	0: normal 1: reset			
1:0		RO	/	0

6.13.2.14 REG 18: Charger, fuel gauge, watchdog on/off control

Bit	Description	R/W	Reset	Default
7:4		RO	/	0
3	Gauge Module enable 0: disable 1: enable	RW	POR	1b
2	Button Battery charge enable 0: disable 1: enable	RW	System Reset	0b
1	Cell Battery charge enable 0: disable 1: enable	RW	System Reset	1b
0	Watchdog Module enable 0: disable 1: enable	RW	System Reset	0b

6.13.2.15 REG 19: Watchdog control

Bit	Description	R/W	Reset	Default
7:6		RO	/	0
5:4	Watchdog Reset Configuration 00: IRQ only 01: IRQ and System Reset 10: IRQ, System Reset and Pull down PWROK 1s 11: IRQ, System Reset, DCDC/LDO PWROFF & PWRON	RW	POR	0b
3	watchdog clear signal 0: normal 1: clear	RWAC	POR	0b
2:0	TWSI watchdog timer configuration 000: 1s 001: 2s 010: 4s 011: 8s 100: 16s 101: 32s 110: 64s 111: 128s	RW	POR	110b

6.13.2.16 REG 1A: Low Battery warning threshold setting

Bit	Description	R/W	Reset	Default
7:4	low battery warning level2 5-20%, 1% per step 0000: 5% 0001: 6% …… 1111: 20%	RW	POR	1010b
3:0	low battery warning level1 0-15%, 1% per step 0000: 0% 0001: 1% …… 1111: 15%	RW	POR	0001b

6.13.2.17 REG 1B: GPIO1 output configure

Bit	Description	R/W	Reset	Default
7:4				
3:2	GPIO1 output configure 00: Hi-z 01: Low 10: Reserved 11: Reserved	RW	POR	00b

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1:0				

6.13.2.18 REG 20: PWRON status

Bit	Description	R/W	Reset	Default
7:6		RO	/	0
5	POWERON always high when EN Mode as POWERON Source 0: no 1: yes	RO	System Reset	0b
4	Battery Insert and Good as POWERON Source 0: no 1: yes	RO	System Reset	0b
3	Battery Voltage > 3.3V when Charged as Source 0: no 1: yes	RO	System Reset	0b
2	VBUS Insert and Good as POWERON Source 0: no 1: yes	RO	System Reset	0b
1	IRQ PIN Pull-down as POWERON Source 0: no 1: yes	RO	System Reset	0b
0	POWERON low for on level when POWERON Mode as POWERON Source 0: no 1: yes	RO	System Reset	0b

6.13.2.19 REG 21: PWROFF status

Bit	Description	R/W	Reset	Default
7	Die Over Temperature as POWEROFF Source 0: no 1: yes	RO	POR	0b
6	DCDC Over Voltage as POWEROFF Source 0: no 1: yes	RO	POR	0b
5	DCDC Under Voltage as POWEROFF Source 0: no 1: yes	RO	POR	0b
4	VBUS Over Voltage as POWEROFF Source 0: no 1: yes	RO	POR	0b
3	Vsys Under Voltage as POWEROFF Source 0: no 1: yes	RO	POR	0b
2	POWERON always low when EN Mode as POWEROFF Source 0: no 1: yes	RO	POR	0b
1	Software configuration as POWEROFF Source 0: no 1: yes	RO	POR	0b
0	POWERON Pull down for off level when POWERON Mode as POWEROFF Source 0: no 1: yes	RO	POR	0b

6.13.2.20 REG 22: PWROFF_EN

Bit	Description	R/W	Reset	Default
7:3		RO	/	0
2	DIE Over-Temperature(LEVEL2) as POWEROFF Source enable 0: disable 1: enable	RW	POR	1b
1	PWRON > OFFLEVEL as POWEROFF Source enable 0: disable 1: enable	RW	POR	1b
0	Function Select when btn_pwroff_en=1 and button power-off occur 0: Power-off 1: Restart	RW	POR	0

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6.13.2.21 REG 23: PWROFF of DCDC OVP/UVP control

Bit	Description	R/W	Reset	Default
7:6		RO	/	0
5	DCDC 120%(130%) high voltage turn off PMIC function 0: disable 1: enable	RW	POR	1b
4	Reserved	RW	POR	1b
3	DCDC4 85% low voltage turn off PMIC function 0: disable 1: enable	RW	POR	1b
2	DCDC3 85% low voltage turn off PMIC function 0: disable 1: enable	RW	POR	1b
1	DCDC2 85% low voltage turn off PMIC function 0: disable 1: enable	RW	POR	1b
0	DCDC1 85% low voltage turn off PMIC function 0: disable 1: enable	RW	POR	1b

6.13.2.22 REG 24: Vsys voltage for PWROFF threshold setting

Bit	Description	R/W	Reset	Default
7:3		RO	/	0
2:0	Battery Voltage for POWEROFF 2.6~3.3V,0.1V/step,8steps 000: 2.6V 001: 2.7V …… 111: 3.3V	RW	POR	EFUSE

6.13.2.23 REG 25: PWROK setting and PWROFF sequence control

Bit	Description	R/W	Reset	Default
7:5		R0	/	0
4	Check the PWROK Pin enable after all DCDC/LDO output valid 128ms 0: disable 1: enable	RW	POR	1b
3	POWEROFF Delay 4ms after PWROK disable 0: disable 1: enable	RW	POR	1b
2	POWEROFF Sequence Control 0: At the same time 1: the reverse of the Startup	RW	POR	0b
1:0	Delay of PWROK after all power output good 00: 8ms 01: 16ms 10: 32ms 11: 64ms	RW	POR	EFUSE

6.13.2.24 REG 26: Sleep and wakeup control

Bit	Description	R/W	Reset	Default
7:5		R0	/	0
4	IRQ Pin low to Wakeup 0: disable 1: enable	RW	POR	0b
3	PWROK be low-level enable when Wakeup 0: disable 1: enable	RW	POR	1b
2	DCDC/LDO Voltage Select when Wakeup 0: The Default 1: The voltage before wakeup	RW	POR	0b
1	Wake Up enable 0: disable 1: enable	RWLC	System Reset	0b

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0	SLEEP enable 0: disable 1: enable	RWLC	System Reset	0b

6.13.2.25 REG 27: IRQLEVEL/OFFLEVEL/ONLEVEL setting

Bit	Description	R/W	Reset	Default
7:6		R0	/	0
5:4	IRQLEVEL configuration 00: 1s 01: 1.5s 10: 2s 11: 2.5s	RW	POR	01b
3:2	OFFLEVEL configuration 00: 4s 01: 6s 10: 8s 11: 10s	RW	POR	01b
1:0	ONLEVEL configuration 00: 128ms 01: 512ms 10: 1s 11: 2s	RW	POR	01

6.13.2.26 REG 28: Fast pwron setting 0

Bit	Description	R/W	Reset	Default
7:6	DCDC4 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b
5:4	DCDC3 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b
3:2	DCDC2 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b
1:0	DCDC1 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b

6.13.2.27 REG 29: Fast pwron setting 1

Bit	Description	R/W	Reset	Default
7:6	ALDO3 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b
5:4	ALDO2 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b
3:2	ALDO1 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b
1:0	Reserved	RW	POR	0b

6.13.2.28 REG 2A: Fast pwron setting 2

Bit	Description	R/W	Reset	Default
7:6	CPUSLDO Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b
5:4	BLDO2 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b
3:2	BLDO1 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b
1:0	ALDO4 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b

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6.13.2.29 REG 2B: Fast pwron setting 3

Bit	Description	R/W	Reset	Default
7	Fast Power On Enable 0: disable 1: enable	RW	POR	0b
6	Fast Wake up Enable 0: disable 1: enable	RW	POR	0b
5:4		RO	/	0b
3:2	DLDO2 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b
1:0	DLDO1 Fast Power On Start Sequence 00~10: Start Sequence Code 11: disable	RW	POR	0b

6.13.2.30 REG 30: ADC Channel enable control 0

Bit	Description	R/W	Reset	Default
7:6		R0	/	0
5	general purpose ADC channel enable 0: disable 1: enable	RW	POR	0b
4	die temperature measure ADC channel enable 0: disable 1: enable	RW	POR	0b
3	system voltage voltage measure ADC channel enable 0: disable 1: enable	RW	POR	0b
2	VBUS voltage measure ADC channel enable 0: disable 1: enable	RW	POR	0b
1	TS pin measure ADC channel enable 0: disable 1: enable	RW	POR	1b
0	battery voltage measure ADC channel enable 0: disable 1: enable	RW	POR	1b

6.13.2.31 REG 34: vbat_h

Bit	Description	R/W	Reset	Default
7:6	ch_dbg_en_l is ch_dbg_en[1:0] ch_dbg_en: 000: disable 001: vbat use all channels 010: ts use all channels 011: vbus use all channels 100: vsys use all channels 101: tdie use all channels 110: gpadc use all channels 111: reserved	RW	POR	0b
5:0	vbat[13:8]	RO	POR	0b

6.13.2.32 REG 35: vbat_l

Bit	Description	R/W	Reset	Default
7:0	vbat[7:0]	RO	POR	0b

6.13.2.33 REG 36: ts_h

Bit	Description	R/W	Reset	Default
7	ADC in low frequency sample mode when PWROFF and Battery only enable(64s) 0: disable 1: enable	RW	POR	1b
6	ch_dbg_en_h is ch_dbg_en[2]	RW	POR	0b

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5:0	ts[13:8]	RO	POR	0b

6.13.2.34 REG 37: ts_l

Bit	Description	R/W	Reset	Default
7:0	ts[7:0]	RO	POR	0b

6.13.2.35 REG 38: vbus_h

Bit	Description	R/W	Reset	Default
7:6		RO	/	0
5:0	vbus[13:8]	RO	POR	0b

6.13.2.36 REG 39: vbus_l

Bit	Description	R/W	Reset	Default
7:0	vbus[7:0]	RO	POR	0b

6.13.2.37 REG 3A: vsys_h

Bit	Description	R/W	Reset	Default
7:6		RO	/	0
5:0	vsys[13:8]	RO	POR	0b

6.13.2.38 REG 3B: vsys_l

Bit	Description	R/W	Reset	Default
7:0	vsys[7:0]	RO	POR	0b

6.13.2.39 REG 3C: tdie_h

Bit	Description	R/W	Reset	Default
7:6		RO	/	0
5:0	tdie[13:8]	RO	POR	0b

6.13.2.40 REG 3D: tdie_l

Bit	Description	R/W	Reset	Default
7:0	tdie[7:0]	RO	POR	0b

6.13.2.41 REG 40: IRQ Enable 0

Bit	Description	R/W	Reset	Default
7	SOC drop to Warning Level2 IRQ(socwl2_irq) enable 0: disable 1: enable	RW	System Reset	1b
6	SOC drop to Warning Level1 IRQ(socwl1_irq) enable 0: disable 1: enable	RW	System Reset	1b
5	Gauge Watchdog Timeout IRQ(gwdt_irq) enable 0: disable 1: enable	RW	System Reset	1b
4	Gauge New SOC IRQ(lowsoc_irq) enable 0: disable 1: enable	RW	System Reset	1b
3	Battery Over Temperature in Charge mode IRQ(bcot_irq) enable 0: disable 1: enable	RW	System Reset	1b

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2	Battery Under Temperature in Charge mode IRQ(bcut_irq) enable 0: disable 1: enable	RW	System Reset	1b
1	Battery Over Temperature in Work mode IRQ(bwot_irq) enable 0: disable 1: enable	RW	System Reset	1b
0	Battery Under Temperature in Work mode IRQ(bwut_irq) enable 0: disable 1: enable	RW	System Reset	1b

6.13.2.42 REG 41: IRQ Enable 1

Bit	Description	R/W	Reset	Default
7	VBUS Insert IRQ(vinsert_irq) enable 0: disable 1: enable	RW	System Reset	1b
6	VBUS Remove IRQ(vremove_irq) enable 0: disable 1: enable	RW	System Reset	1b
5	Battery Insert IRQ(binsert_irq) enable 0: disable 1: enable	RW	System Reset	1b
4	Battery Remove IRQ(bremove_irq) enable 0: disable 1: enable	RW	System Reset	1b
3	POWERON Short PRESS IRQ(ponsp_irq_en) enable 0: disable 1: enable	RW	System Reset	1b
2	POWERON Long PRESS IRQ(ponlp_irq) enable 0: disable 1: enable	RW	System Reset	1b
1	POWERON Negative Edge IRQ(ponne_irq_en) enable 0: disable 1: enable	RW	System Reset	0b
0	POWERON Positive Edge IRQ(ponpe_irq_en) enable 0: disable 1: enable	RW	System Reset	0b

6.13.2.43 REG 42: IRQ Enable 2

Bit	Description	R/W	Reset	Default
7	Watchdog Expire IRQ(wdexp_irq) enable 0: disable 1: enable	RW	System Reset	0b
6	LDO Over Current IRQ(ldooc_irq) enable 0: disable 1: enable	RW	System Reset	1b
5	Reserved	RO	/	0
4	Battery charge done IRQ(chgdn_irq) enable 0: disable 1: enable	RW	System Reset	1b
3	Charger start IRQ(chgst_irq) enable 0: disable 1: enable	RW	System Reset	1b
2	DIE Over Temperature level1 IRQ(dotl1_irq) enable 0: disable 1: enable	RW	System Reset	1b
1	Charger Safety Timer1/2 expire IRQ(chgte_irq) enable 0: disable 1: enable	RW	System Reset	1b
0	Battery Over Voltage Protection IRQ(bovp_irq) enable 0: disable 1: enable	RW	System Reset	1b

6.13.2.44 REG 48: IRQ Status 0

Bit	Description	R/W	Reset	Default
7	SOC drop to Warning Level IRQ 0: no irq 1: irq when SOC >= Warning Level or SOC < shutdown Level to clear it	RW1C	POR	0b
6	SOC drop to Shutdown Level IRQ	RW1C	POR	0b

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	0: no irq 1: irq when SOC >= Shutdown Level to clear it			
5	Gauge Watchdog Timeout IRQ 0: no irq 1: irq	RW1C	POR	0b
4	Gauge New SOC IRQ 0: no irq 1: irq	RW1C	POR	0b
3	Battery Over Temperature in Charge mode IRQ 0: no irq 1: irq Battery Temperature to normal to clear it	RW1C	POR	0b
2	Battery Under Temperature in Charge mode IRQ 0: no irq 1: irq Battery Temperature to normal to clear it	RW1C	POR	0b
1	Battery Over Temperature in Work mode IRQ 0: no irq 1: irq Battery Temperature to normal to clear it	RW1C	System Reset	0b
0	Battery Under Temperature in Work mode IRQ 0: no irq 1: irq Battery Temperature to normal to clear it	RW1C	System Reset	0b

6.13.2.45 REG 49: IRQ Status 1

Bit	Description	R/W	Reset	Default
7	VBUS Insert IRQ 0: no irq 1: irq VBUS Remove to clear it	RW1C	POR	0b
6	VBUS Remove IRQ 0: no irq 1: irq VBUS Insert to clear it	RW1C	POR	0b
5	Battery Insert IRQ 0: no irq 1: irq Battery Remove to clear it	RW1C	POR	0b
4	Battery Remove IRQ 0: no irq 1: irq Battery Insert to clear it	RW1C	POR	0b
3	POWERON Short PRESS IRQ 0: no irq 1: irq	RW1C	System Reset	0b
2	POWERON Long PRESS IRQ 0: no irq 1: irq	RW1C	System Reset	0b
1	POWERON Negative Edge IRQ 0: no irq 1: irq	RW1C	System Reset	0b
0	POWERON Positive Edge IRQ 0: no irq 1: irq	RW1C	System Reset	0b

6.13.2.46 REG 4A: IRQ Status 2

Bit	Description	R/W	Reset	Default
7	Watchdog Expire IRQ 0: no irq 1: irq	RW1C	POR	0b
6	LDO Over Current IRQ 0: no irq 1: irq LDO Current to normal to clear it	RW1C	System Reset	0b
5	Reserved	RO	/	0
4	Battery charge done IRQ	RW1C	POR	0b

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	0: no irq 1: irq Battery charge start to clear it			
3	Battery charge start IRQ 0: no irq 1: irq Battery charge done to clear it	RW1C	POR	0b
2	DIE Over Temperature level1 IRQ 0: no irq 1: irq DIE Temperature to normal to clear it	RW1C	POR	0b
1	Charger Safety Timer1/2 expire IRQ 0: no irq 1: irq	RW1C	POR	0b
0	Battery Over Voltage Protection IRQ 0: no irq 1: irq Battery Voltage to normal to clear it	RW1C	POR	0b

6.13.2.47 REG 50: TS pin control

Bit	Description	R/W	Reset	Default
7:5		RO	/	0
4	TS PIN function select: 0: TS pin is the battery temperature sensor input and will affect the charger 1: TS pin is the external fixed input and doesn't affect the charger	RW	POR	EFUSE
3:2	TS current source on/off enable 00: off 01: on when TS channel of ADC is enabled 10: on only when TS channel is working and off when others channel is working 11: always on	RW	POR	EFUSE
1:0	current source to TS pin configuration 00: 20uA 01: 40uA 10: 50uA 11: 60uA	RW	POR	10b

6.13.2.48 REG 52: TS_HYSL2H setting

Bit	Description	R/W	Reset	Default
7:0	hysteresis for TS from low go to normal Thys = N*16mV (default 32mV)	RW	POR	2h

6.13.2.49 REG 53: TS_HYSH2L setting

Bit	Description	R/W	Reset	Default
7:0	hysteresis for TS from high go to normal Thys = N*4mV (default 4mV)	RW	POR	1h

6.13.2.50 REG 54: VLTF_CHG setting

Bit	Description	R/W	Reset	Default
7:0	VLTF in voltage of charge configuration VLTF = N*32 mV (default is about 0deg) This is also T1 of JEITA	RW	POR	29h

6.13.2.51 REG 55: VHTF_CHG setting

Bit	Description	R/W	Reset	Default

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7:0	VHTF in voltage of charge configuration VHTF = N*2 mV (default is about 55deg) This is also T4 of JEITA	RW	POR	58h

6.13.2.52 REG 56: VLTF_WORK setting

Bit	Description	R/W	Reset	Default
7:0	VLTF in voltage of work configuration VLTF = N*32 mV (default is about -10deg)	RW	POR	3Eh

6.13.2.53 REG 57: VHTF_WORK setting

Bit	Description	R/W	Reset	Default
7:0	VHTF in voltage of work configuration VHTF = N*2 mV (default is about 60deg)	RW	POR	4Ch

6.13.2.54 REG 58: JEITA standard enable control

Bit	Description	R/W	Reset	Default
7:1		RO	/	0
0	JEITA standard enable 0: disable 1: enable	RW	POR	EFUSE

6.13.2.55 REG 59: JEITA CV configuration

Bit	Description	R/W	Reset	Default
7		RO	/	0
6	Current fall of Warm in JEITA Standard 0: 100% 1: 50%	RW	POR	0b
5		RO	/	0
4	Current fall of Cool in JEITA Standard 0: 100% 1: 50%	RW	POR	1b
3:2	Voltage fall of Warm in JEITA Standard 00: 0mV 01: one gear lower than the setting value 10: two gear lower than the setting value 11: reserved	RW	POR	01b
1:0	Voltage fall of Cool in JEITA Standard 00: 0mV 01: one gear lower than the setting value 10: two gear lower than the setting value 11: reserved	RW	POR	00b

6.13.2.56 REG 5A: JEITA Cool configuration

Bit	Description	R/W	Reset	Default
7:0	Cool Temperature(T2) in voltage of charge configuration VHTF = N*16 mV (default is about 10deg)	RW	POR	37h

6.13.2.57 REG 5B: JEITA Warm configuration

Bit	Description	R/W	Reset	Default
7:0	Warm Temperature(T3) in voltage of charge configuration VHTF = N*8 mV (default is about 45deg)	RW	POR	1Eh

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6.13.2.58 REG 5C: ts_cfg_data_h

Bit	Description	R/W	Reset	Default
7:6		RO	/	0
5:0	ts_cfg_data[13:8]	RW	POR	2h

6.13.2.59 REG 5D: ts_cfg_data_l

Bit	Description	R/W	Reset	Default
7:0	ts_cfg_data[7:0], ts_cfg_data is TS Voltage configured by MCU when ts_ch_en = 0b	RO	POR	58h

6.13.2.60 REG 61: Iprechg charger setting

Bit	Description	R/W	Reset	Default
7:4		RO	/	0
3:0	Precharge current limit: 25*N mA 0000: 0mA 0001: 25mA 0010: 50mA 0011: 75mA 0100: 100mA 0101: 125mA 0110: 150mA 0111: 175mA 1000: 200mA 1001~1111: reserved	RW	POR	0101b

6.13.2.61 REG 62: ICC charger setting

Bit	Description	R/W	Reset	Default
7:5		RO	/	0
4:0	constant current charge current limit: 25*N mA if N<=8 200+100*(N-8) mA if N>8 00000: 0mA 00100: 100mA 00101: 125mA 00110: 150mA 00111: 175mA 01000: 200mA 01001: 300mA 01010: 400mA 01011: 500mA 01100: 600mA 01101: 700mA 01110: 800mA 01111: 900mA 10000: 1000mA 10001: 1100mA 10010: 1200mA 10011: 1300mA 10100: 1400mA 10101: 1500mA 10110~11111: reserved	RW	POR	{EFUSE,0b, EFUSE}

6.13.2.62 REG 63: Iterm charger setting and control

Bit	Description	R/W	Reset	Default
7:5		RO	/	0b
4	Charging termination of current enable 0: disable 1: enable	RW	System Reset	1b
3:0	Termination current limit: 25*N mA 0000: 0mA 0001: 25mA 0010: 50mA 0011: 75mA 0100: 100mA 0101: 125mA 0110: 150mA 0111: 175mA 1000: 200mA 1001~1111: reserved	RW	POR	0101b

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6.13.2.63 REG 64: CV charger voltage setting

Bit	Description	R/W	Reset	Default
7:3		RO	/	0
2:0	Charge voltage limit 000: reserved 001: 4.0V 010: 4.1V 011: 4.2V 100: 4.35V 101: 4.4V 11X: reserved	RW	POR	011b

6.13.2.64 REG 65: Thermal regulation threshold setting

Bit	Description	R/W	Reset	Default
7:2		RO	/	0
1:0	Thermal regulation threshold 00: 60deg 01: 80deg 10: 100deg 11: 120deg	RW	System Reset	10b

6.13.2.65 REG 67: Charger timeout setting and control

Bit	Description	R/W	Reset	Default
7	safety timer1/2 setting during DPM or thermal regulation 0: safety timer not slowed during input DPM or thermal regulation 1: safety timer slowed during input DPM or thermal regulation	RW	POR	1b
6	charge done safe timer enable 0: disable 1: enable	RW	POR	1b
5:4	charge done safety timer configuration 00: 5hours 01: 8hours 10: 12hours 11: 20hours	RW	POR	10b
3		RO	/	0
2	pre-charge safe timer enable 0: disable 1: enable	RW	POR	1b
1:0	pre-charge safe timer configuration 00: 40mins 01: 50mins 10: 60mins 11: 70mins	RW	POR	10b

6.13.2.66 REG 68: Battery detection control

Bit	Description	R/W	Reset	Default
7:1		RO	/	0
0	battery detection enable 0: disable 1: enable	RW	POR	1b

6.13.2.67 REG 69: CHGLED setting and control

Bit	Description	R/W	Reset	Default
7:6		RO	/	0
5:4	CHGLED pin output when the register of chgled_func (REG69[2:1]) is set to 10b 00: Hiz 01: Low/Hiz 25%/75% duty 1Hz 10: Low/Hiz 25%/75% duty 4Hz 11: drive low	RW	System Reset	00b
3		RO	/	0

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2:1	CHGLED pin display function configuration 00: display with type A function 01: display with type B function 10: output controlled by the register of chgled_out_ctrl 11: reserved	RW	POR	00
0	CHGLED pin enable 0: disable CHGLED pin function 1: enable CHGLED pin function	RW	POR	1b

6.13.2.68 REG 6A: Button battery charge termination voltage setting

Bit	Description	R/W	Reset	Default
7:3		RO	/	0
2:0	Button Battery charge termination voltage 2.6~3.3V，100mV/step，8steps 000: 2.6V 001: 2.7V 010: 2.8V 011: 2.9V 100: 3.0V 101: 3.1V 110: 3.2V 111: 3.3V	RW	POR	011b

6.13.2.69 REG 80: DCDC ON/OFF and DVM control

Bit	Description	R/W	Reset	Default
7		RO	/	0b
6	force DCDC work in CCM mode 0: disable 1: enable	RW	System Reset	0b
5	DVM voltage ramp control 0: 15.625 us/step 1: 31.250 us/step	RW	System Reset	0b
4		RO	/	0b
3	DCDC4 enable 0: disable 1: enable	RW	System Reset	EFUSE
2	DCDC3 enable 0: disable 1: enable	RW	System Reset	EFUSE
1	DCDC2 enable 0: disable 1: enable	RW	System Reset	EFUSE
0	DCDC1 enable 0: disable 1: enable	RW	System Reset	EFUSE

6.13.2.70 REG 81: DCDC force PWM control

Bit	Description	R/W	Reset	Default
7	DCDC frequency spread enable 0: disable 1: enable	RW	System Reset	0b
6	DCDC frequency spread range control 0: 50KHz 1: 100kHz	RW	System Reset	0b
5	DCDC4 PWM/PFM Control 0: Auto Switch 1: Always PWM	RW	System Reset	0b
4	DCDC3 PWM/PFM Control 0: Auto Switch 1: Always PWM	RW	System Reset	0b
3	DCDC2 PWM/PFM Control 0: Auto Switch 1: Always PWM	RW	System Reset	0b
2	DCDC1 PWM/PFM Control 0: Auto Switch 1: Always PWM	RW	System Reset	0b
1:0	DCDC UVP debounce time configuration	RW	POR	00b

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	00: 60us 01: 120us 10: 180us 11: 240us			

6.13.2.71 REG 82: DCDC1 voltage setting

Bit	Description	R/W	Reset	Default
7:5		RO	/	0
4:0	DCDC1 output voltage configuration 1.5~3.4V,100mV/step,20steps 00000: 1.5V 00001: 1.6V …… 10011: 3.4V 10100~11111: reserved	RW	System Reset	EFUSE

6.13.2.72 REG 83: DCDC2 voltage setting

Bit	Description	R/W	Reset	Default
7	DCDC2 DVM enable control 0: disable 1: enable	RW	System Reset	0b
6:0	DCDC2 output voltage configuration 0.5~1.2V,10mV/step,71steps 1.22~1.54V,20mV/step,17steps 0000000: 0.50V 0000001: 0.51V …… 1000110: 1.20V 1000111: 1.22V 1001000: 1.24V …… 1010111: 1.54V 1011000~1111111: reserved	RW	System Reset	EFUSE

6.13.2.73 REG 84: DCDC3 voltage setting

Bit	Description	R/W	Reset	Default
7	DCDC3 DVM enable control 0: disable 1: enable	RW	System Reset	0b
6:0	DCDC3 output voltage configuration 0.5~1.2V,10mV/step,71steps 1.22~1.54V,20mV/step,17steps 0000000: 0.50V 0000001: 0.51V …… 1000110: 1.20V 1000111: 1.22V 1001000: 1.24V …… 1010111: 1.54V 1011000~1111111: reserved	RW	System Reset	EFUSE

6.13.2.74 REG 85: DCDC4 voltage setting

Bit	Description	R/W	Reset	Default
7		RO	/	0
6:0	DCDC4 output voltage configuration	RW	System	EFUSE

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	0.5~1.2V,10mV/step,71steps 1.22~1.84V,20mV/step,32steps 0000000: 0.50V 0000001: 0.51V …… 1000110: 1.20V 1000111: 1.22V 1001000: 1.24V …… 1100110: 1.84V 1100111~1101000: reserved		Reset	

6.13.2.75 REG 90: LDO ON/OFF control 0

Bit	Description	R/W	Reset	Default
7	dldo1 enable 0: disable 1: enable	RW	System Reset	EFUSE
6	cpusldo enable 0: disable 1: enable	RW	System Reset	EFUSE
5	bldo2 enable 0: disable 1: enable	RW	System Reset	EFUSE
4	bldo1 enable 0: disable 1: enable	RW	System Reset	EFUSE
3	aldo4 enable 0: disable 1: enable	RW	System Reset	EFUSE
2	aldo3 enable 0: disable 1: enable	RW	System Reset	EFUSE
1	aldo2 enable 0: disable 1: enable	RW	System Reset	EFUSE
0	aldo1 enable 0: disable 1: enable	RW	System Reset	EFUSE

6.13.2.76 REG 91: LDO ON/OFF control 1

Bit	Description	R/W	Reset	Default
7:1		RO	/	0
0	dldo2 enable 0: disable 1: enable	RW	System Reset	EFUSE

6.13.2.77 REG 92: ALDO1 voltage setting

Bit	Description	R/W	Reset	Default
7:5		RO	/	0
4:0	aldo1 output voltage configuration 0.5~3.5V，100mV/step，31steps 00000: 0.5V 00001: 0.6V …… 11110: 3.5V 11111: reserved	RW	System Reset	EFUSE

6.13.2.78 REG 93: ALDO2 voltage setting

Bit	Description	R/W	Reset	Default
7:5		RO	/	0

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4:0	aldo2 output voltage configuration 0.5~3.5V，100mV/step，31steps 00000: 0.5V 00001: 0.6V …… 11110: 3.5V 11111: reserved	RW	System Reset	EFUSE

6.13.2.79 REG 94: ALDO3 voltage setting

Bit	Description	R/W	Reset	Default
7:5		RO	/	0
4:0	aldo3 output voltage configuration 0.5~3.5V，100mV/step，31steps 00000: 0.5V 00001: 0.6V …… 11110: 3.5V 11111: reserved	RW	System Reset	EFUSE

6.13.2.80 REG 95: ALDO4 voltage setting

Bit	Description	R/W	Reset	Default
7:5		RO	/	0
4:0	aldo4 output voltage configuration 0.5~3.5V，100mV/step，31steps 00000: 0.5V 00001: 0.6V …… 11110: 3.5V 11111: reserved	RW	System Reset	EFUSE

6.13.2.81 REG 96: BLDO1 voltage setting

Bit	Description	R/W	Reset	Default
7:5		RO	/	0
4:0	bldo1 output voltage configuration 0.5~3.5V，100mV/step，31steps 00000: 0.5V 00001: 0.6V …… 11110: 3.5V 11111: reserved	RW	System Reset	EFUSE

6.13.2.82 REG 97: BLDO2 voltage setting

Bit	Description	R/W	Reset	Default
7:5		RO	/	0
4:0	bldo2 output voltage configuration 0.5~3.5V，100mV/step，31steps 00000: 0.5V 00001: 0.6V …… 11110: 3.5V 11111: reserved	RW	System Reset	EFUSE

6.13.2.83 REG 98: CPUSLDO voltage setting

Bit	Description	R/W	Reset	Default

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7:5		RO	/	0
4:0	cpusldo output voltage configuration 0.5~1.4V，50mV/step，20steps 00000: 0.50V 00001: 0.55V …… 10011: 1.40V 10100~11111: reserved	RW	System Reset	EFUSE

6.13.2.84 REG 99: DLDO1 voltage setting

Bit	Description	R/W	Reset	Default
7:5		RO	/	0
4:0	dldo1 output voltage configuration 0.5~3.4V，100mV/step，29steps 00000: 0.5V 00001: 0.6V …… 11100: 3.3V 11101~11111: reserved	RW	System Reset	EFUSE

6.13.2.85 REG 9A: DLDO2 voltage setting

Bit	Description	R/W	Reset	Default
7:5		RO	/	0
4:0	dldo2 output voltage configuration 0.5~1.4V，50mV/step，20steps 00000: 0.50V 00001: 0.55V …… 10011: 1.40V 10100~11111: reserved	RW	System Reset	EFUSE

6.13.2.86 REG A1: Battery parameter

Bit	Description	R/W	Reset	Default
7:0	Battery parameter ROM	RO	POR	xx

6.13.2.87 REG A2: Fuel gauge control

Bit	Description	R/W	Reset	Default
7:6	reserved	RO	/	0b
5	reserved	RW	POR	0b
4	ROM or SRAM select 0: select rom 1: select sram	RW	POR	0b
3:1	reserved	RO	/	0b
0	brom writer control 0: disable 1: enable	RW	POR	0b

6.13.2.88 REG A4: Battery percentage data

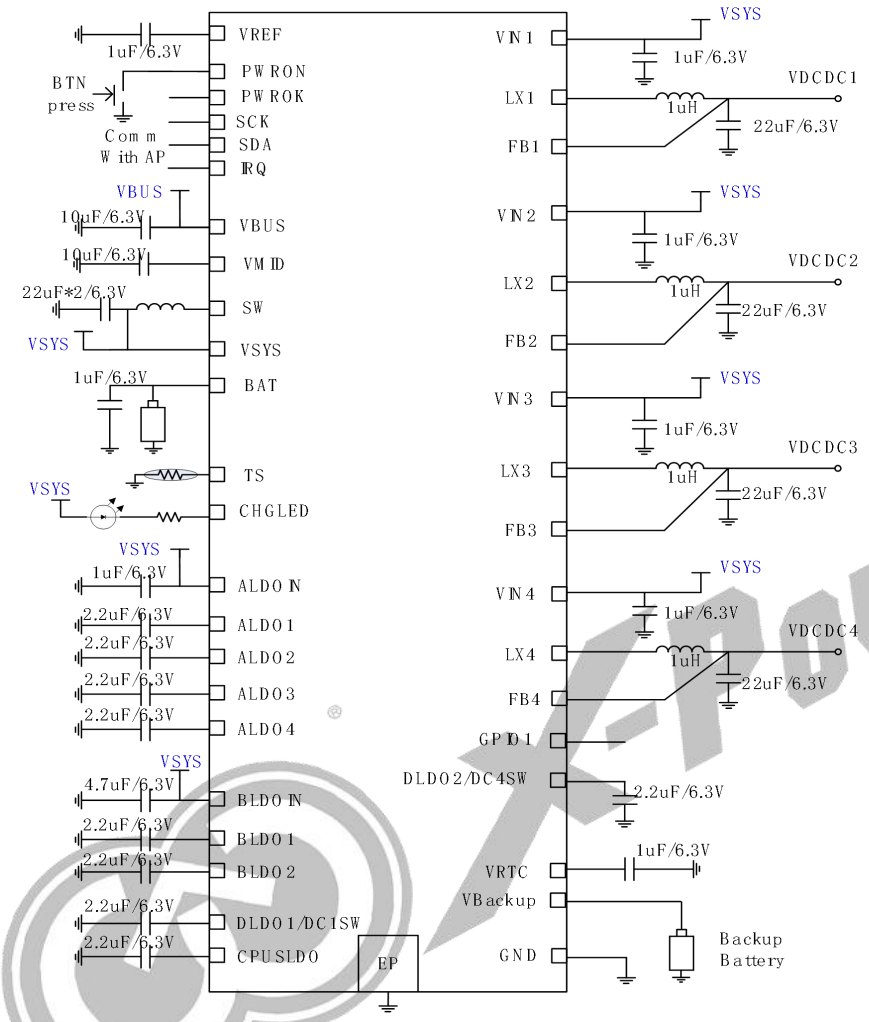
Bit	Description	R/W	Reset	Default
7:0	battery percentage	RO	POR	00h

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7 Application Information

7.1 Typical Application

Figure 7-1 Typical Application



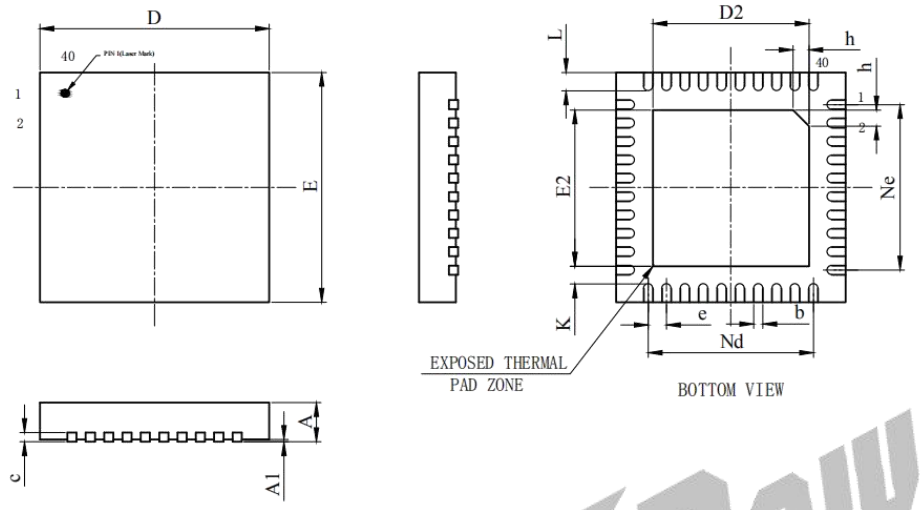
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8 Package, Carrier, Storage and Baking Information

8.1 Package

TG28 package is QFN5*5, 40-pin. Figure 8-1 shows TG28 package.

Figure 8-1 Package Information



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.80	0.85	0.90
A1	0	0.02	0.05
b	0.15	0.20	0.25
c	0.18	0.20	0.25
D	4.90	5.00	5.10
D2	3.30	3.40	3.50
e	0.40BSC		
Nd	3.60BSC		
E	4.90	5.00	5.10
E2	3.30	3.40	3.50
Ne	3.60BSC		
L	0.35	0.40	0.45
K	0.20	--	--
h	0.30	0.35	0.40
L/F载体尺寸 (mil)	150*150		

Figure 8-2 TG28 marking



Table 8-1 describes TG28 marking information.

Table 8-1 TG28 Marking Definitions

No.	Marking	Description	Fixed/Dynamic
1	TG28	Product name	Fixed
2	LLLLLLL	Lot number	Dynamic
3	XXXXX	Date code	Dynamic
4		X-POWERS logo	Fixed
5	White dot	Package pin 1	Fixed

8.2 Carrier

Table 8-2 TG28 Tray Carrier Information

Item	Color	Size
Aluminum foil bags	Silvery white	540mm x 300mm x 0.14mm
Pearl cotton cushion(Vacuum bag)	White	12mm x 680mm x 185mm

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Pearl cotton cushion (The Gap between vacuum bag and inside box)	White	Left-Right:12mm x 180mm x 85mm Front-Back:12mm x 350mm x 70mm
Inside Box	White	396mm x 196mm x 96mm
Outside Box	White	420mm x 410mm x 320mm

Figure 8-3 TG28 Tray Dimension Drawing

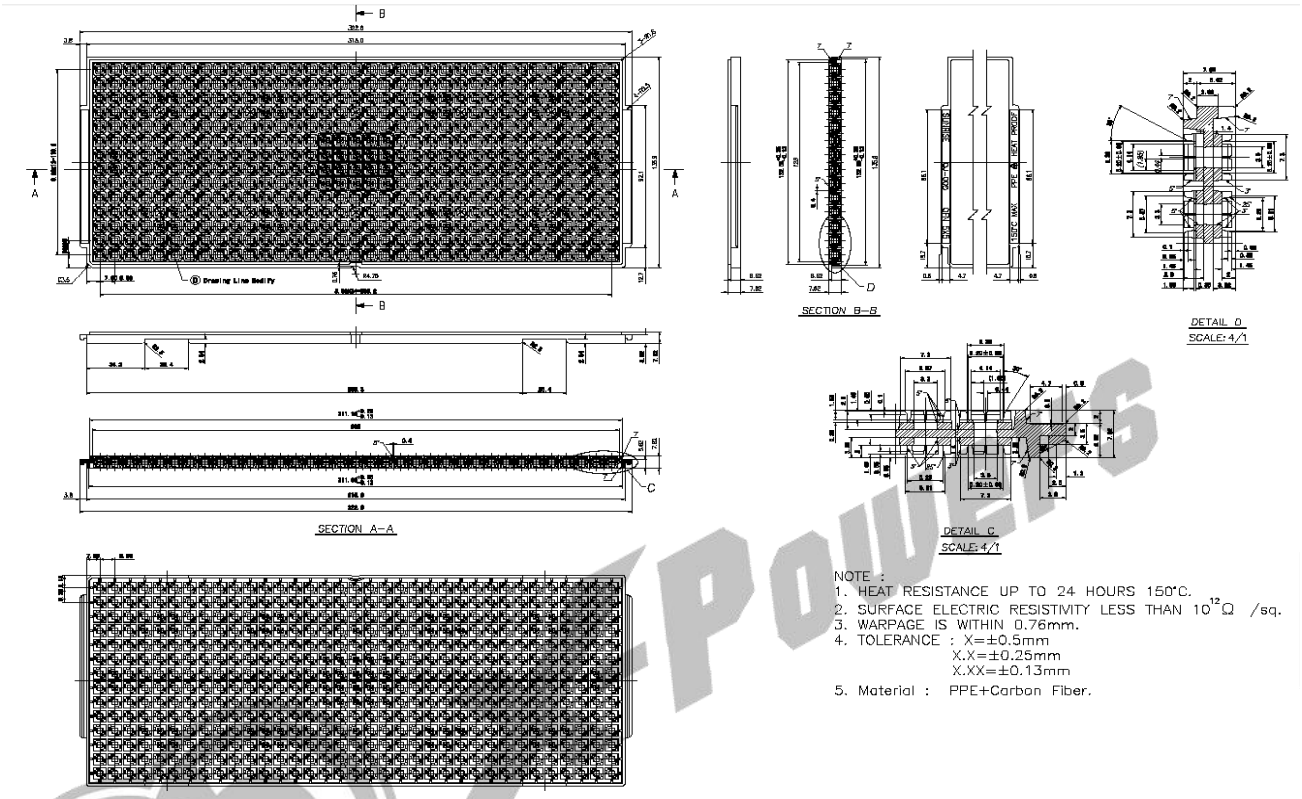


Table 8-3 TG28 Packing Quantity Information

Type	Quantity	Part Number
Tray	490pcs/Tray 10Trays/package	TG28

8.3 Storage

8.3.1 Moisture Sensitivity Level(MSL)

A package’s MSL indicates its ability to withstand exposure after it is removed from its shipment bag, a low MSL device sample can be exposed on the factor floor longer than a high MSL device sample. ALL MSL are defined in Table 8-4.

Table 8-4 MSL Summary

MSL	Out-of-bag floor life	Comments
1	Unlimited	≤30°C/85%RH
2	1 year	≤30°C/60%RH
2a	4 weeks	≤30°C/60%RH
3	168 hours	≤30°C/60%RH
4	72 hours	≤30°C/60%RH
5	48 hours	≤30°C/60%RH

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5a	24 hours	≤30℃/60%RH
6	Time on Label(TOL)	≤30℃/60%RH

TG28 device samples are classified as MSL3.

8.3.2 Bagged Storage Conditions

The shelf life of TG28 are defined in Table 8-5.

Table 8-5 Bagged Storage Conditions

Packing mode	Vacuum packing
Storage temperature	20℃~26℃
Storage humidity	40%~60%RH
Shelf life	12 months

8.3.3 Out-of-bag Duration

It is defined by the device MSL rating. The out-of-bag duration of TG28 is as follows.

Table 8-6 Out-of-bag Duration

Storage temperature	20℃~26℃
Storage humidity	40%~60%RH
Moisture Sensitivity Level(MSL)	3
Floor life	168 hours

For no mention of storage rules in this document, please refer to the latest *IPC/JEDEC J-STD-020C*.

8.4 Baking

It is not necessary to bake TG28 if the conditions specified in Section 8.3.2 and Section 8.3.3 have not been exceeded. It is necessary to bake TG28 if any condition specified in Section 8.3.2 and Section 8.3.3 have been exceeded.

Table 8-7 Baking Conditions

Surrounding	Condition	Note
Nitrogen	Tray: 125℃/8 hours	Bake no more than once.

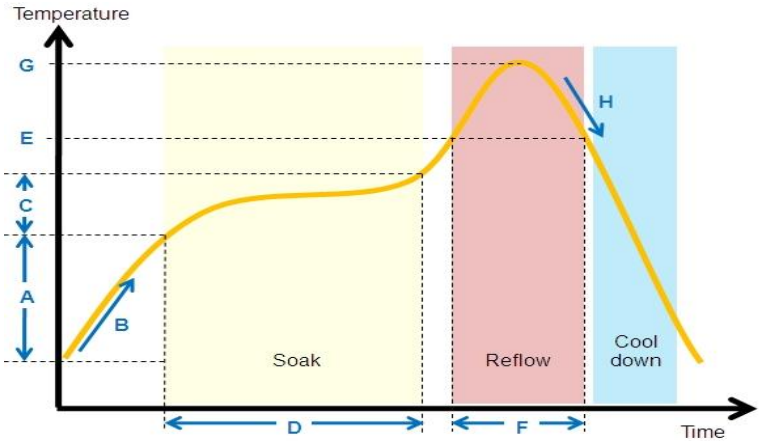
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9 Reflow Profile

The reflow profile recommended in this document is a lead-free reflow profile that is suitable for pure lead-free technology of lead-free solder paste.

Figure 9-1 shows the typical reflow profile of TG28 device sample.

Figure 9-1 TG28 Typical Reflow Profile



Reflow profile conditions of TG28 device sample is given in Table 9-1.

Table 9-1 TG28 Reflow Profile Conditions

	QTI typical SMT reflow profile conditions (for reference only)	
	Step	Reflow condition
Environment	N2 purge reflow usage (yes/no)	Yes, N2 purge used
	If yes, O2 ppm level	O2 < 1500 ppm
A	Preheat ramp up temperature range	25℃ -> 150℃
B	Preheat ramp up rate	1.5-2.5 ℃/sec
C	Soak temperature range	150℃ -> 190℃
D	Soak time	80-110 sec
E	Liquidus temperature	217℃
F	Time above liquidus	60-90 sec
G	Peak temperature	240-250℃
H	Cool down temperature rate	≤4℃/sec

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