

3-Series to 10-Series Li-Ion and Phosphate Cell Battery Monitor

FEATURES

- Internal ADC measures cell voltage, die temperature and operating ambient temperature
- Independent, internal ADC measures battery pack current (coulomb counter)
- Directly Support up to Three Thermistors (103AT)
- Overcurrent in Discharge (OCD), Short-Circuit in Discharge (SCD)
- Overvoltage (OV), Undervoltage (UV)
- Secondary Protector Fault Detection
- I²C Interface
- Integrated Cell Balancing FETs
- Charge, Discharge Low-Side N-Channel FET Drivers
- Alert Interrupt for Host Microcontroller
- Default 3.3V Output Regulator. Can Provide 2.5V
- High Power Supply Absolute Rating:
MS9920T: 36V; MS9930T: 72V
- Random Cell Connection Tolerance

PRODUCT DESCRIPTION

The MS9920T and the MS9930T are analog front-end (AFE) devices. The MS9920T supports up to 5-series cell and the MS9930T supports up to 10-series cell. By I²C, host controller can use the MS99x0T to achieve battery pack management functions, such as monitoring (cell voltage, pack current, pack temperature), protection (control charge/discharge FETs) and balancing battery. These AFEs can be used to manage various battery chemistries, including lithium ion, lithium iron phosphate. The operating temperature ranges from -40°C to 85°C.

APPLICATIONS

- Light Electric Vehicle: Electric Bike, Electric Scooter, Pedal Bicycle
- Electric Tool and Garden Tool
- Battery Backup Unit System (BBUS), Energy Storage System (ESS) and Uninterruptible Power Supply (UPS) System
- Wireless Base Station Backup System
- 12-V、18-V、24-V、36-V Industrial Battery Packs

PRODUCT SPECIFICATION

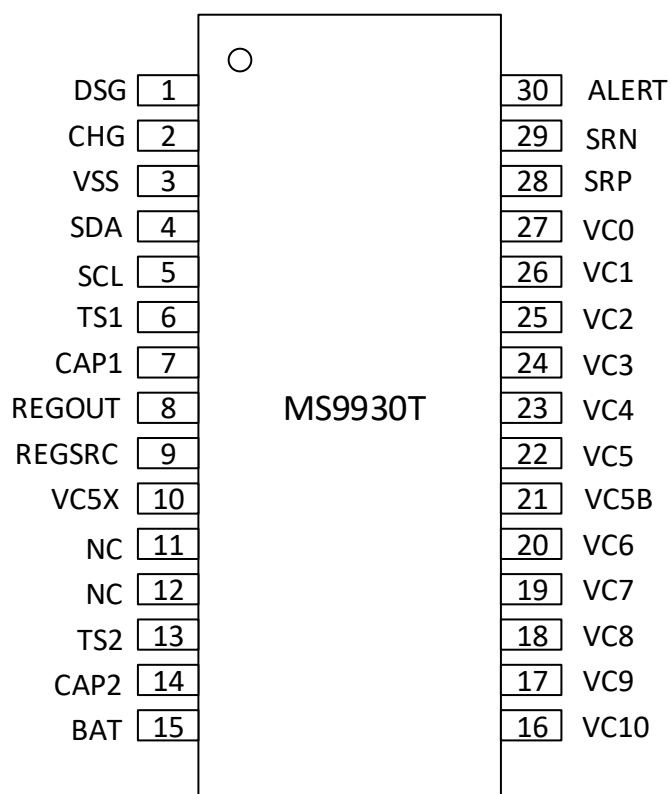
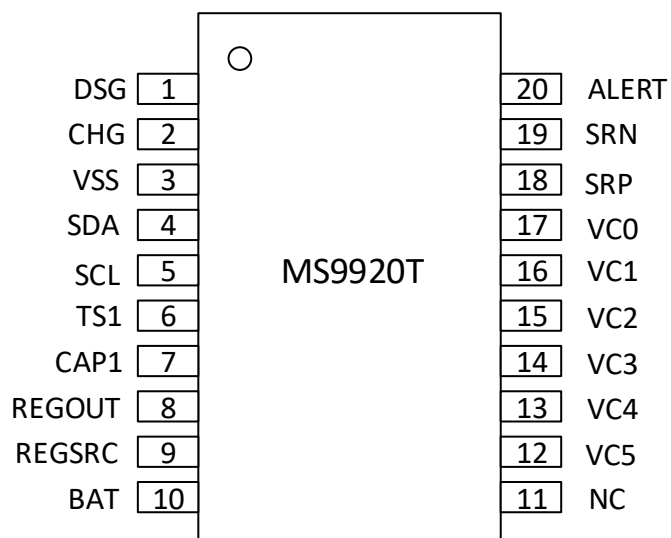
Part Number	Package	RANGE	Cells	I ² C Address(7-bit)	LDO(V)	CRC	Marking
MS9920T	TSSOP20	01	3-5	0x08	2.5	NO	MS9920T
		02				Yes	
		03			3.3	No	
		*04				Yes	
		05		0x18		No	
MS9930T	TSSOP30	01	6-10	0x08	2.5	No	MS9930T
		02				Yes	
		03			3.3	No	
		*04				Yes	
		05		0x18		No	
		06				Yes	

*The product is only available at present. If other needs, please contact Hangzhou Ruimeng Sales Department Center.

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PIN CONFIGURATION



PIN DESCRIPTION

MS9920T

Pin	Name	Type	Description
1	DSG	O	Discharge FET Driver
2	CHG	O	Charge FET Driver
3	VSS	-	Reference Ground
4	SDA	I/O	I ² C Communicate with Host Controller, Data Pin
5	SCL	I	I ² C Communicate with Host Controller, Clock Pin
6	TS1	I	Thermistor 1 Positive Terminal ¹
7	CAP1	O	3.3V Output, Capacitor to VSS
8	REGOUT	-	Output LDO
9	REGSRC	I	Power Supply for Output LDO
10	BAT	-	Battery (Top-most) Terminal
11	NC	-	Not Connection
12	VC5	I	Sense Voltage for 5th Cell Positive Terminal
13	VC4	I	Sense Voltage for 4th Cell Positive Terminal
14	VC3	I	Sense Voltage for 3rd Cell Positive Terminal
15	VC2	I	Sense Voltage for 2nd Cell Positive Terminal
16	VC1	I	Sense Voltage for 1st Cell Positive Terminal
17	VC0	I	Sense Voltage for 1st Cell Negative Terminal
18	SRP	I	Negative Current Sense (Close to VSS)
19	SRN	I	Positive Current Sense
20	ALERT	I/O	Alert Output and Fault Detection Input

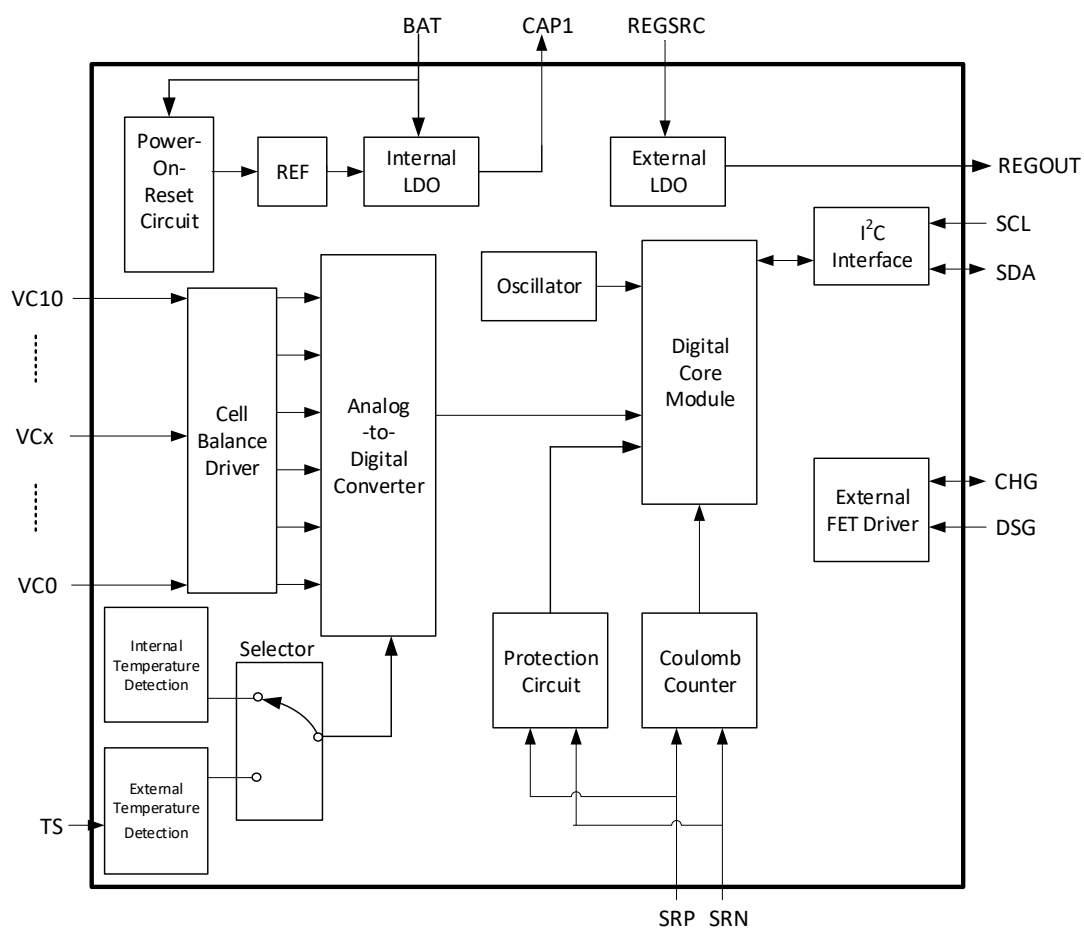
Note 1: If not in use, please pull down to VSS with 10kΩ nominal resistor.

MS9930T

Pin	Name	Type	Description
1	DSG	O	Discharge FET Driver
2	CHG	O	Charge FET Driver
3	VSS	-	Reference Ground
4	SDA	I/O	I ² C Communicate to Host Controller, Data Pin
5	SCL	I	I ² C Communicate to Host Controller, Clock Pin
6	TS1	I	Thermistor 1 Positive Terminal ¹
7	CAP1	O	3.3V Output, Capacitor to VSS
8	REGOUT	-	Output LDO
9	REGSRC	I	Power Supply for Output LDO
10	VC5X	-	Thermistor 2 Negative Terminal
11	NC	-	Not Connection
12	NC	-	Not Connection
13	TS2	I	Thermistor 2 Positive Terminal ¹
14	CAP2	O	3.3V Output, Capacitor to VC5X
15	BAT	-	Battery (Top-most) Terminal
16	VC10	I	Sense Voltage for 10th Cell Positive Terminal
17	VC9	I	Sense Voltage for 9th Cell Positive Terminal
18	VC8	I	Sense Voltage for 8th Cell Positive Terminal
19	VC7	I	Sense Voltage for 7th Cell Positive Terminal
20	VC6	I	Sense Voltage for 6th Cell Positive Terminal
21	VC5B	I	Sense Voltage for 6th Cell Negative Terminal
22	VC5	I	Sense Voltage for 5th Cell Positive Terminal
23	VC4	I	Sense Voltage for 4th Cell Positive Terminal
24	VC3	I	Sense Voltage for 3rd Cell Positive Terminal
25	VC2	I	Sense Voltage for 2nd Cell Positive Terminal
26	VC1	I	Sense Voltage for 1st Cell Positive Terminal
27	VC0	I	Sense Voltage for 1st Cell Negative Terminal
28	SRP	I	Negative Current Sense (Close to VSS)
29	SRN	I	Positive Current Sense
30	ALERT	I/O	Alert Output and Fault Detection Input

Note 1: If not in use, please pull down to VSS with 10kΩ nominal resistor.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Any exceeding absolute maximum rating application causes permanent damage to device. Because long-time absolute operation state affects device reliability. Absolute ratings just conclude from a series of extreme tests. It doesn't represent chip can operate normally in these extreme conditions.

Parameter	Symbol	Condition	Ratings	Unit
Power Supply	V_{BAT}	MS9920T	-0.3 ~ +36	V
		MS9930T	-0.3 ~ +72	V
Input Voltage	REGSRC		-0.3 ~ +45	V
	V_{IN}	$V_{Cn}-V_{SS}, n=1,2,3...10$	-0.3 ~ +n*7.2	V
		$V_{Cn}-V_{Cn-1}, n=1,2,3...10$	-0.3 ~ +9	V
Output Voltage	REGOUT,ALERT		-0.3 ~ +3.6	V
	DSG		-0.3 ~ +20	V
	CHG		-0.3 ~ + $V_{CHGCLAMP}$	V
Balance Current for Each Cell	I_{CB}	MS9920T	70	mA
		MS9930T	5	mA
Input Current, DSG Pin	I_{DSG}	Flow into DSG pin when disabled	7	mA
ESD(HBM)	V_{ESD}		±4000	V

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Device	Condition	Min	Typ	Max	Unit
Power Supply	V_{BAT}	MS9920T	BAT-VSS	7.5		25	V
		MS9930T	(BAT-VC5X),(VC5X-VSS)	7.5		25	V
Input Voltage	V_{IN}		$VCn-VCn-1, n=1,2,3...10$. $VCn-VCn-1, n=1,2,3...10$. Only for in-use cell	2		5	V
		MS9920T	$VCn-VSS, n=1,2,3,4,5$.	0		$5*n$	V
		MS9930T	$VCn-VSS, n=1,2,3,4,5$. $VCn-VC5X, n=6,7,8,9,10$.	0		$5*n$	V
			SRP	-10		10	mV
			SRN	-200		200	mV
		MS9920T	VC0-VSS	-10		10	mV
		MS9930T	VC0-VSS, VC5B-VC5X	-10		10	mV
			SDA, SCL	0		3.6	V
		MS9920T	TS1-VSS	0		3.6	V
		MS9930T	TS1-VSS, TS2-VCX5	0		3.6	V
			REGSRC	6		25	V
Output Voltage	V_{OUT}		CHG, DSG	0		16	V
			REGOUT, ALERT	0		3.6	V
		MS9920T	CAP1-VSS	0		3.6	V
		MS9930T	CAP1-VSS, CAP2-VCX5	0		3.6	V
Balance Current for Each Cell	I_{CB}	MS9920T		0		50	mA
		MS9930T		0		5	mA
External Cell Input Resistor	R_C	MS9920T		40	100	1k	Ω
		MS9930T		500		1k	Ω
External Cell Input Capacitor	C_C			0.1	1	10	μF

Parameter	Symbol	Device	Condition	Min	Typ	Max	Unit
Power-Filtering Capacitor	C _f			1	10	40	μF
Power-Filtering Resistor	R _f			40	100	1k	Ω
Rsns Filtering Resistor	R _{FILT}			100	1k		Ω
REGOUT Load Capacitor	C _L			1	4.7		μF
Decoupling Capacitor	C _{CAP}		CAP1,CAP2,REGSRC	1			μF
External Thermistor	R _{TS}		25°C		10k		Ω
Operating Temperature	T _A			-40		85	°C
Storage Temperature	T _{STG}			-65		150	°C
Lead Temperature (10s)	T _{TOR}				260		°C

ELECTRICAL CHARACTERISTICS

Typical operating conditions are measured at 25°C with VBAT voltages of 18V (MS9920T), 36V (MS9930T). The maximum and minimum values are conditions when temperature ranges from -40°C to +85°C. Unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Normal Mode Current						
ADC Off, CC Off	I _{DD}	Sum current of flowing into BAT and REGSRC		38		μA
ADC On, CC Off				66		μA
ADC Off, CC On				124		μA
ADC On, CC On				152		μA
ADC Off	I _{CC_BAT}	Flow into BAT		25		μA
ADC On				52		μA
CC Off	I _{CC_REGSRC}	Flow into REGSRC		13		μA
CC On				99		μA
SHIP Mode Current						
SHIP Mode Current	I _{SHIP}	Only boot module enabled		0.72		μA
Current Change and Leakage Current						
Normal Mode Current Change	dI _{NOM}	Flow into VC5X		13		μA
SHIP Mode Current Change	dI _{SHIP}	Flow into VC5X		±0.2		μA
Added Current when ALERT Enabled	dI _{ALERT}	Flow into VC5X or add to BAT		13		μA
Input Current when Cell Measurement	dI _{CELL}	Flow into VC0~VC4, VC6~VC9		±0.06		μA
		Flow into VC5, VC10		±0.1		μA
Input Leakage Current	I _{LKG}			0.6		μA
Internal Power Control (Startup and Shutdown)						
Analog POR Threshold	V _{PORA}	MS9920T, BAT pin		6		V
		MS9930T, BAT pin		15		V
Time Delay after Boot Signal on TS1 before I ² C Communications Allowed	t _{I2CSTARTUP}			1		ms
Time Delay between Boot Signal and Complete Startup	t _{BOOTREADY}				10	ms
Shutdown Temperature	T _{SHUTD}			100		°C

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Measurement Time						
Measurement Period from VC1 to VC5	t _{VCELL}	MS9920T/MS9930T		250		ms
Measurement Time for Single Cell	t _{INDCELL}	Cell balance off		50		ms
		Cell balance on		12.5		ms
Balance Time before Cell Measurement	t _{CB_RELAX}			37.5		ms
Temperature Measurement Time	t _{TEMP_DEC}			12.5		ms
Pack Voltage Calculation Period	t _{BAT}			250		ms
Temperature Measurement Interval	t _{TEMP}			2		s
14bit ADC used for Cell Voltage Measurement and Temperature Measurement						
ADC Recommended Measurement Range	ADC _{RANGE}	Cell Voltage	2		5	V
		TS1/Temperature measurement	0.3		3	V
ADC LSB	ADC _{LSB}			357		μV
Cell Measurement Accuracy at 25°C	ADC	V _{CELL} =3.6V~4.3V		±10		mV
		V _{CELL} =3.2V~4.6V		±15		mV
		V _{CELL} =2.0V~5.0V		±25		mV
Cell Measurement Accuracy 0~60°C		V _{CELL} =3.6V~4.3V	-40		40	mV
		V _{CELL} =3.2V~4.6V	-40		40	mV
		V _{CELL} =2.0V~5.0V	-50		50	mV
Cell Measurement Accuracy -40°C~85°C		V _{CELL} =3.6V~4.3V	-40		40	mV
		V _{CELL} =3.2V~4.6V	-40		40	mV
		V _{CELL} =2.0V~5.0V	-50		50	mV
Coulomb Counter for Current Measurement CC						
CC Input Voltage	CC _{RANGE}		-200		200	mV
CC Full-scale	CC _{FSR}		-276.6		276.6	mV
CC LSB	CC _{LSB}			8.44		μV

Parameter	Symbol	Condition	Min	Typ	Max	Unit
CC Conversion Time	tCC _{READ}			250		ms
Integral Non-linearity INL	CC _{INL}	Within input voltage range		±2		LSB
Offset Error	CC _{OFFSET}			±1		LSB
Gain Error	CC _{GAIN}	Within input voltage range		±0.8%		FSR
Gain Error Drift	CC _{GAINDRIFT}	Within input voltage range		20		ppm/°C
Valid Input Resistor	CC _{RIN}			2.5		MΩ

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Thermistor						
Pull-up Resistor	R _{TS}	25°C	9.85	10.00	10.15	kΩ
Pull-up Resistor Drift	R _{TS} DRIFT	-40°C~85°C	9.7		10.3	kΩ
Chip Temperature						
Junction Voltage at 25°C	V _{DIETEMP}		1.25	1.26	1.29	V
Junction Voltage with Chip Temperature	V _{DIETEMP} DRIFT			-4.0		mV/°C
Integrated Hardware Protection						
Overvoltage Threshold	OV _{RANGE}		0x2008		0x2FF8	ADC
Undervoltage Threshold	UV _{RANGE}		0x1000		0x1FF0	ADC
Overvoltage and Undervoltage Threshold Step	OV_UV _{STEP}			16		LSB
Minimum Undervoltage Value	UV _{MINQUAL}	Below UV _{MINQUAL} , cell shorted		0x0518		ADC
Overvoltage Delay Timer Option	OV _{DELAY}	OV delay 1s		1		s
		OV delay 2s		2		s
		OV delay 4s		4		s
		OV delay 8s		8		s
Undervoltage Delay Timer Option	UV _{DELAY}	UV delay 1s		1		s
		UV delay 4s		2		s
		UV delay 8s		4		s
		UV delay 16s		8		s

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Overcurrent Protection Threshold Option	OCD _{RANGE}	Measure SRP-SRN	8		100	mV
Overcurrent Protection Threshold Step	OCD _{STEP}	RSNS=0		2.55		mV
		RSNS=1		5.1		mV
Overcurrent Protection Delay	OCD _{DELAY}		8		1280	ms
Short-circuit Protection Threshold Option	SCD _{RANGE}	Measure SRP-SRN	18.5		181.5	mV
Short-circuit Protection Threshold Step	SCD _{STEP}	RSNS=0		10.2		mV
		RSNS=1		20.4		mV
Short-circuit Protection Delay	SCD _{DELAY}			70		μs
				100		μs
				200		μs
				400		μs
Overcurrent Protection Delay Accuracy	T _{PROTACC}		-20%		+20%	
Overcurrent Protection and Short-circuit Protection Voltage Error	OC _{OFFSET}			3.5		mV
Overcurrent Protection and Short-circuit Protection Scale Accuracy	OC _{SCALEER}		-20%		+20%	

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Charge and Discharge Driver						
CHG and DSG Open	V _{FETON}	REGSRC≥12V, Load resistor 10MΩ	10	12	13.5	V
		REGSRC<12V, Load resistor 10MΩ	REGSRC -1.0	REGSRC -0.8	REGSRC -0.6	V
CHG and DSG Rise Time	t _{FET_ON}	Load 10nF, 10%~90%		10		μs
Fall Time when CHG Pull-down Off	t _{CHG_OFF}	90%~10%		65		μs
Fall Time when DSG Pull-down Off	t _{DSG_OFF}	90%~10%		60		μs

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Resistor to Ground when CHG Pull-down Off	R _{CHG_OFF}	CHG off and keep on 12V		0.7		MΩ
Resistor to Ground when DSG Pull-down Off	R _{DSG_OFF}	DSG off and keep on 12V		2.3		kΩ
Load Detection Threshold	V _{LOAD_DETECT}			1.4		V
CHG Clamp Voltage	V _{CHG_CLAMP}	If CHG pin is pulled up externally, maximum 500μA current flows into CHG pin		20.5		V
ALERT Pin						
Output High-level	V _{ALERT_OH}	I _{OL} =1mA		REGOUT ×0.98		V
Output Low-level	V _{ALERT_OL}	No load		0		V
Input High-level	V _{ALERT_IH}	When ALERT is driven low internally		1.75		V
Pull-down Resistor when ALERT Output Low	R _{ALERT_PD}	ALERT pin to ground		2.0		MΩ
Cell Balance Driver						
Internal Cell Balance Drive Resistor	R _{DSFET}	V _{CELL} =3.6V		3.5		Ω
Cell Balance Startup Time Duty Cycle	X _{BAL}	Every 250ms		70%		

Parameter	Symbol	Condition	Min	Typ	Max	Unit
REGOUT Pin						
External LDO Output Voltage No Load within Total Temperature Range	V _{EXTLDO}	2.5V version	-	-	-	V
		3.3V version	3.2	3.3	3.4	V
Linearity Regulation	V _{EXTLDO_LN}	10mA Load current REGSRC pin increases from 6V to 25V with 100μs		5		mV
Load Regulation	V _{EXTLDO_LD}	Load current from 0mA to 10mA		-1.7%		

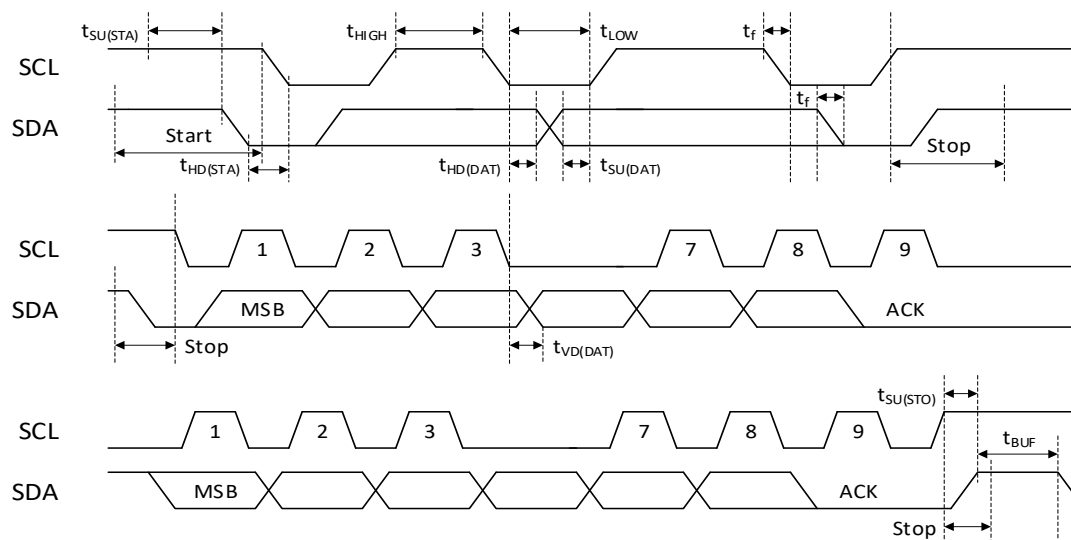
Parameter	Symbol	Condition	Min	Typ	Max	Unit
Minimum Output Voltage with DC Load ¹	V _{EXTLDO_DC}	2.5V version 10mA	-	-		V
		2.5V version 20mA	-	-		V
		3.3V version 10mA		3.21		V
		3.3V version 20mA		3.13		V
External LDO Current Limit	V _{EXTLDO_LIMIT}	REGOUT=0, REGSRC=18V		36.0		mA
Boot Detection						
Boot Threshold Voltage	V _{BOOT}	Measured at TS1 pin. Ensure boot if higher than maximum. Not boot if lower than minimum		700		mV
Apply Boot Signal Duration Time	t _{BOOT}	Measured at TS1 pin. Ensure boot if higher than maximum. Not boot if lower than minimum		125		μs

Parameter	Symbol	Condition	Min	Typ	Max	Unit
I²C Interface						
Input Low-level Voltage	V _{IL}				REGOUT×0.25	V
Input High-level Voltage	V _{IH}		REGOUT×0.75			V
Output Low-level Voltage	V _{OL}			0		V
SCL, SDA Fall Time	t _f			0.4		ns
SCL High-level Pulse Width	t _{HIGH}			1.5		μs
SCL Low-level Pulse Width	t _{LOW}			2.0		μs
Setup Time, Start State	t _{SU,STA}			2.0		μs
Hold Time, Start State	t _{HD,STA}			1.5		μs
Data Setup Time	t _{SU,DAT}			130		ns
Data Hold Time	t _{HD,DAT}			26		μs
Setup Time, Stop State	t _{SU,STO}			2.5		μs

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Bus Idle Wait Time before New Transmission	t_{BUF}			4.0		μs
Clock Low to Data Output Valid	$t_{VD,DAT}$				900	ns
Clock Frequency	f_{SCL}				100	kHz

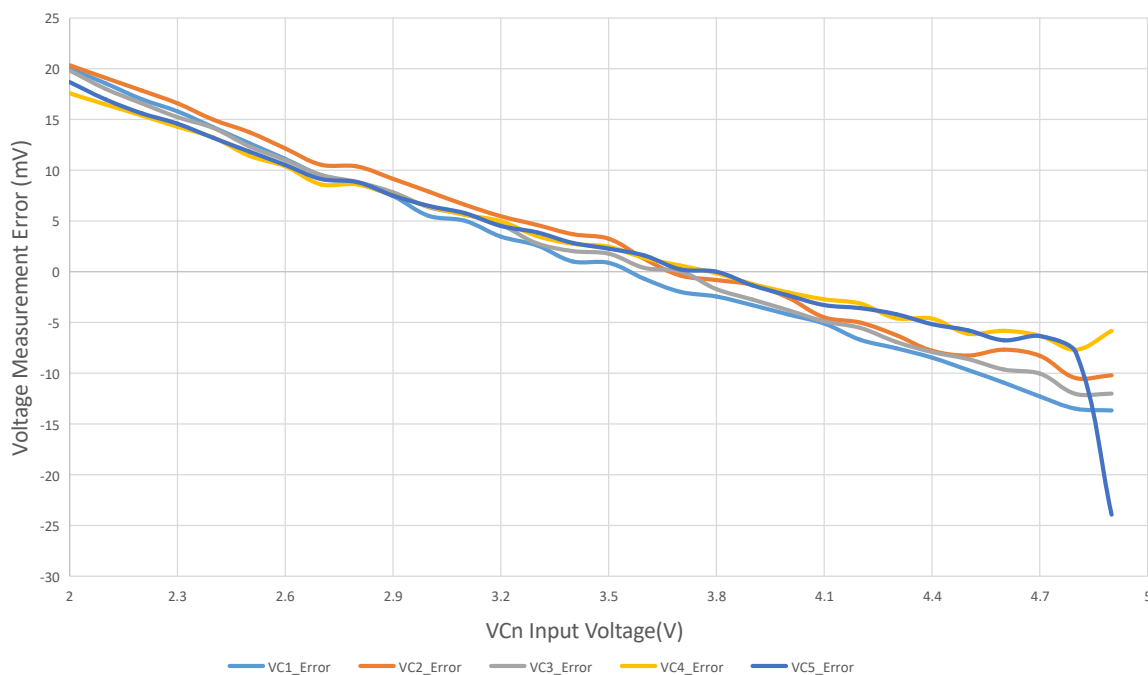
Note 1: The minimum output voltage is relative to REGSRC when DC load. Only when $REGSRC \geq 7.5V$, there is more than 20mA current drive ability and the drop value of output voltage is not more than 10% of output when no load within recommended temperature range. The current ability also decreases with REGSRC voltage decreasing.

Timing Diagram

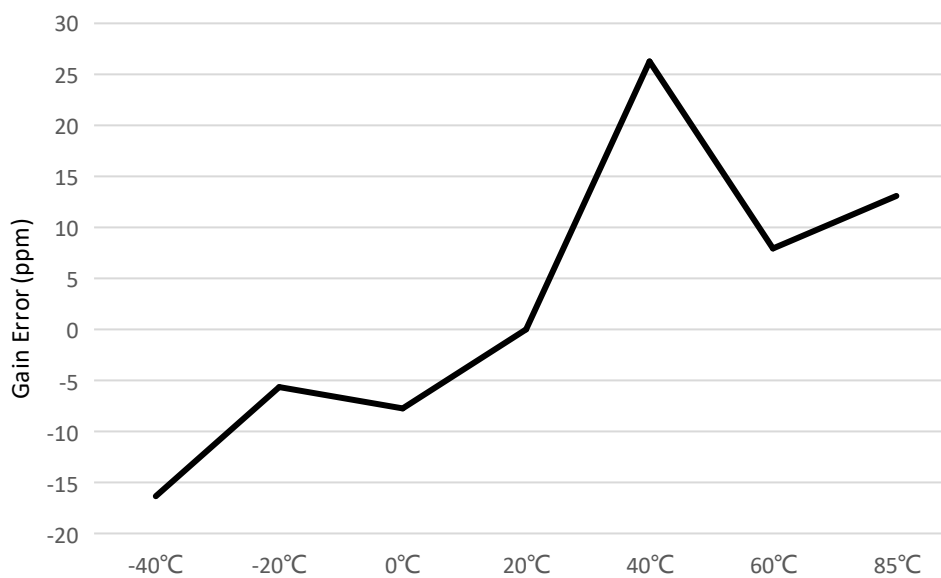


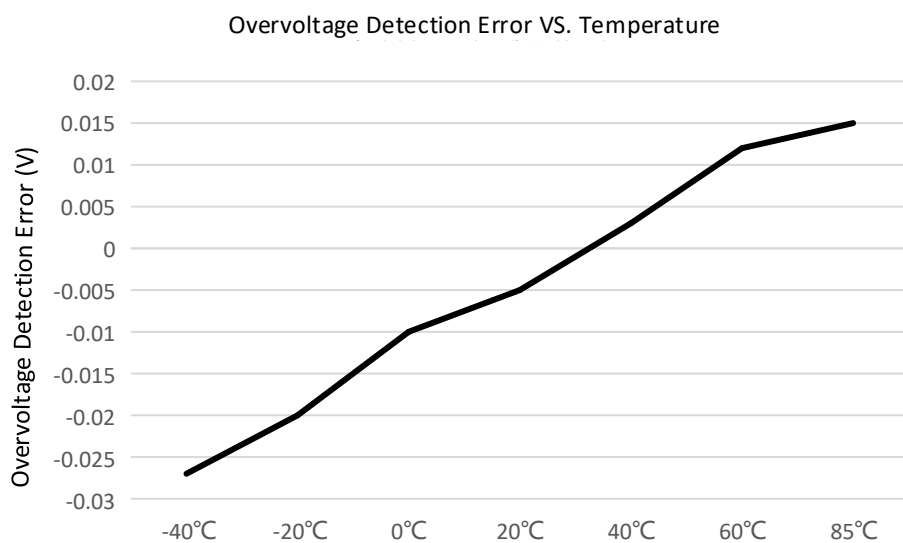
TYPICAL CHARACTERISTICS CURVES

MS9920T Cell Voltage VCn Measurement Error @25°C

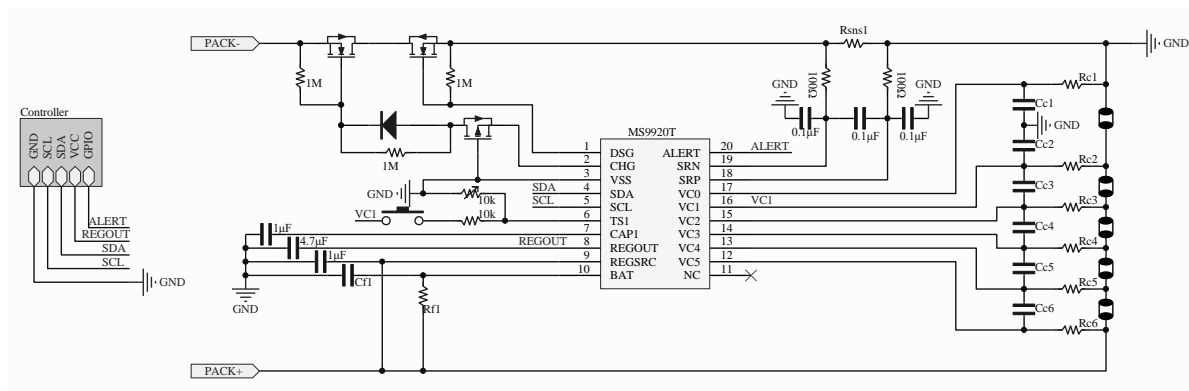


CC Gain Error with Temperature when Input Range from -0.2V to 0.2V

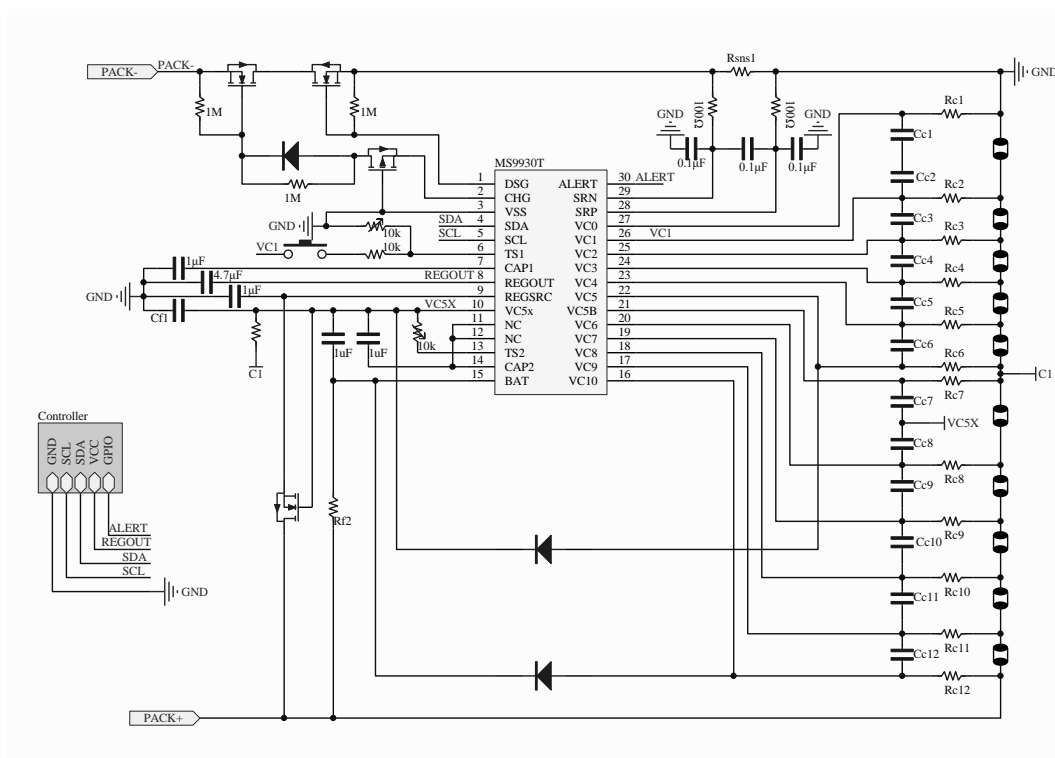




TYPICAL APPLICATION DIAGRAM



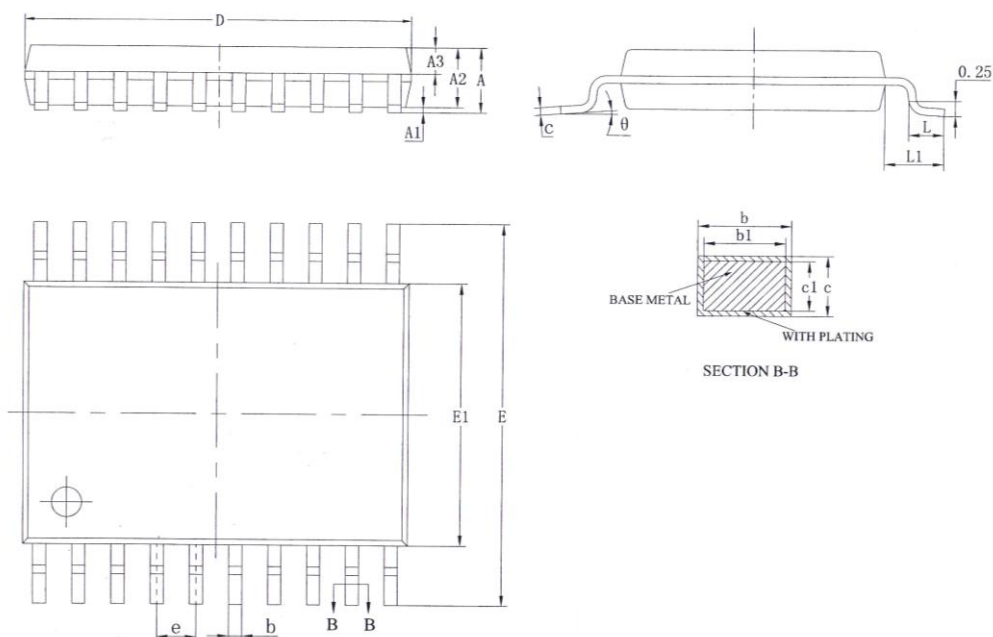
MS9920T Application Diagram



MS9930T Application Diagram

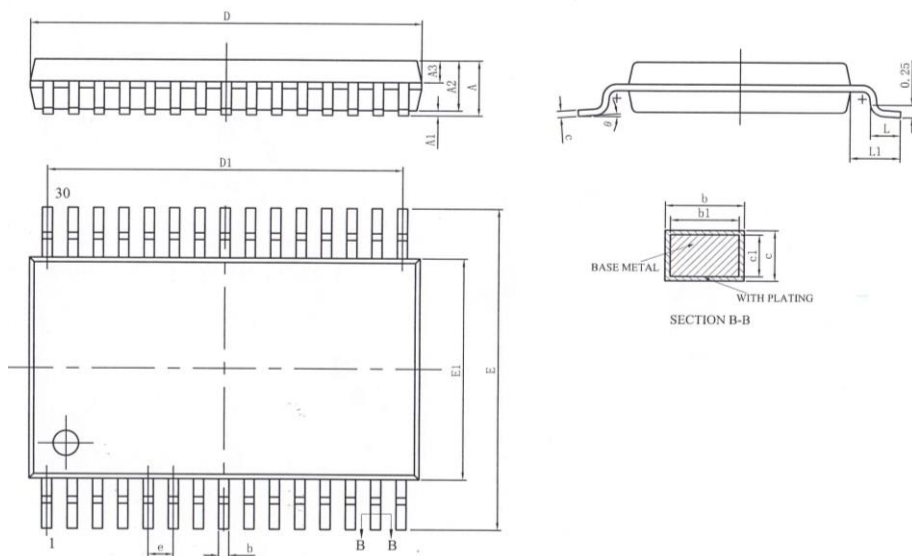
PACKAGE OUTLINE DIMENSIONS

TSSOP20-MS9920T



Symbol	Dimensions in Millimeters		
	Min	Typ	Max
A	-	-	1.20
A1	0.05	-	0.15
A2	0.80	1.00	1.05
A3	0.39	0.44	0.49
b	0.20	-	0.28
b1	0.19	0.22	0.25
c	0.13	-	0.17
c1	0.12	0.13	0.14
D	6.40	6.50	6.60
E1	4.30	4.40	4.50
E	6.20	6.40	6.60
e	0.65BSC		
L	0.45	0.60	0.75
L1	1.00BSC		
θ	0	-	8°

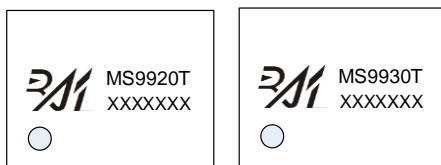
TSSOP30-MS9930T



Symbol	Dimensions in Millimeters		
	Min	Typ	Max
A	-	-	1.20
A1	0.05	-	0.15
A2	0.80	1.00	1.05
A3	0.39	0.44	0.49
b	0.18	-	0.27
b1	0.17	0.20	0.23
c	0.13	-	0.18
c1	0.12	0.13	0.14
D	7.70	7.80	7.90
D1	6.90	7.00	7.10
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.50BSC		
L	0.45	0.60	0.75
L1	1.00BSC		
θ	0	-	8°

MARKING and PACKAGING SPECIFICATION

1. Marking Drawing Description



Product Name: MS9920T, MS9930T

Product Code: XXXXXXX

2. Marking Drawing Demand

Laser printing, contents in the middle, font type Arial.

3. Packaging Specification

Device	Package	Piece/Reel	Reel/Box	Piece/Box	Box/Carton	Piece/Carton
MS9920T	TSSOP20	3000	1	3000	8	24000
MS9930T	TSSOP30	3000	1	3000	8	24000

STATEMENT

- All Revision Rights of Datasheets Reserved for Ruimeng. Don't release additional notice.
Customer should get latest version information and verify the integrity before placing order.
- When using Ruimeng products to design and produce, purchaser has the responsibility to observe safety standard and adopt corresponding precautions, in order to avoid personal injury and property loss caused by potential failure risk.
- The process of improving product is endless. And our company would sincerely provide more excellent product for customer.

**MOS CIRCUIT OPERATION PRECAUTIONS**

Static electricity can be generated in many places. The following precautions can be taken to effectively prevent the damage of MOS circuit caused by electrostatic discharge:

1. The operator shall ground through the anti-static wristband.
2. The equipment shell must be grounded.
3. The tools used in the assembly process must be grounded.
4. Must use conductor packaging or anti-static materials packaging or transportation.



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