LGS5524 Datasheet

Synchronous Boost 4-Cell 2A Lithium Battery Charger Manager

LGS5524

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Features

- **Adjustable charging current up to 2A (limited by heat dissipation and input power)**
- **Supports full charge voltage of 16.8V (other voltages require customization)**
- **Input voltage withstand up to 28V**
- **Battery terminal voltage withstand up to 28V**
- **Wide input operating voltage range: 3.0V~12.3V**
- **Peak efficiency up to 93%, heavy load efficiency up to 90%**
- **External shutdown EN function**
- **Supports maximum temperature increase of 110°C, with charging current thermal regulation**
- **Complete charging status LED indication, single or dual LED options**
- **Ultra-low thermal resistance ESSOP10 package (θuu=3.9°C/W)**
- **Programmable adaptive input current limit, adaptive adapter load capability**
- **Protections: Input overvoltage, battery overvoltage, battery short circuit, over-temperature protection, NTC battery temperature monitoring**
- **Supports hot-swapping of battery packs**
- **All power MOSFETs integrated**

Applications

- **Dual-cell lithium battery pack charging**
- **Smart locks**

Description

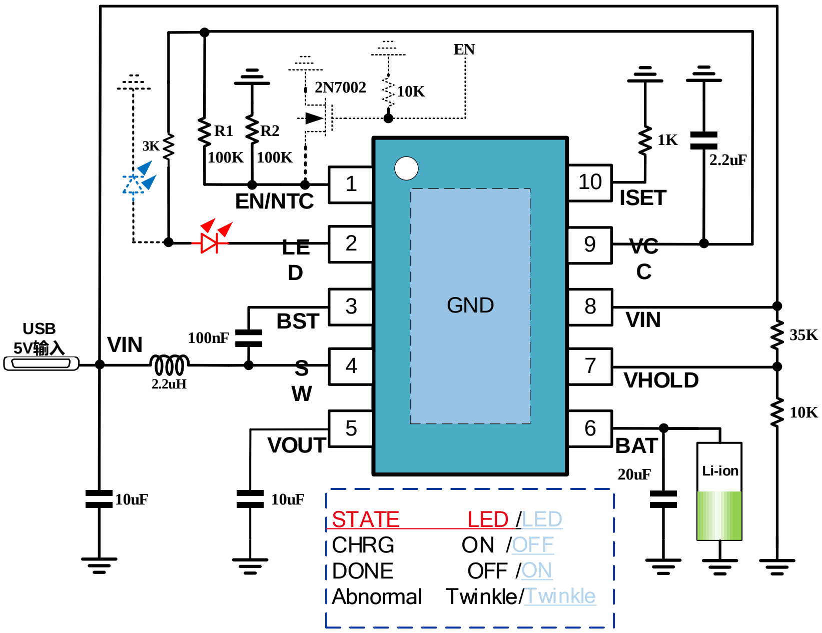
The LGS5524 is a boost-type 3-cell synchronous boost charger, suitable for 4-cell series lithium-ion batteries. The charging current can be set via an external resistor.
The LGS5524 features four charging processes: Short Circuit (SC), Trickle Charge (TC), Constant Current (CC), and Constant Voltage (CV). Short Circuit Charge (SC) can charge a 0V battery; Trickle Charge (TC) can recover a fully discharged battery; Constant Current Charge (CC) can quickly charge the battery; Constant Voltage Charge (CV) ensures safe full charging of the battery. It supports waking up deeply discharged batteries.
The LGS5524 charges up to 16.8V, then stops charging and continuously monitors the battery voltage. If the voltage drops to 16.4V, it automatically recharges. When the input voltage (USB source or AC adapter) is removed, the battery terminal leakage current is 35uA.
The LGS5524 integrates charging and full charge indication, as well as abnormal status indication.

Ordering Guide

Part	Package	Top Mark
LGS5524	**ESSOP10**	5524 YYWWD

YY: Year code. WW: Week code. D: Fixed version number

Typical Application Topology - 5V



5V USB input; dashed components are optional (dual LED).

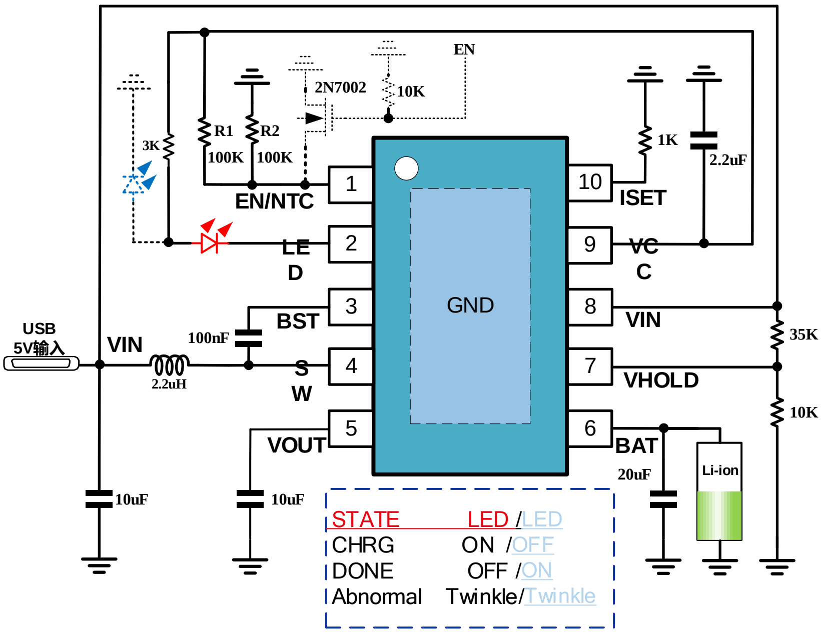
NOTE:

- The capacitors of the boost output VOUT and BAT should be as close to the chip as possible, and the circuit should be as short as possible. This capacitor has the highest priority and can be referenced for PCB layout examples.
- The NTC and EN pins are multiplexed, with EN1.1V being high and 0.7V being low. NTC enables charging only at 25%~85% VCC voltage (1.25V~3.25V).
- In typical NTC applications, a 100K resistance NTC resistor with a B value of 4250K is required to be connected in parallel with an R2 (150K) resistor and then in series with an R1 (57.6K) resistor at the VCC pin. This combination ensures normal charging of the battery in the 0C-60 ℃ range. If using other combinations, please refer to the temperature range provided in the NTC function explanation on page 11 for design or consult our FAE.
- The bottom e Pad GND pin should be connected to the ground plane using coated steel to minimize PCB conduction loss and thermal stress, and prevent a decrease in charging current caused by high chip temperature.
- When using the LED indicator light, a current limiting resistor should be connected to VCC, with a recommended value of 3K. **If you need to use the dual light scheme, you must configure the LED lights according to the colors shown in the picture (red and blue)**. Please purchase LED lights of the corresponding colors for experimentation to ensure that the two lights do not have the same conducting voltage. When charging, the red light will turn on and the blue light will turn off; When full, the blue light is on and the red light is off; During abnormal situations, the red and blue lights flash alternately. If red and green lights are required, please refer to the circuit on page 10.

■ Recommended component selection

Symbol	meaning	Recommended value	remarks
C_{VIN}	USB charging input voltage regulator	10μF，25V，0805，10%	Ceramic capacitors with a withstand voltage greater than 16V
C_{VCC}	System power supply stabilizing capacitor	2.2μF，16V，0603，10%	Ceramic capacitors with a withstand voltage greater than 10V
C_{VOUT}	Boost output stabilizing capacitor	10μF，25V，0805，10%	Ceramic capacitors with a withstand voltage greater than 16V

C_{BAT}	Charging output voltage regulator capacitor, battery end	20µF，50V，0805，10%	Ceramic capacitors with a withstand voltage greater than 16V
C_{BST}	Bootstrap capacitor	100nF，16V，0603，10%	Ceramic capacitors
L	Power inductor	2.2uH is sufficient	Saturation current greater than 5A
R_{ISET}	Set the constant current charging current of the battery	Accuracy 1%	
R1,R2	Assist NTC detection	R1=56K,R2=150K 0℃~60℃。 This configuration ensures normal charging from 0 ℃ to 60C.	**If NTC is disabled, R1=R2=100K Pin below 0.7V, enable shutdown.**
R_{NTC}	NTC thermistor	100K，B value: 4250K, accuracy 1%	According to the design selection
R3,R4	Set VN voltage for adaptive input current limiting	Connect the VHOLD pin to the midpoint of the resistor network from VIN to GND. When the VHOLD voltage drops to 1V, the charger will reduce the charging current.	Short circuit to VCC without using this function



5V USB input; The dashed device is an optional feature (dual lights)

Table of Contents

Absolute Maximum Ratings (†)

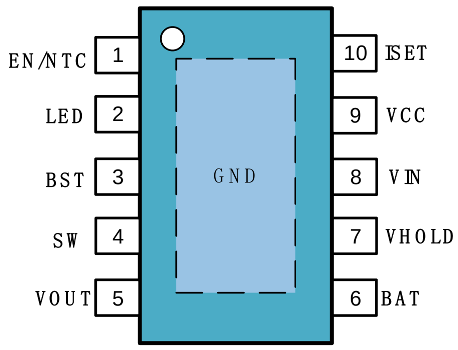
Table 4.1

Parameter	Range
Pin-to-GND Voltage (VIN, BAT, VOUT, SW)	-0.3V~28V
Pin-to-GND Voltage (ISET, VHOLD, NTC, VCC)	-0.3V~6V
Pin-to-SW Voltage (BST)	-0.3V~6V
Maximum Pin Current (SW)	5A
Storage Temperature	-65℃ to 150℃
Operating Temperature	-40℃ to 125℃
ESD Rating (HBM)	±2KV

† † Note: If the device operating conditions exceed the above "Absolute Maximum Ratings," it may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Pin Configuration

Figure 4. Pin Configuration



ESD Warning

	ESD (electrostatic discharge) sensitive devices. Charged components and circuit boards may discharge without being noticed. Although this product has patented or proprietary protection circuits, the device may be damaged in the event of high-energy ESD. Therefore, appropriate ESD prevention measures should be taken to avoid device performance degradation or functional loss.

Functional Block Diagram and Pin Description

Table 3.2 Pin Function Description

Pin Number ESSOP10	Pin Name	Description
1 [(1)]	EN/NTC	NTC and EN pins are multiplexed. EN 1.1V is high, 0.7V is low; NTC enables charging only at 25%~65% VCC voltage (1.25V~3.25V).
2	LED	Charging indication. Open-drain output, connected to LED through a current-limiting resistor to VDD. LED on during charging, off when fully charged.
3	BST	Bootstrap circuit pin. A 100nF bootstrap capacitor must be connected between BST and SW.
4	SW	Internal power switch node. Externally connected to inductor and CBST capacitor.
5	VOUT	Synchronous boost intermediate node. **10uF capacitor must be close to the pin, otherwise malfunction may occur.**
6	BAT	Connected to battery positive terminal. A 20uF ceramic capacitor is bypassed to GND.
7 [(2)]	VHOLD	Adaptive input current limit setting pin. A resistor divider network is connected between SVIN and GND to configure the minimum input voltage limit threshold. VHOLD less than 1V indicates adapter current limit.
8	VIN	Input power supply and detection pin.
9	VCC	Internal power supply pin. At least 2.2uF ceramic capacitor must be connected to GND.
10	ISET	Sets constant current charging current. An external 1% precision resistor is connected to ground to set the charging current. During constant current charging (CC), the voltage at this pin is fixed at 1V. The charging current can be estimated by measuring the voltage at this pin in all charging modes. Formula: $I_{BAT} = \left(V_{ICHG} / R_{ICHG}\right) \times 1000$。
EP	EP	GND, system ground.

(1) **If adaptive current limiting is not used, the V_{HOLD} pin can be shorted to VCC.**

(2) **The NTC pin does not support floating or grounding. (If NTC function is disabled, two 100k resistors can be used to divide the voltage from vin to NTC, and NTC will always be at 50% VCC threshold.)**

Technical Specifications

Unless otherwise specified, all voltages are relative to GND.

Table 5.

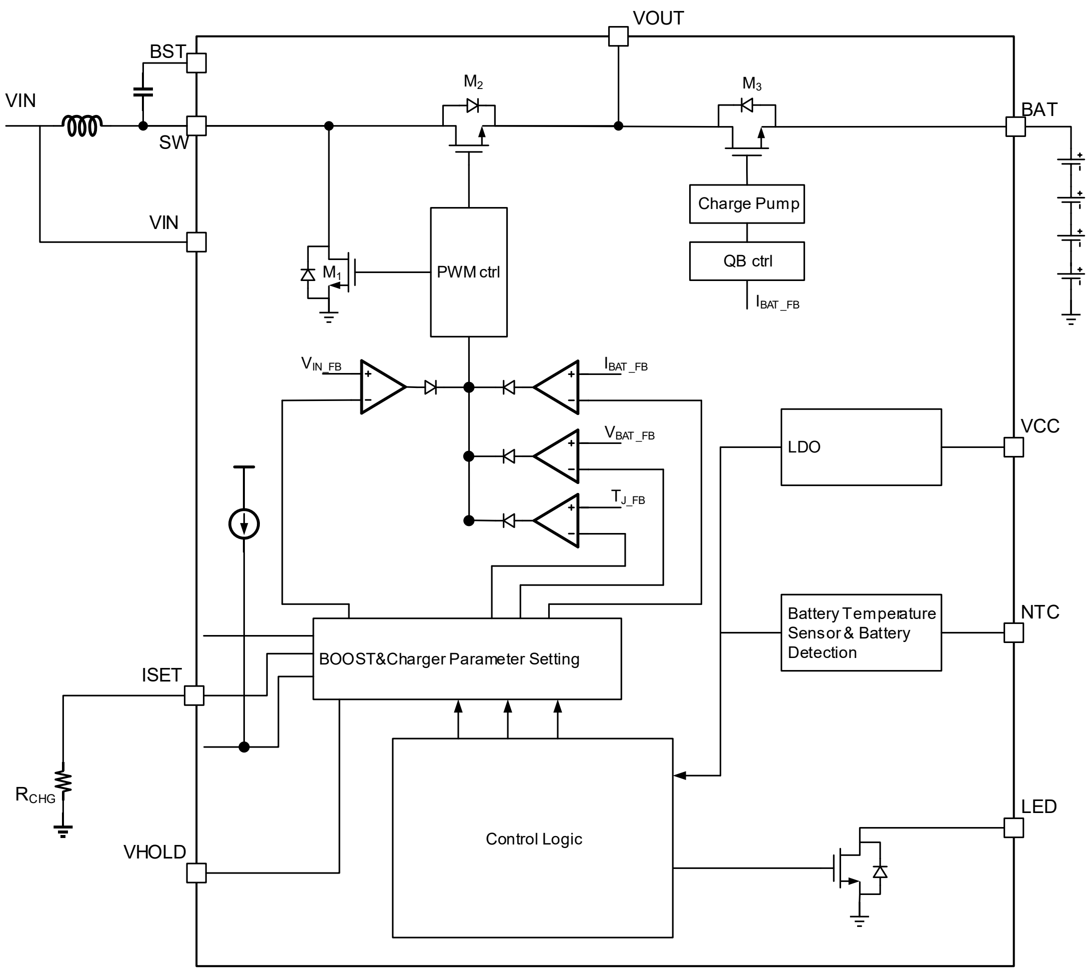
Parameter		Test Conditions	Min	Typ	Max	Unit
Power Input						
V_{VIN}	Input power operating voltage		3	5	6.5	V
V_{UVLO}	Input undervoltage lockout	V_{VIN} rising edge	2.6	2.8	3.0	V
		V_{VIN} falling edge	2.5	2.6	2.9	V
ΔV_{UVLO}	Input undervoltage lockout hysteresis		50	150	300	mV
V_{OVP}	Input overvoltage protection	V_{VIN} rising edge		9.9		V
		V_{VIN} falling edge		9.4		V
ΔV_{OVP}	Input overvoltage protection hysteresis		200		350	mV
Quiescent Current						
I_{BAT}	Battery terminal leakage current	EN=0, VIN=0, BAT=8.4V	25	30	35	µA
I_{VIN}	Input quiescent current	EN=1，BAT floating	150	250	350	mA
	Shutdown Current	EN=0	20	26	30	µA
Power Transistor						
f_{SW}	Boost switching frequency			750		kHz

Charging Voltage						
V_{CV}	Battery full charge voltage setting	12.6V version (default)	12.47	12.6	12.73	V
ΔV_{RCH}	Battery full charge recharging threshold		12.15	12.3	12.45	V
V_{CC}	Constant current charging threshold	Above this threshold, constant current charging Below this threshold, trickle charging	7.96	8.4	8.7	V
V_{TC}	Trickle charging threshold	Above this threshold, trickle charging Below this threshold, short circuit charging	1.6	2	2.4	V
Charging Current						
I_{CC} (1)	Constant current (CC) charging current	I_{SET}=1K	900	1000	1100	mA
I_{TC} (1)	Trickle current (TC) charging current	I_{SET}=1K	90	120	150	mA
I_{SC} (1)	Short circuit (SC) charging current	I_{SET}=1K	30	60	90	mA
I_{TERM}	Constant voltage (CV) charging cutoff current	I_{SET}=1K	60	120	180	mA
BAT OVP						
V_{OVP}	Output voltage OVP threshold	Rising edge		1.2		V_{CV}
		Falling edge		1.1		V_{CV}
Trickle Charge V_{OUT}						
V_{VOUT}	Bus voltage regulation			6.2		V
V_{TRON}	Blocking FET fully turn on threshold $V_{TRON}=V_{BAT}-V_{IN}$	$V_{BAT} > V_{TC}$		100		mV
Control Logic Signal EN						
V_{ENH}	EN high-level input voltage	EN Rising		1.4		V
V_{ENL}	EN low-level input voltage	EN Falling		0.76		V
Battery Temperature Detection NTC						
UTP (2)	Under temperature protection	Rising edge	62%	65%	68%	VCC
	Hysteresis		4%	5%	7%	VCC
OTP (2)	Overtemperature protection	Falling edge	22%	25%	27%	VCC
	Hysteresis		2%	2.6%	3%	VCC
Thermal Regulation and Thermal shutdown						
T_{REG}	Thermal regulation threshold			110		°C
OTP	Overtemperature protection temperature	Rising threshold		160		°C
OTP_{HYS}	Overtemperature protection hysteresis			30		°C

(1) During the charging process, to protect the battery, the chip detects the battery voltage and executes four different charging stages: Short Circuit Charge (SC) → Trickle Charge (TC) → Constant Current Charge (CC) → Constant Voltage Charge (CV) → Charge Stop.

(2) Battery temperature control, the chip detects the NTC pin voltage to determine the battery temperature. The NTC resistor is usually located inside the battery. Other configurations can be used according to the NTC voltage temperature threshold (see page 11).

Functional Block Diagram



Functional Description

Overview

The LGS5524 is a boost-type 3-cell lithium-ion battery charger designed for 5V adapters, with a wide input voltage range of 3.0V~6.5V and a maximum continuous charging current of 2A. The switching frequency is 750KHz.

Normal Charging Cycle (BAT)

LGS5524 offers four main charging stages: short-circuit charging, trickle charging, constant current charging, and constant voltage charging.

Short circuit mode: When VBAT is below the trickle charging turn-on threshold VTC (2V), Boost operates in light load, blocking FET operates in linear mode, and the battery will be charged through the body diode of HS FET. The charging current is 6% of ICC.

Trickle charging mode: When VBAT reaches VTC, Boost operates at light load, adjusts VOUT to 12.3V, and blocks FET operation in linear mode. The charging current is 12% of ICC.

Constant current charging mode: When VBAT is higher than the constant current charging activation threshold VCC, the blocking field-effect transistor is fully conductive, Boost operates in constant current mode, and the charging current is ICC.

Constant voltage charging mode: When VBAT approaches the regulated voltage, the charging current begins to decrease. When the current drops to 1/10 ICC, turn off the charging mode. The charging cycle is completed.

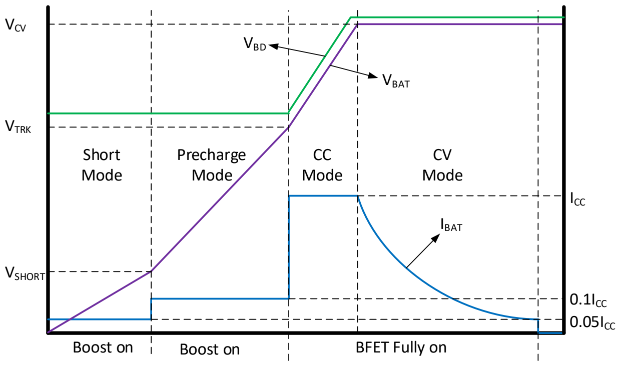


Figure 7. Battery Charging Cycle

Adaptive Input Current Limiting (V_{HOLD})

Adaptive input current limit setting function, VHOLD pin connects a resistive voltage divider network between VIN and GND to configure the minimum VIN limit threshold for input current limiting. LGS5524 has a VIN input voltage stabilization loop. When the VHOLD pin is detected to be less than 1V, the chip will automatically adjust and reduce the charging current to ensure that the input voltage is stable near the set input threshold and adapts to the load capacity of the adapter.

Constant Current Charging Current Setting (I_{SET})

The charging current of the LGS5524 can be set by connecting a resistor between the ISET pin and ground. The resistor value is determined based on the required charging current. The charging current can be estimated by measuring the voltage at this pin in all charging modes. The Viser voltage is fixed at 1V during constant current charging.

Formula:

$$I_{BAT} = (V_{ICHG}/R_{ICHG}) \times 1000$$。

R_{ISET}	ISC	IPRE	ICC	ITERM
2K	30mA	60mA	500mA	60mA
1K	60mA	120mA	1000mA	120mA

Charging Status Indicator (LED)

The LED pin is connected to an LED with a current-limiting resistor R LED to VCC high level.

1.During charging: The LED pin pulls low and remains low, LED stays on.

2.When charging is complete: The LED pin pulls high and remains high, LED turns off.

3.Fault mode: The LED pin alternates between high and low levels at 1Hz, LED blinks.

Charging Status	LED	Single LED
Charging	Low	On
Charging Complete	High	Off
Input Current Limit Protection	Blinking at 6Hz	6Hz Blink
Battery Overheating Battery Under temperature Charging Timeout Protection Input Overvoltage Protection Battery Overvoltage Protection Chip Overheating Protection	Blinking at 1Hz	1Hz Blink

Typical Application Characteristics

***Figure 10.1 USB 5V** Input charging process and efficiency*

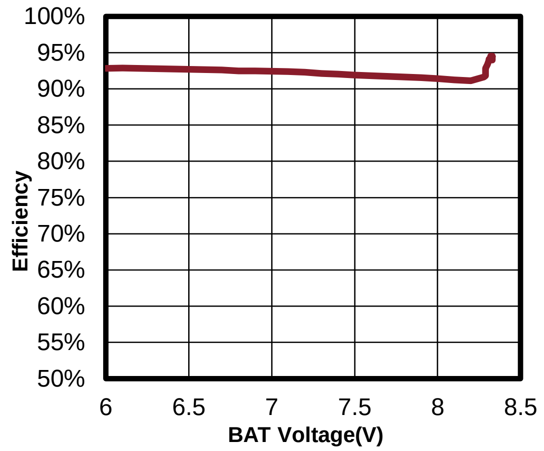


Figure 10.1.a R_{ISET}=1K, Efficiency of constant current and constant voltage charging stages

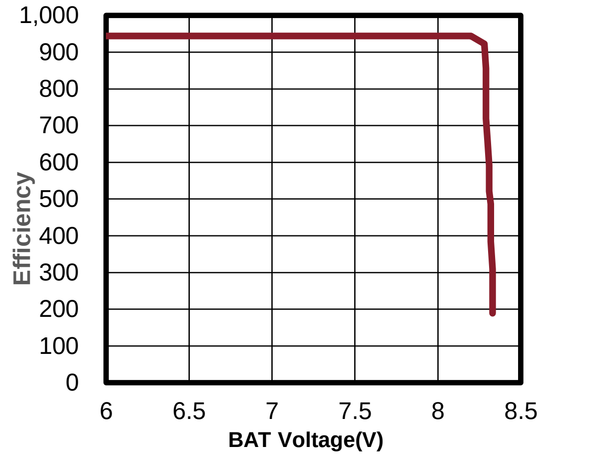


Figure 10.1.a R_{ISET}=1K, Constant current and constant voltage charging current

Figure 11.1 Charging Switch Waveforms at Different Stages

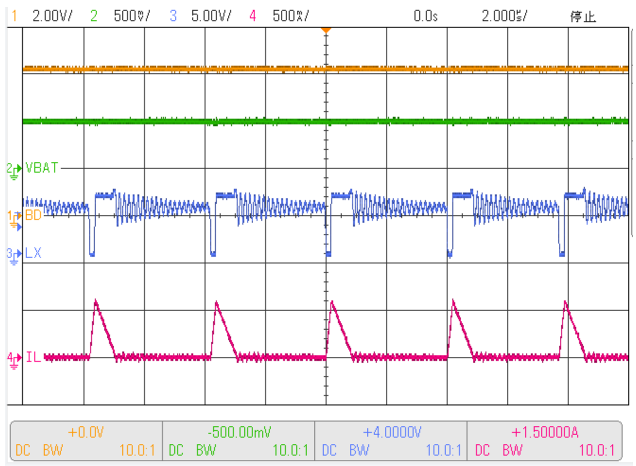


Figure 11.1. a Short Circuit Charge (SC) VBAT=0.5V

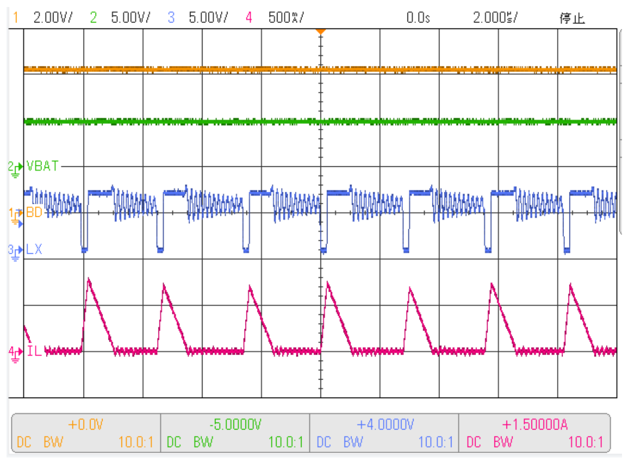


Figure 11.1. b Trickle Charge (TC) VBAT=5V

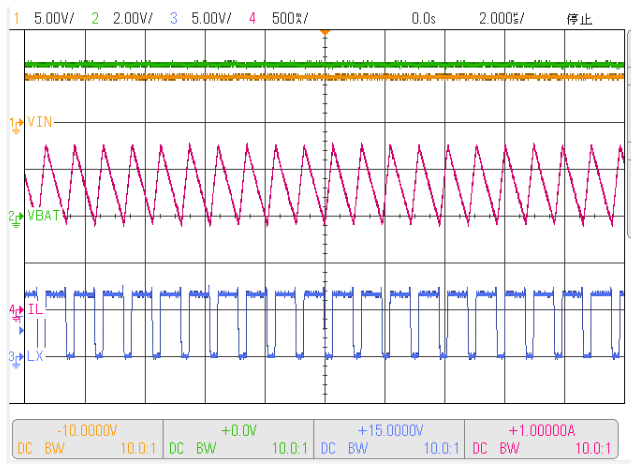


Figure 11.1. c Constant Current Charge (CC) VBAT=8V

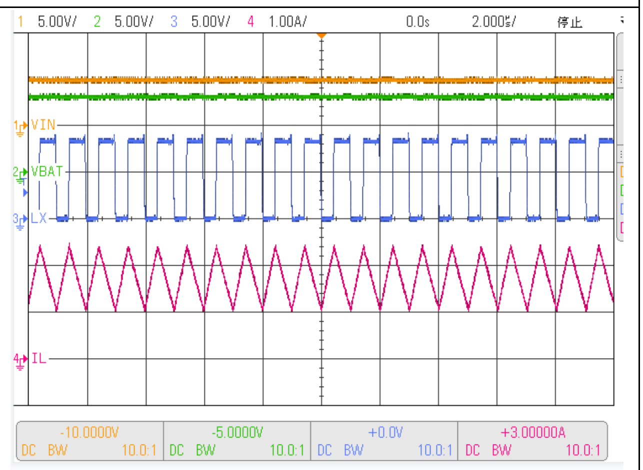


Figure 11.1. d Constant Voltage Charge (CV) VBAT=8.3V

Device Recommendations

Bootstrap Capacitor CBST

The BST pin of the LGS5524 is the bootstrap gate drive pin, providing the gate drive for the rectifier FET. A 0.1μF ceramic capacitor is connected to SW. CBST is recommended to use a 0.1μF capacitor with a voltage rating above 10~16V.

Input Capacitor CVIN

The LGS5524 requires a decoupling capacitor to filter noise interference at the input. The typical recommended value for the decoupling capacitor is 10μF, and the rated voltage must be greater than the maximum input voltage required by the IC, preferably twice the maximum input voltage. Increasing this capacitor can reduce input voltage ripple and maintain input voltage stability during load transients. A 10μF or larger X5R or X7R ceramic capacitor is recommended.

Boost Output Capacitor CVOUT

Select the output capacitor to handle output ripple noise requirements. The ripple voltage is related to the capacitor and its equivalent series resistance (ESR). For best performance, it is recommended to use X5R or better low ESR ceramic capacitors. The output capacitor's rated voltage should be higher than the maximum output voltage. A capacitor larger than 10uF is recommended and should be placed close to the pin.

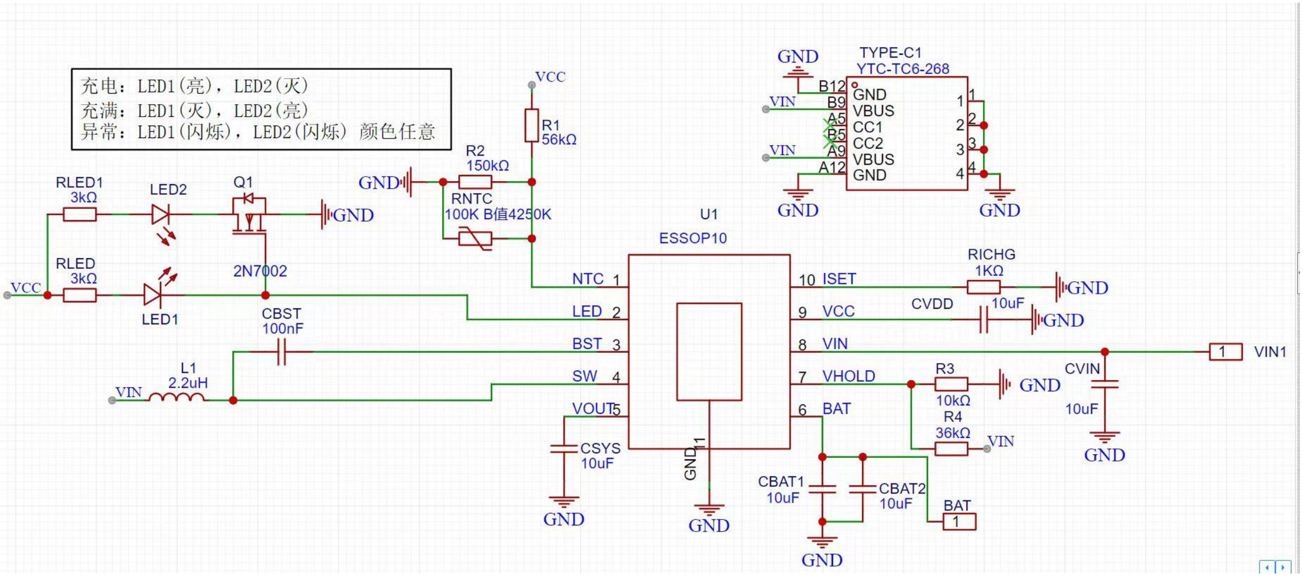
BAT Decoupling Capacitor CBAT

Select the output capacitor to handle output ripple noise requirements. The ripple voltage is related to the capacitor and its equivalent series resistance (ESR). For best performance, it is recommended to use X5R or better low ESR ceramic capacitors. The output capacitor's rated voltage should be higher than the maximum output voltage.

The VRIPPLE is the peak-to-peak output ripple, and ICC is the set charging current.

A capacitor larger than 20uF is recommended and should be placed close to the pin.

Typical Application Circuit (Dual Lamp)

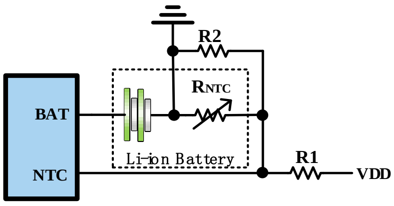


NTC Component Selection

NTC Resistor

To prevent damage to the battery due to excessive temperature, the LGS5524 monitors the battery temperature by measuring the NTC voltage. When the rate K (K=Vnrc/VCC) reaches the UTP (Kut) or OTP (Kot) threshold, the controller triggers UTP or OTP. If the voltage at the NTC pin is less than 25% or greater than 65% of the VCC voltage, it means the battery temperature is too low or too high, and charging is suspended. The temperature sensing network is shown below.

Select R2 and R1 to program the appropriate UTP and OTP temperature threshold points.



1. Calculation steps:

   1、Define KUT, KUT=62%~68%, typical value 65%

   2、Define KOT, KOT=22%~27%, typical value 25%

   3、Assume the battery NTC thermistor is RUT at the UTP threshold and ROT at the OTP threshold.

1. 4、Calculate R1

$$R_1 = \frac{R_{OT}R_{UT}(K_{UT} - K_{OT})}{(R_{UT} - R_{OT})K_{UT}K_{OT}}$$

5. 5、Calculate R2

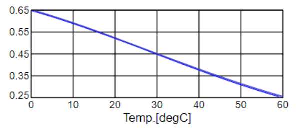
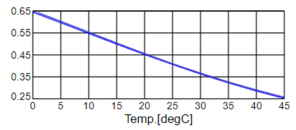
$$R_2 = \frac{R_{OT}R_{UT}(K_{UT} - K_{OT})}{R_{OT}(K_{OT} - K_{OT}K_{UT}) - R_{UT}(K_{UT} - K_{OT}K_{UT})}$$

If the typical values KUT=65% and KOT=25% are selected, then:

$$R_1 = \frac{2.46R_{OT}R_{UT}}{R_{UT} - R_{OT}}$$

$$R_2 = \frac{0.4R_{UT}R_{OT}}{0.0875R_{UT} - 0.4875R_{OT}}$$

We selected a commonly available 100K NTC resistor with a B value of 4250K. The calculated R1 and R2 for battery temperature charging between 0°C~60°C are R1=56K and R2=150K.

Temperature	R_{NTC}	**Resistor B Value**	R1	R2	**Model**
0℃~60℃	10K，1% accuracy	3380K	8.2K	36K	
0℃~60℃	100K，1% accuracy	4250K	56K	150K	
-10℃~60℃	10K，1% accuracy	3380K	7.87K	22K	
0℃~45℃	10K，1% accuracy	3380K	14.3K	820K	
0℃~45℃	100K，1% accuracy	4250K	110K	470K	
0℃~45℃	10K，1% accuracy	3380K	15K	NC	

Reference PCB Layout

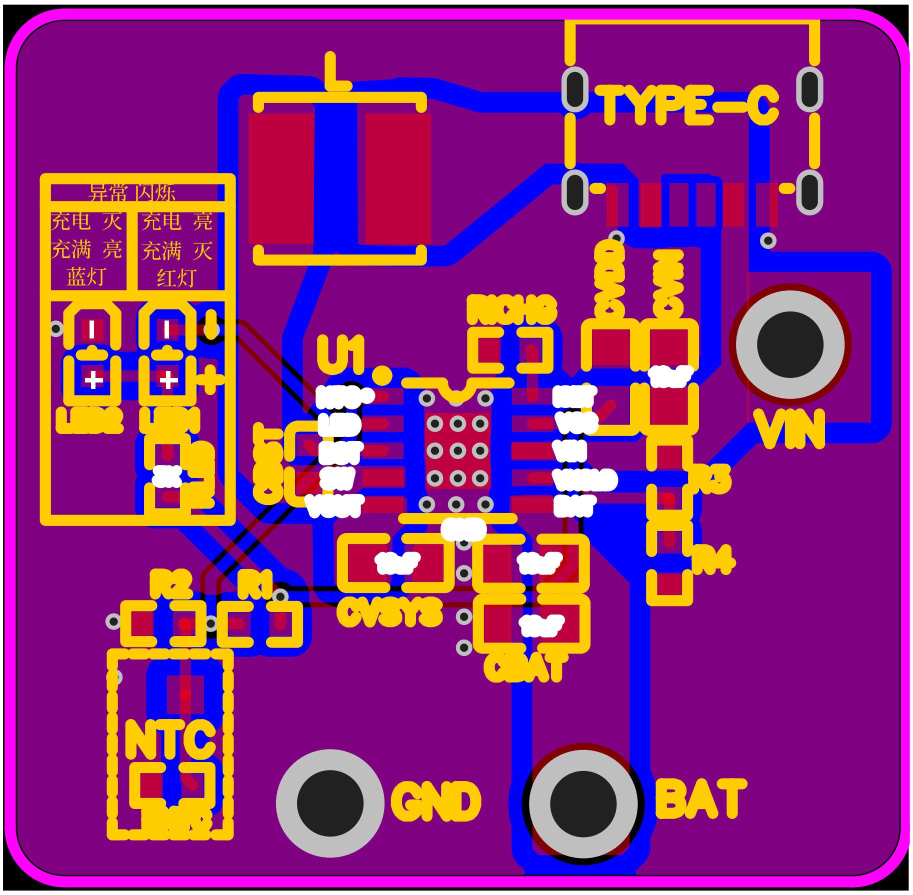
Overview

The layout design of the LGS5524 boost lithium-ion battery charger is relatively simple. To achieve the best efficiency and minimize noise issues, the following components should be placed close to the IC: CSVIN, L, CVOUT (CVOUT capacitor must be placed closest to the pin with the highest priority).

- The power loop must be as short as possible.
- The output loop C_{VOUT} capacitor should be close to the VOUT and PGND pins of the chip.
- The C_{BST} capacitor is the bootstrap capacitor and should be close to the BST pin of the chip.
- The C_{BAT} capacitor should be as close as possible to the BAT and PGND pins of the chip.
- The NTC should be kept away from the SW signal to reduce noise interference.
- For high-current paths, larger PCB copper areas should be used, including SW, PGND pins, and the bottom thermal pad. This helps minimize PCB conduction losses and thermal stress.
- To minimize via conduction losses and reduce module thermal stress, multiple vias should be used to interconnect the top layer with other power or ground layers (opening vias

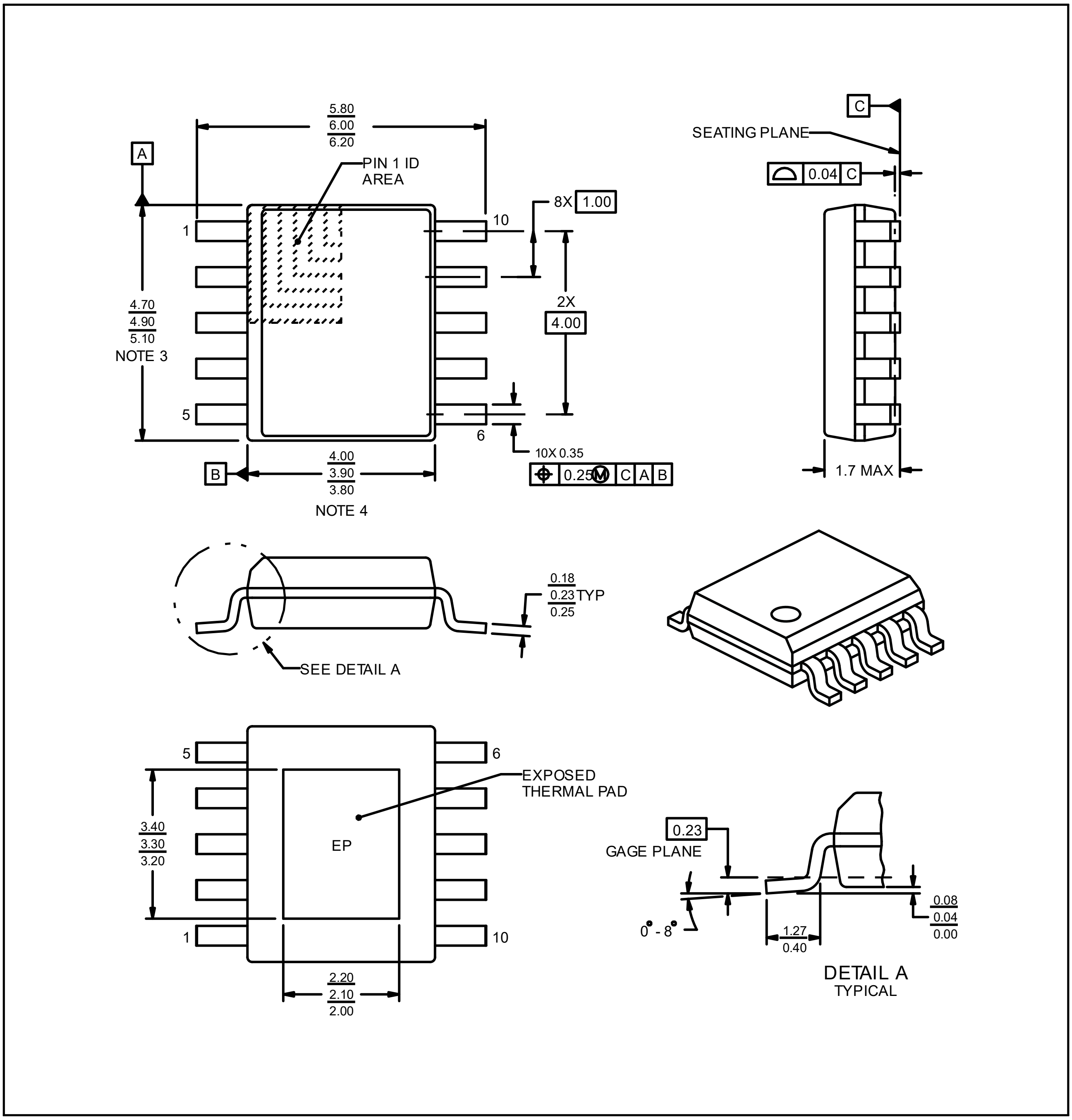
on the bottom pad of the chip helps improve thermal performance).

- RNTC is a thermistor used to detect battery temperature, usually located inside the battery. If placed on the PCB, it is recommended to keep it away from the chip and inductor to avoid heat interference.
- The VOUT capacitor must be placed as close as possible to the chip, and the capacitor can be placed above or below the VOUT and GND pins.



Package Outline Description (ESSOP10)

10-Pin Plastic SOIC with Bottom ePad

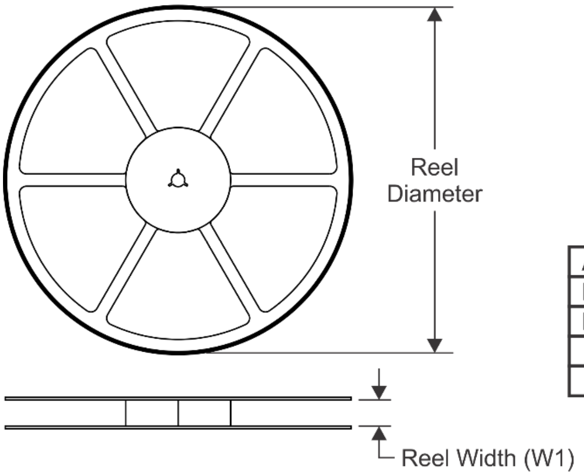


Note:

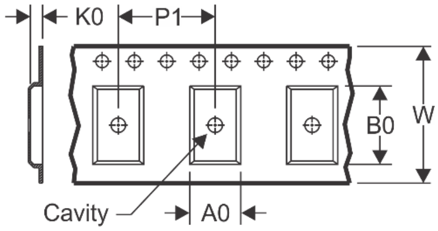
- All dimensions are in millimeters, and any dimensions in parentheses are for reference only.
- This drawing is subject to change without notice.
- This dimension does not include mold flash, protrusions, or gate burrs.

Packaging Information

REEL DIMENSIONS

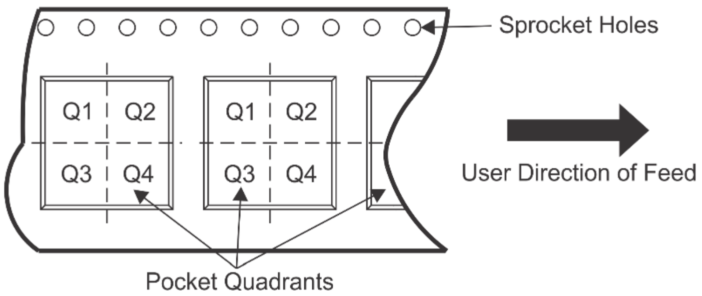


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

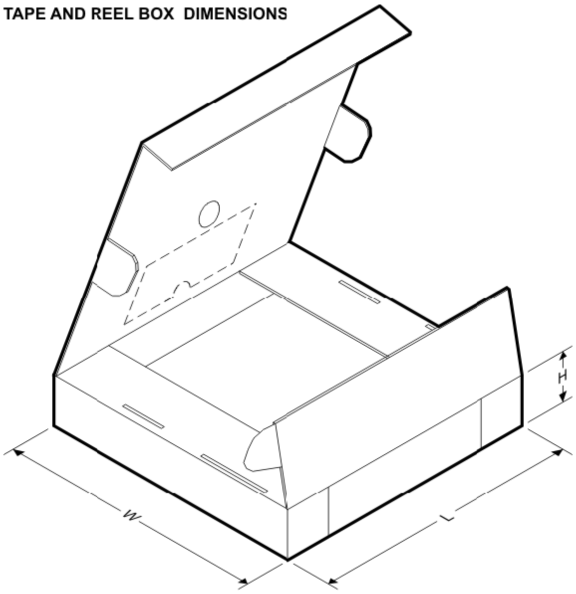
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*ALL dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1(mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LGS5524ES	ESSOP10	ES	10	4000	330	12.4	6.4	5.2	2.1	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



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Revision History (1) (†)

Rev.D V1.0	Page Number
※ D version. This manual describes and acknowledges the parameters related to the D version.	ALL
Rev.D V1.1	**Page Number**
※ **D version. Added dual LED typical application circuit (Page 10).**	**ALL**

† NOTE: Page numbers in previous versions may differ from those in the current version.