DIO5841J

1 A, Single-Input, Single Cell Li-Ion and Li-Pol Battery Charger with Auto-Start

Features

- Input rating of 24 V
- Input overvoltage protection with 6.7 V
- Charge voltage accuracy: 1%
- Charge current accuracy: 10%
- Pin ISET2 can select 100 mA or 450 mA as the maximum input current limit
- Programmable termination and trickle threshold
- Fixed 10-hour safety timer
- Status indication – charging or completion
- Integrated auto-start function for production
- 125°C thermal regulation
- 155°C thermal shutdown protection
- Battery short-circuit protection
- Charge solutions for JEITA
  - ○ No charge at Temp > 55°C and Temp < 0°C
  - ○ 0.5 × CC (constant-current) at Temp = 0°C ~ 10°C;
  - ○ Constant-Current at Temp = 10°C ~ 45°C
  - ○ 1.0 × CC and battery voltage = V_{BAT} - 0.1 at Temp = 45°C ~ 55°C
- Automatic termination and timer disable mode (TTDM) for absent battery pack with thermistor
- Package: DFN2*2-10

Applications

- Low-power handheld devices
- Smartphones
- MP3 players
- PDAs

Descriptions

The DIO5841J is a highly integrated lithium-ion (Li-Ion) and lithium-polymer (Li-Pol) linear charger, suitable for portable applications with limited space. A USB port or AC adapter powers the device. The high input voltage range with input overvoltage protection supports low-cost, unregulated adapters.

The DIO5841J has a single power output and can charge batteries. If the average system load fails to charge the battery during the 10-hour safety timer, the system load can be connected in parallel with the battery.

The device has three stages for charging a Li-Ion battery: regulation, constant current, and constant voltage. In all charging stages, the IC junction temperature is monitored by the internal control loop. When the charging current exceeds the internal temperature threshold, the internal control loop will reduce the charging current.

The charger power level and charging current induction function are fully integrated. The charger has a high-precision current and voltage regulation circuit function, charging status display, and charging termination function. Trickle-charge current and terminal current threshold can be programmed by an external resistance on the DIO5841J. The value of constant current can also be programmed by an external resistance.

Ordering Information

Part Number	Top Marking	RoHS	T_A	Package	
DIO5841JCN10	EH4J	Green	-40 to 85°C	DFN2*2-10	Tape & Reel, 3000

Pin Assignment

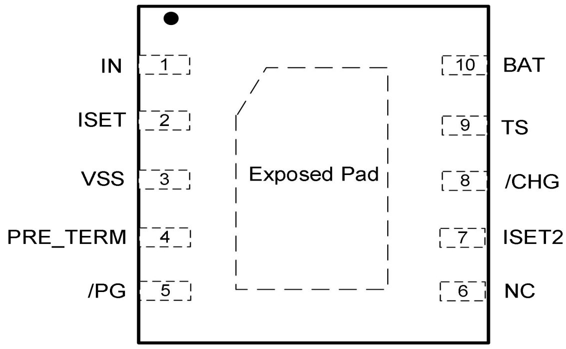


Figure 1. Top View

Pin Descriptions

Name	Description
IN	Input power. Connected to external DC supply (AC adapter or USB port). Expected range of bypass capacitors connected from IN to VSS: 4.7 ~ 10 μF.
ISET	Programs the constant charge current setting. External resistor from ISET to VSS defines constant charge current value. Range is 9 kΩ (50 mA) to 0.45 kΩ (1000 mA).
ISET2	Programs the Input/Output current limit for the USB or adapter source: High = 450 mA max; Low = ISET; Float = 100 mA max.
VSS	Ground.
PRE_TERM	Programs the current termination threshold (5% to 40% of IBAT, which is set by ISET) and sets the trickle current to double the termination current level. Expected range of programming resistor is 1 kΩ to 5.1 kΩ.
/PG	Low (FET on) indicates the input voltage is above UVLO and the BAT (battery) voltage.
NC	No connection.
/CHG	Low (FET on) indicates charging and open-drain (FET off) indicates no charging or charging completed.
TS	Temperature sense terminal connected to the DIO5841J -10 kΩ at 25°C NTC thermistor, in the battery pack. Floating terminal or pulling high puts the part in termination and timer disable mode (TTDM) charger mode and disables TS monitoring, timers, and termination. Pulling terminal low disables the IC. If the NTC sensing is not needed, connect this terminal to VSS through an external 10 kΩ resistor. A 250 kΩ from TS to ground will prevent the IC from entering TTDM mode when the battery with a thermistor is removed.
BAT	Battery connection. System load may be connected. Expected range of bypass capacitors: 1 μF to 10 μF.
Exposed pad	The exposed thermal pad and the VSS terminal are internally connected. The thermal pad must be connected to the same potential as the VSS terminal on the printed circuit board. Do not use the thermal pad as the primary ground input for the device.

Absolute Maximum Ratings

Stresses beyond those listed under the Absolute Maximum Rating table may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Symbol	Parameter		Rating	Unit
V_{IN}	Input voltage	IN (with respect to VSS)	-0.3 to 36	V
		BAT (with respect to VSS)	-0.3 to 7	
		PRE_TERM, ISET, ISET2, TS, /CHG, /PG (with respect to VSS)	-0.3 to 7	
I_{IN}	Input current		1.25	A
BAT	Output current (continuous)		1.25	A
/CHG	Output sink current		15	mA
T_J	Junction temperature		-40 to 150	°C
T_{STG}	Storage temperature		-65 to 150	°C
$R_{\theta JA}$	Junction-to-ambient thermal resistance		63.5	°C/W
ESD	Electrostatic discharge	Human-body model (HBM)	±6000	V

Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. DIOO does not recommend exceeding them or designing to absolute maximum ratings.

Symbol	Parameter	Min	Max	Unit
V_{IN}	IN voltage range	3.5	24	V
	IN operating voltage range, restricted by and V_{OVP}	4.45	6.25	V
I_{IN}	Input current, IN terminal		1	A
I_{BAT}	Current, BAT terminal		1	A
T_J	Junction temperature	0	125	°C
R_{PRE_TERM}	Programs trickle charge and termination current thresholds	1	5.1	kΩ
R_{ISET}	Constant charge current programming resistor	0.45	20	kΩ
R_{TS}	10 kΩ NTC thermistor range without entering TTDM	1.66	500	kΩ

Electrical Characteristics

Over junction temperature range 0°C ≤ T_J ≤ 125°C and recommended supply voltage (unless otherwise noted).

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Input						
UVLO	Undervoltage lockout exit	V_{IN} from low to high	3.2	3.4	3.6	V
V_{HYS_UVLO}	Hysteresis			180		mV
V_{IN_DT}	Input power good detection threshold is V_{BAT} plus V_{IN_DT}	(Input power good if V_{IN} > V_{BAT} + V_{IN-DT}); V_{BAT} = 3.6 V, V_{IN} from 3.5 V to 4 V		120		mV
$V_{HYS-INDT}$	Hysteresis on V_{IN-DT} falling			80		mV
V_{OVP}	Input overvoltage protection threshold	V_{IN} from 5 V to 12 V	6.4	6.7	6.9	V
$V_{HYS-OVP}$	Hysteresis on OVP	V_{IN} from 12 V to 5 V		200		mV
$I_{IN-USB-CL}$	USB input I-limit 100 mA	ISET2 = Float; R_{ISET} =1 kΩ	75	90	105	mA
	USB input I-limit 450 mA	ISET2 = High; R_{ISET} =1 kΩ	400	445	490	
Battery short protection						
$V_{BAT(SC)}$	BAT terminal short-circuit detection threshold / trickle charge threshold	V_{BAT} from 3 V to 0.5 V, no deglitch	0.75	0.8	0.85	V
$V_{BAT(SC-HYS)}$	BAT terminal short hysteresis	Recovery ≥ $V_{BAT(SC)}$ + $V_{BAT(SC-HYS)}$; rising, no deglitch		20		mV
$I_{BAT(SC)}$	Source current to BAT terminal during short-circuit detection			10		mA
Quiescent current						
$I_{BAT(PDWN)}$	Battery current into BAT terminal	V_{IN} = 0 V			1	μA
$I_{BAT(DONE)}$	BAT terminal current, charging terminated	V_{IN} = 6 V, V_{BAT} > $V_{BAT(REG)}$			1	
$I_{IN(STDBY)}$	Standby current into IN terminal	TS = Low, V_{IN} ≤ 6 V			125	μA
I_{CC}	Active supply current, IN terminal	TS = Open, V_{IN} = 6 V, T_{TDM} – no load on the BAT terminal; V_{BAT} > $V_{BAT(REG)}$; IC enabled		0.4	0.5	mA

Battery charger constant-charge						
$V_{BAT(REG)}$	Battery regulation voltage	V_{IN} = 5 V, ($V_{TS\text{-}45°C} \le V_{TS} \le V_{TS\text{-}0°C}$)	4.31	4.35	4.38	V
$V_{O\_HT(REG)}$	Battery hot regulation Voltage	V_{IN} = 5 V, ($V_{TS\text{-}55°C} \le V_{TS} \le V_{TS\text{-}45°C}$)		4.25		V
$I_{BAT\_(RANGE)}$	Programmed output "constant charge" current	$V_{BAT(REG)} > V_{BAT} > V_{LOWV}$; V_{IN} = 5 V, ISET2 = Low, R_{ISET} = 9 kΩ to 0.45 kΩ	50		1000	mA
I_{BAT}	Output constant current formula	$V_{BAT(REG)} > V_{BAT} > V_{LOWV}$; V_{IN} = 5 V, ISET2 = Low	(1V/R_{ISET}) × 450			A
		$V_{BAT(REG)} > V_{BAT} > V_{LOWV}$; V_{IN} = 5 V, ISET1=1.875 kΩ ISET2 = Low	216	240	264	mA
		$V_{BAT(REG)} > V_{BAT} > V_{LOWV}$; V_{IN} = 5 V, ISET1 = 900 Ω ISET2 = Low	450	500	550	mA
Trickle current – set by pre_term terminal						
V_{LOWV}	Trickle current to constant current charge transition threshold		2.4	2.5	2.6	V
$I_{Trickle}$	Trickle current, default setting	$V_{BAT} < V_{LOWV}$; R_{ISET} = 1 kΩ; R_{PRE_TERM} = High Z	18	24	28	%$I_{BAT\text{-}CC}$
	Trickle current, formula		I_{BAT} × 100 u × R_{PRE_TERM} / 1			mA
$I_{Trickle\_acc}$	Trickle current accuracy	V_{CC} = 5 V, T = 25°C, R_{ISET} = 1.13 kΩ, R_{PRE_TERM} = 1 kΩ	30	40	50	mA
Termination – set by PRE_TERM terminal						
Terminal	Termination threshold current, default setting	$V_{BAT} > V_{RCH}$; R_{ISET} = 1 kΩ; R_{PRE_TERM} = High Z	9	12	14	%$I_{BAT\text{-}CC}$
	Termination current threshold formula	I_{TERM} > 70 mA	(I_{BAT} × 50 u × R_{PRE_TERM} / 1) +10			mA
		$I_{TERM} \le$ 70 mA	I_{BAT} × 50 u × R_{PRE_TERM} / 1			mA
I_{PRE_TERM}	Current for programming the term and trickle with resistor. $I_{Term\text{-}Start}$ is the initial PRE_TERM current	R_{PRE_TERM} = 2 kΩ, V_{BAT} = 4.15 V	45	50	55	μA

I_{terper}	Termination current accuracy	V_{CC} = 5 V, T = 25°C, R_{ISET} = 1.13 kΩ, R_{PRE_TERM} = 1 kΩ	15	20	25	mA
Recharge or refresh						
V_{RCH}	Recharge detection threshold – Normal Temp	V_{IN} = 5 V, V_{TS} = 0.5 V, V_{BAT} from 4.25 V to V_{RCH}	$V_{O(REG)}$ -0.2	$V_{O(REG)}$ -0.15	$V_{O(REG)}$ -0.1	V
	Recharge detection threshold – Hot Temp	V_{IN} = 5 V, 45°C < Temp < 55°C, V_{BAT} from 4.15 V to V_{RCH}	$V_{O\_HT(REG)}$ -0.2	$V_{O\_HT(REG)}$ -0.15	$V_{O\_HT(REG)}$ -0.1	V
Battery-pack NTC monitor; TS terminal						
$I_{NTC-10k}$	NTC bias current	V_{TS} = 0.3 V	48	50	52	μA
$V_{TTDM(TS)}$	Termination and timer disable mode threshold – enter	V_{TS} from 1.5 V to 4 V; timer held in reset	3.6	3.7	3.8	V
$V_{HYS-TTDM(TS)}$	Hysteresis			100		mV
$V_{CLAMP(TS)}$	TS maximum voltage clamp	V_{TS} = Open (float)		V_{IN}		V
$V_{TS-0°C}$	Low temperature CHG Pending	Low temp charging to pending; V_{TS} from 1 V to 1.5 V			1.384	V
$V_{HYS-0°C}$	Hysteresis at 0°C	Charge pending to low temperature charging; V_{TS} from 1.5 V to 1 V		60		mV
$V_{TS-10°C}$	Low temperature, half charge	Normal charging to low temperature charging; V_{TS} from 0.5 V to 1 V		920		mV
$V_{HYS-10°C}$	Hysteresis at 10°C	Low temperature charging to normal CHG; V_{TS} from 1 V to 0.5 V		20		mV
$V_{TS-45°C}$	High temperature at 4.1 V	Normal charging to high temperature CHG; V_{TS} from 0.5 V to 0.2 V		242.6		mV
$V_{HYS-45°C}$	Hysteresis at 45°C	High temperature charging to normal CHG; V_{TS} from 0.2 V to 0.5 V		10		mV
$V_{TS-55°C}$	High temperature disable	High temperature charge to pending; V_{TS} from 0.2 V to 0.1 V	175			mV
$V_{HYS-55°C}$	Hysteresis at 55°C	Charge pending to high temperature CHG; V_{TS} from 0.1 V to 0.2 V		10		mV
$V_{TS-EN-10k}$	Charge enable threshold, (10 kΩ NTC)	V_{TS} from 0 V to 0.175 V		100		mV

$V_{TS\text{-}DIS\_HYS\text{-}10k}$	HYS below $V_{TS\text{-}EN\text{-}10k}$ to disable, (10 kΩ NTC)	V_{TS} from 0.125 V to 0 V		12		mV
Thermal regulation						
$T_{J(REG)}$	Temperature regulation limit			135		°C
$T_{J(OFF)}$	Thermal shutdown temperature			155		°C
$T_{J(OFF\text{-}HYS)}$	Thermal shutdown hysteresis			20		°C
Logic levels on ISET2						
V_{IL}	Logic low input voltage	Sink 0.5 μA			0.5	V
V_{IH}	Logic high input voltage	Source 0.9 μA	2.5			V
I_{IL}	Sink current required for LO	V_{ISET2} = 0.5 V		0.5		μA
I_{IH}	Source current required for HI	V_{ISET2} = 2.5 V		0.9		μA
V_{FLT}	ISET2 float voltage		1.1	1.5	1.9	V
Logic levels ON /CHG AND /PG						
V_{OL}	Output low voltage	I_{SINK} = 5 mA			0.4	V
I_{LEAK}	Leakage current into IC	$V_{/CHG}$ = 5 V, $V_{/PG}$ = 5 V			1	μA
Input						
$t_{DGL(PG\_PWR)}$	Deglitch time on exiting sleep	Time measured from V_{IN}: 0 V → 5 V 1 μs rise-time to /PG = Low, V_{BAT} = 3.6 V		0.5		ms
$t_{DGL(OVP\text{-}SET)}$	Input over-voltage blanking time	V_{IN}: 5 V → 12 V		5		μs
$t_{DGL(OVP\text{-}REC)}$	Deglitch time exiting OVP	Time measured from V_{IN}: 12 V → 5 V 1 μs fall-time to /PG = Low		100		μs
Trickle charge – set by PRE_TERM pin						
$t_{DGL1(LOWV)}$	Deglitch time on trickle current to constant current transition			70		μs
$t_{DGL2(LOWV)}$	Deglitch time on constant current to trickle current transition			32		ms
$t_{DGL(TERM)}$	Deglitch time, termination detected			30		ms
Recharge or refresh						
$t_{DGL1(RCH)}$	Deglitch time, recharge threshold detected	V_{IN} = 5 V, V_{TS} = 0.5 V, V_{BAT} from 4.25 V to 3.5 V in 1 μs; $t_{DGL(RCH)}$ is time		29		ms

		to ISET ramp				
$t_{DGL2(RCH)}$	Deglitch time, recharge threshold detected in BAT-detect mode	V_{IN} = 5 V, V_{TS} = 0.5 V, V_{BAT} = 3.5 V inserted; $t_{DGL(RCH)}$ is time to ISET ramp		150		us
Battery charging timers and fault timers						
$T_{TRICKLE\text{-}CHG}$	Trickle safety timer value	Restarts when entering trickle charge; always enabled when in trickle charge.	1700	1940	2250	s
t_{MAXCH}	Charge safety timer value	Clears fault or resets at UVLO, TS disable, BAT short, exiting LOWV and refresh	34000	38800	45000	s
Battery-pack NTC monitor; TS terminal						
$t_{DGL(TTDM)}$	Deglitch exit TTDM between states			57		ms
	Deglitch enter TTDM between states			400		μs
$t_{DGL(TS\_10°C)}$	Deglitch for TS thresholds: 10°C.	Normal to cold operation; V_{TS} from 0.6 V to 1 V		50		ms
		Cold to normal operation; V_{TS} from 1 V to 0.6 V		20		ms
$t_{DGL(TS)}$	Deglitch for TS thresholds: 0/45/55°C.	Battery charging		30		ms

Specifications subject to change without notice.

Feature Description

Overview

The DIO5841J is an integrated 1 A linear charger for one-cell Li-Ion, Li-Polymer, targeted at space-limited portable applications. The device is powered by a USB port or AC adapter. High input-voltage range with input overvoltage protection supports low-cost unregulated adapter. The charger is designed for a single power path from the input to the output to charge a single cell Li-Ion or Li-Pol battery pack. Upon the application of a 5 V DC power source, the ISET and BAT short checks are performed to assure a proper charge cycle.

The charger has three phases of charging, shifting the charging mode between the trickle charging, constant current charging and constant voltage charging mode. The charger also comes with a full set of safety features: JEITA temperature standard, overvoltage protection, and safety timers. All of these features and more are described in the following details.

If the battery voltage is below the LOWV threshold, the battery is discharged and a preconditioning cycle begins. The amount of trickle current can be programmed by using the PRE_TERM terminal which programs a certain percentage of constant charge current (5% to 40%) as the trickle current. This feature is useful when the system load connected to the battery steals the battery current. The trickle current can be set higher to account for the system loading while allowing the battery to be properly conditioned. The PRE_TERM terminal is a dual function terminal which sets the trickle current level and the termination threshold level. The termination current threshold is always half of the programmed trickle current level.

As soon as the battery voltage has charged to the V_{LOWV} threshold, a constant current charge is applied. The constant current is programmed by using the ISET terminal. The constant current provides the bulk of the charge. Power dissipation in the IC is greatest in constant charge with a lower battery voltage. If the IC reaches 125°C the IC enters thermal regulation, slows the timer clock by half, and reduces the charge current as needed to keep the temperature from rising any further.

As soon as the cell has charged to the regulation voltage, the voltage loop takes control and holds the battery at the regulation voltage until the current decreases to the termination threshold. The termination can be disabled if desired. The /CHG terminal is low during the charge cycle only and turns off as soon as the termination threshold is reached, regardless if termination, for charge current, is enabled or disabled.

Power-Down or Undervoltage Lockout (UVLO)

An internal undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the undervoltage lockout threshold. The UVLO circuit has a built-in hysteresis of 180 mV. The DIO5841J is in power-down mode if the IN terminal voltage is less than UVLO. The part is considered "dead" and all the terminals are high impedance.

Overvoltage Protection (OVP) – Continuously Monitored

Additionally, an overvoltage protection (OVP) circuit is implemented that shuts off the internal LDO and discontinues charging when V_{IN} is larger than V_{OVP} for a period longer than $t_{DGL(OVP)}$. As soon as the OVP condition is removed, a new power on sequence starts. The safety timers are reset and a new charge cycle will be indicated by the CHG output.

Power-up

When the input voltage at IN is within the valid range: VIN > UVLO, all internal timers and other circuit blocks are reset. The device then checks for short-circuits at the ISET pin. If no short-circuit conditions exist, the device starts charging properly. Sets the input current limit threshold base on the ISET2 terminal, starts the safety timer and enables the /CHG terminal.

Sleep Mode

If the IN terminal voltage is between (V_{BAT} + V_{DT}) and UVLO, the charge current is disabled, the safety timer counting stops (not reset) and the /PG and /CHG terminals are high impedance. As the input voltage rises and the charger exits sleep mode, the /PG terminal goes low, the safety timer continues to count, the charge is enabled and the /CHG terminal returns to its previous state.

Power Good Indication (/PG)

The /PG pin is an internal open-drain FET output that becomes highly resistant when UVLO or OVP occurs in VIN and temperature sense is disabled. The rest are low-resistivity output path to ground.

/CHG Terminal Indication

The charge terminal has an internal open-drain FET which is on (pulls down to VSS) during the charge only (independent of TTDM) and is turned off as soon as the battery reaches voltage regulation and the charge current decreases to the termination threshold set by the PRE_TERM resistor. The charge terminal is high impedance in sleep mode.

The /CHG terminal is reset when input power cycles, the TS terminal is pulled low or the part enters trickle charge mode cause. The pin goes low if power is good and a discharged battery is attached. The charging starts when the /CHG terminal is reset.

/PG and /CHG LED Pull-up Source

For host monitoring, a pull-up resistor is used between the STATUS terminal and the VCC of the host and for a visual indication a resistor in series with an LED is connected between the STATUS terminal and a power source. The /CHG or /PG source is capable of exceeding 8 V. If the source is the BAT terminal, note that as the battery changes voltage, the brightness of the LEDs varies.

Charging State	/CHG FET/LED
Charge after V_{IN} applied	ON
Refresh charge	
OVP	OFF
SLEEP	
V_{IN} Power Good State	**/PG FET/LED**
UVLO	OFF
SLEEP mode	
OVP mode	
TS_disable	
Normal input (V_{BAT} + V_{DT} < V_{IN} < V_{OUP})	ON

New Charge Cycle

A new charge cycle is started when a good power source is applied and when performing a chip disable/enable (TS terminal), exiting termination and timer disable mode (TTDM), or the BAT voltage drop terminal below the V_{RCH} threshold. The /CHG terminal is active low only during the charge cycle, therefore exiting TTDM or a drop terminal below V_{RCH} will not turn on the /CHG terminal FET if the /CHG terminal is already high impedance.

BAT

The charger's BAT terminal provides current to the battery and to the system, if present. This IC can be used to charge the battery plus power the system, or charge just the battery or just power the system (TTDM) assuming the loads do not exceed the available current. The BAT terminal is a current limited source and is inherently protected against shorts. If the system load ever exceeds the output programmed current threshold, the output will be discharged unless there is sufficient capacitance or a charged battery present to supplement the excessive load.

ISET

An external resistor is used to program the output current (50 to 1000 mA) and can be used as a current monitor.

$$I_{BAT} = (1\ V/R_{ISET}) \times 450 \qquad (1)$$

where:

- I_{BAT} is the desired constant charge current.

ISET2

A low state will program a regulated constant charge current via the ISET resistor and the maximum allowed input/output current for any ISET2 setting. Leaving the pin float will program a 100 mA current limit. A high state will program a 500 mA current limit.

PRE_TERM – Trickle Charge and Termination Programmable Threshold

PRE_TERM is used to program both the trickle charge current and the termination current threshold. The trickle charge current level is a factor of two higher than the termination current level. The termination can be set between 5% and 50% of the programmed output current level set by ISET. Only charging cut-off is supported when 10 mA ≤ I_{TERM} < 20 mA. If the pin is left floating, the termination and trickle are set internally at 10% and 20% respectively. The trickle-charge-to-constant-charge, V_{LOWV} threshold is set to 2.5 V.

$$I_{Trickle} = (100\ uA \times R_{PRE\_TERM}/1) \times I_{BAT} \qquad (2)$$

$$I_{TERM} = (50\ uA \times R_{PRE\_TERM}/1) \times I_{BAT} + 10\ mA^{(1)} \qquad (3)$$

where:

- $I_{Trickle}$ is the trickle current;
- I_{TERM} is the termination current (Note1: when I_{TERM} > 70 mA, we need to add 10 mA to calculate);
- R_{PRE_TERM} is trickle and terminal resistor.

Temperature Sense

The TS function is designed to follow the new JEITA temperature standard for Li-Ion and Li-Pol batteries. There are now four thresholds: 55°C, 45°C, 10°C, and 0°C.

Normal operation occurs between 10°C and 45°C. Between 0°C and 10°C, the charge current level is 0.5 × I_{BAT}. Between 45°C and 55°C, the regulation voltage is reduced to V_{BAT} - 0.1 V. If the temperature is less than 0°C or more than 55°C, the charging current is disabled.

The temperature sense feature is implemented by using an internal 50 μA current source to bias the thermistor designed for use with a 10 kΩ NTC (recommend CN0402R103B3435FB from Sensicom Electronics Technology CO.) connected from the TS terminal to VSS. If this feature is not useful, a fixed 10 kΩ resistor can be placed between TS and VSS to allow normal operation. This may be done if the host is monitoring the thermistor and then the host would determine when to pull the TS terminal low to disable charge.

The TS terminal has two additional features when the TS terminal is pulled low, floated, or driven high. A low state disables charge and a high state puts the charger in TTDM.

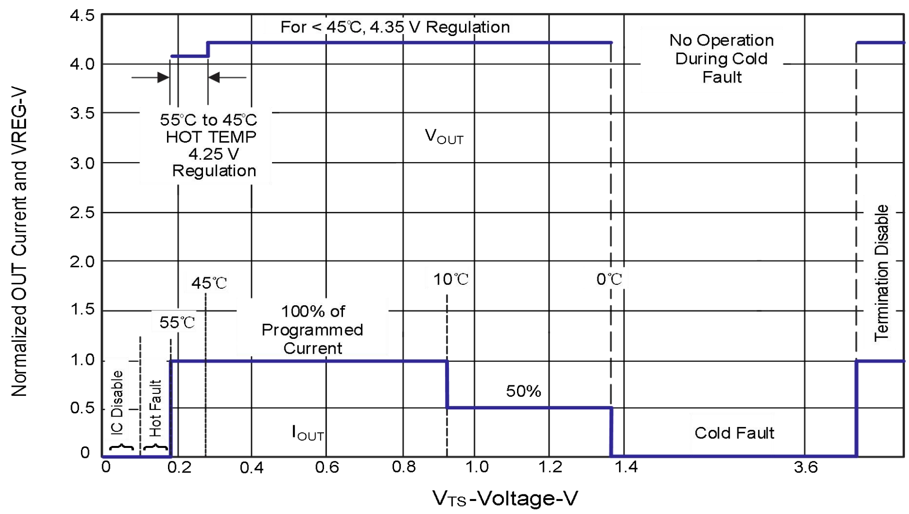


Figure 2. Operation Over TS Bias Voltage

Termination and Timer Disable Mode (TTDM) - TS Terminal High

The battery charger is in TTDM when the TS terminal goes high by removing the thermistor (removing the battery pack or floating the TS terminal) or by pulling the TS terminal up to the TTDM threshold. When entering TTDM, the 10-hour safety timer is held in reset and termination is disabled. The charging profile does not change (still has trickle-charge, constant current charge, and constant voltage modes). This implies the battery is still charged safely and the current is allowed to taper to zero.

Termination

As soon as the BAT terminal goes above V_{RCH} (reaches voltage regulation) and the current tapers down to the termination threshold, the /CHG terminal goes high impedance. If the battery is present, the charge current will terminate. If the battery was removed along with the thermistor, then the TS terminal is driven high and the charge enters TTDM.

Recharge Threshold

If the BAT terminal voltage drops to V_{RCH} (lower than the specified 150 mV) after the termination, then start a new charging.

Timers

The trickle-charge timer is set to 30 minutes. The trickle-charge current can be programmed to offset any system load, making sure that the 30 minutes is adequate.

The constant charge timer is fixed at 10 hours and can be increased in real-time by going into thermal regulation, if in USB current limit. The timer clock slows by a factor of two, resulting in a clock that counts half as fast when in these modes. If either the 30-minute or ten-hour timer times out, the charging is terminated and the /CHG terminal goes high impedance if not already in that state. The timer is reset by disabling the IC, cycling power, or going into and out of TTDM.

Typical Applications

$I_{BAT\_CONSTANT\_CHG}$ = 500 mA; $I_{BAT\_TRICKLE\_CHG}$ = 100 mA; I_{BAT_TERM} = 50 mA

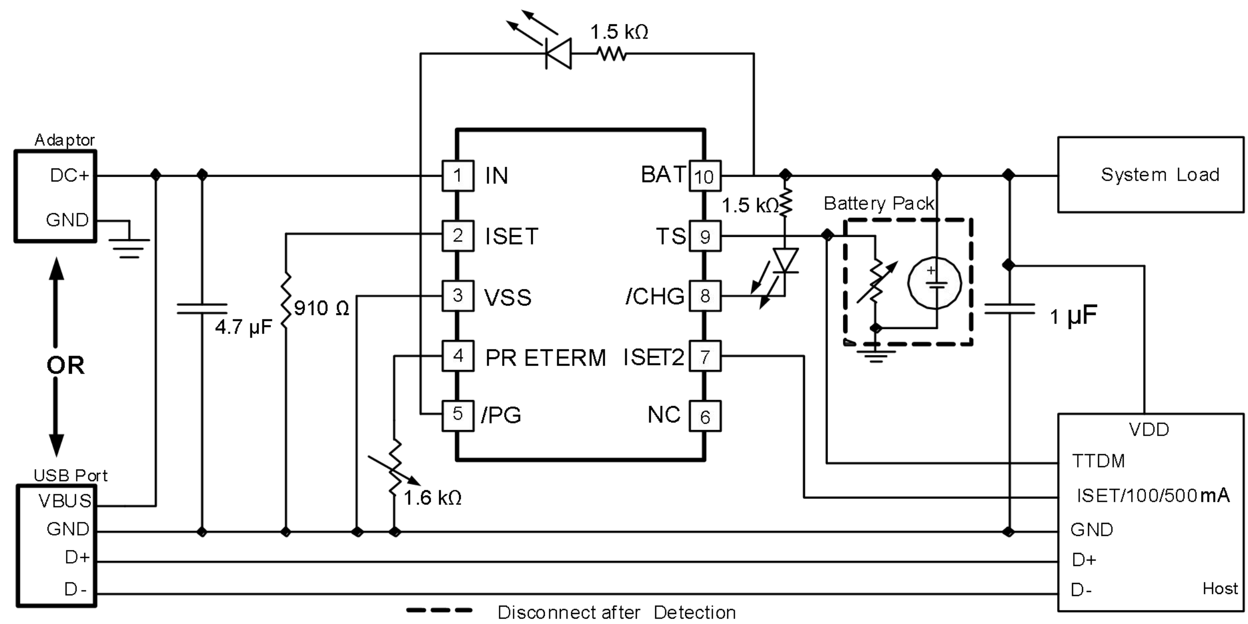


Figure 3. Typical Applications for DIO5841J

Design Requirements

• Supply voltage = 5 V

• Constant charge current: I_{BAT} = 400 mA; I_{SET} ≈ 1130 Ω

• Termination current threshold: I_{TERM} = 20mA; R_{PRE_TERM} = 1 kΩ

• Trickle-charge current by default is twice the termination current or approximately 40 mA

• TS – battery temperature sense = 10 kΩ NTC (β = 3435 k)

• Program the constant charge current, I_{SET}:

$$R_{ISET} = [450 \times 1\ V/I_{BAT}] \qquad (4)$$

• Program the termination current threshold, I_{TERM}:

$$R_{PRE\_TERM} = (I_{Trickle}/I_{BAT}) \times (1V/100\ uA) \quad (5)$$

$$R_{PRE\_TERM} = I_{TERM}/(I_{BAT} \times 50\ uA) \quad (6)$$

Temperature Sense Function

Use a 10 kΩ NTC thermistor in the battery pack.

To disable the temperature sense function, use a fixed 10 kΩ resistor between the TS (terminal 1) and Vss.

/CHG and /PG

LED status: connect a 1.5 kΩ resistor in series with a LED between the BAT terminal and the /CHG terminal. Connect a 1.5 kΩ resistor in series with a LED between the BAT terminal and the /PG terminal.

Processor monitoring: connect a pull-up resistor between the processor's power rail and the /CHG terminal. Connect a pull-up resistor between the power rail of the processor and the /PG terminal.

Selecting in and BAT Terminal Capacitors

In most applications, all that is needed is a high-frequency decoupling capacitor (ceramic) on the power terminal, and input and output terminals. The values shown in Figure 3 are recommended. After evaluation of these voltage signals with real system operational conditions, one can determine if capacitance values can be adjusted toward the minimum recommended values (DC load application) or higher values for fast high amplitude pulsed load applications. Note if designed for high input voltage sources (bad adapters or wrong adapters), the capacitor needs to be rated appropriately. Ceramic capacitors are tested to 2x their rated values, so a 16 V capacitor may be adequate for a 30 V transient (verify tested rating with capacitor manufacturer).

Thermal Package

The DIO5841J is packaged in a thermally enhanced DFN2*2-10 package. The package includes a thermal pad to provide effective thermal contact between the IC and the printed circuit board (PCB). The power pad should be directly connected to the VSS terminal. The most common measure of package thermal performance is thermal impedance (θ_{JA}) measured (or modeled) from the chip junction to the air surrounding the package surface (ambient). The mathematical expression for θ_{JA} is:

$$\theta_{JA} = (T_J - T_A)/P_D \quad (7)$$

where:

- T_J = chip junction temperature
- T_A = ambient temperature
- P_D = device power dissipation

Factors that can influence the measurement and calculation of θ_{JA} include:

1. Whether or not the device is board mounted
2. Trace size, composition, thickness, and geometry
3. Orientation of the device (horizontal or vertical)
4. Volume of the ambient air surrounding the device under test and airflow
5. Whether other surfaces are close to the device being tested

Due to the charge profile of Li-Ion and Li-Pol batteries the maximum power dissipation is typically seen at the beginning of the charge cycle when the battery voltage is at its lowest. Typically after constant charge begins the pack voltage increases to ≉3.4 V within the first 2 minutes. The thermal time constant of the assembly typically takes a few minutes to heat up so when doing maximum power dissipation calculations, 3.4 V is a good minimum voltage to use. This is verified, with the system and a fully discharged battery, by plotting temperature on the bottom of the PCB under the IC (pad should have multiple vias), the charge current and the battery voltage as a function of time. The constant charge current will start to taper off if the part goes into thermal regulation.

Layout

To obtain optimal performance, the decoupling capacitor from IN to VSS (thermal pad) and the output filter capacitors from BAT to VSS (thermal pad) should be placed as close as possible to the DIO5841J, with short trace runs to both IN, BAT and VSS (thermal pad).

All low-current VSS connections should be kept separate from the high-current charge or discharge paths from the battery. Use a single-point ground technique incorporating both the small signal ground path and the power ground path.

The high current charge paths into IN terminal and from the BAT terminal must be sized appropriately for the maximum charge current in order to avoid voltage drops in these traces.

The DIO5841J is packaged in a thermally enhanced DFN2*2-10 package. The package includes a thermal pad to provide an effective thermal contact between the IC and the printed circuit board (PCB); this thermal pad is also the main ground connection for the device. Connect the thermal pad to the PCB ground connection. It is best to use multiple 10 mil vias in the power pad of the IC and close enough to conduct the heat to the bottom ground plane. The bottom ground place should avoid traces that cut off the thermal path. The thinner the PCB, the less temperature rise.

Typical Performance Characteristics

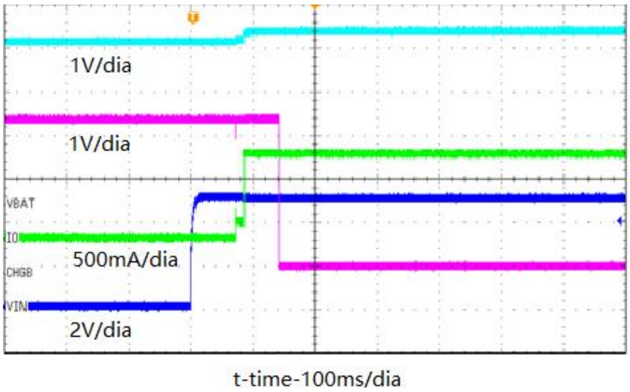


Figure 4. Power up

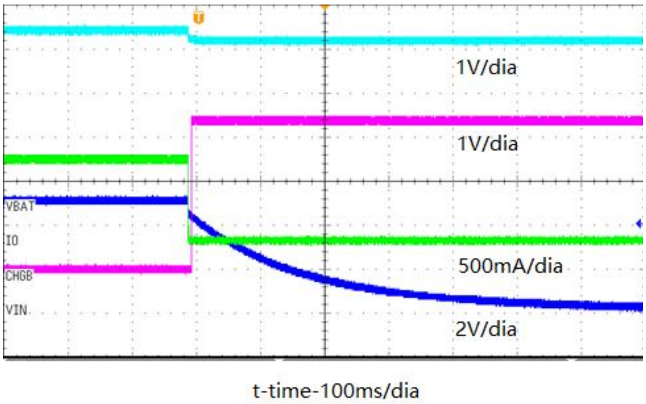


Figure 5. Power down

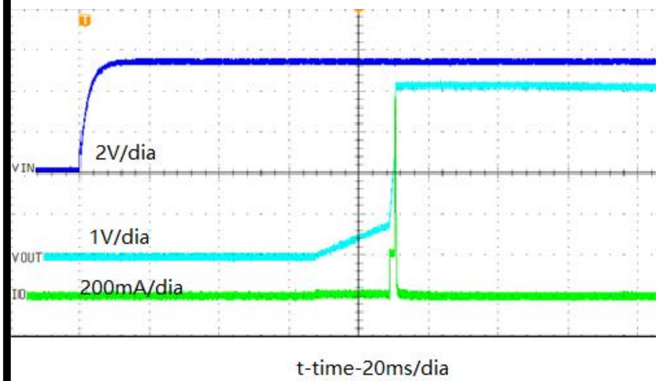


Figure 6. AC Charging

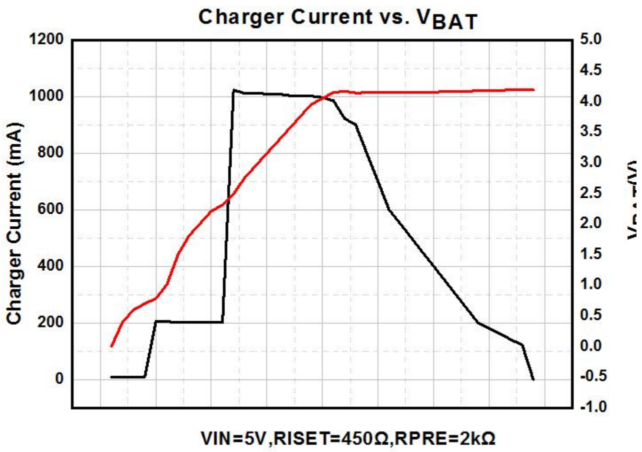


Figure 7. Charger Current vs. V_{BAT}

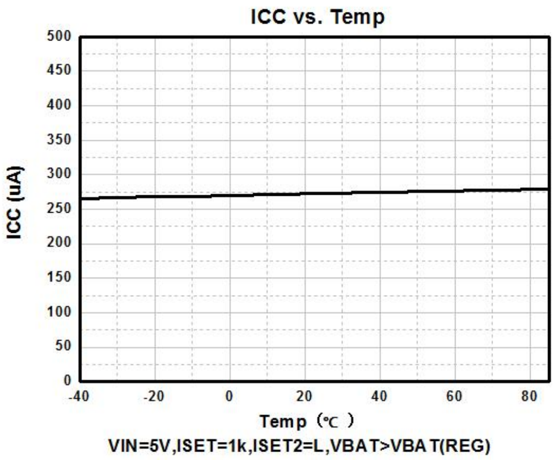


Figure 8. ICC vs. Temp

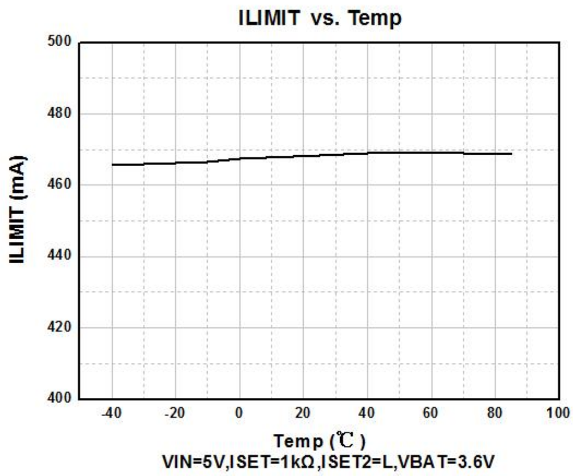


Figure 9. ILIMIT vs. Temp

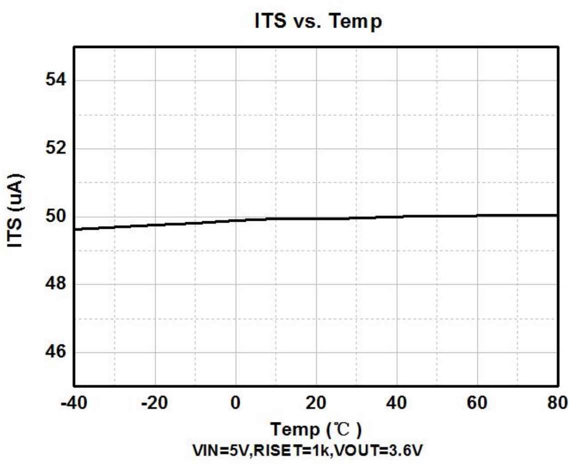
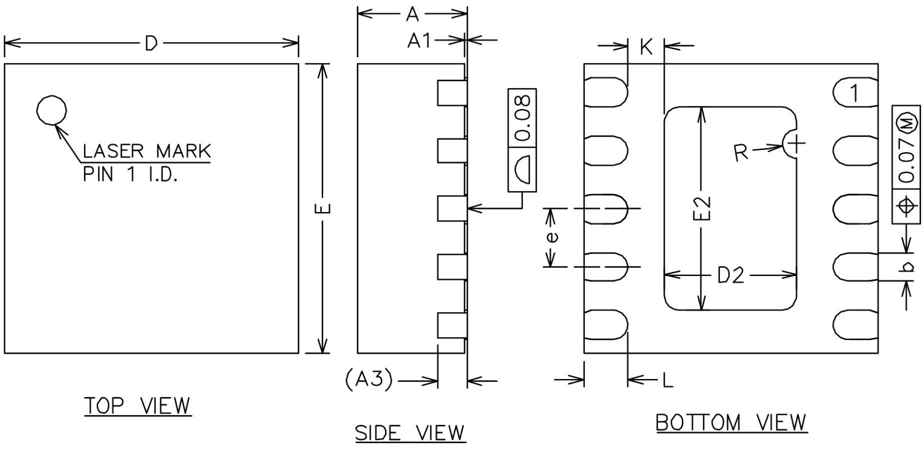
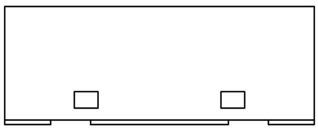


Figure 10. ITS vs. Temp

Physical Dimensions: DFN2*2-10





Common Dimensions (Units of Measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3	0.20 REF		
b	0.15	0.20	0.25
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D2	0.80	0.90	1.00
E2	1.30	1.40	1.50
e	0.30	0.40	0.50
K	0.15	0.25	0.35
L	0.25	0.30	0.35
R	0.10 REF		

CONTACT US

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