DIO50581A/B/D
10~300mA, Single Cell Charger

Features

- Broad Programmable Charging Current: 10~300mA
- Maximum Voltage Power Input: 30V
- Programmable Charge Termination Current
- Automatic Recharge Threshold:
  DIO50581A: 4.25V
  DIO50581B: 4.215V
  DIO50581D: 4.05V
- Final Float Voltage:
  DIO50581A: 4.4V
  DIO50581B: 4.365V
  DIO50581D: 4.2V
- Trickle Charge Threshold: 2.5V
- Charge Status Output Pin
- Soft-Start Limits Inrush Current
- Over Voltage Lockout Protection
- Over-Temperature Protection
- Under Voltage Lockout Protection
- Reverse current protection between BAT and GND pins
- Package: DFN2*2-10, DFN3*3-10

Descriptions

The DIO50581A/B/D is a complete constant-current / constant voltage linear charger for single cell Lithium-Ion batteries. No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.4V for DIO50581A, 4.365V for DIO50581B and 4.2V for DIO50581D, the charge current and the terminal current can be programmed externally with resistors. The input voltage is up to 30V.

When the input supply (wall adapter or USB supply) is removed, the DIO50581A/B/D automatically enters a low current state, dropping the battery drain current to less than 1.0μA.

The DIO50581A/B/D is available in packages with DFN2*2-10 and DFN3*3-10.

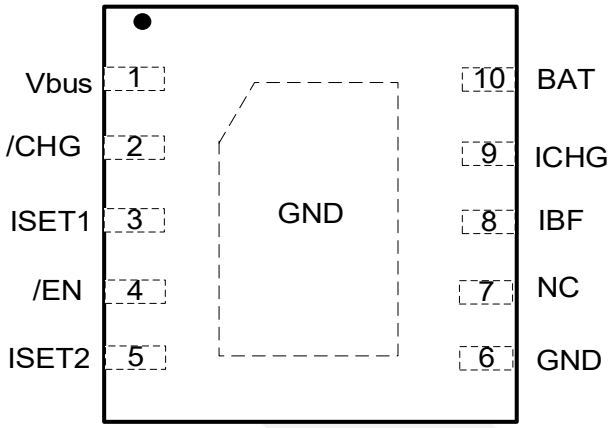
Applications

- Wireless phone
- MP3/MP4 Player
- Bluetooth device

Ordering Information

Order Part Number	Top Marking		T_A	Package	
DIO50581ACD10	D5HAA	Green	-40°C to 85°C	DFN3*3-10	Tape & Reel, 5000
DIO50581BCD10	D5HAB	Green	-40°C to 85°C	DFN3*3-10	Tape & Reel, 5000
DIO50581DCD10	D5HAD	Green	-40°C to 85°C	DFN3*3-10	Tape & Reel, 5000
DIO50581ACN10	EHAA	Green	-40°C to 85°C	DFN2*2-10	Tape & Reel, 3000
DIO50581BCN10	EHAB	Green	-40°C to 85°C	DFN2*2-10	Tape & Reel, 3000
DIO50581DCN10	EHAD	Green	-40°C to 85°C	DFN2*2-10	Tape & Reel, 3000

Pin Assignment



DFN2*2-10/DFN3*3-10

Figure 1. Top View

Pin Descriptions

Name	Description
Vbus	Power Supply. The absolute maximum input voltage is 30V.
/CHG	Open-Drain Charge Status Output. This pin is low during charging.
/EN	Charger IC Enable. Drive to high to disable the charger. When this pin is driven to low or left floating, the charger is enabled. This pin has an internal 2MΩ pull-down resistor.
ISET1, ISET2	When ISET1 and ISET2 are driven to different high and low levels, the charging state of IC is different. See page 3 charge state. This pin has an internal 1MΩ pull-down resistor.
GND	Ground.
NC	No Connect.
IBF	Terminal Current Programming Pin. This pin to an external resistor to program the charge termination current.
ICHG	Charge current setting, charge current monitor and shutdown pin. The charging current is given by I_{ICHG}= (1/R_{ICHG})*200. The chip will be shutdown when ICHG pin floating. The maximum trickle charging current does not exceed 1 / 20 of I_{ICHG}.
BAT	Charge Current Output. Provides charge current to the battery an regulates the final float voltage to 4.4V/4.365V/4.2V.
GND(Exposed Pad)	This pin must be connected to GND, and punch to the main GND to facilitate heat dissipation.

Charge State

ISET1	ISET2	I_{charge}
0	0	1C
0	1	2C
1	0	0.5C
1	1	0

Note:1C= $(1/R_{ICHG})*200$.

Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Rating” 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.

Parameter		Rating	Unit
Supply Voltage		-0.3 to 30	V
BAT Voltage		-0.3 to 10	V
Other Pin Voltage		-0.3 to 8	V
BAT Pin Current		150	mA
Junction Temperature		160	°C
Operation Temperature		-40 to 85	°C
Storage Temperature		-65 to 125	°C
Lead Temperature (Soldering 10s)		260	°C
ESD	HBM	2000	V
Latch up		200	mA

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.

Parameter	Rating	Unit
Input Supply Voltage	4.7 to 5.5	V
Operating Temperature Range	-40 to 85	°C

Electrical Characteristics

V_{bus}=5V, T_A=25°C (unless otherwise noted)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$I_{SPLYCHRG}$	Charge Mode Supply Current	R_{ICHG}=10kΩ		240	2100	μA
		R_{ICHG}=20kΩ		180	2100	μA
$I_{BATCHRG}$	Charge Mode Battery Current	R_{ICHG}=1kΩ	180	200	230	mA
		R_{ICHG}=10kΩ	18	20	25	mA
		R_{ICHG}=20kΩ	8.8	9.8	11	mA
$V_{ICHGCHRG}$	ICHG Pin Voltage	R_{ICHG}=10kΩ	0.93	1.00	1.07	V
		R_{ICHG}=20kΩ	0.93	1.00	1.07	V
$I_{SPLYSTBY}$	Standby Mode Supply Current	Charge Terminated		90	550	μA
$I_{BATSTBY}$	Standby Mode Battery Current	Charge Terminated	0	±0.05	±2	μA
$I_{SPLYASD}$	Shutdown Mode Supply Current	Vbus<V_{BAT}	20	36	90	μA
I_{BATASD}	Shutdown Mode BAT Pin Current	Vbus<V_{BAT}		±0.05	±2	μA
$I_{SPLYUVLO}$	UVLO Mode Supply Current	Vbus<V_{UV}	20	35	55	μA
$I_{BATUVLO}$	UVLO Mode BAT Pin Current	Vbus<V_{UV}		±0.05	±2	μA
$I_{SPLYOVP}$	OVP Mode Supply Current	Vbus>V_{OVP}	20	42	90	μA
I_{BATOVP}	OVP Mode BAT Pin Current	Vbus>V_{OVP}		±0.05	±2	μA
$I_{SPLYSHUT}$	Shutdown Mode Supply Current	R_{ICHG} not Connected	20	83	90	μA
$I_{BATSHUT}$	Shutdown Mode BAT Pin Current	R_{ICHG} not Connected		±0.05	±2	μA
$I_{BATSLEEP}$	Sleep Mode BAT Pin Current	Vbus=0V		±0.05	±2	μA
$V_{/EN\_VIH}$	/EN Pin Logic Input High		1.2			V
$V_{/EN\_VIL}$	/EN Pin Logic Input Low				0.6	V
$R_{/EN\_Pull\ Down}$	/EN Pin Internal Pull Down Resistance			2		MΩ
$I_{SPLYSHUT\_/EN}$	Shutdown Mode Supply Current		20	38	55	μA
$I_{BATSHUT\_/EN}$	Shutdown Mode BAT Pin Current			±0.05	±2	μA
V_{ISET1_VIH}	ISET1 Logic Input High		1.2			V
V_{ISET1_VIL}	ISET1 Logic Input Low				0.6	V
V_{ISET2_VIH}	ISET2 Logic Input High		1.2			V
V_{ISET2_VIH}	ISET2 Logic Input Low				0.6	V
$R_{ISET1\_Pull\ Down}$	ISET1 Pin Internal Pull Down Resistance			1		MΩ
$R_{ISET2\_Pull\ Down}$	ISET2 Pin Internal Pull Down Resistance			1		MΩ

$I_{Charge\_terminated}$		R_{BF}=51kΩ, R_{ICHG}=10kΩ		2.9		mA
$V_{Charge\_terminated}$		R_{BF}=51kΩ, R_{ICHG}=10kΩ		0.5		V
V_{FLOAT}	Float Voltage	DIO50581A	4.365	4.4	4.435	V
		DIO50581B	4.330	4.365	4.399	V
		DIO50581D	4.165	4.2	4.235	V
I_{TRIKL}	Trickle Charge Current	R_{ICHG}=5kΩ			2	mA
V_{TRIKL}	Trickle Charge Voltage Threshold	R_{ICHG}=10kΩ		2.5		V
$V_{TRIKL, HYS}$	Trickle Charge Voltage Hysteresis	R_{ICHG}=10kΩ		100		mV
V_{UVLO}	UVLO Threshold	From Vbus Low to High	3.52	3.70	3.92	V
$V_{UVLO, HYS}$	UVLO Hysteresis			140		mV
V_{OVP}	OVP Threshold	From Vbus Low to High		6.4		V
V_{OVP_HYS}	OVP Hysteresis			250		mV
V_{ASD}	V_{bus}-V_{BAT} Lockout Threshold Voltage	Vbus from low to High Vbus from High to Low		140 80		mV mV
ΔV_{RECHRG}	Auto Recharge Battery Voltage		100	150	200	mV
$V_{/CHG}$	/CHG Pin Output Low Voltage	$I_{/CHG}$=5mA		0.3	0.6	V
T_{LIM}	Junction Temperature In CT Mode			160		°C
T_{SS}	Soft-Start Time	R_{ICHG}=2kΩ		50		μs
T_{RECHRG}	Recharge Comparator Filter Time			4		ms
T_{TERM}	Termination Comparator Filter Time			7.5		ms
I_{ICHG}	ICHG Pin Pull-up Current		0.4	1.1	1.5	μA

Specifications subject to change without notice.

Typical Performance Characteristic

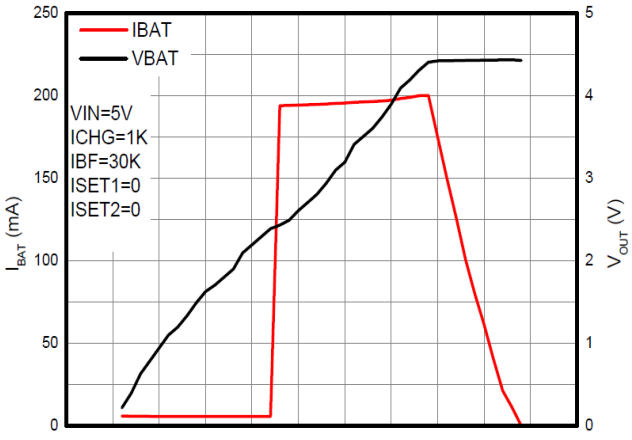


Figure 2. IBAT vs VOUT

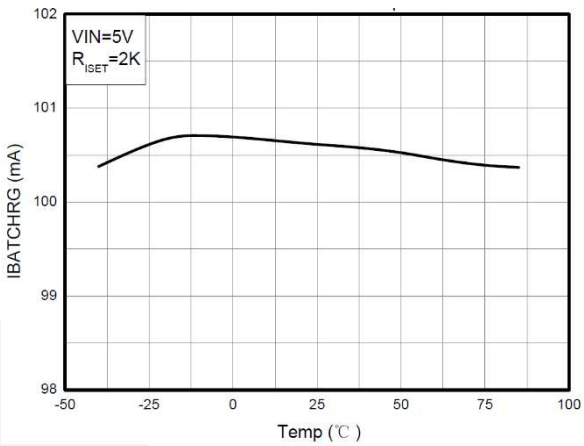


Figure 3. IBATCHRG vs Temp

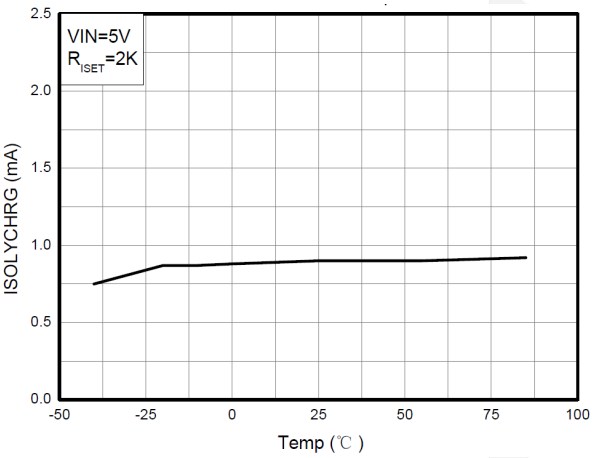


Figure 4. ISOLYCHRG vs Temp

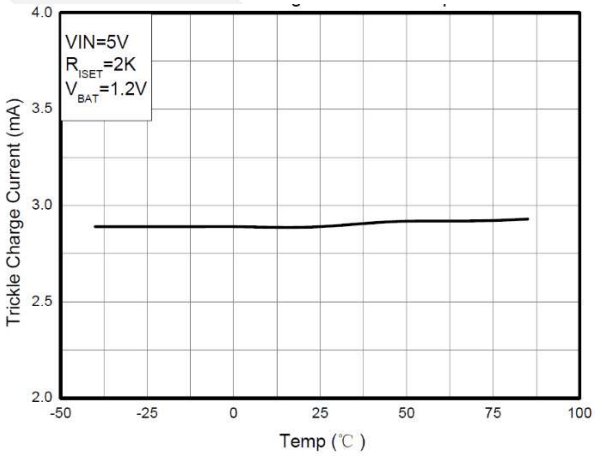
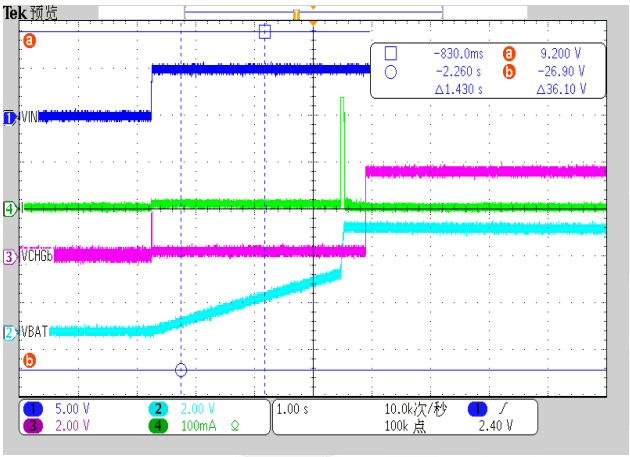


Figure 5. Trickle Charge Current vs Temp



V_{IN}=5V, R_{ISET}=680Ω, C_{IN}=10uF, C_{OUT}=10000uF, EN=L

Figure 6. Charging and Discharging Process

Detailed Description

The DIO50581A/B/D is a single cell Lithium-Ion battery charger using a constant-current / constant-voltage algorithm. It can deliver up to 100mA of charge current with a final float voltage accuracy of ±0.8%. The DIO50581A/B/D includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required; thus, the basic charger circuit requires only two external components. Furthermore, the DIO50581A/B/D is capable of operating from a USB power source.

Normal Charge Cycle

A charge cycle begins when the voltage at the Vbus pin rises above the UVLO threshold level and a 1% program resistor is connected from the ICHG pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 2.5V, the charger enters trickle charge mode. In this mode, the DIO50581A/B/D supplies approximately 1/20 the programmed charge current to bring the battery voltage up to a safe level for full current charging.

When the BAT pin voltage rises above 2.5V, the charger enters constant-current mode, where the programmed charge current is supplied to the battery. When the BAT pin approaches the final float voltage, the DIO50581A/B/D enters constant-voltage mode and the charge current begins to decrease. The charge cycle ends when the IBF voltage is less than 500mV.

Programming Charge Current

The charge current is programmed using a single resistor from the ICHG pin to ground. The battery charge current of constant current mode is 100 times the current out of the ICHG pin. The program resistor and the charge current of constant current are calculated using the following equations:

$$I_{CHRG} = \left(\frac{1V}{R_{ICHG}} \right) * 200$$

Programming Charge Termination

The terminal current is programmed using a single resistor from the IBF pin to ground. When the IBF pin voltage falls below 500mV for longer than T_{TERM} (typically 7.5ms), charging is terminated. The charge current is latched off and the DIO50581A/B/D enters standby mode, where the input supply current drops to 130μA. The DIO50581A/B/D terminates the charge cycle and ceases to provide any current through the BAT pin, the chip will be put into standby mode. In this state, all loads on the BAT pin must be supplied by the battery. The range of R_{BF} is recommend: $10*R_{ICHG} < R_{BF} < 30*R_{ICHG}$.

Vbus=5V, R_{ICHG}=2K	
R_{IBF}	$I_{charge\_terminated}$ (mA)（Typ.）
60K	1.59
50K	2.17
42.9K	2.90
37.5K	3.55
33.3K	4.47
30K	5.69
27.3K	6.71
25K	7.56
23K	9.10
21.41K	10.43
20k	11.11

The DIO50581A/B/D constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.05V/4.25V/4.215V recharge threshold (V_{RECHRG}), another charge cycle begins and current is once again supplied to the battery. The state diagram of a typical charge cycle is as Figure 7.

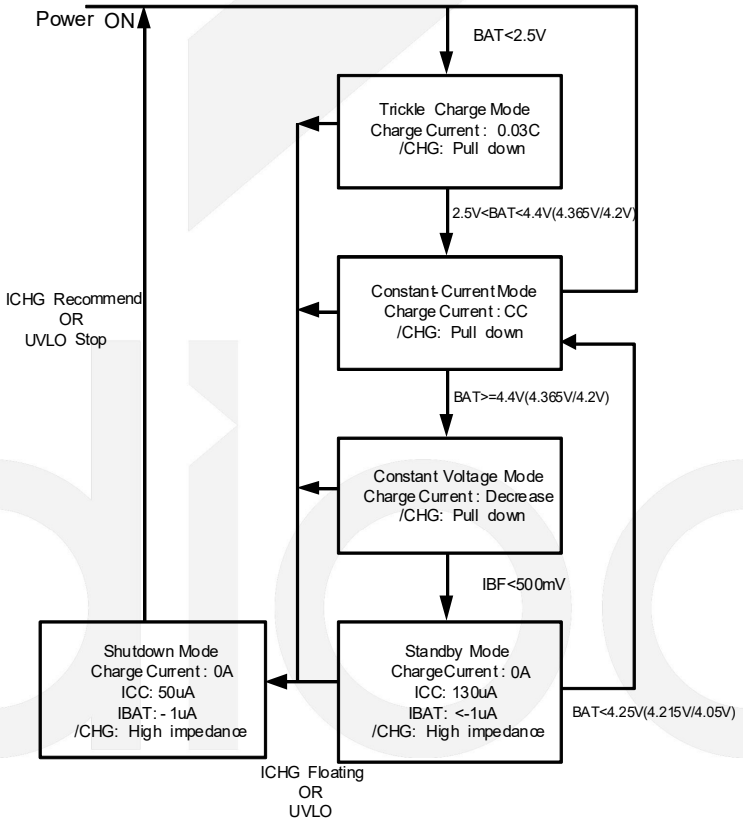


Figure 7. State Diagram of a Typical Charge Cycle

Charge Status Indicator

DIO50581A/B/D has an open-drain status indicator output /CHG. /CHG is pull-down when the DIO50581A/B/D in a charge cycle. In other status /CHG is in high impedance.

Thermal Limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 160°C. This feature protects the DIO50581A/B/D from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging the DIO50581A/B/D. The charge current can be set according to typical (not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions.

Undervoltage Lockout (UVLO)

An internal undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until Vbus rises above the undervoltage lockout threshold. The UVLO circuit has a built-in hysteresis of 200mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit keeps the charger in shutdown mode if Vbus falls to within 50mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until Vbus rises 120mV above the battery voltage.

Overvoltage Lockout (OVLO)

An internal overvoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until Vbus fall down the overvoltage lockout threshold. The OVLO circuit has a built-in hysteresis of 320mV. Furthermore, to protect against reverse current in the power MOSFET, the OVLO circuit keeps the charger in shutdown mode if Vbus falls to within 50mV of the battery voltage. If the OVLO comparator is tripped, the charger will not come out of shutdown mode until Vbus rises 120mV above the battery voltage.

EN Input

EN is an active-low logic input to enable the charger. Drive the EN pin to low or leave it floating to enable the charger. This pin has a 2MΩ internal pull-down resistor so when left floating, the input is equivalent to logic low. Drive this pin to high to disable the charger. The threshold for high is given in the Electrical Characteristics table.

Manual Shutdown

At any point in the charge cycle, the DIO50581A/B/D can be put into shutdown mode by removing R_{ICHG} thus floating the ICHG pin. This reduces the battery drain current to less than 1.0μA and the supply current to less than 50μA. A new charge cycle can be initiated by reconnecting the program resistor.

In manual shutdown, The /CHG pin is in a high impedance state if the DIO50581A/B/D is in manual shutdown mode or in the undervoltage lockout mode: either Vbus is within 120mV of the BAT pin voltage or insufficient voltage is applied to the Vbus pin.

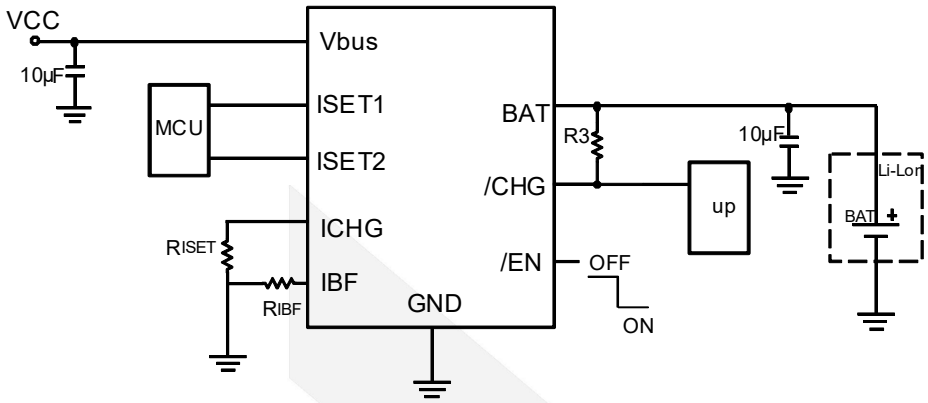


Figure 8. Manual Shutdown Mode Application Circuit

Automatic Recharge

Once the charge cycle is terminated, the DIO50581A/B/D continuously monitors the voltage on the BAT pin using a comparator with a 4ms filter time (T_{RECHRG}). A charge cycle restarts when the battery voltage falls below 4.05V/4.25V/4.215V (Typ.) (which corresponds to approximately 80% to 90% battery capacity). This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations. /CHG output enters a pull-down state during recharge cycles.

Application Information

Typical Application

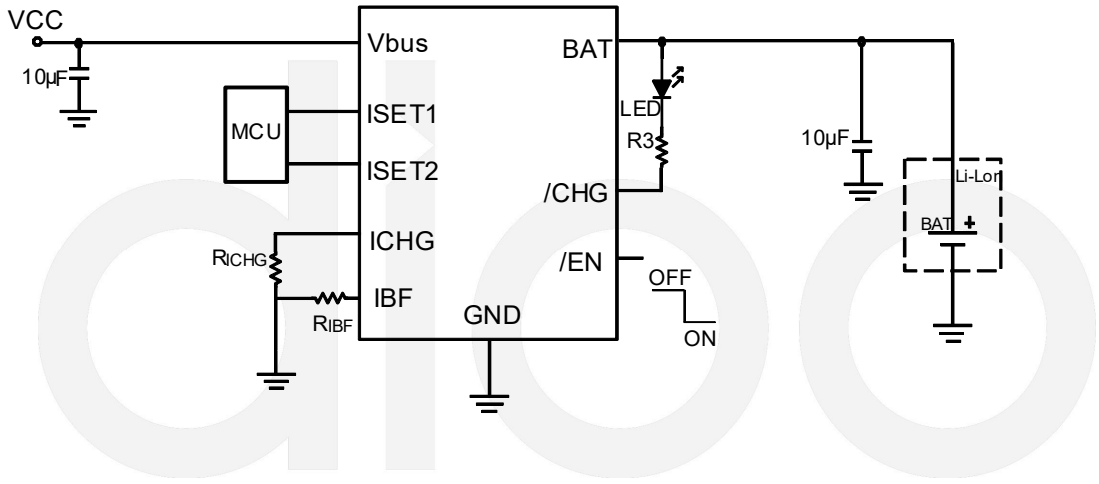


Figure 9. Typical applications W/T LED indicate

Stability Considerations

The constant-voltage mode feedback loop is not stable without an output capacitor provided a battery is connected to the charger output. With no battery present, an output capacitor is recommended to reduce ripple voltage. When using high value, low ESR ceramic capacitors, it is recommended to add a 1Ω resistor in series with the capacitor. No series resistor is needed if tantalum capacitors are used.

In constant-current mode, the ICHG pin is in the feedback loop, not the battery. The constant-current mode stability is affected by the impedance at the ICHG pin. With no additional capacitance on the ICHG pin, the charger is stable with program resistor values as high as 51KΩ. However, additional capacitance on this node reduces the maximum allowed program resistor thus it should be avoided.

Thermal Limit

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 160°C. This feature protects the DIO50581A/B/D from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging the DIO50581A/B/D. The charge current can be set according to typical (not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions.

Power Dissipation

The conditions that cause the DIO50581A/B/D to reduce charge current through thermal feed-back can be approximated by considering the power dissipated in the IC. Nearly all of this power dissipation is generated by the internal MOSFET. This is calculated to be approximately:

$$P_D = (V_{CC} - V_{BAT}) * I_{BAT}$$

It is important to remember that DIO50581A/B/D applications do not be designed for worst-case thermal conditions since the IC will automatically reduce power dissipation when the junction temperature reaches approximately 160°C (Constant temperature mode).

Vbus Bypass Capacitor

Many types of capacitors can be used for input bypass, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, a 10μF ceramic capacitor is recommended for this bypass capacitor. Due to a high voltage transient will be generated under some start-up conditions, such as connecting the charger input to a live power source.

Charge Current Soft-start

The DIO50581A/B/D includes a soft-start circuit to minimize the inrush current at the start of a charge cycle. When a charge cycle is initiated, the charge current ramps from zero to the full-scale current over a period of approximately 100μs. This has the effect of minimizing the transient current load on the power supply during start-up.

CONTACT US

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