Descriptions

The HP4059D6-42Y series of devices are highly integrated Li-Ion and Li-Pol linear chargers targeted at small capacity battery for portable applications. It is a complete constant-current/constant voltage linear charger. No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. It can deliver up to 300mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of±1%. The charge voltage is fixed at 4.2V or 4.35V, and the charge current can be programmed externally with a single resistor. The charger function has high accuracy current and voltage regulation loops and charge termination.

The HP4059D6-42Y automatically terminates the charge cycle when the charge current drops to 1/10 the programmed value after the final float voltage is reached.

When the input supply (wall adapter or USB supply) is removed, the AS5LC4059 will shut off, only 40nA leakage current coming from battery at sleep mode when ambient temperature is 85℃, so it can save energy and improve standby time.

The HP4059D6-42Y is available in a small package with DFN1X1. Standard product is Pb-free and Halogen-free.

Features

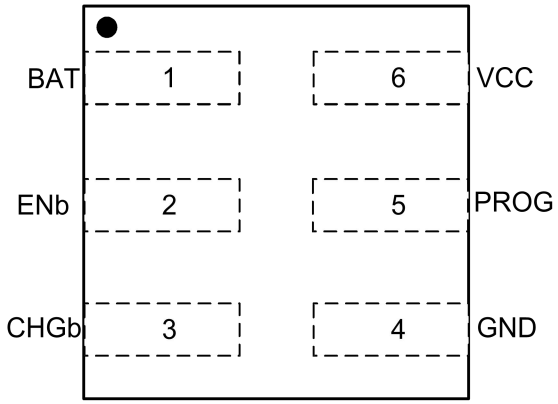
- 1% Charge Voltage Accuracy
- 5% Charge Current Accuracy
- Programmable Charge Current 1mA~300mA
- Over-Temperature Protection
- Under Voltage Lockout Protection
- 2.5V Trickle Charge Threshold
- Soft-Start Limits Inrush Current
- Charge Status Output Pin
- Automatic Recharge

Applications

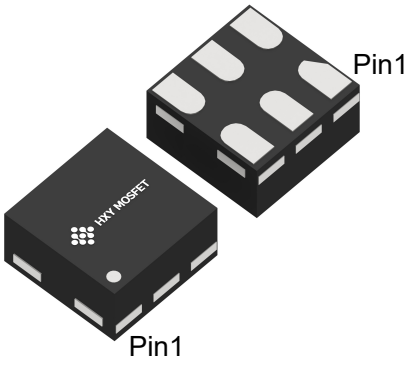
- Fitness Accessories
- Smart Watches
- Bluetooth Handsets
- Wireless Low-Power Handheld Devices

Pin Configuration

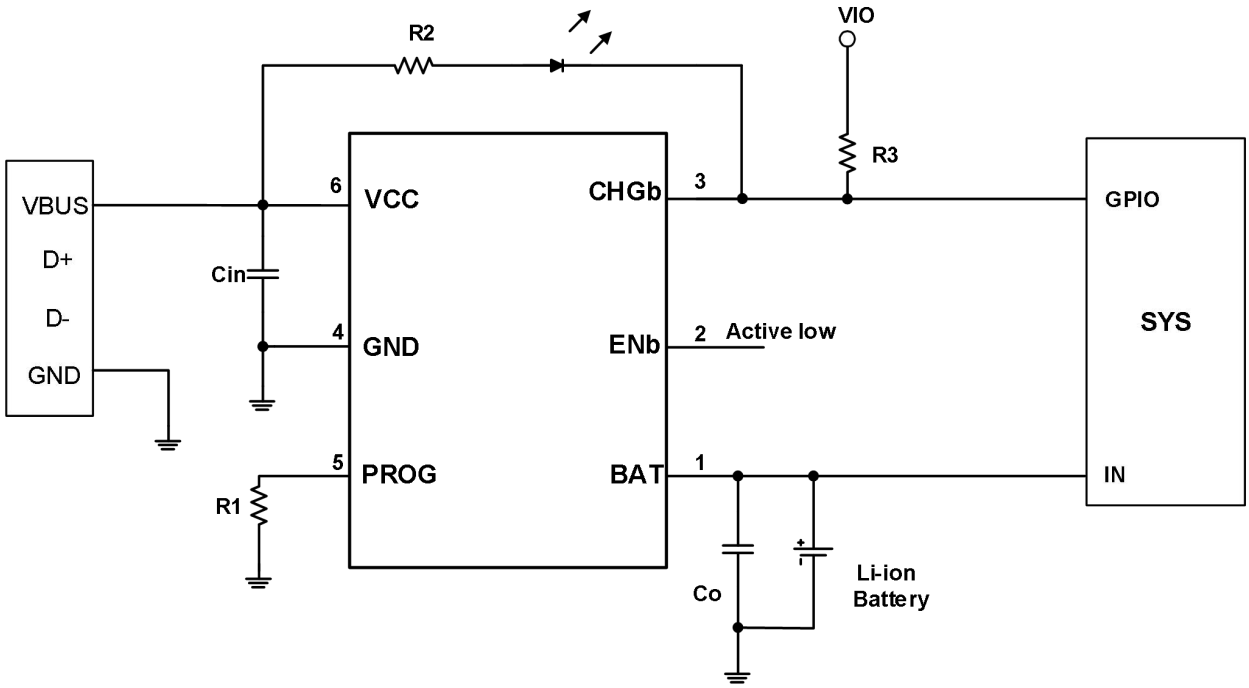
DFN1X1(TDFN-6L(1x1))



Pin configuration (Top view)



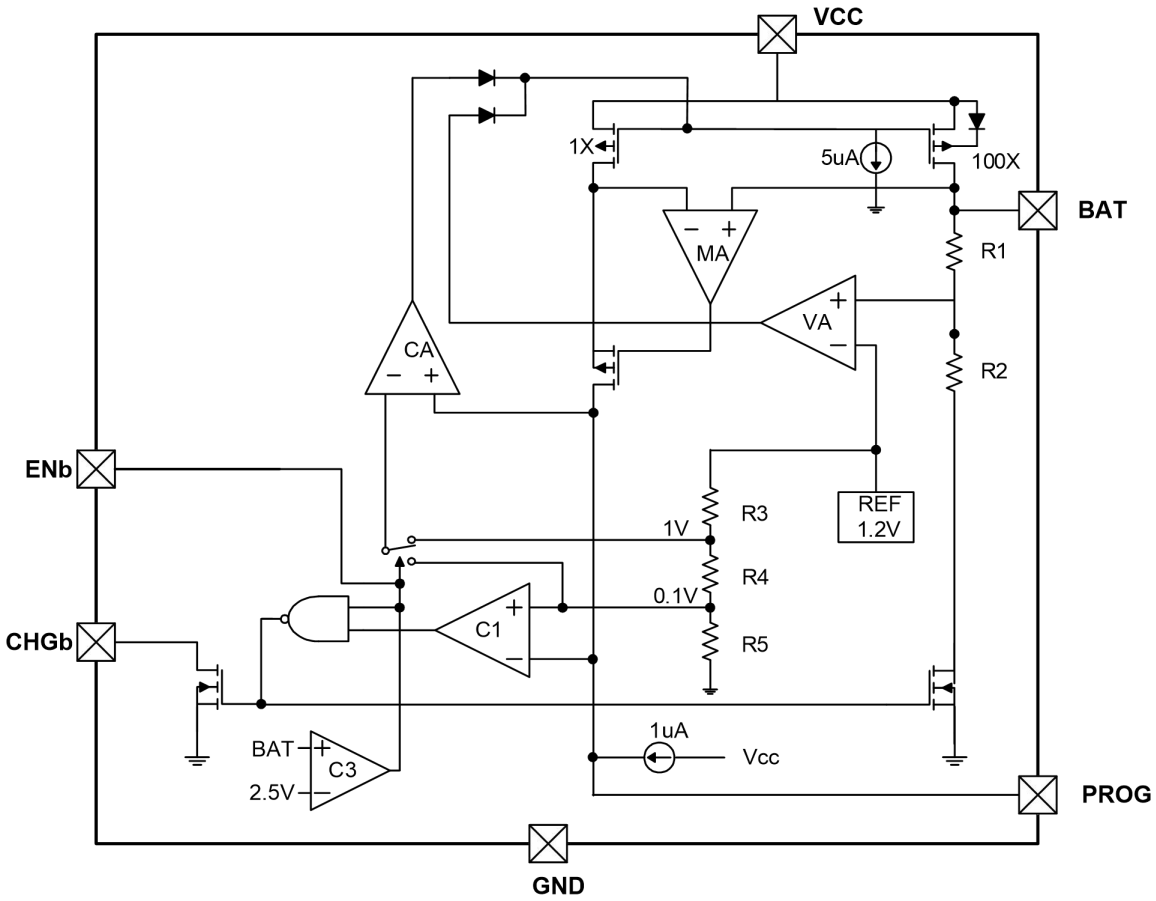
Typical Applications



Pin Descriptions

Pin Number	Pin Name	I/O	Function
1	BAT	O	Charge Current Output. Provides charge current to the battery and regulates the final float voltage to 4.35V (A4059B).
2	ENb	I	Enable control, When Enb is low the charging is enabled and the otherwise is disabled.
3	CHGb	I	Open-Drain Charge Status Output. When the battery is charging, the CHGb pin is pulled low. When the charge cycle is completed or VCC is removed, the CHGb is forced high impedance.
4	GND	Ground	Ground
5	PROG	O	Charge current setting, charge current monitor. The charging current is given by I_{BAT}= 100/R_{PROG}(A). Please choose 1% precision resistor for R_{PROG}.
6	VCC	Power	Power Supply

Block Diagram



Absolute Maximum ratings

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage	V_{CC}	-0.3	5	7	V
PROG Voltage	V_{PROG}	-0.3	1	7	V
BAT Voltage	V_{BAT}	-0.3		7	V
CHGb Voltage	V_{CHGb}	-0.3		7	V
ENb Voltage	V_{ENb}	-0.3		7	V
BAT Pin Current	I_{BAT}	1	100	300	mA
Junction Temperature	T_j	-40		125	°C
Operation Temperature	T_{op}	-40		85	°C
Storage Temperature	T_{sg}	-55		150	°C
Lead Temperature (Soldering 10s)				260	°C

Thermal Resistance Characteristics

Symbol	Parameter	Typ.	Unit
$R_{\theta JA1}$	Thermal Resistance, Junction to Ambient –**Note1**	230	°C/W

Note1: Surface mounted on FR4 Board using 1 in sq pad size, 2oz Cu.

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

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{CC}	Input Supply Voltage	A4059	4	5	7	V
V_{FLOAT}	Float Voltage	A4059A	4.158	4.2	4.242	V
		A4059B	4.306	4.35	4.394	V
		A4059C	4.356	4.4	4.444	V
		A4059D	4.455	4.5	4.545	V
I_{CC}	Input Supply Current In Different Mode(or GND Current)	Charge Mode, R_{PROG}=1kΩ	48	69	125	uA
		Standby Mode(Charge Terminated)	40	57	80	uA
		No R_{PROG} Mode	28	36	45	uA
		V_{CC}<V_{BAT} Mode	28	35	45	uA
		UVLO Mode	20	29	50	uA
		Shutdown Mode(V_{ENb}=5V)		0	1	uA
I_{BAT}	BAT Pin Current In Different Mode	R_{PROG}=1kΩ	95	100	105	mA
		R_{PROG}=2kΩ	46	48.5	51	mA
		R_{PROG}=4kΩ	22.3	23.5	24.7	mA
		Standby Mode, V_{BAT}=4.2V(DA)	0.5	1.67	3	uA
		No R_{PROG} Mode	-1	0	1	uA
		V_{CC}<V_{BAT} Mode	-1	0	1	uA
		UVLO Mode	-1	0	1	uA
		Sleep Mode, V_{CC} =0	-1	0	1	uA
I_{TRIKL}	Trickle Charge Current	R_{PROG}=1kΩ	7.8	8.85	9.9	mA
		R_{PROG}=2kΩ	3.6	4.2	4.8	mA
		R_{PROG}=4kΩ	1.6	2	2.4	mA
V_{TRIKL}	Trickle Charge Voltage Threshold	V_{BAT} from low to high	2.4	2.5	2.6	V
V_{TRHYS}	Trickle Charge Voltage Hysteresis	V_{BAT} from high to low		100		mV
V_{UVLO}	UVLO Threshold	V_{CC} from Low to High	3.6	3.8	4	V
$V_{UVLO, HYS}$	UVLO Hysteresis	V_{CC} from High to Low		200		mV
V_{MSD}	Manual Shutdown Threshold Voltage	PROG Pin Rising		1.2	1.3	V
		PROG Pin Falling		1		V
V_{ASD}	V_{CC}-V_{BAT} Lockout Threshold Voltage	V_{CC} from Low to High		100		mV
		V_{CC} from High to Low	5	50		mV
I_{TERM}	C/10 Termination Current Threshold	R_{PROG}=1kΩ	7.5	9	10.5	mA
ΔV_{RECHRG}	Auto Recharge Battery Voltage		100	150	200	mV
R_{ON}	Power FET ON Resistance			1.5		Ω
V_{CHGb}	CHGb Pin Output Low Voltage	I_{CHGb}=5mA	0.04	0.28	0.4	V
I_{PROG}	PROG Pin Pull-up Current		0.1	0.25	1	uA
V_{ENb}	ENb high threshold	ENb from low to high	1.5		VCC	V
	ENb Low threshold	ENb from high to low	0		0.4	V
t_{SS}	Soft-Start Time	R_{PROG}=1kΩ		100		us
t_{RECHRG}	Recharge Comparator Filter Time			2		ms
t_{TERM}	Charge Terminated Filter Time			1		ms

Operation Information

The HP4059D6-42Y is a single cell Li-Ion and Li-Pol battery linear charger using a constant-current/ constant-voltage algorithm. It is designed specially for small capacity battery that is used in handheld devices, such as GPS tracker, Smart wrist and U-Key. It can deliver up to 300mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%. The HP4059D6-42Y includes an internal P-channel power MOSFET and current regulation circuitry. No blocking diode or external current sense resistor is required, thus the basic charger circuit requires only two external components. Furthermore, the HP4059D6-42Y is capable of operating from a USB power source.

Normal charge cycle

A charge cycle begins when the voltage at the VCC pin rises above the UVLO threshold level and a 1% program resistor is connected from the PROG 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 A4059 supplies approximately 1/10 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 A4059 enters constant-voltage mode and the charge current begins to decrease. The charge cycle ends when the PROG voltage is less than 100mV.

Programming charge current

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

$$I_{BAT}= 100/R_{PROG}(A$$

For example, I_{BAT}=0.1A, R_{PROG}=1kΩ, I_{BAT}=0.05A, R_{PROG}=2kΩ. Please choose 1% precision resistor for R_{PROG}, this will effect the accuracy of CC charge current and termination current.

Charge termination

A charge cycle is terminated when the charge current falls to 1/10 of the programmed value after the final float voltage is reached. This condition is detected by using an internal, filtered comparator to monitor the PROG pin. When the PROG pin voltage falls below 100mV for longer than T_{TERM} (typically 1ms), charging is terminated. The charge current is latched off and the A4059 enters standby mode, where the input supply current drops to 57uA. (Note: 1/10 CC termination is disabled in trickle charging mode).

When charging, transient loads on the BAT pin can cause the PROG pin to fall below 100mV for short periods of time before the DC charge current has dropped to 1/10 of the programmed value. The 1ms filter time (T_{TERM}) on the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termination. Once the average charge current drops below 1/10 of the programmed value, the A4059 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 theBAT pin must be supplied by the battery.

The HP4059D6-42Y constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the Vfloat-0.15V(typically) recharge threshold (V_{RECHRG}), another charge cycle begins and current is once again supplied to the battery.

Charge status indicator(CHGb

The charge status output indicator is an open drain circuit. The indicator has two different states: pulldown (~10mA), and high impedance. The pull-down state indicates that the HP4059D6-42Y is in a charge cycle. High impedance indicates that the charge cycle is complete. The CHGb also can be used to detect the charge states by a microprocessor with a pull-up resistor.

Shutdown mode

The HP4059D6-42Y will be put into shutdown mode when the battery voltage is higher than the V_{CC} voltage or V_{CC}-V_{BAT} is less than V_{ASD}. This reduces the battery drain current to less than 0.5uA and the supply current to less than 36uA. A new charge cycle can be initiated when the V_{CC}-V_{BAT} is high than V_{ASD}.

The HP4059D6-42Y also be put into shutdown mode when V_{CC} voltage down to UVLO threshold. In this state, the CHGb pin is high impedance state. The CHGb pin is also in a high impedance state if the charge cycle is completed.

Automatic recharge

Once the charge cycle is terminated, the A4059 continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time (T_{RECHRG}). A charge cycle restarts when the battery voltage falls below delta V_{RECHRG} (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. CHGb output enters a pull-down state during recharge cycles.

ENb Control

The ENb is a low effective control logical pin, when it is below low threshold voltage, the HP4059D6-42Y is enabled to charge battery. The typical low threshold value is 0.75V when Enb is from high to low. HP4059D6-42Y is disabled to charge when it is higher than 1.5V, and the VCC’s current consumption is lower than 1uA in this condition.

Application informations

Stability considerations

The constant-voltage mode feedback loop is 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.

In constant-current mode, the PROG pin is in the feedback loop, not the battery. The constant-current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with program resistor values as high as 100kΩ. However, additional capacitance on this node reduces the maximum allowed program resistor thus it should be avoided.

Power dissipation

HP4059D6-42Y has low temperature coefficient, at higher temperatures, the charging current will decrease slightly. To -40℃~125℃ temperature range the change of the charging current is very small. Nearly all of this power dissipation is generated by the internal MOSFET. This is calculated to be approximately:

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

Maximum allowable power dissipation limited by the packaging format and cooling conditions in actual applications. For DFN1X1 package example, PD is not allowed to exceed 0.3W. For example, the worst case application of HP4059D6-42Y is V_{CC}=5.5V, V_{BAT}=3V, I_{BAT}=0.1A, so P_D=0.25W, it is safe. At charge cycle, the battery voltage is rising gradually, so the power dissipation is reduce accordingly. The power dissipation turns into heat, please take into consideration when designing system.

VCC bypass capacitor

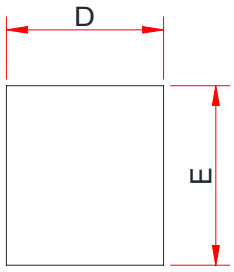
Many types of capacitors can be used for input bypass, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, a 10uF/16V ceramic capacitor is recommended for this bypass capacitor. Due to 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

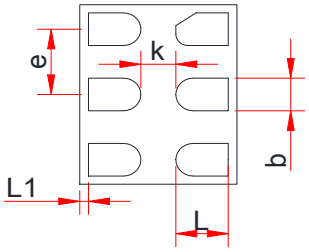
The HP4059D6-42Y includes a soft-start circuit to minimize the inrush current at the start of a charge cycle. When a charge cycle is initiated, the charge current ramps from zero to the full-scale current over a period of approximately 100us. This has the effect of minimizing the transient current load on the power supply during start-up.

Package Outline Dimensions

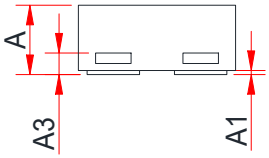
DFN1x1(TDFN-6L(1x1))



TOP VIEW



BOTTOM VIEW



SIDE VIEW

Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
A3		0.15 Ref.	
b	0.10	0.15	0.20
D	0.95	1.00	1.05
E	0.95	1.00	1.05
e		0.35 BSC	
L	0.30	0.40	0.50
L1		0.05 Ref.	
k		0.20 Ref.	

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