MPS Battery Management Product Line

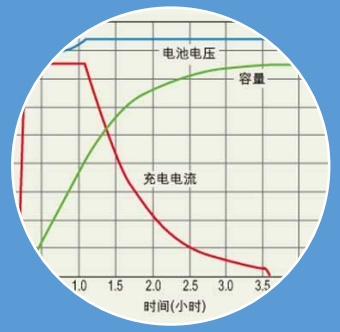
充电管理IC的重要参数解析及
带NVDC路径管理开关充电IC的工作机制

May. 2019

https://www.monolithicpower.com/Company/Contact-Us

For Live Broadcasting Only

电池管理三类应用



Charger IC

Analog Front End

Fuel Gauge

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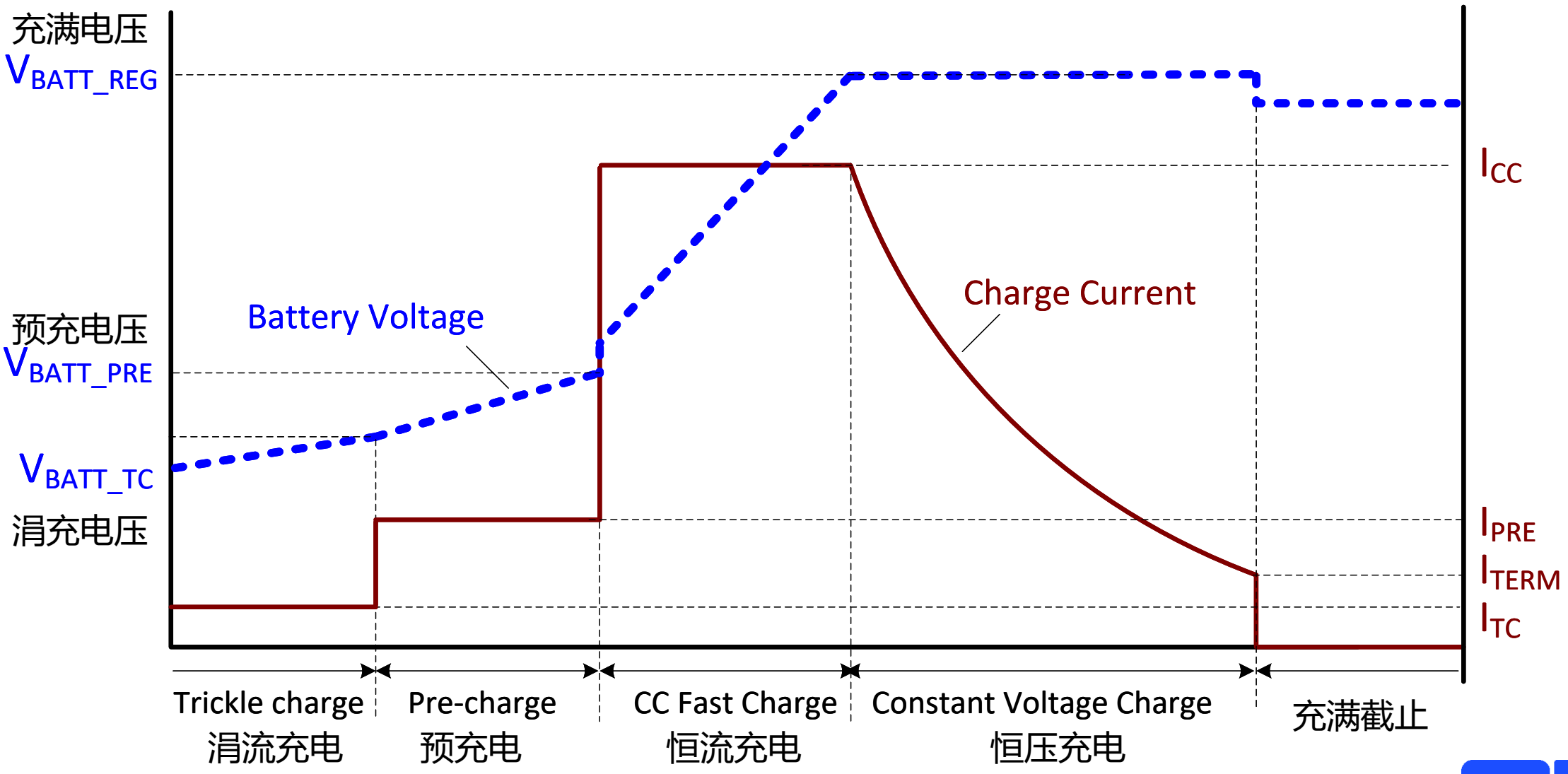
锂离子电池充电曲线



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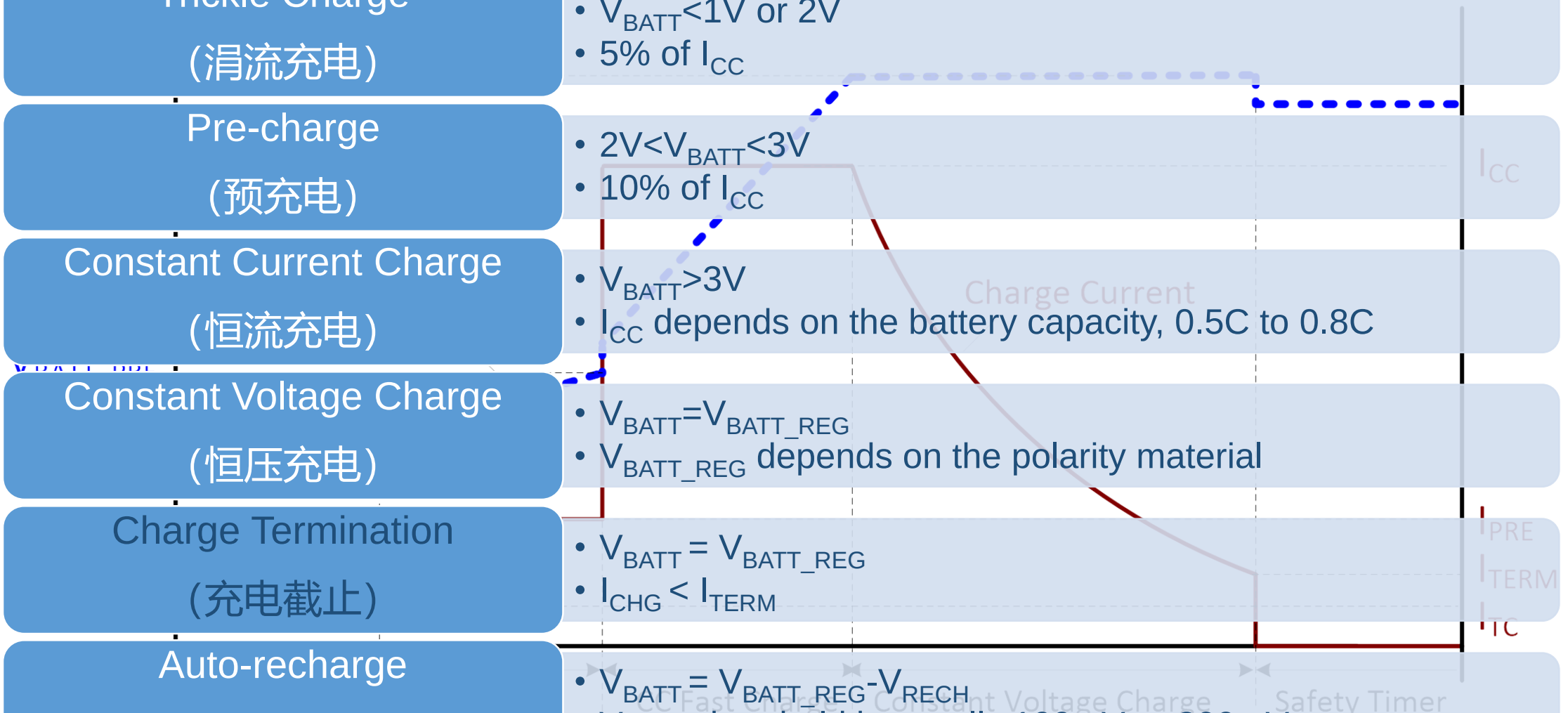
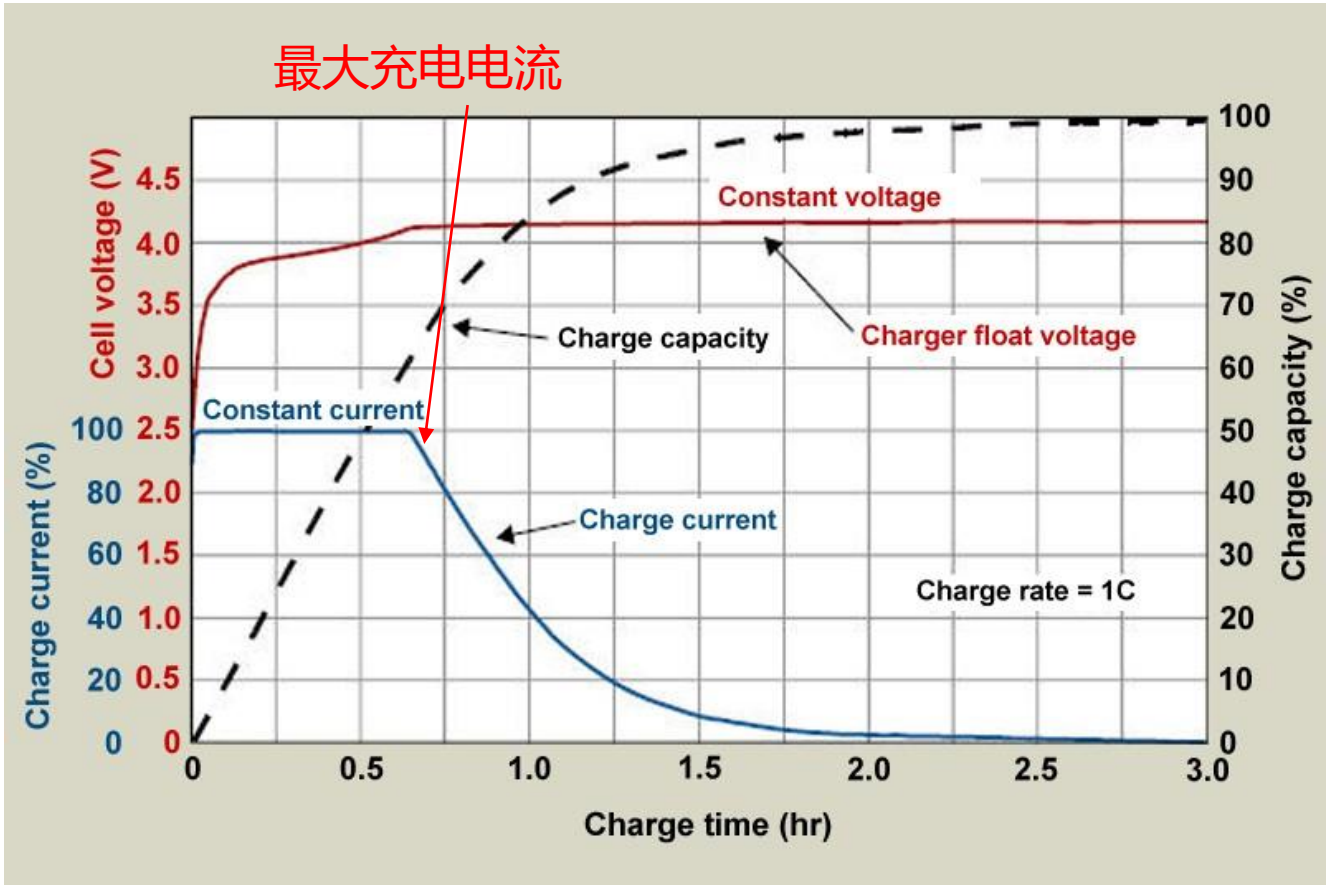
锂离子电池充电参数

Trickle Charge (涓流充电)	• V_{BATT}<1V or 2V • 5% of I_{CC}
Pre-charge (预充电)	• 2V<V_{BATT}<3V • 10% of I_{CC}
Constant Current Charge (恒流充电)	• V_{BATT}>3V • I_{CC} depends on the battery capacity, 0.5C to 0.8C
Constant Voltage Charge (恒压充电)	• V_{BATT}=V_{BATT_REG} • V_{BATT_REG} depends on the polarity material
Charge Termination (充电截止)	• V_{BATT} = V_{BATT_REG} • I_{CHG} < I_{TERM}
Auto-recharge (自动复充)	• V_{BATT} = V_{BATT_REG}-V_{RECH} • V_{RECH} threshold is usually 100mV or 200mV



恒流充电电流的选择

- 在许多情况下，电池组制造商会用“C”来指定最大充电电流。这等于电池组的容量(以毫安时为单位)除以一小时。那么，一个3360mAh的电池可以用1C充电的话，恒流充电电流即为3.36A。



充电管理IC特征的四个维度

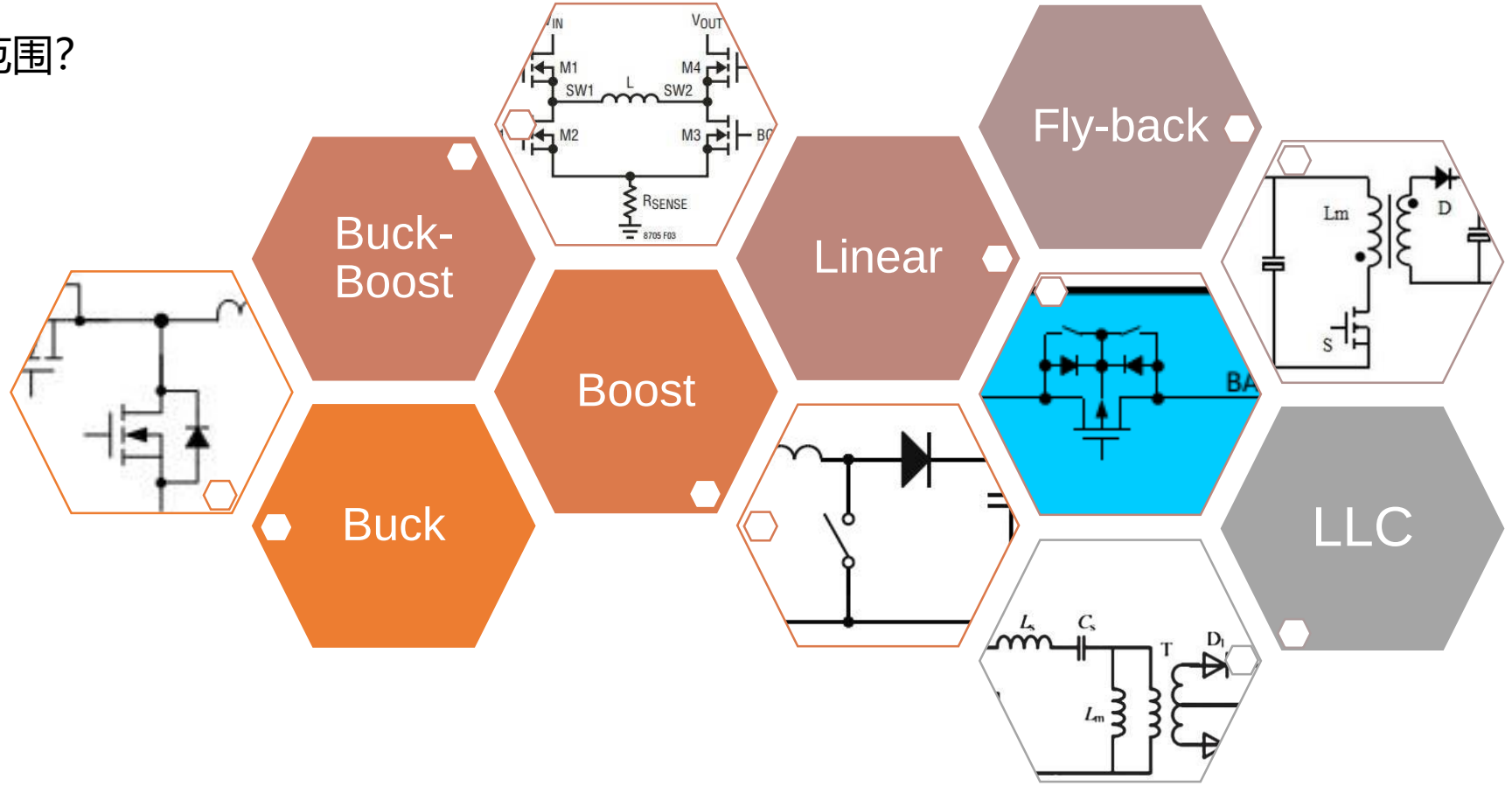
因素1：拓扑

充电IC的拓扑

几节电池串联?

输入电压范围?

充电功率?



工作电压范围:电源类型

- 大多数便携式设备从USB端口充电，有以下几种类型
  - USB-A:通常5V @ 1.5A最大，但可以支持快速充电和其他标准高达12V
  - USB-C: 5V @ 3A最大，但如果USB-PD是支持的，这可以增加到20V @ 5A
- 如果设备通过USB充电，它必须始终支持5V操作，这意味着充电器IC拓扑必须能够支持这个操作。
  - 例如，对于2s电池(最大Vbatt >= 8.4V)，需要使用boost或buck-boost拓扑
- 如果设备不从USB充电，那么几乎总是一个降压拓扑可以使用，因为输入电压将总是高于电池电压。

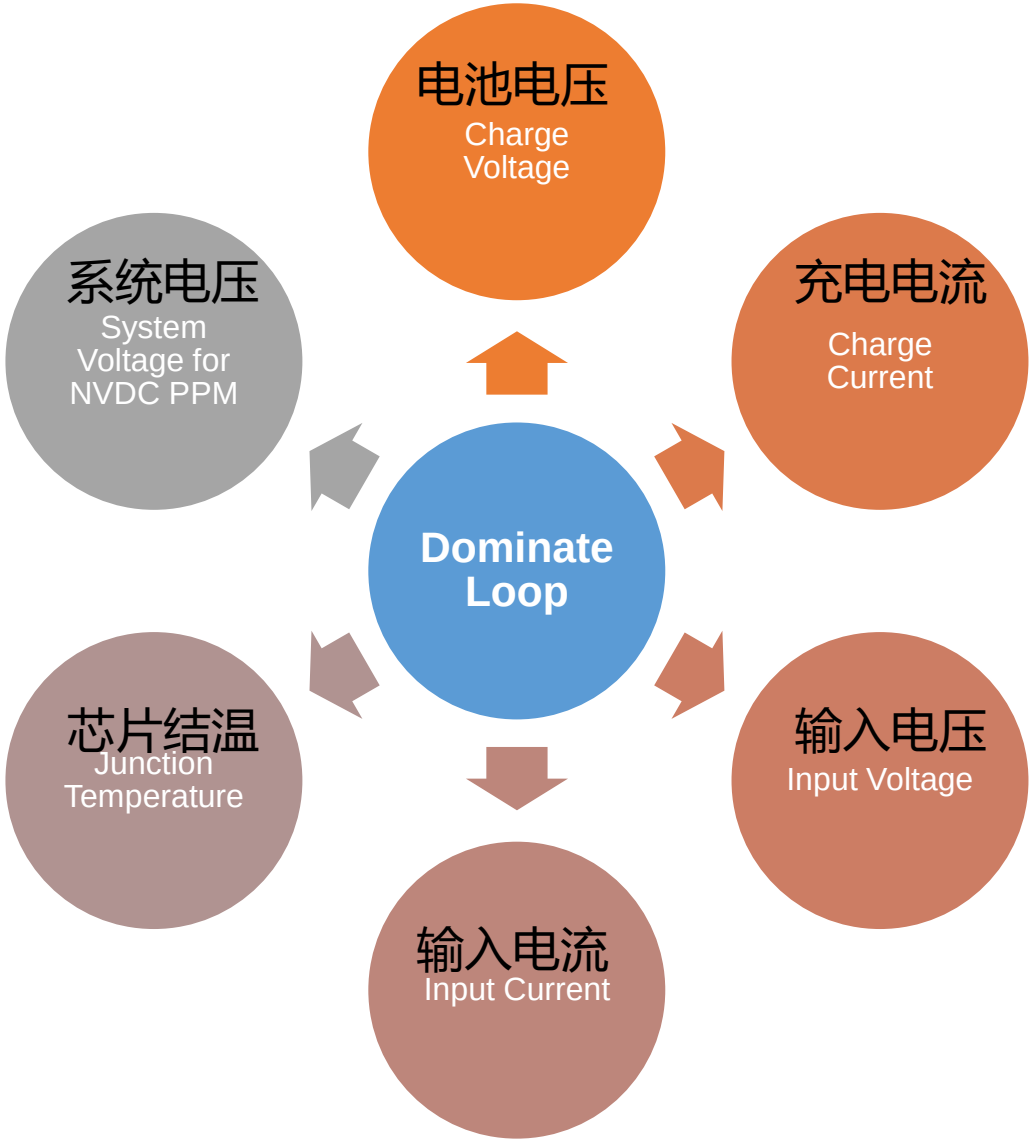
USB-C

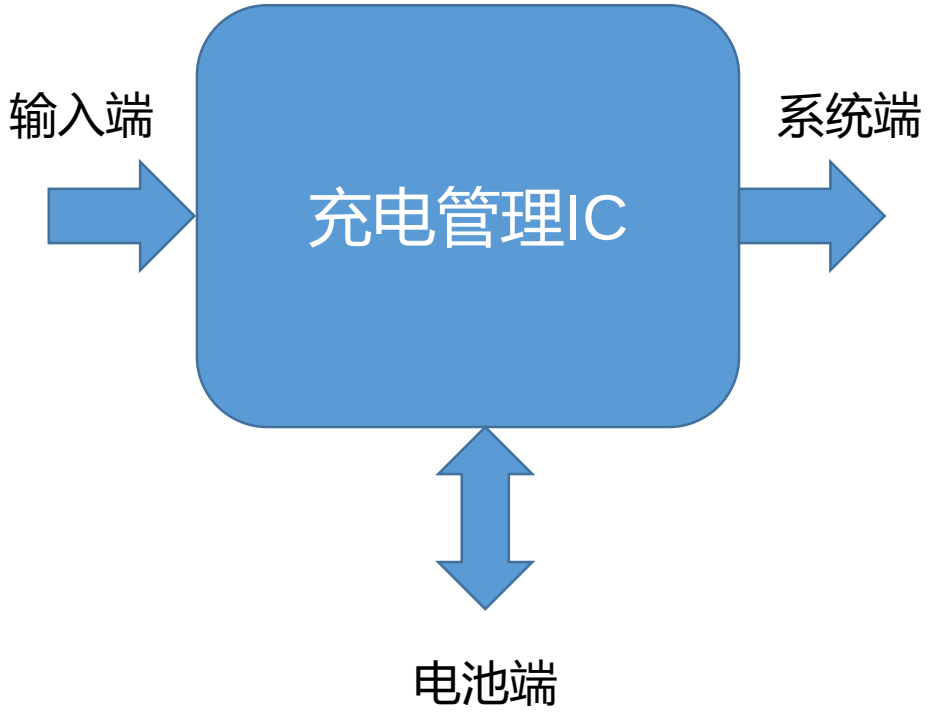
USB-A

Barrel Jack

因素2：控制环路

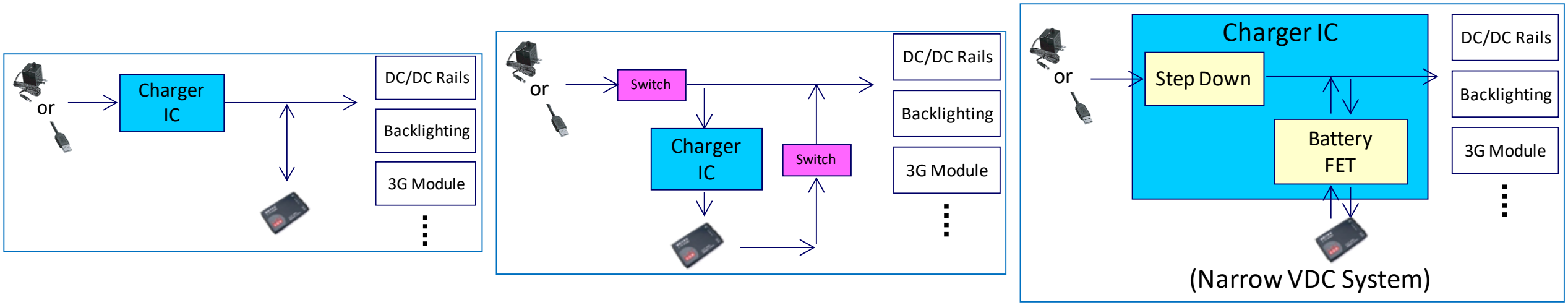
充电管理IC的环路控制





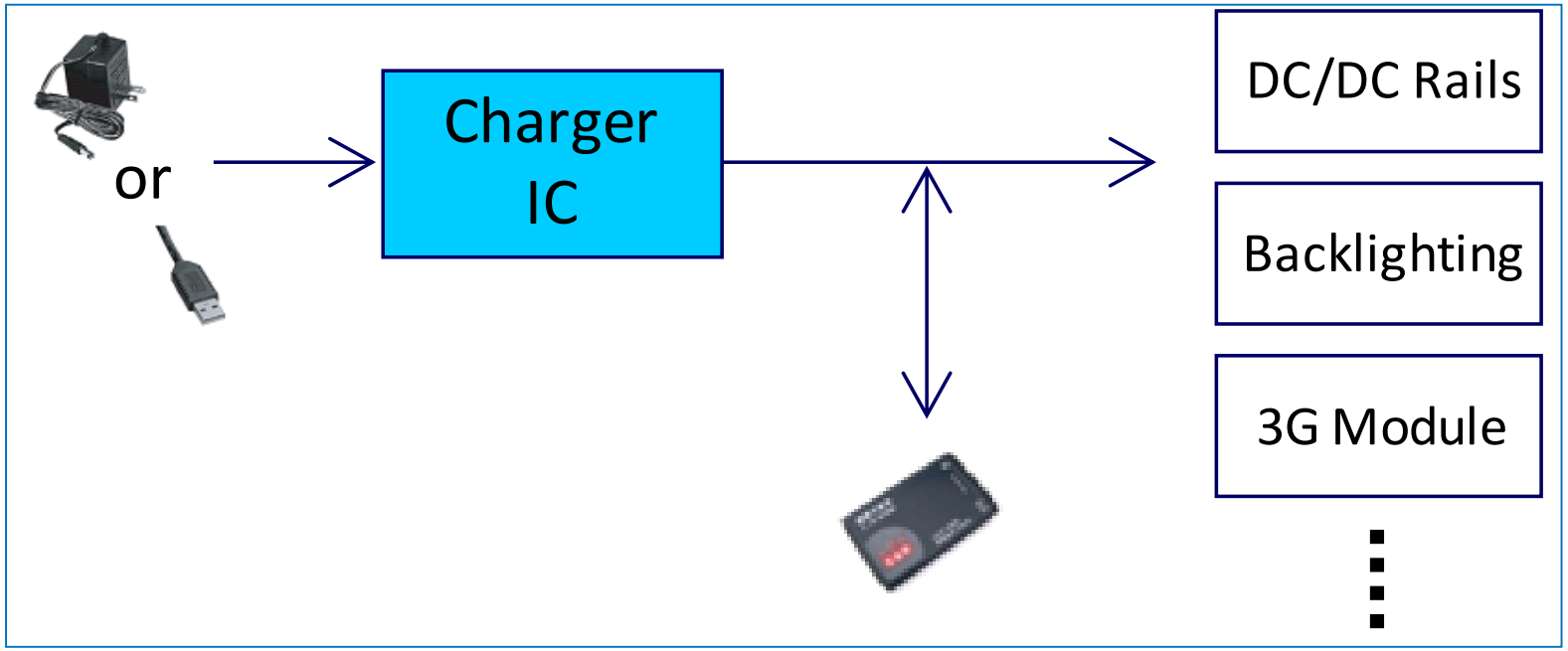
因素3：路径管理

路径管理策略



Battery Feed	Pass Through/ OR Selector	NVDC
电池直供	旁路模式	Narrow Voltage DC (窄直流电压调节)

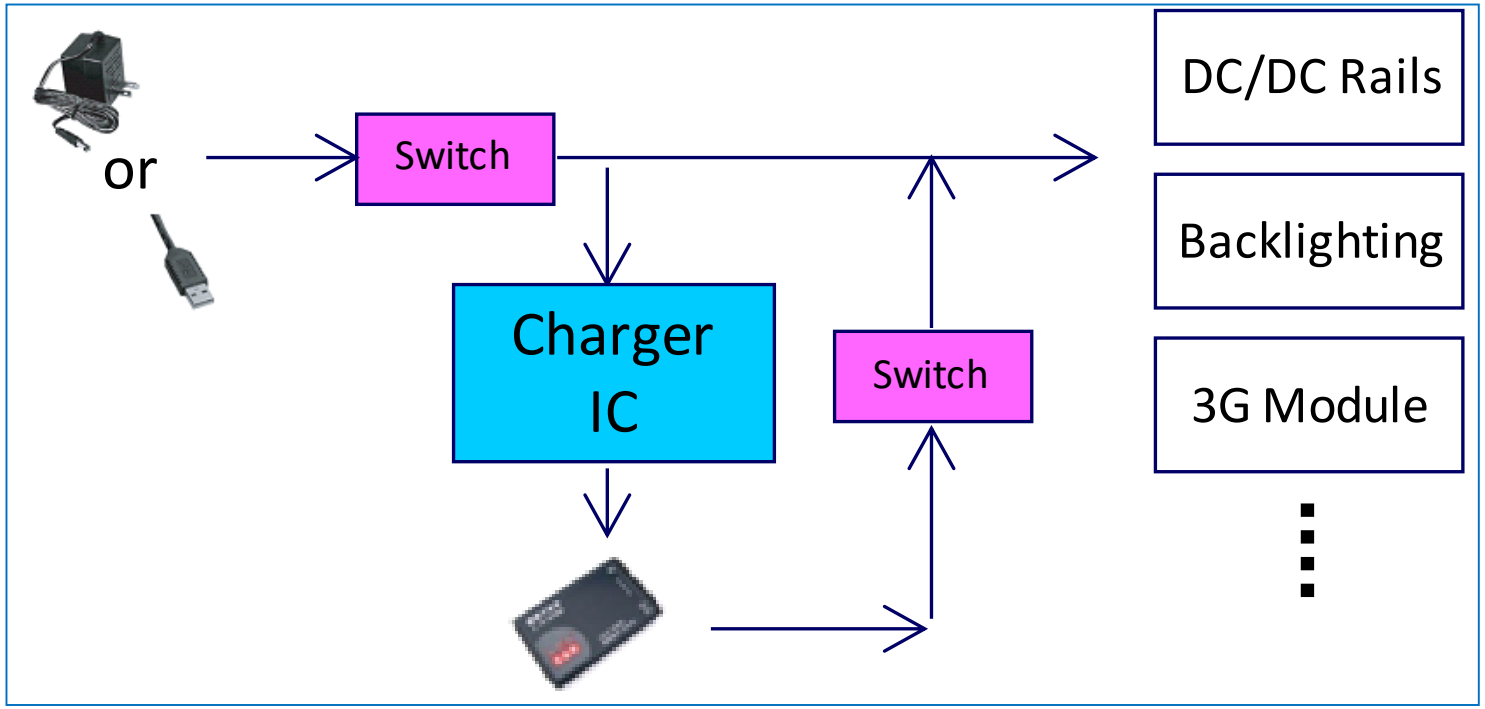
路径管理 – 电池直供



☹低压电池不能使系统立即启动

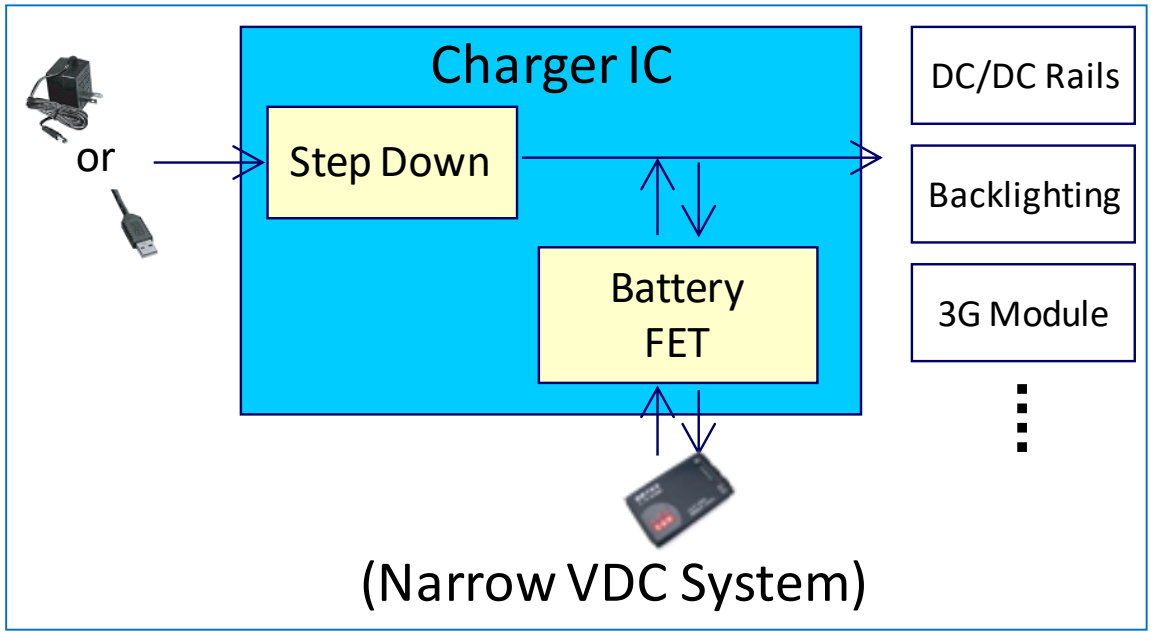
☹由于系统端的持续耗电，如蓝牙、WIFI等，电池会频繁充电甚至不充电。

路径管理 – 旁路模式



☹当有输入时，系统电压等于输入电压，这意味着系统需要容忍输入的最大电压。
☹当输入过载时，电池很难作为系统的补充。适配器的功率需要覆盖系统的峰值功率。

路径管理 – NVDC 模式



☺ 最小系统电压调节使用低压电池可瞬间启动
☺ 系统始终跟随电池电压，以减小系统各部件的电压应力。
☺ 当输入功率有限时，电池可以作为系统的补充。
☺ 系统可以从电池断开，以支持运输模式

因素4：反向工作

USB On-the-Go and USB PD Source Mode

Battery Charging Specification

Revision 1.2

December 7, 2010

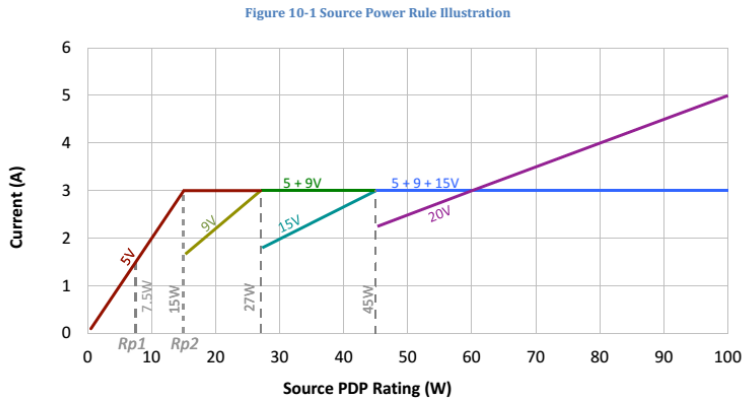
Parameter	Symbol	Conditions	Min.[5]	Max5	Units	Ref
VBUS Voltage:						
VBUS Average Voltage (low power)[6]	VA_VBUS_AVG_LO	IA_VBUS_RATED ≤ 100 mA	4.4	5.25	V	4.2.1

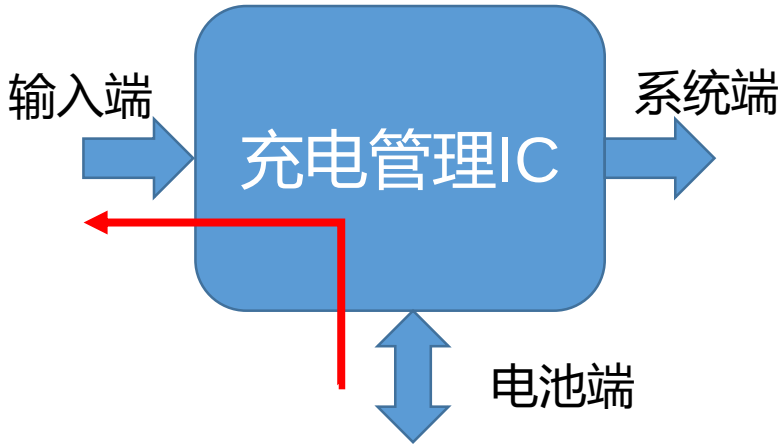
On-The-Go: An OTG product is a portable device that uses a single Micro-AB receptacle (and no other USB receptacles) to operate at times as a USB Targeted Host and at times as a USB peripheral. OTG devices must always operate as a standard peripheral when connected to a standard USB host.

Universal Serial Bus

Power Delivery Specification

2.7.4.1 Source





Each Provider will contain one or more Sources that are shared between one or more ports. These Sources are controlled by the Local Policy. Sources start up in USB Default Operation where the Port applies ***vSafe0V*** or ***vSafe5V*** on V_{BUS} and return to this state on Detach or after a Hard Reset. If the Source applies ***vSafe0V*** as their default, it detects Attach events and transitions its output to ***vSafe5V*** upon detecting an Attach.

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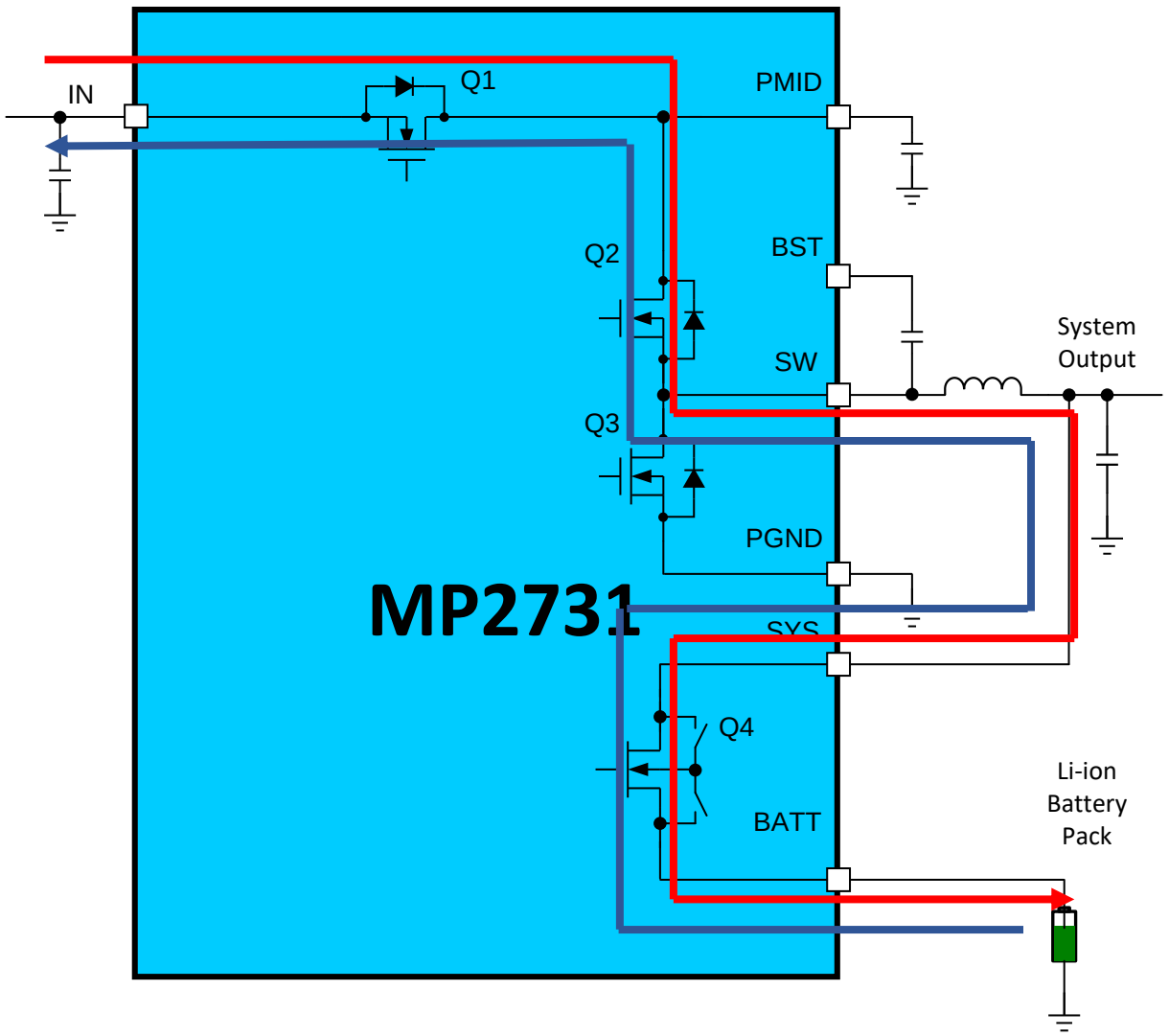
Charger IC Matrix

Battery Management Product Families

Product Family (Type)	Number of Series Cells	Input Type	Input Voltage	Max Charge Current	Power Path?	Example Product
1s Linear Charger	1	USB	5V	< 1A	No	MP26029
1s Linear Charger with Power Path	1	USB	5V	< 1A	Yes	MP2662
1s Buck Charger	1	USB	5V	>= 1A	No	MP2615
1s Buck Charger with Power Path	1	USB	5V	>= 1A	Yes	MP2723
1s High Vin Buck Charger	1	USB PD or other (barrel)	> 5V	>= 1A	No	MP2695
1s High Vin Buck Charger with Power Path	1	USB PD or other (barrel)	> 5V	>= 1A	Yes	MP2731
Boost Charger	2	USB	5V	>= 1A	No	MP2639C
Boost Charger with Power Path	2	USB	5V	>= 1A	Yes	MP2672
>=2s Buck Charger	>=2	Other (barrel)	> 5V	>= 1A	No	MP2659
>=2s Buck Charger with Power Path	>=2	Other (barrel)	> 5V	>= 1A	Yes	MP2759
Buck-Boost Charger	>=2	USB PD	> 5V	>= 1A	No	MP2651
Buck-Boost Charger with Power Path	>=2	USB PD	> 5V	>= 1A	Yes	MP2760

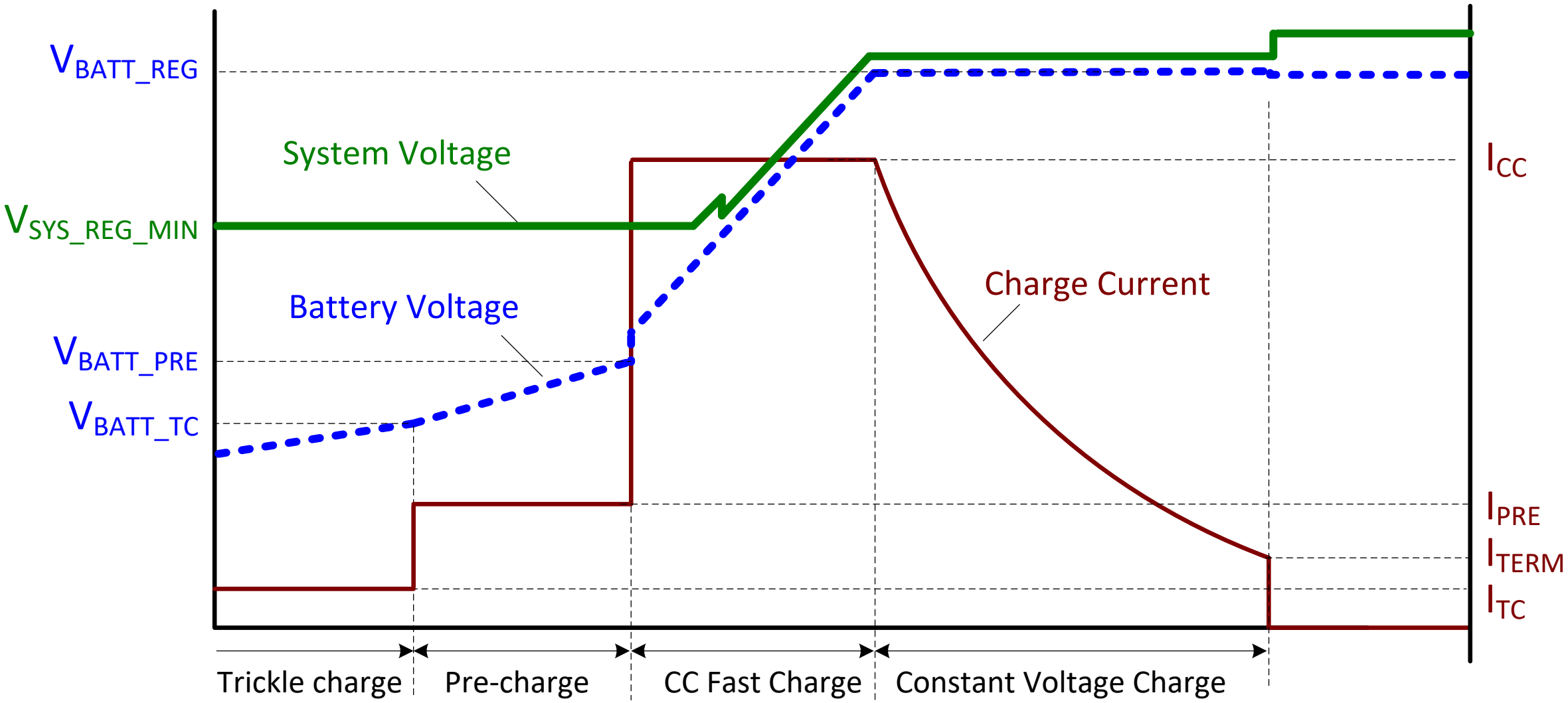
MP2731 Family



Topology	→	Buck
Power path	→	BFET for NVDC
Bi-direction	→	OTG Mode
Loops	→	Six + Two Loops

- 功率管全集成
- 支持快充和PD输入电压
- 输入DM/DP检测
- NVDC 路径管理
- 可编程NTC保护
- 反向OTG工作模式
- 支持运输模式
- I2C 控制/集成ADC

Charge Profile of NVDC Charger



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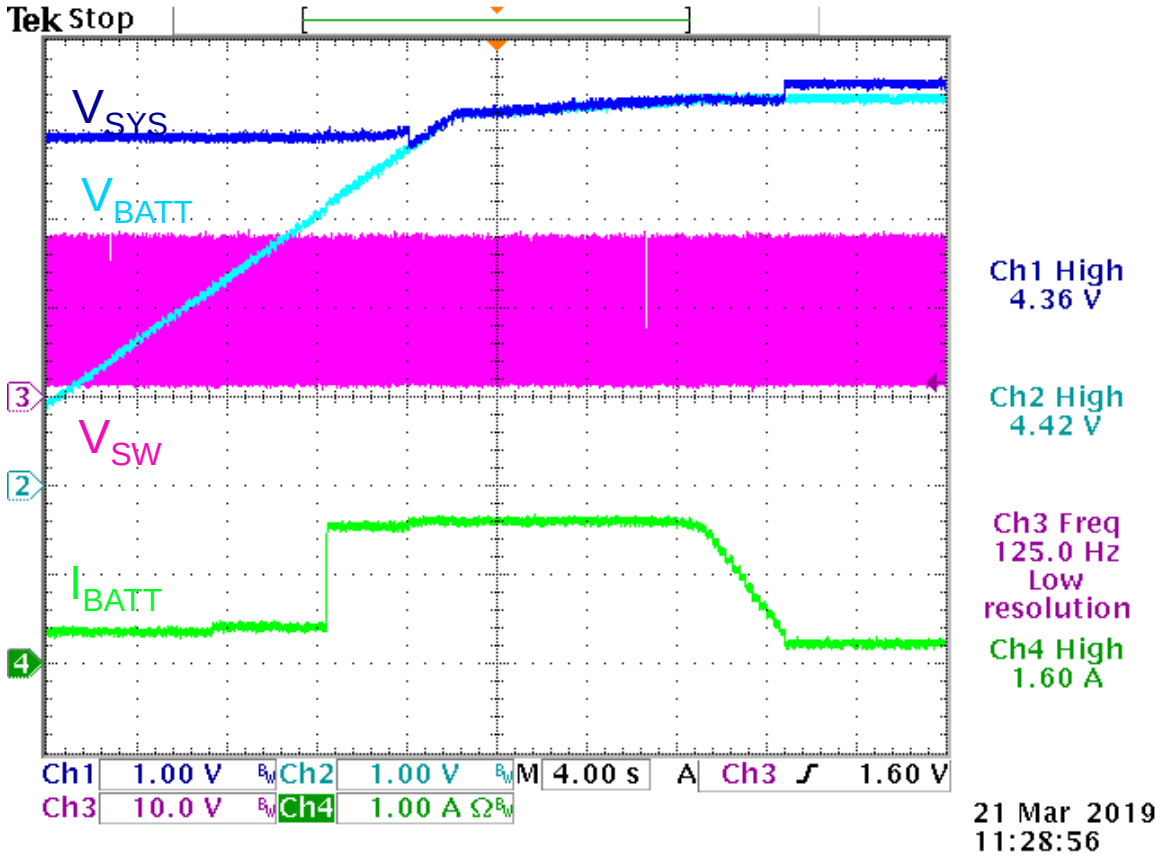
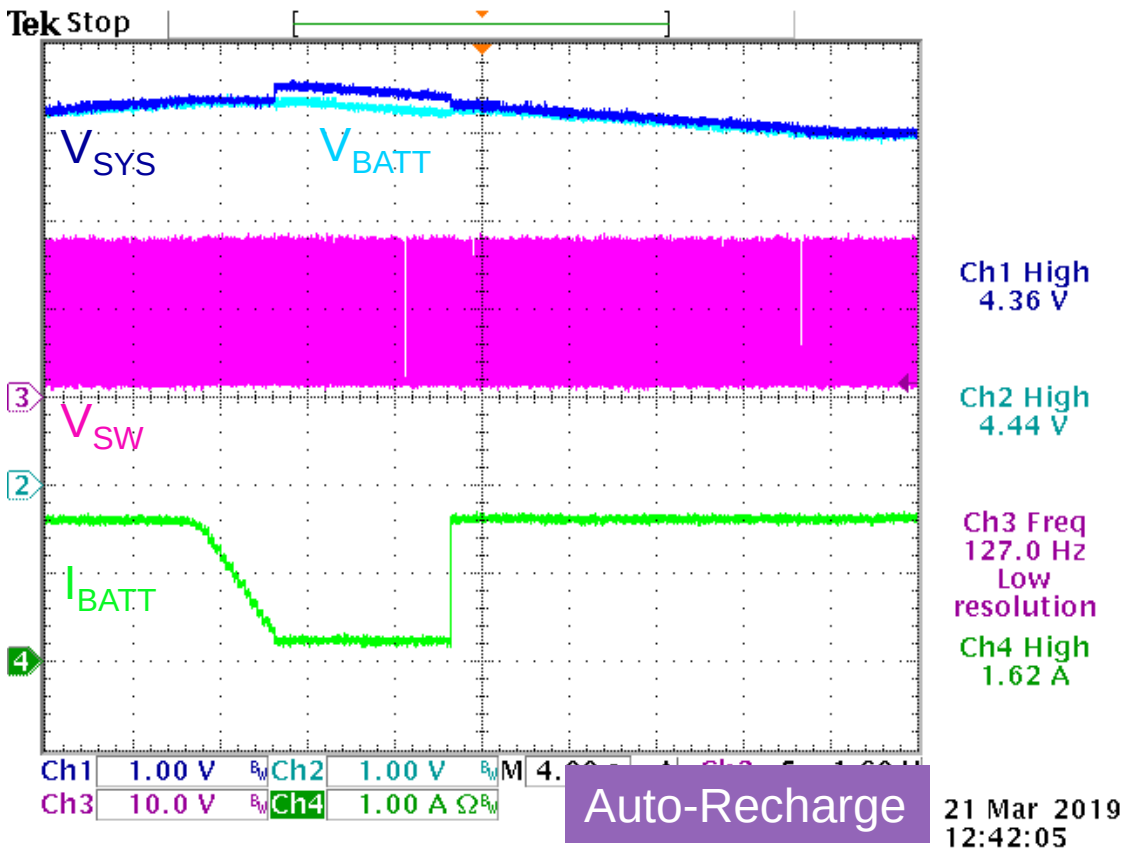
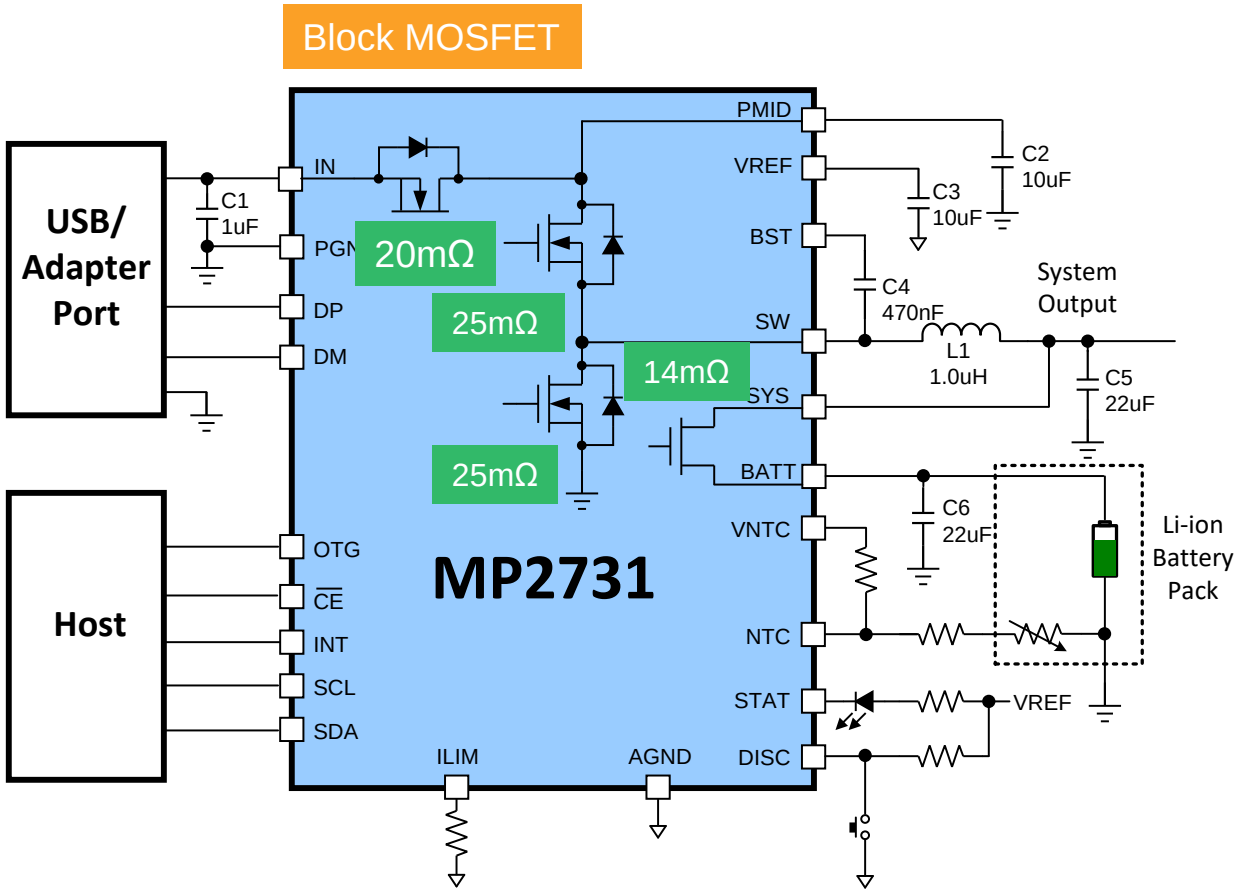
典型充电曲线

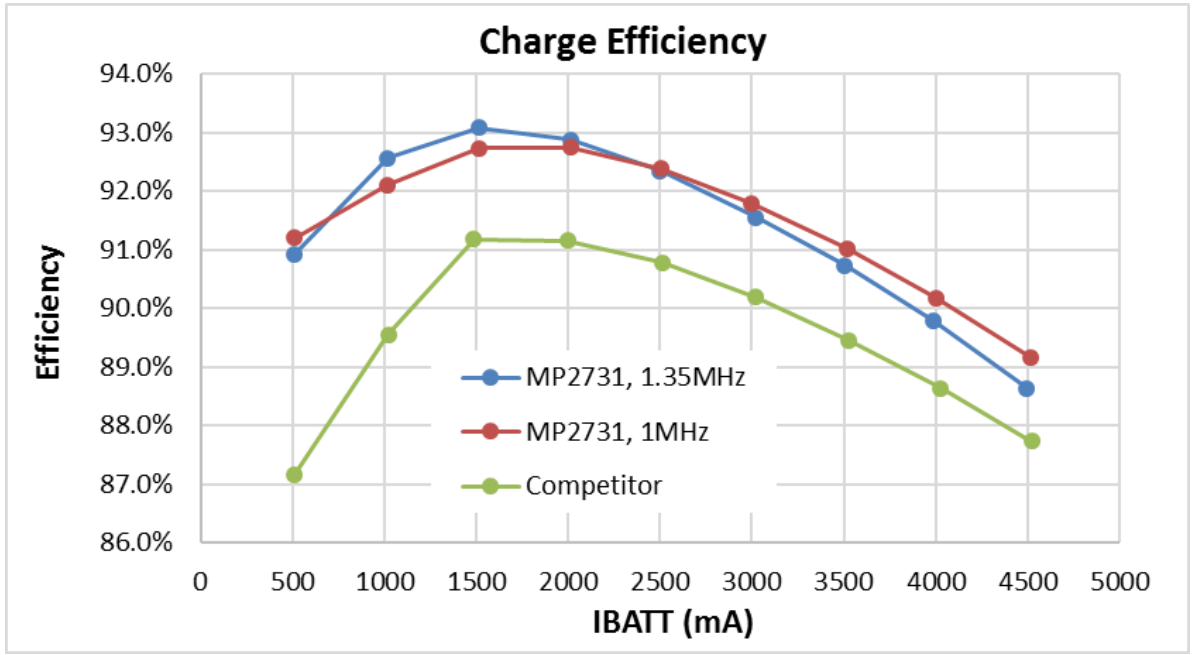
工作条件：V_{IN}=16V, V_{BATT} ramp from 0V, I_{CHG}=1.84A, I_{SYS}=1A



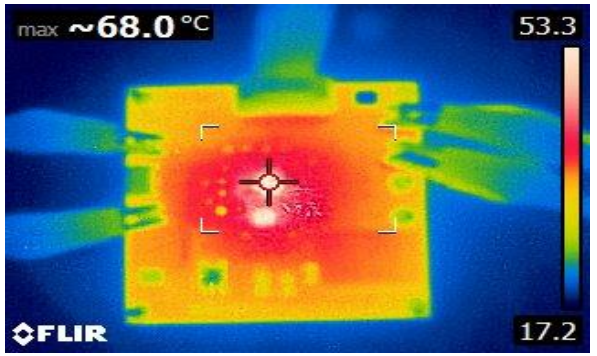


MP2731 效率与热性能

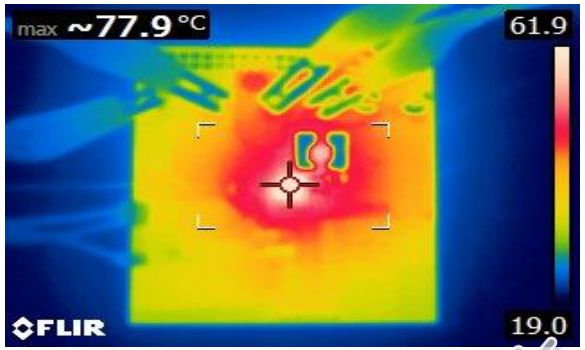




MP2731



Competitor



V_{IN}=9V, V_{BATT}=3.8V, I_{BATT}=4.5A, Ta=17°C

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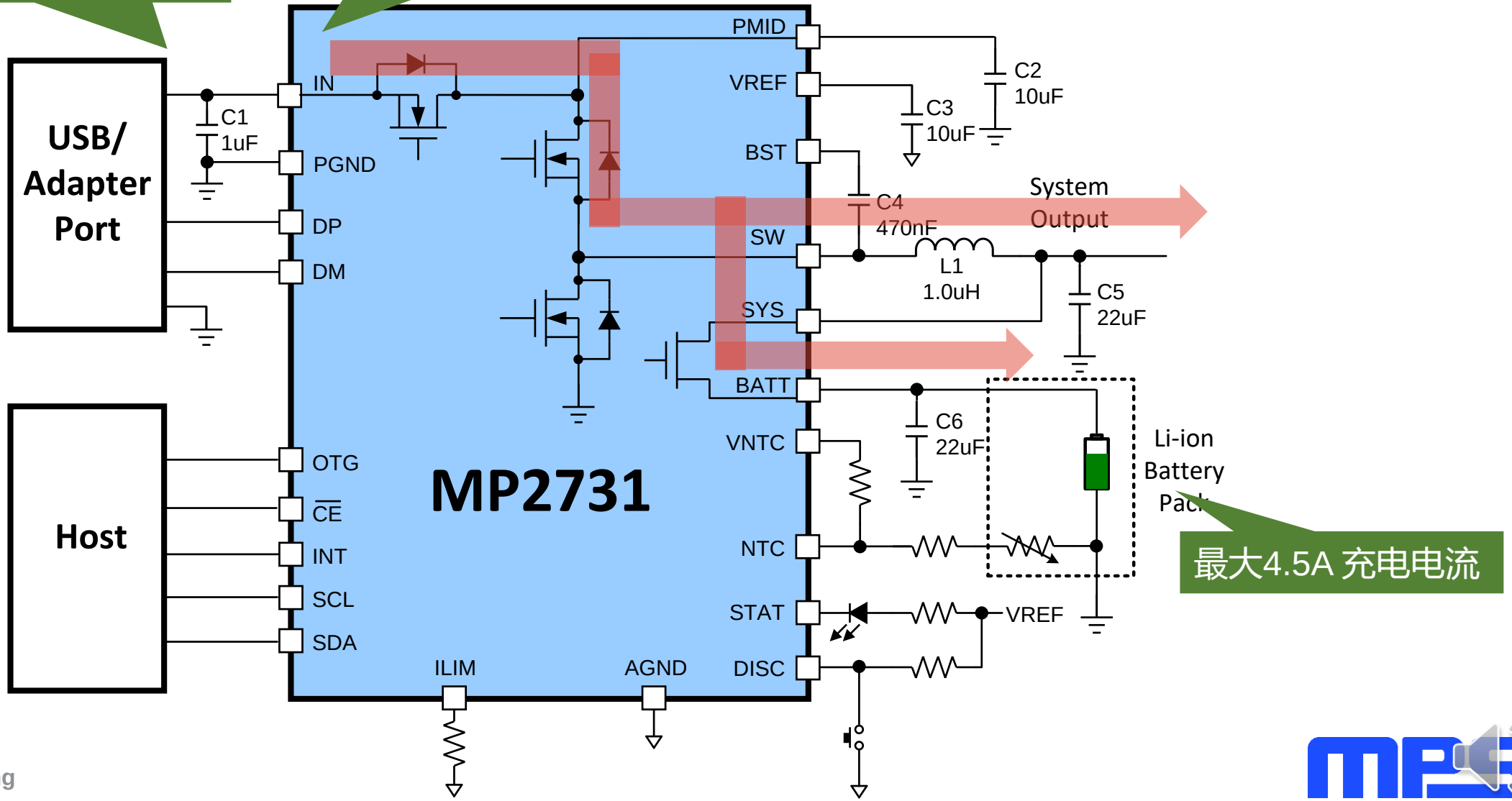
MP2731 典型性能介绍

3.7V to 16V 工作电压
22V 耐受电压

最大3A 输入电流限制



最大4.5A 充电电流

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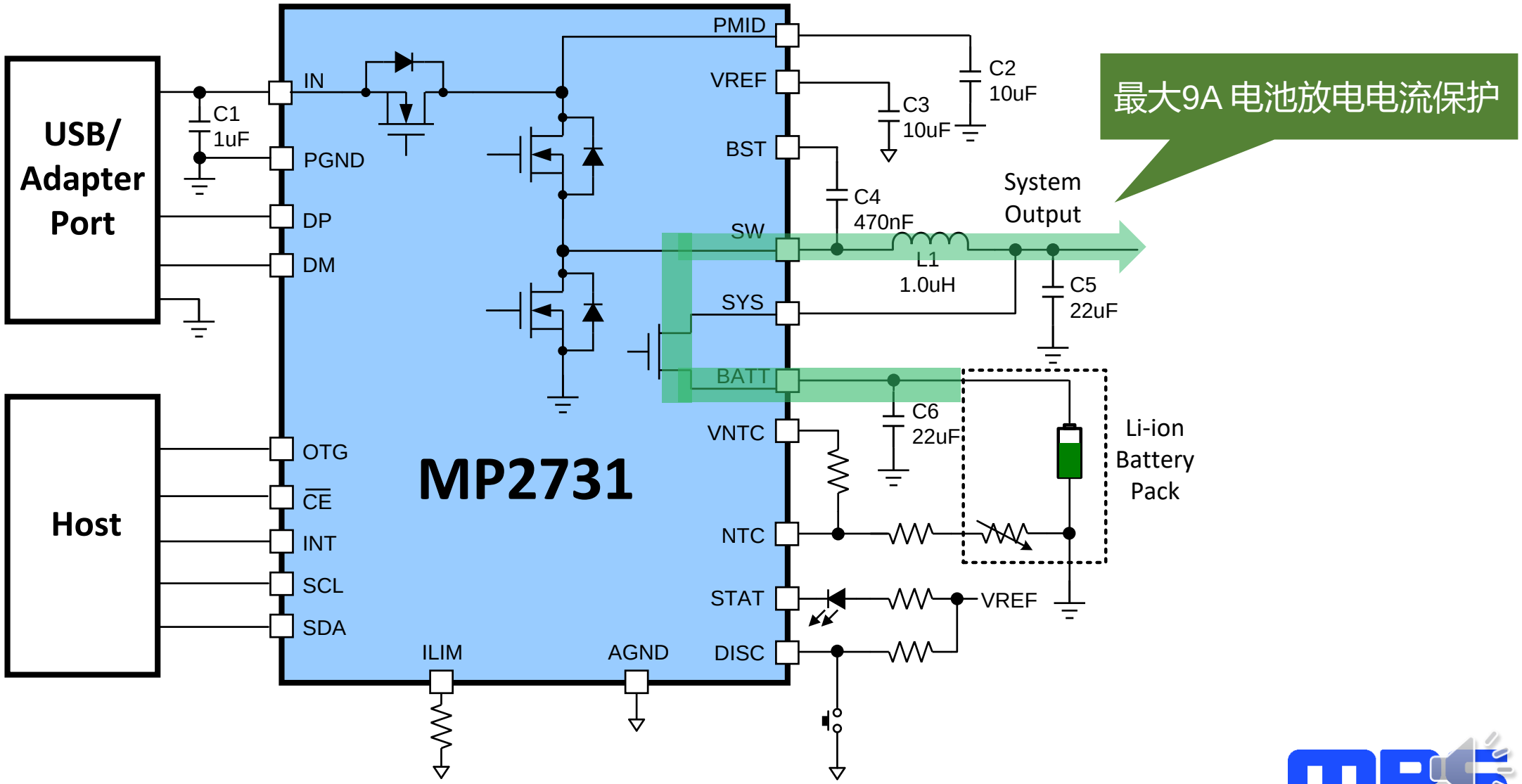
MP2731 典型性能介绍



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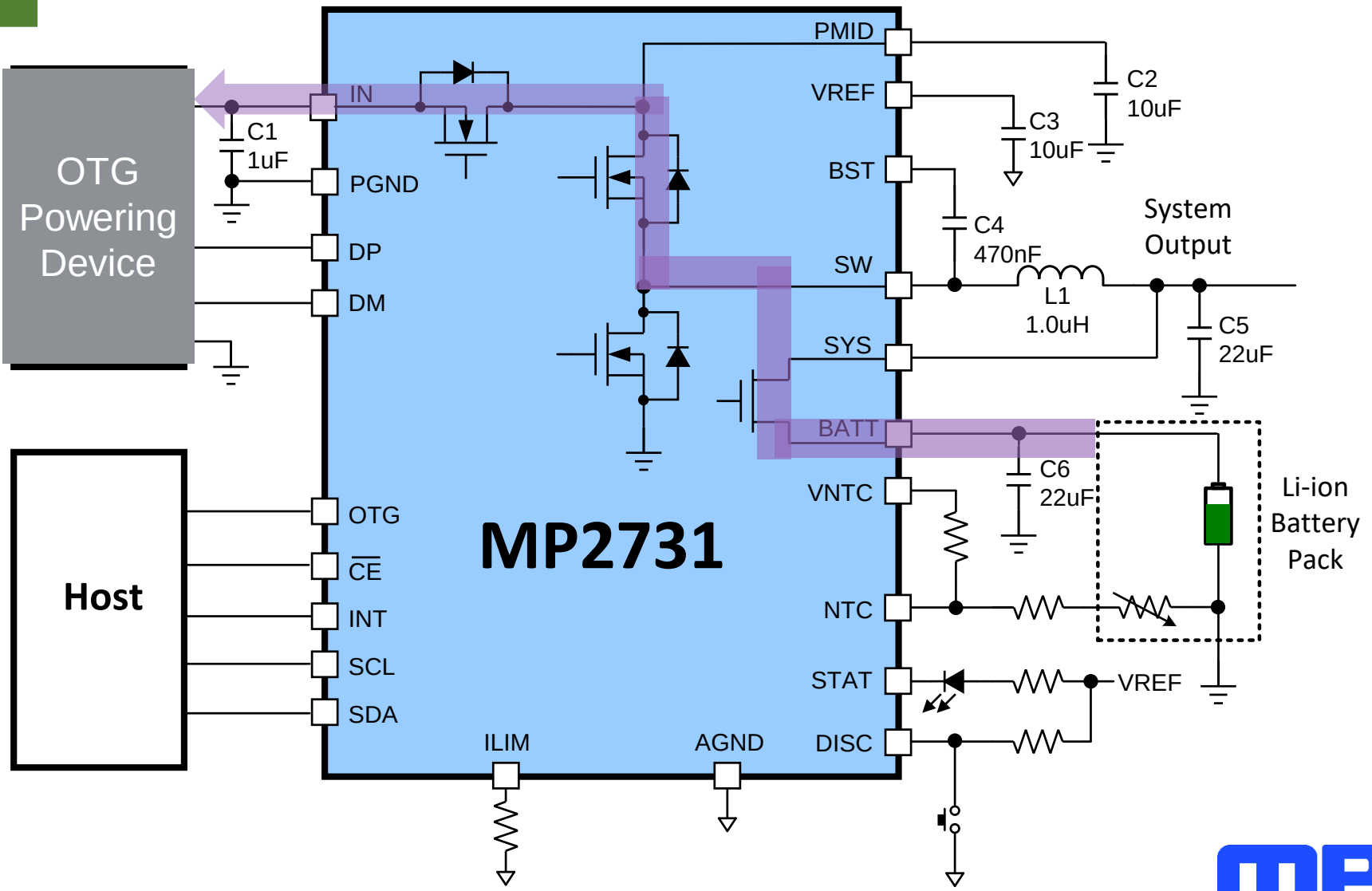
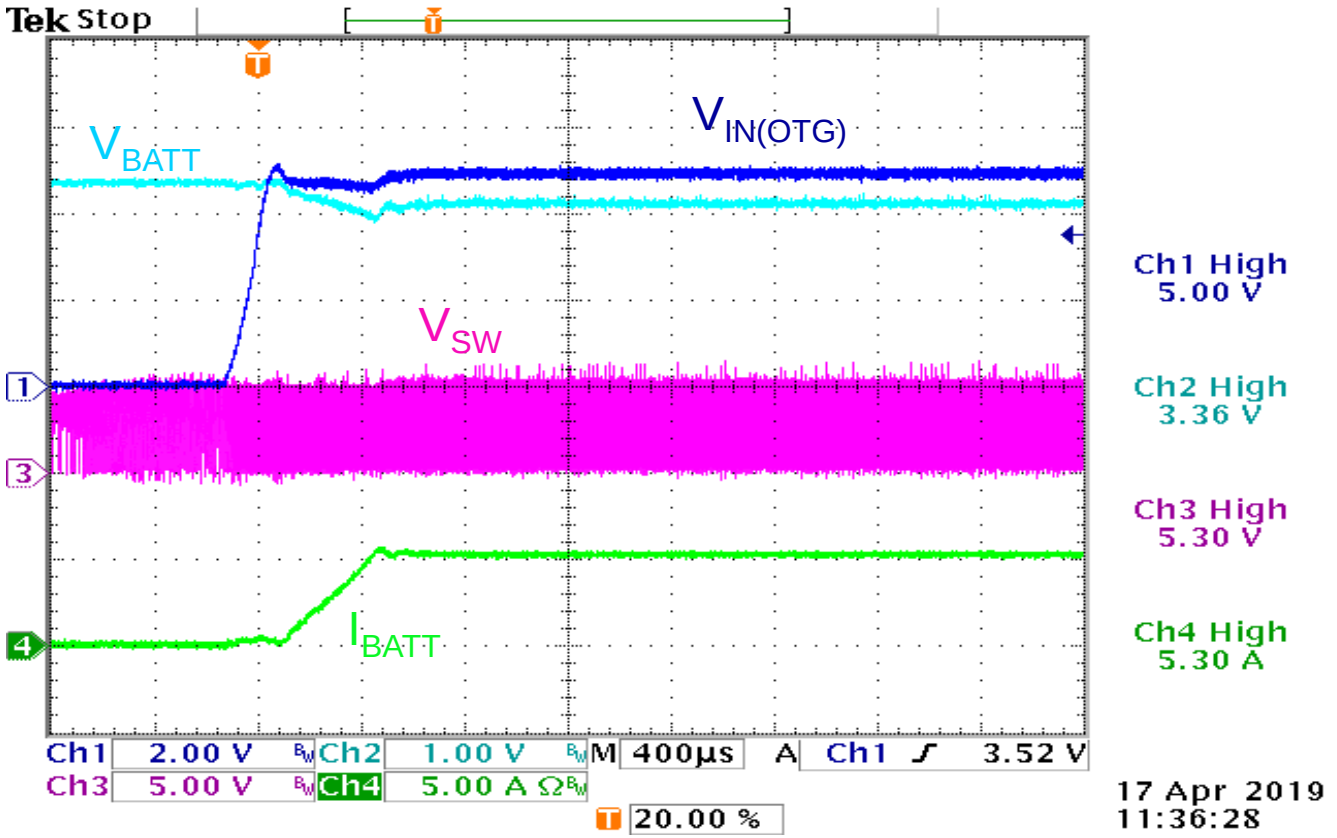
MP2731 Introduction –OTG Mode

4.8V to 5.5V OTG 输出电压
0.5A to 3.0A OTG 输出限流



OTG启动

工作条件： $V_{IN(OTG)}$=5V, V_{BATT}=3.3V, I_{OTG}=2.9A

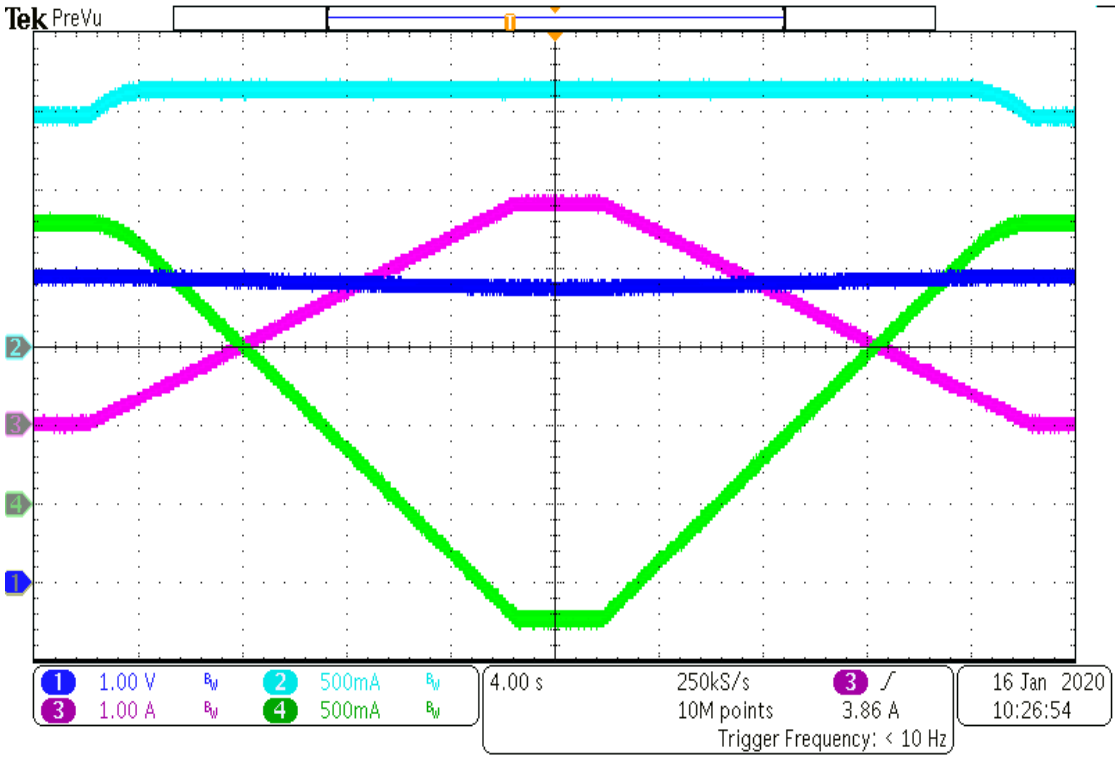


路径管理性能

Input Current Limit

V_{IN}=5V, V_{BATT}=3.8V, I_{IN_LIM}=1800mA

VSYS | IIN | ISYS | IBATT

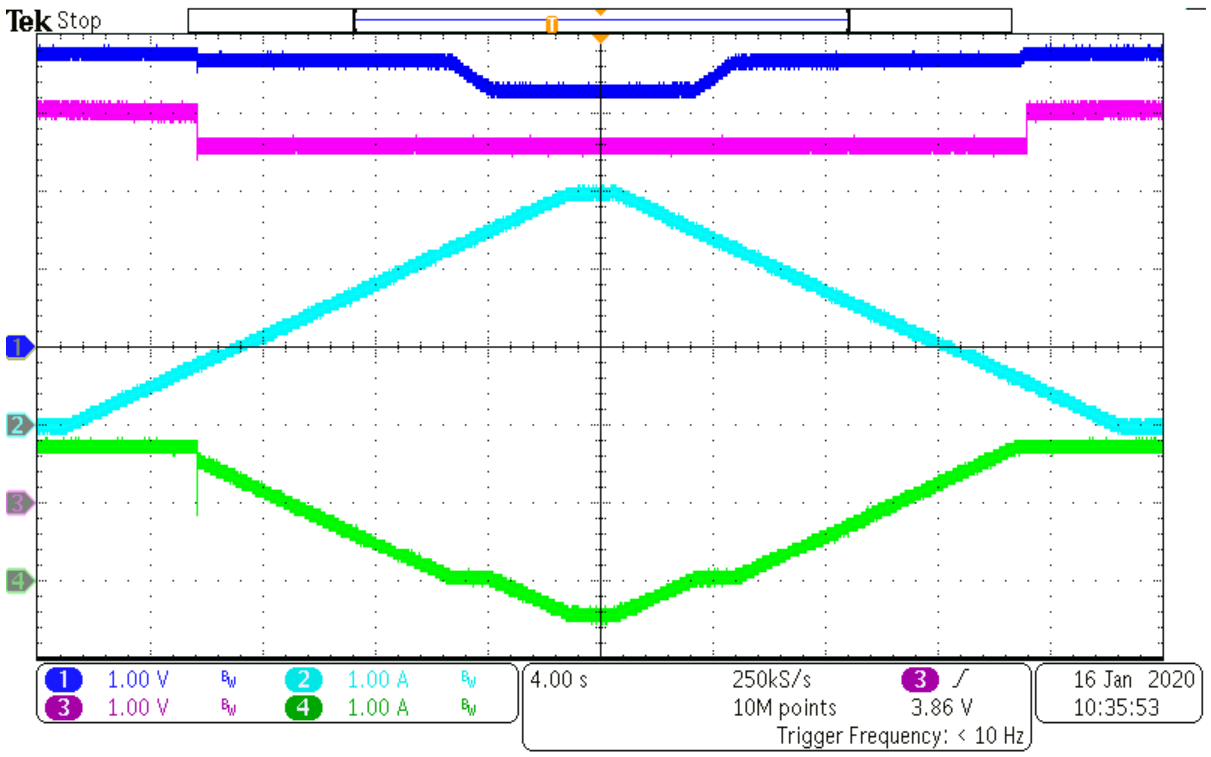


MDO3014 - 10:34:17 1/16/2020

Input Voltage Limit

V_{IN}=5V(2A), V_{BATT}=3.3V, V_{IN_MIN}=4.6V

VSYS | ISYS | VIN | IBATT



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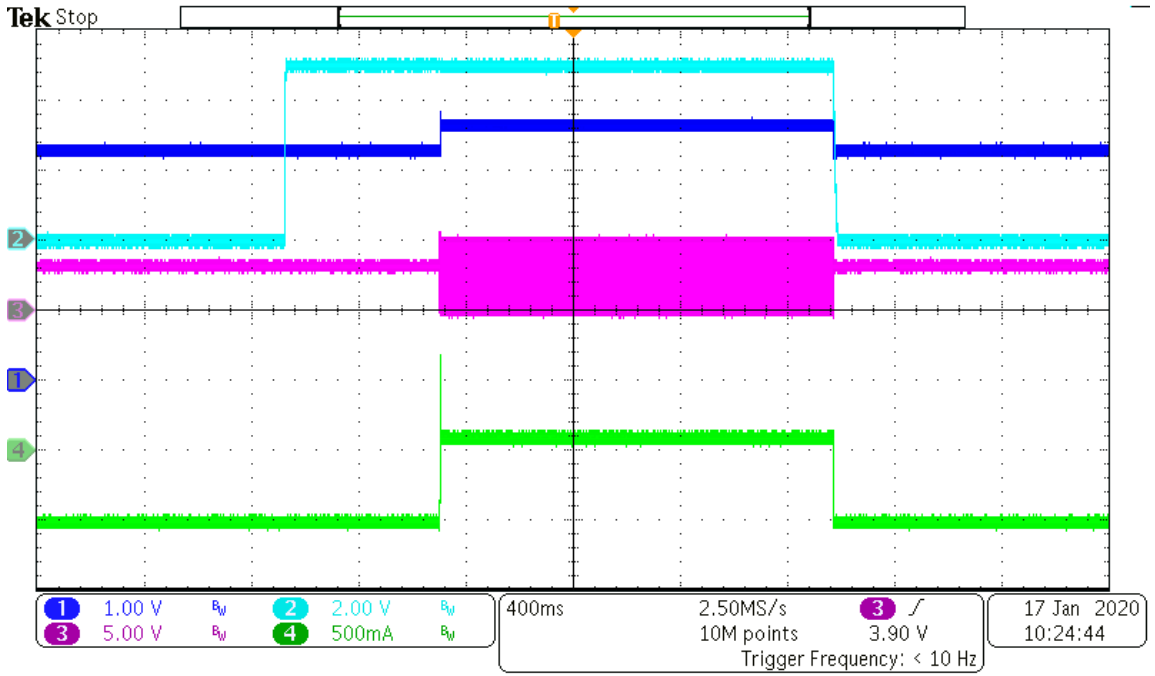
路径管理

Power On/Off Waveform

V_{IN}=5V, I_{IN_LIM}=500mA, V_{BATT}=3.8V, I_{SYS}=2.5A

VSYS VIN VSW IBATT

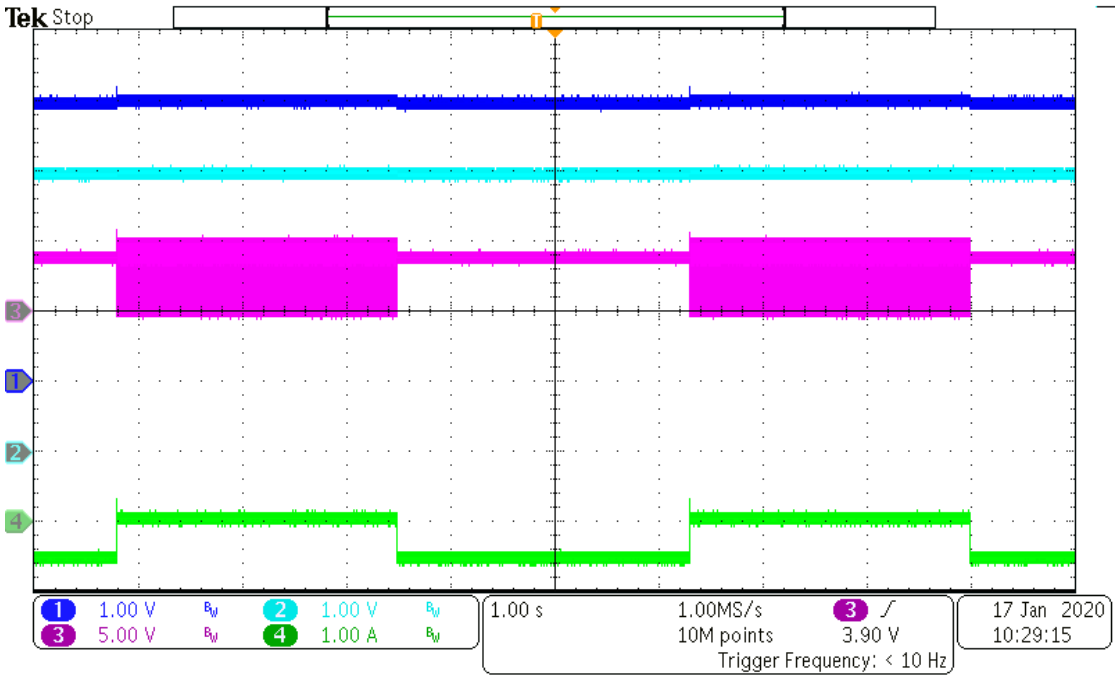


MDO3014 - 10:32:11 1/17/2020

Suspend Mode On/Off

V_{IN}=5V, I_{IN_LIM}=500mA, V_{BATT}=4.0V, I_{SYS}=0.5A

VSYS VBATT VSW IBATT



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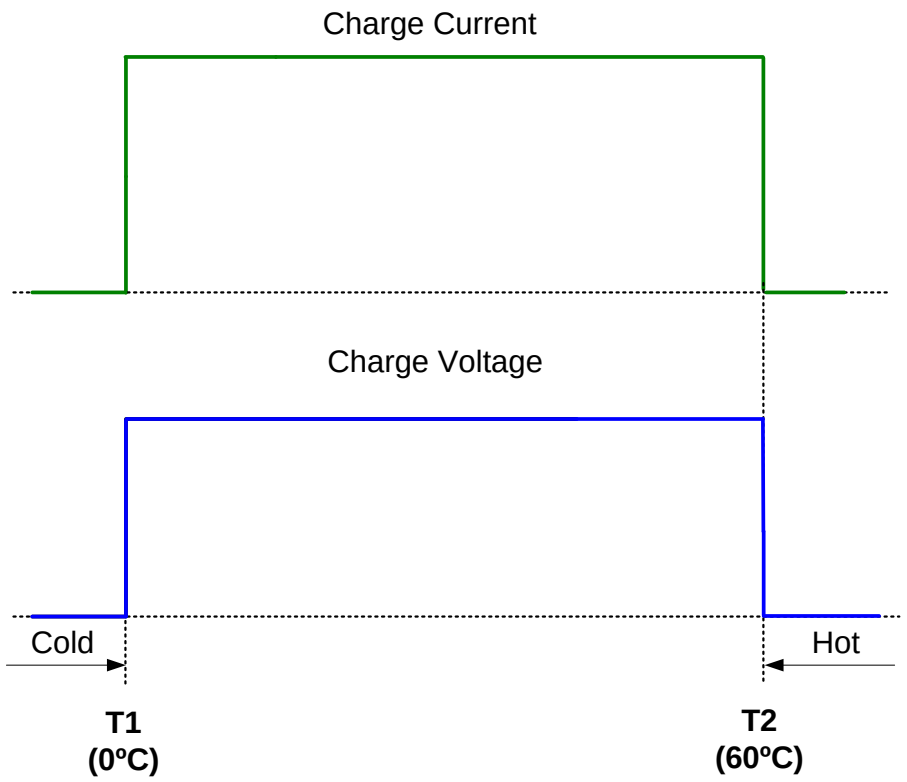
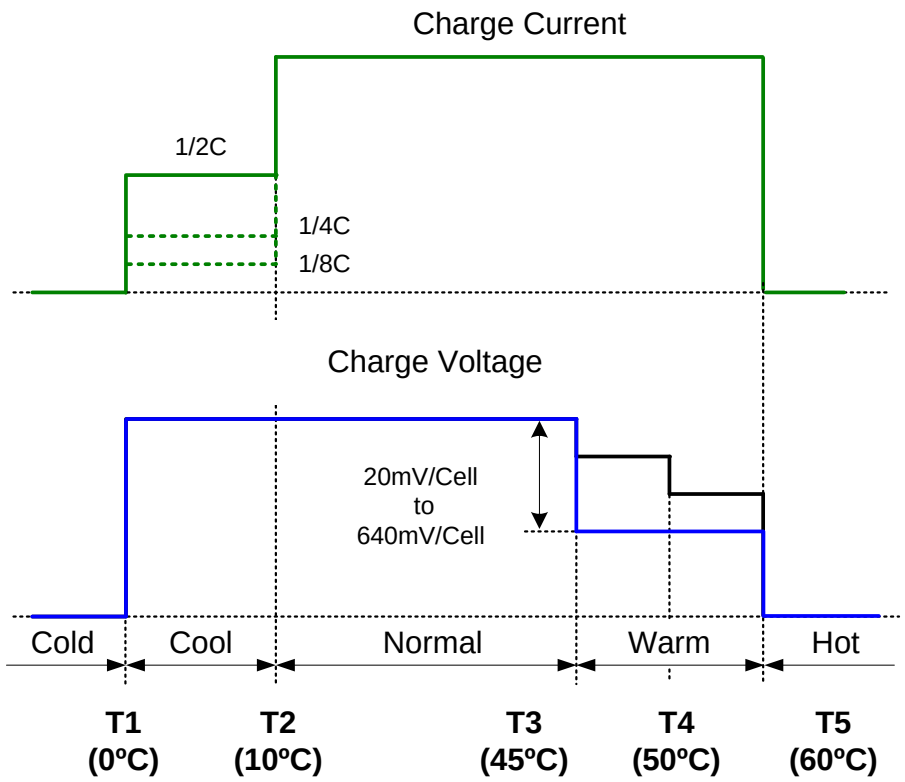
电池温度保护



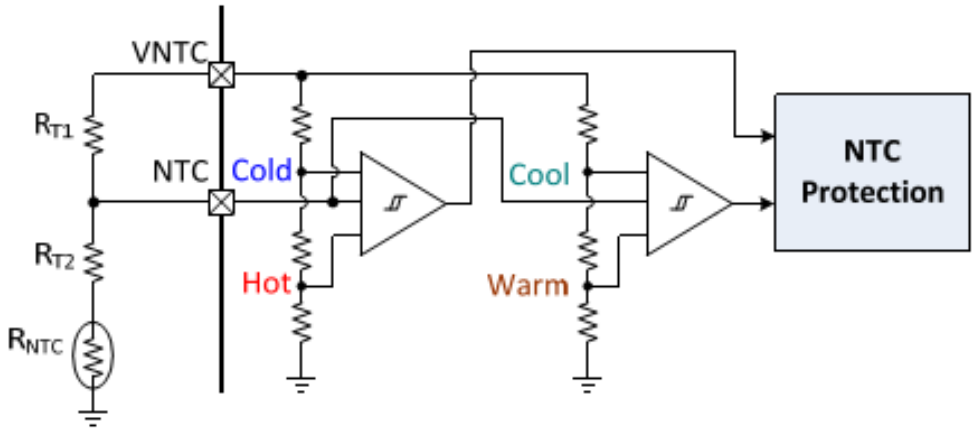
Standard NTC Protection Window



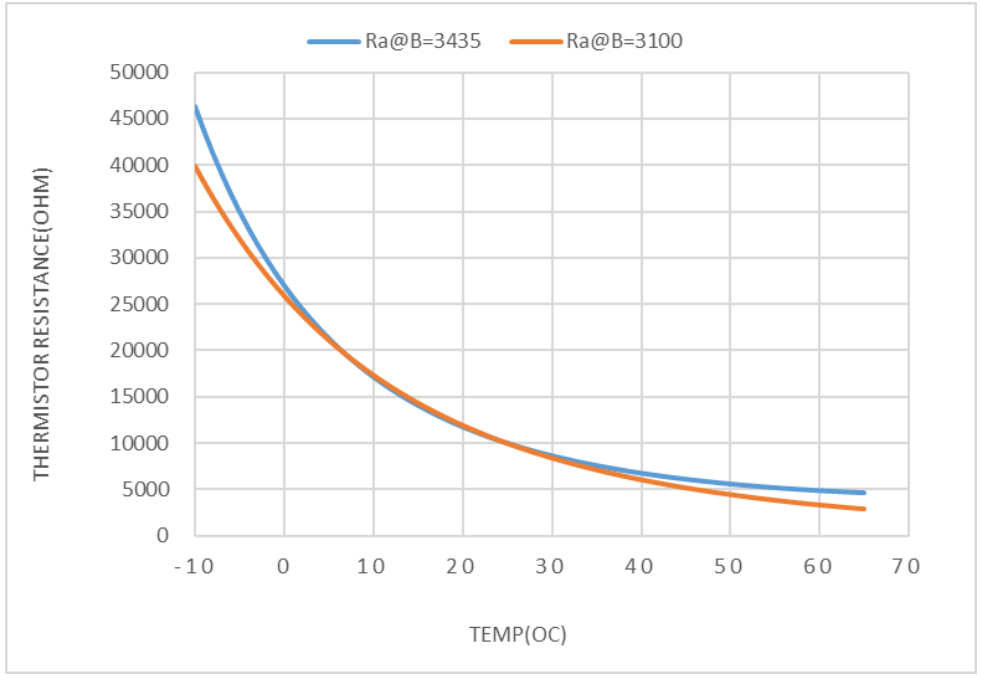
JEITA* Compliant NTC Protection Window

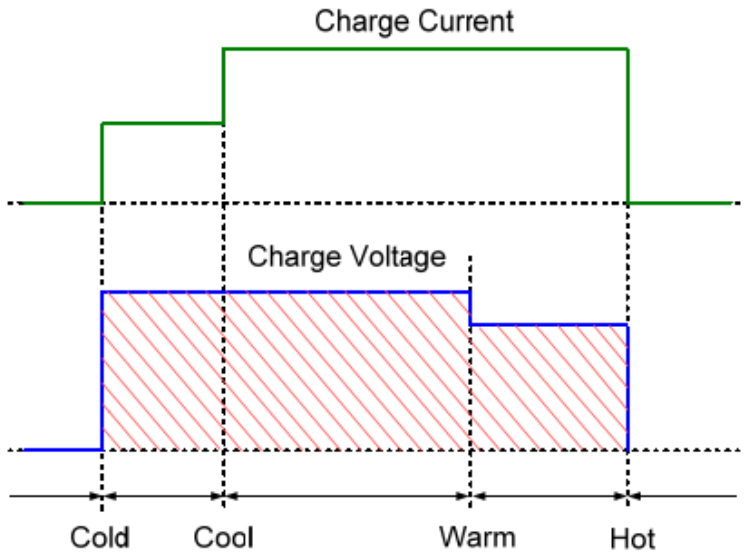
JEITA: Japan Electronics and Information Technology Industries Association
https://www.jeita.or.jp/english/

Programmable JEITA



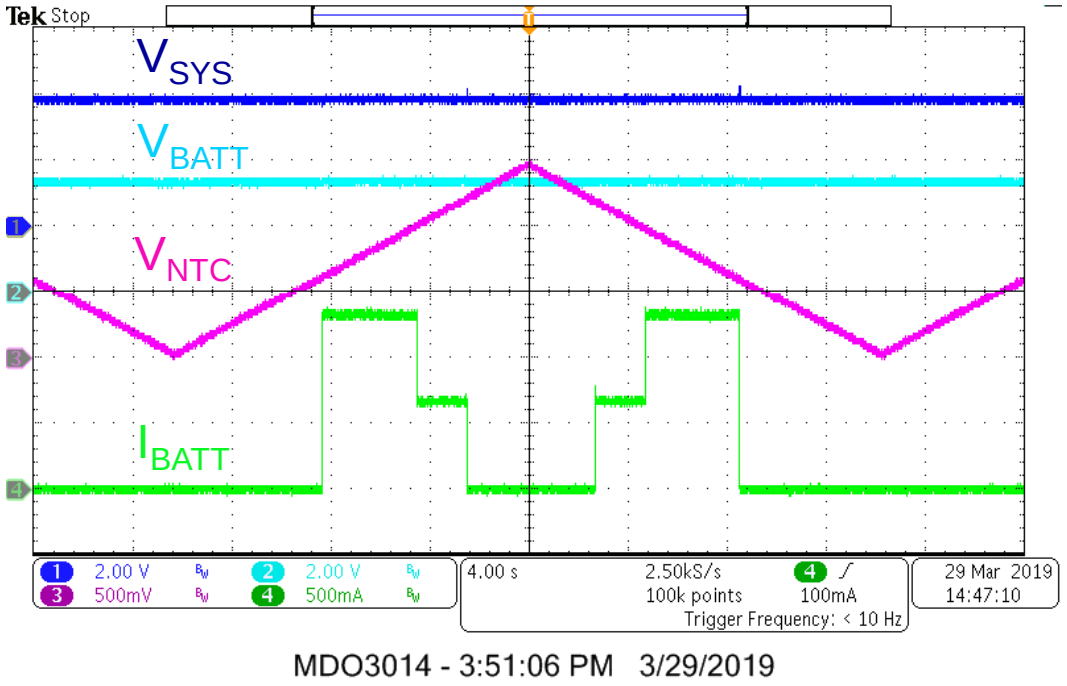
Bit	Name	POR	Reset by REG_RST	Reset by WTD	R/W	Description
7	JEITA_VSET	1	Y	Y	R/W	0: V_{BATT_REG} minus 100mV 1: V_{BATT_REG} minus 200mV
6	JEITA_ISET	1	Y	Y	R/W	0: 50% of ICHG 1: 16.7% of ICHG
5	V_{TH_HOT}	1	Y	Y	R/W	0: 34.0%; (60°C) 1: 36.0%; (55°C)
4	V_{TH_WARM}[1]	0	Y	Y	R/W	00: 43.0%; (40°C) 01: 40.0%; (45°C) 10: 38.0%; (50°C) 11: 36.0%; (55°C)
3	V_{TH_WARM}[0]	1	Y	Y	R/W	
2	V_{TH_COOL}[1]	1	Y	Y	R/W	00: 72.0%; (0°C) 01: 68.0%; (5°C) 10: 64.0%; (10°C) 11: 60.0%; (15°C)
1	V_{TH_COOL}[0]	1	Y	Y	R/W	
0	V_{TH_COLD}	0	Y	Y	R/W	0: 72.0%; (0°C) 1: 68%; (5°C)



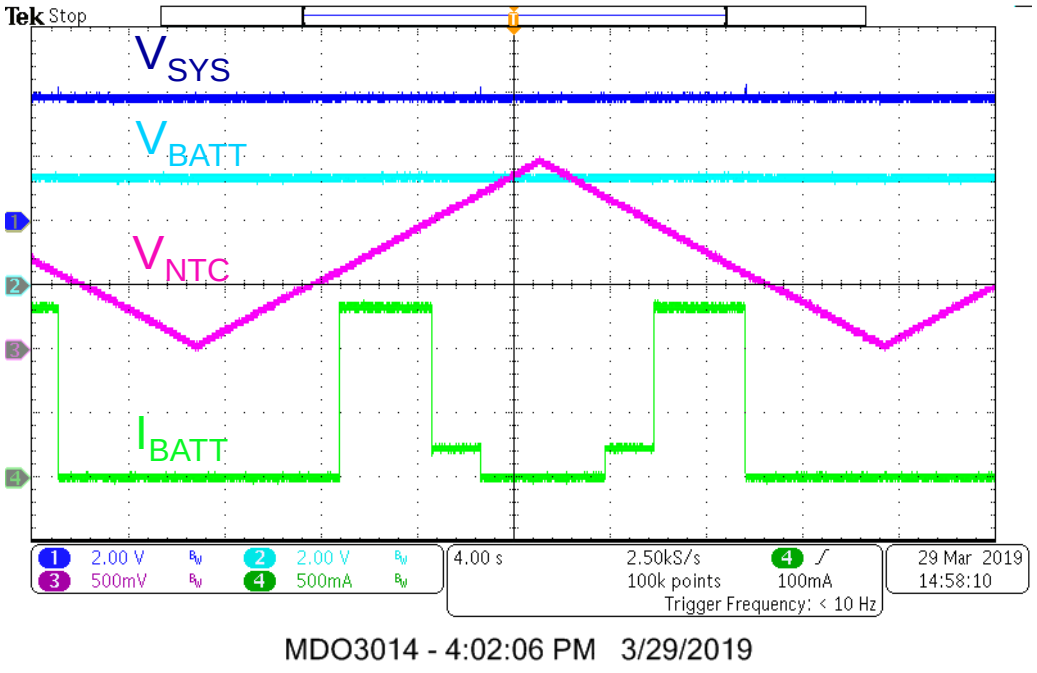


NTC- JIETA Protection

V_{IN}=5V, V_{BATT}=3.3V, I_{SYS}=0A, JIETA_ISET=50%

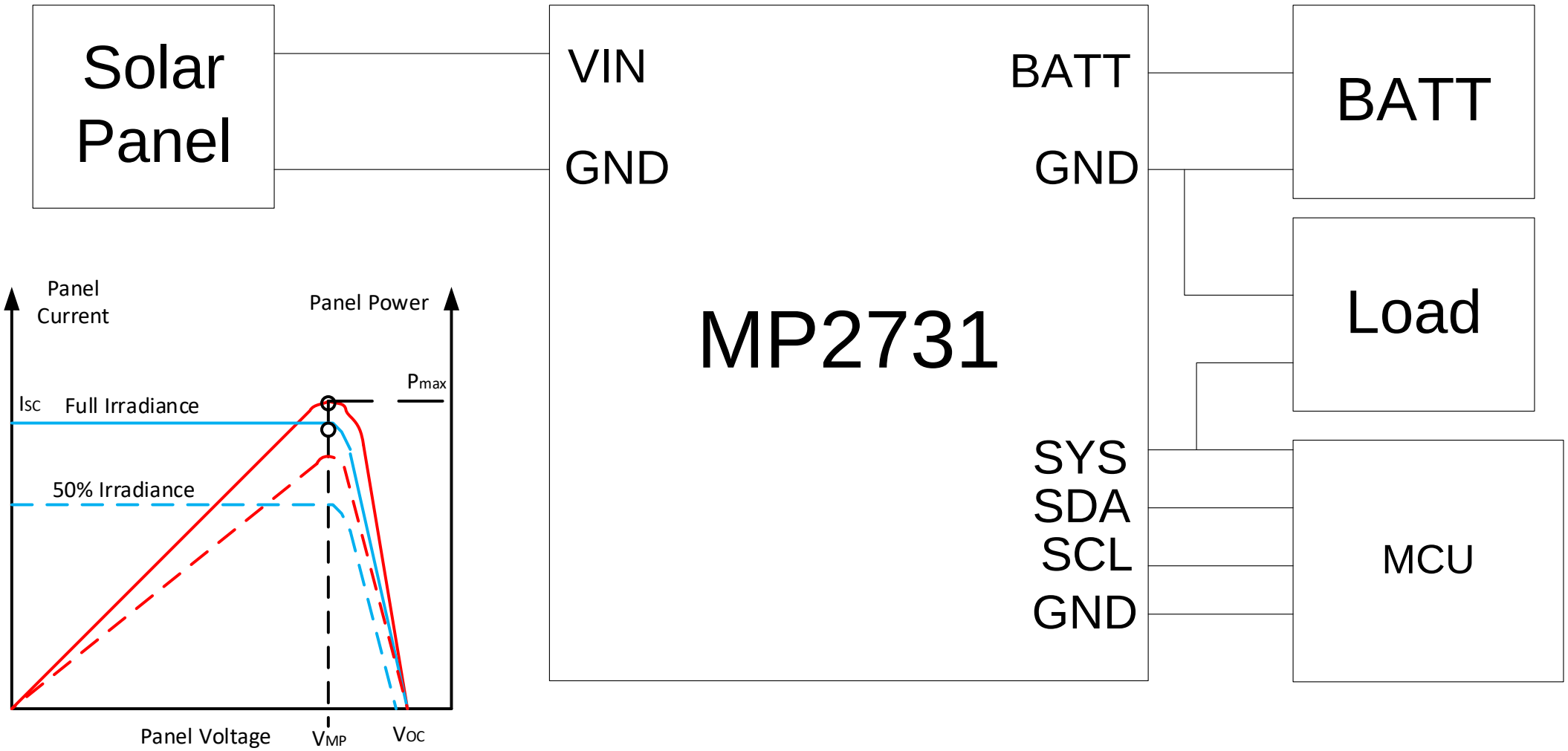


V_{IN}=5V, V_{BATT}=3.3V, I_{SYS}=0A, JIETA_ISET=16.7%



For Live Broadcasting

MPPT Reference Design



谢谢大家！

欢迎提问！