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FPF3003 IntelliMAX™ Full Functional Input Power Path Management Switch for Dual-Battery Portable System

Features

- 2.3V to 5.5V Input Voltage Operating Range
- Low R_{ON} between Battery and Load
Maximum 50mΩ at $V_{IN} = 4.2V$
- Low R_{ON} between Charger and Battery
Maximum 125mΩ at $V_{IN} = 4.2V$
- Maximum DC Current for Load Switch: 2.5A
- Maximum DC Current for Charge Switch: 1.5A
- Slew Rate Controlled to 30μs Nominal Rise Time
- Seamless Break-Before-Make Transition
- Quiescent Current: 30μA Typical
- Thermal Shutdown
- Reverse Current Blocking (RCB) between Battery A and Battery B
- RESET Timer Delay: 7s Typical
- ESD Protected:
 - Human Body Model: >2.5kV
 - Charged Device Model: >1.5kV
 - IEC 61000-4-2 Air Discharge: >15kV
 - IEC 61000-4-2 Contact Discharge: >8kV
- 1.6mm X 1.6mm, 16-Bump, 0.4mm Pitch, WLCSP

Description

The FPF3003 is a single-chip solution for dual-battery power-path switching, including integrated P-channel switches and analog control features. The input voltage range operates from 2.3V to 5.5V. The device selects one of two batteries to provide power to the system, enabling one battery to be charged by the external battery charger.

The FPF3003 has battery voltage monitoring to determine if the battery is under voltage. Special driver and digital circuitry allows the device to switch quickly between battery A and battery B, which allows hot swapping of battery packs. Maximum current from battery to load per channel is limited to a constant 2.5A and internal thermal shutdown circuits protect the part during fault conditions.

The FPF3003 is available in a 1.6mm x 1.6mm, 16-bump, Wafer-Level Chip-Scale Package (WLCSP).

Applications

- Dual-Battery Cell phone
- Dual-Battery Portable Equipment

Ordering Information

Part Number	Top Mark	(Charger-Battery) Max. R_{ON} at 4.2V _{IN}	(Battery-Load) Max. R_{ON} at 4.2V _{IN}	Typical t_R	Package
FPF3003UCX	QW	125mΩ	50mΩ	30μs	16-Bump, 0.4mm Pitch, 1.6mm x 1.6mm WLCSP

Typical Application Diagram

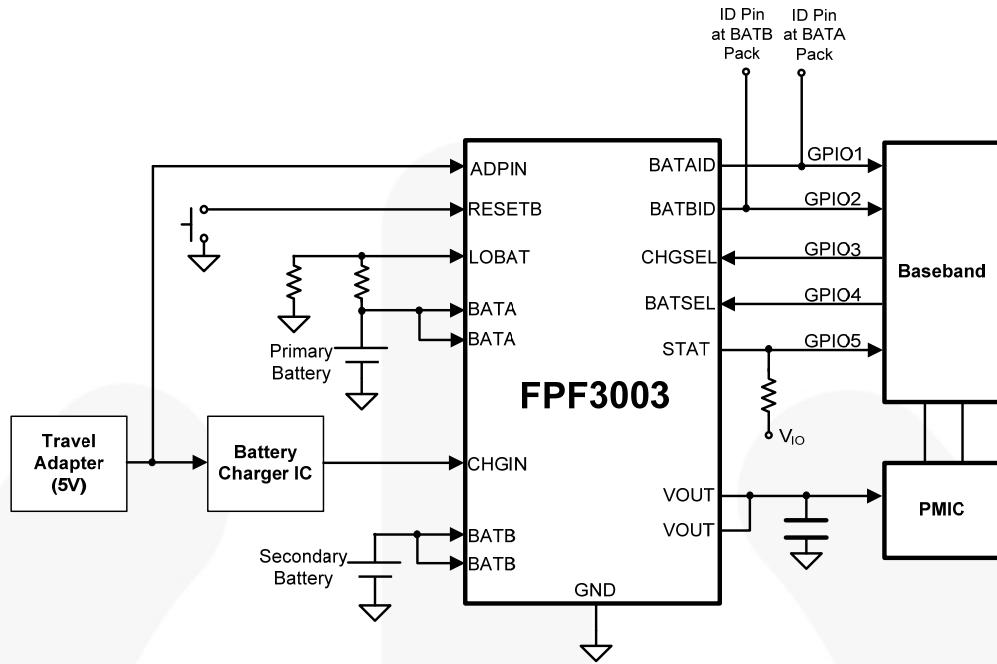


Figure 1. Typical Application

Functional Block Diagram

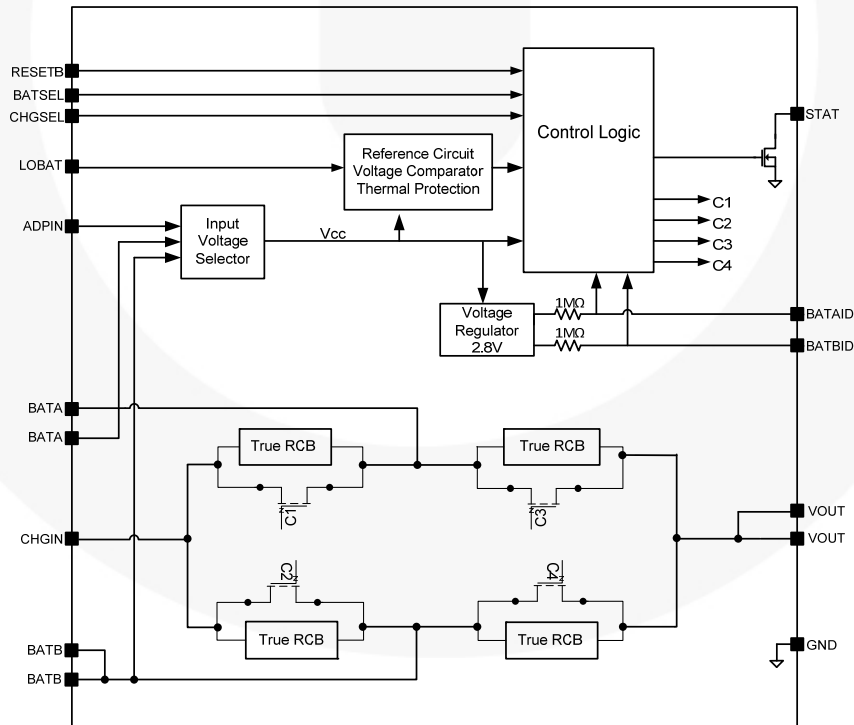


Figure 2. Functional Block Diagram

Pin Configuration

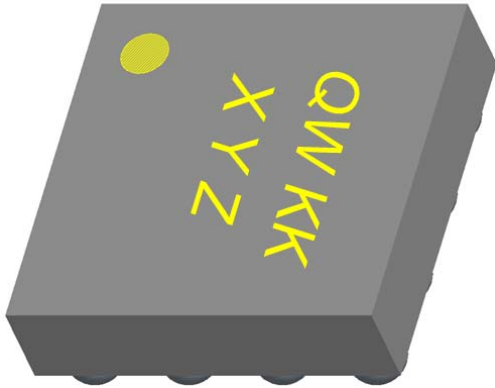


Figure 3. Pin Assignments (Top View)

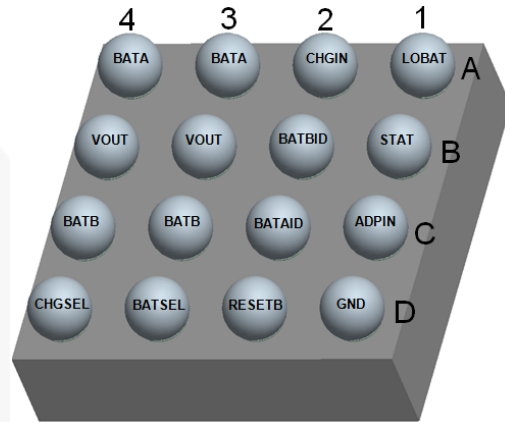


Figure 4. Pin Assignments (Bottom View)

Pin Description

Pin #	Name	Description
A1	LOBAT	Low Battery A Voltage Input. Connect to the resistive divider to set the trip level for chip-on moment. If LOBAT is less than 0.8V, V_{OUT} is connected to BATB.
A2	CHGIN	Charging Input. Charging path input.
A3, A4	BATA	Supply Input. Battery A voltage input.
B1	STAT	Battery Selector Status. Open-drain output. HIGH (Hi-Z) means battery A connects to VOUT. LOW means battery B connects to VOUT.
B2	BATBID	Battery B Indicator. Connect this pin with the ID pin at the battery pack of BATB. HIGH means battery B absent; LOW means battery B present.
B3, B4	VOUT	Switch Output. Connect to system load.
C1	ADPIN	Adapter Input. 5V input for battery charger.
C2	BATAID	Battery A Indicator. Connect this pin with the ID pin at the battery pack of BATA. HIGH means battery A absent; LOW means battery A present.
C3, C4	BATB	Supply Input. Battery B voltage input.
D1	GND	Ground
D2	RESETB	Reset Input. Active LOW. Both system path switches are disconnected from system load.
D3	BATSEL	Battery Selection Input. HIGH means to switch battery B to VOUT; LOW means to switch battery A to VOUT.
D4	CHGSEL	Charge Selection Input. HIGH means to charge battery B; LOW means to charge battery A.

Absolute Maximum Ratings

Stresses exceeding the Absolute Maximum Ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameters		Min.	Max.	Unit
V_{IN}	All Pins To GND		-0.3	6.0	V
I_{SW}	Maximum Continuous Switch Current to Load			2.5	A
	Maximum Continuous Switch Current to Charger			1.5	A
P_D	Power Dissipation at $T_A = 25^\circ\text{C}$			1.7	W
T_{STG}	Operating and Storage Junction Temperature		-65	150	$^\circ\text{C}$
Θ_{JA}	Thermal Resistance, Junction to Ambient (1in. Square Pad of 2oz. Copper)			72 ⁽¹⁾	$^\circ\text{C/W}$
ESD	Electrostatic Discharge Capability	Human Body Model, JESD22-A114	2.5		kV
		Charged Device Model, JESD22-C101	1.5		
		Air Discharge (BATA, BATB, ADPIN to GND), IEC61000-4-2 System Level	15.0		
		Contact Discharge (BATA, BATB, ADPIN to GND), IEC61000-4-2 System Level	8.0		

Note:

1. Measured using 2S2P JEDEC std. PCB.

Recommended 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. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameters		Min.	Max.	Unit
V_{IN}	ADPIN		4.6	5.5	V
	BATA, BATB		2.3	5.5	V
T_A	Ambient Operating Temperature		-40	85	$^\circ\text{C}$

Electrical Characteristics

ADPIN=4.6 to 5.5V, $V_{BATA}=V_{BATB}=2.3$ to 5.5V, $T_A=-40$ to 85°C unless otherwise noted. Typical values are at ADPIN=5V, CHGIN= $V_{BATA}=V_{BATB}=4.2$ V, RESETB=HIGH, and $T_A=25^\circ\text{C}$.

Symbol	Parameters	Condition	Min.	Typ.	Max.	Unit	
Static Characteristics							
V_{ADPIN}	Adapter Input Voltage		4.6		5.5	V	
V_{ADPIN_TH}	ADPIN Threshold	ADPIN Rising		4.5		V	
		ADPIN Falling		4.2			
V_{BATA}, V_{BATB}	Battery Input Voltage		2.3		5.5	V	
I_Q	Quiescent Current	$I_{OUT}=0\text{mA}$		30		μA	
R_{ON}	On Resistance to Load Switch, BATA or BATB to VOUT	$V_{BATA}=V_{BATB}=5.5\text{V}, I_{OUT}=300\text{mA}, T_A=25^\circ\text{C}^{(2)}$		34		m Ω	
		$V_{BATA}=V_{BATB}=4.2\text{V}, I_{OUT}=300\text{mA}, T_A=25^\circ\text{C}$		38	50		
		$V_{BATA}=V_{BATB}=3.7\text{V}, I_{OUT}=300\text{mA}, T_A=25^\circ\text{C}$		43	55		
		$V_{BATA}=V_{BATB}=2.3\text{V}, I_{OUT}=300\text{mA}, T_A=25^\circ\text{C}^{(2)}$		62			
	On Resistance to Charger Switch, CHGIN to BATA	$V_{BATA}=V_{BATB}=5.5\text{V}, I_{CHG}=200\text{mA}, T_A=25^\circ\text{C}^{(2)}$		66			
		$V_{BATA}=V_{BATB}=4.2\text{V}, I_{CHG}=200\text{mA}, T_A=25^\circ\text{C}$		73	90		
		$V_{BATA}=V_{BATB}=3.7\text{V}, I_{CHG}=200\text{mA}, T_A=25^\circ\text{C}$		80	95		
		$V_{BATA}=V_{BATB}=2.3\text{V}, I_{CHG}=200\text{mA}, T_A=25^\circ\text{C}^{(2)}$		101			
	On Resistance to Charger Switch, CHGIN to BATB	$V_{BATA}=V_{BATB}=5.5\text{V}, I_{CHG}=200\text{mA}, T_A=25^\circ\text{C}^{(2)}$		92			
		$V_{BATA}=V_{BATB}=4.2\text{V}, I_{CHG}=200\text{mA}, T_A=25^\circ\text{C}$		99	125		
		$V_{BATA}=V_{BATB}=3.7\text{V}, I_{CHG}=200\text{mA}, T_A=25^\circ\text{C}$		105	130		
		$V_{BATA}=V_{BATB}=2.3\text{V}, I_{CHG}=200\text{mA}, T_A=25^\circ\text{C}^{(2)}$		128			
V_{IH}	Input Logic HIGH Voltage	$V_{BATA}=V_{BATB}=2.3\text{V} - 5.5\text{V}, \text{CHGSEL}, \text{BATSEL}$	0.90			V	
		$V_{BATA}=V_{BATB}=2.3\text{V} - 5.5\text{V}, \text{RESETB}$	1.15				
		$V_{BATA}=V_{BATB}=2.3\text{V} - 5.5\text{V}, \text{BATAID}, \text{BATBID}$	1.70				
V_{IL}	Input Logic LOW Voltage	$V_{BATA}=V_{BATB}=2.3\text{V} - 5.5\text{V}, \text{CHGSEL}, \text{BATSEL}$			0.6	V	
		$V_{BATA}=V_{BATB}=2.3\text{V} - 5.5\text{V}, \text{RESETB}$			0.8		
		$V_{BATA}=V_{BATB}=2.3\text{V} - 5.5\text{V}, \text{BATAID}, \text{BATBID}$			0.9		
V_{STAT_LO}	STAT Logic LOW Voltage	$I_{SINK}=1\text{mA}$			0.3	V	
V_{LOBAT}	LOBAT Threshold	$V_{BATA}=V_{BATB}=2.3\text{V} - 5.5\text{V}$		0.8		V	
t_{LOBAT}	LOBAT De-Glitch Time	$V_{BATA}=V_{BATB}=2.3\text{V} - 5.5\text{V}$		1.3		ms	
T_{SD}	Thermal Shutdown	Shutdown Threshold		150		$^\circ\text{C}$	
		Return from Shutdown		140			
		Hysteresis		10			
V_{DROOP_OUT}	Output Voltage Droop while Battery Switching	$V_{BATA}=4.2\text{V}, V_{BATB}=4.2\text{V}, \text{Switching from } V_{BATA} \rightarrow V_{BATB}, R_L=100\Omega, C_{OUT}=10\mu\text{F}$			100	mV	

Continued on the following page...

Electrical Characteristics

ADPIN=4.6 to 5.5V, $V_{BATA}=V_{BATB}=2.3$ to 5.5V, $T_A=-40$ to 85°C unless otherwise noted. Typical values are at ADPIN=5V, CHGIN= $V_{BATA}=V_{BATB}=4.2$ V, RESETB=HIGH, and $T_A=25^\circ\text{C}$.

Symbol	Parameters	Condition	Min.	Typ.	Max.	Unit
Reverse Current Blocking between V_{BATA} and V_{BATB}						
V_{T_RCB}	RCB Protection Trip Point	$V_{OUT} - V_{BATA}$ or V_{BATB}		20		mV
V_{R_RCB}	RCB Protection Release Trip Point	V_{BATA} or $V_{BATB} - V_{OUT}$		30		mV
	Hysteresis			50		mV
Dynamic Characteristics: See Definitions Below						
t_R	V_{OUT} Rise Time ^(2,3,4)	$V_{BATA}=V_{BATB}=4.2\text{V}$, $R_L=100\Omega$, $T_A=25^\circ\text{C}$, $C_L=10\mu\text{F}$, BATAID=HIGH to LOW, BATBID=HIGH		30		μs
t_{DON}	Turn-On Delay ^(2,3,4)			5		μs
t_{ON}	Turn-On Time ^(2,3,4)			35		
t_F	V_{OUT} Fall Time ^(2,3,5)	$V_{BATA}=V_{BATB}=4.2\text{V}$, $R_L=100\Omega$, $T_A=25^\circ\text{C}$, $C_L=10\mu\text{F}$, BATAID=LOW to HIGH, BATBID=HIGH		2.5		ms
t_{DOFF}	Turn-Off Delay ^(2,3,5)			0.1		ms
t_{OFF}	Turn-Off Time ^(2,3,5)			2.6		ms
t_{DSEL}	Selection Delay ^(2,3)	$V_{BATA}=V_{BATB}=4.2\text{V}$, $R_L=100\Omega$, $T_A=25^\circ\text{C}$, $C_L=10\mu\text{F}$, CHGSEL or BATSEL=LOW to HIGH		1		ms
t_{DRST}	RESET Timer Delay ^(2,3)	$V_{BATA}=V_{BATB}=4.2\text{V}$, $R_L=100\Omega$, $T_A=25^\circ\text{C}$, $C_L=10\mu\text{F}$, RESETB=Floating to LOW		7		s

Notes:

- This parameter is guaranteed by design and characterization; not production tested.
- $t_{DON}/t_{DOFF}/t_R/t_F$ is defined in Figure 5.
- $t_{ON}=t_R + t_{DON}$.
- $t_{OFF}=t_F + t_{DOFF}$.

Timing Diagram

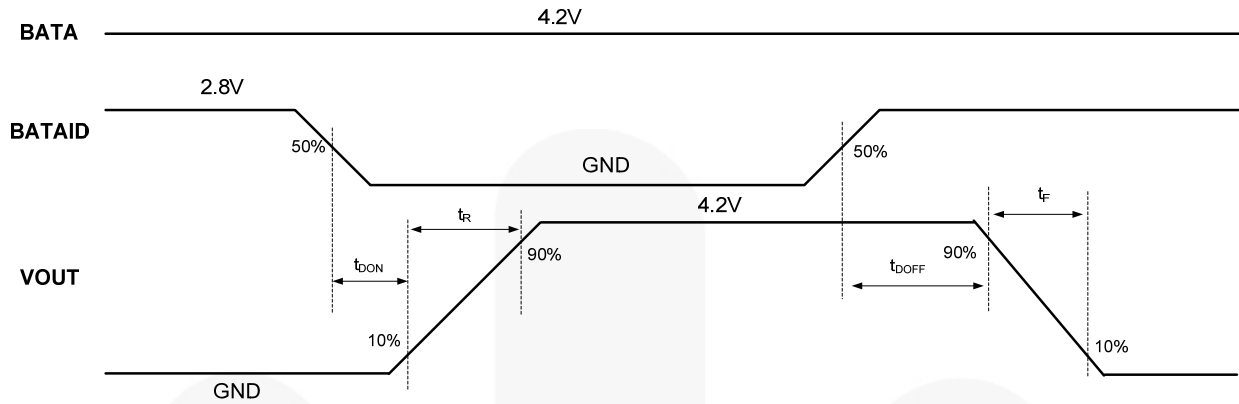


Figure 5. ON/OFF Behavior ($V_{BATA}=4.2V$)

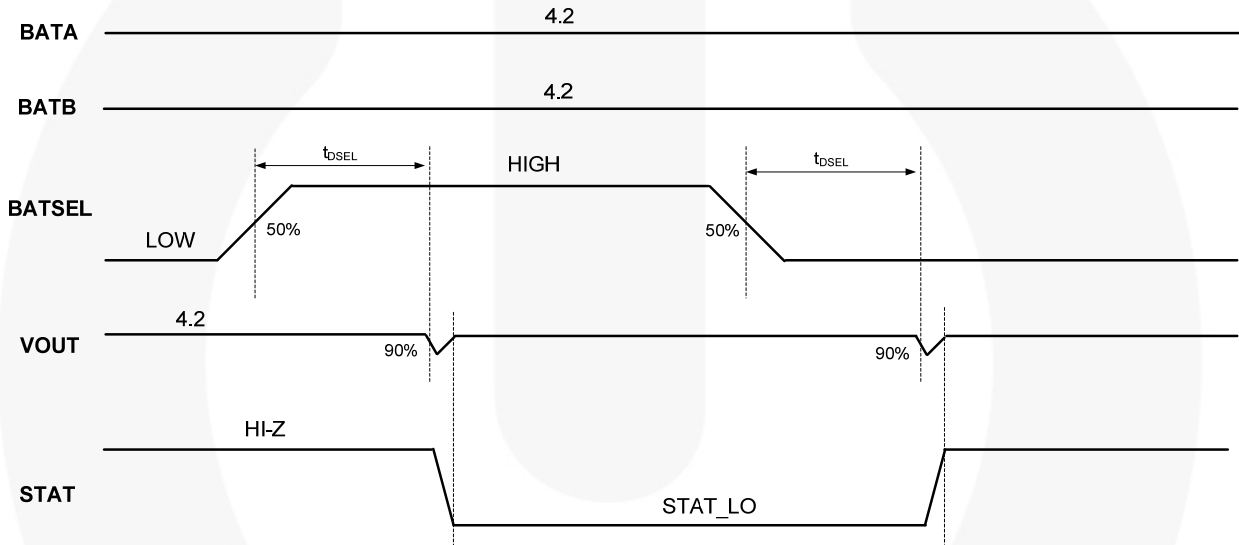
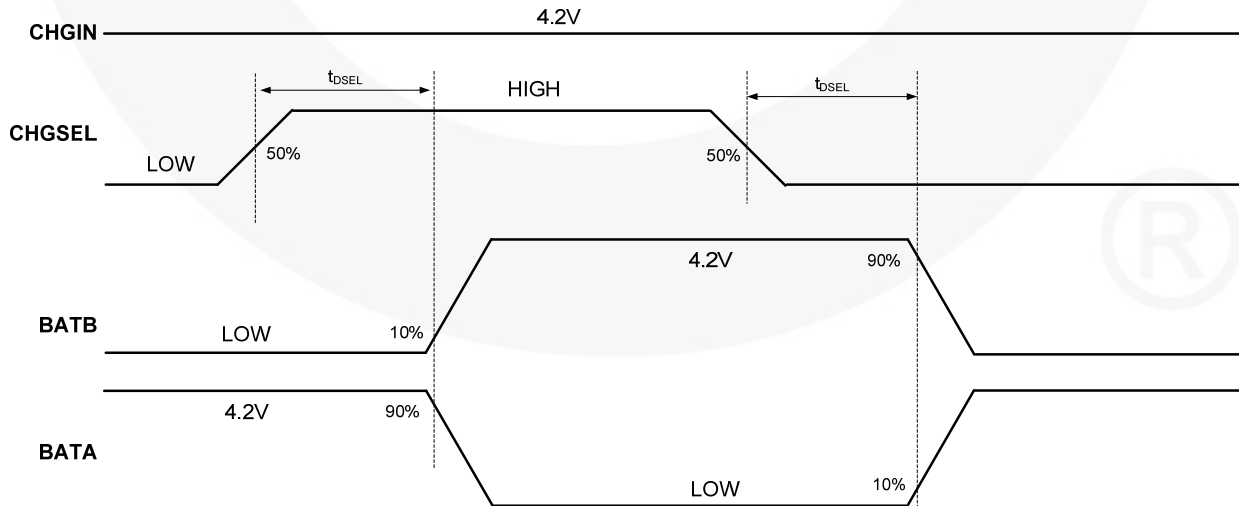


Figure 6. Battery-to-System Path Selection Behavior by BATSEL ($V_{BATA}=V_{BATB}=4.2V$)



**Figure 7. Charging Path Selection Behavior by CHGSEL
($ADPIN=5V$, $CHGIN=4.2V$, $V_{BATA}=V_{BATB}=Floating$ with $1\mu F$)**

Timing Diagrams (Continued)

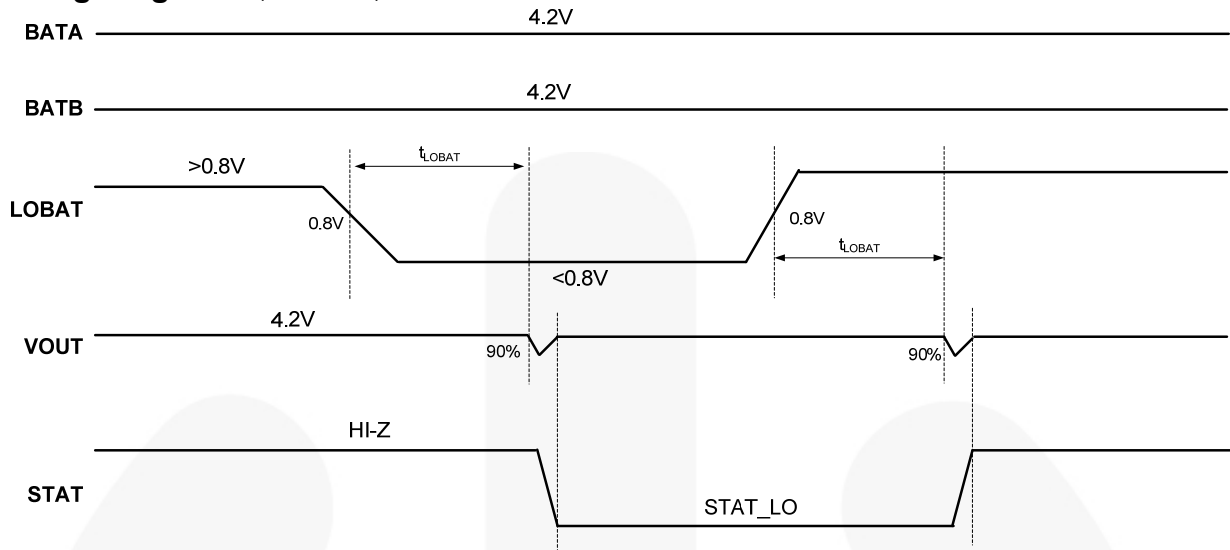


Figure 8. Transition from V_{BATA} to V_{BATB} Behavior by LOBAT ($V_{BATA}=V_{BATB}=4.2V$)

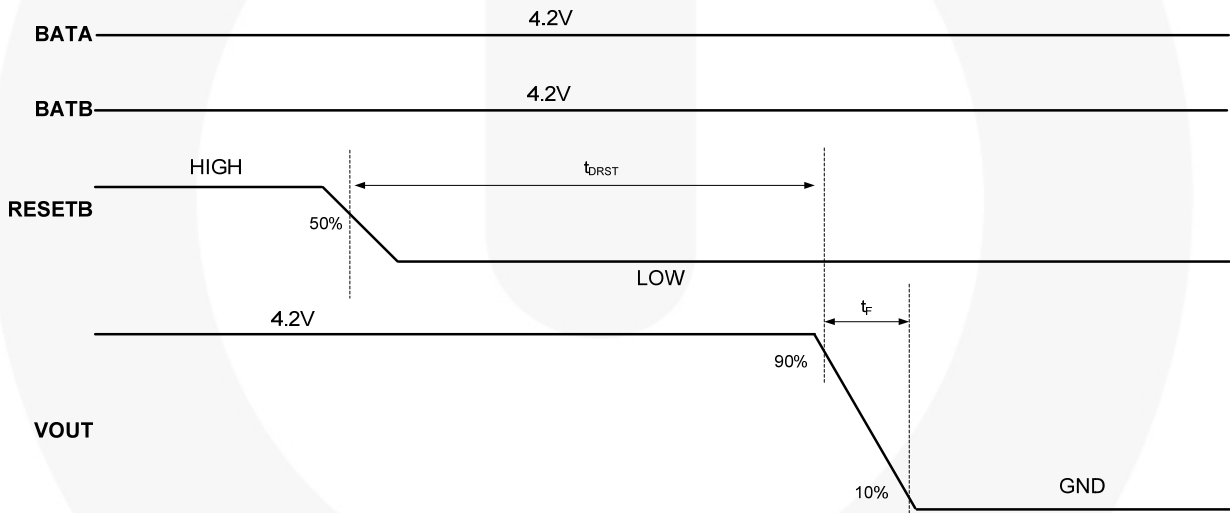


Figure 9. System Reset Behavior by RESETB ($V_{BATA}=V_{BATB}=4.2V$)

Typical Characteristics

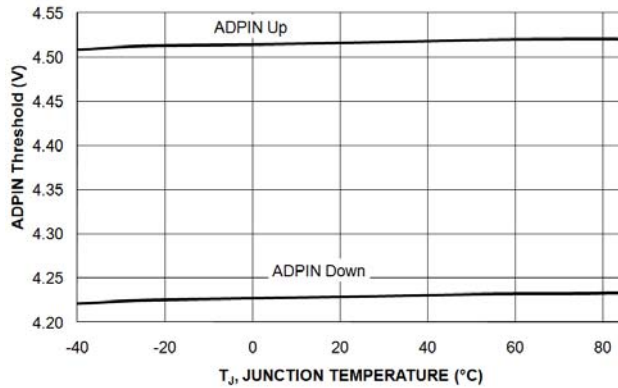


Figure 10. ADPIN vs. Temperature

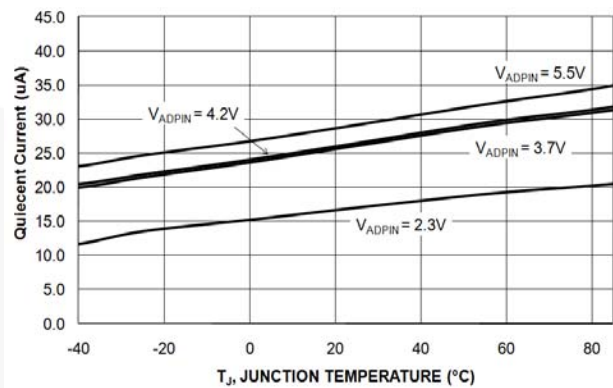


Figure 11. Supply Current vs. Temperature

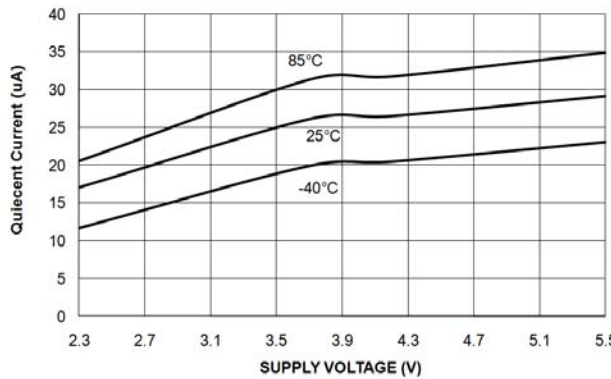


Figure 12. Supply Current vs. Supply Voltage

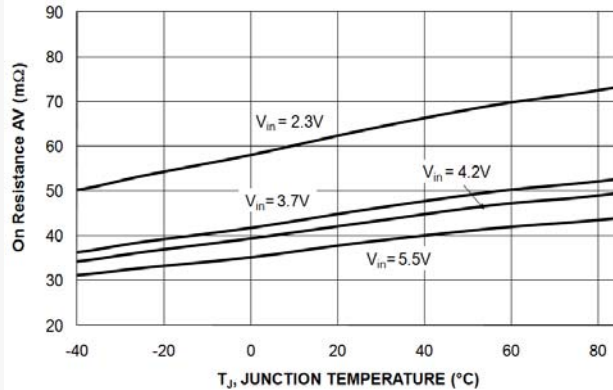


Figure 13. R_{ON} (V_{BATA} or V_{BATB} to V_{OUT}) vs. Temperature

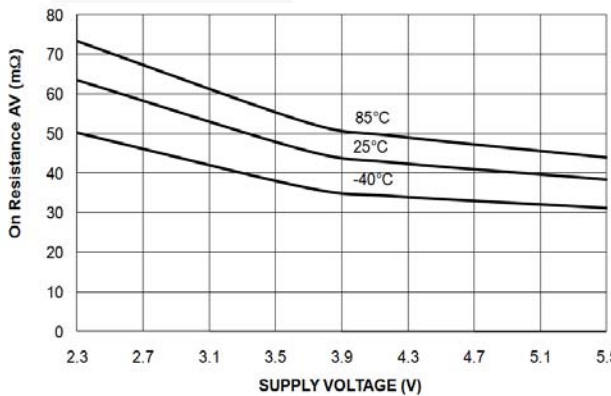


Figure 14. R_{ON} (V_{BATA} or V_{BATB} to V_{OUT}) vs. Supply Voltage

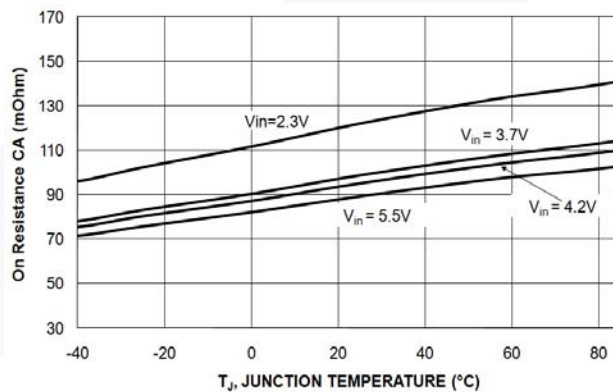


Figure 15. R_{ON} ($CHGIN$ to V_{BATA}) vs. Temperature

Typical Characteristics

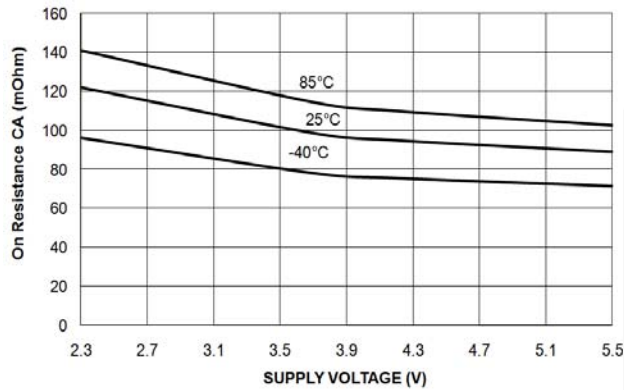


Figure 16. R_{ON} (CHGIN to V_{BATA}) vs. Supply Voltage

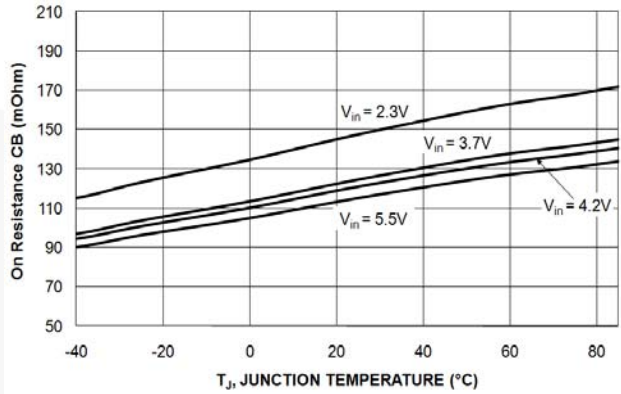


Figure 17. R_{ON} (CHGIN to V_{BATB}) vs. Temperature

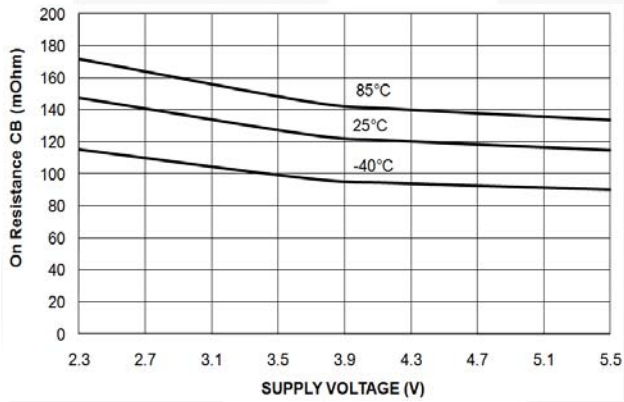


Figure 18. R_{ON} (CHGIN to V_{BATB}) vs. Supply Voltage

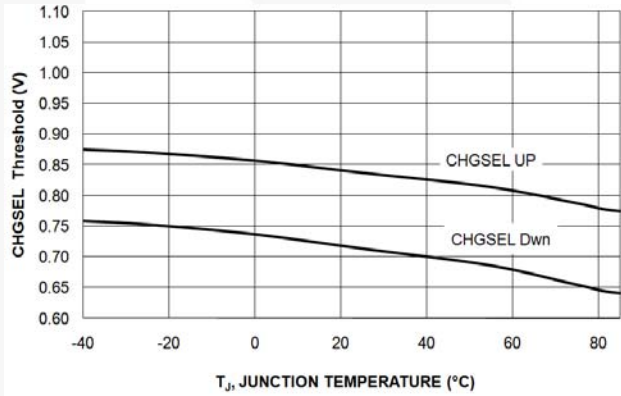


Figure 19. CHGSEL vs. Temperature

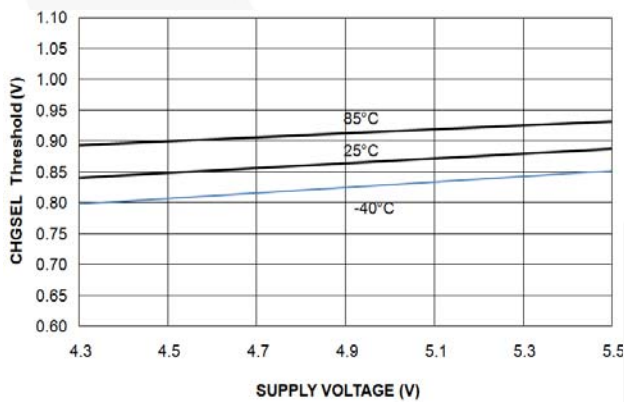


Figure 20. CHGSEL vs. ADPIN Voltage

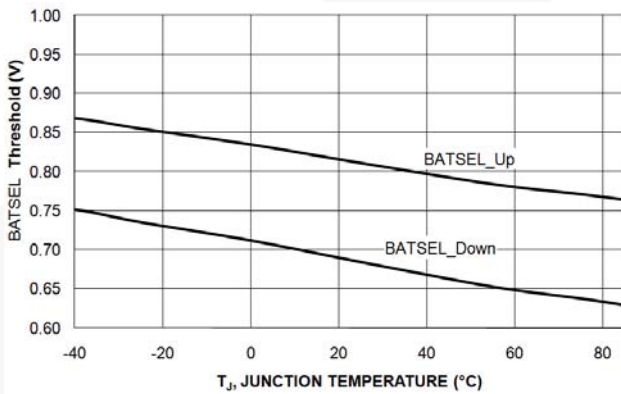


Figure 21. BATSEL vs. Temperature

Typical Characteristics

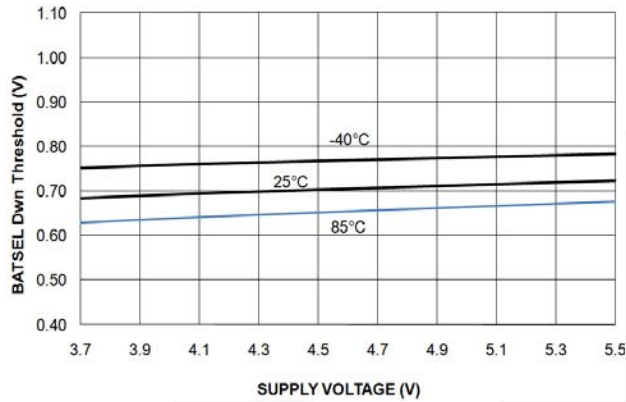


Figure 22. BATSEL vs. Supply Voltage

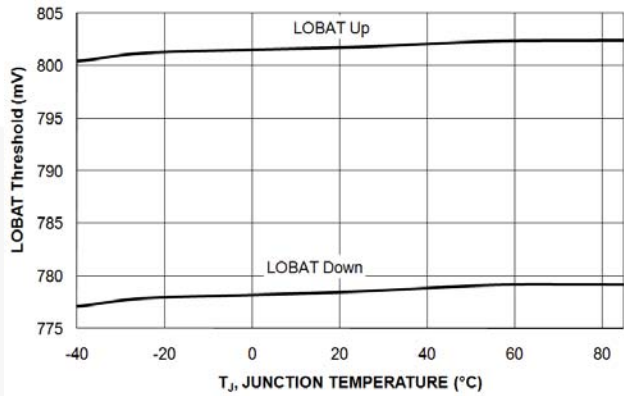


Figure 23. LOBAT vs. Temperature

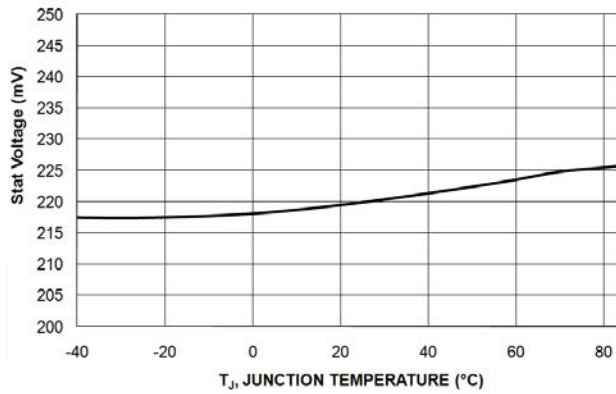


Figure 24. STAT LOW vs. Temperature

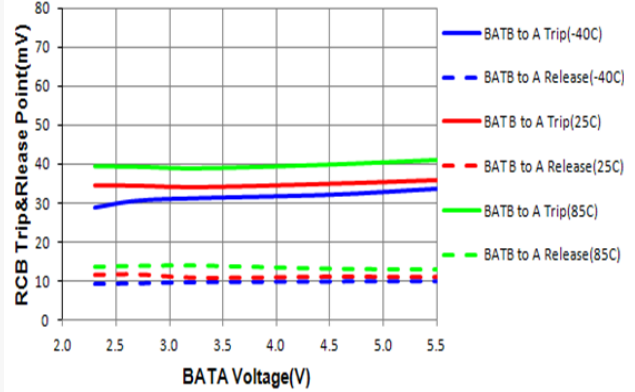


Figure 25. RCB (V_{BATA} and V_{OUT}) vs. Temperature

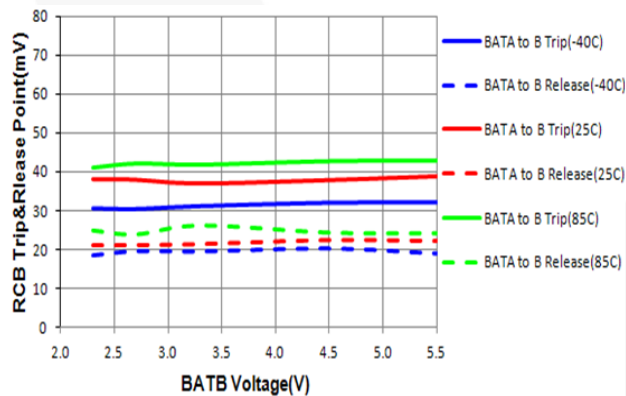


Figure 26. RCB (V_{BATB} and V_{OUT}) vs. Temperature

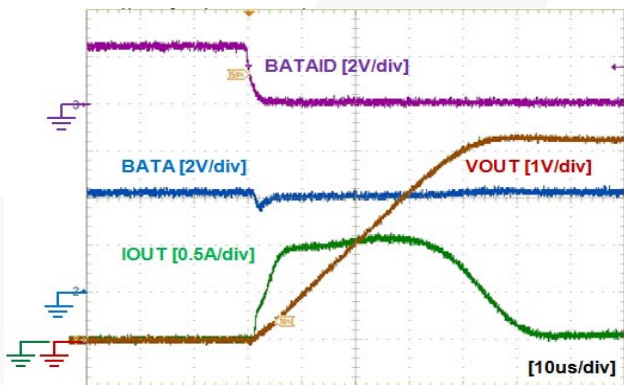


Figure 27. Turn-On Response
($V_{BATA}=4.2V$, $C_{OUT}=10\mu F$, $R_L=100\Omega$)

Typical Characteristics

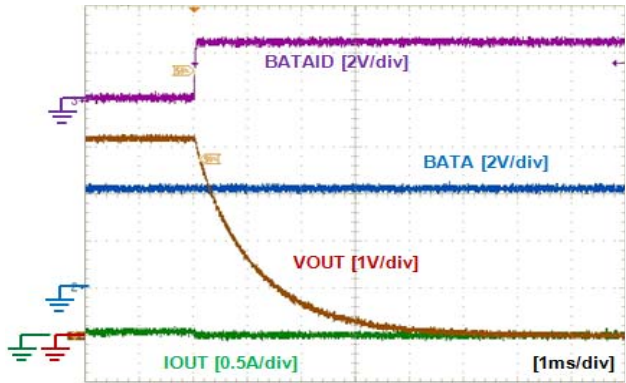


Figure 28. Turn-Off Response
($V_{BATA}=4.2V$, $C_{OUT}=10\mu F$, $R_L=100\Omega$)

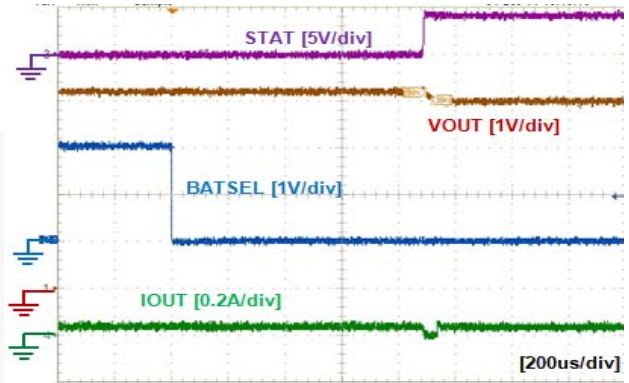


Figure 29. Battery Selection by BATSEL = HIGH → LOW
($V_{BATA}=4V$, $V_{BATB}=4.2V$, $C_{OUT}=100\mu F$, $R_L=100\Omega$)

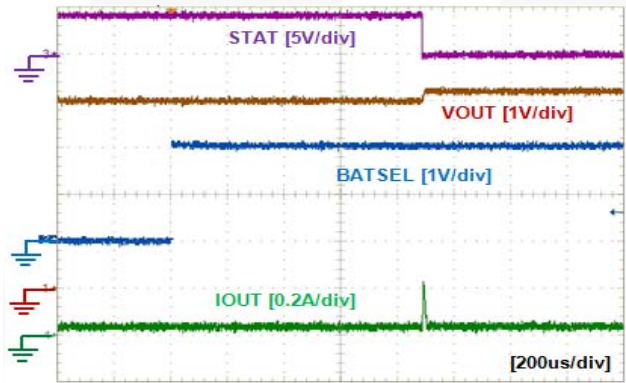


Figure 30. Battery Selection by BATSEL = LOW → HIGH
($V_{BATA}=4V$, $V_{BATB}=4.2V$, $C_{OUT}=10\mu F$, $R_L=100\Omega$)

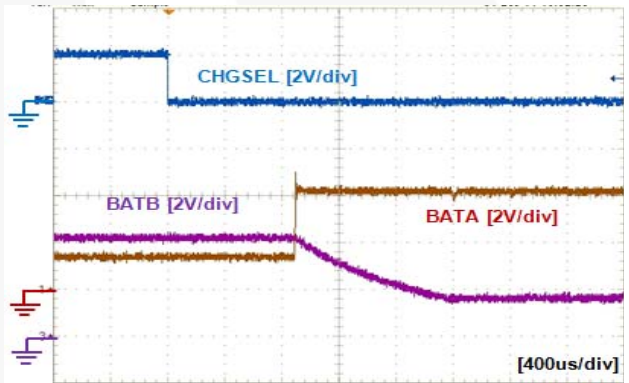


Figure 31. Charge Path Selection by CHGSEL = HIGH → LOW
($V_{CHGIN}=4V$, $V_{BATA}=V_{BATB}$ =Floating with $1\mu F$)

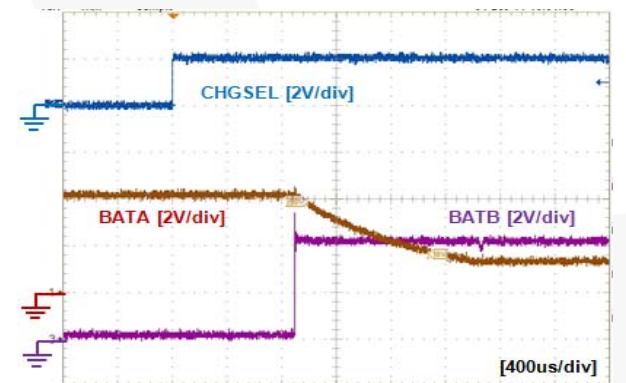


Figure 32. Charge Path Selection by CHGSEL = HIGH → LOW
($V_{CHGIN}=4V$, $BATA=BATB$ =Floating with $1\mu F$)

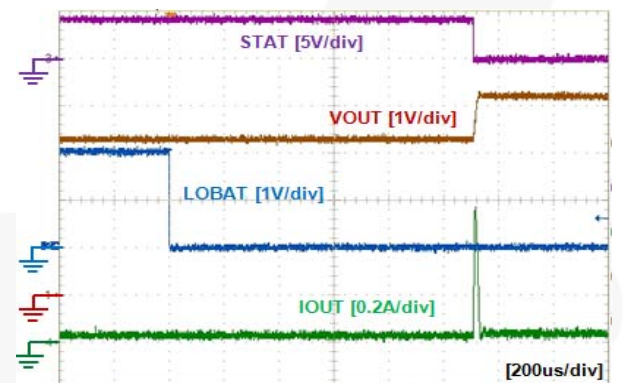


Figure 33. Battery Selection by LOBAT=HIGH → LOW
($V_{BATA}=3.8V$, $V_{BATB}=4.2V$, $C_{OUT}=100\mu F$, $R_L=100\Omega$)

Typical Characteristics

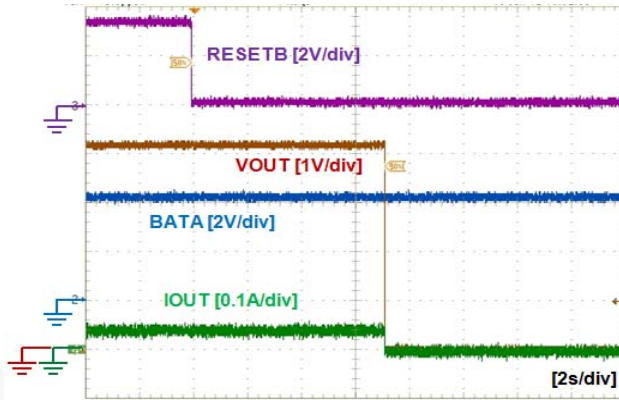


Figure 34. System Reset by RESETB: HIGH → LOW ($V_{BATA}=V_{BATB}=4.2V$, $C_{OUT}=100\mu F$, $R_L=100\Omega$)

Operation and Application Information

The FPF3003 is a low- R_{ON} , P-channel-based, input-source-selection power management switch for dual-battery systems. The FPF3003 input operating range is from 2.3V to 5.5V on BATA and BATB, while ADPIN has a range of 4.6V to 5.5V.

The FPF3003 controls the charging path from the charger to the battery with up to 1.5A and the discharging path from the battery to system load with up to 2.5A. The system or PMIC selects one of two batteries to provide power and enables one of the batteries to be charged by the external battery charger.

The FPF3003 has 30 μ s slew-rate control to reduce inrush current when engaged and thermal shutdown protection for reliable system operation.

The internal circuit is powered from the highest voltage source among BATA, BATB, and ADPIN.

Battery Presence Detection

The FPF3003 monitors whether or not a battery is present via the BATAID and BATBID pins. If any of these pins are LOW; FPF3003 recognizes the battery is present. Each pin is connected with an internal LDO output, so no pull-up resistor is required.

Output Capacitor

During battery source transition, voltage droop depends on output capacitance and load current condition. Advanced break-before-make operation minimizes the droop with minimum capacitance. At least 10 μ F is a good starting value in design.

Primary Battery Under-Voltage Set

FPF3003 monitors the primary battery of BATA for under-voltage condition. Once under-voltage condition is confirmed, the system power source changes from BATA to valid BATB automatically.

The under-voltage threshold level can be programmed with 0.8V of LOBAT and R divider (R1 and R2) as:

$$\frac{R1}{R2} = \frac{BATA_LO}{0.8} - 1 \quad (1)$$

where BATA_LO = Low BATA threshold to set.

If 3.4V of BATA is desired, $R1/R2=3.25$. If R2 is chosen 1M Ω , R1 is 3.25M Ω . Higher R2 is recommended to reduce leakage current from BATA.

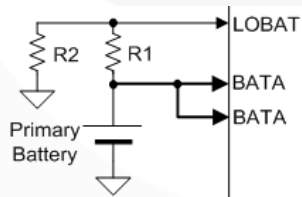


Figure 35. BATA Under-Voltage Level Setting

LOBAT has a 1.3ms of deglitch time to ensure BATA is in true under-voltage rather than transient battery voltage drop during GSM transmission operation.

Battery Selection

The load path can be controlled by the BATSEL pin. When BATSEL is LOW, the system is powered from BATA. When BATSEL is HIGH, BATB powers the system.

Figure 36 is state diagram showing how the power path from battery to system is determined.

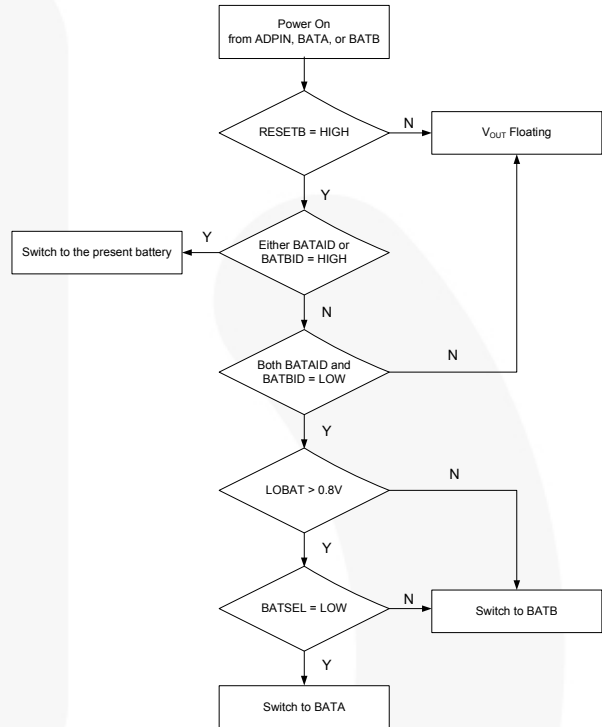


Figure 36. Power Path from Battery to System

The open-drain STAT pin is used to determine which battery powers the system. STAT becomes LOW if BATB is connected to the system. STAT is HIGH (HI-Z) if BATA is connected.

Battery Charging Path Selection

The charging path can be controlled by the CHGSEL pin. When CHGSEL is LOW, BATA can be charged from the charger. When CHGSEL is HIGH, BATB can be charged from the charger.

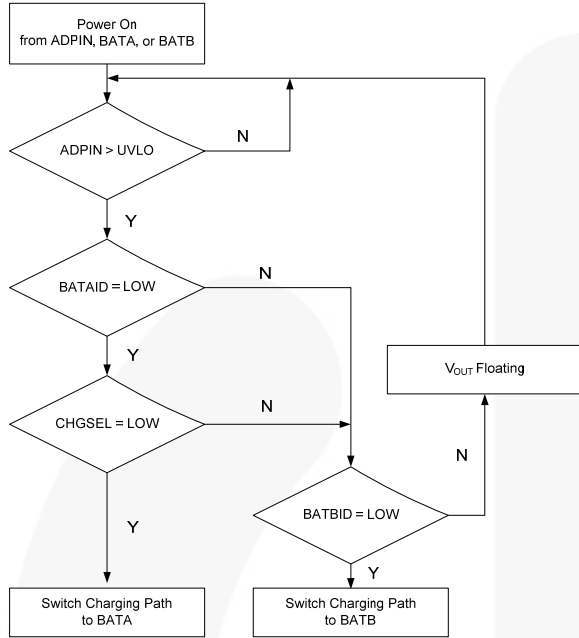


Figure 37. Battery Charging Path

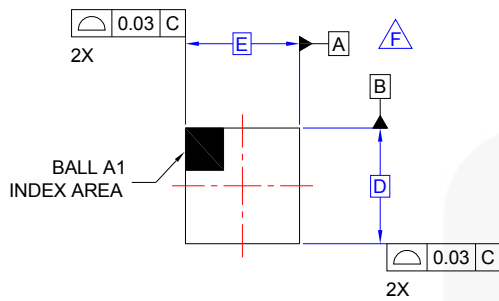
System RESET

The RESETB pin allows the system to be turned off without detaching the battery pack. It has typical 7s delay to avoid transient abnormal signal.

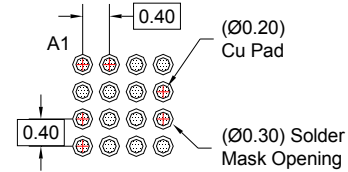
Board Layout

For best performance, all power traces (BATA, BATB, CHGIN, ADPIN, and VOUT) should be as short as possible to minimize the parasitic electrical effects and the case-to-ambient thermal impedance. The output capacitor should be placed close to the device to minimize parasitic trace inductance.

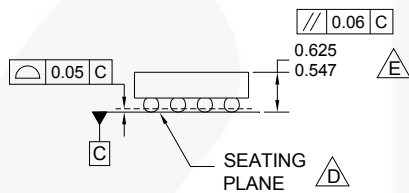
Packaging Information



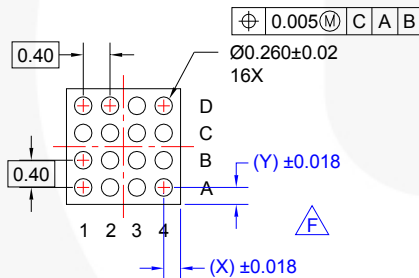
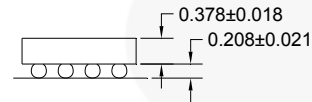
TOP VIEW



RECOMMENDED LAND PATTERN (NSMD PAD TYPE)



SIDE VIEWS



BOTTOM VIEW

NOTES:

- A. NO JEDEC REGISTRATION APPLIES.
- B. DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS AND TOLERANCE PER ASME Y14.5M, 1994.
- D. DATUM C IS DEFINED BY THE SPHERICAL CROWNS OF THE BALLS.
- E. PACKAGE NOMINAL HEIGHT IS 586 MICRONS ±39 MICRONS (547-625 MICRONS).
- F. FOR DIMENSIONS D, E, X, AND Y SEE PRODUCT DATASHEET.
- G. DRAWING FILNAME: MKT-UC016AArev2.

Figure 38. 1.6mmx1.6mm WLCSP, 16-Bumps 0.4mm Pitch

Product-Specific Dimensions

Product	D	E	X	Y
FPF3003UCX	1560µm ±30µm	1560µm ±30µm	180µm	180µm

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