Surge and Over-Voltage Protection Switch for VBUS

FPF2188UCX

WLCSP20 2.03x1.77x0.585
CASE 567ZF

Description

The FPF2188 features a surge and over voltage protection switch for power path in USB type C/PD applications.

The FPF2188 has Single Input Single Output (SISO) power path. Power path (V_{BUS} to V_{OUT}) is an active−low, 28 V / 5.5 A rated, power MOSFET switch with an internal clamp supporting surge protection, selectable OVP at 13.7 V or 21.9 V by GPIO.

BUS_DET is paired with always ON LDO to power downstream devices when VBUS is greater than 3.1 V, regardless of OVLO and ENB State. This provides system power supply without battery.

The FPF2188 features OTG_DET pin to supply the device when OTG device is inserted. It will support to turn on the power MOSFET even when VBUS voltage is low.

The FPF2188 has active discharge path at VBUS which can meet USB type C w/ PD compliance.

The FPF2188 is available in a 20−bump, 1.77 mm x 2.03 mm Wafer−Level Chip−Scale Package (WL−CSP) with 0.4 mm pitch.

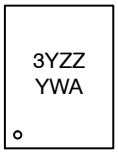
Features

- SISO (Single Input Single Output) Surge and Over−Voltage Protection Switch
- ±200 V Surge Protection at V_{BUS} under IEC 61000−4−5
- VBUS Voltage Range: 2.7 V ~ 21.0 V
- Max Continuous Current Capability: 5.5 A
- Low ON−Resistance: typical 22 mΩ at 5 V / 25°C
- Selectable OVP Trip Level by GPIO
- Ultra−fast OV Response Time : typ 50 ns
- Always ON LDO Output, BUS_DET
- OTG_DET for OTG Start−up Power Supply
- Active Discharge Path at V_{BUS}
- Open Drain OVP FLAGB
- Over−Temperature Protection (OTP)

Typical Applications

- Mobile Handsets and Tablets

MARKING DIAGRAM



3Y	= Specific Device Code
ZZ	= Assembly Lot Code
Y	= Year
W	= Work Week
A	= Assembly Location

ORDERING INFORMATION

See detailed ordering and shipping information on page 10 of this data sheet.

Application Diagram

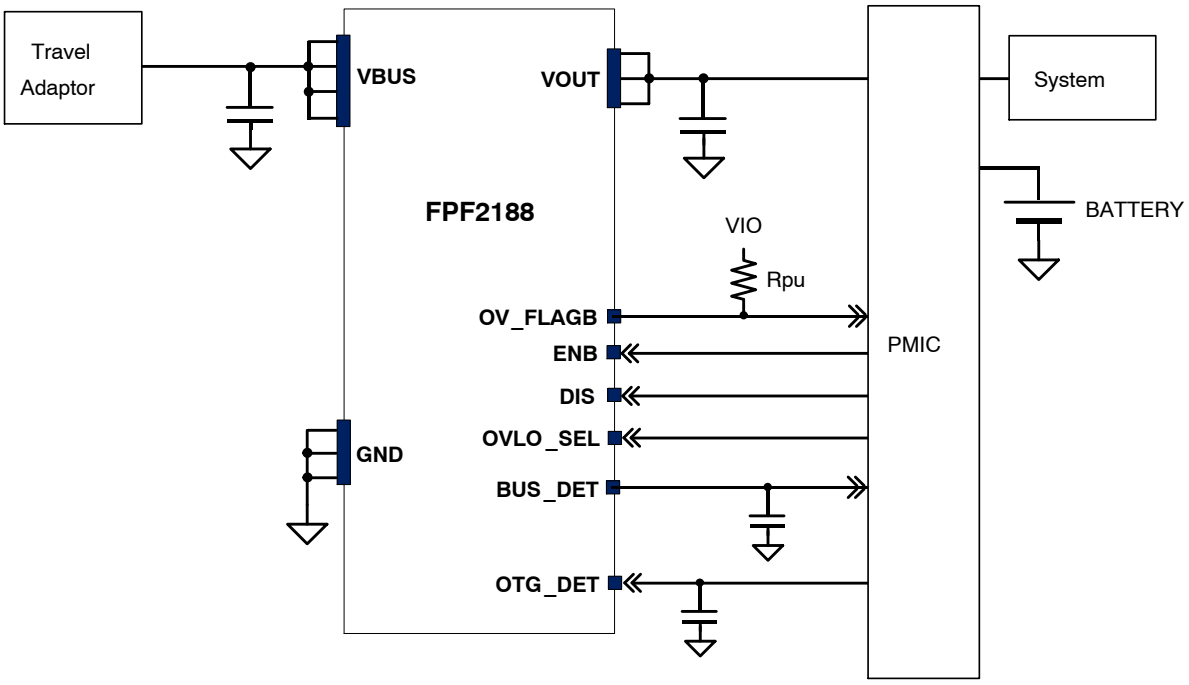


Figure 1. Typical Application Schematic

Block Diagram

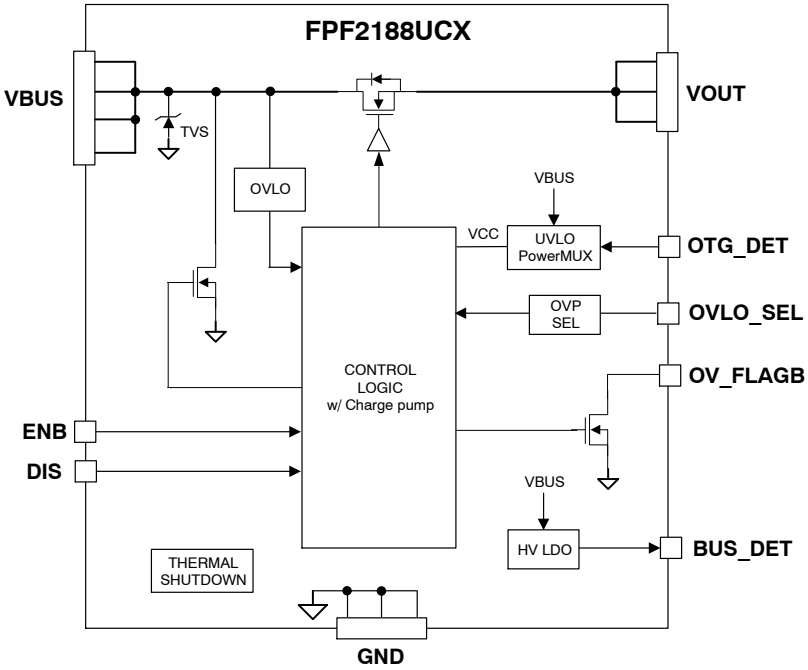


Figure 2. Functional Block Diagram

Pin Configuration

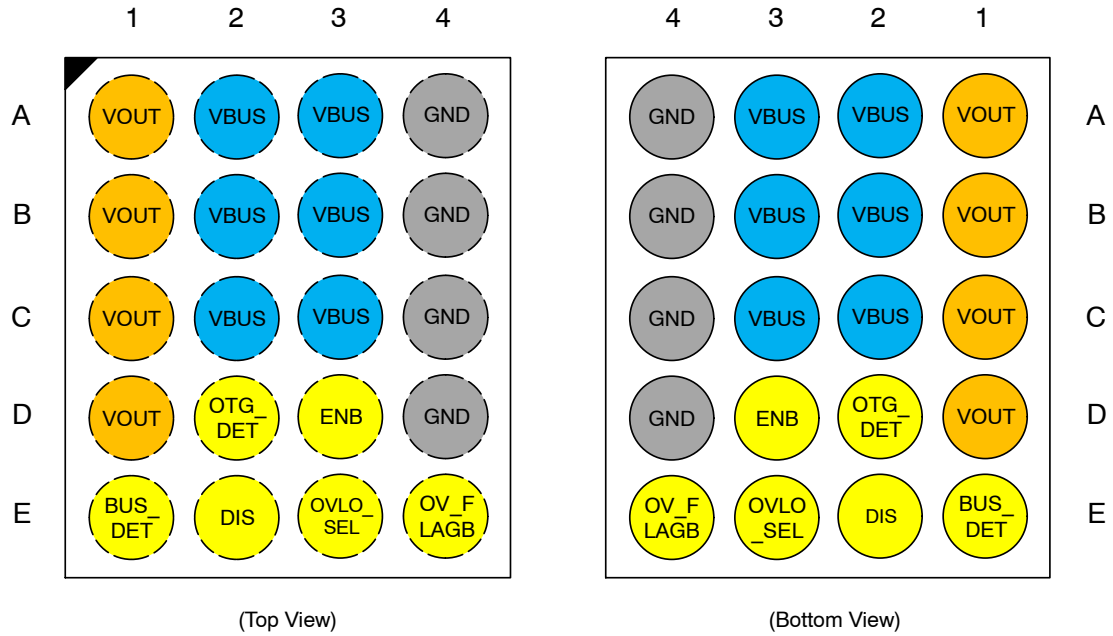


Figure 3. Pin Configuration

Table 1. PIN DEFINITIONS

Name	Bump	Type	Description
VBUS	A2, A3, B2, B3, C2, C3	Input/Supply	Switch Input/Output and Power Paths Block Power Supply
VOUT	A1, B1, C1, D1	Output/Supply	Switch Output/Input to Load
OTG_DET	D2	Input	VBUS charge pump power supply for OTG start−up.
BUS_DET	E1	Output	Regulated output according to VBUS
ENB	D3	Input	Active LOW for Power Path. Internal pull−down resistor of 1 MΩ is included.
DIS	E2	Input	Active HIGH for discharge path at VBUS node. Internal pull−down resistor of 1 MΩ is included.
OVLO_SEL	E3	Input	Over−Voltage Lockout Selection for VOUT path. Internal pull−down resistor of 1 MΩ is included. When OVLO_SEL = LOW then OVLO is set typ 13.7 V. When OVLO_SEL = HIGH then OVLO is set typ 21.9 V.
OV_FLAGB	E4	Output	Open drain output for OV state. External pull−up resistor with bias voltage are required. If not used, leaves the pin floating.
GND	A4, B4, C4, D4	GND	Ground

Table 2. ABSOLUTE MAXIMUM RATINGS

Symbol	Parameters		Min.	Max.	Unit
VBUS	VBUS to GND & VBUS to VOUT = GND or Float		−0.3	28	V
VOUT	VOUT to GND		−0.3	26	V
BUS_DET	BUS_DET to GND		−0.3	6	V
$V_{ENB\_OTG\_DET\_DIS\_OV\_FLAGB}$	ENB, OTG_DET, DIS, OVLO_SEL or OV_FLAGB to GND		−0.3	6	V
$I_{IN\_VBUS\_VOUT}$	Continuous VBUS to VOUT Current		–	5.5	A
	Peak VBUS to VOUT Current (5 ms)		–	11	A
$I_{IN\_BUS\_DET}$	Continuous BUS_DET Current		–	10	mA
t_{PD}	Total Power Dissipation at T_A = 25°C		–	1.66	W
T_{STG}	Storage Junction Temperature		−65	+150	°C
T_J	Operating Junction Temperature		–	+150	°C
T_L	Lead Temperature (Soldering, 10 Seconds)		–	+260	°C
Θ_{JA}	Thermal Resistance, Junction−to−Ambient (1in.^{2} pad of 2 oz. copper)		–	63.3 (Note 1)	°C/W
ESD	Electrostatic Discharge Capability	Human Body Model, ANSI/ESDA/JEDEC JS−001	2	–	kV
		Charged Device Model, JESD22−C101	1	–	
	IEC61000−4−2 System Level	Air Discharge at VBUS	15	–	
		Contact Discharge at VBUS	8	–	
Surge	IEC61000−4−5	V_{BUS}	−200	+200	V

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Measured using 2S2P JEDEC std. PCB

Table 3. RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min.	Max.	Unit
V_{BUS}	VBUS Operating Voltage	2.7	21.0	V
V_{OTG_DET}	OTG_DET Operating Voltage	3.1	4.85	V
V_{OUT_OTG}	VOUT Operating Voltage in OTG operation	5.0	5.4	V
C_{IN} (Note 2)	Input Capacitance for VBUS. Minimum rating 50 V (Note 3)	1	–	μF
C_{OUT} (Note 2)	Output Capacitance for VOUT. Minimum rating 25 V (Note 3)	1	–	μF
C_{OTG_DET} (Note 2)	Capacitance for OTG_DET. Minimum rating 10 V (Note 3)	1	–	μF
C_{BUS_DET} (Note 2)	Capacitance for BUS_DET. Minimum rating 10 V (Note 3)	1	–	μF
T_A	Ambient Operating Temperature, T_A	−40	85	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

2. Bypass capacitor should be placed to the device as close as possible in order to reduce the parasitic inductance.
3. Each capacitor's DC rating is depending on Samsung's internal guidance.

Table 4. ELECTRICAL CHARACTERISTICS

Unless otherwise noted, VBUS = 2.7 to 21.0 V, T_A= −40 to 85 °C; Typical values are at VBUS= 5 V, $I_{IN} \leq 1$ A, ENB = DIS = LOW, OVLO_SEL = GND, BUS_DET = Floating, C_{IN} = 1 μF and T_A = 25 °C.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Basic Operation						
I_{Q_PWR}	Power Input Quiescent Current enable	VBUS = 5 V, ENB = LOW	–	150	220	μA
	Power Input Quiescent Current disable	VBUS = 5 V, ENB = HIGH	–	130	200	
I_{IN_OVLO}	OVLO Supply Current	VBUS = 15 V, VOUT = 0 V, ENB = LOW, OVLO_SEL = GND	–	190	250	μA
		VBUS = 23 V, VOUT = 0 V, ENB = LOW, OVLO_SEL = HIGH	–	190	250	
V_{UVLO}	Under−Voltage Trip Level	VBUS Rising, T_A= −40 to 85 °C	2.35	2.5	2.65	V
		VBUS Falling, T_A= −40 to 85 °C	2.2	2.35	2.5	V
R_{PD}	VBUS Discharge Resistance	VBUS = 5 V, DIS = 1.8 V	–	550	–	Ω
t_{DIS_ON}	VBUS Discharge ON Delay Time	VOUT = 5 V, Time from DIS = HIGH to Discharge path ON	–	0.5	–	μs
t_{DIS_OFF}	VBUS Discharge OFF Delay Time	VOUT = 5 V, Time from DIS = LOW to Discharge path OFF	–	1	–	μs
t_{DIS}	VBUS Discharge Time	VOUT = 5 V, V_{OTG_DET} = 0 V, C_{BUS} = 1 μF, C_{OUT} = 1 μF, DIS = ENB = LOW to HIGH, VOUT supply disabled at the same time, Time from 5 V to 0.5 V at VBUS	–	21	–	ms
		VOUT = 5 V, V_{OTG_DET} = 0 V, C_{BUS} = 1 μF, C_{OUT} = 10 μF, DIS = ENB = LOW to HIGH, VOUT supply disabled at the same time, Time from 5 V to 0.5 V at VBUS	–	90	–	
T_{SDN}	Thermal Shutdown (Note 4)		–	145	–	°C
T_{SDN_HYS}	Thermal Shutdown Hysteresis (Note 4)		–	20	–	°C
Integrated Bi−directional TVS						
V_{RW_P}	Positive Reverse Working Voltage		–	–	28	V
V_{BR_P}	Positive Breakdown Voltage	I_{IN} = 1 mA	–	35	38	V
V_{CL_P}	Positive Clamping Voltage (Note 5)	+200 V Surge (IEC61000−4−5), T_A = −40 °C to 85 °C	–	39	42	V
$I_{IN\_PK\_P}$	Positive Peak Current During Surge test	+200 V Surge (IEC61000−4−5), T_A = −40 °C to 85 °C	–	–	100	A
V_{RW_N}	Negative Reverse Working Voltage		−0.2	–	–	V
V_{F_TVS}	Forward Voltage of TVS	I_{IN} = −10 mA	−0.2	−0.6	−0.8	V
V_{CL_N}	Negative Clamping Voltage	−200 V Surge (IEC61000−4−5)	−3	–	–	V
$I_{IN\_PK\_N}$	Negative Peak Current During Surge test	−200 V Surge (IEC61000−4−5), T_A = −40 °C to 85 °C	−103	–	–	A
VBUS to VOUT Switch						
V_{OVLO}	Over−Voltage Trip Level	VBUS Rising, OVLO_SEL = GND T_A= −40 to 85 °C	13.4	13.7	14.0	V
		VBUS Falling, OVLO_SEL = GND T_A= −40 to 85 °C	–	13.4	–	V
		VBUS Rising, OVLO_SEL = HIGH T_A= −40 to 85 °C	21.5	21.9	22.3	V
		VBUS Falling, OVLO_SEL = HIGH T_A= −40 to 85 °C	–	21.5	–	V

Table 4. ELECTRICAL CHARACTERISTICS (continued)
Unless otherwise noted, VBUS = 2.7 to 21.0 V, T_A= −40 to 85 °C; Typical values are at VBUS= 5 V, $I_{IN} \le 1$ A, ENB = DIS = LOW, OVLO_SEL = GND, BUS_DET = Floating, C_{IN} = 1 μF and T_A = 25 °C.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
VBUS to VOUT Switch						
R_{ON_VOUT}	On−Resistance (Note 5)	VBUS = 5 V, I_{OUT} = 200 mA, T_A = 25 °C	−	21	25	mΩ
		VBUS = 5 V, I_{OUT} = 200 mA, T_A = −40 °C to 85 °C	−	−	30	
		VBUS = 12 V, I_{OUT} = 200 mA, T_A = 25 °C	−	21	25	
		VBUS = 12 V, I_{OUT} = 200 mA, T_A = −40 °C to 85 °C	−	−	30	
		VBUS = 21 V, I_{OUT} = 200 mA, T_A = 25 °C	−	21	25	
		VBUS = 21 V, I_{OUT} = 200 mA, T_A = −40 °C to 85 °C	−	−	30	
t_{DEB_VOUT}	Debounce Time	Time from V_{UVLO} < VBUS < V_{OVLO} to VOUT = 0.1 × VBUS	−	28	−	ms
t_{ON_VOUT}	Switch Turn−On Time	R_L = 100 Ω, C_L = 1 μF, VOUT from 0.1 × VBUS to 0.9 × VBUS,	−	200	−	μs
t_{OFF_OVP}	Switch Turn−Off Time (Note 5)	R_L = 100 Ω, no C_{OUT} , VBUS > V_{OVLO} to V_{OUT} stop rising, OVLO_SET = HIGH or LOW, Measured under IEC61000−4−5 standard	−	50	90	ns
t_{OFF_ENB}	Switch Turn−Off Time by control	R_L = 100 Ω, C_{OUT} = 1 μF, V_{ENB} > V_{IH} to V_{OUT} = 0.9 × VBUS	−	12	18	μs
VOUT to VBUS Switch (OTG Mode)						
R_{ON_OTG}	On−Resistance	VOUT = 5 V, I_{BUS} = 200 mA, T_A = 25 °C	−	21	25	mΩ
V_{UVLO_OTG}	OTG_DET Under−Voltage Lockout Level	OTG_DET Rising, T_A= −40 to 85 °C	2.80	2.95	3.10	V
		OTG_DET Falling, T_A= −40 to 85 °C	2.65	2.80	2.95	V
t_{DON_OTG}	OTG Start−up Delay Time (Note 5)	Time from OTG_DET > UVLO_OTG to VBUS FET Fully ON	−	0.6	1	ms
I_{OTG_DET}	Current at OTG_DET	OTG_DET < V_{POR}, VOUT = 0 V, ENB = LOW, VBUS open, T_A = −40 °C to 85 °C	−	−	2	μA
		V_{POR} < OTG_DET < 2.8 V, VOUT = 0 V, ENB = LOW, VBUS open, T_A = −40 °C to 85 °C	−	−	60	
		OTG_DET = 5 V, VOUT = 0V, ENB = LOW, VBUS open, T_A = −40 °C to 85 °C	−	80	120	
		OTG_DET = 4.85 V, VOUT = 5 V, ENB = LOW, VBUS open, T_A = −40 °C to 85 °C	−	−	1	
Always ON LDO, BUS_DET						
V_{BUS_DET}	BUS_DET Output Voltage	VBUS = 5 V, I_{BUS_DET} = 0 mA, T_A = 25 °C	3.8	4.0	4.2	V
		VBUS = 21 V, I_{BUS_DET} = 0 mA, T_A = 25 °C	3.8	4.0	4.2	
		VBUS = 5 V, I_{BUS_DET} = 10 mA, T_A = 25 °C	3.8	4.0	4.2	
		VBUS = 21 V, I_{BUS_DET} = 10 mA, T_A = 25 °C	3.8	4.0	4.2	
$t_{START\_BUS\_DET}$	BUS_DET Output Startup de−bounce time	Time from VBUS > V_{UVLO} to BUS_DET = 0.1 × V_{BUS_DET}	−	5.0	−	ms
$t_{R\_BUS\_DET}$	BUS_DET Output Rising time	Time from BUS_DET = 0.1 × V_{BUS_DET} to BUS_DET = 0.9 × V_{BUS_DET}, C_{BUS_DET} = 1 μF, R_L = 10 kΩ	−	0.1	−	ms
Digital Signals						
V_{FLAGB_OL}	OV_FLAGB Output LOW Voltage	I_{OV_FLAGB} = 1mA	−	−	0.36	V
t_{FLAGB_DELAY}	OV_FLAGB Assertion delay Time	Time from VBUS = V_{OVLO} to OV_FLAGB assertion, ENB = HIGH or LOW	−	−	3	μs
$t_{FLAGB\_REC\_EN}$	OV_FLAGB Recovery de−bounce Time when enabled	Time from VBUS < V_{OVLO} to OV_FLAGB de−assertion, ENB = LOW	−	33	−	ms

Table 4. ELECTRICAL CHARACTERISTICS (continued)
Unless otherwise noted, VBUS = 2.7 to 21.0 V, T_A= −40 to 85 °C; Typical values are at VBUS= 5 V, $I_{IN} \leq 1$ A, ENB = DIS = LOW, OVLO_SEL = GND, BUS_DET = Floating, C_{IN} = 1 μF and T_A = 25 °C.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Digital Signals						
$t_{FLAGB\_REC\_OT}$	OV_FLAGB Recovery de−bounce Time when the device in thermal shutdown status	Time from VBUS < V_{OVLO} to OV_FLAGB de−assertion, device in thermal shutdown mode	–	3	–	ms
$t_{FLAGB\_REC\_DIS}$	OV_FLAGB Recovery de−bounce Time when disabled	Time from VBUS = V_{OVLO} to OV_FLAGB de−assertion, ENB = HIGH	–	200	–	μs
$R_{PD\_ENB\_DIS\_OVSEL}$	Internal Pull−Down Resistor at ENB, DIS and OVLO_SEL pin		–	1	–	MΩ
$V_{IH\_ENB\_DIS\_OVSEL}$	Logic Enable HIGH Voltage	VBUS operating range	1.2	–	–	V
$V_{IL\_ENB\_DIS\_OVSEL}$	Logic Enable LOW Voltage	VBUS operating range	–	–	0.5	V
$I_{BUS\_DET\_LEAK}$	BUS_DET Leakage Current	V_{BUS_DET} = 5 V, VBUS = 0 V	–	–	1	μA

4. Self−heating is not included
5. Guaranteed by characterization and design.

Timing Diagrams

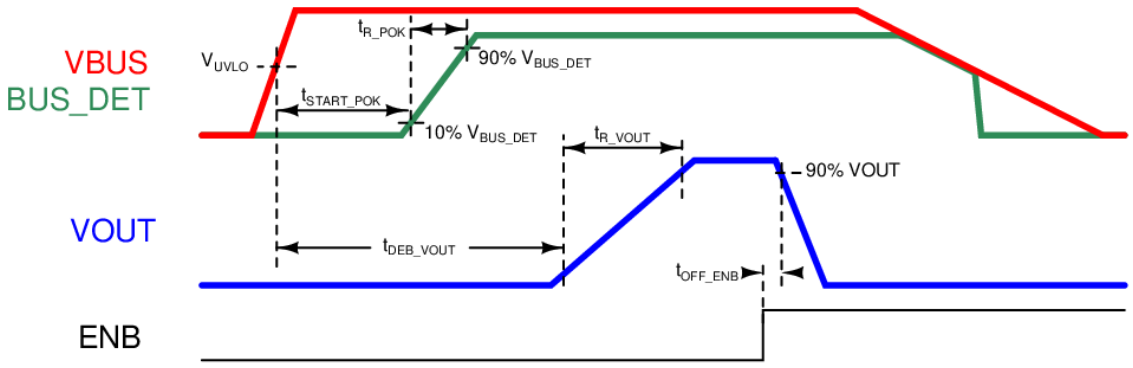


Figure 4. VBUS to VOUT Power Up/Down and Normal Operation

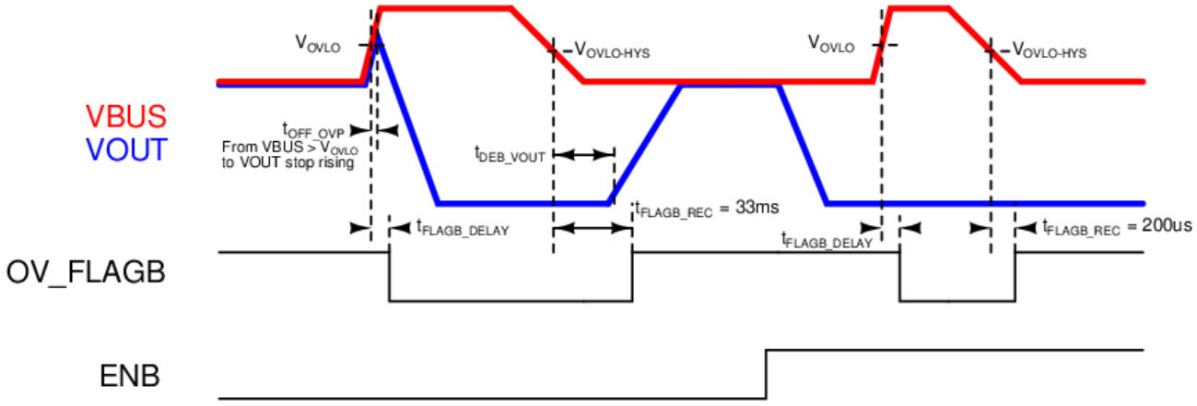


Figure 5. VBUS to VOUT OVLO Operation

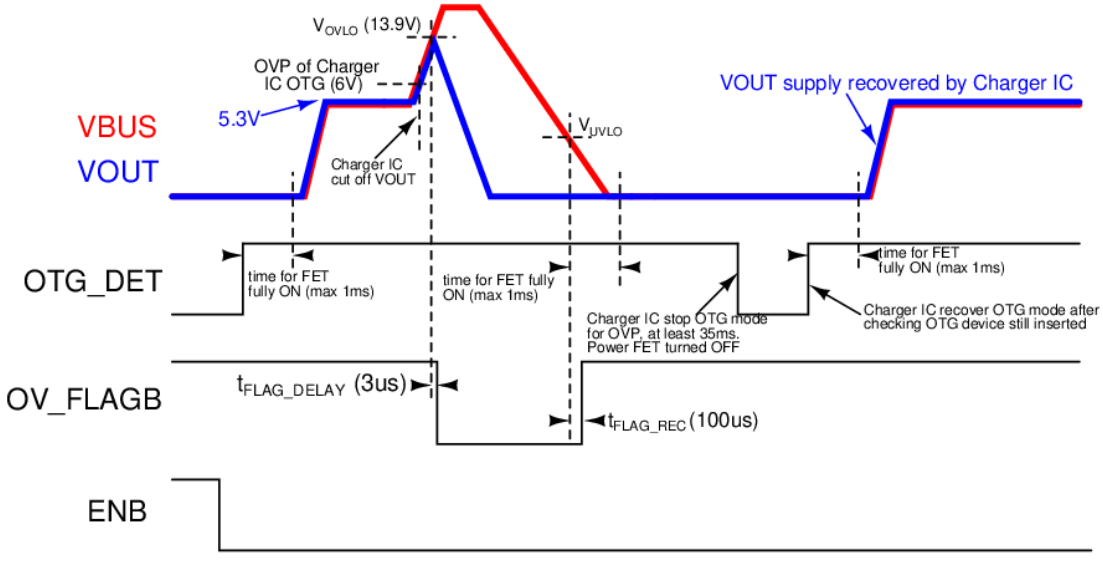


Figure 6. OVP in OTG Mode Operation (with Charger IC Internal OVP 6 V)

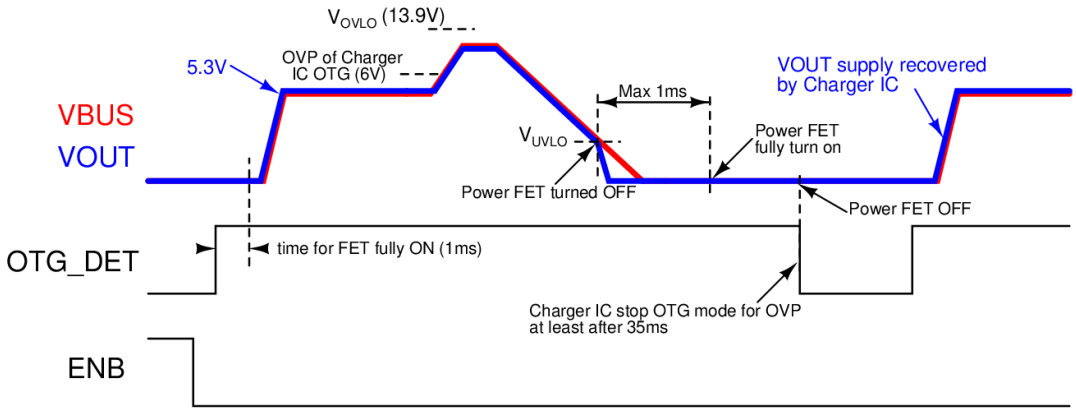


Figure 7. HV Event without OVLO in OTG Mode Operation (with Charger IC Internal OVP 6 V)

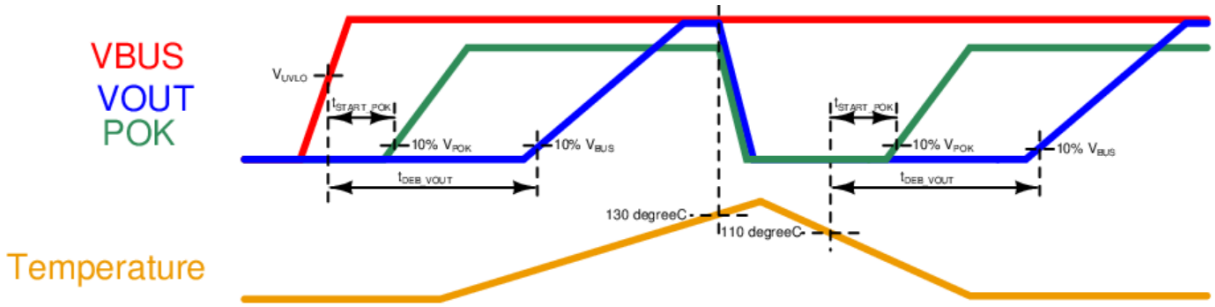


Figure 8. Thermal Shutdown Operation

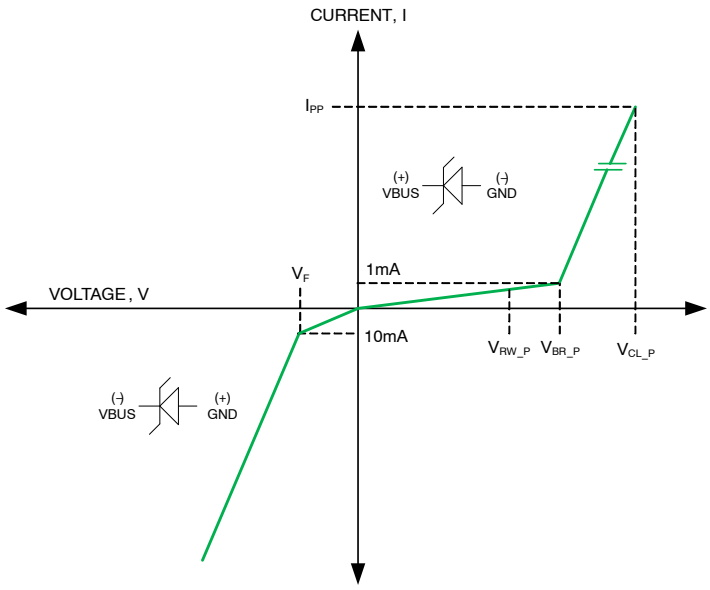


Figure 9. Integrated TVS IV Curve at VBUS

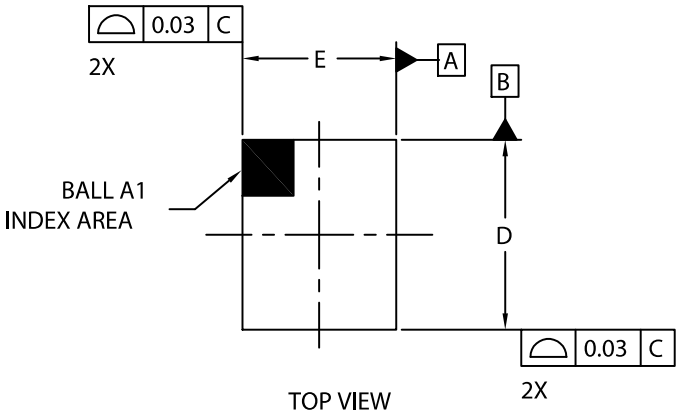
ORDERING INFORMATION

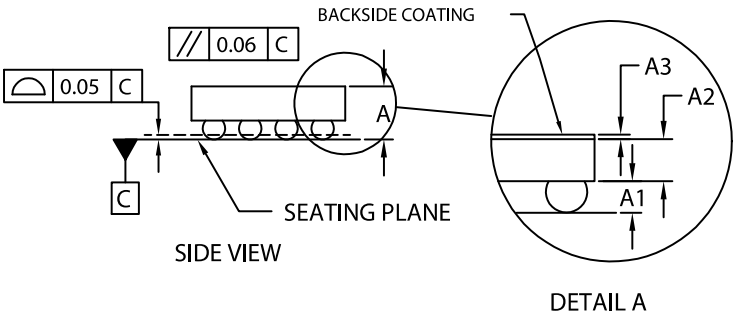
Part Number	Top Marking	Operating Temperature Range	Package	Shipping†
FPF2188UCX	3Y	−40°C to +85°C	WLCSP20 (Pb−Free)	3000 / Tape & Reel

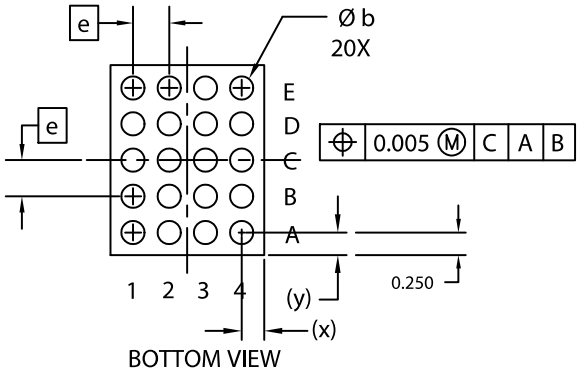
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

PACKAGE DIMENSIONS

WLCSP20 2.03x1.77x0.585
CASE 567ZF
ISSUE A



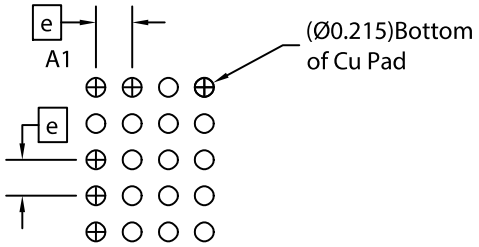




NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DATUM C APPLIES TO THE SPHERICAL CROWN OF THE SOLDER BALLS

DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	0.560	0.585	0.610
A1	0.184	0.194	0.204
A2	0.354	0.366	0.378
A3	0.022	0.025	0.028
b	0.240	0.260	0.280
D	2.000	2.030	2.060
E	1.740	1.770	1.800
e	0.40 BSC		
x	0.270	0.285	0.300
y	0.200	0.215	0.230



RECOMMENDED MOUNTING FOOTPRINT*
(NSMD PAD TYPE)

*For additional information on our Pb−Free strategy and soldering details, please download the **onsemi** Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Email Requests to: orderlit@onsemi.com

onsemi Website: www.onsemi.com

TECHNICAL SUPPORT
North American Technical Support:
Voice Mail: 1 800−282−9855 Toll Free USA/Canada
Phone: 011 421 33 790 2910

Europe, Middle East and Africa Technical Support:
Phone: 00421 33 790 2910
For additional information, please contact your local Sales Representative

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