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FPF1320 / FPF1321 IntelliMAX™ Dual-Input Single-Output Advanced Power Switch with True Reverse-Current Blocking

Features

- DISO Load Switches
- Input Supply Operating Range: 1.5 V ~ 5.5 V
- R_{ON} 50 mΩ at V_{IN}=3.3 V Per Channel (Typical)
- True Reverse-Current Blocking (TRCB)
- Fixed Slew Rate Controlled 130 μs for < 1 μF C_{OUT}
- I_{SW}: 1.5 A Per Channel (Maximum)
- Quick Discharge Feature on FPF1321
- Logic CMOS IO Meets JESD76 Standard for GPIO Interface and Related Power Supply Requirements
- ESD Protected:
 - Human Body Model: >6 kV
 - Charged Device Model: >1.5 kV
 - IEC 61000-4-2 Air Discharge: >15 kV
 - IEC 61000-4-2 Contact Discharge: >8 kV

Applications

- Smart phones / Tablet PCs
- Portable Devices
- Near Field Communication (NFC) Capable SIM Card Power Supply

Description

The FPF1320/21 is a Dual-Input Single-Output (DISO) load switch consisting of two sets of slew-rate controlled, low on-resistance, P-channel MOSFET switches and integrated analog features. The slew-rate-controlled turn-on characteristic prevents inrush current and the resulting excessive voltage droop on the power rails. The input voltage range operates from 1.5 V to 5.5 V to align with the requirements of low-voltage portable device power rails. FPF1320/21 performs seamless power-source transitions between two input power rails using the SEL pin with advanced break-before-make operation.

FPF1320/21 has a TRCB function to block unwanted reverse current from output to input during ON/OFF states. The switch is controlled by logic inputs of the SEL and EN pins, which are capable of interfacing directly with low-voltage control signals (GPIO).

FPF1321 has 65 Ω on-chip load resistor for output quick discharge when EN is LOW.

FPF1320/21 is available in 1.0 mm x 1.5 mm WLCSP, 6-bump, with 0.5 mm pitch. FPF1321B is available in 1.0 mm x 1.5 mm WLCSP, 6-bump, 0.5 mm pitch with backside laminate.

Ordering Information

| Part Number | Top Mark | Channel | Switch Per Channel (Typ.) at 3.3 V _{IN} | Reverse Current Blocking | Output Discharge | Rise Time (t _R) | Package |
|-------------|----------|---------|--|--------------------------|------------------|-----------------------------|---|
| FPF1320UCX | QS | DISO | 50 mΩ | Yes | NA | 130 μs | 1.0 mm X 1.5 mm Wafer-Level Chip-Scale Package (WLCSP) 6-Bumps, 0.5 mm Pitch |
| FPF1321UCX | QT | DISO | 50 mΩ | Yes | 65 Ω | 130 μs | |
| FPF1321BUCX | QT | DISO | 50 mΩ | Yes | 65 Ω | 130 μs | 1.0 mm X 1.5 mm Wafer-Level Chip-Scale Package (WLCSP) 6-Bumps, 0.5 mm Pitch with Backside Laminate |

Application Diagram

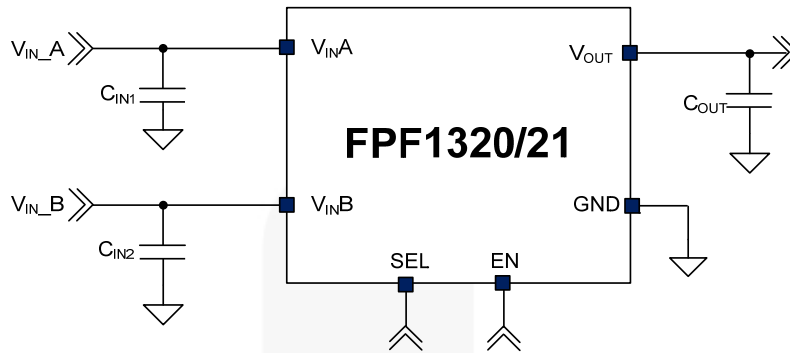


Figure 1. Typical Application

Block Diagram

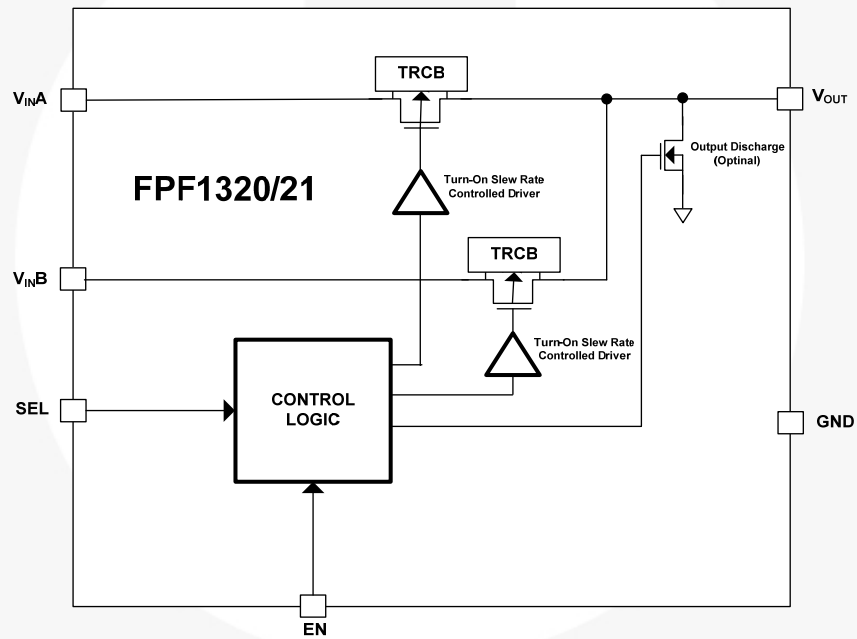


Figure 2. Functional Block Diagram (Output Discharge Path for FPF1321 Only)

Pin Configuration

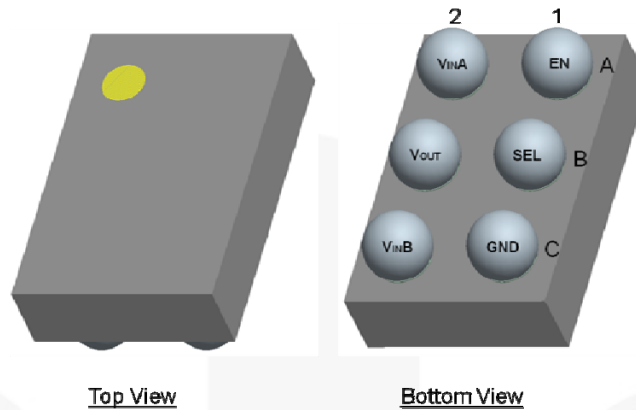


Figure 3. Pin Configuration in Package View with Pin 1 Indicator

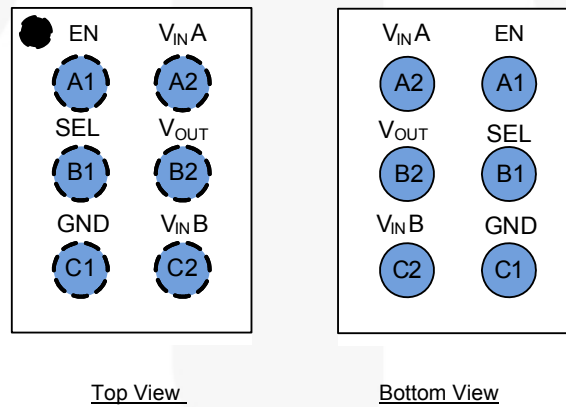


Figure 4. Pin Assignments

Pin Description

| Pin # | Name | Description |
|-------|-------------------|--|
| A1 | EN | Enable input. Active HIGH. There is an internal pull-down resistor at the EN pin. |
| B1 | SEL | Input power selection inputs. See Table 1. There are internal pull-down resistors at the SEL pins. |
| A2 | V _{IN A} | Supply Input. Input to the power switch A. |
| B2 | V _{OUT} | Switch output |
| C1 | GND | Ground |
| C2 | V _{IN B} | Supply Input. Input to power switch B. |

Table 1. Truth Table

| SEL | EN | Switch A | Switch B | V _{OUT} | Status |
|------|------|----------|----------|---|----------------------------|
| LOW | HIGH | ON | OFF | V _{IN A} | V _{IN A} Selected |
| HIGH | HIGH | OFF | ON | V _{IN B} | V _{IN B} Selected |
| X | LOW | OFF | OFF | Floating for FPF1320 GND for FPF1321 | Both Switches are OFF |

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} | V_{INA} , V_{INB} , V_{SEL} , V_{EN} , V_{OUT} to GND | -0.3 | 6 | V |
| I_{SW} | Maximum Continuous Switch Current per Channel | | 1.5 | A |
| P_D | Total Power Dissipation at $T_A=25^\circ\text{C}$ | | 1.2 | W |
| T_{STG} | Operating and Storage Junction Temperature | -65 | 150 | $^\circ\text{C}$ |
| Θ_{JA} | Thermal Resistance, Junction-to-Ambient (1 in. ² Pad of 2-oz. Copper) | | 85 ⁽¹⁾ | $^\circ\text{C/W}$ |
| | | | 110 ⁽²⁾ | |
| ESD | Electrostatic Discharge Capability | Human Body Model, JESD22-A114 | 6.0 | kV |
| | | Charged Device Model, JESD22-C101 | 1.5 | |
| | | Air Discharge (V_{INA} , V_{INB} to GND), IEC61000-4-2 System Level | 15.0 | |
| | | Contact Discharge (V_{INA} , V_{INB} to GND), IEC61000-4-2 System Level | 8.0 | |

Notes:

1. Measured using 2S2P JEDEC std. PCB.
2. Measured using 2S2P JEDEC PCB cold-plate method.

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} | Input Voltage on V_{INA} , V_{INB} | 1.5 | 5.5 | V |
| T_A | Ambient Operating Temperature | -40 | 85 | $^\circ\text{C}$ |

Electrical Characteristics

$V_{IN A}=V_{IN B}=1.5$ to 5.5 V, $T_A=-40$ to 85°C unless otherwise noted. Typical values are at $V_{IN A}=V_{IN B}=3.3$ V and $T_A=25^\circ\text{C}$.

| Symbol | Parameters | Condition | Min. | Typ. | Max. | Unit |
|--------------------------------------|---|---|------|------|------|---------------|
| Basic Operation | | | | | | |
| $V_{IN A}, V_{IN B}$ | Input Voltage | | 1.5 | | 5.5 | V |
| I_{SD} | Shutdown Current | SEL=HIGH or LOW, EN=GND, $V_{OUT}=GND$, $V_{IN A}=V_{IN B}=5.5$ V | | | 5 | μA |
| I_Q | Quiescent Current | $I_{OUT}=0\text{mA}$, SEL=HIGH or LOW, EN=HIGH, $V_{IN A}=V_{IN B}=5.5$ V | | 12 | 22 | μA |
| R_{ON} | On-Resistance | $V_{IN A}=V_{IN B}=5.5$ V, $I_{OUT}=200$ mA, $T_A=25^\circ\text{C}$ | | 42 | 60 | m Ω |
| | | $V_{IN A}=V_{IN B}=3.3$ V, $I_{OUT}=200$ mA, $T_A=25^\circ\text{C}$ | | 50 | | |
| | | $V_{IN A}=V_{IN B}=1.8$ V, $I_{OUT}=200$ mA, $T_A=25^\circ\text{C}$ to 85°C | | 80 | | |
| | | $V_{IN A}=V_{IN B}=1.5$ V, $I_{OUT}=200$ mA, $T_A=25^\circ\text{C}$ | | | 170 | |
| V_{IH} | SEL, EN Input Logic High Voltage | $V_{IN A}, V_{IN B}=1.5$ V – 5.5 V | 1.15 | | | V |
| V_{IL} | SEL, EN Input Logic Low Voltage | $V_{IN A}, V_{IN B}=1.8$ V – 5.5 V | | | 0.65 | V |
| | SEL, EN Input Logic Low Voltage | $V_{IN A}, V_{IN B}=1.5$ V – 1.8 V | | | 0.60 | |
| V_{DROOP_OUT} | Output Voltage Droop while Channel Switching from Higher Input Voltage Lower Input Voltage ⁽³⁾ | $V_{IN A}=3.3$ V, $V_{IN B}=5$ V, Switching from $V_{IN A} \rightarrow V_{IN B}$, $R_L=150$ Ω , $C_{OUT}=1$ μF | | | 100 | mV |
| I_{SEL}/I_{EN} | Input Leakage at SEL and EN Pin | | | | 1.2 | μA |
| R_{SEL_PD}/R_{EN_PD} | Pull-Down Resistance at SEL or EN Pin | | | 7 | | M Ω |
| R_{PD} | Output Pull-Down Resistance | SEL=HIGH or LOW, EN=GND, $I_{FORCE}=20$ mA, $T_A=25^\circ\text{C}$, FPF1321 | | 65 | | Ω |
| True Reverse Current Blocking | | | | | | |
| V_{T_RCB} | RCB Protection Trip Point | $V_{OUT} - V_{IN A}$ or $V_{IN B}$ | | 45 | | mV |
| V_{R_RCB} | RCB Protection Release Trip Point | $V_{IN A}$ or $V_{IN B} - V_{OUT}$ | | 25 | | mV |
| I_{RCB} | $V_{IN A}$ or $V_{IN B}$ Current During RCB | $V_{OUT}=5.5$ V, $V_{IN A}$ or $V_{IN B}$ =Short to GND | | 9 | 15 | μA |
| t_{RCB_ON} | RCB Response Time when Device is ON ⁽³⁾ | $V_{IN A}$ or $V_{IN B}=5$ V, $V_{OUT}V_{IN A,B}=100$ mV | | 5 | | μs |

Continued on the following page...

Electrical Characteristics (Continued)

 $V_{IN A}=V_{IN B}=1.5$ to 5.5 V, $T_A=-40$ to 85°C unless otherwise noted. Typical values are at $V_{IN A}=V_{IN B}=3.3$ V and $T_A=25^\circ\text{C}$.

| Symbol | Parameters | Condition | Min. | Typ. | Max. | Unit |
|--------------------------------|--|--|------|------|------|---------------|
| Dynamic Characteristics | | | | | | |
| t_{DON} | Turn-On Delay ⁽⁴⁾ | $V_{IN A}$ or $V_{IN B}=3.3$ V, $R_L=150$ Ω , $C_L=1$ μF , $T_A=25^\circ\text{C}$, SEL: HIGH, EN: LOW \rightarrow HIGH | | 120 | | μs |
| t_R | V_{OUT} Rise Time ⁽⁴⁾ | | | 130 | | μs |
| t_{ON} | Turn-On Time ⁽⁶⁾ | | | 250 | | μs |
| t_{DOFF} | Turn-Off Delay ⁽⁴⁾ | $V_{IN A}$ or $V_{IN B}=3.3$ V, $R_L=150$ Ω , $C_L=1$ μF , $T_A=25^\circ\text{C}$, SEL: HIGH, EN: HIGH \rightarrow LOW | | 15 | | μs |
| t_F | V_{OUT} Fall Time ⁽⁴⁾ | | | 320 | | μs |
| t_{OFF} | Turn-Off Time ⁽⁷⁾ | | | 335 | | μs |
| t_{DOFF} | Turn-Off Delay ^(4,5) | $V_{IN A}$ or $V_{IN B}=3.3$ V, $R_L=150$ Ω , $C_L=1$ μF , $T_A=25^\circ\text{C}$, SEL: HIGH, EN: HIGH \rightarrow LOW, Output Discharge Mode, FPF1321 | | 6 | | μs |
| t_F | V_{OUT} Fall Time ^(4,5) | | | 110 | | μs |
| t_{OFF} | Turn-Off Time ^(5,7) | | | 116 | | μs |
| t_{TRANR} | Transition Time LOW \rightarrow HIGH ⁽⁴⁾ | $V_{IN A}=3.3$ V, $V_{IN B}=5$ V, Switching from $V_{IN A} \rightarrow V_{IN B}$, SEL: LOW \rightarrow HIGH, EN: HIGH, $R_L=150$ Ω , $C_L=1$ μF , $T_A=25^\circ\text{C}$ | | 3 | | μs |
| t_{SLH} | Switch-Over Rising Delay ⁽⁴⁾ | | | 1 | | μs |
| t_{TRANF} | Transition Time HIGH \rightarrow LOW ⁽⁴⁾ | $V_{IN A}=3.3$ V, $V_{IN B}=5$ V, Switching from $V_{IN B} \rightarrow V_{IN A}$, SEL: HIGH \rightarrow LOW, EN: HIGH, $R_L=150$ Ω , $C_L=1$ μF , $T_A=25^\circ\text{C}$ | | 45 | | μs |
| t_{SHL} | Switch-Over Falling Delay ⁽⁴⁾ | | | 5 | | μs |

Notes:

- This parameter is guaranteed by design and characterization; not production tested.
- $t_{DON}/t_{DOFF}/t_R/t_F/t_{TRANR}/t_{TRANF}/t_{SLH}/t_{SHL}$ are defined in Figure 5.
- FPF1321 output discharge is enabled during off.
- $t_{ON}=t_R + t_{DON}$.
- $t_{OFF}=t_F + t_{DOFF}$.

Timing Diagram

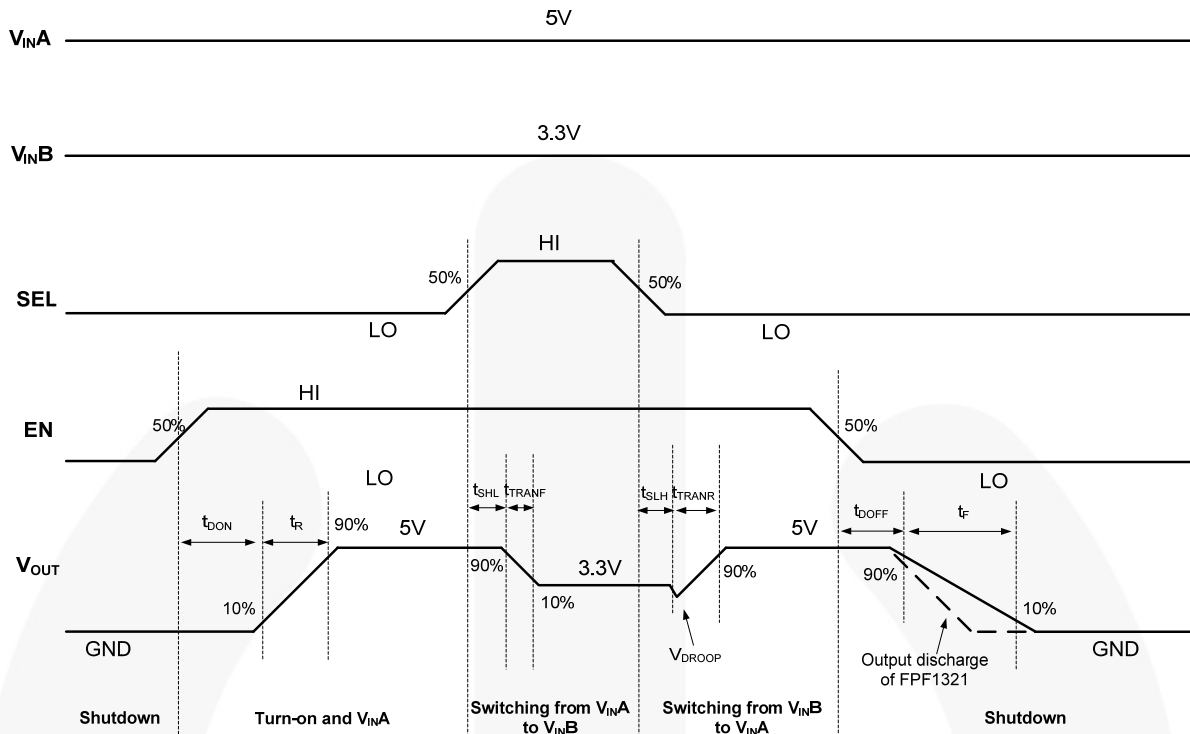


Figure 5. Dynamic Behavior Timing Diagram

Typical Characteristics

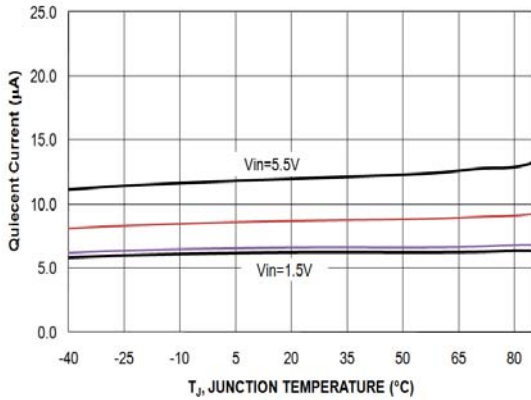


Figure 6. Supply Current vs. Temperature

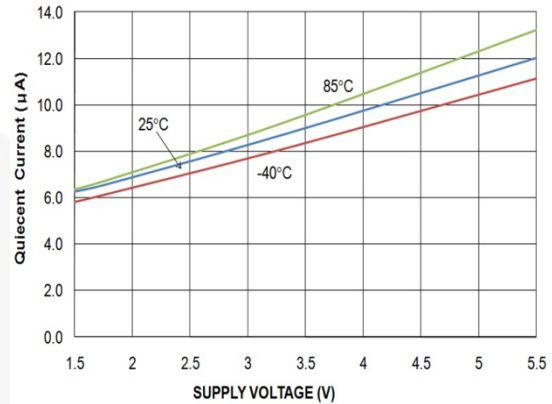


Figure 7. Supply Current vs. Supply Voltage

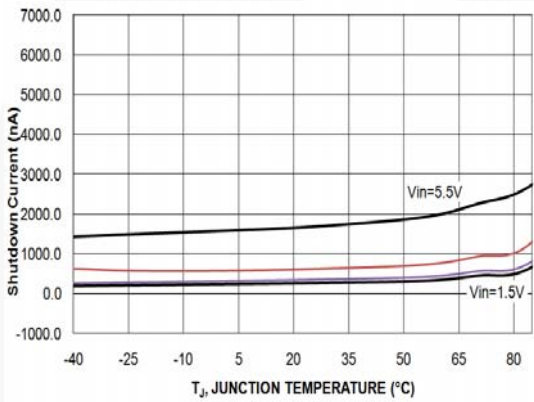


Figure 8. Shutdown Current vs. Temperature

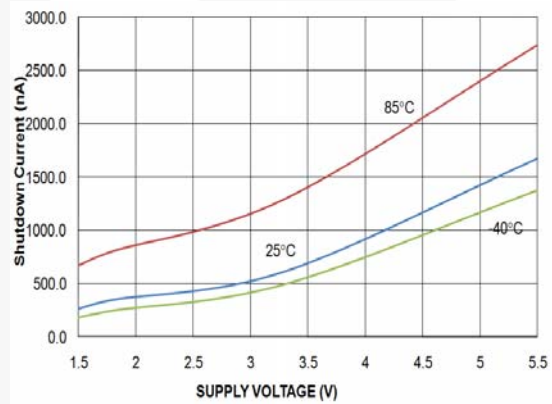


Figure 9. Shutdown Current vs. Supply Voltage

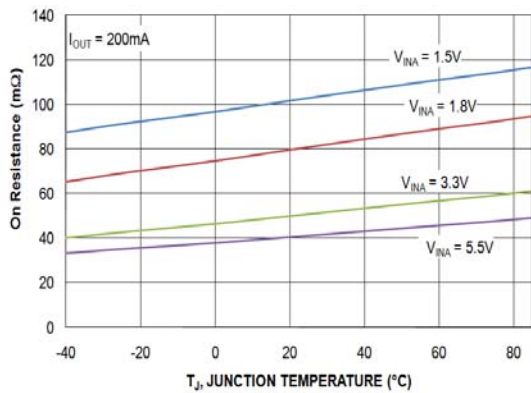


Figure 10. R_{ON} vs. Temperature

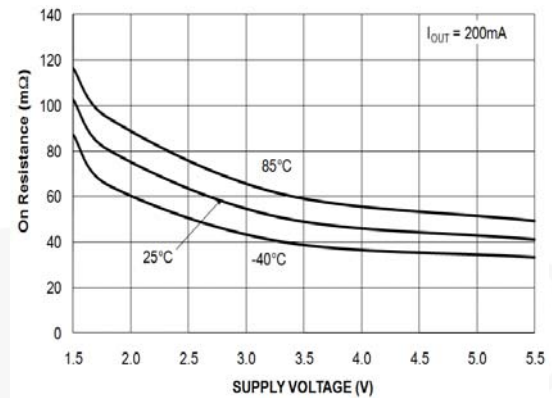


Figure 11. R_{ON} vs. Supply Voltage

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Typical Characteristics

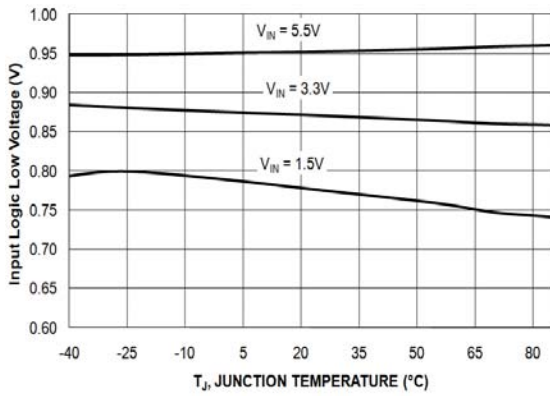


Figure 12. V_{IL} vs. Temperature

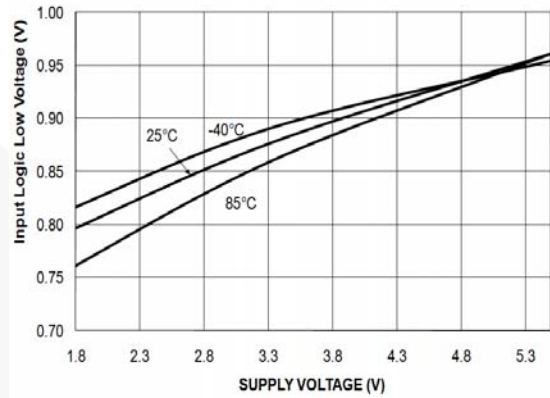


Figure 13. V_{IL} vs. Supply Voltage

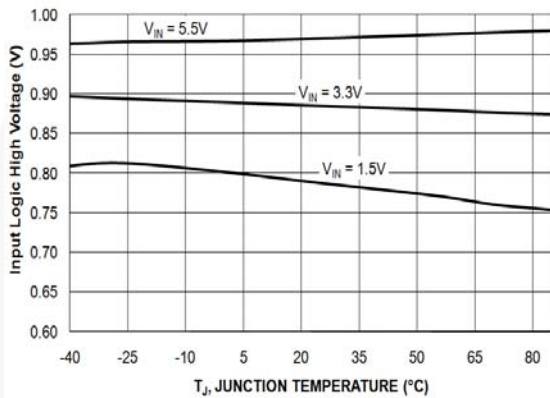


Figure 14. V_{IH} vs. Temperature

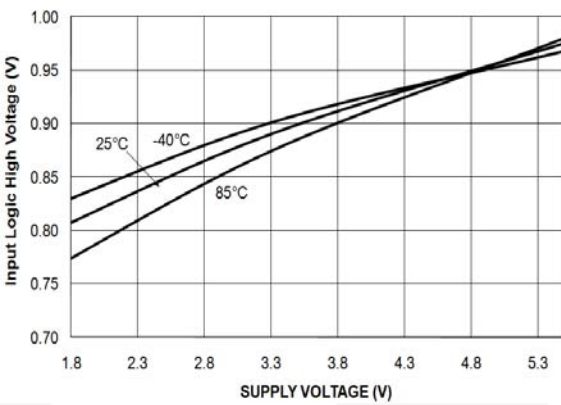


Figure 15. V_{IH} vs. Supply Voltage

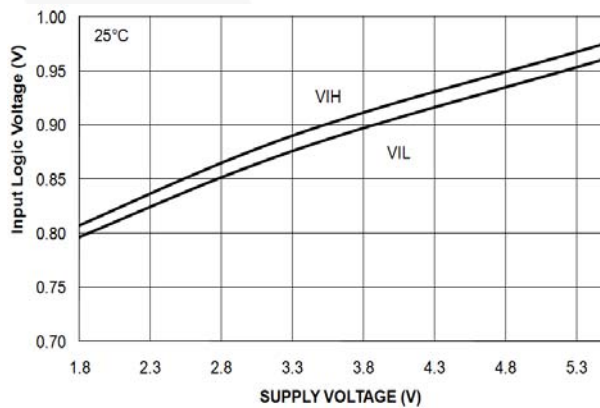


Figure 16. V_{IH} / V_{IL} vs. Supply Voltage

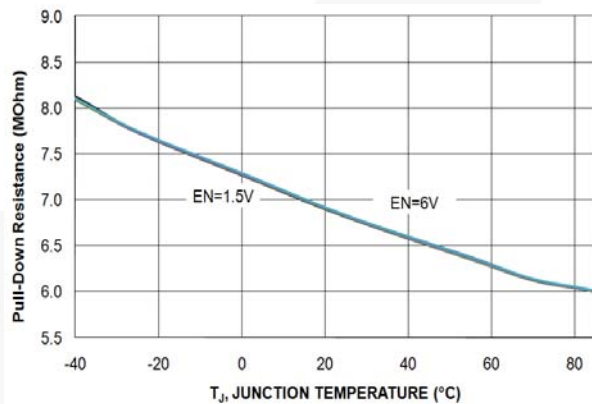


Figure 17. R_{SEL_PD} and R_{EN_PD} vs. Temperature

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Typical Characteristics

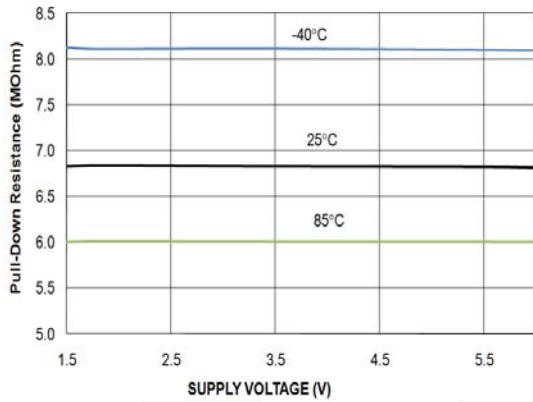


Figure 18. R_{SEL_PD} and R_{EN_PD} vs. Supply Voltage

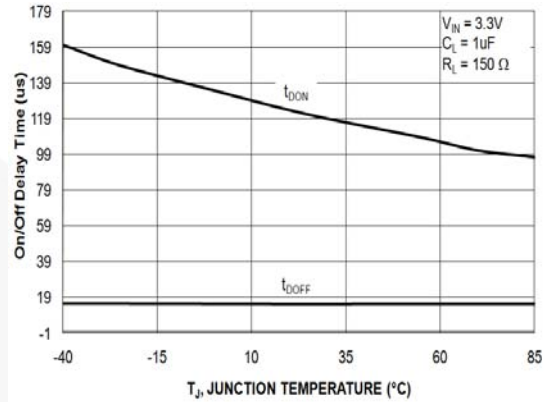


Figure 19. t_{DON} and t_{DOFF} vs. Temperature

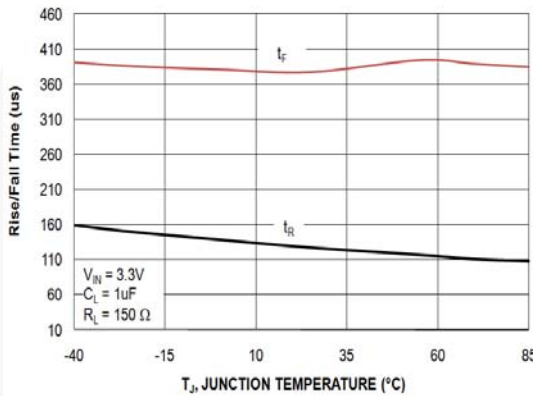


Figure 20. t_R and t_F with FPF1320 vs. Temperature

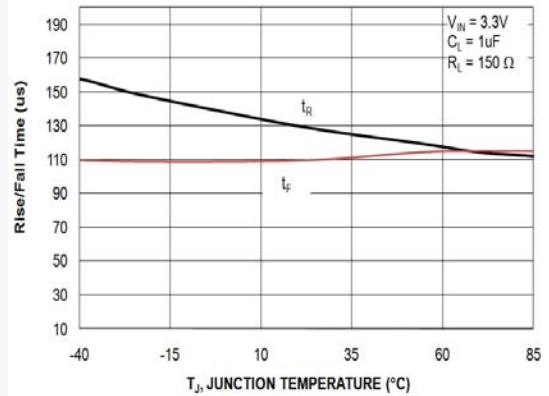


Figure 21. t_R and t_F with FPF1321 vs. Temperature

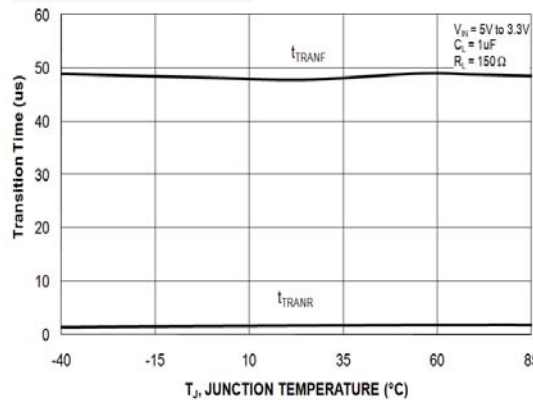


Figure 22. Transition Time vs. Temperature

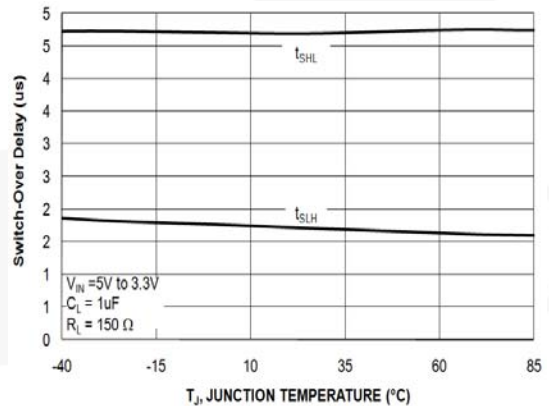


Figure 23. Switch Over Time vs. Temperature

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Typical Characteristics

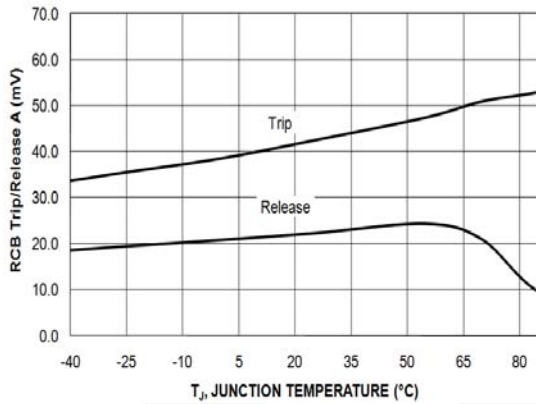


Figure 24. TRCB Trip and Release vs. Temperature

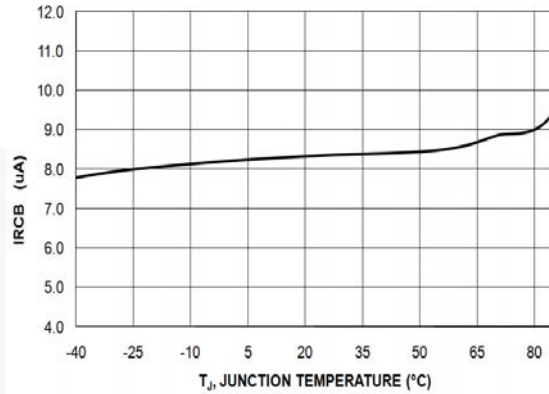


Figure 25. I_{RCB} vs. Temperature

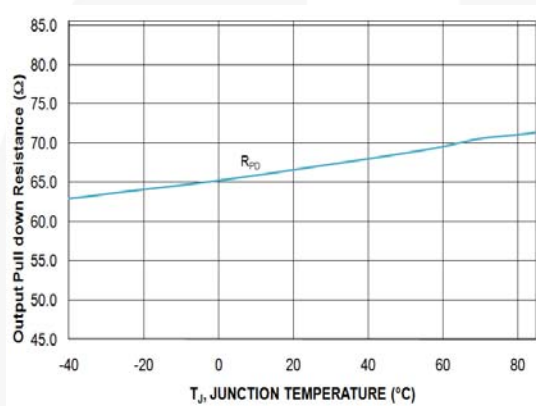


Figure 26. R_{PD} with FPF1321 vs. Temperature

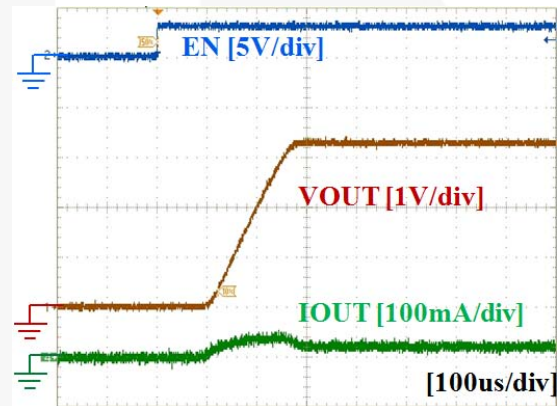


Figure 27. Turn-On Response
($V_{IN A}=3.3\text{ V}$, $C_{IN}=1\text{ }\mu\text{F}$, $C_{OUT}=1\text{ }\mu\text{F}$, $R_L=150\text{ }\Omega$,
 $SEL=LOW$)

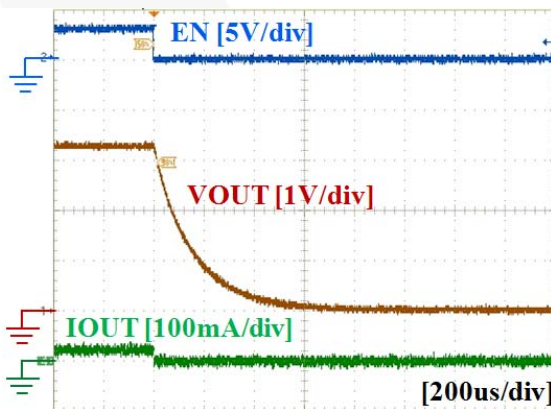


Figure 28. Turn-Off Response with FPF1320
($V_{IN A}=3.3\text{ V}$, $C_{IN}=1\text{ }\mu\text{F}$, $C_{OUT}=1\text{ }\mu\text{F}$, $R_L=150\text{ }\Omega$,
 $SEL=LOW$)

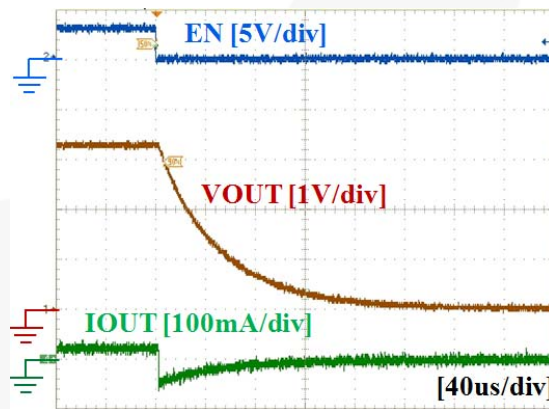


Figure 29. Turn-Off Response with FPF1321
($V_{IN A}=3.3\text{ V}$, $C_{IN}=1\text{ }\mu\text{F}$, $C_{OUT}=1\text{ }\mu\text{F}$, $R_L=150\text{ }\Omega$,
 $SEL=LOW$)

Continued on the following page...

Typical Characteristics

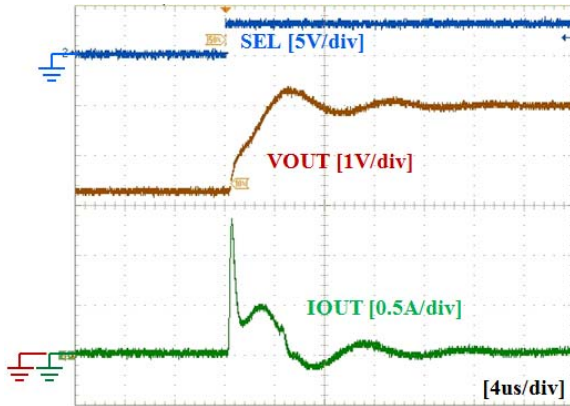


Figure 30. Power Source Transition from 3.3 V to 5 V ($V_{IN A}=3.3$ V, $V_{IN B}=5$ V, $C_{IN}=1$ μ F, $C_{OUT}=1$ μ F, $R_L=150$ Ω)

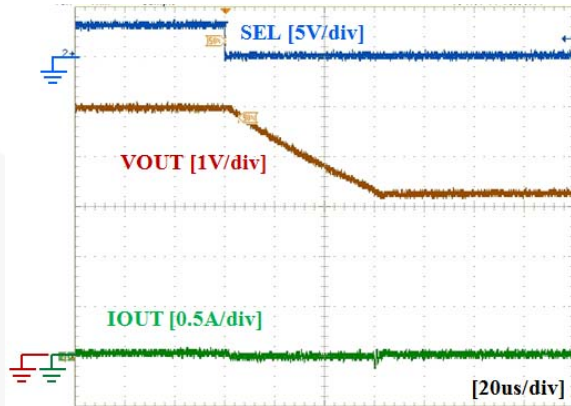


Figure 31. Power Source Transition from 5 V to 3.3 V ($V_{IN A}=3.3$ V, $V_{IN B}=5$ V, $C_{IN}=1$ μ F, $C_{OUT}=1$ μ F, $R_L=150$ Ω)

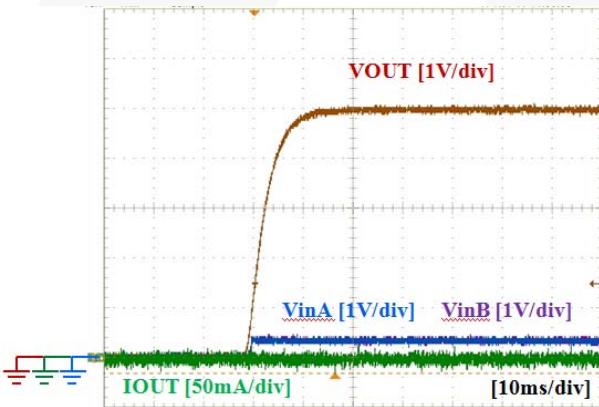


Figure 32. TRCB During Off ($V_{IN A}=V_{IN B}$ =Floating, $V_{OUT}=5$ V, $C_{IN}=1$ μ F, $C_{OUT}=1$ μ F, $EN=LOW$, No R_L)

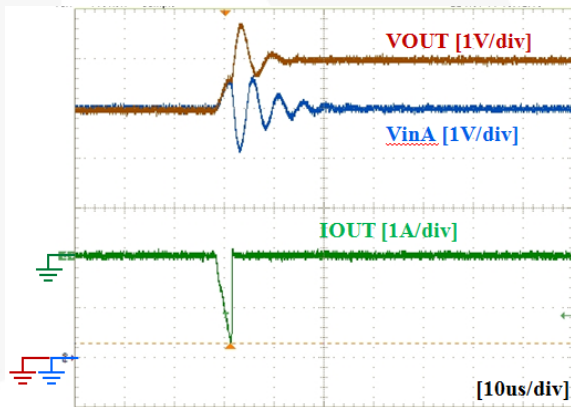


Figure 33. TRCB During On ($V_{IN A}=5$ V, $V_{OUT}=6$ V, $C_{IN}=1$ μ F, $C_{OUT}=1$ μ F, $EN=HIGH$, No R_L)

Operation and Application Description

The FPF1320 and FPF1321 are dual-input single-output power multiplexer switches with controlled turn-on and seamless power source transition. The core is a 50 mΩ P-channel MOSFET and controller capable of functioning over a wide input operating range of 1.5 V to 5.5 V per channel. The EN and SEL pins are active-HIGH, GPIO/CMOS-compatible input. They control the state of the switch and input power source selection, respectively. TRCB functionality blocks unwanted reverse current during both ON and OFF states when higher V_{OUT} than $V_{IN A}$ or $V_{IN B}$ is applied. FPF1321 has a 65 Ω output discharge path during off.

Input Capacitor

To limit the voltage drop on the input supply caused by transient inrush current when the switch turns on into a discharged load capacitor; a capacitor must be placed between the $V_{IN A}$ or $V_{IN B}$ pins to the GND pin. At least 1 μF ceramic capacitor, C_{IN} , placed close to the pins, is usually sufficient. Higher-value C_{IN} can be used to reduce more the voltage drop.

Inrush Current

Inrush current occurs when the device is turned on. Inrush current is dependent on output capacitance and slew rate control capability, as expressed by:

$$I_{INRUSH} = C_{OUT} \times \frac{V_{IN} - V_{INITIAL}}{t_R} + I_{LOAD} \quad (1)$$

where:

C_{OUT} : Output capacitance;

t_R : Slew rate or rise time at V_{OUT} ;

V_{IN} : Input voltage, $V_{IN A}$ or $V_{IN B}$;

$V_{INITIAL}$: Initial voltage at C_{OUT} , usually GND; and

I_{LOAD} : Load current.

Higher inrush current causes higher input voltage drop, depending on the distributed input resistance and input capacitance. High inrush current can cause problems.

FPF1320/1 has a 130 μs of slew rate capability under 3.3 V_{IN} at 1 μF of C_{OUT} and 150 Ω of R_L so inrush current and input voltage drop can be minimized.

Power Source Selection

Input power source selection can be controlled by the SEL pin. When SEL is LOW, output is powered from $V_{IN A}$ while SEL is HIGH, $V_{IN B}$ is powering output. The SEL signal is ignored during device OFF.

Output Voltage Drop during Transition

Output voltage drop usually occurs during input power source transition period from low voltage to high voltage. The drop is highly dependent on output capacitance and load current.

FPF1320/1 adopts an advanced break-before-make control, which can result in minimized output voltage drop during the transition time.

Output Capacitor

Capacitor C_{OUT} of at least 1 μF is highly recommended between the V_{OUT} and GND pins to achieve minimized output voltage drop during input power source transition. This capacitor also prevents parasitic board inductance.

True Reverse-Current Blocking

The true reverse-current blocking feature protects the input source against current flow from output to input regardless of whether the load switch is on or off.

Board Layout

For best performance, all traces should be as short as possible. To be most effective, the input and output capacitors should be placed close to the device to minimize the effect that parasitic trace inductance on normal and short-circuit operation. Wide traces or large copper planes for power pins ($V_{IN A}$, $V_{IN B}$, V_{OUT} and GND) minimize the parasitic electrical effects and the thermal impedance.

Physical Dimensions

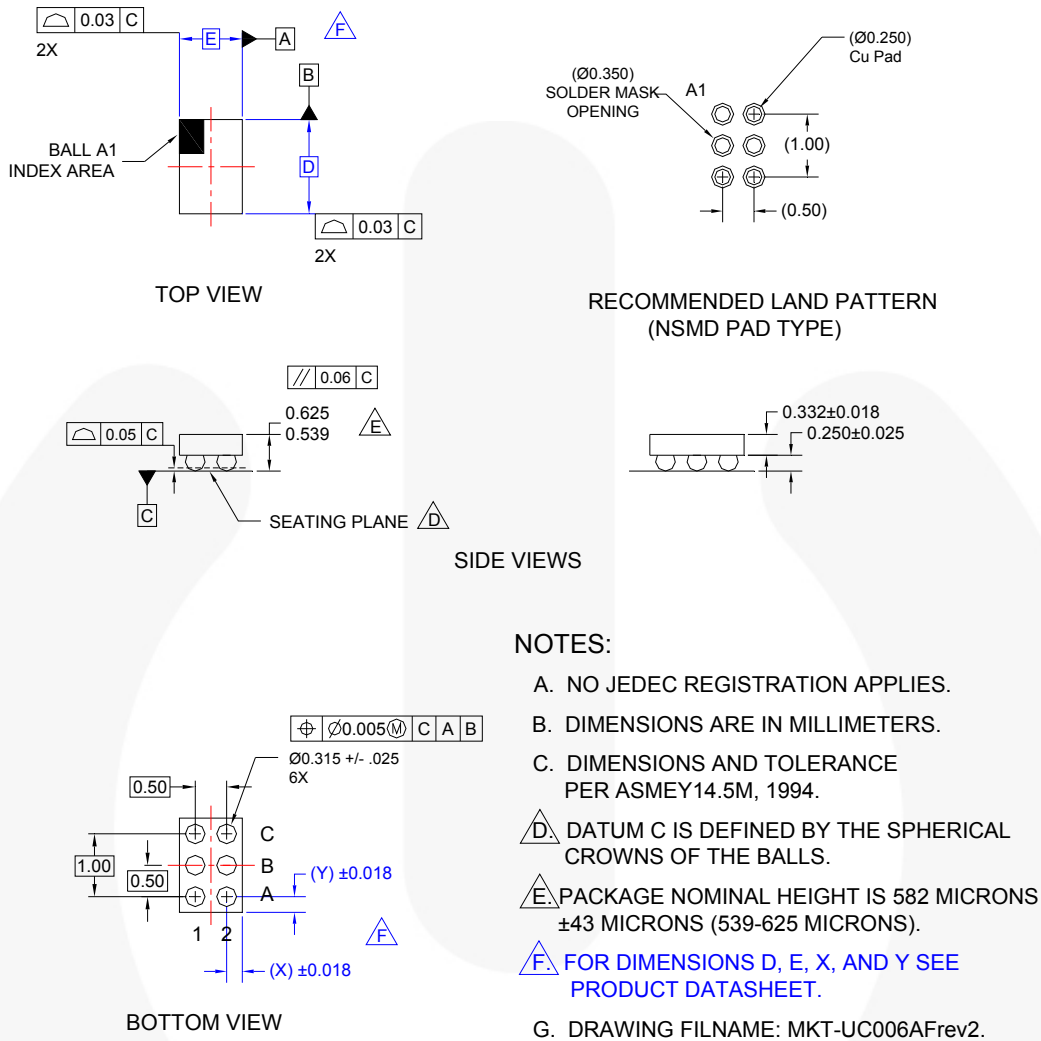


Figure 34. 6-Ball, 1.0 x 1.5 mm, Wafer-Level Chip-Scale Package (WLCSP)

Product-Specific Dimensions

| Product | D | E | X | Y |
|-------------|----------------|---------------|--------|--------|
| FPF1320UCX | 1460 µm ±30 µm | 960 µm ±30 µm | 230 µm | 230 µm |
| FPF1321UCX | 1460 µm ±30 µm | 960 µm ±30 µm | 230 µm | 230 µm |
| FPF1321BUCX | 1460 µm ±30 µm | 960 µm ±30 µm | 230 µm | 230 µm |

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