# USB PD and Type-C Power Switch

## Features

- **VIN supply voltage range from 4.0V to 5.5V**
- **All time reverse current protection with ultra fast RCP recovery**
- **Adjustable current limit up to 3.7A**
- **Clamped current output in over-current condition**
- **29V high voltage tolerance on VBUS pin**
- **Low ON resistance of the power FETs: 35mΩ (typical) in total**
- **Over temperature protection**
- **Specified from -40°C to +85°C ambient temperature**
- **UL 2367 Recognition-File NO. E232223**
- **IEC 60950-1 Certified**
- **IEC 62368-1 Certified**

## Applications

- **Mobile communications**
- **Notebooks and PDA's**
- **Battery powered electronics**
- **General purpose portable device**
- **General purpose low voltage applications**

## General Description

The G3712A is a precision adjustable current-limited power switch for USB PD application. The device is equiped with UVLO and OT protection. VBUS pin can stand 29V ensures the device is able to work on a USB PD port; ILIM pin defines the over-current limit threshold; $\overline{FLT}$ pin indicates when a fault condition has occurred.

The device has built in soft start to minimize current surges during normal turn on. However, user can disable the soft start and request a fast output by pulling FO pin HIGH.

A fast RCP recovery circuit has been added to the switch to prevent any reverse current flowing back to power source at all times. When exiting from reverse current protection state, the power MOSFET will turn on within 50μs. The fast RCP recovery ensures the voltage on VBUS doesn't drop too much in a power source swap application.

G3712A is available in the WLCSP4X4-16 package.

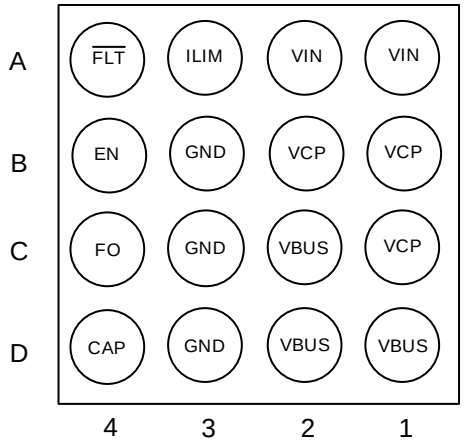
## Ordering Information

| ORDER NUMBER | MARKING | TEMP. RANGE | PACKAGE (Green) |
|---|---|---|---|
| G3712AB61U | 3712A | -40°C~ +85°C | WLCSP4X4-16 (0.5mm) |

Note:B6: WLCSP4X4-16
1: Bonding code
U: Tape & Reel
Green : Lead Free / Halogen Free.

## Pin Configuration

**G3712A 16 Bump WLCSP**




**Bottom View**
**WLCSP4X4-16**

## Absolute Maximum Ratings

VBUS . . . . . -0.3V to 29V
VBUS 20µs Pulse Width . . . . . -0.3V to 30.5V
VBUS Surge Protection: IEC 61000-4-5
Open Circuit Voltage ( tp = 1.2/50µs ) . . . . . .100V
Peak Pulse Current ( tp = 8/20µs ) . . . . . 22A
VIN, VCP, ILIM, EN, FO, CAP, $\overline{FLT}$ . . . . -0.3V to 7V
$I_{VBUS}$ (while applying VIN) . . . . . 3.6A
Continuous Power Dissipation ($T_A$ = +25°C)
WLCSP4X4-16 . . . . . 1.77W
Thermal Resistance of Junction to Ambient ($\theta_{JA}$)
WLCSP4X4-16. . . . . 51.88 °C/W
Operating Junction Temperature $T_J$ . . -40°C to 150°C
Storage Temperature $T_{stg}$ . . . . . -65°C to 150°C

## Recommended Operating Conditions

VBUS(OFF state) . . . . . 0V to 24V
VIN . . . . . 4.0V to 5.5V
VCP, ILIM, EN, FO, CAP, $\overline{FLT}$ . . . . . 0V to 5.5V
$R_{ILIM}$ . . . . . 14.3KΩ to 140KΩ
$C_{BUS}$ . . . . . 10µF to 100µF
$I_{VBUS}$ . . . . . 3A
ESD (HBM) . . . . . ±2KV
ESD (CDM) . . . . . ±500V
Operating Temperature ($T_A$) . . . . . -40°C to 85°C

## Electrical Characteristics

**$V_{IN}$ = 5.0V, $V_{EN}$ = $V_{IN}$, $C_{BUS}$ = 10µF, $T_A$ = 25°C**

The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Input Voltage Rage | VIN | | 4.0 | --- | 5.5 | V |
| Under Voltage Lockout Voltage | $V_{UVLO}$ | VIN Pin | --- | 3.6 | 3.8 | V |
| Under Voltage Lockout Hysteresis Voltage | $V_{HYS(UVLO)}$ | | --- | 100 | --- | mV |
| VIN Supply Current | $I_{(VIN)}$ | VBUS open; $V_{I(VIN)}$=5V | --- | --- | --- | |
| | | EN=GND (Low power mode) | --- | 1 | --- | µA |
| | | EN=VIN=5V, $R_{ILIM}$=30kΩ | --- | 1 | --- | mA |
| | | EN=VIN=5V, $R_{ILIM}$=14.3kΩ | --- | 1 | --- | mA |
| VIN OFF-State Leakage Current | $I_{S(OFF)}$ | VIN=5V, VBUS=0V, EN=LOW | -5 | 0.1 | --- | µA |
| VBUS OFF-State Leakage Current | | VIN=5V, VBUS=5V, EN=LOW | -5 | 0.1 | --- | µA |
| | | VIN=0V, VBUS=20V, EN=LOW | -5 | 0.1 | --- | µA |
| ON resistance | $R_{DS(on)}$ | $I_{VIN}$ =0.2A | --- | 35 | --- | mΩ |
| Over current protection current | $I_{OCP}$ | VIN=5V, $R_{ILIM}$=30KΩ | 1.6 | 1.84 | 2.1 | A |
| | | VIN=5V, $R_{ILIM}$=14.3KΩ | 3.4 | 3.7 | 4.0 | A |
| Turn on Delay (From EN to VBUS=10%) | $t_{DON}$ | $R_L$=100Ω, FO=LOW, see Figure 1 | --- | 0.75 | --- | ms |
| | | $R_L$=100Ω, FO=HIGH, see Figure 1 | --- | 60 | --- | µs |
| VBUS LOW to HIGH output transition time | $t_{TLH}$ | $R_L$=100Ω, FO=LOW, see Figure 1 | --- | 2 | --- | ms |
| | | $R_L$=100Ω, FO=HIGH, see Figure 1 | --- | 100 | 150 | µs |
| RCP recovery time From VBUS drops below VIN to FET-B ON. | $T_{ON(RCP)}$ | EN=HIGH | --- | --- | 50 | µs |
| FET-B RCP turn OFF time | $t_{dis(RCP)}$ | FET-B RCP turn OFF time *1 | --- | 1 | --- | µs |
| $\overline{FLT}$ de-glitch time | $t_{deg}$ | $\overline{FLT}$ in OCP | --- | 10 | --- | ms |
| EN, FO HIGH-level Input Voltage | $V_{IH}$ | EN, FO, VIN=5V | 1.2 | --- | --- | V |
| EN, FO LOW-level Input Voltage | $V_{IL}$ | EN, FO, VIN=5V | --- | --- | 0.4 | V |
| EN, FO input Leakage Current | $I_I$ | EN=FO=VIN=5V | --- | --- | 7 | µA |
| LOW-Level Output Voltage | $V_{OL}$ | $\overline{FLT}$ , $I_o$=4mA | --- | --- | 0.3 | V |
| Over temperature shutdown threshold temperature | OT | *1 | --- | 140 | --- | °C |
| Hysteresis of over temperature protection threshold temperature | $OT_{HYS}$ | *1 | --- | 25 | --- | °C |

Note
*1 Guaranteed by designed

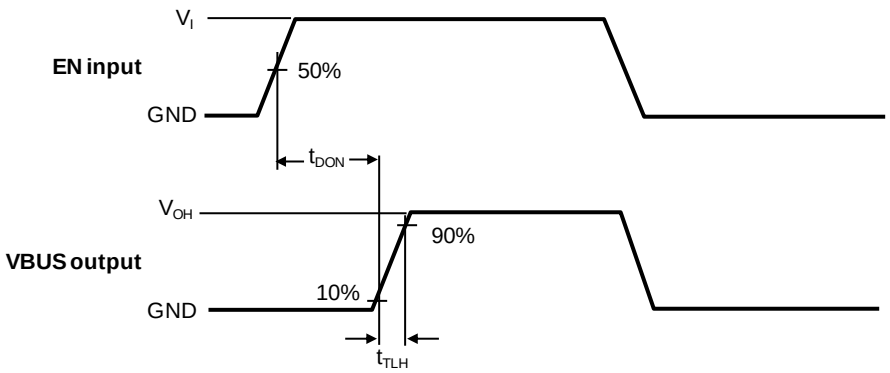
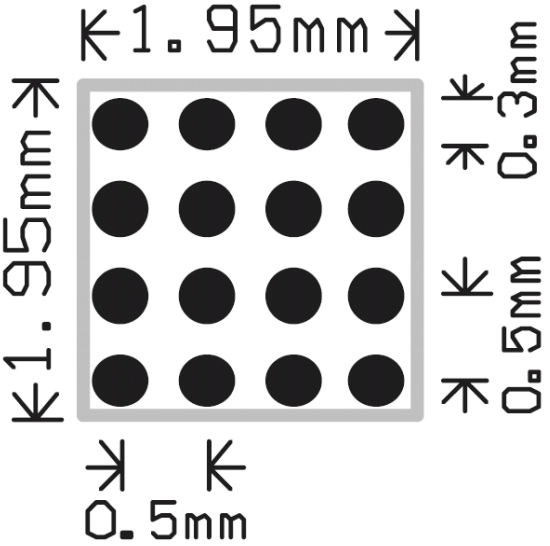



**Figure 1**

## Minimum Footprint PCB Layout Section

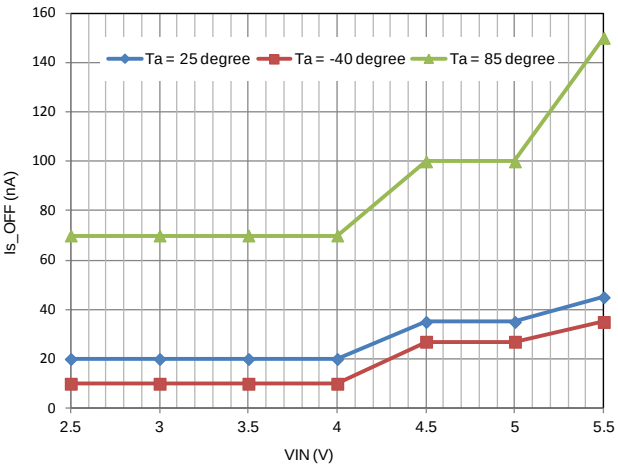
**WLCSP4X4-16**



## Typical Performance Characteristics

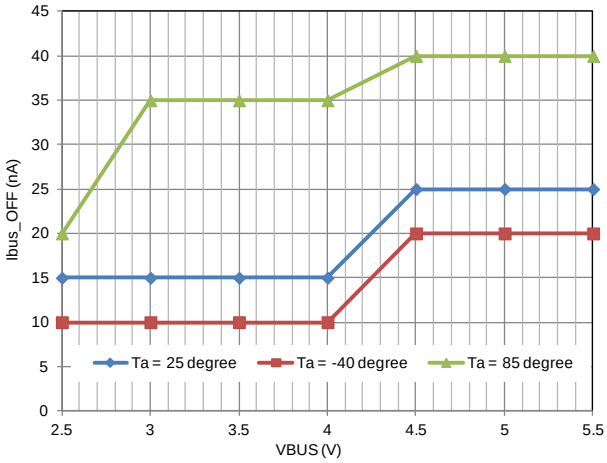
**VIN=5.0V, CINT=10μF, CBUS=10μF, Cb=1nF, TA=25°C, unless otherwise note.**

**VBUS off state leakage versus temperature**



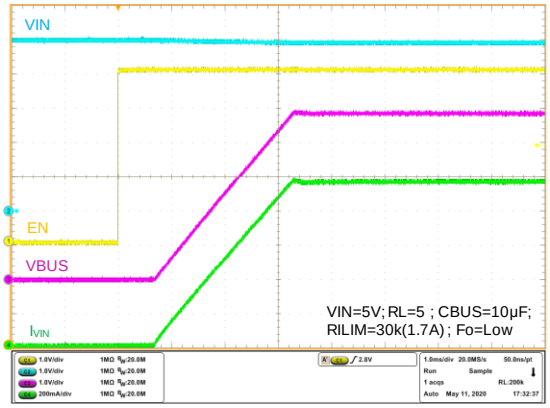

EN= GND;VBUS=0V; RILIM=30k(1.7A); X=VIN from 2.5V to 5.5V; Y=I(VIN)

**VIN off state leakage versus temperature**



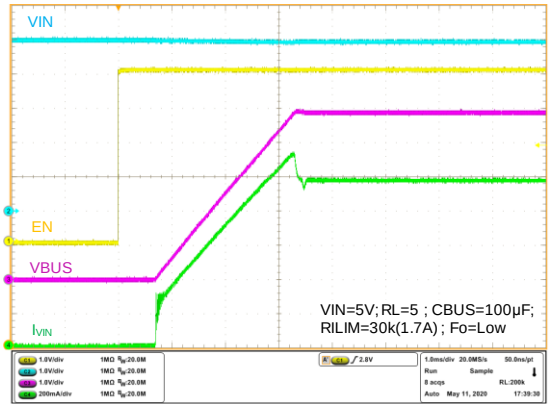

EN=GND; VIN=0 V; RILIM=30k(1.7 A); X=VBUS from 2.5V to 5.5V; Y=I(VIN)

**Typical 10μF enable time versus inrush current**



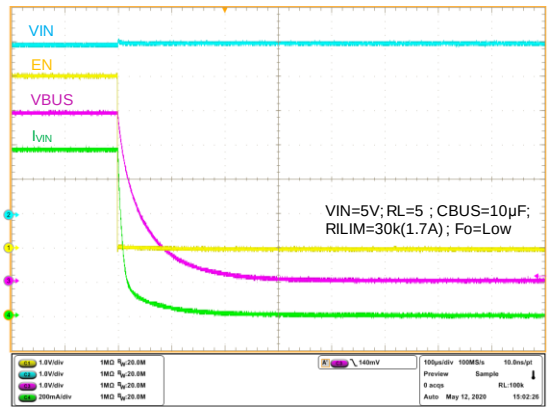

CH1：EN(1V/div), CH2：VIN(1V/div), CH3：VBUS(1V/div), CH4：$I_{VIN}$(200mA/div)

**Typical 100μF enable time versus inrush current**



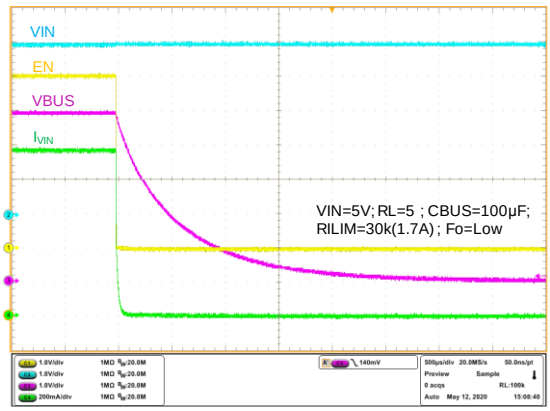

CH1：EN(1V/div), CH2：VIN(1V/div), CH3：VBUS(1V/div), CH4：$I_{VIN}$(200mA/div)

**Typical 10μF disable time**




CH1：EN(1V/div), CH2：VIN(1V/div), CH3：VBUS(1V/div), CH4：$I_{VIN}$(200mA/div)

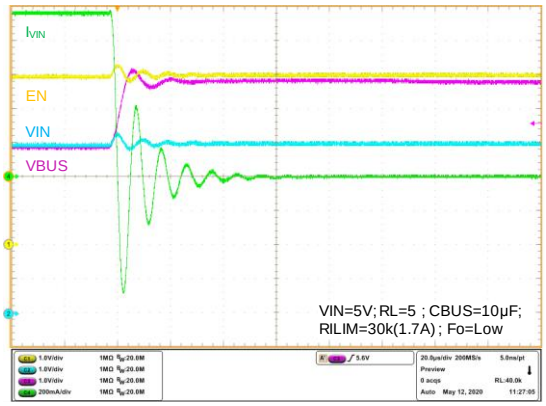
**Typical 100μF disable time**




CH1：EN(1V/div), CH2：VIN(1V/div), CH3：VBUS(1V/div), CH4：$I_{VIN}$(200mA/div)

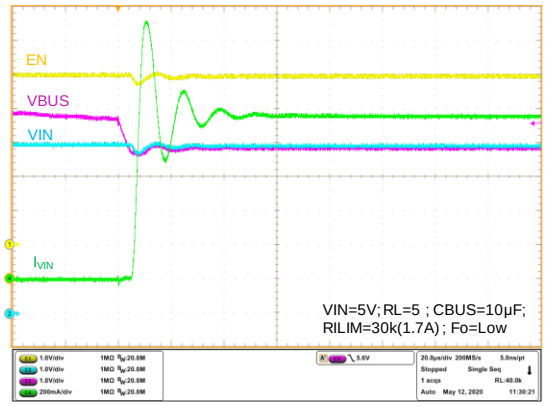
## Typical Performance Characteristics (Continued)

**Reverse-current protection response**



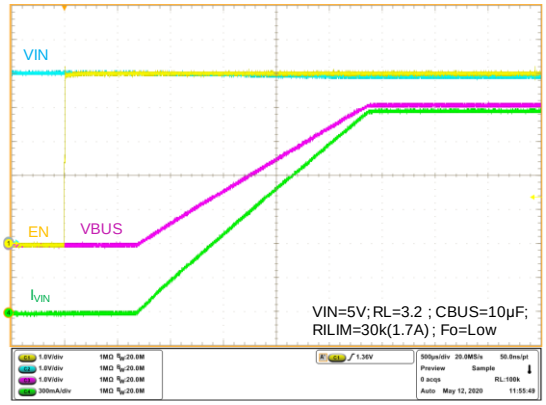

CH1：EN(1V/div), CH2：VIN(1V/div), CH3：VBUS(1V/div), CH4：

**Reverse-current protection recovery**



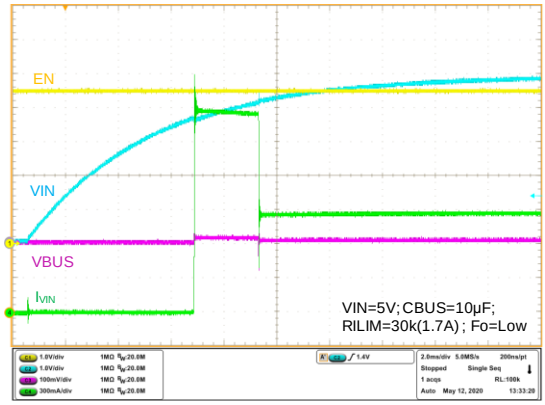

CH1：EN(1V/div), CH2：VIN(1V/div), CH3：VBUS(1V/div), CH4：$I_{VIN}$(200mA/div)

**Device enabled into current limit mode (Fo = Low)**



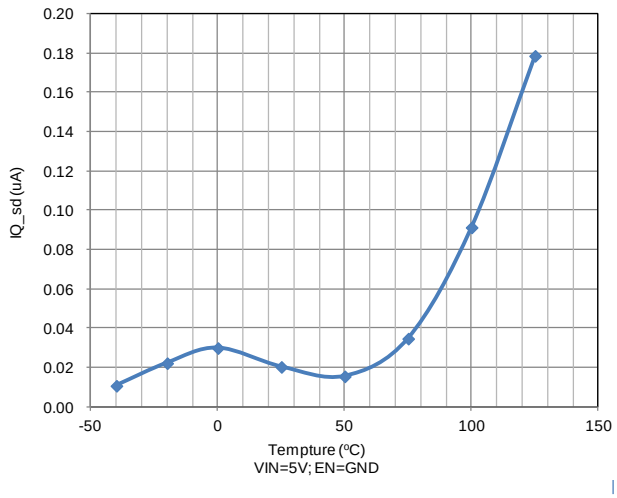

CH1：EN(1V/div), CH2：VIN(1V/div), CH3：VBUS(1V/div), CH4：$I_{VIN}$(300mA/div)

**Device start up in VBUS short to GND (Fo = Low)**

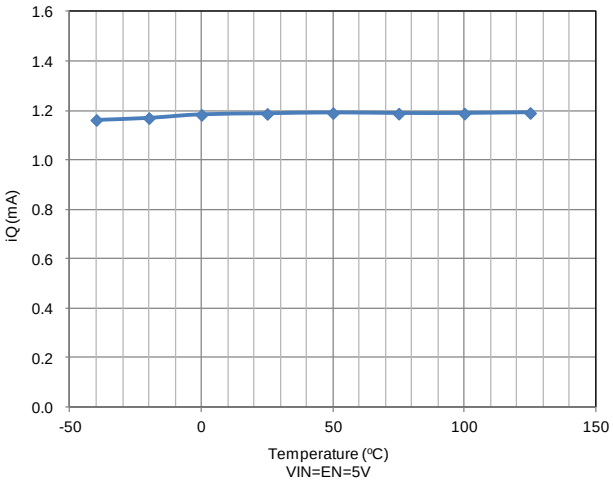



CH1：EN(1V/div), CH2：VIN(1V/div), CH3：VBUS(1V/div), CH4：$I_{VIN}$(300mA/div)

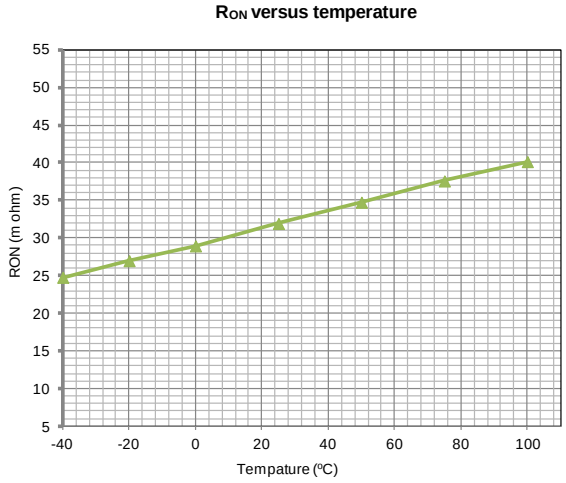
**OFF state supply current versus temperature**




**ON state supply current versus temperature**



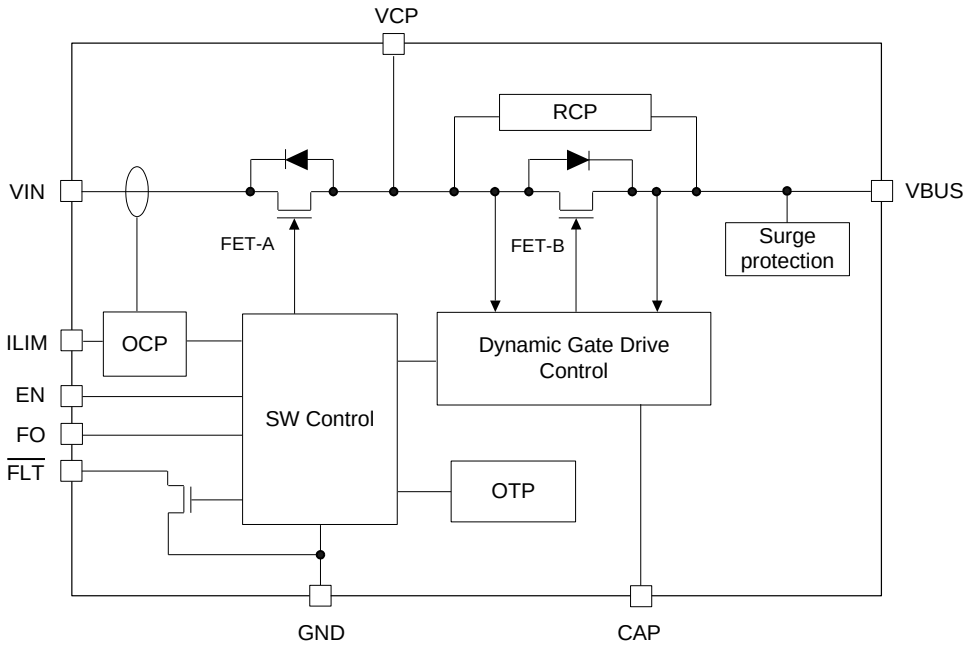
## Typical Performance Characteristics (Continued)



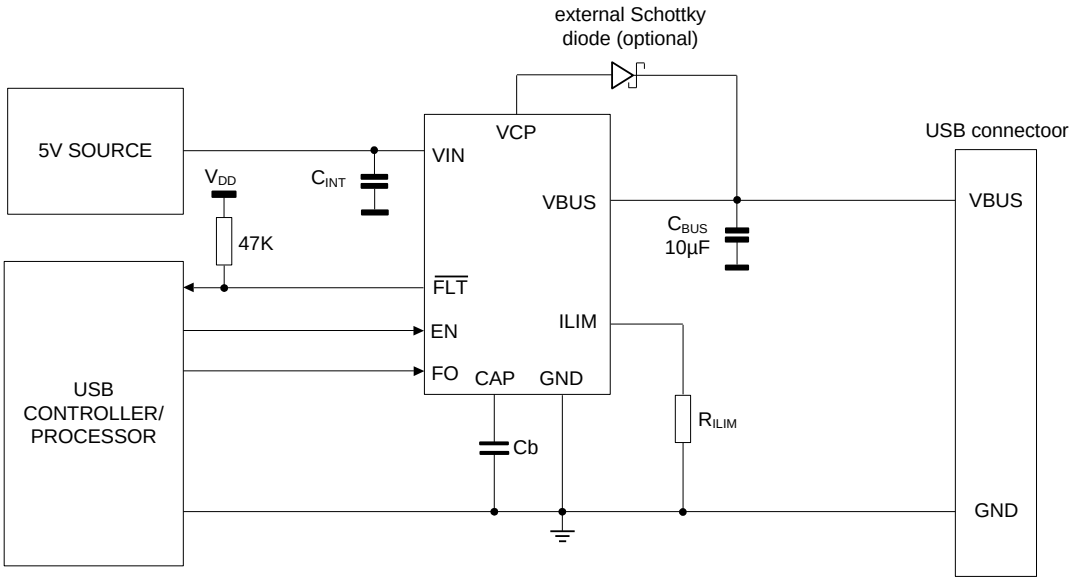
## Pin Description

| Pin | Name | Type | Description |
|---|---|---|---|
| A1, A2 | VIN | I | Input voltage. |
| B1, B2, C1 | VCP | | Central point of between FET-A and FET-B. |
| C2, D1, D2 | VBUS | O | Output voltage |
| A3 | ILIM | I | Current limit setting.<br>Connect a resistor to GND to adjust the current limit level. |
| A4 | $\overline{FLT}$ | O | Fault condition indicator (open-drain output) |
| B4 | EN | I | Enable input (active HIGH with internal 1MΩ pull down resister) |
| B3, C3, D3 | GND | | Ground |
| C4 | FO | I | Fast turn on. Pull this pin HIGH to enable fast turn-on feature.<br>FO pin is with 1MΩ pull down resister integrated. |
| D4 | CAP | O | Connect a capacitor to GND |

## Function Diagram



## Application Diagram



## Functional Description

**VIN and VBUS**

VIN (input) is the power supply connection to the logic circuitry and the drain of the FET-A. VBUS is the drain of the FET-B. In a typical application, current flows through the switch from VIN to VBUS toward the load. Both VIN pins must be connected to the power supply. Both VBUS pins must be connected together to the load.

The RCP circuit, together with dynamic gate drive control circuit, act like an “ideal diode”. That protects the VIN lift by the reverse current when VBUS have a hot plug in as following conditions and limit the VIN voltage lift <200mV,

- VBUS<24V, plug in when G3712A is on
- $C_{IN}$ is in the range of 50µF - 100µF
- $C_{BUS}$ is in the range of 10µF - 22µF

If the VBUS, CIN, CBUS are not in the range or conditions, there may have more reverse current and the VIN voltage lift depends on the conditions.

**EN**

All the FETs will be disabled when EN is set LOW, the device will enter low-power mode disabling all protection circuits and setting the $\overline{FLT}$ output high impedance. When EN is set HIGH, all protection circuits will be enabled and the main power FET-A and FET-B will be turned on if no fault condition exists.

**$\overline{FLT}$**

The $\overline{FLT}$ open-drain output is asserted (active low) when an over current condition is encountered after a 10ms deglitch timeout. The output remains asserted until the over current condition is removed. Over temperature condition is also reported immediately by $\overline{FLT}$ open-drain output.

**FO (Fast ON, Support Fast Role Swap)**

In order to reduce inrush current during powering on, G3712A has designed slew rate control for normal turn on; the rising time is around 2ms. However, in the fast role swap application, fast turn on is requested. The customer can achieve this by pulling FO pin “High”. Rising time will be reduced to about 100µs level. FO pin is with an internal 1MΩ pull-down resistance. The fast turn on is achieved by turn off OCP feature in the fast start stage. It is recommended to add 10µF capacitor close to VIN pin to limit the inrush current in fast turn on mode.

FO is only applied for fast role swap, FO pin should be controlled by USB PD PHY. When a fast role swap event is detected by USB PD PHY, the FO pin should be pull “High” first, then enable the EN pin of G3712A when the FRS is requested. Depending on the voltage on VBUS, there are two scenarios when FO is set at HIGH.

- V(VBUS) <= V(VIN)
  The switch will perform a fast turn ON, the turn on time is 150µs.
- V(VBUS) > V(VIN)
  The switch will enter RCP mode. Once the voltage on VBUS drops below VIN voltage, switch will be immediately turn on within 50µs.

When fast role swap is finished and G3712A is in all the other conditions, FO pin should be remaining as “LOW” to limit the inrush current.

**Table1. Truth Table**

| EN | FO | VIN | $\overline{FLT}$ | Main Power Switch |
|---|---|---|---|---|
| X | X | <4.0V | Z | Under voltage lockout, switch open |
| L | X | 4.0V to 5.5V | Z | Disabled; switch open |
| H | L | 4.0V to 5.5V | Z | Enabled; switch turns on with slew rate control |
| H | H | 4.0V to 5.5V | Z | Enabled; switch turns on without slew rate control; fast turn on |
| H | X | 4.0V to 5.5V | L | In current limit condition or over temperature protection |
| X | X | 4.0V to 5.5V and VIN ≤ VBUS | Z | Reverse protection; switch open |

[1] H=HIGH voltage level; L=LOW voltage level,

**ILIM (Over Current Protection Setting)**

The G3712A over current protection (OCP) threshold is programmed with a resistor from ILIM to ground. The typical value is determined by $R_{ILIM}$. We can choose the proper $R_{ILIM}$ by Table2. The chart of the typical OCP versus external resistance $R_{ILIM}$ and formula is shown in the figure2.

**Table 2. Over Current Protection Setting**

| $R_{ILIM}$ (KΩ) | Current Limit (A) |
|---|---|
| 30 | 1.84 |
| 14.3 | 3.70 |

1% tolerance resistor is recommend for $R_{ILIM}$

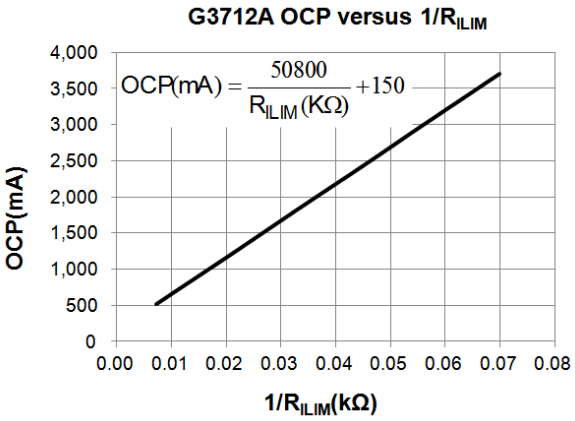



**Figure 2**

**Fast recovery Reverse-Current Protection (RCP)**

G3712A uses dynamic gate drive control loop to achieve reverse-current protection. During normal operation, device will always try to regulate the VBUS output voltage to be VIN - 70mV.

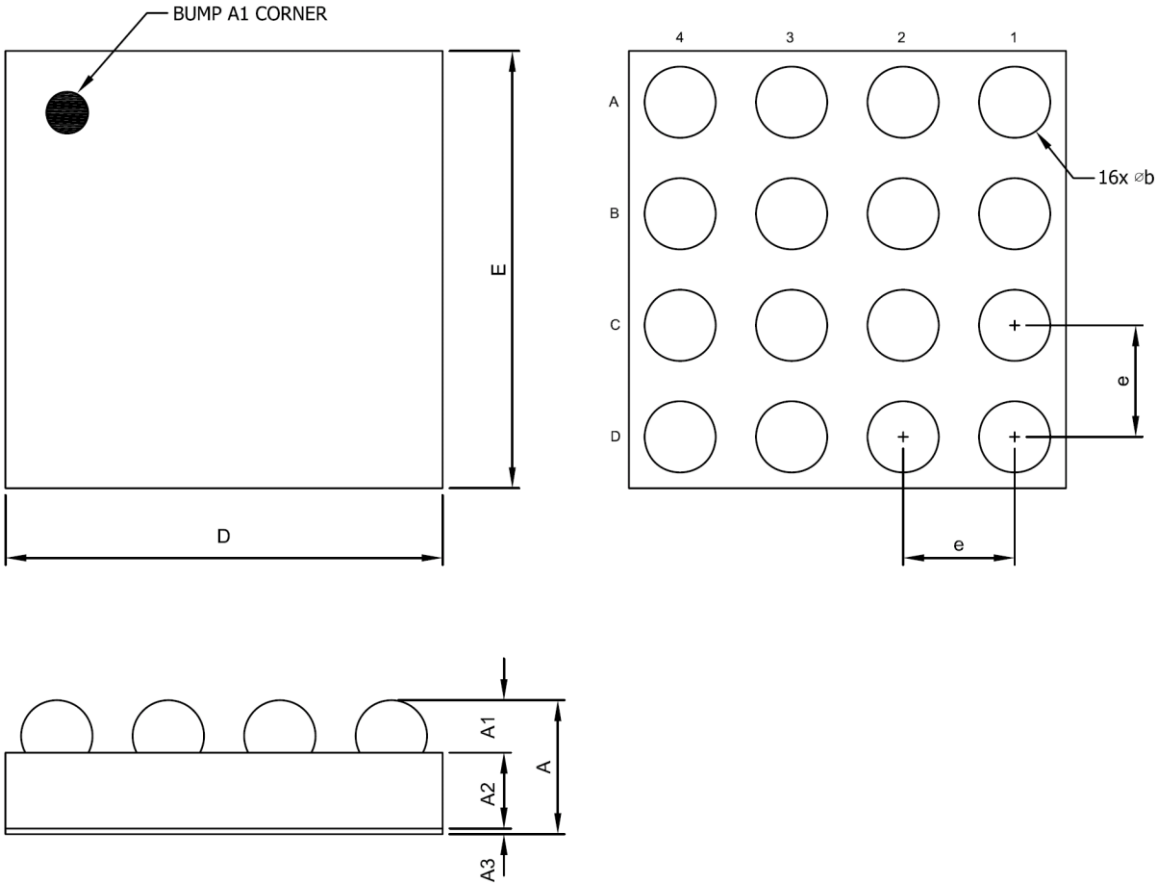
When the load current produces a drop voltage greater than 70mV, the gate control loop will drive the power MOSFET to lower its $R_{DSON}$ to try to achieve the 70mV. In the heavy load condition, the gate control loop will keep increasing the gate driving current of the MOSFET until it is fully on and will remain fully on if the voltage drop at that time still exceeds 70mV.

In light load condition, when the drop voltage is below 70mV, the gate control loop will reduce the gate driving current to increase the $R_{DSON}$ to try to achieve the 70mV drop voltage, which leads to the complete shutdown of the power MOSFET in reverse voltage condition.

If VBUS voltage is higher than VIN when enabling the device, the power MOSFET will never turn on. The device will always do pre-check before switching on the power MOSFETs.

In the RCP state, EN is HIGH; when the VBUS drops below VIN, the device will exit the RCP state and turn on the power FET-B again within 50μs. The fast recovery of the power FET is assisted by the external boost capacitor at CAP pin.

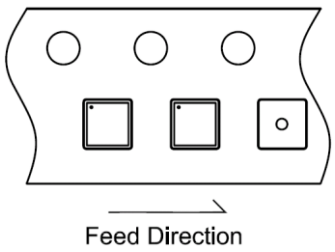
## Package Information




**WLCSP4X4-16 Package**

| Symbol | DIMENSION IN MM | | | DIMENSION IN INCH | | |
|---|---|---|---|---|---|---|
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| A | 0.540 | 0.600 | 0.650 | 0.0212 | 0.0236 | 0.0256 |
| A1 | 0.210 | 0.235 | 0.260 | 0.0083 | 0.0093 | 0.0102 |
| A2 | 0.305 | 0.340 | 0.375 | 0.0120 | 0.0134 | 0.0148 |
| A3 | 0.025 REF | | | 0.0010 REF | | |
| D | 1.920 | 1.960 | 2.000 | 0.0756 | 0.0772 | 0.0787 |
| E | 1.920 | 1.960 | 2.000 | 0.0756 | 0.0772 | 0.0787 |
| b | 0.300 | 0.320 | 0.340 | 0.0118 | 0.0126 | 0.0134 |
| e | 0.50 BSC | | | 0.0197 BSC | | |

## Taping Specification




| PACKAGE | Q'TY/REEL |
|---|---|
| WLCSP4X4-16 | 3,000 ea |