FAIRCHILD SEMICONDUCTOR®

November 2012

# FSA3200 —Two-Port, High-Speed USB2.0 Switch with Mobile High-Definition Link (MHL™)

## Features

- Low On Capacitance: 2.7 pF / 3.1 pF MHL / USB (Typical)
- Low Power Consumption: 30µA Maximum
- Supports MHL Rev. 2.0
- MHL Data Rate: 4.68 Gbps
- $V_{BUS}$ Powers Device with No $V_{CC}$
- Packaged in 16-Lead UMLP (1.8 x 2.6 mm)
- Over-Voltage Tolerance (OVT) on all USB Ports Up to 5.25 V without External Components

## Applications

- Cell Phones and Digital Cameras

## Description

The FSA3200 is a bi-directional, low-power, two-port, high-speed, USB2.0 and video data switch. Configured as a double-pole, double-throw (DPDT) switch for data and a single-pole, double-throw (SPDT) switch for ID; it is optimized for switching between high- or full-speed USB and Mobile Digital Video sources (MDV), including supporting the MHL™ Rev. 2.0 specification.

The FSA3200 contains special circuitry on the switch I/O pins, for applications where the $V_{CC}$ supply is powered off ($V_{CC}$=0), that allows the device to withstand an over-voltage condition. This switch is designed to minimize current consumption even when the control voltage applied to the control pins is lower than the supply voltage ($V_{CC}$). This feature is especially valuable to mobile applications, such as cell phones, allowing direct interface with the general-purpose I/Os of the baseband processor. Other applications include switching and connector sharing in portable cell phones, digital cameras, and notebook computers.

## Ordering Information

| Part Number | Top Mark | Operating Temperature Range | Package |
|---|---|---|---|
| FSA3200UMX | GB | -40 to +85°C | 16-Lead, Ultrathin Molded Leadless Package (UMLP), 1.8 x 2.6 mm |

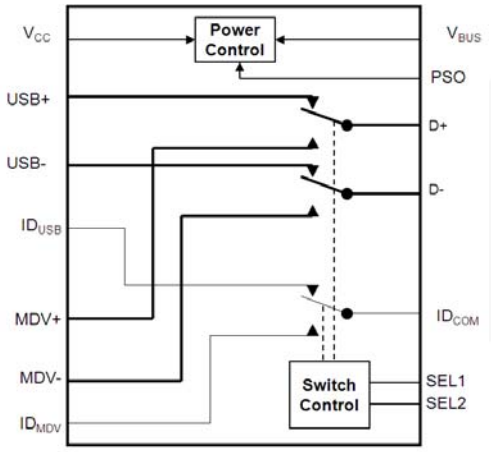



**Figure 1. Analog Symbol**

## Switch Power Operation

In normal operation, the FSA3200 is powered from the $V_{CC}$ pin, which typically is derived from a regulated power management device. In special circumstances, such as production test or system firmware upgrade, the device can be powered from the $V_{BUS}$ pin. In this mode of operation, a valid $V_{BUS}$ voltage is present (per USB2.0 specification) and $V_{CC}$=0 V, typically due to a no-battery condition. With the SELn pins strapped LOW (via external resistor), the FSA3200 closes the USB path, enabling the initial programming of the system directly from the USB connector. Once the system has normal operating supply power with $V_{CC}$ present, the $V_{BUS}$ supply is not utilized and normal switch operation commences. Optionally, the Power Select Override (PSO) pin can be set HIGH to force the device to be powered from $V_{BUS}$.

The $V_{BUS}$ / $V_{CC}$ detection capability is not intended to be an accurate determination of the voltages present, rather a state condition detection to determine which supply should be used. These state determinations rely on the voltage conditions as described in the Electrical Characterization tables below.

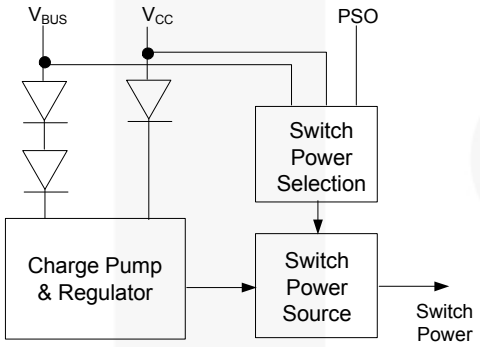



**Figure 2. Simplified Logic of Switch Power Selection Circuit**

**Table 1. Switch Power Selection Truth Table**

| $V_{CC}$ | $V_{BUS}$ | PSO(1) | Switch Power Source |
|---|---|---|---|
| 0 | 0 | 0 | No switch power, switch paths high-Z |
| 0 | 1 | 0 | $V_{BUS}$ |
| 1 | 0 | 0 | $V_{CC}$ |
| 1 | 1 | 0 | $V_{CC}$ |
| 0 | 0 | 1 | No switch power, switch paths high-Z |
| 0 | 1 | 1 | $V_{BUS}$ |
| 1 | 0 | 1 | $V_{CC}$(2) |
| 1 | 1 | 1 | $V_{BUS}$ |

**Notes:**
1. Control inputs should never be left floating or unconnected. If the PSO function is used, a weak pull-up resistor (3 MΩ) should be used to minimize static current draw. If the PSO function is not used, tie directly to GND.
2. PSO control is overridden with no $V_{BUS}$ and the power selection is switched to $V_{CC}$.

**Table 2. Data Switch Select Truth Table**

| SEL1(3) | SEL2(3) | Function |
|---|---|---|
| 0 | 0 | D+/D- connected to USB+/USB-, $ID_{CO}$ connected to $ID_{USB}$ |
| 0 | 1 | D+/D- connected to USB+/USB-, $ID_{COM}$ connected to $ID_{MDV}$ |
| 1 | 0 | D+/D- connected to MDV+/MDV-, $ID_{COM}$ connected to $ID_{USB}$ |
| 1 | 1 | D+/D- connected to MDV+/MDV-, $ID_{COM}$ connected to $ID_{MDV}$ |

**Note:**
3. Control inputs should never be left floating or unconnected. To guarantee default switch closure to the USB position, the SEL pins should be tied to GND with a weak pull- down resistor (3 MΩ) to minimize static current draw.

## Pin Configuration

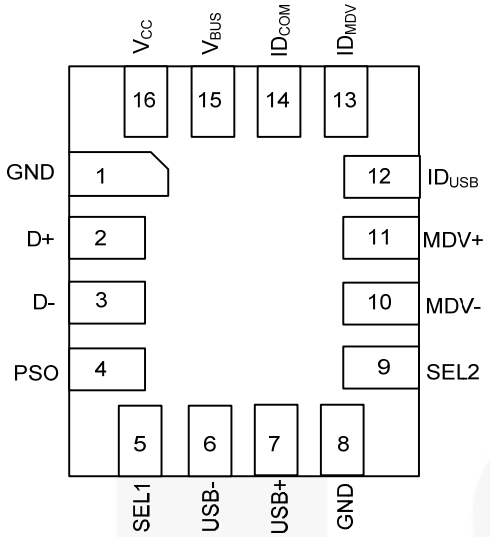



**Figure 3. Pin Assignments (Top-Through View)**

## Pin Definitions

| Pin# | Name | Description |
|---|---|---|
| 1 | GND | Ground |
| 2 | D+ | Data Switch Output (Positive) |
| 3 | D- | Data Switch Output (Negative) |
| 4 | PSO | Power Select Override |
| 5 | SEL1 | Data Switch Select |
| 6 | USB- | USB Differential Data (Negative) |
| 7 | USB+ | USB Differential Data (Positive) |
| 8 | GND | Ground |
| 9 | SEL2 | ID Switch Select |
| 10 | MDV- | MDV Differential Data (Negative) |
| 11 | MDV+ | MDV Differential Data (Positive) |
| 12 | $ID_{USB}$ | ID Switch MUX Output for USB |
| 13 | $ID_{MDV}$ | ID Switch MUX Output for MDV |
| 14 | $ID_{COM}$ | ID Switch Common |
| 15 | $V_{BUS}$ | Device Power when $V_{CC}$ Not Available |
| 16 | $V_{CC}$ | Device Power from System[4] |

**Note:**

4. Device automatically switches from $V_{BUS}$ when valid $V_{CC}$ minimum voltage is present.

## 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 | Parameter | | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{CC}$, $V_{BUS}$ | Supply Voltage | | -0.5 | 5.5 | V |
| $V_{CNTRL}$ | DC Input Voltage (SELn, PSO)[5] | | -0.5 | $V_{CC}$ | V |
| $V_{SW}$[6] | DC Switch I/O Voltage[5] | | -0.50 | 5.25 | V |
| $I_{IK}$ | DC Input Diode Current | | -50 | | mA |
| $I_{OUT}$ | DC Output Current | | | 100 | mA |
| $T_{STG}$ | Storage Temperature | | -65 | +150 | °C |
| MSL | Moisture Sensitivity Level (JEDEC J-STD-020A) | | | 1 | |
| ESD | Human Body Model, JEDEC: JESD22-A114 | All Pins | | 3.5 | kV |
| | IEC 61000-4-2, Level 4, for D+/D- and $V_{CC}$ Pins[7] | Contact | | 8.0 | |
| | IEC 61000-4-2, Level 4, for D+/D- and $V_{CC}$ Pins[7] | Air | | 15.0 | |
| | Charged Device Model, JESD22-C101 | | | 2.0 | |

**Notes:**
5. The input and output negative ratings may be exceeded if the input and output diode current ratings are observed.
6. $V_{SW}$ refers to analog data switch paths (USB, MDV, and ID).
7. Testing performed in a system environment using TVS diodes.

## 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 | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{BUS}$ | Supply Voltage Running from $V_{BUS}$ Voltage | 4.20 | 5.25 | V |
| $V_{CC}$ | Supply Voltage Running from $V_{CC}$ | 2.7 | 4.5 | V |
| $t_{RAMP(VBUS)}$ | Power Supply Slew Rate from $V_{BUS}$ | 100 | 1000 | µs/V |
| $t_{RAMP(VCC)}$ | Power Supply Slew Rate from $V_{CC}$ | 100 | 1000 | µs/V |
| $\Theta_{JA}$ | Thermal Resistance | | 336 | C°/W |
| $V_{CNTRL}$ | Control Input Voltage (SELn, PSO)[8] | 0 | 4.5 | V |
| $V_{SW(USB)}$ | Switch I/O Voltage (USB and ID Switch Paths) | -0.5 | 3.6 | V |
| $V_{SW(MDV)}$ | Switch I/O Voltage (MDV Switch Path) | 1.65 | 3.45 | V |
| $T_A$ | Operating Temperature | -40 | +85 | °C |

**Note:**
8. The control inputs must be held HIGH or LOW; they must not float.

## DC Electrical Characteristics

All typical value are at $T_A$=25°C unless otherwise specified.

| Symbol | Parameter | Condition | $V_{CC}$ (V) | $T_A$=- 40ºC to +85ºC | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| $V_{IK}$ | Clamp Diode Voltage | $I_{IN}$=-18 mA | 2.7 | | | -1.2 | V |
| $V_{IH}$ | Control Input Voltage High | SELn, PSO | 2.7 to 4.3 | 1.25 | | | V |
| $V_{IL}$ | Control Input Voltage Low | SELn, PSO | 2.7 to 4.3 | | | 0.6 | V |
| $I_{IN}$ | Control Input Leakage | $V_{SW}$=0 V to 3.6 V, $V_{CNTRL}$=0 V to 1.98 V | 4.3 | -1 | | 1 | µA |
| $I_{OZ(MDV)}$ | Off-State Leakage for Open MDV Data Paths | $V_{SW}$=1.65 V ≤ MDV ≤ 3.45 V | 4.3 | -1 | | 1 | µA |
| $I_{OZ(USB)}$ | Off-State Leakage for Open USB Data Paths | $V_{SW}$=0 V ≤ USB ≤ 3.6 V | 4.3 | -1 | | 1 | µA |
| $I_{OZ(ID)}$ | Off-State Leakage for Open ID Data Path | $V_{SW}$=0 V ≤ ID ≤ 3.6 V | 4.3 | -0.5 | | 0.5 | µA |
| $I_{CL(MDV)}$ | On-State Leakage for Closed MDV Data Paths[9] | $V_{SW}$=1.65 V ≤ MDV ≤ 3.45 V | 4.3 | -1 | | 1 | µA |
| $I_{CL(USB)}$ | On-State Leakage for Closed USB Data Paths[9] | $V_{SW}$=0 V ≤ USB ≤ 3.6 V | 4.3 | -1 | | 1 | µA |
| $I_{CL(ID)}$ | On-State Leakage for Closed[9] ID Data Path | $V_{SW}$=0 V ≤ ID ≤ 3.6 V | 4.3 | -0.5 | | 0.5 | µA |
| $I_{OFF}$ | Power-Off Leakage Current (All I/O Ports) | $V_{SW}$=0 V or 3.6 V, Figure 5 | 0 | -1 | | 1 | µA |
| $R_{ON(USB)}$ | HS Switch On Resistance (USB to D Path) | $V_{SW}$=0.4 V, $I_{ON}$=-8 mA Figure 4 | 2.7 | | 3.9 | 6.5 | Ω |
| $R_{ON(MDV)}$ | HS Switch On Resistance (MDV to D Path) | $V_{SW}$=$V_{CC}$-1050mV, $I_{ON}$=-8mA, Figure 4 | 2.7 | | 5 | | Ω |
| $R_{ON(ID)}$ | LS Switch On Resistance (ID Path) | $V_{SW}$=3V, $I_{ON}$=-8mA Figure 4 | 2.7 | | 12 | | Ω |
| $\Delta R_{ON(MDV)}$ | Difference in $R_{ON}$ Between MDV Positive-Negative | $V_{SW}$=$V_{CC}$-1050 mV, $I_{ON}$=-8 mA, Figure 4, | 2.7 | | 0.03 | | Ω |
| $\Delta R_{ON(USB)}$ | Difference in $R_{ON}$ Between USB Positive-Negative | $V_{SW}$=0.4 V, $I_{ON}$=-8 mA Figure 4 | 2.7 | | 0.18 | | Ω |
| $\Delta R_{ON(ID)}$ | Difference in $R_{ON}$ Between ID Switch Paths | $V_{SW}$=3 V, $I_{ON}$=-8 mA Figure 4 | 2.7 | | 0.4 | | Ω |
| $R_{ONF(MDV)}$ | Flatness for $R_{ON}$ MDV Path | $V_{SW}$=1.65 V to 3.45 V, $I_{ON}$=-8 mA, Figure 4 | 2.7 | | 1 | | Ω |
| $I_{VBUS}$ | $V_{BUS}$ Quiescent Current | $V_{BUS}$=5.25 V, $V_{CNTRL}$=0 V or 1.98 V, $I_{OUT}$=0 | 4.3 | | | 100 | µA |
| $I_{CC}$ | $V_{CC}$ Quiescent Current | $V_{BUS}$=0 V, $V_{CNTRL}$=0 V or 1.98 V, $I_{OUT}$=0 | 4.3 | | | 30 | µA |

**Note:**

9. For this test, the data switch is closed with the respective switch pin floating.

## AC Electrical Characteristics

All typical value are for $V_{CC}$=3.3 V and $T_A$=25°C unless otherwise specified.

| Symbol | Parameter | Condition | $V_{CC}$ (V) | $T_A$=- 40ºC to +85ºC | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| $t_{ON}$ | Turn-On Time, SELn to Output | $R_L$=50 Ω, $C_L$=5 pF, $V_{SW(USB)}$=0.8 V, $V_{SW(MDV)}$=3.3 V, Figure 6, Figure 7 | 2.7 to 3.6 | | 445 | 600 | ns |
| $t_{OFF}$ | Turn-Off Time, SELn to Output | $R_L$=50 Ω, $C_L$=5 pF, $V_{SW(USB)}$=0.8 V, $V_{SW(MDV)}$=3.3V, Figure 6, Figure 7 | 2.7 to 3.6 | | 125 | 300 | ns |
| $t_{PD}$ | Propagation Delay(10) | $C_L$=5 pF, $R_L$=50 Ω, Figure 6, Figure 8 | 2.7 to 3.6 | | 0.25 | | ns |
| $t_{BBM}$ | Break-Before-Make(10) | $R_L$=50 Ω, $C_L$=5 pF, $V_{ID}$=$V_{MDV}$=3.3 V, $V_{USB}$=0.8 V, Figure 10 | 2.7 to 3.6 | 2.0 | | 13 | ns |
| $O_{IRR(MDV)}$ | Off Isolation(10) | $V_S$=1 $V_{pk-pk}$, $R_L$=50 Ω, f=240 MHz, Figure 12 | 2.7 to 3.6 | | -45 | | dB |
| $O_{IRR(USB)}$ | | $V_S$=400m $V_{pk-pk}$, $R_L$=50Ω, f=240MHz, Figure 12 | 2.7 to 3.6 | | -38 | | dB |
| $Xtalk_{MDV}$ | Non-Adjacent Channel(10) Crosstalk | $V_S$=1 $V_{pk-pk}$, $R_L$=50 Ω, f=240 MHz, Figure 13 | 2.7 to 3.6 | | -44 | | dB |
| $Xtalk_{USB}$ | | $V_S$=400 $mV_{pk-pk}$, $R_L$=50 Ω, f=240 MHz, Figure 13 | 2.7 to 3.6 | | -39 | | dB |
| BW | Differential -3 db Bandwidth(10) | $V_{IN}$=1 $V_{pk-pk}$, MDV Path, $R_L$=50 Ω, $C_L$=0 pF, Figure 11, Figure 16 | 2.7 to 3.6 | | 2.34 | | GHz |
| | | $V_{IN}$=400 $mV_{pk-pk}$, USB Path, $R_L$=50 Ω, $C_L$=0 pF, Figure 11, Figure 17 | | | 1.59 | | |
| | | ID Path, $R_L$=50 Ω, $C_L$=0 pF, Figure 11 | | | 100 | | MHz |

**Note:**

10. Guaranteed by characterization.

## USB High-Speed AC Electrical Characteristics

Typical values are at $T_A$= -40ºC to +85ºC.

| Symbol | Parameter | Condition | $V_{CC}$ (V) | Typ. | Unit |
|---|---|---|---|---|---|
| $t_{SK(P)}$ | Skew of Opposite Transitions of the Same Output[11] | $C_L$=5 pF, $R_L$=50 Ω, Figure 9 | 3.0 to 3.6 | 3 | ps |
| $t_J$ | Total Jitter[11] | $R_L$=50 Ω, $C_L$=5 pf, $t_R$=$t_F$=500 ps (10-90%) at 480 Mbps, PN7 | 3.0 to 3.6 | 15 | ps |

**Note:**
11. Guaranteed by characterization.

## MDV AC Electrical Characteristics

Typical values are at $T_A$= -40ºC to +85ºC.

| Symbol | Parameter | Condition | $V_{CC}$ (V) | Typ. | Unit |
|---|---|---|---|---|---|
| $t_{SK(P)}$ | Skew of Opposite Transitions of the Same Output[12] | $R_{PU}$=50 Ω to $V_{CC}$, $C_L$=0 pF | 3.0 to 3.6 | 3 | ps |
| $t_J$ | Total Jitter[12] | f=2.25 Gbps, PN7, $R_{PU}$=50 Ω to $V_{CC}$, $C_L$=0 pF | 3.0 to 3.6 | 15 | ps |

**Note:**
12. Guaranteed by characterization.

## Capacitance

Typical values are at $T_A$= -40ºC to +85ºC.

| Symbol | Parameter | Condition | Typ. | Unit |
|---|---|---|---|---|
| $C_{IN}$ | Control Pin Input Capacitance[13] | $V_{CC}$=0 V, f= 1 MHz | 1.5 | pF |
| $C_{ON(USB)}$ | USB Path On Capacitance[13] | $V_{CC}$=3.3 V, f=240 MHz, Figure 15 | 3.1 | |
| $C_{OFF(USB)}$ | USB Path Off Capacitance[13] | $V_{CC}$=3.3 V, f=240 MHz, Figure 14 | 1.6 | |
| $C_{ON(MDV)}$ | MDV Path On Capacitance[13] | $V_{CC}$=3.3 V, f=240 MHz, Figure 15 | 2.7 | |
| $C_{OFF(MDV)}$ | MDV Path Off Capacitance[13] | $V_{CC}$=3.3 V, f=240 MHz, Figure 14 | 1.1 | |

**Note:**
13. Guaranteed by characterization.

## Test Diagrams

**Note:**
14. HSD refers to the high-speed data USB or MDV paths.

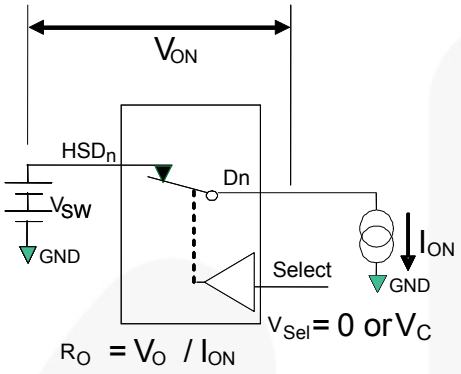



**Figure 4. On Resistance**

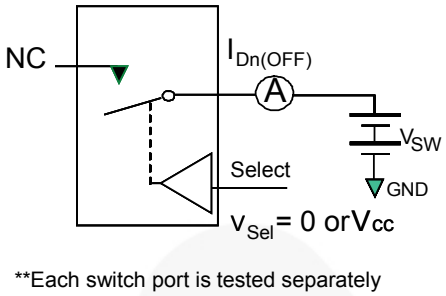



**Figure 5. Off Leakage**

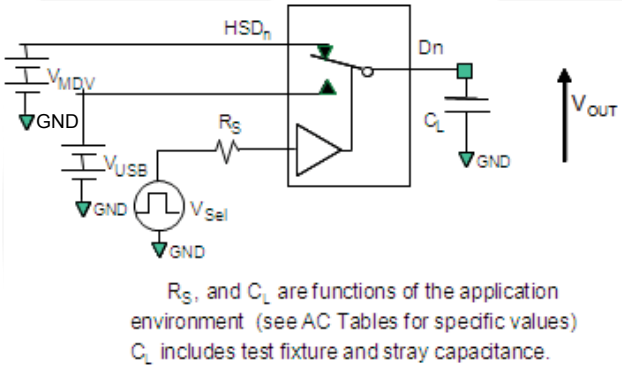



**Figure 6. AC Test Circuit Load**

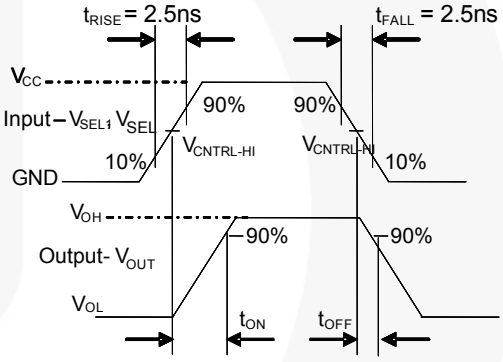



**Figure 7. Turn-On / Turn-Off Waveforms**

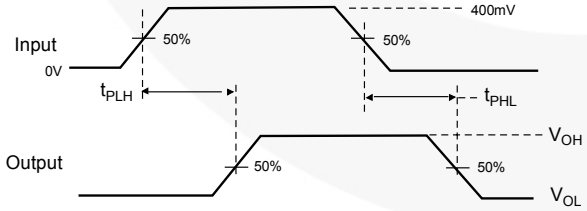



**Figure 8. Propagation Delay ($t_{RtF}$ – 500 ps)**

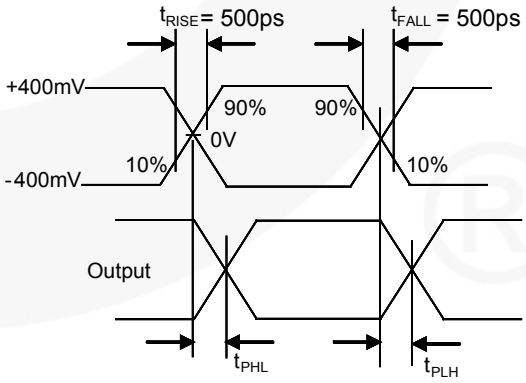
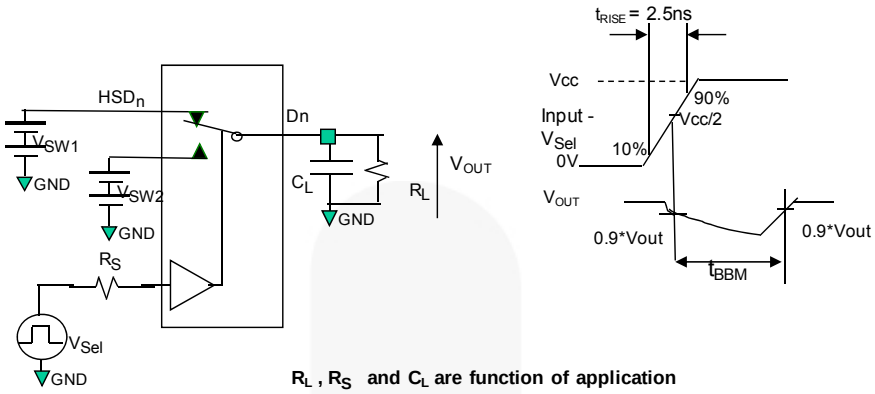


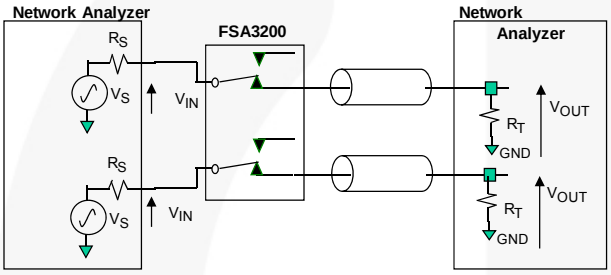

**Figure 9. Intra-Pair Skew Test $t_{SK(P)}$**

## Test Diagrams (Continued)



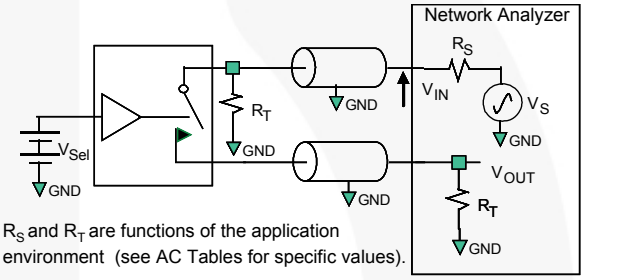

**$R_L$ , $R_S$ and $C_L$ are function of application environment (see AC Tables for specific values)**
**$C_L$ includes test fixture and stray capacitance**

**Figure 10. Break-Before-Make Interval Timing**




**$V_S$, $R_S$ and $R_T$ are function of application environment (see AC/DC Tables for values)**

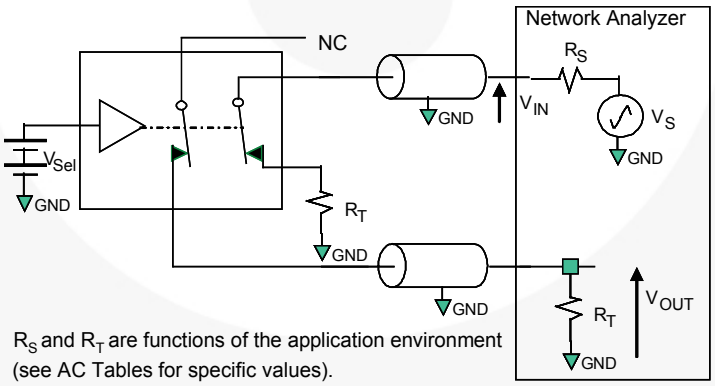
**Figure 11. Insertion Loss**




$R_S$ and $R_T$ are functions of the application environment (see AC Tables for specific values).

Off isolation = 20 Log ($V_{OUT}$ / $V_{IN}$)

**Figure 12. Channel Off Isolation**




$R_S$ and $R_T$ are functions of the application environment (see AC Tables for specific values).

Crosstalk = 20 Log ($V_{OUT}$ / $V_{IN}$)

**Figure 13. Non-Adjacent Channel-to-Channel Crosstalk**

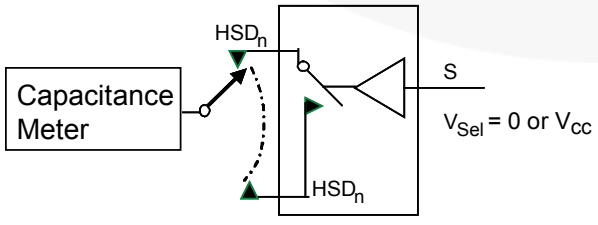



**Figure 14. Channel Off Capacitance**

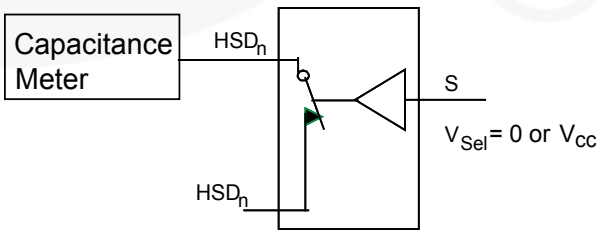



**Figure 15. Channel On Capacitance**

## Insertion Loss

One of the key factors for using the FSA3200 in mobile digital video applications is the small amount of insertion loss experienced by the received signal as it passes through the switch. This results in minimal degradation of the received eye. One of the ways to measure the quality of the high data rate channels is using balanced ports and 4-port differential S-parameter analysis, particularly SDD21.

Bandwidth is measured using the S-parameter SDD21 methodology. Figure 16 shows the bandwidth (GHz) for the MDV path and Figure 17 the bandwidth curve for the USB path.

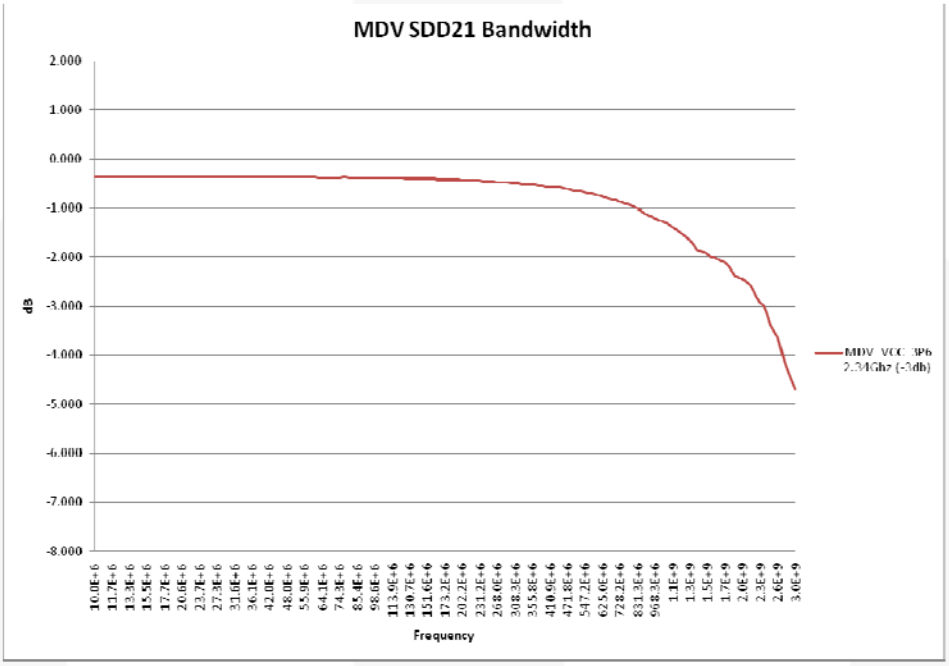



**Figure 16. MDV Path SDD21 Insertion Loss Curve**

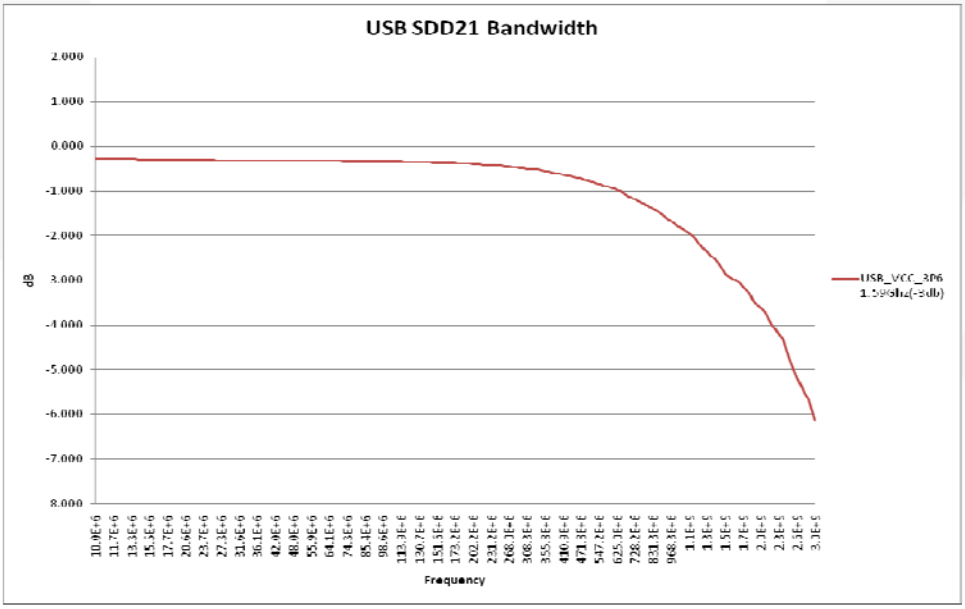



**Figure 17. USB Path SDD21 Insertion Loss Curve**

## Typical Applications

Figure 18 shows the FSA3200 utilizing the $V_{BUS}$ connection from the micro-USB connector. The 3M resistor is used to ensure, for manufacturing test via the micro-USB connector, that the FSA3200 configures for connectivity through the FSA9280A accessory switch. Figure 19 shows the configuration for the FSA3200 "self powered" by the battery only.

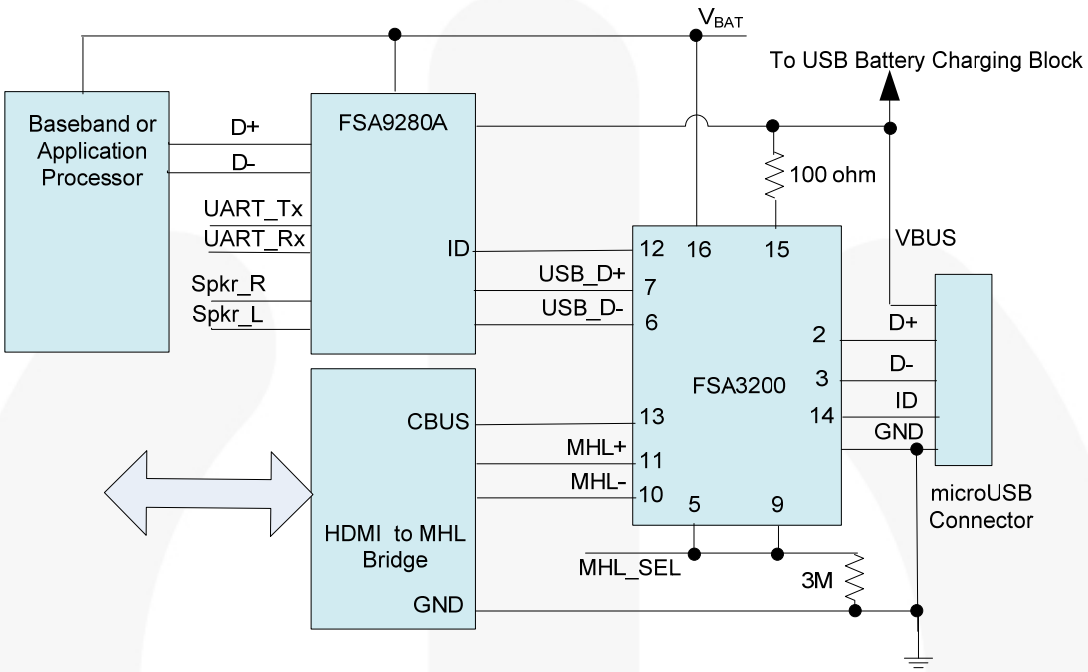



**Figure 18. Typical FSA3200 Application Using $V_{BUS}$**

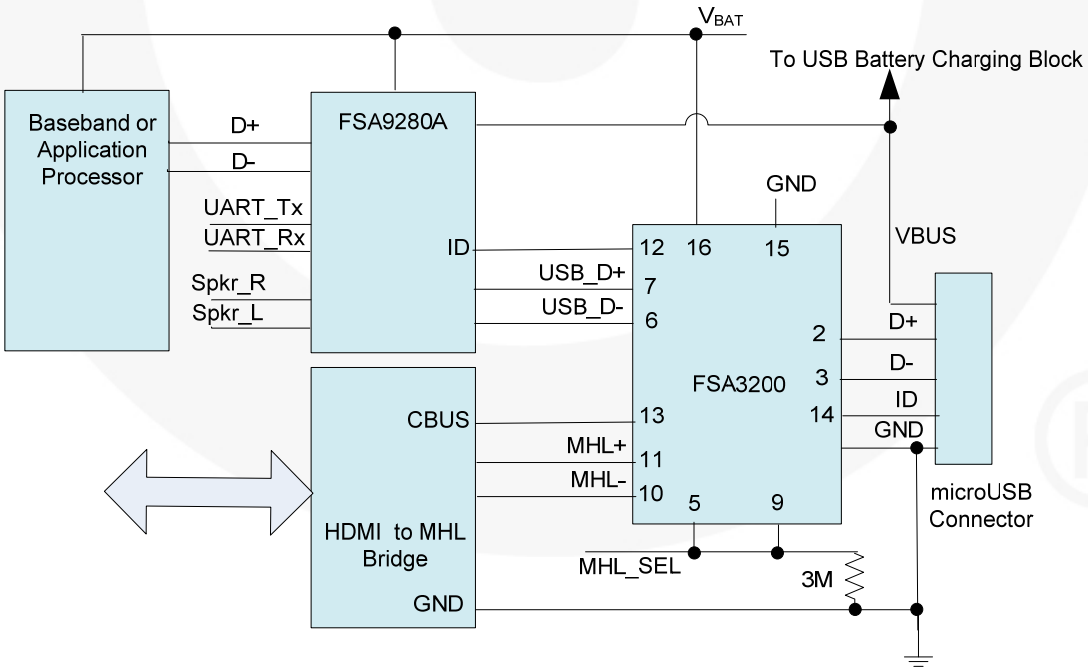
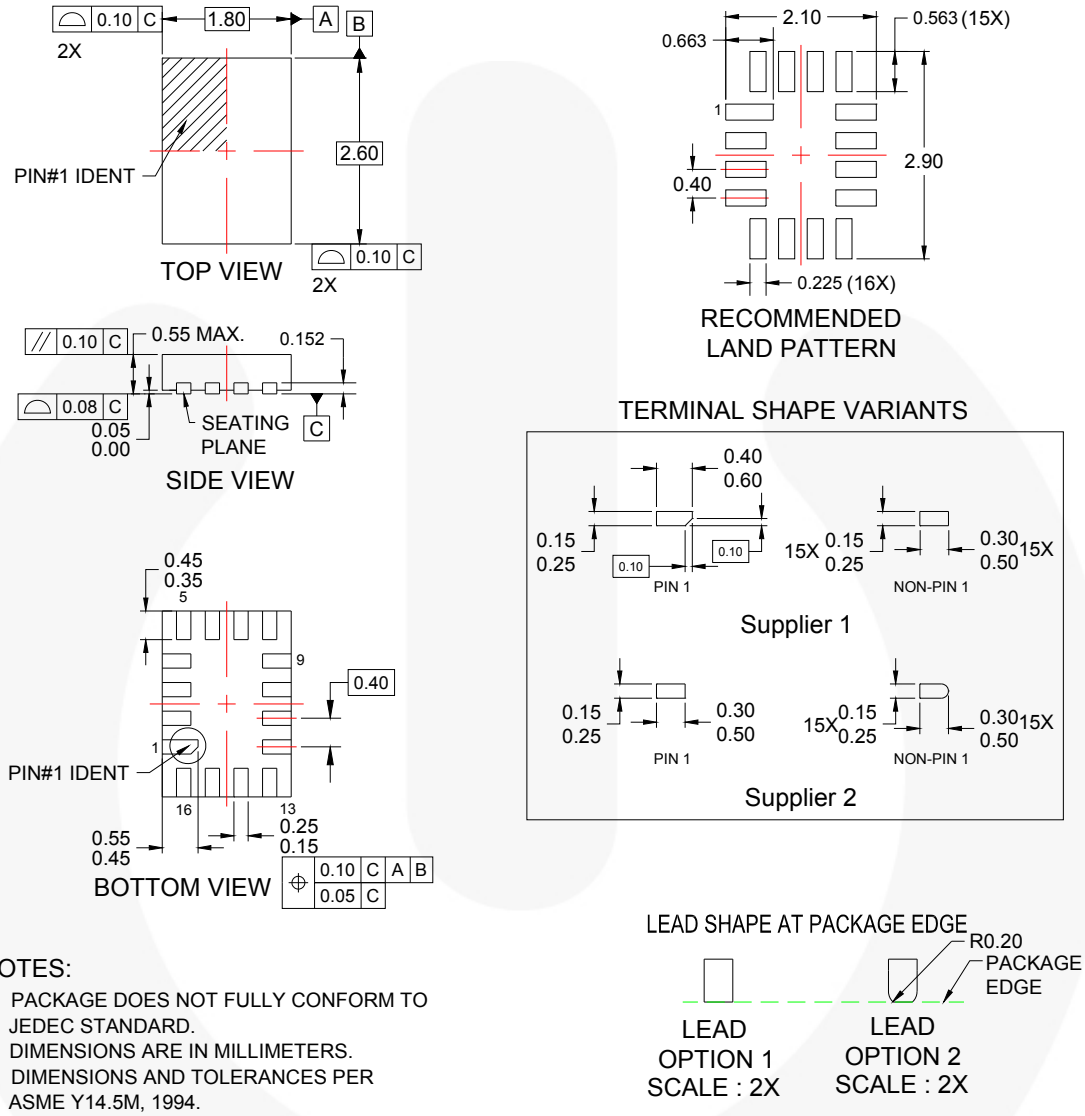



**Figure 19. Typical FSA3200 "Self-Powered" Application Using $V_{BAT}$**

## Physical Dimensions




NOTES:

A. PACKAGE DOES NOT FULLY CONFORM TO JEDEC STANDARD.
B. DIMENSIONS ARE IN MILLIMETERS.
C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
D. LAND PATTERN RECOMMENDATION IS BASED ON FSC DESIGN ONLY.
E. DRAWING FILENAME: MKT-UMLP16Arev4.
F. TERMINAL SHAPE MAY VARY ACCORDING TO PACKAGE SUPPLIER, SEE TERMINAL SHAPE VARIANTS.

**Figure 20. 16-Lead, Ultrathin Molded Leadless Package (UMLP)**

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