**Features**

- Compliant to USB specifications
- Dual independent switches control
- 2.7V to 5.5V input voltage
- 500mA minimum continuous current per port
- 110mΩ typical on-resistance
- 1.25A maximum short circuit current limit
- Independent open-drain fault flag pins
- 110μA typical on-state supply current
- 1μA typical off-state supply current
- Output can be forced higher than input (off-state)
- Thermal shutdown
- 2.4V typical under voltage lockout (UVLO)
- 1ms turn-on (soft-start) and fast turn-off
- Enable active-high (H) or active-low (L)
- SOP-8L: Available in “Green” Molding Compound (No Br, Sb)
- Lead Free Finish/ RoHS Compliant (Note 1)

**General Description**

The AP1212 series are dual integrated high-side power switch with independent enable and flag functions, optimized for self-powered and bus-powered Universal Serial Bus (USB) applications. The AP1212 series support the following USB requirements: each switch channel supplies up to 500mA as required by USB downstream devices; the switch’s low on-resistance meets USB voltage drop requirements; fault current is limited to typically 1000mA, well below the UL 25VA safety requirements; and a flag output is available to indicate fault conditions to the local USB controller. Soft start eliminates the momentary voltage drop on the upstream port that may occur when the switch is enabled in bus-powered applications. Additional features include thermal shutdown to prevent catastrophic switch failure from high-current loads, under voltage lockout (UVLO) to ensure that the device remains off unless there is a valid input voltage present, and 3.3V and 5V logic compatible enable inputs.

**Applications**

- USB hubs
- Hot plug-in power supplies
- Battery-charger circuits

**Typical Application Circuit**
Ordering Information

AP1212 X S X - 13

Enable
H : Active High
L : Active Low

Package
S : SOP-8L

Lead Free
L : Lead Free
G : Green

Packing
13 : Tape & Reel

AP1212XSL-13
S SOP-8L 2500/Tape & Reel -13

AP1212XSG-13
S SOP-8L 2500/Tape & Reel -13

Notes:
2. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at http://www.diodes.com/datasheets/ap02001.pdf.

Pin Assignments

(Top View)

<table>
<thead>
<tr>
<th>Pin Description</th>
<th>Pin Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENABLE: Logic-compatible enable input. (H: active high, L: active low). Do not float.</td>
<td>EN1, EN2</td>
</tr>
<tr>
<td>active-low, open-drain output. Indicates over current, UVLO, and thermal shutdown.</td>
<td>FLG1, FLG2</td>
</tr>
<tr>
<td>Supply return.</td>
<td>GND</td>
</tr>
<tr>
<td>Output MOSFET drain. Also supplies IC’s internal circuitry. Connect to positive supply.</td>
<td>IN</td>
</tr>
<tr>
<td>Switch Output: Output MOSFET source. Typically connect to switched side of load.</td>
<td>OUT1, OUT2</td>
</tr>
</tbody>
</table>
NOT RECOMMENDED FOR NEW DESIGN PLEASE USE AP2146 OR AP2156

AP1212
DUAL USB HIGH-SIDE POWER SWITCH

Block Diagram

Test Circuit (Note 3)

Notes:
3. Before EN is asserted, a delay of 10ms minimum from when the supply voltage, Vcc, becomes stable must be allowed.

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### Absolute Maximum Ratings (Note 4)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESD HBM</td>
<td>Human Body Model ESD Protection (Note 5)</td>
<td>500</td>
<td>V</td>
</tr>
<tr>
<td>ESD MM</td>
<td>Machine Model ESD Protection (Note 5)</td>
<td>150</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IN}$</td>
<td>Supply Voltage</td>
<td>+7</td>
<td>V</td>
</tr>
<tr>
<td>$V_{FLG}$</td>
<td>Fault Flag Voltage</td>
<td>+7</td>
<td>V</td>
</tr>
<tr>
<td>$I_{FLG}$</td>
<td>Fault Flag Current</td>
<td>50</td>
<td>mA</td>
</tr>
<tr>
<td>$V_{OUT}$</td>
<td>Output Voltage</td>
<td>+7</td>
<td>V</td>
</tr>
<tr>
<td>$V_{EN}$</td>
<td>Control Input Range</td>
<td>-0.3 to $V_{IN}$ +2</td>
<td>V</td>
</tr>
<tr>
<td>$T_{ST}$</td>
<td>Storage Temperature</td>
<td>-65 to +150</td>
<td>°C</td>
</tr>
<tr>
<td>MSL</td>
<td>Moisture Sensitivity Level</td>
<td>3</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes:
- 4. Exceeding the absolute maximum rating may damage the device.
- 6. The device is not guaranteed to function outside its operating rating.

### Recommended Operating Conditions (Note 6)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IN}$</td>
<td>Supply Voltage</td>
<td>2.7</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>$T_{A}$</td>
<td>Operating Ambient Temperature</td>
<td>-40</td>
<td>125</td>
<td>°C</td>
</tr>
</tbody>
</table>

Notes:
- 4. Exceeding the absolute maximum rating may damage the device.
- 6. The device is not guaranteed to function outside its operating rating.
## Electrical Characteristics

(Under the conditions of $V_{IN} = +5V$ and $T_A = 25^\circ C$, unless otherwise specified)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{CC}$</td>
<td>Supply Current</td>
<td>Switch off, OUT = open (Note 7)</td>
<td>0.50</td>
<td>5</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All switches on, OUT = open (Note 7)</td>
<td>110</td>
<td>160</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>$V_{IT}$</td>
<td>Enable Input Threshold</td>
<td>(Note 7)</td>
<td>0.8</td>
<td>1.7</td>
<td>2.40</td>
<td>V</td>
</tr>
<tr>
<td>$I_{EN}$</td>
<td>Enable Input Current</td>
<td>$V_{EN} = 0V$ to 5.5V</td>
<td>-1</td>
<td>±0.01</td>
<td>1</td>
<td>μA</td>
</tr>
<tr>
<td>$C_{EN}$</td>
<td>Enable Input Capacitance</td>
<td></td>
<td>1</td>
<td>pF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_{DS(ON)}$</td>
<td>Switch Resistance</td>
<td>$V_{IN} = 2.7V \sim 5.5V$, $I_{OUT} = 500mA$, each switch</td>
<td>110</td>
<td>140</td>
<td>mΩ</td>
<td></td>
</tr>
<tr>
<td>$T_{ON}$</td>
<td>Output Turn-On Delay</td>
<td>$R_L = 10\Omega$ each output</td>
<td>30</td>
<td>μS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_{R}$</td>
<td>Output Turn-On Rise Time</td>
<td>$R_L = 10\Omega$ each output</td>
<td>1</td>
<td>mS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_{OFF}$</td>
<td>Output Turnoff Delay</td>
<td>$R_L = 10\Omega$ each output</td>
<td>0.5</td>
<td>10</td>
<td>μS</td>
<td></td>
</tr>
<tr>
<td>$T_{F}$</td>
<td>Output Turnoff Fall Time</td>
<td>$R_L = 10\Omega$ each output</td>
<td>0.5</td>
<td>10</td>
<td>μS</td>
<td></td>
</tr>
<tr>
<td>$I_{LEAK}$</td>
<td>Output Leakage Current</td>
<td>Each output (output disabled)</td>
<td>10</td>
<td>μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{OUT}$</td>
<td>Continuous Load Current</td>
<td>Each output</td>
<td>0.6</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{OS}$</td>
<td>Short-circuit Current Limit</td>
<td>Each output (enable into load), $V_{OUT} = 0V$</td>
<td>0.8</td>
<td>1.0</td>
<td>1.25</td>
<td>A</td>
</tr>
<tr>
<td>$I_{LIM}$</td>
<td>Current-Limit Threshold</td>
<td>Ramped load applied to enabled output</td>
<td>1.0</td>
<td>1.2</td>
<td>1.4</td>
<td>A</td>
</tr>
<tr>
<td>$T_{TS}$</td>
<td>Over-temperature Shutdown Threshold</td>
<td>$T_J$ increasing</td>
<td>140</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_J$ decreasing</td>
<td>130</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_{FO}$</td>
<td>Error Flag Output Resistance</td>
<td>$V_{IN} = 5V$, $I_L = 10mA$</td>
<td>10</td>
<td>25</td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{IN} = 3.3V$, $I_L = 10mA$</td>
<td>15</td>
<td>40</td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td>$I_{FLO}$</td>
<td>Error Flag Off Current</td>
<td>$V_{FLAG} = 5V$</td>
<td>0.01</td>
<td>1</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>$UVLO$</td>
<td>UVLO Threshold</td>
<td>$V_{IN}$ increasing</td>
<td>2.5</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{IN}$ decreasing</td>
<td>2.3</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\theta_{JA}$</td>
<td>Thermal Resistance Junction-to-Ambient</td>
<td>SOP-8L</td>
<td>165</td>
<td>°C/W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\theta_{JC}$</td>
<td>Thermal Resistance Junction-to-Case</td>
<td>SOP-8L</td>
<td>26</td>
<td>°C/W</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: 7. Off is $V_{EN} \leq 0.8V$ and on is $V_{EN} \geq 2.4V$ for the AP1212H. Off is $V_{EN} \geq 2.4V$ and on is $V_{EN} \leq 0.8V$ for the AP1212L.
Typical Performance Characteristics

### On-Resistance vs. Supply Voltage

- **RL = 10ohm, T = 25°C**
- **V_supply = 3.3V, V_supply = 5V**

### On-Resistance vs. Temperature

- **V_supply = 3.3V, V_supply = 5V**

### Turn-On Rise Time vs. Supply Voltage

- **RL = 10ohm, CL = 47uF**
- **V_supply = 3.3V, V_supply = 5V**

### Turn-On Rise Time vs. Temperature

- **RL = 10ohm, CL = 47uF**

### On-Current vs. Supply Voltage

- **25°C, -40°C, 85°C**
- **V_supply = 3.3V, V_supply = 5V**

### On-Current vs. Temperature

- **V_supply = 3.3V, V_supply = 5V**
Typical Performance Characteristics

Off-Current vs. Supply Voltage

Off-Current vs. Temperature

Enable Threshold vs. Supply Voltage

Enable Threshold vs. Temperature

Short-Circuit Current-Limit vs. Supply Voltage

Short-Circuit Current-Limit vs. Temperature
Typical Performance Characteristics (Continued)

Current-Limit Threshold vs. Supply Voltage

Current-Limit Threshold vs. Temperature

UVLO Threshold vs. Temperature
Typical Performance Characteristics (Continued)

**Turn-On/Turn-Off (AP1212H)**
- **TIME (10mS/div.):**
  - VIN = 5V
  - CL = 47μF
  - RL = 35Ω
  - Inrush Current: 140 mA

**Turn-On (AP1212H)**
- **TIME (200μS/div.):**
  - Output Turn-On Rise Time
  - VIN = 5V
  - CL = 47μF
  - RL = 35Ω
  - Inrush Current: 140 mA

**Turn-Off (AP1212H)**
- **TIME (2mS/div.):**
  - Enabled Into Short (AP1212H)
  - VIN = 5V
  - CL = 47μF
  - RL = 35Ω
  - Short-Circuit Current

**Current-Limit Response (AP1212H)**
- **TIME (50mS/div.):**
  - Current-Limit Threshold
  - Short-Circuit Current
  - Thermal Shutdown
  - Hysteresis (10°C)

**Current-Limit Response (AP1212H)**
- **TIME (20μS/div.):**
  - Current-Limit Threshold
  - Short-Circuit Current
Functional Description

Error Flag
An open-drained output of N-channel MOSFET, the FLG output is pulled low to signal the following fault conditions: input under voltage, output current limit, and thermal shutdown.

Current Limit
The current limit threshold is preset internally. It protects the output MOSFET switches from damage due to undesirable short circuit conditions or excess inrush current often encountered during hot plug-in. The low limit of the current limit threshold of the AP1212 allows a minimum current of 0.5A through the MOSFET switches. A current limit condition will signal the error flag.

Thermal Shutdown
When the chip temperature exceeds 140ºC for any reason other than over current fault of either one of the two MOSFET switches, the thermal shutdown function turns off both MOSFET switches and signals the error flag. A hysteresis of 10ºC prevents the MOSFETs from turning back on until the chip temperature drops to below 130ºC.

Enable
Before EN is asserted, a delay of 10ms minimum from when the supply voltage, Vcc, becomes stable must be allowed.

Supply Filtering
A 0.1µF to 1µF bypass capacitor from IN to GND, located near the device, is strongly recommended to control supply transients. Without a bypass capacitor, an output short may cause sufficient ringing on the input (from supply lead inductance) to damage internal control circuitry.

Transient Droop Requirements
USB applications support dynamic attachment (hot plug-in) of peripherals. A current surge is caused by the input capacitance of downstream device. Ferrite beads are recommended in series with all power and ground connector pins. Ferrite beads reduce EMI and limit the inrush current during hot-attachment by filtering high-frequency signals.

Short Circuit Transient
Bulk capacitance provides the short-term transient current needed during a hot-attachment event. With a 33µF, 16V tantalum or 100µF, 10V electrolytic capacitor mounted close to downstream connector per port should provide transient drop protection.

Printed Circuit Layout
The power circuitry of USB printed circuit boards requires a customized layout to maximize thermal dissipation and to minimize voltage drop and EMI.
Marking Information

(1) SOP-8L

( Top View )

H : Active High
L : Active Low
YY : Year : 08, 09, 10~
WW : Week : 01~52; 52 represents 52 and 53 week
X : Internal Code
L : Lead Free
G : Green

Package Information  (All Dimensions in mm)

(1) Package Type: SOP-8L

Land Pattern Recommendation
(Unit: mm)
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