

## VBUS OVP with a PTVS Diode

### General Description

The RT9746H is an over-voltage protection devices feature a low 35mΩ (typ) R<sub>ON</sub> internal FET with PTVS diode. The PTVS also protects the devices from surges up to 100V. When the input voltage exceeds the over-voltage threshold, the internal FET is turned off to prevent damage to the protected down stream components.

The internal Over-Voltage Protection (OVP) thresholds are preset to 6.8V typical.

The RT9746H is offered in a small WL-CSP-12B (BSC) package provides small PCB area applications.

### Ordering Information

RT9746H □  
 Package Type  
 WSC : WL-CSP-12B 1.92x1.27

Note :

Richtek products are :

- ▶ RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- ▶ Suitable for use in SnPb or Pb-free soldering processes.

### Features

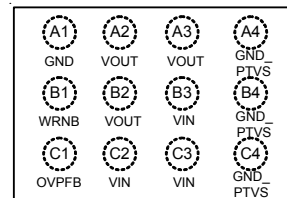
- PTVS Diode Embedded for VBUS Surge Protection
- Warning Indicator for OVP or UVP
- 28V Maximum Rating for DC Adapter
- Integrated Over-Voltage Protection FET on VBUS for Fault Isolation

### Applications

- Cellular Phone
- Smart Handheld Device

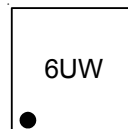
### Pin Configuration

(TOP VIEW)



WL-CSP-12B 1.92x1.27 (BSC)

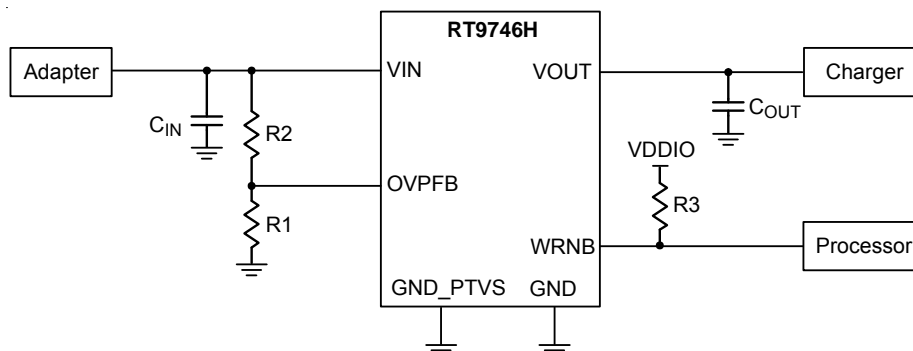
### Marking Information



6U : Product Code

W : Date Code

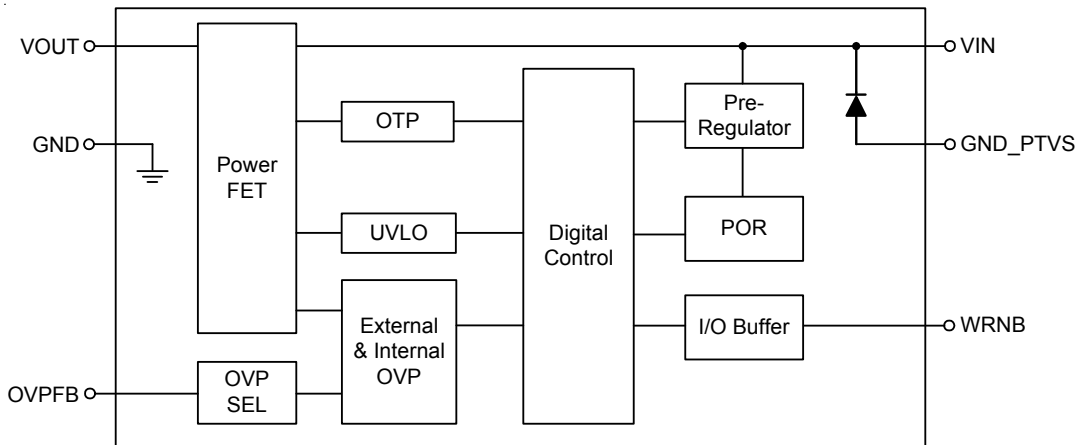
### Simplified Application Circuit



## Functional Pin Description

| Pin No     | Pin Name | Pin Function  |
|------------|----------|---|
| A1         | GND      | Common ground of internal circuits.   |
| A2, A3, B2 | VOUT     | Output from VBUS load-switch.   |
| B1         | WRNB     | Inverse warning signal (OTP, OVP, UVLO) flag output (open-drain).                           |
| A4, B4, C4 | GND_PTVS | Common ground of power TVS diode, and pin lay-out place as close as possible VIN capacitor. |
| B3, C2, C3 | VIN      | VBUS from power adapter.  |
| C1         | OVPFB    | External OVP adjustment setting. (If no used, be surely tied to GND)                        |

## Functional Block Diagram



**Absolute Maximum Ratings** (Note 1)

- VIN, OVPFB ----- -0.3V to 28V
- VOUT ----- -0.3V to 22V
- <10μs ----- -0.3V to 30V
- WRNB ----- -0.3V to 6V
- System Level with Air Discharger, VIN, GND ----- ±15kV
- System Level with Contact Discharger, VIN, GND ----- ±8kV
- Power Dissipation, P<sub>D</sub> @ T<sub>A</sub> = 25°C
- WL-CSP-12B 1.92x1.27 (BSC) ----- 1.67W
- Package Thermal Resistance (Note 2)
- WL-CSP-12B 1.92x1.27 (BSC), θ<sub>JA</sub> ----- 59.6°C/W
- Junction Temperature ----- 150°C
- Lead Temperature (Soldering, 10 sec.) ----- 260°C
- Storage Temperature Range ----- -65°C to 150°C
- ESD Susceptibility (Note 3)
- HBM (Human Body Model) ----- 2kV
- Surge (VIN) ----- 100V

**Recommended Operating Conditions** (Note 4)

- Supply Input Voltage, VIN ----- 3V to 20V
- I/O Supply Voltage (V<sub>DDIO</sub>) ----- 1.8V to 3.6V
- VOUT Capacitors ----- 1μF to 100μF
- Junction Temperature Range ----- -40°C to 125°C
- Ambient Temperature Range ----- -40°C to 85°C

**Electrical Characteristics**

(V<sub>IN</sub> = 5V, T<sub>A</sub> = 25°C, unless otherwise specified)

| Parameter                              | Symbol                | Test Conditions  | Min | Typ  | Max  | Unit |
|--|-----------------------|--|-----|------|------|------|
| <b>DC Characteristics</b>              |                       |  |     |      |      |      |
| Input Clamp Voltage                    | V <sub>IN_CLAMP</sub> | I <sub>IN</sub> = 10mA   | --  | 31   | --   | V    |
| VIN Supply Current                     | I <sub>VIN_S</sub>    | V <sub>IN</sub> = 5V, I <sub>OUT</sub> = 0mA                       | --  | 90   | 130  | μA   |
| OVP Supply Current                     | I <sub>OVP_S</sub>    | V <sub>OVP</sub> = 3V, V <sub>IN</sub> = 5V, V <sub>OUT</sub> = 0V | --  | 63   | 100  | μA   |
| VIN POR Threshold Only for VOUT        | V <sub>POR</sub>      | Rising   | 2.5 | 2.7  | 2.9  | V    |
| VIN POR Hysteresis Only for VOUT       | V <sub>POR_HYS</sub>  |  | --  | 100  | --   | mV   |
| OVP Threshold Voltage                  | V <sub>OVP</sub>      | Rising   | 6.6 | 6.8  | 7    | V    |
| OVP Hysteresis                         | V <sub>OVP_HYS</sub>  |  | --  | 150  | --   | mV   |
| OVP Propagation Delay to Turn Off VOUT | t <sub>OVP_PD</sub>   | V <sub>BUS</sub> = 5V to 10V (6V/μs)                               | --  | 0.18 | 0.25 | μs   |
| OVP Recover Delay                      | t <sub>OVP_RD</sub>   | V <sub>BUS</sub> = 10V to 5V (6V/μs)                               | --  | 8    | --   | ms   |
| OTP Threshold to Turn Off VOUT         | T <sub>OTP_FET</sub>  | Rising (Note 5)  | --  | 130  | --   | °C   |

| Parameter                                | Symbol                   | Test Conditions   | Min  | Typ | Max  | Unit |
|--|--------------------------|---|------|-----|------|------|
| OTP Threshold Hysteresis                 | T <sub>OTP_FET_HYS</sub> | Falling (Note 5)  | --   | 20  | --   | °C   |
| OTP Recover Delay                        | t <sub>OTP_RD</sub>      |   | --   | 8   | --   | ms   |
| FET On Resistance                        | R <sub>ON_FET</sub>      | I <sub>BUS_OUT</sub> = 1000mA, V <sub>BUS</sub> = 5V<br>T <sub>A</sub> = 25°C   | --   | 35  | 42   | mΩ   |
| External OVP Setting Threshold           | V <sub>REF_EXT</sub>     |   | 1.12 | 1.2 | 1.24 | V    |
| External OVP Adjustment Range            | V <sub>OVP_EXT</sub>     |   | 4    | --  | 20   | V    |
| External OVP Select Threshold            | V <sub>OVP_SEL</sub>     | Rising  | --   | 0.3 | --   | V    |
| External OVP Select Threshold Hysteresis | V <sub>OVP_HYS</sub>     |   | --   | 100 | --   | mV   |
| WRNB Open-Drain Impedance                |                          | V <sub>BUS</sub> = 5V   | --   | --  | 15   | Ω    |
| OVP Leakage Current                      | I <sub>OVP_LK</sub>      |   | -100 | --  | 100  | nA   |
| WRNB Output Low Voltage                  | V <sub>OL</sub>          | V <sub>DDIO</sub> = 3.3V, I <sub>SINK</sub> = 1mA   | --   | --  | 0.4  | V    |
| WRNB Leakage Current                     | I <sub>WRNB_LK</sub>     | V <sub>DDIO</sub> = 3.3V, WRNB deasserted   | -0.5 | --  | 0.5  | μA   |
| <b>Timing Characteristics</b>            |                          |   |      |     |      |      |
| Debounce Time                            | t <sub>DEB</sub>         | Time from 2.5V < V <sub>IN</sub> < V <sub>IN_OVP</sub> to V <sub>OUT</sub> = 0.1 x V <sub>IN</sub>  | --   | 16  | --   | ms   |
| Soft-Start Time                          | t <sub>START</sub>       | Time from V <sub>IN</sub> = V <sub>IN_MIN</sub> to 0.2 x WRNB, V <sub>IO</sub> = 1.8V with 10kΩ pull-up resistor                              | --   | 30  | --   | ms   |
| Switch Turn-On Time                      | t <sub>ON</sub>          | V <sub>IN</sub> = 5V, R <sub>L</sub> = 100Ω, V <sub>OUT</sub> from 0.1 x V <sub>IN</sub> to 0.9 x V <sub>IN</sub> , C <sub>LOAD</sub> = 100μF | --   | 1.5 | --   | ms   |
| Switch Turn-Off Time                     | t <sub>OFF</sub>         | R <sub>L</sub> = 100Ω, C <sub>LOAD</sub> = 0μF, V <sub>IN</sub> > V <sub>OVP</sub> to V <sub>OUT</sub> = 0.8 x V <sub>IN</sub> (Note 5)       | --   | 125 | --   | ns   |

**Note 1.** Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

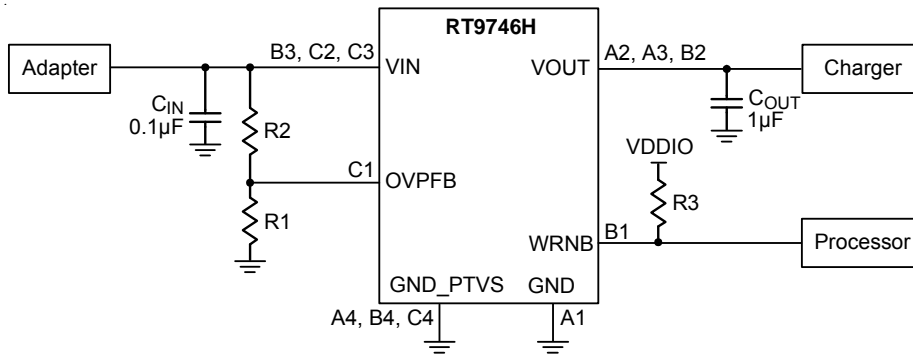
**Note 2.** θ<sub>JA</sub> is measured under natural convection (still air) at T<sub>A</sub> = 25°C with the component mounted on a high effective-thermal-conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard.

**Note 3.** Devices are ESD sensitive. Handling precaution is recommended.

**Note 4.** The device is not guaranteed to function outside its operating conditions.

**Note 5.** Guaranteed by design.

**Typical Application Circuit**



Timing Diagram

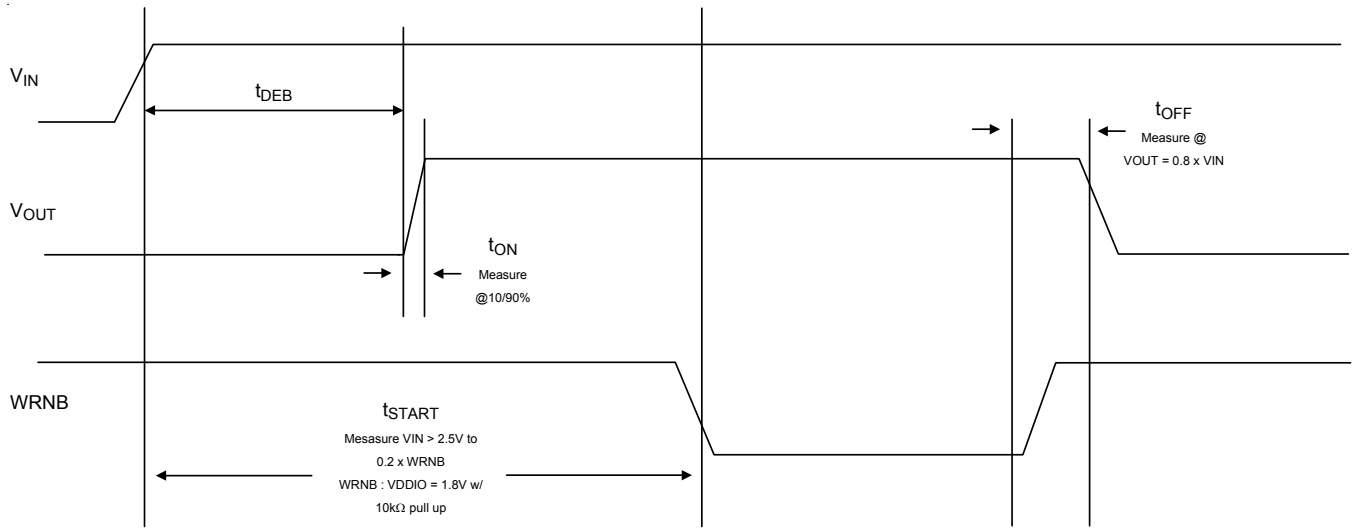


Figure 1. Timing for Power Up and Normal Operation

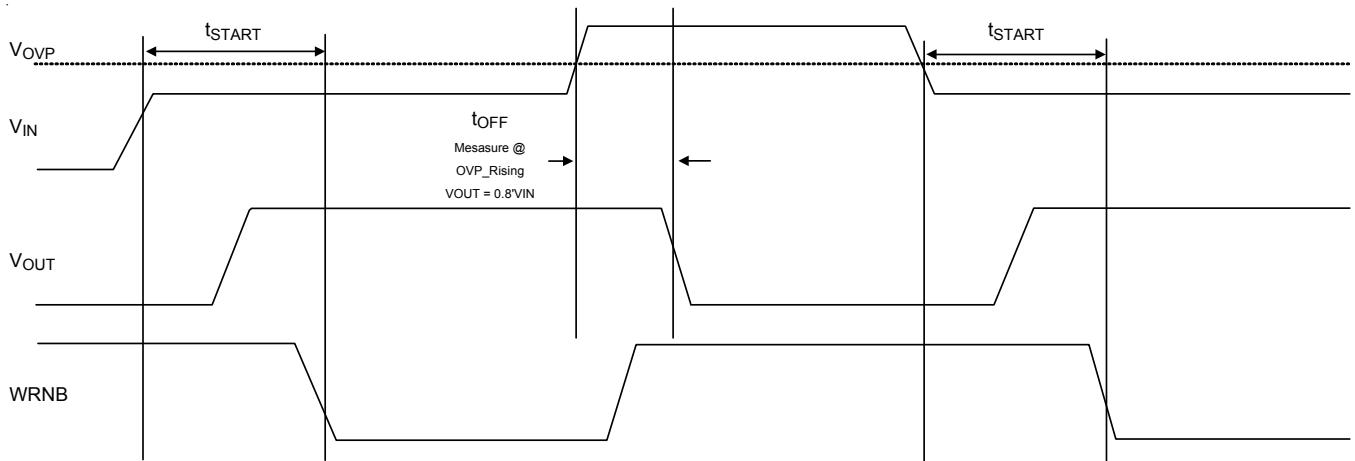
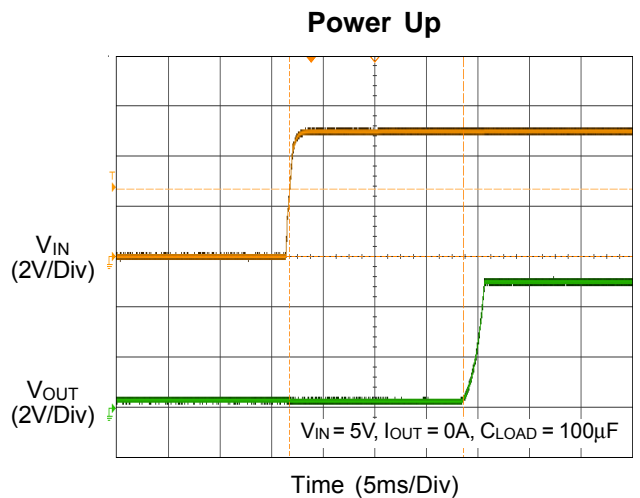
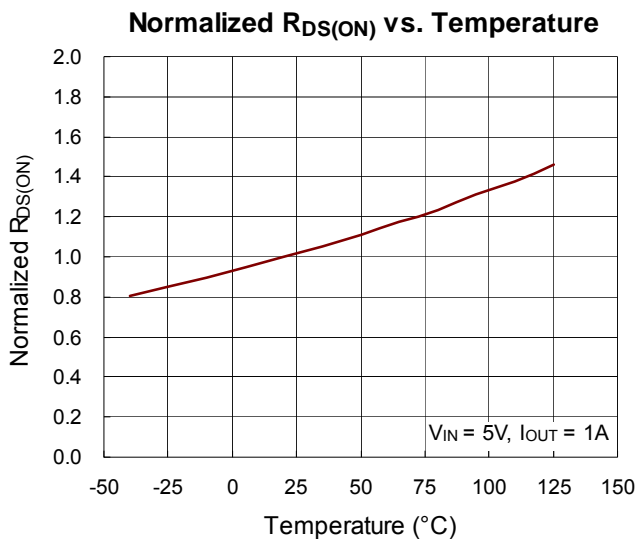
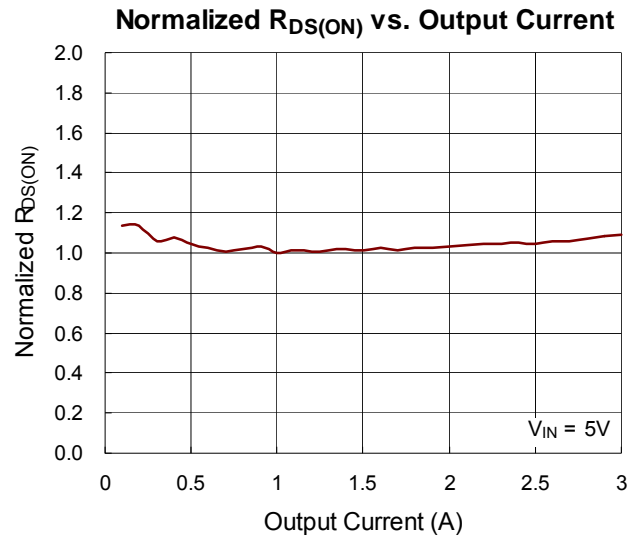
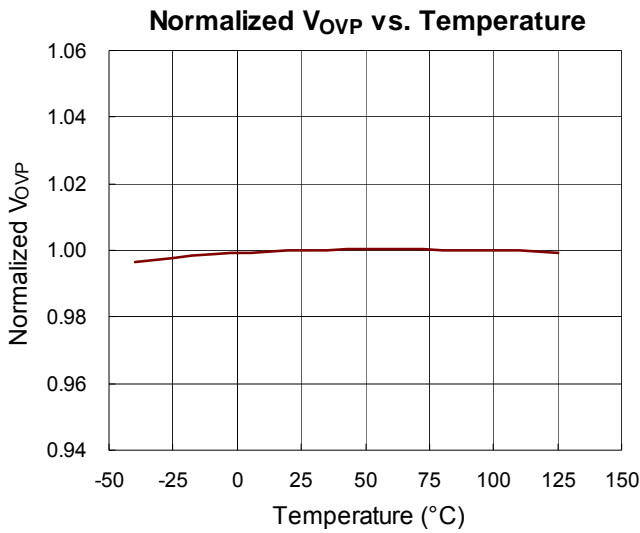
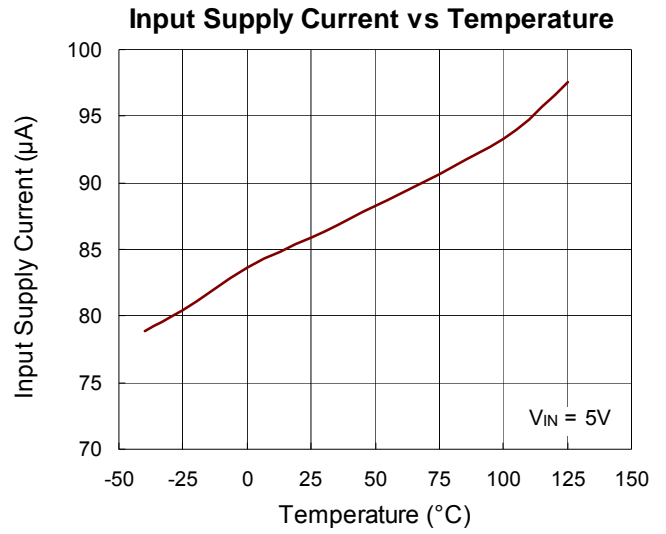
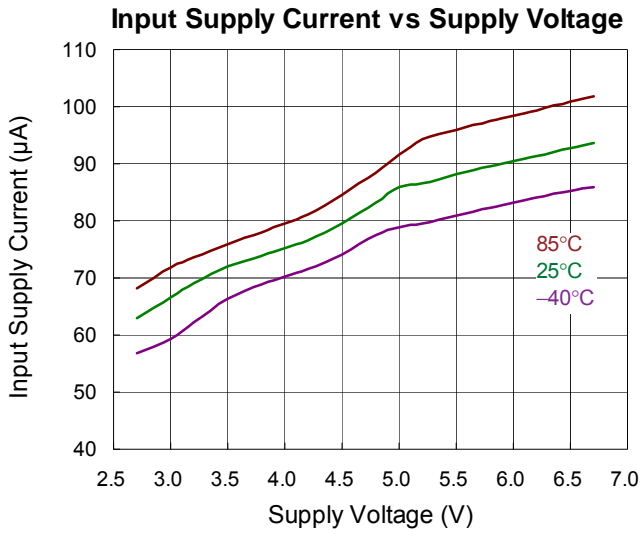
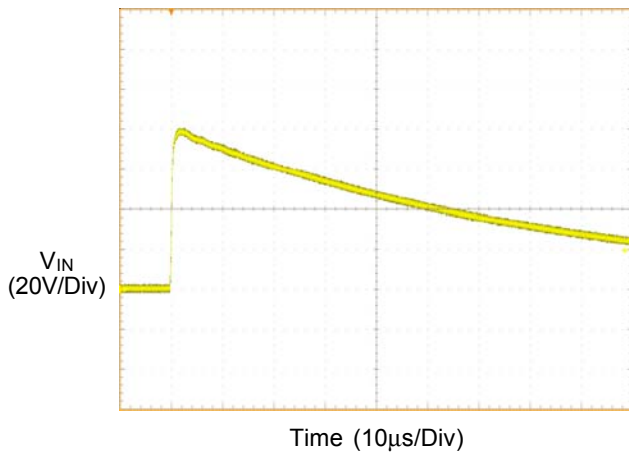


Figure 2. Timing for OVP Trip

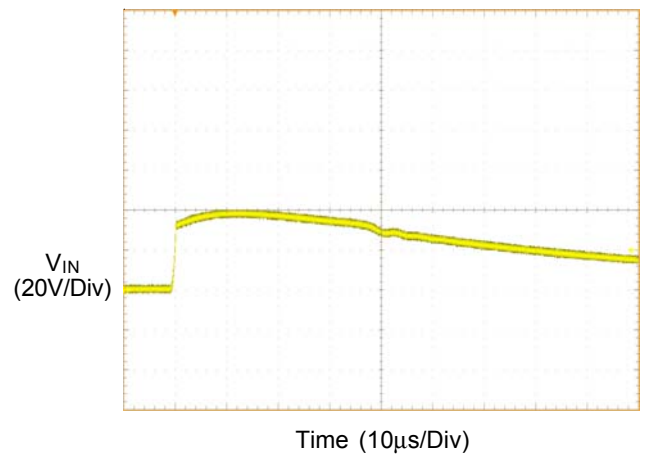
**Typical Operating Characteristics**



### 80V Surge without RT9746H



### 80V Surge with RT9746H





**Application Information**

**Power Up**

The RT9746H has a threshold of 2.7V power on reset (POR) with a built-in hysteresis of 100mV. Before the input voltage reaches the POR threshold, the RT9746H is off. When the input voltage is over the POR threshold, the VOUT of the RT9746H will delay for 16ms which includes soft-start time of 8ms. The 16ms delay allows the transient at the input during a hot insertion of the power supply to settle down before the IC starts to operate. During the soft-start transition, the RT9746H slowly turns on the internal MOSFET to reduce the inrush current.

**Over-Temperature Protection (OTP)**

The RT9746H monitors its internal temperature to prevent thermal failures. The chip turns off the MOSFET when the junction temperature reaches 130°C. The IC will resume after the junction temperature is cooled down 20°C.

**Input Over-Voltage Protection**

The RT9746H provides input over-voltage protection via internal or external resistor to set OVP level. If OVPFB is connected to GND, the RT9746H uses the internal OVP level setting. If an external resistor-divider is connected to OVPFB and  $V_{OVPFB}$  exceeds the VOVP\_SEL voltage, the RT9746H will adopt external OVP level setting. The OVP level VOVP is set as below.

$$V_{OVP} = V_{REF\_EXT} \times \left( 1 + \frac{R2}{R1} \right)$$

When the input volatge exceeds the OVP level, the RT9746H will turn off internal MOSFET around 0.18μs to prevent the high input volatge from damaging the end system. When the input volatge returns to normal operation volatge range with hysteresis (internal 150mV, external 100mV), the RT9746H will turn on the MOSFET to re-enable output.

**Thermal Considerations**

The junction temperature should never exceed the absolute maximum junction temperature  $T_{J(MAX)}$ , listed under Absolute Maximum Ratings, to avoid permanent

damage to the device. The maximum allowable power dissipation depends on the thermal resistance of the IC package, the PCB layout, the rate of surrounding airflow, and the difference between the junction and ambient temperatures. The maximum power dissipation can be calculated using the following formula :

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

where  $T_{J(MAX)}$  is the maximum junction temperature,  $T_A$  is the ambient temperature, and  $\theta_{JA}$  is the junction-to-ambient thermal resistance.

For continuous operation, the maximum operating junction temperature indicated under Recommended Operating Conditions is 125°C. The junction-to-ambient thermal resistance,  $\theta_{JA}$ , is highly package dependent. For a WL-CSP-12B 1.92x1.27 (BSC) package, the thermal resistance,  $\theta_{JA}$ , is 59.6°C/W on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. The maximum power dissipation at  $T_A = 25^\circ\text{C}$  can be calculated as below :

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (59.6^\circ\text{C/W}) = 1.67\text{W for a WL-CSP-12B 1.92x1.27 (BSC) package.}$$

The maximum power dissipation depends on the operating ambient temperature for the fixed  $T_{J(MAX)}$  and the thermal resistance,  $\theta_{JA}$ . The derating curves in Figure 3 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

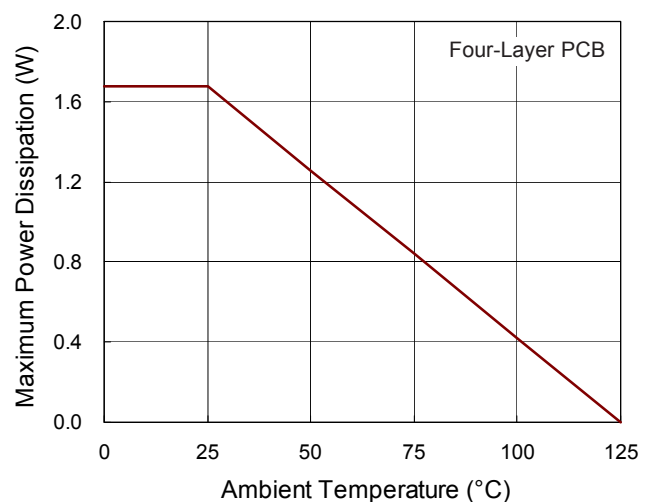
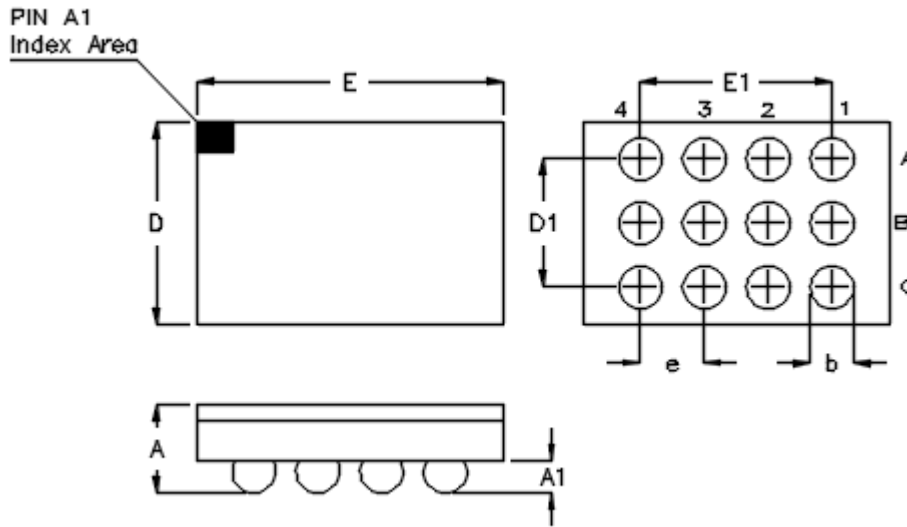


Figure 3. Derating Curve of Maximum Power Dissipation

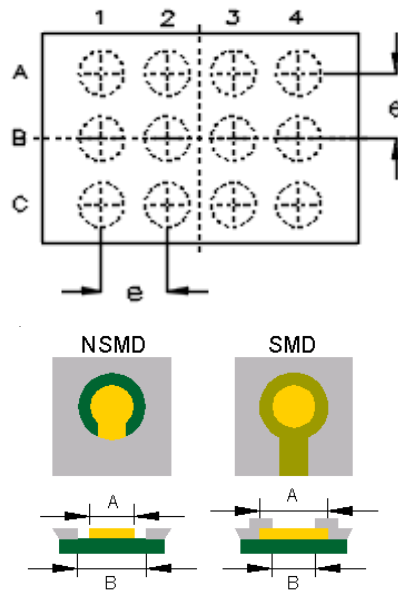
Outline Dimension



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min                       | Max   | Min                  | Max   |
| A      | 0.500                     | 0.600 | 0.020                | 0.024 |
| A1     | 0.170                     | 0.230 | 0.007                | 0.009 |
| b      | 0.240                     | 0.300 | 0.009                | 0.012 |
| D      | 1.220                     | 1.320 | 0.048                | 0.052 |
| D1     | 0.800                     |       | 0.031                |       |
| E      | 1.870                     | 1.970 | 0.074                | 0.078 |
| E1     | 1.200                     |       | 0.047                |       |
| e      | 0.400                     |       | 0.016                |       |

WL-CSP-12B 1.92x1.27 (BSC)

**Footprint Information**



| Package                 | Number of Pin | Type | Footprint Dimension (mm) |       |       | Tolerance |
|-------------------------|---------------|------|--------------------------|-------|-------|-----------|
|                         |               |      | e                        | A     | B     |           |
| WL-CSP1.92x1.27-12(BSC) | 12            | NSMD | 0.400                    | 0.240 | 0.340 | ±0.025    |
|                         |               | SMD  |                          | 0.270 | 0.240 |           |

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