# Micro USB Switch with OVP and I²C Interface

## General Description

The RT8973A is a USB port accessory detector and switch that is optimized to protect low voltage system from abnormal high input voltage (up to 28V). The RT8973A supports high speed USB operation and I²C interface control.

The RT8973A provides a device detection function by using the USB ID pin signal and the VBUS voltage. The ID pin resistance and VBUS voltage determine the unique characteristics for variety accessories. The host microprocessor can use I²C interface to control the switch position and read the results of the accessory detection. The RT8973A also detects USB chargers including dedicated chargers (D+/D- shorted) and high power host/ hub chargers.

## Features

- Hi-Speed USB Operation
- UART Switch
- Interrupt for Device Insertion and Removal
- Interrupt for Protection Function
- Default Startup Mode for Factory Support
- Battery Charger Detection (BCD 1.2) Compliant
- 28V Maximum Rating for DC Adapter
- Integrated Over-Voltage and Over-Current Protection FET On VBUS for Fault Isolation
- I²C Controlled Interface

## Applications

- Cellular Phone
- Smart Handheld Device

## Ordering Information

RT8973A□

└─ Package Type
  WSC : WL-CSP-18B 1.27x2.47 (BSC)

Note :

Richtek products are :

▸ RoHS compliant and compatible with the current require-ments of IPC/JEDEC J-STD-020.

▸ Suitable for use in SnPb or Pb-free soldering processes.

## Marking Information

1QW
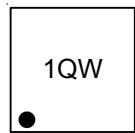
1Q : Product Code

W : Date Code

## Simplified Application Circuit

# RT8973A

## Pin Configuration

(TOP VIEW)

```
GND   (A1)   (A2)   (A3)   VBUS_OUT
           VBUS_OUT
BAT   (B1)   (B2)   (B3)   VBUS
            INTB
U1    (C1)   (C2)   (C3)   COMN1
            BOOT
U2    (D1)   (D2)   (D3)   COMP2
            JIG
DN1   (E1)   (E2)   (E3)   ID
            VDDIO
DP2   (F1)   (F2)   (F3)   SCL
            SDA
```
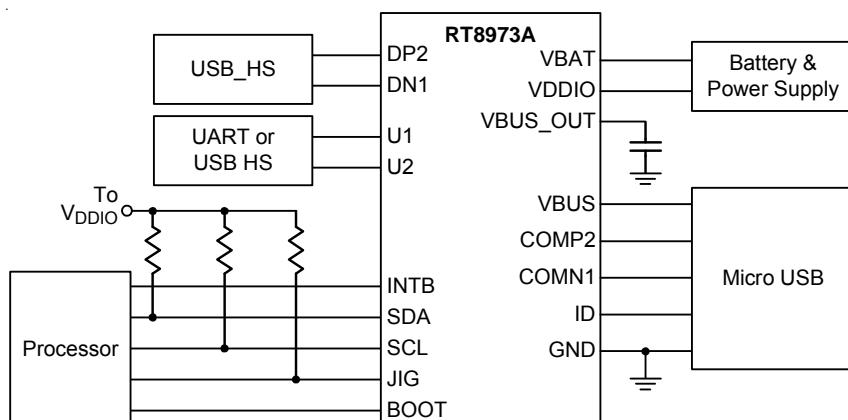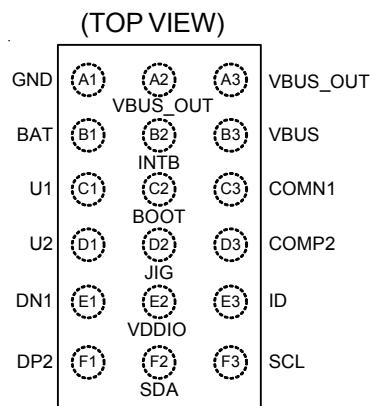
WL-CSP-18B 1.27x2.47 (BSC)

## Functional Pin Description

| Pin No. | Pin Name | Pin Function |
|---------|----------|--------------|
| A1 | GND | Ground. |
| A2, A3 | VBUS_OUT | Output through the power MOSFET. |
| B1 | VBAT | Connected to battery. |
| B2 | INTB | Interrupt to host (push-pull). |
| B3 | VBUS | Connected to USB receptacle. |
| C1 | U1 | UART port. |
| C2 | BOOT | BOOT mode out (push-pull). |
| C3 | COMN1 | USB D- port connected to USB receptacle. |
| D1 | U2 | UART port. |
| D2 | JIG | JIG detection (open drain). |
| D3 | COMP2 | USB D+ port connected to USB receptacle. |
| E1 | DN1 | USB DN port connected to host. |
| E2 | VDDIO | I/O voltage reference. |
| E3 | ID | USB ID port connected to USB receptacle. |
| F1 | DP2 | USB DP port connected to host. |
| F2 | SDA | $I^2C$ serial data input/output. Connect an external pull up resistor. |
| F3 | SCL | $I^2C$ serial clock input. Connect an external pull up resistor. |

## Functional Block Diagram
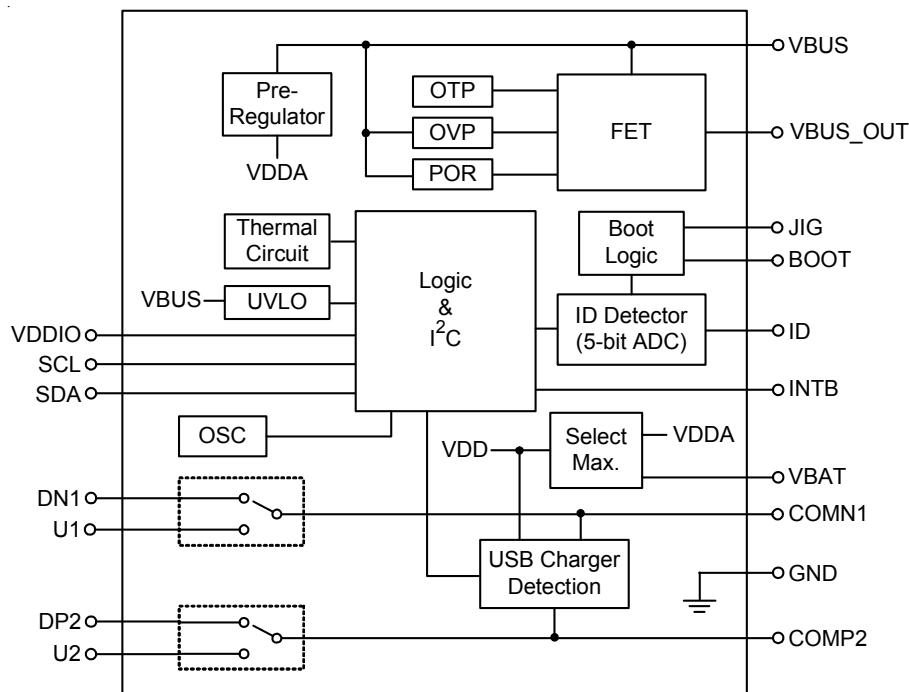


## Operation

The RT8973A is a USB port accessory detector and switch of USB and UART. The OVP function is optimized to protect low voltage system from abnormal high input voltage (up to 28V). The RT8973A supports accessory detection function through the unique characteristics from VBUS voltage, ID resistance and USB data line status.

The RT8973A is programmable by $I^2C$ interface and it can communicate with microprocessor.

## Absolute Maximum Ratings  (Note 1)

- VBUS to GND ------------------------------------------------------------------------------------------- −0.3V to 28V
- Other Pins to GND ------------------------------------------------------------------------------------- −0.3V to 6V
- Power Dissipation, $P_D$ @ $T_A$ = 25°C
  WL-CSP-18B 1.27x2.47 (BSC) ------------------------------------------------------------------------ 2.2W
- Package Thermal Resistance  (Note 2)
  WL-CSP-18B 1.27x2.47 (BSC), $θ_{JA}$ ------------------------------------------------------------- 45.4°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

## Recommended Operating Conditions  (Note 4)

- Battery Supply Voltage, VBAT ---------------------------------------------------------------------------- 2.8V to 5.5V
- USB Supply Voltage, VBUS ------------------------------------------------------------------------------- 4.3V to 6.7V
- Processor Supply Voltage, VDDIO ----------------------------------------------------------------------- 1.8V to 3.6V
- Junction Temperature Range ------------------------------------------------------------------------------ −40°C to 125°C
- Ambient Temperature Range ------------------------------------------------------------------------------- −40°C to 85°C

## Electrical Characteristics

($V_{BAT}$ = 3.7V, $T_A$ = 25°C, unless otherwise specified)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|-----------|--------|-----------------|-----|-----|-----|------|
| **DC Characteristics** | | | | | | |
| VBUS UVP Voltage | $V_{UVP}$ | | 3.5 | 3.7 | 3.9 | V |
| OTP | $T_{OTP}$ | (Note 5) | -- | 135 | -- | °C |
| OTP Hysteresis | $T_{OTP\_H}$ | (Note 5) | -- | 10 | -- | °C |
| VBAT UVLO | $V_{VBATUVLO}$ | | 1.1 | 1.8 | 2.1 | V |
| VBAT Supply Current | $I_{VBAT\_S}$ | $V_{BAT}$ = 4.2V, $V_{BUS}$ = 0V, ID = OPEN, and ADC_EN = 1 | -- | 25 | -- | μA |
| VBAT Leakage Current | $I_{VBAT\_L}$ | $V_{BAT}$ = 4.2V, $V_{BUS}$ = 0V, ID = OPEN, and ADC_EN = 0 | -- | 10 | 15 | μA |
| VBUS Supply Current | $I_{VBUS\_S}$ | $V_{BAT}$ = 4.5V, $V_{BUS}$ = 5V, ID = OPEN, and ADC_EN = 1 | -- | 700 | -- | μA |
| VDDA | $V_{DDA}$ | $V_{BUS}$ = 5V | -- | 4.5 | -- | V |
| **Battery Charging Spec.** | | | | | | |
| VDP_SRC Voltage | $V_{DP\_SRC}$ | With $I_{DAT\_SRC}$ = 0 to 250μA | 0.5 | -- | 0.7 | V |
| VDAT_REF Voltage | $V_{DAT\_REF}$ | | 0.25 | -- | 0.4 | V |
| VLGC Voltage | $V_{LGC}$ | | 0.8 | -- | 2 | V |
| DN Sink Current | $I_{DN\_SINK}$ | May be a resistance if desired | 50 | -- | 150 | μA |

| Parameter | | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **USB Analog Switch (DN1, DP2)** | | | | | | | |
| Analog Signal Range | | $V_{DN}$, $V_{DP}$ | | 0 | -- | $V_{DDA}$ | V |
| On-Resistance | | $R_{ON\_USB}$ | $V_{BAT}$ = 4.2V, $I_{COM}$ = 10mA, $V_{COM}$ = 0.75V | -- | 7.5 | -- | Ω |
| On-Resistance Match Between Channels | | $\Delta R_{ON\_USB}$ | $V_{BAT}$ = 4.2V, $I_{COM}$ = 10mA, $V_{COM}$ = 400mV | -- | 0.5 | -- | Ω |
| Off Leakage Current | | $I_{USB(OFF)}$ | $V_{BAT}$ = 4.2V, switch open, $V_{DN1}$ or $V_{DP2}$ = 0.3V, 2.5V, $V_{COM}$ = 2.5V, 0.3V | −360 | -- | 360 | nA |
| On Leakage Current | | $I_{USB(ON)}$ | $V_{BAT}$ = 4.2V, switch closed, $V_{DN1}$ or $V_{DP2}$ = 0.3V, 2.5V | −360 | -- | 360 | nA |
| **UART/USB Analog Switch (U1, U2)** | | | | | | | |
| Analog Signal Range | | $V_{U1}$, $V_{U2}$ | | 0 | -- | $V_{DDA}$ | V |
| On-Resistance | | $R_{ON\_UART}$ | $V_{BAT}$ = 4.2V, $I_{COM}$ = 10mA, $V_{COM}$ = 0V to 3V | -- | 7.5 | -- | Ω |
| On-Resistance Match Between Channels | | $\Delta R_{ON\_UART}$ | $V_{BAT}$ = 4.2V, $I_{COM}$ = 10mA, $V_{COM}$ = 1.5V | -- | 0.5 | -- | Ω |
| Off Leakage Current | | $I_{UART\_OFF}$ | $V_{BAT}$ = 4.2V, switch open, $V_{U1}$ or $V_{U2}$ = 0.3V, 2.5V, $V_{COM}$ = 2.5V, 0.3V | −360 | -- | 360 | nA |
| On Leakage Current | | $I_{UART\_ON}$ | $V_{BAT}$ = 4.2V, switch closed, $V_{U1}$ or $V_{U2}$ = 0.3V, 2.5V | −360 | -- | 360 | nA |
| **Digital Signals (INTB, SCL, SDA)** | | | | | | | |
| Input Voltage | Logic-High | $V_{IH}$ | | 1.4 | -- | -- | V |
| | Logic-Low | $V_{IL}$ | | -- | -- | 0.4 | V |
| Input Leakage Current | | $I_{INLEAK}$ | | −1 | -- | 1 | μA |
| Open Drain Low | | $V_{ODOL}$ | $I_{SINK}$ = 1mA | -- | -- | 0.4 | V |
| **Dynamic** | | | | | | | |
| I²C Max Clock | | $F_{I^2CCLK}$ | | -- | -- | 400 | kHz |
| Analog Switch Turn-On Time | | $t_{ON}$ | I²C stop to switch on; $R_L$ = 50Ω | -- | -- | 1 | ms |
| Analog Switch Turn-Off Time | | $t_{OFF}$ | I²C stop to switch off; $R_L$ = 50Ω | -- | -- | 1 | ms |
| Break-Before-Make Delay Time | | $t_D$ | $R_L$ = 50Ω | >0 | -- | -- | μs |
| VDAT_SRC On-Time | | $t_{DP\_SRC\_ON}$ | | 40 | -- | -- | ms |
| **FET On Path** | | | | | | | |
| VBUS POR Threshold Only for VBUS_OUT | | $V_{POR}$ | Rising | 2.5 | 2.7 | 2.9 | V |
| VBUS POR Hysteresis Only for VBUS_OUT | | $V_{POR\_HYS}$ | Falling | -- | 100 | -- | mV |
| Deglitch Time of POR Only for VBUS_OUT | | $t_{POR}$ | Rising | -- | 300 | -- | ms |

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| VBUS OVP Threshold Voltage | $V_{OVP}$ | Rising | 6.6 | 6.8 | 7 | V |
| VBUS OVP Hysteresis | $V_{OVP\_HYS}$ | Falling | -- | 60 | 100 | mV |
| VBUS OVP Propagation Delay to Turn-Off VBUS_OUT | $t_{OVP\_PD}$ | $V_{BUS}$ = 5V to 10V | -- | -- | 2 | $\mu$s |
| VBUS OVP Recover Delay | $t_{OVP\_RD}$ | $V_{BUS}$ = 10V to 5V | -- | 8 | -- | ms |
| Deglitch Time of OVP for 0x03 OVP | $t_{OVP\_D}$ | Rising | -- | 128 | -- | $\mu$s |
| OCP Threshold Current | $I_{OCP}$ | | 2.3 | 2.5 | 2.7 | A |
| OCP Blanking Time | $t_{OCP\_B}$ | | -- | 180 | -- | $\mu$s |
| OCP Recover Delay | $t_{OCP\_RD}$ | | -- | 64 | -- | ms |
| OTP Threshold to Turn-Off Only for VBUS_OUT | $T_{OTP\_FET}$ | Rising        (Note5) | -- | 140 | -- | °C |
| OTP Threshold Hysteresis Only for VBUS_OUT | $T_{OTP\_FET\_HYS}$ | | -- | 20 | -- | °C |
| OTP Recover Delay | $t_{OTD\_FET}$ | | -- | 8 | -- | ms |
| Soft-Start Time | $t_{SS}$ | | -- | 8 | -- | ms |
| FET On-Resistance | $R_{ONFET}$ | $I_{BUS\_OUT}$ = 1000mA, 4.3V < $V_{BUS}$ < 6.5V | -- | 100 | 200 | m$\Omega$ |

**Note 1.** Stresses beyond those listed "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.** $\theta_{JA}$ is measured under natural convection (still air) at $T_A$ = 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.

**RT8973A**

## Typical Application Circuit

# RT8973A
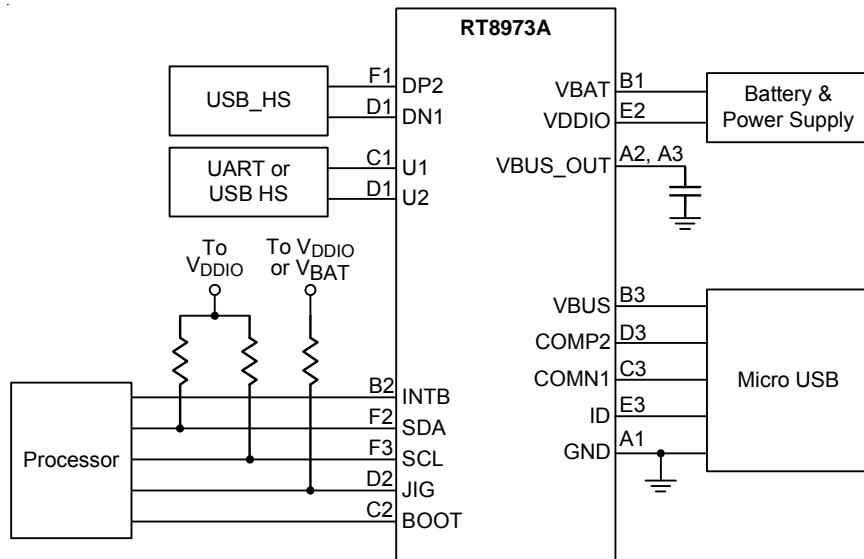
## Typical Operating Characteristics

**Current Limit vs. Input Voltage**

V_BAT = 3.8V
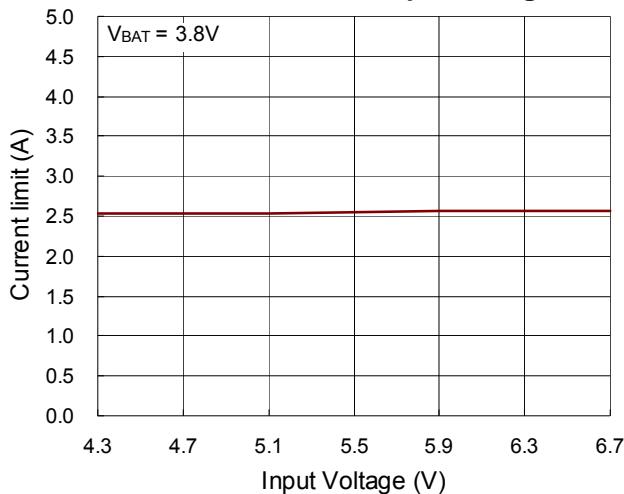
**Battery Supply Current vs. Input Voltage**

V_BUS = 0V
ID = OPEN
ADC_EN = 1
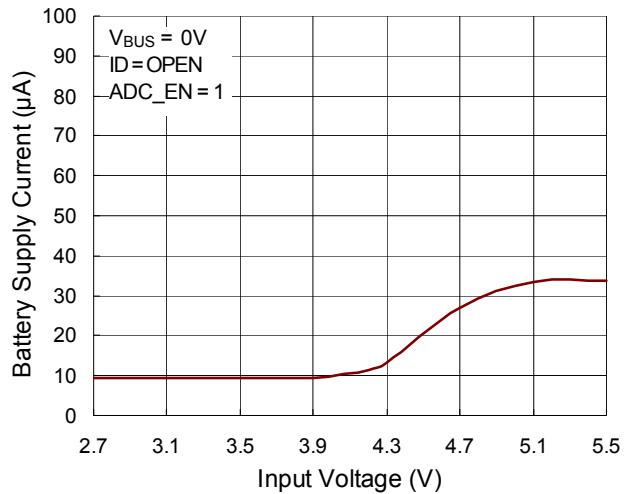
**Battery Leakage Current vs. Input Voltage**

V_BUS = 0V
ID = OPEN
ADC_EN = 0
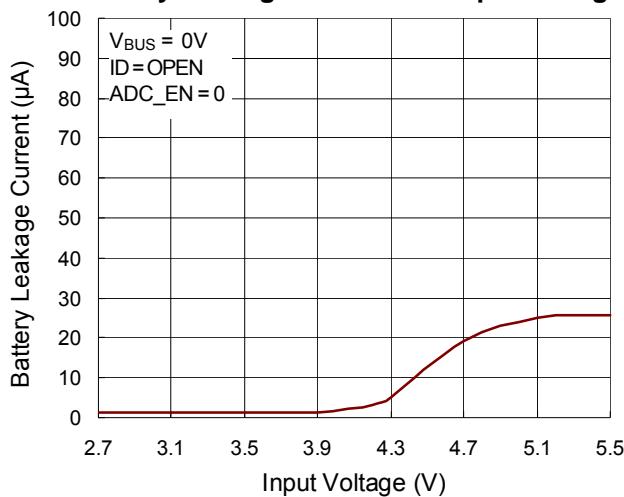
**BUS Supply Current vs. Input Voltage**

V_BAT = 3.8V
ID = OPEN
ADC_EN = 1
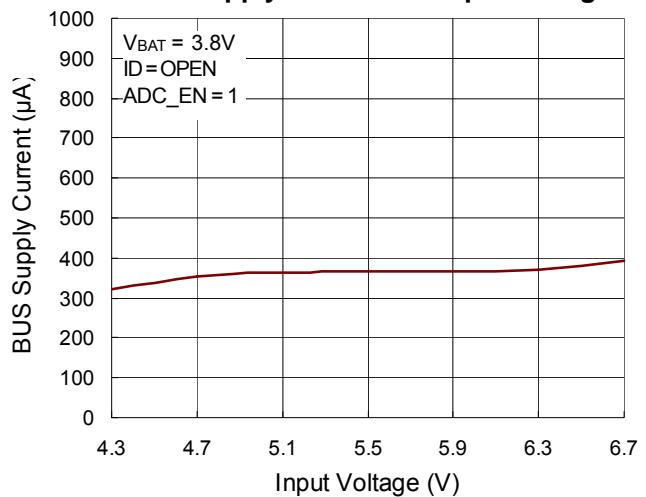
## Application Information

### Device Identification

The RT8973A supports multiple accessories by detecting unique characteristics including VBUS voltage, ID resistance and USB data line status. These characteristics are shown in Tables 1 to 3.

**Table 1. ID Accessory Detection**

| ADC Code | | | | | $V_{BUS}$ (V) | Equivalent $R_{ID}$ | | | Description |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 3 | 2 | 1 | 0 | | Min. | Target | Max. | |
| 0 | 0 | 0 | 0 | 0 | N/A | -- | 0 | -- | OTG |
| 0 | 0 | 0 | 0 | 1 | N/A | 1.9kΩ | 2kΩ | 2.1kΩ | Audio Send_End Button |
| 0 | 0 | 0 | 1 | 0 | N/A | 2.5kΩ | 2.6kΩ | 2.7kΩ | Audio Remote S1 Button |
| 0 | 0 | 0 | 1 | 1 | N/A | 3.1kΩ | 3.2kΩ | 3.3kΩ | Audio Remote S2 Button |
| 0 | 0 | 1 | 0 | 0 | N/A | 3.9kΩ | 4.01kΩ | 4.1kΩ | Audio Remote S3 Button |
| 0 | 0 | 1 | 0 | 1 | N/A | 4.7kΩ | 4.82kΩ | 5.0kΩ | Audio Remote S4 Button |
| 0 | 0 | 1 | 1 | 0 | N/A | 5.8kΩ | 6.03kΩ | 6.2kΩ | Audio Remote S5 Button |
| 0 | 0 | 1 | 1 | 1 | N/A | 7.8kΩ | 8.03kΩ | 8.3kΩ | Audio Remote S6 Button |
| 0 | 1 | 0 | 0 | 0 | N/A | 9.7kΩ | 10kΩ | 10.3kΩ | Audio Remote S7 Button |
| 0 | 1 | 0 | 0 | 1 | N/A | 11.7kΩ | 12kΩ | 12.4kΩ | Audio Remote S8 Button |
| 0 | 1 | 0 | 1 | 0 | N/A | 14.0kΩ | 14.5kΩ | 14.9kΩ | Audio Remote S9 Button |
| 0 | 1 | 0 | 1 | 1 | N/A | 16.7kΩ | 17.2kΩ | 17.7kΩ | Audio Remote S10 Button |
| 0 | 1 | 1 | 0 | 0 | N/A | 19.9kΩ | 20.5kΩ | 21.1kΩ | Audio Remote S11 Button |
| 0 | 1 | 1 | 0 | 1 | N/A | 23.3kΩ | 24.1kΩ | 24.8kΩ | Audio Remote S12 Button |
| 0 | 1 | 1 | 1 | 0 | N/A | 27.8kΩ | 28.7kΩ | 29.6kΩ | Reserved Accessory #1 |
| 0 | 1 | 1 | 1 | 1 | N/A | 33.0kΩ | 34kΩ | 35.0kΩ | Reserved Accessory #2 |
| 1 | 0 | 0 | 0 | 0 | N/A | 39.0kΩ | 40.2kΩ | 41.4kΩ | Reserved Accessory #3 |
| 1 | 0 | 0 | 0 | 1 | N/A | 48.4kΩ | 49.9kΩ | 51.4kΩ | Reserved Accessory #4 |
| 1 | 0 | 0 | 1 | 0 | N/A | 63.0kΩ | 64.9kΩ | 66.8kΩ | Reserved Accessory #5 |
| 1 | 0 | 0 | 1 | 1 | N/A | 77.6kΩ | 80kΩ | 82.4kΩ | Audio Device Type 2 |
| 1 | 0 | 1 | 0 | 0 | N/A | 98.9kΩ | 102kΩ | 105.1kΩ | Phone Powered Device |
| 1 | 0 | 1 | 0 | 1 | N/A | 117.4kΩ | 121kΩ | 124.6kΩ | Unknown Accessory |
| 1 | 0 | 1 | 1 | 0 | N/A | 145.5kΩ | 150kΩ | 154.5kΩ | Unknown Accessory |
| 1 | 0 | 1 | 1 | 1 | 5 | 176.4kΩ | 200kΩ | 206kΩ | Travel Adapter (TA) or Car Kit Type 1 Charger |
| 1 | 1 | 0 | 0 | 0 | 5 | 247.3kΩ | 255kΩ | 262.7kΩ | Factory Mode Boot OFF-USB |
| 1 | 1 | 0 | 0 | 1 | 5 | 291.9kΩ | 301kΩ | 310.1kΩ | Factory Mode Boot ON-USB |
| 1 | 1 | 0 | 1 | 0 | N/A | 354kΩ | 365kΩ | 375.9kΩ | Unknown Accessory |
| 1 | 1 | 0 | 1 | 1 | N/A | 428.7kΩ | 442kΩ | 455.3kΩ | Unknown Accessory |
| 1 | 1 | 1 | 0 | 0 | Open | 507.3kΩ | 523kΩ | 538.7kΩ | Factory Mode Boot OFF-UART |
| 1 | 1 | 1 | 0 | 1 | Open | 600.4kΩ | 619kΩ | 637.6kΩ | Factory Mode Boot ON-UART |
| 1 | 1 | 1 | 1 | 0 | N/A | 750kΩ | 1000kΩ | 1030kΩ | Unknown Accessory |
| 1 | 1 | 1 | 1 | 1 | 5 | 3MΩ | Open | Open | USB Accessory |
| Not any code above | | | | | | 3MΩ | None of the above ranges | | Unknown Accessory |

Table 2. ID Factory Cable Detection

| Configuration Type | | COMP2 | COMN1 | ID | | | BOOT | JIG |
|---|---|---|---|---|---|---|---|---|
| Factory Mode Jig : UART | Boot_On | U2 | U1 | 600kΩ | 619kΩ | 637kΩ | HIGH | LOW |
| | Boot_Off | U2 | U1 | 507kΩ | 523kΩ | 538kΩ | LOW | LOW |
| Factory Mode Jig : USB | Boot_On | DP2 | DN1 | 292kΩ | 301kΩ | 310kΩ | HIGH | LOW |
| | Boot_Off | DP2 | DN1 | 247kΩ | 255kΩ | 262kΩ | LOW | LOW |

Note : The max allowable leakage current on ID must be less than 0.05μA.

Table 3. ID and VBUS Detection Table for USB Devices

| $V_{BUS\_IN}$ | D+ | D− | ID resistance to GND | | | Accessory Detected |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| 5V | Not Checked | Not Checked | 174.6kΩ | 200kΩ | 206kΩ | TA (travel adapter) Charger (180kΩ) and Car Kit Charger Type 1 only (200kΩ) |
| 5V | Shorted to D− | Shorted to D+ | 3MΩ | Open | Open | USB Dedicated Charging Port, Travel Adapter or Dedicated Charger (DCP) |
| 5V | DP | DN | 3MΩ | Open | Open | USB Charging Downstream Port (CDP) |
| 5V | DP | DN | 3MΩ | Open | Open | USB Standard Downstream Port (SDP) |

## Table 4. I²C Register Information

**Address : 0010100x**

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---|---|---|---|---|---|---|---|---|---|
| 0x01 | Device ID | | Revision Number | | | | Vendor ID | | |
| | Reset Value | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | Read/Write | R | R | R | R | R | R | R | R |
| 0x02 | Control1 | ADC_EN | USBCHDEN | CHGTYP | Switch Open | I²CRST_EN | Auto Config | Reserved | INT Mask |
| | Reset Value | 1 | 1 | 1 | 0 | 0 | 1 | N/A | 1 |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| 0x03 | Interrupt | OTP | ADC_CHG | Connect | OVP | DCD_T | CHGDET | Detach | Attach |
| | Reset Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Read/Write | R | R/C | R | R | R/C | R/C | R/C | R/C |
| 0x04 | Interrupt2 | OVP_OCP | OCP | OCP_LATCH | OVP_FET | OTP_FET | POR | UVLO | Reserved |
| | Reset Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Read/Write | R/C | R/C | R | R/C | R/C | R | R | R |
| 0x05 | Interrupt Mask | OTP | ADC_CHG | Connect | OVP | DCD_T | CHGDET | Detach | Attach |
| | Reset Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| 0x06 | Interrupt Mask2 | OVP_OCP | OCP | OCP_LATCH | OVP_FET | OTP_FET | POR | UVLO | Reserved |
| | Reset Value | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| 0x07 | ADC | Reserved | Reserved | Reserved | ADC Values | | | | |
| | Reset Value | N/A | N/A | N/A | 1 | 1 | 1 | 1 | 1 |
| | Read/Write | R | R | R | R | R | R | R | R |
| 0x0A | Device 1 | Reserved | DCPORT | CDPORT | Car Kit Type1 | UART | SDPORT | Reserved | OTG |
| | Reset Value | N/A | 0 | 0 | 0 | 0 | 0 | N/A | 0 |
| | Read/Write | R | R | R | R | R | R | R | R |
| 0x0B | Device 2 | Unknown Accessory | Reserved | Reserved | Reserved | JIG UART OFF | JIG UART ON | JIG USB OFF | JIG USB ON |
| | Reset Value | 0 | N/A | N/A | N/A | 0 | 0 | 0 | 0 |
| | Read/Write | R | R | R | R | R | R | R | R |

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------|------|------|------|------|------|------|------|------|------|
| 0x13 | MANUAL SW1 | D− Switching | | | D+ Switching | | | Reserved | Reserved |
| | Reset Value | 0 | 0 | 0 | 0 | 0 | 0 | N/A | N/A |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| 0x14 | MANUAL SW2 | Reserved | Reserved | Reserved | Reserved | BOOT SW | JIG ON | Reserved | FET_ON |
| | Reset Value | N/A | N/A | N/A | N/A | 0 | 0 | N/A | 1 |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| 0x1B | RESET | Reserved | Reserved | Reserved | Reserved | Reserved | Reserved | Reserved | RESET |
| | Reset Value | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0 |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

**Table 5. Device ID 0x00 - Read Only**

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------|------|------|------|------|------|------|------|------|------|
| 0x01 | Device ID | | | Revision Number | | | | Vendor ID | |
| | Reset Value | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | Read/Write | R | R | R | R | R | R | R | R |
| Revision Number | | Rev. 1 = 00001 | | | | | | | |
| Vendor ID | | Richtek = 010 | | | | | | | |

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------|------|------|------|------|------|------|------|------|------|
| 0x02 | Control1 | ADC_EN | USBCHDEN | CHGTYP | Switch Open | I$^2$CRST _EN | Auto Config | Reserved | INT Mask |
| | Reset Value | 1 | 1 | 1 | 0 | 0 | 1 | N/A | 1 |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

| Name | Description | | |
|------|-------------|---|---|
| ADC_EN | 0 : Disable ID pin detection function | | |
| | 1 : Enable ID pin detection function | | |
| USBCHDEN | 0 : Disable USB charger detection function | | |
| | 1 : Enable USB charger detection function | | |
| CHGTYP | 0 : Disable 2$^{nd}$ detection of USB charger function | | |
| | 1 : Enable 2$^{nd}$ detection of USB charger function | | |
| Switch Open | 0 : Automatic switching by accessory status | | |
| | 1 : Open all switches | | |
| I$^2$CRST_EN | 0 : Disable I$^2$C pull low reset (default) | | |
| | 1 : Enable I$^2$C pull low reset (SCL & SDA = 0 > 30ms typical) | | |
| Auto Config | 0 : Manual switching | | |
| | 1 : Auto-configuration | | |
| INT_mask | 0 : Unmask interrupt – interrupt baseband processor on change of state in Interrupt register | | |
| | 1 : Mask interrupt – do not interrupt baseband processor | | |

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------|------|------|------|------|------|------|------|------|------|
| 0x03 | Interrupt | OTP | ADC_CHG | Connect | OVP | DCT_T | CHGDET | Detach | Attach |
| | Reset Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Read/Write | R | R/C | R | R | R/C | R/C | R/C | R/C |

| | |
|---|---|
| OTP | Monitor over temperature<br>0 : T < 125°C<br>1 : T > 135°C<br>Any change in this bit triggers an interrupt. |
| ADC_CHG | 0 : ADC values is not changed<br>1 : ADC values is changed<br>The bit will interrupt only when ADC_CHG goes from 0 to 1, and clear after Baseband reads. |
| Connect | 0 : Switch is not connected<br>1 : Switch is connected<br>Any Change in this bit triggers an interrupt. |
| OVP | This OVP with 128μ deglitch time<br>0 : VBUS over voltage is not detected<br>1 : VBUS over voltage is detected<br>Any Change in this bit triggers an interrupt. |
| DCD_T | 0 : Data Contact Detection timeout is not detected<br>1 : Data Contact Detection timeout is detected<br>The bit will interrupt only when DCD_T goes from 0 to 1. |
| CHGDET | Output of USB charger detection. The bit will be set to "1" if COMN > VDAT_REF & COMN < VLGC<br>0 : COMN < VDAT_REF or COMN > VLGC (charger port is not detected)<br>1 : COMN > VDAT_REF & COMN < VLGC (charger port is detected)<br>The bit will interrupt only when CHGDET goes from 0 to 1. |
| Detach | 0 : Accessory not detached<br>1 : Accessory detached<br>The bit will interrupt only when Detach goes from 0 to 1, and clear to 0 after Baseband reads. |
| Attach | 0 : Accessory not attached<br>1 : Accessory attached<br>The bit will interrupt only when Attach goes from 0 to 1, and clear to 0 after Baseband reads. |

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------|------|------|------|------|------|------|------|------|------|
| 0x04 | Interrupt2 | OVP_OCP | OCP | OCP_LATCH | OVP_FET | OTP_FET | POR | UVLO | Reserved |
| | Reset Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Read/Write | R/C | R/C | R | R/C | R/C | R | R | R |

| | |
|---|---|
| OVP_OCP | 0 : VBUS OCP AND VBUS OVP not detected<br>1 : VBUS OCP OR VBUS OVP detected<br>The bit will interrupt only when OVP_OCP goes from 0 to 1, and this bit will be clear to 0 after baseband reads. |
| OCP | 0 : VBUS OCP is not detected<br>1 : VBUS OCP is detected<br>The bit will interrupt only when OCP_EN goes from 0 to 1, and this bit will be clear to 0 after baseband reads. |

| | |
|---|---|
| OCP_LATCH | 0 : VBUS OCP does not occur for consecutive 16 times.<br>1 : VBUS OCP occurs for consecutive 16 times. FET will be turn off unless the VBUS power re-toggle or 0x14 FET_ON set 1 to 0 to 1.<br>Any change in this bit triggers an interrupt |
| OVP_FET | This OVP without deglitch time<br>0 : VBUS over voltage is not detected<br>1 : VBUS over voltage is detected<br>The bit will interrupt only when OVP_FET goes from 0 to 1, and this bit will be clear to 0 after baseband reads. |
| OTP_FET | This over-temperature of MOSFET<br>0 : T <120°C<br>1 : T >150°C<br>The bit will interrupt only when OTP_FET goes from 0 to 1, and this bit will be clear to 0 after baseband reads. |
| POR | 0 : VBUS > 2.7V with 300ms deglitch time<br>1 : VBUS < 2.6V<br>Any change in this bit triggers an interrupt. |
| UVLO | 0 : VBUS voltage is higher than VUVP voltage<br>1 : VBUS voltage is lower than VUVP voltage<br>Any change in this bit triggers an interrupt. |

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---|---|---|---|---|---|---|---|---|---|
| 0x05 | Interrupt Mask | OTP | ADC_CHG | Connect | OVP | DCD_T | CHGDET | Detach | Attach |
| | Reset Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

| | |
|---|---|
| OTP | 0 : Unmask OTP interrupt<br>1 : Mask OTP interrupt |
| ADC_CHG | 0 : Unmask ADC_CHG interrupt<br>1 : Mask ADC_CHG interrupt |
| Connect | 0 : Unmask connect interrupt<br>1 : Mask connect interrupt |
| OVP | 0 : Unmask OVP interrupt<br>1 : Mask OVP interrupt |
| DCD_T | 0 : Unmask DCD_T interrupt<br>1 : Mask DCD_T interrupt |
| CHGDET | 0 : Unmask CHGDET interrupt<br>1 : Mask CHGDET interrupt |
| Detach | 0 : Unmask detach interrupt<br>1 : Mask detach interrupt |
| Attach | 0 : Unmask attach interrupt<br>1 : Mask attach interrupt |

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| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------|------|------|------|------|------|------|------|------|------|
| 0x06 | Interrupt Mask2 | OVP _OCP | OCP | OCP _LATCH | OV _FET | OTP _FET | POR | UVLO | Reserved |
| | Reset Value | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

| OVP_OCP | 0 : Unmask OVP_OCP interrupt<br>1 : Mask OVP_OCP interrupt |
|---------|---|
| OCP | 0 : Unmask OCP interrupt<br>1 : Mask OCP interrupt |
| OCP_LATCH | 0 : Unmask OCP_LATCH interrupt<br>1 : Mask OCP_LATCH interrupt |
| OVP_FET | 0 : Unmask OVP_FET interrupt<br>1 : Mask OVP_FET interrupt |
| OTP_FET | 0 : Unmask OTP_LATCH interrupt<br>1 : Mask OTP_LATCH interrupt |
| POR | 0 : Unmask POR interrupt<br>1 : Mask POR interrupt |
| UVLO | 0 : Unmask UVLO interrupt<br>1 : Mask UVLO interrupt |

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------|------|------|------|------|------|------|------|------|------|
| 0x07 | ADC | Reserved | Reserved | Reserved | ADC Values | | | | |
| | Reset Value | N/A | N/A | N/A | 1 | 1 | 1 | 1 | 1 |
| | Read/Write | R | R | R | R | R | R | R | R |

| ADC | ADC Values from ID Pin Detection |
|-----|---|

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------|------|------|------|------|------|------|------|------|------|
| 0x0A | Device 1 | Reserved | DCPORT | CDPORT | Car Kit Type1 | UART | SDPORT | Reserved | OTG |
| | Reset Value | N/A | 0 | 0 | 0 | 0 | 0 | N/A | 0 |
| | Read/Write | R | R | R | R | R | R | R | R |

| DCPORT | 0 : USB Dedicated Charging Port (DCP) charger not detected<br>1 : USB Dedicated Charging Port (DCP) charger detected |
|--------|---|
| CDPORT | 0 : USB Charging Downstream Port (CDP) charger not detected<br>1 : USB Charging Downstream Port (CDP) charger detected |
| Car Kit Type 1 | 0 : Car Kit Type 1 & TA not detected<br>1 : Car Kit Type 1 & TA detected |
| UART | 0 : UART cable not detected<br>1 : UART cable detected |
| Standard USB (SDPORT) | 0 : USB Standard Downstream Port (SDP) charger not detected<br>1 : USB Standard Downstream Port (SDP) charger detected |
| OTG | 0 : OTG cable not detected<br>1 : OTG cable detected |

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---|---|---|---|---|---|---|---|---|---|
| 0x0B | Device 2 | Unknown Accessory | Reserved | Reserved | Reserved | JIG UART OFF | JIG UART ON | JIG USB OFF | JIG USB ON |
| | Reset Value | 0 | N/A | N/A | N/A | 0 | 0 | 0 | 0 |
| | Read/Write | R | R | R | R | R | R | R | R |

| Name | Description |
|---|---|
| Unknown Accessory | 0 : Unknown accessory not detected<br>1 : Any accessory detected as unknown or an accessory that cannot be detected as being valid |
| JIG UART OFF | 0 : Factory mode BOOT_OFF_UART not detected<br>1 : Factory mode BOOT_OFF_UART detected |
| JIG UART ON | 0 : Factory mode cable UART path with BOOT_ON not detected<br>1 : Factory mode cable UART path with BOOT_ON detected |
| JIG USB OFF | 0 : Factory mode cable USB path with BOOT_OFF not detected<br>1 : Factory mode cable USB path with BOOT_OFF detected |
| JIG USB ON | 0 : Factory mode cable USB path with BOOT_ON not detected<br>1 : Factory mode cable USB path with BOOT_ON detected |

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---|---|---|---|---|---|---|---|---|---|
| 0x13 | MANUAL SW1 | D− Switching | | | D+ Switching | | | Reserved | Reserved |
| | Reset Value | 0 | 0 | 0 | 0 | 0 | 0 | N/A | N/A |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

| Name | Description |
|---|---|
| D− Switching | 000 : Switch Open<br>001 : COMN1 connected to DN1 of USB port<br>011 : COMN1 connected to U1 or UART port<br>All others values : do not use |
| DP Switching | 000 : Switch Open<br>001 : COMP2 connected to DP2 of USB port<br>011 : COMP2 connected to U2 or UART port<br>All others values : do not use |

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---|---|---|---|---|---|---|---|---|---|
| 0x14 | MANUAL SW2 | Reserved | Reserved | Reserved | Reserved | BOOT SW | JIG ON | Reserved | FET_ON |
| | Reset Value | N/A | N/A | N/A | N/A | 0 | 0 | N/A | 1 |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

| Name | Description |
|---|---|
| BOOT SW | 0 : Low<br>1 : High |
| JIG ON | 0 : JIG output = high impedance<br>1 : JIG output = GND |
| FET_ON | FET between VBUS and VBUS_OUT<br>0 : FET is turned off. OVP and OCP function disable<br>1 : FET is active, and FET is depended on OVP and OCP function. |

| Address | Name | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------|------|------|------|------|------|------|------|------|------|
| 0x1B | RESET | Reserved | Reserved | Reserved | Reserved | Reserved | Reserved | Reserved | RESET |
| | Reset Value | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0 |
| | Read/Write | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| RESET | | 0 : Do not reset the RT8973A<br>1 : Reset the RT8973A | | | | | | | | |

## Power Up

The RT8973A 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 RT8973A is off. When the input voltage is over the POR threshold, the RT8973A will delay for 300ms and the soft-start will be activated after the 300ms delay. The 300ms 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 RT8973A slowly turns on the internal MOSFET to reduce the inrush current.

## Enable Control

When 0x14 FET_ON is set at 1 (default = 1), over voltage and over current protection function will be turned on. When 0x14 FET_ON is set at 0, the internal MOSFET will be turned off.

## Over-Temperature Protection (OTP)

The RT8973A monitors its internal temperature to prevent thermal failures. The chip turns off the MOSFET when the junction temperature reaches 135°C. The IC will resume after the junction temperature is cooled down 10°C.

## Input Over-Voltage Protection

The RT8973A monitors input voltage to prevent the input over-voltage lead to output system failures. The RT8973A input OVP threshold is set by the internal resistor. When the input voltage exceeds the threshold, the RT8973A outputs a logic signal to turn off the internal MOSFET within 2µs to prevent the high input voltage from damaging the electronics in the handheld system. The hysteresis of the input OVP threshold is 60mV. When the input voltage returns to normal operation voltage range, the RT8973A will re-enable the MOSFET.

## Over-Current Protection (OCP)

The RT8973A monitors the output current to prevent the output short or the charging of the battery with an excessive current. The RT8973A has a built-in 180µs delay time to prevent any transient noise triggering the OCP. If the OCP situation keeps for 180µs, the internal MOSFET will be turned off and the 0x04 OCP_LATCH will change from 0

to 1. When the OCP happens for consecutive 16 times, the internal MOSFET will be turned off permanently unless the input power is recycled or the 0x14 FET_ON is changed from 0 to 1.

## 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-18B 1.27x2.47 (BSC) package, the thermal resistance, $\theta_{JA}$, is 45.4°C/W on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. The maximum power dissipation at $T_A$ = 25°C can be calculated as below :

$P_{D(MAX)} = (125°C – 25°C) / (45.4°C/W) = 2.2W$ for a WL-CSP-18B 1.27x2.47 (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 1 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.
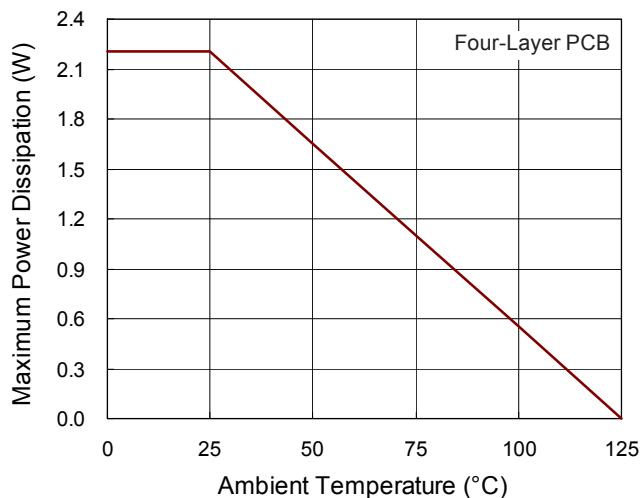
Figure 1. Derating Curve of Maximum Power Dissipation

## Outline Dimension
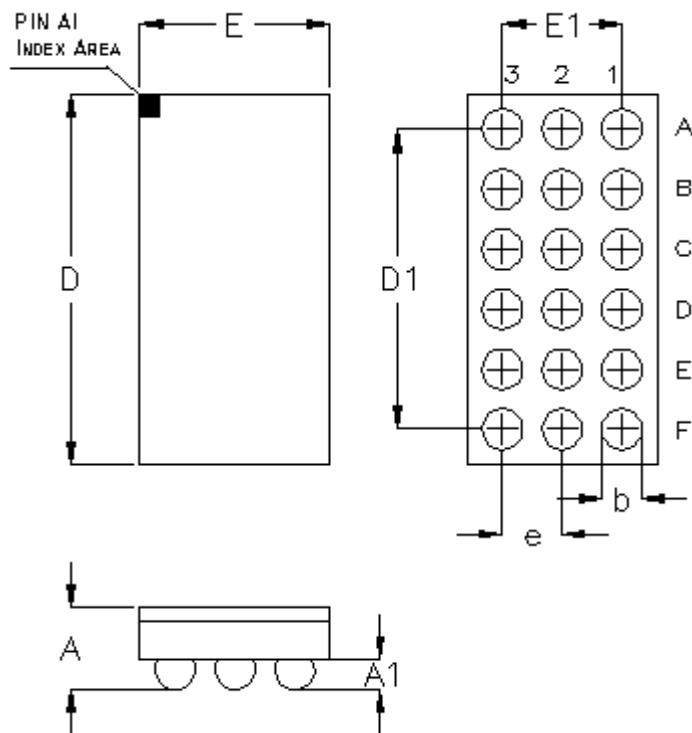


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|--------|------|------|------|------|
| | **Min** | **Max** | **Min** | **Max.** |
| A | 0.500 | 0.600 | 0.020 | 0.024 |
| A1 | 0.170 | 0.230 | 0.007 | 0.009 |
| b | 0.240 | 0.300 | 0.009 | 0.012 |
| D | 2.420 | 2.520 | 0.095 | 0.099 |
| D1 | 2.000 | | 0.079 | |
| E | 1.220 | 1.320 | 0.048 | 0.052 |
| E1 | 0.800 | | 0.031 | |
| e | 0.400 | | 0.016 | |

**18B WL-CSP 1.27x2.47 Package (BSC)**

## Footprint Information
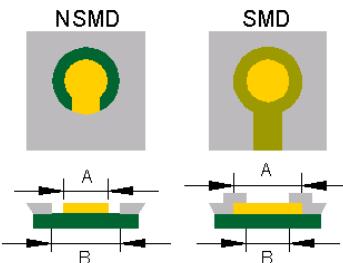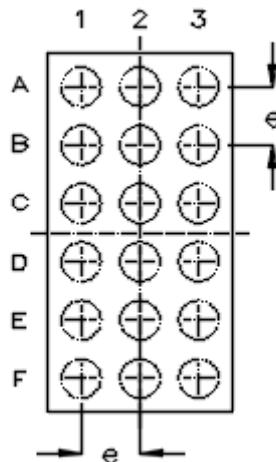


| Package | Number of Pin | Type | Footprint Dimension (mm) | | | Tolerance |
|---|---|---|---|---|---|---|
| | | | e | A | B | |
| WL-CSP1.27*2.47-18(BSC) | 18 | NSMD | 0.400 | 0.240 | 0.340 | ±0.025 |
| | | SMD | | 0.270 | 0.240 | |

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