# SINGLE CHIP BATTERY PROTECTION SOLUTION FOR 1-CELL Li+ BATTERY PACK

## Description

The DIODES™ AP9221 is a single-chip protection solution specially designed for 1-cell Li+ rechargeable battery pack applications.

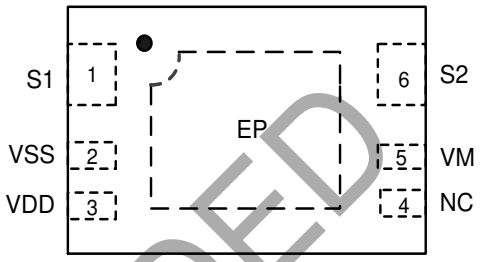
The AP9221 includes a 1-cell Lithium ion battery protection chip and dual N-CH MOSFET with common drain.

The AP9221 provides rich battery protection features and can turn-off the N-CH MOSFET by detecting overcharge voltage/current, overdischarge voltage/current, or load short circuit. The AP9221 has built-in fixed delay time to save external components.

The AP9221 is available in the U-DFN2030-6 (Type C) package.

## Pin Assignments

**(Top View)**




**U-DFN2030-6 (Type C)**

## Features

- High Voltage CMOS Process, Up to 24V (VDD to VM)
- Low Quiescent Current (+25°C)
- In Normal Mode, 3.0μA (Typ.), 4.5μA (Max.) $V_{DD}$ = 3.5V
- In Power-Down Mode, 0.1μA (Max.)
- High-Accuracy Voltage Detection Circuit (+25°C)
- Overcharge Detection Voltage: 3.5V to 4.5V (5mV Steps) Accuracy-15mV, +25mV
- Overcharge Hysteresis Voltage Range: 0.1V to 0.4V (50mV Steps) Accuracy ±50mV
- Overdischarge Detection Voltage: 2.0V to 3.4V (10mV Steps) Accuracy ±35mV
- Overdischarge Hysteresis Voltage Range: 0V to 0.7V (40mV Steps) Accuracy ±65mV
- Discharge Overcurrent Detection Voltage: 0.025V to 0.2V (10mV Steps) Accuracy ±12mV
- Short Current Detection Voltage: 0.12V to 0.45V (50mV Steps) Accuracy ±50mV
- Charge Overcurrent Detection Voltage: -0.2V to -0.025V (10mV Steps) Accuracy ±12mV
- Overcharger Detection Voltage: 8.0V (Fixed) Accuracy ±2V
- Overcharger Release Voltage: 7.3V (Fixed) Accuracy ±2V
- Built-In Fixed Detection Delay Time (+25°C), Accuracy ±20%
- Power-Down Mode Selectable (Yes or No)
- 0V Battery Charge Selectable (Permission or Inhibition)
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen- and Antimony-Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

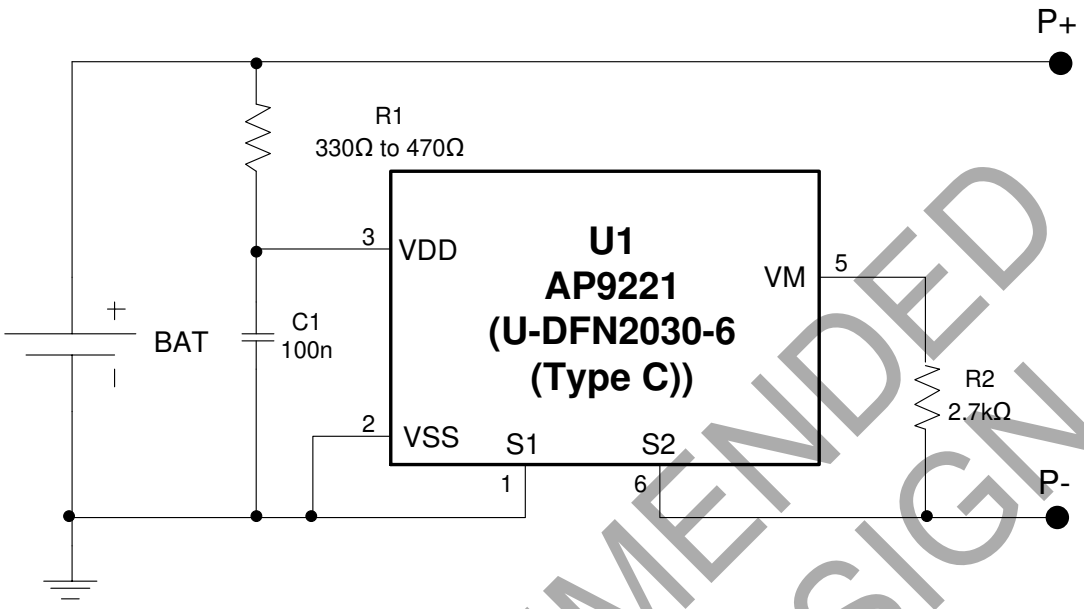
## Applications

- Li+ rechargeable battery packs



Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

## Typical Applications Circuit (Note 4)




Note: 4. R1 and C1 are used to stabilize the supply voltage of the AP9221. The recommended range of the R1 value is 330Ω to 470Ω and C1 value is 10nF to 1000nF, typical value is 100nF. R2 should be connected between P- to VM sense terminal to monitor the status of charger and the charge/discharge current. The R2 should be between 300Ω and 4kΩ, typical value is 2.7kΩ. R1 and R2 are also used as current limit resistors if the battery or charger is connected reversely. Polarity reversing may cause the power consumption of R1 and R2 to go over their power dissipation rating, therefore R1 and R2 values should be selected appropriately for the actual application. If R2 is more than 4kΩ resistor, charge may not be off due to the voltage drop on R2.

For power down mode, when first connecting AP9221 system board to the battery, it is necessary to use charger or to short P- to the battery negative polarity. Once the AP9221 is activated, the charger or connection can be removed, otherwise the battery cannot discharge current through system board.

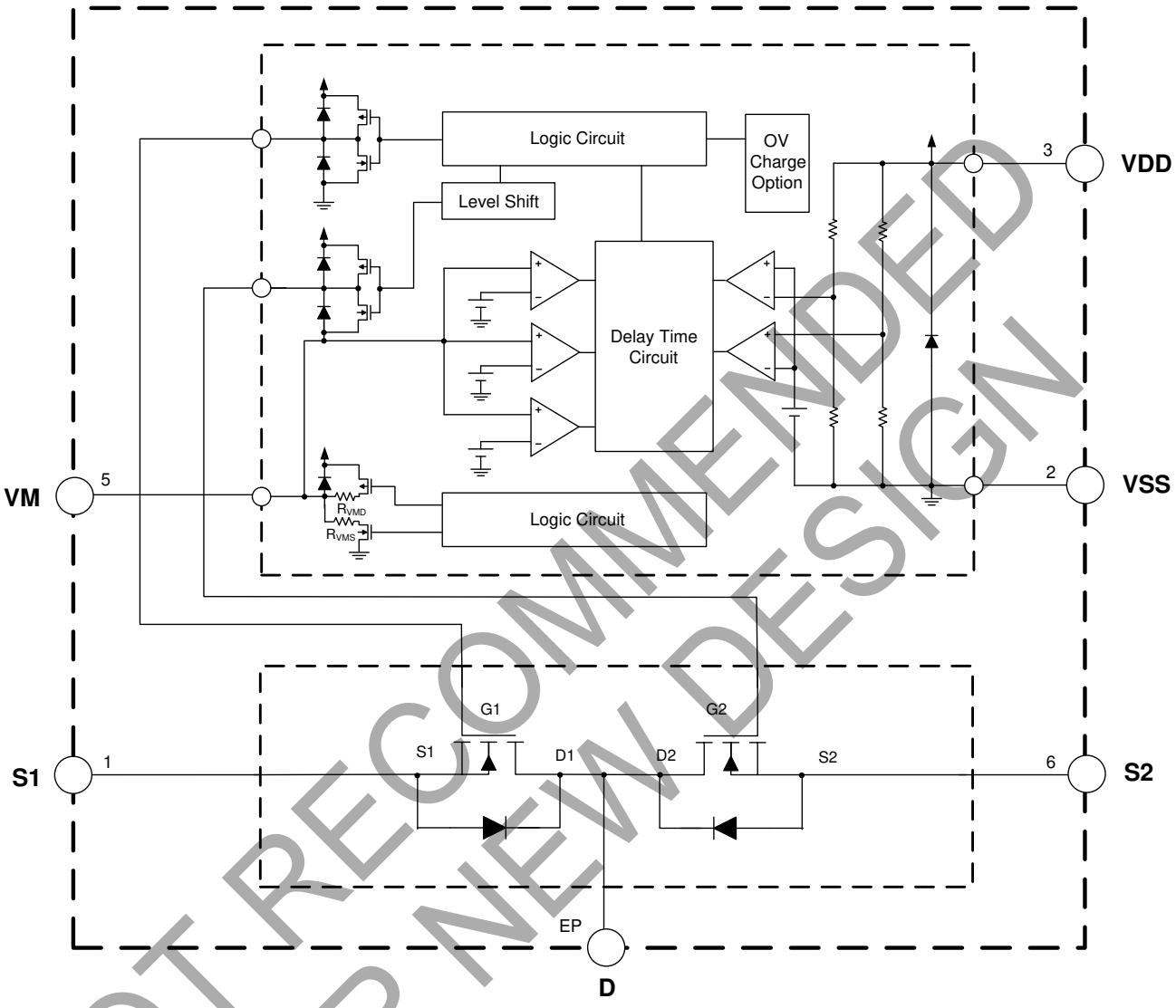
The values selected should follow the recommended typical range mentioned above. It has not been confirmed whether the operation is normal or not in circuits other than the above example of connection. In addition, the example of connection shown above and the typical value do not exactly guarantee proper operation. Please perform the actual application to set the suitable value through your complete evaluation.



## Pin Descriptions

| Pin Number | Pin Name | Function |
|---|---|---|
| 1 | S1 | Source pin of discharging MOSFET, connecting this pin to battery negative pole. |
| 2 | VSS | Negative power supply pin |
| 3 | VDD | Positive power supply pin, connecting this pin to battery positive pole through R1 |
| 4 | NC | Not connected, leave this pin floating |
| 5 | VM | Charger negative input pin, short this pin to S2 pin through R2 |
| 6 | S2 | Source pin of charging MOSFET, connecting this pin to charge negative input. |
| EP | D | Thermal PAD is common drain of charge and discharge MOSFET, so in PCB layout, prefer to use large copper area to cover this pad for better thermal dissipation, then leave it open. |

## Functional Block Diagram



## Absolute Maximum Ratings (Notes 5 & 6)

| Symbol | Parameter | Rating | Unit |
|---|---|---|---|
| $V_{DD}$ | Supply Voltage (Between VDD and VSS) | -0.3 to 12 | V |
| $V_{DM}$ | Charge Input Voltage (Between VDD and VM for Protection Chip) | -0.3 to 24 | V |
| $V_{DSS}$ | MOSFET Drain-to-Source Voltage | 20 | V |
| $V_{GSS}$ | MOSFET Gate-to-Source Voltage | ±12 | V |
| $I_D$ | Continuous Drain Current, $V_{GS}$ = 4.5V, $T_A$ = +25°C | 2.8 | A |
| | Continuous Drain Current, $V_{GS}$ = 4.5V, $T_A$ = +70°C | 2.2 | A |
| $P_D$ | Power Dissipation | 1,000 | mW |
| $T_J$ | Maximum Junction Temperature | +150 | °C |
| $T_{STG}$ | Storage Temperature Range | -65 to +150 | °C |
| — | ESD (Charged-Device Model) | 1,000 | V |
| — | ESD (Human Body Model) | 2,000 | V |

Notes: 5. Stresses beyond those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods can affect device reliability.

6. Ratings apply to ambient temperature at +25°C. The JEDEC High-K board design used to derive this data was a 2 inch × 2 inch multilayer board with 2 ounce internal power and ground planes and 2-ounce copper traces on the top and bottom of the board.

## Recommended Operating Conditions

| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| $V_{DD}$ | Supply Voltage (Between VDD and VSS) | 1.5 | 5.5 | V |
| $V_{DM}$ | Charge Input Voltage (Between VDD and VM) | -0.3 | 5.5 | V |
| $T_A$ | Operating Ambient Temperature | -40 | +85 | °C |

## Electrical Characteristics ($T_A$ = +25°C, $V_{DD}$ = 3.5V, $V_{SS}$ = 0V, R1 = 220Ω, R2 = 1.0kΩ, C1 = 100nF, unless otherwise specified.)

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{CU}$ | Overcharge Detection Voltage | $V_M$ = 0V | $V_{CU}$ - 0.015 | $V_{CU}$ | $V_{CU}$ + 0.025 | V |
| $V_{CL}$ | Overcharge Release Voltage | $V_{CL} \neq V_{CU}$ | $V_{CL}$ - 0.050 | $V_{CL}$ | $V_{CL}$ + 0.050 | V |
| | | $V_{CL} = V_{CU}$ | $V_{CL}$ - 0.015 | $V_{CL}$ | $V_{CL}$ + 0.025 | V |
| $V_{DL}$ | Overdischarge Detection Voltage | $V_M$ = 0V | $V_{DL}$ - 0.035 | $V_{DL}$ | $V_{DL}$ + 0.035 | V |
| $V_{DU}$ | Overdischarge Release Voltage | $V_{DU} \neq V_{DL}$ | $V_{DU}$ - 0.065 | $V_{DU}$ | $V_{DU}$ + 0.065 | V |
| | | $V_{DU} = V_{DL}$ | $V_{DU}$ - 0.035 | $V_{DU}$ | $V_{DU}$ + 0.035 | V |
| $V_{DOC}$ | Discharge Overcurrent Detection Voltage | $V_{DD}$ = 3.5V | $V_{DOC}$ -0.012 | $V_{DOC}$ | $V_{DOC}$ +0.012 | V |
| $V_{SHORT}$ | Load Short-Circuiting Detection Voltage | $V_{DD}$ = 3.5V | $V_{SHORT}$ -0.050 | $V_{SHORT}$ | $V_{SHORT}$ +0.050 | V |
| $V_{COC}$ | Charge Overcurrent Detection Voltage | $V_{DD}$ = 3.5V | $V_{COC}$ -0.012 | $V_{COC}$ | $V_{COC}$ +0.012 | V |
| **$I_{CC}$ (Power Down Function)** | | | | | | |
| $I_{CC}$ | Current Consumption During Operation | $V_{DD}$ = 3.5V, $V_M$ = 0V | — | 3.0 | 4.5 | μA |
| $I_{PDN}$ | Current Consumption During Power-Down Mode | $V_{DD}$ = 1.8V, VM Pin Floating | — | — | 0.1 | μA |
| **$I_{CC}$ (Auto-Wake Up Function)** | | | | | | |
| $I_{CC}$ | Current Consumption During Operation | $V_{DD}$ = 3.5V, $V_M$ = 0V | — | 3 | 4.5 | μA |
| $I_{AUTO}$ | Current Consumption During Auto-Wake Mode | $V_{DD}$ = 1.8V, VM Pin Floating | — | 3.5 | 5.5 | μA |
| $R_{VMD}$ | Resistance Between VM Pin and VDD Pin | $V_{DD}$ = 1.8V, $V_M$ = 0V | 150 | 300 | 500 | kΩ |
| $R_{VMS}$ | Resistance Between VM Pin and VSS Pin | $V_{DD}$ = 3.5V, $V_M$ = 1.0V | 10 | 30 | 50 | kΩ |
| $V_{0CHA}$ | 0V Battery Charge Starting Charge Voltage | 0V Battery Charging “Available” | 1.2 | — | — | V |
| $V_{0INH}$ | 0V Battery Charge Inhibition Battery Voltage | 0V Battery Charging “Unavailable” | — | — | 0.45 | V |
| $V_{OVCHG}$ | Overvoltage Charge Detection Voltage | $V_{DD}$ = 3.5V | 6.0 | 8.0 | 10.0 | V |
| $V_{OVCHGR}$ | Overvoltage Charge Release Voltage | $V_{DD}$ = 3.5V | 5.3 | 7.3 | 9.3 | V |
| $t_{CU}$ | Overcharge Detection Delay Time | $V_{DD}$ = 3.6 to 4.5V | 800 | 1000 | 1200 | ms |
| $t_{CUR}$ | Overcharge Release Delay Time | $V_M$ = 0V | 1.6 | 2 | 2.4 | ms |
| $t_{DL}$ | Overdischarge Detection Delay Time | $V_{DD}$ = 3.6V to 2.0V | 92 | 115 | 138 | ms |
| $t_{DLR}$ | Overdischarge Release Delay Time | $V_M$ = 0V | 1.6 | 2 | 2.4 | ms |
| $t_{DOC}$ | Discharge Overcurrent Detection Delay Time | $V_{DD}$ = 3.6V | 8 | 10 | 12 | ms |
| $t_{DOCR}$ | Discharge Overcurrent Release Delay Time | $V_M$ = 0V | 1.6 | 2 | 2.4 | ms |
| $t_{SHORT}$ | Load Short Detection Delay Time | $V_{DD}$ = 3.6V | 288 | 360 | 432 | μs |
| $t_{COC}$ | Charge Overcurrent Detection Delay Time | $V_{DD}$ = 3.6V | 8 | 10 | 12 | ms |
| $t_{COCR}$ | Charge Overcurrent Release Delay Time | $V_M$ = 0V | 1.6 | 2 | 2.4 | ms |

## Electrical Characteristics (continued) ($T_A$ = -40°C to +85°C, $V_{DD}$ = 3.5V, $V_{SS}$ = 0V, R1 = 220Ω, R2 = 1.0kΩ, C1 = 100nF, unless otherwise specified.)

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{CU}$ | Overcharge Detection Voltage | $V_M$ = 0V | $V_{CU}$ - 0.050 | $V_{CU}$ | $V_{CU}$ + 0.040 | V |
| $V_{CL}$ | Overcharge Release Voltage | $V_{CL} \neq V_{CU}$ | $V_{CL}$ - 0.070 | $V_{CL}$ | $V_{CL}$ + 0.060 | V |
| | | $V_{CL} = V_{CU}$ | $V_{CL}$ - 0.050 | $V_{CL}$ | $V_{CL}$ + 0.040 | V |
| $V_{DL}$ | Overdischarge Detection Voltage | $V_M$ = 0V | $V_{DL}$ - 0.080 | $V_{DL}$ | $V_{DL}$ + 0.080 | V |
| $V_{DU}$ | Overdischarge Release Voltage | $V_{DU} \neq V_{DL}$ | $V_{DU}$ - 0.150 | $V_{DU}$ | $V_{DU}$ + 0.190 | V |
| | | $V_{DU} = V_{DL}$ | $V_{DU}$ - 0.080 | $V_{DU}$ | $V_{DU}$ + 0.080 | V |
| $V_{DOC}$ | Discharge Overcurrent Detection Voltage | $V_{DD}$ = 3.5V | $V_{DOC}$ -0.030 | $V_{DOC}$ | $V_{DOC}$ +0.030 | V |
| $V_{SHORT}$ | Load Short-Circuiting Detection Voltage | $V_{DD}$ = 3.5V | $V_{SHORT}$ -0.10 | $V_{SHORT}$ | $V_{SHORT}$ +0.10 | V |
| $V_{COC}$ | Charge Overcurrent Detection Voltage | $V_{DD}$ = 3.5V | $V_{COC}$ -0.040 | $V_{COC}$ | $V_{COC}$ +0.040 | V |
| **$I_{CC}$ (Power-Down Function)** | | | | | | |
| $I_{CC}$ | Current Consumption During Operation | $V_{DD}$ = 3.5V, $V_M$ = 0V | — | 3.0 | 7.0 | μA |
| $I_{PDN}$ | Current Consumption During Power-Down Mode | $V_{DD}$ = 1.8V, VM Pin Floating | — | — | 1.0 | μA |
| $I_{CC}$ (Auto-Wake Up Function) | | | | | | |
| $I_{CC}$ | Current Consumption During Operation | $V_{DD}$ = 3.5V, $V_M$ = 0V | — | 3 | 4.5 | μA |
| $I_{AUTO}$ | Current Consumption During Auto-Wake Mode | $V_{DD}$ = 1.8V, VM Pin Floating | — | 6 | 8 | μA |
| $R_{VMD}$ | Resistance between VM Pin and VDD Pin | $V_{DD}$ = 1.8V, $V_M$ = 0V | 100 | 300 | 650 | kΩ |
| $R_{VMS}$ | Resistance between VM Pin and VSS Pin | $V_{DD}$ = 3.5V, $V_M$ = 1.0V | 5 | 30 | 65 | kΩ |
| $V_{0CHA}$ | 0V Battery Charge Starting Charge Voltage | 0V Battery Charging "Available" | 1.2 | — | — | V |
| $V_{0INH}$ | 0V Battery Charge Inhibition Battery Voltage | 0V Battery Charging "Unavailable" | — | — | 0.3 | V |
| $V_{OVCHG}$ | Overvoltage Charge Detection Voltage | $V_{DD}$ = 3.5V | 5.5 | 8.0 | 10.5 | V |
| $V_{OVCHGR}$ | Overvoltage Charge Release Voltage | $V_{DD}$ = 3.5V | 5.0 | 7.3 | 9.5 | V |
| $t_{CU}$ | Overcharge Detection Delay Time | $V_{DD}$ = 3.6V to 4.5V | 600 | 1000 | 1400 | ms |
| $t_{CUR}$ | Overcharge Release Delay Time | $V_M$ = 0V | 1.2 | 2 | 2.8 | ms |
| $t_{DL}$ | Overdischarge Detection Delay Time | $V_{DD}$ = 3.6V to 2.0V | 69 | 115 | 161 | ms |
| $t_{DLR}$ | Overdischarge Release Delay Time | $V_M$ = 0V | 1.2 | 2 | 2.8 | ms |
| $t_{DOC}$ | Discharge Overcurrent Detection Delay Time | $V_{DD}$ = 3.6V | 6 | 10 | 14 | ms |
| $t_{DOCR}$ | Discharge Overcurrent Release Delay Time | $V_M$ = 0V | 1.2 | 2 | 2.8 | ms |
| $t_{SHORT}$ | Load Short Detection Delay Time | $V_{DD}$ = 3.6V | 216 | 360 | 504 | μs |
| $t_{COC}$ | Charge Overcurrent Detection Delay Time | $V_{DD}$ = 3.6V | 6 | 10 | 14 | ms |
| $t_{COCR}$ | Charge Overcurrent Release Delay Time | $V_M$ = 0V | 1.2 | 2 | 2.8 | ms |

## Electrical Characteristics (continued) (Notes 7 & 8) ($T_A$ = +25°C, $V_{DD}$ = 3.5V, $V_{SS}$ = 0V, R1 = 220Ω, R2 = 1.0kΩ, C1 = 100nF, unless otherwise specified.)

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{DS}$ = 20V, $V_{GS}$ = 0 | — | — | 1.0 | μA |
| $R_{SS(ON)1}$ | Static Source-Source On-Resistance 1 | $V_{DD}$ = 4.5V, $I_D$ = 1A | — | 130 | — | mΩ |
| $R_{SS(ON)2}$ | Static Source-Source On-Resistance 2 | $V_{DD}$ = 3.0V, $I_D$ = 1A | — | 120 | — | mΩ |
| $R_{SS(ON)2}$ | Static Source-Source On-Resistance 2 | $V_{DD}$ = 2.5V, $I_D$ = 500mA | — | 120 | — | mΩ |
| $V_{SD}$ | Diode Forward Voltage | $V_{GS}$ = 0V<br>$I_S$ = 1A | — | 0.75 | 1.0 | V |

Notes: 7. In case of Gate-Source voltage of charging MOSFET is 0V. In case of Gate-Source voltage of discharging MOSFET is 0V.
8. These specifications are guaranteed by design and will not be tested in production.

## Application Information

**Operation Mode**

**1. Normal Status**

The AP9221 monitors the battery voltage and voltage difference between the VDD pin and VSS pin to control battery charging and discharging. The AP9221 will turn on discharging and charging MOSFET when the battery voltage is between the overdischarge detection voltage ($V_{DL}$) and overcharge detection voltage ($V_{CU}$), and the VM pin voltage is between the charge overcurrent detection voltage ($V_{COC}$) and discharge overcurrent detection voltage ($V_{DOC}$). In these conditions, the battery can charge and discharge freely. The $R_{VMD}$ also does not connect to the VDD pin. In this status, the $R_{VMS}$ does not connect to VSS pin.

**2. Overcharge Status**

If the battery voltage is more than $V_{CU}$ during charging status for the overcharge detection delay time ($t_{CU}$) or longer, the AP9221 turns off the charging MOSFET to stop charging. $R_{VMD}$ and $R_{VMS}$ are not connected in overcharge status.

When VM pin voltage is lower than $V_{DOC}$ and battery voltage falls below $V_{CL}$, the AP9221 will release from overcharge status.
When VM pin voltage is equal or more than $V_{DOC}$ and battery voltage falls below $V_{CU}$, the AP9221 will release from overcharge status.

**3. Overdischarge Status**

If the battery voltage is less than $V_{DL}$ during discharging status for the overdischarge detection delay time ($t_{DL}$) or longer, the AP9221 turns off the discharging MOSFET to stop discharging. In overdischarge status, the $R_{VMD}$ is connected to the VDD, and VM pin voltage is pulled up to $V_{DD}$ by $R_{VMD}$ (but $R_{VMS}$ is not connected). For the power-down mode version, the AP9221 recovers into normal status from overdischarge status only by charging the battery through the charger.

When VM pin voltage to VSS pin voltage is less than the typical -0.7V and the battery voltage rises over $V_{DL}$, the AP9221 will release from overdischarge status. If VM pin voltage to VSS pin voltage is higher than the typical -0.7V, the AP9221 will release from overdischarge status until the battery voltage rises over $V_{DU}$.

For auto-wake-up version DIODES™ AP9221SA, the device recovers into normal status from overdischarge status if either of these two conditions are satisfied:

If a charger is connected: the AP9221SA overdischarge status is released in the same way as described above in “AP9221S Overdischarge Status” section.

If no charger is connected: 1) the battery voltage reaches the overdischarge release voltage ($V_{DU}$) or higher;

2) it maintains continuous time more than overdischarge release delay time $t_{DLR}$.

**4. Discharge Overcurrent and Short Current Status**

If the battery is in discharge overcurrent status, the voltage of the VM pin to VSS pin is equal or more than $V_{DOC}$ to $V_{SHORT}$, and detection lasts for the discharge overcurrent detection delay time ($t_{DOC}$) or longer, the AP9221 turns off the discharging MOSFET to stop discharging.

If the battery is in short current status, the voltage of the VM pin to VSS pin is equal to or more than $V_{SHORT}$, and the detection lasts for the short current detection delay time or longer, the AP9221 turns off the discharge MOSFET to stop discharging.

In discharge overcurrent or short current status, $R_{VMS}$ is connected to $V_{SS}$, but $R_{VMD}$ is not connected. The voltage of VM pin is almost equal to $V_{DD}$ as long as the load is connected. When the load is disconnected, the voltage of VM pin will become almost equal to $V_{SS}$ (due to $R_{VMS}$ being connected) and then the AP9221 will release from discharge overcurrent or short current status.

**5. Charge Overcurrent Status**

If the battery is in charge current status, the voltage of the VM pin to VSS pin is equal to or less than $V_{COC}$, and the detection continues for the charge overcurrent detection delay time ($t_{COC}$) or longer, the AP9221 turns off the charging MOSFET to stop charging.

## Application Information (continued)

**6. 0V Battery Charging Function (Option)**

This function is available as an option and can be factory set internally. The AP9221 has this function built-in.

0V charging function permits the charger to recharge the battery when its voltage is 0V due to self-discharge. If the 0V charging function is not present, the device will prevent the charger from recharging the battery when its voltage is 0V due to self-discharge.

(If a device without 0V charging function is needed, please contact the Diodes Incorporated sales team.)

**7. Overvoltage Charger Detection Circuit**

This function is used to monitor the charger voltage between the VDD pin and VM pin. When this voltage exceeds overvoltage charger detection voltage (8.0V Typ.), the AP9221 will turn off the charging MOSFET. When this voltage drops below overvoltage charger release voltage (7.3V Typ.), it then turns on the charging MOSFET. There are no delay times set for the detection and release.

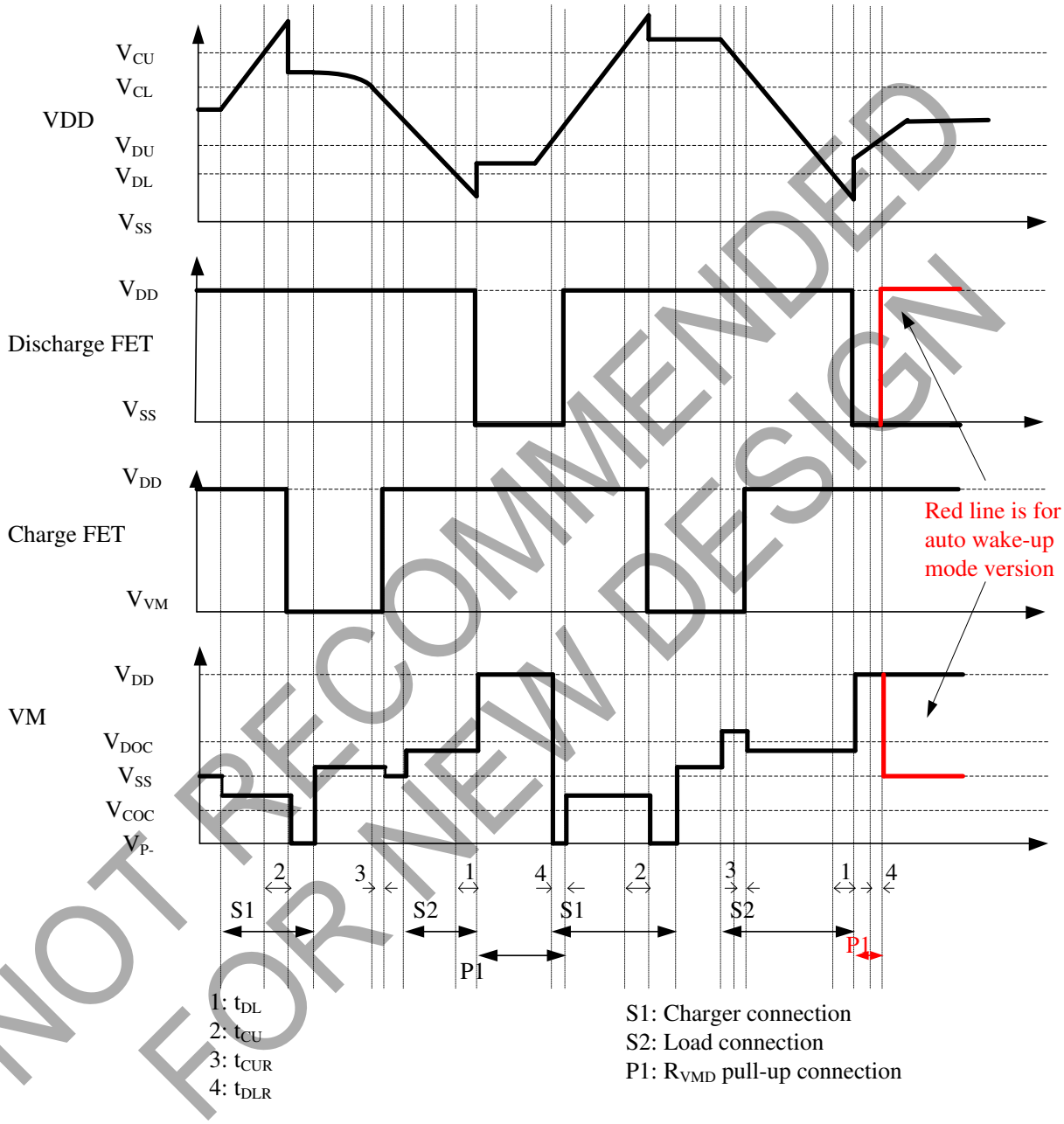
**8. Power-Down Mode or Auto-Wake-Up Function Option**

In a device with a power-down function, the device enters the overdischarge status during power-down mode. The IC enters sleep mode and the current consumption becomes very low, typically 0.1µA. To release from power-down status to the normal status, charger connection is required.

In a device with auto-wakeup mode, the IC remains active in the overdischarge state. The IC is released into the normal state by any operation that increases the battery voltage more than the overdischarge release voltage.

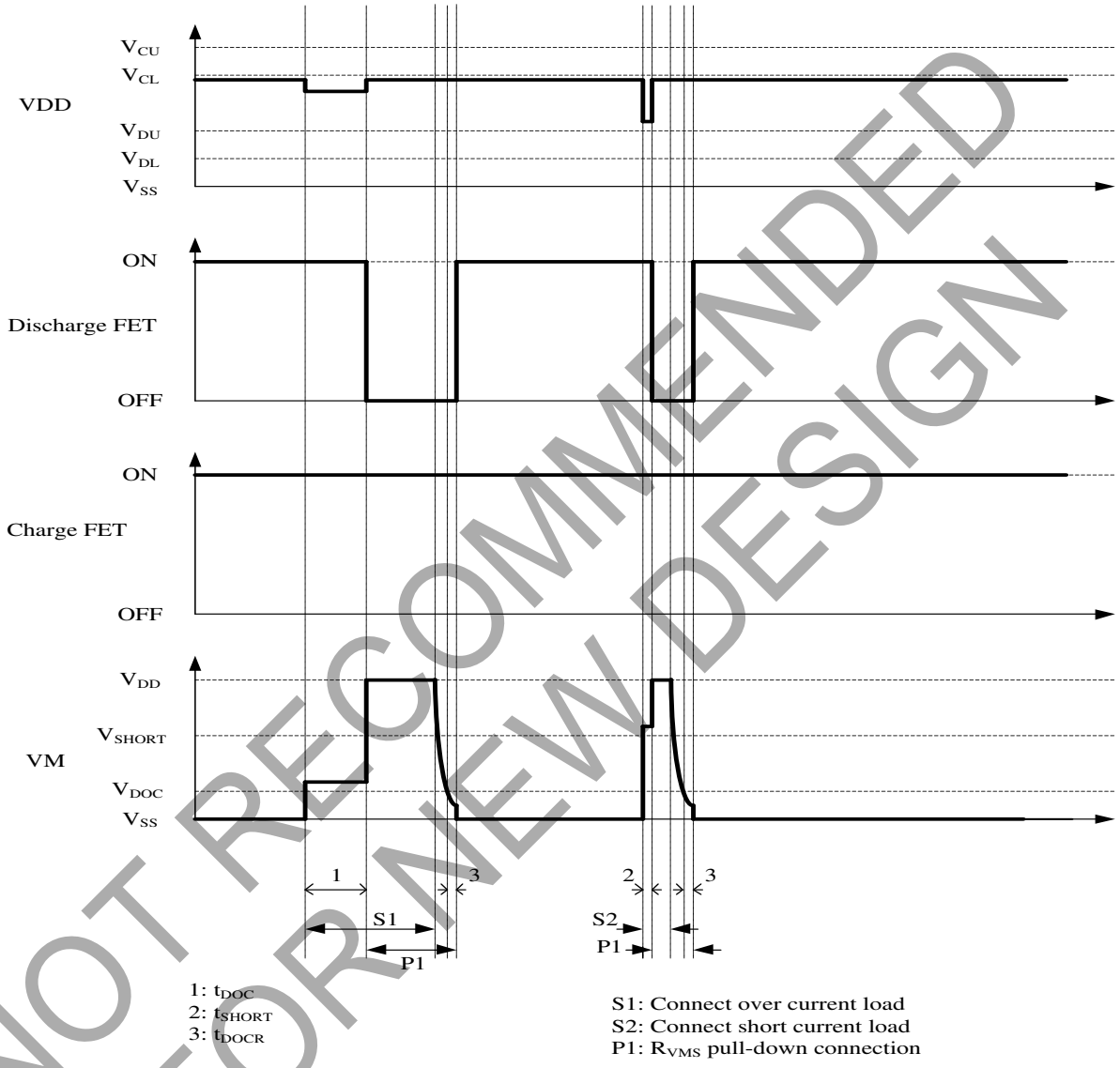
## Application Information (Timing Chart)

**1. Overcharge and Overdischarge Detection**



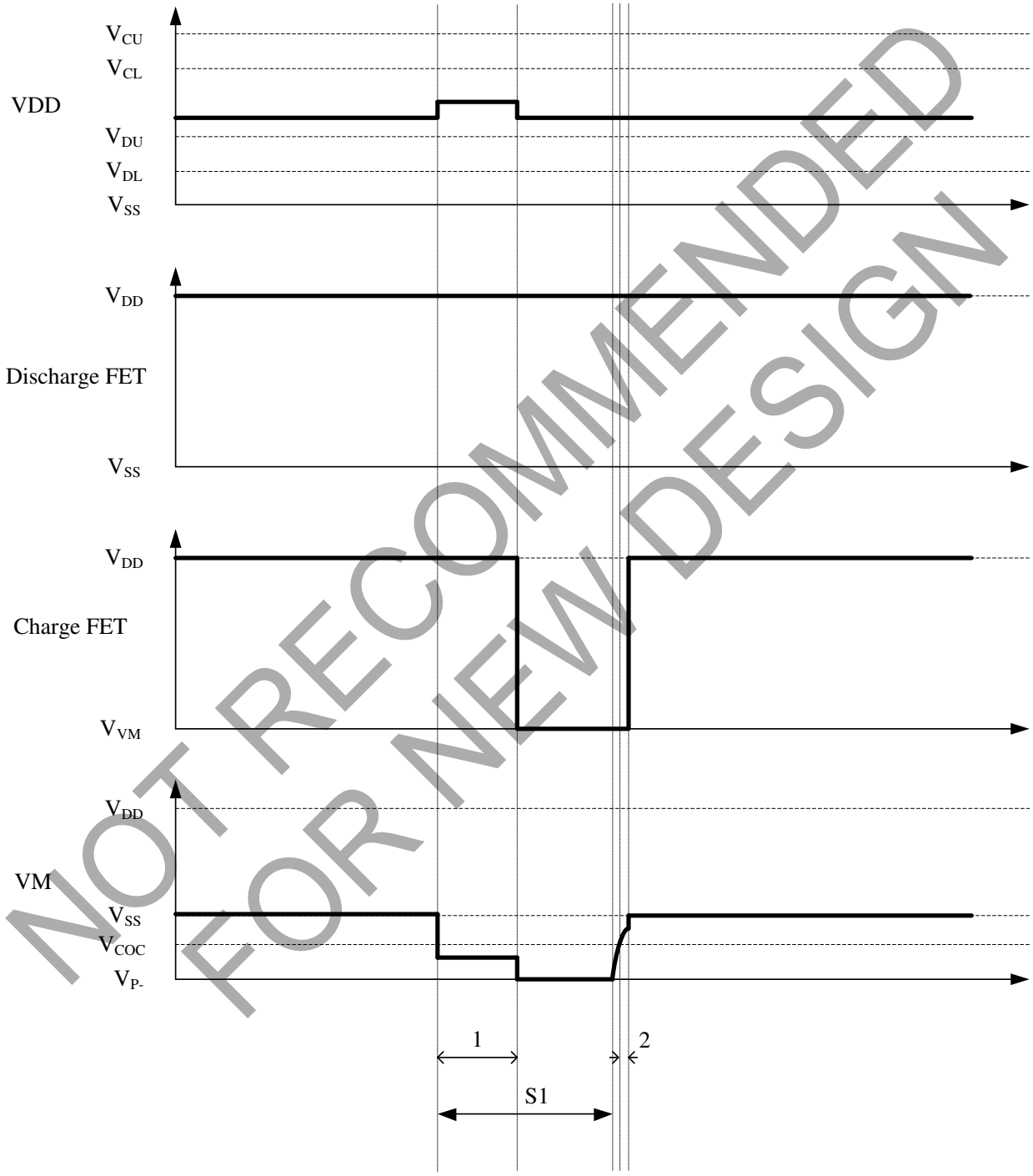
## Application Information (Timing Chart) (continued)

**2. Discharge Overcurrent Detection**



## Application Information (Timing Chart) (continued)

**3. Charge Overcurrent Detection**




1: $t_{COC}$
2: $t_{COCR}$

S1: Connect over current charger

## Ordering Information

**AP9221X X - X - X - X**

| $R_{SS(ON)}$ | Power Down Mode | Product Code | Package | Packing |
|---|---|---|---|---|
| S: Standard | Blank: Yes<br>A: No (Auto-wake-up) | CC: Voltage Combination Code | HAC: U-DFN2030-6 (Type C) | 7: Tape & Reel |

| Part Number | Package Code | Package | Packing | |
|---|---|---|---|---|
| | | | Qty. | Carrier |
| AP9221SA-CC-HAC-7 | HAC | U-DFN2030-6 (Type C) | 3000 | 7" Tape & Reel |
| AP9221SA-AS-HAC-7 | HAC | U-DFN2030-6 (Type C) | 3000 | 7" Tape & Reel |
| AP9221SA-CR-HAC-7 | HAC | U-DFN2030-6 (Type C) | 3000 | 7" Tape & Reel |

**Voltage Combination (Note 9)**

| Part Number | Overcharge Detection Voltage $V_{CU}$ (V) | Overcharge Release Voltage $V_{CL}$ (V) | Over-discharge Detection Voltage $V_{DL}$ (V) | Over-discharge Release Voltage $V_{DU}$ (V) | Discharge Overcurrent Detection Voltage $V_{DOC}$ (V) | Load Short Detection Voltage $V_{SHORT}$ (V) | Charge Overcurrent Detection Voltage $V_{COC}$ (V) | Overvoltage Charge Detection Voltage $V_{OVCHG}$ (V) | Overvoltage Charge Release Voltage $V_{OVCHGR}$ (V) | Power-Down Function | Overcharge Protection Mode | 0V Battery Charge Function |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AP9221SA-CC-HAC-7 | 4.200 | 4.000 | 2.750 | 2.950 | 0.055 | 0.276 | -0.113 | 8.0 | 7.3 | Auto Wake-up | Auto Release | Prohibition |
| AP9221SA-AS-HAC-7 | 4.275 | 4.175 | 2.850 | 2.970 | 0.025 | 0.120 | -0.020 | 8.0 | 7.3 | Auto Wake-up | Auto Release | Prohibition |
| AP9221SA-CR-HAC-7 | 4.370 | 4.220 | 2.800 | 3.000 | 0.130 | 0.350 | -0.130 | 8.0 | 7.3 | Auto Wake-up | Auto Release | Prohibition |

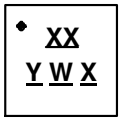
Note: 9. If any other voltage version options are needed, please contact the local sales office.

**The AP9221 Delay Time Combination**

| Part Number | Overcharge Detection Delay Time $t_{CU}$ | Overcharge Release Delay Time $t_{CUR}$ | Overdischarge Detection Delay Time $t_{DL}$ | Overdischarge Release Delay Time $t_{DLR}$ | Discharge Overcurrent Detection Delay Time $t_{DOC}$ | Discharge Overcurrent Release Delay Time $t_{DOCR}$ | Charge Overcurrent Detection Delay Time $t_{COC}$ | Charge Overcurrent Release Delay Time $t_{COCR}$ | Load Short Detection Delay Time $t_{SHORT}$ |
|---|---|---|---|---|---|---|---|---|---|
| AP9221SX-XX-HAC-7 | 1.0s | 2.0ms | 115ms | 2.0ms | 10.0ms | 2.0ms | 10.0ms | 2.0ms | 360µs |

## Marking Information

**(Top View)**



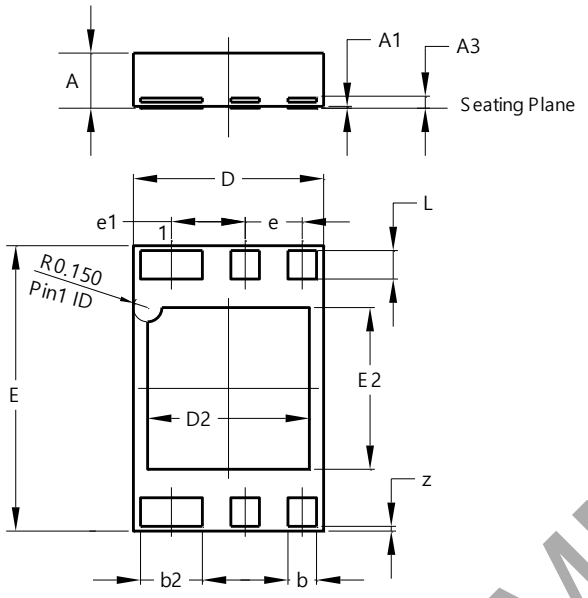

XX : Identification Code
Y : Year : 0 to 9
W : Week : A to Z : 1 to 26 Week;
a to z : 27 to 52 Week; z Represents 52 and 53 Week
X : A to Z : Internal Code

| Part Number | Package | Identification Code |
|---|---|---|
| AP9221SA-CC-HAC-7 | U-DFN2030-6 (Type C) | 2C |
| AP9221SA-AS-HAC-7 | U-DFN2030-6 (Type C) | 2D |
| AP9221SA-CR-HAC-7 | U-DFN2030-6 (Type C) | 2E |

## Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

**U-DFN2030-6 (Type C)**



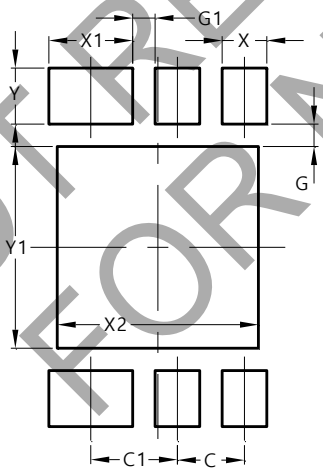

| U-DFN2030-6 (Type C) | | | |
|---|---|---|---|
| **Dim** | **Min** | **Max** | **Typ** |
| **A** | 0.50 | 0.60 | -- |
| **A1** | 0.00 | 0.05 | 0.02 |
| **A3** | -- | -- | 0.127 |
| **b** | 0.25 | 0.35 | 0.30 |
| **b2** | 0.60 | 0.70 | 0.65 |
| **D** | 1.90 | 2.10 | 2.00 |
| **D2** | 1.60 | 1.80 | 1.70 |
| **E** | 2.90 | 3.10 | 3.00 |
| **E2** | 1.60 | 1.80 | 1.70 |
| **e** | -- | -- | 0.60 |
| **e1** | -- | -- | 0.775 |
| **L** | 0.25 | 0.35 | 0.30 |
| **z** | 0.0500 Ref | | |
| **All Dimensions in mm** | | | |



## Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

**U-DFN2030-6 (Type C)**




| Dimensions | Value (in mm) |
|---|---|
| **C** | 0.600 |
| **C1** | 0.775 |
| **G** | 0.200 |
| **G1** | 0.200 |
| **X** | 0.400 |
| **X1** | 0.750 |
| **X2** | 1.800 |
| **Y** | 0.500 |
| **Y1** | 1.800 |

## Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish NiPdAu over Copper Leadframe Solderable per MIL-STD-202,Method 208 e4
- Weight: 0.011 grams (Approximate)

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