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# NCP392A

## Adjustable Front End Overvoltage Protection Controller with Protected Vbus Output

The NCP392A is an overvoltage front end protection and be able to disconnect the systems from its output pin in case wrong input operating conditions are detected, up to +28 V. Due to this device using internal NMOS, no external device is necessary, reducing the system cost and the PCB area of the application board.

Internal OVLO threshold is available, or can be adjusted if external resistor bridge is used (A version).

At power up ( $\overline{\text{EN}}$  pin = low level), the Vout turns on tstart time after internal timer elapsed.

A LDO, internally connected on IN pin, provided a protected output voltage even if an over voltage is present on IN pin.

### Features

- Over-voltage Protection Up to + 28 V
- On-chip Low  $R_{\text{DS(on)}}$  NMOS Transistors: Typical 34 m $\Omega$
- Over-voltage Lockout (OVLO)
- Externally Adjustable OVLO
- Protected VBUS Indicator Output VBUS\_DET
- Internal 15 ms Startup Delay
- 100 ms Start Up Delay Option (B Version)
- Shutdown  $\overline{\text{EN}}$  Input
- + 86 V Surge Capability, in Compliance with IEC61000-4-5
- Compliance to IEC61000-4-2 (Level 4)
  - 8 kV (Contact)
  - 15 kV (Air)
- ESD Ratings:
  - Machine Model = B (200 V)
  - Human Body Model = 2 (2 kV)
- CSP-12 package 1.3 x 2.0 mm, 0.4 mm Pitch
- This is a Pb-Free Device

### Typical Applications

- Cell Phones
- Tablets
- Camera Phones
- Digital Still Cameras
- Personal Digital Applications.



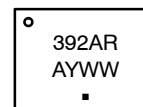
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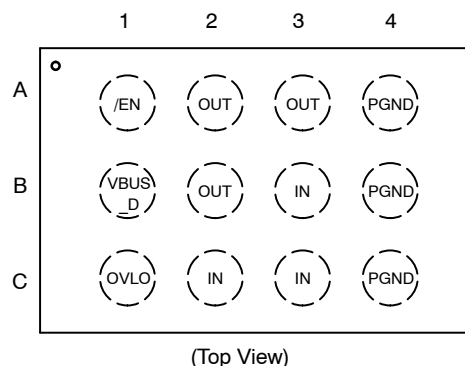
WLCSP 12  
FCC SUFFIX  
CASE 567JM

### MARKING DIAGRAM



A = Assembly Location  
Y = Year  
WW = Work Week  
▪ = Pb-Free Package

### PIN CONNECTION



### ORDERING INFORMATION

See detailed ordering, marking and shipping information on page 9 of this data sheet.

# NCP392A

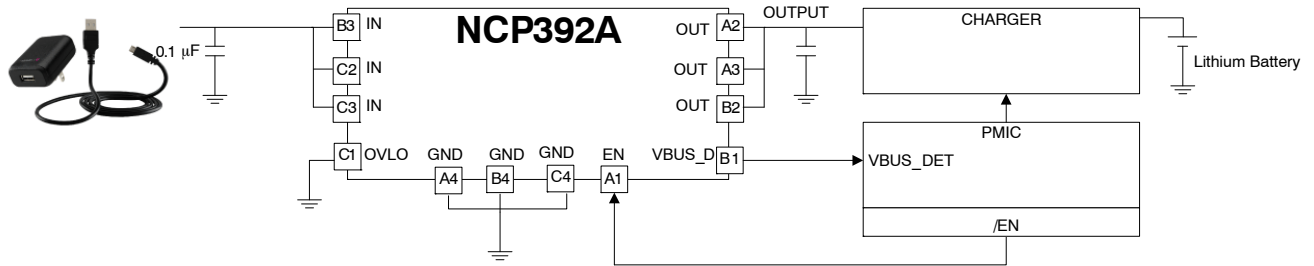


Figure 1. Typical Application Circuit: NCP392A with Adjustable OVLO

## FUNCTIONAL BLOCK DIAGRAM

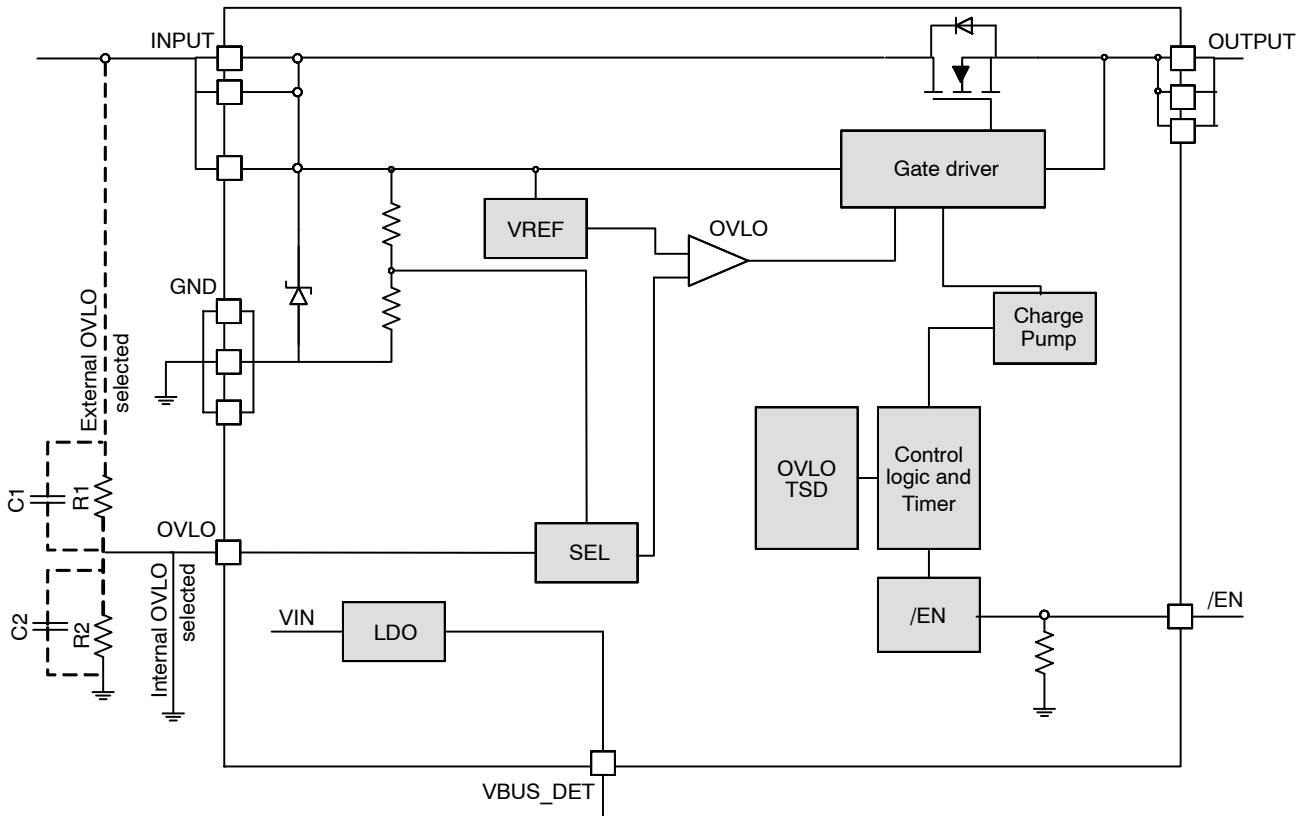
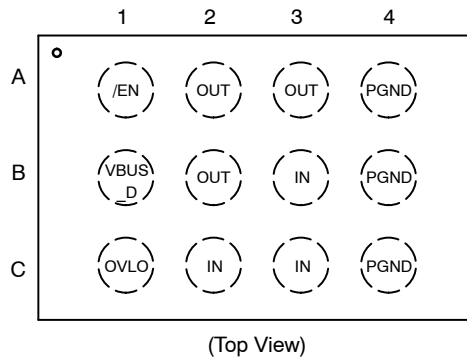


Figure 2. Functional Block Diagram: Version A

# NCP392A

## PIN FUNCTION DESCRIPTION



**Figure 3. Pinout**

**Table 1. NCP392 PIN DESCRIPTION**

| Pin              | Pin Name | Type   | Description  |
|------------------|----------|--------|--|
| A1               | EN       | I/O    | Enable pin bar.<br>The device enters in shutdown mode when this pin is tied to a high level. In this case the output is disconnected from the input.<br>To allow normal functionality, the $\overline{\text{EN}}$ pin is tied low with internal pull down.<br>This pin does not have an impact on the VBUS_DET.  |
| A2,<br>A3,<br>B2 | OUT      | OUTPUT | Output voltage pins.<br>These pins follow IN pins, with debounce time, when “no fault” are detected.<br>The outputs are disconnected from the Vin power supply when the input voltage is below UVLO, above OVLO threshold or internal thermal protection is exceeded.<br>The three OUT pins must be hardwired together and used for power dissipation. |
| A4,<br>B4,<br>C4 | PGND     | POWER  | Ground. The three GND pins must be hardwired together and connect to the system GND.   |
| B1               | VBUS_DET | OUTPUT | Vbus detect pin. This pin reflects Vin pin, and be in pass through mode up to regulation level. Upper this trip, this output regulates IN voltage whatever OVLO event or /EN setting.  |
| B3,<br>C2,<br>C3 | IN       | POWER  | Input voltage pins.<br>These pins are connected to the power supply.<br>The three IN pins must be hardwired together.  |
| C1               | OVLO     | INPUT  | External OVLO Adjustment. Connect external resistor bridge to OVLO pin to select a different OVLO threshold. Connect OVLO pin to GND if not used. In this case internal OVLO will be selected.   |



# NCP392A

**Table 2. MAXIMUM RATINGS**

| Rating   | Symbol               | Value                                      | Unit         |
|--|----------------------|--|--------------|
| Minimum Voltage (IN, OVLO to GND)  | V <sub>minIN</sub>   | -0.3                                       | V            |
| Minimum Voltage (All others to GND)  | V <sub>min</sub>     | -0.3                                       | V            |
| Maximum Voltage (IN to GND)  | V <sub>maxIN</sub>   | 29   | V            |
| Maximum Voltage (OVLO to GND)  | V <sub>maxOVLO</sub> | 14   | V            |
| Maximum Voltage (OUT to GND)   | V <sub>maxOUT</sub>  | 22   | V            |
| Maximum Voltage (VBUS_DET to GND)  | V <sub>maxVBUS</sub> | 10   | V            |
| Maximum Voltage (All others to GND)  | V <sub>max</sub>     | 7  | V            |
| Maximum DC current   | I <sub>max</sub>     | 4.5  | A            |
| Peak input current   | I <sub>peak</sub>    | 8  | A            |
| Thermal Resistance, Junction-to-Air  | R <sub>θJA</sub>     | 70   | °C/W         |
| Operating Ambient Temperature Range  | T <sub>A</sub>       | -40 to +85                                 | °C           |
| Storage Temperature Range  | T <sub>stg</sub>     | -65 to +150                                | °C           |
| Junction Operating temperature   | T <sub>J</sub>       | + 125                                      | °C           |
| ESD Withstand Voltage (IEC 61000-4-2)<br>Human Body Model (HBM), model = 2 (Note 1)<br>Machine Model (MM) model = B (Note 2) | V <sub>esd</sub>     | 15 kV air, 8 kV contact<br>2000 V<br>200 V | kV<br>V<br>V |
| Moisture Sensitivity   | MSL                  | Level 1                                    |              |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

- Human Body Model, 100 pF discharged through a 1.5 kΩ resistor following specification JESD22/A114.
- Machine Model, 200 pF discharged through all pins following specification JESD22/A115

**Table 3. ELECTRICAL CHARACTERISTICS** Min / Max limits values (-40°C < T<sub>A</sub> < +85°C and T<sub>J</sub> = 125°C) and V<sub>in</sub> = +5 V (Unless otherwise noted). Typical values are T<sub>A</sub> = +25°C.

| Characteristics                                    | Symbols                             | Conditions   | Min  | Typ   | Max  | Unit |
|--|-------------------------------------|--|------|-------|------|------|
| Input Voltage Range                                | V <sub>in</sub> , V <sub>OVLO</sub> |  | 2.8  |       | 28   | V    |
| Under voltage Lockout                              | UVLO                                | V <sub>in</sub> rising   |      |       | 2.8  | V    |
| Under voltage Lockout hysteresis                   | UVLO <sub>hyst</sub>                | V <sub>in</sub> falling  | 40   | 60    | 80   | mV   |
| Internal Over voltage Lockout threshold NCP392AR   | OVLO                                | V <sub>in</sub> rising (Note 3)<br>OVLO pin tied to GND<br>25°C  | 5.9  | 5.95  | 6    | V    |
| Internal Over voltage Lockout hysteresis           | OVLO <sub>hyst</sub>                | V <sub>in</sub> falling  | 1.5  |       | 2.5  | %    |
| External OVLO Reference                            | OVLO_EXT                            |  | 1.18 | 1.221 | 1.26 | V    |
| External Adjustable OVLO                           |                                     |  | 4    |       | 20   | V    |
| Over-Voltage Lockout Hysteresis                    | OVLO_EXT <sub>hyst</sub>            | V <sub>in</sub> falling  |      | 2     |      | %    |
| External OVLO select                               | OVLO_SEL                            |  | 0.2  |       | 0.3  | V    |
| V <sub>in</sub> versus V <sub>out</sub> Resistance | R <sub>DSon</sub>                   | V <sub>in</sub> = 5 V, /EN = GND, -40°C < T <sub>J</sub> < 125°C |      | 34    | 50   | mΩ   |
| Supply Quiescent Current                           | I <sub>dd</sub>                     | No load, /EN = 0.4 V   |      | 90    | 200  | μA   |
| Standby Current                                    | I <sub>stb</sub>                    | No load, /EN = 1.2 V,<br>No load on VBUS_DET                     |      |       | 150  | μA   |
| OVLO select leakage                                | I <sub>OVLO</sub>                   |  |      |       | 100  | nA   |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

- Please contact your ON Semiconductor representative for additional OVLO threshold.

Electrical parameters are guaranteed by correlation across the full range of temperature.

# NCP392A

**Table 3. ELECTRICAL CHARACTERISTICS** Min / Max limits values ( $-40^{\circ}\text{C} < T_A < +85^{\circ}\text{C}$  and  $T_J = 125^{\circ}\text{C}$ ) and  $V_{in} = +5\text{ V}$  (Unless otherwise noted). Typical values are  $T_A = +25^{\circ}\text{C}$ .

| Characteristics             | Symbols        | Conditions                            | Min            | Typ | Max      | Unit     |
|-----------------------------|----------------|---------------------------------------|----------------|-----|----------|----------|
| <b>VBUS_DET (A Version)</b> |                |                                       |                |     |          |          |
| VBUS_DET Regulation         | $VBUS_{THRES}$ | $V_{in} > VBUS_{THRES}$               | 6.5            |     | 9        | V        |
| VBUS_DET Pass Through       |                | $V_{in} < VBUS_{THRES}$ , I load 1 mA | $V_{in} - 0.2$ |     | $V_{in}$ | V        |
| VBUS_DET ron                | $LDO_{RON}$    |                                       |                | 60  |          | $\Omega$ |
| VBUS_DET Current            |                |                                       |                | 1.5 |          | mA       |

### LOGIC

|                                    |           |  |     |     |     |           |
|------------------------------------|-----------|--|-----|-----|-----|-----------|
| EN Voltage High                    | $V_{ih}$  |  | 1.2 |     |     | V         |
| $\overline{\text{EN}}$ Voltage Low | $V_{il}$  |  |     |     | 0.4 | V         |
| $\overline{\text{EN}}$ Pull-down   | $EN_{pd}$ |  |     | 100 |     | $k\Omega$ |

### TIMINGS

|                    |             |   |  |     |   |               |
|--------------------|-------------|---|--|-----|---|---------------|
| Start up Time      | $t_{START}$ | From $V_{in} > 2.8\text{ V}$ to 10% $V_{out}$ , /EN low                                 |  | 15  |   | ms            |
| Enable time        | $t_{EN}$    | $V_{in}$ present, From /EN high to low, 10% $V_{out}$                                   |  | 15  |   | ms            |
| Soft start         | $t_{RISE}$  | From 10% to 90% of $V_{out}$ , C load 100 $\mu\text{F}$ , Rload, 100 $\Omega$ , /EN low |  | 1   |   | ms            |
| VBUS_DET rise time | $t_{VBUS}$  | /EN low, From $V_{in}$ applied to 90% $VBUS\_DET$ , 4.7 $\mu\text{F}$ load              |  |     | 2 | ms            |
| Turn off time      | $t_{OFF}$   | Surge off time  |  | 100 |   | ns            |
| Disable time       | $t_{DIS}$   | From EN $> 1.2\text{ V}$ to 90% $V_{out}$ , No load                                     |  | 20  |   | $\mu\text{s}$ |
| OVLO turn off time | $t_{OVLO}$  | $V_{in}$ rising 2 V/ $\mu\text{s}$  |  | 1.5 |   | $\mu\text{s}$ |

### TSD

|                           |           |  |  |     |  |                    |
|---------------------------|-----------|--|--|-----|--|--------------------|
| Thermal shutdown          | TSD       |  |  | 140 |  | $^{\circ}\text{C}$ |
| Thermal shutdown rearming | TSD rearm |  |  | 115 |  | $^{\circ}\text{C}$ |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

3. Please contact your ON Semiconductor representative for additional OVLO threshold.

Electrical parameters are guaranteed by correlation across the full range of temperature.

# NCP392A

## Operation

The NCP392A provides over-voltage protection for positive voltage surge, up to +28 V. An additional clamp, between IN and GND, protects the part against surge test, following IEC 61000-4-5 standard. A protected VBUS\_DET output pin provides a secondary supply for the application biasing.

## Under-voltage Lockout (UVLO)

To ensure proper operation under any conditions, the device has a built-in under-voltage lock out (UVLO) circuit. This circuit has a built-in hysteresis to provide noise immunity to transient conditions.

## Over-voltage Lockout (OVLO)

To protect connected systems on Vout pin from over-voltage, the device has a built-in over-voltage lock out (OVLO) circuit. During over-voltage condition, the output remains disabled until the input voltage is above OVLO – hysteresis.

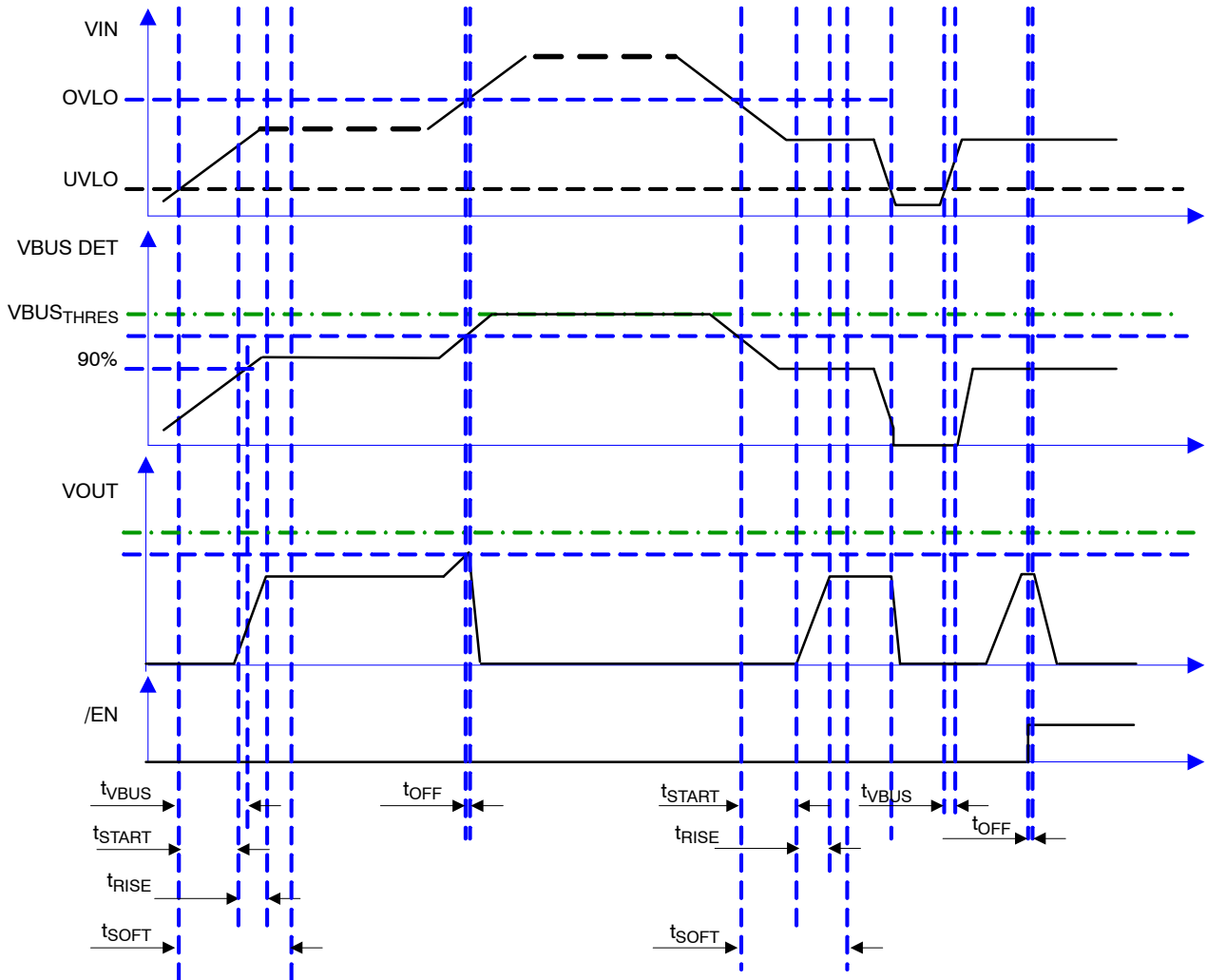


Figure 4. UVLO, OVLO and /EN Functionality

To select the internal OVLO threshold, the OVLO pin must be externally tied to GND.

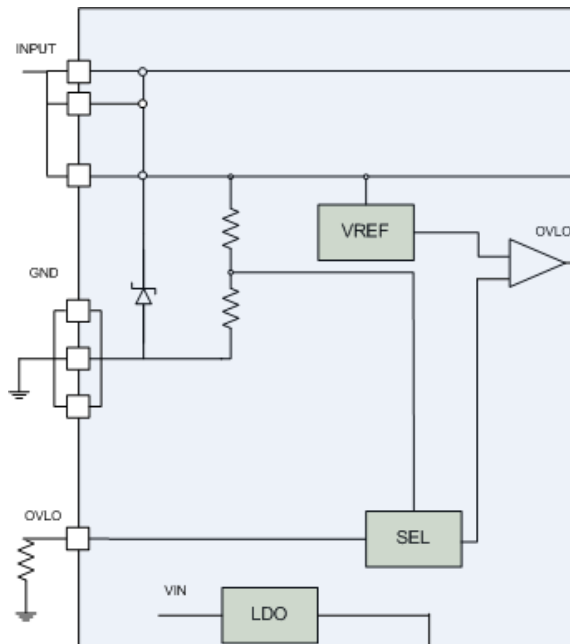


Figure 5. External Connection to GND of OVLO

If OVLO pin is not grounded, and by adding external bridge resistor on OVLO pin, between IN and GND, overvoltage protection can be adjusted as following:

$$NEW\_OVLO_{TH} = \frac{OVLO_{EXT} \times (R_1 + R_2)}{R_2} \quad (eq. 1)$$

With:  $OVLO_{EXT} = 1.221$  V Typical (OVLO External Reference)

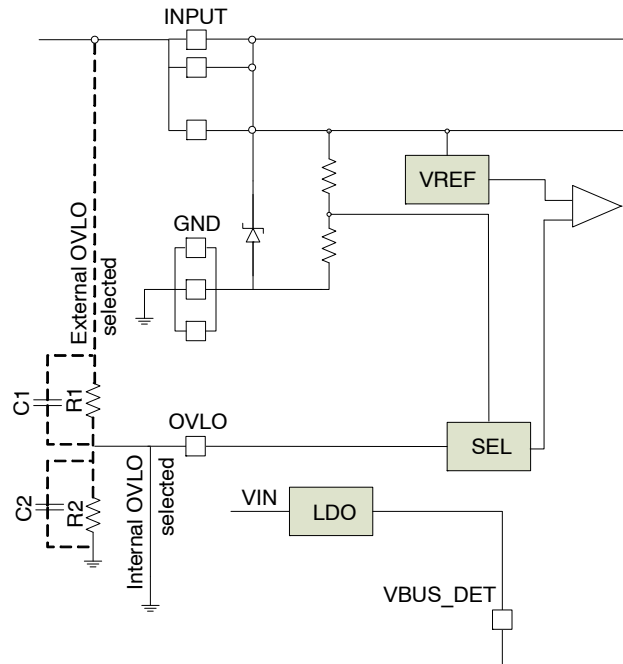


Figure 6. External Connection to Resistor Bridge of OVLO

Example:  
OVLO target 12 V.

$$R_1 = R_2 \times \left( \frac{OVLO}{1.221} - 1 \right) = R_2 \times \left( \frac{12}{1.221} - 1 \right) = 8.828 \times R_2 \quad (eq. 2)$$

Taking into account external input bridge doesn't have excessive current consumption, and 1% is recommended:

R2 arbitrarily fixed at 1.05 MΩ

R1 = 9.269 MΩ (9.31 MΩ standard value)

Obtained typical OVLO = 12.04 V

C1 and C2 should be selected in such a way that the time constant  $R_1C_1 = R_2C_2$ .



# NCP392A

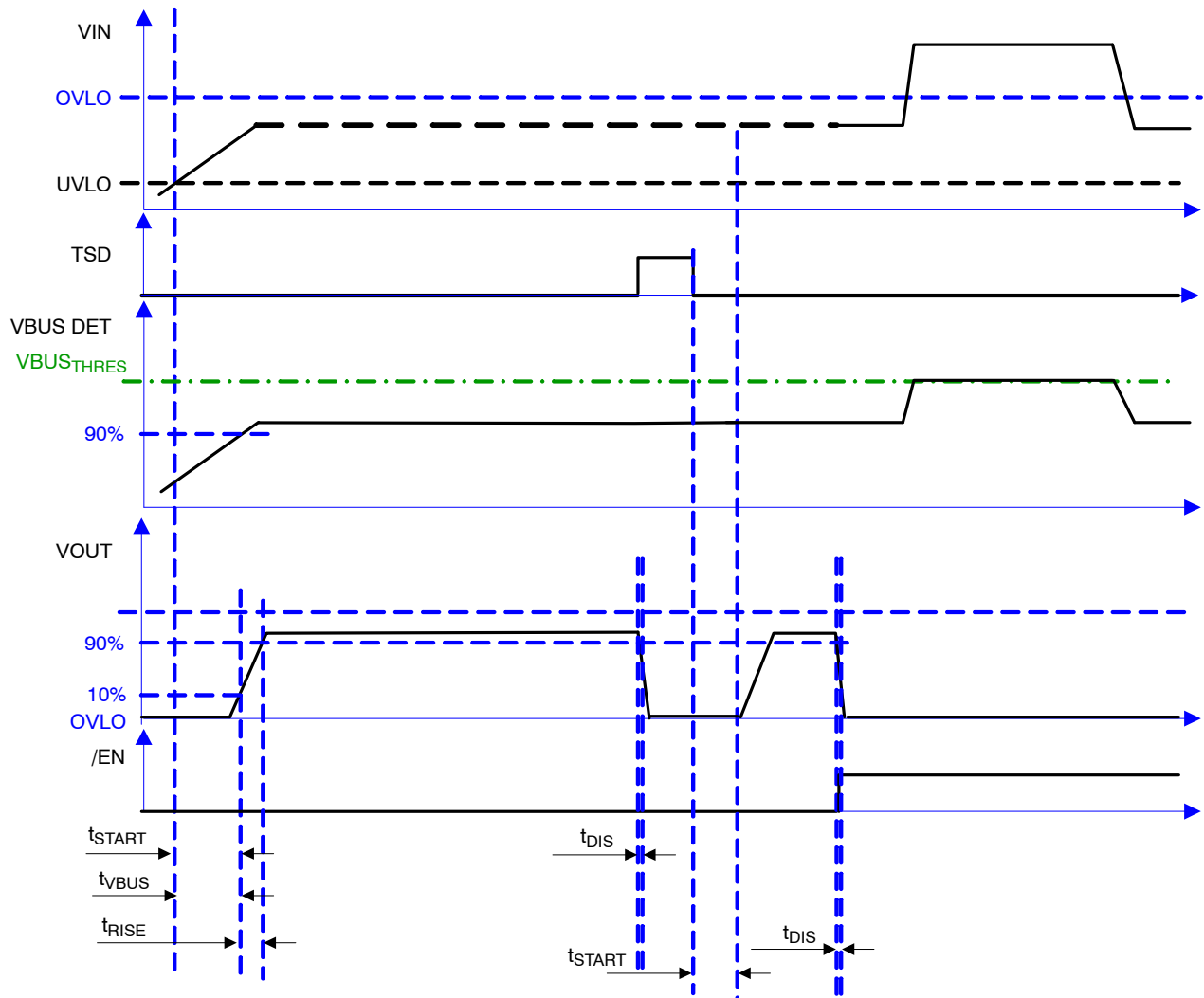


Figure 7. OVLO<sub>EXT</sub>, TSD Modes

## $\overline{EN}$ Inputs and Production Mode

To enable normal operation, the  $\overline{EN}$  pin has to be at low level. Internal pull down is embedded in the part.

A high level on the pin, disconnects OUT pin from IN pin.

Table 4. CONTROL LOGIC MODES

| OVP State<br>NCP392Ax |      | OVLO EXT                |      |
|-----------------------|------|-------------------------|------|
|                       |      | Low                     | High |
| /EN                   | Low  | ON $T_{start}$<br>15 ms | OFF  |
|                       | High | OFF                     | OFF  |

## Thermal Shutdown Protection

In case of internal overheating, the integrated thermal Inputs shutdown (TSD) protection allows to open the internal MOSFET in order to instantaneously decrease the device temperature.

Embedded hysteresis allows to reengage the MOSFET when the junction temperature decreases.

If the fault event is still present, the temperature increases again and engages the thermal shutdown one more time until fault event disappeared.

## PCB Recommendations

To limit internal power dissipation, PCB routing must be carefully done to improve current capability.

The NCP392A is declined in a CSP package. So power dissipation can be decreased on each pin connection but main thermal area must be as large as possible around IN and OUT pins. Taking into account and respectively, four IN and OUT pins must be hardwired together on the PCB.

# NCP392A

Maximum power dissipation can be calculated with following formula:

$$T_J - T_A = R_{\theta JA} \times P_d \quad (\text{eq. 3})$$

$T_J$ : junction temperature

$T_A$ : ambient temperature

$R_{\theta JA}$ : thermal resistance of the junction to air through the case and board.

$P_d$ : power dissipation =  $R_{DS(on)} \times I^2$

## ESD Tests

The NCP392A fully supports the IEC61000-4-2, level 4 (Input pin, 1  $\mu$ F mounted on board).

That means, in Air condition,  $V_{in}$  has a  $\pm 15$  kV ESD protected input. In Contact condition,  $V_{in}$  has  $\pm 8$  kV ESD protected input.

Please refer to the Figure 8 to see the IEC 61000-4-2 electrostatic discharge waveform.

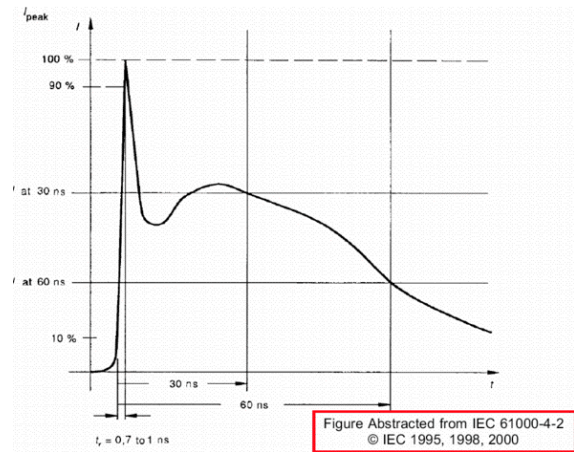


Figure 8.  $I_{peak} = f(t)$  / IEC61000-4-2

## ORDERING INFORMATION

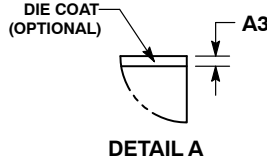
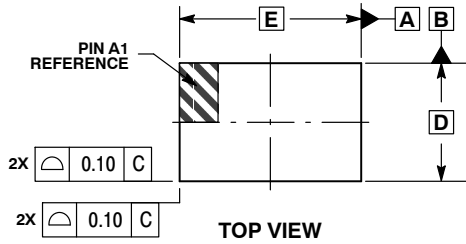
| Device         | Marking | Package            | Shipping†          |
|----------------|---------|--------------------|--------------------|
| NCP392ARFCCT1G | 392AR   | WLCSP<br>(Pb-Free) | 3000 / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

# NCP392A

## PACKAGE DIMENSIONS

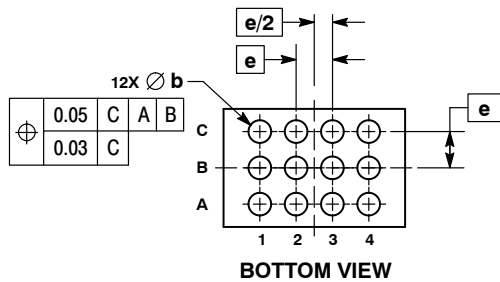
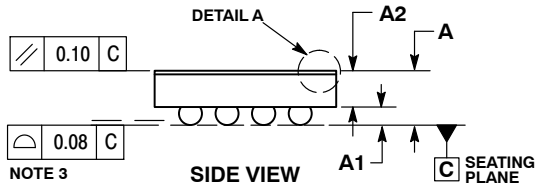
### WLCSP12, 1.3x2.0 CASE 567JM ISSUE A



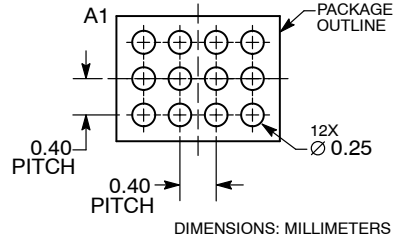
NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. COPLANARITY APPLIES TO SPHERICAL CROWNS OF SOLDER BALLS.


| MILLIMETERS |          |      |
|-------------|----------|------|
| DIM         | MIN      | MAX  |
| A           | ---      | 0.60 |
| A1          | 0.17     | 0.23 |
| A2          | 0.36 REF |      |
| A3          | 0.04 REF |      |
| b           | 0.24     | 0.30 |
| D           | 1.26     | 1.31 |
| E           | 2.01     | 2.04 |
| e           | 0.40 BSC |      |



### RECOMMENDED SOLDERING FOOTPRINT\*



\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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