

# NCP4328

## Secondary Side CV/CC Controller

The NCP4328 is a secondary side SMPS controller designed for use in applications which requires constant current and/or constant current regulation.

The NCP4328x consists of two OTA amplifiers for voltage and current loop regulation with precise internal voltage references. Outputs of OTAs are open drain type (OTAs sink current only).

The NCP4328B includes a LED driver pin implemented with an open drain MOSFET driven by a 1 kHz square wave with a 12.5% duty cycle working when VCC is above UVLO for indication purpose.

The NCP4328A is available in TSOP-5 package while the NCP4328B is available in TSOP-6 package.

### Features

- Operating Input Voltage Range: 2.5 V to 36.0 V
- Supply current < 100  $\mu$ A
- $\pm 0.5\%$  Reference Voltage Accuracy ( $T_J = 25^\circ\text{C}$ )
- Constant Voltage and Constant Current (A versions) Control Loop
- Indication LED PWM Modulated Driver (NCP4328B)
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

### Typical Applications

- Offline Adapters for Notebooks, Game Stations and Printers
- LED Lightening
- High Power AC-DC Converters for TVs, Set-Top Boxes, Monitors etc.



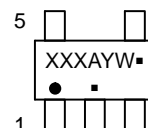
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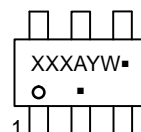
### MARKING DIAGRAMS



**TSOP-5  
SN SUFFIX  
CASE 483**



**TSOP-6  
SN SUFFIX  
CASE 318G**



XXX = Specific Device Code

A = Assembly Location

Y = Year

W = Work Week

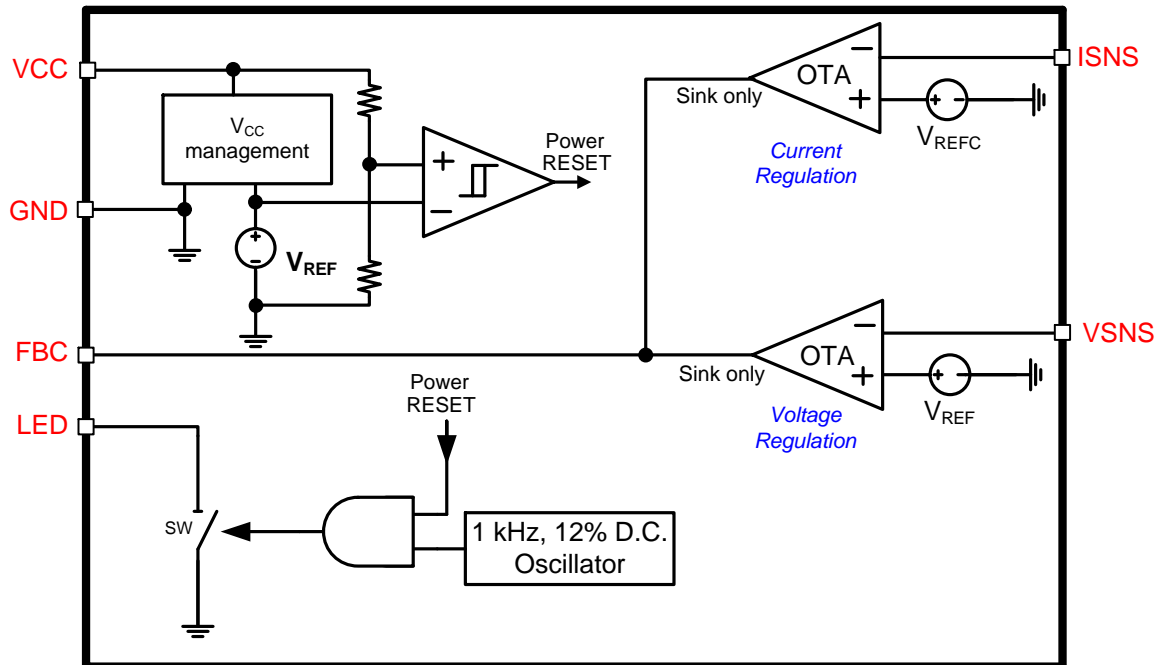
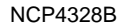
■ = Pb-Free Package

(Note: Microdot may be in either location)

### ORDERING INFORMATION

See detailed ordering, marking and shipping information on page 8 of this data sheet.

NCP4328A



2

# NCP4328

## PIN FUNCTION DESCRIPTION

| NCP4328A<br>TSOP-5 | NCP4328B<br>TSOP-6 | Pin Name | Description                                                                                                              |
|--------------------|--------------------|----------|--------------------------------------------------------------------------------------------------------------------------|
| 1                  | 1                  | VCC      | Supply voltage pin                                                                                                       |
| 2                  | 2                  | GND      | Ground                                                                                                                   |
| 5                  | 6                  | VSNS     | Output voltage sensing pin, connected to output voltage divider                                                          |
| 4                  | 4                  | ISNS     | Current sensing input for output current regulation, connect it to shunt resistor in ground branch.                      |
| –                  | 5                  | LED      | PWM LED driver output. Connected to LED cathode with current define by external serial resistance                        |
| 3                  | 3                  | FBC      | Output of current sinking OTA amplifiers driving feedback optocoupler's LED. Connect here compensation networks as well. |

## ABSOLUTE MAXIMUM RATINGS

| Rating                                        | Symbol              | Value                  | Unit |
|-----------------------------------------------|---------------------|------------------------|------|
| Input Voltage                                 | $V_{CC}$            | –0.3 to 40.0           | V    |
| FBC, LED Voltage                              | $V_{FBC}, V_{LED}$  | –0.3 to $V_{CC} + 0.3$ | V    |
| VSNS, ISNS Voltage                            | $V_{SNS}, V_{ISNS}$ | –0.3 to 10.0           | V    |
| LED Current                                   | $I_{LED}$           | 10                     | mA   |
| Thermal Resistance – Junction-to-Air (Note 1) | $R_{\theta JA}$     | 315                    | °C/W |
| Junction Temperature                          | $T_J$               | –40 to 150             | °C   |
| Storage Temperature                           | $T_{STG}$           | –55 to 150             | °C   |
| ESD Capability, Human Body Model (Note 2)     | $ESD_{HBM}$         | 2000                   | V    |
| ESD Capability, Machine Model (Note 2)        | $ESD_{MM}$          | 250                    | V    |

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.

1. 50 mm<sup>2</sup>, 1.0 oz. Copper spreader.

2. This device series incorporates ESD protection and is tested by the following methods:

ESD Human Body Model tested per JESD22–A114F

ESD Machine Model tested per JESD22–A115C

Latchup Current Maximum Rating tested per JEDEC standard: JESD78D.

# NCP4328

## ELECTRICAL CHARACTERISTICS

$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ;  $V_{CC} = 15\text{ V}$ ; unless otherwise noted. Typical values are at  $T_J = +25^{\circ}\text{C}$ .

| Parameter                       | Test Conditions  | Symbol          | Min | Typ | Max  | Unit          |
|---------------------------------|------------------|-----------------|-----|-----|------|---------------|
| Maximum Operating Input Voltage |                  | $V_{CC}$        |     |     | 36.0 | V             |
| VCC UVLO                        | $V_{CC}$ rising  | $V_{CCUVLO}$    | 3.3 | 3.5 | 3.7  | V             |
|                                 | $V_{CC}$ falling |                 | 2.3 | 2.5 | 2.7  |               |
| VCC UVLO Hysteresis             |                  | $V_{CCUVLOHYS}$ | 0.8 | 1.0 |      | V             |
| Quiescent Current               | NCP4328A         | $I_{CC}$        |     | 105 | 130  | $\mu\text{A}$ |
|                                 | NCP4328B         |                 |     | 115 | 140  |               |

### VOLTAGE CONTROL LOOP OTA

|                              |                                                                                   |             |       |       |       |    |
|------------------------------|-----------------------------------------------------------------------------------|-------------|-------|-------|-------|----|
| Transconductance             | Sink current only                                                                 | $g_{mV}$    |       | 1     |       | S  |
| Reference Voltage            | $2.8\text{ V} \leq V_{CC} \leq 36.0\text{ V}$ , $T_J = 25^{\circ}\text{C}$        | $V_{REF}$   | 1.244 | 1.250 | 1.256 | V  |
|                              | $2.8\text{ V} \leq V_{CC} \leq 36.0\text{ V}$ , $T_J = 0 - 85^{\circ}\text{C}$    |             | 1.240 | 1.250 | 1.264 |    |
|                              | $2.8\text{ V} \leq V_{CC} \leq 36.0\text{ V}$ , $T_J = -40 - 125^{\circ}\text{C}$ |             | 1.230 | 1.250 | 1.270 |    |
| Sink Current Capability      | $V_{FBC} > 1.5\text{ V}$                                                          | $I_{SINKV}$ | 2.5   |       |       | mA |
| Inverting Input Bias Current | $V_{SNS} = V_{REF}$                                                               | $I_{BIASV}$ | -100  |       | 100   | nA |

### CURRENT CONTROL LOOP OTA

|                              |                                   |             |      |      |      |    |
|------------------------------|-----------------------------------|-------------|------|------|------|----|
| Transconductance             | Sink current only                 | $g_{mC}$    |      | 3    |      | S  |
| Reference Voltage            | $T_J = 25^{\circ}\text{C}$        | $V_{REFC}$  | 61.2 | 62.5 | 63.8 | mV |
|                              | $T_J = -20 - 85^{\circ}\text{C}$  |             | 60.5 | 62.5 | 64.5 |    |
|                              | $T_J = -40 - 125^{\circ}\text{C}$ |             | 60.0 | 62.5 | 65.0 |    |
| Sink Current Capability      | $V_{FBC} > 1.5\text{ V}$          | $I_{SINKC}$ | 2.5  |      |      | mA |
| Inverting Input Bias Current | $I_{SNS} = V_{REFC}$              | $I_{BIASC}$ | -100 |      | 100  | nA |

### LED DRIVER (NCP4328B Only)

|                     |                         |             |      |      |      |          |
|---------------------|-------------------------|-------------|------|------|------|----------|
| Switching Frequency |                         | $f_{SWLED}$ |      | 1    |      | kHz      |
| Duty Cycle          | (Note 3)                | $D_{LED}$   | 10.0 | 12.5 | 15.0 | %        |
| Switch Resistance   | $I_{LED} = 5\text{ mA}$ | $R_{SW}$    |      | 50   |      | $\Omega$ |

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. Guaranteed by design.

TYPICAL CHARACTERISTICS

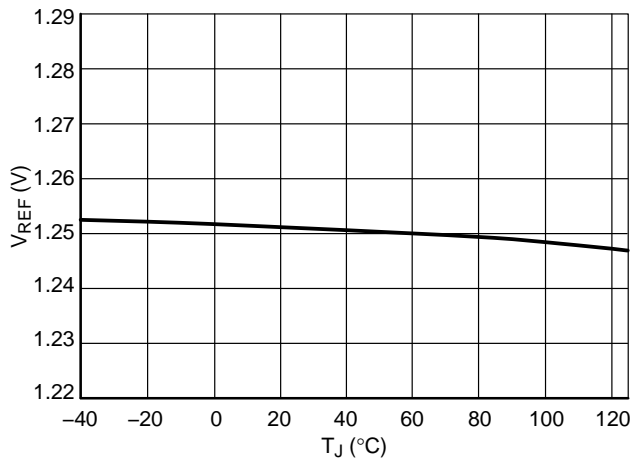


Figure 2. V<sub>REF</sub> at V<sub>CC</sub> = 15 V

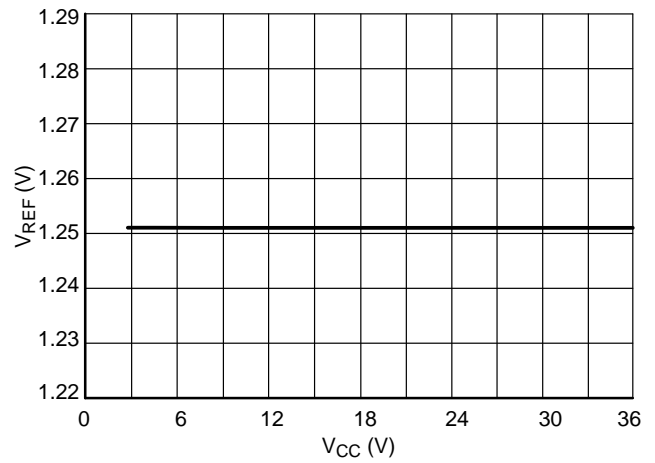


Figure 3. V<sub>REF</sub> at T<sub>J</sub> = 25°C

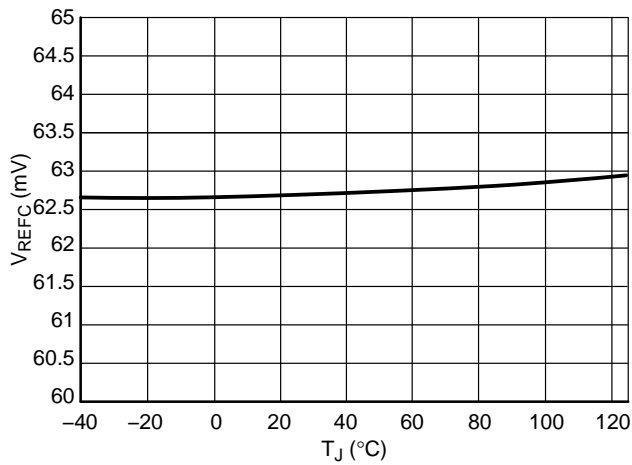


Figure 4. V<sub>REFC</sub> at V<sub>CC</sub> = 15 V

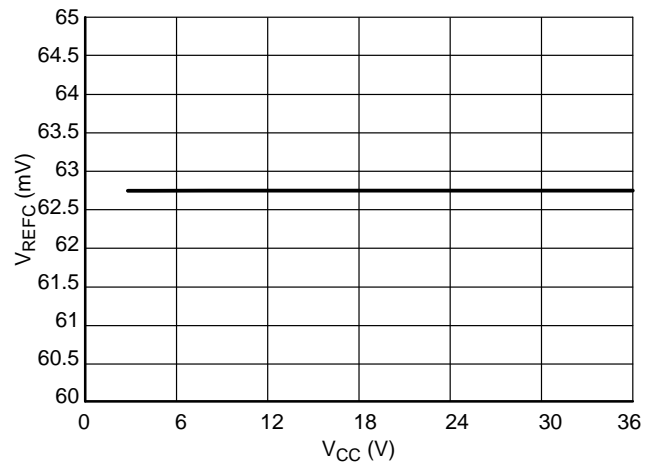


Figure 5. V<sub>REFC</sub> at T<sub>J</sub> = 25°C

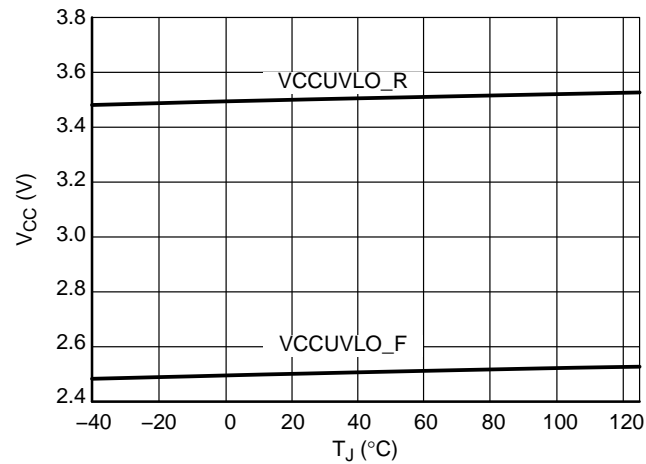


Figure 6. V<sub>CCUVLO</sub>

# NCP4328

## TYPICAL CHARACTERISTICS

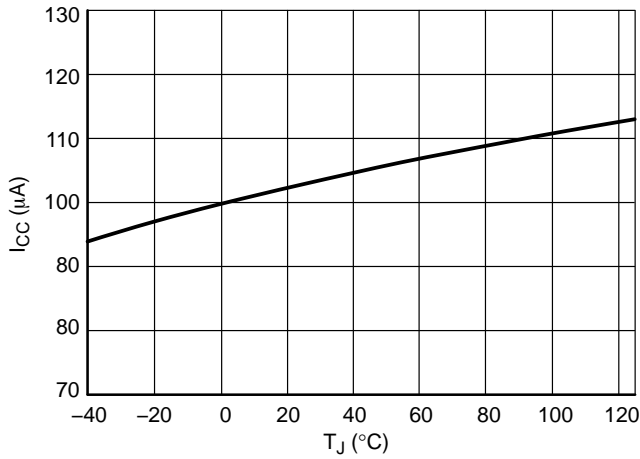


Figure 7.  $I_{CC}$  at  $V_{CC} = 15\text{ V}$  for NCP4328A

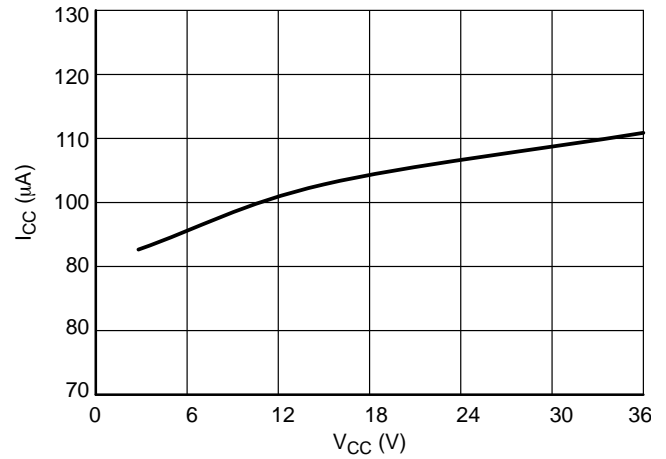


Figure 8.  $I_{CC}$  at  $T_J = 25^\circ\text{C}$  for NCP4328A

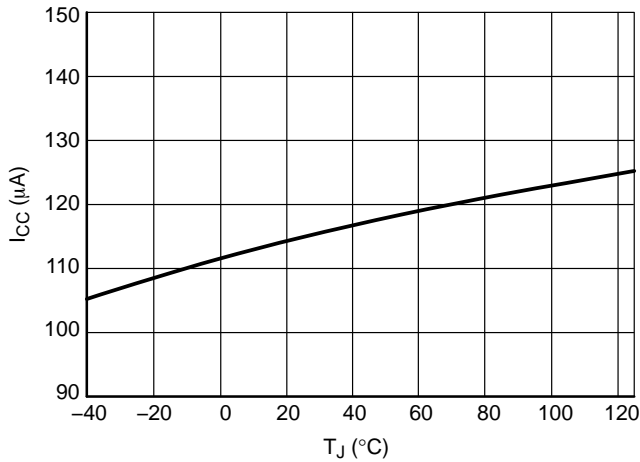


Figure 9.  $I_{CC}$  at  $V_{CC} = 15\text{ V}$  for NCP4328B

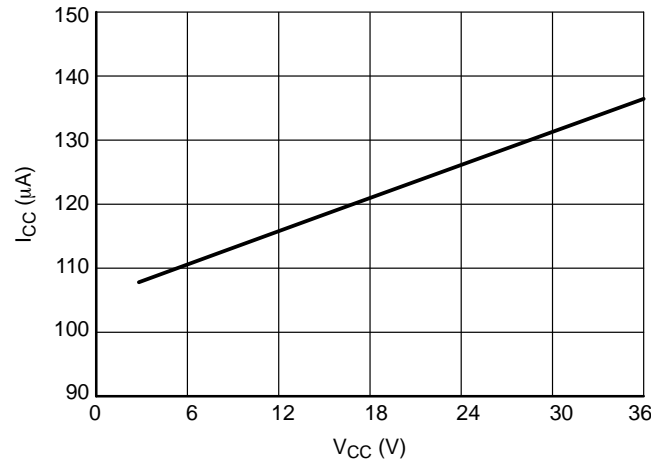


Figure 10.  $I_{CC}$  at  $T_J = 25^\circ\text{C}$  for NCP4328B

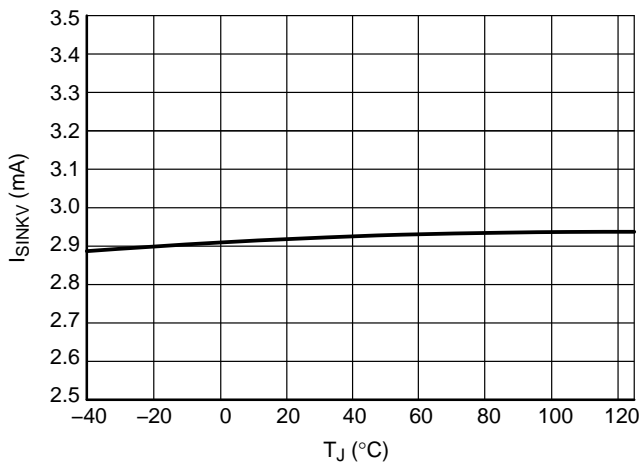


Figure 11. Voltage OTA Current Sink Capability

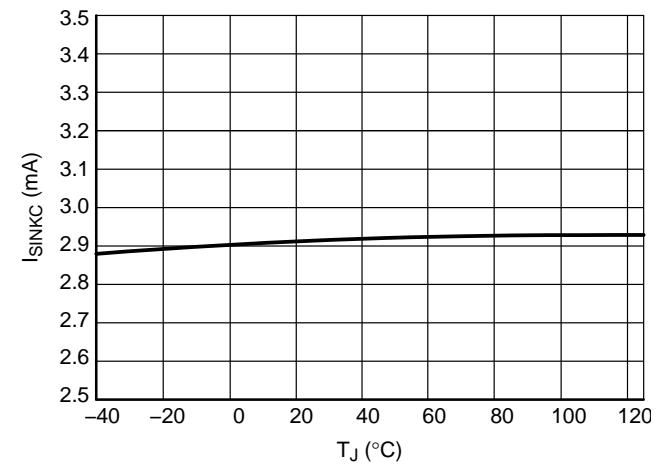


Figure 12. Current OTA Current Sink Capability

## TYPICAL CHARACTERISTICS

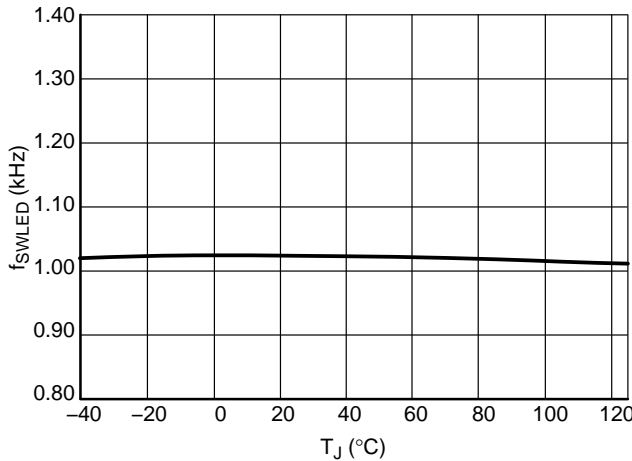


Figure 13. LED Switching Frequency at  
V<sub>CC</sub> = 15 V

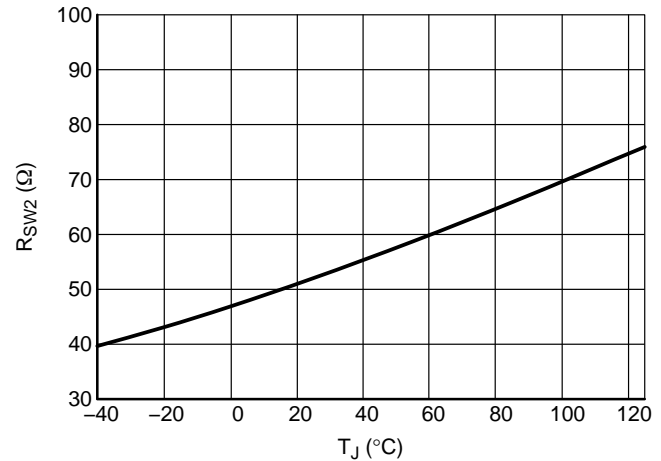


Figure 14. R<sub>SW</sub> at V<sub>CC</sub> = 15 V

## APPLICATION INFORMATION

Typical application circuit for NCP4328A is shown in Figures 15 and 16 shows typical application circuit for NCP4328B that includes internal LED driver for indication purpose.

### Power Supply

The NCP4328 is designed to operate from a single supply up to 36 V. It starts to operate when V<sub>CC</sub> voltage reaches 3.5 V and stops when V<sub>CC</sub> voltage drops below 2.5 V. V<sub>CC</sub> can be supplied by direct connection to the V<sub>OUT</sub> voltage of the power supply. It is highly recommended to add a RC filter (R1 and C2) in series from V<sub>OUT</sub> to V<sub>CC</sub> pin to reduce voltage spikes and drops that are produced at the converter's output capacitors. Recommended values for this filter are 220 Ω and 1 μF.

### Voltage Regulation Path

The output voltage is detected on the VSNS pin by the R3 and R4 voltage divider. This voltage is compared with the internal precise voltage reference. The voltage difference is amplified by g<sub>mV</sub> of the transconductance amplifier. The amplifier output current is connected to the FBC pin. The compensation network is also connected to this pin to provide frequency compensation for the voltage regulation path. This FBC pin drives regulation optocoupler that provides regulation of primary side. The optocoupler is supplied via direct connection to V<sub>OUT</sub> line through resistor R2.

Regulation information is transferred through the optocoupler to the primary side controller where its FB pin is usually pulled down to reduce energy transferred to secondary output.

The output voltage can be computed by Equation 1.

$$V_{OUT} = V_{REF} \frac{R3 + R4}{R4} \quad (\text{eq. 1})$$

### Current Regulation

The output current is sensed by the shunt resistor R5 in series with the load. Voltage drop on R5 is compared with internal precise voltage reference V<sub>REFC</sub> at I<sub>SNS</sub> transconductance amplifier input.

Voltage difference is amplified by g<sub>mC</sub> to output current of amplifier, connected to FBC pin. Compensation network is connected between this pin and I<sub>SNS</sub> input to provide frequency compensation for current regulation path. Resistor R6 separates compensation network from sense resistor. Compensation network works into low impedance without this resistor that significantly decreases compensation network impact.

Current regulation point is set to current given by Equation 2.

$$I_{OUTLIM} = \frac{V_{REFC}}{R5} \quad (\text{eq. 2})$$

### LED Driver (NCP4328B only)

LED driver is active when V<sub>CC</sub> is higher than V<sub>CCMIN</sub>. LED driver consists of an internal power switch controlled by a PWM modulated logic signal and an external current limiting resistor R9. LED current can be computed by Equation 3

$$I_{LED} = \frac{V_{OUT} - V_{F\_LED}}{R9} \quad (\text{eq. 3})$$

PWM modulation is used to increase efficiency of LED.

## NCP4328

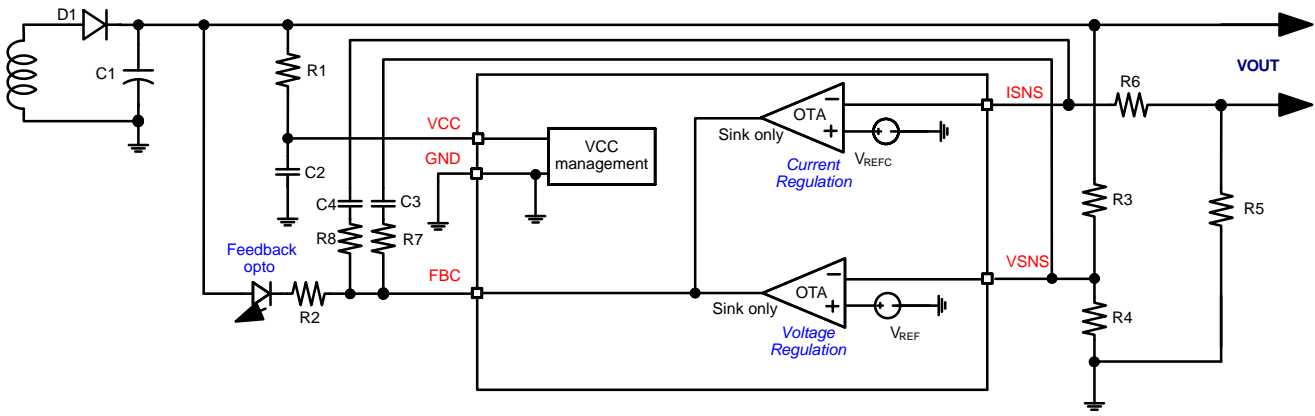


Figure 15. Typical Application Schematic for NCP4328A

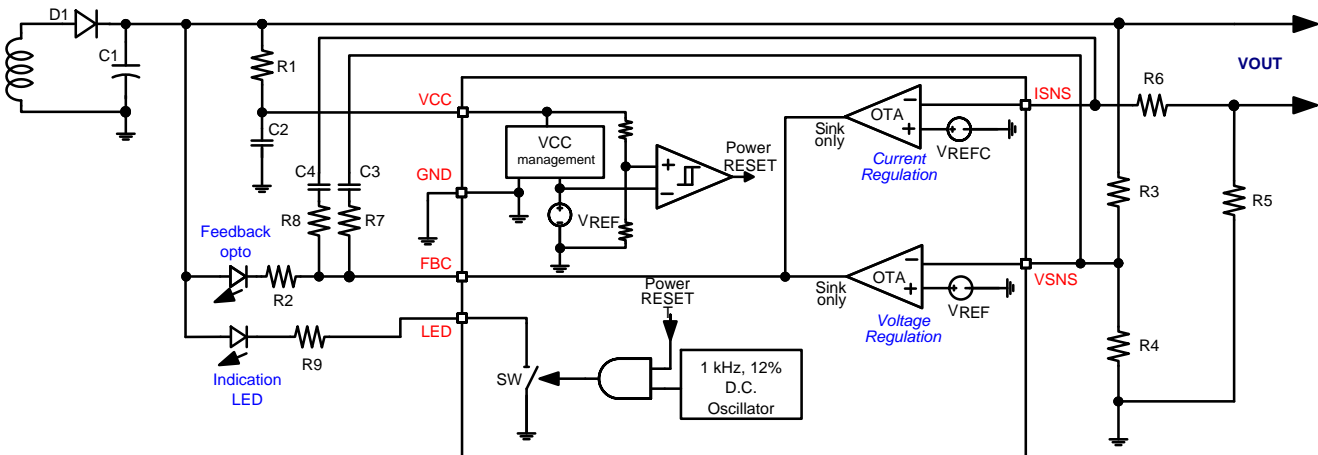


Figure 16. Typical Application Schematic for NCP4328B

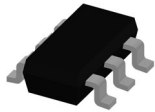
### ORDERING INFORMATION

| Device        | Marking | LED Driver | Package             | Shipping†          |
|---------------|---------|------------|---------------------|--------------------|
| NCP4328ASNT1G | A32     | No         | TSOP-5<br>(Pb-Free) | 3000 / Tape & Reel |
| NCP4328BSNT1G | U32     | Yes        | TSOP-6<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.

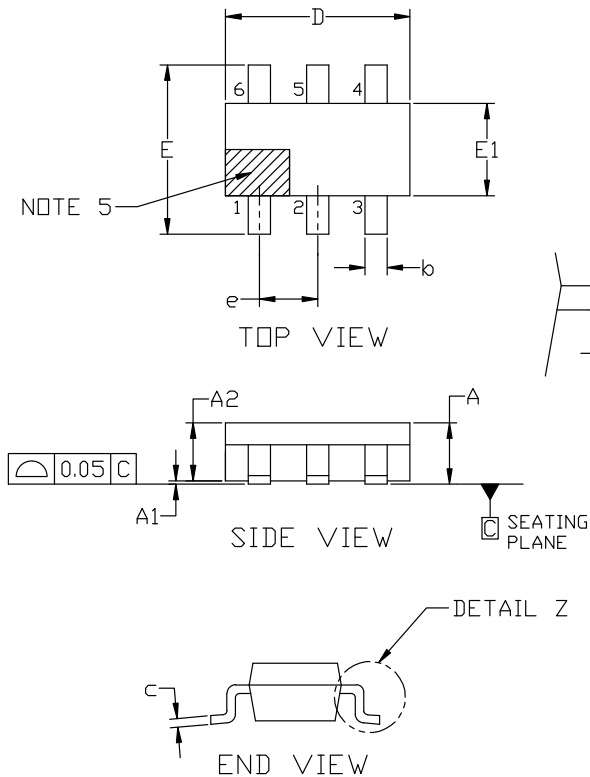


# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



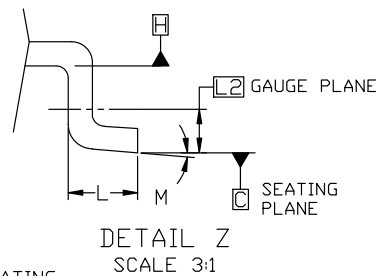
**TSOP-6 3.00x1.50x0.90, 0.95P**  
**CASE 318G**  
**ISSUE W**

**DATE 26 FEB 2024**

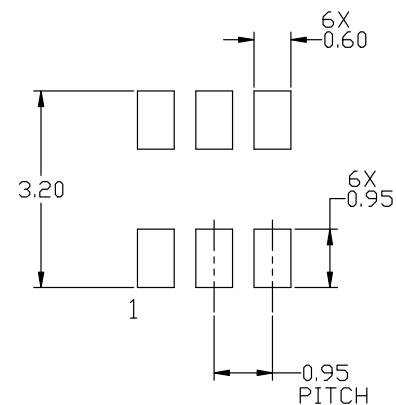


## NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2018.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS D AND E1 DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE. DIMENSIONS D AND E1 ARE DETERMINED AT DATUM H.
5. PIN 1 INDICATOR MUST BE LOCATED IN THE INDICATED ZONE



| MILLIMETERS |          |      |      |
|-------------|----------|------|------|
| DIM         | MIN      | NOM  | MAX  |
| A           | 0.90     | 1.00 | 1.10 |
| A1          | 0.01     | 0.06 | 0.10 |
| A2          | 0.80     | 0.90 | 1.00 |
| b           | 0.25     | 0.38 | 0.50 |
| c           | 0.10     | 0.18 | 0.26 |
| D           | 2.90     | 3.00 | 3.10 |
| E           | 2.50     | 2.75 | 3.00 |
| E1          | 1.30     | 1.50 | 1.70 |
| e           | 0.85     | 0.95 | 1.05 |
| L           | 0.20     | 0.40 | 0.60 |
| L2          | 0.25 BSC |      |      |
| M           | 0°       | ---  | 10°  |



## RECOMMENDED MOUNTING 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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# MECHANICAL CASE OUTLINE

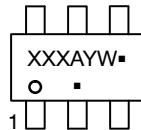
## PACKAGE DIMENSIONS



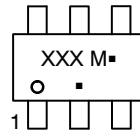
TSOP-6 3.00x1.50x0.90, 0.95P  
CASE 318G  
ISSUE W

DATE 26 FEB 2024

### GENERIC MARKING DIAGRAM\*



IC



STANDARD

XXX = Specific Device Code  
A = Assembly Location  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

XXX = Specific Device Code  
M = Date Code  
▪ = Pb-Free Package

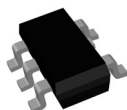
\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

|                                                                                                   |                                                                                                               |                                                                                                              |                                                                                                      |                                                                                                            |                                                                                                       |
|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| STYLE 1:<br>PIN 1. DRAIN<br>2. DRAIN<br>3. GATE<br>4. SOURCE<br>5. DRAIN<br>6. DRAIN              | STYLE 2:<br>PIN 1. EMITTER 2<br>2. BASE 1<br>3. COLLECTOR 1<br>4. EMITTER 1<br>5. BASE 2<br>6. COLLECTOR 2    | STYLE 3:<br>PIN 1. ENABLE<br>2. N/C<br>3. R BOOST<br>4. Vz<br>5. V in<br>6. V out                            | STYLE 4:<br>PIN 1. N/C<br>2. V in<br>3. NOT USED<br>4. GROUND<br>5. ENABLE<br>6. LOAD                | STYLE 5:<br>PIN 1. EMITTER 2<br>2. BASE 2<br>3. COLLECTOR 1<br>4. EMITTER 1<br>5. BASE 1<br>6. COLLECTOR 2 | STYLE 6:<br>PIN 1. COLLECTOR<br>2. COLLECTOR<br>3. BASE<br>4. EMITTER<br>5. COLLECTOR<br>6. COLLECTOR |
| STYLE 7:<br>PIN 1. COLLECTOR<br>2. COLLECTOR<br>3. BASE<br>4. N/C<br>5. COLLECTOR<br>6. EMITTER   | STYLE 8:<br>PIN 1. Vbus<br>2. D(in)<br>3. D(in)+<br>4. D(out)+<br>5. D(out)<br>6. GND                         | STYLE 9:<br>PIN 1. LOW VOLTAGE GATE<br>2. DRAIN<br>3. SOURCE<br>4. DRAIN<br>5. DRAIN<br>6. HIGH VOLTAGE GATE | STYLE 10:<br>PIN 1. D(OUT)+<br>2. GND<br>3. D(OUT)-<br>4. D(IN)-<br>5. VBUS<br>6. D(IN)+             | STYLE 11:<br>PIN 1. SOURCE 1<br>2. DRAIN 2<br>3. DRAIN 2<br>4. SOURCE 2<br>5. GATE 1<br>6. DRAIN 1/GATE 2  | STYLE 12:<br>PIN 1. I/O<br>2. GROUND<br>3. I/O<br>4. I/O<br>5. VCC<br>6. I/O                          |
| STYLE 13:<br>PIN 1. GATE 1<br>2. SOURCE 2<br>3. GATE 2<br>4. DRAIN 2<br>5. SOURCE 1<br>6. DRAIN 1 | STYLE 14:<br>PIN 1. ANODE<br>2. SOURCE<br>3. GATE<br>4. CATHODE/DRAIN<br>5. CATHODE/DRAIN<br>6. CATHODE/DRAIN | STYLE 15:<br>PIN 1. ANODE<br>2. SOURCE<br>3. GATE<br>4. DRAIN<br>5. N/C<br>6. CATHODE                        | STYLE 16:<br>PIN 1. ANODE/CATHODE<br>2. BASE<br>3. EMITTER<br>4. COLLECTOR<br>5. ANODE<br>6. CATHODE | STYLE 17:<br>PIN 1. EMITTER<br>2. BASE<br>3. ANODE/CATHODE<br>4. ANODE<br>5. CATHODE<br>6. COLLECTOR       |                                                                                                       |

|                  |                              |                                                                                                                                                                                     |
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| DESCRIPTION:     | TSOP-6 3.00x1.50x0.90, 0.95P | PAGE 2 OF 2                                                                                                                                                                         |

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# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

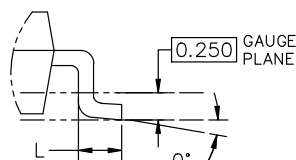
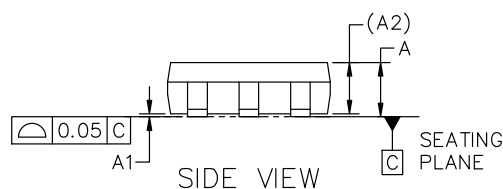
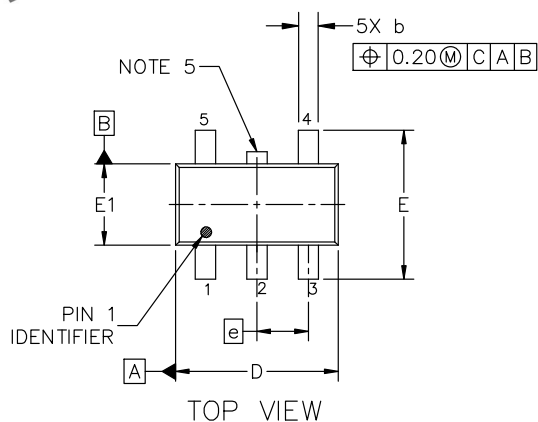


**TSOP-5 3.00x1.50x0.95, 0.95P**

**CASE 483**

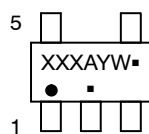
**ISSUE P**

**DATE 01 APR 2024**

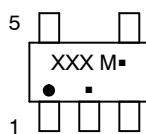


SCALE 2:1

## GENERIC MARKING DIAGRAM\*



**Analog**



**Discrete/Logic**

XXX = Specific Device Code  
A = Assembly Location  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

XXX = Specific Device Code  
M = Date Code  
▪ = Pb-Free Package

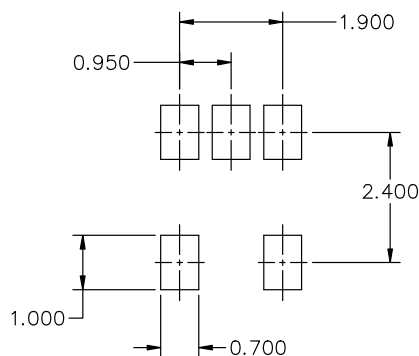
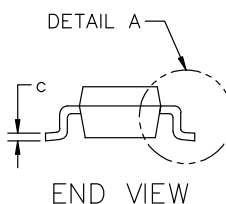
(Note: Microdot may be in either location)

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

## NOTES:

1. DIMENSIONING AND TOLERANCING CONFORM TO ASME Y14.5-2018.
2. ALL DIMENSION ARE IN MILLIMETERS (ANGLES IN DEGREES).
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS D AND E1 DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OF GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE. DIMENSION D.
5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.

| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN.        | NOM.  | MAX.  |
| A   | 0.900       | 1.000 | 1.100 |
| A1  | 0.010       | 0.055 | 0.100 |
| A2  | 0.950 REF.  |       |       |
| b   | 0.250       | 0.375 | 0.500 |
| c   | 0.100       | 0.180 | 0.260 |
| D   | 2.850       | 3.000 | 3.150 |
| E   | 2.500       | 2.750 | 3.000 |
| E1  | 1.350       | 1.500 | 1.650 |
| e   | 0.950 BSC   |       |       |
| L   | 0.200       | 0.400 | 0.600 |
| θ   | 0°          | 5°    | 10°   |



## RECOMMENDED MOUNTING FOOTPRINT\*

\* FOR ADDITIONAL INFORMATION ON OUR Pb-FREE STRATEGY AND SOLDERING DETAILS, PLEASE DOWNLOAD THE ON SEMICONDUCTOR SOLDERING AND MOUNTING TECHNIQUES REFERENCE MANUAL, SOLDERM/D.

|                         |                                     |                                                                                                                                                                                  |
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