

# NCV8501 Series

## Micropower 150 mA LDO Linear Regulators with **ENABLE**, **DELAY**, **RESET**, and **Monitor FLAG**

The NCV8501 is a family of precision micropower voltage regulators. Their output current capability is 150 mA. The family has output voltage options for adjustable, 2.5 V, 3.3 V, 5.0 V, 8.0 V, and 10 V.

The output voltage is accurate within  $\pm 2.0\%$  with a maximum dropout voltage of 0.6 V at 150 mA. Low quiescent current is a feature drawing only 90  $\mu\text{A}$  with a 100  $\mu\text{A}$  load. This part is ideal for any and all battery operated microprocessor equipment.

Microprocessor control logic includes an active  $\overline{\text{RESET}}$  (with DELAY), and a FLAG monitor which can be used to provide an early warning signal to the microprocessor of a potential impending  $\overline{\text{RESET}}$  signal. The use of the FLAG monitor allows the microprocessor to finish any signal processing before the  $\overline{\text{RESET}}$  shuts the microprocessor down.

The active  $\overline{\text{RESET}}$  circuit operates correctly at an output voltage as low as 1.0 V. The  $\overline{\text{RESET}}$  function is activated during the power up sequence or during normal operation if the output voltage drops outside the regulation limits.

The regulator is protected against reverse battery, short circuit, and thermal overload conditions. The device can withstand load dump transients making it suitable for use in automotive environments. The device has also been optimized for EMC conditions.

### Features

- Output Voltage Options: Adjustable, 2.5 V, 3.3 V, 5.0 V, 8.0 V, 10 V
- $\pm 2.0\%$  Output
- Low 90  $\mu\text{A}$  Quiescent Current
- Fixed or Adjustable Output Voltage
- Active  $\overline{\text{RESET}}$
- ENABLE
- 150 mA Output Current Capability
- Fault Protection
  - ♦ +60 V Peak Transient Voltage
  - ♦ -15 V Reverse Voltage
  - ♦ Short Circuit
  - ♦ Thermal Overload
- Early Warning through  $\overline{\text{FLAG}}$ /MON Leads
- NCV Prefix for Automotive and Other Applications Requiring Site and Change Control
- Pb-Free Packages are Available

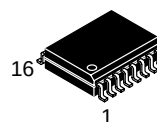


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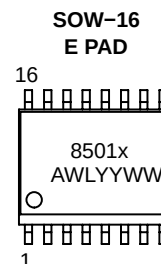
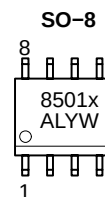


SO-8  
D SUFFIX  
CASE 751



SOIC 16 LEAD  
WIDE BODY  
EXPOSED PAD  
PDW SUFFIX  
CASE 751R

### MARKING DIAGRAMS



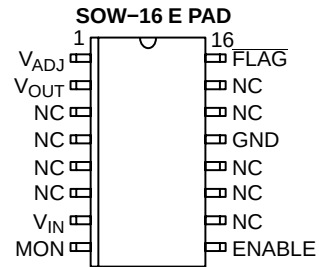
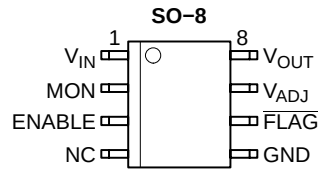
x = Voltage Ratings as Indicated Below:  
A = Adjustable  
2 = 2.5 V  
3 = 3.3 V  
5 = 5.0 V  
8 = 8.0 V  
1 = 10 V  
A = Assembly Location  
WL, L = Wafer Lot  
YY, Y = Year  
WW, W = Work Week

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 13 of this data sheet.

# NCV8501 Series

## PIN CONNECTIONS, ADJUSTABLE OUTPUT



## PIN CONNECTIONS, FIXED OUTPUT

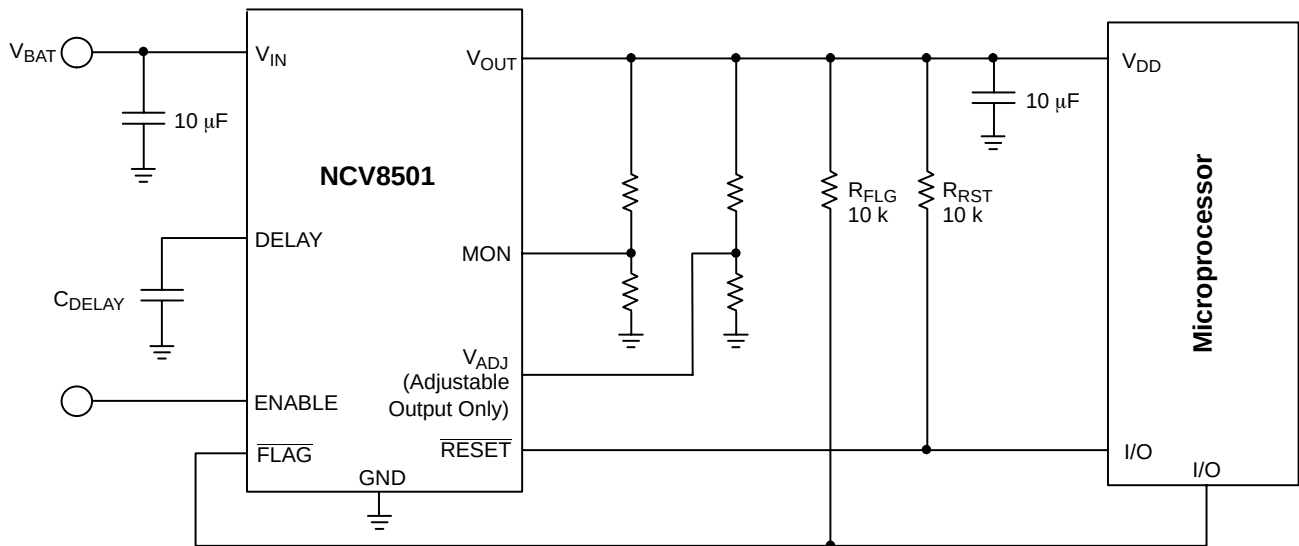
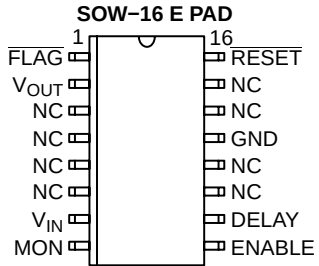
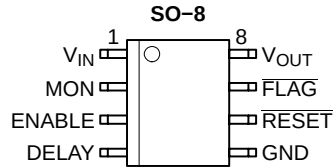


Figure 1. Application Diagram

## NCV8501 Series

### MAXIMUM RATINGS\*

| Rating                                                                                                                                                                 | Value                                      | Unit                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|----------------------|
| V <sub>IN</sub> (dc)                                                                                                                                                   | −15 to 45                                  | V                    |
| Peak Transient Voltage (46 V Load Dump @ V <sub>IN</sub> = 14 V)                                                                                                       | 60                                         | V                    |
| Operating Voltage                                                                                                                                                      | 45                                         | V                    |
| V <sub>OUT</sub> (dc)                                                                                                                                                  | 16                                         | V                    |
| Voltage Range (RESET, FLAG)                                                                                                                                            | −0.3 to 10                                 | V                    |
| Input Voltage Range (MON)                                                                                                                                              | −0.3 to 10                                 | V                    |
| Input Voltage Range (ENABLE)                                                                                                                                           | −0.3 to 10**                               | V                    |
| ESD Susceptibility (Human Body Model)                                                                                                                                  | 2.0                                        | kV                   |
| Junction Temperature, T <sub>J</sub>                                                                                                                                   | −40 to +150                                | °C                   |
| Storage Temperature, T <sub>S</sub>                                                                                                                                    | −55 to 150                                 | °C                   |
| Package Thermal Resistance, SO−8:<br>Junction-to-Case, R <sub>θJC</sub><br>Junction-to-Ambient, R <sub>θJA</sub>                                                       | 45<br>165                                  | °C/W<br>°C/W         |
| Package Thermal Resistance, SOW−16 E PAD:<br>Junction-to-Case, R <sub>θJC</sub><br>Junction-to-Ambient, R <sub>θJA</sub><br>Junction-to-Pin, R <sub>θJP</sub> (Note 1) | 15<br>56<br>35                             | °C/W<br>°C/W<br>°C/W |
| Lead Temperature Soldering:<br>Reflow: (SMD styles only) (Note 2)                                                                                                      | 240 peak<br>260 Peak (Pb-Free)<br>(Note 3) | °C                   |

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

\*During the voltage range which exceeds the maximum tested voltage of  $V_{IN}$ , operation is assured, but not specified. Wider limits may apply.

Thermal dissipation must be observed closely.

**\*\*Reference Figure 14 for switched-battery ENABLE application.**

1. Measured to pin 16.
2. 150 second maximum above 183°C, Pb-Free – 150 second maximum above 217°C.
3. -5°C / +0°C allowable conditions, applies to both Pb and Pb-Free devices.

## NCV8501 Series

**ELECTRICAL CHARACTERISTICS** ( $I_{OUT} = 1.0 \text{ mA}$ ,  $ENABLE = 5.0 \text{ V}$ ,  $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ;  $V_{IN}$  dependent on voltage option  
(Note 4); unless otherwise specified.)

| Characteristic                                                                                                                  | Test Conditions                                                                                                                                                                                                      | Min                        | Typ                                | Max                                   | Unit                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|------------------------------------|---------------------------------------|----------------------------------------------------------------------------------------------------|
| <b>Output Stage</b>                                                                                                             |                                                                                                                                                                                                                      |                            |                                    |                                       |                                                                                                    |
| Output Voltage for 2.5 V Option                                                                                                 | $6.5 \text{ V} < V_{IN} < 16 \text{ V}$ , $100 \mu\text{A} \leq I_{OUT} \leq 150 \text{ mA}$<br><b><math>5.5 \text{ V} &lt; V_{IN} &lt; 26 \text{ V}</math></b> , $100 \mu\text{A} \leq I_{OUT} \leq 150 \text{ mA}$ | 2.450<br>2.425             | 2.5<br>2.5                         | 2.550<br>2.575                        | V<br>V                                                                                             |
| Output Voltage for 3.3 V Option                                                                                                 | $7.3 \text{ V} < V_{IN} < 16 \text{ V}$ , $100 \mu\text{A} \leq I_{OUT} \leq 150 \text{ mA}$<br><b><math>5.5 \text{ V} &lt; V_{IN} &lt; 26 \text{ V}</math></b> , $100 \mu\text{A} \leq I_{OUT} \leq 150 \text{ mA}$ | 3.234<br>3.201             | 3.3<br>3.3                         | 3.366<br>3.399                        | V<br>V                                                                                             |
| Output Voltage for 5.0 V Option                                                                                                 | $9.0 \text{ V} < V_{IN} < 16 \text{ V}$ , $100 \mu\text{A} \leq I_{OUT} \leq 150 \text{ mA}$<br><b><math>6.0 \text{ V} &lt; V_{IN} &lt; 26 \text{ V}</math></b> , $100 \mu\text{A} \leq I_{OUT} \leq 150 \text{ mA}$ | 4.90<br>4.85               | 5.0<br>5.0                         | 5.10<br>5.15                          | V<br>V                                                                                             |
| Output Voltage for 8.0 V Option                                                                                                 | <b><math>9.0 \text{ V} &lt; V_{IN} &lt; 26 \text{ V}</math></b> , $100 \mu\text{A} \leq I_{OUT} \leq 150 \text{ mA}$                                                                                                 | 7.76                       | 8.0                                | 8.24                                  | V                                                                                                  |
| Output Voltage for 10 V Option                                                                                                  | <b><math>11 \text{ V} &lt; V_{IN} &lt; 26 \text{ V}</math></b> , $100 \mu\text{A} \leq I_{OUT} \leq 150 \text{ mA}$                                                                                                  | 9.7                        | 10                                 | 10.3                                  | V                                                                                                  |
| Output Voltage for Adjustable Option                                                                                            | $V_{OUT} = V_{ADJ}$ (Unity Gain)<br>$6.5 \text{ V} < V_{IN} < 16 \text{ V}$ , $100 \mu\text{A} < I_{OUT} < 150 \text{ mA}$<br>$5.5 \text{ V} < V_{IN} < 26 \text{ V}$ , $100 \mu\text{A} < I_{OUT} < 150 \text{ mA}$ | 1.254<br>1.242             | 1.280<br>1.280                     | 1.306<br>1.318                        | V<br>V                                                                                             |
| Dropout Voltage ( $V_{IN} - V_{OUT}$ )<br>(5.0 V, 8.0 V, 10 V, and<br>Adj. > 5.0 V Options Only)                                | $I_{OUT} = 150 \text{ mA}$<br>$I_{OUT} = 1.0 \text{ mA}$                                                                                                                                                             | –<br>–                     | 400<br>100                         | 600<br>150                            | mV<br>mV                                                                                           |
| Load Regulation                                                                                                                 | $V_{IN} = 14 \text{ V}$ , $5.0 \text{ mA} \leq I_{OUT} \leq 150 \text{ mA}$                                                                                                                                          | –30                        | 5.0                                | 30                                    | mV                                                                                                 |
| Line Regulation                                                                                                                 | $[V_{OUT}(\text{Typ}) + 1.0] < V_{IN} < 26 \text{ V}$ , $I_{OUT} = 1.0 \text{ mA}$                                                                                                                                   | –                          | 15                                 | 60                                    | mV                                                                                                 |
| Quiescent Current, Low Load<br>2.5 V Option<br>3.3 V Option<br>5.0 V Option<br>8.0 V Option<br>10 V Option<br>Adjustable Option | $I_{OUT} = 100 \mu\text{A}$ , $V_{IN} = 12 \text{ V}$ , $MON = V_{OUT}$                                                                                                                                              | –<br>–<br>–<br>–<br>–<br>– | 90<br>90<br>90<br>100<br>100<br>50 | 125<br>125<br>125<br>150<br>150<br>75 | $\mu\text{A}$<br>$\mu\text{A}$<br>$\mu\text{A}$<br>$\mu\text{A}$<br>$\mu\text{A}$<br>$\mu\text{A}$ |
| Quiescent Current, Medium Load<br>All Options                                                                                   | $I_{OUT} = 75 \text{ mA}$ , $V_{IN} = 14 \text{ V}$ , $MON = V_{OUT}$                                                                                                                                                | –                          | 4.0                                | 6.0                                   | mA                                                                                                 |
| Quiescent Current, High Load<br>All Options                                                                                     | $I_{OUT} = 150 \text{ mA}$ , $V_{IN} = 14 \text{ V}$ , $MON = V_{OUT}$                                                                                                                                               | –                          | 12                                 | 19                                    | mA                                                                                                 |
| Quiescent Current, ( $I_Q$ )<br>Sleep Mode                                                                                      | $ENABLE = 0 \text{ V}$ , $V_{IN} = 12 \text{ V}$                                                                                                                                                                     | –                          | 12                                 | 30                                    | $\mu\text{A}$                                                                                      |
| Current Limit                                                                                                                   | –                                                                                                                                                                                                                    | 151                        | 300                                | –                                     | mA                                                                                                 |
| Short Circuit Output Current                                                                                                    | $V_{OUT} = 0 \text{ V}$                                                                                                                                                                                              | 40                         | 190                                | –                                     | mA                                                                                                 |
| Thermal Shutdown                                                                                                                | (Guaranteed by Design)                                                                                                                                                                                               | 150                        | 180                                | –                                     | $^{\circ}\text{C}$                                                                                 |

### Reset Function (RESET)

|                                                                           |                                                                                                        |              |                |                                                |        |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------|----------------|------------------------------------------------|--------|
| RESET Threshold for 2.5 V Option<br>HIGH ( $V_{RH}$ )<br>LOW ( $V_{RL}$ ) | $5.5 \text{ V} \leq V_{IN} \leq 26 \text{ V}$ (Note 5)<br>$V_{OUT}$ Increasing<br>$V_{OUT}$ Decreasing | 2.28<br>2.25 | 2.350<br>2.300 | $0.98 \times V_{OUT}$<br>$0.97 \times V_{OUT}$ | V<br>V |
| RESET Threshold for 3.3 V Option<br>HIGH ( $V_{RH}$ )<br>LOW ( $V_{RL}$ ) | $5.5 \text{ V} \leq V_{IN} \leq 26 \text{ V}$ (Note 5)<br>$V_{OUT}$ Increasing<br>$V_{OUT}$ Decreasing | 3.00<br>2.97 | 3.102<br>3.036 | $0.98 \times V_{OUT}$<br>$0.97 \times V_{OUT}$ | V<br>V |
| RESET Threshold for 5.0 V Option<br>HIGH ( $V_{RH}$ )<br>LOW ( $V_{RL}$ ) | $V_{OUT}$ Increasing<br>$V_{OUT}$ Decreasing                                                           | 4.55<br>4.50 | 4.70<br>4.60   | $0.98 \times V_{OUT}$<br>$0.97 \times V_{OUT}$ | V<br>V |

4. Voltage range specified in the Output Stage of the Electrical Characteristics in boldface type.

5. For  $V_{IN} \leq 5.5 \text{ V}$ , a RESET = Low may occur with the output in regulation.

## NCV8501 Series

**ELECTRICAL CHARACTERISTICS** ( $I_{OUT} = 1.0 \text{ mA}$ ,  $ENABLE = 5.0 \text{ V}$ ,  $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ;  $V_{IN}$  dependent on voltage option  
(Note 4); unless otherwise specified.)

| Characteristic                                                            | Test Conditions                                                       | Min          | Typ          | Max                                            | Unit          |
|---------------------------------------------------------------------------|-----------------------------------------------------------------------|--------------|--------------|------------------------------------------------|---------------|
| <b>Reset Function (RESET)</b>                                             |                                                                       |              |              |                                                |               |
| RESET Threshold for 8.0 V Option<br>HIGH ( $V_{RH}$ )<br>LOW ( $V_{RL}$ ) | $V_{OUT}$ Increasing<br>$V_{OUT}$ Decreasing                          | 6.86<br>6.80 | 7.52<br>7.36 | $0.98 \times V_{OUT}$<br>$0.97 \times V_{OUT}$ | V<br>V        |
| RESET Threshold for 10 V Option<br>HIGH ( $V_{RH}$ )<br>LOW ( $V_{RL}$ )  | $V_{OUT}$ Increasing<br>$V_{OUT}$ Decreasing                          | 8.60<br>8.50 | 9.40<br>9.20 | $0.98 \times V_{OUT}$<br>$0.97 \times V_{OUT}$ | V<br>V        |
| Output Voltage<br>Low ( $V_{RLO}$ )                                       | $1.0 \text{ V} \leq V_{OUT} \leq V_{RL}$ , $R_{RESET} = 10 \text{ k}$ | –            | 0.1          | 0.4                                            | V             |
| DELAY Switching Threshold ( $V_{DT}$ )                                    | –                                                                     | 1.4          | 1.8          | 2.2                                            | V             |
| DELAY Low Voltage                                                         | $V_{OUT} < \overline{RESET}$ Threshold Low(min)                       | –            | –            | 0.1                                            | V             |
| DELAY Charge Current                                                      | DELAY = 1.0 V, $V_{OUT} > V_{RH}$                                     | 1.5          | 2.5          | 3.5                                            | $\mu\text{A}$ |
| DELAY Discharge Current                                                   | DELAY = 1.0 V, $V_{OUT} = 1.5 \text{ V}$                              | 5.0          | –            | –                                              | mA            |

### FLAG/Monitor

|                           |                                        |      |      |      |               |
|---------------------------|----------------------------------------|------|------|------|---------------|
| Monitor Threshold         | Increasing and Decreasing              | 1.10 | 1.20 | 1.31 | V             |
| Hysteresis                | –                                      | 20   | 50   | 100  | mV            |
| Input Current             | MON = 2.0 V                            | –0.5 | 0.1  | 0.5  | $\mu\text{A}$ |
| Output Saturation Voltage | MON = 0 V, $I_{FLAG} = 1.0 \text{ mA}$ | –    | 0.1  | 0.4  | V             |

### Voltage Adjust (Adjustable Output only)

|               |                            |      |   |     |               |
|---------------|----------------------------|------|---|-----|---------------|
| Input Current | $V_{ADJ} = 1.28 \text{ V}$ | –0.5 | – | 0.5 | $\mu\text{A}$ |
|---------------|----------------------------|------|---|-----|---------------|

### ENABLE

|                 |                |          |        |          |               |
|-----------------|----------------|----------|--------|----------|---------------|
| Input Threshold | Low<br>High    | –<br>3.0 | –<br>– | 0.5<br>– | V<br>V        |
| Input Current   | ENABLE = 5.0 V | –        | 1.0    | 5.0      | $\mu\text{A}$ |

4. Voltage range specified in the Output Stage of the Electrical Characteristics in boldface type.
5. For  $V_{IN} \leq 5.5 \text{ V}$ , a RESET = Low may occur with the output in regulation.

## NCV8501 Series

### PACKAGE PIN DESCRIPTION, ADJUSTABLE OUTPUT

| Package Pin Number |                       | Pin Symbol       | Function                                                                                       |
|--------------------|-----------------------|------------------|------------------------------------------------------------------------------------------------|
| SO-8               | SOW-16<br>E PAD       |                  |                                                                                                |
| 1                  | 7                     | V <sub>IN</sub>  | Input Voltage.                                                                                 |
| 2                  | 8                     | MON              | Monitor. Input for early warning comparator. If not needed connect to V <sub>OUT</sub> .       |
| 3                  | 9                     | ENABLE           | ENABLE control for the IC. A high powers the device up.                                        |
| 4                  | 3-6, 10-12,<br>14, 15 | NC               | No connection.                                                                                 |
| 5                  | 13                    | GND              | Ground. All GND leads must be connected to Ground.                                             |
| 6                  | 16                    | FLAG             | Open collector output from early warning comparator.                                           |
| 7                  | 1                     | V <sub>ADJ</sub> | Voltage Adjust. A resistor divider from V <sub>OUT</sub> to this lead sets the output voltage. |
| 8                  | 2                     | V <sub>OUT</sub> | ±2.0%, 150 mA output.                                                                          |

### PACKAGE PIN DESCRIPTION, FIXED OUTPUT

| Package Pin Number |                        | Pin Symbol                | Function                                                                                 |
|--------------------|------------------------|---------------------------|------------------------------------------------------------------------------------------|
| SO-8               | SOW-16<br>E PAD        |                           |                                                                                          |
| 1                  | 7                      | V <sub>IN</sub>           | Input Voltage.                                                                           |
| 2                  | 8                      | MON                       | Monitor. Input for early warning comparator. If not needed connect to V <sub>OUT</sub> . |
| 3                  | 9                      | ENABLE                    | ENABLE control for the IC. A high powers the device up.                                  |
| 4                  | 10                     | DELAY                     | Timing capacitor for $\overline{\text{RESET}}$ function.                                 |
| 5                  | 13                     | GND                       | Ground. All GND leads must be connected to Ground.                                       |
| 6                  | 16                     | $\overline{\text{RESET}}$ | Active reset (accurate to V <sub>OUT</sub> ≥ 1.0 V)                                      |
| 7                  | 1                      | FLAG                      | Open collector output from early warning comparator.                                     |
| 8                  | 2                      | V <sub>OUT</sub>          | ±2.0%, 150 mA output.                                                                    |
| –                  | 3-6, 11, 12,<br>14, 15 | NC                        | No connection.                                                                           |

TYPICAL PERFORMANCE CHARACTERISTICS

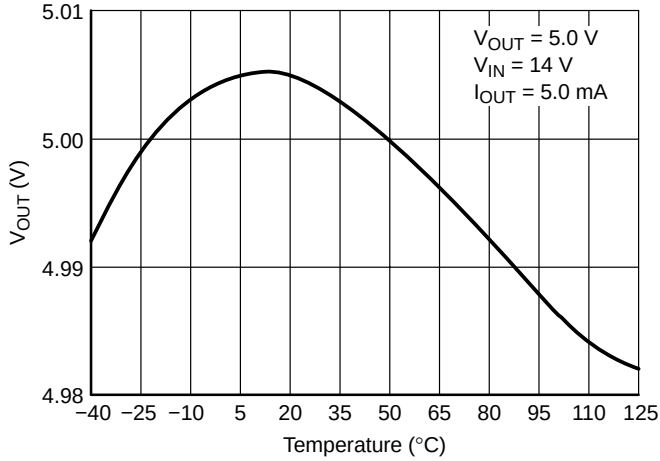


Figure 2. Output Voltage vs. Temperature

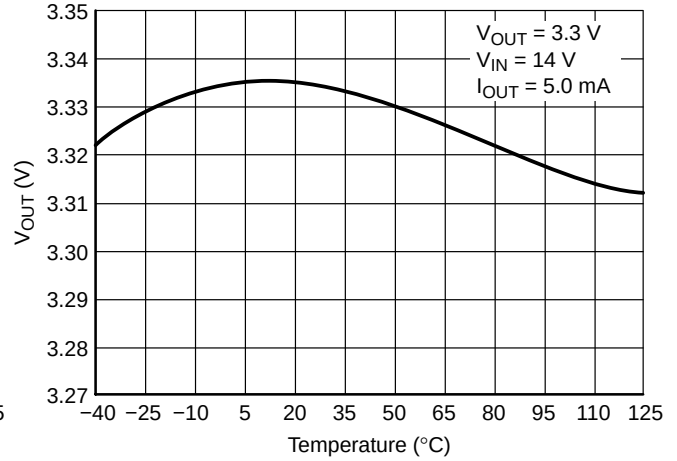


Figure 3. Output Voltage vs. Temperature

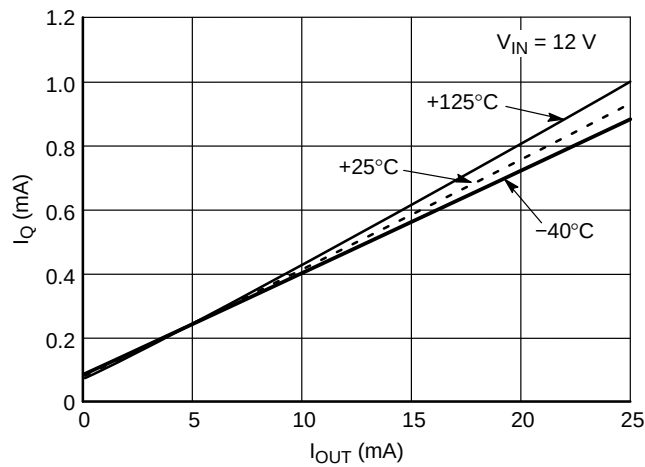


Figure 4. Quiescent Current vs. Output Current

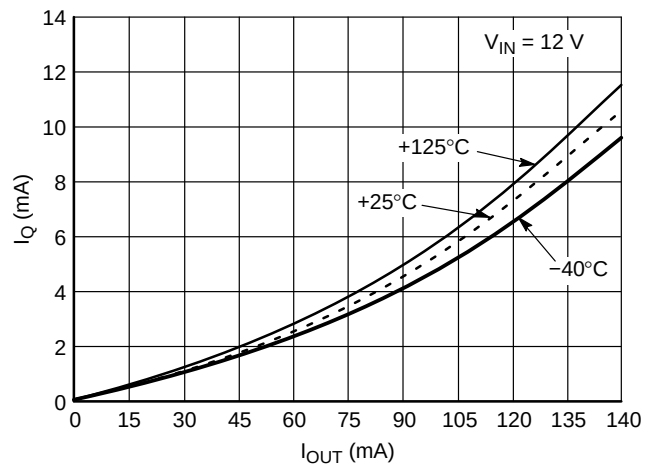


Figure 5. Quiescent Current vs. Output Current

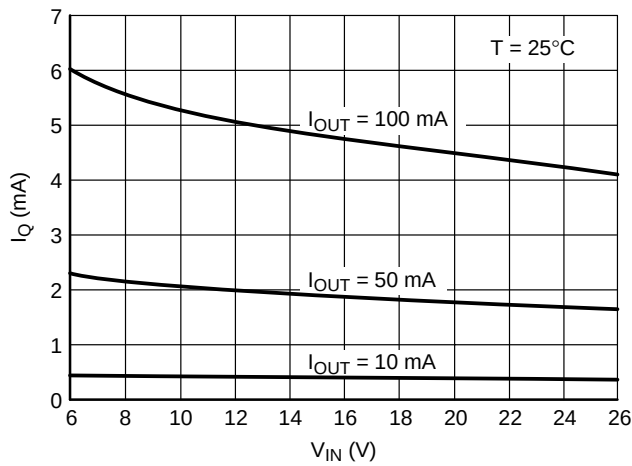


Figure 6. Quiescent Current vs. Input Voltage

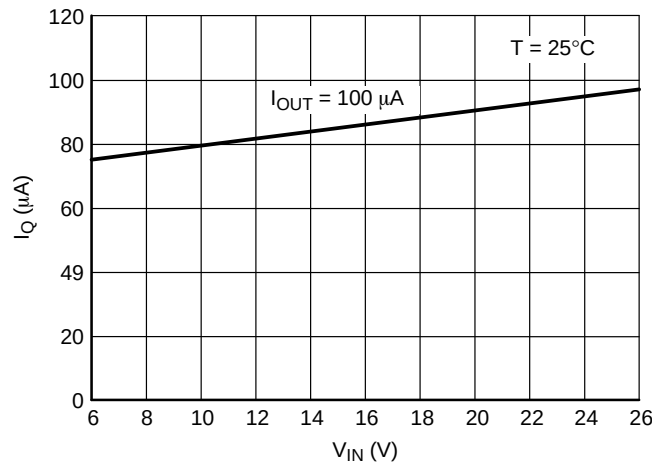


Figure 7. Quiescent Current vs. Input Voltage

TYPICAL PERFORMANCE CHARACTERISTICS

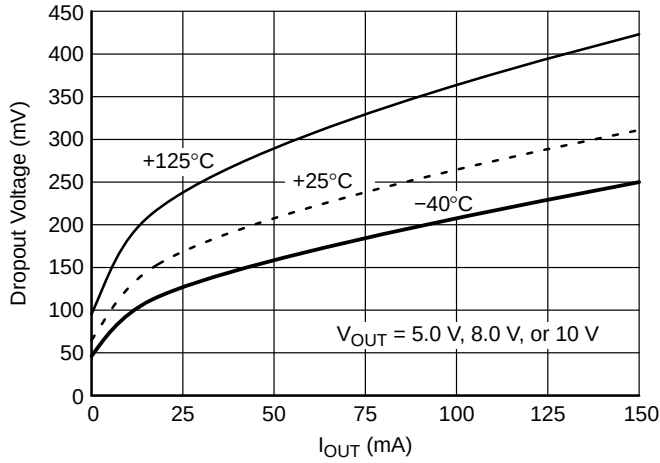


Figure 8. Dropout Voltage vs. Output Current

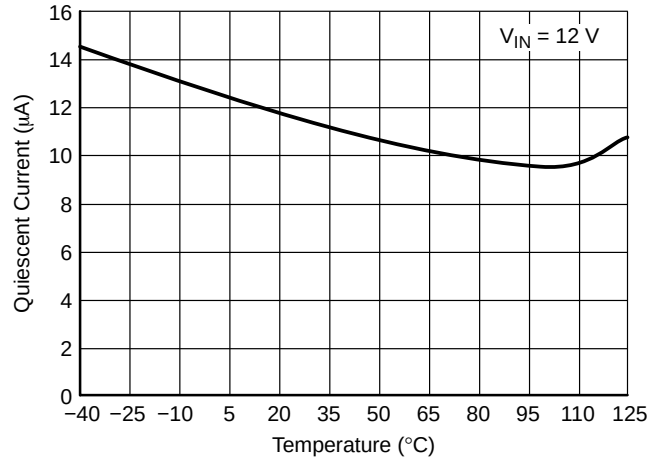


Figure 9. Sleep Mode  $I_Q$  vs. Temperature

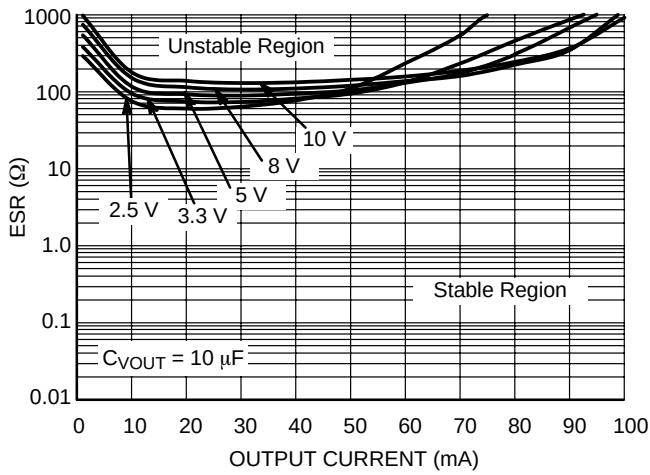


Figure 10. Output Stability with Output Voltage Change

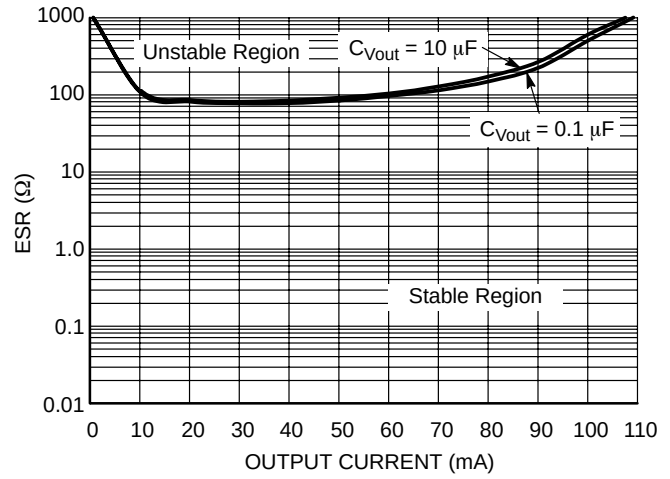


Figure 11. Output Stability with Output Capacitor Change



# NCV8501 Series

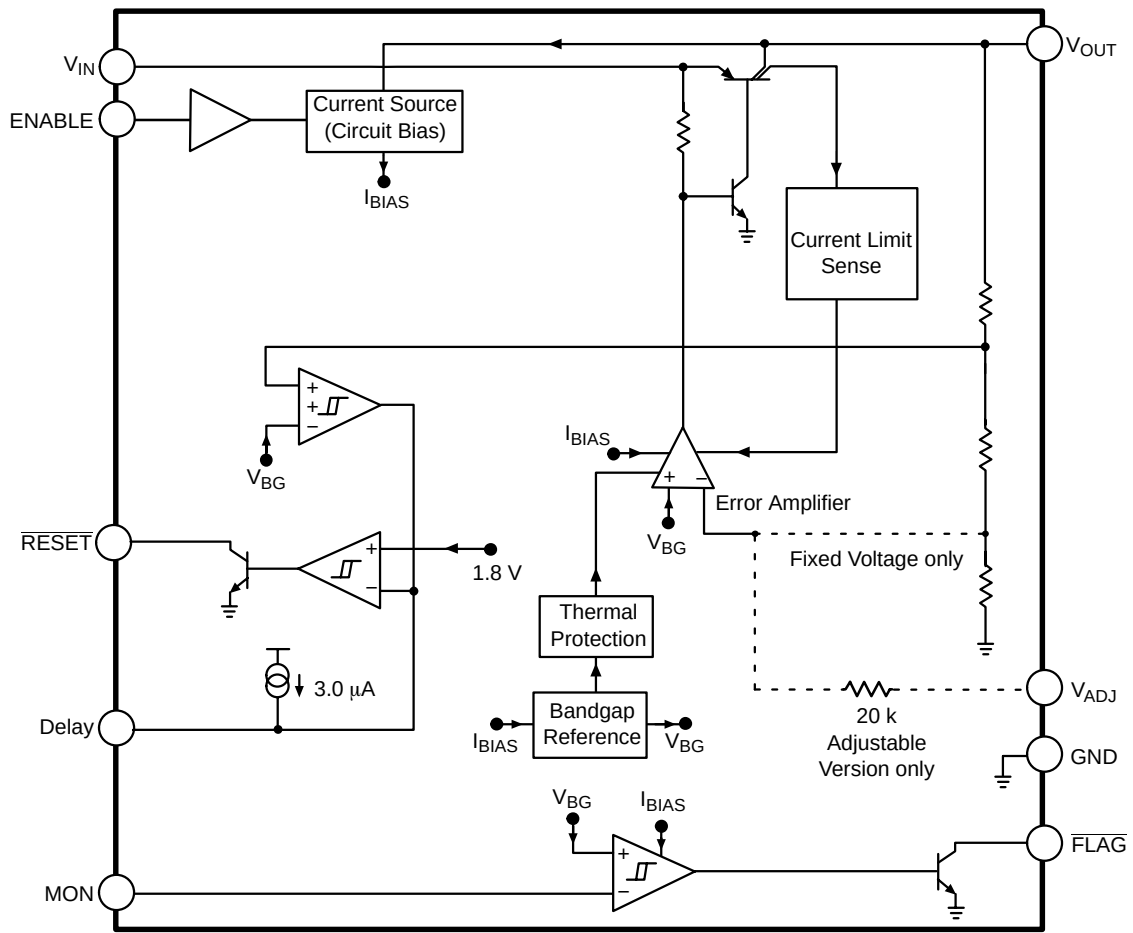


Figure 12. Block Diagram

## CIRCUIT DESCRIPTION

### REGULATOR CONTROL FUNCTIONS

The NCV8501 contains the microprocessor compatible control function  $\overline{\text{RESET}}$  (Figure 13).

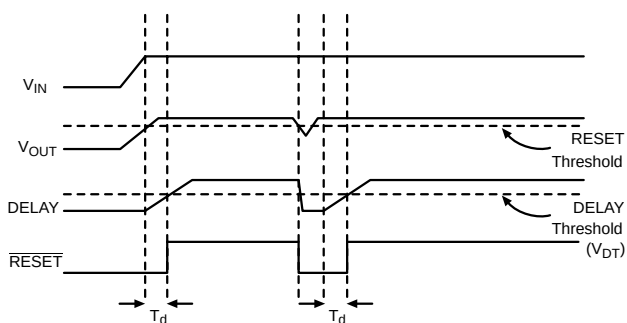


Figure 13. Reset and Delay Circuit Wave Forms

### $\overline{\text{RESET}}$ Function

A  $\overline{\text{RESET}}$  signal (low voltage) is generated as the IC powers up until  $V_{\text{OUT}}$  is within 6.0% of the regulated output voltage, or when  $V_{\text{OUT}}$  drops out of regulation, and is lower than 8.0% below the regulated output voltage. Hysteresis is included in the function to minimize oscillations.

The  $\overline{\text{RESET}}$  output is an open collector NPN transistor, controlled by a low voltage detection circuit. The circuit is functionally independent of the rest of the IC thereby guaranteeing that the  $\overline{\text{RESET}}$  signal is valid for  $V_{\text{OUT}}$  as low as 1.0 V.

### ENABLE Function

The part stays in a low  $I_{\text{Q}}$  sleep mode when the ENABLE pin is held low. The part has an internal pull down if the pin is left floating. This is intended for failure modes only. An external connection (active pulldown, resistor, or switch) for normal operation is recommended.

The integrity of the ENABLE pin allows it to be tied directly to the battery line through an external resistor. It will withstand load dump potentials in this configuration.

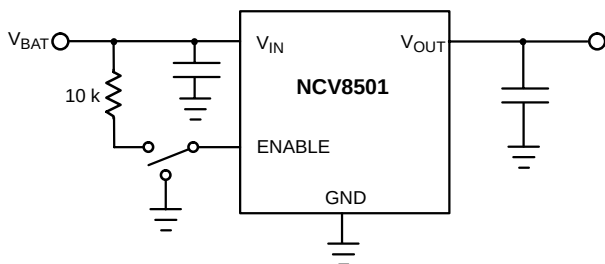


Figure 14. ENABLE Function

### DELAY Function

The reset delay circuit provides a programmable (by external capacitor) delay on the  $\overline{\text{RESET}}$  output lead.

The DELAY lead provides source current (typically 2.5  $\mu\text{A}$ ) to the external DELAY capacitor during the following proceedings:

1. During Power Up (once the regulation threshold has been verified).
2. After a reset event has occurred and the device is back in regulation. The DELAY capacitor is discharged when the regulation ( $\overline{\text{RESET}}$  threshold) has been violated. This is a latched incident. The capacitor will fully discharge and wait for the device to regulate before going through the delay time event again.

### $\overline{\text{FLAG}}$ /Monitor Function

An on-chip comparator is provided to perform an early warning to the microprocessor of a possible reset signal. The reset signal typically turns the microprocessor off instantaneously. This can cause unpredictable results with the microprocessor. The signal received from the  $\overline{\text{FLAG}}$  pin will allow the microprocessor time to complete its present task before shutting down. This function is performed by a comparator referenced to the bandgap reference. The actual trip point can be programmed externally using a resistor divider to the input monitor (MON) (Figure 15). The typical threshold is 1.20 V on the MON pin.

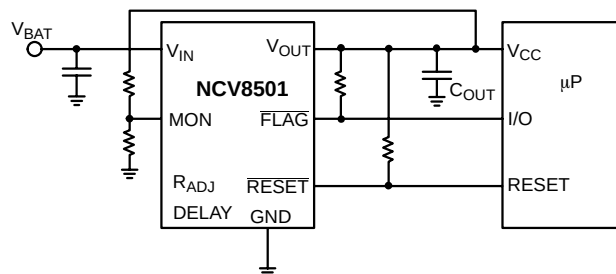


Figure 15.  $\overline{\text{FLAG}}$ /Monitor Function

### Voltage Adjust

Figure 16 shows the device setup for a user configurable output voltage. The feedback to the  $V_{\text{ADJ}}$  pin is taken from a voltage divider referenced to the output voltage. The loop is balanced around the Unity Gain threshold (1.28 V typical).

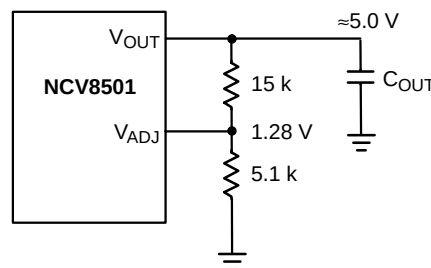


Figure 16. Adjustable Output Voltage

## APPLICATION NOTES

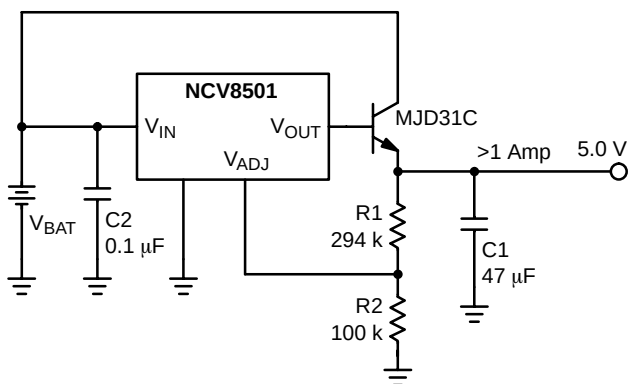


Figure 17. Additional Output Current

### Adding Capability

Figure 17 shows how the adjustable version of parts can be used with an external pass transistor for additional current capability. The setup as shown will provide greater than 1 Amp of output current.

### FLAG MONITOR

Figure 18 shows the FLAG Monitor waveforms as a result of the circuit depicted in Figure 15. As the output voltage falls ( $V_{OUT}$ ), the Monitor threshold is crossed. This causes the voltage on the  $\overline{FLAG}$  output to go low sending a warning signal to the microprocessor that a  $\overline{RESET}$  signal may occur in a short period of time.  $T_{WARNING}$  is the time the microprocessor has to complete the function it is currently working on and get ready for the  $\overline{RESET}$  shutdown signal.

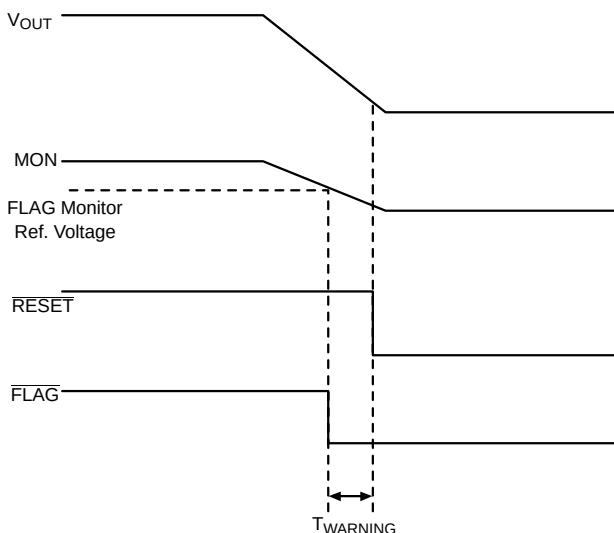
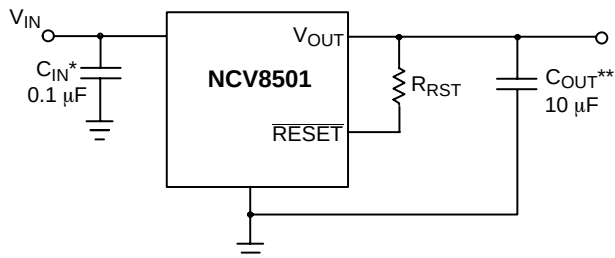


Figure 18. FLAG Monitor Circuit Waveform



\* $C_{IN}$  required if regulator is located far from the power supply filter

\*\* $C_{OUT}$  required for stability. Capacitor must operate at minimum temperature expected

Figure 19. Test and Application Circuit Showing Output Compensation

### SETTING THE DELAY TIME

The delay time is controlled by the Reset Delay Low Voltage, Delay Switching Threshold, and the Delay Charge Current. The delay follows the equation:

$$t_{DELAY} = \frac{[C_{DELAY}(V_{dt} - \text{Reset Delay Low Voltage})]}{\text{Delay Charge Current}}$$

Example:

Using  $C_{DELAY} = 33 \text{ nF}$ .

Assume reset Delay Low Voltage = 0.

Use the typical value for  $V_{dt} = 1.8 \text{ V}$ .

Use the typical value for Delay Charge Current =  $2.5 \mu\text{A}$ .

$$t_{DELAY} = \frac{[33 \text{ nF}(1.8 - 0)]}{2.5 \mu\text{A}} = 23.8 \text{ ms}$$

### STABILITY CONSIDERATIONS

The output or compensation capacitor helps determine three main characteristics of a linear regulator: start-up delay, load transient response and loop stability.

The capacitor value and type should be based on cost, availability, size and temperature constraints. A tantalum or aluminum electrolytic capacitor is best, since a film or ceramic capacitor with almost zero ESR can cause instability. The aluminum electrolytic capacitor is the least expensive solution, but, if the circuit operates at low temperatures ( $-25^{\circ}\text{C}$  to  $-40^{\circ}\text{C}$ ), both the value and ESR of the capacitor will vary considerably. The capacitor manufacturers data sheet usually provides this information.

The value for the output capacitor  $C_{OUT}$  shown in Figure 19 should work for most applications, however it is not necessarily the optimized solution.

### CALCULATING POWER DISSIPATION IN A SINGLE OUTPUT LINEAR REGULATOR

The maximum power dissipation for a single output regulator (Figure 20) is:

$$P_{D(max)} = [V_{IN(max)} - V_{OUT(min)}]I_{OUT(max)} + V_{IN(max)}I_Q \quad (\text{eq. 1})$$

where:

$V_{IN(max)}$  is the maximum input voltage,

$V_{OUT(min)}$  is the minimum output voltage,

$I_{OUT(max)}$  is the maximum output current for the application, and

$I_Q$  is the quiescent current the regulator consumes at  $I_{OUT(max)}$ .

Once the value of  $P_{D(max)}$  is known, the maximum permissible value of  $R_{\theta JA}$  can be calculated:

$$R_{\theta JA} = \frac{150^{\circ}\text{C} - T_A}{P_D} \quad (\text{eq. 2})$$

The value of  $R_{\theta JA}$  can then be compared with those in the package section of the data sheet. Those packages with  $R_{\theta JA}$ 's less than the calculated value in Equation 2 will keep the die temperature below  $150^{\circ}\text{C}$ .

In some cases, none of the packages will be sufficient to dissipate the heat generated by the IC, and an external heatsink will be required.

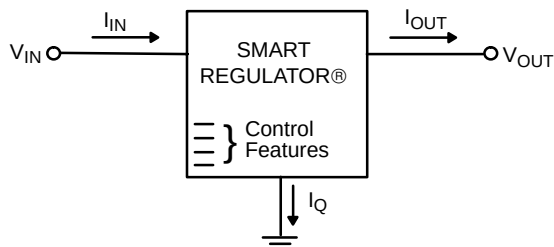


Figure 20. Single Output Regulator with Key Performance Parameters Labeled

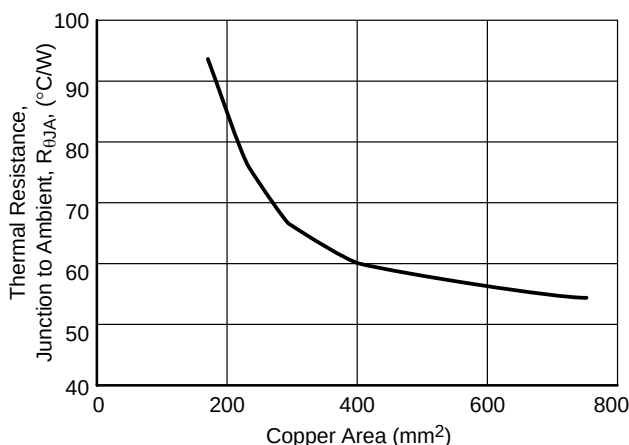


Figure 21. 16 Lead SOW (Exposed Pad),  $\theta_{JA}$  as a Function of the Pad Copper Area (2 oz. Cu Thickness), Board Material = 0.0625" G-10/R-4

### HEATSINKS

A heatsink effectively increases the surface area of the package to improve the flow of heat away from the IC and into the surrounding air.

Each material in the heat flow path between the IC and the outside environment will have a thermal resistance. Like series electrical resistances, these resistances are summed to determine the value of  $R_{\theta JA}$ :

$$R_{\theta JA} = R_{\theta JC} + R_{\theta CS} + R_{\theta SA} \quad (\text{eq. 3})$$

where:

$R_{\theta JC}$  = the junction-to-case thermal resistance,

$R_{\theta CS}$  = the case-to-heatsink thermal resistance, and

$R_{\theta SA}$  = the heatsink-to-ambient thermal resistance.

$R_{\theta JC}$  appears in the package section of the data sheet. Like  $R_{\theta JA}$ , it too is a function of package type.  $R_{\theta CS}$  and  $R_{\theta SA}$  are functions of the package type, heatsink and the interface between them. These values appear in heatsink data sheets of heatsink manufacturers.

## NCV8501 Series

### ORDERING INFORMATION

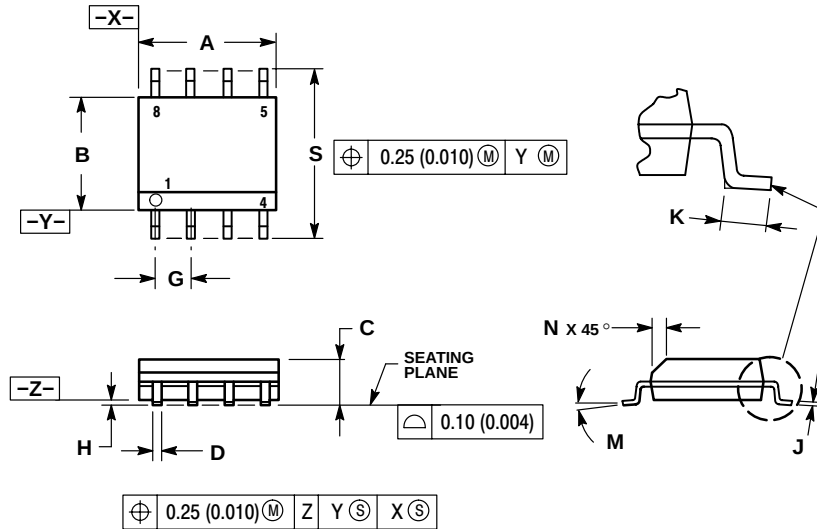
| Device          | Output Voltage | Package            | Shipping†        |
|-----------------|----------------|--------------------|------------------|
| NCV8501DADJ     | Adjustable     | SO-8               | 98 Units/Rail    |
| NCV8501DADJG    | Adjustable     | SO-8<br>(Pb-Free)  | 98 Units/Rail    |
| NCV8501DADJR2   | Adjustable     | SO-8               | 2500 Tape & Reel |
| NCV8501DADJR2G  | Adjustable     | SO-8<br>(Pb-Free)  | 2500 Tape & Reel |
| NCV8501PDWADJ   | Adjustable     | SOW-16 Exposed Pad | 47 Units/Rail    |
| NCV8501PDWADJR2 |                |                    | 1000 Tape & Reel |
| NCV8501D25      | 2.5 V          | SO-8               | 98 Units/Rail    |
| NCV8501D25G     | 2.5 V          | SO-8<br>(Pb-Free)  | 98 Units/Rail    |
| NCV8501D25R2    | 2.5 V          | SO-8               | 2500 Tape & Reel |
| NCV8501D25R2G   | 2.5 V          | SO-8<br>(Pb-Free)  | 2500 Tape & Reel |
| NCV8501PDW25    | 2.5 V          | SOW-16 Exposed Pad | 47 Units/Rail    |
| NCV8501PDW25R2  |                |                    | 1000 Tape & Reel |
| NCV8501D33      | 3.3 V          | SO-8               | 98 Units/Rail    |
| NCV8501D33G     | 3.3 V          | SO-8<br>(Pb-Free)  | 98 Units/Rail    |
| NCV8501D33R2    | 3.3 V          | SO-8               | 2500 Tape & Reel |
| NCV8501D33R2G   | 3.3 V          | SO-8<br>(Pb-Free)  | 2500 Tape & Reel |
| NCV8501PDW33    | 3.3 V          | SOW-16 Exposed Pad | 47 Units/Rail    |
| NCV8501PDW33R2  |                |                    | 1000 Tape & Reel |
| NCV8501D50      | 5.0 V          | SO-8               | 98 Units/Rail    |
| NCV8501D50G     | 5.0 V          | SO-8<br>(Pb-Free)  | 98 Units/Rail    |
| NCV8501D50R2    | 5.0 V          | SO-8               | 2500 Tape & Reel |
| NCV8501D50R2G   | 5.0 V          | SO-8<br>(Pb-Free)  | 2500 Tape & Reel |
| NCV8501PDW50    | 5.0 V          | SOW-16 Exposed Pad | 47 Units/Rail    |
| NCV8501PDW50R2  |                |                    | 1000 Tape & Reel |
| NCV8501D80      | 8.0 V          | SO-8               | 98 Units/Rail    |
| NCV8501D80G     | 8.0 V          | SO-8<br>(Pb-Free)  | 98 Units/Rail    |
| NCV8501D80R2    | 8.0 V          | SO-8               | 2500 Tape & Reel |
| NCV8501D80R2G   | 8.0 V          | SO-8<br>(Pb-Free)  | 2500 Tape & Reel |
| NCV8501PDW80    | 8.0 V          | SOW-16 Exposed Pad | 47 Units/Rail    |
| NCV8501PDW80R2  |                |                    | 1000 Tape & Reel |
| NCV8501D100     | 10 V           | SO-8               | 98 Units/Rail    |
| NCV8501D100G    | 10 V           | SO-8<br>(Pb-free)  | 98 Units/Rail    |
| NCV8501D100R2   | 10 V           | SO-8               | 2500 Tape & Reel |
| NCV8501D100R2G  | 10 V           | SO-8<br>(Pb-Free)  | 2500 Tape & Reel |
| NCV8501PDW100   | 10 V           | SOW-16 Exposed Pad | 47 Units/Rail    |
| NCV8501PDW100R2 |                |                    | 1000 Tape & Reel |

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

# NCV8501 Series

## PACKAGE DIMENSIONS

SO-8 NB  
D SUFFIX  
CASE 751-07  
ISSUE AB

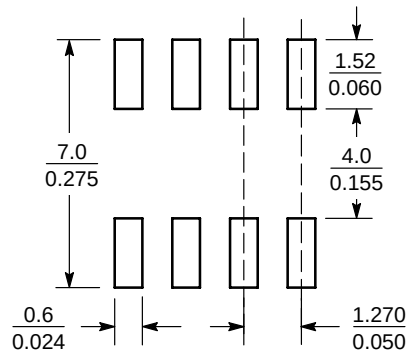


### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751-01 THRU 751-06 ARE OBSOLETE. NEW STANDARD IS 751-07.

| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 4.80        | 5.00 | 0.189     | 0.197 |
| B   | 3.80        | 4.00 | 0.150     | 0.157 |
| C   | 1.35        | 1.75 | 0.053     | 0.069 |
| D   | 0.33        | 0.51 | 0.013     | 0.020 |
| G   | 1.27 BSC    |      | 0.050 BSC |       |
| H   | 0.10        | 0.25 | 0.004     | 0.010 |
| J   | 0.19        | 0.25 | 0.007     | 0.010 |
| K   | 0.40        | 1.27 | 0.016     | 0.050 |
| M   | 0°          | 8°   | 0°        | 8°    |
| N   | 0.25        | 0.50 | 0.010     | 0.020 |
| S   | 5.80        | 6.20 | 0.228     | 0.244 |

## SOLDERING FOOTPRINT\*



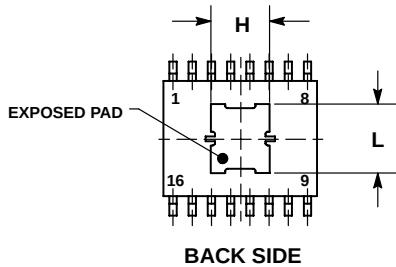
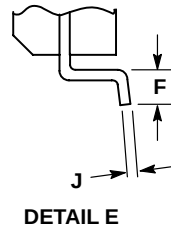
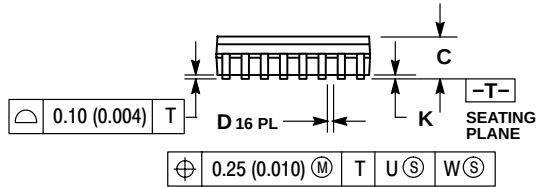
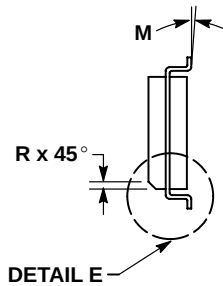
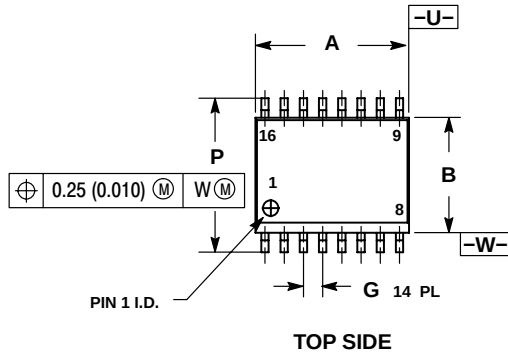
SCALE 6:1  $\left( \frac{\text{mm}}{\text{inches}} \right)$

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

# NCV8501 Series

## PACKAGE DIMENSIONS

SOIC 16 LEAD WIDE BODY  
EXPOSED PAD  
PDW SUFFIX  
CASE 751R-02  
ISSUE A



### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.13 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751R-01 OBSOLETE, NEW STANDARD 751R-02.

| DIM | MILLIMETERS |       | INCHES    |       |
|-----|-------------|-------|-----------|-------|
|     | MIN         | MAX   | MIN       | MAX   |
| A   | 10.15       | 10.45 | 0.400     | 0.411 |
| B   | 7.40        | 7.60  | 0.292     | 0.299 |
| C   | 2.35        | 2.65  | 0.093     | 0.104 |
| D   | 0.35        | 0.49  | 0.014     | 0.019 |
| F   | 0.50        | 0.90  | 0.020     | 0.035 |
| G   | 1.27 BSC    |       | 0.050 BSC |       |
| H   | 3.76        | 3.86  | 0.148     | 0.152 |
| J   | 0.25        | 0.32  | 0.010     | 0.012 |
| K   | 0.10        | 0.25  | 0.004     | 0.009 |
| L   | 4.58        | 4.78  | 0.180     | 0.188 |
| M   | 0°          | 7°    | 0°        | 7°    |
| P   | 10.05       | 10.55 | 0.395     | 0.415 |
| R   | 0.25        | 0.75  | 0.010     | 0.029 |

# NCV8501 Series

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