

# NCP502, NCP502A

## 80 mA CMOS Low I<sub>q</sub> Voltage Regulator in an SC70-5

The NCP502/A series of fixed output linear regulators are designed for handheld communication equipment and portable battery powered applications which require low quiescent. The NCP502/A series features an ultra-low quiescent current of 40  $\mu$ A. Each device contains a voltage reference unit, an error amplifier, a PMOS power transistor, resistors for setting output voltage, current limit, and temperature limit protection circuits.

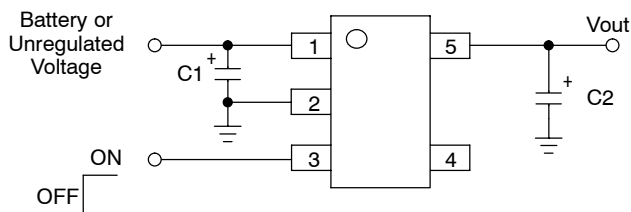
The NCP502/A has been designed to be used with low cost ceramic capacitors. The device is housed in the micro-miniature SC70-5 surface mount package. Standard voltage versions are 1.5 V, 1.8 V, 2.5 V, 2.7 V, 2.8 V, 3.0 V, 3.3 V, 3.5 V, and 5.0 V. Other voltages are available in 100 mV steps.

### Features

- Pb-Free Packages are Available
- Low Quiescent Current of 40  $\mu$ A Typical
- Excellent Line and Load Regulation
- Low Output Voltage Option
- Output Voltage Accuracy of 2.0%
- Industrial Temperature Range of -40°C to 85°C
- NCP502: 1.3 V Enable Threshold High, 0.3 V Enable Threshold Low
- NCP502A: 1.0 V Enable Threshold High, 0.4 V Enable Threshold Low

### Typical Applications

- Cellular Phones
- Battery Powered Consumer Products
- Hand-Held Instruments
- Camcorders and Cameras



This device contains 86 active transistors

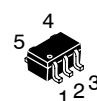
**Figure 1. Typical Application Diagram**



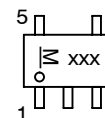
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<http://onsemi.com>

### MARKING DIAGRAM

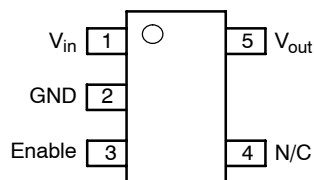


**SC70-5**  
**SQ SUFFIX**  
**CASE 419A**



xxx = Specific Device Code  
M = Date Code

### PIN CONNECTIONS



(Top View)

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 8 of this data sheet.

# NCP502, NCP502A

## PIN FUNCTION DESCRIPTION

| Pin No. | Pin Name         | Description                                                                                                                                                                                         |
|---------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | V <sub>in</sub>  | Positive power supply input voltage.                                                                                                                                                                |
| 2       | GND              | Power supply ground.                                                                                                                                                                                |
| 3       | Enable           | This input is used to place the device into low-power standby. When this input is pulled low, the device is disabled. If this function is not used, Enable should be connected to V <sub>in</sub> . |
| 4       | N/C              | No internal connection.                                                                                                                                                                             |
| 5       | V <sub>out</sub> | Regulated output voltage.                                                                                                                                                                           |

## MAXIMUM RATINGS

| Rating                                                                                                        | Symbol                             | Value                        | Unit      |
|---------------------------------------------------------------------------------------------------------------|------------------------------------|------------------------------|-----------|
| Input Voltage                                                                                                 | V <sub>in</sub>                    | 12                           | V         |
| Enable Voltage                                                                                                | Enable                             | -0.3 to V <sub>in</sub> +0.3 | V         |
| Output Voltage                                                                                                | V <sub>out</sub>                   | -0.3 to V <sub>in</sub> +0.3 | V         |
| Power Dissipation and Thermal Characteristics<br>Power Dissipation<br>Thermal Resistance, Junction to Ambient | P <sub>D</sub><br>R <sub>θJA</sub> | Internally Limited<br>400    | W<br>°C/W |
| Operating Junction Temperature                                                                                | T <sub>J</sub>                     | +125                         | °C        |
| Operating Ambient Temperature                                                                                 | T <sub>A</sub>                     | -40 to +85                   | °C        |
| Storage Temperature                                                                                           | T <sub>stg</sub>                   | -55 to +150                  | °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.

1. This device series contains ESD protection and exceeds the following tests:  
Human Body Model 2000 V per MIL-STD-883, Method 3015.  
Machine Model Method 200 V.
2. Latchup capability (85°C) ± 100 mA DC with trigger voltage.

# NCP502, NCP502A

**ELECTRICAL CHARACTERISTICS** ( $V_{in} = V_{out(nom.)} + 2.0\text{ V}$ ,  $V_{enable} = V_{in}$ ,  $C_{in} = 1.0\text{ }\mu\text{F}$ ,  $C_{out} = 1.0\text{ }\mu\text{F}$ ,  $T_J = 25^\circ\text{C}$ , unless otherwise noted.)

| Characteristic                                                                                                                                                                                                           | Symbol              | Min                                                                          | Typ                                                         | Max                                                                         | Unit                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------------------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------|
| Output Voltage ( $T_A = 25^\circ\text{C}$ , $I_{out} = 10\text{ mA}$ ) $V_{in} = V_{out(nom.)} + 1.0\text{ V}$<br>1.5 V<br>1.8 V<br>2.5 V<br>2.7 V<br>2.8 V<br>3.0 V<br>3.3 V<br>3.5 V<br>5.0 V                          | $V_{out}$           | 1.455<br>1.746<br>2.425<br>2.646<br>2.744<br>2.94<br>3.234<br>3.43<br>4.900  | 1.5<br>1.8<br>2.5<br>2.7<br>2.8<br>3.0<br>3.3<br>3.5<br>5.0 | 1.545<br>1.854<br>2.575<br>2.754<br>2.856<br>3.06<br>3.366<br>3.57<br>5.100 | V                     |
| Output Voltage ( $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ , $I_{out} = 10\text{ mA}$ ) $V_{in} = V_{out(nom.)}$<br>1.5 V<br>1.8 V<br>2.5 V<br>2.7 V<br>2.8 V<br>3.0 V<br>3.3 V<br>3.5 V<br>5.0 V                  | $V_{out}$           | 1.455<br>1.746<br>2.425<br>2.619<br>2.716<br>2.910<br>3.201<br>3.43<br>4.900 | 1.5<br>1.8<br>2.5<br>2.7<br>2.8<br>3.0<br>3.3<br>3.5<br>5.0 | 1.545<br>1.854<br>2.575<br>2.781<br>2.884<br>3.09<br>3.399<br>3.57<br>5.100 | V                     |
| Line Regulation ( $V_{in} = V_{out} + 1.0\text{ V}$ to $12\text{ V}$ , $I_{out} = 10\text{ mA}$ )                                                                                                                        | $\text{Reg}_{line}$ | –                                                                            | 0.4                                                         | 3.0                                                                         | mV/V                  |
| Load Regulation ( $I_{out} = 1.0\text{ mA}$ to $80\text{ mA}$ )                                                                                                                                                          | $\text{Reg}_{load}$ | –                                                                            | 0.2                                                         | 0.8                                                                         | mV/mA                 |
| Output Current ( $V_{out} = (V_{out} \text{ at } I_{out} = 80\text{ mA}) - 3\%$ )                                                                                                                                        | $I_{o(nom.)}$       | 80                                                                           | 180                                                         | –                                                                           | mA                    |
| Dropout Voltage ( $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ , $I_{out} = 80\text{ mA}$ , Measured at $V_{out} - 3.0\%$ )<br>1.5 V–1.7 V<br>1.8 V–2.4 V<br>2.5 V–2.6 V<br>2.7 V–2.9 V<br>3.0 V–4.0 V<br>4.1 V–5.0 V | $V_{in} - V_{out}$  | –<br>–<br>–<br>–<br>–<br>–                                                   | 1500<br>1300<br>1000<br>850<br>850<br>600                   | 1900<br>1700<br>1400<br>1300<br>1200<br>900                                 | mV                    |
| Quiescent Current<br>(Enable Input = 0 V)<br>(Enable Input = $V_{in}$ , $I_{out} = 1.0\text{ mA}$ to $I_{o(nom.)}$ )                                                                                                     | $I_Q$               | –<br>–                                                                       | 0.1<br>40                                                   | 1.0<br>90                                                                   | $\mu\text{A}$         |
| Output Short Circuit Current ( $V_{out} = 0\text{ V}$ )                                                                                                                                                                  | $I_{out(max)}$      | 90                                                                           | 200                                                         | 500                                                                         | mA                    |
| Ripple Rejection ( $f = 1.0\text{ kHz}$ , $15\text{ mA}$ )                                                                                                                                                               | RR                  | –                                                                            | 55                                                          | –                                                                           | dB                    |
| Output Voltage Noise ( $f = 100\text{ Hz}$ to $100\text{ kHz}$ )                                                                                                                                                         | $V_n$               | –                                                                            | 180                                                         | –                                                                           | $\mu\text{V}_{rms}$   |
| Enable Input Threshold Voltage (NCP502)<br>(Voltage Increasing, Output Turns On, Logic High)<br>(Voltage Decreasing, Output Turns Off, Logic Low)                                                                        | $V_{th(en)}$        | 1.3<br>–                                                                     | –<br>–                                                      | –<br>0.3                                                                    | V                     |
| Enable Input Threshold Voltage (NCP502A)<br>(Voltage Increasing, Output Turns On, Logic High)<br>(Voltage Decreasing, Output Turns Off, Logic Low)                                                                       | $V_{th(en)}$        | 1.0<br>–                                                                     | –<br>–                                                      | –<br>0.4                                                                    | V                     |
| Output Voltage Temperature Coefficient                                                                                                                                                                                   | $T_C$               | –                                                                            | 100                                                         | –                                                                           | ppm/ $^\circ\text{C}$ |

3. Maximum package power dissipation limits must be observed.

$$PD = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

4. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.

# NCP502, NCP502A

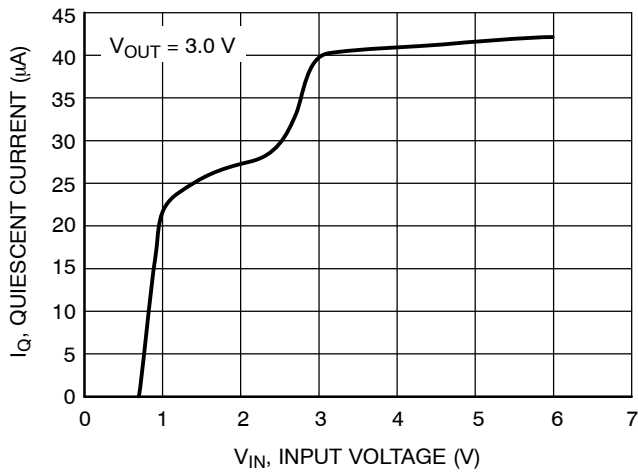


Figure 2. Quiescent Current versus Input Voltage

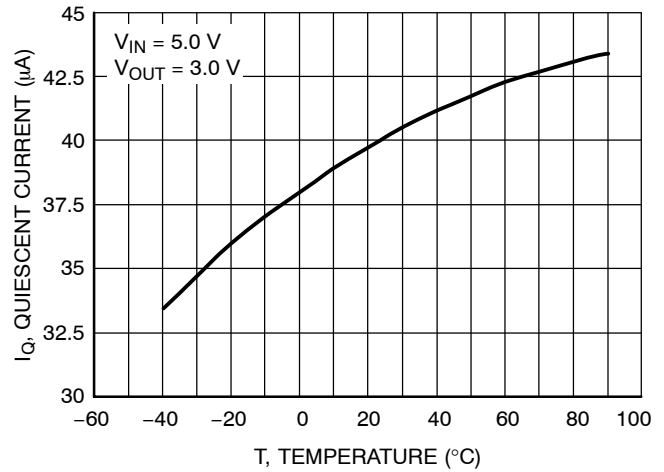


Figure 3. Quiescent Current versus Temperature

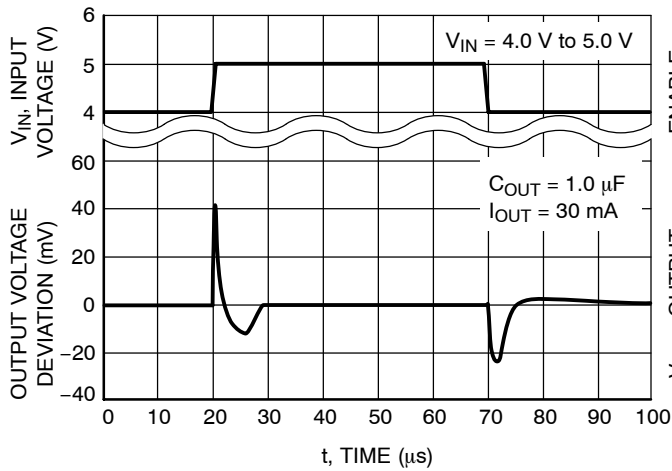


Figure 4. Line Transient Response

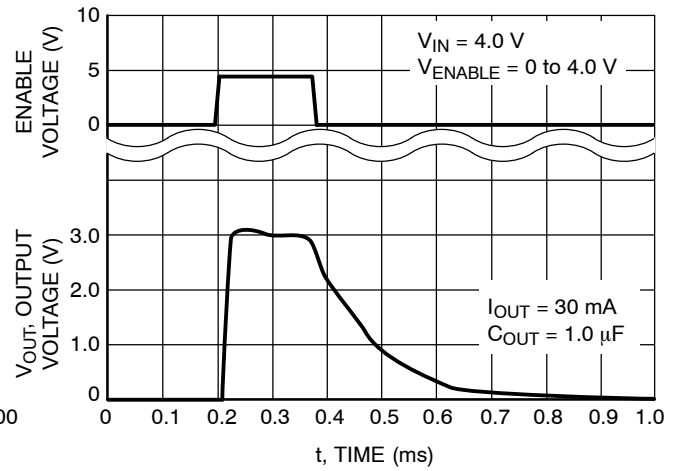


Figure 5. Enable Response

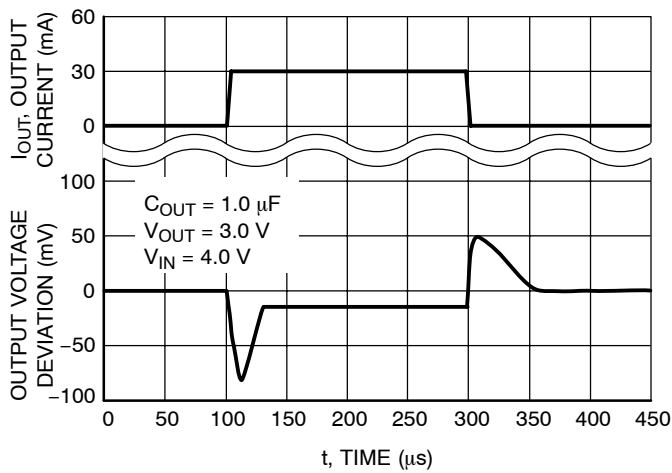


Figure 6. Load Transient Response

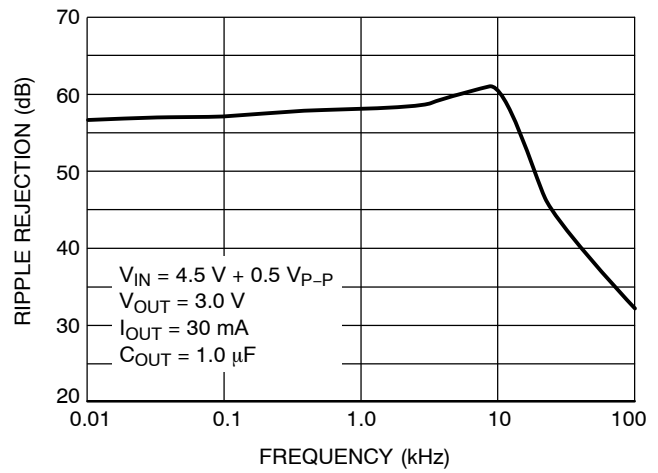


Figure 7. Ripple Rejection/Frequency

# NCP502, NCP502A

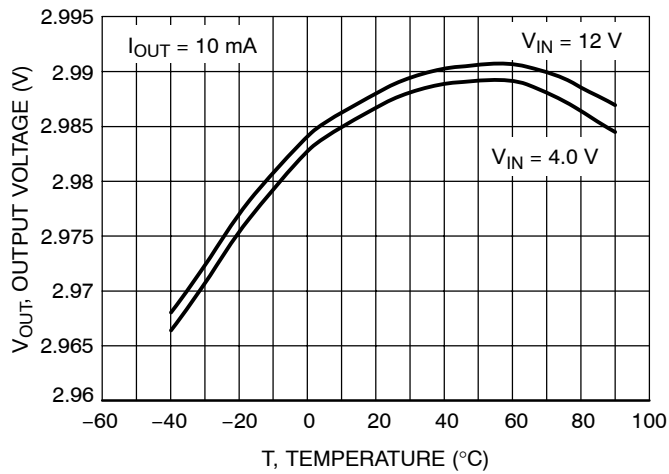


Figure 8. Output Voltage versus Temperature

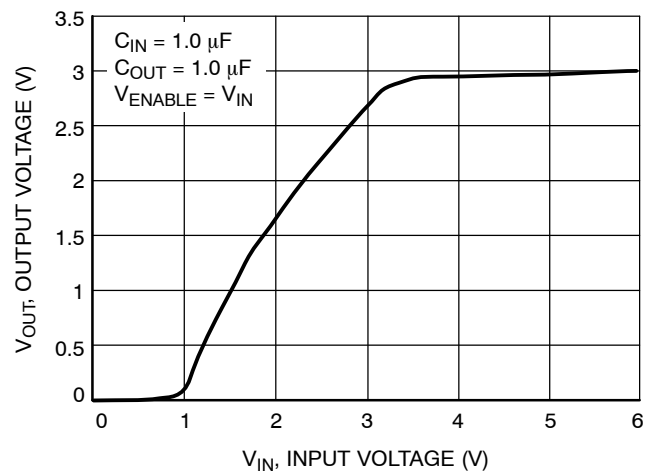


Figure 9. Output Voltage versus Input Voltage

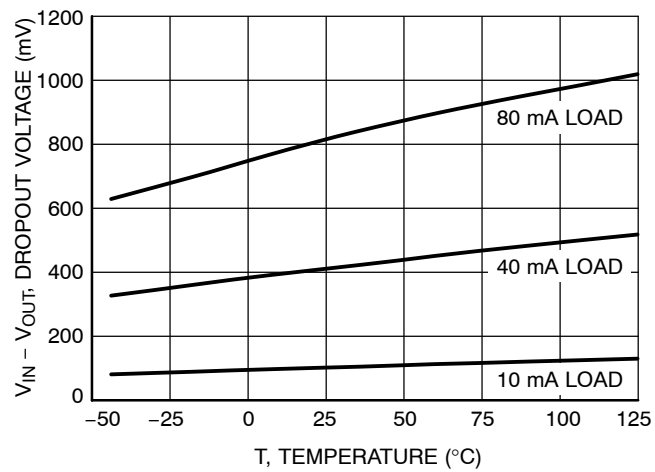


Figure 10. Dropout Voltage versus Temperature

## DEFINITIONS

### Load Regulation

The change in output voltage for a change in output current at a constant temperature.

### Dropout Voltage

The input/output differential at which the regulator output no longer maintains regulation against further reductions in input voltage. Measured when the output drops 3.0% below its nominal. The junction temperature, load current, and minimum input supply requirements affect the dropout level.

### Maximum Power Dissipation

The maximum total dissipation for which the regulator will operate within its specifications.

### Quiescent Current

The quiescent current is the current which flows through the ground when the LDO operates without a load on its output: internal IC operation, bias, etc. When the LDO becomes loaded, this term is called the Ground current. It is actually the difference between the input current (measured through the LDO input pin) and the output current.

### Line Regulation

The change in output voltage for a change in input voltage. The measurement is made under conditions of low dissipation or by using pulse technique such that the average chip temperature is not significantly affected.

### Line Transient Response

Typical over and undershoot response when input voltage is excited with a given slope.

### Thermal Protection

Internal thermal shutdown circuitry is provided to protect the integrated circuit in the event that the maximum junction temperature is exceeded. When activated at typically 160°C, the regulator turns off. This feature is provided to prevent failures from accidental overheating.

### Maximum Package Power Dissipation

The maximum power package dissipation is the power dissipation level at which the junction temperature reaches its maximum operating value, i.e. 125°C. Depending on the ambient power dissipation and thus the maximum available output current.

**APPLICATIONS INFORMATION**

A typical application circuit for the NCP502/A series is shown in Figure 1, front page.

**Input Decoupling (C1)**

A 1.0  $\mu\text{F}$  capacitor either ceramic or tantalum is recommended and should be connected close to the NCP502/A package. Higher values and lower ESR will improve the overall line transient response. If large line or load transients are not expected, then it is possible to operate the regulator without the use of a capacitor.

TDK capacitor: C2012X5R1C105K, or C1608X5R1A105K

**Output Decoupling (C2)**

The NCP502/A is a stable regulator and does not require any specific Equivalent Series Resistance (ESR) or a minimum output current. Capacitors exhibiting ESRs ranging from a few  $\text{m}\Omega$  up to  $5.0\ \Omega$  can thus safely be used. The minimum decoupling value is 1.0  $\mu\text{F}$  and can be augmented to fulfill stringent load transient requirements. The regulator accepts ceramic chip capacitors as well as tantalum devices. Larger values improve noise rejection and load regulation transient response.

TDK capacitor: C2012X5R1C105K, C1608X5R1A105K, or C3216X7R1C105K

**Enable Operation**

The enable pin will turn on the regulator when pulled high and turn off the regulator when pulled low. These limits of threshold are covered in the electrical specification section of this data sheet. If the enable is not used then the pin should be connected to  $V_{\text{in}}$ .

**Hints**

Please be sure the  $V_{\text{in}}$  and GND lines are sufficiently wide. When the impedance of these lines is high, there is a

chance to pick up noise or cause the regulator to malfunction.

Set external components, especially the output capacitor, as close as possible to the circuit, and make leads as short as possible.

**Thermal**

As power across the NCP502/A increases, it might become necessary to provide some thermal relief. The maximum power dissipation supported by the device is dependent upon board design and layout. Mounting pad configuration on the PCB, the board material and also the ambient temperature effect the rate of temperature rise for the part. This is stating that when the NCP502/A has good thermal conductivity through the PCB, the junction temperature will be relatively low with high power dissipation applications.

The maximum dissipation the package can handle is given by:

$$PD = \frac{T_{J(\text{max})} - T_A}{R_{\theta JA}}$$

If junction temperature is not allowed above the maximum  $125^\circ\text{C}$ , then the NCP502/A can dissipate up to 250 mW @  $25^\circ\text{C}$ .

The power dissipated by the NCP502/A can be calculated from the following equation:

$$P_{\text{tot}} = [V_{\text{in}} * I_{\text{gnd}} (I_{\text{out}})] + [V_{\text{in}} - V_{\text{out}}] * I_{\text{out}}$$

or

$$V_{\text{inMAX}} = \frac{P_{\text{tot}} + V_{\text{out}} * I_{\text{out}}}{I_{\text{gnd}} + I_{\text{out}}}$$

If an 80 mA output current is needed then the ground current from the data sheet is  $40\ \mu\text{A}$ . For an NCP502/A (3.0 V), the maximum input voltage will then be 6.12 V.

## NCP502, NCP502A

### ORDERING INFORMATION

| Device        | Nominal Output Voltage | Marking | Package          | Shipping <sup>†</sup> |
|---------------|------------------------|---------|------------------|-----------------------|
| NCP502SQ15T1  | 1.5                    | LCC     | SC70-5           | 3000 / Tape & Reel    |
| NCP502SQ18T1  | 1.8                    | LCD     | SC70-5           | 3000 / Tape & Reel    |
| NCP502SQ18T1G | 1.8                    | LCD     | SC70-5 (Pb-Free) | 3000 / Tape & Reel    |
| NCP502SQ25T1  | 2.5                    | LCE     | SC70-5           | 3000 / Tape & Reel    |
| NCP502SQ27T1  | 2.7                    | LCF     | SC70-5           | 3000 / Tape & Reel    |
| NCP502SQ28T1  | 2.8                    | LCG     | SC70-5           | 3000 / Tape & Reel    |
| NCP502SQ30T1  | 3.0                    | LCH     | SC70-5           | 3000 / Tape & Reel    |
| NCP502SQ33T1  | 3.3                    | LCI     | SC70-5           | 3000 / Tape & Reel    |
| NCP502SQ33T1G | 3.3                    | LCI     | SC70-5 (Pb-Free) | 3000 / Tape & Reel    |
| NCP502SQ35T1  | 3.5                    | LGO     | SC70-5           | 3000 / Tape & Reel    |
| NCP502SQ35T1G | 3.5                    | LGO     | SC70-5 (Pb-Free) | 3000 / Tape & Reel    |
| NCP502SQ50T1  | 5.0                    | LCJ     | SC70-5           | 3000 / Tape & Reel    |
| NCP502ASQ15T1 | 1.5                    | LGP     | SC70-5           | 3000 / Tape & Reel    |
| NCP502ASQ18T1 | 1.8                    | LGQ     | SC70-5           | 3000 / Tape & Reel    |
| NCP502ASQ25T1 | 2.5                    | LGR     | SC70-5           |                       |
| NCP502ASQ27T1 | 2.7                    | LGS     | SC70-5           | 3000 / Tape & Reel    |
| NCP502ASQ28T1 | 2.8                    | LGT     | SC70-5           | 3000 / Tape & Reel    |
| NCP502ASQ30T1 | 3.0                    | LGU     | SC70-5           | 3000 / Tape & Reel    |
| NCP502ASQ33T1 | 3.3                    | LGV     | SC70-5           | 3000 / Tape & Reel    |
| NCP502ASQ35T1 | 3.5                    | LGW     | SC70-5           | 3000 / Tape & Reel    |
| NCP502ASQ50T1 | 5.0                    | LGX     | SC70-5           | 3000 / Tape & Reel    |

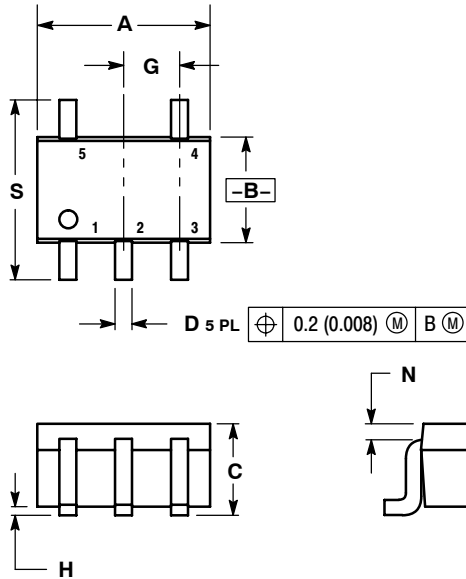
Additional voltages in 100 mV steps are available upon request by contacting your ON Semiconductor representative.

†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.

# NCP502, NCP502A

## PACKAGE DIMENSIONS

SC70-5  
SQ SUFFIX  
CASE 419A-02  
ISSUE G

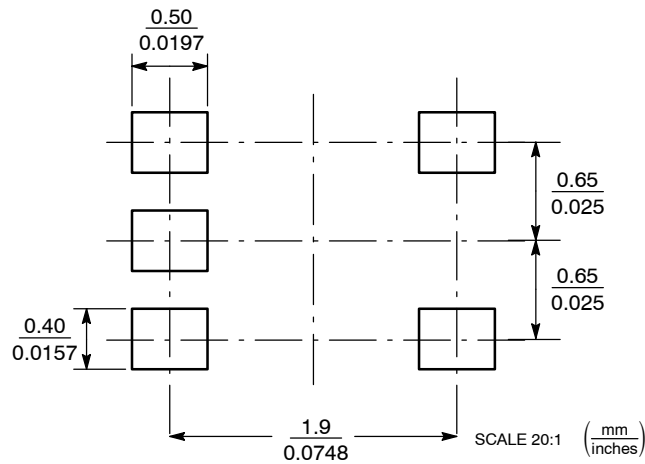


### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. 419A-01 OBSOLETE. NEW STANDARD 419A-02.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

| DIM | INCHES    |       | MILLIMETERS |      |
|-----|-----------|-------|-------------|------|
|     | MIN       | MAX   | MIN         | MAX  |
| A   | 0.071     | 0.087 | 1.80        | 2.20 |
| B   | 0.045     | 0.053 | 1.15        | 1.35 |
| C   | 0.031     | 0.043 | 0.80        | 1.10 |
| D   | 0.004     | 0.012 | 0.10        | 0.30 |
| G   | 0.026 BSC |       | 0.65 BSC    |      |
| H   | ---       | 0.004 | ---         | 0.10 |
| J   | 0.004     | 0.010 | 0.10        | 0.25 |
| K   | 0.004     | 0.012 | 0.10        | 0.30 |
| N   | 0.008 REF |       | 0.20 REF    |      |
| S   | 0.079     | 0.087 | 2.00        | 2.20 |

### 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.

# NCP502, NCP502A

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