

# Voltage Regulator - Low Noise, RF LDO

1 A

## NCP59800

The NCP59800 is a 1 A low-dropout linear regulators (LDOs) offering high power-supply ripple rejection (PSRR) and ultra-low output noise. This LDO uses an advanced BiCMOS process to achieve very good electrical performance. It is an ideal choice for noise sensitive Analog RF Front-Ends used in Telecom Equipment. The NCP59800 is available in the 3 mm x 3 mm DFN8 package.

### Features

- Operating Input Voltage Range: 2.2 V to 6.0 V
- Output Voltage Range: 0.8 V to 5 V (adjustable)
- Quiescent Current typ. 60  $\mu$ A
- Low Dropout: 200 mV typ. at 1 A,  $V_{OUT} = 2.5$  V
- $\pm 2.5\%$   $V_{OUT}$  Accuracy across Load/Line/Temperature
- Stable with Small 4.7  $\mu$ F Ceramic Capacitors
- Very-Low Noise: Typically 15  $\mu$ V<sub>RMS</sub> from 100 Hz to 100 kHz
- Over-Current and Thermal Shutdown Protection
- Available in 3 x 3 mm DFN8 Package
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

### Typical Applications

- Telecom Infrastructure
- Audio
- High-Speed I/F (PLL/VCO)

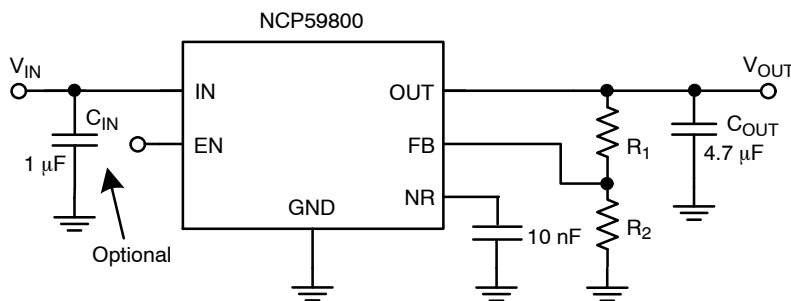
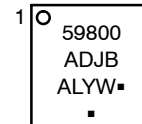


Figure 1. Typical Application Schematics



DFN8  
3 x 3 mm  
CASE 506DB

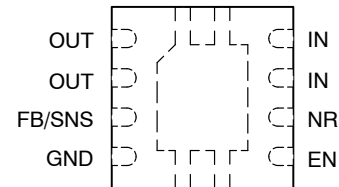
### MARKING DIAGRAM



A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

(Note: Microdot may be in either location)

### PIN CONNECTIONS



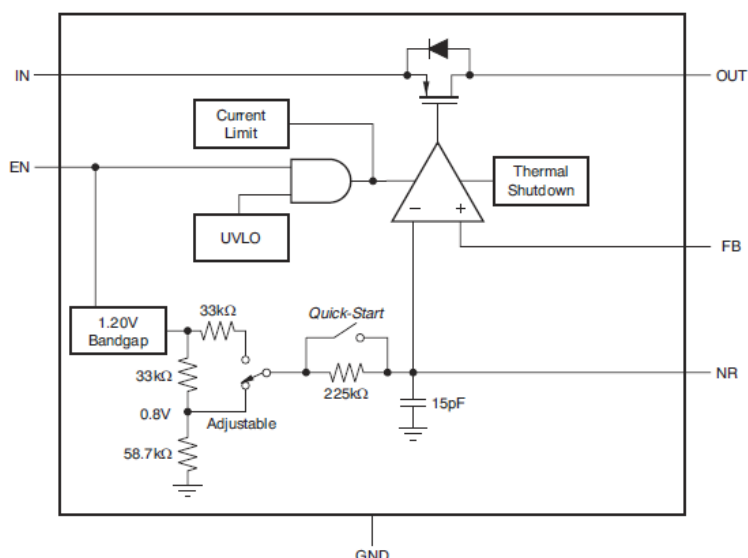
(Top View)

3 mm x 3 mm DFN8 0.65 P

### ORDERING INFORMATION

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

**NCP59800**



### Figure 2. Internal Block Diagram

**Table 1. PIN FUNCTION DESCRIPTION**

| Pin No. DFN8 | Pin Name | Description                                                                                                                                                                                                                  |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7,8          | IN       | Unregulated input supply.                                                                                                                                                                                                    |
| 4, EPAD      | GND      | Ground.                                                                                                                                                                                                                      |
| 5            | EN       | Driving the enable pin (EN) high turns on the regulator.<br>Driving this pin low puts the regulator into shutdown mode.                                                                                                      |
| 6            | NR       | Connect an external capacitor between this pin and ground to reduce the output noise to very low levels. The capacitor slows down the $V_{OUT}$ ramp as well (soft-start).<br>Max recommended $C_{NR}$ value is 0.47 $\mu F$ |
| 3            | FB       | This pin is the input to the control loop error amplifier and is used to set the output voltage of the device.                                                                                                               |
| 1,2          | OUT      | Regulator output. A 4.7 $\mu F$ to 100 $\mu F$ capacitor is required for stability.                                                                                                                                          |

**Table 2. ABSOLUTE MAXIMUM RATINGS**

| Rating                                    | Symbol              | Value                                      | Unit |
|-------------------------------------------|---------------------|--------------------------------------------|------|
| Input Voltage (Note 1)                    | IN                  | 6.5                                        | V    |
| Output Voltage                            | OUT                 | $-0.3 \text{ to } (V_{IN} + 0.3) \leq 6.5$ | V    |
| Enable Input Voltage                      | EN                  | $-0.3 \text{ to } 6.5$                     | V    |
| FB Input Voltage                          | FB                  | $-0.3 \text{ to } 3.6$                     | V    |
| Output Current                            | I <sub>OUT</sub>    | Internally Limited                         | mA   |
| Maximum Junction Temperature              | T <sub>J(MAX)</sub> | 150                                        | °C   |
| Operating Ambient Temperature Range       | T <sub>A</sub>      | $-40 \text{ to } +125$                     | °C   |
| Storage Temperature                       | T <sub>STG</sub>    | $-55 \text{ to } 150$                      | °C   |
| ESD Capability, Human Body Model (Note 2) | ESD <sub>HBM</sub>  | 2000                                       | V    |
| ESD Capability, Machine Model (Note 2)    | ESD <sub>MM</sub>   | 200                                        | 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. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
2. This device series incorporates ESD protection and is tested by the following methods:
  - ESD Human Body Model tested per AEC-Q100-002 (EIA/JESD22-A114)
  - ESD Machine Model tested per AEC-Q100-003 (EIA/JESD22-A115)
  - Latchup Current Maximum Rating tested per JEDEC standard: JESD78

**Table 3. RECOMMENDED OPERATING CONDITIONS**

| Parameter            | Symbol   | Min                           | Max  | Unit |
|----------------------|----------|-------------------------------|------|------|
| Input Voltage        | $V_{IN}$ | $(V_{OUT} + V_{DO}) \geq 2.2$ | 6.0  | V    |
| Junction Temperature | $T_J$    | -40                           | +125 | °C   |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

**Table 4. THERMAL CHARACTERISTICS**

| Rating                                                                                    | Symbol          | Value | Unit |
|-------------------------------------------------------------------------------------------|-----------------|-------|------|
| Thermal Characteristics, DFN8 3 mm x 3 mm<br>Thermal Resistance, Junction-to-Air (Note 3) | $R_{\theta JA}$ | 52    | °C/W |

3. The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.

**Table 5. ELECTRICAL CHARACTERISTICS** Over the operating temperature range of  $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ,  $V_{IN} = (V_{OUT(NOM)} + 0.5\text{ V})$  or  $2.2\text{ V}$  (whichever is greater),  $I_{OUT} = 1\text{ mA}$ ,  $V_{EN} = 2.2\text{ V}$ ,  $C_{OUT} = 4.7\text{ }\mu\text{F}$ , and  $C_{NR} = 0.01\text{ }\mu\text{F}$ , unless otherwise noted. NCP59800 Adjustable device is tested at  $V_{OUT} = 0.8\text{ V}$  and  $V_{OUT} = 5.0\text{ V}$ . Typical values are at  $T_J = +25^{\circ}\text{C}$ .

| Parameter                        | Test Conditions                                                                                                                                      | Symbol                            | Min                           | Typ                 | Max  | Unit                |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-------------------------------|---------------------|------|---------------------|
| Input Voltage Range              |                                                                                                                                                      | $V_{IN}$                          | $(V_{OUT} + V_{DO}) \geq 2.2$ |                     | 6.0  | V                   |
| Internal Reference               |                                                                                                                                                      | $V_{NR}$                          |                               | 0.8                 |      | V                   |
| Output Voltage                   | Adjustable                                                                                                                                           | $V_{OUT}$                         | 0.8                           |                     | 5.0  | V                   |
| Output Voltage Accuracy (Note 4) | $V_{OUT} + 0.5\text{ V} \leq V_{IN} \leq 6.0\text{ V}$ , $V_{IN} \geq 2.2\text{ V}$<br>$1\text{ mA} \leq I_{OUT} \leq 1\text{ A}$                    | $V_{OUT}$                         | -2.5                          | $\pm 0.3$           | +2.5 | %                   |
| Line Regulation                  | $V_{OUT} + 0.5\text{ V} \leq V_{IN} \leq 6.0\text{ V}$ , $V_{IN} \geq 2.2\text{ V}$<br>$I_{OUT} = 1\text{ mA}$                                       | $\Delta V_{OUT} / \Delta V_{IN}$  |                               | 150                 |      | $\mu\text{V/V}$     |
| Load Regulation                  | $1\text{ mA} \leq I_{OUT} \leq 1\text{ A}$                                                                                                           | $\Delta V_{OUT} / \Delta I_{OUT}$ |                               | 2.0                 |      | $\mu\text{V/mA}$    |
| Dropout Voltage                  | $V_{OUT} + 0.5\text{ V} \leq V_{IN} \leq 6.0\text{ V}$ , $V_{IN} \geq 2.2\text{ V}$<br>$I_{OUT} = 500\text{ mA}$ , $V_{FB} = \text{GND}$             | $V_{DO}$                          |                               |                     | 250  | mV                  |
|                                  | $V_{OUT} + 0.5\text{ V} \leq V_{IN} \leq 6.0\text{ V}$ , $V_{IN} \geq 2.5\text{ V}$<br>$I_{OUT} = 750\text{ mA}$ , $V_{FB} = \text{GND}$             |                                   |                               |                     | 350  | mV                  |
|                                  | $V_{OUT} + 0.5\text{ V} \leq V_{IN} \leq 6.0\text{ V}$ , $V_{IN} \geq 2.5\text{ V}$<br>$I_{OUT} = 1\text{ A}$ , $V_{FB} = \text{GND}$                |                                   |                               |                     | 500  | mV                  |
| Output Current Limit             | $V_{OUT} = 0.85 V_{OUT(NOM)}$ , $V_{IN} \geq 3.3\text{ V}$                                                                                           | $I_{CL}$                          | 1.1                           | 1.6                 | 2.5  | A                   |
| Ground Pin Current               | $I_{OUT} = 0.1\text{ mA}$                                                                                                                            | $I_{GND}$                         |                               | 60                  | 100  | $\mu\text{A}$       |
|                                  | $I_{OUT} = 1\text{ A}$                                                                                                                               |                                   |                               |                     | 450  | $\mu\text{A}$       |
| Shutdown Current ( $I_{GND}$ )   | $V_{EN} \leq 0.4\text{ V}$ , $V_{IN} \geq 2.2\text{ V}$ , $R_L = 1\text{ k}\Omega$ ,<br>$0^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$         | $I_{SHDN}$                        |                               | 0.2                 | 2.0  | $\mu\text{A}$       |
| Feedback Pin Current             | $V_{IN} = 6.0\text{ V}$ , $V_{FB} = 0.8\text{ V}$                                                                                                    |                                   |                               | 0.02                | 1.0  | $\mu\text{A}$       |
| Power Supply Rejection Ratio     | $I_{OUT} = 750\text{ mA}$ ,<br>$V_{OUT} = 3.3\text{ V}$ ,<br>$V_{IN} = 4.3\text{ V}$                                                                 | PSRR                              | $f = 100\text{ Hz}$           | 77                  |      | dB                  |
|                                  |                                                                                                                                                      |                                   | $f = 1\text{ kHz}$            | 63                  |      |                     |
|                                  |                                                                                                                                                      |                                   | $f = 1\text{ MHz}$            | 27                  |      |                     |
| Output Noise Voltage             | $BW = 100\text{ Hz} - 100\text{ kHz}$ , $I_{OUT} = 100\text{ mA}$ ,<br>$C_{NR} = 100\text{ nF}$ , $V_{IN} = 4.3\text{ V}$ , $V_{OUT} = 3.3\text{ V}$ | $V_N$                             |                               | $15 \times V_{OUT}$ |      | $\mu\text{V}_{RMS}$ |
| Enable Input Current             | $V_{IN} = V_{EN} = 6.0\text{ V}$                                                                                                                     | $I_{EN}$                          |                               | 0.02                | 1.0  | $\mu\text{A}$       |
| Soft-Start Charging Current      | $V_{NR} = 0.5\text{ V}$                                                                                                                              | $I_{SS}$                          |                               | 7.2                 |      | $\mu\text{A}$       |
| EN Pin Threshold Voltage         | EN Input Voltage "H"                                                                                                                                 | $V_{ENH}$                         | 1.2                           |                     |      | V                   |
|                                  | EN Input Voltage "L"                                                                                                                                 | $V_{ENL}$                         |                               |                     | 0.4  |                     |

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.

4. As for NCP59800 (adjustable); it does not include external resistor tolerances and it is not tested at this condition:

$V_{OUT} = 0.8\text{ V}$ ,  $4.5\text{ V} \leq V_{IN} \leq 6.0\text{ V}$ , and  $750\text{ mA} \leq I_{OUT} \leq 1\text{ A}$  because of power dissipation higher than maximum rating of the package.

# NCP59800

**Table 5. ELECTRICAL CHARACTERISTICS** Over the operating temperature range of  $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ,  $V_{IN} = (V_{OUT(NOM)} + 0.5\text{ V})$  or  $2.2\text{ V}$  (whichever is greater),  $I_{OUT} = 1\text{ mA}$ ,  $V_{EN} = 2.2\text{ V}$ ,  $C_{OUT} = 4.7\text{ }\mu\text{F}$ , and  $C_{NR} = 0.01\text{ }\mu\text{F}$ , unless otherwise noted. NCP59800 Adjustable device is tested at  $V_{OUT} = 0.8\text{ V}$  and  $V_{OUT} = 5.0\text{ V}$ . Typical values are at  $T_J = +25^{\circ}\text{C}$ .

| Parameter                      | Test Conditions                                                                                                                            |                          | Symbol               | Min  | Typ | Max  | Unit |
|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------|------|-----|------|------|
| Start-Up Time                  | V <sub>OUT(NOM)</sub> = 3.3 V<br>V <sub>OUT</sub> = 0% to 90%<br>V <sub>OUT(NOM)</sub><br>R <sub>L</sub> = 3.3kΩ, C <sub>OUT</sub> =4.7 μF | C <sub>NR</sub> = 10 nF  | t <sub>STR</sub>     |      | 1.0 |      | ms   |
|                                |                                                                                                                                            | C <sub>NR</sub> = 100 nF |                      |      | 10  |      | ms   |
| Undervoltage Lockout           | V <sub>IN</sub> rising, R <sub>L</sub> = 1 kΩ                                                                                              |                          | UVLO                 | 1.86 | 2.0 | 2.1  | V    |
| UVLO Hysteresis                | V <sub>IN</sub> falling, R <sub>L</sub> = 1 kΩ                                                                                             |                          |                      |      | 75  |      | mV   |
| Thermal Shutdown               | Shutdown, temperature increasing                                                                                                           |                          | T <sub>SD_TEMP</sub> |      | 160 |      | °C   |
| Thermal Shutdown Recovery      | Reset, temperature decreasing                                                                                                              |                          | T <sub>SD_HYST</sub> |      | 140 |      |      |
| T <sub>J</sub> Operating Range |                                                                                                                                            |                          |                      | −40  |     | +125 | °C   |

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

4. As for NCP59800 (adjustable); it does not include external resistor tolerances and it is not tested at this condition:

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TYPICAL CHARACTERISTICS

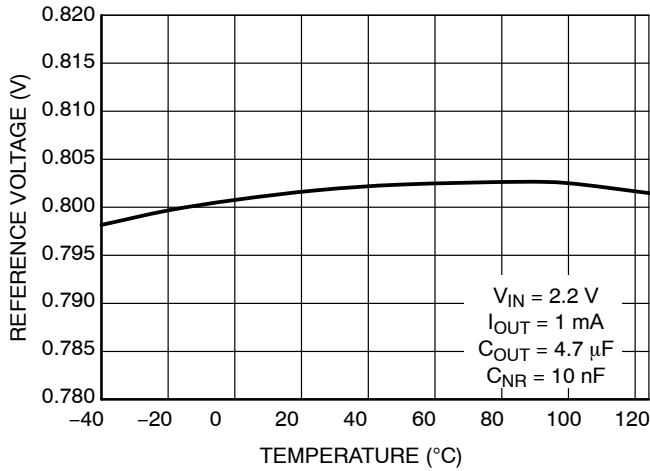


Figure 3. Output Voltage vs. Temperature –  
 $V_{OUT} = 0.8 \text{ V}$  (Adjustable reference)

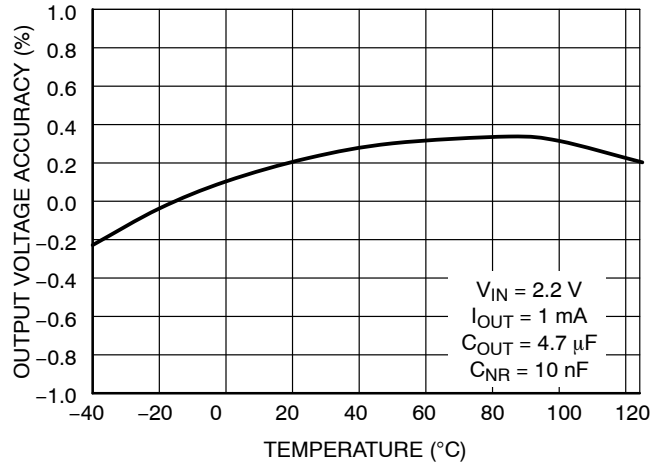


Figure 4. Output Voltage Accuracy vs.  
Temperature

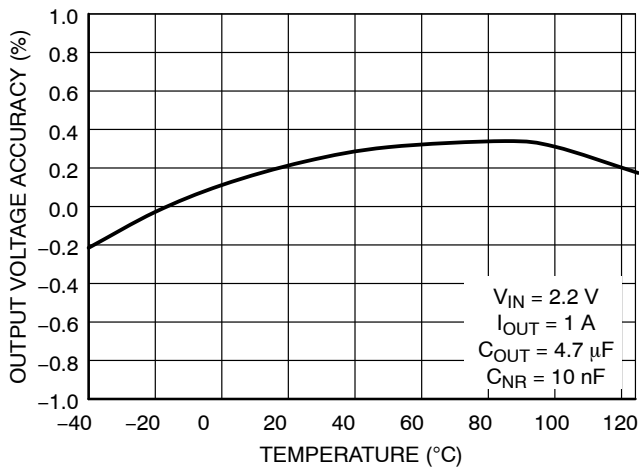


Figure 5. Output Voltage Accuracy vs.  
Temperature

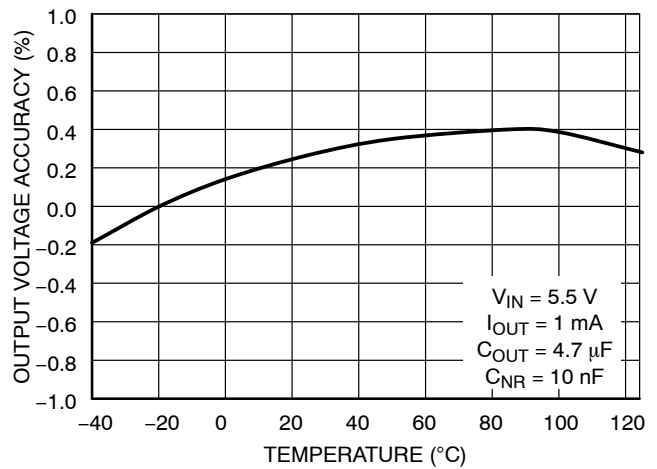


Figure 6. Output Voltage Accuracy vs.  
Temperature

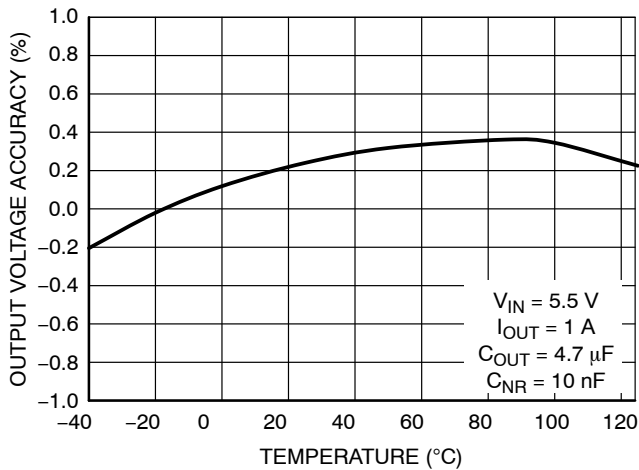


Figure 7. Output Voltage Accuracy vs.  
Temperature

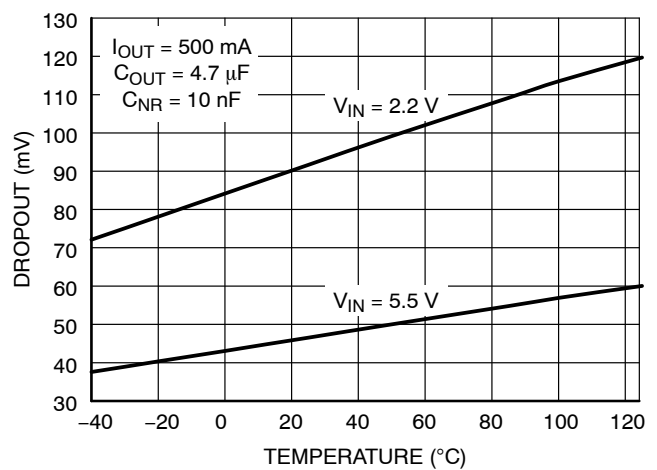


Figure 8. Dropout Voltage vs. Temperature –  
 $I_{OUT} = 500 \text{ mA}$

TYPICAL CHARACTERISTICS

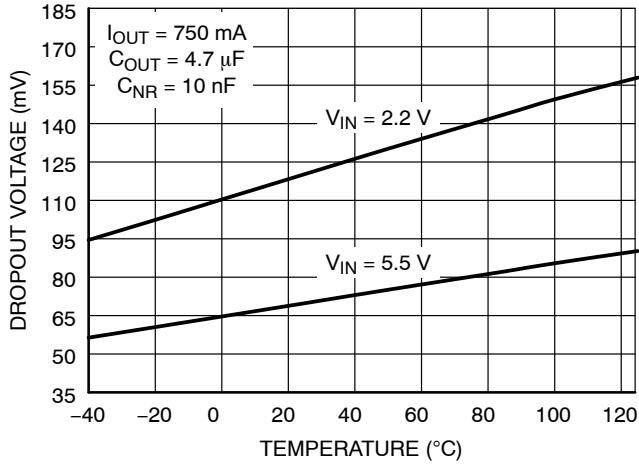


Figure 9. Dropout Voltage vs. Temperature –  $I_{OUT} = 750 \text{ mA}$

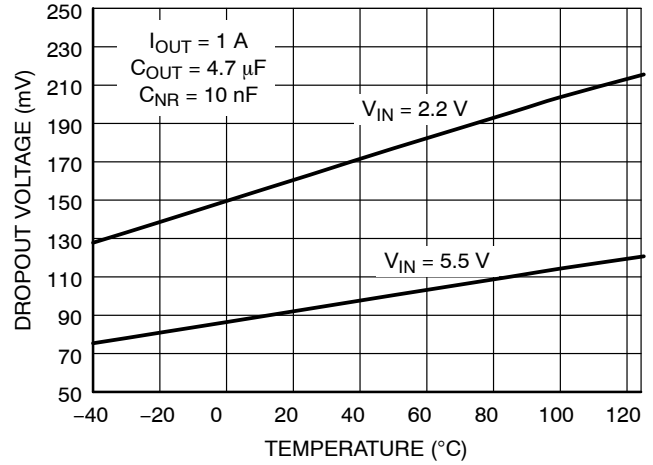


Figure 10. Dropout Voltage vs. Temperature –  $I_{OUT} = 1 \text{ A}$

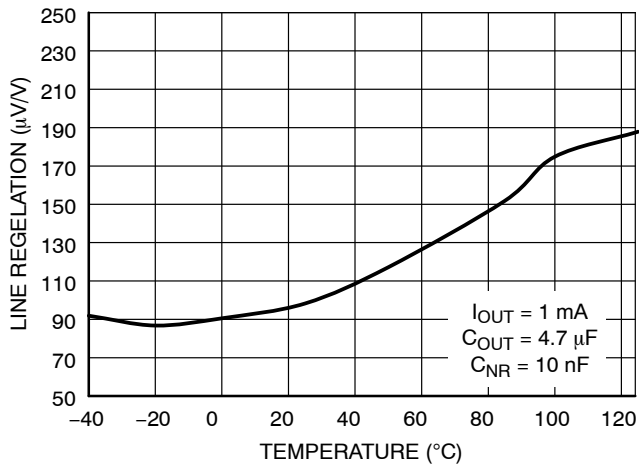


Figure 11. Line Regulation vs. Temperature

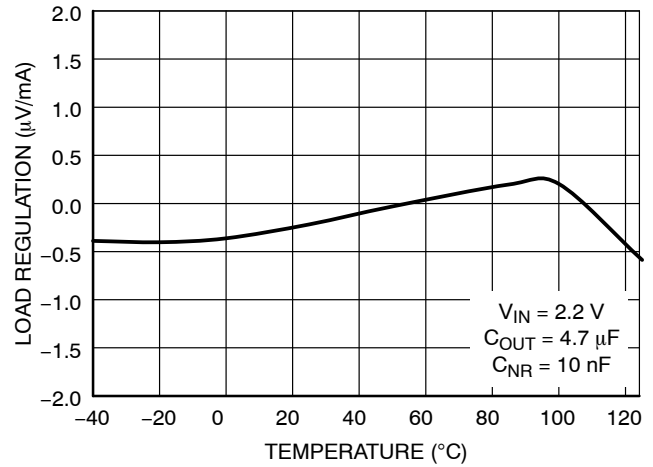


Figure 12. Load Regulation vs. Temperature

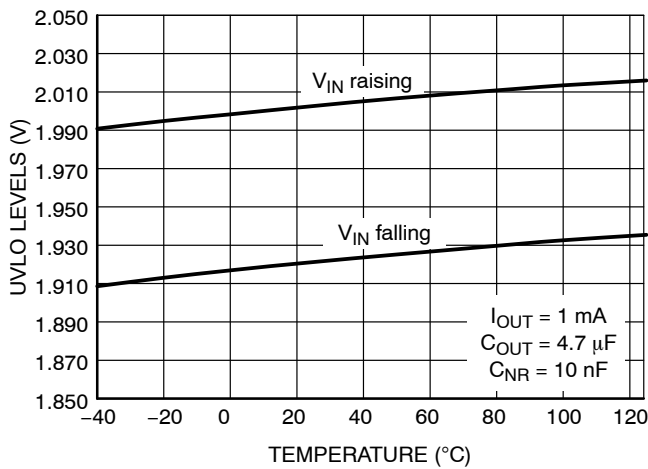


Figure 13. UVLO Thresholds vs. Temperature

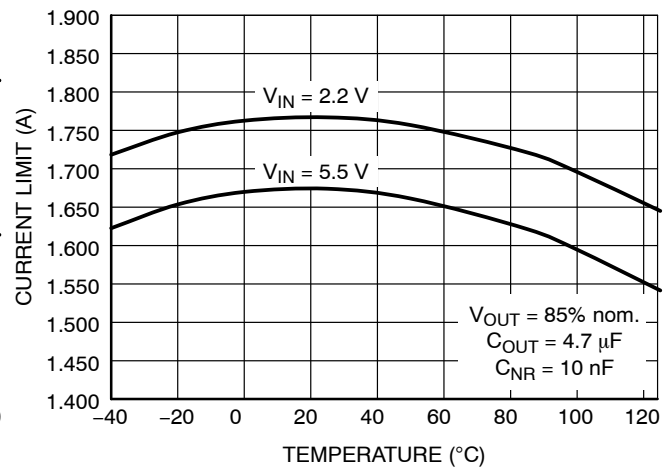


Figure 14. Current Limit vs. Temperature

TYPICAL CHARACTERISTICS

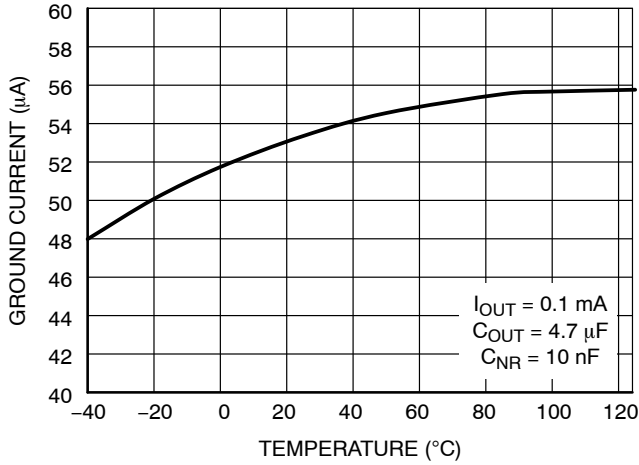


Figure 15. Ground Current vs. Temperature

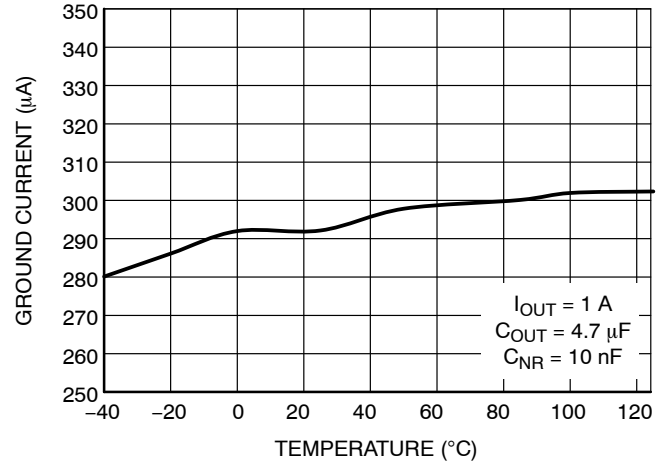


Figure 16. Ground Current vs. Temperature

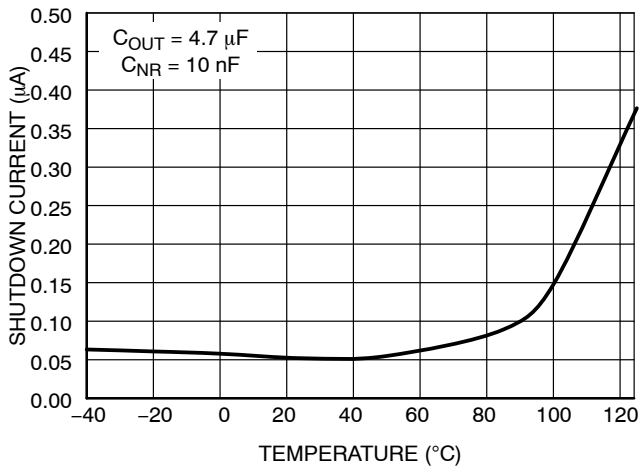


Figure 17. Shutdown Current vs. Temperature

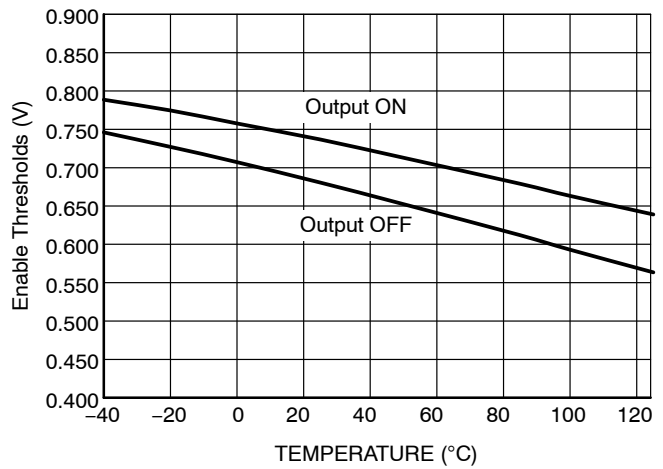


Figure 18. Enable Thresholds vs. Temperature

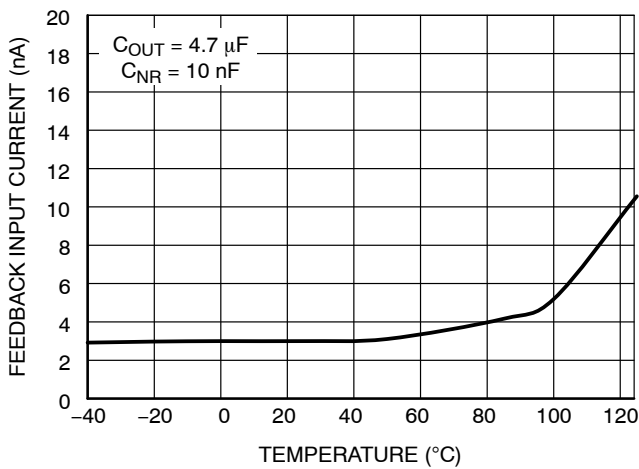


Figure 19. Feedback Input Current vs. Temperature (Adjustable Option)

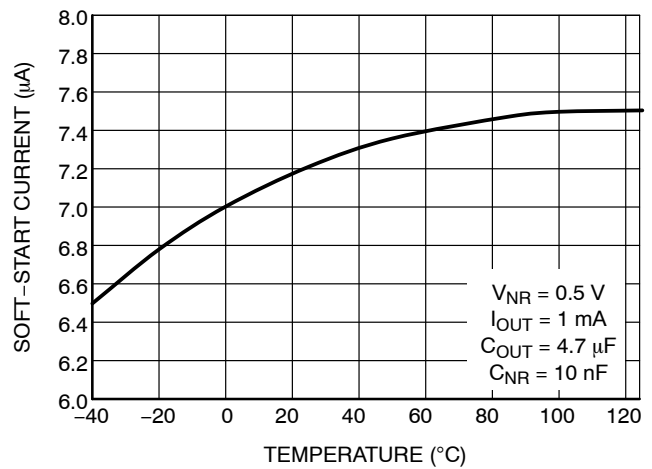


Figure 20. Soft-Start Current vs. Temperature

TYPICAL CHARACTERISTICS

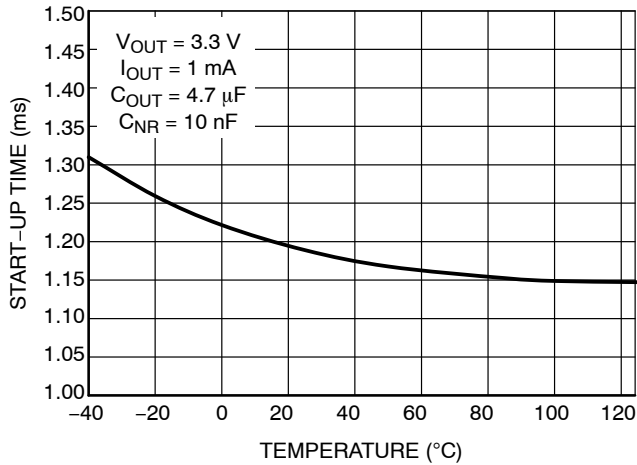


Figure 21. Start-up Time vs. Temperature

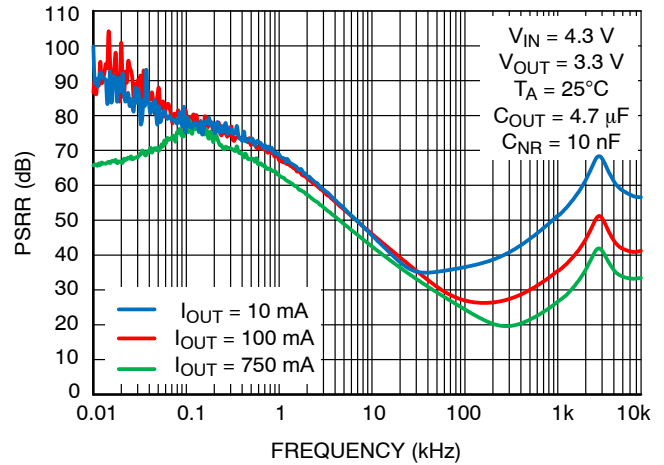


Figure 22. Power Supply Rejection Ratio for  $V_{OUT} = 3.3\text{ V}$ ,  $C_{OUT} = 4.7\text{ }\mu\text{F}$ ,  $C_{NR} = 10\text{ nF}$

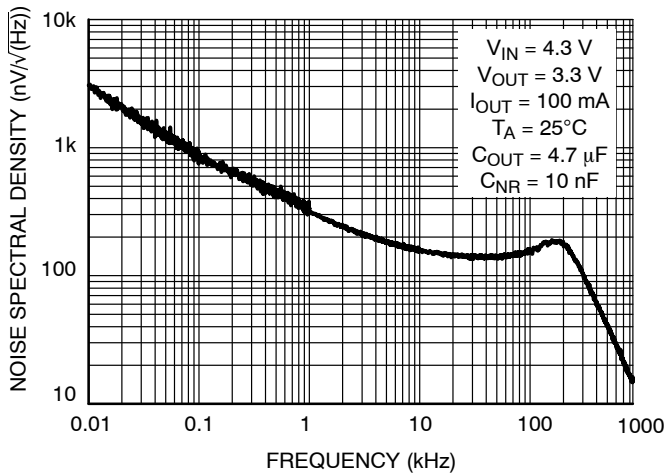


Figure 23. Output Voltage Noise Spectral Density for  $V_{OUT} = 3.3\text{ V}$ ,  $C_{OUT} = 4.7\text{ }\mu\text{F}$ ,  $C_{NR} = 100\text{ nF}$

## APPLICATIONS INFORMATION

### General Information

The NCP59800 regulator is equipped with Noise Reduction pin (NR) for noise sensitive applications. A noise reduction capacitor ( $C_{NR}$ ) at the NR pin bypasses noise generated by the bandgap reference. This family of regulators offers sub-bandgap output voltages, current limit, and thermal protection, and is fully specified from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , assuming resistors with zero error. For the actual design, pay attention to any resistor error factors. Figure 24 gives the Typical Application Schematics.

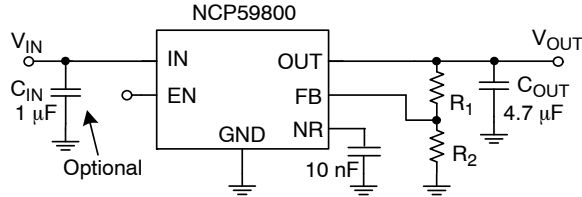


Figure 24. Typical Application Schematics

### Output Voltage Setting

The output voltage can be adjusted from 0.8 V to 5.0 V using resistors divider between the output and the FB input. The values of  $R_1$  and  $R_2$  can be calculated for any voltage using the following formula:

$$V_{OUT} = 0.8 \text{ V} \left( 1 + \frac{R_1}{R_2} \right)$$

Recommended resistor values for frequently used voltages can be found in the Table 6.

### Capacitors Selection

Although an input capacitor is not required for stability, it is good analog design practice to connect a 0.1  $\mu\text{F}$  to 1.0  $\mu\text{F}$  low equivalent series resistance (ESR) capacitor across the input supply near the regulator. The NCP59800 is designed to be stable with standard ceramic output capacitors of

capacitance values 4.7  $\mu\text{F}$  up to 100  $\mu\text{F}$ . This device is evaluated using a 4.7  $\mu\text{F}/10 \text{ V}$ , 10% tolerance, X5R type Ceramic Capacitors of 0805 size.

X5R- and X7R-type capacitors are highly recommended because they have minimal variation in value and ESR over temperature.

### Startup Response

The  $C_{NR}$  serves not only for noise reduction. During Start-Up the  $C_{NR}$  capacitor works like the Soft Start timing capacitor. The controlled monotonic ramping of Voltage Reference (adjustable Soft-Start) is limiting the Inrush Current.

Table 6. RECOMMENDED 1% FEEDBACK RESISTOR Values for Frequently Used Nominal Output Voltages

| V <sub>OUT</sub> | R <sub>1</sub>     | R <sub>2</sub>  |
|------------------|--------------------|-----------------|
| 0.8 V            | 0 $\Omega$ (Short) | 10.0 k $\Omega$ |
| 1.0 V            | 2.49 k $\Omega$    | 10.0 k $\Omega$ |
| 1.2 V            | 4.99 k $\Omega$    | 10.0 k $\Omega$ |
| 1.5 V            | 8.87 k $\Omega$    | 10.0 k $\Omega$ |
| 1.8 V            | 12.5 k $\Omega$    | 10.0 k $\Omega$ |
| 2.5 V            | 21.0 k $\Omega$    | 10.0 k $\Omega$ |
| 3.3 V            | 30.9 k $\Omega$    | 10.0 k $\Omega$ |
| 5.0 V            | 52.3 k $\Omega$    | 10.0 k $\Omega$ |

### Power Dissipation

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 the ambient temperature affect the rate of junction temperature rise for the part. For reliable operation junction temperature should be limited to  $+125^{\circ}\text{C}$ .

Table 7. ORDERING INFORMATION

| Device            | Output Voltage | Marking       | Package               | Shipping <sup>†</sup> |
|-------------------|----------------|---------------|-----------------------|-----------------------|
| NCP59800BMNADJTAG | ADJ            | 59800<br>ADJB | DFN8 3x3<br>(Pb-Free) | 3000/Tape & Reel      |
| NCP59800BMNADJTBG | ADJ            | 59800<br>ADJB |                       |                       |

<sup>†</sup>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.

NOTE: The A or B letter in the device suffix represents part orientation in the tape.

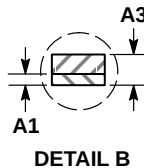
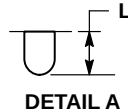
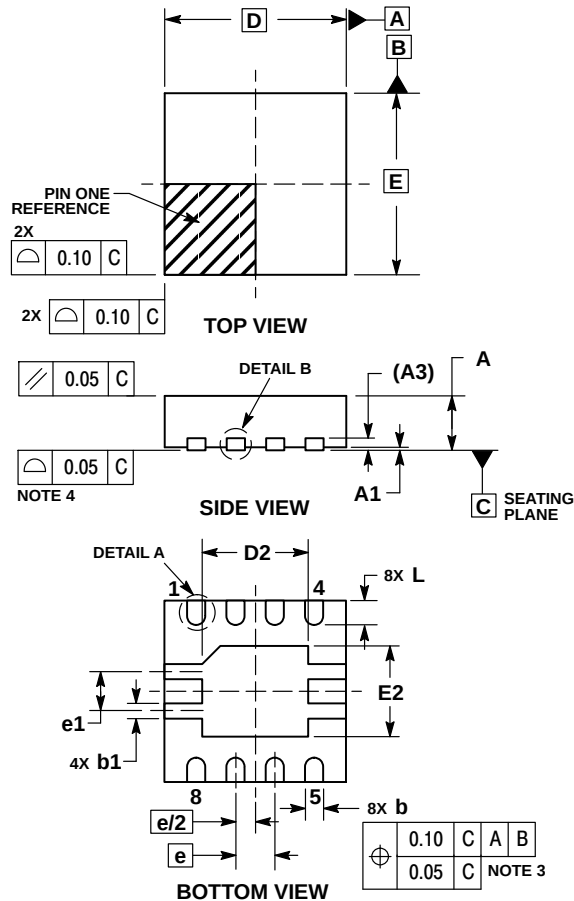
\*To order other package and voltage variants, please contact your ON sales representative.



SCALE 2:1

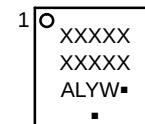
**DFN8, 3x3, 0.65P**  
CASE 506DB  
ISSUE A

DATE 12 OCT 2016


**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30mm FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

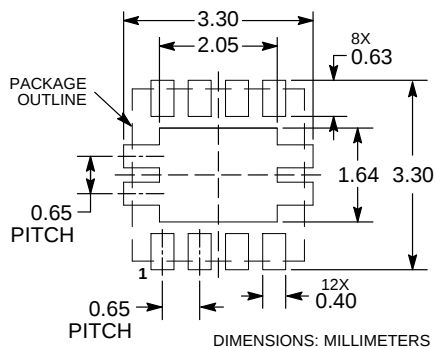
| MILLIMETERS |      |      |
|-------------|------|------|
| DIM         | MIN  | MAX  |
| A           | 0.80 | 1.00 |
| A1          | 0.00 | 0.05 |
| A3          | 0.20 | REF  |
| b           | 0.25 | 0.35 |
| b1          | 0.20 | 0.30 |
| D           | 3.00 | BSC  |
| D2          | 1.65 | 1.85 |
| E           | 3.00 | BSC  |
| E2          | 1.40 | 1.60 |
| e           | 0.65 | BSC  |
| e1          | 0.65 | REF  |
| L           | 0.30 | 0.50 |
| L1          | 0.00 | 0.15 |

**GENERIC MARKING DIAGRAM\***


XXXXXX = Specific Device Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
▪ = 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.

**RECOMMENDED SOLDERING FOOTPRINT\***


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

|                         |                         |                                                                                                                                                                                     |
|-------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| <b>DESCRIPTION:</b>     | <b>DFN8, 3X3, 0.65P</b> | <b>PAGE 1 OF 1</b>                                                                                                                                                                  |

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