# NCP2860

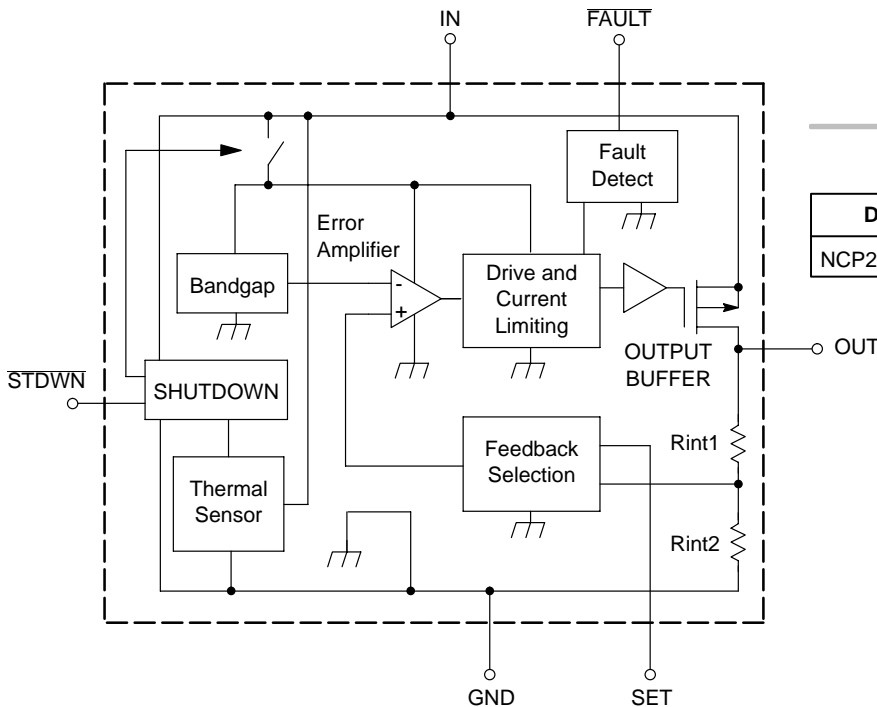## 300 mA Very Low Noise, Low Dropout Linear Regulator

The NCP2860 is a low noise, low dropout linear regulator that is offered with an output voltage of 2.77 V. It supplies 300 mA from 3.0 V to 6.0 V input. If wished, the "SET" pin enables to adjust the output voltage level that then depends on the voltage applied to this pin. The excellent performances that the NCP2860 features in terms of transient responses, PSRR and noise, make it an ideal solution for audio applications (e.g. audio amplifier drivers).

### Features

- High Output Current (300 mA Max)
- Low Output Voltage Noise: 60 µVrms
- Low Dropout (150 mV @ $I_{out}$ = 300 mA)
- Thermal Overload and Short Circuit Protections
- Very Low Consumption in Shutdown Mode (10 nA)
- High Power Supply Rejection Ratio (60 dB @ 1.0 kHz)
- $\overline{FAULT}$ Indicator
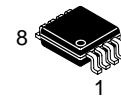- Programmable Output Voltage
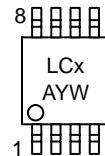- Soft Start

### Typical Applications

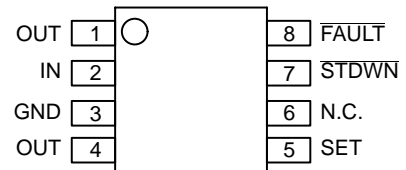- Cellular Phone
- Handheld Instruments

**ON Semiconductor®**

**http://onsemi.com**

**PIN CONNECTIONS**

| | | |
|---|---|---|
| OUT | 1 | 8 $\overline{FAULT}$ |
| IN | 2 | 7 $\overline{STDWN}$ |
| GND | 3 | 6 N.C. |
| OUT | 4 | 5 SET |

(Top View)

**1**

# NCP2860

## PIN DESCRIPTION

| Pin | Name | Description |
|-----|------|-------------|
| 1, 4 | OUT | "OUT" is the regulator output. A low ESR, bypass capacitor should be connected for stable operation. |
| 2 | IN | "IN" is the supply input that is connected to the power source (up to 6.0 V). Bypass with a 2.2 $\mu$F capacitor. |
| 3 | GND | Ground |
| 5 | SET | Ground the "SET" pin to set the output voltage to 2.77 V. Refer to the "output voltage setting" paragraph if you need to program another value. |
| 6 | N.C. | This pin is non-connected. |
| 7 | $\overline{\text{STDWN}}$ | If the "$\overline{\text{STDWN}}$" pin is low, the circuit enters the shutdown mode. |
| 8 | $\overline{\text{FAULT}}$ | The "$\overline{\text{FAULT}}$" terminal is a high impedance, open drain output. If the circuit is out of regulation, the voltage pin goes low. Otherwise (normal operation or shutdown mode), this pin is high impedance. Connect the pin to ground, if unused. |

## MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|--------|--------|-------|------|
| Input Voltage, Shutdown Pin, Voltage Range (Note 1) | $V_{inmax}$ | -0.3, +6.0 | V |
| Thermal Resistance (Note 2) | - | 230 | °C/W |
| Maximum Junction Temperature | $T_{Jmax}$ | 150 | °C |
| Storage Temperature Range | $T_{Smax}$ | - 65 to +150 | °C |
| Lead Temperature (Soldering, 10s) | $T_{Lmax}$ | 300 | °C |
| ESD Capability<br>  Human Body Model<br>  Machine Model | -<br>- | 2.0<br>200 | kV<br>V |
| Latch-up Capability @ 85°C | - | +/-100 | mA |

1. The recommended input voltage range for NCP2860 proper operation is 2.7 V to 6.0 V.
2. Circuit being mounted on a board that has no metal oxide traces attached to the leads. The addition of plated copper can lower the thermal resistance.

**TYPICAL ELECTRICAL CHARACTERISTICS\*** ($V_{in}$ = 3.6 V, SET = GND, $T_A$ from -25°C to +85°C, unless otherwise noted.)

| Characteristic (2.7 V Option) | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Output Voltage @ $I_{out}$ = 100 μA, 300 mA, $V_{in}$ = 3.2 V and $T_A$ = 25°C<br>$T_A$ from -25°C to +85°C | $V_{out}$ | 2.73<br>2.70 | 2.77<br>2.77 | 2.81<br>2.84 | V |
| Supply Current @ $I_{out}$ = 0, $V_{in}$ = 3.2 V | $I_{cc-0}$ | - | 355 | 700 | μA |
| Supply Current @ $I_{out}$ = 300 mA, $V_{in}$ = 3.2 V | $I_{cc-300}$ | - | 1.1 | - | mA |
| Supply Current in Shutdown Mode ($\overline{STDWN}$ Pin Grounded)<br>@ $T_A$ = 25°C | $I_{stdwn}$ | - | 0.01 | 1.0 | μA |
| Dropout Voltage @ $I_{out}$ = 1.0 mA (Note 3) | $V_{drop-1}$ | - | 0.6 | - | mV |
| Dropout Voltage @ $I_{out}$ = 150 mA (Note 3) | $V_{drop-150}$ | - | 75 | 150 | mV |
| Dropout Voltage @ $I_{out}$ = 300 mA (Note 3) | $V_{drop-300}$ | - | 150 | 250 | mV |
| SET Threshold (SET = OUT) @ $I_{out}$ = 1.0 mA and $V_{in}$ = 3.6 V or 6.0 V, $T_A$ = 25°C<br>$T_A$ from -25°C to +85°C | $V_{ref}$ | 1.226<br>1.220 | 1.244<br>1.244 | 1.262<br>1.270 | V |
| SET Input Leakage Current @ $V_{SET}$ = 1.25 V and $T_A$ = 25°C | $I_{leak}$ | - | 10 | 200 | nA |
| Short Circuit Output Current Limitation @ $V_{in}$ = 3.2 V and $V_{out}$ = 2.2 V | $I_{max\_cc}$ | 310 | 465 | 700 | mA |
| Start-Up Current Limitation @ $T_A$ = 25°C, $V_{in}$ = 3.2 V and $V_{out}$ = 2.2 V | $I_{max\_stup}$ | - | 220 | - | mA |
| Line Regulation, $V_{in}$ varying between 3.0 V and 6.0 V @ $I_{out}$ = 1.0 mA | $Line_{Reg1}$ | -0.1 | 0.01 | 0.1 | %/V |
| Line Regulation, $V_{in}$ varying between 3.0 V and 6.0 V @ $I_{out}$ = 10 mA | $Line_{Reg2}$ | -0.1 | 0.01 | 0.1 | %/V |
| Line Regulation, $V_{in}$ varying between 3.0 V and 6.0 V @ $I_{out}$ = 1.0 mA<br>and (SET = OUT) | $Line_{Reg3}$ | -0.1 | 0.03 | 0.1 | %/V |
| Line Regulation, $V_{in}$ varying between 3.0 V and 6.0 V @ $I_{out}$ = 10 mA<br>and (SET = OUT) | $Line_{Reg4}$ | -0.1 | 0.03 | 0.1 | %/V |
| Load Regulation, $I_{out}$ varying from 0.1 mA to 300 mA, SET = OUT, @ $V_{in}$ = 3.2 V | $Load_{Reg1}$ | - | 0.0002 | - | %/mA |
| Load Regulation, $I_{out}$ varying from 0.1 mA to 300 mA, SET Grounded, @ $V_{in}$ = 3.2 V | $Load_{Reg2}$ | - | 0.001 | - | %/mA |
| Output Voltage Noise @ SET = OUT, $C_{out}$ = 22 μF (Note 4)<br>10 Hz < f < 10 kHz<br>10 Hz < f < 100 kHz | - | -<br>-<br>- | <br>15<br>35 | -<br>-<br>- | μVrms |
| Output Voltage Noise @ SET = GND, $C_{out}$ = 22 μF (Note 4)<br>10 Hz < f < 10 kHz<br>10 Hz < f < 100 kHz | - | -<br>-<br>- | <br>35<br>60 | -<br>-<br>- | μVrms |
| Output Voltage Noise Density @ SET = GND, $C_{out}$ = 22 μF, 10 Hz < f < 100 kHz<br>(Note 4) | - | - | 400 | - | nV(Hz)$^{-1/2}$ |
| Power Supply Rejection Ratio @ 1.0 kHz and $I_{out}$ = 100 mA | PSRR | - | 60 | - | dB |
| Shutdown Threshold (with hysteresis) @ $V_{in}$ = 5.0 V | $V_{stdwn}$ | 0.63 | - | 2.65 | V |
| Shutdown Pin Bias Current @ $\overline{STDWN}$ = IN or GND and $T_A$ = 25°C | $I_{stdwn}$ | - | - | 100 | nA |
| $\overline{FAULT}$ Detection Voltage @ $I_{out}$ = 200 mA | $V_{fault-th}$ | - | 120 | 280 | mV |
| $\overline{FAULT}$ Output Low Voltage @ $I_{sink}$ = 2.0 mA | $V_{fault-out}$ | - | 0.15 | 0.4 | V |
| $\overline{FAULT}$ Output OFF Leakage Current @ $T_A$ = 25°C | $I_{fault}$ | - | 0.1 | 100 | nA |
| Start-Up Time @ $C_{out}$ = 10 μF, $V_{out}$ = 2.7, $I_{out}$ = 100 mA (Note 4) | $T_{stup}$ | - | 60 | - | μs |
| Thermal Shutdown Threshold | $T_{limit}$ | - | 170 | - | °C |
| Thermal Shutdown Hysteresis | $H_{temp}$ | - | 30 | - | °C |

\*The specification gives the targeted values. This specification may have to be slightly adjusted after the temperature characterization of the die.
3. The dropout voltage is defined as ($V_{in}$-$V_{out}$) when $V_{out}$ is 100 mV below the value of $V_{out}$ when $V_{in}$ = 3.1 V.
4. Refer to characterization curves for more details.

# NCP2860

## TYPICAL ELECTRICAL CHARACTERISTICS

($V_{in}$ = $V_{out}$ + 0.5 V, $C_{in}$ = $C_{out}$ = 2.2 $\mu$F, SET = GND, $T_A$ = 25°C, unless otherwise noted.)
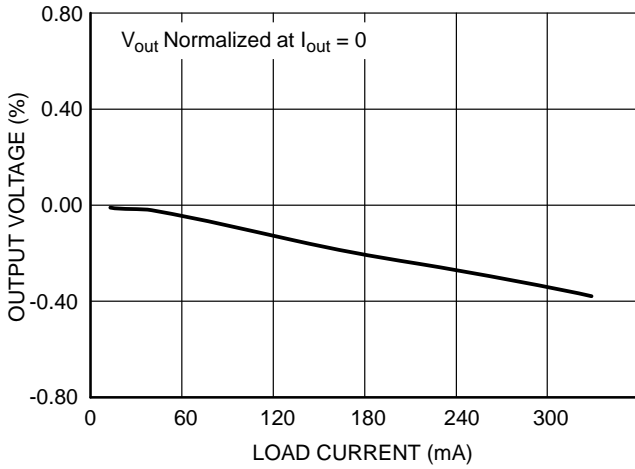
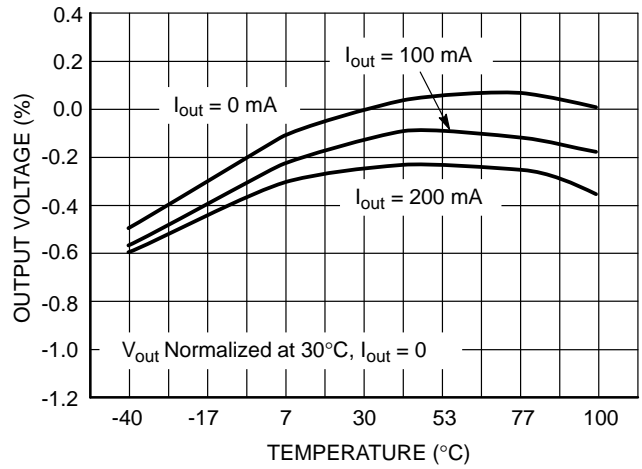**Figure 1. Normalized Output Voltage vs. Load Current**

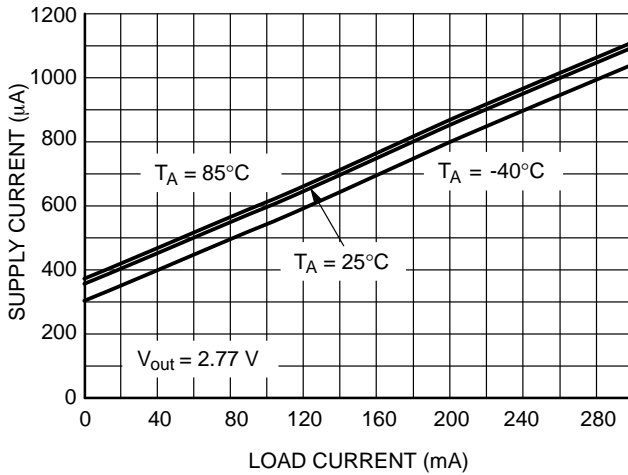**Figure 2. Normalized Output Voltage vs. Temperature**
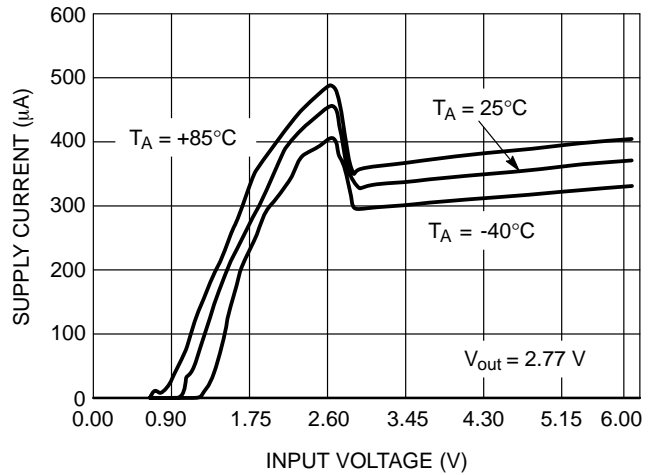
**Figure 3. Supply Current vs. Load Current**

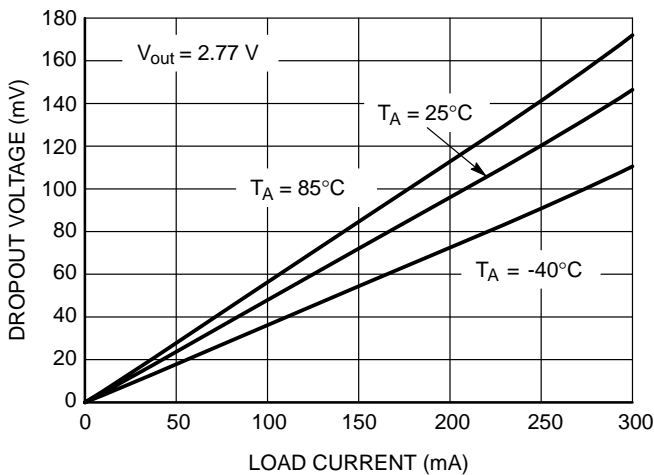**Figure 4. No Load Supply Current vs. Input Voltage**
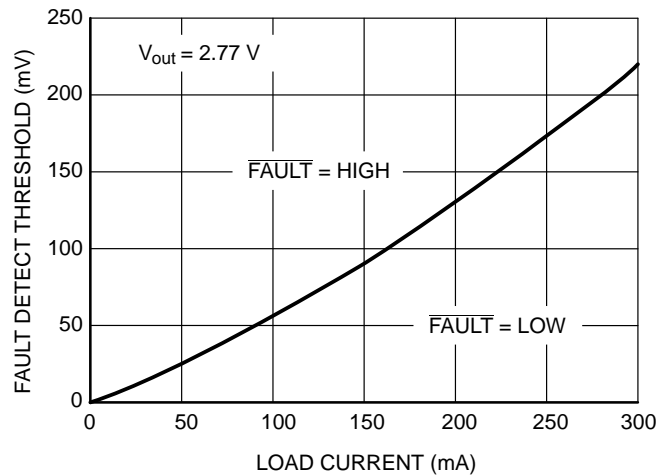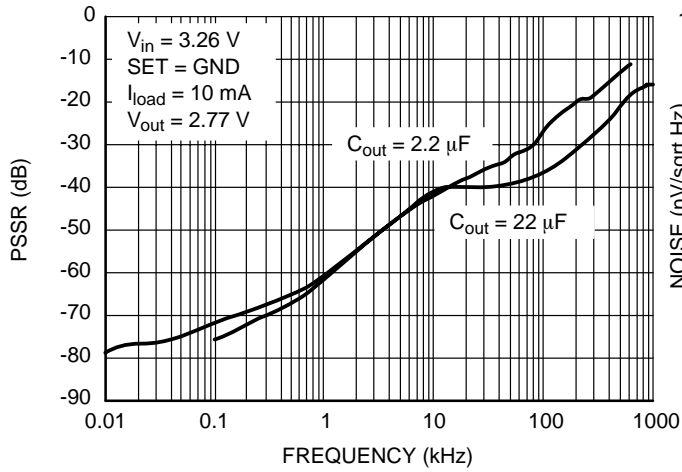
**Figure 5. Dropout Voltage vs. Load Current**

**Figure 6. Fault Detect Threshold vs. Load Current**

# NCP2860

## TYPICAL ELECTRICAL CHARACTERISTICS

($V_{in}$ = $V_{out}$ + 0.5 V, $C_{in}$ = $C_{out}$ = 2.2 $\mu$F, SET = GND, $T_A$ = 25°C, unless otherwise noted.)

**Figure 7. Power Supply Rejection Ratio**

Plot axes: PSSR (dB) vs FREQUENCY (kHz)

$V_{in}$ = 3.26 V
SET = GND
$I_{load}$ = 10 mA
$V_{out}$ = 2.77 V
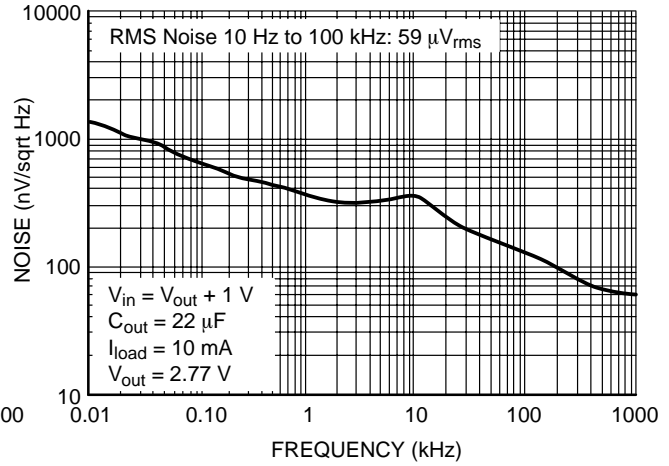
$C_{out}$ = 2.2 $\mu$F

$C_{out}$ = 22 $\mu$F

**Figure 8. Output Noise Spectral Density**

Plot axes: NOISE (nV/sqrt Hz) vs FREQUENCY (kHz)

RMS Noise 10 Hz to 100 kHz: 59 $\mu$V$_{rms}$

$V_{in}$ = $V_{out}$ + 1 V
$C_{out}$ = 22 $\mu$F
$I_{load}$ = 10 mA
$V_{out}$ = 2.77 V
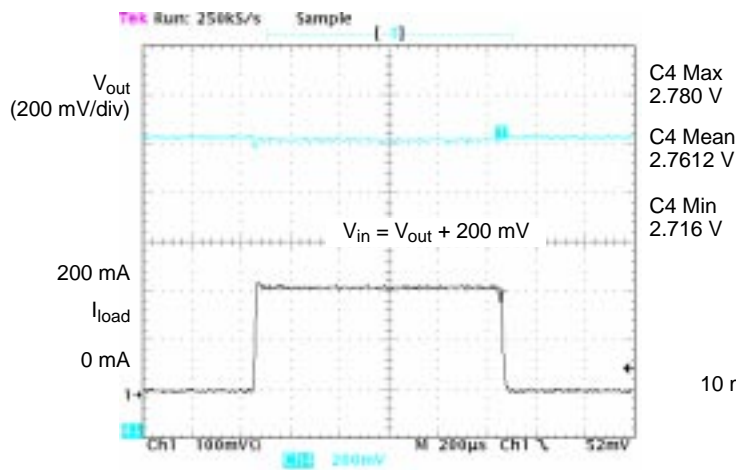
**Figure 9. Load Transient Response**

Tek Run: 250kS/s    Sample

$V_{out}$ (200 mV/div)

C4 Max 2.780 V
C4 Mean 2.7612 V
C4 Min 2.716 V

$V_{in}$ = $V_{out}$ + 200 mV

200 mA
$I_{load}$
0 mA

Ch1  100mVΩ        M 200μs  Ch1    52mV
        200mV
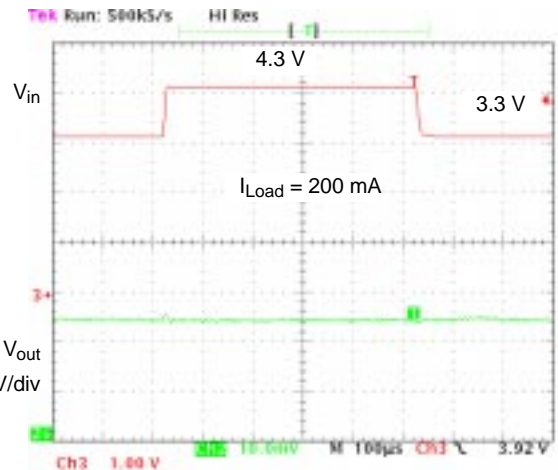
**Figure 10. Line Transient**

Tek Run: 500kS/s    Hi Res

4.3 V

$V_{in}$        3.3 V

$I_{Load}$ = 200 mA

$V_{out}$ 10 mV/div

Ch3  1.00 V        10.0mV    M 100μs  Ch3    3.92 V

# NCP2860

## TYPICAL ELECTRICAL CHARACTERISTICS

($V_{in}$ = $V_{out}$ + 0.5 V, $C_{in}$ = $C_{out}$ = 2.2 μF, SET = GND, $T_A$ = 25°C, unless otherwise noted.)
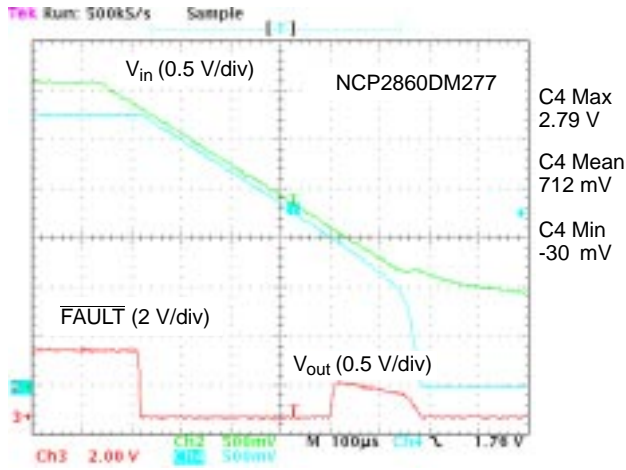
**Figure 11. Power-Down Response ($I_{load}$ = 100 mA)**

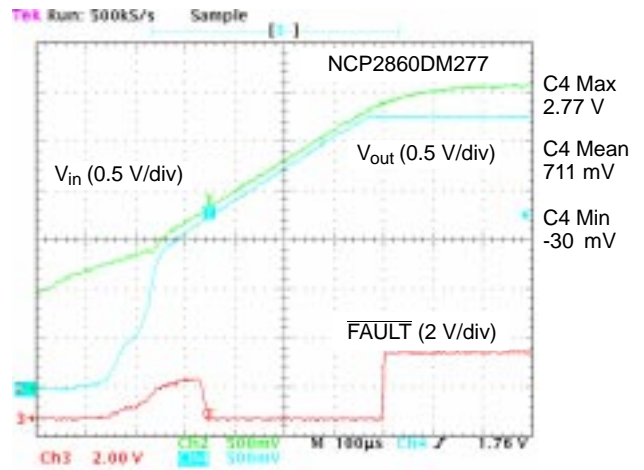**Figure 12. Power-Up Response ($I_{load}$ = 100 mA)**

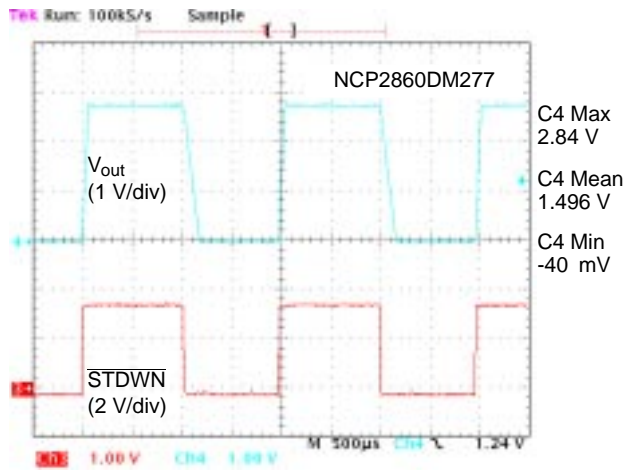**Figure 13. Shutdown/Power-Up ($V_{in}$ = $V_{out}$ + 0.5 V, $I_{load}$ = 50 mA)**

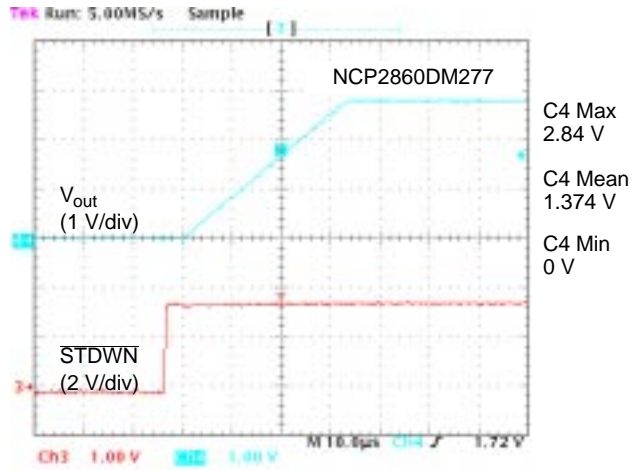**Figure 14. Shutdown/Power-Up ($V_{in}$ = $V_{out}$ + 0.5 V, $I_{load}$ = 0 mA)**

## DETAILED OPERATING DESCRIPTION

### Internal Pass Transistor

The NCP2860 incorporates a 0.5 Ω typical P-channel MOSFET pass transistor. The P-channel MOSFET requires no drive current and then compared to the PNP based regulators, this solution drastically reduces the quiescent current and associated losses.

### Shutdown Block

The circuit turns into shutdown mode when the shutdown pin is in low state. In this mode, the internal biasing current sources are disconnected so that the pass transistor is off and the consumption reduced to a minimum value. Practically, the shutdown consumption is in the range of 10 nA. When this function is unused, "IN" is generally applied to the shutdown pin.

### Current Limitation

The NCP2860 incorporates a short circuit protection that prevents the pass transistor current from exceeding 465 mA typically. The current limit is set to 220 mA during the start-up phase.

### Thermal Protection

The thermal protection protects the die against excessive overheating. Practically, when the junction temperature exceeds 170°C for the 2.77 V option and 150°C for the 3.0 V option, an internal thermal sensor sends a logical signal to the shutdown block so that the circuit enters the shutdown mode. Once the die has cooled enough (typically 30°C), the circuit enters a new working phase.

### Output Voltage Setting

The output voltage is set to 2.77 V if the "SET" pin is grounded. It can also be programmed to a different value. To do so, a portion of the output voltage must be applied to the "SET" pin. If a (R1, R2) resistors divider is used, then:

$$V_{out} = (1 + R1/R2) * V_{ref}$$

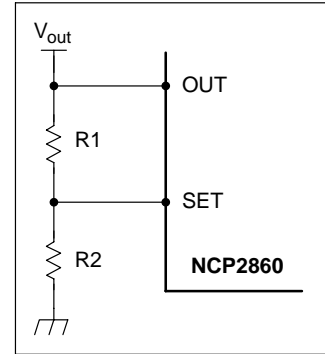Therefore, as $V_{ref}$ typically equals 1.244 V:

$$V_{out} = 1.244 * (1 + R1/R2).$$

Now if R1 and R2 are high impedance resistors, the leakage current that is absorbed by the "SET" pin, may have to be taken into account as follows:

$$V_{out} = [1.244 * (1 + R1/R2)] + (R1*I_{lk})$$ where $I_{lk}$ is the "SET" pin leakage current.

If the output voltage is directly applied to the "SET" pin, $V_{out} = V_{ref} = 1.244$ V.



### Regulation

The circuit incorporates a transconductance error amplifier. The error amplifier output varies in response to load and input voltage variations to control the pass transistor current so that the "OUT" pin delivers the wished voltage. No compensation capacitor is required.

### Fault Detection Circuitry

The circuit detects when the input-output differential voltage is too low to ensure a correct load and line regulation at the output. The input-output differential threshold scales proportionally with the load current to be always just higher than the dropout.

When the circuit detects a fault condition, an internal switch connects "$\overline{FAULT}$" to ground. In normal operation, the "$\overline{FAULT}$" terminal is an open-drain-N-channel MOSFET and if a pull-up resistor is connected between "OUT" and "$\overline{FAULT}$", "$\overline{FAULT}$" goes high. The pull-up resistor is generally selected in the range of 100 kΩ to minimize the current consumption.

### Application Information

It is recommended to use 2.2 μF capacitors on the input and on the output of the NCP2860. Capacitor type is not very critical. Simply the ESR should be lower than 0.5 Ω to ensure a stable operation over the temperature and output current ranges. It could be convenient to increase the capacitor size and its quality (lower ESR) only if it was necessary to further improve the noise performances, the Power Supply Rejection Ratio or the fast transient response.
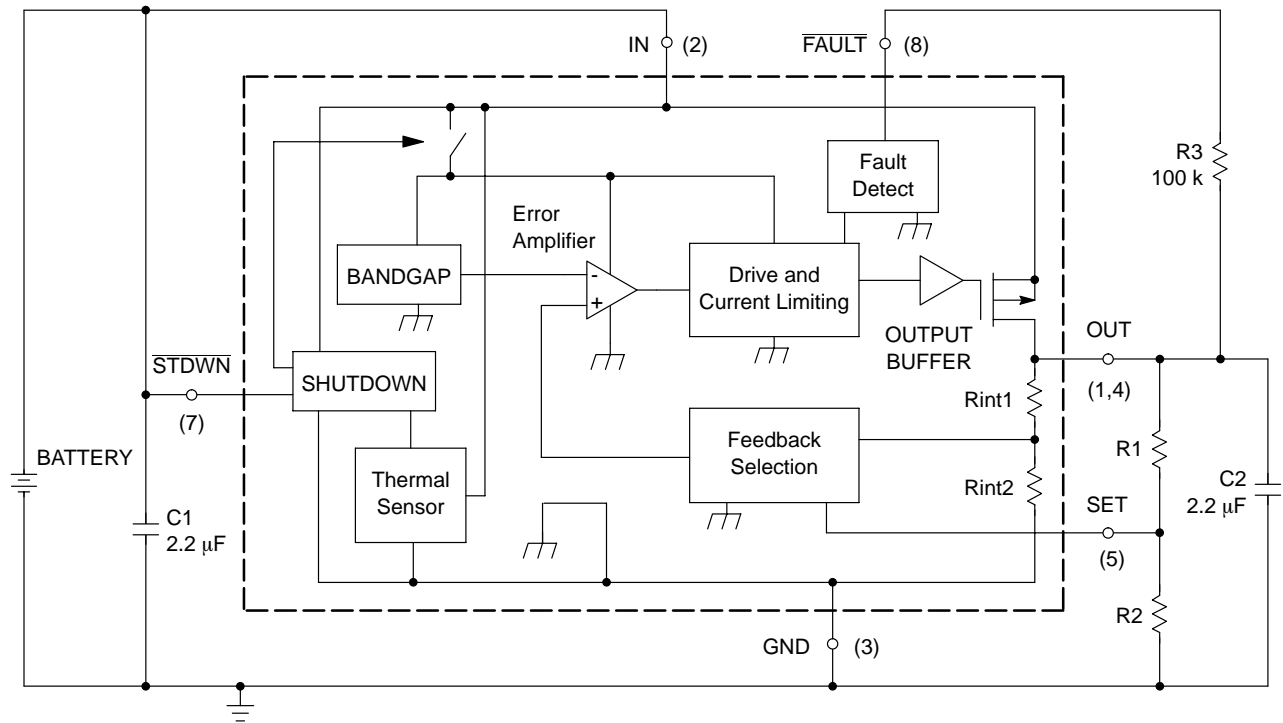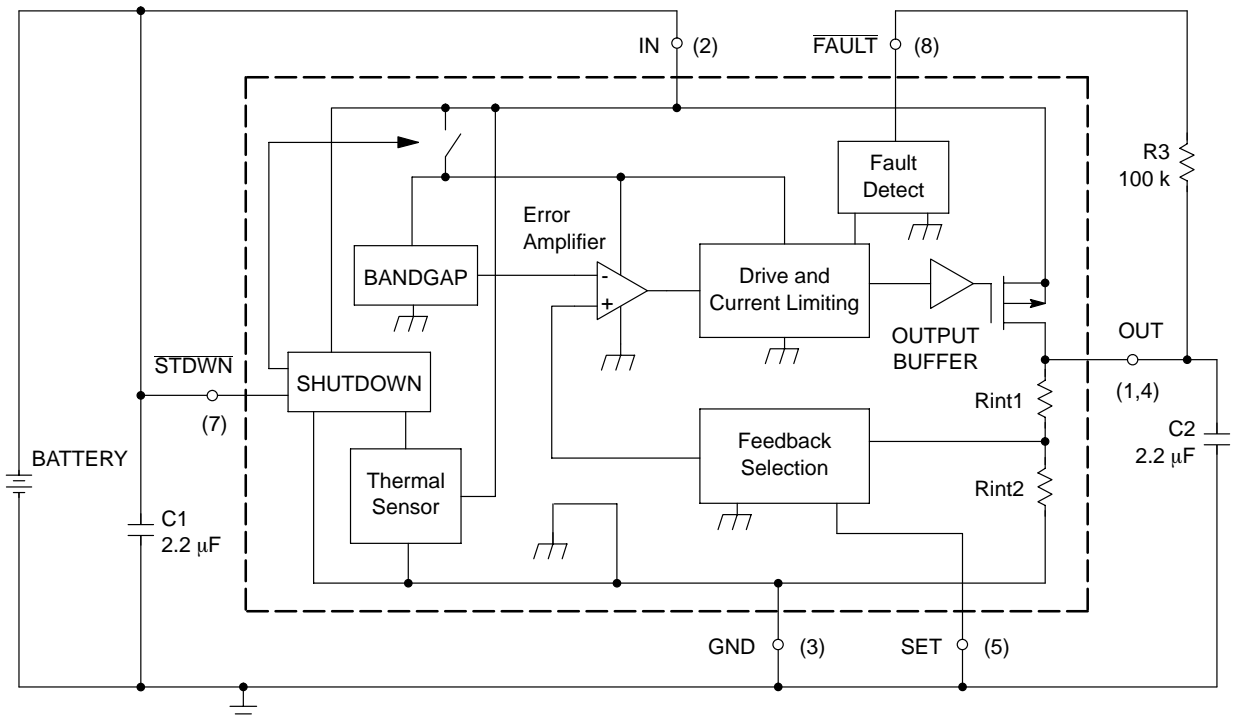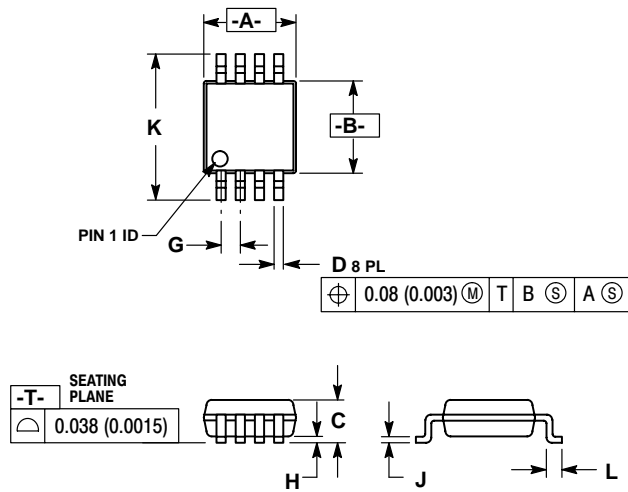
**Figure 15. With External Output Voltage Adjustment**



**Figure 16. Application for 2.77 V Output Voltage**

# NCP2860

## PACKAGE DIMENSIONS

**Micro8**
**DM SUFFIX**
CASE 846A-02
ISSUE F

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. 846A–01 OBSOLETE, NEW STANDARD 846A–02.

| DIM | MILLIMETERS | | INCHES | |
|-----|-----|-----|-----|-----|
| | MIN | MAX | MIN | MAX |
| A | 2.90 | 3.10 | 0.114 | 0.122 |
| B | 2.90 | 3.10 | 0.114 | 0.122 |
| C | --- | 1.10 | --- | 0.043 |
| D | 0.25 | 0.40 | 0.010 | 0.016 |
| G | 0.65 BSC | | 0.026 BSC | |
| H | 0.05 | 0.15 | 0.002 | 0.006 |
| J | 0.13 | 0.23 | 0.005 | 0.009 |
| K | 4.75 | 5.05 | 0.187 | 0.199 |
| L | 0.40 | 0.70 | 0.016 | 0.028 |

# Notes

# Notes

# NCP2860

Micro8 is a trademark of International Rectifier.

**NCP2860/D**