NCP2860

300 mA Very Low Noise, Low Dropout Linear Regulator

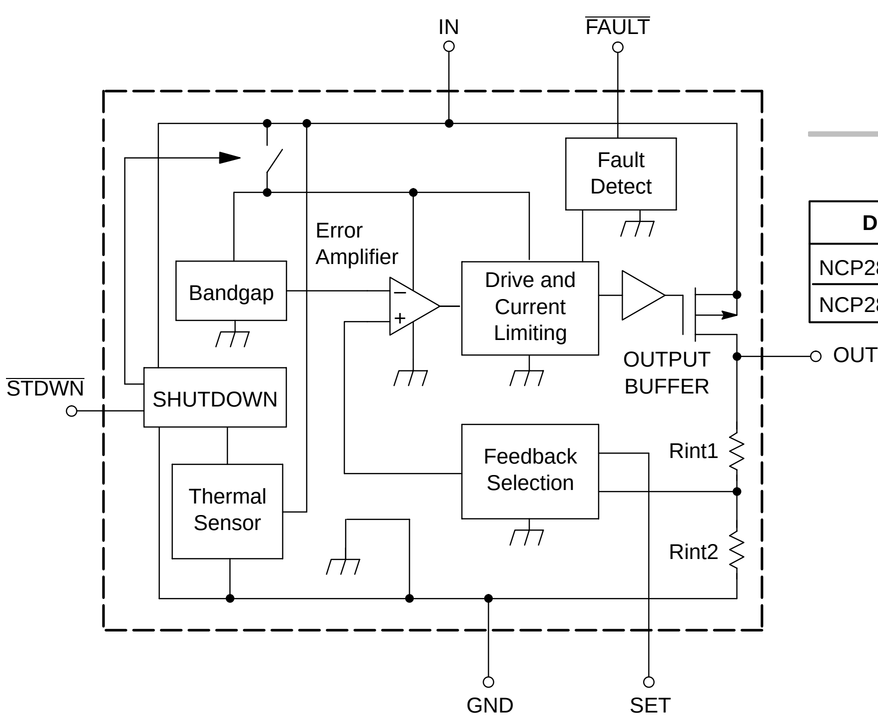
The NCP2860 is a low noise, low dropout linear regulator that is offered with an output voltage of 2.77 V and 3.0 V. It supplies 300 mA from 3.0 V to 6.0 V input. If wished, the “SET” pin enables to adjust the output voltage level that then depends on the voltage applied to this pin. The excellent performances 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)
- $\overline{\text{FAULT}}$ Indicator
- Programmable Output Voltage
- Soft Start

Typical Applications

- Cellular Phone
- Handheld Instruments



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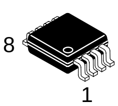
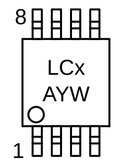
MARKING DIAGRAM

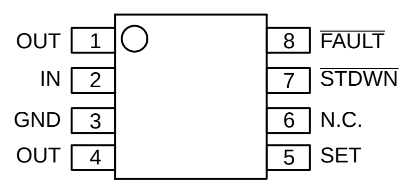


Micro8™
DM SUFFIX
CASE 846A



x = Z for NCP260DM277
  3 for NCP2860DM300
A = Assembly Location
Y = Year
W = Work Week

PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

Device	Package	Shipping
NCP2860DM277R2	Micro8	4000 Units/Reel
NCP2860DM300R2	Micro8	4000 Units/Reel

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 μF 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 Human Body Model Machine Model	 – –	 2.0 200	 kV 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 T_A from –25°C to +85°C	V_{out}	2.73 2.70	2.77 2.77	2.81 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) @ 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 T_A from –25°C to +85°C	V_{ref}	1.226 1.220	1.244 1.244	1.262 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 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 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) 10 Hz $<$ f $<$ 10 kHz 10 Hz $<$ f $<$ 100 kHz	–	 – –	 15 35	 – –	μV_{rms}
Output Voltage Noise @ SET = GND, C_{out} = 22 μF (Note 4) 10 Hz $<$ f $<$ 10 kHz 10 Hz $<$ f $<$ 100 kHz	–	 – –	 35 60	 – –	μV_{rms}
Output Voltage Noise Density @ SET = GND, C_{out} = 22 μF, 10 Hz $<$ f $<$ 100 kHz (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.

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

Characteristic (3.0 V Option)	Symbol	Min	Typ	Max	Unit
Output Voltage @ I_{out} = 100 μA, 300 mA, V_{in} = 3.6 V and T_A = 25°C T_A from –25°C to +85°C	V_{out}	2.96 2.93	3.0 3.0	3.04 3.07	V
Supply Current @ I_{out} = 0, V_{in} = 3.6 V	I_{cc-0}	–	355	700	μA
Supply Current @ I_{out} = 300 mA, V_{in} = 3.6 V	I_{cc-300}	–	1.1	–	mA
Supply Current in Shutdown Mode ($\overline{STDWN}$ Pin Grounded) @ T_A = 25°C	I_{stdwn}	–	0.01	1.0	μA
Dropout Voltage @ I_{out} = 1.0 mA (Note 5)	V_{drop-1}	–	0.6	–	mV
Dropout Voltage @ I_{out} = 150 mA (Note 5)	$V_{drop-150}$	–	65	150	mV
Dropout Voltage @ I_{out} = 300 mA (Note 5)	$V_{drop-300}$	–	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 T_A from –25°C to +85°C	V_{ref}	1.226 1.220	1.244 1.244	1.262 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} = 3.6 V and V_{out} = 2.6 V	I_{max_cc}	310	465	700	mA
Start–Up Current Limitation @ T_A = 25°C, V_{in} = 3.6 V and V_{out} = 2.6 V	I_{max_stup}	–	220	–	mA
Line Regulation, V_{in} varying between 3.2 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 3.2 V and 6.0 V @ I_{out} = 10 mA	$Line_{Reg2}$	–0.1	0.01	0.1	%/V
Line Regulation, V_{in} varying between 3.2 V and 6.0 V @ I_{out} = 1.0 mA and (SET = OUT)	$Line_{Reg3}$	–0.1	0.03	0.1	%/V
Line Regulation, V_{in} varying between 3.2 V and 6.0 V @ I_{out} = 10 mA 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} = 3.6 V	$Load_{Reg1}$	–	0.0002	–	%/mA
Load Regulation, I_{out} varying from 0.1 mA to 300 mA, SET Grounded, @ V_{in} = 3.6 V	$Load_{Reg2}$	–	0.001	–	%/mA
Output Voltage Noise @ SET = OUT, C_{out} = 22 μF (Note 6) 10 Hz $<$ f $<$ 10 kHz 10 Hz $<$ f $<$ 100 kHz	–	 – –	 15 35	 – –	μV_{rms}
Output Voltage Noise @ SET = GND, C_{out} = 22 μF (Note 6) 10 Hz $<$ f $<$ 10 kHz 10 Hz $<$ f $<$ 100 kHz	–	 – –	 35 60	 – –	μV_{rms}
Output Voltage Noise Density @ SET = GND, C_{out} = 22 μF, 10 Hz $<$ f $<$ 100 kHz (Note 6)	–	–	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	$V_{fault-th}$	–	170	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} = 3.0 V, I_{out} = 100 mA (Note 6)	T_{stup}	–	87	–	μs
Thermal Shutdown Threshold	T_{limit}	–	150	–	°C
Thermal Shutdown Hysteresis	H_{temp}	–	50	–	°C

*The specification gives the targeted values. This specification may have to be slightly adjusted after the temperature characterization of the die.
5. 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} = 3.5 V.
6. Refer to characterization curves for more details.

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.)

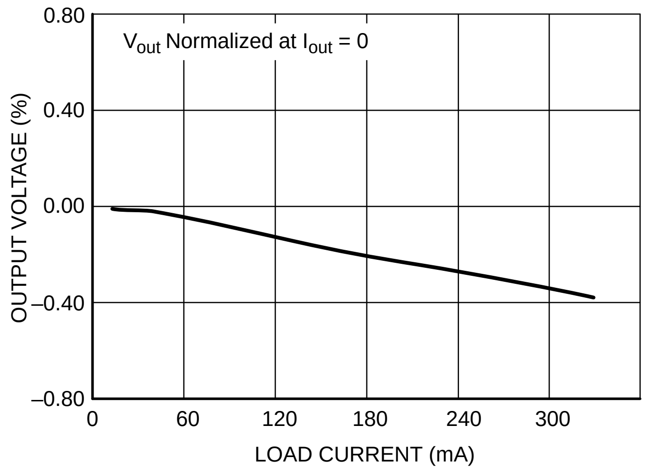


Figure 1. Normalized Output Voltage vs. Load Current

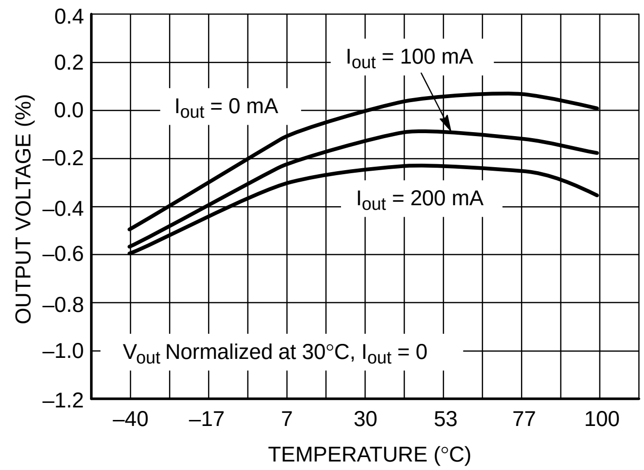


Figure 2. Normalized Output Voltage vs. Temperature

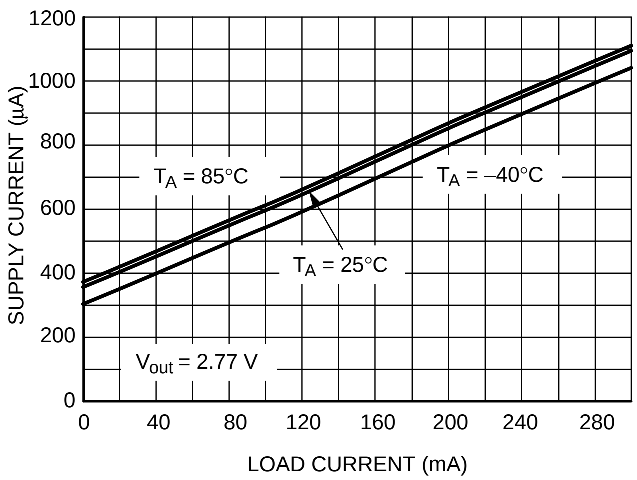


Figure 3. Supply Current vs. Load Current

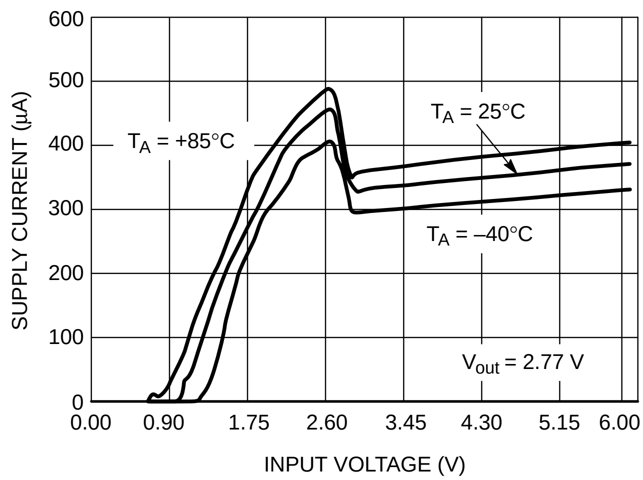


Figure 4. No Load Supply Current vs. Input Voltage

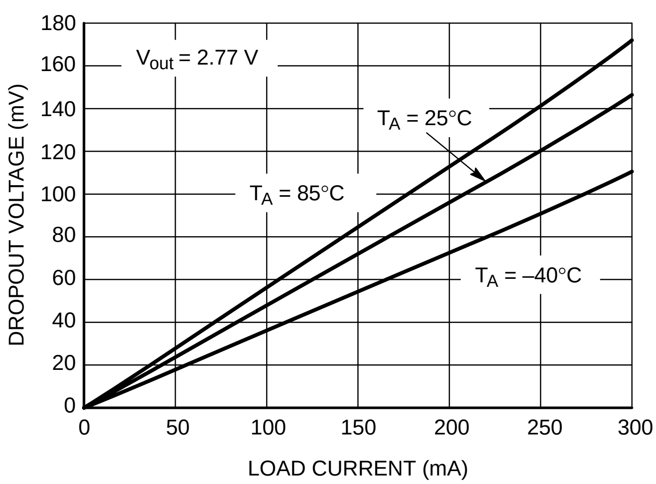


Figure 5. Dropout Voltage vs. Load Current

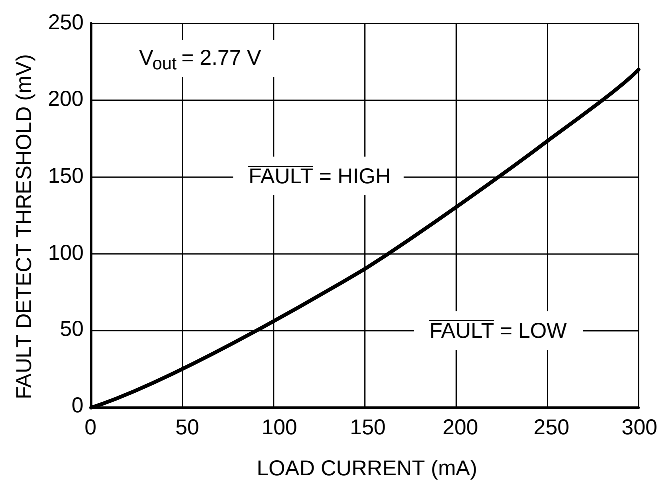


Figure 6. Fault Detect Threshold vs. Load Current

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.)

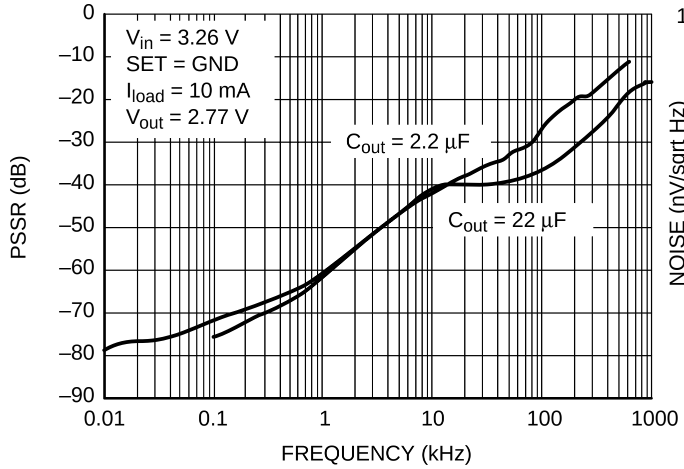


Figure 7. Power Supply Rejection Ratio

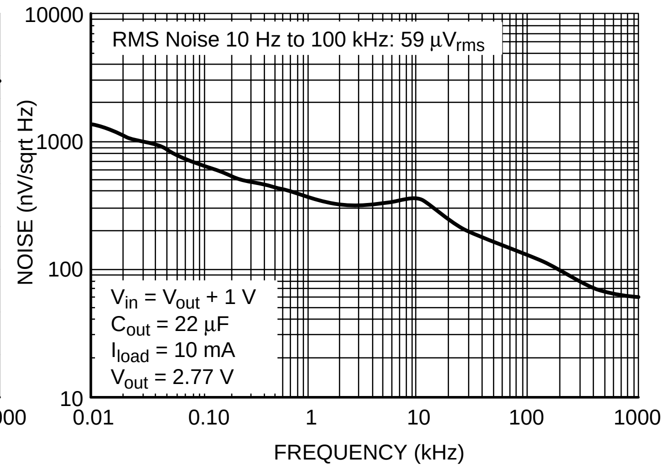


Figure 8. Output Noise Spectral Density

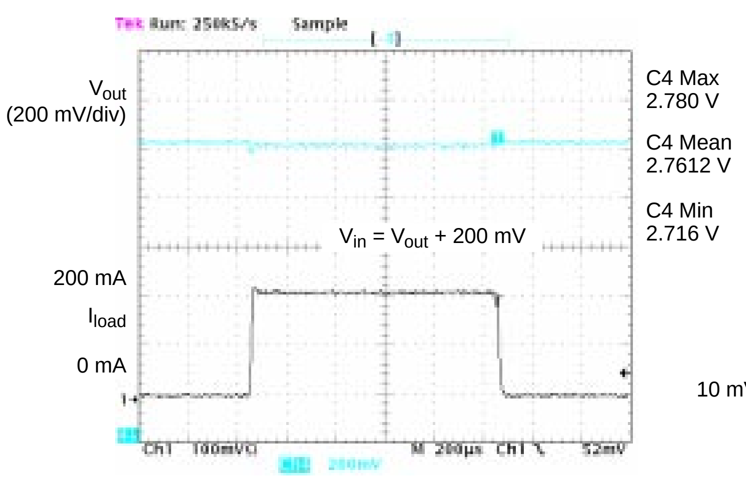


Figure 9. Load Transient Response

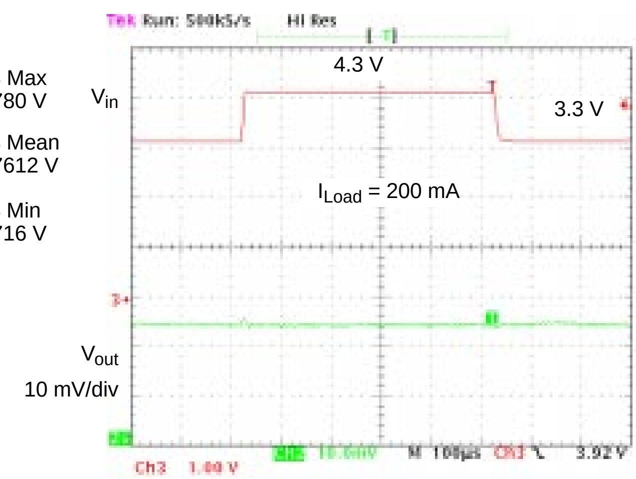


Figure 10. Line Transient

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.)

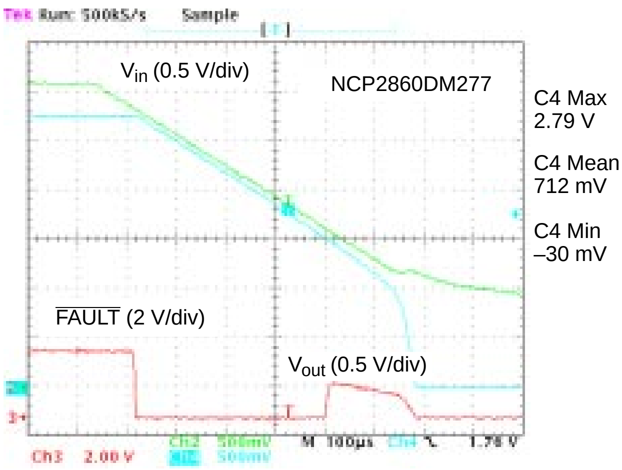


Figure 11. Power–Down Response (I_{load} = 100 mA)

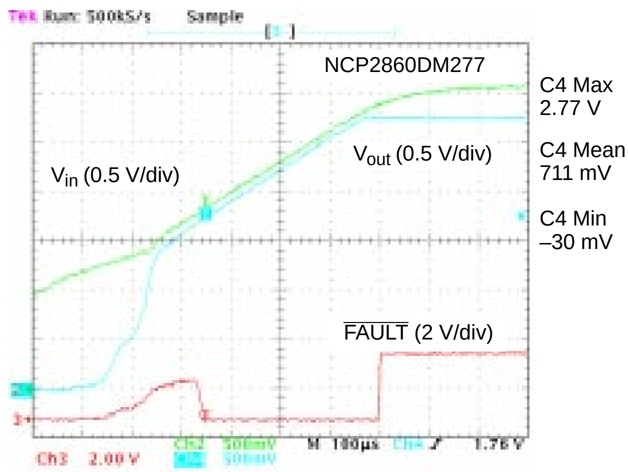


Figure 12. Power–Up Response (I_{load} = 100 mA)

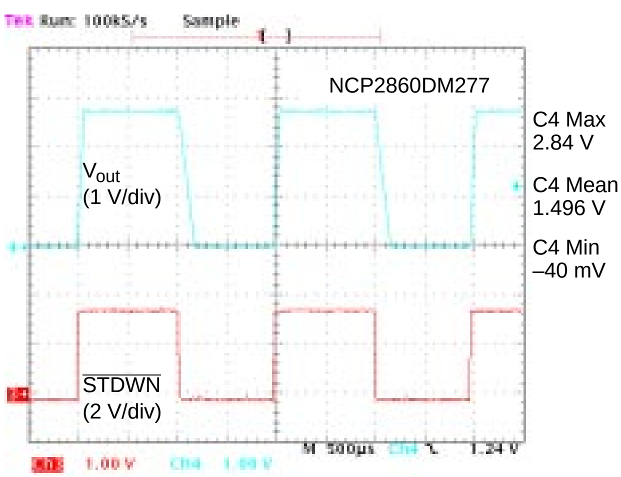


Figure 13. Shutdown/Power–Up ($V_{in} = V_{out}$ + 0.5 V, I_{load} = 50 mA)

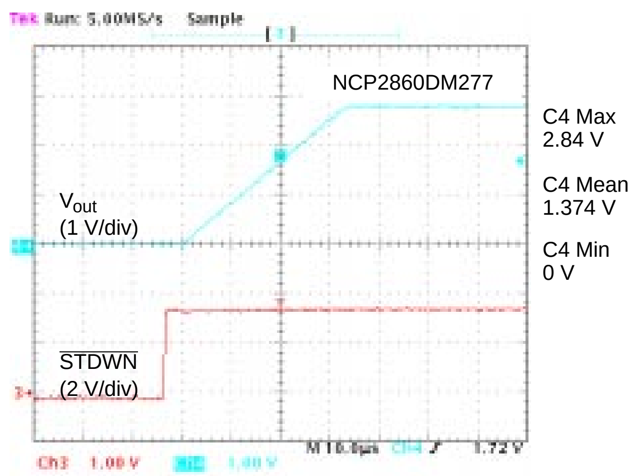


Figure 14. Shutdown/Power–Up ($V_{in} = V_{out}$ + 0.5 V, I_{load} = 0 mA)

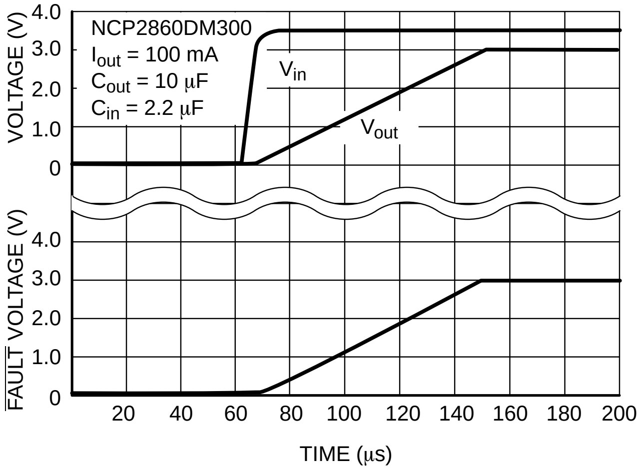


Figure 15. Power–Up Response

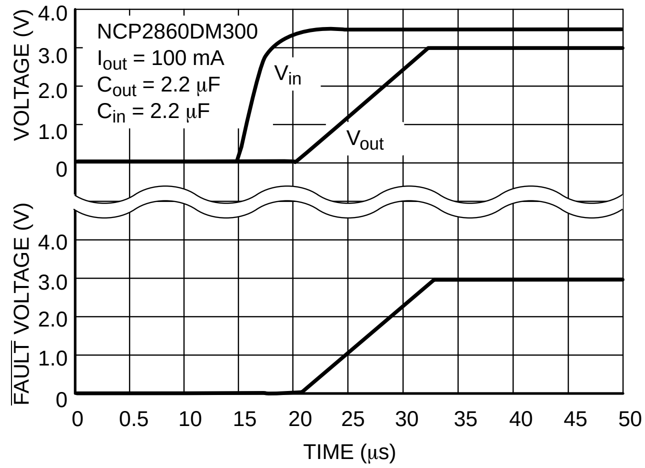


Figure 16. Power–Up Response

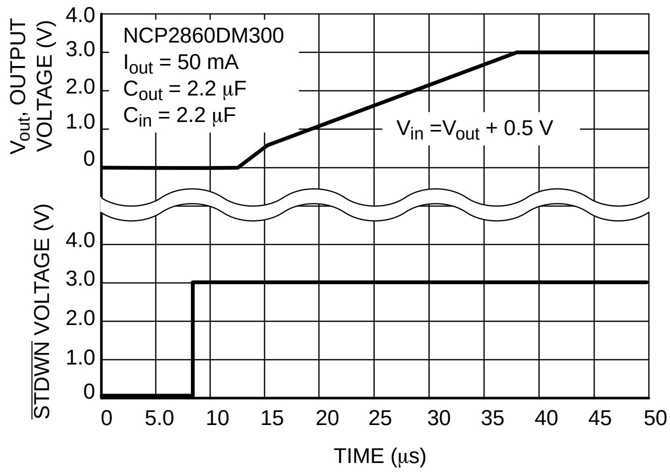


Figure 17. Shutdown/Power–Up

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 (or 3.0 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:

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

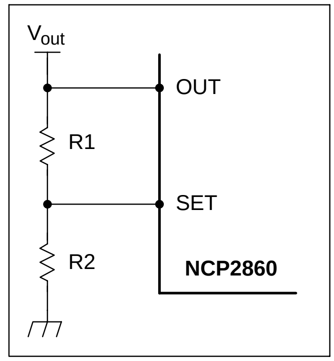
Therefore, as V_{ref} typically equals 1.244 V:

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

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 “$\overline{\text{FAULT}}$” to ground. In normal operation, the “$\overline{\text{FAULT}}$” terminal is an open–drain–N–channel MOSFET and if a pull–up resistor is connected between “OUT” and “$\overline{\text{FAULT}}$”, “$\overline{\text{FAULT}}$” 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.

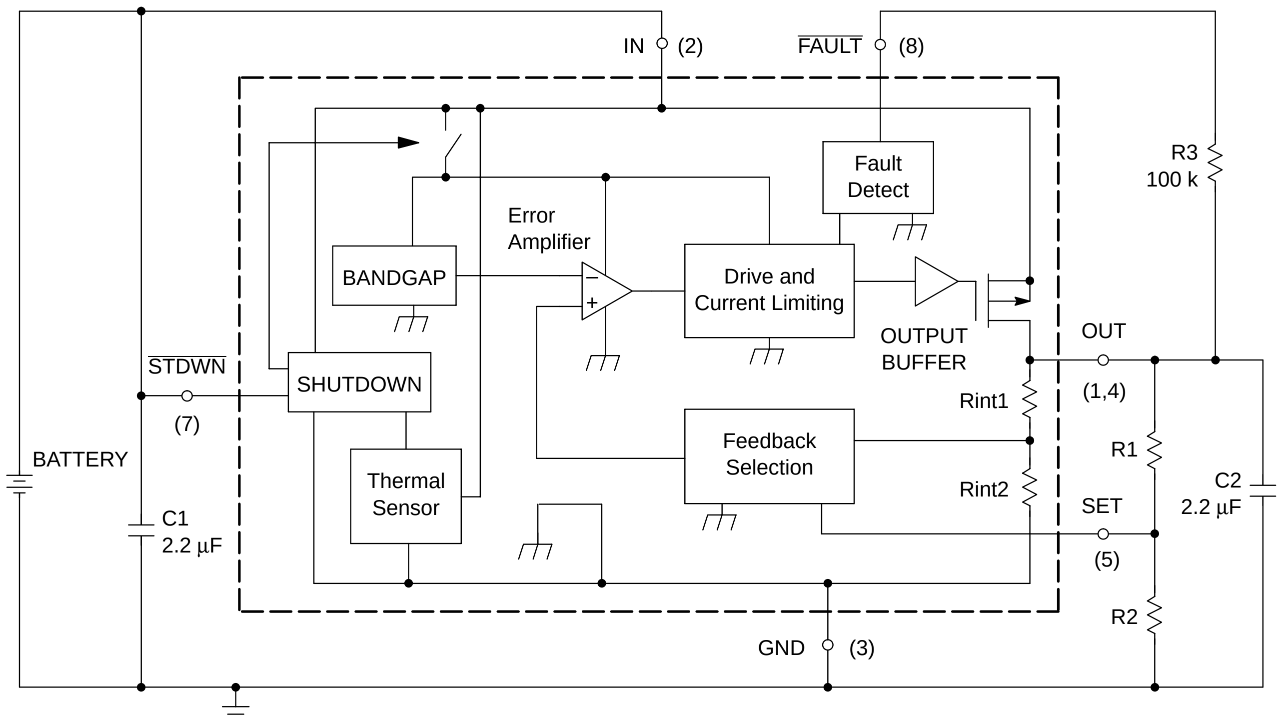


Figure 18. With External Output Voltage Adjustment

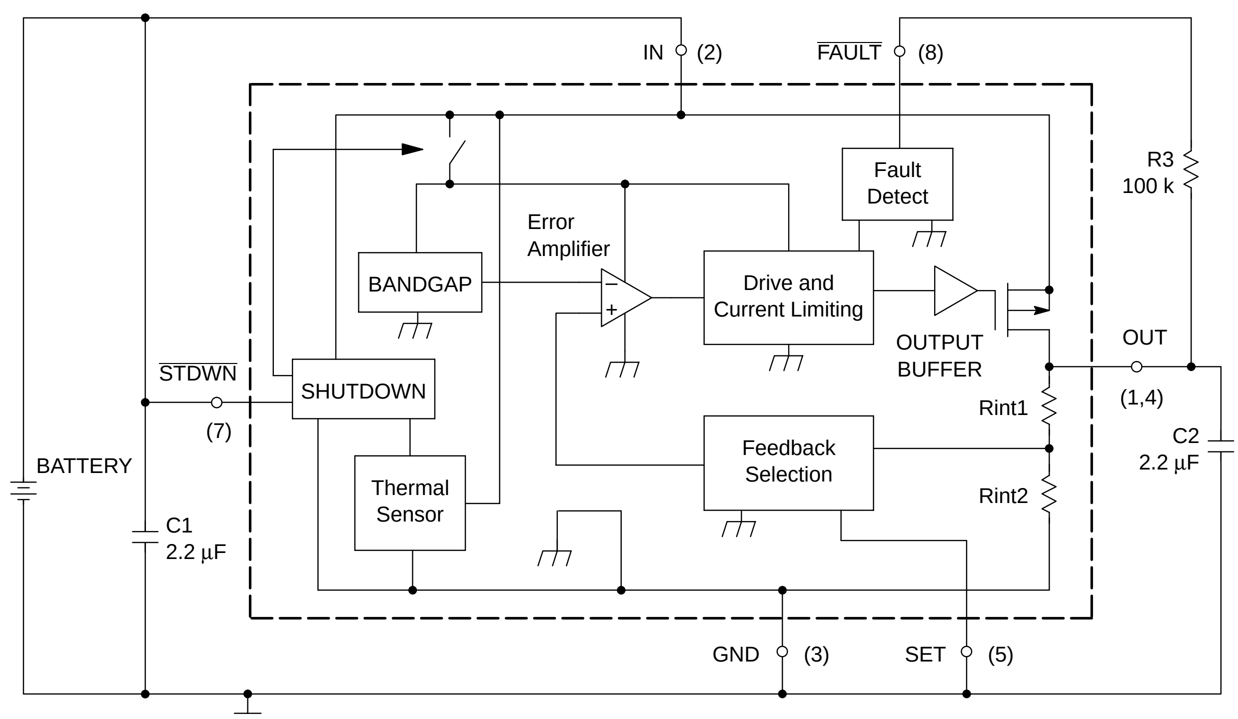
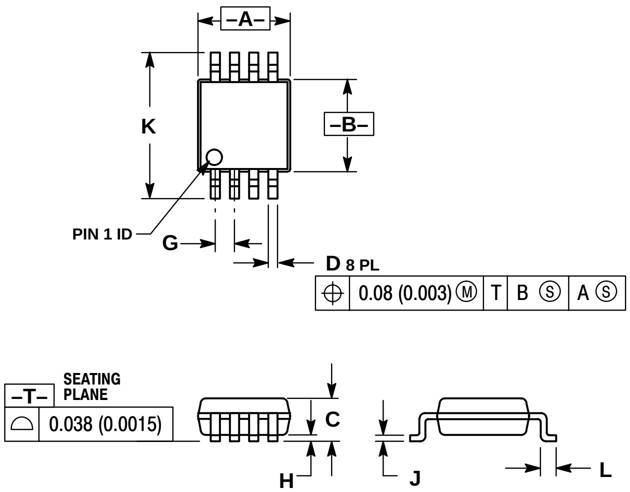


Figure 19. Application for 2.77 V Output Voltage

PACKAGE DIMENSIONS

Micro8
DM SUFFIX
CASE 846A–02
ISSUE E



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.

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

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