

# MDNCV8170A

## Ultra-Low $I_Q$ 150 mA CMOS LDO Regulator

The MDNCV8170A CMOS low dropout regulator is designed specifically for portable battery-powered applications which require ultra-low quiescent current. The ultra-low consumption of typ. 500 nA ensures long battery life and dynamic transient boost feature improves device transient response for wireless communication applications. The device is available in a small  $1 \times 1$  mm xDFN4 package.

### Features

- Operating Input Voltage Range: 2.2 V to 5.5 V
- Output Voltage Range: 1.2 V to 3.6 V (0.1 V Steps)
- Ultra-Low Quiescent Current Typ. 0.5  $\mu$ A
- Low Dropout: 170 mV Typ. at 150 mA
- High Output Voltage Accuracy  $\pm 1\%$
- Stable with Ceramic Capacitors 1  $\mu$ F
- Over-Current Protection
- Thermal Shutdown Protection
- AEC-Q100 Qualified
- Available in Small  $1 \times 1$  mm xDFN4 Package
- These are Pb-Free Devices

### Typical Applications

- Medical Applications

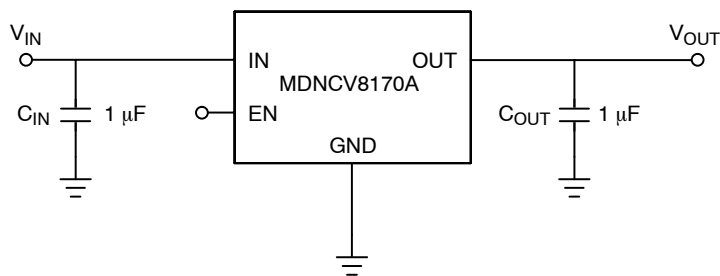


Figure 1. Typical Application Schematic



ON Semiconductor®

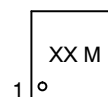
[www.onsemi.com](http://www.onsemi.com)



XDFN4  
MX SUFFIX  
CASE 711AJ

### MARKING DIAGRAMS

XDFN4



XX = Specific Device Code  
M = Date Code

### ORDERING INFORMATION

See detailed ordering, marking and shipping information on page 11 of this data sheet.

# MDNCV8170A

## PIN FUNCTION DESCRIPTION

Pin No. XDFN4	Pin Name	Description
4	IN	Power Supply Input Voltage
2	GND	Power Supply Ground
3	EN	Chip Enable Pin (Active "H")
1	OUT	Output Pin
EPAD	EPAD	Internally Connected to GND

## ABSOLUTE MAXIMUM RATINGS

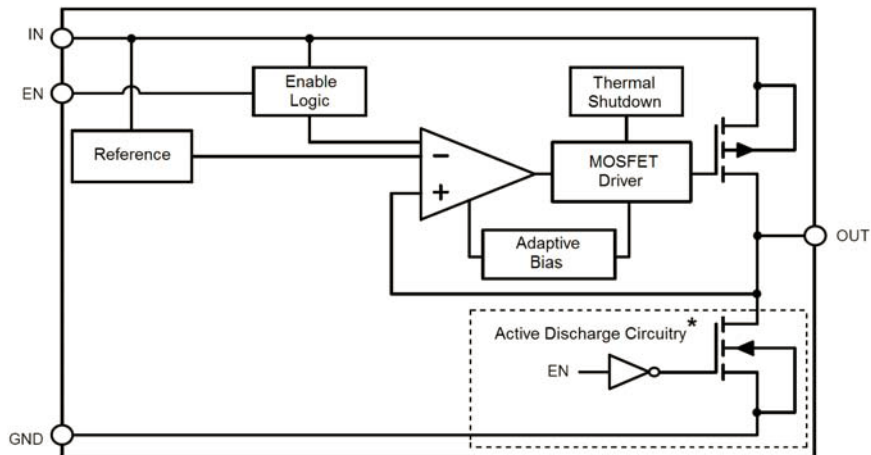
Symbol	Rating	Value	Unit
$V_{IN}$	Input Voltage (Note 1)	6.0	V
$V_{OUT}$	Output Voltage	-0.3 to $V_{IN} + 0.3$	V
$V_{CE}$	Chip Enable Input	-0.3 to 6.0	V
$T_{J(MAX)}$	Maximum Junction Temperature	125	°C
$T_{STG}$	Storage Temperature	-55 to 150	°C
ESD <sub>HBM</sub>	ESD Capability, Human Body Model (Note 2)	2000	V
ESD <sub>MM</sub>	ESD Capability, Machine Model (Note 2)	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

## THERMAL CHARACTERISTICS

Symbol	Rating	Value	Unit
$R_{\theta JA}$	Thermal Characteristics, Thermal Resistance, Junction-to-Air XDFN4 1 × 1 mm	250	°C/W



\* Active discharge feature is present only in NCV8170AxxvvvTyG devices

Figure 2. Simplified Block Diagram

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## ELECTRICAL CHARACTERISTICS – VOLTAGE VERSION 2.5 V

( $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ;  $V_{IN} = 3.5\text{ V}$ ;  $I_{OUT} = 1\text{ mA}$ ,  $C_{IN} = C_{OUT} = 1.0\ \mu\text{F}$ , unless otherwise noted. Typical values are at  $T_A = +25^{\circ}\text{C}$ .) (Note 3)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$V_{IN}$	Operating Input Voltage		2.2	–	5.5	V
$V_{OUT}$	Output Voltage	$T_A = +25^{\circ}\text{C}$	2.475	2.5	2.525	V
		$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$	2.450	2.5	2.550	
$\text{Line}_{\text{Reg}}$	Line Regulation	$3.5\text{ V} < V_{IN} \leq 5.5\text{ V}$ , $I_{OUT} = 1\text{ mA}$	–	0.05	0.20	%/V
$\text{Load}_{\text{Reg}}$	Load Regulation	$0\text{ mA} < I_{OUT} \leq 150\text{ mA}$ , $V_{IN} = 3.5\text{ V}$	–20	1	20	mV
$V_{DO}$	Dropout Voltage	$I_{OUT} = 150\text{ mA}$ (Note 4)	–	240	350	mV
$I_{OUT}$	Output Current	(Note 5)	150	–	–	mA
$I_{SC}$	Short Circuit Current Limit	$V_{OUT} = 0\text{ V}$	–	225	–	mA
$I_Q$	Quiescent Current	$I_{OUT} = 0\text{ mA}$	–	0.5	0.9	$\mu\text{A}$
$I_{STB}$	Standby Current	$V_{EN} = 0\text{ V}$ , $T_J = 25^{\circ}\text{C}$	–	0.1	0.5	$\mu\text{A}$
$V_{ENH}$	EN Pin Threshold Voltage	EN Input Voltage “H”	1.2	–	–	V
$V_{ENL}$	EN Pin Threshold Voltage	EN Input Voltage “L”	–	–	0.4	V
$I_{EN}$	EN Pull Down Current	$V_{EN} \leq V_{IN} \leq 5.5\text{ V}$ (Note 6)	–	10	–	nA
PSRR	Power Supply Rejection Ratio	$f = 1\text{ kHz}$ , $V_{IN} = 3.5\text{ V} + 200\text{ mVpp}$ Modulation $I_{OUT} = 150\text{ mA}$	–	57	–	dB
$V_{NOISE}$	Output Noise Voltage	$V_{IN} = 5.5\text{ V}$ , $I_{OUT} = 1\text{ mA}$ $f = 100\text{ Hz}$ to $1\text{ MHz}$ , $C_{OUT} = 1\ \mu\text{F}$	–	125	–	$\mu\text{V}_{\text{rms}}$
$R_{LOW}$	Active Output Discharge Resistance (A option only)	$V_{IN} = 5.5\text{ V}$ , $V_{EN} = 0\text{ V}$ (Note 6)	–	100	–	$\Omega$
$T_{SD}$	Thermal Shutdown Temperature	Temperature Increasing from $T_J = +25^{\circ}\text{C}$ (Note 6)	–	175	–	$^{\circ}\text{C}$
$T_{SDH}$	Thermal Shutdown Hysteresis	Temperature Falling from $T_{SD}$ (Note 6)	–	25	–	$^{\circ}\text{C}$

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.

3. Performance guaranteed over the indicated operating temperature range by design and/or characterization production tested at  $T_J = T_A = 25^{\circ}\text{C}$ . Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.

4. Characterized when  $V_{OUT}$  falls 75 mV below the regulated voltage and only for devices with  $V_{OUT} = 2.5\text{ V}$ .

5. Respect SOA.

6. Guaranteed by design and characterization.

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## ELECTRICAL CHARACTERISTICS – VOLTAGE VERSION 2.8 V

( $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ;  $V_{IN} = 3.8\text{ V}$ ;  $I_{OUT} = 1\text{ mA}$ ,  $C_{IN} = C_{OUT} = 1.0\ \mu\text{F}$ , unless otherwise noted. Typical values are at  $T_A = +25^{\circ}\text{C}$ .) (Note 7)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$V_{IN}$	Operating Input Voltage		2.2	–	5.5	V
$V_{OUT}$	Output Voltage	$T_A = +25^{\circ}\text{C}$	2.772	2.8	2.828	V
		$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$	2.744	2.8	2.856	
$\text{Line}_{\text{Reg}}$	Line Regulation	$3.8\text{ V} < V_{IN} \leq 5.5\text{ V}$ , $I_{OUT} = 1\text{ mA}$	–	0.05	0.20	%/V
$\text{Load}_{\text{Reg}}$	Load Regulation	$0\text{ mA} < I_{OUT} \leq 150\text{ mA}$ , $V_{IN} = 3.8\text{ V}$	–20	1	20	mV
$V_{DO}$	Dropout Voltage	$I_{OUT} = 150\text{ mA}$ (Note 8)	–	210	315	mV
$I_{OUT}$	Output Current	(Note 9)	150	–	–	mA
$I_{SC}$	Short Circuit Current Limit	$V_{OUT} = 0\text{ V}$	–	195	–	mA
$I_Q$	Quiescent Current	$I_{OUT} = 0\text{ mA}$	–	0.5	0.9	$\mu\text{A}$
$I_{STB}$	Standby Current	$V_{EN} = 0\text{ V}$ , $T_J = 25^{\circ}\text{C}$	–	0.1	0.5	$\mu\text{A}$
$V_{ENH}$	EN Pin Threshold Voltage	EN Input Voltage “H”	1.2	–	–	V
$V_{ENL}$	EN Pin Threshold Voltage	EN Input Voltage “L”	–	–	0.4	V
$I_{EN}$	EN Pull Down Current	$V_{EN} \leq V_{IN} \leq 5.5\text{ V}$ (Note 10)	–	10	–	nA
PSRR	Power Supply Rejection Ratio	$f = 1\text{ kHz}$ , $V_{IN} = 3.8\text{ V} + 200\text{ mVpp}$ Modulation $I_{OUT} = 150\text{ mA}$	–	40	–	dB
$V_{\text{NOISE}}$	Output Noise Voltage	$V_{IN} = 5.5\text{ V}$ , $I_{OUT} = 1\text{ mA}$ $f = 100\text{ Hz}$ to $1\text{ MHz}$ , $C_{OUT} = 1\ \mu\text{F}$	–	125	–	$\mu\text{V}_{\text{rms}}$
$R_{\text{LOW}}$	Active Output Discharge Resistance (A option only)	$V_{IN} = 5.5\text{ V}$ , $V_{EN} = 0\text{ V}$ (Note 10)	–	100	–	$\Omega$
$T_{\text{SD}}$	Thermal Shutdown Temperature	Temperature Increasing from $T_J = +25^{\circ}\text{C}$ (Note 10)	–	175	–	$^{\circ}\text{C}$
$T_{\text{SDH}}$	Thermal Shutdown Hysteresis	Temperature Falling from $T_{\text{SD}}$ (Note 10)	–	25	–	$^{\circ}\text{C}$

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.

7. Performance guaranteed over the indicated operating temperature range by design and/or characterization production tested at  $T_J = T_A = 25^{\circ}\text{C}$ . Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.

8. Characterized when  $V_{OUT}$  falls 84 mV below the regulated voltage and only for devices with  $V_{OUT} = 2.8\text{ V}$ .

9. Respect SOA.

10. Guaranteed by design and characterization.

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## ELECTRICAL CHARACTERISTICS – VOLTAGE VERSION 3.3 V

( $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ;  $V_{IN} = 4.3\text{ V}$ ;  $I_{OUT} = 1\text{ mA}$ ,  $C_{IN} = C_{OUT} = 1.0\text{ }\mu\text{F}$ , unless otherwise noted. Typical values are at  $T_A = +25^{\circ}\text{C}$ .) (Note 11)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$V_{IN}$	Operating Input Voltage		2.2	–	5.5	V
$V_{OUT}$	Output Voltage	$T_A = +25^{\circ}\text{C}$	3.267	3.3	3.333	V
		$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$	3.234	3.3	3.366	
$\text{Line}_{\text{Reg}}$	Line Regulation	$4.3\text{ V} < V_{IN} \leq 5.5\text{ V}$ , $I_{OUT} = 1\text{ mA}$	–	0.05	0.20	%/V
$\text{Load}_{\text{Reg}}$	Load Regulation	$0\text{ mA} < I_{OUT} \leq 150\text{ mA}$ , $V_{IN} = 4.3\text{ V}$	–20	1	20	mV
$V_{DO}$	Dropout Voltage	$I_{OUT} = 150\text{ mA}$ (Note 12)	–	180	250	mV
$I_{OUT}$	Output Current	(Note 13)	150	–	–	mA
$I_{SC}$	Short Circuit Current Limit	$V_{OUT} = 0\text{ V}$	–	195	–	mA
$I_Q$	Quiescent Current	$I_{OUT} = 0\text{ mA}$	–	0.5	0.9	$\mu\text{A}$
$I_{STB}$	Standby Current	$V_{EN} = 0\text{ V}$ , $T_J = 25^{\circ}\text{C}$	–	0.1	0.5	$\mu\text{A}$
$V_{ENH}$	EN Pin Threshold Voltage	EN Input Voltage “H”	1.2	–	–	V
$V_{ENL}$	EN Pin Threshold Voltage	EN Input Voltage “L”	–	–	0.4	V
$I_{EN}$	EN Pull Down Current	$V_{EN} \leq V_{IN} \leq 5.5\text{ V}$ (Note 14)	–	10	–	nA
PSRR	Power Supply Rejection Ratio	$f = 1\text{ kHz}$ , $V_{IN} = 4.3\text{ V} + 200\text{ mVpp}$ Modulation $I_{OUT} = 150\text{ mA}$	–	41	–	dB
$V_{NOISE}$	Output Noise Voltage	$V_{IN} = 5.5\text{ V}$ , $I_{OUT} = 1\text{ mA}$ $f = 100\text{ Hz}$ to $1\text{ MHz}$ , $C_{OUT} = 1\text{ }\mu\text{F}$	–	125	–	$\mu\text{V}_{\text{rms}}$
$R_{LOW}$	Active Output Discharge Resistance (A option only)	$V_{IN} = 5.5\text{ V}$ , $V_{EN} = 0\text{ V}$ (Note 14)	–	100	–	$\Omega$
$T_{SD}$	Thermal Shutdown Temperature	Temperature Increasing from $T_J = +25^{\circ}\text{C}$ (Note 14)	–	175	–	$^{\circ}\text{C}$
$T_{SDH}$	Thermal Shutdown Hysteresis	Temperature Falling from $T_{SD}$ (Note 14)	–	25	–	$^{\circ}\text{C}$

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.

11. Performance guaranteed over the indicated operating temperature range by design and/or characterization production tested at

$T_J = T_A = 25^{\circ}\text{C}$ . Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.

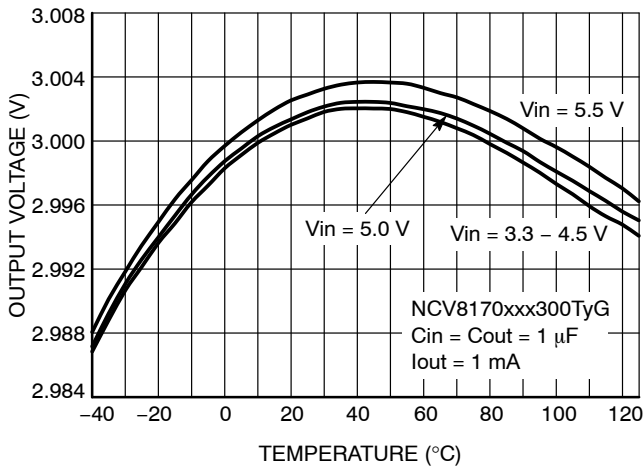
12. Characterized when  $V_{OUT}$  falls 99 mV below the regulated voltage and only for devices with  $V_{OUT} = 3.3\text{ V}$ .

13. Respect SOA.

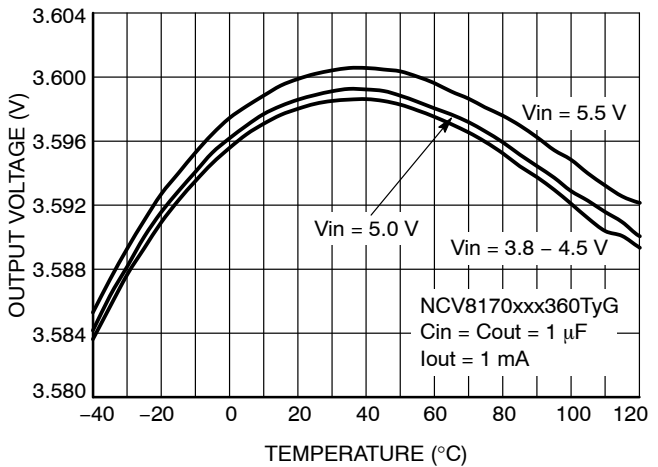
14. Guaranteed by design and characterization.

# MDNCV8170A

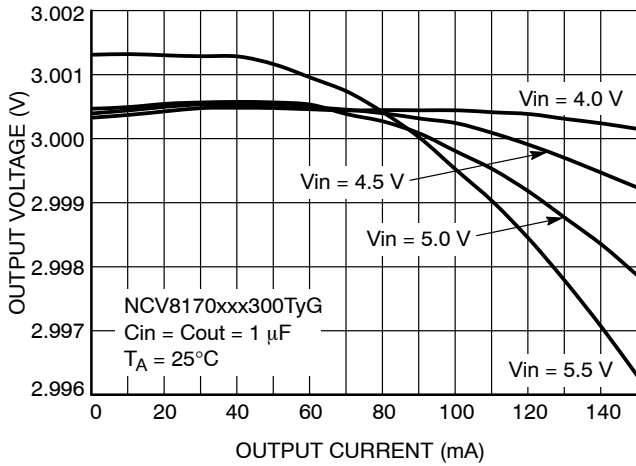
## TYPICAL CHARACTERISTICS



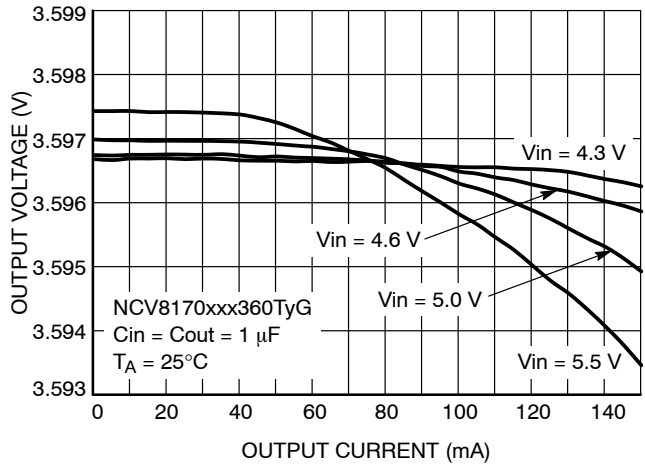
**Figure 3. Output Voltage vs. Temperature, Vout = 3.0 V**



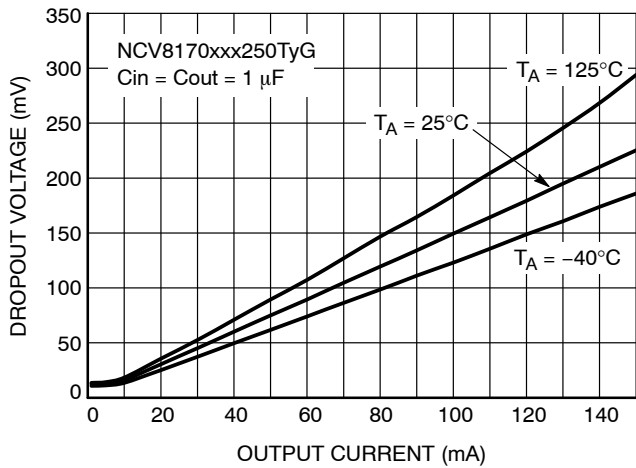
**Figure 4. Output Voltage vs. Temperature, Vout = 3.6 V**



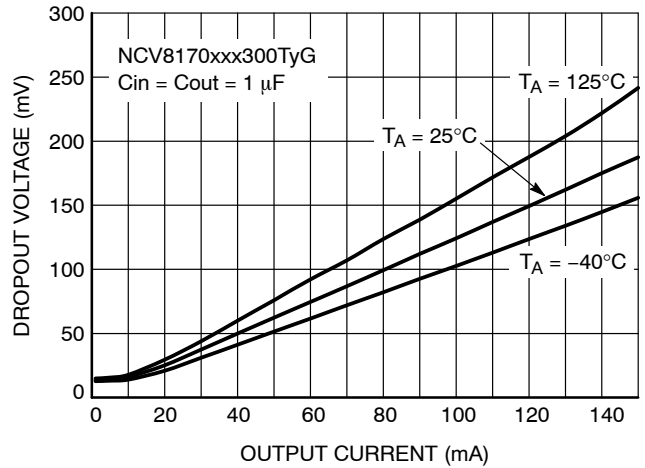
**Figure 5. Output Voltage vs. Output Current, Vout = 3.0 V**



**Figure 6. Output Voltage vs. Output Current, Vout = 3.6 V**



**Figure 7. Dropout Voltage vs. Output Current, Vout = 2.5 V**



**Figure 8. Dropout Voltage vs. Output Current, Vout = 3.0 V**

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## TYPICAL CHARACTERISTICS

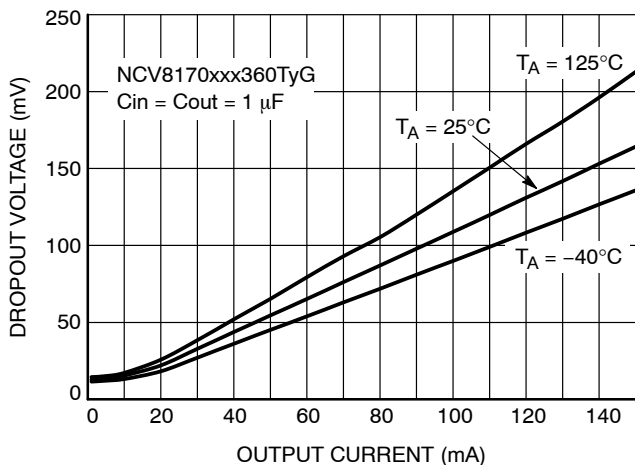


Figure 9. Dropout Voltage vs. Output Current, Vout = 3.6 V

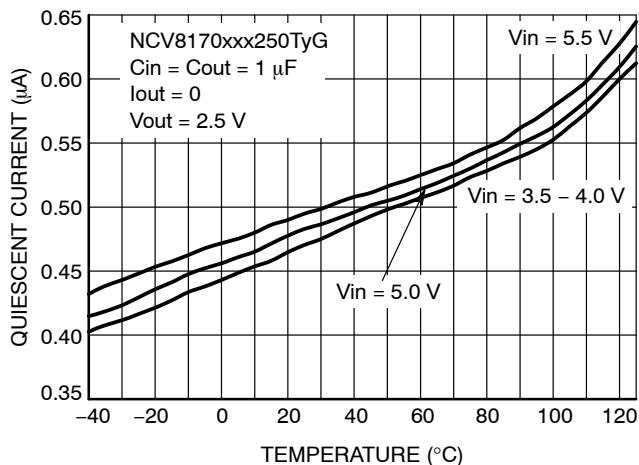


Figure 10. Quiescent Current vs. Temperature, Vout = 2.5 V

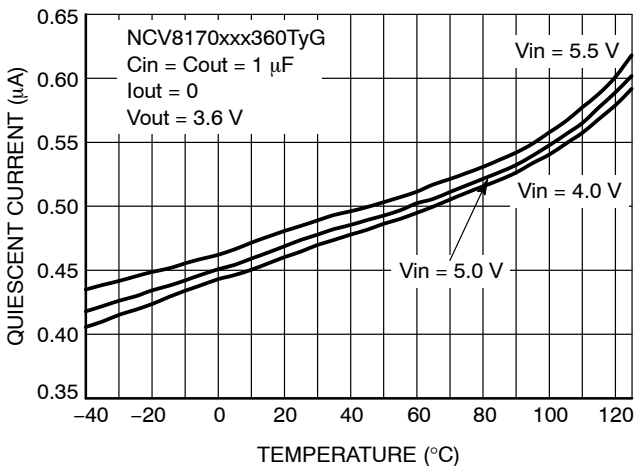


Figure 11. Quiescent Current vs. Temperature, Vout = 3.6 V

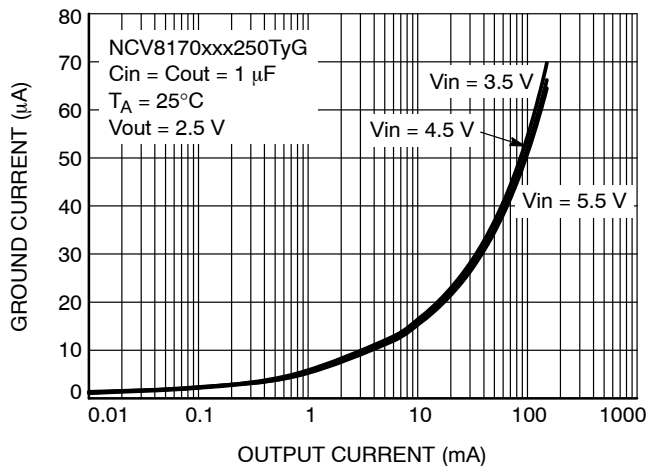


Figure 12. Ground Current vs. Output Current, Vout = 2.5 V

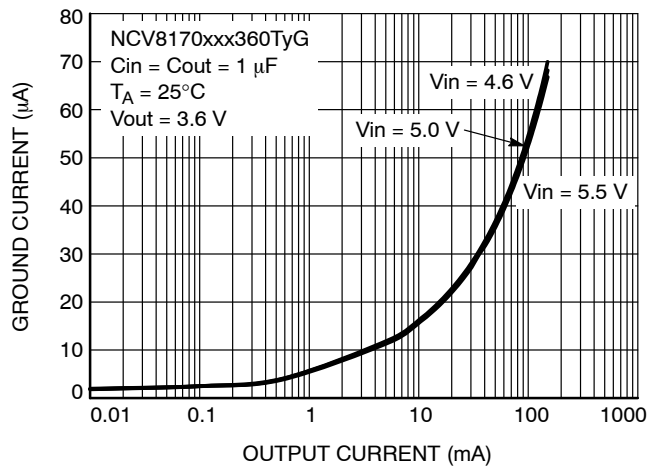


Figure 13. Ground Current vs. Output Current, Vout = 3.6 V

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## TYPICAL CHARACTERISTICS

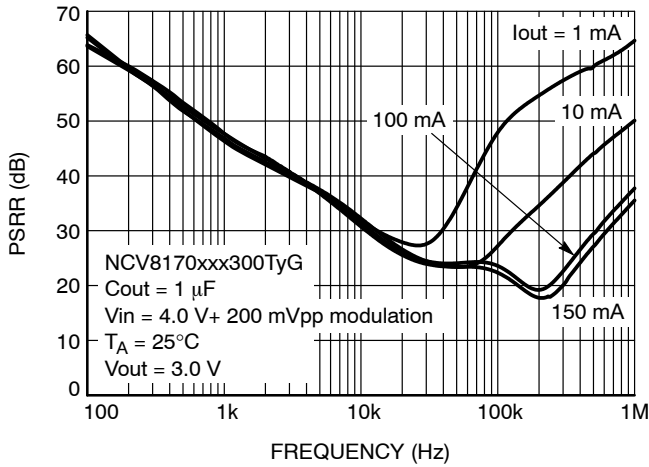


Figure 14. PSRR vs. Frequency, Vout = 3.0 V

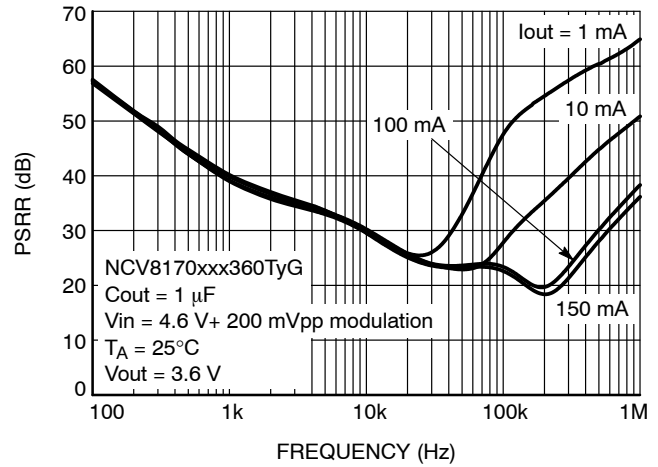


Figure 15. PSRR vs. Frequency, Vout = 3.6 V

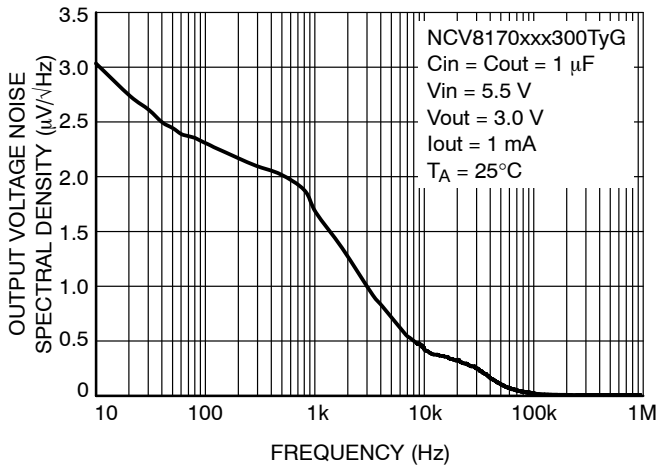


Figure 16. Output Voltage Noise Spectral Density, Vout = 3.0 V

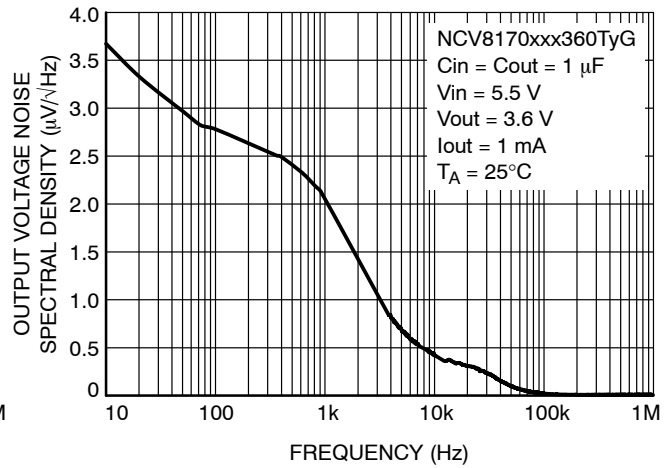


Figure 17. Output Voltage Noise Spectral Density, Vout = 3.6 V



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## TYPICAL CHARACTERISTICS

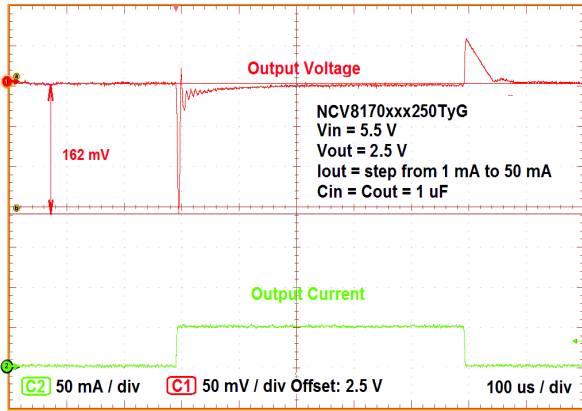


Figure 18. Load Transient Response at Load Step from 1 mA to 50 mA, Vout = 2.5 V

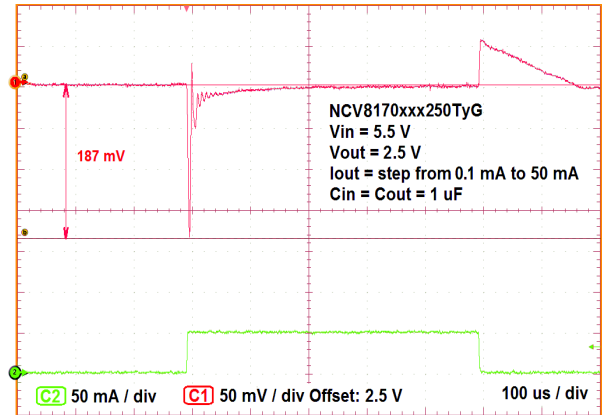


Figure 19. Load Transient Response at Load Step from 0.1 mA to 50 mA, Vout = 2.5 V

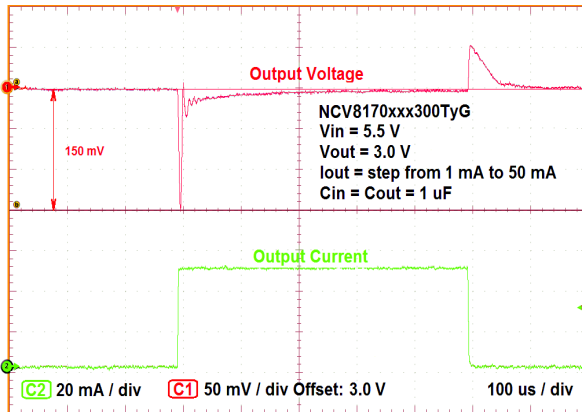


Figure 20. Load Transient Response at Load Step from 1 mA to 50 mA, Vout = 3.0 V

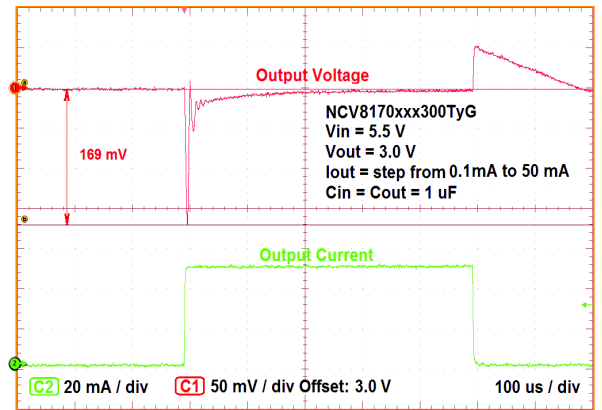


Figure 21. Load Transient Response at Load Step from 0.1 mA to 50 mA, Vout = 3.0 V

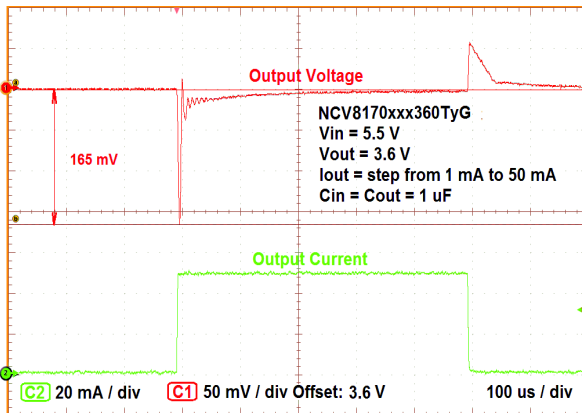


Figure 22. Load Transient Response at Load Step from 1mA to 50 mA, Vout= 3.6 V

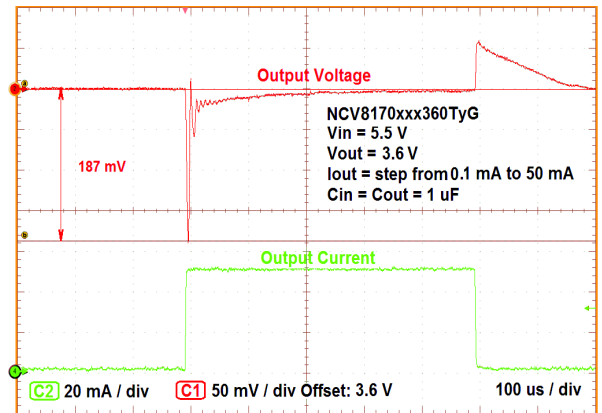


Figure 23. Load Transient Response at Load Step from 0.1 mA to 50 mA, Vout = 3.6 V

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## TYPICAL CHARACTERISTICS

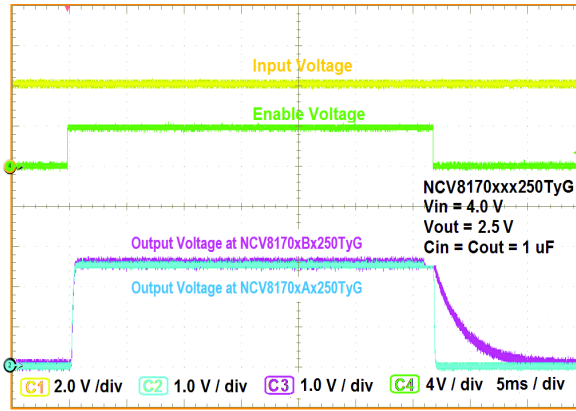


Figure 24. Output Voltage With and Without Active Discharge Feature, Vout = 2.5 V

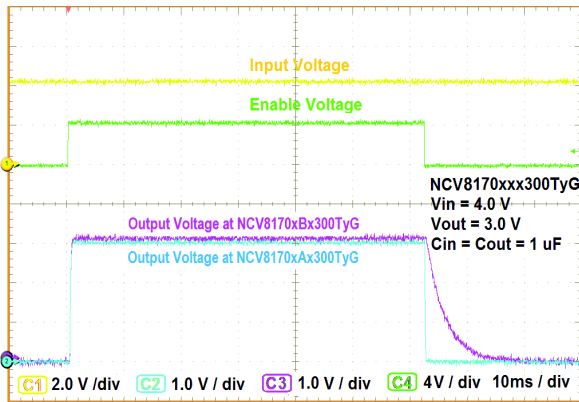


Figure 25. Output Voltage With and Without Active Discharge Feature, Vout = 3.0 V

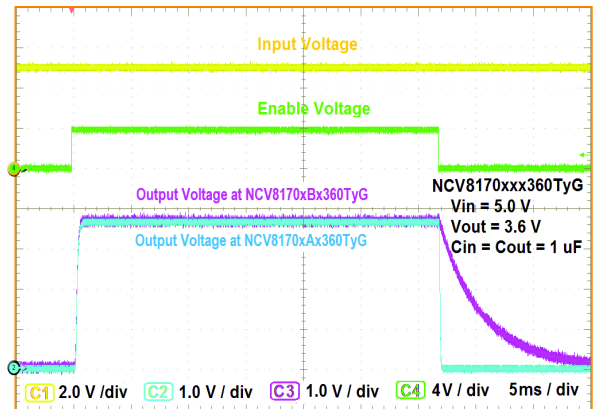


Figure 26. Output Voltage With and Without Active Discharge Feature, Vout = 3.6 V

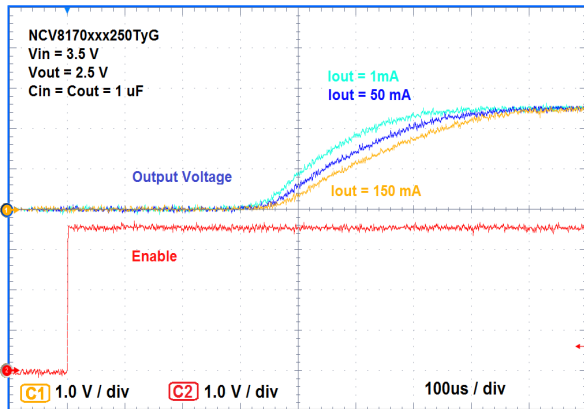


Figure 27. Enable Turn-on Response at Vout = 2.5 V

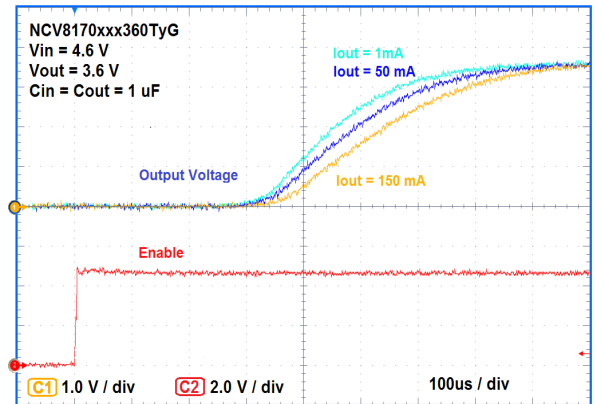


Figure 28. Enable Turn-on Response at Vout = 3.6 V

# MDNCV8170A

## APPLICATIONS INFORMATION

### General

The MDNCV8170A is a high performance 150 mA Linear Regulator with Ultra Low IQ. This device delivers low Noise and high Power Supply Rejection Ratio with excellent dynamic performance due to employing the Dynamic Quiescent Current adjustment which assure ultra low  $I_Q$  consumption at no – load state. These parameters make this device very suitable for various battery powered applications.

### Input Decoupling ( $C_{IN}$ )

It is recommended to connect at least a 1  $\mu$ F Ceramic X5R or X7R capacitor between IN and GND pins of the device. This capacitor will provide a low impedance path for any unwanted AC signals or Noise superimposed onto constant Input Voltage. The good input capacitor will limit the influence of input trace inductances and source resistance during sudden load current changes.

Higher capacitance and lower ESR Capacitors will improve the overall line transient response.

### Output Decoupling ( $C_{OUT}$ )

The MDNCV8170A does not require a minimum Equivalent Series Resistance (ESR) for the output capacitor. The device is designed to be stable with standard ceramics capacitors with values of 1.0  $\mu$ F or greater up to 10  $\mu$ F. The X5R and X7R types have the lowest capacitance variations over temperature thus they are recommended. There is recommended connect the output capacitor as close as possible to the output pin of the regulator.

### Enable Operation

The MDNCV8170A uses the EN pin to enable /disable its device and to activate /deactivate the active discharge function at devices with this feature. If the EN pin voltage is pulled below 0.4 V the device is guaranteed to be disable. The active discharge transistor at the devices with Active Discharge Feature is activated and the output voltage  $V_{OUT}$  is pulled to GND through an internal circuitry with effective resistance about 100 ohms.

If the EN pin voltage is higher than 1.2 V the device is guaranteed to be enabled. The internal active discharge

circuitry is switched off and the desired output voltage is available at output pin. In case the Enable function is not required the EN pin should be connected directly to input pin.

### Thermal Shutdown

When the die temperature exceeds the Thermal Shutdown point ( $T_{SD} = 175^{\circ}\text{C}$  typical) the device goes to disabled state and the output voltage is not delivered until the die temperature decreases to  $150^{\circ}\text{C}$ . The Thermal Shutdown feature provides a protection from a catastrophic device failure at accidental overheating. This protection is not intended to be used as a substitute for proper heat sinking.

### Power Dissipation and Heat sinking

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. The maximum power dissipation the NCV8170 device can handle is given by:

$$P_{D(MAX)} = \frac{[T_{J(MAX)} - T_A]}{R_{\theta JA}} \quad (\text{eq. 1})$$

The power dissipated by the NCV8170 device for given application conditions can be calculated from the following equations:

$$P_D \approx V_{IN}(I_{GND} + I_{OUT}) + I_{OUT}(V_{IN} - V_{OUT}) \quad (\text{eq. 2})$$

or

$$V_{IN(MAX)} \approx \frac{P_{D(MAX)} + (V_{OUT} \times I_{OUT})}{I_{OUT} + I_{GND}} \quad (\text{eq. 3})$$

### Hints

$V_{IN}$  and GND printed circuit board traces should be as wide as possible. When the impedance of these traces is high, there is a chance to pick up noise or cause the regulator to malfunction. Place external components, especially the output capacitor, as close as possible to the MDNCV8170A, and make traces as short as possible.

## ORDERING INFORMATION

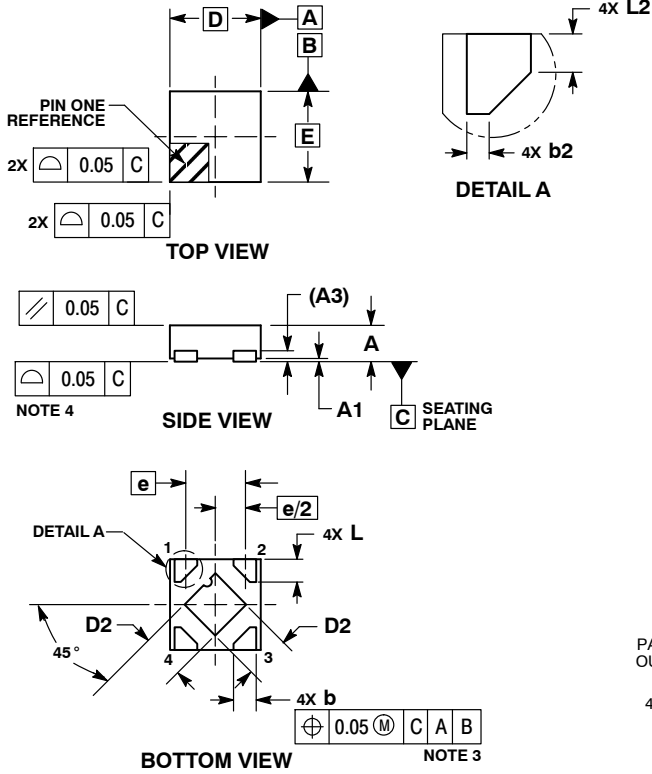
Device	Nominal Output Voltage	Marking	Active Discharge	Package	Shipping†
MDNCV8170AAMX250TCG	2.5	AX	Yes	XDFN4 1.0 x 1.0 (Pb-Free)	3000 / Tape & Reel
MDNCV8170AAMX280TCG	2.8	AY			
MDNCV8170AAMX330TCG	3.3	AZ			

†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.

# MDNCV8170A

## PACKAGE DIMENSIONS

**XDFN4 1.0x1.0, 0.65P**  
**MX SUFFIX**  
**CASE 711AJ**  
**ISSUE O**

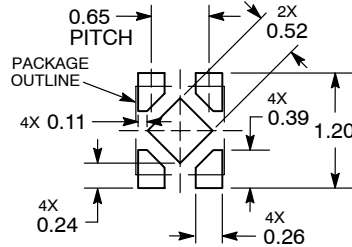


**NOTES:**

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 0.20 mm FROM THE TERMINAL TIPS.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

MILLIMETERS		
DIM	MIN	MAX
A	0.33	0.43
A1	0.00	0.05
A3	0.10	REF
b	0.15	0.25
b2	0.02	0.12
D	1.00	BSC
D2	0.43	0.53
E	1.00	BSC
e	0.65	BSC
L	0.20	0.30
L2	0.07	0.17

**RECOMMENDED MOUNTING FOOTPRINT\***



DIMENSIONS: MILLIMETERS

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

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