Linear Regulator - Low Output Voltage, Ultra-Fast Low Dropout, Enable

1.0 A

NCP5661, NCV5661

The NCP5661/NCV5661 is a high performance, low dropout linear regulator designed for high power applications that require up to 1.0 A current. It is offered in both fixed and adjustable output versions. With output voltages as low as 0.9 V and ultra−fast response times for load transients, the NCP5661/NCV5661 also provides additional features such as Enable and Error Flag (for the fixed output version), increasing the utility of these devices. A thermally robust, 5 pin DPAK or DFN 3x3.3 mm, combined with an architecture that offers low ground current (independent of load), provides for a superior high−current LDO solution.

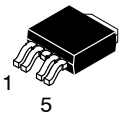
Features

- Ultra−Fast Transient Response (Settling Time: 1−3 μs)
- Low Noise Without Bypass Capacitor (26 μV_{rms})
- Low Ground Current Independent of Load (3.0 mA Maximum)
- Fixed/Adjustable Output Voltage Versions
- Enable Function
- Error Flag (Fixed Output Version)
- Current Limit Protection
- Thermal Protection
- 0.9 V Reference Voltage for Ultra−Low Output Operation
- Power Supply Rejection Ratio > 65 dB
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- These are Pb−Free Devices

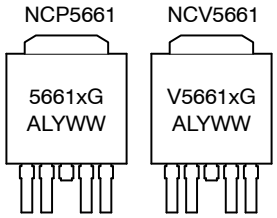
Applications

- Servers
- ASIC Power Supplies
- Post Regulation for Power Supplies
- Constant Current Source
- Networking Equipment
- Gaming and STB Modules

MARKING DIAGRAMS

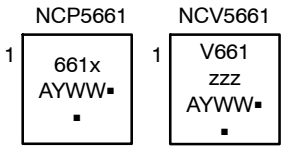


DPAK−5 CENTER LEAD CROP CASE 175AA





DFN6 MN SUFFIX CASE 506AX



x = A for Adjustable Version
B for Fixed 1.2 V
C for Fixed 3.3 V
D for Fixed 1.5 V
E for Fixed 1.8 V
F for Fixed 2.5 V
G for Fixed 2.8 V
H for Fixed 3.0 V

zzz = 12 for Fixed 1.2 V
15 for Fixed 1.5 V
18 for Fixed 1.8 V
25 for Fixed 2.5 V
28 for Fixed 2.8 V
30 for Fixed 3.0 V
33 for Fixed 3.3 V
ADJ for Adjustable Version

A = Assembly Location
L = Wafer Lot
Y = Year
WW = Work Week
G = Pb−Free
▪ = Pb−Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

NOTE: Some of the devices on this data sheet have been **DISCONTINUED**. Please refer to the table on page 10.

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PIN FUNCTION DESCRIPTION

Pin Adj/Fixed DFN6	Pin Adj/Fixed DPAK−5	Pin Name	Description
1	1	Enable	This pin allows for on/off control of the regulator. To disable the device, connect to Ground. If this function is not in use, connect to V_{in}.
2,3	2	V_{in}	Positive Power Supply Input Voltage
4, EPAD	3, TAB	Ground	Power Supply Ground
5	4	V_{out}	Regulated Output Voltage
6	5	Adj (Adjustable Version)	This pin is connected to the resistor divider network and programs the output voltage.
6	5	Error Flag (Fixed Version)	An Error Flag is triggered when the output voltage is out of regulation excluding transient signals that may occur. Requires a pullup resistor ≈ 100 kΩ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage	V_{in}	18	V
Output Pin Voltage	V_{out}	−0.3 to Vin +0.3	V
Adjust Pin Voltage	V_{adj}	−0.3 to Vin +0.3	V
Enable Pin Voltage	V_{en}	−0.3 to Vin +0.3	V
Error Flag Voltage	V_{ef}	−0.3 to Vin +0.3	V
Error Flag Current	I_{ef}	3.0	mA
Thermal Characteristics, DPAK−5 (Note 1) Thermal Resistance, Junction−to−Air Thermal Resistance, Junction−to−Case	 $R_{\theta JA}$ $R_{\theta JC}$	 100 8.0	°C/W
Thermal Characteristics, DFN6 (Note 2) Thermal Resistance, Junction−to−Air Thermal Resistance, Junction−to−Lead (Note 3)	 $R_{\theta JA}$ $R_{\theta JL}$	 82 18	°C/W
Operating Junction Temperature Range	T_J	−40 to +150	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

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.

NOTE: This device series contains ESD protection and exceeds the following tests:

Human Body Model (HBM) JESD 22−A114−B

Machine Model (MM) JESD 22−A115−A.

The maximum package power dissipation is:

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

The bipolar process employed for this IC is fully characterized and rated for reliable 18 V V_{CCmax} operation. To avoid damaging the part or degrading it's reliability, power dissipation transients should be limited to under 20 W for DPAK.

For open−circuit to short−circuit transient,

$P_{DTransient} = V_{CCmax} * I_{SC}$.

1. 1 oz copper, 0.26 in^2 copper area (minimum pad)
2. 1 oz copper, 1 in^2 copper area
3. Lead 2

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ELECTRICAL CHARACTERISTICS

(V_{in} – V_{out} = 1.5 V, for typical values T_J = 25°C, for min/max values T_J = –40°C to 125°C, C_{in} = C_{out} = 150 μF unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ADJUSTABLE OUTPUT VERSION					
Input Voltage	V_{in}	2.0	–	9.0	V
Output Noise Voltage (f = 10 Hz to 100 kHz)	V_n	–	26	–	μV_{rms}
Output Voltage Accuracy T_J = 25°C (I_{out} = 10 mA to 1.0 A) T_J = –20 to +125°C (I_{out} = 10 mA to 1.0 A) T_J = –40 to +150°C (I_{out} = 10 mA to 1.0 A)	V_{out}	 –1% –1.5% –2%	 – 0.9 –	 +1% +1.5% +2%	V
Adjustable Pin Input Current	I_{adj}	–	40	–	nA
Line Regulation (I_{out} = 10 mA, V_{out}+1.5 V < V_{in} < 7.0 V)	REG_{line}	–	0.03	–	%
Load Regulation (10 mA < I_{out} < 1.0 A)	REG_{load}	–	0.03	–	%
Dropout Voltage (I_{out} = 1.0 A)	V_{DO}	–	1.0	1.3	V
Peak Output Current Limit	I_{out}	1.0	–	–	A
Internal Current Limitation	I_{lim}	–	1.5	–	A
Ripple Rejection (120 Hz) Ripple Rejection (1.0 kHz)	RR	– –	70 65	– –	dB
Thermal Shutdown (Guaranteed by Design)	T_{SHD}	–	160	–	°C
Ground Current I_{out} = 1.0 A Disabled State	 I_q I_{qds}	 – –	 1.3 10	 3.0 300	 mA μA
Enable Input Threshold Voltage Voltage Increasing, On State, Logic High Voltage Decreasing, Off State, Logic Low	V_{en}	 1.3 –	 – –	 – 0.3	V
Enable Input Current Enable Pin Voltage = 0.3 V_{max} Enable Pin Voltage = 1.3 V_{min}	I_{en}	 – –	 0.5 0.5	 – –	μA

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.

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ELECTRICAL CHARACTERISTICS

(V_{in} – V_{out} = 1.5 V, for typical values T_J = 25°C, for min/max values T_J = –40°C to 125°C, C_{in} = C_{out} = 150 μF unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FIXED OUTPUT VOLTAGE					
Input Voltage	V_{in}	2.0	–	9.0	V
Output Noise Voltage (V_{out} = 0.9 V)	V_n	–	26	–	μV_{rms}
Output Voltage Accuracy T_J = 25°C (I_{out} = 10 mA to 1.0 A) T_J = –20 to +125°C (I_{out} = 10 mA to 1.0 A) T_J = –40 to +150°C (I_{out} = 10 mA to 1.0 A)	V_{out}	 –1% –1.5% –2%	 – V_{out} –	 +1% +1.5% +2%	V
Line Regulation (I_{out} = 10 mA, V_{out}+1.5 V < V_{in} < 7.0 V)	REG_{line}	–	0.03	–	%
Load Regulation (10 mA < I_{out} < 1.0 A)	REG_{load}	–	0.2	–	%
Dropout Voltage (I_{out} = 1.0 A)	V_{DO}	–	1.0	1.3	V
Peak Output Current Limit	I_{out}	1.0	–	–	A
Internal Current Limitation	I_{lim}	–	1.5	–	A
Ripple Rejection (120 Hz) Ripple Rejection (1.0 kHz)	RR	– –	70 65	– –	dB
Thermal Shutdown (Guaranteed by Design)	T_{SHD}	–	160	–	°C
Ground Current I_{out} = 1.0 A Disabled State	 I_q I_{qds}	 – –	 1.3 30	 3.0 300	 mA μA
Enable Input Threshold Voltage Voltage Increasing, On State, Logic High Voltage Decreasing, Off State, Logic Low	V_{en}	 1.3 –	 – –	 – 0.3	V
Enable Input Current Enable Pin Voltage = 0.3 V_{max} Enable Pin Voltage = 1.3 V_{min}	I_{en}	 – –	 0.5 0.5	 – –	μA
Error Flag (Fixed Output) 1.2 V Output 1.5 V Output 1.8 V Output 2.5 V Output 2.8 V Output 3.0 V Output 3.3 V Output	V_{eflt}	 88 88 88 88 88 88 90	 92 92 92 92 92 92 94	 97 97 97 97 97 97 97	% of V_{out}
Error Flag Output Low Voltage Saturation (I_{ef} = 1.0 mA)	V_{efdo}	–	200	–	mV
Error Flag Leakage	I_{efleak}	–	1.0	–	μA
Error Flag Blanking Time (Note 4)	T_{ef}	–	50	–	μs

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. Error Flag Blanking Time

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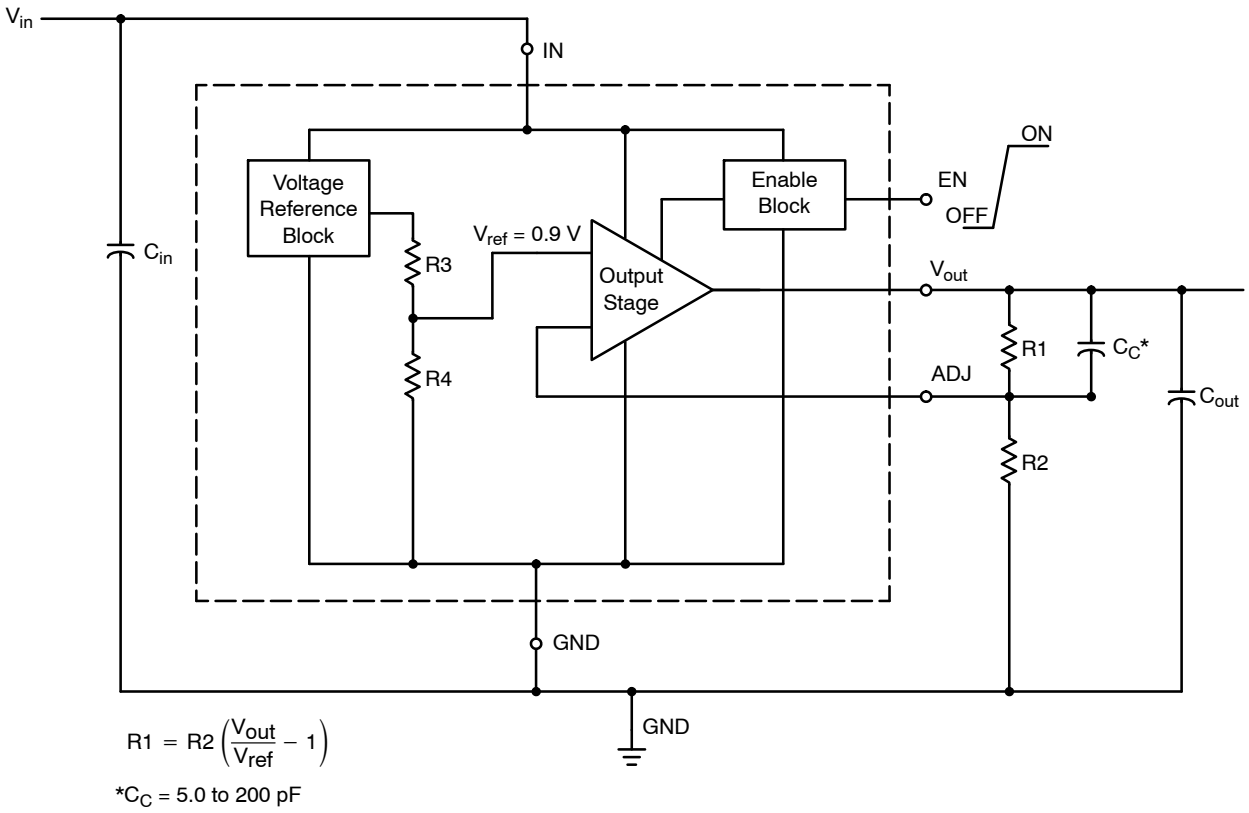

Figure 1. Typical Schematic, Adjustable Output Version

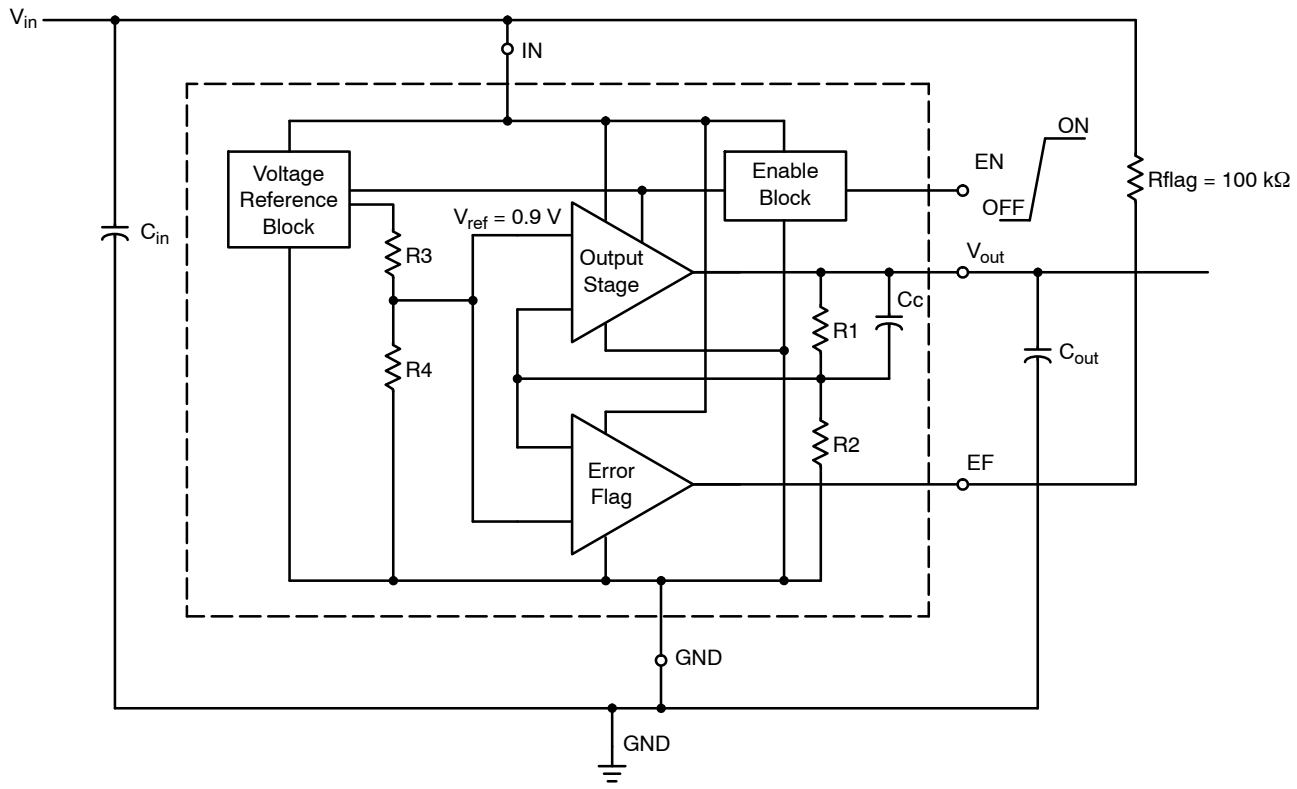

Figure 2. Typical Schematic, Fixed Output Version

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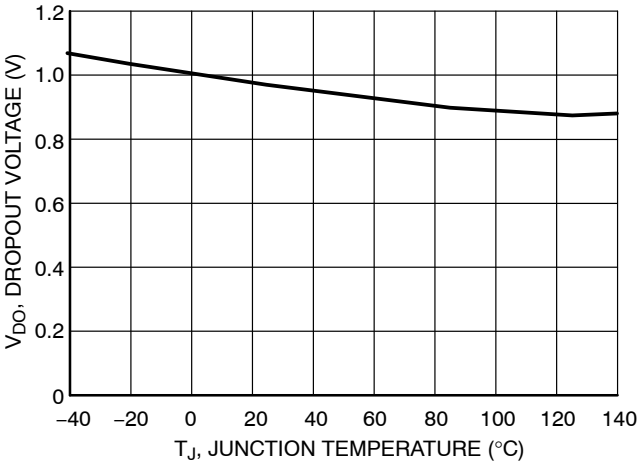

Figure 3. Dropout Voltage vs. Temperature

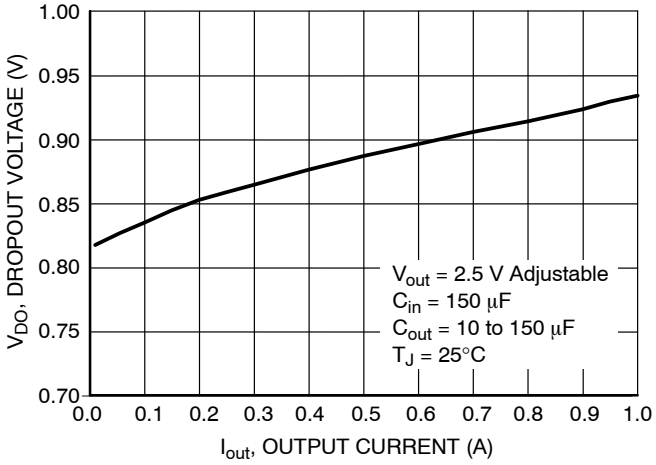

Figure 4. Dropout Voltage vs. Output Current

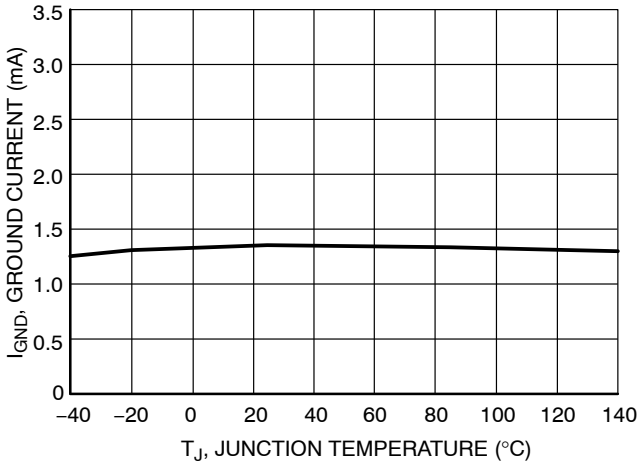

Figure 5. Ground Current vs. Temperature

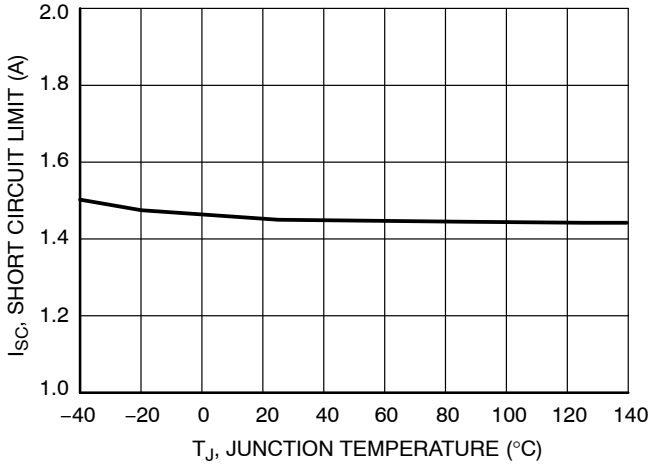

Figure 6. Short Circuit Current Limit vs. Temperature

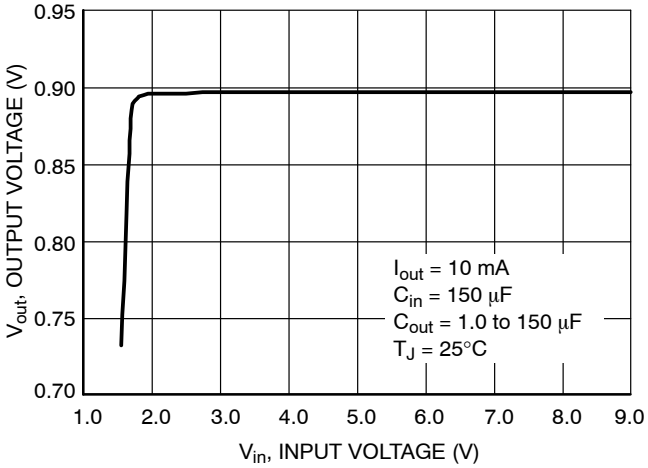

Figure 7. Output Voltage vs. Input Voltage

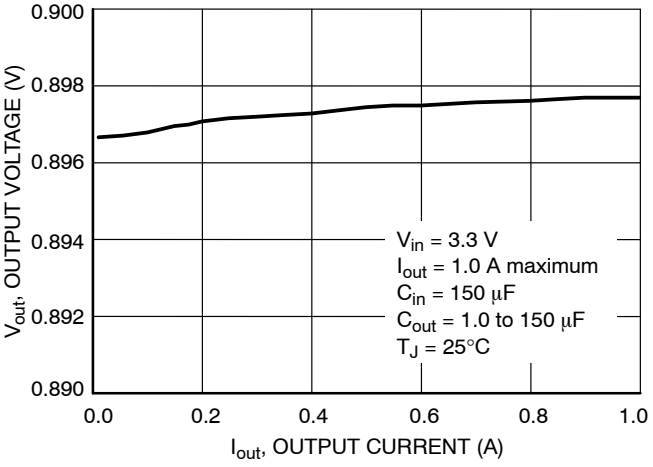

Figure 8. Output Voltage vs. Output Load Current

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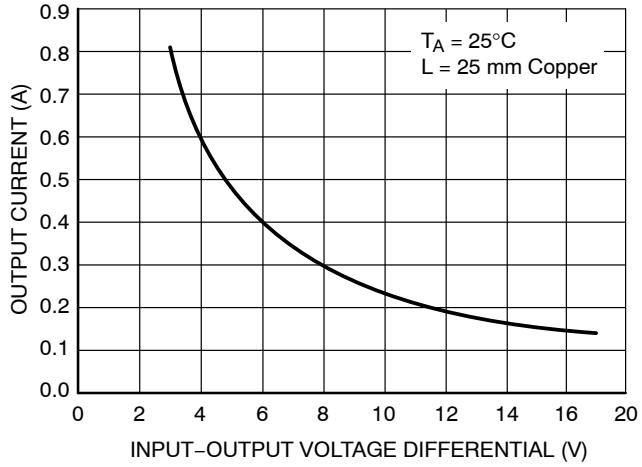

Figure 9. Output Current vs. Input−Output Voltage Differential

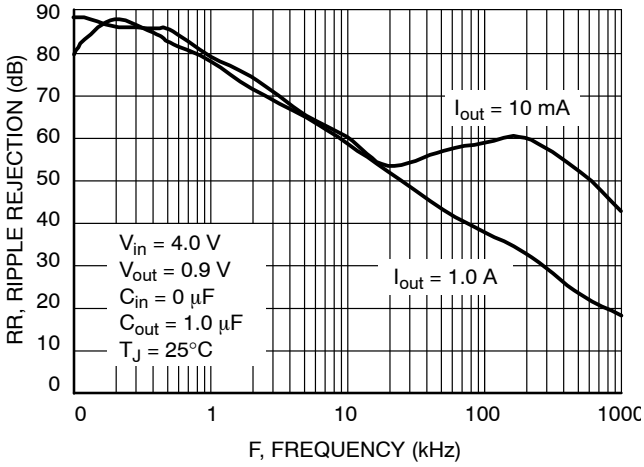

Figure 10. Ripple Rejection vs. Frequency

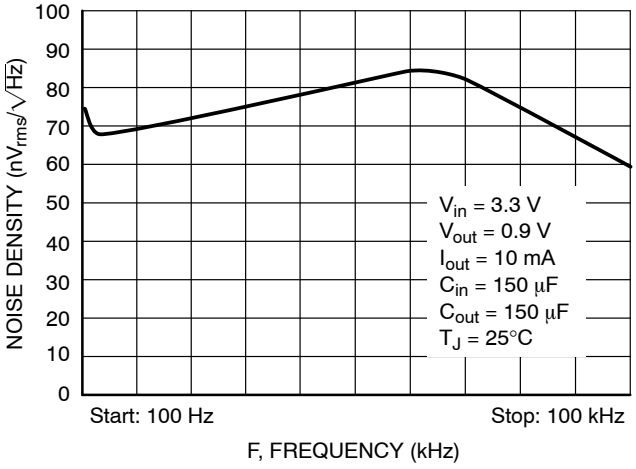

Figure 11. Noise Density vs. Frequency

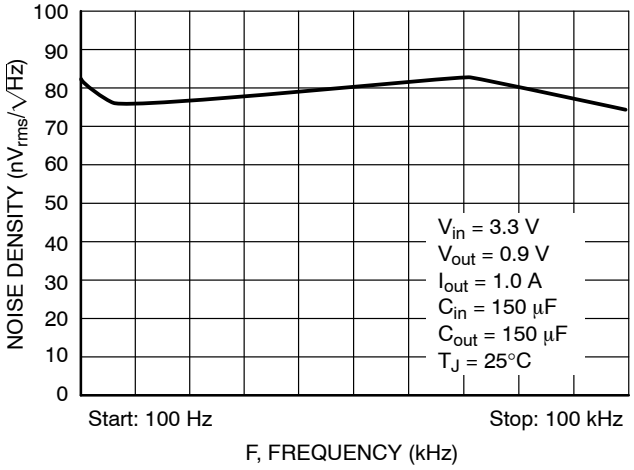

Figure 12. Noise Density vs. Frequency

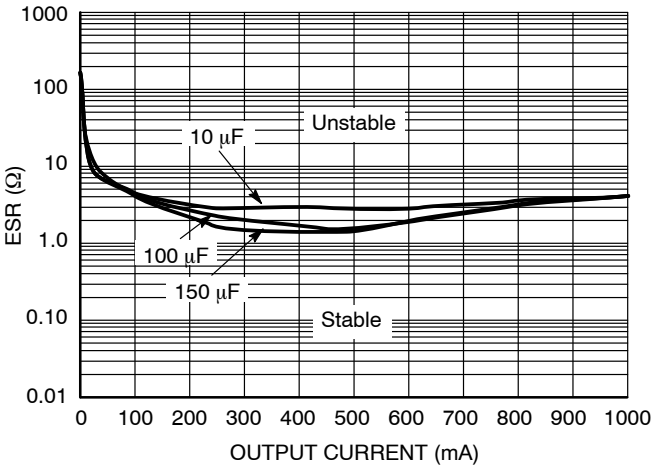

Figure 13. 1.2 Volt Output Stability with Output Capacitor ESR

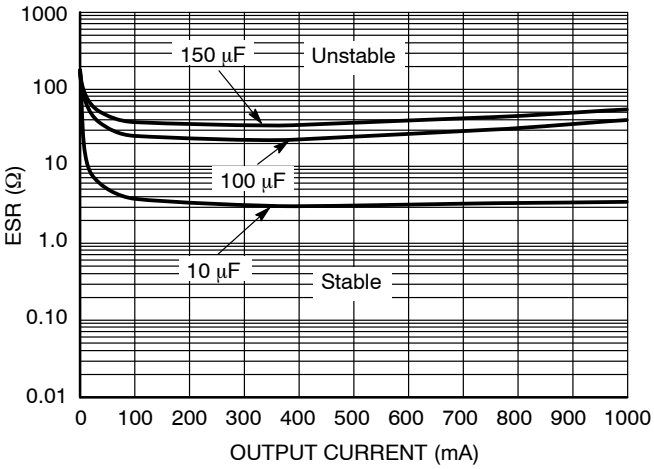

Figure 14. 3.3 Volt Output Stability with Output Capacitor ESR

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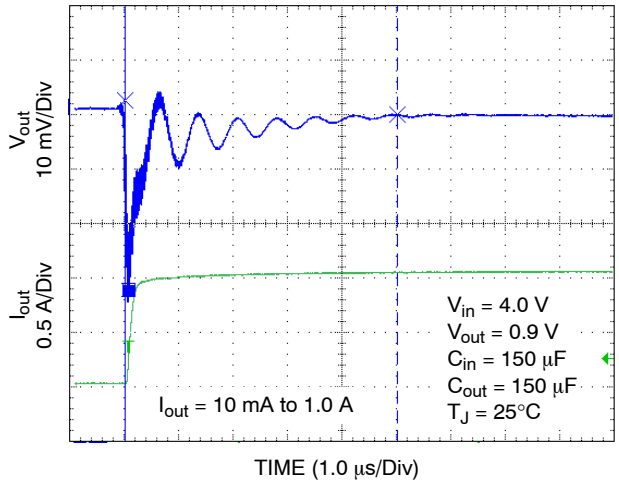

Figure 15. Load Transient Response

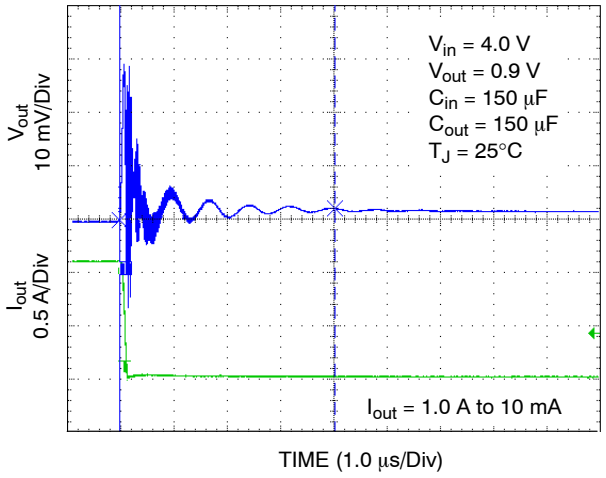

Figure 16. Load Transient Response

APPLICATION INFORMATION

The NCP5661 is a high performance low dropout 1.0 A linear regulator suitable for high power applications, featuring an ultra−fast response time and low noise without a bypass capacitor. It is offered in both fixed and adjustable output versions with voltages as low as 0.9 V. Additional features, such as Enable and Error Flag (fixed output version) increase the utility of the NCP5661. It is thermally robust and includes the safety features necessary during a fault condition, which provide for an attractive high current LDO solution for server, ASIC power supplies, networking equipment applications, and many others.

Input Capacitor

The recommended input capacitor value is a 150 μF OSCON with an Equivalent Series Resistance (ESR) of 50 mΩ. It is especially required if the power source is located more than a few inches from the NCP5661. This capacitor will reduce device sensitivity and enhance the output transient response time. The PCB layout is very important and in order to obtain the optimal solution, the Vin and GND traces should be sufficiently wide to minimize noise and unstable operation.

Output Capacitor

Proper output capacitor selection is required to maintain stability. The NCP5661 is guaranteed to be stable at an output capacitance of C_{out} > 10 μF. In the case of using electrolytic capacitors, low ESR type (ESR < 300 mΩ) should be used to maintain device stability. Multilayer ceramic capacitors can also be used with this device. For PCB layout considerations, place the recommended ceramic capacitor close to the output pin and keep the leads short. This should help ensure ultra−fast transient response times.

Adjustable Output Operation

The application circuit for the adjustable output version is shown in Figure 1. The reference voltage is 0.9 V and the adjustable pin current is typically 40 nA. A resistor divider network, R1 and R2, is calculated using the following formula:

$$R1 = R2\left(\frac{V_{out}}{V_{ref}} - 1\right)$$

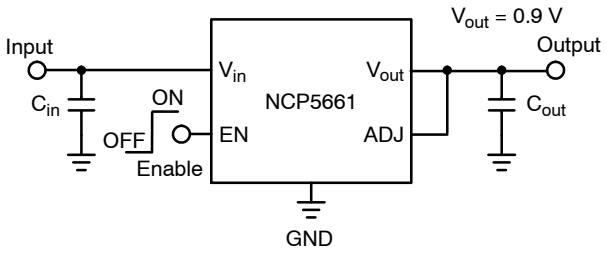

Figure 17. To achieve the minimum output voltage, ADJ to V_{out} has to be connected together

Current Limit Operation

As the peak output current increases beyond its limitation, the device is internally clampled to 1.5 A, thus causing the output voltage to decrease and go out of regulation. This allows the device never to exceed the maximum power dissipation.

Error Flag Operation

The Error Flag pin on the NCP5661 will produce a logic Low when it drops below the nominal output voltage. Refer to the electrical characteristics for the threshold values at which point the Error Flag goes Low. When the NCP5661 is above the nominal output voltage, the Error Flag will remain at logic High.

The external pullup resistor needs to be connected between V_{in} (Pin 1) and the Error Flag pin (Pin 5). A resistor of approximately 100 kΩ is recommended to minimize the current consumption. No pullup resistor is required if the Error Flag output is not being used.

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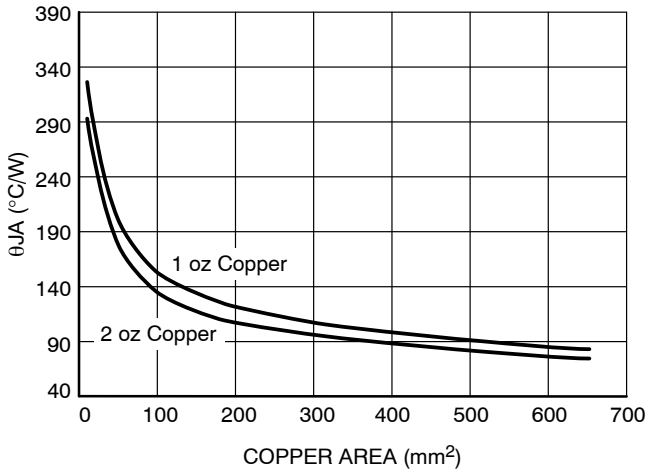

Figure 18. DFN6 Thermal Resistance vs. Copper Area

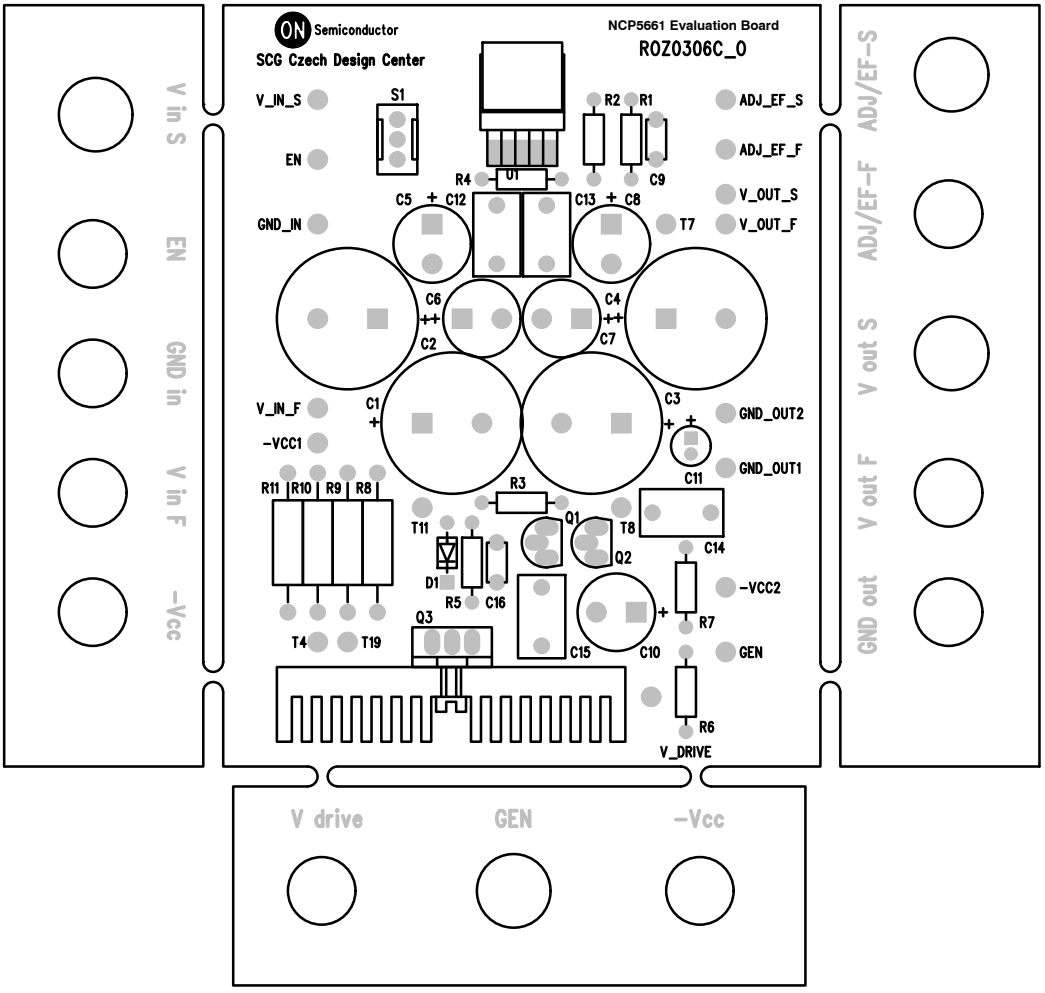

Figure 19. Test Board used for Evaluation

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ORDERING INFORMATION

Device	Nominal Output Voltage	Package	Shipping†
NCP5661DTADJRKG	Adj (Pb−Free)	DPAK	2500 / Tape & Reel
NCV5661DTADJRKG*	Adj (Pb−Free)		
NCV5661DT12RKG*	Fixed, 1.2 V (Pb−Free)		
NCV5661DT33RKG*	Fixed, 3.3 V (Pb−Free)		
NCP5661MN15T2G	Fixed, 1.5 V (Pb−Free)	DFN6 3x3.3 mm	3000 / Tape & Reel
NCP5661MN28T2G	Fixed, 2.8 V (Pb−Free)		
NCP5661MN30T2G	Fixed, 3.0 V (Pb−Free)		
NCV5661MNADJT2G*	Adj (Pb−Free)		
NCV5661MN12T2G*	Fixed, 1.2 V (Pb−Free)		
NCV5661MN15T2G*	Fixed, 1.5 V (Pb−Free)		
NCV5661MN18T2G*	Fixed, 1.8 V (Pb−Free)		
NCV5661MN28T2G*	Fixed, 2.8 V (Pb−Free)		
NCV5661MN30T2G*	Fixed, 3.0 V (Pb−Free)		
NCV5661MN33T2G*	Fixed, 3.3 V (Pb−Free)		

DISCONTINUED (Note 5)

NCP5661DT12RKG	Fixed, 1.2 V (Pb−Free)	DPAK	2500 / Tape & Reel
NCP5661DT18RKG	Fixed, 1.8 V (Pb−Free)		
NCP5661DT25RKG	Fixed, 2.5 V (Pb−Free)		
NCP5661DT33RKG	Fixed, 3.3 V (Pb−Free)		
NCV5661DT18RKG*	Fixed, 1.8 V (Pb−Free)		
NCP5661MNADJT2G	Adj (Pb−Free)	DFN6 3x3.3 mm	3000 / Tape & Reel
NCP5661MN12T2G	Fixed, 1.2 V (Pb−Free)		
NCP5661MN18T2G	Fixed, 1.8 V (Pb−Free)		
NCP5661MN25T2G	Fixed, 2.5 V (Pb−Free)		
NCP5661MN33T2G	Fixed, 3.3 V (Pb−Free)		
NCV5661MN25T2G*	Fixed, 2.5 V (Pb−Free)		

NOTE: Additional Fix output voltages are available upon request.

†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.

*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable

5. **DISCONTINUED:** These devices are not recommended for new design. Please contact your **onsemi** representative for information. The most current information on these devices may be available on www.onsemi.com.

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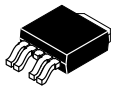
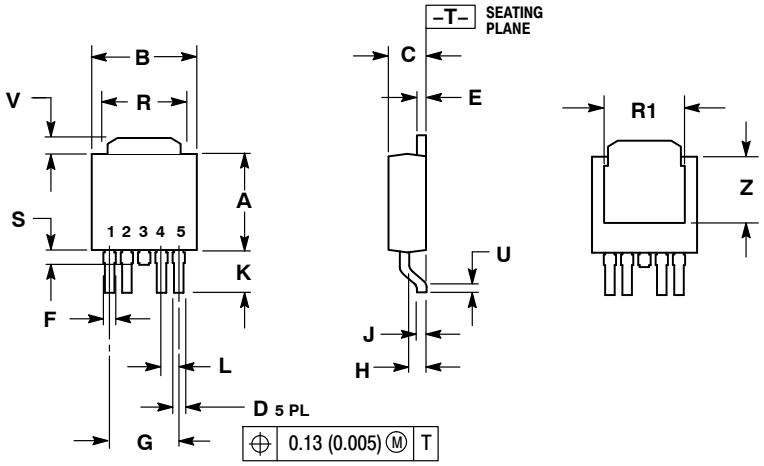


SCALE 1:1

DPAK−5, CENTER LEAD CROP
CASE 175AA
ISSUE B

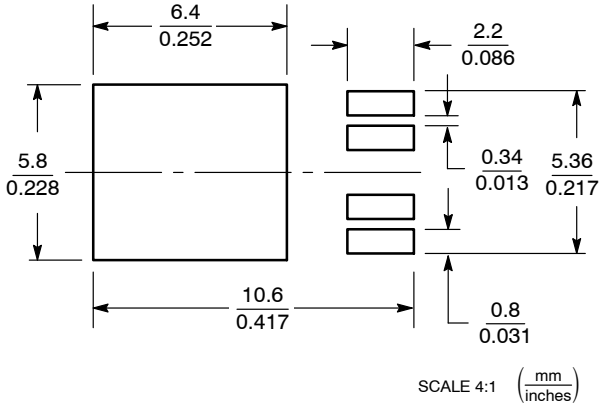
DATE 15 MAY 2014



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

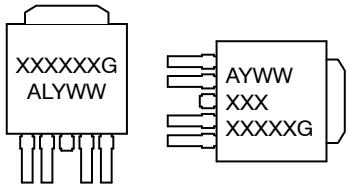
	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.235	0.245	5.97	6.22
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.020	0.028	0.51	0.71
E	0.018	0.023	0.46	0.58
F	0.024	0.032	0.61	0.81
G	0.180 BSC		4.56 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.102	0.114	2.60	2.89
L	0.045 BSC		1.14 BSC	
R	0.170	0.190	4.32	4.83
R1	0.185	0.210	4.70	5.33
S	0.025	0.040	0.63	1.01
U	0.020	−−−	0.51	−−−
V	0.035	0.050	0.89	1.27
Z	0.155	0.170	3.93	4.32

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.

GENERIC MARKING DIAGRAMS*



IC **Discrete**

XXXXXX	= Device Code
A	= Assembly Location
L	= Wafer Lot
Y	= Year
WW	= Work Week
G	= Pb−Free Package

*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.

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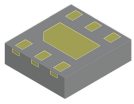

DFN6 3.0x3.3, 0.95P
CASE 506AX
ISSUE A

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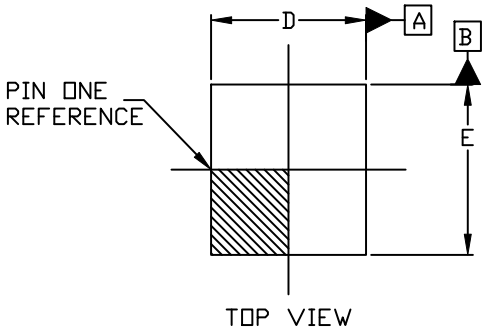
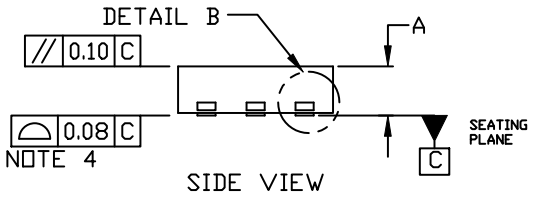
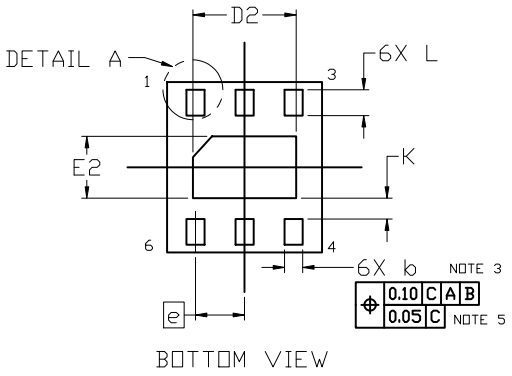
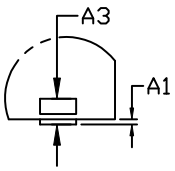
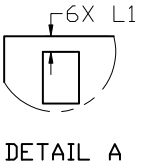




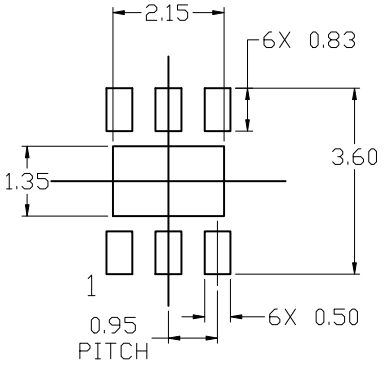


NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b APPLIES TO PLATED TERMINALS AND IS MEASURED BETWEEN 0.15 AND 0.30MM FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
5. POSITIONAL TOLERANCE APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.



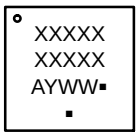


DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	0.80	0.90	1.00
A1	0.00	---	0.05
b	0.30	0.35	0.40
D	2.90	3.00	3.10
D2	1.90	2.00	2.10
E	3.20	3.30	3.40
E2	1.10	1.20	1.30
e	0.95 BSC		
K	0.40 REF		
L	0.40	0.50	0.60
L1	0.00	---	0.15



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

GENERIC MARKING DIAGRAM*



XXXX = Specific Device Code
A = Assembly Location
Y = Year
WW = 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. Some products may not follow the Generic Marking.

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