

## 5.0 V Dual Micropower Low Dropout Regulator with ENABLE and RESET

The CS8361 is a precision Micropower dual voltage regulator with ENABLE and RESET.

The 5.0 V standby output is accurate within  $\pm 2\%$  while supplying loads of 100 mA and has a typical dropout voltage of 400 mV. Quiescent current is low, typically 140  $\mu$ A with a 300  $\mu$ A load. The active RESET output monitors the 5.0 V standby output and is low during power-up and regulator dropout conditions. The RESET circuit includes hysteresis and is guaranteed to operate correctly with 1.0 V on the standby output.

The second output tracks the 5.0 V standby output through an external adjust lead, and can supply loads of 250 mA with a typical dropout voltage of 400 mV. The logic level ENABLE lead is used to control this tracking regulator output.

Both outputs are protected against overvoltage, short circuit, reverse battery and overtemperature conditions. The robustness and low quiescent current of the CS8361 makes it not only well suited for automotive microprocessor applications, but for any battery powered microprocessor applications.

### Features

- 2 Regulated Outputs
  - Standby Output 5.0 V  $\pm 2\%$ ; 100 mA
  - Tracking Output 5.0 V; 250 mA
- Low Dropout Voltage (0.4 V at Rated Current)
- RESET Option
- ENABLE Option
- Low Quiescent Current
- Protection Features
  - Independent Thermal Shutdown
  - Short Circuit
  - 60 V Load Dump
  - Reverse Battery
- Internally Fused Leads in SO-16L Package
- These are Pb-Free Devices

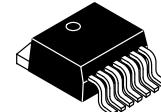


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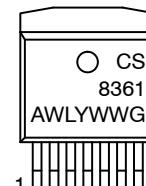
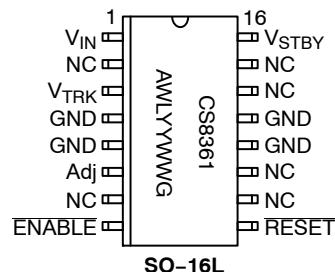


SO-16L  
DW SUFFIX  
CASE 751G



D2PAK-7  
DPS SUFFIX  
CASE 936AB

### PIN CONNECTIONS AND MARKING DIAGRAM



D2PAK-7

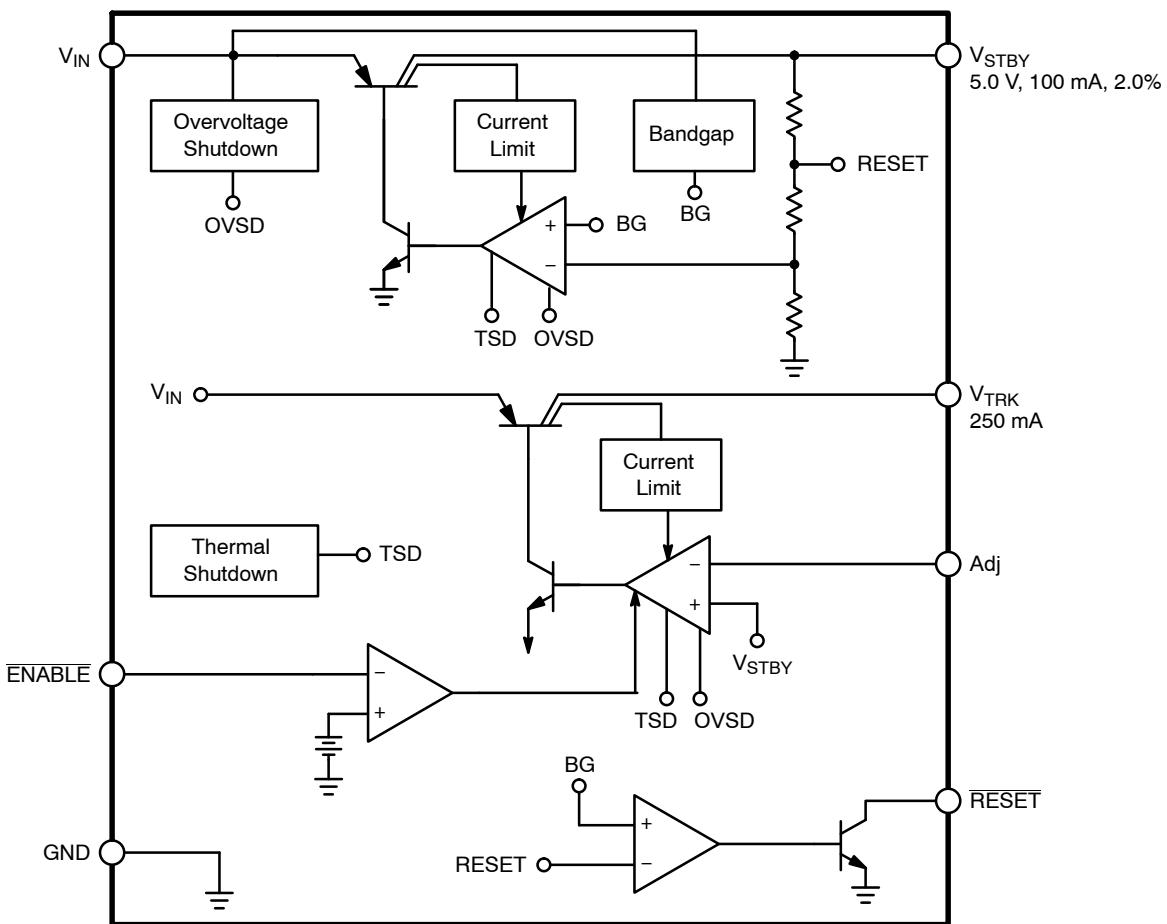
Pin 1. V<sub>STBY</sub>  
2. V<sub>IN</sub>  
3. V<sub>TRK</sub>  
4. GND  
5. Adj  
6. ENABLE  
7. RESET

CS8361 = Device Code  
A = Assembly Location  
WL = Wafer Lot  
YY = Year  
WW = Work Week  
G = Pb-Free Package

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 6 of this data sheet.

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



**Figure 1. Block Diagram. Consult Your Local Sales Representative for Positive ENABLE Option**

## MAXIMUM RATINGS\*

Rating	Value	Unit
Supply Voltage, $V_{IN}$	-16 to 26	V
Positive Transient Input Voltage, $tr > 1.0$ ms	60	V
Negative Transient Input Voltage, $T < 100$ ms, 1.0 % Duty Cycle	-50	V
Input Voltage Range (ENABLE, RESET)	-0.3 to 10	V
Tracking Regulator ( $V_{TRK}$ , Adj)	20	V
Standby Regulator ( $V_{STBY}$ )	10	V
Junction Temperature	-40 to +150	°C
Storage Temperature Range	-55 to +150	°C
ESD Susceptibility (Human Body Model)	2.0	kV
Lead Temperature Soldering	Wave Solder (through hole styles only) Note 1 Reflow (SMD styles only) Note 2	260 peak 230 peak
		°C °C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

1. 10 seconds max.
2. 60 seconds max above 183°C

\*The maximum package power dissipation must be observed.

**ELECTRICAL CHARACTERISTICS** (6.0 V  $\leq$  V<sub>IN</sub>  $\leq$  26 V, I<sub>OUT1</sub> = I<sub>OUT2</sub> = 100  $\mu$ A,  $-40^{\circ}$ C  $\leq$  T<sub>A</sub>  $\leq$   $+125^{\circ}$ C,  $-40^{\circ}$ C  $\leq$  T<sub>J</sub>  $\leq$   $+150^{\circ}$ C; unless otherwise stated.)

Characteristic	Test Conditions	Min	Typ	Max	Unit
<b>Tracking Output (V<sub>TRK</sub>)</b>					
V <sub>TRK</sub> Tracking Error (V <sub>STBY</sub> - V <sub>TRK</sub> )	6.0 V $\leq$ V <sub>IN</sub> $\leq$ 26 V, 100 $\mu$ A $\leq$ I <sub>TRK</sub> $\leq$ 250 mA. Note 3	-25	-	+25	mV
Adjust Pin Current, I <sub>Adj</sub>	Loop in Regulation	-	1.5	5.0	$\mu$ A
Line Regulation	6.0 V $\leq$ V <sub>IN</sub> $\leq$ 26 V. Note 3	-	5.0	50	mV
Load Regulation	100 $\mu$ A $\leq$ I <sub>TRK</sub> $\leq$ 250 mA. Note 3	-	5.0	50	mV
Dropout Voltage (V <sub>IN</sub> - V <sub>TRK</sub> )	I <sub>TRK</sub> = 100 $\mu$ A. I <sub>TRK</sub> = 250 mA	- -	100 400	150 700	mV mV
Current Limit	V <sub>IN</sub> = 12 V, V <sub>TRK</sub> = 4.5 V	275	500	-	mA
Quiescent Current	V <sub>IN</sub> = 12 V, I <sub>TRK</sub> = 250 mA, No Load on V <sub>STBY</sub>	-	25	50	mA
Reverse Current	V <sub>TRK</sub> = 5.0 V, V <sub>IN</sub> = 0 V	-	200	1500	$\mu$ A
Ripple Rejection	f = 120 Hz, I <sub>TRK</sub> = 250 mA, 7.0 V $\leq$ V <sub>IN</sub> $\leq$ 17 V	60	70	-	dB
<b>Standby Output (V<sub>STBY</sub>)</b>					
Output Voltage, V <sub>STBY</sub>	6.0 V $\leq$ V <sub>IN</sub> $\leq$ 26 V, 100 $\mu$ A $\leq$ I <sub>STBY</sub> $\leq$ 100 mA.	4.9	5.0	5.1	V
Line Regulation	6.0 V $\leq$ V <sub>IN</sub> $\leq$ 26 V.	-	5.0	50	mV
Load Regulation	100 $\mu$ A $\leq$ I <sub>STBY</sub> $\leq$ 100 mA.	-	5.0	50	mV
Dropout Voltage (V <sub>IN</sub> - V <sub>STBY</sub> )	I <sub>STBY</sub> = 100 $\mu$ A. I <sub>STBY</sub> = 100 mA	- -	100 400	150 600	mV mV
Current Limit	V <sub>IN</sub> = 12 V, V <sub>STBY</sub> = 4.5 V	125	200	-	mA
Short Circuit Current	V <sub>IN</sub> = 12 V, V <sub>STBY</sub> = 0 V	10	100	-	mA
Quiescent Current	V <sub>IN</sub> = 12 V, I <sub>STBY</sub> = 100 mA, I <sub>TRK</sub> = 0 mA V <sub>IN</sub> = 12 V, I <sub>STBY</sub> = 300 $\mu$ A, I <sub>TRK</sub> = 0 mA	- -	10 140	20 200	mA $\mu$ A
Reverse Current	V <sub>STBY</sub> = 5.0 V, V <sub>IN</sub> = 0 V	-	100	200	$\mu$ A
Ripple Rejection	f = 120 Hz, I <sub>STBY</sub> = 100 mA, 7.0 V $\leq$ V <sub>IN</sub> $\leq$ 17 V	60	70	-	dB
<b>RESET ENABLE Functions</b>					
ENABLE Input Threshold	-	0.8	1.2	2.0	V
ENABLE Input Bias Current	V <sub>ENABLE</sub> = 0 V to 10 V	-10	0	10	$\mu$ A
RESET Threshold High (V <sub>RH</sub> )	V <sub>STBY</sub> Increasing	4.59	4.87	V <sub>STBY</sub> - 0.02	V
RESET Hysteresis	-	60	120	180	mV
RESET Threshold Low (V <sub>RL</sub> )	V <sub>STBY</sub> Decreasing	4.53	4.75	V <sub>STBY</sub> - 0.08	V
RESET Leakage	-	-	-	25	$\mu$ A
Output Voltage, Low (V <sub>RLO</sub> )	1.0 V $\leq$ V <sub>STBY</sub> $\leq$ V <sub>RL</sub> , R <sub>RST</sub> = 10 k $\Omega$	-	0.1	0.4	V
Output Voltage, Low (V <sub>RPEAK</sub> )	V <sub>STBY</sub> Power Up, Power Down	-	0.6	1.0	V
<b>Protection Circuitry (Both Outputs)</b>					
Independent Thermal Shutdown	V <sub>STBY</sub> V <sub>TRK</sub>	150 150	180 165	- -	°C °C
Overvoltage Shutdown	-	30	34	38	V

3. V<sub>TRK</sub> connected to Adj lead. V<sub>TRK</sub> can be set to higher values by using an external resistor divider.

## PACKAGE PIN DESCRIPTION

PACKAGE PIN #		PIN SYMBOL	FUNCTION
D <sup>2</sup> PAK, 7 Pin	SO-16L		
1	16	V <sub>STBY</sub>	Standby output voltage delivering 100 mA.
2	1	V <sub>IN</sub>	Input voltage.
3	3	V <sub>TRK</sub>	Tracking output voltage controlled by ENABLE delivering 250 mA.
4	4, 5, 12, 13	GND	Reference ground connection.
5	6	Adj	Resistor divider from V <sub>TRK</sub> to Adj. Sets the output voltage on V <sub>TRK</sub> . If tied to V <sub>TRK</sub> , V <sub>TRK</sub> will track V <sub>STBY</sub> .
6	8	ENABLE	Provides on/off control of the tracking output, active LOW.
7	9	RESET	CMOS compatible output lead that goes low whenever V <sub>STBY</sub> falls out of regulation.
	2, 7, 10, 11, 14, 15	NC	No connection.

## CIRCUIT DESCRIPTION

## ENABLE Function

The ENABLE function switches the output transistor for V<sub>TRK</sub> on and off. When the ENABLE lead voltage exceeds 1.4 V (Typ), V<sub>TRK</sub> turns off. This input has several hundred millivolts of hysteresis to prevent spurious output activity during power-up or power-down.

## RESET Function

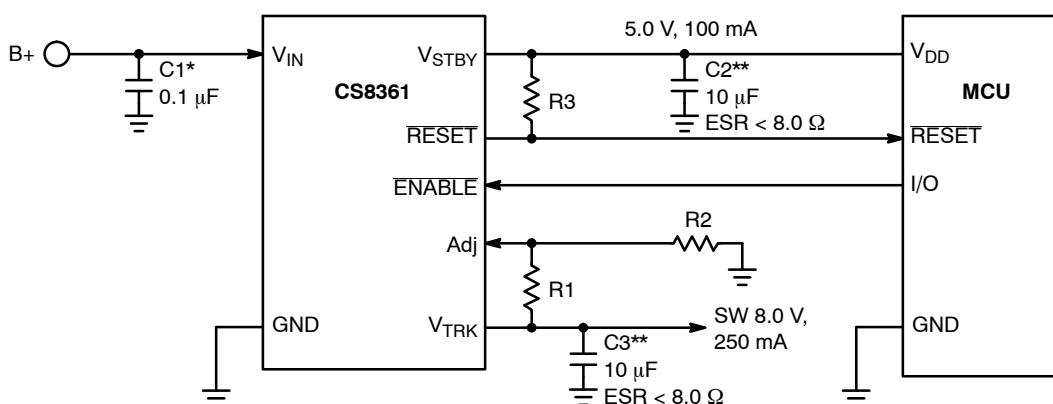
The RESET is an open collector NPN transistor, controlled by a low voltage detection circuit sensing the V<sub>STBY</sub> (5.0 V) output voltage. This circuit guarantees the RESET output stays below 1.0 V (0.1 V Typ) when V<sub>STBY</sub> is as low as 1.0 V to ensure reliable operation of microprocessor-based systems.

V<sub>TRK</sub> Output Voltage

This output uses the same type of output device as V<sub>STBY</sub>, but is rated for 250 mA. The output is configured as a tracking regulator of the standby output. By using the standby output as a voltage reference, giving the user an external programming lead (Adj lead), output voltages from 5.0 V to 20 V are easily realized. The programming is done with a simple resistor divider (Figure 2), and following the formula:

$$V_{TRK} = V_{STBY} \times (1 + R1/R2) + I_{Adj} \times R1$$

If another 5.0 V output is needed, simply connect the Adj lead to the V<sub>TRK</sub> output lead.



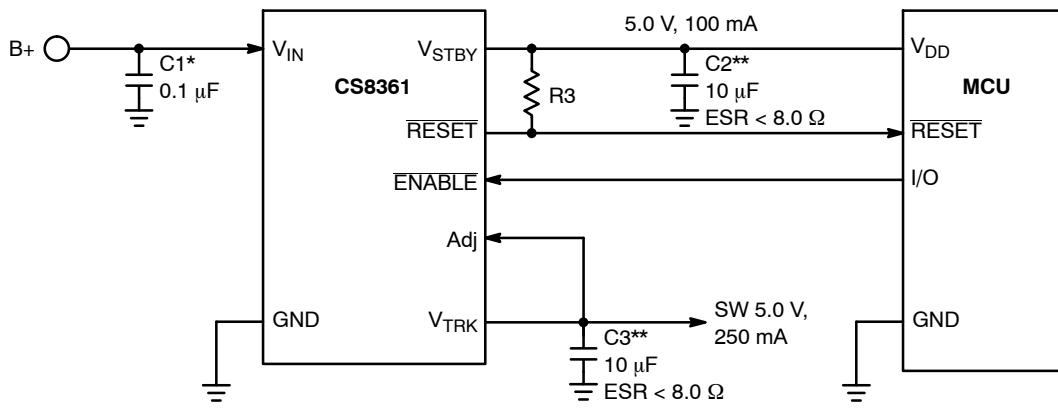
$$V_{TRK} \sim V_{STBY}(1 + R1/R2)$$

For V<sub>TRK</sub> ~ 8.0 V, R1/R2 ~ 0.6

\*C1 is required if regulator is located far from power supply filter.

\*\*C2 and C3 are required for stability.

Figure 2. Test and Application Circuit, 5.0 V, 8.0 V Regulator



\*C1 is required if regulator is located far from power supply filter.

\*\*C2 and C3 are required for stability.

**Figure 3. Test and Application Circuit, Dual 5.0 V Regulator**

## APPLICATION NOTES

### External Capacitors

Output capacitors for the CS8361 are required for stability. Without them, the regulator outputs will oscillate. Actual size and type may vary depending upon the application load and temperature range. Capacitor effective series resistance (ESR) is also a factor in the IC stability. Worst-case is determined at the minimum ambient temperature and maximum load expected.

Output capacitors can be increased in size to any desired value above the minimum. One possible purpose of this would be to maintain the output voltages during brief conditions of negative input transients that might be characteristic of a particular system.

Capacitors must also be rated at all ambient temperatures expected in the system. To maintain regulator stability down to  $-40^{\circ}\text{C}$ , capacitors rated at that temperature must be used.

More information on capacitor selection for SMART REGULATOR®s is available in the SMART REGULATOR application note, "Compensation for Linear Regulators," document number SR003AN/D, available through the Literature Distribution Center or via our website at <http://www.onsemi.com>.

### Calculating Power Dissipation in a Dual Output Linear Regulator

The maximum power dissipation for a dual output regulator (Figure 4) is

$$P_{D(\text{max})} = (V_{IN(\text{max})} - V_{OUT1(\text{min})})I_{OUT1(\text{max})} + (V_{IN(\text{max})} - V_{OUT2(\text{min})})I_{OUT2(\text{max})} + V_{IN(\text{max})}I_Q \quad (1)$$

where:

$V_{IN(\text{max})}$  is the maximum input voltage,

$V_{OUT1(\text{min})}$  is the minimum output voltage from  $V_{OUT1}$ ,

$V_{OUT2(\text{min})}$  is the minimum output voltage from  $V_{OUT2}$ ,

$I_{OUT1(\text{max})}$  is the maximum output current, for the application,

$I_{OUT2(\text{max})}$  is the maximum output current, for the application, and

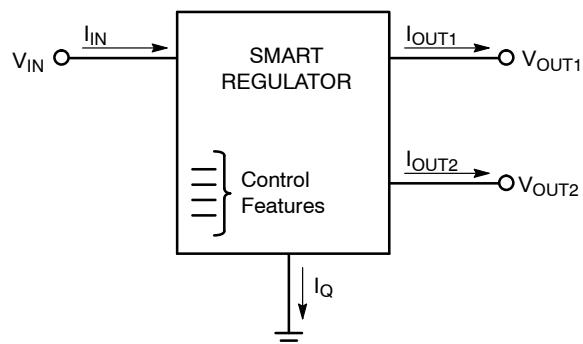
$I_Q$  is the quiescent current the regulator consumes at both  $I_{OUT1(\text{max})}$  and  $I_{OUT2(\text{max})}$ .

Once the value of  $P_{D(\text{max})}$  is known, the maximum permissible value of  $R_{\theta JA}$  can be calculated:

$$R_{\theta JA} = \frac{150^{\circ}\text{C} - T_A}{P_D} \quad (2)$$

The value of  $R_{\theta JA}$  can be compared with those in the package section of the data sheet. Those packages with  $R_{\theta JA}$ 's less than the calculated value in equation 2 will keep the die temperature below  $150^{\circ}\text{C}$ .

In some cases, none of the packages will be sufficient to dissipate the heat generated by the IC, and an external heatsink will be required.



**Figure 4. Dual Output Regulator With Key Performance Parameters Labeled.**

**Heat Sinks**

A heat sink effectively increases the surface area of the package to improve the flow of heat away from the IC and into the surrounding air.

Each material in the heat flow path between the IC and the outside environment will have a thermal resistance. Like series electrical resistances, these resistances are summed to determine the value of  $R_{\theta JA}$ :

$$R_{\theta JA} = R_{\theta JC} + R_{\theta CS} + R_{\theta SA} \quad (3)$$

where:

$R_{\theta JC}$  = the junction-to-case thermal resistance,  
 $R_{\theta CS}$  = the case-to-heatsink thermal resistance, and  
 $R_{\theta SA}$  = the heatsink-to-ambient thermal resistance.

$R_{\theta JC}$  appears in the package section of the data sheet. Like  $R_{\theta JA}$ , it too is a function of package type.  $R_{\theta CS}$  and  $R_{\theta SA}$  are functions of the package type, heatsink and the interface between them. These values appear in heat sink data sheets of heat sink manufacturers.

**ORDERING INFORMATION\***

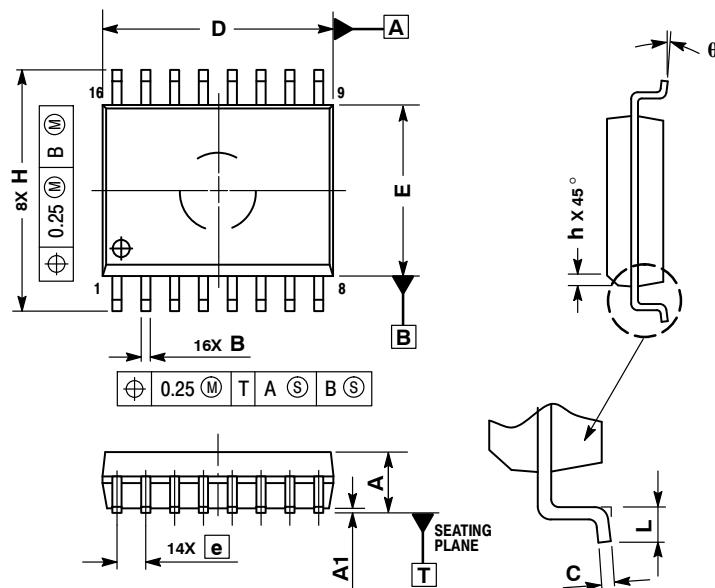
Device	Package	Shipping <sup>†</sup>
CS8361YDPS7G	D <sup>2</sup> PAK-7 (Pb-Free)	50 Units/Rail
CS8361YDPSR7G	D <sup>2</sup> PAK-7 (Pb-Free)	750 / Tape & Reel
CS8361YDWF16G	SO-16L (Pb-Free)	46 Units/Rail
CS8361YDWFR16G	SO-16L (Pb-Free)	1000 / Tape & Reel

<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.

\*Contact your local sales representative for other package options including PSOP-20, TO-220-7, DIP-16, and SO-20L.

## PACKAGE DIMENSIONS

SO-16L  
DWF SUFFIX  
CASE 751G-03  
ISSUE C



NOTES:

1. DIMENSIONS ARE IN MILLIMETERS.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
3. DIMENSIONS D AND E DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.
5. DIMENSION B DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.13 TOTAL IN EXCESS OF THE B DIMENSION AT MAXIMUM MATERIAL CONDITION.

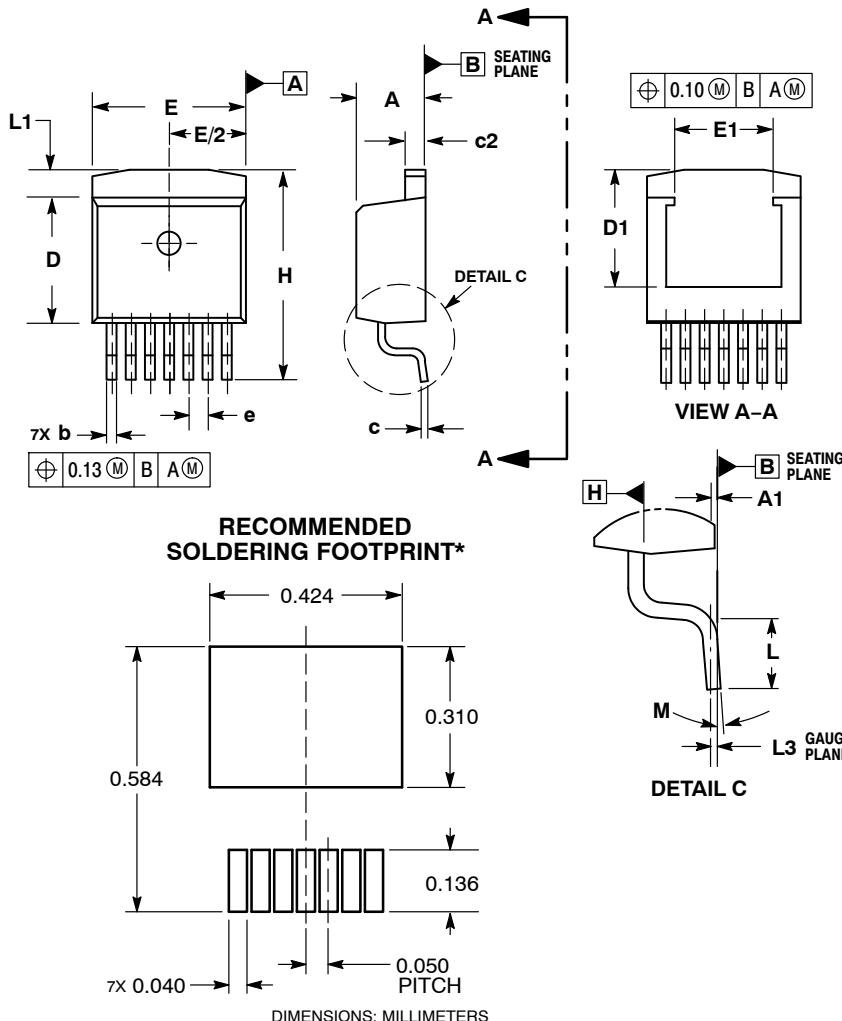
DIM	MILLIMETERS	
	MIN	MAX
A	2.35	2.65
A1	0.10	0.25
B	0.35	0.49
C	0.23	0.32
D	10.15	10.45
E	7.40	7.60
e	1.27 BSC	
H	10.05	10.55
h	0.25	0.75
L	0.50	0.90
θ	0 °	7 °

## PACKAGE THERMAL DATA

Parameter		SO-16L	D <sup>2</sup> PAK, 7-Pin	Unit
R <sub>θJC</sub>	Typical	18	3.5	°C/W
R <sub>θJA</sub>	Typical	75	10-50*	°C/W

\*Depending on thermal properties of substrate. R<sub>θJA</sub> = R<sub>θJC</sub> + R<sub>θCA</sub>.

## PACKAGE DIMENSIONS

D<sup>2</sup>PAK-7 (SHORT LEAD)  
DPS SUFFIX  
CASE 936AB-01  
ISSUE B

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH AND GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.005 MAXIMUM PER SIDE. THESE DIMENSIONS TO BE MEASURED AT DATUM H.
4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E, L1, D1, AND E1. DIMENSIONS D1 AND E1 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THE THERMAL PAD.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.170	0.180	4.32	4.57
A1	0.000	0.010	0.00	0.25
b	0.026	0.036	0.66	0.91
c	0.017	0.026	0.43	0.66
c2	0.045	0.055	1.14	1.40
D	0.325	0.368	8.25	9.53
D1	0.270	---	6.86	---
E	0.380	0.420	9.65	10.67
E1	0.245	---	6.22	---
e	0.050 BSC	1.27 BSC	1.27	1.27
H	0.539	0.579	13.69	14.71
L	0.058	0.078	1.47	1.98
L1	---	0.066	---	1.68
L3	0.010 BSC	0.25 BSC	0.25	0.25
M	0°	8°	0°	8°

\*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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