# ISL78307

40V, Low Quiescent Current, 50mA Linear Regulator for Automotive Applications

FN7658
Rev 3.00
April 7, 2015

The ISL78307 is a high voltage, low quiescent current linear regulator ideally suited for “always-on” and “keep alive” automotive applications. The ISL78307 operates from an input voltage of +6V to +40V under normal operating conditions and operates down to +3V under a cold crank. It consumes only 18µA of quiescent current at no load on the adjustable version.

The ISL78307 is available in fixed 3.3V, 5V and adjustable output voltage (2.5V to 12V) options. It features an EN pin that can be used to put the device into a low-quiescent current shutdown mode where it draws only 1.8µA of supply current. The device features over-temperature shutdown and current limit protection.

The ISL78307 is AEC-Q100 qualified. It is rated over the -40°C to +125°C automotive temperature range and is available in an 8 Ld EPSOIC with exposed pad package.

## Applications

- Automotive
- Industrial
- Telecom

## Features

- Optimized for “always-on” automotive applications
- 18µA typical quiescent current
- Guaranteed 50mA output current
- Operates through cold crank down to 3V
- 40V tolerant logic level (TTL/CMOS) enable input
- 1.8µA of typical shutdown current
- Low dropout voltage of 120mV at 50mA
- Fixed +3.3V, +5.0V and adjustable output voltage options
- Stable operation with 10µF output capacitor
- Thermal shutdown and current limit protection
- -40°C to +125°C operating temperature range
- Thermally enhanced 8 Ld exposed pad SOIC package
- AEC-Q100 qualified
- 6kV ESD HBM rated
- Pb-free (RoHS compliant)

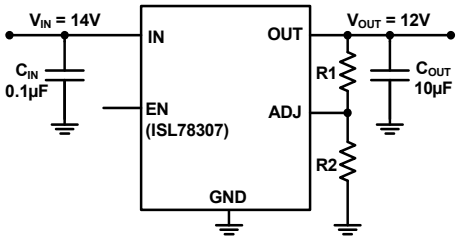



FIGURE 1. TYPICAL APPLICATION - ADJ VERSION

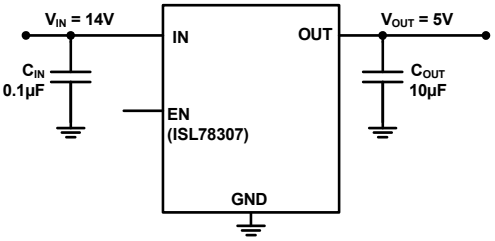



FIGURE 2. TYPICAL APPLICATION - FIXED VERSION

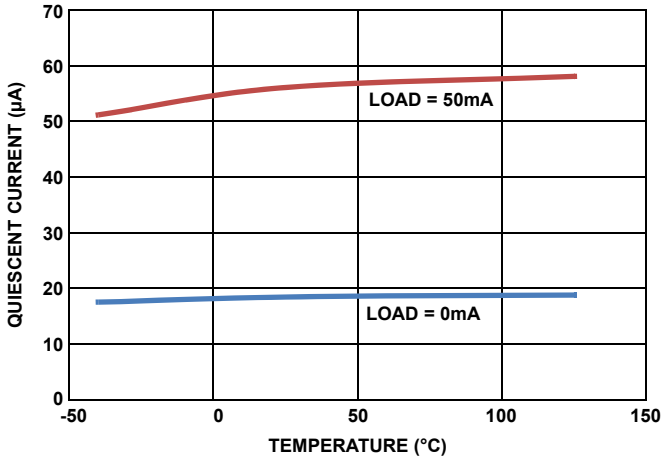
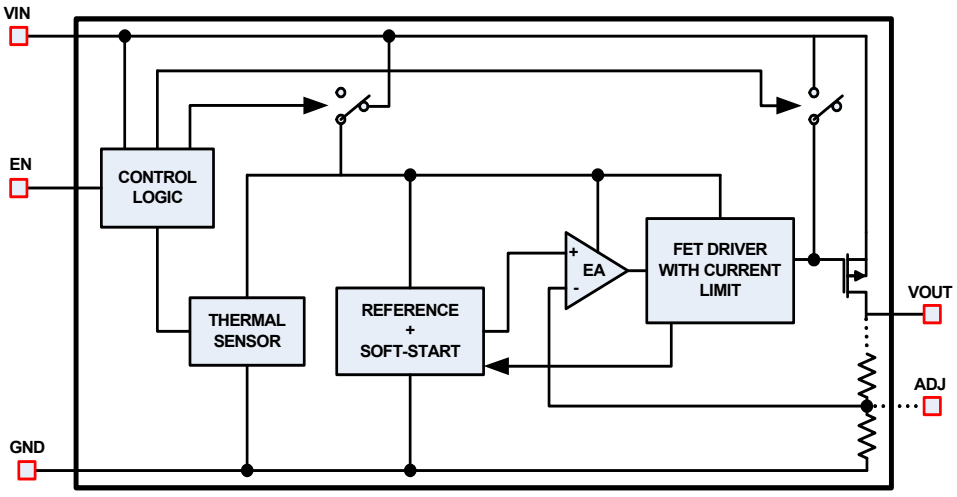


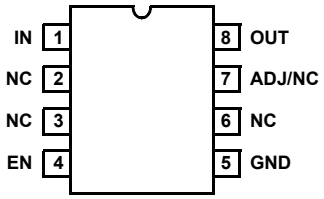

FIGURE 3. QUIESCENT CURRENT vs LOAD CURRENT (ADJ VERSION AT UNITY GAIN). $V_{IN}$ = 14V

## Block Diagram




## Pin Configuration

ISL78307
(8 LD EPSOIC)
TOP VIEW




## Pin Descriptions

| PIN NUMBER | PIN NAME | DESCRIPTION |
|---|---|---|
| 1 | IN | Input voltage pin. A minimum 0.1µF X5R/X7R capacitor is required for proper operation. |
| 2, 3, 6 | NC | Pins have internal termination and can be left unconnected. Connection to ground is optional. |
| 4 | EN | High on this pin enables the device. |
| 5 | GND | Ground pin. |
| 7 | ADJ/NC | In the adjustable output voltage option, this pin is connected to the external feedback resistor divider which sets the LDO output voltage. In the 3.3V and 5V options, this pin is not used and can be connected to ground. |
| 8 | OUT | Regulated output voltage. A 10µF X5R/X7R output capacitor is required for stability. |
| | EPAD | It is recommended to solder the EPAD to the ground plane. |

## Ordering Information

| PART NUMBER (Notes 1, 2, 3) | PART MARKING | TEMP. RANGE (°C) | ENABLE PIN | OUTPUT VOLTAGE (V) | PACKAGE (Pb-Free) | PKG. DWG. # |
|---|---|---|---|---|---|---|
| ISL78307FBEAZ | 78307 FBEAZ | -40 to +125 | Yes | 3.3 | 8 Ld EPSOIC | M8.15B |
| ISL78307FBEBZ | 78307 FBEBZ | -40 to +125 | Yes | 5.0 | 8 Ld EPSOIC | M8.15B |
| ISL78307FBECZ | 78307 FBECZ | -40 to +125 | Yes | ADJ | 8 Ld EPSOIC | M8.15B |

NOTES:

1. Add "-T*" suffix for tape and reel. Please refer to TB347 for details on reel specifications.
2. These Intersil Pb-free plastic packaged products employ special Pb-free material sets, molding compounds/die attach materials, and 100% matte tin plate plus anneal (e3 termination finish, which is RoHS compliant and compatible with both SnPb and Pb-free soldering operations). Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.
3. For Moisture Sensitivity Level (MSL), please see device information page for ISL78307. For more information on MSL please see techbrief TB363.

## Absolute Maximum Ratings

Supply Voltage, VCC . . . . . +45V
IN pin to GND Voltage. . . . . GND - 0.3V to VCC
OUT pin to GND Voltage . . . . . GND - 0.3V to 16V
EN pin to GND Voltage . . . . . GND - 0.3V to VCC
Output Short-circuit Duration . . . . . Indefinite
ESD Rating
Human Body Model (Tested per JESD22-A114E). . . . . 6kV
Machine Model (Tested per JESD-A115-A) . . . . . 350V
Charge Device Model (Tested per AEC-Q100-011). . . . . 2.2kV
Latch Up (Tested per JESD78B; Class II, Level A) . . . . . 100mA

## Thermal Information

| Thermal Resistance (Typical) | $\theta_{JA}$ (°C/W) | $\theta_{JC}$ (°C/W) |
|---|---|---|
| 8 Ld EPSOIC Package (Notes 4, 5). . . . . | 50 | 9 |

Maximum Junction Temperature . . . . . +150°C
Maximum Storage Temperature Range . . . . . -65°C to +175°C
Pb-Free Reflow Profile . . . . . see TB493

## Recommended Operating Conditions

Ambient Temperature Range . . . . . -40°C to +125°C
IN pin to GND Voltage. . . . . +3V to +40V
OUT pin to GND Voltage . . . . . +2.5V to +12V
EN pin to GND Voltage . . . . . 0V to +40V

*CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.*

NOTES:

4. $\theta_{JA}$ is measured in free air with the component mounted on a high effective thermal conductivity test board with "direct attach" features. See Tech Brief TB379.
5. For $\theta_{JC}$, the "case temp" location is the center of the exposed metal pad on the package underside.

## Electrical Specifications

Recommended Operating Conditions, unless otherwise noted. $V_{IN}$ = 14V, $I_{OUT}$ = 1mA, $C_{IN}$ = 0.1µF, $C_{OUT}$ = 10µF, $T_A$ = $T_J$ = -40°C to +125°C, unless otherwise noted. Typical specifications are at $T_A$ = +25°C. **Boldface limits apply across the operating temperature range, -40°C to +125°C.**

| PARAMETER | SYMBOL | TEST CONDITIONS | | MIN (Note 8) | TYP | MAX (Note 8) | UNIT |
|---|---|---|---|---|---|---|---|
| Input Voltage Range | $V_{IN}$ | | | **6** | | **40** | V |
| | | Cold Crank condition | | **3** | | **40** | V |
| Guaranteed Output Current | $I_{OUT}$ | $V_{IN}$ = $V_{OUT}$ + VDO | | **50** | | | mA |
| Output Voltage | $V_{OUT}$ | EN = High<br>$V_{IN}$ = 14V<br>$I_{OUT}$ = 0.1mA | 3.3V Version | **3.267** | 3.3 | **3.333** | V |
| | | | 5V Version | **4.950** | 5 | **5.050** | V |
| | | | ADJ pin voltage | **1.211** | 1.223 | **1.235** | V |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | 3V ≤ $V_{IN}$ ≤ 40V<br>$I_{OUT}$ = 1mA | | | 0.04 | **0.115** | % |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | $V_{IN}$ = $V_{OUT}$ +$V_{DO}$<br>$I_{OUT}$ = 100µA to 50mA | | | 0.25 | **0.5** | % |
| Dropout Voltage (Note 6) | $\Delta V_{DO}$ | $I_{OUT}$ = 1mA, $V_{OUT}$ = 3.3V | | | 10 | **38** | mV |
| | | $I_{OUT}$ = 50mA, $V_{OUT}$ = 3.3V | | | 130 | **340** | mV |
| | | $I_{OUT}$ = 1mA, $V_{OUT}$ = 5V | | | 10 | **48** | mV |
| | | $I_{OUT}$ = 50mA, $V_{OUT}$ = 5V | | | 120 | **350** | mV |
| Shutdown Current | $I_{SHDN}$ | EN = LOW | | | 1.8 | **3.64** | µA |
| Quiescent Current | IQ | EN = High<br>$V_{IN}$ = 14V | $I_{OUT}$ = 0mA, ADJ Version, $V_{OUT}$ = $V_{ADJ}$ | | 18 | **24** | µA |
| | | | $I_{OUT}$ = 1mA, ADJ Version, $V_{OUT}$ = $V_{ADJ}$ | | 22 | **42** | µA |
| | | | $I_{OUT}$ = 10mA, ADJ Version, $V_{OUT}$ = $V_{ADJ}$ | | 34 | **60** | µA |
| | | | $I_{OUT}$ = 50mA, ADJ Version, $V_{OUT}$ = $V_{ADJ}$ | | 56 | **82** | µA |
| | | | $I_{OUT}$ = 0, 3.3V and 5.0V Version | | 22 | **28** | µA |
| | | | $I_{OUT}$ = 1mA, 3.3V and 5.0V Version | | 27 | **45** | µA |
| | | | $I_{OUT}$ = 10mA, 3.3V and 5.0V Version | | 37 | **65** | µA |
| | | | $I_{OUT}$ = 50mA, 3.3V and 5.0V Version | | 62 | **90** | µA |

**Electrical Specifications** Recommended Operating Conditions, unless otherwise noted. $V_{IN}$ = 14V, $I_{OUT}$ = 1mA, $C_{IN}$ = 0.1µF, $C_{OUT}$ = 10µF, $T_A$ = $T_J$ = -40°C to +125°C, unless otherwise noted. Typical specifications are at $T_A$ = +25°C. **Boldface limits apply across the operating temperature range, -40°C to +125°C. (Continued)**

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN (Note 8) | TYP | MAX (Note 8) | UNIT |
|---|---|---|---|---|---|---|
| Power Supply Rejection Ratio | PSRR | f = 100Hz; Vin_ripple = 500m$V_{P-P}$; Load = 50mA | | 58 | | dB |
| **EN FUNCTION** | | | | | | |
| EN Threshold Voltage | $V_{EN\_H}$ | $V_{OUT}$ = Off to On | | | **1.485** | V |
| | $V_{EN\_L}$ | $V_{OUT}$ = On to Off | **0.935** | | | V |
| EN Pin Current | $I_{EN}$ | $V_{OUT}$ = 0V | | 0.026 | | µA |
| EN to Regulation Time (Note 7) | $t_{EN}$ | | | 1.65 | **1.93** | ms |
| **PROTECTION FEATURES** | | | | | | |
| Output Current Limit | $I_{LIMIT}$ | $V_{OUT}$ = 0V | **60** | 118 | | mA |
| Thermal Shutdown | $T_{SHDN}$ | Junction Temperature Rising | | +165 | | °C |
| Thermal Shutdown Hysteresis | $T_{HYST}$ | | | +20 | | °C |

NOTES:

6. Dropout voltage is defined as ($V_{IN}$ - $V_{OUT}$) when $V_{OUT}$ is 2% below the value of $V_{OUT}$ when $V_{IN}$ = $V_{OUT}$ + 3V.
7. Enable to Regulation is the time the output takes to reach 95% of its final value with $V_{IN}$ = 14V and EN is taken from $V_{IL}$ to $V_{IH}$ in 5ns. For the adjustable versions, the output voltage is set at 5V.
8. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified. Temperature limits established by characterization and are not production tested.

## Typical Performance Curves

$V_{IN}$ = 14V, $I_{OUT}$ = 1mA, $V_{OUT}$ = 5V, $T_J$ = +25 °C unless otherwise specified.

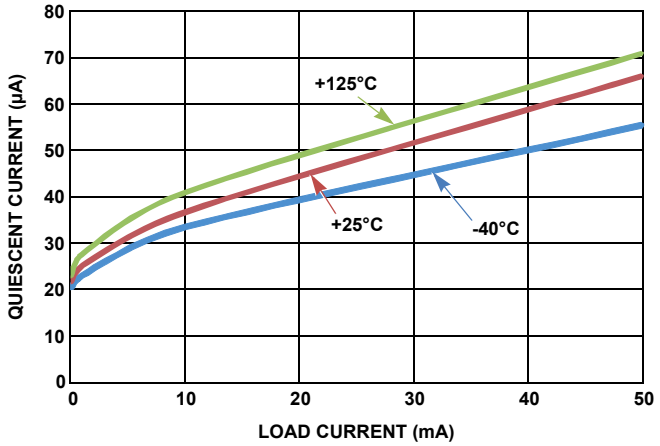



FIGURE 4. QUIESCENT CURRENT vs LOAD CURRENT

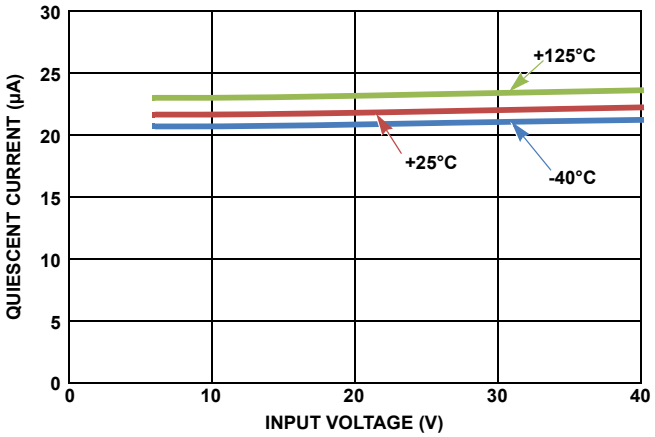



FIGURE 5. QUIESCENT CURRENT vs INPUT VOLTAGE (NO LOAD)

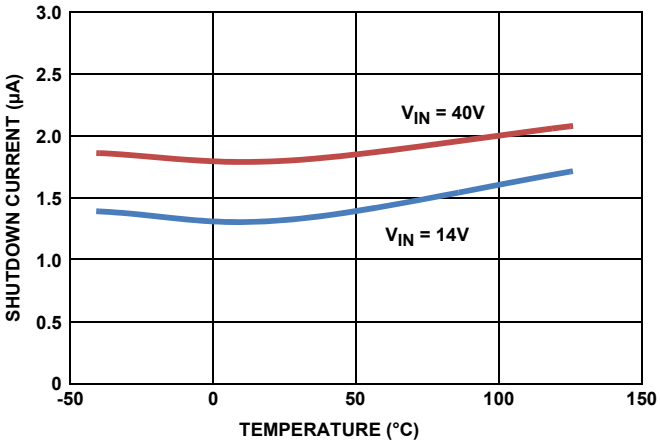



FIGURE 6. SHUTDOWN CURRENT vs TEMPERATURE (EN = 0)

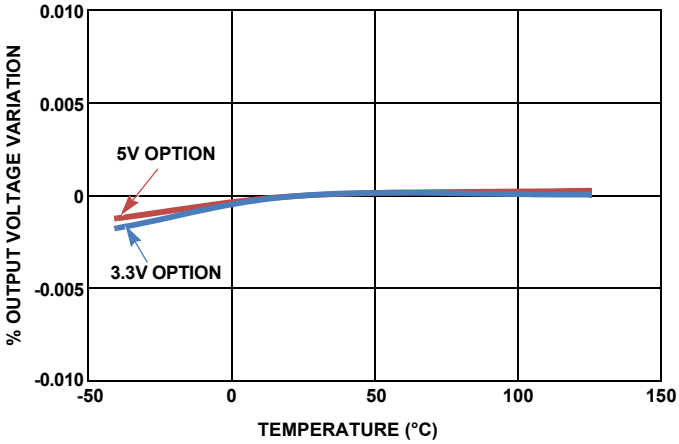



FIGURE 7. OUTPUT VOLTAGE vs TEMPERATURE (LOAD = 50mA)

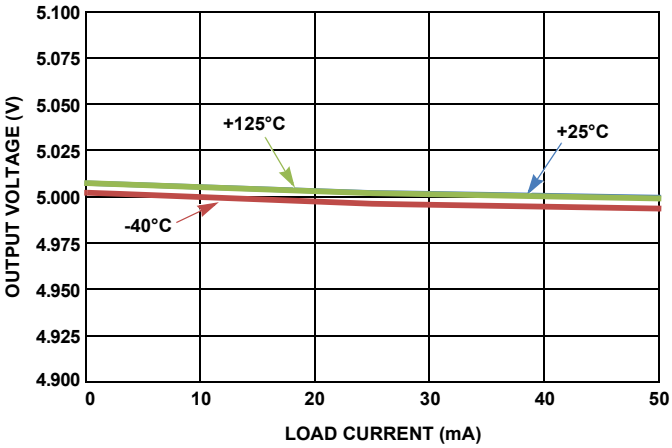



FIGURE 8. OUTPUT VOLTAGE vs LOAD CURRENT

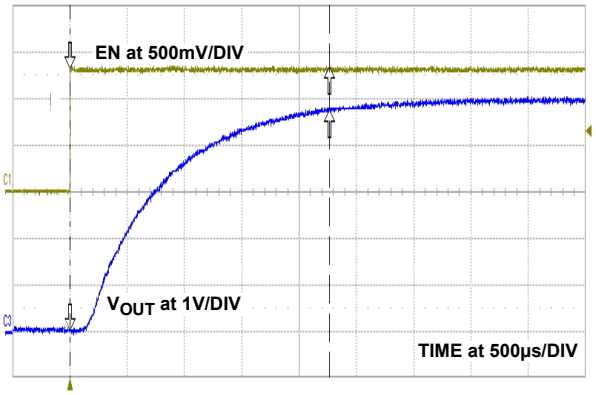



FIGURE 9. START-UP WAVEFORM

## Typical Performance Curves

$V_{IN}$ = 14V, $I_{OUT}$ = 1mA, $V_{OUT}$ = 5V, $T_J$ = +25 °C unless otherwise specified. **(Continued)**

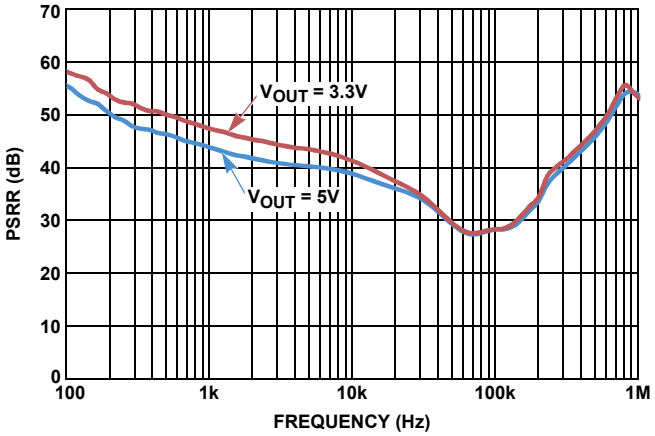



FIGURE 10. POWER SUPPLY REJECTION RATIO (LOAD = 50mA)

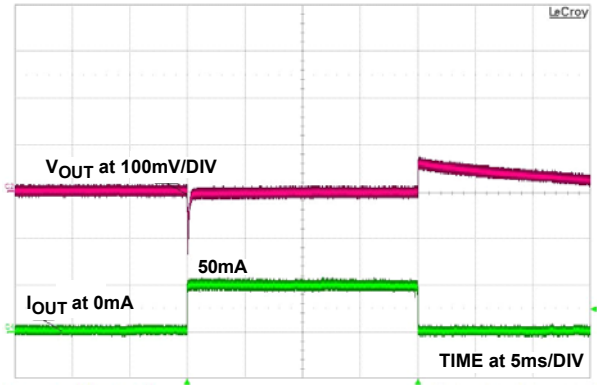



FIGURE 11. LOAD TRANSIENT RESPONSE

# Functional Description

## Functional Overview

The ISL78307 is a high performance, high voltage, low-dropout regulator (LDO) with 50mA sourcing capability. The part is qualified to operate over the -40°C to +125°C automotive temperature range. Featuring ultra-low quiescent current, it makes an ideal choice for “always-on” automotive applications. It works well under a “load-dump condition” where the input voltage could rise up to 40V. The LDO continues to operate down to 3V under a “cold-crank” condition. The device also features current limit and thermal shutdown protection.

## Enable Control

The ISL78307 features an enable pin. When it is pulled low, the IC goes to a shutdown mode. In this condition, the device draws less than 2µA. Driving the pin high turns the device on.

## Current Limit Protection

The ISL78307 has internal current limit functionality to protect the regulator during fault conditions. During current limit, the output sources a fixed amount of current largely independent of the output voltage. If the short or overload is removed from $V_{OUT}$, the output returns to normal voltage regulation mode.

## Thermal Fault Protection

In the event the die temperature exceeds typically +165°C, the output of the LDO will shut down until the die temperature cools down to typically +145°C. The level of power dissipated, combined with the ambient temperature and the thermal impedance of the package, will determine if the junction temperature exceeds the thermal shutdown temperature. See section on “Power Dissipation”.

# Application Information

## Input and Output Capacitors

For the output, a ceramic capacitor (X5R or X7R) with a capacitance of 10µF is recommended for the ISL78307 to maintain stability. The ground connection of the output capacitor should be routed directly to the GND pin of the device and also placed close to the IC. A minimum of 0.1µF (X5R or X7R) is recommended at the input.

## Output Voltage Setting

For the adjustable version of the ISL78307, the output voltage is programmed using an external resistor divider as shown in Figure 12.

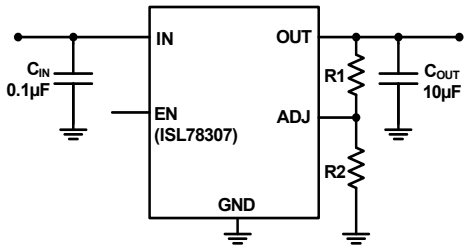



FIGURE 12. ADJUSTABLE VERSION

The output voltage is calculated using Equation 1:

$$V_{OUT} = 1.223V \times \left(\frac{R_1}{R_2} + 1\right) \quad \text{(EQ. 1)}$$

## Power Dissipation

The junction temperature must not exceed the range specified in “Recommended Operating Conditions” on page 3. The power dissipation can be calculated using Equation 2:

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_{GND} \quad \text{(EQ. 2)}$$

The maximum allowable junction temperature, $T_{J(MAX)}$ and the maximum expected ambient temperature, $T_{A(MAX)}$ will determine the maximum allowable junction temperature rise ($\Delta T_J$), as shown in Equation 3:

$$\Delta T_J = T_{J(MAX)} - T_{A(MAX)} \quad \text{(EQ. 3)}$$

To calculate the maximum ambient operating temperature, use the junction-to-ambient thermal resistance ($\theta_{JA}$) as shown in Equation 4:

$$T_{J(MAX)} = P_{D(MAX)} \times \theta_{JA} + T_A \quad \text{(EQ. 4)}$$

## Board Layout Recommendations

A good PCB layout is important to achieve expected performance. Consideration should be taken when placing the components and routing the trace to minimize the ground impedance, and keep the parasitic inductance low. The input and output capacitors should have a good ground connection and be placed as close to the IC as possible. The feedback trace in the adjustable version should be away from other noisy traces. Connect EPAD to the ground plane for better heat dissipation. Thermal vias on the EPAD increase heat dissipation.

# Revision History

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to web to make sure you have the latest Rev.

| DATE | REVISION | CHANGE |
|---|---|---|
| April 7, 2015 | FN6705.2 | "Absolute Maximum Ratings" on page 3,Charged device Model(tested per JESD22-C101C)....2.2kV to Charged device Model(tested per AEC-Q100-011).....2.2kV |
| December 7, 2013 | FN7658.2 | Page 9 - 2nd line of the disclaimer changed from:<br>"Intersil products are manufactured, assembled and tested utilizing ISO9001 quality systems as noted"<br>to:<br>"Intersil Automotive Qualified products are manufactured, assembled and tested utilizing TS16949 quality systems as noted". |
| May 13, 2011 | FN7658.1 | Page 4, Removed the EN Pin Current MAX spec; added TYP spec of 0.026. |

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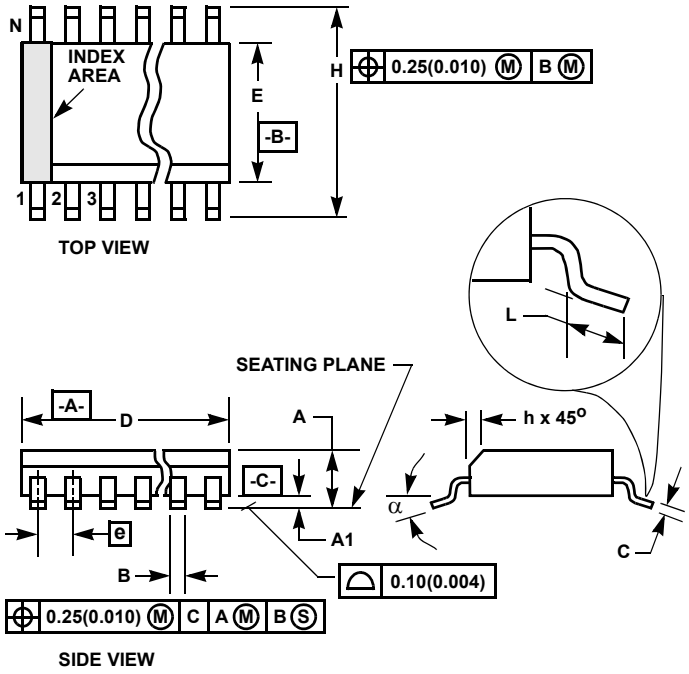
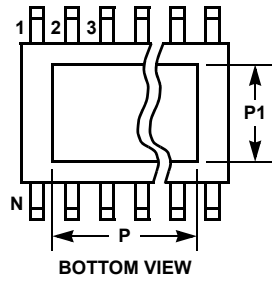
## *Small Outline Exposed Pad Plastic Packages (EPSOIC)*




### M8.15B

**8 LEAD NARROW BODY SMALL OUTLINE EXPOSED PAD PLASTIC PACKAGE**

| SYMBOL | INCHES | | MILLIMETERS | | NOTES |
|---|---|---|---|---|---|
| | MIN | MAX | MIN | MAX | |
| A | 0.056 | 0.066 | 1.43 | 1.68 | - |
| A1 | 0.001 | 0.005 | 0.03 | 0.13 | - |
| B | 0.0138 | 0.0192 | 0.35 | 0.49 | 9 |
| C | 0.0075 | 0.0098 | 0.19 | 0.25 | - |
| D | 0.189 | 0.196 | 4.80 | 4.98 | 3 |
| E | 0.150 | 0.157 | 3.81 | 3.99 | 4 |
| e | 0.050 BSC | | 1.27 BSC | | - |
| H | 0.230 | 0.244 | 5.84 | 6.20 | - |
| h | 0.010 | 0.016 | 0.25 | 0.41 | 5 |
| L | 0.016 | 0.035 | 0.41 | 0.89 | 6 |
| N | 8 | | 8 | | 7 |
| α | 0° | 8° | 0° | 8° | - |
| P | - | 0.094 | - | 2.387 | 11 |
| P1 | - | 0.094 | - | 2.387 | 11 |

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NOTES:

1. Symbols are defined in the “MO Series Symbol List” in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension “E” does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. “L” is the length of terminal for soldering to a substrate.
7. “N” is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width “B”, as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch).
10. Controlling dimension: INCH. Converted millimeter dimensions are not necessarily exact.
11. Dimensions “P” and “P1” are thermal and/or electrical enhanced variations. Values shown are maximum size of exposed pad within lead count and body size.