

### FEATURES

- 16-pin, 4x4 mm QFN Package
- Very low power dissipation
  - Class AB operation
- 5 programmable states
- No external gain resistors required
- RoHS compliant

### APPLICATIONS

- Power Line Communications
- Home Networking
- HPNA
- G.HN

### DESCRIPTION

The Le87411 is a single channel differential amplifier designed to work in Home Plug Alliance HPAV2 systems with very low power dissipation.

The Le87411 contains a pair of wideband amplifiers designed with Microsemi's HV15 Bipolar SOI process for low power consumption.

The line driver gain is fixed internally. The amplifiers are powered from a single supply.

The device can be programmed to one-of-three preset Bias levels or to impedance controlled Disable or Standby states. The control pins respond to input levels that can be generated with a standard tri-state GPIO.

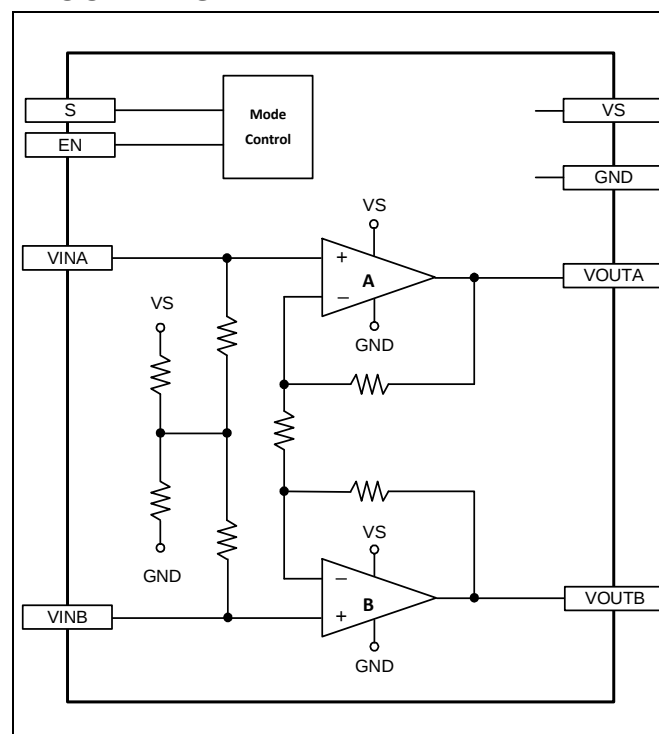
The Le87411 is available in a 16-pin (4 mm x 4 mm) QFN package with exposed pad for enhanced thermal conductivity.

### ORDERING INFORMATION

|             |                          |               |
|-------------|--------------------------|---------------|
| Le87411NQC  | 16-pin QFN Green Package | Tray          |
| Le87411NQCT | 16-pin QFN Green Package | Tape and Reel |

The green package meets RoHS 2 Directive 2011/65/EU of the European Council to minimize the environmental impact of electrical equipment.

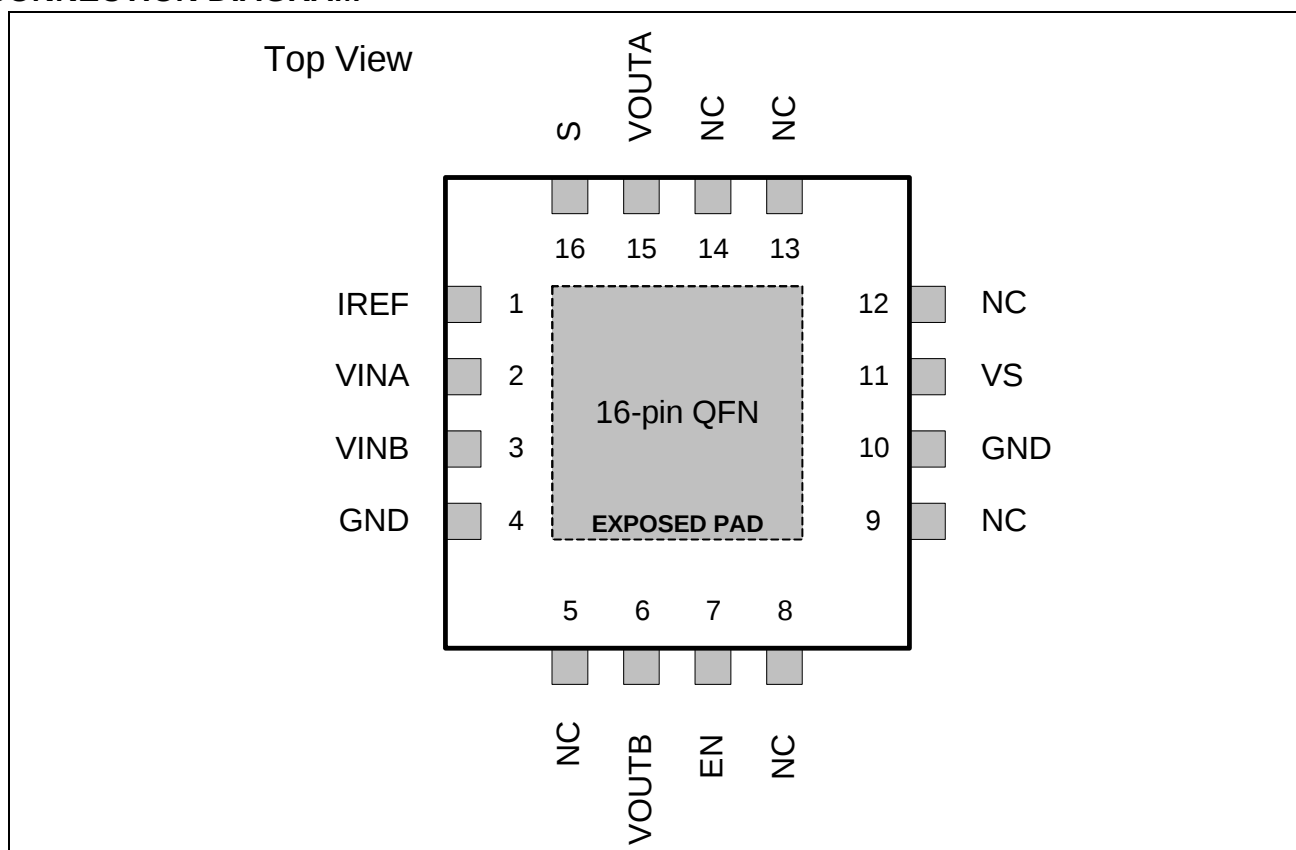
### BLOCK DIAGRAM



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## CONNECTION DIAGRAM

**Note:**

1. Pin 1 is marked for orientation.
2. The Le87411 device incorporates an exposed die pad on the underside of its package. The pad acts as a heat sink and must be connected to a copper plane through thermal vias, for proper heat dissipation. It is electrically isolated and may be connected to GND.

**PIN DESCRIPTIONS**

| Pin # | Pin Name    | Type   | Description                                                                 |
|-------|-------------|--------|-----------------------------------------------------------------------------|
| 1     | IREF        | Input  | Device internal reference current. Connect a resistor ( $R_{REF}$ ) to GND. |
| 2     | VINA        | Input  | Non-inverting input of amplifier A                                          |
| 3     | VINB        | Input  | Non-inverting input of amplifier B                                          |
| 4     | GND         | Ground | Reference ground                                                            |
| 5     | NC          |        | No internal connection                                                      |
| 6     | VOUTB       | Output | Amplifier B output                                                          |
| 7     | EN          | Input  | Enable transmission                                                         |
| 8     | NC          |        | No internal connection                                                      |
| 9     | NC          |        |                                                                             |
| 10    | GND         | Ground | Reference ground                                                            |
| 11    | VS          | Power  | Power Supply, +12 V                                                         |
| 12    | NC          |        | No internal connection                                                      |
| 13    | NC          |        |                                                                             |
| 14    | NC          |        |                                                                             |
| 15    | VOUTA       | Output | Amplifier A output                                                          |
| 16    | S           | Input  | State control                                                               |
|       | Exposed pad |        | Electrically isolated thermal conduction pad, can be grounded               |

## ABSOLUTE MAXIMUM RATINGS

Stresses above the values listed under *Absolute Maximum Ratings* can cause permanent device failure. Functionality at or above these limits is not implied. Exposure to absolute maximum ratings for extended periods can affect device reliability.

|                                                                                                  |                                                  |
|--------------------------------------------------------------------------------------------------|--------------------------------------------------|
| Storage Temperature                                                                              | $-65 \leq T_A \leq +150\text{ }^{\circ}\text{C}$ |
| Operating Junction Temperature <sup>(1)</sup>                                                    | $-40 \leq T_J \leq +150\text{ }^{\circ}\text{C}$ |
| VS with respect to GND                                                                           | -0.3 V to +16 V                                  |
| Control inputs with respect to GND                                                               | -0.3 V to 4 V                                    |
| Continuous Driver Output Current                                                                 | 100 mA                                           |
| Maximum device power dissipation, continuous <sup>(2)</sup> - $T_A = 85^{\circ}\text{C}$ , $P_D$ | 1.0 W                                            |
| Junction to ambient thermal resistance <sup>(2,3)</sup> , $\theta_{JA}$                          | 52.0 $^{\circ}\text{C/W}$                        |
| Junction to board thermal resistance <sup>(2)</sup> , $\theta_{JB}$                              | 26.0 $^{\circ}\text{C/W}$                        |
| Junction to case bottom (exposed pad) thermal resistance, $\theta_{JC}$ (BOTTOM)                 | 14.6 $^{\circ}\text{C/W}$                        |
| Junction-to-top characterization parameter <sup>(2)</sup> , $\psi_{JT}$                          | 3.1 $^{\circ}\text{C/W}$                         |
| ESD Immunity (Human Body Model)                                                                  | JESD22 Class 2 compliant                         |
| ESD Immunity (Charge Device Model)                                                               | JESD22 Class IV compliant                        |

### Notes:

1. Continuous operation above 145°C junction temperature may degrade device reliability.
2. See [Thermal Resistance](#).
3. No air flow.

## Thermal Resistance

The thermal performance of a thermally enhanced package is assured through optimized printed circuit board layout. Specified performance requires that the exposed thermal pad be soldered to an equally sized exposed copper surface, which, in turn, conducts heat through multiple vias to larger internal copper planes.

## Package Assembly

The green package devices are assembled with enhanced, environmental compatible lead-free, halogen-free, and antimony-free materials. The leads possess a matte-tin plating which is compatible with conventional board assembly processes or newer lead-free board assembly processes.

Refer to IPC/JEDEC J-Std-020 Table 4 for recommended peak soldering temperature and Table 5-2 for the recommended solder reflow temperature profile.

## OPERATING RANGES

Microsemi guarantees the performance of this device over the 0°C to 85°C temperature range by conducting electrical characterization over each range and by conducting a production test with single insertion coupled with periodic sampling. These characterization and test procedures comply with the Telcordia GR-357-CORE Generic Requirements for Assuring the Reliability of Components Used in Telecommunications Equipment.

|                     |                        |                |
|---------------------|------------------------|----------------|
| Ambient temperature | $T_A$                  | 0°C to +85°C   |
| Power Supply        | VS with respect to GND | +12 V $\pm$ 5% |

## DEVICE SPECIFICATIONS

**Typical Conditions:** As shown in the basic test circuit ([Figure 1](#)) with  $V_S = +12\text{ V}$ ,  $R_{REF} = 75\text{ k}\Omega$ , and  $T_A = 25^\circ\text{C}$ .

**Min/Max Parameters:**  $T_A = 0\text{ to }+85^\circ\text{C}$ .

**Table 1. Electrical Specifications**

| Symbol                                                                  | Parameter Description        | Condition                                           | Min  | Typ  | Max | Unit   | Notes |
|-------------------------------------------------------------------------|------------------------------|-----------------------------------------------------|------|------|-----|--------|-------|
| Supply Current Characteristics                                          |                              |                                                     |      |      |     |        |       |
| P <sub>IS</sub>                                                         | Supply Current               | Full Power State                                    | 17   | 23   | 29  | mA     |       |
|                                                                         |                              | Medium Power State                                  | 11   | 19   | 23  |        |       |
|                                                                         |                              | Low Power State                                     | 5    | 10.5 | 15  |        |       |
|                                                                         |                              | Disable Power State                                 | 1    | 5    | 6   |        |       |
|                                                                         |                              | Standby State                                       |      | 1    | 1.5 |        |       |
| Control Input (S, EN) Specifications                                    |                              |                                                     |      |      |     |        |       |
| V <sub>IH</sub>                                                         | Input High Voltage           |                                                     | 2.0  | 3.3  | 3.6 | V      |       |
| V <sub>IM</sub>                                                         | Input Middle Voltage         |                                                     |      | 1.5  |     | V      |       |
| V <sub>IL</sub>                                                         | Input Low Voltage            |                                                     | -0.3 | 0    | 0.8 | V      |       |
|                                                                         | Enable Time                  |                                                     |      | 500  |     | ns     |       |
|                                                                         | Disable Time                 | Disable state                                       |      | 500  |     | ns     |       |
| Amplifier Characteristics                                               |                              |                                                     |      |      |     |        |       |
|                                                                         | Differential Gain            | Full Power State, V <sub>OUT</sub> /V <sub>IN</sub> | 5.5  | 6.5  | 7.5 | V/V    |       |
|                                                                         | Bandwidth, -3 dB             | Full Power State                                    |      | 200  |     | MHz    |       |
|                                                                         |                              | Medium Power State                                  |      | 200  |     |        |       |
|                                                                         |                              | Low Power State                                     |      | 115  |     |        |       |
| V <sub>O</sub>                                                          | Output Voltage               |                                                     |      | 10   |     | V      |       |
| I <sub>O</sub>                                                          | Output Current               |                                                     | 150  |      |     | mA     | 1     |
| Z <sub>I</sub>                                                          | Input Impedance              | Differential                                        | 13   | 15   | 18  | kΩ     |       |
| Z <sub>O</sub>                                                          | Output Impedance             | Disable state                                       |      | 60   |     | Ω      |       |
| Amplifier Dynamic Characteristics                                       |                              |                                                     |      |      |     |        |       |
| Noise                                                                   | Input Referred Noise         | 2 – 106 MHz                                         |      | 9    | 15  | nV/√Hz | 1     |
| TSD                                                                     | Thermal Shutdown Temperature |                                                     |      | 170  |     | °C     |       |
| Notes:                                                                  |                              |                                                     |      |      |     |        |       |
| 1. Not tested in production. Guaranteed by characterization and design. |                              |                                                     |      |      |     |        |       |

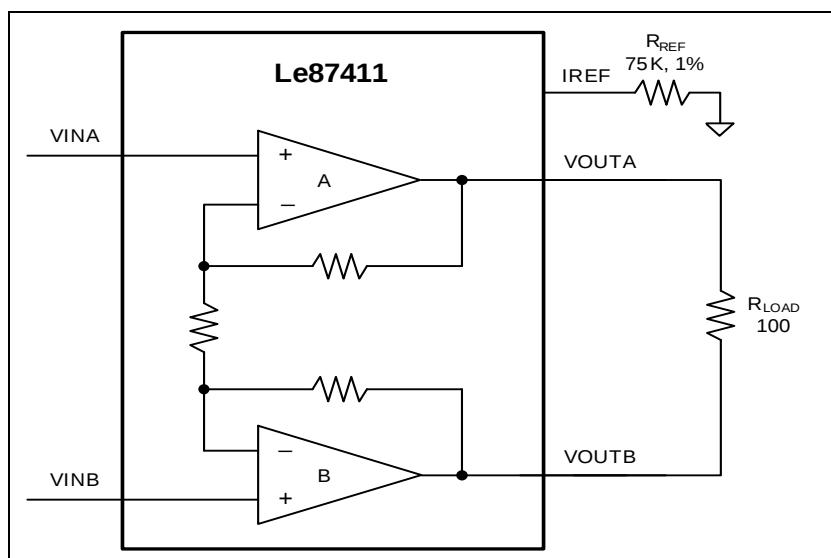


Figure 1. Basic Test Circuit

## STATE CONTROL

S and EN pins are used as combinatorial logic inputs to control the line driver operating states. [Table 2](#) shows the programmable states.

S and EN are tri-state inputs that accept three operating levels. These pins have internal resistors tied to +1.5 V which force a middle logic input level when the control to these pins is tri-stated.

Table 2. Control Matrix

| S    | EN   | State              |
|------|------|--------------------|
| X    | 0    | Disable            |
| X    | Open | Standby            |
| 0    | 1    | Enable Low Bias    |
| Open | 1    | Enable Medium Bias |
| 1    | 1    | Enable Full Bias   |

**Disable State:** Amplifier output =  $V_S/2$ . The Disable state should be used during the receive period. The device presents a controlled low impedance to the line during this state.

**Standby State:** Amplifier bias current removed. This is the lowest power state. Amplifier output is high impedance. Gain-setting feedback resistors are still connected across amplifier output pins, creating 1300 ohm differential impedance at pins.

**Bias States:** Line Driver is active for transmission. States are different only in the amount of bias current to the amplifiers, and therefore power consumption. There is a trade-off between bias current and bandwidth.

## APPLICATIONS

The Le87411 integrates a set of high-power line driver amplifiers designed for low distortion for signals up to 106 MHz.

Figure 2 shows an application circuit with amplifiers A and B in transmission.

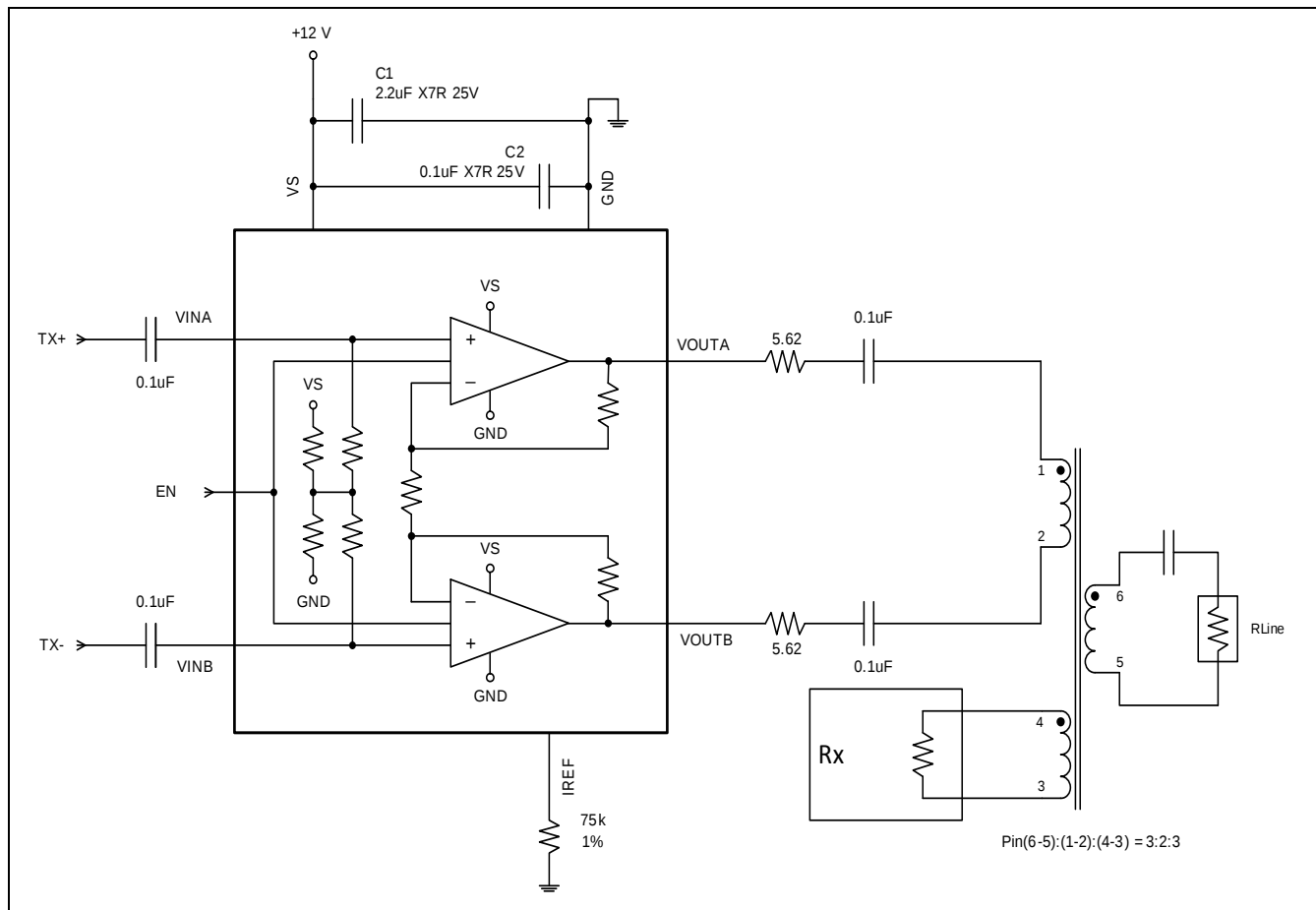


Figure 2. Typical Application Circuit

### Input Considerations

The driving source impedance should be less than 100 nH to avoid any ringing or oscillation.

### Output Driving Considerations

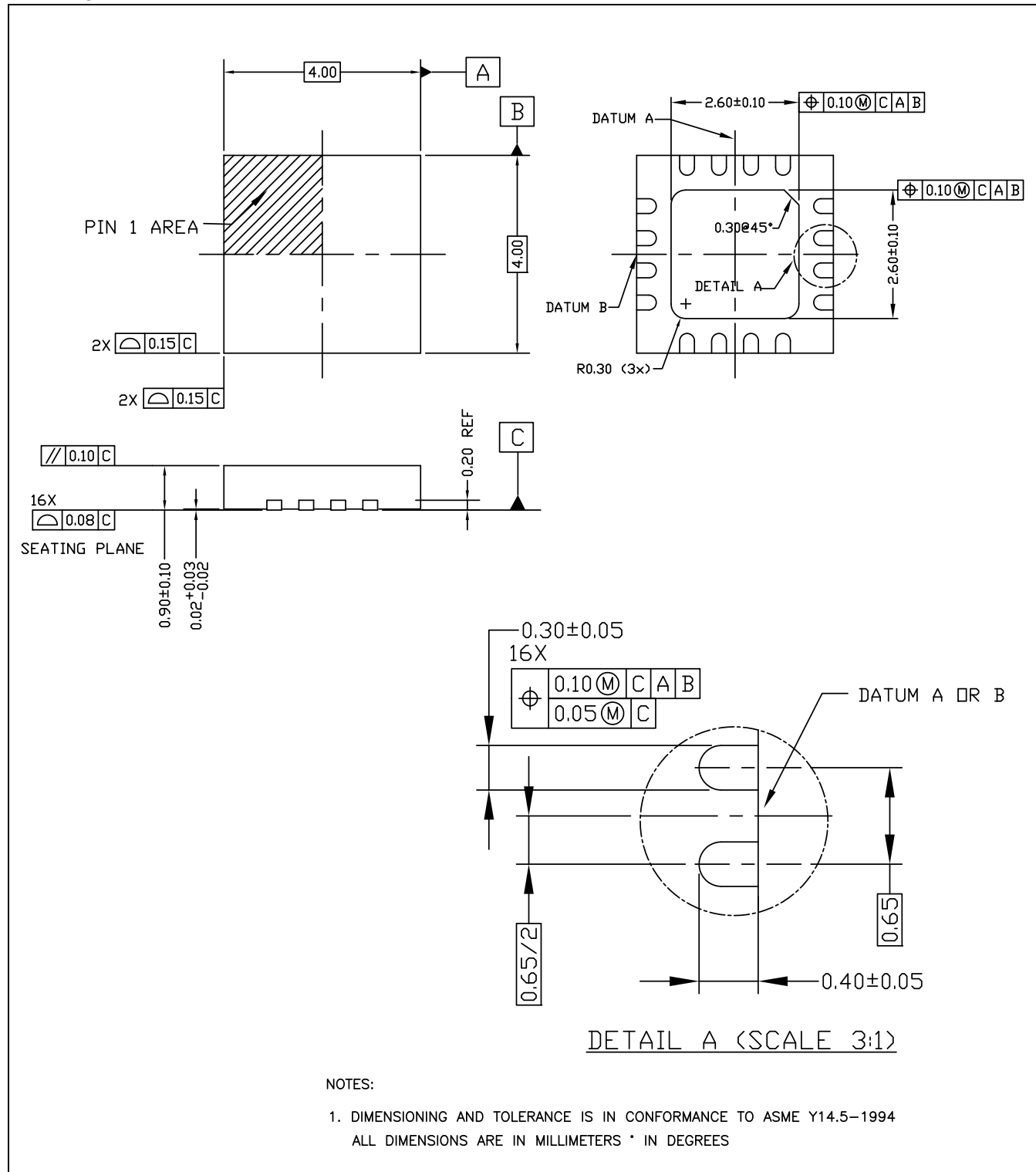
The internal metallization is designed to carry up to about 100 mA of steady DC current and there is no current limit mechanism. The device does feature integrated thermal shutdown protection however with hysteresis. Driving lines with no series resistor is not recommended.

### Power Supplies and Component Placement

The power supplies should be well bypassed close to the Le87411 device. A 2.2 µF tantalum capacitor and a 0.1 µF ceramic capacitor for the VS supply is recommended.

# PHYSICAL DIMENSIONS

## 16-Pin QFN



### Note:

Packages may have mold tooling markings on the surface. These markings have no impact on the form, fit or function of the device. Markings will vary with the mold tool used in manufacturing.

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