

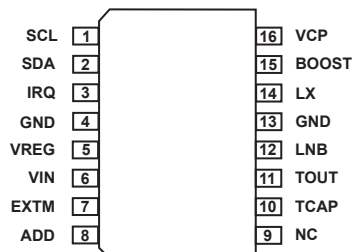
Preliminary Data Sheet  
Subject to Change without Notice  
January 21, 2004

# A8285/A8287

## LNB Supply and Control Voltage Regulator

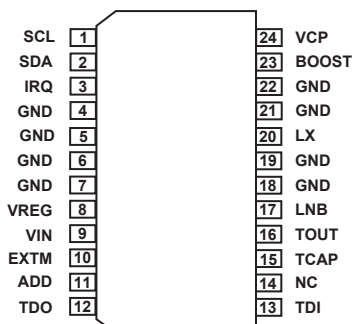
A8285SIB  
SOIC

Scale 1:1



A8287SIB  
SOIC

Scale 1:1



Intended for analog and digital satellite receivers, the LNB (low noise block) converter regulator is a monolithic linear and switching voltage regulator, specifically designed to provide power and interface signals to an LNB downconverter, via coaxial cable.

The device uses a 2-wire bidirectional serial interface, compatible with the I<sup>2</sup>C (Inter-C bus) standard, that operates up to 400 kHz.

The A8285 is supplied in a 16-lead plastic power SOIC with copper batwing tabs (suffix *LB*). The A8287 is supplied in a 24-lead plastic power SOIC with copper batwing tabs (part number suffix *LB*).

### ABSOLUTE MAXIMUM RATINGS

Load Supply Voltage,  $V_{IN}$  ..... 16 V

Output Current,  $I_{OUT}$  ..... Internally Limited\*

Output Voltage

LNB, BOOST ..... -0.3 V to 28 V

TOUT ..... -0.3 V to 22 V

Logic Input

EXTM ..... -0.3 V to 5 V

Other ..... -0.3 V to 7 V

Logic Output ..... -0.3 V to 7 V

Package Power Dissipation ..... See power dissipation information in the Application Information section

Operating Temperature

Ambient,  $T_A$  ..... -20°C to +85°C

Junction,  $T_J$  ..... -20°C to +150°C

Storage,  $T_S$  ..... -55°C to +150°C

\* Output current rating may be limited by duty cycle, ambient temperature, and heat sinking. Under any set of conditions, *do not exceed* the specified current rating or a junction temperature of +150°C.

### FEATURES

- LNB selection and standby function
- Provides up to 500 mA load current
- Two-wire serial I<sup>2</sup>C interface
- Built-in tone oscillator, factory-trimmed to 22 kHz; facilitates DiSEqC™ 2.0 encoding
- Auxiliary modulation input
- 22 kHz tone detector facilitates DiSEqC™ decoding (A8287 only)
- Tracking switch-mode power converter for lowest dissipation
- LNB overcurrent protection and diagnostics
- Internal overtemperature protection
- LNB voltages (16 possible levels) compatible with all common standards

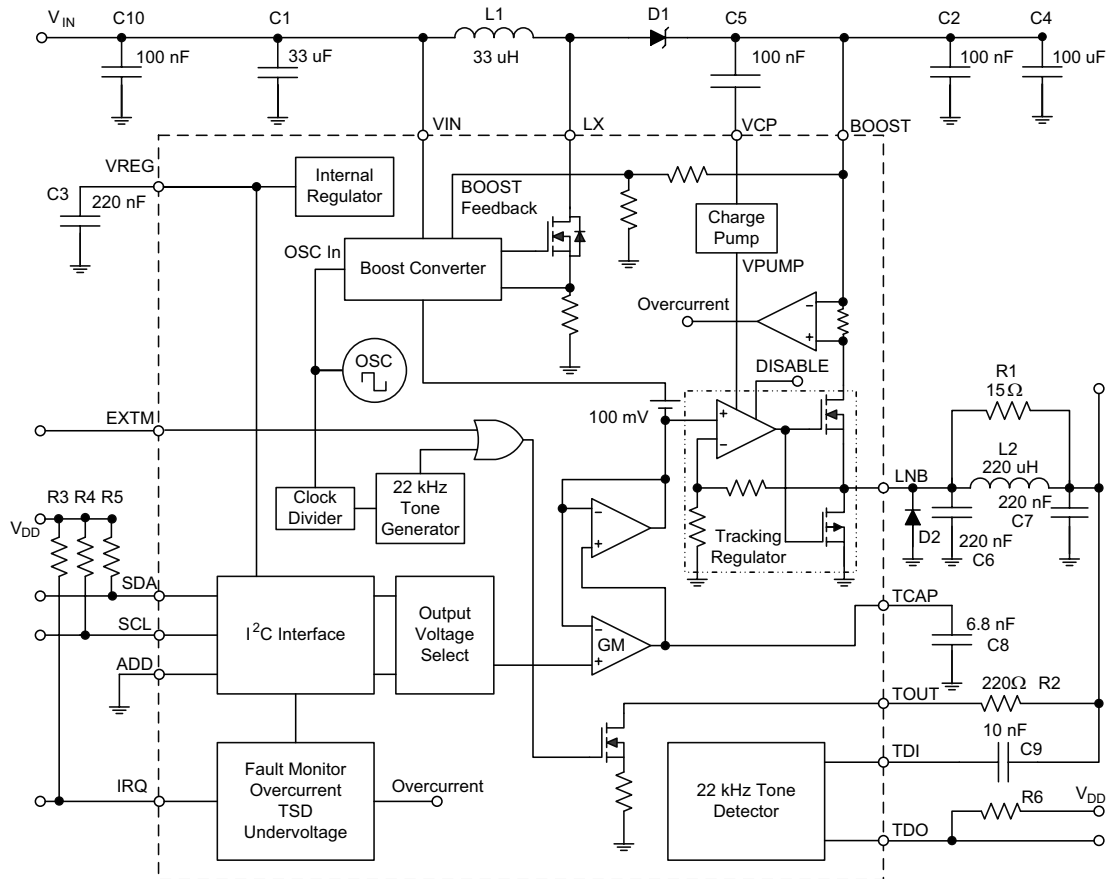
Use the following complete part numbers when ordering:

| Part Number | Package              | Description              |
|-------------|----------------------|--------------------------|
| A8287SLB    | 24-pin, batwing SOIC | All features             |
| A8285SLB    | 16-pin, batwing SOIC | Tone detect not provided |

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## LNB Supply and Control Voltage Regulator

### Functional Block Diagram



Tone detector and leads TDI and TDO are not provided in 16-pin package (A8285).

| ID          | Characteristics                                                | Suggested Manufacturer                                              |
|-------------|----------------------------------------------------------------|---------------------------------------------------------------------|
| C1          | 33 $\mu$ F, 25 V, esr < 200 m $\Omega$ , $I_{ripple}$ > 350 mA | Nichicon, part number UHC1E330MET                                   |
| C2, C5, C10 | 100 nF, 50 V, X5R or X7R                                       |                                                                     |
| C4          | 100 $\mu$ F, 35 V, esr < 75 m $\Omega$ , $I_{ripple}$ > 800 mA | Nichicon, part number UHC1V101MPT                                   |
| C3, C6, C7  | 220 nF, 50 V, X5R or X7R                                       |                                                                     |
| C8          | 6.8 nF, 50 V; Y5V, X5R, or X7R                                 |                                                                     |
| C9          | 10 nF (maximum), 50 V; Y5V, X5R, or X7R                        |                                                                     |
| R1          | 15 $\Omega$ , 1%, 1/8 W                                        |                                                                     |
| R2          | 220 $\Omega$ , 1%, 1/2 W                                       |                                                                     |
| R3-R6       | Value determined by $V_{DD}$ , bus capacitance, etc.           |                                                                     |
| L1          | 33 $\mu$ H, $I_{DC}$ > 1.3 A                                   | TDK, part number TSL0808-330K1R4; Coilcraft, part number DR0810-333 |
| L2          | 220 $\mu$ H, $I_{DC}$ > 0.5 A                                  | TDK, part number TSL0808-221KR54; Coilcraft, part number DR0810-224 |
| D1          | 1 A, 35 V or 40 V, Schottky diode                              | Various, part number 1N5819; Sanken, part number AW04               |
| D2          | 1 A, 100 V, 1N4002                                             |                                                                     |

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## *LNB Supply and Control Voltage Regulator*

**ELECTRICAL CHARACTERISTICS** at  $T_A = +25^\circ\text{C}$ ,  $V_{IN} = 10$  to  $16\text{ V}$  (unless otherwise noted)

| Characteristics                              | Symbol           | Test Conditions                                                                       | Min.  | Typ. | Max. | Units            |
|----------------------------------------------|------------------|---------------------------------------------------------------------------------------|-------|------|------|------------------|
| Set-point Accuracy, load and line regulation | $V_{O1}$         | Relative to target voltage selected, with:<br>$I_{LOAD} = 0$ to $500\text{ mA}$       | -4.5  | 0    | 4.5  | %                |
| Supply Current                               | $I_{CC}$         | ENB = Low, LNB output disabled                                                        | –     | –    | 7    | mA               |
|                                              | $I_{CCEN}$       | ENB = High, LNB output enabled, $I_{LOAD} = 0\text{ mA}$                              | –     | –    | 15   | mA               |
| Boost Switch-On Resistance                   | $R_{DSBOOST}$    | $T_J = 25^\circ\text{C}$ , $I_{LOAD} = 500\text{ mA}$                                 | –     | 400  | 500  | $\text{m}\Omega$ |
| Switching Frequency                          | $f_o$            | –                                                                                     | 320   | 352  | 384  | kHz              |
| Switch Current Limit                         | –                | $V_{IN} = 12\text{ V}$                                                                | 2.0   | 3    | 4.0  | A                |
| Linear Regulator Voltage Drop                | $\Delta V_{REG}$ | $V_{BOOST} - V_{LNB}$ , no tone signal, $I_{LOAD} = 500\text{ mA}$                    | 400   | 600  | 800  | mV               |
| Slew Rate Current on TCAP                    | $I_{CAP}$        | Charging                                                                              | -12.5 | -10  | -7.5 | $\mu\text{A}$    |
|                                              |                  | Discharging                                                                           | 7.5   | 10   | 12.5 | $\mu\text{A}$    |
| Output Voltage Slew Period                   | $t_{slew}$       | $V_{LNB} = 13$ to $18\text{ V}$ , TCAP = $6.8\text{ nF}$ , $I_{LOAD} = 500\text{ mA}$ | –     | 500  | –    | $\mu\text{s}$    |
| Output Reverse Current                       | $I_{OR}$         | ENB = Low, $V_{LNB} = 28\text{ V}$ with C4 fully charged                              | –     | 1    | 5    | mA               |
| Ripple and Noise on LNB Output               | $V_{RN}$         | See notes 1 and 2                                                                     | –     | –    | 50   | $\text{mV}_{pp}$ |
| <b>Protection Circuitry</b>                  |                  |                                                                                       |       |      |      |                  |
| Overcurrent Limit                            | $I_{LIM}$        | High limit                                                                            | 550   | 700  | 850  | mA               |
|                                              |                  | Low limit                                                                             | 400   | 500  | 600  | mA               |
| Overcurrent Disable Time                     | $t_{DIS}$        | –                                                                                     | 1.2   | –    | 1.7  | ms               |
| $V_{IN}$ Undervoltage Threshold              | $UV_{OFF}$       | Guaranteed turn-off                                                                   | 8.65  | 9.15 | 9.65 | V                |
| $V_{IN}$ Turn-On Threshold                   | $UV_{ON}$        | Guaranteed turn-on                                                                    | 8.75  | 9.25 | 9.75 | V                |
| Power-Not-Good Flag Set                      | $PNG_{set}$      | –                                                                                     | 77    | 85   | 93   | % $V_{LNB}$      |
| Power-Not-Good Flag Reset                    | $PNG_{reset}$    | –                                                                                     | 82    | 90   | 98   | % $V_{LNB}$      |
| Thermal Shutdown Threshold                   | $T_J$            | See note 1                                                                            | –     | 165  | –    | $^\circ\text{C}$ |
| Thermal Shutdown Hysteresis                  | $\Delta T_J$     | See note 1                                                                            | –     | 20   | –    | $^\circ\text{C}$ |

*Continued on next page*

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## LNB Supply and Control Voltage Regulator

**ELECTRICAL CHARACTERISTICS** (continued) at  $T_A = +25^\circ\text{C}$ ,  $V_{IN} = 10$  to  $16$  V (unless otherwise noted)

| Characteristics                      | Symbol       | Test Conditions                                      | Min. | Typ.       | Max. | Units         |
|--------------------------------------|--------------|------------------------------------------------------|------|------------|------|---------------|
| <b>Tone Characteristics</b>          |              |                                                      |      |            |      |               |
| Tone Frequency                       | $f_{TONE}$   | —                                                    | 20   | 22         | 24   | kHz           |
| Tone Pull-Down Current               | $I_{TONE}$   | —                                                    | 30   | 40         | 50   | mA            |
| Tone Turn-On and Turn-Off Delays     | $t_{DEL}$    | Using EXTM pin                                       | —    | —          | 1    | $\mu\text{s}$ |
| External Tone Logic Input            | $V_{IH}$     | —                                                    | 2    | —          | —    | V             |
|                                      | $V_{IL}$     | —                                                    | —    | —          | 0.8  | V             |
| Input Leakage                        | $I_{IL}$     | —                                                    | —1   | —          | 1    | $\mu\text{A}$ |
| Tone Detector Input Amplitude        | $V_{TDI}$    | $f_{IN} = 22$ kHz                                    | 260  | —          | 1000 | mV            |
| Tone Detector Frequency Capture      | $f_{TDI}$    | 600 mV <sub>pp</sub> sinewave                        | 17.6 | —          | 26.4 | kHz           |
| Tone Detector Input Impedance        | $Z_{TDI}$    | See note 1                                           | —    | 8.6        | —    | k $\Omega$    |
| Tone Detector Output Voltage         | $V_{OL}$     | Tone present, $I_{LOAD} = 3$ mA                      | —    | —          | 0.4  | V             |
| Tone Detector Output Leakage         | $I_{OL}$     | Tone absent, $V_O = 7$ V                             | —    | —          | 10   | $\mu\text{A}$ |
| <b>I<sup>2</sup>C Interface</b>      |              |                                                      |      |            |      |               |
| Logic Input (SDA,SCL) Low Level      | $V_{IL}$     | —                                                    | —    | —          | 0.8  | V             |
| Logic Input (SDA,SCL) High Level     | $V_{IH}$     | —                                                    | 2    | —          | —    | V             |
| Input Hysteresis                     | $V_{HYS}$    | —                                                    | —    | 150        | —    | mV            |
| Logic Input Current                  | $I_{IN}$     | $V_{IN} = 0$ V to $7$ V                              | —10  | $<\pm 1.0$ | 10   | $\mu\text{A}$ |
| Output Voltage (SDA, IRQ)            | $V_{OL}$     | $I_{LOAD} = 3$ mA                                    | —    | —          | 0.4  | V             |
| Output Leakage (SDA, IRQ)            | $I_{OL}$     | $V_O = 0$ V to $7$ V                                 | —    | —          | 10   | $\mu\text{A}$ |
| SCL Clock Frequency                  | $f_{CLK}$    | —                                                    | 0    | —          | 400  | kHz           |
| Output Fall Time                     | $t_{OF}$     | $V_{IH}$ to $V_{IL}$                                 | —    | —          | 250  | ns            |
| Bus Free Time Between Stop and Start | $t_{BUF}$    | See I <sup>2</sup> C Interface Timing Diagram        | 1.3  | —          | —    | $\mu\text{s}$ |
| Hold Time for Start Condition        | $t_{HD:STA}$ | See I <sup>2</sup> C Interface Timing Diagram        | 0.6  | —          | —    | $\mu\text{s}$ |
| Setup Time for Start Condition       | $t_{SU:STA}$ | See I <sup>2</sup> C Interface Timing Diagram        | 0.6  | —          | —    | $\mu\text{s}$ |
| SCL Low Time                         | $t_{LOW}$    | See I <sup>2</sup> C Interface Timing Diagram        | 1.3  | —          | —    | $\mu\text{s}$ |
| SCL High Time                        | $t_{HIGH}$   | See I <sup>2</sup> C Interface Timing Diagram        | 0.6  | —          | —    | $\mu\text{s}$ |
| Data Setup Time                      | $t_{SU:DAT}$ | See note1; I <sup>2</sup> C Interface Timing Diagram | 100  | —          | —    | ns            |
| Data Hold Time                       | $t_{HD:DAT}$ | See I <sup>2</sup> C Interface Timing Diagram        | 0    | —          | 900  | ns            |
| Setup Time for Stop Condition        | $t_{SU:STO}$ | See I <sup>2</sup> C Interface Timing Diagram        | 0.6  | —          | —    | $\mu\text{s}$ |

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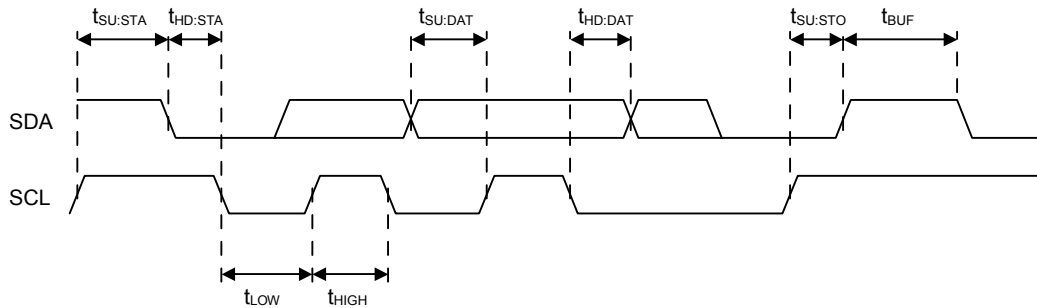
**ELECTRICAL CHARACTERISTICS** (continued) at  $T_A = +25^\circ\text{C}$ ,  $V_{IN} = 10$  to  $16\text{ V}$  (unless otherwise noted)

| Characteristics                       | Symbol   | Test Conditions | Min. | Typ. | Max. | Units |
|---------------------------------------|----------|-----------------|------|------|------|-------|
| <b>I<sup>2</sup>C Address Setting</b> |          |                 |      |      |      |       |
| ADD Voltage for Address 0001,000      | Address1 | —               | 0    | —    | 0.7  | V     |
| ADD Voltage for Address 0001,001      | Address2 | —               | 1.3  | —    | 1.7  | V     |
| ADD Voltage for Address 0001,010      | Address3 | —               | 2.3  | —    | 2.7  | V     |
| ADD Voltage for Address 0001,011      | Address4 | —               | 3.3  | —    | 5    | V     |

<sup>1</sup> Guaranteed by design.

<sup>2</sup> Use recommended components and adhere to layout guidelines.

I<sup>2</sup>C Interface Timing Diagram



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## LNB Supply and Control Voltage Regulator

### Functional Description

**Boost Converter/Linear Regulator.** A current-mode boost converter provides the tracking regulator a supply voltage that tracks the requested LNB output voltage. The converter operates at 16 times the internal tone frequency, 352 kHz nominal.

The tracking regulator provides minimum power dissipation across the range of output voltages, assuming the input voltage is less than the output voltage, by adjusting the BOOST pin voltage 600 mV nominal above the LNB output voltage selected. Under conditions where the input voltage is greater than the output voltage, the tracking regulator must drop the differential voltage. When operating in this condition, care must be taken to ensure that the safe operating temperature range of the A8285/A8287 is not exceeded. For additional information, see *Power Dissipation* in the Application Information section.

Note: To conserve power at light loads, the boost converter operates in a pulse-skipping mode.

**Overcurrent Protection.** The A8285/A8287 is protected against both overcurrent and short circuit conditions by limiting the output current to  $I_{LIM}$ . In the event of an overcurrent, the current limit can be applied indefinitely. Alternatively, if the ODT feature is enabled, and the fault current appears for longer than the disable time  $t_{DIS}$ , then the device is turned off. The device can be enabled again via the I<sup>2</sup>C interface. If the overcurrent is removed before the disable time has elapsed, the device remains functioning. These settings are made in the Control register and the Status register.

**Charge Pump.** Generates a supply voltage above the internal tracking regulator output to drive the linear regulator control.

**Slew Rate Control.** During either start-up or when the output voltage on the BOOST pin is being changed, the output voltage rise and fall times can be programmed by an external capacitor located on the TCAP pin. Note that during start-up, the BOOST pin is precharged to the input voltage minus a diode drop. As a result, the slew rate control occurs from this point.

The value for TCAP can be calculated using the following formula:

$$TCAP = (I_{CAP} \times 8) / (\Delta V/s)$$

where  $\Delta V/s$  is required slew rate. The smallest value for TCAP is 2.2 nF.

Modulation is unaffected by the choice of TCAP. If limiting LNB output voltage rise and fall times is not required, the TCAP terminal must have a value of at least a 2.2 nF to minimize output noise.

**External Tone Modulation.** To improve design flexibility and to allow implementation of proposed LNB remote control standards, the logic modulation input pin EXTM is provided. The logic signal supplied to this pin creates a 650 mV  $\pm$  250 mV tone signal on the TOUT pin by controlling a 40 mA current pull-down device through the DiSEqC™ filter. The shape of the tone waveform depends on the filter components used and the LNB/cable capacitance.

**Tone Detection.** A 22 kHz tone envelope detector is provided in the A8287 solution. The detector extracts the tone signal and provides it as an open-collector signal on the TDO pin. The maximum tone out error is  $\pm 1$  tone cycle, and the maximum tone out delay with respect to the input is  $\pm 1$  tone cycle.

**Control Register.** The main functions of the A8285/A8287 are controlled via the I<sup>2</sup>C interface by writing to the control register. The power-up states for the control functions are all zero. Control functions include the following:

- **Internal Tone Modulation Enable (ENT).** When the ENT bit is set to 1, the internal tone generator controls a 40 mA pull-down device, thus creating the tone signal after the DiSEqC™ filter in a way identical to the EXTM scheme. The internal oscillator is factory-trimmed to provide a tone of 22  $\pm$  2 kHz. No further adjustment is required. Burst coding of the 22 kHz tone is accomplished due to the fast response of the serial command and rapid tone response. This allows implementation of the DiSEqC™ 2.0 protocols.
- **Select Output Voltage Amplitude (VSEL0, VSEL1, VSEL2, VSEL3).** The LNB output voltage can be programmed to a particular voltage according to the Output Voltage Amplitude Selection table shown on the following page.
- **Enable (ENB).** When set to 1, the LNB output is enabled. When reset to 0, the LNB output is disabled.
- **Overcurrent Limit ( $I_{LIM}$ ).** Selects the output overcurrent limit. When set to 0, the limit is 500 mA. When set to 1, the limit is 700 mA.
- **Overcurrent Disable Time (ODT).** When set to 1, in the event of an overcurrent occurring for a duration exceeding the disable time, the device is turned off. When set to 0,

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this feature is disabled and the device is not turned off during an overcurrent.

**Status Register.** The status of the A8285/A8287 read register can be interrogated by the system master controller via the I<sup>2</sup>C interface. Status functions include the following:

- **Power Not Good (PNG).** When the LNB output is enabled, and the LNB output is below 85% of the programmed LNB voltage, the PNG bit is set.

- **Disable (DIS).** Provides the status of the LNB output. When set, this indicates that the output is disabled, either intentionally or by a fault.

- **Thermal Shutdown (TSD).** When the junction temperature exceeds the maximum threshold, the thermal shutdown bit is set, which disables the LNB output. DIS also is set.

- **Overcurrent (OCP).** This disables LNB output when an overcurrent appears on the LNB output for a period greater than the ODT (ODT must be enabled for this feature to take effect). In addition, the DIS bit is set. Note: If an overcurrent occurs and ODT is disabled, the A8285/A8287 will operate in current limit indefinitely and the OCP bit will not be set.

- **Undervoltage Lockout (VUV).** When the input voltage ( $V_{IN}$ ) drops below the undervoltage threshold, the undervoltage bit VUV is set, disabling the output.

When  $V_{IN}$  is initially applied to the A8285/A8287, the VUV bit is set, indicating that an undervoltage condition has occurred.

**IRQ Flag.** The IRQ flag is activated when any fault condition occurs, including: thermal shutdown, overcurrent, undervoltage, or the occurrence of a power-up sequence. Note that the IRQ flag is not activated when either (a) the channel is disabled (DIS), as it may have been disabled intentionally by the master controller, or (b) if PNG is active, as the A8285/A8287 may be starting up. Fault conditions are stored in the status registers. Also note that the IRQ flag will not activate when an overcurrent occurs and ODT is disabled. In this condition, the device operates within  $I_{LIM}$ .

When the IRQ flag is activated during either of the above fault conditions, and the system master controller addresses the A8285/A8287 with the read/write bit set to 1, then the IRQ flag is reset once the A8285/A8287 acknowledges the address. When the master controller reads the data and is acknowledged, the status registers are updated. If the fault is removed, the A8285/A8287 is again ready for operation (being re-enabled via a write command). Otherwise, the controller can keep polling the A8285/A8287 until the fault is removed.

When  $V_{IN}$  is initially applied to the A8285/A8287, the I<sup>2</sup>C interface will not function until the internal logic supply  $V_{REG}$  has reached its operating level. Once  $V_{REG}$  is within tolerance, the VUV bit in the status register is set and the IRQ is activated to inform the master controller of this condition. (The IRQ is effectively acting as a power-up flag.) The IRQ is reset when the A8285/A8287 acknowledges the address. Once the master has read the status registers, the VUV bit is reset. The device is then ready for operation.

**I<sup>2</sup>C Interface.** This is a serial interface that uses two bus lines, SCL and SDA, to access the internal Control and Status registers of the A8285/A8287. Data is exchanged between a microcontroller (master) and the A8285/A8287 (slave). The clock input to SCL is generated by the master, while SDA functions as either an input or an open drain output, depending on the direction of the data.

Output Voltage Amplitude Selection Table

| VSEL3 | VSEL2 | VSEL1 | VSEL0 | LNB (V) |
|-------|-------|-------|-------|---------|
| 0     | 0     | 0     | 0     | 12.709  |
| 0     | 0     | 0     | 1     | 13.042  |
| 0     | 0     | 1     | 0     | 13.375  |
| 0     | 0     | 1     | 1     | 13.709  |
| 0     | 1     | 0     | 0     | 14.042  |
| 0     | 1     | 0     | 1     | 14.375  |
| 0     | 1     | 1     | 0     | 14.709  |
| 0     | 1     | 1     | 1     | 15.042  |
| 1     | 0     | 0     | 0     | 18.042  |
| 1     | 0     | 0     | 1     | 18.375  |
| 1     | 0     | 1     | 0     | 18.709  |
| 1     | 0     | 1     | 1     | 19.042  |
| 1     | 1     | 0     | 0     | 19.375  |
| 1     | 1     | 0     | 1     | 19.709  |
| 1     | 1     | 1     | 0     | 20.042  |
| 1     | 1     | 1     | 1     | 20.375  |

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### Application Information

#### Timing Considerations

The control sequence of the communication through the I<sup>2</sup>C interface is composed of several steps in sequence:

1. **Start Condition.** Defined by a negative edge on the SDA line, while SCL is high.
2. **Address Cycle.** 7 bits of address, plus 1 bit to indicate read (1) or write (0), and an acknowledge bit. The first five bits of the address are fixed as: *00010*. The four optional addresses, defined by the remaining two bits, are selected by the ADD input. The address is transmitted MSB first.
3. **Data Cycles.** 8 bits of data followed by an acknowledge bit. Multiple data bytes can be read. Data is transmitted MSB first.
4. **Stop Condition.** Defined by a positive edge on the SDA line, while SCL is high.

Except to indicate a Start or Stop condition, SDA must be stable while the clock is high. SDA can only be changed while SCL is low. It is possible for the Start or Stop condition

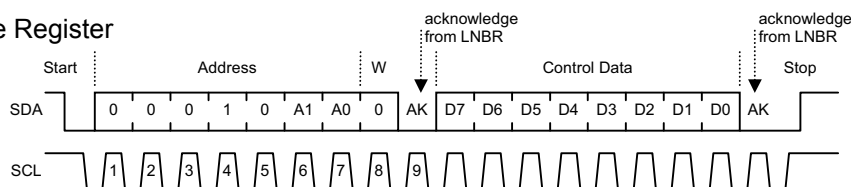
to occur at any time during a data transfer. The A8285/A8287 always responds by resetting the data transfer sequence.

The Read/Write bit is used to determine the data transfer direction. If the Read/Write bit is high, the master reads one or more bytes from the A8285/A8287. If the Read/Write bit is low, the master writes one byte to the A8285/A8287. Note that multiple writes are not permitted. All write operations must be preceded with the address.

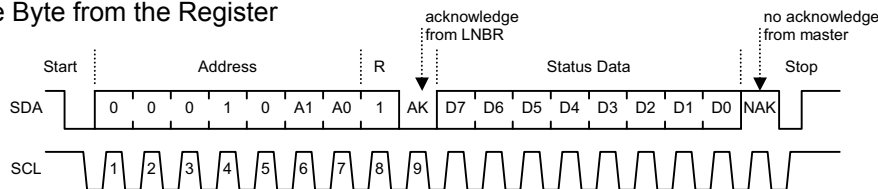
The Acknowledge bit has two functions. It is used by the master to determine if the slave device is responding to its address and data, and it is used by the slave when the master is reading data back from the slave. When the A8285/A8287 decodes the 7-bit address field as a valid address, it responds by pulling SDA low during the ninth clock cycle.

During a data write from the master, the A8285/A8287 also pulls SDA low during the clock cycle that follows the data byte, in order to indicate that the data has been successfully received. In both cases, the master device must release the

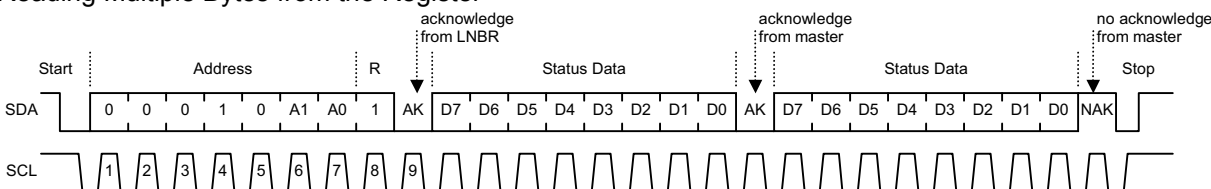
#### Writing to the Register



#### Reading One Byte from the Register



#### Reading Multiple Bytes from the Register



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SDA line before the ninth clock cycle, in order to allow this handshaking to occur.

During a data read, the A8285/A8287 acknowledges the address in the same way as in the data write sequence, and then retains control of the SDA line and send the data to the master. On completion of the eight data bits, the A8285/A8287 releases the SDA line before the ninth clock cycle, in order to allow the master to acknowledge the data. If the master holds the SDA line low during this Acknowledge bit, the A8285/A8287 responds by sending another data byte to the master. Data bytes continue to be sent to the master until the master releases the SDA line during the Acknowledge bit. When this is detected, the A8285/A8287 stops sending data and waits for a stop signal.

**Interrupt Request.** The A8285/A8287 also provides an interrupt request pin IRQ, which is an open-drain, active-low output. This output may be connected to a common IRQ line with a suitable external pull-up and can be used with other I<sup>2</sup>C devices to request attention from the master controller. The IRQ output becomes active when either the A8285/A8287 first recognizes a fault condition, or at power-on when the main supply  $V_{IN}$  and the internal logic supply  $V_{REG}$  reach the correct operating conditions. It is only reset to inactive when the I<sup>2</sup>C master addresses the A8285/A8287 with the Read/Write bit set (causing a read). Fault conditions are indicated by the TSD, VUV, and OCP bits in the status register (see description of OCP for conditions of use). The DIS and PNG bits do not cause an interrupt. When the master recognizes an interrupt, it addresses all slaves connected to the interrupt line in sequence, and then reads the status register to determine which device is requesting attention. The A8285/A8287 latches all conditions in the status register until the completion of the data read.

The action at the resampling point is further defined in the description for each of the status bits. The bits in the status

register are defined such that the all-zero condition indicates that the A8285/A8287 is fully active with no fault conditions.

When  $V_{IN}$  is initially applied, the I<sup>2</sup>C interface does not respond to any requests until the internal logic supply  $V_{REG}$  has reached its operating level. Once  $V_{REG}$  has reached this point, the IRQ output goes active, and the VUV bit is set. After the A8285/A8287 acknowledges the address, the IRQ flag is reset. Once the master reads the status registers, the registers are updated with the VUV reset.

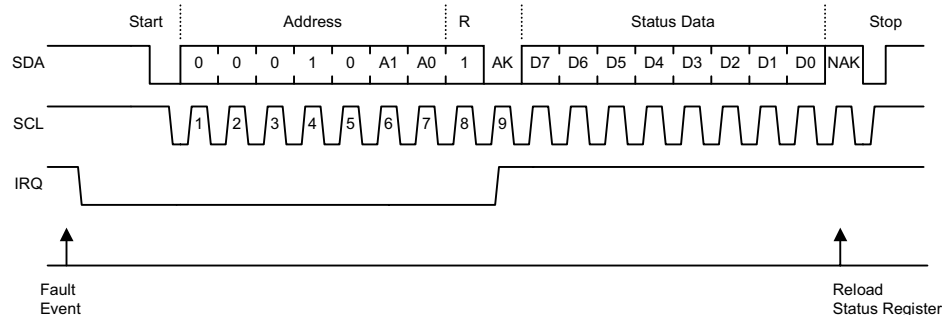
**Control Register (I<sup>2</sup>C Write Register).** All main functions of the A8285/A8287 are controlled through the I<sup>2</sup>C interface via the 8-bit Control register. This register allows selection of the output voltage and current limit, enabling and disabling the LNB output, and switching the 22 kHz tone on and off. The power-up state is 0 for all of the control functions.

**Bit 0 (VSEL0), Bit 1 (VSEL1), and Bit 2 (VSEL2).** These provide incremental control over the voltage on the LNB output. The available voltages provide the necessary levels for all the common standards plus the ability to add line compensation in increments of 333 mV. The voltage levels are defined in the Output Voltage Amplitude Selection table.

**Bit 3 (VSEL3).** Switches between the low-level and high-level output voltages on the LNB output. A value of 0 selects the low level voltage and a value of 1 selects the high level. The low-level center voltage is 12.709 V nominal, and the high level is 18.042 V nominal. These may be increased, in increments of 333 mV, by using the VSEL2, VSEL1, and VSEL0 control register bits.

**Bit 4 (ODT).** When set to 1, enables the ODT feature (disables the A8285/A8287 if the overcurrent disable time is exceeded during an overcurrent condition on the output). When set to 0, the ODT feature is disabled.

### Reading the Register After an Interrupt



# A8285/A8287

## LNB Supply and Control Voltage Regulator

**Bit 5 (ENB).** When set to 1, enables the LNB output. When set to 0, the LNB output is disabled.

**Bit 6 (I<sub>LIM</sub>).** Selects the I<sub>LIM</sub> level. When set to 0, the lower limit (typically 500 mA) is selected. When set to 1, the higher limit (typically 700 mA), is selected.

**Bit 7 (ENT).** When set to 1, enables modulation of the LNB output with the the internal 22 kHz tone. Since the I<sup>2</sup>C interface is compatible with the 400 kHz transfer speed, this bit may be used to encode DiSEqC™ 2.0 tone bursts for communication with the LNB or switcher at the far end of the coaxial cable.

**Status Register (I<sup>2</sup>C Read Register).** The main fault conditions: overcurrent, undervoltage, and overtemperature, are all indicated by setting the relevant bit in the Status register. In all fault cases, once the bit is set it is not reset until the A8285/A8287 is read by the I<sup>2</sup>C master. The current status of the LNB output is also indicated by DIS. DIS and PNG are the only bits that may be reset without an I<sup>2</sup>C read sequence. The normal sequence of the master in a fault condition is to detect the fault by reading the Status register, then rereading the Status register until the status bit is reset, indicating the fault condition has been reset. The fault may be detected by: continuously polling, responding to an interrupt request (IRQ), or detecting a fault condition externally and performing a diagnostic poll of all slave devices. Note that the fully operational condition of the Status register is all 0s. This simplifies checking of the status byte.

**Bit 0 (TSD).** A 1 indicates that the A8285/A8287 has detected an overtemperature condition and has disabled the LNB output. DIS is set and the A8285/A8287 does not re-enable the output until so instructed by writing the relevant bit into the Control register. The status of the overtemperature condition is sampled on the rising edge of the ninth clock pulse in the data read sequence. If the condition is no longer present, then the TSD bit is reset, allowing the master to re-enable the LNB output if required. If the condition is still present, then the TSD bit remains at 1.

**Bit 1 (OCP) Overcurrent.** If the A8285/A8287 detects an overcurrent condition for greater than the detection time, and if ODT is enabled, the LNB output is then disabled. Also, the OCP bit is set to indicate that an overcurrent has occurred, and the DIS bit is set. The Status register is updated on the rising edge of the ninth clock pulse. The OCP bit is reset in all cases, allowing the master to re-enable the LNB output. If the overcurrent timer is not enabled, the A8285/A8287 operates in current limit indefinitely, and the OCP bit is not set.

**Bit 2 and 3.** Reserved.

**Bit 4 (PNG) Power Not Good.** Set to 1 when the LNB output is enabled and the LNB output volts are below 85% of the programmed LNB voltage. The PNG is reset when the LNB volts are within 90% of the programmed LNB voltage.

**Bit 5 (DIS) LNB output disabled.** DIS is used to indicate the current condition of the LNB output. At power-on, or if a fault condition occurs, the disable bit is set. Having this bit change to 1 does not cause the IRQ to activate because the LNB output may be disabled intentionally by the I<sup>2</sup>C master. This bit also is reset at the end of a write sequence, if the LNB output is enabled.

**Bit 6.** Reserved.

**Bit 7 (VUV) Undervoltage lockout.** Set to 1 to indicate that the A8285/A8287 has detected that the input supply V<sub>IN</sub> is, or has been, below the minimum level and that an undervoltage lockout has occurred, which has disabled the LNB output. Bit 5 also is set, and the A8285/A8287 does not re-enable the output until so instructed (by having the relevant bit written into the Control register). The status of the undervoltage condition is sampled on the rising edge of the ninth clock pulse in the data read sequence. If the condition is no longer present, the VUV bit is reset, allowing the master to re-enable the LNB output if required. If the condition is still present, the VUV bit remains set to 1.

**Control (I<sup>2</sup>C Write) Register Table**

| Bit | Name  | Function                                                          |
|-----|-------|-------------------------------------------------------------------|
| 0   | VSEL0 | See Output Voltage Amplitude Selection Table                      |
| 1   | VSEL1 |                                                                   |
| 2   | VSEL2 |                                                                   |
| 3   | VSEL3 | 0: LNBx = Low range<br>1: LNBx = High range                       |
| 4   | ODT   | 0: Overcurrent disable time off<br>1: Overcurrent disable time on |
| 5   | ENB   | 0: Disable LNB Output<br>1: Enable LNB Output                     |
| 6   | ILIM  | 0: Overcurrent Limit = 500mA<br>1: Overcurrent Limit = 700mA      |
| 7   | ENT   | 0: Disable Tone<br>1: Enable 22KHz internal tone                  |

# A8285/A8287

## LNB Supply and Control Voltage Regulator

### Power Dissipation

To ensure that the device operates within the safe operating temperature range, several checks should be performed. An approximate operating junction temperature can be determined by estimating the power losses and the thermal impedance characteristics of the printed circuit board solution. To do so, perform the following procedure:

1. Estimate the maximum ambient temperature ( $T_A$ ).
2. Define the maximum running junction temperature ( $T_J$ ) of A8285/A8287. Note that the absolute maximum junction temperature should never exceed 150°C.
3. Determine worst case power dissipation:

- (a) Estimate the duty cycle D:

$$D = 1 - [V_{IN} / (V_{OUT} + V_D + \Delta V_{REG})]$$

where:

$V_D$  is the voltage drop of the boost diode, and

$\Delta V_{REG}$  can be taken from the specification table.

- (b) Estimate the peak current in boost stage  $I_{PK}$ :

$$I_{PK} = V_{OUT} \times [I_{LOAD} / (0.89 \times V_{IN})]$$

- (c) Estimate boost  $R_{DS}$  ( $R_{DSBOOST}$ ) at maximum running junction temperature.  $R_{DSBOOST}$  is a function of junction temperature and it rises by 2.7 mΩ/°C with respect to the specified figure,  $R_{DSBOOST(25^\circ C)}$ , when  $T_J$  equals 25°C.

$$\text{Actual } R_{DSBOOST} = R_{DSBOOST(25^\circ C)} + [(T_J - 25) \times 2.7 \text{ m}\Omega]$$

- (d) Determine losses in each block  $P_{TOT}$ ; based on the relative value of  $V_{IN}$ , perform either (i) or (ii):

- (i) When  $V_{IN} < V_{OUT} + V_D + \Delta V_{REG}$ . Note that worst case dissipation occurs at minimum input voltage.

$$P_{TOT} = P_{d\_Rds} + P_{d\_sw} + P_{d\_control} + P_{d\_lin}$$

where

$$P_{d\_Rds} = I_{PK}^2 \times R_{DSBOOST} \times D$$

$$P_{d\_control} = 15 \text{ mA} \times V_{IN}$$

$$P_{d\_lin} = \Delta V_{REG} \times I_{LOAD}$$

and  $P_{d\_sw}$  (switching losses estimate); worst case = 70 mW.

- (ii) When  $V_{IN} > V_{OUT} + V_D + \Delta V_{REG}$ . Note that worst case dissipation in this case occurs at maximum input voltage.

$$P_{TOT} = P_{d\_control} + P_{d\_lin}$$

where:

$$P_{d\_control} = 15 \text{ mA} \times V_{IN}$$

$$P_{d\_lin} = (V_{IN} - V_D - V_{OUT}) \times I_{LOAD}$$

- Step 4.** Determine the thermal impedance required in the solution:

$$R_{\theta JA} = (T_J - T_A) / P_{TOT}$$

The  $R_{\theta JA}$  for one or two layer PCBs can be estimated from the  $R_{\theta JA}$  vs. Area charts on the following page.

Note: For maximum effectiveness, the PCB area underneath the IC should be filled copper and connected to pins 4 and 13 for A8285, and pins 6, 7, 18, and 19 for A8287. Where a PCB with two or more layers is used, apply thermal vias, placing them adjacent to each of the above pins, and underneath the IC.

Status (I<sup>2</sup>C Read) Register Table

| Bit | Name | Function              |
|-----|------|-----------------------|
| 0   | TSD  | Thermal Shutdown      |
| 1   | OCP  | Overcurrent           |
| 2   |      | Reserved              |
| 3   |      | Reserved              |
| 4   | PNG  | Power Not Good        |
| 5   | DIS  | LNB output disabled   |
| 6   |      | Reserved              |
| 7   | VUV  | $V_{IN}$ Undervoltage |

# A8285/A8287

## LNB Supply and Control Voltage Regulator

### Example.

Given:

$$V_{IN} = 12 \text{ V}$$

$$V_{OUT} = 18 \text{ V}$$

$$I_{LOAD} = 500 \text{ mA}$$

Two-layer PCB.

Maximum ambient temperature = 70 °C,

Maximum allowed junction temperature = 110 °C

Assume:

$$V_D = 0.4 \text{ V and select } \Delta V_{REG} = 0.7 \text{ V}$$

$$D = 1 - (12 / (18 + 0.4 + 0.7)) = 0.37$$

$$I_{PK} = 18 \times 0.5 / (0.89 \times 12) = 843 \text{ mA}$$

$$R_{DSBOOST} = 0.5 + (110 - 25) \times 2.7 \text{ m}\Omega = 730 \text{ m}\Omega$$

Worst case losses can now be estimated:

$$P_{d\_Rds} = 0.843^2 \times 0.73 \times 0.37 = 192 \text{ mW}$$

$$P_{d\_sw} = 70 \text{ mW}$$

$$P_{d\_control} = 15 \text{ mA} \times V_{IN} = 180 \text{ mW}$$

$$P_{d\_lin} = 0.7 \times 0.5 = 350 \text{ mW}$$

and therefore

$$P_{TOT} = 0.192 + 0.07 + 0.18 + 0.35 = 0.792 \text{ W}$$

The thermal resistance required is:

$$(110 - 70) / 0.792 = 50.5^\circ\text{C/W}$$

Note: For the case of the A8287, the area of copper required on each layer is approximately 1.2 in<sup>2</sup>.

### Layout Considerations

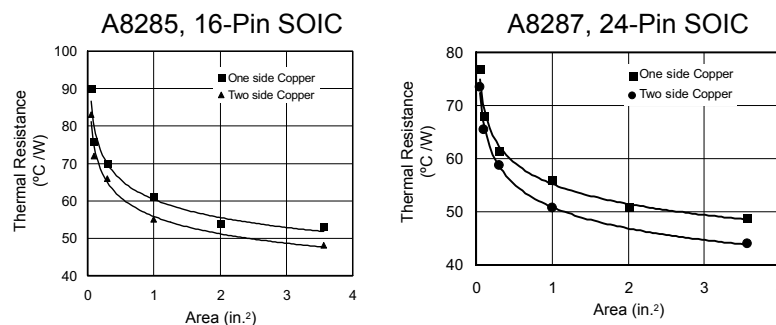
Recommended placement of critical components and tracking for the A8287 is shown in the PCB Layout digigram on the following page. It is recommended that the ground plane be separated into two areas, referred to as *switcher* and *control*, on each layer using a ground plane. With respect to the input connections, VIN and 0V, the two ground plane areas are isolated as shown by the dotted line and the ground plane areas are connected together at pins 6, 7, 18, and 19. This configuration minimizes the effects of the noise produced by the switcher on the noise-sensitive sections of the circuit.

Power-related tracking from INPUT to L1, LNB (pin 17) to L2 then OUTPUT, LX (pin 20) to D1 and L1, VBOOST (pin 23) to C4 and D1 should be as short and wide as possible. Power components such as the boost diode D1, inductor L1, and input/output capacitors C1, C9, and C4, should be located as close as possible to the IC. The DiSEqC inductor L2 should be located as far away from the boost inductor L1 to prevent potential magnetic crosstalk.

The filter capacitor (VREG), charge pump capacitor (VCP), ac coupling tone detect capacitor (TDI), tone pull-down resistor (TOUT), and LNB output capacitor/protection diode (LNB) should be located directly next to the appropriate pin.

Where a PCB with two or more layers is used, it is recommended that four thermal vias be deployed as shown in the PCB Layout diagram. Note that adding additional vias does not enhance the thermal characteristics.

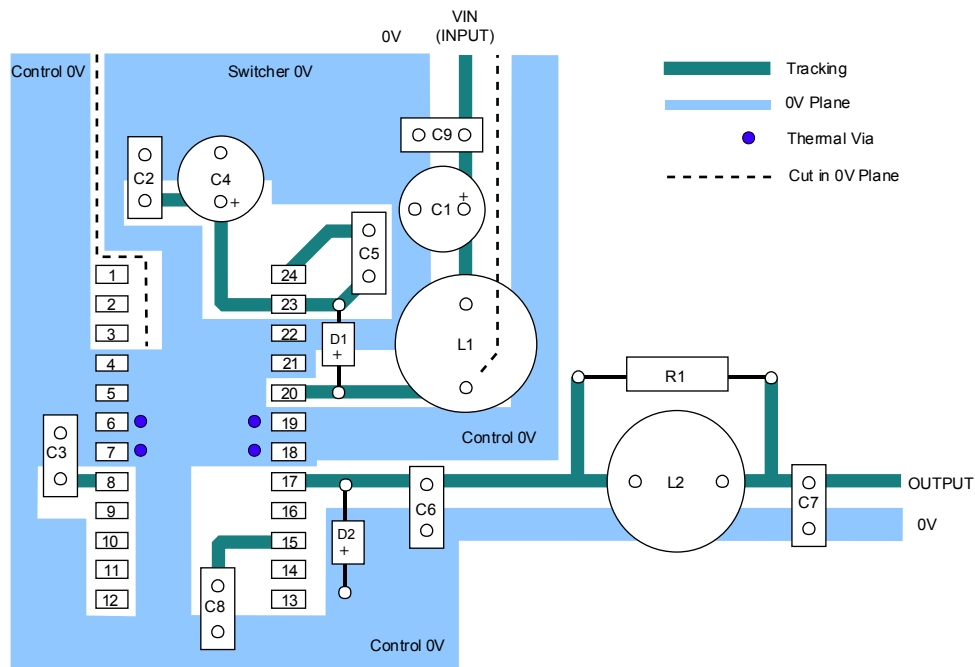
R<sub>θJA</sub> vs. Area Charts



# A8285/A8287

## LNB Supply and Control Voltage Regulator

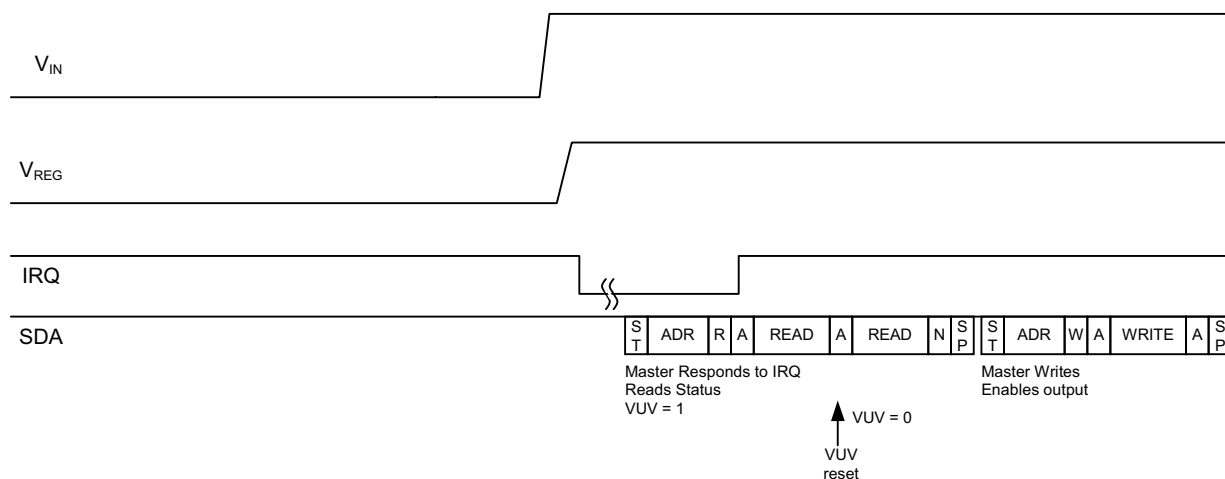
PCB Layout Diagram



Note that to add additional connections, e.g. SCL, SDA, IRQ, VIN, EXTM, ADD, TDO, and TDI, some modifications to the control ground plane will be necessary.

Refer to Functional Block diagram for circuit connections.

Power-on Reset I<sup>2</sup>C Sequence

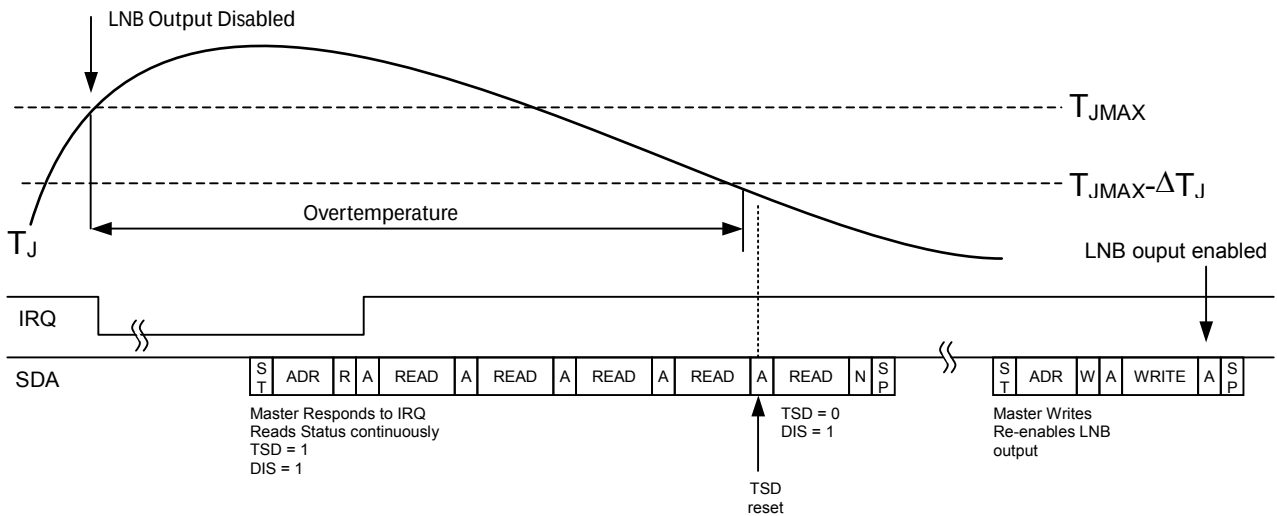


# A8285/A8287

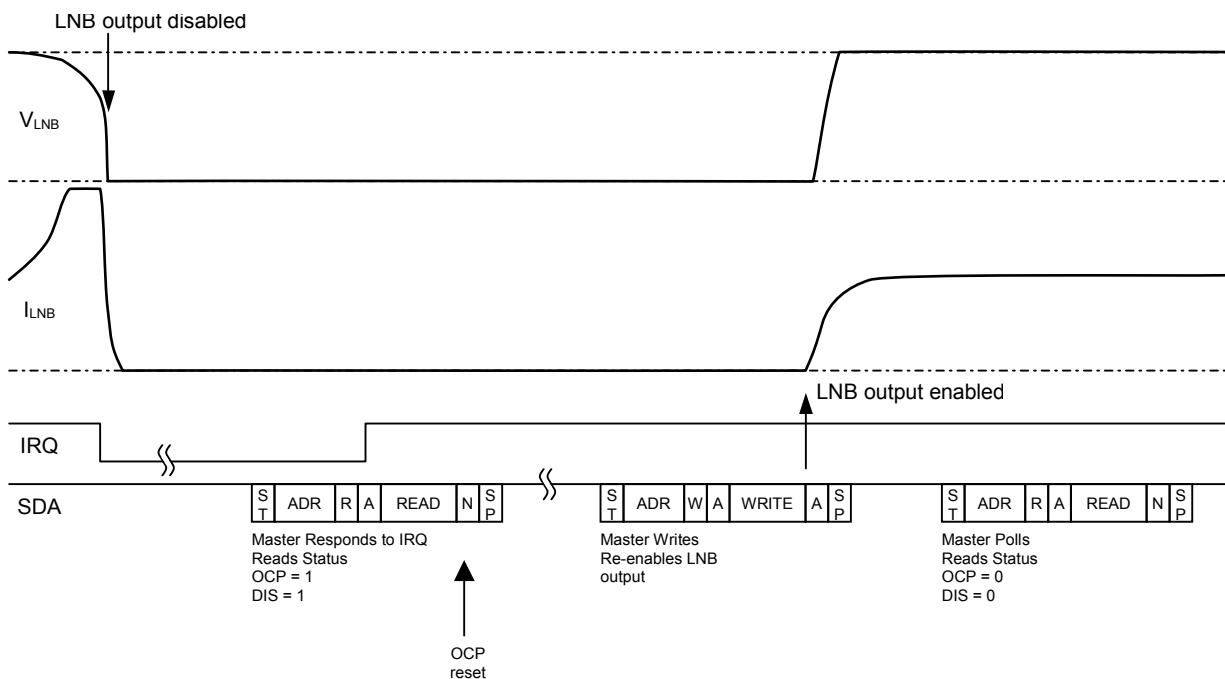
## LNB Supply and Control Voltage Regulator

### Overtemperature and Overcurrent I<sup>2</sup>C Sequences

#### Response to Overtemperature fault condition using multiple byte read



#### Response to Overcurrent fault condition using single byte read



# A8285/A8287

## *LNB Supply and Control Voltage Regulator*

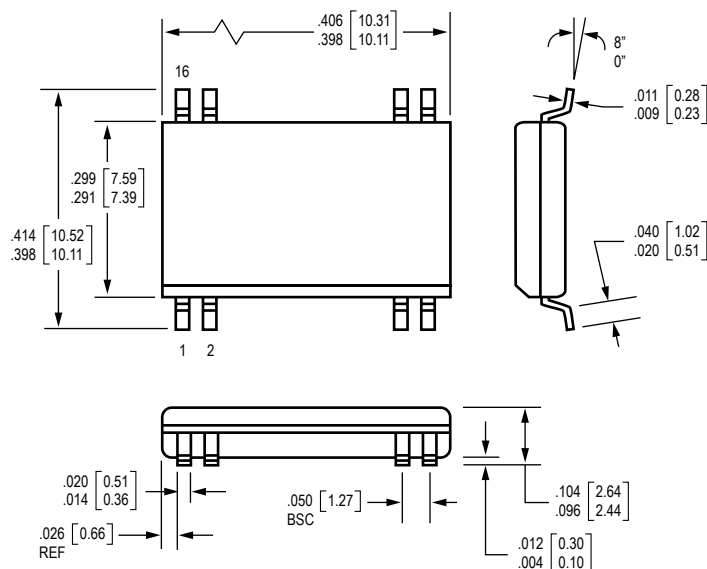
**Terminal List Table**

| Pin Name | Pin Description                                                | A8287SLB<br>SOIC-24 | A8285SLB<br>SOIC-16 |
|----------|----------------------------------------------------------------|---------------------|---------------------|
| SCL      | I2C Clock Input                                                | 1                   | 1                   |
| SDA      | I2C Data Input/Output                                          | 2                   | 2                   |
| IRQ      | Interrupt Request                                              | 3                   | 3                   |
| GND      | Ground                                                         | 4,5,6,7             | 4                   |
| VREG     | Analog Supply                                                  | 8                   | 5                   |
| VIN      | Supply Input Voltage                                           | 9                   | 6                   |
| EXTM     | External Modulation Input                                      | 10                  | 7                   |
| ADD      | Address Select                                                 | 11                  | 8                   |
| TDO      | Tone Detect Out                                                | 12                  | -                   |
| TDI      | Tone Detect Input                                              | 13                  | -                   |
| NC       | No Connection                                                  | 14                  | 9                   |
| TCAP     | Capacitor for setting the rise and fall time of the LNB output | 15                  | 10                  |
| TOUT     | Tone Generation                                                | 16                  | 11                  |
| LNB      | Output voltage to LNB                                          | 17                  | 12                  |
| GND      | Ground                                                         | 18,19               | 13                  |
| LX       | Inductor drive point                                           | 20                  | 14                  |
| GND      | Ground                                                         | 21,22               | -                   |
| BOOST    | Tracking supply voltage to linear regulator                    | 23                  | 15                  |
| VCP      | Gate supply voltage                                            | 24                  | 16                  |

# A8285/A8287

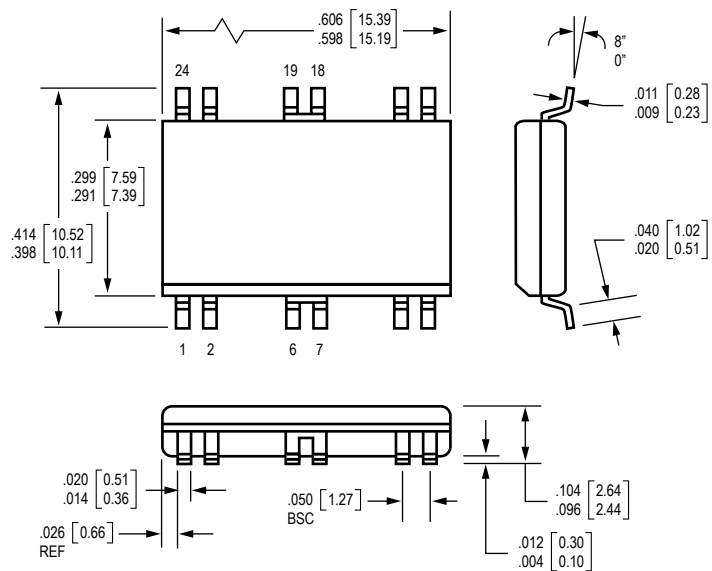
## LNB Supply and Control Voltage Regulator

### A8285SLB 16-Pin Batwing SOIC



Leads 4 and 13 are connected inside the device package.

### A8287SLB 24-Pin Batwing SOIC



Leads 6, 7, 18 and 19 are connected inside the device package.

#### NOTES:

1. Exact body and lead configuration at vendor's option within limits shown.
2. Lead spacing tolerance is non-cumulative.
3. Supplied in standard sticks/tubes of 49 devices or add "TR" to part number for tape and reel.

# **A8285/A8287**

## ***LNB Supply and Control Voltage Regulator***

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