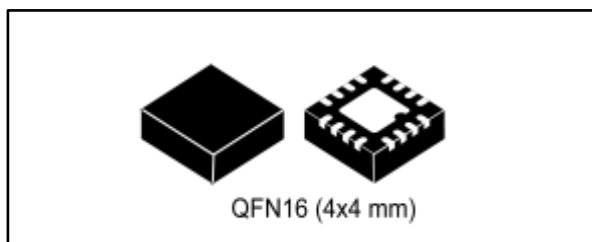


## LNB supply and control IC with step-up and I<sup>2</sup>C interface

Datasheet - production data



### Features

- Complete interface between LNB and I<sup>2</sup>C bus
- Built-in DC-DC converter for single 12 V supply operation and high efficiency (typ. 93% @ 0.5 A)
- Selectable output current limit by external resistor
- Compliant with main satellite receiver output voltage specifications
- EXT pin, auxiliary 44 kHz modulation input extends design flexibility
- Low drop post regulator and high efficiency step-up PWM with integrated power NMOS allowing low power losses

- Overload and overtemperature internal protection with I<sup>2</sup>C diagnostic bits
- LNB short-circuit dynamic protection
- +/- 4 kV ESD tolerant on output power pins

### Applications

- STB satellite receivers
- TV satellite receivers
- PC card satellite receivers

### Description

Intended for the Japanese market for digital dual satellite receivers/Sat-TV, and Sat-PC cards, the LNBH30 is a monolithic voltage regulator and interface IC, assembled in QFN16 (4x4 mm) specifically designed to provide the power supply and the 44 kHz tone signaling to the LNB down-converter in the antenna dish or to the multi-switch box. In this application field, it offers a complete solution with extremely low component count, low power dissipation together with simple design and I<sup>2</sup>C standard interfacing.

Table 1: Device summary

| Order code | Package     | Packing       |
|------------|-------------|---------------|
| LNBH30QTR  | QFN16 (4x4) | Tape and reel |

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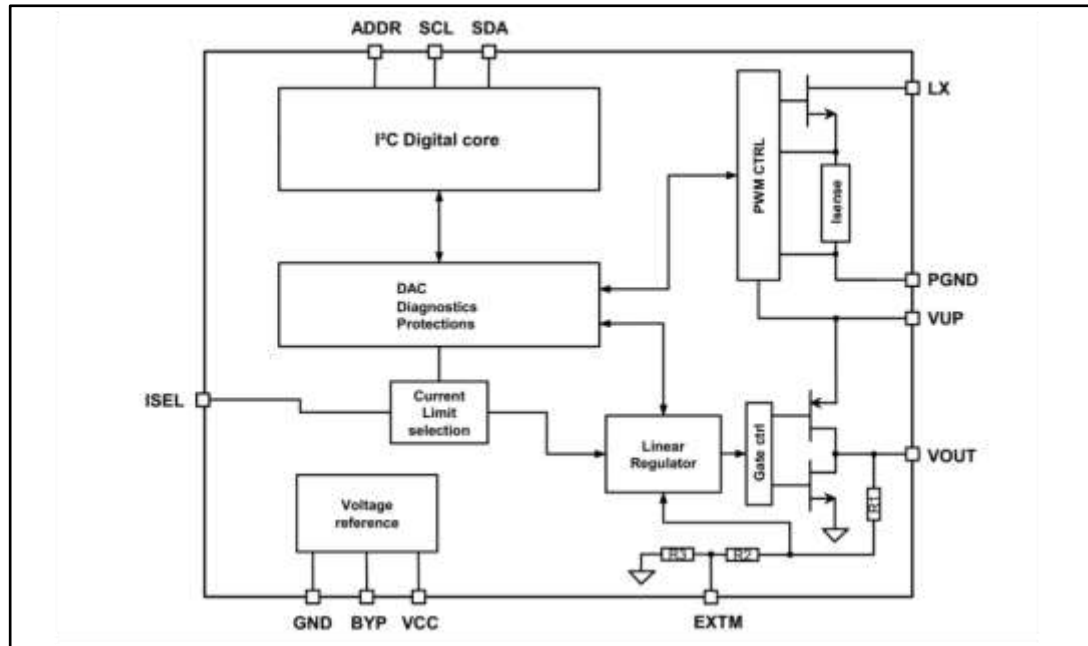
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# 1 Block diagram

Figure 1: Block diagram



## 2 Application information

This IC has a built-in DC-DC step-up converter that, from a single source of typically 12 V, generates the voltages ( $V_{UP}$ ) that allow the linear post-regulator to work at a minimum dissipated power of 0.5 W typ. @ 500 mA load (it is internally kept at  $V_{UP} - V_{OUT} = 1$  V typ.). An undervoltage lockout circuit disables the whole circuit when the supplied  $V_{CC}$  drops below a fixed threshold (4.7 V typ.). The step-up converter is provided with a soft-start function which reduces the in-rush current during startup. The SS time is internally fixed at 5 ms typ. to switch from 0 to 15 V.

### 2.1 Data encoding

In order to improve design flexibility, an analogical modulation input pin is available (EXTM) to generate the 44 kHz tone superimposed to the VOUT DC output voltage. An appropriate DC blocking capacitor must be used to couple the 44 kHz modulating signal source to the EXTM pin. The EXTM pin modulates the VOUT voltage through the series decoupling capacitor, so that:

$V_{OUT}(AC) = V_{EXTM}(AC) \times G_{EXTM}$  where:  $V_{OUT}(AC)$  and  $V_{EXTM}(AC)$  are, respectively, the peak-to-peak AC voltage on the VOUT pin and on the EXTM pin, while  $G_{EXTM}$  is the voltage gain between the EXTM voltage and VOUT signal.

### 2.2 Output current limit selection

The linear regulator current limit threshold can be set by an external resistor connected to the ISEL pin. The resistor value defines the output current limit as per the following equation:

$$I_{MAX}(typ.) = \frac{13915}{RSEL^{1.111}}$$

where RSEL is the resistor connected between ISEL and GND expressed in kΩ and  $I_{MAX}(typ.)$  is the typical current limit threshold expressed in mA.  $I_{MAX}$  can be set up to 0.55 A.

### 2.3 Output voltage selection

The linear regulator channel output voltage level can be easily programmed in order to accomplish application specific requirements, using 3 bits of the internal DATA register see [Section 7.1: "Write mode transmission"](#) and [Table 6: "Data \(read/write register, register address = 0x1\)"](#) for exact programmable values. Register writing is accessible via the I<sup>2</sup>C bus.

### 2.4 COMP: boost capacitors and inductor

The DC-DC converter compensation loop can be optimized in order to properly work with both ceramic and electrolytic capacitors ( $V_{UP}$  pin). For this purpose, one I<sup>2</sup>C bit in the DATA register (see COMP) can be set to "1" or "0" as follows:

COMP = 0 for electrolytic capacitors

COMP = 1 for ceramic capacitors

For recommended DC-DC capacitor and inductor values refer to [Section 5: "Typical application circuits"](#) and to the BOM in [Table 5: "Typical application circuit bill of material"](#).

## 2.5 Diagnostic and protection functions

The LNBH30 has 5 diagnostic internal functions provided by the I<sup>2</sup>C bus, by reading 5 bits on the status register (in read mode). All the diagnostic bits are, in normal operation, set to LOW. Two diagnostic bits are dedicated to the overtemperature and overload protection status (OTF and OLF) while the remaining 3 bits are dedicated to the output voltage level (VMON), to external voltage source presence on the VOUT pin (PDO) and to the input voltage power not good function (PNG). Once the OLF (or OTF or PNG) bit is active (set to "1"), it is latched to "1" until the relevant cause is removed and a new register reading operation is performed.

## 2.6 VMON: output voltage diagnostic

When the device output voltage is active (VOUT pin), its value is internally monitored and, as long as the output voltage level is below the guaranteed limits, the relevant VMON I<sup>2</sup>C bit is set to "1" (see [Table 12: "Output voltage diagnostic \(VMON bit, status register\) characteristics"](#) for more details).

## 2.7 PDO: overcurrent detection on output pull-down stage

When an overcurrent occurs on the pull-down output stage due to an external voltage source greater than the LNBH30 nominal V<sub>OUT</sub>, and for a time longer than I<sub>SINK\_TIME\_OUT</sub> (10 ms typ.), the corresponding PDO I<sup>2</sup>C bit is set to "1". This may happen due to an external voltage source presence on the LNB output (VOUT pin).

For current threshold and deglitch time details, see [Table 9: "Electrical characteristics"](#).

## 2.8 Power-on I<sup>2</sup>C interface reset and undervoltage lockout

The I<sup>2</sup>C interface built into the LNBH30 is automatically reset at power-on. As long as the V<sub>CC</sub> stays below the undervoltage lockout (UVLO) threshold (4.7 V typ.), the interface does not respond to any I<sup>2</sup>C command and all DATA register bits are initialized to zeroes, therefore keeping the power blocks disabled. Once the V<sub>CC</sub> rises above 4.8 V typ., the I<sup>2</sup>C interface becomes operative and the DATA registers can be configured by the main microprocessor.

## 2.9 PNG: input voltage minimum detection

When input voltage (V<sub>CC</sub> pin) is lower than LPD (low power diagnostic) minimum thresholds, the PNG I<sup>2</sup>C bit is set to "1". Refer to [Section 8: "Electrical characteristics"](#) for threshold details.

## 2.10 OLF: overcurrent and short-circuit protection and diagnostic

In order to reduce the total power dissipation during an overload or a short-circuit condition, the device is provided with a dynamic short-circuit protection. The overcurrent protection circuit works dynamically: as soon as an overload is detected, the output current is provided for T<sub>ON</sub> time (90 ms) and after that, the output is set in shutdown for a T<sub>OFF</sub> time of typically 900 ms. Simultaneously, the corresponding diagnostic OLF I<sup>2</sup>C bit of the status register is set to "1". After this time has elapsed, the involved output is resumed for a time T<sub>ON</sub>. At the end of T<sub>ON</sub>, if the overload is still detected, the protection circuit cycles again through T<sub>OFF</sub> and T<sub>ON</sub>. At the end of a full T<sub>ON</sub> in which no overload is detected, normal operation is resumed and the OLF diagnostic bit is reset to LOW after register reading is performed. Typical T<sub>ON</sub> + T<sub>OFF</sub> time is 990 ms and is determined by an internal timer. This dynamic operation can greatly reduce the power dissipation in short-circuit condition, still ensuring excellent power-on startup in most conditions.

## 2.11 OTF: thermal protection and diagnostic

The LNBH30 is also protected against overheating: when the junction temperature exceeds 150 °C (typ.), the step-up converter and the liner regulators are shut off, the diagnostic OTF bit in the status register is set to “1”. As soon as the overtemperature condition is removed, normal operation is automatically re-enabled while the OTF bit is reset to “0” after a register reading operation.

### 3 Pin configuration

Figure 2: Pin connections (top view)

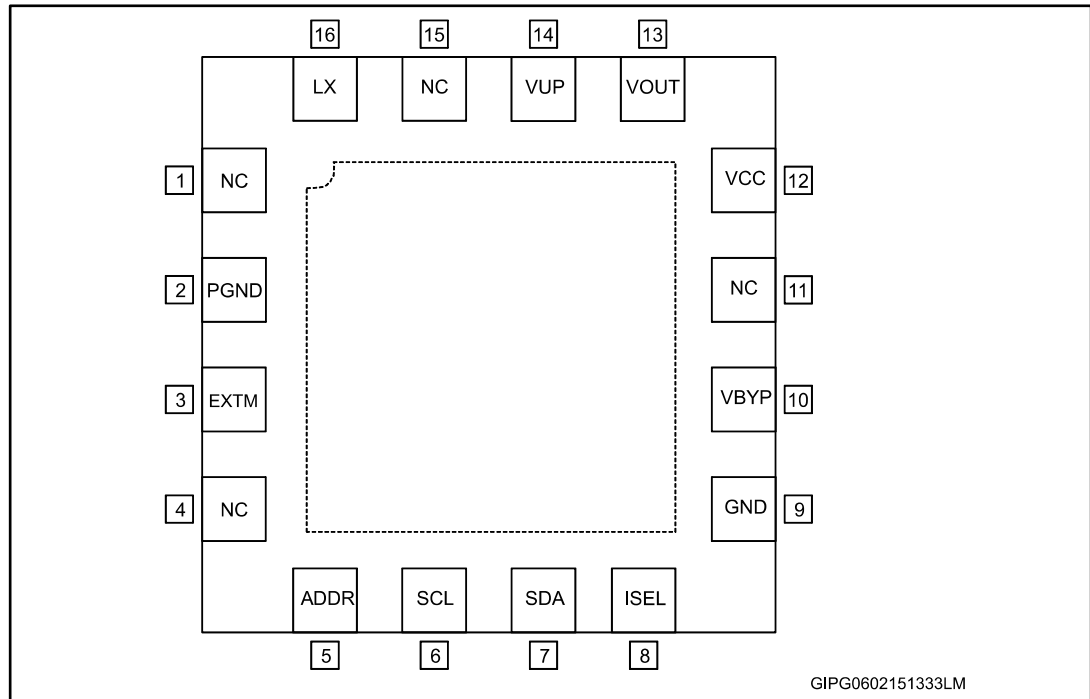


Table 2: Pin description

| Pin | Symbol | Name                       | Pin function                                                                                                                                                                                                                   |
|-----|--------|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2   | PGND   | Power ground               | DC-DC converter power ground. To be connected directly to the exposed pad                                                                                                                                                      |
| 3   | EXTM   | External 44 kHz tone input | The “external tone modulation” input acts on the integrated linear regulator loop to superimpose an external 44 kHz signal to the VOUT pin DC voltage. DC decoupling is needed for AC source                                   |
| 5   | ADDR   | Address setting            | Two I <sup>2</sup> C bus addresses available by setting the address pin level voltage. See <a href="#">Table 11: “Address pin characteristics”</a>                                                                             |
| 6   | SCL    | Serial clock               | Clock from I <sup>2</sup> C bus                                                                                                                                                                                                |
| 7   | SDA    | Serial data                | Bi-directional data from/to I <sup>2</sup> C bus                                                                                                                                                                               |
| 8   | ISEL   | Current selection          | The resistor “RSEL” connected between ISEL and GND defines the linear regulator current limit threshold. Refer to <a href="#">Section 2.2: “Output current limit selection”</a>                                                |
| 9   | GND    | Analog ground              | Analog circuit ground. To be connected directly to the exposed pad                                                                                                                                                             |
| 10  | BYP    | Bypass capacitor           | Needed for internal pre-regulator filtering. The BYP pin is intended to connect an external ceramic capacitor only. Any connection of this pin to external current or voltage sources may cause permanent damage to the device |
| 12  | VCC    | Supply input               | 10 to 17.5 V IC DC-DC power supply                                                                                                                                                                                             |
| 13  | VOUT   | LNB output port            | Output of the integrated very low drop linear regulator. See <a href="#">Table 8: “Output voltage selection (data register, write mode)”</a>                                                                                   |

| Pin       | Symbol | Name                            | Pin function                                                                                                                                                        |
|-----------|--------|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 14        | VUP    | Step-up voltage                 | Input of linear post-regulator. The voltage on this pin is monitored by the internal step-up controller to keep a minimum dropout across the linear pass transistor |
| 16        | LX     | NMOS drain                      | Integrated N-channel power MOSFET drain                                                                                                                             |
| 1,4,11,15 | NC     | Not internally connected output | Not internally connected pins. These pins may be connected to GND to improve thermal performance                                                                    |
| Epad      | Epad   | Exposed pad                     | To be connected with power ground and to the ground layer through vias to dissipate heat                                                                            |

## 4 Maximum ratings

Table 3: Absolute maximum ratings

| Symbol            | Parameter                                                                     | Value              | Unit |
|-------------------|-------------------------------------------------------------------------------|--------------------|------|
| V <sub>CC</sub>   | DC power supply input voltage pins                                            | -0.3 to 20         | V    |
| V <sub>UP</sub>   | DC input voltage                                                              | -0.3 to 40         | V    |
| I <sub>OUT</sub>  | Output current                                                                | Internally limited | mA   |
| V <sub>OUT</sub>  | DC output pin voltage                                                         | -0.3 to 40         | V    |
| V <sub>I</sub>    | Logic input pin voltage (SDA, SCL, DSQIN, ADDR pins)                          | -0.3 to 7          | V    |
| V <sub>EXTM</sub> | EXTM pin voltage                                                              | -0.3 to 2          | V    |
| LX                | LX input voltage                                                              | -0.3 to 30         | V    |
| V <sub>BYP</sub>  | Internal reference pin voltage                                                | -0.3 to 4.6        | V    |
| I <sub>SEL</sub>  | Current selection pin voltage                                                 | -0.3 to 3.5        | V    |
| T <sub>STG</sub>  | Storage temperature range                                                     | -50 to 150         | °C   |
| T <sub>J</sub>    | Operating junction temperature range                                          | -25 to 125         | °C   |
| ESD               | ESD rating with human body model (HBM) for all pins, except power output pins | 2                  | kV   |
|                   | ESD rating with human body model (HBM) for power output pins                  | 4                  |      |

Table 4: Thermal data

| Symbol            | Parameter                                                                                                                 | Value | Unit |
|-------------------|---------------------------------------------------------------------------------------------------------------------------|-------|------|
| R <sub>thJC</sub> | Thermal resistance junction-case                                                                                          | 2     | °C/W |
| R <sub>thJA</sub> | Thermal resistance junction-ambient with device soldered on 2s2p 4-layer PCB provided with thermal vias below exposed pad | 40    | °C/W |



Absolute maximum ratings are those values beyond which damage to the device may occur. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect the device reliability. All voltage values are with respect to network ground terminal.

## 5 Typical application circuits

Figure 3: Application circuit

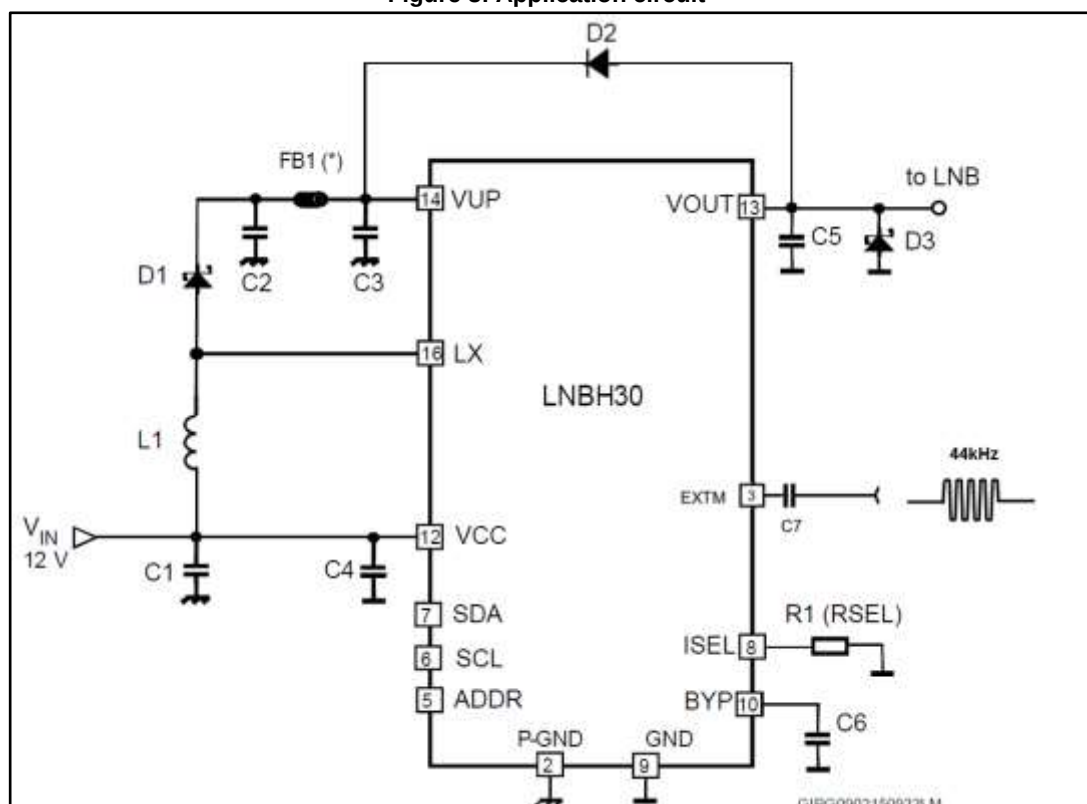


Table 5: Typical application circuit bill of material

| Component | Notes                                                                                                                                                                                  |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C1        | > 25 V electrolytic capacitor, 100 $\mu$ F or higher is suitable<br>or<br>> 25 V ceramic capacitor, 10 $\mu$ F or higher is suitable                                                   |
| C2        | With COMP = 0, > 25 V electrolytic capacitor, 100 $\mu$ F or higher is suitable<br>or<br>with COMP = 1, > 35 V ceramic capacitor, 22 $\mu$ F (or 2 x 10 $\mu$ F) or higher is suitable |
| C3        | 2.2 $\mu$ F ceramic capacitor placed as close as possible to VUP pins. Higher values allow lower DC-DC noise                                                                           |
| C5        | From 100 nF to 220 nF ceramic capacitor. Higher values allow lower DC-DC noise                                                                                                         |
| C4, C6    | 220 nF ceramic capacitors                                                                                                                                                              |
| C7        | 100 nF or higher is suitable                                                                                                                                                           |
| D1        | STPS130A or similar Schottky diode                                                                                                                                                     |
| D2        | 1N4001-07, S1A-S1M, or any similar general purpose rectifier                                                                                                                           |
| D3        | BAT54, BAT43, 1N5818, or any low power Schottky diode with $I_F(AV) > 0.2$ A, $V_{RRM} > 25$ V, $V_F < 0.5$ V. To be placed as close as possible to VOUT pin                           |

| Component | Notes                                                                                                                                                                                                                                                                 |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L1        | With COMP=0, use 10 $\mu$ H inductor with $I_{SAT} > I_{PEAK}$ where $I_{PEAK}$ is the boost converter peak current<br>or<br>with COMP=1 and C2 = 22 $\mu$ F, use 6.8 $\mu$ H inductor with $I_{SAT} > I_{PEAK}$ where $I_{PEAK}$ is the boost converter peak current |
| FB1       | Optional. Ferrite bead to be added if lower DC-DC noise is required                                                                                                                                                                                                   |

## 6 I<sup>2</sup>C bus interface

Data transmission from the main microprocessor to the LNBH30 and vice versa takes place through the 2-wire I<sup>2</sup>C bus interface, consisting of the 2-line SDA and SCL (pull-up resistors must be externally connected to positive supply voltage).

### 6.1 Data validity

As shown in [Figure 4: "Data validity on the I<sup>2</sup>C bus"](#), the data on the SDA line must be stable during the high semi-period of the clock. The HIGH and LOW state of the data line can only change when the clock signal on the SCL line is LOW.

### 6.2 Start and stop condition

As shown in [Figure 5: "Timing diagram of I<sup>2</sup>C bus"](#), a start condition is a HIGH to LOW transition of the SDA line while SCL is HIGH. The stop condition is a LOW to HIGH transition of the SDA line while SCL is HIGH. A STOP condition must be sent before than each START condition.

### 6.3 Byte format

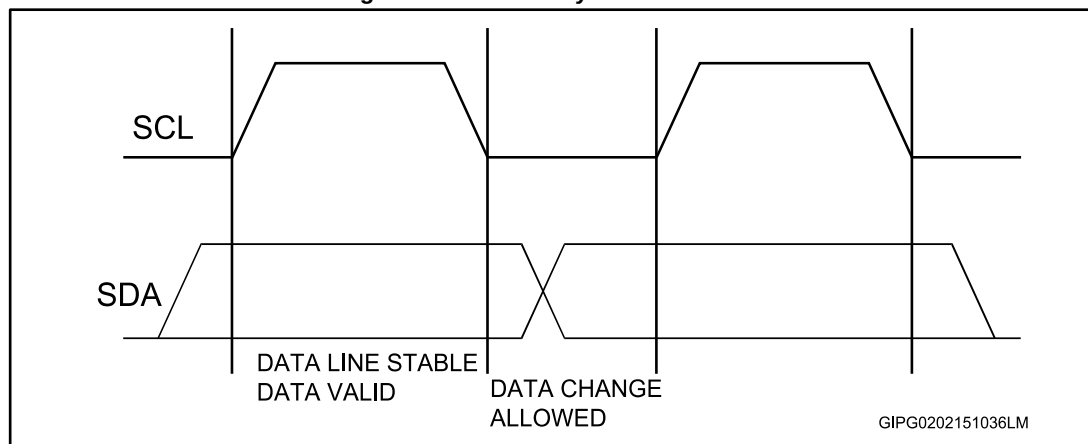
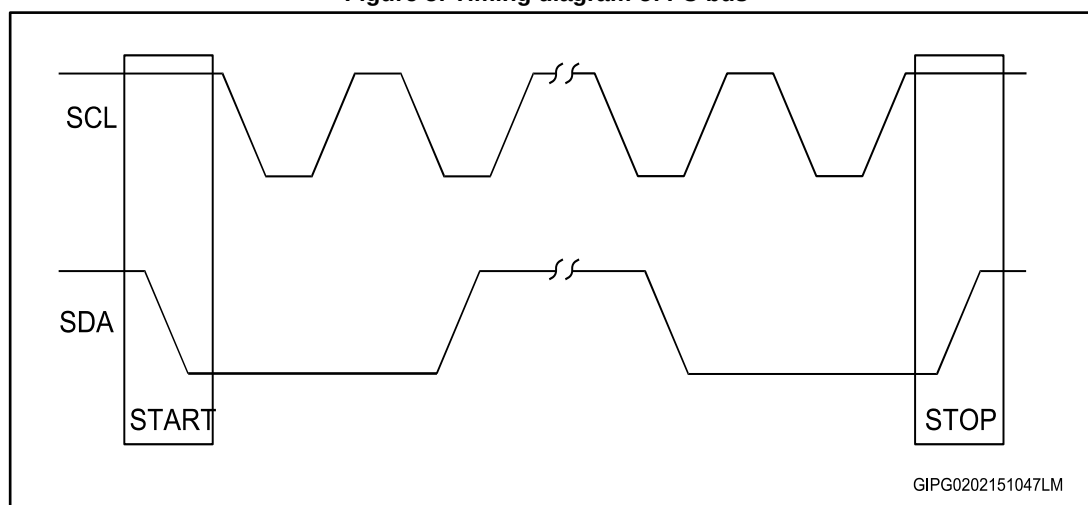
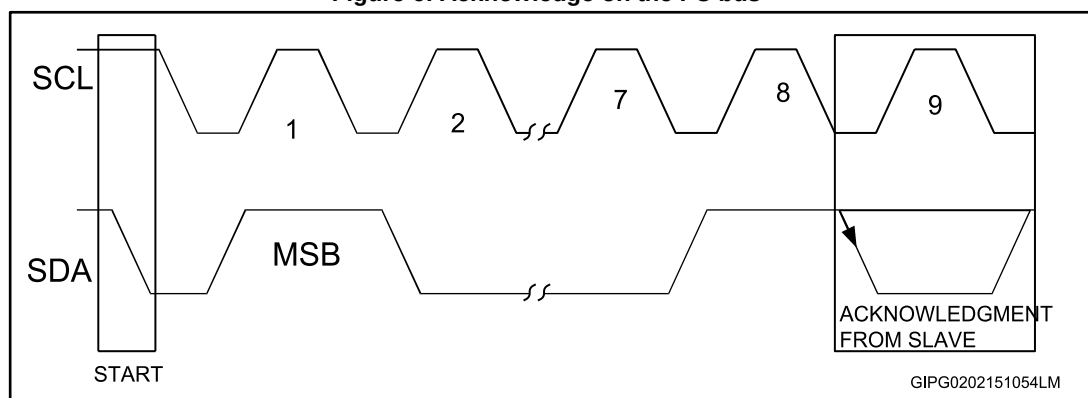
Every byte transferred to the SDA line must contain 8 bits. Each byte must be followed by an acknowledge bit. The MSB is transferred first.

### 6.4 Acknowledge

The master (microprocessor) puts a resistive HIGH level on the SDA line during the acknowledge clock pulse (see [Figure 6: "Acknowledge on the I<sup>2</sup>C bus"](#)). The peripheral (LNBH30), which acknowledges, must pull down (LOW) the SDA line during the acknowledge clock pulse, so that the SDA line is stable LOW during this clock pulse. The peripheral, which has been addressed, must generate acknowledge after the reception of each byte, otherwise the SDA line remains at the HIGH level during the nine<sup>th</sup> clock pulse time. In this case the master transmitter can generate the STOP information in order to abort the transfer. The LNBH30 does not generate acknowledge if the V<sub>CC</sub> supply is below the undervoltage lockout threshold (4.7 V typ.).

### 6.5 Transmission without acknowledge

If detection of the acknowledge of the LNBH30 is not required, the microprocessor can use a simpler transmission: it simply waits for one clock without checking the slave acknowledging, and sends the new data. This approach is of course less protected from misworking and decreases noise immunity.

Figure 4: Data validity on the I<sup>2</sup>C busFigure 5: Timing diagram of I<sup>2</sup>C busFigure 6: Acknowledge on the I<sup>2</sup>C bus

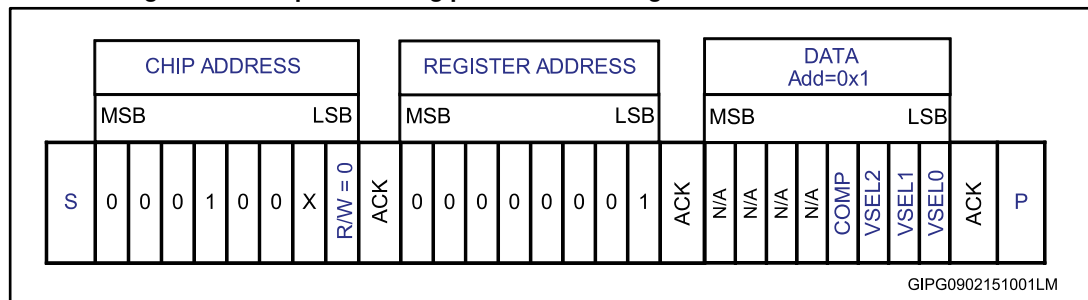
## 7 I<sup>2</sup>C interface protocol

### 7.1 Write mode transmission

The LNBH30 interface protocol is made up of:

- a start condition (S)
- a chip address byte with the LSB bit R/W = 0
- a register address (internal address of the first register to be accessed)
- a sequence of data (byte to write to the addressed internal register + acknowledge)
- a stop condition (P). The transfer lasts until a stop bit is encountered
- the LNBH30, as slave, acknowledges every byte transfer

**Figure 7: Example of writing procedure starting with first data address 0x1**



ACK = acknowledge

S = start

P = stop

R/W = 1/0, read/write bit

X = 0/1, set the values to select the chip address



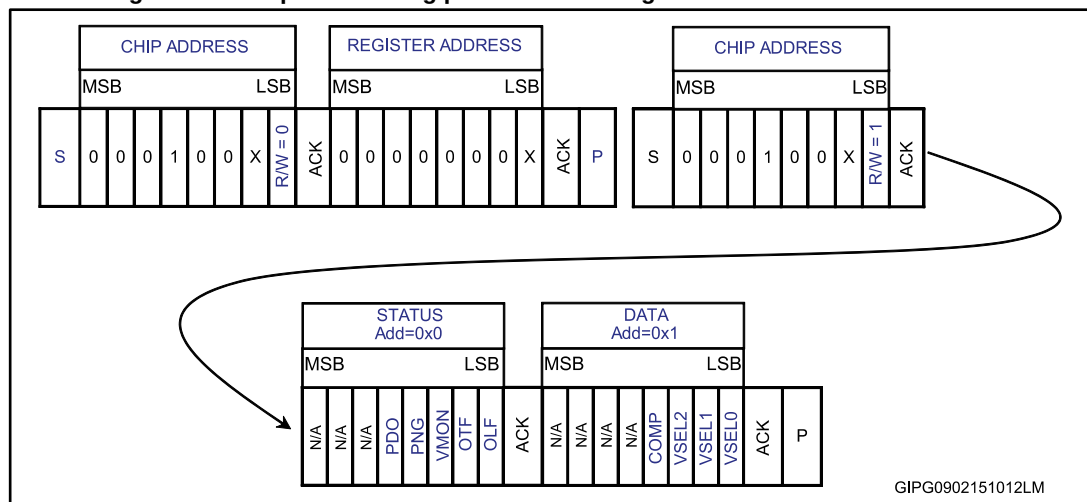
Only one data register address 0x1 is available for the writing procedure.

### 7.2 Read mode transmission

In read mode the byte sequence must be as follows:

- a start condition (S)
- a chip address byte with the LSB bit R/W=0
- the register address byte of the internal first register to be accessed
- a stop condition (P)
- a new master transmission with the chip address byte and the LSB bit R/W=1
- after the acknowledge the LNBH30 starts sending the addressed register content. As long as the master keeps the acknowledge LOW, the LNBH30 transmits the next address register byte content
- the transmission is terminated when the master sets the acknowledge HIGH with a following stop bit

Figure 8: Example of reading procedure starting with first status address 0x0



ACK = acknowledge

S = start

P = stop

R/W = 1/0, read/write bit

X = 0/1, sets the values to select the chip address and to select the register address (0x0 for status register and 0x1 for data register)



The reading procedure can start from any register address (status or data) by simply setting the X values in the register address byte (after the first chip address in the above figure). It can be also stopped by the master by sending a stop condition after any acknowledge bit.

## 7.3 Data registers

The data register can be addressed both to write and read mode. In read mode it returns the last writing byte status received in the previous write transmission.



The following table provides the data register values and a function description of each bit.

Table 6: Data (read/write register, register address = 0x1)

| Bit         | Name  | Value | Description                                                                                                                                                       |
|-------------|-------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bit 0 (LSB) | VSEL0 | 0/1   | Output voltage selection bits                                                                                                                                     |
| Bit 1       | VSEL1 | 0/1   |                                                                                                                                                                   |
| Bit 2       | VSEL2 | 0/1   |                                                                                                                                                                   |
| Bit 3       | COMP  | 0/1   | DC-DC converter internal compensation: set to "0" to use standard ESR capacitors (VUP pin)<br>Set to "1" to use very low ESR capacitors or ceramic caps (VUP pin) |
| Bit 4       | N/A   | 0     | Reserved. Keep to "0"                                                                                                                                             |

| Bit        | Name | Value | Description |
|------------|------|-------|-------------|
| Bit 5      | N/A  | 0     |             |
| Bit 6      | N/A  | 0     |             |
| Bit 7(MSB) | N/A  | 0     |             |

N/A=reserved bit

All bits reset to "0" at power-on

## 7.4 Status registers

The status register can be only addressed to read mode and provides the diagnostic functions described in the following tables.

**Table 7: Status (read register, register address = 0x0)**

| Bit         | Name | Value | Description                                                                                                                                                                       |
|-------------|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bit 0 (LSB) | OLF  | 1     | Output short-circuit or VOUT pin overload protection has been triggered ( $I_{OUT} > I_{MAX}$ )                                                                                   |
|             |      | 0     | No overload protection has been triggered to VOUT pin ( $I_{OUT} < I_{MAX}$ )                                                                                                     |
| Bit 1       | OTF  | 1     | Junction overtemperature is detected, $T_J > 150\text{ }^{\circ}\text{C}$                                                                                                         |
|             |      | 0     | Junction overtemperature is not detected, $T_J < 135\text{ }^{\circ}\text{C}$ . $T_J$ is below thermal protection threshold                                                       |
| Bit 2       | VMON | 1     | Output voltage (VOUT pin) lower than VMON specification thresholds. Refer to <a href="#">Table 9: "Electrical characteristics"</a>                                                |
|             |      | 0     | Output voltage (VOUT pin) is within the VMON specifications                                                                                                                       |
| Bit 3       | PNG  | 1     | Input voltage (VCC pin) lower than LPD minimum thresholds. Refer to <a href="#">Table 9: "Electrical characteristics"</a>                                                         |
|             |      | 0     | Input voltage (VCC pin) higher than LPD minimum thresholds. Refer to <a href="#">Table 9: "Electrical characteristics"</a>                                                        |
| Bit 4       | PDO  | 1     | Overcurrent detected on output pull-down stage for a time longer than the deglitch period. This may happen due to an external voltage source present on the LNB output (VOUT pin) |
|             |      | 0     | No overcurrent detected on output pull-down stage                                                                                                                                 |
| Bit 5       | N/A  | -     | Reserved                                                                                                                                                                          |
| Bit 6       | N/A  | -     |                                                                                                                                                                                   |
| Bit 7 (MSB) | N/A  | -     |                                                                                                                                                                                   |

N/A = reserved bit

All bits reset to 0 at power-on

Table 8: Output voltage selection (data register, write mode)

| VSEL2 | VSEL1 | VSEL0 | VOUT min. | VOUT pin voltage | VOUT max. | Function                                         |
|-------|-------|-------|-----------|------------------|-----------|--------------------------------------------------|
| 0     | 0     | 0     |           | 0.000            |           | VOUT disabled. The LNBH30 is set in standby mode |
| 0     | 0     | 1     | 11.387    | 11.800           | 12.213    |                                                  |
| 0     | 1     | 0     | 11.580    | 12.000           | 12.420    |                                                  |
| 0     | 1     | 1     | 11.900    | 12.333           | 12.765    |                                                  |
| 1     | 0     | 0     | 14.475    | 15.000           | 15.525    |                                                  |
| 1     | 0     | 1     | 14.796    | 15.333           | 15.870    |                                                  |
| 1     | 1     | 0     | 15.119    | 15.667           | 16.215    |                                                  |
| 1     | 1     | 1     | 15.440    | 16.000           | 16.560    |                                                  |

## 8 Electrical characteristics

Refer to [Section 5: "Typical application circuits"](#),  $T_J$  from 0 to 85 °C, data register bits set to 0 except VSEL0 = 1, RSEL = 16.2 k $\Omega$ ,  $V_{IN}$  = 12 V,  $I_{OUT}$  = 50 mA, unless otherwise stated. Typical values are referred to  $T_J$  = 25 °C.  $V_{OUT}$  =  $V_{OUT}$  pin voltage. See [Section 7: "I<sup>2</sup>C interface protocol"](#).

Table 9: Electrical characteristics

| Symbol        | Parameter                            | Test conditions                            | Min. | Typ.         | Max. | Unit     |
|---------------|--------------------------------------|--------------------------------------------|------|--------------|------|----------|
| $V_{IN}$      | Supply voltage                       |                                            | 10   | 12           | 17.5 | V        |
| $I_{IN}$      | Supply current                       | $I_{OUT}$ = 0 mA                           |      | 6            |      | mA       |
|               |                                      | VSEL0=VSEL1=VSEL2=0                        |      | 1            |      |          |
| $V_{OUT}$     | Output voltage total accuracy        | Valid at any $V_{OUT}$ selected level      | -3.5 |              | +3.5 | %        |
| $V_{OUT}$     | Line regulation                      | $V_{IN}$ = 8 to 16 V                       |      |              | 40   | mV       |
| $V_{OUT}$     | Load regulation                      | $I_{OUT}$ from 50 to 500 mA                |      |              | 100  |          |
| $I_{MAX}$     | Output current limiting thresholds   | RSEL = 16.2 k $\Omega$                     | 500  | 650          | 750  | mA       |
|               |                                      | RSEL = 22 k $\Omega$                       | 350  |              | 550  |          |
| $I_{SC}$      | Output short-circuit current         | RSEL = 16.2 k $\Omega$                     |      | 400          |      | mA       |
| SS            | Soft-start time                      | $V_{OUT}$ from 0 to 11.8 V                 |      | 4            |      | ms       |
| SS            | Soft-start time                      | $V_{OUT}$ from 0 to 15 V                   |      | 5            |      | ms       |
| T11-15        | Soft transition rise time            | $V_{OUT}$ from 11.8 V to 15 V              |      | 1.5          |      | ms       |
| T15-11        | Soft transition fall time            | $V_{OUT}$ from 15 V to 11.8 V              |      | 1.5          |      | ms       |
| $T_{OFF}$     | Dynamic overload protection off-time | Output shorted                             |      | 900          |      | ms       |
| $T_{ON}$      | Dynamic overload protection on-time  | Output shorted                             |      | $T_{OFF}/10$ |      |          |
| $G_{EXTM}$    | External modulation gain             | $\Delta V_{OUT}/\Delta V_{EXTM}$ , @44 kHz |      | 7.5          |      |          |
| $V_{EXTM}$    | External modulation input voltage    | EXTM AC coupling <sup>(1)</sup>            |      |              | 400  | mVpp     |
| $Z_{EXTM}$    | External modulation impedance        |                                            |      | 230          |      | $\Omega$ |
| $Eff_{DC/DC}$ | DC-DC converter efficiency           | $I_{OUT}$ = 500 mA                         |      | 93           |      | %        |
| $F_{SW}$      | DC-DC converter switching frequency  |                                            |      | 440          |      | kHz      |
| UVLO          | Undervoltage lockout thresholds      | UVLO threshold rising                      |      | 4.8          |      | V        |
|               |                                      | UVLO threshold falling                     |      | 4.7          |      |          |
| $V_{LPD}$     | Low power                            | $V_{LPD}$ threshold rising                 |      | 7.2          |      | V        |

| Symbol               | Parameter                     | Test conditions                                                                                                      | Min. | Typ. | Max. | Unit |
|----------------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------|------|------|------|------|
|                      | diagnostic (LPD) thresholds   | $V_{LPD}$ threshold falling                                                                                          |      | 6.7  |      |      |
| $I_{OBK}$            | Output backward current       | All $VSELX = 0$ , $V_{OBK} = 30\text{ V}$                                                                            |      | -3   | -6   | mA   |
| $I_{SINK}$           | Output low-side sink current  | $V_{OUT}$ forced at $V_{OUT\_NOM} + 0.1\text{ V}$                                                                    |      | 50   |      | mA   |
| $I_{SINK\_TIME-OUT}$ | Low-side sink current timeout | $V_{OUT}$ forced at $V_{OUT\_NOM} + 0.1\text{ V}$ , PDO I <sup>2</sup> C bit is set to 1 after this time has elapsed |      | 10   |      | ms   |
| $I_{REV}$            | Max. reverse current          | $V_{OUT}$ forced at $V_{OUT\_NOM} + 0.1\text{ V}$ , after PDO bit is set to 1 ( $I_{SINK\_TIME-OUT}$ elapsed)        |      | 2    |      | mA   |
| $T_{SHDN}$           | Thermal shutdown threshold    |                                                                                                                      |      | 150  |      | °C   |
| $\Delta T_{SHDN}$    | Thermal shutdown hysteresis   |                                                                                                                      |      | 15   |      | °C   |

**Notes:**

<sup>(1)</sup>External signal maximum voltage for which the EXT<sub>M</sub> function is guaranteed.

$T_J$  from 0 to 85 °C,  $V_I = 12\text{ V}$

**Table 10: I<sup>2</sup>C electrical characteristics**

| Symbol    | Parameter                | Test conditions                           | Min. | Typ. | Max. | Unit |
|-----------|--------------------------|-------------------------------------------|------|------|------|------|
| $V_{IL}$  | Low level input voltage  | SDA, SCL                                  |      |      | 0.8  | V    |
| $V_{IH}$  | High level input voltage | SDA, SCL                                  | 2    |      |      |      |
| $I_{IN}$  | Input current            | SDA, SCL $V_{IN} = 0.4$ to $4.5\text{ V}$ | -10  |      | 10   | μA   |
| $V_{OL}$  | Low level output voltage | SDA (open drain), $I_{OL} = 6\text{ mA}$  |      |      | 0.6  | V    |
| $F_{MAX}$ | Maximum clock frequency  | SCL                                       |      |      | 400  | kHz  |

$T_J$  from 0 to 85 °C,  $V_I = 12\text{ V}$

**Table 11: Address pin characteristics**

| Symbol       | Parameter                                | Test conditions                                                      | Min. | Typ. | Max. | Unit |
|--------------|------------------------------------------|----------------------------------------------------------------------|------|------|------|------|
| $V_{ADDR-1}$ | "0001000(R/W)" address pin voltage range | R/W bit determines the transmission mode: read (R/W=1) write (R/W=0) | 0    |      | 0.8  | V    |
| $V_{ADDR-2}$ | "0001001(R/W)" address pin voltage range | R/W bit determines the transmission mode: read (R/W=1) write (R/W=0) | 2    |      | 5    | V    |

Refer to [Section 5: "Typical application circuits"](#),  $T_J$  from 0 to 85 °C, data register bits set to "0",  $R_{SEL} = 16.2\text{ k}\Omega$ ,  $DSQIN = \text{low}$ ,  $V_{IN} = 12\text{ V}$ ,  $I_{OUT} = 50\text{ mA}$ , unless otherwise stated. Typical values are referred to  $T_J = 25\text{ °C}$ .  $V_{OUT} = V_{OUT}$  pin voltage.

**Table 12: Output voltage diagnostic (VMON bit, status register) characteristics**

| Symbol     | Parameter                                             | Test conditions                   | Min. | Typ. | Max. | Unit |
|------------|-------------------------------------------------------|-----------------------------------|------|------|------|------|
| $V_{TH-L}$ | Diagnostic low threshold at $V_{OUT} = 11.8\text{ V}$ | $VSEL0 = 1$ , $VSEL1 = VSEL2 = 0$ | 80   | 90   | 95   | %    |
| $V_{TH-L}$ | Diagnostic low threshold at $V_{OUT} = 15\text{ V}$   | $VSEL1=0$ , $VSEL0 = VSEL2 = 1$   | 80   | 90   | 95   | %    |



If the output voltage is lower than the min. value the VMON I<sup>2</sup>C bit is set to 1.

If  $VMON=0$  then  $V_{OUT} > 80\%$  of  $V_{OUT}$  (typ.)

If  $VMON=1$  then  $V_{OUT} < 95\%$  of  $V_{OUT}$  (typ.)

## 9 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: **[www.st.com](http://www.st.com)**. ECOPACK® is an ST trademark.

## 9.1 QFN16 (4x4 mm) package information

**Figure 9: QFN16 (4x4 mm) package outline**

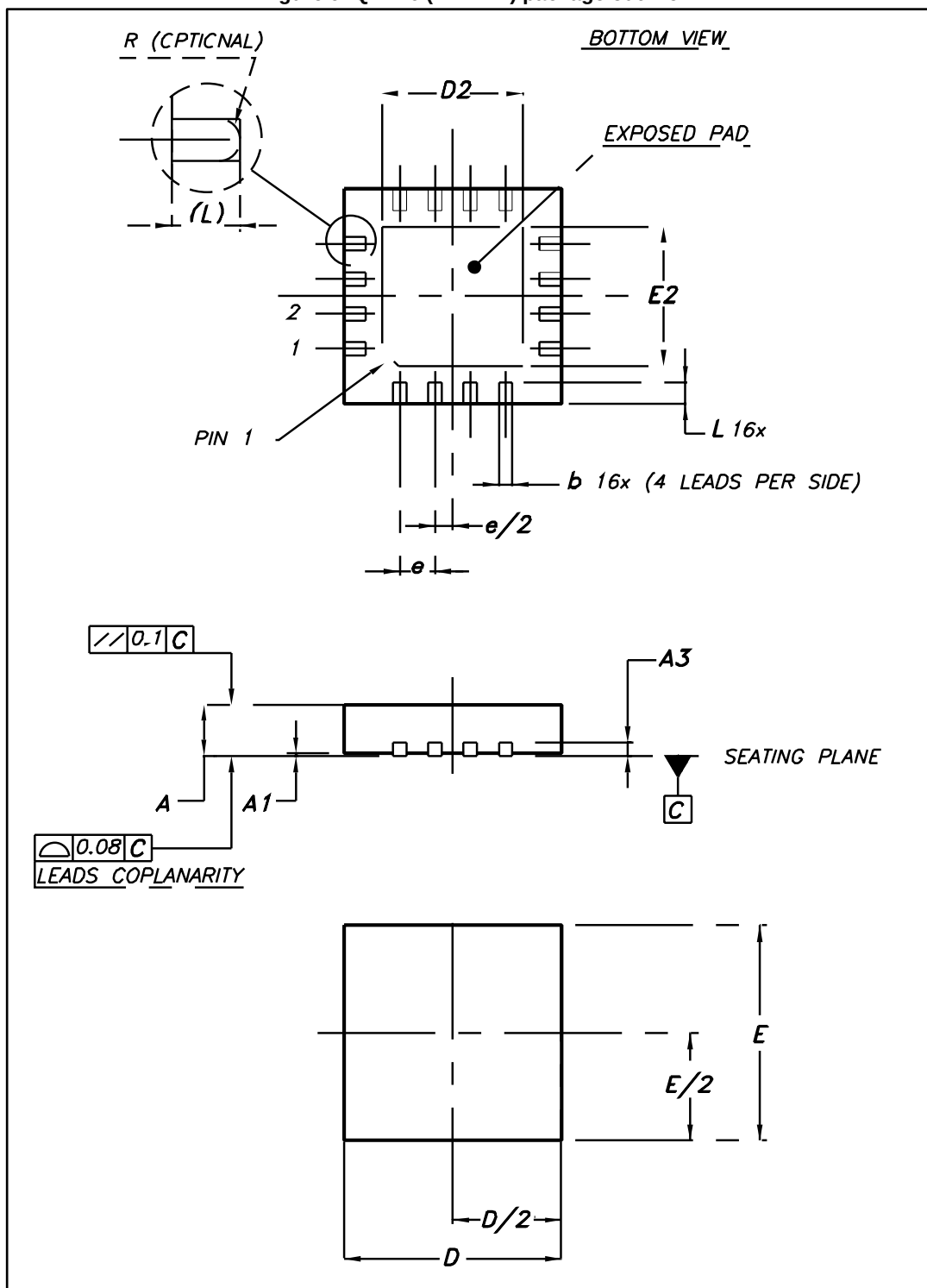
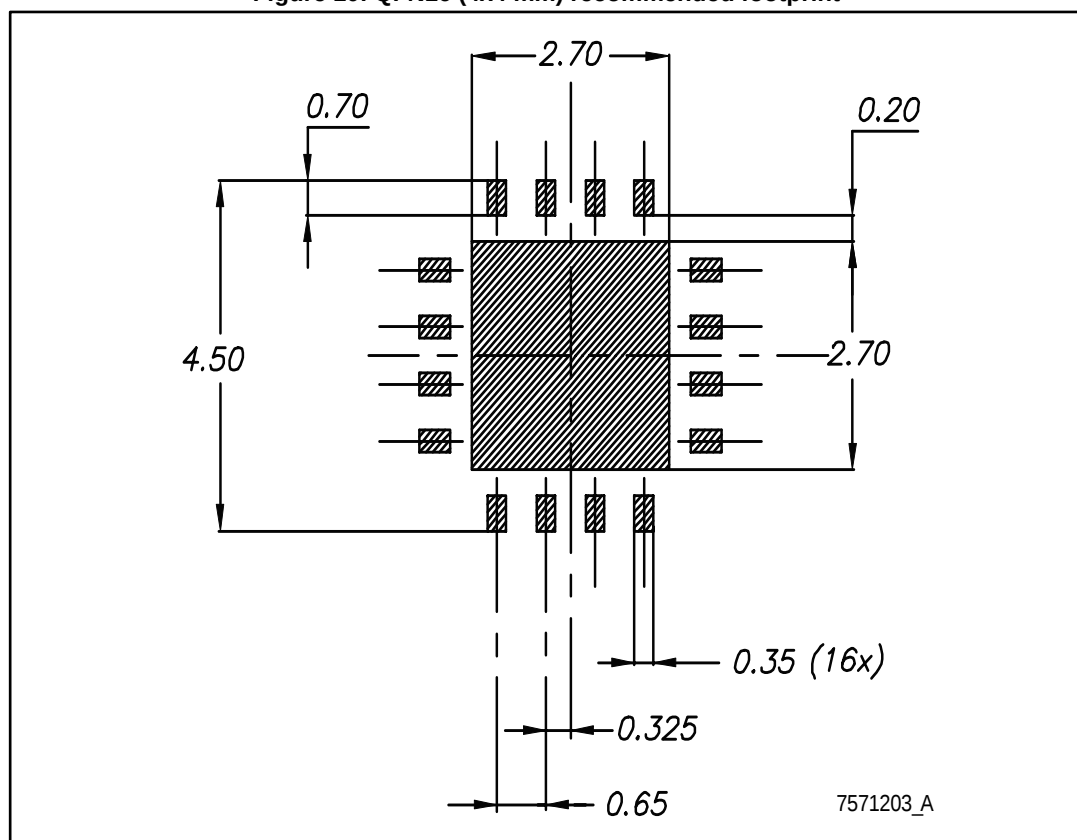


Table 13: QFN16 (4x4 mm) mechanical data

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 0.80 | 0.90 | 1.00 |
| A1   | 0.00 | 0.02 | 0.05 |
| A3   |      | 0.20 |      |
| b    | 0.25 | 0.30 | 0.35 |
| D    | 3.90 | 4.00 | 4.10 |
| D2   | 2.50 |      | 2.80 |
| E    | 3.90 | 4.00 | 4.10 |
| E    | 3.90 | 4.00 | 4.10 |
| E2   | 2.50 |      | 2.80 |
| e    |      | 0.65 |      |
| L    | 0.30 | 0.40 | 0.50 |

Figure 10: QFN16 (4x4 mm) recommended footprint



## 10 Revision history

**Table 14: Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16-Oct-2012 | 1        | Initial release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 19-Mar-2015 | 2        | Update Section 2.1: "Output current limit selection" and Table 9: "Electrical characteristics".                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 11-Oct-2017 | 3        | Updated features and description in cover page.<br>Updated <a href="#">Section 2.1: "Data encoding"</a> .<br>Updated <a href="#">Table 2: "Pin description"</a> , <a href="#">Table 3: "Absolute maximum ratings"</a> , <a href="#">Table 5: "Typical application circuit bill of material"</a> and <a href="#">Table 9: "Electrical characteristics"</a> .<br>Updated <a href="#">Figure 1: "Block diagram"</a> , <a href="#">Figure 2: "Pin connections (top view)"</a> and <a href="#">Figure 3: "Application circuit"</a> . |

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