# GS-BT2416C1.H

## Bluetooth® class 1 module with embedded HCI FW

## Features

- Bluetooth® specification V.1.2 compliant
- Transmission rate up to 721 Kbps
- Output power class 1 ( 20 dBm max)
- Working distance  up to 100 meters
- ACL and SCO links
- AFH interference resistance
- Supports USB (1.1) /UART/PCM (pulse code modulation)/SPI/ I²C interfaces
- Optimized link manager and control
- Support wireless LAN coexistence in collocated scenario
- Integrated 4 Mbit Flash, 64 Kbytes RAM, 4 Kbytes ROM
- 3.3 V single supply voltage
- Hardware based UART flow control

## Applications

- Serial cable replacement
- Industrial control
- Laptops
- POS terminals
- Data acquisition equipment
- Internet access points
- Machine control
- Sensor monitoring
- Robotic and bionic control
- Security control
- Patient monitoring
- Audio gateway applications
- Hands-free sets
- Wireless printers
- Cordless terminals
- Laptops, PCs and accessories
- Hand held devices and accessories
- HID devices (keyboard, mouse, joystick, game controller...)



## Description

ST Bluetooth® modules are highly integrated for easy implementation in embedded applications. Class 1 modules enable wireless communication with other Bluetooth® enabled devices up to 100 m away. The GS-BT2416C1.H integrates on a unique FR4 PCB support: BT 1.2 radio and baseband, memory, 32 kHz and 13 MHz oscillator, Vreg as well PA function. The module embeds customer framework up to HCI level allowing interoperability with HCI top resident on Host. The antenna has not been included in order to grant a degree of freedom to the user in selecting the most suitable design and placement between external and integrated antenna that could be SMA aerial or a low cost antenna trace designed on PCB. For more details pleas refer to GS-BT2416C1DB application note. The GS-BT2416C1.H is the HCI module of the GS-BT2416C1.xx series. GS-BT2416C1.H is BQB pre-qualified. Conformance testing through Bluetooth® qualification program enables a fast time to market after system integration by ensuring a high degree of compliance and interoperability.

# Contents

# 1 Certifications

- CE compliant (IMQ Exp. opinion 0081-AREF00017)
    - Safety EN60950-1 (2001)
    - EMC EN301 489 17V1.2.1
    - Radio ES 300 328 V1.6.
    - FCC certified on GS-BT2416C1DB (for a more exhaustive explanation, please refer to GS-BT2416C1DB application note)
    - FCC ID: S9NBT2416C1DB
- BQB compliant

# 2 Maximum ratings

## 2.1 Absolute maximum ratings

Absolute maximum ratings (see *Table 1*) indicate limits beyond which damage to the device may occur. Sustained exposure to these limits will adversely affect device reliability.

Operating ranges (see *Table 2*) define the limits for functional operation and parametric characteristics of the module. Functionality outside these limits is not implied.

**Table 1.  Absolute maximum ratings**

| Symbol | Parameter | Values | | Unit |
|--------|-----------|--------|--------|------|
| | | Min | Max | |
| $V_{DD}$ | Module supply voltage | | 4 | V |
| $V_{IN}$ | Input voltage on any digital pin | $Vss_1$-0.5 | Vdd+0.3 | V |
| $T_{stg}$ | Storage temperature | -40 | +85 | °C |
| $T_{sold}$ | Soldering temperature | | 240 | |

## 2.2 Operating ranges

**Table 2.  Operating ranges**

| Symbol | Parameter | Conditions | Values | | | Unit |
|--------|-----------|-----------|--------|------|------|------|
| | | | Min | Typ | Max | |
| $V_{DD}$ | Module supply voltage | - 20 °C < T < 70 °C | 3.13 | 3.3 | 3.47 | V |
| $T_{stg}$ | Operating ambient temperature | | -20 | | +70 | °C |

# 3 Electrical characteristics

## 3.1 DC I/O specification

**Table 3.    DC input / output specification**

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------|-----------|------------|-----|-----|-----|------|
| | | | Values | |
| $V_{il}$ | Low level input voltage | $3.13\ V < V_{DD} < 3.47\ V$ | | | 0.8 | V |
| $V_{ih}$ | High level input voltage | $3.13\ V < V_{DD} < 3.47\ V$ | 2 | | | V |
| $V_{hyst}$ | Schmitt trigger hysteresis | $3.13\ V < V_{DD} < 3.47\ V$ | 0.4 | | | V |
| $V_{ol}$ | Low level output voltage | Io load = pin drive capability | | | 0.15 | V |
| $V_{oh}$ | High level output voltage | Io load = pin drive capability | $V_{DD}$-0.15 | | | V |

# 4 Bluetooth® section

**Table 4.    Bluetooth® section**

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------|-----------|------------|-----|-----|-----|------|
| | | | Values | |
| CHs | Channel space | | | 1 | | MHz |
| Hop | Hopping | | | 1600 | | Hops/sec |
| 13M CK | System clock | | | 13 | | MHZ |
| | System clock stability | - 20 °C to 70 °C | - 20 | | 20 | ppm |
| LP CK | Low power clock | | | 32 | | kHz |
| | Low power clock accuracy | | - 200 | | 200 | ppm |
| Tra | Transmission rate asynchronous | | | | 721 | Kbits/sec |
| Trs | Transmission rate synchronous | | | | 432 | Kbits/sec |
| Iop | Operation current TX mode | | | 180 | | mA |
| | Operation RX mode | | | 60 | | mA |

## 4.1      RF performance characteristics

In the performance characteristics table the following applies:

● Test condition: nominal
   – Voltage typical Vdd 3.3 V
   – Temperature typical $T_A$ = 25 °C

Parameters are given at antenna pin

**Table 5.      Transmitter and receiver performance characteristics**

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| TX Pout | TX output power | 2.402 GHz | | 18 | 20 | dBm |
| | | 2.441 GHz | | 18 | 20 | dBm |
| | | 2.480 GHz | | 18 | 20 | dBm |
| ACP | TX output spectrum adjacent channel power | IM-NI = 2 | | - 36 | | dBm |
| | | IM-NI ≥ 3 | | - 44 | | dBm |
| RX sens | Receiver sensitivity | @BER 0.1 % | | - 84 | | dBm |

**Table 6.      Synthesizer performance characteristics**

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| RF in RF out | Input and output frequency range | | 2402 | | 2480 | MHz |
| TX out | TX output spectrum at -20 dB Bandwidth | | | 920 | 1000 | kHz |
| ΔF | TX initial carrier frequency tolerance | | - 75 | | 75 | kHz |
| IΔF –pn I | TX carrier frequency drift | DH1 data packet | | | 25 | kHz |
| | | DH3 data packet | | | 40 | kHz |
| | | DH5 data packet | | | 40 | kHz |
| IΔF/50µsI | | Drift rate | | | 20 | Hz |

# 5     Integrate firmware

The GS-BT2416C1.H includes customer framework up to HCI (host control interface)

**Figure 1.    HCI firmware implementation**
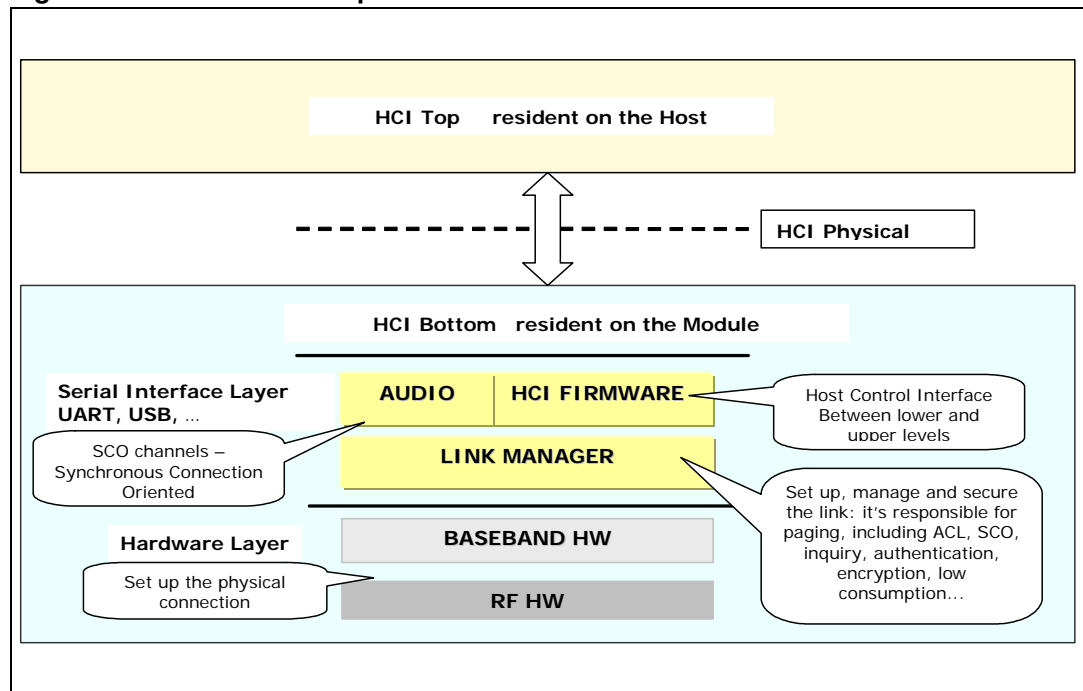


## 5.1     Features

The module with HCI embedded is interoperable with qualified BT stack protocols and suitable for any BT applications.

## 5.2     Command interface

The HCI commands are accessible through the serial port using the host control SW any HCI SW for example bluesoleil (most popular Bluetooth® PC open SW).

## 5.3     Usage scenarios

The module with embedded HCI FW is completely open to any custom implementation, strictly depending on the BT stack and profiles that will be added. Module can be configured both as master or slave. Master can support point to point connection or standard point to multi point Pico net up to seven points.

# 6        Application information

Here below there are some suggestions to better implement the module in the final application.

● Module is usually put on a motherboard, avoid that traces with switching signals are routed below the module. The best would be to have a ground plane underneath the module.

● Connect the supply voltage ground of the module with the other grounds present on the motherboard in a star way.

● Keep the RF ground separate from the module supply voltage ground; the two grounds are already connected inside the module in one point, see below a possible implementation.

**Figure 2.    Module foot print**
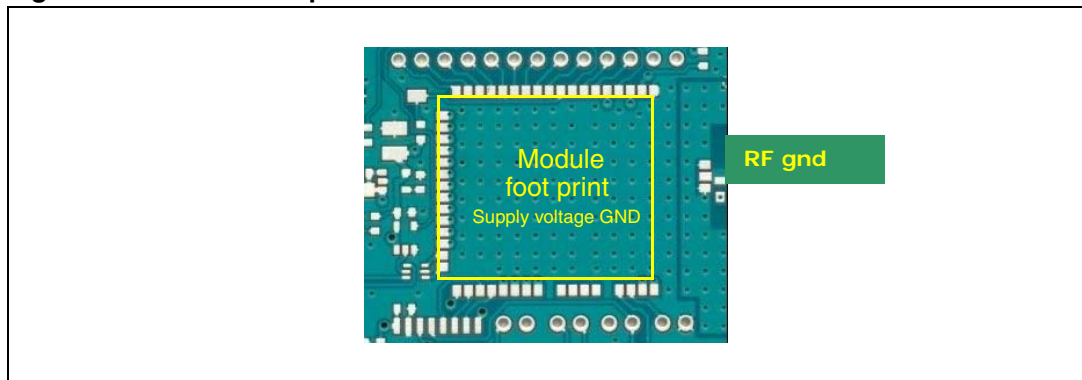
## 6.1        Antenna reference

RF output pin must be connected to an antenna which could be:

● Antenna directly printed on the pcb (*Figure 3.*)

● Integrated antenna as, for example, antenova® 30-30-A5839-01, Murata ANCV12G44SAA127, pulse W3008, Yageo CAN4311153002451K. (*Figure 4.*)

● External antenna connected by means a SMA connector (*Figure 5.*)

**Figure 3.    Antenna on PCB        Figure 4.    Antenna examples    Figure 5.    SMA connector for external antenna**



● Despite of the type of antenna chosen, the connection between the RF out pin and the antenna must be executed in such a way that the connection trace must be matched to have characteristic impedance (Z0) of 50 Ω to get the maximum power transfer.

● Matching for 50 Ω is depending on the various factors, elements to be taken into consideration are:

  – Type of material, i.e. FR4

  – The electrical characteristics of the material, i.e. the εr, electric constant at 2.4 GHz

  – Mechanical dimensions of the PCB and traces, i.e. PCB thickness, trace/ reference ground thickness, trace width, trace thickness.

  – Just to give an example, using a 1 mm thick FR4 board, with an εr = 4.3 at 2.4 GHz, with Cu thickness of 41 μm, the resulted width of 50 Ω strip-line is 1.9 mm (Microstrip type calculation).

**Figure 6.    Parameters for trace matching**
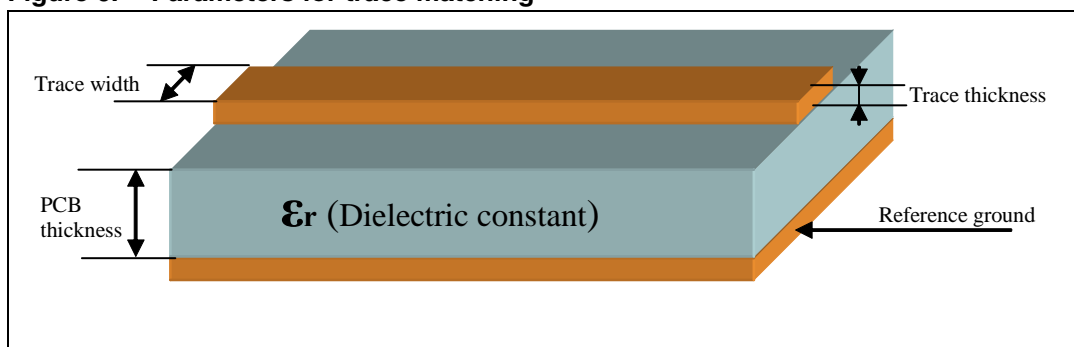


Tools for calculating the characteristic impedance, based on the physical and mechanical characteristics of the PCB, can be easily found on the web.
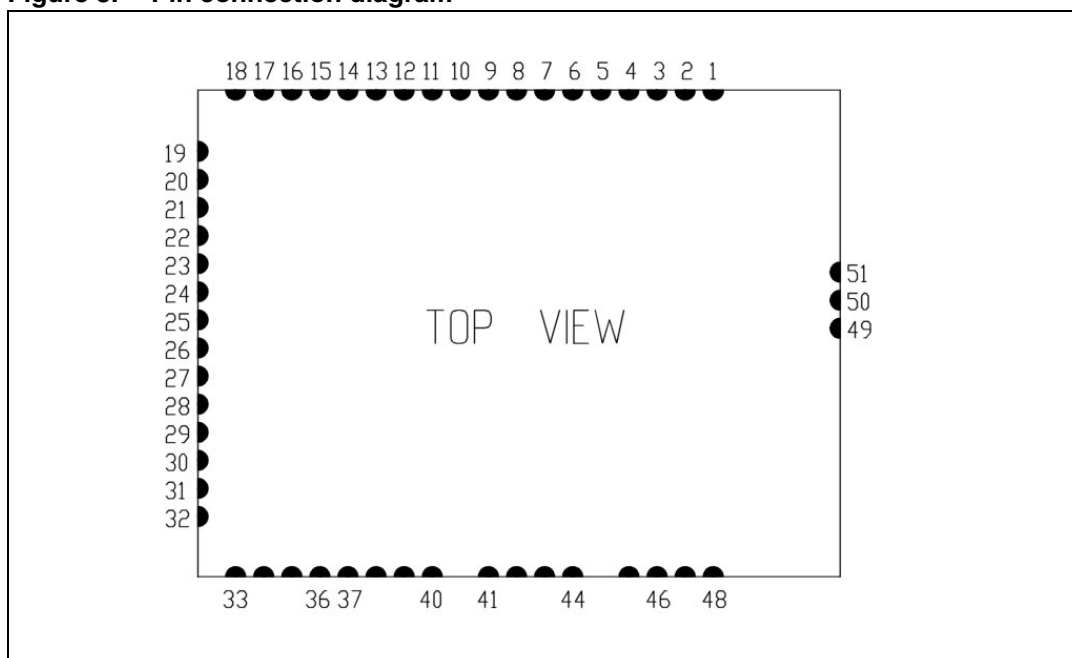
# 7 Block diagram

**Figure 7.    Block diagram**
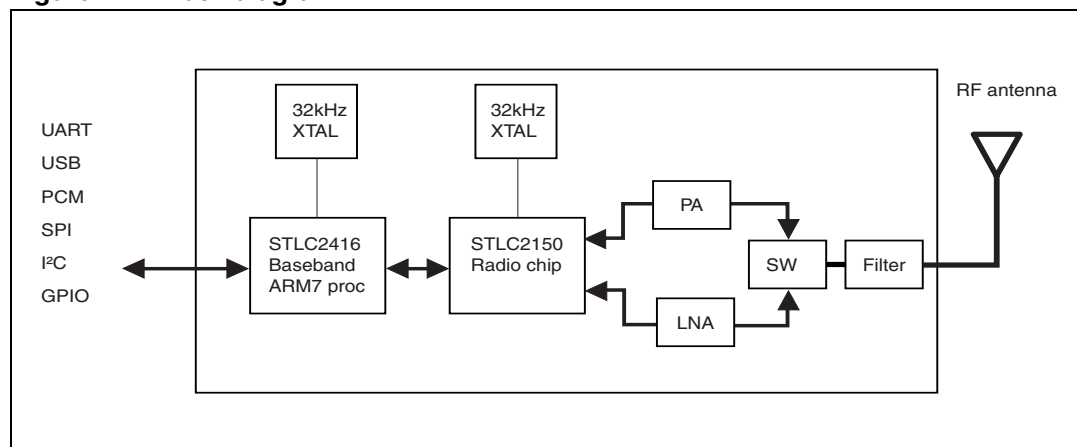
# 8 Pin settings

## 8.1 Pin connections

**Figure 8.    Pin connection diagram**

## 8.2 Pin descriptions

**Table 7. Pin descriptions**

| Pin N° | Name | I/O | Description |
|--------|------|-----|-------------|
| **Power, ground and system signal** | | | |
| 1 | $Vss_1$ | --- | GND |
| 2 | Vdd | --- | Module supply voltage- single 3.3 V |
| 41 | 1V8 | O | 1.8 V digital supply out (test purpose) to be left not connected |
| 42 | 3V3 | O | 3.3 V I/O power supply out (test purpose) to be left not connected |
| 43 | $Vss_1$ | --- | GND (test purpose) to be left not connected |
| 44 | 2V7 | O | 2.7 digital core supply out (test purpose) to be left not connected |
| 45 | RESET | I | Reset pin (active low) |
| 46 | BOOT | I | External downloading enable (active low) internally pull-upped to 1.8 V by 10 k$\Omega$ |
| 13 | LP CLOCK OUT | O | 32 kHz out |
| 26 | INT1 | I | External Interrupt signal internally connected to VSS1 with 10 k$\Omega$ / If not used connect to VSS1 |
| **General purpose signals** | | | |
| 3 | GPIO0 | I/O | General purpose I/O line |
| 4 | GPIO1 | I/O | General purpose I/O line |
| 5 | GPIO2 | I/O | General purpose I/O line |
| 6 | GPIO3 | I/O | General purpose I/O line |
| 7 | GPIO4 | I/O | General purpose I/O line |
| 8 | GPIO5 | I/O | General purpose I/O line |
| 10 | GPIO7 | I/O | General purpose I/O line |
| 11 | GPIO8 | I/O | General purpose I/O line |
| 12 | GPIO9 | I/O | General purpose I/O line |
| 14 | GPIO11 | I/O | General purpose I/O line |
| **No connect signals** | | | |
| 9 | ---- | I/O | Not to be used internally used for RX/TX switch |
| 15 | ---- | I/O | Not to be used internally used for TX gain setting |
| 16 | ---- | I/O | Not to be used internally used for TX gain setting |
| 17 | ---- | I/O | Not to be used internally used for TX gain setting |
| 18 | ---- | I/O | Not to be used internally used for TX gain setting |

**Table 7.** **Pin descriptions (continued)**

| Pin N° | Name | I/O | Description |
|---|---|---|---|
| **Test interface signals** | | | |
| 19 | TDI | --- | JTAG pin |
| 20 | TDO | --- | JTAG pin |
| 21 | TMS | --- | JTAG pin |
| 22 | NTRST | --- | JTAG pin |
| 23 | TCK | --- | JTAG pin If not used connect to VSS1 |
| **I2C interface signals** | | | |
| 24 | I2C_dat | I/O | I2C bus interface data to be connected to VDD with 10 k$\Omega$ resistor |
| 25 | I2C_clk | I/O | I2C bus interface clock to be connected to VDD with 10 k$\Omega$ resistor |
| **PCM interface signals** | | | |
| 27 | PCM_SYNC | I/O | PCM 8 kHz synch |
| 28 | PCM_CLK | I/O | PCM clock |
| 29 | PCM_A | I/O | PCM data in/out |
| 30 | PCM_B | I/O | PCM data in//out |
| **USB interface signals** | | | |
| 31 | USB_DN | I/O | USB data - If not used connect to VSS1 |
| 32 | USB_DP | I/O | USB data + If not used connect to VSS1 |
| **UART interface signals** | | | |
| 33 | UART2_RXD | I | UART2 data input If not used connect to VDD |
| 34 | UART2_TXD | O | UART2 data output |
| 35 | UART2_I1 | I | UART2 clear to send input If not used connect to VDD |
| 36 | UART2_02 | O | UART2 ready to send output |
| 47 | UART10_TXD | O | UART1 data output |
| 48 | UART11_RXD | I | UART1 data input If not used connect to VDD |
| **SPI interface signals** | | | |
| 37 | SPI_FRM | I/O | Synchronous serial interface frame synch |
| 38 | SPI_CLK | I/O | Synchronous serial Interface clock |
| 39 | SPI_TXD | O/T | Synchronous serial Interface transmit data |
| 40 | SPI_RXD | I | Synchronous serial Interface receive data If not used connect to VSS1 |
| **Antenna signals** | | | |
| 49 | Vss$_2$ ( RF GND) | --- | RF GND |
| 50 | +ANTENNA | --- | Antenna out |
| 51 | Vss$_2$ (RF GND) | --- | RF GND |

# 9 Soldering

Soldering phase has to be execute with care: in order to avoid undesired melting phenomenon, particular attention has to be take on the set up of the peak temperature.

Here following some suggestions for the temperature profile based on IPC/JEDEC J-STD-020C, July 2004 recommendations.

**Table 8.     Soldering**

| Profile feature | PB free assembly |
|---|---|
| Average ramp up rate ($T_{SMAX}$ to TP) | 3 °C / sec  max |
| Preheat<br>Temperature min ($T_S$ min)<br>Temperature max ($T_S$ max)<br>Time ($t_S$ min to $t_S$ max) ($t_S$) | <br>150 °C<br>200 °C<br>60 – 100 sec |
| Time maintained above:<br>Temperature $T_L$<br>Time $t_L$ | <br>217 °C<br>40 – 70 sec |
| Peak temperature  ($T_p$) | 240 + 0 °C |
| Time within  5 °C  of actual peak temperature ($t_P$) | 10 – 20 sec |
| Ramp down rate | 6 °C / sec |
| Time from 25 °C to peak temperature | 8 minutes max |

**Figure 9.     Soldering**
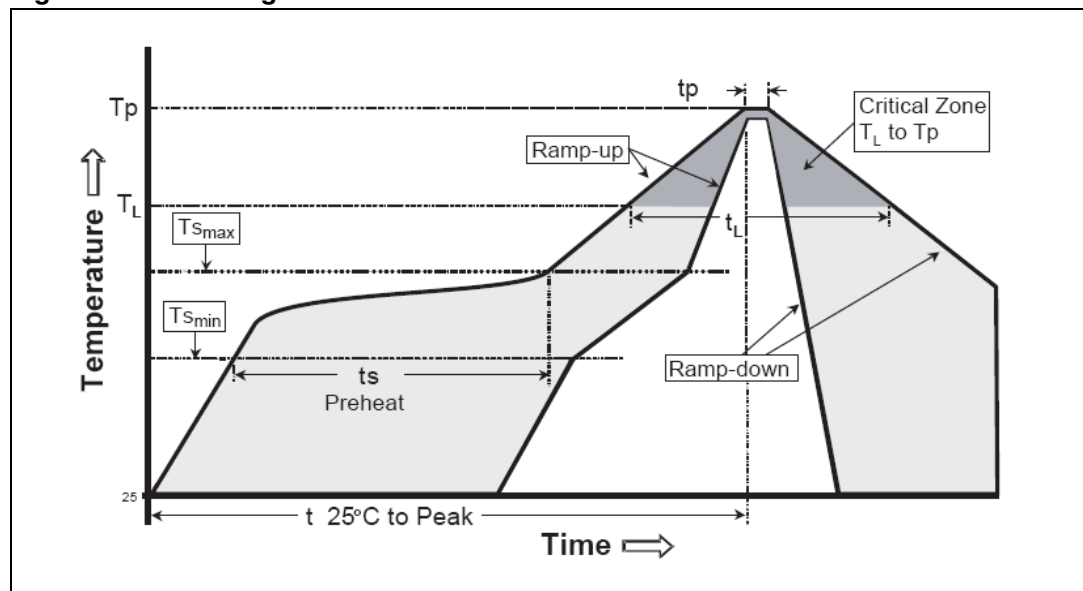
# 10    Mechanical dimensions

In order to meet environmental requirements, ST offers these devices in ECOPACK®
packages. These packages have a lead-free second level interconnect. The category of
second level interconnect is marked on the package and on the inner box label, in
compliance with JEDEC Standard JESD97. The maximum ratings related to soldering
conditions are also marked on the inner box label. ECOPACK is an ST trademark.
ECOPACK specifications are available at: www.st.com.

**Figure 10.  Mechanical dimensions**

**Figure 11.  Land pattern**



RECOMMENDED LAND PATTERN TOP VIEW
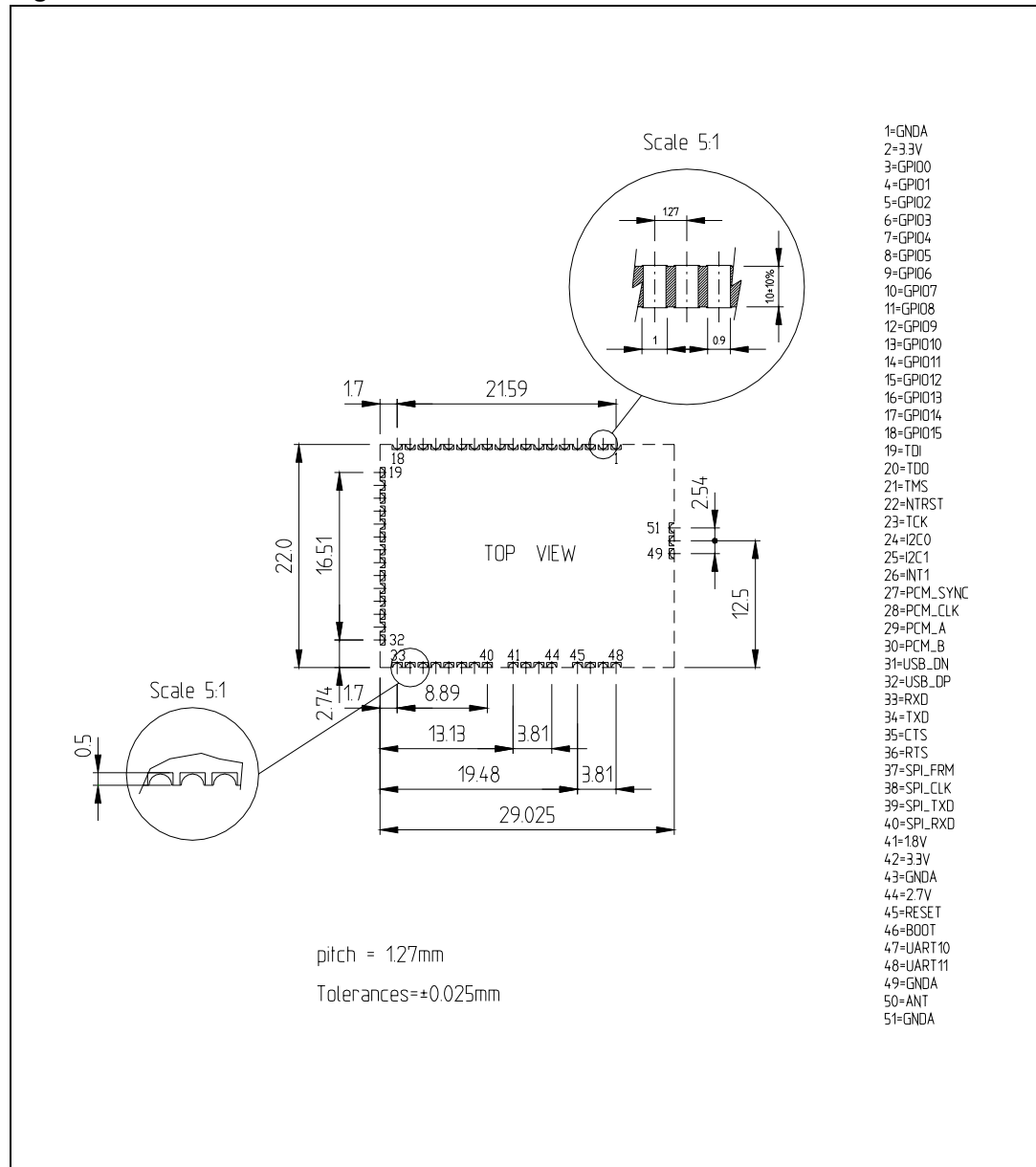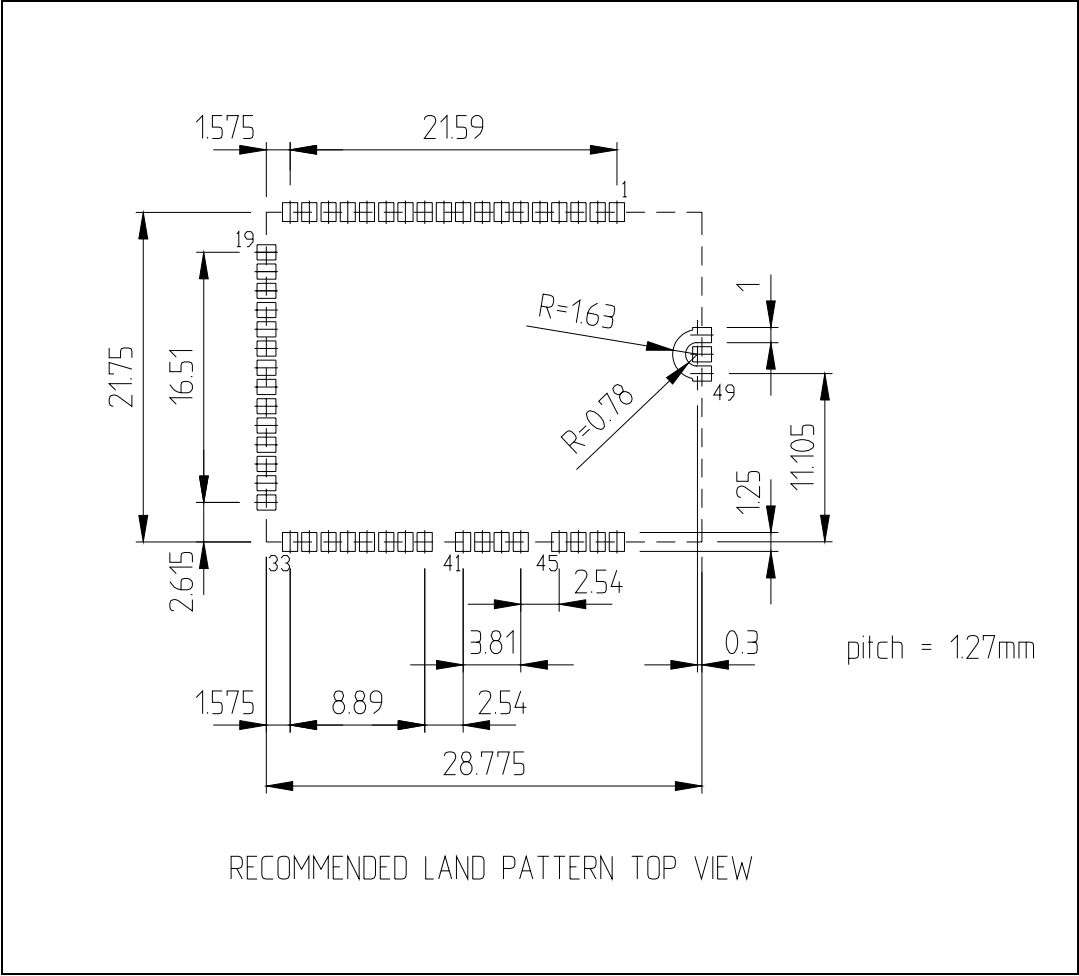
# 11 Ordering information scheme

**Table 9.    Ordering information scheme**

|  | GS-BT | 2416 | C1 | H |
|---|---|---|---|---|
| Bluetooth® modules | | | | |
| V 1.2 compliant | | | | |
| Class 1 | | | | |
| Embedded HCI | | | | |

# 12 Revision history

**Table 10. Revision history**

| Date | Revision | Changes |
|------|----------|---------|
| 31-Aug-2006 | 1 | First release |
| 27-May-2008 | 2 | Updated: Cover page<br>Added: *Section 9 on page 14* |

**Please Read Carefully:**