Successful Bluetooth® Radio Certification

Texas Instruments
Application Note
September 2005
Revised February 2013

1.0 Introduction

The key to successful Bluetooth certification is preparation. This document is organized into these sections covering reasons for certification, certification requirements, and the all-important preparation process:

2.0 Bluetooth Technology

Bluetooth technology is a simple cable replacement medium for voice and data transfer. Normally, where a cable would be used between two devices 5 to 10 m apart, Bluetooth class 2 modules may be used instead. Several solutions are possible, ranging from chip-based using separate radio and baseband chips to an integrated module, complete with passive components and preprogrammed software.

The LMX9820A and LMX9830 Simply Blue products can be used in various embedded designs and cable replacements. LMX5452 and LMX5453 HCI modules can be used for USB dongles for PCs and wireless interface to peripheral devices such as digital cameras, PDAs, and medical instrumentation.

3.0 Certification Required

Because Bluetooth radio involves transmitting power at 2.4 GHz at up to 100 mW, it has to be controlled and regulated like any other electronic device. Figure 1 shows the FCC spectrum allocation in the region around the Industrial/Scientific/Medical (ISM) band between 2.4 and 2.5 GHz. Bluetooth radio uses 79 1 MHz channels in the ISM band, between 2.4000 and 2.4835 GHz.

Regulatory tests are those required by law to ensure safety for the user from any electronic equipment and its compatibility with other electronic equipment operating within the same vicinity. The regulations vary depending on the country in which the equipment is being used. For example, CE regulations govern the European market, and FCC regulations govern the United States. In addition to this, the equipment may have to be tested for SAR which places a maximum limit on the absorption of radiation by the human body for all equipment that is worn, such as headsets. EMC testing for unwanted spurious emissions and tolerance of emissions from other sources is a key requirement. LVD testing ensures that equipment operating within a certain voltage range (especially the AC line) meets the approved safety requirements for the user and meets the single European market requirements.

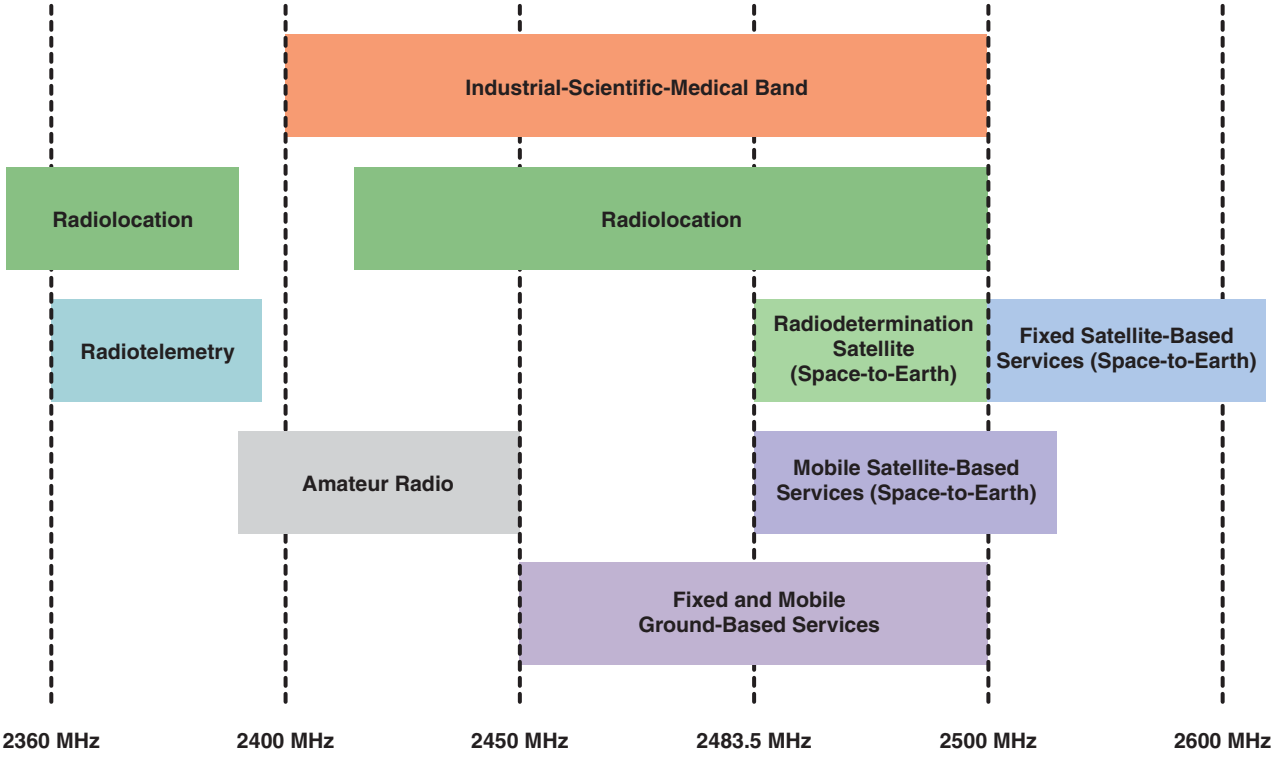

Figure 1. FCC Spectrum Allocation

The tests required depend on the system being evaluated, for example a GSM mobile phone or a DECT phone. In the case of a Bluetooth radio the tests required are as below. More details can be found under FCC part 15.247 which gives a complete listing together with test equipment settings, device settings and test limits.

Table 1. FCC Test Case Summary

Test Case	Description
Peak Power	Ensure the device is transmitting below a specified limit.
20 dB Bandwidth	Ensure that the device transmit spectrum (spectral mask) is within specified limits.
Carrier Frequency Separation	For Bluetooth, the center-to-center distance between channels is 1 MHz.
Number of Hopping Frequencies	Bluetooth typically has 79 separate channels between 2.400 and 2.483 GHz.
Time of Occupancy (Dwell time)	To make sure that the power is evenly distributed across the band.
Band Edge Compliance	Check power spill-over into neighboring bands.
Power Spectral Density	Spectral density implies the average power in a given band.
Conducted and Radiated Spurious Emissions	Ensure the device is not transmitting above a specified amount of power into other bands.

All eight test cases must be passed to be compliant with the American standard. CE test cases for Europe are very similar and are designed to comply with safety and interoperability with other electronic equipment within Europe. CE allows self-certification, meaning that you can test in-house and present data to guarantee performance is within specification.

Bluetooth Qualification testing, however, is specifically designed to meet the standards set forth by the Bluetooth SIG, which governs these standards and requires devices to meet these standards for official listing as Bluetooth compliant. The tests are listed in Table 2, and a complete description can be found under the ETSI specification, document number 20.B.353.

Table 2. Bluetooth RF Qualification Test Cases

Transmitter	Receiver
Output Power	Sensitivity
Power Density	C/I Performance
Power Control	Blocking Performance
Frequency Range	Intermodulation Performance
20 dB Bandwidth	Maximum Input Level
Adjacent Channel Power	
Modulation Characteristics	
Initial Carrier Frequency	
Carrier Drift	
Spurious Emissions (out-of-band)	

3.1 Certification Process

Figure 2 shows the process required to gain Bluetooth qualification approval. In addition to Bluetooth qualification, there is also regulatory approval which must be obtained before the product can be manufactured and sold.

The product manufacturer needs to become a adopter or Bluetooth member to sell products with the Bluetooth logo and technology. The product manufacturer submits the device with all relevant documentation to the BQTF. The device is then measured against the test cases shown in Table 1 and Table 2. All test cases in Table 1 must be passed, otherwise the Member cannot sell the device. Only when all tests shown in both tables have passed can the results and documentation be passed to the BQB, who then reviews and approves the test report and passes it on to the BQA for officially listing as an approved Bluetooth device.

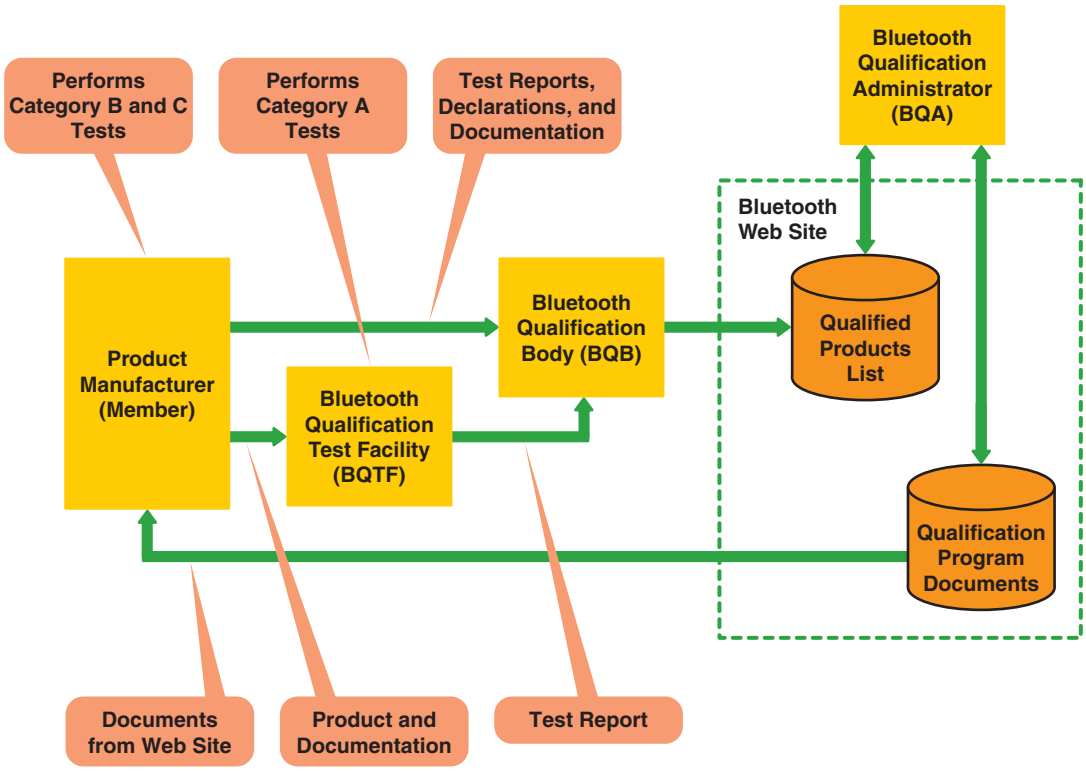

Figure 2. Bluetooth Qualification Process Flow

4.0 Preparation and the Pitfalls

Because Bluetooth is targeted for cable replacement, it must be inexpensive, small, low power consumption, and seamless. More and more chip manufacturers are turning to highly integrated “plug-and-play” prequalified modules which have radio, baseband processor, most passive components, and the entire Bluetooth stack on board. These modules can be integrated into an end product with a minimum number of tests before release to production.

However, these modules can be misleading to designers that are not familiar with wireless high frequency technology. For example, the RF performance parameters are greatly dependent on any external components such as passive devices and voltage regulators, as well as the PCB layout for the module. A greater number of external components and more complex of layout will add to its performance uncertainly. Therefore, it is critical to make careful measurements on the final design to confirm the performance before entering certification testing.

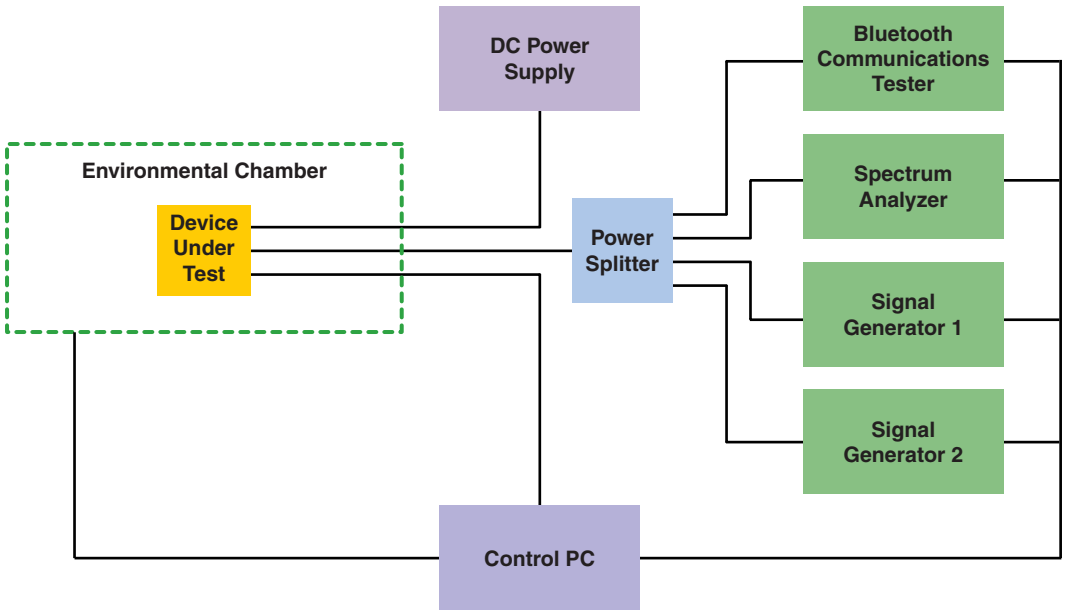

Figure 3. DUT Measurement Setup

Figure 3 shows a typical equipment setup for evaluating a DUT for certification compliance. The communications tester can exercise most of the Bluetooth qualification test cases, while the spectrum analyzer is used for the majority of regulatory test cases. The two signal generators provide the necessary interference signals required for blocking and intermodulation measurements. Ideally, all tests listed in Table 1 and Table 2 should be performed to get a true indication of DUT performance. However, the BQB will inform the DUT manufacturer (if a prequalified component is used) exactly which tests are needed, so that time does not have to be wasted with unnecessary tests. For regulatory approvals, most tests will need to be conducted on the final product because spurious emissions may come from other parts of the circuitry.

5.0 Preparation Steps

The most important part towards achieving Bluetooth certification is preparation of the device. A short summary is given here and in the summary chart (Figure 4). The overall design/qualification process can be broken down into these main steps:

1. Become an Adopter or Member of the Bluetooth SIG.
2. Review the data sheet and complete documentation package for a selected Texas Instruments product.
3. Design the schematic and component layout. The critical grounding and decoupling required for the radio must be studied in detail.
4. Generate the schematic and layout Gerber files for the final application.
5. Compare schematics and layout files to details in datasheet, reference designs and application notes.
6. Implement the design changes as agreed in the review.
7. Production of first prototypes (between 10 and 20 units).
8. At least five units must be tested fully over the temperature range.
9. Any failure or marginal pass of the specification must be corrected by component change or layout modification.
10. Test the DUTs again to verify that all parameters are within specification.
11. Prepare three “golden units” for the BQTF, two with antenna connectors and one with an original antenna.
12. Select the BQTF and prepare documentation for DUTs.
13. Submit the documentation and DUTs to the BQTF for regulatory and Bluetooth qualification tests.
14. Product will be listed on the official Bluetooth web page as Bluetooth compliant when all test cases have passed.
15. Release product to manufacturing.

Main parameters and areas to check:

- **Device Grounding**—The center slug of the radio chip must be soldered to the PCB ground or in the case of the module in a BGA package, all ground pins must have numerous vias and short connections to ground.
- **Power Supply Decoupling**—Power supply LDO must be low noise and decoupled using 2.2 µF or larger capacitors. The chip or module Vcc pins should have a capacitor pair placed close to the pins.
- **Loop Filter Values**—Check the LMX5252, LMX5452, or LMX9830 data sheets for the recommended values, bearing in mind that further tweaks of these values may be needed for optimum performance.
- **Antenna Design and Matching**—Review the Bluetooth Antenna Design application note.
- **Crystal Frequency**—Must be within 240 Hz (20 ppm) of the target frequency (12 MHz).
- **Temperature Range**—Although it is recommended that all parameters are checked over the temperature range when a design change is made, the following are the most critical:
  - Power Output
  - Sensitivity
  - Modulation Index
  - C/I Ratio
  - Frequency Drift

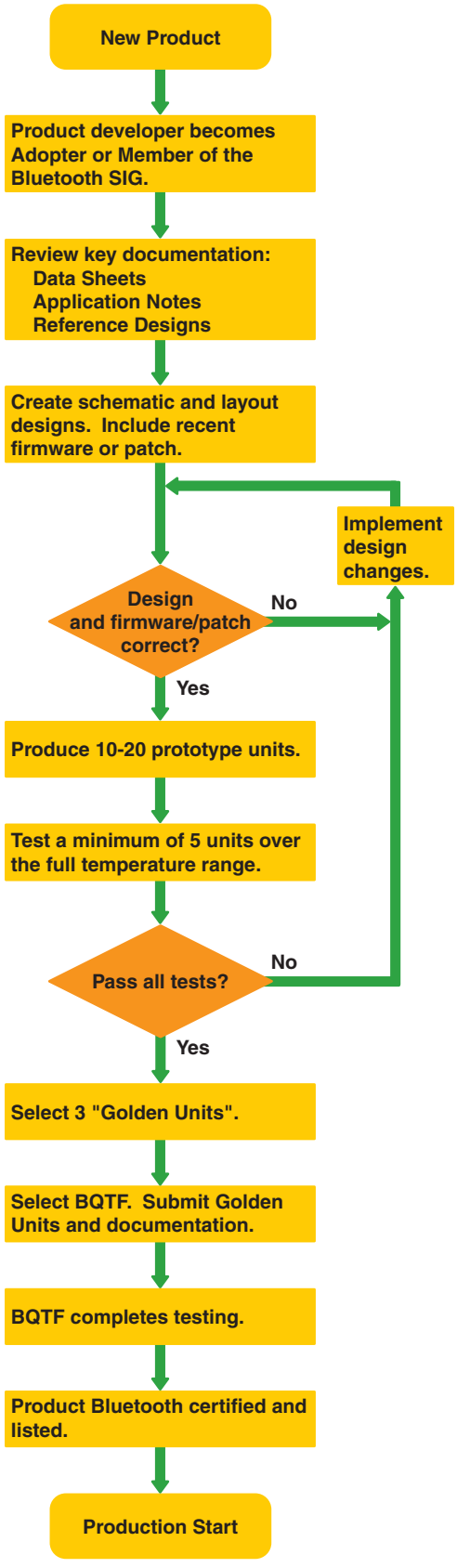

Figure 4. Summary of Preparation Steps

6.0 Abbreviations

BB	Baseband Processor	HCI	Host Controller Interface
BER	Bit Error Rate	HFK	Hands-Free Kit
BQA	Bluetooth Qualification Administrator	L2CAP	Logical Link Controller and Adaptation Protocol
BQB	Bluetooth Qualification Body	LM	Link Manager
BQRB	Bluetooth Qualification Review Board	LVD	Low Voltage Directive
BQTF	Bluetooth Qualification Test Facility	NEC	National Electrical Code
CE	Compliance European	PCB	Printed Circuit Board
C/I	Carrier-to-Interferer Ratio	QPL	Qualified Products List
DECT	Digital European Cordless Telephony	RF	Radio Frequency
DOC	Declaration of Conformity	SAR	Specific Absorption Ratio
DUT	Device Under Test	SDOC	Supplier's Declaration of Conformity
EMC	Electromagnetic Compatibility	SDP	Service Discovery Protocol
ETSI	European Telecommunications Standard Institute	SIG	Special Interest Group
FCC	Federal Communications Commission	SPP	Serial Port Protocol
GAP	Generic Application Profile	TX/RX	Transmit/Receive
GSM	Global System for Mobile Communications	USB	Universal Serial Bus

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265