Bluetooth® Certification Guide

National Semiconductor
Application Note
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1.0 Scope

This document describes the steps and preparation needed to get full regulatory and Bluetooth certification for a new product, including lists of required tests and detailed procedures.

2.0 Abbreviations

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

3.0 Introduction

To use the Bluetooth trademark and get authorization to enter the market with a product that includes Bluetooth functionality, it is required to pass the Bluetooth Qualification program (system conformance requirements). Bluetooth Qualification is the process by which the Bluetooth Member (product manufacturer) demonstrates compliance with the Bluetooth system specifications, as required by the Bluetooth Member agreement. The Bluetooth Qualification program is the framework that establishes the qualification rules and procedures. The qualification process is regulated by the SIG (Special interest Group). Products and components are approved and listed by a Bluetooth Qualification Body (BQB), pointed out by the SIG.

Bluetooth Qualification is not a part of regulatory authority requirements. Regulatory requirements and governmental type approval requirements are outside the scope of the Bluetooth Qualification Program. It is the sole responsibility of the Member to fulfill the relevant national regulatory requirements before product launch and use.

A Bluetooth module (seen as a component) is not required to pass the regulatory requirements such as EMC, safety and RF end-user product requirements (for example, those of FCC, ETSI, etc.). However, the Bluetooth module will be subject to those parts of FCC/ETSI requirements which are referenced in the Bluetooth RF specification.

It is necessary to meet ETSI/FCC RF and EMC requirements as well as safety requirements both to pass Bluetooth Qualification and to ensure that the end product will pass the regulatory requirements for the end-user product (for example, a USB dongle).

The level of effort for passing Bluetooth qualification and regulatory approval tests for various end products such as: PDAs, USB dongles, headsets, etc. is in general the same. The size of the overall approval scope (number of test cases) may differ depending on the implemented functionality (software profiles) for the end product.

The basic mandatory requirements are: RF, BB, LM, L2CAP, SDP, GAP, and SPP for Bluetooth and RF, EMC, safety, and SAR for the regulatory parts will be the same.

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4.0 Entering Global Markets

Bluetooth wireless technology uses the 2.4-GHz ISM band which is available and unlicensed in most countries worldwide. Despite harmonization efforts, approval processes as well as spectrum allocation and radio requirements vary regionally. Depending on the targeted market, compliance with applicable Radio, EMC, and product safety standards, including SAR where appropriate, will be required to gain necessary approvals.

In addition to (and independent of) any national government regulatory approvals, the product will also need to comply with Bluetooth Compliance Requirements as defined by the Bluetooth Qualification Process.

Figure 1. Product Compliance

5.0 Key Points for Achieving Certification

The most important part towards achieving Bluetooth certification is preparation of the device. This is described in greater detail later in the document but a short summary is given here. See also the summary chart (Figure 2). The Member (product manufacturer) can retrieve relevant specifications and documentation from the Bluetooth qualification website at http://qualweb.bluetooth.org/.

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 National Semiconductor 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. Review also LMX5252 PLL and Loop Filter Design guide and Easy-PLL design tool on National’s Webench. Loop filter values will be slightly different for 12- and 13-MHz crystals.
- **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 2 summarizes the overall process of achieving certification, and the remainder of this document provides a detailed description of this process.

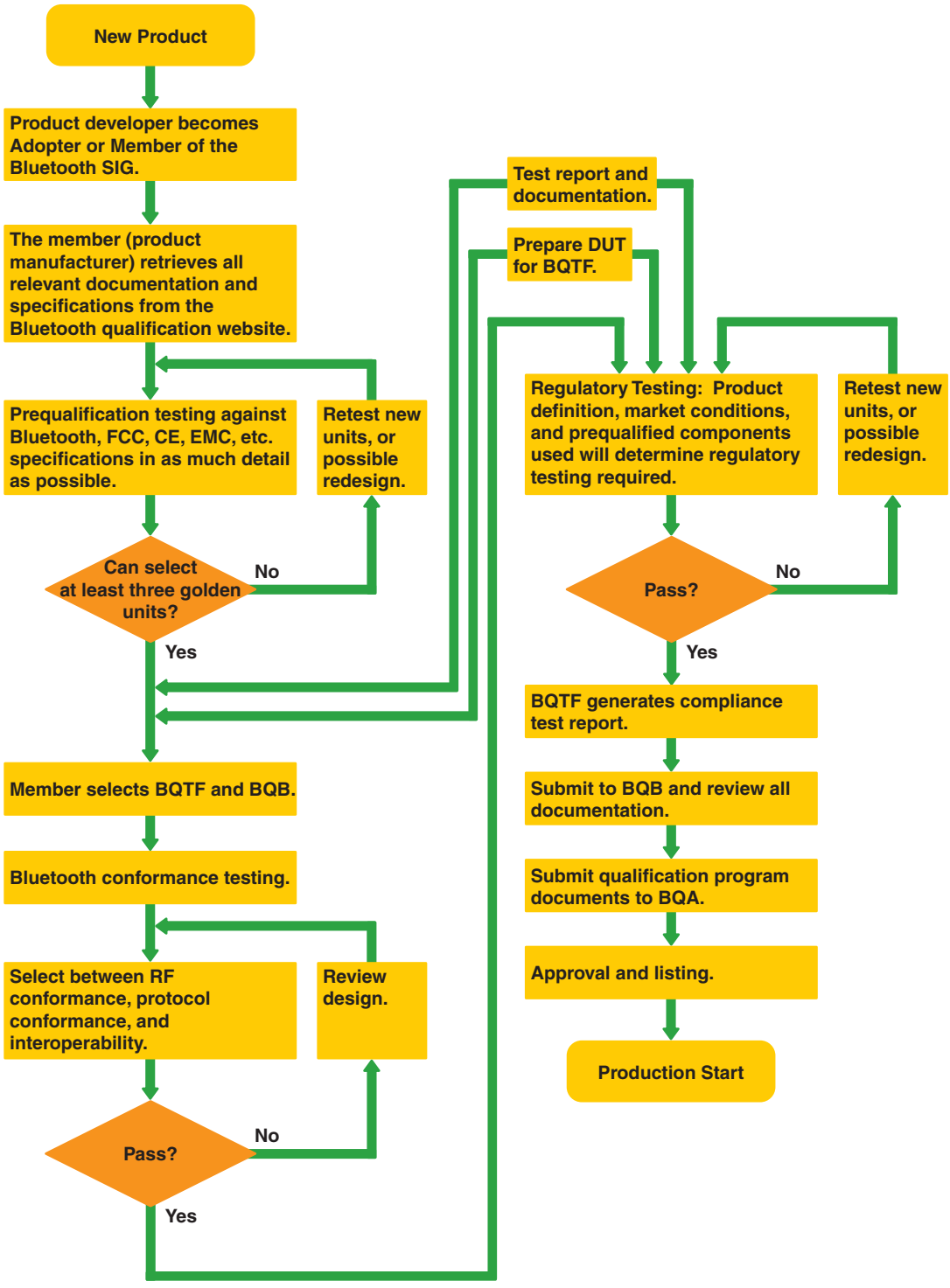

Figure 2. Certification Process

6.0 Bluetooth Qualification Process

An entity intending to produce or market a product which includes Bluetooth functionality must first become a Bluetooth Member by executing the applicable Bluetooth Agreements, which are available from the Bluetooth web site. Next, the Member must demonstrate that each particular product design complies with the Bluetooth System Specifications (including Compliance Requirements). Table 1 and Figure 3 introduce the process by which a Member qualifies a product.

Table 1. Process for Bluetooth Product Qualification

	Pre-Test Preparation	Testing	Post-Test Assessment and Listing
Member	■ Product development ■ Engineering testing ■ Prepare ICS, test case mapping, reference design, application note ■ Test planning	■ Conduct category B, C, and D tests ■ Generate test reports for category B and C tests ■ Build compliance folder	■ Provide inputs to BQB ■ Pay listing fee
BQB	Assist Member in, for example: ■ Test planning ■ Qualification requirement review	■ Assist Member in issues related to Qualification testing ■ Build compliance folder in collaboration with Member	■ Assess compliance folder ■ List Qualified Product
BQTF	**Not Required** May assist Member in, for example: ■ Test planning ■ Qualification requirement review	■ Conduct category A tests ■ Generate test reports for category A tests ■ Available resource, may assist in category B and C tests	**Not Required**

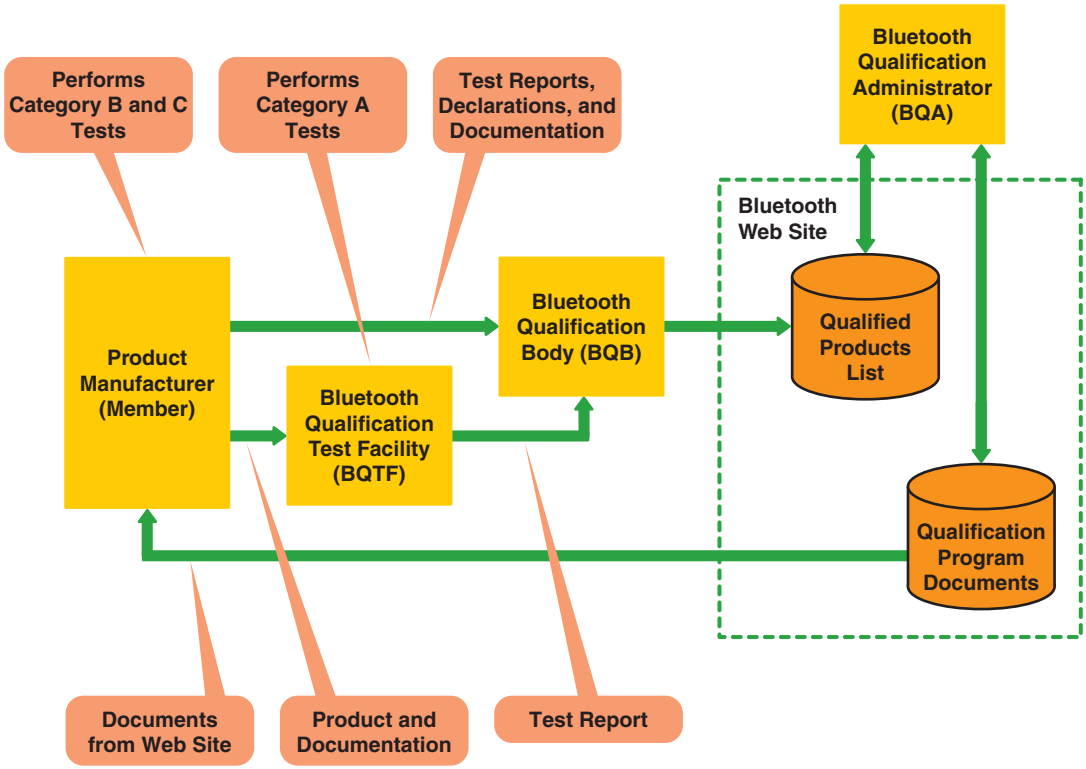

Figure 3. Bluetooth Qualification Process Flow

7.0 Bluetooth Qualification Testing

The Bluetooth qualification requirements include:

- RF Conformance Tests
- Protocol Conformance Tests
- Profile Interoperability Tests
- Compliance Declarations
- Documentation Review

7.1 Bluetooth Conformance Testing

Conformance testing of a Bluetooth product is defined as testing according to the applicable procedures given in the Bluetooth RF and protocol test specifications and the Bluetooth profile conformance test specification, when tested against a reference test system. The objective of the RF, protocol, and profile test specifications is to provide a basis for conformance tests for Bluetooth wireless devices that will provide a high probability of compliance with the Bluetooth System Specifications. The conformance tests are performed by an accredited BQTF or the Member, according to the test case category.

7.2 Bluetooth Interoperability Testing

Interoperability testing is defined as functional testing against another operational Bluetooth wireless product performed according to the applicable instructions and guidelines given in the Bluetooth Profile Interoperability Test Specification.

7.2.1 Blue Units

The Qualification Program was launched before validated Conformance Test Systems were available. To provide consistency of testing and to improve the likelihood of interoperability in the field while this situation prevailed, the BQRB has recognized certain products for protocol testing called Blue Units. Testing using Blue Units will establish confidence in the lower layer protocols of Bluetooth wireless technology. Testing using Blue Units will be phased out as the validated protocol conformance test capability becomes available. Until then, the specifications remain the only authoritative source regarding compliance.

7.3 Test Procedure

The Member selects a BQB from the list of recognized BQBs found on the Bluetooth web site. The BQB can assist the Member throughout the entire product qualification process. The Member prepares a compliance folder and works with the BQB to develop a product test plan. If the product test plan requires testing services of a BQTF, the Member can select a BQTF that has been accredited to perform the type of testing required. All necessary documentation to demonstrate compliance to the specification is provided to the BQB by the Member, e.g. technical product description, user's manual, and the Implementation Conformance Statement (a *pro forma* for this document is available on the Bluetooth web site), etc. The Member provides test reports of all required tests to the BQB.

The Member is responsible for establishing any necessary non-disclosure agreements and contracts for services with the BQTF, BQB, and BQA.

The BQB reviews the submittals and prepares a qualified product notice. If the BQB has a question regarding the conformance or interoperability of a product, the BQB may, with the Member's permission, submit information through the BQA to the BQRB for a ruling. If the BQRB must be consulted, the Member will be requested to prepare a submission according to BQRB guidelines.

When all current requirements are satisfied, the BQB informs the Member that the product is ready for listing as a Bluetooth Qualified Product. A fee for product listing shall be paid by the BQB to Bluetooth SIG, Inc.

7.4 Chain of Activities

The process of obtaining product qualification is summarized below, showing the steps necessary to accomplish this task. Product qualification can be accomplished using the following steps, but not necessarily in this order. The listed steps are considered typical, but they do not cover all possible steps in the Qualification Process.

1. The listing applicant becomes a Member.
2. The Member retrieves from the Bluetooth Qualification Program web site information including the following:
   - Current PRD (Qualification Program reference document)
   - Applicable Test Specifications
   - Test Case Reference List
   - ICS/IXIT *pro forma*
   - Applicable Test Case Mapping Table
3. The Member selects a BQB to provide advice and assistance during the process.
4. The Member prepares material necessary for the Compliance Folder (see next section for details) to be submitted to the BQB.
5. The Member prepares and submits an application for Bluetooth product qualification to the BQB for each unique product containing a Bluetooth interface.
6. The Member performs all required tests (with Category A tests performed by an accredited BQTF, see below). Test reports or evidence of successful test completion for all tests are to be included in the Compliance Folder.

7.5 Compliance Folder

The Compliance Folder submitted to the BQB shall include the following documents:

7.5.1 Applicable Bluetooth Agreement

Only Members of the Bluetooth SIG may have products listed in the QPL. It is the responsibility of the manufacturer submitting products for qualification, to substantiate their Bluetooth SIG membership to the BQB. This may be done by including a signed copy of the Bluetooth Agreement in the Compliance Folder. For each of the nine Promoter companies, this requirement can be met by submitting a declaration attesting that the company is a Bluetooth SIG Promoter company.

7.5.2 Product Description

The Member must prepare and submit to the BQB a description of the product, including these items (when relevant):

- Descriptive Name
- Exact Model Number
- Hardware Version Number
- Software Version Number
- Bluetooth Profiles Supported

This information will appear on the Bluetooth Qualified Products List when the product is fully qualified.

In addition to the identifying information, the Member must also submit to the BQB sufficient technical documentation to allow the BQB to determine whether the product should be qualified. This documentation includes at a minimum:

- Preliminary user manual or user guide
- Functional block diagram and technical description

7.5.3 Declaration of Compliance

The Member must submit to the BQB the Declaration of Compliance (DoC) using the current version available on the Bluetooth web site. The DoC shall identify the specific product to be listed, including the hardware and software version numbers to be covered by the listing.

7.5.4 Prequalified Products

Evidence of prequalified subparts of the qualification.

7.5.5 Application Note

Where applicable for component reference designs.

7.5.6 Product Test Plan

The Member, with advice from the BQB, will generate a product test plan, detailing all required testing for product qualification. The Test Case Reference List, test case mapping table, ICS, and IXIT should be used as information resources for generation of the product test plan. If the test plan dictates Category A testing, the product test plan will be used to coordinate the BQTF test efforts. The Member may also request a BQTF to perform Category B tests and use the product test plan to coordinate the test efforts. The ICS is used with the test case mapping tables to determine which test cases are applicable for a product. The Test Case Reference List (TCRL) shows the category for each test case, and the date that category becomes active for the test case. The categorization of test cases is key to where test cases should be performed as well as the type of evidence that is required.

7.5.7 Implementation Conformance Statement

To evaluate a particular implementation, it is necessary to have a statement of capabilities and profiles which have been implemented for a specific product. This statement is called an Implementation Conformance Statement (ICS). The Member prepares an ICS for use by the BQB and BQTF.

The Implementation Extra Information for Testing (IXIT) provides information related to the Implementation Under Test (IUT) and the testing environment required to run the appropriate test suite (e.g. addressing information and upper tester interface). The use of the answers to IXIT questions is for testing purposes, i.e. parameterization of test cases.

The Bluetooth ICS/IXIT *pro forma* for Bluetooth protocols and profiles is available on the Bluetooth web site.

7.5.8 Test Reports

A test report is required for all Category A and B test cases. The report is necessary to demonstrate evidence of test results and to justify that all interoperability and conformance requirements are fulfilled.

7.6 Certification

The formal certification is performed by the BQB. The BQB lists the product on the Bluetooth web site as a qualified product on the QPL (Qualified Products List).

8.0 Market-Specific Requirements

To enter target markets, the certification and regulatory regimes of those target markets must be fulfilled. Compliance with applicable radio, EMC, and product safety standards, including SAR where appropriate, will be required to gain the necessary approvals. If the product also provides a connection to the national public switched telephone network (PSTN), then applicable requirements and approvals for the wired interface must be obtained.

8.1 Regulatory Requirements

The regulatory requirements are divided into two main markets (US and Europe). A good strategy is to cover these two markets as an approval platform and to use these approvals for entrance into other markets, because a large number of countries worldwide accept US or European approvals as the basis for their national approvals.

For Bluetooth end-products, the regulatory requirements include:

- EMC (Electromagnetic Compatibility)
- Product Safety
- RF (Radio Frequency) Spectrum
- SAR (Specific Absorption Ratio)

8.1.1 Components and Modules

The regulatory requirements are end-product requirements. A component, for example a chip or a module, is not subject to testing used for final product approval such as EMC and product safety tests. However, a component shall be constructed to meet the final product requirements for the components intended use. For example, a Bluetooth module cannot be subject to final product approval, but shall be subject to the authority for required RF requirements (FCC/CE) to demonstrate fundamental compliance for that type of component.

8.1.2 European Market Regulations

The European community directives (CE marking requirements) require the manufacturer to generate a TCF (Technical Construction File) including:

- Manufacturers name, address, and contact person
- Design documents and components list
- Product specification
- Product description
- All relevant test reports according to the EC directive requirements
- User's manual
- Supplier's Declaration of Conformity

The Supplier's Declaration of Conformity (SDOC) is the document in which the manufacturer ensures compliance with the relevant EC directive(s). The document shall be signed by the person with sole responsibility for the product's market entrance.

The TCF together with the SDOC and the compulsory CE-mark are essential for the self-declaration route within the European Union. The CE-mark is the manufacturer's declaration that the product complies with the relevant EC-directives, and the TCF and SDOC are the basis for CE marking.

The Technical Construction File for each product shall be sampled in a binder and placed in the "approval safety lock".

8.1.3 European Product Standards

The 1999/5/EC radio equipment/telecommunications terminal equipment directive establishes the regulatory framework for market entry, free movement, and operational use of radio equipment and telecommunications terminal equipment. This directive came into force in April 2000. The general requirement is that the product shall conform to the directive. The manufacturer can either verify the product itself or use a competent body. Relevant harmonized ETS standards with reference numbers published in the official journal of the European Communities are used to show compliance with the R&TTE-directive.

Compliance with all relevant parts of the R&TTE-directive is a prerequisite for the CE marking. The relevant parts for RF products (Bluetooth, GSM) concern EMC, product safety, SAR, and RF requirements.

Applicable European standards for Bluetooth products are:

- **EN 60950-1**—Safety of information technology equipment including electrical business equipment.
- **ETSI EN 301 489-17**—Electromagnetic compatibility (EMC) standard for 2.4 GHz wideband transmission systems and Hiperlan.
- **ETSI EN 300 328-1**—Radio equipment and systems (RES), Wideband transmission systems. Technical characteristics and test conditions for data transmission equipment operating in the 2.4 GHz ISM band and use of spread spectrum modulation.
- **EN 50360**—Product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300 MHz–3 GHz).

8.1.4 US Market Regulations

Authorities regulate US market entrance, and third-party testing through a recognized test facility is required. The specific authority will sample the test reports and certifications will be issued. National Semiconductor will receive copies of test reports and certificates.

Copies of test reports and certificates for each product shall be sampled in a binder and placed in a "approval safety lock".

8.1.5 US Market Standards

The FCC (Federal Communications Commission) regulates the EMC, SAR, and radio-frequency spectrum requirements.

Product safety requirements are based on the NEC (National Electrical Code). All electrical products shall be listed by an NRTL (National Recognized Test Laboratory) appointed by OSHA (Occupational Safety and Health Administration).

Applicable US standards for Bluetooth products are:

- **CFR 47 FCC Part 15**—Emission requirements for radio frequency devices
- **CFR 47 FCC Part 15.247**—RF requirements for radio frequency devices (Bluetooth)
- **FCC OET Bulletins 65**—Evaluating human exposure, supplement C, mobile and portable devices
- **CFR 47 FCC Part 2.1091**—Mobile device exclusions, time averaging considerations
- **UL 60950-1**—Safety of information technology equipment including electrical business equipment.

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 2. 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.

To run tests for Simply Blue or HCI devices, files have been prepared to set up the radio in test modes. The file for Simply Blue is SBC_FCC.dir, shown in Figure 4. The file for HCI devices is HCI_FCC.dir, shown in Figure 5.

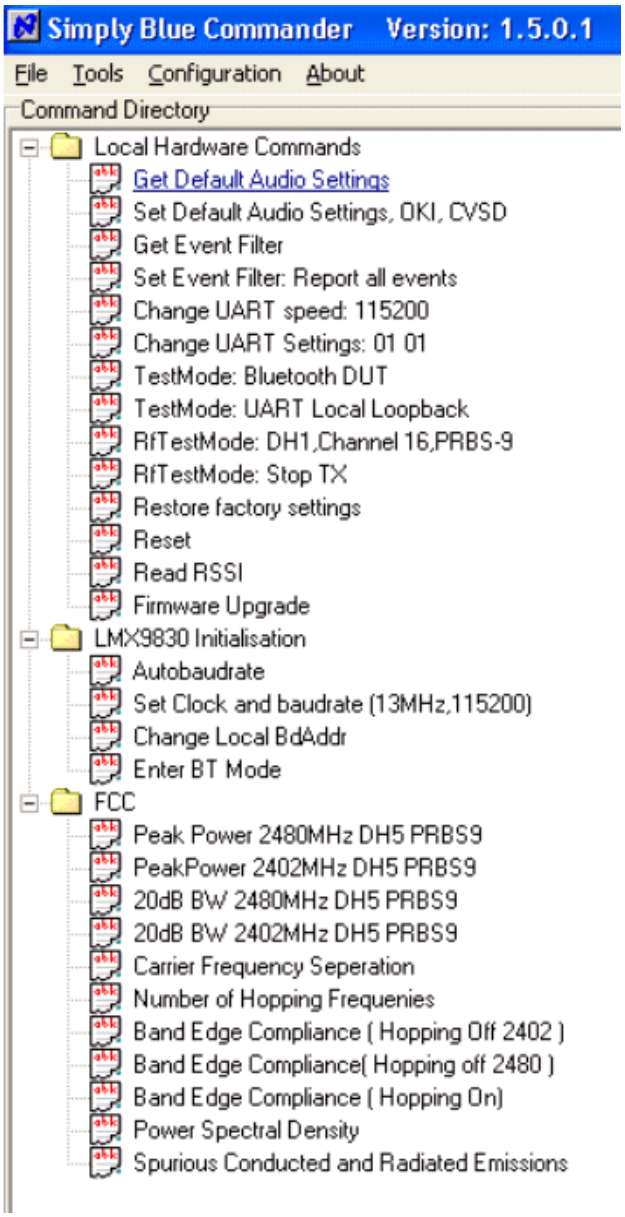

Figure 4. SBC_FCC.dir File Contents

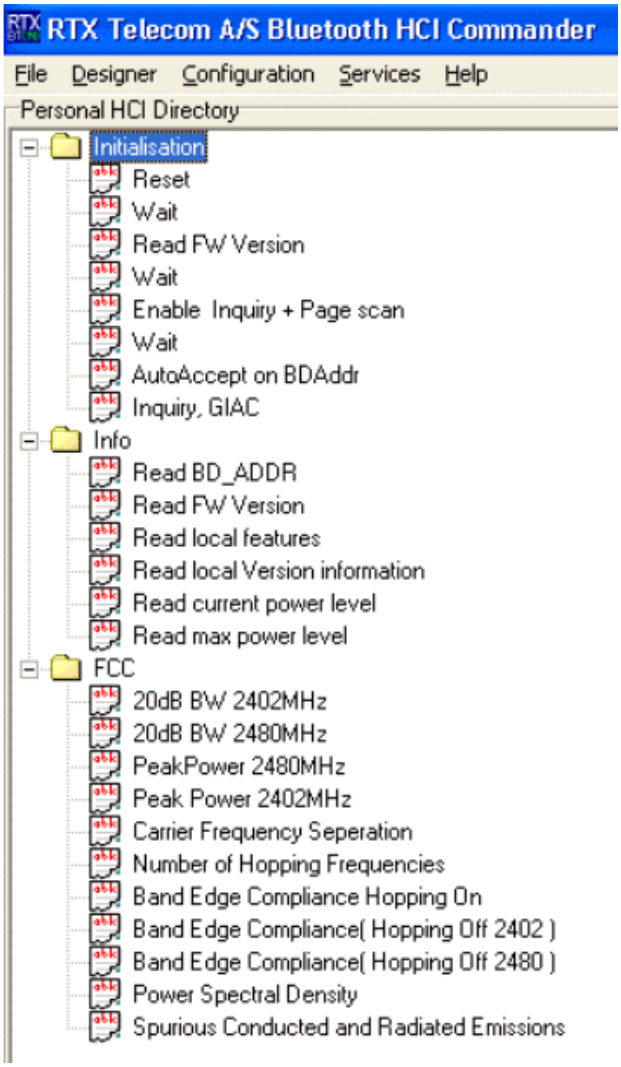

Figure 5. HCI_FCC.dir File Contents

9.0 Generic Regulatory Approval Process

Figure 6 shows the generic product regulatory approval process, divided into preparation, test execution, and maintenance phases. The process shall be used for the EMC, product safety, RF, and SAR testing parts of the overall regulatory approval of a product.

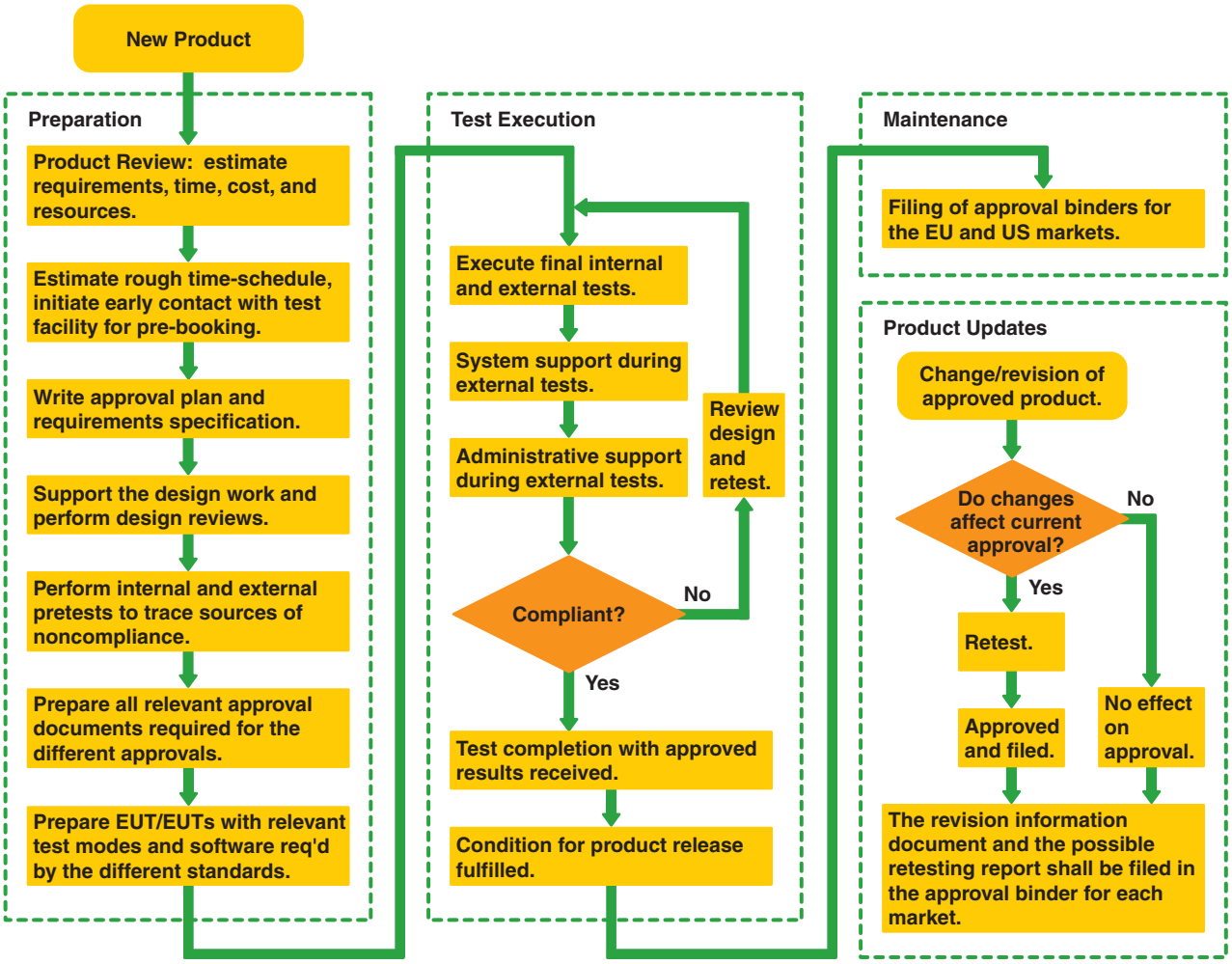

Figure 6. Regulatory Approval Process

9.1 Preparation Phase

The preparation phase can be performed when the essential information about the product has been specified. The following tasks are included in the preparation phase:

- Review the product design to estimate time, costs, resources, and other requirements, for the approval.
- Establish as soon as possible a rough time-schedule so that early contact with a suitable external test facility can be initiated for prebooking of testing time.
- Write an approval plan/requirement specification with references to every applicable requirement/standard for the applicable product.
- Support the design work to eliminate remarks before the final test. If necessary, perform design reviews. Make sure that the person responsible for approval will be invited to design reviews.
- Perform internal and external pretests to trace sources of non-compliance against the applicable standards in the approval plan.
- Make sure that all relevant approval documentation such as schematic diagrams, users manual, product description, marking, etc. required for the different approvals are prepared.
- Allocate resources (hardware and personnel) needed during the test execution phase.

9.2 Test Execution Phase

The final test execution phase can take place when the product has reached pre-serial status and the product version is final/intended for market entrance. The final tests can be performed internally or at a third-party test facility, depending on the requirement scope for the specific tests.

- Execute final tests.
- Provide external test facility with system support during the tests to avoid delays.
- Support external test facility with administrative support in terms of specifications, pictures etc. to avoid delays.
- If any non-compliance occurs, try to solve it during the test phase to avoid remarks associated with time delays/retests/more costs.
- If remarks are not possible to solve when the test occurs, make sure that prompt action is taken to solve the remark as soon as possible and new test time is booked with the test facility for re-test.

9.3 Maintenance Phase

When the test execution phase is completed and all test reports and approval documents have been received, all evidence shall be sampled separately for the European and US markets.

10.0 Regulatory Test Cases

10.1 FCC Test Cases

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.

Taking FCC as an example, it requires that all electronic equipment pass approval tests. The FCC also regulates the use of radio spectrum to fulfill the communications needs of businesses, local and state governments, public safety service providers, aircraft and ship operators, and individuals.

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 shown below. More details can be found under FCC part 15.247 which gives a complete list together with test equipment settings, DUT settings, and test limits. The majority of these tests are performed with a spectrum analyzer.

10.1.1 Peak Power

The DUT transmitter power must be below a specified limit. Any power transmitted above this limit will interfere with other equipment operating within the same band.

This is a conducted measurement made using a spectrum analyzer with specified settings at nominal and extreme temperature and voltage. The test limit is <30 dBm.

10.1.2 20 dB Bandwidth

The DUT transmitter spectrum (its spectral mask) must be within specified limits. A spectral mask that violates these limits will cause excess interference to other equipment operating on neighboring channels.

This test is made using a spectrum analyzer with specified settings at nominal and extreme conditions (voltage and temperature). The test limit is <1500 kHz.

10.1.3 Carrier Frequency Separation

For Bluetooth, the separation between channels is typically 1 MHz, but FCC requires that the separation is greater than the 20 dB bandwidth to ensure that the total power spectral density across the whole band is below a set limit. The test is performed at nominal conditions.

10.1.4 Number of Hopping Frequencies

Bluetooth typically has 79 channels between 2.400 and 2.483 GHz. FCC requires that the DUT hops between at least 75 channels to make sure the power in the band is spread equally under normal hopping conditions.

10.1.5 Time of Occupancy (Dwell Time)

Again, to make sure that the power is evenly distributed across the band, the maximum time allowed on one specific channel during a 30-second period is 0.4 seconds. This test is required only under nominal conditions.

10.1.6 Band Edge Compliance

This is the same procedure as the bandwidth test, but it is applied to the extreme low and high channels. It is required to make sure the DUT does not transmit higher than the allowed power outside of the Bluetooth band, where it may interfere with other electronic equipment operating in neighboring bands.

Test limit <20 dBc at nominal operating conditions only.

10.1.7 Power Spectral Density

Spectral density implies the average power in a given bandwidth. The test is performed by using the spectrum analyzer to look at a narrow region of a single-frequency carrier averaged using a slow sweep rate.

Test limit <8 dBm peak.

10.1.8 Spurious Conducted and Radiated Emissions

The DUT must not transmit above a specified power level into other bands. This may lead to interference with other electronic devices operating at unrelated frequencies. The spectrum analyzer must operate up to 25 GHz, and no unwanted emission from the DUT above -20 dB is allowed between 0 and 25 GHz.

10.2 CE Test Cases

Like FCC in the United States, CE applies to the European market, and its function is much the same. The requirements are produced in response to a mandate from the European Commission issued under Council Directive 98/34/EC and are listed in detail in ETSI EN 300 328. Below is a summary of the technical requirements. Unlike FCC testing, which must be performed by a thrid party, CE allows self-certification, meaning that the Member can perform all testing in-house to guarantee that specifications are met. This provides a lower cost certification process, but only for products within the European Union.

10.2.1 EIRP

Defined as the total radiated power from the transmitter in all directions of the antenna assembly and shall be equal to or less than 100 mW

10.2.2 Maximum Spectral Power Density

Defined as the highest power level in watts/hertz generated by the transmitter within the modulation or power envelope. Limted to 10 mW per MHz EIRP.

10.2.3 Frequency Range

Determined by the highest and lowest frequencies f_H and f_L in which the power drops to -30 dBm/100 kHz bandwidth, where f_H < 2.4835 GHz and f_L > 2.4000 GHz.

10.2.4 Transmitter Surious Emissions

Measured between 30 MHz and 12.75 GHz. The maximum allowed limit varies with the frequency band but is generally < -36 dBm during operation and < -57 dBm during standby.

10.2.5 Receiver Spurious Emissions

These have a stricter limit than the transmitter spurious because the receiver is not designed to transmit any power at all. They are measured with the DUT set to constant receive mode in which the maximum limit between 30 MHz and 12.75 GHz is -57 dBm

10.3 Medical Device Directive

For devices that are intended for medical use, for example measuring devices that transmit medical data via Bluetooth to a PC for example. These require special medical EMC approval and testing in addition to the CE test-cases already described.

The Medical Devices Safety Service (MDSS) provides guidelines for manufacturers of all devices that are intended for medical use and/or are a multi-purpose devices that could be used for medical purposes. These guidelines ensure compatibility with other medical devices and safety for patients. The MDSS specialises in European regulatory affairs and is its authorised representative, details can be found under http://www.mdss.com/

10.3.1 Definition of a medical device

There are two types of medical device, the first is wholly for medical purposes such as the specialist equipment seen in most hospitals, for example a lung capacity meter or EEG monitoring meter that is used for no other purpose than medical. The second is a multi-purpose device that can be used in a medical environment but is not wholly intended for that purpose, for example a PC.

The first type must comply with medical EMC requirements, however the second type may not have to since this is a grey area that must be judged on an individual basis. Most medical facilities outlaw the use of non-compliant equipment on their premises such as mobile phones that may cause interference.

Measuring devices further more shall meet the following requirements as put down by the directive;

a) The device is intended by the manufacturer to measure quantitatively a physiological or anatomical parameter, or a quantity or a qualifiable characteristic of energy or of substances delivered to or removed from the human body.

b) The result of the measurement is displayed in legal units or other acceptable units within the meaning of directive is compared to at least one point of reference indicated in legal units or other acceptable units in compliance with the pre-mentioned directive.

c) The intended purpose implies accuracy, claimed explicitly or implicitly, where a non-compliance with the implied accuracy could result in a significant adverse effect on the patient's health and safety

10.3.2 EMC Requirements

The standard EN 60601-1-2 is applied as a harmonised standard for EMC. To allow for a common approach for already existing standards, the following recommendations are made;

Radio frequency emissions

Classification according to EN 55011 into class A or B is made by the manufacturer, based on the intended use of the equipment and the fact, that even within hospitals there are areas of quite different electromagnetic environment. In

general, equipment will be class A, equipment intended for home use, class B.

High frequency surgical equipment

Testing according to EN 55011, class A, group 2, operation condition of the device according to EN 60601-2-2.

Low frequency emission

No tests required (64 % of the NBs do not agree on the necessity of this test).

Electrostatic discharge

Testing as specified according to EN 61000-4-2 with 3 kV and 8 kV respectively.

Radiated radio frequency fields

Testing according to EN 61000-4-3, level 2 (3 V/m)

Bursts

Testing as specified according to EN 61000-4-4.

Surges

Testing as specified according to EN 61000-4-5

Voltage dips, short interruptions and voltage variations on power supply input lines

Testing according to EN 61000-4-11

Conducted disturbances, induced by radio frequency fields

Testing according to IEC 1000-4-6

Note// Details of the standards quoted here can be found under;

http://europa.eu.int/comm/enterprise/medical_devices/meddev/index.htm

11.0 Bluetooth Qualification Test Cases

These tests, unlike FCC-mandated tests, are not required by law, but nevertheless are mandatory for all Bluetooth equipment. There are 16 separate RF tests which ensure the DUT meets the standards set forth by the Bluetooth Qualification Review Board (BQRB) for ensuring interoperability with other Bluetooth equipment. 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 3, and a complete description can be found under the ETSI specification, document number 20.B.353.

Table 3. 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)	

11.1 Output Power

Bluetooth devices are classified into three categories based on output power: Class 1, 2, and 3 which must transmit below 20 dBm, between 4 and -6 dBm, and below 0 dBm respectively. The LMX5252, for example, is a Class 2 radio with typical output power of +1 dBm.

11.2 Power Density

With hopping enabled, this measurement is made with a spectrum analyzer to determine the amount of power per kHz within the band of operation. Test limit <100 mW per 100 kHz.

11.3 Power Control

This test is only a requirement for Class 1 devices. For Class 2 and 3, this is optional. A Class 1 DUT must have power control capability with output power from +4 to +20 dBm in step sizes between 2 and 8 dBm. This improves the frequency re-use area such that power can be decreased to minimize interference with other users or increased to improve range.

11.4 Transmit Output Spectrum

There are three tests that govern the transmitter output spectrum, these ensure the DUT transmits over the full frequency range allocated and that the spectral mask does not violate given limits causing interference to neighboring channels.

11.5 Frequency Range

The DUT must be able to transmit and receive over the full band that is allocated, 2.4000 to 2.4835 GHz.

11.6 20 dB Bandwidth

This is the same test procedure as the FCC bandwidth test, however the spectrum analyzer settings are slightly different. The spectral mask due to modulation must be less than 1000 kHz.

11.7 Adjacent Channel Power

This test serves a function similar to the 20dB bandwidth test. It ensures that the output power from one channel falling onto the second and third adjacent channels is below specified limits, so that it will not interfere with other Bluetooth devices operating in these channels.

Test limits are <20 dBm for the second adjacent channels and <40 dBm for the third adjacent channels.

11.8 Modulation Characteristics

There is a detailed procedure to ensure that the frequency deviation due to modulation lies within specified limits for two different patterns. However, the tester will measure and calculate the values.

Using a 11110000 pattern, the tester measures the average of the deviation and logs this as $\Delta F1_{AVERAGE}$. In addition, there is a minimum deviation required which is recorded as $\Delta F2_{MAX}$. Using a 1010 pattern, the tester determines the average deviation $\Delta F2_{AVERAGE}$. The ratio between $\Delta F1_{AVERAGE}$ and $\Delta F2_{AVERAGE}$ must be >0.8, $\Delta F1_{AVERAGE}$ must be between 140 and 175 kHz deviation, and $\Delta F2_{MAX}$ must be >115 kHz for 99.9% of packets measured.

11.9 Initial Carrier Frequency

Each Bluetooth channel has its own center frequency. The DUT TX/RX frequency after the PLL has settled must be within ±75 kHz of this frequency to ensure interoperability with other Bluetooth devices.

11.10 Carrier Drift

Once the DUT PLL is locked, it must not drift during TX/RX bursts. The maximum drift and drift rate allowed depend on the size of the packets. For DH1 packets, drift must be <25 kHz. For DH3 and DH5 packets, drift must be <40 kHz. The drift rate must be <20 kHz per 50 µs anywhere in the packet.

11.11 Spurious Emissions

This test serves the same purpose as the corresponding FCC tests to ensure that there are no unwanted emissions up to a frequency of 12.75 GHz that may interfere with other electronic equipment. Table 4, taken from ETSI 20.B.353, shows the limits.

Table 4. Spurious Emission Limits

Frequency Range	Limit While Operating	Limit in Standby Mode
30 MHz–1 GHz	-36 dBm	-57 dBm
1 GHz–12.75 GHz	-30 dBm	-47 dBm
1.8 GHz–1.9 GHz	-47 dBm	-47 dBm
5.15 GHz–5.3 GHz	-47 dBm	-47 dBm

11.12 Sensitivity

The DUT must be able to maintain a link with 0.1% BER at less than -70 dBm power entering its receiver front end. The input power where the BER is equal to 0.1% is the sensitivity of the DUT.

The sensitivity is measured for single and multi-slot packets, using the same specification.

11.13 C/I Performance

The DUT receiver must be able to work in the presence of unwanted interfering signals either at the same frequency as the desired signal or very close to it. This ability to tolerate interference is measured relative to the carrier level as C/I ratio. The further the interfering signal is from the carrier, the lower the C/I ratio becomes, which is specified accordingly.

Table 5. Interference Tolerance

Interferer Frequency	C/I Ratio	Wanted Signal Level P[dB] > Reference Sensitivity
Co-Channel Interference ($C/I_{Co\text{-}Channel}$)	11 dB	10
Adjacent (1 MHz) Interference ($C/I_{1\ MHz}$)	0 dB	10
Adjacent (2 MHz) Interference ($C/I_{2\ MHz}$)	-30 dB	10
Adjacent ($\geq$3 MHz) Interference ($C/I_{\geq 3\ MHz}$)	-40 dB	3
Image Frequency Interference (C/I_{Image})	-9 dB	3
Adjacent (1 MHz) Interference to In-Band Mirror Frequency ($C/I_{1\ MHz}$)	-20 dB	3

Table 5 shows the limits for the Bluetooth 1.2 specification. The Bluetooth 1.1 specification has limits for co-channel, first adjacent channel, and image channel interference that are 3–4 dB relaxed compared to Bluetooth 1.2.

11.13.1 Blocking Performance

This is similar to the C/I tests, except the interfering signal is outside of the Bluetooth band of operation. Sometimes an external bandpass filter is required to pass this test. For the LMX5252, it is preferable to have a front-end ceramic or LC filter to meet these requirements. Review the Bluetooth Antenna Design application note for further information.

Table 6. Blocking Performance

Interfering Signal Frequency	Interfering Signal Power Level
30 MHz–2 GHz	-10 dBm
2 GHz–2.4 GHz	-27 dBm
2.5 GHz–3 GHz	-27 dBm
3 GHz–12.7 GHz	-10 dBm

11.13.2 Intermodulation Performance

Two interfering signals entering the receiver will produce an intermodulation product due to the inherent non-linearity. If the frequency of the interfering signals is such that the product falls on the same frequency as the IF (2 MHz for LMX5252), then it cannot be filtered and will cause serious performance degradation. The receiver must be able to maintain at least 0.1% BER at -64 dBm wanted level when the interference signals are at -39 dBm.

11.13.3 Maximum Input Level

This is opposite to the sensitivity specification, in which BER increases due to a very small signal entering the receiver. This is due to a very large signal resulting in front-end saturation. The receiver must be able to maintain 0.1% BER or less at -20 dBm input level. The difference between the maximum input level and sensitivity is called the dynamic range or useful range of operation.

12.0 Preparing the DUT for Radio Certification

Once the electrical design of the DUT is complete, it must be tested against the Bluetooth parameters described in the previous sections. A full description of the DUT and equipment setup can be found under FCC part 15.247, ETSI EN 300 328, and ETSI Bluetooth specification 20.B.353, but this application note will provide a broad description of what is required. Normally, a precertified component will be used, such as the LMX5252 radio chip or LMX9820A module, however the performance of the entire DUT (especially in the case of the radio) will not just depend on the performance of the chip or module as measured on their corresponding reference boards. It will also depend on factors such as PCB layout, power supply noise, external passive components, and crystal oscillator noise and stability. Therefore, the performance of the DUT as a whole may be considerably different from that of the individual components. For the DUT to pass the certification tests, it is important that the PCB is designed following recommended guidelines given by the device manufacturer and that it is tested over the specified temperature range in as much detail as possible before submission to the BQTF.

Selecting a DUT for submission to the BQTF depends on the results of such pre-compliance tests. Initially, a random sample of six or more units should be chosen and room temperature tests performed, such as output power, sensitivity, transmit spectrum, and spurious emissions that are most critical to overall device quality. Statistical analysis of the results should show a normal distribution due to device and component tolerance. From this, at least three “golden units” should be picked that pass these parameters by a wide margin. In the case of the LMX5252, the results should be comparable to the device performance on its reference PCB, i.e. power 0 dBm, sensitivity -82 dBm, 20 dB bandwidth around 950 kHz, and spurious emissions 3–5 dB below specification. If three devices cannot be found with this level of performance, then the design needs to be reviewed and possibly redesigned. However, the three devices once selected are now ready for more extensive measurements.

12.1 Equipment Setup and Data Collection

Figure 7 below shows a typical equipment setup for pre-compliance measurements. The DUT is placed in an environmental chamber where the temperature can be precisely adjusted and connected to a bench power supply and control PC for enabling test mode. The RF power cable runs to a power splitter where it has a 6 dB split going to the Bluetooth communications tester, spectrum analyzer, and two signal generators. All test equipment apart from the power supply is connected to the PC through a GPIB bus such that Matlab or Labview may be

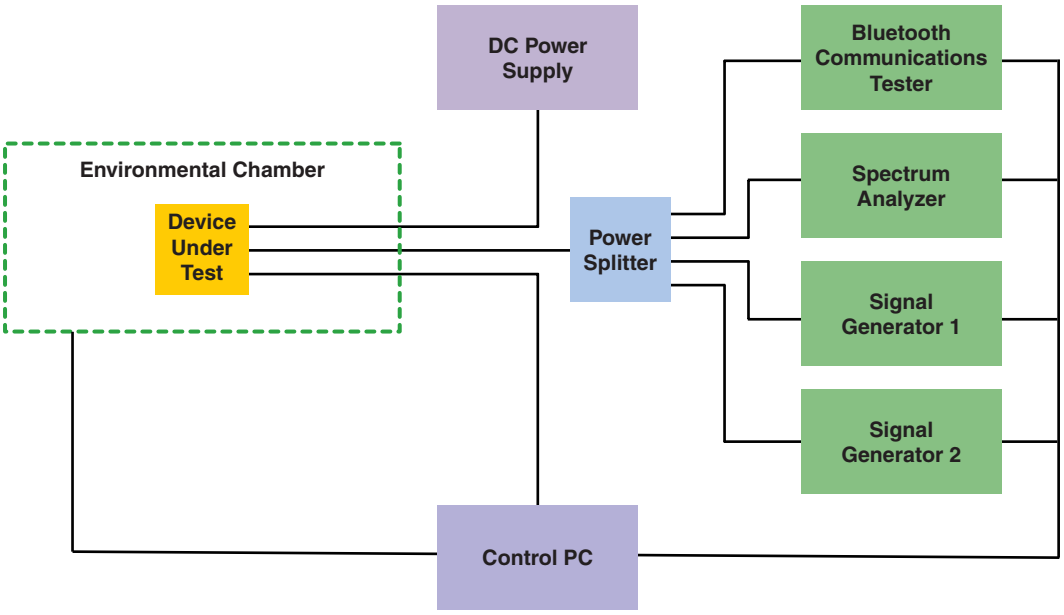

Figure 7. DUT Measurement Setup

12.2 Suggested Equipment

Table 7 shows equipment recommended for the test setup.

Table 7. Equipment Recommendations

Equipment	Recommended Unit
Environmental Chamber	Capable of -40 to +85ºC for automotive temperature range
Bluetooth Test Set	MT8852A from Anritsu
Signal Generators	SMIQ03B from Rohde and Schwartz, from 300 kHz to 3.3 GHz
Spectrum Analyzer	FSEM 30 from Rohde and Schwartz, from 20 Hz to 26.5 GHz
Power Supply	Any stable bench power supply, low noise
Power Splitter	4-way, 6 dB splitter/combiner from Mini-Circuits

The majority of the FCC test cases are performed using the spectrum analyzer. It is also useful to monitor the link between the Bluetooth test set and the DUT. However, most of the qualification test cases will be made with the Bluetooth test set, except for transmit output spectrum and spurious emissions that are made with the spectrum analyzer. The signal generators are used for C/I, blocking and intermodulation tests together with the Bluetooth test set.

The results should be logged along with screen captures from the spectrum analyzer so that they can be used as a reference when the DUT is submitted for certification. Although it may be very time consuming to make full certification tests, a cut-down version of all major test cases should be made in as much detail as allowed by project schedules so that any potential problem areas are detected at this stage. Using ATE software such as Matlab or Labview speeds up test times and automatically logs results.

12.3 Golden Unit Selection

Once the measurements are as complete as possible, units should be selected for which all FCC and qualification test cases were passed by a wide margin. These are the “golden units” that are submitted to the BQTF. If no golden units can be found because some parameters are consistently failing, it may be necessary to go back to the design stage and re-examine the problem. Ideally, three golden units should be selected.

12.4 Other Preparations

The DUT should also have additional features that make it easier for the BQTF to evaluate.

12.4.1 Test Mode Software

Test mode enables a Bluetooth test set, like the TS8960 used by the BQTF, to make a link with and control the DUT in slave mode. It should be easy to enable this test mode and also reliable. Ideally, the submitted DUT should power up in test mode so that no external commands are required at all. This provides the simplest solution.

12.4.2 Test Signals

In test mode, it should also be possible to enable a range of test signals without the need for making a link with the Bluetooth test set. For example, transmitter powered up with various test patterns (1010, 11110000, or pseudorandom), using with DH1, DH3, or DH5 packet types. This will make measurement of the output spectrum, spurious emissions, and power simpler and faster. There is also a test case for CE that only uses the receiver, with the transmitter turned off. It should therefore be possible to power up the receiver only, for different channels.

12.4.3 Output Connector

The connector used for making all conducted measurements should be a female SMA type, because most BQTFs use male SMA connectors for hooking up the DUT. If an SMA connector is not used because normally the antenna would be mounted, then it should be possible to remove the antenna and solder a semi-rigid cable to the PCB at the antenna input.

12.4.4 DUT Description

Along with the DUT prepared as described, a description of the DUT should be submitted to the BQTF. Most will have their own documentation that needs completing by the client. It is important to specify any precertified parts such as the LMX9820A so that the BQB (Bluetooth Qualification Body) can assess whether all certification test cases are required. Normally, a reduced testing program may be used, which saves time and money.

13.0 Prequalified Components and Modules

All products which contain Bluetooth technology must be qualified. This is required to obtain a license for the intellectual property used to implement Bluetooth devices. However, the rules regarding qualification allow the use of preapproved components and modules to ease or eliminate the qualification burden. Bluetooth modules and reference designs are available in a number of different formats, which can be broadly categorized as described in the following sections.

13.1 Serial Module, End Product Type

Qualified as finished or “end product”. These modules must contain a complete Bluetooth stack, at least one Bluetooth profile implementation, oscillator, and a non-removable antenna. They can be used in an end product without further Bluetooth qualification.

Note: The regulatory tests for RF and EMC still have to be considered. Government regulatory approval is not a part of Bluetooth qualification.

13.2 Bluetooth Module, Component Type

Qualified as a component. Although these modules may contain a protocol stack, profiles, and antenna, they do not have full product qualification. Products using them must, at a minimum, pass interoperability profile qualification.

13.3 RF Integrated Circuits, Chip Type

An RF integrated circuit qualification covers only the chip itself, as implemented in a reference design. The manufacturer offers the integrated circuit to other manufacturers. The RF behavior is affected by external components and the implementation (oscillator, VCO, PLL, PCB material, baluns, capacitors, etc.).

The RF chip may not be considered pretested for part A (RF) covered functionality. Full part A testing is required when preparing to list a Bluetooth end product that uses such a component.

13.4 Baseband Processor, Chip Type

A baseband integrated circuit qualification including LM software can be seen as a prequalified component for Part B and C (BB, LM) when integrated in an end product. Limited testing may be required for baseband timing and other physical baseband test cases.

13.5 RF Reference Designs and Modules

An RF module will be sold to end-product manufacturers as a complete implementation with defined interfaces (DC power input, buffered data, antenna, reference oscillator, etc.). Normally, additional external shielding would not be required for passing the test cases.

A complete new TRC/CA/01/C (out-of-band spurious emission under normal conditions) is always required. When integrating a pretested RF module into an end product, conformance implications may result from design changes relative to the reference design tested. In general, if no external oscillator, external antenna, or host power supply regulator is added, the out-of-band spurious emission measurement is sufficient, if preconditions such as temperature range for the end product are within the range of the pretested RF module.

13.6 Examples

For the LMX5252 radio transceiver and CP3 platforms, full regulatory testing is required. However, for more integrated prequalified solutions such as the LMX9820A or LMX5452, omissions can be made (see Table 8). There are certain omissions for part A (RF tests), but most notable are the omissions for part B (BB tests).

13.7 Summary of Test Requirements

Part of Table 8 is based on the BTAB official guideline version 1.03 “Guideline to integrate components including RF functionality”.

- An X in the table means activity/retest required.
- An empty box means no activity/retest required.
- n.a means not applicable.

Table 8. Testing Requirements for Prequalified Components

Bluetooth Requirements (Bluetooth Core Specification)		Integrating Prequalified RF Component in an End Product (Bluetooth Qualification Including RF, BB, and LM Compliance)						Integrating Prequalified RF and Baseband Components in an End Product (Bluetooth Qualification Including RF, BB, and LM Compliance)	
System Conformance/Bluetooth Specification	Test Cases and Requirements	RF Module with Internal Oscillator and Internal Antenna (Complete Bluetooth Module)	RF Module with Internal Oscillator and Internal Antenna (Complete Bluetooth Module Without Temperature Profile)	RF Module with External Oscillator and Internal Antenna	RF Module with Internal Oscillator and External Antenna	RF Module with External Oscillator and External Antenna (e.g. LMX9820A)	Two Chips in One Package with External Oscillator and External Antenna (e.g. LMX5452)	RF Chip (e.g. LMX5252)	Baseband Processor Chip (e.g. CP3 Platforms)
Part A (RF)	TRM/CA/01/C		X		X	X	X	X	
	TRM/CA/02/C		X					X	
	TRM/CA/03/C							X	
	TRM/CA/04/C		X	X	X	X	X	X	
	TRM/CA/05/C		X	X		X	X	X	
	TRM/CA/06/C		X	X		X	X	X	
	TRM/CA/07/C		X	X		X	X	X	
	TRM/CA/08/C		X	X		X	X	X	
	TRM/CA/09/C		X	X		X	X	X	
	TRC/CA/01/C (Conducted)			X		X	X	X	
	TRC/CA/01/C (Radiated)	X	X	X	X	X	X	X	X
	RCV/CA/01/C		X					X	
	RCV/CA/02/C		X	X		X	X	X	
	RCV/CA/03/C			X		X	X	X	
	RCV/CA/04/C			X		X	X	X	
	RCV/CA/05/C							X	
	RCV/CA/06/C							X	
Part B (BB)	Complete Part B							n.a.	X
	TP/PHYS/TRX/BV-05-C	X	X	X				n.a.	
Part C (LM)	Complete Part C							n.a.	X
Listing Approval Administration Process	Compliance Folder to be Created to Apply for Bluetooth Qualification	X	X	X	X	X	X	X	X

Whether or not the retest cases in Table 8 shall be performed in extreme conditions (temperature or voltage) is determined by the BQB.

In the absence of a temperature profile test report or documentation for the placement of the module in the end product, no reliable correlation between the temperatures in the end product and the integrated module are known. Therefore, it is impossible to demonstrate compliance with the RF specification without testing the end product. In this case, the column for “RF module without temperature profile” shall apply.

13.8 Software Stack

The software stack used in the end product (current profiles) together with integrated hardware can be tested separately, but a limited number of test cases (GAP tests) have to be performed to verify interoperability between the hardware and the software stack.

13.9 BQTF Required Test Cases

Note: All RF test cases are category A. Category A means that the test cases have to be performed at a third party BQTF (Bluetooth Qualified Test Facility) to achieve approval from BQB.

13.10 Bluetooth "Own Branding"

Manufacturers are allowed to relabel qualified products under the following conditions:

- The manufacturer who is relabeling a branding, with the original manufacturers approval, must be a Member of the Bluetooth SIG.
- The product or the accompanying literature must clearly show in print the original Qualified Product Listing reference.

14.0 Regulatory Implementation Guide

Components (RF module or chip) are not required to pass regulatory tests such as EMC, safety, and RF that apply to end products. However, a Bluetooth RF component will be subject to parts of FCC/ETSI requirements, which are referenced in the Bluetooth RF specification. *Components must be designed to meet FCC/ETSI RF regulatory requirements to ensure that end products based on these components will pass Bluetooth qualification and gain regulatory approval.*

Table 9. Standards Applicable to Components and End Products

Regulatory Conformance Sub-Areas	Regulatory/EU Market (CE) Requirements	Regulatory/US Market Requirements	RF Module or RF/Baseband Chip (Component intended for end product)	End Product (USB, CompactFlash, etc.) (Contains RF Module or RF/Baseband Chip)
RF Spectrum Requirements	ETSI EN 300 328-1	CFR 47/FCC part 15.247	n.a.	X
EMC Requirements	ETSI EN 301 489-1 ETSI EN 301 489-17	CFR 47/FCC part 15	n.a.	X
Safety Requirements	EN 60950-1	EN 60950-1	n.a.	X
SAR Requirements	EN 50360	FCC OET bulletin 65 CFR 47/FCC part 2.1091	n.a.	X

15.0 Regulatory Activities for RF Module in End Product

- Product Safety requirements according to standards in Table 9. Minor test activities (90% of the safety requirements are not applicable to this type of product).
- SAR requirements according to standards in Table 9. For this type of low power transmitter, no testing is required, only evidence in form of calculations proving that the SAR is far below the allowed limit.
- EMC requirements according to standards in Table 9. The testing concerns the immunity parts of EMC (ESD and radiated disturbance). These requirements are only applicable to the EU market (CE). For the US market, only emission requirements apply, which are already included in the Bluetooth system requirements.
- RF requirements according to standards in Table 9. The relevant testing is already performed within the Bluetooth qualification and can be referenced for both the EU and US markets. (The only exception is radiated out-of-band spurious emission.)

The administrative route for EU (self-declaration route) is:

- Create a TCF (Technical Construction File) including test reports, certificates, technical documentation and manufacturer declaration of conformity. This is the basis for CE-marking. The CE mark is required within the EU member countries and is the manufacturers declaration on the end product that it fulfills the relevant EU directives.

The administrative route for US is:

- Third-party certification required for RF, EMC, SAR (FCC), and safety (UL). Product marking required (FCC and UL).

16.0 Potential Pitfalls

Being unprepared for Bluetooth certification leads to project delays and costs time and money. Time wasted at the BQTF is potentially very expensive! Some difficulties encountered by Bluetooth application manufacturers are listed here.

- Using a precertified part such as the LMX9820A can provide key benefits in reducing test time to qualification, however care must be taken, because mounting the device on a new PCB design will change its performance due to factors such as power supply noise, crystal stability, external component tolerance, etc. Therefore, it is important to evaluate the module as part of the final design to make certain that all parameters are within specification.
- It is important to reserve time in the schedule between precompliance testing and the time booked with the BQTF, to handle any design issues that are encountered. DUT preparation and testing before certification is an evaluation stage, and at this stage an extra layout revision may be required to get the DUT to a state in which golden units can be selected. Otherwise, time wasted at the BQTF will be even more costly in the long run.
- Making the DUT too complex can also lead to unnecessary delays. For example a complicated procedure for enabling test mode may leave the test engineer at the BQTF struggling to make a link to the DUT. During tests with the TS8960, the link to the DUT is frequently dropped, and the DUT has to be power cycled to reset it. Ideally, it should power up in test mode which makes the procedure simpler and faster.
- Even after golden unit selection is made, detailed precompliance evaluation is complete, and a results report shows all parameters passing with margin, the DUT may still fail at the BQTF! This is because the TS8960 used by the BQTFs worldwide is the only conformance tester that is approved by the BQRB, while the smaller test sets used by Bluetooth equipment manufacturers in their labs are not approved. There are three types of testers commonly available: the MT8852A from Anritsu, the CMU200 from Rohde and Schwartz, and the E1852A from Agilent Technologies. All three differ slightly from each other when it comes to making accurate measurements, and more importantly they differ slightly from the TS8960. Therefore, it is important to make a visit to the selected BQTF with a reference unit and correlate the lab results with those obtained using the TS8960. This will increase confidence that the golden unit will pass certification without unnecessary surprises. Figure 5 below shows one of these conformance testers at ETS in Berlin.

Figure 8. TS8960 Conformance Tester

17.0 Sample End Product Qualification and Certification

The Bluetooth qualification and regulatory certification process for end products can differ depending on both the module's own integration and the type of end product into which the module will be integrated. The comparison tables below show differences between LMX5452 and LMX9820A implementations only referring to the required RF test cases. Higher profile and stack integration as on LMX9820A compared to LMX5452 is not considered.

Table 10. Qualification and Certification Requirements for LMX5452-Based End Products

Product Configuration	Bluetooth Qualification	Regulatory Requirements
LMX5452 used in a prequalified USB dongle reference design with integrated oscillator and antenna.	This case shows a complete qualified Bluetooth product including oscillator. An end customer should be able to reuse National Semiconductor's qualification completely. The end customer can either use the "own branding" route or qualify the product. The qualification in this case should only be paperwork.	Because the LMX5452 is Bluetooth qualified, both EU and FCC RF regulatory parts including radiated emission are covered. May be subject to immunity EMC tests (ETSI).
LMX5452 built-in to a laptop computer.	This case shows a qualified Bluetooth product excluding integrated oscillator. In this case the customer has to qualify the complete end product. A large number of RF test cases must be performed.	When integrating a Bluetooth module into an end product, the EMC part must be considered. In this case, both radiated emission (FCC and ETSI) and radiated disturbance (ETSI) must be tested for the laptop.

Table 11. Qualification and Certification Requirements for LMX9820A-Based End Products

Product Configuration	Bluetooth Qualification	Regulatory Requirements
LMX9820A used in a prequalified UART serial port dongle reference design with integrated oscillator and antenna.	This case shows a complete qualified Bluetooth product including oscillator. An end customer should be able to reuse National Semiconductor's qualification completely. The end customer can either use the "own branding" route or qualify the product. The qualification in this case should only be paperwork.	Because the LMX9820A is Bluetooth qualified, both EU and FCC RF regulatory parts including radiated emission are covered. May be subject to immunity EMC tests (ETSI).
LMX9820A built-in to a sensor.	This case shows a qualified Bluetooth product excluding integrated oscillator. In this case the customer has to qualify the complete end product. A large number of RF test cases must be performed.	When integrating a Bluetooth module into an end product, the EMC part must be considered. In this case, both radiated emission (FCC and ETSI) and radiated disturbance (ETSI) must be tested for the sensor.

18.0 Frequently Asked Questions

The following are questions that are frequently asked by application manufacturers who want to have Bluetooth functionality within their product and want to get it certified.

If following the layout recommendations from the radio chip manufacturer and the radio is already precertified and tested, then is it necessary to make detailed pre-compliance checks on the final application? This adds delay to the project!

Yes, the final design must be checked in as much detail as possible. Even when closely following the radio chip vendor's layout guidelines, there could still be major deviations in behavior due to trace and component parasitics. Time spent at this stage of the project will save much more time in the future due to unforeseen issues that may arise.

Should I always use a golden unit for qualification, or can I pick any functioning part from the production line and submit it?

Always use parts that have passed precompliance tests. These are referred to as "golden units" and are selected specifically for certification. Though a randomly picked part from the production line may pass all test cases, it is an unknown quantity, and if issues arise, there are no reference measurements to rely on.

How many golden units should be submitted to the BQTF?

Two or three units should be submitted to the BQTF, two with SMA connectors for conducted measurements and one with the original antenna for making radiated measurements. Testing at the BQTF will be facilitated if they have many units to select from and tests can be carried out in parallel. Also, if one unit fails, a backup unit is immediately available.

Do all test cases have to pass on a single DUT?

No, two separate DUTs can be used if needed. For example, if a DUT is irreparably damaged during testing, the results obtained with it do not have to be discarded.

Is it possible to combine results from two different BQTFs?

Yes. If the BQTF is approved by the BQRB, then it is an approved test center for Bluetooth certification and their conformance tester has been correctly calibrated. It is possible to make some of the qualification RF measurements at one center and the remainder at the other. Results from both will be complied into a one report before being submitted for approval by a BQB.

Should I be present at the BQTF during testing?

Although not required, it is a good idea if any issues arise during testing. An engineer familiar with the DUT can correct the issue much faster than the test engineer working for the BQTF. Otherwise, the DUT may have to be returned to the client with incomplete measurements, which adds unnecessary delay.

Should not all manufactured parts in production be golden units? If certain parts are failing certain parameters, should they be discarded?

Ideally all manufactured parts should be like golden units and pass all parameters with margin. In reality, this is very difficult to accomplish, and it is unnecessary as long as all manufactured parts are functional and meet the desired quality requirement. This quality requirement is determined by the application manufacturer, not the chip or module manufacturer.

What's the difference between Bluetooth Specification version 1.1 and 1.2 in terms of RF measurements required?

There is a note in version 1.1 that relaxes the C/I requirement. Co-channel interference is +14 dB rather than +11 dB, first adjacent channel interference is +4 dB rather than 0 dB and image channel interference is -6 dB rather than -9 dB. It is therefore easier to meet version 1.1 than 1.2. Other than these, the RF specifications are the same. However, even in version 1.1, the relaxed specifications are only temporary.

19.0 Bluetooth Qualification Test Facilities

A full list of approved BQTFs can be found on the Bluetooth qualification program website http://qualweb.bluetooth.org/. The BQRB defines a BQTF as:

A Bluetooth Qualification Test Facility (BQTF) is formally recognized by the BQRB as competent to perform those Bluetooth qualification conformance tests identified as "Category A" in the Test Case Reference List (See website). The definitive description of the BQTF role is in the Bluetooth Qualification Program Reference Document (PRD) section 4.3.3. Members contract directly with a BQTF for testing services. BQTF may also offer additional Bluetooth testing services.

The scope of a BQTFs recognition covers one or both of the following areas of competence:

- Radio conformance testing, covering the RF, baseband, and physical test specifications.
- Protocol and Profile conformance testing, covering the Baseband, Link Manager, L2CAP, and profile conformance test specifications.

There are 24 BQTFs worldwide. Table 12 lists a few that have been used by National Semiconductor or its customers.

Table 12. BQTF Contact Information

Name	Address	Phone Number
ETS Dr. Genz GmbH	Storkower Strasse 38 C Reichenwalde Germany D-15526	+49 33631 888 411
HYPER Taiwan Technology, Inc.	15800 Via Rivera San Lorenzo, CA 94580 USA	+1 (510) 415 7179
Taiyo Yuden	5607-2 Nakamuroda Haruna-Machi Gunma-Gun Gunma Japan 370-3347	81-27 (360) 8328
Centro de Tecnología de las Comunicaciones S.A. (CETECOM)	PTA, c/Severo Ochoa 2 Campanillas Málaga Spain 29590	+34-952-61-91-23
7 layers, Inc.	9361 Irvine Blvd Irvine, CA 92618 USA	+1 (949) 716 6512 ext. 217
7 layers	Borsigstr. 11 Ratingen Germany 40880	+49 2102 749 481

National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Francais Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560

www.national.com