



Bluetooth™ qualification in development and quality assurance

RF Test System TS8960



ROHDE & SCHWARZ

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An essential precondition for the success of *Bluetooth** technology is the interoperability and undisturbed function of different products. To ensure this, the Special Interest Group (SIG) has defined a qualification program that has to be passed by every product to be marketed under the *Bluetooth* label. The Test System TS8960 (FIG 1) has been designed for RF measurements in line with the *Bluetooth* qualification program and for in-depth measurements in development and quality assurance.



FIG 1 RF Test System TS8960: all required *Bluetooth* test cases are preset. Test case parameters can be modified and adapted as required.

RF measurements in line with the *Bluetooth* qualification program

16 test programs for measuring the RF characteristics of an EUT in line with the *Bluetooth* test specifications run on the Test System TS8960. The RF measurements are organized into transmitter, receiver and transceiver tests.

Transmitter tests determine the output power of the EUT, the quality of the RF output spectrum, and modulation parameters such as frequency deviation, frequency accuracy and drift.

A transmitter test in the TS8960 starts with a call setup and the TEST_MODE_ACTIVATE command, which switches the EUT into the test mode. Call setup and the transmitter measurements have to be performed in

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the hopping mode which means that the EUT carries out 1600 frequency hops per second within the 79 channels of the frequency band.

Since the spectrum analyzer cannot synchronize to the hop sequence of the EUT, it is set to a fixed frequency. With all measurements in the time domain, the *Bluetooth* signalling unit emits a trigger signal at the moment the EUT sends on the analyzer receive frequency, and thus starts the measurement in the analyzer. This method is used to carry out the power measurement, for example.

A special feature of **modulation analysis** is that the spectrum analyzer acts as an I/Q demodulator for the measurements. The demodulated I/Q data is applied on the IEEE bus to the system controller, where it is processed. This is necessary because the spectrum analyzer performs only 4-fold sampling at the most. According to the *Bluetooth* test specifications, this is sufficient, but because the sampling time and the symbol time are not in sync, the reproducibility of measurement results is limited. For this reason, the I/Q data in the TS8960 is interpolated to a sampling rate of up to 64 by fast Fourier transform.

The sensitivity of the *Bluetooth* **receiver** and its immunity to modulated and unmodulated interfering signals in the useful and adjacent channels are measured in the receiver tests. The main difference between these tests and the transmitter tests is that all receiver tests are carried out in the non-hopping mode, i. e. the EUT sends only at a fixed frequency. To meet the high demands on stability and spectral purity of the test signals required for receiver tests, a Vector Signal Generator SMIQ.03 is used instead of the RF frontend of the signalling unit.

Switchover from the internal frontend to the external signal generator is performed after call setup. Baseband data (data, clock and frame clock) is applied to the external interface of the modulation coder of the SMIQ.03. Since this switchover is carried out within one timeslot, the EUT is not affected.

The EUT is in the loopback test mode and returns the data sent by the TS8960. The signalling unit receives this data and evaluates it in a bit error rate (BER) measurement.

“Dirty transmitter” Since *Bluetooth* units are normally stationary, there are no fading effects. However, the signals used for measuring the receiver sensitivity are not completely undisturbed. The *Bluetooth* specification defines a dirty transmitter, the signal of which features a drift for many parameters such as frequency, symbol duration, deviation and modulation index. The dirty transmitter is realized in the TS8960 by the interplay of several components. The *Bluetooth* signalling unit produces the symbol drift, and the SMIQ.03 varies the deviation, frequency and modulation index.

Other receiver tests are the measurement of carrier /interference performance, blocking performance and intermodulation performance.

The specification defines an **“out-of-band spurious emissions”** transceiver test. According to the European standard, spurious emissions are searched for “only” in a frequency range of up to 12.75 GHz, but the American standard prescribes measurements up to 25 GHz.

The standard model of the Test System TS8960 is designed for fully automatic measurements of conducted interference up to 12.75 GHz. Options are available for measurements up to 25 GHz and for measurements of radiated spurious emissions.

Additional measurements for development and quality assurance

All parameters can be varied All test cases can also be performed with parameters that differ from those in the test specification. For example, the level and frequencies of the test signal and noise signal generators can be varied in a wide range for receiver tests. Packet types and even signalling parameters can also be changed.

Other tests can be performed in addition to the measurements defined by the test specification. For example, the **“search sensitivity test”** can be used to determine the current receiver sensitivity. For this measurement, the test signal level can be reduced until the bit error rate just exceeds the 0.1% defined by the specification. The level at which the BER is still within the 0.1% limit corresponds to the receiver sensitivity. Another example is the **“free receiver measurement”**, which permits user-configured receiver tests to be performed.

The test system also provides a **number of auxiliary programs**, e. g. the program for measuring the unmodulated part of the burst, the inquiry scan program for determining the EUT address and also complementary test methods with a great variety of setting capabilities.

User-specific test programs The Linux operating system, a fast C compiler and a wide selection of debugging capabilities allow efficient and fast development of user-specific test programs.

Wilfried Tiwald

Straightforward measurements for quick results

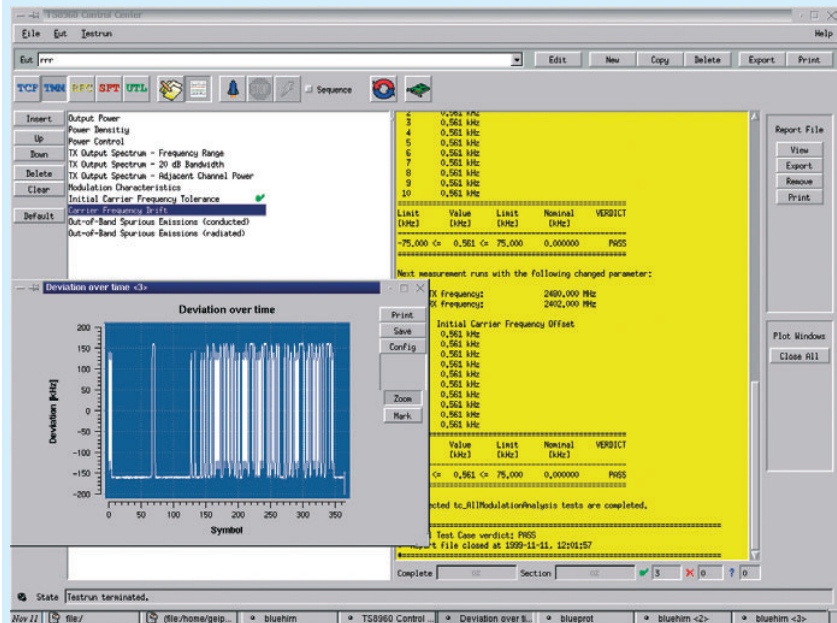


FIG 2 Straightforward control of test system via graphical user interface

More information and test systems for Bluetooth at www.rohde-schwarz.com (search word: Bluetooth)



Bluetooth measurement solutions for R&D, qualification, type approval and production
Overview of main measuring instruments and test systems from Rohde & Schwarz for measurements on Bluetooth equipment.

REFERENCES

- ◆ Protocol Tester PTW 60 for Bluetooth applications – Comprehensive protocol tests to Bluetooth™ qualification program. News from Rohde & Schwarz (2000) No. 169, pp 8–10
- ◆ Bluetooth RF Test Specification 1.1, Revision 0.91, 02 July 2001
- ◆ Bluetooth Core Specification, Revision 1.1, 22 February 2001

An **easy-to-use graphical user interface** ensures straightforward operation of the TS8960 (FIG 2). Menus are available for equipment under test (EUT), test cases (TCF, TMM), path compensation (RFC), selftest (SFT) and utilities (UTL).

In the EUT menu, the characteristics of the EUT, such as power class, Bluetooth address, signalling information, supported data packets, antenna gain, etc, must be entered. Subsequently, one or more test cases can be selected and executed in the test case menu. When the selftest menu is selected, a comprehensive system selftest is performed.

Path compensation The measurement accuracy can be increased in many ways in the path compensation menu. Path compensation takes into account all losses within the test system up to the antenna connector of the EUT; i.e. also line losses between the test system and the EUT.

Documentation After the test has been completed, the system documents all the main measurement results in a comprehensive test report and in plots. Zoom and marker functions allow fast and accurate evaluation of graphs.

Design and characteristics of the TS8960 test system

Bluetooth operates in the license-free ISM (industrial scientific medical) band at 2.4 GHz. A data rate of 1 Mbit/s makes this standard ideal for wireless data communication in many applications.

The Test System TS8960 has been designed for RF measurements in line with the *Bluetooth* qualification program and for in-depth measurements in development and quality assurance. According to the specification, two test modes are available for RF measurements, the Tx test mode and the loopback test mode. In the Tx test mode, the EUT sends a settable data pattern; in the loopback test mode, the data pattern sent by the test system to the EUT is returned and is thus available for evaluation.

The instruments in the test system are controlled by a system controller via the IEEE bus and an Ethernet link (FIG 3). The signalling unit in the system is responsible for call setup, test mode selection and the BER measurement. It contains an RF front-end for transmission and reception.

Two Vector Signal Generators SMIQ03 are provided in addition. One produces the useful signal, the other the *Bluetooth*-modulated interference signal for receiver tests. A third generator provides the unmodulated interference signal for measuring blocking and intermodulation suppression. The spectrum analyzer measures the power, the modulation spectrum and the spurious emissions.

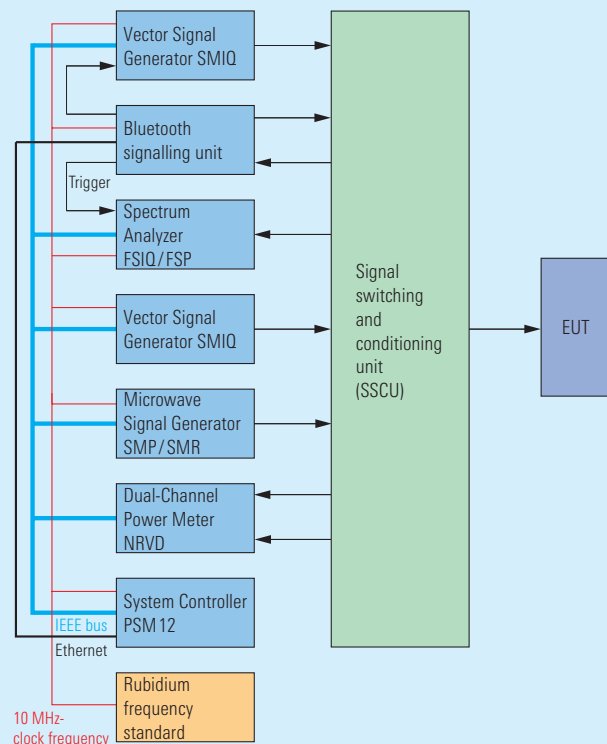
All signals are amplified and filtered in the signal switching and conditioning unit (SSCU), which contains relays, directional couplers, combiners, amplifiers and several filters. Since accurate level values are required for RF measurements, the Test System TS8960 performs fully automatic path compensation to minimize measurement errors. For this purpose, two RF probes are installed at essential test points in the SSCU. Channel A of the Dual-Channel Power Meter NRVD is used for monitoring the transmit level of the simulator, channel B for monitoring the received levels. Any level errors that occur in the current measurements are automatically corrected with the aid of stored reference values.

A Rubidium frequency standard supplies the highly accurate reference frequency. The system can optionally be equipped with power supply units for the EUTs.

Main characteristics of TS8960

- ◆ All test cases are in line with *Bluetooth* test specifications
- ◆ Test mode signalling
- ◆ "Dirty transmitter"
- ◆ Comprehensive system selftest
- ◆ High measurement accuracy due to automatic path compensation
- ◆ Many auxiliary programs for everyday use
- ◆ Upgradable (e.g. for remote control of power supply units, climatic cabinets, etc)

FIG 3 Block diagram of TS8960





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