Development of ME7873L LTE RF Conformance Test System

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[Summary] The LTE RF Conformance Test System was developed to support tests of LTE (FDD/TDD) mobile terminals. The new hardware has a variable frequency filter for flexible support of more than 30 bands. The dual-rack configuration and small main frame allow quicker setup, resulting in easier maintenance. The new software incorporates a modular structure and database to configure various LTE conformance test parameters efficiently and achieve the most approved test cases in the industry.

1 Introduction

The increase in mobile speeds due to the spread of 3G and HSPA (3.5G) technologies has resulted in worldwide deployment of usable mobile Internet services. 4G technologies have been taking the lead since around 2007 and the 3rd Generation Partnership Project (3GPP) started developing specification plans to develop 3G into LTE (Long Term Evolution) with two parallel technologies, one using frequency division duplexing (FDD) and the other using time division duplexing (TDD).

The FDD technology was investigated as a development of mobile W-CDMA/GSM mobile communications and there has been a widespread trend among carriers in N. America using CDMA2000 to adopt LTE-FDD. However, carriers in China are developing plans to deploy LTE using the TDD technology for which they have high expectations. Against this market background, Anritsu has developed its ME7873L LTE RF Conformance Test System for LTE terminal R&D and verification while contributing to setting the 3GPP LTE test specification in the early stage.

In 2009, carriers in N. America and Japan announced plans to deploy LTE services by late 2010 bringing a sudden urgency to the need for terminal verification tests to assure the quality of LTE communications. Terminal verification is approved by the Global Certification Forum (GCF) for frequency bands in Europe and by the PCS Type Certification Review Board (PTCRB) for bands in N. America. The ME7873L received approval as a conformance test system for 80% of FDD Band 1 and Band 13 test cases at the October 2010 GCF meeting.

Figure 1 ME7873L RF Conformance Test System

Due to the subsequent spread of smartphones coupled with growing social demand for fast, high-function smartphones, use of new frequency bands was investigated. On the assumption that extended frequency bands would be needed, we redesigned both the ME7873L hardware to support a new variable frequency filter as well as the platform software to support easy extendibility of various test parameters. As a result, in October 2011, the ME7873L achieved the world's largest number of approved test cases with the earliest support for verification tests of terminals using the new frequency bands.

Figure 1 shows an external view of the ME7873L.

2 Development Concept

The key items required by a conformance test system are listed below.

- Full compliance with requirements of 3GPP TS36.521-1 and TS36.521-3

  The system must have the performance, functions and methods required by the 3GPP TS36.521-1 and TS36.521-3 standards for RF conformance test systems.

- Adherence to changes to 3GPP standards

  The system must be able to comply with revisions and additions to the 3GPP standards published by the 3GPP meetings every 3 months.

- Approval by GCF/PTCRB for all test cases

  The system must receive approval from GCF/PTCRB for standards are revised.

- Easy addition of frequency band options

  Since each user requires different frequency bands, the instrument configuration must allow selection of any frequency band. In addition, when users add frequency band options, the hardware design should minimize setup downtime and band addition should be easy.

- Supports upgrade from ME7873F and ME7874F W-CDMA Conformance Test System

  The current ME7873F/ME7874F system configuration must be upgradeable to support both W-CDMA and LTE conformance tests.

3 System Design

3.1 Key Hardware Design Points

3.1.1 Multiband Interface Unit Configuration

LTE test cases are divided into RF tests of Tx characteristics, Rx characteristics, and performance standardized by 3GPP TS36.521-1, and Radio Resource Management (RRM) performance tests standardized by 3GPP TS36.521-3.

Figure 2 shows the hardware block diagram.

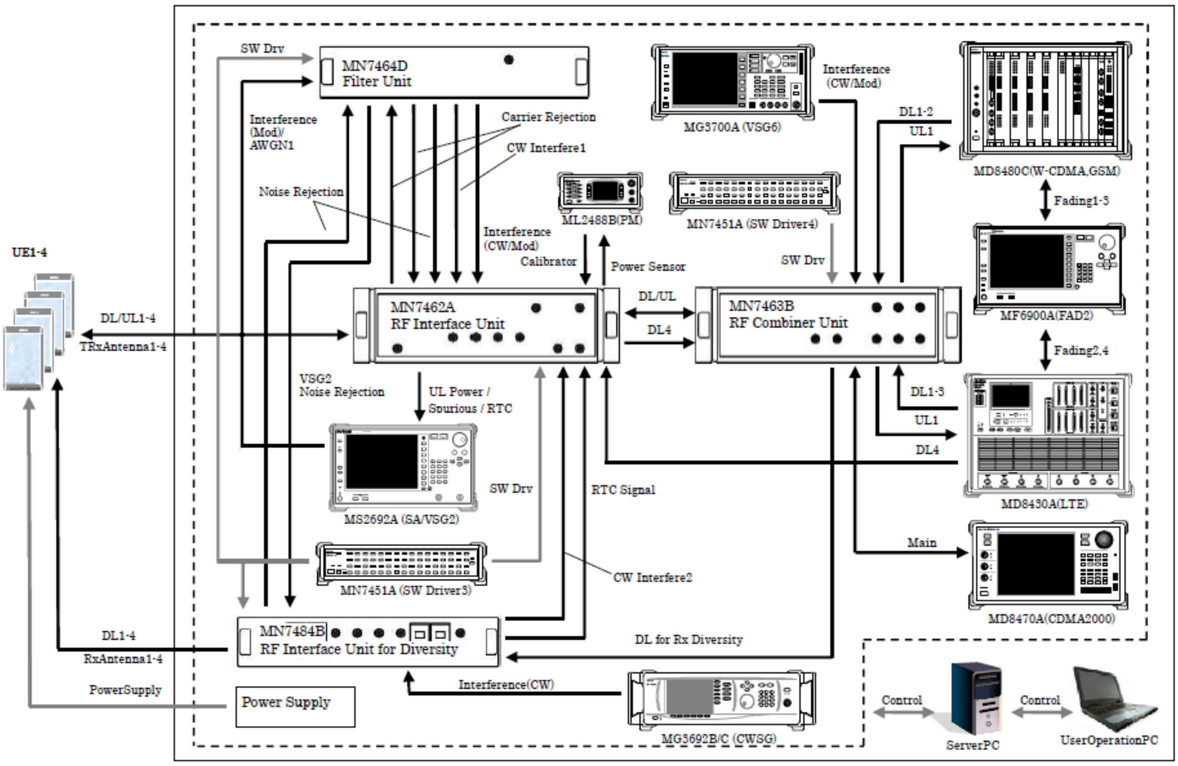

Figure 2 Block diagram of test system hardware

To measure all four groups of test cases outlined above, the test system must be configured from various instruments such as a base station simulator for each test case (MD8430A Signalling Tester/MD8480C W-CDMA Signalling Tester/MD8470A Signalling Tester), a signal generator for interference waveforms, a signal analyzer, etc.

Moreover, since test cases with different test contents must be run continuously, the system has an interface unit for auto-switching the connection path between the terminal RF input and each measuring instrument as well as a combiner unit for combining signals.

The system circuits and key instruments are listed below.

(1) MN7462A RF Interface Unit

This interface unit connects the terminal RF TRx antenna and the main system inputs and outputs.

It has a maximum 5 W input power to support the 3GPP-specified UE power class. In addition, it has internal correction circuits for achieving the 3GPP signal output and power measurement accuracies.

(2) MN7484B Diversity RF Interface Unit

This interface unit connects the terminal RF Rx antenna and the diversity output. Like the MN7462A is supports a maximum input of 5W and has an internal correction circuit. The path loss difference with the TRx antenna can be corrected by fine adjustment using a 0.25 dB step attenuator with a frequency range up to 13 GHz.

(3) MN7464D Filter Unit

To support 3GPP systems, it is necessary to completely filter out unwanted spurious caused by the instruments configuring the measurement system. In conventional systems, to eliminate unwanted waveforms in the uplink and downlink bands when running specific test cases, a fixed Band Rejection Filter (BRF) was inserted at each band increase. To reduce the user downtime for adding instruments and cut costs, the ME7873L has a multiband variable frequency filter for adding bands without changing hardware.

(4) MN7463B RF Combiner Unit

This unit has circuits for synthesizing downlink signals for simulating non-LTE bases stations, such as W-CDMA/GSM/CDMA2000 and for dividing the main inputs and outputs and the diversity output. Like the MN7484B, it incorporates an internal step attenuator (S-ATT) for correcting the main I/O path loss difference.

3.1.2 Space-Saving Rack Mount

The ME7873F/ME7874F occupies three racks while the size reduction achieved by using a multiband variable frequency filter has reduced the system size to two racks, saving one rack of space.

Moreover, users who already have the M7873F/ME7874F can easily configure a flexible four-rack system supporting simultaneous W-CDMA and LTE tests.

3.1.3 Stable System Performance

A Run Time Correction (RTC) function uses thermal monitoring to respond to temperature fluctuations and assure stable operation and constant test results.

Additionally, the dedicated self-test cable from the ME7873F/ME7874F is supported and an N-type torque wrench is provided for securely tightening the ME7873L self-test cable. This assures consistent self-test results and can easily detect changes in characteristics due to aging, etc.

3.2 Measurement Technology Meeting 3GPP Standards

To comply with the severe 3GPP Uncertainty requirements, the following two correction methods are used to achieve accurate measurement.

3.2.1 Fundamental Correction

The fundamental correction function corrects the absolute level of the path loss and the frequency characteristics, the attenuation linearity, and the time delay characteristics. It is targeted at passive devices with little change in characteristics and provides a correction value at system installation. This correction value is not cumulative for each unit and corrects the test system as a single instrument.

3.2.2 Run-Time Correction

Instruments such as the signal generator, signal analyzer, base station simulator, etc., suffer from temperature and aging changes and it is very difficult to achieve the required 3GPP TS36.521-1 and TS36.521-3 Uncertainty specification using only the fundamental correction outlined above.

To solve this problem, the ME7873L has a built-in Run Time Correction (RTC) function that auto-corrects the output level, etc., from the start of measurement. The RTC function has the following characteristics.

(1) Output Level Correction (for downlink and interference wave signals)

The output of the signal generator is measured by the ML2488B Wideband Power Meter and SC7816 Thermal Sensor with highly accurate reproducibility using the path in the interface unit to correct variations in power due to temperature changes.

(2) Preselector Tuning Correction

The 6 to 12.75-GHz band of the spectrum analyzer in the MS2692A Signal Analyzer is measured using the internal preselector. This preselector suffers from degraded level measurement accuracy due to sweep tuning drift caused by temperature and aging changes. Consequently, auto-tuning correction is performed for the frequency detected at spurious measurement using the signal generator in the system configuration.

(3) Variable Frequency Filter Frequency Characteristics Correction

Paths including the MN7464D Variable Frequency Filter suffer from filter tuning drift and changes in frequency characteristics due to temperature and aging changes. The thermal sensor and signal generator in the system are used to correct the frequency characteristics in the same manner as fundamental correction at system installation.

(4) Main I/O and Diversity Output Level Correction

To output signals at the same time at the main I/O and diversity output antenna, the base station simulator signal is split in the MN7463B and the difference in the output signal levels at each antenna is adjusted using the S-ATT in the MN7463B.

3.3 Standards Plan

Currently, 3GPP meetings are held every 3 months; the minimum requirements for terminal and base station test specifications are decided by the RAN WG4 working group, while the terminal conformance test specifications are decided by the RAN WG5 working group.

At development of the ME7873F/ME7874F Conformance Test System for W-CDMA, many specifications had already been decided at the design stage, and the design followed the need for a complex calibration system to assure the strict Uncertainty, etc., requirements would be met.

However, at development of the ME7873L, planning for the LTE test specifications was still in the first stages, 3GPP meetings were still being actively joined and completion of test cases was progressing. Discussions about standardization of the above-described Uncertainty were spearheaded by Anritsu and a simple measurement method was achieved.

However, a protocol procedure matching the active procedure for each terminal was required for U-plane connections and data transmissions as a standard connection method for terminal LTE protocol tests and there were some concerns over the need for individual adjustments for terminals.

In planning the terminal connection procedure for RF tests, progress had been made in simplifying protocol procedures and clarifying messages. In particular, the specifications for a common connection procedure independent of individual terminal features were decided using the TS36.509 test mode procedure and transmission of MAC padding data.

4 Software

4.1 Outline

The ME7873L software runs as an application on Windows Server.

The test system is pre-programmed to run required multiple test cases, which it executes automatically step-by-step. The preprogrammed execution requirements are a list of test cases to be executed called the test scenario as well as a parameter set created using the user interface of this software.

Figure 3 shows the software structure.

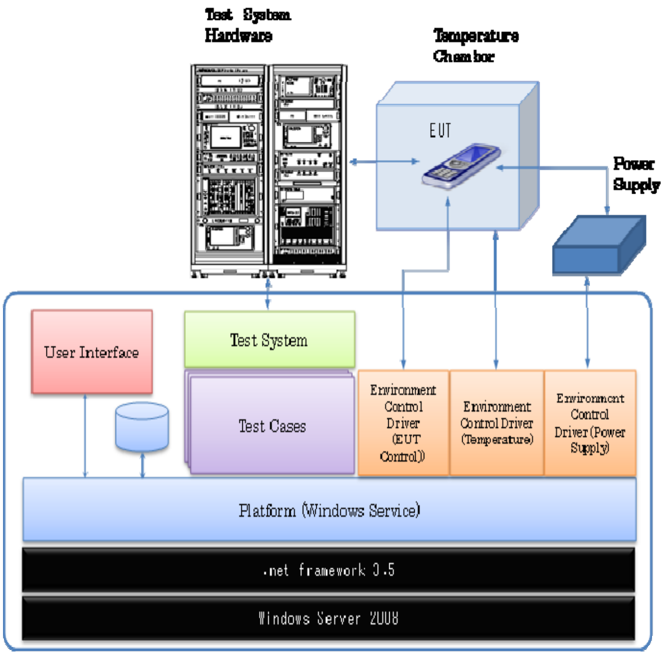

Figure 3 Block diagram of test system software

The software can be broadly divided into function, platform, environmental control drivers, user interface, test case, and test system parts.

The platform is the software core; it interprets test cases, creates and cancels each functional component required at execution, manages test sequences, measurement results, etc., using a database, and allocates shared tasks required for executing test cases, such as creation of test result reports.

The user interface connects to the platform and handles communications with the user via a GUI. It runs on an external PC connected to the system via a network.

The environmental drivers control the temperature and humidity of the temperature chamber and the power supply (voltage and on/off) to the EUT (Equipment Under Test) as required by the test case. They are completely independent of the test case and test system parts and can be customized according to the user's various required conditions.

The test system part virtualizes the test system hardware, executes the previously described calibration systems, and assigns the measurements required by the test case to the test system hardware.

The test case part determines the execution procedure for each test case. It executes them one-by-one independently and test cases can be added to or removed from the system.

4.2 Screen Image

Figures 4 and 5 show examples of the user interface main screen and report display screen, respectively.

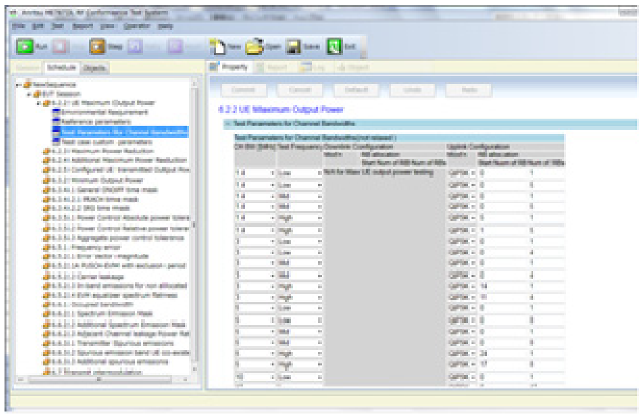

Figure 4 Main screen

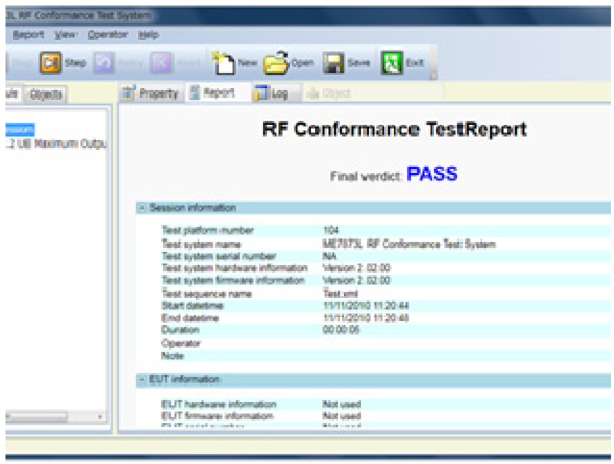

Figure 5 Report screen

5 Test Functions

5.1 TRx/Performance Test Features

This software executes the tests of the Tx and Rx characteristics, and performance described in section 6, 7, and 8, respectively, of the 3GPP TS36.521-1 standard describing the required PHY layer performance tests for FDD and TDD terminals.

The Tx characteristics test tests the RF characteristics of the uplink signal output from the terminal. The test results for all measurements are captured at the MS2692A.

The Rx characteristics test inputs a combination of the downlink signal and the interference waveform to the terminal, and uses the base station simulator to record the successful or failed demodulation of the downlink data fed-back from the terminal to measure the throughput and capture results, such as the Rx sensitivity.

The performance test combines an Additive White Gaussian Noise (AWGN) signal with the faded downlink signal from the MF6900A Fading Simulator and inputs it to the terminal before measuring the demodulation precision using the successful or failed demodulation information for the downlink channel fed-back from the terminal.

The channel state information report characteristics measures the accuracy of channel state information reported from the terminal. This measurement compares the throughput or Block Error Rate (BLER) when the downlink environment is either changed according to the Channel State Information (CSI) or fixed. In addition, this software also has the following new functions not described in the 3GPP standards.

(1) Fail Retry

When a test is failed, this function automatically repeats the same test over. The number of test repeats can be specified to confirm the failure reproducibility. In addition, using this function at auto-measurement supports unmanned retesting.

(2) Search Mode

This function performs repeated Rx characteristics and performance tests while changing the output level of the downlink and interference wave signal, and the SNR (ratio of strength of Downlink and AWGN signals).

Verifying the level where the test pass/fail results change provides information about the terminal performance limits. The signal level change setting can be specified so the test conditions become more or less severe.

5.2 RRM Test Features

Sections 4 to 9 of 3GPP TS36.521-3 specify items for testing the combined performance including RF related to the terminal RRM function. These tests test the terminal operations such as re-selection, handover, etc., in a specified RF environment as well as the downlink signal measurement function and the response function.

The TRx and performance tests mainly test the PHY layer functions of the terminal. The main feature of the RRM test is to test the overall operation, including MAC/RLC/RRC. As a result, the RRM test puts heavy emphasis on the layer-3 protocol sequence.

To execute typical RRM tests, the ME7873L features the following functions.

(1) Measuring Instrument Synchronization

A large part of the RRM test is testing changes in the RF environment over time and the terminal operation in response to these changes. Changes in the RF environment are standardized according to the elapsed time from measurement start or signalling message TRx time.

The ME7873L also supports Inter-RAT tests between LTE and W-CDMA/GSM/CDMA2000; it performs synchronized measurement for the required multiple base station simulators (MD8430A/MD8480C/MD8470A) according to the RF environment specified by each test case. Consequently, it can test terminal operations according to changes in the RF test environment over time for each test case.

Moreover, LTE/W-CDMA RF fading environment tests are also standardized. The ME7873L has a digital IQ connector for connection with the MD8430A/MD8480C and MF6900A. The connection can be auto-switched according to the test case to configure an LTE/W-CDMA fading environment.

(2) Real-time Operation

The RRM test software monitors the base station simulator frames (10-ms resolution)/subframes (1-ms resolution), generates primitives for the base station simulators, analyzes messages from the terminal, and synchronizes the evaluation conditions and operations between base stations to offer a completely integrated real-time operation system.

Furthermore, accurate output is achieved for changes in the downlink signal power due to changes in the RF environment by controlling the base station simulator baseband and the combined output power of the RF attenuator.

6 Summary

We have developed the ME7873L RF Conformance Test System in full compliance with the recommendations of 3GPP TS36.521-1 and TS36.521-3.

In particular, the multiple bands required by 3GPP are supported and the built-in RTC function achieves the 3GPP-required system measurement accuracy. As a result, the ME7873L has been approved by GCF and PTCRB as a test platform for verifying 3GPP mobiles.

In October 2010, this was the first LTE RF Conformance system in the world to obtain approval for 80% of the GCF test cases. In December 2010, it also became the first system in the world to receive approval for 80% of LTE RRM test cases. Now (October 2011) it has the largest number of approved test cases in the world.

We intend to continue active development to assure that the ME7873L keeps up with future changes in 3GPP standards and to maximize our customers' investment in a flexible and responsive test system meeting their R&D needs while reducing instrumentation costs.

References

1) C. Tagawa, M. Tsuchiya, M. Oonuki, M. Miyamoto, and K. Iwata, "Development of RF Conformance Test System Compliant with 3GPP Specifications", Anritsu Technical No.82, pp. 11-17 (March 2006), in Japanese.

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