Development of MT8870A Universal Wireless Test Set

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[Summary] Smartphones, tablet computers, and similar devices can support a variety of wireless systems, such as a cellular, wireless LAN, Bluetooth, GPS, DVB-H, ISDB-Tmm and FM radio. Anritsu has developed the MT8870A Universal Wireless Test Set as a non-signaling test instrument for today's wireless technologies with the expandability to support the next generation of wireless systems and the flexibility to satisfy the exacting needs of large-scale manufacturing.

1 Introduction

Recent mobile terminals typified by smartphones and tablets have become increasingly more functional and capable of receiving a wide variety of Internet services via connections to cellular and wireless LAN (WLAN) networks. Additionally, other devices such as headsets and keyboards are connected over Bluetooth, mapping services receive signals from Global Navigation Satellite Systems (GNSS), and digital broadcasts and FM radio use DVB-H and ISDB-Tmm, etc.

On the other hand, from the viewpoint of communications network infrastructure, increases in the numbers of subscribers using smartphones and the explosion in data size of rich- content services are driving demand for expansion of frequency bands and adoption of new communications technologies.

Supporting these many diverse wireless systems requires a large number of performance tests of the wireless modules installed in the mobile terminal, and the increased measurement inspection setup times and number of pieces of equipment are a major factor in increased manufacturing costs.

We developed the MT8870A against this background to support performance tests for a wide variety of wireless communications methods and future expansion towards next-generation technologies.

Figure 1 Front of MT8870A Universal Wireless Test Set (Four MU887000A TRX Test Modules Installed)

2 Development Concept

Mobile communications can be broadly classified according to function into cellular technologies such as LTE, W-CDMA, TD-SCDMA, CDMA2000, 1xEV-D0, and GSM systems, short range technologies such as WLAN (Wireless LAN), and Bluetooth, broadcast systems such as FM radio, DVB-H, and ISDB-Tmm, and GPS systems using GNSS. We developed the MT8870A based on the following concepts to test these functions and performance at manufacturing.

2.1 Economic and Flexible Modular Instrument for Manufacturing

To assure flexibility in mass production and testing of wireless devices, the MT8870A Universal Test Set is designed as a modular Mainframe in which up to four compact and low-cost modules (MU887000A TRX Test Module) are installed.

Each measurement module has the functions to perform TRx measurements of wireless devices independently. The measurement module is composed of sections for sending and receiving signals, a user interface and a signal analysis section.

The Mainframe has slots for installing up to four measurement modules, connectors for communicating with a remote controller, a common power supply for all measurement modules, a common reference signal, and common communications signaling.

(1) Small Footprint/Low Price

The MT8870A Mainframe accommodates up to four MU887000A modules, each with the same function and reducing the footprint to 25% that of four separate instruments. Moreover, the shared power supply, reference signals, and software licenses for all modules help keep down the overall price.

(2) Flexible

Swapping the measurement modules between Mainframe according to changes in the wireless device production line capacity helps optimize production. Additionally, since Mainframe manages the licenses, there is no need to purchase extra software licenses or reinstall software when swapping or adding measurement modules.

2.2 Basic Performance

(1) Supported Frequency Range

Each wireless service uses various different frequency bands. For example, cellular uses 400 MHz to 3.8 GHz, WLAN uses 2.4 GHz and 5 GHz, FM radio uses 65 to 110 MHz, and Near Field Communication (NFC) uses 13.56 MHz. All these wireless system bands are used simultaneously and new bands will be added in future, requiring software updates to support them. The MT8870A has been designed to measure the RF range from 10 MHz to 6 GHz with a 1-Hz resolution, supporting all current and future TRx tests.

(2) Wide Bandwidth and Wide Dynamic Range

The measurement bandwidth for both Tx and Rx signals is 160 MHz, supporting the maximum WLAN 11ac signal bandwidth. However, measurement of the Spectrum Emission Mask for LTE wireless terminals requires a bandwidth of 75.1 MHz centered on the carrier frequency. Although this band can be divided and measured, a merit of the wide bandwidth is that this signal band can be measured at one time, greatly increasing measurement speed.

When measuring WLAN signals, dynamic range is critically important. For the case of a WLAN 11b transmit spectrum mask measurement, the measurement system must be capable of measuring power spectral density of –50 dBr per 100 kHz or less at an offset of ±22 MHz from the carrier. For WLAN 11ac signals, the system must be capable of measuring power spectral density of 40 dBr per 100 kHz at an offset of ±30 MHz or more from the carrier.

To support measurement when inputting signals with a power of less than –10 dBm to the measuring instrument, the MU887000A internal residual noise must be less than –133.4 dBm/Hz for the WLAN 11b 2.4-GHz band and less than –132.4 dBm/Hz for the WLAN 11ac 5-GHz band. Consequently, we designed the residual noise of the Tx measurement system to be lower than these values.

(3) High-Speed Measurement

The wireless test specifications for the 3GPP and 3GPP2 cellular, IEEE802.11 WLAN, and Bluetooth standards describe the RF performance tests to be executed while the wireless device and test equipment simulating the communications system are communicating with each other. However, wireless devices are manufactured with functions (List mode) to simulate the communications state and shorten test times by omitting communications procedures. In concrete terms, makers of chipsets used in wireless devices each have their own unique method for supporting the List mode.

The List mode is a method for performing setting of the wireless device and test instrument and measurement repeatedly using the conventional test procedure; it supports execution of required tests by presetting the test procedure for the wireless device and test instrument, shortening the time intervals when the test instrument in not performing measurement. However, depending on which method the chipset maker chose to use, the measurement start time, send and receive signal frequencies, and signal level switching timing are all different. Consequently, to support the List mode, the MU887000A hardware switch timing can be set to any value. Moreover, the Tx measurement time is shortened by performing analysis while the signal is being captured.

2.3 Expandability

Expandability to support both next-generation LTE-Advanced and new frequency bands for existing systems is assured by using both an analog section supporting 160-MHz bandwidth TRx measurements at frequencies ranging from 10 MHz to 6 GHz plus an FPGA in the digital section, which supports function updates and additions using software updates without changing hardware.

3 Circuit Structure

Figure 2 shows the MU887000A circuit block diagram.

3.1 Transmitter Section

IQ data from the arbitrary waveform memory is processed by an FPGA at a sampling rate of 400 to 800 MHz. The digital data is converted directly to RF by the orthogonal modulator to produce an RF signal in the range 1 GHz to 6 GHz. An additional down conversion process is used to produce signals in the range 10 MHz to 1 GHz. The frequency-converted signal then passes via the amplifier section and electronic attenuator for input to the divider section.

3.2 Receiver Section

The Tx signal to be measured that is output from the divider section passes via the electronic attenuator of the receiver section. Up-conversion is performed for the 10 to 500 MHz measurement frequency by the frequency converter before input to the next downstream frequency converter. The 500 MHz to 6000 MHz measurement frequency is input as is to the next downstream frequency converter where it is down-converted to a fixed IF frequency (either 100 or 300 MHz), converted to a digital IF signal by the analog-to-digital converter, and then sent to the SA DSP Block in the FPGA. The sampling frequency at the analog-to-digital converter is 400 MHz.

With the need for wideband measurements, measurement of existing W-CDMA, CDMA2000, 1xEV-DO, GSM systems is necessary. These current communications services have a Downlink (or Forward) signal separated by 30 or 40 MHz from the Uplink (or Reverse) signal. Consequently, filtering is required to prevent the Downlink (or Forward) signal entering the measurement band. The IF filter path and IF frequency are selected to isolate the bandwidth required for measurement and separate out signals not required for analysis. The IF filter in-band frequency characteristics are calibrated by signal processing following analog-to-digital conversion to achieve a flatness of within 1.0 dB.

Table 1 IF Filter Routing

Analysis Bandwidth	IF Frequency	IF Stage Filter
≤25 MHz	100 MHz	100 MHz BPF
≤80 MHz	100 MHz	140 MHz LPF
≤160 MHz	300 MHz	300 MHz BPF

3.3 Divider Section

The MU887000A incorporates four RF connectors (Ports 1 to 4). Ports 1 and 2 are full-duplex connectors supporting simultaneous input and output of Tx and Rx signals. As a consequence, the transmitter and receiver sections are coupled by a Divider. The Tx and Rx sections connected by the internal divider have an isolation of better than 20 dB, reducing the mutual effect of the Tx and Rex sections on each other and enabling them to be controlled independently.

Ports 3 and 4 are half-duplex connectors using switching to support signal transmitting or receiving. The switch (SW) switches the connection to either the port connector connected to the transmitter or the port connected to the receiver.

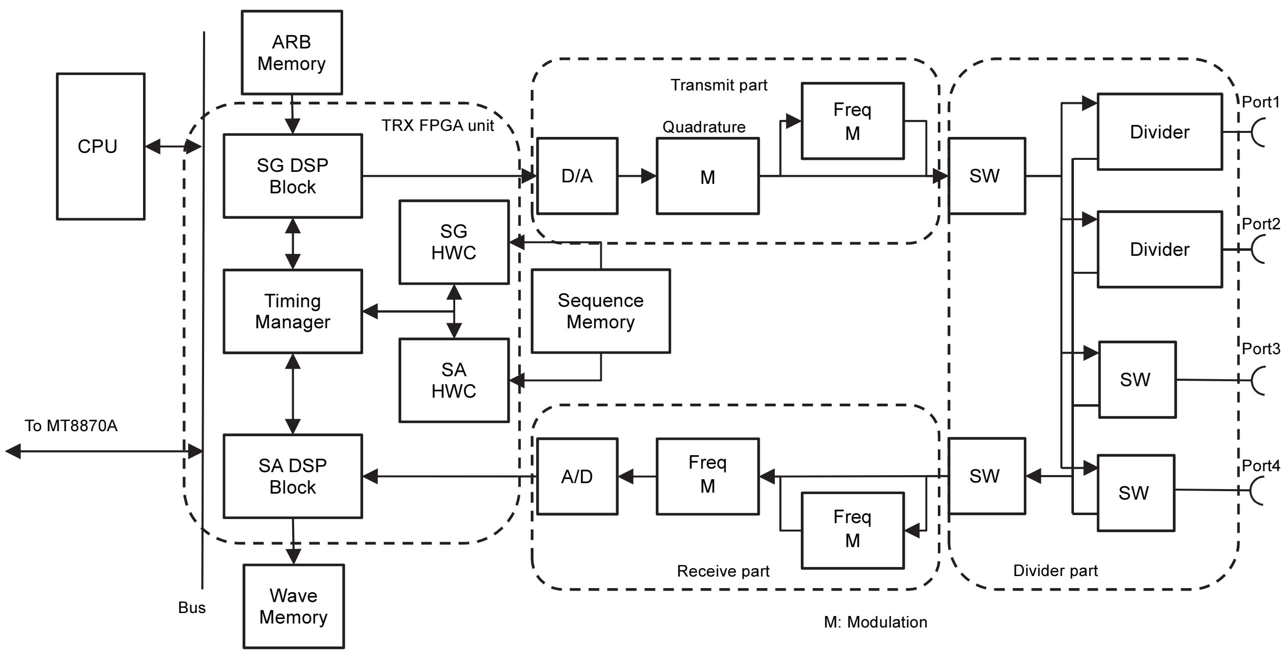

Figure 2 MU887000A Block Diagram

3.4 TRX FPGA Section

3.4.1 SG DSP Block

The signal generator's clock generation circuit that provides the ARB (ARBitrary waveform generator) function has sufficient setting resolution to support current and future communications systems. When regenerating the 160-MHz bandwidth signal for WLAN 11ac, it operates at a sampling rate of 200 MHz; it can also operate at a sampling rate of 16253968.254 Hz for ISDB-T. The block has a built-in large 4-GB memory (1 Gsamples) but to regenerate more waveforms there is also a function for synthesizing waveforms and a sequence function for repeating any part of the waveform data. Cellular mobile terminals operate by synchronizing to a synchronous signal transmitted by the base station. Consequently, a signal that simulates a base station must be output using the ARB function; the data forming this signal is a mixture of a repeated long-period pattern, short-period pattern, and identical pattern. In cases where there are repeating patterns in the ARB waveform data, only one copy of each pattern is stored. The system is able to recreate the required waveform dynamically by generating the stored patterns in sequence according to stored instructions. This greatly improves the capacity of the system to generate long, complex waveforms.

3.4.2 SA DSP Block

The SA DSP Block performs in-band calibration of the 400-MHz sampling rate digital IF signal from the receiver section before conversion to IQ data using orthogonal demodulation followed by rate conversion to the best sampling rate for analysis. Rate conversion can be performed at frequencies from 200 MHz to 1 MHz. Following rate conversion, the IQ data is converted to floating-point data and simultaneously calibrated according to the receiver hardware settings before sending the IQ data for the true level to the waveform memory. Since the true-level IQ data is in floating-point format, there is no need for subsequent data conversion and calibration processing at analysis processing by software. Moreover, the SA DSP Block has other functions such as trigger detection using changes in the signal level, recording of trigger timing information for waveform data, and real-time power measurement to reduce the signal search and power measurement processing at analysis.

3.4.3 Hardware Control Block

The Hardware Control Block (HWC) is the section that executes setting of all hardware. Normal hardware settings are executed by commands from the CPU. At remote operation, sequence information composed of hardware setting values and setting timings is stored in the sequence memory and the HWC sets the hardware according to the sequence information. The sequence memory and the HWC are both independent for the transmitter and receiver. A timing manager distributes the operation timing triggers to the independent transmitter and receiver. The timing manager is connected to both the SG DSP Block, and SA DSP Block and all trigger information is collected by the timing manager. Additionally, the timing manager has several internal timing functions for generating periodic triggers that can be used to generate frame timing and slot timing triggers matching each wireless technology as well as for setting the hardware at those timings. The operation in the List mode is achieved by coordinating the timing manager and HWC.

3.5 Analysis

The IQ data output from the SA DSP Block is analyzed using software running on the CPU to perform measurements, such as modulation analysis, power measurement, and spectrum analysis.

4 Software Structure

4.1 MU887000A Software

Figure 3 shows the structure of the MU887000A software, which is composed of Platform and Application blocks.

(1) Platform Block

The Platform block is composed of the Framework and Hardware Library. The Framework part processes remote commands at either GPIB or Ethernet connection, manages information about the MT8870A Mainframe and handles Application block processing. The Hardware Library controls hardware installed in the MU887000A and passes data between the hardware and Application block.

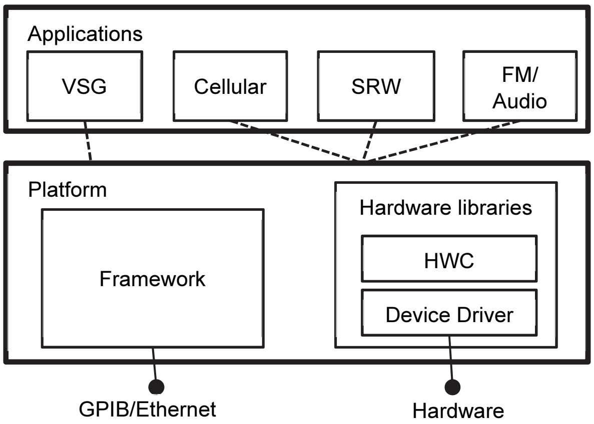

Figure 3 MU887000A Software Structure

Moreover, there is also an API for controlling hardware supporting the Application block. Once a list sequence – comprising a sequence of frequencies, levels and times – has been set up by the application, the HWC system controls the hardware register settings as the sequence is executed, without further intervention from the application.

(2) Application Block

The Application block is the part that executes signal generation settings and analysis according to remote commands. The execution functions are defined in application units (applications hereafter) that run either simultaneously or exclusively. The MU887000A signal output function is run continuously by the VSG application. The three Cellular, Short Range Wireless (SRW), and FM Audio signal analysis applications run exclusively.

The Cellular application manages Tx measurements of W-CDMA, GSM, LTE-FDD/TDD, CDMA2000, 1xEVDO, and TD-SCDMA systems as well as W-CDMA, GSM, and TD-SCDMA Rx measurement functions.

The SRW application manages Tx measurements of IEEE802.11b/a/g/n/ac and Bluetooth BR (Basic Rate)/EDR (Enhanced Data Rate)/LE (Low Energy) systems.

The FM/Audio application manages Tx and Rx measurements of monaural/stereo FM Radio, and Radio Data System (RDS) systems.

At measurement of application-supported wireless systems, there is no switching wait time because applications are executed without switching. In addition, the application switching time about 3 ms because all applications are always running.

4.2 CombiView

Since the MT8870A and MU887000A have no screen display functions, manual operation is performed from an external PC controller running the dedicated MX880050A CombiView software.

The PC and MU887000A are connected via the MT8870A Mainframe using either GPIB or Ethernet and the CombiView software performs remote control of the software in the MU887000A. When CombiView is started, it auto-detects the MU887000A modules connected to the PC and displays a list of the controllable modules. The user selects the target MU887000A to be controlled from the displayed list.

CombiView is composed of a shared section and plug-ins; the shared section boots the software and detects the test equipment. The plug-ins manage control of measurement applications running on the MU887000A. There is a one-to-one correspondence between the applications and plug-ins. Moreover, it is also possible to add a plug-in to CombiView when adding an application. A new plug-in is provided with each new application.

4.3 Utility Tools

We have also developed the MX887900A Utility Tool software, which runs on the external PC in the same manner as CombiView, for installing MT8870A and MU887000A license keys, upgrading software, and updating and maintaining waveform files for the arbitrary waveform generator.

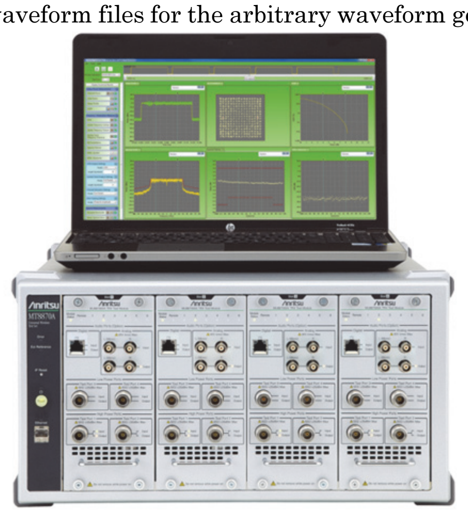

Figure 4 CombiView

This utility tool auto-detects the PC and connected MT8870A and MU887000A modules, installs the license keys for all detected MU887000A modules, upgrades software and transfers waveform files as a batch execution job.

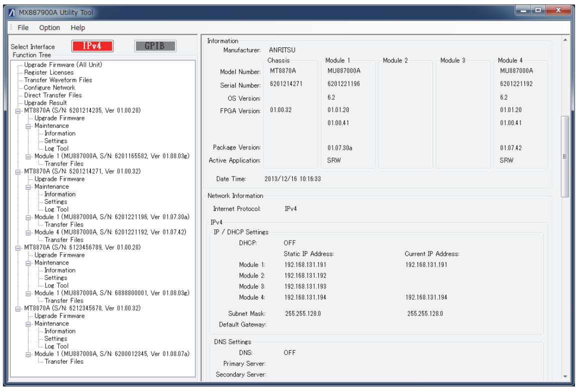

Figure 5 Utility Tool

5 Measurements and Functions

This section explains the measurement software functions and describes some usage examples.

Like the measurement functions of its predecessor MT8820C, the MT8870A supports both fundamental and sequence measurements. The fundamental measurement function measures steady-state signals. The sequence measurement function executes measurements in the above-described List mode. The fundamental and sequence measurement items are listed below:

- LTE-FDD/TDD, W-CDMA, TD-SCDMA
  Tx Power; Frequency Error; Occupied Bandwidth; Spectrum Emission Mask; Adjacent Channel Leakage Power; Modulation Analysis
- CDMA2000, EV-DO
  Tx Power; Frequency Error; Occupied Bandwidth; Code Domain Power; Modulation Analysis
- GSM
  Tx Power; Frequency Error; Output RF Spectrum, Modulation Analysis
- WLAN 11b/a/g/n/ac
  Tx Power; Frequency Error; Occupied Bandwidth; Spectrum Emission Mask; Adjacent Channel Leakage Power; Modulation Analysis
- Bluetooth BR/EDR/LE
  Tx Power; Frequency Error; Occupied Bandwidth; Spectrum Emission Mask; Adjacent Channel Leakage Power; Modulation Analysis

These items are measured by capturing data one time. Moreover, setting the number of averagings measures the time-continuous target signal without missing any measurements. The measurement method is shortened using these types of measurement methods. Figure 6 shows an example of WLAN 11ac measurement using CombiView.

In the measurement example in figure 6, a LAN measurement is being performed in the OFDM signal auto-evaluation mode. The auto-evaluation mode is a function for evaluating any of the WLAN 11a, 11g, 11n and 11 ac signals, using the MU887000A to analyze the WLAN OFDM signal. The MU88700A analysis results are captured by remote command and the measurement results are displayed using CombiView.

The measurement results in figure 6 show the results for five WLAN 11ac signal packets using a table to display average, maximum and minimum numeric results. In addition, the measurement results can be displayed simultaneously as power vs time, spectrum, and constellation waveforms.

6 Main Specifications

Tables 2 and 3 list the main specifications of the MT8870A Universal Wireless Test Set and MU887000A TRX Test Module.

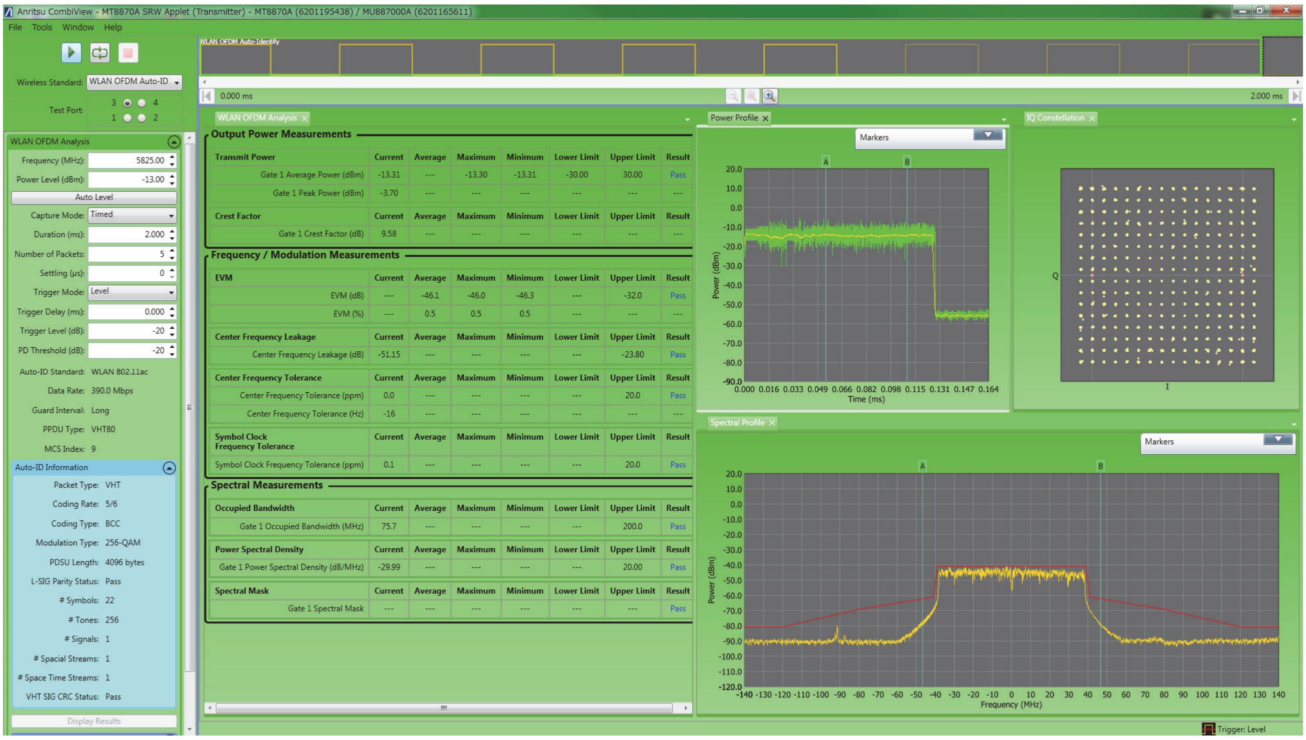

Figure 6 WLAN 11ac Measurement Results

7 Summary

The MT8870A Universal Wireless Test Set and MU887000A TRX module have been developed with the functions and performance for supporting not only conventional digital mobile terminals, short-range wireless such as WLAN and Bluetooth, FM radio, digital broadcasting, and GNSS, but also for next-generation communications systems. Optional measurement software supporting LTE-FDD, WCDMA, GSM, CDMA2000, 1xEV-DO, WLAN11b/g/a/n/ac, and Bluetooth were commercialized at the same time as the Mainframe launch in August 2012. Other audio measurement hardware plus LTE-TDD, TD-SCDMA, and FM/Audio measurement software options as well as waveforms for GPS, DVB-T, and ISDB-T signals were commercialized in December 2012. As a result, the MT8870A Universal Wireless Test Set is an all-in-one platform for testing world wireless systems as represented by the smartphone. It is the ideal space-saving set for efficient testing on production lines and offers complete support for GLONASS signal waveforms now being introduced by the latest smartphones, etc. It meets the needs of mobile terminal manufacturers by shortening test times for current and future communication systems.

References

1) ANRITSU TECHNICAL REVIEW No.21 2013: "Development of MT8820C Radio Communication Analyzer which supports 2G, 3G and LTE"

2) ANRITSU TECHNICAL No.86 2008: "Development of MS269xA Signal Analyzer Series for Next generation Systems"

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Table 2 MT8870A Universal Wireless Test Set Specifications

General Specifications	No. of Expansion Slots	4
	External Controller	Remote control (excluding power) from external controller Ethernet (1000BASE-T, RJ-45 connectors) on back and front panels With MT8870A-001/101 installed GPIB (IEEE488 bus connector) on back panel, with connectors (4) for each slot
	Dimensions and Mass	Dimensions: 221.5 (H) × 426 (W) × 498 (D) mm (excluding projections) Mass: ≤11.5 kg (excluding modules and options)
	Power Supply	100/120 Vac, 200/240 Vac, 50/60 Hz, ≤900 VA (max. values including all options and all modules)
	Temperature Range	Operating: 5° to 45°C, Storage: –20° to 60°C

Table 3 MU887000A TRX Test Module Specifications

Connections	RF Test Ports	TestPort1/2: N (female) TestPort3/4: N (female)
	Impedance	50 Ω (nominal)
	VSWR	Test Port1/2 <1.5 (10 MHz ≤ Frequency < 400 MHz) <1.2 (400 MHz ≤ Frequency ≤ 2700 MHz) <1.3 (2700 MHz < Frequency ≤ 3800 MHz) <1.5 (3800 MHz < Frequency ≤ 6000 MHz) Test Port3/4 <1.8 (10 MHz ≤ Frequency < 30 MHz) <1.5 (30 MHz ≤ Frequency ≤ 3800 MHz) <1.6 (3800 MHz < Frequency ≤ 6000 MHz)
	Max. Input Level	TestPort1/2: +35 dBm TestPort3/4: +25 dBm
RF Signal Generator	Frequency Range	10 to 3800 MHz 10 to 6000 MHz (with MU887000A-001 installed)
	Frequency Resolution	1 Hz
	Level Setting Range	TestPort1/2: –130 to –10 dBm (Frequency ≤ 3800 MHz) –130 to –18 dBm (Frequency > 3800 MHz) TestPort3/4: –120 to 0 dBm (Frequency ≤ 3800 MHz) –120 to –8 dBm (Frequency > 3800 MHz)
	Level Setting Resolution	0.1 dB
	Level Accuracy	TestPort1/2 (CW, Output level ≥ –120 dBm (Frequency ≤ 3800 MHz), Output level ≥ –100 dBm (Frequency > 3800 MHz), after CAL) 10 MHz ≤ Frequency < 400 MHz ±1.3 dB (10° to 40°C) 400 MHz ≤ Frequency ≤ 3800 MHz ±1.0 dB, ±0.7 dB (typ.) (10° to 40°C) 3800 MHz < Frequency ≤ 6000 MHz ±1.3 dB, ±1.0 dB (typ.) (10° to 40°C) TestPort3/4 (CW, Output level ≥ –110 dBm, after CAL) 10 MHz ≤ Frequency < 400 MHz ±1.3 dB (10° to 40°C) 400 MHz ≤ Frequency ≤ 3800 MHz ±1.0 dB, ±0.7 dB (typ.) (10° to 40°C) 3800 MHz < Frequency ≤ 6000 MHz ±1.3 dB, ±0.7 dB (typ.) (10° to 40°C)
	Harmonic Distortion	<–25 dBc
	Vector Modulation	Max Modulation bandwidth 160 MHz

Signal Analyzer	Frequency Range	10 to 3800 MHz 10 to 6000 MHz (with MU887000A-001 installed)
	Frequency Resolution	1 Hz
	Level Setting Range	TestPort1/2: –65 to +15 dBm (CW, 10 MHz ≤ Frequency < 350 MHz) –65 to +35 dBm (CW, 350 MHz ≤ Frequency ≤ 6000 MHz) TestPort3/4: –65 to +15 dBm (CW, 10 MHz ≤ Frequency < 350 MHz) –65 to +25 dBm (CW, 350 MHz ≤ Frequency ≤ 6000 MHz)
	Level Setting Resolution	0.1 dB
	Level Accuracy	At CW, Measurement bandwidth = 300 kHz, RBW = 100 kHz, after CAL TestPort1/2: 10 MHz ≤ Frequency < 400 MHz, Signal Generator = Off, at 10° to 40°C –30 dBm ≤ Level ≤ +15 dBm ±0.7 dB –55 dBm ≤ Level < –30 dBm ±0.9 dB –65 dBm ≤ Level < –55 dBm ±1.1 dB 400 MHz ≤ Frequency ≤ 3800 MHz, at 10° to 40°C –30 dBm ≤ Level < +35 dBm ±0.3 dB (typ.)/±0.5 dB –55 dBm ≤ Level < –30 dBm ±0.7 dB –65 dBm ≤ Level < –55 dBm ±0.9 dB 3800 MHz < Frequency ≤ 6000 MHz, at 20° to 30°C –30 dBm ≤ Level ≤ +35 dBm ±0.7 dB –55 dBm ≤ Level < –30 dBm ±0.9 dB –65 dBm ≤ Level < –55 dBm ±1.1 dB TestPort3/4; 10 MHz ≤ Frequency < 400 MHz, Signal Generator = Off at 10° to 40°C –30 dBm ≤ Level ≤ +15 dBm ±0.7 dB –55 dBm ≤ Level < –30 dBm ±0.9 dB –65 dBm ≤ Level < –55 dBm ±1.1 dB 400 MHz ≤ Frequency ≤ 3800 MHz, at 10° to 40°C –30 dBm ≤ Level < +25 dBm ±0.7 dB –55 dBm ≤ Level < –30 dBm ±0.9 dB –65 dBm ≤ Level < –55 dBm ±1.1 dB 3800 MHz < Frequency ≤ 6000 MHz, at 20° to 30°C –30 dBm ≤ Level ≤ +25 dBm ±0.7 dB –55 dBm ≤ Level < –30 dBm ±0.9 dB –65 dBm ≤ Level < –55 dBm ±1.1 dB
	Level Linearity	At CW, Measurement bandwidth = 300 kHz, RBW =100 kHz TestPort1/2: ±0.2 dB (0 to –40 dB, ≥ –55 dBm) ±0.4 dB (0 to –40 dB, ≥ –65 dBm) TestPort3/4: ±0.2 dB (0 to –40 dB, ≥ –55 dBm) ±0.4 dB (0 to –40 dB, ≥ –65 dBm)
	Max. Analysis Bandwidth	25 MHz (10 MHz ≤ Setting frequency < 500 MHz) 80 MHz (500 MHz ≤ Setting frequency < 1900 MHz) 160 MHz (1900 MHz ≤ Setting frequency ≤ 6000 MHz)
Other	Remote Control	Ethernet: Remote control using Mainframe Ethernet I/F GPIB: Remote control using GPIB I/F when GPIB option installed in Mainframe Interface functions: SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT0, C0, E2
	Dimensions and Mass	Dimensions: 193.6 (H) × 90 (W) × 325 (D) mm (excluding projections) Mass: ≤5 kg (excluding options)
	Temperature Range	Operating: 5° to 45°C, Storage: –20° to 60°C