GS-8800 Conformance System Measurement Uncertainty

Application Note

Overview

When measurements are performed there are unavoidable factors that can vary the result. Though often minuscule, these variances are referred to as measurement uncertainty (MU) and they are inherent in every measurement.

For a conformance test system, it is a requirement that the system MU be taken into account based on the standard MU guidelines: the “Guide to the Expression of Uncertainty in Measurement” (GUM) (1995). The Agilent Technologies GS-8800 conformance test system is designed in accordance to this MU standard as required by regulatory and accreditation bodies. This adherence ensures that a level of system measurement repeatability and reproducibility is achieved and meets the ISO 17025 standard. This application note explains how MU affects GS-8800 system measurements and demonstrates how MU is derived for the conformance test system.

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Measurement Uncertainty in GS-8800

The GS-8800 conformance test system provides complete automated testing to perform user equipment (UE) RF measurements according to the 3GPP standard. The system is an integrated dual-bay rack consisting of a one-box tester, a signal analyzer, additional signal generators for fading and adjacent channel simulation, and switching and band-dependent filtering (Figure 1). All of the instruments in the system are connected to the RF interface (RFIF) box before UE can be connected to the RFIF box for an automated measurement.

The instruments and cables connected to the RFIF box contribute to MU. The GS-8800 system has a calibration tool that corrects these RF signal path losses during test case measurements.

The RFIF box within the GS-8800 system is calibrated using an Agilent power meter and power sensor; thus enabling the RFIF box to be compliant to the ISO 17025 standard. This proves that all of the MU calculations performed for the respective RF sections of the system directly comply with ISO 17025 standard requirements.

With the GS-8800, the instrument used for the test case measurement varies from one test case to the next. Therefore, each test case has its own MU value based on the instrument used for the measurement and the RF path which it switches/uses.

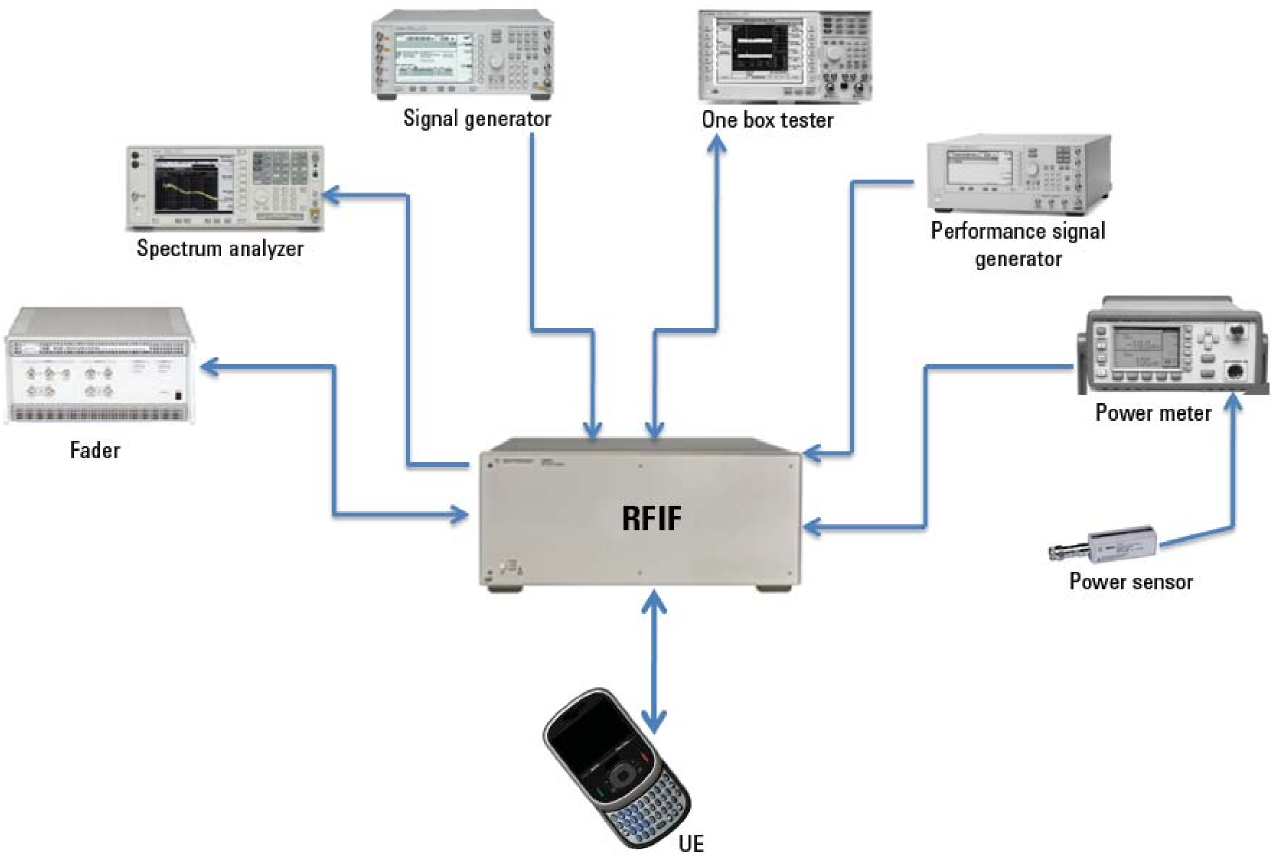


Figure 1. Components of the GS-8800 conformance test system

System Measurement Uncertainty Calculation Method

The system uncertainty of the GS-8800 test system can be introduced by a variety of sources including instrument stability, instrument linearity, mismatch between UE and the test system, and the repeatability of the RF interface box switching.

The MU combines all of the major factors that contribute to the overall uncertainty of the actual RF measurement into a single quantitative value representing the total expected deviation of a measurement from the actual value being measured.

- In the GS-8800 conformance system, the combined uncertainties are derived from five components:
  - Total calibration uncertainty
  - RF interface repeatability
  - RF interface flatness
  - RF interface mismatch loss uncertainty
  - Instruments measurement uncertainty

with the assumption that:

- Components with negligible contributions to the mismatch uncertainty are disregarded
- Type A measurement is based on the actual measurements whereas Type B measurement is evaluated based on scientific judgment using all relevant information
- Based on worst case scenario of handset, voltage standing wave ratio (VSWR) of UE is assumed to be 1.4
- Based on actual measurement, VSWR of the RF interface is assumed to be 1.6
- The uncertainty figures are valid for a confidence level of 95% according to ETSI specification
- Gaussian distribution is considered for the measurements
- RF interface flatness is assumed to be ±0.3 dB for the worst case scenario

As mention earlier, the GS-8800 MU is calculated based on the GUM-classified methods of uncertainty evaluation (for input estimates) which is Type A or Type B.

Type A: method of evaluation by statistical analysis of a series of observations

Type B: method of evaluation by any means other than statistical analysis of a series of observations

The five components mentioned previously are derived from the classified methods below.

1. Total calibration uncertainty

This component is about combined calibration uncertainty and it is derived from the Type B evaluation method.

2. RF interface repeatability

Since all the instruments are connected to the RFIF for automated measurement for all the test cases, this is a Type A evaluation done by performing repeated measurements and determining the statistical distribution of the results.

Five readings are taken and the standard deviation of the readings are calculated based on the formula,

$$s^2(X_k) = \frac{1}{n-1}\sum_{K-1}^{n}(X_k - X)^2$$

where $\mathbf{s(X_k)}$ is the standard deviation, **X** is the mean and **n** is number of samples.

The standard uncertainty:

$$u = \frac{S}{\sqrt{n}}$$

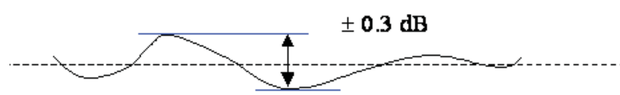
The expanded uncertainty, U = K x u, where **k** is the coverage factor. Therefore:

$$S = \frac{\sqrt{n-u}}{K}$$

3. RF interface flatness

RF interface flatness is caused by component behavior and it is derived from the Type B evaluation method.

A typical flatness curve is given below:



The flatness curve follows a normal distribution, where the probability of the values occurring is higher for those closer to the mean. The standard uncertainty for a normal distribution is computed by dividing the quoted specification by the coverage factor. In GS-8800 system, the RF interfaces flatness uncertainty is calculated based on the assumption that ±0.3 dB is the worst case scenario.

4. RF interface mismatch loss uncertainty

During the measurement, not all UE power is transferred to the RF interface because UE and RF interface impedances are not always equal to the transmission line (cable) characteristic impedance, Z_o.

The uncertainty due to this mismatch loss is derived from the Type B evaluation method and calculated as:

$$U = \frac{1}{\sqrt{2}} \times \mathbf{max}imum \left| \Gamma_s \right| \times \mathbf{max}imum \left| \Gamma_L \right|$$

This calculation is based on a uniform Γ_S and Γ_L distribution within the maximum circle. The reflection coefficient is given by the formula:

$$\Gamma = \frac{\mathbf{VSWR - 1}}{\mathbf{VSWR - 1}}$$

5. Instruments measurement uncertainty

No single instrument is 100% accurate and this includes instruments used in the GS-8800 conformance test system. Each instrument has its own inherent amount of uncertainty in its measurement. The instrument accuracy is usually specified in the specification sheet of the instrument and it is derived from Type B evaluation. As this warranted accuracy is conservatively specified, the standard uncertainty may assume a normal distribution in calculating the GS-8800 system MU.

In order for the uncertainty to be accurately determined for the GS-8800 system, a combined standard uncertainty ($\mathbf{u}_c$) from all five sources of uncertainty must be calculated using summation in quadrature, which is also known as root sum of the squares (RSS) as shown below:

$$\mathbf{u}_c = \sqrt{(\mathbf{component}_1)^2 + (\mathbf{component}_2)^2 + (\mathbf{component}_3)^2 + (\mathbf{component}_4)^2 + (\mathbf{component}_5)^2}$$

An expanded uncertainty (**U**) is then calculated from the combined standard uncertainty ($\mathbf{u}_c$) to achieve a 95% level of confidence as per the industrial and regulatory requirements using a coverage factor **K**, which is set to 2.

$$U = K \times u_c$$

Summary

In summary, the GS-8800 calibration routine performs the required full calibration of the RF system in order for it to be used in conformance testing/validation. This routine is carried out prior to using the system to test RF communication devices. A fully-calibrated GS-8800 system enables it to perform the RF test measurements with higher accuracy and as per 3GPP standards requirements for 2G, 3G and LTE. This calibration data is saved and retrieved when performing measurements to eliminate erroneous results when conducting testing on any type of mobile communication device. Consequently, this proves that all of the measurement uncertainty calculations performed for the respective RF sections of the system directly comply with the ISO 17025 standard requirements.

Related Information

Agilent E5515C Wireless Communications Test Set,
technical overview, literature number 5990-3238EN

Agilent PSA Series Spectrum Analyzers,
data sheet, literature number 5980-1284E

Agilent E4438C ESG Vector Signal Generator,
data sheet, literature number 5988-4039EN

Agilent E8257D PSG Microwave Analog Signal Generator,
data sheet, literature number 5989-0698EN

Agilent N1913A and N1914A EPM Series Power Meters,
data sheet, literature number 5990-4019EN

U.S. Guide to the Expression of Uncertainty in Measurement (GUM), 1995

www.agilent.com
www.agilent.com/find/GS8800

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