APPLICATION NOTE

# Wide Dynamic Range Multi-Channel Power Measurements

## Achieving Fast and Accurate Multi-Channel Power Measurements Over a Wide Dynamic Range for Wireless Manufacturing

## Introduction

The traditional key requirements for RF power measurements for wireless chipset or power amplifier manufacturing are good repeatability, fast measurement speed, and high accuracy. Now, an emerging requirement is becoming increasingly important: obtaining a wide power measurement range, especially on the lower power level. This new requirement is due to the emergence of chipsets designed to handle a wider power range to support higher data throughput and wider coverage area.

In this application note, we illustrate the typical power measurement test setup for wireless chipset or power amplifier manufacturing and explain the recommended sensor's settings base on different signal formats. These setups will help you achieve the fastest measurement speed, and most accurate power measurement over the widest power range. The paper concludes with the key features and benefits offered by the Keysight Technologies, Inc. U2040 and U/L2050/60 X-Series USB/LAN wide dynamic range power sensors, which have the world's widest dynamic range of 96 dB. The X-Series power sensors delivers the speed, accuracy, and wide power range that you need to ramp up and maximize your manufacturing throughput.

## Typical Test Setup

Figure 1 shows the typical test setup for wireless chipset manufacturing test. Three power sensors are used to measure the chipset's input power, output power, and reflected power. A spectrum analyzer, like the Keysight Technologies MXA, is used to measure other critical parameters such as ACPR, EVM, and harmonics. Care should be taken to ensure that the power to be measured does not exceed the sensor's measurable power range to avoid damaging the sensor, particularly at the power amplifier's output. Depending on the signal formats, a trigger output signal from the signal source can be connected to the trigger input ports of the power sensors to synchronize the signal timing and sensors' measurement acquisitions.

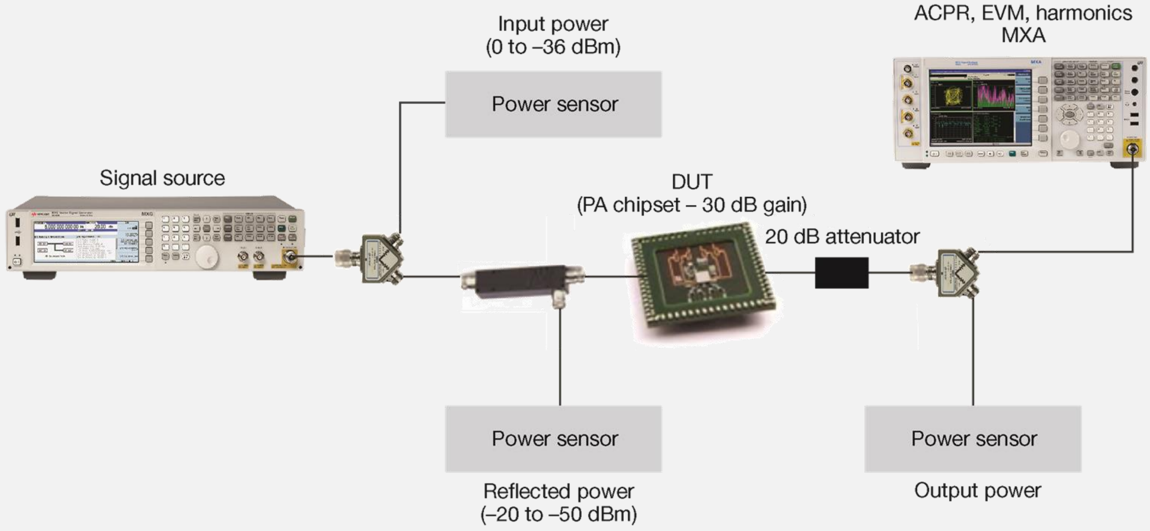



Figure 1. Typical test setup for wireless chipset manufacturing test

## Recommended Sensor Settings for Wireless Tests

To achieve the most accurate and fastest measurements, the X-Series USB/LAN power sensors can be configured into different modes based on the signal formats. Below are a few common wireless signal formats and the recommended sensor settings.

Table 1. Common wireless signal formats and recommended settings

| Type of measurement | Signals | Recommend sensor settings | Topic reference |
|---|---|---|---|
| Burst average power for signals with burst/frame structure | LTE-TDD, GSM, EDGE, WLAN | Average mode time-selectivity | Example 1 |
| Waveform average power for signals with burst/frame structure | LTE-TDD, GSM, EDGE, WLAN | Average mode time-selectivity | Example 2 |
| Waveform average power for continuous modulated signals | W-CDMA, LTE-FDD | Free run, fast mode | Example 3 |
| Time slotted signals without external trigger signals | GSM, EDGE | Normal mode time-gated power measurement | Example 4 |
| Time slotted signals with external trigger signals | GSM, EDGE | Normal mode time-gated power measurement | Example 5 |
| | | Average mode time-selectivity | Example 6 |

# Average Mode Time-Selectivity Measurements

The X-Series USB/LAN power sensors offers a new feature called average mode time-selectivity which allows you to configure the aperture duration of measurement capture with reference to the immediate trigger, internal trigger as well as external trigger. The aperture duration is settable from 20 µs to 200 ms with a resolution of 100 ns — a resolution low enough to cover any radio format. This new feature allows you to control which portion of the waveform is measured, giving you the same results as those provided by time-gated power measurements made in conventional normal mode (peak mode). The key benefits of this feature are that it enables the sensor to perform both waveform average and time-selectivity average power measurement across the full 96 dB of dynamic range and offers real time measurements of up to 50,000 readings per second. This is a significant improvement compared to conventional sensors, which typically clip time gated power dynamic range measurement at around 50 dB and have a maximum speed of 1000 readings per second.

Examples 1 and 2 below show how to perform average mode time-selectivity measurements for LTE signals.

## Example 1. LTE-TDD measurement using burst average power

For an LTE-TDD sub-frame of 1 ms, for example, you can measure the burst average power of one sub-frame by setting the aperture duration to match the sub-frame length (1 ms in this case). With the external trigger setting, the X-Series USB/LAN power sensors enables accurate measurement down to –50 dBm with an average count of 1. This provides you with assurance that the sensors are measuring every continuous 1 ms sub-frame.

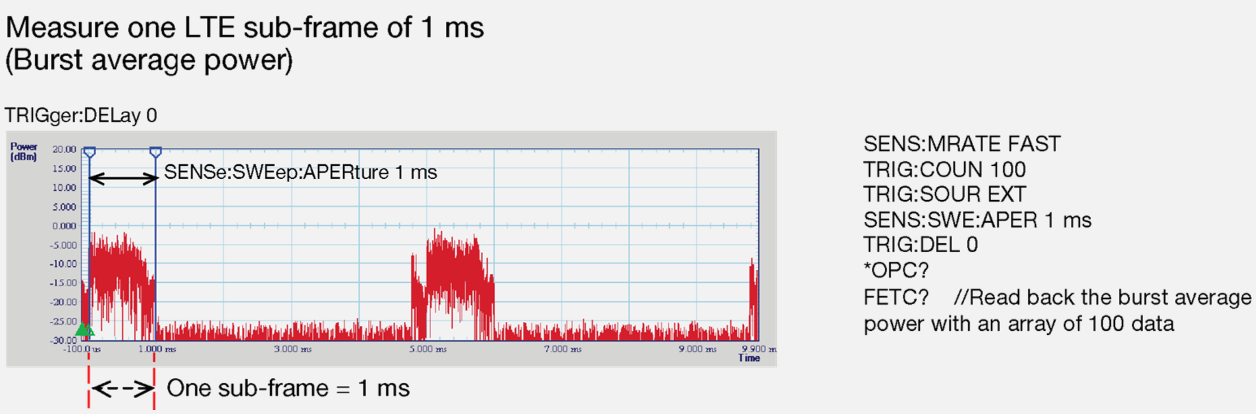



Figure 2. Measure one LTE sub-frame of 1 ms (burst average power). Measurement results for one 1 ms LTE sub-frame using burst average power setting.

## Example 2. LTE-TDD measurement using waveform average power measurements

If you want to measure the average power of the whole LTE-TDD waveform, the aperture duration should be set equal to the LTE frame duration of 10 ms (which includes both the burst on and off period). No trigger alignment (TRIG:SOUR IMM) or high average count setting is required since the sensor is always measuring the full period of the burst, returning highly accurate and repeatable power measurements, while providing fast power measurement of the entire LTE waveform.

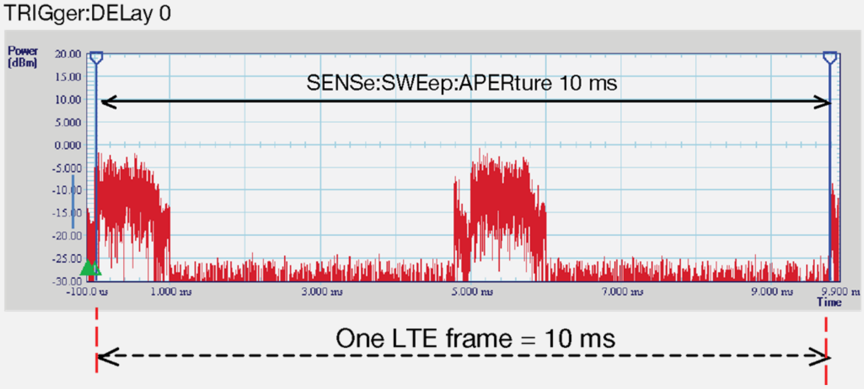
Alternatively, you can set the average count multiplied by the aperture duration to equal multiple integers of the pulse period:

Average count x Aperture duration = N x pulse period

Performing the same measurement with a conventional sensor requires a high average count since you have no control over the aperture duration, which needs to match the burst period.

### Measure one LTE frame of 10 ms

TRIGger:DELay 0




SENS:MRATE FAST
TRIG:COUN 100
SENS:SWE:APER 10 ms
SENS:SOUR IMM
TRIG:DEL 0
*OPC?
FETC? //Read back the waveform average power with an array of 100 data

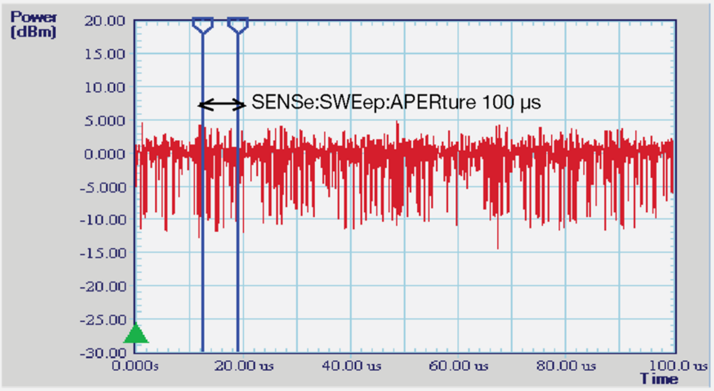
Figure 3. Measure one LTE frame of 10 ms. Measurement of one LTE frame over 10 ms using waveform average power setting.

## Example 3. W-CDMA measurement using waveform average power measurement setting

The new average mode time-selectivity also can be used for continuous modulated signals such as W-CDMA or LTE-FDD. Typically for these types of signals, only the average power of the waveform is measured. Using the X-Series power sensors, no special setting is required to complete this task when the sensor is set to its default-free run. The X-Series power sensors provides highly accurate average power measurements. To obtain the fastest measurement speed, set the speed mode to fast, aperture duration to 20 µs, and trigger count to 200. Real-time measurements performed at 50,000 readings per second are achievable using these settings.

### Continuous WCDMA waveform (Free run average power)

TRIGger:SOURce:IMMediate




To obtain real time measurement of 10,000 readings per second, set the following:

```
CAL:AUTO OFF   //optional setting
SENS:AVER:COUN 1   //optional setting
SENS:AVER:SDET OFF   //optional setting
TRIG:DEL:AUTO OFF  //optional setting
UNIT:POW W   //optional setting
FORM REAL
SENS:MRATE FAST
TRIG:COUN 100
SENS:SOUR IMM
SENS:SWE:APER 100 µs
TRIG:DEL 0
*OPC?
FETC?    //Read back the waveform average power with an array of 100 data
```

Figure 4. Continuous WCDMA waveform (free run average power). Continuous W-CDMA waveform capture using free run average power setting.

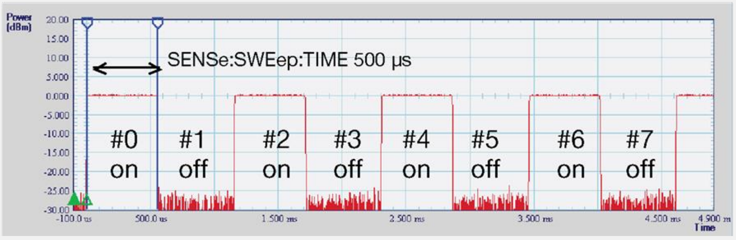
## Normal Mode Time-Gated Power Measurements

In some wireless applications, such as wireless module or board level testing, it is not possible to derive an external trigger signal from the device-under-test (DUT) or signal generator. Therefore, it is the power sensor that must provide the internal trigger function. Using the internal trigger, the DUT output signal level is compared against the internal trigger level setting in the sensor to qualify for a valid trigger.

As shown in the prior section, the new average-only mode time-selectivity function only supports the immediate trigger and external trigger for measurement timing control. For an application where the external trigger signal is not available and timing of the measurement is important, Keysight recommends using the conventional time-gated measurement mode under normal mode (peak mode). In this mode, you can set the trigger source to immediate, internal, or external.

### Measure GSM alternate timeslot (Internal trigger time-gated average power)

SENSe:SWEep:OFFSet:TIME 50 µs




```
SENS:MRATE FAST
TRIG:COUN 100
TRIG:SOUR INT
TRIG:SEQ:LEV -10
SENS:SWE:OFFS:TIME 500 µs
SENS:SWE:TIME 50 µs
CALC:FEED “POW:AVER ON SWEEP”
FETC?    //Read back gated average power with an array of 100 data
```

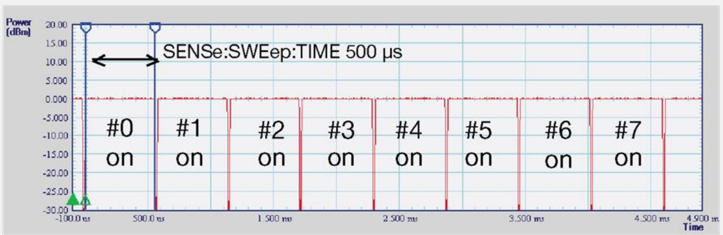
Figure 5. Measure GSM alternate timeslot (Internal trigger time-gated average power). Measurement of GSM alternative time slot using internal trigger time-gated average power.

## Example 5. GSM measurements using external trigger time-gated average power measurement

To measure every timeslot of a GSM frame, Keysight recommends using the external trigger setting. The X-Series power sensors can measure every timeslot with a measurement speed of 577 µs per reading; a rate that is like the GSM timeslot duration.

**Measure GSM all timeslot**
**(External trigger time-gated average power)**

SENSe:SWEep:OFFSet:TIME 50 µs




```
SENS:MRATE FAST
TRIG:COUN 100
TRIG:SOUR EXT
SENS:SWE:OFFS:TIME 500 µs
SENS:SWE:TIME 50 µs
CALC:FEED “POW:AVER ON SWEEP”
FETC?    //Read back gated average power
with an array of 100 data
```

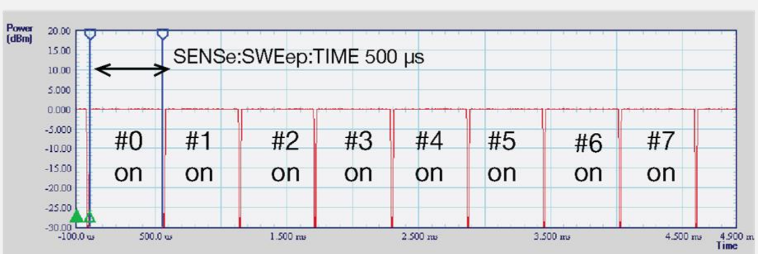
Figure 6. Measure GSM all timeslot (external trigger time-gated average power). Measurement of all GSM timeslots using external trigger time-gated average power setting.

## Example 6. GSM measurements using external trigger average mode time-selectivity

As an alternative to using the external trigger time-gated average power measurement, you can use average mode time-selectivity to measure every timeslot of GSM frame. The benefit of this method is that it provides a much wider dynamic range.

**Measure GSM all timeslot**
**(External trigger average mode time-selectivity)**

SENSe:SWEep:OFFSet:TIME 50 µs




```
SENS:MRATE FAST
TRIG:COUN 100
TRIG:SOUR EXT
SENS:SWE:APER 500 µs
TRIG:DEL 50 µs
*OPC?
FETC?    //Read back time-selectivity
average power with an array of 100 data
```

Figure 7. Measure GSM all timeslot (external trigger average mode time-selectivity). Measurement of all GSM timeslots using external trigger average mode time-selectivity.

# Keysight U2040 and U/L2050/60 X-Series USB/LAN Wide Dynamic Range Power Sensors Key Features

## Features and benefits

The U2040 and U/L2050/60 X-Series USB/LAN wide dynamic range power sensors are the ideal solution to reduce the cost of testing and increase production throughput while maintaining high accuracy and repeatability. It offers unique features that:

- Increase test coverage with its wide dynamic range
- Cover a broad range of wireless signal formats including the broadband
- LTE-Advance or WLAN 802.11ac
- Achieve very good accuracy down to 0.2 dB over the full specified operating temperature and frequency range
- Enable flexible configuration and cost-effective multi-channel power measurements

## Fast measurement speed

The X-Series power sensors takes up to 50,000 real time readings per second in average mode. This improvement is more than 10 times that of Keysight's previous sensor offerings. This measurement speed is fast enough to measure every continuous pulse without leaving time gaps in between measurement acquisitions.

## World widest dynamic range power sensor

With its total dynamic range of 96 dB, no other sensor can match the Keysight X-Series' power sensor capability. Having the industry's widest dynamic range allows the sensor to measure a wide range of signals whether they are high power amplifier (PA) outputs or small reflected signals from the well-matched PA.

## High accuracy and repeatability

The X-Series power sensors offers high accuracy: < 0.2 dB up to 18 GHz and < 0.3 dB up to 33 GHz over the full operating temperature range of 0 to 55 °C. There is no other instrument that can offer a similar level of accuracy over this temperature or frequency range. You may be able to find a spectrum analyzer or network analyzer that provides accuracy close to this range, but that accuracy is only valid for certain power levels and at a specific temperature. With X-Series power sensors, you can be assured that there will be no over rejecting of good parts due to tight tolerances or limited specification margins. All the measurements obtained with the X-Series power sensors are traceable to standards set by national or international standard laboratories.

## Broadband coverage

The X-Series power sensors makes accurate average or time-gated average power measurements for any modulated signal, and covers all common wireless signals such as LTE, LTE-Advanced with 100 MHz bandwidth, and WLAN 802.11ac with 80/160 MHz bandwidth. A four-path diode stack design with parallel paths to ADC (analog to digital converter) provides seamless range transition with high accuracy and repeatability. The four-path diode stack design enables all the diodes to operate in the diode's square law region, allowing the X-Series power sensors to function like thermocouple power sensors to provide accurate RMS power for broadband modulated signals.

## Cost-effective and flexible solution for multi-channel power measurements

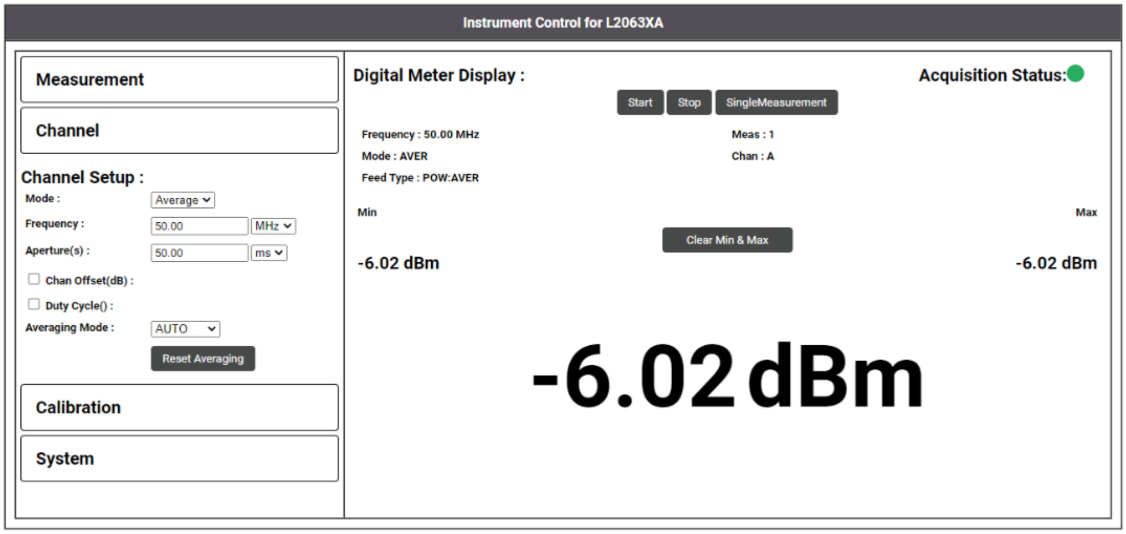
This series of sensors is a cost-effective solution for multi-channel power measurements as illustrated in Figure 1. A complete multi-channel power measurement solution of a PA's chipset's input power, output power, and reflected power can be achieved with three X-Series power sensors, while providing high accuracy and fast measurement speed that is suitable for any broadband wireless signal format. The sensors provide a very flexible solution and can be reused for other calibration purposes to improve the accuracy of a test system over a wide frequency, power, and temperature range.

## Variable Sampling Rate 1M samples/sec and Long Memory 1M Samples Data Storage

The U/L206x X-series power sensors were specifically designed to meet the European Telecommunications Standard Institute (ETSI) power measurement requirement capturing 1 MHz sampling waveforms from the power sensor and requires at least 1 MB memory per second. The new U/L206x X-series power sensors come with a feature of adjustable sampling rate up to 1 Msa/s and long internal memory up to 1 MB. The variable sampling rate function allows you to slow down the measurement from the default 20 Ms/s to 1M Sa/s, and the internally can hold data up to 1 M data samples. Multi-channel synchronous power measurement can be extended and set up easily with multiple U/L206x X-Series power sensors and using external triggering time synchronization. The output data samples are stored and kept for offline power measurement analysis as specified by the standard.

## LAN Power Sensors Web Interface

The L205x/6x X-Series LAN power sensors include a built-in Web Interface for monitoring and controlling the instrument via a Web browser. The LAN power sensors should be operated remotely from a PC using the web browser interface with the virtual front panel interface that looks and acts as the real front panel on the L205x/6x X-Series LAN power sensors.

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