

Keysight U2000 Series USB Power Sensors

GSM Timeslot Burst Power Measurement

Technical Overview



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An Affordable Solution for Measuring Burst Power in Time-Gated Mode

Measuring pulse, burst, or modulated signals for wireless technology such as TDMA, GSM, WLAN, WiMAX, and LTE is very important. High-performance, average, and peak power meters and power sensors are required for measuring the average power and crest factor (peak-to-average ratio) of modulated signals throughout various research and development stages and the manufacturing verification process. To measure average power of a time-gated pulse or burst signals (in a specific timeframe), you do not need high-performance power meters and power sensors. The Keysight Technologies, Inc. U2000 Series USB power sensor is a low-cost solution for measuring average power of burst signals with frequency ranges up to 24 GHz and dynamic ranges up to 69 dB (–25 dBm to +44 dBm, sensor dependent).

This document explains the methodology of measuring the time-gated burst signal of the GSM timeslot by using a USB power sensor. It covers the key features of the USB power sensor that allows you to optimize your measurement speed and accuracy. The test setup and SCPI command sequence for both externally triggered and internally triggered measurements are also described in this document.

Introduction

There are many ways to analyze a modulated signal. Power-versus-time measurement is a very useful method for examining power level changes due to pulsed or burst carriers.

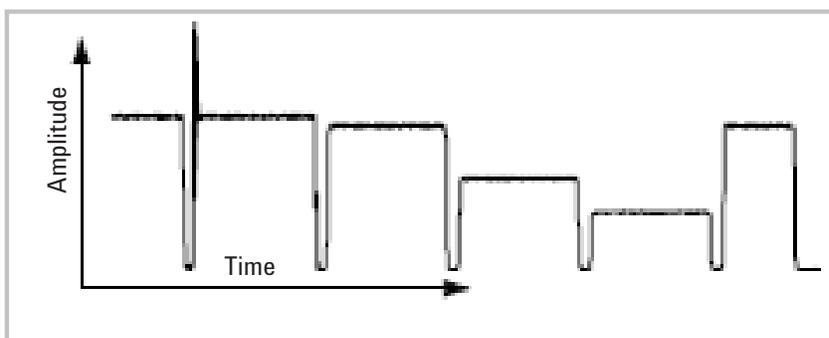


Figure 1. Power-versus-time measurement graph

Average, pulse, and peak envelope power measurements provide different types of information about the signal. Average power (often simply called *power*) measures power that is delivered over several cycles. Pulse power is determined by measuring the average power of the pulse and then dividing the result by the pulse duty cycle. This is a mathematical representation of a pulse power rather than an actual measurement and assumes constant pulse power. Pulse-power measurement averages out any aberrations in the pulse, such as overshoot or ringing. For this reason, it is called pulse power and not peak power or peak envelope power. To ensure accurate pulse-power readings, the modulating signal must be a rectangular pulse with a constant duty cycle. Other pulse shapes such as triangular or Gaussian will cause erroneous results. This technique is not applicable for digital modulation systems, where the duty cycle is not constant, and the pulse amplitude and shape is varying.

Introduction (Continued)

Peak envelope power should be used for more accurate measurements when the pulse becomes non-rectangular and the pulse-power measurement equations would no longer be accurate. This technique is most suitable for modern digital communication systems with variable duty cycles and pulse widths.

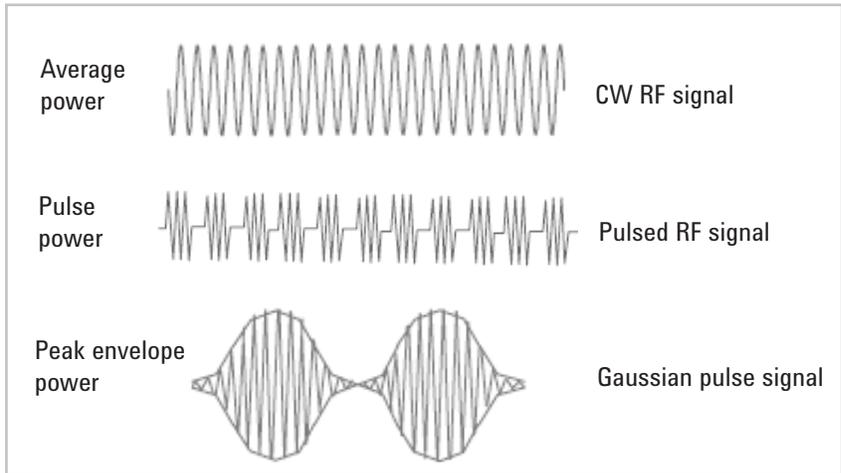


Figure 2. Average, pulse, and peak envelope signal power

Unlike measuring a pulsed signal that has a pulse repetition period and a constant duty cycle, burst signal measurement is considerably more challenging. Measuring a burst signal with an unpredictable burst length that lacks a constant duty cycle requires time-gated functionality (independent measurement gates). This can be accomplished with high-performance power meters and power sensors.

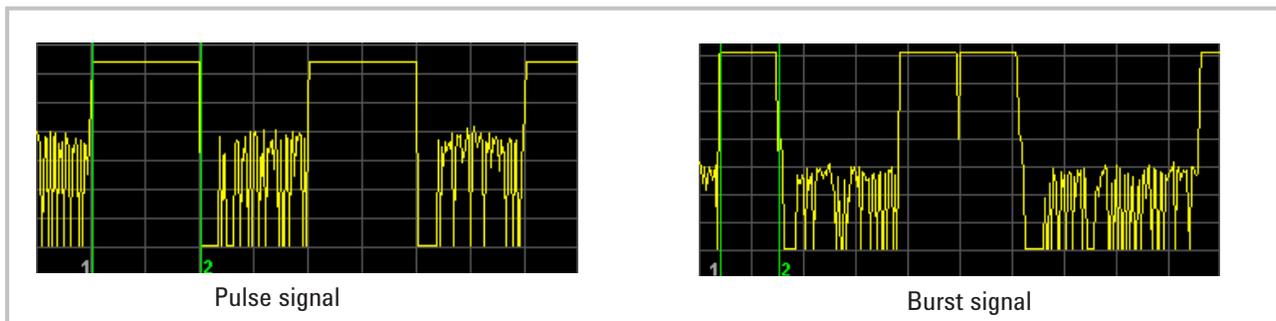


Figure 3. Pulse signal with a constant duty cycle versus burst signal without a constant duty cycle

In high-volume power amplifier (PA) module testing environments, power measurement accuracy, test-time efficiency, and test system cost are the key factors for investment consideration. In this case, using high-performance power meters and power sensors incurs costly investment in equipment setup. In order to reduce equipment setup costs, PA manufacturers have chosen to perform time-gated average power measurements of the PA module.

The Keysight U2000 Series USB power sensor is a low-cost solution for average time-gated power measurement of complex modulation signals. It has two trigger mechanisms, one of which is internal trigger acquired from measured test signal. The other trigger mechanism is external trigger that comes from other instruments in an automated test system via its built-in TTL-compatible trigger input. This enables average power measurement in a specific timeframe (in seconds).

Measuring GSM Timeslot Signal

In the following example, the GSM signal consists of eight timeslots (slots 0 to 7) with 4.613 ms frame duration and with each timeslot being 577 μ s in duration. Using the Keysight U2000 Series USB power sensor to measure the GSM timeslot (with GSM timeslot 0 on) provides 387 μ s for gate duration after having 150 μ s offset at the rising edge of the signal and 40 μ s offset at the falling edge of the signal. This ensures that the measurement is not affected by the trigger jitter and settling time of the USB power sensor.

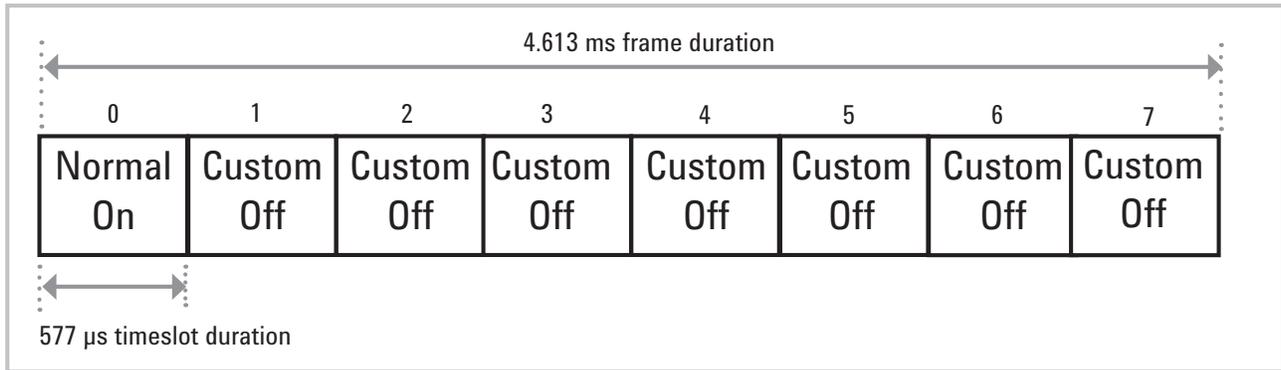


Figure 4. GSM timeslot pattern with timeslot 0 on

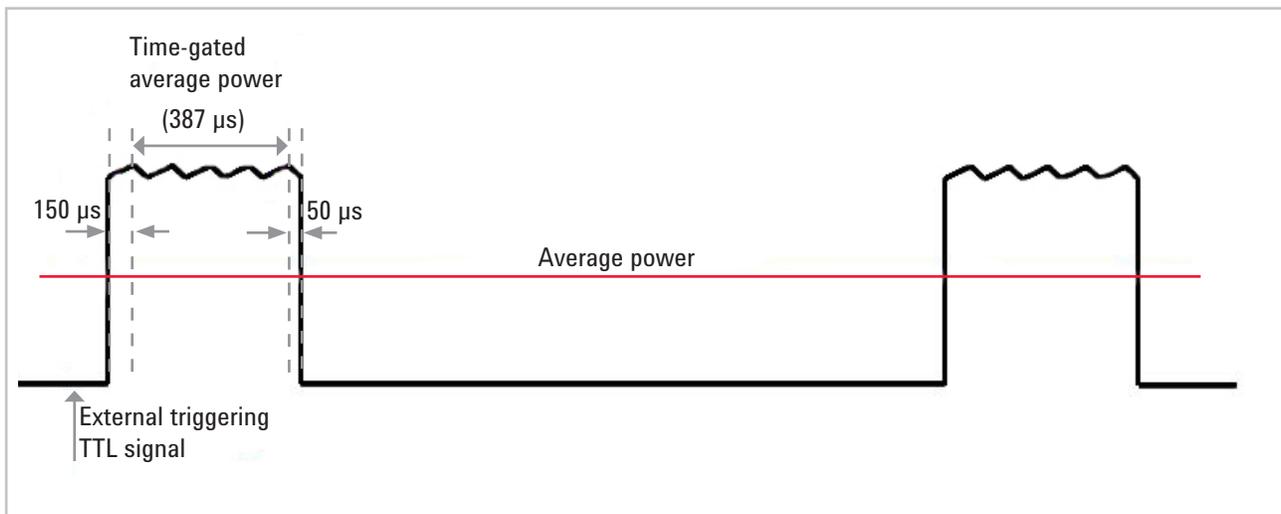


Figure 5. Measuring GSM timeslot 0 with Keysight USB power sensor

Overview of Keysight U2000 Series USB Power Sensors

The Keysight U2000 Series USB power sensor allows the power measurement to be displayed on a PC or on other Keysight instruments without the need for a separate power meter. The compact USB power sensor provides the same functionality and performance as a conventional power meter and a power sensor. The USB power sensor is a cost-effective solution that leverages the latest diode sensor technologies.

With the combined functionality of a power meter and a power sensor, the USB power sensor returns the power measurement readings and displays it on your PC via a USB cable. The readings can be retrieved by using standard SCPI commands or an IVI.COM/IVI.C driver. The SCPI-based command set provides a user-friendly programming environment that enables you to communicate with your power sensor as you are communicating with your power meter.

To optimize the performance of the USB power sensor, the following settings are recommended when measuring burst power by using the USB power sensor's external triggering methodology.

Zeroing the USB Power Sensor

The USB power sensors do not require calibration with a 50 MHz reference source. However, zeroing is necessary before the measurements are made. The purpose is to reduce the zero offset and noise impact so that the accuracy of the RF power measurement is improved. Two types of zeroing are available.

Internal zeroing

Internal zeroing uses an electronic switch to isolate the USB power sensor RF input port from the internal measurement circuitry during the procedure, thereby allowing the sensor to be physically connected to an active RF source. Therefore, you do not need to disconnect or switch off the RF source during internal zeroing.

External zeroing

External zeroing does not utilize the electronic switch to isolate the measurement circuitry from the RF input port. The RF power must be removed from the RF input port either by turning the source off or by physically removing it from the sensor during the external zeroing procedure. External zeroing generally has better zero-set performance. The internal/external zeroing selection should be based on the measurement needs.

The following SCPI commands are used to perform internal/external zeroing.

```
CAL:ZERO:TYPE INT|EXT /* Performs internal or external zeroing.  
CAL /* Initializes the calibration.  
*OPC? /* Waits for the operation to complete.  
Return "1" when zeroing has completed.
```

Note: By default, the USB power sensor will perform internal zeroing upon power-up.

Overview of Keysight U2000 Series USB Power Sensors (Continued)

Measurement Speed

High-speed measurement is essential in high-volume manufacturing of RF and microwave components and systems. Faster testing will improve productivity and enable manufacturers to test more devices in a shorter time.

The measurement time can be improved by switching the measurement speed. There are three types of measurement speed settings: NORMAL (by default), DOUBLE, and FAST. In NORMAL and DOUBLE modes, full sensor functionality is available. In FAST mode, averaging limit is disabled and set to 1, which allows fast measurement with a slight degradation of measurement accuracy at lower power.

Table 1. The measurement speed of the USB power sensor and the associated test time

Measurement Mode	Measurement Speed (readings/second)	Test Time (ms)	Averaging
NORMAL	20	50	On (refer to auto averaging setting in <i>Keysight U2000 Series USB Power Sensors Operating and Service Guide</i>)
DOUBLE	40	25	
FAST	110	9	Off

The following SCPI commands are used to set and query the measurement speed.

```
SENS:MRATE NORM|DOUB|FAST /*Sets the measurement mode.  
SENS:SPEED? /*Queries the measurement speed.
```

Note: By default, the USB power sensor is in NORMAL mode upon power-up.

Step Detector

The step detector is used to reduce the settling time of the filter after a significant step in the measured power. The filter can be set to re-initialize upon detection of a step increase or decrease in the measured power. In AUTO filter mode, the average of the last four values entered into the filter is compared with the average of the entire filter. If the difference between the two averages is greater than 12.5%, the digital filter is cleared. The filter then starts to store new measurement values.

During gated pulse/burst measurement, spikes may occur that can accidentally trigger the step detector and thus prevent completion of the final averaging. Consequently, the measurement results will be inconsistent. Under these circumstances, we recommend that you turn off the step detector.

The following SCPI command is used to turn the step detector on or off.

```
SENS:AVER:SDET ON|OFF
```

Note: By default, the step detector of the USB power sensor is turned on upon power-up.

Time-Gated Burst Power Measurement (External Triggering)

A recent firmware enhancement, version A.03.01 (and above), for the U2000 Series USB power sensor offers internal triggering capabilities in addition to the external trigger which is available since firmware version A.02.01. This feature allows you to set the gate offset and gate length and configure the USB power sensor in gated mode in order to perform the measurement.

The USB power sensor has a built-in trigger circuitry that controls the timing of a pulse-signal capture to enable measurement synchronization with an external instrument or event. An external signal greater than 1.9 V applied to the TRIG IN of the USB power sensor will trigger the power sensor to capture data.

As for the internal trigger, an adjustable measurement dependent threshold is used to define the trigger point of the signal being measured. This is especially useful for measuring pulses that do not occur at fixed intervals.

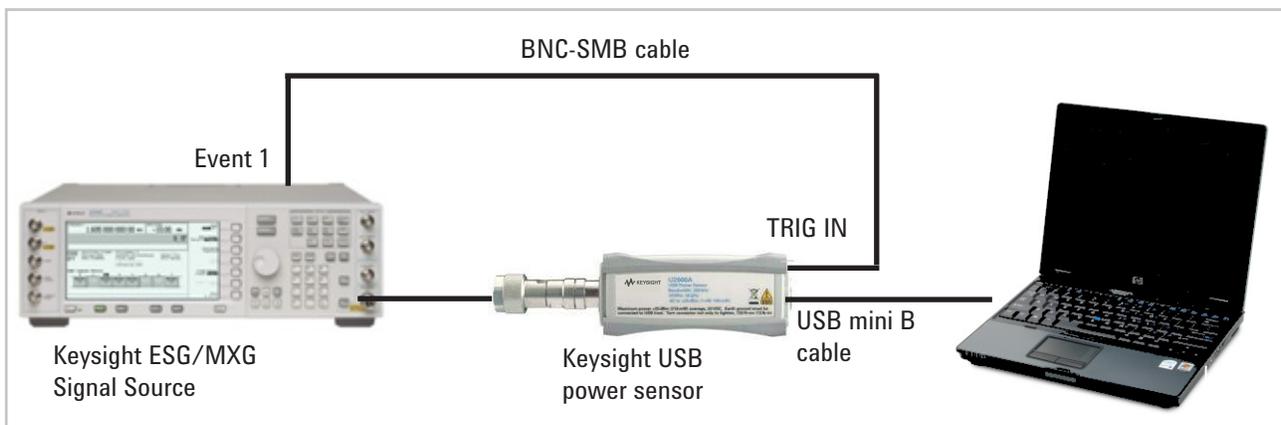


Figure 6. Simplified diagram for the setup of a time-gated burst power measurement (external triggering)

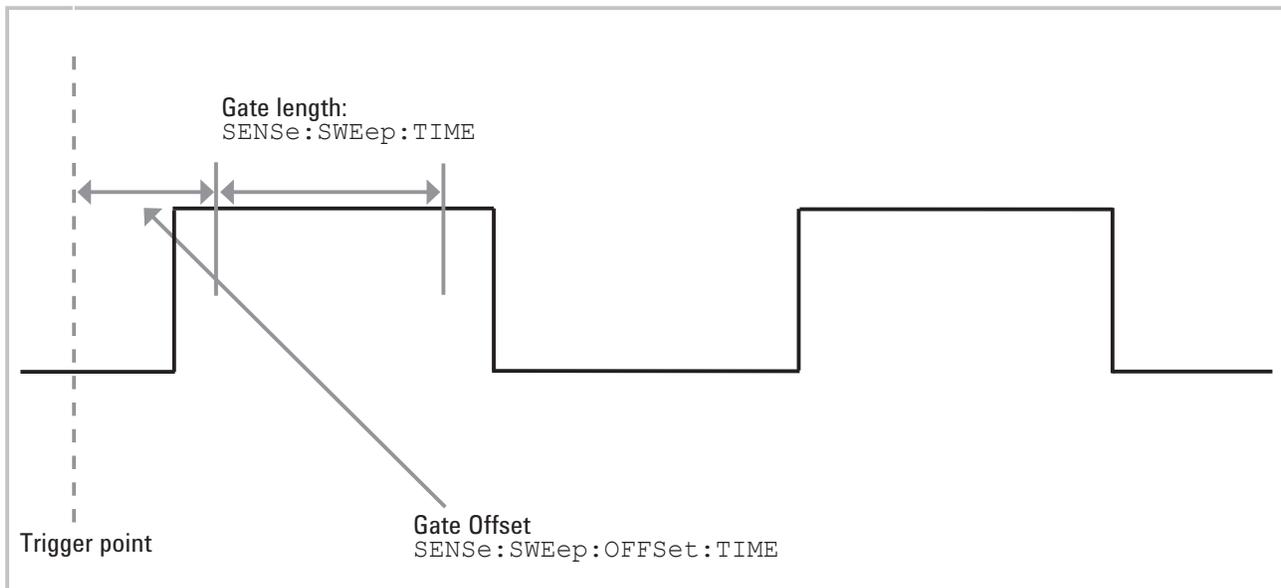


Figure 7. Diagram of a time-gated signal

Time-Gated Burst Power Measurement (External Triggering) (Continued)

The following table shows the sampling rate, maximum capture length, range settling time, dynamic range of the gated power measurements, and other specifications related to making time-gated measurement.

Table 2. Time-gated measurement specifications

Parameters ¹	Performance
Maximum video bandwidth	40 kHz
Minimum rise time	40 μ s
Minimum fall time	40 μ s
Rabge settling time	150 μ s
Minimum pulse width	200 μ s
Sampling rate	1.47 Msps
Maximum capture length	150 ms
Maximum pulse repetition rate	150 kHz
Dynamic range	U2000/1/2A: -30 dBm to + 20 dBm U2000/1/2H: -10 dBm to + 30 dBm U2000/1B: 0 dBm to + 44 dBm

1. Not applicable for U2004A

Customer Application of GSM Power Amplifier (PA) Testing in Manufacturing

Figure 8 shows the testing of a GSM power amplifier module in one of the manufacturing sites. The signal generator produces a constant amplitude CW RF signal with a frequency sweep from 800 MHz to 2 GHz (GSM frequency range). The function generator generates a pulse with a $\frac{1}{8}$ duty cycle into the GSM power amplifier module. The power amplifier module will be switched to GSM mode. The time-gated average power measurements (on the GSM timeslot) will be performed at the output of the amplifier module, after the attenuator, by using a Keysight USB power sensor. The USB power sensor is synchronizing with the function generator via an external triggering signal. This setup is done in production for fast tester measurement.

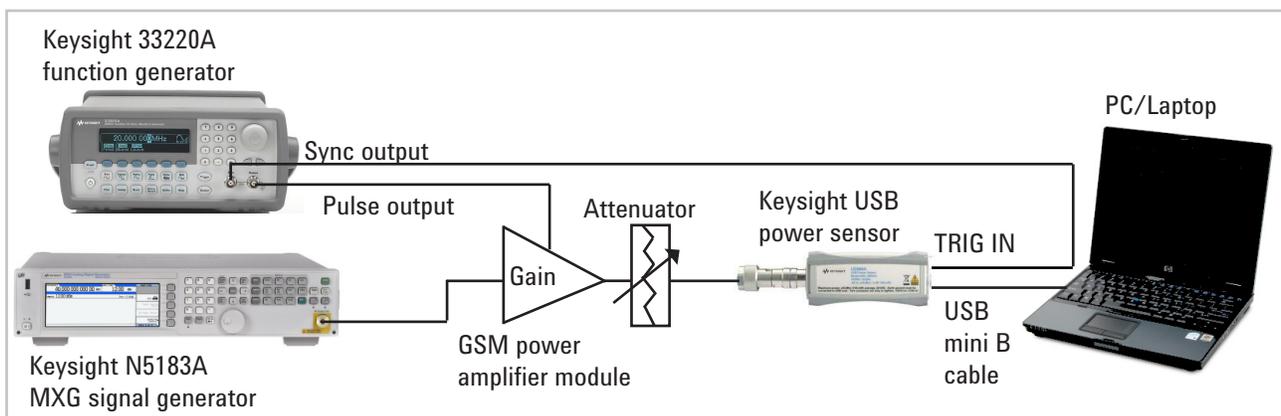


Figure 8. Simple setup diagram of GSM power amplifier module testing

Figure 9 shows another real-world example of using the USB power sensor with external trigger capability to measure the time-gated signal of the power amplifier module. Event 1 at the signal generator is used to synchronize or trigger the USB power sensor via TRIG IN before starting to capture the time-gated GSM signal (generated by the signal generator).

Customer Application of GSM Power Amplifier (PA) Testing in Manufacturing (Continued)

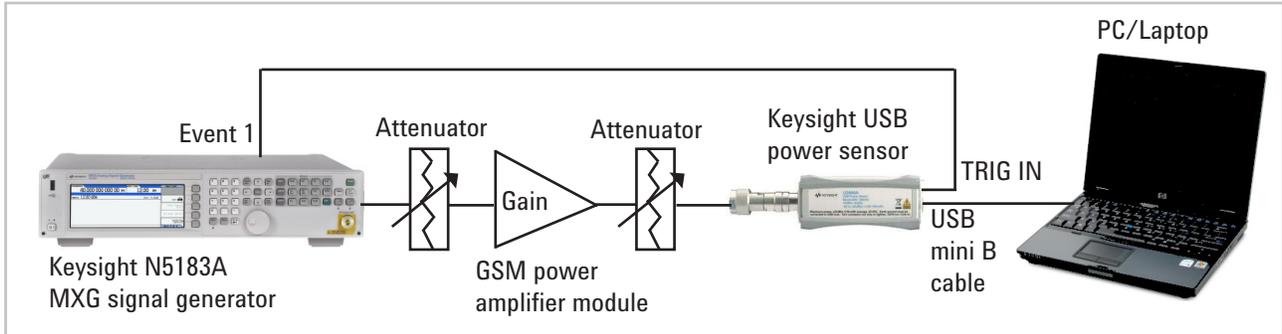


Figure 9: Simple setup diagram of time-gated burst power measurement (external triggering)

Figure 10 depicts test setup when using the USB power sensor with internal trigger to measure the burst gated signal of a power amplifier module.

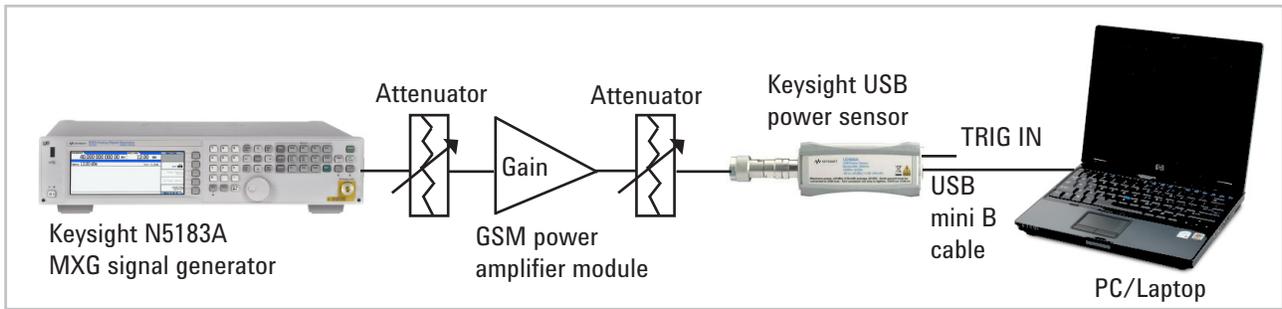


Figure 10: Simple setup for gated burst power measurement

Programming Examples

The following SCPI commands are used for CW measurement, used to measure the average power of the entire GSM waveform.

```

SYST:PRES           /* Presets the instrument.
SENS:FREQ 900MHZ    /* Sets the frequency of testing.
SENS:AVER:SDET OFF  /* Turns off the step detector.
SENS:DET:FUNC AVER
CALC:FEED "POW:AVER" /* Configures the measurement to CW mode.
<Start time>
FETCH?              /* Queries the measurement.
<End time>
    
```

Note: The measurement time is calculated based on this equation: End time - Start time

Programming Examples (Continued)

The following SCPI commands are used for time-gated burst power measurement of the GSM timeslot with internal trigger.

```
SYST:PRES /* Presets the instrument.
SENS:FREQ 900MHZ /* Sets the frequency of testing.
SENS:AVER:SDET OFF /* Turns off the step detector.
SENS:DET:FUNC NORM
TRIG:SOUR INT /* Switches the trigger source to internal.
TRIG:SEQ:LEVEL -6dBm /* Sets the trigger level at -6dBm.
SENS:SWEEP:TIME 0.000387 /* Configures the sweep time (gate length) of the burst duration (for example:
387µs).
SENS:SWEEP:OFFSET:TIME 0.00015 /* Configures the offset sweep time (offset length) of the burst duration or delay
between trigger point and time-gated period
(for example: 150 µs).
CALC:FEED "POW:AVER ON SWEEP" /* Configures the measurement to gated mode.
<Start time>
FETCH? /* Queries the measurement.
<End time>
```

Note: The measurement time is calculated based on this equation: $\text{End time} - \text{Start time}$

The following SCPI commands are used for time-gated burst power measurement of the GSM timeslot with external trigger.

```
SYST:PRES /* Presets the instrument.
SENS:FREQ 900MHZ /* Sets the frequency of testing.
SENS:AVER:SDET OFF /* Turns off the step detector.
SENS:DET:FUNC NORM
TRIG:SOUR EXT /* Switches the trigger source to external.
TRIG:SEQ:LEVEL -6dBm /* Sets the trigger level at -6dBm.
SENS:SWEEP:TIME 0.000387 /* Configures the sweep time (gate length) of the burst duration (for
example: 387µs).
SENS:SWEEP:OFFSET:TIME 0.00015 /* Configures the offset sweep time (offset length) of the burst duration
or delay between trigger point and time-gated period
(for example: 150 µs).
CALC:FEED "POW:AVER ON SWEEP" /* Configures the measurement to gated mode.
<Start time>
FETCH? /* Queries the measurement.
<End time>
FETCH? /* Queries the measurement.
<End time>
```

Note: The measurement time is calculated based on this equation: $\text{End time} - \text{Start time}$

Conclusion

Accurately measuring the average power of burst signals (within specific timeframes) is important for power amplifier module testing. It can be achieved not only with high-performance power meters and power sensors, but also with the low-cost Keysight USB power sensor. The trigger mechanisms offered by the USB power sensor allows you to measure the average burst signal accurately within the desired timeframe.

References

- *Fundamental of RF and Microwave Power Measurements (Part 1)*, Literature Number 5988-9213EN
- *Fundamental of RF and Microwave Power Measurements (Part 2)*, Literature Number 5988-9214EN
- *Fundamental of RF and Microwave Power Measurements (Part 3)*, Literature Number 5988-9215EN
- *Fundamental of RF and Microwave Power Measurements (Part 4)*, Literature Number 5988-9216EN
- *4 Steps for Making Better Power Measurements*, Literature Number 5989-8167EN
- *Choosing the Right Power Meter and Sensors Product Note*, Literature Number 5968-7150EN

Related Literature

- *Keysight U2000 Series USB Power Sensors Technical Overview*, Literature Number: 5989-6279EN
- *Keysight U2000 Series USB Power Sensors Data Sheet*, Literature Number: 5989-6278EN
- *Keysight U2000 Series USB Power Sensors Programming Guide*, Part Number: U2000-90411

Related Link

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