IQMASTER

IQ6400 – Vector Signal Generator and Analyzer

75MHz-6000MHz

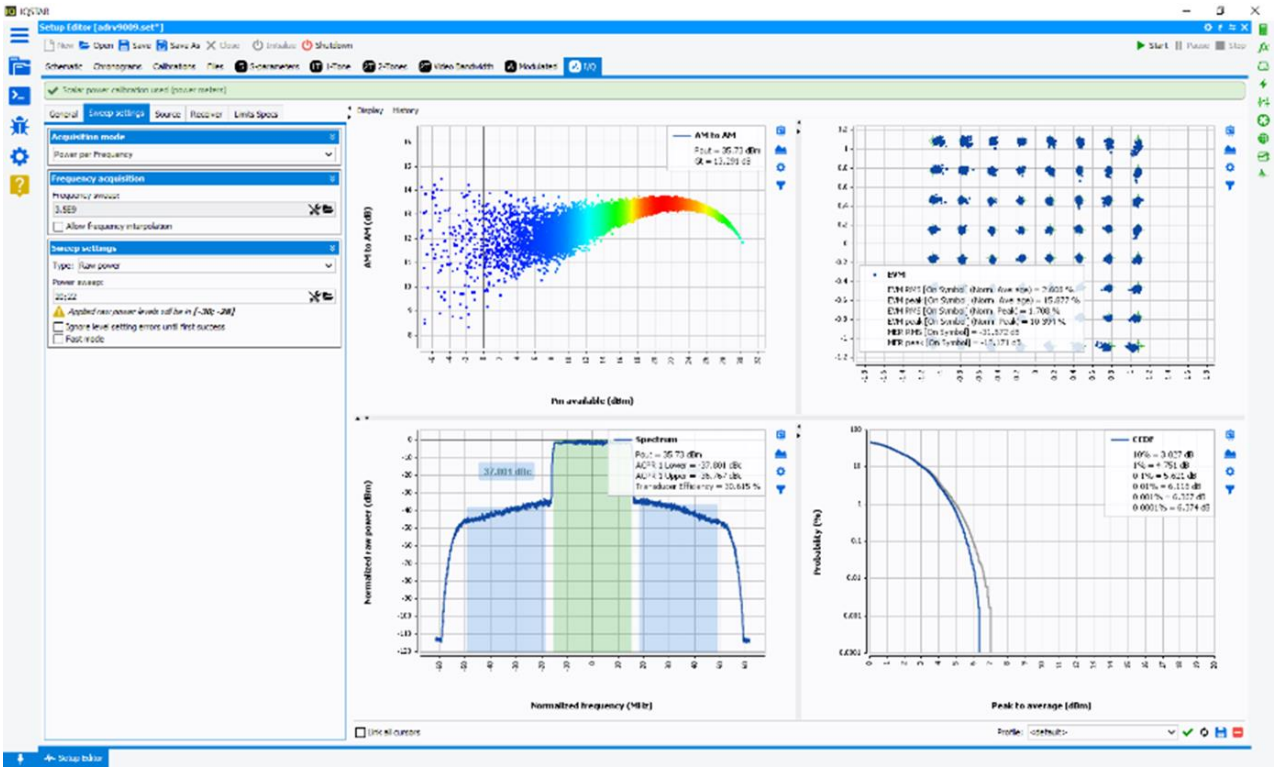
400MHz BW

AMCAD

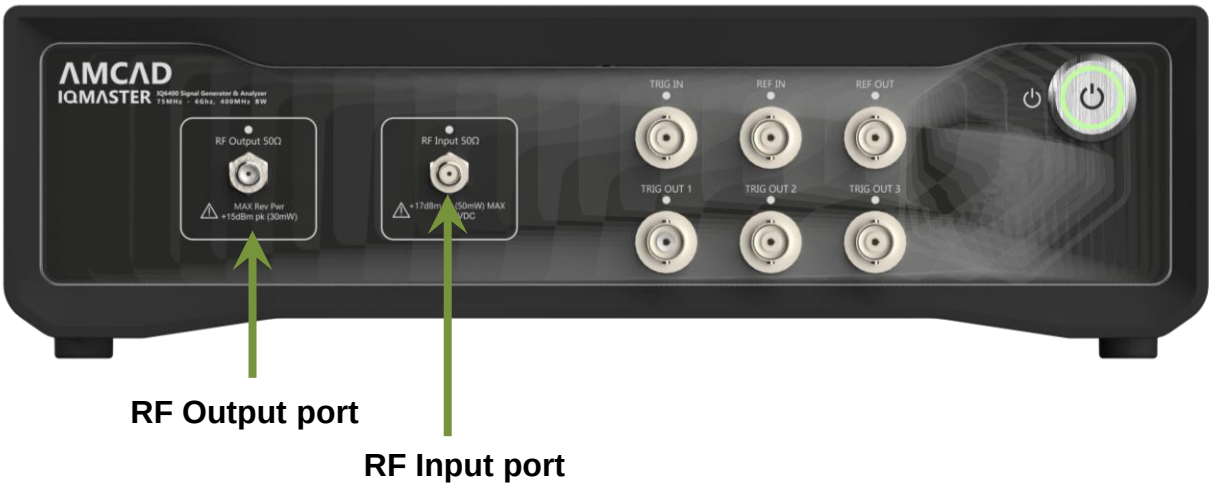
Table of contents

Main features

- 75MHz-6GHz Vector Signal Transceiver (VST) based on Radio Unit SoC Technologies
- Turnkey solutions for IQSTAR measurement software
- Dedicated firmware to run the VST like a benchtop instrument grade solution
- Measurement of RF Power Amplifier in base station-like conditions
  - LTE/5G PA Tests with signal generation and analysis bandwidth up to 400 MHz
  - 1-tone measurements: CW and pulsed CW characterization with configurable rise/fall time
  - 2-tone measurements for video bandwidth analysis
  - IQ signal generation and analysis with Digital Predistortion capabilities - Acquisition averaging up to 8192 in IQ modulation mode for high dynamic range characterization
- Trigger and 10 MHz IN/OUT available to connect power meters, multimeter or spectrum analyzer
- High data transfer rate (Gigabit LAN interface)



Platform description



RF Output Port : Main output channel of the vector signal generator.

The transmitter uses an innovative direct conversion modulator that achieves high modulation accuracy and a wide attenuation adjustment range with fine granularity to optimize SNR.

The transmitter can operate in a wide range of operating modes such as CW, pulsed CW, two tones and IQ waveforms.

The maximum power that the transmitter can output depends on the center frequency, see section “Typical performance” in the datasheet for more information.

RF Input Port

Wide bandwidth receiver (400 MHz). Attenuation is controlled automatically to deliver full-scale measurement.

The receiver includes automatic dc offset correction, quadrature error correction (QEC) and digital filtering.

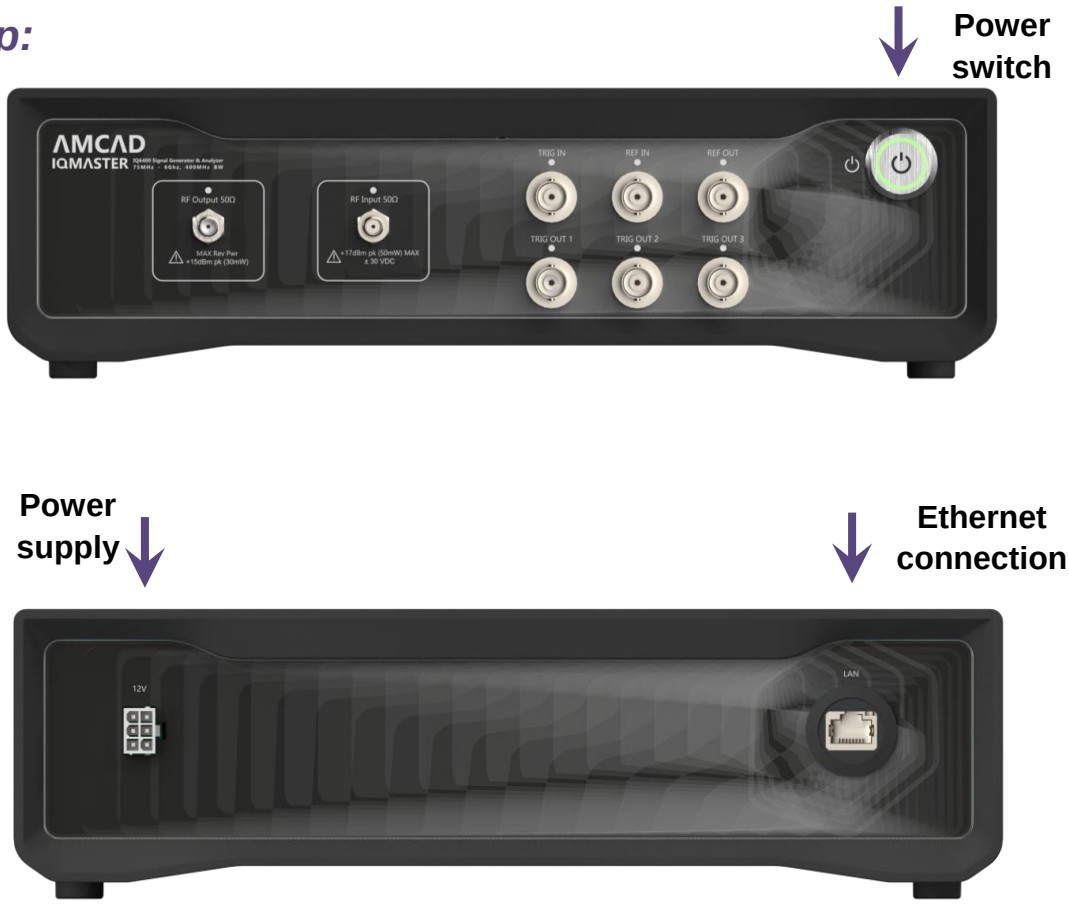
Quick start guide

Unboxing guide:

This section describes the unboxing of the IQMaster test platform that contains the following equipment:

- IQ6400 VST.
- SD card with the platform firmware.
- Power supply and cabling (EU, US and UK plug).
- External SMA filters (mini-circuits).

Start-up:

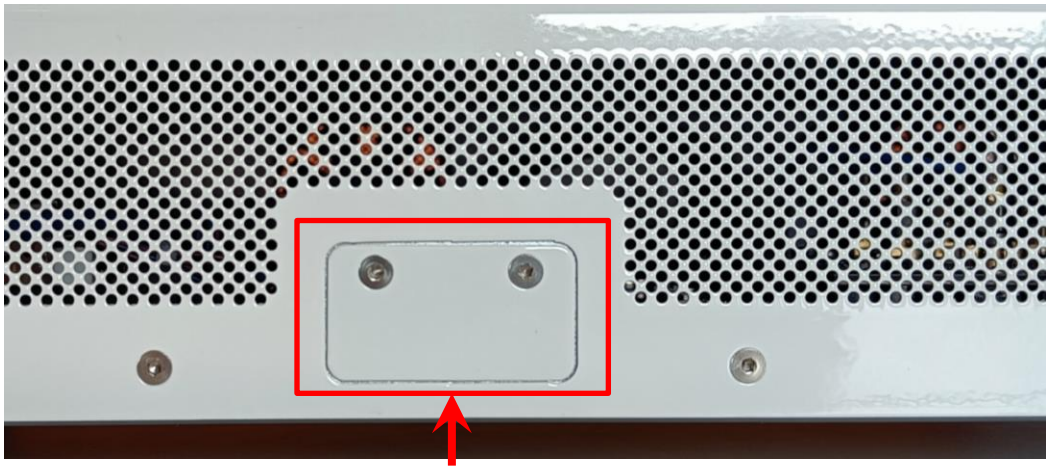


Quick start guide

Before starting-up the platform, change the IP address of the platform if needed. The IP address is contained on the SD card included in the kit.

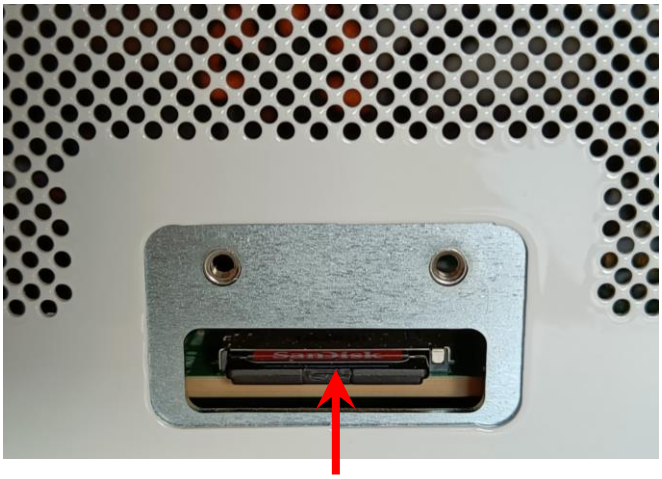
To access the SD card, follow these instructions:

1. Remove the two screws holding the SD card enclosure with a 2mm hew wrench



SD card enclosure

2. Remove the cover to expose the SD card

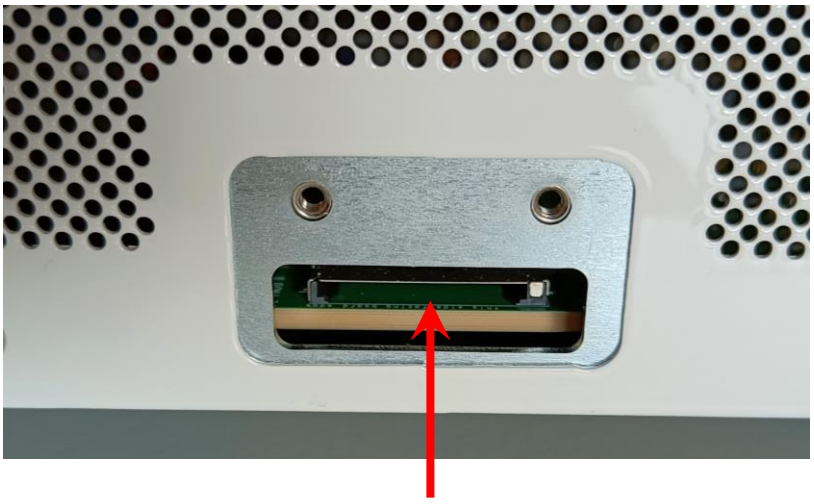


SD card

Quick start guide

3. Press inward onto the SD card until the spring-loaded detent pushes the SD card slightly out of the IQ6400 enclosure

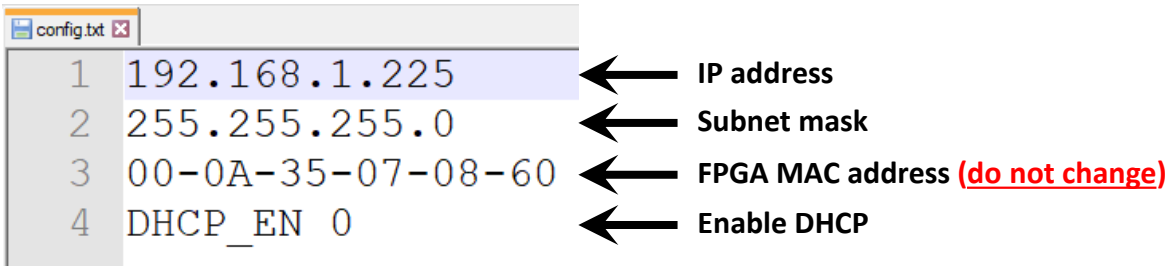
4. Grab the protruding SD card



Empty SD card slot

Quick start guide

After connecting the SD card to a computer using the supplied SD/USB card adapter, a text file named "config.txt" on the disk named "DATA" is accessible. This file is editable, and describes the following properties:



To change the IP address, the first line of the config.txt file must simply be modified by entering the chosen IP address. If the gateway has to choose an IP address automatically, simply enable DHCP (DHCP_EN_1).

After configuring the network properties, the SD card should be placed back in its slot and the cover must be closed with the two screws before starting the device.

The power supply can now be connected, and the device can be switched on by pressing the power switch. Below are the characteristics of the power supply:

A L.T.E LI TONE ELECTRONICS CO., LTD.

ITE ADAPTATOR
MODEL: LTE65ES-S2-1
INPUT: 100-240V 50/60Hz, 2A
OUTPUT: 12V 5A MAX: 60W

Quick start guide

How to access the instrument via a Web Browser

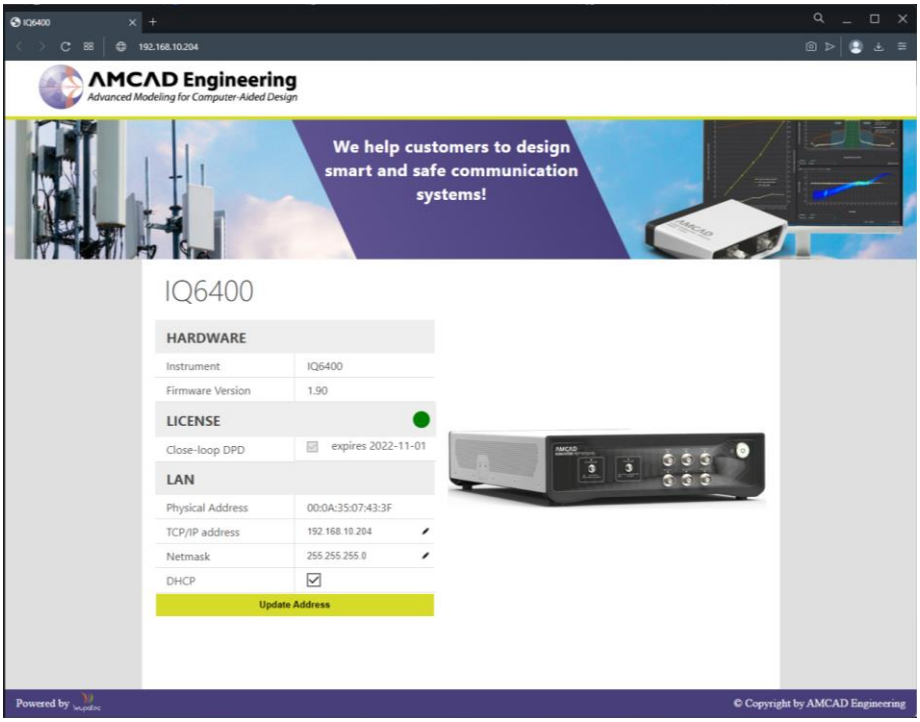
A user can access the instrument's information remotely from another connected device..

To access the instrument via a web browser:

1. Start a web browser that supports html5 (W3C compliant).
2. Enter the IP address of the instrument in the browser's address bar.

To change the TCP/IP address of the instrument:

1. Write the new TCP/IP address on the cell next to "TCP/IP address“
2. Click on "Update Address" to update the address of the hardware



Optional

1. Change the network mask (used to change the TCP/IP address)
2. Select the DHCP checkbox (prepare DHCP state)
   - To apply the DHCP state, reboot the hardware.
3. To see the license status in more detail, hover your cursor over the circle

Quick start guide

After the platform is started, the power button is illuminated with an orange color during initialization:

When the power button color turns green, the platform is fully initialized and ready for use.

Troubleshooting:

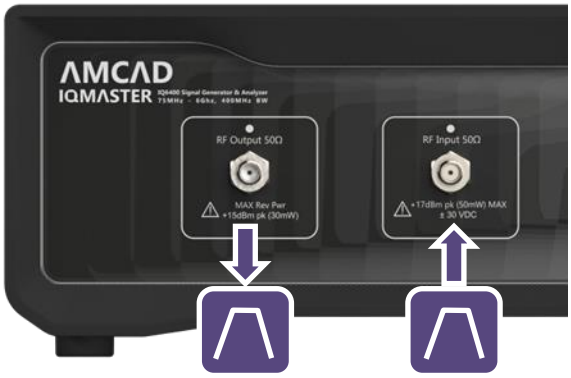
- If it is not possible to connect from the computer, check the network configuration (see the section above on setting the platform IP address).
- If the instrument cannot be started, check that the power supply is properly connected. The wall power supply must meet the above specifications (100-240V 50/60Hz).
- Make sure the power button is fully depressed and remains locked in.
- If the power button remains orange for an extended period of time (> 1 minute), check that the Ethernet cable is properly connected.
- If the power button never turns green, contact support.

Theory of operation

External input/output filters:

The VST PA test platform does not incorporate adaptive filters at the RF input/output ports. To eliminate unwanted harmonics at the RF input/output ports, appropriate external SMA filters must be connected to the RF input and output ports consisting of SMA connectors.

Do not over-tighten the SMA connectors, use an appropriate torque wrench for SMA RF connectors.



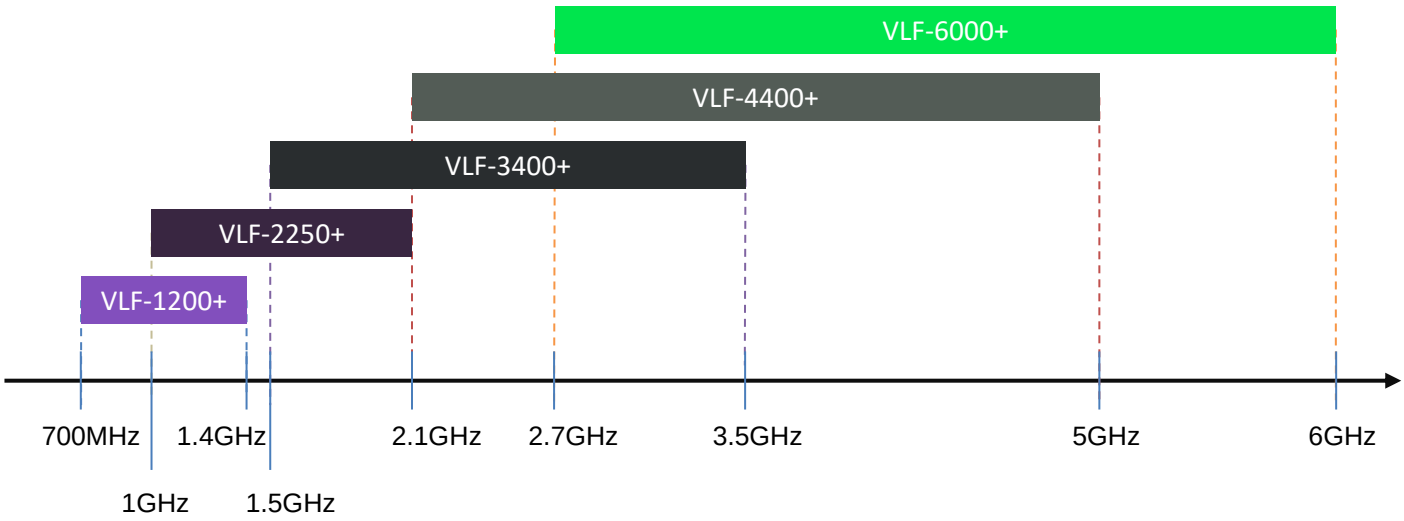
Several filter pairs are available to cover the entire frequency range of the platform. Below are the recommended filter pairs for the RF frequencies to be measured:

Output filters to use according to the RF frequency	
Center frequency	**Filter reference**
75 MHz – 100MHz	**SLP-100+**
100MHz – 150MHz	**VLF-105+**
150 MHz – 200 MHz	**VLF-160+**
200 MHz – 300 MHz	**VLF-225+**
300 MHz – 400 MHz	**VLF-320+**
400 MHz – 600 MHz	**VLF-490+**
600 MHz – 900 MHz	**VLF-800+**
750 MHz – 1400 MHz	**VLF-1200+**
1000 MHz – 2100 MHz	**VLF-2250+**
1500 MHz – 3500 MHz	**VLF-3400+**
2100 MHz – 5000 MHz	**VLF-4400+**
2700 MHz – 6000 MHz	**VLF-6000+**

Theory of operation

External input/output filters:

At higher RF frequencies (> 1 GHz), the filters provide overlapping bandwidth for greater flexibility. The following figure shows the maximum and minimum center frequency of these filters.



External filters bandwidth overlapping

This overlap allows the user to choose a filter that covers the entire frequency range of typical applications, for example the VLF-3400+ filter covers the 1.8GHz-2.2GHz bandwidth while the VLF-2250+ is too limited in maximum frequency.

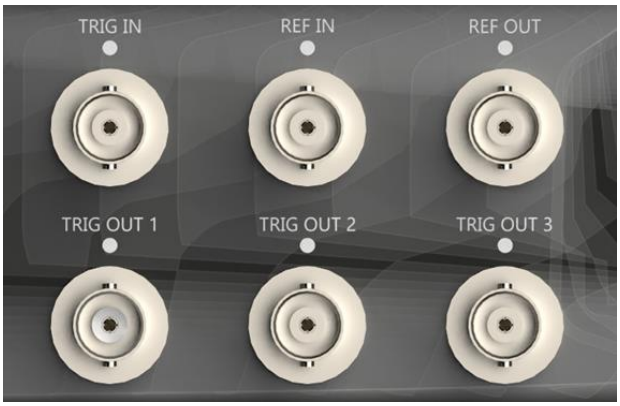
A second example is the 3.4GHz-3.8GHz bandwidth which is covered by the VLF-4400+.

The three filter sets provided (VLF-2250+, VLF-3400+ and VLF-4400+) cover most of the usual applications between 1GHz and 5GHz.

Theory of operation

BNC input / output connectors:

The IQ6400 VST has a variety of BNC output and input ports to synchronize external instruments:



In the front, BNC connectors are available, a 10 MHz clock reference (REF OUT) allows the triggering of external instruments to be synchronized with the IQ6400. For example, an external spectrum can be synchronized to compare measurements between different instruments.

Similarly, a 10 MHz reference clock can be supplied to the IQ6400 at the REF IN connector. When a clock signal is detected on REF IN, the LED will light up.

Three output triggers are available to synchronize measurements with external units. For example, these outputs will mainly be used to trigger power sensors and multimeters during CW pulse measurements. When the output signals of the triggers are active, the corresponding LED lights up.

An external trigger can be connected to TRIG IN to synchronize the IQ6400 measurement with an external unit. When a valid trigger is detected on the connector, the LED will light up.

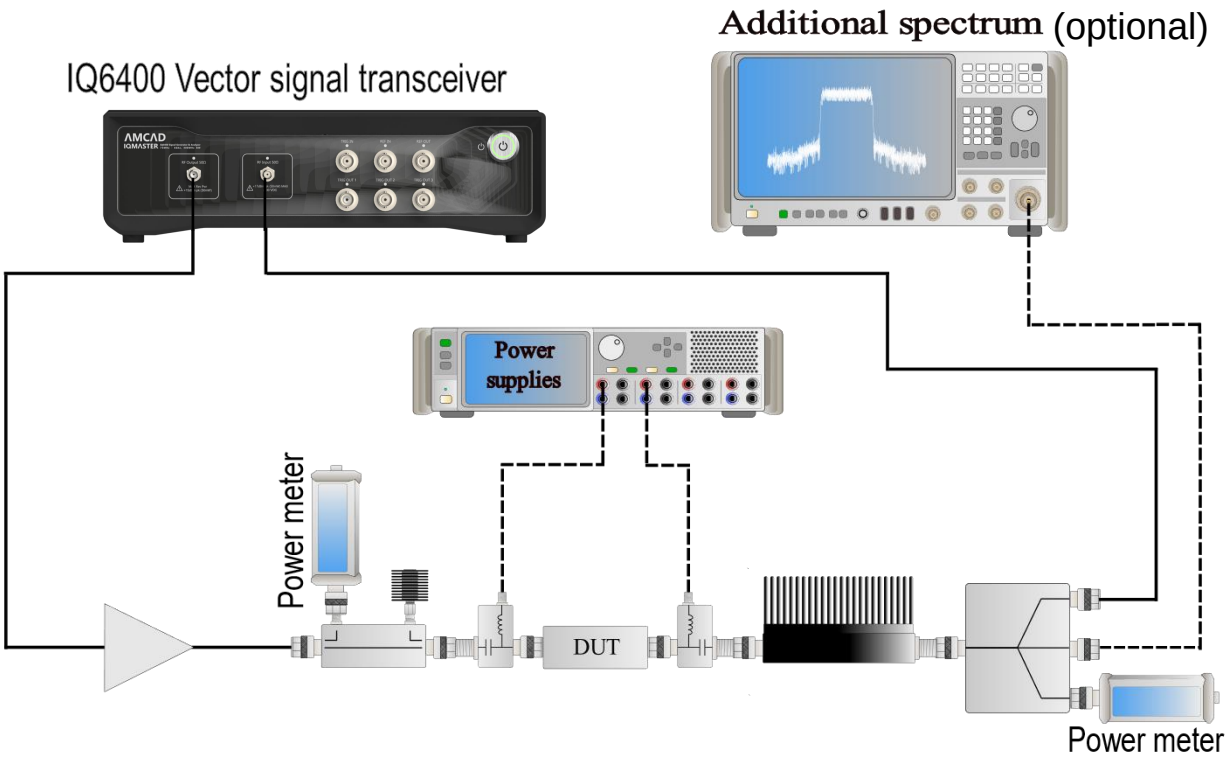
Please refer to the data sheet in the "INPUTS AND OUTPUTS" section for more details regarding the technical specifications of these digital inputs/outputs.

Theory of operation

The IQ6400 VST incorporates numerous automatic corrections and calibration algorithms to improve signal generation and acquisition linearity.

Each time the platform provides an RF signal, several calibrations are performed such as LO leakage or quadrature error correction (QEC). In order to perform all these internal calibrations, there must always be a feedback loop to the RF input port.

Below is the following example of a bench, this one will work for all types of measurements (CW, pulsed CW, two tone, modulated signal):



Whenever the RF output port is turned on, all internal calibrations are performed automatically.

Make sure that the control amplifier and power supplies are turned on before turning on the RF output port.

It is recommended to reach +15dBm at the RF input port to obtain measurements with good dynamic range.

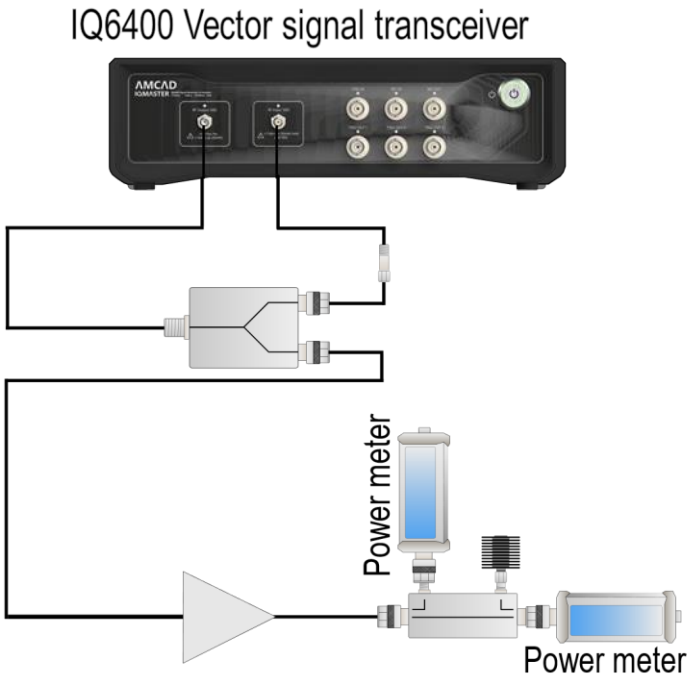
Theory of operation

Calibrations:

Scalar power calibration in IQSTAR is available when at least two power sensors and one RF source are enabled in the configuration editor. The power calibration is done in two steps.

Input power calibration:

Input power sensor calibration to extract losses between the input power sensor and the reference plane of the input DUT.



Input Power Sensor calibration with loopback schematic

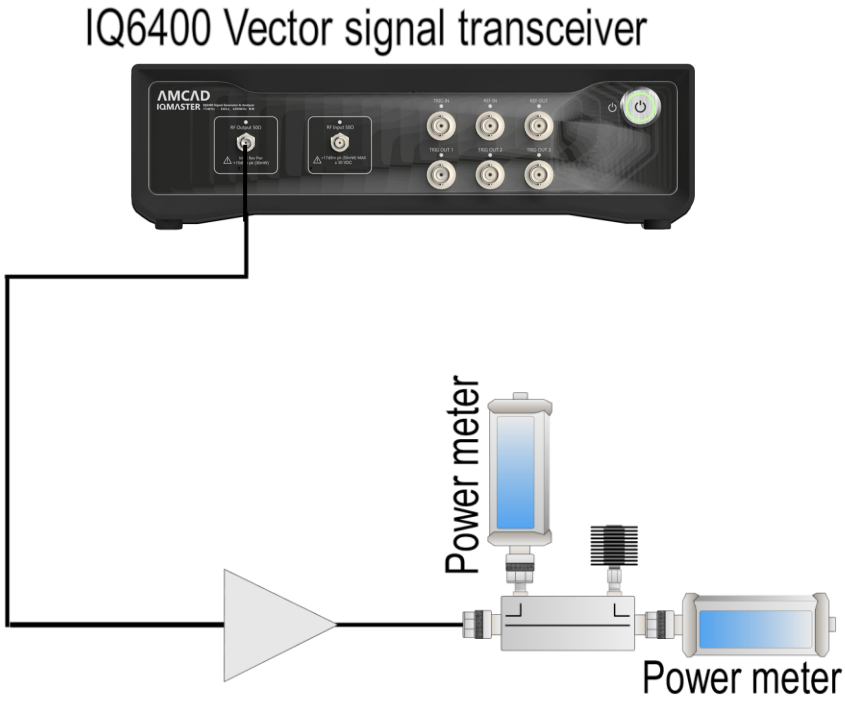
To improve the accuracy of the calibration, a feedback loop to the RF input port should be set up as shown in the diagram above using a two-way splitter.

Theory of operation

During the input port calibration process, if it is not possible to establish a feedback loop to the RF input, LO leakage at the RF output port should introduce calibration uncertainty.

In this case, it is recommended that the test bench be properly configured to eliminate the risk of power sensor damage due to LO leakage.

If the test bench configuration is properly managed, the LO leakage is always less than the CW output signal, even without a feedback loop. However, if the source power is very low during the calibration process due to poor power budget management, the LO leakage may be higher than the CW output signal, which may damage the power sensors.

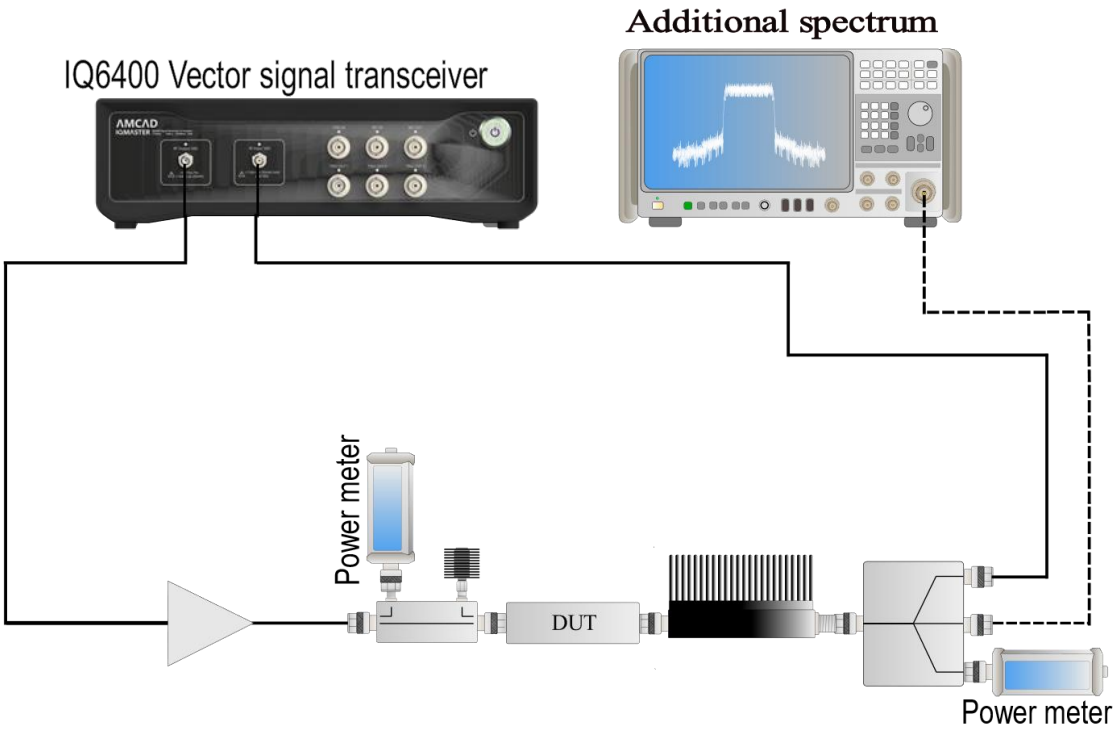


Input Power Sensor calibration without loopback schematic

Theory of operation

Output power calibration:

An output power sensor calibration is performed to extract the losses between the output power sensor and the plane of the output DUT, using the input power calibration as a reference.



Output Power Sensor calibration schematic

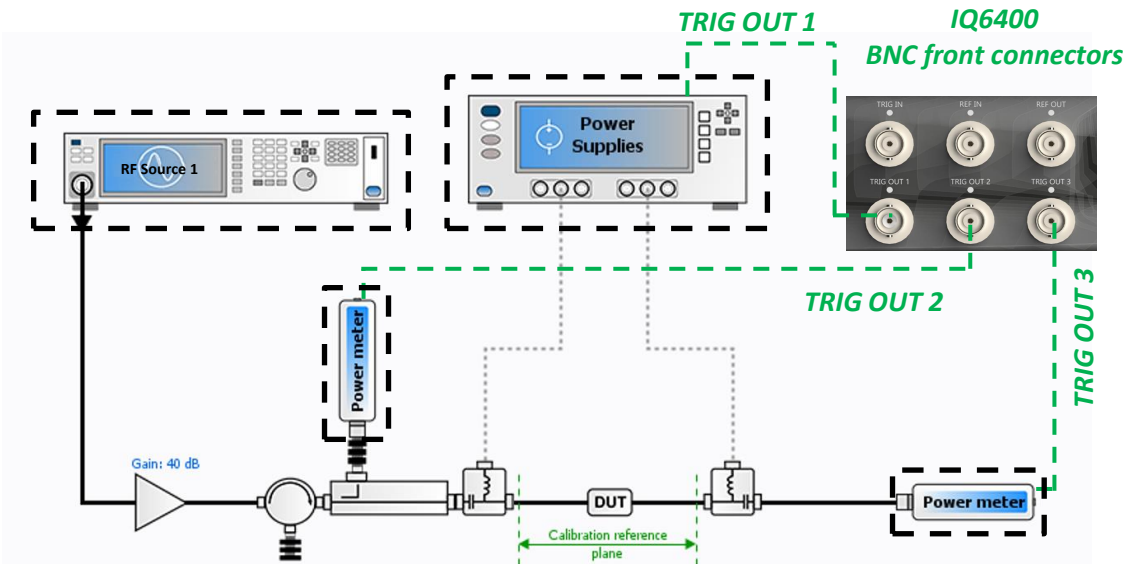
Theory of operation

Setup example:

Pulsed CW measurements:

The IQ6400 VST provides a pulsed CW signal in the 75MHz-6GHz frequency range to measure power, gain, and added power efficiency. The RF pulse delay, pulse width, pulse period and pulse slope can be easily set in the IQSTAR software.

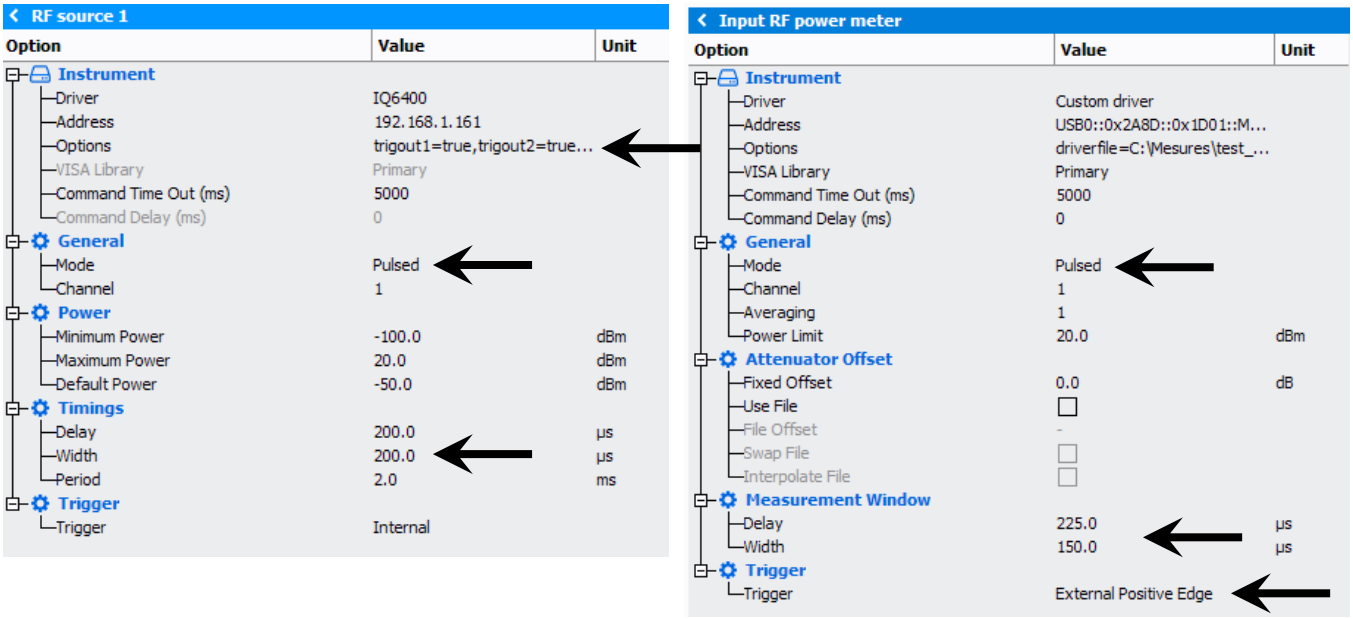
Below is an example of configuration in IQSTAR and a guide to configuration in IQSTAR:



IQSTAR test setup for CW and pulsed CW PA characterization

In order to configure the test platform for pulsed measurements, the RF source, power sensors and multimeters must first be configured.

Theory of operation



In the RF source panel, the triggers must be enabled in the instrument options.

The slope time must be defined with an RF source mode set in pulsed mode.

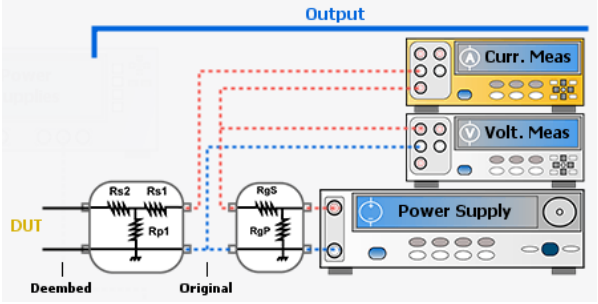
Finally, the pulses can be adjusted (delay, width, period).

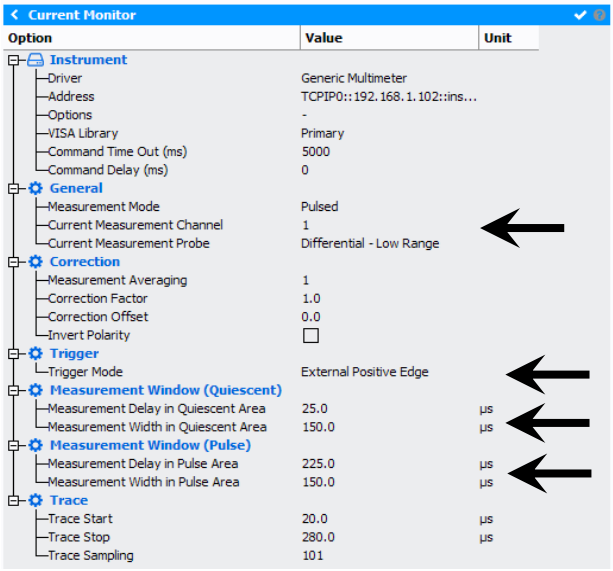
For the input and output power sensors, the pulsed mode must also be chosen, and the measurement windows configured.

The triggers must be activated. The average mode can also be used with the correct attenuator offset if required.

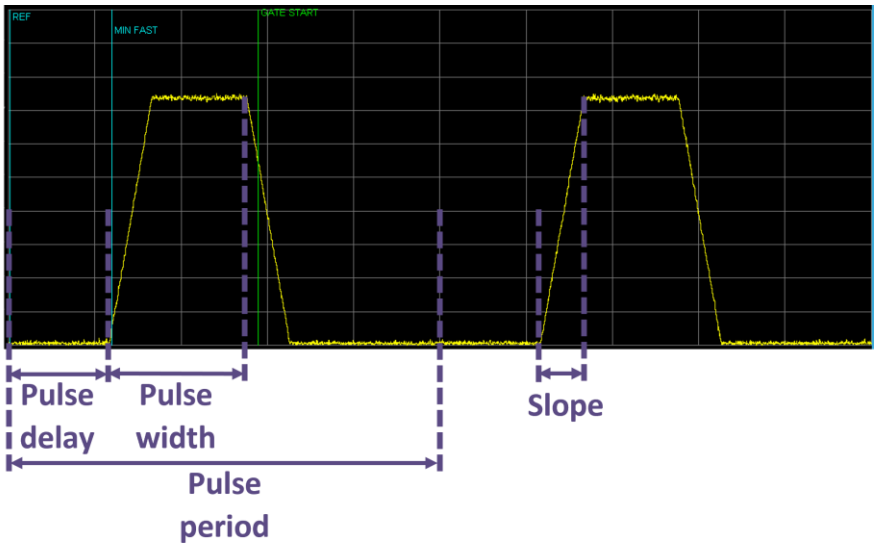
Theory of operation

In the power supplies window, the use of multimeters can also be defined. In this case, the trigger signals must also be activated:





The chronograms tab allows a visual display of the pulse settings, this tab allows to finalize the configuration if necessary. However, the chronograms tool does not consider the slope time.



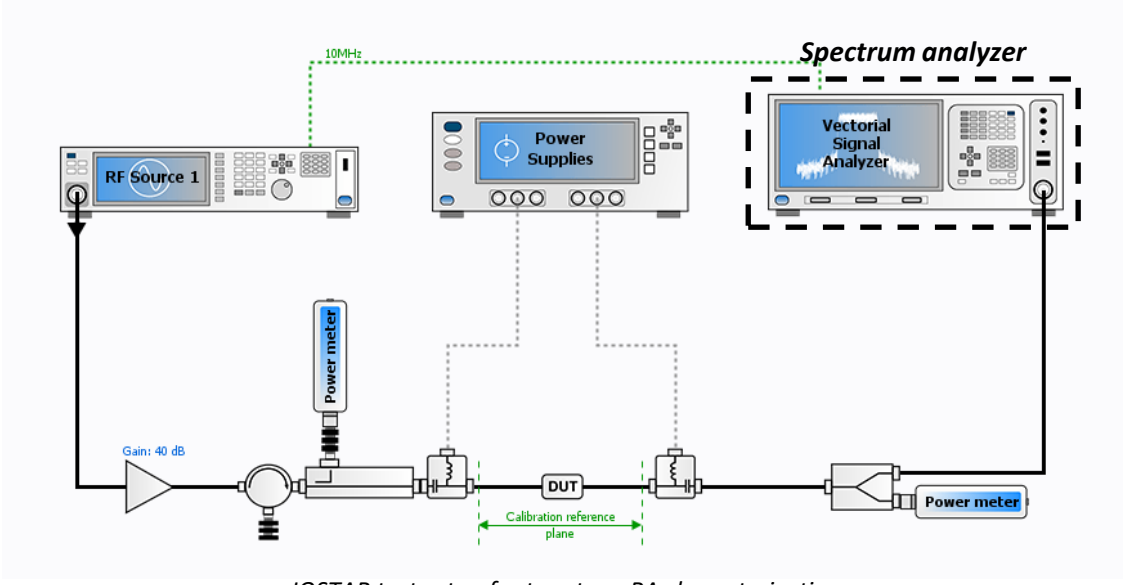
The rise time of the pulse is included in the pulse width .

Theory of operation

Two tone signal measurements:

The IQ6400 VST can generate a two-tone signal to evaluate the video bandwidth of the power amplifier. The tone spacing can be set in a frequency range from 100 kHz to 400 MHz.

Below is an example of a configuration in IQSTAR:



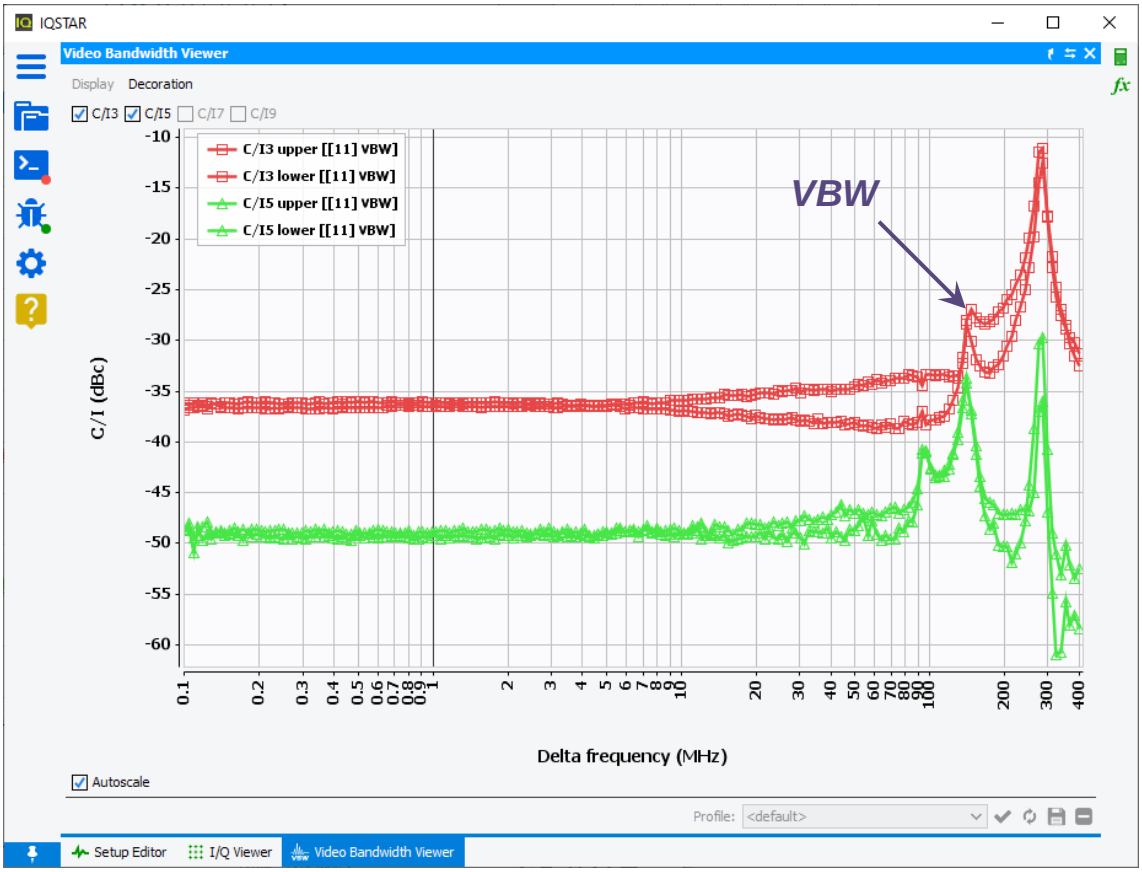
IQSTAR test setup for two-tone PA characterization

Alternatively, if a bandwidth analysis higher than 400MHz is needed to measure Intermodulation tones (IMD), an external spectrum analyzer can be added to the setup to cover the required frequency bandwidth.

The spectral analysis window should be specified accordingly. The RF source and power sensors must be selected in CW mode, and the power supplies in DC mode.

Theory of operation

In the example below, a 50W power amplifier is characterized. The two-tone spacing sweep exhibits a PA's video bandwidth of 150MHz.



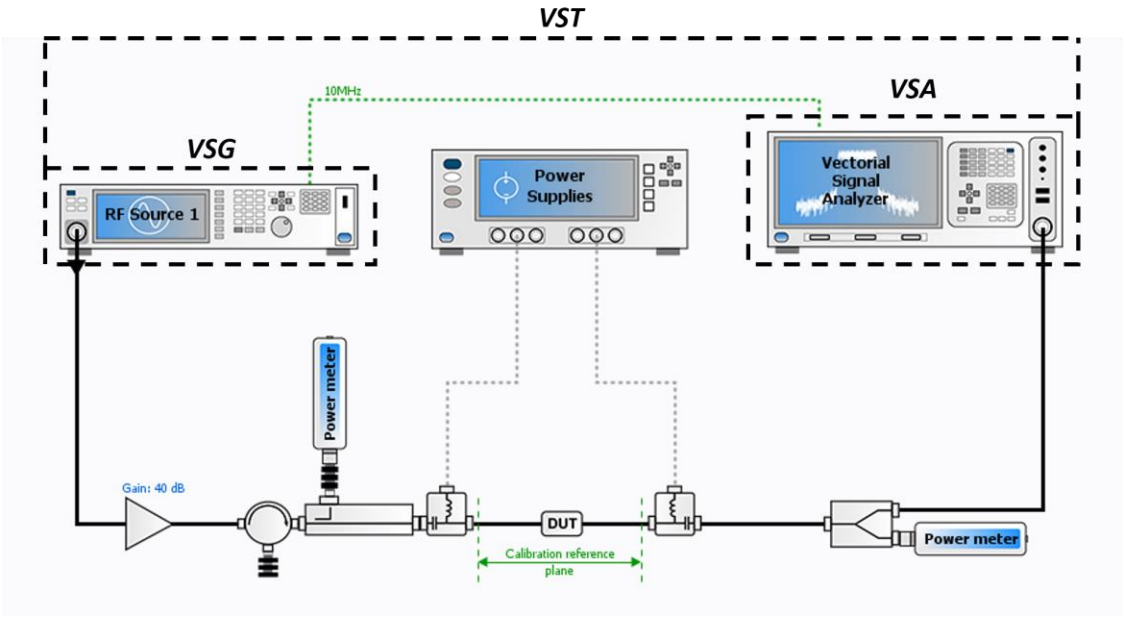
Two-tone measurement results in the 100kHz – 400MHz range

Theory of operation

Modulated signal measurements:

The IQ6400 VST is capable of accurate, high-speed measurements of modulated signals to evaluate the performance of power amplifiers with the LTE/5G modulation scheme.

The instrument can easily measure ACPR down to -60dBc with a modulation bandwidth of 100MHz.Below is an example of installation and configuration in IQSTAR:



IQSTAR test setup for modulated signal PA characterization

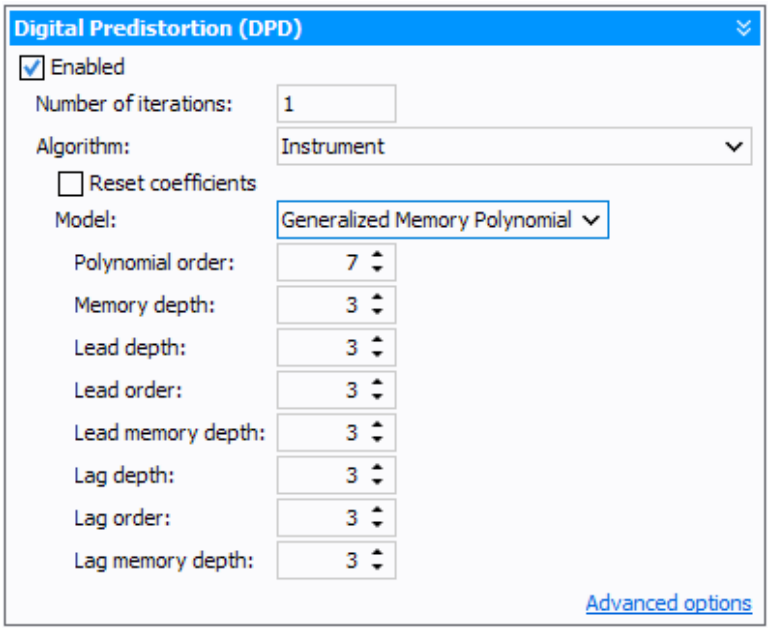
In this case, there is no need to use an additional spectrum analyzer, the IQ6400 VST is capable of generating and acquiring an instantaneous bandwidth of up to 400 MHz.

The test platform can be used with all of the pre-distribution techniques and algorithms available in IQSTAR to verify that the power amplifier under test can be linearized with varying degrees of complexity.

The VST PA test platform can be used to measure ACPR, EVM and power efficiency

Theory of operation

The IQ6400 incorporates a real-time, closed-loop DPD algorithm controlled by IQSTAR. To use the on-board DPD, select the DPD algorithm “Instrument” menu.



IQ6400 DPD control panel

The DPD extraction and application is performed entirely by the IQ6400 FPGA to deliver a speed advantage up to 10 times faster than the standard software DPD performed by the IQSTAR high level software, with the same linearized PA performance.

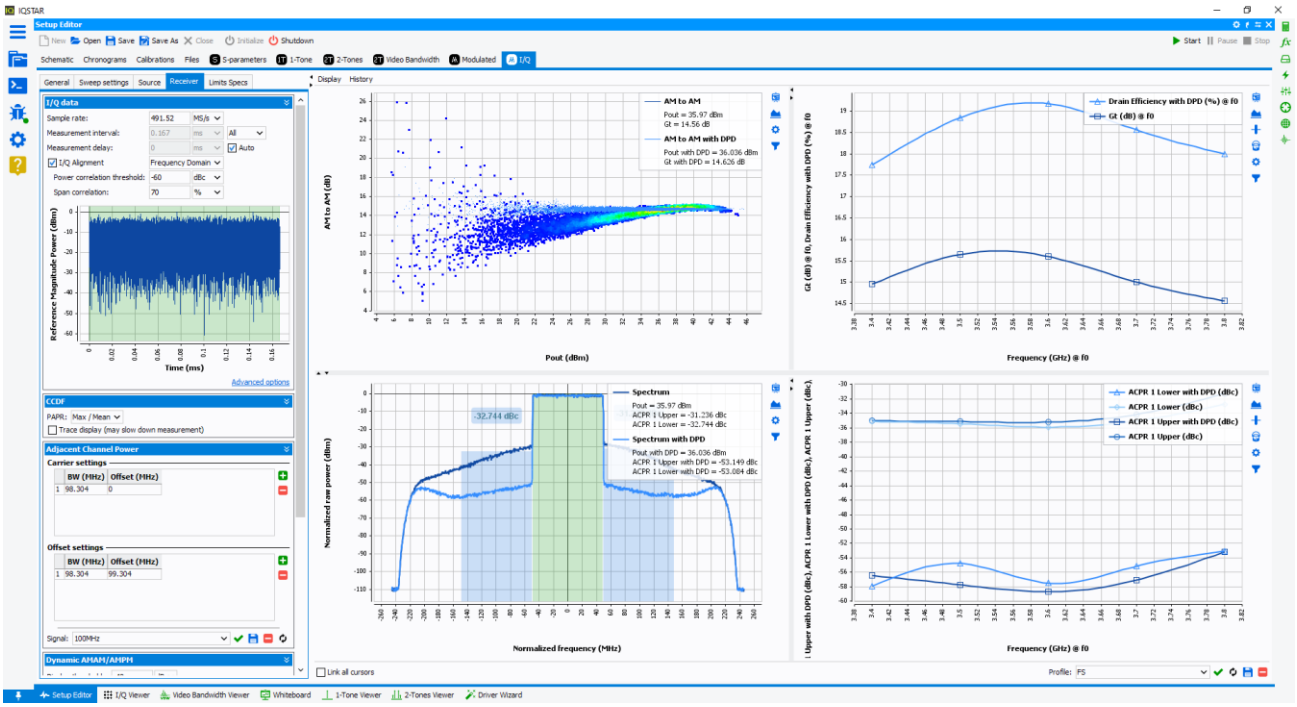
Read our article : “Pros & cons of controlling-software-based DPD”

https://www.amcad-engineering.com/instrument-based-versus-software-based-dpd/

Theory of operation

In the example below, a single stage power amplifier is linearized in the 3.4GHz-3.8GHz frequency range.

A 5G signal of 100MHz bandwidth is used, the amplifier operates at constant output power (36dBm) and is pre-distorted using the IQ6400's polynomial memory DPD algorithm.



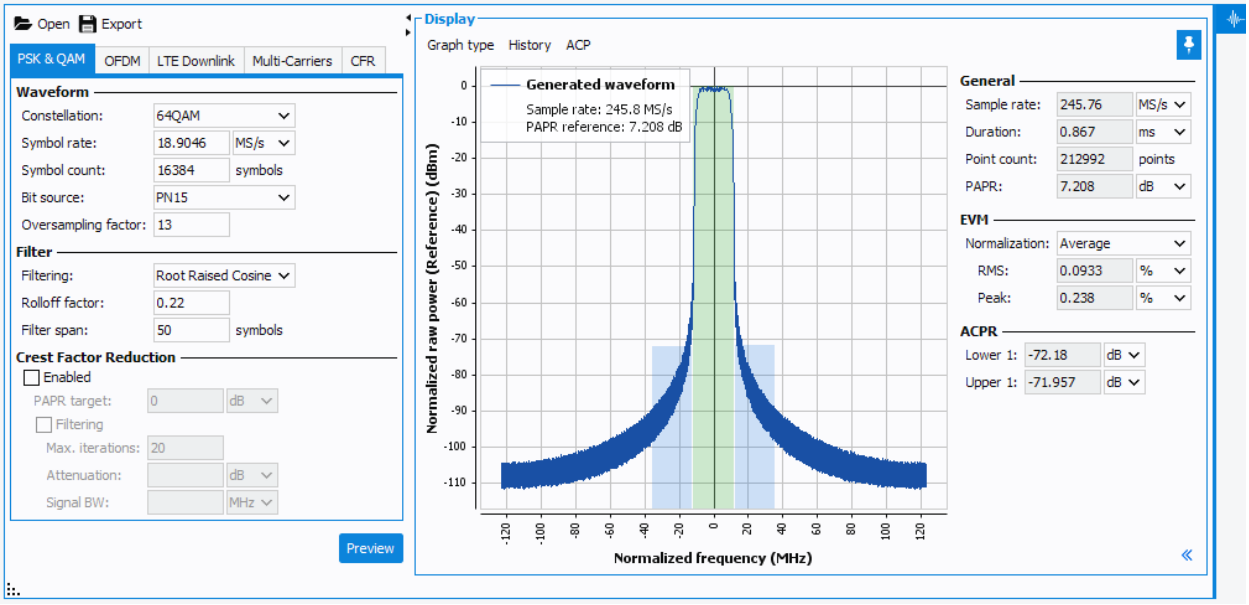
Spectrum measurement on a Signal Analyzer / 1-stage Power Amplifier evaluation

Theory of operation

Waveform generation:

Modulated signals used with the IQ6400 VST can be generated using the integrated IQSTAR waveform generator.

The IQSTAR waveform generator can be used to generate waveforms with a modulation scheme ranging from simple QAM to standard LTE / 5G test patterns. Below is an example of a waveform generator in IQSTAR:



IQSTAR Waveform Generator example

As the VST embeds a System-on-Chip initially produced for base station equipment, constraints specific to the IQ6400 must be taken into account when configuring the waveform generator.

The two main constraints are the sampling rate and the length of the waveform.

- The IQ6400 only supports three sample rates: 122.88MSa/s, 245.76MSa/s and 491.52MSa/s. The waveform generator must be properly configured to generate a waveform with one of these exact frequencies.
- The length of the waveform (number of points) must be an integer multiple of 16384 points.

Theory of operation

Waveform Generator example:

In this example, a waveform is generated with the following characteristics:

- Modulation type: 64QAM
- Symbol rate: 19MS/s
- Symbol count > 2000
- Oversampling factor > 10 -> sampling rate (Fs) = 245.76MSa/s

Step 1: **Compute the closest possible symbol rate**

The sampling rate is fixed at Fs = 245.76MSa/s, the oversampling factor is computed with the following formula:

- Oversampling factor = Fs / Symbol rate = 245.76M / 19M = 12.93

The oversampling factor must be an integer, 13 is the rounded equivalent value.

The rounded symbol rate for this oversampling factor is calculated as follows:

Symbol rate = Fs / oversampling factor = 245.76M / 13 = 18.9046MS/s

Step 2: **Compute the minimum number of symbols**

The waveform length (number of points at Fs = 245.76MSa/s) must be an integer multiple of 16384 points.

An integer N for which the result of N x 16384 / oversampling factor is an integer must be found.

With Oversampling factor = 13, N = 13

Theory of operation

With N, the minimum number of symbols can be computed using the formula:

- Symbol count min = N x 16384 / Oversampling factor = 13 x 16384 / 13 = 16384 symbols

The Symbol count of the waveform must be a multiple of 16384 symbols.

***Note**: an even oversampling factor will result in a lower minimum symbol count, an oversampling factor that is a power of 2 will result with N = 1*

Step 3: Generate the waveform

The following computed values can be then entered in IQSTAR Waveform Generator as shown in the figure page 27:

- Constellation: 64QAM
- Symbol rate: 18.9046MS/s
- Symbol count: 16384
- Oversampling factor: 13

Warranty

Any AMCAD product comes with a two-year parts and labour warranty, when returned to our workshops. A phone support service is also available for the same period.
At the end of the initial two-year period, a further contract can be subscribed, including:

- a preventive functional check and calibration of the modules (on site or in our workshop)
- a further two-year warranty period

Quality Regulations & Environment

AMCAD Systems and all modules are compliant to the applicable European directive and hold the CE mark.

- Products are designed and manufactured in France.
- Serial number-based life cycle management
- All products are 100% tested (test reports on demand)
- To ensure a correct operation, the fans must not be obstructed
- Maintenance will only be performed by the manufacturer AMCAD. Do not allow anyone to perform electrical maintenance on the VST.
- AMCAD only uses RoHS compliant components and does not use substances banned by the COSHH regulation.
- AMCAD complies with the relevant national regulations related to the safety and health of its employees against hazardous substances.
- As we are always seeking to improve our products, the information in this document gives only a general indication of the product capacity, performance and suitability, none of which shall form part of any contract. We reserve the right to make design changes without notice.

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