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RF Power Amplifier Test Benches

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Measurement Results for Expressions for RF Power Amplifier Test Benches

Measurement results from a wireless test bench have associated names that can be used in Expressions. Those expressions can further be used in specifying goals for Optimization and Monte Carlo/Yield analysis. For details on using expressions, see the *Measurement Expressions* (expmeas) documentation. For details on setting analysis goals using Optimization and Monte Carlo/Yield analysis, see the *Tuning, Optimization, and Statistical Design* (optstat) documentation.

You can use an expression to determine the measurement result independent variable name and its minimum and maximum values. The following example expressions show how to obtain these measurement details where MeasResults is the name of the measurement result of interest:

- The *Independent Variable Name* for this measurement result is obtained by using the expression
  `indep(MeasResults)`
- The *Minimum Independent Variable Value* for this measurement result is obtained by using the expression
  `min(indep(MeasResults))`
- The *Maximum Independent Variable Value* for this measurement result is obtained by using the expression
  `max(indep(MeasResults))`

The following tables list the measurement result names and independent variable name for each test bench measurement. Expressions defined in a MeasEqn block must use the full *Measurement Results Name* listed. Expressions used in the Data Display may omit the leading test bench name. You can also locate details on the measurement result minimum and maximum independent variable values by

- Referring to the measurement parameter descriptions when they are available (not all measurement parameter descriptions identify these minimum and maximum values).
- Observing the minimum and maximum independent variable values in the Data Display for the measurement.

RF_PAE_EVM_ACLR Measurement Results

Measurement Results Name	Independent Variable Name
RF_PAE_EVM_ACLR.R1.DCPower_W	time
RF_PAE_EVM_ACLR.R1.PAE_pct	time
RF_PAE_EVM_ACLR.R1.RFAddedPower_W	time
RF_PAE_EVM_ACLR.R1.RFPin_W	time
RF_PAE_EVM_ACLR.R1.RFPout_W	time
RF_PAE_EVM_ACLR.R1.RF_in	time
RF_PAE_EVM_ACLR.R1.RF_out	time
RF_PAE_EVM_ACLR.R1.S1	freq
RF_PAE_EVM_ACLR.R1.EVM.EVM_Results	Index

RF DUT Limitations for RF Power Amplifier Test Benches

This section describes test bench use with typical RF DUTs, improving test bench performance when certain RF DUT types are used, and improving simulation fidelity.

The RF DUT, in general, may be a circuit design with any combination and quantity of analog and RF components, transistors, resistors, capacitors, etc. suitable for simulation with the Agilent Circuit Envelope simulator. More complex RF circuits will take more time to simulate and will consume more memory.

Test bench simulation time and memory requirements can be considered to be the combination of the requirements for the baseline test bench measurement with the simplest RF circuit plus the requirements for a Circuit Envelope simulation for the RF DUT of interest.

An RF DUT connected to a wireless test bench can generally be used with the test bench to perform default measurements by setting the test bench parameters. Default measurement parameter settings can be used for a typical RF DUT that:

- Requires an input (RF) signal with constant RF carrier frequency.
  The test bench RF signal source output does not produce an RF signal whose RF carrier frequency varies with time. However, the test bench will support an output signal that contains RF carrier phase and frequency modulation as can be represented with suitable I and Q envelope variations on a constant RF carrier frequency.
- Produces an output signal with constant RF carrier frequency.
  The test bench input signal must not contain a carrier frequency whose frequency varies with time. However, the test bench will support an input signal that contains RF carrier phase noise or contains time varying Doppler shifts of the RF carrier. These signal perturbations are expected to be represented with suitable I and Q envelope variations on a constant RF carrier frequency.
- Requires an input signal from a signal generator with a 50-ohm source resistance.
- Requires an input signal with no spectrum mirroring.
- Produces an output signal that requires a 50-ohm external load resistance.
- Produces an output signal with no spectrum mirroring.
- Relies on the test bench for any measurement-related bandpass signal filtering of the RF DUT output signal.

Improving Test Bench Performance

The PAE is measured in a general way on the full signal and without regard to the power-on interval in a wireless signal frame.

- This test bench is intended to provide a simple and fast estimate for the PA PAE performance. The true PA PAE performance should be made only during the wireless

signal power-on interval in its signal frame. For signal frame based PAE, use the RF_PAE test bench templates for any of the wireless technology schematic templates.

The EVM is measured in a general way by comparison of a test and reference waveform.

- This test bench is intended to provide a simple and fast estimate for the PA EVM performance. The true PA EVM performance should be made using an EVM measurement that is compliant to wireless signal standard test requirements. For standards based EVM, use the EVM test designs in wireless library examples or schematic templates.

The ACLR is measured in a general way based on analysis of spectrum frequencies.

- This test bench is intended to provide a simple and fast estimate for the PA ACLR performance. The true PA ACLR performance should be made using an ACLR measurement that is compliant to wireless signal standard test requirements. For standards based ACLR, use the ACLR test designs in wireless library examples or schematic templates.

RF Power Amplifier PAE, EVM, and ACLR Test

RF_PAE_EVM_ACLR_test is the test bench for testing RF Power Amplifiers (PA) to measure the PA Power Added Efficiency (PAE), Error Vector Magnitude (EVM) and Adjacent Channel Leakage Ratio (ACLR). The test bench provides a way for users to connect to an RF circuit device under test (DUT) and determine its performance.

The PAE is measured in a general way on the full signal and without regard to the power-on interval in a wireless signal frame.

- This test bench is intended to provide a simple and fast estimate for the PA PAE performance. The true PA PAE performance should be made only during the wireless signal power-on interval in its signal frame. For signal frame based PAE, use the RF_PAE test bench templates for any of the wireless technology schematic templates.

The EVM is measured in a general way by comparison of a test and reference waveform.

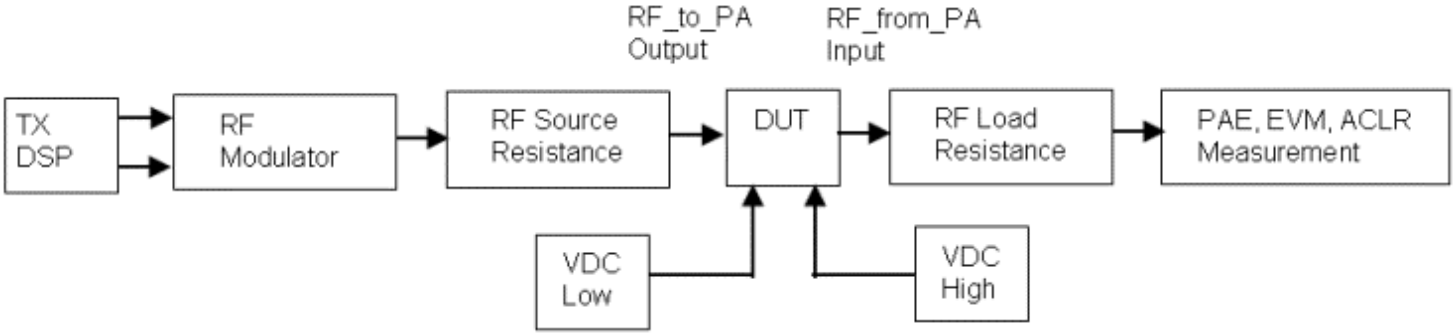
- This test bench is intended to provide a simple and fast estimate for the PA EVM performance. The true PA EVM performance should be made using an EVM measurement that is compliant to wireless signal standard test requirements. For standards based EVM, use the EVM test designs in wireless library examples or schematic templates.

The ACLR is measured in a general way based on analysis of spectrum frequencies.

- This test bench is intended to provide a simple and fast estimate for the PA ACLR performance. The true PA ACLR performance should be made using an ACLR measurement that is compliant to wireless signal standard test requirements. For standards based ACLR, use the ACLR test designs in wireless library examples or schematic templates.

This test bench includes a DSP section, an RF modulator, RF output source resistance, RF DUT connection, and DSP measurement blocks, as illustrated in the following figure. The generated test signal is sent to the DUT.

RF PAE, EVM, ACLR Test Bench Block Diagram

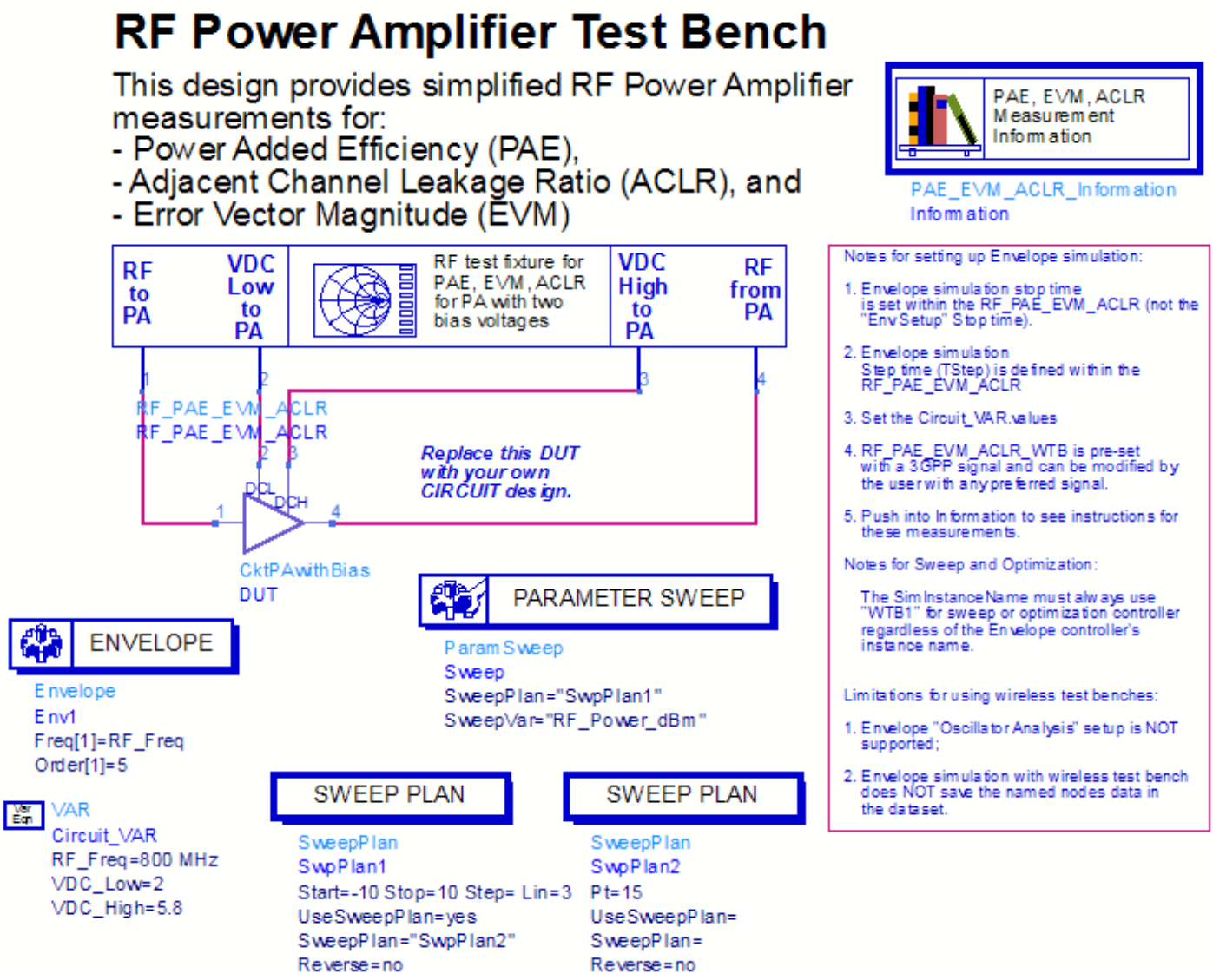


The RF_PAE_EVM_ACLR design is setup so that the user can easily switch the test signal from one type to another. The signal source is represented by the combined TX DSP, RF Modulator, RF Source Resistance sections in the above block diagram.

Test Bench Basics

A template is provided for this test bench.

RF Power Amplifier PAE, EVM and ACLR Test Bench



To access the template:

1. In an Analog/RF schematic window select *Insert > Template.*
2. In the *Insert > Template* dialog box, choose *RF_PAE_EVM_ACLR_test*, click *OK*; click left to place the template in the schematic window.

The basics for using the test bench are:

- Connect to an RF DUT that is suitable for this test bench.
- Configure SweepPlans to define a power sweep. You can add more SweepPlan controllers as needed.
- Set the Circuit_VAR value for: RF_Freq.
- Run the simulation and view Data Display page for your measurement.

> **Note**
> The default values work with the DUT provided. Set the values based on your DUT requirements.

Test Bench Details

The following sections provide details for setting up a test bench, setting measurement parameters for more control of the test bench, and simulation measurement displays.

Note
This test bench is not designed for use with other parameter sweeps, optimizations or other controllers. Such usage will result in warning messages against its internal MeasEqns. These warning messages do not prevent the simulation. However, the data display template is not usable with the resultant data.

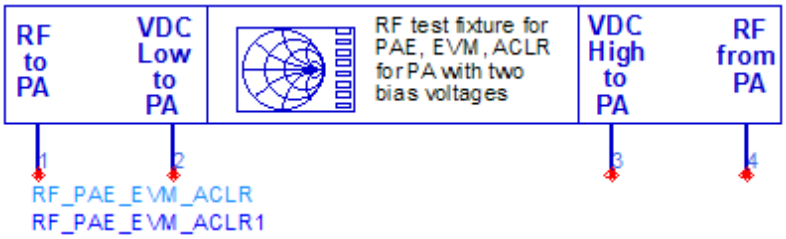
Test bench setup is detailed here.

1. Replace the DUT (CktPAwithBias is provided with this template) with an RF DUT that is suitable for this test bench.
   For information regarding using certain types of DUTs, see *RF DUT Limitations for RF Power Amplifier Test Benches* (rfpwrampwtb).
2. Set the Circuit_VAR values
   - RF_Freq defines the RF frequency for the signal input to the RF DUT and signal output from the RF DUT.
   - VDC_Low is the low bias voltage for the RF DUT.
   - VDC_High is the high bias voltage for the RF DUT.
   - SweepPlans are used to define a power sweep for the RF signal input to the DUT so that the measurements can be observed as a function of the DUT input power.
3. More control of the test bench can be achieved by customizing the signal source. For details refer to *Customizing the Signal Source* (rfpwrampwtb).

   Note
   Refer to *RF_PAE_EVM_ACLR* (rfpwrampwtb) for details on customizing the signal source.
4. The RF modulator (shown in the block diagram in *RF PAE Wireless Test Bench Block Diagram* (adswtb3g)) uses RF_Freq and the swept power. RF output (and input to the RF DUT) is at the frequency specified (RF_Freq), with 50 ohm source resistance and with power delivered into a matched load.
   Note that the RF_from_PA point of the test bench provides a resistive load to the RF DUT fixed at 50 ohms.
   The RF_from_PA signal contains linear and nonlinear signal distortions and time delays associated with the RF DUT input to output characteristics.
5. More control of Circuit Envelope analysis can be achieved by setting Envelope controller parameters. Setting these simulation options is described in *Setting Circuit Envelope Analysis Parameters* (adswtbsim). However, Circuit Envelope settings for Fast Cosim are not intended for use with PAE measurements.
6. After running a simulation, results will appear in a Data Display window for the measurement. *Simulation Measurement Displays* (rfpwrampwtb) describes results for each measurement. For general WTB Data Display details refer to *Viewing WTB Analysis Results* (adswtbsim).

RF_PAE_EVM_ACLR

This section provides information for the measurement.



Description RF Power Amplifier PAE, EVM, and ACLR test

Pin Inputs

Pin	Name	Description	Signal Type
4	RF_from_PA	Test bench measurement RF input from RF circuit	timed

Pin Outputs

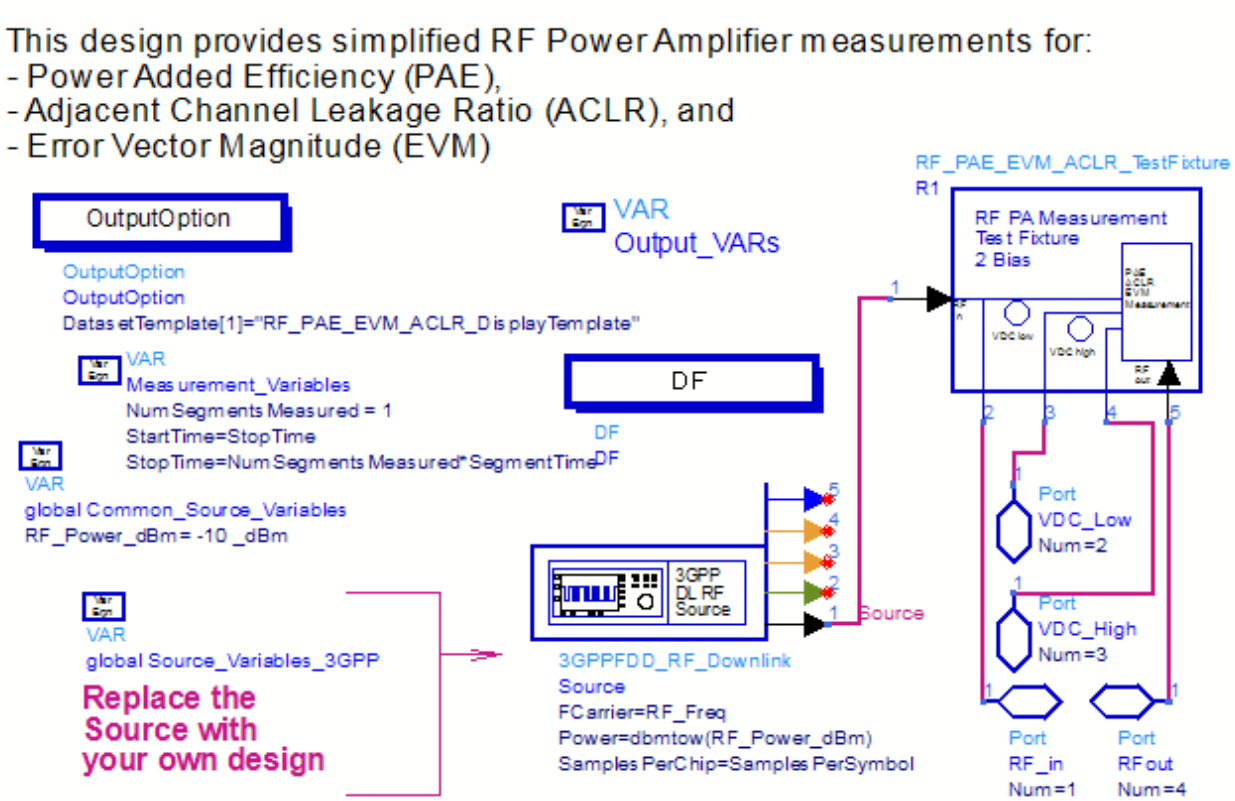
Pin	Name	Description	Signal Type
1	RF_to_PA	Test bench RF output to RF circuit	timed
2	VDC_Low_to_PA	Test bench Low VDC voltage to RF circuit	timed
3	VDC_High_to_PA	Test bench High VDC voltage to RF circuit	timed

Customizing the Signal Source

More control of the test bench can be achieved by customizing the signal source.

Note
For *required* parameter information, see *Set the Required Parameters* (rfpwrampwtb).

The following figure shows the RF_PAE_EVM_ACLR schematic design.



Description RF_PAE_EVM_ACLR schematic design

Replace the Source instance and define the Source_Variables according to your needs. As a minimum, these Source_Variables must be defined:

- TStep (the simulation time step),
- SamplesPerSymbol (number of samples per symbol for EVM measurement),
- SegmentTime (the signal segment time interval for defining the stop time),
- SymbolRate (the signal symbol rate for EVM measurement),
- ACLR_MeasurementBW (the frequency bandwidth for the ACLR measurement),
- ACLR_ChannelSpacing (the frequency spacing between signal channels for ACLR measurement), and
- ACLR_ResBW (the spectrum resolution bandwidth for ACLR measurement).

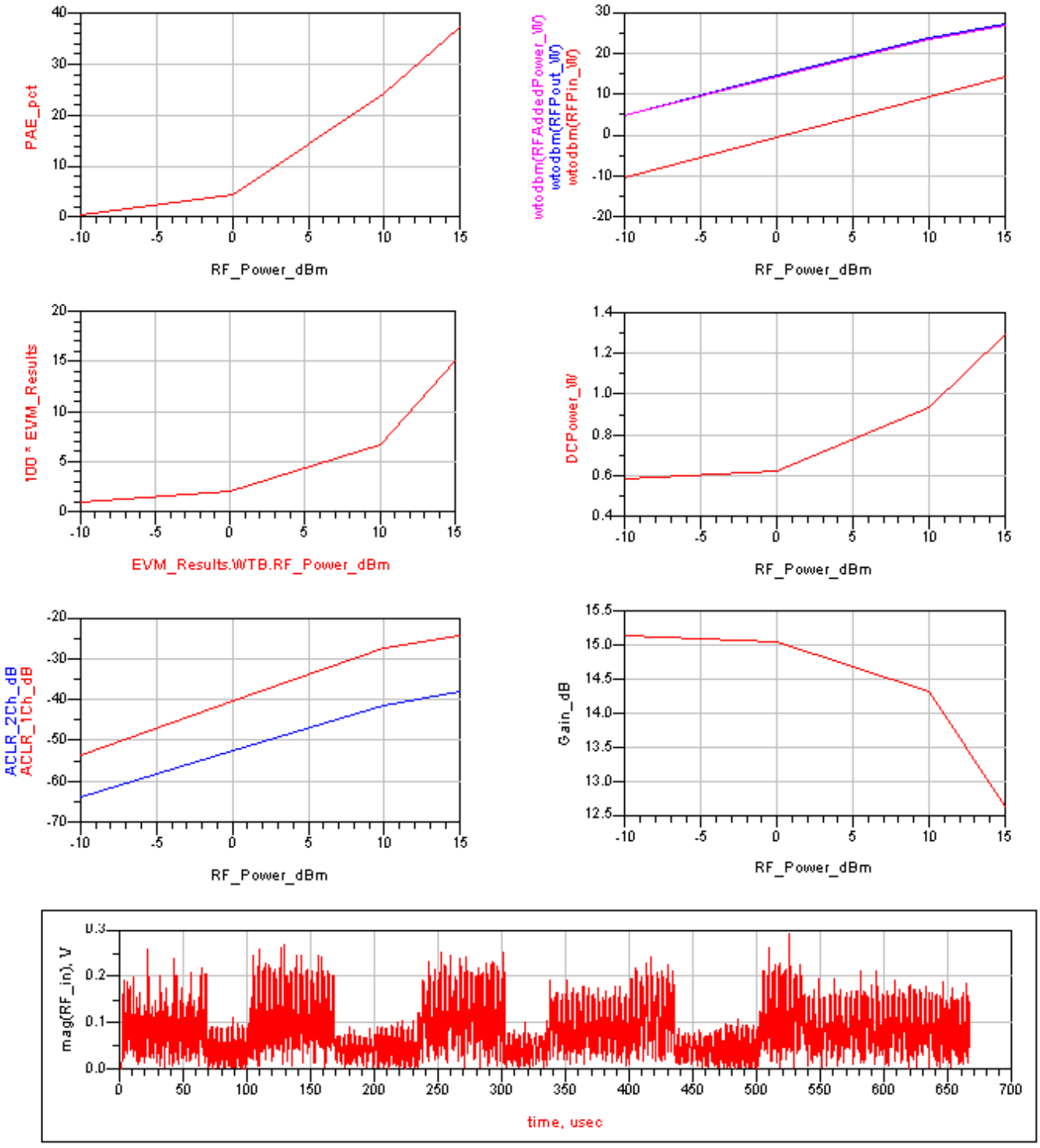
Simulation Measurement Displays

After running the simulation, results are displayed in the Data Display pages for each measurement activated.

Note
Measurement results from a wireless test bench have associated names that can be used in Data Display Expressions. For more information, refer to *Measurement Results for Expressions for RF Power Amplifier Test Benches* (rfpwrampwtb).

The following figure shows results for the default settings and DUT.

PAE, EVM and ACLR Measurement Results



References

Setting up a Wireless Test Bench Model (adswtbsim) explains how to use test bench windows and dialogs to perform analysis tasks.

Setting Circuit Envelope Analysis Parameters (adswtbsim) explains how to set up circuit envelope analysis parameters such as convergence criteria, solver selection, and initial guess.