Strengthen, Accelerate and Secure your System Design Flow

VISION 2.4.2

Behavioral Modeling for System Design

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PART 1

VISION

PRESENTATION

VISION

KEY FINDINGS

To remain competitive, System Designers in charge of developing Radio Frequency (RF) communication chains must use optimal design flow methodologies, avoiding empirical approaches such as "try-and-cut" approach.

VISION Software Platform

Radio chains have become more complex due to their architecture and the nature of modulated signals to be processed. Despite increasingly stringent constraints, these systems must be high-performing, efficient, robust in harsh electromagnetic environments. Furthermore, such a work must be cost-effective. The performance of the RF chain must be analyzed in detail even before the production phase.

The testing, adjustment and retro-engineering phase is often the bottleneck in an optimal design flow.

While the Microsoft Office Excel tool or similar solutions has served a lot of architects well, enabling them to develop their own basic visual routines to see what it would be like to assemble several RF circuits one behind the other. Due to the complexity of these systems and their high level of integration, in-house chain dimensioning solutions are beginning to reach their limits in terms of performance and industrialization.

This is becoming increasingly difficult because of the complex phenomena that occur in circuits, and the characteristics of the modulated signals to be processed.

CHALLENGES RELATED TO RF SYSTEM DESIGN FLOW

CHALLENGES

To be truly useful, a bottom-up system simulation must provide at least the same level of confidence as the results obtained in the experimental testing phases. However, the bottleneck to accurate simulation has always been the quality of the models. VISION meets this challenge with a unique equation solver and a set of pedagogical tools for extracting realistic behavioral models from various types of RF circuits.

EXPENSES

The use of a new system simulation tool, allowing for the a priori qualification of the performance of a new Radio Frequency chain architecture, may be perceived as an additional expense alongside existing simulation tools in the company, such as circuit simulators. But how much does it cost to work without the VISION software suite ? Such an investment will be significantly cost-effective, as it can shorten or even eliminate time-consuming calibration and experimental adjustment phases for complex RF systems.

ADVANTAGES

In addition to improving efficiency in the development of innovative, high-performance architectures, VISION interfaces easily with other CAD tools already in place within companies. It enables different teams to communicate more effectively internally, analog, RF and digital electronic engineers can speak the same language, using a unified design work-flow.

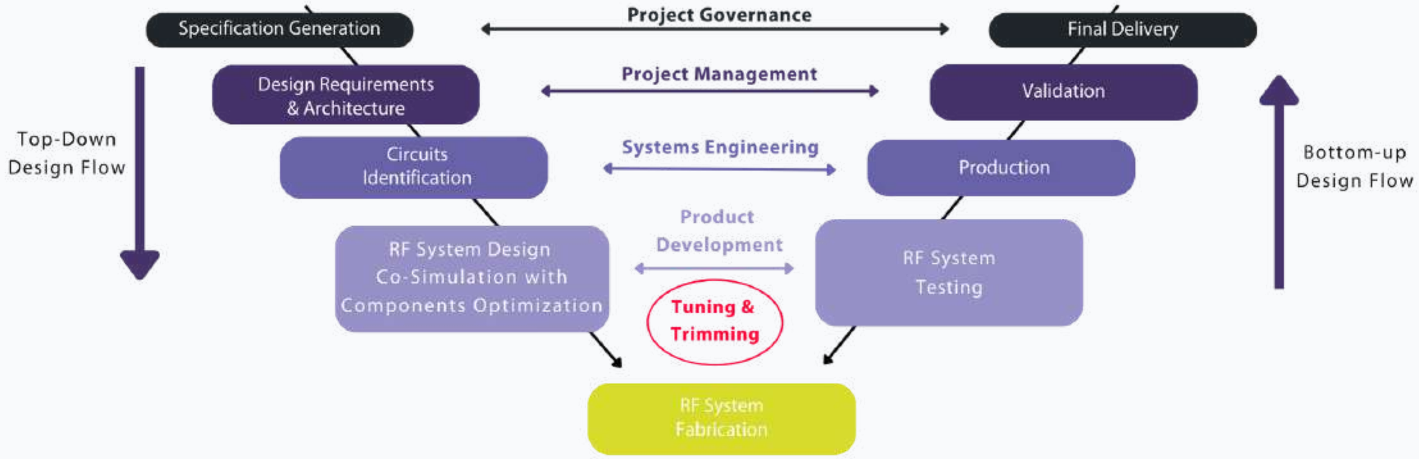
HOW THINGS STACK UP

Impact on the V-cycle design:

In the downward phase of the V-cycle design, the Radio Architect must define the specifications for each integrated circuit in the chain, starting from the global specifications of the system.

In the bottom-up phase, the flow consists of validating that the specifications of each circuit chosen to be part of the chain meet the system specifications.

Testing a complex architecture, such as an active antenna in an anechoic chamber, can prove to be extremely costly and time-consuming, especially when the tested architecture is large, such as a large scale active antenna. This process involves the use of numerous testing equipment and requires qualified teams for testing phases.



THE REALM OF POSSIBILITIES

The VISION software aims to elevate the confidence in results obtained from system simulations to a level at least equivalent to that of results achieved through physical testing. This capability enables clients to virtually qualify the system architectures proposed by equipment manufacturers.

Finally, Vision opens the realm of possibilities, and fully exploits the experience and imagination of system architects. What couldn't be validated by tests before, because of budgets or the complexity of experiments, can now be validated by convincing simulation results.

CASE STUDY

A world leader in the space industry needs to design Low-Earth Orbit satellites, equipped with innovative antennas to dynamically manage the signal link.

Challenges

Effective communication in low Earth orbit (LEO) satellites necessitates high scanning angles for sustaining signal connectivity. The escalating intricacy of these systems heightens the susceptibility to potential disruptions. To minimize prototyping expenses and enhance system efficiency, having superior RF circuit models becomes crucial for simulating the true performance of the RF chain.

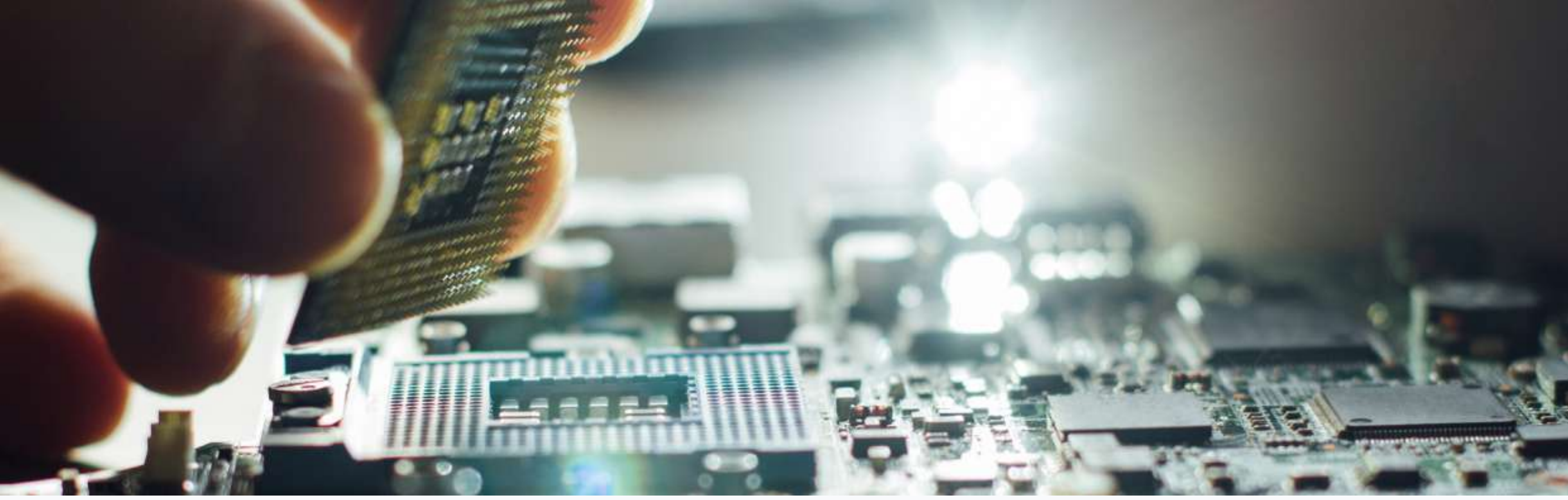
Moreover, antenna designers face fresh obstacles. While the proximity of radiating elements facilitates significant scan angles, the interactions between these elements can no longer be disregarded. Linking a power amplifier to each antenna port may induce load-pull effects, compromising the amplifier's performance and, consequently, the overall system efficiency. Consequently, a tool capable of scrutinizing these effects using advanced behavioral models for beam steering analysis is indispensable.

Results

VISION was used to extract behavioral models of the MMICs and antenna elements integrated into the satellite equipment. A comparison was made between the circuit simulator associated with the EM simulator and the simulation performed by Vision. The simulation results were perfectly aligned using simple signals to validate the simulation flow foundation.

Simulation results were also validated when broadband spatial signals were used, but simulation speed was improved by an order of magnitude thanks to the use of behavioral models.

Finally, the simulation was pushed to the point of producing results that were simply not accessible until now, such as the simulation of the modulated signal radiated by the antenna, with simulation times compatible with the project's constraints.



VOICE OF CUSTOMER

Involved in the design of communication chains

Vision has enabled us to reduce the development time of our Front End (FE) Tx & Rx with models based on actual measurement of functions through

- *Simulation of output power, EVM, ACPR and overall consumption throughout the RF chain, using specific signal waveforms during the simulation/characterization approach*
- *Simulation of Noise Figure, Power gain, Power consumption and Phase drift of the Rx channel*

Thus, VISON helped a lot to anticipate the calibration phases of the Rx chain

We were able to reduce Integration and Verification time by using the automatic tests and reports generated by the WHITEBOARD tool, available both in the measurement domain with IQSTAR, and in the simulation domain, with VISION.

After a first week's training with AMCAD' application engineer, we were able to measure and fine-tune RF functions and estimate their critical performance with CW signals and digital modulations.

Therefore, we can monitor the development margin on critical performances such as- Emitted Noise, Output Power Consumption, NF, System Desensitization, Linearity (EVM,ACPR) using the Whiteboard, from the simulation phase to qualification.

We were able to analyze performance statistically on a sample batch, rather than basing our analyses only on nominal operation or worst-case scenarios.

Involved in the design of antenna array systems

We conducted extensive comparisons between our conventional circuit simulator combined with our Electromagnetic (EM) simulation software and VISION. These comparisons were performed for a radiating element of 25 elements, and we observed a perfect match, with simulation times 50 times faster using VISION compared to our reference circuit simulator, for over 1000 simulation points. This allowed us to surpass what was previously achievable in terms of the final system size.

For a power amplifier, we accurately simulated the system's behavior with modulated signals to observe merit criteria such as Noise Power Ratio (NPR). This process takes one minute with Vision, compared to 20 minutes with our circuit simulation tool, using identical signal and analysis criteria.

In the case of an n-element network, the VISION simulation allowed for the simulation of the modulated radiated signal in 27 minutes; other simulators simply do not enable this type of simulation.

Thanks to the multi-block system in the schematic editor, the schematic remains the same regardless of the network size.

Now, we can perform a statistical analysis of our system's performance by introducing typical performance variations measured across a set of power amplifiers.

We can sweep the angle and azimuth of our antenna, tracking the impact on each amplifier block, especially the output power and Power Added Efficiency (PAE).

We can simulate a failure of a certain number of RF front-end circuits or simulate an architecture without isolators, observing the precise impact on radiation diagrams.

The tool is easy to use, highly ergonomic, and every day I came up with new simulation ideas. I greatly enjoyed working with this software and the responsive support teams at AMCAD.

Whiteboard enables the display of any quantity for N channels simultaneously. For instance, we can visualize active power for all N channels at once.

To our knowledge, VISION is the only software capable of handling ready-to-use precise models for multi-state components, such as beamformers.

VISION FEATURES

Ready-to-use gateways for easy import of reference results

- **Import of reference data from Circuit and EM simulators**
- **Import of measurement data from IQSTAR instrument control software**

An intuitive toolbox RF circuit behavior modeling

- **Multi-state linear component models**
- **Library of amplifier models**
- **Mixer models**
- **Consideration of temperature and memory effects**
- **Taking into account the influence of impedance mismatches**

Simulation engines adapted to bilateral effects

- **Transient mode (Spice like)**
- **EnvelopeTransient Analysis (Baseband IQ, Time domain Noise Analysis)**
- **Steady state analysis (Carrier frequency, Frequency noise analysis)**
- **Associated solver : ODE (Data Flow unilateral Current or Voltage) DEA (balancing Current and Voltage)**

Powerful schematic editor for defining RF chain architecture

- **Creating, saving and archiving simulation projects**
- **Hierarchical blocks enabling multiple blocks to be encapsulated in a single block to define different levels of architecture depth**
- **Bus ports: parallelized topology for the design of complex architectures.**
- **Automatic validation of simulation flow against measured signals: pre-configuration of a simulation diagram similar to the IQSTAR measurement signal configuration.**
- **IQ probes acting as vector signal analyzers: automatic signal processing of EVM, constellation, CCDF, ACPR data.**

A flexible, high-performance data analysis environment

- **Automated graph layout based on imported data format**
- **Dynamic data filtering using appropriate tools (filters, sliders, etc.)**
- **Definition of specific calculation functions via an adapted script editor**
- **Create interactive and shareable simulation reports**

Adapting the solution to the existing simulator environment

- **Vision models can be exported to external system simulators**
- **Exported models integrate the equation solver, maintaining the accuracy of the system simulation**
- **Models are compatible with the FMI-FMU format.**
- **Multi-platform operation WINDOWS > 7.0 and LINUX (ALMA, CENTOS, REDHAT)**

MODELING FLOW

VISION software allows extracting behavioral models of RF and microwave circuits to accurately simulate complex RF systems using time-domain signal analysis.

The **"Device Modeler"** application is a tool for extracting models from measurement or circuit simulation data. This application is used to model different electronic functions available in 2 modules depending on the complexity of the behaviour to be described: **VIS100C-1** and **VIS100C-2**.

The **"System architect"** application is a simulation environment that makes full use of the models extracted from VISION. Several VISION models can be assembled in a schematic editor to simulate the whole behavior of the subsystem and observe the contribution of each circuit to the overall performance. The fine time-domain analysis of the signal envelope can be made while considering complex parasitic phenomena such as high and low-frequency memory effects, inter-stage mismatch and the dynamic influence of temperature. A wide range of simulation features are available with the module **VIS100E**.

Alternatively, the system architect can also be used for a top-down design flow when used only with ideal linear and non-linear circuit models, using the "MATLAB® block" connection port (see System Architect feature description).

Simulation results can be easily visualized using **"Whiteboard"** module's graphical and control functions (**WHIT-10**). **"SCRIPTING"** module (**SCRPT**) offers a wide range data processing options. Also, results can be exported to third-party EM simulator using **"EM Link"** module (**VIS100D**).

Once RF subsystem is designed in **"System Architect"**, VISION allows the export as a global macro-model to third-party system simulators (**VIS100F**). The macro-model's built-in simulation engine ensures consistent precision in time-domain simulations across all dataflow simulators.

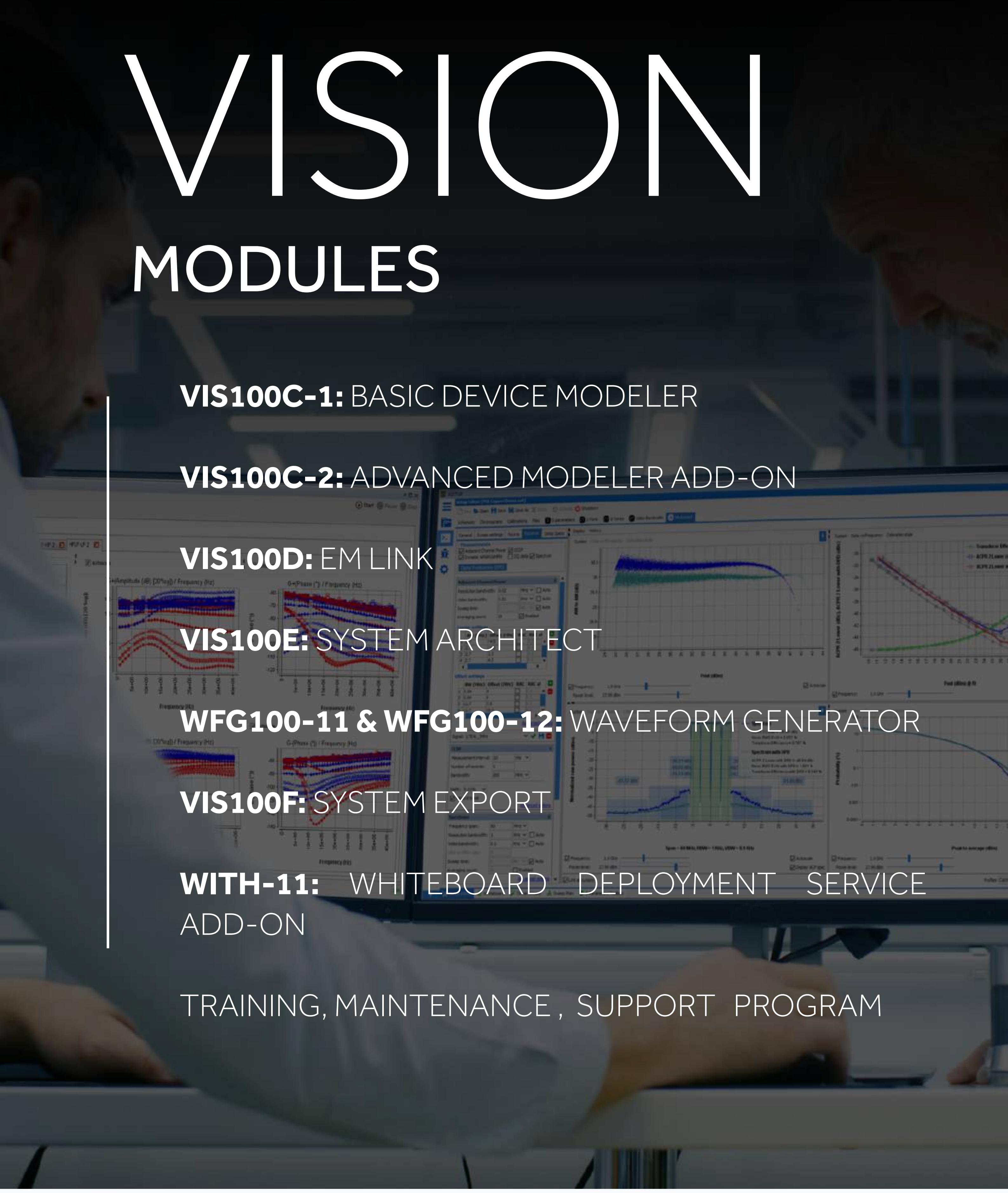
PART 2

VISION

MODULES

- **VIS100C-1:** BASIC DEVICE MODELER
- **VIS100C-2:** ADVANCED MODELER ADD-ON
- **VIS100D:** EM LINK
- **VIS100E:** SYSTEM ARCHITECT
- **WFG100-11 & WFG100-12:** WAVEFORM GENERATOR
- **VIS100F:** SYSTEM EXPORT
- **WITH-11:** WHITEBOARD DEPLOYMENT SERVICE ADD-ON

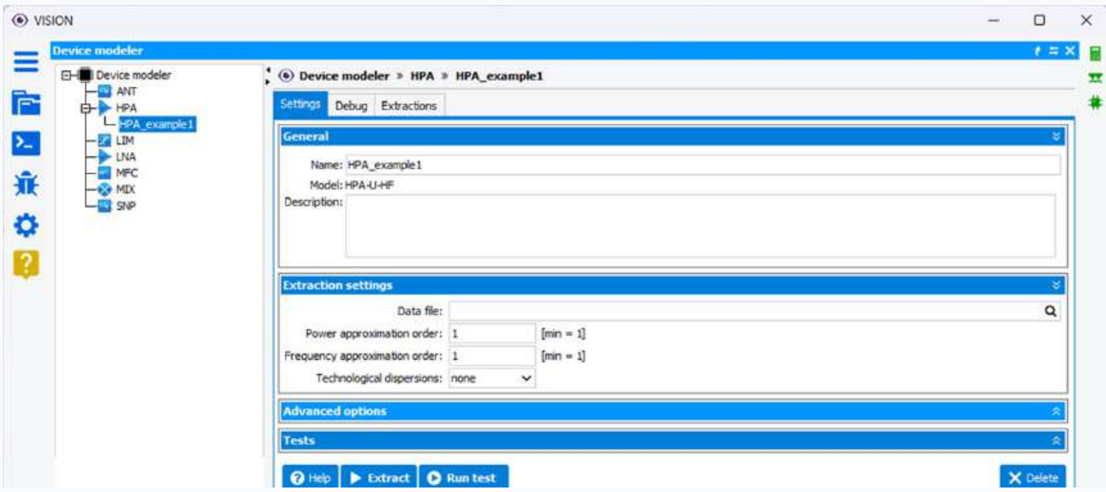
TRAINING, MAINTENANCE , SUPPORT PROGRAM



VISION MODULES

VIS100C-1: BASIC DEVICE MODELER

The “Basic Device Modeler" module allows extracting models of the various electronic functions of a transmission chain to enable time-domain simulations. Using the VIS100C-1 module, the user can extract elementary models of this chain, starting with all passive circuits that can be characterized by S-parameter data up to unilateral nonlinear amplifier model embedding high frequency memory effects. Before exporting the model to the system Architect panel, a test plan can be programmed to verify the model's behavior over a wide range of operating conditions (carrier frequency, envelope modulation, power), thus validating the model's robustness before its use in the final design. Below are the electronic functions that can be modeled using this module:



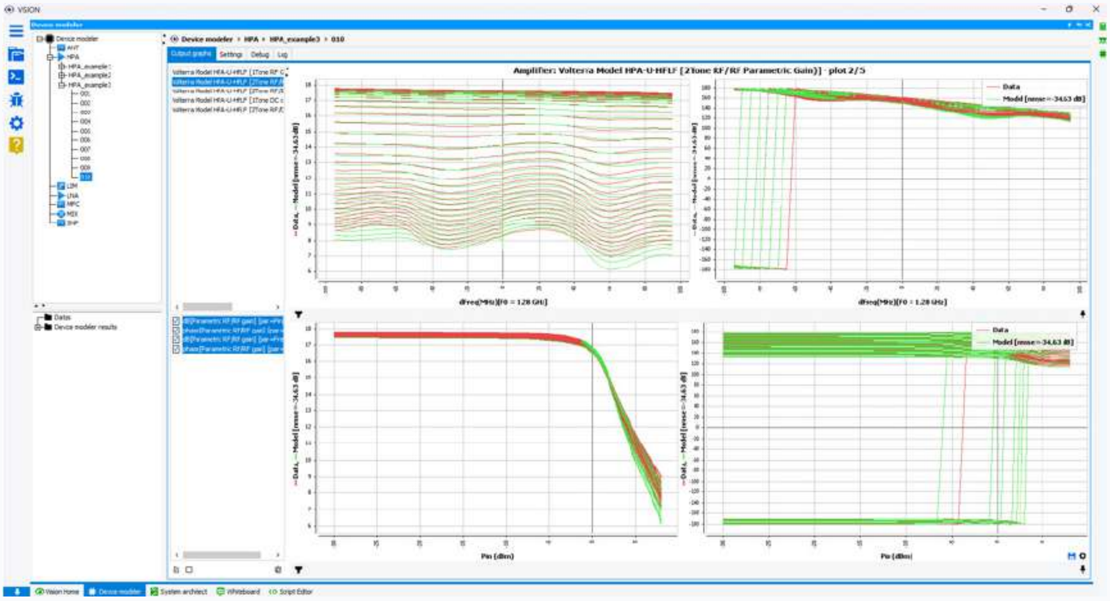
The model engineer can check and balance the various parameters available in the nonlinear function descriptions of the model extraction such as

- **Order of non-linear power approximation functions**
- **Order of non-linear frequency approximation functions**
- **Technological dispersions.**

In the Basic Device Modeler module, some models are bilateral, i.e. current flows through a 2-port model in both directions, so that the influence of the load impedance on the circuit’s input impedance is taken into account.

Various graphs are available to check the quality of the model along two dimensions: power and frequency.

The first extraction is an opportunity to check the data, particularly in the event of noise or measurement error. This type of phenomenon can make model extraction difficult and can lead to aberrant results when the model is driven with modulated signals. VISION offers post-processing tools for limiting or eliminating these phenomena.



Library of Models part of the BASIC DEVICE MODELER module

- **LIMITER MODELER:** Non-linear model of power limiters
- **MIXER MODELER:** Bilateral non-linear model for mixers, configurable in frequency and power
- **LNA MODELER:** Bilateral model of Low Noise Amplifiers
- **HPA MODELER:** Unilateral Non-Linear Model of High-Power Amplifiers integrating high-frequency

(HF) memory effects in matched conditions (50 ohms; U) (HPA-U-HF)

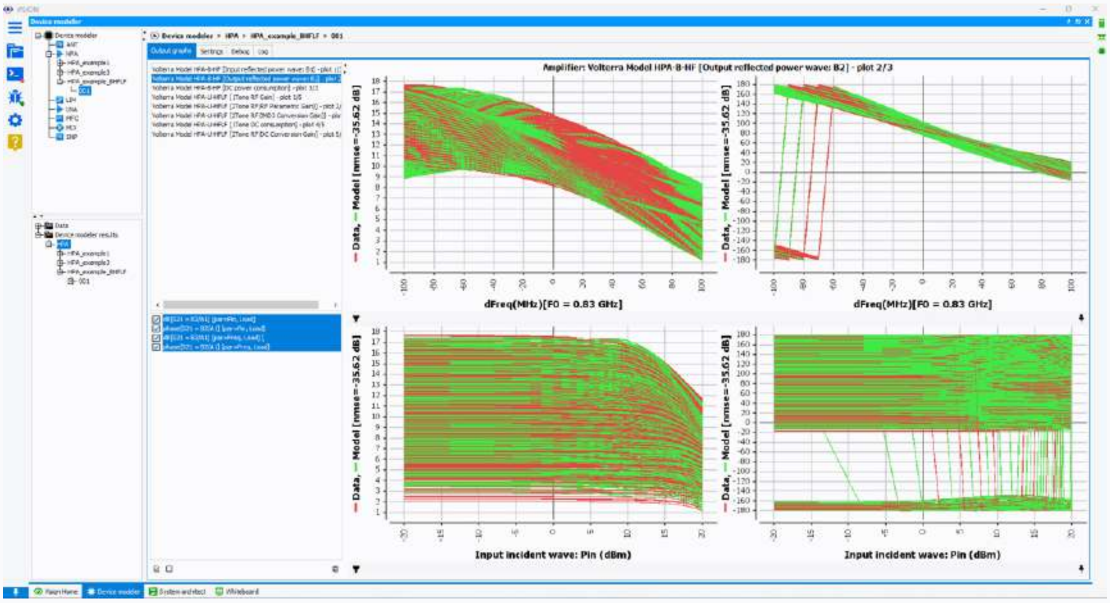
	Nonlinear	Mismatch	In-band Memory	Low frequency Memory	Noise
LIMITER MODELER	✓	X	✓	X	X
MIXER MODELER	✓	✓	✓	X	✓
PASSIVE MODELER	X	✓	✓	X	✓
LNA MODELER	✓	✓	✓	X	✓
HPA MODELER	✓	X	✓	X	X

VIS100C-2: ADVANCED MODELER ADD-ON

Compared with the Basic Device Modeler, the Advanced Device Modeler provides even more comprehensive models, taking complex phenomena into account. It enables parametric models to be extracted for circuits whose performance may vary as a function of digital controls (such as variable gain amplifiers, programmable phase shifters and beamformers). See Multi-Function Chip (MFC) behavioral modeling for accurate beamforming simulations Whitepaper.

The most complete power amplifier model is also available in this module. This incorporates all the phenomena that can occur in a circuit as described herafter.

Finally, the antenna modeler can be used to use far-field simulation data supplied by a third-party EM simulator, to extract an equivalent model of the antenna, so that the antenna impedance can be used directly to simulate the realistic behavior of the power amplifier when the two circuits are assembled.



The Advanced Device Modeler Add-On allows more advanced behavioral models extraction for different circuit types:

• HPA-B-HF-LF MODELER:

Bilateral (B) nonlinear model of power amplifiers with high-frequency (HF) memory effects linked to the carrier frequency and low-frequency (LF) memory effects linked to the modulation frequency of the envelope with electrical and thermal phenomena.

The HPA-B-HF-LF model family can be used to generate other HPA models depending on the input Data available to extract the model: HPA-U-HF, HPA-B-HF, HPA-B-HF-T°, HPA-U-HF-LF.

• MULTI-FUNCTION CHIP MODELER:

Linear models of multifunction circuits, integrating commands defining the attenuation and phase parameters of the component characterized by multi-state S-parameters (citi-file format)

• ANTENNA MODELER :

An SnP block representing the antenna model to consider the mutual coupling between different unitary radiating elements of the array.

This modeling tool allows importing into VISION the S-parameter files provided by EM simulation such as CST (A Dassault Systèmes' EM simulator). HFSS (an Ansys' EM simulator) far-field data are supported.

VISION can calculate the incident and reflected signal at each port of the antenna array, allowing accurate calculation of the active impedance and radiation.

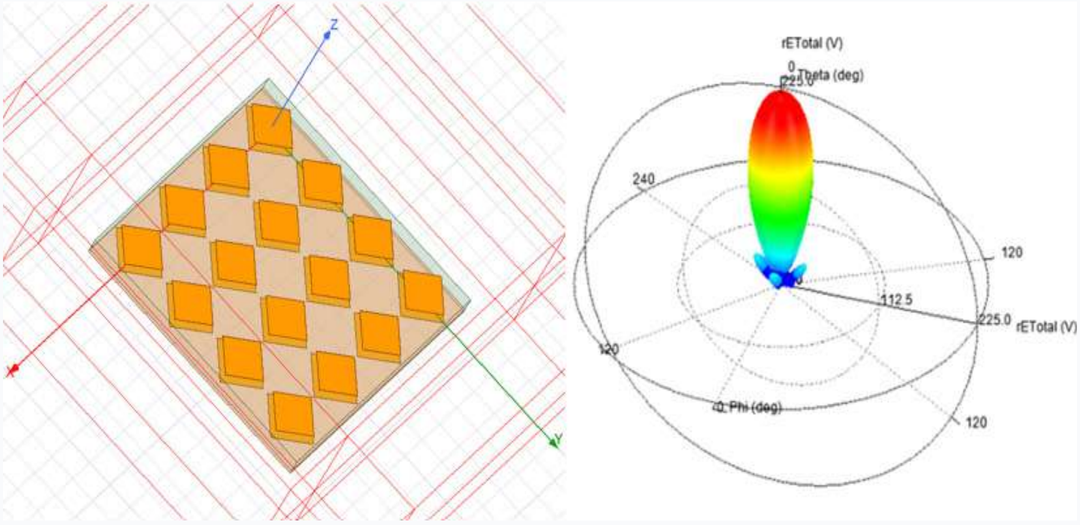
	Non linear	Mismatch	In-band Memory	Low Frequency Memory (electrical + thermal)	Noise
MULTI FUNCTION CHIP MODELER	x	✓	✓	x	x
HPA-B-HF-LF MODELER	✓	✓	✓	✓	x
ANTENNA MODELER	x	✓	✓	x	✓

DEVICE MODELER ADD-ON

VIS100D: EM LINK

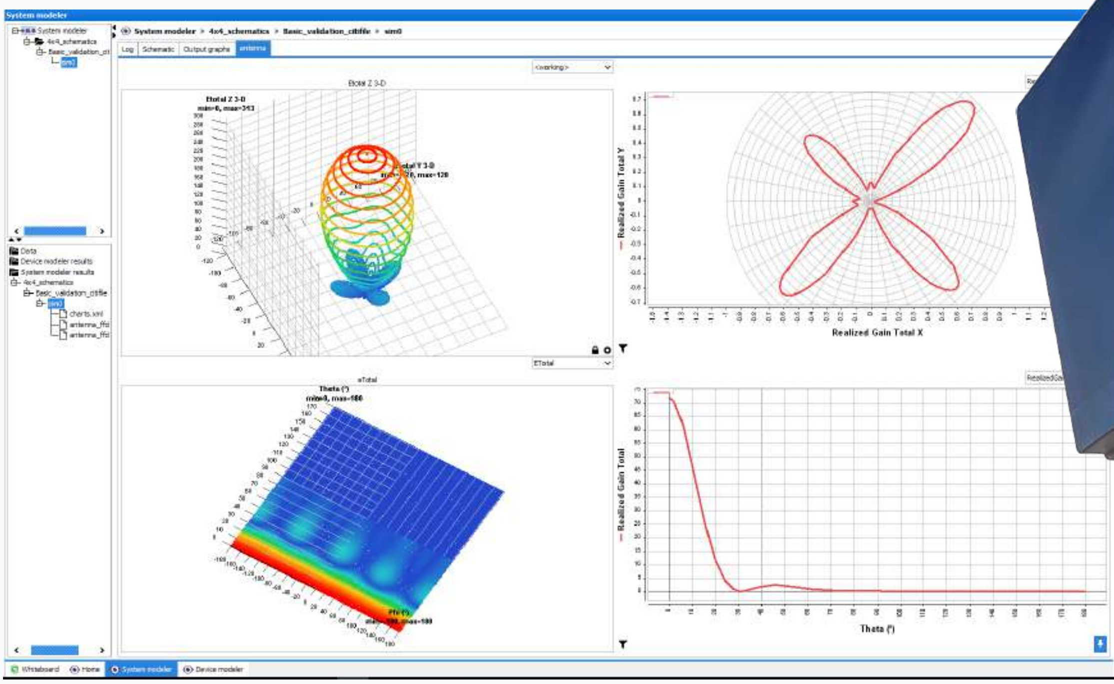
The "EM Link" module provides a suitable bridge between the functionalities offered by VISION and those offered by an electromagnetic simulator. For example, Vision can export the amplitude and phase of the signal emitted by each front-end circuit and update the EM simulator parameters automatically.

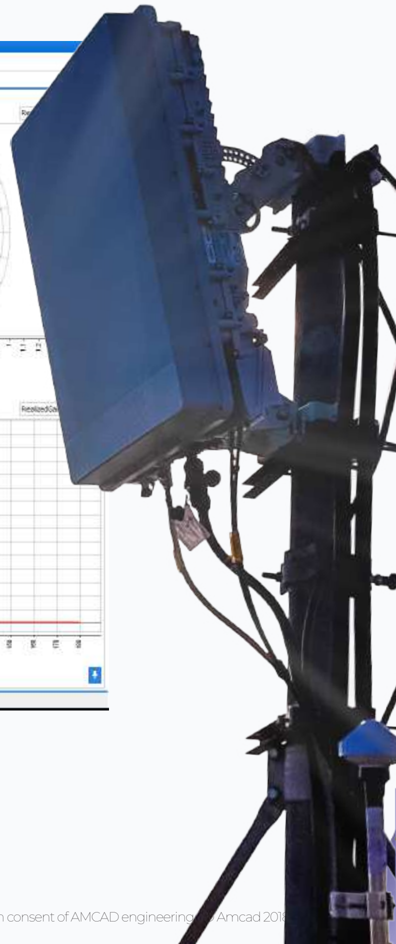
The radiation pattern of the multi-port antenna array displayed in the EM simulator interface, provides then a realistic representation of the signal emitted by the antenna. The interactions between the antenna and the RF circuits are properly managed.



Example of Antenna Design provided with HFSS (An EM Simulator provided by Ansys), fed with RF signals computed by VISION

Couplings between antenna ports, depending on the antenna's pointing, can create active SWR phenomena, disrupting the operation of upstream power amplifiers. If this interaction is not taken into account, system simulation may prove inaccurate in certain cases.



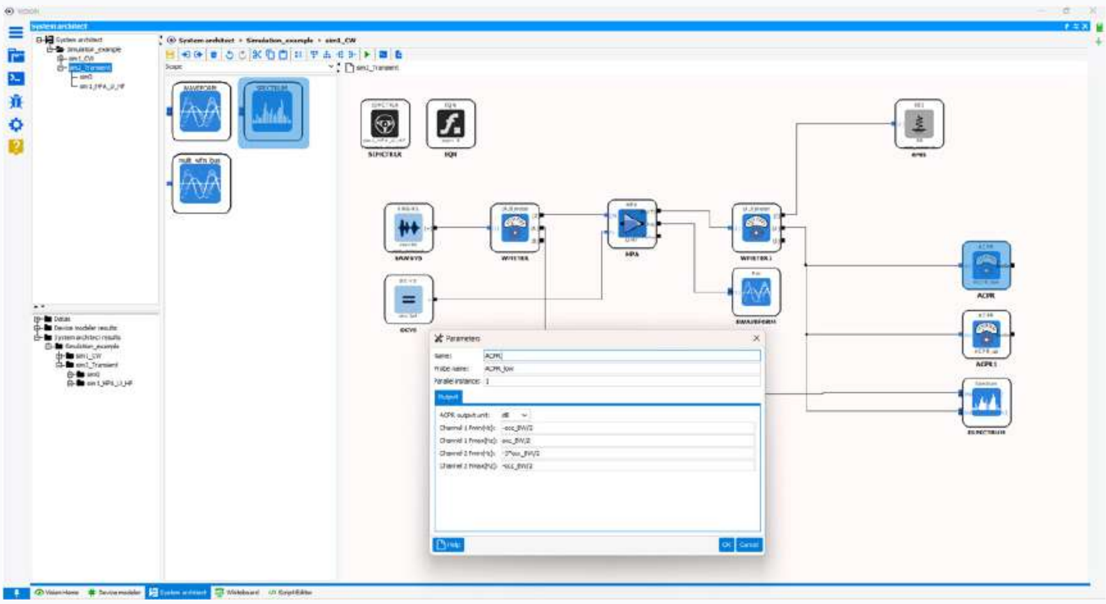


VIS100E: SYSTEM ARCHITECT

Once the various circuits used in the chain have been identified and modeled, they are represented by icons, which can be used directly in the schematic editor to reproduce the system architecture.

Different families of tools can be used to check the system performances

- **Simulation control blocks:** Configure simulation by selecting solver (algebraic/dataflow), domain (CW/envelope transient) and analysis type (nominal, sweep, statistical, noise) and set multithreading option.
- **Nonlinear blocks:** VISION behavioral models such as HPA and LNA.
- **Linear distributed & lumped blocks:** RLC and ground components, VISION SNP behavioral models and advanced function capabilities for Phased-Array Antenna analysis.
- **Source blocks:** Provide inputs for simulation by defining and generating signals (CW, 2-tone, pulse) or loading signals (custom IQ data or using Waveform Generator)
- **Scope & Probes blocks:** waveform & spectrum analyzers, performance analysis such as Instantaneous Power, Average Power, Power Added Efficiency (PAE), Adjacent Channel Power Ratio (ACPR), Noise Figure (NF)
- **Transducer blocks:** Mathematical function blocks and route signal blocks such as Bus.
- **Multiblock and connector blocks:** User-defined blocks designed from edited VISION diagram with customizable input and output ports.
- **Co-simulation blocks:** Custom block function block linked to MATLAB® script or user API dll, import function block of exported VISION macro-model with VIS100F module



VIS100E: SYSTEM ARCHITECT

To manage architectures of increasing size and complexity, an effective strategy is to organize the equivalent system diagram into several groups using components known as "multi-blocks".

A multiblock is essentially a group of circuits within a diagram that encapsulates a subset. It is therefore possible to include several multi-blocks in a single diagram, or even to nest multi-blocks within one another. Therefore, an architecture with greater depth can be defined, with the following benefits:

- **A hierarchical organization in the schematic editor can be based on a multi-layer structure for an easy navigation**
- **it simplifies diagram display by minimizing the number of blocks visible in the main window.**
- **Specific interfaces with specific inputs and outputs improve integration and interaction within the block diagram.**

Once created, on multiblock can be added in the library of available models, and reused in different schematics across different project templates.

VIS100E: SYSTEM ARCHITECT

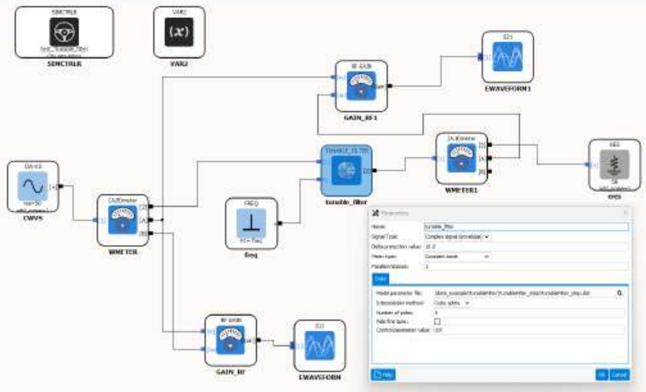
Linear Parametric Model

VISION **VIS100E** module provides **Parametric SnP or tunable filter models.** These models can be used to model an adhoc network. In this type of structure, optimizations are complex because all frequencies can be used, and mismatching effects due to active elements are numerous.

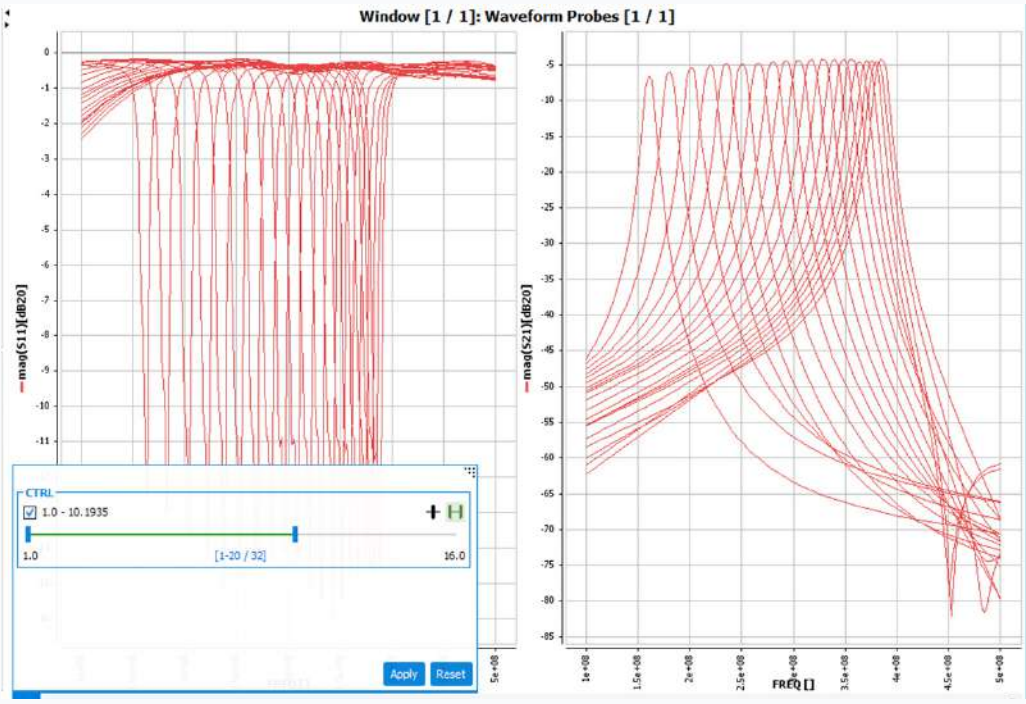
A challenge in complex networks with multiple tunable filters is to be able to calibrate these systems via an algorithm based on the number of commands and the values of the operating frequency. Thanks to these models, the development of these calibration functions is now possible.

Vision proposes an interesting technical solution that also enables us to model the broadband behavior of a passive dipole whose tuning frequency varies, even in the presence of strong frequency resonances. This time-frequency representation enables the user to check the performance of his system after determining a calibration law in the face of modulated signals.

Handling such a model is simplified by the fact that the graphical interface manages a list of measurement files (i.e. s2p files) in Touchstone format via a simple configuration file. Interpolation between the control values of discrete measurements is performed in the case of a tunable filter.



TUNABLE FILTER BLOCK

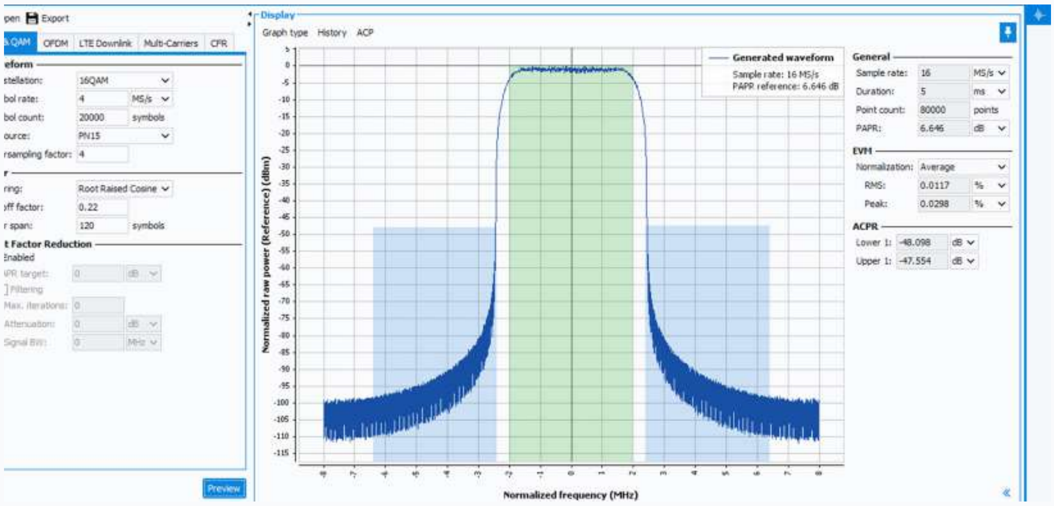


TUNABLE FILTER SIMULATION RESULTS

VIS100E: SYSTEM ARCHITECT

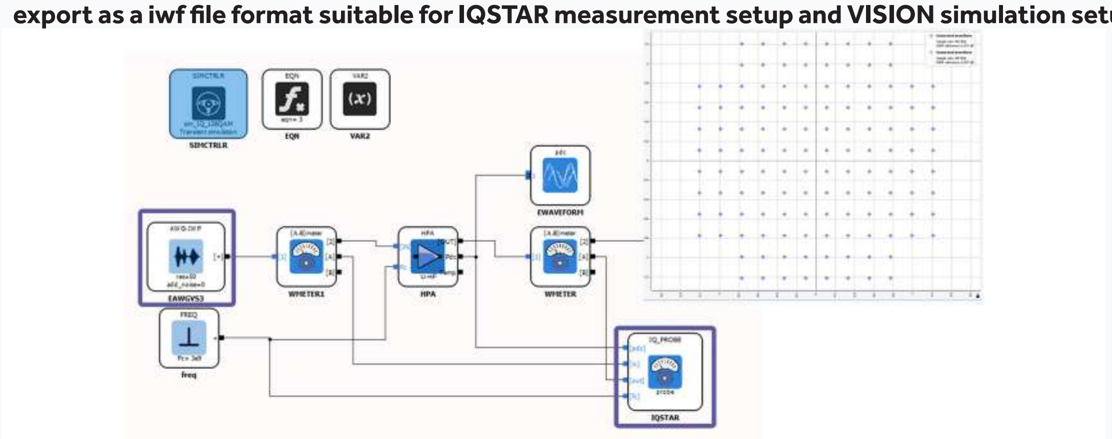
Waveform Generator & IQSTAR probe feature

Module **VIS100E** provides **Waveform Generator** tool for evaluating in simulation key performances of modern telecommunication systems such as EVM and BER figures of merit. The **Waveform Generator** interface allows to:



WAVEFORM GENERATOR

- **build complex IQ waveforms without programming skills requirements (limited to PSK&QAM modulation and NPR signal generation included in module VIS100E)**
- **get a graphical preview by plotting the spectrum or CCDF**
- **export as a iwf file format suitable for IQSTAR measurement setup and VISION simulation setup.**



VISION & WHITEBOARD EDITOR BUNDLE SOLUTION

The diagram editor provides signal source block to import iwf file generated from Waveform Generator and IQSTAR probe for demodulation and analysis. Simulation results are formatted in such a way that they can be easily compared with IQ validation measurements made with IQSTAR software.

VIS100E: SYSTEM ARCHITECT

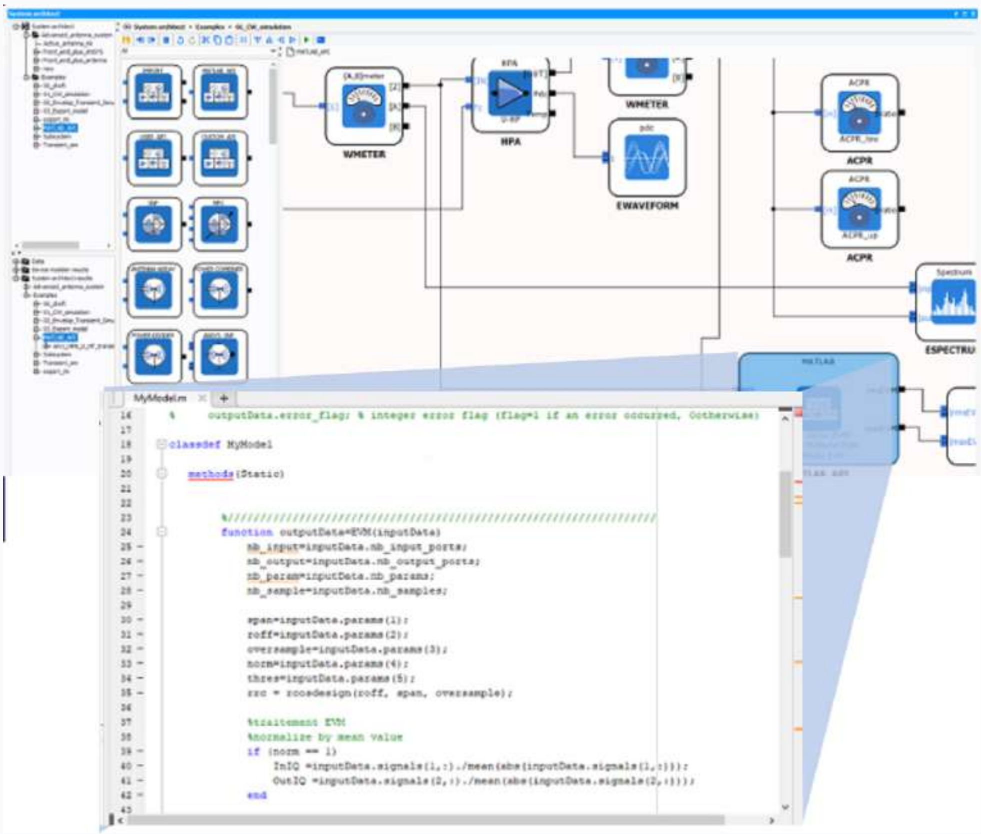
MATLAB® API feature

With the System Architect, algorithms designed in MATLAB® (a product of Mathworks) or C/C++ languages can be used during the simulation.

The USER & MATLAB® Application Programming Interfaces allow customizing models and/or signal processing algorithms by integrating user-defined C/C++ dlls.

Alternatively, user-defined MATLAB® scripts can be encapsulated within a MATLAB® block in the diagram editor. As a result, IP and source code previously developed to run in a specific simulation environment can be reused and leveraged through realistic circuit models, extracted from the VISION environment.

This combination unifies the design flow of RF analog engineers and digital programming engineers to anticipate the true system behavior, made of both digital and analog circuits.



For MATLAB and Simulink product information, please contact:
The MathWorks, Inc.
3 Apple Hill Drive
Natick, MA, 01760-2098 USA
Tel: 508-647-7000
Fax: 508-647-7001 E-mail: info@mathworks.com

MATLAB®

VIS100E: SYSTEM ARCHITECT

Whitebord Editor Bundle

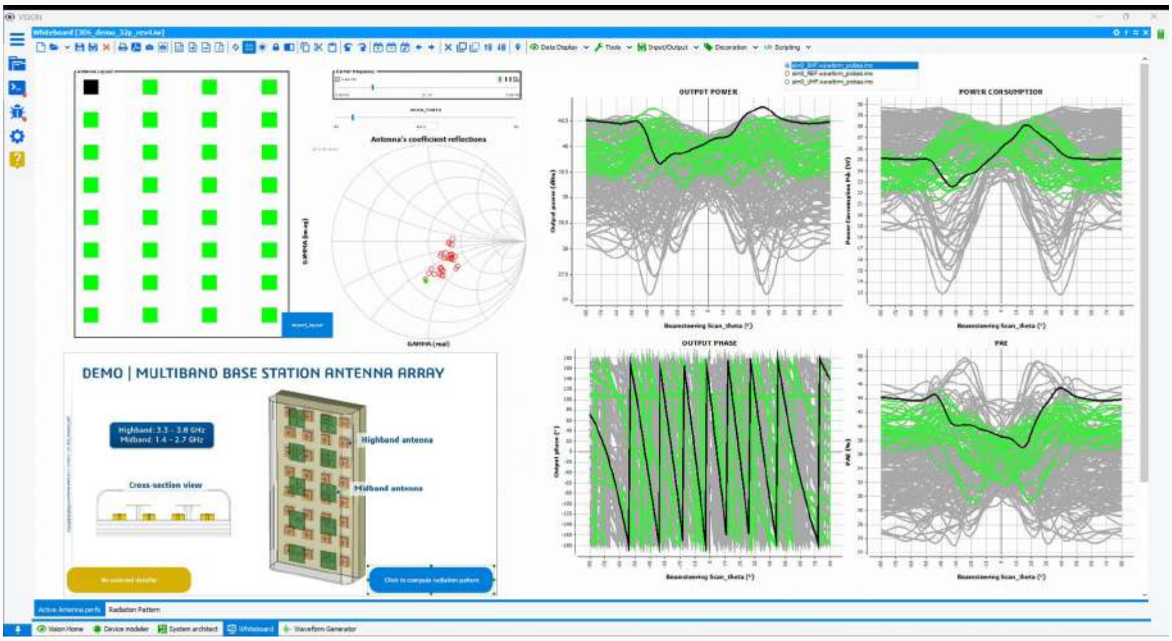
The Whiteboard tool allows the analysis of as much simulation data as possible without compromising flexibility. Circuit or system designers generally wish to import measurement or simulation data into a suitable environment to verify their design and/or the agreement between simulated results, measured performances, and reference data. If they don't have dedicated tools, they use homemade ones, which are generally costly in development time, workforce, and maintenance.

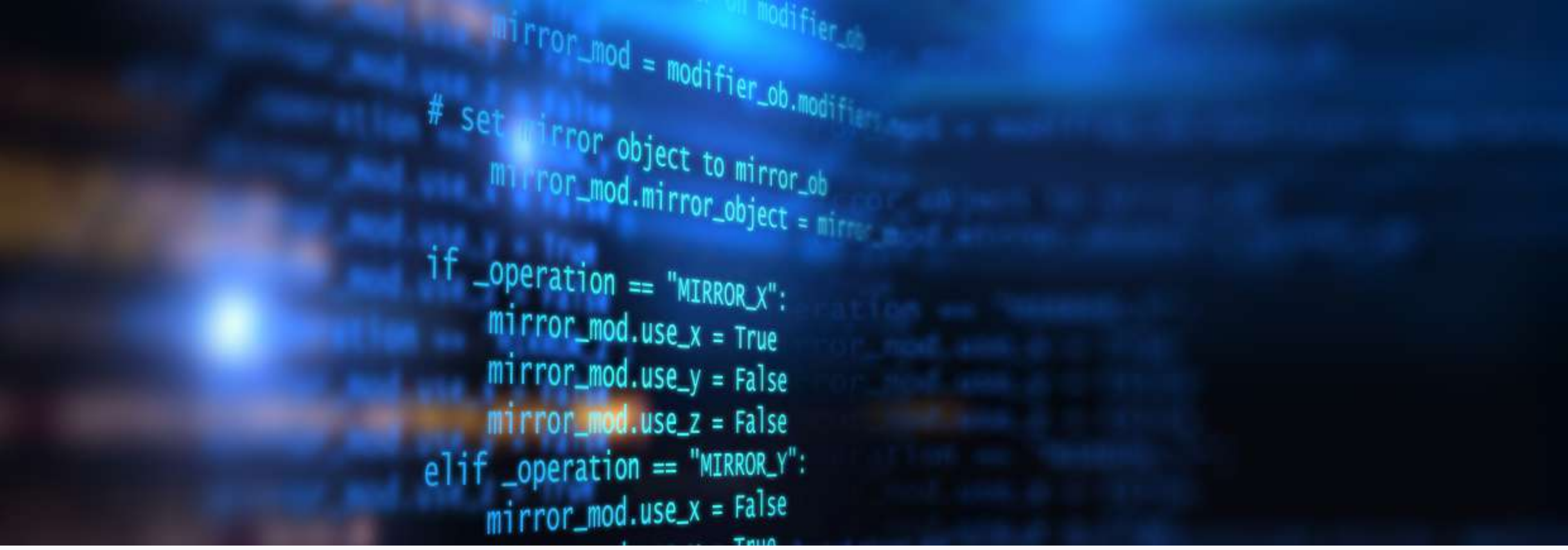
This Whiteboard module allows creating and customizing as many graphics as necessary and positioning them into a user-defined template. It is possible to incorporate texts and images. An interactive display can be generated using different filters or sliders, including tables and graphics.

The data can be analyzed in a raw format or processed via an equation editor, allowing the analysis to be customized. The user can reload new measurements or simulation data in a predefined and customized analysis environment with a few clicks.

This tool is essential for the in-depth analysis of RF systems simulation results. The simulated quantities, the variables used, and the data size can be parameterized at any time.

Using the "Whiteboard Editor" (included in the VISION & Whiteboard bundle), the user can choose to analyze all the data on a single page or on multiple pages to create customized simulation reports.





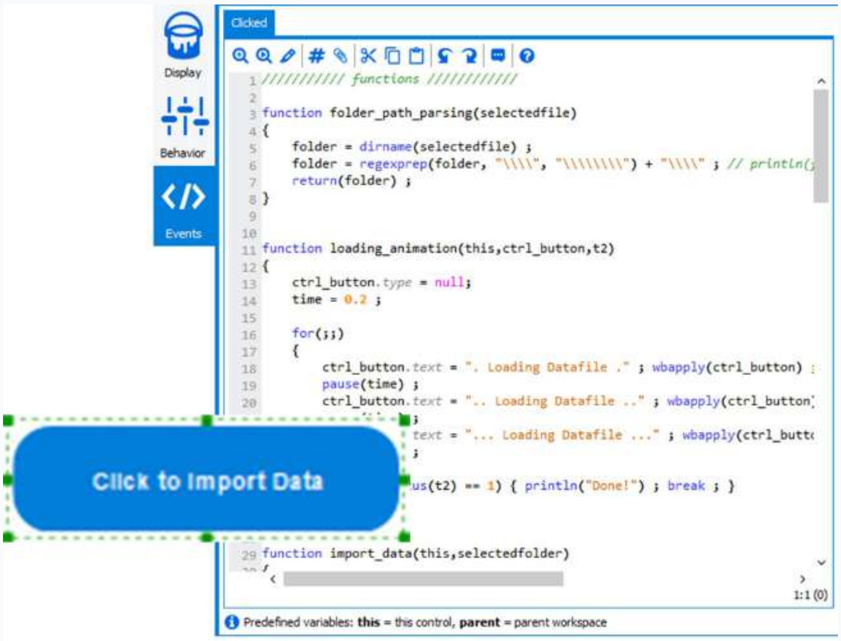
VIS100E: SYSTEM ARCHITECT

Whitebord Editor / Scripting

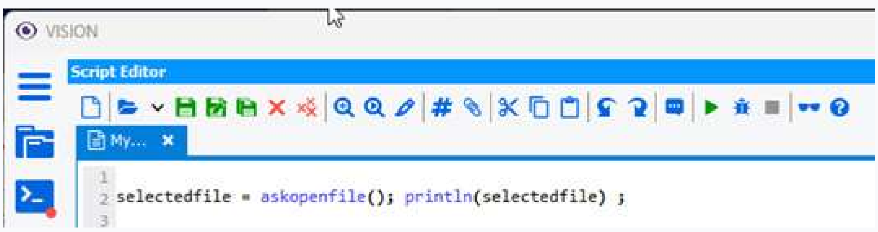
Scripting module is a complementary and alternative solution used in the whiteboard (**SCRPT module included in VIS100 System Architect module**). This unlocks the complete control of the whiteboard project, from its page management to the data management including all the controls (Graph, Filter. Button etc...)

When a set of commands or functions needs to be executed several times, or saved for later use, this one can be developed and stored in a custom script.

In addition, built-in function libraries related to the simulation engine can be called up and tested in a complete program based on the Script Editor language, using the **Integrated Development Environment** (IDE).



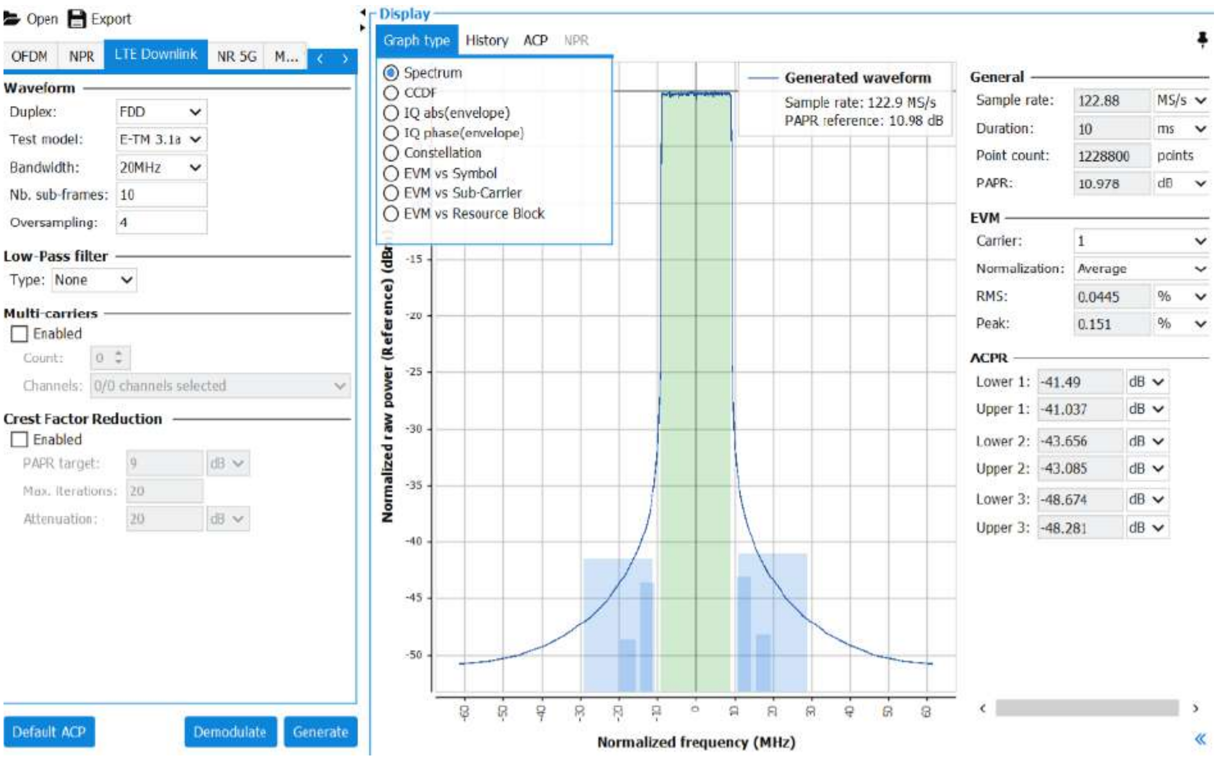
The (IDE) Script Editor offers powerful debugging functions to help the programmer developing its own data processing and methodology for a deep analysis of the results.



WFG100-11: Advanced Waveform Generation & Demodulation - LTE - Susbscription

The new waveform generator WFG100-11 introduces the capabilities to generate and demodulate an LTE signal by analyzing the IQ signal in VISION and calculating the EVM on symbols. This new module will manage directly the demodulation of the modulated signal in time domain, allowing a direct observation of the EVM constellation in VISION. The new module also supports multi-carrier for LTE signals.

The management of the modulation and demodulation of the LTE signal is performed in accordance with the 3GPP compliance standards.

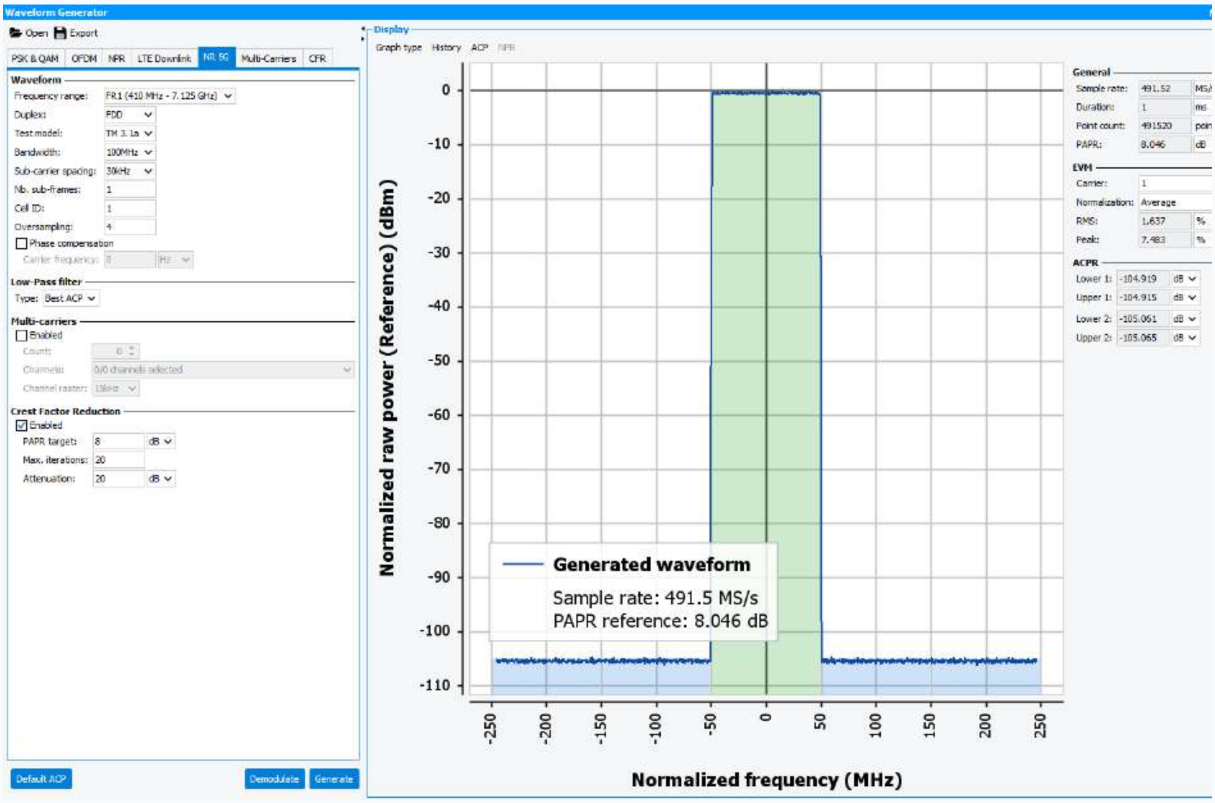


LTE WAVEFORM GENERATOR

WFG100-12: Advanced Waveform Generation & Demodulation - 5g Add-On - Subscription

The new waveform generator WFG100-12 introduces the capabilities to generate and demodulate an NR 5G signal by analyzing the IQ signal in time domain and calculating the EVM on symbols. This new module manages the demodulation of the signal and enables a direct observation of the EVM constellation. The new module also supports multi-carrier for NR 5G signals. The management of the modulation and demodulation of the 5G NR signal is performed in accordance with the 3GPP compliance standards.

The WFG100-11 LTE is a pre-requisite for the WFG100-12 5G-NR Option.



5G-NR WAVEFORM GENERATOR

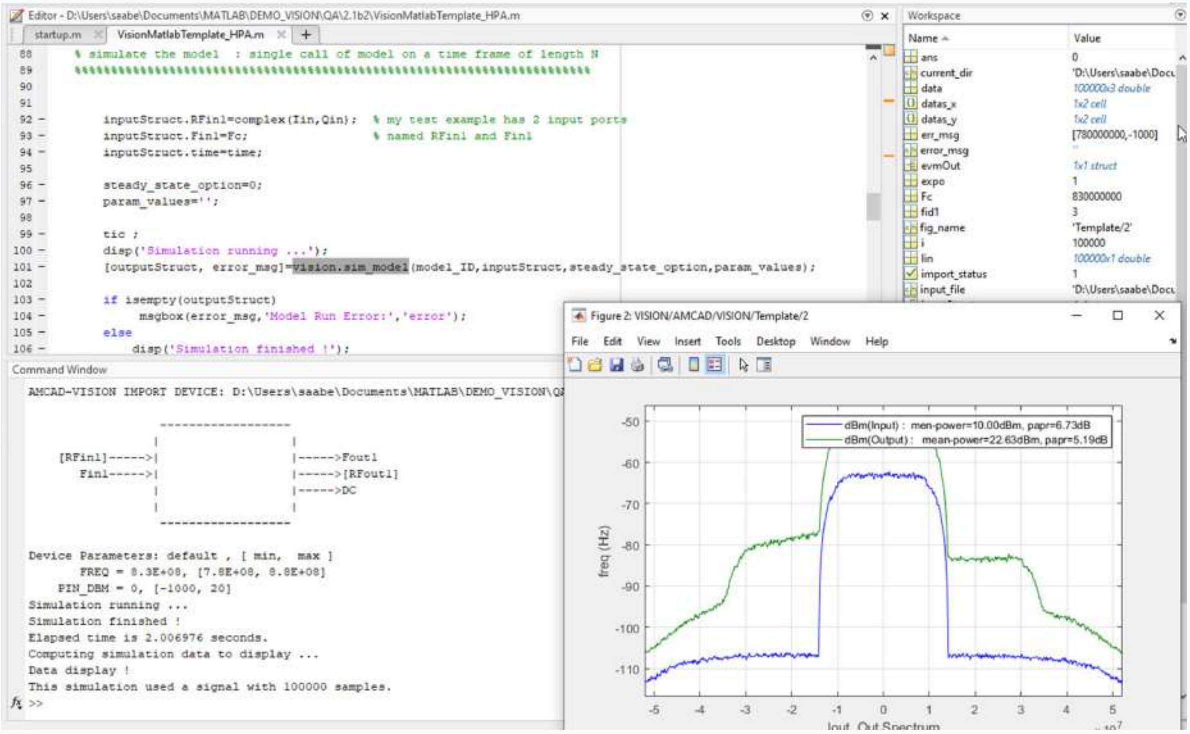
VIS100F: SYSTEM EXPORT

For all VISION licenses under active maintenance program, this option allows exporting the system's model, represented in the SYSTEM ARCHITECT schematic editor, to an external system simulator, in the form of a Macro-model.

This Macro-model **embeds its equation solver**, which allows keeping the same precision in the target system simulator, even if the latter is not natively equipped with an equation solver as powerful as VISION in 'Data-Flow' mode, for example, to take into account the phenomena of mismatches between circuits.

In that matter, VISION is a unique tool that allows unifying a global design process, from measurement or simulation at the circuit level to system simulation.

A specific VISION toolbox is used to facilitate the use of the advanced model in MATLAB®. This can also be used in 3rd party system simulator that embeds co-simulation with MATLAB®.



Example of using the VISION model from an API developed in MATLAB® language

The Modelica Association Project aims to develop and promote the Functional Mock-up Interface (FMI) standard.
https://fmi-standard.org/

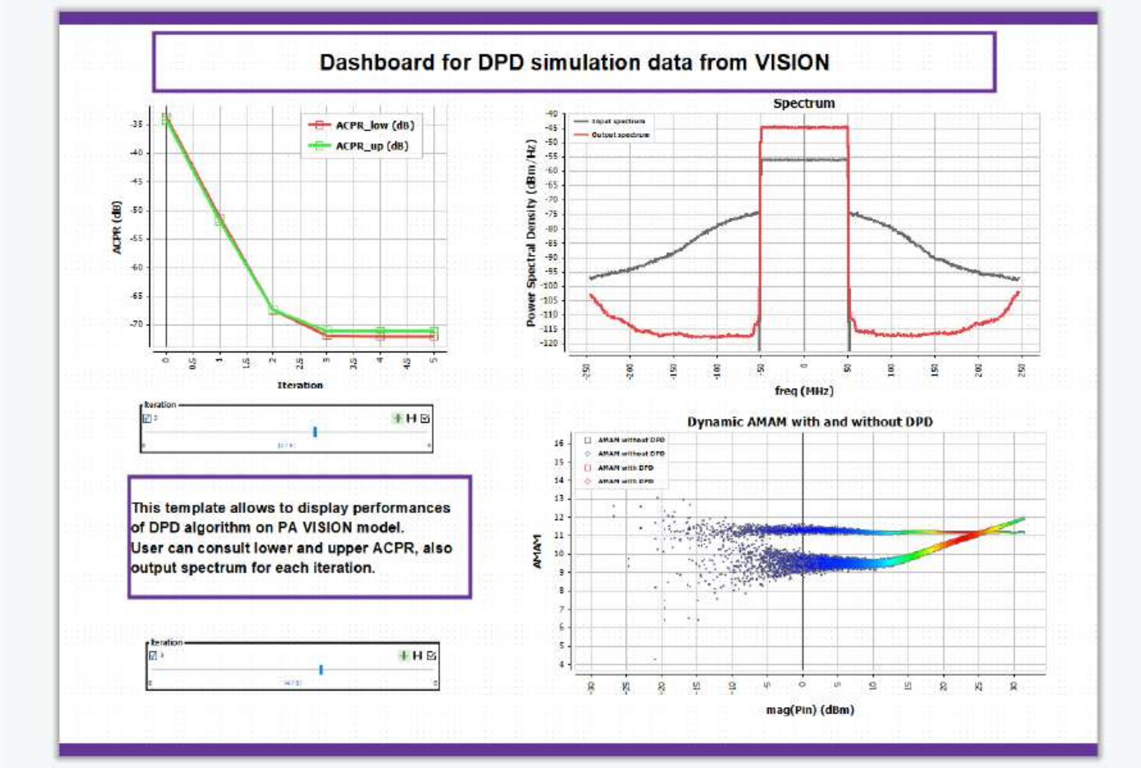
The goal is to streamline the generation, storage, sharing, and (re)utilization of dynamic system models across various simulation systems, catering to model/software/hardware-in-the-loop simulations, cyber-physical systems, and other applications. VISION can export models compatible with (FMI) standards.

WITH-11: WHITEBOARD DEPLOYMENT SERVICE ADD-ON

It is sometimes observed that engineers use simulation tools solely because of the user-friendliness offered by the visualization and data processing environment.

In such cases, not all the potentialities of the license used are fully exploited by the user, particularly the simulation engines, sometimes to the detriment of other potential license users.

To solve this problem, the WHIT-11 Whiteboard deployment service add-on is a solution that enables the entire dataset environment designed by the engineer in charge of simulations to be deployed to colleagues who simply wish to analyze these results within the same visualization environment.



Each data reader must use

- **Either a WHIT-20 Deployed Viewer license, if the reader wishes to reload new data files from other simulations on the fly, into a dynamic visualization environment designed by the owner of the Whiteboard Editor (solution integrated into the Architect System Design tool)**
- **Or a WHIT-30 Workspace Free Viewer license, if the reader wants to use a dynamic visualization environment integrating a hardcopy of simulation data, designed by the owner of Whiteboard Editor (solution integrated into the System Architect tool).**
- **In the latter case, the number of licenses that can be generated by the owner of the WHIT-11 Whiteboard deployment service add-on is unlimited, for any VISION license with an active maintenance program.**

PART 3

TRAINING MAINTENANCE SUPPORT PROGRAM

TRAINING PROGRAM

Although we intend to make circuit modeling and system simulation very intuitive and easy for our customers, we strongly recommend taking full advantage of VISION through advanced training provided by our highly skilled application engineers.

When carried out at AMCAD, this training can also include measurement work on predefined circuits for model extraction in our laboratories. Alternatively, this training can be delivered at the customer's international site.

A 3 or 5 days domestic training or customer site training program is available on-demand

- **VIS-CST3 (3 days training at International Customer site)**
- **VIS-EUT3 (3 days training at Euro Zone & UK Customer site)**
- **VIS-CST5 (5 days training at International Customer site)**
- **VIS-EUT5 (5 days training at Euro Zone & UK Customer site)**
- **VIS-OST3 (3 days training at AMCAD site)**
- **VIS-OST5 (5 days training at AMCAD site)**

MAINTENANCE PROGRAM*

AMCAD Engineering considers maintenance a critical asset for its customers to provide a premium assistance program for one year from the delivery date. After this initial period, you will be kindly invited to extend this maintenance through a support agreement.

Three different maintenance programs are available:

- **One-year maintenance agreement**
- **Two-year maintenance agreement**
- **Three-year maintenance agreement**

Also, with ongoing customer support, this maintenance program keeps your software version up to date so that you can benefit from all the improvements and fixes available with the latest release. For legacy perpetual licenses, the maintenance program is essential to keep certain Vision features enabled, such as the VIS100F system model export function.

Additional charges apply if the maintenance program has been interrupted for any reason. For current leased licenses, the maintenance program is part of the leased solution.

Customers on the maintenance program can request bug fixes if any. Bug fixes are collected with all customer requests and are prioritized by AMCAD. Corrections are integrated into subsequent releases, for all users.

***** *Visit www.amcad-engineering.com/terms to learn more on Support And Maintenance Services and related SMSA Agreement.*

SUPPORT PROGRAM*

Prerequisite: Active maintenance program.

This support program entitles you to the following services:

- **Priority access to application engineers**
- **Special support session for each new version, to validate the backward compatibility of the functionalities offered in relation to your use cases.**
- **High-priority requests for a particular customer can be handled under a specific support program.**

The support program is provided by our application engineers for a fixed number of hours according to 2 programs:

AMSP35	35 hours Vision modeling support
AMSP70	70 hours Vision modeling support

***** *Visit www.amcad-engineering.com/terms to learn more on Support And Maintenance Services and related SMSA Agreement.*

AMCAD Engineering

joins

SIMULIA