Product Introduction

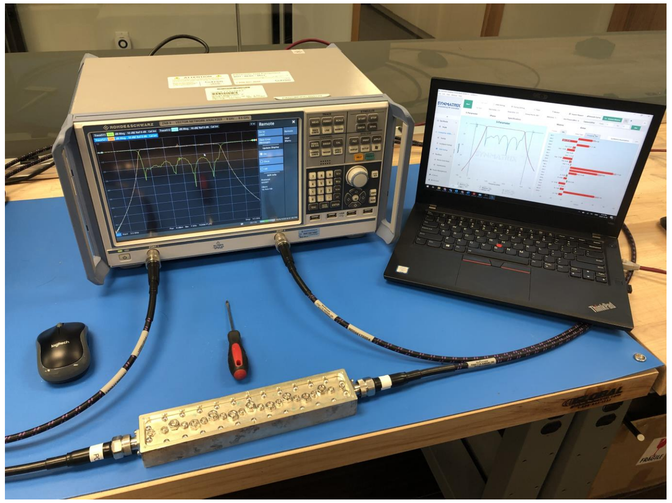
A RF filter design and real-time tuning platform specializing in 5G and mmWave applications.

SYNMATRIX
Empowering RF Innovation

About SynMatrix

One RF filter platform for design, optimization, and test tuning

- SynMatrix Technologies Inc. is a software technology company located in Toronto, Canada that develops engineering and test measurement tools for RF passive components
- Official Ansys solutions partner with direct HFSS integration
- Emerging global channel partner ecosystem and technology alliance partners



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Partner Ecosystem and Academia

01

MICROWAVE JOURNAL TECH FEATURE

SEPTEMBER 2020

Ceramic Waveguide Filter Design Using Computer-Aided Tuning

-Microwave Journal

02

RESEARCH PUBLICATION

JULY 2020

Neural Network Of Calibrated Coarse Model And Application To Substrate Integrated Waveguide Filter Design

- International Journal Of RF And Microwave Computer-aided Engineering

03

RESEARCH PUBLICATION

JUNE 2020

A High-Selectivity D-Band Mixed-Mode Filter Based on the Coupled Overmode Cavities

- Institute of Electrical and Electronics Engineers (IEEE)

04

RESEARCH PUBLICATION

Dec 2020

Design of an 11-Pole BPF Using Cascaded Triplets of TM010 Mode Dielectric Ring Resonators

- Institute of Electrical and Electronics Engineers (IEEE) NEMO

Current Global Channel Partner Network

CADFEM

tSNE (주) 태성에스엔이

numesys NUMERICAL SYSTEMS

ENTUPLE TECHNOLOGIES

CADMEN Taiwan Auto-Design Co. 虎門科技股份有限公司

Ozen

Technical Alliance Partners

ANSYS PREFERRED SOLUTION PARTNER

RS

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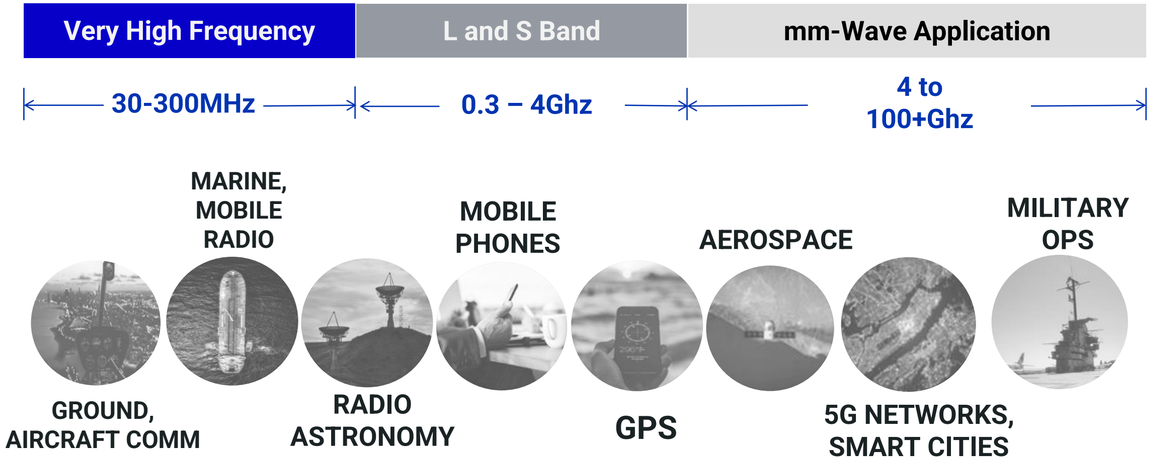
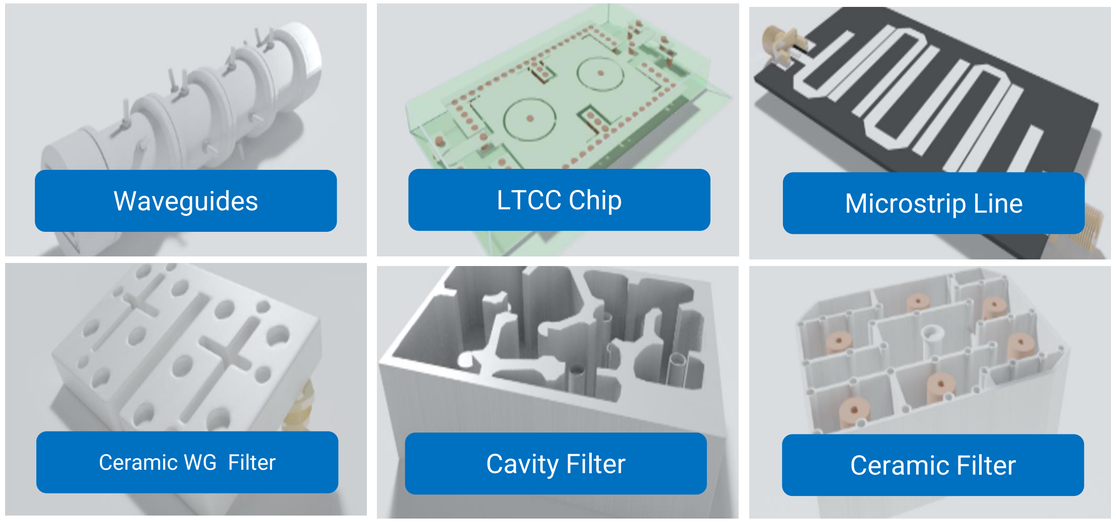
Filter Application Overview





- Supports filter designs from various industries
- Supports very high frequency to mmWave applications
- SynMatrix supports various structures including co-axials, ceramics, cavity and waveguide structures

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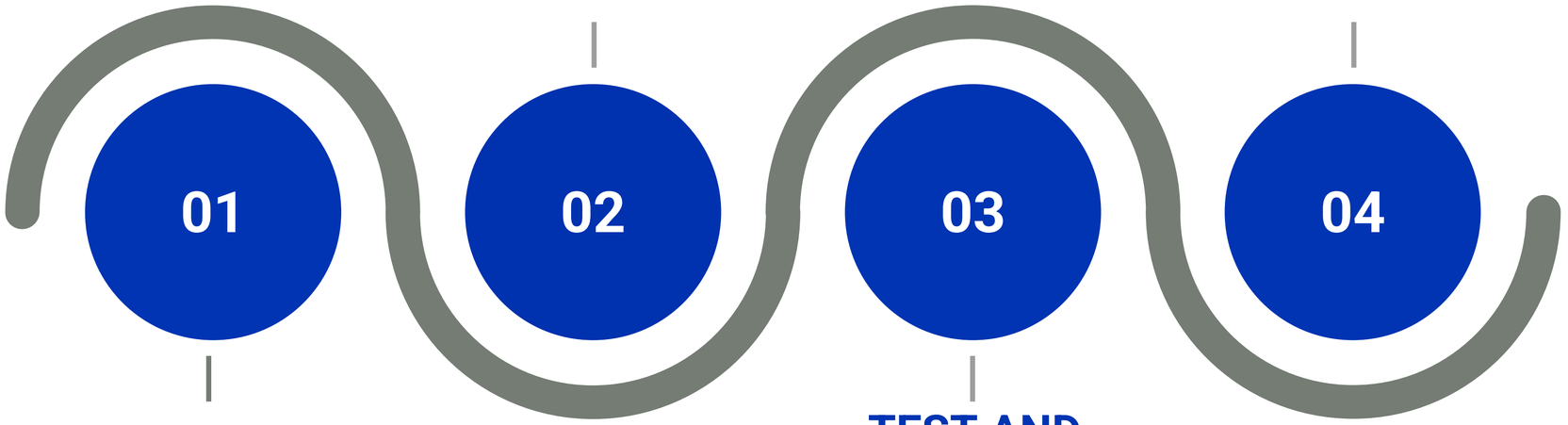
One platform for design, optimization and test tuning

OPTIMIZATION

Features an advanced Computer-Aided Tuning and AI-Optimization system with Ansys HFSS integration.

MANUFACTURING

Faster and more accurate volume production with real-time manufacturing line tuning (Coming Soon)



SPEC ANALYSIS

A feature-packed design and analysis platform for complex microwave filter engineering.

TEST AND MEASUREMENT

Real-time tuning and a test and measurement user workflow from an easy-to-use GUI.

KEYSIGHT TECHNOLOGIES

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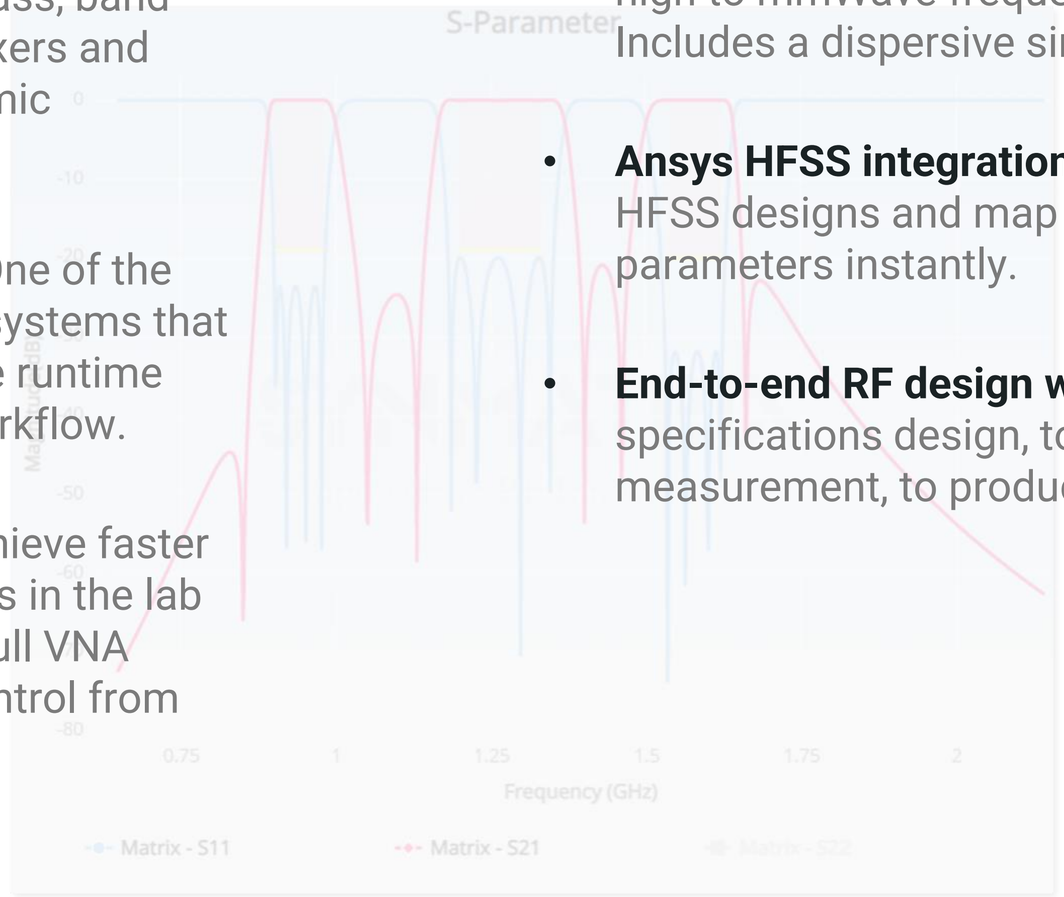
Features Summary

- **Supports a comprehensive array of filter types and structures.** Bandpass, band stop, LPF, multi-bands. Diplexers and triplexers. Ceramic and ceramic waveguide filters.
- **Automatic AI optimization.** One of the world's first AI-optimization systems that runs automatically. Complete runtime integration with the HFSS workflow.
- **Precise real-time tuning.** Achieve faster test and measurement results in the lab and on the production line. Full VNA integration with complete control from one easy-to-use GUI.
- **5G and mmWave ready.** Designed for very high to mmWave frequency applications. Includes a dispersive simulator function.
- **Ansys HFSS integration.** Import your HFSS designs and map physical parameters instantly.
- **End-to-end RF design workflow.** From specifications design, to test and measurement, to production line tuning.



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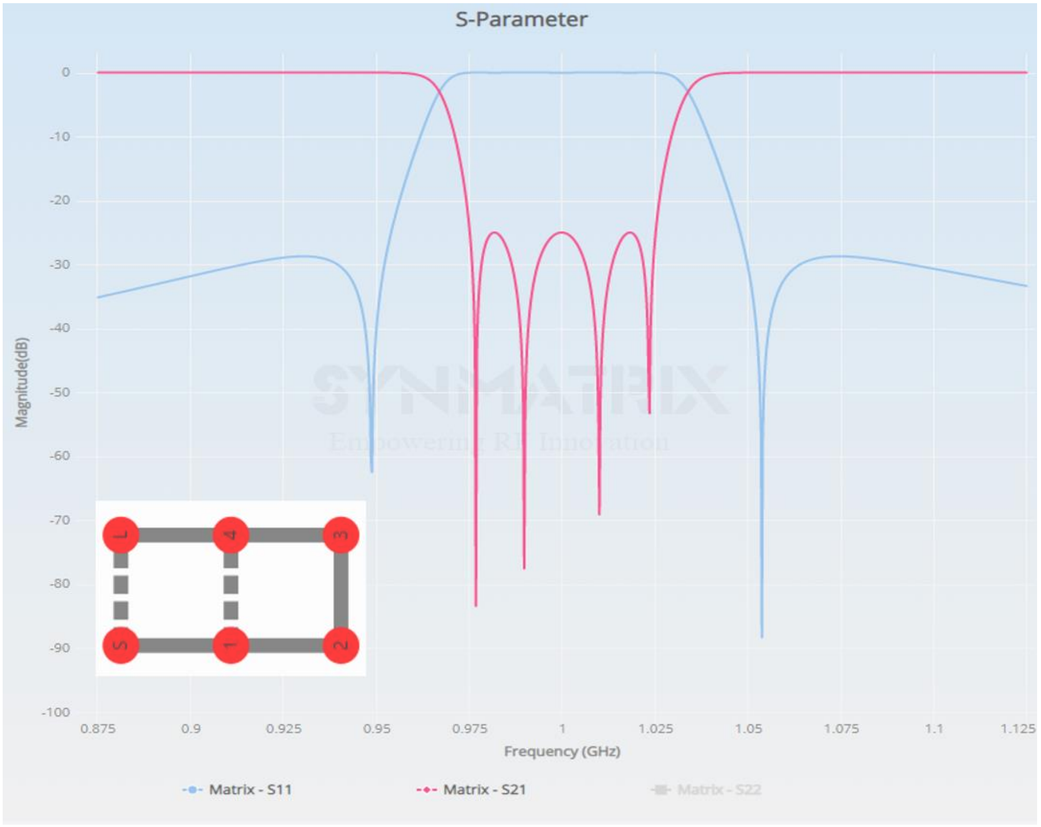
Benefits

- **Reduce R&D cycle time and realize labour savings.** Design and tune filters faster, more accurately and more efficiently.

- **No more prototype build cycles.** With improved design simulation accuracy, fabricating prototype samples will no longer be needed to verify designs.

- **Eliminate labour specialization.** Using a tuning tool to help guide the tuning process will remove the dependency on more expensive, highly experienced technicians.

- **Improve manufacturing speed, quality and yield.** With a tuning tool client designed for production, technicians can implement a repeatable tuning solution.



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Specification Analysis

01

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OPTIMIZATION

Features an advanced Computer-Aided Tuning and AI-Optimization system with Ansys HFSS integration.

MANUFACTURING

Faster and more accurate volume production with real-time manufacturing line tuning (Coming Soon)

01 02 03 04

SPEC ANALYSIS

A feature-packed design and analysis platform for complex microwave filter engineering.

- BPF, BSF, LPF, Multi-band
- Dispersive effect analysis
- Power handling analysis
- Monte-Carlo analysis
- Thermal drift analysis
- Etc.

TEST AND MEASUREMENT

Real-time tuning and a test and measurement user workflow from an easy-to-use GUI.

One platform for design, optimization and test tuning

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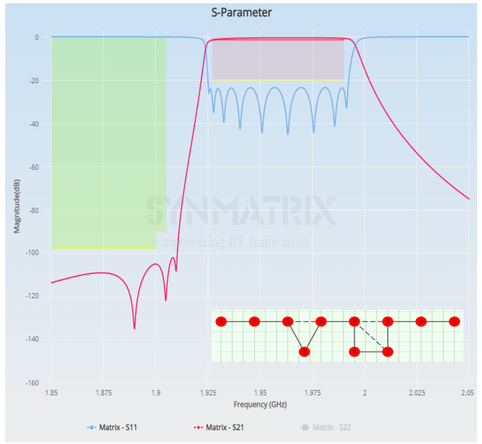
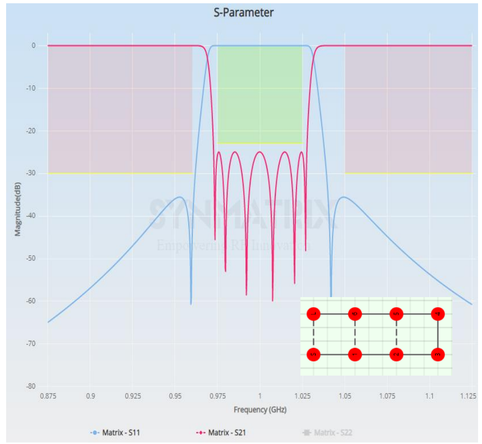
Specification Analysis

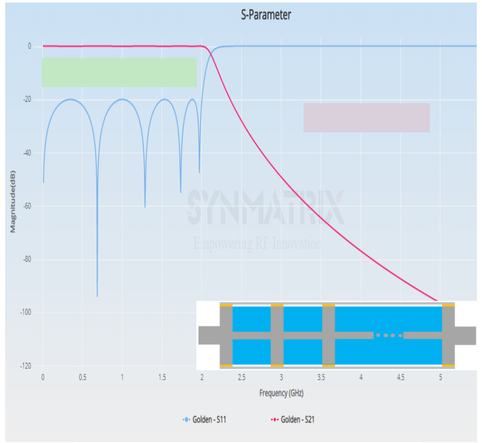
SynMatrix supports a variety of filter types for synthesis:



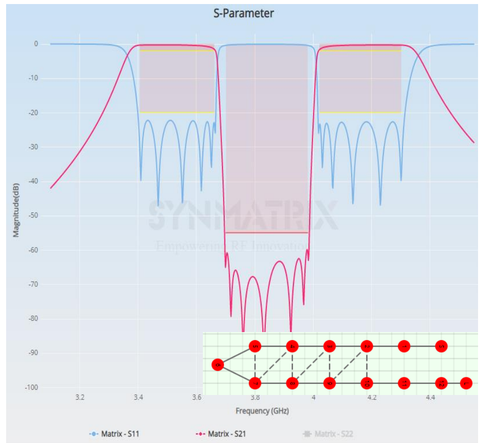
Band Pass Filter



Band Stop Filter



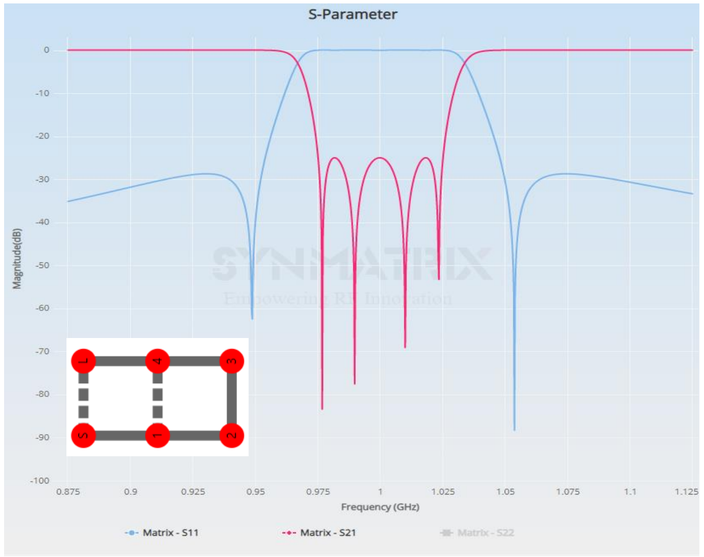
Low Pass Filter



Multi Band Filter

- Coupling matrix synthesis
- Arbitrary topology setup
- User-defined transmission zeroes positioning
- Coupling-aided tuning
- Low pass filter features automatic modelling

Specification Analysis | **Band Stop Filter**



Band stop filter features:

- Coupled resonant solution
- Support “Cul-De-Sac” and “Folded” topologies
- Support both inductive and capacitive ¼ wavelength end loading structure

Two different formats for the same topology

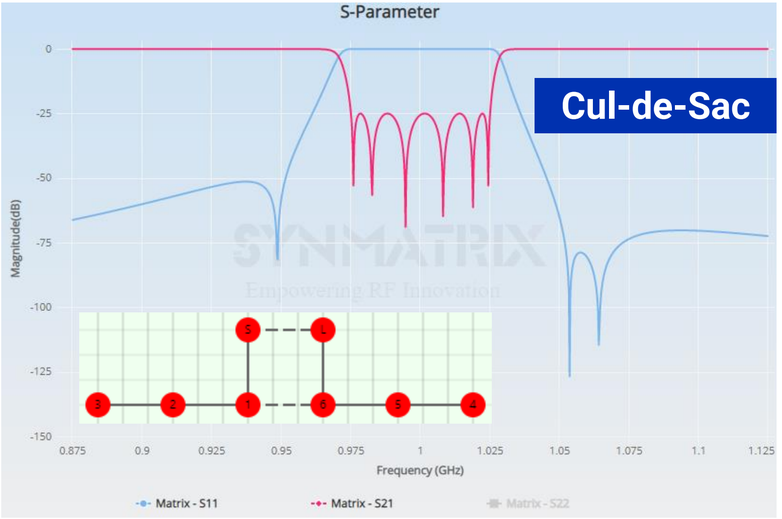
	S	1	2	3	4	L
S	0	1.6061	0	0	0	-1.0000
1	1.6061	0	0.9830	0	-1.5107	0
2	0	0.9830	0	0.8451	0	0
3	0	0	0.8451	0	0.9830	0
4	0	-1.5107	0	0.9830	0	1.6061
L	-1.0000	0	0	0	1.6061	0

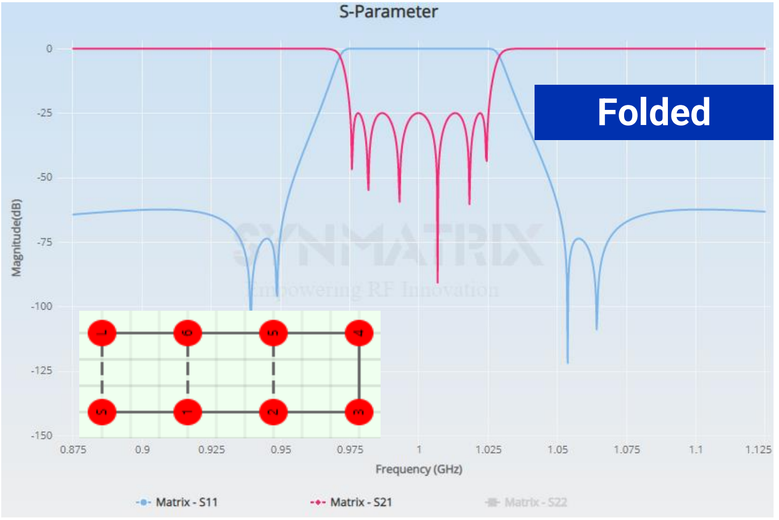
Format 1: 3/4 guided wavelength connection

	S	1	2	3	4	L
S	0	1.6061	0	0	0	1.0000
1	1.6061	0	0.9830	0	1.0688	0
2	0	0.9830	0	0.8451	0	0
3	0	0	0.8451	0	0.9830	0
4	0	1.0688	0	0.9830	0	1.6061
L	1.0000	0	0	0	1.6061	0

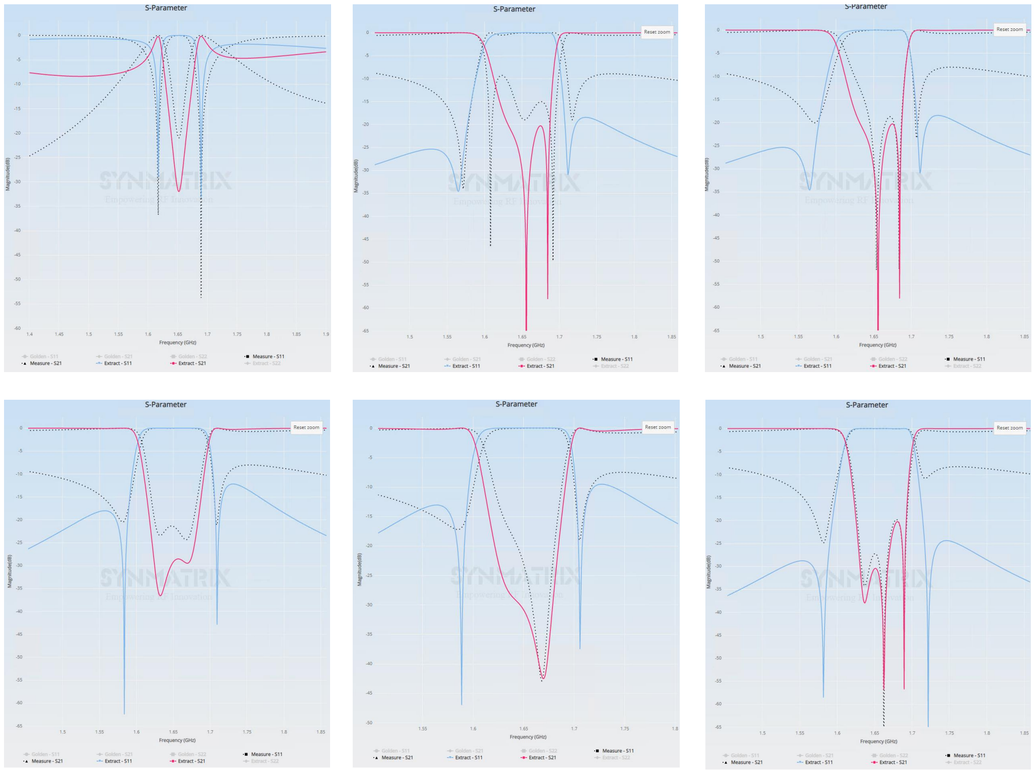
Format 2: 1/4 guided wavelength connection

Support different types of topologies

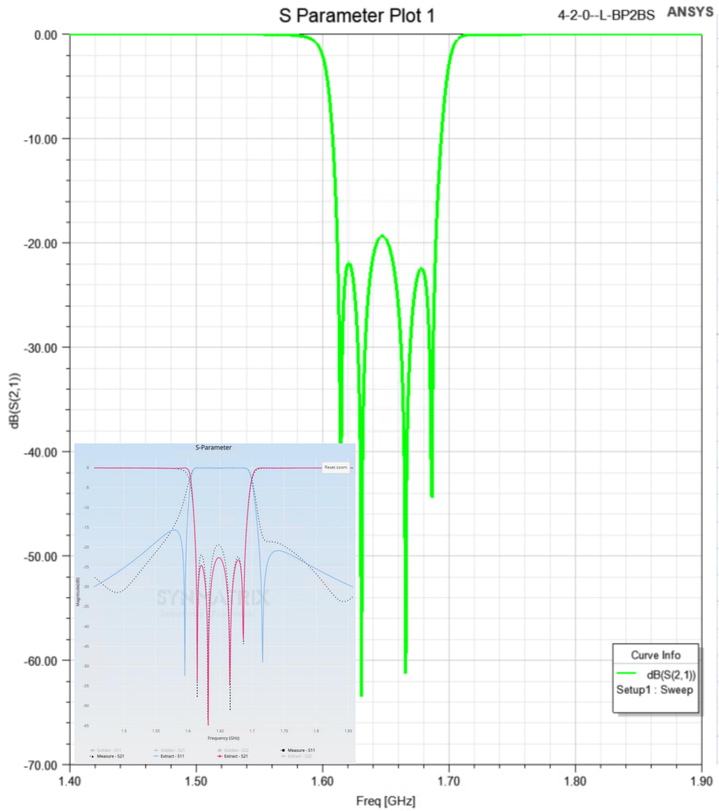


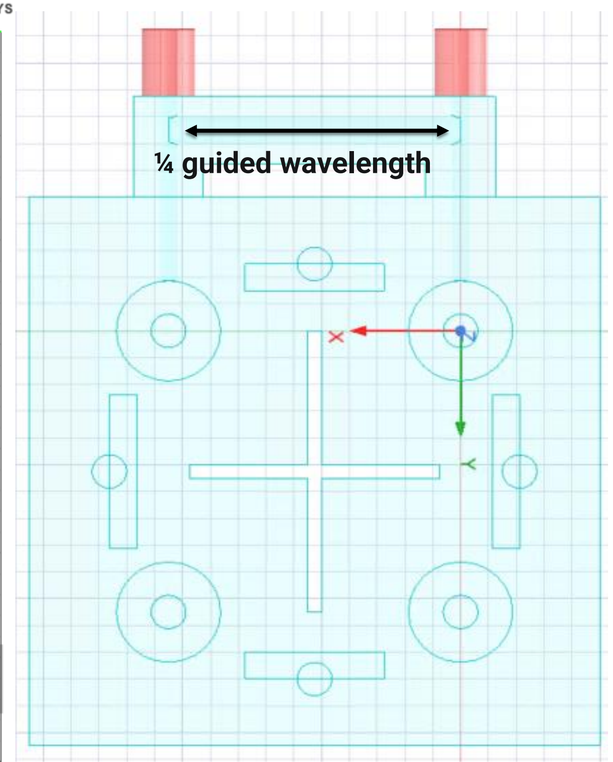


Specification Analysis | **Band Stop Filter**



Computer-aided tuning optimization process



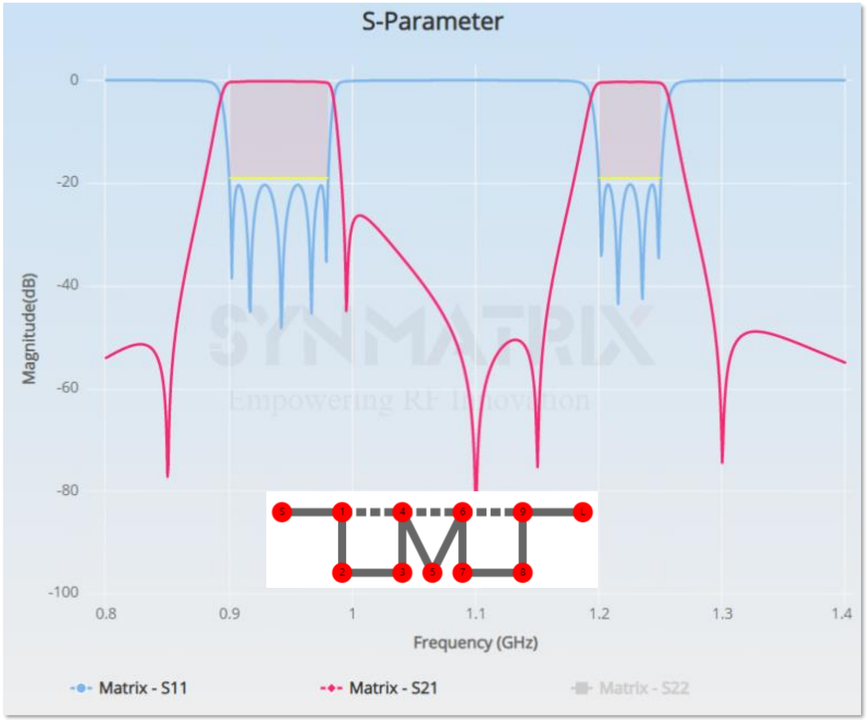


HFSS 3D model and Simulation Results

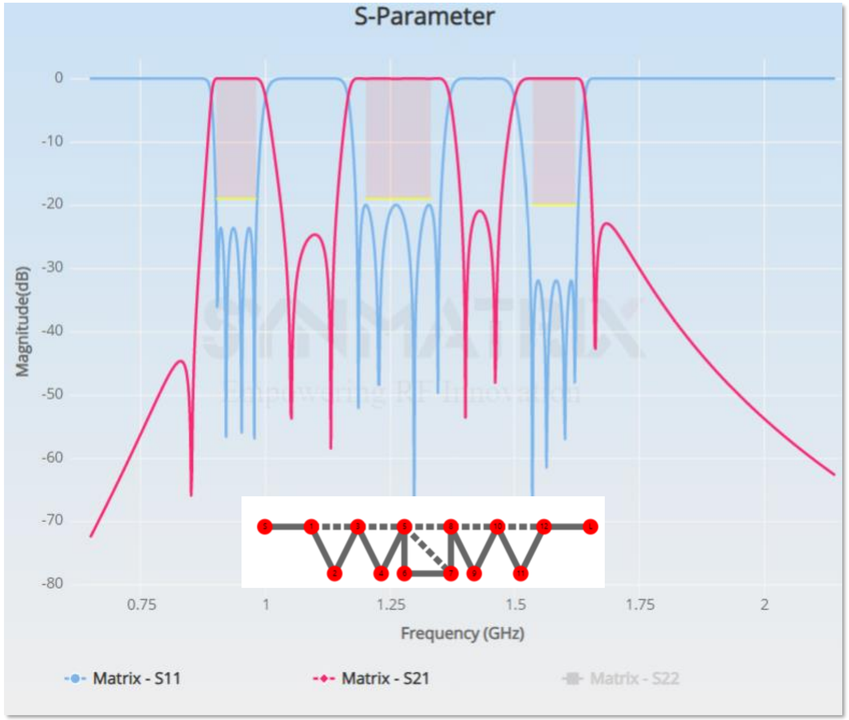
Specification Analysis | **Multi-band Filter**

Features:

- Support dual-band and triple band coupling matrix synthesis with arbitrary topology
- Supports symmetric and asymmetric RF performance
- Flexible transmission zero position designation



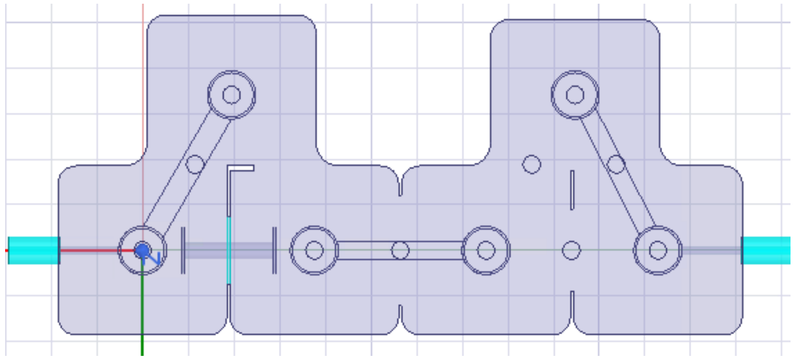
Dual-band band pass filter

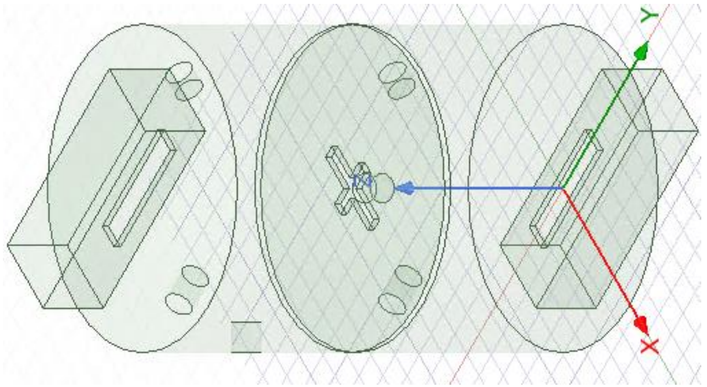


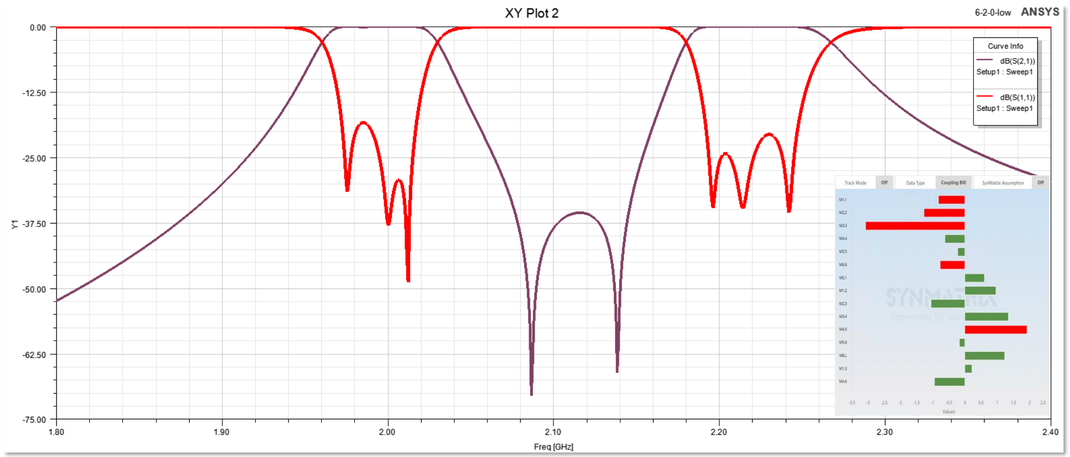
Triple band pass filter

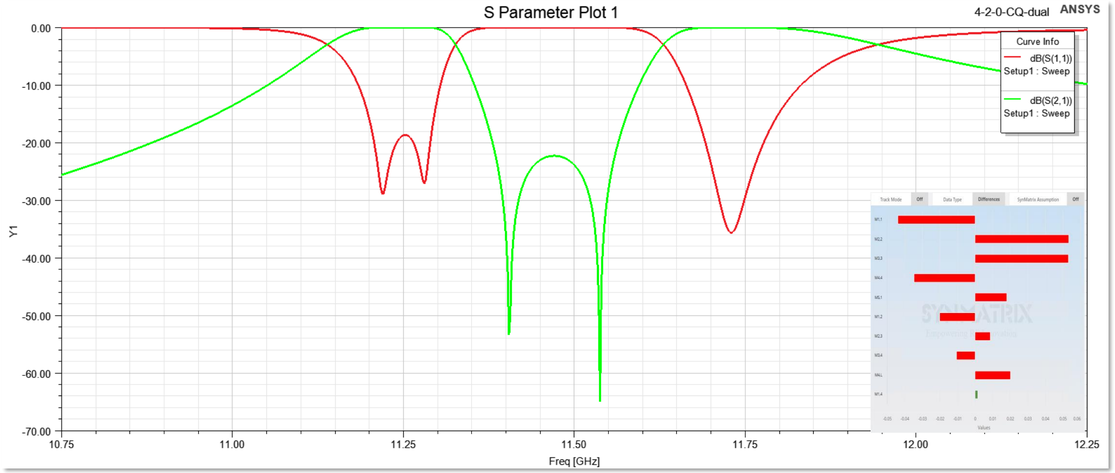
Specification Analysis | **Multi-band Filter**

Computer-aided tuning





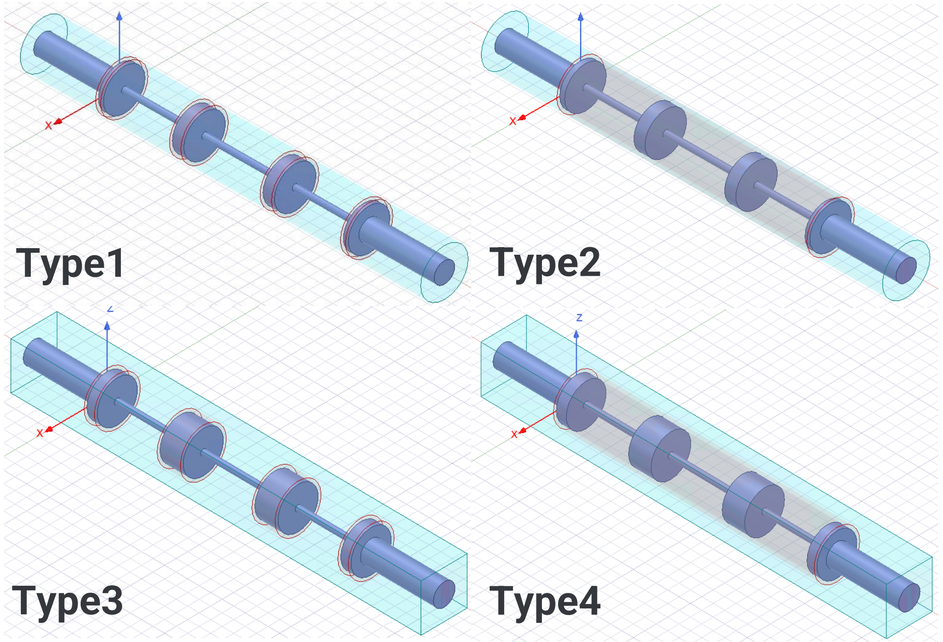




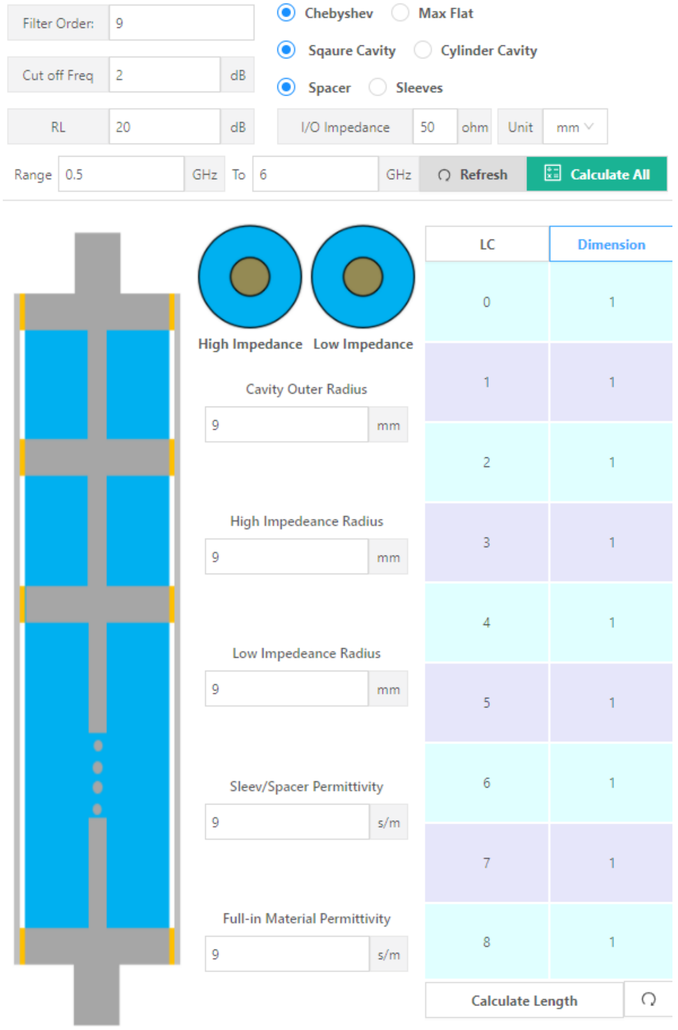
6 poles Coaxial Cavity

Triple band pass filter

Specification Analysis | **Low-pass Filter**



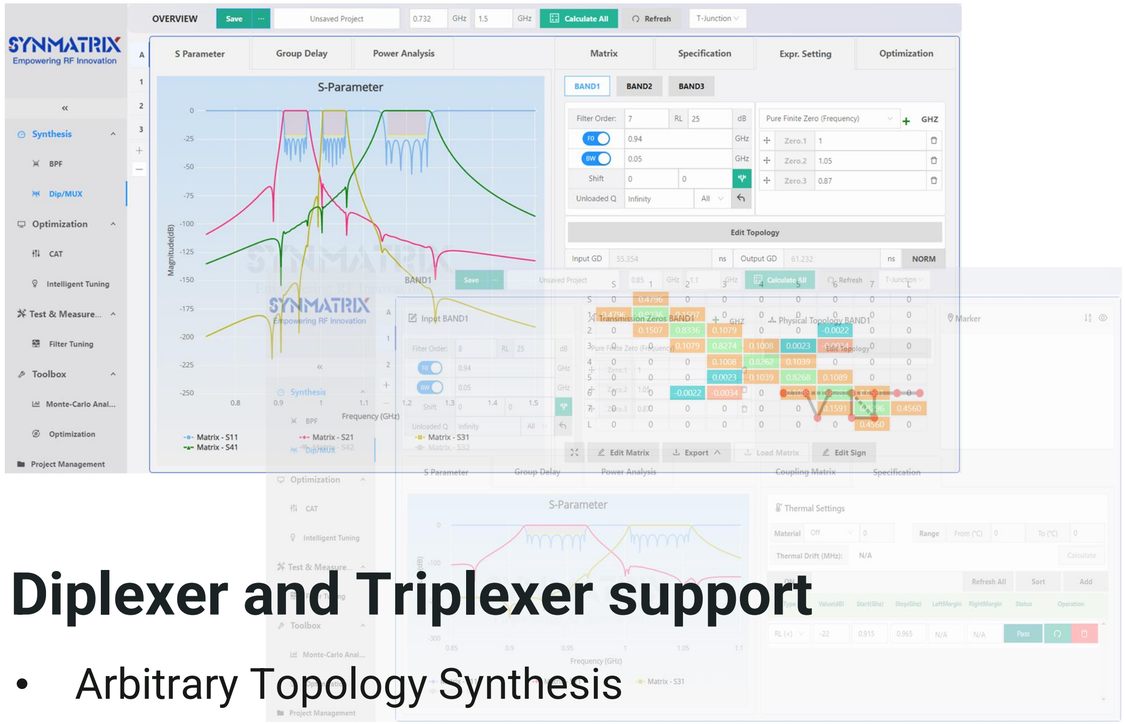
Four Practical Engineering Structures

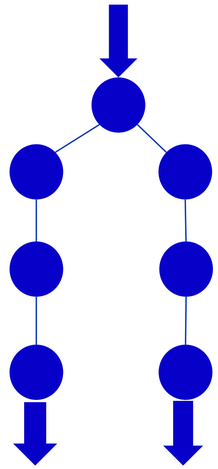


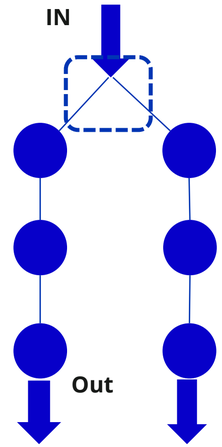
Features

- Supports 4 step impedance coaxial structures
- Offers direct dimension synthesis and builds the model automatically
- Calculates both circuit model and physical dimensions
- Provides a generic model-based optimizer to match with the EM simulation

Specification Analysis | **Di/Triplexers**

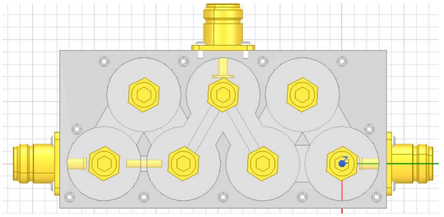




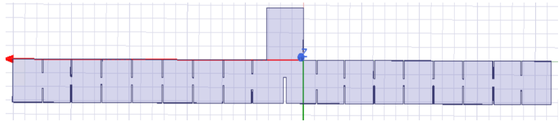


Diplexer and Triplexer support

- Arbitrary Topology Synthesis
- T-Junction and Common Resonator
- Waveguide T-junction optimization
- Generic Matrix Optimizer
- Stored Energy Analysis



Coaxial Cavity Diplexer—common resonator



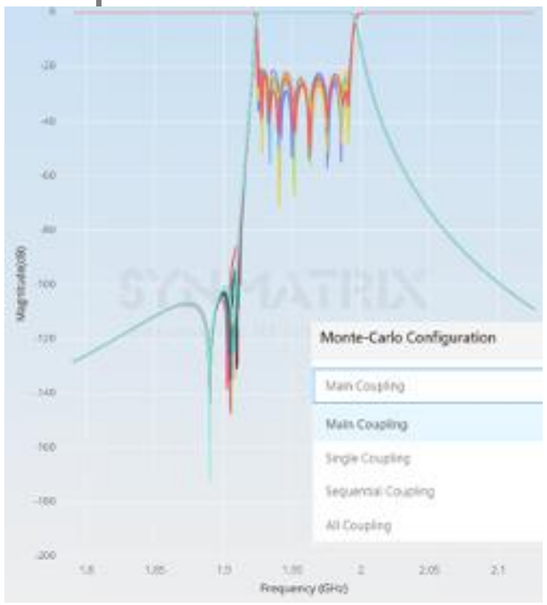
Waveguide Diplexer—T-Junction

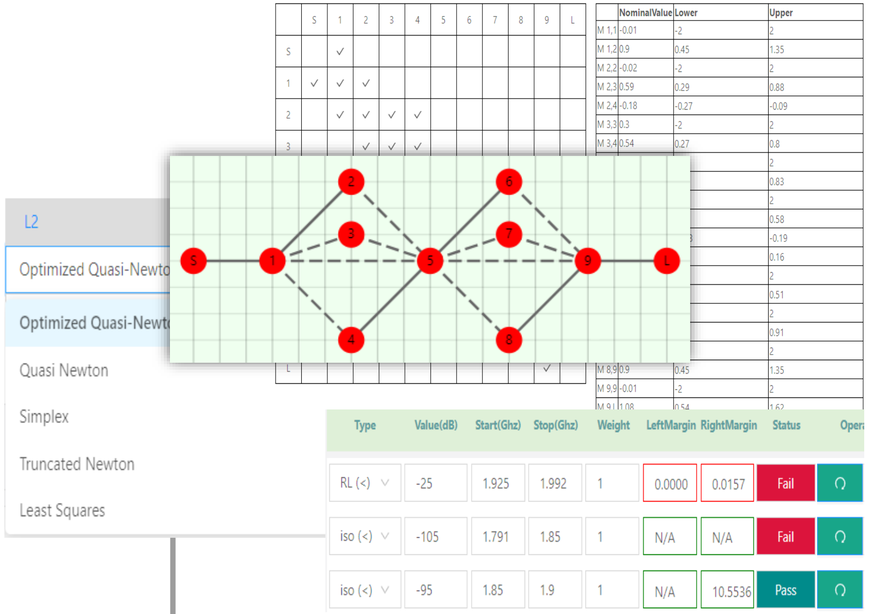
Specification Analysis | **Matrix Optimization**

Matrix Sensitivity Analysis and Optimization

- Monte Carlo analysis
- **Matrix Optimization:** easy set up and fast convergence for special topologies

01 Monte-Carlo analysis



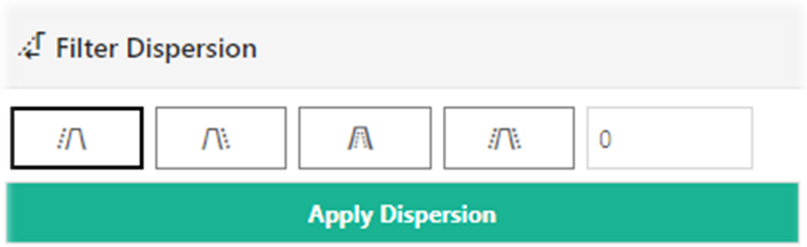


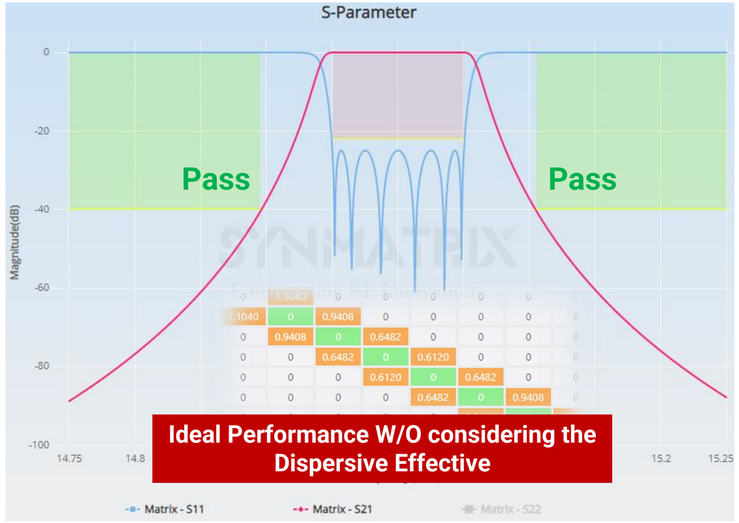
02 Matrix optimization

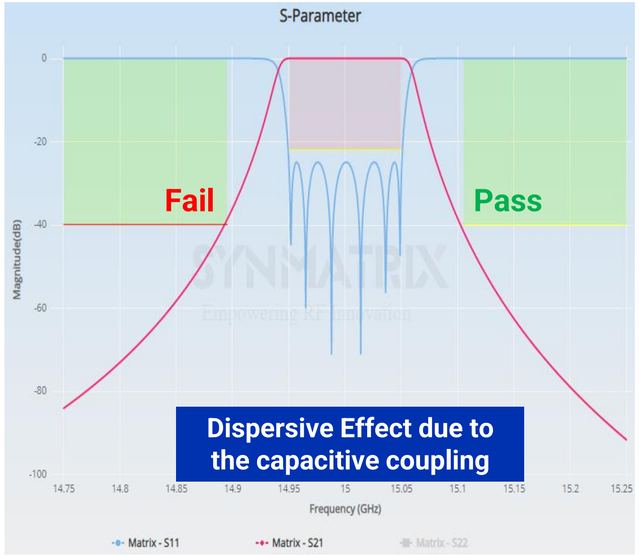
Specification Analysis | **Dispersive Effect Control**

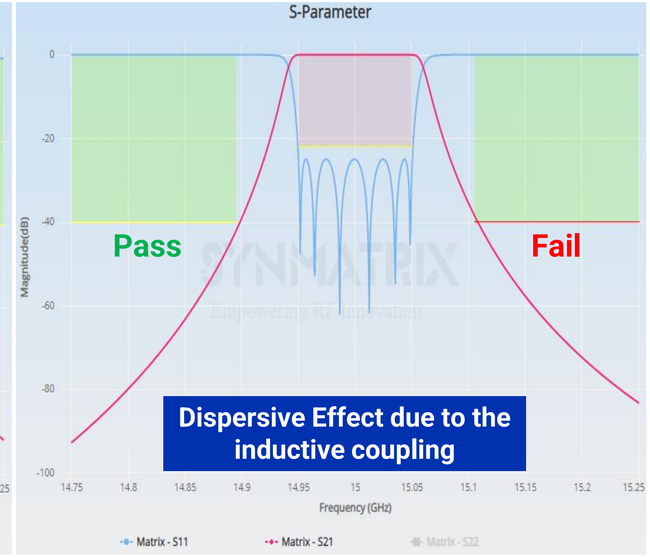
Predict RF performance with dispersive effect:

- Wideband applications
- Four types of dispersive effects

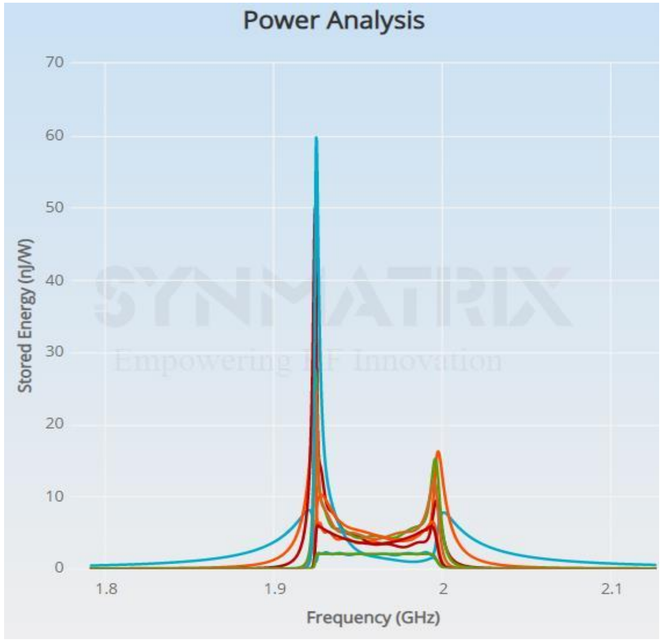








Specification Analysis | **Other Features**



Stored Energy

	S	1	2	3	4	5	6	L
S	0	-1.1062	0	0	0	0	0	0
1	-1.1062	0.0169	-0.9446	0	0	0	0	0
2	0	-0.9446	0.0169	-0.6508	0	0	0	0
3	0	0	-0.6508	0.0169	-0.6145	0	0	0
4	0	0	0	-0.6145	0.0169	0.6508	0	0
5	0	0	0	0	0.6508	0.0169	0.9446	0
6	0	0	0	0	0	0.9446	0.0169	1.1062
L	0	0	0	0	0	0	1.1062	0

Apply & Save

Row	Col
3	4
1	2

Matrix Edition and Import/Export SNP

Thermal Settings

Material: Aluminum | 23 | Range | From (°C): -25 | To (°C): 80

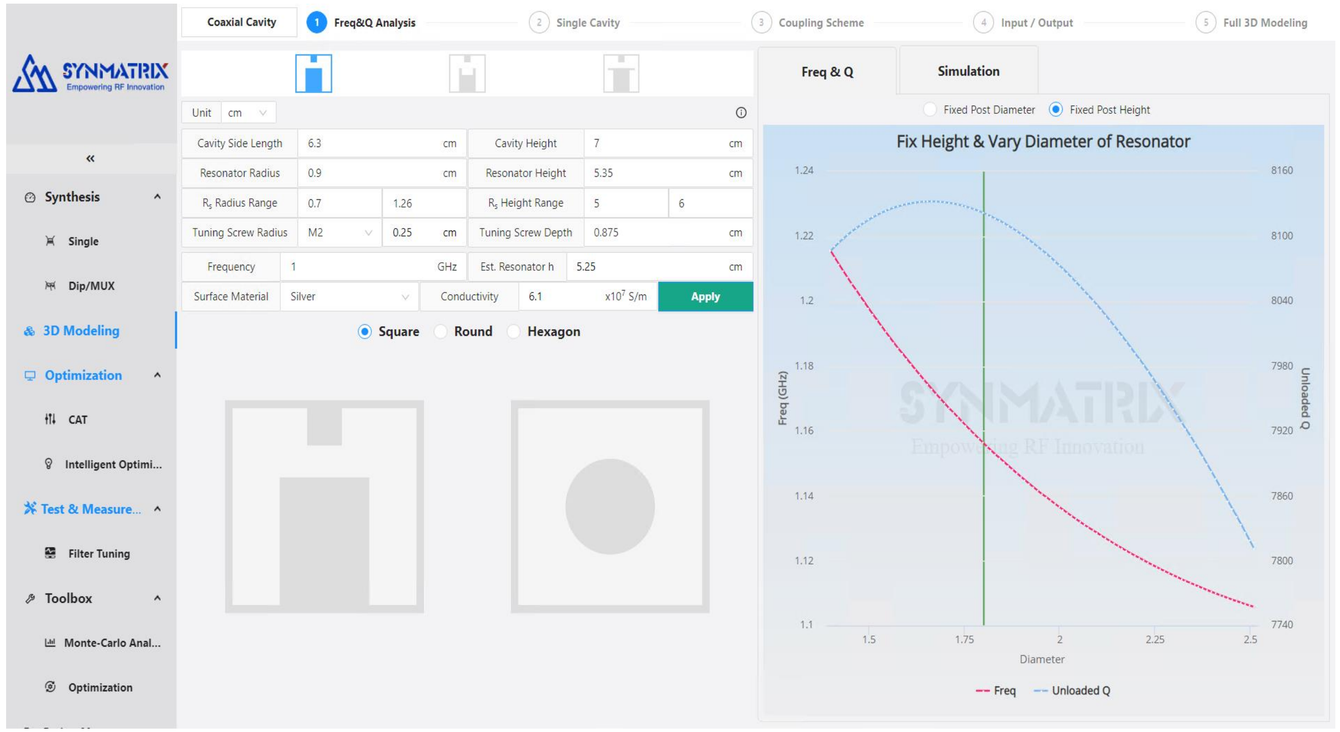
Thermal Drift (MHz): 18.0689 | Calculate

Type	Value(dB)	Start(Ghz)	Stop(Ghz)	LeftMargin	RightMargin	Status	Operation
RL (<)	-16	3.6	3.8	7.6529	7.3274	Pass	
IL (>)	-1.5	3.6	3.8	8.9352	8.7076	Pass	
iso (<)	-40	3.3	3.54	Infinity	9.5105	Pass	
iso (<)	-40	3.86	4	6.7261	Infinity	Pass	

Thermal Drift prediction and Spec Analysis

- Peak power analysis
- Stored energy
- Thermal drift predication
- Coupling matrix edition
- Specification analysis
- Marker analysis

3D Modelling Function



- Automatic 3D modelling design workflow
- Single resonator modelling and analysis
- Adjacent coupling and input/output coupling modelling and analysis
- Customized full 3D modelling function

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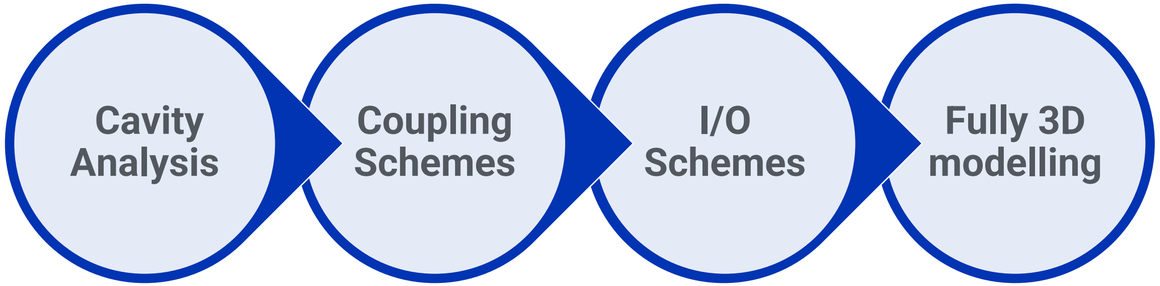
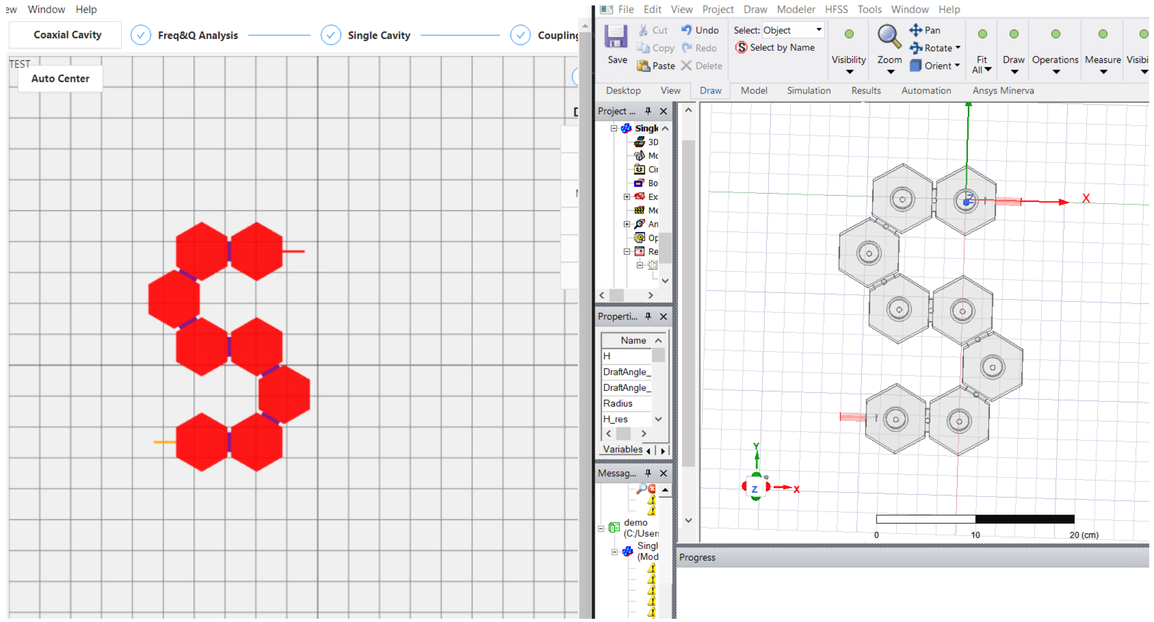
3D Modelling Function





- Resonator analysis and synthesis with several shapes supported
- One-click automatic 3D model generation from a user-defined topology
- Fully integrated with Ansys HFSS simulation
- Frequency and unloaded Q analysis
- Perform parametric studies
- All parameters can be passed to optimizer

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Optimization

02

SYNMATRIX
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OPTIMIZATION

Features an advanced Computer-Aided Tuning and AI-Optimization system with Ansys HFSS integration.

MANUFACTURING

Faster and more accurate volume production with real-time manufacturing line tuning (Coming Soon)

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02

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SPEC ANALYSIS

A feature-packed design and analysis platform for complex microwave filter engineering.

TEST AND MEASUREMENT

Real-time tuning and a test and measurement user workflow from an easy-to-use GUI.

One platform for design, optimization and test tuning

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Optimization

Computer-Aided Tuning

- **Coupling matrix extraction**. Two-port coupling matrix extraction, multiport tuning and generic circuit-EM optimization.
- **Advanced algorithms.** Dispersive effect and spurious prediction can be used to extract the error information precisely.

Intelligent Optimization

- **AI Optimization.** Features automatic runtime processing with Ansys HFSS integration and space mapping capabilities.
- **Custom Optimization.** Features linear and non-linear optimization modes. Offers step-by-step, master control for more experienced designers.

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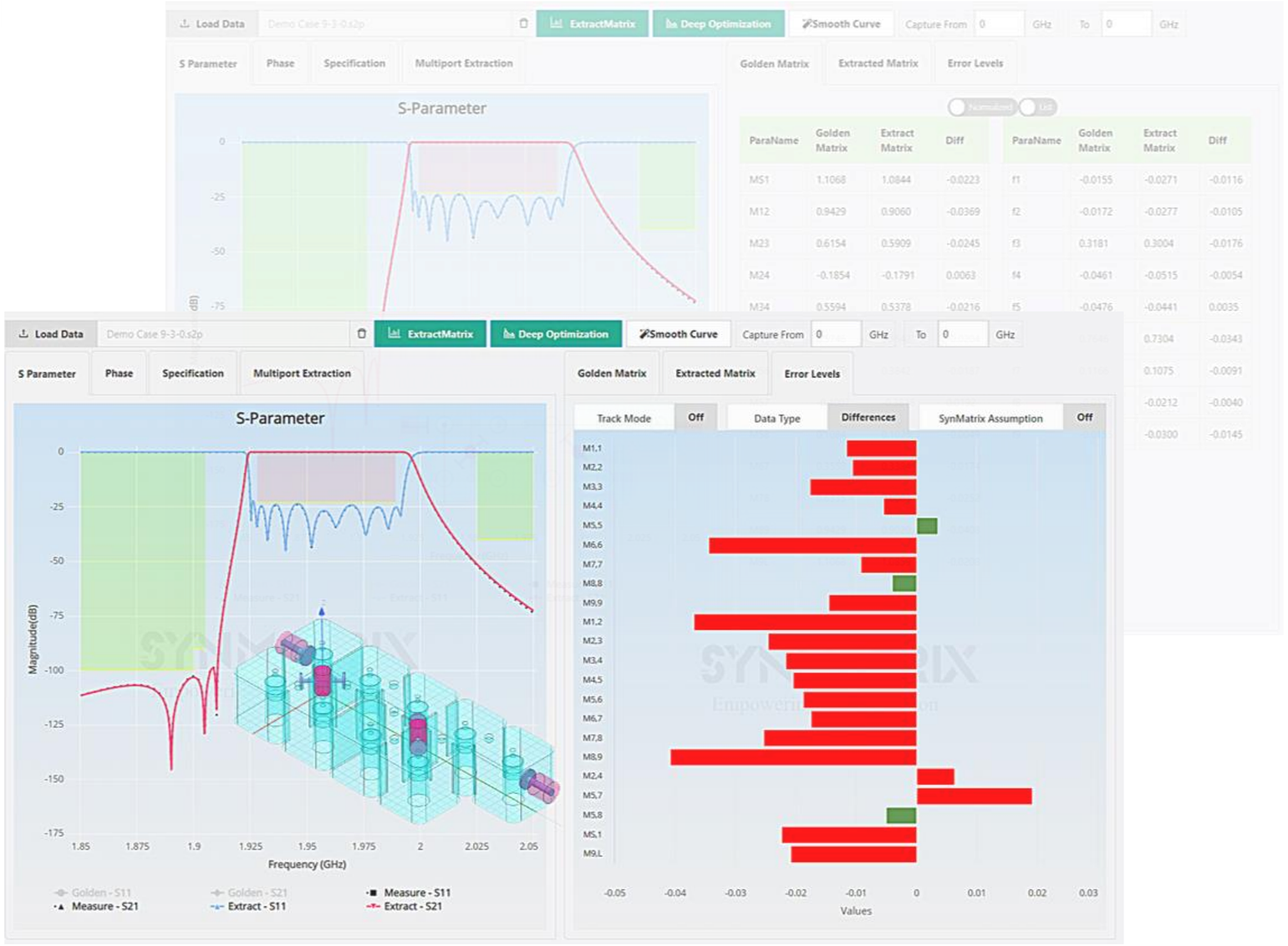
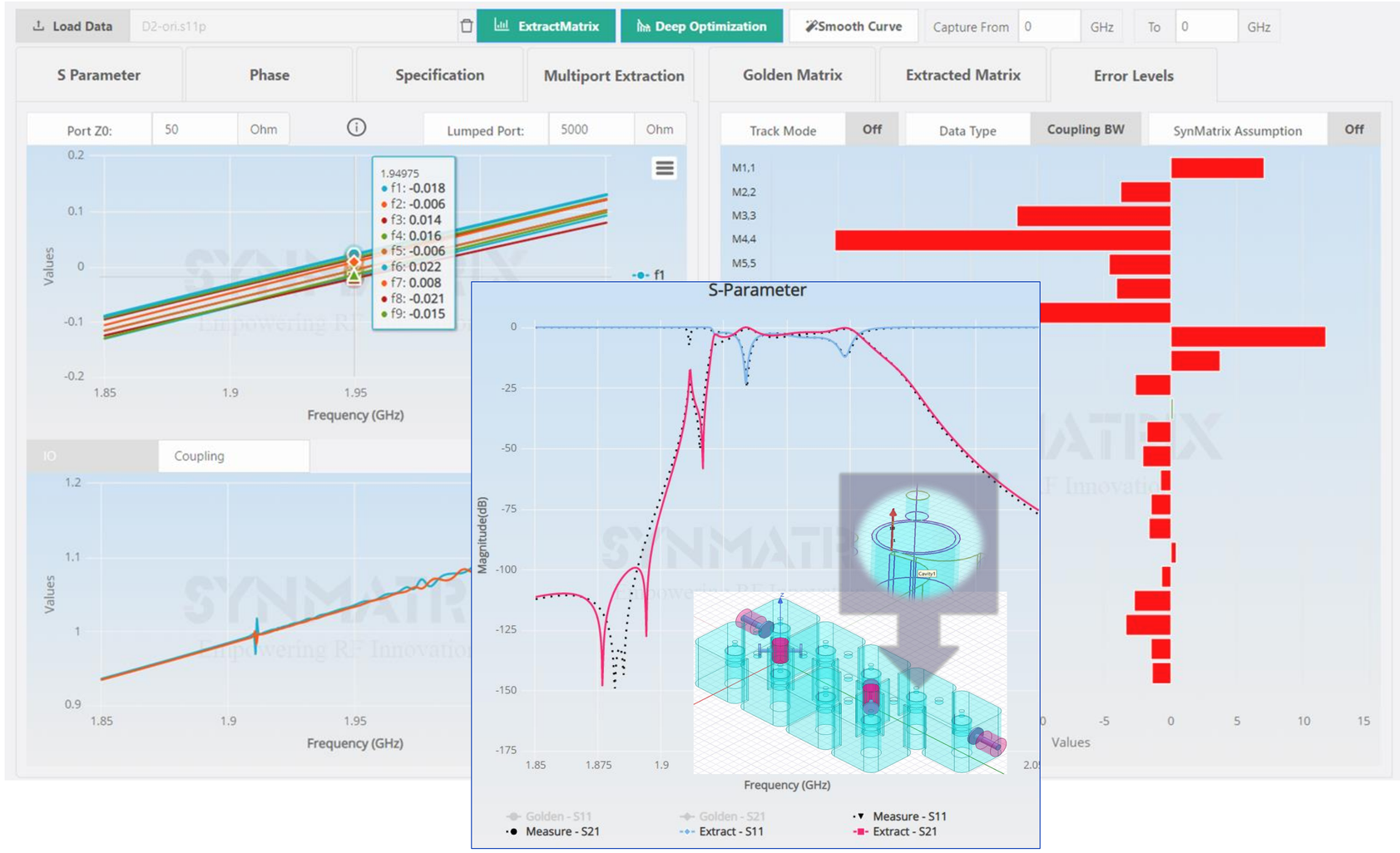
Computer-Aided Tuning | **Two-Port Tuning**



- Advanced coupling matrix extraction technique
- Evaluate RF performance by extracting error information directly from the simulation or test data (regardless of the lossy or lossless data)

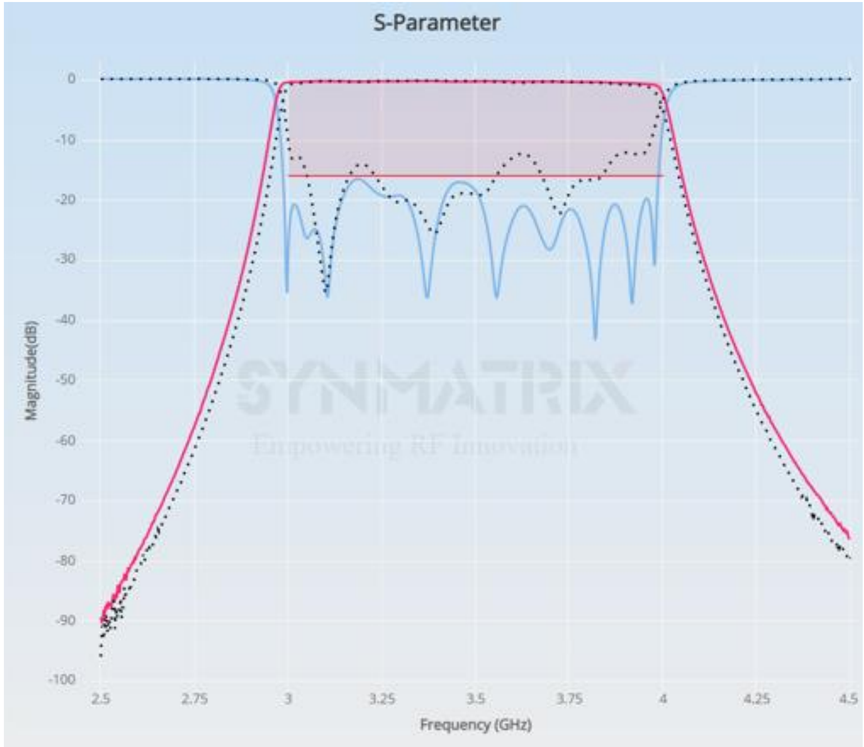
Computer-Aided Tuning | **Multi-Port Tuning**

- Most popular coupling matrix extraction technique based on Y parameters
- Define the lump port in your 3D simulation structure and extract frequency and coupling error info



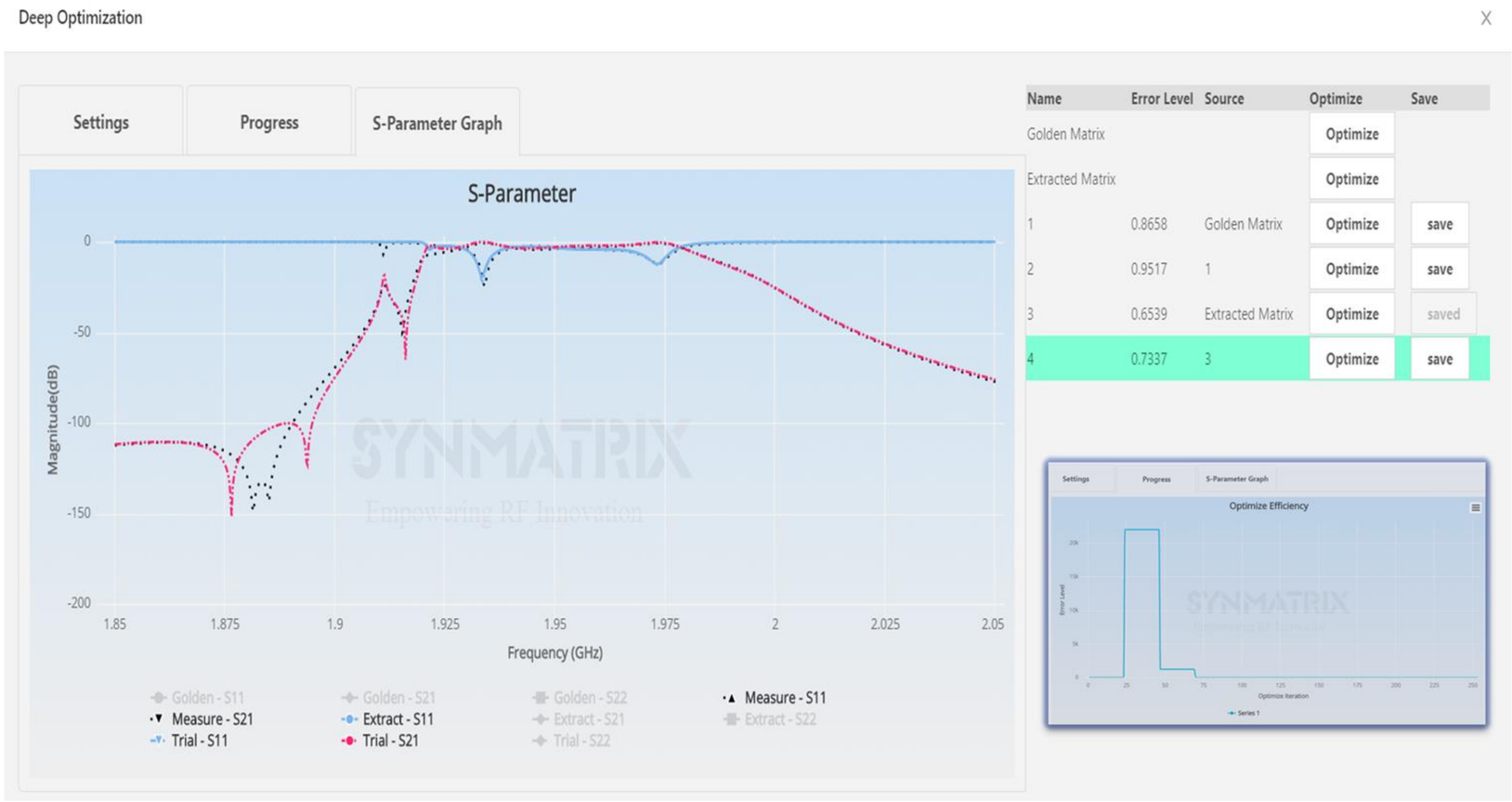
Computer-Aided Tuning | **Time Domain Tuning**

- Synthesize, import a custom coupling matrix file, or import your S2P data to help support your use cases
- Support both computer-aided tuning and real-time tuning workflows

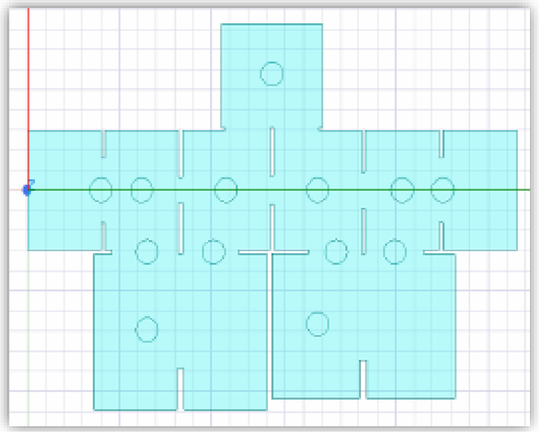


Computer-Aided Tuning | **Generic Optimization**

- Based on circuit model
- Retrieves EM simulation error by curve fitting the target through a variety of optimization methods



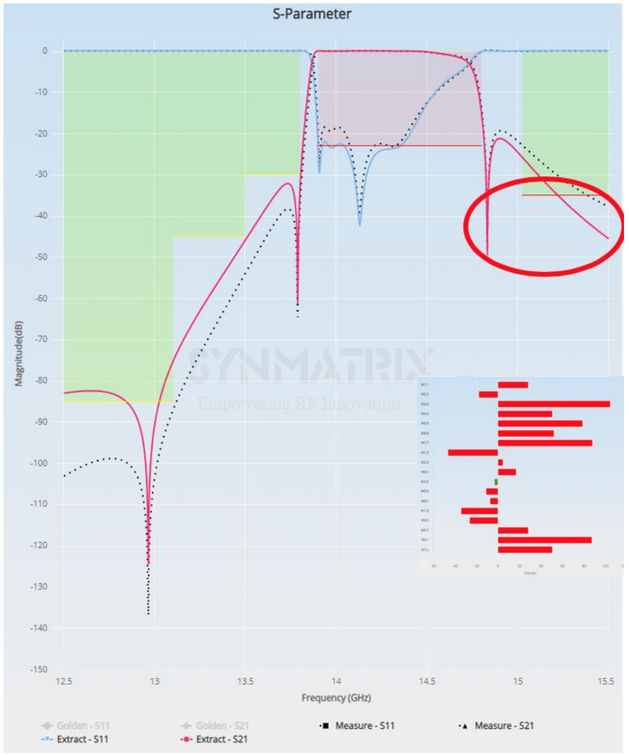
Computer-Aided Tuning | **Dispersive Effect Control**



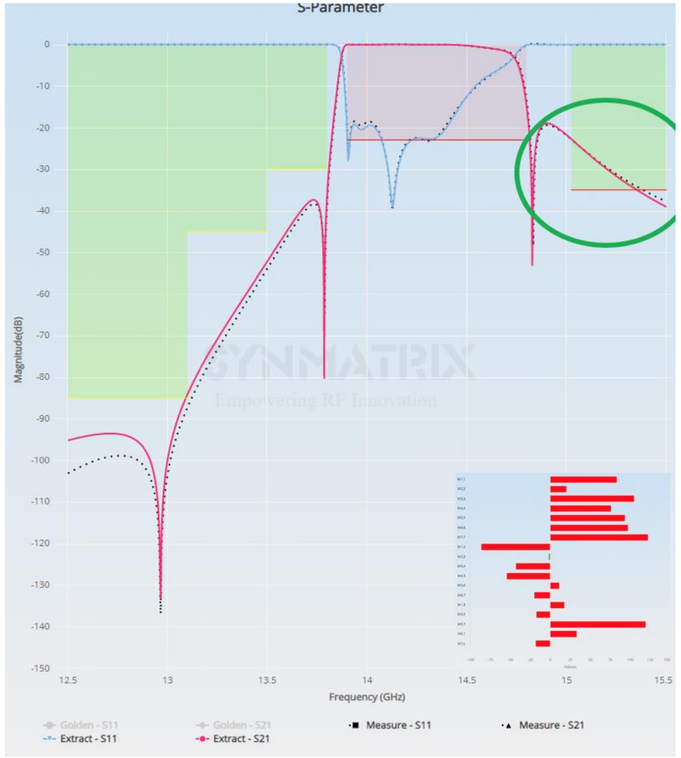
Design specification:

Filter order=7; f0=14.35GHz; BW=0.9GHz; RL=20dB
12.5~13.1GHz<-80dB; 13.1~13.5GHz<-40dB
13.5~13.8GHz<-25dB; 15~15.5GHz<-35dB

- Manage higher frequency applications with dispersive effect control tools
  - Planar/Co-planar structures
  - Wideband application
  - Ceramic/Waveguide

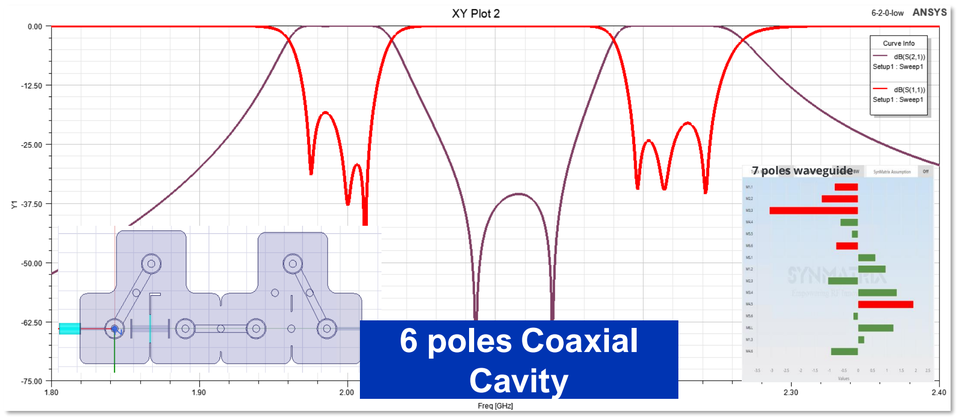


Without Dispersive control

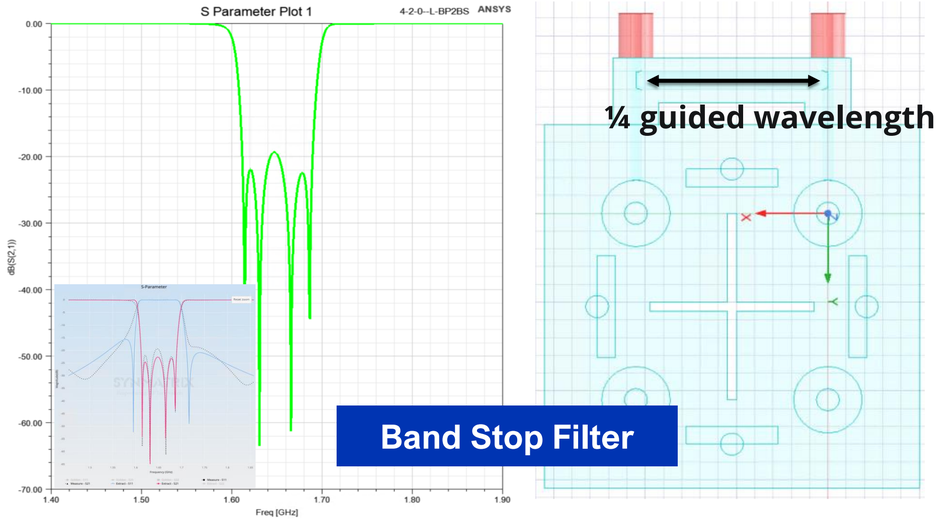


With Dispersive control

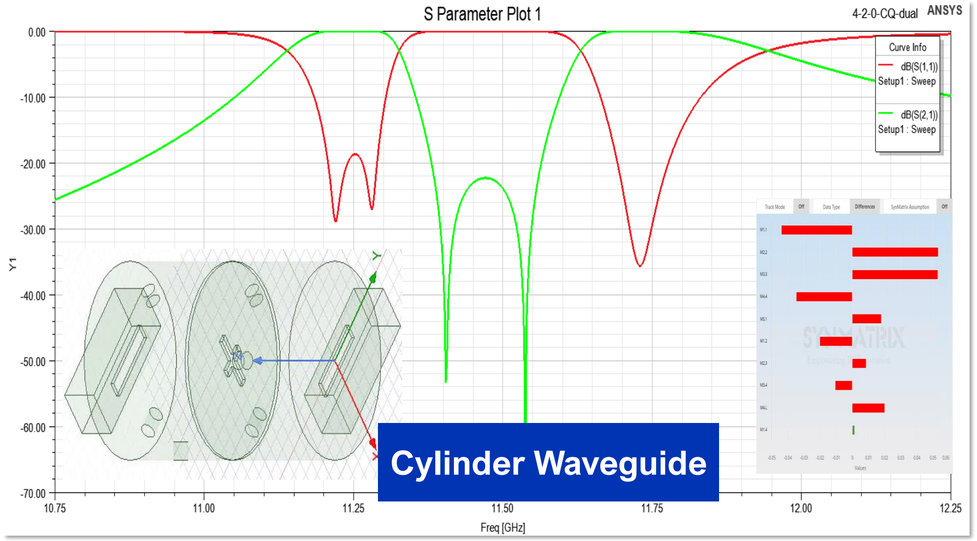
Computer-Aided Tuning | **Bandpass, Band stop, Dual-band**



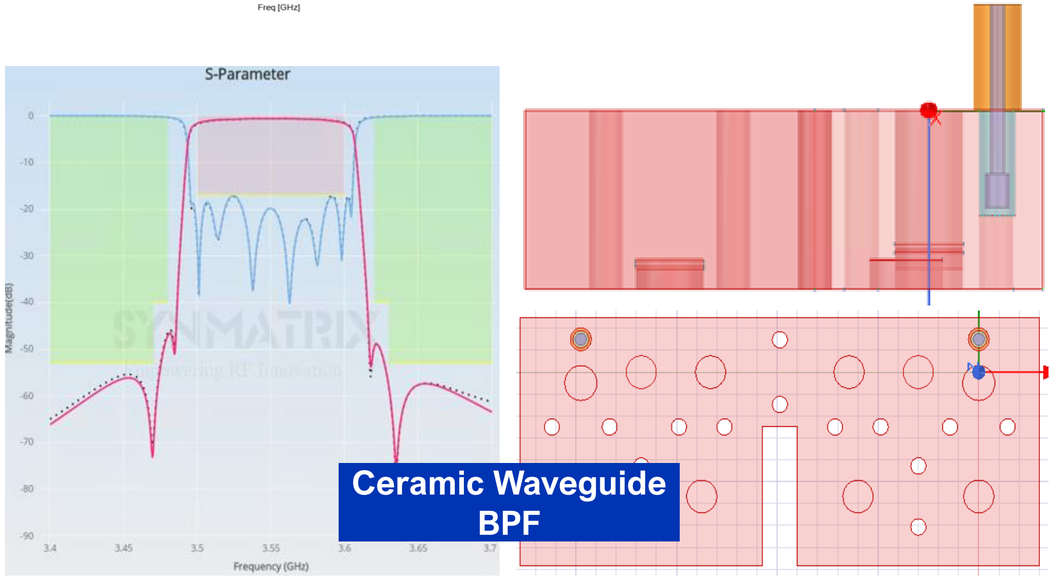
6 poles Coaxial Cavity



Band Stop Filter



Cylinder Waveguide



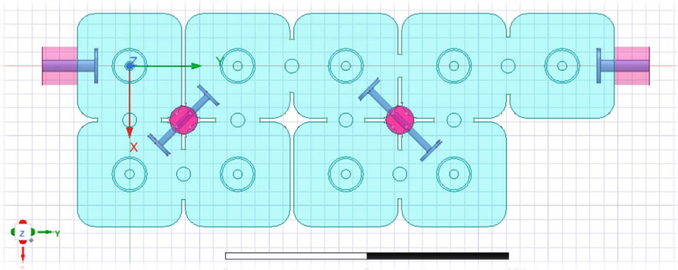
Ceramic Waveguide BPF

Intelligent Optimization | **Perturbation System**

The new released perturbation system is an independent automatic function to calculate the derivative matrix. The perturbated information can be used as the initial starting point either for space mapping or AI optimization to improve the overall optimization performance.

$$\begin{bmatrix} \frac{\partial M_s}{\partial D_1} & \frac{\partial M_s}{\partial D_2} & \cdots & \frac{\partial M_s}{\partial D_{n-1}} & \frac{\partial M_s}{\partial D_n} \\ \frac{\partial M_{11}}{\partial D_1} & \frac{\partial M_{11}}{\partial D_2} & \ddots & \frac{\partial M_{11}}{\partial D_{n-1}} & \frac{\partial M_{11}}{\partial D_n} \\ \vdots & & & \vdots & \\ \frac{\partial M_l}{\partial D_1} & \frac{\partial M_l}{\partial D_2} & \cdots & \frac{\partial M_l}{\partial D_{n-1}} & \frac{\partial M_l}{\partial D_n} \end{bmatrix}$$

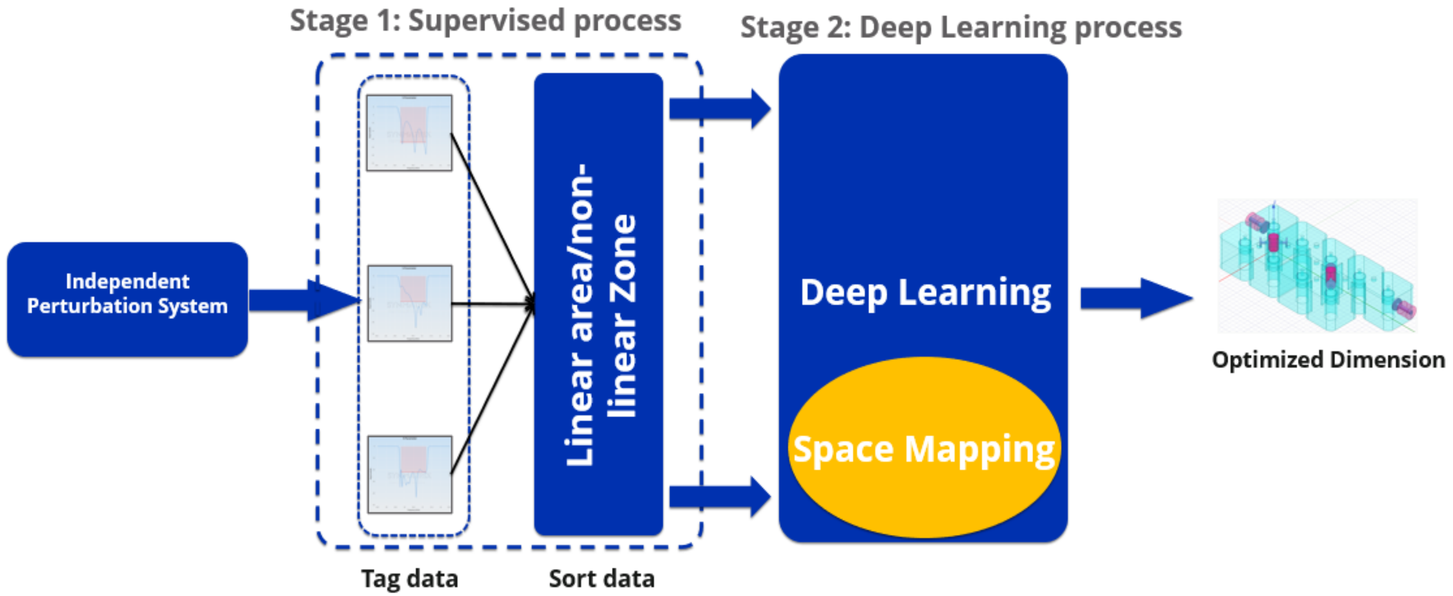
	S	1	2	3	4	5	6	7	8	9	L
S	0	1.0455	0	0	0	0	0	0	0	0	0
1	1.0455	-0.0132	0.8672	0	0	0	0	0	0	0	0
2	0	0.8672	-0.0146	0.5785	-0.1720	0	0	0	0	0	0
3	0	0	0.5785	0.2990	0.5302	0	0	0	0	0	0
4	0	0	-0.1720	0.5302	-0.0393	0.5447	0	0	0	0	0
5	0	0	0	0	0.5447	-0.0405	0.3850	-0.3770	0.0995	0	0
6	0	0	0	0	0	0.3850	0.7231	0.3397	0	0	0
7	0	0	0	0	0	-0.3770	0.3397	0.1086	0.5952	0	0
8	0	0	0	0	0	0.0995	0	0.5952	-0.0146	0.8672	0
9	0	0	0	0	0	0	0	0	0.8672	-0.0132	1.0455
L	0	0	0	0	0	0	0	0	0	1.0455	0



Intelligent Optimization | **AI**

Combines supervised deep learning method with SynMatrix's proprietary knowledge to converge to a solution

- 2-stage process to analyze the RF characteristics
- Self-adaptive coupling matrix error correction to improve accuracy
- Hybrid optimization method with space mapping integration



Intelligent Optimization | **AI**

Full Training System

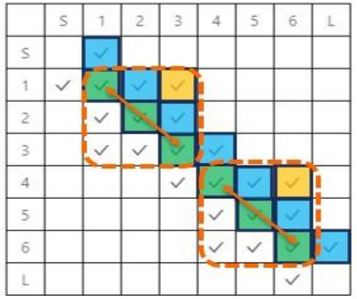
Full deviation matrix built with co-coupling effects. Suitable for complicated cases with quasi-linear coupling performance.

$$\begin{bmatrix} \frac{\partial M_s}{\partial D_1} & \frac{\partial M_s}{\partial D_2} & \cdots & \frac{\partial M_s}{\partial D_{n-1}} & \frac{\partial M_s}{\partial D_n} \\ \frac{\partial M_{11}}{\partial D_1} & \frac{\partial M_{11}}{\partial D_2} & \ddots & \frac{\partial M_{11}}{\partial D_{n-1}} & \frac{\partial M_{11}}{\partial D_n} \\ \vdots & & & \vdots & \\ \frac{\partial M_l}{\partial D_1} & \frac{\partial M_l}{\partial D_2} & \cdots & \frac{\partial M_l}{\partial D_{n-1}} & \frac{\partial M_l}{\partial D_n} \end{bmatrix}$$

Fully trained deviation matrix

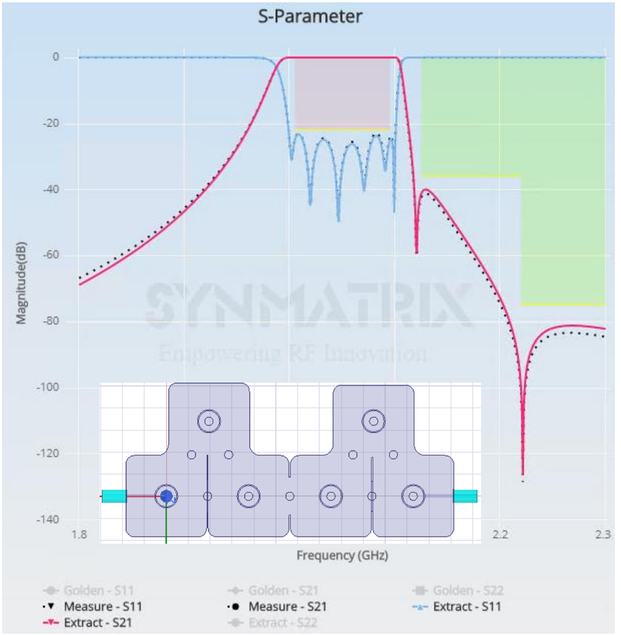
Smart Training system

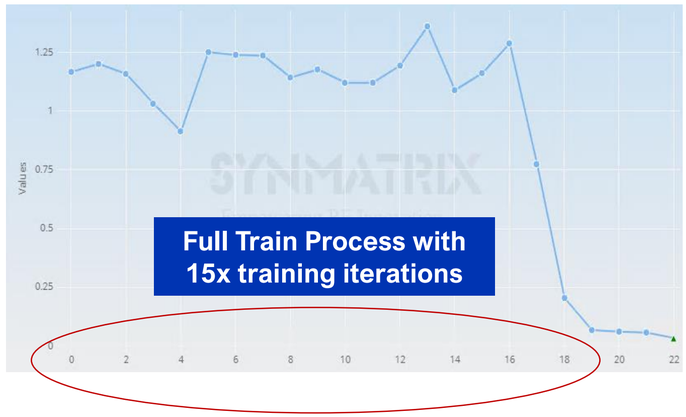
Intelligently detects key training elements from user defined topology. Suitable for traditional CT and CQ topologies.

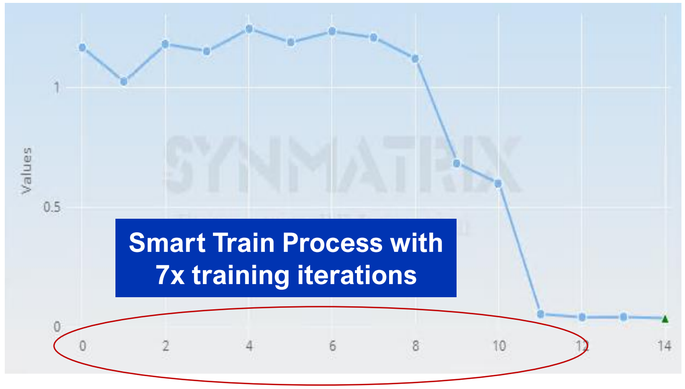


Adjacent energy leakage is considered

Example Used







Save up to 50% training time with Smart Training Process

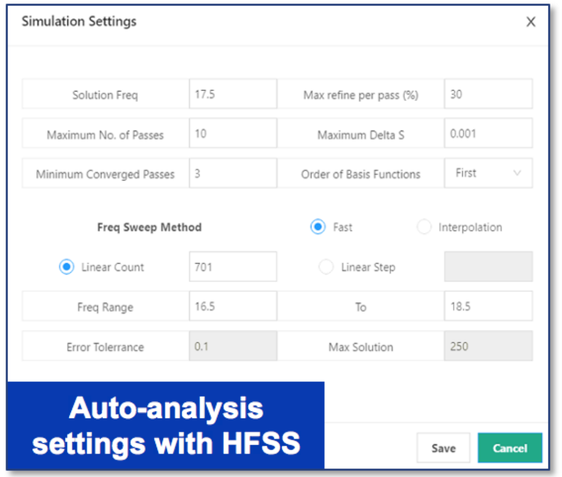
Intelligent Optimization | **AI**

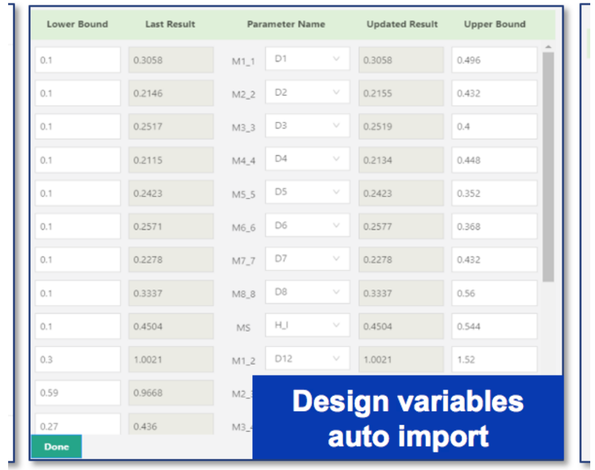
Ansys HFSS Integration

- HFSS analysis set up automation
- Auto-import HFSS variables
- Runtime automation
- Save the mapping file automatically
- Compatible with HFSS v15.0+

01

HFSS configuration control from the SynMatrix GUI





Automatically map physical dimensions

02

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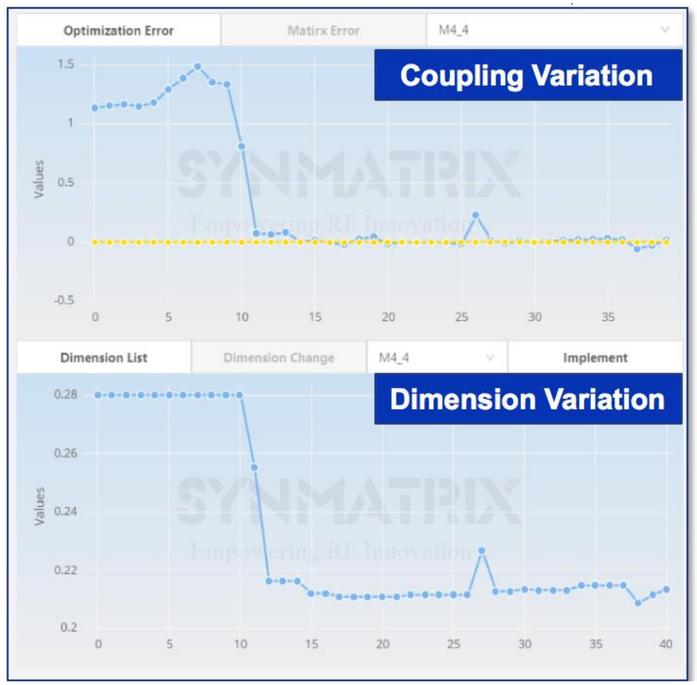
Intelligent Optimization | **AI**

Workflow Management Tools

- S2P file storage with simulation process recap
- Run process overview
- Dimension vs. coupling coefficients
- Recommends best result with seamless integration



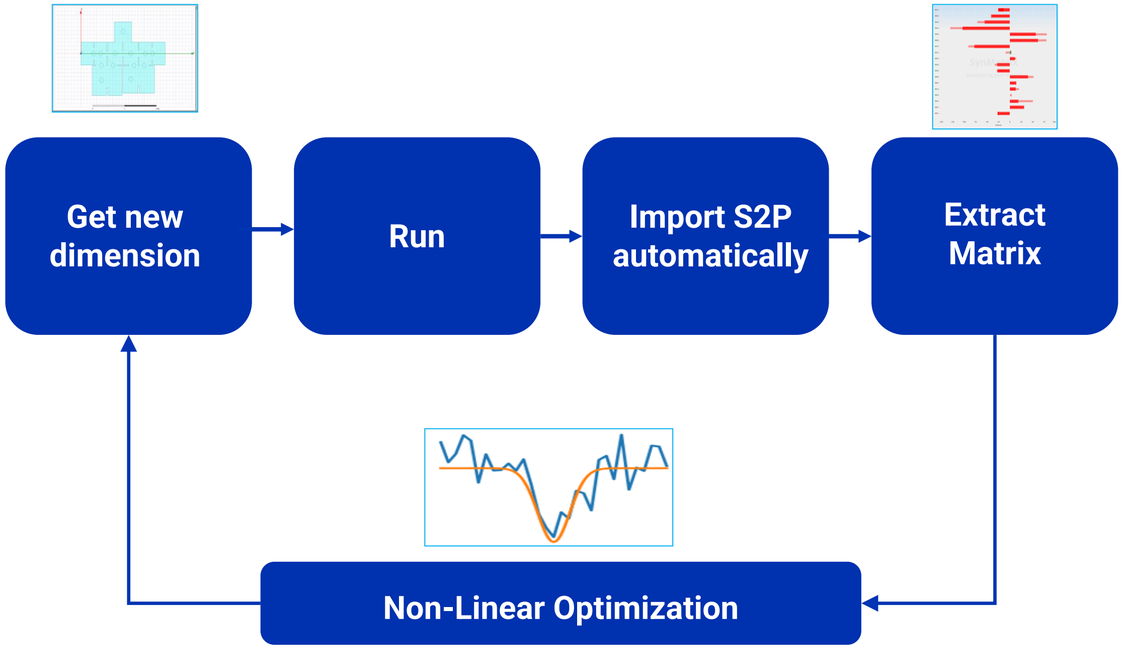
Intelligent Optimization | **Custom workflow**

Flexible Tuning Methods
Choose between linear and non-linear tuning methods.

Solve for Non-Linear Methods
Based on Aggressive Space Mapping (ASM) or the Linear Slope method.

Easy to Use
One-touch set up and full HFSS remote control.

Regression Analysis
Using the nonlinear curve fitting technique to predict the 3D dimension variation.



Test and Measurement

03

SYNMATRIX
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OPTIMIZATION

Features an advanced Computer-Aided Tuning and AI-Optimization system with Ansys HFSS integration.

MANUFACTURING

Faster and more accurate volume production with real-time manufacturing line tuning (Coming Soon)

01 02 03 04

SPEC ANALYSIS

A feature-packed design and analysis platform for complex microwave filter engineering.

- Coupling matrix synthesis
- Dispersive effect analysis
- Power handling analysis
- Monte-Carlo analysis
- Thermal drift analysis
- Etc.

TEST AND MEASUREMENT

Real-time tuning and a test and measurement user workflow from an easy-to-use GUI.

One platform for design, optimization and test tuning

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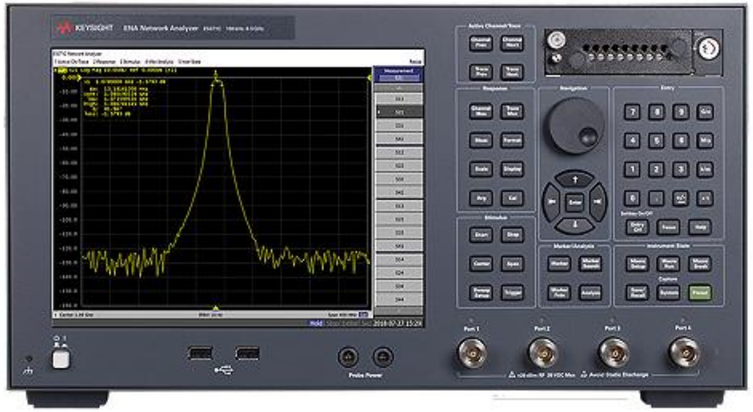
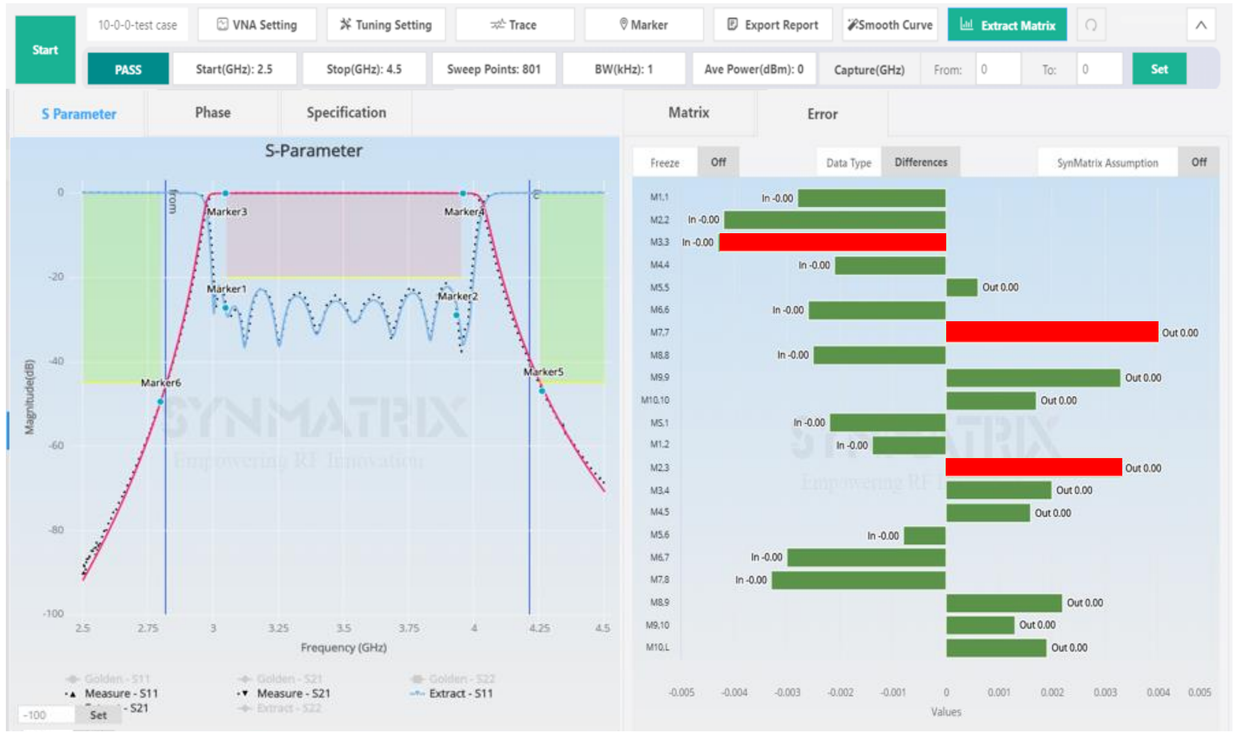
Test and Measurement | **VNA Support**

Rohde & Schwarz



Keysight



- **Support both Rohde & Schwarz and Keysight VNAs**
- **Rohde & Schwarz models: ZNB, ZNL, ZND**
- **Keysight models: E5071C series**
- **Fully control the VNA with the SynMatrix GUI**

Test and Measurement | **Real-time Tuning**

REAL-TIME FILTER TUNING FLOW

Filter tuning was never easier and faster. SynMatrix advanced computer-aided tuning enables real-time filter optimization in an easy guided process using the R&S®ZNB vector network analyzer from Rohde&Schwarz. The SynMatrix solution offers a feature-rich GUI for R&D and lab use, as well as a simplified version for production applications.

Your task

You are working on high frequency applications, and designing and tuning a filter has become more challenging. Using traditional design and verification techniques severely influences R&D processes.

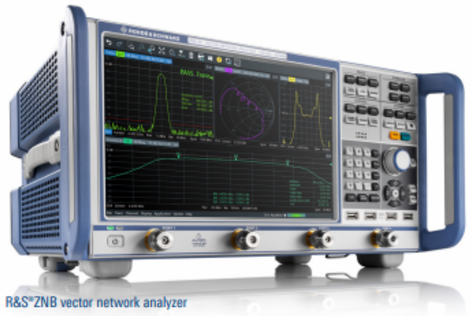
5G and mmWave market growth is increasing volume production demands with better yields, dramatically exceeding the expectations from previous design generations.

Tuning microwave filters requires specialized technicians, which can be very expensive and time consuming. Using a tool that enables non-specialized technicians to perform this task could be the key to accelerating design and manufacturing processes and maintaining high-quality performance.

Solution from Rohde&Schwarz and SynMatrix

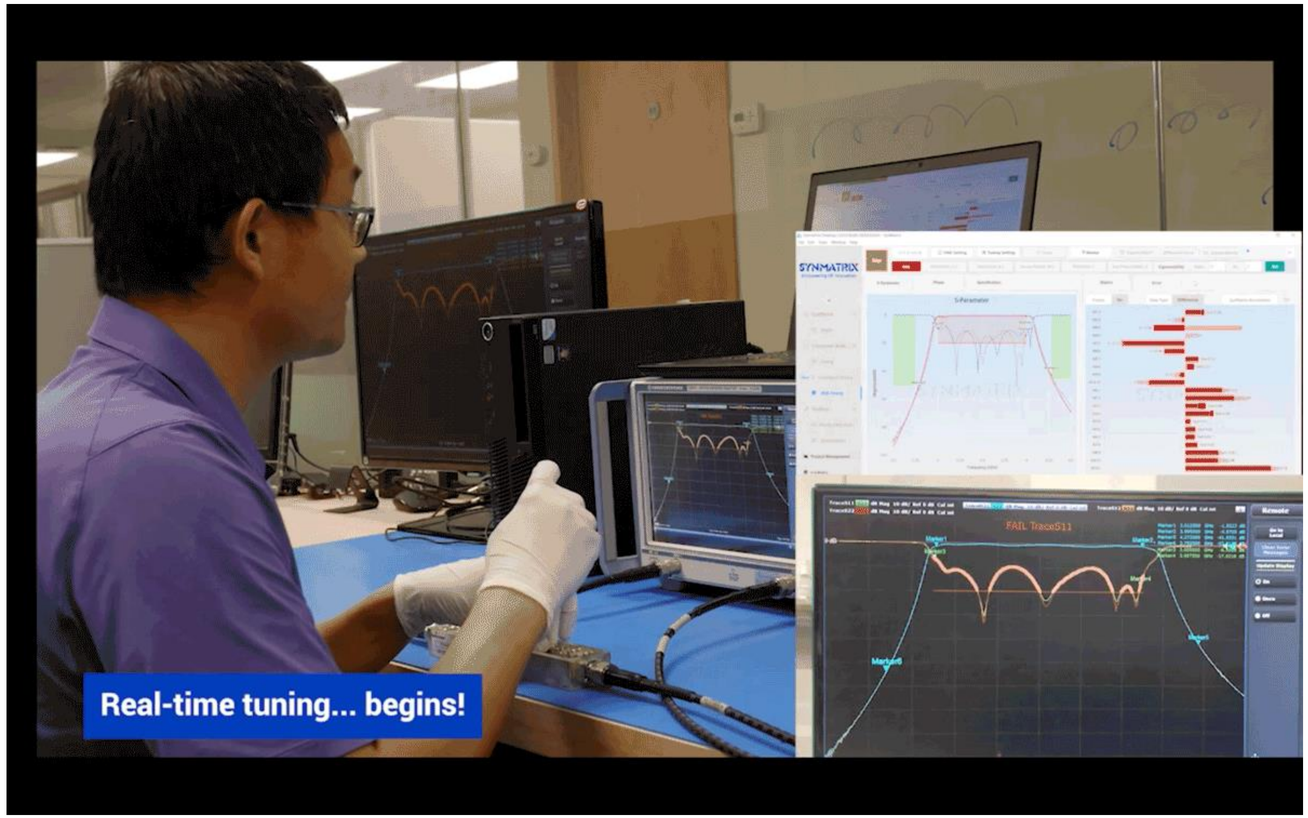
The Rohde&Schwarz-SynMatrix workflow offers a complete test and tuning solution for 5G and mmWave microwave filters. It is a powerful solution for RF engineers and technicians who want to test and tune their designs quickly and accurately.

The R&S®ZNB vector network analyzer provides superior performance, including a wide frequency application range and a large dynamic range up to 140 dB. The short sweep times (4 ms for 401 points) offer fast and accurate measurement response. The Rohde&Schwarz-SynMatrix workflow has been validated by many users with high frequency requirements.



R&S®ZNB vector network analyzer

SynMatrix tuning platform



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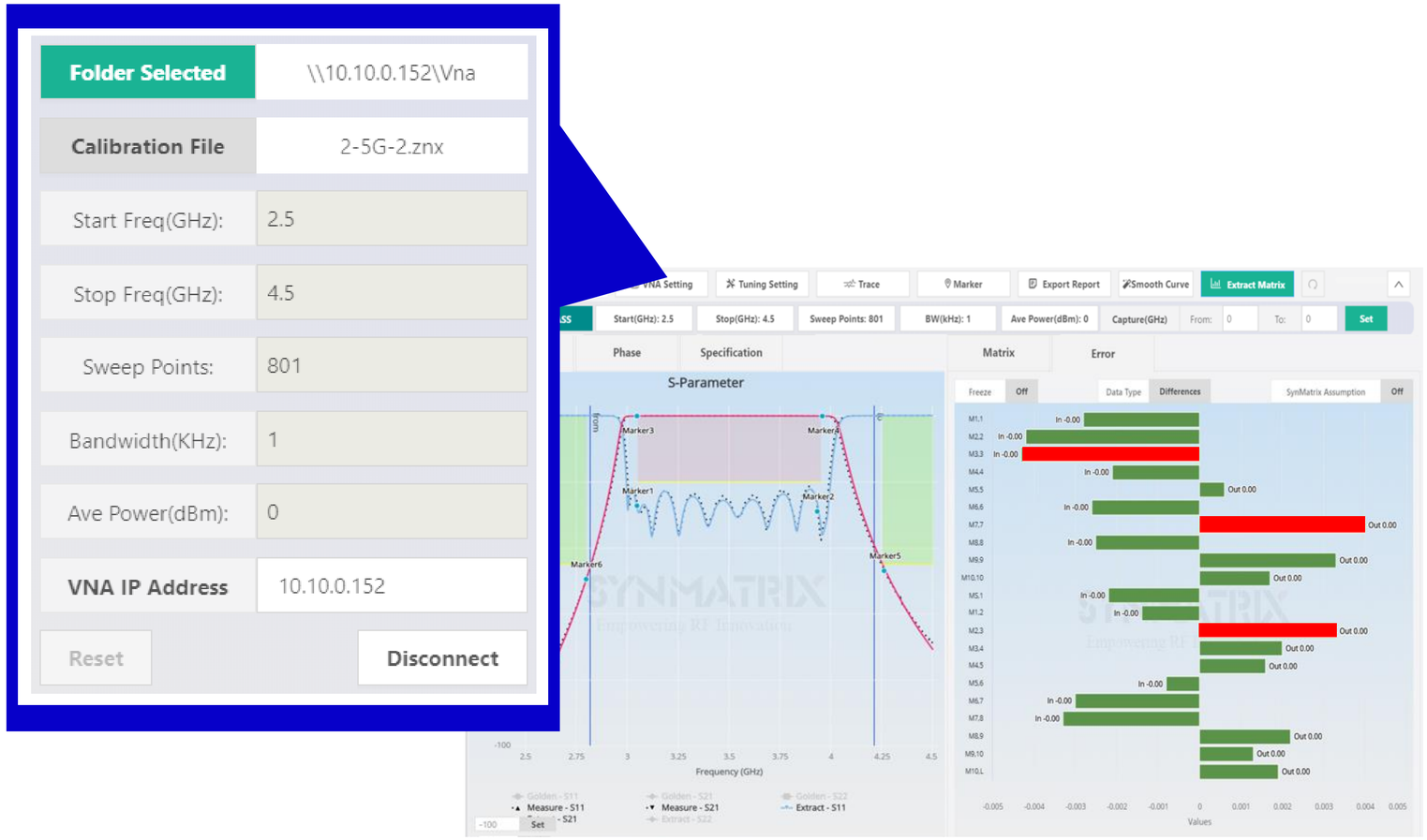
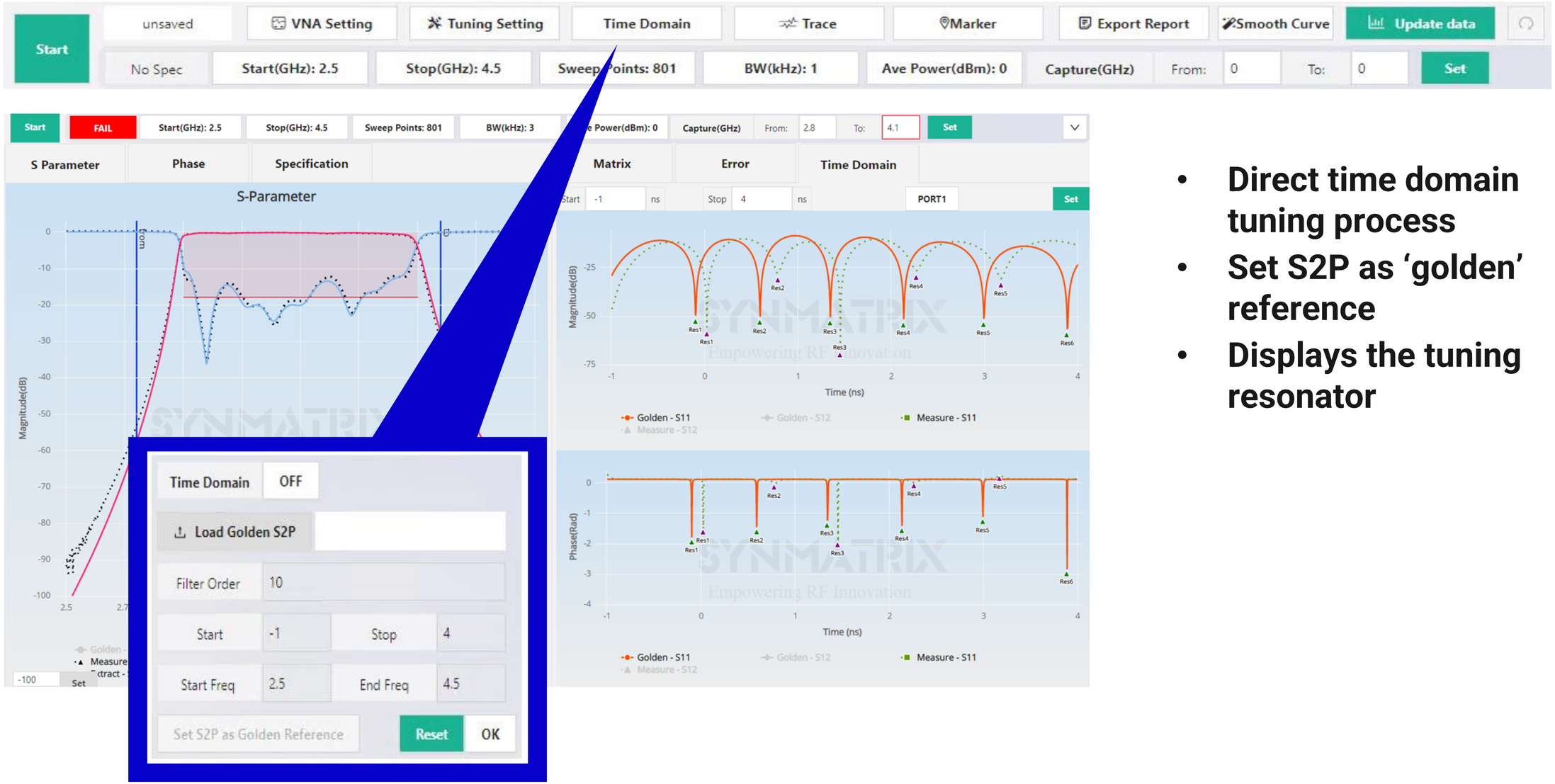
Test and Measurement | **One-Button Connection**



- **Plug and play set up**
- **Complete VNA access via the SynMatrix GUI**

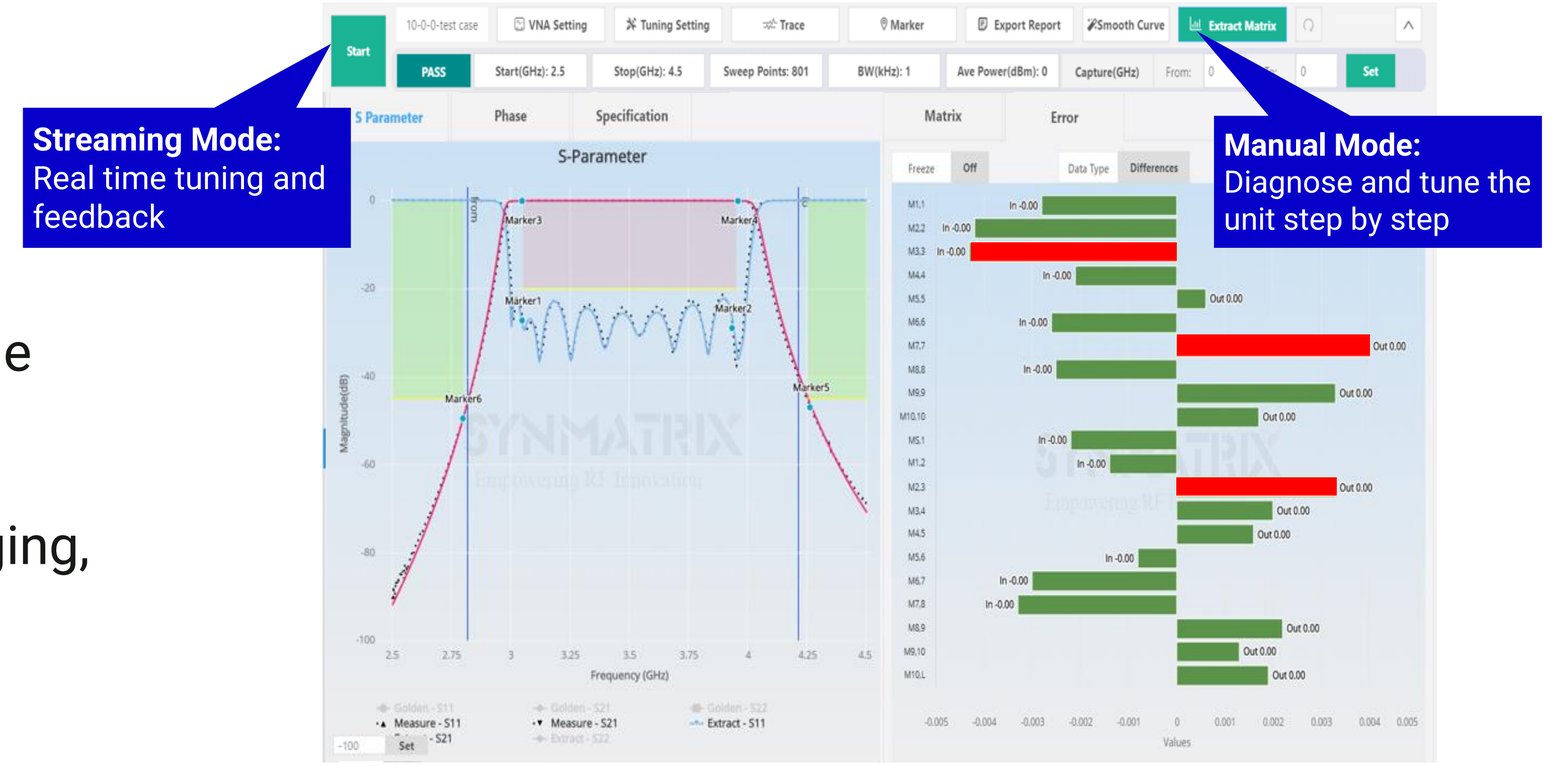
Test and Measurement | **Time Domain Tuning**



- **Direct time domain tuning process**
- **Set S2P as ‘golden’ reference**
- **Displays the tuning resonator**

Test and Measurement | **Streaming, Manual Modes**

- **Streaming mode:** Real-time tuning experience
- **Manual mode:** For debugging, step-by-step tuning experience



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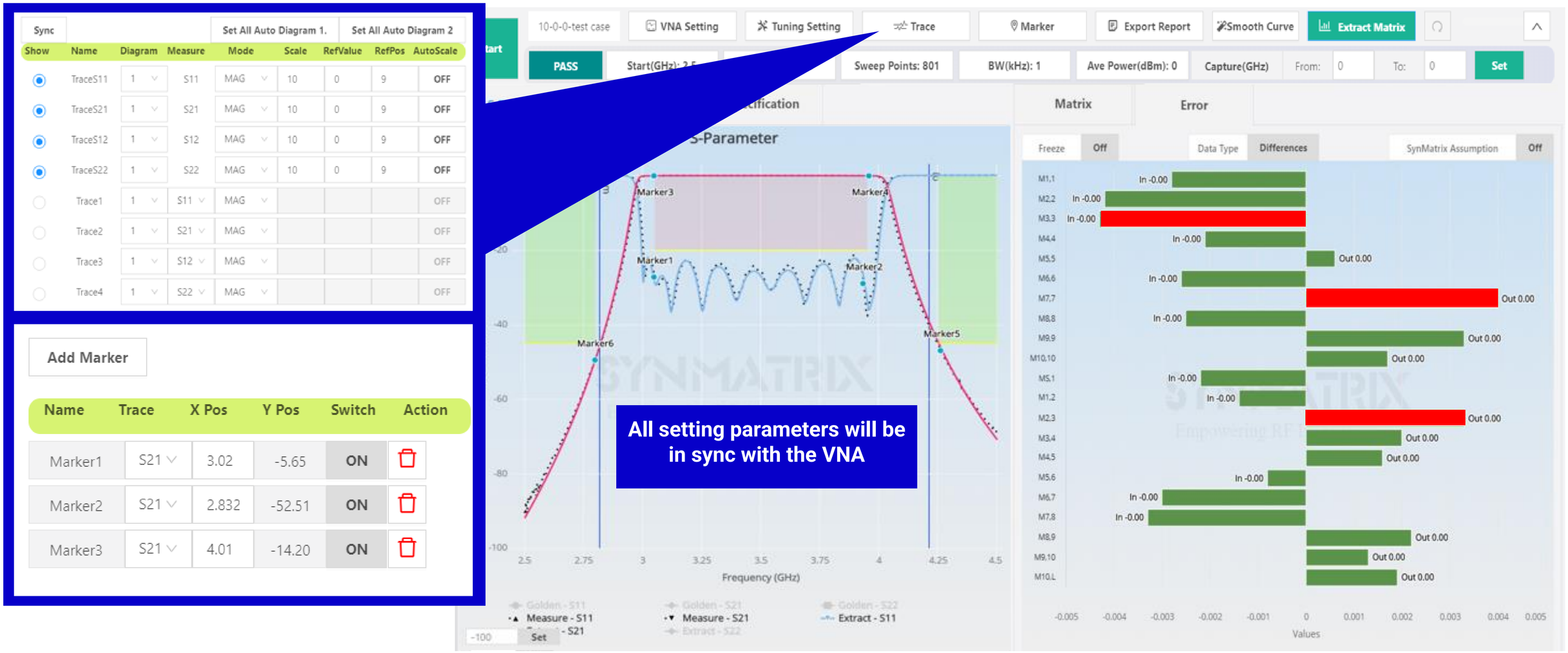
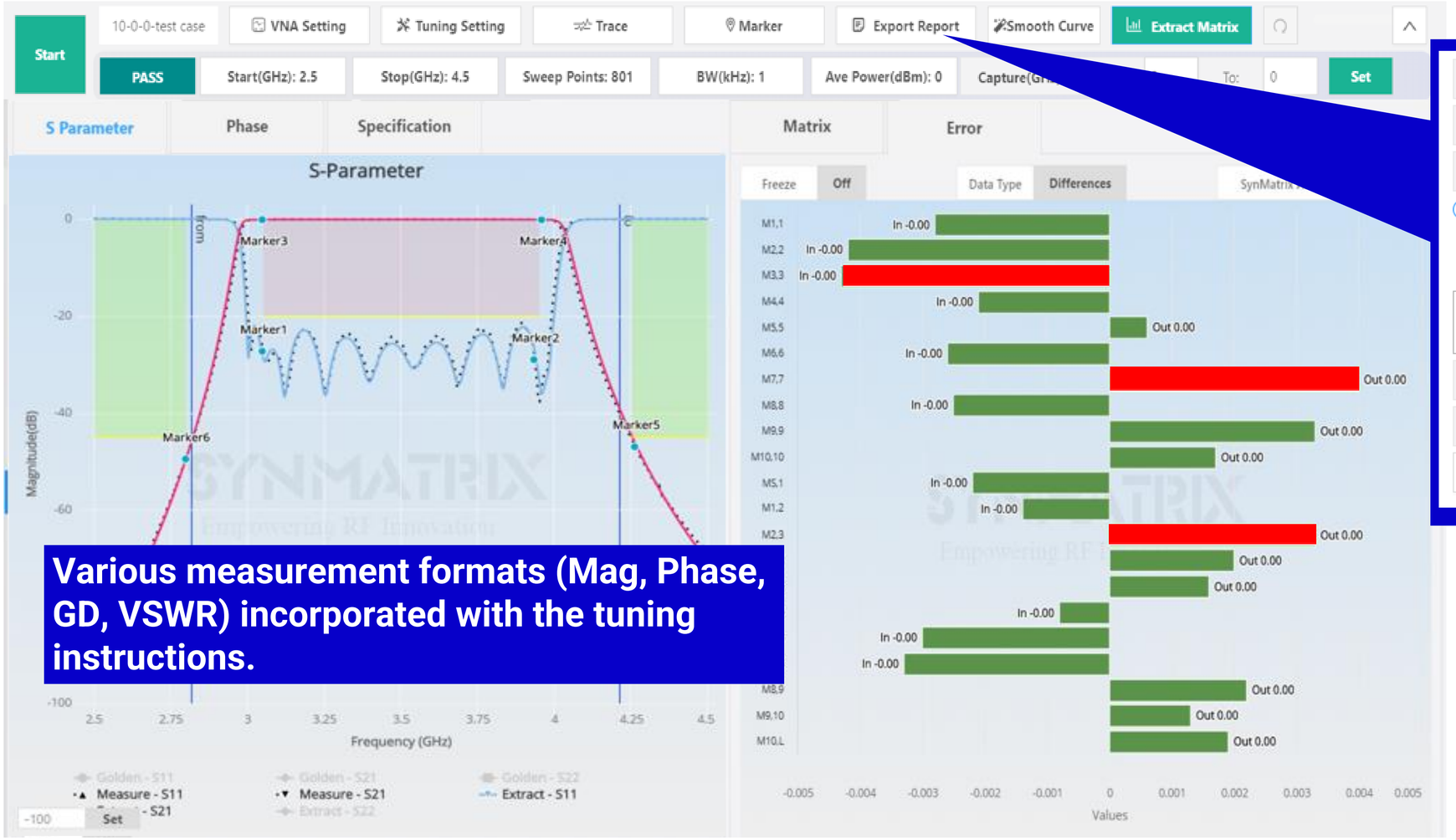
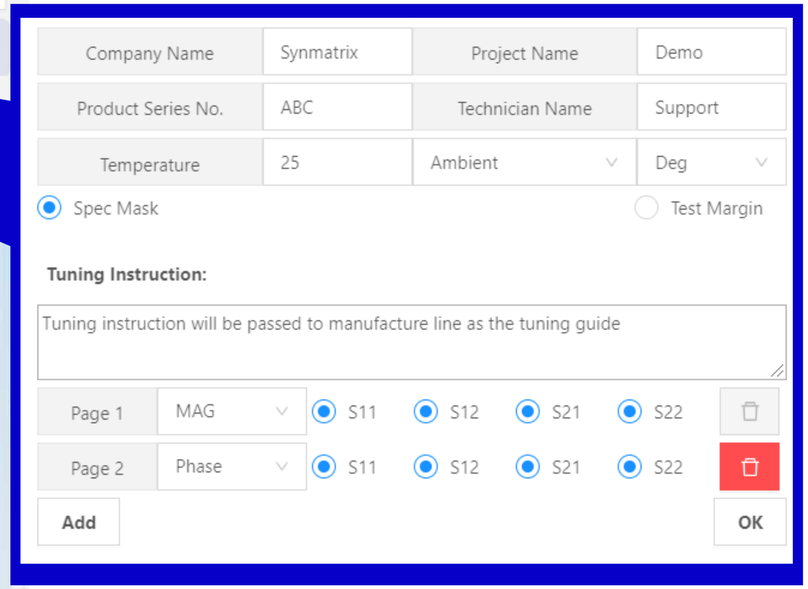
Test and Measurement | **Full VNA Control**



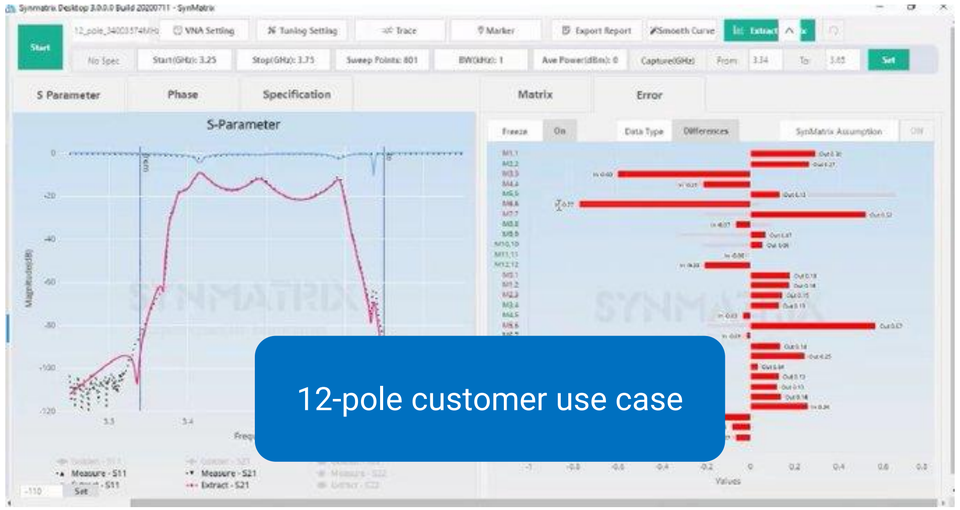
Test and Measurement | **Report Generation**

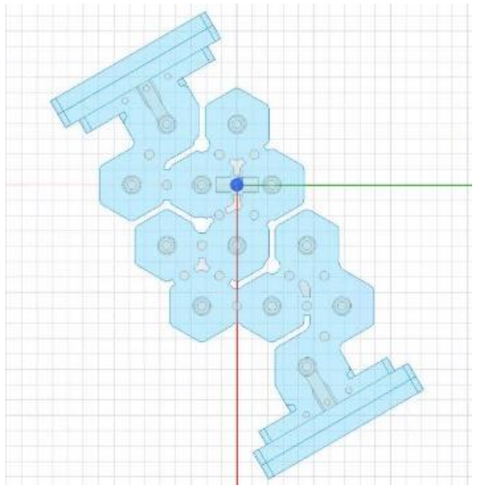


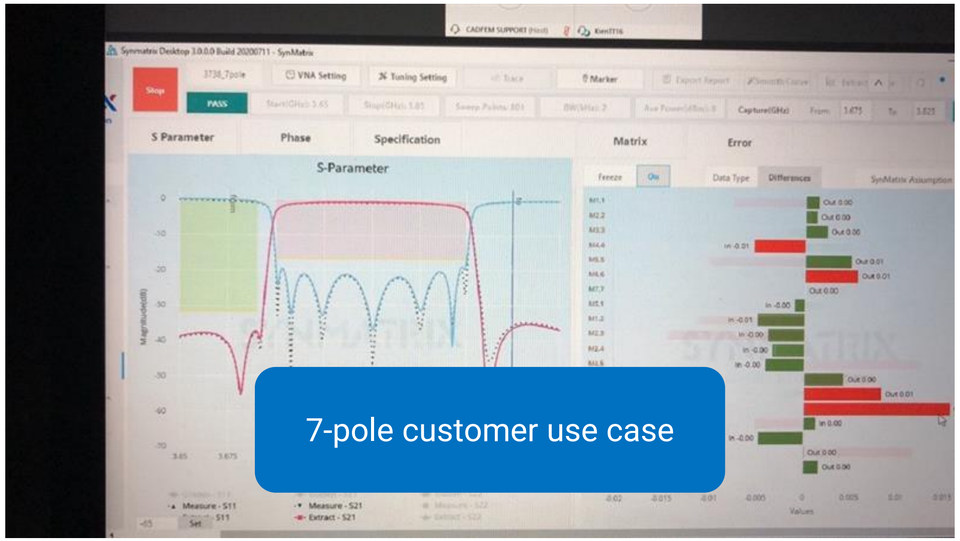
Various measurement formats (Mag, Phase, GD, VSWR) incorporated with the tuning instructions.



Test and Measurement | **Success Stories**







►Customer validation exercise (7-pole with 4 transmission zeros, 12-pole with 4 transmission zeros designs)

- Successfully used SynMatrix to tune both filters
- SynMatrix uses an advanced algorithm that supports more filter geometries and applications
- Competitor's software was unable to tune the 12-pole design

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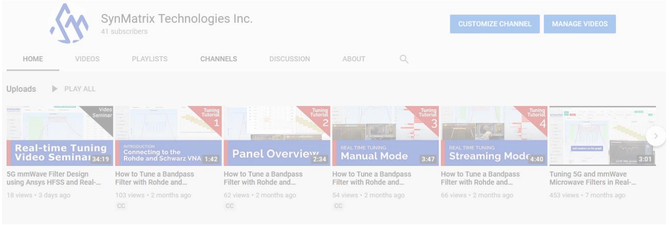
On-Boarding and Support



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- ▶**Trial licence**
  - –Controlled and accessible via the cloud at www.synmatrixtech.com
  - –On-premise options are available for departments without internet access (inquire for more details)

Diamond Liu
Dir. Of R&D

David Shin
Dir. of Business Development

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Thank you!