SAW/BAW Computer-Aided Design: MATLAB and ADS Integration

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1. Introduction

Surface Acoustic Waves (SAW) and Bulk Acoustic Waves (BAW) Computer-Aided Design (CAD) is a critical component of modern RF filter development and production. As device complexity increases, engineers require accurate and efficient modeling and simulation tools wich could be integrated into practical design.

Dr. Alexander Rukhlenko presents a clear and pragmatic vision for advancing SAW/BAW CAD by bridging t he gap between sophisticated *MATLAB®*-based physical models and real-world electronic design and simulation environment. In particular, his approach focuses on integrating advanced acoustic modeling into industry-standard circuit simulation tools such as *Keysight® PathWave Advanced Design System (ADS)*.

This work builds on the author's extensive professional experience (see the *biography page of Dr. Alexander Rukhlenko* for more details) and is acknowledged by the *testimonials of leading SAW/BAW experts*.

2. SAW/BAW CAD Design Challenges

Despite significant technological progress in SAW/BAW filters for mass production, a substantial gap remains between advanced modeling techniques developed in academia and the engineering models commonly used in industrial practice. SAW/BAW researchers typically develop sophisticated models using standalone computational platforms such as MATLAB, Simulink, COMSOL Multiphysics, and Ansys HFSS. While these tools enable accurate

and predictive simulations, these models are generally:

- Complex and computationally intensive, requiring significant memory and processing time
- Not fully self-contained, often depending on external environments or toolchains
- Incompatible with commercial CAD software such as Keysight PathWave Advanced Design System (ADS)

As a result, these advanced modeling approaches are rarely used in production-level SAW/BAW filter design, despite their superiority and advantages.

3. Practical Modeling in SAW/BAW Design

Due to compatibility and efficiency constraints, engineers typically rely on simplified models when designing industrial SAW/BAW devices. These approaches include, but are not limited to:

- ***Closed-form analytical models*** (e.g., Coupling-of-Modes (COM) models for SAW filter design)
- ***Equivalent circuit models*** (e.g., Mason model and modified Butterworth–Van Dyke (mBVD) model for FBAR filters)

Such models are mathematically straightforward, computationally efficient, robust, and fully compatible with standard commercial design tools such as Keysight PathWave Advanced Design System (ADS) and other RF circuit simulators.

Unfortunately, their simplicity comes at a cost. Compared to more physically detailed models developed in environments like MATLAB, these approaches generally offer reduced accuracy and limited predictive capability, particularly for complex or non-ideal devices.

4. Bridging the Gap: MATLAB and ADS Integration

Dr. Alexander Rukhlenko is among a small group of experts who combine deep theoretical knowledge with practical engineering expertise to address this long-standing gap in SAW/BAW CAD design. He has developed a powerful and versatile interface between Keysight ADS circuit simulator and MATLAB, effectively eliminating compatibility barriers between these two modeling and simulation environments.

This approach enables:

- Direct integration of complex acousto-electric SAW/BAW models into ADS
- Co-simulation of SAW/BAW devices with standard ADS electronic components
- Improved modeling accuracy without compromising workflow efficiencyUse of MATLAB models containing an arbitrary number of design parameters and input arguments
- Use of MATLAB models containing an arbitrary number of design parameters and input arguments
- Integration of these parameters into ADS-based simulation, optimization and tuning workflows

Important advantage is that the end user does not need to have MATLAB installed or possess a MATLAB license. Compiled MATLAB models can be executed using MATLAB Runtime (MCR), significantly simplifying deployment and accessibility in industrial design environments.

As a result, engineers can leverage advanced MATLAB physics-based modeling techniques directly within standard RF design platforms without introducing additional software dependencies. This reduces integration effort, simplifies collaboration between modeling and design teams, and allows high-fidelity models to be used within industrial workflows.

The version-independent nature of the approach further ensures long-term stability of the design environment and minimizes the need for repeated model adaptation when software tools are updated.

5. Advanced Design Techniques and Software Development

Beyond tool integration, Dr. Alexander Rukhlenko applies a comprehensive set of engineering and software development techniques to enhance design efficiency and capability, independent of the specific modeling approach used. These include:

- Development of a universal interface between MATLAB models and Keysight ADS component libraries
- Efficient vectorization of MATLAB-based SAW/BAW models, significantly reducing simulation time
- Design of interactive APIs and graphical user interfaces (GUIs)
- ADS AEL (Application Extension Language) programming
- Advanced optimization and iterative design methodologies for RF filter development
- Structured data exchange between ADS and MATLAB simulation environments
- Development of proprietary design toolkits tailored to specific customer requirements
- Automation of routine design and measurement processes

In addition, beyond MATLAB-based development, he utilizes low-level programming languages such as C/C++ and FORTRAN to further improve computational performance, scalability, and model portability. This enables efficient handling of complex models and large parameter spaces while maintaining compatibility with industrial design workflows.

6. Impact on SAW/BAW CAD Design

This systematic and technology-independent approach significantly enhances the SAW/BAW CAD design workflow by:

- Increasing modeling accuracy
- Reducing simulation time

- Shortening overall design cycles
- Improving integration with ADS-based environments
- Eliminating dependency on software installations and/or licensing constraints for end users
- Supporting flexible parameterization and optimization of complex device models

As a result, engineers can achieve faster development of high-performance SAW/BAW filters with improved characteristics, modeling accuracy and reliability.

7. Conclusions

Modern SAW/BAW CAD design requires a careful balance between advanced physical modeling, computational efficiency, and practical implementation. By bridging MATLAB-based models with ADS circuit simulator, it becomes possible to combine the high accuracy and flexibility of MATLAB modeling with the convenience and efficiency of ADS circuit design.

The methodology developed by Dr. Alexander Rukhlenko demonstrates how such integration transforms RF filter design workflow, enabling the efficient development of next-generation SAW/BAW devices using Keysight PathWave ADS as market-leading circuit design and simulation platform.

By combining modeling flexibility, software independence, version-independent implementation, and seamless integration into established design environments, this approach provides a scalable and practical foundation for modern RF filter development.

8. Frequently Asked Questions (FAQ)

What is SAW/BAW CAD design?

SAW/BAW CAD design refers to the use of computer-aided tools to model and design Surface Acoustic Wave (SAW) and Bulk Acoustic Wave (BAW) filters used in RF systems.

Why is MATLAB widely used in SAW/BAW modeling?

MATLAB enables advanced physical modeling and numerical simulation, offering higher accuracy than simplified equivalent circuit models, for example.

What is the role of ADS in RF design?

Keysight ADS is widely used for circuit-level simulation and system integration in RF and microwave engineering.

Why integrate MATLAB with ADS?

Integrating MATLAB with ADS allows engineers to combine accurate physical models with practical circuit-level simulation, improving both precision and efficiency. Moreover, compiled MATLAB models can be deployed in ADS without requiring MATLAB installation or licensing on the end-user system.

Which models are commonly used in SAW/BAW design?

Common designer models include Coupling-of-Modes (COM) for SAW filters and Mason or mBVD equivalent circuit models for BAW devices.

Are the integrated MATLAB models dependent on specific MATLAB or ADS versions?

No. The developed approach is designed to be universal and version-independent, allowing it to remain applicable across different MATLAB and ADS releases.

Can the MATLAB model integrated into ADS use an arbitrary number of design parameters?

Yes. The interface supports MATLAB models with an arbitrary number of input parameters and design variables, making it suitable for advanced optimization and iterative RF filter design

Web version: *SAW/BAW Computer-Aided Design: MATLAB and ADS Integration*