# Compliance-Scope®

## **Virtual Laboratory** for EMI / EMC

## Compliance-Scope® Introduction

Compliance-Scope®, is a virtual EMI/EMC laboratory where designers can validate and improve their hardware at an early stage by uploading their design files. The tool can also be used for post-prototype what-if analysis and debugging at the printed circuit board level.

## Use Compliance-Scope®

Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) contributes to a significant percentage of compliance failures in the verification stage. This leads to loss-of-revenue due to delay-to-market or cancelled projects.

**Design Stage:** Front-loading EMI/EMC compliance testing at the early stage of hardware design is an effective method to analyze and monitor EMI/EMC performance right from the beginning of the PCB layout stage such that possible problems can be addressed early in a cost-effective manner. Such an EMC-aware design process is likely to save, on an average, 6-12 months in time-to-market.

**Before EMI/EMC laboratory measurement:** EMI/EMC simulation can predict future laboratory measurement data such that preventive measures (e.g. changing values of decaps) may be taken or peace of mind is obtained before the critical laboratory testing

When EMI/EMC laboratory measurement indicates a failure: EMI/EMC simulation can be performed to reproduce the failure in simulation. This gives the designer freedom to try out remedial steps in simulation before implementing in hardware for the next iteration of measurement. This gives the user the option to try out multiple what-if analysis before deciding on the final hardware implementation.

Simyog offers Design and Sign-off Simulation Tools for EMI/EMC. Simyog's vision is to enable agile processes for on-schedule time-to-market of electronic hardware. This will be achieved by a new generation of computational software that augments physical science with data-science and reduces time and revenue loss resulting from a lengthy verification process.

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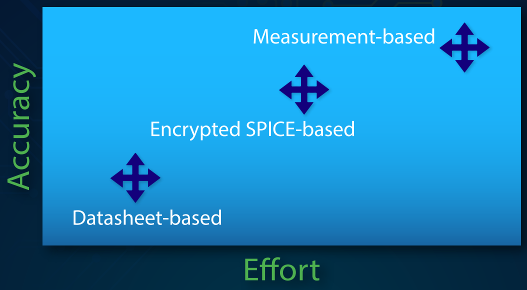
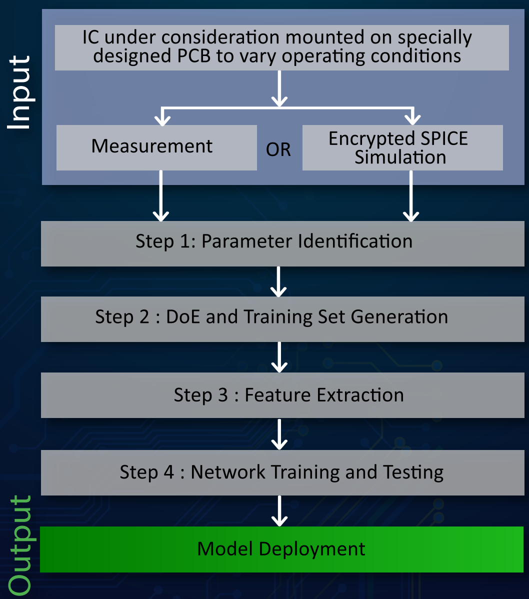
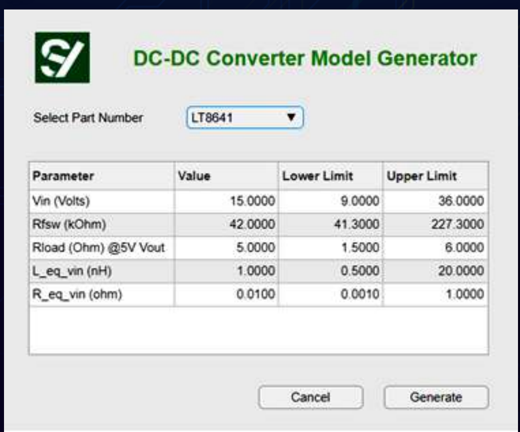
## IC-model Development for EMI/EMC

System-level EMC simulation is challenged by the non-availability of accurate component models, in particular, ICs. IC-model for EMI/EMC refers to a black-box representation of the IC, hiding its internal IP, yet sufficient for predicting EMC performance like CE, RE, BCI, RI accurately. A transistor level SPICE description of the IC may be used to predict EMI/EMC at the system level. However, in most cases such models are either not available or available in encrypted SPICE form. Further, often these SPICE models do not capture the measured IC behaviour especially at higher frequencies. IBIS is a popular model used in Signal Integrity (SI) analysis but does not directly lend itself to capturing EMC features. IEC-62433 series proposes a basic IC-model but is yet to capture the model dependence on operating conditions. At Simyog we are focused on developing IC-models for EMC using datasheet-based, SPICE-based and measurement-based techniques. Today we develop such models through service projects. In the near future, the IC-model library will be available in Compliance-Scope®



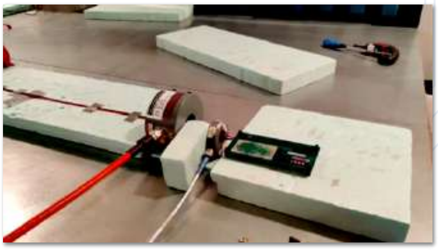

| Parameter | Value | Lower Limit | Upper Limit |
|---|---|---|---|
| Vin (Volts) | 15.0000 | 9.0000 | 36.0000 |
| Rfsw (kOhm) | 42.0000 | 41.3000 | 227.3000 |
| Rload (Ohm) @5V Vout | 5.0000 | 1.5000 | 6.0000 |
| L_eq_vin (nH) | 1.0000 | 0.5000 | 20.0000 |
| R_eq_vin (ohm) | 0.0100 | 0.0010 | 1.0000 |

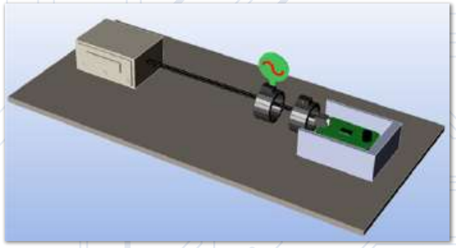
## Basic Idea

Compliance-Scope® is built such that the user can instantiate a laboratory with a chosen EMI/EMC standard on the click of a button. After opening the laboratory, the user can configure the setup using GUI utilities to suit the current experiment.

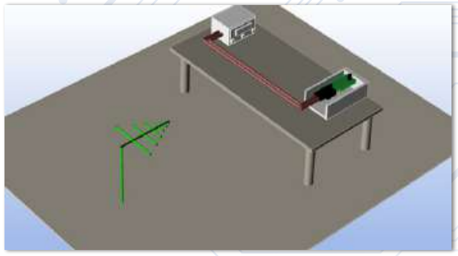
The virtual laboratory bears full resemblance with its physical counterpart as shown

Bulk Current Injection (BCI)

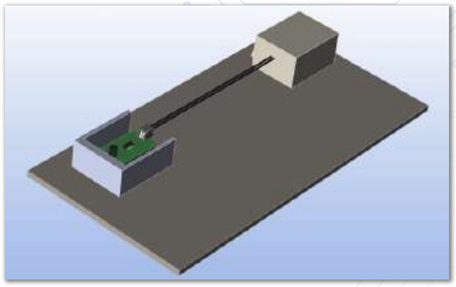




Radiated Emission (RE) and Radiated Immunity (RI)



Conducted Emission (CE)



## Different tests and standards supported

The following EMI/EMC standards are currently supported in Compliance-Scope®. We are constantly prioritizing and making standards available for customers. Please contact info@simyog.com with your requests.

| Test \ Mode | Radiated(through Air) | Conducted (through Copper) |
|---|---|---|
| **Emission** (Lower the emission better its acceptance) | **Radiated Emission (RE)**<br>Source – DUT – Victim<br>Standards supported in Compscope<br>1. CISPR25_RE<br>2. MIL_STD_461G_RE102 | **Conducted Emission (CE)**<br>Source – DUT – Victim<br>Standards supported in Compscope<br>1. CISPR25_CE_VOLTAGE<br>2. CISPR25_CE_CURRENT<br>3. MIL_STD_461G_CE101<br>4. MIL_STD_461G_CE102 |
| **Immunity** (Higher the immunity to noise better its acceptance) | **Radiated Immunity (RI)**<br>Victim – DUT – Source<br>Standards supported in Compscope<br>1. ISO_11452_2_RI<br>2. MIL_STD_461G_RS103 | **Conducted Immunity (CI)**<br>Source – DUT – Victim<br>Standards supported in Compscope<br>1. ISO_11452_4_BCI_OPEN_LOOP<br>2. ISO_11452_4_BCI_CLOSED_LOOP<br>3. MIL_STD_461G_CS114 |

# Compliance-Scope®
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## Pre-processing features

Ability to quickly setup virtual physical laboratory without engthy user intervention
- Support for RE standards: CISPR25-RE, RE-101, RE-102
- Support for CE standards: CISPR25-voltage, CISPR25-current, CE-101, CE-102
- Support for RI/RS standards: ISO-11452-2, RS-103
- Support for CI/CS standards: ISO-11452-4, CS-114

Ability to perform cable drawing:
- Ability to draw multiple cables using cross-section information
- Support for twisted cable
- Support for shielded cable (Coming soon)
- Ability to specify material properties

Equipment under Test (EUT):
- Ability to import PCB (odb++ format)
- Ability to import arbitrary 3D geom: e.g. housing, connector, screws (.sat file format)
- Ability to assemble different modules by easy interfaces like rotation, translation
- Ability to specify material properties
- Ability to import Bill-of-Material components as SPICE or touchstone files
- Ability to import models for ICs

## Modeling features

Ability to model IC immunity and emission behavior (ICIM and ICEM)
- Ability to generate operational condition dependent IC models
- IC-model library (Coming Soon)

Ability to model Injection Probe (CS)
- Ability to model injection probe by physical geometry or electrical model
- Ability to change probe position with respect to DUT Injection probe library included

Monitor Probe (CE, CS)
- Ability to monitor current at monitor probe locations

LISN
- Ability to model LISN using touchstone or SPICE file LISN library included

EMI-Receiver (Coming Soon)

Antenna models (Coming Soon)

## Solver engine features

3D full-wave Electromagnetic Solver
- Method of Moments (MoM)-based 3D full-wave solver
- Low-rank and MLFMA-based solver acceleration
- Support for shared-memory parallelization

2D Electromagnetic Solver (Multi-conductor Transmission Line solver)
- Method of Moments-based RLGC extraction
- RLGC to S/Y/Z-parameter conversion

Automatic Solver Hybridization
- Based on the laboratory, automatic hybridization of 3D/2D solver is enabled

Circuit solver (ng-SPICE)
- Open-source circuit solver is embedded to handle components with SPICE files

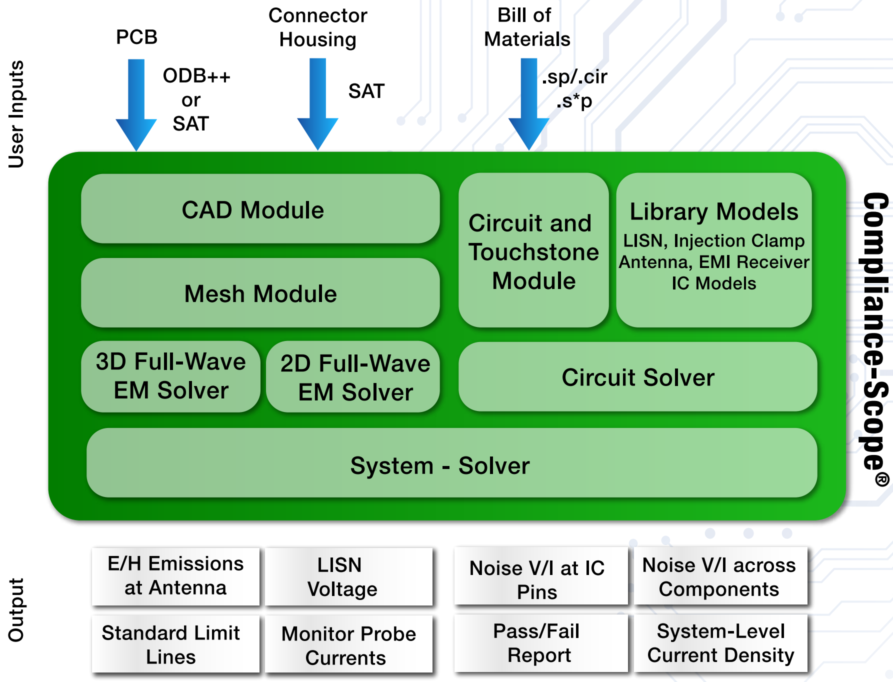
System solver
- Solver umbrella to automatically select appropriate solvers and combine results

Boundary conditions
- Absorbing-boundary condition for anechoic chamber
- PEC boundary condition for laboratory floor

High-performance computing
- Support for shared-memory multi-core parallelization (unlimited cores)
- Job distribution over LSF, SGE etc. (Coming Soon)

## Under-The-Hood

The primary innovation in Compliance-Scope® lies in combining data-based models with physics-based simulation engines:
**Physics-based Simulation:** Fast 3D full-wave Electromagnetic solver, 2D (Multi-conductor Transmission Line) Electromagnetic solver, circuit and system solvers.
**Data-based Models:** LISN, Injection clamp, Monitor probe, Antenna, EMI-receiver and operating condition dependent IC-models




## EMI-EMC Simulator vs. 3D EM Solver

Compliance-Scope® benefits from 10 years of research output in the form of theory and algorithms, developed at the Indian Institute of Science (IISc), Bangalore. Summarizing, an EMI/EMC simulator is often confused with a 3D full-wave EM solver. This is not accurate. A 3D full-wave EM solver is a general methodology applicable to a range of different problems including Signal and Power integrity, RCS prediction, EMI/EMC, antenna simulation etc. However, in order to efficiently and reliably solve EMI/EMC problems towards a Virtual EMI/EMC laboratory software, much more than just a 3D full-wave solver is required.

Some of those key ingredients are tabulated below.

| Topic | Sub-Topic | Compliance-Scope® | Market 3D EM Solvers |
|---|---|---|---|
| Data-Models | IC- Models | IC immunity and emission models as per IEC 62433 standards | NA |
| | | Operating condition dependent IC-models | NA |
| | Equipment Models | Injection Clamp Model | NA |
| | | EMI Receiver Model | NA |
| | | Antenna Models | NA |
| | | LISN Models | NA |
| | | Noise Floor Models | NA |
| Physics-based Simulation | 3D fill-wave solver | Fast Method of Moments stable at "low-frequency" O(NlogN) | FEM or FDTD-$O(N^{1.5})$-a problem for scaling to system-level |
| | | Predominantly Surface Mesh=Large Mesh Size | Predominantly volume mesh-problem in radiated EMI/EMC |
| | | Built of many- core - good parallel scalability | Parallel scalability changes from good to bad across tools |
| | Hybrid EM solver | Use of hybrid 3D and 2D EM solvers automatically selected by tool | Both 3D and 2D solvers are available but applicability is left to users |
| | EMI/EMC special features | Adaptive Frequency Sweep on field and LISN voltage outputs for fine frequency samples requried in RE and CE | Adaptive Frequency Sweep only on S-parameters |

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## Post Processing Features

Radiated Emissions

- Electric field at the antenna
- Magnetic field at the receiver (Coming Soon)
- Limit lines
- Field contribution from individual sources

Conducted Emissions

- Potential at LISN
- Current at monitor clamp
- Limit lines
- LISN voltage and current contribution from individual sources

Conducted Susceptibility

- Noise potential at IC pins
- Noise current at IC pins
- Noise power at IC pins
- Ability to import IC-model limit-lines for pass/fail prediction

Radiated Susceptibility

- Noise potential at IC pins
- Noise current at IC pins
- Noise power at IC pins
- Ability to import IC-model limit-lines for pass/fail prediction

Common Features

- Electric surface current density for analysis and debugging
- Report generation in HTML or PDF file format

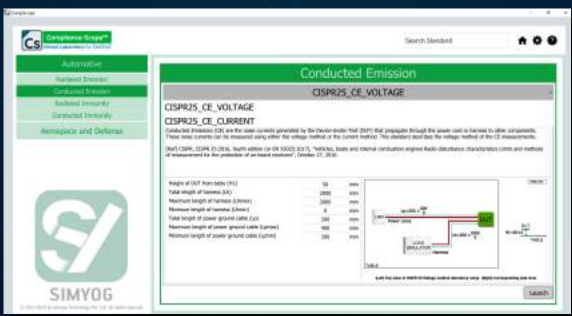
## Demonstrated correlation with measurement

Evidence of correlation with laboratory measurements for

- Radiated Emission
- Conducted Emission
- Radiated Immunity
- Conducted Immunity

## License features

Supports node-locked and floating license
Supports 64-bit Windows/Linux
Supports unlimited cores for multi-core parallelization
Training is included




Front Screen

Project Tree Windows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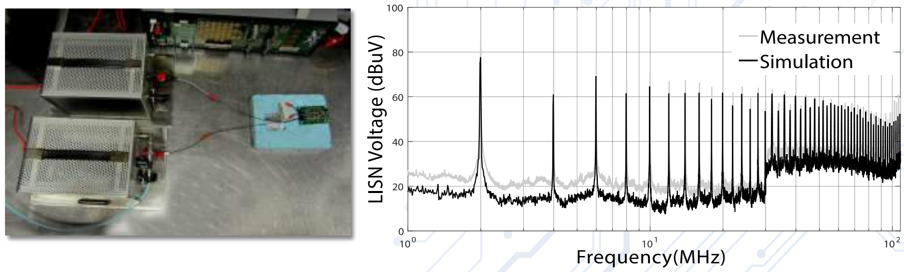
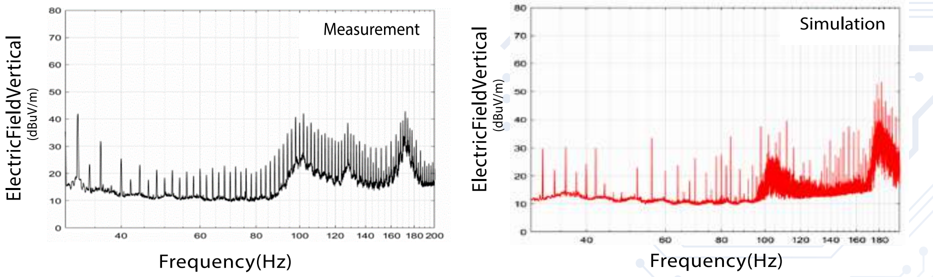
## Simulation vs. Measurement Correlation

In this work, in partnership with Panasonic, Product Analysis Center, the Conducted Emissions (CE) from a DC-DC converter PCB, as measured using CISPR25 voltage method, was correlated to simulation results obtained from Compliance-Scope®.



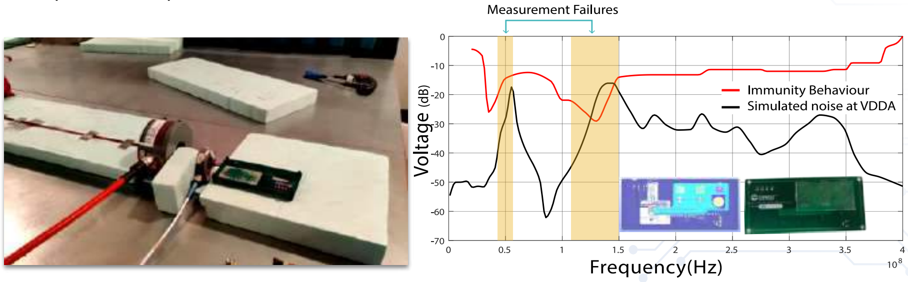

### CE Simulation vs. Measurement Correlation

For the same DC-DC converter unit the Radiated Emissions measurement was performed and correlated with Compliance-scope simulation. Our aim is to be within 6 dB of measurement.




### RE Simulation vs. Measurement Correlation

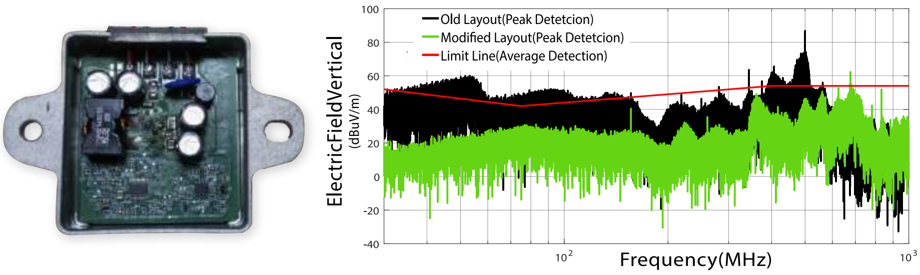
In the next example, in partnership with Cypress Semiconductors (now Infineon Technologies), the Bulk Current Injection failure of a capacitive tough sensor PCB comprised of PSoC4 IC is predicted using PSoC4 IC-model and simulation using Compliance-Scope®, as shown below.



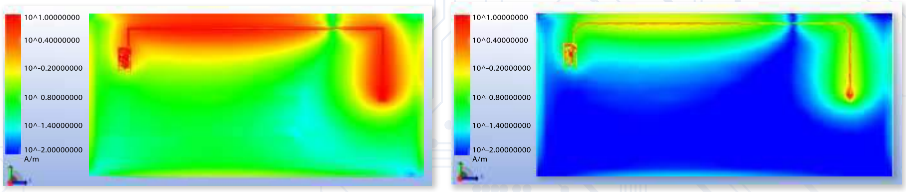

### BCI Simulation vs. Measurement Correlation

## What-if Analysis

One of the key advantages of a Virtual EMI/EMC simulator is its capability to run multiple what-if analysis towards an optimized hardware.
In this example, in partnership with well-known automotive supplier, the Radiated Emissions (RE) from a power converter unit was improved by modification of layout as shown below.




The next example, demonstrates the variation in current density profile on the system-level due to twisting of cables.



No twist in cables    With twisted cable