

USB4 IP IBIS-AMI Modeling with SerDes and SI Toolbox

Use MATLAB Toolboxes in Customized IBIS-AMI Modeling Flow

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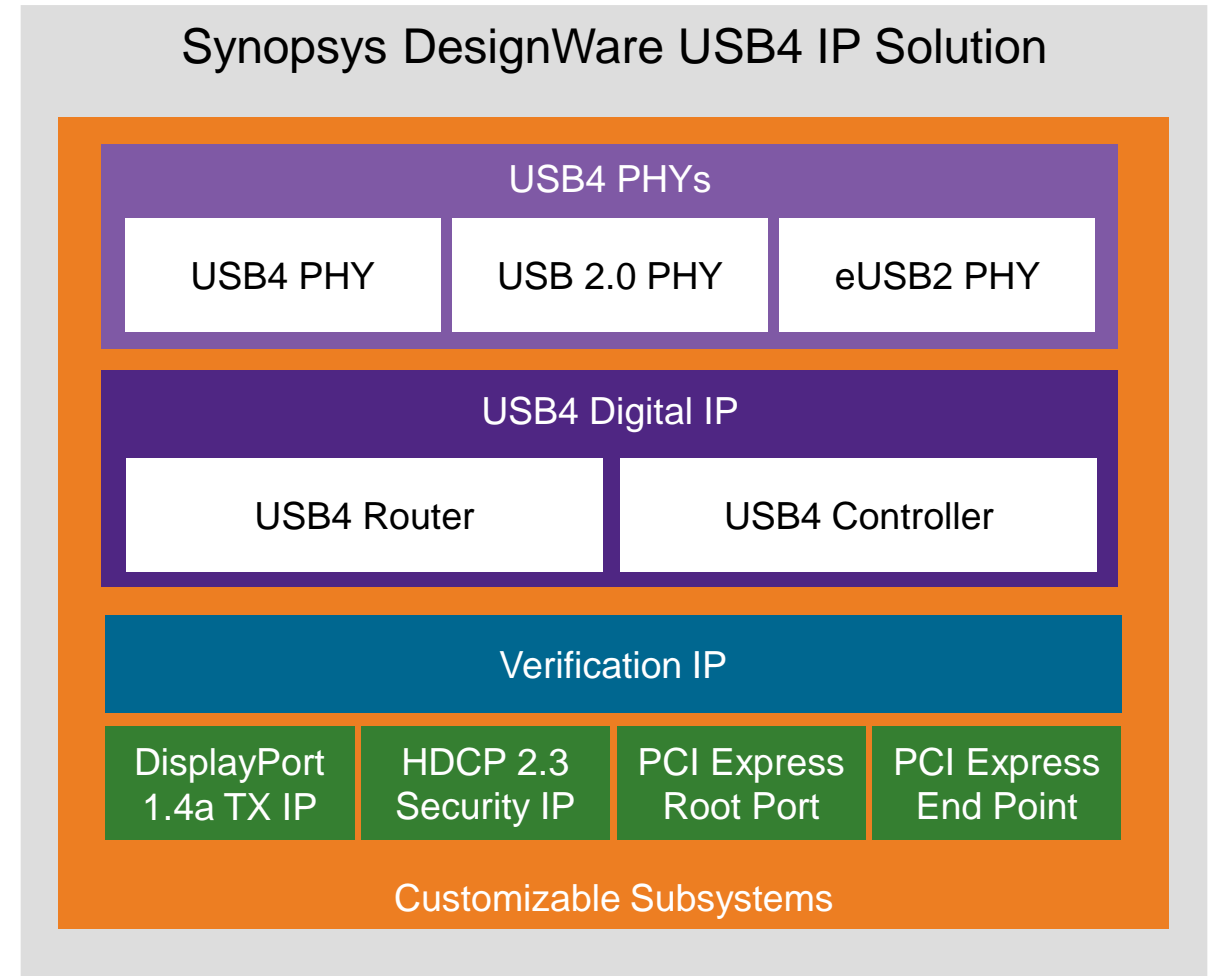
Agenda

- Overview of IBIS-AMI
 - Why using IBIS-AMI model?
 - Common IBIS-AMI modeling approaches
- MATLAB Toolboxes in IBIS-AMI modeling
 - Model generation: from Simulink to SerDes Toolbox
 - C++ project modification with Python scripting
 - Model verification: simulation correlation with SI Toolbox
- Future opportunities
 - Enhancements for flexible IBIS-AMI modeling

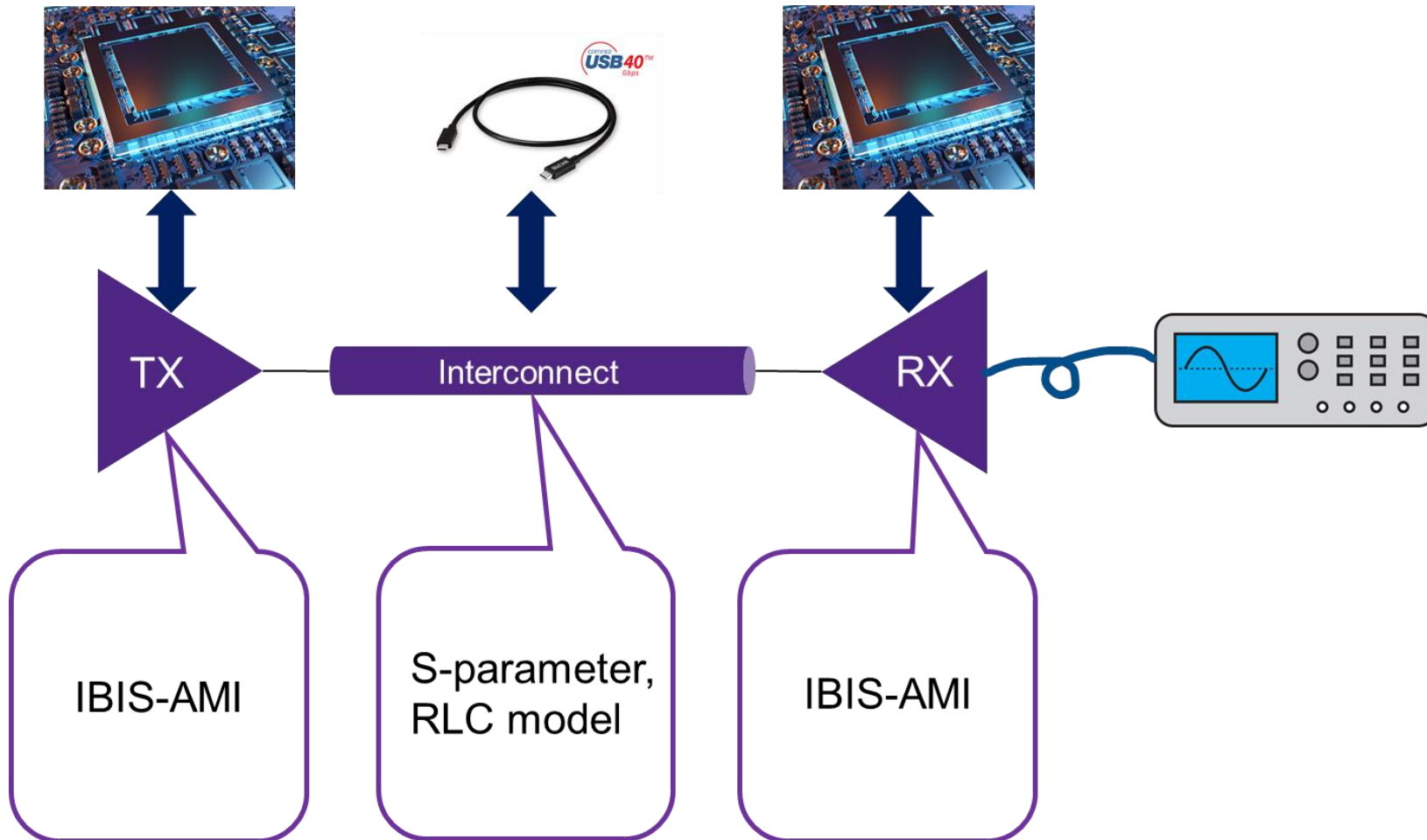
DesignWare USB4 PHY, Router & Controller IP

Flexible solution delivering new speeds and backward compatibility

- DesignWare USB4 IP solution supports all features in the USB4 specification
- USB4, DisplayPort with HDCP 2.3, PCI Express & Thunderbolt 3 through USB Type-C
- New USB4 router IP tunnels USB, PCIe & DisplayPort traffic while optimizing bandwidth
- Throughput of up to 40 or 20 Gbps for high-performance edge AI, storage, PC, and tablet SoC designs



Why Using IBIS-AMI Models?



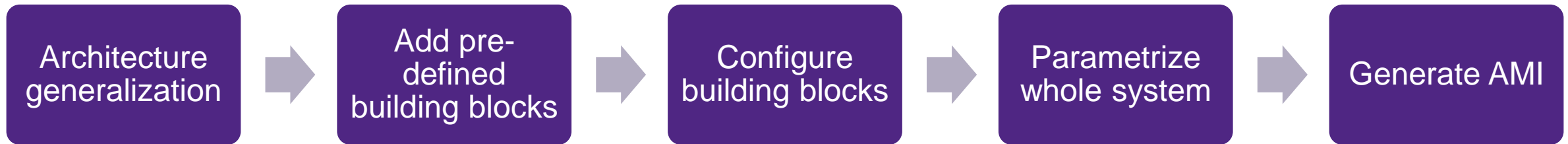
- Fast end-to-end channel simulations with good accuracy
 - Considering tight USB4 insertion loss budget of 23dB at 10GHz (end to end), IBIS-AMI simulations enable agile optimization of interconnect models
- Flexibility in model complexities
- Ability to co-simulate with other industry modeling specification

[1]"USB4 Gen 3 Type-C Cable," www.bizlinktech.com. <https://www.bizlinktech.com/ja/products/detail/1421/USB4+Gen+3+Cable> (accessed Jun. 15, 2022)

[2]"FPGA Prototyping Powers the SoC Design/Verification Process," *From Silicon To Software*, Apr. 15, 2021. <https://blogs.synopsys.com/from-silicon-to-software/2021/04/15/fpga-prototyping-soc-design-2/> (accessed Jun. 15, 2022)

Common IBIS-AMI Modeling Approaches

Alternative 1: generic IBIS-AMI



Alternative 2: direct coding

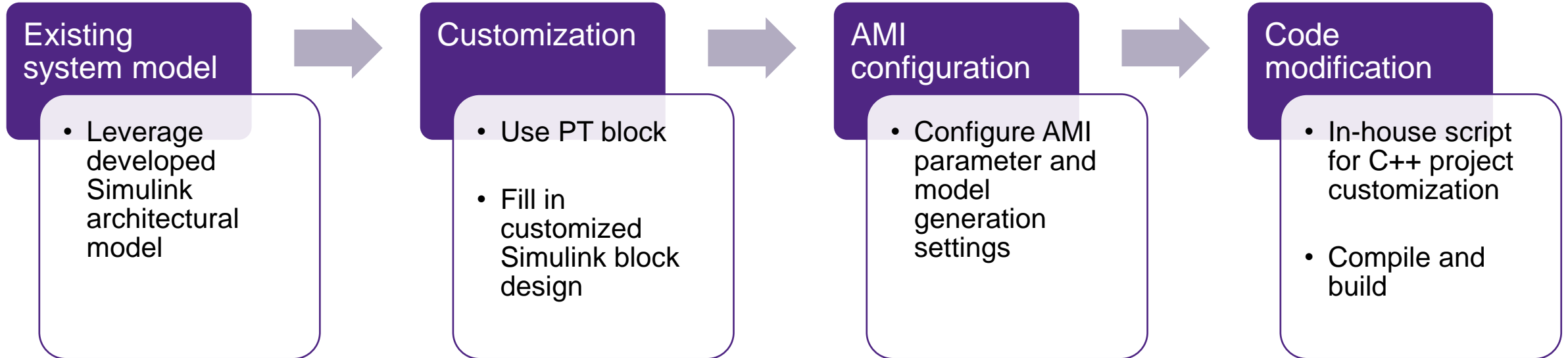


- Alternative 1 enables fast model generation with simplified architecture
- Alternative 2 applies to non-complex architecture

MATLAB Toolboxes in IBIS-AMI Modeling

From SerDes Toolbox Model Generation to SI Toolbox Model Verification

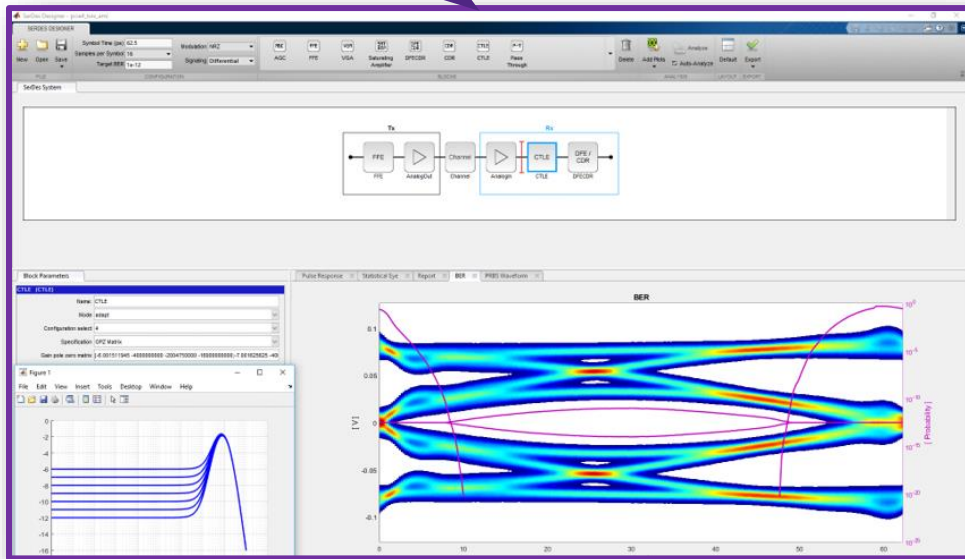
Overview of Modelling Process



Model Generation

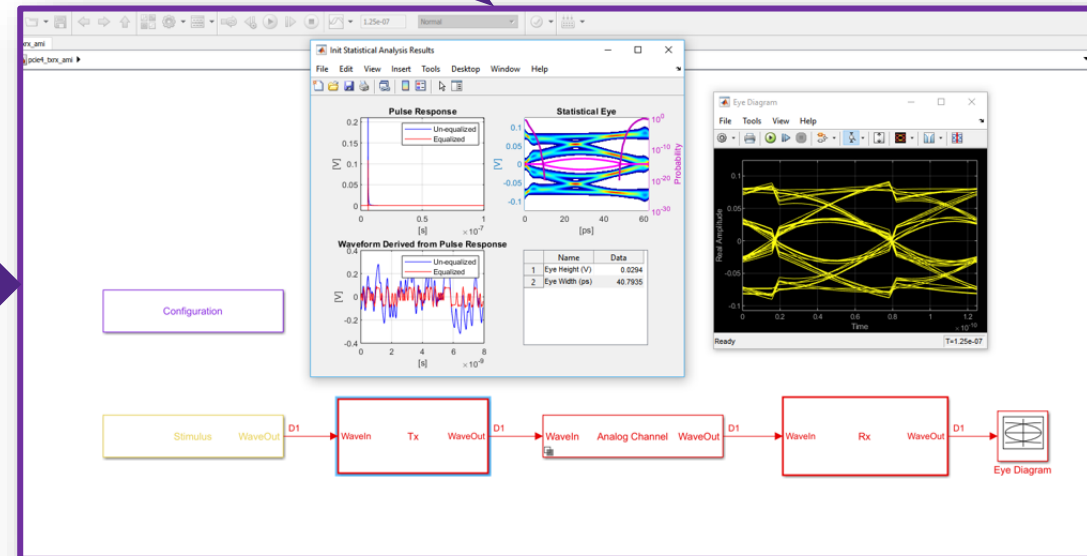
SerDes Toolbox Architecture

- TX to RX Link
- TX/RX with SerDes Toolbox building blocks



Design Export

- Exported Simulink model
- Simulink/MATLAB channel simulations

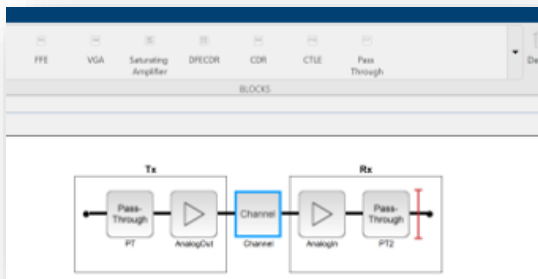


Model Generation (Cont.)

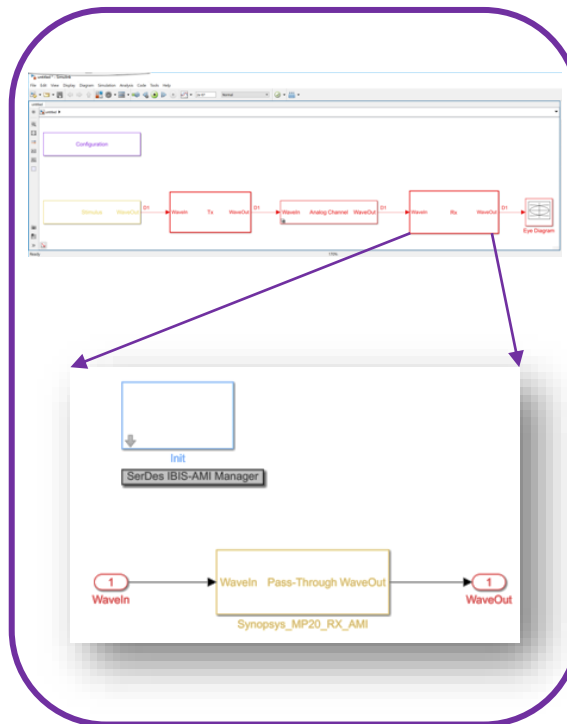
Fitting Customized Implementations

Add Pass-through block

SerDes Toolbox

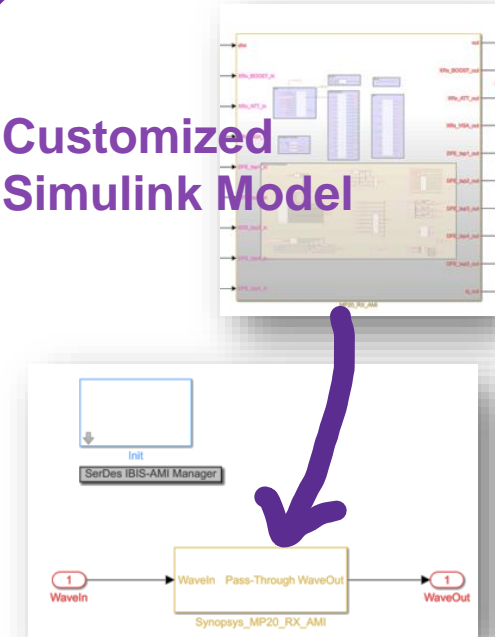


Export design with PT block



Fit customized logic

Customized Simulink Model



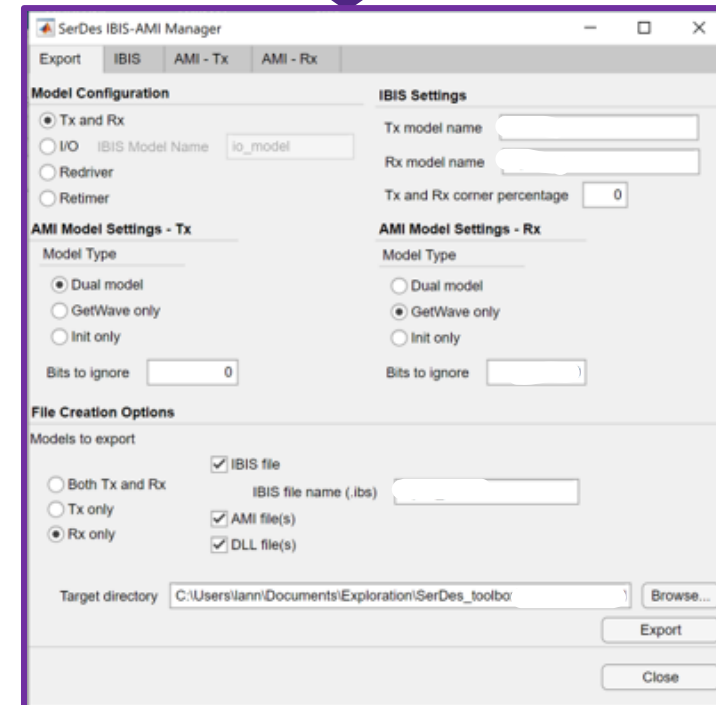
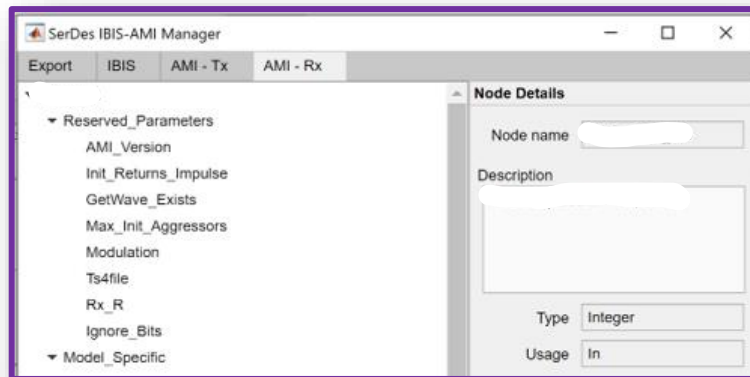
Model Generation (Cont.)

SerDes IBIS-AMI Manager Configurations

AMI parameters configuration

IBIS & executable configurations

Export model



Model Generation (Cont.)

C++ Project Modification with Python Scripts

Compile & build

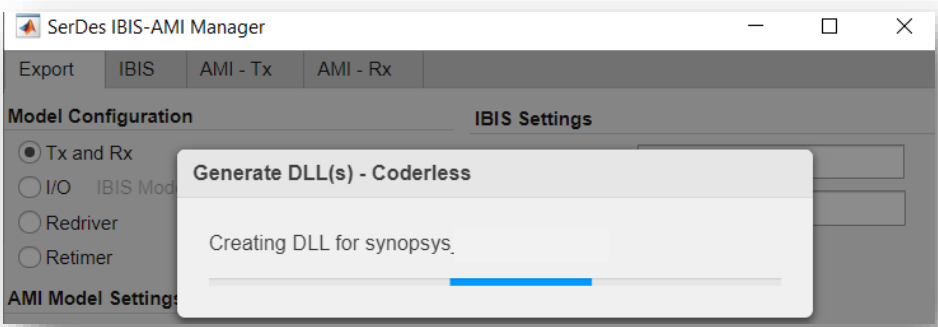
- **Generated C++ AMI project**

Code modification

- **In-house Python utilities**
- **Automatically update C++ project**

Generate executable

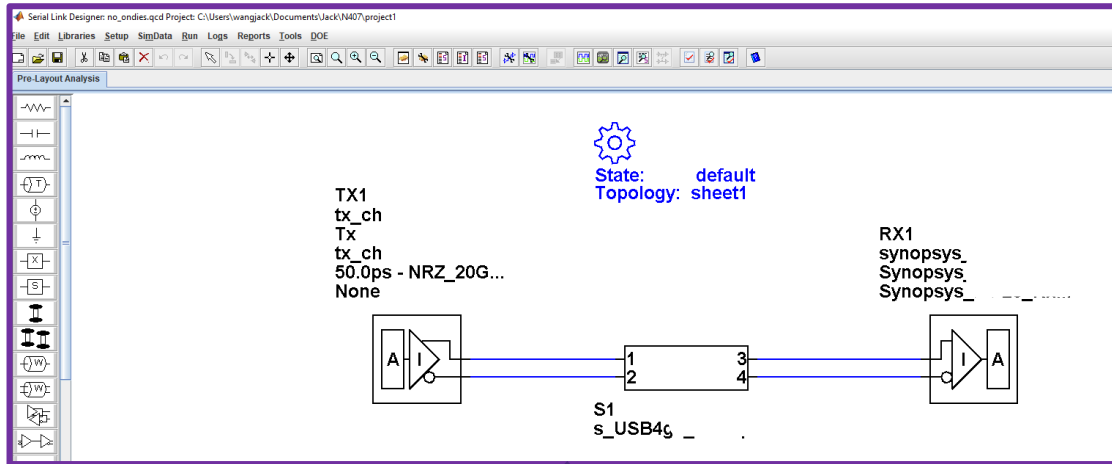
- **Compile & build updated C++ project**



```
122
123 // Open and initialize the debug files
124 fp_debug_m = dbgOpenFile(NULL, (char*)"AMI_Debug.m", (char*)"");
125 fp_init_in = dbgOpenFile((char*)"impulse_matrix_in_file", (char*)
126 "_impulse_response_in.csv", imp_hdrs);
127 if (fp_debug_m != NULL && fp_init_in != NULL) {
128     fprintf(fp_debug_m, (char*)
129         "%s.impulse_matrix_in_data = readmatrix(%s.impulse_matrix_in_file,'NumHeaderLines',1);\n",
130         debug_struct_name, debug_struct_name);
131 }
132
133 fp_init_out = dbgOpenFile((char*)"impulse_matrix_out_file", (char*)
134 "_impulse_response_out.csv", imp_hdrs);
135 if (fp_debug_m != NULL && fp_init_out != NULL) {
136     fprintf(fp_debug_m, (char*)
137         "%s.impulse_matrix_out_data = readmatrix(%s.impulse_matrix_out_file,'NumHeaderLines',1);\n",
138         debug_struct_name, debug_struct_name);
139 }
140
141 fp_wave_in = dbgOpenFile((char*)"wave_in_file", (char*)"_wave_in.csv",
142     wave_hdrs);
143 if (fp_debug_m != NULL && fp_wave_in != NULL) {
```

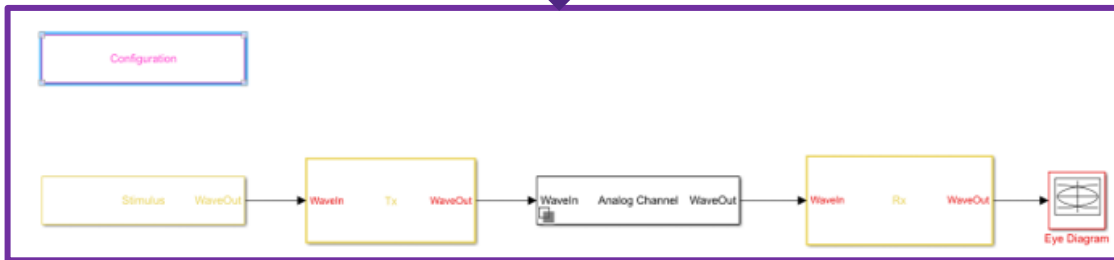
Model Verification

SI Toolbox vs. Simulink



SI Toolbox simulation

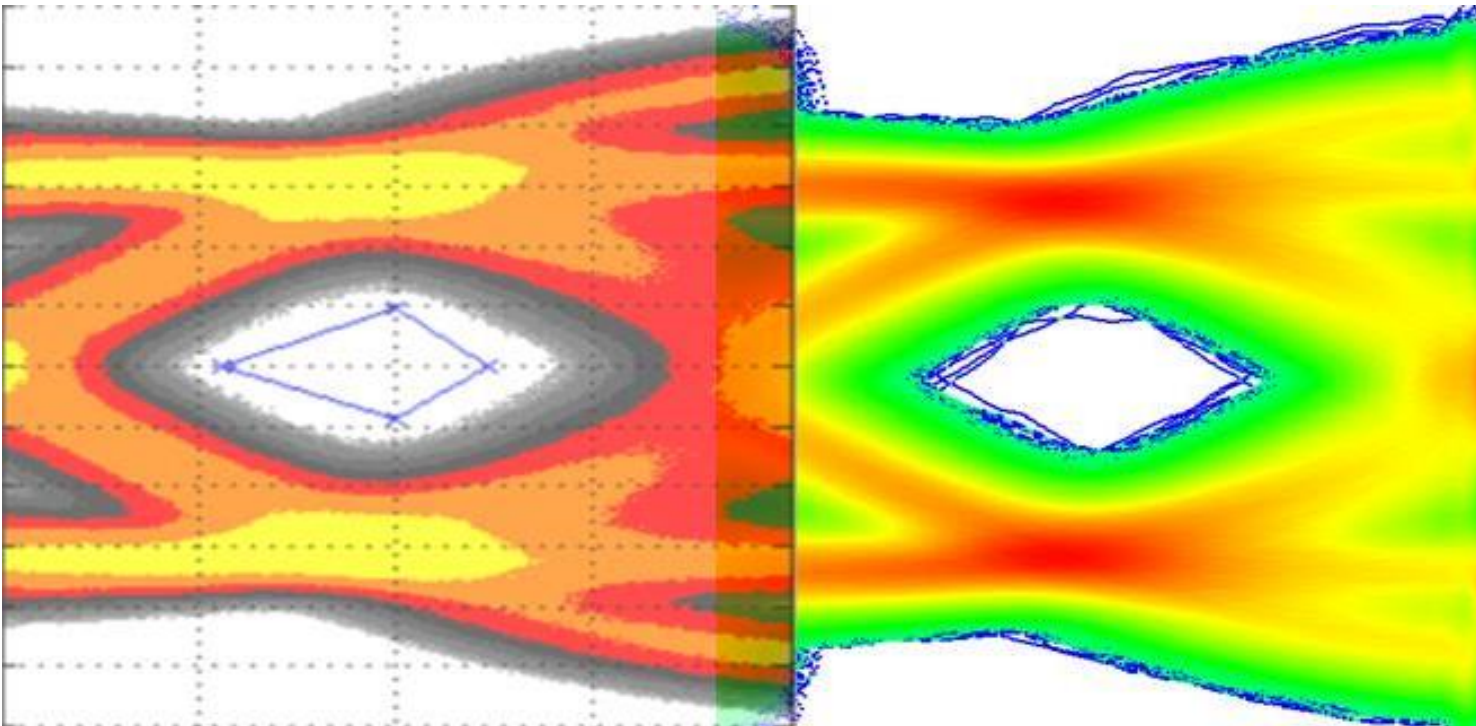
Eye correlation



MATLAB Simulink simulation

Model Verification

Eye Diagrams Correlation



- MATLAB/Simulink simulation results (**Left**)
- SI toolbox simulation results (**Right**)
- Good correlation achieved between two simulation methodologies

Future Opportunities

Enable Flexible IBIS-AMI Modeling Solutions



Flexible IBIS-AMI Modeling Solutions

Make Customized Modeling Trivial



Challenges: single AMI parameter configuration at one time



Can we configure & import all AMI parameters at once?



Proposal: configure and load all AMI parameters by file import

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Thank You

