Wave Digital Filter Modeling for Complex Automotive Sensor Load Case Verification

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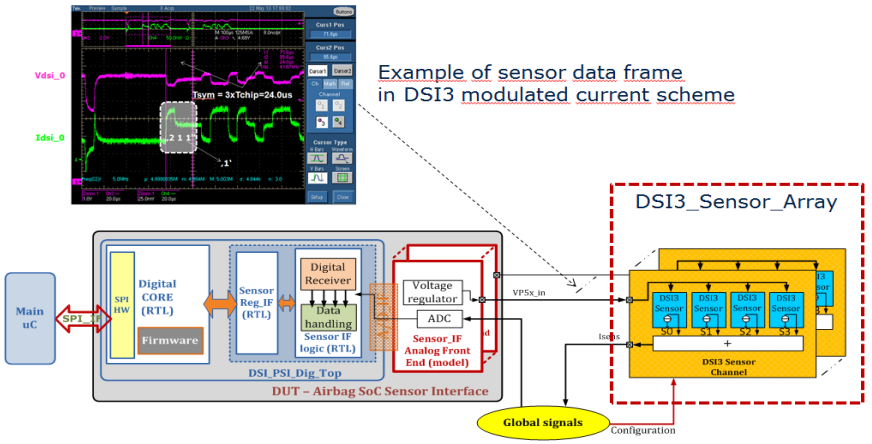
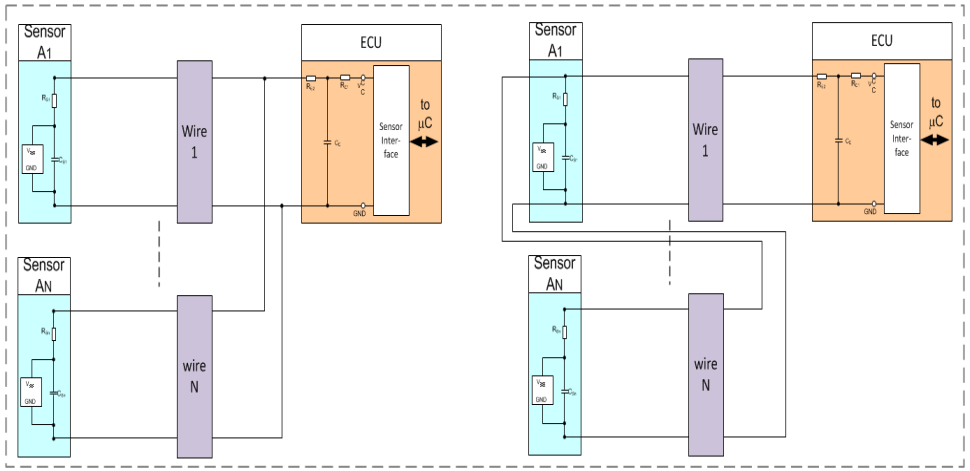
Agenda

- Challenges
- Background
- WDF Model Implementation
- WDF Model Validation
- Conclusion

Challenges - I

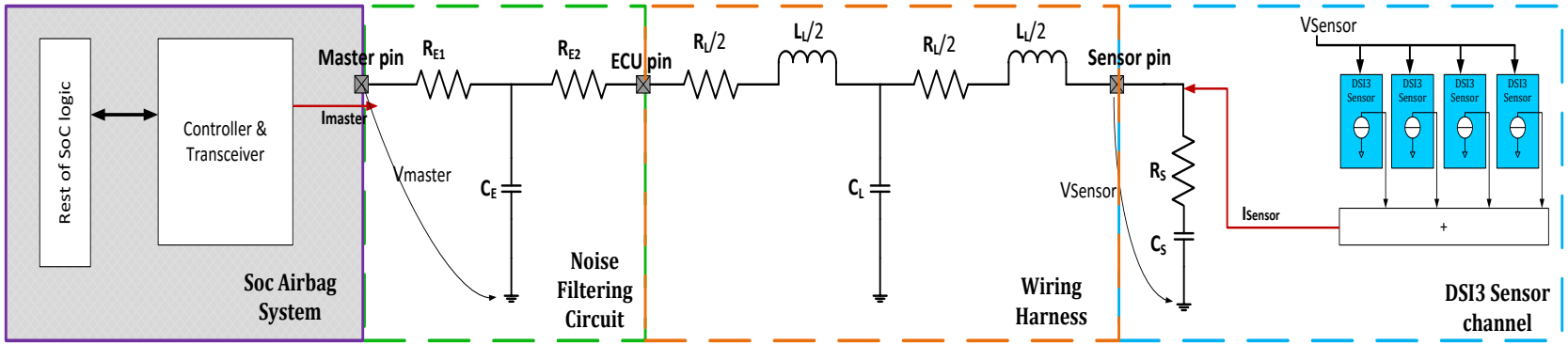
- Event-driven verification on top with real-value modeling for automotive mixed-signal SoCs
- DUT: In-application verification requirement
  - Different bus architectures - serial, parallel and daisy chain
  - Between 1 and 4 sensors per channel
  - Line length 0…12m equal to line inductance 0…8.7mH
  - Capacitive load per sensor 5…20nF





Challenges - II

- Fast simulation using a simple but ”accurate” discrete time model
- Keep the real timing behavior of the real load => solve the delay less loop problem

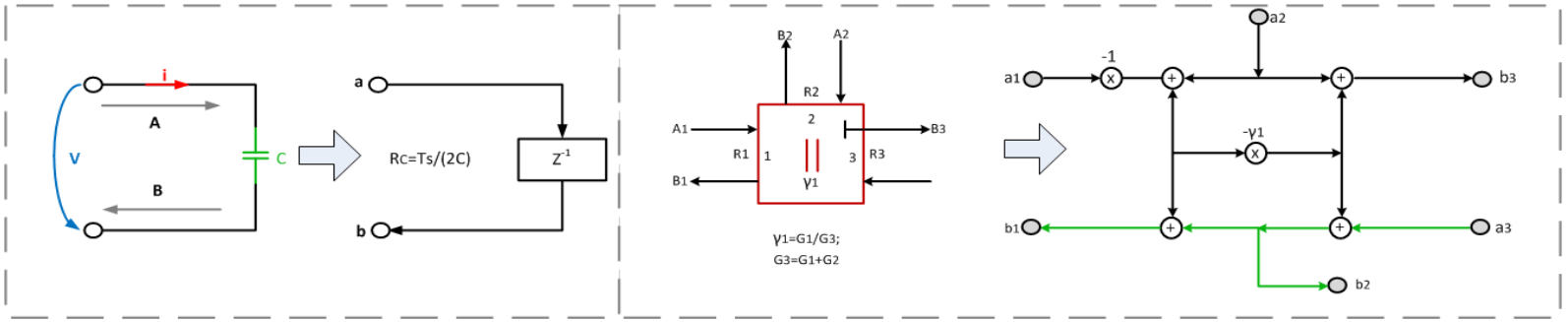


Background

- Wave Digital Filters (WDF) Theory
  - Introduced by Prof. *Alfred Fettweis* in 1971
  - Solve the delay less loop problem by WDF
  - Model the voltage and current by means of waves:

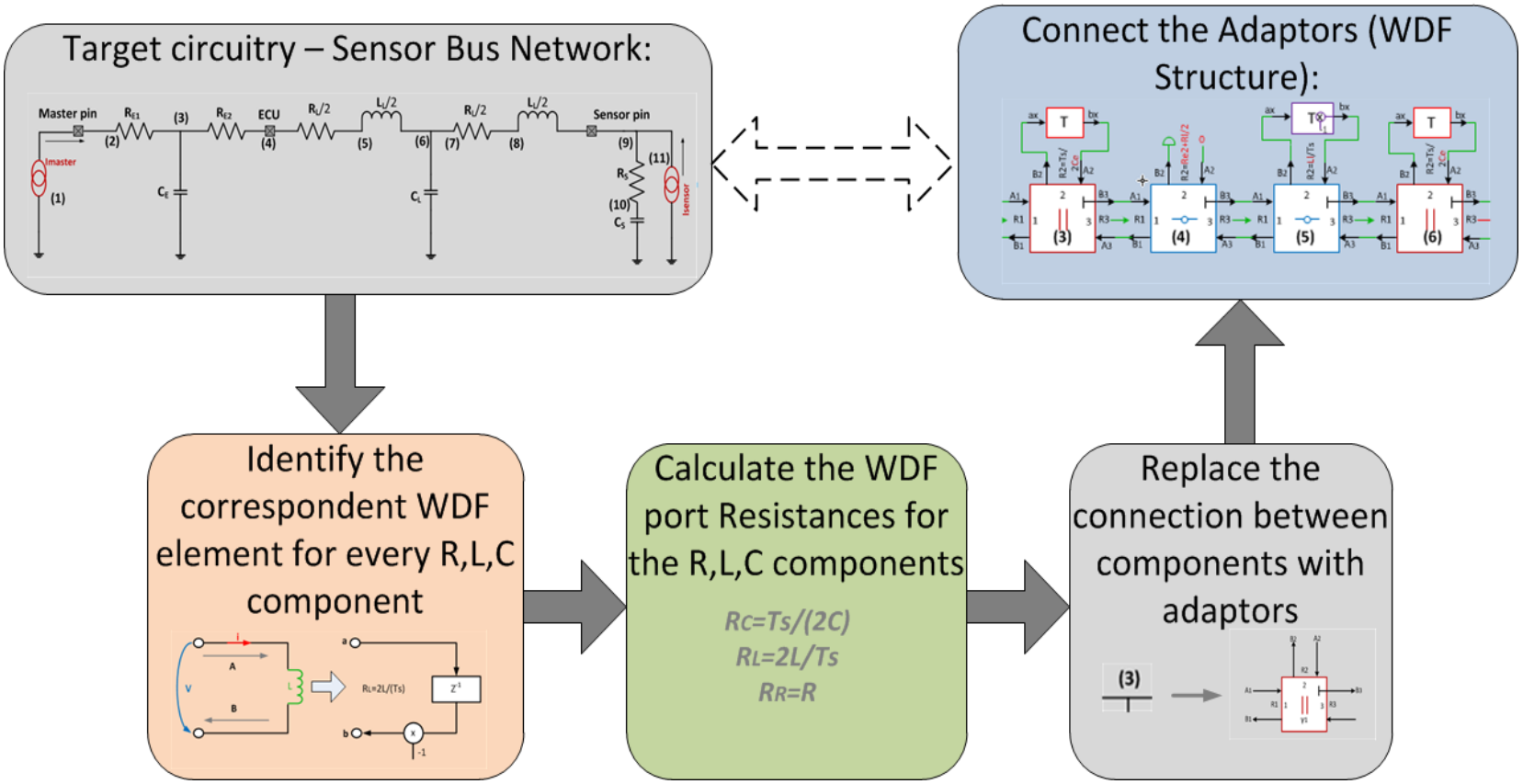
$$v(x) = \frac{a(x) + b(x)}{2}$$
$$i(x) = \frac{a(x) - b(x)}{2R_L}$$

- Key words: waves(incident/reflected), port resistance, WDF elements, Scattering adaptors



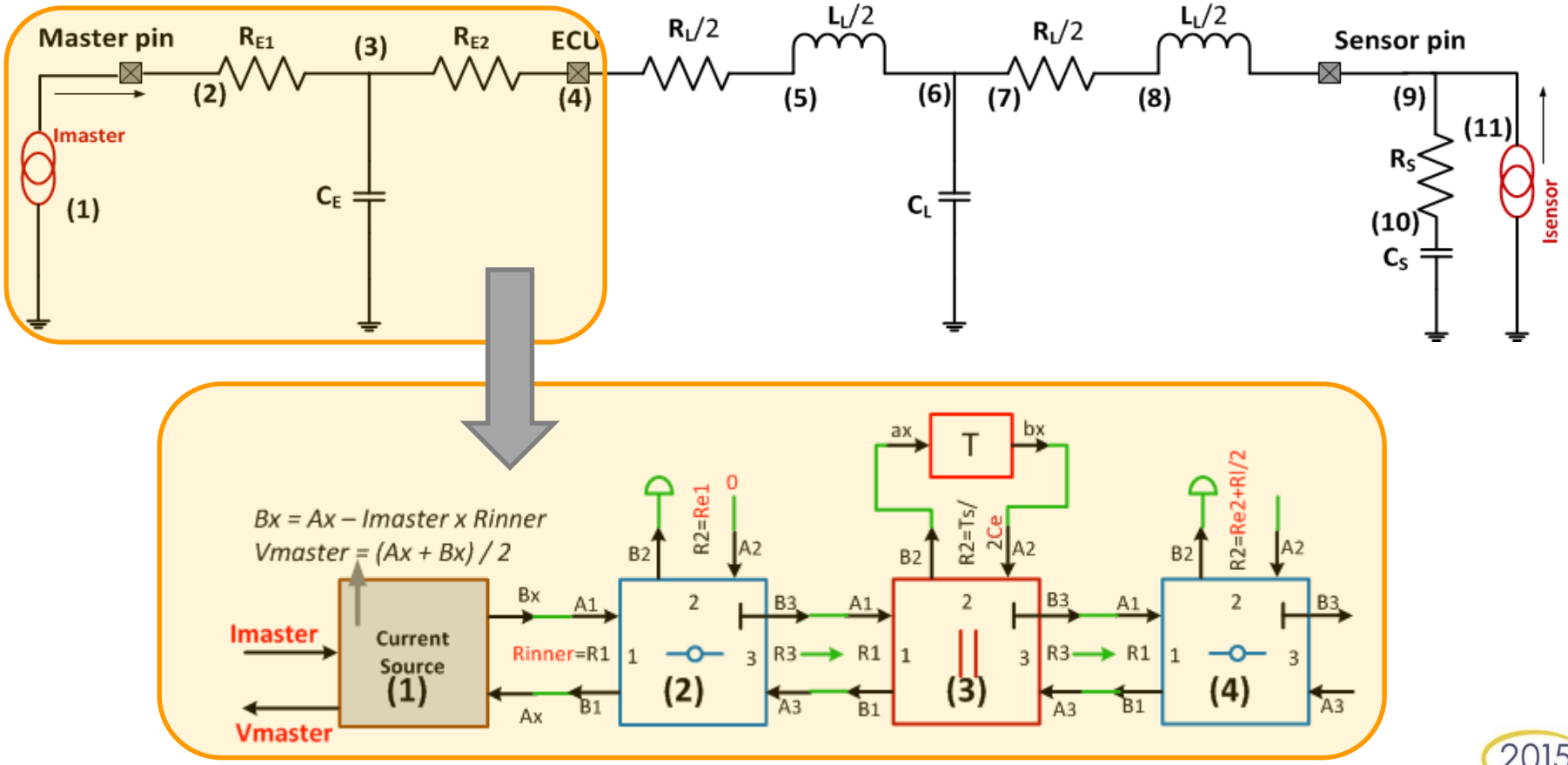
WDF Model Implementation - I

- WDF implementation flow:



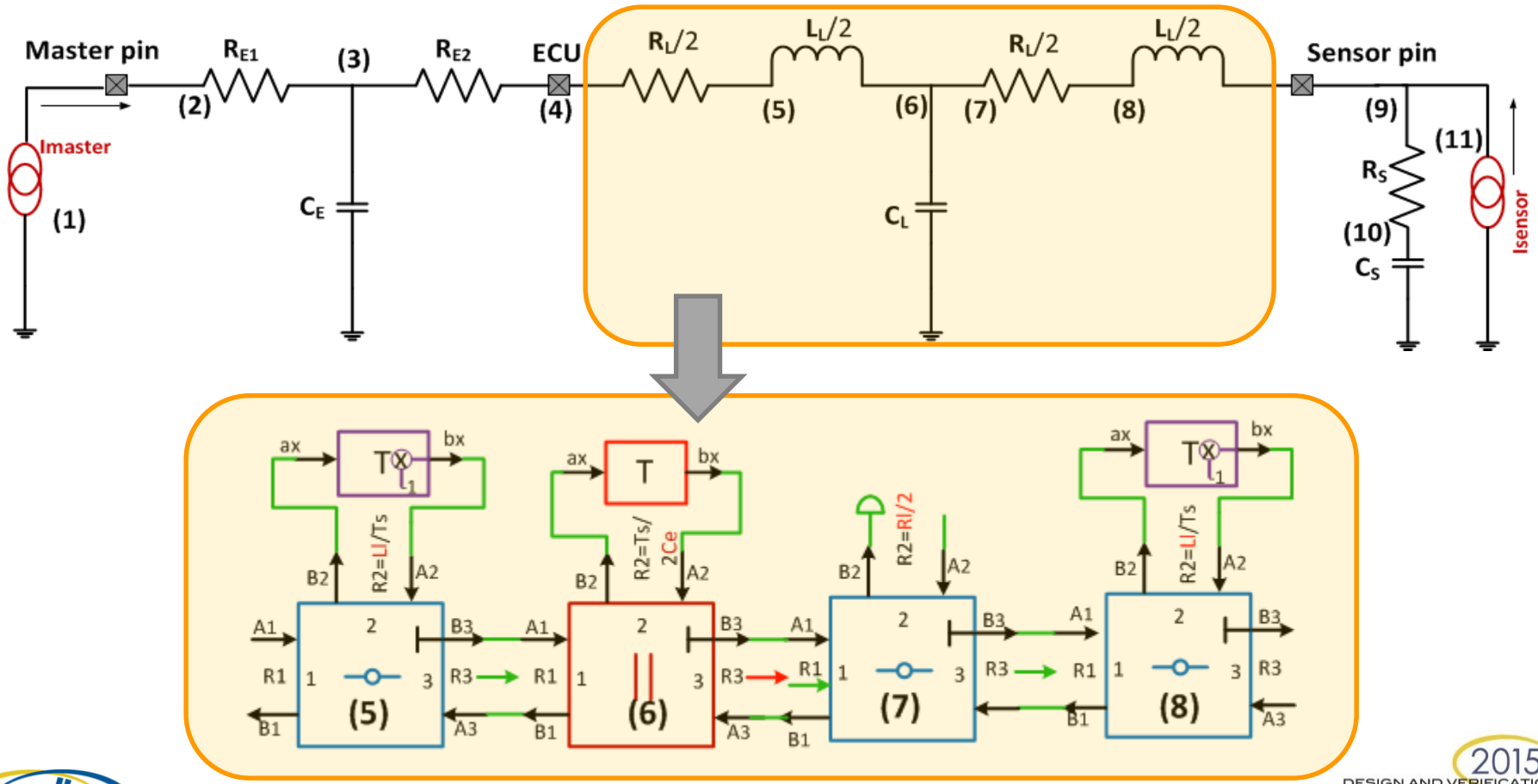
WDF Model Implementation - II

- ECU Noise Filtering:



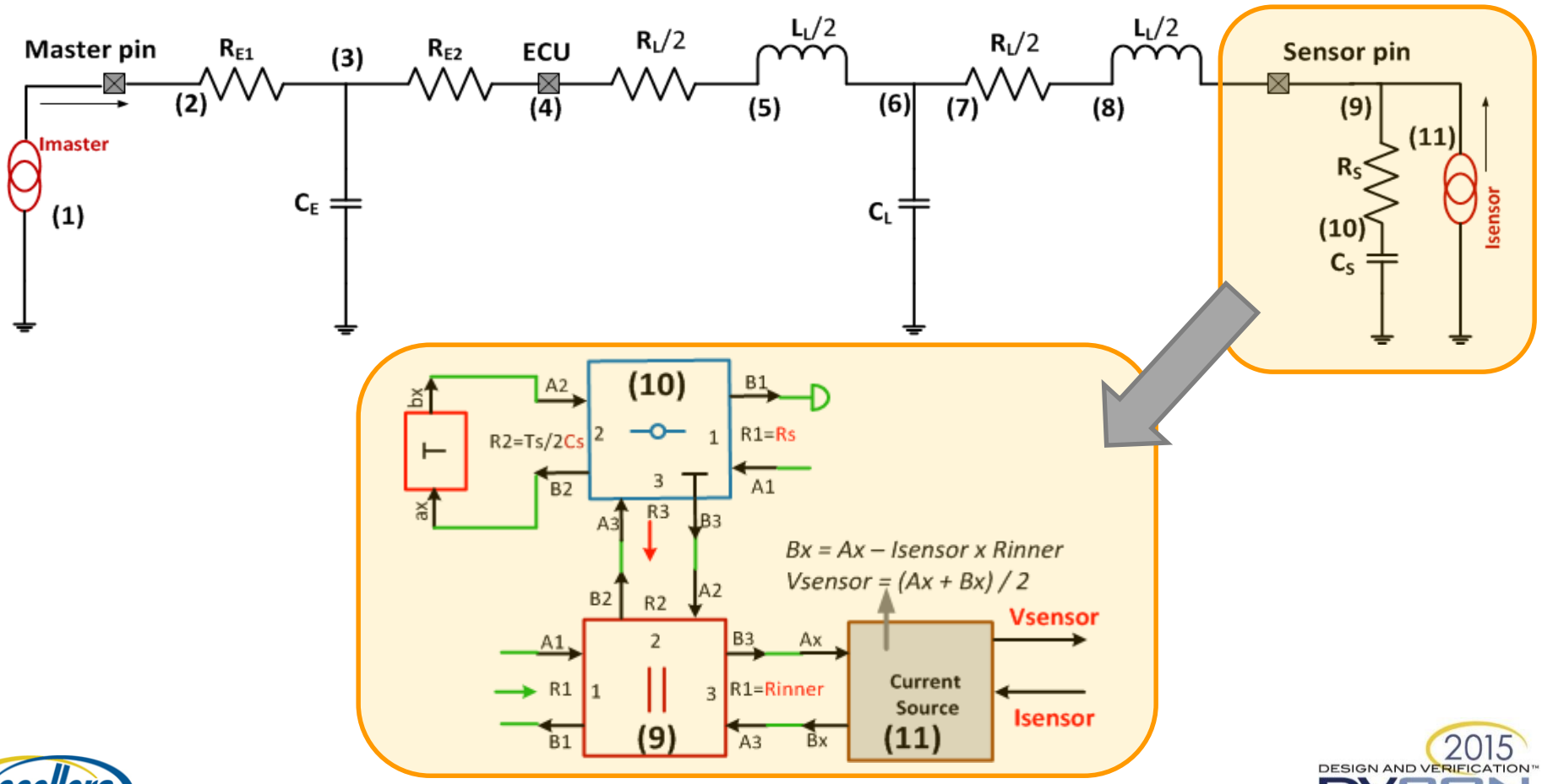
WDF Model Implementation - III

- Wiring Harness:



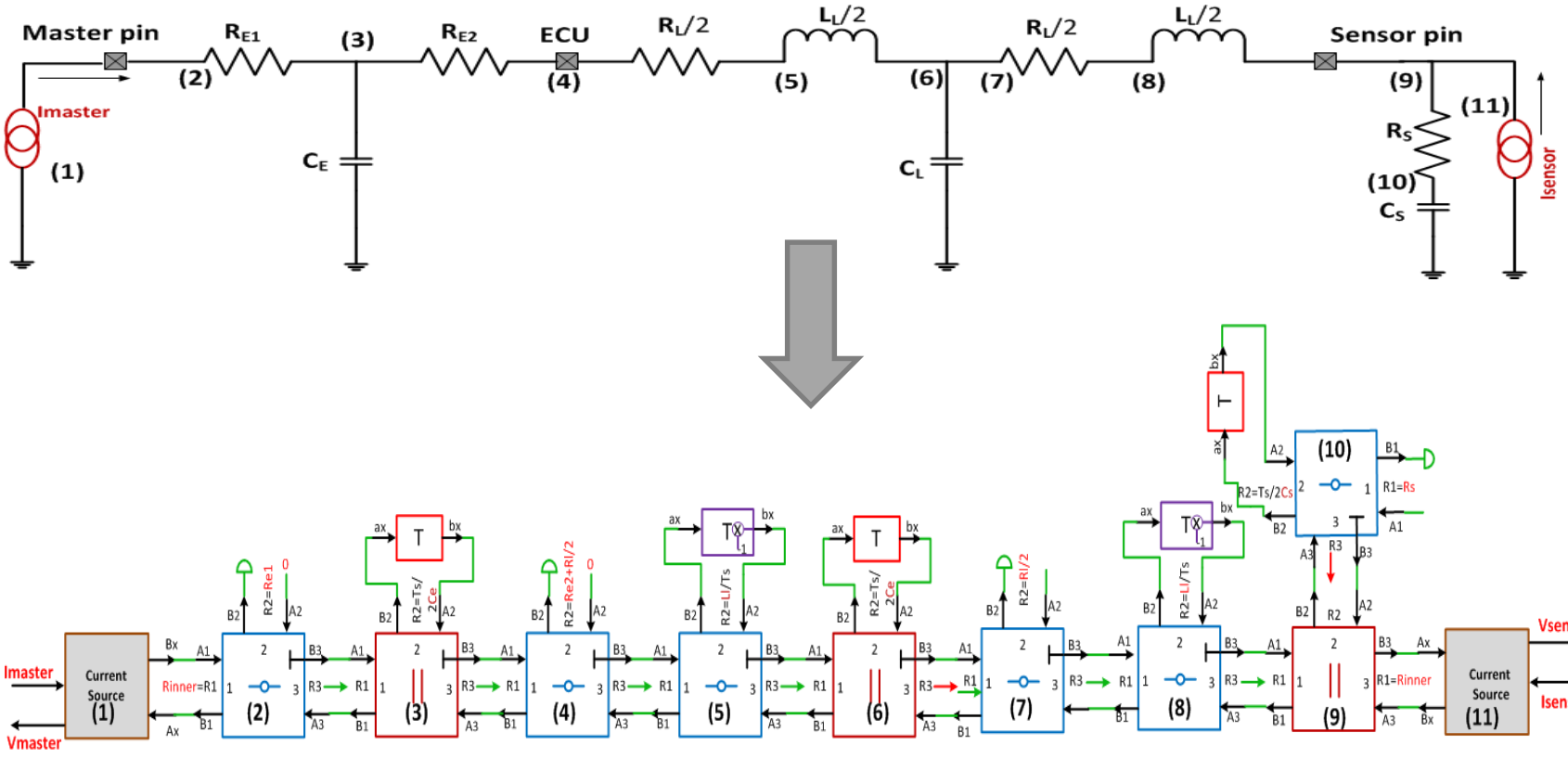
WDF Model Implementation - IV

- Sensor load:



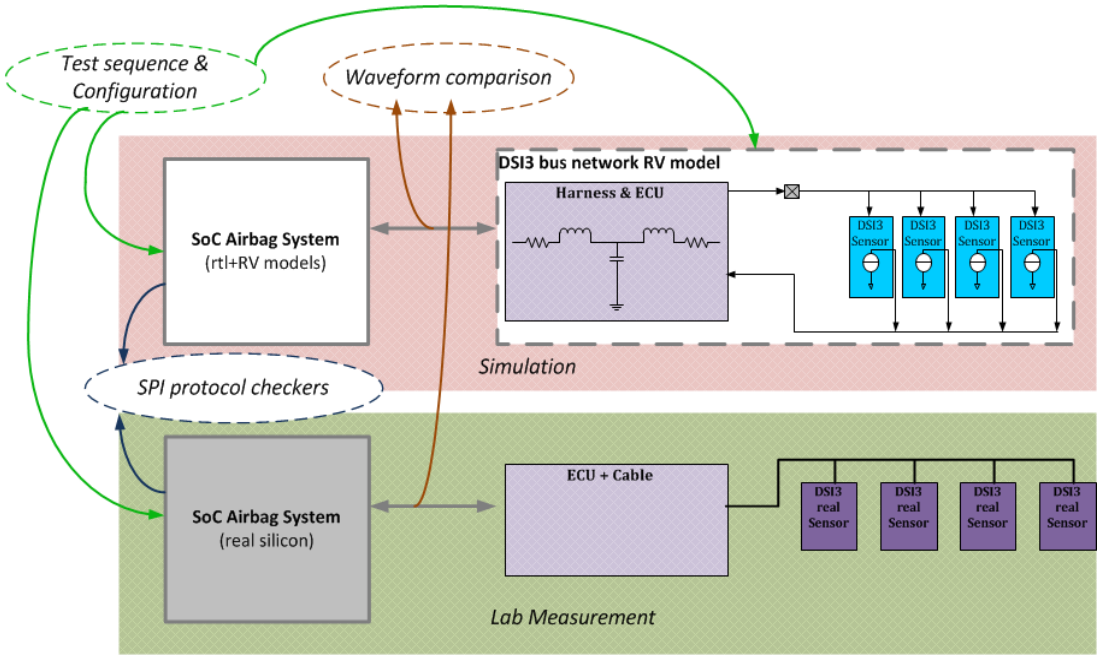
WDF Model Implementation - V

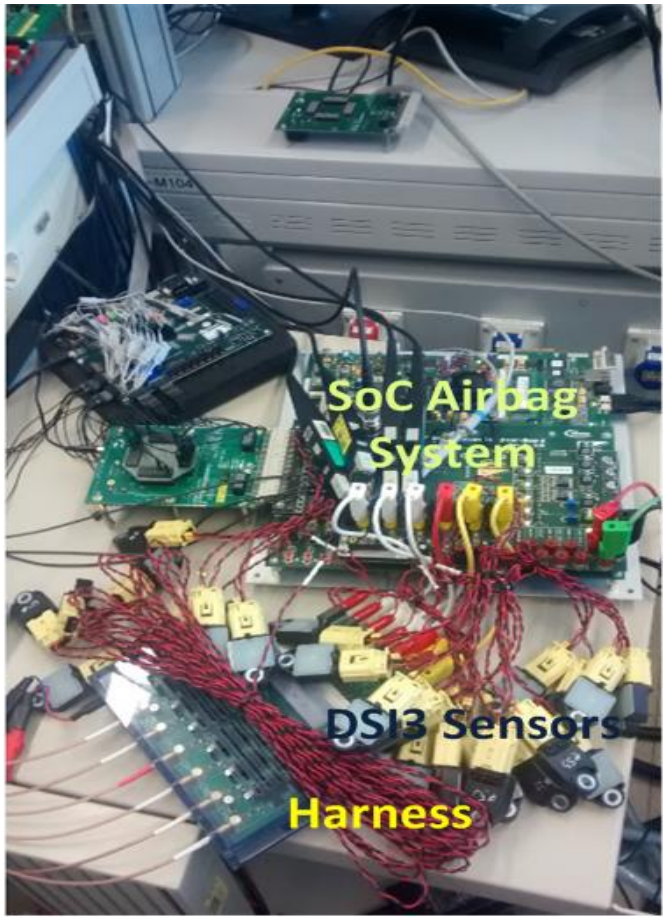
- Sensor bus network - Final WDF Structure:



WDF Model Validation - I

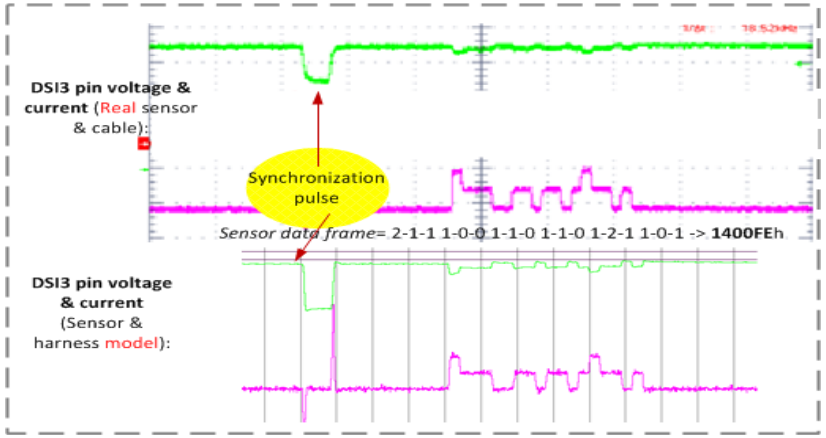
- Validation set-up:



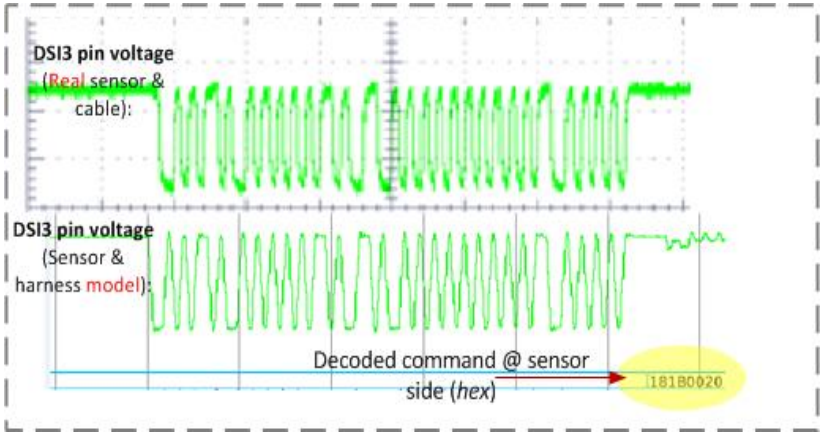


WDF Model Validation - II

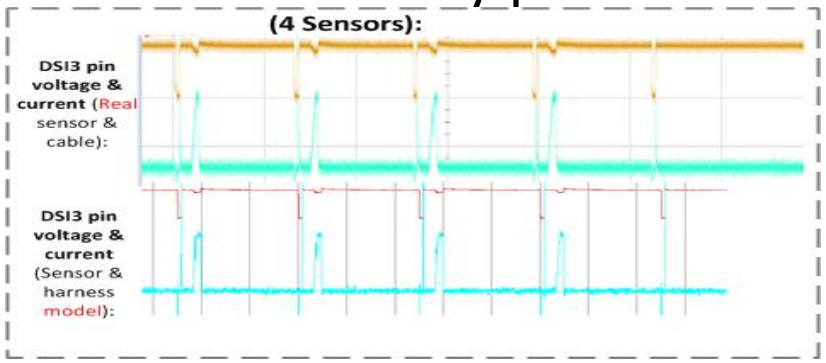
- DSI3 PDCM communication:



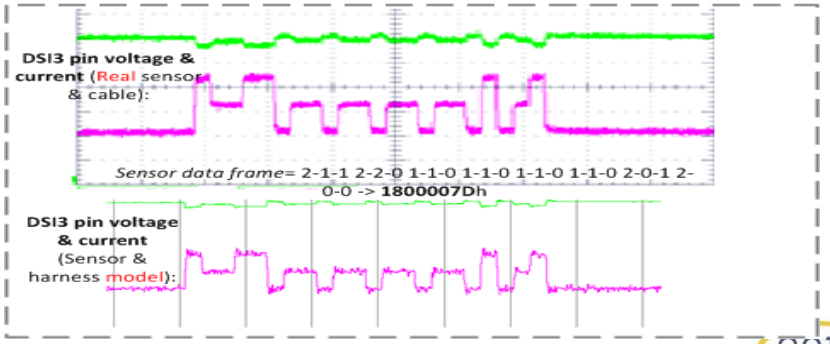
- DSI3 CRM Command:



- DSI3 Discovery phase :

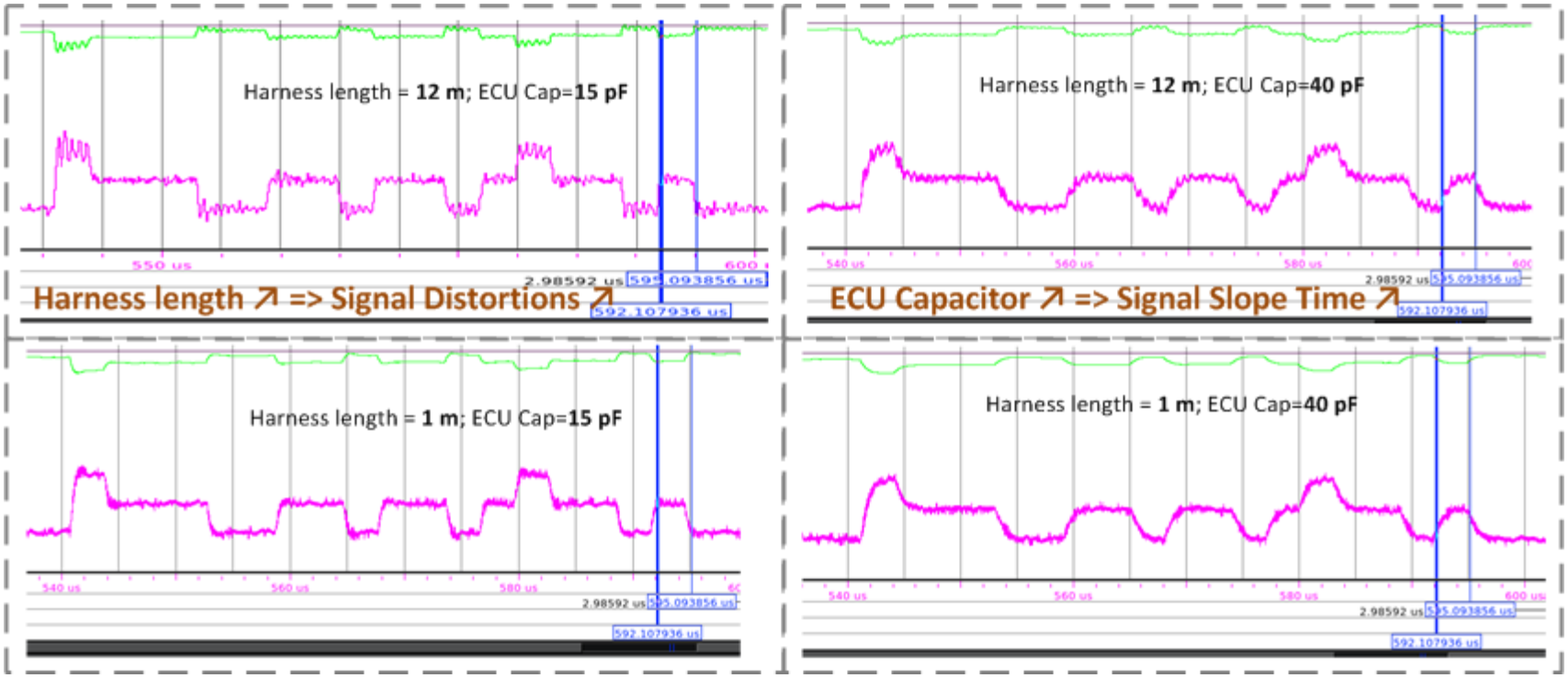


- DSI3 CRM Response:



WDF Model Validation - III

- Sensor signal distortion & Slope time effect:



Conclusion & Outlook

- An innovative (digital, simple but accurate) modeling methodology based on WDF theory is presented
- Verification of the DUT within its application circuits

- Synthesize of WDF wiring harness model into FPGA hardware
- Early in-application integration and validation of product at system level.

Q&A