

CIRCUIT MODELING OF THE ISO 10605 FIELD COUPLED

ELECTROSTATIC DISCHARGE TEST TO DESIGN ROBUST

AUTOMOTIVE INTEGRATED CIRCUITS

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# OUTLINE

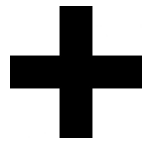
- ISO 10605 Field Coupled Electrostatic Discharge (ESD) Test
- Motivation
- Proposed model
- Validation with an automotive test chip
- Conclusions

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# THE ISO 10605 FIELD COUPLED ELECTROSTATIC DISCHARGE (ESD) TEST

ESD often leads to unwanted behavior (and even damage). Especially in the automotive sector, these unwanted failures cause a great deal of trouble.



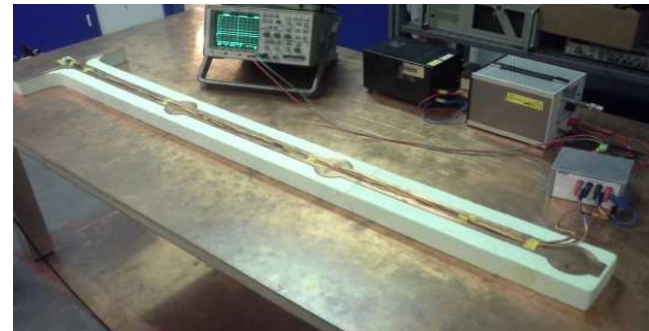
Trends in electronics:

- Miniaturization
- Integration
- Wireless charging

Makes systems even more vulnerable to ESD.



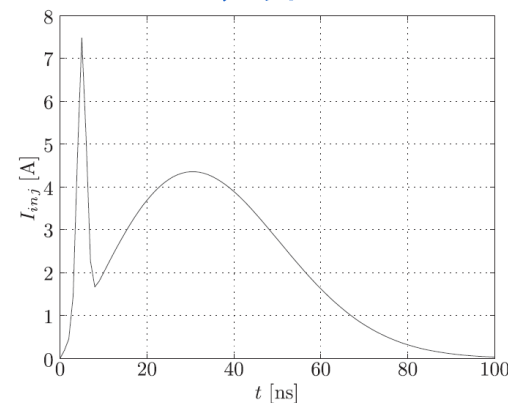
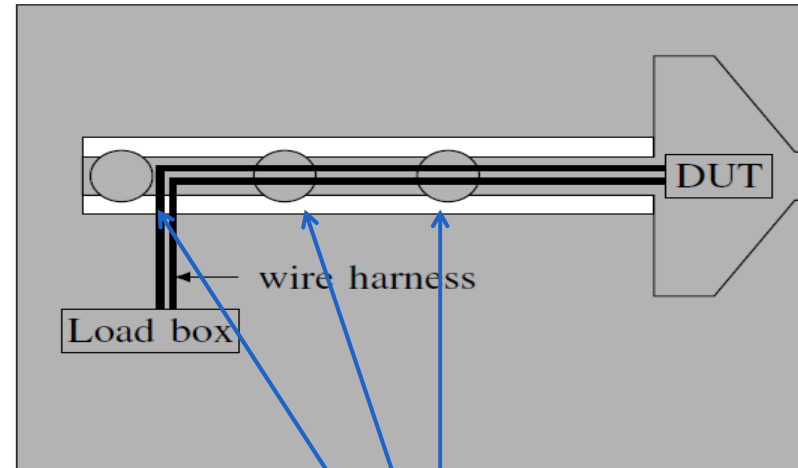
Test method that mimicks possible ESD disturbances at vehicle level: ISO 10605 Field Coupled Electrostatic Discharge Test



# DESCRIPTION OF THE ISO 10605 FIELD-COUPLED ESD TEST

The test setup comprises a **wire harness** connecting a **DUT** with a **load simulator** (aka load box), an **ESD gun** connected to a pulse generator, and a **test bench**

The testbench contains three so-called circular-shaped “islands”. ESD pulses, are injected subsequently at each of the three islands, which its typical IEC 61000 waveforms

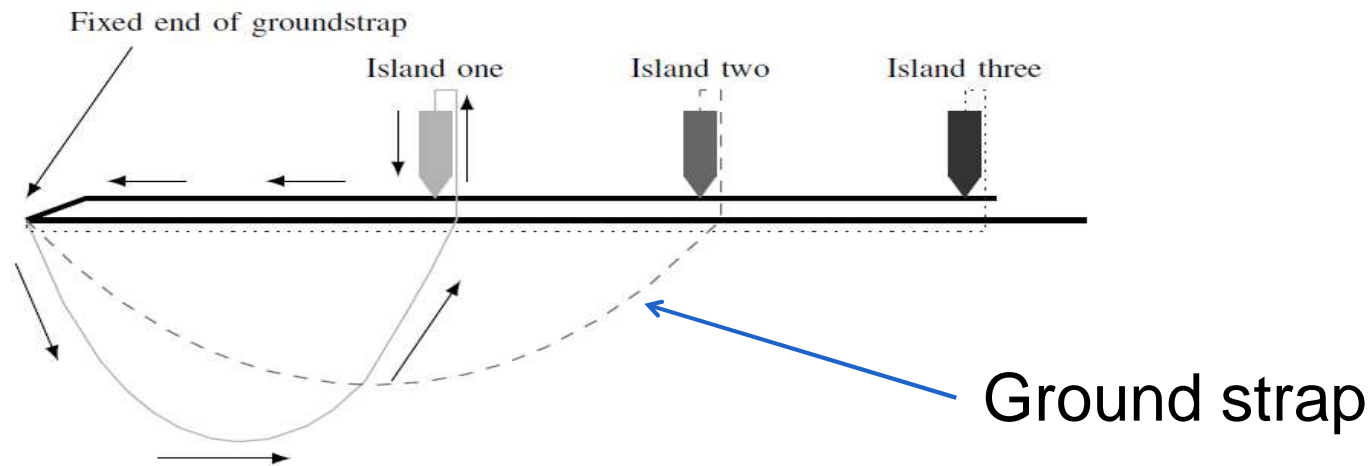


IEC 61000-4-2 waveform

# DESCRIPTION OF THE ISO 10605 FIELD-COUPLED ESD TEST

The ESD gun has a ground strap, which is connected to a fixed point at the testbench.

The ground strap forms a loop -> inductance      This change in geometry leads to a different electrical behavior.      The shape of the ground strap is different for the three injection islands



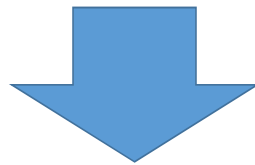
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# MOTIVATION

Predicting the EMC behavior of devices early in the design phase is of the utmost importance since it

- avoids expensive iterations in later stages of the design cycle
  - Measurements and Troubleshooting
- reduces product time-to-market
- leads to cost effective development



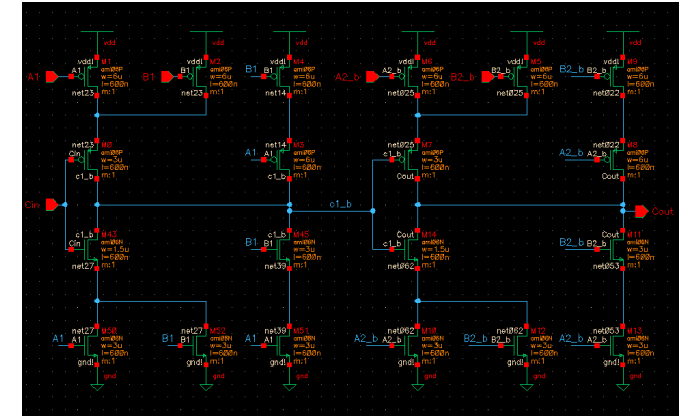
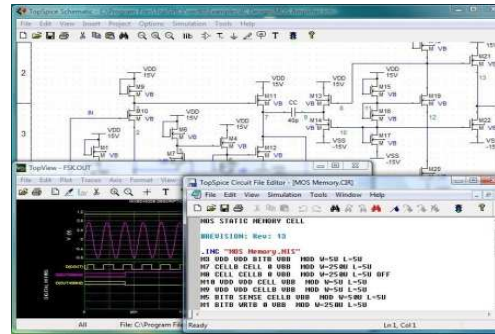
Goal: to construct an accurate **equivalent-circuit model** of all the components of the ISO 10605 Field Coupled Electrostatic Discharge Test



# WHY CIRCUIT MODEL?

- Circuit simulators are
- powerful design tools
  - fast
  - able to study nonlinear systems
  - easily integrated with advanced optimization techniques

Circuits are what the circuit designer needs!!!



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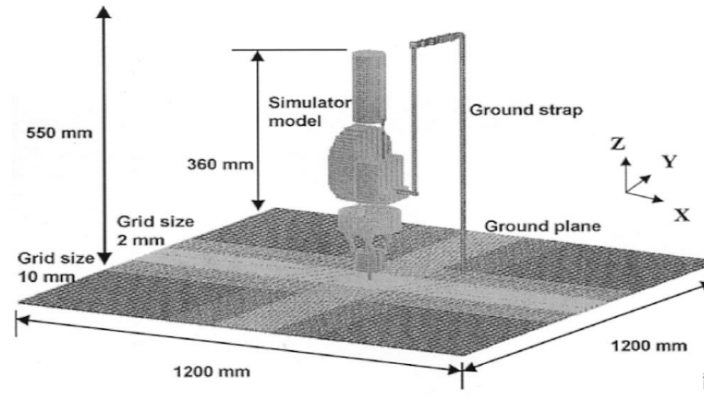
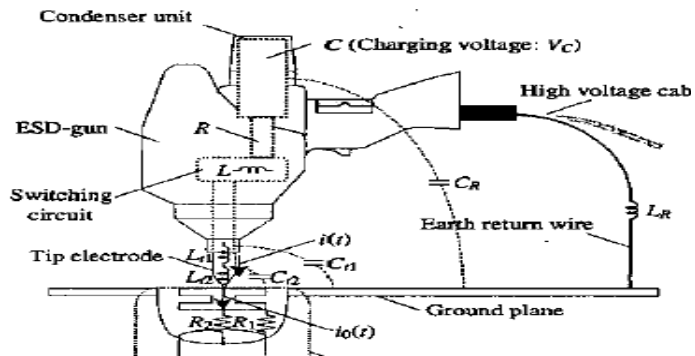
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# PROPOSED METHOD: MODELING OF ESD GUN

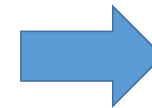
ESD-gun is an inhomogeneous device



Frequent approach: full wave simulation to study the ESD-gun and the groundstrap



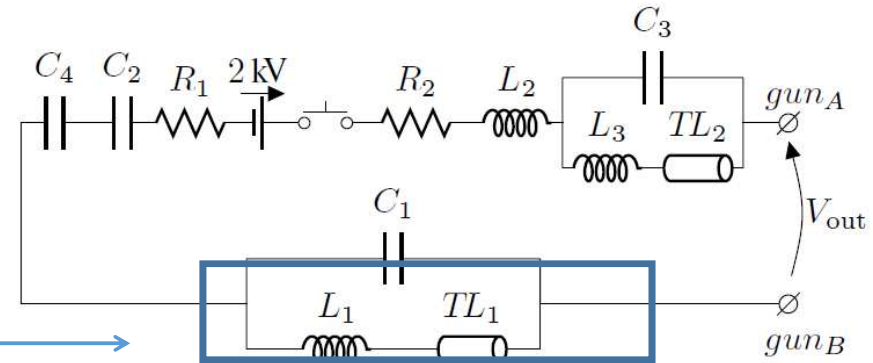
Requires high CPU time and memory allocation!!



Solution: equivalent circuit model based on physical behavior of the ESD gun

# PROPOSED METHOD: MODELING OF ESD GUN

The equivalent circuit representation of the ESD gun is based on the physics of the ESD gun.

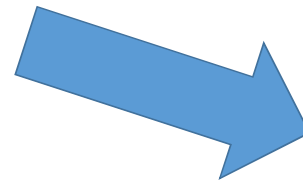
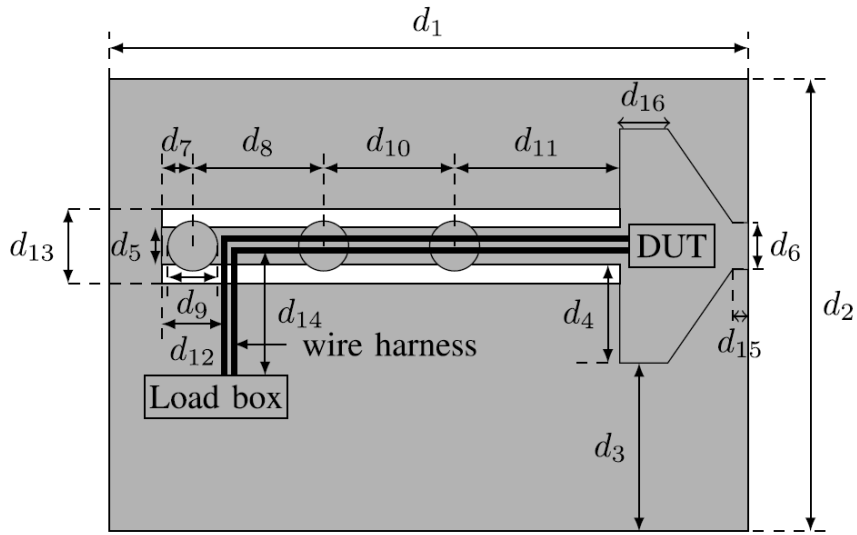


Groundstrap elements

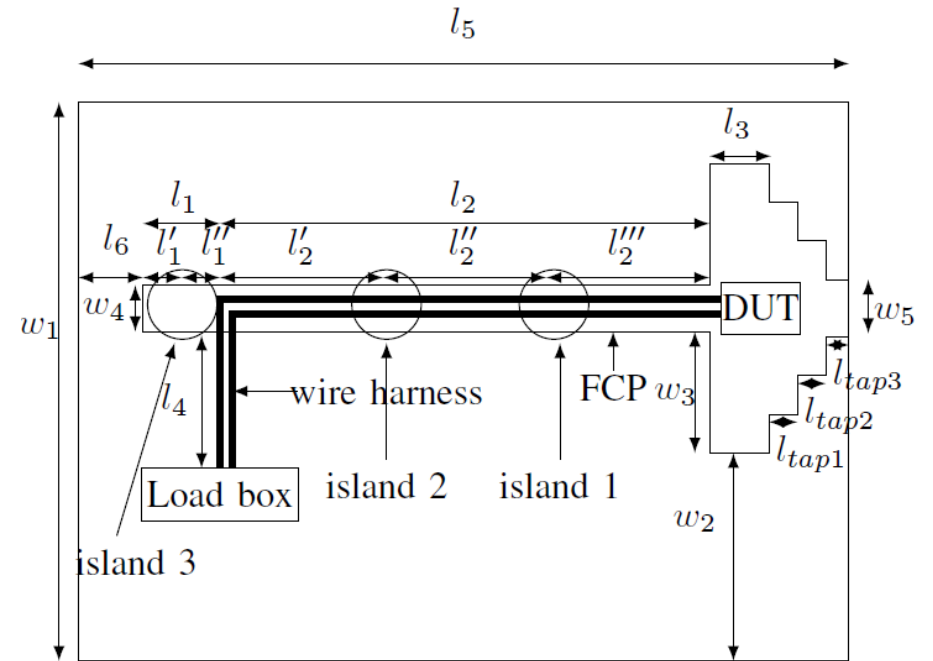
- L1 changes when we inject at a different island.
- TL1 to take the electrical length into account

Island of injection	Loop Inductance L <sub>1</sub>
Island one	2.25 μH
Island two	2.48 μH
Island three	1.56 μH

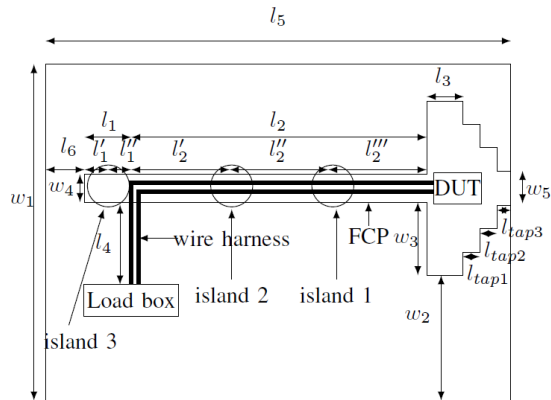
# MODELING OF THE ESD TEST BENCH: MULTICONDUCTOR TRANSMISSION LINES (MTLS)



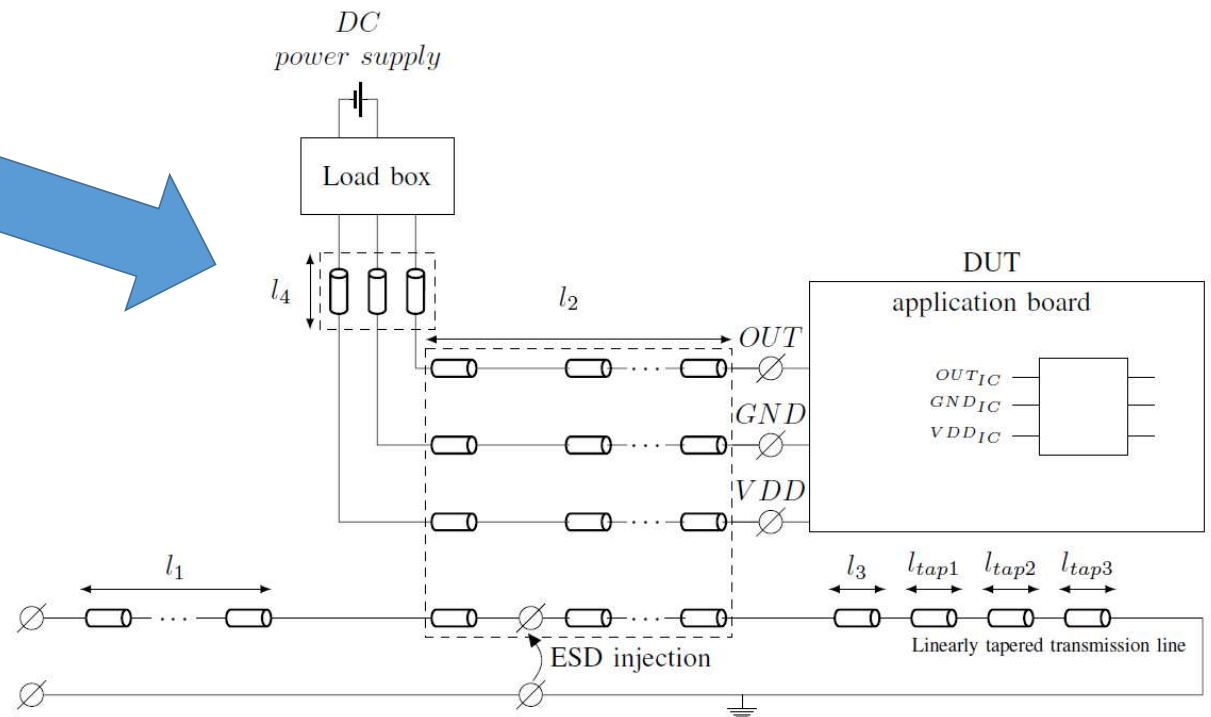
Make simplifications in  
the structure of the test  
bench



# MODELING OF THE ESD TEST BENCH: MTLs



A circuit model is obtained by means of the multiconductor transmission line (MTL) theory

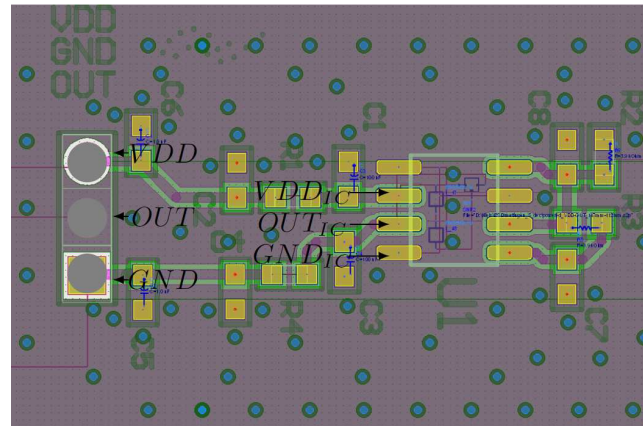


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# DESCRIPTION OF DUT AUTOMOTIVE TEST CHIP

- MLXTC1 = Piezoresistive automotive pressure sensors interface
- Normal output behavior: 2.5 V DC at atmospheric pressure
- In its intended application, the MLXTC1 is mounted on an application board

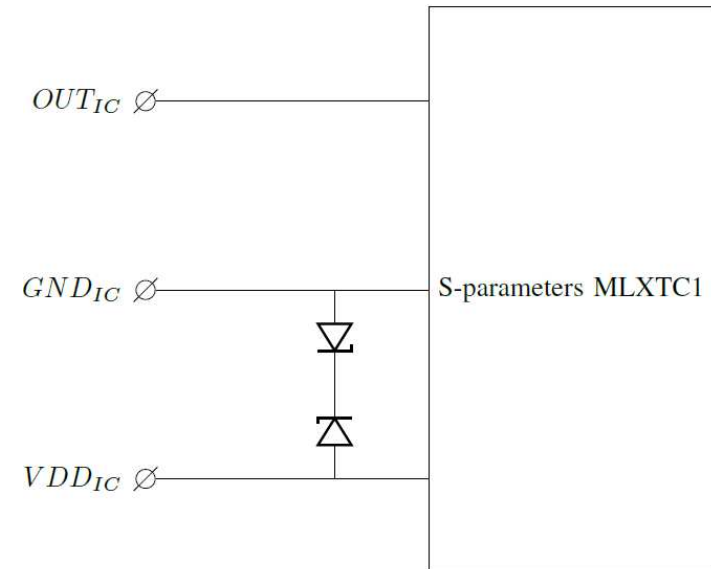




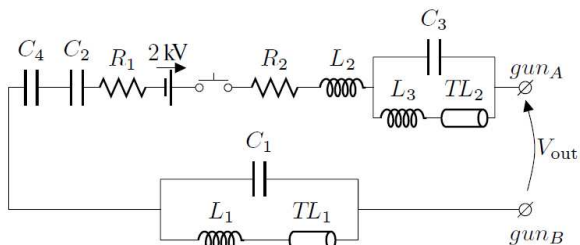
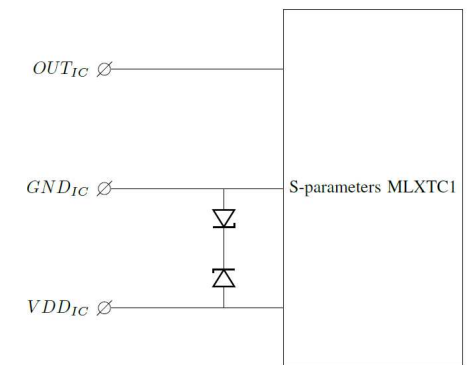
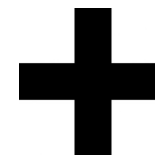
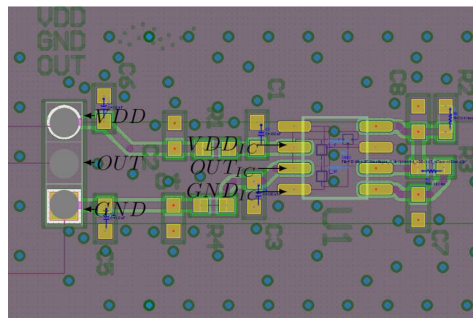
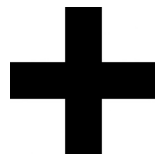
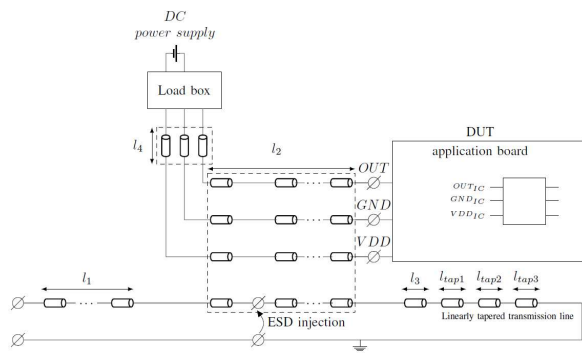
# DESCRIPTION OF DUT AUTOMOTIVE TEST CHIP

Problem: MLXTC1 contains firmware  
-> difficult to model

Solution: - extract S-parameters of MLXTC1  
- Most dominant nonlinear effect  
-> ESD diodes



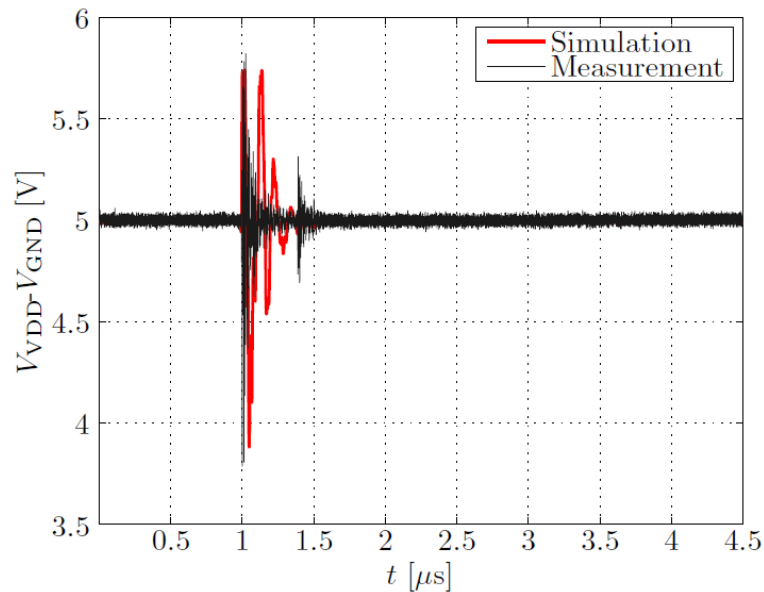
# COMBINATION OF DUT AND PROPOSED MODEL



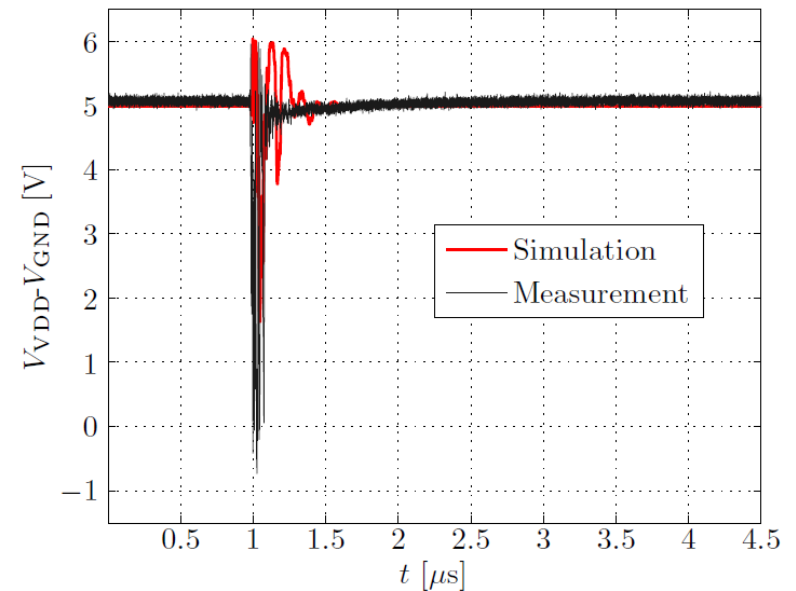
- All modeled in Advanced Design System (ADS), Keysight Technologies
- Application board's S-parameters obtained from full-wave simulations

# RESULTS

Disturbance at the supply of the MLXTC1 when injecting at island two with an ESD pulse of 200V.



Disturbance at the supply of the MLXTC1 when injecting at island two with an ESD pulse of 600V.



The proposed model predicts all salient features of the supply signal, and in particular the magnitude of the disturbance peaks are accurately modeled.

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# CONCLUSIONS

- Novel circuit model approach for the ISO 10605 field coupled ESD test setup
  - Validated with an automotive sensor interface chip
  - Useful to effectively predict and troubleshoot problems related to the ISO 10605 field-coupled ESD testing
  - Easy to implement in every circuit solver
  - Allows optimization for ESD immunity

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