



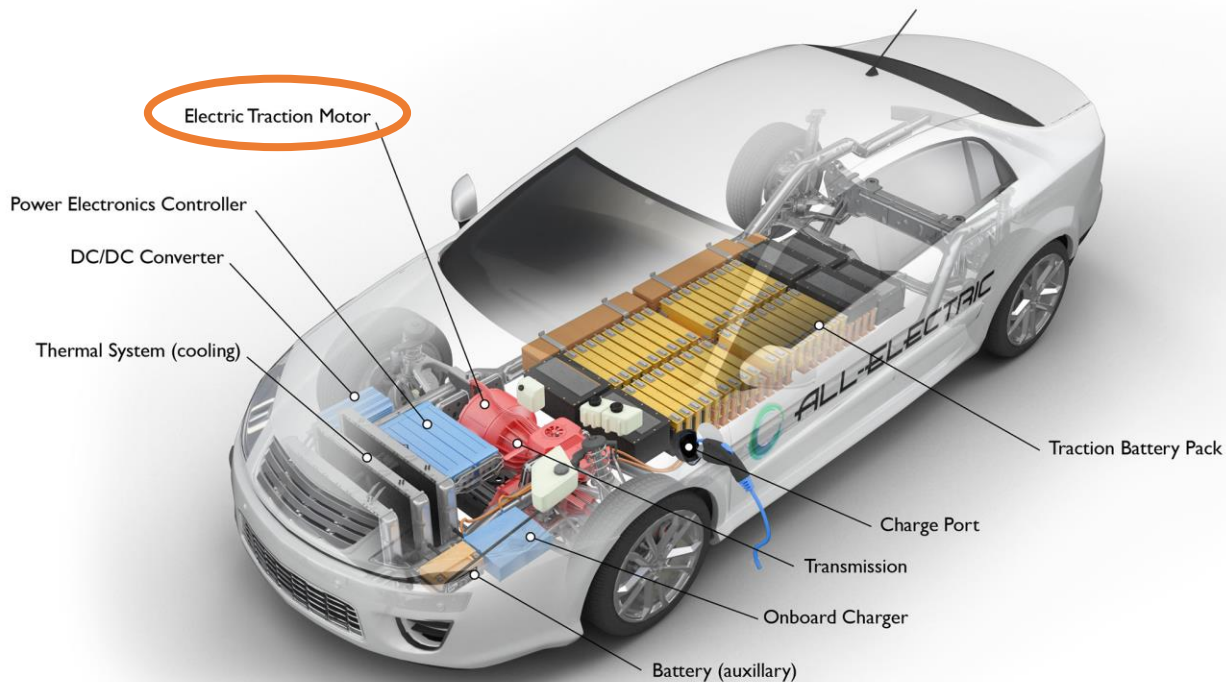
Syntetic Data for Predictive Maintenance in power electronics

Author(s)	Jacopo Ferretti
Co-Author(s)	Mariano Nerone, Igor Valic
Approved by	
Department	Electrification
Version	1.0
Customer	ICPT
Project	Predictive maintenance Lecture
Date	23/03/2026

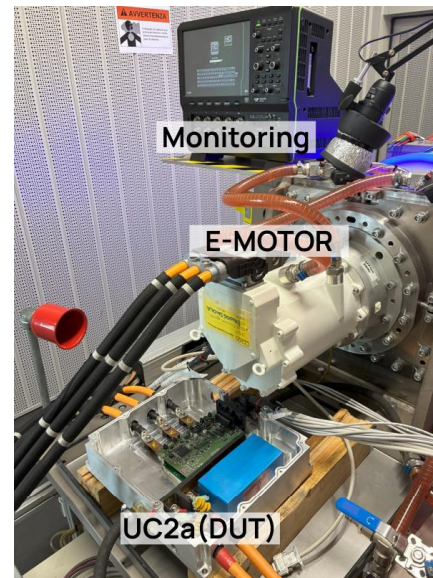
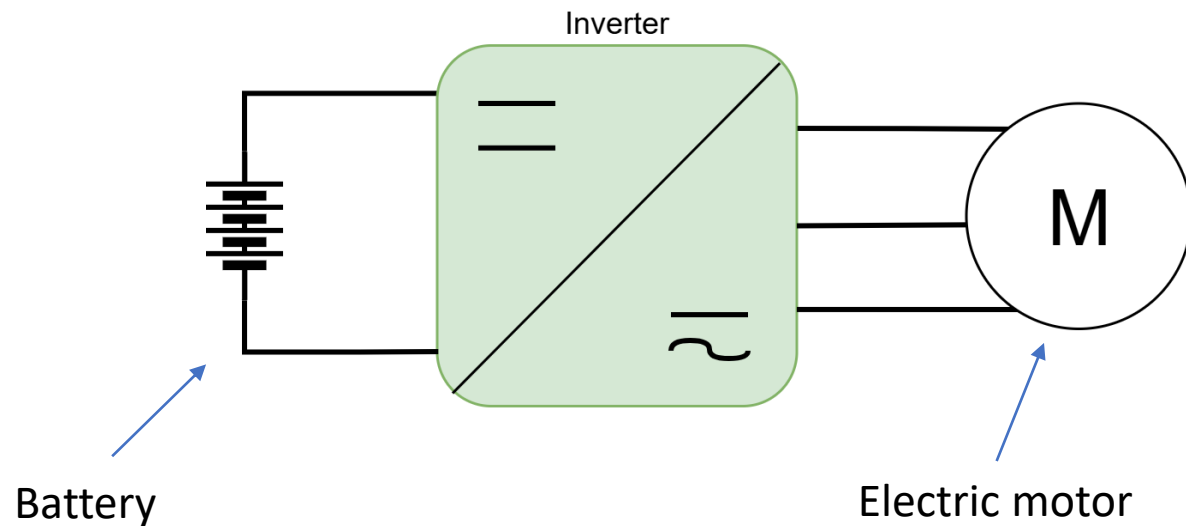


Power electronics in automotive

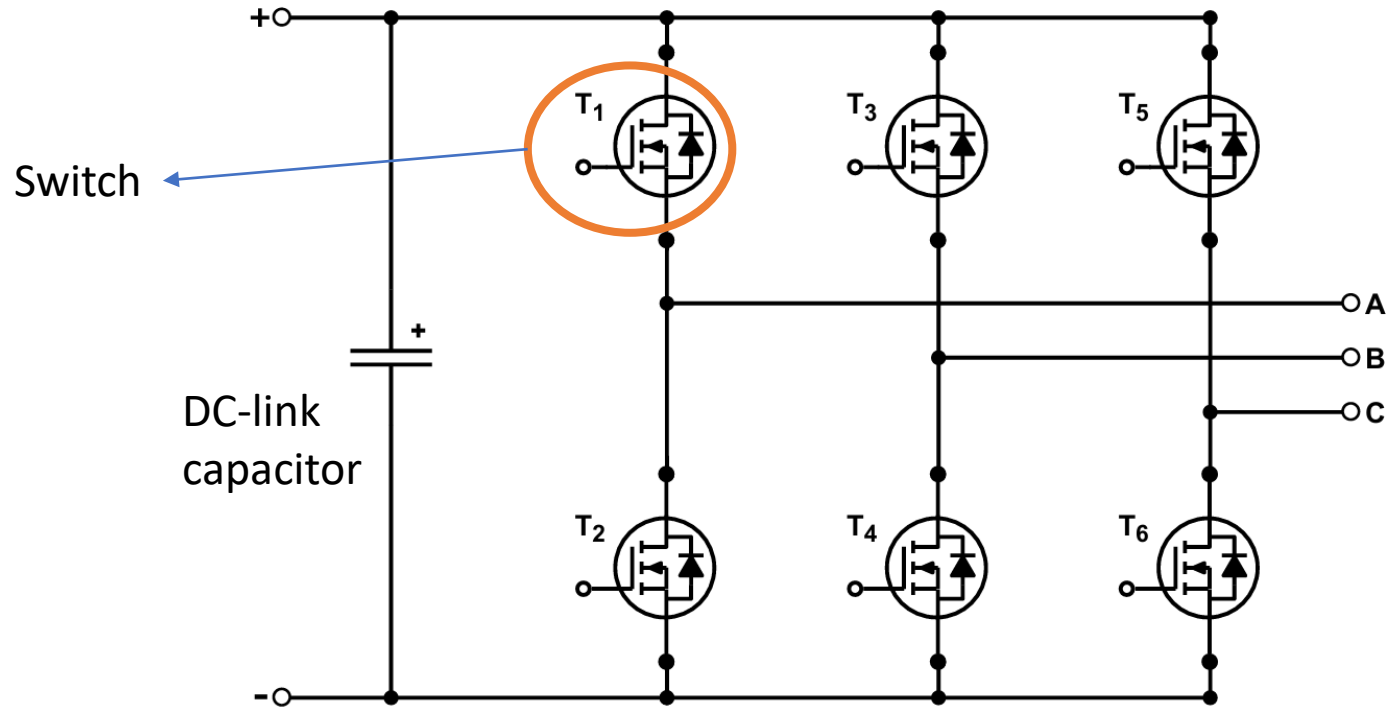
All-Electric Vehicle



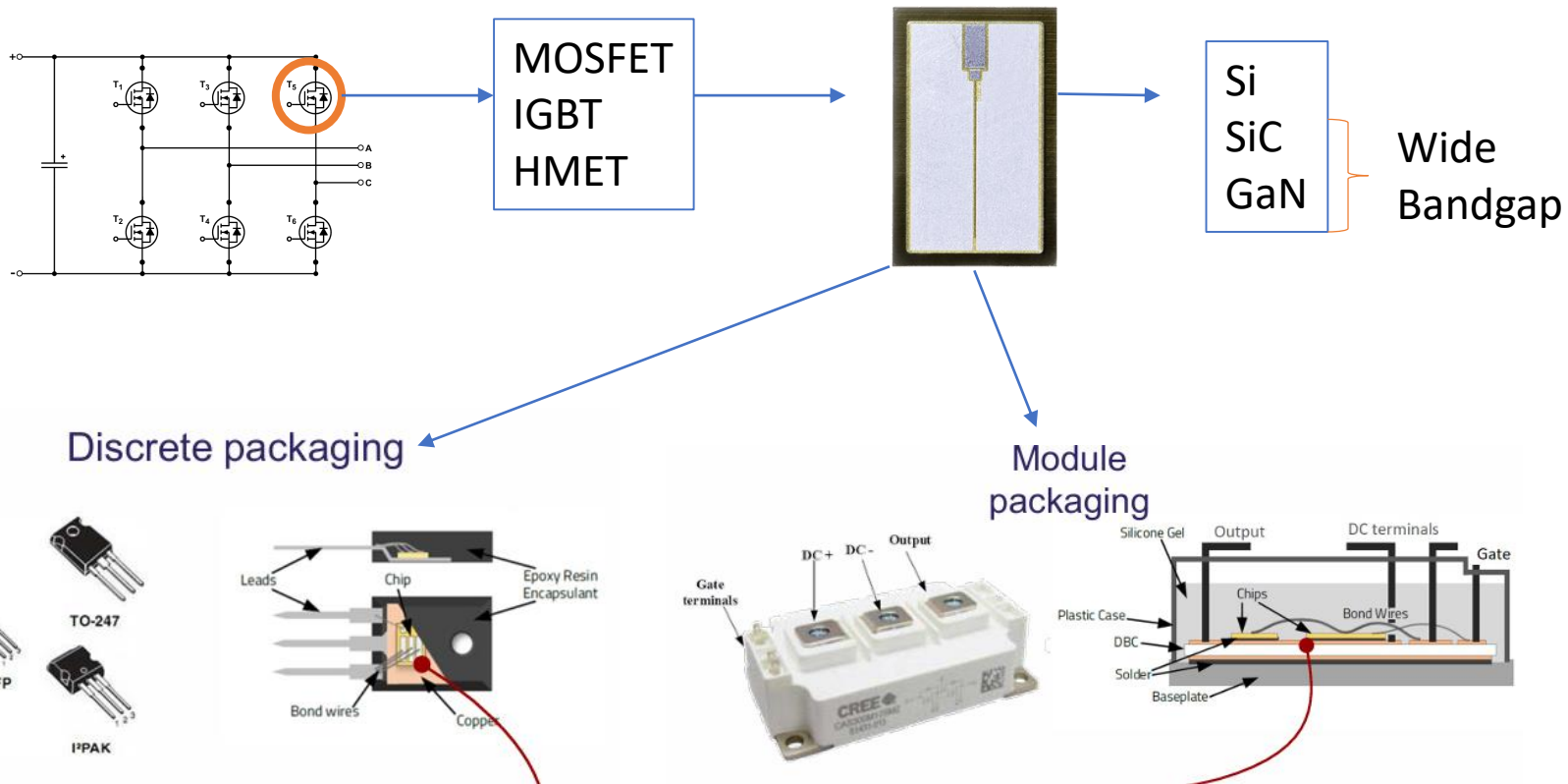
Traction inverter



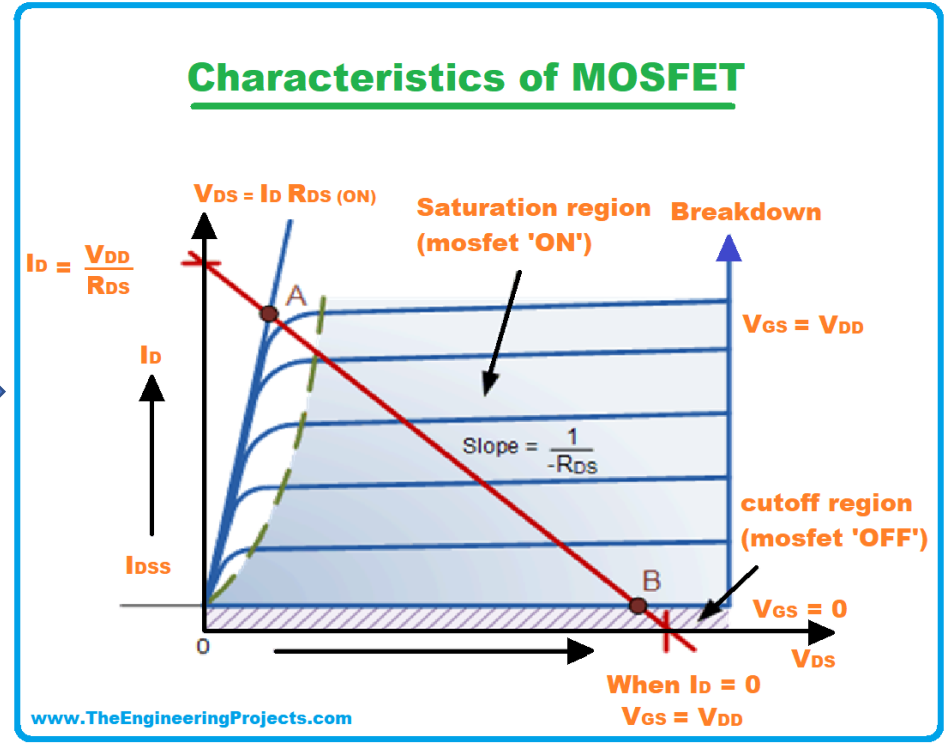
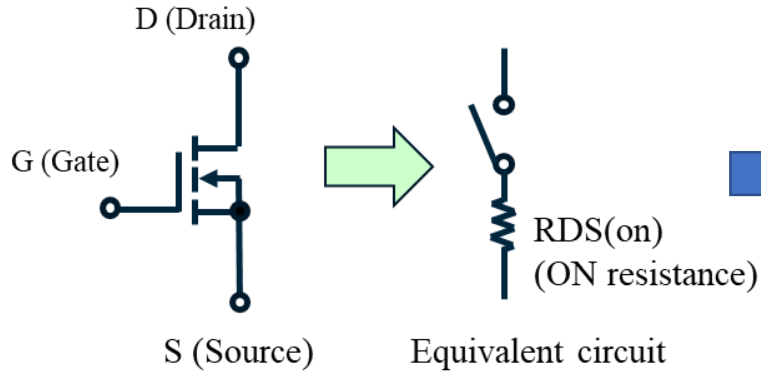
Inverter, how is it made?



Switch, how is it made?

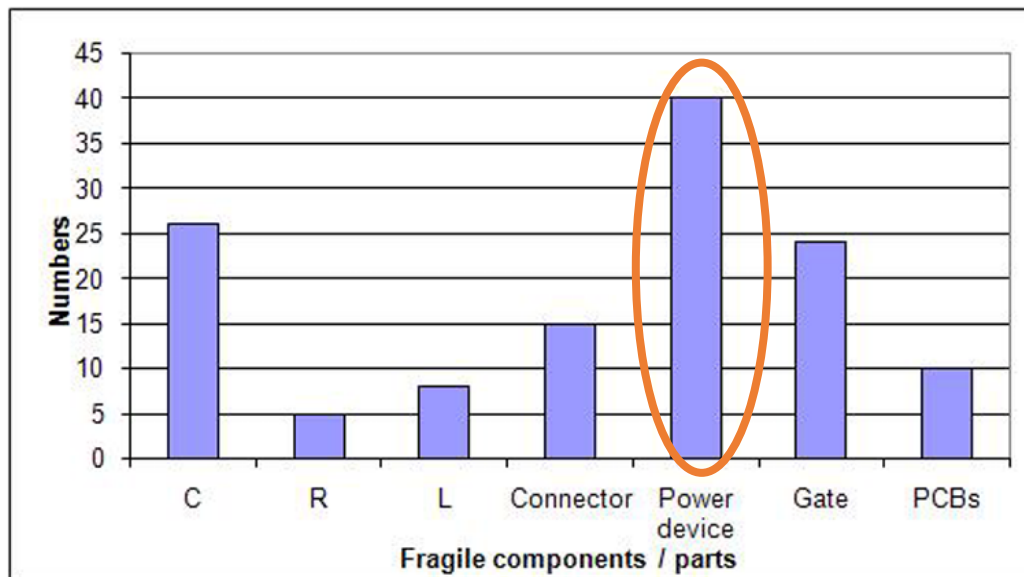


Mosfet Characteristics



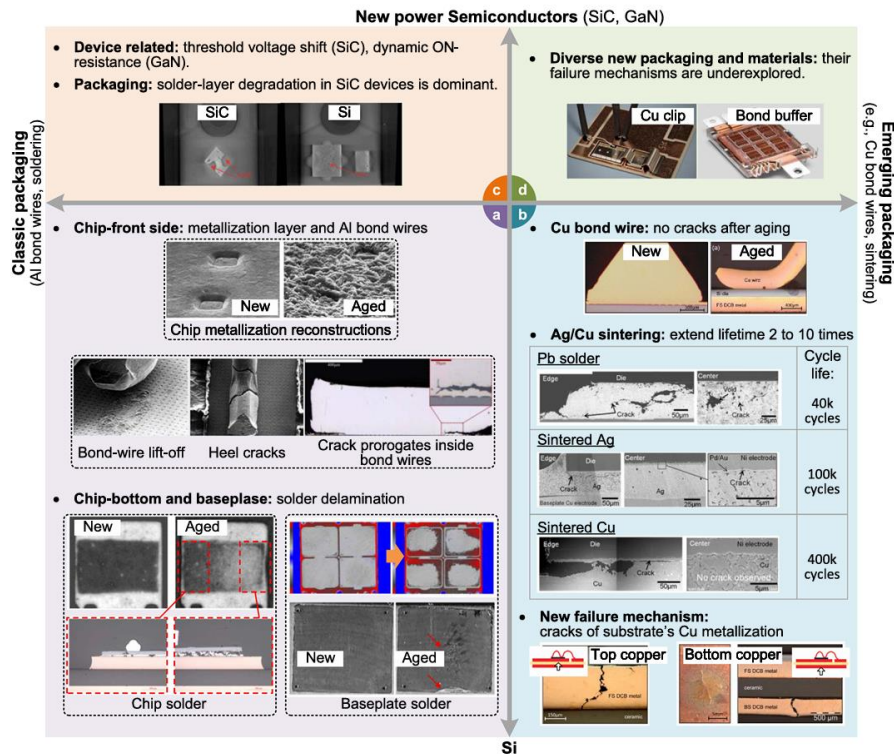
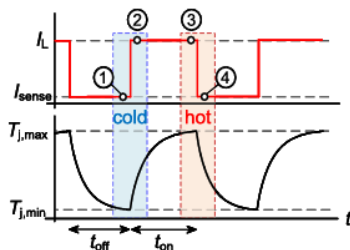
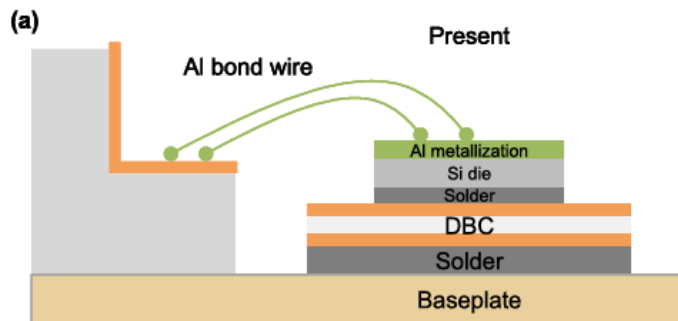
Why so important?

An Industry-Based Survey of Reliability in Power Electronic Converters



How switches breaks?

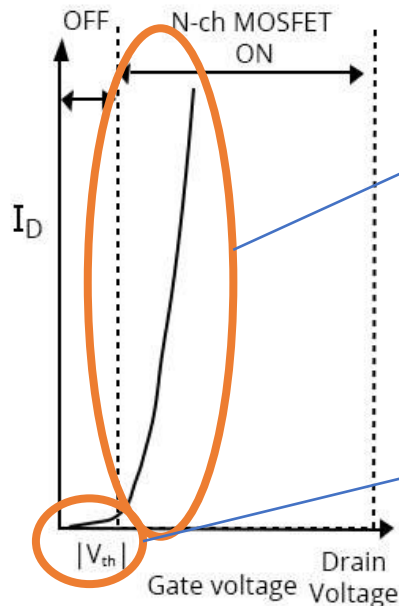
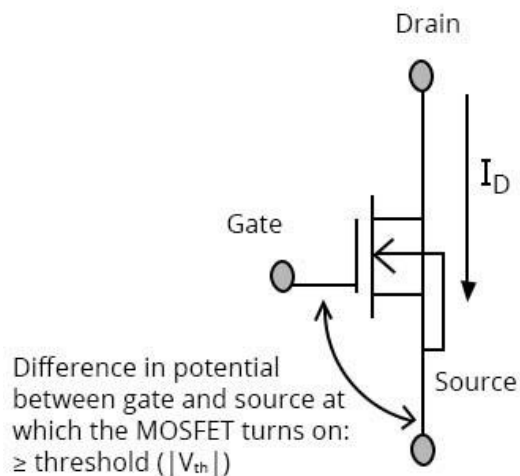
Power Cycling Testing for Power Semiconductor Switches: Methods, Standards, Limitations, and Outlooks



How we can understand it?

- Aging indicators!

Characteristics of the n-channel MOSFET



R_{dson}

V_{th}

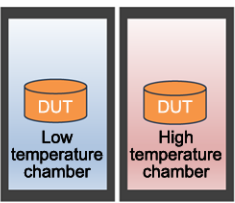
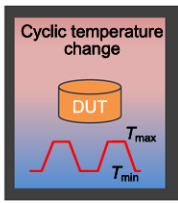
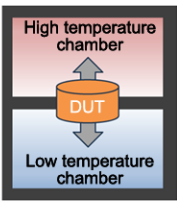
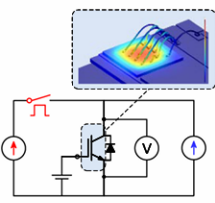
+20% → device broken

Rule of thumb

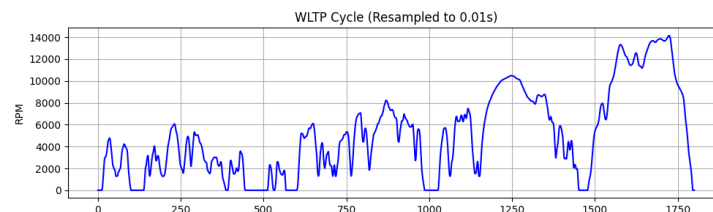
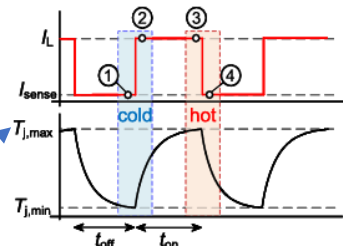
How can we estimate remaining useful life?

• Accelerated lifetime testing!

Time scales:

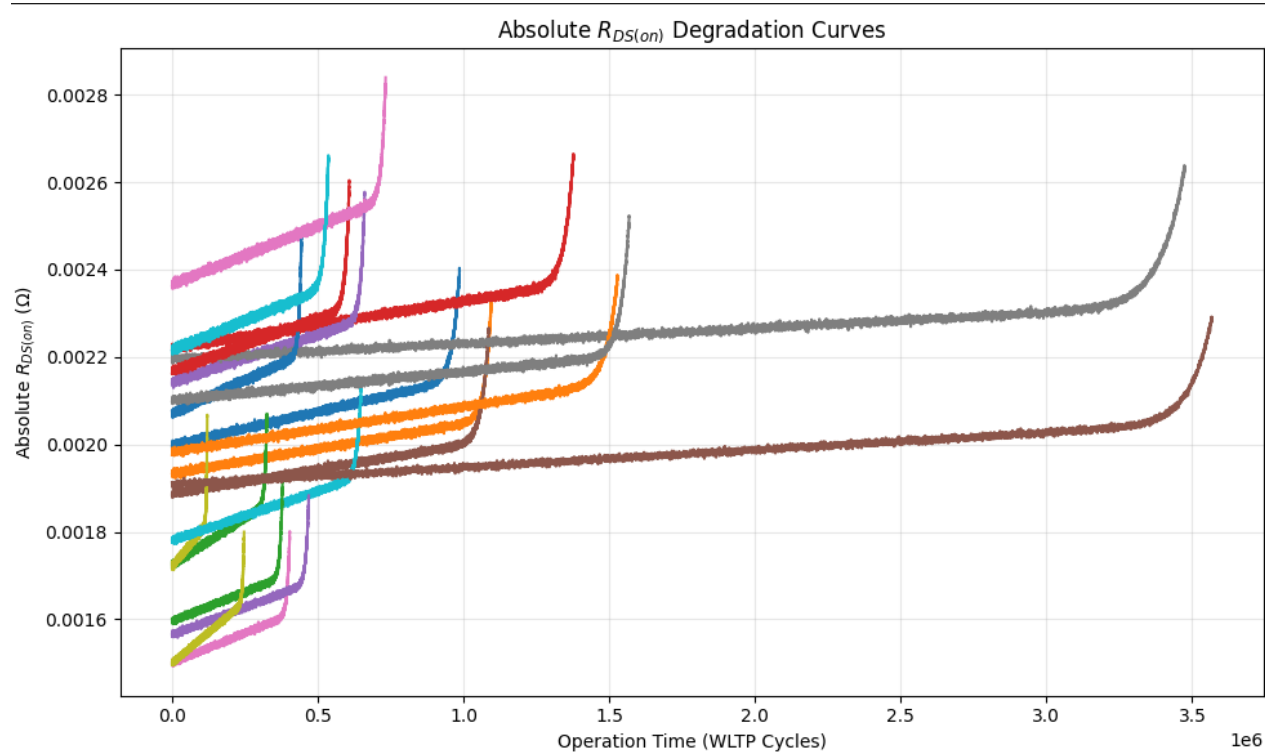
Static	Days, hours	Minutes, seconds	Seconds, milliseconds
- HTS: High Temperature Storage - LTS: Low Temperature Storage	TCT: Thermal Cycling Test	TST: Thermal Shock Test	PCT: Power Cycling Test
Test DUT of withstanding high or low temperature for a prolonged period	Test DUT of withstanding mechanical stresses due to cyclic exposure to thermal effects	Test DUT with very rapid temperature changes, mimic devices' self heating and quick temperature changes in the application.	Test DUT of withstanding cyclic power dissipation, mimic real turn on and off
			
Temperature distribution is homogenous for the DUT and controlled by the environment			Localized thermal gradient
Passive test , DUT is not operating (Test methods are independent of device types)			Active test , DUT is operating (Test methods must be adapted to different devices)

Accelerated cycle

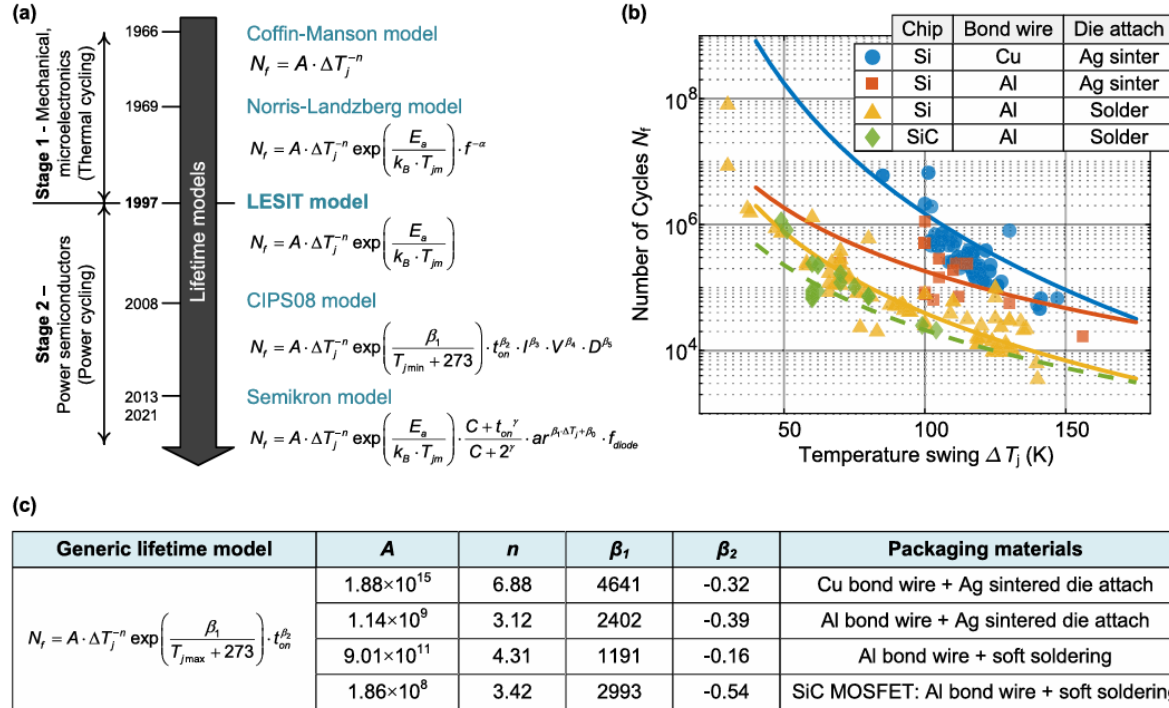


Normal cycle (WLTP)

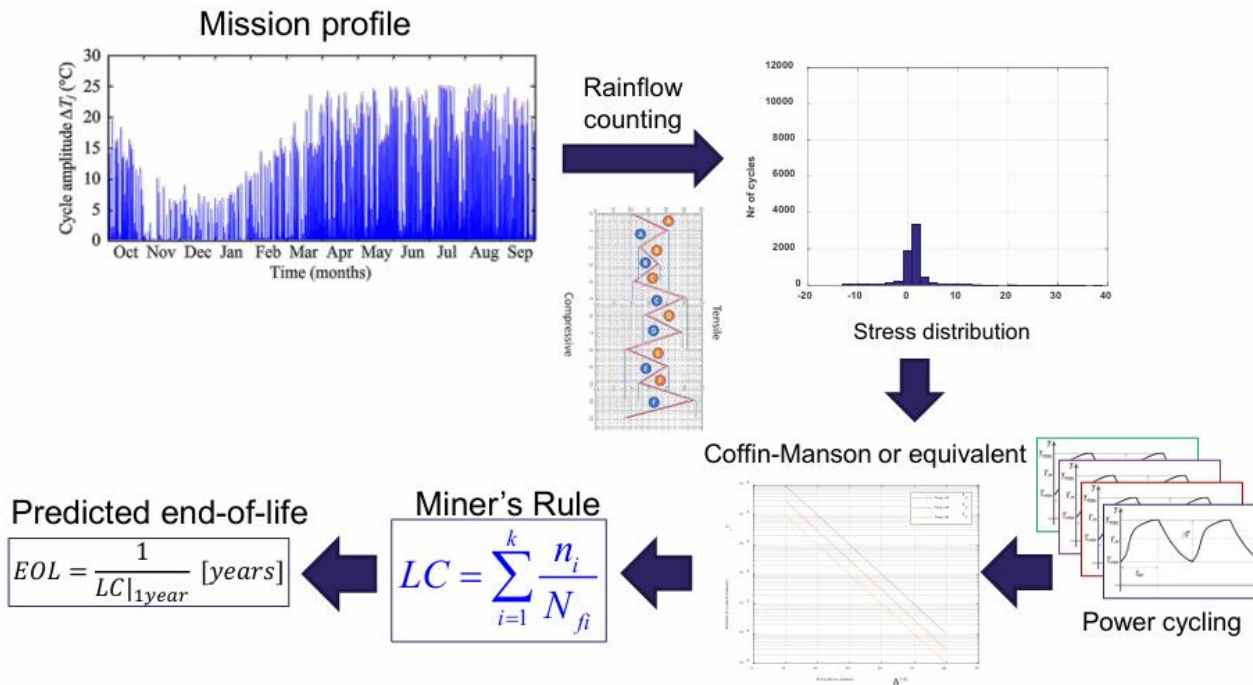
Example of accelerated testing results



Lifetime estimation from ALTs



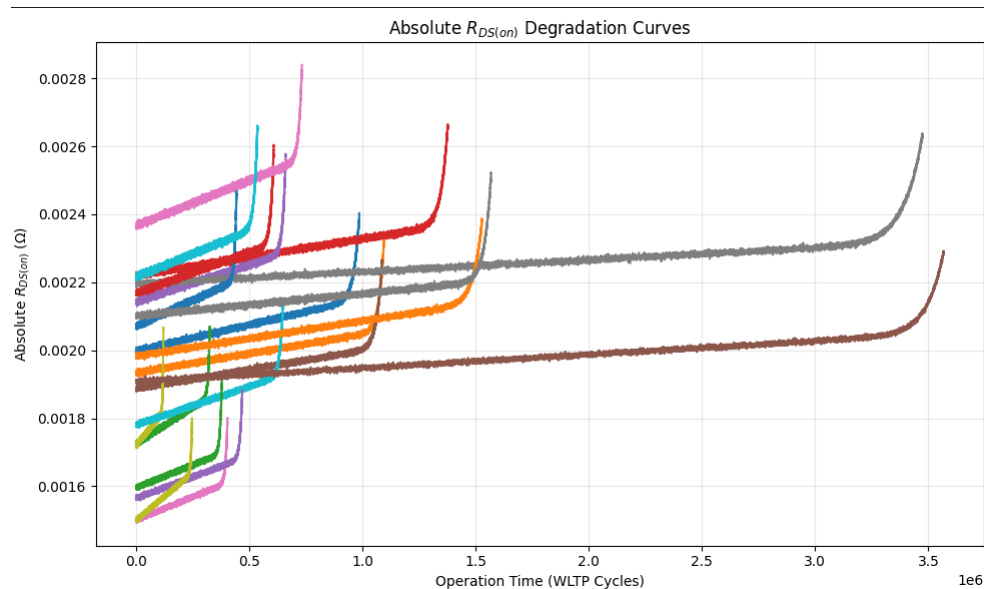
Lifetime estimation from mission profile



Not enough data!

- Time consuming
- Cost
- Hw is difficult to predict

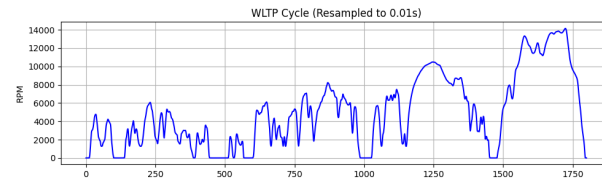
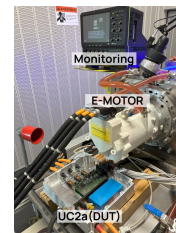
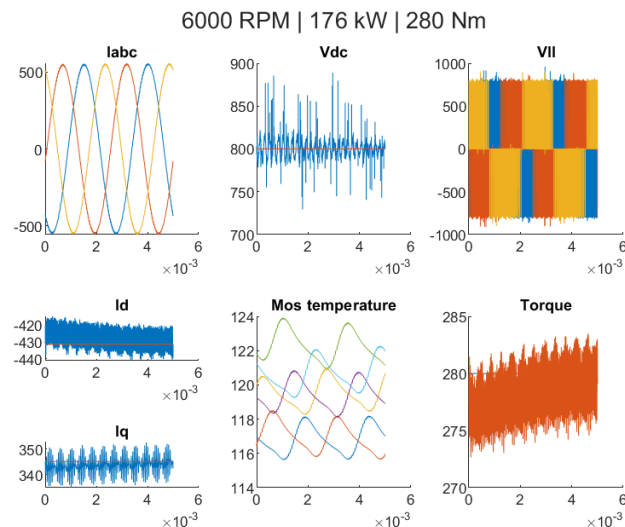
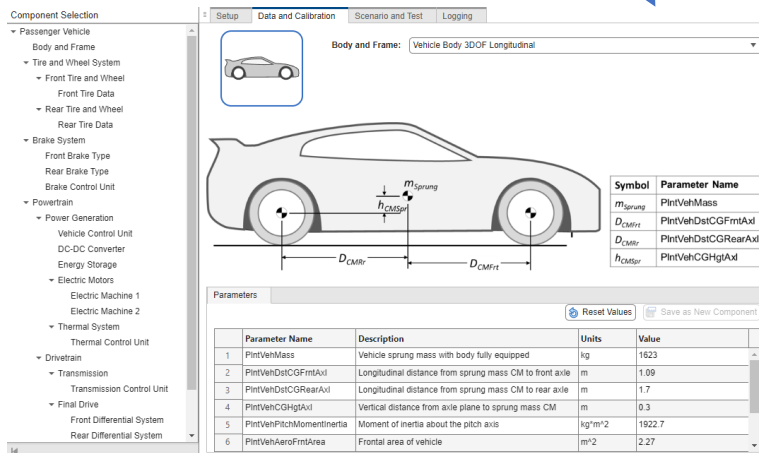
Solution: Synthetic data!



Let's produce syntetic data

Environments :

1. Inverter Simulation (INV+CTRL+MOT) →
2. Vehicle Simulation (driver+MOT) →
3. Generative Simulation (Device)

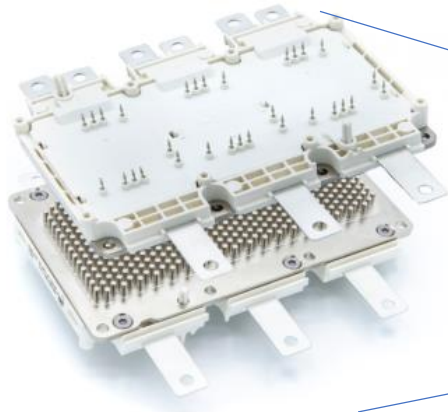


1. Inverter Simulation

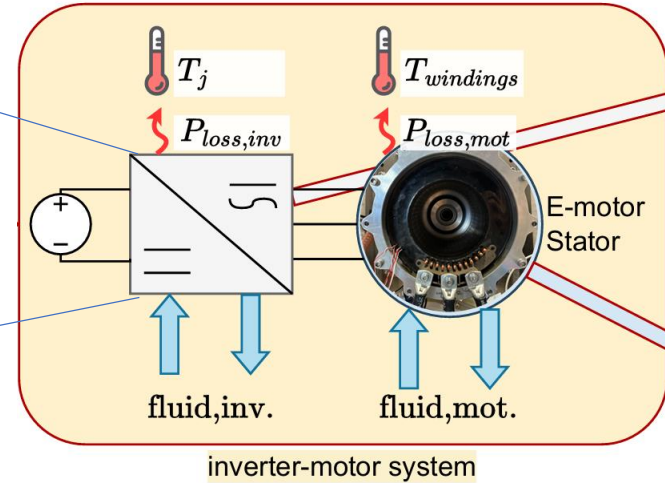
Automotive-grade ACEPACK DRIVE power module, sixpack topology
1200 V, 1.9 mΩ typ. SiC MOSFET gen.3 based

+

HPE PMSM motor



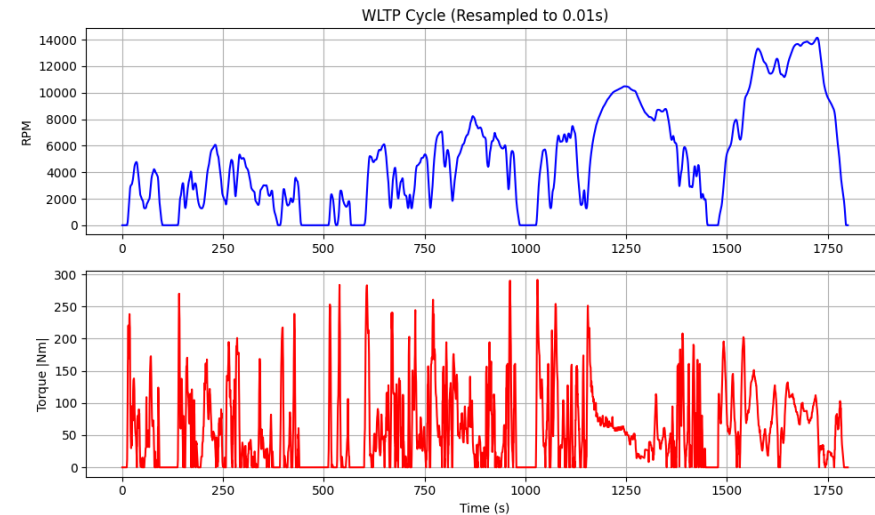
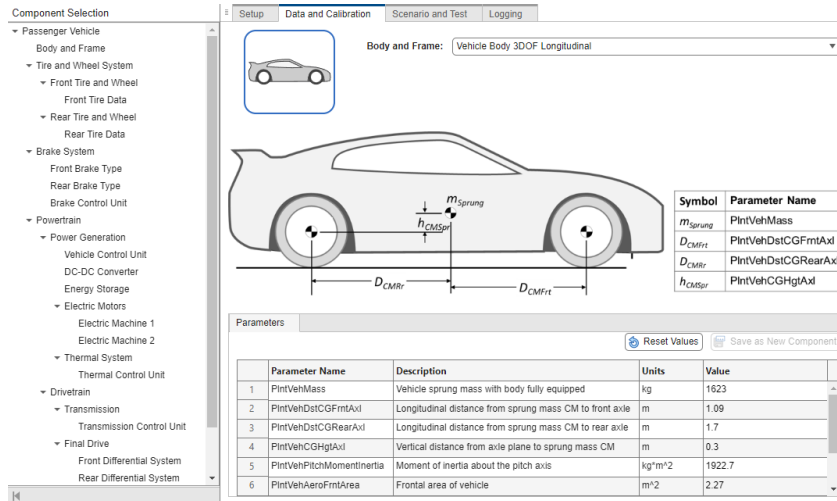
ACEPACK DRIVE



2. Vehicle Simulation (driver+MOT)

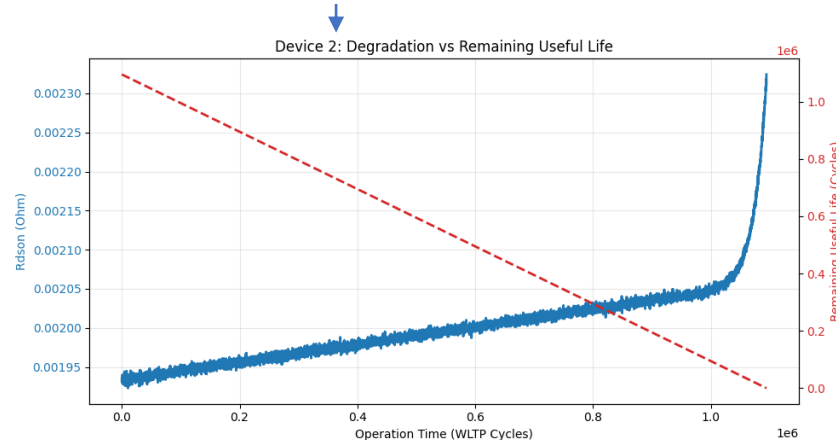
Simulink Vehicle composer

- EV + WLTP drivecycle -> straight forward!



3. Generate Rdson

1. Load Dt(RPM,Trq) map - > each RPM and torque point has a mosfet temperature
2. Load RPM-Trq from vehicle simulation
3. Calculate Dt(t) for the whole drive cycle
4. Calculate Lifetime of the device using stress calculation
5. Extend lifetime results using Monte Carlo
6. Resample and output data for next step, AI prediction



Your turn!

- Clone the repository from:
https://github.com/mrjacopong/ICTP_SyntheticRdson_lect
- Read README.MD for instructions
- Have fun generating Rdson and creating your RUL predictor!

The screenshot shows the GitHub repository page for 'ICTP Synthetic Rds(on) Lecture' by PFERretti. The repository has 4 commits and was updated yesterday. The file list includes Presentation, SRC, .gitignore, README.md, and requirements.txt, all updated yesterday. The README section is expanded, showing the title 'ICTP Synthetic Rds(on) Lecture' and a description: 'Hands-on material for the ICTP lecture in Trieste (March 23, 2026). This repository explains how to generate synthetic MOSFET Rds(on) degradation data from simulations and datasheet-driven assumptions, then use that data for AI-based Remaining Useful Life (RUL) prediction.' Under 'What You Will Find', it lists: Lecture slides for the theory and methodology; Python and MATLAB workflows to generate synthetic Rds(on) data; A challenge notebook to train a model for RUL prediction; and Pre-made WLTP example data from Simulink simulation (Credits Mathworks - Virtual Vehicle Composer). The right sidebar shows repository statistics: 0 stars, 0 watching, 0 forks, 0 releases, 0 packages, and 1 contributor (mrjacopong). A language bar shows Jupyter Notebook at 99.2% and MATLAB at 0.8%.

Any questions ?

Reach out to:

jferretti@hpe.eu