Motivation for More Reliable Power Electronics

Product Drivers for Reliable Power Electronics

Emerging and critical applications | Harsh environments

Reduction of Cost-of-Energy (LCOE)
Increase of power density

→ **Paradigm Shift in Research**

Handbook calculations
Testing to pass
↓
?

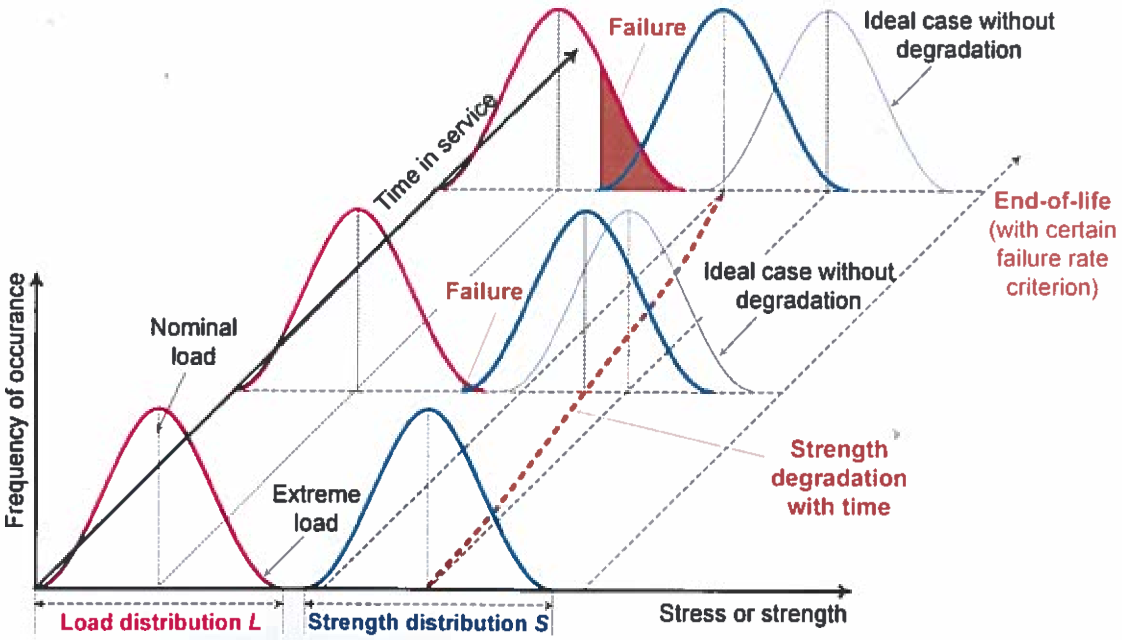
→ **More reliable and cost-effective power electronic systems**

Power Electronics in Renewable Energy Systems

- **Long operation hours under harsh environments**
- **Power electronic subsystems are one of the major failure sources in the last generation product**
- **Next generation product with return rate of ppm level and lifetime of 20-30 years**
- **Increasing labor cost for maintenances**
- **Stringent cost constraint**
- **Competiveness determined by cost-of-energy**

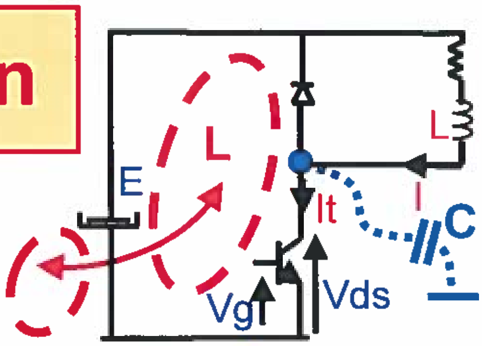
Stress-Strength Analysis

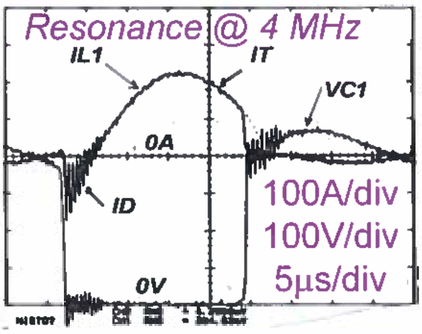
The essence of reliability engineering is to prevent the creation of failure



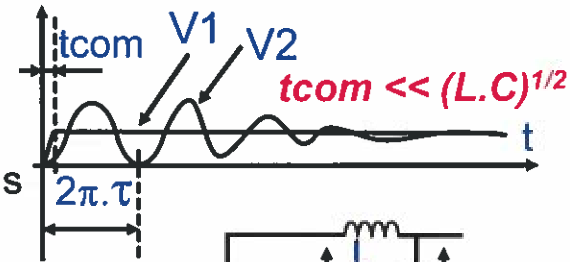
Stress analysis; Strength analysis
Stress control; Strength derating
Design at end-of-life; Consider the variations

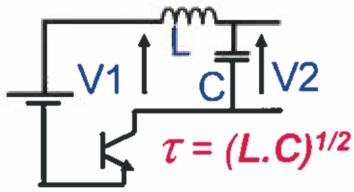
Introduction



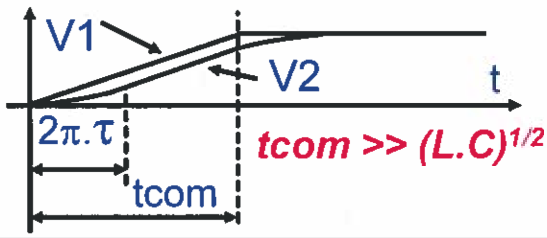


- Commutation times ↓
  i.e. SiC, GaN
  - ⇒ di/dt ↑, dv/dt ↑
  - ⇒ dH/dt ↑, dE/dt ↑
  - ⇒ oscillations, over-voltages
- ☹ **Consequences :**
  - Magnetics aging by dielectric breakdowns
  - Currents sensing perturbations
  - EMI with environment ⇒ shielding effort
  - SiC has low threshold voltage
  - dv/dt ↑ ⇒ miller current ↑ ⇒ restart ??

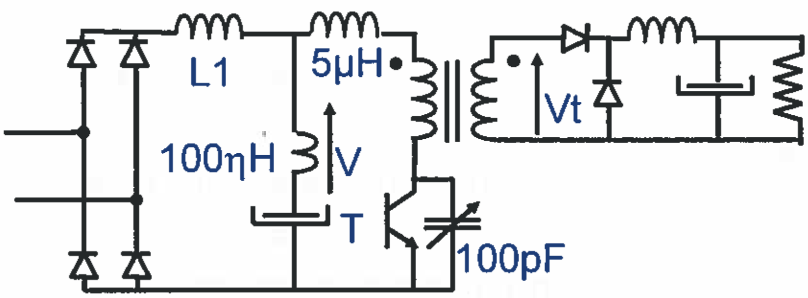


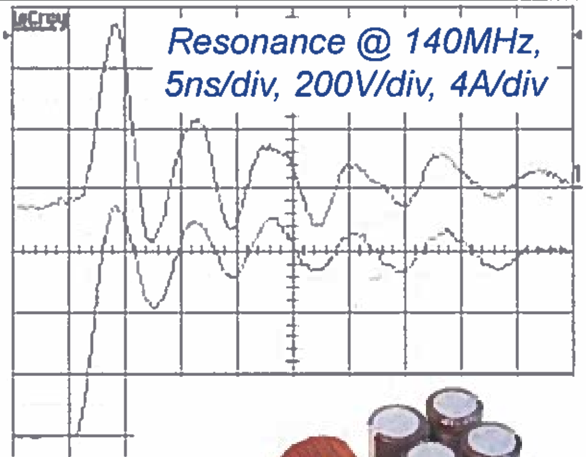


- ☺ **Solution : avoid resonance**
  - i.e. : $tcom > \tau = (L.C)^{1/2}$
  - ⇒ Control Commutation time tcom
  - ⇒ Wiring L↓ & Straight C↓



Within SMPS





- **Resonance between**
  - Leakage inductance of transformer L≈5µH
  - Stray capacitance of transistor C1≈100pF
  - ⇒ Conducted & Radiated EMI

- **RC snubber may damp oscillation**
  - Parallel damping :
    $zp = ½.(1/R).(L/C1)^{1/2} = 0,7$
    ⇒ R ≈ 160 Ω
  - Series damping :
    $zs = ½.R/(L/C2)^{1/2} = 0,7$
    ⇒ C2 ≈ 400 pF