

INPUT POWER PROFILE

- Active power $P(t)$
- Reactive power $Q(t)$
- DC-link voltage
- Ambient temperature profile

ELECTRICAL MODEL

- Modulation index M
- Phase angle
- Instantaneous modulation waveform

Computation of inverter currents, switching instants, and switching events

LOSS MODEL

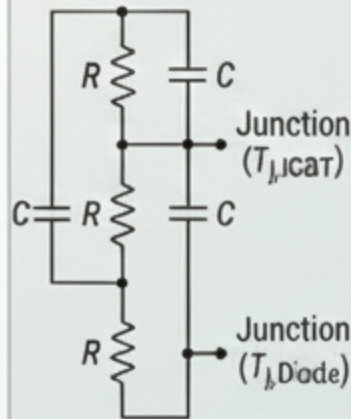
IGBT switching + conduction losses

Diode switching + conduction losses

Output waveforms:
 $P_{IGBT}(t)$, $P_{Diode}(t)$

CAUER THERMAL NETWORK MODEL

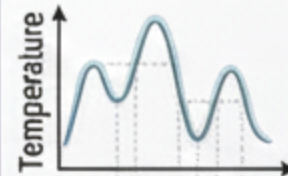
Multi-stage RC ladder for IGBT and diode



Case-to-sink thermal interface
 $R_{th,c-s}$
 $C_{th,c-s}$

Heat sink node
Ambient connection
 T_a

THERMAL CYCLE EXTRACTION (RAINFLOW COUNTING)



- Extract thermal cycles
- Temperature swings ΔT_j
- Mean junction temperature T_{jm}
- Cycle period

LIFETIME MODEL (LESIT 2024)

Low- ΔT extension factor β

Arrhenius factor
 $E = e^{-E_a/kT}$

Time-dependent thermal cycle correction

Output: cycles-to-failure N_f

LIFETIME AGGREGATION

Compute equivalent lifetime in years for IGBT

Compute equivalent lifetime in years for Diode

Compute equivalent lifetime in years for overall module

RESULT