IGBT Conduction and Switching Losses and Junction Temperature

Conduction and switching losses of an IGBT from its on-state model and switching energies scaled to the operating voltage and current, and the junction temperature.

Method: Piecewise-linear on-state model and linear scaling of switching energies

Input parameters

Unit system: SI

Parameter	Value	Unit
On-state threshold voltage	0.90000	V
On-state slope resistance	12.000	mΩ
Average current in the switch	35.000	A
RMS current in the switch	55.000	A
Turn-on energy at the datasheet point	3.5000	mJ
Turn-off energy at the datasheet point	2.8000	mJ
Datasheet test voltage	600.00	V
Datasheet test current	100.00	A
DC link voltage	560.00	V
Average current switched	50.000	A
Switching frequency	8.0000	kHz
Junction-to-case thermal resistance (K/W)	0.25000	
Case-to-ambient (interface and heat sink) thermal resistance (K/W)	0.35000	
Ambient temperature	40.000	°C

Calculated results

Parameter	Value	Unit
Conduction loss	67.800	W
Switching loss	23.520	W
Total loss	91.320	W
Case temperature	71.962	°C
Junction temperature	94.792	°C

Notes for this case

• The on-state voltage is modelled as V_CE0 + r_CE i, so conduction loss is V_CE0 I_av + r_CE I_rms². Switching energies from the datasheet are scaled linearly to the actual DC-link voltage and switched current, then multiplied by the switching frequency. The junction temperature is ambient plus total loss through the thermal resistances. Use datasheet values at the expected junction temperature (usually 125 or 150 °C) and keep a margin below the maximum; add the free-wheeling diode's losses separately.

Formula and method

$$P_{cond} = V_{CE0} I_{av} + r_{CE} I_{rms}^2, \quad P_{sw} = (E_{on} + E_{off}) f_s \frac{V_{dc}}{V_{ref}} \frac{I_{sw}}{I_{ref}}, \quad T_j = T_a + P(R_{\theta JC} + R_{\theta CA})$$

Variables

V_{CE0}	On-state threshold voltage	V

r_{CE}	On-state slope resistance	Ω
I_{av}	Average current in the switch	A
I_{rms}	RMS current in the switch	A
E_{on}	Turn-on energy at the datasheet point	J
E_{off}	Turn-off energy at the datasheet point	J
V_{ref}	Datasheet test voltage	V
I_{ref}	Datasheet test current	A
V_{dc}	DC link voltage	V
I_{sw}	Average current switched	A
f_s	Switching frequency	1/s
$R_{\theta JC}$	Junction-to-case thermal resistance (K/W)	-
$R_{\theta CA}$	Case-to-ambient (interface and heat sink) thermal resistance (K/W)	-
T_a	Ambient temperature	K
P_{cond}	Conduction loss	W
P_{sw}	Switching loss	W
P	Total loss	W
T_c	Case temperature	K
T_j	Junction temperature	K

Method and standards

IGBT losses.

Assumptions and limits

- Linear scaling; steady-state temperatures.

References

Piecewise-linear on-state model and linear scaling of switching energies

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/electronics/igbt-power-loss-junction-temperature

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Reopens the calculator with the inputs of this report.