MOSFET Conduction, Switching and Gate-Drive Losses

Conduction, switching and gate-drive losses of a MOSFET in a hard-switched converter, with the total and the junction temperature for a thermal resistance.

Method: Conduction and linear-ramp switching loss estimates

Input parameters

Unit system: SI

Parameter	Value	Unit
RMS drain current	4.0000	A
On-resistance at operating temperature	15.000	mΩ
Voltage switched	24.000	V
Current switched	5.0000	A
Rise time	0.020000	µs
Fall time	0.015000	µs
Switching frequency	250.00	kHz
Total gate charge	30.000	nC
Gate drive voltage	10.000	V
Junction-to-ambient thermal resistance (K/W)	20.000	
Ambient temperature	40.000	°C

Calculated results

Parameter	Value	Unit
Conduction loss I²R	0.24000	W
Switching loss ½ V I (t_r + t_f) f	0.52500	W
Gate drive power Q_g V_GS f (in the driver)	0.075000	W
Total MOSFET loss (conduction + switching)	0.76500	W
Junction temperature	55.300	°C

Notes for this case

- Hard-switching linear-ramp estimate. R_DS(on) roughly doubles from 25 °C to 125 °C, so use the hot value; reverse recovery of the body diode and output capacitance (½C_oss V² f) add further loss at high voltage.

Formula and method

$$P_{cond} = I_{rms}^2 R_{DS(on)}, \quad P_{sw} = \frac{1}{2} V_{DS} I_{sw} (t_r + t_f) f_s, \quad P_{gate} = Q_g V_{GS} f_s, \quad T_j = T_a + P_{tot} R_{\theta JA}$$

Variables

I_{rms}	RMS drain current	A
$R_{DS(on)}$	On-resistance at operating temperature	Ω
V_{DS}	Voltage switched	V
I_{sw}	Current switched	A
t_r	Rise time	s
t_f	Fall time	s
f_s	Switching frequency	1/s
Q_g	Total gate charge	C

V_{GS}	Gate drive voltage	V
$R_{\theta JA}$	Junction-to-ambient thermal resistance (K/W)	-
T_a	Ambient temperature	K
P_{cond}	Conduction loss I²R	W
P_{sw}	Switching loss ½ V I (t_r + t_f) f	W
P_{gate}	Gate drive power Q_g V_GS f (in the driver)	W
P_{tot}	Total MOSFET loss (conduction + switching)	W
T_j	Junction temperature	K

Method and standards

Semiconductor loss estimation.

Assumptions and limits

- Hard switching, linear current and voltage transitions.

References

Conduction and linear-ramp switching loss estimates

Report details

Report reference	FCC-J7AH-V72Q (the same inputs always give the same reference)
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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/mosfet-power-loss

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.