Thermionic Emission Current and Converter Output

Emission current density from a hot cathode by the Richardson-Dushman law, the back current from the collector and the ideal output of a thermionic converter.

Method: Richardson–Dushman thermionic emission

Input parameters

Unit system: SI

Parameter	Value	Unit
Emitter temperature	1,526.8	°C
Emitter work function	2.5000	eV
Collector temperature	626.85	°C
Collector work function	1.7000	eV
Material correction to the Richardson constant (about 0.5)	0.50000	

Calculated results

Parameter	Value	Unit
Emitter current density	19.482	A/cm²
Collector back-emission current density	0.014712	A/cm²
Net current density	19.467	A/cm²
Ideal output voltage (W_e − W_c)/e	0.80000	V
Ideal output power density	15.574	W/cm²

Notes for this case

• J = λ_R A₀T²exp(−W/kT), A₀ = 4πm_eek²/h³ = 1.2017 × 10⁶ A/(m²K²). Ideal converter: no space charge, output voltage (W_e − W_c)/e. Real converters need caesium vapour to neutralise space charge and lose a few tenths of a volt.

Formula and method

$$J = \lambda_R A_0 T^2 e^{-W/kT}, \quad A_0 = \frac{4\pi m_e e k^2}{h^3}$$

Variables

T_e	Emitter temperature	K
W_e	Emitter work function	J
T_c	Collector temperature	K
W_c	Collector work function	J
λ_R	Material correction to the Richardson constant (about 0.5)	-
J_e	Emitter current density	A/m²
J_c	Collector back-emission current density	A/m²
J	Net current density	A/m²
V	Ideal output voltage (W_e − W_c)/e	V
P/A	Ideal output power density	W/m²

Method and standards

Thermionic emission.

Assumptions and limits

- Ideal converter; no space charge.

References

Richardson–Dushman thermionic emission

Report details

Report reference	FCC-KDB7-XGTH (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/thermionic-emission-current

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.