LED Engineer's Reference Cheat Sheet

Kelvin · CRI · SMD sizes · Ohm's law · resistors · forward voltage · lumens · lux · IP ratings

COLOR TEMPERATURE (CCT)

CCT	Looks like	Use for
1,800–2,200 K	Candlelight, amber	Bars, night lighting, dark-sky outdoor
2,700 K	Incandescent bulb	Living rooms, bedrooms, dining
3,000 K	Halogen lamp	Kitchens, baths, hotels, shops, streets
3,500 K	Neutral warm	Offices, classrooms, retail
4,000 K	Cool-white fluorescent	Offices, garages, workshops, hospitals
5,000 K	Direct midday sun	Color evaluation, art studios, warehouses
6,500 K	Overcast sky (D65)	Display calibration, some task lighting
10,000 K	Clear blue sky	Marine aquariums, effects

CCT AND CRI BY ROOM

Space	CCT	CRI (Ra)	R9
Living room	2,700–3,000 K	90+	50+
Bedroom	2,200–2,700 K	90+	50+
Kitchen	3,000–4,000 K	90+	50+
Bathroom vanity	3,000–4,000 K	90–95+	50+
Home office	3,500–4,000 K	90+	—
Office, classroom	3,500–4,000 K	80–90	—
Retail: fashion, food	3,000–3,500 K	90–98	80+
Museum, gallery	2,700–3,500 K	95–98	90+
Garage, workshop	4,000–5,000 K	80–90	—
Healthcare examination	3,500–5,000 K	90+	50+
Outdoor, streets	3,000 K or less	70+	—

Use one CCT per room so fixtures match. Outdoors near habitats, 2,200–2,700 K with shielded fixtures.

CRI AND TM-30 IN BRIEF

Ra is the average of eight pastel samples, R1–R8 (CIE 13.3). **R9**, saturated red, is not in Ra: cheap LEDs score near zero.

Ra 80 is the indoor minimum (EN 12464-1, ENERGY STAR). **Ra 90+** for homes and shops; **95+ with R9 90+** for color-critical work. California JA8: Ra 90 and R9 ≥ 50.

A 90-CRI LED gives about 10–20% fewer lumens per watt than a similar 80-CRI LED.

TM-30 (ANSI/IES): Rf fidelity 0–100 over 99 samples; Rg gamut, where 100 matches the reference. Specify Rf ≥ 90 for accuracy, or Rf mid-80s+ with Rg 100–110 where colors should look vivid.

SMD LED PACKAGE SIZES

Package	Size (mm)	Dies	Power	lm/W
3528	3.5 × 2.8	1	0.06–0.1 W	60–100
2835	2.8 × 3.5	1–2	0.2–1 W	120–220
3030	3.0 × 3.0	1	0.2–2 W	150–220
5050	5.0 × 5.0	3	0.2–0.3 W	70–110
5630 / 5730	5.6–5.7 × 3.0	1	0.5 W	100–150

The name is length × width in tenths of a millimetre. 2835 and 3030 have large thermal pads, so they run cooler and brighter; 5050 holds three dies for RGB. 3030 uses heat-resistant EMC plastic for high-bays and streetlights.

LED STRIPS PER METRE

Chip	LEDs/m	Power/m	Output/m
3528 white	60 / 120	4.8 / 9.6 W	300–800 lm
2835 white	60–240	6–20 W	600–2,200 lm
5050 white	30 / 60	7.2 / 14.4 W	500–1,400 lm
5050 RGB	30 / 60	7.2 / 14.4 W	200–600 lm
WS2812B (5 V)	30 / 60 / 144	9 / 18 / 43 W	Pixel effects
COB (dotless)	320–528 dies	8–15 W	800–1,500 lm

12 V strips repeat one resistor and three LEDs in series, so they cut every three LEDs. Inject power every 1–2 m on 5 V pixel strips.

DRIVERS AND DIMMING

- **Constant current (CC):** a fixed current such as 350, 700 or 1,050 mA. The string's total V_f must sit inside the driver's voltage window. Use for COBs, high-power LEDs and fixtures.
- **Constant voltage (CV):** 12 V or 24 V for strips and modules with on-board resistors. Size the supply at least 20% above the load.
- **Dimming:** TRIAC or ELV phase-cut in homes; 0–10 V and DALI in commercial buildings; PWM for strips. PWM above about 3 kHz or constant-current reduction avoids flicker (IEEE 1789).
- **Flicker:** percent flicker = 100 × (max − min) ÷ (max + min). At 120 Hz, ≤ 4% has no observable effect and ≤ 9.6% is low risk.

LIFETIME: L70, LM-80 AND TM-21

- **L70**: hours until output falls to 70% of initial (L80 and L90 are stricter). L70B10 means no more than 10% of units are below 70% by then; L70B50 allows half.
- **IES LM-80** tests LED packages for at least 6,000 h at case temperatures of 55 °C, 85 °C and one more chosen by the maker.
- **ANSI/IES TM-21** projects LM-80 data to at most 6 × the test time: 10,000 h of testing supports "L70 > 60,000 h" at most.
- At 12 h/day, 50,000 h is about 11 years; at 4 h/day, about 34 years.

© 2026 LEDlights.org · Free to print and share with attribution. Typical values; always check the datasheet.

LED Engineer's Reference Cheat Sheet

Ohm's law · series resistors · E24 · color code · forward voltage · lumens · lux · IP ratings · formulas

OHM'S LAW AND THE LED SERIES RESISTOR

$V = I \times R \quad \cdot \quad I = V \div R \quad \cdot \quad P = V \times I = I^2 \times R = V^2 \div R$

$R = (V_{supply} - n \times V_f) \div I_f$

$P_R = (V_{supply} - n \times V_f) \times I_f$

Round R **up** to the next E24 value so the current stays at or below target. Choose a resistor rated at least **2 ×** P_R.

Leave at least 0.6 V of headroom across the resistor; with less, small V_f changes swing the current.

Use one resistor per series string, never one for parallel LEDs. Above about 350 mA, use a constant-current driver.

Example: 12 V supply, three white LEDs (3.1 V), 20 mA: R = (12 − 9.3) ÷ 0.02 = 135 Ω → use 150 Ω (brown-green-brown-gold). Actual current 2.7 ÷ 150 = 18 mA; P = 2.7 × 0.018 ≈ 0.05 W, so a ⅛ W or ¼ W resistor is fine.

E24 RESISTOR VALUES (±5% SERIES)

1.0	1.1	1.2	1.3	1.5	1.6	1.8	2.0	2.2	2.4	2.7	3.0
3.3	3.6	3.9	4.3	4.7	5.1	5.6	6.2	6.8	7.5	8.2	9.1

Multiply by 1, 10, 100, 1k, 10k… (IEC 60063). E12 keeps every second value; E96 is the 1% series.

RESISTOR COLOR CODE (IEC 60062)

Color	Digit	Multiplier	Tolerance
Black	0	×1	—
Brown	1	×10	±1%
Red	2	×100	±2%
Orange	3	×1k	—
Yellow	4	×10k	—
Green	5	×100k	±0.5%
Blue	6	×1M	±0.25%
Violet	7	×10M	±0.1%
Grey	8	×100M	—
White	9	×1G	—
Gold	—	×0.1	±5%
Silver	—	×0.01	±10%

Four bands: digit, digit, multiplier, tolerance. Read from the end with the bands bunched together.

KEY FORMULAS

- $\lambda\ (nm) \approx 1240 \div E_g\ (eV)$ · 2.76 eV InGaN → 450 nm
- Efficacy (lm/W) = lumens ÷ watts
- lux = lumens ÷ m² · 1 fc = 10.764 lux
- Lumens needed ≈ area (m²) × lux ÷ 0.6
- DLI (mol/m²/day) = PPFD × hours × 0.0036
- $T_j = T_a + P_{heat} \times R_{\theta(total)}$
- kWh/yr = W × qty × h/day × 365 ÷ 1000

FORWARD VOLTAGE BY COLOR (20 MA)

Color	Wavelength	Material	V_f
Infrared	850–940 nm	GaAs, AlGaAs	1.2–1.6 V
Red	620–660 nm	AlInGaP, AlGaAs	1.8–2.2 V
Orange, amber	590–615 nm	AlInGaP	2.0–2.2 V
Yellow	585–595 nm	AlInGaP	2.0–2.2 V
Green	515–530 nm	InGaN	2.8–3.4 V
Blue	450–475 nm	InGaN	2.8–3.3 V
White	Blue + phosphor	InGaN + YAG	2.8–3.3 V
UV-A	365–405 nm	InGaN, GaN	3.0–3.9 V

High-power LEDs at 350 mA or more run 0.2–0.5 V higher. Always use the datasheet bin.

LUMEN AND WATTAGE EQUIVALENTS

Replacing	Light output	LED
40 W incandescent	~450 lm	4–5 W
60 W incandescent	~800 lm	8–9 W
75 W incandescent	~1,100 lm	11–12 W
100 W incandescent	~1,600 lm	14–16 W
150 W incandescent	~2,600 lm	22–26 W
400 W metal halide (458 W system)	~18,900 lm delivered	135–150 W
400 W HPS (465 W system)	~27,000 lm delivered	150–200 W
3 × 32 W T8 troffer (85 W)	~5,120 lm delivered	35–40 W

Bulbs follow the U.S. FTC Lighting Facts values at about 100 lm/W; fixtures use delivered lumens at 125–140 lm/W. LED street lights often replace HPS with fewer lumens thanks to better optics.

RECOMMENDED LIGHT LEVELS (MAINTAINED)

Space or task	Illuminance
Corridors, garages	50–150 lux
Living rooms	100–300 lux
Offices, classrooms	300–500 lux
Kitchen counters, retail	300–750 lux
Detailed work	750–1,500 lux
Surgical field (IEC 60601-2-41)	40,000–160,000 lux

EN 12464-1 and IES practice. Design 25–40% higher at installation to allow for lumen depreciation and dirt.

IP RATINGS (IEC 60529)

Code	Solids	Water	Typical use
IP20	Fingers	None	Dry indoor spaces
IP44	Wires ≥ 1 mm	Splashing	Bathrooms outside the shower, porches
IP65	Dust-tight	Low-pressure jets	Outdoor walls, shower ceilings
IP66	Dust-tight	Powerful jets	Floodlights, streetlights
IP67	Dust-tight	Immersion to 1 m, 30 min	In-ground lights, outdoor strips
IP68	Dust-tight	Continuous immersion	Pools, ponds, fountains

Sources: CIE 13.3; ANSI/IES TM-30, LM-80 and TM-21; EN 12464-1; IEC 60529, 60062, 60063 and 60601-2-41; IEEE 1789; U.S. FTC Lighting Facts.