



PCB Calculator

November 18, 2019

Contents

1	Introduction	1
2	Calculators	1
2.1	Regulators	1
2.2	Track-Width	2
2.3	Electrical-Spacing	3
2.4	TransLine	3
2.5	RF-Attenuators	5
2.6	Color-Code	6
2.7	Board-Classes	6

*Reference manual***Copyright**

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Feedback

Please direct any bug reports, suggestions or new versions to here:

- About KiCad document: <https://github.com/KiCad/kicad-doc/issues>
- About KiCad software: <https://bugs.launchpad.net/kicad>
- About KiCad software i18n: <https://github.com/KiCad/kicad-i18n/issues>

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1 Introduction

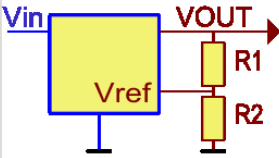
The KiCad PCB Calculator is a set of utilities to help you find the values of components or other paremeters of a layout. The Calculator has the following tools:

- Regulators
- Track Width
- Electrical Spacing
- Trans Line
- RF Attenuators
- Color Code
- Board Classes

2 Calculators

2.1 Regulators

This calculator helps with the task of finding the values of the resistors needed for linear and low-dropout voltage regulators.

Regulators	Track Width	Electrical Spacing	TransLine	RF Attenuators	Color Code	Board Classes
<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <input checked="" type="radio"/> R1: <input type="text" value="10"/> kΩ <input type="radio"/> R2: <input type="text" value="10"/> kΩ <input type="radio"/> Vout: <input type="text" value="12"/> V Vref: <input type="text" value="3"/> V Iadj: <input type="text"/> μA Type: Standard Type </div> </div>						
<input type="button" value="Calculate"/>						
Regulator: Regulators data file: <input type="text"/> <input type="button" value="Browse"/> <input type="button" value="Edit Regulator"/> <input type="button" value="Add Regulator"/> <input type="button" value="Remove Regulator"/>						
Message						
Formula: $V_{out} = V_{ref} * (R1 + R2) / R2$						

For the *Standard Type*, the output voltage V_{out} as a function of the reference voltage V_{ref} and resistors $R1$ and $R2$ is given by:

$$V_{out} = V_{ref} \cdot \left(\frac{R1 + R2}{R1} \right)$$

For the *3 terminal type*, there is a correction factor due to the quiescent current I_{adj} flowing from the adjust pin:

$$V_{out} = V_{ref} \cdot \left(\frac{R1 + R2}{R1} \right) + I_{adj} \cdot R2$$

This current is typically below 100 μA and can be neglected with caution.

To use this calculator, enter the parameters of the regulator *Type*, *Vref* and, if needed, *Iadj*, select the field you want to calculate (one of the resistors or the output voltage) and enter the other two values.

2.2 Track-Width

The Track Width tool calculates the trace width for printed circuit board conductors for a given current and temperature rise. It uses formulas from IPC-2221 (formerly IPC-D-275).

Regulators	Track Width	Electrical Spacing	TransLine	RF Attenuators	Color Code	Board Classes
Parameters:						
Current: 0.744609		A				
Temperature rise: 10.0		deg C				
Conductor length: 20		mm				
Resistivity: 1.72e-8		Ohm-meter				
<p>If you specify the maximum current, then the trace widths will be calculated to suit. If you specify one of the trace widths, the maximum current it can handle will be calculated. The width for the other trace to also handle this current will then be calculated. The controlling value is shown in bold.</p> <p>The calculations are valid for currents up to 35A (external) or 17.5A (internal), temperature rises up to 100 deg C, and widths of up to 400mil (10mm). The formula, from IPC 2221, is</p> $I = K * dT^{0.44} * (W*H)^{0.725}$ <p>where: I = maximum current in amps dT = temperature rise above ambient in deg C W,H = width and thickness in mils K = 0.024 for internal traces or 0.048 for external traces</p>						
External layer traces:						
Trace width: 0.2		mm				
Trace thickness: 0.035		mm				
Cross-section area: 0.007		mm x mm				
Resistance: 0.0491429		Ω				
Voltage drop: 0.0365922		Volt				
Power loss: 0.0272469		Watt				
Internal layer traces:						
Trace width: 0.520288		mm				
Trace thickness: 0.035		mm				
Cross-section area: 0.0182101		mm x mm				
Resistance: 0.0188906		Ω				
Voltage drop: 0.0140661		Volt				
Power loss: 0.0104738		Watt				

2.3 Electrical-Spacing

This table helps finding the minimum clearance between conductors.

Each line of the table has a minimum recommended distance between conductors for a given voltage (DC or AC peaks) range. If you need the values for voltages higher than 500V, enter the value in the box in the left corner and press *Update Values*.

Regulators	Track Width	Electrical Spacing	TransLine	RF Attenuators	Color Code	Board Classes			
<div>mm</div>		Note: Values are minimal values (from IPC 2221)							
Voltage > 500V: 500		B1	B2	B3	B4	A5	A6	A7	
Update Values		0-15V	0.05	0.1	0.1	0.05	0.13	0.13	0.13
		16-30V	0.05	0.1	0.1	0.05	0.13	0.25	0.13
		31-50V	0.1	0.6	0.6	0.13	0.13	0.4	0.13
		51-100V	0.1	0.6	1.5	0.13	0.13	0.5	0.13
		101-150V	0.2	0.6	3.2	0.4	0.4	0.8	0.4
		151-170V	0.2	1.25	3.2	0.4	0.4	0.8	0.4
		171-250V	0.2	1.25	6.4	0.4	0.4	0.8	0.4
		251-300V	0.2	1.25	12.5	0.4	0.4	0.8	0.8
		301-500V	0.25	2.5	12.5	0.8	0.8	1.5	0.8
		> 500V	0.25	2.5	12.5	0.8	0.8	1.5	0.8
<div>* B1 - Internal Conductors</div> <div>* B2 - External Conductors, uncoated, sea level to 3050 m</div> <div>* B3 - External Conductors, uncoated, over 3050 m</div> <div>* B4 - External Conductors, with permanent polymer coating (any elevation)</div> <div>* A5 - External Conductors, with conformal coating over assembly (any elevation)</div> <div>* A6 - External Component lead/termination, uncoated</div> <div>* A7 - External Component lead termination, with conformal coating (any elevation)</div>									

2.4 TransLine

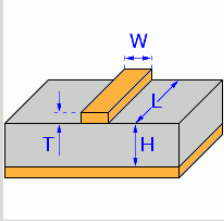
Transmission line theory is a cornerstone in the teaching of RF and microwave engineering.

In the calculator you can choose different sorts of Line Types and their special parameters. The models implemented are frequency-dependent, so they disagree with simpler models at high *enough* frequencies.

This calculator is heavily based on [Transcalc](#).

The transmission line types and the reference of their mathematical models are listed below:

- Microstrip line:
 - H. A. Atwater, “Simplified Design Equations for Microstrip Line Parameters” , Microwave Journal, pp. 109-115, November 1989.
 - Coplanar wave guide.
 - Coplanar wave guide with ground plane.
 - Rectangular waveguide:
 - S. Ramo, J. R. Whinnery and T. van Duzer, ”Fields and Waves in Communication Electronics”, Wiley-India, 2008, ISBN: 9788126515257.
 - Coaxial line.
 - Coupled microstrip line:
 - H. A. Atwater, “Simplified Design Equations for Microstrip Line Parameters” , Microwave Journal, pp. 109-115, November 1989.
 - M. Kirschning and R. H. Jansen, ”Accurate Wide-Range Design Equations for the Frequency-Dependent Characteristic of Parallel Coupled Microstrip Lines,” in IEEE Transactions on Microwave Theory and Techniques, vol. 32, no. 1, pp. 83-90, Jan. 1984. doi: 10.1109/TMTT.1984.1132616.
 - Rolf Jansen, ”High-Speed Computation of Single and Coupled Microstrip Parameters Including Dispersion, High-Order Modes, Loss and Finite Strip Thickness”, IEEE Trans. MTT, vol. 26, no. 2, pp. 75-82, Feb. 1978.
 - S. March, ”Microstrip Packaging: Watch the Last Step”, Microwaves, vol. 20, no. 13, pp. 83.94, Dec. 1981.
 - Stripline.
 - Twisted pair.
-

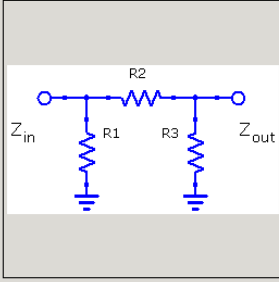
Regulators	Track Width	Electrical Spacing	TransLine	RF Attenuators	Color Code	Board Classes
Transmission Line Type: <input checked="" type="radio"/> Microstrip Line <input type="radio"/> Coplanar wave guide <input type="radio"/> Coplanar wave guide with ground plane <input type="radio"/> Rectangular Waveguide <input type="radio"/> Coaxial Line <input type="radio"/> Coupled Microstrip Line <input type="radio"/> Stripline <input type="radio"/> Twisted Pair			Substrate Parameters Er: 4.6 TanD: 0.02 Rho: 1.72e-08 H: 0.2 mm H_t: 1e+20 mm T: 0.035 mm Rough: 0 mm mu Rel S: 1 mu Rel C: 1		Physical Parameters: W: 0.2 mm L: 50 mm Analyze Synthesize	
			Component Parameters: Frequency: 1 GHz		Electrical Parameters: ZO: 50 Ω Ang_l: 0 Radian Results: ErEff: Conductor Losses: Dielectric Losses: Skin Depth:	

2.5 RF-Attenuators

With the RF Attenuator utility you can calculate the values of the resistors needed for different types of attenuators:

- PI
- Tee
- Bridged Tee
- Resistive Splitter

To use this tool, first select the type of attenuator you need, then enter the desired attenuation (in dB) and input/output impedances (in Ohms).

Regulators	Track Width	Electrical Spacing	TransLine	RF Attenuators	Color Code	Board Classes
Attenuators: <input checked="" type="radio"/> PI <input type="radio"/> Tee <input type="radio"/> Bridged Tee <input type="radio"/> Resistive Splitter			Parameters: Attenuation: 6 dB Zin: 50 Ω Zout: 50 Ω Calculate		Formula Z_{in} desired input impedance in Ω Z_{out} desired output impedance in Ω a attenuation in dB $L = 10^{a/10}$ (the loss) $A = (L + 1)/(L - 1)$ Pi attenuator $R2 = (L - 1)/2 * \sqrt{(Z_{in} * Z_{out})/L}$ $R1 = 1/(A/Z_{in} - 1/R2)$ $R3 = 1/(A/Z_{out} - 1/R2)$	
			Values R1: Ω R2: Ω R3: Ω Messages:			

2.6 Color-Code

This calculator helps translating the color bars from the resistor to its value. To use it, first select the *tolerance* of the resistor: 10%, 5% or equal or smaller than 2%. For example:

- Yellow Violet Red Gold: 4 7 x100 ±5% = 4700 Ohm, 5% tolerance
- 1kOhm, 1% tolerance: Brown Black Black Brown Brown

Regulators

Track Width

Electrical Spacing

TransLine

RF Attenuators

Color Code

Board Classes

1st Band

2nd Band

3rd Band

4th Band

Multiplier

Tolerance

Black	0	0	0	0	x 1	
Brown	1	1	1	1	x 10	± 1%
Red	2	2	2	2	x 100	± 2%
Orange	3	3	3	3	x 1k	
Yellow	4	4	4	4	x 10k	
Green	5	5	5	5	x 100k	± 0.5%
Blue	6	6	6	6	x 1M	± 0.25%
Violet	7	7	7	7	x 10M	± 0.10%
Grey	8	8	8	8	x 100M	± 0.05%
White	9	9	9	9	x 1G	
Gold					x 0.1	± 5%
Silver					x 0.01	± 10%

Tolerance

☐ 10% / 5%

☒ <= 2%

2.7 Board-Classes

Regulators

Track Width

Electrical Spacing

TransLine

RF Attenuators

Color Code

Board Classes

mm

Note: Values are minimal values

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
Lines width	0.8	0.5	0.31	0.21	0.15	0.12
Min clearance	0.68	0.5	0.31	0.21	0.15	0.12
Via: (diam - drill)	--	--	0.45	0.34	0.24	0.2
Plated Pad: (diam - drill)	1.19	0.78	0.6	0.49	0.39	0.35
NP Pad: (diam - drill)	1.57	1.13	0.9	--	--	--