



PCB Calculator

June 7, 2022

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Reference manual

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Contributors

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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>

Publication date and software version

july 17, 2019

1 Introduction

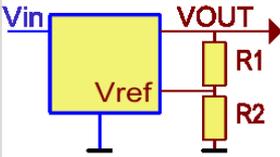
The KiCad PCB Calculator is a set of utilities to help you find the values of components or other paremeters of a layout. The Calculator has the following tools:

- 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; justify-content: space-between;"> <div style="width: 45%;">  </div> <div style="width: 50%;"> <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: <input type="text" value="Standard Type"/> </div> </div> <div style="text-align: right; margin-top: 10px;"><input type="button" value="Calculate"/></div> <div style="margin-top: 10px;"> Regulator: <input type="text"/> 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"/> </div> <div style="margin-top: 10px;"> Message: <input type="text"/> </div> <div style="margin-top: 10px;"> Formula: Vout = Vref * (R1 + R2) / R2 </div>						

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 uA and can be neglected with caution.

To use this calculator, enter the parameters of the regulator *Type*, V_{ref} and, if needed, I_{adj} , 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:	<input type="text" value="0.744609"/>	A				
Temperature rise:	<input type="text" value="10.0"/>	deg C				
Conductor length:	<input type="text" value="20"/>	mm				
Resistivity:	<input type="text" value="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:	<input type="text" value="0.2"/>	mm				
Trace thickness:	<input type="text" value="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:	<input type="text" value="0.520288"/>	mm				
Trace thickness:	<input type="text" value="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 style="display: flex; align-items: flex-start;"> <div style="margin-right: 10px;"> <input type="text" value="mm"/> <input type="text" value="Voltage > 500V: 500"/> <input type="button" value="Update Values"/> </div> <div> <p style="text-align: center;">Note: Values are minimal values (from IPC 2221)</p> <table border="1"> <thead> <tr> <th></th> <th>B1</th> <th>B2</th> <th>B3</th> <th>B4</th> <th>A5</th> <th>A6</th> <th>A7</th> </tr> </thead> <tbody> <tr> <td>0-15V</td> <td>0.05</td> <td>0.1</td> <td>0.1</td> <td>0.05</td> <td>0.13</td> <td>0.13</td> <td>0.13</td> </tr> <tr> <td>16-30V</td> <td>0.05</td> <td>0.1</td> <td>0.1</td> <td>0.05</td> <td>0.13</td> <td>0.25</td> <td>0.13</td> </tr> <tr> <td>31-50V</td> <td>0.1</td> <td>0.6</td> <td>0.6</td> <td>0.13</td> <td>0.13</td> <td>0.4</td> <td>0.13</td> </tr> <tr> <td>51-100V</td> <td>0.1</td> <td>0.6</td> <td>1.5</td> <td>0.13</td> <td>0.13</td> <td>0.5</td> <td>0.13</td> </tr> <tr> <td>101-150V</td> <td>0.2</td> <td>0.6</td> <td>3.2</td> <td>0.4</td> <td>0.4</td> <td>0.8</td> <td>0.4</td> </tr> <tr> <td>151-170V</td> <td>0.2</td> <td>1.25</td> <td>3.2</td> <td>0.4</td> <td>0.4</td> <td>0.8</td> <td>0.4</td> </tr> <tr> <td>171-250V</td> <td>0.2</td> <td>1.25</td> <td>6.4</td> <td>0.4</td> <td>0.4</td> <td>0.8</td> <td>0.4</td> </tr> <tr> <td>251-300V</td> <td>0.2</td> <td>1.25</td> <td>12.5</td> <td>0.4</td> <td>0.4</td> <td>0.8</td> <td>0.8</td> </tr> <tr> <td>301-500V</td> <td>0.25</td> <td>2.5</td> <td>12.5</td> <td>0.8</td> <td>0.8</td> <td>1.5</td> <td>0.8</td> </tr> <tr> <td>> 500V</td> <td>0.25</td> <td>2.5</td> <td>12.5</td> <td>0.8</td> <td>0.8</td> <td>1.5</td> <td>0.8</td> </tr> </tbody> </table> <p>* B1 - Internal Conductors * B2 - External Conductors, uncoated, sea level to 3050 m * B3 - External Conductors, uncoated, over 3050 m * B4 - External Conductors, with permanent polymer coating (any elevation) * A5 - External Conductors, with conformal coating over assembly (any elevation) * A6 - External Component lead/termination, uncoated * A7 - External Component lead termination, with conformal coating (any elevation)</p> </div> </div>								B1	B2	B3	B4	A5	A6	A7	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
	B1	B2	B3	B4	A5	A6	A7																																																																																							
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2.4 TransLine

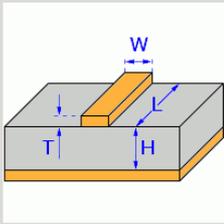
Transmission line theory is a cornerstone in the teaching of RF and microwave engineering.

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: <ul style="list-style-type: none"> <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					
Component Parameters:						
Frequency:	1	GHz				
Physical Parameters:						
W:	0.2	mm				
L:	50	mm				
<input type="button" value="Analyze"/> <input type="button" value="Synthesize"/>						
Electrical Parameters:						
Z0:	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:
 PI
 Tee
 Bridged Tee
 Resistive Splitter

Parameters:
 Attenuation: 6 dB
 Zin: 50 Ω
 Zout: 50 Ω

Calculate [Download]

Values:
 R1: _____ Ω
 R2: _____ Ω
 R3: _____ Ω

Messages:

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

$R2 = (L - 1)/2 * \sqrt{(Z_{in} * Z_{out})/L}$
 $R1 = 1/(A/Z_{in} - 1/R2)$
 $R3 = 1/(A/Z_{out} - 1/R2)$

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: $47 \times 100 \pm 5\% = 4700 \text{ Ohm}$, 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	--	--	--