



**PCB Calculator**

**April 25, 2019**

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*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>

**Publication date and software version**

march 04, 2019

## 1 Introduction

The Kicad Calculator gives you the Chance to calculate the most important Things without leaving Kicad.

The Calculator consists the following Options:

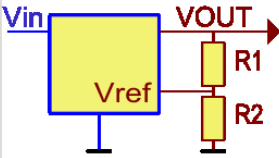
- Regulators
- Track Width
- Electrical Spacing
- Trans Line
- RF Attenuators
- Color Code
- Board Classes

## 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: <input type="text" value="Standard Type"/> </div> </div>						
<input type="button" value="Calculate"/>						
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"/>						
Message						
Formula: <b>Vout = Vref * (R1 + R2) / R2</b>						

For the *Standard Type*, the output voltage  $V_{out}$  as a function of the reference voltage  $V_{ref}$  and resistors  $R_1$  and  $R_2$  is given by:

$$V_{out} = V_{ref} \cdot \left( \frac{R_1 + R_2}{R_1} \right)$$

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

$$V_{out} = V_{ref} \cdot \left( \frac{R_1 + R_2}{R_1} \right) + I_{adj} \cdot R_2$$

This current is typically below 100  $\mu A$  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 calculator calculates the trace width for printed circuit board conductors for a given current. It uses formulas from IPC-2221 (formerly IPC-D-275).

Regulators	Track Width	Electrical Spacing	TransLine	RF Attenuators	Color Code	Board Classes
<b>Parameters:</b> <b>Current:</b> <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						
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						

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.

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

$$I = K * dT^{0.44} * (W*H)^{0.725}$$

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

### 2.3 Electrical-Spacing

In the Picture you can see that you can edit the Voltage and the Calculator gives you the correct Values.  
 The minimal Values which orientatd at the IPC-2221 too.

Regulators

Track Width

Electrical Spacing

TransLine

RF Attenuators

Color Code

Board Classes

mm

Voltage > 500V:

500

Update Values

Note: Values are minimal values (from IPC 2221)

	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 - 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)

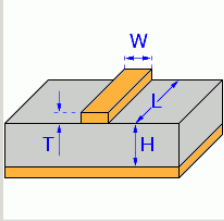
\* A6 - External Component lead/termination, uncoated

\* A7 - External Component lead termination, with conformal coating (any elevation)

### 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.

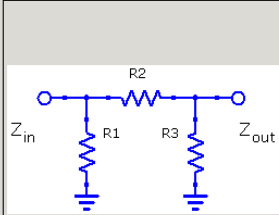
Regulators	Track Width	Electrical Spacing	TransLine	RF Attenuators	Color Code	Board Classes
<b>Transmission Line Type:</b> <input checked="" type="radio"/> Microstrip Line <input type="radio"/> Coplanar wave guide <input type="radio"/> Coplanar wave guide with ground plane <input type="radio"/> Rectangular Waveguide <input type="radio"/> Coaxial Line <input type="radio"/> Coupled Microstrip Line <input type="radio"/> Stripline <input type="radio"/> Twisted Pair			<b>Substrate Parameters</b> 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		<b>Physical Parameters:</b> W: 0.2 mm L: 50 mm Analyze Synthesize	
			<b>Component Parameters:</b> Frequency: 1 GHz		<b>Electrical Parameters:</b> Z0: 50 Ω Ang_L: 0 Radian <b>Results:</b> ErEff: Conductor Losses: Dielectric Losses: Skin Depth:	

## 2.5 RF-Attenuators

With the RF Attenuator you can calculate different things by choosing:

- PI
- Tee
- Bridged Tee
- Resistive Splitter

and change all their Parameters.

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

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	--	--	--