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# Calculator Tools

Team The [FAMILY Given]

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The KiCad project welcomes feedback, bug reports, and suggestions related to the software or its documentation. For more information on how to submit feedback or report an issue, please see the instructions at <https://www.kicad.org/help/report-an-issue/>

## 1. ####

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

- #####

- ###
- ####
- #####
- RF #####
- ### ###
- ### ###

## 2. #####

### 2.1. #####

#####

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:

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

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

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

##### 100 uA #####

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. RF #####

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

- ###
- T#
- ##### T #
- #####

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).

PCB Calculator

レギュレーター 配線幅 導体間隔 伝送線路 **RFアッテネータ** カラーコード ボードクラス

アッテネータ:

- ☒ パイ型
- ☐ T型
- ☐ プリッジT型
- ☐ 抵抗分割型

パラメーター:

減衰量 6 dB

Zin 50 Ω

Zout 50 Ω

計算

値

R1 Ω

R2 Ω

R3 Ω

メッセージ:

計算式

$Z_{in}$  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**

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

$R1 = 1/(A/Z_{in} - 1/R2)$

$R3 = 1/(A/Z_{out} - 1/R2)$

## 2.3. E-Series

This calculator helps to identify combinations of standard E-series resistors that meet a required resistance, optionally excluding several resistor values that are not available.

**PCB Calculator**

Regulators RF Attenuators **E-Series** Color Code TransLine Via Size Track Width Electrical Spacing Board Classes

**Inputs**

Required resistance:  kΩ

Exclude value 1:  kΩ

Exclude value 2:  kΩ

☐ E1 ☐ E3 ☒ E6 ☐ E12 ☐ E24

**Solutions**

Simple solution:  Error:  %

3R solution:  Error:  %

4R solution:  Error:  %

**Calculate**

**Help**

E-series are defined in IEC 60063.

Available values are approximately equally spaced in a logarithmic scale.

E24 (5%): 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

E12 (10%): 1.0 1.2 1.5 1.8 2.2 2.7 3.3 3.9 4.7 5.6 6.8 8.2

E6 (20%): 1.0 - 1.5 - 2.2 - 3.3 - 4.7 - 6.8 -

E3 (50%): 1.0 - - - 2.2 - - - 4.7 - - -

E1 : 1.0 - - - - - - - - - -

- This calculator finds combinations of standard E-series (between 10Ω and 1MΩ) to create arbitrary values.
- You can enter the required resistance from 0.0025 to 4000 kΩ.
- Solutions using up to 4 components are given.

The requested value is always excluded from the solution set.

## 2.4. ###

##### (10%#5% ### 2% ##) #####:

- ###:  $4.7 \times 100 \pm 5\% = 4700 \Omega$ , ##### 5%
- 1 k#, ##### 1%: #####

**PCB Calculator**

レギュレーター 配線幅 導体間隔 伝送線路 RFアッテネータ **カラーコード** ボードクラス

	第1帯	第2帯	第3帯	第4帯	乗数	誤差
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%

誤差

☐ 10% / 5%

☒ ≤ 2%

## 2.5. ####

#####

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 [<http://transcalc.sourceforge.net/>].

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.

**PCB Calculator**

レギュレーター 配線幅 導体間隔 **伝送線路** RFアッテネータ カラーコード ボードクラス

伝送線路のタイプ:

- ☒ マイクロストリップライン
- ☐ コプレーナ導波路
- ☐ グランドプレーン付きコプレーナ導波路
- ☐ 方形導波管
- ☐ 同軸線路
- ☐ カップルドマイクロストリップライン
- ☐ ストリップライン
- ☐ ツイストペア

サブストレートパラメーター:

$\epsilon_r$ :	4.6	...
$\tan\delta$ :	0.02	...
$\rho$ :	1.72e-08	...
H:	0.2	mm
H <sub>t</sub> :	1e+20	mm
T:	0.035	mm
導体荒さ:	0	mm
$\mu$ (サブストレート比透磁率):	1	
$\mu$ (導体の比透磁率):	1	

物理的パラメーター:

W: 0.2 mm

L: 50 mm

分析 合成

電気的パラメーター:

Z<sub>0</sub>: 50  $\Omega$

Ang<sub>l</sub>: 0 ラジアン

結果:

ErEff (実効比誘電率):

導体損失:

誘電体損失:

表皮深さ:

コンポーネントパラメーター:

周波数: 1 GHz

3D Diagram: A 3D perspective view of a microstrip line on a substrate. The width of the strip is labeled 'W', the substrate thickness is 'H', and the thickness of the copper layer is 'T'.

## 2.6. Via Size

The Via Size tool calculates the electrical and thermal properties of a given plated through-hole pad or via.

**PCB Calculator**

Regulators RF Attenuators E-Series Color Code TransLine **Via Size** Track Width Electrical Spacing Board Classes

Parameters:

Finished hole diameter (D):	0.4	mm
Plating thickness (T):	0.035	mm
Via length:	1.6	mm
Via pad diameter:	0.6	mm
Clearance hole diameter:	1.0	mm
Z <sub>0</sub> :	50	$\Omega$
Applied current:	1	A
Plating resistivity:	1.72e-8	$\Omega \cdot m$
Substrate relative permittivity:	4.5	
Temperature rise:	10	$^{\circ}C$
Pulse rise time:	1	ns

Results:

Resistance:	0.000575362 $\Omega$
Voltage drop:	0.000575362 V
Power loss:	0.000575362 W
Thermal resistance:	83.2937 $^{\circ}C/W$
Estimated ampacity:	2.9993 A
Capacitance:	0.599508 pF
Rise time degradation:	32.9729 ps
Inductance:	1.20723 nH
Reactance:	3.79262 $\Omega$

Diagram: A cross-sectional view of a via. The diameter of the hole is labeled 'D', the diameter of the via pad is labeled 'T', and the thickness of the plating is labeled 'T'.

Reset to Defaults

## 2.7. ###

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).

PCB Calculator

レギュレーター 配線幅 導体間隔 伝送線路 RFアッテネータ カラーコード ボードクラス

パラメーター:

電流: 1.0 A

温度上昇: 10.0 °C

導体長: 20 mm

抵抗率: 1.72e-8 電気抵抗計

最大電流を指定した場合、配線幅は適応するように計算されます。  
配線幅の一つを指定した場合、流せる最大電流が計算されます。また、この電流を流すことができるように他のコントロール値は、ボールド体で表示されます。

計算は、電流に対しては 35A (外部) または 17.5A (内部) まで、温度上昇は 100°C まで、幅は 400mil (10mm) まで有効です。  
計算式 (IPC 2221 より) は

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

ここで:  
I = アンペア表記による最大電流  
dT = °C 表記による周囲に対する上昇温度  
W, H = mil 表記による幅と厚さ  
K = 内層配線 0.024 または 外層配線 0.048

外層配線:

配線幅: 0.300387 mm

配線の銅厚: 0.035 mm

断面積: 0.0105135 mm x mm

抵抗: 0.0327197 Ω

電圧降下: 0.0327197 Volt

電力損失: 0.0327197 W

内層配線:

配線幅: 0.781437 mm

配線の銅厚: 0.035 mm

断面積: 0.0273503 mm x mm

抵抗: 0.0125776 Ω

電圧降下: 0.0125776 Volt

電力損失: 0.0125776 W

## 2.8. #####

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*.

PCB Calculator

レギュレーター 配線幅 導体間隔 伝送線路 RFアッテネータ カラーコード ボードクラス

mm

電圧 > 500V:  
10000

値を更新

注: 値は最小値です (IPC 2221 より)

	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	24	50	250	29.775	29.775	30.475	29.775

\* B1 - 内層導体  
\* B2 - 外層導体, コーティングなし, 海拔3050mまで  
\* B3 - 外層導体, コーティングなし, 海拔3050m以上  
\* B4 - 外層導体, 耐久ポリマー コーティング (海拔によらず)  
\* A5 - 外層導体, Assy全体に絶縁保護コーティング (海拔によらず)  
\* A6 - 外層 コンポーネントリード/終端, コーティングなし  
\* A7 - 外層 コンポーネントリード/終端, 絶縁保護コーティング (海拔によらず)

## 2.9. ###

### Performance Classes

In IPC-6011 have been three performance classes established

- **Class 1 General Electronic Products:** Includes consumer products, some computer and computer peripherals suitable for applications where cosmetic imperfections are not important and the major requirement is function of the completed printed board.
- **Class 2 Dedicated Service Electronic Products:** Includes communications equipment, sophisticated business machines, instruments where high performance and extended life is required and for which uninterrupted service is desired but not critical. Certain cosmetic imperfections are allowed.
- **Class 3 High Reliability Electronic Products:** Includes the equipment and products where continued performance or performance on demand is critical. Equipment downtime cannot be tolerated and must function when required such as in life support items or flight control systems. Printed boards in this class are suitable for applications where high levels of assurance are required and service is essential.

### PCB Types

In IPC-6012B there are also 6 Types of PCB defined:

- Printed Boards without plated through holes (1)
  - 1 Single-Sided Board
- And Boards with plated through holes (2-6)
  - 2 Double-Sided Board
  - 3 Multilayer board without blind or buried vias
  - 4 Multilayer board with blind and/or buried vias
  - 5 Multilayer metal core board without blind or buried vias
  - 6 Multilayer metal core board with blind and/or buried vias



PCB Calculator

レギュレーター

配線幅

導体間隔

伝送線路

RFアッテネータ

カラーコード

ポートクラス

mm

注: 値は最小値です

	クラス1	クラス2	クラス3	クラス4	クラス5	クラス6
配線幅	0.8	0.5	0.31	0.21	0.15	0.12
最小クリアランス	0.68	0.5	0.31	0.21	0.15	0.12
ビア: (直径 - ドリル)	--	--	0.45	0.34	0.24	0.2
メッキありパッド: (直径 - ドリル)	1.19	0.78	0.6	0.49	0.39	0.35
メッキなしパッド: (直径 - ドリル)	1.57	1.13	0.9	--	--	--