

Appendix B

Printed Circuit Board (PCB) Design Parameters

Many PCB manufacturers still use imperial or mixed imperial and metric units. In the USA imperial is still the preferred choice of units for almost all applications. Both metric and imperial units are quoted here, although some approximations are made between the two. The units are determined from values given in one unit of measure and converted using $25.4 \text{ mm} = 1 \text{ inch}$ conversion factor.

Laminate Material Properties

Base material	Reference name	Relative dielectric constant ϵ_r	Maximum temperature T_{max} (°C)	Thermal conductivity k (W/m per K)
Difunctional epoxy	FR4	4.2–4.9	120–130	0.18
Tetrafunctional epoxy	FR4	4.4–4.9	>135	0.18
Multifunctional epoxy	FR5	4.2–4.9	140–170	
Alumina ceramic	Al_2O_3	10		20
Polyimide		3.5	260	
Teflon		2.2		

Values of relative dielectric for laminates can vary with the manufacturer. With FR4 it is dependent on the glass fibre to epoxy resin mix. A typical value of 4.7 is used throughout this book.

Copper track properties

Copper weight (oz)	Track thickness		Track resistance ($\text{m}\Omega/\square$)
	mm	inches	
0.5	0.018	0.0008	0.94
1.0	0.035	0.0015	0.49
2.0	0.070	0.0030	0.24

The resistance figure is in milliohms per square ($\text{m}\Omega/\square$). This is the resistance of any single square section of track. For a track which is 1 mm wide and 10 mm long, this would contain 10 square sections, hence for a 0.5 oz copper layer would have a resistance of 9.4 $\text{m}\Omega$. These resistance values are based on an electrical conductivity value of $17 \times 10^{-9} \Omega\text{m}$ for copper.

The most common copper weight in use is 1 oz and is used for the examples in this book.

Standard FR4 laminate and prepreg thicknesses

Laminate		Prepreg		
mm	inches	Code	mm	inches
0.100	0.004	116	0.050	0.002
0.115	0.0045	1080	0.065	0.0025
0.128	0.005	2113	0.075	0.003
0.150	0.006	2125	0.105	0.0042
0.200	0.008	7628	0.180	0.007
0.250	0.010	7648	0.190	0.0075

The table (standard FR4 laminate and prepreg thicknesses) shows some of the smaller commercial standards sizes. Thicker laminates can be constructed from either multiples of the above or combinations of laminate and prepreg. There is also a range of 'off-the-shelf' sizes in 0.05 mm (0.002") steps for both laminates and prepreg available from some manufacturers.

Minimum track and gap dimensions and probable yield

Track width		Gap		Yield (%)
mm	inches	mm	inches	
0.20	0.008	0.20	0.008	96
0.15	0.006	0.20	0.008	94
0.15	0.006	0.15	0.006	90
0.12	0.005	0.15	0.006	99
0.12	0.005	0.12	0.005	83
0.10	0.004	0.12	0.005	75
0.10	0.004	0.10	0.004	50

Fine tracks and gaps generally produce a yield loss at the PCB supplier. This yield loss is passed back to the customer in the form of increased board costs for fine geometry PCB designs. The table (minimum track and gap dimensions and probable yield) gives approximate yield losses for fine line track and gap sizes and may be useful to decide a minimum dimension without relying on the supplier's minimum track capability, which will include a premium.

Minimum drilled hole Size and PCB Thicknesses

PCB thickness		Drilled hole size		Stack height
mm	inches	mm	inches	
<1.6	0.065	<0.2	0.008	1
<1.6	0.065	0.2–0.3	0.008	2
<1.6	0.065	0.3–0.5	0.012–0.020	3
<1.6	0.065	>0.5	>0.020	4
1.6–2.4	0.065–0.095	<0.5	<0.020	1
1.6–2.4	0.065–0.095	>0.5	>0.020	2
2.4–3.2	0.095–0.125	<0.5	<0.020	1
2.4–3.2	0.095–0.125	>0.5	>0.020	2
>3.2	>0.125	any	any	1

The data quoted here is taken from a variety of sources, including manufacturers' data sheets, and is kept deliberately brief. The best source of these data for any given application is the manufacturer of the PCB. More detailed standard PCB design data of this sort can be obtained in the document ANSI/IPC-D-275 Design Standard for Rigid Printed Boards and Rigid Printed Assemblies.