NANODIMENSION

Electrifying Additive Manufacturing®

Design Rules for AME 2D Circuits

DragonFly IV, SW V.1.40

DOC000517

Revision 02

February 2022

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1. Introduction

This document describes the rules required for the successful design of Additively Manufactured Electronics (AME) circuits that are produced by the DragonFly® IV system.

AME circuits are based on the digital processing of acrylate polymer (dielectric) and silver nano-particle (conductive) inks, which are the materials that make functional electronics. The information in this document allows AME circuit designers and developers to attain the best performance by understanding the capabilities of this digital technology, which is governed by pixel size and micron layer build up methodology. Hence it is different from PCB manufacturing based on layering, patterning, drilling and compression of typically FR4 and copper sheets. Performance is subject to the customer following not only these design rules, but also all the required preventive maintenance for the DragonFly® IV printer as defined in the system's user manuals.

2. Mechanical & Physical Structure Rules

Maximum AME dimensions	160 x 160 x 3 mm (x, y, z)		
Overall AME thickness	0.7 – 3.0 mm, tolerance of less than ± 5%		
Signal / plane layer thickness	Min: 17 µm up to 100 µm, tolerance of less than ± 1.5um		
Minimum PTH/Via release/clearance	250 µm		
Minimum Prepreg above signal/plane layers	Signal/plane thickness ± 5%	Min prepreg above conductive layer	
	17-34 µm	50µm	
	35-69 µm	75µm	
	70-99 µm	127µm	
	100 µm	150µm	
Solder mask thickness (automatically generated, same dielectric material as in the entire AME device)	50 µm		
Edge spacing	0.5 mm (Edge plating is optional) *		
Annotations	Printed with conductive ink as part of the solder mask layer. If the annotation falls within 180 µm from a trace, the FLIGHT Control software automatically deletes the annotation.		
Number of signal layers (2D AME)	Stackup options related to 3mm total thickness:		
	Signal layer thickness	17 µm	43 layers
	Signal layer thickness	35 µm	26 layers

	Signal layer thickness	70 µm	15 layers
	Signal layer thickness	100 µm	12 layers
Roughness on top surface**	<2 µm		
Roughness on bottom surface	<0.25 µm		
Bow tolerance	<0.75%		

NOTES

* Edge connectors can be used, however each conductor trace that is not connected to the edge connector must have at least 0.5 mm spacing from the edge.

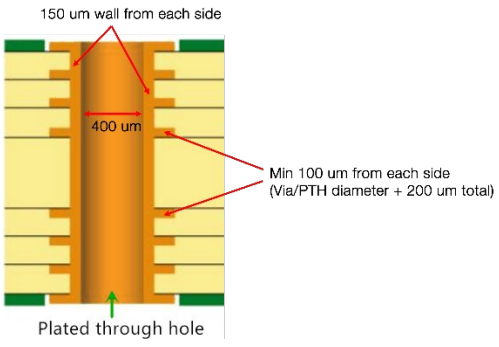
** Per model with an area of more than 0.87mm x 0.66mm.

3. Trace & Clearance Rules in the 2D Signal Layer

AME is digitally printed and has pixelization effects. All features apart from the thickness have discrete steps of 18µm squares. All other steps are converted to this scale.

	Value (µm)	**Trace thickness (µm)**
Minimum recommended trace width	75 ± 9	<100
Minimum recommended electrical clearance	100 ± 9	17-50
Minimum recommended electrical clearance	150 ± 9	50-100

4. Plated / Non-plated TH and VIAS

Through Hole (TH) diameter	Min 400 µm ± 18µm
Plated TH diameter	Min 400 µm ± 18µm Minimum plating ring width 150 µm Pad surrounding TH ≥ (TH diameter + 200µm, 100 each side) 
VIA (filled) diameter	Min 200 micron ± 9µm Pad surrounding Via ≥ (Via diameter + 200 µm, 100 each side)

5. Design Spec: Main Materials

For more information, refer to the Nano Dimension Ink Users Guide.

Conductivity (silver nano particles)*	$2.21x10^7 \pm 0.95x10^7$ S/m at 20 °C							
Dielectric Constant (Dk) (1092 ink)** Acrylate based polymer	200MHz	500MHz	1GHz	2GHz	5GHz	10GHz	15GHz	20GHz
	2.92	2.89	2.86	2.77	2.83	2.80	2.78	2.73
Tangential loss (Df) (1092 ink)** Acrylate based polymer	200MHz	500MHz	1GHz	2GHz	5GHz	10GHz	15GHz	20GHz
	0.024	0.021	0.023	0.015	0.023	0.017	0.018	0.017
Dielectric breakdown voltage (thickness 0.6 mm)	40.3KV, tested based on IPC-TM-650 2.5.6							

NOTES

* Due to the nature of the additive manufacturing process, variation of the conductivity is a result of the position of the ground vs signal planes and proximity to the printing chuck.

**These numbers are measurement technique dependent. They are provided as a reference to start the AME design. For an optimum number it is recommended that customers requiring precise Dk and Df numbers, perform measurements with the equipment they use inhouse.

6. Soldering and Population Process

Component placement	Manual or pick and place. Stencil compatible (customer standard mechanical fixture).
Iron soldering temperature	220°C – 235°C (Refer to the Manual Soldering Guide).
Blower soldering	165°C - 175°C (Refer to the Manual Soldering Guide).

7. Software Compatibility

2D PCB Input files	ODB++, Gerber x274 design files and Excellon drill files.

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