

The Gerber Job File

Including fabrication documentation in Gerber

Rev. 2019.03

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1 Preface

Since decades, Gerber is the standard for describing the 2D images – copper layers, solder mask, drills – in PCB fabrication data. Attributes added with Gerber X2 provide a standard to 'add intelligence to the image' by defining the layer structure – which file is which layer – identify via and SMDs component, pin numbers and reference descriptions.

But PCB fabrication data is not just about images - it includes finish, overall thickness, materials, solder mask color. They are essential for the quoting, planning, engineering, CAM and fabrication of the bare and assembled board. It is often transferred informally, in drawings and texts, and handled manually, wasting time and risking errors.

This specification defines how to transfer this information in a machine-readable manner as part of Gerber fabrication data.

Please send questions or suggestions about this specification to gerber@ucamco.com

2 Specification

2.1 Overview

PCB characteristics pertaining to the job as a whole, such as the finish or overall thickness, are stored in a separate file, the Gerber job file. One job file per PCB. It contains the following sections:

1. **Header:** information about the file itself, such as its creation date.
2. **General specs:** overall board characteristics such as finish.
3. **Material stackup:** specification of the stackup and characteristics of the materials used.
4. **Design rules:** the design rules used when laying out the PCB.
5. **Files attributes:** the polarity and function (e.g. top copper layer) of all Gerber files.

The Gerber job file is a separate file, not part of the image files. It contains only PCB characteristics and no image data. Applications that process a Gerber job file do not need to be image-savvy.

The image format is not changed. Thus, compatibility is achieved. Legacy applications can happily ignore the job file and process the images as before. Existing image input/output code does not need to be changed when implementing the Gerber job file.

The Gerber job file is compatible with both X1 and X2.

Partial implementations are allowed. Better a partial job file than no job file at all.

The job file can be extended with custom information.

The job file is simple and human readable.

The job file intentionally does *not* specify default values for the PCB characteristics. If a characteristic is not present on the job file, it is not defined *in* the job file and must be specified by other means, for instance fabricator defaults or a side agreement. This restriction allows partial implementations, where certain parameters are absent because they are not yet implemented. And anyhow, a mere data transfer format must not pretend to specify what defaults for the PCB industry should be.

The job file intentionally defines the *technical* PCB parameters only, *not* commercial conditions such as delivery times, pricing and quantities. The reason is simple. The same PCB can be ordered at different times, with different commercial conditions, or it can be ordered in a panel. The physical PCB however is the same, and its definition must not be touched. Commercial conditions are best in a separate file.

The job file intentionally does *not* cover assembly arrays. Layout systems are generally designed to generate a single PCB rather than arrays. This makes sense: assembly panels are typically not decided by the designer but by the assembler. The same PCB may be assembled in different panels at different times, of a panel may contain multiple PCB's. Therefore the assembly panel definition must be separate from the single PCB definition. However, the job file contains information that is essential to the assembler, such as the job size.

2.2 Syntax

The job file follows the JSON syntax.

For an introduction to JSON see <http://json.org/> . For an online JSON syntax checker see <http://jsoneditoronline.org/> .

In addition, names follow the restriction of the main Gerber spec. Wherever possible, we re-use the attribute values from the image spec as JSON names or values. Names starting with a "\$" are reserved for custom extensions.

The unit for length is mm.

The standard file extension is ".gbrjob". An example name: `Ctlr54382r4.gbrjob`

Partial implementations are allowed. One can omit entire sections, or e.g. define only a few board characteristics in the general specs section. Missing parameters are not defined, there are no defaults.

2.3 Header

This object has values that provide information about the Gerber job file itself rather than about the PCB it describes, e.g. the creation date of the file.

Name/value	Usage
<pre>"GenerationSoftware": { "Vendor": "<string>", "Application": "<string>", "Version": "<string> }</pre>	Identifies the software generating this file. See the file attribute .GenerationSoftware for the values and their interpretation.
<pre>"CreationDate": "<string>"</pre>	Creation date of the file. See the .CreationDate file attribute for allowed values and their interpretation.
<pre>"Comment": "<string>"</pre>	Comment about the file.



Example:

```
"Header": {  
  "GenerationSoftware": {  
    "Vendor": "Ucamco",  
    "Application": "UcamX",  
    "Version": "2017.12"  
  },  
  "CreationDate": "2018-01-20T15:59:51+01:00",  
  "Comment": "Example"  
}
```

2.4 General Specs

This object contains characteristics that apply to the whole board, such as finish. Characteristics which apply to a specific element, such as the legend color, are stored in other objects where the subject such as legend is identified. The object and all characteristics below are optional.

Name/value	Usage
<pre>"ProjectId": { "Name": "<string>", "GUID": "<string>", "Revision": "<string>" }</pre>	See the file attribute .ProjectId for values and their interpretation.
"Owner": "<string>"	Reference of the design owner, as used by himself.
"Part": "Single"	See the file attribute .Part. As the Gerber job file is about a single PCB the value must be "Single".
<pre>"Size": { "X": <decimal>, "Y": <decimal>, "Tol+": <decimal>, "Tol-": <decimal> }</pre>	Board size, being the size of the axis-aligned enclosing rectangle of the board outline. <i>It is strongly recommended to include this information in any job file.</i> Tolerances are optional.
"LayerNumber": <integer>	Number of copper layers. <i>It is strongly recommended to include this information in any job file.</i>
"BoardThickness": <decimal>	The overall thickness of the base material and all conductive materials deposited thereon.
"IPC-2221-Type": <integer>	The board type according to IPC-2221. The integer can take the values from 1 to 6, corresponding to the six primary board types: <ul style="list-style-type: none"> • Type 1 - Single-sided • Type 2 - Double-sided • Type 3 – Multilayer, TH components only • Type 4 – Multilayer, with TH, blind and/or buried vias. • Type 5 - Multilayer metal-core board, TH components only • Type 6 - Multilayer metal-core
"IPC-600-Class": "(1 2 3 NA)"	
"Standard": <string>	MIL, JSS, IPC6012B, PCA600, ...

"ImpedanceControlled": (true false)	
"UL_Logo": (true false)	Indicates whether an UL logo must be added. The exact PCB requirements this corresponds to are left open at this time.
"Fabricator_Logo": (true false)	Indicates whether a fabrication logo must be added.
"Fabricator_Datecode": (true false)	Indicates whether a fabrication date code must be added.
"ViaProtection": ["<IPC-4761>" {,"<IPC-4761>"}] where <IPC-4761>=(Ia Ib IIa IIb IIIa IIIb IVa IVb V VI VII None)	This via protection types present, according to the IPC-4761 classification: Ia Tented - Single-sided Ib Tented - Double-sided IIa Tented and Covered – Single-sided IIb Tented and Covered – Double-sided IIIa Plugged – Single-sided IIIb Plugged – Double-sided IVa Plugged and Covered – Single-sided IVb Plugged and Covered – Double-sided V Filled (fully plugged) VI Filled and Covered VII Filled and Capped None No protection Which vias are of which type is determined by .AperFunction in the Gerber drill files.
"HolePlatingThickness": <decimal>	The plating thickness in the holes.
"HalogenFree": (true false)	
"Press-fit": (true false)	Presence of press-fit holes. These are holes for connector pins that will not be soldered but pressed in the holes. They require tighter tolerances.
"HeatSinkPaste": (true false)	Indicates the presence of heat sink paste.
"EdgePlating": (true false)	
"Castellated": (true false)	
"EdgeConnector": (true false)	

"EdgeConnectorBevelled": (true false)	
"HardGoldArea": <decimal>	Area of hard gold in mm squared. Where that gold is can be defined with a gold mask file.
"RoHS": (true false)	
"Finish": "(HAL SnPb HAL lead-free Immersion tin Immersion nickel Immersion silver Immersion gold (ENIG) ENEPIG Hard gold OSP HT_OSP None <string>)"	
"Foil": "(Electro-Deposited Rolled <string>)"	Copper foil type
"Substrates": ["<substrate>" {, "<substrate>"}] where <substrate> = (FR4 Polyimide Polyolefin Al PTFE Teflon Ceramic <string>)	The substrate(s) used in the PCB. The order of the substrates in this list is arbitrary and is not related to the physical order in the PCB.
"Material_Tg": <decimal>	Minimal glass transition temperature, in degrees Celcius.
"ITAR": (true false)	The job is ITAR controlled.
"ElectricalTest": (true false)	
"Notes": "<string>"	A free field with informal information.



Example:

```
"GeneralSpecs": {  
  "Part": "Single"  
  "Size": {  
    "X": 160,  
    "Y": 50.8  
  },  
  "LayerNumber": 4,  
  "BoardThickness": 1.6,  
  "IPC-600-Class": 2,  
  "Finish": "Immersion Gold (ENIG)"  
}
```

2.5 Material Stackup

The material stackup array defines the material layers and their attributes. For most standard designs the stackup is obvious and full description not needed and usually not included. However even in simple design one may want to define the solder mask and legend colors, or even the copper weights.

An array element is a layer in the material stackup. The order of the elements is the order of the material layers. The type of material is identified by the "Type:" pair and is mandatory for each array element. Other optional pairs allow to specify properties of each material. Common sense indicates which properties are appropriate for which material.

If a material stackup is included, it must be complete - all layers in the stackup must be present. It is allowed to add a material without any attributes to indicate the presence of that material.

Material Stackup Pairs	
Name/value	Name/value
"Type": " (Copper Dielectric Legend SolderMask CoverLay PeelableMask Carbon <string>)"	
"Thickness": <decimal>	Base thickness. This excludes any extra thickness added by plating.
"Color": " (Red Yellow Green Blue White Black R<integer>G<integer>B<integer>)[, (Gloss Semi-matte Matte)] " (<integer> ranges from 0 to 255)	
"DielectricConstant": <decimal>	Dielectric constant.
"LossTangent": <decimal>	Loss tangent.
"Conductivity": <decimal>	Conductivity in S/m.
"Tg": <decimal>	Minimal glass transition temperature.
"Material": "<substrate>"	Material used as substrate.
"Note": "<string>"	A note on the layer or material.

<pre>"Substacks:" [<integer>{,<integer>}]</pre>	<p>This array is only applicable for flex-rigid boards.</p> <p>It uses the concept of substacks that is used by Polar Instruments in its handling of flex-rigid boards. There is a master stackup, with all material present; it is substack 1. Different parts of the flex-rigid use different substacks, each identified by a positive integer. The array substacks contains the indices of the substacks in which the material is present, in ascending order.</p>
---	---

An example shows best how it is done, it is not rocket science. Here is the material stackup of a four-layer board, with solder mask on both sides and legend on top:



Example:

```
"MaterialStackup": [
  {
    "Type": "Legend",
    "Color": "White"
  },
  {
    "Type": "SolderMask",
    "Thickness": 0.025,
    "Color": "Green"
  },
  {
    "Type": "Copper",
    "Thickness": 0.03556
  },
  {
    "Type": "Dielectric",
    "Thickness": 0.34
  },
  {
    "Type": "Copper",
    "Thickness": 0.01500
  },
  {
    "Type": "Dielectric",
    "Thickness": 0.34,
    "DielectricConstant": 4.7
  },
  {
    "Type": "Copper",
```

```

    "Thickness": 0.01500
  },
  {
    "Type":      "Dielectric",
    "Thickness": 0.34
  },
  {
    "Type":      "Copper",
    "Thickness": 0.03556
  },
  {
    "Type":      "SolderMask",
    "Thickness": 0.02500,
    "Color":     "Green"
  }
]

```

Note that this describes a CAD stackup – also called virtual stackup by Polar Instruments. A layer represents a type of material, such as copper or dielectric. A two or three prepreg layers can be used to fabricate one dielectric layer, and a core can be used for two copper layers separated by a dielectric. In other words, in fabrication the virtual or CAD stackup described here is converted into a real of fabrication stackup.

If we only need to specify the colors the material stackup is as in the example below.



Example:

```

"MaterialStackup": [
  { "Type": "Legend",      "Color": "White" },
  { "Type": "SolderMask", "Color": "Green" },
  { "Type": "Copper"      },
  { "Type": "Dielectric"  },
  { "Type": "Copper"      },
  { "Type": "Dielectric"  },
  { "Type": "Copper"      },
  { "Type": "Dielectric"  },
  { "Type": "Copper"      },
  { "Type": "SolderMask", "Color": "Green" }
]

```

One may remark that this requires plenty of dummy lines to represent just three colors. While true, this is not really a problem. The very generic stackup array allows to define the colors. It makes no sense to introduce a redundant ad-hoc structure dedicated to the colors, just to save a few dummy lines.

2.6 Design Rules

The design rules array contains the intended design rules used by CAD to lay out the copper layers. Thus the intended design rules are known without needing to perform complex geometric analysis of the copper layers. This is useful information for planning and quoting. It helps CAM to detect and handle possible layout problems.

The copper layers are grouped in classes with the same design rules. Typically, design rules are different for inner and outer layer, and then the classes are inner and outer. Each design rule class is an entry in the array. The entry consists of a definition of the layers in the class and their design rules.

Design rules name/value pairs.	
"Layers": "(Inner Outer L<integer>)"	Design rule group. All layers in the group share the same design rules. The precedence is "Ln", "Inner" or "Outer". There is no inheritance, all applicable design rule values must be set for each class.
"PadToPad": <decimal>	
"PadToTrack": <decimal>	
"PadToRegion": <decimal>	Regions are also known as copper pours.
"TrackToTrack": <decimal>	
"TrackToRegion": <decimal>	
"RegionToRegion": <decimal>	
"MinLineWidth": <decimal>	
"MinRing": <decimal>	
"MinClearanceToProfile": <decimal>	
"Notes": "<string>"	Informal information.

An example with the typical inner/outer design rules shows how it works.



Example:

```
"DesignRules": [  
  {  
    "Layers": "Outer",  
    "PadToPad": 0.15,  
    "PadToTrack": 0.15,  
    "TrackToTrack": 0.15,  
    "MinLineWidth": 0.2,  
    "TrackToRegion": 0.381,  
    "RegionToRegion": 0.381  
  },  
  {  
    "Layers": "Inner",  
    "PadToPad": 0.15,  
    "PadToTrack": 0.15,  
    "TrackToTrack": 0.15,  
    "MinLineWidth": 0.254,  
    "TrackToRegion": 0.508,  
    "RegionToRegion": 0.508  
  }  
]
```

2.7 Files Attributes

This section contains meta-information about the files the fabrication data set, not actual fabrication characteristics of the PCB itself. This meta-information can be embedded in Gerber X2 files. However, in legacy formats it cannot. This section allows to attach meta-information to the legacy files without changing the files themselves. In an X2 context this section can still be useful as the meta-information is available centrally, without opening each Gerber image file

The files attributes array attaches attributes to each Gerber file in the archive. Each array element contains the attributes associated with one file; the file is identified by its path, which serves as a unique index for each array element. The order of the files in the array is free; for human readability it is suggested to sort them from top to bottom.

The following attributes are supported.

Name/value	Usage												
"FileFunction": "<string>"	<p>This attribute has the same interpretation and can take the same values as the .FileFunction X2 attribute. See the Gerber File Format Specification.</p> <p>There is one exception where the attribute value can take a value that is not from the Gerber specification. In Gerber plated and non-plated drill holes must be put in separate files, so that plating can be identified at the file level. However, in legacy drill data plated and non-plated holes are sometimes lumped together in the same file. (Specifying plating is then complicated.) The file function value then becomes "XPlated,i,j,XTH", where i,j denotes the drill span. This value is not allowed for as a Gerber file attribute!</p>												
"FilePolarity": "Positive Negative"	<p>This attribute has the same interpretation and can take the same values as the .FilePolarity X2 attribute. See the Gerber File Format Specification. Take care, solder masks are normally negative.</p>												
"FileFormat": " (Gerber XNC NC SM IPC356 Other) "	<p>Identifies the file format.</p> <table border="0"> <tr> <td>Gerber</td> <td>Gerber, both X1 and X2</td> </tr> <tr> <td>XNC</td> <td>XNC format (Exchange NC)</td> </tr> <tr> <td>NC</td> <td>IPC-NC-349 or Excellon</td> </tr> <tr> <td>SM</td> <td>Sieb & Meyer</td> </tr> <tr> <td>IPC356</td> <td>IPC-D-356</td> </tr> <tr> <td>Other</td> <td>Any other format</td> </tr> </table>	Gerber	Gerber, both X1 and X2	XNC	XNC format (Exchange NC)	NC	IPC-NC-349 or Excellon	SM	Sieb & Meyer	IPC356	IPC-D-356	Other	Any other format
Gerber	Gerber, both X1 and X2												
XNC	XNC format (Exchange NC)												
NC	IPC-NC-349 or Excellon												
SM	Sieb & Meyer												
IPC356	IPC-D-356												
Other	Any other format												

An example shows best how it is done, it is not rocket science.



Example:

```
"FilesAttributes": [  
  {  
    "Path": "AZ2375EM_Top_Silk.gbr",  
    "FileFunction": "Legend,Top",  
    "FilePolarity": "Positive",  
    "FileFormat": "Gerber"  
  },  
  {  
    "Path": "AZ2375EM_Top_SolderMask.gbr",  
    "FileFunction": "Soldermask,Top",  
    "FilePolarity": "Negative",  
    "FileFormat": "Gerber"  
  },  
  {  
    "Path": "AZ2375EM_Top_Copper.gbr",  
    "FileFunction": "Copper,L1,Top",  
    "FilePolarity": "Positive",  
    "FileFormat": "Gerber"  
  },  
  {  
    "Path": "AZ2375EM_Bot_Copper.gbr",  
    "FileFunction": "Copper,L2,Bot",  
    "FilePolarity": "Positive",  
    "FileFormat": "Gerber"  
  },  
  {  
    "Path": "AZ2375EM_Bot_SolderMask.gbr",  
    "FileFunction": "Soldermask,Bot",  
    "FilePolarity": "Negative",  
    "FileFormat": "Gerber"  
  },  
  {  
    "Path": "AZ2375EM_Drill.xnc",  
    "FileFunction": "XPlated,1,4,XTH",  
    "FileFormat": "XNC"  
  },  
  {  
    "Path": "AZ2375EM_Test.ipc",  
    "FileFunction": "Other",  
    "FileFormat": "IPC356"  
  },  
  {
```

```
"Path": "AZ2375EM_Drawing.gbr",  
"FileFunction": "FabricationDrawing",  
"FilePolarity": "Positive",  
"FileFormat": "Gerber"  
}  
]
```

3 Examples

3.1 Minimal CAD Job File

Below is the minimal job file that CAD must include in the fabrication data. CAD systems 'know' board size and layer count. CAD systems must output a simple job file with board size and layer count (and ideally any other parameters they might know). This is the basis for pricing and allowing assemblers to define their panels automatically without having to process Gerber image files. Other applications can read and extend this initial job file with more information.

```
{
  "Header": {
    "GenerationSoftware": {
      "Vendor": "Ucamco",
      "Application": "UcamX",
      "Version": "2017.12"
    },
    "CreationDate": "2018-01-20T15:59:51+01:00",
    "Comment": "Example"
  },
  "GeneralSpecs": {
    "Part": "Single",
    "Size": {
      "X": 160.0,
      "Y": 50.8
    },
    "LayerNumber": 4,
    "BoardThickness": 1.6
  }
}
```

3.2 Basic Job File

The job file contains the basic board parameters needed for a quote next to the images.

```
{
  "Header": {
    "GenerationSoftware": {
      "Vendor":      "Ucamco",
      "Application": "UcamX",
      "Version":     "2017.12"
    },
    "CreationDate":  "2018-01-20T15:59:51+01:00",
    "Comment":      "Example"
  },
  "GeneralSpecs": {
    "Part": "Single",
    "Owner": "Galactic Corporation",
    "ProjectId": {
      "Name":      "HFDF Controller nRF52832",
      "GUID":      "f81d4fae-7dec-11d0-a765-00a0c91e6bf6",
      "Revision":  "Rev. 2b"
    },
    "Size": {
      "X": 160.0,
      "Y": 50.8
    },
    "LayerNumber": 4,
    "BoardThickness": 1.6,
    "ROHS": true,
    "B_IPC-600-Class": 2,
    "Finish": "Immersion gold (ENIG)"
  },
  "MaterialStackup": [
    { "Type": "Legend",      "Color": "White" },
    { "Type": "SolderMask", "Color": "Green" },
    { "Type": "Copper",      "Thickness": 0.03556 },
    { "Type": "Dielectric" },
    { "Type": "Copper",      "Thickness": 0.01500 },
    { "Type": "Dielectric" },
    { "Type": "Copper",      "Thickness": 0.01500 },
    { "Type": "Dielectric" },
    { "Type": "Copper",      "Thickness": 0.03556 },
    { "Type": "SolderMask", "Color": "Green" }
  ]
}
```

4 Revisions

Rev 2018.04

This is the initial version of the Gerber Job File specification.

This specification was developed by Karel Tavernier. In January 2017 an initial draft was published for public review by the Gerber user community. Based on the received input the draft went through seven revisions. The review process was closed in April 2018 and resulted in this specification. The following people contributed to this draft: Jean-Pierre Charras, Alan Shrides, Bruce McKibben, Wim De Greve, Ken Caluwaert, Aurelio Bantigue, Luc Samyn, Scott McClusky, Richard Attrill, Paul Wells-Edwards, Remco Poelstra, Rik Breemeersch.

Rev 2019.02

Removed superfluous design rule group **All**.

"Foil" values contained **<f>**, replaced by **<string>**.

"Type" values contained **Other <string>**, replaced by **<string>**

Rev 2019.03

Added file attribute FileFormat to handle files in other formats than Gerber. Jean-Pierre Charras contributed to this enhancement. See section 2.7

Small text corrections.

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