



The Gerber Job Format Specification

Revision 2020.01

Including fabrication documentation in Gerber

This format was developed by Karel Tavernier from Ucamco.



Contents

Contents	3
1 Preface	4
2 Specification	5
2.1 Overview	5
2.2 Syntax	5
2.3 Header	7
2.4 General Specs.....	8
2.5 Material Stackup.....	12
2.6 Design Rules	15
2.7 Files Attributes.....	17
3 Examples	20
3.1 Minimal CAD Job File	20
3.2 Basic Job File	21
4 Revisions	22
5 Copyright	23

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 is necessary to allow partial implementations: otherwise it would be unclear whether a missing parameter specifies the default or is simply not implemented. And anyhow, a mere data transfer format must not pretend to specify what defaults the PCB industry should use.

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 panels or arrays. Layout systems are designed to generate a single PCB. The panel is typically not decided by the designer but by the assembler. The same PCB may be assembled in different panels in different production runs, or multiple PCB's can be mixed on a single panel. Therefore, the assembly panel definition must be separate from the single PCB definition. However, the job file is important to the assembler as it contains essential information such as the board 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/> .

The Gerber Job File is restricted to UTF-8 encoding.

Numbers must fit in the range of an IEEE double. For readability, number that are naturally integer, such as the layer count, must be written as integer, without decimal points.

The length unit is mm.

The standard file extension is ".gbrjob". An example name: `Ct1r54382r4.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 characteristics are undefined, 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>	<p>GenerationSoftware identifies the software that generated the job file. "Vendor" identifies the organization that supplies the generating software to its users; this can be a commercial company, an open source organization, etc.</p> <p>It is semantically identical to the .GenerationSoftware attribute in the Gerber file specification.</p>
<pre>"CreationDate": "<string>"</pre>	<p>Identifies the moment of creation of the Gerber file. The value must conform to the full version of the ISO 8601 date and time format, including the time zone.</p> <p>It is semantically identical to the .CreationDate attribute in the Gerber file specification.</p>
<pre>"Comment": "<string>"</pre>	<p>Comment about the file.</p>



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>	<p>Usually a Gerber file is part of a PCB project with a sequence of revisions. The purpose of the .ProjectId file attribute is to uniquely identify project and revision. This is especially important to check whether all files belong to the same revision. By its nature, these values can only be defined by the creator of the project and revision.</p> <p>"Name" is the id or reference used by the design owner, "GUID" defines the project using a global unique ID and "Revision" specifies its revision. All parameters must conform to the string syntax, with the additional restriction that the ',' character cannot be used. The "GUID" value is a field conforming to RFC4122 version 1 or version 4.</p> <p>It is semantically identical to the .ProjectId attribute in the Gerber file specification.</p>
"Owner": "<string>"	Reference of the design owner, as used by himself.
<pre>"Size": { "X": <number>, "Y": <number>, "Tol+": <number>, "Tol-": <number> }</pre>	<p>Board size, being the size of the axis-aligned enclosing rectangle of the board outline, in mm. <i>It is strongly recommended to include this information in any job file.</i></p> <p>Tolerances are optional.</p>
"LayerNumber": <integer>	Number of copper layers. <i>It is strongly recommended to include this information in any job file.</i>
"BoardThickness": <number>	The overall thickness of the base material and all conductive materials deposited thereon, in mm.
"IPC-2221-Type": <integer>	<p>The board type according to IPC-2221. The integer can take the values from 1 to 6, corresponding to the six primary board types:</p> <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 The protection type of each via tool is specified by .AperFunction in the Gerber drill files.
"HolePlatingThickness": <number>	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)	

<code>"EdgeConnectorBevelled": (true false)</code>	
<code>"HardGoldArea": <number></code>	Area of hard gold in mm squared. Where that gold is can be defined with a gold mask file.
<code>"RoHS": (true false)</code>	
<code>"Finish": "(HASL SnPb HASL lead-free Immersion tin Immersion nickel Immersion silver ENIG ENEPIG Hard gold OSP HT_OSP None <string>)"</code>	
<code>"Foil": "(Electro-Deposited Rolled <string>)"</code>	Copper foil type
<code>"Substrates": ["<substrate>" {,"<substrate>"}] where <substrate> = (FR4 Polyimide Polyolefin Al PTFE Teflon Ceramic <string>)</code>	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.
<code>"Material_Tg": <number></code>	Minimal glass transition temperature, in °C.
<code>"ITAR": (true false)</code>	The job is ITAR controlled.
<code>"ElectricalTest": (true false)</code>	
<code>"Notes": "<string>"</code>	A free field with informal information.

 **Example:**

```
"GeneralSpecs": {  
  "Size": {  
    "X": 160,  
    "Y": 50.8  
  },  
  "LayerNumber": 4,  
  "BoardThickness": 1.6,  
  "IPC-600-Class": 2,  
  "Finish": "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 a full description is not needed. 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": <number>	Base thickness in mm. This does <i>not</i> include 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": <number>	Dielectric constant.
"LossTangent": <number>	Loss tangent.
"Conductivity": <number>	Conductivity in S/m.
"Tg": <number>	Minimal glass transition temperature in °C.
"Material": "<substrate>"	Material used as substrate.
"Name": "<string>"	A name for the layer. It has no board functionality but it can be referred to in associated documents and be used to help in communication.
"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. 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": 0.015
  },
  {
    "Type": "Dielectric",
    "Thickness": 0.34,
    "DielectricConstant": 4.7
  },
  {
    "Type": "Copper",
    "Thickness": 0.015
  },
  {
```

```

    "Type":      "Dielectric",
    "Thickness": 0.34
  },
  {
    "Type":      "Copper",
    "Thickness": 0.03556
  },
  {
    "Type":      "SolderMask",
    "Thickness": 0.025,
    "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. 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 is converted into a real fabrication stackup.

If we only need to specify the colors the material stackup is very simple, see 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 layers, 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. (Unit is mm.)	
"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": <number>	
"PadToTrack": <number>	
"PadToRegion": <number>	Regions are also known as copper pours.
"TrackToTrack": <number>	
"TrackToRegion": <number>	
"RegionToRegion": <number>	
"MinLineWidth": <number>	
"MinRing": <number>	
"MinClearanceToProfile": <number>	
"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 PCB characteristics. This meta-information can be embedded in Gerber X2 files. However, in legacy formats it cannot. This section attaches 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 from the location of the job file, 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 style="width: 100%; border: none;"> <tr> <td style="width: 50%;">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.



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": {
    "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": {
    "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,
    "IPC-600-Class": 2,
    "Finish": "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 2020.01

Removed the "Part:" name/value pair. Removed custom names. Restricted the file to UTF-8 encoding. Clarified "GenerationSoftware:", "CreationDate:" and "ProjectId:". Fixed text errors pointed out by Nick Meeker. Text improvements.

Rev 2019.09

Correction in values for finishes in 2.4: replaced 'HAL' by 'HASL' and 'Immersion gold (ENIG)' by 'ENIG'. Add the "Name:" to the material stackup name/value pairs, as requested by Jean-Pierre Charras, see section 2.5.

Rev 2019.05

Correction in example 3.2, pointed out by Arezoo Kashefipour.

Rev 2019.03

Added "FileFormat:" name/value pair to handle files in other formats than Gerber, see section 2.7; Jean-Pierre Charras contributed to this enhancement. Small text corrections.

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 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 Shrives, Bruce McKibben, Wim De Greve, Ken Caluwaert, Aurelio Bantigue, Luc Samyn, Scott McClusky, Richard Attrill, Paul Wells-Edwards, Remco Poelstra, Rik Breemeersch.

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