TECHNICAL PAPER

Three-Dimensional Printing

3D Models / 3D Printing in the HW Development

3D Printing (also called Additive Manufacturing) describes the manufacturing of components layer by layer based on three-dimensional construction data. For such components, the materials can be plastic as well as metal or other materials.

3D printing has increased in popularity in recent years. It can be used for simple things, such as, for example, the production of toys, but also for the manufacturing of far more complex and efficient work pieces.

Today the degree of freedom in 3D modelling makes it possible to apply client-specific 3D models to numerous applications in the professional field. 3D printing enables the manufacturing of simple products such as clips to supports for tools but also more complex applications such as mock-ups of circuit boards.

Simulation

In order to determine if the developed wiring concept can be implemented within the usually extremely restricted space of the target circuit board, a feasibility analysis can be performed prior to the beginning of the hardware/PCB design phase. The 3D rendering is here a tool for the preliminary demonstration of the end product. Months, if not years, before the completion of the end product.

Modern CAD programs can generate 3D models from any circuit because the components used supply 3D models. They also provide the opportunity to define construction specifications such as distances between multi-card setups and height restrictions.

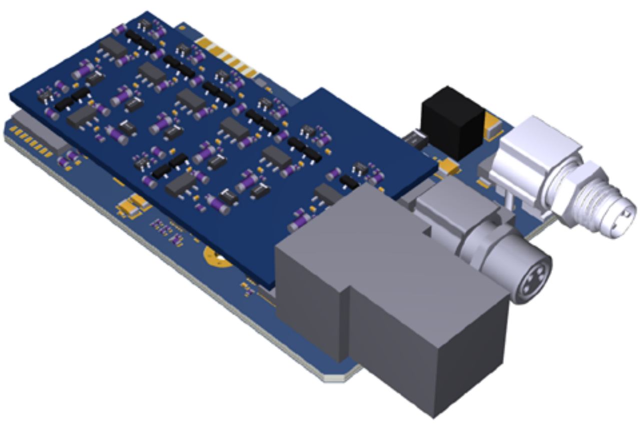

Figure 1: Prototype of a double circuit board; circuit boards placed on top of each other, CAD export

Working with a 3D model has additional advantages. The images below illustrate, for example, the developed circuit board in the housing into which the end product must fit. Restrictions relative to the position or to the component heights are easily recognized here.

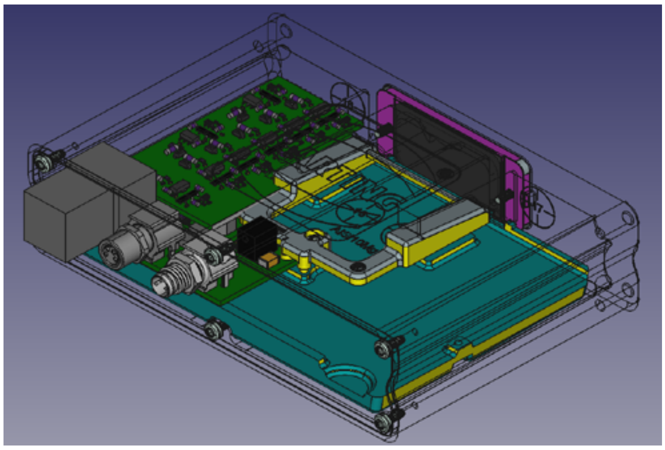

Figure 2: CAD export in the target application (isometric projection)

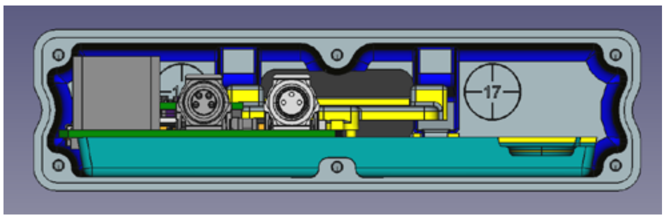

Figure 3: CAD export in the target application (front view)

Printing 3D Data

The 3D models can be printed in 3D printers in the next step. Due to its fine details or specific critical points, the original model for 3D printing generated from the CAD program must, nevertheless, be processed step by step. An air gap between electronic components and the circuit board would be, for example, a very critical point.

Step 1: Rendering Anew

There are primarily two important reasons why the CAD-generated 3D model should be rendered again. First, a PCB design tool is not oriented for the development of physical 3D models. A very high probability of polygon errors in the model exists that could be removed in a special 3D construction program.

Second, the slicer – this is the last step before sending the model to the 3D printer *(see further below, step 2)* – has not been designed to process a great number of details in a fitted circuit board. 3D printers are generally not suitable for printing in the high resolution required for this. In order to increase the comfort for the slicer and thereby the printing quality, the 3D model should be modified in a 3D design program – such as, e.g. Blender or Autodesk® Meshmixer. Such programs provide the opportunity to polish the model by strongly reducing the number of unnecessary details, for example, by reducing the number of polygons*.

*(*Polygon: "Pixel" of a 3D model)*

A common and, in fact, frequently necessary step is a repair of the model to, for example, correct the measurements standards of the surfaces or to fill small gaps in the model.

Step 2: Cutting the model into slices

The prepared 3D model can then be processed with the slicer. In this case, there is a software that translates a 3D model in machine movement code for the 3D printer (often a variant of the G code). The slicer functions like a simple program which is nevertheless deceiving. It contains a great deal of know-how for optimizing the 3D printed result. It can, for example, divide a 3D model into the elementary movement commands of a 3D printer (lines, arcs and circles).

Furthermore, it often offers hundreds of parameters in order to optimize the printing in complex models. These parameters include, among others, printing temperatures, temperature curves, cooling settings, printing speeds for different parts of the model, layer thicknesses, extrusion speeds as well as retraction speeds and distances. Many of these parameters are dependent on each other. A change in the printing speed can, more or less, make an adaption of the printing temperature, the cooling and the extrusion multiplier necessary in certain areas.

Minimizing Risks

There are risks in the realization of the design for circuit board prototypes that can rapidly become costly. Errors in the already produced hardware prototypes frequently require a re-design. 3D renderings and 3D printings resulting from them assist in reducing uncertainties. Primarily, those which are linked to mechanical restrictions.

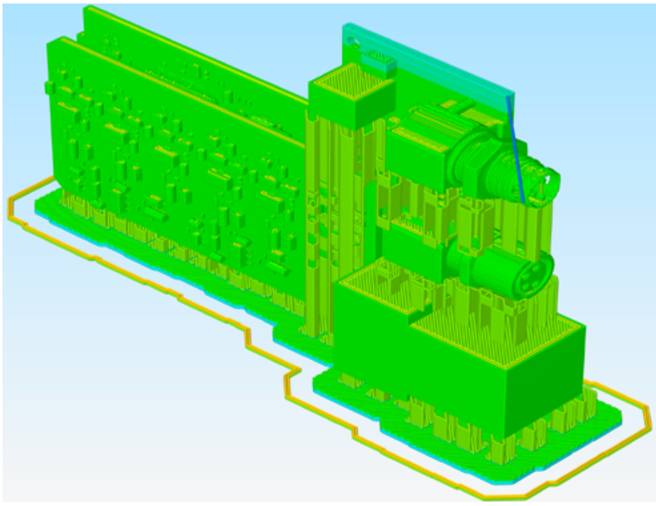

Figure 4: Slicer output for a circuit board. Overhangs must be supported by temporary supporting structures. They are broken off after the model is printed. The corresponding code, the G code file generated by the slicer, consists of ca. 400,000 lines of code.

Renderings of the prototype can be useful in determining if the circuit board has the required dimensions. A physical model of the circuit board can be operated and evaluated much easier than an image. The client has the advantage of viewing the product, holding it in his/her hands and testing it in advance.

Summary

Essentially, 3D printing can considerably aid the agile hardware development in very complex, client-specific requirements. This spares the detailed simulation of circuit boards and demo boards as well as valuable time and costs in the development. As an endorser of this technology, MESCO often assumes that the number of projects supported by 3D printing will continue to grow in the future, in particular against the backdrop of rapidly increasing miniaturization and rising client demands.

…where ideas turn into success!