SMA Science and Mathematics Academy

Optimization of a generic line cord interface box

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Introduction

The Generic Line Cord Interface (GLCI) box serves an important purpose in the production of modern power tools, as it is used to upload code to a power tool by converting DC voltage into an AC signal through an inverter (Horowitz, 2016). For example, the GLCI box would be used in practice to encode a power drill with the information needed to rotate when it is activated, since this function is not hardcoded into the drill itself. The purpose of this project was to design an optimized printed circuit board (PCB) for the GLCI box to perform the same functions as the original at a lower cost. This entailed creating a new bill of materials (BOM) and a new board layout model with more efficient use of overall cost and space.

Materials and Methods

The first step in optimizing the GLCI board was finding new components to replace the outdated components. Maximum power thresholds were reduced in existing parts by changing components from through-hole to surface mounted, in order to minimize the cost and size of components. Required changes in power were calculated and measured through use of an oscilloscope on the outdated PCB. The majority of these new components were found from the online electronics store Digikey®, as well as other smaller suppliers including B&H Electronics® and Mouser®. These new parts gathered were arranged into a shopping list in Microsoft Excel for easy purchase and calculation of price.

The next step in optimizing the board was to revise the old schematic to include the implementation of new features and to improve readability. A program called Altium® was used to create and edit these schematics, since it allows for a wide variety of electrical circuit board and schematic editing options. 3D footprints were then added to the revised components on the schematic, as the old board layout did not utilize 3D models due to its age. These models were acquired from online sources such as 3D Content Central®, as well as created using the modeling software CATIA® for rare components.

After all the footprints were acquired and created, the 3D board model was created in Altium®. This included optimizing the layout of parts and the traces between them to fit on as small of a board area as possible.

Materials and Methods (cont.)

The revised PCB went through multiple iterations before being approved by a board of engineers for correctness in component placement and connection lengths.

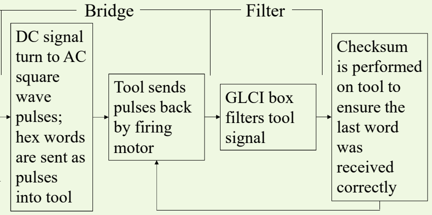
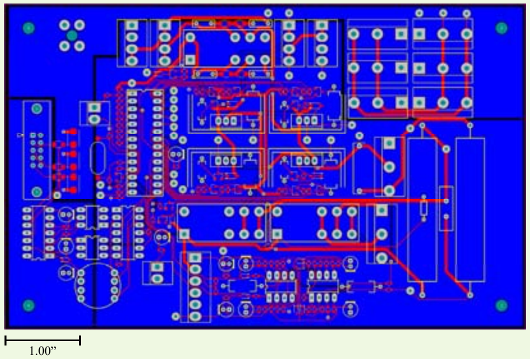


Figure 1 (above): Conceptual schematic showing the functions of the PCB.

Results

Figure 2 (right): The final build of the optimized GLCI box PCB, modeled in 2D. The traces highlighted in red belong to the top half of the board, while the blue traces and planes are on the bottom half of the board.



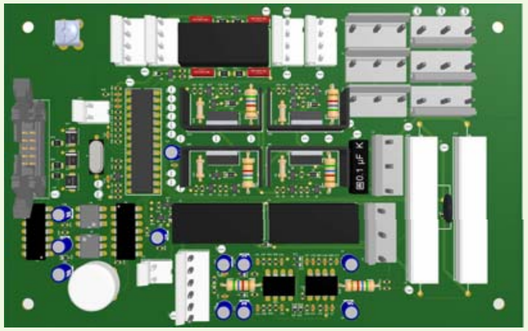


Figure 3 (left): The same optimized GLCI box PCB modeled in 3D. The 3D footprints to each component are shown on this board, demonstrating how the PCB will look when constructed.

Results (cont.)

The board was modeled with two sides, including ground planes on the bottom half and components with connections on the top half. The board was required to be reduced by approximately one third of its original size, while retaining necessary components and connections.

The size of the revised PCB was reduced to 38.25% of that of the initial PCB. The initial PCB had a size of 13.100” by 5.866” with an area of 76.845 in². The redesigned PCB has an improved size of 6.850” by 4.291” with an area of 29.393 in². All parts used in the new PCB can now be purchased due to the removal of obsolete parts. The total cost of electrical components has been reduced from $91.84 to $61.51, for a 33.02% decrease in total component price. Trace lengths on the redesigned PCB have been reduced dramatically compared to the original board, ensuring minimal electrical interference.

Conclusions

The purpose of this project was to redesign and build the PCB used in the GLCI box to be space efficient and cost effective compared to the outdated design created over twenty years ago. The model created during this project shows a realistic approach to optimizing the functions, space, and cost of the PCB. This model can be applied to a physical build to determine its efficiency compared to the old board. In the future, more modifications will be made to the board to improve its efficiency and features. More physical builds may also be made in the future to test the optimized design and ensure its correction, as the board was not physically constructed during this project.

References

Horowitz, P., & Hill, W. (2016). *The art of electronics*. Cambridge: Cambridge University Press.

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