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Design of Ethernet switch cabinet using MSC.NASTRAN

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Abstract

As microelectronics technology steadily packing more chip power into small packages, where balance is an important element of success in this electronic enclosure packaging. The design challenges include thermal management, vibration reduction and balancing reliability and maintainability. The present work, the objective is to design Ethernet switch cabinet/enclosure and the faceplate on which the Ethernet switch enclosure is mounted. Design considerations are made according to equipment requirement and IEEE and IEC standards. Sheet metal module in PRO-E is used to create 3D CAD models. The improvements are made on the basis of the results, using finite element analysis (FEA).

Keywords: Microelectronics technology, electronic enclosure packaging, Ethernet switch.

Introduction

The technological advances have forced to increase the semiconductor device speed, compact in size and reducing number of components to overcome forthcoming challenges of next generation. Modern electronic enclosures and systems had to operate and perform in many types of environments, including residential, commercial establishments and as well as in the specialized environment of telecommunication centers. This poses a major challenge in designing the enclosures. Various factors to be considered for the design of electronic enclosure include environmental conditions like temperature, humidity, vibrations, electromagnetic conditions (EMI/EMC) (Cooley,1977; Warren Boxleitner,1999; Dong *et al*.,2003; Morton A. Johnson, 2004). Whether the unit is to be desktop, portable or mounted in a 19 inch equipment rack the engineer needs to be acquainted with applicable IEEE and IEC standards to ensure that the final design should be compatible with other off-the-shelf equipment. The Ethernet switch has total of eleven ports, one for monitoring LAN traffic and remaining ten are used for site LAN, allowing one site controller and other nine QUAD +2 base radio (BR). To support more than nine QUAD +2 BR's, an additional pair of Ethernet switches would be needed to add to the site. The Ethernet switch is mounted on a 19 inch rack as a pair.

Mechanical design of enclosure

Base structure of the model is 19 inch rack. A face plate is mounted on 19 inch rack. Two enclosures clamped to a face plate. A provision is made on the Ethernet box for the purpose of assembling and dissembling of two units. The weight of the box is to be maintained up to 5.4 kg to satisfy the standard requirements. Intial basic model of Ethernet box assembly was made based on the input requirements and dimensions. The maximum allowable height of the faceplate is 43.6 mm as shown in Fig.1. The Ethernet switch box is modeled based on the PCB floor plan and the features of the electronic components used. The 3D model of Ethernet switch box is shown in Fig. 2. The openings in the box are provided based on the component requirements in the PCB. Sheet metal module in PRO-E is used to create the 3D model. The Box had 3 components; they are top plate, base and front plate. Sheet metal of 1.21 mm thickness is used for all parts of the enclosure/box. Provisions like handle to easily remove the box from the rack, safety for power switch, air vents are made in the design. Overall strength of the cabinet and face plate depends on the method of mounting of the cabinet onto the face plate, number of supporting components (L-clamp, screws) required for mounting and ease of assembly and disassembly.

Face plate design

The face plate attachment with Ethernet box is made with two versions of L-camp and screws. Where dismantling is a problem with L-clamp design since it is mounted in a rack and might be hindered by the units mounted on top of it. The number of components required for assembly is more for the L-clamp design. Screw fitted assembly involved with easy assembly and requires less number of screws to mount the box onto the face plate. The main disadvantage of this is the structural weakness. From the above discussion the L-shaped guide rails are suggested to guide and support the boxes.

MSC.NASTRAN simulations for structural analysis and design optimiztion

Structure analysis

A structural analysis of Ethernet switch box subjected to self weight is performed. The analysis is performed using MSC.NASTRAN. The finite element model is shown in Fig. 3, the top and front plate is connected to the base using rigid elements. The holes in the front plate are constrained in all directions. The box is subjected to

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Fig. 1. Concept sketch of Ethernet switch.

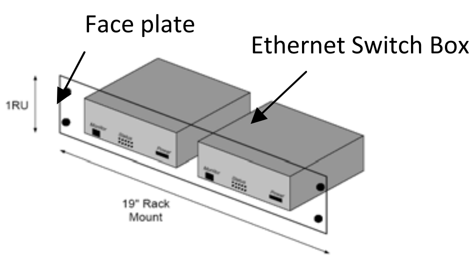


Fig. 2. 3D model of Ethernet switch.

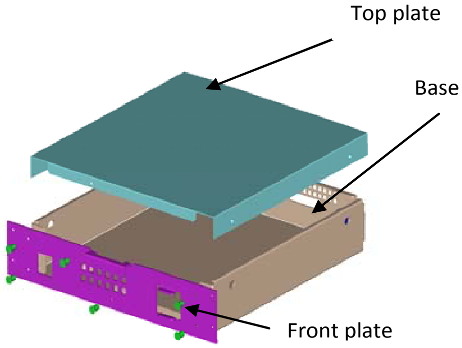


Fig. 3. Mesh model.

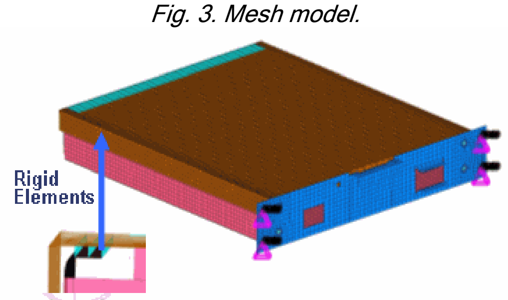


Fig. 4. FE model subjected to self weight.

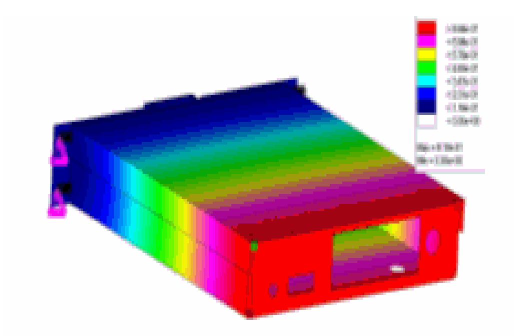


Fig. 5. Face plate with L-clamps-3D.

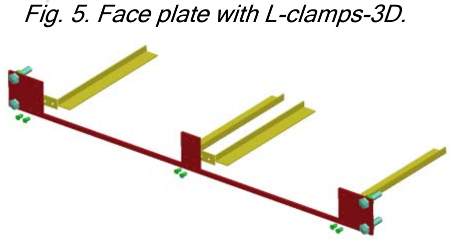


Fig. 6. Face plate with sheet metal bent inwards.

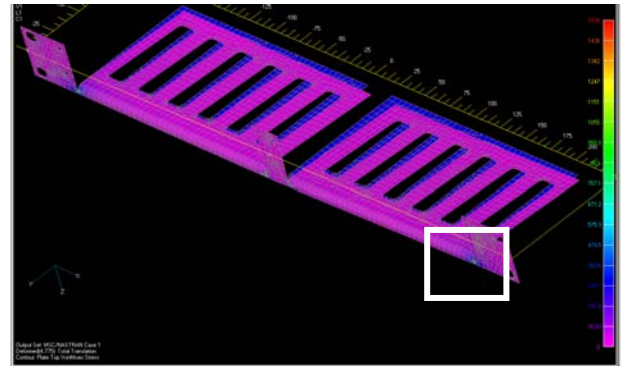


Fig. 7. Final face plate design.

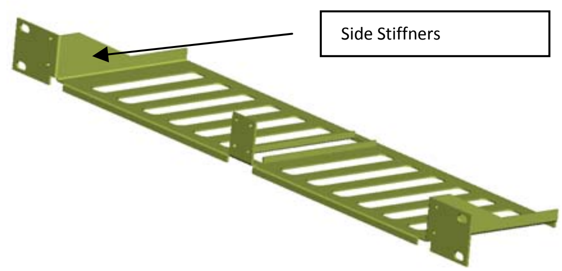


Fig. 8. Design optimization curve for top plate thickness optimization.

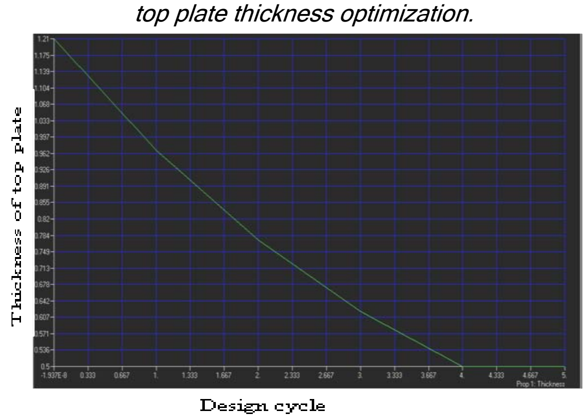


Fig. 9. 250 N load applied on the 5 mm dia circular area on top plate.

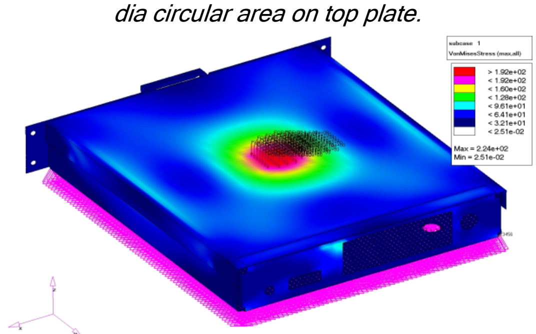


Fig. 10. FEA results for face plate with L-clamps.

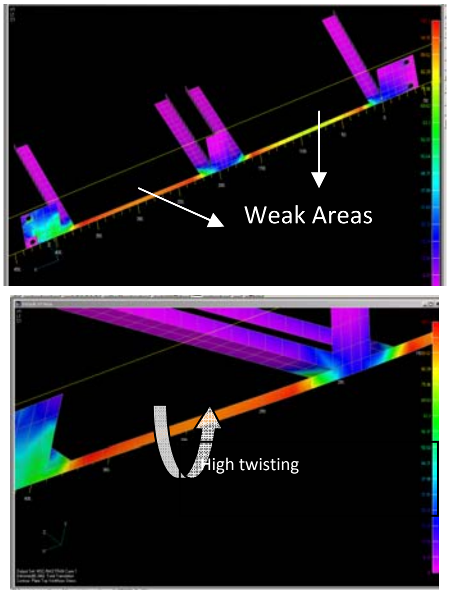


Fig. 11. FEA results for face plate.

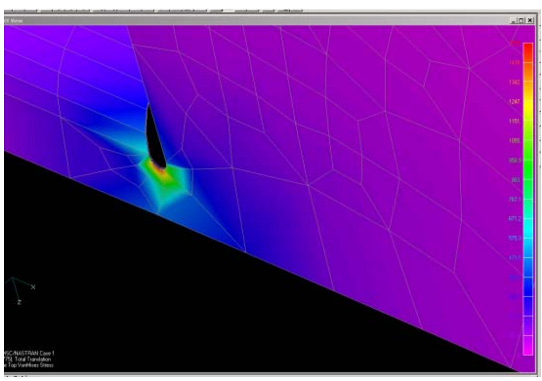


Fig. 12. FEA results for face plate final with sheet metal bent inwards design.

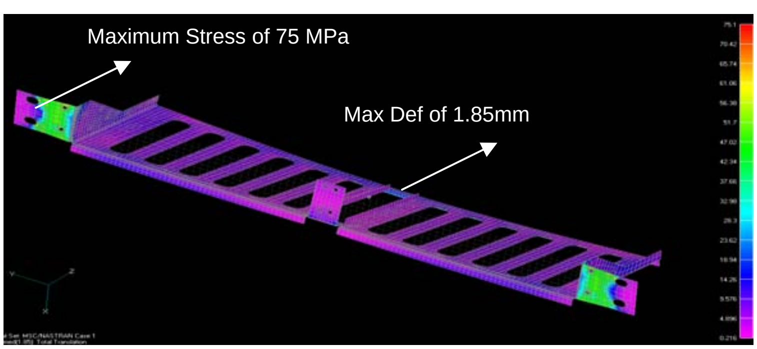
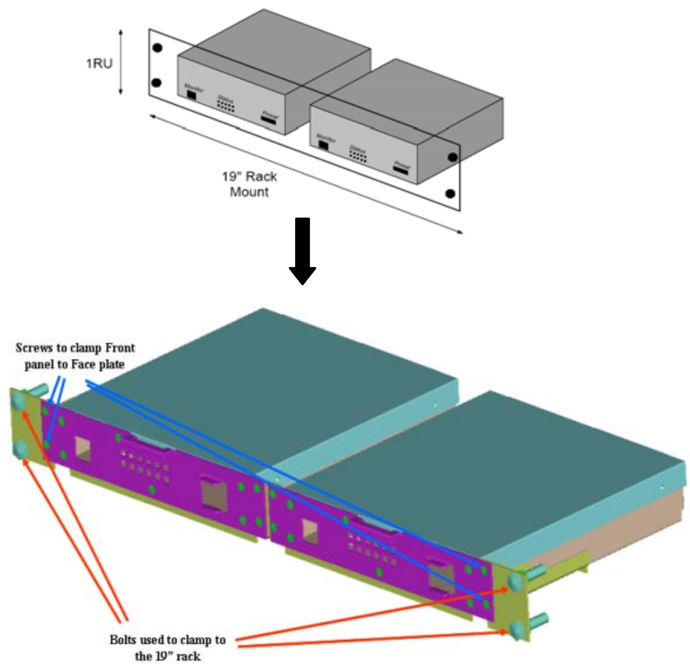


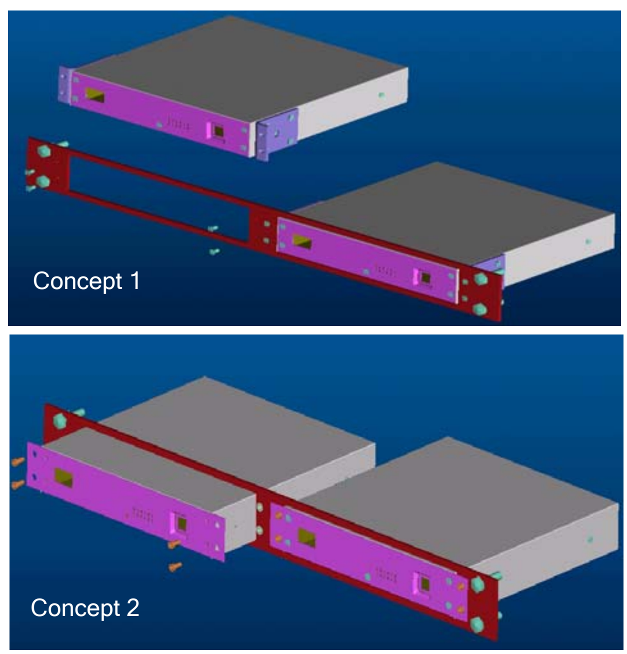
Fig. 13. Final assembly model of Ethernet switch box.

Initial sketch



Final assembly model

Fig. 14. Concept developed from the input requirements.



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self weight using the gravity load applied to whole box. The results are indicated in Fig. 4.

Design optimiztion of top plate

The top plate thickness of the Ethernet switch box is optimized using the deisgn optimization module in NASTRAN. A design optimization analysis is performed to optimize the top plate thickness. Based on the design constraints, for thee stresses below the maximum allowable limit of 207 MPa, an optimization cycle is performed in NASTRAN.

Face plate design optimization

The optimization simulations are carried for 3 subcases. In subcase1, the finite element analysis (FEA) of the face plate with the L-guide rail is performed using MSC.NASTRAN. The 3D model of face plate with L-guide rails which acts as support and as a guide rail to slide the box is shown in Fig. 5. In subcase 2, the base of the face plate is cut and bent inward and simulations are carried on this shape. The geometry for this sub case is shown in Fig. 6. The subcase 3 simulations carried on the face plate which is bent inward into a shape as shown in Fig. 7. Additional support/stability is provided by the side stiffeners and bottom reinforcement.

Results and discussion

Design optimiztion of top plate

Based on the optimization analysis, the top plate thickness is reduced from 1.21 mm to 0.91 mm thick sheet metal. The stability of the optimized top plate thickness is checked by constraining the bottom nodes of the box and applying 250N on the top plate on an circular area of 5 mm diameter. This is analogous to the stability test specified by IEC standards. The decrease in the thickness of the top plate is shown in Fig. 8. Fig. 9 shows that the stresses are within the maximum allowable limits.

Face plate design optimization

Subcase1; The FEA results shown in Fig. 10 indicate that there are certain areas that are weak in the bottom middle portion of the face plate, this is due to increase in weight by the addition of L-clamps. The further improvements in face plate are suggested as the number of components increased, difficulty in assembling and shipping, and more screws are required for clamping the L-clamps.

Subcase2: The relief area near the bottom edge between the base and the bottom edge of face plate is very less as that is shown in Fig. 11. The difficulty with this model is, it is difficult to manufacture such a small relief area. Analyses showed that the relief area between the base and the front of face plate are very highly stressed and lead to fail. Hence, the further optimization is suggested.

Subcase3: Based on the results shown in Fig. 12, the analysis suggests that this model can withstand up to 2 times the weight of the Ethernet switch box with the stress and deformation well within the limits. The maximum stress is 75 MPa as indicated in results which is well within allowable stress limit of 207 MPa. With the above said modifications, the final assembly model of Ethernet switch box is as shown in Fig. 13. The final assembly consist of the face plate that is clamped to the 19 inch rack using 4 bolts. A pair of Ethernet switch box seats into the face plate and the front plate of the box is clamped to the face plate using screws (Fig. 14).

Conclusion

In the present paper, Ethernet switch cabinet/ enclosure and the faceplate is designed for performance as per standards. L-clamps were replaced by a well designed bending of the sheet used in manufacturing the face plate. The modified design resulted in integrated L-clamps shape of the face plate. The removal of L-clamps reduces the number of parts, manufacturing cost and weight. It leads to ease of assembly. The results show that the stresses near the holes are reduced by 20% and increase the stiffness due to addition of bottom reinforcement. Due to slots on the base, there is 25% reduction in weight and reduced friction for the boxes to slide.

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