The Strength Analysis and Structural Modification of VPX Chassis in Flight Environment

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Abstract. The aircraft has severe mechanical conditions such as overload and vibration during operation. The environment in which VPX chassis are located is complex and harsh. In order to reduce the effect of high level vibration and shock on the VPX chassis in Flight Environment, the Strength Analysis of the whole chassis is made. Therefore the structure is modified according to the analysis result to improve its ability of anti-vibration and anti-shock. This paper proposes a iterative optimization method based on the variation characteristics of structural strength through iterative optimization, and by using the Finite Element Method for simulation calculation, the thickness of the area of the lugs of the equipment was adjusted to make the deformation and the stress and the weight suffices requirements of the design. It can shorten the period of product development and lower the product cost by the method presented in this paper.

Keywords: Versatile Protocol Switch Bus (VPX); Mode analysis; Structural Modification.

1. Introduction
The VPX chassis are the important components of the data chain system on the aircraft. The airborne electronic equipment is required to have the ability to maintain stable operating in an complex mechanical environment owing to the fact that he aircraft is prone to violent shaking during flight .Therefore ,in the stage of development ,it is necessary to dig out the weak part of the structure through the Strength Analysis, and change the structure to improve the reliability of the product[1-2].The VPX chassis is mounted inside the aircraft through the nether journal stirrups, therefore ,the abutment position is weak which is prone to be damaged, and needs a further strength analysis and structural modification[3-5]

2. VPX Chassis Modelling and Analysis

2.1. The Establishment of a Finite Element Model
The chassis is mainly composed of the body, the VPX back plate, the circuit boards and the vibration insulator, the overall structure of which is shown in the figure 1. There are four slots on the back panel, which can be inserted four standard 3U modules, as shown in the figure 1.the four modules realize the signal transmission and processing through the VPX backplane, as well as the control and driving of the external components; the electronic connection of the internal function module and the external equipment is realized through the connector. Each part of the chassis is connected by brazing. The materials selected for each component are aluminium plate, using 6063t-T6 aluminium, whose material properties are shown in the Table 1.
The mainly modelling rules are followed as follows: a) Parts that have little effect on the overall structural strength are not included in the finite element model; b) The holes, chamfers and fillets that have no effect on the overall strength are simplified; c) The drawing surface of the basic sheet metal parts is deducted to shell unit, and its thickness is the actual thickness of the parts; d) Fasteners are simulated with CWELD units, diameter and material are defined according to the material of the actual fastener. The module quality is simulated with a centralized quality unit. The total weight is 4.4kg.

2.2. Mode Analysis
The first three natural frequency of the chassis is 27.5, 47.8, 57HZ, respectively, and the fraction is shown in figure 2.

2.3. Operation Conditions
According to the analysis of the whole course of the reverse direction flight, the following experimental requirements of the acceleration, random vibration and impact force are obtained in Table 2,3,4.
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Table 2. Acceleration condition

|   | Z+  | Z-  | Y+  | Y-  | X+  | X-  |
|---|-----|-----|-----|-----|-----|-----|
|   | 30g | 30g | 30g | -30g| -7g | 21g |

Table 3. Random vibration experimental condition

| direction | frequency | Power spectral density | The total rms of the acceleration value | Experimental period |
|-----------|-----------|------------------------|----------------------------------------|---------------------|
| X, Y, Z   | 20~80HZ   | +3dB/oct               | 6.06g                                  | 5min in each direction |
|           | 80~350HZ  | 0.04g2/Hz              |                                        |                     |
|           | 350~2000HZ| -3dB/oct               |                                        | Descend |

Table 4. The response spectrum in direction X, Y, Z

| Frequency | Number of shocks |
|-----------|------------------|
| 50Hz~2000Hz | 60g~15000g |
| 2000Hz~5000Hz| 15000g |

2.4. Strength Check of the VPX Chassis under Acceleration Condition

The stress cloud diagram of the chassis under the X direction on 21g condition are shown in figure 3, the maximum stress occurs at the junction of the front panel of the chassis and the welded parts with a value of 31Mpa.

The stress cloud diagram of the chassis under the Y direction on 30g condition are shown in figure 4, the maximum stress occurs at the installation position of the chassis with a value of 24.8Mpa.

The stress cloud diagram of the chassis under the Z direction on 30g condition are shown in figure 5, the maximum stress occurs at the installation position of the chassis with a value of 9.8Mpa.

![Figure 3. The stress cloud diagram in X](image)

![Figure 4. The stress cloud diagram in Y](image)

![Figure 5. The stress cloud diagram in Z](image)
2.5. The Strength Analysis of the VPX Chassis under Random Vibration

The stress cloud diagram of the chassis under the condition of random vibration in X direction are shown in figure 6, rms value of the maximum random stress occurs at the installation position of the chassis with a value of 5.7Mpa.

The stress cloud diagram of the chassis under the condition of random vibration in Y direction are shown in figure 7, rms value of the maximum random stress occurs at the installation position of the chassis with a value of 23.7Mpa.

The stress cloud diagram of the chassis under the condition of random vibration in Y direction are shown in figure 8, rms value of the maximum random stress occurs at the installation position of the chassis with a value of 7.7Mpa.

![Figure 6. The random stress cloud diagram in X direction](image1)

![Figure 7. The random stress cloud diagram in Y direction](image2)

![Figure 8. The random stress cloud diagram in Z direction](image3)

2.6. The Strength Analysis of the VPX Chassis under Impact Condition

The stress cloud diagram of the chassis under the condition of impact in +X direction are shown in figure 9, the maximum stress occurs at the bottom of the chassis with a value of 199.2Mpa (less than the yield stress, 214Mpa).

The stress cloud diagram of the chassis under the condition of impact in +Y direction are shown in figure 10, the maximum stress occurs at the bottom of the chassis with a value of 76Mpa (less than the yield stress, 214Mpa).

The stress cloud diagram of the chassis under the condition of impact in +X direction are shown in figure 11, the maximum stress occurs at the bottom of the chassis with a value of 207Mpa (less than the yield stress, 214Mpa).
To sum up, the impact spectrum analysis shows that the maximum stress occurs at the bottom of the chassis with a value of 207Mpa, which is relatively close to the yield stress and needs to be redesign the structure of the lugs.

3. Structural Modification of the Lugs of the VPX Chassis

Through the strength analysis of the original structure of the VPX chassis, it is found that the lugs are not ideal enough in the original model, whose edge is not strong enough. The concrete performance is that the VPX chassis occurs a large stress deformation after the impact load in +Z direction, which means the structural modification to corresponding parts of the lugs is needed.

3.1. The Modification Solution

To maintain the overall structure, the local junction structure is modified as shown in figure 12. The structure stress of the lugs are partially enhanced according to the simulation result.

The thickness of the area of the lugs where a larger stress occurs is increased, and the connection area between the lugs and the upper cavity is increased to enhance the strength of these areas, as shown in the left one. According to the analysis, there are right angles in the connection part of the lugs and the
upper cavity where a strength concentration is easily to occur and needs to be changed to fillet, as shown in the right one in figure 12, 13.

3.2. The Modification Solution

The modified VPX chassis is simulated for impact analysis in +Z direction where the maximum stress occurred. It can be found that the maximum stress is reduced from 207Mpa to 102Mpa. The modified chassis can meet the performance requirement which means the measures are effective.

![Figure 14. The impact stress cloud diagram in +Z direction after modification](image)

4. Conclusion

The strength analysis was conducted using the Hyper mesh, Hyper view and Pat ran, and it was found there are weak area in the connection part of the lugs and the cavity of the chassis. According to the analysis result, a modification design is performed. In the after strength analysis of the modified structure, a significant decline of the maximum stress was observed, which proves that the modification performance is effective and the VPX chassis can work normally in the complex in flight environment.

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