650 MHz Coupler Test Stand Redesign

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I. Introduction

The test stand (shown in Figure 1) is used to assess the 650 MHz cryomodule couplers. These couplers provide radio frequency power to the beamline in PIP-II's upcoming linear accelerator. Prior to their installation into the cryomodules, they undergo testing to verify their RF power capabilities. They are put under vacuum in a clean room, then moved to the stand and RF tested. During prototype testing, a multitude of possible improvements to the test stand were identified. While the current test stand design was sufficient from a theoretical standpoint, there were many inefficiencies both in assembly and in testing. The upcoming construction of PIP-II leads to the need to test a much larger number of couplers than previously; therefore, a robust update to the current test stand was deemed worthwhile. The goal of this redesign was to save hours of Fermilab employee time and relieve them of mental and physical strain caused during the testing assembly process.

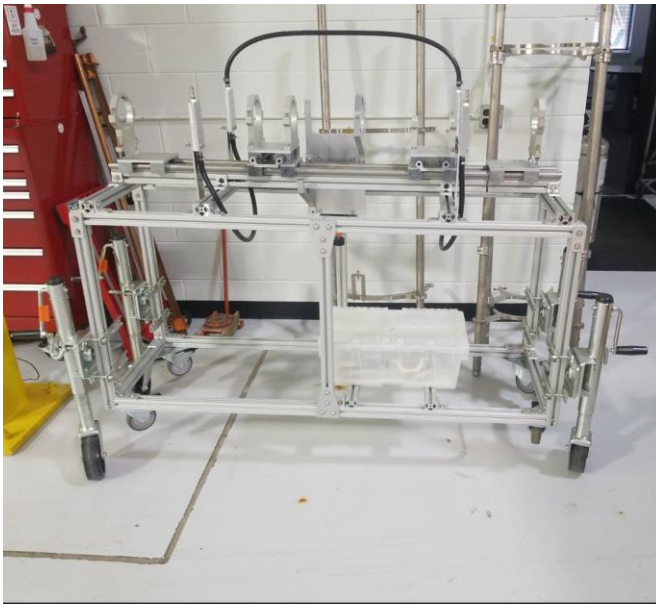

Figure 1: Former Test Stand

II. Methods

The primary method used to identify needed changes in the test stand was user feedback. This came from a variety of sources, including engineers who had worked on the stand and technicians who had an intimate understanding of the stand's ergonomic failings. A Failure Mode and Effects Analysis was performed on the cart's component's functions and on the assembly process of installing the testing equipment. This analysis created a comprehensive understanding of the stand's shortcomings and how to mitigate the risk of creating future issues in the new stand. Once the issues were identified, brainstorming ensued. In order to ensure the optimal design of the stand was reached, a wide variety of solutions were drawn up and compared. A minimum of three solutions were reached per subassembly, after which final designs were selected.

With a broad idea of how the redesigned test stand should function, the process of creating a Computer-Aided-Design (CAD) model began. Throughout this process, design reviews were held to realize any unforeseen interferences or issues that may occur during the process of bringing the test stand into reality.

Siemens NX was used to create the CAD model and its parts were catalogued in Teamcenter. Standard parts such as nuts, bolts, brackets, and frame components were garnered from either the Fermilab Standard Parts Library or vendor websites.

Test Cavity Assembly

The Test Cavity Assembly is composed of the Test Cavity and two vacuum side couplers (one on each side of the test cavity). This assembly is put together in a clean room while mounted on a clean room stand. Then it is removed from the clean room stand and mounted to a temporary stand for transport. After transport, it is removed from the temporary stand and mounted to the test stand.

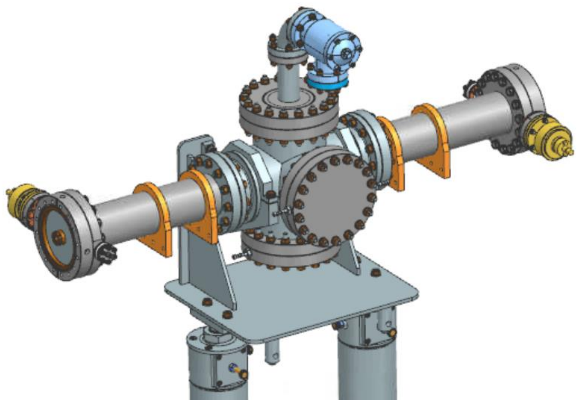

Figure 2 (above): Test Cavity Assembly on clean room stand

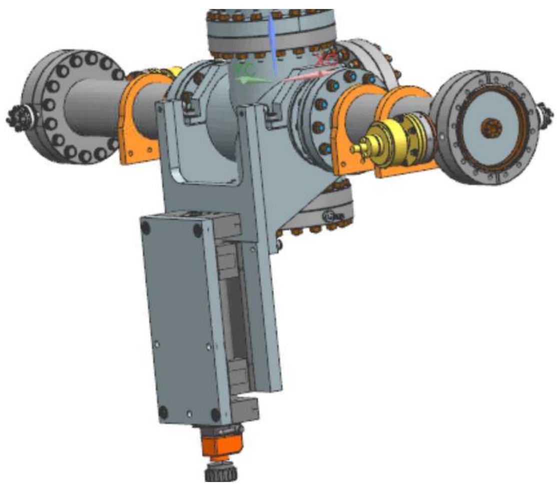

Figure 3 (above): Test Cavity Assembly mounted on the test stand mounting mechanism

To minimize the amount of assembly and disassembly, alterations were made to both the clean room stand and the test stand to allow the Test Cavity Assembly to remain on the clean room stand throughout the process. The test stand was changed to allow the clean room stand to mount directly to it. The changes included adjustment bolts (outlined in yellow in Figure 4) to alter pitch and yaw, a large hole in the center for a bolt, and guiding pins for setting the test stand in place. The pins are threaded rods that are removable. Conceptually, only one set of two would be used--depending on how much adjustability is needed. The set outlined in pink have limited adjustability, but the set outlined in orange allow the stand to have a large range of rotation. (Referring to Figure 4). The holes outlined in green are how the clean room stand mounts in the clean room. This system is more modular; it can be used in a variety of situations and allows the test cavity assembly to be a more mobile unit.

The Test Cavity Assembly mounting was also changed. The bracket that attaches to the cross-weldment of the test cavity assembly was altered to create a more versatile system. Previously, the bracket had tight clearances with assembly components and proved difficult to align with the test stand mounting points. Additionally, future Test Cavity Assembly cross weldments may be altered to have a mounting system (a square plate with threaded holes) welded on. To keep the mounting system consistent between old and new, the current system's mount was changed to have a similar plate mounted via brackets. By changing the current system to the bracket with threads (outlined blue in Figure 4), the goal is to ensure compatibility with future designs and create an easier set-up process for users.

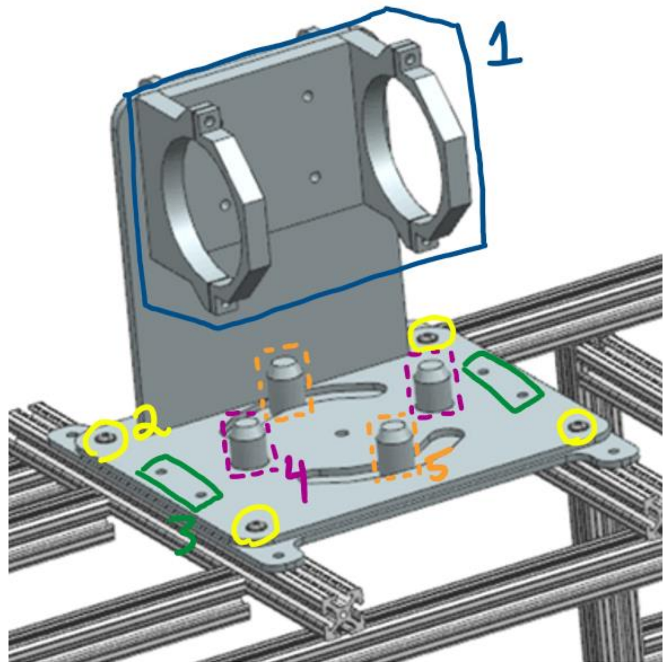

Figure 4 (above): Redesigned Clean Room Stand mounted to the Test Stand. See Table 1 for part names.

TABLE I

FIGURE 4 PART NAMES

Number	Color	Type Styles
1	Blue	Cross Weldment Attachment
2	Yellow	Pitch and Yaw Adjustment Bolts
3	Green	Clean Room Stand Mounting Points
4	Pink	Guiding Pins, limited adjustability
5	Orange	Guiding Pins, rotational range of motion

OUTER CONDUCTOR COUPLER SUPPORTS

One of the major issues the redesign of the test stand needed to address was a way for the outer conductor supports compensate for deviation of the Test Cavity Assembly about the Z-axis. The previous design could translate the supports along the X and Y axis via linear guide rails and carts and had Z-adjustment built into the Test Cavity Assembly mounts. The issue was that the distance and the angle between the supports was not adjustable.

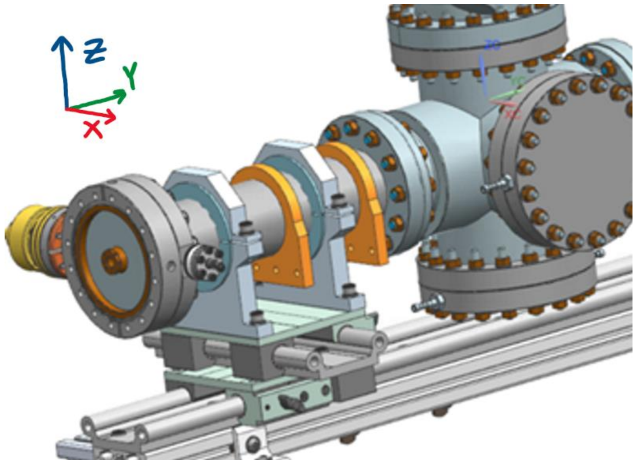

Figure 5: Previous design for coupler supports.

Solving this issue created an interesting dilemma: how can the supports be both modular and, at the same time, retain simplicity. A complex system could present problems in its requirement of substantial operational knowledge, possibility of misuse, or users deeming it more time-consuming than helpful.

The redesigned coupler supports found a good balance of adjustability and simplicity. The outer conductor of the couplers would be locked in place using holding bolts (see Figure 6). A user removes the top half of the bracket, sets height of the bottom bolt to something reasonable, lowers the Test Cavity Assembly into place, then puts the top bracket back on and tightens all the bolts snug against the coupler.

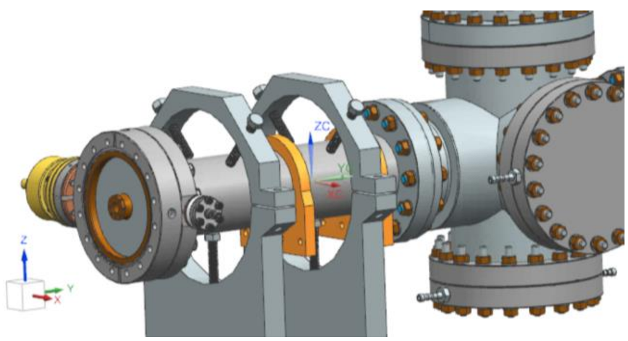

Figure 6: Redesigned Vacuum Side Coupler Supports.

By changing the support from a tight-fighting, rigid pipe-hanger to a three-points-of-contact, wide-range clamp, the adjustability of the coupler support is greatly increased. This results in a much simpler system that does not require linear sliding carts along the X and Y axis, or height adjustability at the Test Cavity Assembly. All the adjustments are set at the couplers' outer conductor supports.

A similar system is used for the Air Side Outer Conductor. The air side coupler (as seen in Figure 7) has a larger radius, but the system remains the same. This also allows for the alignment brackets of the air side coupler to remain in place. These brackets maintain the rigidity of the air side coupler's bellows and ensure that everything is aligned properly during the assembly process. Previously, these components would have had to have been removed during the air side support installation.

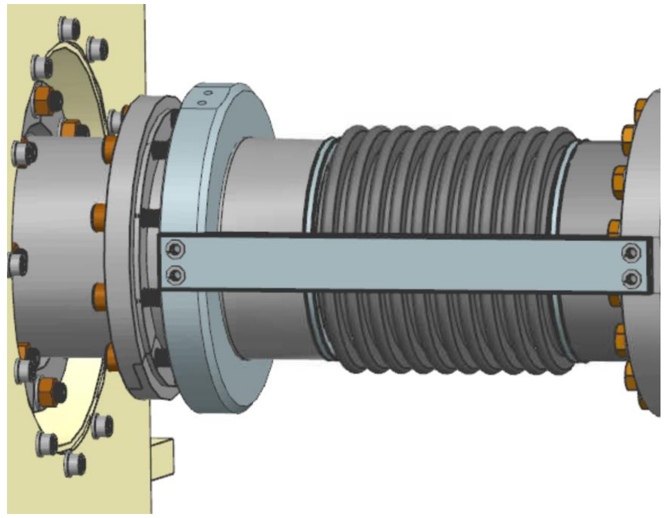

Figure 7: Air side coupler outer conductor and alignment bracket. The support is not shown.

The new support system is intended to use Teflon bolts. This prevents the outer conductors of the couplers from becoming damaged by the surface of the bolts and mitigates the risk of equipment damage through user error such as overtightening.

WAVEGUIDE SUPPORT

The former waveguide support was not originally a part of the test stand. This component was added after the need was identified once use of the stand began. The assembly process of the waveguide manifold (the large metal box resting on the scissor jack) involves sliding the manifold forwards over the inner conductor present inside of the air side coupler. This inner conductor extends as shown in the red box in Figure 8. Previously, this process was somewhat cumbersome. The sliding action of the previous waveguide manifold was coarse. To combat this problem, a linear rail and guide cart was implemented to create a smooth sliding action. The scissor jack provides height adjustability.

MOBILITY CHANGES

The final aspect of the test stand that was changed was its mobility. The 8020 cart frame that the assembly components attached was limited in terms of how it could be moved. This was a problem because the testing process takes place in a separate facility than where the Test Cavity Assembly is put together in the clean room, creating the need to have the test stand be as transportable as possible. One major issue was how the cart's caster wheels interfered with its trailer jack wheels. (Casters are not present in the CAD document). The top deck of the cart must align with fixed components in the testing building, so the trailer jack wheels are all set to a specific height during testing. The high height of the previous cart resulted in the trailer jack wheels not being extended far enough to clear the interference of the caster wheels. By lowering the overall height of the cart, it will need to be raised more to reach the building components. This allows the trailer jack wheels to clear the casters and maintain full range of motion.

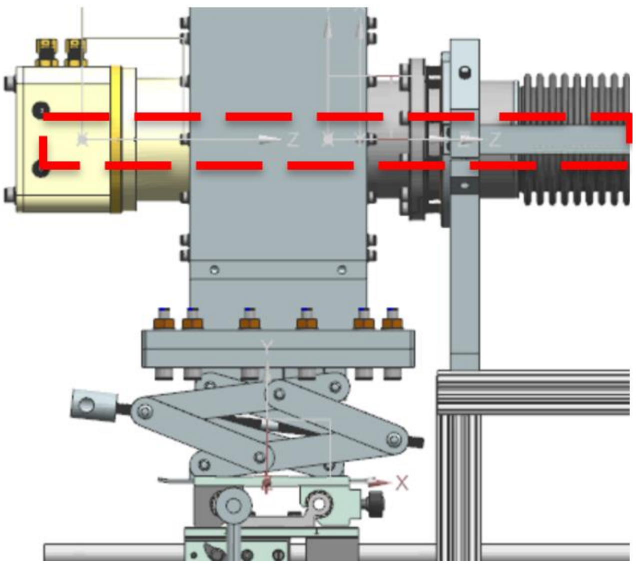

Figure 8: Waveguide manifold resting on a scissor jack. Also present is the Air Side Coupler with support and alignment bracket.

Frame components were also added to create a multitude of transportation options for the stand. The horizontal components outlined in green in Figure 10 are guides for forklift tines. This creates a clear indication to operators where the stand should be lifted from and clears up any ambiguity that may be present. The vertical components outlined in red are there to provide a means to lift the cart via lifting straps. The vertical pieces prevent the straps from sliding towards the center of the stand during lifting and so allow the stand to be lifted using a crane.

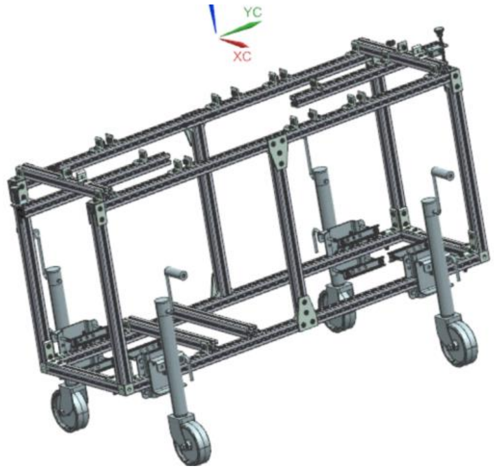

Figure 9 (above): Former cart frame.

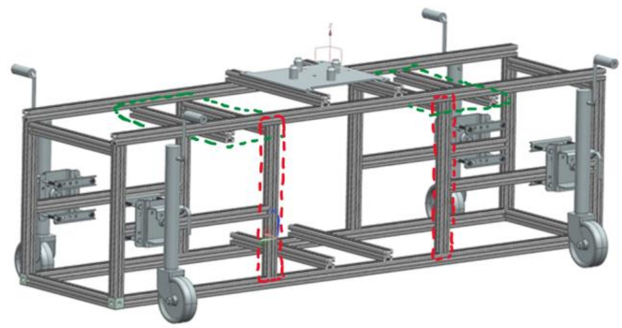

Figure 10: Redesigned cart frame.

CONCLUSION

The goal of the redesigned test stand is to meet the testing needs identified in the FMEA while maintaining as much ergonomic efficiency, simplicity, and reliability as possible. These needs have been met in theory, and the next step is to test them in reality. Once the drafting of the test stand has been completed, acquisition of materials and construction can begin.

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