

ASTROLAB® INC.

4 Powder Horn Drive, Warren, NJ 07059-5105
 TEL: (732) 560-3800 FAX: (732) 560-9570
 Internet: <http://www.astrolab.com> Email: sales@astrolab.com



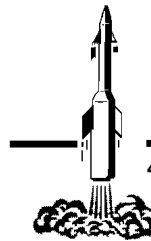
Improvements to RF Contacts for New Communication Systems

Coax contacts have been an integral part of many successfully deployed systems by the military services. Their use has grown as evidenced by the large variety of MIL-C-39029 compliant designs available. These contacts have proved extremely useful in the gang-mate MIL-C-38999 and MIL-C-83823 connectors. The ease of installation and ability to package a large number of individual coax and power transmission lines into a small surface area have made these contacts invaluable to system designers. Fig.1 shows typical connectors with coaxial contacts.

Fig. 1



The applications that are able to utilize these miniature Coax contacts have historically been subject to very stringent limitations. These contacts were initially designed solely for use in power transmission lines and offered no benefit to engineers looking for miniature, high-performance connection solutions for their microwave signal transmission systems. There are many Coax contacts designed for use in 50 Ohm and other impedance systems, but these are typically limited to very low operating frequencies (for example 100 MHz). Contacts that have been designed following the



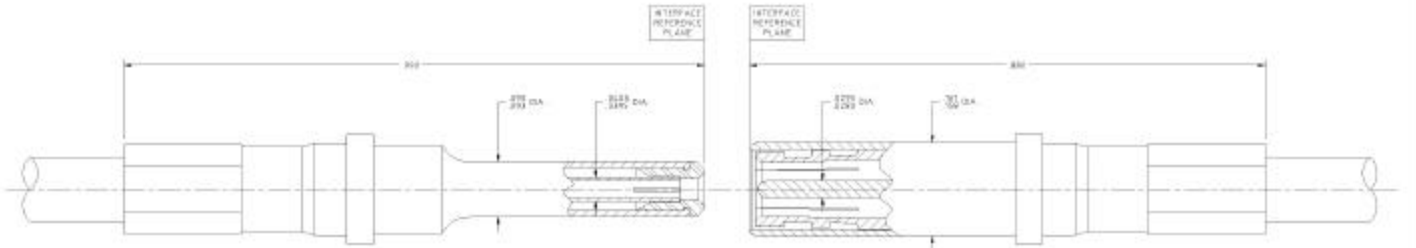
ASTROLAB® INC.

4 Powder Horn Drive, Warren, NJ 07059-5105
 TEL: (732) 560-3800 FAX: (732) 560-9570
 Internet: <http://www.astrolab.com> Email: sales@astrolab.com



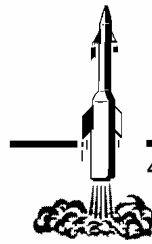
MIL-C-39029 guidelines are often very poorly matched to 50 Ohm systems. The line impedance on some contacts can range as low as 21 Ohms. The reason behind a design with this type of mismatch is that it was much easier to manufacture these contacts with 'fat' center conductors due to the outer dimension constraints.

Fig.2



The miniature line sizes made it very difficult and expensive to produce the minute center conductors needed for a 50 Ohm transmission line. Also, there was no need for a perfectly matched line since high-speed transmission was not on the drawing board yet. However, in the past few years, the industry trend has been toward high-speed data transmission and the results from this kind of electrical mismatch are disastrous for a high-performance system. The additional attenuation and reflection from these mismatched contacts has ruled out their use for high-frequency applications, until now.

As a result of customer requests Astrolab has reviewed the designs of many Coax contacts and found areas that can be optimized to produce high-performance products. Two contacts in particular are the MIL-C-39029/73, /74 and /102, /103 designs. Each of these designs have some very similar design constraints as well as modifications that need to be considered. Looking at the standard line sizes for these contacts, the most noticeable area where improvement is needed is the impedance of the contact. The first challenge was to move the mismatch resonance to a higher frequency and open these products to a wider market. This is easier said than done.



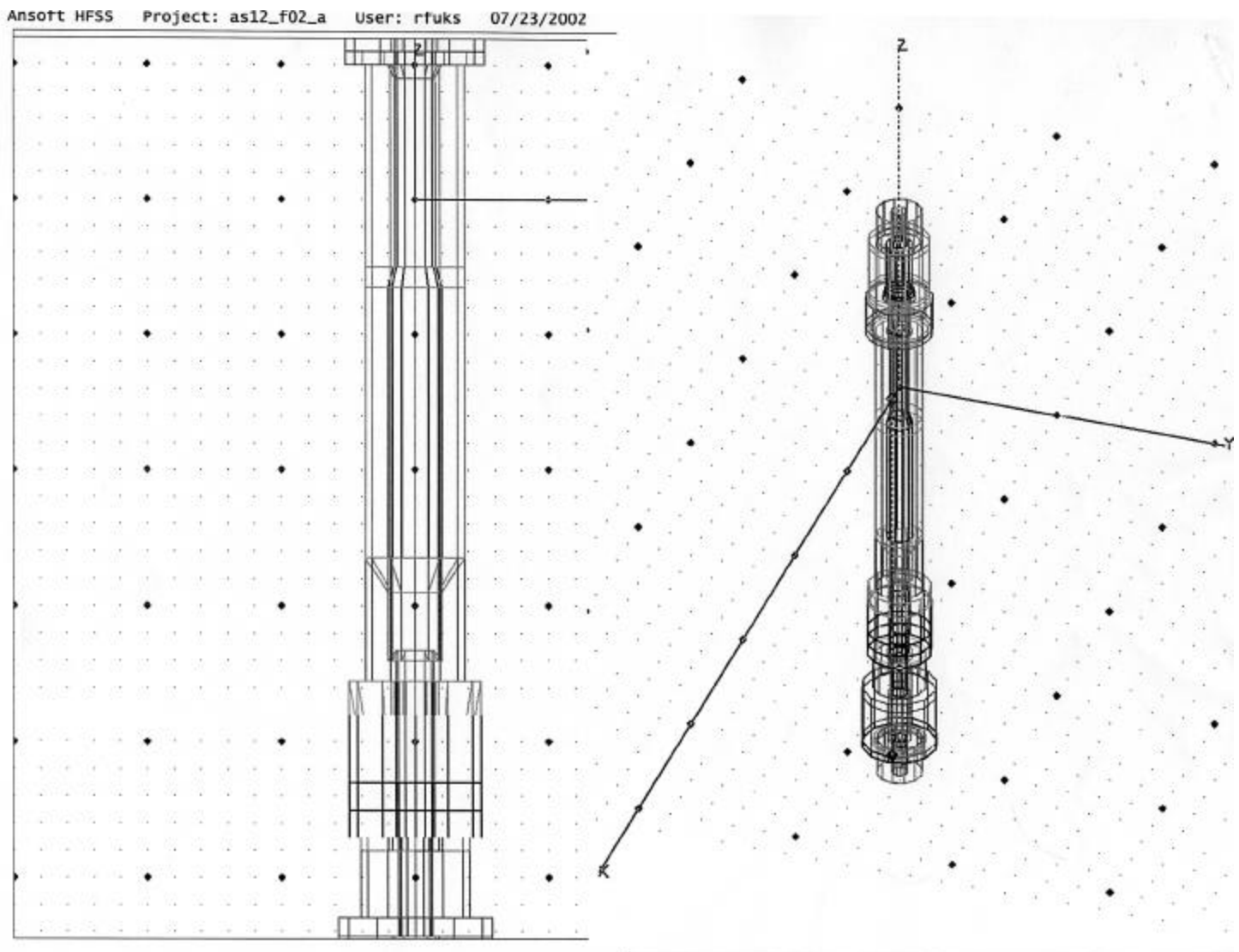
ASTROLAB® INC.

4 Powder Horn Drive, Warren, NJ 07059-5105
TEL: (732) 560-3800 FAX: (732) 560-9570
Internet: <http://www.astrolab.com> Email: sales@astrolab.com

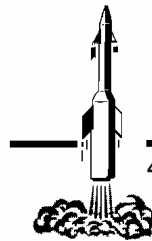


Figure 3 is a computer model.

Fig 3



The primary design constraint with each of these contacts is size. The ability to fit so many contacts in a small area within the gang-mate connector limits the design



ASTROLAB® INC.

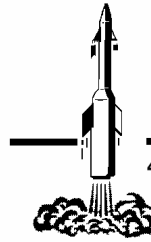
4 Powder Horn Drive, Warren, NJ 07059-5105
 TEL: (732) 560-3800 FAX: (732) 560-9570
 Internet: <http://www.astrolab.com> Email: sales@astrolab.com



options. The outer dimensions of the contact are not independent of its operational use. The inserts of the shell connector that these contacts fit into have been specifically designed to provide RF shielding and weatherproofing. Any modification of the outer profile of the contact would compromise these factors. Thus, to improve the impedance of the contacts, the line sizes need to be reevaluated for higher frequency operation without disturbing the external profile of the contact. By carefully modifying the ratio of inner conductor diameter to outer conductor diameter within the limits allowed, the impedance has been brought much closer to the 50 Ohm target of most systems.

However, matching the internal line size does not solve the entire problem. These newly designed contacts still need to mate with industry standard designs from other manufacturers. Customers looking for better performance in their system need to be able to mate the improved contacts with their existing design. This requires that the contact to be backward compatible to the MIL-C-39029 standard. For this to occur the interface dimensions must be maintained. This limits the effectiveness of a balanced internal line because the mismatch that occurs at the interface junction is still present within the system. To eliminate the resonance caused by mismatch, it is necessary to construct a transition line within the contact that will compensate for the distortion.

The best location for this compensating transition line is in the same plane as the first mismatch. However, this would cause a nonconformance with the established interface dimensions and raise several other problems. Another possibility to compensate for the impedance mismatch was the creation of a high-impedance discontinuity in the transmission line immediately behind the low-impedance interface of the contact. Although this form of compensation limits the operating frequency of the contact, it allows the contacts to operate with exceptional performance up to 2 GHz. The MIL-C-39029/73 and /74 designs originally had such low impedance that any improvements were severely limited by not being able to adjust the interface dimensions. For this reason and to meet the customer's target operating frequency, these two designs are limited to 2 GHz. The design was modified following the second line of reasoning and the increase in performance was exceptional. The improvements realized by this design change include improved operating frequency range, lower attenuation and lower VSWR. The electrical performance was simulated



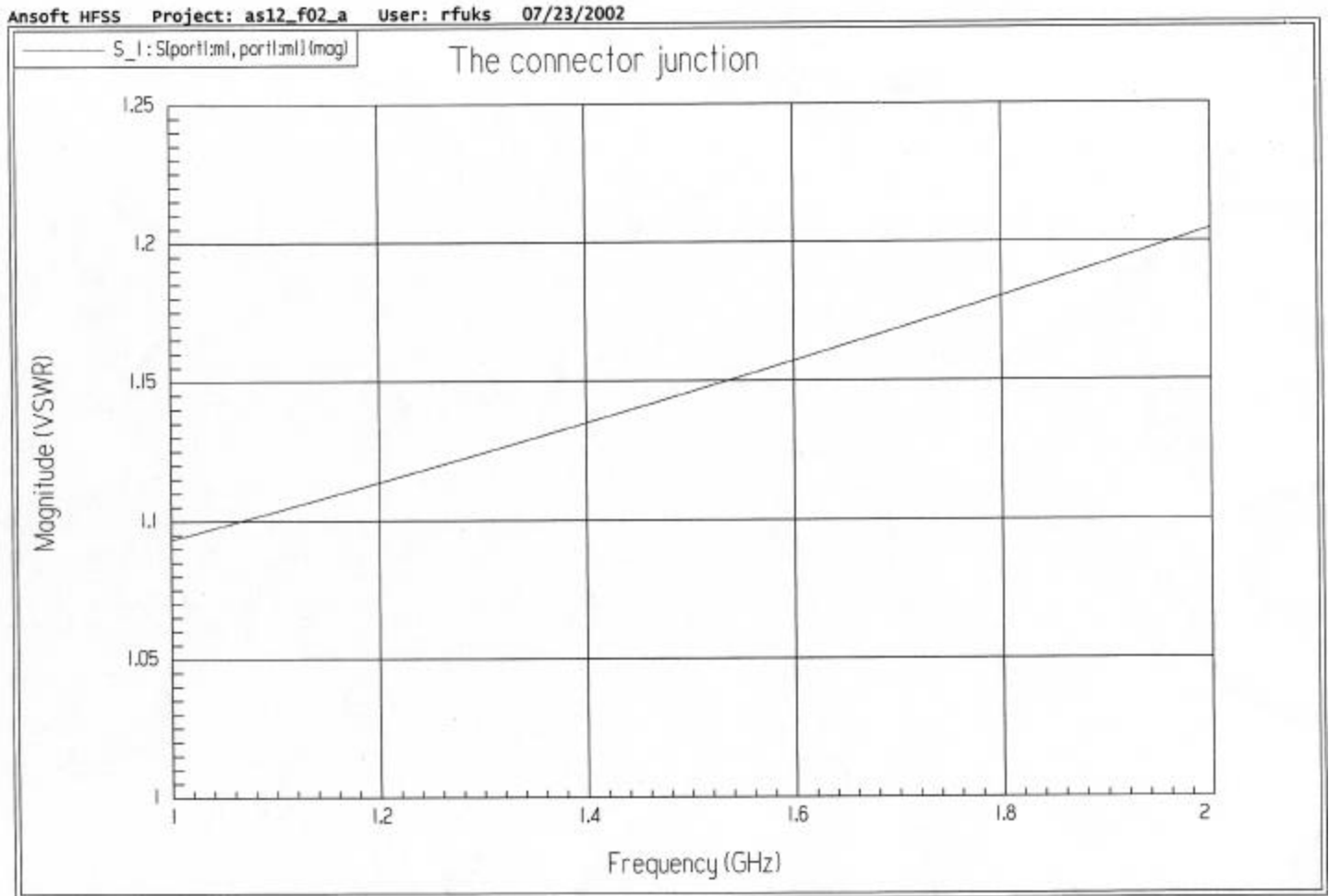
ASTROLAB® INC.

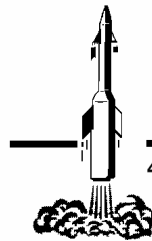
4 Powder Horn Drive, Warren, NJ 07059-5105
TEL: (732) 560-3800 FAX: (732) 560-9570
Internet: <http://www.astrolab.com> Email: sales@astrolab.com



and optimized using a high frequency CAE simulator. Figures 4 shows the results of the simulated mating of a pin and socket RF contact as VSWR versus Frequency.

Fig.4



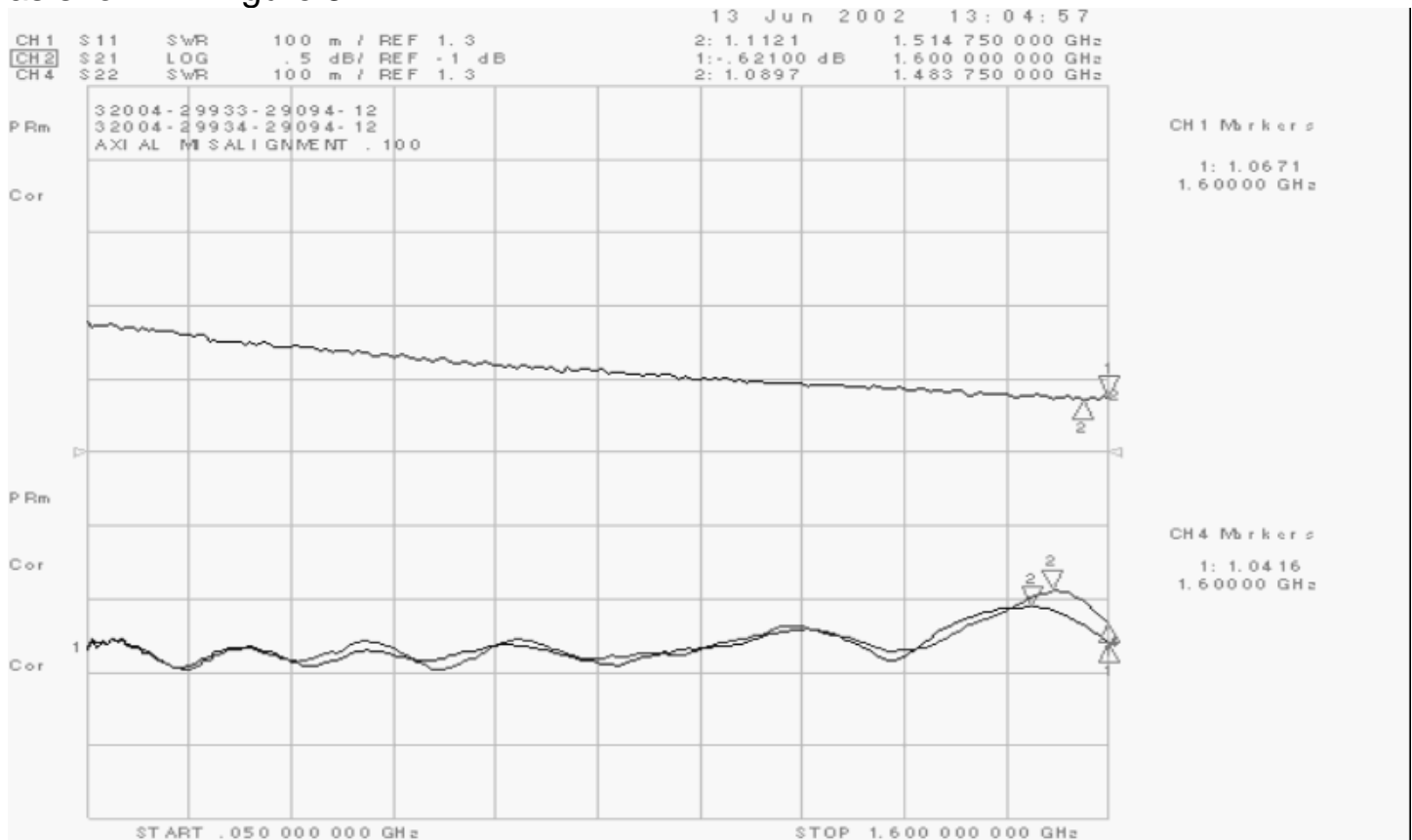


ASTROLAB® INC.

4 Powder Horn Drive, Warren, NJ 07059-5105
 TEL: (732) 560-3800 FAX: (732) 560-9570
 Internet: <http://www.astrolab.com> Email: sales@astrolab.com

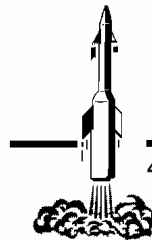


The contacts showed equally comparable performance during pre-production testing as shown in Figure 5.



Here, cable assemblies with socket and pin RF contacts were mated and the test was run through both cables simultaneously. The recorded data is at the same frequency as the simulated data and shows the excellent performance of the RF contacts. Astrolab had similar success with the MIL-C-32029 /102 and /103. These contacts can be used to 12 GHz.

Another issue that arises from the redesign of the transmission line is peak power handling. To achieve a transmission line that has the high-impedance needed to compensate for the low-impedance interface, Teflon insulation must be removed to allow for the new diameters. This change to the dielectric around the center conductor results in a lowering of the peak power handling of the contact. Despite



ASTROLAB® INC.

4 Powder Horn Drive, Warren, NJ 07059-5105
TEL: (732) 560-3800 FAX: (732) 560-9570
Internet: <http://www.astrolab.com> Email: sales@astrolab.com

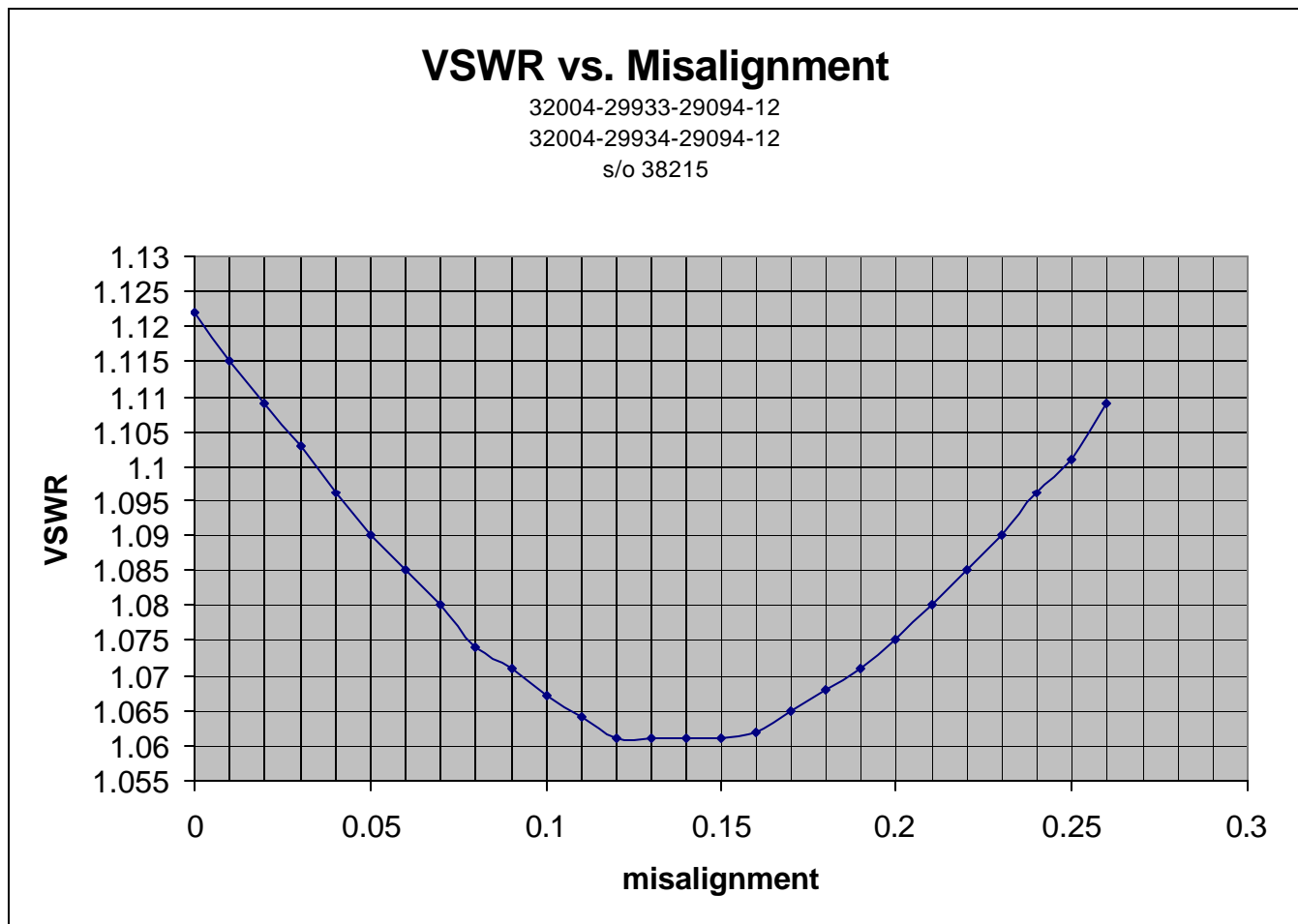


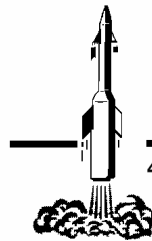
this, the contacts were tested for dielectric withstand voltage handling and successfully handled 900V RMS. A second concern is the electrical performance of two contacts while

axially misaligned. Despite the internal changes designed at Astrolab, the improved design met the requirements for axial misalignment as shown in Figure 5.

The data in Figure 6 shows the VSWR versus axial misalignment from 0 to .250". There is little degradation until disconnection of the contacts.

Fig. 6





ASTROLAB® INC.

4 Powder Horn Drive, Warren, NJ 07059-5105
TEL: (732) 560-3800 FAX: (732) 560-9570
Internet: <http://www.astrolab.com> Email: sales@astrolab.com



The changes that resulted in improving the performance of the RF contacts also require mechanical considerations to be taken into account. In addition to removing some of the insulation that surrounds the center conductor, both the inner and outer conductor diameters were modified to make the best use of the available area within the contact. Typical designs for RF contacts use a brass body for the outer conductor.

While this offers some cost benefit the contact is only able to survive the operating mechanical forces and stresses by utilizing a thick wall design. To increase the size of the outer conductor inside the contact, the wall thickness of the body needed to be reduced. To effectively accomplish this without degrading the mechanical strength of the contact required the use of another material. The preferred solution to this issue is to use Beryllium Copper as the material for the outer conductor. Its high strength and resistance to bending moments and fracture make it an ideal candidate to serve in a thin walled body application such as this. After manufacturing the parts, testing showed excellent strength of the parts versus handling effects.

Through the improvements implemented on these designs, the future for the RF contact in high data rate systems is bright with opportunity. These modifications can be made through similar methods to other styles of coax contacts listed in the MIL-C-39029 specification to provide performance improvements in current systems and implementation in future designs. The small envelope and expanded performance range of these new contacts allows engineers to pursue new avenues of design for their high performance systems and reap the rewards of a more reliable product.