Busbar Contact Resistance Test Results

Astronics AES – Summer 2024 Internship
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1. Purpose

This document summarizes the results of contact resistance testing performed as part of an evaluation of bolt stack-up configurations and pressure-contact behavior in busbar assemblies. Results are drawn from coin compression tests and full-size bolt assembly trials conducted using various torque levels, orientations, and materials.

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2. Key Objectives

- Determine the effect of torque and bolt orientation on contact resistance
- Compare resistance performance between aluminum and copper busbar samples
- Identify optimal bolt configurations for minimizing resistance and improving thermal reliability

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3. Summary of Findings

Test Type	**Key Finding**
Coin Compression	Resistance decreased with increasing pressure and plateaued at higher force levels.
Material Comparison	Copper (110 H02) consistently had lower and more reliable (constant) contact resistance than both aluminum alloys
Bolt Stack-Up	Dual horizontal screws yielded the most consistent and lowest resistance.

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4. Representative Plots

The following plots illustrate resistance behavior under varying pressure and torque conditions across different materials and bolt stack-ups.

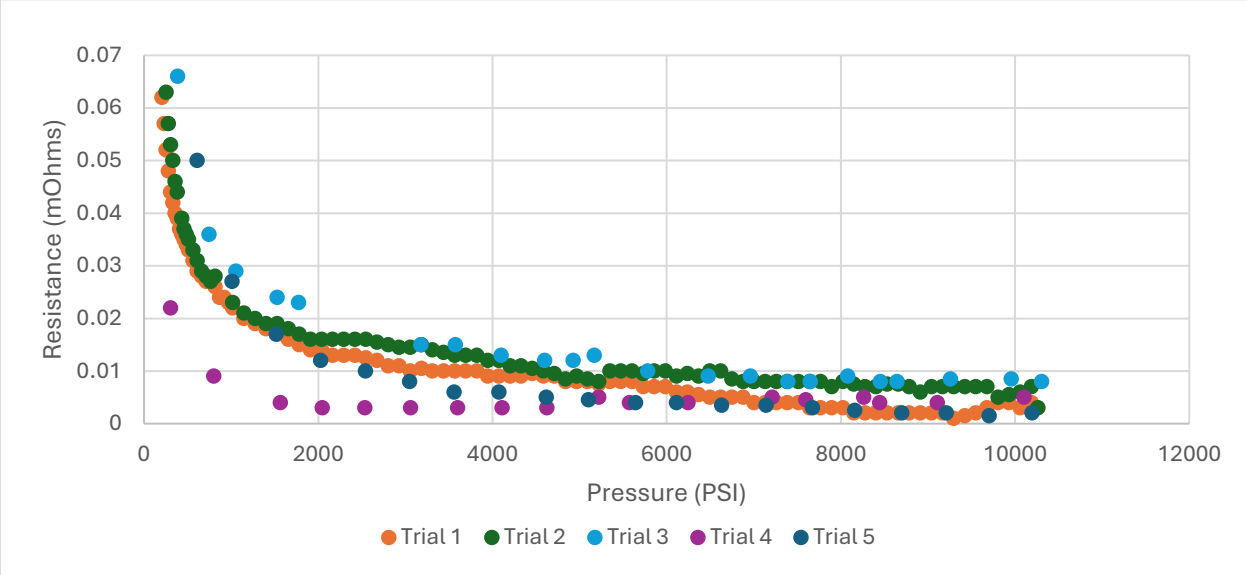

Figure 1. Resistance vs. Pressure - Coin Compression CU110-H02 1/2 Hard.

This plot shows a consistent inverse relationship between applied pressure and electrical resistance across five trials using copper samples. Resistance drops sharply at lower pressures and begins to plateau around 4,000 PSI, consistent with theoretical expectations of contact area saturation.

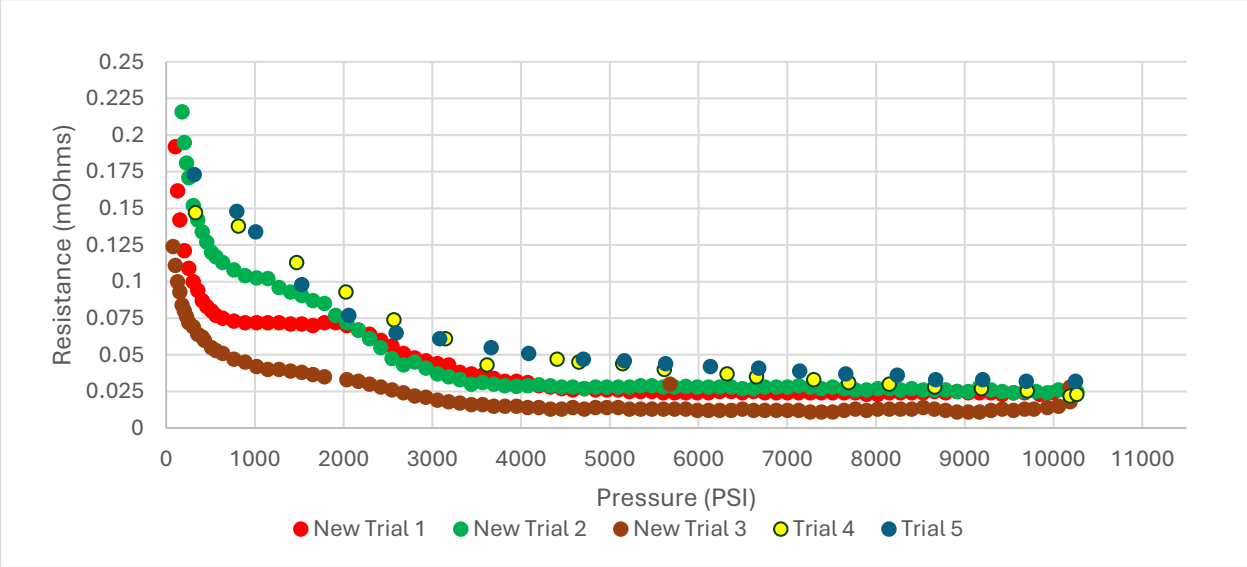

Figure 2. Resistance vs. Pressure - Coin Compression AL6061-T6.

Aluminum exhibited significantly higher resistance values and greater variability than copper. While the general trend also follows a resistance decrease with increasing pressure, aluminum showed more scatter, indicating greater sensitivity to surface condition and material compliance.

Plate:	.25" Aluminum 1100 H14		
Stackup Number	1	2	3
Torque (lb in)	92.17	79.42	38.25
Single Hole (mOhms)	0.022	0.281	0.034
Double Vert (mOhms)	0.006	0.084	0.161
Double Horz (mOhms)	0.0055	0.0145	0.045

Table 1. Bolt Stack-Up Test Matrix for .25" AL1100-H14.

Plate:	.25" Aluminum 6061 T6		
Stackup Number	1	2	3
Torque (lb in)	92.17	79.42	38.25
Single Hole (mOhms)	0.027	0.102	0.143
Double Vert (mOhms)	0.0035	0.181	0.004
Double Horz (mOhms)	0.001	0.074	0.093

Table 2.Bolt Stack-Up Test Matrix for .25" AL6061-T6.

Plate:	.25" Cu 110, H02 1/2 Hard		
Stackup Number	1	2	3
Torque (lb in)	92.17	79.42	38.25
Single Hole (mOhms)	0.0016	0.0119	0.0026
Double Vert (mOhms)	0.0008	0.0061	0.0014
Double Horz (mOhms)	0.0001	0.0009	0.0017

Table 3. Bolt Stack-Up Test Matrix for .25" CU110-H01 ½ Hard.

Tables 1, 2, and 3 summarize results for three separate plates used for bolt stack-up testing. The tables include three bolt stack-ups with varying torque specs and washers used for each stack-up. Of the results, the most notable is the orientation of the bolts; the double-horizontal bolt orientation (two bolts mating the busbar in parallel) consistently yields the lowest contact resistance results across all trials.

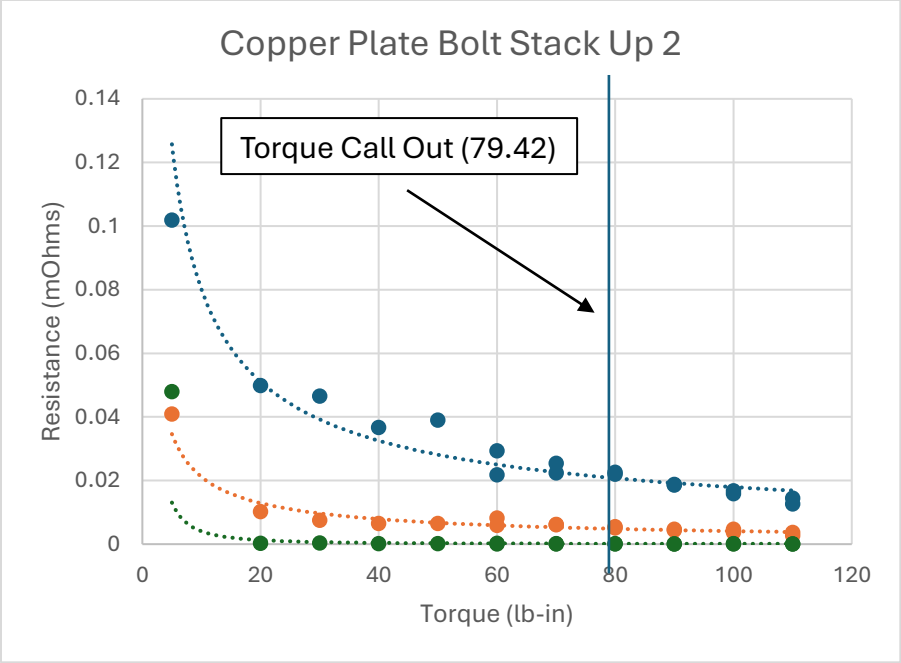

Figure 3. Resistance vs. Torque - Bolt Stack-Up

This figure (Figure 3) presents resistance values measured from a dual-screw horizontal bolt stack-up using copper plates. The data demonstrates a clear drop in resistance as torque increases, with diminishing returns beyond approximately 80 lb-in. The recommended torque setting (79.42 lb-in) corresponds to the plateau zone, indicating efficient clamping without over-tightening.

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5. Conclusions

- Contact pressure is a dominant factor in minimizing resistance.
- Copper connections consistently outperformed aluminum due to higher conductivity and material compliance.
- Standardizing torque specs and washer usage significantly reduced test variability.
- The data supports internal guidelines for busbar bolt torque and hardware configuration.
