Suspension Component Loading and Analysis Using Micro-Measurements® Strain Gages

Authors: Forrest Sheard, Asif Habib, Justin Neves - RIT SAE Baja team members

Rochester Institute of Technology's RIOT Racing with R17 Baja Car

Micro-Measurements® strain gages were used by the RIT SAE Baja Team to record component loading during racing scenarios. Testing was focused on further development of the vehicle suspension and kinematics. Components under test were gaged, calibrated, and tested completely by students with the help of Micro-Measurements®. The collected data was used to produce a lighter, better performing suspension system and will be used for many years for future designs. This level of component validation is what allows RIOT Racing to stay among the top competitors in the SAE Mini-Baja Collegiate Design Series.

Company/Institute: RIOT Racing, Rochester Institute of Technology, Society of Automotive Engineers, Baja SAE

Industry/Application Area: Force measurement for design validation

Products Used:

- C2A-06-125LR-350
- C2A-06-125LW-350
- C2A-13-062LR-350
- C2A-13-250LW-350
- CEA-06-187UV-350
- BAK-200 KIT
- M-COAT FA-2 ALUMINUM
- BARRIER E BUTYL RUBBER

The Challenge

Competitors in the Baja SAE collegiate design and racing competitions are all limited to using the same Briggs and Stratton 10.5 horsepower engine, with no engine modifications allowed. This requires a great deal of ingenuity in order to produce the fastest car on the track. Continually designing a lighter and better maneuvering car is the only way to stay on top of the competition. For years the RIT Baja suspension team has been designing their components with loading scenarios that have been passed down as designers came and went. They doubted the accuracy and reliability of the data, but lacked the means to prove it wrong. For last year's R16 car, our suspension designers produced as light a suspension as they could, pushing safety factors to as low as possible based on the previously collected loading scenarios. Overall the car performed very well, but when it came time to start designing the suspension for this year's R17 car the designers were concerned they could not possibly produce a better suspension based on the loading data they had. Continually being a top competitor in the Baja SAE competition, not improving the design of their suspension was not an option for RIOT Racing. That's when our team reached out to Micro-Measurements® and found the answer we were looking for.

The Solution

Overall suspension testing was broken into three groups; only axial loading components, front bending/axial loading components, and rear components which were only tested for bending.

Our first components to test were the only axial loading suspension members. This included our tie-rods, link 4s, and link 5s. Each of these components was outfitted with a 350Ω gage in a half-bridge configuration. This was done in order to compensate for temperature effects. All components were first calibrated in house using an MTS tensile tester. Data was collected using a National Instruments (NI) data acquisition device with bridge completion using our custom acquisition software. Each component was tested to achieve a linear calibration curve in a loading range large enough to cover what we expected to see out on the track. Once completed, all components were reinstalled back onto the car and covered in order to protect from water, debris, and contaminants. The R16 was packed up and sent to Kentucky for an off-season race. During this event, each gage was measured simultaneously once again using our NI data acquisition system. We collected data from multiple Baja SAE events including maneuverability, suspension and traction, and endurance. By the end of the race we had a 1st place trophy and over 4 hours of collected strain data. All data was collected as raw voltages and later processed using software designed by our team.

Figure 1: Gaged and Calibrated Suspension Components Ready for Testing

The second group tested had components that are subjected to multiple loading conditions. This included our upper and lower A-arms, trailing links, and sway bar. The upper and lower A-arms were outfitted with 350Ω gages in half-bridge configuration for bending and axial loading. The lower A-arms also had a single 350Ω gage placed on the lower shock

mount to measure bending forces caused by the shocks. The trailing link used 350Ω gages in half bridge configuration for bending and also had a single gage on the shock mount to measure the bending forces of the shock. The sway bar used a single 350Ω torsional gage to measure torsional forces. Calibration was done using a combination of hanging calibrated weight sets and ANSYS's strain simulation software. Front and rear components were tested independently. For each test, all gages were recorded simultaneously using our NI data acquisition system. Various tests were performed at our home test track in order to simulate multiple loading scenarios. Once again, all data was collected as raw voltage and later processed with our software.

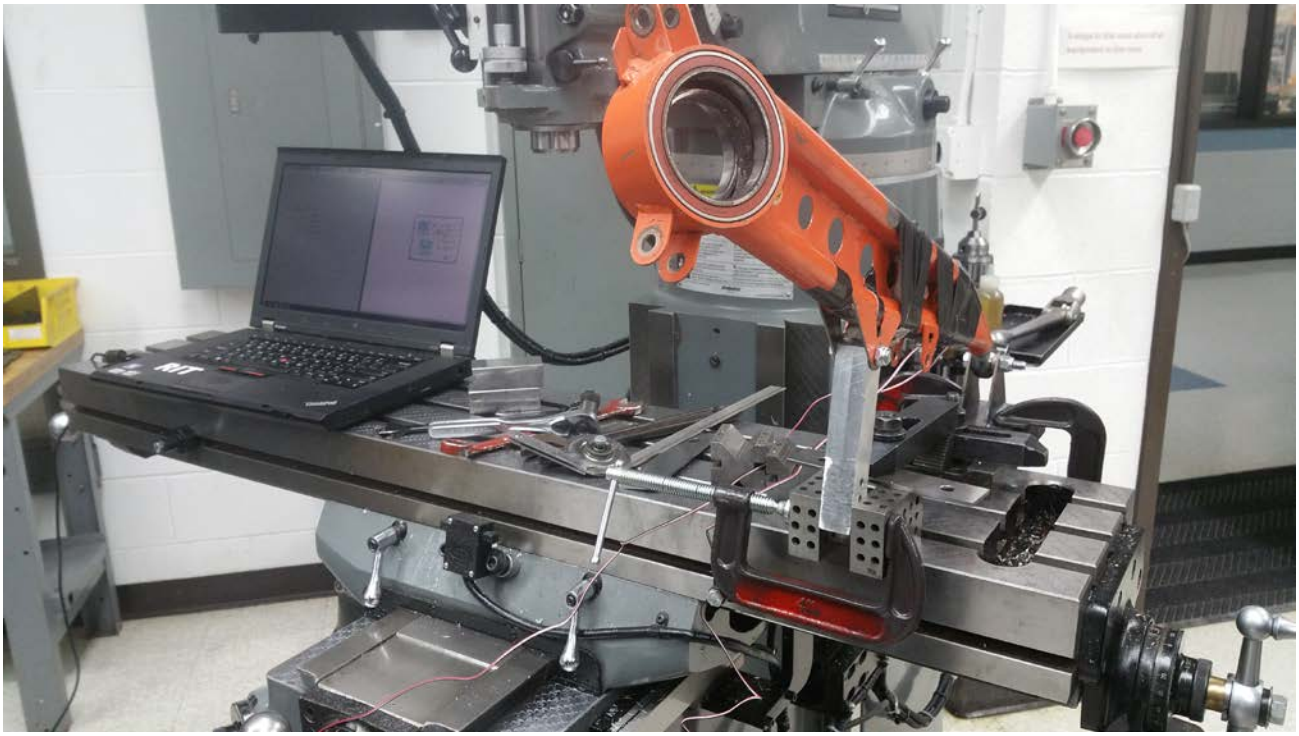

Figure 2: Trailing Link Calibration by Hanging Calibrated Weight Sets
NOTE: Calibration with ANSYS was verified by limited calibrated weight set testing and then used to further apply loads in order to fully cover expected loading ranges.

The User Explains

Micro-Measurements® helped us to produce our lightest car to date. Our suspension team was able to produce a suspension system that was 12% lighter than last year's. This never could have been achieved without the data collected using Micro-Measurements® strain gages. The table below displays our maximum collected forces for each component. Many

of these values reflect worst case scenario testing which was taken into consideration when designing this year's suspension components.

Component	MAX Bending Force	MAX Linear Force	Weight Change
Tie Rod	NA	115 lbs	1%
Link 4	NA	190 lbs	3.5%
Link 5	NA	276 lbs	2%
Upper A-Arm	2788 lbs	1600 lbs	1.5%
Lower A-Arm	3311 lbs	1829 lbs	1.5%
Trailing Link	3729 lbs	327 lbs	2.5%

Acknowledgement

The Society of Automotive Engineers gives students a learning experience that cannot be taught in a classroom. Each year Baja SAE club members work together to design, build, and test an off-road racing vehicle. Students gain invaluable experience involving team work, problem solving, and engineering skills. Although being a full time club member is a big commitment, students do not receive any credit towards their studies. Being a club member is simply for the benefit of the student.

SAE member students are among top candidates for recruiting companies. Many top companies including Toyota, Tesla, and Caterpillar specifically seek SAE members to hire. Talk to any SAE Alumni and they will tell you that joining a SAE club was one of the best decisions they ever made.

RIOT Racing is among the top ten competing teams in the Baja SAE competition and is always looking for more sponsors. We rely heavily on our sponsors in order to continue to be a top competing race team. As we like to say, *"We are only as good as our sponsors are"*. Sponsoring our team gives many opportunities for promotion amongst other teams and companies along with the vast networks of engineers associated with the SAE. If you or your company would like to support the RIT Baja Team, please feel free to contact us.

Contact Information

Forrest Sheard, Instrumentation Lead, '16-'17
Rochester Institute of Technology, Baja SAE
1 Lomb Memorial Drive
Rochester, NY 14623
Email: testsystems@ritbaja.com
Web: http://baja.rit.edu/

Vishay Precision Group, Inc. (VPG)
Micro-Measurements®
mm.us@vpgsensors.com