Powertrain Noise, Vibration, and Harshness

Determine the Cause of the NVH

The following procedures are applicable to R1T/R1S with 4-motor configuration.

1. Remove all contents, especially rolling objects, from all vehicle compartments to ensure there are not additional noises which could be perceived as driveline clunk. After removing any objects, ensure the NVH issue is still repeatable.
2. Inspect drive units for soft set axles (Inspect the inboard joints) and inspect vehicle suspension for worn/torn bushings, suspension damage, loose bolts, or anything else that could be causing a suspension noise.
3. Conduct the click/ting testing by following the procedures in Click/ting test below.
4. Record the residual torque of all four half shaft bolts and add this information as a comment on service ticket with clear labels for the measurement at each corner (Example: FL = XX Nm, FR = YY Nm)
5. Remove half shaft fasteners from all corners.
6. Conduct half shaft spline interference testing by following the procedures in Half-shaft spline interference test below.
7. Update the vehicle to the new torque specification for half shaft bolts by following the procedures in Properly Torque Half Shaft Retention Bolt below.
8. After the half shaft fasteners have been updated to the correct torque specification and if the first round of click/ting testing yielded a noise at any corner, repeat the click/ting testing. Leave a comment in the service ticket indicating whether the updated fastener changed or eliminated the noise.
   If the driveline noise is gone, note your cause as "axle ting" in Quest and close your Quest. If the noise persists, continue.
9. Place the vehicle on a lift and measure gear backlash as outlined in Measure backlash at each axle using inclinometer. Note the backlash measurements and send them to Diagnostics for analysis.
10. Perform the procedure outlined in Determine which axle has the issue. Note your findings.
11. If the noise still cannot be located, follow the procedures in Intermittent issue investigation for both "Is the issue related to loading that causes a component to translate or slip?" and "Is the issue relatd to road grade?".
12. If noises are still present and it is believed that components need to be swapped, follow the procedure outlined in Component swap procedures and requirements

Inspect the inboard joints

> **Important:**
> Inspect the inboard joint of all four half shafts in the vehicle and ensure that the spline is fully engaged in each corner before following the procedures below.

1. Try pulling on the constant-velocity (CV) housing at the inboard joint: a) If the circlip is fully engaged, you won't be able to remove the shaft. b) If the spline isn't fully engaged, you will feel movement in the joint in the axial direction.
2. If it isn't engaged, document which corner wasn't fully engaged.
3. Fully engage the spline in the corner and comment on the ticket any unusual or excessive play observed on the inboard joint. Specifically note if excessive movement is axial or radial.

Click/ting (light load) test

https://apps.goriv.co/ride/quest/nodes/16755

Follow these Rolling Drive > Reverse and Reverse > Drive procedures to conduct the light load test.

1. Select All Purpose drive mode.
2. Roll down all four windows.
3. Shift to Drive.
4. Lightly apply the accelerator to maintain 2-3 mph (above this speed, shift will be inhibited).
5. Shift to Reverse.
6. Let the vehicle decelerate to rest.
7. Begin accelerating in Reverse.
8. Shift to Drive.
9. Let the vehicle decelerate to rest.
10. Begin accelerating in Drive.

Is medium-high-pitched double-clicking noise present?
If yes, the NVH issue relates to ting. Continue to Quest Node 16755.

If no, then no further actions are required and you can move onto next step in procedure. If there is no high-pitched double click, then vehicle is as-intended design state and no concern is present.

If no noise is present, try the alternative Test listed below.

Alternative test

1. On flat ground, decelerate without applying the accelerator pedal from 20 mph down to 2-3 mph. The intent of this deceleration is to provide torque to load components onto the “regen” side of lash.
2. Slowly roll into accelerator pedal to get very mild acceleration to 5 mph. The intent of the acceleration is to ensure lash has crossed with light load, isolating the lash from driveline loading.
3. While slightly accelerating, rapidly apply the accelerator pedal to approximately 20-30% of pedal movement to load up the driveline.

Is the ting present immediately following the rapid apply? If not, repeat the sequence with higher accelerator pedal movement.

Half-shaft spline interference test

1. Remove lug nuts and wheels
2. Remove hub bolt from half shaft
3. Perform Load Check
    a. Document if half shaft retracts back while bolt is being removed

    b. When bolt is removed, apply increasing load to half shaft stem face with a push force gauge (Rivian Tool ID TSN00904-100-A)
        - GaugeMethod: Use force gauge to apply loads

    c. Apply load until half shaft either moves or push force gauge is maxed out.
        - <100N = Low spline interference
        - 100N < X < 300N = Low-Moderate Spline Interference
        - 300N < X < 500N = Moderate-High Spline Interference
        - 500N< = High Spline Interference

    Note down results in the service ticket.

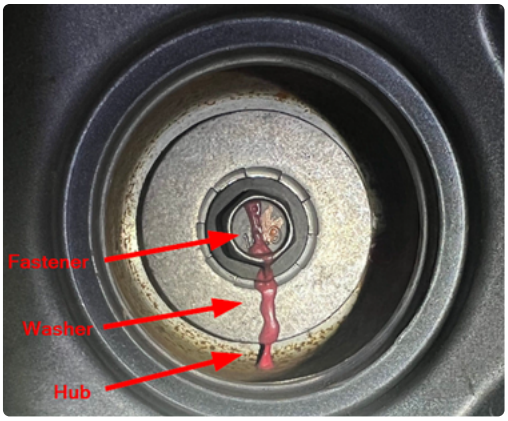
    d. Replace half shaft if spline interference is Low Spline Interference. Wheel hub may need to be replaced if Low-Moderate Spline Interference push force is recorded; escalate to Diagnostics for guidance.

4. Replace and reinstall hub bolt with new hub bolt and torque the bolt as outlined in Properly Torque Half Shaft Retention Bolt

Properly Torque Half Shaft Retention Bolt

Update the vehicle to the new torque specification for half-shaft bolts.
The service manual has been updated with the correct procedures for 4264 Rear Halfshafts. Ensure the bolt has an unused patch of Loctite. The part number should be SC00006346-B / PT00540603-A. Below is what the service manual should show for half-shaft bolt installation.

- Torque fastener to 80 Nm
- Back fastener off one turn
- Torque fastener to 128 Nm
- If a paint marker is available, mark the fastener head location relative to wheel hub. Ensure the paint mark is on the head of the fastener, the washer, and the wheel hub.



Measure backlash at each axle using inclinometer

> **Important:**
> Ensure Electronic Parking Brake is released before attempting to measure rear backlash

1. Hoist the vehicle on an A frame.
2. Remove the wheels from all four corners.
3. Attach a magnetic inclinometer (Rivian Tool ID: TSN00472-100-A) to the brake rotor or wheel lugs.
   An example of either acceptable method of attachment on the corner is provided below:
   
4. Rotate the brake rotor/wheel hub spokes to consume the backlash or "free play" in the system in the forward direction.

   > **Note:**
   > This will *NOT* take considerable force. It is important not to overcome the cogging torque (natural resistance to rotation) of the electric motor and cause the corner to spin past the backlash; this will give a false measurement. If this happens, reset the inclinometer, and start the measurement over again.
5. Rotate the brake rotor/wheel hub spokes to consume the backlash or “free play” in the system in the reverse direction toward the back of the vehicle
6. Zero the inclinometer
7. Next, rotate the brake rotor/wheel hub toward the front of the vehicle to consume the backlash in the system. Record the value. Repeat the measurement at least twice to ensure that you are getting consistent results.
8. Calculate the difference between the angle measurements in both directions. This difference is the total backlash of the system in the respective corner being measured. Repeat the measurement at least twice to ensure that you are getting consistent results.
9. Repeat this process at each corner and record all results in the ticket comments. Label the measurements clearly (FL = XXX deg, FR = XXX deg, etc.).
10. Once you are finished, reinstall the wheels and remove the vehicle from the hoist.

Determine which axle has the issue

> **Important:**
> - Before you begin, take the vehicle to a large *flat, smooth* area where you can perform transitions from acceleration to deceleration and vice versa at speeds ranging from 5-20 mph.
> - It is important for the area to be flat because there are known effects to driveline clunk performance when on a grade, which we would like to avoid any influence from during this investigation.

- Smooth asphalt is also better to isolate powertrain noise from suspension noises.
- Test all conditions in Standard Ride Height.
- Turn off HVAC fan when test conditions allow. For testing in extreme temperatures, limit fan speed to 1.

As you perform the following tests, note the date and time of test and mark any outlier behavior by activating the hazard lights for 1 sec. This will help facilitate future data analysis.

Repeat the test cases below, as necessary, to be confident of the noise and subjectively compare between the front and rear axle. Document the results in the service ticket. Please be clear in the notes which axle (front or rear) the clunk condition was noticeable from and in which test cases (1,2,3, or 4) it was most noticeable.

Finally, once all notes are documented for each test case, capture a video of the *worst* test case behavior. When capturing this video, roll the driver and passenger window down, turn the AC completely off, and hold the video in your hand near chest level in the driver's seat. Be sure that while you perform the test, the video captures both the vehicle speedometer and the power gauge on the driver display. Upload this video to the service ticket along with the notes from each test case.

1. **Test Case 1**
   a. In Conserve mode and while maintaining a speed of less than 10 mph, slowly roll on and off the pedal, ensuring that the change is adequate for the vehicle to transition from drive to regen.
   b. Switch to All Purpose mode and repeat.
   c. Pause and make note of the audible condition in each drive mode and if there is a noticeable difference between the front and rear axle before moving onto the next test case.

2. **Test Case 2**
   a. In Conserve mode and while maintaining a speed of 10-20 mph, slowly roll on and off the pedal, ensuring that the change is adequate for the vehicle to transition from drive to regen.
   b. Switch to All Purpose mode and repeat.
   c. Pause and make note of the audible condition in each drive mode and if there is a noticeable difference between the front and rear axle before moving onto the next test case.

3. **Test Case 3**
   a. In Conserve mode and while maintaining a speed of less than 10 mph, *aggressively* roll on and off the accelerator pedal, ensuring that the change is adequate for the vehicle to transition from drive to regen.
   b. Switch to All Purpose mode and repeat.
   c. Pause and make note of the audible condition in each drive mode and if there is a noticeable difference between the front and rear axle before moving onto the next test case.

4. **Test Case 4**
   a. In Conserve mode and while maintaining a speed of 10–20mph, *aggressively* roll on and off the accelerator pedal, ensuring that the change is adequate for the vehicle to transition from drive to regen.
   b. First perform the test case in Conserve, then switch to All Purpose and repeat.
   c. Pause and make note of the audible condition in each drive mode and if there is a noticeable difference between the front and rear axle before moving onto the next test case.

Intermittent issue investigation

1. **Is the issue related to loading that causes a component to translate or slip?**
   a. While in Park, press the brake to 30–50% of pedal movement while applying the brake throughout the test.

   > **Note:**
   > A safety feature is in place to ensure the brake pedal can always stop the vehicle. Pressing the brake pedal beyond approximately 50% will begin reducing torque.

   b. Shift to Drive.
   c. Slowly apply the accelerator enough for the motor torque to begin loading up the suspension to the point of vehicle movement.
   d. As accelerator pedal is pressed and torque is ramped up, note if the audible click is present.
   e. Slowly release accelerator.

f. Shift to Reverse.

g. Slowly apply the accelerator enough for the motor torque to begin loading up the suspension up to the point of vehicle movement.

h. As accelerator pedal is pressed and torque is ramped up, note if the audible click is present.

i. Repeat steps b–h two times to ensure Drive > Reverse and Reverse > Drive loading occurs. If audible click is noticeable on at least one Drive and one Reverse accelerator pedal apply, the results indicate a torque dependency to the issue. Please note in the comments of the ticket the results of the testing.

2. **Is the issue related to road grade?**
   a. Locate a 5–10% grade.

   > **Note:**
   > Loading dock ramps often fall in this range. If available for viewing, the signal VDM_GradeEst can provide a real-time estimate of the road gradxecute test cases from Determine which axle has the issue as test site allows.

   b. Travel uphill in Drive.

   c. Travel downhill in Drive.

   d. Make note of any degradation in performance as compared to the flat ground tests in Determine which axle has the issue.

Component swap procedures and requirements

> **Note:**
> For front axle noise, don't swap multiple component types at once to remove the noise source.

1. **Front Axle Componenet Replacement Guide**
   a. Replace the half shaft(s).
   b. Document the parts removed.
   c. Retest with conditions of the most egregious test case identified in Determine which axle has the issue. If the issue is corrected, the process is complete. If the issue remains, move on to the next step.
   d. Replace the front drive unit.
   e. Document the part removed.
   f. Retest with conditions of the most egregious test case identified in Determine which axle has the issue. If the issue is corrected, the process is complete. If the issue remains, reach out to a Field Service Engineer.

2. **Rear Axle Componenet Replacement Guide**
    a. Replace the half shaft(s).
    b. Document the parts removed.
    c. Retest with conditions of the most egregious test case identified in Determine which axle has the issue. If the issue is corrected, the process is complete. If the issue remains, move on to the next step.
    d. Replace the disconnects.
    e. Document the part removed.
    f. Retest with conditions of the most egregious test case identified in Determine which axle has the issue. If the issue is corrected, the process is complete. If the issue remains, move on to the next step.
    g. Replace the rear drive unit.
    h. Document the part removed.
    i. Retest with conditions of the most egregious test case identified in Determine which axle has the issue. If the issue is corrected, the process is complete. If the issue remains, reach out to a Field Service Engineer.

Subjective guidance

Audible

Approach to create levels for subjective audible feedback

- NO AUDIBLE Imperceivable with HVAC and radio off
- LOW AUDIBLE Perceivable with HVAC and radio off, but difficult to hear with HVAC fan speed 1
- MEDIUM AUDIBLE Perceivable with HVAC on fan speed 2-4
- HIGH AUDIBLE Perceivable at HVAC fan speeds above 4

When perceived audibly, lash crossing is expected to sound like a single mechanical thud.

Disturbance / Acceleration continuity

- LOW DISTURBANCE Little or no hesitation, less than 70 ms delay. Jerk almost imperceptible on smooth flat road.
- MEDIUM DISTURBANCE Minor hesitation, perceivable if looking for it. Less than 120 ms delay. Jerk perceivable, but not objectionable for given change in acceleration.
- HIGH DISTURBANCE Perceivable delay that becomes annoying over time (over 180 ms) OR jerk that is much larger than the desired change in acceleration.

Accelerator pedal rate of apply	Subjective Characteristic	Front Axle		Rear Axle		
		Below 10 mph	Above 10 mph	Below 10 mph	10 to 30 mph	Above 30 mph
Slow	Audible	LOW AUDIBLE	LOW AUDIBLE	NO AUDIBLE	LOW AUDIBLE	LOW AUDIBLE
	Disturbance	LOW DISTURBANCE	LOW DISTURBANCE	LOW DISTURBANCE	LOW DISTURBANCE	LOW DISTURBANCE
Moderate	Audible	LOW AUDIBLE to MEDIUM AUDIBLE	LOW AUDIBLE to MEDIUM AUDIBLE	NO AUDIBLE	MEDIUM AUDIBLE	MEDIUM AUDIBLE
	Disturbance	LOW DISTURBANCE to MEDIUM DISTURBANCE	LOW DISTURBANCE to MEDIUM DISTURBANCE	LOW DISTURBANCE	MEDIUM DISTURBANCE	MEDIUM DISTURBANCE
Aggressive	Audible	MEDIUM AUDIBLE	MEDIUM AUDIBLE	NO AUDIBLE	HIGH AUDIBLE	MEDIUM AUDIBLE to HIGH AUDIBLE
	Disturbance	MEDIUM DISTURBANCE	MEDIUM DISTURBANCE	LOW DISTURBANCE	MEDIUM DISTURBANCE to HIGH DISTURBANCE	MEDIUM DISTURBANCE