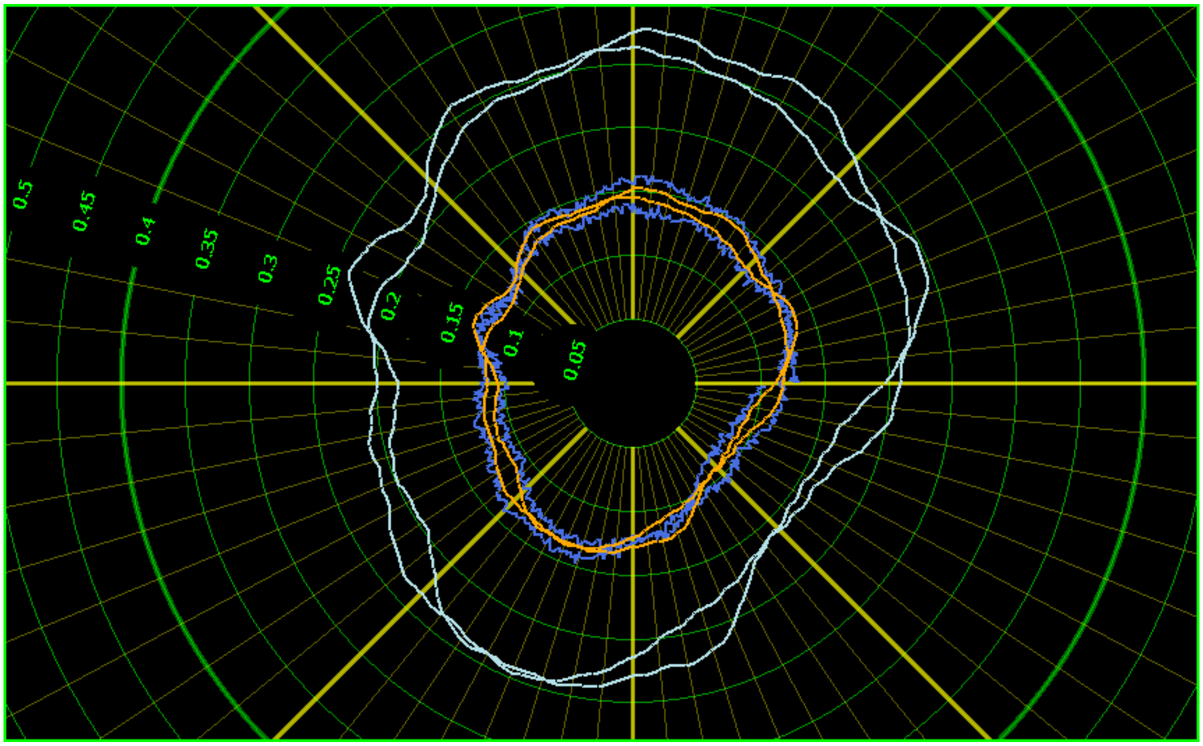
Production Examples of Dynamic Backlash Measurement

The following information is derived from data measured on the OP280 Dynamic Backlash machine on the XCL line at Dana Birmingham, UK.



This graph shows a typical backlash measurement. The polar graph shows a representation of backlash through one or more revolutions of the ring gear. 360 degrees of rotation shown on the graph represents one revolution of the ring gear. This machine measures 2 ring gear revolutions. Note that the graph is not completely circular, and there is some distortion. This distortion corresponds to backlash variation through a single revolution of the ring gear.

Three traces of data are displayed on each graph:

Blue – raw, circular backlash, reported as degrees of arc on the ring gear. This is the data directly generated by the two encoders.

Orange – a filtered version of the raw data. Information which is unlikely to be actual backlash variation (such as rapid fluctuations in backlash) is automatically discounted, while information hat is likely to be actual backlash variation (pinion runout, ring gear runout, etc) is included.

Cyan – scaled version of the filtered (orange) data. The cyan data represents actual part backlash (circular backlash in millimeters) rather than degrees of arc. This data is directly comparable to the part's measurement using a dial indicator (at that particular ring gear / pinion orientation).

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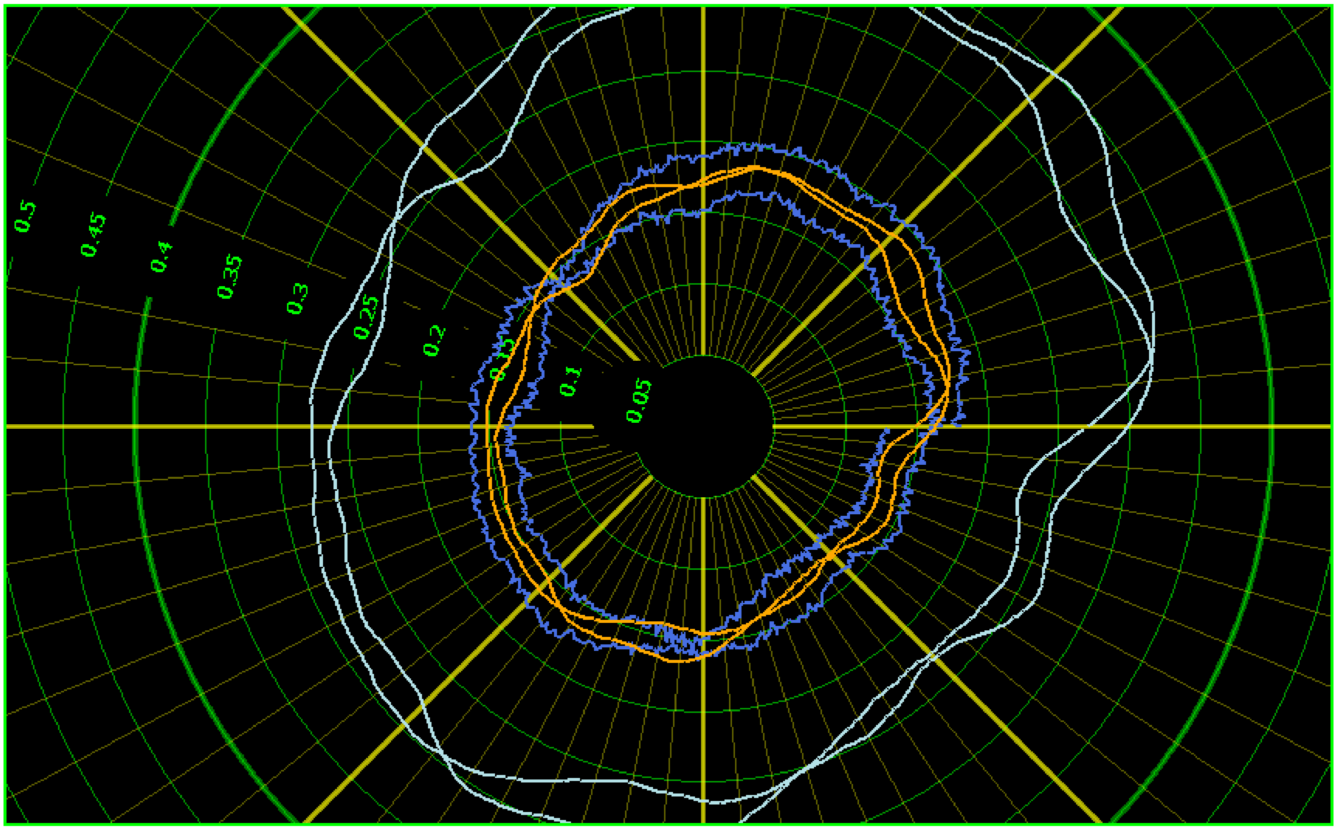
Figure 2: Part Alignment Problem



This is the same part as shown in Figure 1, but with a machine problem artificially induced: the part has been physically forced to one side when mounted, causing poor alignment. This poor alignment shows up as tooling slippage on the ring gear. This is represented by the spiral form of the raw, blue data.

The machine is capable of automatically detecting and rejecting this situation (since under such circumstances, measured backlash is not reliable).

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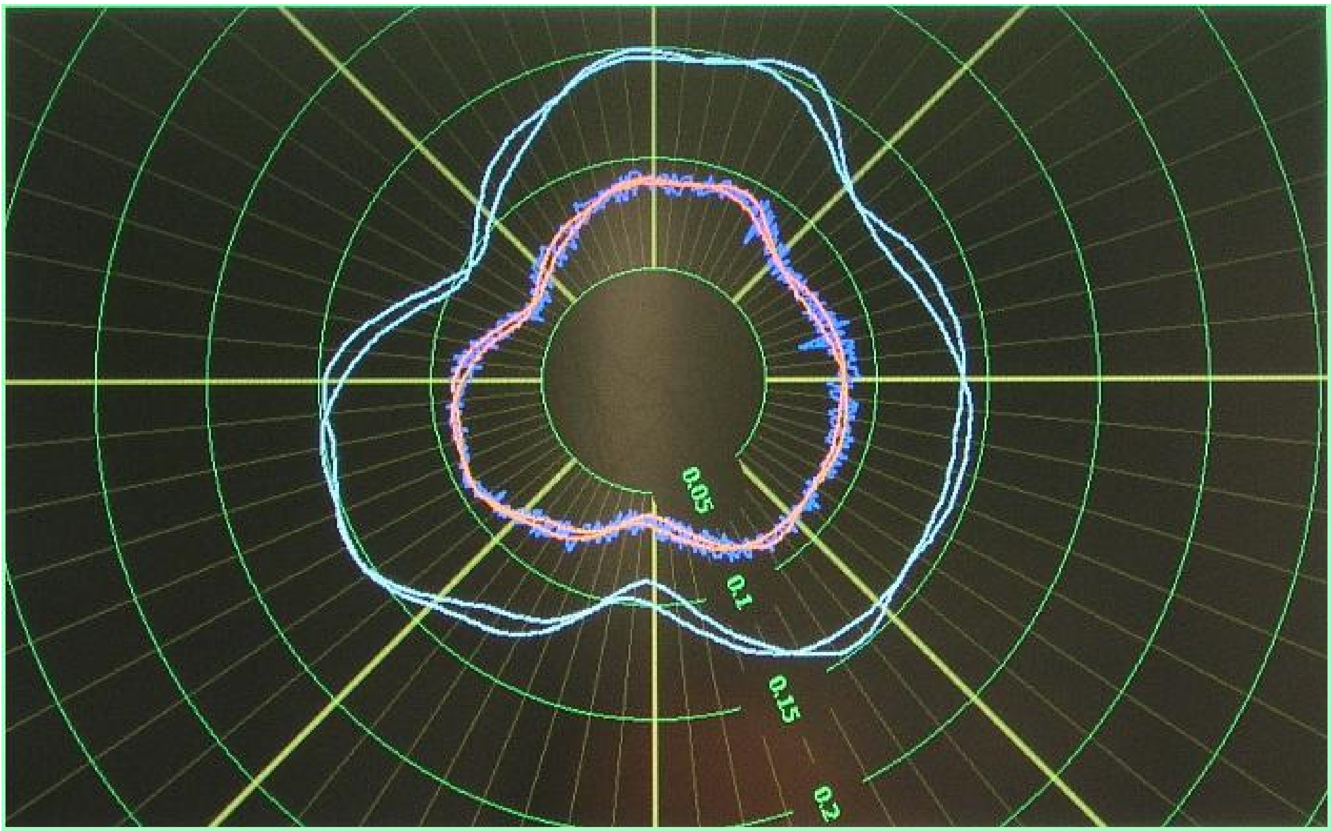
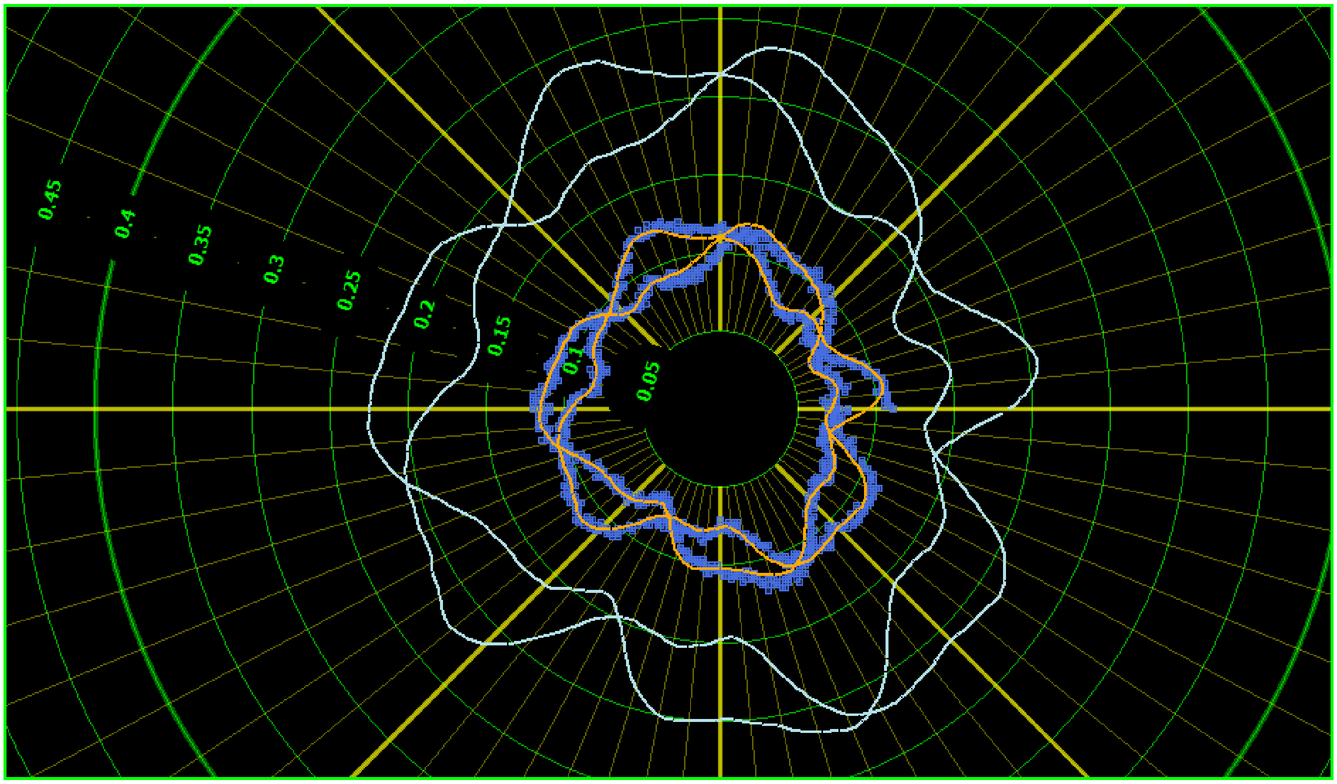
Figure 3: Pinion Runout (3.07:1)



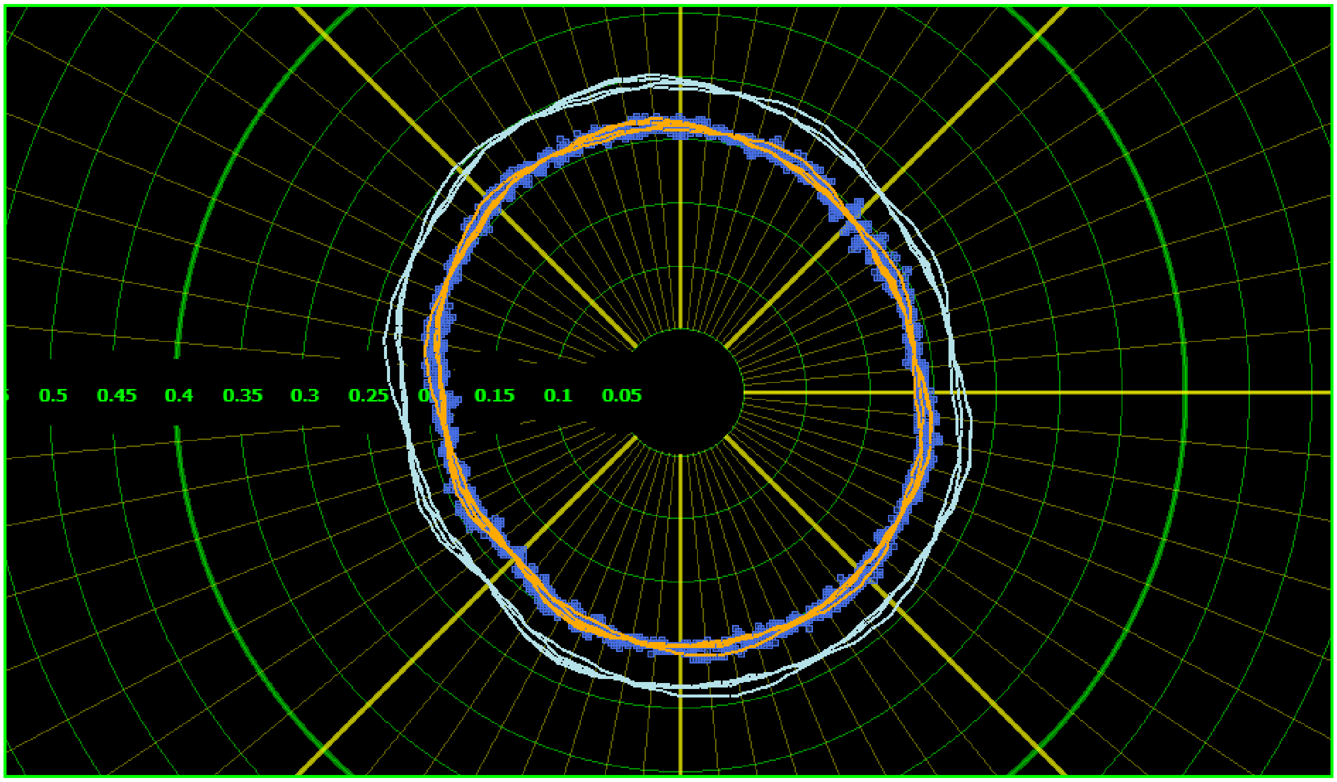
This part shows substantial pinion gear runout. Note the three-lobed appearance of the graph. The pinion to gear ratio of this part is 3.07 to 1, and pinion runout will show up as a change in backlash that cycles a little over 3 times per ring gear revolution. Though this particular machine does not quantify ring gear or pinion gear runout, it is capable of measuring this data.

Figure 4: Pinion Runout (3.30:1)



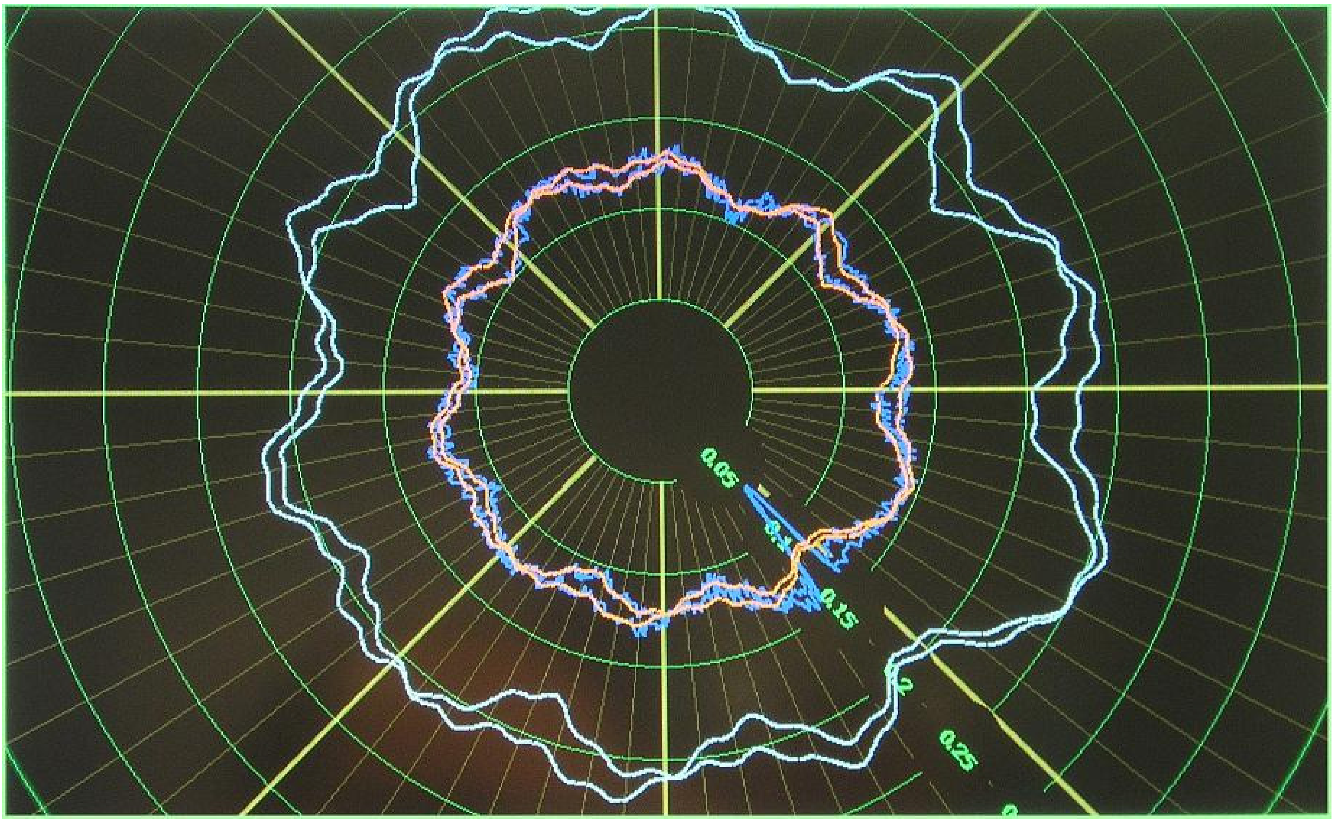
This part also shows substantial pinion runout. The graph appears cluttered over two revolutions. This results from a gear ratio (3.30), which is not close to an integer. However, the runout variation is easily identifiable even though it not repeat every revolution.

Figure 5: Ring Gear Distortion (twice per revolution)



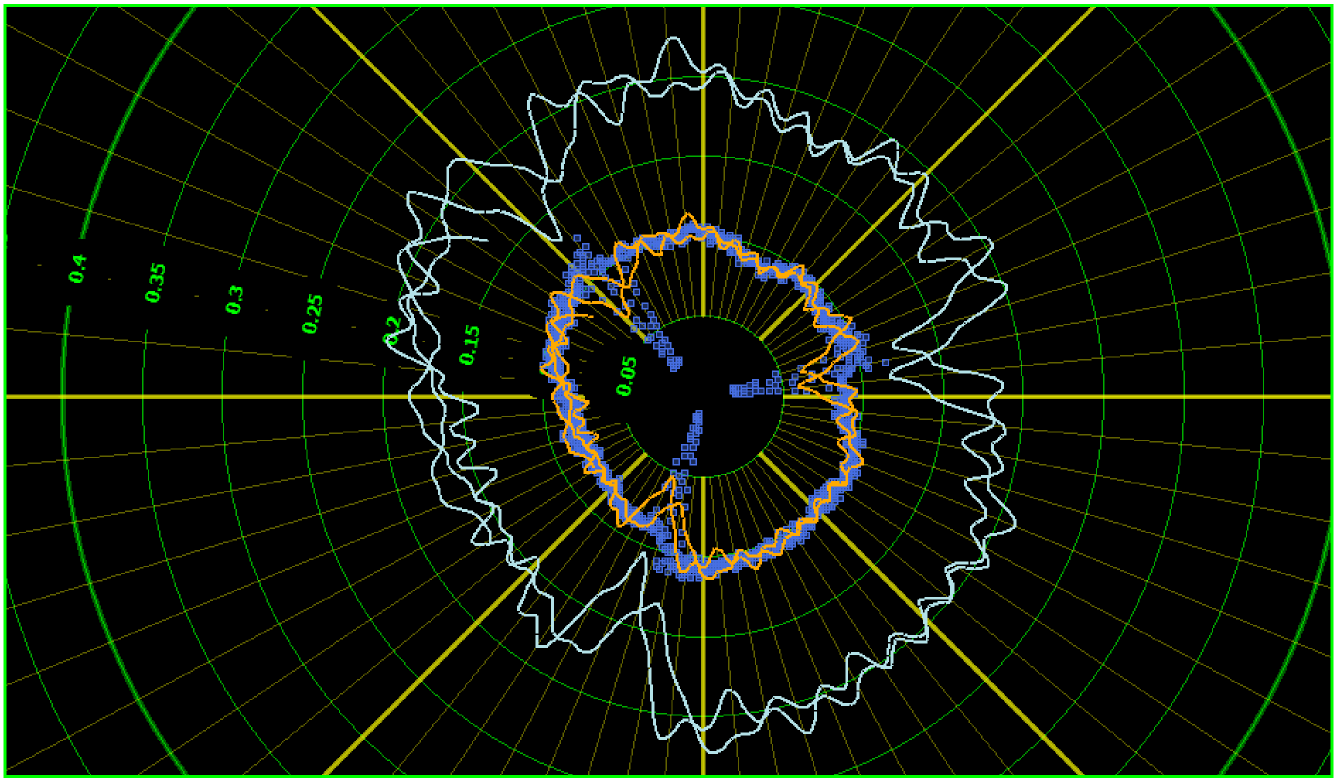
This part shows subtle distortion of the ring gear. Note that the backlash is highest at the north-south axis, and lowest at the east-west axis. Since the backlash variation occurs twice per ring gear revolution (rather than once per revolution) the cause is likely warpage of the ring gear rather than ring gear runout.

Figure 6: Ring Gear Distortion (ten times per revolution)



This part shows moderate backlash variation that occurs exactly ten times per revolution. This ring gear has ten tapped holes used for assembly to the Differential Case, which resulted in distortion of the ring gear during the heat-treating process. This distortion was also measured and rejected at the NVH machine at end of line (ASX2, OP340). The problem was eventually remedied by modifying the gear manufacturing process.

Figure 7: Pinion Debris



Note the spike in backlash that occurs three times per revolution (this is a 3.07 ratio part). The backlash change is very rapid, and is caused by debris on the pinion gear.

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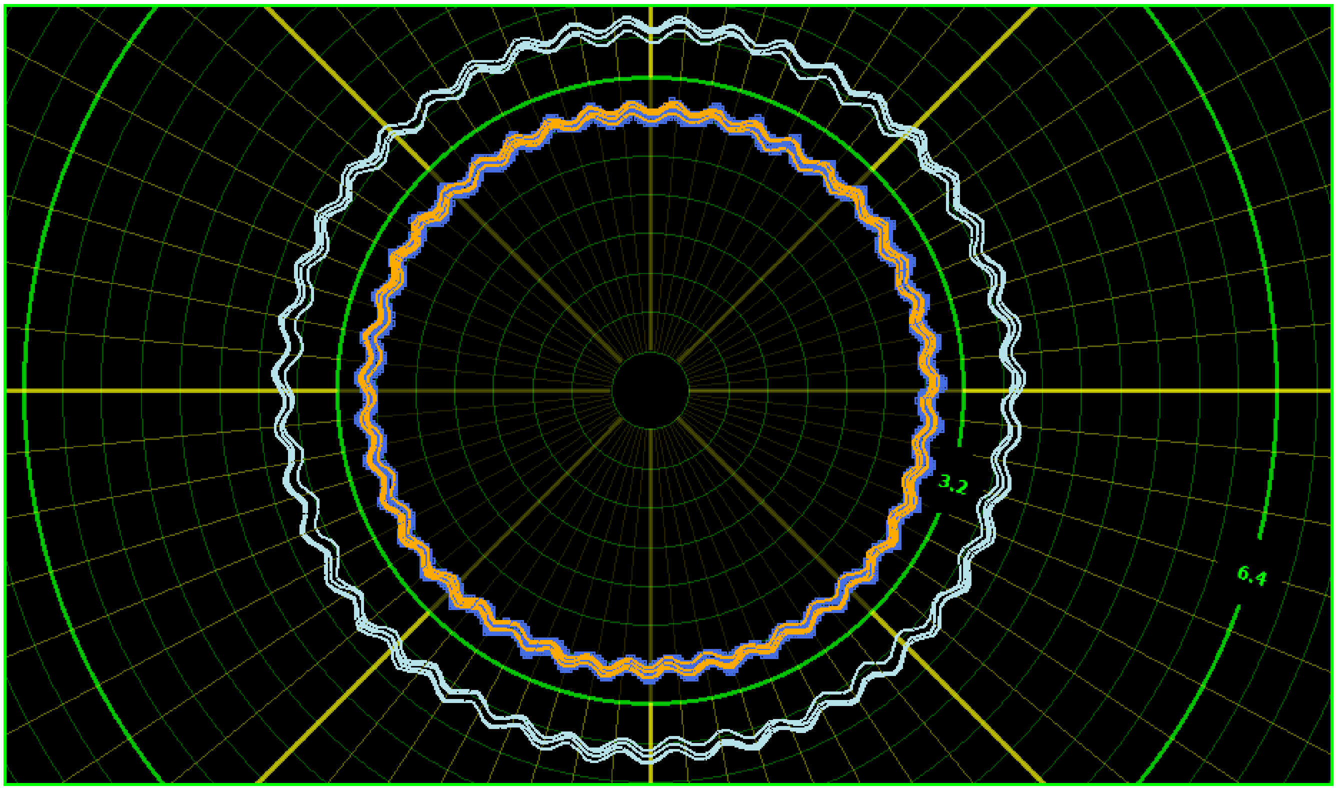
Figure 8: Poor Part Assembly



This part was poorly assembled, and is incorrectly shimmed. Note the backlash measurement is nearly 4 millimeters. Also note the repeating gear-tooth pattern: the number of repetitions corresponds exactly to the number of teeth on the ring gear.

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