Experiment Number 10

Is it possible to use the friction noise signal to trigger high speed data to capture friction events?

Background

High speed friction data can provide early evidence of onset of surface events not detectable from the time smoothed r.m.s. friction. In this experiment, levels of friction noise are used to trigger high speed data acquisition.

Test Conditions

Moving Specimen:	6 mm diameter x 10 mm wide line contact 52100 steel pin
Fixed Specimen:	NSOH BO1 steel gauge plate
Fixed Specimen Hardness:	Through-hardened
Load:	200 N
Lubricant:	Fully formulated lubricant with and without OFM
Temperature:	Ramped from 50^{o}C to 230^{o}C
Stroke:	25 mm
Frequency:	5 Hz

Method

An initial temperature ramp experiment was run to establish which sample produced the higher friction and to determine the friction noise associated with that sample. This was discovered to be of the order of 3 to 4% friction noise. Subsequently, two experiments were performed with temperature incremented in 1 degree steps with high speed data triggered at the first step in each test where the friction noise exceeded 3%, 3.5% and 4%.

Sample 1, as in previous tests, produced significantly higher friction than Sample 2, with friction and friction noise increasing as temperature increased.

Test Results

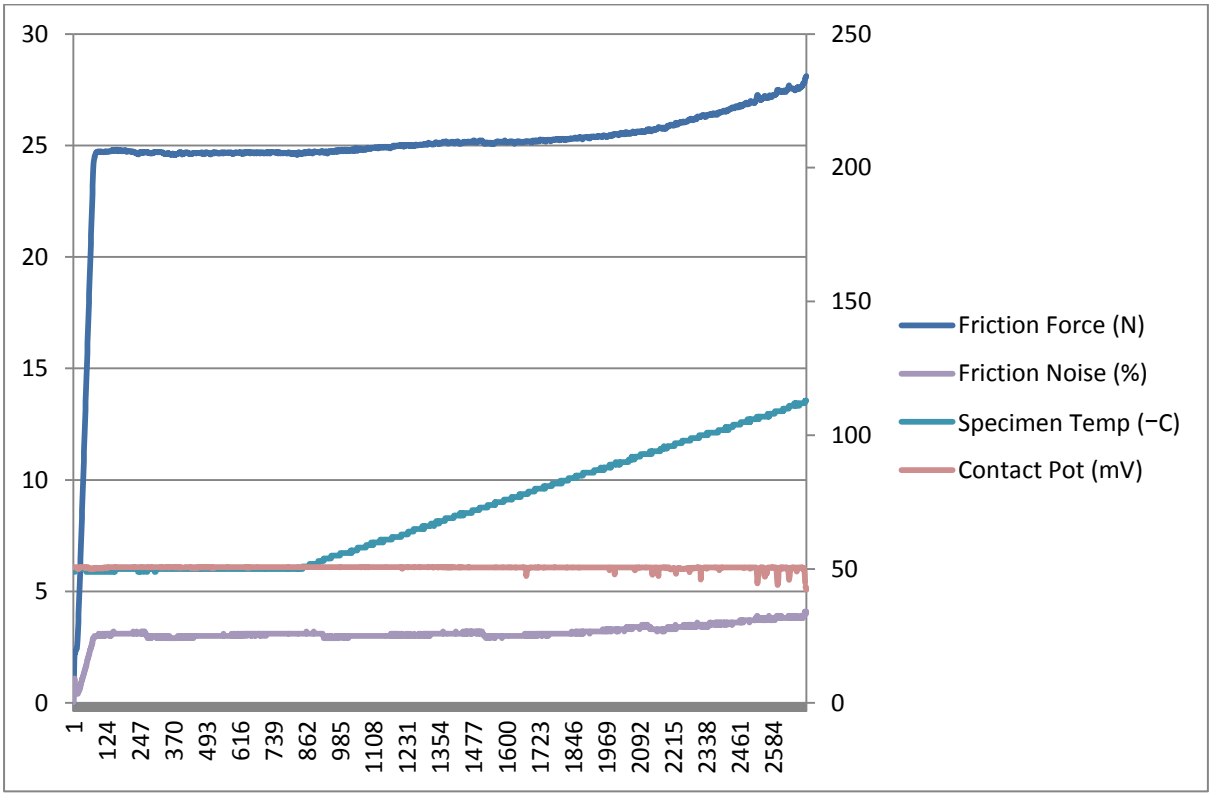

Figure 1: Sample 1: Temperature Ramp - 200 N - 5 Hz - 25 mm

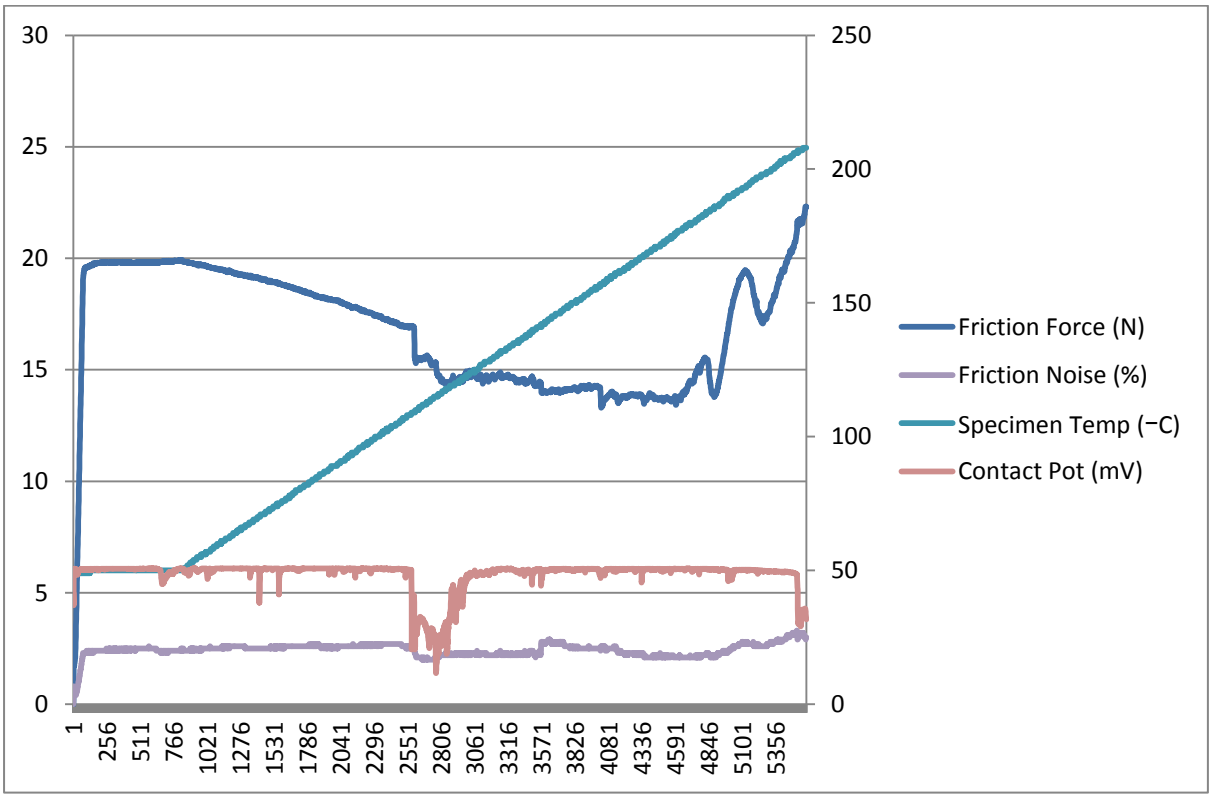

Figure 2: Sample 2: Temperature Ramp - 200 N - 5 Hz - 25 mm

The 4% friction noise limit was exceeded at a temperature of 113°C and the test was terminated shortly afterwards.

Sample 2 produced much lower friction than Sample 1, with some kind of transition occurring at approximately 100°C. At this point, a step change in both contact potential and friction occurred, with both falling sharply. As heating progressed, an increase in contact potential indicated formation of some kind of consistent tribo-film, accompanied by continuing low friction. As the temperature approached 170°C, the friction and friction noise started to increase, with friction noise finally exceeding the 3% trigger value for the first time at 204°C. The test was terminated shortly after this.

High speed data was taken at the start of each test and then triggered on friction noise. For Sample 1, high speed data was triggered at 3% noise at 50°C, 3.5% noise at 99 C and 4% at 113°C. With Sample 2, only one set of noise percentage triggered high speed data was collected, with the 3% trigger being exceeded for the first time at 204°C.

It is apparent that not only does Sample 2 produce lower friction than Sample 1, but that the frictional response is qualitatively different.

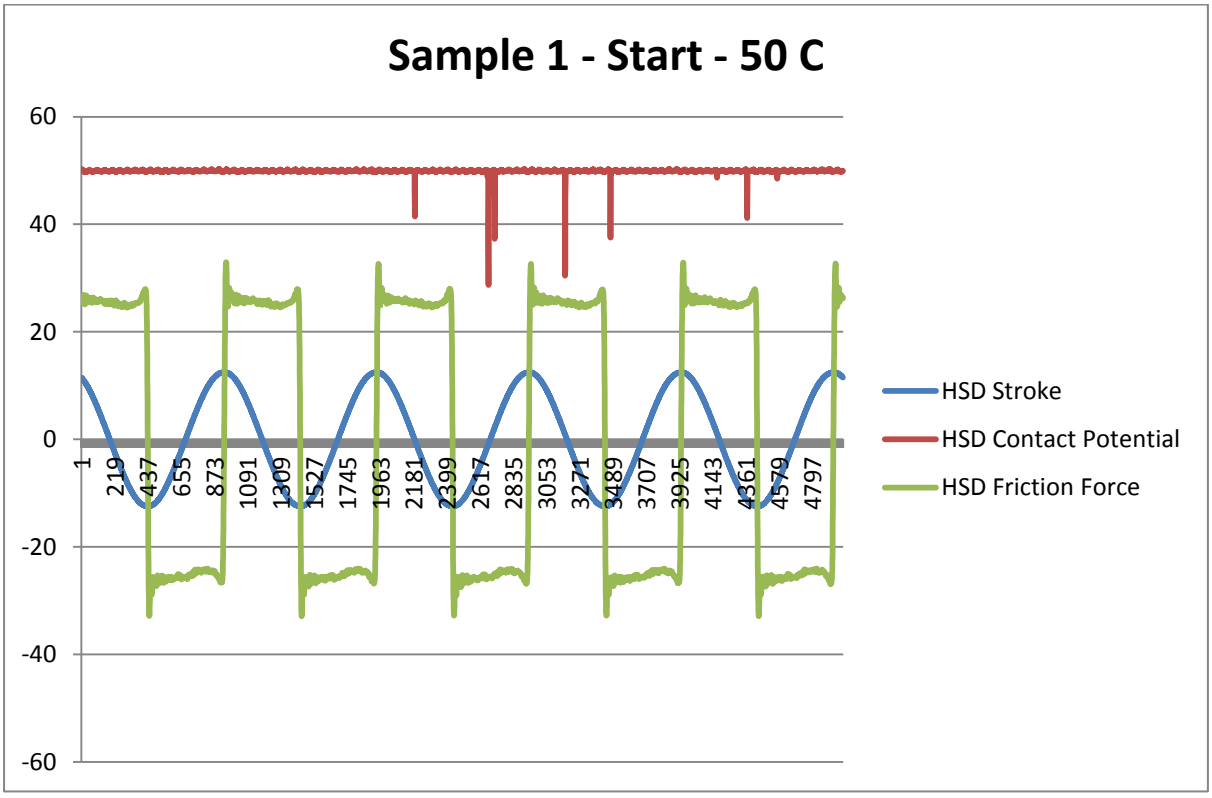

Figure 3: Sample 1 – High Speed Data - 50°C

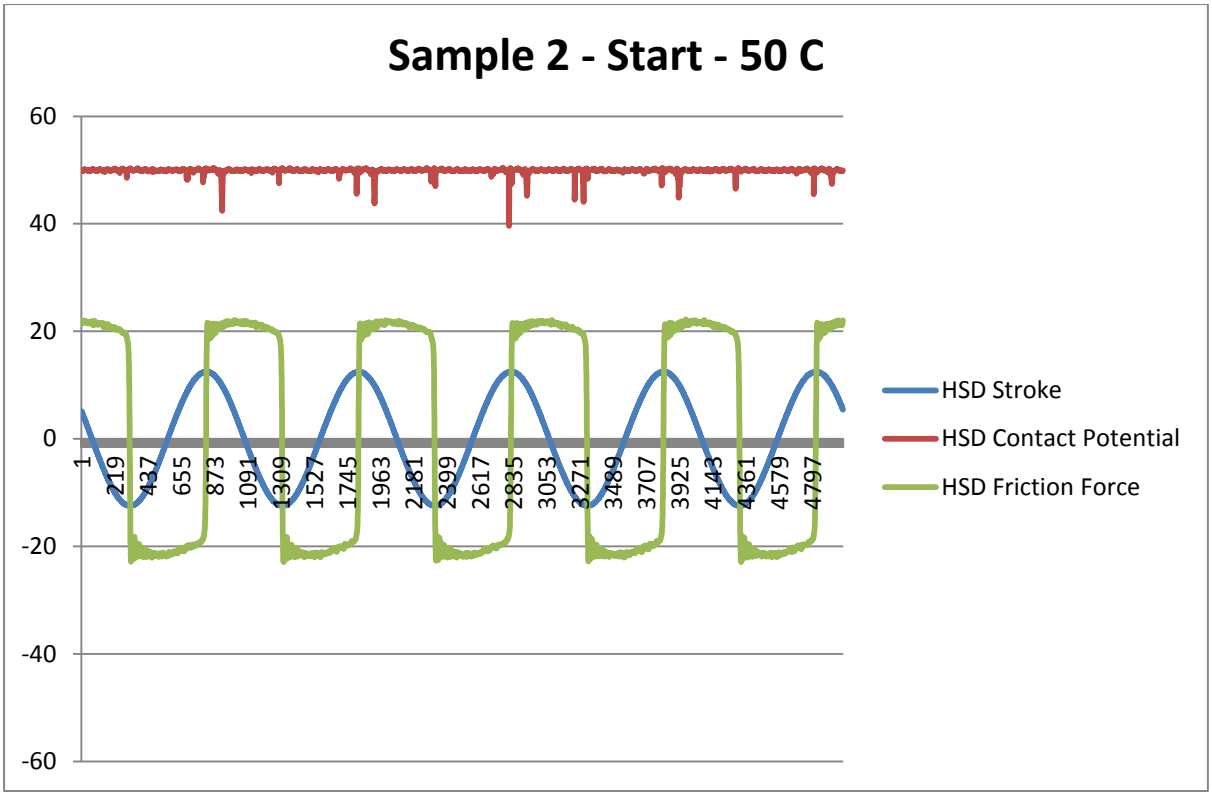

Figure 4: Sample 2 – High Speed Data - 50°C

Sample 1 shows significantly higher friction at the start and end of each stroke, with dynamic friction decreasing with increasing velocity towards the mid-stroke position, followed by a squeeze film type response as the velocity decreases toward the end of the stroke. This is perhaps what might be considered to be a typical “Stribeck” type response, with friction decreasing with increasing sliding speed.

By contrast, with Sample 2, the transition from rest to motion at the start of each stroke is not accompanied by a large static friction spike. Furthermore, it appears that the friction increases with increasing velocity, towards the stroke mid-point, indicating some kind of quasi hydrodynamic or visco-elastic response. This is not a typical “Stribeck” response and it would appear that the fluid, in the transition from boundary to mixed lubrication, produces a “negative” Stribeck curve.

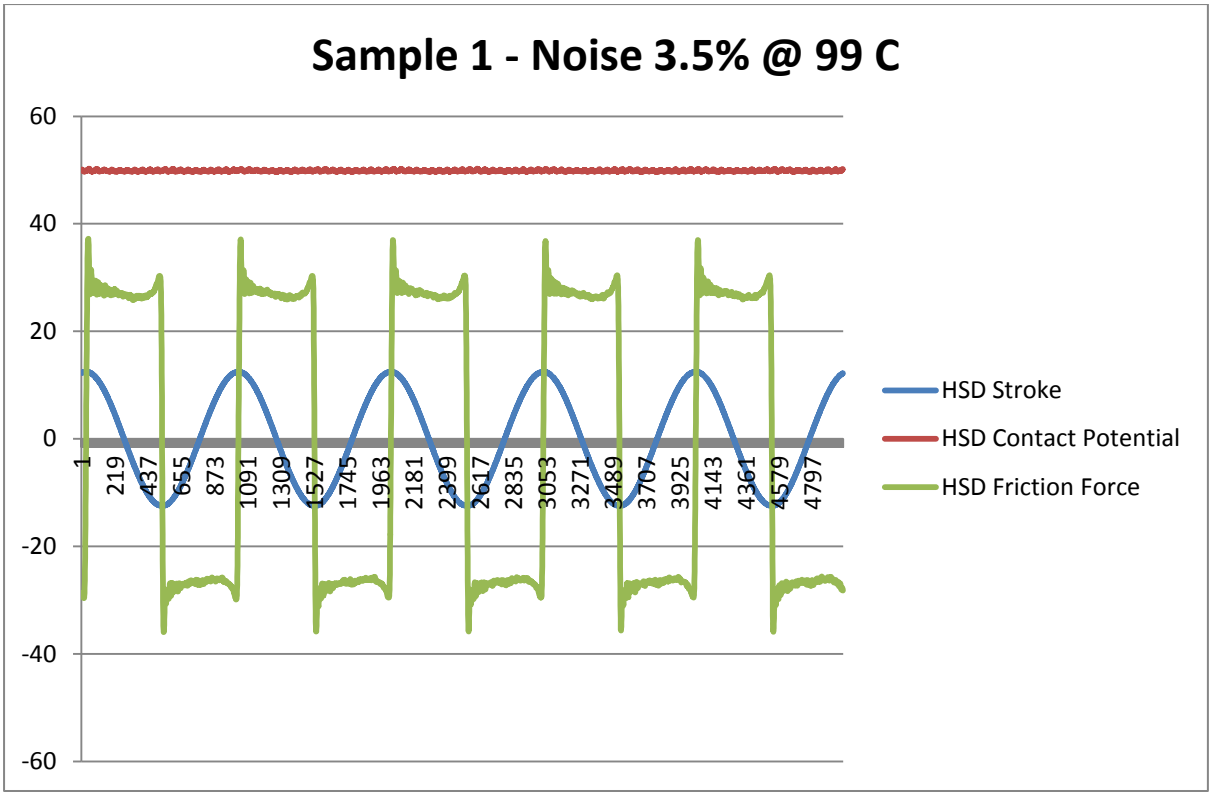

Figure 5: Sample 1 – High Speed Data – 3.5% Noise Trigger @ 99°C

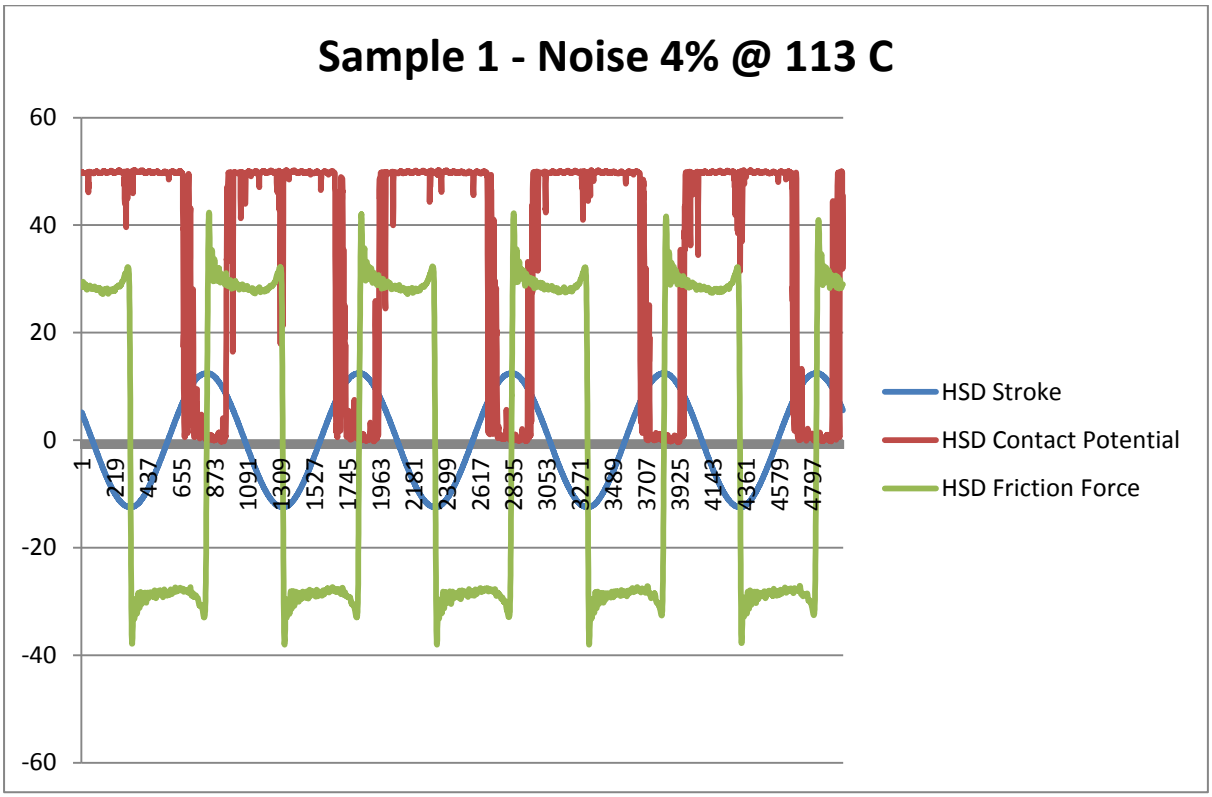

Figure 6: Sample 1 – High Speed Data – 4% Noise Trigger @ 113°C

With Sample 1, the instantaneous data at the 4% trigger level, at 113 C, indicate comprehensive film failure at one end of the stroke, accompanied by a significant increase in static friction.

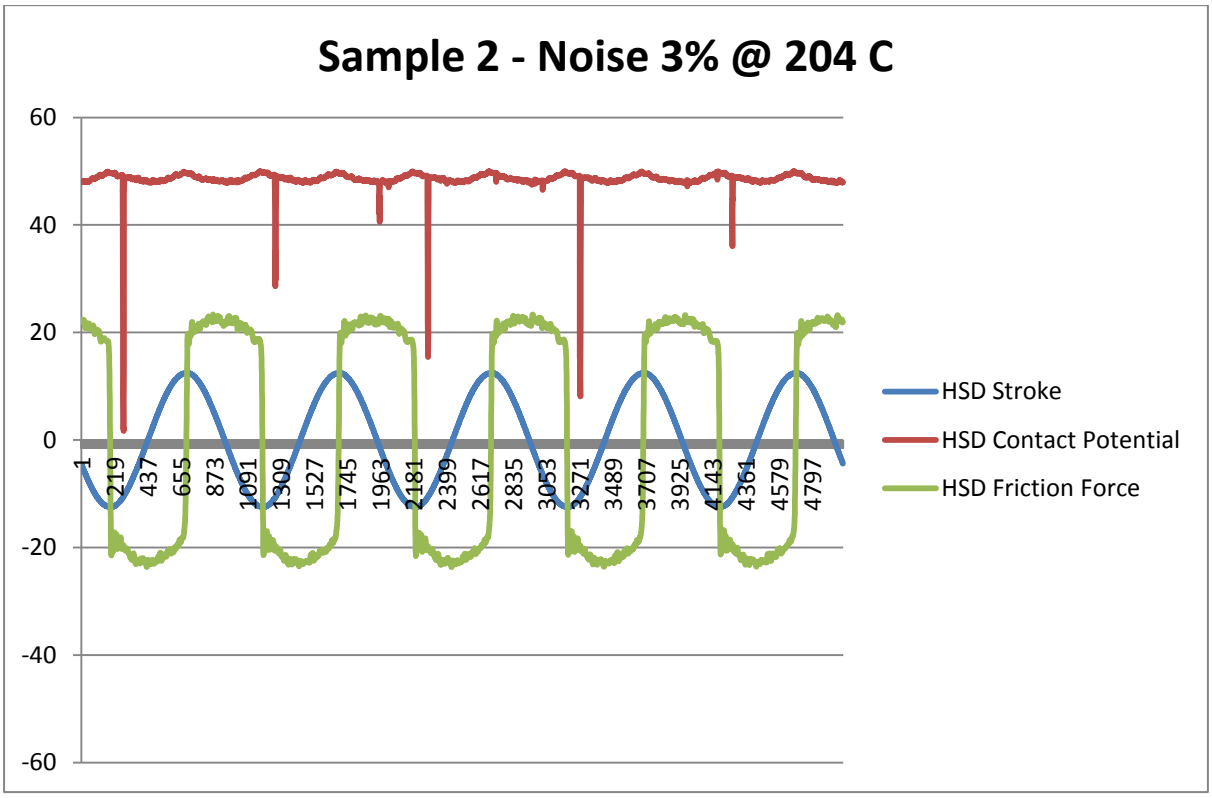

Figure 7: Sample 2 – High Speed Data – 3% Noise Trigger @ 204°C

With Sample 2, the instantaneous data at the 3% trigger level, at 204°C, indicate a very slight increase in static friction and the first signs of penetration of the film, as indicated by downward spikes in the contact potential trace. The "negative" Stribeck curve behaviour is still apparent, but what is really peculiar and difficult to explain is that the contact potential trace is now wavy.

Conclusions

Using friction noise as a trigger has been successfully demonstrated as a means of capturing high speed data.