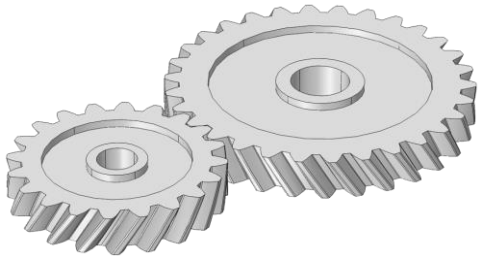
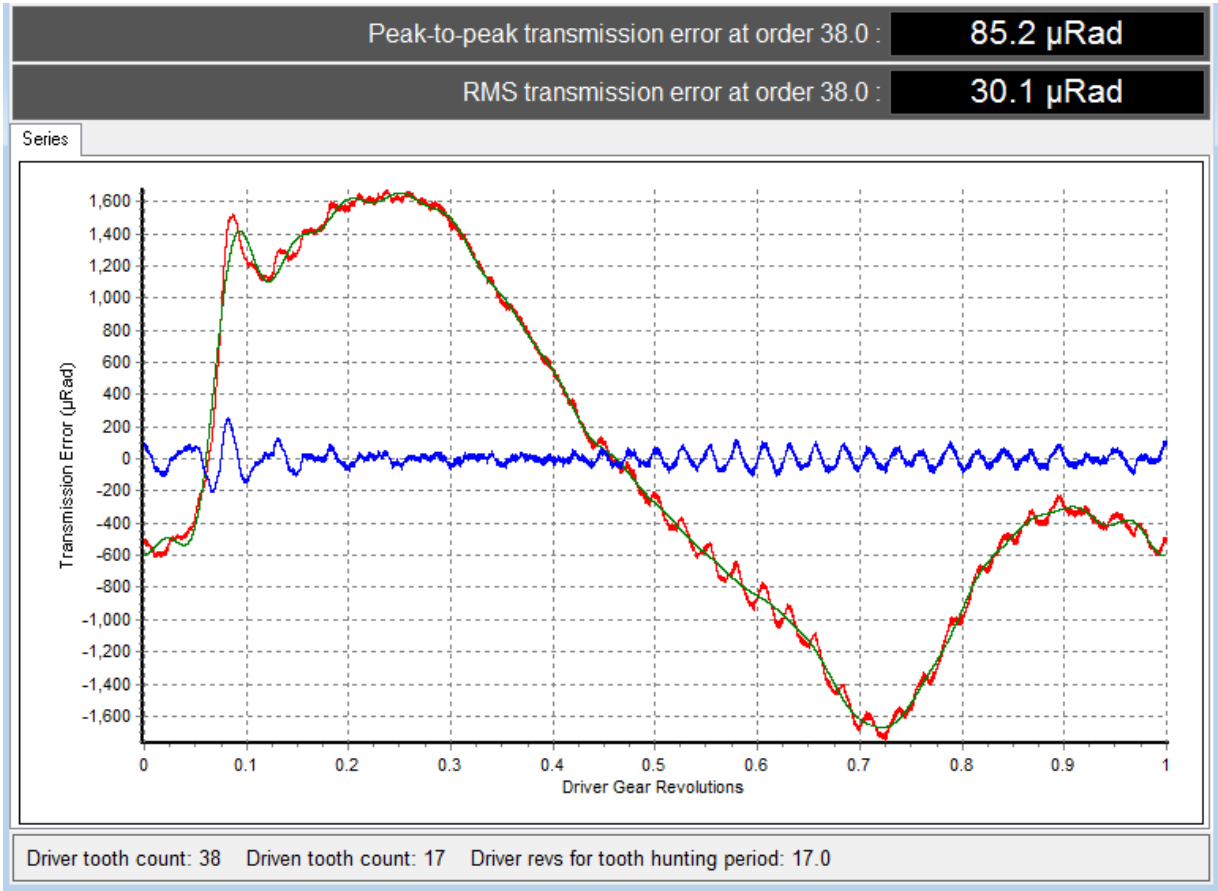
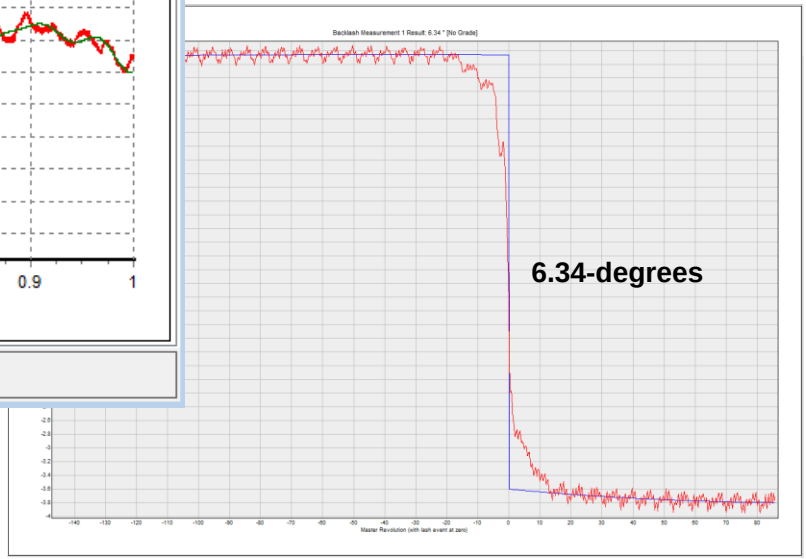
PLATO – METKIT based

Transmission Error & Dynamic Backlash Measurement & Analysis

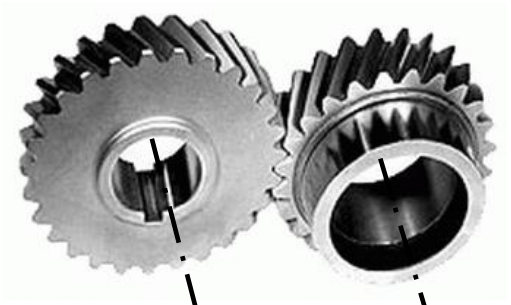






NVH INTERNATIONAL

Gear Transmission Error (TE) & Whine Analysis – via high-precision pulse-timing



Incremental Encoders

NI PCI-6602

OR

NI PCIe-6612

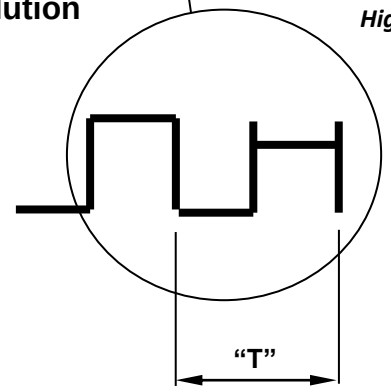
OR

NI PXIe-6612

OR

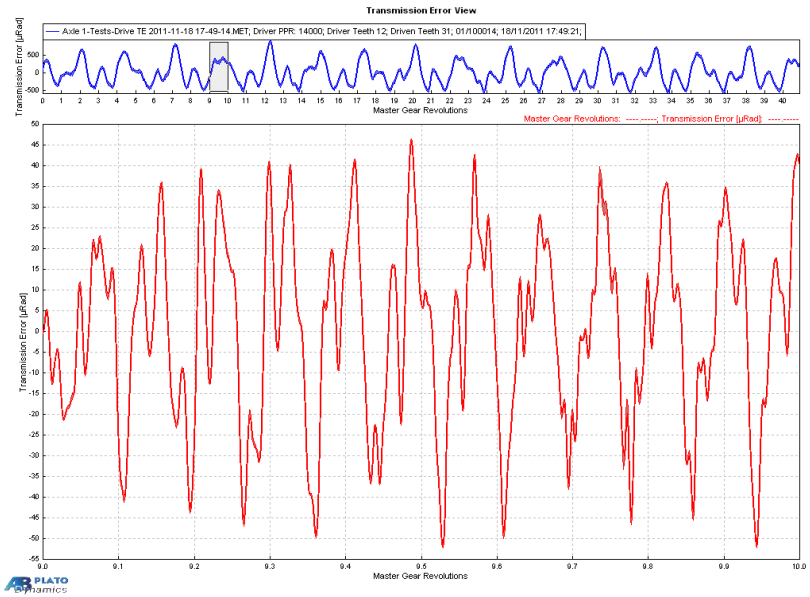
NI cDAQ-91xx Chassis & 9402 High-Speed I/O Modules

- Worldwide standard ***National Instruments*** (***NI***) hardware
- **Event domain** processing (timing rather than sampling)
- Contiguous recording of pulse time intervals (“T”) **±12.5 nano-second resolution**
- Fast DMA data transfers to host PC running ***Plato*** - ***Metkit***
- Up to **8 independent channels** (with PCIe card)
- **Rattle detection** (if 3rd channel fed with quadrature signal)

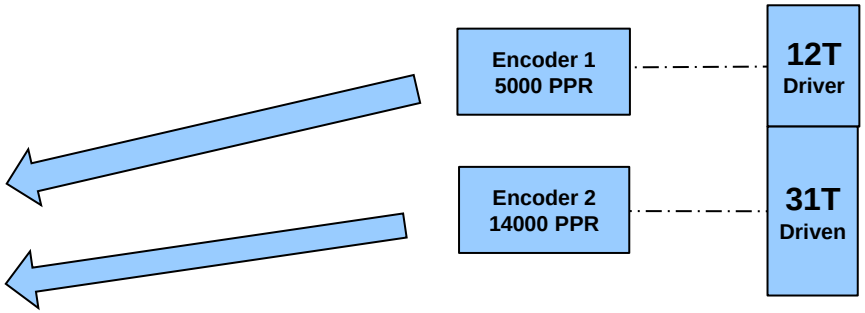


NVH INTERNATIONAL

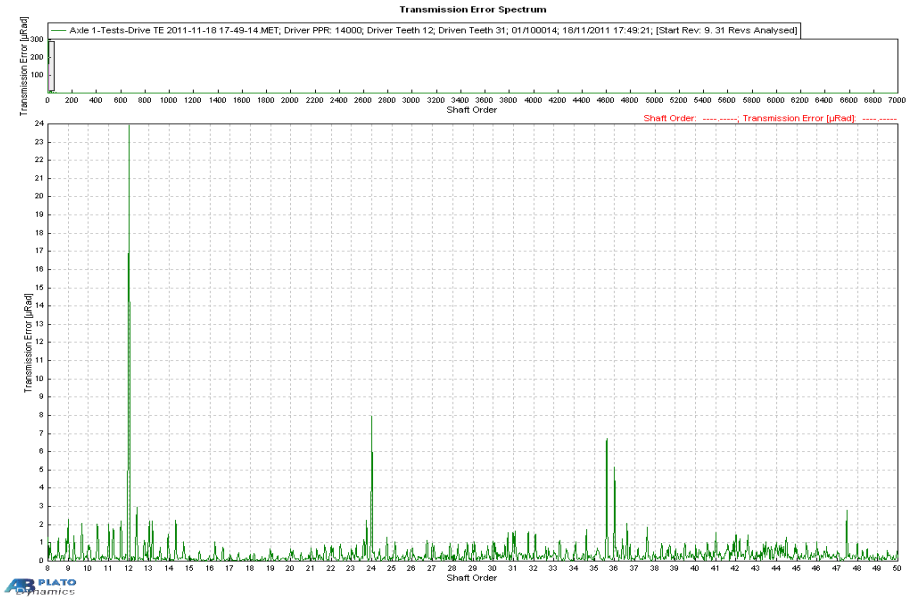
Typical TE Results



Typical Transmission Error Data vs. Master Gear Revolutions (ideally from one complete “over-rolling” of gears)



Typical Transmission Error Order Spectrum



Hanning-Corrected TE-results:
Order 12: 26.924 µRad
Order 24: 8.439 µRad

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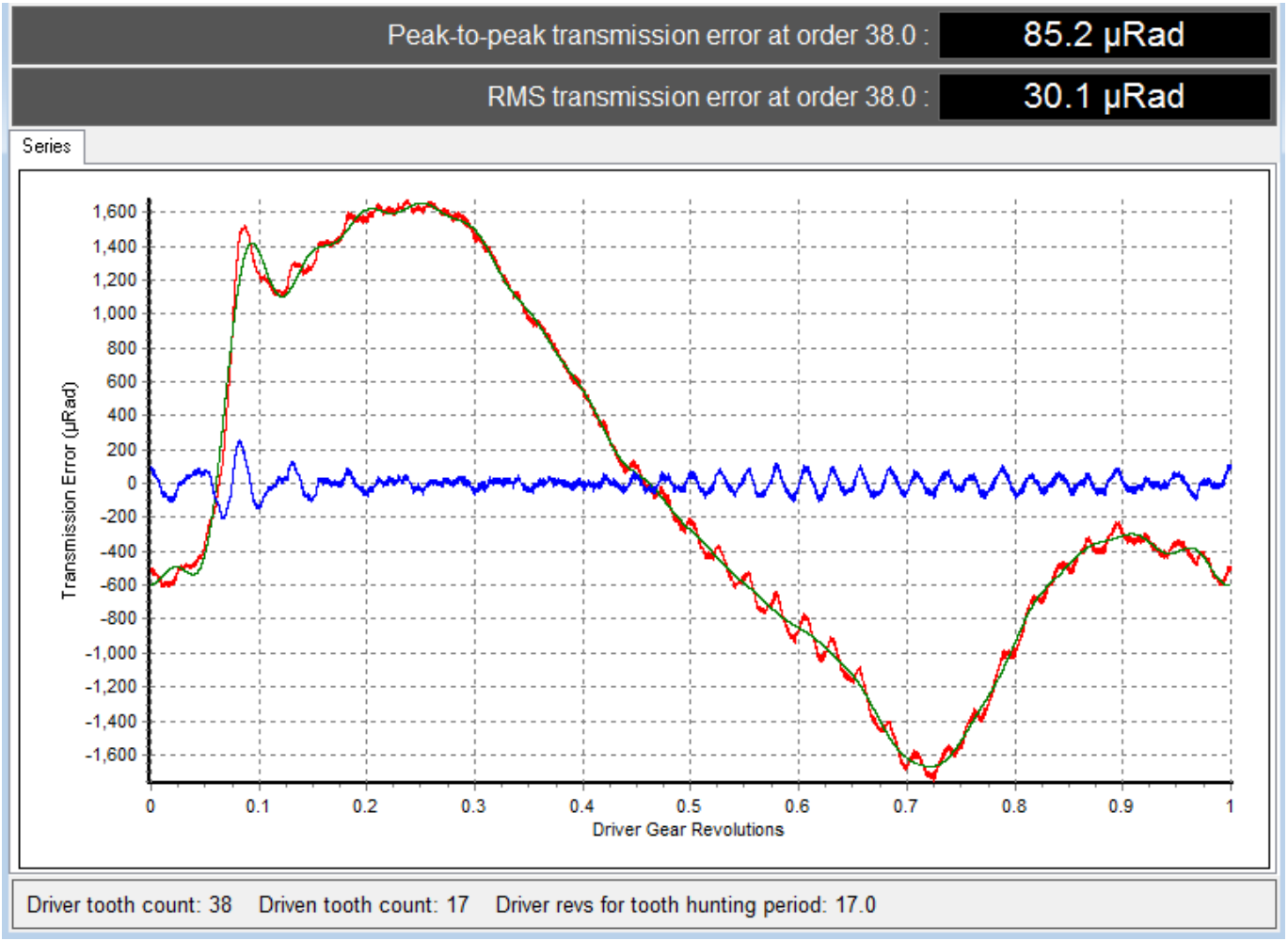
Typical TE Results



Raw result

"Long Wave" result (**non gear-mesh**) result

"Short Wave" (gear-mesh result)

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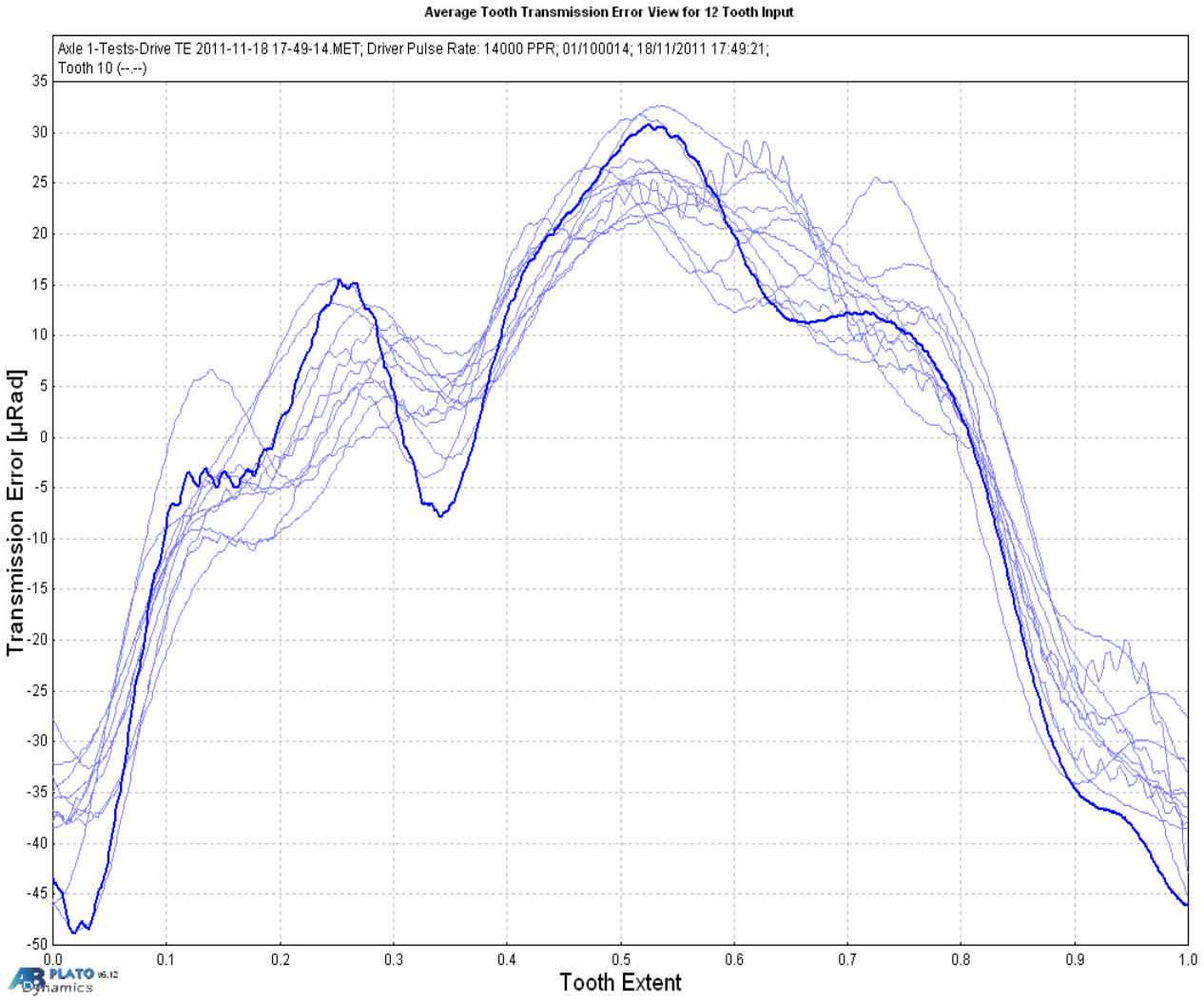
Typical TE Results



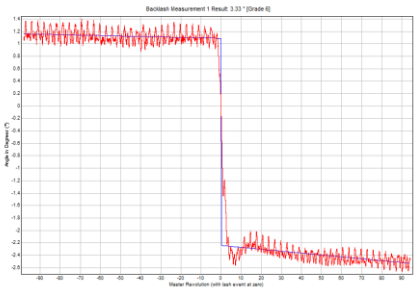
Typical Transmission Error
"Average Tooth" Display

NVH INTERNATIONAL

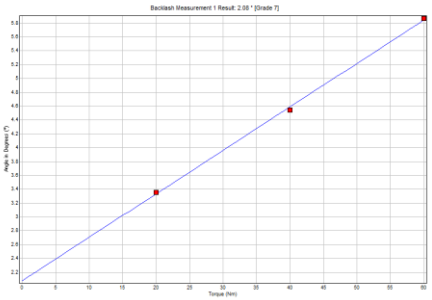
Dynamic Backlash

Dynamic backlash can be measured with the tested product subjected to one of the following:

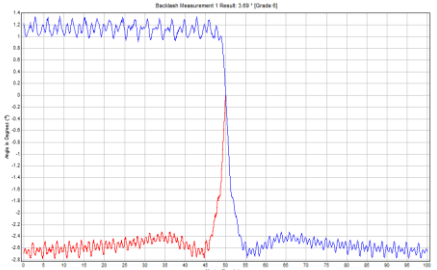
1. **Single Load Swap** to permit measurement of a single discontinuity of transmission at a single load. The measurement will be dependent upon the specific gear teeth meshed at the time.



2. **Zero-load lash computed from multiple load swaps at different loads** uses a number of rapid and increasing (or decreasing) load reversals to compute the backlash present under zero load.

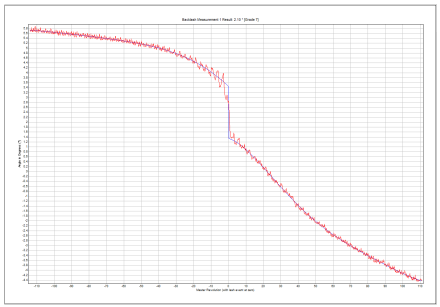


3. **Single reversal of rotation direction with full over-rolling analysis** will compute the backlash characteristics for every possible tooth interaction and report the minimum, maximum or mean backlash value.



4. **Single reversal of rotation direction with single driver gear revolution analysis** works as above but the analysis is restricted to a single full revolution of the driver gear.

5. **Single reversal of rotation direction with single driven gear revolution analysis** works as above but the analysis is restricted to a single full revolution of the driven gear.



6. **Zero-load lash from slow torque sweep through zero**.

Dynamic Backlash

Single Load (Torque) "Flip"

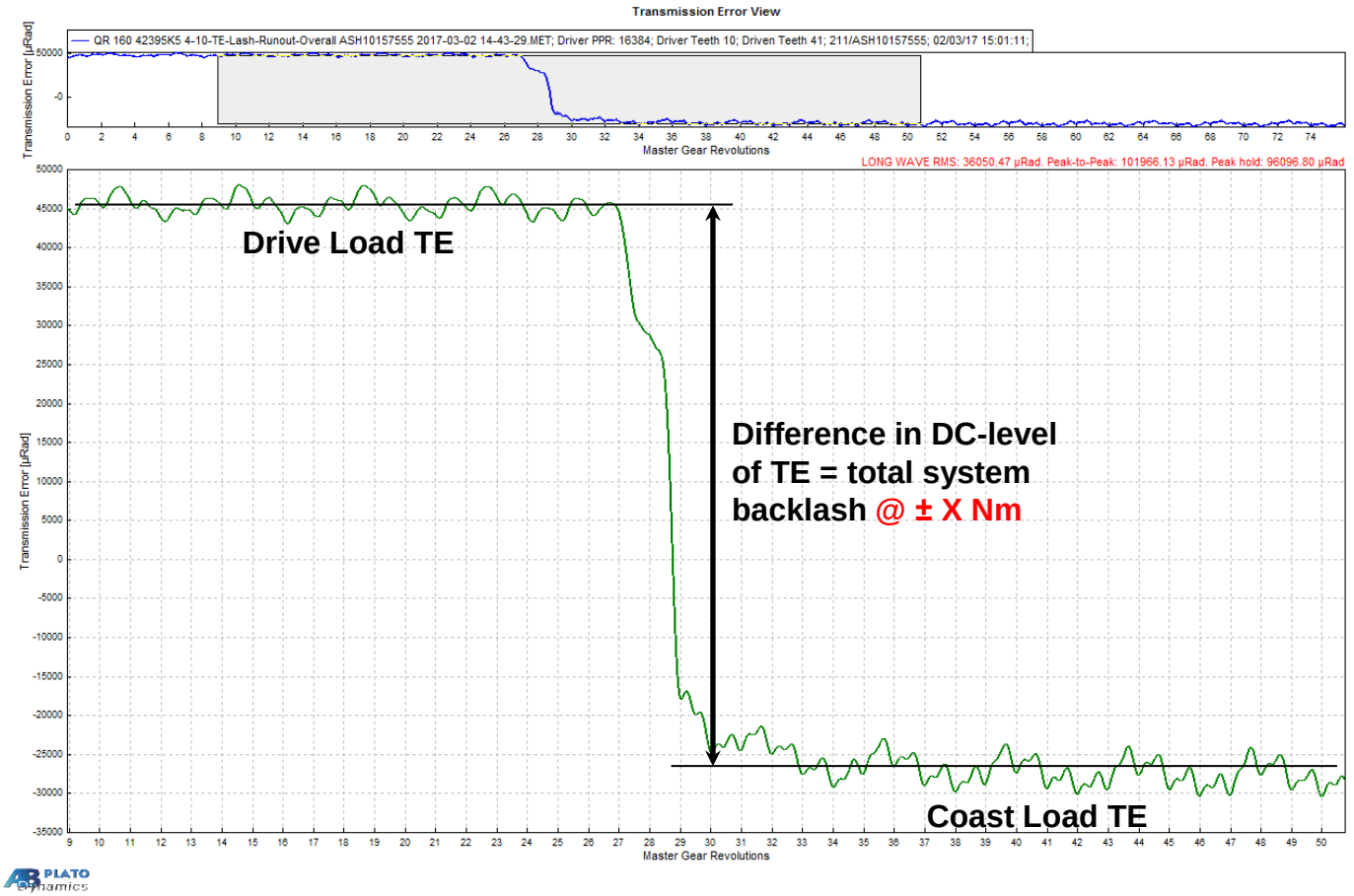
If TE is measured whilst the test conditions swap (flip) the polarity of the load, the difference in DC-levels of TE each side of the flip equals total system backlash.

Total System Backlash =

- backlash in ALL tested gear meshes e.g. hypoid and differential gears

plus

- backlash in tooling* (machine to tested product interfaces)

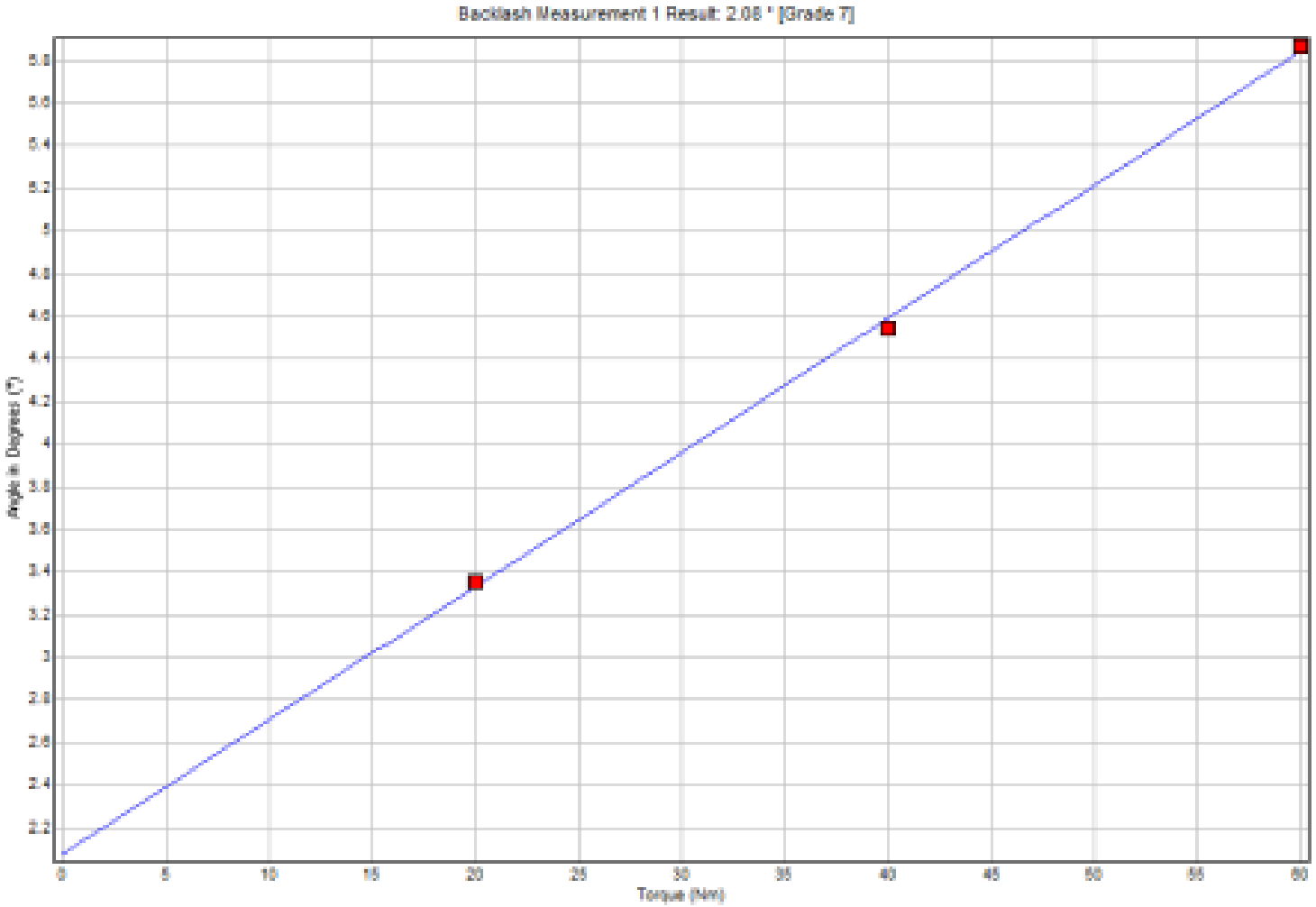


**Tooling backlash can be eliminated with careful design but, if test machine is designed to perform NVH test as well as TE/backlash test, zero-lash tooling can adversely affect NVH result repeatability.*

Dynamic Backlash

Multiple Load (Torque) "Flips"

Backlash results from 2 or more load swaps at different torques (loads) can be used to interpolate and report **zero load backlash**



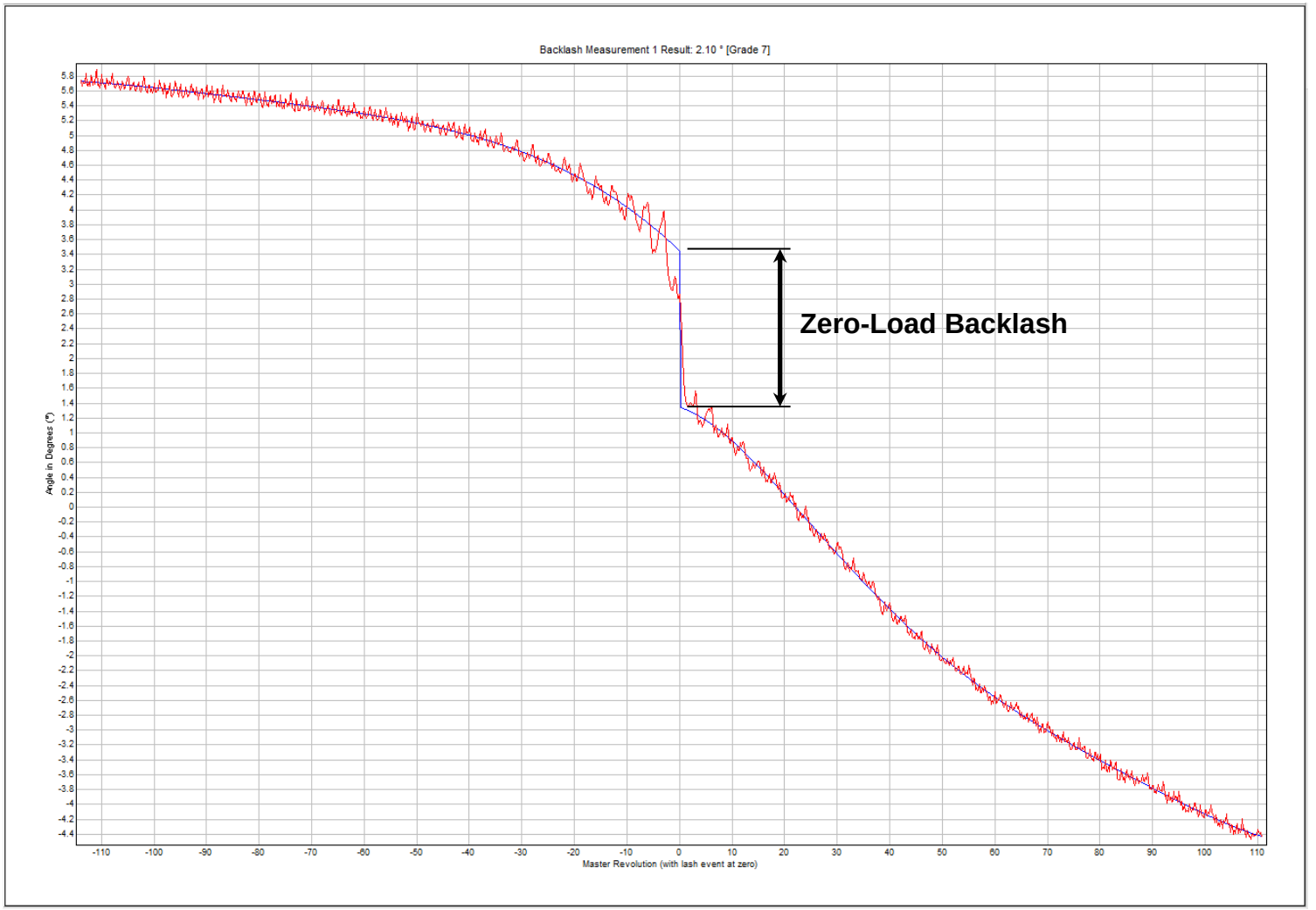
Backlash results with torque flips of ±20Nm, ±40Nm and ±60Nm being used to interpolate "zero-load-lash" of 2.08-degrees

NVH INTERNATIONAL

Dynamic Backlash

Slow Torque Sweep

Exposes **zero-load backlash** (2.10-degrees) during load transition.



Curve-fitting on drive and coast loaded sections of the torque sweep accommodate any driveline compliance ("wind-up")

NVH INTERNATIONAL

Typical TE-measurement Performance Envelope

Continuous Mode – steady speeds		Pulses Per Revolution			
		32768	**16384**	**8192**	**4096**
	KHz / channel				
3-channel	136	250 rpm	500 rpm	1,000 rpm	2,000 rpm
2-channel	205	375 rpm	750 rpm	1,500 rpm	3,000 rpm

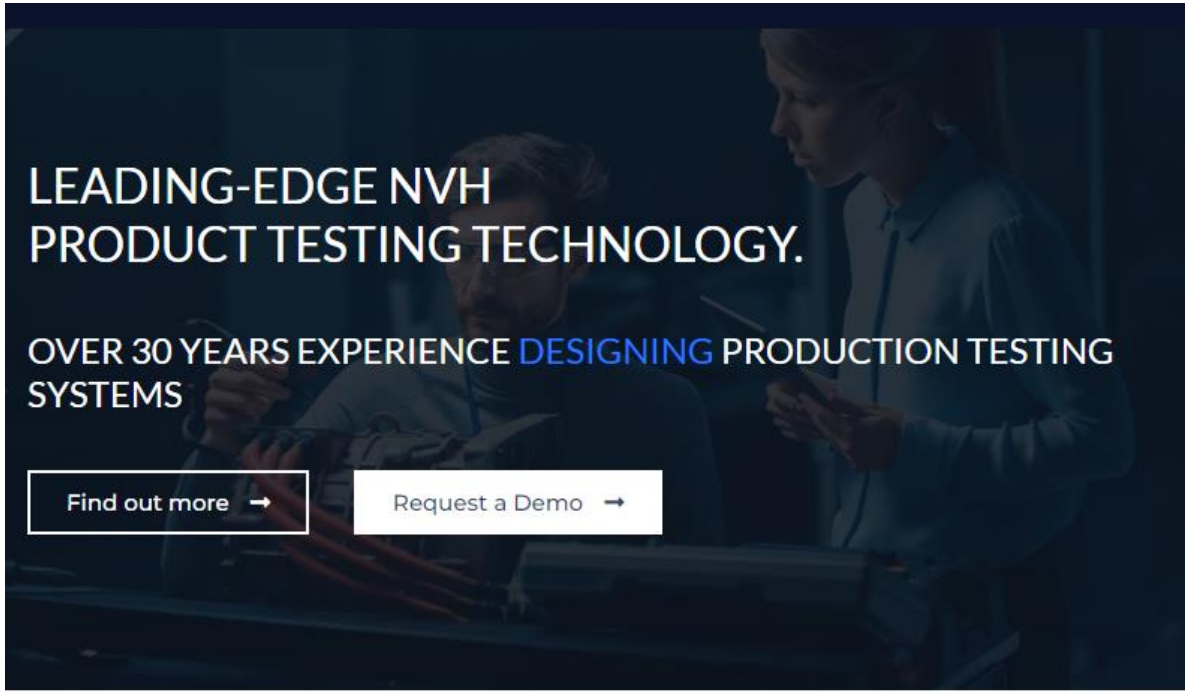
Burst Mode – steady speeds			Pulses Per Revolution			
			32768	**16384**	**8192**	**4096**
	Max. Time	**KHz / channel**				
3-channel	28s	614	1,125 rpm	2,250 rpm	4,500 rpm	9,000 rpm
2-channel	50s	683	1,250 rpm	2,500 rpm	5,000 rpm	10,000 rpm

Burst Mode – typical speed sweeps			Pulses Per Revolution			
			32768	**16384**	**8192**	**4096**
	Max. Time	**KHz / channel**				
3-channel	50s	614	125 - 1,125 rpm	250 - 2,250 rpm	500 - 4,500 rpm	1,000 - 9,000 rpm
2-channel	90s	683	125 - 1,250 rpm	250 - 2,500 rpm	500 -5,000 rpm	1,000 -10,000 rpm

measured on a PC with a 2.4GHz Core 2 Duo CPU and 2GB memory – May 2011

Plato – Metkit Application Areas

- Transmission Error (TE) measurement:
  - master & tested gear
  - tested gear pairs
  - assembled gear trains e.g., axles, carriers, transmissions, transfer cases etc.
  - 3-channel (“compound output”) solutions to accommodate left & right outputs for axles, carriers etc.)
- Dynamic backlash measurement (loaded or zero-load)
- Torsional vibration of engine crankshafts
- Crankshaft damper analysis
- Analysis of engine valve gear drives
- Analysis of engine balancer shaft drives
- Engine misfires
- Clutch centre-plate spring performance
- Torsional vibrations in transmissions & drivelines



PLATO - CORE NVH MEASUREMENT & ANALYSIS SOFTWARE

Leading-edge NVH product testing technology. Over 30-years of experience designing, deploying and supporting production testing systems.

Features

Request a Demo

Our supply model is based on:

- Advice – on test machine design, sensor choice and location, data capture and analysis options
- Product – feature-rich and robust application software
- Services – software set-up, test proving, training
- Support – ongoing assistance for new test set-up, result interpretation, fault-finding etc.

Get in touch with us...

https://www.nvhint.com/contact

Thank you!

- for your time and attention

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