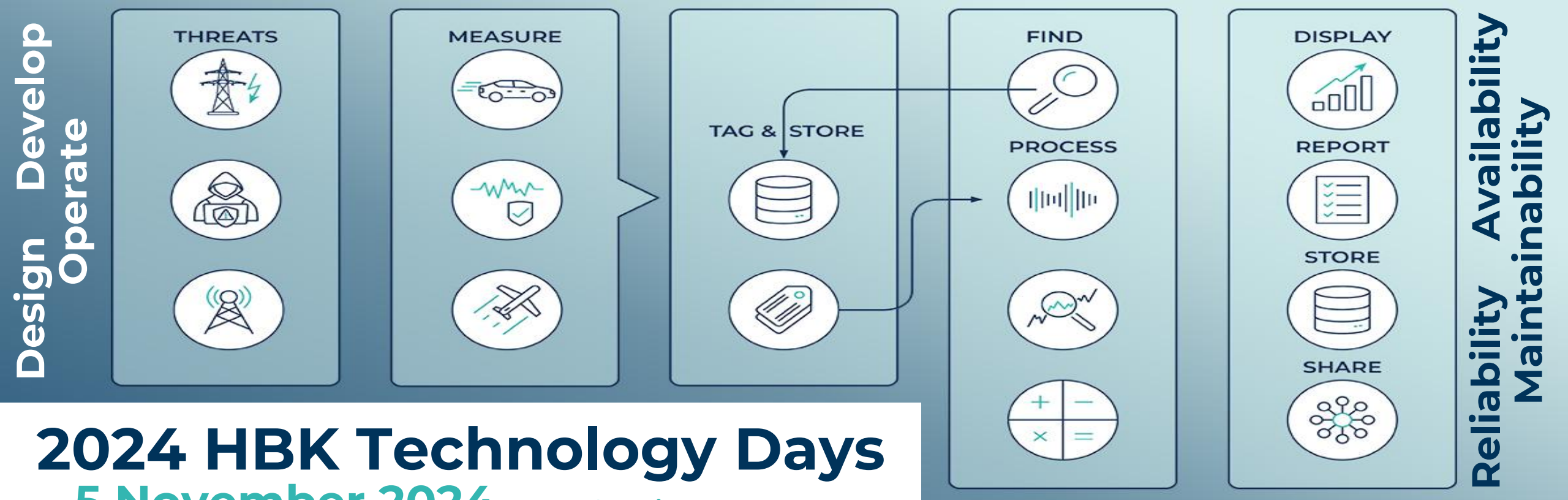


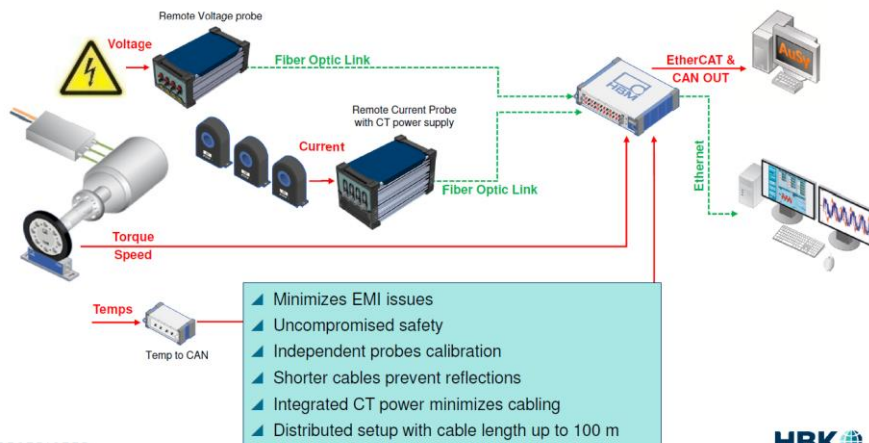


2024 HBK Technology Days

5 November 2024

Session 1: Minimising Electromagnetic Interference to Measurements

New: GN800B card with remote voltage & current probes



- Conquer EMI issues & accurately, rapidly & safely measure & map electric powertrains

Mike Hoyer,
HBK Electric Power Testing

Conquer EMI issues & accurately, rapidly & safely measure & map electric powertrains

Abstract

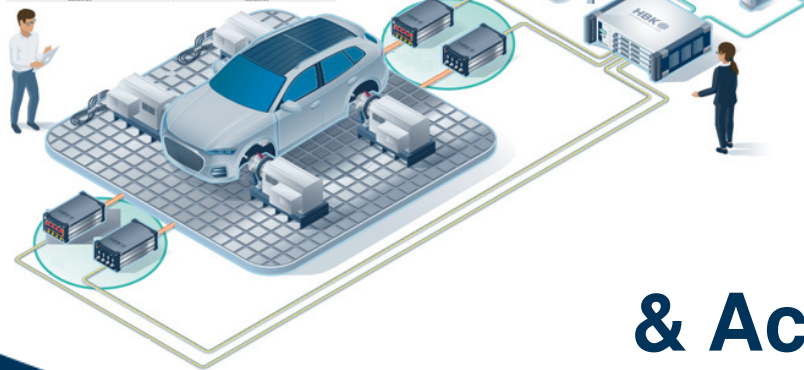
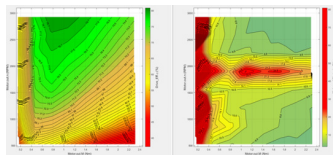
- Learn how to mitigate Electro Magnetic Interference (EMI), map torque ripple (mechanical noise), measure harmonics (electrical noise), improve accuracy, achieve uncompromised safety and rapidly calculate and map Measurement Uncertainty (MU) for every setpoint in your Electric Powertrain Measurements using a future proof testing solution.
- In Electric Powertrain Measurements, learn how to:
 - Greatly improve accuracy and safety
 - Mitigate EMI issues
 - Rapidly calculate and map Measurement Uncertainty for every set point
 - Map torque ripple (mechanical noise)
 - Measure harmonics (electrical noise)

Conquer EMI issues & accurately, rapidly & safely measure & map electric powertrains

▲ About the presenter, Mike Hoyer

Applications Engineer – Electric Power Testing, HBK

- Mike Hoyer is an Applications Engineer with over 33 years' experience for Nicolet / LDS- Nicolet / HBM / HBK. Mike has a Bachelor's of Science in Electrical Engineering from New York Institute of Technology, Old Westbury, NY, and an Associate Degree in Engineering Science from Farmingdale State University of New York. Mike has over 35 years of radio broadcasting experience, and over 35 years of data acquisition and applications engineering experience in automotive, aerospace and power industries, providing solution-oriented results to customers worldwide.



Conquer EMI Issues & Accurately, Rapidly & Safely Measure & Map Electric Powertrains

Mike Hoyer
Applications Engineer
Hottinger, Brüel & Kjær

Mike Hoyer

- ▲ Applications Engineer
 - AE for Nicolet / LDS-Nicolet / HBM / HBK for over 33 years
- ▲ Bachelor's of Science in Electrical Engineering
 - New York Institute of Technology, Old Westbury, NY
- ▲ Associate Degree in Engineering Science
 - Farmingdale State University of New York
- ▲ Over 35 years of radio broadcasting experience
- ▲ Over 35 years of data acquisition and applications engineering experience
 - In automotive, aerospace and power industries, providing solution-oriented results to customers worldwide



Mike Hoyer

Applications Engineer

1-800-578-4260

Mike.Hoyer@hbkworld.com

Agenda

- ▲ **EMI** - What is it? What causes it? How to mitigate it?
- ▲ **Cabling and Sensors** - How to minimize EMI issues for voltage, current, torque, speed, etc.?
- ▲ **Torque Ripple** - What is it? What it causes? How to measure it?
- ▲ **Harmonics** - What is it? What it causes? How to measure it?
- ▲ **Measurement Uncertainty?** - What is it? Why use it? How to measure it?
- ▲ **Rapid Calculations** - Cycle detect is the key to rapid results
- ▲ **The Total Measurement Solution** - One Stop Shop Solutions
- ▲ **More Details** – link, phone and email

What is EMI or Electro-Magnetic Interference?

▲ Noise, interference or electricity from one or more sources can interfere with a “signal”

▲ Galvanic

▲ Inductive

▲ Capacitive

▲ Radiation



Galvanic Coupling

Galvanic issues

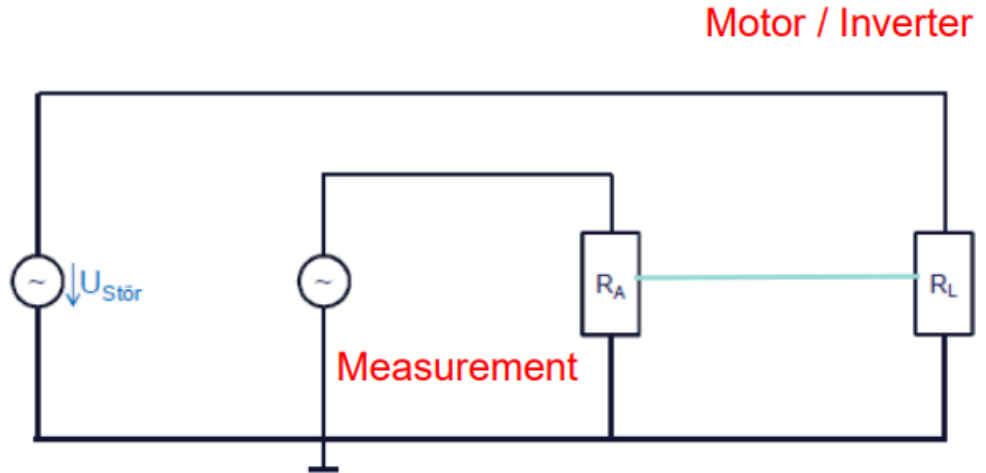
- Physical connection between points
- Ground loops
- Path to ground possibly shorter across another circuit
- Introduce noise into the common path from the load

Dependencies

- Cross section, length and resistance of the wire

Solutions

- Low impedance path to ground
- Eliminate ground loops
- Proper grounding



Inductive Coupling

▲ Inductive issues

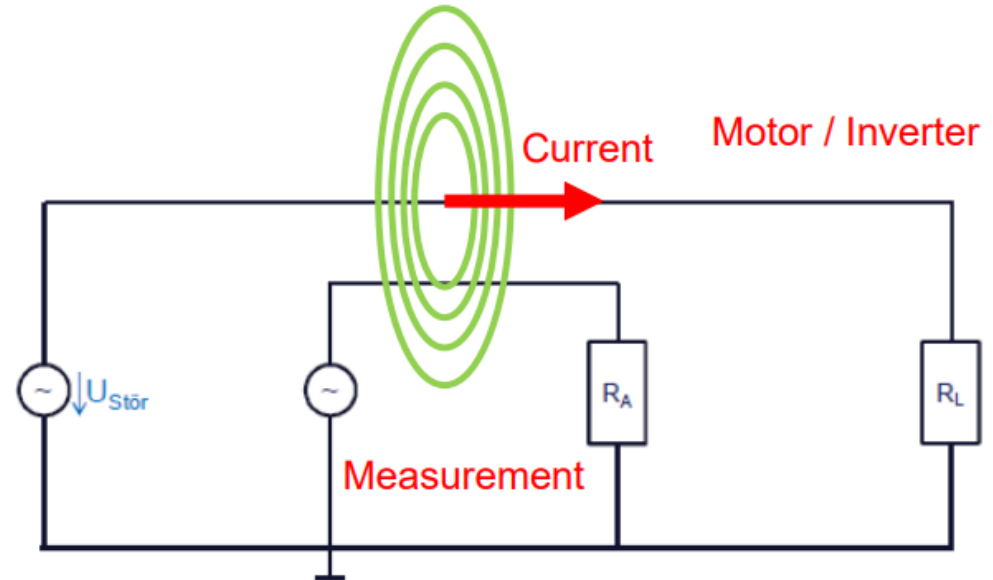
- Current induced from a current carrier to a signal wire
- Transformer effect (i.e. loops of cable)

▲ Dependencies

- dI/dt
- Frequency
- Current amplitude
- Distance
- Cable layout

▲ Solutions

- Shielding
- Eliminate parallel paths & loops
- Distance between cables
- Eliminate copper cabling



Capacitive Coupling

Capacitive issues

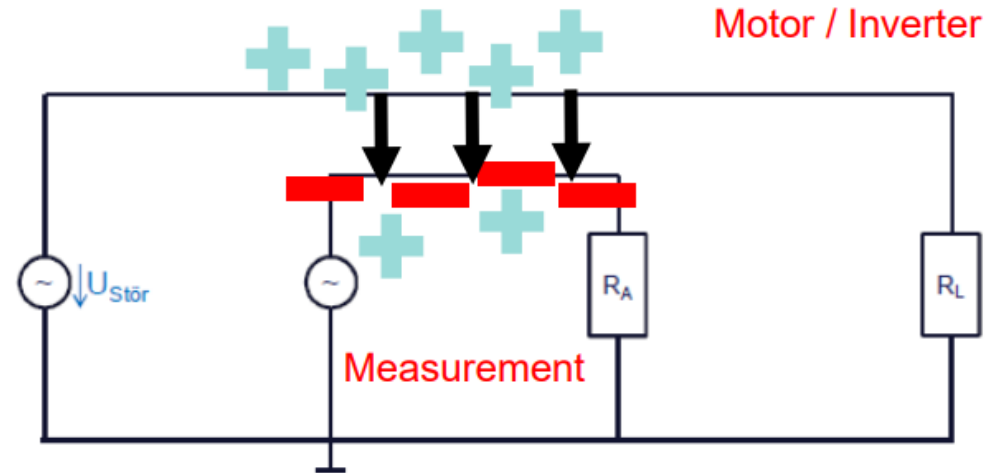
- Charge jumping from one source to another

Dependencies

- dV/dt
- Voltage level
- Frequency
- Distance between cables
- Cable layout

Solutions

- Shielding
- Eliminate parallel paths
- Distance between cables
- Eliminate copper cabling



Radiation Coupling – Far Field

▲ Radiation issues

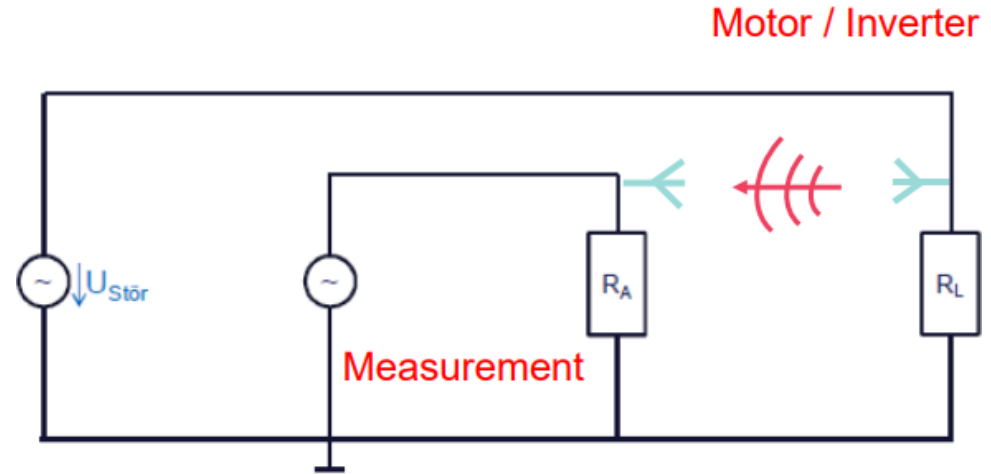
- Electromagnetic field interference
- Radiation over a distance
- High voltage & high current situations

▲ Dependencies

- dI/dt , dV/dt
- Frequency
- Voltage & current levels
- Distance between cables

▲ Solutions

- Shielding
- Cable layout
- Eliminate copper cabling



Additional Testing Issues / Industry Trends ...

▲ Higher voltages

V increases $\rightarrow \frac{dV}{dt}$ Increases

- Battery voltages are increasing
 - to improve driving range, some as high as 800 V and higher
- Need higher measurement ranges and higher voltage safety levels
 - Be sure the Power Analyzer meets the needed Voltage level and Overvoltage Categories
 - Most automotive test rigs are CAT III, so make sure your Power Analyzer is certified for this measurement
 - **Many Power Analyzers on the market are only certified for CAT II or to very limited levels in CAT III**

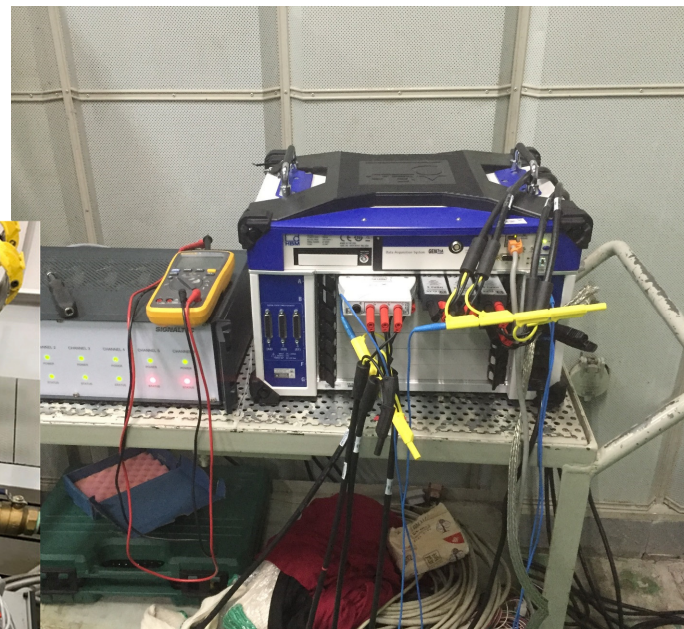
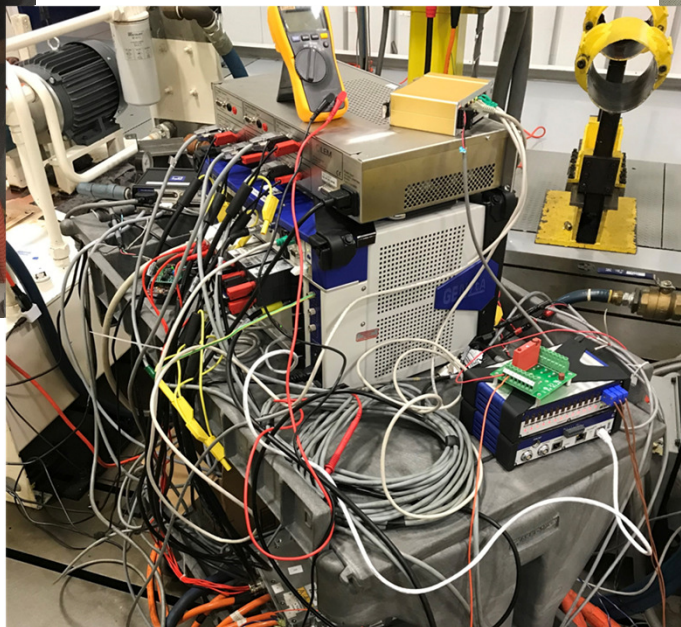
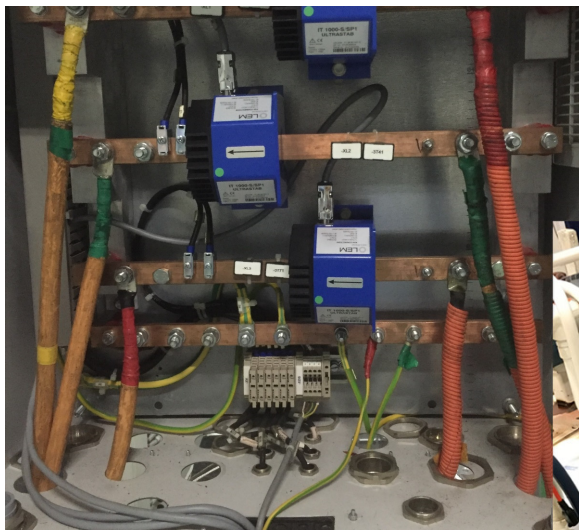
▲ Higher frequencies

Increased EMI

- Increased slew rate leads to more EMI
 - This increases EMI issues
- Increased sensitivity for long cables and cable capacitance
 - This will further limit bandwidth
- Increased measurement errors caused by increased cable reflections

▲ Conclusion ... new powertrain demands are more challenging to measure

Electric powertrain testing in reality



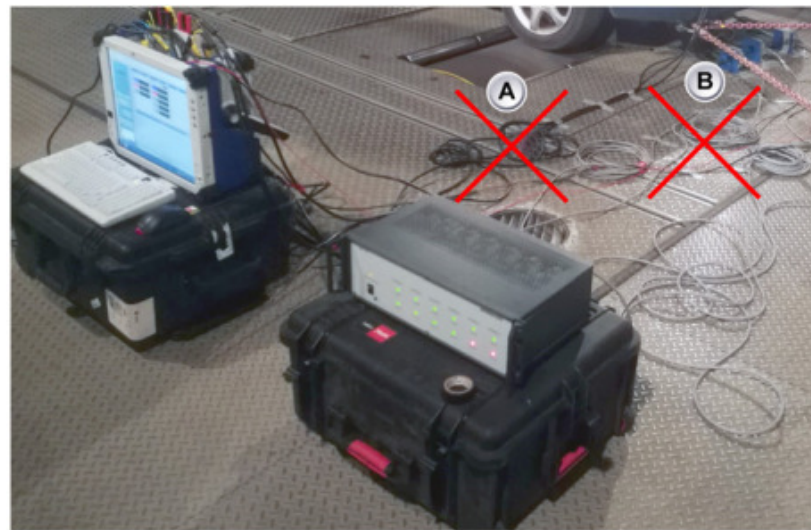
Minimizing Electromagnetic Interference

▲ EMI generators

- Electric motor testing, inverters, variable-frequency drives and other electronic equipment generate lots of electromagnetic interference

▲ Tips to reduce EMI and ensure a more accurate measurement ...

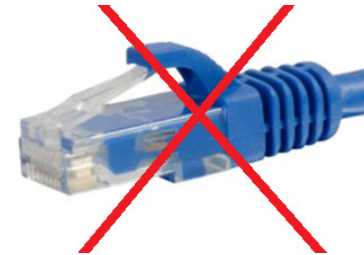
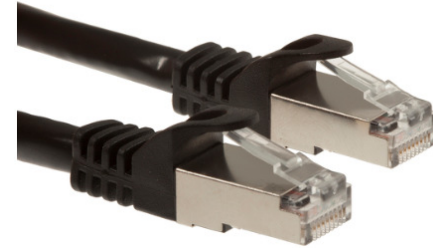
- Keep all current cables away from voltage cables as much as possible (i.e. 3 meters)
- Place the analyzer away from the DUT (Device Under Test) by at least 3 meters.
- Choose the right length of voltage and current cable and avoid rolling up cables.
- When cables are rolled up, high frequency electromagnetic interference induces currents and adds noise to the signal.



(A) Voltage and (B) Current cables should be separated and not rolled up in order to mitigate noise from electromagnetic interference

Ethernet: Cabling Solutions

- ▲ In high EMI environments, use shielded Ethernet cables to achieve noise immunity
 - At minimum use shielded Ethernet CAT6 or greater cables
- ▲ Avoid using plastic/non-shielded Ethernet cables
- ▲ **Ideally use fiber-optic Ethernet solutions** for the ultimate noise immunity and isolation from the high voltage and current environments



Current Sensor Cabling: Problem

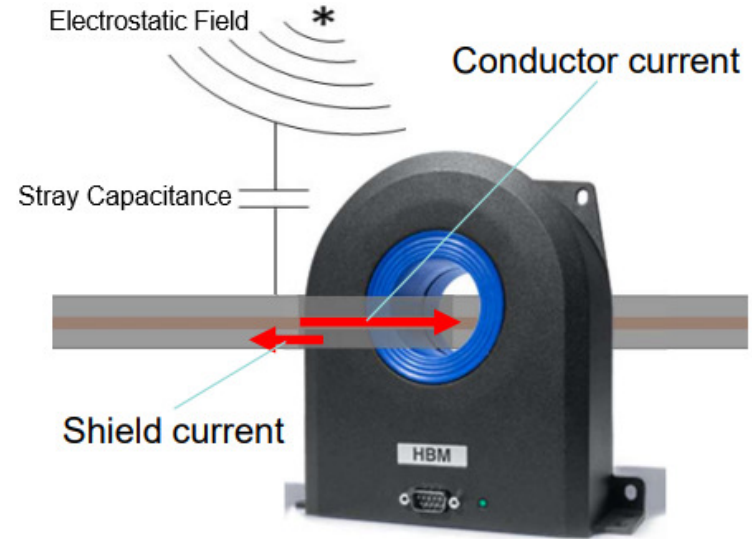
▲ **Unshielded measurement cables** are subject to electrical noise

- High frequency inverters
- Pulse-width modulated voltages
- This results in bad/noisy measurements

▲ **Shielded measurement cables** carry currents

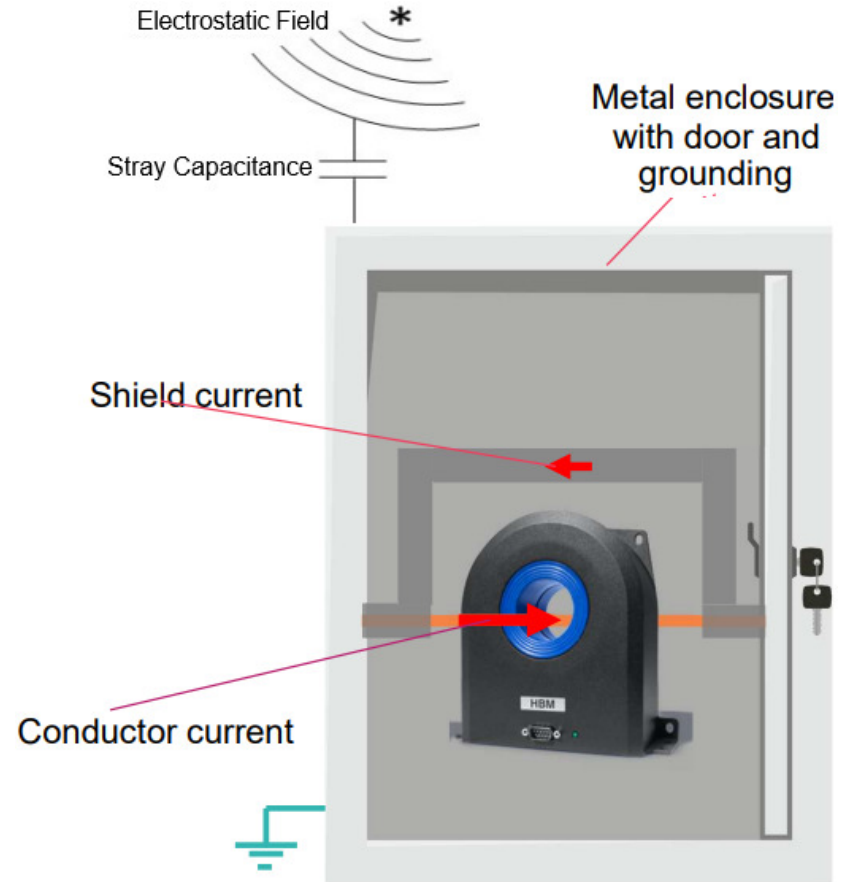
- Center conductor current
- Outer shield current
- Current sensors measure the sum
- $I_{\text{measured}} = I_{\text{center conductor}} + I_{\text{outer shield}}$

▲ **Problem:** How to measure the current in a shielded cable?



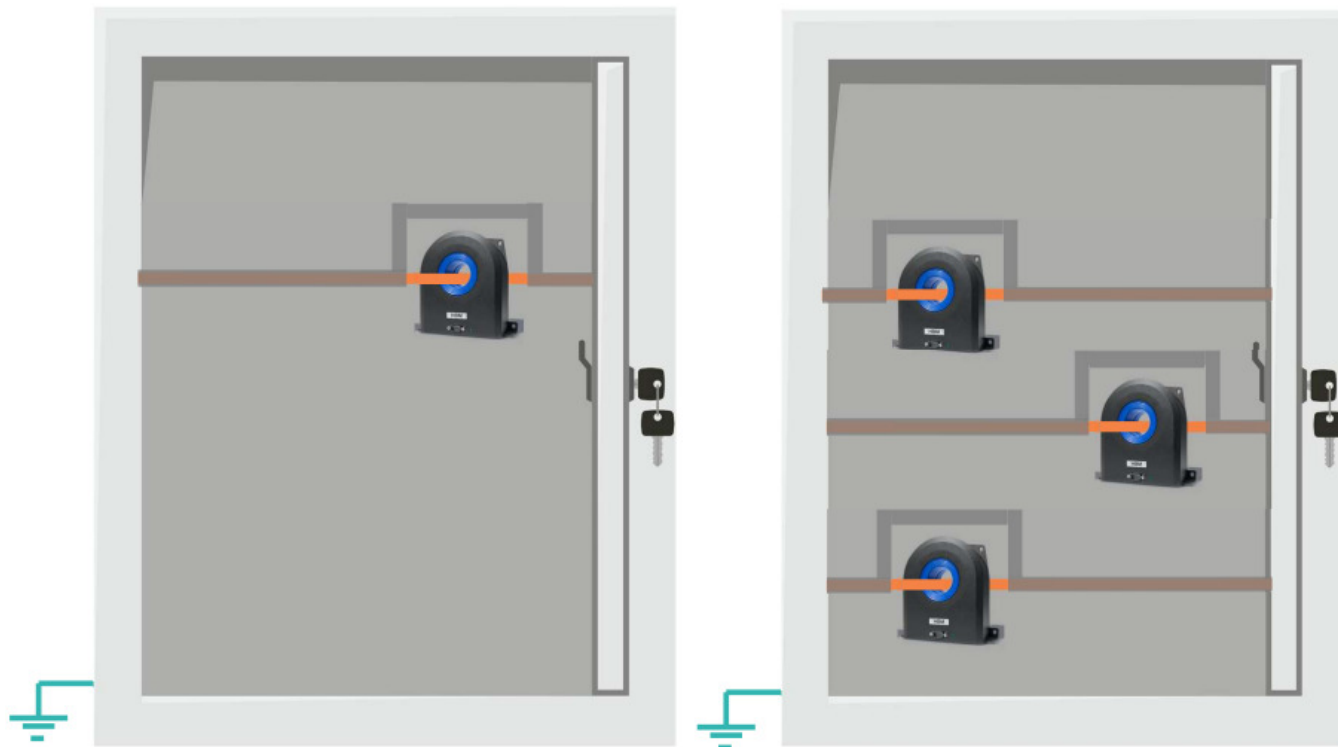
Current Sensor Cabling: Theoretical Solution

- Route shield around sensor
 - Only center conductor is measured
 - Noise is still suppressed by shield
- Sensors are in an EMC cabinet
 - Grounded
 - Sensors spaced to specification
- Straight cables through the sensor



Current Sensor Cabling: Practical Solution

- ▲ DC and AC signals should be separated
- ▲ DC signal on left
- ▲ AC signals on right



New Current Sensors: New CTT series

▲ New CTT series now available

- 1-CTT50ID, 1-CTT100ID, 1-CTT200ID
- Wider bandwidth than CTS versions (2 Mhz vs. 1 MHz)
- Improved linearity (1.5 ppm vs. 8 ppm)

▲ CTN1000ID also available - 1000 A RMS / 1000 A DC

- Lighter and smaller than CTM1200ID
 - 0.75 kg vs 2 kg
 - 4.68" x 4.41" x 1.38" compared to 6.5" x 6.85" x 1.38"
- Added to Sensor Database with v8.72 release

▲ Can quote today

- Delivery via Custom Systems if order placed this year



High Voltage Cabling

■ Cabling

- High voltage shielded measurement cable
 - 1-KAB21390-xx
 - 1.5 m (5'), 3.0 m (10'), 6.0 m (20'), 12 m (40')
 - 1500 V DC CAT III, 1000 V CAT IV
 - 3-phase (Black/Brown/Grey)
 - Single-phase neutral to line
 - Shield connector (Yellow)
- Shielded
 - 3-wire shielded cable
 - Reduces electromagnetic disturbance from high-power inverters and emissions from the rise times of the switching inverter voltages

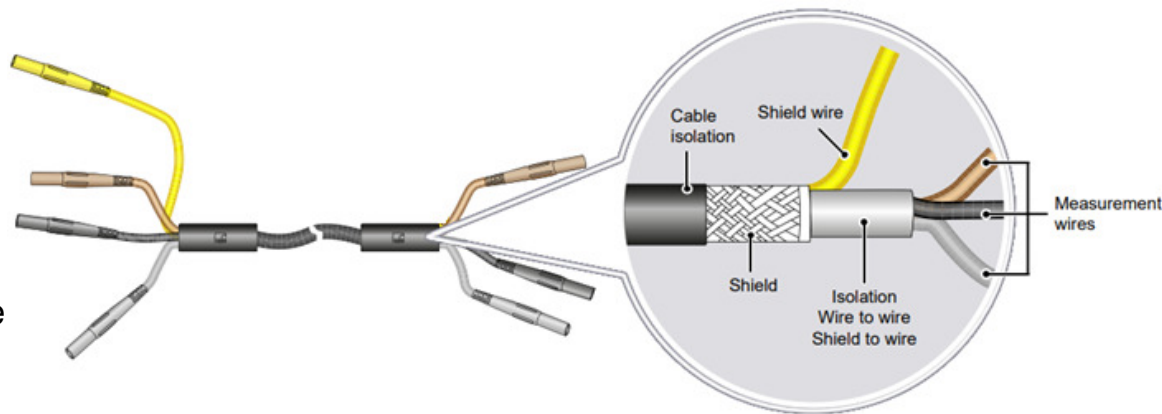


1-KAB2139-XX HV Cable

Up to ± 1500 V DC



1-GN310B / 1-GN311B

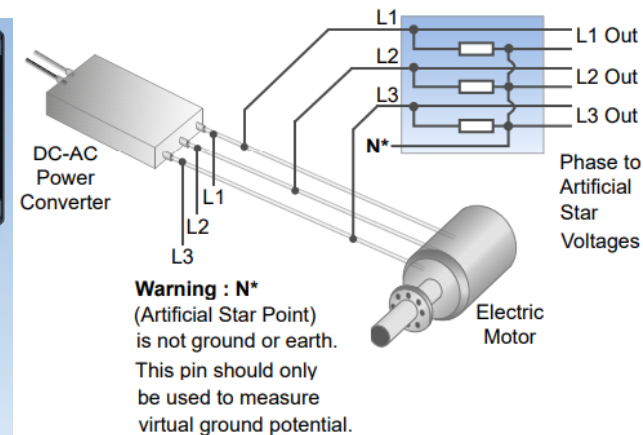
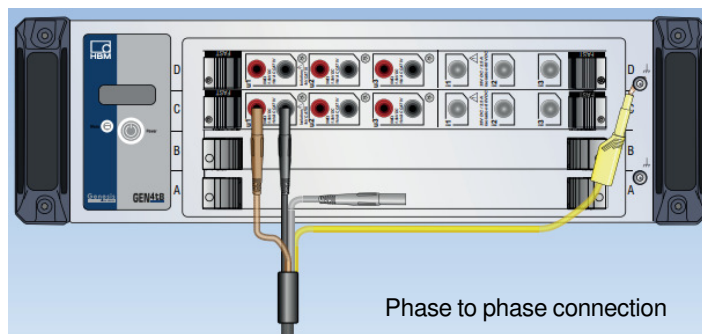
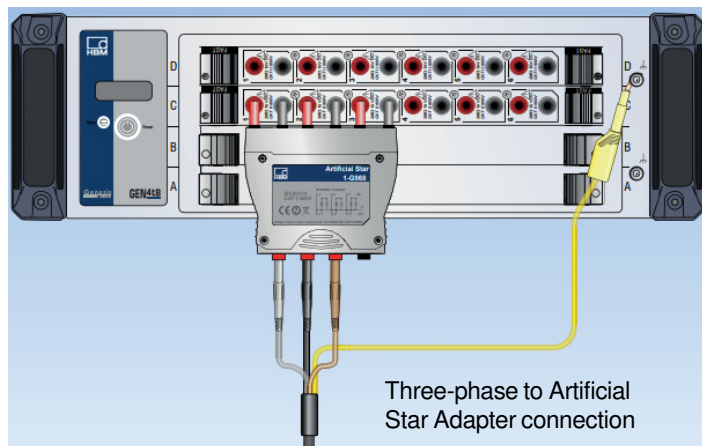


High Voltage Cabling: Connections

Wiring



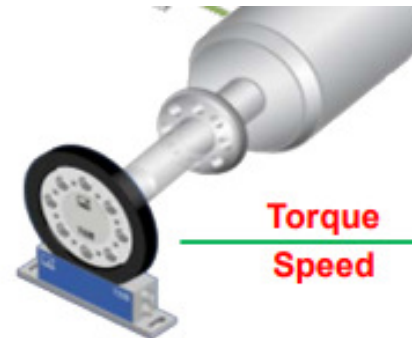
- Artificial star adapter
 - Assumes **balanced** systems
 - For GN31xB cards, use 1-3PH-STR-1K0-CAT2
- Phase to Phase (Line to Line)
 - Best for **unbalanced** systems
- Connect the yellow shield to the mainframe's ground lug



Note:
A phase-to-phase connection can be easily wired using one three phase cable and three stacking banana cables at the inputs to jumper/feed each phase to two banana input phase channels.

Torque & Speed: Cabling Solutions

- ▲ Analog signals ...
 - Are susceptible to noise/EMI
 - Provide low accuracy
- ▲ Digital signals ...
 - Are immune to noise/EMI
 - Offer much higher accuracy



Torque & Speed: Accuracy, Flexibility & Future Proof

▲ Non-contact torque/speed sensors

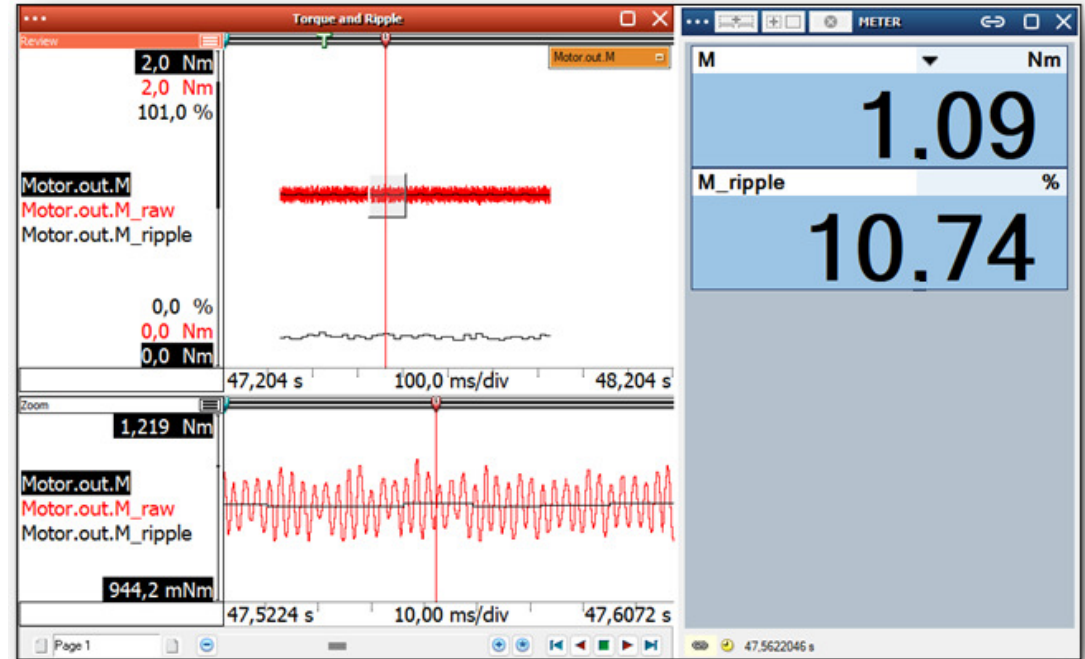
- Most accurate torque sensor ... 0.007% ... **T12**
- Best value for money ... 0.03% ... **T40B**
- Highest bandwidth ... up to 15 kHz ... **T100 Series**
 - 15 kHz bandwidth, excellent for torque ripple measurements
 - No hub antenna ... one stator fits all range rotors
 - Titanium ... less metal yet more rigid
 - 0.03 and 0.01% accuracy



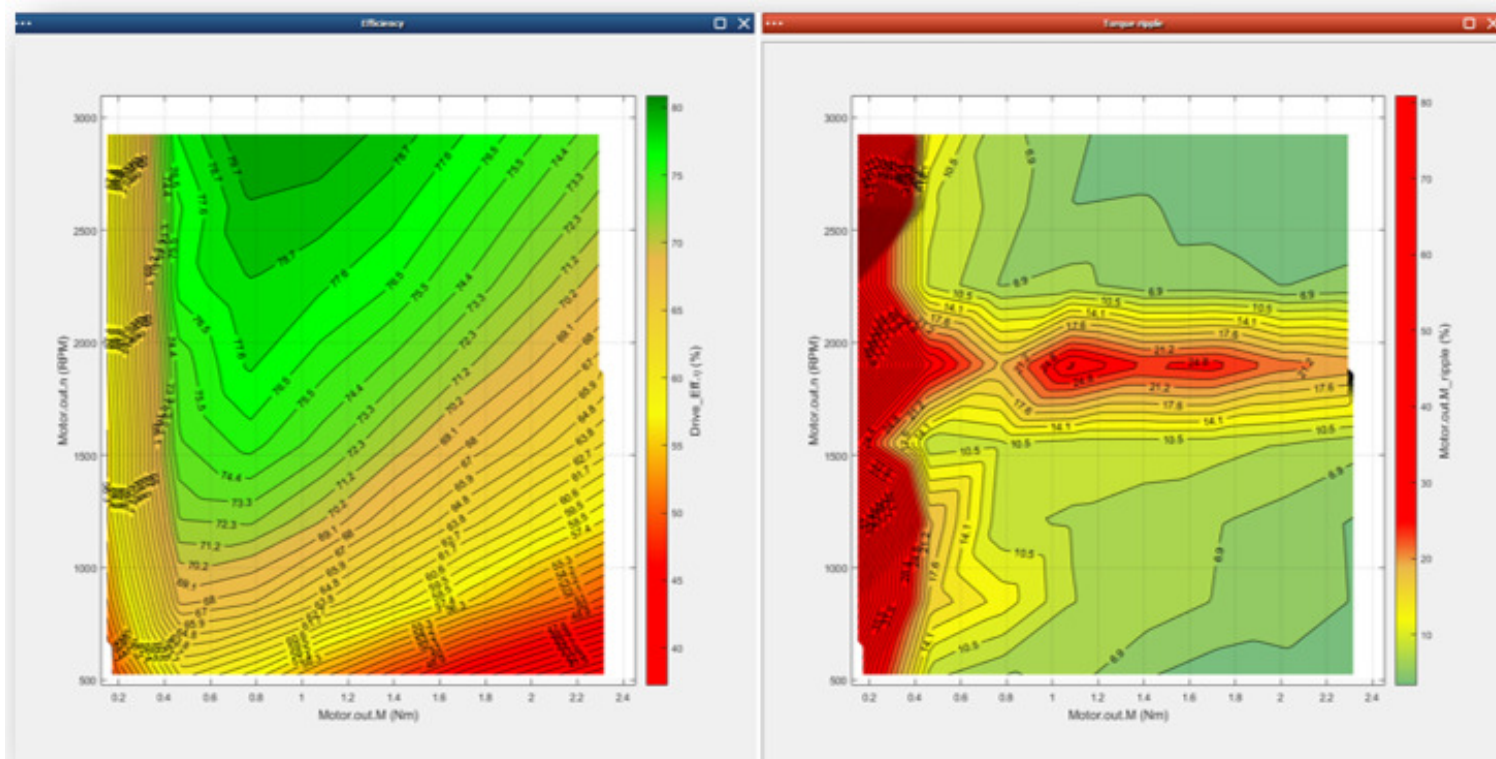
Real-Time Torque ripple analysis – mechanical noise

What is torque ripple?

- Torque ripple is an unwanted effect of an electric drive
- Various causes like modulation method or mechanical design
- Unwanted results like increased noise, vibration and decreased lifetime
- Therefore, it is essential to understand how much torque ripple is generated
- Technically, torque ripple is a small fast AC component on top of the more static mean torque



Real-Time Torque ripple analysis - results



Showing the efficiency map and a torque ripple map next to it.
This gives information where a drive might be efficient but also will vibrate the most....

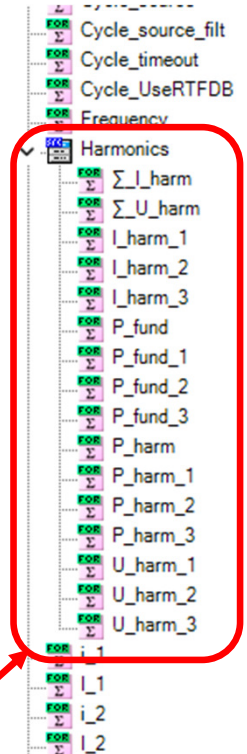
Real-Time Harmonic analysis – electrical noise

Why calculate harmonics?

- In electric drives it is of interest to understand how much of the ACTIVE POWER is in the fundamental, **1st Harmonic - creates torque** which makes the motor turn
- How much is in **all other harmonics - create losses which makes the motor hot**
- The same applies to the respective harmonic RMS current

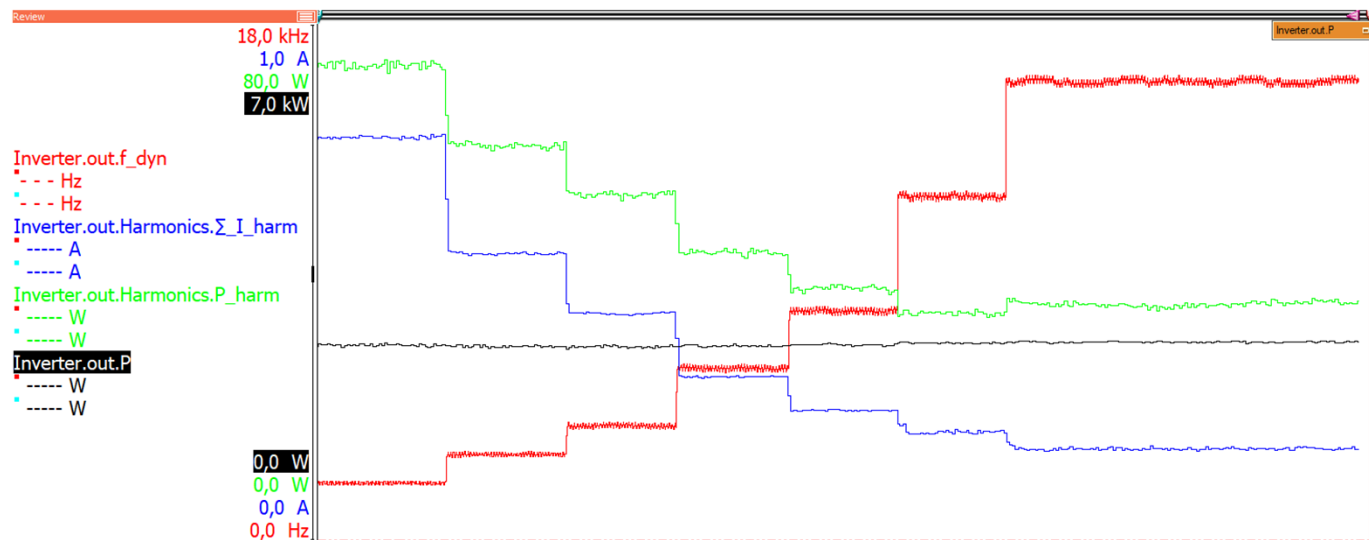
Below is an example of the auto-created Real-Time formulas for phase 1

FOR Σ 191	Inverter.out.Harmonics.P_fund_1	$RTFormulas.Inverter.out.I_fund_1 * RTFormulas.Inverter.out.U_fund_1 * RTFormulas.Inverter.out.Cos\phi_fund_1$	W
FOR Σ 197	Inverter.out.Harmonics.P_harm_1	$RTFormulas.Inverter.out.P_1 - RTFormulas.Inverter.out.Harmonics.P_fund_1$	W
FOR Σ 203	Inverter.out.Harmonics.U_harm_1	$@Sqrt(((RTFormulas.Inverter.out.U_1 * RTFormulas.Inverter.out.U_1) - (RTFormulas.Inverter.out.U_fund_1 * RTFormulas.Inverter.out.U_fund_1)))$	V
FOR Σ 209	Inverter.out.Harmonics.I_harm_1	$@Sqrt(((RTFormulas.Inverter.out.I_1 * RTFormulas.Inverter.out.I_1) - (RTFormulas.Inverter.out.I_fund_1 * RTFormulas.Inverter.out.I_fund_1)))$	A



Example of Real-Time Harmonic Power and RMS calculations

- ▲ In this example, a motor is tested with an inverter and only the switching frequency is increased
- ▲ While increasing the switching frequency ...
 - The output power remains constant, so one may conclude nothing changed
 - Looking at the inverter harmonic power, it decreased, so the motor became more efficient
 - On the other hand, when increasing the switching frequency, you increase the inverter losses
- ▲ Using this tool, you can make further measurements and determine the optimal operating range for the motor and the inverter



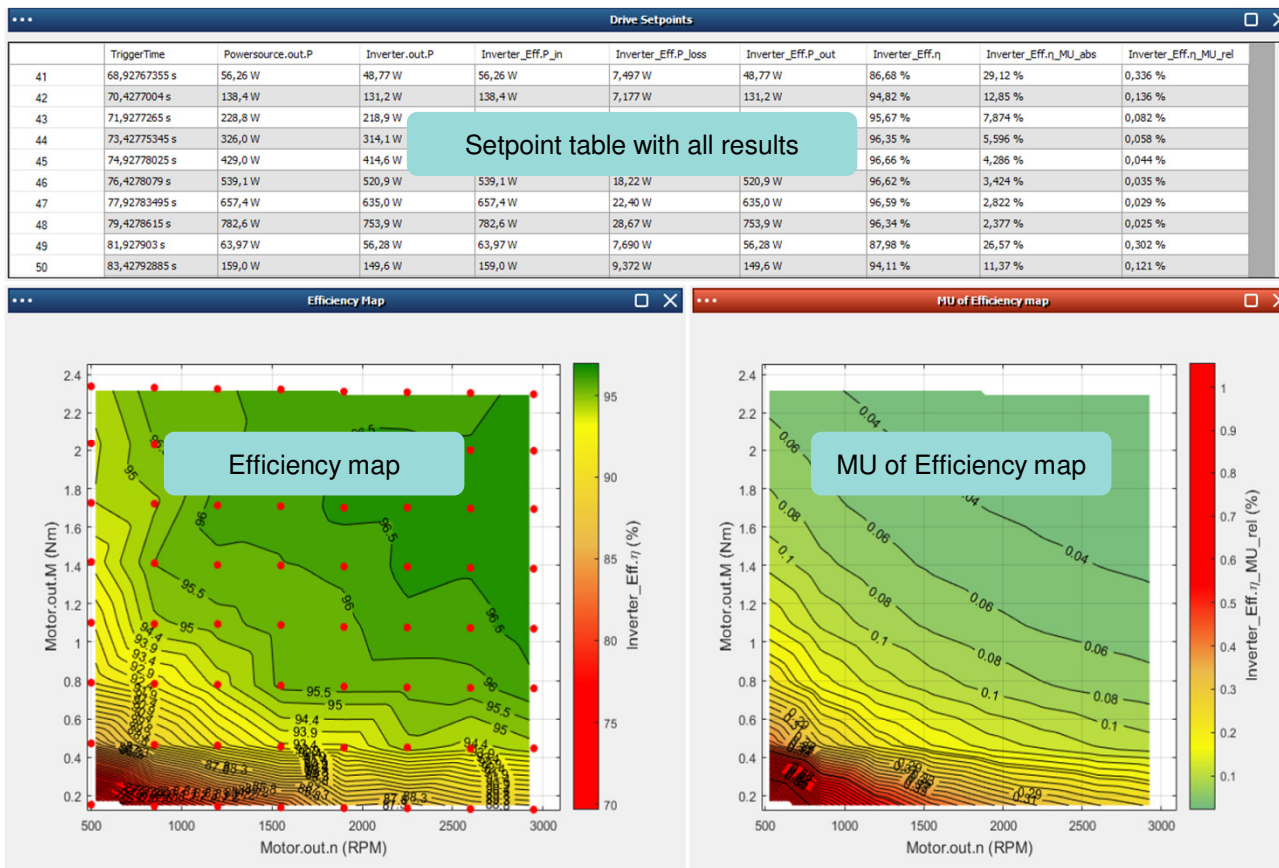
← Inverter fundamental freq
In this example, only the switching frequency increased from 3 kHz, on up ... motor becomes more efficient at higher frequencies

← Inverter power harmonics

← Inverter total power never changes even with changing frequency

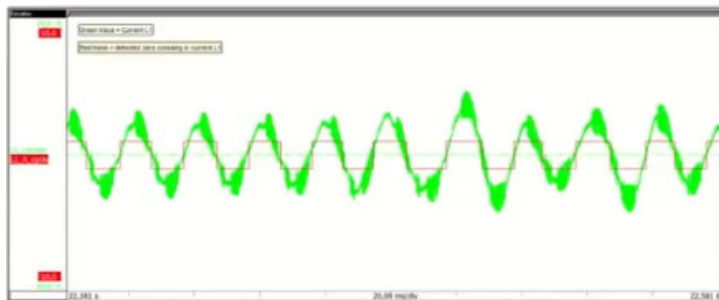
← Inverter current harmonics
inverter losses increase at much higher frequencies

Measurement Uncertainty Auto-Calculated for Every Setpoint

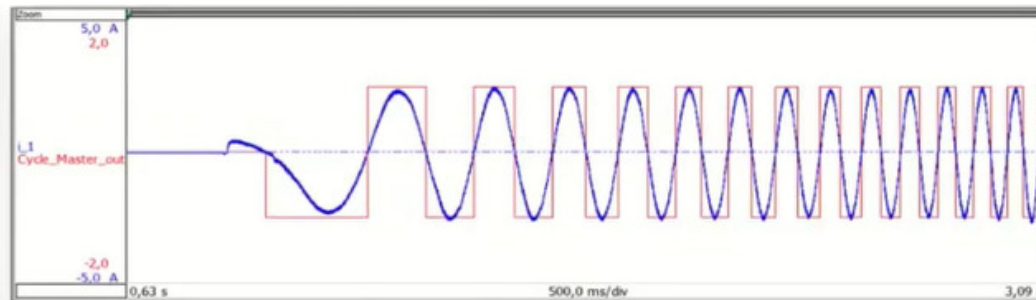


Key To Fast and Accurate Results – Dynamic Power Analyzer

- ▶ Conventional power analyzers perform “Analog” PLL-based calculations
 - Only works in steady-state load conditions like the electric power grid
 - No results are produced while the frequency changes due to load conditions
- ▶ Dynamic power analyzer detects cycles in real time using advanced digital algorithms
 - Power calculations are performed every half or full cycle (or any multiple)
 - Results are provided continuously and accurately even during dynamic load conditions, run up/down
 - Measure electrical and mechanical power accurately on the same cycle, no more >1 efficiency results

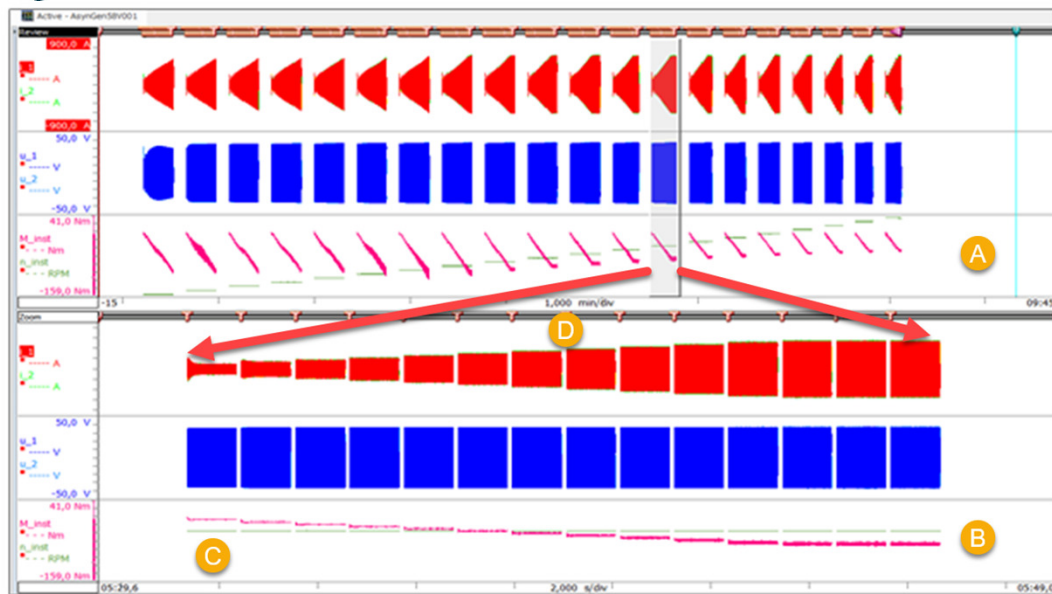


Current trace used for Cycle detection (green)
and resulting “CycleMaster” trace (red)



eDrive Cycle detection working during machine startup
at rapidly changing fundamental frequencies

Dynamic Power Measurements – Accelerate Efficiency Mapping



① Real time raw data storage

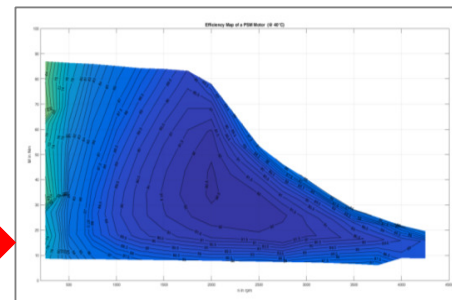
- Example: 280 set points
 - A. 20 different speed values
 - B. 14 different torque values
 - Each set point:
 - C. 1 sec recording
 - D. 100 ms pause, then next torque step
 - After torque ramp,
 - a few secs pause, then next speed step
- ➡ full test in about 8 minutes

Typical analyzer may take 10X longer, 1.5-2 hours
 ~10 s to settle on changing frequency
 Added wait time for motor to cool

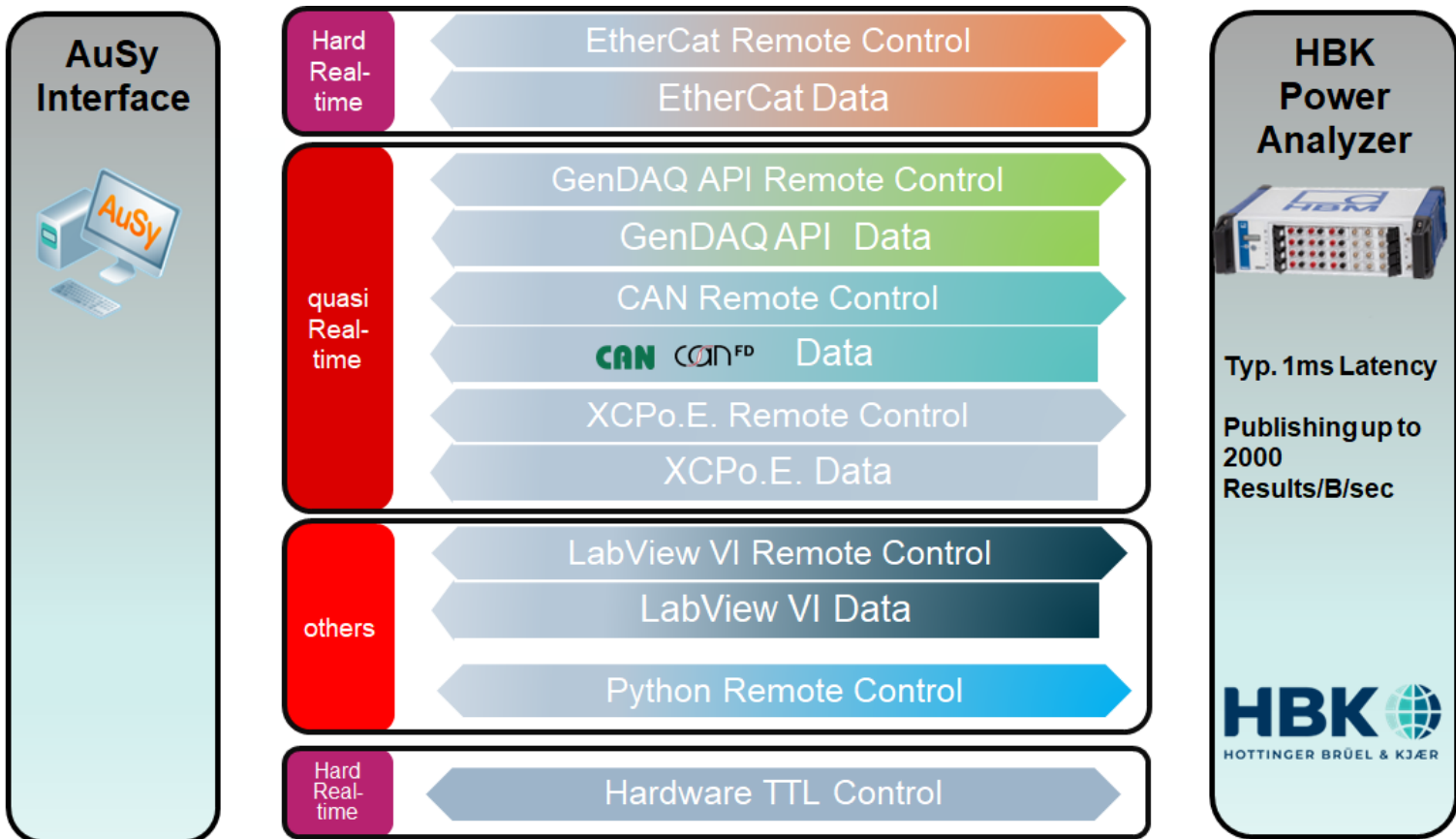
M	n	P_mech	P	n_mech	η	P_in
43.40 Nm	140.00 rpm	1185.11 W	1301.70 W	68.42 %	0.83	1566.51 W
53.88 Nm	140.00 rpm	1485.51 W	1601.51 W	76.27 %	0.88	1848.51 W
63.27 Nm	140.00 rpm	1785.11 W	1901.51 W	83.31 %	0.94	2191.21 W
72.66 Nm	140.00 rpm	2085.11 W	2201.51 W	94.26 %	0.98	2473.51 W
82.05 Nm	140.00 rpm	2385.11 W	2501.51 W	95.34 %	0.99	2856.51 W
91.44 Nm	140.00 rpm	2685.11 W	2801.51 W	95.84 %	0.99	3139.51 W
100.83 Nm	140.00 rpm	2985.11 W	3101.51 W	96.24 %	0.99	3422.51 W
110.22 Nm	140.00 rpm	3285.11 W	3401.51 W	96.44 %	0.99	3705.51 W
119.61 Nm	140.00 rpm	3585.11 W	3701.51 W	96.59 %	0.99	3988.51 W
129.00 Nm	140.00 rpm	3885.11 W	4001.51 W	96.70 %	0.99	4271.51 W
138.39 Nm	140.00 rpm	4185.11 W	4301.51 W	96.80 %	0.99	4554.51 W
147.78 Nm	140.00 rpm	4485.11 W	4601.51 W	96.89 %	0.99	4837.51 W
157.17 Nm	140.00 rpm	4785.11 W	4901.51 W	96.96 %	0.99	5120.51 W
166.56 Nm	140.00 rpm	5085.11 W	5201.51 W	97.01 %	0.99	5403.51 W
175.95 Nm	140.00 rpm	5385.11 W	5501.51 W	97.05 %	0.99	5686.51 W
185.34 Nm	140.00 rpm	5685.11 W	5801.51 W	97.08 %	0.99	5969.51 W
194.73 Nm	140.00 rpm	5985.11 W	6101.51 W	97.10 %	0.99	6252.51 W
204.12 Nm	140.00 rpm	6285.11 W	6401.51 W	97.11 %	0.99	6535.51 W
213.51 Nm	140.00 rpm	6585.11 W	6701.51 W	97.11 %	0.99	6818.51 W
222.90 Nm	140.00 rpm	6885.11 W	7001.51 W	97.10 %	0.99	7101.51 W
232.29 Nm	140.00 rpm	7185.11 W	7301.51 W	97.08 %	0.99	7384.51 W
241.68 Nm	140.00 rpm	7485.11 W	7601.51 W	97.05 %	0.99	7667.51 W
251.07 Nm	140.00 rpm	7785.11 W	7901.51 W	97.00 %	0.99	7950.51 W
260.46 Nm	140.00 rpm	8085.11 W	8201.51 W	96.94 %	0.99	8233.51 W
269.85 Nm	140.00 rpm	8385.11 W	8501.51 W	96.86 %	0.99	8516.51 W
279.24 Nm	140.00 rpm	8685.11 W	8801.51 W	96.76 %	0.99	8799.51 W
288.63 Nm	140.00 rpm	8985.11 W	9101.51 W	96.64 %	0.99	9082.51 W
298.02 Nm	140.00 rpm	9285.11 W	9401.51 W	96.49 %	0.99	9365.51 W
307.41 Nm	140.00 rpm	9585.11 W	9701.51 W	96.32 %	0.99	9648.51 W
316.80 Nm	140.00 rpm	9885.11 W	10001.51 W	96.13 %	0.99	9931.51 W
326.19 Nm	140.00 rpm	10185.11 W	10301.51 W	95.92 %	0.99	10214.51 W
335.58 Nm	140.00 rpm	10485.11 W	10601.51 W	95.68 %	0.99	10497.51 W
344.97 Nm	140.00 rpm	10785.11 W	10901.51 W	95.42 %	0.99	10780.51 W
354.36 Nm	140.00 rpm	11085.11 W	11201.51 W	95.14 %	0.99	11063.51 W
363.75 Nm	140.00 rpm	11385.11 W	11501.51 W	94.84 %	0.99	11346.51 W
373.14 Nm	140.00 rpm	11685.11 W	11801.51 W	94.52 %	0.99	11629.51 W
382.53 Nm	140.00 rpm	11985.11 W	12101.51 W	94.18 %	0.99	11912.51 W
391.92 Nm	140.00 rpm	12285.11 W	12401.51 W	93.82 %	0.99	12195.51 W
401.31 Nm	140.00 rpm	12585.11 W	12701.51 W	93.44 %	0.99	12478.51 W
410.70 Nm	140.00 rpm	12885.11 W	13001.51 W	93.04 %	0.99	12761.51 W
420.09 Nm	140.00 rpm	13185.11 W	13301.51 W	92.62 %	0.99	13044.51 W
429.48 Nm	140.00 rpm	13485.11 W	13601.51 W	92.18 %	0.99	13327.51 W
438.87 Nm	140.00 rpm	13785.11 W	13901.51 W	91.72 %	0.99	13610.51 W
448.26 Nm	140.00 rpm	14085.11 W	14201.51 W	91.24 %	0.99	13893.51 W
457.65 Nm	140.00 rpm	14385.11 W	14501.51 W	90.74 %	0.99	14176.51 W
467.04 Nm	140.00 rpm	14685.11 W	14801.51 W	90.22 %	0.99	14459.51 W
476.43 Nm	140.00 rpm	14985.11 W	15101.51 W	89.68 %	0.99	14742.51 W
485.82 Nm	140.00 rpm	15285.11 W	15401.51 W	89.12 %	0.99	15025.51 W
495.21 Nm	140.00 rpm	15585.11 W	15701.51 W	88.54 %	0.99	15308.51 W
504.60 Nm	140.00 rpm	15885.11 W	16001.51 W	87.94 %	0.99	15591.51 W
513.99 Nm	140.00 rpm	16185.11 W	16301.51 W	87.32 %	0.99	15874.51 W
523.38 Nm	140.00 rpm	16485.11 W	16601.51 W	86.68 %	0.99	16157.51 W
532.77 Nm	140.00 rpm	16785.11 W	16901.51 W	86.02 %	0.99	16440.51 W
542.16 Nm	140.00 rpm	17085.11 W	17201.51 W	85.34 %	0.99	16723.51 W
551.55 Nm	140.00 rpm	17385.11 W	17501.51 W	84.64 %	0.99	17006.51 W
560.94 Nm	140.00 rpm	17685.11 W	17801.51 W	83.92 %	0.99	17289.51 W
570.33 Nm	140.00 rpm	17985.11 W	18101.51 W	83.18 %	0.99	17572.51 W
579.72 Nm	140.00 rpm	18285.11 W	18401.51 W	82.42 %	0.99	17855.51 W
589.11 Nm	140.00 rpm	18585.11 W	18701.51 W	81.64 %	0.99	18138.51 W
598.50 Nm	140.00 rpm	18885.11 W	19001.51 W	80.84 %	0.99	18421.51 W
607.89 Nm	140.00 rpm	19185.11 W	19301.51 W	80.02 %	0.99	18704.51 W
617.28 Nm	140.00 rpm	19485.11 W	19601.51 W	79.18 %	0.99	18987.51 W
626.67 Nm	140.00 rpm	19785.11 W	19901.51 W	78.32 %	0.99	19270.51 W
636.06 Nm	140.00 rpm	20085.11 W	20201.51 W	77.44 %	0.99	19553.51 W
645.45 Nm	140.00 rpm	20385.11 W	20501.51 W	76.54 %	0.99	19836.51 W
654.84 Nm	140.00 rpm	20685.11 W	20801.51 W	75.62 %	0.99	20119.51 W
664.23 Nm	140.00 rpm	20985.11 W	21101.51 W	74.68 %	0.99	20402.51 W
673.62 Nm	140.00 rpm	21285.11 W	21401.51 W	73.72 %	0.99	20685.51 W
683.01 Nm	140.00 rpm	21585.11 W	21701.51 W	72.74 %	0.99	20968.51 W
692.40 Nm	140.00 rpm	21885.11 W	22001.51 W	71.74 %	0.99	21251.51 W
701.79 Nm	140.00 rpm	22185.11 W	22301.51 W	70.72 %	0.99	21534.51 W
711.18 Nm	140.00 rpm	22485.11 W	22601.51 W	69.68 %	0.99	21817.51 W
720.57 Nm	140.00 rpm	22785.11 W	22901.51 W	68.62 %	0.99	22100.51 W
729.96 Nm	140.00 rpm	23085.11 W	23201.51 W	67.54 %	0.99	22383.51 W
739.35 Nm	140.00 rpm	23385.11 W	23501.51 W	66.44 %	0.99	22666.51 W
748.74 Nm	140.00 rpm	23685.11 W	23801.51 W	65.32 %	0.99	22949.51 W
758.13 Nm	140.00 rpm	23985.11 W	24101.51 W	64.18 %	0.99	23232.51 W
767.52 Nm	140.00 rpm	24285.11 W	24401.51 W	63.02 %	0.99	23515.51 W
776.91 Nm	140.00 rpm	24585.11 W	24701.51 W	61.84 %	0.99	23798.51 W
786.30 Nm	140.00 rpm	24885.11 W	25001.51 W	60.64 %	0.99	24081.51 W
795.69 Nm	140.00 rpm	25185.11 W	25301.51 W	59.42 %	0.99	24364.51 W
805.08 Nm	140.00 rpm	25485.11 W	25601.51 W	58.18 %	0.99	24647.51 W
814.47 Nm	140.00 rpm	25785.11 W	25901.51 W	56.92 %	0.99	24930.51 W
823.86 Nm	140.00 rpm	26085.11 W	26201.51 W	55.64 %	0.99	25213.51 W
833.25 Nm	140.00 rpm	26385.11 W	26501.51 W	54.34 %	0.99	25496.51 W
842.64 Nm	140.00 rpm	26685.11 W	26801.51 W	53.02 %	0.99	25779.51 W
852.03 Nm	140.00 rpm	26985.11 W	27101.51 W	51.68 %	0.99	26062.51 W
861.42 Nm	140.00 rpm	27285.11 W	27401.51 W	50.32 %	0.99	26345.51 W
870.81 Nm	140.00 rpm	27585.11 W	27701.51 W	48.94 %	0.99	26628.51 W
880.20 Nm	140.00 rpm	27885.11 W	28001.51 W	47.54 %	0.99	26911.51 W
889.59 Nm	140.00 rpm	28185.11 W	28301.51 W	46.12 %	0.99	27194.51 W
898.98 Nm	140.00 rpm	28485.11 W	28601.51 W	44.68 %	0.99	27477.51 W
908.37 Nm	140.00 rpm	28785.11 W	28901.51 W	43.22 %	0.99	27760.51 W
917.76 Nm	140.00 rpm	29085.11 W	29201.51 W	41.74 %	0.99	28043.51 W
927.15 Nm	140.00 rpm	29385.11 W	29501.51 W	40.24 %	0.99	28326.51 W
936.54 Nm	140.00 rpm	29685.11 W	29801.51 W	38.72 %	0.99	28609.51 W
945.93 Nm	140.00 rpm	29985.11 W	30101.51 W	37.18 %	0.99	28892.51 W
955.32 Nm	140.00 rpm	30285.11 W	30401.51 W	35.62 %	0.99	29175.51 W
964.71 Nm	140.00 rpm	30585.11 W	30701.51 W	34.04 %	0.99	29458.51 W
974.10 Nm	140.00 rpm	30885.11 W	31001.51 W	32.44 %	0.99	29741.51 W
983.49 Nm	140.00 rpm	31185.11 W	31301.51 W	30.82 %	0.99	30024.51 W
992.88 Nm	140.00 rpm	31485.11 W	31601.51 W	29.18 %	0.99	30307.51 W
1002.27 Nm	140.00 rpm	31785.11 W	31901.51 W	27.52 %	0.99	30590.51 W
1011.66 Nm	140.00 rpm	32085.11 W	32201.51 W	25.84 %	0.99	30873.51 W
1021.05 Nm	140.00 rpm	32385.11 W	32501.51 W	24.14 %	0.99	31156.51 W
1030.44 Nm	140.00 rpm	32685.11 W	32801.51 W	22.42 %	0.99	31439.51 W
1039.83 Nm	140.00 rpm	32985.11 W	33101.51 W	20.68 %	0.99	31722.51 W
1049.22 Nm	140.00 rpm	33285.11 W	33401.51 W	18.92 %	0.99	32005.51 W
1058.61 Nm	140.00 rpm	33585.11 W	33701.51 W	17.14 %	0.99	32288.51 W
1068.00 Nm	140.00 rpm	33885.11 W	34001.51 W	15.34 %	0.99	32571.51 W
1077.39 Nm	140.00 rpm	34185.11 W	34301.51 W	13.52 %	0.99	32854.51 W
1086.78 Nm	140.00 rpm	34485.11 W	34601.51 W	11.68 %	0.99	33137.51 W
1096.17 Nm	140.00 rpm	34785.11 W	34901.51 W	9.82 %	0.99	33420.51 W
1105.56 Nm	140.00 rpm	35085.11 W	35201.51 W	7.94 %	0.99	33703.51 W
1114.95 Nm	140.00 rpm	35385.11 W	35501.51 W	6.04 %	0.99	33986.51 W
1124.34 Nm	140.00 rpm	35685.11 W	35801.51 W	4.12 %	0.99	34269.51 W
1133.73 Nm	140.00 rpm	35985.11 W	36101.51 W	2.18 %	0.99	34552.51 W
1143.12 Nm	140.00 rpm	36285.11 W	36401.51 W	0.22 %	0.99	34835.51 W

② A result table is created with P, P_mech, M, n, η values along with the corresponding motor efficiency map in real time

➡ Complete mapping can be done in a few minutes



Integration – wide variety of possibilities



Integration – specifications

		CANFD	EtherCAT	GEN DAQ API	Python	Perception Remote (RPC)
Calculated Result Transfer		Yes	Yes	Yes	No	Yes
Raw Data Transfer		No	Yes	No	No	No
Bus recording		Yes (CAN-recording)	No	N/A	N/A	N/A
Remote Control of Mainframe		Yes	Yes	Yes	Yes	Yes
Timing		Semi real time	Real time	Real time	Real time	Live
Latency (typical)		1 ms plus bus load caused delay	1 ms	1 ms plus bus variance	1 ms plus bus variance	Several ms, unpredictable
Max. Speed (result blocks/s)		1000	1000	2000	N/A	20
Max. block size (results/block)	GEN2tB	256	256	256	N/A	All available RT-FDB results
	GEN4tB	500	500	500	N/A	
	GEN7tA	1000	1000	1000	N/A	
	GEN17tA	1000	1000	1000	N/A	



XCP-over-Ethernet

For real-time result transfer into automotive ECU environments, the HBK power analyzer mainframe can transfer results via XCP-over-Ethernet protocol to standard tools for ECU development.

HBK ... A complete solution



Simple data
collection of electro-
mechanical signals



Fast and accurate
efficiency
measurements



Expandable to
high channel
counts



Recorded Data &
Scope function



Real Time
Calculations &
Feedback

One stop shop

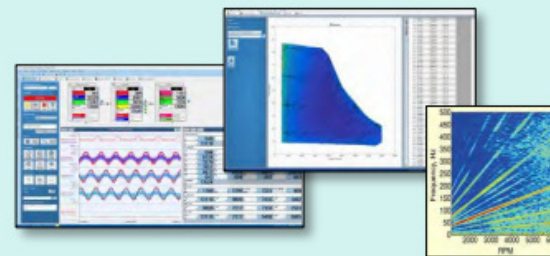
Sensors



Acquisition

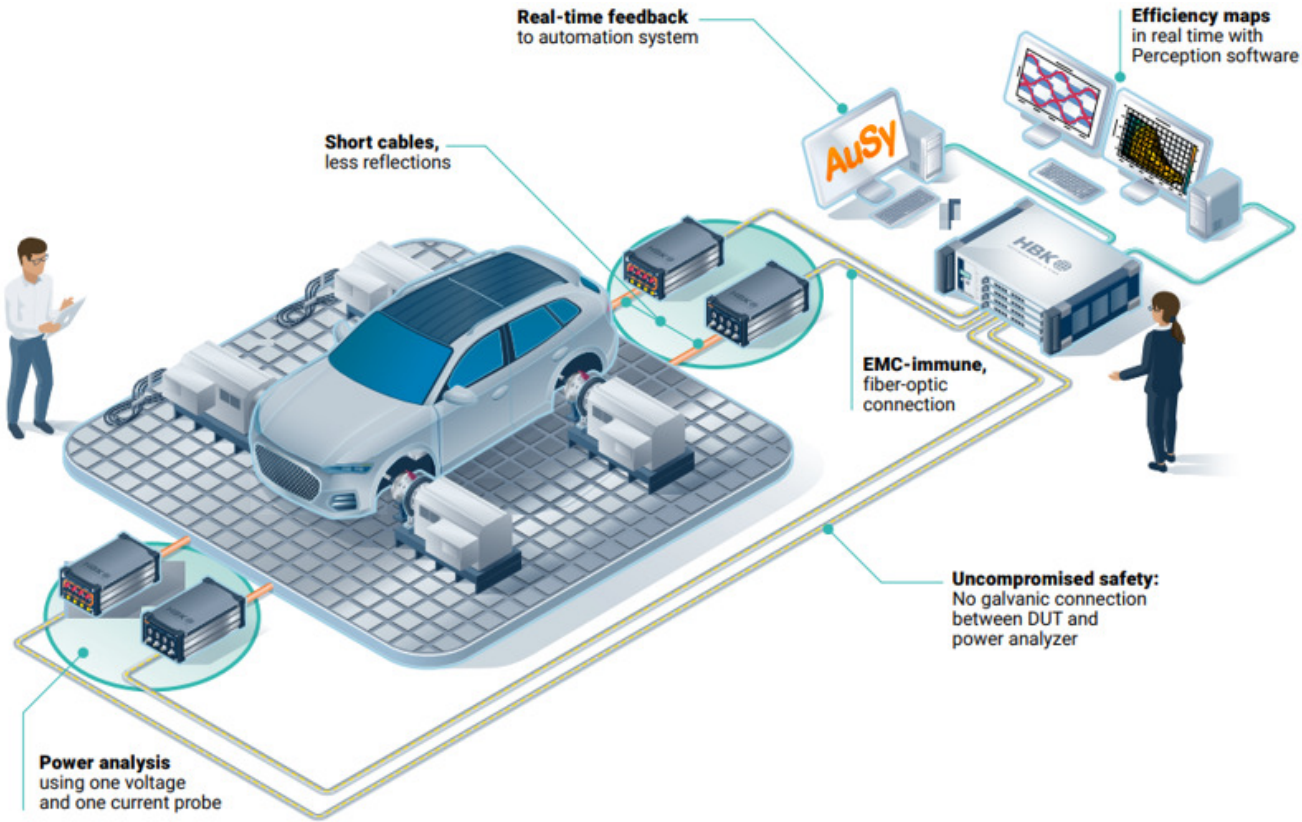


Software



Local Application support and product training

HBK Solutions - More Details ...



▲ www.hbm.com/edrive

- Links to more details

▲ **HBK** Technical Support ...

- **North America:**
- 1-800-578-4260
- support@usa.hbm.com
- **Worldwide:**
- www.hbkworld.com
- support@hbkworl.com

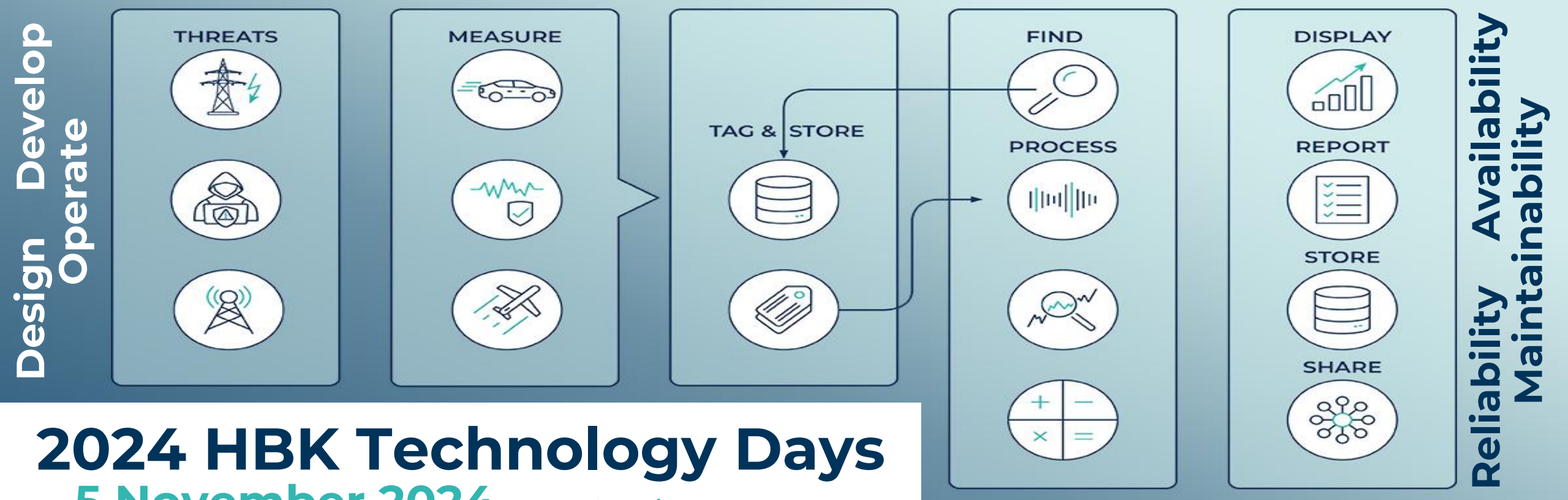
Thank You ... Questions?

MIKE.HOYER@HBKWORLD.COM

Presenter - Mike Hoyer
HBK Applications Engineer



PUBLIC

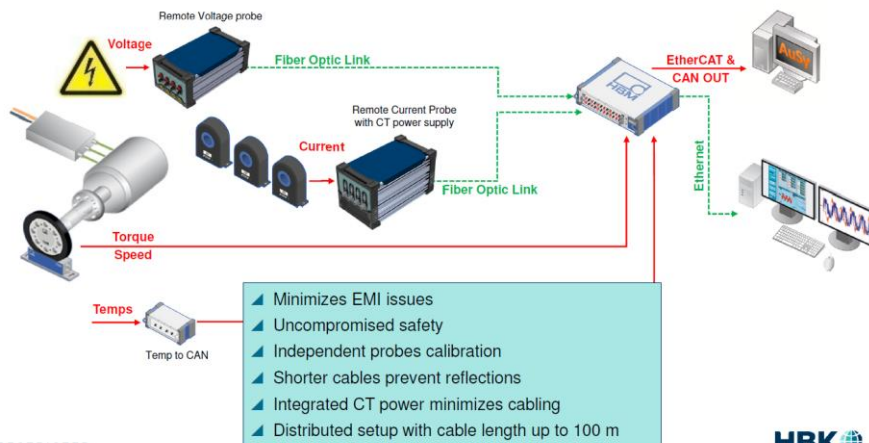


2024 HBK Technology Days

5 November 2024

Session 1: Minimising Electromagnetic Interference to Measurements

New: GN800B card with remote voltage & current probes



- Conquer EMI issues & accurately, rapidly & safely measure & map electric powertrains

Mike Hoyer,
HBK Electric Power Testing