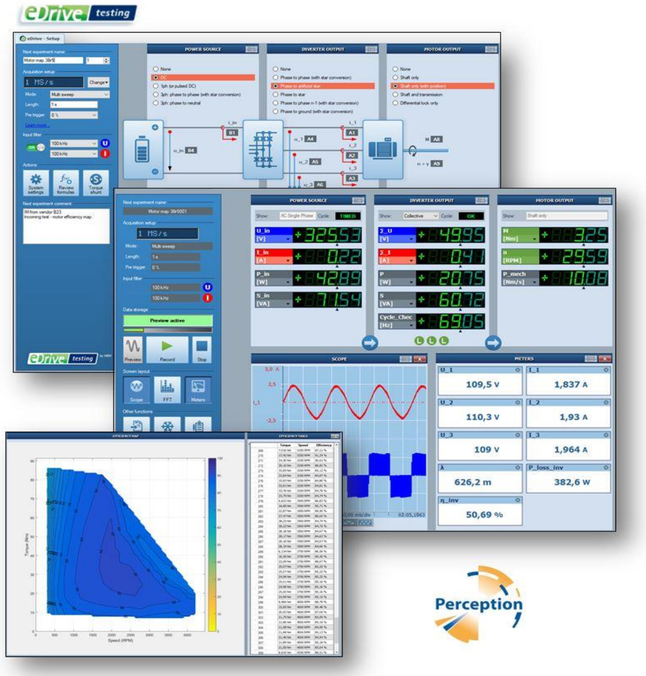
Data sheet

Perception eDrive option

Real time power calculations and raw data acquisition on inverter driven electrical systems



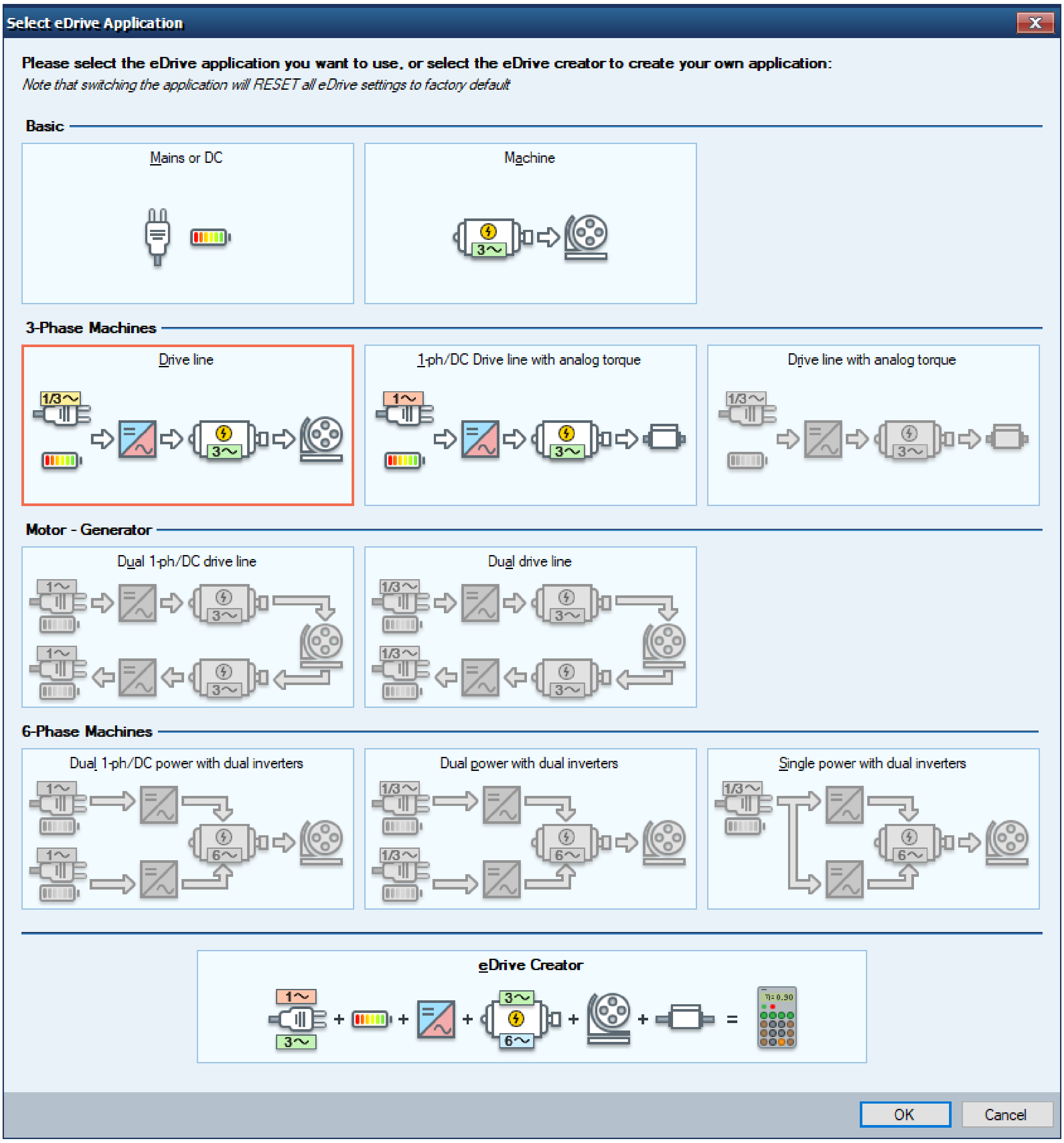
Special features

- Out of the box solution
- Real time computations of RMS, P, S, Q, λ, η, cosφ, fundamental RMS, space vectors and more
- Live scope and FFT displays
- Raw data acquisition (continuous or per set-point) for analysis and verification of results
- Advanced, digital cycle detection
- Automatic real time formula creation, and custom formulas for real time execution
- Analysis of 1 - 20 phase machines
- Support of up to 6 torque & 6 speed transducers and other signals like CAN, vibration or temperature
- Application-oriented graphical setup
- Motor efficiency mapping
- Real time streaming of results to automation system or transfer to EXCEL for mappings

The Perception eDrive software option is a dedicated application solution for real time power calculations with simultaneous raw data acquisition.
It covers the complete test setup from power source/sink to inverter output to machine shaft in a single, easy to operate software environment.
Setting up a measurement is done in a single page, where all information like the measurement method and sensor selection are present. The setup is supported by a graphical representation of the application including wiring diagrams to avoid operator errors.
The acquisition is controlled from the application giving you both the real time readings of a high end power analyzer and a live waveform display including FFTs like a high end scope.
Beyond the standard 3-phase applications, multi-phase systems like 6- or 12-phase machines can be analyzed. Also, complex setups with multiple motors, multi-level inverters or up to six torque transducers can be analyzed in real time as well, without the need for multiple instruments to be daisy chained.
The eDrive option enhances the Perception formula database with advanced analysis like space vector- or dq0-transformation (aka Park transformation), both available in real time or in post process.
The power results are stored as continuous traces, can be transferred straight into Excel for mappings or streamed via real time bus or software interface.

eDrive application selection

Main selection to choose the proper application configuration for eDrive.
Available selections depend on the number of eDrive capable cards available in the mainframe.
Configurations not supported due to not enough eDrive capable cards in the mainframe are grayed out in the selection dialog.
Maximum possible sample rate depends on the used card types.



Application selection dialog accessible under **eDrive-Setup // Select eDrive Application.**

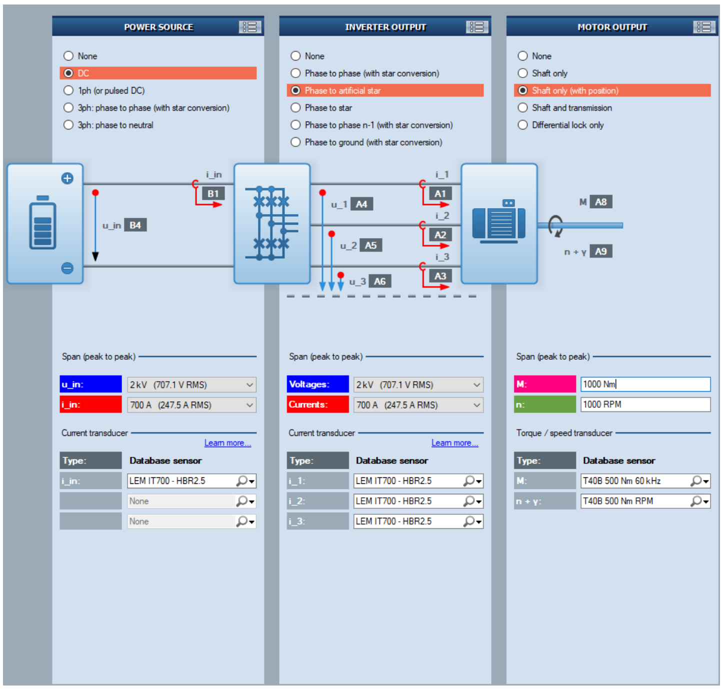
Example shows system equipped with 2 x GN610B cards,
so applications requiring 3 or 4 cards are greyed out.

Supported applications	# of eDrive capable cards needed	Description
Predefined templates		
Basic		
Mains or DC	1	Testing a 50/60/400 Hz mains grid, or a DC source. Only power source/sink (or mains/grid) is analyzed; no inverter output or mechanical measurements are possible.
Machine	1	Testing an electrical machine only. Only machine input (inverter output or grid) and machine output is analyzed; no inverter input measurement possible.
3-Phase Machines		
Drive line	2	Testing a single drive line of power source/sink – inverter – electrical machine. All measurement configurations are supported.
1-ph/DC Drive line with analog torque	2	Testing a single drive line of power source/sink – inverter – electrical machine with an analog out torque transducer. Due to the required analog input channel for torque, the measurement configurations for the power source/sink are limited to DC and AC1ph.
Drive line with analog torque	3	Testing a single drive line of power source/sink – inverter – electrical machine with an analog out torque transducer. As additional analog channels are available, all measurement configurations are supported.
Motor - Generator		
Dual 1-ph/DC drive line	3	Back to back testing of power source – inverter – motor – generator – inverter – power sink. Due to the limited channel count, the measurement configurations for the power source/sink are limited to DC and AC1ph. “Differential Lock” is not supported at the motor output.
Dual drive line	4	Back to back testing of power source – inverter – motor – generator – inverter – power sink. All measurement configurations are supported, except “Differential Lock” at the motor output.
6-Phase Machines		
Dual 1-ph/DC power with dual inverters	3	Testing a single drive line of dual power source/sink – dual inverter – 6-phase electrical machine. Due to the limited channel count, the measurement configurations for the inverter inputs are limited to DC and AC1ph.
Dual power with dual inverters	4	Testing a single drive line of dual power source/sink – dual inverter – 6-phase electrical machine. All measurement configurations are supported.
Single power with dual inverters	3	Testing a single drive line of common power source/sink – dual inverter – 6-phase electrical machine. All measurement configurations are supported.
eDrive Creator		
eDrive Creator	Min of 1	The eDrive creator allow users to do drive efficiency measurement, inverter, motor or drive mappings and system analysis for any configuration, any complexity.

SETUP - Supported electrical drive configurations

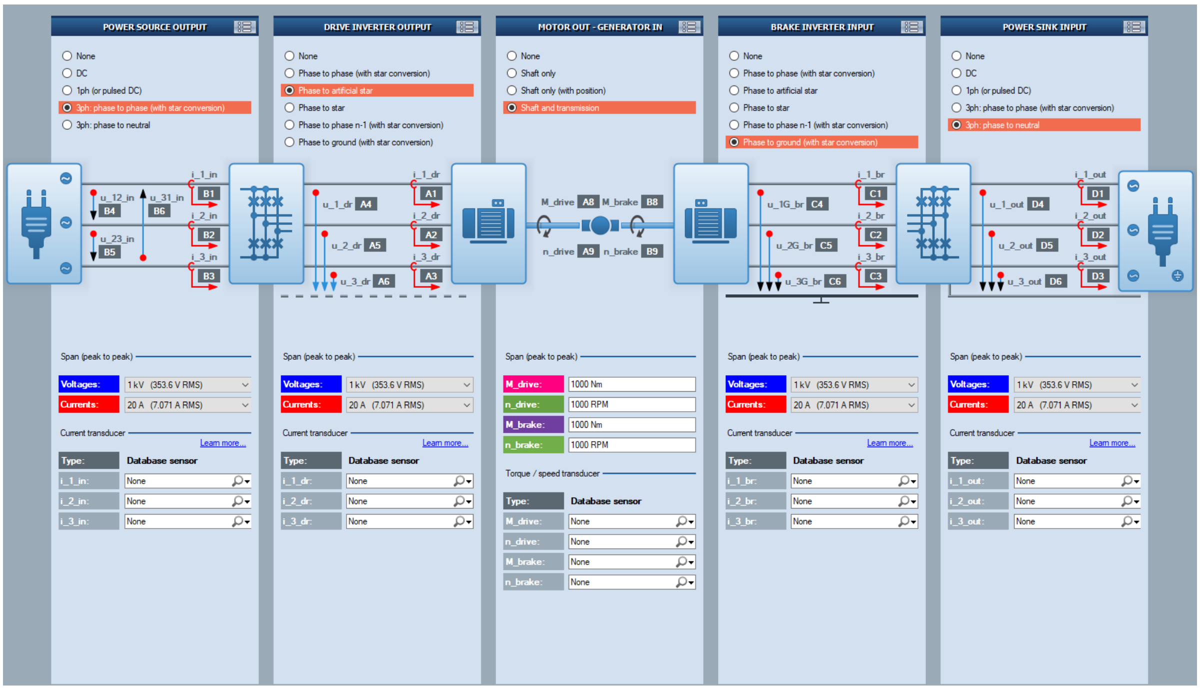
eDrive supports several predefined templates to acquire data and has the option to create a custom configuration.
All of these templates are graphically represented, the real time formulas to compute the desired results are automatically created and the power values are displayed and stored.
For the predefined templates: review formulas for later re-analysis can be created with the press of a button.

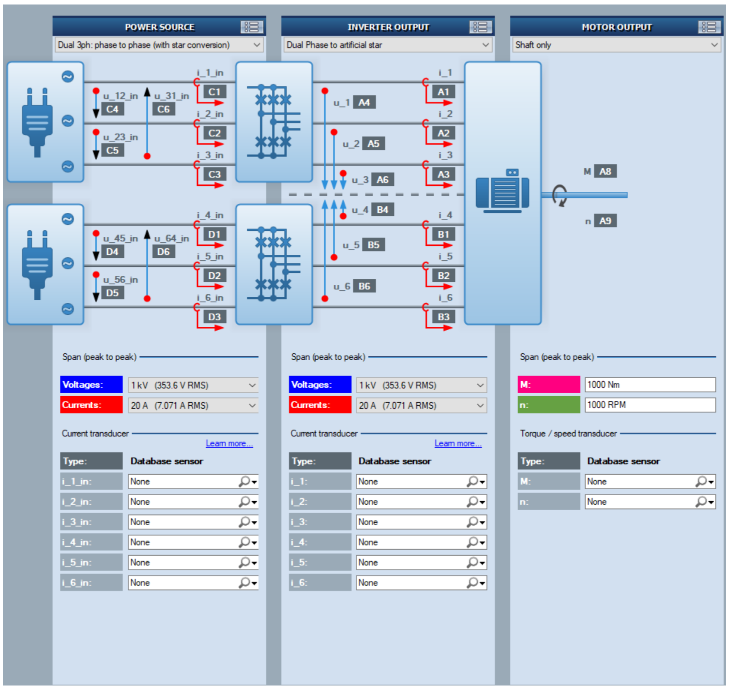
Predefined templates



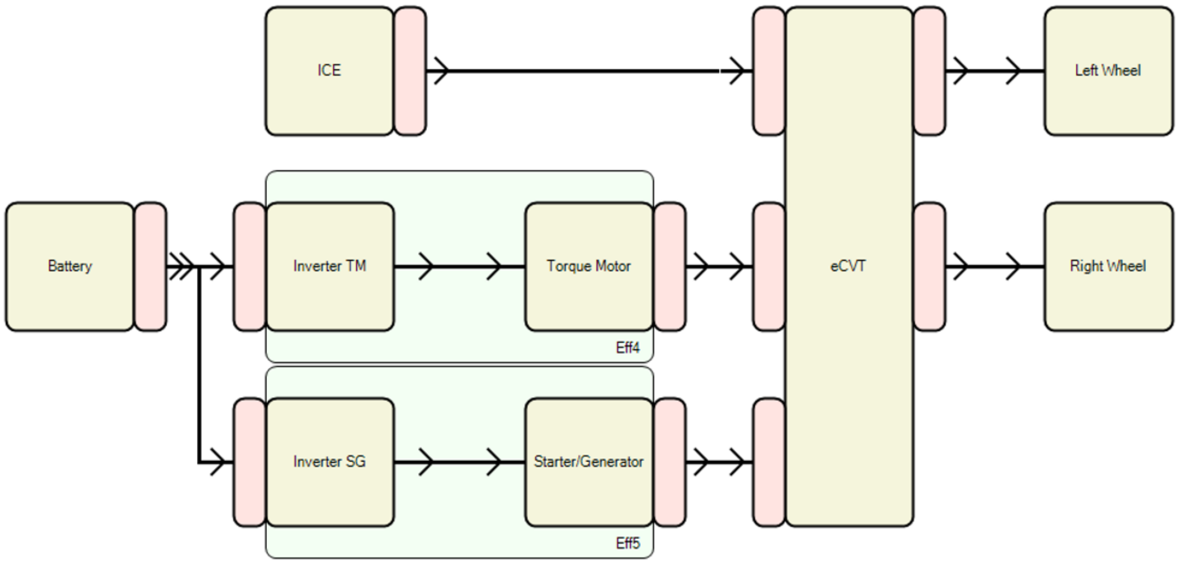
eDrive setup sheet with the following selections:
Application: 3-phase electrical drive line.
Configuration: Power source: DC // Inverter out: Phase to artificial star // Motor out: Shaft only

Configuration block	Supported measurement configuration
Power source	DC AC 1-phase (or pulsed DC) AC 3-phase: phase to phase (with star conversion) AC 3-phase: phase to neutral
Inverter output	AC 3-phase: Phase to phase (with star conversion) AC 3-phase: Phase to artificial star AC 3-phase: Phase to star AC 3-phase: Phase to phase n-1 (with star conversion) AC 3-phase: Phase to ground (with star conversion) Dual AC 3-phase: Phase to phase (with star conversion) Dual AC 3-phase: Phase to artificial star Dual AC 3-phase: Phase to star Dual AC 3-phase: Phase to phase n-1 (with star conversion) Dual AC 3-phase: Phase to ground (with star conversion)
Motor output	With one torque / speed transducer: Shaft only Shaft only (with position) With two torque / speed transducers: Shaft and transmission Differential lock only
Generator support	All available modes for motors and inverters can be used for generators as well without limitation. Energy flow is then in the opposite direction and indicated accordingly.

<table>
<tr><td>Motor-Generator modes</td><td>This is a combination of some of the above mentioned blocks to analyze a drive line with inverter – motor – transmission – generator – inverter.
Due to channel count, this is only possible if at least 3 x GN61xB cards are present.
The 3 card motor – generator mode also requires at least a GEN3i or GEN3t mainframe, while the 4 card motor – generator mode requires a GEN7i, GEN7tA or GEN17t mainframe.</td></tr>
<tr><td colspan="2">

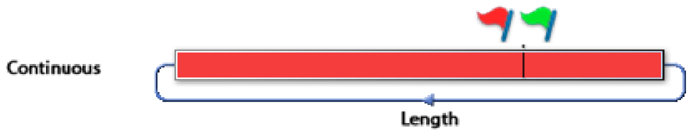
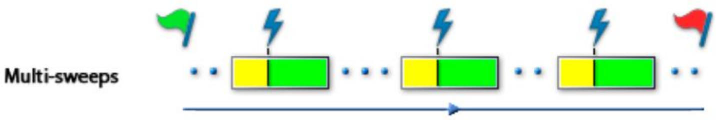
eDrive setup sheet with the following selections:
Application: Two 3-phase electrical machines as Motor – Generator.
Configuration: Power out: 3ph: phase to phase // Inverter out: Phase to artificial star // Motor out – Generator in: Shaft and transmission // Inverter in: Phase to ground // Power in: 3ph: phase to neutral</td></tr>
<tr><td>6-phase inverter modes</td><td>This is a combination of some of the above mentioned blocks to analyse 6-phase electrical machines with dual 3-phase inverters
Due to channel count, this is only possible if at least 3 x GN61xB cards are present.</td></tr>
<tr><td colspan="2">

eDrive setup sheet with the following selections:
Application: 6-phase electrical machine with dual 3-phase inverter and individual 3-phase power.
Configuration: Power out: Dual 3ph: phase to phase // Inverter out: Dual Phase to artificial star // Motor out: Shaft only</td></tr>
</table>

eDrive Creator	
In this mode it is possible to build your own system setup, guided by a graphical representation. Simple configuration selections and channel assignments are sufficient to generate a tailor-made fully functional eDrive system.	
 eDrive creator configuration representing a Hybrid drive with eCVT. Configuration: 6 x AC Power channels, 3 x DC power channels and 5 x torque/speed mechanical power channels	
Supported measurement configuration	AC 1-Phase AC 3-Phase: Phase to artificial star AC 3-Phase: Phase to ground (with star conversion) AC 3-Phase: Phase to phase (Aron) (with star conversion) AC 3-Phase: Phase to phase (with star conversion) AC 3-Phase: Phase to neutral AC n-Phase DC 1-Phase Mech – Torque digital / Speed analog Mech – Torque analog / Speed analog Mech – Torque analog / Speed digital Mech – Torque digital / Speed digital

Acquisition Modes, Sample Rates and Trigger

There are three different acquisition modes supported in eDrive.
Depending on whether a run-up test should be performed, or a motor mapping should be done, the proper acquisition mode can be selected in the user interface.

Acquisition mode	Use case and description
Continuous	Typically used for startup tests or for transient testing like step response of drive on torque steps….  Acquisition started and stopped by the user; or via software command or TTL remote control.
Continuous - Specified time	Typically used for a short series of tests, like drive behavior at different working conditions.  Acquisition started by the user; or via software command or TTL remote control; then stopped automatically after predefined time.
Continuous - Circular	Typically used for long running tests in which only the last recorded data is wanted.  Acquisition started and stopped by the user; or via software command or TTL remote control;
Multi Sweeps	Typically used for a series of tests with hundreds or thousands of events, like motor mapping. For this a very short, triggered event is stored per motor set point.  Acquisition is armed and stopped by the user; or via software command or TTL remote control. After being armed, the system waits for triggers. Every trigger (to start a single, short acquisition) is controlled manually or via software command or via TTL remote control. *Note: Due to the real time storage capabilities of the eDrive hardware and the ability to record triggers without dead time in between, this whole process to acquire raw data and compute results for motor mapping can be done in a few minutes for thousands of set points.*
Dual	Combination of Continuous mode with embedded, triggered Multi Sweeps mode; only supported **outside eDrive using Perception**.
Slow Fast Sweeps	This acquisition mode is **not supported** in the real time formula database and thus also not in eDrive.
Sample rate	All channels used in eDrive sample simultaneously and with the same sample rate (except temperatures and CAN bus data) *Note: eDrive does not support external clock/timebase.*
Maximum sample rate	2 MS/s when only GN610B or GN1202B cards are in the eDrive setup, 200 kS/s when a GN611B is present. For standard eDrive generated formulas only. The maximum sample rate might go down

	pending on the added optional eDrive formulas or the load of additional user formulas.
Minimum sample rate	50 kS/s
Sweep length	50 ms to 5 s *Note: Longer sweeps be done from within Perception, or similar results can be achieved by using* ***Continuous – Specified time*** *mode.*
Trigger	External via TTL input or keyboard command. By software using Perception RPC or GEN DAQ API. Trigger via CAN bus command possible using HCT1 trigger option. No trigger support on analog channels or calculated channels;

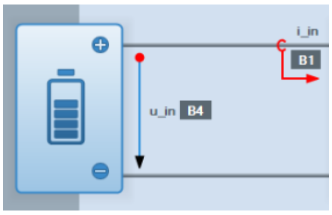
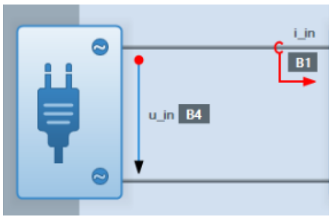
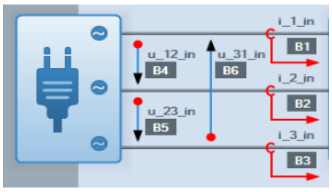
Sensor Support	
Voltage sensors 	The eDrive hardware offers direct voltage inputs up to +/- 1 kV, for applications up to this voltage level no voltage sensors are needed. For higher voltages, the high voltage probe HVD50R (left picture) with an input of 5 kV_{RMS} can be used. Other voltage transducers are supported as well. ***Note**: For higher voltage levels > 5 kV_{RMS}, the HBM ISOBE5600 isolated probe system offers fiber-optic isolation to nearly unlimited levels using 3rd party high voltage dividers in front.*
Current sensors 	The eDrive hardware supports various current sensors: • Zero-flux current transducers can be connected to the optional high precision burden resistors HBRxx. Power supply for current transducers needs to be provided separately. • AC and AC/DC current clamps and Rogowski coils can be directly connected to the voltage inputs; this might need a cable adapter (BNC to 4mm Banana). • Current shunts are supported using the HBM ISOBE5600 isolated probe system only. ***Note:** For best signal fidelity, the lower side of the CTs output circuitry (one input leg of the burden resistor) needs to be grounded. This avoids the CTs floating with the switching frequency and thus overrides the input's common mode rejection of the eDrive hardware.*
Torque transducers 	The eDrive hardware supports the following torque transducers: • Transducers with frequency output like HBM T12 / T40B • Transducers with analog output like HBM T20 / T22 or any other third party transducer with analog voltage output The transducers torque reading can be inverted in the eDrive software.
Speed sensors 	Most incremental encoders (a,b,z signal output or single frequency) for speed (like the HBM T12 / T40B speed measurement systems) are supported. Differential signal lines are recommended for noise immunity; however, TTL types can be connected as well (requires rewiring). HTL types can be connected using external 3rd party level converters. Quadrature encoding is used to improve resolution. The transducers speed reading can be inverted in the eDrive software.
Angle recording (from speed sensors)	The mechanical angle is computed from the a,b,z encoder signal and shown as a trace. This is done first and then the speed is derived from the angle. If a reference pulse is present, the angle trace will be reset to 0° by this pulse. Without reference pulse, the angle trace will be automatically reset to 0° after receiving pulses equivalent to 360°, and is then not referenced. By entering the offset angle between mechanical and electrical angle, and the number of pole pairs of the motor, the measured mechanical angle can be converted into the electrical angle (needed for advanced analysis like dq0-transformation).
Other sensors & signals 	Other sensors like thermocouples, Ptxxx, accelerometers, strain gages, and force transducers can be connected to the eDrive system using optional GN840B/GN1640B input cards or QuantumX satellites; standard Perception user interface is used to set up these channels and to record these signals together with the eDrive signals; post-run analysis (like copper resistance calculation with respect to coil temperature) can be done using the formula database.
Resolvers and **sin / cos encoders** 	Currently not supported by the eDrive hardware; if such sensors should be used, there are 3th party hardware modules available to convert the resolver or sin/cos encoder output signal to an incremental (a,b,z-type) encoder signal, which can be connected to the eDrive hardware.

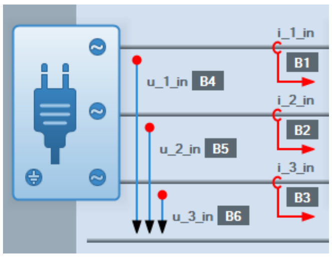
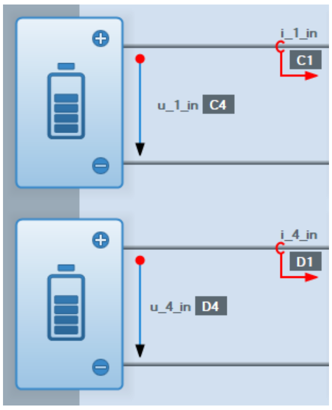
Sensor database	All sensors used in the eDrive application need to be present in the sensor database, as they are used from there. Hundreds of popular HBM sensors are already available in the sensor database and can be used out of the box. Other sensors can be used by entering them into the sensor database first.
Voltage sensors	Voltage sensors to be used with eDrive need to be entered as **voltage probe** sensors, and the probe type needs to be one of the following types: **- Active, differential** **- Voltage transformer** **- Passive, Differential**, **Safety Earthed** **- Passive, Floating Differential.**
Speed sensors	Speed sensors to be used with eDrive need to be entered as frequency sensors, and the frequency type needs to be one of the following types: **- Uni directional** **- Bi directional** **- Quadrature.**
Torque sensors	Digital torque sensors to be used with eDrive need to be entered as **uni-directional frequency** sensors. Analog torque sensors to be used with eDrive need to be entered as **voltage** or **voltage probe** sensors and can be of any type but the scaling units need to be in “Nm”.

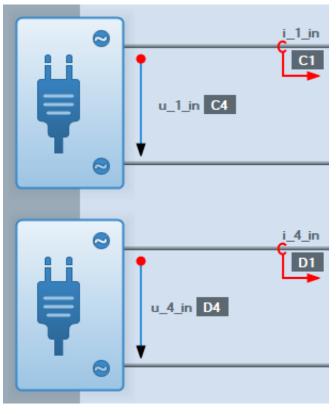
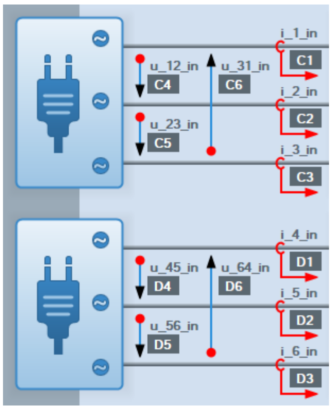
Real time calculations

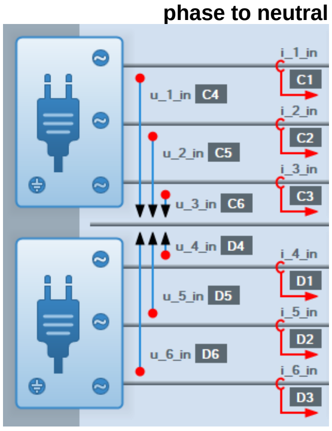
Real time calculations process all data back to back on the cycles found in the continuous data stream (or on a time segment if **Timed** is selected as cycle source; or per mechanical revolution if **Reference pulse** is selected as cycle source).
Power results can be displayed as traces or numerically in meters and tables, or transferred to EXCEL or to a remote PC using Perception RPC, GEN DAQ API, real time EtherCAT bus or CAN bus.
All standard eDrive calculations can be executed on all channels simultaneously up to the full sample rate of the used input boards, or 2 MS/s, whichever is lower.
Very complex configurations with lots of user entered formulas might require to lower the sample rate below this limit..
All calculations can also be redone in post process with the Perception formula database.

Predefined templates

POWER SOURCE	Available calculations depend on selected power source and connection, see below	
DC 	Measured: i_in u_in Calculated: I_in U_in i_in_mean u_in_mean P_in Cycle_Master_in Cycle_Check_in CycleStart_in CycleEnd_in	 Current Voltage RMS of input current RMS of input voltage Mean of input current Mean of input voltage True power Cycle detect result[2] Frequency of cycles detected on Cycle_Master_in Start time of the analysis cycle[3] End time of the analysis cycle[3]
AC 1-phase (or pulsed DC) 	Measured: i_in u_in Calculated: I_in U_in p_in P_in S_in Q_in λ_in φ_fund_in cosφ_fund_in U_fund_in I_fund_in Cycle_Master_in Cycle_Check_in CycleStart_in CycleEnd_in	 Current Voltage RMS of input current RMS of input voltage Instantaneous power True power Apparent power Reactive power Power factor Phase angle of voltage and current fundamentals[1] Cosine of phase angle[1] RMS voltage of the fundamental[1] RMS current of the fundamental[1] Cycle detect result[2] Frequency of cycles detected on Cycle_Master_in Start time of the analysis cycle[3] End time of the analysis cycle[3]
AC 3-phase: phase to phase (with star conversion) 	Measured: i_1_in, i_2_in, i_3_in u_12_in, u_23_in, u_31_in Calculated: I_1_in, I_2_in, I_3_in Σ_I_in u_1_in, u_2_in, u_3_in U_1_in, U_2_in, U_3_in Σ_U_in U_12_in U_23_in U_31_in Σ_U_PP_in p_1_in, p_2_in, p_3_in p_in P_1_in, P_2_in, P_3_in P_in S_1_in, S_2_in, S_3_in S_in Q_1_in, Q_2_in, Q_3_in Q_in λ_1_in, λ_2_in, λ_3_in	 Currents in phases 1-2-3 Voltages phase to phase 1-2 and 2-3 and 3-1 RMS of currents in phases 1-2-3 Collective (mean) RMS current Instantaneous star voltages in phases 1-2-3 RMS of star voltages in phases 1-2-3 Collective (mean) RMS of star voltages RMS of phase to phase voltage 1-2 RMS of phase to phase voltage 2-3 RMS of phase to phase voltage 3-1 Collective (mean) RMS of phase-phase voltages Instantaneous power in phases 1-2-3 Total instantaneous power True power in phases 1-2-3 Total true power Apparent power in phases 1-2-3 Total apparent power Reactive power in phases 1-2-3 Total reactive power Power factor in phases 1-2-3

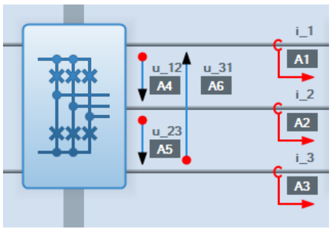
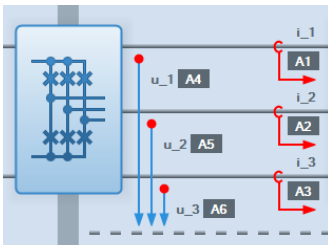
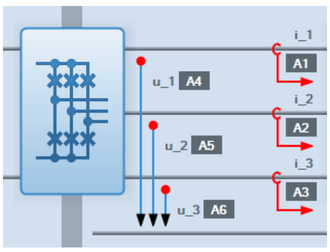
	λ_in φ_fund_1_in φ_fund_2_in φ_fund_3_in cosφ_fund_1_in cosφ_fund_2_in cosφ_fund_3_in U_fund_1_in U_fund_2_in U_fund_3_in Σ_U_fund_in I_fund_1_in I_fund_2_in I_fund_3_in Σ_I_fund_i Cycle_Master_in Cycle_Check_in CycleStart_in CycleEnd_in	Total power factor Phase angle of voltage & current fundamentals phase 1[1)] Phase angle of voltage & current fundamentals phase 2[1)] Phase angle of voltage & current fundamentals phase 3[1)] Cosine of phase angle in phase 1[1)] Cosine of phase angle in phase 2[1)] Cosine of phase angle in phase 3[1)] RMS voltage of the fundamental phase 1[1)] RMS voltage of the fundamental phase 2[1)] RMS voltage of the fundamental phase 3[1)] Collective (mean) RMS of fundamental voltages[1)] RMS current of the fundamental phase 1[1)] RMS current of the fundamental phase 2[1)] RMS current of the fundamental phase 3[1)] Collective (mean) RMS of fundamental currents[1)] Cycle detect result[2)] Frequency of cycles detected on Cycle_Master_in Start time of the analysis cycle[3)] End time of the analysis cycle[3)]
AC 3-phase: phase to neutral  	Measured: i_1_in, i_2_in, i_3_in u_1_in, u_2_in, u_3_in Calculated: I_1_in, I_2_in, I_3_in Σ_I_in U_1_in, U_2_in, U_3_in Σ_U_in p_1_in, p_2_in, p_3_in p_in P_1_in, P_2_in, P_3_in P_in S_1_in, S_2_in, S_3_in S_in Q_1_in, Q_2_in, Q_3_in Q_in λ_1_in, λ_2_in, λ_3_in λ_in φ_fund_1_in φ_fund_2_in φ_fund_3_in cosφ_fund_1_in cosφ_fund_2_in cosφ_fund_3_in U_fund_1_in U_fund_2_in U_fund_3_in Σ_U_fund_in I_fund_1_in I_fund_2_in I_fund_3_in Σ_I_fund_in Cycle_Master_in Cycle_Check_in CycleStart_in CycleEnd_in	 Currents in phases 1-2-3 Voltages from phases 1-2-3 to neutral RMS of input currents in phases 1-2-3 Collective (mean) RMS current RMS of voltages in phases 1-2-3 Collective (mean) RMS voltages Instantaneous power in phases 1-2-3 Total instantaneous power True power in phases 1-2-3 Total true power Apparent power in phases 1-2-3 Total apparent power Reactive power in phases 1-2-3 Total reactive power Power factor in phases 1-2-3 Total power factor Phase angle of voltage & current fundamentals phase 1[1)] Phase angle of voltage & current fundamentals phase 2[1)] Phase angle of voltage & current fundamentals phase 3[1)] Cosine of phase angle in phase 1[1)] Cosine of phase angle in phase 2[1)] Cosine of phase angle in phase 3[1)] RMS voltage of the fundamental phase 1[1)] RMS voltage of the fundamental phase 2[1)] RMS voltage of the fundamental phase 3[1)] Collective (mean) RMS of fundamental voltages[1)] RMS current of the fundamental phase 1[1)] RMS current of the fundamental phase 2[1)] RMS current of the fundamental phase 3[1)] Collective (mean) RMS of fundamental currents[1)] Cycle detect result[2)] Frequency of cycles detected on Cycle_Master_in Start time of the analysis cycle[3)] End time of the analysis cycle[3)]
Dual DC  	Measured: First power source: i_1_in u_1_in Second power source: i_4_in u_4_in Calculated: First power source: I_1_in U_1_in i_1_in_mean u_1_in_mean P_123_in Second power source: I_4_in U_4_in i_4_in_mean	 Current Voltage Current Voltage RMS of input current RMS of input voltage Mean of input current Mean of input voltage True power RMS of input current RMS of input voltage Mean of input current

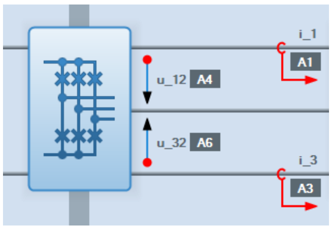
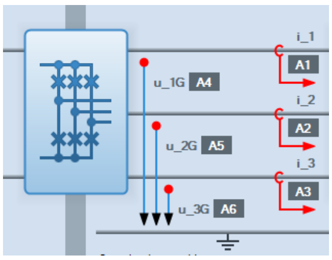
	u_4_in_mean P_456_in Total: P_in Cycle_Master_in Cycle_Check_in CycleStart_in CycleEnd_in	Mean of input voltage True power Total true power Cycle detect result[2] Frequency of cycles detected on Cycle_Master_in Start time of the analysis cycle[3] End time of the analysis cycle[3]
Dual AC 1-phase (or pulsed DC) 	Measured: First power source: i_1_in u_1_in Second power source: i_4_in u_4_in Calculated: First power source: I_1_in U_1_in p_1_in P_123_in S_123_in Q_123_in λ_123_in φ_fund_1_in cosφ_fund_1_in U_fund_1_in I_fund_1_in Second power source: I_4_in U_4_in p_4_in P_456_in S_456_in Q_456_in λ_456_in φ_fund_4_in cosφ_fund_4_in U_fund_4_in I_fund_4_in Total: P_in Cycle_Master_in Cycle_Check_in CycleStart_in CycleEnd_in	 Current Voltage Current Voltage RMS of input current RMS of input voltage Instantaneous power True power Apparent power Reactive power Power factor Phase angle of voltage and current fundamentals[1] Cosine of phase angle[1] RMS voltage of the fundamental[1] RMS current of the fundamental[1] RMS of input current RMS of input voltage Instantaneous power True power Apparent power Reactive power Power factor Phase angle of voltage and current fundamentals[1] Cosine of phase angle[1] RMS voltage of the fundamental[1] RMS current of the fundamental[1] Total true power Cycle detect result[2] Frequency of cycles detected on Cycle_Master_in Start time of the analysis cycle[3] End time of the analysis cycle[3]
Dual AC 3-phase: phase to phase (with star conversion) 	Measured: First power source: i_1_in, i_2_in, i_3_in u_12_in, u_23_in, u_31_in Second power source: i_4_in, i_5_in, i_6_in u_45_in, u_56_in, u_64_in Calculated: First power source: I_1_in, I_2_in, I_3_in Σ_I_123_in u_1_in, u_2_in, u_3_in U_1_in, U_2_in, U_3_in Σ_U_123_in U_12_in U_23_in U_31_in Σ_U_PP_123_in p_1_in, p_2_in, p_3_in p_123_in P_1_in, P_2_in, P_3_in P_123_in S_1_in, S_2_in, S_3_in S_123_in Q_1_in, Q_2_in, Q_3_in Q_123_in λ_1_in, λ_2_in, λ_3_in	 Currents in phases 1-2-3 Voltages phase to phase 1-2 and 2-3 and 3-1 Currents in phases 4-5-6 Voltages phase to phase 4-5 and 5-6 and 6-4 RMS of currents in phases 1-2-3 Collective (mean) RMS current Instantaneous star voltages in phases 1-2-3 RMS of star voltages in phases 1-2-3 Collective (mean) RMS of star voltages RMS of phase to phase voltage 1-2 RMS of phase to phase voltage 2-3 RMS of phase to phase voltage 3-1 Collective (mean) RMS of phase-phase voltages Instantaneous power in phases 1-2-3 Total instantaneous power True power in phases 1-2-3 Total true power Apparent power in phases 1-2-3 Total apparent power Reactive power in phases 1-2-3 Total reactive power Power factor in phases 1-2-3

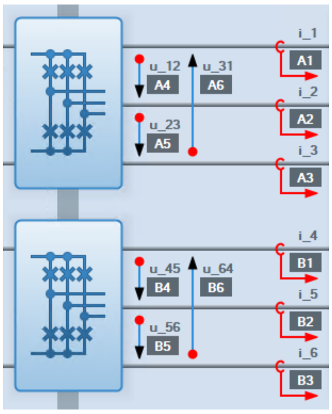
	λ_123_in	Total power factor
	φ_fund_1_in	Phase angle of voltage & current fundamentals phase 1[1)]
	φ_fund_2_in	Phase angle of voltage & current fundamentals phase 2[1)]
	φ_fund_3_in	Phase angle of voltage & current fundamentals phase 3[1)]
	cosφ_fund_1_in	Cosine of phase angle in phase 1[1)]
	cosφ_fund_2_in	Cosine of phase angle in phase 2[1)]
	cosφ_fund_3_in	Cosine of phase angle in phase 3[1)]
	U_fund_1_in	RMS voltage of the fundamental phase 1[1)]
	U_fund_2_in	RMS voltage of the fundamental phase 2[1)]
	U_fund_3_in	RMS voltage of the fundamental phase 3[1)]
	Σ_U_fund_123_in	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_1_in	RMS current of the fundamental phase 1[1)]
	I_fund_2_in	RMS current of the fundamental phase 2[1)]
	I_fund_3_in	RMS current of the fundamental phase 3[1)]
	Σ_I_fund_123_in	Collective (mean) RMS of fundamental currents[1)]
	Second power source:	
	I_4_in, I_5_in, I_6_in	RMS of currents in phases 4-5-6
	Σ_I_456_in	Collective (mean) RMS current
	u_4_in, u_5_in, u_6_in	Instantaneous star voltages in phases 4-5-6
	U_4_in, U_5_in, U_6_in	RMS of star voltages in phases 4-5-6
	Σ_U_456_in	Collective (mean) RMS of star voltages
	U_45_in	RMS of phase to phase voltage 4-5
	U_56_in	RMS of phase to phase voltage 5-6
	U_64_in	RMS of phase to phase voltage 6-4
	Σ_U_PP_456_in	Collective (mean) RMS of phase-phase voltages
	p_4_in, p_5_in, p_6_in	Instantaneous power in phases 4-5-6
	p_456_in	Total instantaneous power
	P_4_in, P_5_in, P_6_in	True power in phases 4-5-6
	P_456_in	Total true power
	S_4_in, S_5_in, S_6_in	Apparent power in phases 4-5-6
	S_456_in	Total apparent power
	Q_4_in, Q_5_in, Q_6_in	Reactive power in phases 4-5-6
	Q_456_in	Total reactive power
	λ_4_in, λ_5_in, λ_6_in	Power factor in phases 4-5-6
	λ_456_in	Total power factor
	φ_fund_4_in	Phase angle of voltage & current fundamentals phase 4[1)]
	φ_fund_5_in	Phase angle of voltage & current fundamentals phase 5[1)]
	φ_fund_6_in	Phase angle of voltage & current fundamentals phase 6[1)]
	cosφ_fund_4_in	Cosine of phase angle in phase 4[1)]
	cosφ_fund_5_in	Cosine of phase angle in phase 5[1)]
	cosφ_fund_6_in	Cosine of phase angle in phase 6[1)]
	U_fund_4_in	RMS voltage of the fundamental phase 4[1)]
	U_fund_5_in	RMS voltage of the fundamental phase 5[1)]
	U_fund_6_in	RMS voltage of the fundamental phase 6[1)]
	Σ_U_fund_456_in	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_4_in	RMS current of the fundamental phase 4[1)]
	I_fund_5_in	RMS current of the fundamental phase 5[1)]
	I_fund_6_in	RMS current of the fundamental phase 6[1)]
	Σ_I_fund_456_in	Collective (mean) RMS of fundamental currents[1)]
	Total:	
	P_in	Total true power
	Cycle_Master_in	Cycle detect result[2)]
	Cycle_Check_in	Frequency of cycles detected on Cycle_Master_in
	CycleStart_in	Start time of the analysis cycle[3)]
	CycleEnd_in	End time of the analysis cycle[3)]
Dual AC 3-phase: phase to neutral 	Measured:	
	First power source:	
	i_1_in, i_2_in, i_3_in	Currents in phases 1-2-3
	u_1_in, u_2_in, u_3_in	Voltages from phases 1-2-3 to neutral
	Second power source:	
	i_4_in, i_5_in, i_6_in	Currents in phases 4-5-6
	u_4_in, u_5_in, u_6_in	Voltages from phases 4-5-6 to neutral
	Calculated:	
	First power source:	
	I_1_in, I_2_in, I_3_in	RMS of input currents in phases 1-2-3
	Σ_I_123_in	Collective (mean) RMS current
	U_1_in, U_2_in, U_3_in	RMS of voltages in phases 1-2-3
	Σ_U_123_in	Collective (mean) RMS voltages
	p_1_in, p_2_in, p_3_in	Instantaneous power in phases 1-2-3
	p_123_in	Total instantaneous power
	P_1_in, P_2_in, P_3_in	True power in phases 1-2-3
	P_123_in	Total true power
	S_1_in, S_2_in, S_3_in	Apparent power in phases 1-2-3
	S_123_in	Total apparent power
	Q_1_in, Q_2_in, Q_3_in	Reactive power in phases 1-2-3

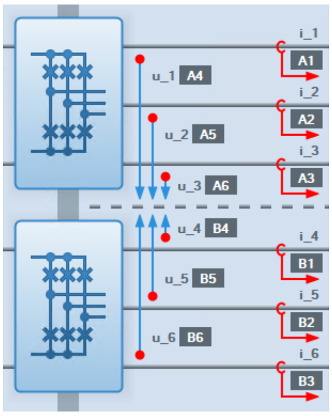
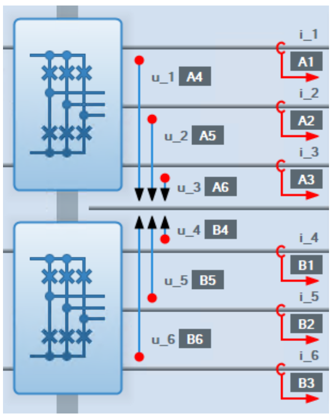
	Q_123_in	Total reactive power
	λ_1_in, λ_2_in, λ_3_in	Power factor in phases 1-2-3
	λ_123_in	Total power factor
	φ_fund_1_in	Phase angle of voltage & current fundamentals phase 1[1]
	φ_fund_2_in	Phase angle of voltage & current fundamentals phase 2[1]
	φ_fund_3_in	Phase angle of voltage & current fundamentals phase 3[1]
	cosφ_fund_1_in	Cosine of phase angle in phase 1[1]
	cosφ_fund_2_in	Cosine of phase angle in phase 2[1]
	cosφ_fund_3_in	Cosine of phase angle in phase 3[1]
	U_fund_1_in	RMS voltage of the fundamental phase 1[1]
	U_fund_2_in	RMS voltage of the fundamental phase 2[1]
	U_fund_3_in	RMS voltage of the fundamental phase 3[1]
	Σ_U_fund_123_in	Collective (mean) RMS of fundamental voltages[1]
	I_fund_1_in	RMS current of the fundamental phase 1[1]
	I_fund_2_in	RMS current of the fundamental phase 2[1]
	I_fund_3_in	RMS current of the fundamental phase 3[1]
	Σ_I_fund_123_in	Collective (mean) RMS of fundamental currents[1]
	Second power source:	
	I_4_in, I_5_in, I_6_in	RMS of currents in phases 4-5-6
	Σ_I_456_in	Collective (mean) RMS current
	U_4_in, U_5_in, U_6_in	RMS of voltages in phases 4-5-6
	Σ_U_456_in	Collective (mean) RMS voltages
	p_4_in, p_5_in, p_6_in	Instantaneous power in phases 4-5-6
	p_456_in	Total instantaneous power
	P_4_in, P_5_in, P_6_in	True power in phases 4-5-6
	P_456_in	Total true power
	S_4_in, S_5_in, S_6_in	Apparent power in phases 4-5-6
	S_456_in	Total apparent power
	Q_4_in, Q_5_in, Q_6_in	Reactive power in phases 4-5-6
	Q_456_in	Total reactive power
	λ_4_in, λ_5_in, λ_6_in	Power factor in phases 4-5-6
	λ_456_in	Total power factor
	φ_fund_4_in	Phase angle of voltage & current fundamentals phase 4[1]
	φ_fund_5_in	Phase angle of voltage & current fundamentals phase 5[1]
	φ_fund_6_in	Phase angle of voltage & current fundamentals phase 6[1]
	cosφ_fund_4_in	Cosine of phase angle in phase 4[1]
	cosφ_fund_5_in	Cosine of phase angle in phase 5[1]
	cosφ_fund_6_in	Cosine of phase angle in phase 6[1]
	U_fund_4_in	RMS voltage of the fundamental phase 4[1]
	U_fund_5_in	RMS voltage of the fundamental phase 5[1]
	U_fund_6_in	RMS voltage of the fundamental phase 6[1]
	Σ_U_fund_456_in	Collective (mean) RMS of fundamental voltages[1]
	I_fund_4_in	RMS current of the fundamental phase 4[1]
	I_fund_5_in	RMS current of the fundamental phase 5[1]
	I_fund_6_in	RMS current of the fundamental phase 6[1]
	Σ_I_fund_456_in	Collective (mean) RMS of fundamental currents[1]
	Total:	
	P_in	Total true power
	Cycle_Master_in	Cycle detect result[2]
	Cycle_Check_in	Frequency of cycles detected on Cycle_Master_in
	CycleStart_in	Start time of the analysis cycle[3]
	CycleEnd_in	End time of the analysis cycle[3]

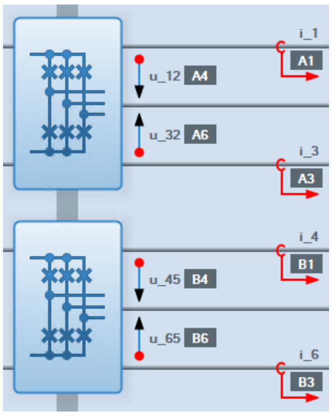
[1] Note: Only calculated if enabled under SYSTEM SETTINGS.
[2] Note: Cycle detect results can be reviewed with Perception, but cannot be reused for further analysis in the Formula database.
[3] Note: Cycle start and end times are valid for RPC retrieved results (GeteDriveResults) only.

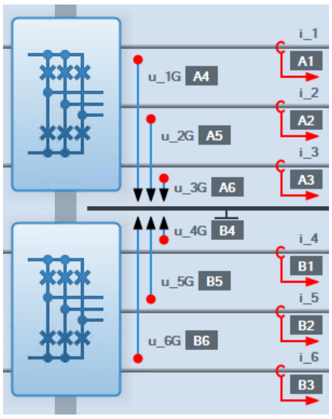
INVERTER OUTPUT	Available calculations are pending on selected connection type, see below	
Phase to phase (with star conversion)	Measured:	
	i_1, i_2, i_3	Currents in phases 1-2-3
	u_12, u_23, u_31	Voltages phase to phase 1-2 and 2-3 and 3-1
	Calculated:	
	I_1, I_2, I_3	RMS of currents in phases 1-2-3
	Σ_I	Collective (mean) RMS current
	u_1, u_2, u_3	Instantaneous star voltages in phases 1-2-3
	U_1, U_2, U_3	RMS of star voltages in phases 1-2-3
	Σ_U	Collective (mean) RMS of star voltages
	U_12	RMS of phase to phase voltage 1-2
	U_23	RMS of phase to phase voltage 2-3
	U_31	RMS of phase to phase voltage 3-1
	Σ_U_PP	Collective (mean) RMS of phase-phase voltages
	p_1, p_2, p_3	Instantaneous power in phases 1-2-3
	p	Total instantaneous power
	P_1, P_2, P_3	True power in phases 1-2-3
	P	Total true power
	S_1, S_2, S_3	Apparent power in phases 1-2-3
	S	Total apparent power
	Q_1, Q_2, Q_3	Reactive power in phases 1-2-3
	Q	Total reactive power
	λ_1, λ_2, λ_3	Power factor in phases 1-2-3
	λ	Total power factor
	φ_fund_1	Phase angle of voltage & current fundamentals phase 1
	φ_fund_2	Phase angle of voltage & current fundamentals phase 2
	φ_fund_3	Phase angle of voltage & current fundamentals phase 3
	cosφ_fund_1	Cosine of phase angle in phase 1
	cosφ_fund_2	Cosine of phase angle in phase 2
	cosφ_fund_3	Cosine of phase angle in phase 3
	U_fund_1	RMS voltage of the fundamental phase 1[1)]
	U_fund_2	RMS voltage of the fundamental phase 2[1)]
	U_fund_3	RMS voltage of the fundamental phase 3[1)]
	Σ_U_fund	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_1	RMS current of the fundamental phase 1[1)]
	I_fund_2	RMS current of the fundamental phase 2[1)]
	I_fund_3	RMS current of the fundamental phase 3[1)]
	Σ_I_fund	Collective (mean) RMS of fundamental currents[1)]
	i_alpha	Alpha component of the current space vector[1)]
	i_beta	Beta component of the current space vector[1)]
	Cycle_Master	Cycle detect result[2)]
	Cycle_Check	Frequency of cycles detected on Cycle_Master
	CycleStart	Start time of the analysis cycle[3)]
	CycleEnd	End time of the analysis cycle[3)]
Phase to artificial star	Measured:	
	i_1, i_2, i_3	Currents in phases 1-2-3
	u_1, u_2, u_3	Star voltages in phases 1-2-3
	Calculated:	
	I_1, I_2, I_3	RMS of currents in phases 1-2-3
	Σ_I	Collective (mean) RMS current
	U_1, U_2, U_3	RMS of star voltages in phases 1-2-3
	Σ_U	Collective (mean) RMS of star voltages
	p_1, p_2, p_3	Instantaneous power in phases 1-2-3
	p	Total instantaneous power
	P_1, P_2, P_3	True power in phases 1-2-3
and	P	Total true power
Phase to star	S_1, S_2, S_3	Apparent power in phases 1-2-3
	S	Total apparent power
	Q_1, Q_2, Q_3	Reactive power in phases 1-2-3
	Q	Total reactive power
	λ_1, λ_2, λ_3	Power factor in phases 1-2-3
	λ	Total power factor
	φ_fund_1	Phase angle of voltage & current fundamentals phase 1
	φ_fund_2	Phase angle of voltage & current fundamentals phase 2
	φ_fund_3	Phase angle of voltage & current fundamentals phase 3
	cosφ_fund_1	Cosine of phase angle in phase 1
	cosφ_fund_2	Cosine of phase angle in phase 2
	cosφ_fund_3	Cosine of phase angle in phase 3
	U_fund_1	RMS voltage of the fundamental phase 1[1)]
	U_fund_2	RMS voltage of the fundamental phase 2[1)]
	U_fund_3	RMS voltage of the fundamental phase 3[1)]

	Σ_U_fund	Collective (mean) RMS of fundamental voltages[1]
	I_fund_1	RMS current of the fundamental phase 1[1]
	I_fund_2	RMS current of the fundamental phase 2[1]
	I_fund_3	RMS current of the fundamental phase 3[1]
	Σ_I_fund	Collective (mean) RMS of fundamental currents[1]
	i_alpha	Alpha component of the current space vector[1]
	i_beta	Beta component of the current space vector[1]
	Cycle_Master	Cycle detect result[2]
	Cycle_Check	Frequency of cycles detected on Cycle_Master
	CycleStart	Start time of the analysis cycle[3]
	CycleEnd	End time of the analysis cycle[3]
Phase to phase n-1 (with star conversion)	Measured:	
	i_1, i_3	Currents in phases 1 and 3
	u_12, u_32	Voltages phase to phase 1-2 and 3-2
	Calculated:	
	I_1, I_2, I_3	RMS of currents in phases 1-2-3
	Σ_I	Collective (mean) RMS current
	u_1, u_2, u_3	Instantaneous star voltages in phases 1-2-3
	i_2	Instantaneous current phase 2
	U_1, U_2, U_3	RMS of star voltages in phases 1-2-3
	Σ_U	Collective (mean) RMS of star voltages
	p_1, p_2, p_3	Instantaneous power in phases 1-2-3
	p	Total instantaneous power
	P_1, P_2, P_3	True power in phases 1-2-3
	P	Total true power
	S_1, S_2, S_3	Apparent power in phases 1-2-3
	S	Total apparent power
	Q_1, Q_2, Q_3	Reactive power in phases 1-2-3
	Q	Total reactive power
	λ_1, λ_2, λ_3	Power factor in phases 1-2-3
	λ	Total power factor
	φ_fund_1	Phase angle of voltage & current fundamentals phase 1
	φ_fund_2	Phase angle of voltage & current fundamentals phase 2
	φ_fund_3	Phase angle of voltage & current fundamentals phase 3
	cosφ_fund_1	Cosine of phase angle in phase 1
	cosφ_fund_2	Cosine of phase angle in phase 2
	cosφ_fund_3	Cosine of phase angle in phase 3
	U_fund_1	RMS voltage of the fundamental phase 1[1]
	U_fund_2	RMS voltage of the fundamental phase 2[1]
	U_fund_3	RMS voltage of the fundamental phase 3[1]
	Σ_U_fund	Collective (mean) RMS of fundamental voltages[1]
	I_fund_1	RMS current of the fundamental phase 1[1]
	I_fund_2	RMS current of the fundamental phase 2[1]
	I_fund_3	RMS current of the fundamental phase 3[1]
	Σ_I_fund	Collective (mean) RMS of fundamental currents[1]
	i_alpha	Alpha component of the current space vector[1]
	i_beta	Beta component of the current space vector[1]
	Cycle_Master	Cycle detect result[2]
	Cycle_Check	Frequency of cycles detected on Cycle_Master
	CycleStart	Start time of the analysis cycle[3]
	CycleEnd	End time of the analysis cycle[3]
Phase to ground (with star conversion)	Measured:	
	i_1, i_2, i_3	Currents in phases 1-2-3
	u_1G, u_2G, u_3G	Voltages from phases 1-2-3 to ground
	Calculated:	
	I_1, I_2, I_3	RMS of currents in phases 1-2-3
	Σ_I	Collective (mean) RMS current
	u_1, u_2, u_3	Instantaneous star voltages in phases 1-2-3
	U_1, U_2, U_3	RMS of star voltages in phases 1-2-3
	Σ_U	Collective (mean) RMS of star voltages
	p_1, p_2, p_3	Instantaneous power in phases 1-2-3
	p	Total instantaneous power
	P_1, P_2, P_3	True power in phases 1-2-3
	P	Total true power
	S_1, S_2, S_3	Apparent power in phases 1-2-3
	S	Total apparent power
	Q_1, Q_2, Q_3	Reactive power in phases 1-2-3
	Q	Total reactive power
	λ_1, λ_2, λ_3	Power factor in phases 1-2-3
	λ	Total power factor
	φ_fund_1	Phase angle of voltage & current fundamentals phase 1[1]
	φ_fund_2	Phase angle of voltage & current fundamentals phase 2[1]

	φ_fund_3	Phase angle of voltage & current fundamentals phase 3[1)]
	cosφ_fund_1	Cosine of phase angle in phase 1[1)]
	cosφ_fund_2	Cosine of phase angle in phase 2[1)]
	cosφ_fund_3	Cosine of phase angle in phase 3[1)]
	U_fund_1	RMS voltage of the fundamental phase 1[1)]
	U_fund_2	RMS voltage of the fundamental phase 2[1)]
	U_fund_3	RMS voltage of the fundamental phase 3[1)]
	Σ_U_fund	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_1	RMS current of the fundamental phase 1[1)]
	I_fund_2	RMS current of the fundamental phase 2[1)]
	I_fund_3	RMS current of the fundamental phase 3[1)]
	Σ_I_fund	Collective (mean) RMS of fundamental currents[1)]
	i_alpha	Alpha component of the current space vector[1)]
	i_beta	Beta component of the current space vector[1)]
	Cycle_Master	Cycle detect result[2)]
	Cycle_Check	Frequency of cycles detected on Cycle_Master
	CycleStart	Start time of the analysis cycle[3)]
	CycleEnd	End time of the analysis cycle[3)]
Dual Phase to phase (with star conversion)  	Measured:	
	First inverter:	
	i_1, i_2, i_3	Currents in phases 1-2-3
	u_12, u_23, u_31	Voltages phase to phase 1-2 and 2-3 and 3-1
	Second inverter:	
	i_4, i_5, i_6	Currents in phases 4-5-6
	u_45, u_56, u_64	Voltages phase to phase 4-5 and 5-6 and 6-4
	Calculated:	
	First inverter:	
	I_1, I_2, I_3	RMS of currents in phases 1-2-3
	Σ_I_123	Collective (mean) RMS current
	u_1, u_2, u_3	Instantaneous star voltages in phases 1-2-3
	U_1, U_2, U_3	RMS of star voltages in phases 1-2-3
	Σ_U_123	Collective (mean) RMS of star voltages
	U_12	RMS of phase to phase voltage 1-2
	U_23	RMS of phase to phase voltage 2-3
	U_31	RMS of phase to phase voltage 3-1
	Σ_U_PP_123	Collective (mean) RMS of phase-phase voltages
	p_1, p_2, p_3	Instantaneous power in phases 1-2-3
	p_123	Total instantaneous power
	P_1, P_2, P_3	True power in phases 1-2-3
	P_123	Total true power
	S_1, S_2, S_3	Apparent power in phases 1-2-3
	S_123	Total apparent power
	Q_1, Q_2, Q_3	Reactive power in phases 1-2-3
	Q_123	Total reactive power
	λ_1, λ_2, λ_3	Power factor in phases 1-2-3
	λ_123	Total power factor
	φ_fund_1	Phase angle of voltage & current fundamentals phase 1[1)]
	φ_fund_2	Phase angle of voltage & current fundamentals phase 2[1)]
	φ_fund_3	Phase angle of voltage & current fundamentals phase 3[1)]
	cosφ_fund_1	Cosine of phase angle in phase 1[1)]
	cosφ_fund_2	Cosine of phase angle in phase 2[1)]
	cosφ_fund_3	Cosine of phase angle in phase 3[1)]
	U_fund_1	RMS voltage of the fundamental phase 1[1)]
	U_fund_2	RMS voltage of the fundamental phase 2[1)]
	U_fund_3	RMS voltage of the fundamental phase 3[1)]
	Σ_U_fund_123	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_1	RMS current of the fundamental phase 1[1)]
	I_fund_2	RMS current of the fundamental phase 2[1)]
	I_fund_3	RMS current of the fundamental phase 3[1)]
	Σ_I_fund_123	Collective (mean) RMS of fundamental currents[1)]
	i_alpha_123	Alpha component of the current space vector[1)]
	i_beta_123	Beta component of the current space vector[1)]
	Second inverter:	
	I_4, I_5, I_6	RMS of currents in phases 4-5-6
	Σ_I_456	Collective (mean) RMS current
	u_4, u_5, u_6	Instantaneous star voltages in phases 4-5-6
	U_4, U_5, U_6	RMS of star voltages in phases 4-5-6
	Σ_U_456	Collective (mean) RMS of star voltages
	U_45	RMS of phase to phase voltage 4-5
	U_56	RMS of phase to phase voltage 5-6
	U_64	RMS of phase to phase voltage 6-4
	Σ_U_PP_456	Collective (mean) RMS of phase-phase voltages
	p_4, p_5, p_6	Instantaneous power in phases 4-5-6
	p_456	Total instantaneous power
	P_4, P_5, P_6	True power in phases 4-5-6

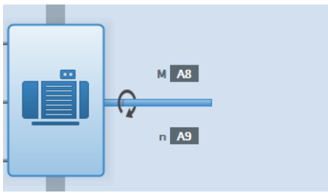
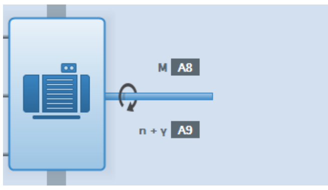
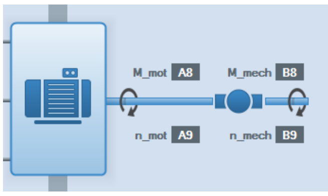
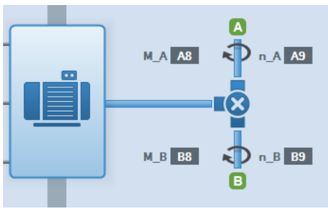
	P_456	Total true power
	S_4, S_5, S_6	Apparent power in phases 4-5-6
	S_456	Total apparent power
	Q_4, Q_5, Q_6	Reactive power in phases 4-5-6
	Q_456	Total reactive power
	λ_4, λ_5, λ_6	Power factor in phases 4-5-6
	λ_456	Total power factor
	φ_fund_4	Phase angle of voltage & current fundamentals phase 4[1)]
	φ_fund_5	Phase angle of voltage & current fundamentals phase 5[1)]
	φ_fund_6	Phase angle of voltage & current fundamentals phase 6[1)]
	cosφ_fund_4	Cosine of phase angle in phase 4[1)]
	cosφ_fund_5	Cosine of phase angle in phase 5[1)]
	cosφ_fund_6	Cosine of phase angle in phase 6[1)]
	U_fund_4	RMS voltage of the fundamental phase 4[1)]
	U_fund_5	RMS voltage of the fundamental phase 5[1)]
	U_fund_6	RMS voltage of the fundamental phase 6[1)]
	Σ_U_fund_456	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_4	RMS current of the fundamental phase 4[1)]
	I_fund_5	RMS current of the fundamental phase 5[1)]
	I_fund_6	RMS current of the fundamental phase 6[1)]
	Σ_I_fund_456	Collective (mean) RMS of fundamental currents[1)]
	i_alpha_456	Alpha component of the current space vector[1)]
	i_beta_456	Beta component of the current space vector[1)]
	Total:	
	P	Total true power
	Cycle_Master	Cycle detect result[2)]
	Cycle_Check	Frequency of cycles detected on Cycle_Master
	CycleStart	Start time of the analysis cycle[3)]
	CycleEnd	End time of the analysis cycle[3)]
Dual Phase to artificial star	Measured:	
	First inverter:	
	i_1, i_2, i_3	Currents in phases 1-2-3
	u_1, u_2, u_3	Star voltages in phases 1-2-3
	Second inverter:	
	i_4, i_5, i_6	Currents in phases 4-5-6
	u_4, u_5, u_6	Star voltages in phases 4-5-6
	Calculated:	
	First inverter:	
	I_1, I_2, I_3	RMS of input currents in phases 1-2-3
	Σ_I_123	Collective (mean) RMS current
	U_1, U_2, U_3	RMS of star voltages in phases 1-2-3
	Σ_U_123	Collective (mean) RMS of star voltages
	p_1, p_2, p_3	Instantaneous power in phases 1-2-3
	p_123	Total instantaneous power
	P_1, P_2, P_3	True power in phases 1-2-3
	P_123	Total true power
	S_1, S_2, S_3	Apparent power in phases 1-2-3
	S_123	Total apparent power
and	Q_1, Q_2, Q_3	Reactive power in phases 1-2-3
Dual Phase to star	Q_123	Total reactive power
	λ_1, λ_2, λ_3	Power factor in phases 1-2-3
	λ_123	Total power factor
	φ_fund_1	Phase angle of voltage & current fundamentals phase 1[1)]
	φ_fund_2	Phase angle of voltage & current fundamentals phase 2[1)]
	φ_fund_3	Phase angle of voltage & current fundamentals phase 3[1)]
	cosφ_fund_1	Cosine of phase angle in phase 1[1)]
	cosφ_fund_2	Cosine of phase angle in phase 2[1)]
	cosφ_fund_3	Cosine of phase angle in phase 3[1)]
	U_fund_1	RMS voltage of the fundamental phase 1[1)]
	U_fund_2	RMS voltage of the fundamental phase 2[1)]
	U_fund_3	RMS voltage of the fundamental phase 3[1)]
	Σ_U_fund_123	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_1	RMS current of the fundamental phase 1[1)]
	I_fund_2	RMS current of the fundamental phase 2[1)]
	I_fund_3	RMS current of the fundamental phase 3[1)]
	Σ_I_fund_123	Collective (mean) RMS of fundamental currents[1)]
	i_alpha_123	Alpha component of the current space vector[1)]
	i_beta_123	Beta component of the current space vector[1)]
	Second inverter:	
	I_4, I_5, I_6	RMS of currents in phases 4-5-6
	Σ_I_456	Collective (mean) RMS current
	U_4, U_5, U_6	RMS of star voltages in phases 4-5-6
	Σ_U_456	Collective (mean) RMS of star voltages
	p_4, p_5, p_6	Instantaneous power in phases 4-5-6
	p_456	Total instantaneous power

	P_4, P_5, P_6	True power in phases 4-5-6
	P_456	Total true power
	S_4, S_5, S_6	Apparent power in phases 4-5-6
	S_456	Total apparent power
	Q_4, Q_5, Q_6	Reactive power in phases 4-5-6
	Q_456	Total reactive power
	λ_4, λ_5, λ_6	Power factor in phases 4-5-6
	λ_456	Total power factor
	φ_fund_4	Phase angle of voltage & current fundamentals phase 4[1)]
	φ_fund_5	Phase angle of voltage & current fundamentals phase 5[1)]
	φ_fund_6	Phase angle of voltage & current fundamentals phase 6[1)]
	cosφ_fund_4	Cosine of phase angle in phase 4[1)]
	cosφ_fund_5	Cosine of phase angle in phase 5[1)]
	cosφ_fund_6	Cosine of phase angle in phase 6[1)]
	U_fund_4	RMS voltage of the fundamental phase 4[1)]
	U_fund_5	RMS voltage of the fundamental phase 5[1)]
	U_fund_6	RMS voltage of the fundamental phase 6[1)]
	Σ_U_fund_456	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_4	RMS current of the fundamental phase 4[1)]
	I_fund_5	RMS current of the fundamental phase 5[1)]
	I_fund_6	RMS current of the fundamental phase 6[1)]
	Σ_I_fund_456	Collective (mean) RMS of fundamental currents[1)]
	i_alpha_456	Alpha component of the current space vector[1)]
	i_beta_456	Beta component of the current space vector[1)]
	Total:	
	P	Total true power
	Cycle_Master	Cycle detect result[2)]
	Cycle_Check	Frequency of cycles detected on Cycle_Master
	CycleStart	Start time of the analysis cycle[3)]
	CycleEnd	End time of the analysis cycle[3)]
Phase to phase n-1 (with star conversion)	Measured:	
	First inverter:	Currents in phases 1 and 3
	i_1, i_3	Voltages phase to phase 1-2 and 3-2
	u_12, u_32	
	Second inverter:	
	i_4, i_6	Currents in phases 4 and 6
	u_45, u_65	Voltages phase to phase 4-5 and 6-5
	Calculated:	
	First inverter:	
	I_1, I_2, I_3	RMS of currents in phases 1-2-3
	Σ_I_123	Collective (mean) RMS current
	u_1, u_2, u_3	Instantaneous star voltages in phases 1-2-3
	i_2	Instantaneous current phase 2
	U_1, U_2, U_3	RMS of star voltages in phases 1-2-3
	Σ_U_123	Collective (mean) RMS of star voltages
	p_1, p_2, p_3	Instantaneous power in phases 1-2-3
	p_123	Total instantaneous power
	P_1, P_2, P_3	True power in phases 1-2-3
	P_123	Total true power
	S_1, S_2, S_3	Apparent power in phases 1-2-3
	S_123	Total apparent power
	Q_1, Q_2, Q_3	Reactive power in phases 1-2-3
	Q_123	Total reactive power
	λ_1, λ_2, λ_3	Power factor in phases 1-2-3
	λ_123	Total power factor
	φ_fund_1	Phase angle of voltage & current fundamentals phase 1[1)]
	φ_fund_2	Phase angle of voltage & current fundamentals phase 2[1)]
	φ_fund_3	Phase angle of voltage & current fundamentals phase 3[1)]
	cosφ_fund_1	Cosine of phase angle in phase 1[1)]
	cosφ_fund_2	Cosine of phase angle in phase 2[1)]
	cosφ_fund_3	Cosine of phase angle in phase 3[1)]
	U_fund_1	RMS voltage of the fundamental phase 1[1)]
	U_fund_2	RMS voltage of the fundamental phase 2[1)]
	U_fund_3	RMS voltage of the fundamental phase 3[1)]
	Σ_U_fund_123	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_1	RMS current of the fundamental phase 1[1)]
	I_fund_2	RMS current of the fundamental phase 2[1)]
	I_fund_3	RMS current of the fundamental phase 3[1)]
	Σ_I_fund_123	Collective (mean) RMS of fundamental currents[1)]
	i_alpha_123	Alpha component of the current space vector[1)]
	i_beta_123	Beta component of the current space vector[1)]
	Second inverter:	
	I_4, I_5, I_6	RMS of currents in phases 4-5-6
	Σ_I_456	Collective (mean) RMS current
	u_4, u_5, u_6	Instantaneous star voltages in phases 4-5-6

	i_5	Instantaneous current phase 5
	U_4, U_5, U_6	RMS of star voltages in phases 4-5-6
	Σ_U_456	Collective (mean) RMS of star voltages
	p_4, p_5, p_6	Instantaneous power in phases 4-5-6
	p_456	Total instantaneous power
	P_4, P_5, P_6	True power in phases 4-5-6
	P_456	Total true power
	S_4, S_5, S_6	Apparent power in phases 4-5-6
	S_456	Total apparent power
	Q_4, Q_5, Q_6	Reactive power in phases 4-5-6
	Q_456	Total reactive power
	λ_4, λ_5, λ_6	Power factor in phases 4-5-6
	λ_456	Total power factor
	φ_fund_4	Phase angle of voltage & current fundamentals phase 4[1)]
	φ_fund_5	Phase angle of voltage & current fundamentals phase 5[1)]
	φ_fund_6	Phase angle of voltage & current fundamentals phase 6[1)]
	cosφ_fund_4	Cosine of phase angle in phase 4[1)]
	cosφ_fund_5	Cosine of phase angle in phase 5[1)]
	cosφ_fund_6	Cosine of phase angle in phase 6[1)]
	U_fund_4	RMS voltage of the fundamental phase 4[1)]
	U_fund_5	RMS voltage of the fundamental phase 5[1)]
	U_fund_6	RMS voltage of the fundamental phase 6[1)]
	Σ_U_fund_456	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_4	RMS current of the fundamental phase 4[1)]
	I_fund_5	RMS current of the fundamental phase 5[1)]
	I_fund_6	RMS current of the fundamental phase 6[1)]
	Σ_I_fund_456	Collective (mean) RMS of fundamental currents[1)]
	i_alpha_456	Alpha component of the current space vector[1)]
	i_beta_456	Beta component of the current space vector[1)]
	Total:	
	P	Total true power
	Cycle_Master	Cycle detect result[2)]
	Cycle_Check	Frequency of cycles detected on Cycle_Master
	CycleStart	Start time of the analysis cycle[3)]
	CycleEnd	End time of the analysis cycle[3)]
Dual Phase to ground (with star conversion)	Measured:	
	First inverter:	
	i_1, i_2, i_3	Currents in phases 1-2-3
	u_1G, u_2G, u_3G	Voltages from phases 1-2-3 to ground
	Second inverter:	
	i_1, i_2, i_3	Currents in phases 4-5-6
	u_1G, u_2G, u_3G	Voltages from phases 4-5-6 to ground
	Calculated:	
	First inverter:	
	I_1, I_2, I_3	RMS of currents in phases 1-2-3
	Σ_I_123	Collective (mean) RMS current
	u_1, u_2, u_3	Instantaneous star voltages in phases 1-2-3
	U_1, U_2, U_3	RMS of star voltages in phases 1-2-3
	Σ_U_123	Collective (mean) RMS of star voltages
	p_1, p_2, p_3	Instantaneous power in phases 1-2-3
	p_123	Total instantaneous power
	P_1, P_2, P_3	True power in phases 1-2-3
	P_123	Total true power
	S_1, S_2, S_3	Apparent power in phases 1-2-3
	S_123	Total apparent power
	Q_1, Q_2, Q_3	Reactive power in phases 1-2-3
	Q_123	Total reactive power
	λ_1, λ_2, λ_3	Power factor in phases 1-2-3
	λ_123	Total power factor
	φ_fund_1	Phase angle of voltage & current fundamentals phase 1[1)]
	φ_fund_2	Phase angle of voltage & current fundamentals phase 2[1)]
	φ_fund_3	Phase angle of voltage & current fundamentals phase 3[1)]
	cosφ_fund_1	Cosine of phase angle in phase 1[1)]
	cosφ_fund_2	Cosine of phase angle in phase 2[1)]
	cosφ_fund_3	Cosine of phase angle in phase 3[1)]
	U_fund_1	RMS voltage of the fundamental phase 1[1)]
	U_fund_2	RMS voltage of the fundamental phase 2[1)]
	U_fund_3	RMS voltage of the fundamental phase 3[1)]
	Σ_U_fund_123	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_1	RMS current of the fundamental phase 1[1)]
	I_fund_2	RMS current of the fundamental phase 2[1)]
	I_fund_3	RMS current of the fundamental phase 3[1)]
	Σ_I_fund_123	Collective (mean) RMS of fundamental currents[1)]
	i_alpha_123	Alpha component of the current space vector[1)]
	i_beta_123	Beta component of the current space vector[1)]

	Second inverter:	
	I_4, I_5, I_6	RMS of currents in phases 4-5-6
	Σ_I_456	Collective (mean) RMS current
	u_4, u_5, u_6	Instantaneous star voltages in phases 4-5-6
	U_4, U_5, U_6	RMS of star voltages in phases 4-5-6
	Σ_U_456	Collective (mean) RMS of star voltages
	p_4, p_5, p_6	Instantaneous power in phases 4-5-6
	p_456	Total instantaneous power
	P_4, P_5, P_6	True power in phases 4-5-6
	P_456	Total true power
	S_4, S_5, S_6	Apparent power in phases 4-5-6
	S_456	Total apparent power
	Q_4, Q_5, Q_6	Reactive power in phases 4-5-6
	Q_456	Total reactive power
	λ_4, λ_5, λ_6	Power factor in phases 4-5-6
	λ_456	Total power factor
	φ_fund_4	Phase angle of voltage & current fundamentals phase 4[1)]
	φ_fund_5	Phase angle of voltage & current fundamentals phase 5[1)]
	φ_fund_6	Phase angle of voltage & current fundamentals phase 6[1)]
	cosφ_fund_4	Cosine of phase angle in phase 4[1)]
	cosφ_fund_5	Cosine of phase angle in phase 5[1)]
	cosφ_fund_6	Cosine of phase angle in phase 6[1)]
	U_fund_4	RMS voltage of the fundamental phase 4[1)]
	U_fund_5	RMS voltage of the fundamental phase 5[1)]
	U_fund_6	RMS voltage of the fundamental phase 6[1)]
	Σ_U_fund_456	Collective (mean) RMS of fundamental voltages[1)]
	I_fund_4	RMS current of the fundamental phase 4[1)]
	I_fund_5	RMS current of the fundamental phase 5[1)]
	I_fund_6	RMS current of the fundamental phase 6[1)]
	Σ_I_fund_456	Collective (mean) RMS of fundamental currents[1)]
	i_alpha_456	Alpha component of the current space vector[1)]
	i_beta_456	Beta component of the current space vector[1)]
	Total:	
	P	Total true power
	Cycle_Master	Cycle detect result[2)]
	Cycle_Check	Frequency of cycles detected on Cycle_Master
	CycleStart	Start time of the analysis cycle[3)]
	CycleEnd	End time of the analysis cycle[3)]

[1)] Note: Only calculated if enabled under SYSTEM SETTINGS.
[2)] Note: Cycle detect results can be reviewed with Perception, but cannot be reused for further analysis in the Formula database.
[3)] Note: Cycle start and end times are valid for RPC retrieved results (GeteDriveResults) only.

MOTOR OUTPUT	Available calculations are pending on mechanical output type and connection, see below	
Shaft only  and **Shaft (with position)** 	Measured: M_raw γ_mech Calculated: Cycle_Master_inst n n_inst M M_inst P_mech Cycle_Master_mech Cycle_Check_mech CycleStart_mech CycleEnd_mech	 Torque RAW signal[1)] Mechanical angle[2)] Averaging cycle signal for all xxx _inst traces (set to 1 ms) rpm rpm averaged Torque Torque averaged Mechanical power Cycle detect result[3)] Frequency of cycles detected on Cycle_Master_mech Start time of the analysis cycle[4)] End time of the analysis cycle[4)]
Shaft and transmission 	Measured: M_mot_raw M_mech_raw γ_mot γ_mech Calculated: Cycle_Master_inst n_mot n_mech n_mot_inst n_mech_inst M_mot M_mech M_mot_inst M_mech_inst P_mot P_mech Cycle_Master_mech Cycle_Check_mech CycleStart_mech CycleEnd_mech	 Torque Motor out RAW signal[1)] Torque Transmission out RAW signal[1)] Mechanical Motor out angle[2)] Mechanical Transmission out angle[2)] Averaging cycle signal for all xxx_inst traces (set to 1 ms) rpm Motor out rpm rpm averaged Motor out rpm averaged Transmission out Torque Motor out Torque Transmission out Torque averaged Motor out Torque averaged Transmission out Mechanical power Motor out Mechanical power Transmission out Cycle detect result[3)] Frequency of cycles detected on Cycle_Master_mech Start time of the analysis cycle[4)] End time of the analysis cycle[4)]
Differential lock only 	Measured: M_A_raw M_B_raw γ_A γ_B Calculated: Cycle_Master_inst n_A n_B n_A_inst n_B_inst M_A M_B M_A_inst M_B_inst M_AB M_diff n_AB n_diff P_mech_A P_mech_B P_mech Cycle_Master_mech Cycle_Check_mech CycleStart_mech CycleEnd_mech	 Torque A RAW signal[1)] Torque B RAW signal[1)] Mechanical A angle[2)] Mechanical B angle[2)] Averaging cycle signal for all xxx_inst traces (set to 1 ms) rpm A rpm B rpm A averaged rpm B averaged Torque A Torque B Torque A averaged Torque B averaged Total torque (M_A + M_B) Differential torque (M_A – M_B) Total rpm ((n_A + n_B) / 2) Differential rpm (n_A – n_B) Mechanical power A Mechanical power B Total mechanical power Cycle detect result[3)] Frequency of cycles detected on Cycle_Master_mech Start time of the analysis cycle[4)] End time of the analysis cycle[4)]

[1] The torque RAW signals are internal signals not useful for display nor for any analysis.

[2] If there is no reference signal, the angle is not reference to a zero position but just a "saw tooth alike" signal from 0° to 360°. Still it is needed as the speed is derived from it.

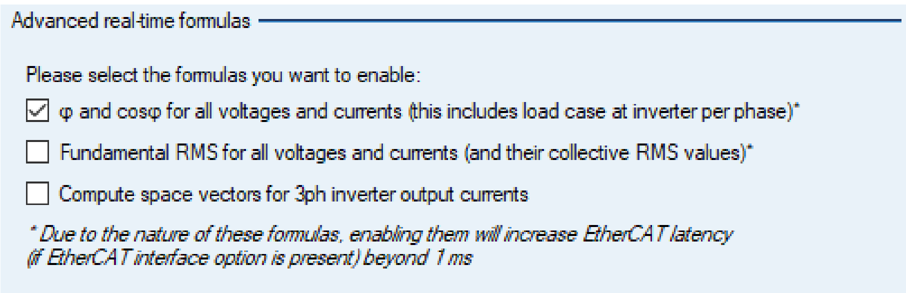
[3] Note: Cycle detect results can be reviewed with Perception, but cannot be reused for further analysis in the Formula database.

[4] Note: Cycle start and end times are valid for RPC retrieved results (GeteDriveResults) only.

Efficiencies and power losses	Available calculations are pending on configuration, see below	
For all configurations and combinations except those with **Shaft and transmission**	η_inv_mot η_inv_gen P_loss_inv η_mech_mot η_mech_gen P_loss_mech η_total_mot η_total_gen P_loss_total	Efficiency of inverter in motor mode[1)] Efficiency of inverter in generator mode[1)] Power loss in inverter[2)] Efficiency of machine in motor mode[1)] Efficiency of machine in generator mode[1)] Power loss in machine[2)] Total efficiency in motor mode[1)] Total efficiency in generator mode[1)] Total power loss[2)]
Any configuration and combination with **Shaft and transmission**	η_mot η_gen P_loss_mot η_trans_mot η_trans_gen P_loss_trans η_inv_mot η_inv_gen P_loss_inv η_mech_mot η_mech_gen P_loss_mech η_total_mot η_total_gen P_loss_total	Efficiency of machine in motor mode[1)] Efficiency of machine in generator mode[1)] Power loss in machine[2)] Efficiency of transmission in motor mode[1)] Efficiency of transmission in generator mode[1)] Power loss in transmission[2)] Efficiency of inverter in motor mode[1)] Efficiency of inverter in generator mode[1)] Power loss in inverter[2)] Efficiency of machine & transmission in motor mode[1)] Efficiency of machine & transmission in generator mode[1)] Power loss in machine & transmission[2)] Total efficiency in motor mode[1)] Total efficiency in generator mode[1)] Total power loss[2)]

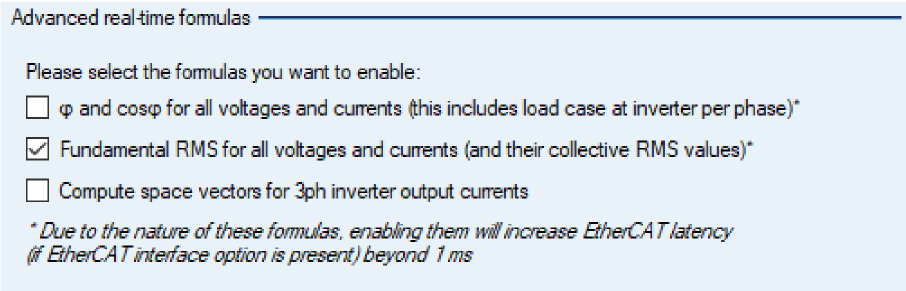
1) As the drive is either in motor mode or in generator mode, only one of the two efficiencies is valid. One is below 100% and thus the correct one for the current mode, the other one is above 100% and can be ignored.
2) The "loss" is positive if in generator mode.

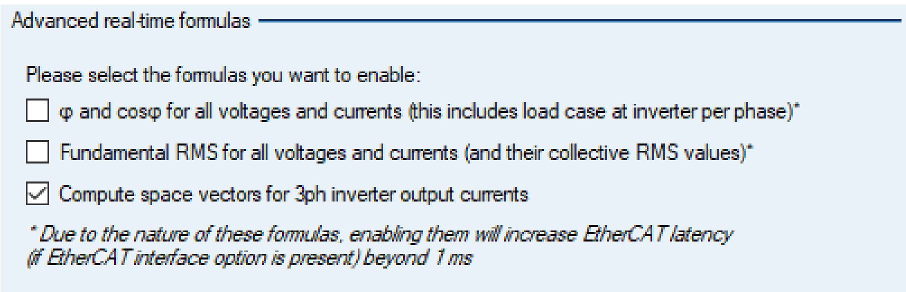
Computation of φ and cosφ of the fundamental	This can be separately enabled in the SYSTEM SETTINGS menu.

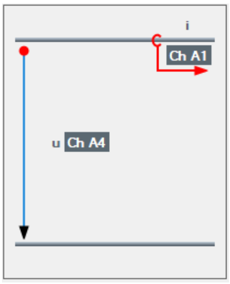
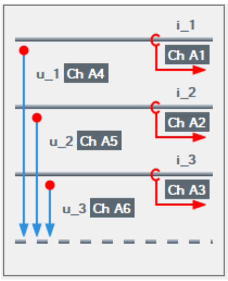
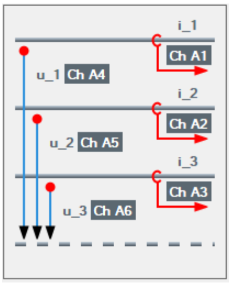


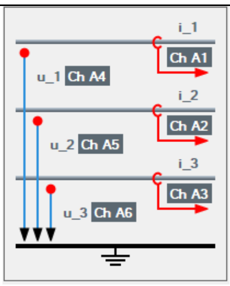
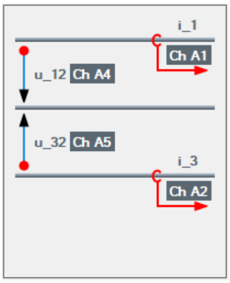
Selection dialog to enable φ and cosφ computation

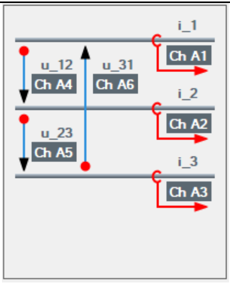
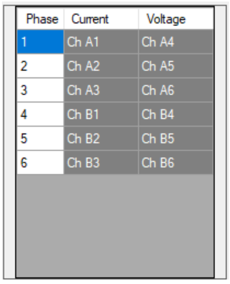
Functionality	Enables / disables computation of phase angle φ (in rad) and cosφ of the first fundamental of the signal
Unit	rad (radians); can be converted to ° (degree) using the RadiansToDegrees real time formula database function.
Minimum fundamental frequency	10 Hz x (# of cycles for averaging). φ and cosφ computations are only possible down to a minimum frequency. Below this frequency, there are no results available for φ and cosφ. In case cycle detection is done per cycle, this minimum frequency is 10 Hz. In case cycle detection is done over multiple input cycles (averaging), the minimum fundamental frequency increases with the # of cycles selected. Example: If "Number of cycles" as set in the block context menu = 5 -> Minimum fundamental frequency is 10 Hz * 5 = 50 Hz. *Note: The initial minimum fundamental frequency (for "Number of cycles" = 1) is a variable (Min_fund_frequency) in the real time formula database; it is set to 10 Hz and cannot be changed by the user.*
Load case computation	If φ and cosφ computation is disabled, the load case L or C of the machine cannot be determined and is also not shown.
Latency increase	If φ and cosφ computation is enabled, the latency on the fieldbus increases above the standard 1 ms. Exact latency is shown as separate column in the real time formula database and depends from several factors.

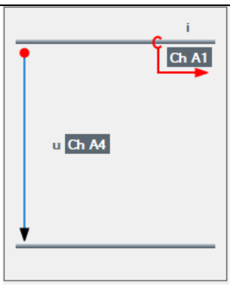
Computation of fundamental RMS and collective fundamental RMS for voltages and currents	This can be separately enabled in the SYSTEM SETTINGS menu.
 Selection dialog to enable fundamental RMS computations	
Functionality	Enables / disables computation of fundamental RMS values of all voltages and currents and their collective values
Unit	V or A, automatically derived from source channel
Minimum fundamental frequency	10 Hz x (# of cycles for averaging). Fundamental RMS computations are only possible down to a minimum frequency. Below this frequency, there are no results available for fundamental RMS values. In case cycle detection is done per cycle, this minimum frequency is 10 Hz. In case cycle detection is done over multiple input cycles (averaging), the minimum fundamental frequency increases with the # of cycles selected. Example: If “Number of cycles” as set in the block context menu = 5 -> Minimum fundamental frequency is 10 Hz * 5 = 50 Hz. *Note: The initial minimum fundamental frequency (for “Number of cycles” = 1) is a variable (Min_fundrms_frequency) in the real time formula database; it is set to 10 Hz and cannot be changed by the user.*
Latency increase	If fundamental RMS calculation is enabled, the latency on the fieldbus increases above the standard 1 ms. Exact latency is shown as separate column in the real time formula database and depends from several factors.

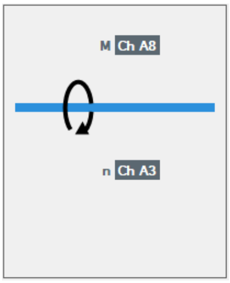
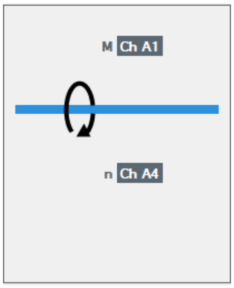
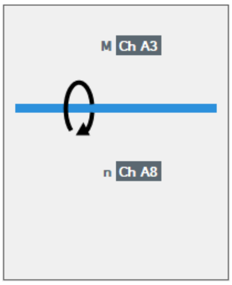
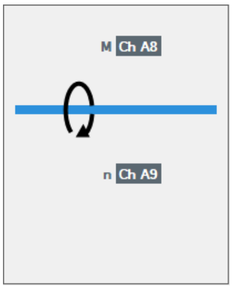
Computation of current space vector of the 3phase inverter output currents.	This can be separately enabled in the SYSTEM SETTINGS menu.
 Selection dialog to enable current space vector computations	
Functionality	Enables / disables computation of current space vector values of the 3phase inverter output currents When enabled the results of these calculations are shown in a special created display sheet called “eDrive - SpaceVector”. On this sheet a display and XY display are present containing the calculation results.
Unit	A, automatically derived from source channel

eDrive Creator		
Electrical configurations		
AC 1-Phase  	Measured: i u Calculated: I U p P S Q λ φ_fund cosφ_fund I_fund U_fund Cycle_Master Cycle_Check	 Current Voltage RMS of input current RMS of input voltage Instantaneous power True power Apparent power Reactive power Power factor Phase angle of voltage and current fundamentals[1)] Cosine of phase angle[1)] RMS current of the fundamental[1)] RMS voltage of the fundamental[1)] Cycle detect result[2)] Frequency of cycles detected on Cycle_Master
AC 3-Phase: **Phase to artificial star**  **AC 3-Phase:** **Phase to neutral**  	Measured: i_1, i_2, i_3 u_1, u_2, u_3 Calculated: I_1, I_2, I_3 Σ_I U_1, U_2, U_3 Σ_U p_1, p_2, p_3 p P_1, P_2, P_3 P S_1, S_2, S_3 S Q_1, Q_2, Q_3 Q λ_1, λ_2, λ_3 λ φ_fund_1 φ_fund_2 φ_fund_3 cosφ_fund_1 cosφ_fund_2 cosφ_fund_3 I_fund_1 I_fund_2 I_fund_3 Σ_I_fund U_fund_1 U_fund_2 U_fund_3 Σ_U_fund i_alpha i_beta Cycle_Master Cycle_Check	 Currents in phases 1-2-3 Star voltages in phases 1-2-3 RMS of currents in phases 1-2-3 Collective (mean) RMS current RMS of star voltages in phases 1-2-3 Collective (mean) RMS of star voltages Instantaneous power in phases 1-2-3 Total instantaneous power True power in phases 1-2-3 Total true power Apparent power in phases 1-2-3 Total apparent power Reactive power in phases 1-2-3 Total reactive power Power factor in phases 1-2-3 Total power factor Phase angle of voltage & current fundamentals phase 1 Phase angle of voltage & current fundamentals phase 2 Phase angle of voltage & current fundamentals phase 3 Cosine of phase angle in phase 1 Cosine of phase angle in phase 2 Cosine of phase angle in phase 3 RMS current of the fundamental phase 1[1)] RMS current of the fundamental phase 2[1)] RMS current of the fundamental phase 3[1)] Collective (mean) RMS of fundamental currents[1)] RMS voltage of the fundamental phase 1[1)] RMS voltage of the fundamental phase 2[1)] RMS voltage of the fundamental phase 3[1)] Collective (mean) RMS of fundamental voltages[1)] Alpha component of the current space vector[1)] Beta component of the current space vector[1)] Cycle detect result[2)] Frequency of cycles detected on Cycle_Master
AC 3-Phase: **Phase to ground** **(with star conversion)**	Measured: i_1, i_2, i_3 u_1G, u_2G, u_3G Calculated: I_1, I_2, I_3 Σ_I u_1, u_2, u_3 U_1, U_2, U_3 Σ_U p_1, p_2, p_3 p P_1, P_2, P_3	 Currents in phases 1-2-3 Voltages from phases 1-2-3 to ground RMS of currents in phases 1-2-3 Collective (mean) RMS current Instantaneous star voltages in phases 1-2-3 RMS of star voltages in phases 1-2-3 Collective (mean) RMS of star voltages Instantaneous power in phases 1-2-3 Total instantaneous power True power in phases 1-2-3

 	P S_1, S_2, S_3 S Q_1, Q_2, Q_3 Q λ_1, λ_2, λ_3 λ φ_fund_1 φ_fund_2 φ_fund_3 cosφ_fund_1 cosφ_fund_2 cosφ_fund_3 I_fund_1 I_fund_2 I_fund_3 Σ_I_fund U_fund_1 U_fund_2 U_fund_3 Σ_U_fund i_alpha i_beta Cycle_Master Cycle_Check	Total true power Apparent power in phases 1-2-3 Total apparent power Reactive power in phases 1-2-3 Total reactive power Power factor in phases 1-2-3 Total power factor Phase angle of voltage & current fundamentals phase 1[1)] Phase angle of voltage & current fundamentals phase 2[1)] Phase angle of voltage & current fundamentals phase 3[1)] Cosine of phase angle in phase 1[1)] Cosine of phase angle in phase 2[1)] Cosine of phase angle in phase 3[1)] RMS current of the fundamental phase 1[1)] RMS current of the fundamental phase 2[1)] RMS current of the fundamental phase 3[1)] Collective (mean) RMS of fundamental currents[1)] RMS voltage of the fundamental phase 1[1)] RMS voltage of the fundamental phase 2[1)] RMS voltage of the fundamental phase 3[1)] Collective (mean) RMS of fundamental voltages[1)] Alpha component of the current space vector[1)] Beta component of the current space vector[1)] Cycle detect result[2)] Frequency of cycles detected on Cycle_Master
AC 3-Phase: **Phase to phase (Aron)** **(with star conversion)**  	Measured: i_1, i_3 u_12, u_32 Calculated: I_1, I_2, I_3 Σ_I u_1, u_2, u_3 i_2 U_1, U_2, U_3 Σ_U p_1, p_2, p_3 p P_1, P_2, P_3 P S_1, S_2, S_3 S Q_1, Q_2, Q_3 Q λ_1, λ_2, λ_3 λ φ_fund_1 φ_fund_2 φ_fund_3 cosφ_fund_1 cosφ_fund_2 cosφ_fund_3 I_fund_1 I_fund_2 I_fund_3 Σ_I_fund U_fund_1 U_fund_2 U_fund_3 Σ_U_fund i_alpha i_beta Cycle_Master Cycle_Check	 Currents in phases 1 and 3 Voltages phase to phase 1-2 and 3-2 RMS of currents in phases 1-2-3 Collective (mean) RMS current Instantaneous star voltages in phases 1-2-3 Instantaneous current phase 2 RMS of star voltages in phases 1-2-3 Collective (mean) RMS of star voltages Instantaneous power in phases 1-2-3 Total instantaneous power True power in phases 1-2-3 Total true power Apparent power in phases 1-2-3 Total apparent power Reactive power in phases 1-2-3 Total reactive power Power factor in phases 1-2-3 Total power factor Phase angle of voltage & current fundamentals phase 1 Phase angle of voltage & current fundamentals phase 2 Phase angle of voltage & current fundamentals phase 3 Cosine of phase angle in phase 1 Cosine of phase angle in phase 2 Cosine of phase angle in phase 3 RMS current of the fundamental phase 1[1)] RMS current of the fundamental phase 2[1)] RMS current of the fundamental phase 3[1)] Collective (mean) RMS of fundamental currents[1)] RMS voltage of the fundamental phase 1[1)] RMS voltage of the fundamental phase 2[1)] RMS voltage of the fundamental phase 3[1)] Collective (mean) RMS of fundamental voltages[1)] Alpha component of the current space vector[1)] Beta component of the current space vector[1)] Cycle detect result[2)] Frequency of cycles detected on Cycle_Master
AC 3-Phase: **Phase to phase** **(with star conversion)**	Measured: i_1, i_2, i_3 u_12, u_23, u_31 Calculated: I_1, I_2, I_3 Σ_I u_1, u_2, u_3 U_1, U_2, U_3 Σ_U	 Currents in phases 1-2-3 Voltages phase to phase 1-2 and 2-3 and 3-1 RMS of currents in phases 1-2-3 Collective (mean) RMS current Instantaneous star voltages in phases 1-2-3 RMS of star voltages in phases 1-2-3 Collective (mean) RMS of star voltages

	U_12 U_23 U_31 Σ_U_PP p_1, p_2, p_3 p P_1, P_2, P_3 P S_1, S_2, S_3 S Q_1, Q_2, Q_3 Q λ_1, λ_2, λ_3 λ φ_fund_1 φ_fund_2 φ_fund_3 cosφ_fund_1 cosφ_fund_2 cosφ_fund_3 I_fund_1 I_fund_2 I_fund_3 Σ_I_fund U_fund_1 U_fund_2 U_fund_3 Σ_U_fund i_alpha i_beta Cycle_Master Cycle_Check	RMS of phase to phase voltage 1-2 RMS of phase to phase voltage 2-3 RMS of phase to phase voltage 3-1 Collective (mean) RMS of phase-phase voltages Instantaneous power in phases 1-2-3 Total instantaneous power True power in phases 1-2-3 Total true power Apparent power in phases 1-2-3 Total apparent power Reactive power in phases 1-2-3 Total reactive power Power factor in phases 1-2-3 Total power factor Phase angle of voltage & current fundamentals phase 1 Phase angle of voltage & current fundamentals phase 2 Phase angle of voltage & current fundamentals phase 3 Cosine of phase angle in phase 1 Cosine of phase angle in phase 2 Cosine of phase angle in phase 3 RMS current of the fundamental phase 1[1)] RMS current of the fundamental phase 2[1)] RMS current of the fundamental phase 3[1)] Collective (mean) RMS of fundamental currents[1)] RMS voltage of the fundamental phase 1[1)] RMS voltage of the fundamental phase 2[1)] RMS voltage of the fundamental phase 3[1)] Collective (mean) RMS of fundamental voltages[1)] Alpha component of the current space vector[1)] Beta component of the current space vector[1)] Cycle detect result[2)] Frequency of cycles detected on Cycle_Master
AC n-Phase 	Measured: i_1, i_2, i_3, i_4, i_n u_1, u_2, u_3, u_4, u_n Calculated: I_1, I_2, I_3, I_4, I_n U_1, U_2, U_3, U_4, U_n p_1, p_2, p_3, p_4, p_n P_1, P_2, P_3, P_4, P_n P S Q φ_fund_1 φ_fund_2 φ_fund_3 φ_fund_4 φ_fund_n cosφ_fund_1 cosφ_fund_2 cosφ_fund_3 cosφ_fund_4 cosφ_fund_n I_fund_1 I_fund_2 I_fund_3 I_fund_4 I_fund_n Σ_I_fund U_fund_1 U_fund_2 U_fund_3 U_fund_4 U_fund_n Σ_U_fund Cycle_Master Cycle_Check	 Currents in phases 1-2-3-4-n Voltages from phases 1-2-3-4-n to common potential RMS of currents in phases 1-2-3-4-n RMS of voltages in phases 1-2-3-4-n Instantaneous power in phases 1-2-3-4-n True power in phases 1-2-3-4-n Total true power Total apparent power Total reactive power Phase angle of voltage & current fundamentals phase 1[1)] Phase angle of voltage & current fundamentals phase 2[1)] Phase angle of voltage & current fundamentals phase 3[1)] Phase angle of voltage & current fundamentals phase 4[1)] Phase angle of voltage & current fundamentals phase n[1)] Cosine of phase angle in phase 1[1)] Cosine of phase angle in phase 2[1)] Cosine of phase angle in phase 3[1)] Cosine of phase angle in phase 4[1)] Cosine of phase angle in phase n[1)] RMS current of the fundamental phase 1[1)] RMS current of the fundamental phase 2[1)] RMS current of the fundamental phase 3[1)] RMS current of the fundamental phase 4[1)] RMS current of the fundamental phase n[1)] Collective (mean) RMS of fundamental currents[1)] RMS voltage of the fundamental phase 1[1)] RMS voltage of the fundamental phase 2[1)] RMS voltage of the fundamental phase 3[1)] RMS voltage of the fundamental phase 4[1)] RMS voltage of the fundamental phase n[1)] Collective (mean) RMS of fundamental voltages[1)] Cycle detect result[2)] Frequency of cycles detected on Cycle_Master
DC 1-Phase	Measured: i u Calculated: I	 Current Voltage RMS of input current

	U i_mean u_mean P Cycle_Master Cycle_Check	RMS of input voltage Mean of input current Mean of input voltage True power Cycle detect result[2)] Frequency of cycles detected on Cycle_Master
[1)] *Note: Only calculated if enabled under SYSTEM SETTINGS.* [2)] *Note: Cycle detect results can be reviewed with Perception, but cannot be reused for further analysis in the Formula database.*		

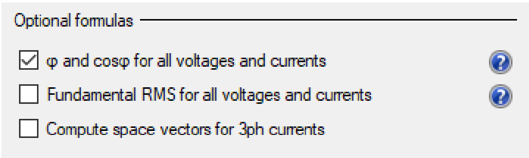
Mechanical configurations		
Mech: **Torque digital / Speed analog**  	Measured: M_raw n_raw Calculated: Cycle_Master_inst n n_inst M M_inst P Cycle_Master Cycle_Check	 Torque RAW signal[1)] Speed signal Averaging cycle signal for all xxx _inst traces (set to 1 ms) rpm rpm averaged Torque Torque averaged Mechanical power Cycle detect result[3)] Frequency of cycles detected on Cycle_Master
Mech: **Torque analog / Speed analog**  	Measured: M_raw n_raw Calculated: n M P Cycle_Master Cycle_Check	 Torque signal Speed signal rpm Torque Mechanical power Cycle detect result[3)] Frequency of cycles detected on Cycle_Master
Mech: **Torque analog / Speed digital**  	Measured: M_raw γ_mech Calculated: Cycle_Master_inst n n_inst M M_inst P Cycle_Master Cycle_Check	 Torque signal Mechanical angle[2)] Averaging cycle signal for all xxx _inst traces (set to 1 ms) rpm rpm averaged Torque Torque averaged Mechanical power Cycle detect result[3)] Frequency of cycles detected on Cycle_Master
Mech: **Torque digital / Speed digital**  	Measured: M_raw γ_mech Calculated: Cycle_Master_inst n n_inst M M_inst P Cycle_Master Cycle_Check	 Torque RAW signal[1)] Mechanical angle[2)] Averaging cycle signal for all xxx _inst traces (set to 1 ms) rpm rpm averaged Torque Torque averaged Mechanical power Cycle detect result[3)] Frequency of cycles detected on Cycle_Master

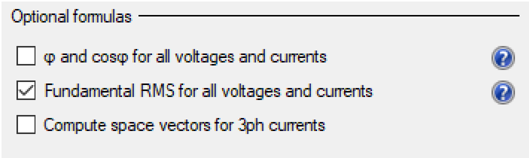
1) The torque RAW signals are internal signals not useful for display nor for any analysis.

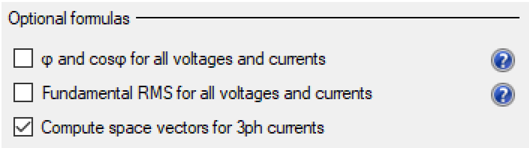
2) If there is no reference signal, the angle is not reference to a zero position but just a "saw tooth alike" signal from 0° to 360°. Still it is needed as the speed is derived from it.

3) Note: Cycle detect results can be reviewed with Perception, but cannot be reused for further analysis in the Formula database.

Efficiencies and power losses		
Energy Flow: **From input(s) to output(s)**	P_in P_out η P_loss	Total incoming active power Total outgoing active power Efficiency (P_out / P_in) Power loss (P_in - P_out)
Energy Flow: **From output(s) to input(s)**	P_in P_out η P_loss	Total incoming active power Total outgoing active power Efficiency (P_in / P_out) Power loss (P_out - P_in)
Energy Flow: **Both directions**	P_in P_out η_input_to_output η_output_to_input P_loss_input_to_output P_loss_output_to_input	Total incoming active power Total outgoing active power Efficiency from input to output (P_out / P_in) Efficiency from output to input (P_in / P_out) Power loss from input to output (P_in - P_out) Power loss from output to input (P_out - P_in)

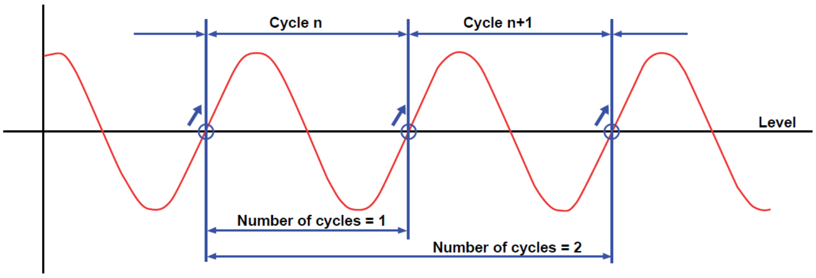
Computation of φ and cosφ of the fundamental	This can be separately enabled in the Optional formulas area of the measurement.
	 Selection to enable φ and cosφ computation
Functionality	Enables / disables computation of phase angle φ (in rad) and cosφ of the first fundamental of the signal
Unit	rad (radians); can be converted to ° (degree) using the RadiansToDegrees real time formula database function.
Minimum fundamental frequency	10 Hz x (# of cycles for averaging). φ and cosφ computations are only possible down to a minimum frequency. Below this frequency, there are no results available for φ and cosφ. In case cycle detection is done per cycle, this minimum frequency is 10 Hz. In case cycle detection is done over multiple input cycles (averaging), the minimum fundamental frequency increases with the # of cycles selected. Example: If "Number of cycles" as set in the block context menu = 5 -> Minimum fundamental frequency is 10 Hz * 5 = 50 Hz. *Note: The initial minimum fundamental frequency (for "Number of cycles" = 1) is a variable (Min_fund_frequency) in the real time formula database; it is set to 10 Hz and cannot be changed by the user.*
Latency increase	If φ and cosφ computation is enabled, the latency on the fieldbus increases above the standard 1 ms. Exact latency is shown as separate column in the real time formula database and depends from several factors.

Computation of fundamental RMS and collective fundamental RMS for voltages and currents	This can be separately enabled in the Optional formulas area of the measurement.
	 Selection dialog to enable fundamental RMS computations
Functionality	Enables / disables computation of fundamental RMS values of all voltages and currents and their collective values
Unit	V or A, automatically derived from source channel
Minimum fundamental frequency	10 Hz x (# of cycles for averaging). Fundamental RMS computations are only possible down to a minimum frequency. Below this frequency, there are no results available for fundamental RMS values. In case cycle detection is done per cycle, this minimum frequency is 10 Hz. In case cycle detection is done over multiple input cycles (averaging), the minimum fundamental frequency increases with the # of cycles selected. Example: If "Number of cycles" as set in the block context menu = 5 -> Minimum fundamental frequency is 10 Hz * 5 = 50 Hz. *Note: The initial minimum fundamental frequency (for "Number of cycles" = 1) is a variable (Min_fundrms_frequency) in the real time formula database; it is set to 10 Hz and cannot be changed by the user.*
Latency increase	If fundamental RMS calculation is enabled, the latency on the fieldbus increases above the standard 1 ms. Exact latency is shown as separate column in the real time formula database and depends from several factors.

Computation of current space vector of the 3phase currents.	This can be separately enabled in the Optional formulas area of the measurement. *Note: Only available for 3 phase electrical configurations.*
	 Selection dialog to enable current space vector computations
Functionality	Enables / disables computation of current space vector values of the 3phase currents
Unit	A, automatically derived from source channel

Cycle Detector

A correct power calculation requires math to be performed over half-cycles or a multiple of half-cycles.
Selecting more cycles improves accuracy in steady state (by averaging) and provides a more stable display readout, while selecting fewer cycles is better suited to capture result in dynamic load change conditions of the drive.



Example of cycle detection

Max number of cycles	The cycle detector can deliver up to 2000 cycles/s at the output. So with a cycle count of 1 the maximum fundamental frequency is 2 kHz. For higher fundamental frequencies, the cycle count is set to >1. Example: Fundamental frequency = 10 kHz // Cycle Count = 20 // -> # of cycles = 500 / s If there are more than 2000 (output) cycles/s, the output will deliver no result.
Multiple cycle sources	The calculations of each measurement configuration can run off different cycle sources. For some applications this is needed to ensure accurate power results. Example: 3ph in / 3ph out industrial inverter • "PowerSource" cycles are detected in the voltage of the input 50/60 Hz grid • "Inverter" cycles are detected in the phase current at the output *Note: As efficiency should be computed from power values averaged over the same cycle, the inverter efficiency in this application might be off for dynamic load changes.*
Cycle source selection	Selects the channel that is used for cycle detection, TIMED, Reference pulse or LINK it to another measurement configuration. Available selections are pending from block and selected configuration, as listed below.
Preconfigured Configurations	
POWER SOURCE	For DC • Link to INVERTER OUT, Link to MOTOR OUTPUT or Timed[1)] For AC 1phase (or pulsed DC): • Voltage u_in, current i_in, Link to INVERTER OUT, Link to MOTOR OUTPUT or Timed[1)] For all AC 3phase configurations: • Voltage u_1_in, current i_1_in, Link to INVERTER OUT, Link to MOTOR OUTPUT or Timed[1)]
INVERTER OUT	For Phase to artificial star & Phase to star: • Voltage u_1, current i_1, Reference Pulse or Timed[1)] For Phase to phase & Phase to phase n-1 (Aron): • Voltage u_12, current i_1, Reference Pulse or Timed[1)] For Phase to ground: • Voltage u_1G, current i_1, Reference Pulse or Timed[1)]
MECHANICAL	Link to INVERTER OUT, Reference Pulse or Timed1)
eDrive Creator Configurations	
Electrical configurations	Voltage u_1, current i_1, Timed[2)] or Linked to other available cycle detectors
Mechanical configurations	Timed[2)], Reference Pulse[3)] or Linked to other available cycle detectors
Number of cycles	Sets the number of cycles that are used for the real time power calculations.
Selections	½, and any integer number from 1 to 50
Default setting	1 cycle
Cycle definition	The time between two identical level crossings with respect to direction (up or down) and level. See above picture.
Level setting	Level to be used to detect cycles. Can be set to any value inside the Cycle Source input range.

	The direction is always set to “positive”, except if cycle count is set to ½. Then both positive as well as negative directions are valid.
Default setting	If voltage sources are selected: 0 V; if current sources are selected: 0 A
Reference Pulse	This selects the reference pulse coming from an a,b,z type incremental encoder to define the cycle length. By doing so the cycle length is equal to one mechanical revolution.

1) *Settings for TIMED are 200 ms, 500 ms, 1 s; one value for the whole system*

2) *Settings for TIMED are 200 ms, 500 ms, 1 s; each cycle detector can have each own value*

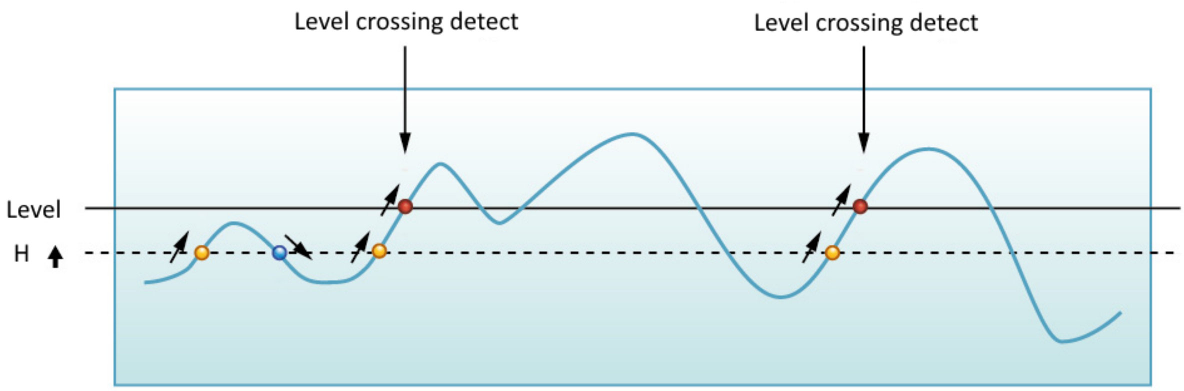
3) *Only possible when measuring digital speed*

Cycle Detector optimization

The signal used for cycle detection is typically not a smooth sine wave but a signal with noise and distortion.
To make cycle detection robust and less susceptible to noise and distortions there are two options:

- Introduce a **hysteresis**
- Enable a holdoff time and a cycle source filter, both defined by a **maximum fundamental frequency**

Hysteresis	The hysteresis function prevents false detections of cycles caused by noise. It is a digital noise suppression technique, and the hysteresis level should be selected to be larger than the noise on the signal.
Hysteresis technique	A level crossing is detected if the signal crosses the chosen hysteresis level first, and then crosses the chosen cycle detect level. After this first level crossing detection the signal must cross again the chosen hysteresis level, and then the cycle detect level for the next level crossing detection, and so on.
Default setting	If voltage sources are selected: 1 V; if current sources are selected: 1 A

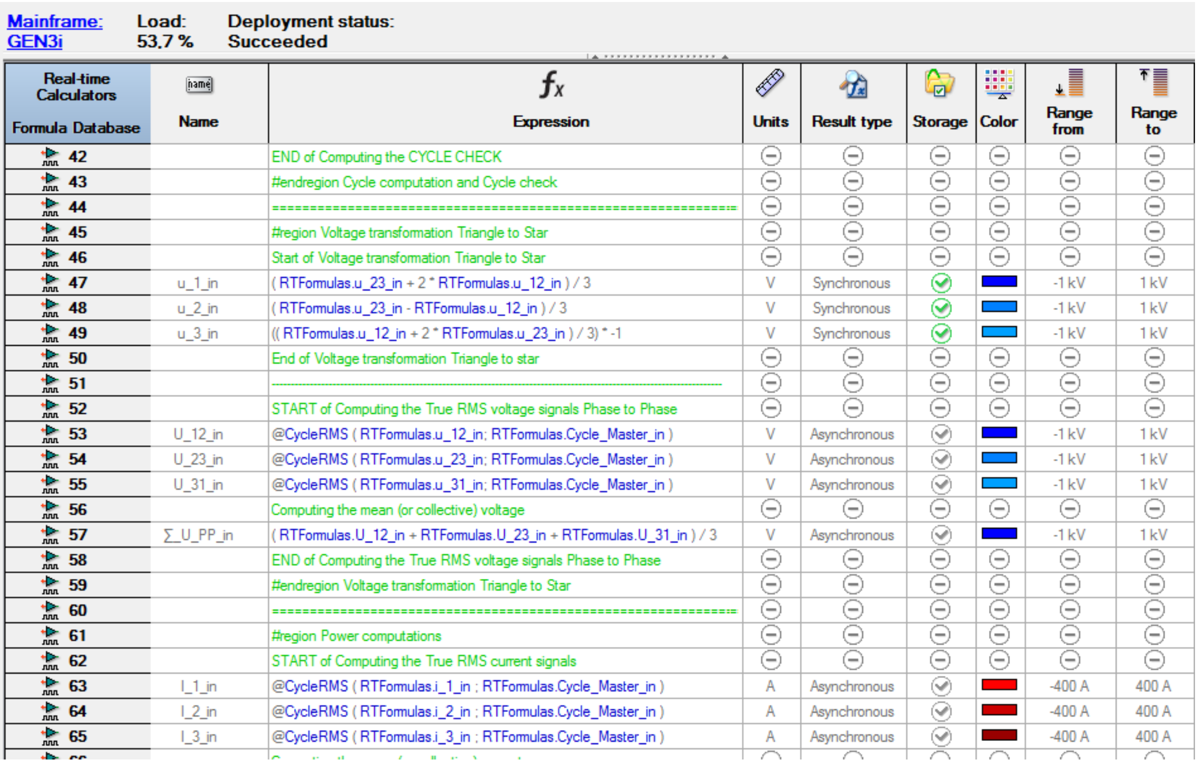


Example of cycle detection optimization using hysteresis techniques

Maximum fundamental frequency	The maximum fundamental frequency defines the highest fundamental frequency expected in the system currently tested. If enabled and entered, it is used to set up two advanced digital techniques to improve cycle detection: • Holdoff time • Cycle source filter
Holdoff time	Holdoff time during which new cycles cannot be detected, the holdoff time is set to half the cycle period of the selected "Maximum fundamental frequency". Any cycle shorter than that time is rejected. Example: Selected "Maximum fundamental frequency" = 50 Hz -> period = 1/50 s = 20 ms …..-> Holdoff time = 10 ms
Cycle source filter	A Bessel low pass filter[1) 2)] eliminates noise on the cycle detect source channel; the filter cutoff frequency is set to twice of the selected "Maximum fundamental frequency". Example: Selected "Maximum fundamental frequency" = 50 Hz -> Filter cutoff frequency = 100 Hz [1)] *The filter introduces a phase shift to the cycle source signal, thus to the cycles found as well with respect to the initial zero crossings of the signal. However, as the math is done on the unfiltered signal and the accuracy of the results do not require proper zero crossings but proper cycles length, the phase shift is not relevant for the results.* [2)] *The filter is only applied for cycle detection, not for power calculations.*

Automatic real time formula creation

Depending on the selected application and measurement configuration, the eDrive software automatically creates all the necessary real time formulas.
When the user changes the configuration, the real-time formulas are automatically updated. This action takes a few seconds.
While the formulas are being updated, the message "Please wait while applying configuration" is displayed.



Mainframe: GEN3i Load: 53.7 % Deployment status: Succeeded

Real-time Calculators Formula Database	Name	Expression	Units	Result type	Storage	Color	Range from	Range to
42		END of Computing the CYCLE CHECK						
43		#endregion Cycle computation and Cycle check						
44		==						
45		#region Voltage transformation Triangle to Star						
46		Start of Voltage transformation Triangle to Star						
47	u_1_in	(RTFormulas.u_23_in + 2 * RTFormulas.u_12_in) / 3	V	Synchronous	✓		-1 kV	1 kV
48	u_2_in	(RTFormulas.u_23_in - RTFormulas.u_12_in) / 3	V	Synchronous	✓		-1 kV	1 kV
49	u_3_in	((RTFormulas.u_12_in + 2 * RTFormulas.u_23_in) / 3) * -1	V	Synchronous	✓		-1 kV	1 kV
50		End of Voltage transformation Triangle to star						
51		--						
52		START of Computing the True RMS voltage signals Phase to Phase						
53	U_12_in	@CycleRMS (RTFormulas.u_12_in; RTFormulas.Cycle_Master_in)	V	Asynchronous	✓		-1 kV	1 kV
54	U_23_in	@CycleRMS (RTFormulas.u_23_in; RTFormulas.Cycle_Master_in)	V	Asynchronous	✓		-1 kV	1 kV
55	U_31_in	@CycleRMS (RTFormulas.u_31_in; RTFormulas.Cycle_Master_in)	V	Asynchronous	✓		-1 kV	1 kV
56		Computing the mean (or collective) voltage						
57	∑_U_PP_in	(RTFormulas.U_12_in + RTFormulas.U_23_in + RTFormulas.U_31_in) / 3	V	Asynchronous	✓		-1 kV	1 kV
58		END of Computing the True RMS voltage signals Phase to Phase						
59		#endregion Voltage transformation Triangle to Star						
60		==						
61		#region Power computations						
62		START of Computing the True RMS current signals						
63	I_1_in	@CycleRMS (RTFormulas.i_1_in ; RTFormulas.Cycle_Master_in)	A	Asynchronous	✓		-400 A	400 A
64	I_2_in	@CycleRMS (RTFormulas.i_2_in ; RTFormulas.Cycle_Master_in)	A	Asynchronous	✓		-400 A	400 A
65	I_3_in	@CycleRMS (RTFormulas.i_3_in ; RTFormulas.Cycle_Master_in)	A	Asynchronous	✓		-400 A	400 A

Example of real time formulas automatically created by the eDrive software

Protection	The formulas created by the eDrive software are protected and cannot be changed by the user.
Storage selection	Always on and protected for all asynchronous (cycle) data streams like RMS, P, Q……; For synchronous data streams like instantaneous power p the storage is OFF and unprotected; so, the user can enable to store these channels as well.
User formulas	At the end of the table with automatically created and protected formulas, the user can append his own formulas – see later chapter.
Syntax checking	The syntax of each formula is checked and a warning or error is given if not correct.
Deployment & load checking	The successful deployment of formulas into the DSP´s is checked and information of the DSP load is given. This is done per input card, for the mainframe and per real time formula function to allow optimization.

Other real time analysis possibilities

The user can enter own real time formulas. These are appended to the formulas automatically created by the eDrive software.

Note: The user defined real time formulas will be executed if total sample rate and computing power requirements allow this.

The list below shows some real time formula functions which might be of interest for eDrive users.
For a full list of available real time formula functions, please refer to the datasheets of the used input cards.

dq0 transformation transforms the α,β-space vectors into a rotating coordinate system and returns the d/q-values.
Atan2 is used to decode a sin/cos angle encoder signal into the position (mechanical angle).
Modulo is used to convert the mechanical angle into electrical angle; also needed for sin/cos decoding.
CycleTHD computes the total harmonic distortion per cycle. *Note: Only possible with reduced sample rate.*
RadiansToDegrees converts results like φ from their native unit “radians” to degrees

Real time formula database results and storage	
The real time formula database can create several different types of data. The two most important ones are • synchronous data[1] (or sample math, like p_1 = u_1 x i_1) • asynchronous data (or cycle math, like U_1 = CycleRMS(u_1))	
Amount of data	
Synchronous	The resulting trace has the same “sample rate” as the source traces. Example: p_1 = u_1 x i_1 will give a 1 MS/s data stream if u_1 and i_1 were sampled at 1 MS/s.
Asynchronous	The resulting trace has a changing “sample rate” which corresponds to the computed Cycle_Master signal. This is typically the fundamental frequency. So it varies between a few S/s and 2 kS/s maximum (maximum cycle frequency). *Note: When reviewed or further math is executed on this asynchronous data, the Perception software first interpolates the signal up to the sample rate of the initial source trace. Otherwise the asynchronous traces could not be displayed nor math could be performed.*
Storage and throughput	
Synchronous	Created with sample rate of source traces and therefore the data rate might be very high. This might add significantly to throughput load and to PNRF file size. Should be store only if really needed.
Asynchronous	Created with frequency of Cycle_Master and therefore the data rate is always ≤ 1 kS/s. Can be neglected for throughput load and PNRF file size. Can always be stored without any notable negative effect.
PNRF data storage	All real time database results are stored in the PNRF file of the recording.
StatStream[2] data	All synchronous results are stored in the PNRF file together with their Min, Max and Mean value over 500 values. Thus accelerated review is possible as with other StatStream[2] based data.
[1] *Synchronous math is only possible with channels from the same recorder* [2] *StatStream is a patented technology for storage and reviewing large amounts of data, patent no 7,868,886.*	

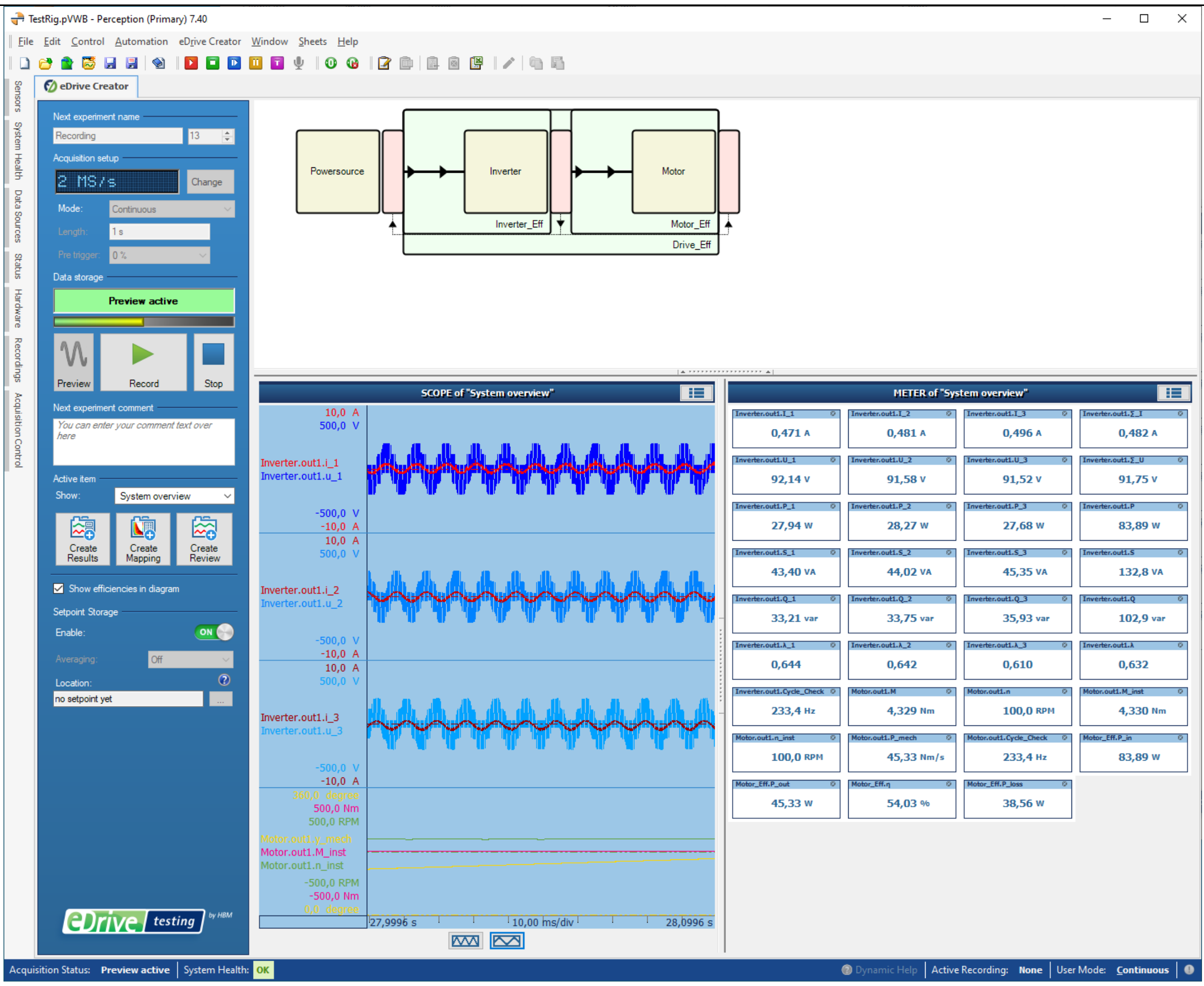
Transfer of real time formula database results	
Asynchronous results from the formula database can the transferred and stored in other files or systems. Typically the synchronous data is way too fast to transfer these out of the eDrive system.	
Real time transfer	Asynchronous results from the real time formula database can be transferred via EtherCAT1) or CAN1) or GEN DAQ API1) and Perception RPC. The (user) selected results are transferred in a single block and are all from the same analysis cycle.
EtherCAT	
Transfer rate	1000 result blocks per second.
Channel count	240 results maximum can be transferred as single result block.
Result selection	User selectable out of all real time formulas with asynchronous result.
CAN 2.0 and CAN FD	
Transfer rate	Up to 1000 result blocks per second.
Channel count	240 results maximum can be transferred as single result block.
Result selection	User selectable out of all real time formulas with asynchronous result.
Software transfer	Asynchronous results from the real time formula database can be transferred via Perception RPC or the GEN DAQ API.
Perception RPC	There are two methods available: All eDrive results can be retrieved in a single call (GeteDriveValues)2) These values are averaged according to the eDrive settings for the METERS. All RT-FDB results with „Storage“ enabled can be retrieved in a single call (GetAsyncRTFDBValues).
Transfer rate	Up to 20 result blocks per second.
Channel count	GeteDriveValues: Number depends on the selected eDrive configuration2) GetAsyncRTFDBValues: All RT-FDB results with “Storage“ enabled
Result selection	GeteDriveValues: Fixed → All eDrive results currently calculated2) GetAsyncRTFDBValues: Fixed → All RT-FDB results with “Storage“ enabled
GEN DAQ API	Published asynchronous results from the real time formula database results can be retrieved in a single call (RequestFieldBusSnapshot) and are all from the same analysis cycle.
Transfer rate	Up to 2000 result blocks per second.
Channel count	240 results maximum can be transferred as single result block.
Result selection	User selectable out of all real time formulas with asynchronous result.
1) Only to 1 of the 3 at the same time. *2) These functions only return valid data when using predefined eDrive configuration. Not when using the eDrive Creator*	

The LIVE sheet – real time display of results, traces, FFTs….

The LIVE sheet is the main display component of eDrive.
It is typically used to view numerical power results as well as live traces during a measurement.
It is preconfigured to a large extend, only few changes are possible.

Note: If the user wants a different layout of the screen showing results, he can always use a User sheet to fully configure his own display sheet.

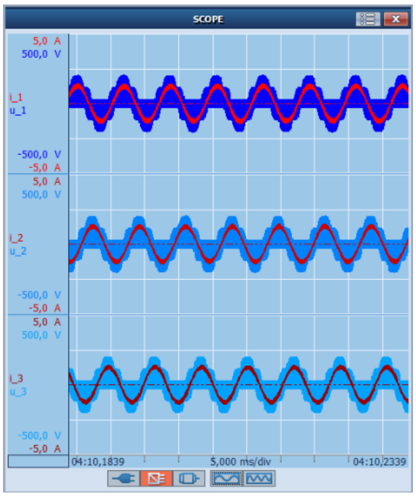
eDrive LIVE sheet with all main display components being activated
(Screen hardcopy shows eDrive running on a monitor with FullHD resolution)

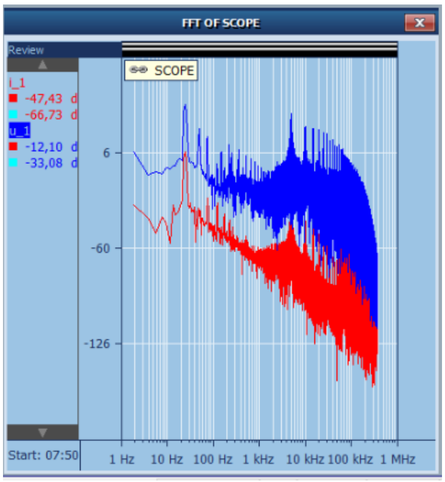


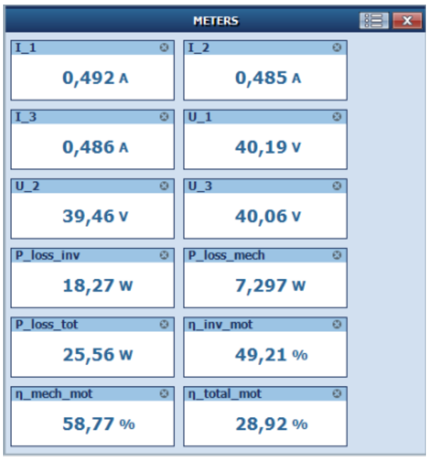
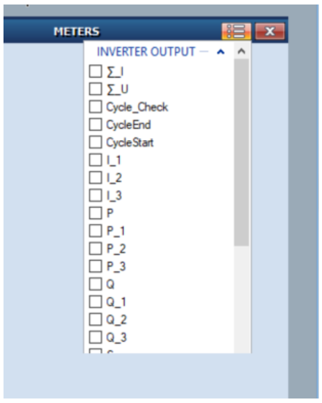
eDrive Creator LIVE view with the system overview as active item

Resolution	The LIVE sheet (and also the SETUP sheet) is optimized for resolutions of 1280 x 1024 or better. If lower resolution is used, horizontal and / or vertical scroll bars will appear and allow moving of the visible area. For motor – generator mode, a resolution of 1920 x 1080 is recommended.
Multi-Monitor support	All sheets can be distributed on multiple monitors, if the used PC supports this. Thus one monitor could show the LIVE sheet, another monitor the SETUP sheet, a third monitor a REVIEW sheet.

(Main) METER display	
The main meters act as the "power meter" in the eDrive software option. They always show the most important calculated results. *Note: In eDrive Creator mode the main meters are not available.*	
Selection	Always on; auto sized depending on available display space and enabled LIVE display options.
Formatting per meter	Selection of unit prefix: none, k (kilo), M (Mega); (M for power entities only). Selection of decimal point position; auto adapts if meter is over ranged.
Content	Fixed; shows most important values for power source / inverter output / motor output; for 3-phase setups, user can select cumulative (mean) values or values per phase
Meter update rate	200 ms, 500 ms or 1 s. Same setting as used for TIMED cycle detection; valid for the whole system. One single value is taken out of the continuous, asynchronous data stream at the choosen time interval and displayed without any averaging.
Energy flow indicators	 Arrows between the individual blocks indicate the direction of the energy flow and thus whether the machine acts as motor or as generator; Definition: • P_in > P and P > P_mech -> motor mode > Arrows pointing to the right • P_in < P and P < P_mech -> Generator mode -> Arrows pointing to the left
Load indicators	 Three individual indicators at the bottom of the INVERTER OUT meter block indicate the load of the machine per phase. • Icon **L** -> Inductive load • Icon **C** -> Capacitive load The value is derived from the phase angle φ per phase: for $0 < \varphi \leq \pi$ -> inductive for $\pi < \varphi \leq 2\pi$ -> capacitive *Note: These indicators are only available when the computation of φ and cosφ is enabled.*

<table>
<tr><th colspan="2">SCOPE Display</th></tr>
<tr><td>The SCOPE display mimics an oscilloscope screen. The content to be shown can be selected.
The amount of data shown can be selected in the drop down menu. This can be all data since the last update or it can be clipped to show exactly what is used to calculate the meter values.</td><td></td></tr>
<tr><td>Activation</td><td>On or off;
auto sized depending on available display space and enabled LIVE display options
Note: In eDrive Creator mode the display is always present when not in edit mode.</td></tr>
<tr><td>Signal selection</td><td>• Power source signals
• Inverter output signals
• Motor output signals
The scope display follows the selection in the upper meter area to display single phase signals or all phases.
For motor – generator mode, also the other two signals blocks can be selected in the scope display.
In eDrive Creator mode the display shows the signals of the active item in the graphical overview. Signal selection can be adapted from the SCOPE display options</td></tr>
<tr><td>Zoom</td><td>Zoom in and out on time axis in fixed steps.</td></tr>
<tr><td>Layout</td><td>Channels overlapped or separated.
Channels to display follows selection in Main meters for which channels to show: individual phases or all phases.</td></tr>
<tr><td>Grid</td><td>On or Off</td></tr>
</table>

FFT Display	
The FFT display shows an FFT of all signals shown in the scope display. *Note: In eDrive Creator mode the FFT display is not available.*	
Activation	On or off; auto sized depending on available display space and enabled LIVE display options.
Signal selection	Follows selection in scope display
Zoom	None; frequency range is defined by displayed time frame in the scope and the sample rate of the shown traces
Layout	Channels always overlapped

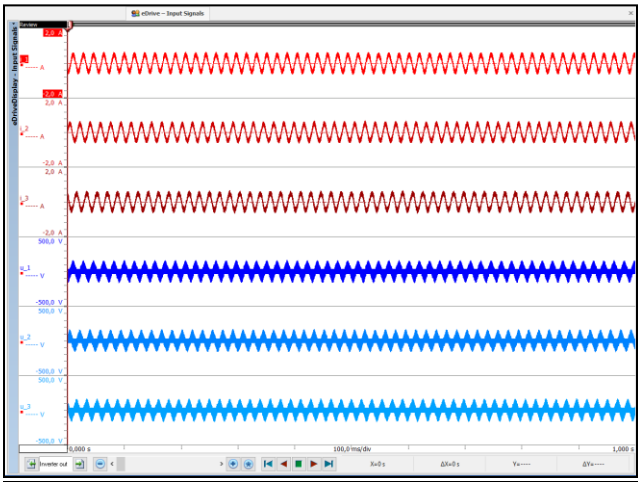
(More) METERS Display	
The METERS display can be used to show more of the real time calculated results than are shown in the main meters area.	  MORE METERS filled with some values Selection pull down list
Activation	On or off; auto sized depending on available display space and enabled LIVE display options.
Signal selection	Selection of values from pull down list in upper right hand of METERS area.
eDrive results	All cycle based results calculated in eDrive can be shown in the MORE METERS section. Just select the desired ones from the pull down list. See section of real time calculations for available results.
User formula results	All cycle base results calculated with user defined formulas in the real time formula database can be shown in the MORE METERS section. Just select the desired ones from the pull down list. *Note: These results are calculated of the same cycle as the eDrive results (if using the same cycle master), so 100% synchronized with eDrive results.* *Note: You can use the @CycleMEAN function to turn instantaneous channels like temperatures from an GN1640B into cycle based results and then show these in the MORE METERS and transfer it to EXCEL via the "Log to EXCEL" function.*
Temperature readings	All MEAN temperature readings available in the system can be shown in the MORE METERS section. Just select the desired ones from the pull down list. *Note: Temperature readings might come from GN840B or GN1640B input cards being in **Thermocouple mode** or **PTxx mode** or from MX1609B / MX809B thermocouple satellites.* *Note: These results are not calculated over cycles but MEAN values derived per recorder card independently. So the values are NOT synchronized with eDrive results (up to ~200ms jitter in MORE METERS, corrected in REVIEW).*
CAN bus readings	All MEAN values of CAN channels available in the system can be shown in the MORE METERS section. Just select the desired ones from the pull down list. *Note: These results are not calculated over cycles but MEAN values derived from the MX471B CAN bus satellite independently. So the values are NOT synchronized with eDrive results (up to ~200ms jitter in MORE METERS, corrected in REVIEW).* In eDrive Creator mode the CAN channels are not available.
Meter arrangement	Fully customized using drag and drop; auto sizing pending from the number of selected values
Meter formatting	Fixed 4 digit formatting, no user selection
Meter update rate	200 ms, 500 ms or 1 s. Same setting as used for TIMED cycle detection; valid for the whole system. With averaging being disabled, one single value is taken out of the continuous, asynchronous data stream at the chosen time interval and displayed.
Averaging	Enables averaging over selected "Update rate" time. So if enabled for an update rate of 200 ms, all readings within this 200 ms interval are averaged. This results in a more stable display. *Note: This averaging effects only the METERS display and the "Log to EXCEL" data, but not the stored data or the data retrieved via RPC command.*

Other LIVE and REVIEW sheets

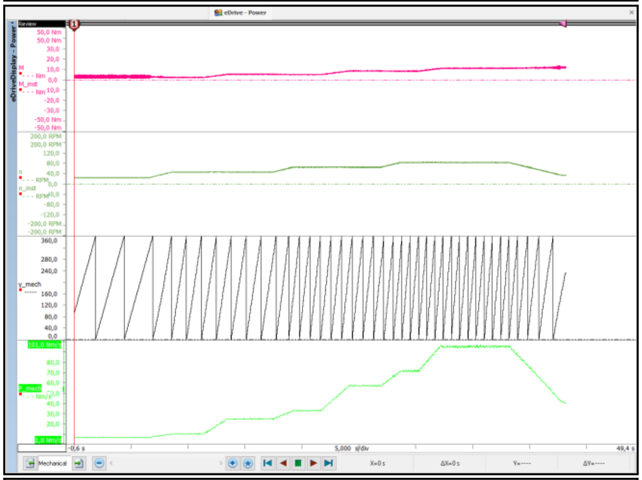
The eDrive application creates several display SHEETS (with even more PAGES) automatically.
These sheets and pages show the most important traces.

Note: For the eDrive creator some basic sheets can be created based on the active item in the graphical system overview.

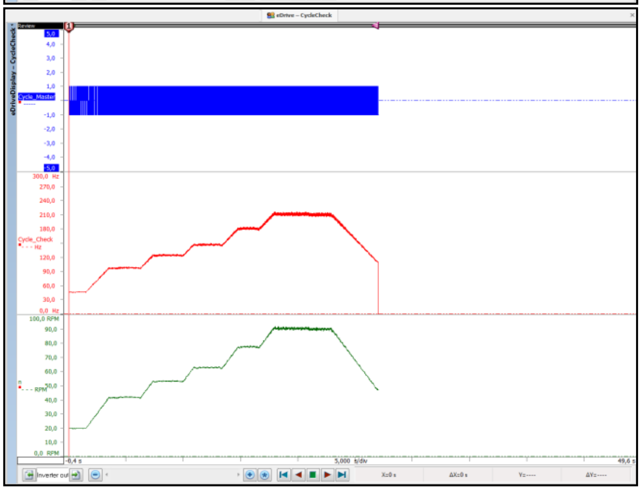
Sheet **eDrive – Input signals**:
page INVERTER OUT
shows
i_1, i_2, i_3 and u_1, u_2, u_3



Sheet **eDrive – Power**:
page MECHANICAL
shows
M, n, γ_mech and P_mech



Sheet **eDrive – CycleCheck**:
page INVERTER OUT
shows
Cycle_Master,
Cycle_Check (frequency of found cycles)
and n



Three examples of the numerous pages created automatically;
Note: For better printing, page background was changed from black to white

Creation	Automatically at eDrive start or whenever the measurement configuration is changed In eDrive Creator mode: via the corresponding buttons in the taskpane.
Protection	Initially, sheets are set to READ ONLY; protection can be removed by user and then sheets can be edited
User modification	Possible after removing READ ONLY protection. Will be overwritten by next automatic update on measurement configuration change.

	Note: The feature USER SHEET – DUPLICATE can be used to copy the sheet and then modify this new user sheet. This new sheet will not be overwritten.
Created sheets	Pages and traces shown in the different pages:
eDrive – Input signals	POWER SOURCE • Measured voltage and current channels INVERTER OUT • Measured voltage and current channels MECHANICAL • Instantaneous values for torque and speed and mechanical angle • Digital channels used to torque and speed
eDrive – Power	POWER SOURCE • RMS values of all voltages and currents • True power values per phase and total • Apparent power values per phase and total • Reactive power values per phase and total INVERTER OUT • RMS values of all voltages and currents • True power values per phase and total • Apparent power values per phase and total • Reactive power values per phase and total MECHANICAL • Instantaneous values for torque and speed • CycleMean values for torque and speed • Mechanical angle • Mechanical power EFFICIENCIES • Input (true) power, Output true power and mechanical power • Inverter efficiencies for motor and generator mode • Machine efficiencies for motor and generator mode • For mode **Shaft and transmission**: Transmission efficiencies for motor and generator mode • Total efficiencies for motor and generator mode
eDrive - CycleCheck	POWER SOURCE • Cycle source In and Cycle Source Filtered In Signals • Cycle Master In • Cycle Check In Signal (= fundamental frequency) at input INVERTER OUT • Cycle source and Cycle Source Filtered Signals • Cycle Master • Cycle Check Signal (= fundamental frequency) at inverter output MECHANICAL • Cycle Master Mech • Cycle Check Mech Signal (= fundamental frequency) at mechanical output

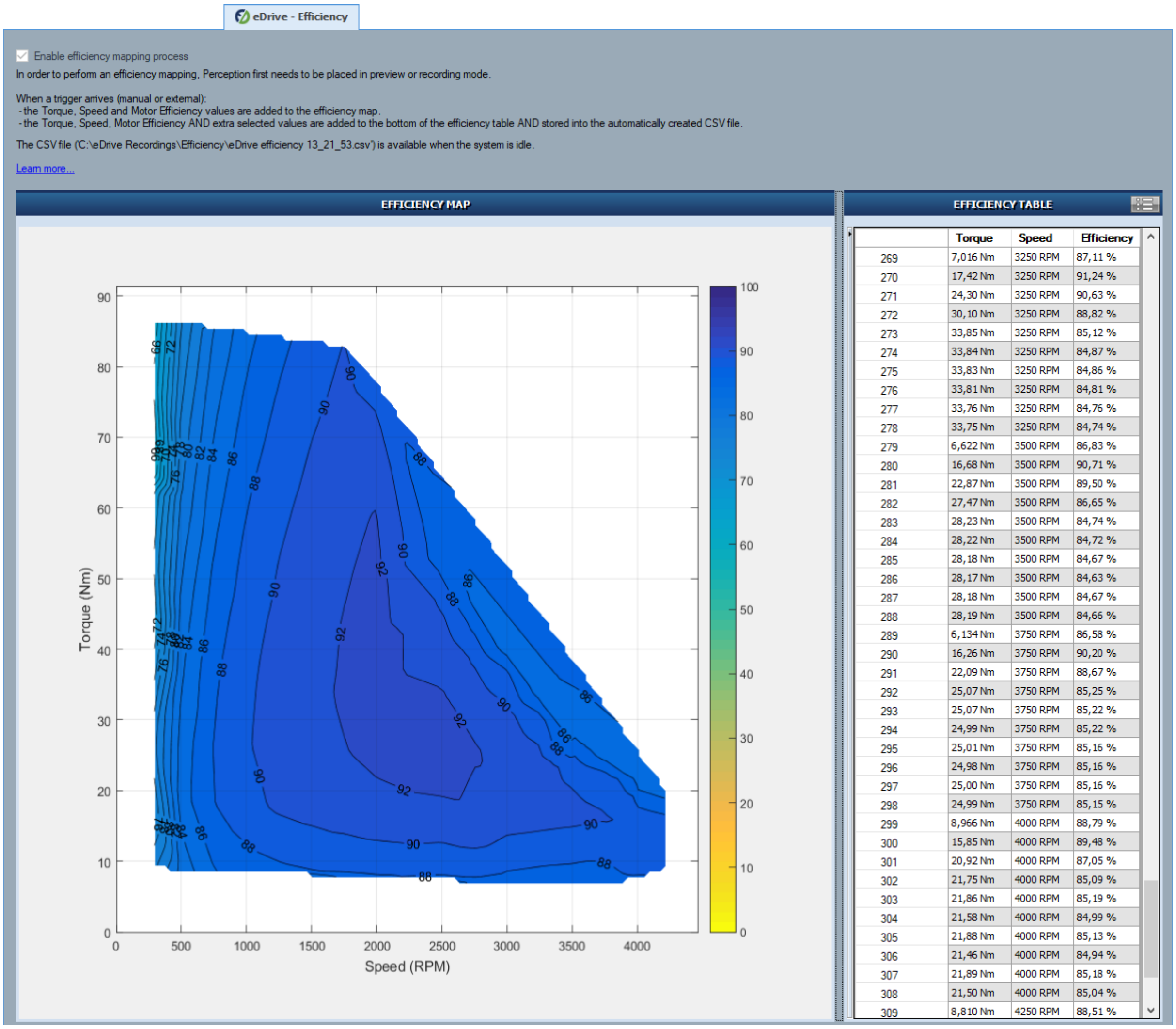
Efficiency mapping

The efficiency sheet can contains a:

- Map containing the contour plot of the torque, speed and efficiency values out of the set points
- A table in which the requested set point values are added on each trigger.

Efficiency mapping: Predefined templates

The efficiency sheet is placed next to the Setup Sheet and Live Sheet and is always present.



	Torque	Speed	Efficiency
269	7,016 Nm	3250 RPM	87,11 %
270	17,42 Nm	3250 RPM	91,24 %
271	24,30 Nm	3250 RPM	90,63 %
272	30,10 Nm	3250 RPM	88,82 %
273	33,85 Nm	3250 RPM	85,12 %
274	33,84 Nm	3250 RPM	84,87 %
275	33,83 Nm	3250 RPM	84,86 %
276	33,81 Nm	3250 RPM	84,81 %
277	33,76 Nm	3250 RPM	84,76 %
278	33,75 Nm	3250 RPM	84,74 %
279	6,622 Nm	3500 RPM	86,83 %
280	16,68 Nm	3500 RPM	90,71 %
281	22,87 Nm	3500 RPM	89,50 %
282	27,47 Nm	3500 RPM	86,65 %
283	28,23 Nm	3500 RPM	84,74 %
284	28,22 Nm	3500 RPM	84,72 %
285	28,18 Nm	3500 RPM	84,67 %
286	28,17 Nm	3500 RPM	84,63 %
287	28,18 Nm	3500 RPM	84,67 %
288	28,19 Nm	3500 RPM	84,66 %
289	6,134 Nm	3750 RPM	86,58 %
290	16,26 Nm	3750 RPM	90,20 %
291	22,09 Nm	3750 RPM	88,67 %
292	25,07 Nm	3750 RPM	85,25 %
293	25,07 Nm	3750 RPM	85,22 %
294	24,99 Nm	3750 RPM	85,22 %
295	25,01 Nm	3750 RPM	85,16 %
296	24,98 Nm	3750 RPM	85,16 %
297	25,00 Nm	3750 RPM	85,16 %
298	24,99 Nm	3750 RPM	85,15 %
299	8,966 Nm	4000 RPM	88,79 %
300	15,85 Nm	4000 RPM	89,48 %
301	20,92 Nm	4000 RPM	87,05 %
302	21,75 Nm	4000 RPM	85,09 %
303	21,86 Nm	4000 RPM	85,19 %
304	21,58 Nm	4000 RPM	84,99 %
305	21,88 Nm	4000 RPM	85,13 %
306	21,46 Nm	4000 RPM	84,94 %
307	21,89 Nm	4000 RPM	85,18 %
308	21,50 Nm	4000 RPM	85,04 %
309	8,810 Nm	4250 RPM	88,51 %

eDrive – Efficiency sheet

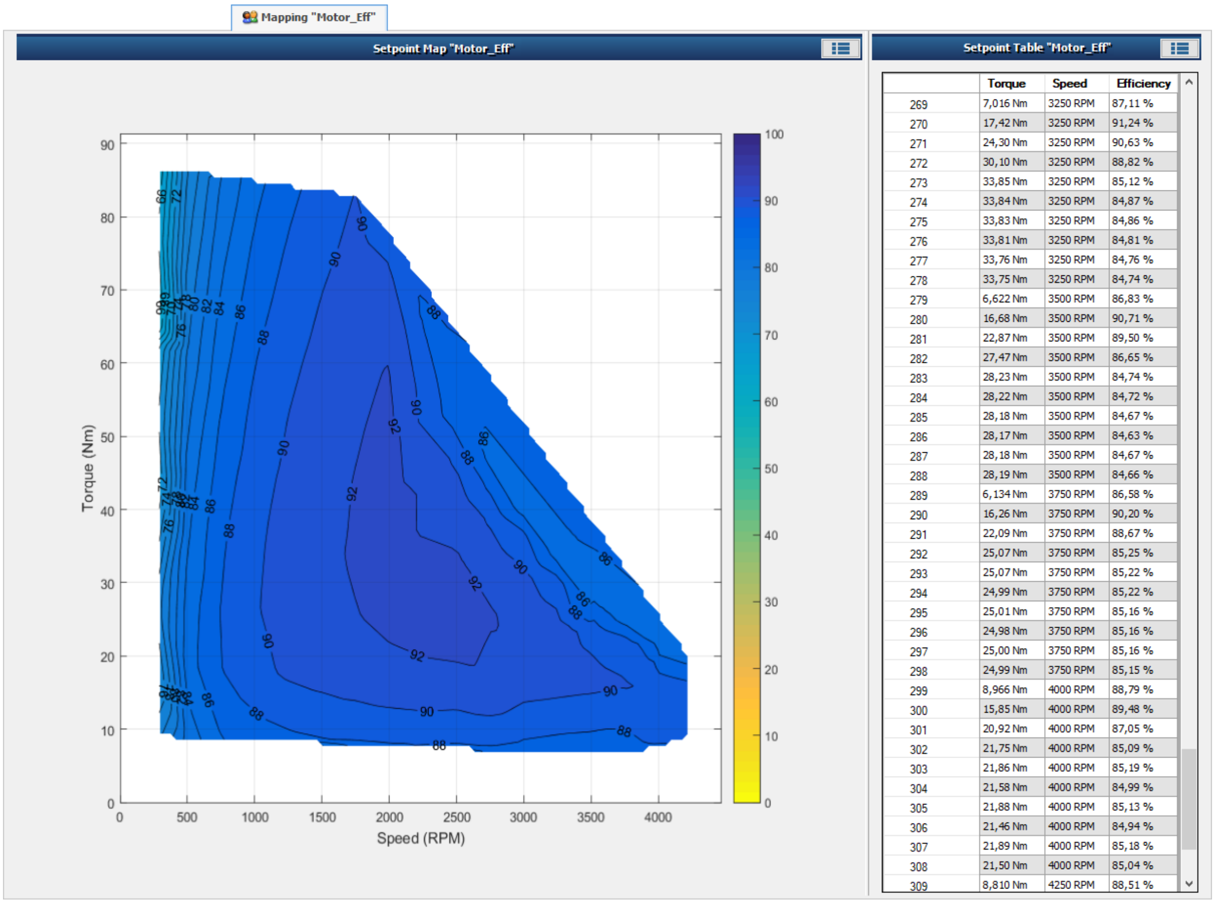
In order to use the efficiency mapping the following requirement are needed:

- An eDrive capable system needs to be connected
- The inverter output configuration needs to be enabled
- The motor output configuration needs to be enabled
- The external trigger need to enabled (default” enabled)
- The “MATLAB Runtime version R2016b” needs to be installed
- The Efficiency mapping process needs to be enabled

The requirements are tracked all the time and if the requirements are not fulfilled this is shown on the screen.

Efficiency mapping: eDrive Creator

With the eDrive creator multiple efficiency maps can be created simultaneously.



	Torque	Speed	Efficiency
269	7,016 Nm	3250 RPM	87,11 %
270	17,42 Nm	3250 RPM	91,24 %
271	24,30 Nm	3250 RPM	90,63 %
272	30,10 Nm	3250 RPM	88,82 %
273	33,85 Nm	3250 RPM	85,12 %
274	33,84 Nm	3250 RPM	84,87 %
275	33,83 Nm	3250 RPM	84,86 %
276	33,81 Nm	3250 RPM	84,81 %
277	33,76 Nm	3250 RPM	84,76 %
278	33,75 Nm	3250 RPM	84,74 %
279	6,622 Nm	3500 RPM	86,83 %
280	16,68 Nm	3500 RPM	90,71 %
281	22,87 Nm	3500 RPM	89,50 %
282	27,47 Nm	3500 RPM	86,65 %
283	28,23 Nm	3500 RPM	84,74 %
284	28,22 Nm	3500 RPM	84,72 %
285	28,18 Nm	3500 RPM	84,67 %
286	28,17 Nm	3500 RPM	84,63 %
287	28,18 Nm	3500 RPM	84,67 %
288	28,19 Nm	3500 RPM	84,66 %
289	6,134 Nm	3750 RPM	86,58 %
290	16,26 Nm	3750 RPM	90,20 %
291	22,09 Nm	3750 RPM	88,67 %
292	25,07 Nm	3750 RPM	85,25 %
293	25,07 Nm	3750 RPM	85,22 %
294	24,99 Nm	3750 RPM	85,22 %
295	25,01 Nm	3750 RPM	85,16 %
296	24,98 Nm	3750 RPM	85,16 %
297	25,00 Nm	3750 RPM	85,16 %
298	24,99 Nm	3750 RPM	85,15 %
299	8,966 Nm	4000 RPM	88,79 %
300	15,85 Nm	4000 RPM	89,48 %
301	20,92 Nm	4000 RPM	87,05 %
302	21,75 Nm	4000 RPM	85,09 %
303	21,86 Nm	4000 RPM	85,19 %
304	21,58 Nm	4000 RPM	84,99 %
305	21,88 Nm	4000 RPM	85,13 %
306	21,46 Nm	4000 RPM	84,94 %
307	21,89 Nm	4000 RPM	85,18 %
308	21,50 Nm	4000 RPM	85,04 %
309	8,810 Nm	4250 RPM	88,51 %

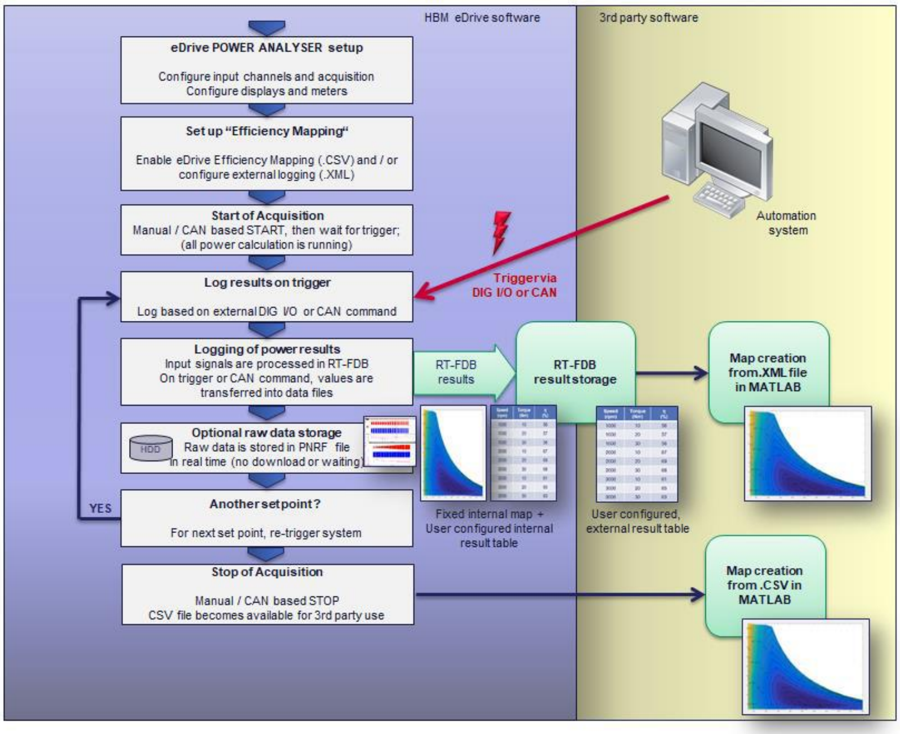
eDrive Creator – Mapping sheet

In order to use the efficiency mapping the following requirement are needed:

- The Setpoint-mapping process needs to be enabled
- Valid sources for the X, Y and Z axis of the Setpoint Map need to be selected from the drop-down menu
- The “MATLAB Runtime version R2016b” needs to be installed

The requirements are tracked all the time and if the requirements are not fulfilled this is shown on the screen.

Efficiency mapping: Process



Motor mapping process flow using "Efficiency Mapping" in a Multi-Sweep acquisition mode

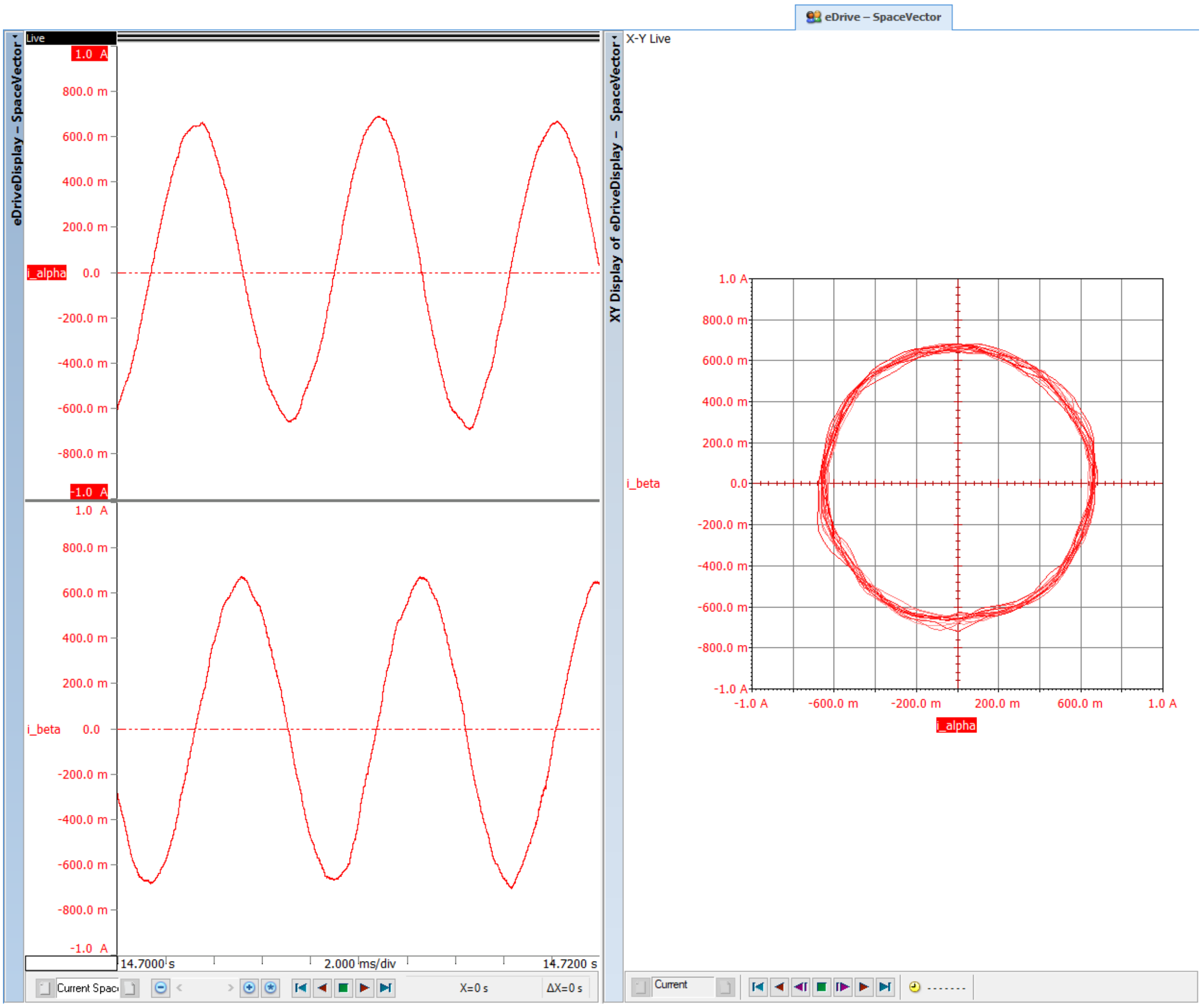
Process	1. Drive device under test to all desired set points 2. When the system is in PREVIEW or RECORD mode and a trigger arrives (manual or external), the Torque, Speed, Motor Efficiency and extra selected values calculated over the NEXT number of defined cycles are stored for this set point. In case an averaging period is selected (under Update rate settings), the values will be averaged using this period on top of the stored values. These set point values are added to the bottom of the efficiency table AND are stored into the automatically created CSV file. The table automatically scrolls to the last added set point values. In RECORD mode all set points in Multi Sweep mode are also stored in the recording. 3. A contour plot of the stored set points is also displayed if applicable. Be aware that a contour plot can only be displayed with at least 3 set points in which the torque/speed values are NOT on a mathematical straight line
Process automation	By external automation system; not included in eDrive nor Perception software
Process interaction	Trigger input to eDrive; received from automation system via TTL, CAN bus command or software command; upon this, and per set point, power results are automatically stored in a CSV file and raw data is stored when recording.
eDrive internal process control	After initial setup and START, the whole process in eDrive is automatically running, only controlled by incoming triggers; finally a STOP command ends the process.
CSV location and filename creation	The CSV automatically gets a name and is stored in a subfolder (called "Efficiency") of the current storage location. The filename generated: • In preview mode: "eDrive efficiency hh_mm_ss.csv". Where the time is the time of the first set point • In recording mode: "<recordingname>.csv" Because the process needs write access to the CSV file, the file is only available to the user when Perception is set to IDLE again.
Lifetime	The values in the efficiency sheet are present until the system goes into preview or record mode again. When this happens the values are cleared in the sheet (but are still in the CSV file). *Note: It is not possible to reload values from the CSV file and display them in the efficiency sheet.*

The eDrive – Space Vector sheet

When the space vector formulas are enabled, extra real-time formulas are added to calculate the space vector transformation of the 3phase inverter output currents.

The results of these calculations are shown in a specially created display sheet called “eDrive - SpaceVector”. On this sheet a display and XY display are present containing the calculation results.

Note: Only applies to predefined templates



eDrive – SpaceVector sheet

Creation	Automatically when the space vector formulas are enabled In eDrive Creator mode this sheet needs to be created and setup manually.
Protection	Initially, sheets are set to READ ONLY; protection can be removed by user and then sheets can be edited
User modification	Possible after removing READ ONLY protection. Will be overwritten by next automatic update on measurement configuration change. *Note: The feature USER SHEET – DUPLICATE can be used to copy the sheet and then modify this new user sheet. This new sheet will not be overwritten.*
Layout	There is only 1 page called “Current SpaceVector” and it contains the alpha and beta component from the space vector transformation of the inverter output currents
Lifetime	When the acquisition state is **Preview** or **Record**, the displays show the live computed results only. In Idle the last recorded computed results are shown

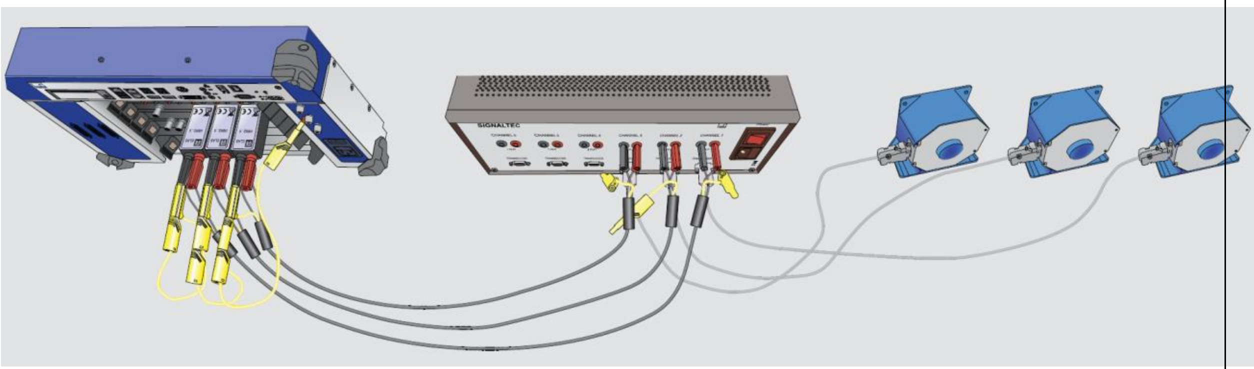
Other Functions: Predefined templates	
Update rate settings	User selectable: 200 ms, 500 ms or 1 s. One setting for whole system. Used for METER update rate and TIMED cycle interval; also sets the initial time axis for the SCOPE display (which can be changed by the user). *Note: If AVERAGING is enabled for the MORE METERS, the Update rate also defines the Averaging period of the MORE METERS. This also effects the values retrieved via Perception RPC.*
Log to XML file / Excel	All real time power results displayed in the eDrive METER and the MORE METER sections can be stored to an XML file. In case EXCEL is installed on the system, and the logging is done while in PAUSE mode, this XML file will be opened automatically and the (growing) content is shown.
Time of logging	User selectable; • Manually at button press • Automatically at predefined time intervals (100 ms or longer) • Automatically a predefined time after each recording start • Automatically at each trigger
XML file name	The filename depends on the system state when logging: - RECORD mode -> (recording name).XML. - PAUSE or IDLE modes -> (time / date of Perception start).XML.
XML file storage location	**c:/eDrive Recordings/Logfiles** (can be changed by the user).
Freeze screen	The screen content can be frozen for closer examination. *Note: This will not stop the real time calculations streamed out via hardware EtherCAT interface but will stop the calculated results available via software interface RPC.*
Copy screen to clipboard	The screen can be copied to the clipboard and inserted into other applications like Microsoft Word.
Torque shunt check	The shunt function of the HBM torque transducers T12 and T40B can be activated. This provides a sanity check of cabling and scaling; shunt value is ~ 50% of full scale.
Review Formulas	All formulas needed for the selected configuration can be re-created for the Perception formula database for post run analysis.
Other Functions: eDrive Creator	
Update rate settings	Fixed: The values are shown as fast as possible, meaning: When the data is received, it is shown in the display and the MORE METERS. *Note: If AVERAGING is enabled for the MORE METERS, the Update rate is also determined by the averaging setting.*
(More) METER averaging settings	User selectable: None, 500 ms, 1 s or 5 s. One setting for whole system
Other Functions: Both	
DC filtering	Different filter settings for AC and DC channels can be setup. *Note: This is only relevant when a DC power source type is selected.*
AUTO-TIMED mode	If auto-timed mode is enabled, values are calculated at least once a second. This setting enables a timeout timer on the cycle detectors which guards if cycles are produced. If one (1) second passes since the last cycle is produced, a new cycle is generated and calculations are done over the past second, even if no cycles are detected in the signal.
Recording comments	A free text comment can be entered and is stored with the recording data.
Voice marks	When in **Continuous** or **Continuous – Predefined time** modes, voice marks can be added during the recording (using a microphone) and are stored in the recording; during review of stored data these voice marks are played back via the PC´s speaker.
RPM and torque trace inversion	Possible for torque and speed signals independently; *Note: Pending from mechanical mounting, it might be necessary to invert torque and / or RPM signals to get proper signs for the readings.*
Angle recording	Supported; The angle is always computed from the speed signal; see SENSOR section of this datasheet.

Angle offset	The mechanical offset angle γ_offset between the mechanical and the electrical zero can be entered in the menu to compensate for mechanical mounting to shaft “zero”. This offset is needed to normalize the electrical angle to do a proper dq0-transformation or other mathematical analysis being based on a rotor based coordinate systems.
Mechanical to electrical angle conversion	Can be done real time or post process

Perception interaction	
eDrive is a user interface on top of HBM´s general purpose data acquisition and analysis software Perception. If eDrive is active, various Perception features typically not needed in this application are hidden. The user can always switch over to Perception to have access to all Perception features.	
Locked features	eDrive locks all Perception and hardware features critical for proper working; the exact listing depends on the selected application; these locked features are greyed out in Perception and cannot be changed from here.
Available features	All other Perception features and hardware settings can still be used.

Using current transducers with eDrive

Supported transducers	Most common current transducers (like zero flux transducers) can be used with the eDrive system. Typically these transducers have a current output, so a burden resistor is needed to convert this current to a voltage then measured by the eDrive system. These burden resistors are available as accessories from HBM. Current transducers with voltage output can be connected directly to the voltage inputs of the eDrive system.

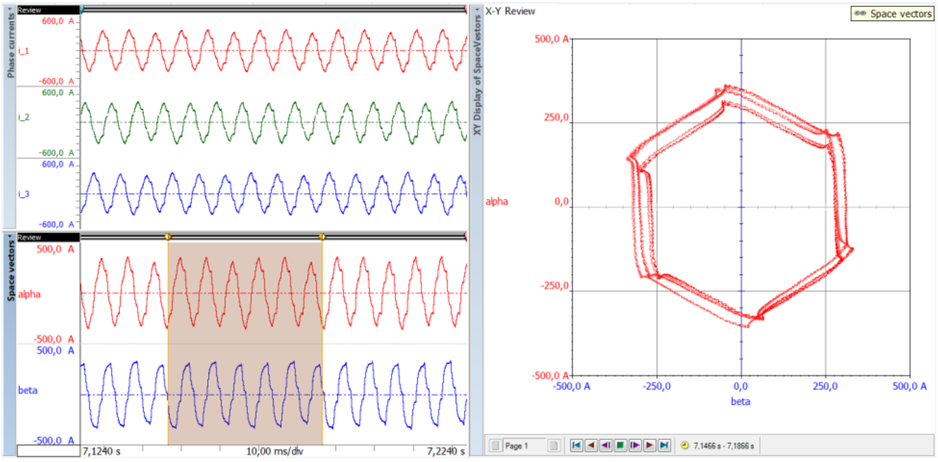


Typical connection of LEM current transducers to the MCTS power supply, and then to the HBM burden resistors in front of the GN61xB card; shielding and grounding is shown as recommended

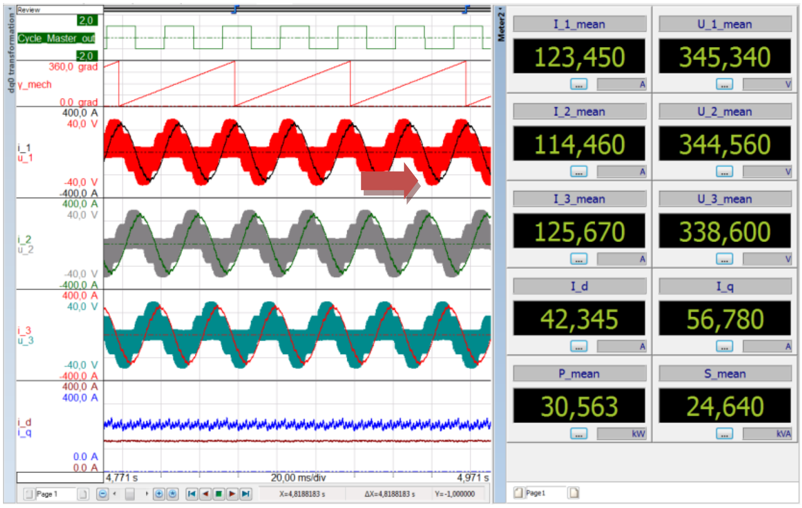
How to use CT´s	In order to use CT´s as current sensors, these need to be entered into the sensor database of Perception first. As the eDrive system has voltage inputs, it is easiest to enter the CT and its burden resistor as a single sensor with a sensitivity of A/V. Several CT´s with burden resistors are already in the sensor database, so it is also possible to use one of these predefined ones and modify if needed. For example, all the ITxxx CT´s from LEM are already in the sensor database including the proper burden resistors.
Shielding	In order to minimize noise, it is recommended to use shielded cables, like the HBM 1-KAB290-xx cables. *Note: Do not use standard BNC cables as the outer shield will pick up noise and connect to the (-) input of GN61xB resulting in noise on the signal.*
Grounding	In some cases, pending from ground conditions, the CT´s output current (voltage) might carry a high frequency common mode voltage. This might override the input of the amplifier and lead to wrong measurements. **Thus it is recommended to ground one side of the burden resistors on the GEN DAQ mainframe side, using the ground plug there.** *Note: The "Ground" switch on the MCTS power supply does not provide real ground, it only connects to ground through a resistor.* Details on proper wiring can be found in a separate manual about CT cabling, available from the HBM web page.  Manual of proper connection and grounding of CT´s when used with eDrive

Post run analysis and data processing

Perceptions post run formula database option offers hundreds of analysis functions. These vary from basic math to advanced filtering and statistics. In addition to the functions in the standard formula database, the eDrive software option adds a few very specific functions to the list.



eDrive analysis example showing phase currents, α,β-currents and a xy diagram of the α,β-currents indicating system balance and control behavior



eDrive analysis example showing phase voltages and currents, mechanical and electrical angle and the computed I_d and I_q currents using dq0 transformation

eDrive specific functions	Space Vector transformation (Clarke transformation) Inverse Space Vector transformation dq0 transformation (Park transformation)
Perception functions of interest (excerpt)	Amongst the hundreds of functions in the formula database, the few listed below can be of interest for further analysis of stored eDrive data: • CycleDetect: finding cycles even in highly distorted signals • CycleRMS: computing the TrueRMS of a trace per cycle • CycleFundamental: computing the fundamental of a trace per cycle using a discrete fourier transformation • CycleTHD: Total harmonic distortion per cycle • CycleCrestFactor: Crest factor per cycle • Modulo: needed to convert mechanical angle into electrical angle using the number of pole pairs • Atan2: needed to convert a sin/cos decoder signal into a position • Comparator: needed to differentiate between use cases like motor or generator mode

eDrive requirements

The eDrive software option requires Perception Enterprise 64 bit software in order to run.
For the applications to be supported as listed there are minimum hardware requirements.

Windows OS	Windows 7, 8, or 10, 64 bit version	
Perception software	Perception 64 bit, version 7.40	
GEN DAQ hardware		
Mainframe	GEN2tB, GEN3i, GEN3t, GEN7i, GEN7tA or GEN17tA	
eDrive capable cards	• GN610B: Isolated 1 kV 2 MS/s Input Card • GN611B: Isolated 1 kV 200 kS/s Input Card • GN1202B: Optical Fiber Isolated 100 MS/s Input Card	
System	• Minimum 1 x eDrive capable card with real time formula database option 1-GEN-OP-RT-FDB; this allows two entry level applications to be addressed; see application selection for details • Typical 2 x GN610B inputs cards for “standard” applications, each with real time formula database option 1-GEN-OP-RT-FDB; this allows most applications to be addressed; see application selection for details • For some specific setups with higher channel count (like motor – generator mode or support for analog torque transducers), more eDrive capable cards are needed to meet the channel count requirement; see application selection for details	
PC configuration for acquisition and analysis	Minimum	Recommended
	Windows® 64 bit, version 7, 8, 10 8 GB RAM Intel i5 processor Gigabit Ethernet FullHD monitor SSD HDD (~100 MB/s throughput minimum)	Windows® 64 bit, version 10 16 GB RAM or more Intel i7 processor (at least 4 cores) Gigabit Ethernet Multiple FullHD monitors SSD RAID0 array (>>100 MB/s throughput)
Data review	Perception software with the eDrive option can be used on other PCs to analyze data	
PC configuration for data review and re-analysis	Minimum	Recommended
	Windows® 64 bit, version 7, 8, 10 8 GB RAM Intel i5 processor FullHD monitor HDD	Windows® 64 bit, version 10 16 GB RAM or more Intel i7 processor (at least 4 cores) Multiple FullHD monitors HDD

eDrive supported hardware packages

The most important hardware packages supported by eDrive are listed below. Please refer to their individual datasheets for more details.

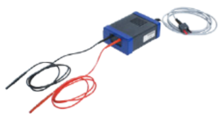
GEN2tB eDrive 3ch POWER ANALYZER package (3 voltage channels 1 kV and 3 current channels via burden resistors and CT´s or via clamps) and 2 x torque / 2 x speed channels; expandable to 6 power channels and with CAN output option Maximum sample rate of 2 MS/s	

GEN2tB eDrive 6ch POWER ANALYZER package (6 voltage channels 1 kV and 6 current channels via burden resistors and CT´s or via clamps) and 2 x torque / 2 x speed channels; expandable with CAN output option Maximum sample rate of 2 MS/s	
GEN2tB eDrive 3ch GRID ANALYZER package (3 voltage channels 1 kV and 3 current channels via burden resistors and CT´s or via clamps) and 2 x torque / 2 x speed channels; expandable to 6 power channels and with CAN output option Maximum sample rate of 200 kS/s	
GEN2tB eDrive 6ch GRID ANALYZER package (6 voltage channels 1 kV and 6 current channels via burden resistors and CT´s or via clamps) and 2 x torque / 2 x speed channels; expandable with CAN output option Maximum sample rate of 200 kS/s	
GEN3i eDrive 6ch POWER ANALYZER package (6 voltage channels 1 kV and 6 current channels via burden resistors and CT´s or via clamps) and 2 x torque / 2 x speed channels; expandable to 9 power channels	

GEN3t eDrive 6ch POWER ANALYZER package (6 voltage channels 1 kV and 6 current channels via burden resistors and CT´s or via clamps) and 2 x torque / 2 x speed channels; expandable to 9 power channels & EtherCAT option	
GEN7i eDrive 6ch POWER ANALYZER package (6 voltage channels 1 kV and 6 current channels via burden resistors and CT´s or via clamps) and 2 x torque / 2 x speed channels; expandable to 21 power channels	
GEN7tA eDrive 6ch POWER ANALYZER package (6 voltage channels 1 kV and 6 current channels via burden resistors and CT´s or via clamps) and 2 x torque / 2 x speed channels; expandable to 21 power channels & EtherCAT or CAN output option	

eDrive supported options and accessories

The most important hardware options and accessories supported by eDrive are listed below. Please refer to their individual datasheets for more details.

 GN61xB 6 channel 1 kV input card for increased channel count; with real time formula database option	 GN1202B 12 channel receiver for optical isolation with real time formula database option
 GN110 / GN111 1 channel Transmitter Optical Isolated Transmitter HV to be used in front of GN1202B	 GN112 / GN113 1 channel Transmitter Optical Isolated Transmitter MV to be used in front of GN1202B
 Other GEN DAQ input cards for Thermocouples, PT100, Accelerometers, Strain gages….	
 1 kV certified, low capacitance, shielded voltage cables; also used for connection CT´s to burden resistor	 1 kV certified, low capacitance, shielded 3 phase voltage cables;
 5 kV_{rms} differential probe for increased input range	 1.5 kV_{rms} differential probe for increased input range
 Zero Flux current transducer and burden resistors HBRxx	 Digital T12 / T40B or analog T20 / T22 or other torque transducers
 EtherCAT interface for the GEN3t, GEN7tA and GEN17tA DAQ mainframes for real time data transfer to automation system	 CAN interface for the GEN2tB, GEN7tA and GEN17tA DAQ mainframes for data transfer to automation system
 CAN bus remote control option: Start / Stop / Trigger eDrive system with CAN bus commands	 QuantumX satellites for CAN bus inputs, thermocouples or HV isolated thermocouples

Ordering Information			
Article		**Description**	**Order No.**
Perception eDrive option	 	**eDrive option** (single license) Allows easy and application oriented test setup and test execution for inverter driven electrical machines with minimum interaction; real time computation and display of n-phase power values using predefined or user formulas; continuous or set-point raw data storage for verification and analysis. Minimum requirements: • Perception Enterprise 64bit software V7.30 or higher • One or more eDrive capable cards with real time formula database option 1-GEN-OP-RT-FDB • Latest generation mainframe GEN2tB / GEN3i / GEN3t / GEN7i / GEN7tA / GEN17tA	1-PERC-OP-EDR-01

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