EDEPT-EDT 2026.1.0

Neutral e-machine switching-frequency simulation case study

Five 400 V operating points simulated in EDEPT-EDT at 6 kHz, 10 kHz and 20 kHz, with authentic GUI evidence.

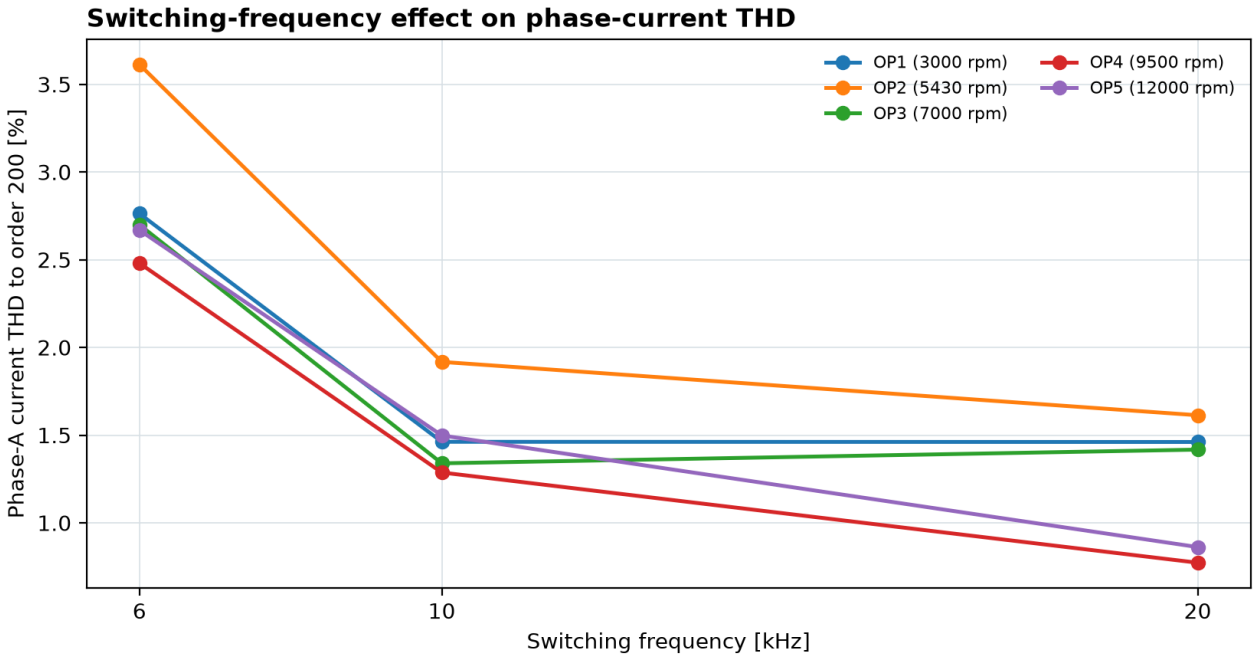
Executive result. EDEPT-EDT completed 15 switching simulations covering MTPA, base-speed, field-weakening and MTPV operation. The 400 V operating-point envelope was retained, while an 800 V waveform-generation bus prevented controller saturation from masking the switching-frequency comparison. Across all cases, requested-to-achieved d-q vector error remained below 0.3%. Current THD generally reduced as switching frequency increased.

Study definition

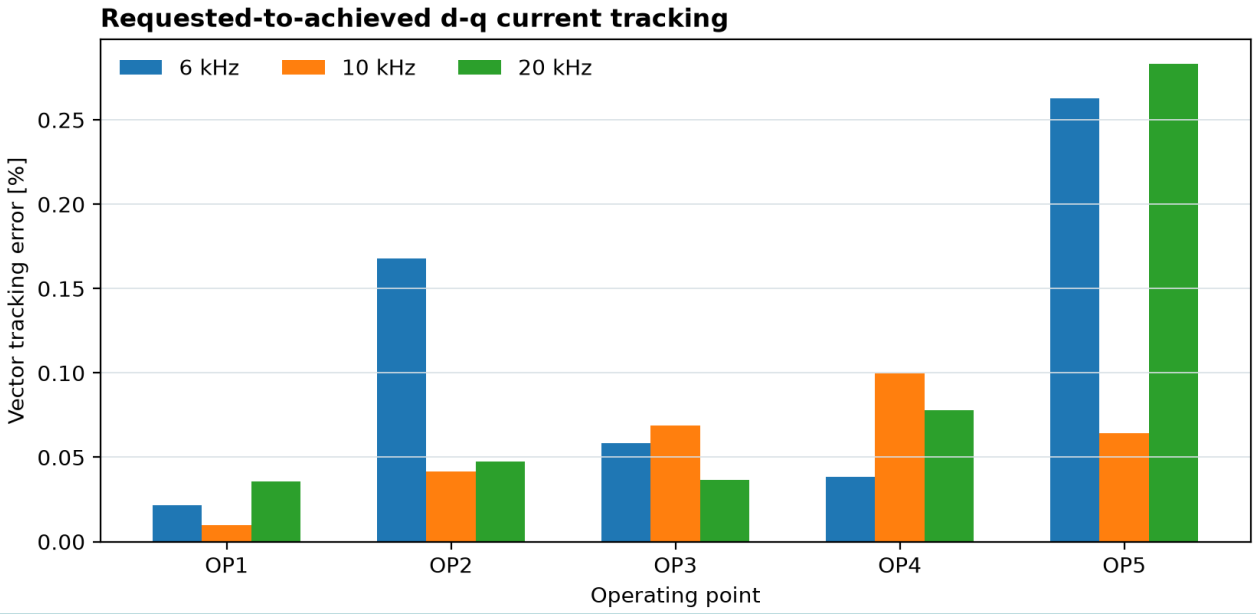
Parameter	Study value
Machine identity	Neutral public e-machine map
Map basis	Motor-CAD saturation/loss map; BPM
Embedded speed / frequency	3000 rpm / 150 Hz
Pole pairs	3
DC-link voltage	400 V
Waveform-generation voltage	800 V (2x headroom for controller tracking)
Switching frequencies	6 kHz, 10 kHz and 20 kHz
Winding temperature	65 degC
Phase resistance at 65 degC	13.588 mOhm
Current sweep	0-1,000 A phase peak in 20 A steps
Advance-angle sweep	-180 to +180 electrical degrees in 10 degree steps
Stated study boundary	500 A RMS = 707.1 A peak
SVPWM phase-voltage limit	230.9 V peak

The map defines the operating points. EDEPT-EDT then applies each requested d-q vector in the switching model and evaluates the final electrical cycle. THD includes all resolvable orders through order 200; the GUI harmonic presentation separately filters even and triplen orders.

Switching-frequency results



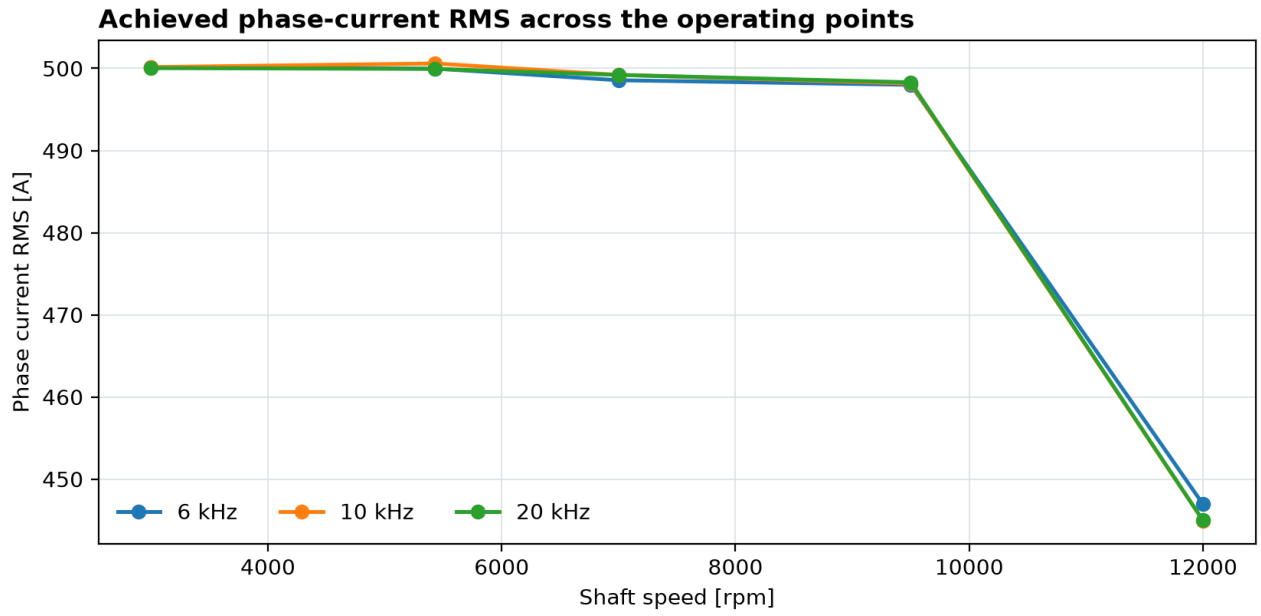
At every operating point, the 6 kHz case has the highest measured phase-current THD. The 10 kHz and 20 kHz runs reduce switching-related distortion, although the improvement is not assumed to be perfectly monotonic because the controller, carrier ratio, sampling and final-cycle spectral window interact.



The factor-two simulation-bus rule achieved its purpose: d-q vector tracking error is below 0.3% for every run. This isolates switching-frequency behaviour from controller voltage saturation.

Fifteen-run evidence table

Point	Speed	fsw	Phase RMS	THD	d-q error
OP1	3000 rpm	6 kHz	500.1 A	2.763%	0.021%
OP1	3000 rpm	10 kHz	500.2 A	1.462%	0.010%
OP1	3000 rpm	20 kHz	500.0 A	1.461%	0.036%
OP2	5430 rpm	6 kHz	500.0 A	3.613%	0.168%
OP2	5430 rpm	10 kHz	500.6 A	1.917%	0.042%
OP2	5430 rpm	20 kHz	499.9 A	1.613%	0.048%
OP3	7000 rpm	6 kHz	498.6 A	2.699%	0.058%
OP3	7000 rpm	10 kHz	499.2 A	1.339%	0.069%
OP3	7000 rpm	20 kHz	499.2 A	1.417%	0.037%
OP4	9500 rpm	6 kHz	498.0 A	2.480%	0.038%
OP4	9500 rpm	10 kHz	498.2 A	1.287%	0.100%
OP4	9500 rpm	20 kHz	498.3 A	0.772%	0.078%
OP5	12000 rpm	6 kHz	446.9 A	2.669%	0.263%
OP5	12000 rpm	10 kHz	444.9 A	1.498%	0.065%
OP5	12000 rpm	20 kHz	445.0 A	0.862%	0.283%



OP1-OP4 request approximately 500 A RMS. OP5 is the deep-MTPV point and requests approximately 445 A RMS. The achieved values remain consistent across the three switching frequencies.

EDEPT-EDT GUI evidence - switching-frequency comparison

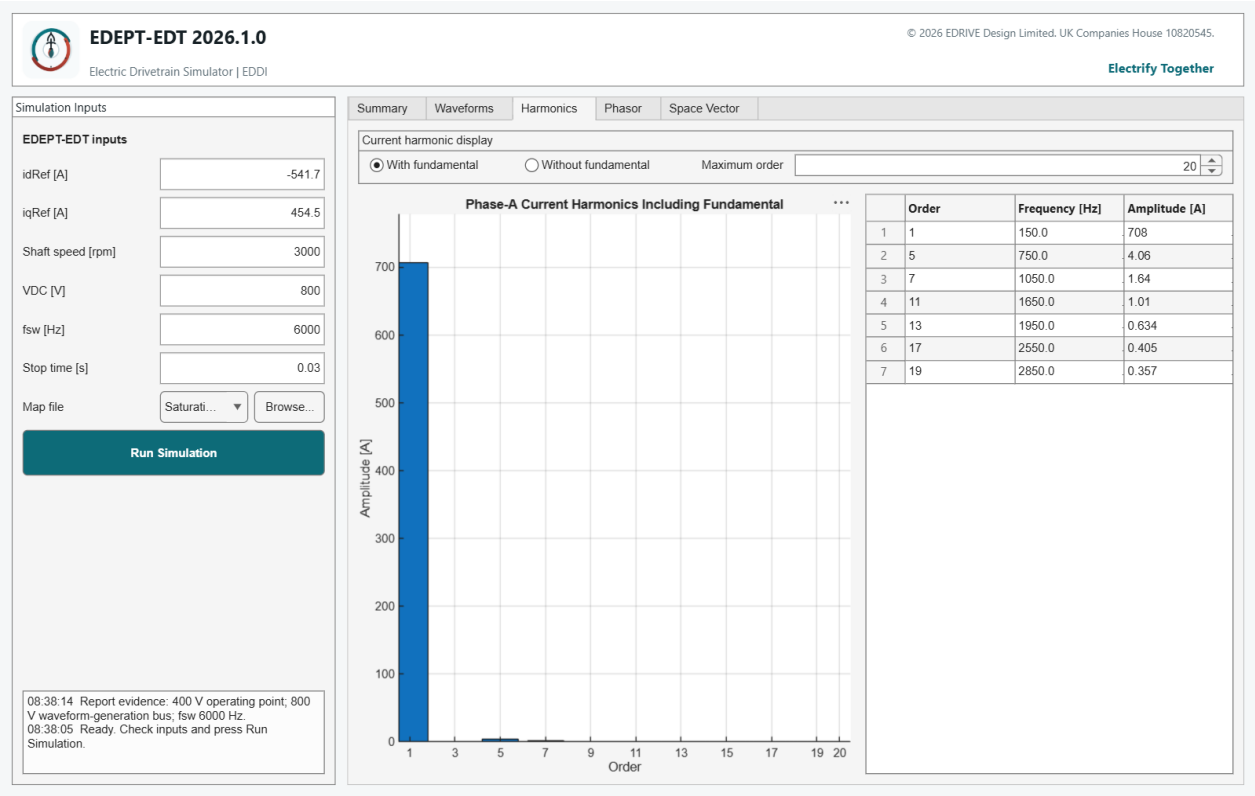
The following images are direct exports of the EDEPT-EDT 2026.1.0 interface populated from the recorded simulation outputs. The left panel records the applied d-q references, speed, 800 V waveform-generation bus and switching frequency.

OP1 at 6 kHz: final-cycle phase/d-q current, PWM voltage and map-estimated torque displayed by EDEPT-EDT.

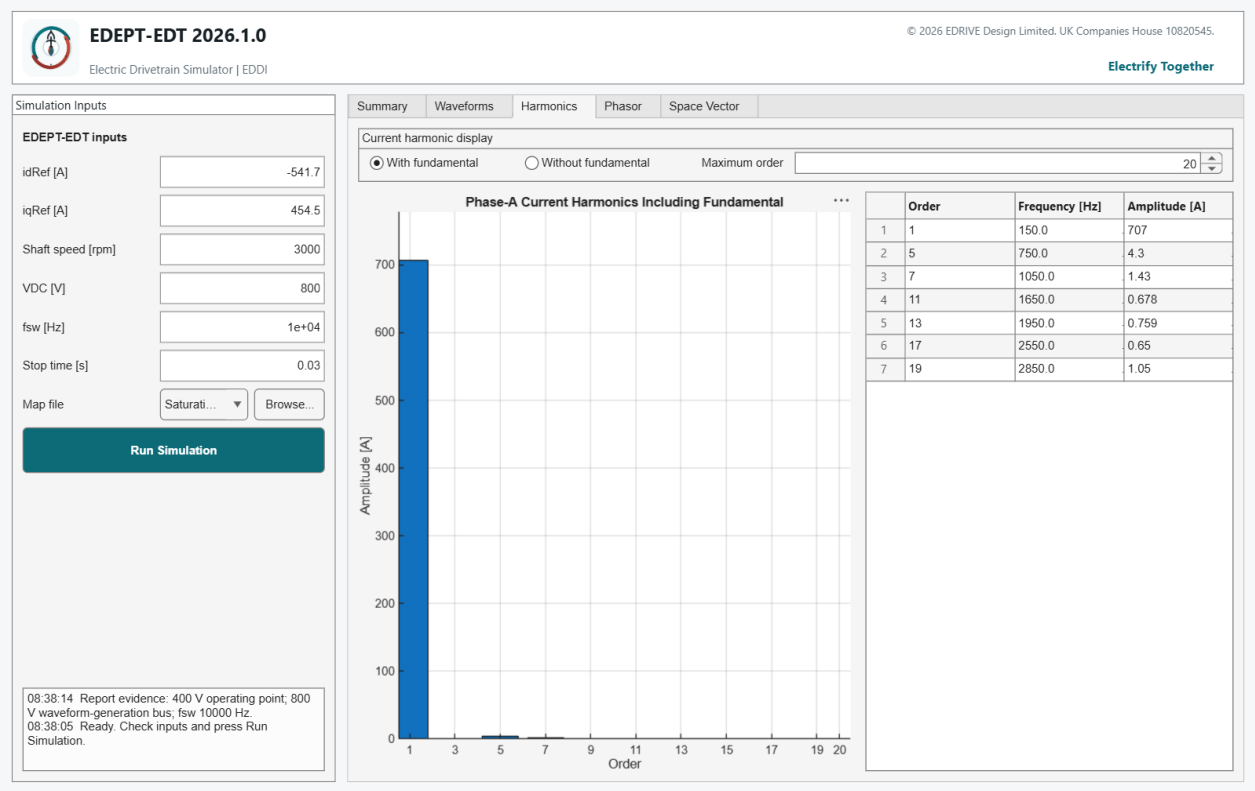
OP1 at 10 kHz: final-cycle phase/d-q current, PWM voltage and map-estimated torque displayed by EDEPT-EDT.

OP1 at 20 kHz: final-cycle phase/d-q current, PWM voltage and map-estimated torque displayed by EDEPT-EDT.

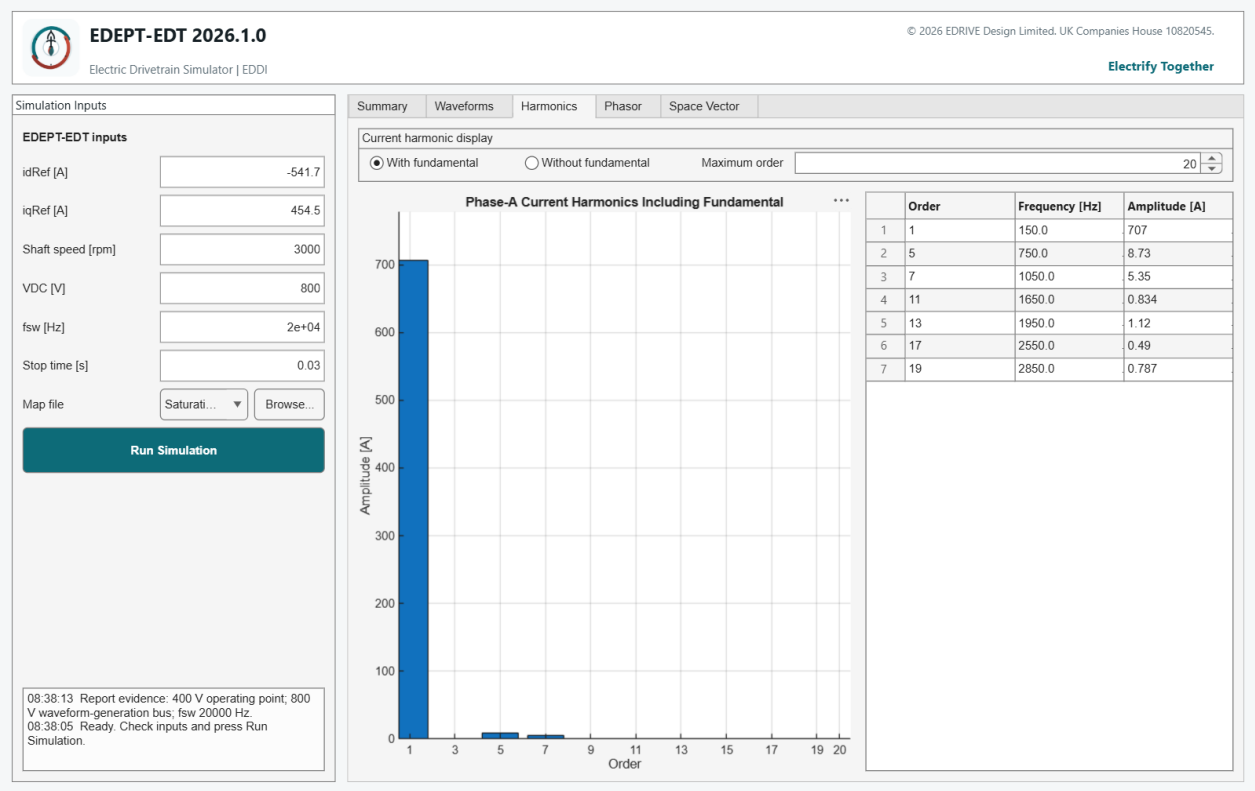
EDEPT-EDT GUI evidence - harmonic view



OP1 at 6 kHz: EDEPT-EDT harmonic tab with linear order axis and odd, non-triplen presentation.



OP1 at 10 kHz: EDEPT-EDT harmonic tab with linear order axis and odd, non-triplen presentation.



OP1 at 20 kHz: EDEPT-EDT harmonic tab with linear order axis and odd, non-triplen presentation.

EDEPT-EDT GUI evidence - operating-region coverage

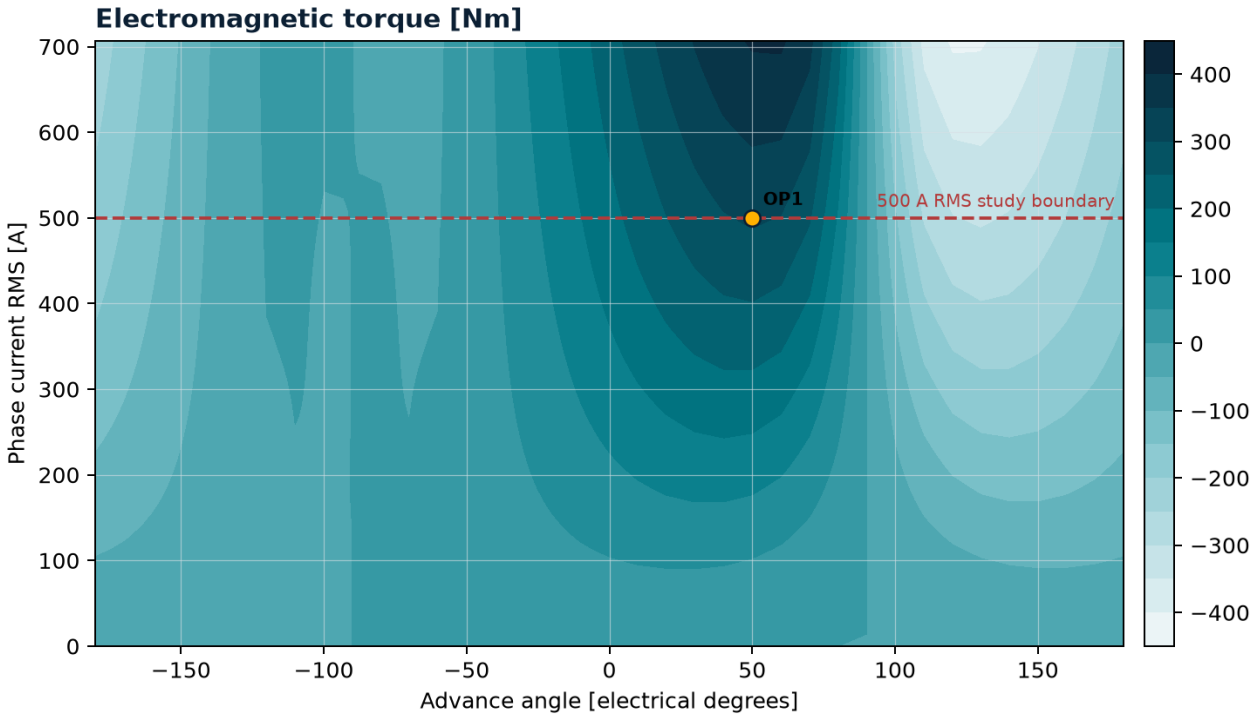
OP3 at 7,000 rpm and 10 kHz demonstrates constant-current field-weakening operation.

OP5 at 12,000 rpm and 10 kHz demonstrates the deep-MTPV point.

Operating-point derivation

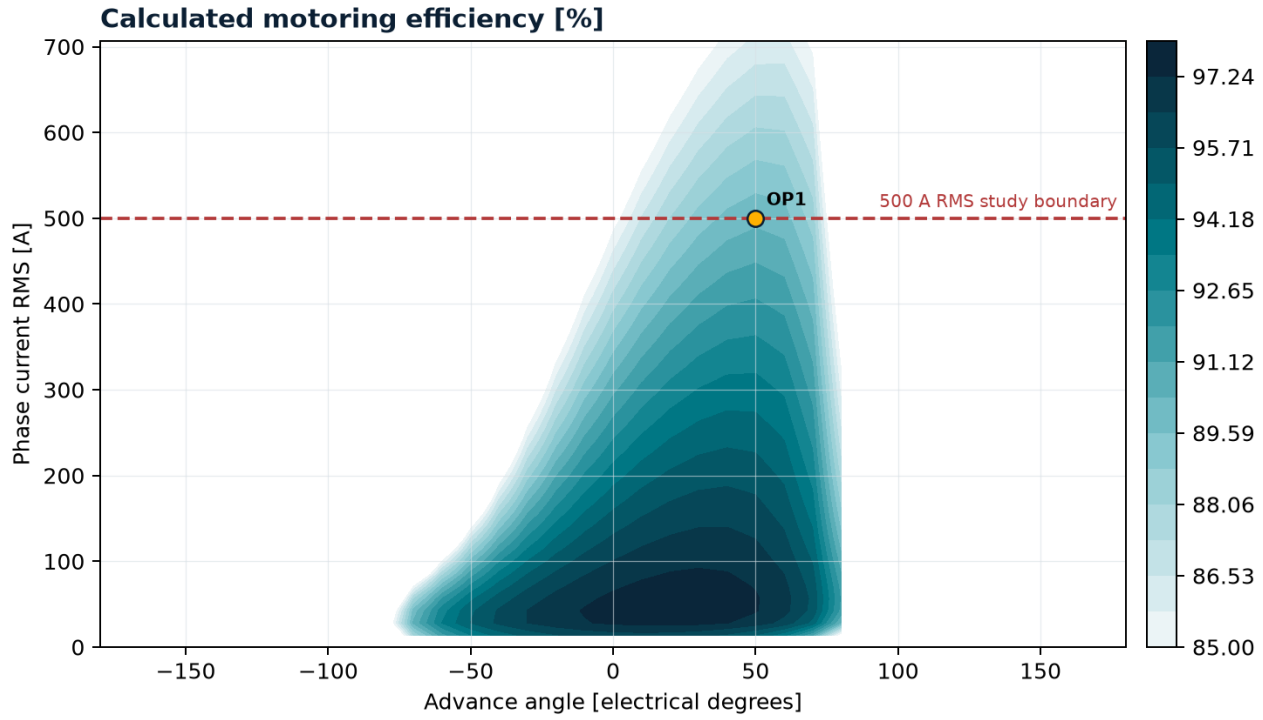
The remainder of the report documents how the neutral public map was used to select the five simulation requests. These map-derived values are inputs to the switching study, not its principal result.

Torque landscape



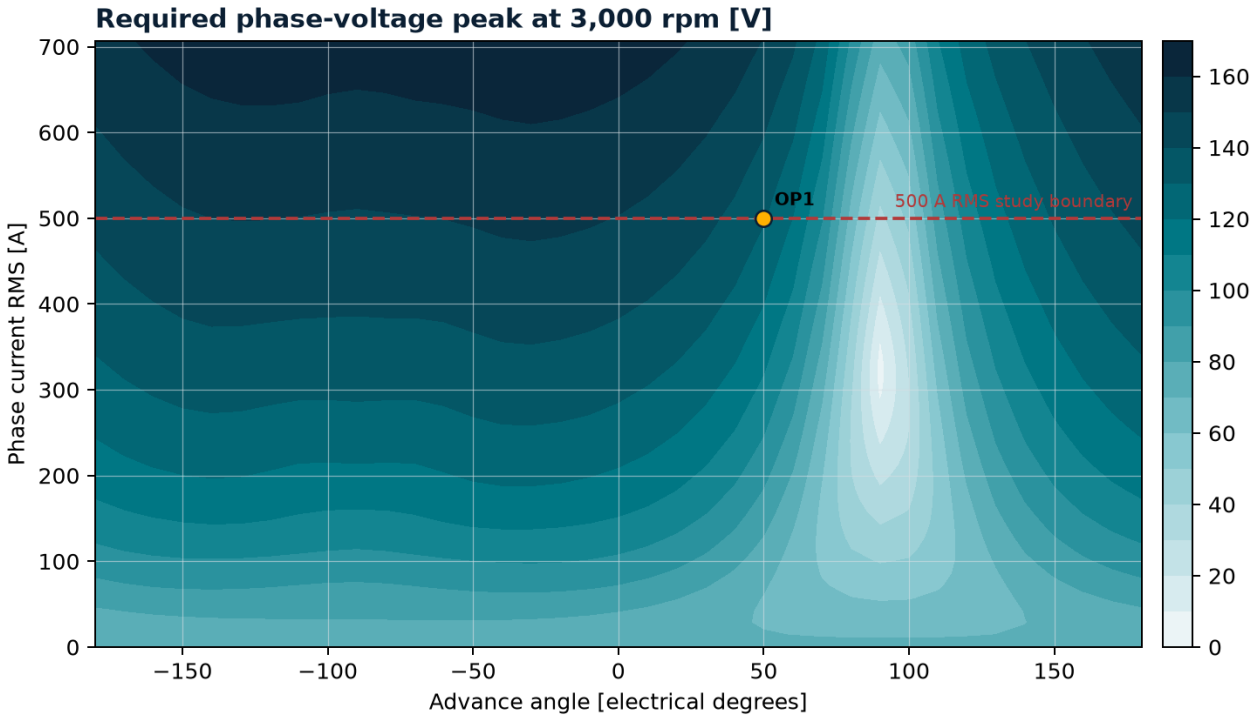
Positive motoring torque occupies a bounded advance-angle region. Within the 500 A RMS boundary, the torque-maximising grid point moves toward approximately 50 electrical degrees at high current. Negative-torque regions are included to show the complete map but are not treated as motoring candidates.

Efficiency landscape



Efficiency is calculated as mechanical output divided by mechanical output plus mapped total loss. The selected marker is the interpolated MTPA point at 707.1 A peak (500 A RMS).

400 V feasibility



Phase-voltage demand is reconstructed from mapped d/q flux linkage, mapped d/q current, electrical speed and the temperature-adjusted phase resistance. It is compared with the 400/sqrt(3) = 230.9 V SVPWM phase-voltage peak boundary.

At 3,000 rpm all positive-torque points up to the 500 A RMS study boundary remain below the reconstructed voltage limit. This does not mean they are thermally continuous: current density, cooling, inverter current capability, demagnetisation and structural limits must be assessed separately.

Selected operating points

Five interpolated points describe the 400 V operating envelope. OP1 is the MTPA point at 3,000 rpm. OP2 carries the same vector to base speed. OP3 is the midpoint of the constant-current field-weakening region. OP4 is the estimated point where the optimum begins to leave the current limit and enter MTPV operation. OP5 is a deep-MTPV solution at 12,000 rpm, where optimal current has fallen below 500 A RMS.

OP1 - 3,000 rpm MTPA at 500 A RMS	
Speed	3000 rpm
Current	500.0 A RMS (707 A peak)
Advance angle	50 electrical degrees
d/q current peak	-541.7 / 454.5 A
Torque	306.6 Nm
Mechanical power	96.33 kW
Calculated efficiency	90.13%
Total mapped loss	10.54 kW
Phase-voltage demand	130.9 V peak
SVPWM utilisation	56.7%
Estimated 400 V speed boundary	5430 rpm
Result basis	interpolated from the supplied 3,000 rpm saturation/loss map

OP1 is the interpolated MTPA point at 3,000 rpm and provides the mapped loss and efficiency evidence.

OP2 - estimated 400 V MTPA base-speed boundary	
Speed	5430 rpm
Current	500.0 A RMS (707 A peak)
Advance angle	50 electrical degrees
d/q current peak	-541.7 / 454.5 A
Torque	306.6 Nm
Mechanical power	174.36 kW
Calculated efficiency	Not claimed at this speed
Total mapped loss	Requires speed-specific analysis
Phase-voltage demand	230.9 V peak
SVPWM utilisation	100.0%
Estimated 400 V speed boundary	5430 rpm
Result basis	steady-state voltage-envelope estimate; losses and efficiency require a speed-specific map or simulation

This is a steady-state voltage-envelope estimate. Losses and efficiency are deliberately not claimed without a speed-specific map or switching simulation.

OP3 - midpoint of 500 A RMS constant-current region	
Speed	7000 rpm
Current	500.0 A RMS (707 A peak)
Advance angle	68 electrical degrees
d/q current peak	-656.3 / 259.4 A
Torque	261.9 Nm
Mechanical power	191.98 kW
Calculated efficiency	Not claimed at this speed
Total mapped loss	Requires speed-specific analysis
Phase-voltage demand	230.9 V peak
SVPWM utilisation	100.0%
Estimated 400 V speed boundary	5430 rpm
Result basis	interpolated constant-current voltage-boundary estimate

This is a steady-state voltage-envelope estimate. Losses and efficiency are deliberately not claimed without a speed-specific map or switching simulation.

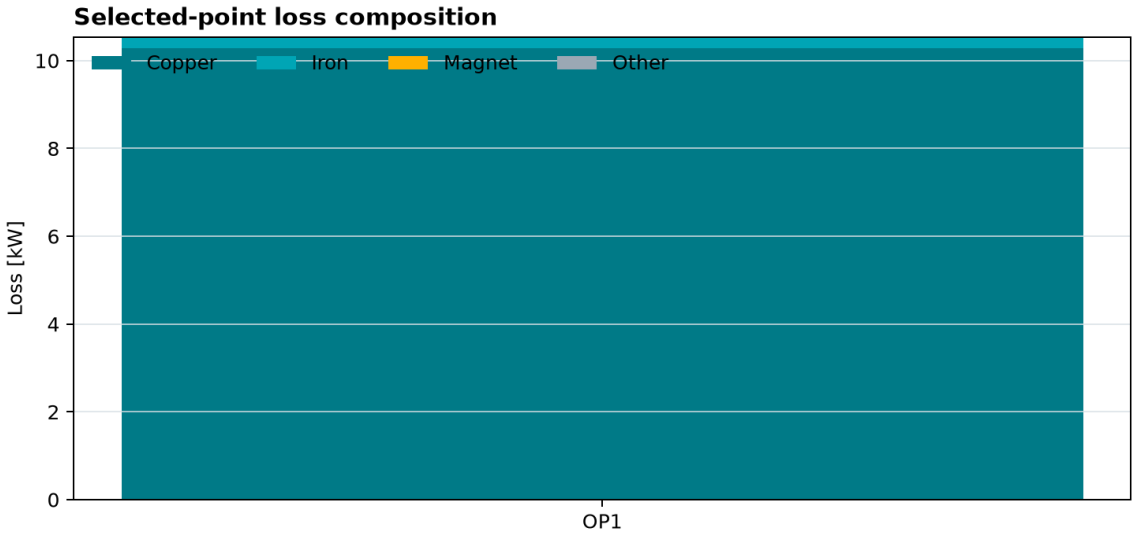
OP4 - estimated MTPV starting-speed point	
Speed	9500 rpm
Current	500.0 A RMS (707 A peak)
Advance angle	76 electrical degrees
d/q current peak	-684.6 / 166.7 A
Torque	185.6 Nm
Mechanical power	184.60 kW
Calculated efficiency	Not claimed at this speed
Total mapped loss	Requires speed-specific analysis
Phase-voltage demand	230.9 V peak
SVPWM utilisation	100.0%
Estimated 400 V speed boundary	5430 rpm
Result basis	estimated transition from 500 A RMS field weakening to MTPV

This is a steady-state voltage-envelope estimate. Losses and efficiency are deliberately not claimed without a speed-specific map or switching simulation.

OP5 - deep-MTPV point at 12,000 rpm	
Speed	12000 rpm
Current	446.0 A RMS (631 A peak)
Advance angle	79 electrical degrees
d/q current peak	-616.9 / 125.5 A
Torque	139.5 Nm
Mechanical power	175.24 kW
Calculated efficiency	Not claimed at this speed
Total mapped loss	Requires speed-specific analysis
Phase-voltage demand	230.9 V peak
SVPWM utilisation	100.0%
Estimated 400 V speed boundary	5430 rpm
Result basis	constrained maximum-torque solution inside the 400 V voltage boundary

This is a steady-state voltage-envelope estimate. Losses and efficiency are deliberately not claimed without a speed-specific map or switching simulation.

Mapped MTPA loss composition



Copper loss dominates the mapped 3,000 rpm MTPA point. The base-speed loss composition is deliberately not extrapolated from this chart.

Method and interpretation

Voltage reconstruction. Peak d/q voltage is calculated as vd = R id - omega_e psi_q and vq = R iq + omega_e psi_d. The vector magnitude is compared with the ideal SVPWM phase-voltage limit. The estimated voltage-limited speed holds the mapped current and flux values fixed; it is an envelope estimate, not a dynamic closed-loop simulation result.

Temperature. Phase resistance is adjusted from the map's 20 degC value using its winding resistivity coefficient. The supplied mapped copper loss is consistent with the requested 65 degC basis. Other loss components are taken directly from the supplied 3,000 rpm map.

Current convention. The supplied sweep is phase-current peak. The requested 500 A RMS boundary equals 707.1 A peak. Points from 720 to 1,000 A peak are visible for context but are outside that stated boundary.

Claims and limitations

- This is a neutral public demonstration and does not identify or represent a production machine.

- Results are map-based engineering estimates, not measured certification data.

- The study does not establish continuous thermal capability, inverter current capability, demagnetisation margin, mechanical stress, acoustic performance or vehicle-level performance.

- The switching results use an 800 V waveform-generation bus to preserve current tracking; they do not demonstrate physical 800 V operation or inverter feasibility.

- Efficiency uses the loss terms in the supplied map and should be compared only with studies using the same loss definitions and build factors.

- The full input map is not reproduced in this report; only derived plots and selected-point values are presented.

Traceability

Source map: SaturationLossMap_Neutral_Public.mat
SHA-256: 556c90c069a45d28d739fd96332d460a9fd9a116105391475b39b1bd44ca7ab0
Study generator: tools/generate_public_neutral_machine_case_study.py
Product: EDEPT-EDT 2026.1.0
Prepared by EDRIVE Design Limited, 25 July 2026.

Engineering investigation tool. Model, map and solver assumptions apply. Independent design verification remains required.