ECE 411 – HW3 & HW4 Exam Cheat Sheet (Lipo–Novotny Conventions)

1) Frames & Conventions

- q-axis ∥ α at $\theta=0$; d is $-90°$ from q (clockwise).
- θ_e: electrical angle ($\alpha \to q$, CCW); $\omega_e = d\theta_e/dt$.
- q = Real{·}, d = −Imag{·}; β = −Imag{$\alpha\beta$} for plotting.

2) Clarke & Park Transforms

Clarke: $\alpha = (2/3)[\,V_a - 0.5V_b - 0.5V_c\,]$

$\beta = (2/3)(\sqrt{3}/2)(V_c - V_b)$

Park: $q = \alpha\cos\theta - \beta\sin\theta$

$d = \alpha\sin\theta + \beta\cos\theta$

Inverse: $\alpha = q\cos\theta + d\sin\theta$; $\beta = -q\sin\theta + d\cos\theta$

3) Phasor Definitions

$a = e^{j2\pi/3}$; $x_{\alpha\beta} = (2/3)(x_a + a\,x_b + a^2 x_c)$

Park: $x_{qd} = x_{\alpha\beta}\,e^{-j\theta_e}$; $q = \mathrm{Re}\{x_{qd}\}$, $d = -\mathrm{Im}\{x_{qd}\}$

$E_0 = \omega_e \Lambda_0$; $\Lambda_0 = E_0/\omega_e$

4) Base Quantities (per-unit)

$V_B = V_{dc}/\sqrt{3}$, $I_B = I_{max}$, $Z_B = V_B/I_B$

$P_B = 1.5\,V_B I_B$, $\omega_B = 2\pi f_B$, $T_B = P_B/\omega_{mB}$

5) Voltage Equations

Round-rotor: $V_q = R_s I_q + \omega_e L_s I_d + E_q$

$V_d = R_s I_d - \omega_e L_s I_q + E_d$

Salient-pole: $V_q = R_s I_q + \omega_e L_d I_d + E_q$

$V_d = R_s I_d - \omega_e L_q I_q + E_d$

6) Torque & Power

$P = 1.5(V_q I_q + V_d I_d)$

$T_e = P/\omega_e$

$T_e = (E_q I_q)/\omega_e + ((L_d - L_q) I_d I_q)/\omega_e$

Salient-pole:

$T_{field} = -(E_0 V_0)/(\omega_e L_d)\sin\delta$

$T_{rel} = -(V_0^2(L_d - L_q))/(2\omega_e L_d L_q)\sin(2\delta)$

One-page review — HW3 & HW4 core equations under Lipo–Novotny convention.

$T_e = T_{field} + T_{rel}$

7) Field Weakening

Voltage limit ($R_s=0$): $V_0^2 = (\omega_e \Lambda_0)^2 - (\omega_e L_s I_0)^2$

$\Lambda_0 = \sqrt{[(V_0/\omega_e)^2 + (L_s I_0)^2]}$

$T_{max} = V_0 I_0/\omega_e$; $P_{max} = V_0 I_0$

Flux ratio = $\Lambda_{new}/\Lambda_{rated}$

8) Rs ≠ 0 Effects

$Z_s = \sqrt{(R_s^2 + (\omega_e L_s)^2)}$

$T_{max} = (V_0 E_0)/(\omega_e Z_s) - (E_0^2 R_s)/(\omega_e Z_s^2)$

$\delta_{max} = \sin^{-1}(R_s/Z_s) - \pi/2$

9) Saliency & Ratios

Saliency ratio $\xi = L_d/L_q$

$T_{rel,max} = T_{field,max} \to L_q = (V_0 L_d)/(2E_0 + V_0 R_s)$

10) Quick Reference (exam tips)

- Open-circuit: $v_q \approx \omega_e \Lambda_0$, $v_d \approx 0$ (confirm q–α alignment).
- Generator: $P_{mech} = -P_{elec}$; motoring → $+T_e$.
- δ increases with load torque; small $\delta \approx$ linear region.
- Keep per-unit bases consistent (V_B, I_B, L in pu).
- q = torque-producing axis; d = flux (field) axis.