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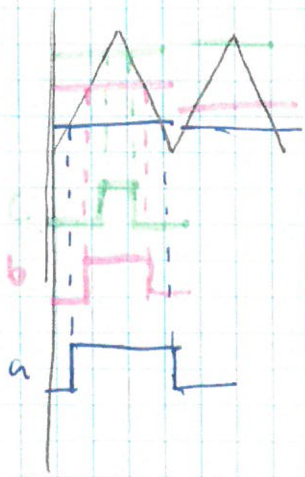
SaC - Exam B

Part 1

1 - 3-phase PWM:

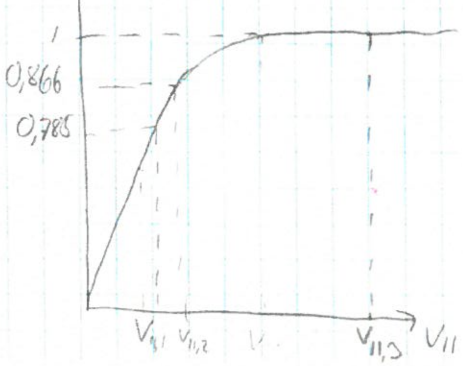
- Three reference is generated from a sine function where each are 120° apart. This is then compared with the carrier wave:



The frequency of the carrier wave much larger than the fundamental frequency.

- The ranges of the modulation index:

$M = \frac{V_0}{\frac{2}{\pi} V_{dc}}$, V_0 : Amplitude of the fundamental voltage.



$V_{11,1}$ - End of linear range for Sine PWM

$V_{11,2}$ - End of linear range for SVM, THI PWM

$V_{11,3}$ - End of Over modulation

$> V_{11,3}$ - Square wave

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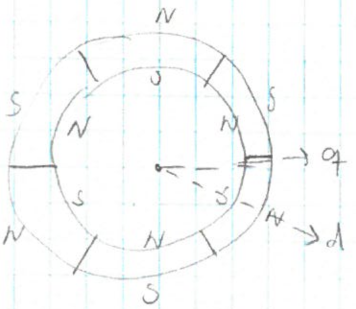
Part 2 - PMSM

- A 6 pole surface mounted Permanent Magnet machine in a synchronously rotating reference frame.

1 - dq - reference frame



2 - Torque

By inserting the expressions for λ_q & λ_d into T_e, it yields:

$$T_e = \frac{3}{2} p \left((L_d i_d + \lambda_{mpm}) i_q - L_q i_q i_q \right)$$

$$= \frac{3}{2} p\, i_q \left((L_d i_d + \lambda_{mpm}) - L_q i_q \right)$$

$$= \frac{3}{2} p \left(\lambda_{mpm} i_q + (L_d - L_q) i_d i_q \right)$$

$\Downarrow$ for a Surface mounted PMSM, $L_d = L_q$

$$T_e = \frac{3}{2} p (\lambda_{mpm} i_q)$$

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- d and q - axes current references for FOC:

  $i^*_{d,ref} = 0$, used to flux, however the flux comes from PM

  $i_{q,ref}$ can be found through a torque reference:

  $$i^*_{q,ref} = \frac{2}{3} \frac{T^*_{e,ref}}{p \lambda_{mpm}}$$

3 - Rotor Electric Speed:

$$w_{r,el} = p\, w_{r,shaft} \Rightarrow w_{r,shaft} = w_{r,el}/p$$
$$= 377 \text{ rad/s} / 3 \cdot \frac{60}{2\pi} = 1200 \text{ rpm}$$

4 - Tuning the current loop PI at zero speed.

At zero speed, the system becomes decouple, hence no back-EMF, thus an LTI model arises.

5 - Control Block Diagram