Flux weakening control of PMSM

This document represents a theoretical study of the flux or filed weakening control FWC. It includes the practical study as well as the results using the STSPIN32G4 and the motor control workbench of STMicroelectronics.

1- The need behind the implementation of this technique:

We all know that every PMSM is characterized with a maximal value of speed that, in normal conditions, we cannot exceed it. This value is called "the No Load Speed at Rated Voltage" ω_{NLR}.

It is to know that the rated voltage represents the maximal voltage value allowed by the constructer. It is figured in the datasheet.

In practice, and in the same normal conditions, we never reach ω_{NLR} because the PMSM is always training a load that needs a training torque. In this case, we are running at a functioning point A, as figured in the *Figure 1*.

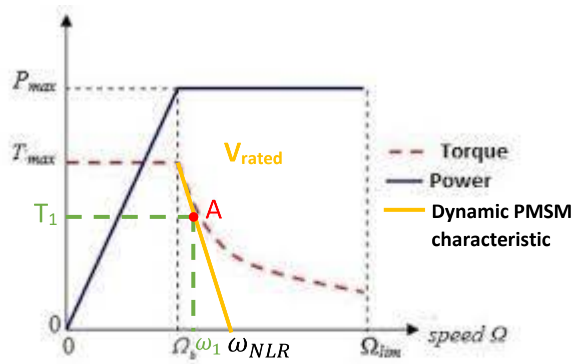

Figure 1: Relation between torque and angular speed – Dynamic characteristic

In this case, with the V_{rated} voltage value, the motor is applying the necessary torque $T_1 < T_{max}$ to train the load and run at ω_1 angular speed.

Let's assume that this application requires running at a speed higher than ω_1. Here comes the need behind the implementation of this technique.

2- Flux weakening control technique:

As mentioned in the previous paragraph, our goal is to increase the angular speed.
The flux weakening control technique offers this desire versus sacrificing flux and torque.

3- Theoretical study of FWC technique:

It is important to mention that this technique is available for bot, salient and non-salient motors.

Let's study the two following equations related to PMSM motor:

$$V_{qs}^{r} = r_s I_{qs}^{r} + \omega_r L_d I_{ds}^{r} + \omega_r \lambda_m^{r} \quad (1)$$

$$V_{ds}^{r} = r_s I_{ds}^{r} - \omega_r L_q I_{qs}^{r} \quad (2)$$

In normal conditions, we always try to make $I_d = 0$ in order to maximize current.

The idea here, and oppositely to the previous philosophy, is to apply a negative d-axis current.

Let's analyze its effects!

A negative value of I_d makes λ_m^r lower which make the Back EMF value lower. So, ω_r increases.

This can be also confirmed when (1) as follows:

$$V_{qs}^{r} - r_s I_{qs}^{r} - \omega_r L_d I_{ds}^{r} = \omega_r \lambda_m^{r} \quad (3)$$

Assuming that $\omega_r > 0$ and $I_d < 0$, then the quantity in the left will increase and so is the quantity in the right. As λ_m^r lower, ω_r increases.

This technique has effects on the dynamic characteristic of the PMSM. It is now as follows:

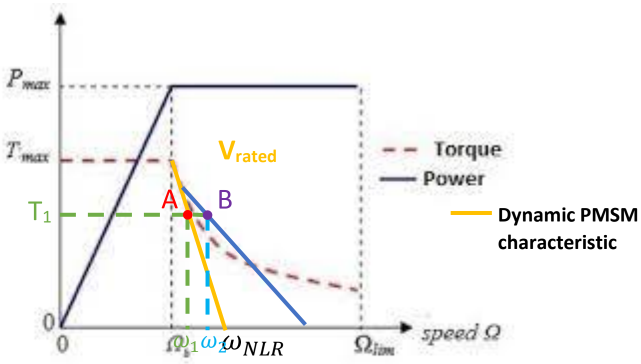

Figure 2: Relation between torque and angular speed – Dynamic characteristic after FWC technique