scaling factor gain. In addition, there is no detail study on the inputs scaling factor tuning effect over a bigger range of UoD. From this hypothesis, the study of influence of the inputs scaling factor is conducted.

This paper investigates the influence of inputs scaling factor and universe of discourse (UoD) towards the speed performance in wide speed range operations. The UoD covers from [-1,1] to [-5,5] domain. The influences of the inputs gain variation are then investigated under rated and wide speed range operations. Simulation and experimental results are presented to validate the performance effects. The proposed input scaling tuning method has shown better controlling ability during transient and steady state performance.

2. Induction Motor Drive

The block diagram of the FLSC with indirect field oriented control of induction motor drive is shown in Figure 1. The drive system consists of induction motor, coordinate transformation, voltage source inverter, current controllers and speed controller.

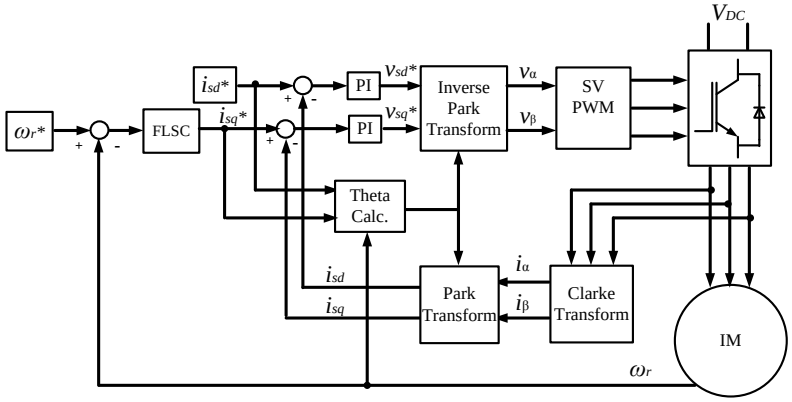

Fig 1: FLSC with indirect FOC method block diagram

The mathematical model of the three phase induction motor in synchronous reference frame is given in [17]. The voltage source inverter is controlled by mean of the Space Vector Pulse Width Modulation (SVPWM) method. Based on the indirect FOC principle, the rotor flux angle, θ_e for coordinate transformation is generated from the integration of rotor speed, ω_r and slip frequency, ω_{sl} as shown in Equation (1).

$$\theta_e = \int (\omega_r + \omega_{sl})\, dt \tag{1}$$

The slip frequency is calculate by using equation (2) below and included in theta calculation block.

$$\omega_{sl} = \frac{L_m}{\tau_r}\frac{i_{sq}}{\varphi_r} \tag{2}$$

The error between reference rotor speed, ω_r^* and actual rotor speed, ω_r is processed in the FLSC. The controller generates the q axis reference current, i_{sq}^*. Meanwhile, a constant d axis reference current, i_{sd}^* is set for the input reference. Both d-axis and q-axis stator current error are then regulated by the proportion integral (PI) controllers. These PI parameters are kept consistence in order to analysis the FLSC performance.

3. FLSC Structure

In general, a standard block diagram of the FLSC structure is shown in Figure 2. The controller consists of pre-processing, FLC and post-processing.