A Study on the Library Development for Power Electronics Circuits Analysis

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Abstract: The purpose of this paper is to verify the appropriation of power electronics circuit by applying the most powerful and widely used simulator PSPICE and SIMULINK for adapted variable control technics. Power electronics librarys modeled and adapted to circuit. It is proved that simulation and excute are almost same.

1. Introduction

Power electronics is rapidly developing owing to new control theory and processor development in an element of semiconductors. Such a development and extension of application department demands to a draft designation through exact simulation to save expense and time rather than system designation based on theory and experiment. Especially, using to power semiconductor device, electricity conversion circuit designation and electrical machine are important re -quirement items in power electronics department.

PSPICE, which is a circuit simulator, is useful to circuit execution as well as has abundant in library. Therefore, it was used in general[1]. In spite of the fact that Microsim Incorporation in electronic department has provided to abundant Library and SIMULINK simulator of MATLAB furnish with a variety of Library for solution of control device. There had a defection that they didn't service the Library in mechanic items department of an induction motor. In additoin to shorten solution of power electronics.

Therefore the thesis mentions to understand power electronics easily. Power semiconductor sockets such as SCR, IGBT and an induction motor simulated power celectronics circuit which making Library in using MATLAB and PSPICE. Furthermore, To prove universal validity of a modeling, modeled library on the basis of senseless vector control executed simulation adapting flux estimater. Through executing experiment and then comparing, we proved propriety of simulation.

2. Modeling

2.1 Modeling of SCR

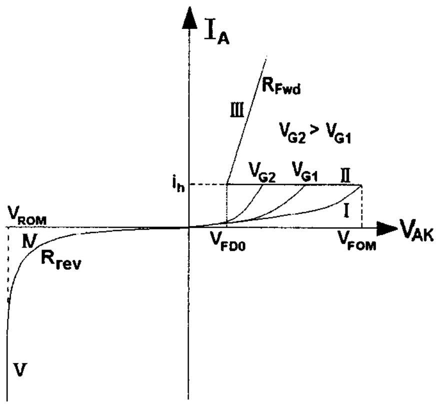


Fig 1. V-I characteristic of SCR

SCR characteristic is showed Fig 1. In SCR condition, flowing current penetrating SCR and function of breakdown voltage V_{FOM}. It is changed range from forward biased resistance R_{FWD} to reverse biased R_{REV}. This voltage is variable by low voltage to Gate and Cathod[2]. If forward transmit feature exists in Ⅲregion, current and voltage characteristics obtains as Eq (1).

$$V_{FD} = V_{FDO} + R_{Fwd} \cdot I_A \tag{1}$$

According to above relation, we could write logical equation as follows;

$$\begin{aligned} &SCR \quad ON \ (\ TH \text{ on}) \\ &I_A \ \ OR \ (V_G \ AND \ V_{AK}) \\ &SCR \quad OFF \ (\ TH \text{ off}) \\ &I_A \ \ AND \ (V_G \ AND \ V_{AK}) \end{aligned} \tag{2}$$

Here logical variable is as follow;

$$\begin{aligned} I_A &= 1 \quad \text{when } i_{TH} > i_h \\ V_G &= 1 \quad \text{when } V_{GK} > V_{GKmin} \\ V_{AK} &= 1 \quad \text{when } V_{AK} > 0 \end{aligned} \tag{3}$$

Therefore, modelling to implement logic equation showed triggering included logical circuit. UI form and IU form of SCR modeling Library name called to [THR(UI)] and [THR(IU)]. Modelling about [THR(UI)] showed Fig.2

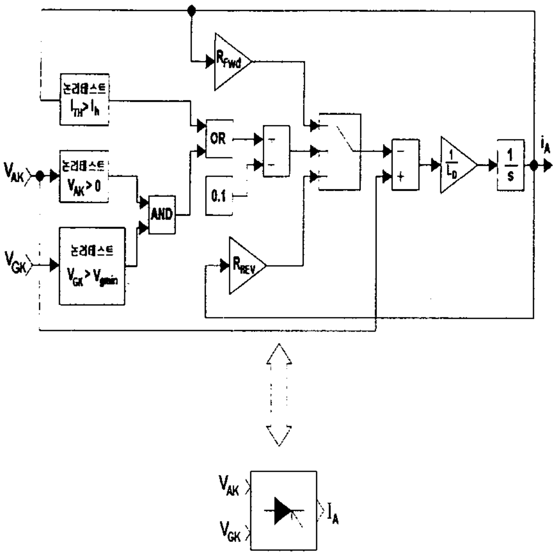


Fig 2. UI form SCR logic model[TH(UI)]

2.2 IGBT's macro modeling[3]

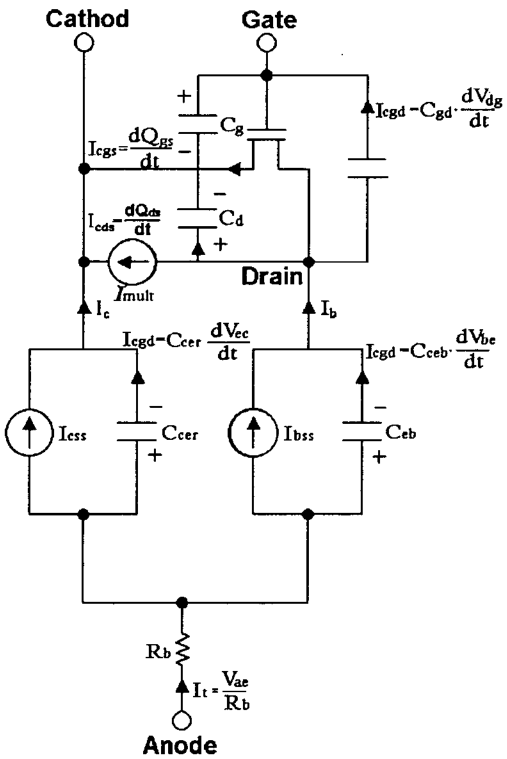


Fig 3. IGBT's equivalent circuit

Fig 3. is equivalent circuit of IGBT. MOSFET part of IGBT operates similarly like VDMOSFET except that thinly doped resistor of epitaxy layer is replaced as bipolar junction transistor's conductivity modulation resistor R_b. Like Figures while micro model knows the properity of exact device. It has weak point that velocity reduction is ascribed to a lot of quality point number change. Macro model is not very accurate but has the advantage of rapid operating. Macro model of IGBT is though of as short. In case of turn-on, on-state resistance define 1E-3[Ω]. In case of turn-off, off-state resistance define 1E6[Ω]. In addition, In case of turn-on, operating voltage works adding 10[V]. Modeled as ideal switch ideal model is described in Fig 4. Library term is [IGBT]

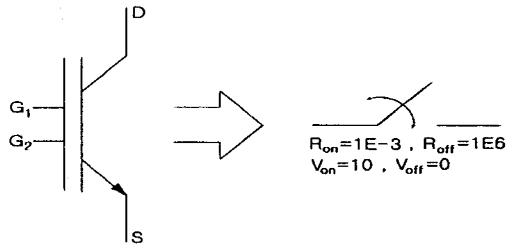


Fig 4. IGBT's macro model

2.3 Modeling of Induction motors

An equation of induction motor is defined as Eq(4)-(7)[4]

$$\frac{d\psi_{ds}}{dt} = v_{ds} - T_s'\psi_{ds} + T_{ms}'\psi_{dr} \tag{4}$$

$$\frac{d\psi_{qs}}{dt} = v_{qs} - T_s'\psi_{qs} + T_{ms}'\psi_{qr} \tag{5}$$

$$\frac{d\psi_{dr}}{dt} = - T_r\psi_{dr} + T_{mr}\psi_{ds} - \omega_r\psi_{qr} \tag{6}$$

$$\frac{d\psi_{qr}}{dt} = - T_r\psi_{qr} + T_{mr}\psi_{qs} - \omega_r\psi_{dr} \tag{7}$$

Here,

$$T_s' = \frac{R_sL_s}{L_sL_r - M^2},\quad T_{ms}' = \frac{R_sM}{L_sL_r - M^2}$$

$$T_r' = \frac{R_rL_r}{L_sL_r - M^2},\quad T_{mr}' = \frac{R_rL_s}{L_sL_r - M^2}$$

phase current is equal to Eq(8)-(11).

$$i_{ds} = \frac{T_s'}{R_s}\psi_{ds} - \frac{T_{ms}'}{R_s}\psi_{dr} \tag{8}$$

$$i_{qs} = \frac{T_s'}{R_s}\psi_{qs} - \frac{T_{ms}'}{R_s}\psi_{qr} \tag{9}$$

$$i_{dr} = \frac{T_r'}{R_r}\psi_{dr} - \frac{T_{mr}'}{R_r}\psi_{ds} \tag{10}$$

$$i_{qr} = \frac{T_r'}{R_r}\psi_{qr} - \frac{T_{mr}'}{R_r}\psi_{qs} \tag{11}$$

Torque is defined as Eq(12). Velocity is defined as Eq(13)..

$$T = \frac{3}{2}\left(\frac{P}{2}\right)(i_{qs}i_{dr} - i_{ds}i_{qr}) \tag{12}$$

$$\frac{d\omega_m}{d} = \frac{1}{J}(T - T_L) \tag{13}$$

Fig 5 is shown the model of the voltage an induction motor using the relationship of the above.

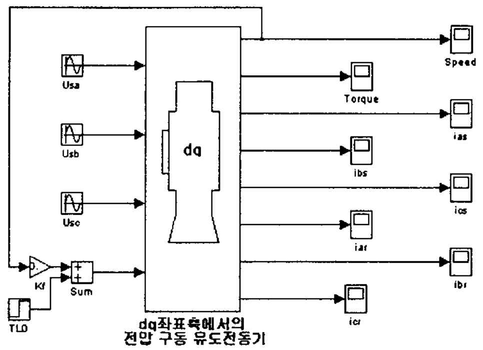


Fig 5. SIMULINK model of induction motor

3. Applying experiment

Here thesis is as follows; we simulated about a rotor velocity assumption system which used closed-loop flux estimation utilizing SIMLUNK and conducted ex -perience on proving that control block diagram is described in Fig 6.

Table 1. Induction motor regularity.

parameter	induction motor
Voltage	220 [V]
Current	12.9 [A]
Output	3.7 [kW]
Speed	1730 [rpm]
Pole	4극
Stater R_s	0.6992 [Ω]
Rotor R_r	0.3552 [Ω]
Stator L_s	0.0661 [H]
Rotor L_r	0.0661 [H]
Mutual L_m	0.0632 [H]
J	0.0918[$kg \cdot m^2$]

This system consists of velocity controller. current cor.troller, voltage model controller, closed-loop ma;netic observer, a rotor velocity observer, PWM wa,e generator and a coordinate convertor etc.[5]

Control loop is divided into velocity control loop and current control loop. current controller operates repeatedly at the period of 100[μs] and velocity controller operates repeatedly at the period of 5[ms]. In addition, induction motor's regularity and parameter used as sample is shown in Table 1.

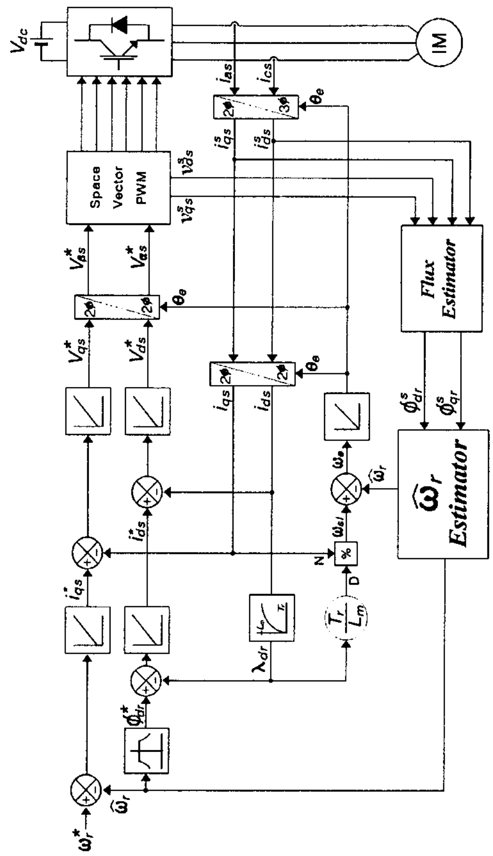


Fig 6. Control block diagram

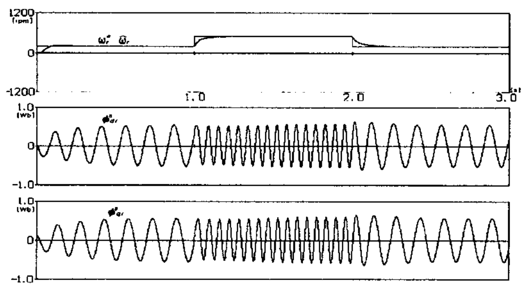
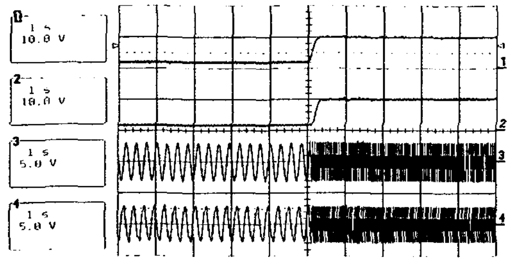


Fig 7. estimation velocity and flux wave at reference velocity change (200→500→200[rpm], no-load)

According to reference velocity change, Fig 7 is sin.ulation wave of system velocity and flux estimation properties utilizing SIMLULIK. Under the no-load state, In case of step-moving ω_r^* as 200[rpm] and step-accelerating ω_r^* as 500[rpm] at t=1.0[s] and step-deceleration ω_r^* as 200[rpm] at t=2.0[s] shows estimation rotor velocity wave $\widehat{\omega_r}$. In addition Fig9 shows d-axis and q-axis's flux wave of closed-loop flux estimator.



velocity:200[rpm]/div, flux:0.2[Wb]/div, time:1[sec]/div
Fig 8. estimation velocity and flux wave at reference velocity change (200->1000[rpm], no-load)

In addition, experimental wave is described in Fig 8(under the no-loaded state). In case of accelerating ω_r^* from 200[rpm] to 1000[rpm]. Figure10 is an assumed rotor velocity subject to closed-loop flux estimator. As a result of velocity observer, a rotor velocity is $\widehat{\omega_r}$ and as a result of closed-loop magnetic observer. The assumed flux velocity is ϕ_{dr}^s and ϕ_{qr}^s. We can make sure that velocity assumption works very well according to standard velocity acceleration.

4. Conclusion

Here, thesis is as follows;
As a result of modeling power electronics device and electrical machine, we obtain a conclusion as follows.

(1) we can simulate easily power & electronic circuit as a result of Library development.

(2) we can simulate rapidly and accurately utilizing Library developed as PSPICE and SIMULINK.

(3) In the consenquence of experiment on induction motor controller, we realized that simulation has done exactly.

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