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THE MAGNETIZING CHARACTERISTIC IN THE AIR GAP OF THE SEIG USING RUNGE KUTTA METHOD AND CORRECTION FACTOR

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ABSTRACT

The Self Excitated Induction Generator (SEIG) is very popular now as a generated alternating power. In this research the induction machine is approached in the physically and mathematically approximated which then transformed from three-phase frame abc to two-axis frame dq using the Park and Clark transformation. Based on the reactive power demand and capacitor mounted on the stator of the induction machine then do the physical and mathematical approach of the system to obtain a state space model. Under known relationships, magnetization reactance and magnetizing current is not linear, so do mathematical approach to the magnetization reactance and magnetization currents characteristic curve to obtain the magnetic reactance equation used in the calculation. Obtained state space model and the magnetic reactance equation is simulated by using Runge Kutta method of fourth order in the exponent equation with correction factor. The influence of the stator current in q axis $\mathbf{i_{qs}}$, is very strong and the equation of this current is non power-invariant then , using take the stator current reference $\mathbf{i_{qs}^{ref}}$ is $(\mathbf{2/3})\,\mathbf{I_{base}}$. The correction factor K_4 has done the magnetizing inductance L_m and also the output terminal voltage of SEIG more precision than before.

Keywords : *Induction Machine, Self Excitated Induction Generator, dq0 Transformation, State Space, Magnetization Characteristic of Induction Machine, Runge Kutta.Method, Correction Factor.*

1. INTRODUCTION

The alternating current machine is known in two type as synchronous machine and asynchronous machine, the synchronous machine is a machine has the rotating rotor and rotating stator flux's are same. The asynchronous machine is machine, what it has the rotating rotor and rotating stator flux's are difference. The asynchronous machine is known also as the induction machine, what it do as a generator needed. One of specialty the induction generator from the synchronous generator can operated above synchronous speed , whice known as Self-Excitation. In this condition. The external elements that can change the voltage profile of SEIG are speed, terminal capacitance and the load impedance. In most of SEIG applications, the rotational speed is rarely controllable. Therefore, the load seen by the generator or terminal capacitance has to be controlled [6]. The generator will use the energy, that it generate from rotor rotation for to generate stator flux and rotor flux using reactive power. The reactive power is given local bank capacitor, that it conected to the stator. This configuration is called as Self Excitated Induction Generator (SEIG). Using the simulation will be done the mathematical approach for hope to achieve a describe about SIEG response . Using the correction factor does the output terminal voltage of SEIG more precision than without the correction factor .

2. METHODOLOGY

The three phase induction generator has some equation. The equation flux average $\bar{\phi}$ is the flux as time function $\lambda(t)$ [1][2]:

The equations stator voltage :

$$v_{as} = i_{as} r_s + \frac{d\lambda_{as}}{dt}$$
$$v_{bs} = i_{bs} r_s + \frac{d\lambda_{bs}}{dt}$$
$$v_{cs} = i_{cs} r_s + \frac{d\lambda_{cs}}{dt} \qquad (1)$$

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The equations rotor voltage

$$v_{ar} = i_{ar}r_r + \frac{d\lambda_{ar}}{dt}$$
$$v_{br} = i_{br}r_r + \frac{d\lambda_{br}}{dt}$$
$$v_{cr} = i_{cr}r_r + \frac{d\lambda_{cr}}{dt} \qquad (2)$$

The stator and rotor turns flux are written in equation 3 until 5:

$$\begin{bmatrix}\lambda_s^{abc}\\ \lambda_r^{abc}\end{bmatrix} = \begin{bmatrix}L_{ss}^{abc} & L_{sr}^{abc}\\ L_{rs}^{abc} & L_{rr}^{abc}\end{bmatrix}\begin{bmatrix}i_s^{abc}\\ i_r^{abc}\end{bmatrix} \qquad (3)$$

$$\lambda_s^{abc} = (\lambda_{as}, \lambda_{bs}, \lambda_{cs})^T \qquad (4)$$

$$\lambda_r^{abc} = (\lambda_{ar}, \lambda_{br}, \lambda_{cr})^T \qquad (5)$$

$$i_s^{abc} = (i_{as}, i_{bs}, i_{cs})^T \qquad (6)$$

$$i_r^{abc} = (i_{ar}, i_{br}, i_{cr})^T \qquad (7)$$

The Inductance stator to stator :

$$L_{ss}^{abc} = \begin{bmatrix}L_{ls}+L_{ss} & L_{sm} & L_{sm}\\ L_{sm} & L_{ls}+L_{ss} & L_{sm}\\ L_{sm} & L_{sm} & L_{ls}+L_{ss}\end{bmatrix} \qquad (8)$$

The Inductance rotor to rotor:

$$L_{rr}^{abc} = \begin{bmatrix}L_{lr}+L_{rr} & L_{rm} & L_{rm}\\ L_{rm} & L_{lr}+L_{rr} & L_{rm}\\ L_{rm} & L_{rm} & L_{lr}+L_{rr}\end{bmatrix} \qquad (9)$$

The Inductance stator to rotor and rotor to stator:

$$L_{sr}^{abc} = \left[L_{rs}^{abc}\right]^T \qquad (10)$$

$$L_{sr} = \begin{bmatrix}\cos\theta_r & \cos\left(\theta_r + \frac{2\pi}{3}\right) & \cos\left(\theta_r - \frac{2\pi}{3}\right)\\ \cos\left(\theta_r - \frac{2\pi}{3}\right) & \cos\theta_r & \cos\left(\theta_r + \frac{2\pi}{3}\right)\\ \cos\left(\theta_r + \frac{2\pi}{3}\right) & \cos\left(\theta_r - \frac{2\pi}{3}\right) & \cos\theta_r\end{bmatrix} \qquad (11)$$

Where :

$L_{ss} = N_s^2 P_g$: stator self inductance (12)

$L_{rr} = N_r^2 P_g$: rotor self inductance (13)

$L_{sm} = N_s^2 P_g \cos(2\pi/3)$: stator mutual inductance (14)

$L_{rm} = N_r^2 P_g \cos(2\pi/3)$: rotor mutual inductance (15)

stator to rotor peak mutual inductance

$L_{sr} = N_s N_r P_g$: stator to rotor peak mutual inductance (16)

N_s : stator total turns stator
N_r : rotor total turns
P_g : air gap permeability

The equation transformation from stator and rotor in $qd0$ axis is obtained from the Clark and Park transformation and is describe as equation 17.

$$[fd \quad fq \quad fo]^T = [T_{dq0}(\theta)][fa \quad fb \quad fc]^T \qquad (17)$$

The equation of stator and rotor position $\theta(t)$

$$\theta_s(t) = \int_0^t \omega(t)dt + \theta_s(0) \qquad (18)$$

$$\theta_r(t) = \int_0^t \omega_r(t)dt + \theta_r(0) \qquad (19)$$

The matric transformation in dq0 axis and its inverse, is shown as in the equations 20-21 :

$$[T_{dq0}(\theta)] = {}^2/_3\begin{bmatrix}\cos\theta & \cos\left(\theta - \frac{2\pi}{3}\right) & \cos\left(\theta + \frac{2\pi}{3}\right)\\ \sin\theta & \sin\left(\theta - \frac{2\pi}{3}\right) & \sin\left(\theta + \frac{2\pi}{3}\right)\\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2}\end{bmatrix} \qquad (20)$$

the inverse of matric transformation in dq0 axis is

$$[T_{dq0}(\theta)]^{-1} = \begin{bmatrix}\cos\theta & \sin\theta & 1\\ \cos(\theta - \frac{2\pi}{3}) & \sin(\theta - \frac{2\pi}{3}) & 1\\ \cos(\theta + \frac{2\pi}{3}) & \sin(\theta + \frac{2\pi}{3}) & 1\end{bmatrix} \qquad (21)$$

The stator and rotor voltage in dq0 axis is shown :

$$v_{qs} = p\lambda_{qs} + \omega_s\lambda_{ds} + r_s i_{qs}$$
$$v_{ds} = p\lambda_{ds} - \omega_s\lambda_{qs} + r_s i_{ds}$$
$$v_{0s} = p\lambda_{0s} + r_s i_{0s} \qquad (22)$$

$$v_{qr} = p\lambda_{qr} + (\omega_s - \omega_r)\lambda_{dr} + r_r i_{qr}$$
$$v_{dr} = p\lambda_{dr} - (\omega_s - \omega_r)\lambda_{qr} + r_r i_{dr}$$
$$v_{0r} = p\lambda_{0r} + r_r i_{0r} \qquad (23)$$

The flux equation in dq0 axis is shown as

$$[\lambda_{qs} \quad \lambda_{ds} \quad \lambda_{0s} \quad \lambda_{qr} \quad \lambda_{dr} \quad \lambda_{0r}]^T =$$

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$$\begin{bmatrix} L_{ls}+L_m & 0 & 0 & L_m & 0 & 0 \\ 0 & L_{ls}+L_m & 0 & 0 & L_m & 0 \\ 0 & 0 & L_{ls} & 0 & 0 & 0 \\ L_m & 0 & 0 & L_{lr}+L_m & 0 & 0 \\ 0 & L_m & 0 & 0 & L_{lr}+L_m & 0 \\ 0 & 0 & 0 & 0 & 0 & L_{lr} \end{bmatrix}\begin{bmatrix} i_{qs} \\ i_{ds} \\ i_{0s} \\ i_{qr} \\ i_{dr} \\ i_{0r} \end{bmatrix} \quad (24)$$

The stator and rotor flux equations in dq0 axis is :

$$\lambda_{qs} = L_s i_{qs} + L_m i_{qr}$$

$$\lambda_{ds} = L_s i_{ds} + L_m i_{dr} \quad (22)$$

$$\lambda_{qr} = L_r i_{qr} + L_m i_{qs}$$

$$\lambda_{dr} = L_r i_{dr} + L_m i_{ds} \quad (26)$$

The Self Excitated Induction Generator(SEIG) using capacitors, is the induction generator as noload operation. This system is described as a three phase induction machine symmetrically and connected to identic bank capacitor. The using model induction machine stationery ,will be obtained the equivalent circuit of the self excitated induction generator SEIG in : d-axis, is shown as figure 1 and q-axis is shown as figure 2, as below [4]:

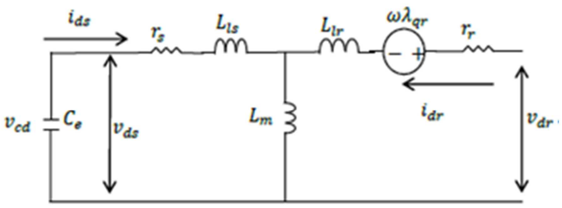

Figure 1 : stasionery circuit at d-axis with excitated capacitor[1] [4]

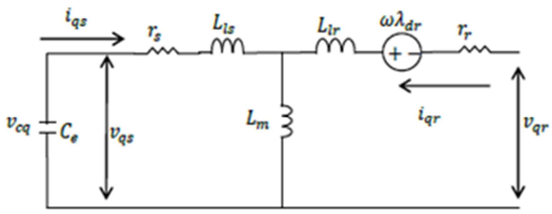

Figure 2 : stasionery circuit at q-axis with excitated capacitor[1] [4]

From the equivalent circuit as figure 1 and figure 2, is obtained the voltage equations in dq axis :

$$[v_{ds} \quad v_{qs} \quad v_{dr} \quad v_{qr}]^T =$$

$$\begin{bmatrix} r_s+L_s p+\frac{1}{pC_e} & 0 & L_m p & 0 \\ 0 & r_s+L_s p+\frac{1}{pC_e} & 0 & L_m p \\ L_m p & \omega L_m & r_r+L_r p & \omega L_r \\ -\omega L_m & L_m p & -\omega L_r & r_r+L_r p \end{bmatrix}\begin{bmatrix} i_{ds} \\ i_{qs} \\ i_{dr} \\ i_{qr} \end{bmatrix}$$

(28) The resistance-inductance load RL series , is connected parallel with the capacitor bank Ce.

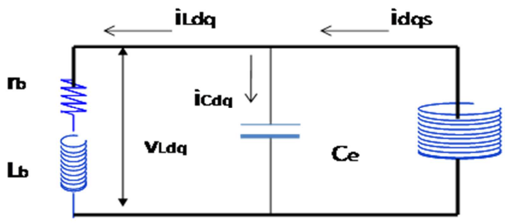

Figure 3 : The SEIG RLC load[4]

$$i_{Cd} = C_e p V_{Ld} = (r_b p C_e + L_b p^2 C_e) i_{Ld}$$
(29)

Where :

$i_{ds} = i_{Cd} + i_{Ld}$, and

$$i_{ds} = (r_b p C_e + L_b p^2 C_e) i_{Ld} + i_{Ld}$$

$$i_{Ld} = \frac{i_{ds}}{r_b p C_e + L_b p^2 C_e + 1} \quad (30)$$

$v_{Ld} = (r_b + L_b p)\, i_{Ld}$ or

$$v_{Ld} = \frac{r_b + pL_b}{r_b p C_e + L_b p^2 C_e + 1}\, i_{ds} \quad (31)$$

Using the the equivalent circuit figure 3 is obtained :

$$V_{Lq} = \frac{r_b + pL_b}{r_b p C_e + L_b p^2 C_e + 1}\, i_{qs} \quad (32)$$

The substitution voltage v_{cd} , v_{cq} and V_{Ld}, V_{Lq} to equation 28, and then :

$$[v_{ds} \quad v_{qs} \quad v_{dr} \quad v_{qr}]^T =$$

$$[Z]\,[i_{ds} \quad i_{qs} \quad i_{dr} \quad i_{qr}]^T \quad (33)$$

$$[Z] = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \quad (34)$$

Where :

$$Z_{11} =$$

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$$\begin{bmatrix} r_s + L_s p + \dfrac{r_b + L_b p}{r_b p C_e + L_b p^2 C_e + 1} & 0 \\ 0 & r_s + L_s p + \dfrac{r_b + L_b p}{r_b p C_e + L_b p^2 C_e + 1} \end{bmatrix}$$

$$Z_{12} = \begin{bmatrix} L_m p & 0 \\ 0 & L_m p \end{bmatrix}$$

$$Z_{21} = \begin{bmatrix} L_m p & \omega L_m \\ -\omega L_m & L_m p \end{bmatrix}$$

$$Z_{22} = \begin{bmatrix} r_r + L_r p & \omega L_r \\ \omega L_{lr} & r_r + L_r p \end{bmatrix}$$

The equation 33 is written in the state space model, as below :

$$p[x] = [A][x] + [B][u] \qquad (35)$$

Where :

The input system is :

$$[B][u] = K \begin{bmatrix} -L_r & 0 & L_m & 0 \\ 0 & -L_r & 0 & L_m \\ L_m & 0 & -L_s & 0 \\ 0 & L_m & 0 & -L_s \end{bmatrix} \begin{bmatrix} V_{ds} \\ V_{qs} \\ V_{dr} \\ V_{qr} \end{bmatrix} \qquad (36)$$

And state vector **x** :

$$[\mathbf{x}] = [i_{ds} \quad i_{qs} \quad i_{dr} \quad i_{qr} \quad V_{Ld} \quad V_{Lq} \quad i_{Ld} \quad i_{Lq}]^T \qquad (37)$$

$$K = 1/\left({L_m}^2 - L_s . L_r\right):$$

The plant matric A is shown by equations 38 until 42 :

$$A = K \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \qquad (38)$$

$$A_{11} = \begin{bmatrix} r_s L_r & -\omega {L_m}^2 & -r_r L_m & -\omega L_m L_r \\ \omega {L_m}^2 & r_s L_r & \omega L_m L_r & -r_r L_m \\ -r_s L_m & \omega L_m L_s & r_r L_s & \omega L_r L_s \\ -\omega L_m L_s & -r_s L_m & -\omega L_r L_s & r_r L_s \end{bmatrix} \qquad (39)$$

$$A_{12} = \begin{bmatrix} L_r & 0 & 0 & 0 \\ 0 & L_r & 0 & 0 \\ -L_m & 0 & 0 & 0 \\ 0 & -L_m & 0 & 0 \end{bmatrix} \qquad (40)$$

$$A_{21} = \begin{bmatrix} {}^1/_{C_e K} & 0 & 0 & 0 \\ 0 & {}^1/_{C_e K} & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \qquad (41)$$

$$A_{22} = \begin{bmatrix} 0 & 0 & {}^{-1}/_{C_e K} & 0 \\ 0 & 0 & 0 & {}^{-1}/_{C_e K} \\ {}^1/_{L_b K} & 0 & 0 & 0 \\ 0 & {}^1/_{L_b K} & 0 & 0 \end{bmatrix} \qquad (42)$$

The reactance of magnetizing inductance Xm is determined using technical approach with the exponential equation as equation 43 :

$$X_m = \omega L_m = V_u / i_m = F.\left(K_1 e^{K_2 {i_m}^2} + K_3\right) \qquad (43)$$

Using the equations of reactance , is done the algorithm of simulation for the self excited induction generator using the " Runge Kutta method of Fourth Order"[5] and the exponent equation.

This simulation uses *Linear Time-Varying State Model* as a discrete computation runge kutta method, and is applied in the state space equation 44 :

$$\dot{x}(t) = f(x,t) \qquad (44)$$

The state vector $x[(n-1)T] = x_T(n-1)$

and $x_T(n) \cong x(nT)$ (45)

The sampling time T is *step interval.* The state space counting programme is using the function $f(x,t)$ for determine $\dot{x}(t) = f(x,t)$ along state vector **x** as a function time t. Using the runge kutta method of fourth order is determined the constant of it method in discrete form equations 46 until 55 :

The state vector derivative $\dot{x}(t)$ in discrete form is written as :

$$x_T(n+1) \cong x((n+1)T) \qquad (46)$$

$$f(x,t) = [A(x(t))][x(t)] + [B(x(t))][u(t)] \qquad (47)$$

And the plant matric A and the input matric B is written as :

$$[A(nT)] = [A_T(n)] = [A_T(x_T(nT))]$$

$$[B(nT)] = [B_T(n)] = [B_T(x_T(nT))] \qquad (48)$$

For n = n+1 then :

$$[A(nT+T)] = [A_T(n+1)] = [A_T(x_T(n+1))]$$

$$[B(nT+T)] = [B_T(n+1)] = [B_T(x_T(n+1))] \qquad (49)$$

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The Runge Kutta method of fourth order is written as:

$$g_o \equiv f[(x_T(n))]$$
$$g_1 \equiv f\left[(x_T(n)) + g_o\left(\frac{T}{2}\right)\right]$$
$$g_2 \equiv f\left[(x_T(n)) + g_1\left(\frac{T}{2}\right)\right]$$
$$g_3 \equiv f[(x_T(n) + g_2 T)]$$
$$g_4 \equiv (g_o + 2g_1 + 2g_2 + g_3)/6 \quad (50)$$

Renew the state vector in the discrete state equation

$$x_T(n+1) = x_T(n) + g_4 T \quad (51)$$

$$[A_T(n+1)] = [A_T(x_T(n+1))] \text{ and } [B_T(n+1)] = [B_T(x_T(n+1))] \quad (52)$$

$$n = (n+1) \text{ and } t = (n)T \quad (53)$$

$$x((n+1)T) = f(x_T(n), nT) \quad (54)$$

$$f(x_T(n), nT) = [A(x_T(n))][x_T(n)] + [B(x_T(n))][u(n)] \quad (55)$$

The exponential equation (43) will be search the constant of K_1, K_2 and K_3 , using the range of magnetizing current i_m and the range is :

$$i_{mi}^{min} = (100\% - err)\, i_{mi} \text{ dan}$$
$$i_{mi}^{max} = (100\% + err)\, i_{mi} \quad (56)$$

So that :

$$i_{mi}^{min} \le i_m \le i_{mi}^{max} \quad (57)$$

Atake the $error$ from 1 percent until 5 percent.

i_{mi}^{min} : miminum range

i_{mi}^{max}: maximum range

i_{mi} : the value i_{m1}, i_{m2}, or i_{m3}.

Tabel 1: measurement of the constant K_1, K_2 and K_3 [4].

i_m amp	V_u Volt	X_m Ohm	Constant Formula
$i_{m1} = i_{m1}$	V_{u1}	$a = X_{m1} = V_{u1}/i_{m1}$	$K_1 = (c - K_3)\left(\frac{a-b}{b-c}\right)^{\frac{49}{24}}$
$i_{m2} = 5i_{m1}$	V_{u2}	$b = X_{m2} = V_{u2}/i_{m2}$	$K_2 = \frac{49}{24}\frac{1}{{i_{m3}}^2}\ln\left(\frac{b-c}{a-b}\right)$
$i_{m3} = 7i_{m1}$	V_{u3}	$c = X_{m3} = V_{u3}/i_{m3}$	$K_3 = \frac{b^2 - ac}{2b - (a+c)}$

3. RESULTS AND ANALYSIS

The data of the self excitated induction generator SEIG, three phase 230/400 volt,50 hertz, 2.2 kW / 3 HP, 8.6 ampere, 4 poles, squirrel cage , delta connection [7]

Table 2 : Data of induction generator [7]

	magnitd	unit		magnitd	unit
r_s	3.35	Ohm	V-base	230	volt
X_s	4.85	Ohm	I-base	4.96	amp
r_r	1.76	Ohm	n-base	1500	rpm
X_r	4.85	Ohm	f	50	hertz

3.1 Simulation using the exponent equation

In this simulation is used the magnetizing inductance in exponent equation :

$$L_m = [0.1027 * (e^{-0.0081 * i_m * i_m})] + 0.0395$$

Base on using exponent equation that it is iterrated by magnetizing current i_m in interval 0.01 A and then determine the exponent equation using the program linear-piecewise equation from relation between the reactance X_m and the air gap voltage V_u in table 3 as below :

Table 3: the magnetizing reactance Xm [7]

$Vu_{min} - Vu_{max}$ (volt)	Xm (ohm)
0 - 117.87	108.000
117.870 - 171.052	135.553-0.233*Vb
171.052 - 211.919	151.160-0325*Vb
211.919 - 344.411	213.919-0.621*Vb
344.411 < V_u	0

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so that is obtained the curve in figure 4, as below :

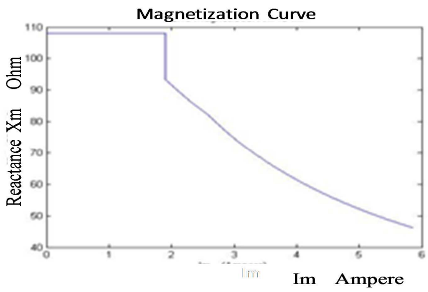

Figure 4: the magnetizing curve using the linear-piecewise

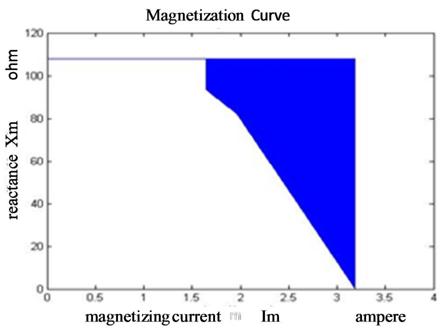

Figure 5 : magnetizing curve using the iteration of magnetizing current i_m

The magnetizing curve shows that the magnetizing current i_m rises to become 1,646 ampere until 3.185 ampere , so that is obtained the constraint of search. From the *linear-piecewise* equation *the minimum value of* X_m , it know is 0.2267 ohm , and using the the search of constant program, and than is obtained the magnetizing current maximum i_{m3} is 1,646 ampere.

Tabel 4. Parameter of the induction machine constant

i_{m3} amp	K_1 (ohm)	$K_2(\frac{1}{\text{amp2}})$	K_3 (ohm)	K_1+K_3 (ohm)
3.15	76.7820	-0.0652	32.227	109.010
3.00	81.5965	-0.0602	27.301	108.898
2.85	93.2129	-0.0507	15.570	108.783
2.80	98.0240	-0.0477	10.723	108.747
2.75	104.347	-0.0442	4.3628	108.710
2.70	107.478	-0.0426	1.2013	108.680
2.69	106.530	-0.0430	2.1454	108.675
2.68	108.439	-0.0421	0.2289	108.668
2.67	0	Infinite	108	108.000
2.66	Not found solution for $K2 > 0$			

3.2 Simulation using the approach $V_u = V_{base}$

The relationship between the air gap voltage Vu, terminal voltage Vb, manetizing current i_m and capacitance current i_c [4] .
The reactance value X_m is counted using air gap voltage V_u same as terminal voltage V_{base} , $230V$ as below :

$211.919 \le V_u \le 344.411$, Vu = = 213.919 volt

X_m = 213.919-(0.621***230**)

$X_m^{ref} = 71.089$ ohm

and than the capacitor value Ce at K_3 *is* $X_m^{ref} =$ 71.089 ohm is:

$$C_e > \frac{1}{F^2 \omega K_3}$$

Is caused the X_m^{ref} value greather than the inductance minimum value X_m , then the value of capacitor Ce

$C_e \ge$ 44,8 μFarad

Using the resistance-inductance RL load
$\boldsymbol{Z} = r_b + j[(\omega L_b) - (1/(\omega C_e))]$

if the load is the resistive load then the reactive load component is zero and is obtained the inductance L_b

$L_b = 1/(\omega^2 C_e) =$ 0.2263 henry

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From , the nominal current generator is 4.96 ampere then the base impedanc Z_{base} grather than (V_{base}/I_{base}) and $Z_{base} > 46.371$ ohm

For load is one percent Z_{base} then ,

$Z_{base} = 4637.1$ ohm

$r_b = Z\cos\varphi$ and the power factor of this load

$\cos\varphi \cong 1$ dan Z_{base} then:

$r_b \cong Z_{base} = 4637.1$ Ohm

Using the value C_e, L_b and r_b and the data of constant K_1, K_2 , K_3 and impulse 10 volt along 0.0003 second until stable condition is obtained the peak value :

Table 5 Data equation approach $V_u = V_{base}$.

i_{qs} (ampere)	i_{qr} (ampere)	V_{Lq} (volt)	i_{Lq} (ampere)
3.5065	0.2349	249.7465	0.0539
3.4793	0.2329	247.8041	0.0534
3.4442	0.2305	245.3062	0.0529
3.4300	0.2295	244.2914	0.0527
3.4169	0.2286	243.3601	0.0525
3.4126	0.2283	243.0553	0.0524
3.4160	0.2285	243.2985	0.0525
3.4125	0.2283	243.0506	0.0524
Can not simulation			

From Table 5 the value of load voltage V_{Lq} is unequal, with the base voltage V_{base} , because the reactance equation X_m does not precise, than the correction technical approach is used.

The stator current in q axis i_{qs}, that it the matric equation is non power-invariant then , take :

$i_{qs}^{ref} = (2/3)\, I_{base} = 3.306667$ ampere

The current i_{qs} in table 5 is grather than the current i_{qs}^{ref} then is used *the correction factor* , because in the matric equation $[\dot{x}]$ is consist of the current i_{qs}, that it the induction equations .

Using $K_4 = i_{qs}^{ref}/i_{qs}$ and is multiplied to equation 43 is obtained the new reactance equation using correction factor.

$$X_m = K_4.F.\left(K_1.e^{K_2.i_m{}^2} + K_3\right) \tag{58}$$

The repeated this process using the equation 58, and data in table 4 , table 5 and the current value i_{qs} is obtained the new data in table 6.

Table 6 : The new data using the correction K_4.

K_4	i_{qs} (amp)	i_{qr} (amp)	V_{Lq} (volt)	i_{Lq} (amp)
0.94301060	3.2548	0.2243	231.8150	0.0500
0.95038274	3.2701	0.2201	232.9028	0.0502
0.96006813	3.2887	0.2208	234.2306	0.0505
0.96404276	3.2937	0.2210	234.5883	0.0506
0.96773879	3.2982	0.2211	234.9075	0.0507
0.96895818	3.2998	0.2212	235.0183	0.0507
0.96799376	3.2991	0.2212	234.9703	0.0507
0.96898657	3.2928	0.2208	234.5206	0.0506
Can not simulation				

4. CONCLUSION

. The precision of the magnetizing inductance equation L_m is very important , because these equations influence in determine of the equation in simulation depend on magnetizing current i_m. The output terminal motor voltage very depend on the precise of the magnetizing inductance L_m, magnetizing current i_m and the air gap between stator and rotor. The influence of the stator current in q axis i_{qs}, is very strong and the equation of this current is non power-invariant then , using take the stator current reference i_{qs}^{ref} is $(2/3)\, I_{base}$. The correction factor K_4 has done the magnetizing inductance L_m and also the output terminal voltage of SEIG more precision than before.

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