Simplified Voltage and Frequency Controller for Six-phase Isolated Induction Generator Feeding Resistive Load

Kiran Singh

IIT, Roorkee.

Abstract: This article deals with a simple and moderate Matlab /Simulink software model of voltage and frequency controller for a stand-alone (or an isolated) six-phase self-excited induction generator (SP-SEIG). A simplified programmed controller circuitry keeps the terminal voltage and generated frequency almost fixed in order to maintain the uniform generator output power despite marginal drop in machine rotor speed during variations in consumer energy demands. Dynamic simulation results verify the proposed control strategy for merely one value of resistive loading at particular instant of time period.

Keywords: Voltage and frequency regulation, Six-phase, Self-excitation, Induction generator

1. Introduction

When an induction machine is directly connected to power supply, it runs only at its rated speed. Additionally, the variable speed characteristic has continued to cause impetus in electrical energy generation from nearby renewable sources. Further, distributed power generation has also been emphasized the need of suitable generating system and natural demand of renewable (or non-conventional) energy source for remote locations. Affectionate utilization of non-conventional sources in fuel redemption have a need of low cost and appropriate generating systems in enlivening the small (or large) scale industrial applications and various future energy demands. Stand-alone induction generators in conjunction with non-conventional energy sources have been attractive substitutes by possessing numerous relative advantages over conventional generators, and, certainly become milestone for electricity production over the past and future. The cost effective utilization of isolated induction generator technology supports new opportunity and development in supplement the electric power from different site resources to underprivileged far-flung and remote areas[1-5].

In order to maintain the quality of consumer power in distributed power generation associated with locally available renewable energy sources, it is also necessary to maintain the simplicity, reliability and user-friendliness of a generating scheme. To meet the requirement of desired consumer power quality, it is also important to develop a suitable controller for self-excited induction generator to avoid the two most important drawbacks which are associated with isolated mode besides its benefits. Two main well known drawbacks that are associated with it i.e. need of more reactive power support during faults, and, poor voltage and frequency regulation during variations in rotor speed, excitation capacitance and connected machine loads. Therefore, the driving and controlling of induction machines are prime concerns in today’s energy conscious world to capture the maximum allowable energy in efficient and economical manner[6-8].

Basically, V and F (Volts and Hz) regulation is a simple and popular scheme of speed regulation in induction machine usually used in industries for several decades. This scheme preserves the constant magnitude of flux (i.e. ratio of litera voltage to frequency) during voltage and across stator resistance. There are number of

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Past frequency regulation at varying speed and load, and disregarding any drop tures (missing words), which demonstrate the improvement of voltage and frequency regulation of SEIG by using additional series capacitors and different types of controllers. Varieties of solid-state controllers were also investigated for improving the voltage and frequency regulation. There is also a need for frequency regulation under varying prime mover speed, excitation capacitance and load characteristics. A considerable amount of work has been directed towards the design and analysis of voltage and frequency regulators for 3Φ (three phase) induction generator[9-14]. Prior investigation was on voltage and frequency (Volts and Hz) control of 3Φ SEIG, but no such work was available on SP-SEIG, So, research work on Volts and Hz control of SP-SEIG has been proposed for exploring the propitious features of multi-phase machine conjointly stand-alone mode of induction generator.

2. Control problem formulation

Block diagram of whole controlled machine system is shown in Fig. 1, which consists of a SP-SEIG, two V and F controllers with their control schemes for each 3Φ sets, and connected equal resistive loads at both 3Φ sets. The detailed of each V and F controller block is illustrated, independently, in **Figure 2** and **Figure 3**, which are combination of solid-state IGBT switch based CC-VSI, AC filter inductors act as a bridge between the outputs of inverters and SEIG terminals, DC bus capacitor for filtering voltage ripples, and chopper for controlling dump powers. Identical control scheme of both V and F controllers for each 3Φ sets is also shown, jointly, in **Figure 4**, for the purpose of voltage regulation, elimination of system harmonics and load balancing. The philosophy of control scheme is based on the mechanism of source current control by virtue of A.C. voltage components i.e. in-phase and quadrature. There are two PI controllers and two PWM generators in each of the control schemes. One PI controller is for A.C. terminal voltage regulation and another is for D.C. bus voltage regulation. Similarly, first PWM generator produces gating pulses T1, T2 and second generates T3, T4 in each control scheme across set I and II, respectively[2,4,9].

3. Description on modelling of V and F controller-SP-SEIG system

Mathematical modelling of whole system is mainly divided in to two sub-sections and demonstrated below for simulation purpose:

3.1 Modelling of control strategy

Proposed Volts and Hz control strategies are considered in closed loop manner in Fig. 4. The aim of control strategies are, to regulate A.C. and D.C. bus voltages and to generate triggering pulses at gates of IGBT switches in VSI and DC chopper for both 3Φ sets as shown in Figs. 2 and 3. Reference source currents can be generated by instantaneous values of in-phase and quadrature components as:

$$i'ra = i'rad + i'raq\ ;\ i'rb = i'rbd + i'rbq\ ;\ i'rc = i'rcd + i'rcq\ ; \quad (1)$$
$$i'rx = i'rxd + i'rxq\ ;\ i'ry = i'ryd + i'ryq\ ;\ i'rz = i'rzd + i'rzq\ ;$$

Where, i´ra, i´rb, i´rc, i´rx, i´ry and i´rz are reference source currents through each of the 3Φ winding sets; i´rad, i´rbd, i´rcd, i´rxd, i´ryd and i´rzd are instantaneous values of their in-phase components; similarly, i´raq, i´rbq, i´rcq, i´rxq, i´ryq and i´rzq are instantaneous values of their quadrature components. The magnitude of in-phase reference source current 'i´rd' is constant for maintaining unvarying power generation and equal to rated value of active power component of machine current. In-phase reference source current 'i´rd' is calculated in Section 5.1.1 and instantaneous values of in-phase reference source current can be written as:

$$i'rad = ha \times i'rd;\ i'rbd = hb \times i'rd'\ \ i'rcd = hc \times i'rd; \quad (2)$$
$$i'rxd = hx \times i'rd;\ i'ryd = hy \times i'rd'\ \ i'rzd = hz \times i'rd;$$

Where, h_a, h_b, h_c, h_x, h_y, and h_z are in-phase unit templates and given below:

$$h_a = V_a / V_{t1}\ ;\ h_b = V_b / V_{t1}\ ;\ h_c = V_c / V_{t1}\ ; \quad (3)$$
$$h_x = V_x / V_{t2}\ ;\ h_y = V_y / V_{t2}\ ;\ h_z = V_z / V_{t2}\ ;$$

$$V_{t1} = sqrt\{(2/3) \times (V_a^2 + V_b^2 + V_c^2)\};$$
$$V_{t2} = sqrt\{(2/3) \times (V_x^2 + V_y^2 + V_z^2)\}; \quad (4)$$

The magnitude of quadrature reference source current 'i´rq' is the output of A.C. terminal voltage PI controller for maintaining constant terminal voltage and it is equal to the final simplified values of following derived equations. The outputs of A.C. voltage PI controllers:

$$i'_{rq1(i)} = i'_{rq1(i-1)} + K_{pa1}\left\{V_{er1(i)} - V_{er1(i-1)}\right\} + K_{ia1}V_{er1(i)}; \quad (5)$$

$$i'_{rq2(i)} = i'_{rq2(i-1)} + K_{pa2}\left\{V_{er2(i)} - V_{er2(i-1)}\right\} + K_{ia2}V_{er2(i)}; \quad (6)$$

Where, $V_{er1\,(i)} = V_{tref(i)} - V_{t1(i)}$; and $V_{er2\,(i)} = V_{tref(i)} - V_{t2(i)}$;

$V_{tref\,(i)}$ is reference AC terminal voltage, and, $V_{t1\,(i)}$ and $V_{t2\,(i)}$ are i^{th} time instant $V_{t1\,(i)}$ and $V_{t2\,(i)}$ can be given by the Equation (4). Kpa1 and Kpi1 are proportional and integral gain constants of the AC terminal voltage 'PI' controller for set I, and, Kpa2 and Kia2 are proportional and integral gain constants of the AC terminal voltage 'PI' controller for set II. Similarly, i´rq1 (i) and i´rq2 (i) are i^{th} instant compared AC voltage controller outputs, and, i´rq1 (i-1) and i´rq2 (i-1) are $(i-1)^{th}$ instant compared AC voltage controller outputs in set I and II, respectively. In same way, $V_{er1(i)}$ and $V_{er2(i)}$ are i^{th} instant AC terminal voltage error on set I and II, respectively, and $V_{er1(i-1)}$ and $V_{er2(i-1)}$ are $(i-1)^{th}$ instant AC terminal voltage error on set I and set II, respectively.

For instantaneous values of quadrature reference source current, following formulation can be written as:

$$\begin{gathered} \mathrm{i'raq} = \mathrm{qa} \times \mathrm{i'rq1};\ \mathrm{i'rbq} = \mathrm{qb} \times \mathrm{i'q1} \\ \mathrm{i'rcq} = \mathrm{qc} \times \mathrm{i'rq1}; \qquad (7) \\ \mathrm{i'rxq} = \mathrm{qx} \times \mathrm{i'rq2};\ \mathrm{i'ryq} = \mathrm{qy} \times \mathrm{i'rq2}; \\ \mathrm{i'rzq} = \mathrm{qz} \times \mathrm{i'rq2} \end{gathered}$$

Where, qa, qb, qc, qx, qy and qz are quadrature unit templates given below:

$$\begin{aligned} q_a &= \left\{(h_c - h_b) / \sqrt{3}\right\}; & i'_{rae} &= i'_{ra} - i_{ra}; \\ q_b &= \left\{\left((h_b - h_c) / \left(2\sqrt{3}\right)\right) + \sqrt{3}h_a/2\right\}; & i'_{rbe} &= i'_{rb} - i_{rb}; \\ q_c &= \left\{\left((h_b - h_c) / \left(2\sqrt{3}\right)\right) - \sqrt{3}h_a/2\right\}; & i'_{rce} &= i'_{rc} - i_{rc}; \\ q_x &= \left\{(h_z - h_y) / \sqrt{3}\right\}; & i'_{rxe} &= i'_{rx} - i_{rx}; \\ q_y &= \left\{\left((h_y - h_z) / \left(2\sqrt{3}\right)\right) + \sqrt{3}h_x/2\right\}; & i'_{rye} &= i'_{ry} - i_{ry}; \\ q_z &= \left\{\left((h_y - h_z) / \left(2\sqrt{3}\right)\right) - \sqrt{3}h_x/2\right\}; & i'_{rze} &= i'_{rz} - i_{rz}; \end{aligned}$$

(8)

While, ira, irb, irc, irx, iry and irz are source currents in PWM current controllers of both 3Φ sets. Comparison generates error signals which are used for the triggering purpose at the gates of IGBTs (S1-S14) in both the VSI bridges of 3Φ sets and are written in Equation (10). The working switching patterns of all switches are mentioned in [10].

3.2 Modelling of V and F controller

Each V and F controller for every set (similar in logic and operation) are shown in Figs. 2 and 3. The basic building blocks of V and F controllers are CC-VSI, series connected dump load and DC bus chopper, and their triggering pulses (T1-T4) from PWM current controllers of control schemes. Modelling of CC-VSI followed by DC bus chopper is presented for better understanding of controllers operations during simulation.

Model of CC-VSI. There are mainly three sections for modelling purpose as mentioned below:

DC bus voltages

$$\rho V_{d1} = \left\{SW_1 \times i_{ai} + SW_2 \times i_{bi} + SW_3 \times i_{ci} + \left((SW_7 \times V_{dc}) / R_d\right)\right\} / C_{dc};$$

(9)

$$\rho V_{d2} = \left\{SW_4 \times i_{Xi} + SW_5 \times i_{Yi} + SW_6 \times i_{Zi} + \left((SW_8 \times V_{dc}) / R_d\right)\right\} / C_{dc};$$

Where, SW_1- SW_8 are switching functions across IGBTs and DC chopper switches for both 3Φ sets in VSI bridges, □ is derivative term and remaining symbols 'R_d' and 'C_d' are 'dump load resistance' and 'DC bus capacitor', respectively, and their values are calculated in Section 5.1.1. V_{dc} is a reference dc bus voltage.

3Φ AC line voltages

$$\begin{aligned} e_{ai} &= (V_{d1}/3) \times (2 \times W_1 - SW_2 - SW_3); \\ e_{bi} &= (V_{d1}/3) \times (2 \times W_1 - SW_2 - SW_3); \\ e_{ci} &= (V_{d1}/3) \times (2 \times W_1 - SW_2 - SW_3); \\ e_{xi} &= (V_{d1}/3) \times (2 \times W_1 - SW_2 - SW_3) \\ e_{yi} &= (V_{d1}/3) \times (2 \times W_1 - SW_2 - SW_3); \\ e_{zi} &= (V_{d1}/3) \times (2 \times W_1 - SW_2 - SW_3) \end{aligned}$$

(10)

Where, e_{ai}, e_{bi}, e_{ci}, e_{xi}, e_{yi} and e_{zi} are instantaneous generated inverter AC phase voltages from the output of VSI. Equation (10) of CC-VSI can be rearranged after applying Kirchoff laws and are used below in Equation (11) in calculation of A.C. inverter currents.

3Φ AC inverter currents

$$\begin{aligned} \rho i_{ai} &= \left(V_a - e_{ai} - i_{ai} \times R_f\right)/L_f; \\ \rho i_{bi} &= \left(V_b - e_{bi} - i_{bi} \times R_f\right)/L_f; \\ \rho i_{ci} &= \left(V_c - e_{ci} - i_{ci} \times R_f\right)/L_f; \\ \rho i_{xi} &= \left(V_x - e_{xi} - i_{xi} \times R_f\right)/L_f; \\ \rho i_{yi} &= \left(V_y - e_{yi} - i_{yi} \times R_f\right)/L_f; \\ \rho i_{zi} &= \left(V_z - e_{zi} - i_{zi} \times R_f\right)/L_f; \end{aligned} \qquad (11)$$

Where, i_{ai}, i_{bi}, i_{ci}, i_{xi}, i_{yi} and i_{zi} are inverter output controlled current. R_f and L_f are ouput a.c. filter resistance and inductance.

Model of DC bus Chopper.

The magnitudes of outputs namely V'_{C1} and V'_{C2} from corresponding D.C. bus voltage PI controllers for maintaining constant D.C. bus voltages from both CC-VSI at i^{th} instant is equal to the simplified values of following derived equations.

Outputs of D.C. bus PI controllers

$$V'_{c1(i)} = V'_{c1(i-1)} + K_{pd1}\left\{V_{de1(i)} - V_{de1(i-1)}\right\} + K_{id1}V_{de1(i)};$$

$$V'_{c2(i)} = V'_{c2(i-1)} + K_{pd2}\left\{V_{de2(i)} - V_{de2(i-1)}\right\} + K_{id2}V_{de2(i)}; \quad (12)$$

Where, K_{pd1} and K_{id1} are proportional and integral gain constants of DC bus voltage PI controller for set I, and, K_{pd2} and K_{id2} are proportional and integral gain constants of DC bus voltage PI controller for set II. Similarly $V'_{c1\,(i)}$ and $V'_{c2\,(i)}$ are i^{th} instant compared output of PI controllers, and V'_{c1} (i-1) and V'_{c2} (i-1) are $(i-1)^{th}$ instant compared output of PI controllers. Similarly, $V_{de1(i)}$ and $V_{de2(i)}$ are i^{th} instant DC bus voltage error on set I and set II, respectively, and $V_{de1(i-1)}$ and $V_{de2(i-1)}$ are $(i-1)^{th}$ instant DC bus voltage error on set I and set II, respectively. DC bus voltage errors are comparative difference between reference and realized DC bus voltages and can be written by following Equations (13).

$$V_{de1\,(i)} = V_{dr(i)} - V_{d1(i)}; \text{ and } V_{de2\,(i)} = V_{dr(i)} - V_{d2(i)}; \quad (13)$$

$V_{dr(i)}$ is reference DC bus voltage. Whereas, $V_{d1(i)}$ and $V_{d2(i)}$ are realized magnitudes of DC bus voltages at i^{th} instant of time. $V_{d1(i)}$ and $V_{d2(i)}$ can be given by the previous Equation (9). The compared outputs between ($V'_{c1(i)}$ or $V'_{c2(i)}$) and carrier wave (V_{tri}, triangular in nature) in PWM controller are responsible for generation of gating pulses in determination of triggering patterns at DC chopper switches using switching functions SD1 and SD2 in both VSI of set I and II. When (SD1 or SD2) is high 'value is 1'indicates ($V'_{c1\,(i)}$ or $V'_{c2\,(i)}$) > V_{tri}) and vice versa.

3.3 Modelling of loaded SP-SEIG

Modelling of SP-SEIG is already demonstrated in Reference[15] for study and analysis purpose. Generator is resistively loaded in simple-shunt scheme across both sets. Only one modification is taken placed during simplification of the controller model for analysis purpose. This is a delta to star conversion at the common coupling points where delta excitation capacitor banks are connected across both 3Φ sets and it is further converted in to star excitation capacitor banks for the simplification in the modelling of controllers. When delta to star conversion was taken placed at common coupling points of capacitor banks across both 3Φ sets, it is transformed like that:

$$\rho V_a = \left\{\left(i_a - i_{ai} - i_{al}\right) - \left(i_b - i_{bi} - i_{bl}\right)\right\} / \left(3 \times C_{p1}\right);$$

$$\rho V_b = \left\{\left(i_a - i_{ai} - i_{al}\right) + 2\times\left(i_b - i_{bi} - i_{bl}\right)\right\} / \left(3 \times C_{p1}\right);$$

$$V_a + V_b + V_c = 0; \quad (14)$$

$$\rho V_x = \left\{\left(i_x - i_{xi} - i_{xl}\right) - \left(i_y - i_{yi} - i_{yl}\right)\right\} / \left(3 \times C_{p2}\right);$$

$$\rho V_y = \left\{\left(i_x - i_{xi} - i_{xl}\right) + 2\times\left(i_y - i_{yi} - i_{yl}\right)\right\} / \left(3 \times C_{p2}\right);$$

$$V_x + V_y + V_z = 0;$$

and, $i_a = \left(i_{ac} + i_{ai} + i_{al}\right)$; $i_b = \left(i_{bc} + i_{bi} + i_{bl}\right)$; $i_c = \left(i_{cc} + i_{ci} + i_{cl}\right)$; $i_x = \left(i_{xc} + i_{xi} + i_{xl}\right)$; $i_y = \left(i_{yc} + i_{yi} + i_{yl}\right)$; $i_z = \left(i_{zc} + i_{zi} + i_{zl}\right)$;

Where i_{al}, i_{bl}, i_{cl} are 3Φ load currents through set I and i_{xl}, i_{yl}, i_{zl} are 3Φ load currents through set II. Whereas, i_a, i_b, i_c are 3Φ line currents through set I and i_x, i_y, i_z are 3Φ line currents through set II. C_{p1} and C_{p2} are no load per phase excitation capacitances which are connected in parallel across both 3Φ sets I and II. Similarly, i_{ac}, i_{bc}, i_{cc}, i_{xc}, i_{yc} and i_{zc} are capacitor currents through set I and set II. Remaining symbols denote their earlier meanings from [15].

Design of V and F controller-SP-SEIG using Simulink Model

The Simulink model of SP-SEIG along with its V and F controllers is constructed using Simulink Matlab software according to logics of given **Figure 1** to **Figure 4**.

4. Results

The performance results from Simulink model are illustrated in **Figure 5**, when SP-SEIG is feeding sudden symmetrical resistive loads at t=1 sec. Transients response of 3Φ line voltages (V_a, V_b, V_c / V_x, V_y, V_z), 3Φ line currents (i_a, i_b, i_c / i_x, i_y, i_z), 3Φ load currents (i_{al}, i_{bl}, i_{cl} / i_{xl}, i_{yl}, i_{zl}), 3Φ CC-VSI currents (i_{ai}, i_{bi}, i_{ci} / i_{xi}, i_{yi}, i_{zi}), Magnitudes of terminal voltage along with A.C. reference voltage (V_{t1} /V_{t2}, V_{tr}), Magnitude of DC bus voltage along with D.C. reference voltage (V_{d1} /V_{d2}, V_{dr}) and generator rotor shaft speed (N_r) are in similar pattern along both 3Φ sets. Similar response of both sets under symmetrical resistive loads are not shown, only one phase of single set response is display out in **Figure 5**. When generator is sudden loaded with a symmetrical resistive loads across both sets at 1 sec, power transformation is started from both controller units towards connected resistive loads across both sets. Result of this, controller current decreases and load current increases. As generator speed (Nr) is also remain constant having minute fluctuations with applied load, it gives indication of a constant V and F during whole operation of machine in simulation. In this way, controller acts like voltage and frequency regulator and also sometimes can be used as load stabilizer.

First of all, i_a, i_b, i_c and i_x, i_y, i_z through both sets are calculated from d-and q-axis currents of machine[15]. From calculated per phase line currents, 3Φ line voltages V_a, V_b, V_c and V_x, V_y, V_z are also calculated from Equation (14).

Then, proportional and integral gain constant i.e. G_{pac1}, G_{iac1}; G_{pac2}, G_{iac2}; G_{pdc1}, G_{idc1}; G_{pdc2}, G_{idc2} of both similar controllers across set I and II, were set on with its tuned values during analysis.

Final tuned values are chosen like that given below:

AC voltage PI gain: G_{pac1} / G_{pac2} = 325; G_{iac1} / G_{iac2} = 40;

DC voltage PI gain: G_{pdc1} / G_{pdc2} = 0.01; G_{idc1} / G_{idc2} = 0.001;

After tuning of both V and F controllers, simulation of whole constructed Simulink model of SP-SEIG along with each 3Φ set controller is performed using Matlab platform with total simulation period of 2 Sec.

Finally, simulated (or analytical) values of generator performance variables with time are illustrated in **Figure 5**.

Appropriate values of different parameters

Controller Parameters.

DC bus voltages of CC-VSI inverters The DC bus voltages 'V_{d1} and V_{d2}' are instantaneous values and can be defined as:

$$V_{d1} = V_{d2} = \sqrt{\frac{2}{3}} \times \left(\frac{2 \times V_{rated}}{m_i} \right);$$

Where, V_{rated} = rated AC line voltage (415).

m_i = modulation index = 1;

Then, V_{d1} = V_{d2} = 677.69 volt, but after safety consideration V_{d1} = V_{d2} = 750 volt;

DC bus capacitors of CC-VSI inverters The choice of DC bus capacitances 'Cd1 and C_{d2}' depend upon the values of voltage drops in DC bus voltages 'Vd1 and V_{d2}' during application and removal of loads across both 3Φ winding sets.

By energy conservation principle as explained in[11]

$$\frac{1}{2} \times C_{d2} \times \left\{ V_{d2}^{2} - V_{d2}^{*2} \right\} = 3 \times V_{rated} \times I_{rated} \times Tc;$$

$$\frac{1}{2} \times C_{d1} \times \left\{ V_{d1}^{2} - V_{d1}^{*2} \right\} = 3 \times V_{rated} \times I_{rated} \times Tc;$$

So, the calculated values of C_{d1} and C_{d2} are about 120µF.

Where, V_{rated} = rated AC line voltage (415 volts), I_{rated} = rated AC line current (2.9 amps) and Tc = assume conservation time (848 µs) and V^{*}_{d1} = V^{*}_{d2} = percentage drop in DC bus voltages V_{d1} and V_{d2} (e.g. 1 % drop in 750 volt) = about 742 volt;

Chopper dump resistances (R_{d1} and R_{d2}) The values of DC dump resistances depend upon rated power 'P_{rated}' of SP-SEIG and DC bus voltages 'V_{d1} and V_{d2}' of CC-VSI.

So, $$R_{d1} = V_{d1}^{2} / P_{rated};$$

$$R_{d2} = V_{d2}^{2} / P_{rated};$$

The calculated values of dump resistances 'R_{d1} and R_{d2}' in similar controllers across both sets are 511 Ω. Where, P_{rated} = 1100 Watt.

A.C. filter resistance (R_f) and inductance (L_f) The output A.C. filters of CC-VSI inverters are comprised of R_f and L_f. The detail selection on filter choke resistance and inductance are mentioned in[12]. The selected values of R_f and L_f are 1.45 Ω and 2.2 mH.

In-phase reference source currents (i´rd) The magnitude of in-phase reference source current 'i´rd' is constant and equal to rated value of active power component of machine current:

$$i'_{rd1} = \sqrt{\frac{2}{3}} \times \left(\frac{P_{rated}}{V_{rated}} \right); \quad i'_{rd2} = \sqrt{\frac{2}{3}} \times \left(\frac{P_{rated}}{V_{rated}} \right);$$

So, for rated power (P_{rated} =1100 Watt), the in-phase reference source currents in similar controllers across both sets are $i'_{rd1} = i'_{rd2}$ =2.16 A.

SEIG and Load Parameters. For simulation purpose, a 1.1-kW squirrel cage induction machine, whose data are taken from[15], are used in whole analysis of computer-based simulation of V and F controller-SP-SEIG. The balanced per phase equal static resistive loads are considered for the validity of analytical approach during simulation work.

6. Discussion

Besides the outstanding and beneficial features of SEIG, however, it also has two prominent and handicap milestone. First is need of reactive power during short circuits and second is poor voltage regulation during isolated mode /capacitor excitation of IGs. On faults, IG's dynamic behaviour deserves special attention. Due to abrupt reduction in torque during short circuits, IG's speed may accelerate to higher extent which leads to terminal voltage collapses due to increase in reactive power of IGs. Simplified and economical volt and hertz controller keeps the value of terminal voltage and generated frequency remains constant (so that machine output power is also almost uniform). It avoids variations in delivered machine output power by keeping constant terminal voltage and system frequency in adjustable speed application of induction generators like pumps & fans, heat pumps & air conditioner, machine tools & robotics, wind generation system etc. Both balanced and /or unbalanced per phase equal and /or unequal static and dynamic loads can be considered in future during performance study of V and F controller-SP-SEIG.

7. Conclusion

The aim of this research article is to present a short description on modelling, controller design and simulation work by using Matlab-Simulink software program for a V and F controller-SP-SEIG at sudden resistive load. In any isolated induction generator, voltage and frequency (V and F) regulation at varying speed and load is necessary to maintain the output power remains constant. The behaviour of V and F controller seems mark able in its operation during variations in loads. The DC chopper keeps generated power remains constant in controller circuits of SP-SEIG. So, V and F controller of SP-SEIG generates constant voltage and frequency by keeping generator output power, as it is, during operation of machine system. Similarly, one can also say, V and F controller unit of SP-SEIG can behave like multi-purpose controller i.e. as voltage regulator, frequency regulator and also as a consumer power regulator /load stabilizer as per prediction from depicted transient behaviour of resistively loaded V and F controller-SP-SEIG unit.

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