ANALYSIS OF THE POSSIBLE USE OF AN INDUCTION GENERATOR IN ISOLATED OPERATION IN RURAL AREA USING THE PRINCIPLES OF ELC TO MAINTAIN STABLE OPERATION

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Abstract: - In independent sustainable power frameworks, the power balance techniques should exist to match the produced power and burden interest; in any case the overabundance power makes the aggravation as far as voltage and recurrence changes. This paper presents a plan and recreation of an electronic burden regulator (ELC) for the power balance in consistent power central player coupled three stage self-energized enlistment generator (SEIG) framework. A current sensor based ELC is planned so that to work the generator unit consistently at its full limit by organizing between the two burden frameworks named as primary and dump load. The regulator unit has an uncontrolled 3-stage full-span rectifier circuit, a sensibly controlled offended door bipolar semiconductor (IGBT) chopper switch, and a current sensor. The current sensor gives the criticism sign to the door trigger circuit of IGBT and which unavoidably controls the ON/OFF position of the switch. The ON state of switch implies a fractional or full part of age power is redirected to the landfill load, and the amount of the two burdens is equivalent to the evaluated limit of SEIG. The proposed framework is mimicked in MATLAB, and the power offset is accomplished with assistance of ELC. The voltage guideline of SEIG is tended to by adding extra responsive power (VAR) pay. Further, in this review, the essential setup of SEIG and the significance of self-excitation peculiarities for voltage age are additionally featured.

Keywords:- Constant power prime-mover, self-excited induction generator (SEIG), electronic load controller (ELC), current-sensor, power balance.

1. INTRODUCTION

To lessen the gigantic measure of ozone depleting substance discharges from the huge scope customary coal and oil-based power age units, little/miniature reach dispersed power age frameworks are arisen in ongoing many years. In this unique circumstance, the power age utilizing environmentally friendly power sources (RES) like breeze, sun based, biomass and little hydro either in lattice or off-network mode is drawing a lot of consideration from both burden end-clients and providers because of many benefits [1]-[19]. The locally accessible RES-based frameworks are not just helpful in diminishes the worldwide temperature alteration issues, yet additionally simple to introduce in the scope of few Kilowatt (kW) to Megawatt (MW). It announced that the regular size of such small size age frameworks for independent applications goes from 1 to20 kW rating. Aside from the sun based, the leftover RE sources need the generator answer for convert the mechanical energy into electrical energy [14], [18], [25].

The choice of generator predominantly relies upon the kind of the accessible source, method of dissemination, i.e., framework or off-network, and rating of associated loads. In limited scope segregated (off-lattice) mode activity, where the heaps in sloping regions and country/far off areas, an enlistment generator (IG) is perhaps the most ideal decision among different generators. A portion of the upsides of IG are simple in activity, minimal expense, tough development of center and twisting, additionally reasonable for cruel climate, and brush-less plan [1]-[12], [15], [17], [22]-[50]. In framework associated activity, the necessary responsive power is provided by the actual matrix to produce the appraised voltage of IG, though on account of off-lattice mode, it ought to be given from the outside source. For the most part, pre-charged capacitors are utilized for such a reason. An appropriate rating of the capacitor bank is expected to interface across the stator terminals and kept up with the rotor speed over the simultaneous speed to produce the voltage; this peculiarity is called self-excitation [1]. The capacitor-based self-energized included IG is known as a self-excitation enlistment generator (SEIG). An exhaustive audit on possibilities of utilizations, arrangements and method of tasks, sorts of central players of acceptance generators for the organization of sustainable power source based limited scope power age frameworks is examined in [7]-[10].

The micro/pico-hydro source reservoirs provide constant power generation. The output power of the turbine depends on the height and discharge of the water reserved in the hydroelectric systems [14]-[20].

In the off-grid mode of operation, the total power generation should always consumed by the loads, where the battery storage not a part of the system. The demand at the load end varies time to time from minimum to maximum. In common practice, the isolated systems are designed for a pre-defined rating of loads, and they are equal or less than to the rated capacity of the generation [22]-[29].

The total system load depends on consumer demand and generation relies on source. If the source input powers constantly available, then power balance operation should take place in the system. Under the loading condition, if the load value is less than the generation, then the excess power

should be consumed by auxiliary or dump load to balance the power. A logical controller- based circuit called the electronic load controller (ELC) is used for power consumption purposes. The ELC mainly consists of i) an uncontrolled bridge rectifier for rectification of generated voltage, ii) a controllable DC- chopper switch, iii) a DC-link capacitor, and iv) a dump resistor. The dump resistor is designed in such a way that to withstand the rated power capacity of the system [25], [26].

Many researchers have reported the design and implementation of ELC with various controllers, such as analog, digital, microprocessor, micro controller, proportional (P), proportional and integral (PI), proportional and derivative (PD), proportional integral derivative (PID) and fuzzy logic controllers are reported in the literature to enhance the efficiency [23]-[50].

The electricity demand in isolated/rural areas is low compared to urban users. In the context of offgrid small-scale energy systems, a load power balancing unit is needed to match with the total generating power. In this work, a current sensor- based ELC is designed for a SEIG isolated load system. The input of SEIG is a micro/pico- hydro turbine and which is emulated by a constant power prime mover; hence the generated power is always persistent and maintained at rated value by connecting the suitable rating of minimum excitation capacitor (Cmin) bank and reactive power (VAR) compensation. In the proposed system , the voltage exception is not allowed from no-load to full-load condition, and only the variation of load current is taken as a feedback signal to logically turn-on the IGBT based DC chopper switch of current sensor based ELC. The voltage drop is compensated by adding the extra VAR to the SEIG. The role of the proposed ELC is to balance the power of the micro/pico hydro isolated system through power electronic based switch without any effect on the generating unit.
The schematic of the proposed SEIG system is discussed in section II. Operating principle and design aspects of current sensor based ELC is described in section
III. Results and discussions are given in section IV. Conclusion is given in section V.

2. SCHEMATICS OF PROPOSED SEIG SYSTEM

This section covers the schematics of the proposed SEIG system and self-excitation phenomena in SEIG.

2.1. Schematics of the proposed SEIG System with ELC:

The schematic diagram of the proposed 3-phase SEIG system with ELC is given in Fig 1. Here, the current sensor based ELC balances the system power between the generation unit, i.e., SEIG and power consumer units, i.e., load and dump load. The self-excitation phenomena of SEIG is given in the next sub-section, and the detailed working principle and design procedure of ELC is discussed in section III.

2.2. Self-excitation Phenomena of SEIG:

In SEIG, the phenomena of self-excitation play a vital role in voltage build-up across the generator terminals under the no-load condition. This is exploited due to continuous energy exchange between the electrical field of the capacitor and the magnetic field of the generator. For generating the rated voltage and frequency of SEIG in the load applications, the following two conditions should meet a) the rotor of the shaft of the machine rotate above the synchronous speed b) suitable rating of reactive power must be supplied to the generator through the external source for core magnetization; This phenomena is called capacitor excitation [1].
The value of stator resistance (Rs) is calculated from the DC test. The blocked rotor test is performed to calculate the leakage impedance. Air-gap voltage ratio (Vg/F) depends on magnetizing reactance (Xm) and the relation obtains from the synchronous impedance test [1]- [10]. The specification of the selected SEIG, equivalent circuit parametersts and value of minimum excitation capacitance (Cmin) are given in the Appendix 1. Under the no-load condition, the process of self-excitation

3. OPERATING PRINCIPLE AND DESIGN PROCEDURE OF PROPOSED CURRENT-BASED ELC

The proposed current sensor- based ELC operation of SEIG system is easy and economical as it requires one uncontrolled bridge rectifier and a DC chopper switch, and easy to practical implementation. Switch. The circuit diagram of the proposed ELC is shown in Fig 3.

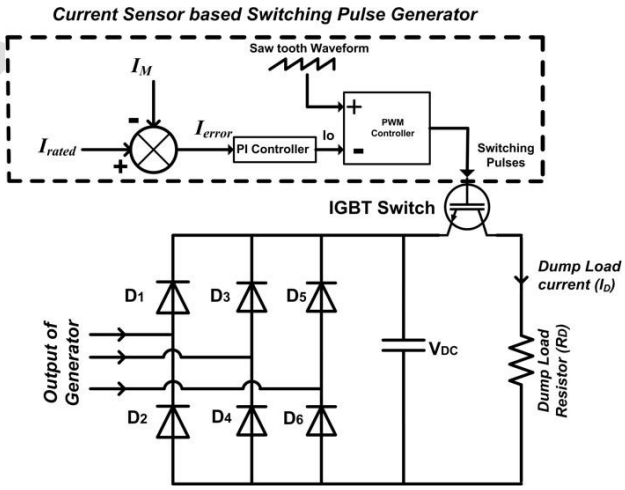


Fig. 3. Circuit diagram of the proposed current sensor-based ELC.

3.1. Operating Principle:

The logical ON or OFF of the IGBT switch depends on a simple logical function. If the actual main load current (IM) is less than the reference current (Irated) i.e., rated load current of SEIG, then the IGBT turn ON to divert the surplus generated power into the dump load. On the other hand, if the load current equal to the reference current, then the IGBT is in the OFF position, which does not allow the power into the dump load. The logic involved in the proposed current based-

ELC is represented by the following steps (1)-(11).

Step 1: Initialize Irated, IM, ID.
Step 2: Turn on: SEIG.
Step 3: Turn on: SEIG Main load. Step 4: while (1) /* infinite loop*/ Step 5: Read Irated, IM
Step 6: if (IM < Irated)
Step 7: Turn ON Dump load
Step 8: else-if (IM=Irated)
Step 9: Turn OFF Dump load Step 10: end-if
Step 11: end-while

3.2. Design Procedure:
It is noted that the main load current should be less or equal to the rated current of the SEIG. Rated current (Irated) of the SEIG is given by (1).

Irated = Prated/1.73*V = 1100/1.73*415 = 1. 53 Amps (1)

As shown in Fig 3, the functioning of the current sensor based switching pulse generator of the proposed ELC is uses the PI controller to generate the triggering pulses to the IGBT switch. The rated current is compared with the sensed current, i.e., main load current (IM) and the error current signal (Ierror) is given to the PI controller as a input and which can be written as (2). The output signal (Io) is written as (3) and which is compared with a saw tooth wave form and proceeded through pulse width modular (PWM) controller to generate the switching pulses to the IGBT [25]-[39]. In (3), kp and ki are the constants of proportional and integral, respectively.

Ierror = Irated - IM (2)
Io = kp. Ierror + ki ∫ Ierror dt (3)

The selection of the output voltage of 3-phase full diode bridge rectifier (Vrect) and dump load resistor (RD) is given by following equations (4) and (5), respectively.

Vrect = 1.35*VLL = 1.35*415 = 560 Volts (4)
RD = (Vrect)2/ Prated = (560)2/1100 = 285 Ohms (5)

4. SIMULATION RESULTS OF THE SEIG SYSTEM WITH PROPOSED CURRENT- SENSOR BASED ELC

In this section, MATLAB/Simulink based SEIG with the proposed ELC system is discussed. The performance of the system is verified by loading the SEIG up to rated current and maintained the power balance through the proposed current sensor- based ELC.

4.1 Voltage and Current profile of SEIG System under rated load
The simulation run time is 8 seconds. The voltage regulation of SEIG is compensated by adding the extra VAR. As shown in Fig. 4, to compensate the drop in the voltage, a total of 326 VAR compensation is added at the rated-load condition of simulation time of 6 - 8 secs to increase the RMS voltage from its 235 V to 305 V. The power quality improved voltage and the corresponding RMS current of SEIG is given in Fig 4 and 5, respectively.

In Fig 5, the simulation time 0-2 sec is the no-load, 2-3 and 3-5 are the with and without VAR compensation at 50% of load, and 5-6- and 6-8-seconds are the with and without VAR compensation at full load.

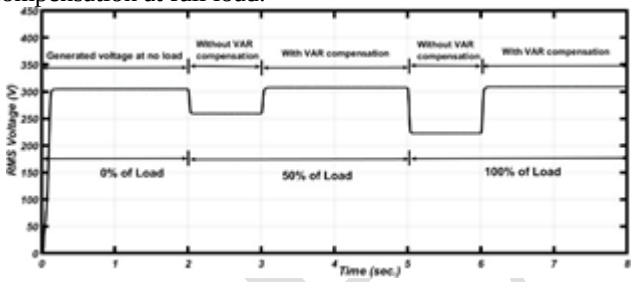
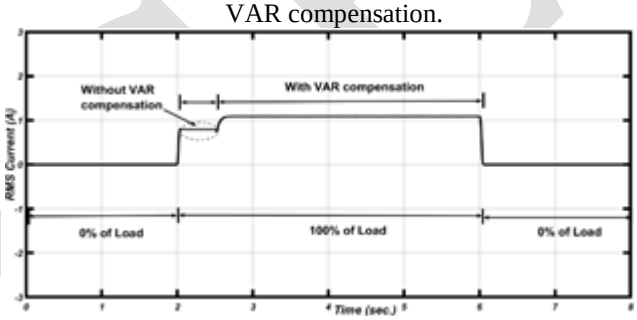


Fig. 4. Variation of RMS voltage according to the load and VAR compensation.



4.2 Load balancing through proposed Current Sensor- based ELC:
The load current balance in main and dump load of the SEIG system through the proposed current sensor based ELC is shown in Fig 6 and 7. The SEIG operation started with the 100% load up to 3 seconds of simulation. Under this condition, the main load draws the total current and hence the no current in the dump load. From 3-6 seconds, the rating of the main load has decreased to below the rated value, so the excess amount of current is diverted to the dump load. The proposed load current sensor- based ELC proved the concept of load power balance in the SEIG based micro isolated hydro system by employing the logical turn ON and turn OFF control of the IGBT DC chopper switch.

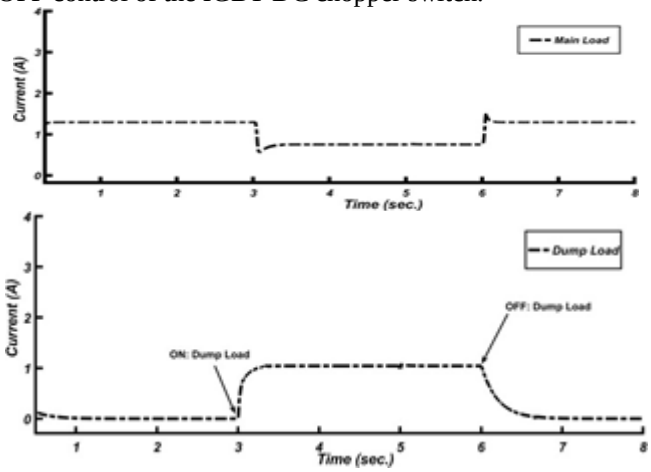


Fig. 7. Load balance of SEIG with proposed ELC: Dump load current.

5. CONCLUSION

In this paper, the plan and working methodology of the current sensor-based electronic burden regulator for power balance in a limited scale SEIG framework are talked about and mimicked in MATLAB. The power nature of the SEIG is improved by adding the VAR pay under the heap condition. By persistent detecting of burden esteem, the excess power can be used for the specific motivation behind warming applications. This arrangement is practical as it requires
just one sensibly worked IGBT switch and precise one for power balance in the arrangement of consistent power driven limited scope disengaged energy creating frameworks. For greater realibility, some other sustainable enerygy sources, as sunlight based and wind sources can be considered in the framework with the connection point of force converters.

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