As per UGC guidelines an electronic bar code is provided to seure your paper

International Journal for Modern Trends in Science and Technology, 7(09): 211-216, 2021

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0709034
Available online at: http://www.ijmtst.com/vol7issue09.html

Design Analysis on Transient, Steady-State and Fault Condition of the Grid connected Renewable Energy Systems and its Correction Techniques

R Sekar[1] | Suresh D S[2] | H Naganagouda[3]

[1]Research Scholar, Department of Electronics and Communication Engineering, Channabasaveshwara Institute of Technology, Gubbi, VTU-Belagavi, Karnataka- India.
[2]Professor, Department of Electronics and Communication Engineering, Channabasaveshwara Institute of Technology, Gubbi, VTU-Belagavi, Karnataka- India.
[3]Formar Director, National Training Centre for Solar Technology, Bangalore, Karnataka- India.

To Cite this Article
R Sekar, Suresh D S and H Naganagouda. Design Analysis on Transient, Steady-State and Fault Condition of the Grid connected Renewable Energy Systems and its Correction Techniques . *International Journal for Modern Trends in Science and Technology* 2021, *7* pp. 211-216. https://doi.org/10.46501/IJMTST0709034

Article Info
Received: 27 August 2021; Accepted: 17 September 2021; Published: 20 September 2021

ABSTRACT

In the recent years, using the existing electrical resources to meet the electrical power demand is a challenging one. To address the issues, an alternative energy resources are bringing together to support the existing resources. And it is known that integrating the electrical resources together having lot more technical issues because of their unique features. So bringing them into the common platform and making them together is a wise solution. This paper also an attempt to address one of the issues on the electrical resources integration in the common DC bus structure. In the common bus, various loads with different ratings use to be connected and its recurrent changes such as ON and OFF are not in the control. Due to this the electrical stress in the common bus will increase. In order to minimize the variations a compensation mechanism must be used for avoiding the disturbance during transient, steady-state and fault conditions.

KEYWORDS: Power electronic converter, Integration of renewable energy resources, Transient condition, Steady-state condition, Multiple renewable energy resources etc.,

INTRODUCTION

In the fast growing renewable energy trend, the part of power electronic converter is very much essential to deliver the power to load. At present the renewable energy sources are migrating from stand- alone operating mode to energy resources integrating mode due to its greater advantages in performance and reliable power supply [1]. Further, the cost of the initial investment required for installing the renewable energy resources are also considerably decreased because of the good number of research outcomes are addressing the issues on performance enhancement in the renewable energy systems. This paper is highlighting one of the significant issues occurs in the renewable energy systems related to its performance improvement.

Due to the various reasons, the renewable energy resources are majorly contributing to the power demand along with the existing electrical resources. In this condition, the renewable energy resources need to be connected together to provide the power to the

electrical grid. In real time, captivating the power from the electrical resources to the load is a challenging assignment. Using the power electronic modules, the task can be achieved easily with the required efficiency.
As it is known that the renewable energy resources are completely depending on the environmental conditions and they supply the electrical power in the intermittent time intervals. Further, it is not uniform in all the time period, in this situation the continuous power delivery to the load is more challenging. By using the suitable power electronic module, the continuous power delivery to the load can be confirmed.
When all the renewable energy resources are connected with the grid, the several loads use to share the grid power. During the frequent changes occurring in the load side such as turn ON and OFF of the loads, the grid electrical parameters will vary severely in the frequent intervals. To compensate the recurrent changes, a suitable mechanism must be incorporated in the power electronic module along with its existing features.

2.OVERVIEW ON THE TRANSIENTS

When it comes to electrical signals, transients are the events over a short period of time that are always deemed undesirable and must be removed from the actual electrical input. In practice, during the electrical loads are turned ON and OFF on a regular basis, transients occur in a short period of time. The transients are depicted in detail in Fig. 1.1.

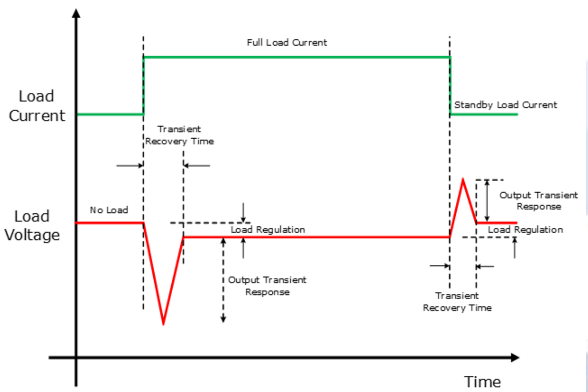

Fig.1.1. Load Voltage and Current variations during Load ON and OFF

The device linked to the sources is turned on, and the current increases up to the working value while the voltage across the device decreases with some disturbance is shown in Fig. 1.1. The elongation lasts for a specific amount of time, which is referred to as transient recovery time [2]. The magnitude is smaller than the prior valueeven after the settling time. The difference in value is referred to as load regulation, and it is determined by the load's complete current consumption.
The situation now is that the load is being turned OFF, and the current value is reducing fast while the voltage waveform is undergoing a shape change. The transient recovery time is defined as the time it takes for a rise in magnitude value to return to its normal value after a short period of time.
From the preceding considerations, it is clear that the changes in the electrical properties occur during transients in the common load bus. As a result, there is a disruption in the reliable power distribution to the loads connected to the common bus. A proper transient suppressing method must be integrated into the system to avoid the mentioned issue.
Transient Recovery Time: When the load is switched ON, which means the load/equipment is allowing current to flow through it, the voltage will dip with a spike due to the inrush current flowing through the load to its maximum, but once the load returns to its normal operating condition, the voltage will settle to the nominal value. The interval between a voltage drop and its settling to its operating value is referred to as transient recovery time. This transient recovery period must be as short as possible for a stable system; if it is longer, the situation is referred to as a fault.
Load regulation: The fluctuation in magnitude of the voltage between the nominal value and after the transient recovery period is known as load regulation. The value is entirely determined by the load that is connected for operation.
Output transient response: The output transient response is the difference between the maximum value of magnitude shoot up and the regular operating magnitude. This used to happen when current is being fed into the device for operation and then stopped to feed into the apparatus.
The other possible electrical correction approach to be described before considering the transient compensation components.
Steady-State: The primary purpose of integrating the sources are providing the continuous power supply to the loads connected with them [3]. There may be

situation to isolate the power resources such as during maintenance, abnormality etc. During the time, the power supply must not be interrupted to the load. To ensure the continuous power to the load, a backup source need to be implemented in the system. So, finding a suitable energy storage equipment for longer duration power delivery to the load must be identified.

Fault Condition: In this paper, the fault condition is relevant to the fault which occurs in the loads. In the common DC bus, there are numerous number of loads might be connected, in which any

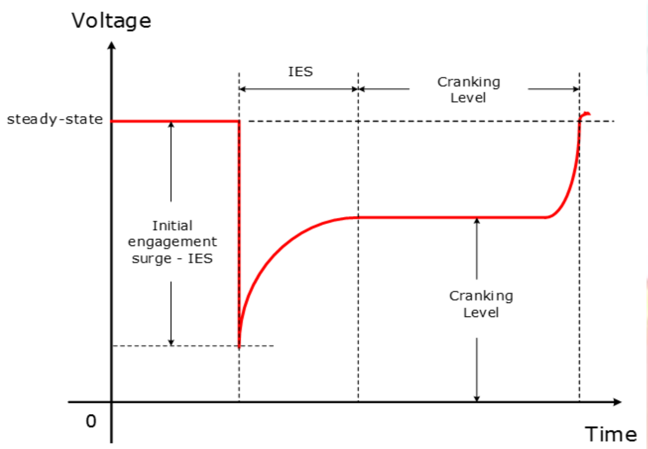

Fig. 1.2. Waveform on Reverse Recovery

one of the load goes under fault, the bus voltage will decrease due to the high current flow [5]. So, finding the suitable component for compensating is mandatory for stabilizing the situation.

The hybrid energy sources are coupled with possible power electronic blocks utilized for supplying DC power to the common bus, where a larger number of DC loads can be connected, as shown in figure 1.2

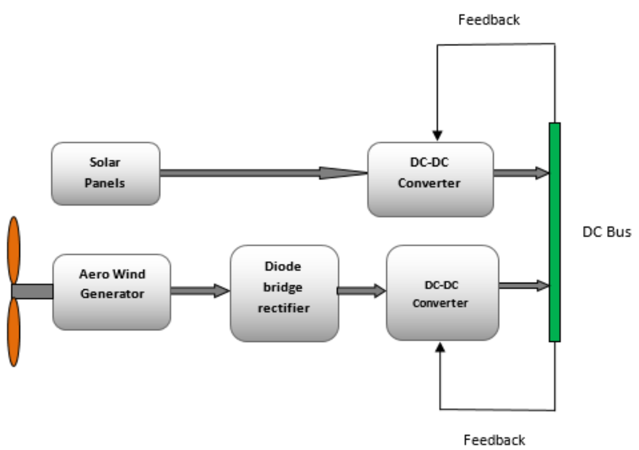

Fig.1.3. Schematic Diagram of Hybrid Renewable Energy Systems

The changes in the DC bus voltage are sensed using feedback in a load transient condition, and the necessary electrical corrections are made. Both DC-DC converters must have a proper controller/triggering circuit to accompany this condition [6]. If the correction time is off, the two sources will not stand in the common bus and the synchronization of the sources and with the common bus will be turned off instantly. This causes problems with power distribution to the load

The figure 1.3 terminologies are very important for taking up this study and developing an external circuit for transient waveform adjustments as a preliminary analysis. Additionally, there is a hint that attempting to change or modify the present value is not a good practice. Further, changing the current value in the load will put a lot of strain on the modulator circuits and related components. As a result, the only option is to compensate the voltage value in a short period of time. The below mentioned figure 1.3 will help in thorough examination

The voltage waveform on the load side in Fig. 1.3 starts with a steady-state working amplitude and continues for some time. During the instant when the electrical device allows current to flow through it, i.e. when it is switched ON, the current value in the bus rapidly increases, and the grid voltage drops with a deeper spike known as Initial Engagement Surge (IES).

The IES magnitude is determined by the load current drawn by the device at the time of start-up. The magnitude of the waveform then gradually decreases from the magnitude of the IES value to time IES (which used to happen extremely occasionally), then to the nominal level, and finally to the pre-steady-state level known as the cranking level [8].

The duration of the cranking level is determined by the source voltage and current rating. Later, with uncertain dampening, the turning from cranking level to steady-state value achieves. During the time equipment (with or without load) has reached/completed 95% of its transient (starting) duration [9]. Even though the transients occur in a very short time, the grid contains many loads of various ratings, and the simultaneous switching ON and OFF of the loads causes the grid/bus voltage to vary tremendously, which is affecting the equipment connected to the DC grid/bus and resulting in failure. The circumstance described above is that of turning on a load connected to the grid. The identical transient event will occur when the load is turned off. Overall, the load side frequent variations in electrical properties must be dealt with an appropriate external circuit.

3.IDENTIFICATION OF TRANSIENT AND STEADY-STATE CORRECTION COMPONENTS

The transients that occur in the DC grid/bus cannot be avoided, but they can be effectively controlled with the help of suitable components, as shown in the preceding paragraphs and figures, and this section focuses on the selection of suitable components for constructing the external transient correction circuit.

According to the study conducted on the supercapacitor and its behaviour/features, the supercapacitor will help in transients. The super capacitor's usefulness in transient operating situations will be demonstrated by the knowledge gained.

Supercapacitor: Supercapacitors also known as Ultracapacitors and are distinguished from other capacitors by their double-layered construction and ability to charge and discharge. This one-of-a-kind design allows the supercapacitor to charge and discharge multiple times in a short period of time with minimum loss. The supercapacitor having the capacity to store and release energy quickly across a larger number of cycles allows it to have a high power density, elevating it to a new level for battery substitution in certain applications [10].

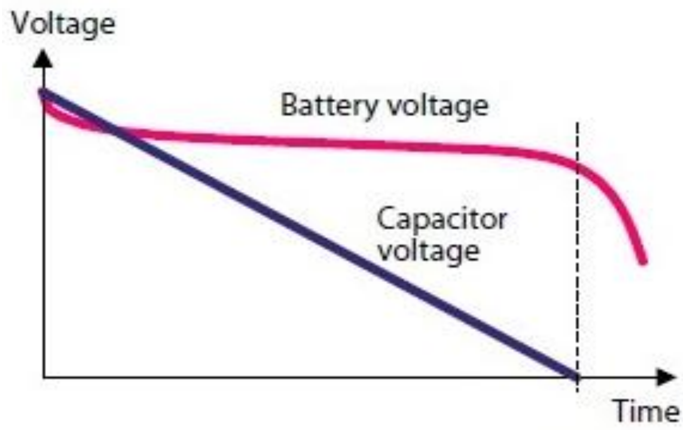

Fig. 1.4. The Discharge characteristics of Supercapacitor and Battery

The characteristics of batteries and supercapacitors are fit with each other for specific applications, in other words, the supercapacitors and batteries are complementing each other by linking series and parallel forms, which helps to extend the battery's life. The demand for peak power and a long discharge time are met by working together. Supercapacitors can be employed as a short-term power backup source due to their high-power density properties.

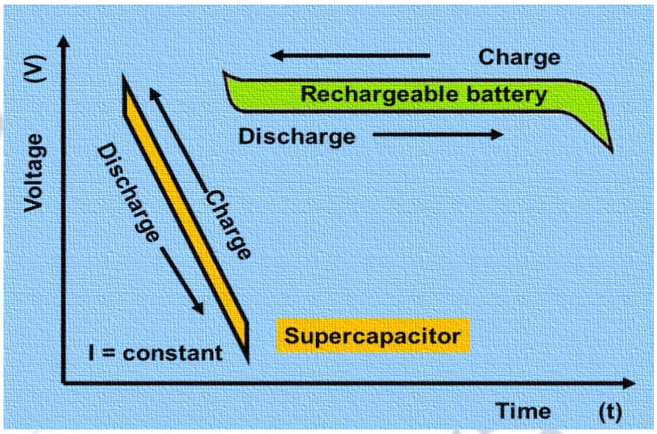

Fig. 1.5. Characteristic Curve of Battery and Supercapacitor

During the current is constant, the charging and discharging behavior of supercapacitors and batteries is depicted in figure 1.5. It is obvious from this that the supercapacitor has a fast charging time and a high power burst. This quick draining capability is ideal for transient voltage correction/compensation, and its quick charging capability allows the capacitor to prepare for the next repeated cycle activity. As a result, more reliable and steady power correction can be achieved. Finally, it is suggested that the supercapacitor can be used as a transient compensation component in the power circuit.

Battery: Through the study carried out on the steady-state scenario along with Fig. 1.5, the battery characteristics are very much significant in charging and discharging. The solid steady state charging and discharging feature with high power density helps the battery as a backup source for the required conditions [7].

Further, the complementary characteristics of both supercapacitors and battery substantiate to select the storage components required during transient and steady state compensation in the work. The suitable rating selection is another important task for all the back-up components.

It is understood that elongation of the transient time leads to fault condition. During the time, the current value will increase drastically and the voltage across the equipments will go down. To stabilize the electrical parameter changes, the supercapacitor and battery will come into action.

4. DESIGN CONSIDERATION OF THE SUPERCAPACITOR AND BATTERY

As it is well known the electrical and electronic components come in a wide variety of ratings in specified/standard values. Because renewable energy sources generate variable output and the components engaged in the system must match with the changes occurring continuously, completing the rating of individual components in accordance with the given standard value is a key task. As a result, the supercapacitors and batteries utilised in this work can be identified with the standard value. The following talks will be helpful in determining the system's supercapacitor and battery ratings.

Let us assume the following,

The power rating of the Solar Panel is 500W

The wind turbine power rating is 500W

Available Battery voltage ratings are 12/24/48 V

Supercapacitor ratings preferred for the work: 2.7V, 100f

Total stored energy is,

$$\frac{1}{2}\ C\ V^2$$

$$\frac{1}{2} X\ 100\ X\ 2.7^2$$

$$364.5\ \text{Joules}$$

To convert into watts,

$$\frac{364.5}{3600}$$

$$0.10125W\ |\ hr$$

It shows that 0.10125 watts of power can be drawn from the supercapacitor about an hour.

The array of ten supercapacitors produced a total voltage of 27V.

The total energy stored can then be estimated as follows:

$$\frac{1}{2} X\ 100\ X\ 27^2$$

$$36450\ \text{Joules}$$

$$\frac{36450}{3600}$$

$$10.125W\ |\ hr$$

$$607.5W\ |\ min$$

$$\mathbf{36,450W\ |\ sec}$$

An array of ten supercapacitors can clearly withstand a load of 36450W for around a second.

The discharge time of a supercapacitor varies from 2 to 5 seconds in general. As a result, the above-mentioned power

$$\mathbf{7,290W\ |\ 5sec}$$

In order to finalise the battery rating, the voltage magnitude that required to appear in the load side must be discussed. Due to the ease with which boost mode operation can be handled, the voltage rating of the battery required to integrate in the power circuit is reduced to almost nothing.

5. CONCLUSION

The suppression of transients that occur in the DC bus as a result of variable load activities is thoroughly explored in this study. The actual characteristics of the supercapacitor and battery are discussed in detail to finalize and decide the transient correction components. The transient on the load side are addressed, along with the waveforms. In addition, the Supercapacitor and Battery design considerations are covered in depth. By demonstrating the design values of the supercapacitor and battery mentioned above, it is clearly stated that during the transients, the supercapacitors must engage the load and during the steady-state conditions, the battery with boosted operation will come into action

REFERENCES

[1] Masathoshi Uno, Rina Oyama and Kazuki Sugiyama, "Partially isolated Single-Magnetic Multiport converter based on integration of series resonant converter and bidirectional PWM converter", IEEE Tran. Power Electron., Vol.33, No.11, November 2018.

[2] Junbiao Han, SarikaKhushalani Solanki and Jignesh Solanki, "Coordinated Predictive Control of a Wind / Battery Microgrid System", IEEE Journal of Emerging and selected topics in Power Electronics, Vol.1, No.4, pp.296-305, Dec. 2013

[3] Hongyu Zhu, Donglai Zhang, Hussain S. Athab, Bin Wu, and Yu Gu, "PV Isolated Three-Port Converter and Energy Balancing Control Method for PV-Battery Power Supply Applications", IEEE Trans. Ind. Electron, Vol.62, No. 6, pp. 3595 – 3606, June 2015

[4] Xiaofeng Sun, Yanfeng Shen, Wuying Li and Hongfei Wu, "A PWM and PFM Hybrid Modulated Three-Port Converter for a Standalone PV/Battery Power System", IEEE Journal of Emerging and selected topics in Power Electronics, Vol.3, No.4, pp. 984 - 1000, April 2015

[5] DipankarDebnath, and Kishore Chatterjee, "A Two Stage Solar Photovoltaic Based Stand-Alone Scheme Having Battery as Energy Storage Element for Rural Deployment", IEEE Transactions on Industrial Electronics, DOI: 10.1109/TIE.2014.2379584, Oct. 2014

[6] Hongrae Kim, BabakParkhideh, Tim D. Bongers and Heng Gao, "Reconfigurable Solar Converter: A Single-Stage Power Conversion PV-Battery System", IEEE Tran. Power Electron, Vol. 28, No.8, pp. 3788 - 3797, Aug. 2013

[7] FarzamNejabatkhah, Saeed Danyali, Seyed Hossein Hosseini, Mehran Sabahi and SeyedabdolkhaleghMozaffariNiapour, "Modeling and Control of a New Three-Input DC–DC Boost Converter for Hybrid PV/FC/Battery Power System", IEEE Tran. Power Electron, Vol.27, No5, pp. 2309 - 2324, May 2012

[8] Hongyu Zhu, Donglai Zhang, Bowen Zhang and Zhicheng Zhou, "A Non-isolated Three-Port DC–DC Converter and Three-Domain Control Method for PV-Battery Power Systems", IEEE Transactions on Industrial Electronics, Vol. 62,No.8, pp. 4937 - 4947 Aug. 2015

[9] Yen-Mo Chen, Alex Q. Huang and Xunwei Yu, "A High Step-Up Three-Port DC–DC Converter for Stand-Alone PV/Battery Power Systems", IEEE Tran. Power Electron, Vol.28, No. 11, pp. 5049 - 5062, Nov. 2013

[10] Kevin Tomas-Manez; Alexander Anthon; Zhe Zhang; Ziwei Ouyang; Toke Franke, "High efficiency non-isolated three port DC-DC converter for PV-battery systems", IEEE 8th International Power Electronics and Motion Control Conference (IPEMC-ECCE Asia), DOI: 10.1109/IPEMC.2016.7512568, July 2016