# State Estimation and Stabilization of an Unstable Islanded Grid Using Wireless Adaptive Sliding Mode Control

M Dhanapal and M Vijayakumar



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# State Estimation and Stabilization of an Unstable Islanded grid using Wireless Adaptive Sliding Mode Control

**M. Dhanapal[1], M. Vijayakumar[2]**

[1]Assistant Professor, Department of EEE, K. S. Rangasamy College of Technology,Tiruchengode, Tamil Nadu - 637 215, India. [2]PG Scholar, K. S. Rangasamy College of Technology, Tiruchengode, Tamil Nadu - 637 215, India. [1]dhanapalm@ksrct.ac.in [2]kkvijay96@gmail.com.

**Abstract-**The smart grid is expected to use the Internet of Things (IoT) network to reliably monitor its status remotely place. However, due to the potentially volatile nature of a SMART Grid plants, especially when using renewable energy sources, and an unreliable wireless channel used in IoT, it's a challenging function to track the status of smart grid reliably. This paper proposes a robust communication framework for state assessment/tracking. A volatile microgrid, which is a major component of a smart grid. We present an IoT integrated smart grid system for monitoring. The status of the microgrid on the wireless network a delay-universal based error correction codes are used to obtain a reliable and real-time estimation of the microgrid. To take advantage of the features of delay-universal coding scheme, we propose an iterative approximation Technique. By means of numerical results, we show that the proposed the plan can closely track the state of the unstable microgrid. We also show the effect of wireless network parameters assessment performance and estimated performance. This paper proposes an adaptive slide mode controller to learn the estimates given the phasor measurement units voltage and current measurements as inputs, with the intent of obtaining accurate and fast predictions during the evaluation phase. The proposed plan is compared with the estimated performance of a traditional error correction coding scheme. We show that the proposed scheme outperforms the conventional plan.

**Keywords: Smart Microgrids, Internet of Things (IoT), Energy Management, State Estimation, Renewable Energy Sources, Wireless Network.**

## I. INTRODUCTION

The future of our energy systems is based on the notion of smart grids, which will allow us to exactly match the energy we need to the generated energy through the connection and state monitoring of production and consumption assets via Internet of Things (IoT) networks. Over multiple applications domain in commercial, residential and industrial energy use. Efforts to achieve reliable and stable grid operation for these applications typically relay on real time state estimation of production and consumption assets over an IoT network. However, state estimation in smart grids is challenging because communication between components of the smart grid, such as the microgrid, and the grid management system is usually accomplished via a wireless link. Therefore, a proper estimation and communication scheme is a prerequisite that is robust in the presence of factors such as fading or noise, which introduce errors into the wireless channel. Significant efforts have been made towards state estimation of smart grids and various algorithms and tools have been proposed in the literature. State estimation techniques can generally be classified into two distinct classes:

(a) Centralized state estimation, where a central state estimation unit collects and processes all measurements from local sensors to obtain global estimates; and
(b) Distributed state estimation, where each local estimator calculates state information based on his individual measurement and forwards its estimate to a central state estimation unit.

In this paper, the proposed model operates on factor, which enables trivial inclusion and exclusion of any type of measurements on the power systems buses and branches, by removing or adding the corresponding nodes. The trained model is thoroughly tested in the various data scenarios which include communication errors in the delivery of isolated phasor data or failures of the complete phasor measurement units in which the power system is unobservable and the reports on the prediction qualities are presented. We present an adoptive communication frame work to track the state of unstable microgrid on IoT networks. For a real time and reliable tracking of the state of the microgrid, we use a delay universal coding scheme to minimize the errors generated by a wireless channels. We propose an iterative estimation technique to exploit some of the unique features of the delay universal codes and proposed estimation techniques the communication approach can closely track the state of an unstable microgrid. It also examine the effect of different parameters of the wireless channels on the estimation performance. The performance of the proposed scheme is compared with the traditional communication and assessment approach. The numerical results show that the proposed scheme significantly outperforms the traditional approach in terms of performance tracking.

## II. OBJECTIVES

The main objective of the paper is the state estimation for smartgrids over an unreliable wireless network. A wireless IoT network integrated communication. The unique features of the delayed universal coding scheme. It proposes a real time communication framework. An increasing power demand in the grid and various devices for the monitoring, analysis and control of the gird.

## III. PROPOSED SYSTEM

The core theme of the IoT concept is to connect devices to the Internet and monitor access those devices from anywhere and anytime. In recent years, IoT has attracted significant attention in the smart grid community as IoT can be a potential solution to monitor and control smart grids in real time. In particular, IoT can play an important role in monitoring or control of microgrids, which can be considering as a subset of smartgrids. The functional block diagram of general structure of an IoT enabled microgrid monitoring system is shown in Fig. 1.

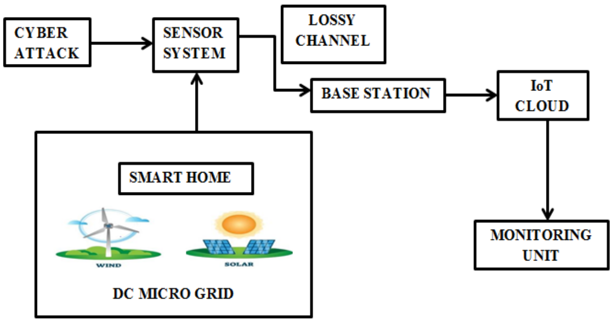


Fig. 1 shows the block diagram of monitoring a DC microgrid through an IoT network

This microgrid consists of a smart sensor system, which senses the status of the microgrid and transmits the sensing information to the power management or monitoring units. Since micrograds are usually located in the remote areas due to space requirements of wind or solar farms, the sensor system communicates with the energy management or monitoring unit via a wireless IoT network. Thus it is necessary to ensure real time or reliable wireless communication between the sensor system and the gateway. E.g. Base station or even satellite. Before presenting a robust communication (technical faults, natural disasters, signal disturbance) framework for an IoT enabled microgrid and dynamic state space model of a microgrid. Smart girds is expected to make use of internet of things networks to reliably monitor its state from remote places. This paper process real time communication framework for smartgrids and also show that the proposed scheme can closely track the state of unstable microgrid is shown in Fig. 2.

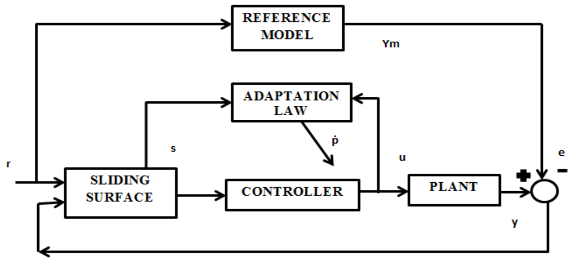


Fig. 2 shows the unstable microgrid

State space model of a DC microgrid in smartgrids

A DC microgrid, which is typically integrates multiple DC sources and DC loads, offers an advantage over an AC microgrid in terms of system size, cost and efficiency because it eliminates unnecessary energy conversion. In general DC microgrid consists of the following component.

- **Source:** The energy gets from nature (RES) is represented by an equivalent DC voltage source.
- **Filters:** A series of line filters are used to reduce the voltage/current harmonics and electromagnetic interferences.
- **Loads:** Motor is considered as DC loads along with the battery and R loads are generally used in DC micrograds.

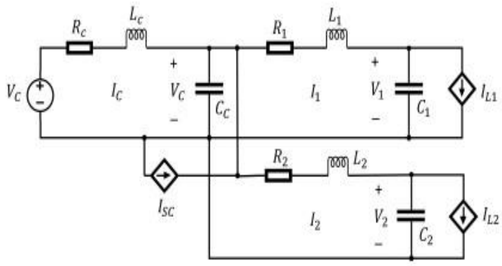

Fig. 3 shows the equivalent circuit diagram of a DC microgrid

Fig. 3 shows the equivalent circuit diagram of a DC microgrid, where R, L, C, I and V are the resistance, inductance, capacitance, current and voltage respectively. Whereas the subscripts c, 1, 2, sc, L1, L2 represent the component of converter, filter 1, filter 2, super capacitor, load 1, load 2 respectively. Fig. 3 the equations of the microgrid can be derived as followed by apply Kirchhoff's laws

$$\Delta I_c(k+1) = \frac{-R_C \Delta I_c(k) - \Delta V_c(k)}{L_C}$$

$$\Delta I_1(k+1) = \frac{-R_1 \Delta I_1(k) + \Delta V_c(k) - \Delta V_1(k)}{L_1}$$

$$\Delta I_2(k+1) = \frac{-R_2\Delta I_2(k) + \Delta V_c(k) - \Delta V_2(k)}{L_1}$$

$$\Delta V_C(k+1) = \frac{\Delta I_C(k) - \Delta I_1(k) - \Delta I_2(k) + \Delta I_{SC}(k)}{C_C}$$

$$\Delta V_1(k+1) = \frac{\Delta I_1(k) + \Delta I_{L1}(k)}{C_1}$$

$$\Delta V_2(k+1) = \frac{\Delta I_2(k) + \Delta I_{L2}(k)}{C_2}$$

Where Δ denotes the deviation of the system state variables around the operating points in the above equations. At any time step k, the above partial differential equations representing the microgrid can be written in the following discrete system dynamic form

$$X_{k+1} = AX_k + BU_k + w_k$$

Where

- w is bounded disturbance or noise with w=$\{w^-, w^+\}$
- A is discretized state matrix= I+αδt, δt= discretized step size.
- B is control distribution matrix= I+βδt
- X is the state of the microgrid defined by X = $[\Delta I_c\ \Delta I_1\ \Delta I_2\ \Delta V_c\ \Delta V_1\ \Delta V_2]$
- U is the control input defined by U =[ $\Delta I_{sc}\ \Delta I_{L1}\ \Delta I_{L2}$]

$$\beta = \begin{bmatrix} 0 & 0 & 0 & \frac{1}{C_C} & 0 & 0 \\ 0 & \frac{1}{C_1} & 0 & 0 & \frac{1}{C_1} & 0 \\ 0 & 0 & \frac{1}{C_2} & 0 & 0 & \frac{1}{C_2} \end{bmatrix}$$

$$\alpha = \begin{bmatrix} -\frac{R_C}{L_C} & 0 & 0 & -\frac{1}{L_C} & 0 & 0 \\ 0 & -\frac{R_1}{L_1} & 0 & \frac{1}{L_1} & -\frac{1}{L_1} & 0 \\ 0 & 0 & -\frac{R_2}{L_2} & \frac{1}{L_2} & 0 & -\frac{1}{L_2} \\ -\frac{1}{C_C} & -\frac{1}{C_C} & -\frac{1}{C_C} & 0 & 0 & 0 \\ 0 & \frac{1}{C_1} & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{C_2} & 0 & 0 & 0 \end{bmatrix}$$

We consider the control input u=0 for simplicity, main focus is to track of the microgrid rather than the control. With above specification of the microgrids are unstable$|A| > 1$ is shown in Table 1. Thus a high probability shows that the state of the microgrid will grow unbounded with progression of time. A finite rate communication link is not sufficient to encode and transmit asynchronous rate. Thanks to bounded noise, we can estimate the state by knowing the noise provided that the initial state is known. In this section, we present the communication approach to transmit bounded noise and estimate it based on the observed bounded noise at the receiver.

Table 1 shows the specification of state space parameters

| Parameters | Description | Values |
|---|---|---|
| $R_1$ | Resistance of filter 1 | 0.8 Ω |
| $R_2$ | Resistance of filter 2 | 0.42 Ω |
| $R_C$ | Resistance of converter | 0.4 Ω |
| $L_1$ | Inductance of filter 1 | 20 x $10^{-3}$ $H$ |
| $L_2$ | Inductance of filter 2 | 19.6 x $10^{-3}$ $H$ |
| $L_C$ | Inductance of converter | 17.3 x $10^{-3}$ $H$ |
| $C_1$ | Capacitance of filter 1 | 200 x $10^{-6}$ $F$ |
| $C_2$ | Capacitance of filter 2 | 1050 x $10^{-6}$ $F$ |
| $C_C$ | Capacitance of converter | 1050 x $10^{-6}$ $F$ |

## IV. PROTETUS EXPERIMENTAL SETUP

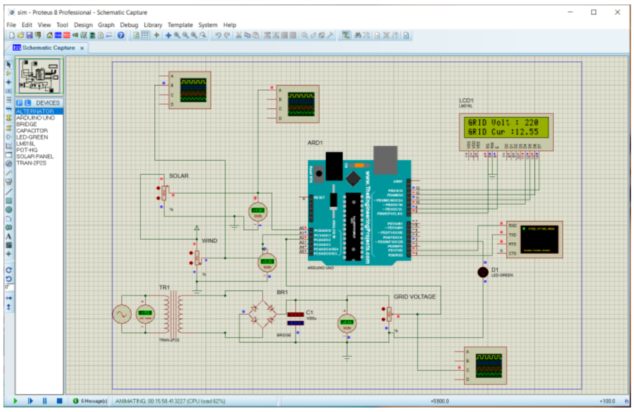


Fig. 4 shows the circuit diagram of monitoring a DC microgrid through an IoT network

A microgrid can be remotely monitored by taking advantage of a wireless communication technology. Due to the uncertainty in wireless networks an adaptive slide mode control communication framework is needed to deal with error handling induced by a wireless channel. In the proposed communication framework is needed to deal with error handling induced by a wireless network. Due to the volatile nature of the microgrid it is not possible to quantify and encode the actual state of the microgrid. The process is noise bound we quantify, encode and transmit the bounded noise rather than the actual state. Fig. 4 shows that the circuit diagram of monitoring a DC microgrid through an IoT Network.

### A. Solar Setup

A solar panel is a set of solar PV modules that are electrically connected and mounted on a supporting structure and module is packed, connected assembly of solar cells is shown in Fig. 5. It can be used a large PV system to generate and supply electricity in residential and commercial applications and so on. The specification of the solar PV Cell is shown in Table 1.

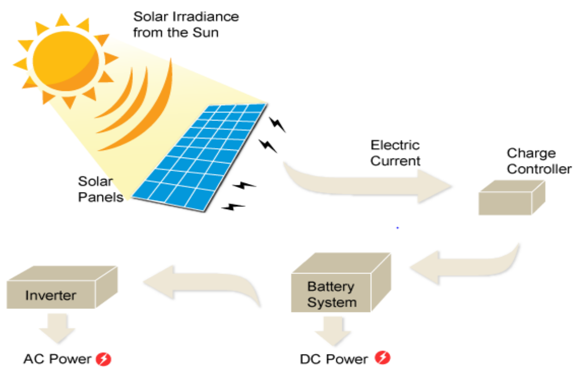


Fig.5 shows the solar energy setup

Table 2 shows specification of the solar PV cell

| | |
|---|---|
| Power | 15 W |
| Operating Voltage | 17.6 V |
| Operating Current | 0.82 A |
| Short Circuit Current | 3.65 |
| Weight | 1.5 Kg |
| Dimensions | 12 x 15 x 1 in. |
| Frame material | Al with plastic edge caps |

The step by step process of the PV effect is generation of the charge carriers due to absorption; separation and collection of photons in the materials form a junction. The working principle of solar cells is essentially the same and it based on the PV effect. The photovoltaic effect refers to the generation of a potential difference at the junction of two different materials in response to visible or other radiations.

### B. Wind Setup

There are two basic types of wind turbines: One with a horizontal axis and another with vertical axis is shown in Table 3.

Table 3 shows the types of wind turbines

| Types of wind turbines | HAWT | VAWT |
|---|---|---|
| Lift Type |  |  |
| Drag Type |  |  |

Most wind turbines have a horizontal axis: a propeller-style design with blades that rotate around a horizontal axis. Horizontal axis turbines are either upwind (wind hits the blades before the tower) or downwind (wind hits the tower before the blades). Upwind turbines also includes a yaw drive and motor components that rotate the nacelle to make the rotor face the wind when its direction changes. While there are many manufactures of vertical axis wind turbines they have not entered the utility scale market (above 100kW) to same degree as horizontal axis turbines. A vertical axis turbine comes in two main designs: Drag based or savonius turbines typically have solid vane rotors that rotate about a vertical axis. Lift based or Darius turbines have a long vertical airfoil style. The windspire is a type of lift based turbine is a type of lift based turbine that being independently tested at the national center for wind technology at the national renewable energy laboratory.

## V. PROTETUS OUTPUT ANALYSIS

In this section using the training model which is used adaptive slide mode control and access the prediction quality of the trained model in various test scenarios. Training, validation and test sets are determined of the system described various measurements samples. The Fig.6a – 6c show the which one is on state can be determined in digital oscilloscope.

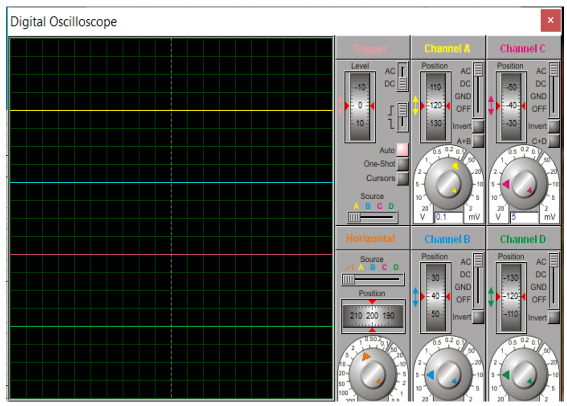


Fig. 6a shows the energy gets from microgrid

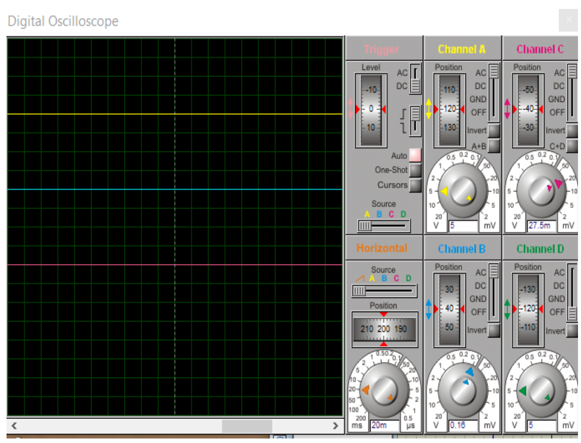


Fig. 6b shows the energy gets from solar energy

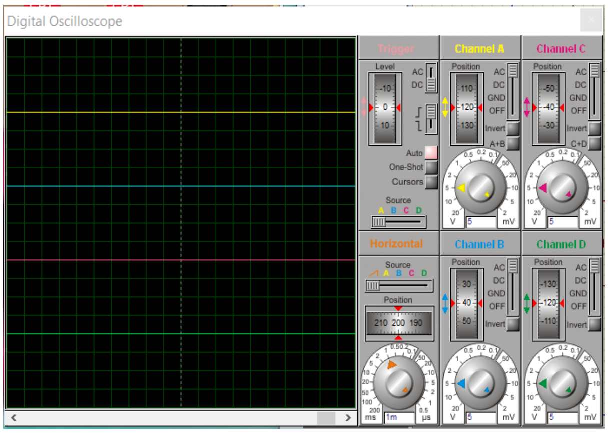


Fig. 6b shows the energy gets from wind energy

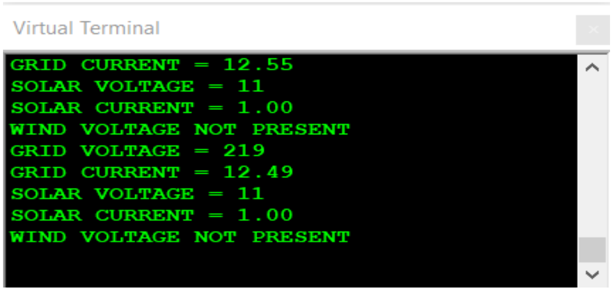


Fig. 7 shows the numerical output

The evaluation of proposed system communication performance frameworks by tracking the state of the microgrid. The state space parameters used in simulation and used chosen from experimental setup. The discretized step size δt is set to 0.002 sec is shown in Fig. 7.

## VI. CONCLUSION

In this work, we have studied the state estimation of smart grids over an unreliable wireless network. A wireless IoT network unified communications framework has been introduced to monitor the status of an unstable microgrid that is an essential part of a smart grid. To reduce the error induced by the wireless channel, we have proposed a delay universal coding scheme in the communication framework. An estimation of the system approach is proposed to exploit the unique features of the delay universal coding scheme. Through numerical results, we have shown that the proposed communication scheme (with the proposed estimation technique) is capable of closely monitoring the state of any unstable microgrid. We have numerically evaluated the effect of wireless network parameters on the tracking performance. We have also compared the performance of the proposed scheme with the performance of the traditional block coding scheme. We have shown that the conventional approach is not sufficient to track unstable micro grids and the proposed scheme far outperforms the conventional approach in terms of tracking performance.

## REFERENCES


[1] Md Noor A Rahim, Mohammad Omar Khyam, Aman Maung, " Robust and Real Time State estimation of Unstable Microgrids over IoT networks", @IEEE System journal, 15(2), Article number:91126752176-2185.

[2] N.Sivaramakrishna, Ch.kasi Ramakrishna Reddy, "Hybrid Power Generation through Combined Solar Wind Power and Modified Solar Panel", IJETT-Volume 4, Issue 5, May-2013, ISSN 2231-5381.

[3] Bharat Raj, Ba Krishna Dubey, "Solar-Wind Hybrid Power Generation System", IRJET, volume 05, Issue 01, Jan 2018.

[4] Sandeep Kumar, Vijay Kumar Garg, "A Hybrid Model of Solar-Wind Power Generation System", IJAREEIE, Volume 02, Issue 08, Aug 2013.

[5] Yasir Saleem, Noel Crespi, Mubashir Husain Rehmani and Rebecca Copeland, "Internet of Things-Aided Smart Grid: Technologies, Architectures, Applications, Prototypes, Future Research Directions", 2019 IEEE ACCESS.

[6] M. M. Rana, W. Xiang, "Smart grid State Estimation and Stabilization", J. Electrical Power Energy Syst., vol. 102, pp. 152–159, Nov. 2018.

[7] M. Noor-A-Rahim, M. Khyam, X. Li, "Sensor fusion and State estimation of IoT enabled wind energy conversion system," Sensors, vol. 19, no. 7, p. 1566, Apr. 2019.

[8] A. Minot, Y. M. Lu, "A Distributed gauss-newton method for power system state estimation", IEEE transactions on power system, Vol. 31, no.1, pp. 3804-3815, 2015.

[9] A. K. Singh, R. Singh, "Stability analysis of networked control in smart grids", IEEE Transactions on Smart Grid, Vol. 6, no. 1, pp. 381-390, 2014.

[10] M. Karbalaye Zadeh, R. Gavagsaz – Ghoachani, "Stability Analysis and Dynamic Performance formance Evaluation of a Power Electronics Based DC distribution System with Active Stabilizer", IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 4, no. 1, pp. 93 – 102, Mar 2016.