# Performance Improvement of Inverter Based Microgrid

[1]Hetal A Chaudhari, [2]Dr. Akshay A Pandya,

[1]PG Student Electrical Engineering Department, Birla Vishvakarma Mahavidhyalaya Anand-388120, [2]Associate Professor, Electrical Engineering Department, Birla Vishvakarma Mahavidhyalaya Anand-388120

*Abstract:* This paper proposes techniques called “estimated droop control” for control of inverter. With different droop gain and different line impedance the conventional droop control method encounters some problems. We have designed simulation circuit of droop control strategy for microgrid. Operation of microgrid with same line impedance and different line impedance is performed using MATLAB/Simulink. Using online estimation Inverters are automatically estimates their droop values according to its output power so, inverters are not using the communication link, as the inverters are independent from each other’s and using their own estimated values, which improves their performance and also the system becomes more reliable.

## I. INTRODUCTION

Recently, our power system faces the problems of increased energy demand, limitations of loads during peak hour losses during transmission and distribution emissions of coverage caused by pollution etc. In order to reduce this we have introduced DISTRIBUTED GENERATION (DG) system. Which are based on renewable energy sources for examples solar power, wind energy, small hydro etc. We arranged all these as all are operated in one system for optimum utilization that is called microgrid.
Gathering of interconnected loads and DISTRIBUTED ENERGY SUORCE (DES) known as microgrid. These DGs can operated as single source act as islanded mode and also enable to interface with grid. A bunch of loads and micro sources working as an independent controllable framework that provides both power and heat to its neighborhood is expected with the idea of microgrid.

In non-communication all units are independent and responsible for their individual control of frequency and voltage. Hence this increases the reliability of system. In microgrid this advantage motivate to use the droop control for DG units. Still this technique is the not perfect it needs some improvements. Drawbacks of the technique are: (1) frequency and voltage of DG units may drop to a lower level values different from the nominal values due to droop characteristics. (2) Different line impedance results when there is large distance between the DG units. Which causes difference in voltage and frequency beyond a certain range. Which results into unsynchronization of DG units.
This project work address this above mentioned two issues, so every unit’s voltage and frequency remains at/around nominal references
Also we are operating microgrid with almost same amplitude and frequency in order to keep the synchronization.

## II. MODELING OF MICROGRID

With unstable output power DG units are not suitable to connect with the main distribution system. The best solution to this problem is microgrid which consists of multiple DG units to provide electrical power in the local domain. On the safety and performance of main utility grid. Microgrid minimize the impact of DG units. Which enable system to shutdown in causes of any fault limited number of DG units can be connected to the utility grid before microgrid, after introducing microgrid; we are able to connect large number of DG units easily although microgrid carry small scale power but it still faces some problems like:

1. An inverters dominated microgrid does not have inertia like conventional power system generator hence it is very sensitive towards disturbance, Variation in loads, interconnection of inverters/network and power sharing can act as disturbance in MG [2]
2. Microgrid experience circulating current because of it has limited capability to handle overload situations and MG can easily get unstable [2]
3. Good power sharing mechanism among different units of microgrid is challenging task.[2]

As a solution firstly we can use communication links to share information between each units this solution is not costly but reliability of the system is affected
Also this kind of solution not practical in remote areas where there is large distance between different DG units ,so to have non communication based power sharing mechanism is best in suitable in MG

## III. CONTROL TECHNIQUE FOR PARALLEL CONNECTED INVERTERS

As an interface between the main utility grid and RES inverters are being used

They are used to process the output power controllable voltage magnitude and frequency. After processing, this output power is fed into microgrid. Which are operating in synchronized mode with main grid of in isolated mode .This can be possible when this inverters are connect in parallel to each other.

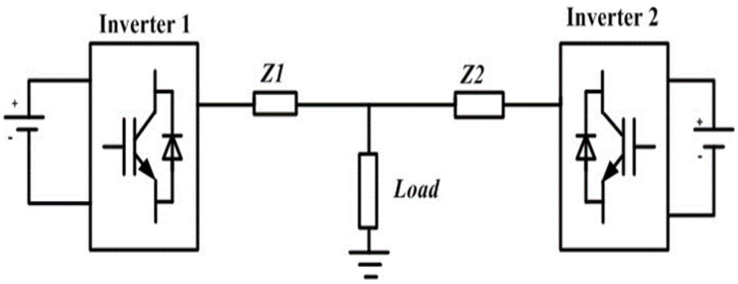



Fig1. Two parallel connected inverters

As shown in figure 1 with tracking of sine wave voltage single. This parallel operated inverter have possibility to upgrade the whole system without any reconfiguration. The parallel operated inverter can also increase the reliability and redundancy of a system different control techniques have been developed by researches for to operate inverter in parallel.

This technique are:

(1) Master slave control: In this technique, one inverter is a master and other are act as slaves to master inverter .Main inverter operates in a Current controlled mode.

The reliability and redundancy of the system will reduce in this scheme as the whole system depends on master inverter any fault in master inverter can stop the operation of whole system [4]Also it needs high bandwidth communicating to share information between the main and other DGS which will increase the cost of system. Solution to this problems are like a Rendon selection of master, on the failure of previous master automatic selection of new master with maximum power rating [1].

(2)Instantaneous current sharing control:

All inverters in centralized control technique , are share information about The current shared between then This is multiple input multiple output (MIMO) System as it gives and receives information from more than one inverter to meet the Requirement of accurate current Sharing there are several schemes. One of them is to detect an Unstable current to minimize active and reactive component of this detected current it needs to regulate voltage and frequency [3].

(3)Voltage and frequency droops control:

This is non communication based control which requires No communication links between inverter. A simple micro controller can be used to perform the task and this technique requires very less computational facilities. This is the advantage of this technique it will Increase the reliability and also reduce the cost of system from the conventional synchronous generator Power system the idea of a droop control in inverter grid comes. In conventional power system by regulating the angle difference between the voltage phases Of two AC machines and magnitude difference between two voltage respectively power system Active and reactive power is controlled by controlling the frequency and amplitude of the output voltage the flow active and reactive power is controlled by following the same principle[4]

Due to the increase in load when the flow of active power increase, frequency of an inverter droops, similarly the voltage will drops when flow of reactive power increases.

For frequency and voltage droops are defined for certain acceptable range in 1 % and 4 % respectively from their nominal value.

For the sake of maximum quality service adequate operating range is necessary.

The slope of line in figure 2 represents the droop gains fundamental droop equation are,

$$\omega = \omega_0 + m(P_0 - P) \qquad (1.1)$$

$$E = E_0 + n(Q_0 - Q) \qquad (1.2)$$

Where $\omega_0$, $E0$, $P0$ and $Q_0$ are reference or rated values.

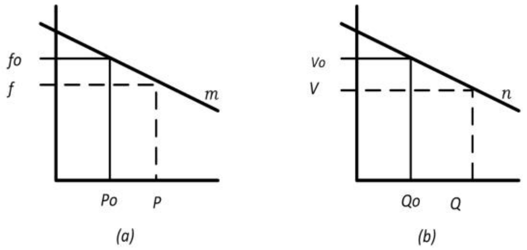



Fig. 2 frequency and voltage droop

There are few advantages of this control technique. It may be possible that all inverter start to operate with new lower value of frequency and amplitude of system voltage. Which are different for set points reference second is the measurement error of voltage and current which can result from luck of robustness that affect the measurement of feedback signal and then the power sharing mechanism will be disturbed [2].

This project work focuses on droop control technique due to its independent and low cost operations of inverter and system reliability.

## IV. PROPOSED DESIGN

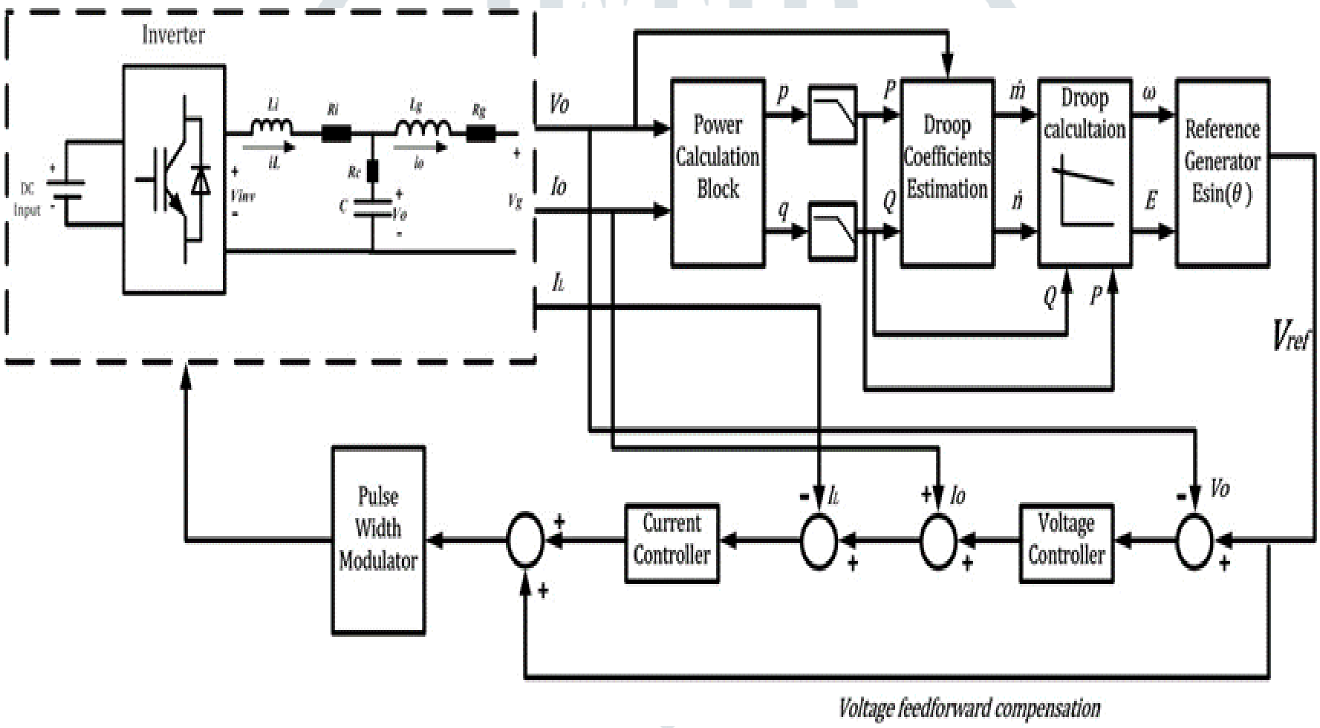



Fig 3 Proposed design of estimated droop control

Proposed design is shown in figure 3 compared to traditional droop control the main difference is the droop coefficient estimation block. With any change in output active and reactive power demand the traditional droop control scheme uses only fixed droop value. This project work proposed a technique in which rather than using fixed value we are estimated droop values by using online estimation mechanism and these value are adopted by droop control block to control the output power.

A droop control scheme uses only PCC voltage and current to detect changes in system and adjust the operating points of the system accordingly. When there is different line impedance between parallel connected DGS, every inverter experiences different lodes. So, every inverter will produce different output power due to the inverters of system runs out of synchronism. Using this estimation technique we are able to operate all inverters in synchronism with different line impedance.

To assist this estimation process following tools have been used

1. Second order generalized integrator (SOGI)
2. Phase locked loop (PLL)

### (1) Second order generalized integrator:

For generation of orthogonal components in a single phase system, Clark and park's transformation are not used, a low pass filters and peak value detector to calculate these parameters are used traditionally to achieved steady state and undesired oscillation these algorithm requires of tradeoff between response speeds.

The second method is to use Second order generalized integrator for generating orthogonal components in this work we have used SOGI method because of its better performance.

The block diagram SOGI is shown in figure 4 it has two output power e and f

Output e is in phase with the input signal f has go phase shift and it's lagging r.t input signal the e and f components have same properties as $\alpha\beta$-components of Clark's transformation [6].

To generate orthogonal components for voltage and current, this structure is used it will enable better calculations of active and reactive power [6].

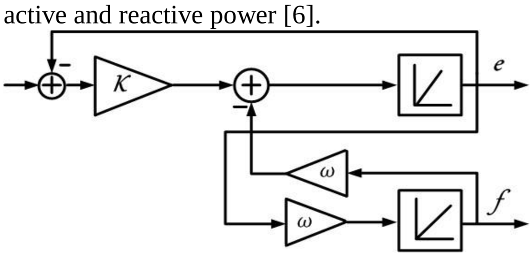



Fig.4: block diagram of SOGI

$$G_e(s) = \frac{Ks}{s^2 + Ks + \omega^2}$$

$$G_f(s) = \frac{K\omega}{s^2 + Ks + \omega^2}$$

Where $k$ is the gain and $\omega$ is the fundamental frequency.

### (2) Phase locked loop:

For estimation of frequency estimated orthogonal components are again used with phase locked loop (PLL)

For better rejection of noise a PLL should have narrow bandwidth if the input signal has harmonics a PLL will fail to lock at designed frequency

PI controller in PLL should be tuned properly to have a constant frequency figure 5 show the block diagram of phase locked loop.

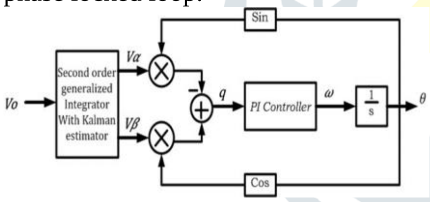



FIG: 5 structure of PLL

## V. RESULTS AND DISCUSSI

#### 4.1 Results of Descriptive Statics of Study Variables

Table 4.1: model data

| | |
|---|---|
| Inverter 1 | 300V |
| Inverter 2 | 300V |
| L1 | 1.25e-3 |
| C | 10e-6 |

Table 4.1: shows the Data of simulation model. The simulation model picture is shown in figure 6

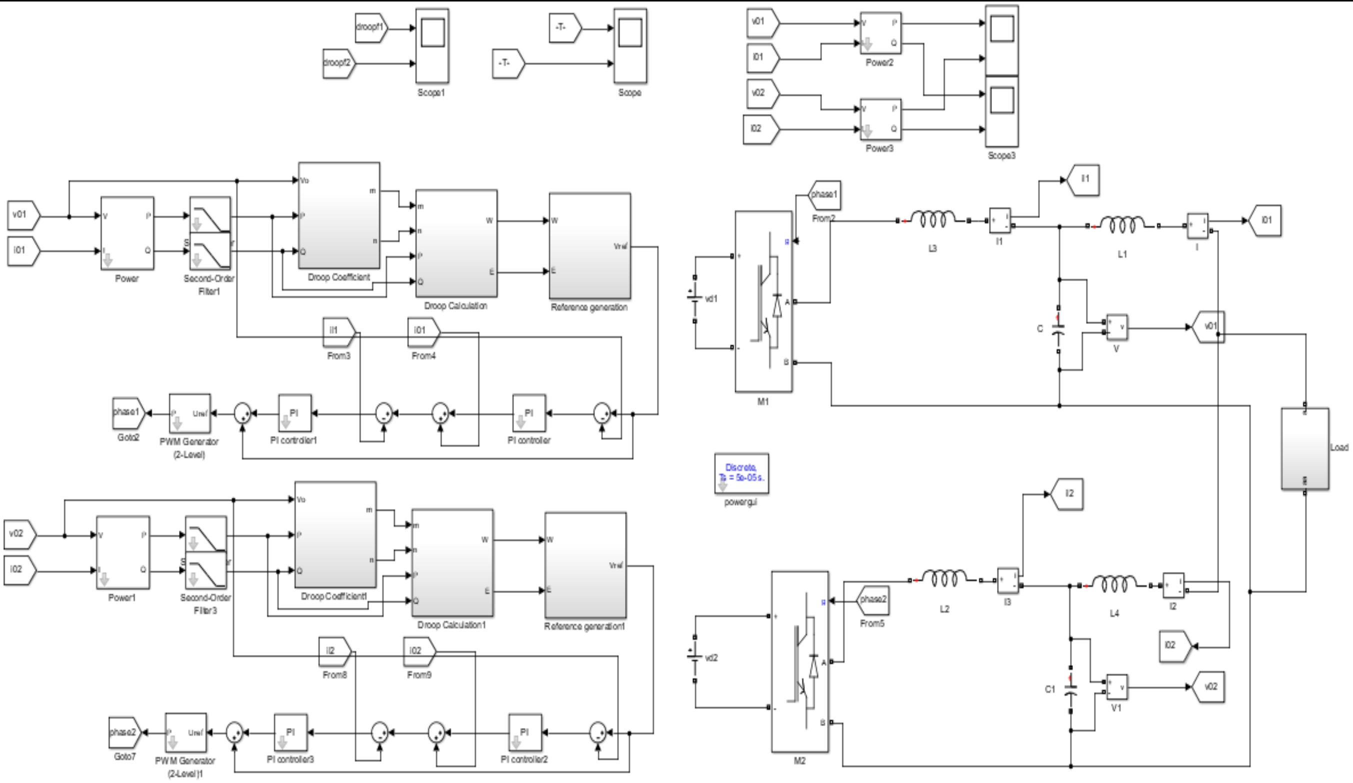
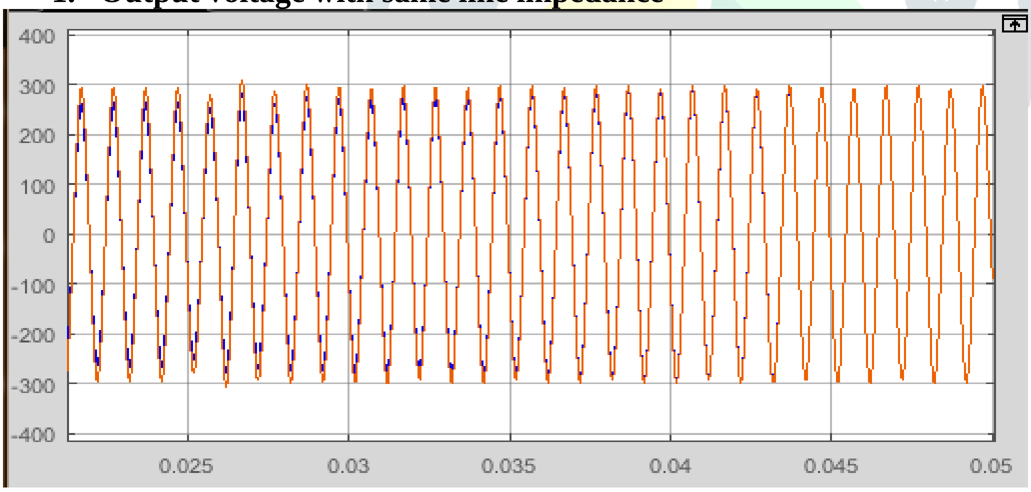


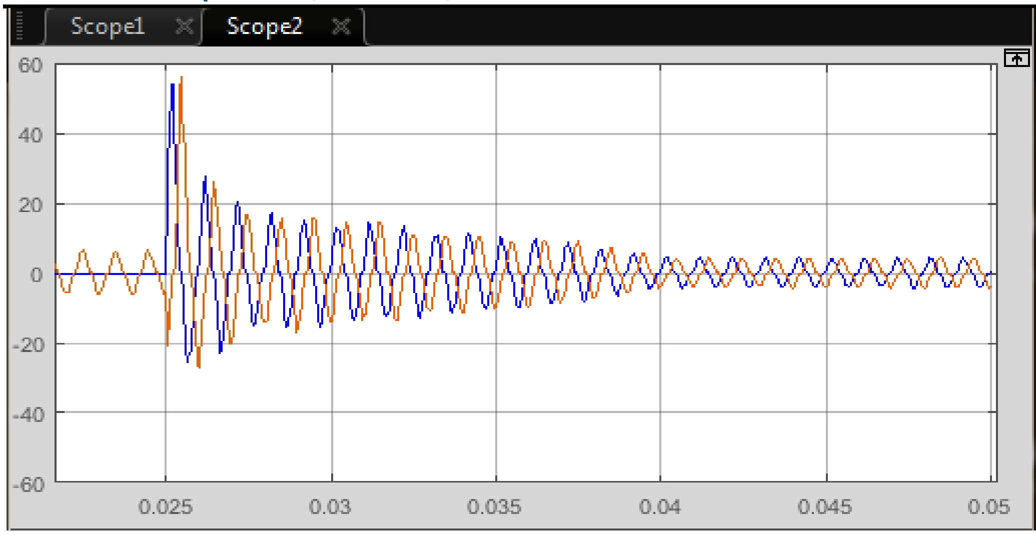

Fig 6: simulation model

**4.2 results:** here in we are have represented the results of inverters with fixed droop gain (traditional droop control) in first section. Ii will be good to understand the problem, by performing the test for 1.) Same line impedance and 2.) With different line impedances. Below figures shows the output voltages V01 and V02, output current I01 and I02 for same impedance and output voltages V01 and V02, output current I01 and I02 for different line impedances respectively.

1. **Output voltage with same line impedance**



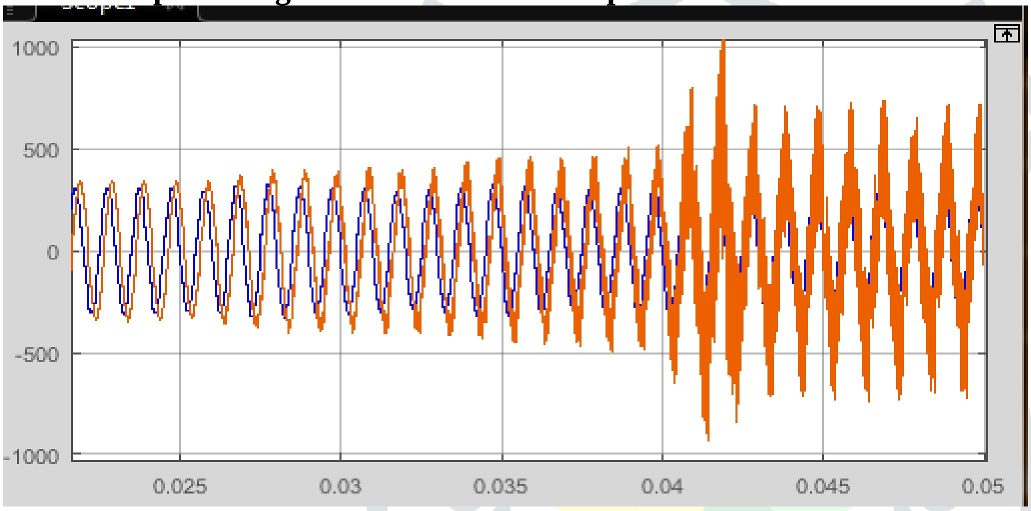

**V01 and V02**



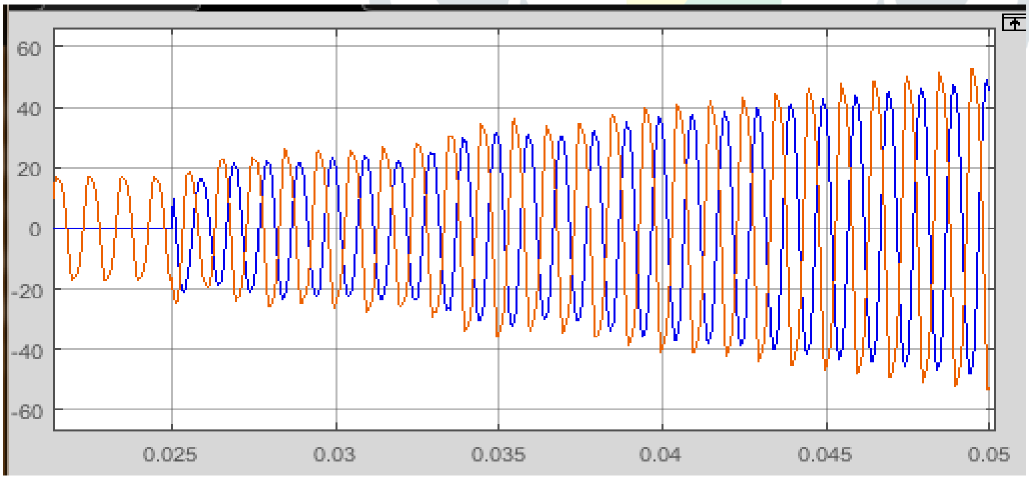

**I01 and I02**

Fig 7 OUTPUT VOLTAGES V01 AND V02, OUTPUT CURRENT I01 AND I02 FOR SAME IMPEDANCE

### 2. Output voltage with Different line impedance




**V01 and V02**




**I01 and I02**

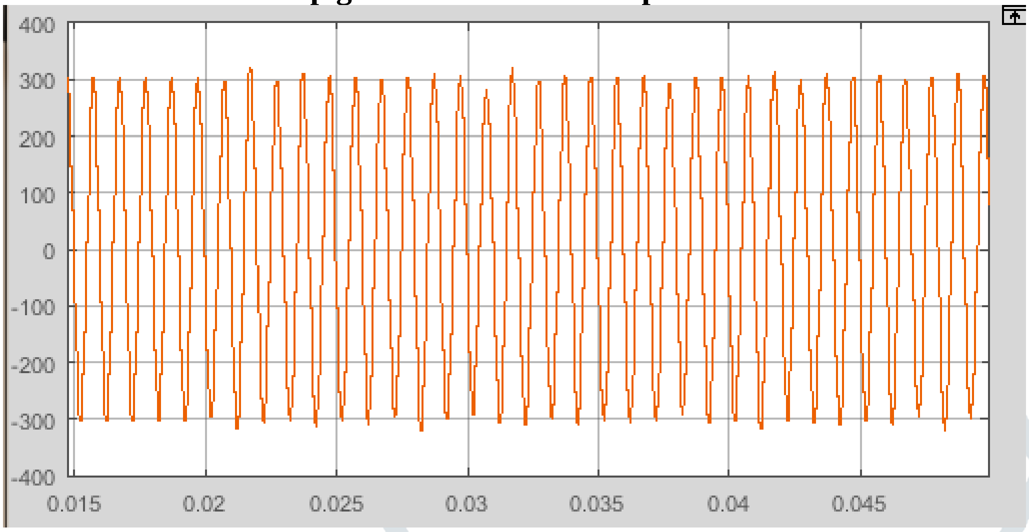
Fig 8 OUTPUT VOLTAGES V01 AND V02, OUTPUT CURRENT I01 AND I02 FOR DIFFERENT LINE IMPEDANCE

Figure7 shows the performance of two parallel connected inverter with same line impedance. Initially, inverter1 is connected to a non-linear load and inverter two is not connected to any load. It can be seen that the output current of inverter 1 is around 15A and 0A for inverter2, likewise, output voltages of two inverter have difference. The sine waves of both voltages crossing zeros at different time which shows the phase different between them.
At time 0.025 inverter2 is connected in parallel, at time of interconnection both inverters have different voltages and different phase angels. As we have connected in parallel both inverters are tend to synchronize. Synchronization means both inverters should have same voltage, frequency and phase. It is obvious from figure 7 that output voltages of both inverters are overlapping, which means inverters are successfully synchronized.at the time of interconnection a huge spike was visible for current graph which is due to the flow of circulating current between two inverters. This issue is dealt by current controller so the both current bring back to the controllable range very quickly.

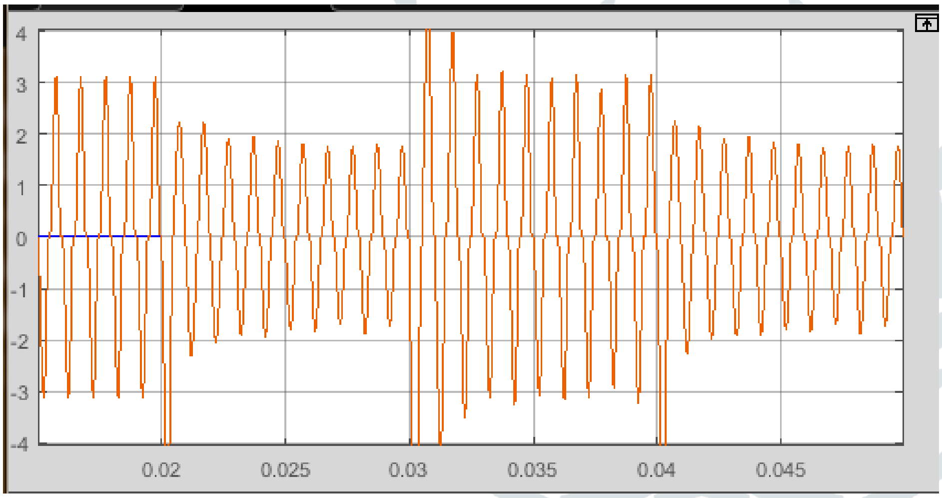
Same test has been performed for different line impedance. It is shown in figure 8 that at time 0.025 as we connect both inverters they become unstable. The voltage, frequency and phase differences increases gradually. The voltage and current of inverters increased to very high value. Which can damage the system. This instability occurs due to difference in reference/tracking signal of both inverters. The difference in line impedance can produce different net load which is responsible for generation of different reference/tracking signals.

Now, simulation results for estimated droop gain have been presented.

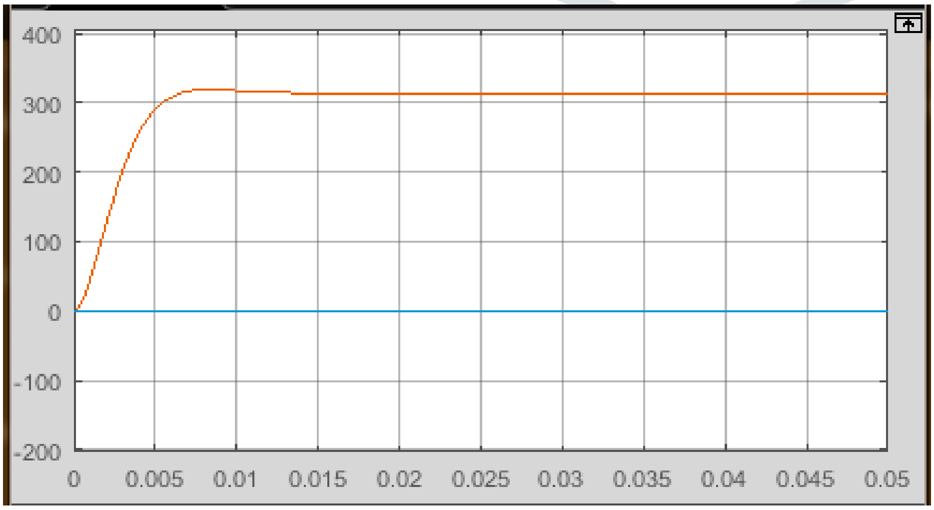
### 1. Estimated droop gain with same line impedance



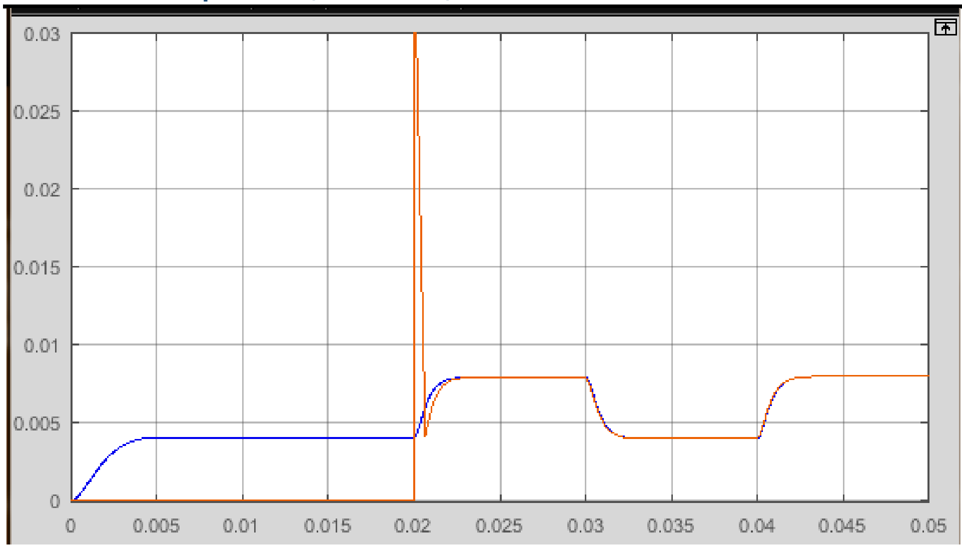

**V01 and V02**



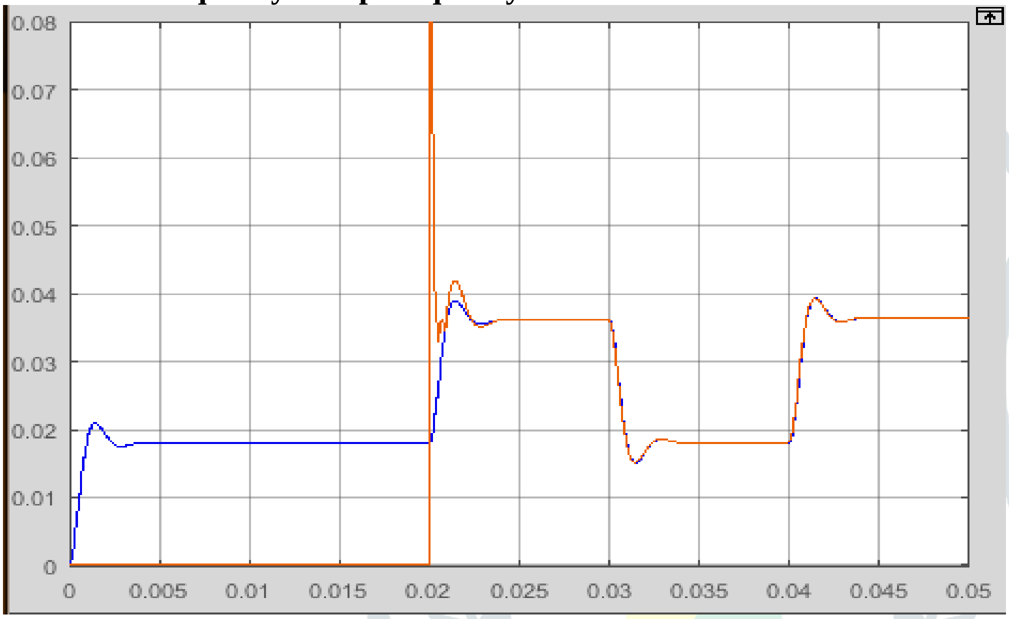

**I01 and I02**



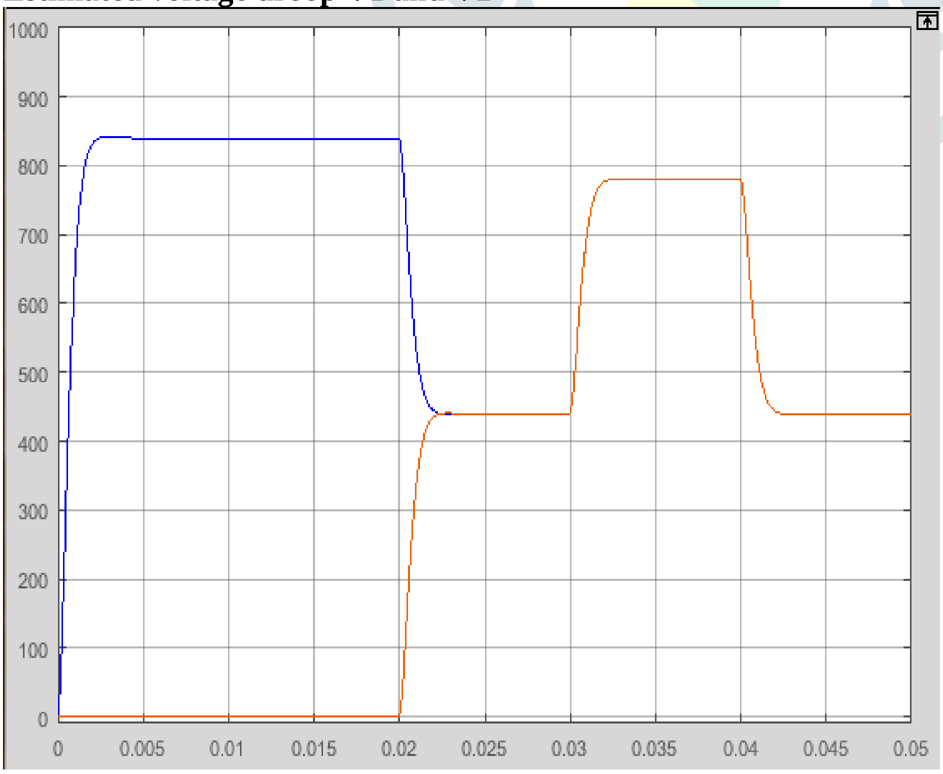

**Angular frequency of Inv1and inv2**



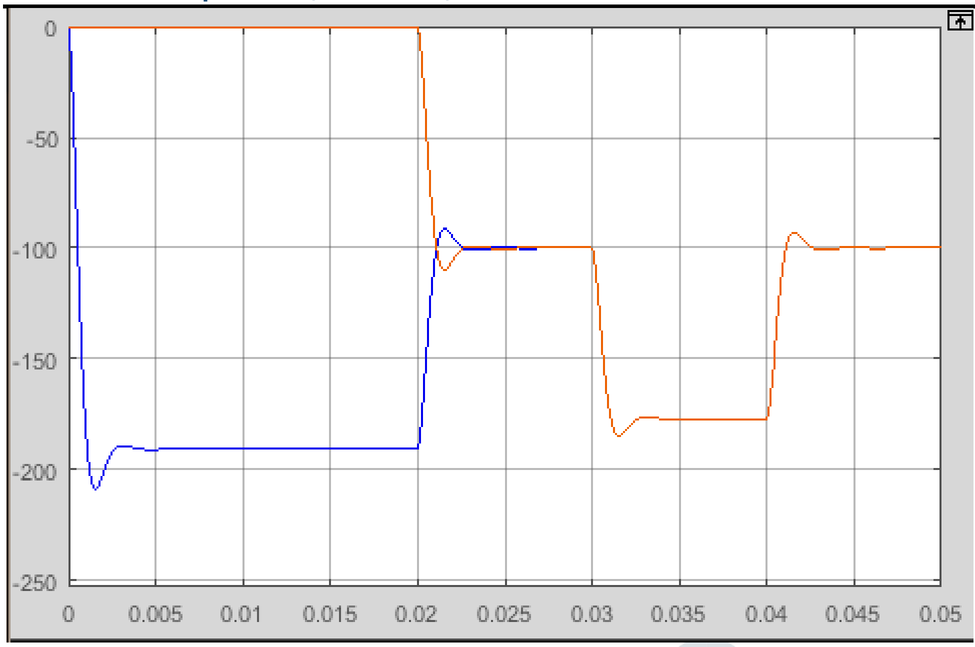

**Estimated frequency droop frequency F1 and F2**




**Estimated voltage droop V1 and V2**




**Active power of VSI of P1 and P2**



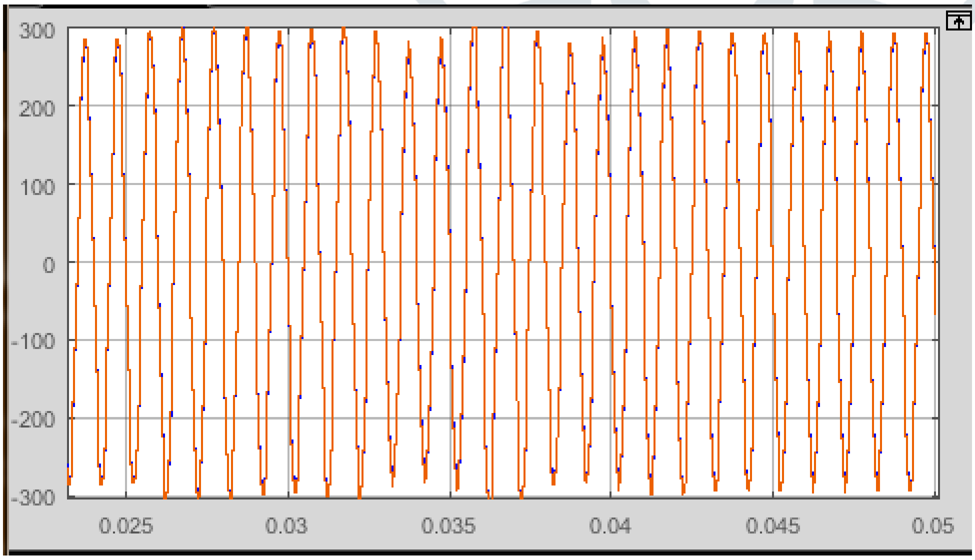

**Reactive power of VSI of P1 and P2**

Fig 9: Output voltage, current and frequency, estimated droop curves of frequency, voltage and active and reactive power of two parallel connected VSIs with Est. droop control and same line impedance

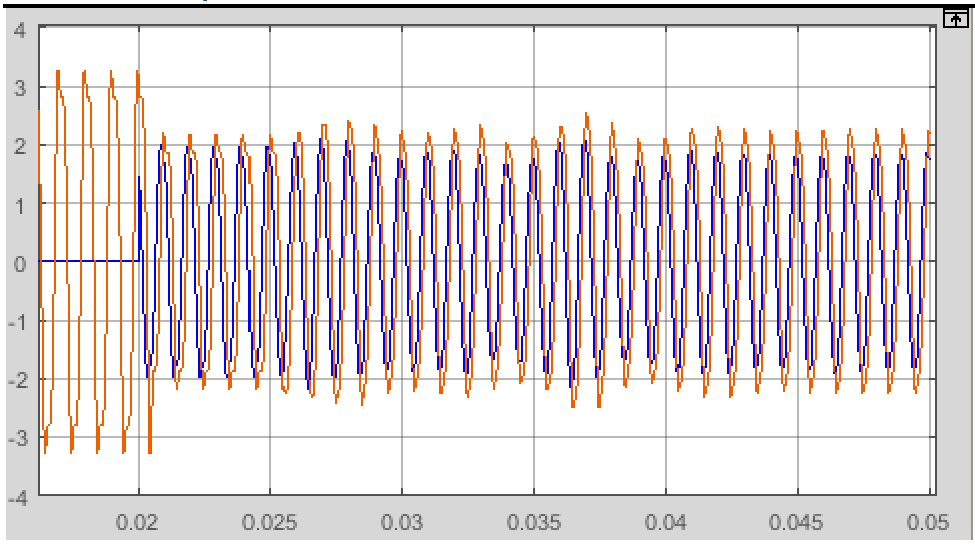
Firstly, we have examined the system performance with same line impedance for both inverters. It can be shown in figure 9 that after connecting inverter2 at time 0.02 both inverter get synchronized very quickly. Which shows the fast system response. Initially, both inverters have different output voltages, as soon as we connect them to parallel they start operating with same voltage. Load decrease at time 0.03 and then increase at 0.04 time. During the operation system frequency maintains constant.

Initially, when no load is connected droop gain estimator gives random values from the flow of active and reactive powers. The blue line shows the droop value for inverter1 and red line indicates the inverter2. Inverter2 is connected with load at time 0.02, before this the droop value of inv2 is zero. After connecting in parallel both inverter have same voltage and frequency droop. Even during disturbances both inverters keep same droop values which shows that they are sharing power equally. Active and reactive powers are also displayed here.

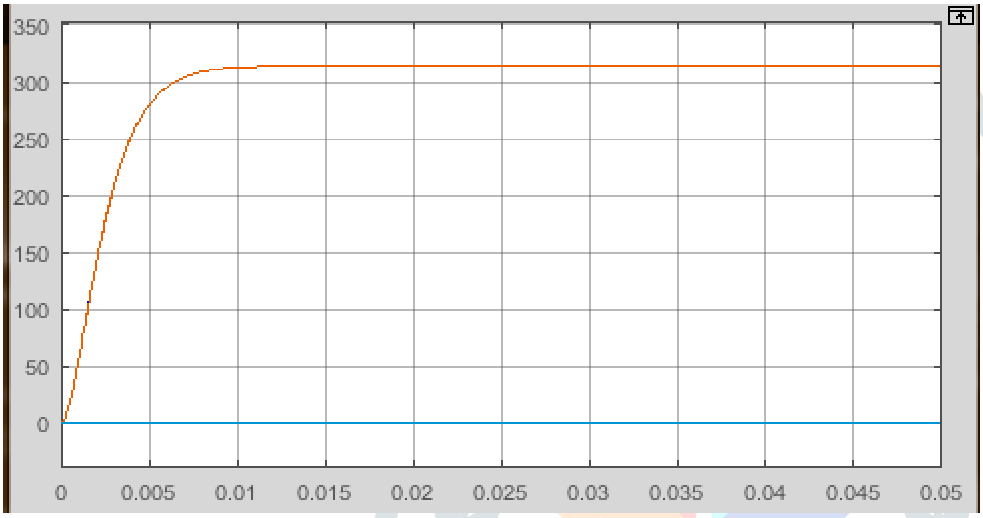
## Estimated droop gain with Different line impedance:



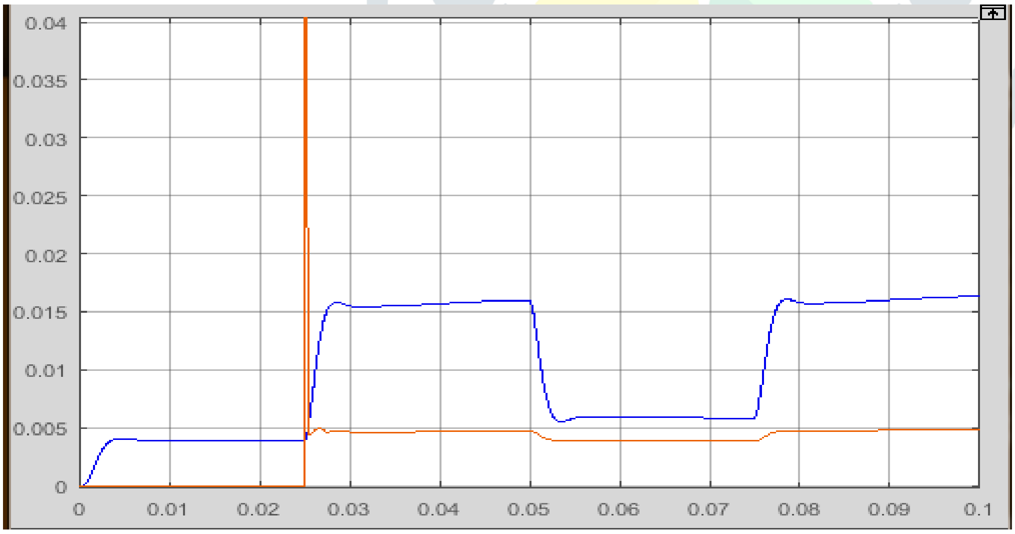

**V01 and V02**



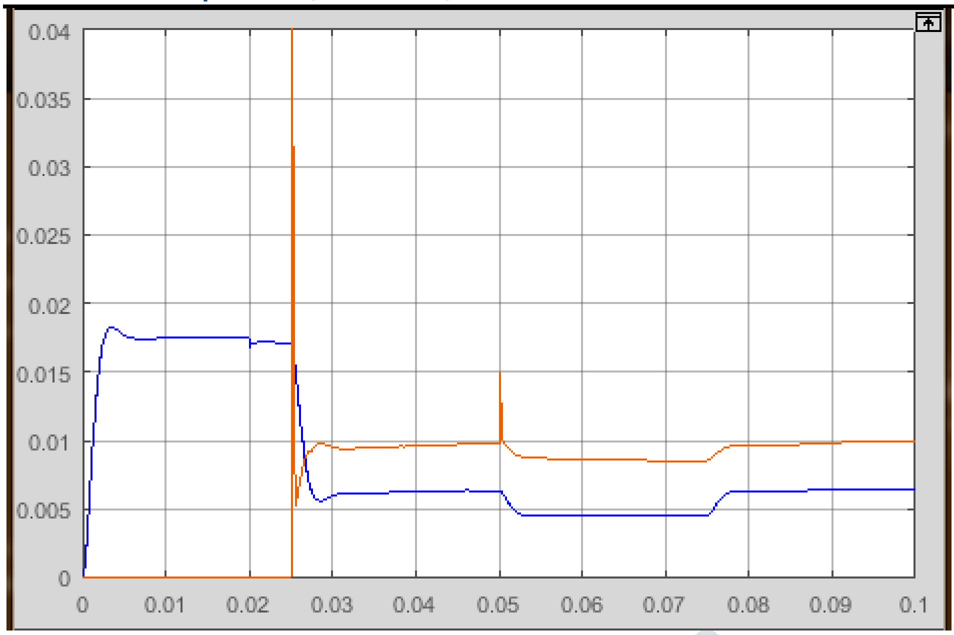

**I01 and I02**



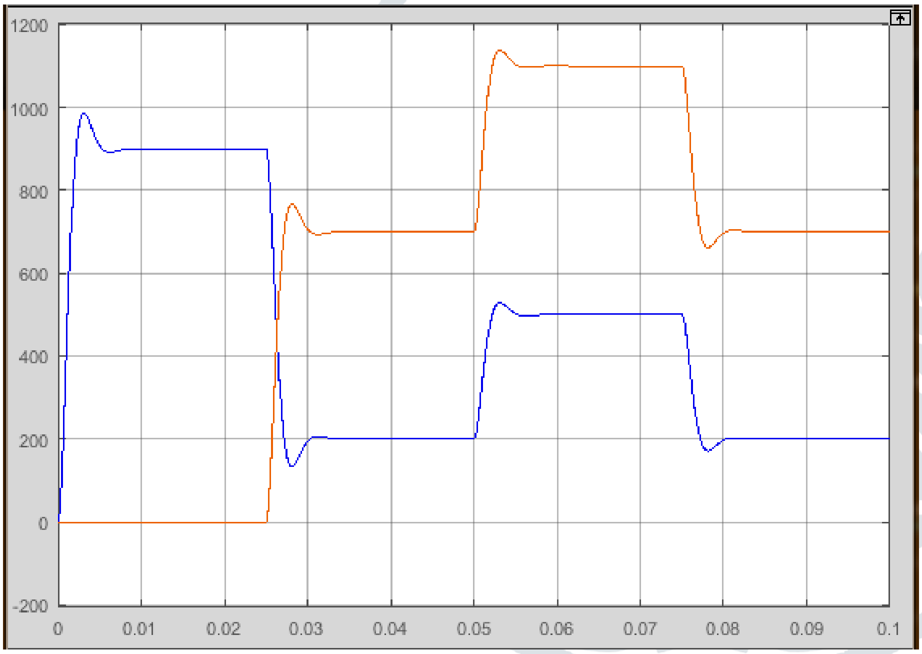

**Angular frequency of Inv1and inv2**



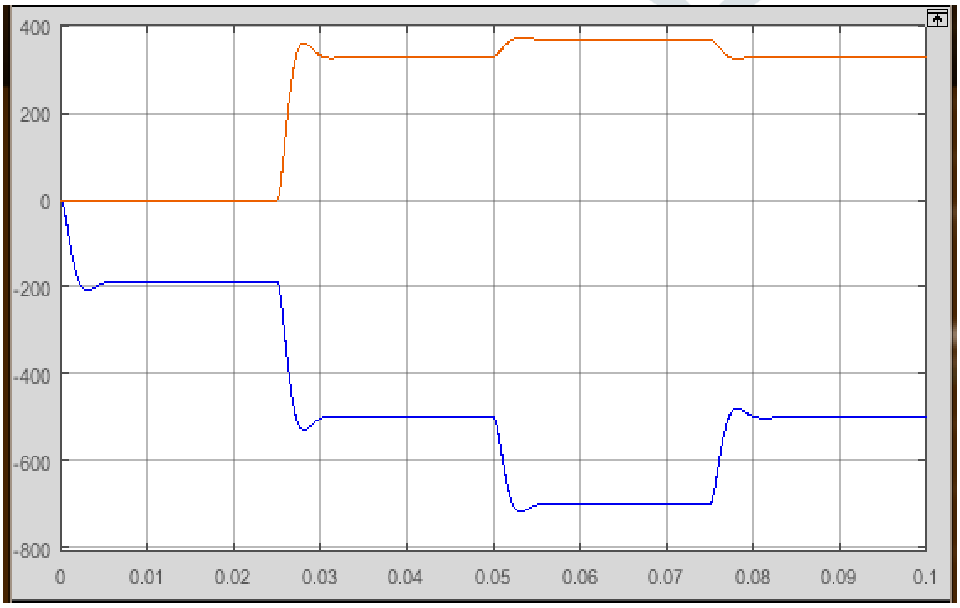

**Estimated Frequency droop F1 and F2**




**Estimated voltage droop V1 and V2**




**Active power of VSI of P1 and P2**




**Reactive power of VSI of Q1 and Q2**

Fig 10: Output voltage, current and frequency, estimated droop curves of frequency, voltage and active and reactive power of two parallel connected VSIs with Est. droop control and different line impedance

Now, we are examine the same test for different line impedance. This test will gave thee surety of success for our system. We have shown above in fig8 that conventional droop system have problem in synchronization with different impedances.
Figure 10 shows the output voltages are almost same during differences. In the case of current, it is different for each inverter as there is different impedances.
During the whole operation the system keeps the voltage, frequency and phase constant. Whereas, convention system can't keep it constant.

## VI. CONCLUSION:

An estimated droop control method with online estimator is tested with same line impedance and different line impedance using MATLAB/ SIMULIMK. The performance of proposed technique is improved by using SOGI and PLL This system maintains synchronism and reliability and works effectively under different conditions of load.
In this method by freeing each inverters from communication link, the reliability of system increases.

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