NASPI Distribution Task Team

Technical Report

NASPI DisTT Use Case:

Synchrophasor Assisted Microgrid Automation

DRAFT December 24, 2016

Use Case

Conventional remote terminal unit (RTU) based automation approaches suffer from slow measurement update and lack of time-stamp values for precise comparison of state parameters at different locations. A t~~T~~ime-synchronized control approach is more favorable for protection event analysis, islanding detection and grid re-synchronization practices.

Background

Microgrids are small scale ~~of~~ decentralized electricity networks featuring more complex structure compared to large generation plants. A microgrid may consists of various types of generation units and local loads, including energy storage. Synchronous generators, induction generators and inverter based distributed energy resources (DER) are the main types of generation units in a microgrid. Load demand management is also often posited as a DER. As the penetration level of DER increases, concerns regarding the stability and interactions between units are becoming more important.

The conventional control and management of the distribution grid, where only voltage magnitudes are measured and utilized at the control center, c~~w~~ould easily ~~undermine~~ misdiagnose these new dynamics and ~~may~~ potentially lead to severe complications in grid operations. This results in growing interest to utilize synchrophasor~~s~~ measurements in distribution system applications.

Experimental Setup

In a pilot microgrid deployment, multiple DERs are to be run collectively by a central control entity. The communication ~~of~~ between a microgrid ~~with~~ and the central control entity is enabled through various network infrastructures, which consist of wired network, such as high speed Ethernet and serial communications, and wireless networks with GPS synchronized time servers.

Commented [MB1]: Should this be written using verbs in past tense? Also, this item in the paper seems to be out of context. Should some transition wording be used, perhaps at the beginning and ending to integrate it into the paper?

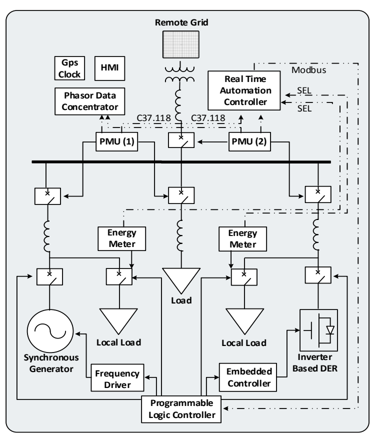

Figure 1: Microgrid involves a synchronous generation unit, an inverter based DER and local loads. Connection to utility grid enables both ~~in~~ grid-connected and islanded operation. Operational voltage is 208 V RMS line-to-line as utility voltage level. (Smart Grid Test Bed at Florida International University)

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Applications

For an accurate phase angle comparison for islanding detection, the phasor measurements should be correlated by means of time-stamp with high data frame rate. Thus, synchrophasor measurements can be effectively used to determine whether the microgrid is islanded. Rate of change of frequency (ROCOF), and phase angle difference and over/under frequency are the most accurate indicators for islanding detection.

Synchrophasors are a viable tool to help solve the problem of DER remote resynchronization without using a local synchroscope. Following a fault or a disturbance of the microgrid, a part of, or the total, microgrid might need to be islanded ~~and separated~~ from the ~~remaining of the~~original network.

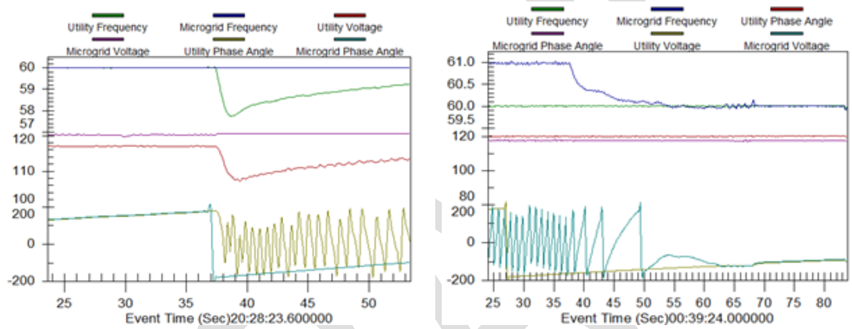

Figure 2: Frequency and phase angle difference upon disconnection of the microgrid from the utility. Frequency, voltage and phase angle differences of the microgrid and utility side during the remote synchronization. (Smart Grid Test Bed at Florida International University)

In general, e~~E~~vent reports ~~are~~ should be generated from synchrophasors measurement data~~s~~ to understand the event trigger and to track corrective actions in order to prevent recurrence and provide lessons learned from that particular application. Events should be investigated and analyzed after faults including any kind of event that causes the problem in the system. This becomes imperative for system security analysis and for revealing the reasons of blackouts or power ~~outages~~disturbances.

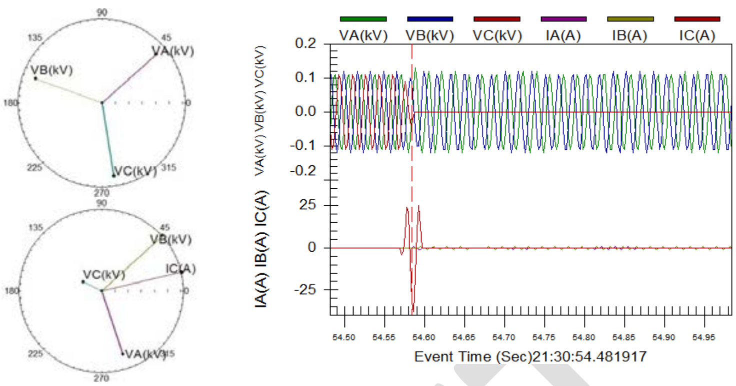

Figure 3: A single phase fault is created to realistically examine the protection scheme with tripping event. Figure shows the dynamic change of voltage and current phasors.

References

[1] M. H. Cintuglu, A. T. Elsayed and O. A. Mohammed, "Microgrid automation assisted by synchrophasors," *2015 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT)*, Washington, DC, 2015, pp. 1-5.

[2] T. Ma; M. H. Cintuglu; O. A. Mohammed, "Control of Hybrid AC/DC Microgrid Involving Storage, Renewable Energy and Pulsed Loads," in *IEEE Transactions on Industry Applications* , vol.PP, no.99, pp.1-1.