IEEE 1547 Compliance Monitoring using Power Quality Data

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***Abstract*— This paper will describe a set of checks and analytics developed to use Power Quality type data for IEEE 1547 compliance. The analytics were developed as a component in an open-source disturbance analytic software.**

Automatically determining IEEE 1547 violations allows utilities to identify any Distributed Energy Resources (DERs) that have compliance issues and can support the case for corrective actions. An open-source visualization tool is also developed as part of this project allowing engineers to look at these violations over an extended period.

Keywords—Asset Health, DER, IEE 1547, DFR Data, PQ Data

I. Introduction

With the recent introduction of new power quality monitors (*PQMs*) and more advanced digital fault recorders (*DFRs*), there is an opportunity to use the measurements obtained from these devices to monitor compliance of Distributed Energy Resources (DER) with voltage and power related interconnection requirements. Historically, compliance with interconnection requirements is checked during the commissioning process. This is to ensure that equipment, such as an inverter, is capable of complying. However, as more DERs come online, it has become clear that interconnection standards, such as IEEE 1547, also require continuous monitoring of the DERs to ensure they continue to comply with the standard as they operate.

This paper describes an Open-Source Disturbance Analytic Software (*OSDA*) that already collects data from various PQMs and DFRs in a near real time fashion [1] and uses this disturbance data as well as longer term power quality trending data to report on the performance of DERs related to IEEE 1547.

Section II describes the IEEE 1547 standard and specifically identifies the parts of the standard that can be monitored using DFR and PQM data. Section III describes the algorithms and checks developed to determine issues with 1547 compliance. Finally, Section IV describes the system implementation in a production environment and the lessons learned at the Tennessee Valley Authority (TVA).

II. IEEE 1547 Standard

IEEE 1547 is a standard that defines the requirements for interconnecting distributed energy resources (DERs) to the electric grid. Monitoring compliance with this standard is important to ensure that DERs are operating safely and efficiently and not causing harm to the electric grid [2].

The standard consists of multiple parts, defining behavior of the DERs under certain operating conditions. While the use of PQM and DFR data allows the utility to monitor the DER's power, frequency and voltage during adverse system conditions, these devices cannot provide continuous point on wave measurements during normal operation of the electric grid.

By using power quality interval data, the PQMs provide a minimum, maximum and average value for these parameters at longer intervals during normal operations. While this data cannot ensure a DER does not move outside compliant operation during that time, it can be used to identify periods where certain limits in the standards are violated.

Specifically, the following limits are monitored using PQ interval data:

(1) Voltage

(2) Frequency

(3) Current

III. Limits and Checks developed

The system consists of 2 separate analytic pieces that analyze (1) compliance with event-based limits and (2) compliance with interval data-based limits.

Fig 1 shows an overview of the system for both trending and event-based data records. The meter records continuous 5-minute interval data and point on wave data when various triggers are in effect. The data is downloaded by an open-source tool that is part of the OSDA [1].

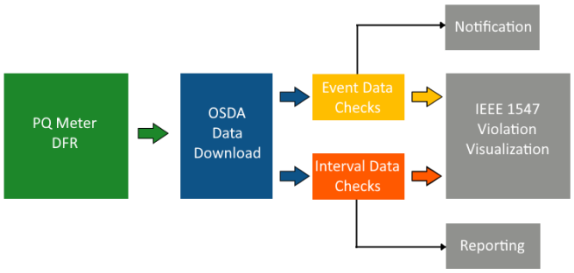

Fig. 1. Overview of the data path through the OSDA

Once the data is downloaded, the OSDA analyzes the data and determines any IEEE 1547 violations based on the following criteria.

1. For any event records recorded by the PQM the following limits are checked for compliance, where the point on wave measurement taken during the event at the point of interconnection of the DER are used.
    a. 7.1 Limitation of DC Current Injection
    b. 7.2.2 Rapid Voltage Change
    c. 7.4.1 Limitation of overvoltage over one fundamental frequency
    d. 7.4.2 Limitation of cumulative instantaneous overvoltage
2. For interval-based compliance, each point of interval data is processed separately to allow the system to determine violation of these limits in near real time. For each interval, the following checks are done
    a. 7.2.3 Flicker (PST)
    b. 7.2.3 Flicker (PLT)
    c. 7.3 Limitation of Current Distortion

IV. TVA Use Case

The checks and algorithm described in the previous section were implemented as part of an open-source software suit, which also includes other near real time analysis [3] and tools to automatically obtain disturbance event records from DFRs in the field, as well as visualization and notification tools [3]

Effectively, TVA now has a system in place that automatically downloads disturbance records from DFRs in the field and moves them to a location in the central IT infrastructure [1]. Once the files are downloaded, they are automatically processed by this system which includes several analytics described in [1] as well as compliance checks for IEEE 1547 compliance. A number of screens have been developed to identify the results of these compliance checks. This includes records of any 1547 violations for a given site, Fig 2shows a table containing all 1547 compliance violations and the specific limits violated.

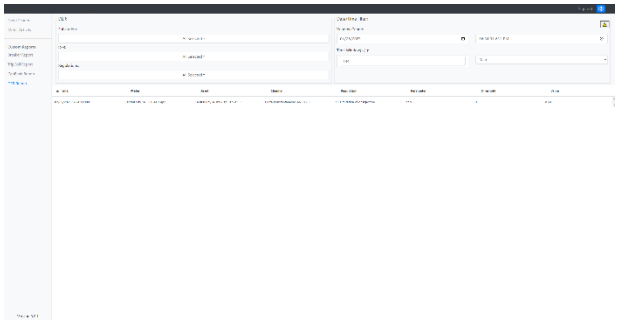

Fig. 2. Open-source visualization tool for protection engineers

Power Quality management staff and interconnection managers can go back to any timeframe previously processed and compare compliance performance of the DER following any remedial action they require the generation owner to take.

Figure 3 shows a screen allowing the engineers to compare recorded point data against the appropriate IEEE 1547 limits.

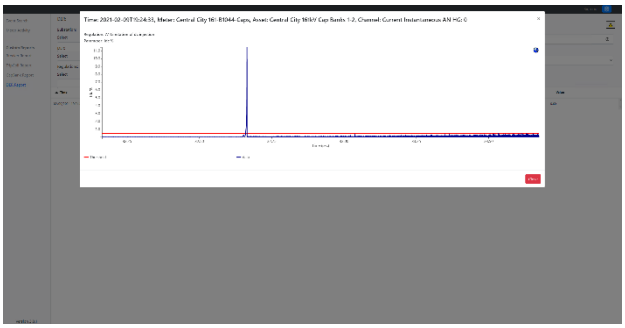

Fig. 3. Open-source visualization tool comparing point ata to 1547 limits

In addition, the open-source tools installed at TVA also allow engineers to investigate a variety of data collected from other systems, such as SCADA, sequence of events databases, Interruption Reports, and Operational logs to supplement the information gained from the automated IEEE 1547 analysis.

V. Conclusion

This paper introduced an algorithm to determine and summarize DER performance based on violations of IEEE 1547 using Power Quality data. The algorithm was implemented in a production grade open-source software application and is used at the Tennessee Valley Authority to track performance of DERs with regard to IEEE 1547 compliance

References

[1] "IEEE Guide for Using IEEE Std 1547 for Interconnection of Energy Storage Distributed Energy Resources with Electric Power Systems," in IEEE Std 1547.9-2022 , vol., no., pp.1-87, 5 Aug. 2022

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