DFR Configuration Control: Solutions for Optimized Performance and Compliance

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Abstract -- With the emerging compliance requirements of PRC-002, ensuring that a digital fault recorder (DFR) maintains proper configuration and consistently monitors without error has never been more important for utilities, especially for those with large and diverse DFR fleets. This paper will describe an automated process that TVA has deployed for downloading configuration and diagnostic files from a large, multi-vendor DFR fleet. The configuration files are automatically retrieved and parsed, and staff are alerted to any detected changes. A change control process is used to review and validate changes or direct appropriate actions to return the device to a functional and compliant state. Finally, to support PRC-002 compliance and potential evidence packaging, the tool allows for tracking and development of remedial action plans.

The Tennessee Valley Authority (TVA) is a generator and transmission owner/operator primarily serving local power companies and transmission-connected industries in the watershed of the Tennessee River Valley. This service area encompasses more than 10 million people, providing power through a network of 16,000 miles of high voltage transmission lines and 2,300 substation buses across a seven-state footprint as shown in Figure 1. To maintain and reliably operate this system, TVA employs a wide array of devices for disturbance monitoring and grid visibility with the digital fault recorder (DFR) being among the most important instruments. The number of units in TVA's DFR fleet continues to steadily increase and DFRs provide data not only for fault analysis but also for power quality monitoring, equipment health indication, and phasor measurement unit data. However, as the business purposes for DFRs have evolved, so too have the compliance standards governing them. In 2006 the North American Electric Reliability Corporation (NERC) adopted PRC-002-1 [1] and PRC-018-1 [2] to serve as the primary standards for disturbance monitoring equipment like DFRs. These standards were superseded in 2015, when PRC-002-2 [3] was adopted. Chief among its differences was a shift moving the overarching governance for DFR installation, configuration, and reporting from the Regional Reliability Organization to more detailed criteria defined by NERC for facility owners of the Bulk Electric System (BES). These changes represented greater rigor and standardization across the industry in identifying BES elements to be monitored, specifying recording functions, channels configuration, recording resolution and duration, data retention, reporting criteria, and corrective action tracking. BES owner/operators were required to have the first 50% of in-scope DME compliant by January 2021 and the balance in compliance by Summer 2022. The governance of PRC-002-2 introduced a new level of compliance burden previously unseen for DFRs and with it, the need to develop a more consistent method to implement best practices of configuration control.

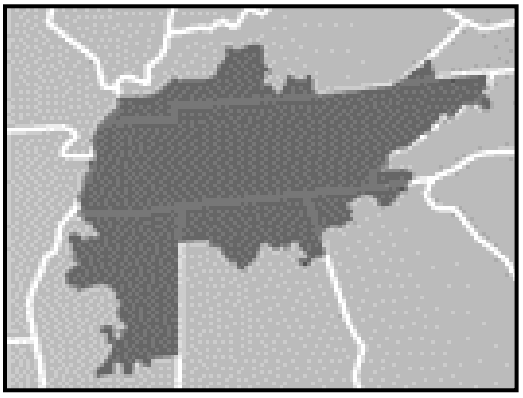


Fig. 1 - Tennessee Valley Authority Service Area

Among the twelve requirements of PRC-002-2, the seven listed in Table 1 contain properties controlled (and evidenced) by individual DFR configuration files. For this reason, TVA identified the need to regularly review as-left DFR setting files with regard to these compliance parameters. As the TVA fleet of DFRs has grown, the diversity of makes, models, and accompanying configurations has made this increasingly complex. Coordinating with field personnel to track and approve configuration changes can be laborious on engineering staff and a hindrance to maintenance or construction tasks. Nevertheless, the emergence of PRC-002-2 has also rendered the ineffectiveness to manage DFR performance problems or consequential device configuration changes unacceptable. It is not uncommon for field personnel to make changes to existing device configuration during routine calibration/maintenance activities or during construction projects requiring temporary transmission system arrangements. A fundamental element to DFR configuration control is establishing the ability to know the device configuration at any given time and detect when instrument configuration changes have been made. It is acknowledged that the entirety of PRC-002-2 compliance is not beholden to the configuration file alone. However, given the relatively high percentage of requirements contained within these files and the proclivity of files to be altered, a methodology to gain visibility and management of device configuration serves as a prudent component of overall compliance.

Table 1

PRC-002-2 Requirement	Configuration File Component
R2	Breaker position
R3	Phase voltages and currents for bus
R4	Record resolution, duration, and trigger for fault recording
R6	Dynamic Data Recording phase voltage and current (Transmission Owner)
R7	Dynamic Data Recording phase voltage and current (Generation Owner)
R8	Dynamic Data Recording trigger
R9	Dynamic Data Recording resolution
R10	Time synchronization

While DFR vendors provide software tools for remote access to their devices, challenges arise both to the variety of different DFR models in use and the large number of instruments in service. To overcome these challenges, TVA is implementing an automated, open-source maintenance and diagnostic monitoring application (MD) to 1) retrieve device configuration and status files, 2) scan the files for changes, 3) determine if changes have compliance and/or performance implications, 4) provide visibility to DFRs needing review or maintenance, and 5) track any required corrective actions to a resolution. DFR diagnostic files are most often related to available memory, time sync status, and processor performance. The MD application has been successful in retrieving information from a variety of field devices regardless of vendor and provides a customizable schedule for polling the instrument and a customizable mask for downloading specific file types from the DFR. TVA's customization of MD provides for a daily review of each DFR configuration file and any other available status or diagnostic files. The first step is to retrieve the DFR configuration and diagnostic files and route them to a repository of files organized by device, location, and bus. Figure 2 provides a sample file structure. Next, MD reviews the most current configuration files as found on the DFR against the most current record held in the repository. If the files match, the system is satisfied that no changes have occurred and the file retrieved for that day is purged. If the files do not match, the previous record held in the repository is moved to the archive and the record retrieved that day supplants it as the current file.

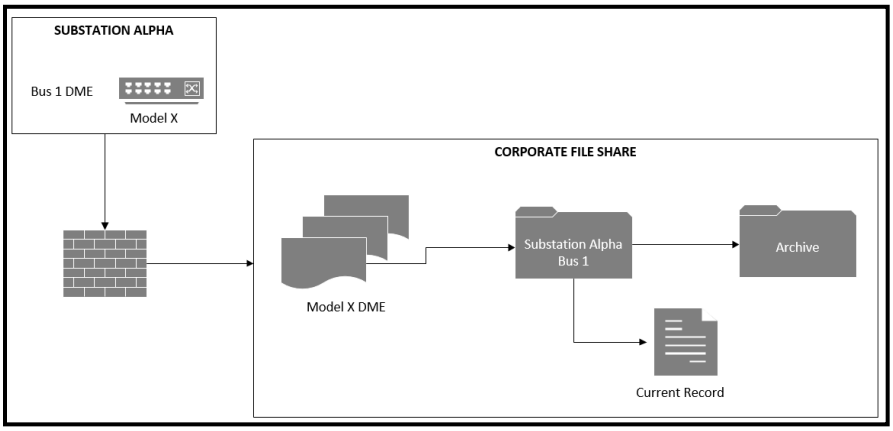
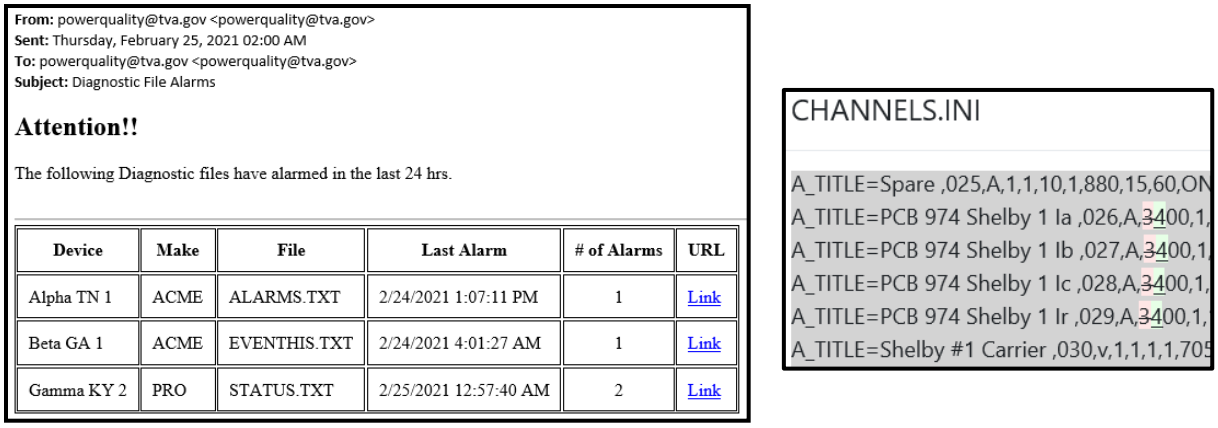


Fig. 2 - Network Diagram Structure for DME Configuration Files

If MD identifies a change to the configuration file, an important next step is to determine if that change is impactful to PRC-002-2 compliance. Since the majority of configuration settings have no relation to the NERC standard, to alarm on every change without first filtering for relevance is to risk over reporting and tempered responses. If problems with the device, such as failed time sync, are found in the diagnostic files, that information is also reported by MD. During DFR commissioning and/or initial compliance certification, all of the configuration settings in a given device file are parsed and organized in MD such that a user can select the individual configuration file fields that should be monitored for compliance as shown in Figure 3. This initial setup within MD creates a static record to serve as the baseline against which changes are flagged for review and possible corrective action. The MD application provides stakeholders a subscription service to receive email reports containing alarms for the devices that are reporting configuration changes. This service can be further customized to call attention to those changes with possible PRC-002-2 compliance implications. Figure 4 provides an example email notification users may receive and a sample of how the MD application would report a CT ratio change from 300:1 to 400:1. With visibility to the nature of the file change, users are routed to the MD which effectively serves as a compliance dashboard.

Category	Field	Type		Value
ANALOG_CHANNELS	(Analog Line Format: A_TITLE	string	=	title(64),chanlnum(3),type(1),primary(
ANALOG_CHANNELS	A_TITLE	string	=	161kV (Main Bus) - Van,001,V,1400,1,
ANALOG_CHANNELS	A_TITLE-5	string	=	161kV (Main Bus) - Vbn,002,V,1400,1,
ANALOG_CHANNELS	A_TITLE-6	string	=	161kV (Main Bus) - Vcn,003,V,1400,1,
ANALOG_CHANNELS	A_TITLE-7	string	=	T1/T2 161kV - In,004,A,40,1,10,.742,1:
ANALOG_CHANNELS	A_TITLE-8	string	=	T2 46kV - In,005,A,160,1,10,1.08,1280

Fig. 3 - User Interface for Configuration Field Selection



From: powerquality@tva.gov <powerquality@tva.gov>
Sent: Thursday, February 25, 2021 02:00 AM
To: powerquality@tva.gov <powerquality@tva.gov>
Subject: Diagnostic File Alarms

Attention!!

The following Diagnostic files have alarmed in the last 24 hrs.

Device	Make	File	Last Alarm	# of Alarms	URL
Alpha TN 1	ACME	ALARMS.TXT	2/24/2021 1:07:11 PM	1	Link
Beta GA 1	ACME	EVENTHIS.TXT	2/24/2021 4:01:27 AM	1	Link
Gamma KY 2	PRO	STATUS.TXT	2/25/2021 12:57:40 AM	2	Link

CHANNELS.INI

A_TITLE=Spare ,025,A,1,1,10,1,880,15,60,ON
A_TITLE=PCB 974 Shelby 1 Ia ,026,A,3400,1,
A_TITLE=PCB 974 Shelby 1 Ib ,027,A,3400,1
A_TITLE=PCB 974 Shelby 1 Ic ,028,A,3400,1,
A_TITLE=PCB 974 Shelby 1 Ir ,029,A,3400,1,
A_TITLE=Shelby #1 Carrier ,030,v,1,1,1,1,705

Fig. 4 - Change Notification Examples

Within the MD application, all devices with active PRC-002-2 alarms are displayed with a progression of colored visual indicators to provide users the status of alarms and provide guidance for next steps to resolution. In the event that configuration file changes are reviewed and approved, the baseline image within the MD is updated to reflect the changes accordingly. Future configuration files retrieved from the affected device will be measured against this new baseline. Figure 5 provides a work flow of the incorporated alarm hierarchy. Another component of the PRC-002-2 standard is the requirement to either bring out-of-compliant devices back into compliance within 90 calendar days or submit a remedial action plan. Another feature incorporated within the MD is a daily counter

tracking the amount of time that has passed since the initial alarm was received for a configuration file change to a compliance-selected field. As the 90-day deadline approaches without the alarm reaching a resolved state, notifications are distributed to stakeholders to raise awareness of the pending reporting requirements. Furthermore, users have the option to enter notes documenting the ongoing review and investigation as well as the submitted remedial action plan, where appropriate. These records can later be retrieved for evidence packaging to support compliance audits.

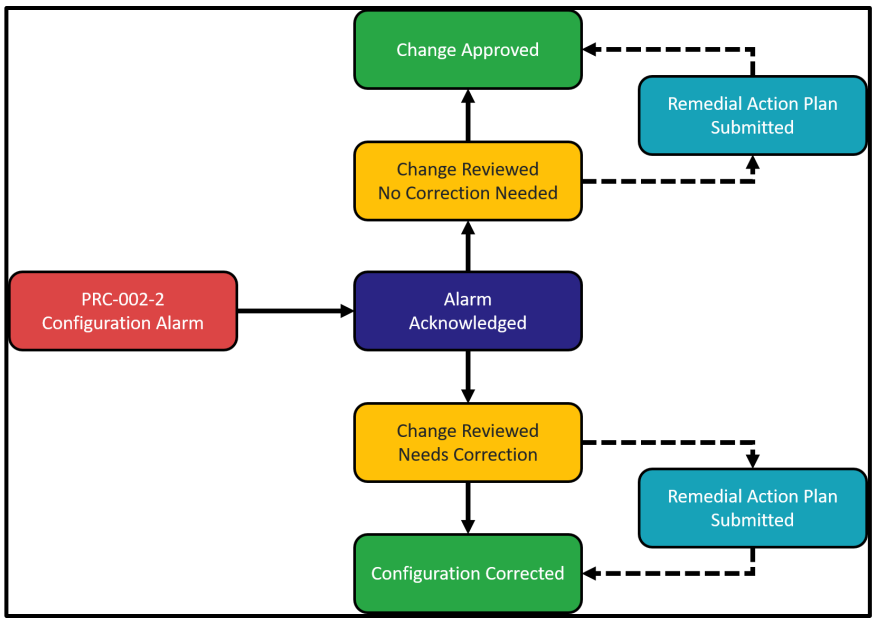


Fig. 5 - MD Alarm Work Flow

The requirements of PRC-002-2 necessitate that utilities develop new methods to keep DME in compliance. Automated services to retrieve and compare configuration files in combination with the stakeholder expertise to perform focused, targeted change reviews serves as an innovative means to monitor and maintain configuration control for large and diverse DME fleets.

References

[1] NERC PRC-002-1, 2006, *Define Regional Disturbance Monitoring and Reporting Requirements*

[2] NERC PRC-018-1, 2006, *Disturbance Monitoring Equipment Installation and Data Reporting*

[3] NERC PRC-002-1, 2015, *Disturbance Monitoring and Reporting Requirements*

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