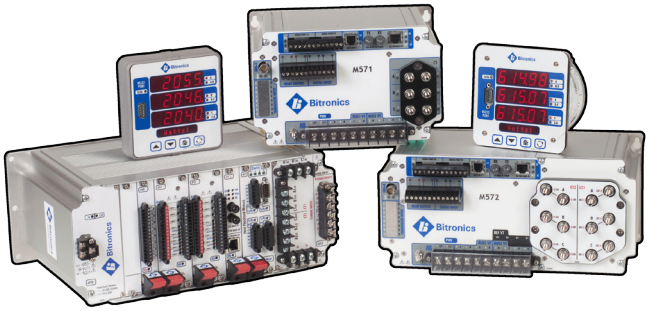
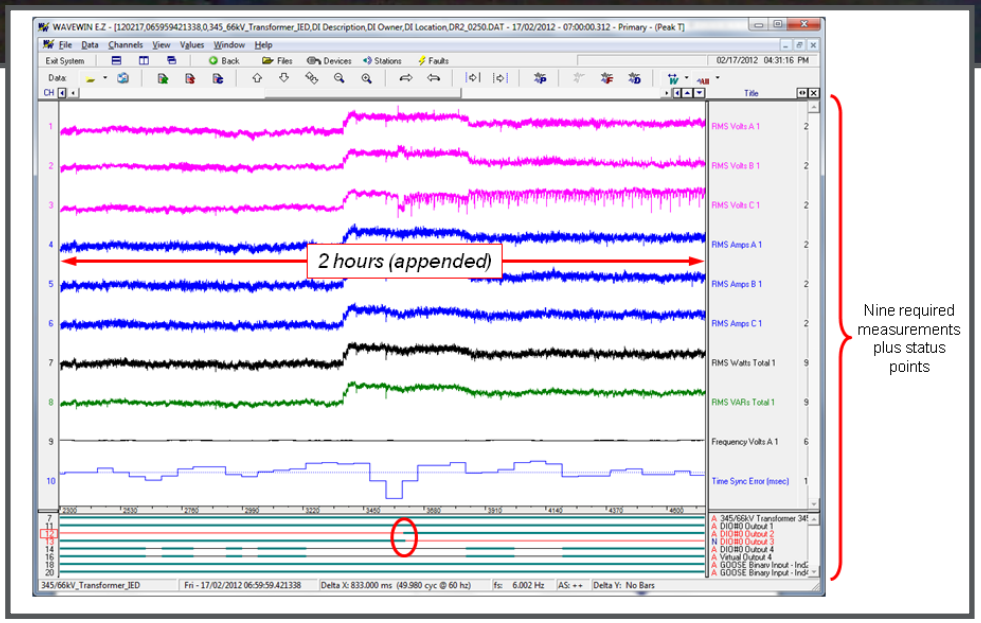
NovaTech®

Disturbance Monitoring Equipment for PRC-002

Disturbance Monitoring Equipment

70 Series IEDs and PRC-002-2 Compliance





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DME and NERC PRC-002-2

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Introduction

The North American Electric Reliability Council (NERC) has defined standards for disturbance monitoring and reporting requirements for transmission and generation systems. The primary standards are PRC-002-1 and PRC-018-1 (both approved August 2006) which are to be replaced by PRC-002-2 when approved. These standards, or versions from the eight regional reliability councils that are charged with compliance enforcement of the NERC standard, establish requirements for installation of Disturbance Monitoring Equipment (DME).

DME is required to be installed at specific places within the generation and transmission infrastructure. DME capable of monitoring and recording system data pertaining to a wide variety of system or equipment disturbances and must provide fault recording, dynamic disturbance recording (DDR), and sequence of event (SOE) recording. Bitronics 70 Series monitoring and recording IEDs (intelligent electronic devices) meet the requirements for DME within the current PRC-002-1 / PRC-018-1, and PRC-002-2 in all of these areas.

NERC PRC-002-2 and the Need for Disturbance Monitoring Equipment (DME)

Key Elements of the Standard

NERC PRC-002-2 is attempting under "Project 2007-11 Disturbance Monitoring" to standardize the regional reliability requirements concerning Disturbance Monitoring Equipment (DME). No date for approval has been established and the project status is in "Informal Development."

The purpose of the project is to establish requirements for installation of DME and reporting of disturbance data to facilitate analyses of events and verify system models.

This project involves modifying two standards:

- PRC-002-1 — Define and Document Disturbance Monitoring and Equipment Requirements
- PRC-018-1 — Disturbance Monitoring Equipment Installation and Data

The project involves replacing "fill-in-the-blank" requirements currently assigned to the Regional Reliability Organization, with requirements for North America that are applicable to other functional entities. As envisioned, each region will supplement PRC-002-2 with a regional standard that will include additional requirements.

The differences in PRC-002-2 are minimal compared to the already approved PRC-002-1 and PRC-018-1 standards so even if PRC-002-2 is not approved, existing requirements established under the two approved standards are driving compliance.

PRC-002 (-1 and -2) requires DME on nearly all lines of 200kV and up, as well as generation connected to the grid at 200kV and above (in general, for transmission substations at 200kV and above and generation connected to the grid at 200kV and above with single generation units of 500 MVA or total nameplate capacity of 1500 MVA or greater). Prior standards generally required DME only on EHV lines (345kV and up) and the nature of the recordings also differed.

PRC-002 describes three recording functions in detail:

- Sequence of Events (SOE) logging
- Fault Recording (FR)
- Dynamic Disturbance Recording (DDR)

While the first two are more widely available, DDR function is comparatively novel, more demanding, and generally only available from newer DFRs such as 70 Series.

Focusing on DDR, PRC-002-2 requires utilities to:

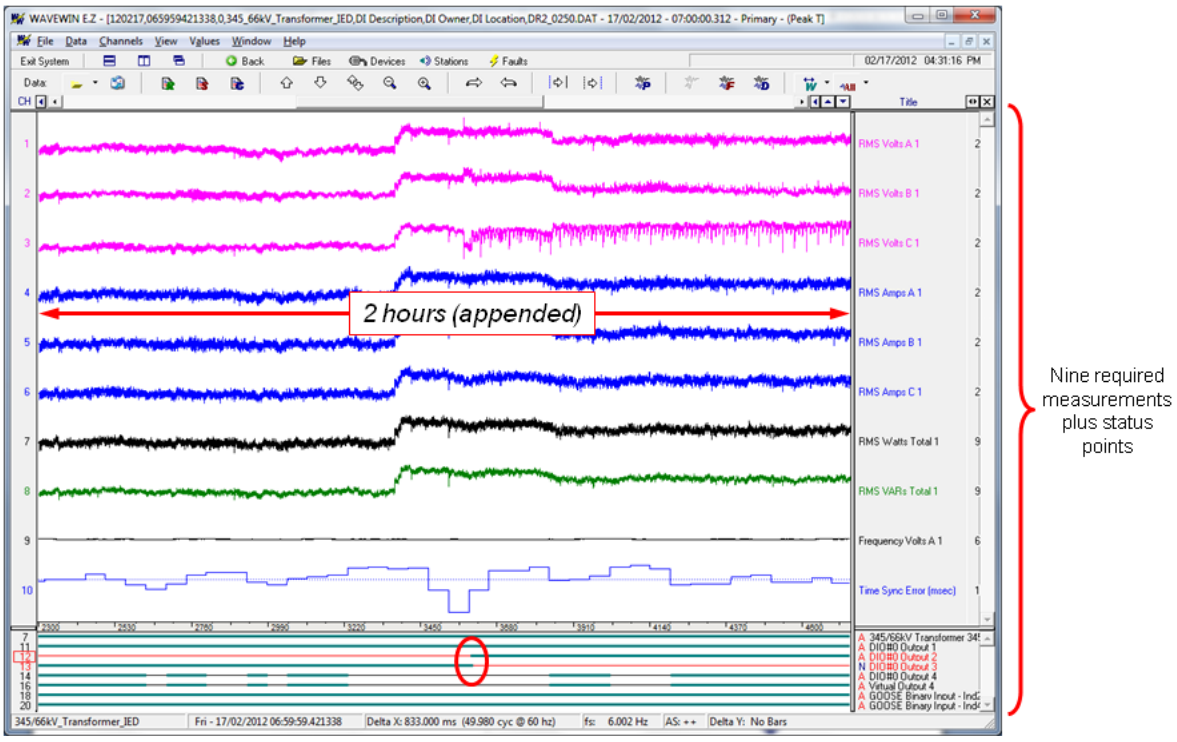
- Capture a continuous recording of up to nine measurements per line (per-phase volts and amps, total MW and MVARs, and frequency) with high resolution (at least 960 samples per second to calculate RMS quantities and at a rate of at least six times per second to store calculated RMS quantities) and make it available in Comtrade (C37.111) format using the "long file naming convention" (C37.232).
- Preserve a continuous record for ten days.
- Archive disturbances indicated as being of interest (Regional Reliability Organization-identified events) for at least three years.

Although some modern protective relays may be able to be configured to provide the SOE points and waveform capture required for PRC-002-2, none provide the combination of continuous recording and memory storage required by DDR.

While the existing requirements are for 200kV and above, NERC has provided a draft definition of the Bulk Electrical System (BES) under Project 2010-17 that defines applicability and exceptions at the **100kV level and above**. So while not a certainty, there exists the possibility that the PRC-002-2 could be extended below 200kV, and in fact Northeast Power Coordinating Council (NPCC) for one is looking to apply PRC-002 to BES levels.

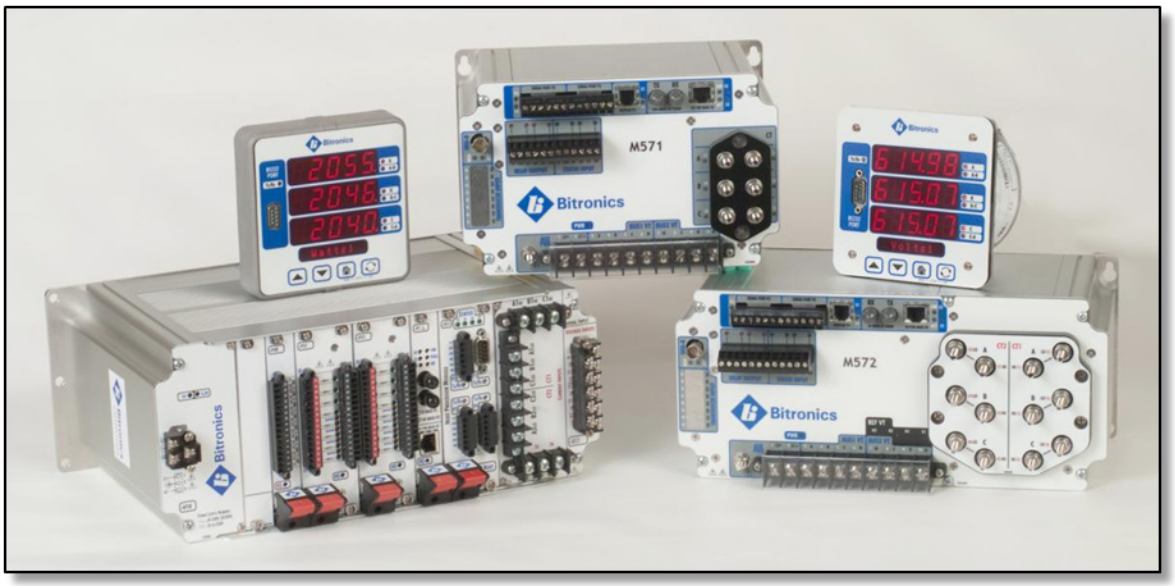
Why This Matters Now?

Being able to comply with NERC and various regional reliability council requirements is becoming increasingly important for transmission and generation operators as the time to comply in some areas is already at hand. For example, the Regional Reliability Organization Reliability First Corporation approved PRC-002-RFC-01 in May 2009, meaning that partial compliance began in 2010, with the majority of compliance required by 2014. Because the standards require DME in some cases where no or minimal recording capabilities existed (installations starting as low as 100kV) operators are in need now of cost-effective solutions that meet the current and upcoming standards.



70 Series two-hour continuous DDR record viewed in Wavewin® with time sync status shown

Bitronics 70 Series



The 70 Series of IEDs consists of the M87x modular family and the M57x compact family. The M87x family provides greater flexibility and increased I/O capability in a modular design, while the M57x provides a more economical option with all hardware selected and built in at time of order. With multi-mode recording and ability to make high speed, high accuracy measurements, both IED families provide information necessary to analyze:

- Network faults such as short circuits, underfrequency, over/under voltage, etc.
- Reactions of the protective devices
- Dynamic response of the network
- Long-term trends
- Substation equipment performance
- Sequence of Events time stamped to 1ms

70 Series serves SCADA metering and automation, control, and disturbance recording applications in the substation including PRC-002 compliance. The 70 Series IEDs can provide automation where electromechanical relays are still employed or can complement digital relays by providing additional recording capability while providing enterprise-wide access to important event files without jeopardizing the security of the protection system. The split-core CT option, described below, simplifies retrofit of 70 Series in these applications and removes the need for an outage.

Memory options up to 512 MB easily allow the recording and storage requirements of PRC-002-2 to be met. 70 Series IEDs provide features to reduce installation costs for faster PRC-002 compliance including:

- IEDs sized for single or dual line for maximum flexibility and scalability
- Wide-range temperature and universal power supply and wiring
- Flexible mounting
- Configurable ports and protocols
- Split-core CTs that don't require an outage to break into existing 5A circuits

The split-core CTs are available for the M571. Three individually calibrated, spring-tension mounted CTs are provided replacing the internal CTs. They are 5A nominal and linear to 100A and give the same accuracy as with the internal version.

70 Series Detached Displays
The 70 Series family of detached displays is available to provide local indication of measured parameters from the M87x and M57x IEDs.

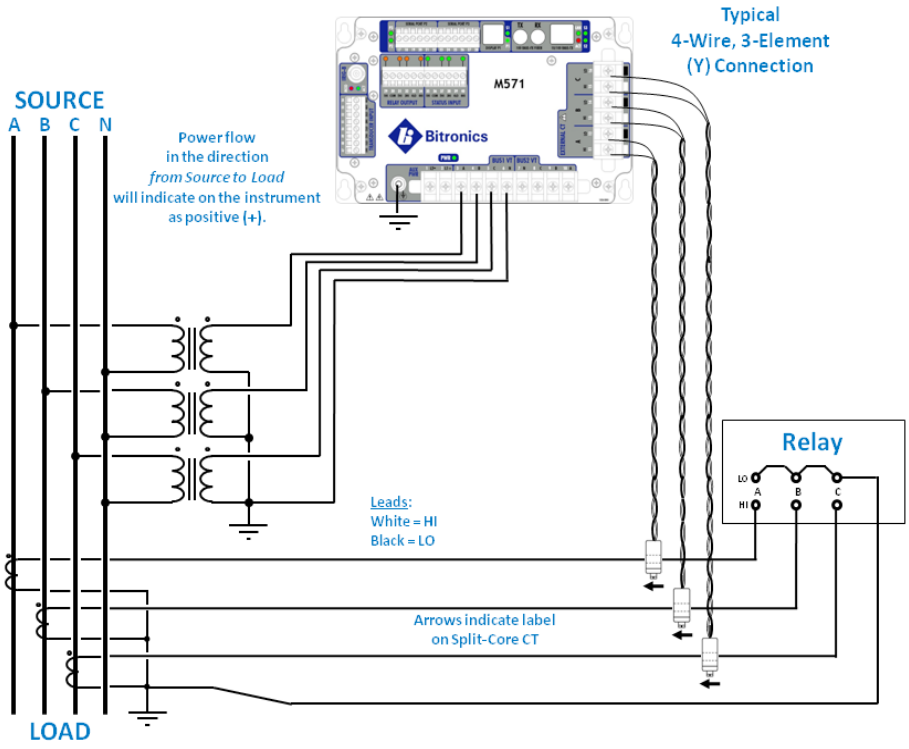
The M570DA is used exclusively with the M57x from which it is powered. The M570DA is mounted up to 15 meters from the IED.

The M870D is self powered, allowing up to 15 displays to be connected to a single M57x or M87x IED. M870D can be installed up to 1000 meters from the IED.

70 Series Software
70 Series application software is available for use with M87x and M57x family of IEDs.

70 Series utility software, which consists of the Configurator used for configuration and BiView used for commissioning and file retrieval, are included with any M87x or M57x IED order. Within BiView, the Retriever software allows the user to set up via a Windows task manager, automatic transfer and storage of record files. Selected record files can be automatically retrieved daily, weekly, or monthly, or immediately upon demand.

Wavewin® Bitronics® software is available for viewing and managing Comtrade record files.
This software is licensed from Softstuf, Inc.



Typical wiring of Bitronics M571 with Split-Core CTs in PRC-002-2 application

Summary: Bitronics 70 Series Compliance to PRC-002-2 Requirements

Bitronics 70 Series IEDs are compliant with PRC-002 existing and upcoming standards in all three recording areas. With memory option up to 512MB there is more than adequate storage to meet the required number of recordings. They offer the ability to record both the time sync status as well as the time sync error for the DDR. The biggest advantage for a 70 Series recorder is as a one-unit-per-line device it can be retrofitted into existing substations much more easily and cost effectively than adding a full-size DFR. The following table summarizes the requirements and Bitronics 70 Series compliance.

PRC-002-2 Requirement for SOE Equipment

Requirement	Reference	Compliance	Notes
Record opening and closing of breaker auxiliary contacts	R1, R2	✓	Up to 48 digital inputs per line using M871
Record the time stamp to within four milliseconds of input received for change in circuit breaker position	R3	✓	Input Delay Time (from terminals): <100µs

PRC-002-2 Requirement for Fault Recording

Requirement	Reference	Compliance	Notes
Record 3 phase-to-phase or phase-to-neutral voltages on monitored line or bus or on Generator Step-up (GSU) transformers	R4.1, R5.1, R5.4	✓	Each IED can record all three phases on a line. M87x can record neutral current, M57x records residual. Mx72 can record two 3-phase lines.
Record three phase currents and the residual or neutral currents of each monitored line and transformer or on Generator GSU transformers	R4.2, R5.2, R5.3	✓	
Record at least two cycles of pre-trigger data	R6.1	+	Pre and Post-trigger record configurable up to 2000 cycles.
Record post trigger of at least 50 cycles or first three cycles of an event and the final cycle of an event	R6.1	+	
Record at a minimum rate of 16 samples per cycle	R6.2	+	128 samples per cycle typical, 256 samples per cycle max.

PRC-002-2 Requirement for Dynamic Disturbance Recorder (DDR)

Requirement	Reference	Compliance	Notes
Record voltage and current from at least one phase (on the same phase) for all transmission lines at 200 kV or above	R7.1, R8.1, R9.1, R10	✓	Each IED can record all three phases on a line. M87x can record neutral current, M57x records residual. Mx72 can record two 3-phase lines.
Record at least one phase-to-neutral or phase-to-phase voltage of the high or low side for each GSU transformer and at least one phase current (same phase as voltage)	R7.3, R8.3, R9.1, R10	✓	
Record frequency (at least one at the required substation)	R7.2, R8.2, R10	✓	
Record power and reactive power (MW and MVAR) on a three-phase basis (per each monitored line or transformer)	R7.4, R8.4, R10	✓	
Sample data at a rate of at least 960 samples per second to calculate RMS electrical quantities	R9.2, R10	+	7680 samples per second (60 Hz) used for all RMS calculations
Store calculated RMS values of electrical quantities at a rate of at least 6 times per second	R9.3, R10	✓	Resolution configurable up to 10 times per second
Fault Recording and DDR data must be capable of being viewed and analyzed as COMTRADE (IEEE Std. C37.111-1997 or successor) files	D1.5.1	✓	Stored in Comtrade format on IED. No off-line conversion required.
Data files shall be named in conformance with IEEE C37.232, Recommended Practice for Naming Time Sequence Data Files	D1.5.1	✓	

Customer Experience Using 70 Series for PRC-002

In 2009 Baltimore Gas & Electric (BGE), completed Disturbance Monitoring Equipment (DME) installation at Graceton substation. This project was part of BGE's overall plans to address NERC Standard PRC-018 requiring all transmission owners have or install DME in accordance with the Regional Reliability Organization's (PRC-002) requirements.

Goals of the Graceton project were to design and install a system that would not only meet the PRC-002-RFC requirements, but also realize design templates for future DME work and address some aging infrastructure issues.

The basic project achievements included:

- Met the PRC-002-RFC-01 requirements.
- Created templates for future DME work.
- Reduced physical control wiring.
- Reduced aging infrastructure and maintenance.
- Installed a distributed recording solution that cost less than a conventional approach.

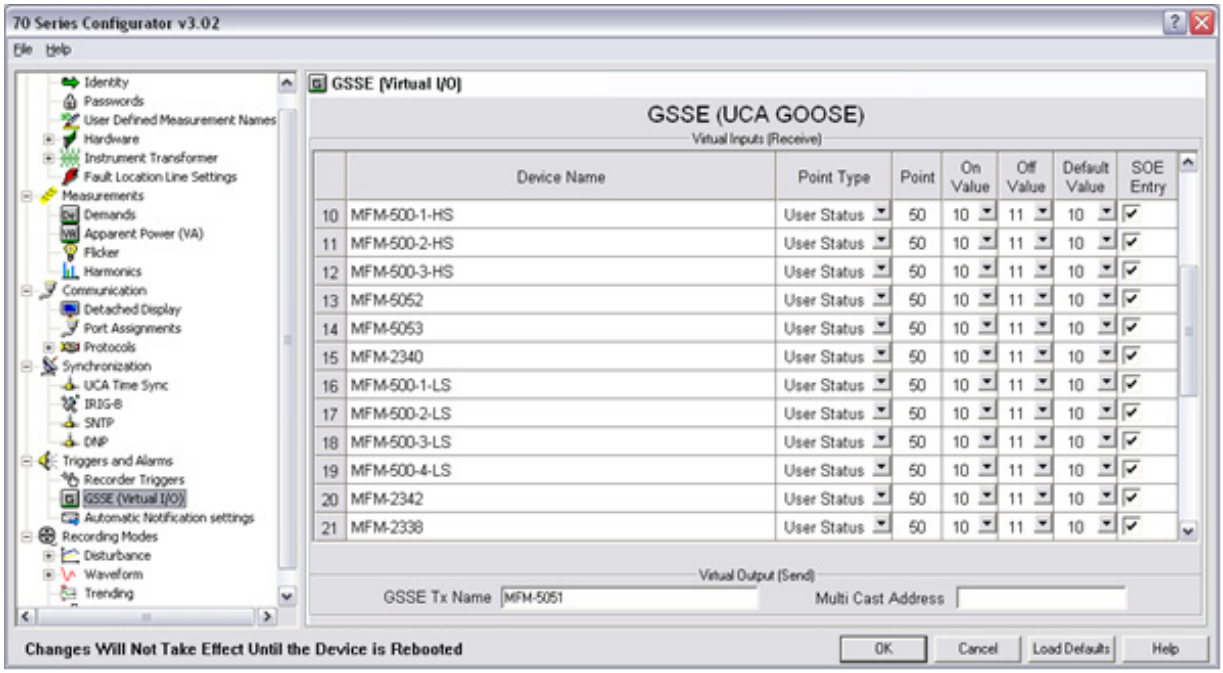
BGE falls under the Regional Organization sanctions of Reliability First Corporation (RFC). Their standard PRC-002-RFC-01 requires that DME be installed to monitor three-phase currents, three-phase potentials, and breaker status on all lines and transformers in substations 200KV and above. Installed DME must be capable of digital fault recording (DFR), dynamic disturbance recording (DDR) at locations meeting specific criteria, and sequence-of-events (SOE) recording.

The Graceton Substation is a 230 KV substation which terminates four transmission lines and a 230/115 KV transformer and was therefore affected by this standard. Graceton Substation did not have any DME equipment installed and design concepts were put forth to address the issue.

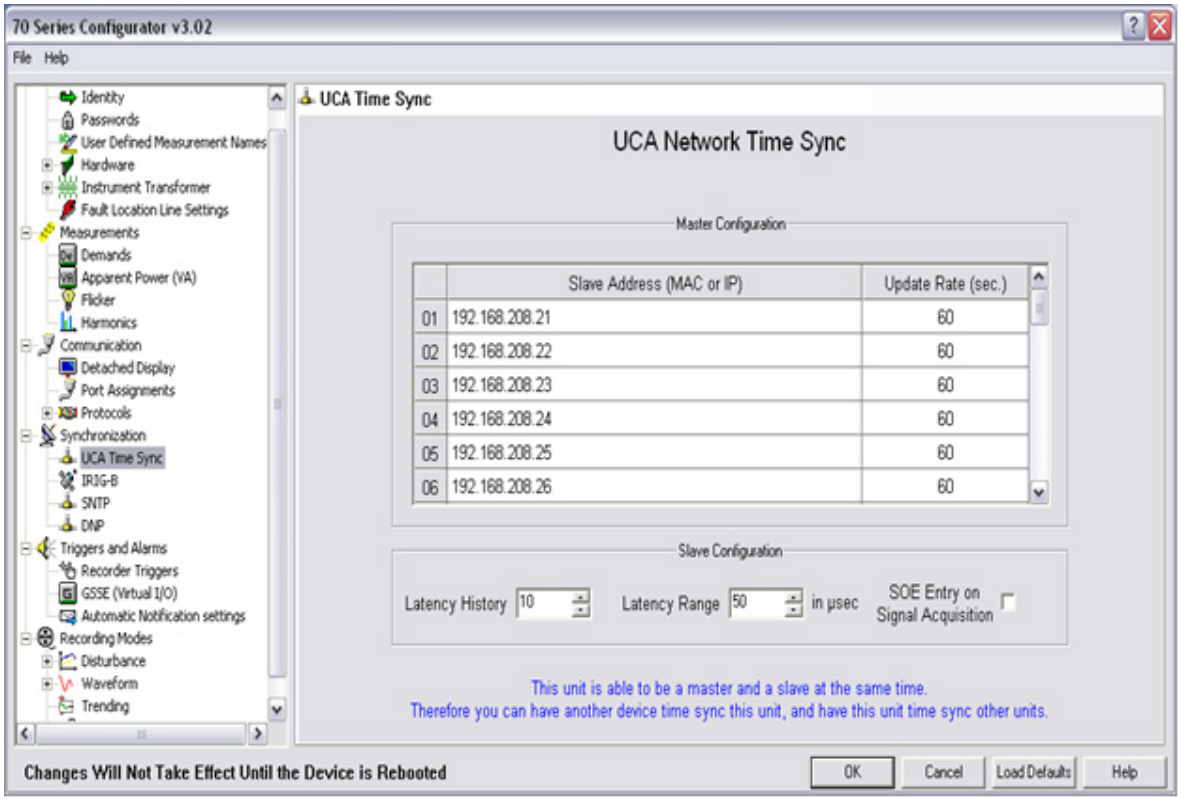
The team approach to resolving the PRC-002-RFC requirements was unique in that it chose a design concept of distributed recording, where multiple pieces of installed equipment were linked together via communications to form a complete recording system.

The equipment selected was Bitronics 70 series IEDs (M871 and M571) which were installed on every line circuit. To use the IEDs in distributed recording each IED was connected to an Ethernet switch allowing communication of GSSE (UCA GOOSE) messages. If an IED recognized a system event it would cross trigger all other IEDs to record at that instant, thus capturing all power system reactions at the substation.

Bitronics M571 recorders used for PRC-002 compliance mounted in back of cabinet

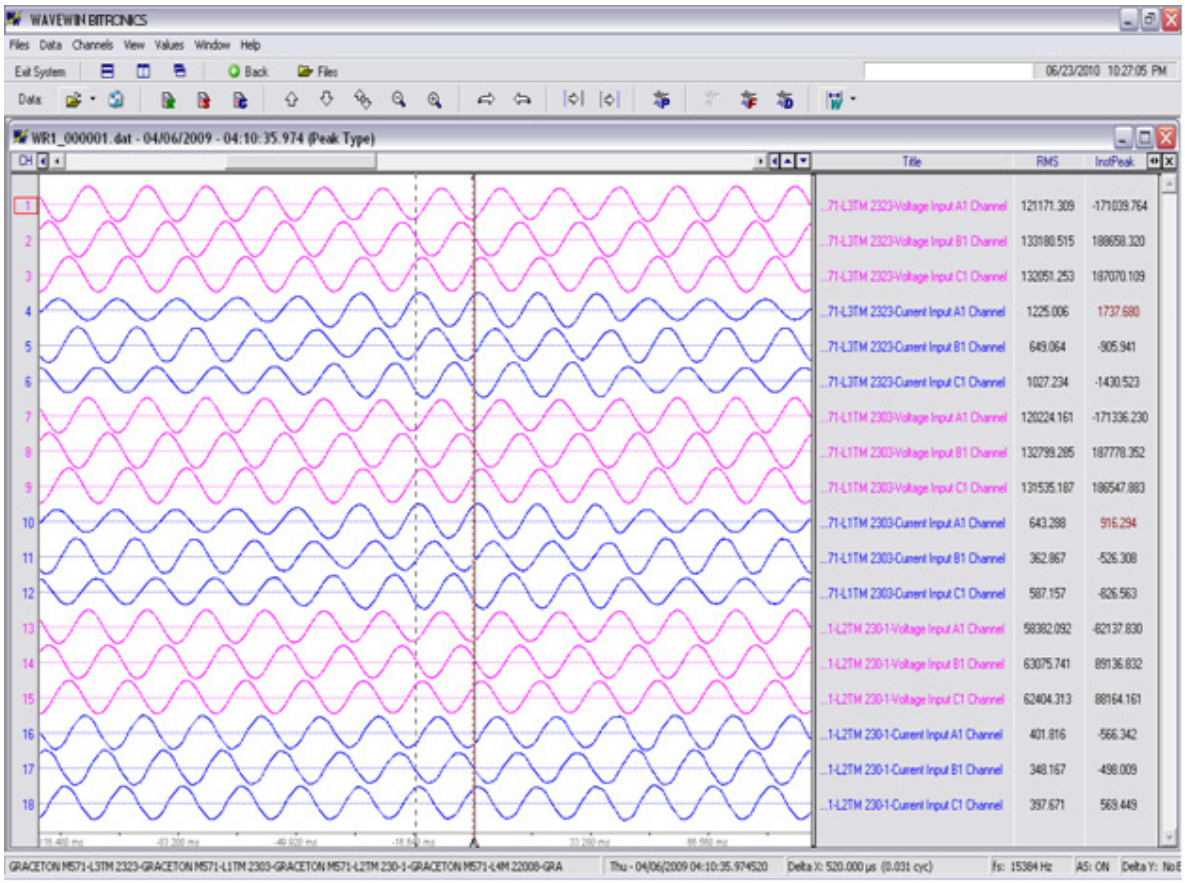


Setup of virtual inputs for GSSE (UCA GOOSE) cross triggering



Setup of UCA Network Time Sync which allows one IED to act as a time sync master

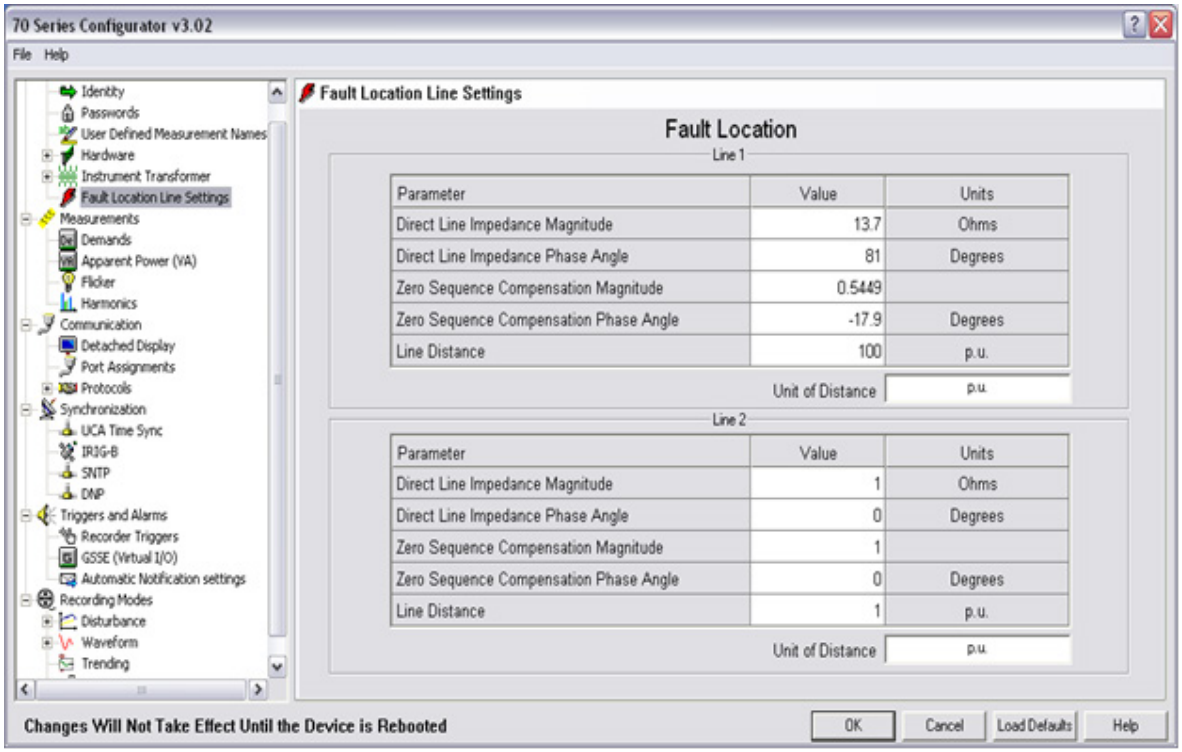
Part of the project required a mechanism to retrieve the individual meter records and compile the information. BGE installed a secure work station that used vendor supplied software. The software allows the downloading of records and the sinusoidal traces of a recorded event from a group of meters can be combined to form a DFR view of the event at the station.



Combined waveform capture from multiple 70 Series IEDs

Implementing the integrated design and commissioning the equipment went seamlessly in very little time due to careful planning and the use of developed setting templates.

Other highlights and benefits included the ability to report fault distance on the transmission circuits back to the control center saving analysis time. The installed IEDs also allowed BGE to retire aging analog transducers, upgrade reported analogs to three phase digital readings and report billing metering on two of the interconnect lines.



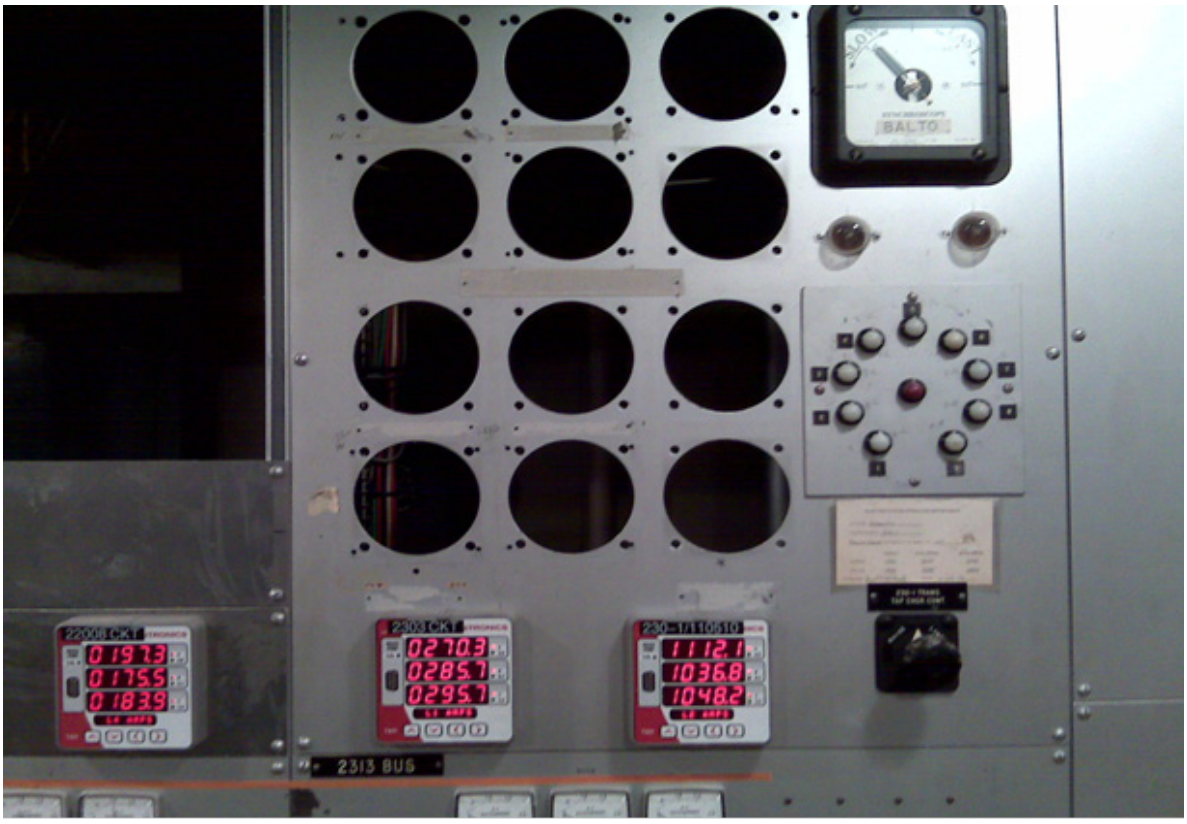
Fault Location setup in 70 Series Configurator

BGE realized savings by not installing expensive DFR equipment in using the distributive recording approach and enhanced station metering as an additional benefit.

Cost Reductions

The innovations detailed in the previous section led to reductions in field labor and time. The DME project has been received well by BGE field personnel saving maintenance costs by replacing analog transducers and meters with digital equipment thus extending maintenance intervals. The distributed fault recording design has also saved thousands of dollars compared to installing a conventional digital fault recorder solution.

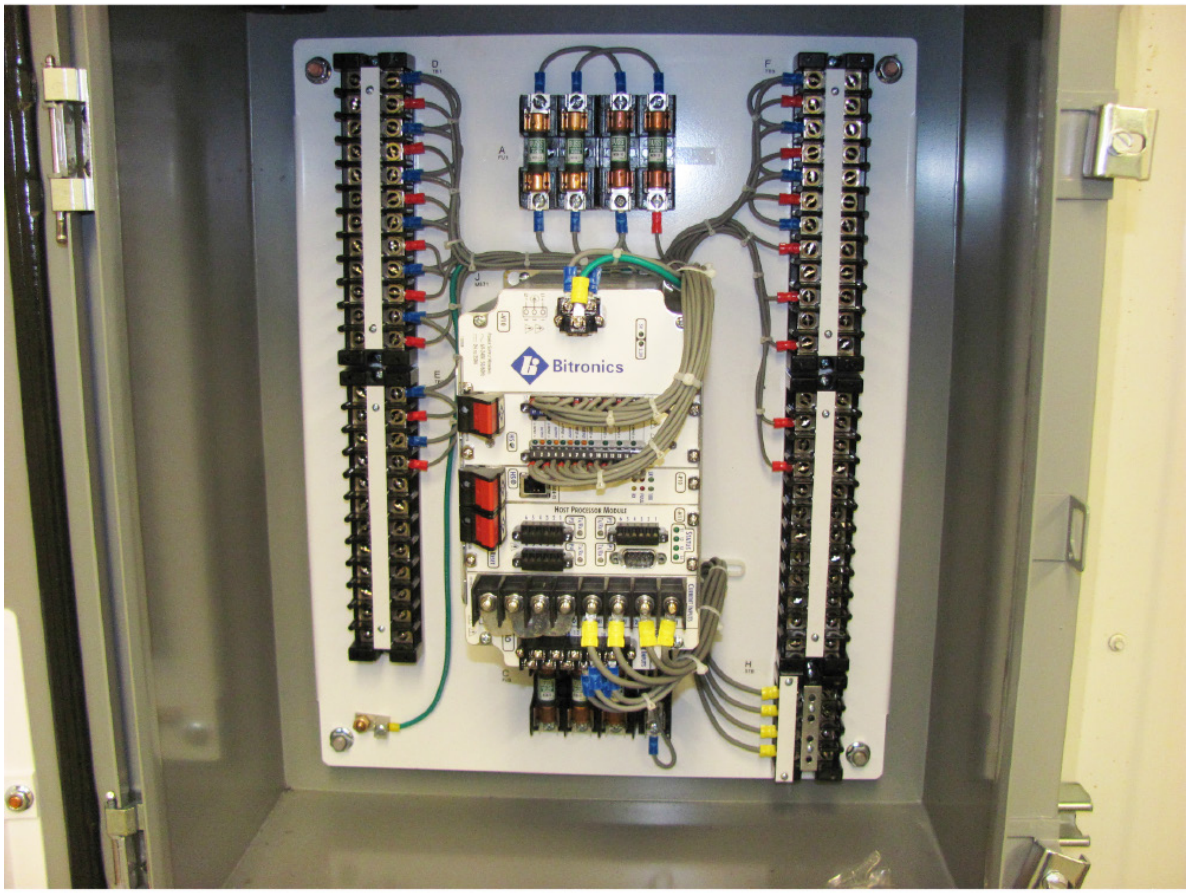
- Substation Equipment Enhancement – The new DME equipment that was selected, the Bitronics 70 Series, has enhanced substation metering. The upgrade from analog to digital has provided more accurate metering for both local and remote reporting. The functionality of the equipment also allows for fault distance reporting on the transmission circuits, saving some up front analysis time.
- Reduction of Aging Infrastructure - BGE's integrated design and carefully selected equipment has allowed the retirement of analog metering transducers and analog meters within the substation.



70 Series Installation allowed removal of analog metering

PRC-002 Solution for Natural Gas Plant

Recently, Exponential Engineering of Fort Collins, CO was asked to develop a PRC-002 compliant solution for an 800 MW natural gas plant in Texas. They utilized the M871 in a Hoffman enclosure as shown in the picture below.

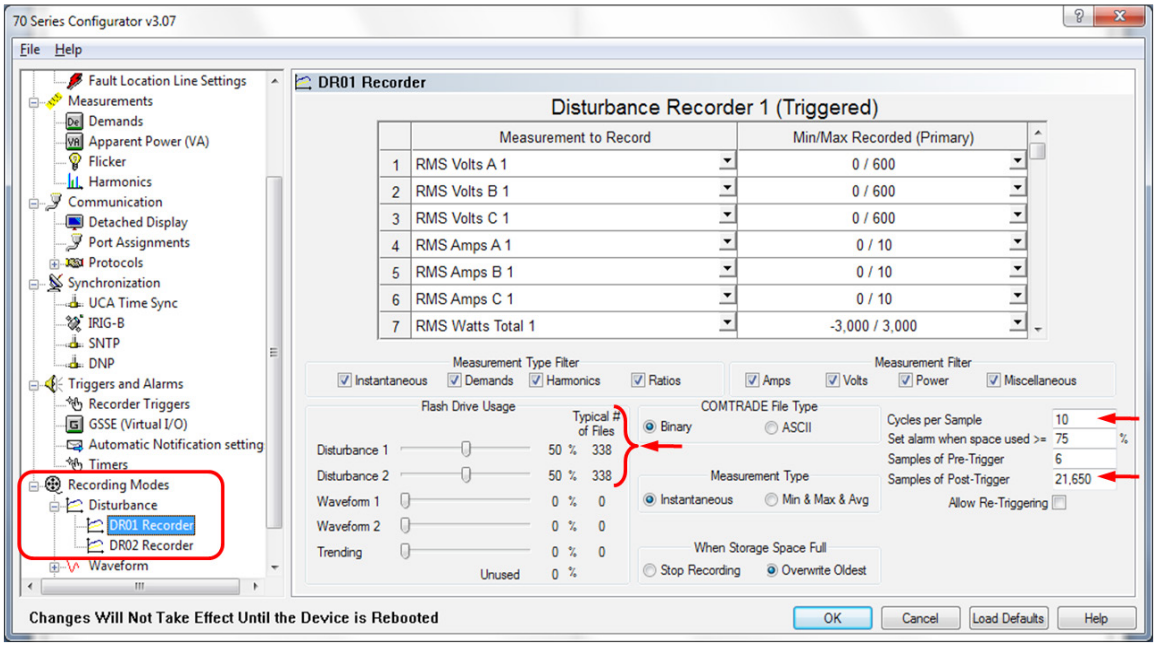


Exponential Engineering design of single line DME for PRC-002

Example Configuration

How does the DDR work?

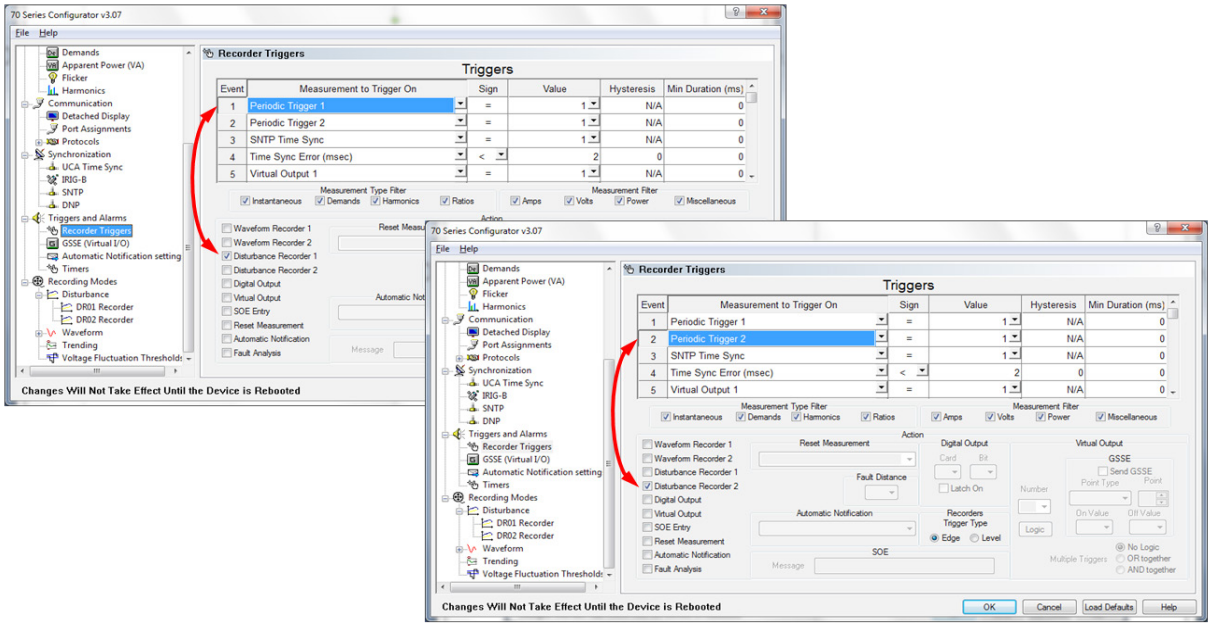
DDR uses both *Disturbance Recorders* (DR1 and DR2)



Configuration of the Disturbance Recorders used in the DDR

1. DR1 and DR2 alternates recording during successive hours. This is done to avoid any loss of data during the time when one recorder would end and the other start. Manageable files of one - two hours each are created, making locating fault files simpler.
2. The resolution of 10 Cycles per Sample (see arrow) at 60Hz produces six samples per second on the recording required by PRC-002.
3. Each RMS measurement is calculated by a Digital Signal Processor operating many times faster than the minimum sample rate needed for PRC-002 compliance.
4. A record Length of 21,650 samples (see arrow) at 6 samples/sec = 1 hour plus a few seconds of overlap at each hour transition between recorders.
5. Ten days of on-board storage (the PRC-002 requirement) of 24 one-hour-long recordings requires a capacity of only 240 files. The recorder in the above image is indicating 338 DR1 + 338 DR2 records = 28 days capacity on a 256MB CF card. A 512MB CF card is also available if more memory is desired.

DR1 and DR2 alternate by using "Periodic Triggers" which were added to accomplish a continuous 7x24 recording

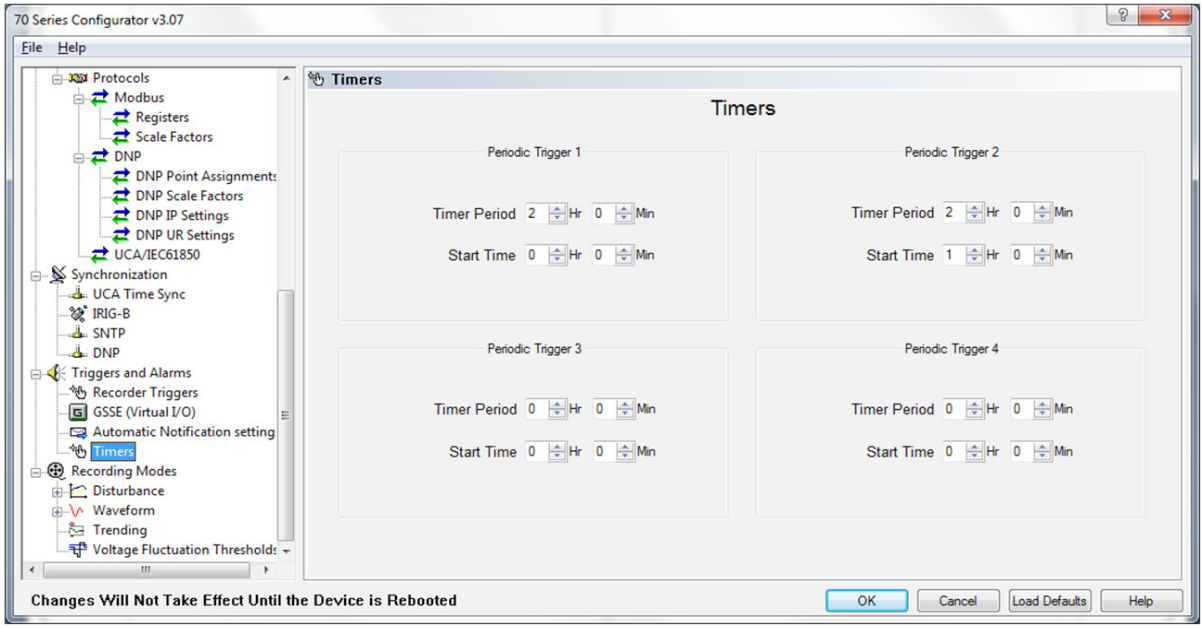


Use of Periodic Triggers for continuous recording

DR1 and DR2 run in alternate hours in order to insure no interruption in data at the transition between the end of one record and the beginning of the next.

One-hour-long records occupy about 200kB of memory each and are a convenient interval length because of the time it takes to download files, the ease of locating exactly the recordings that are of interest, and because the performance of most commercial Comtrade viewer software (such as Wavewin) begins to suffer if more than a few hours are appended into a single continuous record.

Four independent Periodic Triggers are provided.
Only two are required to accomplish the DDR function.



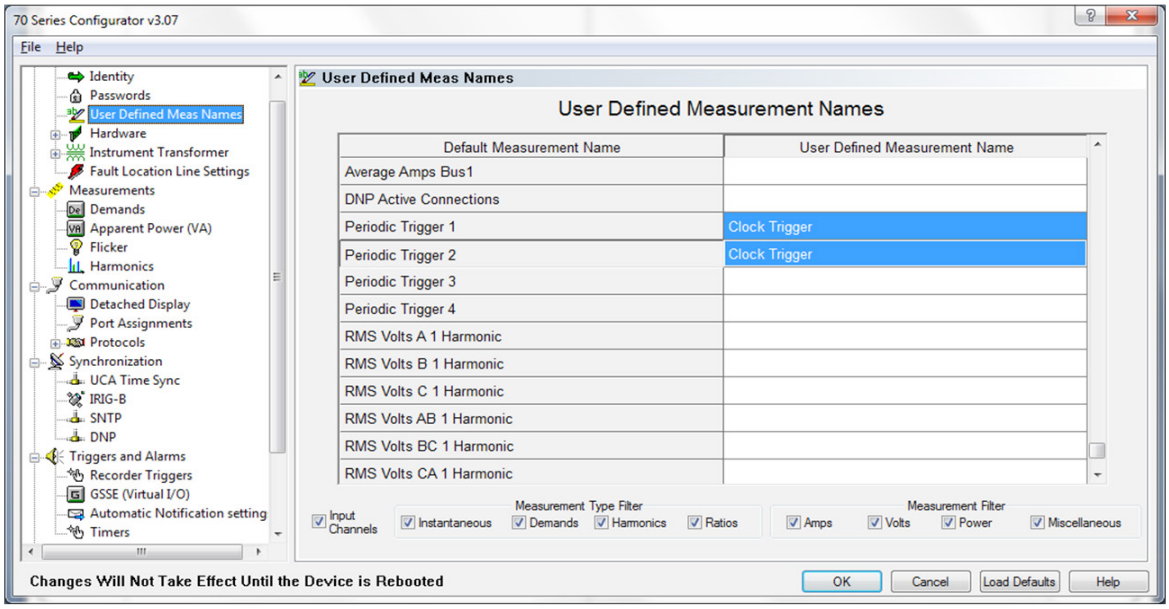
Two Timers used for DDR staggered by one hour

On the preceding page we saw that Periodic Trigger 1 initiates DR1 and Periodic Trigger 2 initiates DR2. The image above shows how the two periodic triggers are configured.

Periodic triggers operate as a "soft" binary point that changes state, dwells for about ten milliseconds, then returns to its initialized state.

Observe how both triggers have a two-hour interval, that is, they fire every two hours, but the start times are staggered by one hour, so the one trigger operates in each alternate hour.

By assigning the same name to PT1 and PT2, the Disturbance Records DR1 and DR2 can be appended into multi-hour continuous recordings

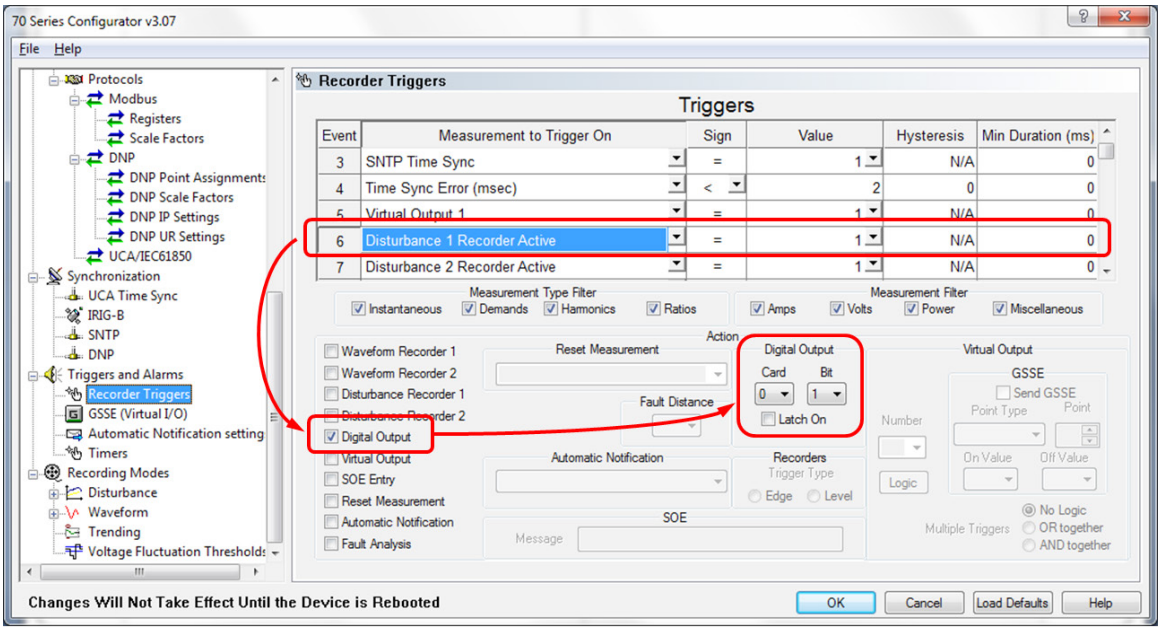


Using Defined Measurement Names makes it easier to append separate records

The trigger (either PT1 or PT2) appears as one of the binary traces in each Comtrade file. That is PT1 appears in each DR1 file and PT2 appears in each DR2 file. Since the same trace has a different name in DR1 and DR2, the two recordings would not normally be able to be appended by most Comtrade viewer software (like WaveWin). But by manually assigning the same name to both traces, users can string together up to four Comtrade files into a single contiguous recording.

Note, because of the large amount of data, the smooth performance of Comtrade viewer software can be degraded by appending more than a few one-hour-long records together.

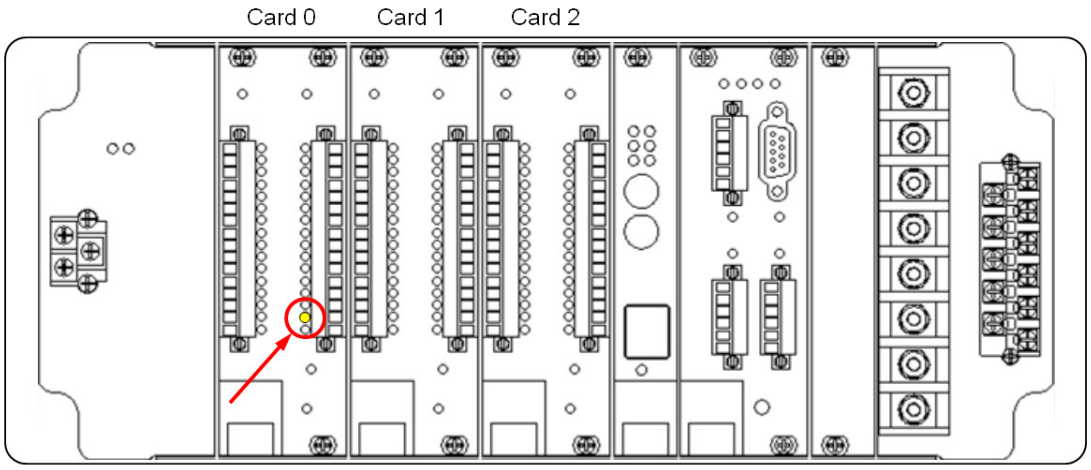
Logic (1): Local indication that the recorder is active.



Setting up digital output for visual evidence that recorder is active

Local indication (LED lights on front of M871 unit) is optional, but very useful feedback for operators.

Logic (1): Local indication that the recorder is active.

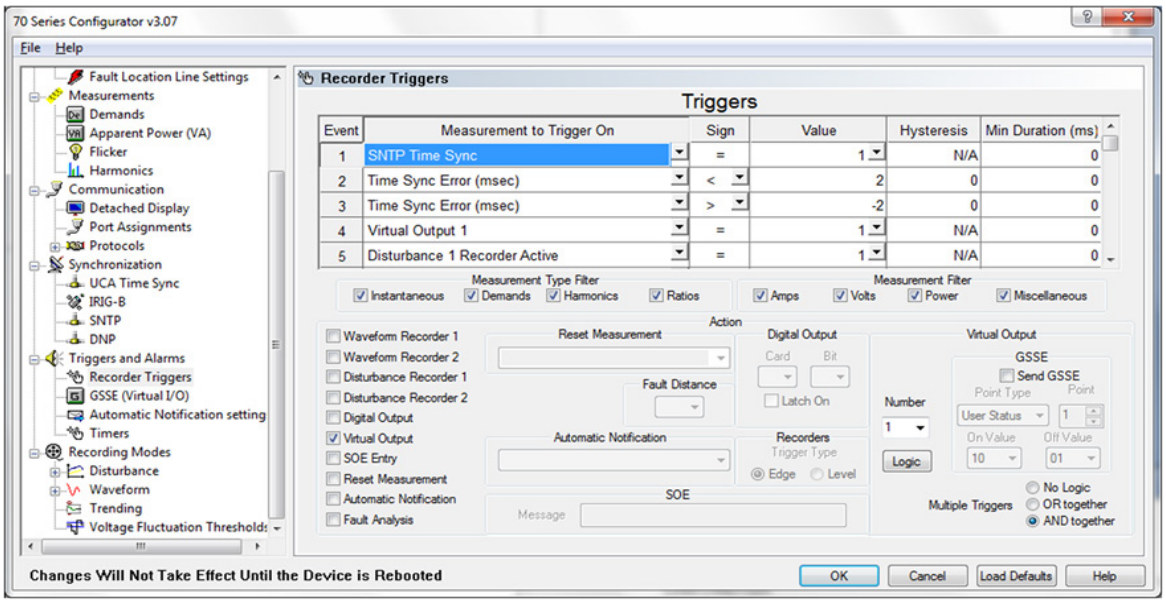


Card 0, Output 1 = DR1 is active

Card 0, Output 2 = DR2 is active

LED on Digital I/O Module indicates that DDR is functioning

Logic (2): Local indication of time sync status.



Using AND Logic to determine time sync is active and within spec

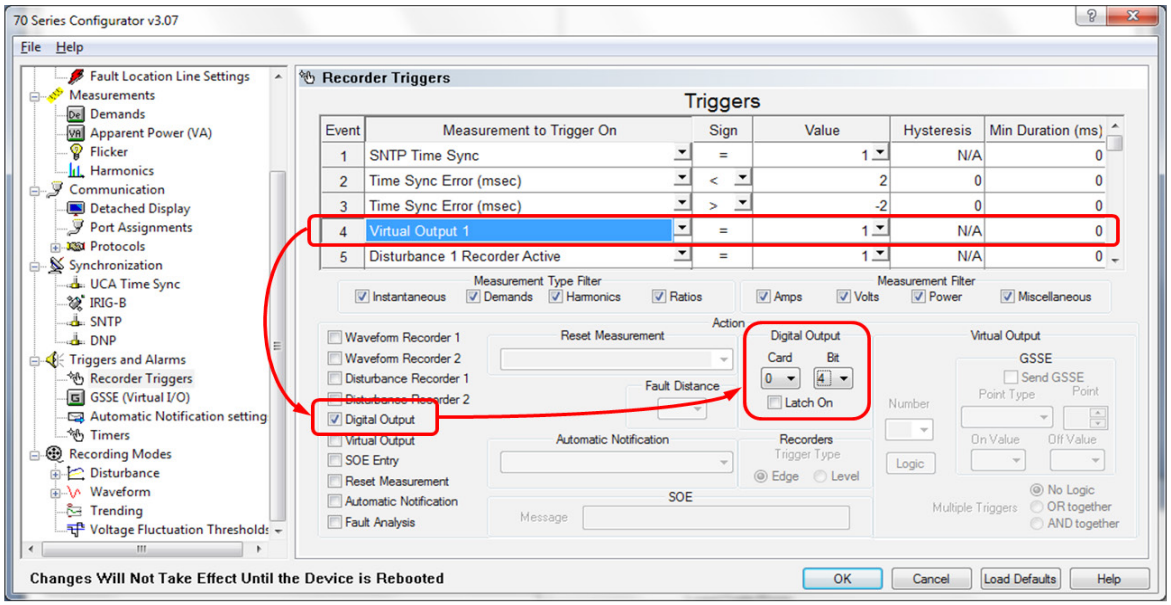
Event 1 is a binary condition that indicates when an SNTP server is connected and the M871 is receiving a valid signal (does not distinguish accuracy of the server).

Events 2 and 3 are analog measurements that measure the difference between the clock on the SNTP server and the clock on the M871. PRC-002 requires time sync to be +/-2ms or better.

Event 1, 2 and 3 all have the same configuration: Virtual Output 1 will operate only when the AND logic is satisfied.

On the next page, the results of Virtual Output 1 operating is described.

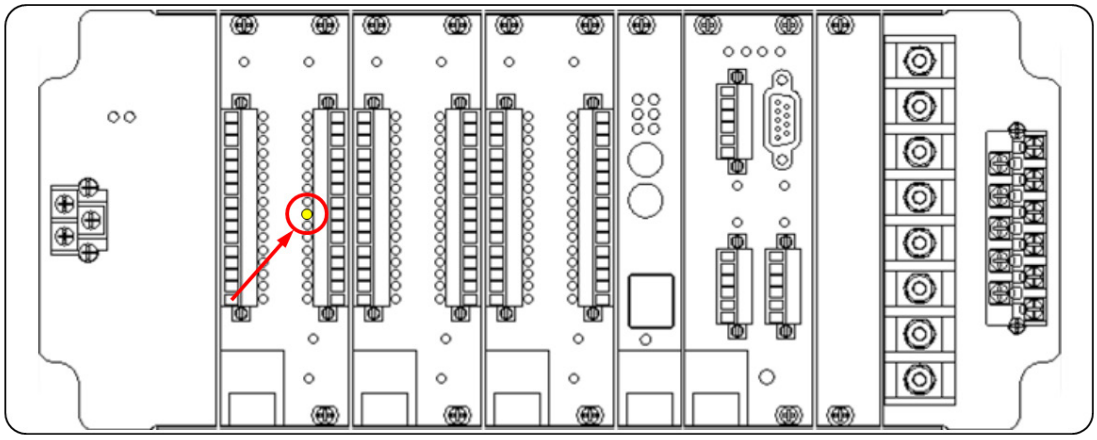
Logic (2): Local indication of time sync status.



Setup for local indication of time sync status

When the AND-logic is satisfied, Virtual Output 1 operates, causing the Digital Output 4 on Card 0 to operate, closing the contact and illuminating an LED for positive indication the clock on the M871 is synchronized with the SNTP server.

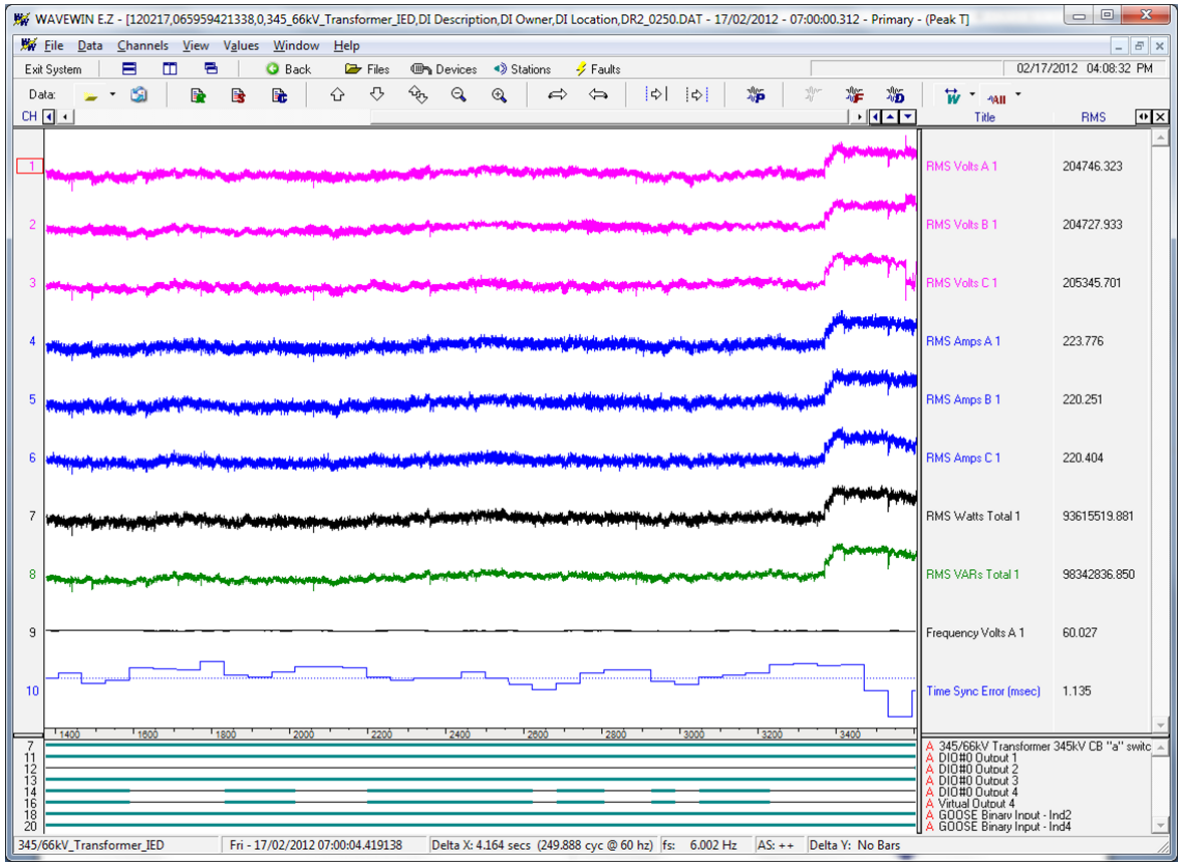
Logic (2): Local indication of time sync status.



Card 0, Output 4 = SNTP is active AND $\triangle t < 2$ms.

LED showing time sync active and within spec

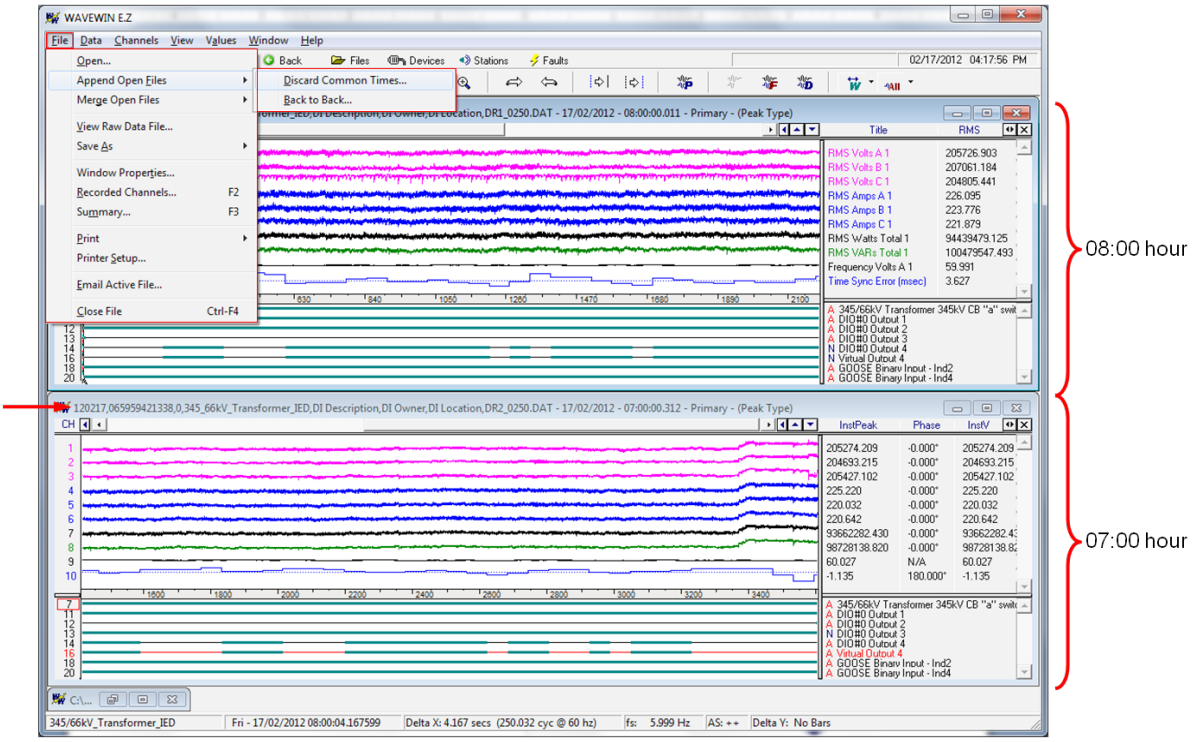
What does it look like?



Single record of nine measurements required in DDR plus status points

Note the following:

1. Traces are RMS, not oscillographic: it's a DDR, not a fault record.
2. Digital Trace #16 is the sync status, the virtual output that represents the result of the AND-Logic described in the previous page. Trace #14 mimics #16 because we are using the virtual point to drive a digital output contact (lights an LED on the panel) as an outward indication of sync status.



Appending DDR records in Wavewin

Using WaveWin® software, successive records can be appended by opening both files and selecting "Append Open Files" under the File menu.

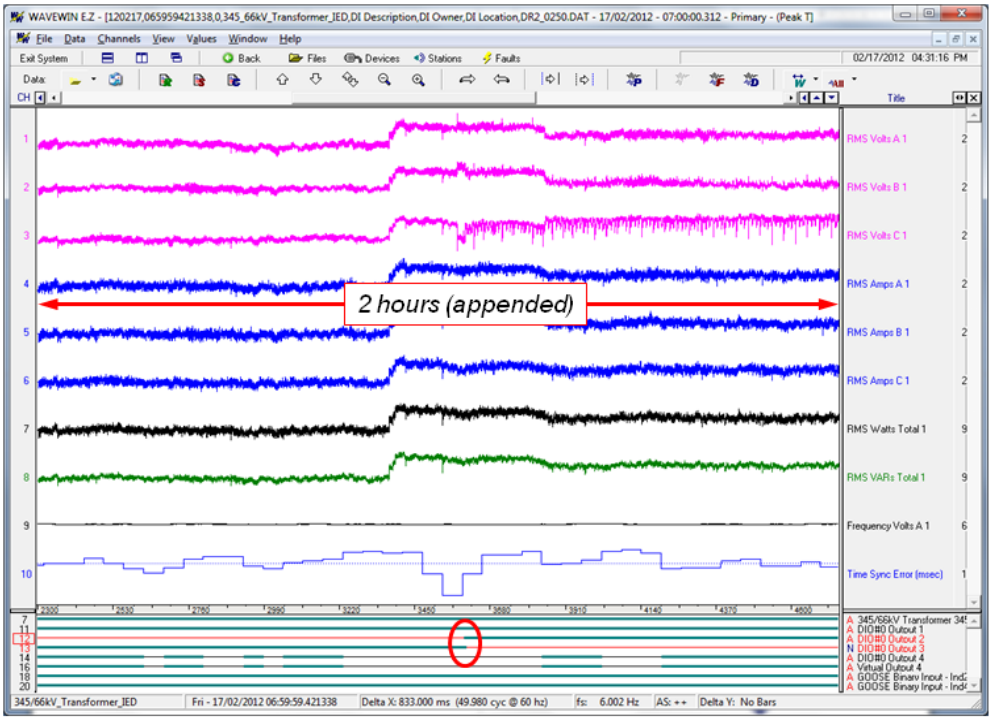
Note the use of the long file naming convention (file name of the lower recording is 120217,065959421338,0,345_kV_Transformer_IED,DI Description,DI Owner,DI Location,DR2_0250.DAT):

120217 = 2012, February 17

065959421338 = 06:59:59 (other digits take time-stamp down to the microsecond)

0 = time zone (not supported)

Other fields are populated from the Identity page in the Configurator



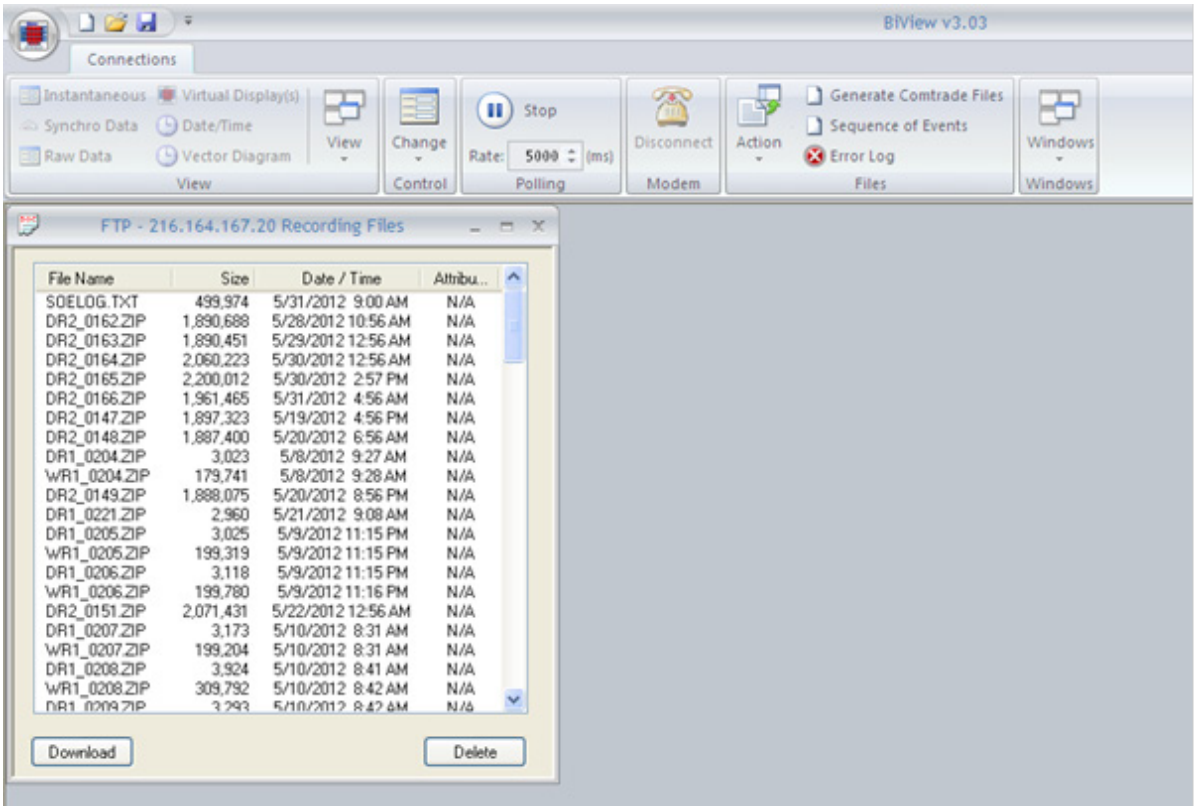
Appended DDR records in Wavewin

The result of appending 2 one-hour-long disturbance recordings. See the status change from Digital Output 13 (on to off) to Digital Output 12 (off to on) in the center of the screen capture at 08:00, with the 8-second overlap removed.

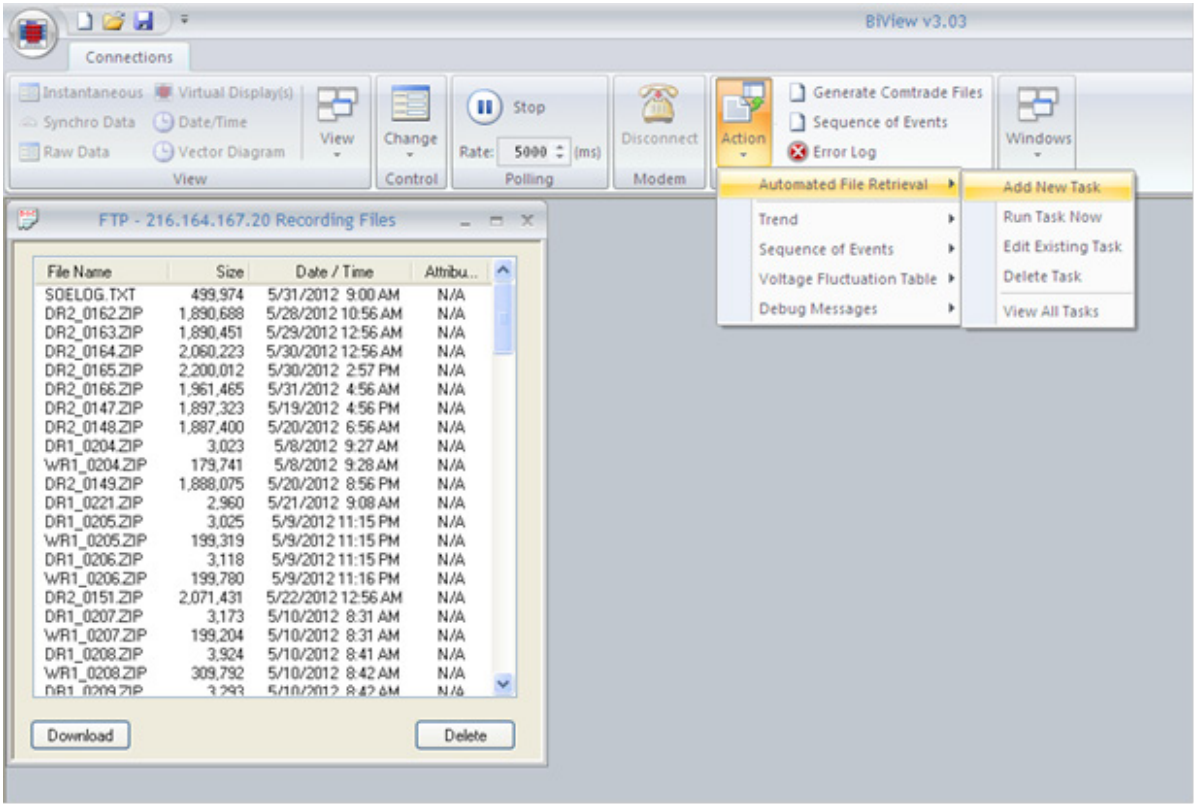
Incidental: Trace 10 is of some interest: See how the time sync error rises and falls, with occasional losses of sync (when trace #16 =0). This occurred because we used an internet-connected SNTP server in the demo. In a real substation with a clean network from the SNTP server to the recorders, trace 10 would be pretty flat, but this illustrates the functionality of the time-sync logic in use.

File Retrieval

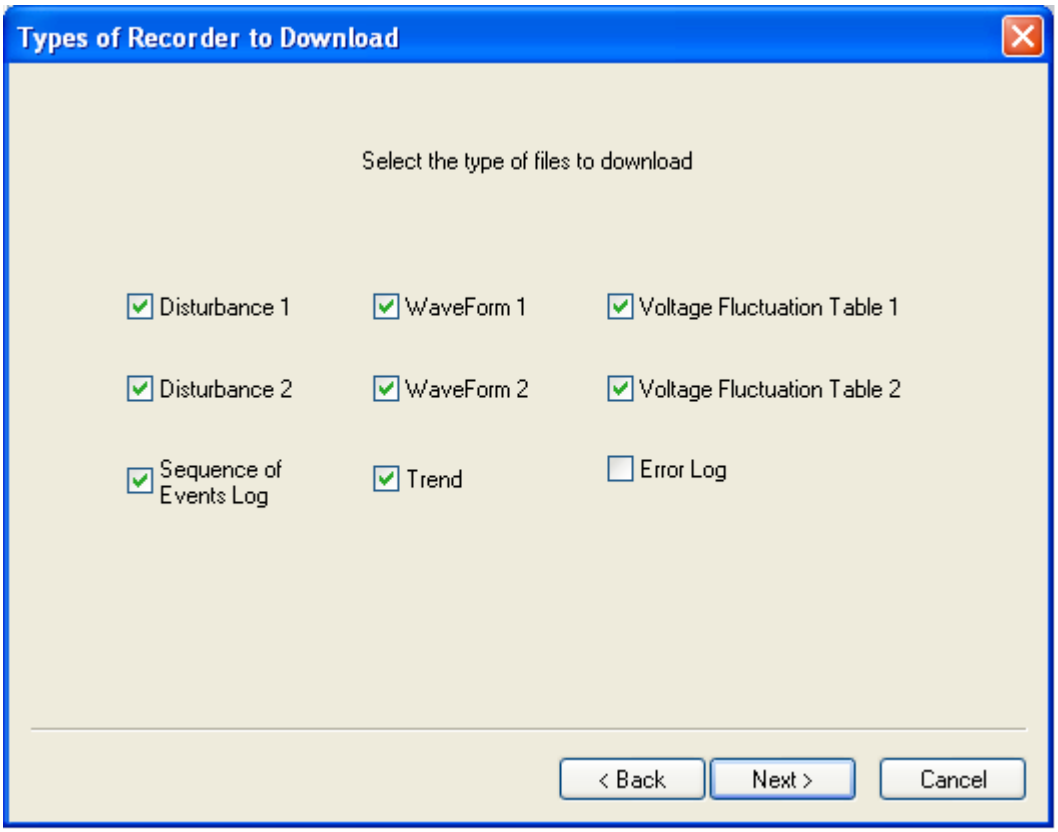
BiView and the Retriever function within BiView can be used for manual or automatic file retrieval of SOE, Waveform, and Disturbance Records required to meet PRC-002.



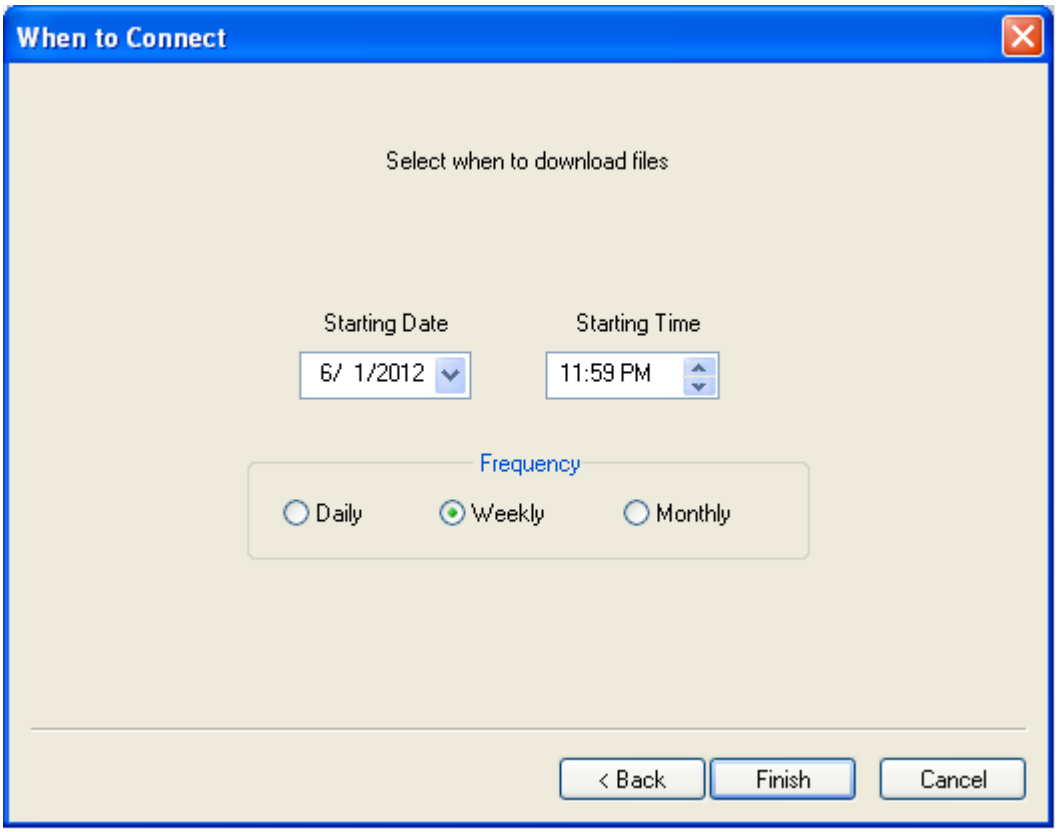
BiView connecting to 70 Series for manual file download



Using the Automated File Retrieval (Retriever) function within BiView



BiView Retriever allows you to select the record files you want to download



BiView Retriever lets you select the time/date and frequency to automatically download record files

NovaTech Utility Systems and Services

Overview and Capabilities

NovaTech has been successfully designing, delivering, and supporting utility systems and services for over 30 years, including custom panels and installation services for Bitronics instruments. The Utility Systems and Services staff in Lenexa, Kansas includes project engineers, SCADA engineers, panel assemblers, software engineers, quality engineers and training instructors. The Lenexa staff works with other NovaTech locations – in Bethlehem, PA; Owings Mills, MD; Aiken, SC; Shelby, NC and Quezon City in the Philippines - to coordinate field installation and commissioning.

Our 37,000 square foot facility in Lenexa features a professionally designed climate controlled manufacturing area, state of the art testing laboratories, and fully equipped engineering areas.

Systems and Engineering Services:	Support and Training Services:
Programmable Logic Controller (PLC) Engineering • Logic generation, testing, and documentation • Mounting and wiring **SCADA and HMI Engineering** • Conventional (PC-based) and Web-based SCADA • Database generation • Communications engineering • HMI screen development • RTU engineering • Project Engineering **Distribution Automation Systems Engineering** • Configuration for fault isolation and restoration • Configuration of load checking logic • Simulation and testing • Communications / radio engineering • Project Engineering **Radio Systems Engineering** • Site survey • System design • Coordinate work with installation contractor **Electrical Mechanical Relay "Upgrade"** • Services to configure, install, and commission Bitronics instruments alongside E/M relays to provide SCADA and recording. **Onsite Installation and Configuration Services** • Work with Utility personnel to install Bitronics and Orion products • Perform point-by-point checkout • Debug communications systems **.001Hz Certification Service** • To satisfy NERC requirements for generation sites • Return Bitronics instrument for testing and certification	**NCare Services Agreement** • Training and support • Annual protocol licenses • Extended life-cycle • Universal configurations • Supply Chain and procurement programs **Educational Services** • Customized Training • Conducted on-site or at one of our training locations • Technology Courses *Product Courses* • Orion Automation Processor • Distributed I/O Products • Bitronics 70 Series IED *Application Courses* • SEL® Relay Integration • Email • Math and Logic • Webpage Design • SER and Alarms Configuration *Technology Courses* • Ethernet in Substations • DNP3 • Serial Communications

About NovaTech

NovaTech designs and manufactures power measurement, communication, and automation products including the Bitronics® Instruments, Orion Substation Automation Platform, and the D/3® Distributed Control System. NovaTech has experienced solid growth as a result of our commitment to customer service, innovative products, and a level of customization unmatched by the competition. With global presence and over thirty years of experience, we are proud to be a trusted resource to clients in electric utility T&D, smart power distribution, agriculture, brewing, pharmaceuticals, bio-sourced and specialty chemicals, plastics, metals, and other essential industries. For additional information about NovaTech, LLC, please visit www.novatechweb.com.

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