EXPERIENCE.
KNOWLEDGE.
INSIGHT.

SOLUTIONS BUILT ON A CENTURY
OF INNOVATION AND EXPERTISE.

DOBLE ENGINEERING COMPANY

doble®

SOLUTIONS

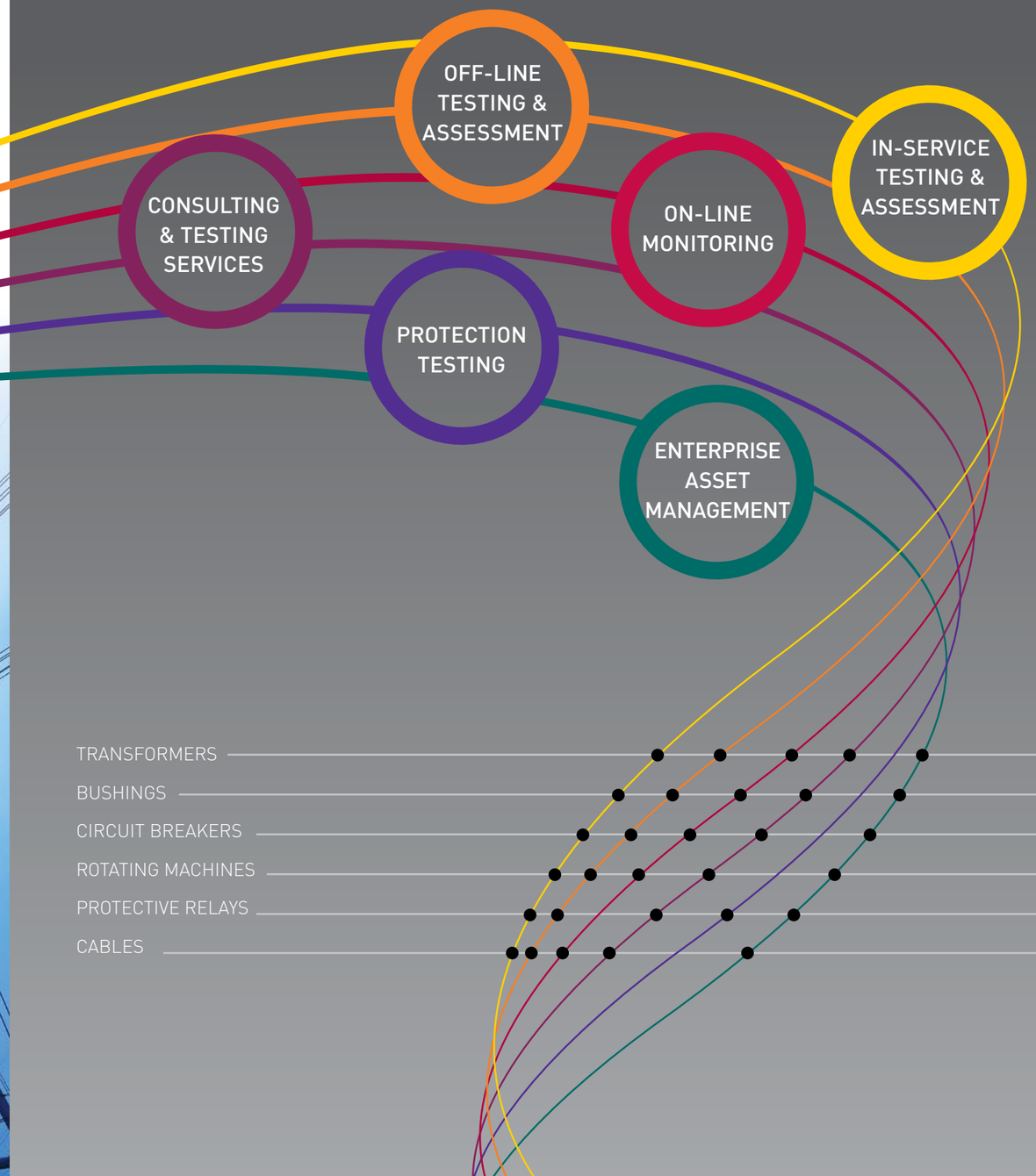
OPTIMIZE OPERATIONS WITH DOBLE SOLUTIONS

You need to understand the condition of your assets. Doble understands the way you work, and we build our diagnostic test equipment and software solutions to suit your operations and testing practices. Our role is to simplify the complexity you face and we do that by offering testing solutions for critical assets and scaling up through enterprise level solutions. Whether you need one testing device, several substation monitoring platforms, or a comprehensive risk management system, Doble has the answer.

PROVIDING FLEXIBILITY FOR YOUR OPERATIONS

Doble provides flexibility for your business, with solutions and service levels that fit your procurement models. So now you can invest capital resources wisely across the asset ownership cycle.

DOBLE'S RANGE OF SOLUTIONS FOR ALL YOUR ASSETS



- TRANSFORMERS
- BUSHINGS
- CIRCUIT BREAKERS
- ROTATING MACHINES
- PROTECTIVE RELAYS
- CABLES

PROTECTION TESTING

PROTECTION SOFTWARE SOLUTIONS

Whether you are testing electromechanical relays or state-of-the-art, IEC 61850 designs, Doble has the software you need to verify system protection.

Our office and field software options help you verify any protection and control circuit and simulate system conditions. Options are flexible so you can customize your testing program and adhere to your company's practices and procedures, while meeting regulatory requirements. Choose which combinations make sense for your organization.

PowerBase

PowerBase is the premier application for administrators to manage and report on protection asset maintenance and engineering records.

PowerBase is the core piece of your protection testing program: manage your workflows, connect with existing work management systems, automate activities, eliminate manual processes, maintain compliance and optimize efficiency within your organization.

CLIENT/SERVER DATABASE APPLICATION

Numerous workstation computers run PowerBase simultaneously from a single database that operates on a local or Doble-hosted server.

VENDOR-NEUTRAL DATABASE THAT HANDLES ANY POWER SYSTEM ASSET

PowerBase tracks maintenance on relays, CTs/VTs, breakers, transformers, batteries and any other asset. PowerBase features import and export modules for data transfer with other systems and testing tools.

SETTINGS MANAGEMENT WAREHOUSE

PowerBase houses and manages relay settings, allowing you to consolidate settings data from disparate applications, spreadsheets and files.

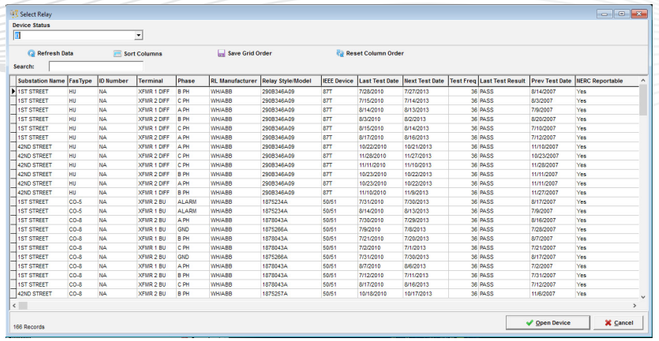
REPORT ENGINE

PowerBase features a powerful, user-friendly report generator. Reports can be configured to suit your business needs.

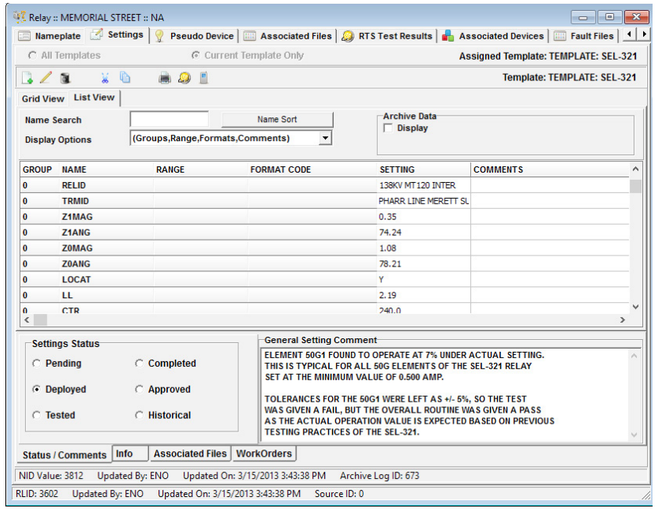
COMPLETE PROTECTION ASSET & COMPLIANCE DASHBOARD

Users can easily find information and see a dashboard presenting the whole maintenance picture. This is possible even with many workers and the variety of engineering and testing software products they use.

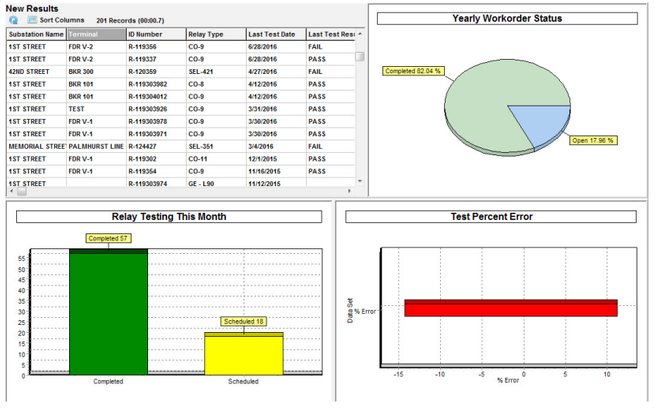
PowerBase is a product of ENOSERV, a Division of Doble.



DATABASE OF ALL ASSETS



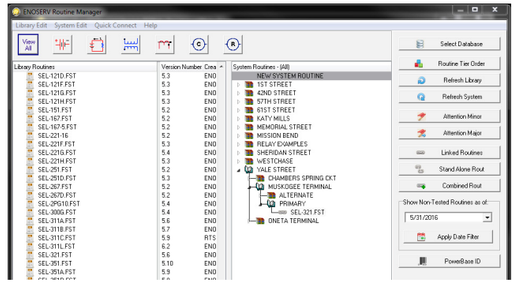
RELAY SETTINGS MANAGEMENT



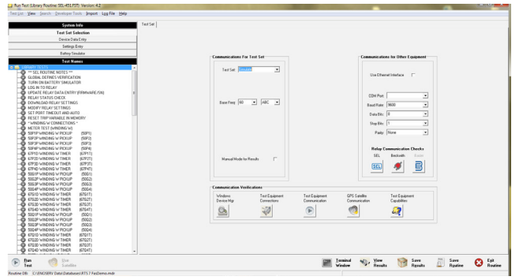
CUSTOMIZED DASHBOARDS TO TRACK DATA

FIELD TESTING SOFTWARE

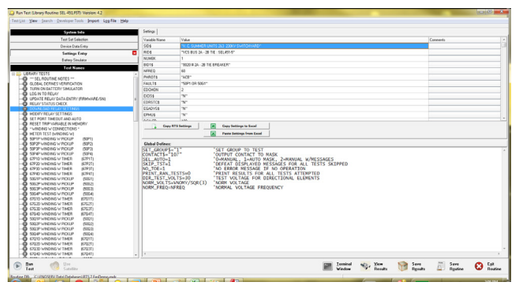
Choose the field software that best fits your testing program. Doble offers a variety of options for basic through complex testing requirements.



SELECT YOUR TEST FROM THE LIBRARY



SET UP EQUIPMENT & RELAY COMMUNICATIONS



RUN TEST

RTS

RTS is ideal for testing and capturing data during commissioning and field performance/ compliance testing.

RTS is a vendor-neutral software which allows you to connect to a variety of relay test sets in your test equipment inventory.

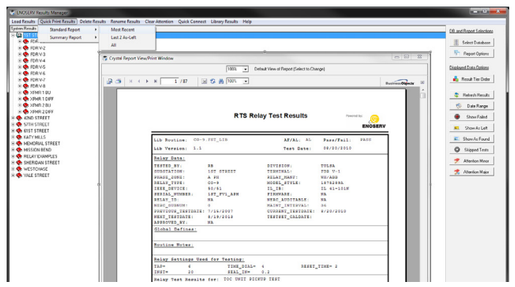
RTS features powerful automation tools that reduce complexity. It offers an extensive relay test plan library to quickly perform standardized tests. Your teams will save time thanks to the robust communication tools that help automate and simplify testing.

You can also make test plan modifications in one location by quickly editing in the library, which updates hundreds of relay test plans.

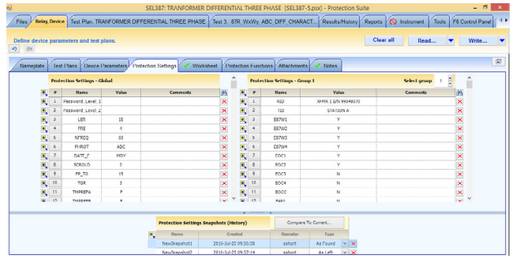
RTS can also capture and store important maintenance information for CTs/VTs, DC control circuitry, communication systems and more.

RTS works seamlessly with PowerBase as your complete protection testing program from the field to the office.

RTS is a product of ENOSERV, a Division of Doble.

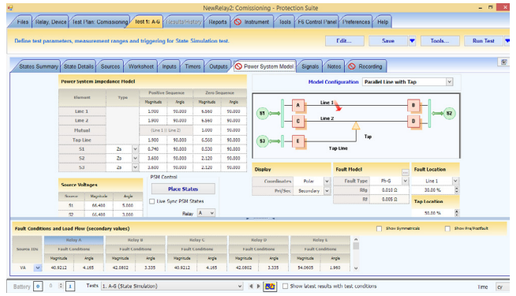


GENERATE YOUR REPORT



IMPORT RELAY SETTINGS

RUN SPECIALIZED TESTS



POWER SYSTEM MODELS

Protection Suite

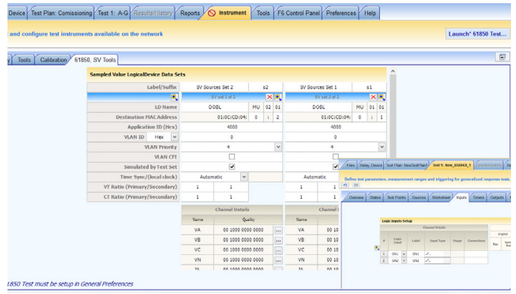
Protection Suite software is a complete, no-compromise, protection testing solution. Run manual and automated tests for protection-scheme verification, including IEC 61850 sampled values and GOOSE schemes.

With changes in technology, you need a software tool that allows you to test old and new types of devices. Protection Suite is your solution with its time-tested static, dynamic and digital test routines. Quickly create tests with the basic wizard tool and power system models.

Protection Suite offers users the capability to control and manipulate test types, giving users multiple ways of testing and proving a device. Simulate realistic system conditions and power quality issues, such as flicker and harmonic in-rush, using the transient wave generator.

Protection Suite is used with Doble's F-series test equipment; it also connects with PowerBase to create a comprehensive data-management system for storing, trending, system planning analysis and for reporting to regulatory agencies.

Protection Suite is available in a number of levels. Mix and match the levels that are appropriate for your organization's testing and reporting requirements.



IEC 61850 COMPLIANT TESTING

61850 TesT

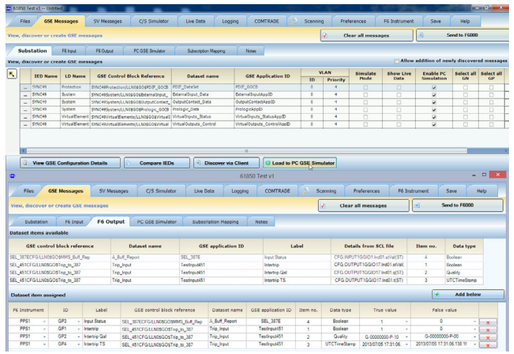
Simulate, monitor and test IEDs on your digital substation network with 61850 TesT software.

Use with Doble's F6150sv and Protection Suite software to apply sampled values (SV) and generic substation event (GSE) simulations to functionally test and receive status messages from substation devices. Create fault conditions to verify control scheme coordination to ensure proper design of IED logic.

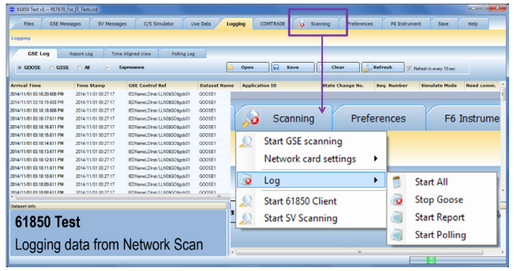
Use this IEC 61850 test software to identify and map logical nodes or objects to virtual inputs on the F6150sv. Then use Doble's Protection Suite testing software to verify the performance of your protection system.

Read SCL files or discover IEDs in the network, and configure the F6150sv for GOOSE message subscription and publishing in preparation for testing. Use the live data, annunciator and logging features to visualize the test.

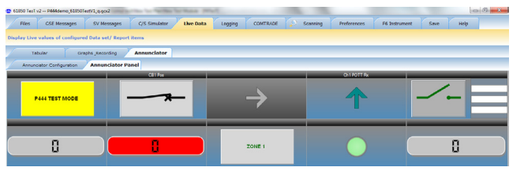
Use the built-in client simulator to read reports, request information from IEDs, and test the control functions such as closing a circuit breaker with interlock checking and synchro-check.



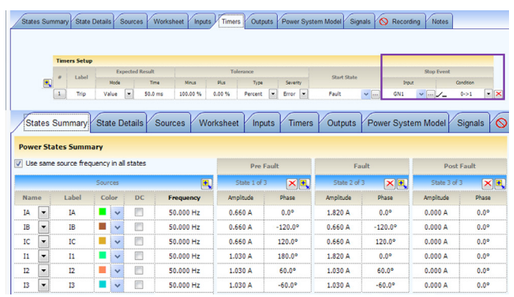
DISCOVER GOOSE MESSAGES & CONFIGURE F6150SV FOR GOOSE PUBLISHING & SUBSCRIPTION



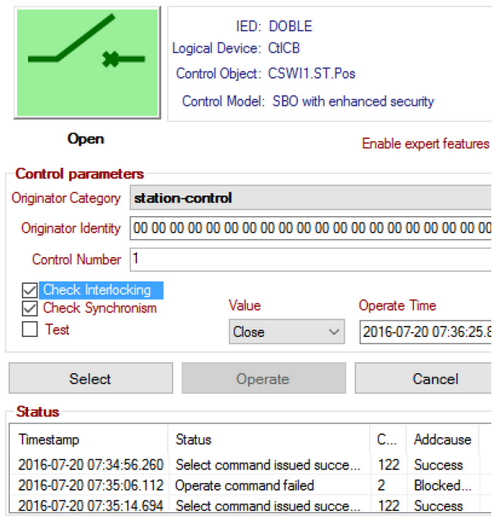
SCANNING & LOGGING



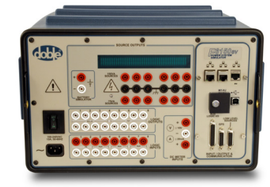
ANNUNCIATOR PANEL HELPS VISUALIZE TEST



TESTING WITH GOOSE MESSAGES



CLIENT SIMULATOR BREAKER CONTROL



F6150sv*
Power System Simulator

F6350e
External Amplifier

F6052
Universal Time Synchronizer

DUC
Doble Universal Controller

F6080
Field Calibration Unit

PROTECTION HARDWARE

Doble's F-Series power system simulators are the industry's trusted diagnostic device for protection testing.

Testing requirements can vary from team to team and company to company.

That's why Doble's F-series power system simulators are customizable. Choose what functions you need in order to perform testing of protection devices and schemes.

You can maximize your testing capabilities with accessories for communication, amplification, calibration and more.

From manual testing through to high burden testing, choose the options and accessories that make sense for your budget and business requirements.

**The F6150sv is UCAIUG IEC 61850 certified Level A by DNV-GL for:*
- IEC 61850 Server (GOOSE Publisher/Subscriber), Editions 1 and 2
- IEC 61850 Sampled Values 9-2LE Publisher, Edition 1

PROTECTION TRAINING

PROTECTION TRAINING
PRINCIPLES, APPLICATIONS & TESTING

We offer a wide range of protection training courses that will help prepare you for a modern grid, power plant and industrial facility.

Training courses are presented in an easy to understand format with real life case studies and examples for a truly unique training experience.

Choose which courses are right for you and your team.

Classes are geared towards engineers, technicians, supervisors and managers who are involved with protection assets.

Learn more at
events.doble.com/protection

DOBLE PROTECTION TESTING

F6150e

Power System Simulator

VERSATILE SOLUTION FOR TESTING PROTECTION DEVICES AND SCHEMES

The Doble F6150e is your versatile solution for testing protection relays and schemes. This power system simulator performs the simplest through the most complex tests. Meeting all your testing needs, the F6150e is available in four of different models. Whether you need to test an individual component or test an entire scheme, the F6150e is the proven solution to assess protection system performance.

FEATURES

- Performs standard relay calibration and verification testing of high burden and microprocessor relays
- Analog testing of 1A and 5A protection devices
- Performs state simulation and transient testing
- Tests 0.2-class metering CTs and transducers
- Implements end-to-end testing of communications-based schemes with GPS time syncing
- Maximum of 12 Sources (six voltage, six current) configurable for bench testing and proof-of-concept testing for complicated relaying schemes
- Delivers full VA power with resistive, inductive and capacitive loads at maximum current rating (6x35, 3x70, 1x210 amps)
- Wi-Fi capable (optional)
- Control all sources from a tablet device for basic, manual protection testing

BENEFITS

- Select from a number of instrument models that feature varying power levels and complexity. Choose the best solution according to your testing and budgetary requirements.
- Rugged construction and proven state-of-the art design provide laboratory accuracy with uncompromising field performance
- Convenient front-panel display indicates active voltage/current amplitudes and phase values during testing
- High-precision measurements for energy meter and transducer testing

DOBLE F6150e CUSTOMIZED MODELS

NAME	F6150e	F6150e-D	F6150e-SP	F6150e-IRC
DESCRIPTION	PREMIER MODEL	DISTRIBUTION MODEL	SINGLE PHASE MODEL	IRC MODEL
Applications	Test traditional electromechanical, electronic and microprocessor relays and devices Maximum power to test high-burden relays Test complex schemes	Test digital three-phase systems Test single phase & low-burden, three phase relays	Test single phase relays	Test S&C Electric IntelliRupter® and other devices using low-level sources
Technical Highlights	Maximum of 12 high-level analog sources are available at any time Maximum of 12 low-level analog sources are available at any time	Maximum of 8 high-level analog sources are available at any time Maximum of 8 low-level analog sources are available at any time	Maximum of 4 high-level analog sources are available at any time Maximum of 4 low-level analog sources are available at any time	Maximum of 12 low-level analog sources are available at any time
Technical Details	6 AC/DC Amplifiers: 3 x 150 VA Voltages & 3 x 150/225 VA currents AC volts: (1 x 600 V), (3 x 300 V), (6 x 150 V) AC amps: (1 x 180 A), (3 x 60 A), (6 x 30 A) Each 150 VA Voltage/Current amplifier can be split into 2 x 75 VA sources; total 12 sources	4 AC/DC Amplifiers: 2 x 150 VA Voltages, 2 x 175/262.5 VA currents AC volts: (1 x 600 V), (2 x 300 V), (4 x 150 V) AC amps: (1 x 120 A), (2 x 60 A), (4 x 30 A) Each 150 VA Voltage/Current amplifier can be split into 2 x 75 VA sources; total 8 sources	2 AC/DC Amplifiers: 1 x 150 VA Voltages, 1 x 175/262.5 VA currents AC volts: (1 x 300 V), (2 x 150 V) AC amps: (1 x 60 A), (2 x 30 A) Each 150 VA Voltage/Current amplifier can be split into 2 x 75 VA sources; total 4 sources	
	WITH OPTIONAL F6005 INCLUDED	WITH F6005 OPTION INCLUDED	WITH F6005 OPTION INCLUDED	
	Each 175/262.5 VA Current amplifier can be split into 2 x 87.5/131.25 VA sources; total 6 sources AC amps: (1 x 210 A), (3 x 70 A), (6 x 35 A) Each 175/262.5 VA Current source can be combined into 1 x 525/787.5 VA source or 1 x 175/262.5 VA & 1 x 350/525 VA sources	Each 175/262.5 VA Current amplifier can be split into 2 x 87.5/131.25 VA sources; total 4 sources AC amps: (1 x 140 A), (2 x 70 A), (4 x 35 A) Each 175/262.5 VA Current source can be combined into 1 x 350/525 VA source	The 175/262.5 VA Current amplifier can be split into 2 x 87.5/131.25 VA sources; total 2 sources AC amps: (1 x 70 A), (2 x 30 A)	

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www.doble.com

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DOBLE PROTECTION TESTING

F6150sv

Power System Simulator

ALL-IN-ONE SOLUTION FOR TESTING IEC 61850-BASED PROTECTION DEVICES AND SCHEMES

The Doble F6150sv is your versatile solution for testing IEC 61850-based protection devices and schemes. This power system simulator performs the simplest through the most complex tests. The F6150sv has the highest output current of any simulator on the market - all within a single box. Meeting all your testing needs, the F6150sv is available in three different models. The F6150sv tests IEC 61850-based systems at the process level and station level using both sampled values and GOOSE messages.*

FEATURES

- Simulate three streams of IEC 61850 9-2LE sampled values through one fiber-optic port and one copper (RJ45) port*
- Wi-Fi capable (optional)
- Simulates (publishes) and subscribes to IEC 61850 GOOSE messages involving multiple IEDs**
- Performs standard relay calibration and verification testing of high-burden (electromechanical), solid-state, and microprocessor-based relays
- Delivers full VA power with resistive, inductive and capacitive loads at maximum current rating. The following ranges are available with the F6005 Enhanced Rating Option: (6 x 35, 3 x 70, 1 x 210 A).
- Performs state simulation and transient testing
- Tests 0.2-class metering CTs and transducers
- Implements end-to-end testing of communications-based schemes with GPS time syncing
- Maximum of 12 high-level analog sources (six voltage, six current) configurable for bench testing and proof-of-concept testing for complicated relaying schemes

BENEFITS

- Select from a number of instrument models that feature various power levels and complexity. Choose the best solution according to your testing and budgetary requirements.
- Rugged construction and proven state-of-the art design provide laboratory accuracy with uncompromising field performance
- Convenient front-panel display indicates active voltage/current amplitudes and phase values during testing

**F6870 Sampled Values option required*

***F6860 GSE Configurator option required*

www.doble.com

DOBLE F6150sv CUSTOMIZED MODELS

NAME	F6150sv	F6150sv-SGD	F6150sv-IEC
DESCRIPTION	PREMIER MODEL	GRID DISTRIBUTION MODEL	IEC MODEL
Applications	Test IEC 61850-based protection devices and schemes Maximum power to test high-burden relays Test complex schemes Run in mixed mode	Test IEC 61850-based protection devices and schemes Test digital three-phase systems Test single-phase & low-burden, three-phase relays	Test IEC 61850-based protection devices and schemes Test S&C Electric IntelliRupter® and other devices using low-level sources
Technical Highlights	Maximum of 12 high-level analog sources are available at any time Maximum of 12 low-level analog sources are available at any time	Maximum of 8 high-level analog sources are available at any time Maximum of 8 low-level analog sources are available at any time	Maximum of 12 low-level analog sources are available at any time
Technical Details	6 AC/DC Amplifiers: 3 x 150 VA Voltages & 3 x 150/225 VA currents AC volts: (1 x 600 V), (3 x 300 V), (6 x 150 V) AC amps: (1 x 180 A), (3 x 60 A), (6 x 30 A) Each 150 VA Voltage/Current amplifier can be split into 2 x 75 VA sources; total 12 sources	4 AC/DC Amplifiers: 2 x 150 VA Voltages, 2 x 175/262.5 VA currents AC volts: (1 x 600 V), (2 x 300 V), (4 x 150 V) AC amps: (1 x 120 A), (2 x 60 A), (4 x 30 A) Each 150 VA Voltage/Current amplifier can be split into 2 x 75 VA sources; total 8 sources	
	WITH OPTIONAL F6005 INCLUDED	WITH F6005 OPTION INCLUDED	
	Each 175/262.5 VA Current amplifier can be split into 2 x 87.5/131.25 VA sources; total 6 sources AC amps: (1 x 210 A), (3 x 70 A), (6 x 35 A) Each 175/262.5 VA Current source can be combined into 1 x 525/787.5 VA source or 1 x 175/262.5 VA & 1 x 350/525 VA sources	Each 175/262.5 VA Current amplifier can be split into 2 x 87.5/131.25 VA sources; total 4 sources AC amps: (1 x 140 A), (2 x 70 A), (4 x 35 A) Each 175/262.5 VA Current source can be combined into 1 x 350/525 VA source	

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DOBLE PROTECTION TESTING

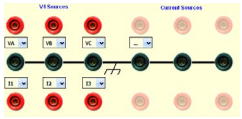
CUSTOM OPTIONS

Features to Customize Your Doble Power System Simulators

HIGH BURDEN TESTING

F6810

Convertible Voltage/Current Sources



The F6810 option allows you to properly test high-burden, ground over current relays, these are the protection devices that are relied on the most when everything else fails to detect high resistance faults. This option can be used in a current mode with a unique direct coupled power amplified design. It provides multiple ranges, each capable of delivering full power during testing. It also gives your test set high compliance voltages that can be used for high power testing at low current range.

F6005

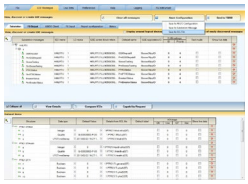
Enhanced ratings

The F6005 enhanced power rating option allows for expanded range and power output (VA) of the power current amplifiers. The output range and power of the currents are increased to provide high power for an extended period of time.

DIGITAL TESTING

F6860

GSE Configurator



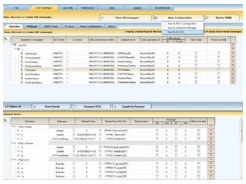
The F6860 and Doble 61850 TesT software simplify IEC 61850 compliant protection testing. The F6860 allows you to connect the F6150 test set to the station communication network to test an IED or a scheme of multiple IEDs.

This enables the test set to receive messages and status information from all IEDs connected to the network while simultaneously simulating one or more IEDs and publishing messages to the IEDs under test. It also tests hybrid systems that include GSE messages and conventional hard-wired logic connections. The GSE software reads IEC 61850 SCL files, scans the network for messages and simplifies configuration of the input and output messages. This option includes Doble 61850 TesT Basic Software.

Available only in the F6150sv.

F6870

Sampled Values



The F6870 option simulates up to 3 streams of sampled values per UCA2 9-2 LE implementation guidelines. Each stream has 4 voltages and 4 currents with a total of 24 sources.

Primary values are used per IEC 61850 standard for parameter setting of IEDs and for displaying test quantities of voltage, current and impedance. It supports hybrid protection systems using IEC 61850 sampled values, conventional currents and voltages from VTs and CTs, as well as low-level analog outputs.

Available only in the F6150sv.

MANUAL TESTING

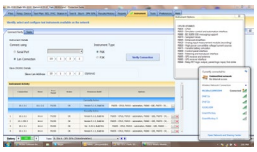
F6011

Mobile Control Panel Application

The F6011 Mobile Control Panel Application runs basic, manual protection testing from any device connected to a web browser. Whether you are testing with a PC, tablet or smart phone, Doble's F6011 option allows you to connect to and control your Doble power system simulator without the need for additional software.

F6803

Internal Wi-Fi



The F6803 Wi-Fi option, as per 802.11 B&G, is for easier testing in space restricted areas. This option is necessary if you want to use the F6011 with tablet devices.

AUTOMATED TESTING

F6910

Advanced Automation and Communication

The F6910 automates protection testing using an external computer. This option can be used to perform automated testing with Doble protection testing software or any third party software system.

SPECIALIZED FUNCTIONS

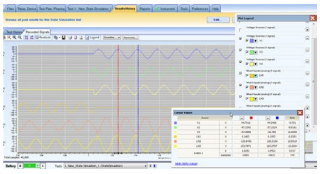
F6351

Amplifier conversion

Doble's adaptive product design allows your current F6150e/sv to function as an F6350e amplifier with a simple switch within the firmware. This option includes F6 Multi-Amp Configurator Software.

F6820

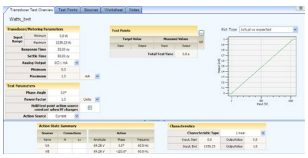
Analog Input Measurement



Doble's Analog Input Measurement (AIM) option gives you the ability to record external analog or digital signals using your test set's logical inputs. You can also record the internal analog signal generated by the test set. The AIM option allows you to evaluate the performance of a protection scheme in the field or lab. It can also be used during commissioning. Logic-input connections can be used to record the transformer's output and can determine the correct polarity connection to the protection scheme for NERC required VT & CT verifications (phasing or load checks).

F6800

Transducer Interface



The F6800 transducer interface gives you the capability to test energy meters and transducers. Perform simple performance verification tests and develop a library of automated tests based on specific practices and test results using Protection Suite Software. Develop detailed reports for compliance requirements. This option includes Protection Suite Basic Software.

F6885

GPS Receiver Interface

The F6885 synchronizes multiple F6000 instruments with a GPS satellite system. Testing capabilities include Phasor Measurement Units, IEC 61850 time stamped relay results, end-to-end testing and testing of communication equipment. See Doble's F6051, F6052 and F6895 for time synchronization hardware options.

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DOBLE PROTECTION TESTING

ACCESSORIES

Maximize Capabilities of Your Doble Power System Simulators

COMMUNICATION ACCESSORIES

F6051
IRIG-B Converter

The F6051 is a compact IRIG-B time protocol converter designed to meet industry and security standards by providing precise time synchronization. It is designed for interior use when you are unable to run a satellite antenna cable outside due to CIP compliance concerns. It is ideal for locations where an IRIG-B source is available.

F6052
Universal Time Synchronizer

The F6052 is a portable station clock capable of time synchronization for PMU, IEC 61850, end-to-end scheme testing & telecommunication coordination delays. It is ideal for use in hydro dams, security restricted substations, nuclear power plants, test laboratories, metropolitan areas and other locations with limited sky availability.

F6895
GPS Receiver/Antenna

The F6895 option includes a GPS antenna/receiver with 100ft. cable and is used with the F6885 GPS Receiver Interface to provide a GPS signal to the test instrument.

TRANSDUCER METERING TEST OPTIONS

F6071
Infrared Optical Pickup

The F6071 Infrared Optical Pickup is used to sense infrared pulses from device LEDs. Allows automated calibration of solid state watthour, varhour and vahour meters.

F6072
Visible Light Optical Pickup

The F6072 Visible Light Optical Pickup is available for those solid state meters that have a visible calibration LED.

F6073
Meter Disk Sensor

The F6073 Meter Disk Sensor is a suction mount reflective pickup assembly used to sense the disk rotation of an induction type meter.

OPTIMIZATION ACCESSORIES

F5850
Testing Interface for the IntelliRupter® PulseCloser

Use the F5850 to effectively test and verify correct operation of the S&C IntelliRupter® PulseCloser. The F5850 is a portable test interface that is used in combination with your power system simulator to test setting and logic schemes of the IntelliRupter Control Module.

F6300e
External Amplifier

Use Doble's F6300e External Amplifier with your Power System Simulator for critical high burden relay testing and to perform necessary system modeling with 3rd party software. This amplifier features 12 enhanced current sources. When combined with Doble's Protection Suite software, you will have the ultimate flexibility to test complex schemes using the new Power System Model engine to test models that require multiple currents such as bus differential schemes and multi-winding transformer models.

F6816
External Input/Output Unit

Double the number of inputs and outputs you can use for testing with the F6816, a unit that provides eight additional inputs and 8 additional outputs. With 16 inputs and outputs you can monitor and control a large number of relay contacts. This is helpful in elaborate end-to-end tests and dynamic testing of protection schemes.

F6080
Field Calibration Unit

Properly calibrate your power system simulator with the F6080 Field Calibration Module, which helps save time and money by giving you the capability to calibrate your test system in the field. The F6080 provides automatic recalibrations of voltage and current sources for all ranges. It also checks and calibrates logic inputs and outputs. Protection Suite Software is used to test the calibration.

F6350e
External Amplifier

Use Doble's F6350e External Amplifier with your Power System Simulator for critical high burden relay testing and to perform necessary system modeling with 3rd party software. This amplifier features 6 voltage and 6 enhanced current sources. When combined with Doble's Protection Suite software, you will have the ultimate flexibility to test complex schemes using the new Power System Model engine to test models that require multiple currents such as bus differential schemes and multi-winding transformer models.

Compact AC Current Clamp
High Accuracy Voltage Output Current Clamp

Doble's Compact AC Current Clamp is designed to help you perform precise protection testing in wiring tight circuits. This highly accurate current probe is used with your Doble protection series test instruments (and the F6820 AIM option) for monitoring and recording parameters.

Lead Bag
Complete Cable Kit

Inside this durable bag you will find all the leads and related components needed for your standard relay tests. This set includes all your cables with retractable test leads, lugs, spade connectors, crocodile clips, adapters, clip connectors and more.

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DOBLE PROTECTION TESTING

F6300e

External Amplifier

FOR HIGH POWER PROTECTION TESTING APPLICATIONS WHEN YOU NEED ADDITIONAL CURRENT SOURCES

Use Doble's F6300e External Amplifier with your Power System Simulator for critical high burden relay testing and to perform necessary system modeling with 3rd party software. This amplifier features 12 enhanced current sources. When combined with Doble's Protection Suite software, you will have the ultimate flexibility to test complex schemes using the new Power System Model engine to test models that require multiple currents such as bus differential schemes and multi-winding transformer models.

FEATURES

- 12 enhanced current sources for running high burden and amplitude faults (12 x 35 A, 12 x 131.25 VA/131.25 W)
- Battery Simulator
- Test bus power system models up to six current nodes
- Works with Doble Protection Suite or 3rd party software
- Configure up to 16 external amplifiers for 192 sources when using Doble F6 configurator software

BENEFITS

- Robust design suitable for laboratory and field testing applications
- Perform necessary system modeling with 3rd party software
- Critical for high burden relay testing
- Multiple sources in one amplifier reduce the number of boxes needed for testing
- The industry's most current sources in one amplifier

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DOBLE PROTECTION TESTING

F6350e

External Amplifier

FOR HIGH POWER PROTECTION TESTING APPLICATIONS WHEN YOU NEED ADDITIONAL CURRENT AND VOLTAGE SOURCES

Use Doble's F6350e External Amplifier with your Power System Simulator for critical high burden relay testing and to perform necessary system modeling with 3rd party software. This amplifier features 6 voltage and 6 enhanced current sources. When combined with Doble's Protection Suite software, you will have the ultimate flexibility to test complex schemes using the new Power System Model engine to test models that require multiple currents such as bus differential schemes and multi-winding transformer models.

Doble's adaptive product design allows your current F6150e/sv to function as an F6350e amplifier with a simple switch within the firmware (option F6351). Now you can easily switch between test set and amplifier through software settings.

FEATURES

- 12 sources for running high burden and amplitude faults
- 6 Voltages, 6 Enhanced Currents (6 x 35 A, 6 x 131.25 VA/131.25 W)
- Battery Simulator
- Test bus power system models up to six current nodes
- Works with Doble Protection Suite or 3rd party software
- Configure up to 16 external amplifiers for 192 sources when using Doble F6 configurator software

BENEFITS

- Robust design suitable for laboratory and field testing applications
- Perform necessary system modeling with 3rd party software
- Critical for high burden relay testing
- Multiple sources in one amplifier reduce the number of boxes needed for testing
- The industry's most current sources in one amplifier

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DOBLE PROTECTION TESTING

F6051

Time Synchronizer

PROVIDES PRECISE TIME SYNCHRONIZATION IN AREAS WITH ACCESS TO STATION TIME CLOCKS

The Doble F6051 is a compact, IRIG-B time protocol converter for when you need precise time synchronization according to industry and security standards. With the Doble F6051, interior time stamping is possible. Use Doble's F6051 in combination with Doble's F-Series Power System Simulators to accept modulated or demodulated signals from station satellite clocks.

FEATURES

- Generates a 1pps signal for accurate time stamping
- Accepts modulated or demodulated signals from station satellite clocks
- IRIG-B signal enters through a BNC connector
- GPS 1pps signal exits through an RS-422 connector

BENEFITS

- Use when you are unable to run a satellite antenna cable outside
- Generate time stamp even if doors and windows cannot be opened for prolonged period due to CIP compliance concerns
- Capable of time synchronization for PMU, IEC 61850, & end-to-end testing where an IRIG-B source is available
- Eliminates tangled satellite cables
- Fits conveniently in your lead bag

DOBLE F6051 TECHNICAL SPECIFICATIONS

GENERAL SPECIFICATIONS	
POWER INPUT/OUTPUT	**RANGE**
Power Supply	120-240 volt AC (1 amp max)
F6051	+12V, max power 15 watts
F6051 BNC Data input	5 volts peak
1PPS signal	±1.5V minimum and ±2.5V maximum
DATA INPUT	**FORMAT**
IRIG-B BNC input	Unmodulated IRIG-B000 Modulated IRIG-B120
DATA OUTPUT	**FORMAT**
RS422, 15 pin D type connector	1pps
ENVIRONMENT	**RANGE**
Temperature	Operating: 0°C to 50°C (32°F to 122°F) Storage: -20°C to 80°C (-4°F to 176°F)
DIMENSIONS & WEIGHT	
Length	164 mm/ 6. 5 in without end caps, 173 mm/ 6.8 in with end caps
Width	107.5 mm/ 4.2 in without end caps, 114 mm/ 4.5 in with end caps
Height	29.5 mm/ 1.2 in without end caps, 36 mm/ 1.43 in with end caps
Weight	0.45 kg/ 16 oz

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DOBLE PROTECTION TESTING

F6052

Universal Time Synchronizer

PORTABLE TIME SOURCE FOR AREAS RESTRICTED BY SPACE, DISTANCE & SECURITY

Doble's F6052 is a lightweight, portable time source for when you need a time reference or time stamp, but cannot access reliable time sources or GPS signals. The F6052 keeps its accuracy for over 8 hours and can run on AC or battery power. Use Doble's F6052 in combination with Doble's F-Series Power System Simulators for satellite time synchronization for protection testing in previously inaccessible areas, such as hydro-electric or nuclear facilities, areas with tall buildings, test vaults or locations with line of sight restrictions.

FEATURES

- Maintain accuracies of 200 nanoseconds for over 2 hours and 5 microseconds for over 8 hours with no GPS signal input
- Self-calibrating when connected or with access to a GPS signal
- Rechargeable battery allows operation for 6 hours when no power source available

BENEFITS

- Ideal for use in hydro dams, security restricted substations, nuclear power plants, test laboratories, metropolitan areas and other locations with limited sky availability
- Capable of time synchronization for PMU, IEC 61850, end-to-end scheme testing & telecommunication coordination delays
- Compatible with most types of test equipment, with a variety of outputs for use with old & new devices

F6052 TECHNICAL SPECIFICATIONS

GENERAL SPECIFICATIONS	
IPPS Holdover	200 nanoseconds over 2 hours 5 microseconds over 8 hours
Inputs	+5V dc: Mini B USB GPS antenna: SMA Ethernet (PTP & SNTP/NTP): RJ45 10/100 Ethernet (management): RJ45 10/100 1PPS (phase 2): BNC
Outputs	1PPS: BNC 2.048 MHz frequency: BNC G.703 10 MHz frequency: BNC G.703 IRIG-B: BNC RS232: 9 way D-Type 9600 baud RS422: 15 way D-Type 9600 baud Ethernet (PTP & SNTP/NTP) (Max 10 clients): RJ45 10/100 Ethernet (management): RJ45 10/100
CHARGING POWER SUPPLY UNIT	
Input voltage	100-240 VAC, 50-60Hz
Input current	250mA AC
Input Power	60VA
Output voltage	+15VDC
Output current	700mA DC
Output power	10.5VA
INPUTS	
+15V dc	2.1mm socket
GPS antenna	SMA
1PPS	BNC (available in future release)
OUTPUTS	
1PPS	BNC
Frequency 1	BNC G.703
Frequency 2	BNC G.703
IRIG-B	IRIG-B000-000, 004 un-modulated IRIG-B120-120 modulated, 1KHz IRIG-B120 150 modulated, 1MHz IRIG-B120 220 modulated, Manchester coded
RS-232	9 way D-Type 9600 band
Ethernet (F6052 and SNTP/NTP) (Max 10 clients)	RJ45 10/100
Ethernet (management)	RJ45 10/100
ENVIRONMENTAL	
Operating temperature: Mains powered Battery powered	 0°C to +40°C (32°F to 104°F) 0°C to +50°C (32°F to 122°F)

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DOBLE PROTECTION TESTING

F5850

Testing Interface

EXCLUSIVELY FOR TESTING THE S&C INTELLIRUPTER® PULSECLOSER

Effectively test and verify correct operation of the S&C IntelliRupter® PulseCloser. Use the F5850, a portable testing interface, with Doble's F-Series Power System Simulators and the IntelliRupter docking station to test setting and logic schemes. This combination of equipment simulates the actual physical switch and power system conditions necessary to test the operation of this critical protective device.

FEATURES

- Single-phase and three-phase testing
- Test all protective functions
- Use a variety of control options for simulating manual switch positions
- Connect analog signals through the low-level-source cable
- Rugged design for field testing
- Powered from IntelliRupter Docking Station through test cable connection

BENEFITS

- Test in the field and in the laboratory
- Simple testing setup uses only three cable connections
- Make proper connections every time—inputs and outputs connect to the Aux Logic I/O connector on your Doble Power System Simulator
- Pair with any F6150e/sv instrument to choose the best solution that meets your specific testing and budgetary requirements
- Operate and control the F5850 from specifically designed instruments: F6150sv-IEC and the F6150e-IRC; other models of the F6150e/sv include additional testing capabilities

DOBLE F5850 TECHNICAL SPECIFICATIONS

GENERAL SPECIFICATIONS	
Weight	6.85 lb (3.1 kg)
Dimensions	14 x 11 x 6.5 in (35.6 x 27.9 x 16.5 cm)
Input Current	150 mA @ 24 V RMS
Temperature Range	0°C to 50°C (32°F to 122°F)

Equipment for Every Situation

Doble offers a number of different models of our power system simulators to meet your testing and budgetary requirements. The F6150sv-IEC and the F6150e-IRC are specific models that operate and control the F5850. Other models in the F-Series line also operate the F5850, but include additional testing capabilities.

Ask Doble about which model is right for you and your company.

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DOBLE PROTECTION TESTING

F5851

Recloser/Controller Interface Cables

OPTIMIZE DISTRIBUTION TESTING CAPABILITIES WITH ACCESSORY CABLES FOR YOUR DOBLE POWER SYSTEM SIMULATOR

The F5851 Recloser/Controller Interface Cables are a series of performance-rated cables for testing distribution reclosers, sectionalizers, capacitor-bank controls, and load-tap-changer controls. Each unique cable is specific to the application, providing easy connectivity to a control unit from a F6150/e/sv Power System Simulator. Use Protection Suite software to perform all protection-scheme tests and checks: test elements, perform operation (dynamic) testing, check scheme logic, confirm communication.

FEATURES

- Cable sets connect the F6150/e/sv to simulate the external power system, providing the proper conditions for testing
- Each cable provides the required number of voltages and currents to a specific recloser or control unit, such as capacitor-bank and load-tap-changer controllers
- Capacitor-bank test cables connect capacitor-banks controls to test all protective and control functions properly

BENEFITS

- Simulate and test single-pole and multi-pole reclosing operations to verify proper lockout and reclose-timing intervals
- Confirm proper switching and fault-reclosing operational coordination
- Choose the cables you need - select the cable sets for the reclosers types you need to test

DOBLE F5851 RECLOSER/CONTROLLER INTERFACE CABLES

CABLE	RECLOSING OR SWITCHING DEVICE	COMPATIBLE CONTROL UNITS	DESCRIPTION
F5851-32V 	G&W Viper Elastimold	SEL-351R SEL-651R Beckwith Electric M-7976	Test reclosers configured with a 32-pin connector for three-pole and single-pole tripping capabilities. Test Plans are available using Protection Suite software to perform element and functional operational verification of relay logic.
F5851-14K 	Traditional Cooper Power/ Kyle/Eaton Reclosers	Cooper Power/Eaton: Form 3, Form 4, Form 5, Form 6 SEL-351R; SEL-651R; SEL-351R Falcon Beckwith Electric M-7976	Test reclosers configured with a 14-pin connector for three-pole tripping capabilities. Test Plans are available using Protection Suite software to perform element and functional operational verification of relay logic.
F5851-8K 	Cooper Power/Kyle/Eaton Reclosers with up to six Voltage Sensors	Cooper Power/Eaton: Form 3, Form 4, Form 5, Form 6 SEL-351R; SEL-651R; SEL-351R Falcon Beckwith Electric M-7976	Test reclosers configured with voltage inputs for tripping and control.

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DOBLE PROTECTION TESTING

F6080

Field Calibrator

FOR CALIBRATION OF DOBLE POWER SYSTEM SIMULATORS IN THE FIELD OR OFFICE

The Doble F6080 Field Calibrator is the most effective way to keep your Doble Power System Simulator properly calibrated. Verify the calibration of your current and voltage sources without needing to send your equipment to a calibration laboratory or Doble service center. The Doble F6080 contains everything you need to calibrate your protection testing equipment in the field or office, saving you time and money by improving the productivity of your testing crews.

FEATURES

- Simple calibration procedure with step-by-step instructions
- Automatically recalibrate voltage and current sources for all ranges
- Check and calibrate logic inputs and outputs
- Contains high accuracy shunts and crystals needed for source calibration
- Generate a calibration report for your records

BENEFITS

- Ensure accuracy of testing by regularly checking calibration
- Save time and money by keeping your Power System Simulators in the field
- Each F6080 is supplied with calibration certificate from Doble, valid for one year
- Recertify your F6080 each year with Doble

DOBLE F6080 TECHNICAL SPECIFICATIONS

GENERAL SPECIFICATIONS	
Dimensions	14.2 x 11.4 x 6.5 in /36.1 x 29.0 x 16.5 cm
Weight	8.52 lb /3.87 kg
Power Supply	100–240 V, 50/60 Hz
Interfaces	RS 232 control to computer
Operating Temperature	20°C to 30°C/ 68°F to 86°F
Storage Temperature	-25°C to 70°C/ -13°F to 158°F
Humidity	Up to 95% relative humidity, non-condensing
Warmup Time	30 minutes
Voltage/Current Measurement Accuracy	± 0.02%
Frequency Measurement Accuracy	± 0.2 ppm
Logic Input Timer Pulse Accuracy	± 1 ppm of setting ± 10 µ sec

Please note: Contact Doble for further details if you are planning to use the F6080 for calibration of test equipment used in nuclear facilities. Additional calibration may be required.

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DOBLE PROTECTION TESTING

F6011

Mobile Control Panel Application

RUN MANUAL PROTECTION TESTING FROM ANY WEB-ENABLED DEVICE

Choose Doble's F6011 Mobile Control Panel Application to run basic, manual protection testing from any device connected to a web browser. Whether you are testing with a PC, tablet or smart phone, Doble's F6011 option allows you to connect to and control your Doble power system simulator. Perform basic protection testing functions to verify that a relay is operating correctly. With this application, you do not need additional software to perform basic protection testing, you simply need the web-enabled device of your choice.

FEATURES

- Use common web browsers to connect to F6 instrument through an IP address
- Change amplitude, phase, frequency and range of sources
- Set up logical inputs and outputs
- Configure up to two timers
- Display amplitude and phase configuration as vectors
- Perform step, ramp and pulse tests
- Battery simulator control

BENEFITS

- Control your Doble power system simulator with a handheld device
- Simplify manual protection testing
- Verify correct relay operation
- Reduce time needed to perform basic testing
- Complete mobility around the substation with no need for extra cables and cords with the F6011 and the F6803 Internal Wi-Fi option
- Avoid hazardous areas

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DOBLE ACCESSORIES

COMPACT AC CURRENT CLAMP

High Accuracy Voltage Output Current Clamp

CAPTURE CURRENT READINGS FOR CIRCUIT BREAKER AND PROTECTION TESTING

Doble's Compact AC Current Clamp is designed to help you perform precise protection or circuit breaker testing in tight wiring circuits. This highly accurate current probe is used with your Doble F-Series test instruments (and the F6820 AIM option) for monitoring and recording parameters or Doble TDR circuit breaker test instruments. Its "clothes pin" shape makes it ideal for testing in and around control panels, cabinets and outlets.

TECHNICAL SPECIFICATIONS

ELECTRICAL SPECIFICATIONS	
Current Range	1mA to 10A AC, continuous
Output Signal	100mV AC/A AC (1V @ 10A)
Accuracy and Phase Shift	Reference conditions: 23°C ± 3°K, 20 to 85% RH, 48 to 65Hz, external magnetic field < 40A/m, no DC component, no external current-carrying conductor, test sample centered. Load impedance 1MΩ
Accuracy	1mA to 10A: 2% ± 2mA 40Hz to 3kHz: 3.5% ± 2mA
Phase Shift	45 to 65Hz 100A to 10A: less than or equal to 8°
Overload	20A continuous
Frequency Range	30 to 5kHz
Load Impedance	100kΩ minimum
Working Voltage	250V AC
Common Mode Voltage	30V AC
MECHANICAL SPECIFICATIONS	
Operating Temperature	-13° to 122° F (-25° to 50° C)
Storage Temperature	-40° to 176° F (-40° to 80° C)
Temperature Influence	<0.2% per 10°K
Dimensions	1.26 x 4.5 x 0.87 inch (32 x 115 x 22mm)
Weight	6oz (160g)
Colors	Dark gray handles with red cover
Polycarbonate material	Handle: 10% fiberglass charged polycarbonate UL 94 VO
Output	Insulated 5 ft (1.5m) lead with safety banana plug
SAFETY SPECIFICATIONS	
Electrical	3kV 50/60Hz dielectric for 1mm between core and output cable

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OFF-LINE TESTING & ASSESSMENT

DOBLE OFF-LINE TESTING & ASSESSMENT

M4100 4TH GEN

High Voltage Apparatus Tester

THE INDUSTRY STANDARD FOR COMMISSIONING, DIAGNOSTIC & SCHEDULED MAINTENANCE TESTING

The M4100 is the industry standard for power apparatus and insulation testing. Its unique combination of test capabilities and artificial intelligence analysis software makes it the power industry's most trusted Power Factor/Tan-Delta instrument. These instruments are used around the globe thanks to their comprehensive testing options, safety features and measurement accuracy.

FEATURES

- Power Factor/Tan-Delta testing to confirm insulation integrity and quality
- Capacitance testing to measure physical changes that may have occured to the apparatus
- HV turns ratio testing to detect shorted turns or winding damage
- Leakage reactance/short circuit impedance testing to evaluate winding deformation
- Single phase excitation current testing to evaluate transformer magnetizing circuit
- Capacitor bank testing to detect deteriorating or failed capacitors within a bank
- Generates its own precise sine wave test signal
- Self-calibrating in the field
- Easy and accurate testing with Doble Test Assistant software (DTA)

BENEFITS

- Safety is our priority with dual safety switches, power strobes and ground earth relay interlocks
- Eliminates the effect of varying electrostatic interference with patented Line Frequency Modulation, which makes measurements at a frequency above and below the system frequency
- Reliability & Accuracy—generates its own clean test signal using an internal waveform generator for reliable results and stable readings
- Software firmware system senses abnormal current, temperature and voltage operation even before a user would notice
- Instantly analyze your test results, providing clear recommendations and explanations with FRANK™, the First Response Analytics Knowledgebase

M4100 4TH GEN TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS	
Operating Temperature	-20° to 50°C / -4° to 122°F
Dry Heat	IEC 60068-2-2
Cold	IEC 60068-2-1
Shock & Vibration	IEC 60068-2-27, IEC 60068-2-7 & ASTM D999.75
Drop Test	EC 60068-2-6
Weight	95 lb / 43 kg
Dimensions	10.3 H x 20 W x 25.3 D (in) 26 H x 50.8 W x 64.1 D (cm)
Software	DTA6 Basic
Power Input	95-264 VAC, Auto Sensing 47 to 63 Hz Accommodates Inverter and Portable Generators 16 A max at 110 V 10 A max at 220 V Accommodates GFIC/RCBO Class A & B
Field Verification & Calibration	Integrated Self-Calibration & Verification Module 3 Resistive Standards Amplifier Test Range: 7-All Nominal Test Ranges Coverage: Watts, Amps, PF/Tan-Delta, Internal Source Loss, HV Cable, LV Cable(s)
Safety Features	Open Ground Detection Circuit Abnormal Current Sensing System with continuous temperature compensation Safety Switches: 2-Deadman Safety Strobe
Source Output	3 kVA 25 V to 12 kV Output Current: Continuous @ 100 mA at 10 kV 30 minutes @ 200 mA at 10 kV 4 minutes @ 300 mA at 10 kV
Power Factor/Tan-Delta Measurement	Range: 0 to ±100.00% Resolution: 0.01% (0.0001) Typical Accuracy: ± 0.005%
Capacitance Measurement	Range: 0 to 100 µF Resolution: 0.01 pF
Inductance Measurement	Range: 6 H to 10 MH Resolution: 0.01 H
Watts Measurement	Range: 0 to 2 kW, actual power Resolution: 0.5 mW

ORDERING INFORMATION

PART #	PRODUCT
M4K60	M4100 with cables, strobe, T/H Sensor, safety switches(2), DTA6 Basic software, M4151 Field Calibration Module & 65' HV Cable.
M4K100	Includes all of the above with 100' HV Cable instead of 65' HV Cable.
	INCLUDED ACCESSORIES
02D-0024-02	HV Cable 65' with Hook (included with M4K60)
02D-0024-01	HV Cable 100' with Hook (included with M4K100
02B-0020-03	Lead, Low Voltage Red 65'
02B-0020-02	Lead, Low Voltage Blue 65'
020-0048-01	1 Set Hot Collars (5 at different lengths)
02B-0026-02	5' Copper Bare Copper Jumper
03B-1137-01	C2 Tap Adapters, ASEA GO Types
02B-0089-01	C2 Tap Adapters, Westinghouse type O "hockey stick"
212-0416	C2 Tap Adapters, Westinghouse type O Plus
02B-0012-01	C2 Tap Adapters, Westinghouse type OS, S
03C-1318-02	Temperature/Humidity Sensor
05B-0493-01	Temperature/Humidity Sensor Cable
2FA-0280-01	Hook M2 Cable 3-inch, M Series
09C-0613-01	Safety Strobe Light
05B-0492-01	Safety Strobe Light Cable
	OPTIONAL ACCESSORIES
M4300	M4300 Field Transporter for M4100
903-0031	M4100 Transportation Case
903-0034	M4300 Field Transporter Transportation Case
02C-5200-01	MFL (M-Oil) Liquid Insulation Test Cell and carrying case
010-0105-01	M4110 Leakage Reactance Interface (includes cables)
030-1684-01	M4140 CapBank Kit
03D-2010-01	Doble Universal Controller™, Tablet PC Controller
03B-0706-01	doble TTR Capacitor and Carry Case

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MKT_SL_M4100_4TH_GEN_11/15

DOBLE OFF-LINE TESTING & ASSESSMENT

M7100™

High-Voltage Asset Analyzer

THE MOST-COMPREHENSIVE SOLUTION FOR COMMISSIONING, DIAGNOSTIC AND SCHEDULED MAINTENANCE TESTING

The Doble M7100 High-Voltage Asset Analyzer is your complete solution for high voltage testing. With an intuitive design and patented dual high-voltage leads, the M7100 greatly reduces the number of ladder trips technicians are exposed to per job—sometimes cutting the number to nearly one third. This significantly improves the safety and quality of field work by limiting exposure to the workforce and reducing errors.

The M7100 automates multiple tests, previously performed by several pieces of equipment, cutting down testing time from seven hours to one and a half hours. By dramatically reducing testing time, you can now maximize outage periods by performing more maintenance during the hours previously devoted to testing.

FEATURES

- Built-in Low Voltage/High Current Multi-Frequency Source
- Combined Source and Measurement Test Leads
- True 4-Terminal measurements
- Intuitive design where the color or number is the connection
- Patented dual high-voltage leads that allow you to switch between Source and Measurement—both capabilities are within each HV lead
- Enhanced safety features include new safety switch design

BENEFITS

- Finish testing in a third of the time
- Maximize your outages and limit safety risk
- Replace a truck full of instruments and cables
- Greatly reduce the number of ladder trips technicians are exposed to per job

SUPPORTED STANDARDS	
NETA	2011 Maintenance 7.2.2 2007 Acceptance 7.19.2
IEEE	C57.152 C57.13 C57.13.6 C57.19.01 286
IEC	60076-1 60137 61850-9-2-Ed.2 B
IEC/TR	60894

TEST CAPABILITIES
Power Factor/Tan Delta
Variable Frequency Power Factor/Tan Delta
Demagnetization Feature
3 Phase Turns Ratio
10 kV Turns Ratio
Leakage Reactance (1Ø, 3Ø)
3 Phase Winding DC Resistance
3 Phase 10kV (Single Phase) Exciting Current and Loss

FUTURE ENHANCEMENTS
OLTC Dynamic Resistance Measurement (DRM)
External Reference
Capacitor Bank
Primary Injection
µΩ Meter

INCLUDED ACCESSORIES	
SYSTEM CABLES	
Type	Quantity
High Voltage Cables	2
Low Voltage Cables (Red, Blue, Yellow, Black)	4
Measurement Cables (Red, Blue, Yellow)	3
Ground Lead (Copper)	1
OLTC Control Cable	1
USB Cable	1
Ethernet Cable	1
AC Power Cord	1
External Temperature & Humidity Module w/Cable	1
External LED Strobe Lamp w/Cable	1
8' (2.4M) Integrated Safety Switch/Cable	1
65' (19.8M) Integrated Safety Switch/Cable	1
Doble Bushing Tap Adapters	4
Hot Collar Straps	7
5 ft Copper Jumpers	5

OPTIONAL ACCESSORIES
M7 Truck
MFL Liquid Insulation Test Cell
Type C Resonator (Up to 12 kV)
Doble Universal Controller (DUC)
IEC 61850 Adapter Kit *Coming in 2017*
M140 Capacitor Bank Kit *Coming in 2017*
M110 DC AMP *Coming in 2017*
M120 AC AMP *Coming in 2017*

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MKT_SL_M7_07/16

DOBLE OFF-LINE TESTING & ASSESSMENT

M5400

Sweep Frequency Response Analyzer

SFRA TOOL FOR DETECTING "HIDDEN" TRANSFORMER FAULTS

Use the Doble M5400 Sweep Frequency Response Analyzer to detect mechanical failure or movement of windings due to short circuits, mechanical stresses or transportation. Sweep Frequency Response Analysis is a proven technique, pioneered by Doble, for making accurate and repeatable measurements. The sweep approach is the industry standard and the preferred method for making frequency domain measurements.

FEATURES

- Instrument sends excitation signals to transformer and measures the returning signals across a broad frequency range
- Provides a frequency response measurement from 10 Hz to 25 MHz
- Measures frequency response at logarithmically spaced intervals of 1.2%
- Auto-scales each frequency measurement for an overall dynamic range of 80 dB with a ±1 dB accuracy
- Highest combination of dynamic range and accuracy available
- Simple, robust test leads that meet IEC standards

BENEFITS

- Ensure transformer performance, reduce maintenance costs and increase the service life of transformers
- Identify problems such as core movement, winding deformation & displacement, faulty core grounds, partial winding collapse, hoop buckling, broken or loose clamping structures, shorted turns & open windings
- Use as part of your regular maintenance program or any time you suspect a problem
- Measurements are highly repeatable so even subtle changes can be used for diagnostic purposes

M5400 TECHNICAL SPECIFICATIONS

EXCITATION SOURCE	
Channels	1
Frequency Range	10 Hz – 25 MHz
Output Voltage	20 V peak-to-peak at 50 Ohms
Output Protection	Short circuit protected
Source Impedance	50 Ohms
Calibration Interval	3 years
MEASUREMENT CHANNELS	
Channels	2
Sampling	Simultaneous
Frequency Range	10 Hz – 25 MHz
Max. Sampling rate	100 MS/s
Input Impedance	50 Ohms
Calibration Interval	3 years
DATA COLLECTION	
Test Method	Sweep Frequency
PC Comm	Ethernet USB/Serial
Frequency Range	10 Hz – 25 MHz
Number of Points	1000 points (Default) Up to1800 points (Extended Range)
Point Spacing	1.2 % Logarithmic
Dynamic Range	>90 dB
Repeatability	±1 dB to –80 dB
IF Bandwidth	< 10% of active frequency
DATA DISPLAY	
Scaling	Linear/Log
Frequency Range	10 Hz – 25 MHz, user defined within frequency range
Plotting	Frequency vs. Magnitude / Phase
Analysis	Difference, Sub-band Cross-Correlation
PHYSICAL SPECIFICATIONS	
Dimensions	18.2 x 13.4 x 6.7 inch 46.2 x 34.0 x 17.0 cm
Weight	13.1 lbs (6.0 kg)
Power Supply	100-240V AC
Temperature	0° to 50°C operating, -25° to + 70°C storage
Relative Humidity	0% to 95 % non condensing
TEST LEADS CONSTRUCTION	

Integrated three lead system in single cable set
Standard (362 kV and below): 60 ft/ 18 m
Optional (> 362 kV): 100 ft/ 30 m

M5400 RANGE

The M5400 provides a frequency response measurement from 10 Hz to 25 MHz. Doble recommends the default setting of 20 Hz - 2 MHz for transformers as there is limited diagnostic value in measurements outside of this range. The diagnostic frequency range of 20 Hz to 2 MHz covers the most important diagnostic areas:

- Core and Magnetic Properties
- Winding Movement and Deformation
- Interconnections – Leads and Tap Changers

M5400 RESOLUTION

The M5400 measures the frequency response at logarithmically spaced frequency intervals of 1.2%. A constant excitation level is maintained for each frequency measurement. The M5400 has the ability to auto-scale each frequency measurement providing an overall dynamic range of 80 dB with a ±1 dB accuracy. This gives the highest combination of dynamic range and accuracy available.

ORDERING INFORMATION

PART #	PRODUCT
M5400	Doble M5400 Sweep Frequency Response Analyzer
	Includes test set, instruction materials, software, 60 ft. SFRA test lead, ground extensions, safety ground, power cord and communication cables.

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MKT_SL_M5400_07/15

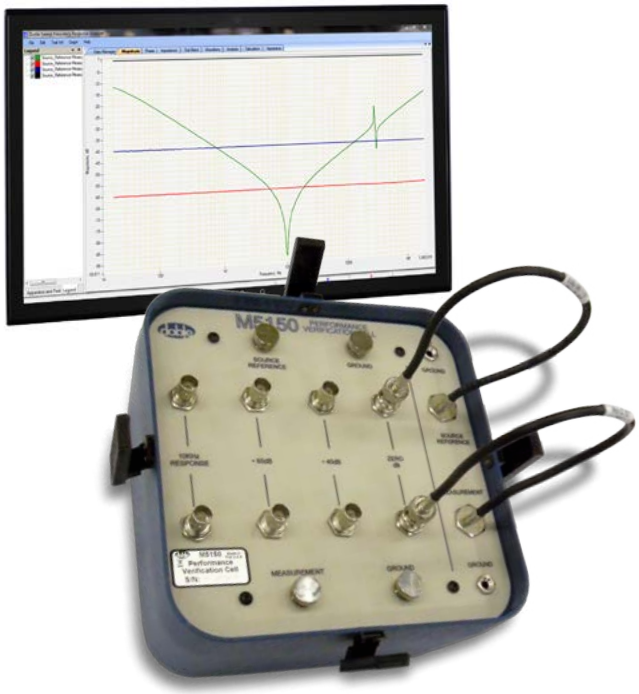
DOBLE OFF-LINE TESTING & ASSESSMENT

M5150

Performance Verification Cell

ENSURE SFRA TEST QUALITY BY VERIFYING TEST INSTRUMENTS AND LEADS

Rely on Doble's M5150 Performance Verification Cell for confirmation that your Doble SFRA field instruments and leads are working correctly. This highly-accurate verification device confirms that your equipment is providing you with results you can trust. The Doble M5150 can be used in the field or in the office allowing you to isolate problems between hardware and cables. Test your SFRA instrument and leads together or test the instrument using the included hook up cables.



FEATURES

- Easy configuration for simple and accurate testing of SFRA instruments and leads
    - Four standard responses:
    - 10 KHz notch filter response
    - -0 dB response
    - -40 dB response
    - -60 dB response
    - Includes cable bag with necessary hook up cables to test SFRA instruments

BENEFITS

- Confirm accuracy of SFRA test equipment and leads
- Isolate problems between hardware and cables
- Use in the field or office

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MKT_SL_M5150_07/15

DOBLE OFF-LINE TESTING & ASSESSMENT

TDR9100

Circuit Breaker Test System

THE ESSENTIAL TEST SET FOR YOUR CIRCUIT BREAKER TESTING

The TDR9100 is a state-of-the-art circuit breaker test system to test all types of circuit breakers with efficient and accurate performance measurements. The TDR9100 provides main contact timing, motion, resistance and capacitance measurements with the flexibility to double or triple your usable channels. Use this inclusive, rugged and field-portable instrument for simple and complex testing of circuit breakers. TDR9100 controls circuit breaker trip and close commands and supports the following operations: Trip (O), Close (C), Reclose (O-0.3s-C), Tripfree (CO), O-CO, O-0.3s-CO, First Trip (O), Slow Close (C).

FEATURES

- Test circuit breakers with up to 4 breaks per phase, 3 motion channels and 6 event channels
- Testing Flexibility - the test set can be ganged as a set of 2 or 3 units effectively doubling or tripling your usable channels and main contacts for circuit breakers with up to 12 breaks per phase
- Sampling rates up to 20kHz and expanded analog measurement ranges
- Rugged and Reliable - a single box solution, providing the accuracy of a laboratory instrument with durability for field use
- Complete Test Reports - provided in MS Excel™, Word™ and PDF formats
- User-friendly software interface - T-Doble software features an intuitive control panel for quick, efficient and simple testing of circuit breakers
- Includes pre-insertion resistor and capacitance measurement capability
- Detects main contact and resistor contact timing errors
- Measure additional parameters in the mechanism cabinet using Doble or 3rd party transducers

BENEFITS

- Use Doble's patented digital rotary and linear transducers to provide early diagnosis of mechanical problems
- Easily detect main contact and resistor contact timing errors
- Immune to Interference - the accuracy of test results is unaffected by the severe conditions of electrostatic and electromagnetic interference that are normally present in harsh substation environments
- Control with a Doble Universal Controller (DUC), tablet or PC

TDR9100 TECHNICAL SPECIFICATIONS

MAIN/RESISTOR CONTACT TIMING	
OCB Configuration	3 Contacts
EHV Configuration:	12 Contacts - up to 36 with ganged units
Resolution	50 µs / at max sample rate
Maximum Sample Rate	20 kHz
Resistor Detection Range	10 Ω to 10 kΩ
Resistor (Insertion) Value Range	10 to 7000 Ω
Measurement Accuracy Resistor Value Capacitor Value	 ± 10% ± 10%
Capacitance Detection Range	75 to 10,000 pF
Voltage Isolation to Chassis	1.0 kV

TRIP/CLOSE INITIATION CONTROL	
Maximum Input Current	± 100 A
Maximum Input Voltage	± 300 V
Voltage Isolation to Chassis	1.0 kV

MOTION CHANNELS	
Number of Channels	3 - up to 9 with ganged units
Connector	15-pin "D"
Voltage Isolation to Chassis	1.0 kV

EVENT CHANNELS	
Dual function, Analog or Auxiliary, user programmable	
Number of Channels	6 - up to 18 with ganged units
Analog Measurement Channels	Maximum Input Voltage: ± 300 V Input Impedance: 1 MΩ Resolution:12 Bit Number of Ranges: Ten - 0.2 to 300 V Analog Accuracy: ± 1% of reading, ± 1.5% full scale offset Voltage Isolation to Chassis: 1.0 kV
Auxiliary Contact Channels	Sense Mode: Voltage Sense/Contact Sense Maximum Input Voltage: ± 300 V Open Circuit Voltage: 30 V ± 10% Closed Circuit Current: 28 mA ± 10% Voltage Isolation to Chassis: 1.0 kV

GENERAL SPECIFICATIONS	
Recordings	25 seconds (all channels at max resolution) Up to 87 minutes (reduced resolution)
Communication	USB or Ethernet
Safety	Safety Ground Remote Safety Switch Audible Indication (test in progress)
Pending Certifications	CE, C-Tick, CSA Compliant

PHYSICAL SPECIFICATIONS	
Dimensions	24.0 X 15.5 X 8.5 in, 60.9 X 39.4 X 21.6 cm
Weight	24 lbs / 11 kg
Power Supply	100 – 240 V, 50/60 Hz
Temperature	0° to 50° C operating, -25° to + 70° C storage
Humidity	Up to 95% relative humidity non-condensing

TDR9100 OPTIONAL ACCESSORIES:
OCB & EHV Contact Cable Sets
Analog/Auxiliary Cable Kit - T9940
Doble Current Probe (20 A / 200 A Ranges)
10' or 60' Instrument Ganging Cable
Full line of Motion Transducers & Adapters
Mechanical Adapter Clamp Set
Safety Switch Bypass Flag

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MKT_SL_TDR9100_C6_11/15

OFF-LINE TESTING & ASSESSMENT

TDR900

PERFORMS TIMING FUNCTIONS FOR UP TO 4 BREAKS PER PHASE WITH MOTION MEASUREMENTS FOR ANY CIRCUIT BREAKER

CIRCUIT BREAKER TEST SYSTEM

The TDR900 is a state-of-the-art Circuit Breaker Test System engineered to test all types of circuit breakers. The TDR900 provides efficient and accurate performance measurements for circuit breakers. It allows simple to complex testing of circuit breakers using a single, rugged, field-portable instrument. TDR900 controls circuit breaker trip and close commands and supports the following operations: Trip (O), Close (C), Reclose (O-0.3s-C), Tripfree (CO), O-CO, O-0.3s-CO, First Trip (O), Slow Close (C).

T-Doble Software (included with the TDR900) allows simple configurable display of results and user configurable reports

FEATURES

- Test circuit breakers with up to 4 breaks per phase, 3 motion channels, 3 auxilary contact channels, and 3 analog channels
- Rugged and Reliable — the TDR900 is a single box solution, providing the accuracy of a laboratory instrument with durability for field use
- Complete Test Reports — provided in MS Excel™, MS Word™, and PDF formats
- User-friendly PC interface — T-Doble Software features an intuitive control panel for quick, efficient and simple testing of circuit breakers
- Measure additional parameters in the mechanism cabinet using Doble or 3rd party transducers

BENEFITS

- Use Doble's patented digital rotary and linear transducers to provide early diagnosis of mechanical problems
- Easily detect main contact and resistor contact timing errors
- Immune to Interference—the accuracy of test results is unaffected by the severe conditions of electrostatic and electromagnetic interference that are normally present in harsh substation environments
- Control with a Doble Universal Controller (DUC), tablet or PC

MAIN CONTACT AND RESISTOR SWITCH TIMING

Number of Phases:	3
Breaks Per Phase:	4
OCB Configuration:	3 Contacts
EHV Configuration:	[3, 6, 9, 12] Contacts
Resolution:	100 µs
Resistor Detection Range:	10 Ω to 10 kΩ
Voltage Isolation to Chassis:	1.0 kV

TRIP/CLOSE INITIATION CONTROL

Maximum Input Current:	± 25 A
Maximum Input Voltage:	± 300 V
Voltage Isolation to Chassis:	1.0 kV

MOTION CHANNELS

Number of Channels:	3
Connector:	15-pin "D"
Voltage Isolation to Chassis:	1.0 kV

ANALOG MEASUREMENT CHANNELS (3A)

Maximum Input Voltage:	± 300 V
Input Impedance	1 MΩ
Analog Accuracy	± 1% or reading ± 1.5% full scale offset
Voltage of Isolation to Chassis	1.0 kV

AUXILIARY CONTACT CHANNELS (3X)

Sense Mode	Voltage Sense/Contact Sense
Maximum Input Voltage	± 300 V
Open Circuit Voltage:	29 V ± 10%
Close Circuit Current:	28 mA ± 10%
Voltage Isolation to Chassis:	1.0 kV

DIGITAL LINEAR/ROTARY MOTION TRANSDUCER

	Linear	Rotary
Range:	0.0 to 40.0" 0.0 to 1000.0 mm	0.0 to 2880.0°
Accuracy:	+/- 0.1% of the value +/- 0.1" max error	+/- 0.1% of the value +/- 0.1" max error
Measurement Resolution:	0.00125" 0.03 mm	0.09°
Velocity:	50 ft/s 15 m/s	120 rev/s max
Acceleration:	1200 g for 50 ms max	$30x10^6$°/s^2 max
General Recordings:	25 seconds (all channels at max resolution) Up to 30 min (reduced resolution)	
Communication:	USB or Ethernet	
Safety:	Safety Ground Safety Switch (local and remote) Audible Indication (test in progress)	

PHYSICAL SPECIFICATIONS

Dimensions:	24.0 X 15.5 X 8.5 in 60.9 X 39.4 X 21.6 cm
Weight:	22 lbs / 10 kg
Power Supply:	100–240 V, 50/60 Hz
Temperature:	0° to 50° C operating, -25° to + 70° C storage
Humidity:	Up to 95% relative humidity non-condensing

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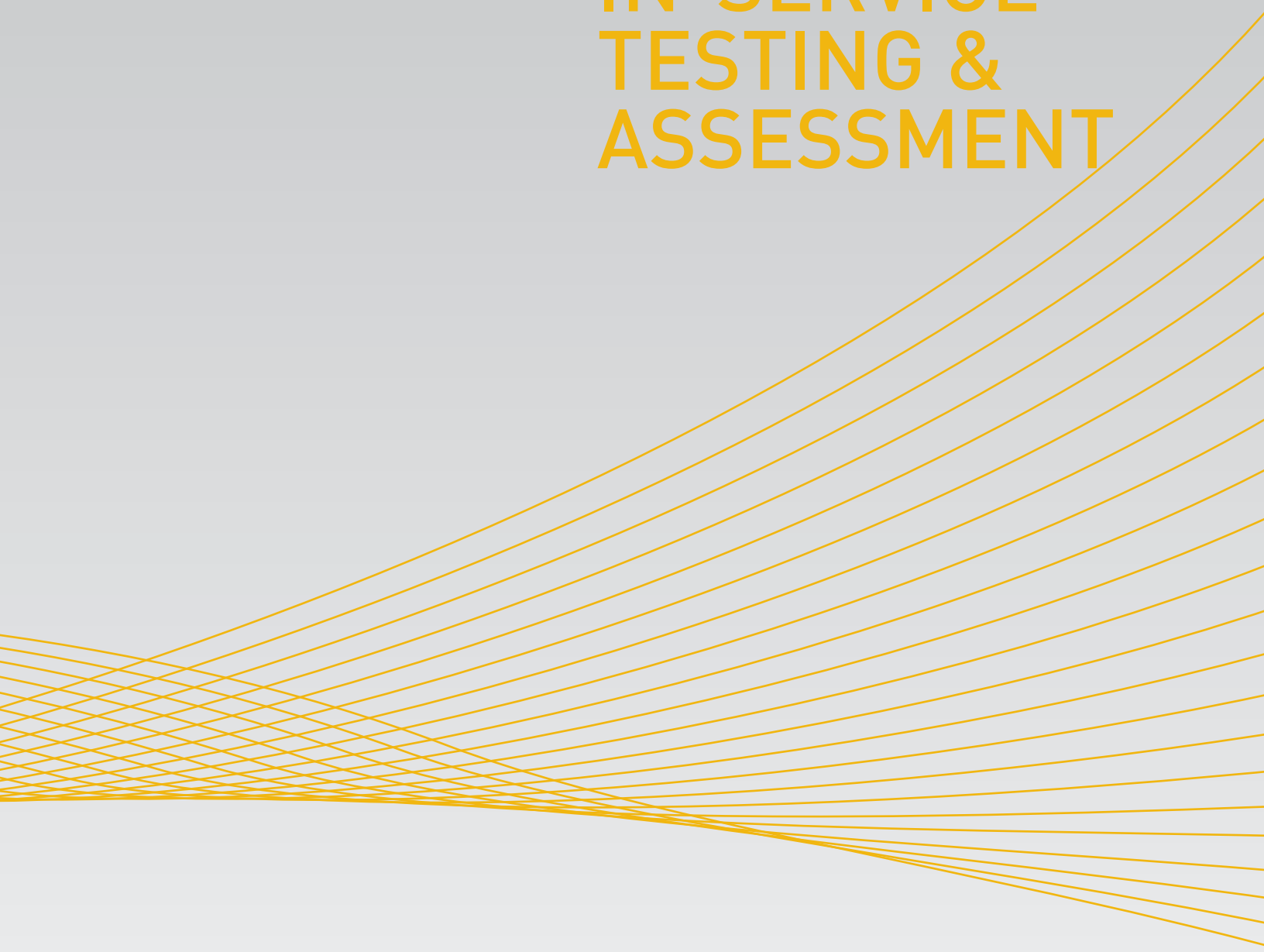
MKT_SL_TDR900_03/16

IN-SERVICE TESTING & ASSESSMENT



DOBLE IN-SERVICE TESTING & ASSESSMENT

PDS100

Partial Discharge Surveyor

CHECK IN-SERVICE SUBSTATION EQUIPMENT FOR SIGNS OF INTERNAL INSULATION DAMAGE

The Doble PDS100 Partial Discharge Surveyor is an RFI surveying tool that is designed for use in a live substation. Without the need for outages, the PDS100 can detect partial discharge (PD) in just a few seconds, thus making it an ideal tool for a condition based maintenance program. Whole substations can be quickly surveyed and analyzed.

FEATURES

- Uses RFI technology to identify and locate defects
- Rugged, light-weight, hand-held instrument
- Works with a variety of sensors, probes and antennae for various applications

BENEFITS

- Safe and effective method for PD detection
- Non-invasive inspection method for substation surveys
- Use on a daily basis or during routine substation inspections together with other methods such as infrared scanning

PDS100 TECHNICAL SPECIFICATIONS

POWER SUPPLY	
External supply	External DC adaptor, 12 V @ 2 A
DC adapter	85 - 264 V AC (47 - 63 Hz)/ 12 V DC
Internal battery	Li-Ion, 7.2 V, 6.6 Ah
Battery life	> 4 hours
DETECTION AND SWEEP FUNCTIONS	
Detector modes	Peak, Average and Separate Peak and Average Mode(SPAM)
Sweep modes	Continuous, Counted and Single Mode
FREQUENCY	
Measurement range	50 MHz - 1000 MHz
AMPLITUDE	
Display unit	X/Y-axis: ms - MHz / dBm
DATA STORAGE/ TRANSFER	
Internal	SD-Card (fixed)
External	USB storage class compliant, including Memory stick
Data Transfer	USB A/B to and from computer
LCD SCREEN	
Size	132 x 100 mm / 5.20 x 3.94 in (W x H)
Resolution	640 x 480 pixels, 256 colors
MECHANICAL	
Size	350 x 220 x 70 mm / 8.85 x 12.20 x 2.25 in (WxHxD)
Weight	2.2 kg / 4.85 lbs
ENVIRONMENT	
IP classification	IP64 with top covers closed IP51 with top covers open
Humidity	0 - 95% non-condensing
Operating temperature	0°C to + 50°C / 14°F to 122°F
Storage temperature	-20°C to + 70°C / -4°F to 158°F

USER-FRIENDLY

The PDS100 is a rugged, light-weight and powerful high-tech instrument with a big display and large soft key buttons. The instrument is easy to use and the software enables the operator to record and analyze PD signals and make decisions for further actions.

TECHNOLOGY

The instrument searches for PD in the radio frequency area. Harmful PD will reveal itself by the electromagnetic energy emitted from the area where the activity is. The PDS100 captures the electromagnetic energy in the RF spectrum and displays a "footprint" of the RF interference from partial discharge causing the radiation.

ORDERING INFORMATION

PART #	PRODUCT
TN-80000	PDS100: Complete with Case, Antenna, Adapter and PC software
	ACCESSORIES
	A variety of sensors, probes, and antennae are available for various applications

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MKT_SL_PDS100_12/15

DOBLE IN-SERVICE TESTING & ASSESSMENT

PDS200

PD Surveyor with EMI Capabilities

FIND INSULATION AND OTHER SYSTEM DEFECTS IN TRANSFORMERS, CABLE TERMINATIONS, HV SUBSTATION AND PLANT EQUIPMENT

The PDS200 Surveyor measures and analyses the radio frequency (RFI) and the lower frequency electromagnetic (EMI) emissions that are associated with faulty or degraded insulation and other system defects. EMI analysis can discriminate between different defects and discharge sources.

The presence of partial discharge (PD) is a precursor to complete insulation failure or an early indication of other electrical and mechanical defects. It is important to detect and trend these discharge phenomena from an early stage and follow the development of the problem. The PDS200 allows the operator to quickly make a system wide survey thus making it an ideal tool for utilities that desire a system diagnostics approach and early warning of incipient failures.

FEATURES

- Easy to use, handheld device with large display screen
- Captures the electromagnetic emissions in the RFI and EMI spectrum and displays a "fingerprint" of the defect causing the radiation
- User selection of measurement parameters maximises sensitivity to emissions
- Signal capture may be synchronised to the power cycle to facilitate phase resolved PD analysis
- Connection to sensing devices such as HFCT's, probes and directional antenna for different applications
- Synchronous sampling and display of detector outputs provides discrimination of telecommunication carriers, noise and discharge phenomena
- Logging of key parameters for short/medium term trending of emissions

BENEFITS

- Quickly perform surveys without costly outages
- No physical connections to the unit under test; detection method is truly non-invasive
- Safe, effective method to detect insulation and mechanical defects
- Provides immediate trending of measurements
- The software enables the operator to record and analyze the emissions and make decisions for further actions
- Convenient, simple tool for routine PD surveys

PDS200 TECHNICAL SPECIFICATIONS

DESCRIPTION

The PDS200 is a dual function instrument capable of analysing both EMI and RFI emissions from insulation and system defects using a variety of sensors. During a survey, the three presentation and analysis modes (Spectrum Analyzer, Time Resolved, and Level Meter) provide different ways to present and trend a frequency 'signature' of the defect and provide the analysis to fingerprint the defect.

User selection of the measurement parameters maximise sensitivity to emissions or follow the spirit of the CISPR-16 standard to ensure compatibility of measurement and results interpretation across different EMI measurement instruments. The instrument can make synchronized measurement with the power frequency when the wireless adapter is connected to a power outlet within 100m (300ft).

DETECTION AND SWEEP FUNCTIONS

Detector Modes	Peak, Average, Synchronous Peak and Average Mode (S.P.A.M.), Quasi-Peak, Synchronous Peak and Quasi Peak (S.P.Q.P.)
Sweep Processing	Continuous, Counted and Single Mode
Signal Triggering	Based on signal level or by phase Phase plot with up to 5000 hits
Synchronization	Synthesized phase or wireless synchronized to power frequency

FREQUENCY

	EMI	RFI
Frequency Range	50 kHz - 100 MHz	50 MHz -1000 MHz
Resolution Bandwidth (RBW)	9 kHz / 120 kHz	120 kHz / 6 MHz
Accuracy	± 10 kHz	± 100 kHz

AMPLITUDE

Display units	MHz/dBm or Mhz/dBµV

POWER SUPPLY

External Supply	External DC adapter, 12V @ 2A
DC Adapter	85-264 VAC (47-63 Hz) / 12 VDC
Internal Battery	Li-Ion, high capacity 7.2V, 6.6Ah
Battery Life	>6 hours
Charging Time	3 hours

CONNECTIVITY

USB 1.1 Host and Client, WiFi. For use with tablet or PC based apps to trend or archive survey data and simple firmware upgrades.

DATA STORAGE

Internal	NV Flash Memory
External	USB Storage compliant USB Flash Drive / Hard Disk Drive
File Format	XML for use with Doble PDViewer software
Real Time Clock	Battery backed

LCD SCREEN

Display	TFT, 6.4" Transreflective
Size (W x H)	132 x100 mm
Resolution	640 x 480 pixels, 256 colours
Backlight	LED

MECHANICAL

Instrument	225 x 310 x 70 mm (WxHxD) 2.4 kg
Transport Case	425 x 284 x 155 mm (WxHxD) 3.4 kg
Total Weight	5.8 kg (incl. instrument, transport case, charger etc.)

ENVIRONMENTAL

Enclosure	IP64 – top covers closed IP51 – top covers open
Transport case	IP67
Electrostatic discharge according to EN 61000-4-2	
Humidity	0-95% non-condensing
Temperature	Operating temperature: -10°C to +50°C / 32°F to 122°F Storage temperature: -20°C to +70°C / -4°F to 158°F

ORDERING INFORMATION

PRODUCT

Doble PDS200
Complete with transport case, antennae (telescopic and whip), battery charger, neck strap and wireless synchronization adapter. PDViewer software is included.

OPTIONAL ACCESSORIES

HFCT
Scan for electrical pulses (f<200 MHz) as evidence of PD to earth. Can be clipped on an apparatus ground wire (transformers, dead tank breakers) and connected to a PDS200.

Directional Antenna
Provides more specific location of RFI sources. With this combination you not only determine the presence of PD sources, you can also establish the direction of the emissions.

UHF Drain Valve Probe DN50/DN80
Insert into the suspect transformer to find RFI as evidence of partial discharge.

Transient Earth Voltage (TEV) capacitive probe
Find PD in metal-clad switchgear (GIS).

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MKT_SL_PDS200_05/16

DOBLE IN-SERVICE TESTING & ASSESSMENT

EMI Surveyor

For Rotating Machine & Power Plant Applications

FIND INSULATION AND CONDUCTOR DEFECTS IN MOTORS, GENERATORS, TRANSFORMERS, SWITCHGEAR, CABLE TERMINATIONS & OTHER HV EQUIPMENT

Doble's EMI Surveyor is a non-invasive, in-service survey solution that can identify more than 65 different electrical and mechanical defects that other technologies are unable to detect in HV electrical plant equipment. The EMI Surveyor measures the release of electromagnetic (EMI) energy resulting from HV electrical insulation-related partial discharge defects, corona, random noise, as well as LV/HV mechanical conductor-related arcing defects.

The EMI Surveyor comes complete with the PDS200 spectrum analyzer, EMI sniffer, split-core high-frequency current transformer, wireless synchronization adapter and all required antennae and cables for a complete EMI assessment.

For more effective risk management and outage maintenance & repair planning, many nuclear and fossil plants routinely conduct EMI testing 3-6 months prior to an outage. Peaking plants routinely conduct EMI testing in conjunction with the plant's annual emission monitoring relative accuracy test audits.

FEATURES

- Portable, easy to use, handheld devices
- Provides dual EMI and RFI partial discharge spectrum capabilities
- Easily connects to multiple sensors including high-frequency current transformers, UHF drain valve, TEV probes, and directional antennae for various applications
- Listen to radio noise generated from defects for more in-depth analysis
- Signal can be power cycle synchronized to facilitate phase resolved PD analysis

BENEFITS

- Efficiently plan outages by improving prioritization of needed maintenance & repairs
- Non-invasive, in-service electrical "system assessment" surveying solution
- No permanent high-voltage connection mitigates arc flash hazards
- Proven technology providing asset maintenance recommendations after the first test

ASSET PERFORMANCE SERVICES

Leverage Doble's expert EMI Diagnostics field services team to perform testing at your plant for a comprehensive electrical plant assessment. Doble can also provide comprehensive classroom and field data acquisition training enabling your team to capture EMI/RFI data and forward to Doble's experts for detailed data analysis, report writing and follow up consultation.

Testing with the EMI Surveyor

Using the PDS200, data is collected from the temporary placement of a split-core high frequency current transformer around the power conduit, safety ground or neutral lead of the component being tested.

EMI testing measures a broad spectrum of radio frequencies to allow the test engineer to view unique patterns at each frequency, including corona, gap discharges, random noise, arcing and more. Arcing has 50/60Hz current flow and is produced by many mechanical defects such as a wiped bearing, loose connections or broken rotor bars in an induction motor.

The test engineer can evaluate time domain patterns and listen to corresponding radio noise for a more in-depth analysis. A handheld EMI sniffer is also used to measure EMI signals radiated from each component or system defect, aiding in identifying and locating the defect.

Training Services

Add two days of classroom and hands-on field training at your location. A typical training session would include:

- Overview of EMI, PD and RFI detection applications
- EMI fundamentals
- International standards
- Working with the EMI Surveyor
- Taking reliable measurements
- Analyzing data for proper data acquisition
- Managing PDS200 data and firmware
- Overview of PDViewer software

PDS200 TECHNICAL SPECIFICATIONS

DETECTION AND SWEEP FUNCTIONS	
Detector Modes	Peak, Average, Synchronous Peak and Average Mode (S.P.A.M.), Quasi-Peak, Synchronous Peak and Quasi Peak (S.P.Q.P.)
Sweep Processing	Continuous, Counted and Single Mode

FREQUENCY	EMI	RFI
Frequency Range	50 kHz - 100 MHz	50MHz -1000 MHz
Resolution Bandwidth (RBW)	9kHz / 120 kHz	120 kHz / 6 MHz
Accuracy	± 10 kHz	± 100 kHz

POWER SUPPLY	
External Supply	External DC adapter, 12V @ 2A
DC Adapter	85-264 VAC (47-63 Hz) / 12 VDC
Internal Battery	Li-Ion, high capacity 7.2V, 6.6Ah
Battery Life	>6 hours
Charging Time	3 hours

ENVIRONMENTAL	
Enclosure	IP64 – top covers closed IP51 – top covers open
Transport case	IP67
Electrostatic discharge according to EN 61000-4-2	
Humidity	0-95% non-condensing
Temperature	Operating temperature: -10°C to +50°C / 32°F-122°F Storage temperature: -20°C to +70°C / -4°F - 158°F

ORDERING INFORMATION

PRODUCT DETAILS
Doble EMI Surveyor *Complete with PDS200, whip antenna, wireless sync transmitter with antenna, EMI sniffer, split-core HFCT (1 – 100 MHz with 5-inch window), noise isolating earphones, all required cables, power cord, transport case and user guide. PDViewer software included.*

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MKT_SL_EMISurveyor_03/16

DOBLE IN-SERVICE TESTING & ASSESSMENT

DFA300

Radio Frequency Interference and Acoustic Signal Surveyor

CHECK FOR INSULATION OR MECHANICAL PROBLEMS IN GAS INSULATED SWITCHGEAR OR IN-SERVICE SUBSTATIONS

Identify and locate insulation defects with the DFA300, a surveying tool that combines radio frequency interference (RFI) and acoustic emission (AE). It can detect and locate partial discharge (PD) in a few seconds. Designed for surveying live, high voltage apparatus, its versatility makes it the perfect, multi-purpose tool for condition-based maintenance programs.

FEATURES

- Combination tool uses both RFI and acoustic technology
- Registers RFI from apparatus with insulation problems including PD and arcing
- Locate and diagnose internal problems using the acoustic sensor on grounded surfaces
- Easy to use, handheld device with large display screen

BENEFITS

- Perform non-invasive surveys of critical assets
- Identify and locate insulation defects in gas insulated and open air substations, transformers, instrument transformers and cable terminations
- Convenient tool for daily use or routine substation surveys along with thermography

DFA300 TECHNICAL SPECIFICATIONS

INPUT CHANNEL DESCRIPTION
The DFA300 is a dual function instrument capable of analysing either acoustic or RF emissions. There is a single input connection which can accept either a RF or an acoustic sensor.

ACOUSTIC EMISSION CHANNEL	
Inputs	1 channel
Connector	BNC
Input Impedance	50Ω or 22kΩ, software switchable (low noise preamp: 22kΩ only)
AE Operating Frequency	10 kHz to 500 kHz at -3dB points
Phantom Power	28 VDC on BNC centre conductor (100mA current limited), software switchable
AE Sensor	R3α (standard), R6α, R6I, R15α R15I (optional)

UHF CHANNEL	
Inputs	1 channel
Connector	BNC
Input Impedance	50Ω
Bandwidth	50-1000 MHz with 6 MHz RBW
Accuracy	± 100 kHz
Detection Types	Peak and average detector
Sweep Processing	Continuous, Average, Max Hold and differential

POWER SUPPLY	
External Supply	External DC adapter, 12V @ 2A
DC Adapter	85-264 VAC (47-63 Hz) / 12 VDC
Internal Battery	Li-Ion, high capacity 7.2V, 91 Wh
Battery Life	>6 hours
Charging Time	± 3 hours

MECHANICAL	
Instrument	225 x 310 x 70 mm (WxHxD) Weight 2.4 kg
Transport Case	425 x 284 x 155 mm (WxHxD) Weight 3.4 kg
Total Weight	6.0 kg incl. instrument, transport case, manuals, CD and charger

LCD SCREEN	
Display	TFT, 6.4" Transreflective
Size (W x H)	132 x100 mm
Resolution	640 x 480 pixels, 256 colours
Backlight	LED

DATA STORAGE	
Internal	NV Flash memory (SD)
External	USB storage class compliant USB Flash Drive/Hard Disk Drive
Data Transfer	Measurements can be downloaded to a PC
Real Time Clock	Battery backed

ENVIRONMENTAL	
Enclosure	IP64 – top covers closed IP51 – top covers open
Transport Case	IP67
Electrostatic discharge according to EN 61000-4-2	
Humidity	0-95% non-condensing
Temperature	Operating temperature: -10 to +50°C Storage temperature: -20 to +70°C

ORDERING INFORMATION

PRODUCT

Doble DFA300

Complete with transport case, antennas, acoustic sensor, battery charger, neck strap and wireless synchronization adapter. Software is included.

ACCESSORIES

Transient Earth Voltage (TEV) capacitive probe

Find PD in metal-clad switchgear (GIS). To be connected directly on the antenna input of the DFA300

HF CT

Scan for electrical pulses (f<200 MHz) as evidence for partial discharge to earth. Can be clipped on an apparatus ground wire (incl.transformers and dead tank breakers) and connected to a DFA300.
(N to BNC cable required)

DA100 Directional Antenna

Provides more specific location of RFI sources for substation surveys. Including direction of the emissions.

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DOBLE IN-SERVICE TESTING & ASSESSMENT

PD-Smart

Partial Discharge Analyzer

IN-DEPTH PARTIAL DISCHARGE TESTING IN THE FIELD

The Doble PD-Smart is a versatile, partial discharge analyzer used to detect PD in all types of in-service equipment including transformers, rotating machines, cables and switchgear. The PD-Smart works with Doble couplers or your existing, pre-installed couplers.

FEATURES

- High measurement accuracy and sample rate
- Complies with IEC 60270 and various VDE, ANSI and IEEE standards
- Advanced noise suppression tools include windowing, gating, frequency band shifting and an adjustable internal digital filter
- Uses well-known and advanced Lemke Noise Gating Technology where the elimination of external noises happens via an external antenna
- Measures both the PD and the actual applied voltage under test
- User interface features a customizable dashboard layout to make PD testing easier and more intuitive
- UHF mode for detection of radiated and conducted high frequency activity from partial discharge

BENEFITS

- Use for in-house and on-site applications of all types of HV apparatus
- Combines state-of-the-art technology with 40 years of Lemke`s Partial Discharge knowledge within one smart solution
- Noise suppression techniques make it possible to perform tests in rough and noisy environments
- A simple way to add partial discharge analysis to your condition-based maintenance testing program
- Versatile test instrument for both directly coupled sensors and indirectly coupled sensors, such as UHF antennae and high frequency current transformers

PD-SMART TECHNICAL SPECIFICATIONS

MEASUREMENT PARAMETERS	
INPUT FREQUENCY RANGE	
Test voltage	20 Hz - 1.2 kHz
PD signal	35 kHz - 20 MHz
INPUT VOLTAGE	
Test voltage	50V rms (max)
PD signal	70V rms (max)
INTEGRATION IN TIME AND FREQUENCY RANGE	
Time range	140 ns...8µs
Frequency range	0 Hz...20 MHz
Filter bandwidths	Freely adjustable
DYNAMIC RANGE	
Test voltage	16 bit, 80 dB
PD signal	16 bit, 100 dB
ADDITIONAL MEASUREMENT PARAMETERS	
Selectable input attenuation	64 dB / 8 dB - 16 dB
Single pulse resolution capability	≥ 100 kHz repetition rate (deviation < 10 %)
Single pulse detection	< 3 ns
Max. double pulse resolution	< 200 ns (time range, super position error < 1%)
Max. pulse frequency	> 2 MHz
Synchronization between units	< 800 ps
Minimum detectable apparent charge	0.2 pC
Maximum input pulse amplitude	100 V, max. 100 nC
I/O	
Outputs	1 x FOL-output with E/O converter as Ethernet 1 x FOL-output Downlink 1 x FOL-output Uplink 1 x TNC Trigger output 1 x FOL Trigger output
Inputs	1 x TNC HF PD-signal 1 x TNC LF voltage signal 1 x TNC HF gating signal
PD input coupling	DC, AC
PD input protection	Input protection against over-voltage and short-circuit
INPUT IMPEDANCE	
Test voltage	1 MΩ
PD signal	50 Ω
UHF MODULE	
UHF Spectrum analyzer	Integrated zero span function
UHF Sensor pre-amplifier	Optional 38 dB amplification for frequencies 110 – 850 MHz over-voltage protection
UHF Processing unit	TNC type signal input attenuation unit: 62 dB software controlled in 2-dB steps Band stop filter 7 MHz Software controlled adjustment 110-850 MHz
IF Mixer Unit	Internal IF signal (peak detected) as output signal for the digital input unit, with bandwidth 110-850 MHz at 7 MHz (IF)

SYSTEM PARAMETERS	
Power Supply	14.4 V DC with battery
External power supply	100-240 V, 50-60 Hz
Warming-up period	15 Minutes (only required with UHF unit when in calibration mode)
Power consumption	50 VA
TEMPERATURE RANGE	
Operation	0°C to 45°C, 32°F to 113°F
Storage	-10°C to 60°C, 14°F to 114°F
Humidity	5% ... 95%, non-condensing

OPTIONAL ACCESSORIES	
Calibrators	Calibrators for external calibration of the PD measuring circuit
LDC-7/UHF	Function tester, UHF pulse signal injector
ROTATING MACHINES	
Couplers and connections	Range of Doble PD Couplers with integrated measuring impedance According to IEC EN 60270 Including splitting box and connection box
BC Matching Unit	To adapt conventional PD measuring methods to maximum 4 low-capacitance line couplers
MV/HV CABLES	
HFCT-300 Sensor	For highly sensitive PD measurements with superposed line currents or high reactive currents (50/60 Hz) which can reach up to 300 A. Also available in potted version.
LDWS-T	Cable sealing end UHF sensor
HV TRANSFORMERS AND SWITCHGEAR	
TEV Sensor	Detection PD signals behind metal surfaces, i.e. metalclad switchgear and transformers
HFCT-300 Sensor	(as above)
HV TRANSFORMERS	
DN-50/80	Drain Valve UHF PD-probe
UHF PD Plate Sensor	Integrated UHF sensort
HFCT-Mini	For use with bushing PD detection
MEASURING IMPEDANCE AT MV/HV CABLES & HV TRANSFORMERS	
LDM-5 /U5	Measuring impedance for signal and test voltage decoupling
Coupling Capacitor	Range of coupling capacitors to be used with LDM-5/U5
LDF-6/FU - Filter Unit	Filter for suppression of radio interferences to be used with LDM-5/U5

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DOBLE IN-SERVICE TESTING & ASSESSMENT

LDS-6

Partial Discharge Analyzer

IN-DEPTH TESTING AND ANALYSIS OF PARTIAL DISCHARGE FOR FACTORY AND LABORATORY TESTING

Doble LDS-6 allows for Partial Discharge (PD) tests on HV assets, diagnosis on developing insulating materials and fault location for power cables. The LDS-6 works with Doble couplers or existing, pre-installed couplers (if IEC-compliant). The instrument is specially designed for calibrated electric partial discharge measurements according to IEC 60270, as well as various IEEE standards.

The LDS-6 is field-proven and got high acceptance in the manufacturing and research industry for PD quality tests on motors, generators, transformers, MC and HV cable system, switchgear and other HV accessories. Additionally, it's the perfect instrument for PD commissioning tests and maintenance tests on HV equipment.

FEATURES

- Uses advanced Doble Lemke Noise Gating Technology™ with two seperate channels for real hardware gating and an external antenna (gating sensor) for elimination of external noise
- Complies with IEC 60270, VDE 0434 and various IEEE standards
- Single pulse recognition capability up to 100 kHz pulse repetition rate
- Minimal Superposition error
- Highly-sophisticated PD statistics, diagnosis and analysis software
- DC processing unit for DC Testing (optional)
- Multiplexer (optional)

BENEFITS

- Evaluate measuring results through the sophisticated software in the most convenient and expert manner
- Use for test floor and on-site applications of all types of HV apparatus
- Noise Gating Technology™ makes it possible to perform tests in noisy environments
- Modular, rack-mounted system that can be expanded to include a RIV pulse processing unit for transformer testing and a cable fault location unit

LDS-6 TECHNICAL SPECIFICATIONS

MEASUREMENT PARAMETERS	
INPUT FREQUENCY RANGE	
Test voltage	**DC to 10 kHz**
PD signal	20Hz - 20MHz
INPUT VOLTAGE	
U_{rms}	50V
U_{peak}	71V
PD Signal	100V
FREQUENCY RANGE	
Narrow Band Unit	240 kHz: 200-280 kHz 480 kHz: 440-520 kHz 1.6 MHz: 1.1-2.1 MHz Optional : FU Filter Unit
DYNAMIC RANGE	
Test Voltage	12-bit, 80 dB
PD-Signal	Sensitivity range: 1pC to 100,000pC (Autoranging 0-93db)
Wide Band Logarithmic Processing Unit	12-bit, 60dB (30pC-30nC approx.)
ADDITIONAL MEASUREMENT PARAMETERS	
Selectable input attenuation	0-93 dB (per 3 dB)
Single pulse resolution capability	up to 100 kHz pulse repetition rate (deviation < 10 %)
Double pulse resolution	10 µs
Sensitivity Range	1 pC - 100,000 pC (Autoranging 0-93 dB)
Max. input pulse amplitude	above 100 nC
INPUT IMPEDANCE	
Test voltage	1 MΩ
PD signal	50 Ω
COMMUNICATIONS	
Ethernet	
POWER SUPPLY	
Power Supply	100-240 V, 50-60 Hz
Power consumption	50 VA
ENVIRONMENTAL	
Operating Temperature	5°C to 45°C
Humidity	<80% non-condensing
Protection Class	IP22
MECHANICAL	
Dimensions (WxHxD)	46 x 42 x 14 cm
Weight	8,6 kg

ORDER INFORMATION	
LDS-6 Partial Discharge Analyzer - Rack-mounted unit to diagnose, analyze and evaluate PD (incl. Windowing Unit). Available in: Standard version Standard + Plug-in for cable fault location Standard + Plug-in for RIV measurements (for transformers) Standard + Plug-in for DC	
LDC-TR Software Automation	Optional software for PD and RIV measurements on HV transformers according to NEMA-CISPR and IEC 60076-3. Including report generator
OPTIONAL ACCESSORIES	
LDC-5 Calibrator	Calibrated charge injector (5, 20, 100 and 500pC)
HFCT-300 Sensor	For highly sensitive PD measurements
ROTATING MACHINES	
Couplers and connections	Range with integrated measuring impedance. According to EN60270. Including splitting box and connection box
BC Matching Unit	To adapt conventional PD measuring methods to maximum 4 low-capacitance line couplers
ACCESSORIES FOR MEASURING IMPEDANCE AT MV/HV CABLES AND HV TRANSFORMERS	
LDM-5 /U5	Measuring impedance for signal and test voltage decoupling
HV Coupling Capacitors	Range of Coupling Capacitors. To be used with LDM-5/U5
LDF-6/FU - Filter Unit	Filter for suppression of radio interferences. To be used with LDM-5/U5
LDM-5/U-RIV Measuring Impedance	PD Measuring Impedance with additional 2 switches for 4 CU's. For transformer testing according to IEC 60270 or NEMA-CISPR
LDM-5/M8-Switching box	Switching box for channel switching of the PD- and voltage channels (software-controlled), 8 channels for usage. More channels on request available

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DOBLE IN-SERVICE TESTING & ASSESSMENT

LCM500

Leakage Current Monitor

FOR THE ASSESSMENT OF IN-SERVICE SURGE ARRESTERS

A surge arrester may be inexpensive, but it has an important role in protecting your transformers. The Doble LCM500 can measure condition while the arrester is still in service, measuring the quality of the metal oxide blocks and helping manage the risk of failure. With the LCM500, it takes less than 15 minutes to establish that your surge arresters are healthy and the transformer is still protected.

FEATURES

- Portable, battery-operated instrument for regular condition assessment of surge arresters
- Unique identification of each surge arrester makes data management easy
- Instrument can store 1000 surge arrester IDs and measurements performed in the field
- Defines individual surge arrester types including operational parameters
- Software includes possibility to perform evaluation of groups of surge arresters e.g. same type of arresters or alternatively for a region.

BENEFITS

- Safe and effective assessment of metal oxide surge arresters
- Inspection of a surge arrester takes less than 15 minutes on location and can be performed with the arrester in service
- Can be used for short-term monitoring of one arrester to investigate details in leakage current changes versus time

LCM500 TECHNICAL SPECIFICATIONS

MECHANICAL	
Dimensions (WxHxD)	47 x 35.7 x 17.6 cm 18.50 x 14.06 x 6.93 in
Weight	7.5 kg / 16.5 lbs
ENVIRONMENTAL	
IP classification	IP67 (closed case) IP51 (open lid)
Operating temperature	-10°C to +50°C / 14°F to 122°F
Storage temperature	-20°C to +70°C / -4°F to 158°F
POWER SUPPLY	
12 - 15 VDC or 85 - 264 VAC 47 - 63 Hz	
Battery	9.6V 2600 mAh
Capacity	8 hours
Charging time	1.5 hours
MEASURING RANGE	
Total arrester leakage current	200 – 16000 µA
Resistive current	0 – 9000 µA
Frequency range	47 – 63 Hz (system voltage 50Hz or 60Hz)
Field probe	0-5Vac
Accuracy	±5 % or ±5 uA
WIRELESS SENSORS	
Battery powered wireless current probe and field antenna	Rechargeable (charges in instrument lid) 9V 500mAh Digital radio communication at 434.075-434.525 MHz* Probes can be set at 16 distinct channels Probes are in addition separated by their serial numbers

** May vary between countries*

LCM TECHNIQUE

Well-proven and acknowledged monitoring technique using third-order harmonic analysis with compensation. Rated according IEC 60099-5 as the best field monitoring technique for Metal Oxide Surge Arresters (MOSA). LCM500 measurements are automatically normalized to standard ambient temperature (+20°C) and 0.7x rated arrester voltage based on recorded temperature and operating voltage during field measurement. Measurements performed under different conditions can thereby easily be compared.

PERFORMING FIELD MEASUREMENTS

LCM500 is designed for trending the condition of metal oxide surge arresters. Arrester ID is downloaded from PC software to LCM500 instrument prior to performing inspection of surge arresters. LCM500 can store 1000 arrester IDs. On location choose correct arrester ID and perform measurement. After completion of field measurements stored data are transferred from LCM500 instrument to PC software. You are now ready to perform analysis and plan your next inspection.

APPLICATION

Doble leakage current monitors can be used to trend the condition of all types of metal oxide surge arresters on an insulated base with one separate grounding system conductor.

ORDERING INFORMATION

PART #	PRODUCT
TN-25000	LCM500 with case, Clip-on CT, Field Probe, Rod Adapter, power cable and test cables *Field Probe rod is not included.*
	ACCESSORIES
TN-25156	Field Probe Rod (delivered in separate transport case) *Field Probe Rod made of insulating materials.*

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DOBLE IN-SERVICE TESTING & ASSESSMENT

TEV Probe

Partial Discharge Accessory

ASSISTS IN THE DETECTION OF PARTIAL DISCHARGE ACTIVITY IN METAL CLAD SWITCHGEAR, CONNECTION BOXES AND THROUGH TRANSFORMER TANK WALLS

Use the Doble Transient Earth Voltage (TEV) Probe for the detection of partial discharge in metal clad switchgear, connection boxes and even through transformer tank walls. This accessory can detect partial discharge activity through steel sheet covers, such as metal enclosures for switchgear and transformers. The TEV Probe is used with Doble's surveying tools, such as the PDS100 and DFA300, and the Doble PD-Smart Partial Discharge Analyzer.

TEV PROBE TECHNICAL SPECIFICATIONS	
Frequency	100 ... 1200 MHz, approx.
Recommended Load Impedance	50 Ω
Impulse Responds Sensitivity	120 mV/V, approx.
Output Connector	BNC
Dimensions	65 x 45 x 32 mm
Weight	58g
Insulation Material	Polyamide 6
Fastening	Permanent Magnet

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DOBLE IN-SERVICE TESTING & ASSESSMENT

DA100

Accessory to PD and RFI Surveyors

TO EVALUATE THE POTENTIAL DIRECTION OF PD AND RFI SOURCES IN SUBSTATIONS

Use the Doble DA100 Directional Antenna with PD and RFI Surveyors to provide more specific location of Radio Frequency Interference (RFI) and Partial Discharge (PD) sources. With this combination you not only determine the presence of PD sources, you can also establish the direction of the RFI and PD emissions. This information gives you a more detailed assessment of the potential positions of such sources within substations or electrical environments, allowing you to identify faulty equipment, which can then be scheduled for monitoring, repair or replacement as necessary.

The DA100 Directional Antenna detects PD and RFI signals in the range 250MHz to 1GHz. It can be either hand held or mounted on a tripod. Connect to PD and RFI Surveyors with a 50 Ω BNC coax cable.

DA100 TECHNICAL SPECIFICATIONS

DATA ACQUISITION	
Inputs	1 Channel
Output Connector	BNC
Frequency Range Sensitivity	250MHz – 1GHz
MECHANICAL DATA	
Diameter	290mm / 11.5in
Thickness	40mm / 1.5in
Weight	1kg / 2.2 lbs
Construction	Aluminium / polycarbonate
ENVIRONMENTAL	
Humidity	0-95% non-condensing
Operating Temperature	-20°C to +50°C
Storage Temparature	-20°C to +70°C

SCOPE OF DELIVERY	
Doble DA100 - Directional Antenna	Handle, Wall/Pole Bracket, 1/4" Tripod Mount, Laser Sight, Transport Case
THIRD PARTY ACCESSORIES	
Tripod. 50 Ω BNC coax cable (1 m for handheld mode, 1-10 m in tripod mounted mode).	

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ON-LINE MONITORING

doblePRIME™

Condition Monitoring Platform

doblePRIME is a modular condition monitoring platform to improve decision-making and analysis of key assets.

It is comprised of a set of integrated tools that give you the data and analysis you need to make timely tactical and strategic decisions based on real-time information.

Choose from a combination of sensors for dissolved gas analysis, partial discharge, bushings and operational values, including load, tap position and temperatures.

doblePRIME features configurable smart analysis tools, including threshold and limit analysis, trending and expert system analysis, and immediate response.

GETTING STARTED

Unsure about how to begin? Doble will work with you to help determine the most effective approach to intelligent condition monitoring.

doblePRIME is built to respond to your needs: targeted application for a single parameter on a suspect bushing, or comprehensive monitoring which covers multiple transformers and assets across multiple locations. Identify the motivations for condition monitoring, including PD, DGA, leakage currents, and ensure that they are being addressed with specific monitors.

SECURE ACCESS

Access doblePRIME dashboards within your cyber secure infrastructure using smart phones, tablets or computers.

doblePRIME works within your existing security infrastructure to supply data and analysis where it is needed: proprietary databases, proprietary software and cloud connections are not needed.

FAILURE MODES

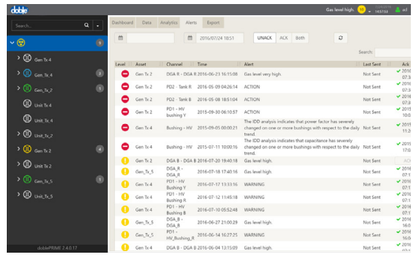
Different assets may have different failure modes - each with its own timescale for operation. It is important to apply condition monitoring which can detect changes in a timely manner.

For example, a monitor which looks at the asset every 12 hours will possibly miss a failure mode which takes 3 hours to begin and lead to a failure. doblePRIME can be configured to the most appropriate rate for the application.

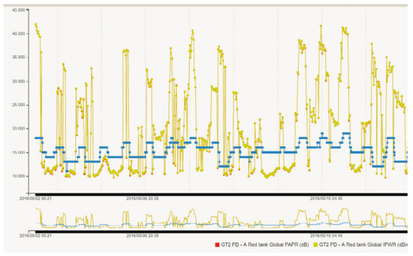
ENCLOSURES

doblePRIME condition monitoring is deployed in IP66/NEMA 4X rated enclosures – including options for climate control, communications, data backup and a separate safety box for power and sensor isolation.

CONDITIONING MONITORING IN THE FIELD
Comprehensive monitoring configuration



VIEW ALERTS
Navigation tree & alert dashboard



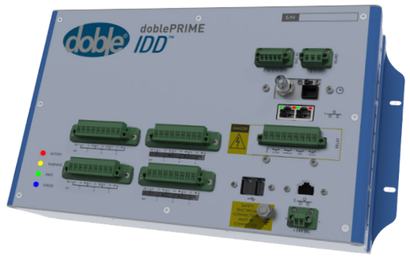
ANALYZE DATA
Identify trends & correlations

doblePRIME IDD
Bushing Monitoring

The doblePRIME IDD Bushing Monitor detects deterioration in bushings, finding abnormalities in the insulation and issuing actionable alerts.

The doblePRIME IDD provides leakage current and phase analysis for up to 12 bushings, measuring parameters for each bushing individually and together. The doblePRIME IDD will accept voltage reference for improved analysis with True Power Factor.

Based on thousands of installations worldwide, the doblePRIME IDD can operate as a standalone device or as part of a doblePRIME Condition Monitoring Platform.



AVOIDING BUSHING FAILURES: KNOW THE SIGNS

Over almost 20 years of successful bushing monitoring, Doble has identified two distinct failure modes—rapid onset and graceful decay—and have documented and reported cases of averting bushing failures in both modes.

In the graceful failure mode, deterioration in insulation power factor (dissipation factor or tan-delta) occurs over several weeks. For example, Doble bushing monitoring was used on a 'gracefully' failing bushing. It was watched and was able to remain in service until a replacement could be brought in and an outage planned at a convenient time.[+]

In an example of the rapid-onset failure mode, Doble bushing monitoring detected the leakage current through a bushing rose by almost 50% in two hours. The system generated an alert. The team had a response plan in place, acted within 120 seconds, and saved the bushing.[+]

DATA COLLECTION: CURRENT & VOLTAGE

The doblePRIME IDD collects raw data waveforms from which rms current can be calculated. By performing an auto-correlation the fundamental power system frequency can be calculated and then the rms and harmonics derived.

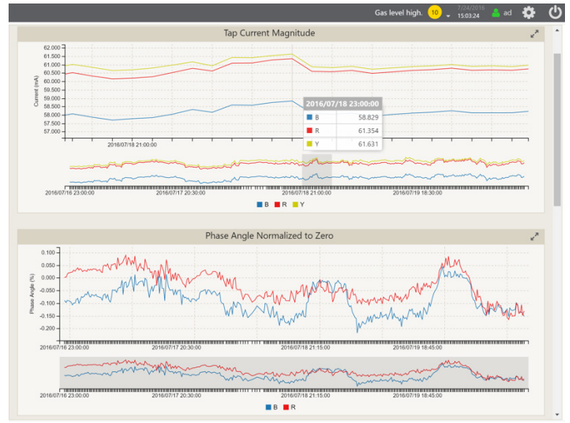
The phase angle is measured so relative phase between bushings can be calculated. If a voltage reference value is available, that may also be recorded (as a waveform) for derivation of the voltage phase angle and calculation of True Power Factor for each bushing. View raw current and voltage waveforms in a diagnostic scope mode.

Measurements are time stamped to externally sourced GPS, IRIG-B or system clock. Waveforms may be stored for future reference and diagnostics.

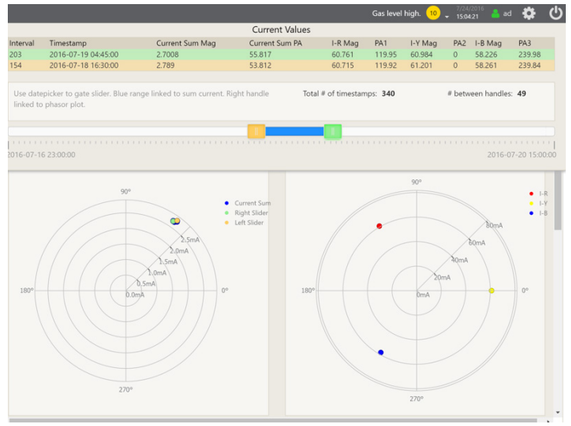
[+]*"Condition Monitoring in the Real World", International Conference of Doble Clients, 2013*

doblePRIME IDD KEY FEATURES

- Captures bushing current waveforms in real time
- Calculates values for power factor and capacitance
- Records data at user specified intervals, or ad hoc
- Displays alerts locally and remotely on mobile phone, tablet or PC
- No proprietary data formats or software needed
- Intelligent Expert System learns what is normal for your bushings
- Responds to and creates a history of subtle changes in bushing condition
- Modular system available in six or twelve channel versions
- Voltage ratio capability
- Optional external voltage reference inputs for true power factor



IDD RAW DATA
Individual leakage currents & phase angles plotted against time



SUM CURRENTS DATA
Data is animated to show development of possible fault

SAFETY: STARTING AT INSTALLATION

The doblePRIME IDD uses multiple redundant safety systems and ground paths, including transorbs and sparkgaps, to ensure transients are safely conducted to ground.

During an installation, the tap cap is replaced with an IDD bushing adapter; the grounding of the tap is then maintained through the doblePRIME IDD.

For harsh environments, armored cables are available, meeting full military specification protection. For high criticality applications, and for those in areas with significant switching transients, protection remote from the bushing is available.

doblePRIME PD-GUARD

Partial Discharge Monitoring

Partial discharge eats away at insulation – putting assets at risk and system reliability in jeopardy. Early indications of insulation deterioration can be detected with partial discharge tools.

Use **the doblePRIME PD-Guard** Partial Discharge Monitor in cases where early detection of partial discharge is critical, or where continuous updates on partial discharge status is required.

The doblePRIME PD-Guard can operate as a standalone device or as part of a doblePRIME Condition Monitoring Platform.

CLEAR ANALYSIS

Analysis of partial discharge signals can be complex. We built our anaylsis tools to be clear and powerful - detecting and alerting on rising partial discharge levels.

Our sensitive statistical tools track the level and severity of the discharge sources. This is achieved by taking spectral data and deriving a measure of the 'spikiness' or PD-like nature of the signals, and simultaneously tracking the energy of the signal.

If the measured signals are growing in PD nature and energy, there is strong indication that further investigation is required.

UNDERSTANDING THE DATA & ALERTS

PD monitoring can generate a lot of data. PD signals in the time domain may be measured up to 1 GHz and produce a large quantity of data points.

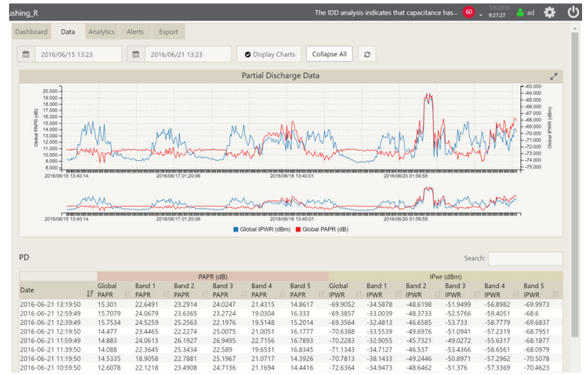
For monitoring purposes, we apply a statistical approach to track the energy of the signals recorded and the severity of the PD. These allow for tracking and trending over time, and generation of meaningful alerts.

Deeper investigation using spectra and phase or time resolved plots may also be performed through the PD-Guard.

The alerts generated by PD signals are managed by an Alert State Machine. This allows for discrimination of likely PD signals against noise signals such as would be generated by tap changer operations or switching surges. A number of successive measurements above the threshold are required before an alert state is triggered.

doblePRIME PD-GUARD KEY FEATURES

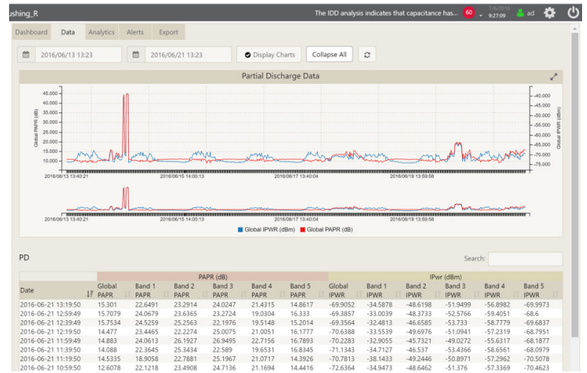
- An independent PD monitoring system, accessed & configured via computer, tablet or web-enabled device
- Local visual alert status indication
- Alert State Machine thresholds allow for detection of PD while avoiding false positives due to noise events such as tap changer operations or breaker switching
- Alarm relays for external notification
- Broadband RF signal detection including peak, average and quasi-peak
- Quasi-peak detector is designed in the spirit of the CISPR 16-1-1:2010 EMI standard and in line with best field practices
- Use phase-resolved and time-resolved plots for detailed diagnostics



Date	PAPR (dB) Global PAPR	Band 1 PAPR	Band 2 PAPR	Band 3 PAPR	Band 4 PAPR	Band 5 PAPR	IPwr (dBm) Global IPWR	Band 1 IPWR	Band 2 IPWR	Band 3 IPWR	Band 4 IPWR	Band 5 IPWR
2016-06-21 13:19:50	15.301	22.6491	23.2914	24.0247	21.4315	14.8617	-69.9052	-34.5878	-48.6198	-51.9499	-56.8982	-69.9973
2016-06-21 12:59:49	15.7079	24.0679	23.6365	23.2724	19.0304	16.333	-69.3857	-33.0039	-48.3733	-52.5766	-59.4051	-68.6
2016-06-21 12:39:49	15.7534	24.5259	25.2563	22.1976	19.5148	15.2014	-69.3564	-32.4813	-46.6585	-53.733	-58.7779	-69.6837
2016-06-21 12:19:50	14.477	23.4465	22.2274	25.0075	21.0051	16.1777	-70.6388	-33.5539	-49.6976	-51.0941	-57.2319	-68.7951
2016-06-21 11:59:49	14.883	24.0613	26.1927	26.9495	22.7156	16.7893	-70.2283	-32.9055	-45.7321	-49.0272	-55.6317	-68.1877
2016-06-21 11:39:50	14.088	22.3645	25.3434	22.589	19.6531	16.8345	-71.1343	-34.7127	-46.537	-53.4366	-58.6561	-68.0979
2016-06-21 11:19:50	14.5335	18.9058	22.7881	25.1967	21.0717	14.3926	-70.7813	-38.1433	-49.2446	-50.8971	-57.2962	-70.5078
2016-06-21 10:59:50	12.6078	22.1218	23.4908	24.7136	21.1694	14.4416	-72.6364	-34.9473	-48.6462	-51.376	-57.3369	-70.4623

TYPICAL BUSHING PARTIAL DISCHARGE DATA

Typical statistics tracked over two weeks for a single transformer bushing



Date	PAPR (dB) Global PAPR	Band 1 PAPR	Band 2 PAPR	Band 3 PAPR	Band 4 PAPR	Band 5 PAPR	IPwr (dBm) Global IPWR	Band 1 IPWR	Band 2 IPWR	Band 3 IPWR	Band 4 IPWR	Band 5 IPWR
2016-06-21 13:19:50	15.301	22.6491	23.2914	24.0247	21.4315	14.8617	-69.9052	-34.5878	-48.6198	-51.9499	-56.8982	-69.9973
2016-06-21 12:59:49	15.7079	24.0679	23.6365	23.2724	19.0304	16.333	-69.3857	-33.0039	-48.3733	-52.5766	-59.4051	-68.6
2016-06-21 12:39:49	15.7534	24.5259	25.2563	22.1976	19.5148	15.2014	-69.3564	-32.4813	-46.6585	-53.733	-58.7779	-69.6837
2016-06-21 12:19:50	14.477	23.4465	22.2274	25.0075	21.0051	16.1777	-70.6388	-33.5539	-49.6976	-51.0941	-57.2319	-68.7951
2016-06-21 11:59:49	14.883	24.0613	26.1927	26.9495	22.7156	16.7893	-70.2283	-32.9055	-45.7321	-49.0272	-55.6317	-68.1877
2016-06-21 11:39:50	14.088	22.3645	25.3434	22.589	19.6531	16.8345	-71.1343	-34.7127	-46.537	-53.4366	-58.6561	-68.0979
2016-06-21 11:19:50	14.5335	18.9058	22.7881	25.1967	21.0717	14.3926	-70.7813	-38.1433	-49.2446	-50.8971	-57.2962	-70.5078
2016-06-21 10:59:50	12.6078	22.1218	23.4908	24.7136	21.1694	14.4416	-72.6364	-34.9473	-48.6462	-51.376	-57.3369	-70.4623

SPIKES SHOW SEVERE INDICATION OF PD PRESENCE

Sustained PD burst detected and used to generate alerts

SURVEY. TEST. MONITOR.

Doble recommends a three-step approach to the detection and management of partial discharge in key assets.

SURVEY – Requiring minimal training, use the proven, handheld PDS or DFA tools for simple spectral analysis. Regular surveys provide baseline and comparative scans to detect sources of partial discharge at a location.

TEST – Using the PD-Smart, make detailed analysis of partial discharge in equipment. Diagnose and assess the level of deterioration using phase-resolved, time-resolved, and spectral analysis. Use this information to help plan your next steps.

MONITOR – Use the doblePRIME PD-Guard in cases where early detection of partial discharge is critical, or where continuous updates on partial discharge status are required.

doblePRIME DELPHI

Dissolved Gas Analysis Monitoring

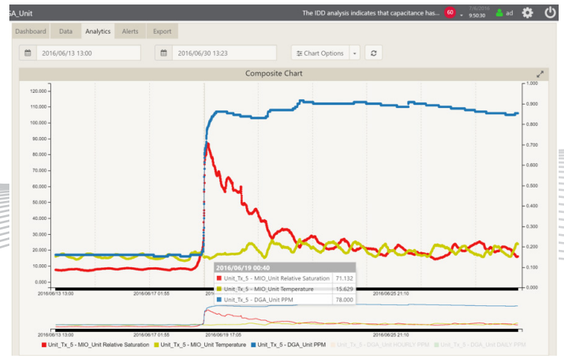
The doblePRIME Delphi is a dissolved gas analysis (DGA) monitor that provides early warning signs of problems such as overheating, insulation degradation or mechanical movement.

The doblePRIME Delphi provides this valuable information in real time, second by second, through analysis of the insulating oil.

The Delphi is immune to oil surges and vacuums that may affect other sensors; in addition, the Delphi contains self-testing diagnostics to monitor its own performance.

doblePRIME DELPHI KEY FEATURES

- Patented vacuum resistant membrane prevents failure during oil surges, maintenance or other activities
- Rapid response – less than 8 minutes for 90% response to step change
- Alarms and closing contacts – relays, digital and analog outputs
- Available as a composite gas monitor or hydrogen monitor in standard and mini versions



DGA, RELATIVE HUMIDITY & OIL TEMPERATURE
Composite data from Delphi and DOMINO monitors

doblePRIME ANALYTICS

Integration & Analysis Module

doblePRIME condition monitoring devices can stand alone and provide targeted data and alerts.

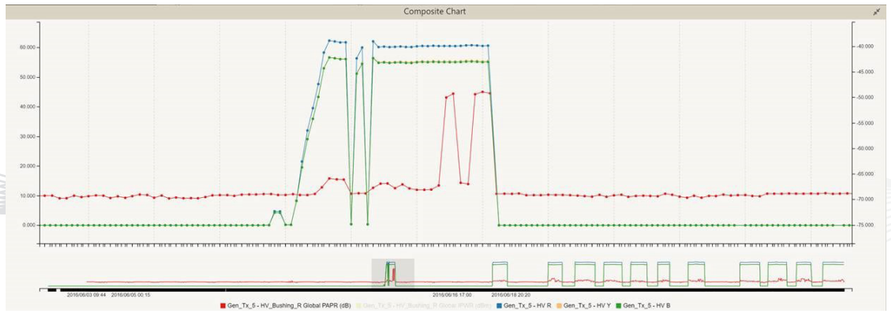
The doblePRIME Analytics module provides a means to collate and combine data from multiple modules in a single user interface with charting and analysis capabilities.

The doblePRIME Analytics unit provides back-up storage for individual monitors, allowing for years of data archiving, and appropriate expert system and analysis tools to identify and alert you to anomalous asset performance.

doblePRIME Analytics offers data visualization, system configuration, communications and data management tools.

doblePRIME ANALYTICS KEY FEATURES

- Accepts data from multiple condition monitoring devices
- Provides network and hub capabilities and a single point of contact for all devices
- Applies analytics and displays/overlays data from multiple devices
- Backs up data from multiple units for redundant storage



ANALYZE DATA FROM VARIOUS MODULES
PD from a bushing overlaid by leakage current provides more context for analysis

doblePRIME DOMINO

Moisture-in-oil Monitoring

The doblePRIME DOMINO provides real time data for moisture in oil, giving indications of relative saturation or absolute ppm levels.

This is useful information, especially when a transformer is being loaded in excess of nameplate or when the transformer is undergoing abnormal load cycles.

The doblePRIME DOMINO provides continuous reliable measurement of the water content of electrical insulating liquids and other types of oils.

doblePRIME DOMINO KEY FEATURES

- Continuous results in parts per million (ppm), relative saturation and temperature
- Monitors oil reconditioning in systems as small as a single filter cartridge – to as large as a mobile or stationary processing plant
- Helps determine filter changeout, process efficiency and when to terminate processing

doblePRIME iO

Analog & Digital Data Module

The doblePRIME iO is a device that accepts current, voltage, temperature and relay inputs to your doblePRIME system.

Data sources include load or operational data, tap position indicators, inputs from other vendor devices, and more.

doblePRIME iO KEY FEATURES

- Multiple analog/digital inputs, including currents, voltages, temperature sensors
- Stores and displays data
- Provides a means to record operational parameters and data
- Fully networkable

doblePRIME™
Flexible & Modular Monitoring

BUSHING LEAKAGE CURRENT
High, low, tertiary
Add voltage reference for true power factor

OPERATIONAL PARAMETERS
Tap position
Load
Voltage
Temperatures
Pumps & fans status
Vibration
Oil level

PARTIAL DISCHARGE
Bushings
Main tank
Neutral

DGA
Main tank
Optional tap changer

doblePRIME MEASUREMENT PARAMETERS
Select the appropriate measurement parameters to support your condition monitoring decisions

Every substation or system is slightly different as are the operational and budgetary considerations that go along with them.

By taking a platform approach, you can cost-effectively deploy a solution that fulfills your needs today and can scale whenever you are ready or necessity dictates.

doblePRIME can also link to an asset risk management system such as **dobleARMS®** for the advanced analytics, root cause and financial analysis needed to justify capital decisions and long-term strategic asset plans.

Together, doblePRIME and dobleARMS underpin smart decisions for an intelligent grid and can provide value from day one of deployment.

Package Options

doblePRIME is a flexible and expandable condition monitoring system. It can grow to meet developing or changing needs.

Each module (IDD, PD-Guard, iO, etc.) can stand alone or can be part of a more comprehensive monitoring system. What you choose to use should be defined by your goals for condition monitoring.

We have outlined a number of package options for common monitoring arrangements. We can also help you customize your doblePRIME monitoring options.

Packages are available preconfigured and in prewired enclosures.

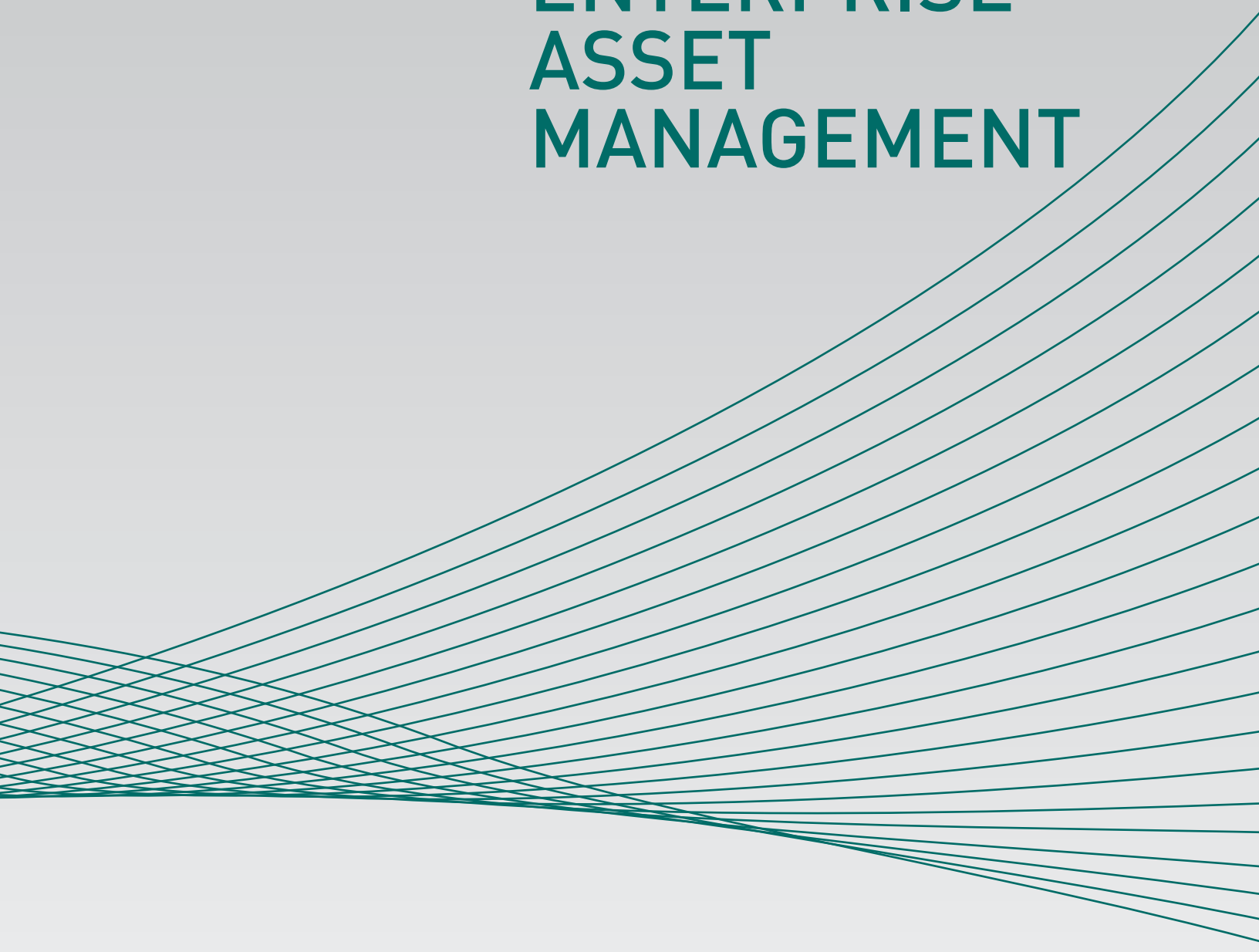
MONITORING PACKAGE OPTIONS*	DESCRIPTION	IDD	PD-GUARD	ANALYTICS	iO	DELPHI	DOMINO
dP Bushing	Bushing leakage current monitoring with relative voltage option	✓					
dP Bushing+	Bushing monitoring with temperature compensation	✓			✓		
dP PD + Bushing	Overall partial discharge (bushings/ neutral/main-tank) & bushing	✓	✓				
dP Oils	DGA/Moisture for oil analysis			✓		✓✓	✓✓
dP Complete	Bushings/PD/Oil/temperatures & operational data for a transformer or three phase bank	✓	✓	✓	✓	✓	✓
dP Station	Site system – multiple transformers, multiple monitors, single point of access	✓✓	✓✓	✓	✓✓	✓✓	✓✓

✓ One of this specific module is included in this package

✓✓ Multiple modules are recommended in this type of package

**We have outlined a number of package options for common monitoring arrangements. We can also help you customize your doblePRIME monitoring options.*

ENTERPRISE ASSET MANAGEMENT



DOBLE ENTERPRISE ASSET MANAGEMENT

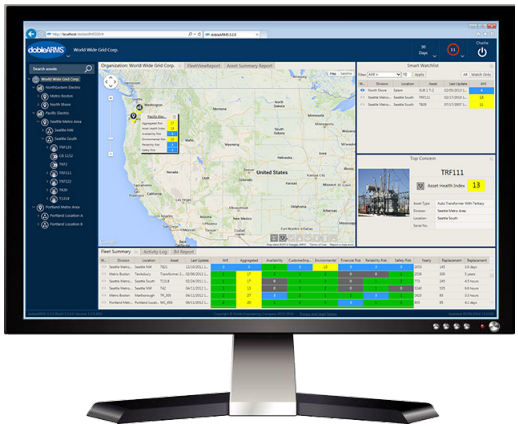
dobleARMS®

Asset Risk Management System

UNDERSTAND ASSET CONDITION, CONDUCT LONG-TERM PLANNING AND PREVENT IMPENDING FAILURES

Doble's Asset Risk Management System (dobleARMS®) brings decades of knowledge and experience with power systems diagnostics and data analysis to the areas of online monitoring, condition assessment and the strategic management of assets. It's a new breed of application offering real-time event notification around a sophisticated suite of analytics that are infused with Doble's expertise in asset life-cycle and associated risks. dobleARMS® provides intelligent alerts and event notification so organizations can make more informed decisions between times of crisis and long-range operational planning. With dobleARMS®, companies can move beyond traditional notions of condition-based maintenance allowing employees to think more strategically about managing risks.

dobleARMS® is a cost-effective tool for monitoring assets across the enterprise and providing the needed information to maintain and optimize assets - thereby reducing unplanned shutdowns, boosting production, increasing operational efficiency and decreasing maintenance costs.



The dobleARMS® Difference

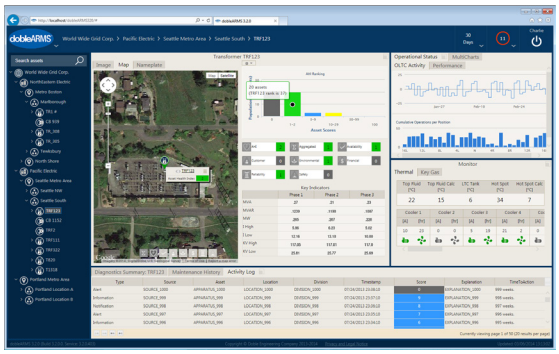
Too few or too many details - those are the typical complaints about most asset management systems. Asset managers need to know when a "notification" is a real or developing problem, and which asset needs the most attention. That's why dobleARMS® combines real-time with online and offline data sources and then compares the analytic results to Doble's decades-worth of benchmark data on asset performance. Doble's knowledgebase contains 80 years of information and over 35 million records from equipment around the world, and offers a considerable advantage to enhanced interpretation and analysis of asset issues.

A Consolidated View

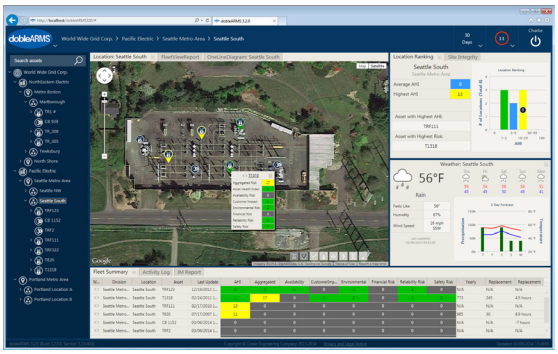
dobleARMS® is transformational by providing a clear view of asset health from the convenience of your workstation. Instead of wasting critical time searching for the right information, dobleARMS® searches for the needle in the haystack which is an asset event, and rolls up the salient details to a higher level - offering a consolidated geospatial view with clear, visual understanding of asset condition, criticality and risks.
dobleARMS® gives you the power to drill down to the specific details you want and need to see.

A COMMON SENSE APPROACH TO THE SMART GRID

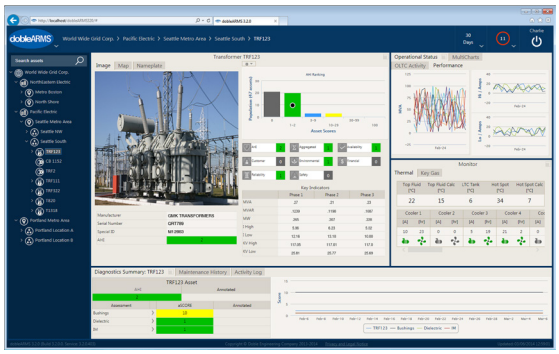
- Meets FERC, NERC and NIST security and Smart Grid Standards
- Flexible, secure and scalable infrastructure supporting offline and real-time data collection from a variety of data sources
- Places a non-proprietary layer of model management on top of "point-based" protocols
- Eliminates the need to manually manage interface points and changes



Apparatus view – Presents key details on a specific unit's status and snapshot of comparable positioning to rest of fleet, as well as summaries of the automated data analysis.



Substation view – Summary of assets by substation site, providing specific substation detailed view, comparable positioning to rest of sites locations in your fleet.



Assessment view – In-depth detailed rendering on key subsystems of an asset, with full results view of the automated data analysis.

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ENTERPRISE ASSET MANAGEMENT

FIELD FORCE AUTOMATION

Workforce optimization and data management solutions

FOCUS YOUR FIELD CREWS ON WHAT MATTERS MOST – TESTING.

Too often, crews are stalled by time spent downloading and uploading test data in the office or struggling with equipment that won't connect to computers. Test data doesn't always make it back to the office and crews don't always have the documentation they need to pass field audits.

These are just some of the situations Doble is helping you address with the Doble Field Force Automation Solutions. It's a customizable solution that standardizes your testing program by putting all your Doble software onto secure controllers and automating the downloading and saving of test data. It is a system that simplifies testing, automates data processes, improves efficiency and streamlines business processes.

Tailored to your testing practices and business requirements, it even offers instant sharing and distribution of documents, a feature that allows you to do everything from putting the most up-to-date SOPs and bulletins into the hands of your crews - to automating the safety tailboard process.

FEATURES

- Configured as locked-down devices; rugged, secure controllers guaranteed to connect to your Doble test equipment
- Easy system-wide software version control; no need for IT support
- Instant sharing and distribution of documents between field & office, e.g. SOPs, safety tailboards
- Customizable program that can automate 7 manual steps in traditional testing workflows

BENEFITS

- No longer blocked by IT firewalls
- Standardize processes across your workforce
- Save time and improve efficiency of test crews
- Stay ahead of audits in the field and office
- Ease of use; guaranteed to work with your Doble equipment
- No time lost troubleshooting instrument connections with seamless test equipment connection
- Most recent data is available to the tester when they turn on the controller
- No more losing test data; data management process is automated and behind the scenes
- Delivered ready to work, nothing to install

ENTERPRISE ASSET MANAGEMENT

TEST DATA SOLUTIONS

Data management support solutions

SOLUTIONS TO ELIMINATE MANUAL, REDUNDANT TASKS AND STANDARDIZE TEST DATA MANAGEMENT

Standardizing testing and data management processes across a division or company is a complex and time-consuming project. Doble has developed a number of solutions to help eliminate manual and redundant work processes, saving you time and ensuring clean, consistent data files for field testing and regulatory reporting.

DTA, T-Doble, SFRA, PD Data Options:

- Data clean up
- Data conversion
- Test plan creation (DTA)
- "Historic" file conversion
- Import existing test data
- Continuing support of Test Data Solutions

Relay Test Data Options:

- ProTesT to Protection Suite data conversion
- Data clean up
- Transition of files to Protection Web
- Creation of customized relay test plan forms
- Import exiting test data
- Continuing support of Test Data Solutions

Battery Test Data Options:

- Data clean up
- Import existing test data
- Continuing support of Test Data Solutions

Learn more about our Doble Test Data Solutions by contacting datasolutions@doble.com or 617.393.3010.

DOBLE ACCESSORIES

DUC™

Doble Universal Controller™

AN ULTRA RUGGED, RELIABLE CONTROLLER FOR ALL YOUR DOBLE TESTING

The Doble Universal Controller™ is a ultra rugged tablet device powerful enough to operate Doble's suite of high voltage test equipment and software solutions while being tough enough to withstand the rigors of electrical field testing.

The DUC™ provides the processing power necessary to run advanced software in the field. It is designed for durability and is built to withstand the same tough requirements of Doble's test equipment. Testing is even possible in full sunlight thanks to its bright, transreflective display.

FEATURES

- Withstands operational 4' drop to concrete and operational 7' drop to plywood
- Fully submersible (up to 30 minutes)
- Impenetrable to dust and debris
- Operates in -30°F to 140°F temperatures
- Crash-resistant with magnesium alloy chassis, 26 direction bumper protection, non-moving SSD drives
- Intel® i5- 4300 Processor with Turbo Boost
- Sunlight readable screen
- Built-in Bluetooth
- Integrated 4G LTE communications equipped
- Full shift battery life - up to 8.5 hours

BENEFITS

- Use as part of your field-force automation and data management program
- Convenient app-style interface
- Designed to automatically work with Doble software products and user administration
- One tablet to operate your Doble software and test equipment

DUC™ TECHNICAL SPECIFICATIONS

GENERAL SPECIFICATIONS	
Fully Rugged	Multi-layered magnesium chassis MIL-STD-810G and IP67 tested Hazardous Location Certified Piston Sealing, Rugged SSD Cartridge
Processor	Intel® Core™ i5-4300U processor Turbo Boost Technology (2.9 GHz)
Display	10.4" XGA (1024x768) rugged LED backlit display Transreflective sunlight readable display, 1300 NIT Automatic light sensor, NVIS compatible
Memory	4 GB DDR3L (1600 mHz)
Operating System	Genuine Microsoft® Windows® 8.1, 64-bit
Battery	Up to 8.5 hour battery life
Power Supply	Auto-sensing 100-240 V, 50-60 Hz supplying 19 VDC
Integrated Communications	LAN: 10/100/1000 Gigabit Ethernet (RJ-45) WIRELESS LAN: Intel® 7260 (802.11 ac) Integrated Mobile Broadband Equipped BLUETOOTH: 4.0
Collaboration	Integrated Barcode Ready 5 Megapixel digital camera (front and rear-facing)
Ports	AC/DC power Docking connector USB 3.0 (x2) RJ-45 Combination Headphone/speaker and microphone 9-pin Serial port (RS232/RS422/RS485) MicroSD and SIM socket (tool-less removable door)

ENVIRONMENTAL SPECIFICATIONS	
	Independently-tested to MIL-STD-810G
Operating Temperature	-30° F to 140° F (-34° C to 60° C)
Storage Temperature	-60° F to 160° F (-51° C to 71° C)
Humidity	3% - 95% non-condensing
Thermal Shock	-60° F to 160° F (-51° C to 71° C)
Blowing Rain	4"/hr (101.6 mm/hr), 40 mph wind, 30 min. per side
Blowing Sand and Dust	30 mph wind source, 30 min.
Vibration	Minimum Integrity, Vehicle Vibration, US Highway Truck Vibration
Salt Fog	5% saline exposure, 48 hr exposure
Altitude	50,000 ft (15240 m) operating
Other Tests	Functional and Crash Shock, Contamination by Fluids, Fungus and Solar Radiation

BEYOND MIL-STD-810G	
Transit Drop - Operating	4' (1.22 m) drop direct to concrete while system is operating, 26 drops
Transit Drop - Operating	7' (2.13 m) drop direct to plywood over concrete while system is operating, 26 drops
IEC Ingress Testing	IEC (60529) Ingress Tested to an IP67 standard Submersion-Resistant, Dust-Tight

EMISSIONS, IMMUNITY, & SAFETY	
Emissions	FCC Part 15, CE Mark EN55022 (CISPR22) Class B, E-Mark(XDock)
Immunity	EN55024, ENG6100-3-3
Safety	UL and EN60950-1 2nd Ed, ATEX/IECEx Zone 2/Category 3 Compliant, UL 1604 (ANSI/ISA 12.12.01-2012, CSA C22.2 no.2013-M 1987 (R2008)) Class I/ Division II (Z: A, B, C, and D) Certified
Other	ROHS, 5-Star Energy Compliant

ORDERING INFORMATION

PRODUCT
Doble Universal Controller™ (DUC™) Includes power supply, battery, stylus w/ tether, 4G LTE equipped, Windows 8.1 Pro, and user guide

OPTIONAL ACCESSORIES
Replacement Lithium-Ion battery, 80.75 WHR
Replacement Stylus
DUC™ STAND
AC Power Supply Kit
Hardside Custom Case Kit Includes wireless keyboard/touchpad combo, custom foam insert

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DOBLE ACCESSORIES

DUC™ NOTEBOOK

Notebook-Style Doble Universal Controller™

AN ULTRA RUGGED, NOTEBOOK-STYLE CONTROLLER FOR ALL YOUR DOBLE TESTING

The DUC Notebook is a notebook-style Doble Universal Controller™. It is a rugged tablet device powerful enough to operate Doble's suite of high voltage test equipment and software solutions while being tough enough to withstand the rigors of electrical field testing.

DUC Notebooks are built with the most robust materials available, including impact-resistant ultra polymers and sturdy magnesium alloy. They have been independently tested to military standards including drops up to 6 feet, as well as ingress protection, emissions and hazardous materials certifications by an accredited third-party testing facility.

These controllers feature a crisp 14" Direct-View outdoor-readable display so you can see everything clearly from bright sunlight to low light conditions. Their resistive touch screens allow you to operate the device with your gloves on.

Use the DUC Notebook as part of your field force automation and data management program.

FEATURES

- Sealed doors and compression gasketing protect your device and data
- Withstands 6' drop
- Displays are readable in sunlight and low-light conditions
- Thermal management lets you operate the device in high temperatures
- Powerful and efficient with fourth-generation Intel® processors and solid state storage
- Full shift battery life – up to 8.5 hours

BENEFITS

- Use as part of your field-force automation and data management program
- Convenient app-style interface
- Designed to automatically work with Doble software products and user administration
- One device to operate all your test software and test equipment

DUC™ NOTEBOOK TECHNICAL SPECIFICATIONS

GENERAL SPECIFICATIONS	
Processor	Fourth-generation Intel® Core™ i5 dual-core processor
Display	14" HD (1366 x 768) 16:9 Direct-View outdoor-readable display with resistive touchscreen, 530 NIT
Memory	16GB DDR3L (1600 mHz)
Operating System	Windows® 8.1 Pro (64-bit)
Graphics	Integrated Intel HD Graphics 4400
Storage	256GB mobility solid state drives
Battery	6-cell (65 Whr) lithium-ion batteries
Power	65W AC adapters
Multimedia	High-quality speaker, integrated noise-reducing array microphones, stereo headphone/microphone combo jack, optional integrated FHD video webcamera with privacy shutter
Ports	"USB 3.0 (2), USB 2.0 (2), native RS-232 serial ports (2), RJ-45 gigabit Ethernet network connectors (2), stereo headphone/microphone combo jack, pogo-pin docking connector, VGA, HDMI"
Dimensions	(WxDxH) 14" x 9.7" x 2.03" (356 x 247 x 52 mm)
Weight	7.79 lbs. (3.54 kg) with 6-cell battery
Input	Customizable RGB backlit keyboard Optional rubberized RGB backlit keyboard (English only) Resistive touchpad Resistive single-point gloved-capable touch screen
CONNECTIVITY	
10/100/1000 gigabit Ethernet and triple RF-passthough (GPS, mobile broadband and WLAN)	
Wireless LAN	Intel® Dual Band Wireless-AC 7260 (802.11ac, dual band, 2x2, up to 867 Mbps) with Bluetooth® 4.0 + vPro™
Mobile broadband	4G LTE card (US and Canada only)
GPS	Optional SiRFstarV™ dedicated GPS and antenna (2 meter accuracy)
ENVIRONMENTAL SPECIFICATIONS	
Energy Star 6.0, EPEAT	
MIL-STD-810G testing	Transit drop (72",60",48"; single unit; 78 drops), operating drop (36"), blowing rain, blowing dust, blowing sand, vibration, functional shock, humidity, salt fog (with rubberized keyboard), altitude, explosive atmosphere, solar radiation, thermal extremes, thermal shock, freeze/thaw, tactical standby to operational
Operating thermal range	-20°F to 145°F (-29°C to 63°C)
Non-operating range	-60°F to 160°F (-51°C to 71°C)
IEC 60529 ingress protection[1]	IP-65 (dust-tight, protected against pressurized water)
Hazardous locations	ANSI/ISA.12.12.01 certification capable[1] (Class I, Division 2, Groups A, B, C,D)
Electromagnetic interference	MIL-STD-461F certified[1]

[1] Based on testing and certification to MIL-STD-810G, IEC 60529 (IP-65), MIL-STD-461F, and ANSI/ISA.12.12.01 standards, performed and reported independently by accredited testing companies. ANSI/ISA.12.12.01 must be specified at time of order for certification.

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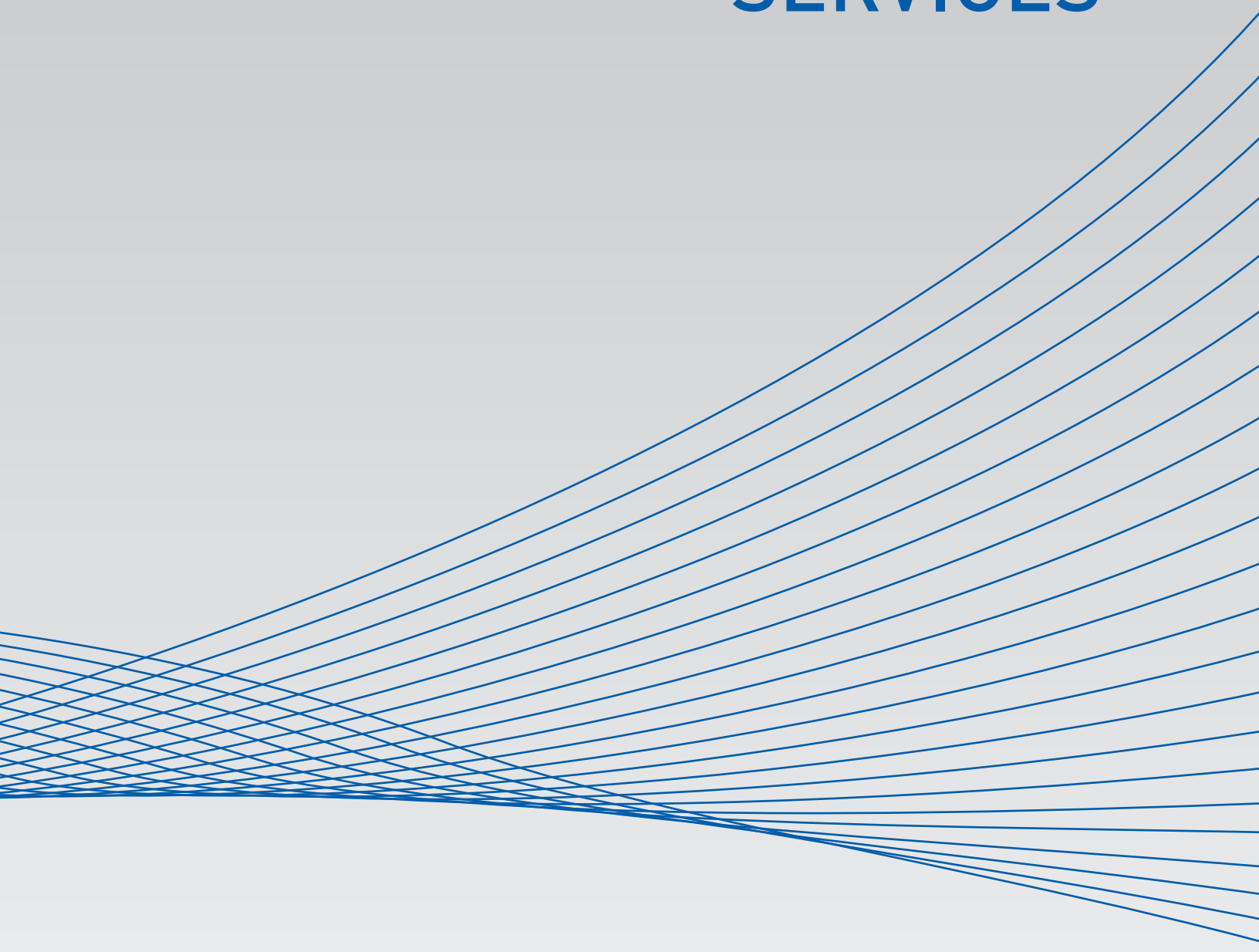
SERVICES



SERVICES

DYNAMIC SUPPORT WITH DOBLE SERVICES

Our depth of experience allows us to provide you with an array of services that goes beyond tools and technology. Our global, multidisciplinary team of chemists and engineers works as an extension of your organization, providing comprehensive, unbiased expert advice and support. We provide neutral and independent insight into the problems you face.

DOBLE CLIENT SERVICES GROUP

THE FULL DOBLE COMMUNITY ENGAGEMENT

For even the most experienced technician, situations in the field are rarely black and white. Membership in the Doble Client Services Group gives you certainty and reliability. Make the right interpretation and the right decision – the first time and every time. Trust that your testing and diagnostic instrumentation is state-of-the-art and works on demand, or will be replaced within 24 hours. Train your test technicians and power engineers on the most current test practices and procedures.

As part of the Doble Client Services Group, you gain the full Doble experience. You join a vast community of experts. You gain access to the industry's most comprehensive resource libraries on the power grid. You also learn what your peers are doing, and what apparatus troubles and failures they are experiencing.

Today, more than ever, you need to invest your workforce and capital resources wisely across the ownership cycle of every asset. Take advantage of the full Doble community promise.

DOBLE CONSULTING & TESTING SERVICES

INDUSTRY EXPERTS AT YOUR SERVICE

Today many companies are increasingly looking to outsource for answers to their toughest testing and diagnostic challenges. You need a partner with broad expertise in chemistry, on-line and off-line electrical testing, and transformer design and manufacturing experience. Our wide variety of skills fits together with yours, collaborating with your in-house experts, and giving you a complete picture of your situation, so you can focus your resources where they are really needed. Services include:

- Specification writing & review
- Design reviews
- Manufacturing plant inspections
- Factory witness testing
- Test data review
- Root cause analysis
- Condition assessment
- Fleet asset health review
- Forensic analysis
- Partial discharge testing
- EMI diagnostics survey
- In-service substation surveys
- Off-line electrical testing
- High-voltage laboratory services

DOBLE INSULATING MATERIALS LABORATORY SERVICES

TRULY ONE OF A KIND

The industry has come to rely on Doble's expert laboratory services, which were established in 1933. Today, Doble possesses the widest scope of insulating material testing capabilities in asset diagnostics. We offer over 200 different tests on liquid and solid insulating materials.

Our chemists and engineers will help you identify the cause of apparatus problems and provide detailed test reports with data analysis and recommendations for next steps. Testing categories include:

- Transformer oil purchase specification testing
- Corrosive sulfur & passivators
- Dissolved gas analysis
- Furanic compounds in oil
- Water-in-oil analysis
- Degree of polymerization
- Oil quality screens
- Metals-in-oil
- Polychlorinated biphenyls (PCBs)

DOBLE HAS HELPED MORE THAN 5500 CLIENTS IN 110 COUNTRIES IMPROVE OPERATIONS & OPTIMIZE SYSTEM PERFORMANCE.

THAT'S EXPERIENCE YOU CAN COUNT ON.

DOBLE CLIENT SERVICES GROUP
THE FULL DOBLE COMMUNITY PROMISE

EXPERIENCE. KNOWLEDGE. INSIGHT.

DOBLE ENGINEERING COMPANY

DOBLE CLIENT SERVICES GROUP: THE FULL DOBLE COMMUNITY PROMISE

Worry-free equipment, customized service, unbiased expertise and integrated resources instantly fortify your current diagnostic testing processes and fulfill all your power testing needs

For even the most experienced technician, situations in the field are rarely black-and-white.

Having a Doble Client Services Group membership contract, gives you certainty and reliability. Make the right interpretation and the right decision – the first time and every time. Trust that your testing and diagnostic instrumentation is state-of-the-art and works on demand, or will be replaced within 24 hours. Train your test technicians and power engineers on the most current test practices and procedures.

For a century, Doble has been the independent community hub for the global power industry, providing comprehensive testing equipment, unbiased insights, education and professional development, training and best-practices.

Nowhere in the world will you find a more concentrated or experienced group of Power engineering peers and leaders than with the community of than with the community of Doble engineers, clients like yourself, and 'client committee' members.

As a Doble Services Client, you gain the full Doble experience. You join this vast standing community of experts. You gain access to the industry's most comprehensive resource libraries on the power grid. You also learn what your peers are doing, and what apparatus troubles and failures other electric power companies are experiencing.

Free from the distraction of vendors or commercial interests, the Doble Client Service Group provides each member a highly individual experience that draws upon a wealth of resources.

Ultimately, your organization gains the tools and knowledge needed to maximize power delivery by increasing reliability, and reducing unplanned outages caused by preventable equipment failures.

Today, more than ever, you need to invest and use your workforce and capital resources wisely across the ownership cycle of every asset on the grid. Take advantage of the full Doble community promise.

ONE DOBLE

ADDRESSING YOUR COMPLETE ASSET OWNERSHIP CYCLE

Maintaining the health and fitness of most things, mechanical or living, requires a comprehensive approach. Delivering safe, reliable power requires that every phase of an asset's lifecycle is considered — from planning and design and through the continuing education of technicians.

Doble delivers solutions that specifically address the concerns and challenges faced at every distinct step to ensure better and longer performing assets.

PLANNING

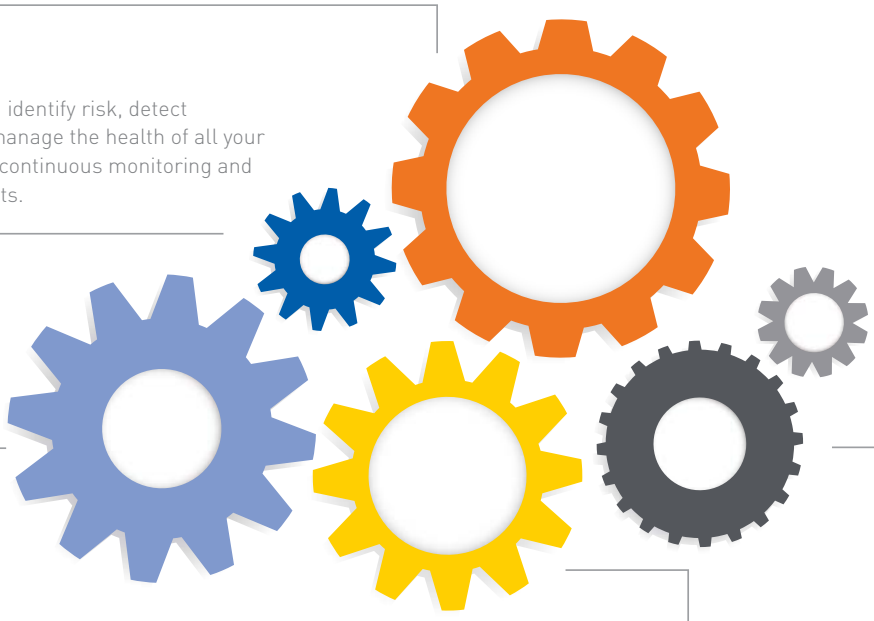
Improve your planning process with services such as procurement consulting, commissioning design and test planning taking into account your maintenance, replacement, and repair strategy for a more reliable system

DIAGNOSE

From testers, analyzers, surveyors and through to enterprise management systems and insulating materials laboratories, Doble's diagnostic tools and laboratory services help you understand what went wrong, so you can better plan and prevent future occurrences.

MANAGE

Doble helps you identify risk, detect problems and manage the health of all your assets through continuous monitoring and risk assessments.



PREVENT

Doble tools help prevent costly unplanned outages by identifying and detecting early indicators of damage, wear and malfunction.

EDUCATE

On the pulse of our industry, Doble provides training, industry conferences, education and The Doble Knowledge Database.

THE DOBLE CLIENT SERVICE ADVANTAGE

When you become a Doble Client Service Group member, a team of engineers has your back. This resource – backed by the deepest knowledge base in the power industry – is always there when you need it: when there's a problem, a question in the field, and when schedules are tight.

You gain access to:

- Over 30 field experts with more than 600 cumulative man-years of combined industry experience.
- 2500 power engineer community members – accessible via online forums and events.
- 32 million technical and maintenance data points, on over 100,000 assets, collected over decades.

Doble Client Service members renew year after year, decade after decade – because of the many benefits of membership:

KNOWLEDGE

Become the "go to" person in your company on apparatus reliability and maintenance.

CONFIDENCE

When there's an issue, we answer questions in real time, while the tester is still out in the field so that mistakes can be detected or investigative tests can be performed before an asset is returned to service.

BEST-PRACTICES

Gain the insights and best practices of the very best of the industry, based on actual field experiences worldwide, to keep your operation performing in peak condition. Anticipate issues based on troubles and failures being experienced throughout the industry, accurately decide on asset repairs versus replacements, discover different operating philosophies and practices, and stay up to date on technical advancements.

RELIABILITY

Never be in possession of obsolete, battered or inaccurate test equipment. If any problem is encountered, a complete replacement test set is shipped within 24 hours. All test sets are constantly updated with the latest engineering enhancement and newest features.

"YOU GUYS ARE DEPENDABLE, NOT JUST YOUR EQUIPMENT BUT YOUR PEOPLE.

I CAN PICK UP THE PHONE AND GET MY QUESTIONS ANSWERED IN A TIMELY FASHION, THAT'S WORTH SOMETHING"

Ferguson Electric
Paul Reily, President

GET THE MOST FROM YOUR DOBLE CLIENT SERVICE ENGAGEMENT

A perpetual warranty, equipment upgrades and worry-free use of Doble test instruments is only the beginning. Doble Client Service engagements support every aspect of your testing and diagnostic needs.

We are your long-term workforce development partner and your emergency expert on-call when situations are urgent. Take full advantage with:

- **Unlimited expert consultation** with a dedicated Doble Principal Engineer on matters related to testing procedures, test data analysis and apparatus maintenance. Doble's Client Service engineers serve as an extension of your own team, providing the assistance you need to manage your assets.
- Maintain and improve your staff's skill set with five days of **on-site training** every year. Doble's experienced engineers tailor training to your needs, including testing theory and techniques, how to apply the right test to the right situation, and hands-on field testing and test results analysis.
- Doble also offers on-site transformer factory test training, for impartial perspective and report analysis for additional fee.
- Access the '**Ask Doble' Technical Exchange Forum** where 2500 industry power engineers exchange knowledge, share advice, discuss problems and successes, poll peers for vendor recommendations, and get feedback and ideas.
- Take advantage of **Doble material insulation laboratory services** to provide answers and solutions based on a wide range of testing capabilities – from the standard to the highly specialized customized test protocols for unique cases.

WORKFORCE TRAINING

FIELD TEST

KNOWLEDGE RESOURCES

CONTINUOUS LEARNING

ASSET PROBLEM

EMERGENCY SERVICE

24 HOUR REPLACEMENT, OR ENGINEER ON THE PHONE WITH YOU IN THE MIDDLE OF THE NIGHT TO WALK YOU THROUGH INTERPRETATION AND NEXT STEPS

PARTICIPATE IN THE ANNUAL INTERNATIONAL CONFERENCE OF DOBLE CLIENTS

This is the leading forum in the world dealing with day-to-day issues involving apparatus problems. Interact with peers, leading experts and industry vendors. Doble may be considered as the de-facto industry association, and hosts this premier event that is created by Doble clients, for Doble clients.

ACCESS THE DOBLE KNOWLEDGE RESOURCE LIBRARY, ARGUABLY THE DEEPEST COLLECTION OF REAL-WORLD BEST-PRACTICE AND BENCHMARKING DATA

- Library of Reference Books/Guides
- 50 years of Doble Conference proceedings
- Apparatus Manufacturer's Service Advisories
- Industry Trouble and Failure reports
- Doble Client Tutorials
- Doble SFRA Resource Center
- Doble Partial Discharge (PD) Resource Center
- Doble Insulating Materials Resource Center
- Doble Protection & Automation Resource Center
- Doble Relay Test Plan Library
- AskDoble archive

This also includes access to Doble's database of more than 25 million apparatus test results.

Join and participate in the activities of the nine doble client technical committees.

Be a part of the industry conversation.

DOBLE IS WITH YOU
EVERY STEP OF THE WAY.

From products to training via our consulting services offering, we're here to support clients' critical infrastructure and the workforce that manages it. Our mission is simple – to facilitate robust interactions among our global clients in order to bring measurable value to their organizations.

Contact us to learn more about becoming a Doble Client Service Group member today.

"I RECEIVED EXACTLY THE TRAINING I EXPECTED, I AM VERY PLEASED"

Entergy Pilgrim

A CLIENT SERVICE AGREEMENT: IS IT RIGHT FOR YOU?

Client service members see the value most clearly when there's a problem in the field, when an issue arises, and when pressure is high. For example:

1. You just learned that a breaker failed at a utility on the other side of the world. You have the same circuit breaker. This early warning gives you critical lead time to diagnose that your breaker has the same potential failure mechanism – before crisis hits you.
2. You're having problems with a specific transformer. You gain powerful insights in learning that, in fact, 5 other utilities are having that same problem with the same asset.
3. You are commissioning a substation and the schedule is tight. Your test set was damaged. You receive a new one, the next day.
4. You are in a substation testing a transformer. The results look unusual but you are not sure and there is pressure to re-energize it. Talk with an expert in real-time to determine your options: reenergize with confidence or plan for corrective maintenance. Get the answer while the tester is still out in the field, so that mistakes or investigative tests can be performed before the transformer is returned to service.
5. You have elevated test results on a specific apparatus but your boss is questioning your analysis. Compare your results with a population of hundreds of identical apparatus and graphically show that your results are substantially higher than the norm.
6. Set your own strategic agenda to increase reliability, decrease cost, extend apparatus life, and enhance personnel safety from your interactions at the Doble Client Services Group Fall Committee Meeting where you can become an active voice in the industry.
7. Your boss assigns you to solve a problem that is affecting the reliability of substation equipment. Network with over 2,000 other utility engineers via our e-mail discussion forums and conferences, and receive support and assistance from colleagues to your questions, concerns and failures.

With over 80 years of service to the electric power industry, Doble Engineering continues to be the world leader in apparatus maintenance and power management for energy delivery.

www.doble.com

CONSULTING & TESTING SERVICES

DOBLE CONSULTING & TESTING SERVICES

POWER SERVICES OVERVIEW

Today many companies are increasingly looking to outsource for answers to their toughest engineering problems. Trust Doble Power Services' consulting, testing and laboratory services for expert, unbiased diagnosis and assessment of critical assets.

Doble Power Services leverages the resources of Doble's library and team of more than 70 engineers with extensive experience in transformer, substation, rotating machinery and power systems engineering applications. When you hire Doble, you benefit from the shared experience of our entire engineering team to ensure the highest level of consulting services and knowledge-based solutions.

Services include:

- Expert consulting services
- On-line substation surveys
- Laboratory services
- Advanced & routine testing
- Partial discharge testing
- EMI Diagnostics℠ survey
- Condition assessment services
- Forensic analysis

Products supported include:

- Transformers
- Generators, motors and rotating machinery
- Circuit breakers
- GIS, switchgear and cable
- Iso-phase bus

Typical benefits:

- Unbiased, expert opinion
- Recommends maintenance strategies based on assessment
- Enables limited maintenance budgets to be targeted toward critical and/or problematic units
- Provides metrics to evaluate maintenance program effectiveness or improvement initiatives

Why Doble Power Services?

Extensive Global Experience

Doble has more than 40 consulting engineers each with extensive experience in power systems engineering applications.

Independent Expert Opinion

Trust Doble's expert consulting & testing services for unbiased diagnosis and assessment of critical assets.

Doble Peer Review Process

When you hire Doble, you are hiring the shared experience of our entire engineering team. Each Doble field service report is reviewed by at least one other consulting engineer.

Doble KnowledgeBase

Provides valuable benchmark data for use in evaluating test results on your equipment.

Power Transformer Services

- Expert consulting services
  - Specification writing and review
  - Factory audits
  - Proposal evaluation
  - Design review
  - Independent test witnessing
- Forensic analysis
- Condition assessment services
  - Asset health review
  - On-site condition assessment
- Advanced and routine testing
  - Commissioning/acceptance testing
  - Partial discharge (UHF)
  - IR and RFI survey
  - Acoustic
  - Insulation condition (power factor, capacitance, insulation resistance)
  - Electrical/magnetic (winding resistance, excitation current)
  - Mechanical (SFRA, leakage reactance)

On-site condition assessment & consulting services

Power Cable Services

- On-line PD tests at MV & HV cables
  - DC insulation
  - AC power factor and capacitance
  - AC partial discharge
- Off-line PD tests MV power cables
  - Tan delta
  - Partial discharge and PD fault location
  - Recovery charge voltage

Network and Substation Services

- On-line partial discharge testing
  - RFI survey
  - Partial discharge (UHF)
- Surge arrester testing
- GIS commissioning & applied voltage testing
- GIS partial discharge survey
- Additional on-line tests
  - Infrared
  - Acoustic
  - SF6 leak detection
  - Moisture in oil

On-line substation partial discharge survey using Doble PDS100.

Laboratory Services

- Over 200 different tests offered on both liquid and solid insulation
  - Dissolved gas analysis
  - Oil quality
  - Water in oil
  - Aging/oxidation
  - Furanic compounds in oil
  - Corrosive sulfur
  - Degree of polymerization
  - Metals in oil
  - Polychlorinated Biphenyls (PCBs)
- High voltage laboratory
- Laboratory diagnostic seminars
- Doble Oil "Survey"
- Doble Domino® USS
- Doble LTC diagnostics (LTCare)
- Doble OCB diagnostics (DBA)

Doble provides complete laboratory analysis and engineering guidance.

Rotating Machinery Services

- On-line tests
- On-line partial discharge testing on stator windings
- EMI DiagnosticsSM survey
- Off-line generator tests
  - Visual inspection
  - DC insulation
  - AC power factor and capacitance
  - AC partial discharge
  - Air gap search coils
  - Rotor winding integrity (RSO)
  - AVR testing
  - ELCID and Ring Flux
- Motor tests
  - Visual inspection
  - Vibration monitoring
  - MCA test for induction motors
  - Off-line tan delta and partial discharge

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DOBLE CONSULTING & TESTING SERVICES

POWER TRANSFORMER SERVICES OVERVIEW

Doble has been a trusted name in transformer diagnostic solutions for over 90 years. Doble's unique business proposition combines three elements—diagnostic test instruments, expert consulting and testing services, and the world's largest resource library of related knowledge—into complete diagnostic solutions.

Doble Power Services offers the following:

- Expert consulting services
  - > Specification writing and review
  - > Factory audits
  - > Proposal evaluation
  - > Design review
  - > Independent test witnessing
- Laboratory services
- Forensic analysis
- On-line substation survey
- Condition assessment services
  - > Asset health review
  - > On-site condition assessment
- Advanced and routine testing
  - > Commissioning/acceptance testing
  - > Partial discharge (UHF)
  - > IR and RFI survey
  - > Acoustic
  - > Insulation condition (power factor, capacitance, insulation resistance)
  - > Electrical/magnetic (winding resistance, excitation current)
  - > Mechanical (SFRA, leakage reactance)
- Doble Life of a Transformer™ Seminars

Why Doble Power Services?

Extensive Global Experience

Doble has more than 40 consulting engineers each with extensive experience in power systems engineering applications.

Independent Expert Opinion

Trust Doble's expert consulting & testing services for unbiased diagnosis and assessment of critical assets.

Doble Peer Review Process

When you hire Doble, you are hiring the shared experience of our entire engineering team. Each Doble field service report is reviewed by at least one other consulting engineer.

Doble KnowledgeBase

Provides valuable benchmark data for use in evaluating test results on your equipment.

EXPERT CONSULTING SERVICES

Procurement of large transformers has become global, driven by capacity shortfalls and an ongoing search for cost-effective purchasing. Doble engineers undertake this for our customers in preparing specifications, evaluating proposals, auditing individual factories for capability and performance, performing design reviews and fingerprinting new transformers prior to and after installation.

LABORATORY SERVICES

Doble has been providing laboratory services to the electric power industry since the 1930s. More than 200 different analytical tests and variations are offered on a routine basis encompassing both solid and liquid insulation. Doble lab analysts are considered to be the preeminent experts in DGA, oil quality and corrosive sulfur analysis.

ON-LINE SUBSTATION SURVEYS

A partial discharge survey from Doble is a non-invasive measurement technique that allows problems to be detected while the equipment remains in service. Using the advanced Doble PDS100 with HFCT/TEV probe, substations can be surveyed in a short amount of time (typically less than one day). Highlighted areas can then be investigated in greater detail using more focused on-line techniques, and problematic areas can be targeted for off-line testing.

FORENSIC ANALYSIS

If expensive assets reach their end of life point sooner than expected, it is important to figure out why. Doble conducts failure analysis involving a review of operating and maintenance records, oil analysis, on-site inspections and tests, and microscopic, infrared and x-ray analysis.

Doble's vast database of historical transformer failures, test results and design reviews are used to obtain the most accurate analysis possible. Detailed reports are prepared explaining the failure mechanism, original root cause and recommendations.

CONDITION ASSESSMENT SERVICES

Asset Health Review

Doble will review operations, maintenance, DGA, loading history and abnormal event service records given to Doble by the customer. This review will give an overview of transformer condition and provide a basis for additional investigation.

On-Site Condition Assessment

This assessment determines the fitness of the transformer for continued service. It includes a review of the asset health review report, an external visual inspection and a full suite of off-line tests. The customer will receive a comprehensive report indicating areas of concern and recommendations.

WHY TEST POWER TRANSFORMERS FOR PARTIAL DISCHARGE?

When transformers demonstrate increasing rates of gas generation, it's important to test them for partial discharge (PD) to determine if the gassing is coming from PD or other sources.

CASE STUDY

Manufacturer: General Electric

Year: 1983

Rating: 230/69 kV, 22/32/40/45 MVA

Expansion/Preservation system: Nitrogen blanket

Transformer showed an increasing rate of gas generation (from 1.2 ppm/day to 27 ppm/day of H2). Since these were heavily loaded units, the owner was extremely concerned about PD.

Possible sources of hydrogen:

- Partial discharge activity
  – H2, some methane
- Stray gassing
  – When high almost all H2
- Free water reaction with iron
  – All H2
- Electrolysis of free water in galvanized valves
  – H2 & oxygen
- Overheating of core
  – Almost all H2
- Some steels and galvanized materials
  – All H2
- Improperly cured primer
  – Observed high H2

Through our advanced laboratory and partial discharge testing services, Doble determined that the problem was free water in valves. When flushed out well, H2 levels went back to normal levels.

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DOBLE CONSULTING & TESTING SERVICES

TRANSFORMER CONSULTING SERVICES

Doble Power Services leverages the resources of Doble's extensive library and experienced engineering team to deliver the highest level of consulting services and knowledge-based solutions.

Constituting one of the largest investments in a utility, plant or industrial system, transformers are extremely critical apparatus for providing reliable energy flow. Procurement has become global, driven by capacity shortfalls and an ongoing search for cost-effective purchasing.

Doble engineers help mitigate risk by assisting clients in preparing transformer specifications, auditing individual factories for capability and performance, evaluating proposals, overseeing design reviews, conducting factory inspections and witnessing factory tests.

WHY HIRE EXTERNAL TRANSFORMER CONSULTANTS?

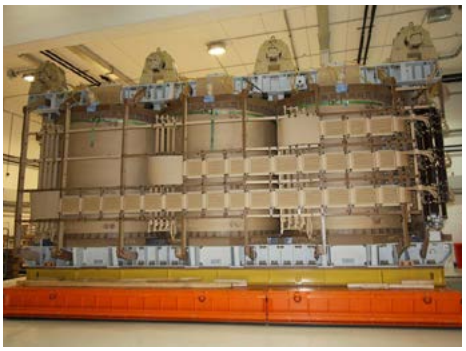
- Verify specific requirements are met during the design and production processes
- Mitigate transformer schedule risk
- Establish a clear, communication line between the client and manufacturer
- Address problems before transformer leaves the factory to avoid high cost and delays associated with field repair
- Represent your interests with specialized expertise in design, manufacturing and factory testing of power transformers

PARTNERING WITH DOBLE POWER SERVICES PROVIDES THE FOLLOWING BENEFITS:

- Knowledgeable team of transformer design and consulting engineers for critical or long-term replacement projects requiring highly specialized engineering resources
- Extensive global experience, especially important when considering new off-shore transformer suppliers (Asia, South America, etc.)
- Latest transformer design and evaluation criteria for new engineers who may be working with outdated specifications
- Independent, expert opinion during the entire procurement and commissioning process

DOBLE POWER SERVICES OFFERS THE FOLLOWING EXPERT CONSULTING SERVICES:

- Specification writing and review
- Factory audits
- Proposal evaluation
- Transformer design review
- Independent inspection and test witnessing
  - > Core and coil inspection
  - > Pre-processing inspection
  - > Pre-tanking inspection
  - > Acceptance testing



SPECIFICATION WRITING AND REVIEW

The Doble design engineer and client will identify details of the client's transformer application including:

- Loading requirements
- Environmental conditions
- Voltage variations
- Short circuit stresses

The Doble engineer then utilizes his experience in transformer design to translate client's needs into a purchase specification incorporating state-of-the-art design, manufacturing and testing requirements that are tailored to meet the demands of the client's specific application.

FACTORY AUDITS

Doble will perform a comprehensive review of the transformer factory and procedures including:

- Design
- Manufacturing
- Quality assurance and control
- Supply chain
- Problem mitigation

The audit also assesses productivity, delivery performance, process control metrics, general safety practices, technology level, quality records, service history, training programs and management philosophy. Plant layout, cleanliness, modernization and throughout are other important parts of the audit.

PROPOSAL EVALUATION

The Doble engineer incorporates their knowledge of the various transformer designs and capabilities of the manufacturers to perform a comprehensive evaluation of bids for new or rebuilt units. Factors involved with a comprehensive evaluation include:

- Specification considerations
- Past performance
- Schedules
- Application needs
- Factory capabilities and condition
- Worksmanship and reliability considerations

DESIGN REVIEW

The Doble engineer meets with the manufacturer shortly after the award is executed. The transformer manufacturer provides detailed technical information on the thermal, dielectric and mechanical aspects of the transformer design. Materials, electrical clearances, oil flow, conductor properties and many other design aspects are thoroughly reviewed to ensure that the technical requirements of the client's specification are fulfilled.

INDEPENDENT INSPECTION AND TEST WITNESSING

After the manufacturer obtains design approval, manufacturing of the transformer begins. The various stages of the construction process are then monitored at pre-selected surveillance points to ensure that a high quality product free of defects is provided.

Common selection points include:

- Core and coil inspection
- Pre-processing inspection
- Pre-tanking inspection
- Acceptance testing

Why Doble Power Services?

Extensive Global Experience

Doble has more than 40 consulting engineers each with extensive experience in power systems engineering applications.

Independent Expert Opinion

Trust Doble's expert consulting & testing services for unbiased diagnosis and assessment of critical assets.

Doble Peer Review Process

When you hire Doble, you are hiring the shared experience of our entire engineering team. Each Doble field service report is reviewed by at least one other consulting engineer.

Doble KnowledgeBase

Provides valuable benchmark data for use in evaluating test results on your equipment.

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DOBLE CONSULTING & TESTING SERVICES

TRANSFORMER RELIABILITY

CONDITION ASSESSMENT SERVICES

IMPROVING ASSET RELIABILITY THROUGH UNDERSTANDING TRANSFORMER HEALTH

Transformer reliability assessment services from Doble Power Services provide a solid foundation for an effective transformer life-cycle management program. No one can precisely answer when equipment will fail, but it's essential to manage the risk. Whether evaluating an individual transformer or a fleet, reliability assessments are complex and require a proven methodology and an experienced team of design engineers, chemists and technicians using numerous evaluation criteria.

WHO SHOULD USE DOBLE'S TRANSFORMER RELIABILITY ASSESSMENT SERVICES?

Doble works with asset managers, corporate lead engineers and plant/system engineers who typically have a large fleet of critical transformers and are looking for a trusted energy infrastructure partner to help identify units at risk of failure so that limited maintenance resources can be focused where needed most. They may also have an at-risk transformer and be looking for mitigating steps they can take to improve reliability and extend asset life.

Doble has assembled a transformer condition assessment team with unmatched expertise:

- Extensive global experience
- Proven transformer reliability assessment methodology
- Global, industry-leading laboratory diagnostics research
- Independent, unbiased expert opinion not affiliated with manufacturers
- Doble KnowledgeBase containing decades of statistically significant data including 25 million test results on over 350,000 types of electrical apparatus

CONDITION ASSESSMENT METHODOLOGY

Doble has adopted a two-stage approach with the intent of consolidating all sources of transformer asset health information into an integrated view.

Asset Health Review Survey (Level 1)

- Initial review of existing test data
- Assess technical condition and develop a general condition overview to identify units that are at greatest risk of failure (red, yellow or green)
- Prioritize where to undertake a more detailed investigation

Comprehensive Assessment (Level 2)

- Detailed review of transformer condition including a design family evaluation
- May include a full-suite of on-line and off-line diagnostic testing
- Benchmark oil analysis and electrical test data against Doble KnowledgeBase
- Second refinement of technical condition and risk assessment to highlight areas of concern

ASSET HEALTH REVIEW SURVEY (LEVEL 1)

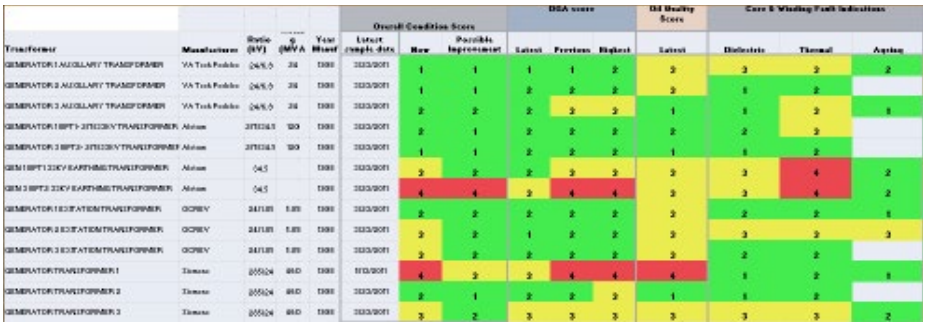
Using available test data, Doble will perform an initial survey rating important criteria (Table 1) on a 5-point scale (Table 2) to develop a general condition overview (rating of green, yellow or red) of the transformer population & prioritize resources.

- Prepare an asset health register
- Systematically collect and review all available test data
  - Nameplate
  - Design and factory test data
  - DGA and oil analysis data
  - Electrical field test data
  - Operations and loading history
  - Fault and short circuit history
  - Maintenance and repair history
  - Existing infrared and RFI survey data
- Identify critical information gaps and develop process for periodic updating
- Using Doble's proven asset health review methodology, score transformer on up to nine (9) criteria and overall health

Table 1. Key Survey Criteria

- Overall condition
- Dissolved gas analysis (DGA)
- Oil quality
- Water content
- Furans
- Dielectric, Thermal & Mechanical
- Bushings
- Load tap changer DGA & condition

Asset Health Review Survey



Units that are strategic or at risk of failure are identified and scheduled for additional investigation and off-line testing.

Table 2. Rating Scale

CONDITION	DEFINITION
As New	No damage or deterioration
Normal/Aging Performance	Reasonable for age, no action required
Aged/Some Performance Issues	Some aging; in need of monitoring but not urgent
Suspect/Major Performance Issues	Clearly identified aging and at significant risk of failure. Remedial action plan required.
Unacceptable	Unacceptable aging deficiencies; implement remedial action plan immediately

COMPREHENSIVE ASSESSMENT (LEVEL 2)

Detailed review of transformer condition focusing on units from the asset health review that indicate significant risk in order to determine suitability for continued service. Assessment will highlight areas of concern and provide remedial action recommendations to improve reliability.

- For units scored yellow or red, perform detailed review to identify faults or accelerated aging & possible root causes
- Perform thorough design family review
- Benchmark oil analysis and electrical test data against Doble KnowledgeBase
- Provide specific remedial action recommendations to improve transformer reliability and overall condition
- May include full-suite of on-line and off-line diagnostic testing

Additional On-line and Off-line Diagnostic Tests May Include:

- Laboratory analytical tests
- Thermal aging and hot spots
- Dielectric condition (electrical test)
- Mechanical condition (electrical tests, visual inspection)
- Tank and external metalwork (visual inspection)
- Bushings (electrical tests, inspections)
- Tap changers (oil condition)
- Arresters (leakage current test, visual inspection)

ADDITIONAL SERVICES

Doble provides a comprehensive suite of transformer life-cycle management solutions specifically designed to meet your needs.

- Transformer maintenance program development consulting
- Transformer or component (LTC, bushings, etc.) failure analysis
- Routine & advanced testing
- Partial discharge testing
- Consulting services for new transformer procurement
  - > Specification writing and review
  - > Factory audits
  - > Proposal evaluation
  - > Design review
  - > Factory test witnessing

For more information about how these services can provide you a competitive advantage, contact Doble at services@doble.com.

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MKT-SL_Transformer Reliability_12/15

DOBLE CONSULTING & TESTING SERVICES

GENERATOR AND MOTOR TESTING

with EMI Diagnostics[SM]

An Electromagnetic Interference (EMI) Diagnostics survey from Doble is an on-line, non-invasive test that can detect a wide variety of defects in generators, motors and associated electrical system components. Trending data is not required and maintenance recommendations can be provided on the very first test. EMI data collection follows the international standard CISPR 16. The test equipment is very sensitive and measurement accuracy is traceable to national standards.

Electric generators are usually reliable pieces of equipment, however, a large portion of the existing generating fleet is approaching or has exceeded their design life. EMI Diagnostics has been successfully performed on electric power systems since 1980. It has been proven with over 8,000 successful field tests on more than 500 different designs with over 70 types of defects and conditions identified, catalogued and verified.

Electromagnetic interference is the precise frequency domain measurement and identification of radio frequency energy that results from electrical partial discharge and arcing at defects. EMI data is collected from the temporary placement of a single split core radio frequency current transformer around the power conduit, safety ground or neutral lead of the component being tested. No hot connection is required to any energized conductor, and no hardware installation modifications are required.

The acquired radio frequency spectrum, or EMI signature, is unique for each physical location and defect present within the electrical system. EMI Diagnostics can detect a wide variety of electrical and mechanical system component defects in:

- Generators
- Motors
- Transformers
- Iso-phase bus
- Cables
- Switchgear
- Associated electrical system components

BENEFITS OF EMI DIAGNOSTICS

- Provides broader view of system defects including partial discharge
- Enables limited maintenance budgets to be targeted toward critical and/or problematic units
- Empowers improved condition assessment and optimized preventative maintenance programs

GAIN A SYSTEM-WIDE VIEW OF YOUR PLANT AND EQUIPMENT

Partial discharges and arcing generate light (visible and UV), chemical changes (ozone), audible noise (sound), heat (IR) and electromagnetic interference (EMI). EMI Diagnostics detects the radio frequency emissions resulting from partial discharges and arcing. EMI Diagnostics can be used to identify the following:

Generator conditions

- Stator bar slot discharges from conductive coating erosion
- Stator slot side-packing erosion
- Stator bar stress grading system deterioration
- Loose stator wedging (stator bars)
- Loose end winding ties
- Blocking and circuit rings
- Loose or broken stator sub conductors
- Winding contamination (dirt, oil or water)

Motor conditions

- Stator coil partial discharges
- Deterioration in slots and on end
- Winding contamination (dirt, oil, carbon black or coal dust)
- Defective bolted or crimped stator lead connections
- Broken induction motor rotor bars
- Bearing problems
- Misalignment
- Shaft oil seal rub

OPTIMIZE CONDITION BASED MAINTENANCE PROGRAMS

Doble's experience has shown that 80% of the equipment tested does not require maintenance during the next outage. However, 15% are in the process of developing a problem and 5% need immediate attention to prevent premature equipment failure. Identifying the 80% is extremely important since it releases maintenance resources to the 5% that require immediate attention. Additional inspections or tests can be scheduled to confirm the existence of these conditions and condition based maintenance can be scheduled before a failure occurs.

About Doble Power Services

Doble has been a trusted name in electric power diagnostic solutions for over 90 years. Doble's unique business proposition combines three elements—diagnostic test instruments, expert consulting and testing services, and the world's largest resource library of related knowledge—into complete diagnostic solutions. Doble Power Services leverages the resources of Doble's extensive library and experienced team of engineers to deliver the highest level of consulting services and knowledge-based solutions.

Why Doble Power Services?

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MKT_SL_GeneratorandMotorEMI_12/15

DOBLE CONSULTING & TESTING SERVICES

ISOLATED PHASE BUS DUCT TESTING

with EMI Diagnostics℠

What is the condition of your isolated phase bus that delivers power from your generator to transformers? Consider the consequences to your plant operation if your bus fails.

Your present testing program should be able to identify the following defects:

- Loose or broken support insulators
- Loose or corroded hardware
- Defective insulation
- Stray circulating currents
- Foreign material or objects inside bus
- Defective bus PT connections
- Open PT high-voltage fuses
- Contaminated insulators (dirt, dust or water)

An Electromagnetic Interference (EMI) Diagnostics survey from Doble is an on-line, non-invasive test that can detect a wide variety of defects in isolated phase bus duct, transformers, generators, motors and associated electrical system components that other technologies are unable to detect. EMI Diagnostics has been successfully performed on electric power systems since 1980. It has been proven with over 8,000 successful field tests on more than 500 different designs with over 70 types of defects and conditions identified, catalogued and verified.

Electromagnetic interference is the precise frequency domain measurement and identification of radio frequency energy that results from electrical partial discharge and arcing at defects. EMI data is collected from the temporary placement of a single split core radio frequency current transformer (RFCT) around the power conduit, safety ground or neutral lead of the component being tested. The acquired radio frequency spectrum, or EMI signature, is unique for each physical location and defect present within the electrical system.

BENEFITS OF EMI DIAGNOSTICS

- Provides broader view of system defects including partial discharge
- Enables limited maintenance budgets to be targeted toward critical and/or problematic units
- Empowers improved condition assessment and optimized preventative maintenance programs

IDENTIFY LOOSE BOLTED CONNECTIONS IN YOUR BUS DUCT

Phase 1: Loose Connections

Problems with iso-phase frequently begin with loose bolted connections which causes pitting and discoloration due to heating and arcing in the early stages of the developing problem. At this point, heat generated is not likely to heat the bus duct enclosure, but the defect will produce an electromagnetic field which can be detected by EMI Diagnostics.

Phase 2: Melting of the Metal

If allowed to continue, heating will melt the metal. Current is still flowing and at this point discharge activity would be obvious on the EMI Diagnostic survey. You may be able to detect the problem with infrared scanning techniques at this point. Do you want to wait until the problem reaches this point before detection? Even now, time consuming and costly repairs are needed.

Phase 3: Failure

It does not take long to get from phase 2 to complete failure. At this point, a forced outage will shut down the generating unit and the cost will include lost production as well as the cost of replacing the iso-phase bus connection. This could have been prevented with an annual EMI Diagnostics survey from Doble.

OPTIMIZE CONDITION BASED MAINTENANCE PROGRAMS

Doble's experience has shown that 80% of the equipment tested does not require maintenance during the next outage. However, 15% are in the process of developing a problem and 5% need immediate attention to prevent premature equipment failure. Identifying the 80% is extremely important since it releases maintenance resources to the 5% that require immediate attention. Additional inspections or tests can be scheduled to confirm the existence of these conditions and condition based maintenance can be scheduled before a failure occurs.

IDENTIFY CRACKED INSULATORS WITH EMI DIAGNOSTICS

Another problem that can lead to bus duct failures is damaged insulators. Cracks and chips in insulators will result in discharge activity which EMI can detect.

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DOBLE CONSULTING & TESTING SERVICES

ON-LINE SUBSTATION PARTIAL DISCHARGE SURVEY

High-voltage equipment is exposed to electrical, mechanical and thermal stresses as well as environmental conditions that can act to accelerate the deterioration of insulation, and hence electrical integrity, eventually leading to failure. Detection and measurement of partial discharge (PD) phenomena, a symptom of insulation deterioration, can provide early warning. Different on-line techniques to detect PD include dissolved gas analysis (DGA), acoustic emission and radio frequency interference (RFI).

Well-established as an on-line, non-invasive, early-stage assessment technique, RFI scanning can quickly and accurately document problem areas before they may begin generating heat and be detected with thermography. Equipment identified as having above normal RFI levels can then be investigated in greater detail using more focused on-line (partial discharge, infrared, acoustic, ultrasonic, UV, etc.) and off-line testing techniques.

RFI surveying works particularly well in detecting PD generated in both passive and active substation equipment such as insulators and instrument transformers where no non-invasive, on-line methods presently exist.

Apparatus supported include:

- Insulators
- Arresters
- Instrument transformers (CTs, VTs, CVTs)
- Cable terminations
- Disconnectors
- Circuit breakers
- Transformers

Let Doble Power Services carry out a full suite of on-line surveys to ascertain the health of your substation and plant equipment. Doble also offers consulting and training services for PD surveyor professionals and predictive maintenance programs worldwide.

BENEFITS OF RFI SURVEYING

- Complete substations can be surveyed in short amount of time
- Non-invasive, conducted while facility is fully operational
- Rate and severity of discharge can be monitored and trended
- New substations can be given a clean bill of health as part of commission process
- Assessment of remedial, renovation or upgrade works

RFI TESTING

RFI inspections from Doble Power Services provide clients with the convenience and quality of a testing program established utilizing industry best practices. Doble's certified engineers bring decades of experience in predictive maintenance techniques from utility, power plant and industrial applications. Doble can support periodic inspections up to larger programs requiring full-time staff placement. Doble offers a complete solution including:

- Partial discharge
- Infrared
- Acoustic
- Moisture in oil

RFI CONSULTING

Thinking about incorporating RFI surveying into your existing testing programs?

Not sure how your current programs stack up against industry best practices?

Program development services from Doble Power Services are a great place to start. Doble can assist organizations at any stage of their program to form a roadmap for the development or improvement of an existing program including:

- Applications
- Safety practices
- Routes & scheduling
- Analysis & reporting
- Performance & metrics

RFI TRAINING

The right training provides the foundation necessary for the success of any predictive maintenance program. Our classes are led by Doble instructors who together have decades of experience and knowledge in the industry.

TYPES OF PARTIAL DISCHARGES

External:

- Surface discharges caused by pollution on insulator surfaces
- Leakage currents on insulator surfaces
- Insulator damage
- Loose connections
- Corona discharges

Internal:

- Insulation voids
- Poor conductor-insulation interfaces
- Poor insulator-insulator interfaces

CASE STUDY

Doble PDS 100 detects and locates sources of PD in a substation

A RFI survey was carried out on an entire 400 kV substation, and measurements of RFI were recorded at various survey locations for future trending. During the survey, a strong source of PD was triangulated to bus coupler isolator. Figure 1 illustrates measurements of RFI emissions taken at the suspect apparatus (trace in RED) and compared with the baseline measurement (trace in BLUE) for that section of the substation. Uplifts of 60 dB and 30 dB are evident at spot frequencies 400 MHz and 1000 MHz respectively, providing evidence that this apparatus is exhibiting significant signs of deterioration and that a fault condition exists.

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MKT-SL_Online Substation PD Survey_12/15

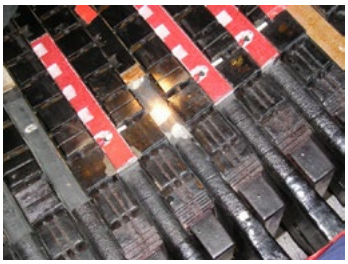
DOBLE CONSULTING & TESTING SERVICES

ROTATING MACHINERY SERVICES OVERVIEW

Rotating machinery assessment services from Doble Power Services provide a solid foundation for effective condition-based maintenance programs based on industry best practices. No one can precisely answer when equipment will fail, but it's essential to manage the risk.
The Doble condition assessment method for turbo-generators, hydro-generators, motors and other rotating machinery types follows the same evidence-based process used for other major plant items. Assessment services are performed by experienced Doble engineers, technicians and analysts using proprietary software and methods to establish asset health.

Typical benefits:

- Unbiased, expert opinion
- Recommends maintenance strategies based on assessment
- Enables limited maintenance budgets to be targeted toward critical and/or problematic assets
- Provides metrics to evaluate maintenance program effectiveness or improvement initiatives



ON-LINE TESTS

On-line Stator Winding Partial Discharge

PD-Guard Services

Doble offers a complete solution for continuous PD monitoring on rotating machines including the Doble PD-Guard, couplers, calibrators, interference rejection sensors and all necessary connectors. Doble provides site commissioning, training and diagnostic services available 24/7.

PD Testing Services using PD-Smart

Utilizing the Doble PD-Smart, Doble Power Services provides on-line PD testing services for generators, motors and other rotating machinery.

Doble's solution utilizes low frequency 2 nF Failsafe and LC coupling capacitors which, unlike high frequency capacitors, provides a superior PD testing solution. And using a coupling adapter, Doble can interface with previously installed capacitance couplers.

The PD-Smart can be extended to perform synchronous multi-channel measurement. It also provides advanced statistical analysis using Star-Diagram analysis to reject interference, cross-coupling and to identify separate PD features.

Electromagnetic Interference (EMI) Diagnostics Survey

Non-invasive, on-line survey that will detect a far broader range of electrical and mechanical system (generators, motors, transformers, iso-phase bus, cables, switchgear, etc.) component defects than stator winding partial discharge testing alone.

Trending data is not required and maintenance recommendations can be provided on the very first test. EMI Diagnostics has been proven with over 8,000 successful field tests on more than 500 different designs with over 70 types of defects and conditions identified, catalogued and verified.

OFF-LINE GENERATOR TESTS

DC Insulation Resistance and Polarisation Index

The insulation resistance test is a check that the stator will not be at risk from AC testing at lower gas pressure following degassing. At the end of the outage, it is an important indicator of adequate dryness and absence of foreign bodies.

AC Power Factor and Capacitance

After satisfactory completion of DC tests, these high-voltage AC tests measure power factor (or loss tangent), capacitance and partial discharge. They give a measure of contamination, moisture debonding and void growth within the insulation and contamination on the end-winding.

AC Partial Discharge

The partial discharge characteristic can be used to identify the type of defect and adds an additional diagnostic tool to the power factor tip up. If end covers are removed and end-winding discharge is indicated, these areas can be scanned when the winding is energized using ultrasonics and a corona camera to locate the discharge area.

Air Gap Search Coils

A current carrying inter-turn fault is best detected using pre-installed air gap search coils. Doble can monitor the condition and analyze results with the generators on load.

Rotor Winding Integrity using RSO

Rotor winding insulation inter-turn and earth faults are detected using the recurrent surge oscillograph (RSO) method. The test is very sensitive and will provide an early stage indication of an inter-turn fault.

ELCID and Ring Flux

The electromagnetic core imperfection detector (ELCID) identifies the presence of faulty core insulation by an electromagnetic technique. It operates on the basis that currents will flow through failed or significantly aged core insulation even when a flux equivalent to a few percent of rated voltage is induced in it.

AVR Testing

AVRs are inspected off load plus a test sequence involving three-phase injection with DC sequence and operating load tests during re-commissioning of the unit.

Test for Instrumentation

Thermocouples, RTDs and insulated bearings are checked with a low-voltage DC test for continuity and resistance to earth.

Generator Condition Monitor

Many generators have a detector to identify particulate products of overheating. Doble will visit on a three-month schedule to check the functionality of your system.

MOTOR TESTS

Vibration Monitoring

This is a simple test made on a routine visit to indicate unusual vibration levels.

Motor Current Signature Analysis (MCSA)

On smaller motors rated at 600V or less, the stator current in one phase can be measured with a portable clamp-on CT placed on a phase lead, either in the motor terminal box or at the motor control center or breaker.

For larger motors rated above 600V, the current is usually measured by a clamp-on power frequency CT, on the secondary of the CT, that measures the supply current to the motor for protection purposes (usually at the MCC). MCSA provides on-line monitoring and analysis of current to assess the condition of an induction motor drive system.

MSCA helps to effectively diagnose problems prior to motor drive failure including:

- Broken rotor bars
- Abnormal air-gap eccentricity
- Shorted turns in LV stators
- Abnormal rotor dynamics
- Pump wear
- Misalignment

Off-line Tan Delta and Partial Discharge

High-voltage AC tests that involve measurement of power factor (or loss tangent), capacitance and partial discharge.

VISUAL INSPECTION

This inspection is one of the most valuable processes and needs to be done with care by an experienced engineer. In a minor outage this is confined to the end winding areas. With the rotor removed, the visual inspection will be more extensive when slot wedges and core teeth are visible. Wedge tightness can also be checked.

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DOBLE LABORATORY SERVICES

Complete laboratory analysis & support

DOBLE ENGINEERING COMPANY

DOBLE LABORATORY SERVICES

DOBLE INSULATING MATERIALS LABORATORIES

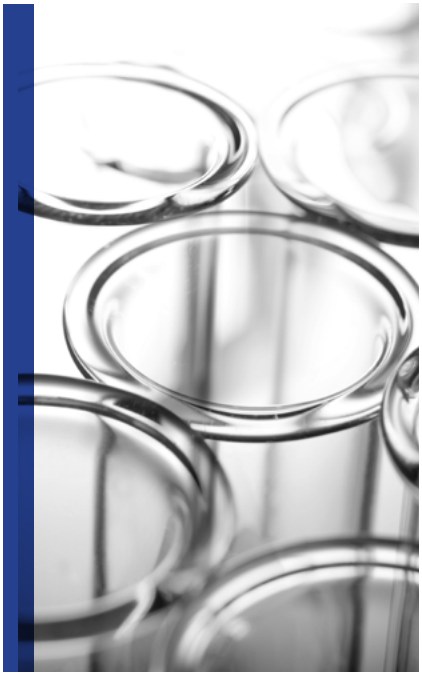
LABORATORY ANALYSIS & ENGINEERING GUIDANCE TO HELP MANAGE CRITICAL ASSET RISK

Oil testing is the best, most cost-effective means to determine the health of your generation, transmission and distribution transformers and other oil-filled assets. Developing problems can be detected at an early stage and then managed with further monitoring to detect serious deterioration or conditions that might result in failure. These tests can also be used to detect deterioration of the insulating oil that can result in formation of sludge and other by-products that can affect the quality of the electrical insulating materials and the cooling ability of the transformer.

With over 200 different tests available, let Doble's experienced laboratory team support your solid and liquid materials testing. Assisting customers since 1933, rely on our expertise for quality data and independent knowledgeable interpretation of results. Let us help you develop a test program fit for your needs. Doble offers routine and emergency testing, development of routine or comprehensive testing programs from all of our offices located in Massachusetts, Indiana, North Carolina and Texas.

KNOWLEDGE COMMUNITY

Doble has published hundreds of papers on testing and diagnostics associated with electrical insulating liquids and insulating paper. Doble has performed leading edge studies on static electrification, stray gassing and corrosive sulfur problems in transformers. In addition, Doble is a leader in the evaluation of new electrical insulating oils.



OIL COMMITTEE

Join the Doble Oil Committee members who have a common interest in the quality of new oils and verification that products meet specifications. This group also explores new methods and technologies for assessment of dielectric oils. The group discusses problems and decides which areas require research. Oil Committee members have a direct interest in and often primary responsibility for procuring and maintaining mineral oil in their organizations.

ANNUAL OIL SURVEY

Be in the know about available transformer oils and their quality. The Doble Annual Oil Survey publishes data and analysis of commercially available transformer mineral oils. Issued since 1953, the report compares current data with historical reports to evaluate product consistency. This survey provides the test data and information you need to evaluate transformer oils refined worldwide.

TRANSFORMER OIL PURCHASE SPECIFICATION

Many companies use the Doble Transformer Oil Purchase Specification (TOPS) and the Annual Oil Survey to qualify oil suppliers, using these materials as independent assessments of commercially available oils. TOPS is a set of specifications developed and maintained by the Doble Oil Committee and is the basis for the Annual Oil Survey testing.

KEY DIAGNOSTIC & OIL QUALITY TESTS

Dissolved Gas-in-oil Analysis (ASTM D3612/IEC 60567)

The most important test for oil-filled equipment. Amounts, relative composition and rates of generation of key gases are used to detect and monitor developing faults in electric apparatus. Detects and distinguishes between thermal and electrical problems before failure occurs.

Furanic Compounds-in-oil Analysis (ASTM D5837/IEC 61198)

Paper is the most important electrical insulating material in transformers. When the paper breaks down, furanic compounds are generated. The amount and rate of generation of these compounds are used to assess the condition of the paper insulation. Furanic compounds are soluble in oil and therefore easy to sample.

Oil Quality & Water Content

Oil quality should be determined and periodically verified that it will perform its functions as a coolant and dielectric. Doble offers a variety of oil quality screen test packages for new and service-aged insulating liquids which can include:

Color (ASTM D1500) | Dielectric Breakdown Voltage (ASTM 1816) | **Interfacial Tension (ASTM D971)** | Neutralization Number (ASTM D974/IEC 62021) | **Visual (ASTM D1524)** | Water Content (ASTM D1533/IEC 60814) and Relative Saturation | **Power Factor @ 25°C & 100°C (ASTM D924/IEC 60247)** | Specific Gravity (ASTM D1298)

Corrosive Sulfur

Doble has been at the forefront of corrosive sulfur research and the significant effect it can have on large power transformer systems. Doble offers more than 15 laboratory tests to assess and mitigate corrosive sulfur risk.

Degree of Polymerization of Paper (ASTM D4243/IEC 60450)

This test requires a sample of the paper and is a direct measure of paper aging which correlates with important physical properties such as resistance to tearing and bursting.

Wear Metals In Oil (Doble Test Method)

Pumped cooling systems are susceptible to bearing wear which can create metal particles. Oil is analyzed for particulate metals such as copper, iron, zinc, and lead.

Dissolved Metals in Oil (ASTM D7151)

High temperature fault conditions can create dissolved metals. High concentrations of certain metals can help locate fault sources.

Load Tap Changer Program

Load tap changers can fail mechanically and electrically from various wear and deterioration conditions. Doble's LTCare program includes dissolved gas-in-oil analysis (DGA), particle count, microscopic particle examination, Doble Carbon Code, several oil quality tests and dissolved metals-in-oil.

Breaker Analysis Program

Bulk oil circuit breakers can also fail mechanically and electrically from various deterioration mechanism. Our DBA program also includes DGA, particle count, microscopic particle examination, Doble Carbon Code, several oil quality tests and dissolved metals-in-oil.

DOBLE CONSULTING & TESTING SERVICES

LABORATORY SERVICES

FOR HIGH & MEDIUM-VOLTAGE ROTATING MACHINES

Design and manufacturing problems can cause premature equipment failure. To minimize that risk, Doble's high-voltage laboratory offers a wide range of qualification and acceptance tests for medium-voltage and high-voltage rotating machines.

Doble's team has more than 100 years combined experience testing and evaluating generator and motor insulation systems, including large rotating machine stator bars and coils. Our laboratories can perform over 200 laboratory tests on both solid and liquid insulation and have been serving satisfied customers for over 80 years.

In addition to laboratory testing, Doble specialists have extensive field testing experience in power factor, partial discharge, electromagnetic signature analysis, EL CID and AC/DC Hi-Pot testing as well as visual inspection, condition assessment and failure investigation of generators, motors, transformers, cables and other power apparatus.

QUALIFICATION & QUALITY CONTROL OF MANUFACTURED COILS

- Voltage endurance test as per IEEE-1043 & IEEE-1553
- Thermal cycling test as per IEEE-1310
- Dissipation factor and tip-up test
- Partial discharge test
- Turn-to-turn insulation test
- AC Hi-Pot test for groundwall insulation integrity
- Dissection & microscopic examination of coils
- Customer technical specification preparation
- Independent factory inspections, material verification & quality conformance

VOLTAGE ENDURANCE TESTS

The voltage endurance test is performed according to IEEE-1043 and IEEE-1553. An AC high voltage is applied to the coils for 400 hours. The heaters are set to 90°C -120°C and thermocouples are placed in the heater plates to monitor temperature. Several diagnostic tests such as polarization index, Hi-Pot, partial discharge, dissipation factor and tip-up are carried out.

To pass the test, the coils should not fail in less than 400 hours (time length depending on voltage). Failing the voltage endurance test can indicate a manufacturing quality issue even if similar coils have previously passed the voltage endurance test.

HIGH-VOLTAGE LABORATORY TESTING SOLUTIONS INCLUDE:

- AC 300 kV, DC 400 kV, Impulse 1,200 kV
- Different waveforms including lightning & switching impulses, power frequency, etc.
- Wide range of rotating machine stator bar tests include voltage endurance testing & thermal cycling
- Wide range of cable test including accelerated aging & thermal cycling

THERMAL CYCLING TESTS

The thermal cycling test is intended to simulate the thermal-mechanical ageing that the stator insulation system can experience due to severe cyclical duty.

The coils are heated by passing high currents through to cause a temperature increase over a certain time period (e.g. 40 oC to 155 oC). The current will be removed and the test objects will be brought to initial temperature using a controlled cooling fan; then the cycle is repeated (e.g. 500 times). Thermocouples will be placed on coils under test to monitor temperature.

Diagnostic tests such as partial discharge, dissipation factor and tip-up are carried out prior to this test and at several number of cycles in order to monitor and assess the degradation of the insulation during thermal cycling test. Thermal cycling test can be followed by a voltage endurance test on the same coils.

DIAGNOSTIC TESTS

- Visual inspection of coils to check for any defects, impressions or damages
- Tap test to check for any delaminations
- Surface partial discharge test (lights-out test
- Surface resistivity measurement
- Insulation resistance and polarization index test as per IEEE 43-2000
- Dissipation factor and tip-up test
- Partial discharge test

TURN-TO-TURN INSULATION TESTS

An impulse test can be performed per IEEE 522-2004 to evaluate turn-to-turn insulation in multi-turn coils.

AC BREAKDOWN TESTS

Doble can perform insulation breakdown tests on stator coils and bars. The failure site can be dissected.

COIL DISSECTIONS

Dissection locations are chosen by an experienced generator insulation specialist to discover the weakest insulation spots. If a coil fails voltage endurance testing, a dissection is required at the failure location. A Doble specialist will determine the cause of failure based on knowledge and experience of the generator insulation system.

Microscopic examination on dissected samples can be conducted to check any manufacturing quality issues.

About Doble Power Services

Doble has been a trusted name in electric power diagnostic solutions for over 90 years. Doble's unique business proposition combines three elements—diagnostic test instruments, expert consulting and testing services, and the world's largest resource library of related knowledge—into complete diagnostic solutions. Doble Power Services leverages the resources of Doble's extensive library and experienced team of engineers to deliver the highest level of consulting services and knowledge-based solutions.

Why Doble Power Services?

Extensive Global Experience

Doble has more than 40 consulting engineers each with extensive experience in power systems engineering applications.

Independent Expert Opinion

Trust Doble's expert consulting & testing services for unbiased diagnosis and assessment of critical assets.

Doble Peer Review Process

When you hire Doble, you are hiring the shared experience of our entire engineering team. Each Doble field service report is reviewed by at least one other consulting engineer.

Doble KnowledgeBase

Provides valuable benchmark data for use in evaluating test results on your equipment.

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KNOWLEDGE

GET EMPOWERED WITH THE DOBLE KNOWLEDGE COMMUNITY

Doble community engagement is all-embracing. We're your professional development partner. Whether you're an experienced power professional, or just starting out, we're here to support you through our conferences, technical publications, and active role in industry research and standards. It's a role we've cherished since the days of our founder, Frank Doble. The Doble Knowledge Community is your community. And Doble is committed to the development of this community by listening to you, working with you, and growing with the needs of our changing industry.

EDUCATION

Doble supports educational initiatives that train the current and future workforce and is committed to advancing the science used in electric power industry testing. Doble invests in scholarship programs, professional education courses accredited by IACET, and university grants for research and development at leading academic institutes, creating centers of technology excellence.

KNOWLEDGE

Knowledge is part of Doble's DNA. Whether it is the knowledge of the Doble team, renowned experts in their field, or the actual data in our Knowledgebase, this knowledge fuels everything we do. With over 44 million data points sourced from electrical apparatus, the Doble Knowledgebase contains over 70 years of historical and comparative data. This unmatched resource, combined with the expertise of the Doble team, powers the solutions, services, and knowledge we provide you as members of the Doble community.

EVENTS

Doble has been hosting acclaimed educational events for over eight decades. These industry-leading conferences, technical seminars, and user group meetings bring together expertise across the power industry. At client-only conferences as well as open training programs, you and your industry peers can exchange best practices, get hands-on experience, and benefit from the collective knowledge of this learning community.

Client conferences and field seminars take place regionally, across the globe, and culminate in the annual International Conference of Doble Clients where attendees help define the future of the power industry. Additional training events focus on specific assets or testing practices, including transformers, circuit breakers, rotating machinery, and laboratory diagnostics.

THE DOBLE KNOWLEDGE COMMUNITY IS YOUR COMMUNITY

& SOLUTIONS, SERVICES, KNOWLEDGE COMMUNITY

SOLUTIONS AND SERVICES YOU NEED. AND A COMMUNITY THAT ENHANCES THEM.

Wherever you are in the power industry, at any given place in your asset ownership cycle, through all your testing practices, Doble is with you, through solutions, services and our knowledge community.

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