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Submission ID: **1272883848**

**ANALISIS PARTIAL DISCHARGE
DAN PREDIKSI USIA LAYAK ISOLASI BELITAN STATOR
GENERATOR 143,4 MVA**

LAPORAN TUGAS AKHIR

LAPORAN INI DISUSUN UNTUK MEMENUHI SALAH SATU SYARAT
MEMPEROLEH GELAR S1 PADA PRODI TEKNIK ELEKTRO FAKULTAS
TEKNOLOGI INDUSTRI UNIVERSITAS ISLAM SULTAN AGUNG SEMARANG



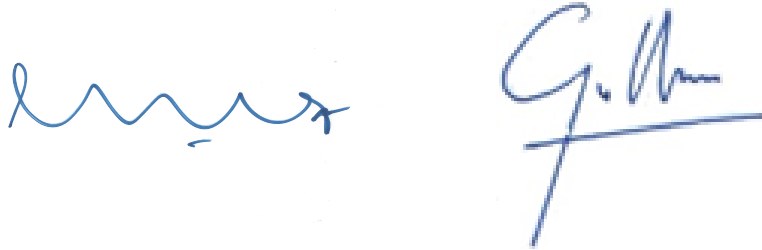
DISUSUN OLEH :

**KUKUH WIDODO
NIM 30601700064**

**PROGRAM STUDI TEKNIK ELEKTRO
FAKULTAS TEKNOLOGI INDUSTRI
UNIVERSITAS ISLAM SULTAN AGUNG
SEMARANG
2020**

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✓ APPROVED



ANALISIS PARTIAL DISCHARGE DAN PREDIKSI USIA LAYAK ISOLASI BELITAN STATOR GENERATOR 143,4 MVA PLTG TAMBAK LOROK

by Kukuh Widodo

Submission date: 10-Mar-2020 05:23PM (UTC+0800)

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ANALISIS PARTIAL DISCHARGE DAN PREDIKSI USIA LAYAK ISOLASI BELITAN STATOR GENERATOR 143,4 MVA PLTG TAMBAK LOROK

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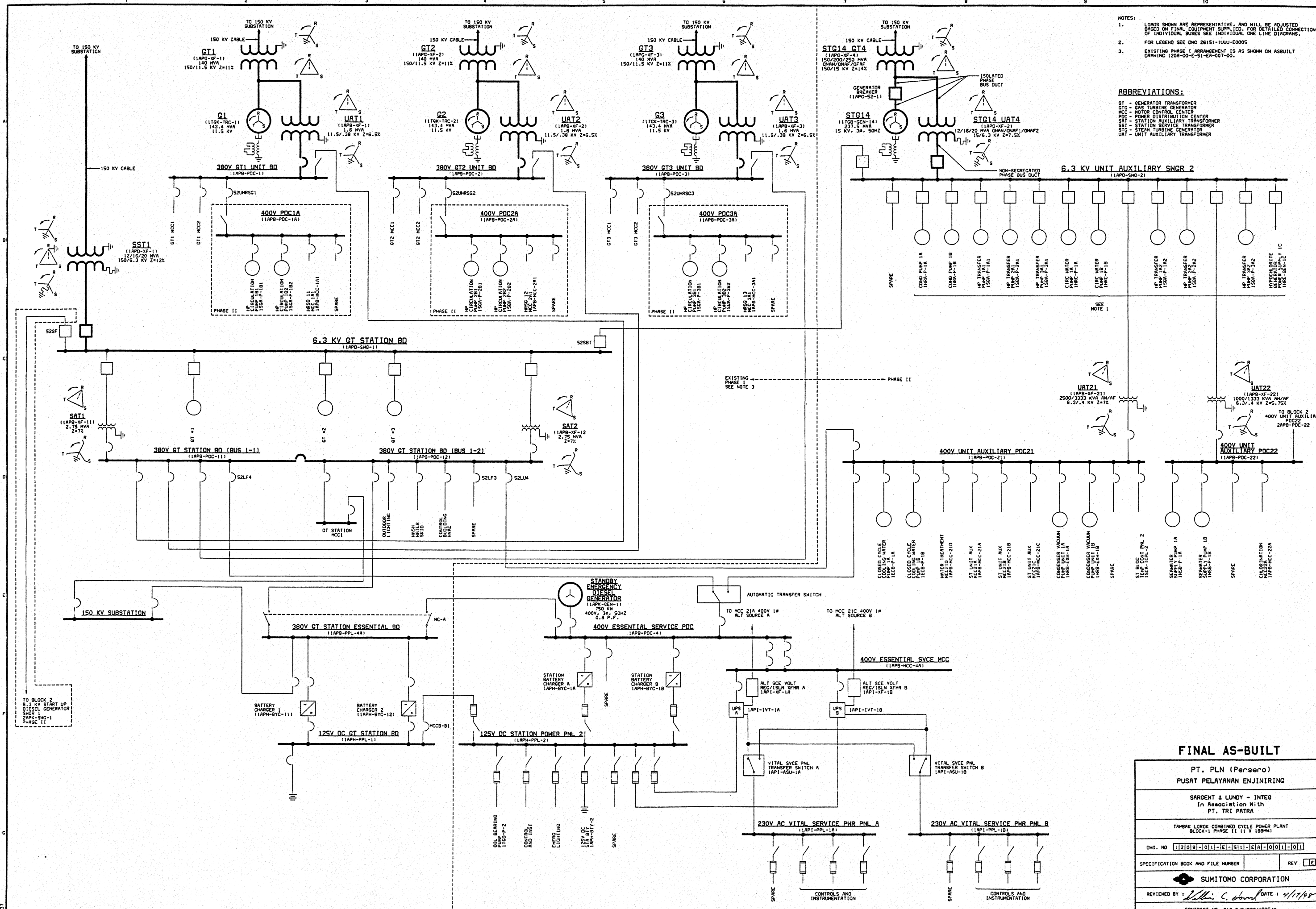
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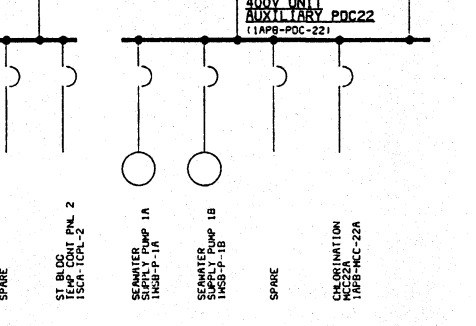
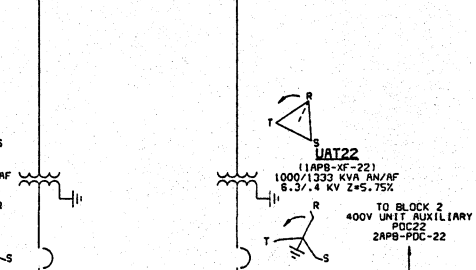
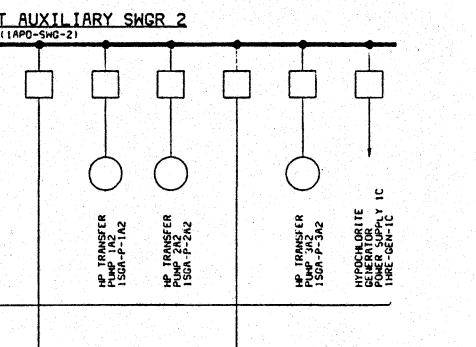
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- NOTES:
- LOADS SHOWN ARE REPRESENTATIVE, AND WILL BE ADJUSTED BASED ON FINAL EQUIPMENT SUPPLIED. FOR DETAILED CONNECTIONS OF INDIVIDUAL BUSES SEE INDIVIDUAL ONE-LINE DIAGRAMS.
 - FOR LEGEND SEE DWG 26151-1000-0005
 - EXISTING PHASE I ARRANGEMENT IS AS SHOWN ON ASBUILT DRAWING 1208-00-E-51-EA-007-00.

- ABBREVIATIONS:
- GT - GAS TURBINE GENERATOR
 - GTO - GAS TURBINE GENERATOR
 - MCC - MOTOR CONTROL CENTER
 - PDC - POWER DISTRIBUTION CENTER
 - SAT - STATION AUXILIARY TRANSFORMER
 - SST - STATION SERVICE TRANSFORMER
 - STG - STEAM TURBINE GENERATOR
 - UAT - UNIT AUXILIARY TRANSFORMER



FINAL AS-BUILT

PT. PLN (Penero)
PUSAT PELAYANAN ENJINIRING

SARGENT & LUNDY - INTEG
In Association With
PT. TRI PATRA

TAMBAK LOROK COMBINED CYCLE POWER PLANT
BLOCK-1 PHASE II (11 X 188MW)

DWG. NO. 112018-011-E-511-EA-1001-011

SPECIFICATION BOOK AND FILE NUMBER: _____ REV: E

SUMITOMO CORPORATION

REVIEWED BY: *William C. ...* DATE: 4/17/98

CONTRACT NO. 012.PJP/922/1995/M

219700115 ACAD 12.c4
04/17/98 01:43:17

NO.	DATE	REVISIONS AND RECORD OF ISSUE	BY	CHECKED
1	17DEC97	CONFORMED TO CONSTRUCTION RECORDS	EP40CBHCH	
2	25APR98	ISSUED TO CONTRACTOR/REVISED FOR PLN APPROVAL	RD.M.JBRLS	
3	14DEC95	ISSUED TO CONTRACTOR/REVISED FOR PLN APPROVAL	RD.M.JBRLS	
4	27JUL95	ISSUED FOR PLN APPROVAL	HJB.RD.DCB	
5	17APR98	FINAL AS-BUILT	EP40CBHCH	

BLACK & VEATCH INTERNATIONAL

TAMBAK LOROK COMBINED CYCLE PLANT
BLOCK 1 PHASE II

PROJECT: 26151-1APU-E1001

DWG. NO.: 112018-011-E-511-EA-1001-011

ONE-LINE DIAGRAM
OVERALL

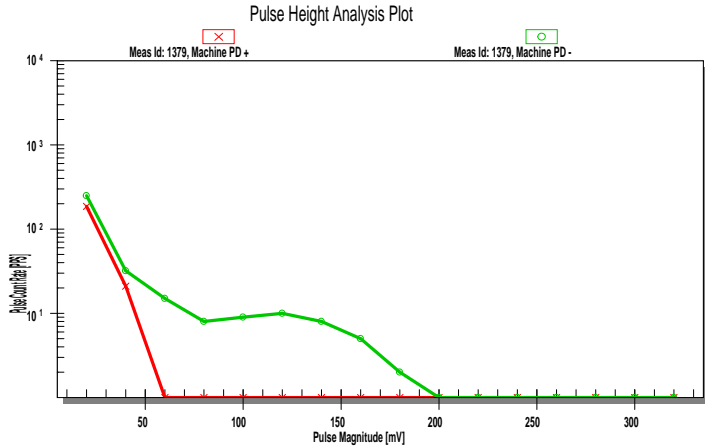
DATE: 4/17/98

Pulse Height Analysis

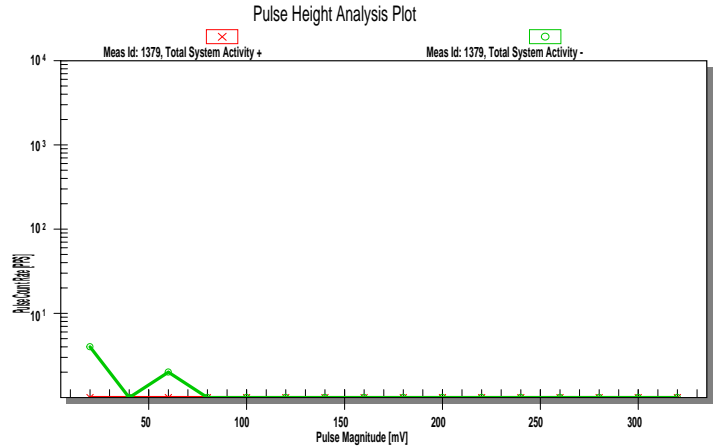
Asset Name: MACHINE

Folder: PLTGU Blok IGTG 1.1, Asset Class: Gas Turbine
 Class: Directional BUS (TGA), Sensor Type: Epoxy Mica Capacitor (80pF)

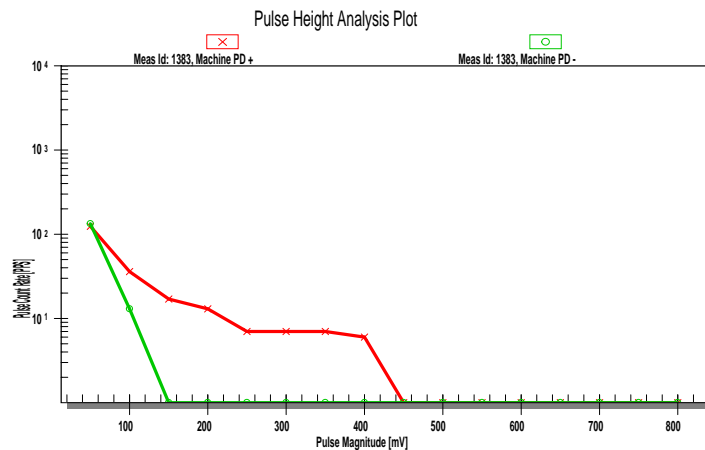
Operating Load: 75.00 MW, Reactive Load: 2.10 MVar, Operating Asset Temp: 94 deg C, Operating Voltage: 10.71 kV
 Ambient Temp: 34 deg C, Ambient Humidity: 53.00 % Freq. (Test Duration): 50 Hz, (5 sec.)
 Insulation Type: Epoxy Mica Operating Gas Pressure: 28.00 psi-g Gas Pressure Rating: 30.00 psi-g



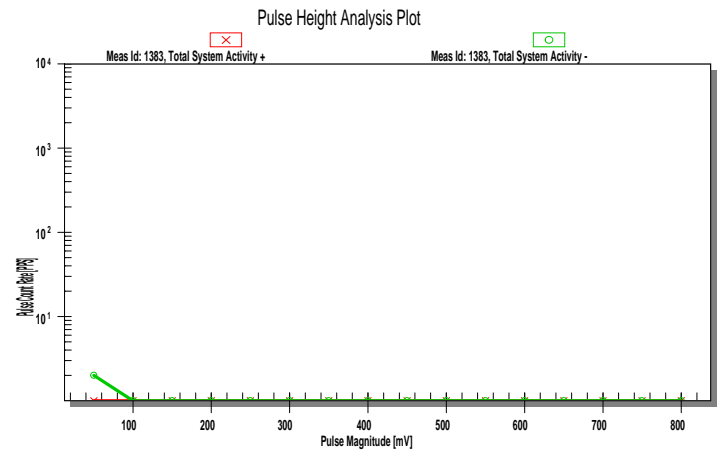
Phase: A, Sensor(s): R-MIR-S1 Delay Time: 7
 Machine: NQN+ 72, NQN- 202, Qm+ 51, Qm- 122 K-scale: 1.00



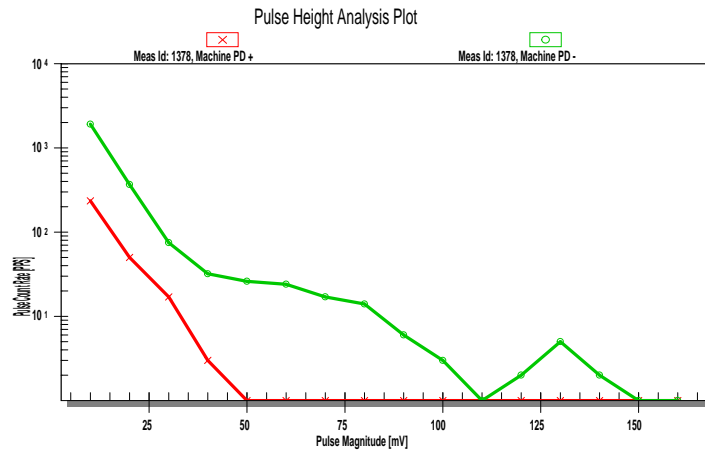
Start Time: 10/16/2018 10:17:29, Status: Good
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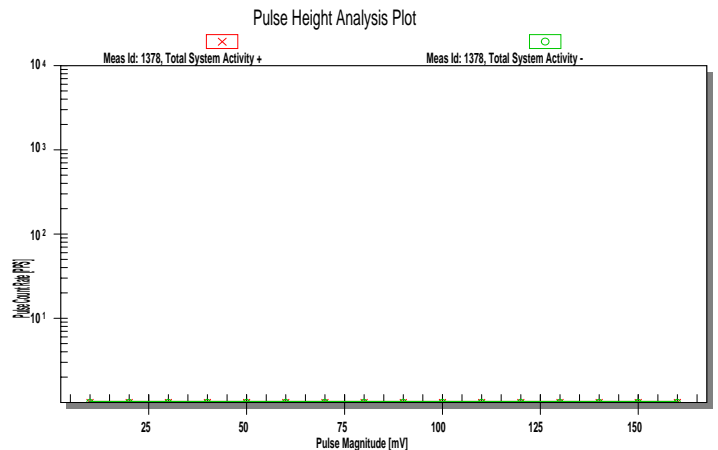
Phase: B, Sensor(s): S-M2S-S2 Delay Time: 12
 Machine: NQN+ 480, NQN- 176, Qm+ 228, Qm- 115 K-scale: 1.00



Start Time: 10/16/2018 10:25:29, Status: Good
 Activity: NQN+ N/A, NQN- 22, Qm+ N/A, Qm- N/A



Phase: C, Sensor(s): T-M3T-S3 Delay Time: 18
 Machine: NQN+ 59, NQN- 175, Qm+ 35, Qm- 85 K-scale: 1.00



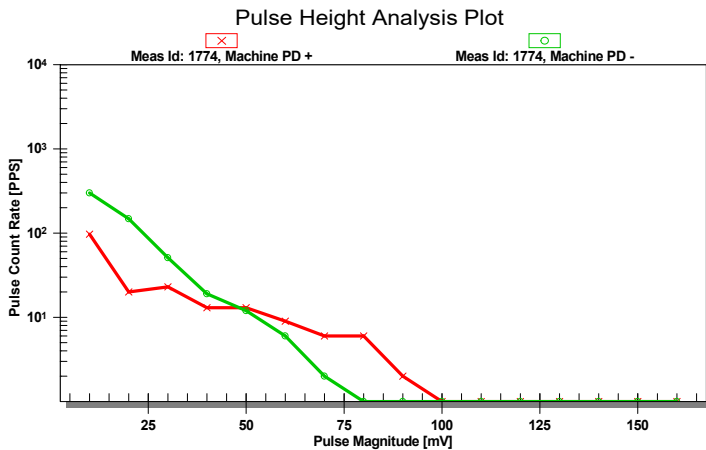
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 Activity: NQN+ N/A, NQN- 1, Qm+ N/A, Qm- N/A

Pulse Height Analysis

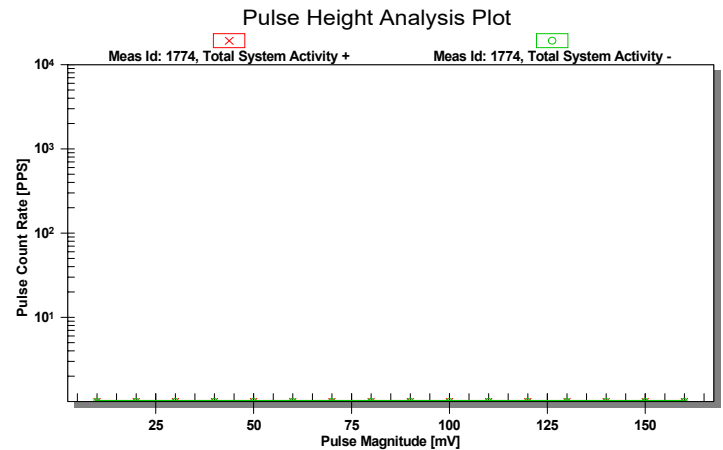
Asset Name: MACHINE

Folder: PLTGU Blok I\GTG 1.1\, Asset Class: Gas Turbine
 Class: Directional BUS (TGA), Sensor Type: Epoxy Mica Capacitor (80pF)

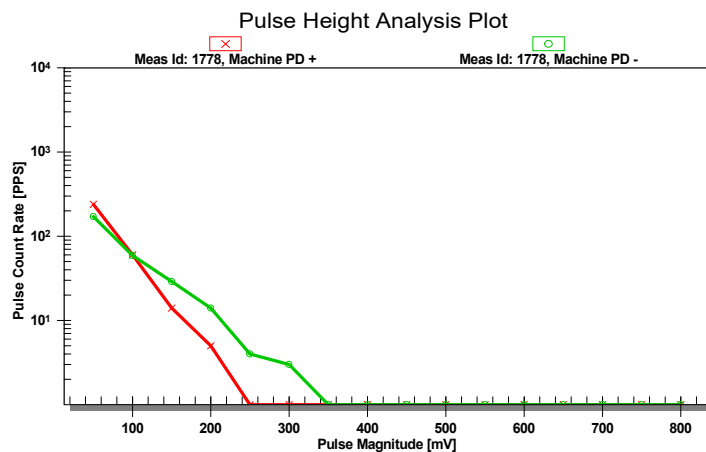
Operating Load: 69.60 MW, Reactive Load: 20.80 MVAR, Operating Asset Temp: 65 deg C, Operating Voltage: 11.11 kV
 Ambient Temp: 35 deg C, Ambient Humidity: 49.00 % Freq. (Test Duration): 50 Hz, (5 sec.)
 Insulation Type: Epoxy Mica Operating Gas Pressure: 30.50 psi-g Gas Pressure Rating: 30.00 psi-g



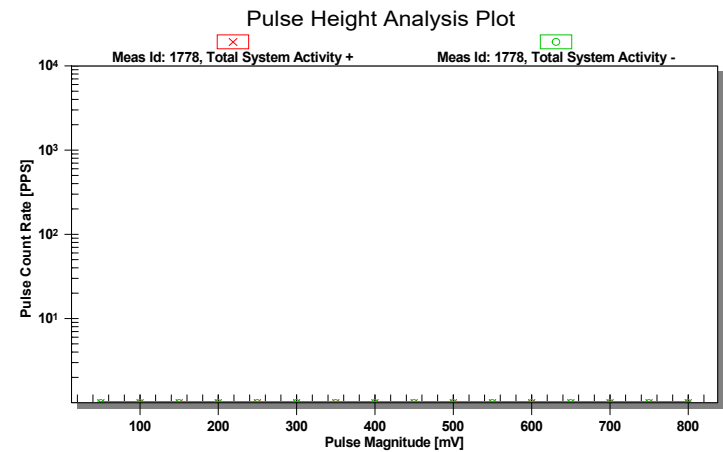
Phase: A, Sensor(s): R-M1R-S1 Delay Time: 7
 Machine: NQN+ 98, NQN- 101, Qm+ 57, Qm- 53 K-scale: 1.00



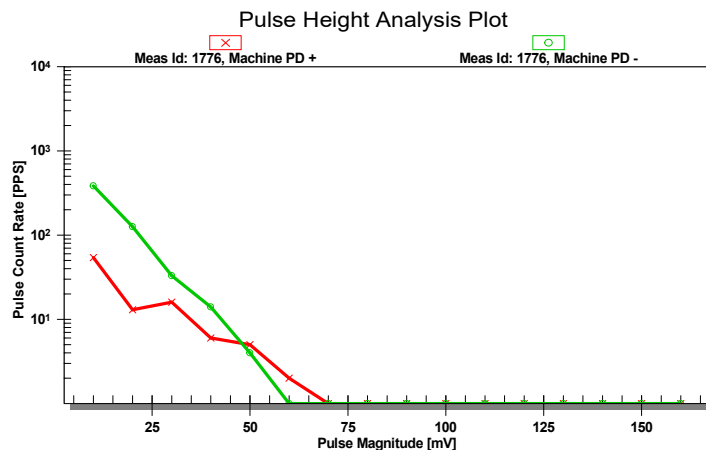
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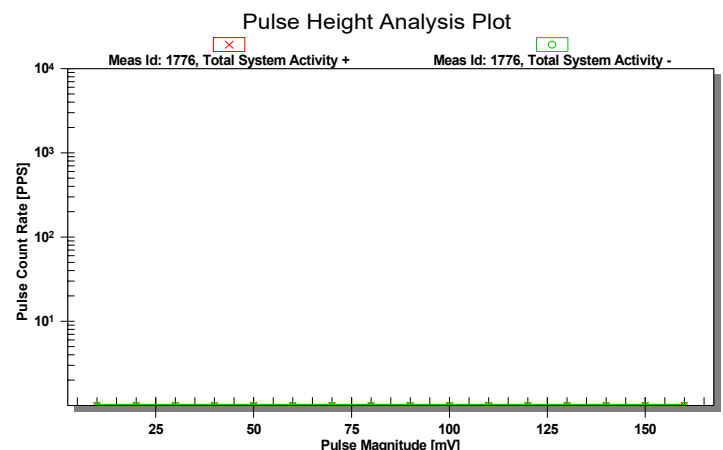
Phase: B, Sensor(s): S-M2S-S2 Delay Time: 12
 Machine: NQN+ 304, NQN- 394, Qm+ 176, Qm- 220 K-scale: 1.00



Start Time: 08/30/2019 10:06:17, Status: Good
 Activity: NQN+ N/A, NQN- N/A, Qm+ N/A, Qm- N/A



Phase: C, Sensor(s): T-M3T-S3 Delay Time: 18
 Machine: NQN+ 62, NQN- 81, Qm+ 36, Qm- 44 K-scale: 1.00



Start Time: 08/30/2019 10:02:25, Status: OVR,POVRL
 Activity: NQN+ N/A, NQN- N/A, Qm+ N/A, Qm- N/A

Pulse Phase Analysis (PRPD, rotation:ABC)

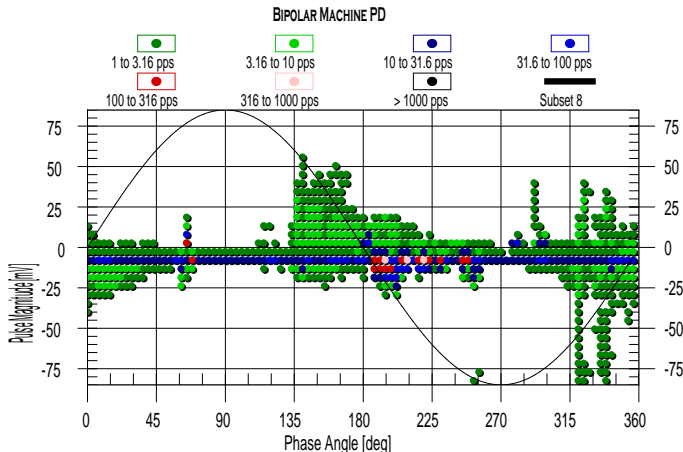
Asset Name: MACHINE



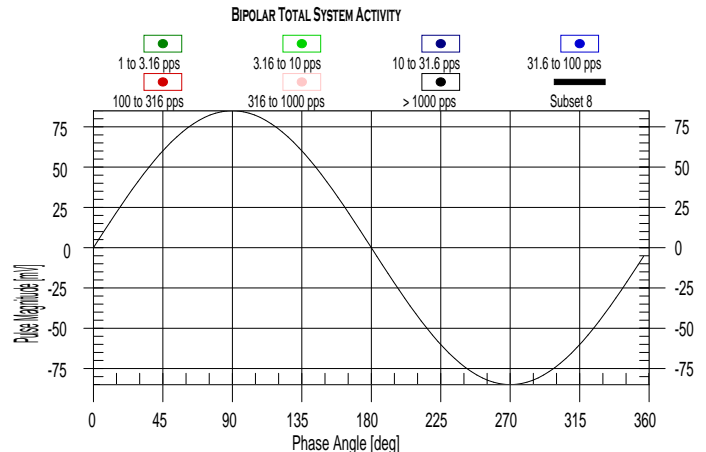
A QUALITROL Company
www.irispower.com

Folder: PLTGU Blok NGTG 1.1, Asset Class: Gas Turbine
Class: Directional BUS (TGA), Sensor Type: Epoxy Mica Capacitor (80pF)

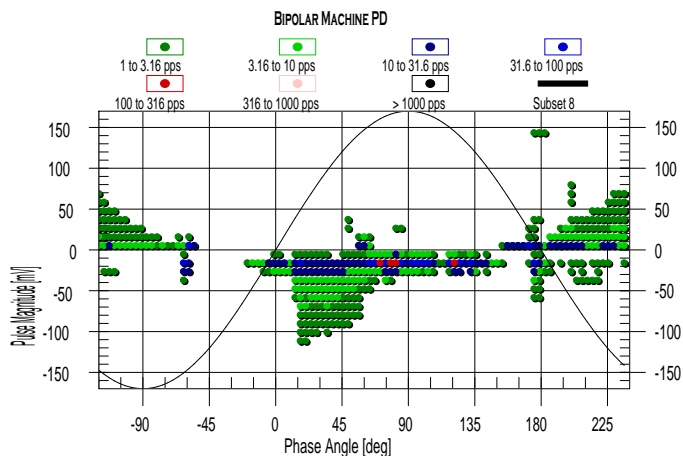
Operating Load: 75.00 MW, Reactive Load: 2.10 MVar, Operating Asset Temp: 94 deg C, Operating Voltage: 10.71 kV
Ambient Temp: 34 deg C, Ambient Humidity: 53.00 % Freq. (Test Duration): 50 Hz, (5 sec.)
Insulation Type: Epoxy Mica Operating Gas Pressure: 28.00 psi-g Gas Pressure Rating: 30.00 psi-g



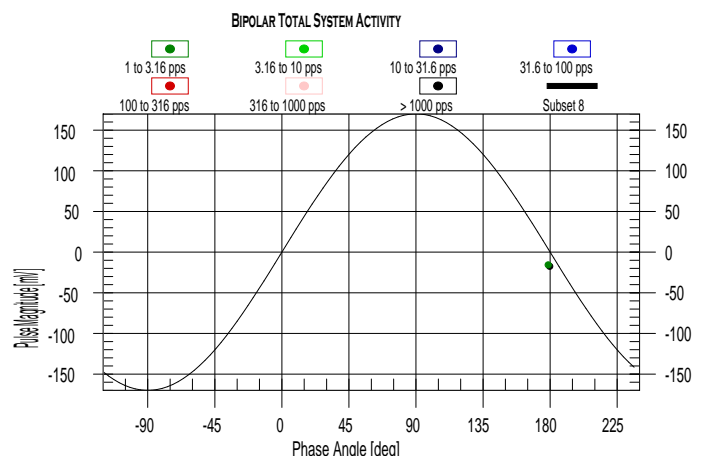
Phase: A, Sensor(s): R-MIR-S1 Delay Time: 7
Machine: NQN+ 87, NQN- N/A, Qm+ 48, Qm- 42 K-scale: 1.00



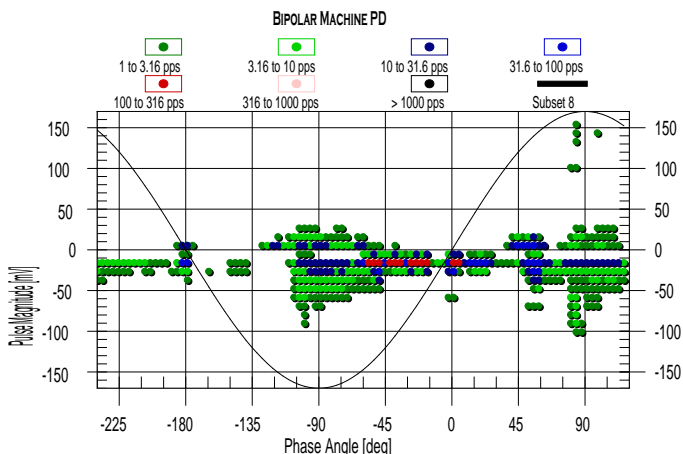
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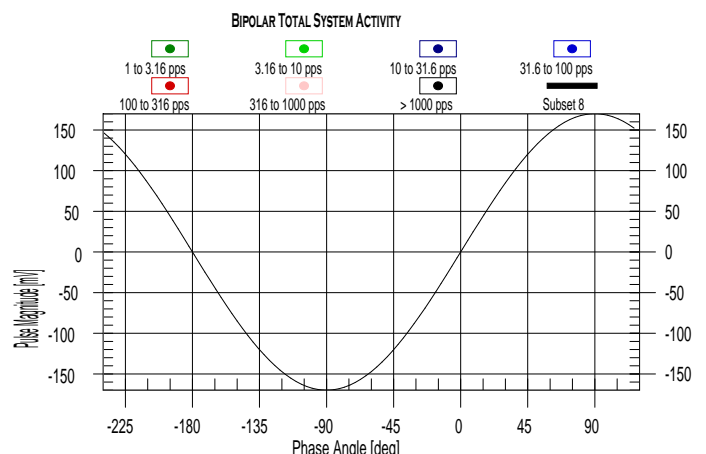
Phase: B, Sensor(s): S-M2S-S2 Delay Time: 12
Machine: NQN+ N/A, NQN- 201, Qm+ 132, Qm- 97 K-scale: 1.00



Start Time: 10/16/2018 10:10:46, Status: OVR
Activity: NQN+ N/A, NQN- N/A, Qm+ N/A, Qm- N/A



Phase: C, Sensor(s): T-MBT-S3 Delay Time: 18
Machine: NQN+ 59, NQN- 175, Qm+ 35, Qm- 85 K-scale: 1.00



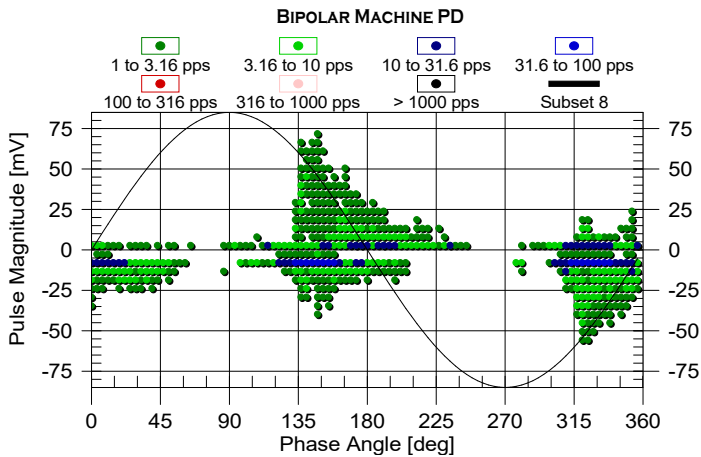
Start Time: 10/16/2018 10:12:40, Status: OVR,POVRL
Activity: NQN+ N/A, NQN- 1, Qm+ N/A, Qm- N/A

Pulse Phase Analysis (PRPD, rotation:ABC)

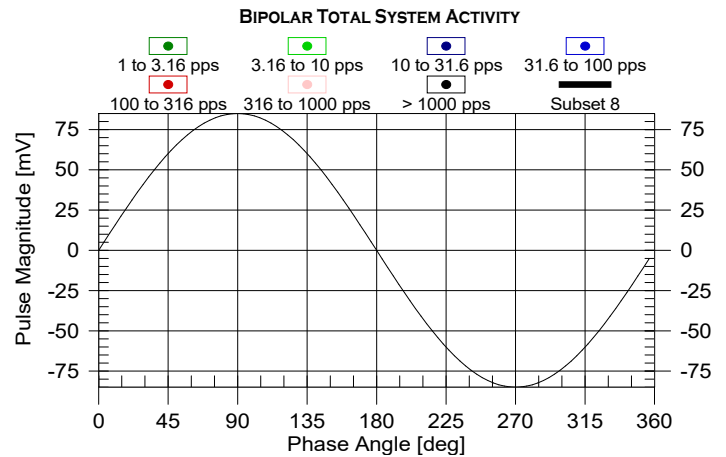
Asset Name: MACHINE

Folder: PLTGU Blok I\GTG 1.1, Asset Class: Gas Turbine
 Class: Directional BUS (TGA), Sensor Type: Epoxy Mica Capacitor (80pF)

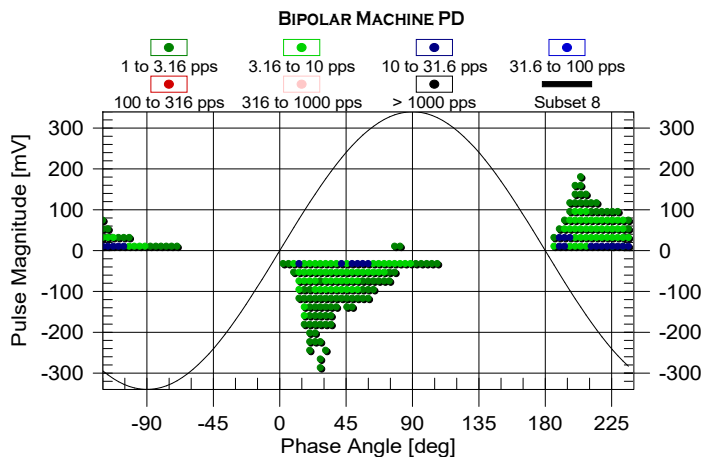
Operating Load: 69.60 MW, Reactive Load: 20.80 MVAR, Operating Asset Temp: 65 deg C, Operating Voltage: 11.11 kV
 Ambient Temp: 35 deg C, Ambient Humidity: 49.00 % Freq. (Test Duration): 50 Hz, (5 sec.)
 Insulation Type: Epoxy Mica Operating Gas Pressure: 30.50 psi-g Gas Pressure Rating: 30.00 psi-g



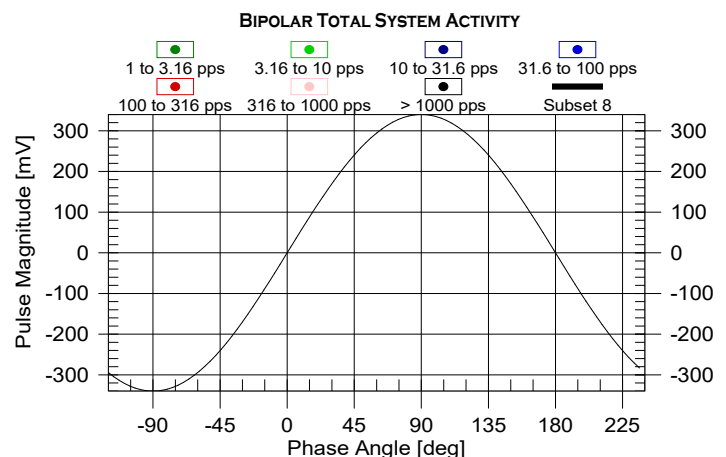
Phase: A, Sensor(s): R-M1R-S1 Delay Time: 7
 Machine: NQN+ N/A, NQN- 83, Qm+ 45, Qm- 41 K-scale: 1.00



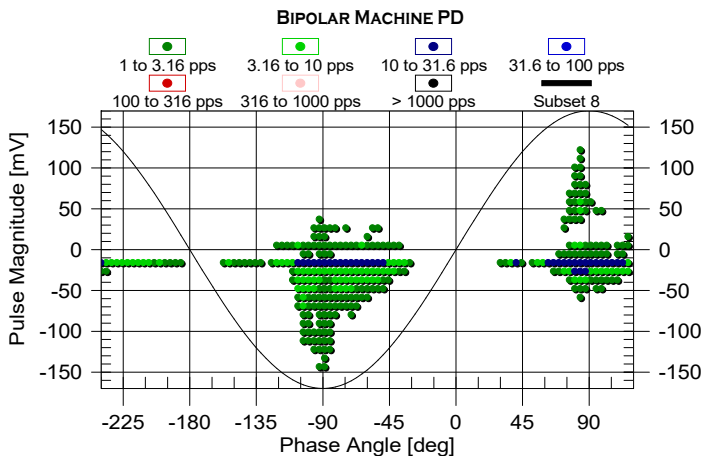
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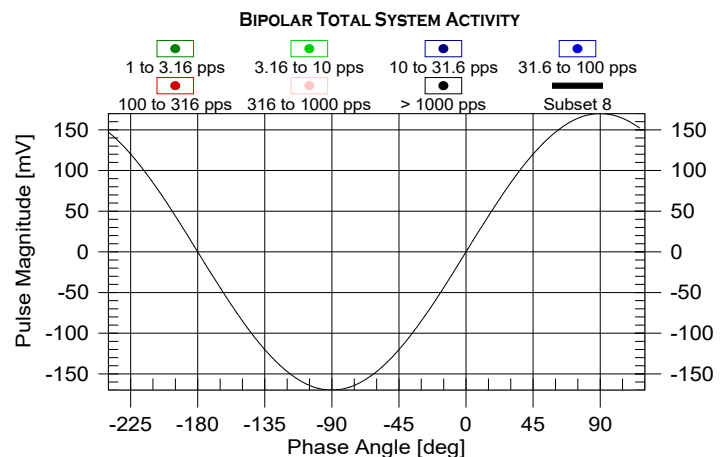
Phase: B, Sensor(s): S-M2S-S2 Delay Time: 12
 Machine: NQN+ 296, NQN- 344, Qm+ 152, Qm- 172 K-scale: 1.00



Start Time: 08/30/2019 09:25:09, Status: OVR
 Activity: NQN+ N/A, NQN- N/A, Qm+ N/A, Qm- N/A



Phase: C, Sensor(s): T-M3T-S3 Delay Time: 18
 Machine: NQN+ 62, NQN- 81, Qm+ 36, Qm- 44 K-scale: 1.00

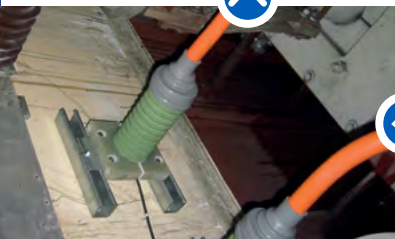


Start Time: 08/30/2019 10:02:25, Status: OVR,POVRL
 Activity: NQN+ N/A, NQN- N/A, Qm+ N/A, Qm- N/A

Development Of Iris Power Partial Discharge Monitoring

The development of Iris Power partial discharge testing instruments in 1990's was funded by the North American utility industry (CEA and EPRI) to provide machine owners a method of detecting stator insulation problems and obtaining adequate data to make maintenance decisions independent of equipment manufacturers.

The TGA-B was designed specifically for monitoring partial discharges under normal electrical, mechanical and thermal machine operating stresses without interference from external noise such as power system corona, output bus arcing or other common electrical disturbances. There are now over 65,000 Iris Power partial discharge Epoxy Mica Capacitive Sensors installed across thousands of motors, generators and metal glad switchgear globally that are monitored by Iris Power portable and continuous instruments.



Sensor Installation and Configuration

Iris Power Epoxy Mica Capacitors (EMCs) are 80pF capacitors that are used to block high voltage output from the generator since impedance is inversely proportional to frequency. The 60 Hz or 50 Hz power frequency is filtered with >30 MΩ impedance while the high frequency partial discharge pulses up to 250 MHz easily pass through the EMC with only 10's Ω impedance. This allows us to see small partial discharge pulses of under 100 mV on rotating machines rated over 3.3kV.

Iris Power typically installs two 80pF epoxy mica capacitive couplers per phase on generators. Noise pulses originating outside the machine arrive at the sensor closer to the power system first. Partial discharge pulses originating in the machine winding arrive at the sensor nearest the machine first. This allows the TGA-B to automatically distinguish between noise and winding partial discharge based on pulse arrival time.

Motors with over 30m of cable the switchgear may require only one epoxy mica capacitor per phase. The TGA-B automatically analyzes the pulse shapes to separate distorted pulses originating from the power system from machine partial discharges.

Epoxy Mica Capacitors Installed On Generator BUS

Epoxy Mica Capacitors (80pF)

Data Collection Method

- The online partial discharge test takes less than 30 minutes per machine with data collected in a simple, safe and non-destructive manner based on sound principles that are recommended by manufacturers and industry standards such as IEEE Std. 1434-2014 and IEC60034-27-2: 2012.
- The operator connects low voltage coaxial cable from the Iris Power TGA-B portable instrument to a coupler termination box. The TGA-B instrument is then connected to a control computer that runs the PDLite Pro and PDView software using a USB or Ethernet cable.
- The test is initiated through the PDLite Pro software which automatically collects the partial discharge data while the machine is running and without any interference to normal operation of the generator.



Termination Box



Control Computer Installed with PDLitePro & PDView

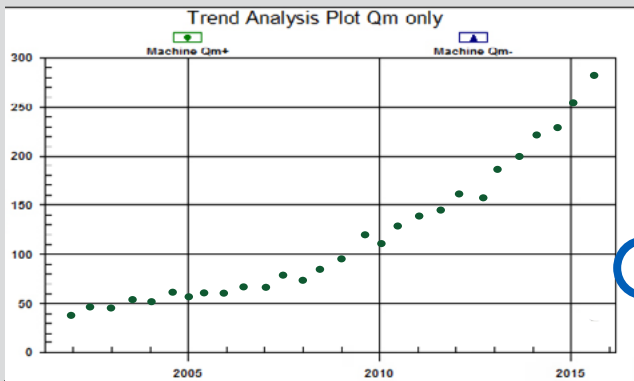


Iris Power TGA-B

Data Analysis and Information Outputs

Iris Power is foremost focused on providing a clear, reliable and repeatable result that allows the user to understand the true condition of the motor or generator and to make educated decisions on operations and maintenance. The TGA-B instrument has been designed to automatically collect partial discharge data and output the relevant information needed to provide a decisive means of:

- Identifying Partial Discharge Severity
- Identifying Probable Causes of Winding Deterioration
- Comparing Relative Health Across Machines



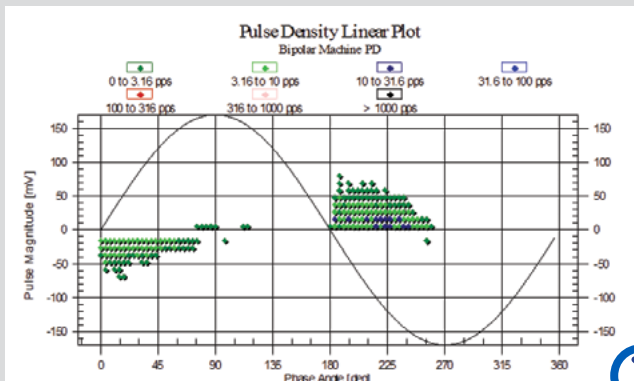
Peak Partial Discharge Magnitude (Qm) Trend Graph Showing Increasing Rate of Partial Discharge Severity

Peak Partial Discharge Magnitude

Peak pulse magnitude (Qm) values are automatically calculated by the TGA-B instrument and output to help understand the relative health of each asset. The Qm value is defined in IEEE 1434 and IEC 60032-27-2 to allow several means of comparison including the following:

Trending of Qm to show any major change in the rate deterioration of the stator winding insulation.

Comparison of generator condition against similar machines using the freely available Iris Partial Discharge Severity Tables which are composed of over 550,000 test results collected across most makes and sizes of machines.

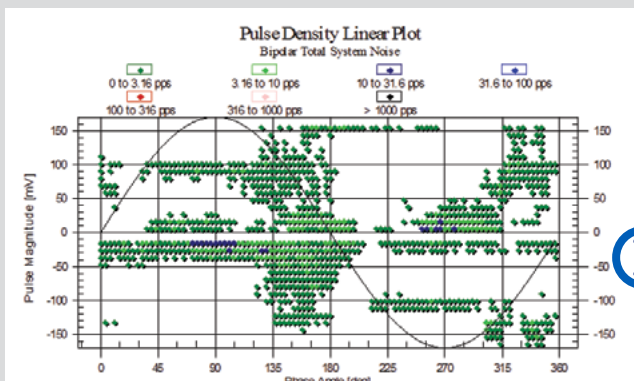


Phase Resolved Partial Discharge Plot showing pulse magnitude (mV) and frequency (pulses per second) by phase angle in the machine

Machine Partial Discharge

Electrical disturbances including partial discharges in the transmission lines (corona) or transformer as well as sparking of overhead cranes or on-site welding can create pulses similar to partial discharges. It is important to be able to understand the difference between power system noise and machine partial discharges to avoid false positive indications, to prevent unnecessary shut-downs and to avoid in-service failures.

The Iris Power TGA-B is designed specifically for Turbine Generators and Motors to ensure machine partial discharges are viewed and analyzed separately from system noises.



Phase Resolved Partial Discharge Plot showing pulse magnitude (mV) and frequency (pulses per second) by phase angle from the system

Separation of System Noise

Installation of two couplers per phase allows the TGA-B instrument to automatically distinguish between power system noise by evaluating pulse shape and the time of arrival of pulses.

Pulses originating outside the generator which arrive to the instrument through sensor closest to the system so can be automatically separated and classified as disturbances.

The pulses that arrive at the machine side sensor are automatically classified as machine partial discharges. Any pulses between the two sensors are automatically classified as pulses on the isolated phase bus.

Product Overview

The Iris Power TGA-B instrument provides the most reliable and accurate portable partial discharge monitoring solution on the market that is designed specifically for motors and generators.

- Advanced noise separation based on pulse shape and time of arrival methods to consistently quantify and isolate partial discharges from system disturbances.
- Test frequency range from 40 MHz to 350MHz while working with 80 pF Epoxy Mica Capacitors (EMCs) and 2 MHz to 350 MHz with 1 - 2 nF capacitive couplers.
- Optional capability for offline partial discharge testing of individual stator bars, coils and windings.
- Ability to operate instrument from 12V battery pack



Partial Discharge Pulse Measurement

Frequency Bandwidth	0.1 MHz - 350 MHz
Phase Windows	100 phase windows per cycle
Pulse Amplitude Range	2 mV - 34,000 mV 10 Sensitivity Range Settings
Data Acquisition Time	5s per magnitude window
Resolution	6ns for EMCs
Ambient Sensors	Ambient Temperature Sensor Ambient Humidity Sensor
Sensor Compatibility	80 pF EMC (6.9kV - 35 kV) - 6 Sensor Inputs

Operating Conditions

Operating Temperature	-15°C to 45°C (5°F to 113°F)
Relative Humidity	Up to 95% non-condensing

Accessories Included

Power Supply Cord	1.8m (6 ft)
Power Supply Adapter	Input: 100–240 VAC, 1.5A, 50–60Hz Output: 12 VDC, 5A
Ethernet Cable	3m (10ft) CAT-5
AC Reference Cable	1.8m (6ft) Shrouded Plug
USB Cable	1.5m (5ft)
Impact Resistant Case	41 cm x 31 cm x 21 cm (WxDxH) 16" x 12" x 8" (WxDxH) 10 kg (22 lbs)

Software & Manual

PDLITEPRO	Included
PDVIEW Standard Edition	Included
PDVIEW Advanced Edition	Optional
User & Installation Manuals	Included

Testing And Certification

Vibration Test	IEC 60068-2-6
Shock Test	IEC 60068-2-27
Transit Vibration	MIL-STD 810G, Method 514
Electrical	CE, UL

Options

Controlling Computer	Details Available On Request
Sensor Compatibility	Stator Slot Coupler (TGA-SB) Hydro EMC Couplers (TGA-BP)
VFD Motor Operation	20 Hz - 120 Hz Reference Circuit Capacitive Divider
Low Frequency Test	Offline Testing 80pF EMC 25kV or 28 kV 50 kHz- 5 MHz

IRIS POWER EPOXY MICA CAPACITORS (80 pF)

Partial Discharge Sensors for Testing Motors and Generators

Iris Power Epoxy Mica Capacitors (EMCs) are designed to detect Partial Discharge (PD) activity in motors, generators and bus without imposing on the machine's operation or reliability in any way.

Iris Power EMCs are permanently installed, with at least one per phase, as close as possible to the stator winding to maximize sensitivity.

Iris Power's 80 pF EMCs are designed to block the 50/60 Hz power frequency and allow only high frequency (>40MHz) signals to pass through, be collected and analyzed by an Iris Power portable instrument or continuous monitor.

Iris Power offers four different Epoxy Mica Couplers to accommodate voltage ratings:

- **6.9 kV**
- **16 kV**
- **25 kV**
- **28 kV**

The EMCs meet all the reliability requirements in IEC TS 60034-27-2 and IEEE 1434 for PD sensors.

MICA SPLITTINGS DIELECTRIC

Iris Power EMCs are safe for use in operating equipment because they have the excellent electrical properties of the mica splitting dielectric. For example, there is an 80 mm (3 inch) layer of epoxy impregnated mica splitting as the main dielectric in the 16 kV version. In comparison, a typical 13.8 kV stator coil has only about 3 mm (0.12 inch) thickness of epoxy mica paper.

VOLTAGE ENDURANCE TESTING

Independent voltage endurance testing (IEEE 1043) proved that the 16 kV Iris Power EMC withstands over 1,000 hours at 30 kVrms. According to statistical methods (IEEE 930-1987), this translates into 60,000 years of use at normal operating voltage. By comparison, the average 13.8 kV stator winding coil is expected to withstand only 400 hours of exposure to 30 kVrms.

The Iris Power EMC's excellent endurance and thermal stability is due to the use of mica splittings, as opposed to mica paper or ceramics.



Over 80,000 Iris Power Epoxy Mica Capacitors are in service around the world, and have accumulated tens-of-thousands of years of reliable operation.



Iris Power EMCs are provided in coupler kits complete with all materials required for installation including the silicone rubber insulating boot.

IRIS POWER EPOXY MICA CAPACITORS (80 pF)

EMC Voltage Rating	6.9 kV	16 kV	25 kV	28 kV
DEV @ 1pC	8.0 kV	18.6 kV	29.0 kV	32.3kV
AC Hipot	15 kVrms	33 kVrms	51 kVrms	57 kVrms
Mass	1.1 kg	1.6 kg	2.0 kg	2.0 kg
Height	95mm (3.75")	127mm (5.0")	206mm (8.1")	206mm (8.1")
Diameter	86mm (3-3/8")	86mm (3-3/8")	86mm (3-3/8")	86mm (3-3/8")

DC AND IMPULSE CAPABILITY (BIL)

Iris Power EMCs have been independently tested to DC Hipot and lightning impulse strengths greater than any other apparatus in its voltage class. For example, the 16 kV EMC have passed over 50kV DC and 90kV BIL required by ANSI C37.20.2.

HAZARDOUS LOCATIONS

The Iris Power EMCs can also be used in hazardous environments with options available for ATEX certified EMCs (II 2 Exe II Tx Gb).

RADIATION ENVIRONMENTS

Iris Power EMC kits with installation material according to IEEE 323-1983 for nuclear power generating stations are available.

OTHER SPECIFICATIONS:

- Voltage endurance tested: >1,000 hours at 30 kVrms for the 16 kV EMC
- Capacitance rating: 80 pF +/- 4 pF
- Dissipation factor: 0.10%
- PDEV Sensitivity: 1 pC (ASTM D1868 and IEC 60270)
- Bandwidth into 50 ohms: (-3dB); 40 MHz to 350 MHz
- Operating temperature range: -50°C to +130°C (-58°F to +266°F)
- Calculated 60,000 year life (IEEE 930- 1987)
- Thermal Cycle Testing to -40°C to +150°C
- Inclined Plane Tracking Test: 300 min (ASTM D2303-85)
- Comparative Tracking Index: 600 min (IEC 60112)
- Lifetime Warranty on Manufacturers Defects (contact for details)



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