MOTOR & GENERATOR HIGH VOLTAGE AC TESTING
A LOOK AT WITHSTAND & DIAGNOSTIC METHODS

PRESENTER

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EVENT

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TOPICS TO BE COVERED

- How Do You Test Your Motors & Generators?
- Testing Motors & Generators With Over-voltage
- AC Vs. DC Voltage. Why AC Is Preferred
- Over-voltage AC Testing – What Do I Need To Know
- What Test Should I Perform Overview? What Products Do I Need For Each?
- Common Methods Used
  - AC Withstand Testing - Over-Voltage Hipoting
  - AC Diagnostic Testing - Tan Delta Measurement & Partial Discharge Detection
- AC High Voltage Sources Available
  - Power Frequency Hipots
  - Series & Parallel Resonant Sets
  - VLF – Very Low Frequency 0.10 Hz AC Technology
- Selecting The Right AC Tester
  - Knowing The Load Charging Current
  - Size, Weight And Cost Constraints
- Photos & Descriptions Of Various Vendors' Instruments
- Conclusion

HIGH VOLTAGE AC TESTING

MOTOR/GENERATOR COILS & OTHER APPARATUS

Off-Line, Elevated Voltage, Withstand & Diagnostic Testing

1. Withstand/Proof/Pass-Fail Hipot Test
2. Tan Delta Insulation Quality Measurements
3. Partial Discharge Detection, Measurement, & Location

Technologies Available and Methods Used

1. 50/60 Hz. AC Dielectric Test Sets
2. Series & Parallel Resonant Sets
3. 0.10 Hz. Very Low Frequency (VLF) Technology

PLEASE TEST RESPONSIBLY

DO YOU OVER-VOLTAGE TEST YOUR COILS? Y/N?

If Yes – Is It To The Maximum Voltage Required?

If No – Why Not: Time, Expense, Risk Of Failure, …?

Motors, Generators, and related apparatus of should benefit from over-voltage testing using AC voltage. A **Withstand** test and/or **Diagnostic** tests should be performed. There is no substitute for these tests to determine the **AC dielectric breakdown integrity of the insulation.**

WE PERFORM MANY TESTS ON NEW OR REWOUND COILS …

… YET, FAIL TO APPLY AN OVERVOLTAGE TEST TO CHECK THE DIELECTRIC INTEGRITY OF THE INSULATION.

INFORMATION TO KNOW TO PERFORM OVER-VOLTAGE TESTS

- Most Commonly Performed or Required Tests
- Technologies Used & Methods of Each
- Test Equipment Needed for Each Test Type

HOW DO YOU TEST YOUR GENERATORS?

ANSWERS TOO OFTEN HEARD…

"WITH DC… *BECAUSE THAT'S THE WAY WE'VE ALWAYS DONE IT."*

or…."OH, WE JUST MEGGER IT."

Two bad answers, *neither derived from sound engineering analyses based on physics and facts*. These methods may be easier, quicker, and less expensive, but they *lack the ability to measure the AC integrity of the insulation* within an acceptable degree of certainty.

DC is fine for *some* testing of *some* apparatus, but *not most* - *not stators.*

WHAT HV TESTING IS COMMONLY DONE?
ANY INDUSTRY STANDARDS TO FOLLOW?

- Many use DC voltage, even for Withstand testing
  - Some use AC voltage, depending on the kVA needed
    - Many perform no over-voltage testing at all

Question: How best to verify the AC dielectric breakdown strength?

Answer: AC overvoltage testing at 2 – 3 times normal.

Standards: Yes, IEEE, ANSI, IEC, and other Standards

NEW OR REPAIRED GENERATOR HAS PASSED ALL LV TESTS. IT'S NOW STRESS TIME!

Your Coils Passed LV Testing – Great, But You're Not Done. Must still verify the dielectric integrity of the design, insulation materials, varnishing process, and assembly workmanship. **It's HIPOT time!**

Perform Elevated Voltage Withstand & Diagnostic Testing

AC or DC Voltage?   How High?   Expected mA Readings?

- **AC Withstand Test?** 60 sec. Pass/Fail, Go/No-Go, Proof Test
- **Diagnostic Tests?** How good is it? Test for IR, Power Factor, Tan Delta, Partial Discharge, Polarization, etc.

OVER-VOLTAGE TESTING MOTORS/GENERATORS

3 QUESTIONS NEED ANSWERS

1. AC or DC VOLTAGE – WHICH?
2. WHAT TESTS SHOULD I PERFORM?
3. WHAT PRODUCTS DO I NEED?

OVERVOLTAGE TESTING MOTORS & GENERATORS

1. AC or DC VOLTAGE – WHICH?

AC ONLY - DC MEANS DON'T CONSIDER DC

DC voltage is not useful for hipoting stator windings and other loads to ground or turn to turn. DC does not replicate the operational stresses when in service. Many external causes of variable leakage current influence numbers. More reasons exist for avoiding DC and are explained in countless papers.

Summarizing the Main Points

AC voltage best replicates the dielectric and magnetic stresses when in service.

AC voltage divides across a coil by the relative capacitive reactance of each turn, stressing each equally. DC does not.

AC is necessary for Diagnostic tests like Tan Delta and Partial Discharge testing.

BUT…ISN'T *DC NON-DESTRUCTIVE* & *AC DESTRUCTIVE?*

IT'S NOT THAT SIMPLE

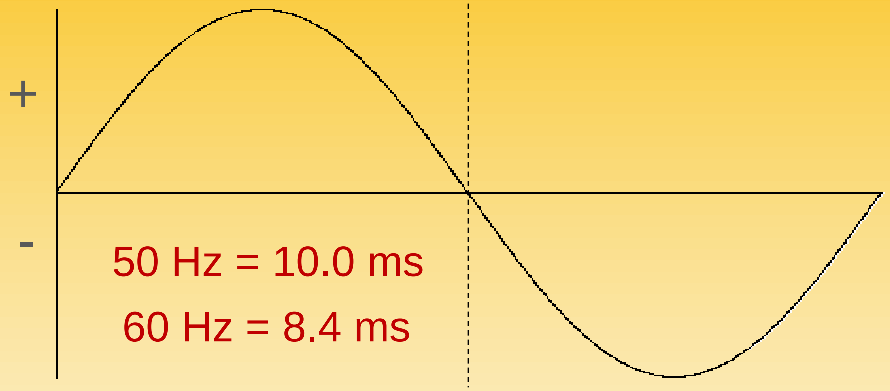
Theoretically, DC does not cause failure during the test, or is non-destructive (if the tester closely watches the current meter for tip-up and turns off the voltage in time)

But, DC does cause material polarization and degradation that hastens future failure; that's destructive. Also, DC leakage currents are often meaningless, always changing and with no established benchmarks. They don't always measure what you think.

AC is destructive *to defects triggered into PD under the test voltage* and stressed till failure – a successful test. Same materials are factory tested at $4U_o – 5U_o$, and $\sim 3U_o$ for field Acceptance. *AC is non-destructive to materials that are healthy or contain only minor defects not affected by test voltage or triggered into partial discharge.*

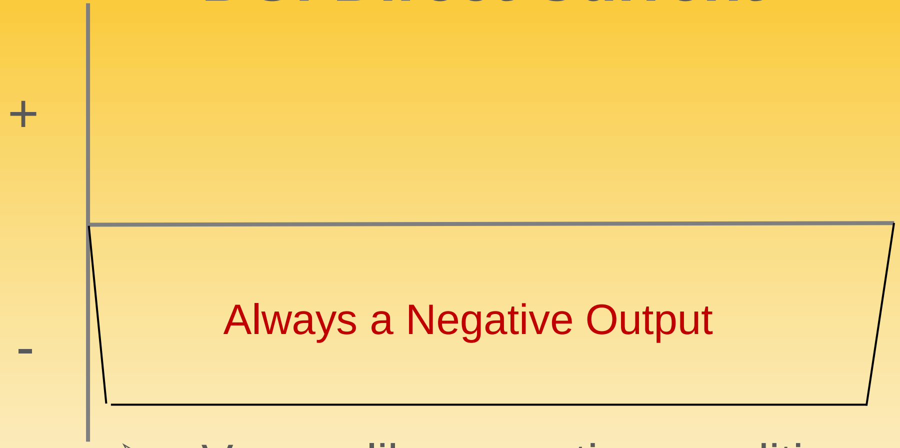
AC or DC VOLTAGE? DIFFERENCES?

AC: Alternating Current



- Identical to operating conditions
- Polarity reversals every half cycle
- No polarization of molecules
- No residual space charges
- Load charges/discharges every 8.4 ms
- Minimal stored energy in the load
- Voltage stress divides more evenly across coils
- AC Sine Wave needed for diagnostics: Tan Delta and Partial Discharge

DC: Direct Current



- Very unlike operating conditions
- No polarity reversals – always negative
- Polarization of molecules – dipole effect
- Residual space charges result
- Stored energy in load likely
- Voltage field stress divides across coils and materials by resistance, not Xc.
- Leakage currents measure surface tracking than inner dielectric properties

OVERVOLTAGE TESTING MOTORS & GENERATORS

2. WHAT TESTS SHOULD I DO? DEPENDS ON JOB & SPEC.

BASIC — **OVERVOLTAGE WITHSTAND.** Typically performed at ≤ 2 Uo, or two times normal operating voltage, for 60 seconds.

BASIC+ — **TAN DELTA.** A diagnostic test that measures the quality of the insulation overall. How deteriorated is the insulation? Absolute and comparative results analyzed.

ADVANCED — **PARTIAL DISCHARGE.** Under variable and elevated voltage, the presence of partial discharges are measured. The **Inception Voltage** and the **Extinction Voltage** are measured along with the severity and location of electrical noise.

OVERVOLTAGE TESTING MOTORS & GENERATORS

3. WHAT PRODUCTS DO I NEED?

Test voltages are known, but what's the current needed? Must know the AC charging current at the voltage level of the tests.

BASIC WITHSTAND: A Hipot is needed with voltage rating ≤ maximum test voltage & current rating reached at maximum test voltage applied.

Example: 4,160 V generator: U = 4,160 V, Uo = 2,400 V.

Typical test voltage = 2U + 1000 x ~0.8 (80% of new) = 7,456 V. (= 3.1 Uo)

Example: 12,500 V generator: U = 13,200 V, Uo = 7,621 V.

Typical test voltage = 2U + 1000 x ~0.8 (80% of new) = 27,400 V. (= 3.1 Uo)

The AC charging current will depend on the capacitance of the load. A hipot current rated for 10 mAac may be good for small motor coils while a current rating of 1 amp may be needed for medium sized generator coils. A very large generator with high capacitance coils may need 5 amps.

OVERVOLTAGE TESTING MOTORS & GENERATORS

3. WHAT PRODUCTS DO I NEED?

BASIC:	**WITHSTAND:** A Hipot is needed with a voltage rating ≥ maximum test voltage & a current rating ≥ the current reached at maximum test voltage.
BASIC+	**TAN DELTA:** TD testing is usually performed up to 2 Uo, or 2x normal L - G voltage. A hipot is needed that reaches this voltage. If only TD testing, and not Withstand testing, then the hipot current rating can decrease to be equal to the coil charging current at the lower TD test voltage. Also, a Tan Delta measurement device is needed to capture and analyze the current into the load.
ADVANCED	**PARTIAL DISCHARGE:** A hipot is needed with the same specs as described for TD testing. PD testing is usually also up to 2Uo in voltage, or 2x normal operating L-G voltage. Also needed is a PD measurement device and possibly an AC Separation Filter to reduce background noises.
SOFTWARE	For TD and PD testing, usually custom software is provided by the vendor of the hardware, used for data logging, waveform analyses, and report generation.

AC ELEVATED VOLTAGE TESTING

THREE COMMON METHODS USING 50/60 Hz or 0.1 Hz

AC WITHSTAND TEST (known as PROOF, GO/NO-GO, PASS/FAIL, STRESS, or PRESSURE TEST.)

Apply the test voltage, usually for 60 seconds. Coil either holds the voltage or arcs and fails.

AC DIAGNOSTIC TESTS **Do not want to fail the insulation – just learn of its quality to estimate life.**

TANGENT DELTA (TD or TAN δ) MEASUREMENT also known as **Dissipation Factor** or **Loss Angle**

POWER FACTOR (PF or COS Θ) MEASUREMENT similar to TD but measuring the complementary angle.

Both TD & PF measure the overall level of insulation degradation.

PARTIAL DISCHARGE (PD) **Measures the location and severity of electric noise**

Variable voltage from 0 - ≤ 2 Uo is applied with PD activity monitored

PD Inception Voltage (PDIV) & PD Extinction Voltage (PDEV) measured.

AC ELEVATED VOLTAGE TESTING

OFF-LINE OVER-VOLTAGE TESTING

AC WITHSTAND TEST ***Apply the voltage - load holds or fails***

Plug in the hipot, connect the HV output to the motor leads and ground/return to station ground, turn on the hipot, turn up the voltage, wait 60 seconds, then turn it off.

This test is the easiest of all to perform and provides complete certainty of results. No current readings to monitor, no stored energy in the load, less pre-test preparation, and it takes only one minute.

For M/G testing, the typical Acceptance test voltage is 2x line-line voltage +1000 volts, or less.

If new motor: Test V. = $2U_o$ + 1k = 6,600 volt x 2 + 1,000 = 14,200 volts.

If aged motor: Test V. = $2U_o$ + 1k x .8 = 6,600 x 2 +1,000 x .8 = 11,360 volts.

AC ELEVATED VOLTAGE TESTING

DIAGNOSTIC METHODS COMMONLY USED

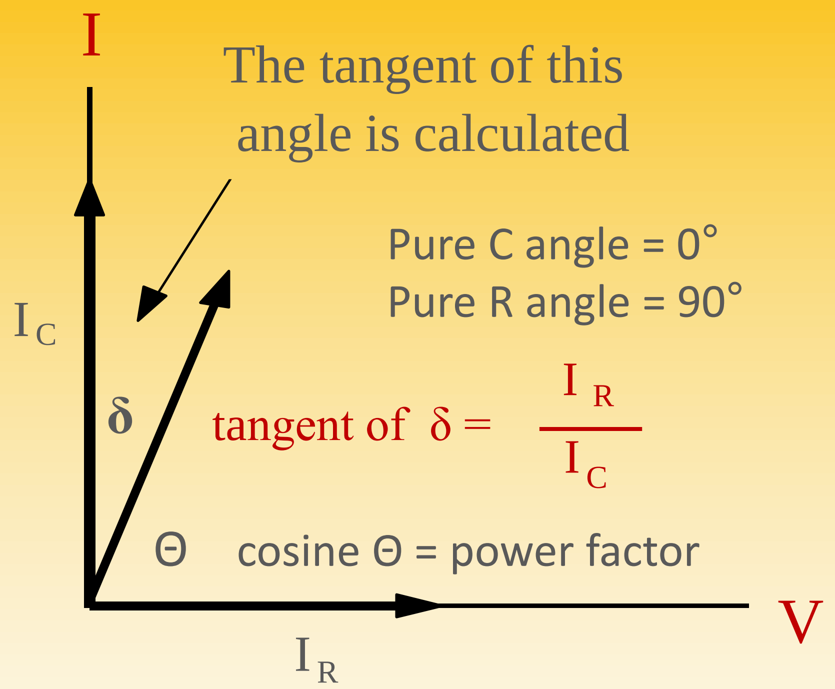
TANGENT DELTA (TD or TAN δ) MEASUREMENT

Also known as DISSIPATION FACTOR or LOSS ANGLE TEST

Over time, all insulation deteriorates due to many factors. A TD test measures the change in dielectric properties from new, perfect insulation to something less as it degrades. Absolute numbers, readings versus increasing voltage, and trends over time are all important factors indicating the level of insulation decay. Very helpful for comparative testing of many cables, coils, etc.

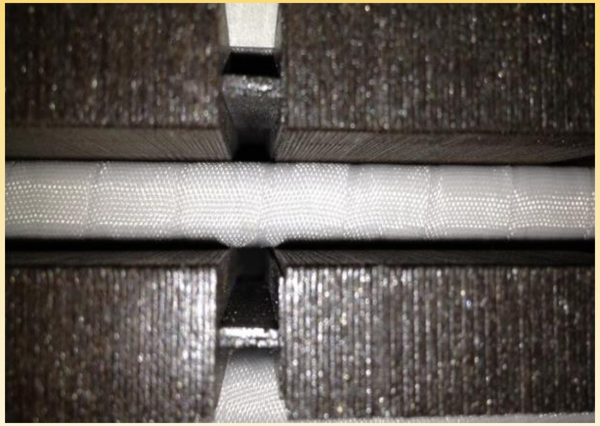
AC ELEVATED VOLTAGE TESTING

TANGENT DELTA TESTING (cont.)



Tan Delta (δ) = $I_R/I_C = 1/(2\pi fCR)$

Stator winding insulation and core



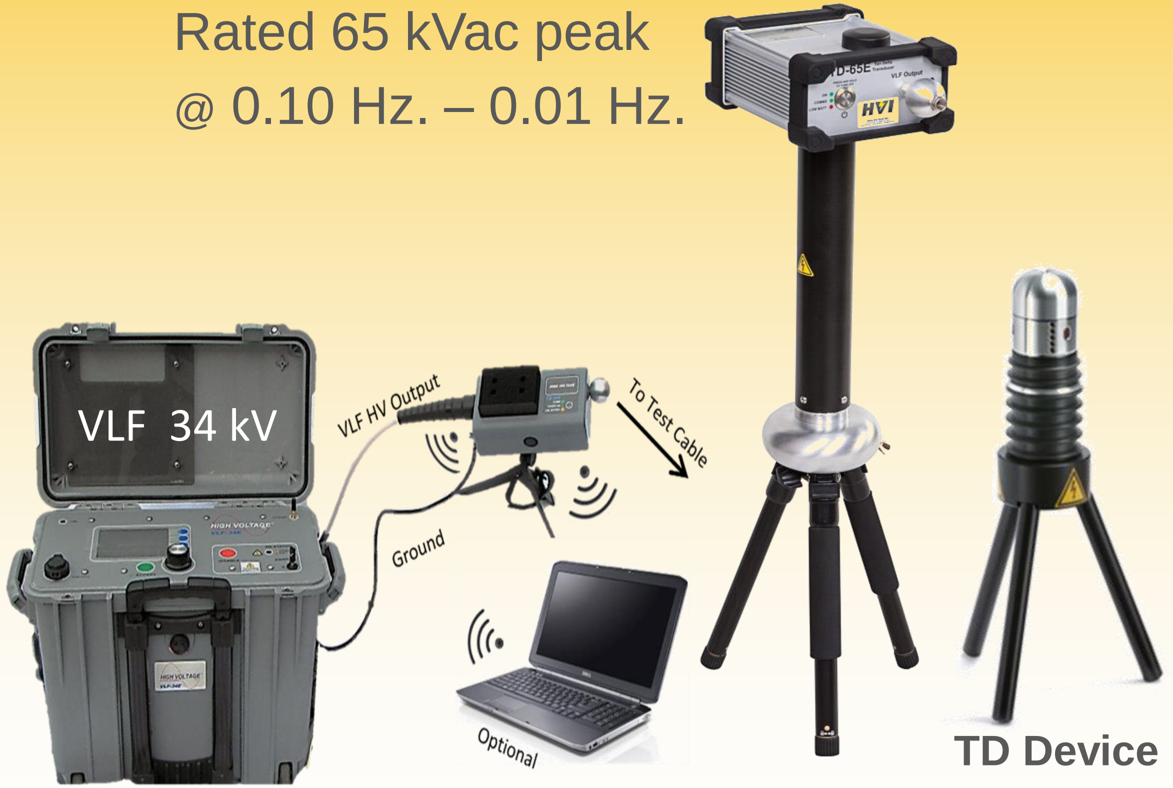
If the insulation is perfect, the Tan δ reading is 0, as the insulated copper stator bar and adjacent grounded core act as a capacitor, with the current I_C 90° phase-shifted from the voltage V, making the angle δ = 0°. The more degraded the material, the less it appears as a perfect capacitor and the greater the angle δ, as a resistive element is introduced to the circuit, no longer pure C.

AC ELEVATED VOLTAGE TESTING

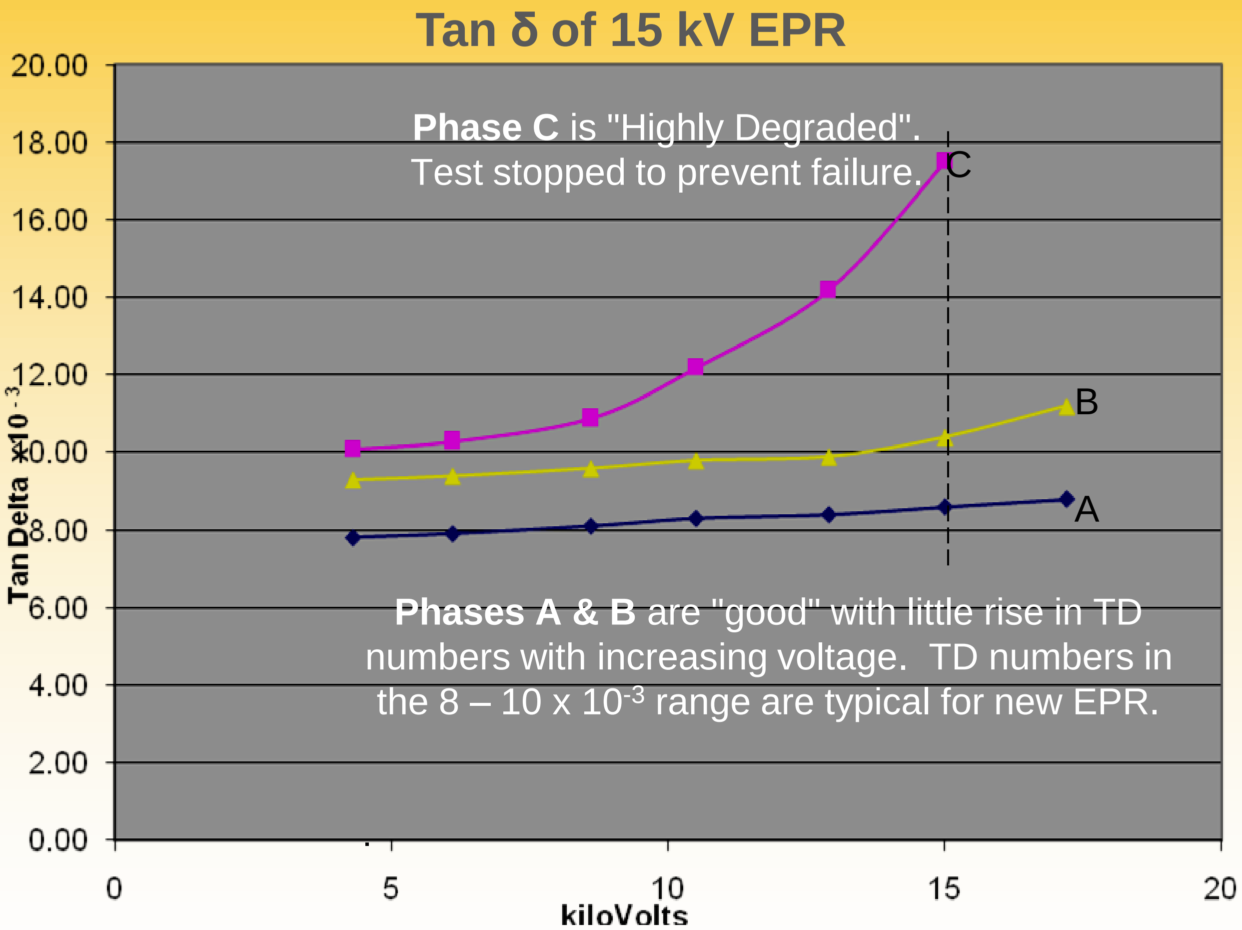
TANGENT DELTA TESTING (cont.)

TD Measurement Device

Rated 65 kVac peak
@ 0.10 Hz. – 0.01 Hz.



TD Device
Rated 34 kVac peak
@ 0.10 Hz. – 0.01 Hz.



AC ELEVATED VOLTAGE TESTING

TANGENT DELTA TESTING (cont.)

Sample TD Graph of Rising Voltage vs. TD Levels

TD Device
Rated 34 kVac peak
@ 0.10 Hz. – 0.01 Hz.

VLF with TD

AC ELEVATED VOLTAGE TESTING

DIAGNOSTIC METHODS COMMONLY USED

PARTIAL DISCHARGE (PD) TESTING

Measures the location and severity of electrical "noise", and the *PD Inception Voltage* (PDIV) & *PD Extinction Voltage* (PDEV)

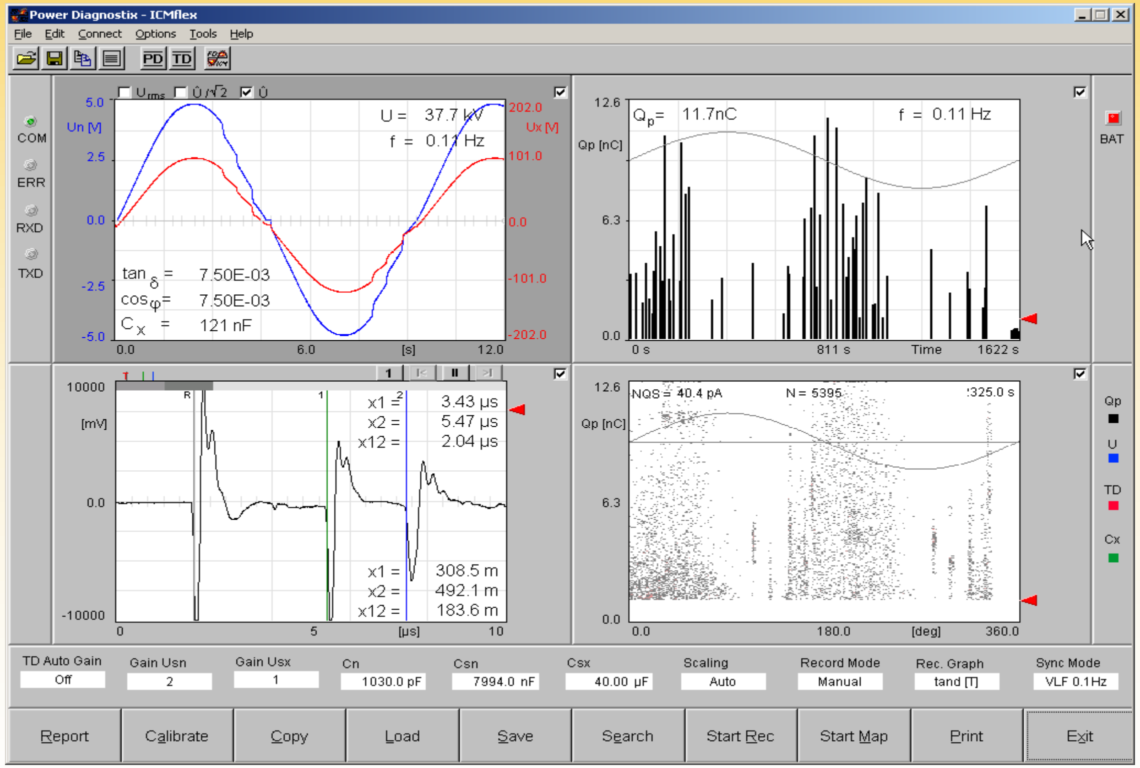
Where Are The Bad Spots And How Bad Are They?

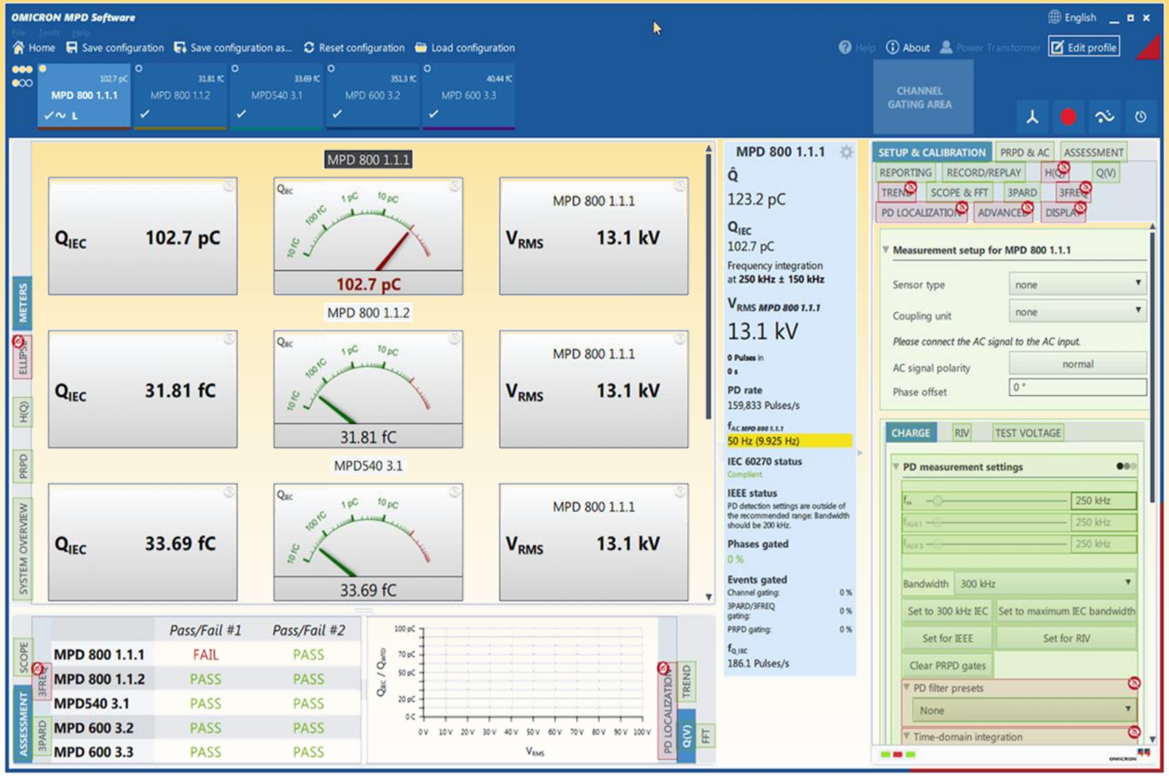
- Where are the PD locations?
- What is the PDIV as the test voltage is raised? Starts?
- What is the PDEV when the voltage is lowered? Stops?
- What are the IV & EV relative to operating voltage?
- How severe is the PD? Very localized or widespread?
- Is the PD location accessible for a repair?
- Is the PD in the insulation or in terminations?

AC ELEVATED VOLTAGE TESTING

PARTIAL DISCHARGE (PD) TESTING

TWO VENDORS PD ANAYSIS SCREENS





AC ELEVATED VOLTAGE TESTING

PARTIAL DISCHARGE TESTING

APPLICATION NOTE – PD SPEC FOR POWER SUPPLY

For testing for Partial Discharge, the output of the power supply must be "quiet," or very low in its own PD generation. The power supply must be designed so that it creates very little electro-magnetic "noise", or PD discharges, that will influence the load pd readings.

For testing power cables, this means < 5 pc. For motors, generators, switchgear, and other apparatus, this could mean 100 pc. The PD level specified makes a huge difference in the design and cost of the system.

If only using the AC set for Withstand voltage testing, PD output doesn't matter. Don't pay much more for it if not needed.

AC HIGH VOLTAGE SOURCES

HOW TO CHOOSE A TEST METHOD & INSTRUMENT?

CHOICE OF TEST SET DESIGN DEPENDS ON:

- Test type (factory certification @ 60 Hz. or field maintenance.)
- Withstand Test only and/or Diagnostics?
- Load Test Current needed (based on load capacitance)
- Input power available to run test.
- Is Partial Discharge free output needed from Hipot for PD testing?
- Portability required? size & weight limits?
- Economic constraints

AC HIGH VOLTAGE SOURCES

TEST METHOD? 3 TECHNOLOGIES COMMONLY USED

- 50/60 Hz Power Frequency Dielectric Test Sets (Hipots)
- Series/Parallel Resonant or Variable Frequency Systems
- Very Low Frequency (VLF) 0.10 Hz. AC Technology

AC HIPOTS

VLF

RESONANT SETS

AC HIGH VOLTAGE SOURCES

HIPOTS - 50/60 Hz. AC DIELECTRIC TEST SETS

A conventional AC hipot designed to operate at 50/60 Hz.

Pros: Operates at power frequency like motors/generators
Testing simulates real-world stresses.
Best option for power needs up to ~ 200 kVA
Sine wave output is needed for TD testing
Low PD output is needed for PD testing

Cons: Requires the highest input power to operate
Heaviest, largest, usually most expensive option

AC HIGH VOLTAGE SOURCES

HIPOTS - 50/60 Hz. AC DIELECTRIC TEST SETS

Power Frequency 50/60 Hz. Input & Output.

Approximate kVA of Model Lines Shown Below. (from HVI)

- **AC Portable Hipots:** .5 kVA – 3 kVA
- **AC Mobile Units:** 5 kVA – 10 kVA
- **AC Dielectric Test Sets:** 5 kVA – 100 kVA
- **Parallel Resonant Systems**: 50 kVA – 500 KVA
- **Very Low Frequency (VLF) AC:** ≤ ~30 µF Load Capacitance

  VLF Hipots Output 0.10 Hz. – 0.01 Hz. Instead of 50/60 Hz.

AC HIGH VOLTAGE SOURCES
SERIES & PARALLEL RESONANT
& VARIABLE FREQUENCY SYSTEMS

A ***Resonant transformer*** system is designed to test very high capacitance loads at high voltages while minimizing the amount of real power pulled from the input line. Compared to a conventional 60 Hz test set, the input power required can be 10 – 30 times less depending on the pf of the load, called the **Q factor.**

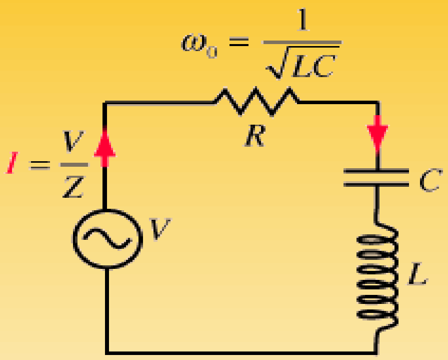
The HV reactor has a variably adjustable air gap in the steel core. The internal *"inductance L"* of the supply is *"tuned"* by adjusting the core's air gap to match the load *"capacitance C".* At resonance, the load appears mostly resistive, requiring little power to apply high voltage.

A ***Variable Frequency*** *tester offers a variable output from ~ 30 Hz. – 500 Hz. To test the coil over a range of frequencies and able to tune to resonance as well.*

SERIES & PARALLEL RESONANT SYSTEMS

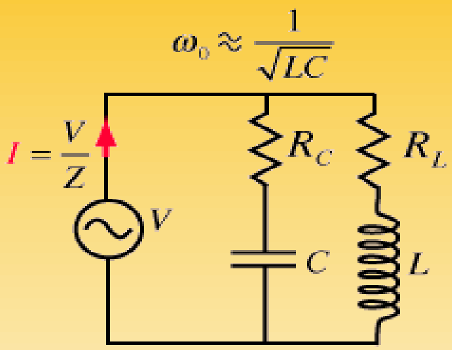
Resonance occurs when $X_c = X_L$

Minimum impedance at resonant frequency



Series Resonance

Maximum impedance at resonant frequency



Parallel Resonance

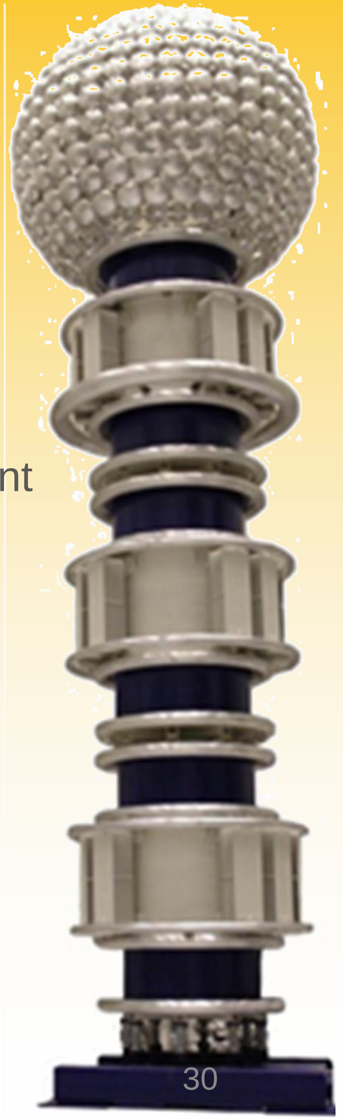
$$F_R = \frac{1}{2\pi\sqrt{LC}}$$

F_R = Resonant Frequency

Parallel Resonant
0 - 32 kVac @
250 kVA

Series Resonant HV Tank
~ 500 kVac @ 500 kVA

Series Resonant
Modular
~ 1200 kVac



AC HIGH VOLTAGE SOURCES

VLF - VERY LOW FREQUENCY 0.1 Hz. AC TECHNOLOGY

A VLF hipot is simply an AC high voltage instrument but with a *frequency output of 0.10 Hz and lower rather than 50/60 Hz.*

Basics Physics: the lower the frequency of the applied voltage, the lower the current and power required to test high capacitance loads like rotating machinery and cables. VLF technology permits the field testing of high uF loads with AC voltage while reducing size, weight, and cost to manageable levels.

The technology was developed to offer an alternative to using DC to test solid dielectric power cables. DC was and is used successfully for testing fluid-filled insulated cables but is not worldly accepted for testing solid dielectric cables and other apparatus. What better method than to use AC, and by dropping the frequency, **portable and affordable products could be produced for field use**.

LOWER FREQUENCY = LOWER POWER

VLF Output Sinusoidal and Meets Waveform Standards

Very Low Frequency: 0.1 Hz and lower. By decreasing the frequency, it is possible to test very large, highly capacitive generators and motors, and to test miles of cable, **with a small, portable, and affordable power supply** compared to a 60 Hz or Resonant system.

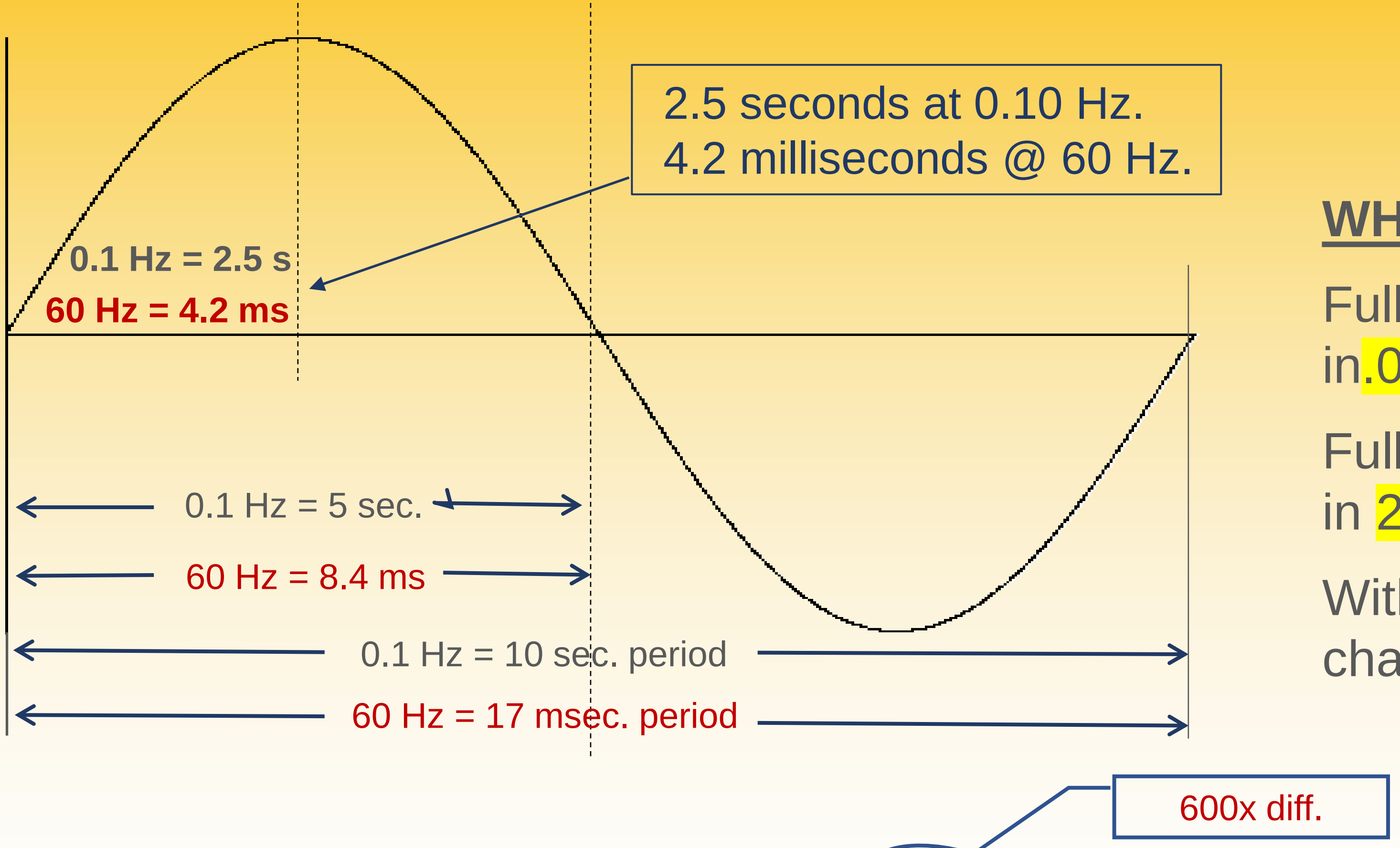
IEEE 433-2009 defines the use of 0.1 Hz for testing rotating machinery. (Original standard published in 1974)

IEEE 400 (1,2,3,4)-2013 is the standard for testing MV & HV cables. In both cases, 0.1 Hz is allowed for use for TD, PF, and PD diagnostic testing.

At 0.1 Hz, ≤ 600 times less power to test a motor or cable than at 60 Hz. For Withstand testing, frequencies from **0.1 Hz – 0.01 Hz** are permitted, offering an even greater advantage.

VLF DIFFERENCE: 0.10 Hz. vs. 60 Hz.

SINE WAVE PERIOD = 10 SECONDS @ 0.10 Hz. & 16.7 ms @ 60 Hz.



WHY VLF IS SO EFFECTIVE

Full voltage at 90° must occur in .0042 seconds at 60 Hz.

Full voltage at 90° must occur in 2.5 seconds @ 0.10 Hz.

With 600x more seconds to charge, less current is needed.

At 0.10 Hz. the time to maximum voltage is 2.5 seconds.

At 60 Hz. the time to maximum voltage is only .0042 seconds.

VLF EXPLAINED – CALCULATING Xc

X_c = Capacitive Reactance (AC Resistance)

$$X_c = \frac{1}{2 \times pi \times \underline{\mathbf{f}} \times C}$$

The lower the frequency, the higher the capacitive reactance, or X_c. The higher X_c, (or resistance across the power supply's voltage output) the lower the current and power needed to apply voltage.

Lower frequency = higher resistance = less current

WHAT A DIFFERENCE THE FREQ. MAKES

VLF 0.10 Hz. vs. 60 Hz. CHARGING CURRENTS

At 60 Hz. a .4 µF coil has an X_c of 6.6 kOhms.

At 28 kV rms *****, it requires 4.3 amps of current to test.

Total power supply rating must be **120 kVA**

At 0.1 Hz, the X_c is 3.98 megohms.

At 28 kV rms x 1.63 for VLF peak,

the current needed is only 12 mA.

Total power supply needed is only .531 kVA

*** 28 kV rms @ 60 Hz (40 kV peak) if a 13.8 kV rms motor.**

Equivalent VLF test = 28 kV rms x 1.63 = 45.6 kV VLF peak.

VARIOUS VENDORS' VLF/TD/PD MODELS

High Voltage, Inc. - NY

Baur - Austria

Megger/Seba Germany

b2HV/Omicron Switzerland

The above VLF models and companies shown are the most widely known in the US.

SELECTING AN AC DIELECTRIC TEST SET

WE KNOW THE TEST VOLTAGE, BUT WHAT'S THE CURRENT?

AC ≠ DC. A small 5 mA DC hipot is adequate to test a coil or cable of high capacitance since the test voltage can be raised slowly to control the charging current. Not so with an AC hipot operating at 60 Hz, that must charge the load every ¼ cycle, from 0 – 90^{o}, in just 4.2 ms. More AC power is needed than DC.

To calculate the AC current needed: ***AC Amps Required = 2πfCV***

C = load capacitance in Farads V = test voltage in Volts

Example: a .2 uF, 6000V coil tested at 13 kVac ($2U_o$ + 1k) will need a 60 Hz. tester rated for the following current and kVA:

A = 2πfCV = 377 x (.2 x 10^{-6}) x 13,000 = .98 amps

Power supply rating = 15 kVac x 1 A for 15 kVA of power.

Cost ~ $ 20,000.00 USD

CALCULATING AC CURRENT DRAW

MUST BE KNOWN TO SIZE HIPOT KVA RATING

AC CURRENT DRAW > DC CURRENT DRAW AT SAME VOLTAGE

AC voltage testing requires far more power than DC voltage testing. When applying AC voltage, the current draw is determined by the capacitance of the load, not the resistance as when DC testing.

$A = \omega CV$. Formula for calculating the AC current when hipoting.

A = AC Amps (Amperes)

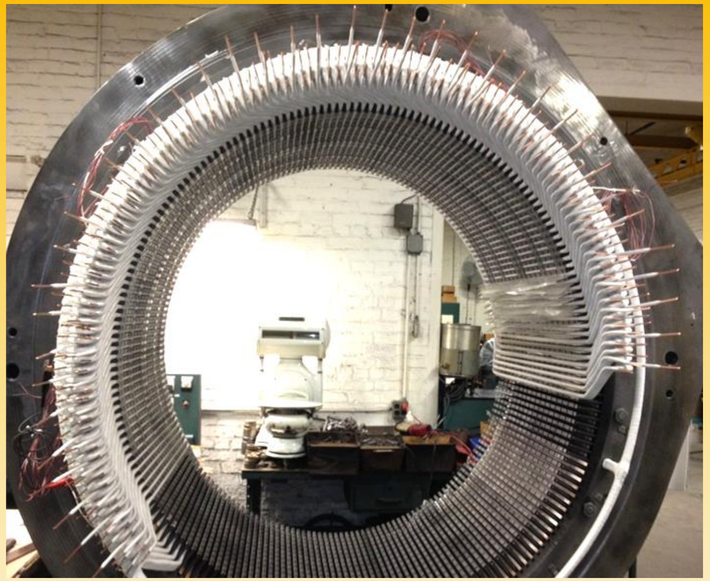
$\omega = 2\pi f$

f = Frequency of Applied Voltage (Hz)

C = Capacitance of Load (Farads)

V = Voltage Applied (Volts)

TEST EXAMPLE & EQUIPMENT SIZING



Stator Winding Test After Repair

4000 V, 400 hp 3 Ph., 60 Hz.

66 coils/ph. x 3 = 198 coils

Test voltage = 9 kVac (4 kV x 2 + 1000V)

Each coil draws ~ 3.3 mA @ 9 kVac, all 3 ph. = 660 mAac

A 10 kVac @ 1 A supply is needed to test three phases at once.

If **AC Hipot** used

10 kVac @ 10 kVA

If **DC Hipot** used

0 - 20 kVdc @ 5 or 10 mA

Actual Coils

EXAMPLE CURRENT CALCULATIONS & EFFECT ON HIPOT NEEDED

4,000 Volt Motor with 100 Turn/Bar Stator Coils Each Phase

Capacitance each stator bar to ground = .1 µf = .1 x 10^{-6} farads

AC test voltage = 9 kVac (4 kV x 2 + 1000)

Test amps required = (2πf)CV = 377(60 Hz.) X (.1 x 10^{-6}) x 9000 = .34 ma

Each 100-turn coil's total test current = .34 mAac x 100 bars = 34 mAac

Hipot To Test One Bar

0 -10 kVac @ .34 mA = 3.4 VA

10 mAac Hipot

Hipot To Test One Coil

0 -10 kVac @ 34 mA = 340 VA

50 mAac Hipot

Hipot To Test Three Coils

0 -10 kVac @ 102 ma = 1 kVA

100 mAac Hipot

OVERVOLTAGE TESTING MOTORS & GENERATORS

AC Hipots

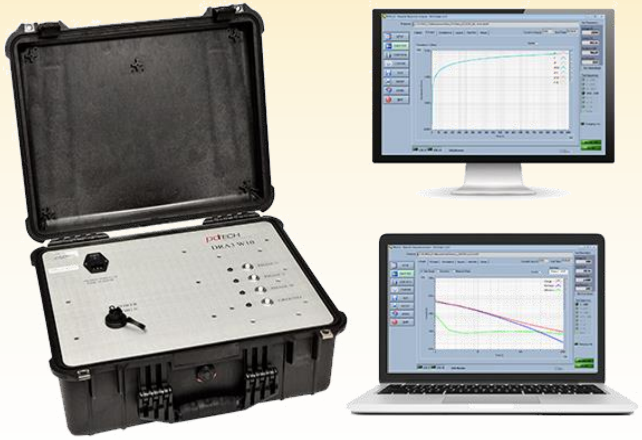
AC Dielectric Test Sets

Resonant Sets

VLF

IRIS & PDTECH PRODUCTS FOR M/G TESTING

The **Iris Power DCR 60-2** is a simple off-line DC tester to identify problems in the stator ground wall insulation system of generators and motors before an unexpected in-service failure occurs. Unlike the pass or fail of a DC or AC hi-pot test, the DC ramp test gives diagnostic information and can be stopped before a failure occurs.



The **Iris Power - PDTech Deltamaxx** instrument is an integrated system that measures dissipation factor, capacitance and partial discharges in stator bars, coils and complete stator windings.

The Corona Probe is an off-line instrument to accurately pinpoint the source of partial discharge (PD) in a particular slot in generators and motors.

PDTech Dielectric Response Analyzer (DRA-3) The dielectric response analyzer is used for off-line insulation diagnosis for generators and motors and is also applicable to transformers. It measures the charging and discharging currents (also called polarization and depolarization currents or PDC) of the winding of stator or rotor insulation.

Motors & Generators, like most other electrical apparatus, should be tested with elevated AC voltage to verify the dielectric integrity of the insulation under the stress of operating frequency and voltage. Other low voltage tests and elevated DC voltage tests are useful but are not substitutes for a proper AC Withstand test and/or AC voltage Diagnostic tests.

Thank You - Michael T. Peschel

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