

## 1 Hz Power factor/dissipation factor (PF/DF)

For over 25 years, the use of frequencies beyond line frequency (50 or 60 Hz) has become a fundamental tool in the dielectric assessment of complex dielectric systems. Power transformer operators have benefited from the use of frequency spectrums covering values above and below line frequency.

An advanced application of power factor / dissipation factor is dielectric frequency response (DFR) where measurements of capacitance and dissipation factor as a function of frequency are used to determine the moisture concentration in the solid insulation (cellulose) or the conductivity in the liquid insulation (oil). DFR is a definitive tool to identify the level of degradation in the complex insulation system of power, distribution transformers, and HV and EHV bushings.

On the other hand, the use of line frequency values in the dielectric analysis has encountered its limitations:

- Limit values set by standards might be too conservative
- A better assessment requires historical data
- Temperature correction is limited to the use of reference tables
- Assessment is inconclusive

To advance the understanding of dielectric conditions of transformers and bushings, Megger has implemented wide-ranging changes to its insulation diagnostic test sets. These changes improve the interpretation of 50 and 60 Hz results, providing peace of mind for both managers and field operators that the insulation systems of critical assets will function as intended when put back into service.



## DELTA4000



In 2009, Megger launched the DELTA4000, a revolutionary 12 kV insulation diagnostic test set with features never seen in high power test equipment:

- Frequency ranges from 1 to 505 Hz
- Individual Temperature correction (ITC) algorithm for transformers and bushings
- Voltage dependence detection

The DELTA4000 performs testing in the field at frequencies beyond 50 or 60 Hz in a practical way:

- Additional equipment or accessories is not required
- Same test connection as a 50 or 60 Hz test
- Software is configured to run additional test frequencies automatically

### DELTA4000 ITC and 1 Hz testing and assessment

The information below describes the use of PowerDB Lite to configure the DELTA4000 insulation tests to include ITC and 1 Hz assessment of a two-winding transformer, including HV bushings.

*Accurate nameplate information is critical in your dielectric testing.* The DELTA4000 uses ambient temperature and the nameplate voltage and oil temperature to determine test voltages and accurate temperature correction using ITC. Please fill out the nameplate in its entirety!

## NAMEPLATE DATA

MFR \_\_\_\_\_ CLASS \_\_\_\_\_ PHASES 3

SER NO \_\_\_\_\_ COOLANT OIL REASON \_\_\_\_\_

YEAR \_\_\_\_\_ TANK TYPE SEALED WEIGHT \_\_\_\_\_ lb

WINDING MATERIAL Cu

OIL VOLUME \_\_\_\_\_ GAL

OIL TEMP \_\_\_\_\_ °C

IMPEDANCE \_\_\_\_\_ %

WEATHER \_\_\_\_\_

BIL \_\_\_\_\_ kV

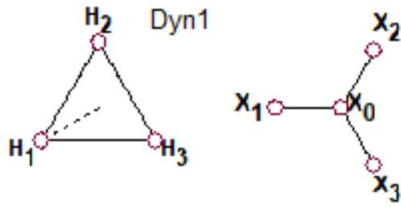


Diagram # 5 (ANSI)

	VOLTAGE (kV)		kVA	RATED I	# TAPS	NOMINAL	CHANGER	TAP SETTING
	L-L	L-G						
PRIMARY:					5	3	DETC	
SECOND:					1		OLTC	

PowerDB forms for the DELTA4000 are preconfigured to measure 1 Hz PF/DF using the same test connections as those for the power frequency PF/DF measurement. First, select the type of test you want to perform.

Select Tests:

Overall Test <input checked="" type="checkbox"/>	Oil Tests <input type="checkbox"/>	Bushing C1 <input checked="" type="checkbox"/>	Bushing C2 <input type="checkbox"/>
Surge Arresters <input type="checkbox"/>	Hot Collar Test <input type="checkbox"/>	TTR <input type="checkbox"/>	Exciting Current <input checked="" type="checkbox"/>
Manual Tests <input checked="" type="checkbox"/>			

# Application Note

Multiple test modes are available in the overall test table:

1. Recommended: Line frequency and 1 Hz tests with ITC
2. Basic: Line frequency with table correction factors
3. Advanced: NB DFR 1 – 505 Hz dielectric sweep with ITC

For the recommended mode, the test form will look like the following:

Transformer Overall Test				Test Mode: <b>Line Frequency + 1Hz</b> <input type="radio"/> <b>ITC</b> <input checked="" type="radio"/>		View Individual Temp. Correction Factors										
Multiple Test <input checked="" type="radio"/>				Connections		60Hz				1Hz						
Test No.	NB DFR	Insulation Tested	Test Mode	Click image for detailed connection information	TEST kV	Cap (pF)	Equivalent @ 10kV		POWER FACTOR %			%VDF	POWER FACTOR %			
							mA	Watts	Measured	@ 20°C	IR		Measured	@ 20°C	IR	
1		C <sub>HG</sub> + C <sub>HL</sub>	GST-GND													
2	✗	C <sub>HG</sub>	GSTg-RB													
3	✗	C <sub>HL</sub>	UST-R													
4		C <sub>HL</sub> '		Test 1 Minus Test 2												
5		C <sub>LG</sub> + C <sub>HL</sub>	GST-GND													
6	✗	C <sub>LG</sub>	GSTg-RB													
7		C <sub>HL</sub>	UST-R													
8		C <sub>HL</sub> '		Test 5 Minus Test 6												
9		C <sub>HG</sub> '		C <sub>HG</sub> Minus H Bushings												
10		C <sub>LG</sub> '		C <sub>LG</sub> Minus L Bushings												

After completing the test, PowerDB automatically provides a colour-coded condition assessment of the insulation for tests performed at power frequency and 1 Hz. The table below displays the 'traffic light' assessment values for power frequency and 1 Hz temperature-corrected, % PF/DF test results:

Overall %PF @ 20° C Limits							
	As New	<	Good	<	Aged	<	Investigate
LF	0.40	<	0.50	<	1.00	<	Investigate
1Hz	0.50	<	1.00	<	1.75	<	Investigate

The vast majority of installed HV and EHV bushings are oil-impregnated paper (OIP) constructed. This makes these critical assets perfect candidates for 1 Hz assessment. Further, OIP, resin impregnated paper (RIP), and resin impregnated synthetic (RIS) have different construction and failure modes. The use of frequencies greater than line frequency simplifies the detection of manufacturing and/or installation deficiencies.

Bushing C1 Test			Test Mode: <span style="background-color: yellow;">Line Frequency + 1Hz + 505Hz</span>										ITC <span style="background-color: yellow;">●●●</span>			View Individual Temp. Correction Factors		
Connection Diagram			60Hz										1Hz			505Hz		
Test No.	NB DFR	Dsg	Test Mode	TEST kV	Capacitance		Equivalent @ 10 kV		POWER FACTOR %			Δ %PF @ 20°C	%VDF	POWER FACTOR %			POWER FACTOR %	
					C (pF)	Δ pF	mA	Watts	Measured	@ 20°C	IR			Measured	@ 20°C	IR	Measured	@ 20°C
11	✗	H1	UST-R															
12	✗	H2	UST-R															
13	✗	H3	UST-R															
14	✗	NA	UST-R															
15	✗	X1	UST-R															
16	✗	X2	UST-R															
17	✗	X3	UST-R															
18	✗	X0	UST-R															
19	✗		UST-R															

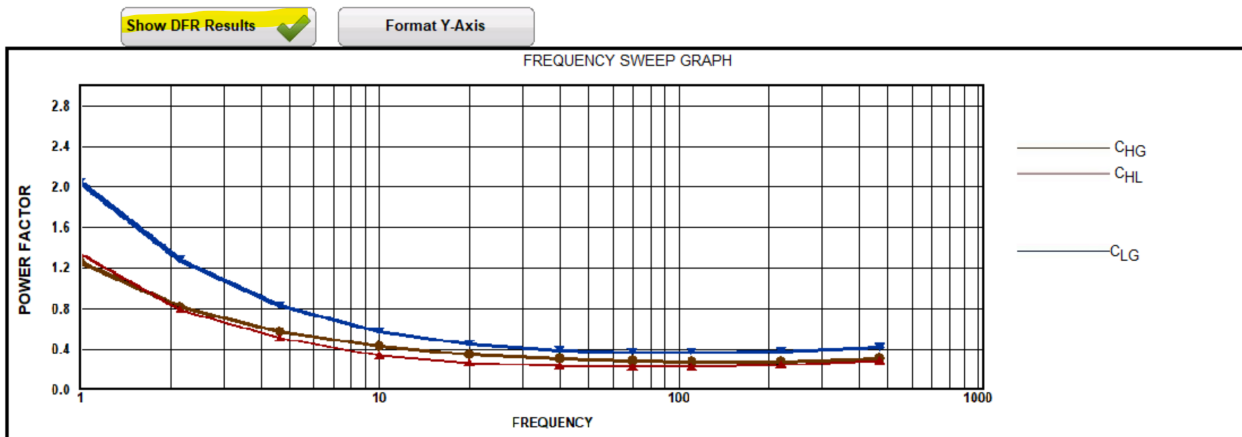
### Bushing %PF @ 20° C Limits

	As New	<	Good	<	Aged	<	Investigate
LF	0.40		0.50		1.00		
1Hz	0.40		0.75		1.25		

Enable advanced dielectric testing from 1 to 505 Hz by selecting the narrowband DFR (NB DFR) check/tick mark next to the asset you are testing:

Bushing C1 Test				Test Mode: Line Frequency + 1Hz + 505Hz										ITC			View Individual Temp. Correction Factors		
Connection Diagram				60Hz										1Hz			505Hz		
Test No.	NB DFR	Dsg	Test Mode	TEST kV	Capacitance		Equivalent @ 10 kV		POWER FACTOR %			$\Delta$ %PF @ 20°C	%VDF	POWER FACTOR %			POWER FACTOR %		
					C (pF)	$\Delta$ pF	mA	Watts	Measured	@ 20°C	IR			Measured	@ 20°C	IR	Measured	@ 20°C	
11	<input checked="" type="checkbox"/>	H1	UST-R																
12	<input checked="" type="checkbox"/>	H2	UST-R																
13	<input checked="" type="checkbox"/>	H3	UST-R																
14	<input checked="" type="checkbox"/>	N/A	UST-R																
15	<input checked="" type="checkbox"/>	X1	UST-R																
16	<input checked="" type="checkbox"/>	X2	UST-R																
17	<input checked="" type="checkbox"/>	X3	UST-R																
18	<input checked="" type="checkbox"/>	X0	UST-R																
19	<input checked="" type="checkbox"/>		UST-R																

When the test(s) is complete, view the results in graph form. X-axis (frequency) is logarithmic scale by default, and the Y-axis can be adjusted in linear or logarithmic scales.



The superior sensitivity of 1 Hz PF/DF detects insulation changes well before PF/DF measured at power frequency does. Combined with a 10 kV traditional PF/DF instrument, 1 Hz PF/DF provides the means to immediately validate line frequency PF/DF results.