

# AC core loss measurement on high phase angle material

Power Magnetics @ High Frequency – Eliminating the Smoke and Mirrors Technology Demonstration Session on 3rd March, 2018

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#### **PRODUCTS OF IWATSU ELECTRIC**

#### **PRODUCTS (Test and Measurement Business)**

- B-H Analyzer
- Digital Oscilloscope
- Curve Tracer
- Isolation System up to 500MHz BW
- Basic Measurement (DMM, Counter, Signal Generator)
- Isolation Probe
- Current and Voltage Probe











## Think Important Issue for Power Loss Measurement

- Measuring method
  - Excitation method ?
    - Power Analyzer
    - B-H Analyzer
    - Digitizer





#### – Condition

- Temperature ?
- Humidity ?

#### 1. Power Loss Measurement by Power Analyzer

# 1.1 Issues in low power factor of the power measurement



When close to the power factor = 0,

$$Pc = I_{rms} \cdot V_{rms} \cdot \cos\theta$$

Maximum of the power error at zero power factor.

**Reference N4L Application** 

#### 1.2 Power Analyzer Accuracy



21 Nov 2011 17:35 Script file: KinetiQ PPA5500 low power factor test v2.01 Automatic Calibration Environment release ACE v2.33 NEWTONS4TH,PPA5530,00773,2.51 Fluke,6105A,176162845,2.12

Summary report

Verify power measurement at different phase angles at 220V 5A

|     | , panar   |           |          |        |   |   |           |          |           |          |           | VA                |         | W         |          |
|-----|-----------|-----------|----------|--------|---|---|-----------|----------|-----------|----------|-----------|-------------------|---------|-----------|----------|
|     | frequency |           | applied  |        |   |   | phase 1   |          | phase 2   |          | phase 3   | deviation spec    | : devi  | ation spe | C        |
| OK: | 55.00 Hz  | 1.1000kvA | 1.1000kw | 0.000° | 7 | 6 | 1.0998kVA | 1.0998kw | 1.0998kVA | 1.0997kw | 1.0998kvA | 1.0998kw <-0.02%> | [0.14%] | <-0.03%   | [0.14%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 1.0958kw | 5.000° | 7 | 6 | 1.0998kVA | 1.0956kw | 1.0998kVA | 1.0956kw | 1.0998kVA | 1.0956kw <-0.02%> | [0.14%] | <-0.02%>  | [0.14%]* |
| OK: | 55.00 Hz  | 1.1000kVA | 1.0833kw | 10.00° | 7 | 6 | 1.0998kVA | 1.0831kw | 1.0998kVA | 1.0831kw | 1.0998kVA | 1.0831kw <-0.02%> | [0.14%] | <-0.02%>  | [0.14%]* |
| OK: | 55.00 Hz  | 1.1000kVA | 1.0625kw | 15.00° | 7 | 6 | 1.0998kVA | 1.0623kw | 1.0998kVA | 1.0623kw | 1.0998kVA | 1.0623kw <-0.02%> | [0.14%] | <-0.02%>  | [0.15%]* |
| OK: | 55.00 Hz  | 1.1000kVA | 1.0337kw | 20.00° | 7 | 6 | 1.0999kVA | 1.0335kw | 1.0998kVA | 1.0335kw | 1.0998kVA | 1.0335kw <-0.02%> | [0.14%] | <-0.02%>  | [0.15%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 996.94 W | 25.00° | 7 | 6 | 1.0998kVA | 996.78 W | 1.0998kVA | 996.75 W | 1.0998kVA | 996.77 W <-0.02%> | [0.14%] | <-0.02%>  | [0.15%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 952.63 W | 30.00° | 7 | 6 | 1.0998kVA | 952.48 W | 1.0998kVA | 952.45 W | 1.0998kVA | 952.47 W <-0.02%> | [0.14%] | <-0.02%>  | [0.16%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 901.07 W | 35.00° | 7 | 6 | 1.0998kVA | 900.93 W | 1.0998kVA | 900.91 W | 1.0998kVA | 900.93 W <-0.02%> | [0.14%] | <-0.02%>  | [0.17%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 842.65 W | 40.00° | 7 | 6 | 1.0998kVA | 842.53 W | 1.0998kVA | 842.51 W | 1.0999kVA | 842.52 W <-0.02%> | [0.14%] | <-0.02%>  | [0.18%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 777.82 W | 45.00° | 7 | 6 | 1.0998kVA | 777.70 W | 1.0998kVA | 777.69 W | 1.0999kVA | 777.70 W <-0.02%> | [0.14%] | <-0.02%>  | [0.19%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 707.07 W | 50.00° | 7 | 6 | 1.0998kVA | 706.97 W | 1.0998kVA | 706.96 W | 1.0999kVA | 706.96 W <-0.02%> | [0.14%] | <-0.02%>  | [0.20%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 630.93 W | 55.00° | 7 | 6 | 1.0999kVA | 630.85 W | 1.0998kVA | 630.84 W | 1.0999kvA | 630.84 W <-0.01%> | [0.14%] | <-0.01%>  | [0.23%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 550.00 W | 60.00° | 7 | 6 | 1.0999kVA | 549.93 W | 1.0998kVA | 549.93 W | 1.0999kvA | 549.93 W <-0.01%> | [0.14%] | <-0.01%>  | [0.25%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 464.88 W | 65.00° | 7 | 6 | 1.0999kVA | 464.81 W | 1.0998kVA | 464.82 W | 1.0999kVA | 464.82 W <-0.01%> | [0.14%] | <-0.02%>  | [0.30%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 376.22 W | 70.00° | 7 | 6 | 1.0999kVA | 376.17 W | 1.0999kVA | 376.18 W | 1.0999kVA | 376.17 W <-0.01%> | [0.14%] | <-0.01%>  | [0.36%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 284.70 W | 75.00° | 7 | 6 | 1.0999kVA | 284.66 W | 1.0999kVA | 284.67 W | 1.0999kVA | 284.67 W <-0.01%> | [0.14%] | <-0.01%>  | [0.46%]* |
| OK: | 55.00 Hz  | 1.1000kvA | 191.01 W | 80.00° | 7 | 6 | 1.0999kVA | 190.99 W | 1.0999kvA | 191.00 W | 1.0999kvA | 190.99 W <-0.01%> | [0.14%] | <-0.01%>  | [0.68%]* |
| OK: | 55.00 Hz  | 1.1000kVA | 95.871 W | 85.00° | 7 | 6 | 1.0999kvA | 95.848 W | 1.0999kVA | 95.867 W | 1.0999kVA | 95.855 W <-0.01%> | [0.14%] | <-0.02%>  | [1.32%]* |
|     |           |           |          |        |   |   |           | IVVAIJ   |           |          |           |                   |         |           |          |

#### 1.3 Reactor loss Measurement



#### 1.4 Power Analyzer Accuracy for Reactor loss error

- Sin wave accuracy on the Volage
  - 0.01% Rdg+0.038% Rng+(0.004% × kHz Rdg)+5mV
- Sin wave accuracy on the Current

0.01% Rdg+0.038% Rng+ $(0.004\% \times kHz Rdg)$ +  $300\mu$ A

Voltage
Current

- Sin wave accuracy on the Power
  - 10 mHz-2MHz [0.03%+0.03%/pf+(0.005% × kHz)/pf] Rdg+0.03%VA Rng
  - 40-850Hz  $[0.03\%+0.03\%/pf+(0.005\% \times kHz)/pf]$  Rdg+0.03%VA Rng
- Fourier series expansion for square

• 
$$f(x) = \frac{4}{\pi} \{ sin(x) + \frac{1}{3}sin(3x) + \frac{1}{5}sin(5x) + \frac{1}{7}sin(7x) + \cdots \} \}$$

• Fourier series expansion for triangle

• 
$$f(x) = \frac{8}{\pi} \{ sin(x) + \frac{1}{9} sin(3x) + \frac{1}{25} sin(5x) + \frac{1}{49} sin(7x) + \cdots \} \}$$

The deskew can not be highly accurate measurement. In this case, it can be measured by high accuracy measurement.

#### 1.5 It is difficult to measure "Zero". ~A problem in evaluating loss of low loss materials~

Core loss Pc when Current I and Voltage V are single sine waves;

$$Pc = I_{rms} \cdot V_{rms} \cdot \cos\theta$$



#### 2. Power Loss Measurement by B-H Analyzer

## 2.1 The principles of High-precision Core loss Measurement

- Standard : IEC 62044-3
- Japanese Industrial Standards(JIS)





SY-8218/19 adopts CROSS-POWER method that the Standards above employ.



# 2.2 What is the measurement principle of AC magnetic property?



Ac; Effective cross-section area

## 2.3 Comparison of Core loss measurement by presence or absence of phase correction



**CROSS-POWER** method is adopted in IEC 62044-3.

#### Data by Metropolitan University

0

0

5

10

Bm (mT)

15

## 2.4 What is CROSS-POWER method?



## 2.5 Comparison between Digitizer method and CROSS-POWER method

1. Both Digitizer and CROSS-POWER methods capture excitation current waveforms and inductive voltage waveforms through time sampling as the time axis waveforms (sampling data).

However, these two methods are distinguished

by the way of dealing with the time axis waveforms.

- 2. Digitizer method executes the time integration calculation directly as the time axis waveforms.
- 3. CROSS-POWER method, on the other idea
  - (1) converts the time axis waveforms into the frequency spectrum and executes integral calculation with no phase difference and compensates the amplitude and the phase error of current detection sensor.
    - (2) executes the compensation of the amplitude and the phase property of the detection circuit on the frequency axis.
    - (3) captures the time axis waveforms with little error by returning the frequency spectrum having the error compensation to the time axis waveforms.

#### 2.6 B-H / Core loss measurement

• B-H Analysis

| Sample Parameters   | Excited Conditions   |
|---|--|
| Sample Name : SAMPLE  | Function : Frequency : 0.05 [kHz]  |
| Le: 83 878 [mm] Ve: 171 1 [mm3] N1: 37  | Hm : 130 [A/m]   |
|   | Television at Table (N)  |
| Ae:   2.04 (III*) we   1.2 (8) W2   3/  | Tolerance: ±1 2 (%)  |
| Mode Select Cursor Values   | Measured Values  |
| B-H   | 8m : 1076.8 [mT]   |
| B : V:  | Br : 929 68 [mT]   |
|   | Hm : 420.40 [A/m]  |
| FOO [mT] /div Fine B  | 129.10 (d) m   |
|   | He (A/m)   |
|   | Br/Bm; 36.912 IA/ III  |
|   | 0.8634   |
|   | Pa 6637.2  |
|   | Pc : 1.3736E-03 [W]  |
|   | Pcv : 8.0279 [kW/m <sup>3</sup> ]  |
|   | Pcm : 1.1447 [W/kg]  |
|   | 0 : 73.443 [deg]   |
| //  | 2 0 m : 4.3932E-06 [Wb]  |
| / / н   | V2m : 0.1064 [V]   |
|   | :  |
|   | :  |
| -d  | :  |
|   |  |
|   | Configurations   |
|   | Average : 16 Pod Type : SY-951 Pwr Amp Gain : 10   |
|   | Retry : 8 Pwr Amp : HSA4101-IW   |
| 50 A / m / / div  |  |
| 00 fv/ m1/mv  | Max-Avg: 2 OSC-OUT: v 0.1  |
| 100 47 43 7 00<br>10047153L1 5Y-8218 2010-03-04 08:51:04<br>Sample Parameters   | Mov-Ave: 3 OSC-OUT: × 0.1  |
| IVWATERLI         SY-8218         2010-03-04 06:51:04           Sample Parameters         Sample Name : SAMPLE         :           Le :         83.878 [mm] Ve : 171.1 [mm <sup>3</sup> ] N1 : 37   | Mov-Avs: 3 OSC-OUT: ★ 0.1  |
| IVWATELL SY-8218         2010-03-04 00:51:04           Sample Parameters         Sample Name : SAMPLE           Le:         83.878 [mm] Ve:         171.1 [mm <sup>3</sup> ] N1:         37           Ae:         2.02 [mm <sup>2</sup> ] We:         1.2 [g] N2:         37  | Mov-Avs : 3 OSC-OUT : ★ 0.1  |
| Sample Parameters           Sample Name :         SAMPLE           Le :         83.878 [mm] Ve :         171.7 [mm <sup>3</sup> ] N1 :         37           Ac:         202 [mm <sup>2</sup> ] We :         1.2 [s] N2 :         37           Mode         Select         Cursor Values   | Mov-Ave : 3 OSC-OUT : ★ 0.1<br>Excited Conditions<br>Function : Frequency : 0.05 [kHz]<br>Hm : 130 [A/m]<br>Tolerance : ± 2 [%]<br>Measured Values   |
| IVWATESLI SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name:           Sample Name:         SAMPLE           Le:         83.878 (mm) Ve:         171.1 (mm3) N1:           Ae:         200 (mm2) We:         1.2 (mm3) N1:           Ae:         Sample Current Ref.         L:   | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm<:  |
| Sample Parameters           Sample Parameters           Sample Name:           Samp   | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm<:  |
| IWATTELL         SY-8218         2010-03-04 06:51:04           Sample Parameters         Sample Name : SAMPLE         5.000000000000000000000000000000000000  | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance: ±         2         [k]           Measured Values         Bm         :         1076.8         [mT]           Br         :         1076.8         [mT]         Im]   |
| Sample Parameters           Sample Parameters           Sample Name:           SARTELL SY-8218           2010-03-04 08:51:04           Sample Name:  | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm<:  |
| IVMATTELL         SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name:         SAMPLE           Le:         83.878 [mm]         Ve:         171.1 [mm <sup>3</sup> ] N1:         37           Ae:         20.0 [mm <sup>2</sup> ] We:         12 [s]         N2:         37           Mode         Select         Cursor Values         I:         I:           B-H         III         B:         V:         IIII  | Mov-Ave: 3         OSC-OUT: x 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Toterance:         2         [k]           Measured Values         Bm         :         1076.8         [mT]           Hm         129.68         [mT]         Im]         Im]           Hm         :         0.2927         [A/m]         Im]           Hm         :         0.2927         [A/m]         Im]   |
| IWATTELL         SY-8218         2010-03-04 06:51:04           Sample Parameters         Sample Name : SAMPLE         Sample Name : SAMPLE           Le:         83.878 mail Ve : 171.1 (mm <sup>3</sup> ) N1 : 37           Ac:         200 (mm <sup>2</sup> ) Ve : 1.2 (s) N2 : 37           Mode         Select           Current         H : 1 : 1 : 1           B : V :         V : 1.2 (s) N2 : 37  | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance: ±         2         [K]           Bm         :         1076.8         [mT]           Br         :         929.68         [mT]           Hm         :         0.2202         [A/m]           Hm         :         0.2927         [A/m]           Br / 8m         :         36.912         [A/m]  |
| WATTELL SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name:           Sample Name:         SAMPLE           Le:         83.878 [mm] Ve:         171.1 [mm <sup>3</sup> ] N1:           Ac:         200 [mm <sup>2</sup> ] We:         12 [g] N2:           Mode         Select         Cursor Values           B-H         E:         V:           Fine         B:         V:  | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions<br>Function:         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance:         ±         2         [%]           Measured Values         Bm         :         1076.8         [mT]           Br         :         929.68         [mT]           Hm         :         128.10         [A/m]           Im         :         0.2027         [A/m]           Br/Bm:         :         0.8634         :  |
| IVMATTELL         SY-8218         2010-03-04 06:51:04           Sample Parameters         Sample Name:         SAMPLE           Le:         83.878 [mm]         Ve:         171.1 [mm <sup>3</sup> ] N1:         37           Ae:         200         mm <sup>2</sup> ] We:         12 [a]         N2:         37           Mode         Select         Cursor Values         I:         B:         V:         V:           Fine         B:         V:         V:         V:         V:         V:         V:   | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance: ±         2         [k]           Measured Values         [m]         1076.8         [mT]           Br         :         1076.8         [mT]           Im         :         0.292.68         [mT]           Im         :         0.292.7         [A]           Br/Bm:         0.8637.2         [m]         [m]  |
| So w/ 3) (3)           IWATELI SY-8218         2010-03-04 08-51:04           Sample Parameters           Baret         Sample Parameters <td>Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance: ±         2         [%]           Measured Values         ImT]         ImT]           Br         :         922.68         [mT]           Hm         :         129.10         [A/m]           Itm         :         0.2827         [A/m]           Hc         :         36.912         [A/m]           Br/Bm:         0.8634         [A/m]           Wa         :         6637.2         [W]           Pc         :         1.376E-03         [W]</td> | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance: ±         2         [%]           Measured Values         ImT]         ImT]           Br         :         922.68         [mT]           Hm         :         129.10         [A/m]           Itm         :         0.2827         [A/m]           Hc         :         36.912         [A/m]           Br/Bm:         0.8634         [A/m]           Wa         :         6637.2         [W]           Pc         :         1.376E-03         [W]  |
| IWATTELL SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name : SAMPLE           Le :         83.878 [mm] Ve:         171.1 [mm <sup>3</sup> ] N1:           Ae:         2005 [mm <sup>2</sup> ] We:         1.2 [g] N2:           Mode         Select         Ursor Values           B-H         B:         V:  | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions<br>Function:         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance:         ±         2         [%]           Measured Values         Bm         :         1076.8         [mT]           Hm         :         129.10         [A/m]           Imm         :         0.2927         [A/m]           Br/Bm         :         0.8634         [M]           Br/Bm         :         0.8634         [M]           Pc         :         1.3736E-03         [W]           Pcv         :         8.0279         [kW/m³]   |
| IVMATTELL         SY-8218         2010-03-04 06:51:04           Sample Parameters         Sample Name:         SAMPLE           Le:         83.878 [mm]         Ve:         171.1 [mm <sup>3</sup> ] N1:         37           Ae:         2.00 [mm <sup>2</sup> ] We:         1.2 [a]         N2:         37           Mode         Select         Cursor Values         I:         I:           B-H         Image: Select         H:         I:         I:           Fine         B         500 [m <sup>2</sup> ] / dv         I:         I:   | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance: ±         2         [%]           Measured Values         Im 1         1076.8         [mT]           Br         :         929.68         [mT]           Hm         :         122.10         [A/m]           Itm         :         0.2927         [A]           Hc         :         36.912         [A/m]           Ha         :         6637.2         Pc           Pcv         :         1.3736E-03         [W]           Pcm         :         1.1447         [W/kg]  |
| IVMATTELL         SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name:         SAMPLE           Le:         83.878 (mm) Ve:         171.1 (mm <sup>3</sup> ) N1:         37           Ac:         202 (mm <sup>2</sup> ) We:         12 (a) N2:         37           Mode         Select         Ursor Values         1:           B-H         E         B:         V:  | $\begin{array}{c c} \text{Mex-Ave:} 3 & \text{OSC-OUT:} \star 0.1 \\ \hline \\ \hline \\ \text{Excited Conditions} \\ \hline \\ \text{Function:} \\ \text{Frequency:} & 0.05 \\ \text{Hm} : & 130 \\ \text{Hm} : & 130 \\ \text{Hm} : & 130 \\ \text{Iderance:} \pm & 2 \\ \text{IM} \\ \hline \\ \hline \\ \text{Measured Values} \\ \hline \\ \text{Bm} : & 1076.8 \\ \text{Im} \\ \text{Im} : & 222.66 \\ \text{Im} \\ \text{Im} \\ \text{Im} : & 222.66 \\ \text{Im} \\ \text{Im} \\ \text{Im} : & 0.2927 \\ \text{IA} \\ \text{Hc} : & 36.912 \\ \text{IA} / \text{Im} \\ \text{Im} : & 0.8634 \\ \text{Ia} : & 6637.2 \\ \text{Pc} : & 1.3738 \\ \text{E-03} \\ \text{IW} \\ \text{Pcm} : & 1.1447 \\ \text{0} : & 7.3443 \\ \text{Ideg} \\ \hline \end{array}$  |
| IVMATTELL         SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name:         SAMPLE           Le:         S3.878 [mm] Ve:         171.1 [mm <sup>3</sup> ] N1:         37           Ae:         20.0 [mm <sup>2</sup> ] We:         12 [s] N2:         37           Mode         Select         H:         I:           B-H         O         B:         V:   | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance: ±         2         [k]           Mm         130         [A/m]           Tolerance: ±         2         [k]           Mm         122.10         [A/m]           Im         122.10         [A/m]           Hm         0.2927         [A]           Hc         36.912         [A/m]           Br/Bm:         0.863.4         [W]           Pcv         1.3738E-03         [W]           Pcm         1.1447         [W/kg]           0         7.343         [deg]           2 dm         4.3932E-06         [Wb]  |
| WATTELL SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name:           Sample Name:         SAMPLE           Le:         83.878 (mm) Ve:         171.1 (mm <sup>3</sup> ) N1:           Ae:         202 (mm <sup>2</sup> ) We:         1.2 (s) N2:           Mode         Select         Cursor Values           B-H         Cursor Values         1:           B:         V:         V:           Mode         So(a/m) /div         0.05 (V) /div  | $\begin{array}{c c} \text{Mex-Ave: 3} & \text{OSC-OUT: } \star 0.1 \\ \hline \\ \hline \\ \text{Excited Conditions} \\ \hline \\ \text{Function:} \\ \text{Frequency:} \\ 0.05 \\ \text{Hm} : \\ 130 \\ \text{(A/m)} \\ \hline \\ \text{Tolerance: } \pm \\ 2 \\ \text{(b)} \\ \hline \\ \hline \\ \text{Measured Values} \\ \hline \\ \text{Bm} : \\ 0.292, 68 \\ \text{(mT)} \\ \text{Hm} : \\ 129, 10 \\ \text{(A/m)} \\ \text{Hm} : \\ 0.292, 68 \\ \text{(mT)} \\ \text{(mT)} \\ \text{Hm} : \\ 0.292, 68 \\ \text{(mT)} \\$ |
| WATTELL SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name: [SAMPLE           Le:         83.878 [mm] Ve:         171.1 [mm <sup>3</sup> ] N1:         37           Ac:         2.02 [mm <sup>2</sup> ] We:         1.2 [s] N2:         37           Mode         Select         H:         I:           B-H         Offer         B:         V:           B:         V:         H:         I:           B:         V:         H:         V:           Mode         Solect         H:         I:           B:         V:         H:         V:   | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$  |
| WATTELL SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name:           Sample Name:         SAMPLE           Le:         33.878 [mm] Ve:           11:         37           Ac:         20.0 (mm²) We:           12 [a] N2:         37           Mode         Select           Current Ref.         H:           B:         V:  | Mov-Ave: 3         OSC-OUT: × 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance: ±         2         [K]           Measured Values         Im         130         [A/m]           Br         :         929.68         ImT]           Hm         :         129.10         [A/m]           Im         :         0.2927         [A/m]           Br / Bm         0.8634         [A/m]           Br / Bm         0.8634         [A/m]           Pc :         1.3738E-03         [W]           Pcm :         1.1447         [W/kg]           0         :         73.443         [degl           2 dm :         4.3932E-06         [W]         [V]  |
| B         Current Ref.           B-H         Current Ref.  | $\begin{array}{c c} \text{Mov-Ave:} 3 & \text{OSC-OUT:} \star 0.1 \\ \hline \\ \hline \\ \text{Excited Conditions} \\ \hline \\ \text{Function:} \\ \text{Frequency:} \\ \text{Hm} : \\ 130 \\ \text{Iderance:} \\ \pm \\ 2 \\ \text{[M]} \\ \hline \\ \text{Measured Values} \\ \hline \\ \text{Bm} : \\ 1076.8 \\ \text{Im} \\ 1 \\ \text{m} : \\ 129.10 \\ \text{Im} \\ 1 \\ \text{m} : \\ 129.10 \\ \text{Im} \\ 1 \\ \text{m} : \\ 129.10 \\ \text{Im} \\ 1 \\ \text{m} : \\ 129.10 \\ \text{Im} \\ 1 \\ \text{m} : \\ 13736E-03 \\ \text{Im} \\ 1 \\ \text{M} \\ \text{m} : \\ 1.3736E-03 \\ \text{Im} \\ 1.1447 \\ 0 \\ \text{m} : \\ 0.1064 \\ \text{Wb} \\ 1 \\ \text{m} \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ $  |
| B         Current Ref.           B-H         CurrentRef.   | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$  |
| Bit         Current Ref.           Bit         V:   | $\begin{array}{c c} \text{Mov-Ave: 3} & \text{OSC-OUT: } \star 0.1 \\ \hline \\ \hline \\ \text{Excited Conditions} \\ \hline \\ \text{Function:} \\ \text{Frequency:} \\ 0.05 \\ \text{Hm} : \\ 130 \\ \text{(A/m)} \\ \hline \\ \text{Tolerance: } \pm \\ 2 \\ \text{(b)} \\ \hline \\ \hline \\ \text{Measured Values} \\ \hline \\ \text{Bm} : \\ 0.292, 68 \\ \text{(mT)} \\ \text{Hm} : \\ 129, 10 \\ \text{(A/m)} \\ \text{Hm} : \\ 0.292, 68 \\ \text{(mT)} \\ \text{(mT)} \\ \text{Hm} : \\ 0.292, 68 \\ \text{(mT)} \\ \text{(mT)} \\ \text{Hm} : \\ 0.292, 68 \\ \text{(mT)} \\ \text{(mT)} \\ \text{Hm} : \\ 0.292, 68 \\ \text{(mT)} \\ \text{(mT)} \\ \text{Hm} : \\ 0.292, 68 \\ \text{(mT)} \\ \text{(mT)}$   |
| WATTELL SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name: [SAMPLE           Le:         83.878 [mm] Ve:         171.1 [mm <sup>3</sup> ] N1:           Ac:         200 [mm <sup>2</sup> ] We:         1.2 [s] N2:           Mode         Select         H:           B-H         Current Ref.         B:           V:         B:         V:  | Mov-Aver : 3         OSC-OUT: x 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance:         ±         2 [%]           Measured Values         Bm         :         1076.8         [mT]           Br         :         929.68         [mT]         Im           Hm         :         129.10         [A/m]           Im         :         929.26         [mT]           Hm         :         129.10         [A/m]           Im         :         929.27         [A/m]           Im         :         0.2927         [A/m]           Hc         :         36.912         [A/m]           Br/Bm         0.86374         Pc         :           Pc         :         1.3736E-03         [W]           Pc         :         1.1447         [W/kg]         0           0         :         :         0.1064         [V]           :         :         :         :         :           Dem :         :         :         :         :           0         :         :         :  |
| WATTELL SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name:           Sample Name:         SAMPLE           Le:         83.878 [mm] Ve:         171.1 [mm3] N1:           Ae:         201 [mm2] We:         1.2 [N2:           Mode         Select         H:           B-H         Current Ref.         B:           V:         B:         V:   | Mov-Ave: 3         OSC-OUT: x 0.1           Excited Conditions         Frequency:         0.05         [kHz]           Hm         130         [A/m]           Tolerance: ±         2         [k]           Measured Values         Im         130         [A/m]           Br         :         929.68         ImT]           Hm         :         129.10         [A/m]           Im         :         0.2927         [A]           Hc         :         38.912         [A/m]           Br /Bm         0.48634         [A/m]           Pc         :         1.3736E-03         [W]           Pcv         :         8.0279         [kW/m3]           Pcm         :         1.1447         [W/kg]           0         :         .0.1064         [V]           :   |
| WATTELL SY-8218         2010-03-04 08:51:04           Sample Parameters         Sample Name: [SAMPLE           Le:         83.878 [mm] Ve:         171.1 [mm <sup>3</sup> ] N1:           Ae:         202 [mm <sup>2</sup> ] We:         12 [g] N2:           Mode         Select         Current Ref.           B:         V:         I:           H         Image: Ref.         B:         V:   | Mov-Ave::3       OSC-OUT::×0.1         Excited Conditions       Frequency:       0.05       [kHz]         Hm       130       [A/m]         Tolerance: ±       2       [k]         Measured Values       ImT]       ImT]         Br       :       029.68       ImT]         Hm       :       129.10       [A/m]         Itm       :       0.2927       [M]         Hc       :       0.2927       [A/m]         Hc       :       0.2927       [A/m]         Hc       :       0.3634       [A/m]         Pc       :       1.3736E-03       [W]         Pc       :       1.3738E-03       [W]         Pcm       :       1.1447       [W/k]         0       :       :       [W]         V2m       :       0.1064       [W]         :       :       :  |

**Core Loss Feature** 

Excitation condition

Change in Temperature

•Evaluation under a condition equal to an actual use condition



#### 2.7 B-H / Core loss measurement



## 2.8 Constant Temperature Chamber Scanner System



#### 2.9 Is the target Magnetic field (Current) or Flux density (Voltage) ?

- Hm designated method: Designate Hm (Max.Magnetic field)
- 2. Bm designated method: Designate Bm (Max.flux density)
- 3. Current designated method: Designate Excitation current
- 4. Voltage designated method: Designate Inductive voltage

# 2.10 Hm method

- a. Keep measurement frequency constant and excite the sample slowly.
- b. Capture the excitation current waveform and the inductive voltage waveform and calculate magnetic field waveform by the excitation current waveform.
- c. Adjust the output voltage of power amplifier manually or automatically so that the maximum value is within the tolerance level of the targeted magnet field.
- d. After the adjustment,

calculate the saturation magnetic flux density Bs, etc. with B-H curve calculated from magnetic field waveform and magnetic flux density.

e. This method is suitable for the measurement of saturation property such as saturation magnetic flux density, residual magnetic flux and coercive force.



# 2.11 Bm method

- a. Keep measurement frequency constant and excite the sample slowly.
- b. Capture the excitation current waveform and the inductive voltage waveform, and calculate magnetic field waveform by time integration of inductive voltage waveform.
- c. Adjust the output voltage of power amplifier manually or automatically so that the maximum value is within the targeted magnet flux density Bm.
- d After the adjustment, calculate time integration of multiplication of excitation current waveform by inductive voltage waveform, and then calculate core loss.
- e. Calculate the phase angle by the ratio between Core loss and Appearance power, and the permeability at Max. magnetic field Hm via Max. magnetic field and Max. flux density, ie. the amplitude ratio of permeability respectively.
- f. This method is suitable for the measurement of property for the large amplitude such as core loss, amplitude ratio of permeability, phase angle, etc.



# 2.12 Outline of DC bias tester

- Fully-automatic control is available with SY-8219 and future B-H series.
- Continuously-variable current value is available.
- DC bias non-sine wave (chopper excitation) is also available.
- DC bias current of Max.30[A] is supported.
- Ripple current of Max.5[A] is supported.
- Measurement frequency: Max.3MHz(sine wave)
- Measurement frequency: Max.1MHz(Chopper excitation)





# 2.14 Measurement method when DC bias is overlapped with a chip inductor



## 2.15 An measurement example of DC bias tester on chip inductor measurement (Pulse excitation)



## 2.16 Chip Inductor





#### 2.17 Toroidal Core Inductor







# 2.18 DC-Bias Sysytem





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## Future Events and Contact us

• Contact Us

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