Analysis Appendinx

Equation List

$$H = n_1(LS)^{-1}V_s \quad (1)$$

$$B = RC(n_2A_c)^{-1}V_s \quad (2)$$

$$P = AVf \quad (3)$$

$$V = L * \text{Area of sample face} \quad (4)$$

$$B = \mu_0 \mu_r H \quad (5)$$

$$\mu_0 = 4\pi * 10^{-7} \quad (6)$$

$$\text{flux density} = H\mu_r \quad (7)$$

Apparatus Measurements

n1 = 160 turns
n2 = 150 turns
S = 0.1 +/- 5% Ohms
R = 1e6 +/- 5% Ohms
C = 0.5e-6 +/- 2% F

Sample Measurements

Iron Magnetic Length**: 333 +/- 5mm**
Iron Cross Sectional Area: 759.08 +- 0.5 mm^2
Carbon Magnetic Length: 78 mm +/- 0.5 mm^2
Carbon Cross Sectional Area: 844.32 mm^2

Table 1 –Series Resistor Voltage and Capacitor Voltage for Iron Sample with C = 0.5e-6 +/- 2% F and S = 0.1 +/- 5% Ohms (Small sample of full dataset with 2000 points)

Time [s]	Vc [V]	Vc [V]
-2.50E-02	3.42E-01	-3.40E-01
-2.50E-02	3.38E-01	-3.39E-01
-2.50E-02	3.34E-01	-3.39E-01
-2.49E-02	3.31E-01	-3.39E-01
-2.49E-02	3.27E-01	-3.39E-01
-2.49E-02	3.22E-01	-3.38E-01
-2.49E-02	3.18E-01	-3.38E-01
-2.48E-02	3.13E-01	-3.38E-01
-2.48E-02	3.09E-01	-3.38E-01
-2.48E-02	3.06E-01	-3.37E-01
-2.48E-02	3.01E-01	-3.37E-01
-2.47E-02	2.96E-01	-3.36E-01
-2.47E-02	2.91E-01	-3.36E-01

Table 2 - Series Resistor Voltage and Capacitor Voltage for Carbon Steel Sample with C = 0.5e-6 +/- 2% F and S = 0.1 +/- 5% Ohms (Small sample of full dataset with 2000 points)

Time [s]	Vc [V]	Vc [V]
-2.50E-02	3.58E-01	1.78E-01
-2.50E-02	3.56E-01	1.78E-01
-2.50E-02	3.55E-01	1.77E-01
-2.49E-02	3.53E-01	1.78E-01
-2.49E-02	3.51E-01	1.77E-01
-2.49E-02	3.49E-01	1.77E-01
-2.49E-02	3.46E-01	1.76E-01
-2.48E-02	3.44E-01	1.76E-01
-2.48E-02	3.40E-01	1.75E-01
-2.48E-02	3.39E-01	1.75E-01
-2.48E-02	3.35E-01	1.73E-01
-2.47E-02	3.34E-01	1.75E-01
-2.47E-02	3.30E-01	1.72E-01

Table 3 - Hysteresis Saturation Point for Iron Sample with C = 0.5e-6 +/- 2% F and S = 0.1 +/- 5% Ohms

Variac Voltage [V]	Top-right corner X [mV]	Top-right corner Y [mV]	Error in corner X [mV]	Error in corner Y [mV]
3	13.75	26.87	0.5	1
5	18.25	43.75	0.5	2
7	21	56.25	0.5	2
10	25.5	72.5	0.5	2
13	33.5	95.3	1	5
17	42	118.8	1	5
20	50.5	139.1	1	5
23	61.5	160.9	1	5
25	68	170.3	2	5
30	88	196.9	2	10
35	120	228.1	2	10
40	167.5	259.4	5	10
45	227.5	284.4	5	10
50	315	303.1	10	10
55	460	318.8	10	10

Sample Calculations

H and B Values:

```
Hi = (n1/(Li*S)).*Vsi;
Bi = (R*C/(n2*Aci)).*Vci;
Hs = (n1/(Ls*S)).*Vss;
Bs = (R*C/(n2*Acs)).*Vcs;
```

Remanence and Coercive Forces:

```
remi = [];
coerci = [];
for i=1:length(Hi)-1
    if (Hi(i) >= 0 && Hi(i+1) < 0)
        remi(end + 1) = Bi(i);
        remi(end + 1) = Bi(i + 1);
    end

    if (Bi(i) >= 0 && Bi(i+1) < 0)
        coerci(end + 1) = Hi(i);
        coerci(end + 1) = Hi(i + 1);
    end
end
```

Iron Remanence (mean) = 0.838 +/- 0.003 T
Iron Coercive Force (SEM) = -252 +/- 1 A/m
Steel Remanence (mean) = 0.440 +/- 0.002 T
Steel Coercive Force (SEM) = -3390 +/- 10 A/m

Power Dissipated By Steel Sample:

```
Ps1 = (2.11e-2 - 1.24e-2)*2;
Ps2 = (2.11e-2 - 4.49e-3);
fs = 0.5*((1/Ps1)+(1/Ps2));
Ps_err = Ps * (0.002/Ls + Ac_err/Acs + 2/fs);
```

P = 100 +/- 6 W

Maximum Relative Permeability and Flux Density:

```
Uo = 4*pi*(10^-7); %http://physics.info/constants/
Ur = Bi4./Hi4./Uo;
Ur_err = Ur .* (Bi4_err./Bi4 +  Hi4_err./Hi4)./2;
Flux = Ur_max*Hi4(ind);
Flux_err = Flux .* (Ur_err(ind)./Ur_max  + Hi4_err(ind)./Hi4(ind))
```

Relative permeability= 1900 +/- 200 H/m
Calculated as: 333000 +/- 6000 N/(Am)