LAB NOTES

1. Prelab Notes

1.1. **pre 1.** large loop
$8.56{\cdot}10^-7H$
small loop: $7.96{\cdot}10^-9H$

1.2. **pre2.** $I = \frac{V}{Z} = \frac{V}{R+2\pi fL}$
$V = 2U$
$13dB = 10Log(U)$
$U = 10^{1.3}$
$I = \frac{10^{1.3}}{50+2\pi 8.56{\cdot}10^{-7}f}$

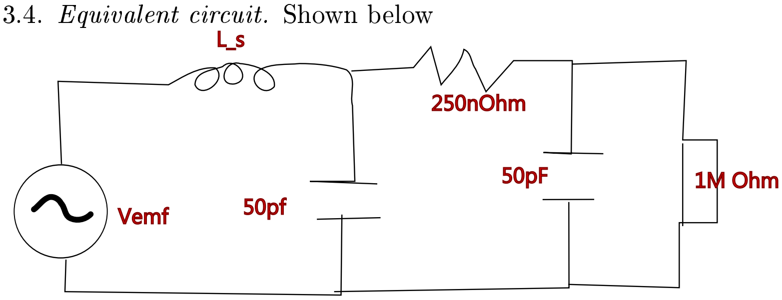
1.3. **pr3.**

1.3.1. *H.* $H = \frac{I}{2\pi d}$
$I = 0.192$A
$d = 0.03$m
$H = 1.02$ A/m

1.3.2. *Flux.* $\psi = \int B \cdot dS = \int_d^{d+w} \frac{I\mu_0}{2\pi r} w dr$
$w = 0.03$m
$d = 0.03$m
we can assume, (since frequency is low) the current is constant accros the loop
$\psi = \frac{I\mu_0}{2\pi}$ w $\int_d^{d+w} \frac{1}{r} dr$
$\psi = \frac{I\mu_0}{2\pi} w \left[ln\,(d+w) - ln\,(d)\right]$
$\psi = \frac{I\mu_0}{2\pi} w \left[ln\,(\frac{d+w}{d})\right]$
$\psi = \frac{0.192\times 4\pi\times 10^{-7}}{2\pi} \left[ln\,(1+\frac{0.03}{0.03})\right]$
$\psi = 2 \times 0.192 \times 10^{-7} \times ln(2) = 2.66 \times 10^{-8}$Wb

1.3.3. *Voltage.* $V_{emf} = |-N\frac{d\psi}{dt}| = |j2\pi f\psi| = 2\pi f\psi$
$V_{emf} = 2\pi \times 10^7 \times 2.66 \times 10^{-8}$
$V_{emf} = 1.67$V

1.3.4. *Equivalent circuit.* Shown below



1.3.5. *Predict.*

2. Experiment 1

2.1. Results.

f (Mhz)	I mA (Prelab)	I mA (Exp)	I dBuA Prelab	I dBuA exp
1	360.296	41.45	111.13	92.35
2	328.401	51.29	110.33	94.2
5	259.489	32.62	108.28	90.27
10	192.251	24.72	105.68	87.86
20	126.629	16.07	102.05	84.12
50	62.563	7.54	95.93	77.55
100	33.942	3.99	90.61	72.02
200	17.725	2.03	84.97	66.15
500	7.284	0.64	77.25	56.12

2.2. e) Differences from prediction from prelab.

Prelab predictions are roughly a order of magnitude greater than the measured results.

There is a constistant factor difference the Prediction is roughly 8.4× the measured;

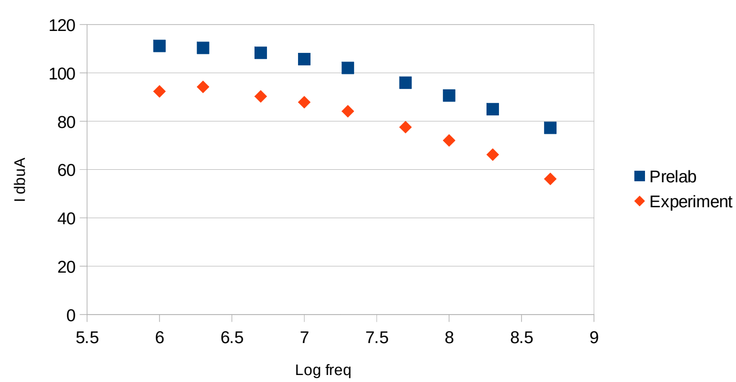
or in logeritmic scale there is a difference of 18.4 dBuA.

This may a result of a magnitude error in the prelab calculations.

As can be seen in the graph below, the curve shape is very similar.

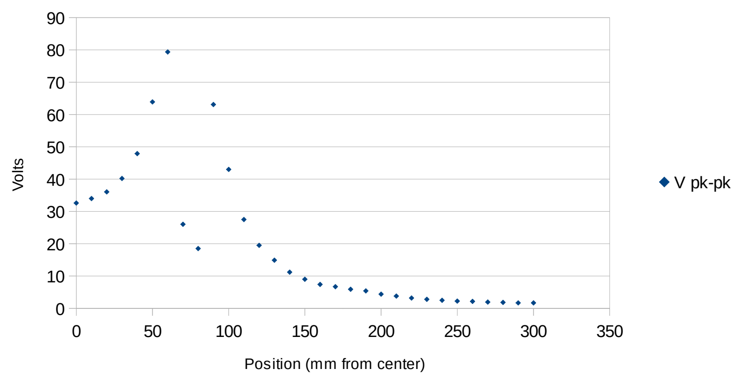
2.3. f) Graph.

see below



\frac{(-30)^{k}}{k}

3. Experiment 2



Shown above for illustration is a graph of measured voltage vs position.

It is much more informative than the raw numbers.

We can see the voltage on the small loop loop rising as we get closter and closer to the edge of the large loop (at 75 mm),

then we see it falling away as we go out side the loop.

We also see the two supprisingly low results at 70mm and 80mm.

This is where the the small loop was overlapping the large loop, and so some of the flux (and thus voltage) was canceled.

3.1. **d.** We found the lowest voltage was when the small loop was 75mm from the cener of the big loop, ie it was straddling the loop.

When this happened, the voltage was practically reduced to zero.

3.2. **f.** The voltage asymptotically approaches zero as the distance from the center increases beyond 90mm (where there is no overlap).

ie $V \propto \dfrac{1}{s}$.

This is because

$\psi = \int B \cdot dS = \int_s^{s+w} \frac{I\mu_0}{2\pi r} w dr = \frac{I\mu_0}{2\pi} w \left[ln\left(\frac{s+w}{s}\right)\right]$

and $V_{emf} = |-N\frac{d\psi}{dt}| = 2\pi f \psi$

so Voltage is directly proportional to the flux (given a signosiodal current is creating it).

$V_{emf} = I\mu_0 w \left[ln\left(\frac{s+w}{s}\right)\right]$

$V_{pk-pk} = 2A_I \mu_0 w \left[ln\left(\frac{s+w}{s}\right)\right]$

Such a logerithm is approximately similar to $\frac{1}{s}$. the taylor expanstion for $ln\left(\frac{s+w}{s}\right) = -\sum_{k=1}^{\infty} \frac{(-30)^k}{k} \cdot \left(\dfrac{1}{s}\right)^k$

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In more general terms,

the voltage is proportional to the flux,

While still quiet close to the wire we can approximate the wire as a infinte wire of charge

$B = \frac{\mu_0 I}{2\pi} \cdot \frac{1}{s}$

and the flux is just the integral of this over the the area of the small loop.

3.3. e Mutual inductance. $M = k\sqrt{L_1 L_2} = k\sqrt{8.56{\cdot}10{-}7 \times 7.96{\cdot}10{-}9} = k \times 8.25 \times 10^{-8}$

where k is the coupling coefficient, $k \in [0, 1]$, but k will vary with position

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$M(d) = \frac{\psi_{small}}{I_{large}} =$

$I_{large} = 0.192A$ From prelab.

$V_{pk-pk}(d = 0) = 32.6$

$V_{pk-pk}(d = 0.1) = 43.0V$

$V_{pk-pk}(d = 0.2) = 4.4V$

$V_{pk-pk}(d = 0.3) = 1.7V$