A SIMPLE DATA ACQUISITION SYSTEM FOR USE IN THE ELECTRICAL MACHINES LABORATORY

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ABSTRACT: In recent years data acquisition systems have been made a lot more user friendly. It was found that a simple combination of a digital storage oscilloscope, a software package called Anywave[TM] , a personal computer and an interface card was all we needed to do to obtain reasonable results. We applied this system to our electrical machines laboratory.

DATA ACQUISITION SYSTEM: We performed two laboratory experiments using a data acquisition system. The first one is called Faraday's Law[1]. In this experiment we generated voltage by using a simple permanent magnet and a coil. The signal generated is stored in a digital storage oscilloscope, and then transferred to our personal computer via the software package Anywave[3]. See figure 1.
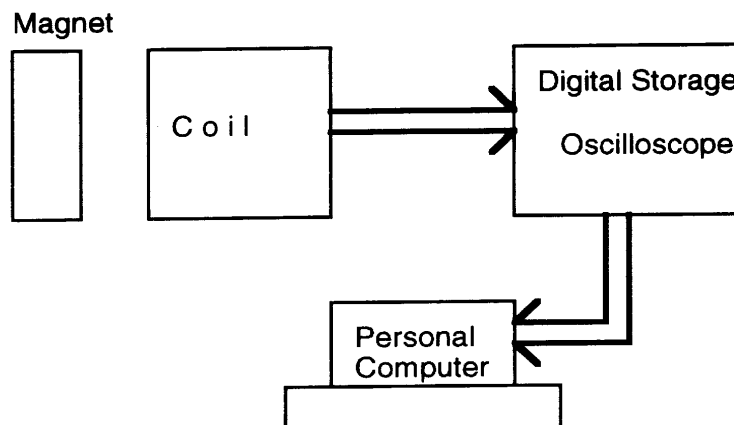

Figure 1. Block diagram for a data acquisition system
used in the Faraday's Law experiment.

The output for this experiment is shown in figure 2. This consists, as expected, of an alternating signal. Observe that this program's output gives a table of information on the right hand. It is important to notice that this output shows the frequency of the signal and automatically scales the X-Y axis.

At this point we introduce the important concept of power generation via Faraday's Law. In figure 3, we show the concept of Fast Fourier Transform (FFT) and its spectrum.

Using the spectrum, we can indicate the harmonics generated, and explain the importance of a clean and smooth sinusoidal signal.
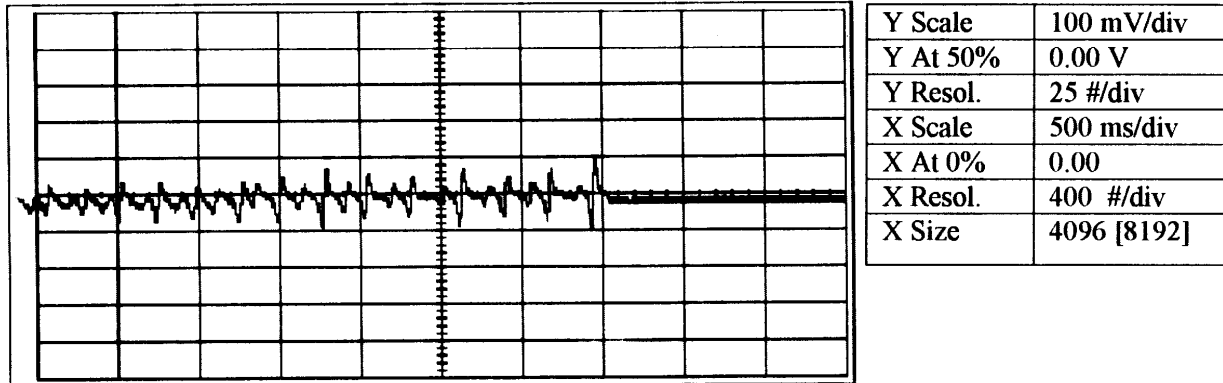
Y Scale	100 mV/div
Y At 50%	0.00 V
Y Resol.	25 #/div
X Scale	500 ms/div
X At 0%	0.00
X Resol.	400 #/div
X Size	4096 [8192]

Figure 2. Personal computer output
for Faraday's Law experiment.

Spectrum: No window, % scale, 80 frequency components

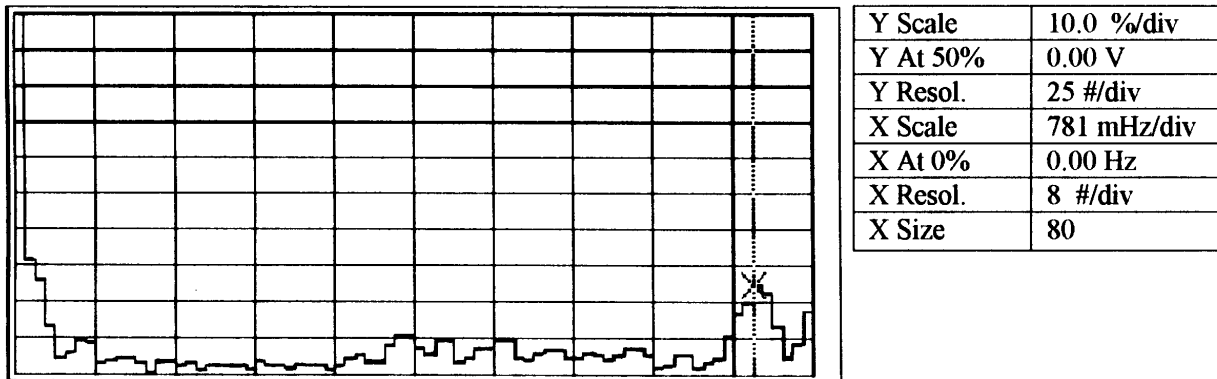| Y Scale	10.0 %/div
Y At 50%	0.00 V
Y Resol.	25 #/div
X Scale	781 mHz/div
X At 0%	0.00 Hz
X Resol.	8 #/div
X Size	80

Figure 3. FFT and Spectrum obtained
in the Faraday's Law Experiment.

The second experiment[1], consists of determining the air core and ferromagnetic hysterisis loop. In this case we generate two alternating signals. One for flux, and the second one for current. Using the basic equation :

$$\phi = \frac{1}{N} \int e dt$$

Where:
ϕ = Flux [Webbers]
e = Voltage induced [V]

N = Turns

Then, we integrate the voltage induced. For current we use Ampere's law:

$$i = H \frac{L}{N}$$

i = Current [A]
H = Magnetic Field Intensity [At/m]
L = Mean length
N = Turns

A block diagram of the layout used for this experiment is shown in figure 4.
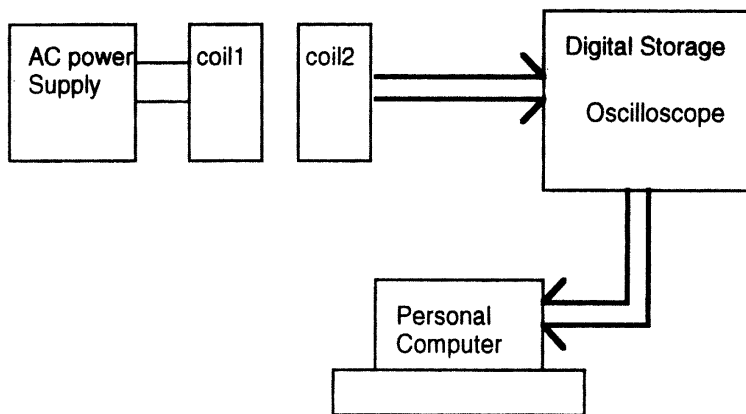

Figure 4. Layout for experiment 2, Air-core
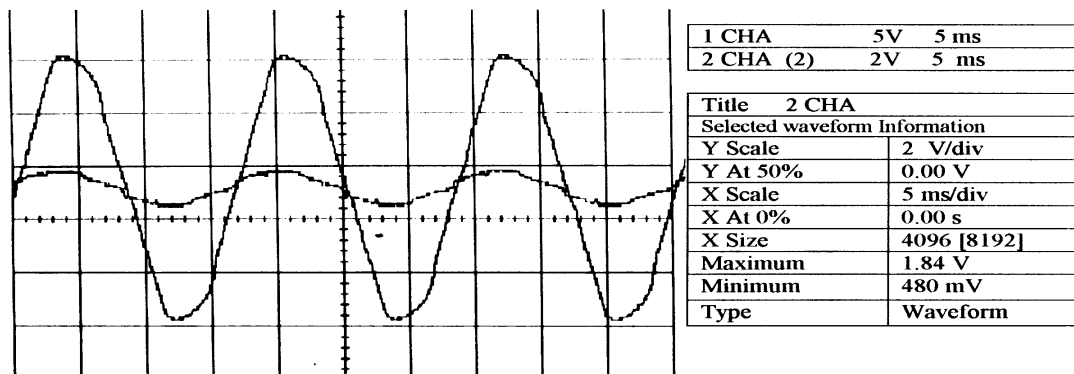and ferromagnetic core hysterisis loops.

1 CHA	5V	5 ms
2 CHA (2)	2V	5 ms

Title 2 CHA	
Selected waveform Information	
Y Scale	2 V/div
Y At 50%	0.00 V
X Scale	5 ms/div
X At 0%	0.00 s
X Size	4096 [8192]
Maximum	1.84 V
Minimum	480 mV
Type	Waveform

Figure 5. Alternating signals obtained
from experiment 2. Air core was used.

Since we can conclude that $\phi \alpha \int e \, dt$, then if we integrate the voltage we should obtain the magnetic flux. Similarly, since $i \, \alpha \, H$, all we need is to measure voltage across a resistor. Now that we have both channels of the oscilloscope ready, we storage the signals in the digital storage oscilloscope and we send them to the personal computer via Anywave. The output for this part is shown in figure 5.

Figure 5 shows no distortion in the signals, therefore the spectrum of the hysterisis loop for an air core coupling has no harmonics. This is due to the fact that:

$$B = \mu_o \, H$$

Where:
B = the magnetic flux density [T]
μ_o = permeability of free air [H/m]
H = magnetic field intensity [At/m]

The hysterisis loop is thought of a B-H curve. Since μ_o is constant then we expect a straight line. In order to have a straight line we must have two perfect sinusoidal curves in phase. Since this is the case as seen in figure 5, the spectrum of the signals contains no harmonics, and therefore no spectrum analysis is necessary.

Figure 6, shows two signals from a ferromagnetic coupling. As it can be seen the current waveform has some distortion, whereas the flux signal remains quite clean in its sinusoidal form. In this case the introduction of a ferromagnetic material causes the distortion due to the fact that μ_r (relative permeability) is present. The magnetic flux density becomes:
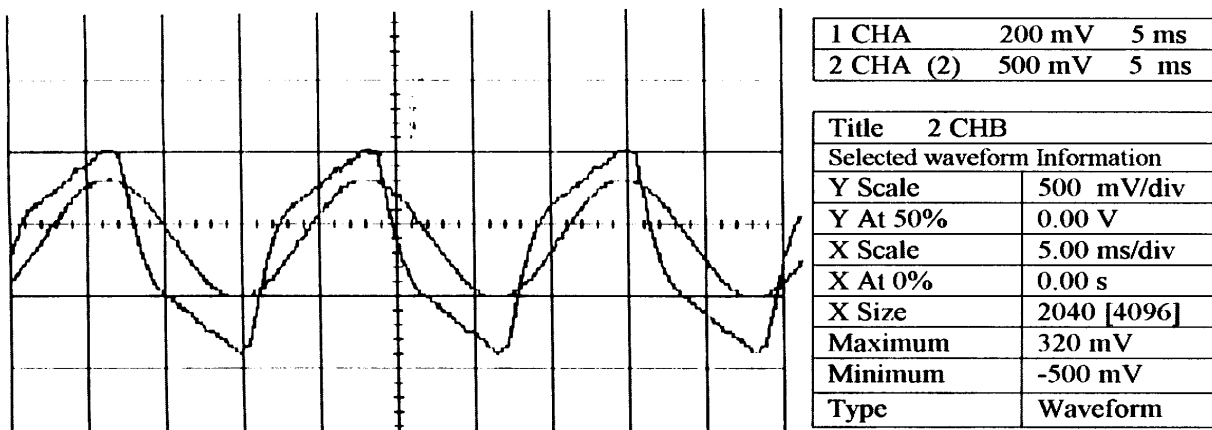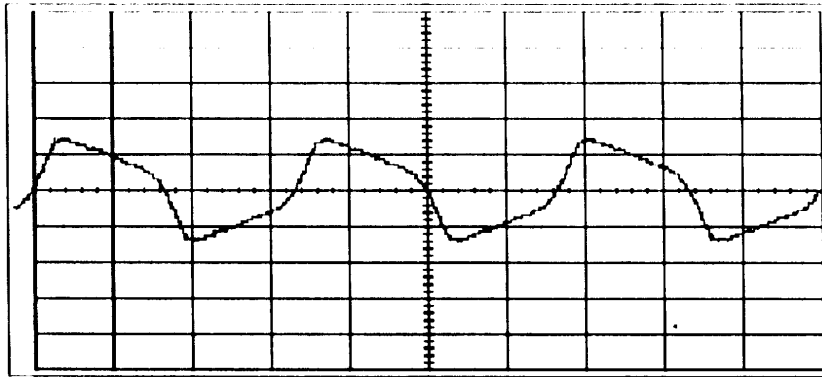
$$B = \mu_o \mu_r \, H \quad [T]$$

1 CHA	200 mV	5 ms
2 CHA (2)	500 mV	5 ms

Title	2 CHB
Selected waveform Information	
Y Scale	500 mV/div
Y At 50%	0.00 V
X Scale	5.00 ms/div
X At 0%	0.00 s
X Size	2040 [4096]
Maximum	320 mV
Minimum	-500 mV
Type	Waveform

Figure 6. Alternating signals obtained for experiment 2.
Ferromagnetic core was used.

Y Scale	200 mV/div
Y At 50%	0.00 V
Y Resol.	25 #/div
X Scale	5.00 ms/div
X At 0%	0.00 s
X Resol.	400 #/div
X Size	4000 [8192]

Figure 7. Distorted current signal for experiment 2.
Ferromagnetic core was used.

In figure 7 we show the classic distorted current signal due to ferromagnetic materials. The spectrum of the distorted signal (current signal) from figure 7, is shown in figure 8. Observe that the highest harmonic is the third as expected.
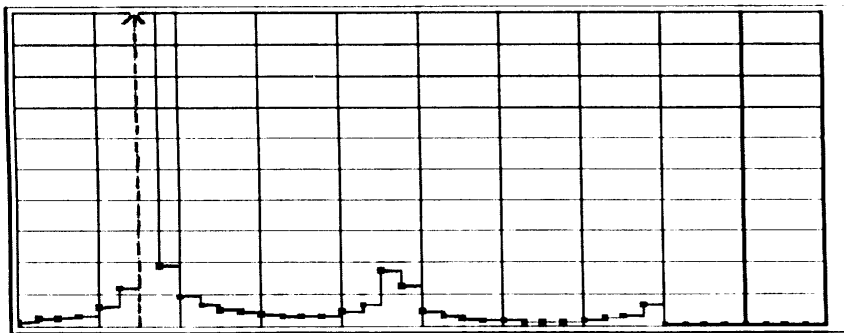
Y Scale	10.0 %/div
Y At 50%	0.00 V
Y Resol.	25 #/div
X Scale	39.1 mHz/div
X At 0%	0.00 Hz
X Resol.	4 #/div
X Size	40

Figure 8. Spectrum of the current signal due
to a ferromagnetic core material.

ANYWAVE[TM]: This software package is part of Labview[TM] [3]. Its cost is under $400.00 for academic use, and it seems to be quite powerful for signal analysis.

We have reduced the operating manual to the basic following steps:

1. Have a handshake between the PC and the Digital Storage Oscilloscope.
2. Go to **DOS** operating system and type: **c:\anywave>anywave** <cr>
3. In the Digital Storage Oscilloscope[5]:
   - Press the **digital memory** button.
   - Press the **INTF** button.
   - Press **RS232.**
   - Press **BAUD**. (suggest 4800).
4. In the personal computer do the following:

- Choose **CONNECT** and click right button.
- Choose **WAVEFORM**.
- Pull down **WAVEFORM** and choose **RECEIVE**.
- Click **OK**.
- Pull down **FILE** and choose **PRINT.**

As it can be seen the manual for ANYWAVE was reduced to thirteen sequential steps. This is the beauty of this data acquisition system.

CONCLUSIONS: It is important to realize that the students that use this equipment are electromechanical option and Electrical Engineering majors with emphasis in electric power systems. Therefore, the students are more interested in the systems use of the Data Acquisition equipment. In other words, the students want to learn the application of the equipment at hand, and understand the concepts of the material. Also, the interest in learning the versatility of the equipment is quite high.

The introduction of high technology into the classroom, especially in electric power systems has been a real success in our program. As we are all aware, deregulation of the power industry has basically killed most of the power systems programs (i.e. there are a few jobs available in the classical power systems areas). Well, at CSUN we have been able to survive and be able to offer two power courses. I believe this is due to the introduction of high technology in the classroom. These courses are Electric Machines and Power Electronics, they are optional and therefore the enrollment is very competitive.

This paper demonstrates that we can introduce state of the art technology into our curriculum, and catch the eye of our students. No doubt these two laboratory experiments in conjunction with some state of the art advances in energy conversion and rotating electric machinery, keep the interest of our students , and help them get jobs in companies that they never thought they could find work.

BIBLIOGRAPHY
[1] Bruno Osorno, "*Electrical Machines Laboratory*". CSUN 1997.
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