NASSAU COMMUNITY COLLEGE
LAB COVER SHEET

Sample Name
ELT115 D1

Date of Experiment: February 5,2002
Date Due: February 14,2002

Experiment Number 2

Partners:
XXXXXXX XXXXX
YYYYYYY YYYYY

Measurements of Capacitors

Instructor: Prof. Wade

Note: this is a sample lab; it is not meant to be perfect and, in some cases, less than optimum presentation methods are used in order to show various options. In many places there are symbols (XXXXX) instead of data or information. In an actual lab real information should be included in these places. Also occasional comments are inserted (in italics) which would not be a part of an actual lab.

Comment: This sample took over 4 hours to type. It would be expected that an actual lab report would take significantly longer.

Objective

In this experiment we will use various test instruments to measure that value of various capacitors. We will also combine some of those capacitors in parallel and serial and see their combined values as well as how charge distributes among capacitors in parallel.

Theory

The general formula for capacitance is:
$C=Q/V$ (Textbook, page XX)

When capacitors are in parallel the same voltage is applied to each so each stores a charge based on its capacitance and the voltage applied. The total charge stored is $Q1 + Q2 + \ldots$ and, since the voltage is the same, the total equivalent capacitance is $C1+ C2 + \ldots$.

When capacitors are in series the current through each must be identical and so the total charge (Q) on each must be the same regardless of their capacitance or the voltage on each. Therefore $C1=Q/V1$, $C2=Q/V2$, $C3=Q/V3$, etc. Or $V1=Q/C1$, $V2=Q/C2$, etc. But $Ct=Q/Vt$ or $Vt=Q/Ct$.
In a series circuit $Vt=V1+V2+\ldots$ Therefore, substituting Q/C for each V:
$Q/Ct=Q/C1 + Q/C2 + Q/C3, \ldots$ and dividing both sides by Q:
$1/Ct=1/C1 + 1/C2 + 1/C3 +\ldots$
which will allow us to calculate the equivalent capacitance of capacitors in series.

If a capacitor is charged to a voltage, then disconnected from the source and connected in parallel to another, identical, capacitor, we expect the charge to be divided equally between them. Since each will have half the charge of the original, we would expect each to have one half the voltage. In the case of connecting to another 2, identical, capacitors, we would expect each to have a voltage one third of the orignial.

Equipment Used:

Test Equipment:
Sencore Z-meter, Model XX, serial # XXXXX
DMM: Fluke model 77, serial # XXX
Analog Meter: Simpson Model 270, serial # XXXX
Capacitance Meter: B & K Precision Model XXX, serial # not available
DC Power Supply, HP model XXX, serial # XXXXX

Capacitors:
.047 μF, Film, manufactured by XXX
.047 μF, Electrolytic, manufactured by XXX
.022 μF, Ceramic, manufactured by unknown
5.0 μF, Film, manufactured by XXX
47 μF, Electrolytic, manufactured by XXX
.033 μF, Silver Mica, manufactured by unknown

Procedure, Results, and Analysis:

Comment: This sample is written in a style that combines the procedure, presentation of results, and the analysis of each result. The classic style of report would have separate sections.

1) We set up to measure the value of each capacitor. First we discharged it by putting a piece of bare wire shorting out the two leads. Then we connected the leads to the leads from the test equipment and measured it. In the case of the Sencore, the test voltage was set to 15V (the other meters did not have a setting for the DC bias voltage).

For results, see table 1 (done on spreadsheet), page 4. The formulas used for all spreadsheet calculations are shown on page 6.

Comment: In this style, it is clearer to insert the data right in the report where is referenced. In the case of a table produced be a different program or hand drawn, it may be inserted as a separate page and clearly referenced.

Analysis of results: as seen in the table the measured values all came very close to the nominal values (10% maximum error). Since the tolerances on the capacitors used were + or - 20%, and the meters have an accuracy of + or - 5%, this is within specifications. The two meters agreed with each other within 6%. This is well within their specified accuracy.

In the case of the qualitative responses of the Simpson and Fluke multi-meters, we note that in all cases the meters indicated a very low resistance and, as the capacitors charged up, ended up reading very high (infinite or overload).

2) We measured the individual values of three 5μF capacitors and then measured them in parallel. We calculated their equivalent capacitance using the measured values of the individual cap's in the formulas from the theory section on a spreadsheet. As shown in table 2, page 4, the calculated values agreed with the measured values within 4%, which is within the error of the meter.

3) We measured the individual values of three 5μF capacitors and then measured them in series. We calculated their equivalent capacitance using the measured values of the individual cap's in the formulas from the theory section on a spreadsheet. As shown in table 2, page 4, the calculated values agreed with the measured values within 3%, which is within the error of the meter.

4) We measured the leakage of each of the capacitors using the Sencore and the Fluke DMM. The Sencore DC bias voltage was set to 15V. The circuit used for the Fluke is shown in figure 1, below.

Data Sheets

Experiment 2 DATA SHEET

Capacitor		Simpson	Fluke	B& K	diff from	Sencore	diff from	diff between
uF	type	response	Response	(uF)	nominal	(uF)	nominal	meters
0.47	film	XXXXX	XXXXXXX	0.46	-2.1%	0.483	2.8%	4.8%
0.47	'lytic	XXXXX	XXXXXXX	0.5	6.4%	0.495	5.3%	-1.0%
0.22	ceramic	XXXXX	XXXXXXX	0.22	0.0%	0.23	4.5%	4.3%
5	film	XXXXX	XXXXXXX	5.1	2.0%	5.13	2.6%	0.6%
47	'lytic	XXXXX	XXXXXXX	51	8.5%	51.9	10.4%	1.7%
0.33	mica	XXXXX	XXXXXXX	0.32	-3.0%	0.34	3.0%	5.9%

Table 1. Results from procedure 1.

Individual		Parallel-procedure 2 (uF)			
(uF)		measured	calculated		% diff
5.14		16	15.4		3.9%
5.06					
5.2					
		Series-procedure 3 (uF)			% diff
		1.76	1.710897121		2.9%

Table 2. Results from procedures 2 and 3.

Capacitor		Fluke (mA)	Sencore (uA)
uF	type	0	0
0.47	film	0	0
0.47	'lytic	0	0
0.22	ceramic	0	0
5	film	0	0
47	'lytic	0	20
0.33	mica	0	0

Table 3. Results from procedure 4.

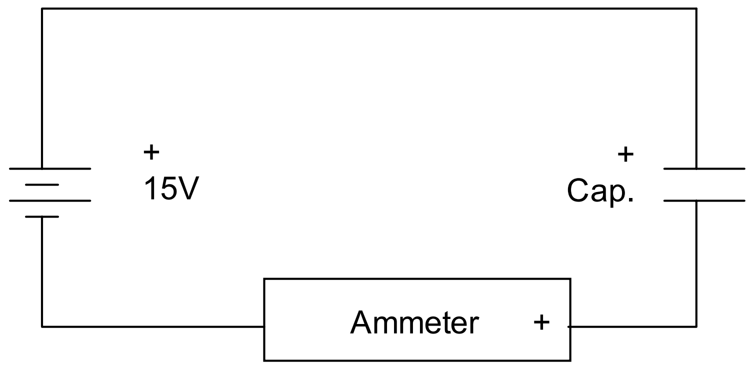

Figure 1. Circuit used in step 4.

The results are shown in table 3, page 4. All of the capacitors except the 47 μF electrolytic had leakage below the 1-microamp resolution of the Sencore. The 20 μA leakage of the 47 μF electrolytic was not visible on Fluke since the smallest reading the Fluke could show was 0.1 mA. Manufacturer's spec's were not available for the capacitors so we cannot compare them with the measurements but it is known that electrolytic capacitors generally have a higher leakage and so it not surprising that the larger electrolytic showed leakage.

5) We attempted to show how charge distributes between parallel capacitors using the same three 5 μF cap's from parts 2 and 3. We first discharged all of them. Then connected one of them (with a voltmeter attached) to a 15V DC power supply to charge it up. We then disconnected the power supply and, as quickly as possible, connected either one or two cap's in parallel to the original one. As discussed in the theory this should result in either 7.5 V over 2 cap's or 5 V over 3 cap's.

One added capacitor (2 in parallel)			
Original voltage (V)	Measured V	Calculated V	% difference
15	7.41	15/2=7.5	-1.2%
Two added capacitors (3 in parallel)			
Original voltage (V)	Measured V	Calculated V	% difference
15	4.84	15/3=5	-3.2%

Table 4, results from step 5.

In both cases our results were very close but slightly lower than the calculated values. I would attribute this to the fact that the capacitor discharged slightly through the voltmeter while we were making the connections. When we left the connections on, we could observe that the voltage continued to drop.

Experiment 2 Data Calculations Shown

Experiment 2 DATA

Capacitor		Simpson	Fluke	B& K	diff from	Sencore	diff from	diff between
uF	type	response	Response	(uF)	nominal	(uF)	nominal	meters
0.47	film	XXXXX	XXXXXXX	0.46	=(E4-A4)/A4	0.483	=(G4-A4)/A4	=(G4-E4)/G4
0.47	'lytic	XXXXX	XXXXXXX	0.5	=(E5-A5)/A5	0.495	=(G5-A5)/A5	=(G5-E5)/G5
0.22	ceramic	XXXXX	XXXXXXX	0.22	=(E6-A6)/A6	0.23	=(G6-A6)/A6	=(G6-E6)/G6
5	film	XXXXX	XXXXXXX	5.1	=(E7-A7)/A7	5.13	=(G7-A7)/A7	=(G7-E7)/G7
47	'lytic	XXXXX	XXXXXXX	51	=(E8-A8)/A8	51.9	=(G8-A8)/A8	=(G8-E8)/G8
0.33	mica	XXXXX	XXXXXXX	0.32	=(E9-A9)/A9	0.34	=(G9-A9)/A9	=(G9-E9)/G9

Table 1. Results from

Individual		Parallel-procedure 2 (uF)			
(uF)		measured	calculated		% diff
5.14		16	=A16+A17+A18		=(C16-D16)/D16
5.06					
5.2					
		Series-procedure 3 (uF)			% diff
		1.76	=1/(1/A16+1/A17+1/A18)		=(C20-D20)/D20

Table 2. Results from

Capacitor		Fluke (mA)	Sencore (uA)
uF	type	0	0
0.47	film	0	0
0.47	'lytic	0	0
0.22	ceramic	0	0
5	film	0	0
47	'lytic	0	20
0.33	mica	0	0

Table 3. Results from

Conclusions

Various meters can directly measure capacitance values but even meters that do not directly measure the value can be used to give a qualitative indication of capacitance.

By direct measurement we have confirmed the formulas for combining capacitors in series and parallel. Also we have observed that a charged capacitor can transfer its charge onto uncharged capacitors.

Comment: following this page should be the signed rough data and then the printed experiment sheet.