ELEC-302-81

Experiment Number 302-101B
Power and Power Factor

February 5, 20[redacted]

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The work contained herein is my own.
I have neither knowingly given nor received any portion of this laboratory report.

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INTRODUCTION

The purpose of this experiment is to theoretically and experimentally determine circuit power and power factor in both series and parallel RLC circuits, and to compare the theoretical and experimentally-determined results.

PROCEDURE

In the following discussion, source voltages are to be considered RMS voltages with a normal power line frequency of 60 Hz. The value of the resistor R and the DC resistance of the inductor L are to be measured manually before power is applied to the circuit. Capacitance and inductance are taken at face value without measurement.

Series Circuit

The series RLC circuit to be analyzed is depicted in Figure 101-1. The circuit is to be analyzed for each of the following three cases:

Case 1: Vs = 65 V, C = 26.4 μF
Case 2: Vs = 60 V, C = 16.6 μF
Case 3: Vs = 85 V, C = 8.8 μF

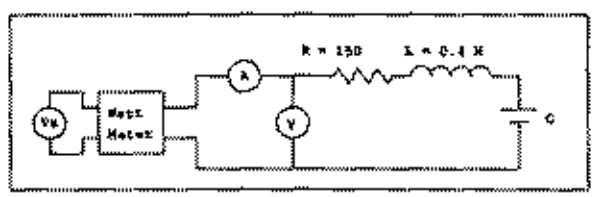

Figure 101-1

Values to be determined and measured are the current I for the circuit and the voltages V_R, V_L and V_C across the resistor, inductor and capacitor. These values, in turn, will be used to calculate the apparent power S, the real power P, and the power factor *pf* of the circuit. The symbols A and V represent ammeter and voltmeter, respectively. The watt meter will be used to measure the power delivered to the circuit.

Parallel Circuit

The parallel RLC circuit to be analyzed is depicted in Figure 101-2. This circuit is to be analyzed for the following three cases:

Case 1: Vs = 40 V, C = 26.4 μF
Case 2: Vs = 60 V, C = 16.6 μF
Case 3: Vs = 60 V, C = 8.8 μF

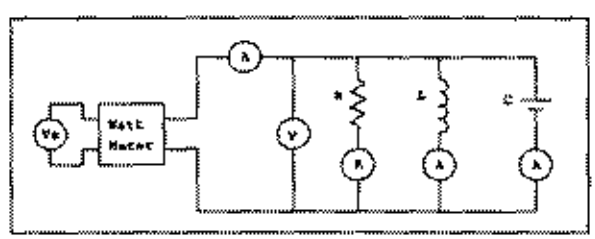

Figure 101-2

The values for R and L are the same as for the series circuit. Values to be determined and measured are the current I for the circuit and the currents I_R, I_L and I_C through the resistor, inductor and capacitor. These values again will be used to calculate the apparent power S, the real power P, and the power factor *pf* of the circuit. As before, the symbols A and V represent ammeter and voltmeter, respectively, and the watt meter will be used to measure the power delivered to the circuit.

RESULTS

The circuits portrayed in Figures 101-1 and -2 were constructed, the appropriate voltages for each case applied, and measurements taken. Before power was applied, the DC resistance of the resistor R was determined to be 152Ω, and the inductor was found to have a DC resistance of 7.3Ω. These values were taken into account in the theoretical calculations. The voltages and currents previously described were measured, the theoretical values calculated, comparisons made, and a percent difference calculated for each measured-calculated pair. These results are presented in tabular form in Appendix 101-A of this document. Field calculations for each case, including phasor diagrams, may be found in Appendix 101-B.

Series Circuit

Referring to the results presented in Appendix 101-A for the series circuit, it may be noted that the measured and theoretical results in Cases 1 and 2 compare very well, differing by less than ±5 percent. The voltage, current and power factor results for Case 3 compare similarly. However, the observed and calculated results for real power P differ by almost 13 percent. As apparent power S was calculated by dividing real power by the power factor (i.e., $S = P/pf$), these results also differ by a similar percentage. It may be that the watt meter should have been re-zeroed before measurements were taken at this point, and that the measurements taken from the watt meter were erroneous.

Parallel Circuit

Referring to the results presented in Appendix 101-A for the parallel circuit, it may be noted that these results do not compare as favorably as those for the series circuit. Indeed, in the worst case, the measured and calculated results for real power P in Case 1 differ by more than 36 percent. It may be noted again that the watt meter perhaps should have been re-zeroed before these measurements were made. Also, due to a procedural error, measurements of the input voltage were taken at the source V_s in Figure 101-2 rather than at the point in the circuit indicated by the voltmeter. If the source voltage V_s and the voltage at the circuit side of the watt meter differed significantly, the resulting currents through the R, L and C components would indeed vary from what would be expected analytically using V_s as the circuit input voltage.

CONCLUSION

In general, the observed values in this experiment corresponded favorably with the analytically-determined values for each case. While differences were noted, no values differed wildly from what would be expected. The observed variations can be attributed to instrument error, components whose values vary with temperature, component values taken at face value rather than measured, and, of course, human error in all its splendid variety. If a lesson may be taken from this experiment, it may be that "the devil is indeed in the details."

Appendix 101-A
Comparison of Theoretical and Measured Values

Series Circuit

		Measured	Calculated	%diff
Case 1	I (mA)	375	389	-3.60%
	VR (volts)	56.3	59.1	-4.74%
	VL (volts)	57.9	58.7	-1.36%
	VC (volts)	38.2	39.1	-2.30%
	P (watts)	24	24.1	-0.41%
	S (VA)	25.5	25.3	0.79%
	pf	0.94	0.95	-1.05%
Case 2	I (mA)	382	377	1.33%
	VR (volts)	55.1	57.3	-3.84%
	VL (volts)	56.7	56.9	-0.35%
	VC (volts)	56	56.8	-1.41%
	P (watts)	23	22.6	1.77%
	S (VA)	23	22.6	1.77%
	pf	1	1	0.00%
Case 3	I (mA)	390	388	0.52%
	VR (volts)	59.5	58.9	1.02%
	VL (volts)	61.1	58.5	4.44%
	VC (volts)	118.9	116.9	1.71%
	P (watts)	27	23.9	12.97%
	S (VA)	37.5	33	13.64%
	pf	0.72	0.73	-1.37%

Parallel Circuit

		Measured	Calculated	%diff
Case 1	IT (mA)	362	307	17.92%
	IR (mA)	285	263	8.37%
	IL (mA)	280	265	5.66%
	IC (mA)	438	398	10.05%
	P (watts)	15	11	36.36%
	S (VA)	15.8	12.3	28.46%
	pf	0.95	0.9	5.56%
Case 2	IT (mA)	459	414	10.87%
	IR (mA)	398	395	0.76%
	IL (mA)	390	397	-1.76%
	IC (mA)	405	398	1.76%
	P (watts)	28.2	24.8	13.71%
	S (VA)	28.2	24.8	13.71%
	pf	1	1	0.00%
Case 3	IT (mA)	496	458	8.30%
	IR (mA)	405	395	2.53%
	IL (mA)	398	397	0.25%
	IC (mA)	215	199	8.04%
	P (watts)	29	24.8	16.94%
	S (VA)	31.9	27.5	16.00%
	pf	0.91	0.9	1.11%