Chapter 17 – Projects

17.1 Introduction

The project description is an overview for the various circuits. Development of details and implementation is left to the designer. Projects can be conducted by an individual or a team of two. 10% will be deducted for each day the project is late up to a maximum of 50%.

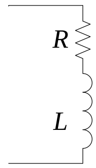
17.2 Project Descriptions

Develop each project. Write a brief discussion of your observations. Provide the circuit, equivalent circuit impedance, and a table of measurements and calculation parameters.

1. Electromagnet

Construct electromagnets using different core designs.
Use magnet wire rather than traditional insulated hook-up wire. Count the turns.
Apply 9 Vdc.

a. Use an air core.
b. Use a ferrous rod, such as a nail.
c. Use a core with a complete path.
d. Place a spacer to slightly separate the complete cores.

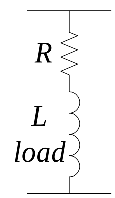


Determine the north and south poles of each magnet and mark the north pole.
Measure the voltage, current, and third parameter.
Calculate the equivalent circuit of the coils.
Count how many paper clips the magnets will pick-up.
There will be a contest to determine who can lift the most paper clips.

To determine the inductance a frequency is applied. This will provide X_L, which can be used to calculate L.

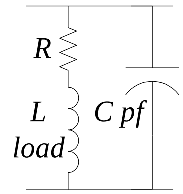
$$X_L = 2\pi fL$$

2. Transmission line and power factor



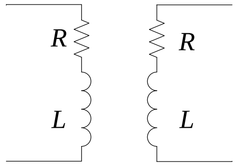
Construct a typical load for a transmission line.
Use a 6 Vac Class 2 transformer for a supply. It is operating at 60 Hz.
Use another Class 2 transformer for the load.
Connect the supply transformer to the instrument system input
Connect the load to the instrument system output.

Measure the voltage, current, and third parameter for each test.
Calculate the equivalent circuit.



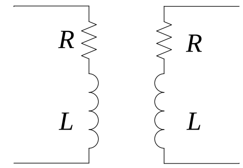
Calculate the capacitance required to correct the power factor to unity. This is at resonance.
Equivalent reactance method should be used. $X_L = X_C$
Connect a capacitor that is near the desired capacitor in shunt across the load transformer.
Measure the voltage, current, and third parameter for each test.
Calculate the equivalent circuit.

3. Transformer construction



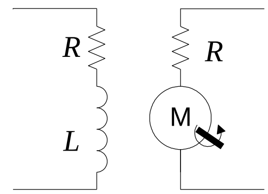
Construct an iron core transformer.
Wind the transformer windings on top of each other.
Count number of turns on the primary and the secondary.
Connect the input to the 12 VA transformer.
Measure the input voltage and current and the output voltage.
Discuss the performance and why.

4. Transformer test



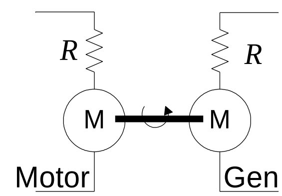
Use a commercial transformer, rated 120 / 6 Vac, at least 10 W, class 2.
Be very careful. 120 Vac is dangerous and can be fatal.
Connect the 120 Vac to a Variac transformer to adjust the voltage.
Make all possible measurements on the low voltage side of the transformer.
Conduct open circuit, short circuit, and near full load tests.
Measure the voltage, current, and third parameter for each test.
Calculate the equivalent circuit.

5. Motor test



Use a commercial direct current motor.
A permanent magnet motor will not have the field connection, since the field is fixed.
Conduct no load and blocked rotor tests.
Measure the voltage, current, and third parameter for each test.
Calculate the equivalent circuit for each test.

6. Motor / generator test

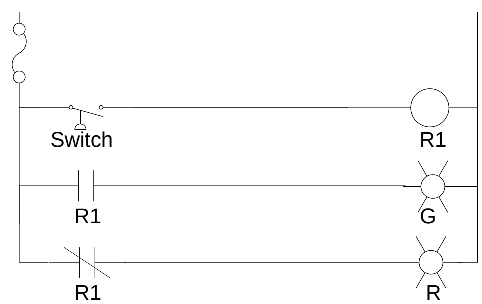


Create a motor generator system by coupling two commercial motor shafts.
Use a power supply for control of the motor.
Vary the applied voltage for lowest (zero) speed to full speed (maximum voltage rating).
Observe the speed change.
Measure the voltage out of the generator for each change in the input voltage.

7. DC motor contest

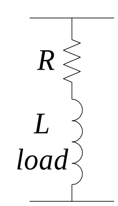
Build a dc motor using any design.
A contest will be conducted based on the criteria provided.

8. Relay logic

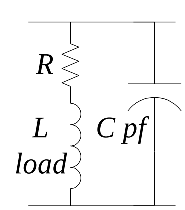


Use an electromechanical relay with a coil rated at 5 Vdc.
Implement a ladder logic control system.
Connect switches as inputs.
Connect LEDs as outputs. Remember to use current limit resistors.
Write the control logic using Boolean algebra, wire the system, and control the system.

9. Antenna tuning



Construct an antenna similar to the transmission line load.
Use a 1 mHy inductor for the load.
Connect it to a variable frequency signal generator, rather than the 60 Hz transformer.
Conduct tests at 1 kHz and 1 Mhz.
As an interesting option, test at 145 Mhz in the 2-meter band.
Measure the voltage, current, and waveform at the frequencies.
Calculate the equivalent circuit.



Calculate the capacitor needed to tune the circuit to 1 kHz, 1 Mhz, and optionally 145 Mhz. This is at resonance.
Resonance frequency method should be used.
Connect the capacitor.

Apply 5 Vdc to the circuit input.
Measure the voltage, current, and waveform at the frequencies.

Calculate the equivalent circuit

10. Wireless integration

Integrate technical principles and practices of electromagnetic machines with communications system.
Complete a project option of your choice and prepare a memo.

11. Buzzer

Construct a buzzer or vibrator that operates from the 12 Vac transformer.
The only requirement is to illustrate the sound. What is the frequency of buzz?
Provide the circuit used.

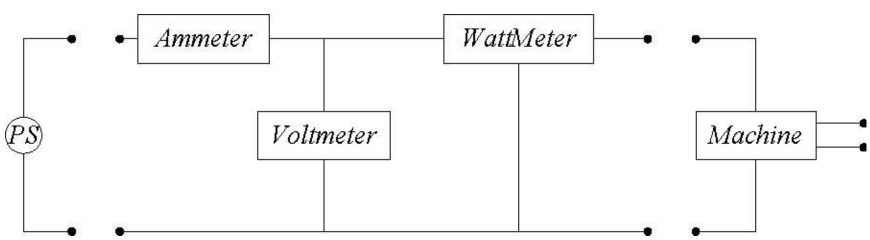
12. Your own custom

Design your own project. It will likely be a variation of one of the other projects.
It can be a transformer, machine, controller, or logic system or combinations of these.
Do not make the project time consuming or complex.
It should take about the same time as the other projects.
Other related topics have interesting potential.

a. Transient protection
b. Induction machine
c. Stepper motor
d. AC controller using triac, scr, or similar.

17.3 Test Connections

The tests on machines are conducted with the following instrumentation connections. The source is a variable voltage such as dc power supply, ac variac or frequency generator that can adjust the voltage into the machine. The ammeter and the wattmeter may have a shunt that is used to bypass excessive current.



Read voltage, current, and a third parameter at each test.
For open circuit tests, connect as shown with no load. Run at rated voltage.
For short circuit tests, short the terminals of the transformer or block the rotor of the machine. Start at low voltage and increase voltage until near rated current.

No load / open circuit test
Set rated voltage, frequency
Read reduced I
I through core / excitation

Blocked Rotor / short circuit test
Reduce V to set I near rated current
Read reduced V
I through rotor

The equivalent circuit is expressed as impedance, Z = R + jX

17.4 Third Parameter

Using the Triad Principle, in addition to voltage and current magnitudes, a third parameter is required to determine a circuit. Traditionally power has been preferred for most tests on larger machines. In some circumstances a power meter is not available so an alternative real value, resistance, is easily recorded.

Resistance may be preferred for small loads with current less than 1 A. For a thorough analysis, resistance should be compensated for temperature and ac skin effect. However, at room temperatures with small wires, this is generally not significant.

The calculation process is very similar. With voltage and current and a real parameter, the phase angle can be calculated. From those three parameters, all other items can be determined.

$$\cos\theta = \frac{P}{V \times I} = \frac{R}{V/I}$$

17.5 Other Relationships

From three measured values, all circuit parameters can be calculated. These can be manipulated in numerous ways. The variety of forms allows considerable creativity in analyzing electrical and magnetic interactions. The trig form is simple.

$$\sin\theta = \frac{Q}{S} = \frac{X}{Z}$$

$$\tan\theta = \frac{Q}{P} = \frac{X}{R}$$

The quadratic form is somewhat more complex.

$$Q = \sqrt{S^2 - P^2} = S\sin\theta = P\tan\theta$$

$$X = \sqrt{Z^2 - R^2} = Z\sin\theta = R\tan\theta$$

The following table contains the items that completely define a circuit. Note the ones that are measured. The remainder are calculated.

Voltage	Current	Angle	App-Power	Power	Reactive	Impedance	Resistance	Reactance
V	I	θ	S	P	Q	Z	R	X

17.6 Parts List

1. Transformer, 120/6 VAC, 8 W, Class 2 (Wall Wart)
2. DC Supply, 120/5 VDC, 8 W, Class 2 (Wall Wart)
3. Motor, dc small permanent magnet field, 5 VDC armature
4. Relay, electromagnetic, 5 VDC, SPDT
5. Resistor, 150 Ohm, 1 W
6. Inductor, 1 mHy
7. Capacitor, 0.25 mfd
8. Capacitor, 0.001 mfd
9. Wire, magnet
10. Wire, hook-up
11. Nail
12. Magnetic core
13. LED's and current limiting resistor

17.7 Example

An exemplar is typical or representative of a system. The example illustrates the third parameter relationship for angles.

Situation:

V=4, I=2, R=1.5

Calculate S, Z

$$S = V \times I = 4 \times 2 = 8$$

$$Z = V/I = 4/2 = 2$$

Calculate P

$$P = I^2 R = 2^2 \times 1.5 = 6$$

Calculate angle:

$$\cos\theta = \frac{R}{V/I} = \frac{1.5}{2} = 0.75$$

$$\cos\theta = \frac{P}{V \times I} = \frac{6}{8} = 0.75$$

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