PE 22

Three Phase AC Generator

(*Updated 03 Dec 2009*)

A Practical Exercise Name:_________________ Section: _____________

I. Purpose.

1. Introduce AC generator operations.
2. Introduce 3-Phase Wye-to-Delta AC circuits.

II. Equipment.

Agilent 34401A Digital Multimeter (DMM)
Oscilloscope
Hampden DC Machine
Hampden Synchronous Machine
Hampden load panel
Digital contact tachometer

III. Pre-lab Calculations: None.

IV. Preparation.

This practical exercise will utilize deadly combinations of voltage potential and currents. Review your safety brief.

V. Lab Procedure. Time Required: 40 minutes. Check off each step as you complete it.

Step One: Prime Mover

Before we build the circuit we must first ground the Hampden DC Machine and the Hampden Synchronous Machine.

☐ Connect both grounding points on the Hampden DC Machine and the Hampden Synchronous Machine to a ground point on the Hampden control panel. The ground points are the green terminals located on one side of both input panels of the Hampden DC Machine and the Hampden Synchronous Machine.

In this practical exercise we will use the Hampden DC Machine (DC motor) as the prime mover to rotate the Hampden Synchronous Machine (AC generator).

☐ Ensure that the DC motor and the AC generator are attached to each other and secured to their mounts.

Recall that the Hampden DC machine uses an electromagnet not permanent magnet in its stator to create a magnetic field across its rotor. We will create a “permanent” magnet field by applying DC voltage from the laboratory bench excitation supply (Figure 1) across the stator’s field windings (Figure 1).

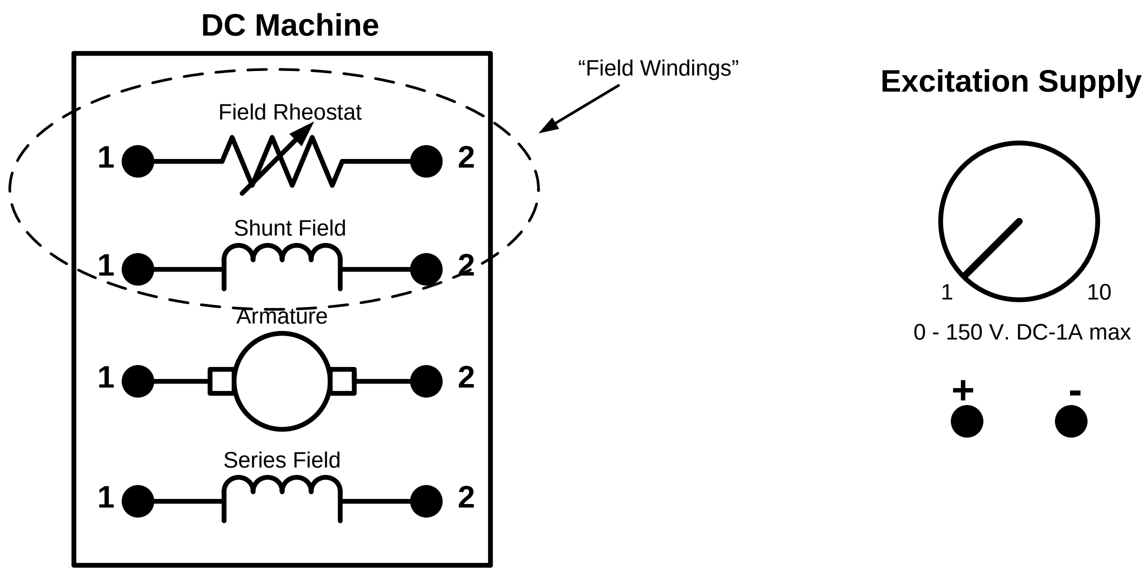

Figure 1

☐ Connect the Field Rheostat and the Shunt Field in series (Figure 2).

☐ Connect the excitation supply to the "Field Windings" (Figure 2).

☐ Rotate the Excitation Supply knob (Figure 2) to the full counter-clockwise position (off).

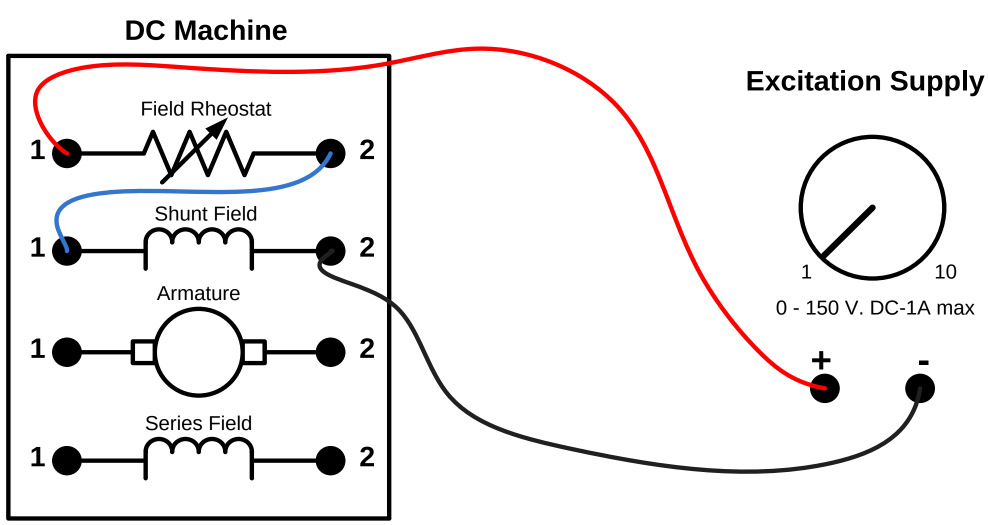

Figure 2

☐ Turn the field rheostat knob that is located on top of the DC Machine input panel to the full counter-clockwise position, then rotate the knob approximately ¼ turn clockwise.

DC motors require DC current to be applied across the DC motor's armature loops (rotor) via the commutator.

☐ Connect the DC machine's armature (Figure 3) to the Variable DC Supply on the lab bench.

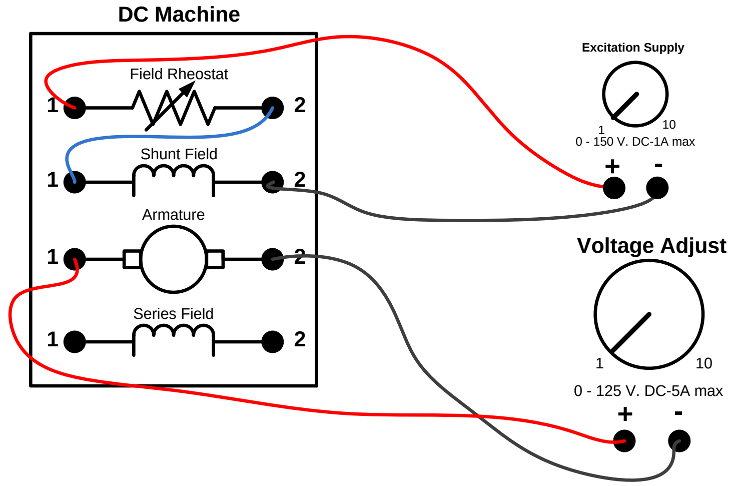

Figure 3

☐ Rotate the Variable DC Supply knob to the full counter-clockwise position (off).

Step Two: AC Generator

Similar to the Hampden DC machine, the Hampden Synchronous Machine (AC generator) uses an electromagnet (not a permanent magnet) in its rotor to create a magnetic field across its stator. In this practical exercise we will create a "permanent" magnet field by applying DC voltage from the laboratory bench excitation supply (Figure 4) across the rotor's field windings (Figure 4).

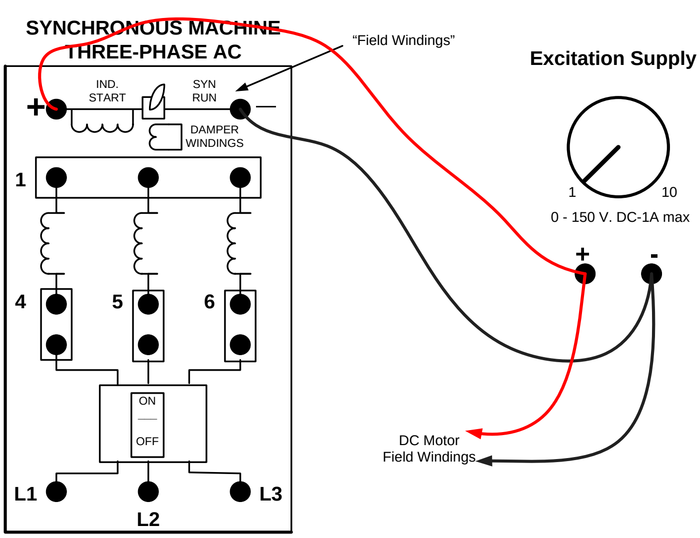

Figure 4

☐ Connect Excitation Supply (Figure 4) to synchronous machine "field windings".

☐ Ensure that the toggle switch on the field windings is toggled to "SYN RUN".

These Hampden Synchronous Machines have three separate armature windings that are 120 degrees apart and are "Y" connected. Terminal 1 is the common connection for all three armature windings (neutral), and terminals 4 or L1, 5 or L2, and 6 or L3 are the AC generator output terminals. See Figure 5.

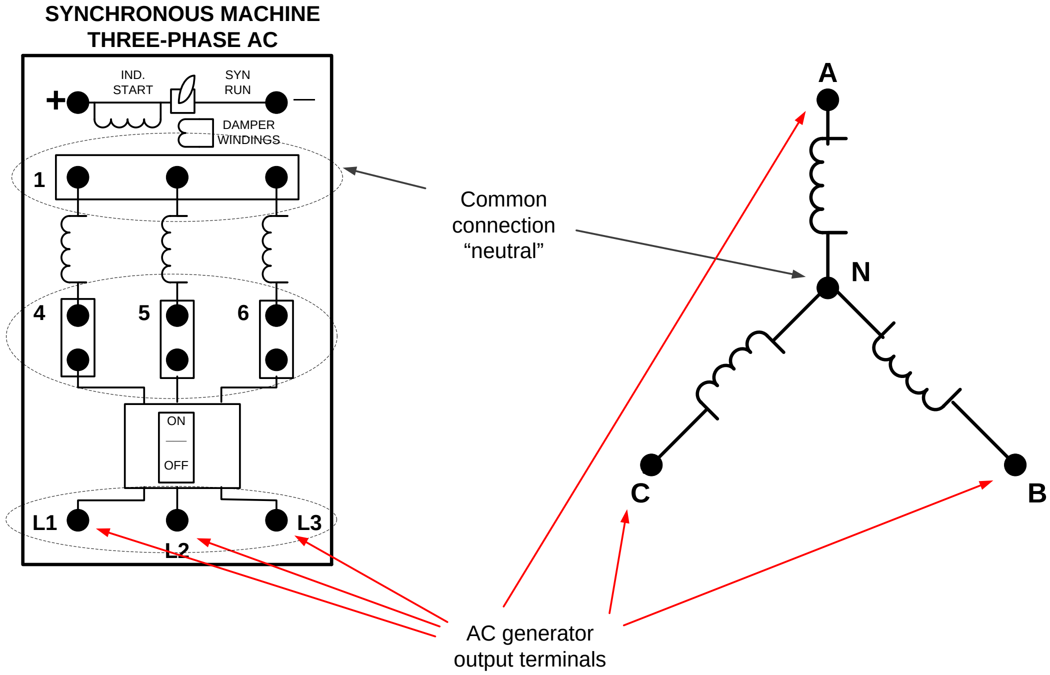

Figure 5

Step Three: Construct a 3 Phase Delta connected load (Figure 6).

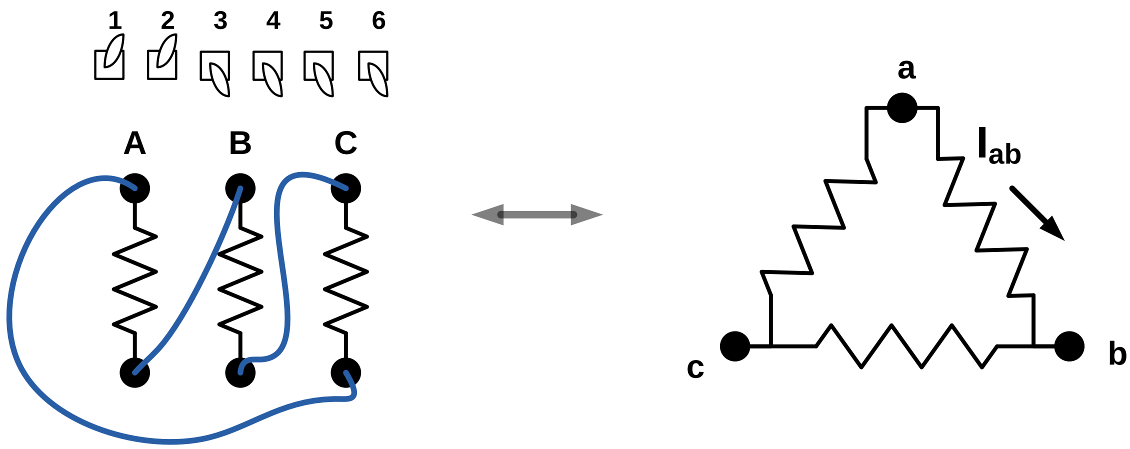

Figure 6

☐ Construct a Delta-connected load by connecting the neutral points of the resistor loads "A", "B", and "C" to the appropriate resistor load RED / BLUE / BLACK connections (Figure 6).

☐ Adjust your load by toggling up load switches 1 and 2, and toggling down load switches 3 through 6. This will create two 2000 ohm resistors in parallel on each branch.

Step Four: Construct a three phase Wye to Delta AC circuit (Figure 7).

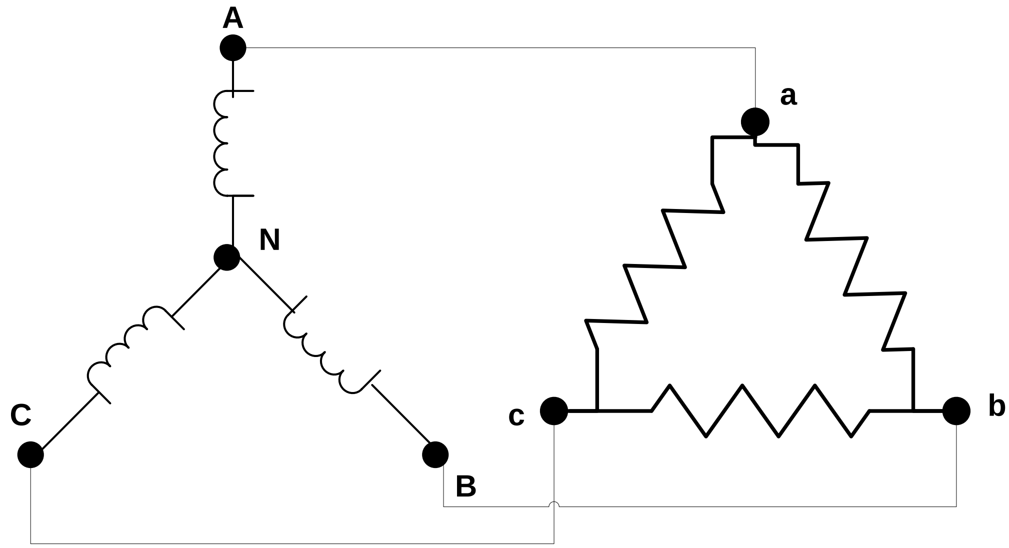

Figure 7

☐ Construct a three phase Wye-to-Delta AC circuit by connecting the AC generator outputs to their respective resistor load leads (RED / BLUE / BLACK – see Figure 8). Connect phase A output via the DMM (set to AAC) to phase a on the resistor load panel, so that it measures the line current, $\mathbf{I_A}$.

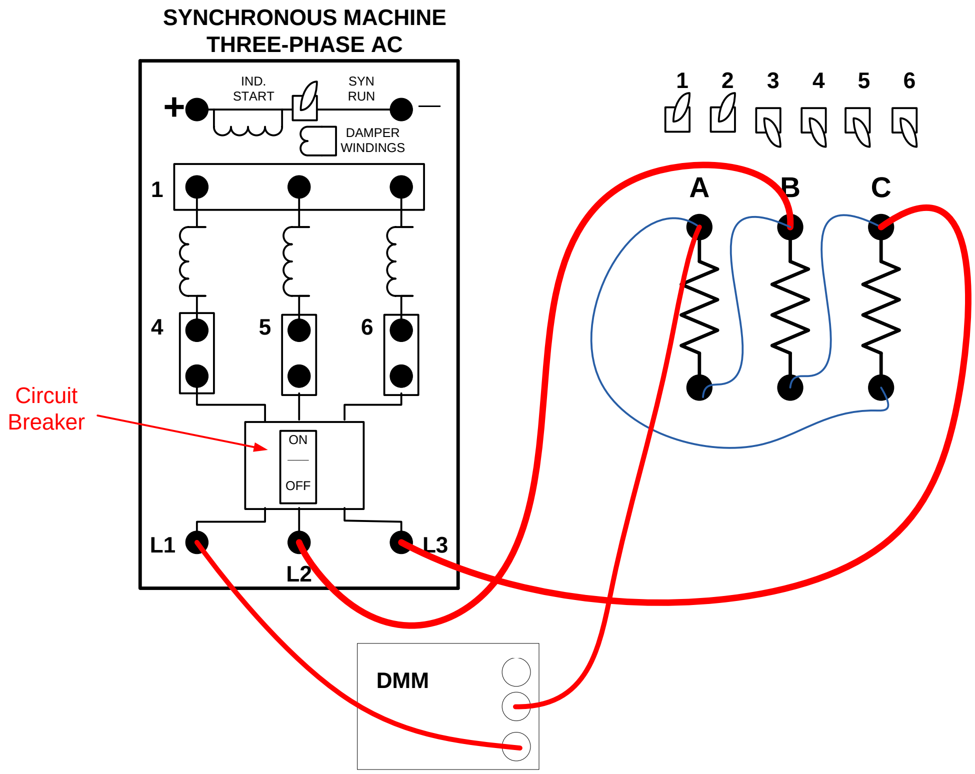

Figure 8

☐ Ensure that the circuit breaker on the AC generator panel is "ON" (Figure 8).

☐ Using the probes, connect your oscilloscope so that it will measure the voltage across $\mathbf{E_{NA}}$ and $\mathbf{E_{BA}}$ (Figure 9).

- ☐ CH 1's probe must be connected to the neutral point (position 1 on the Hampden synchronous machine) and CH 1's alligator clip must be connected to the terminal end of phase "A" (position 4 on the Hampden synchronous machine).
- ☐ CH 2's probe must be connected to the terminal end of phase "B" (position 5 on the Hampden synchronous machine) and CH 2's alligator clip must be connected to the terminal end of phase "A" (position 4 on the Hampden synchronous machine).

☐ **Verify that the oscilloscope is set to the "10X" setting:** Press and release the CH 1 button on the oscilloscope. Use the appropriate soft button to set the "Probe" setting for CH 1 to "10X" if it is not already so. Repeat this process for CH 2.

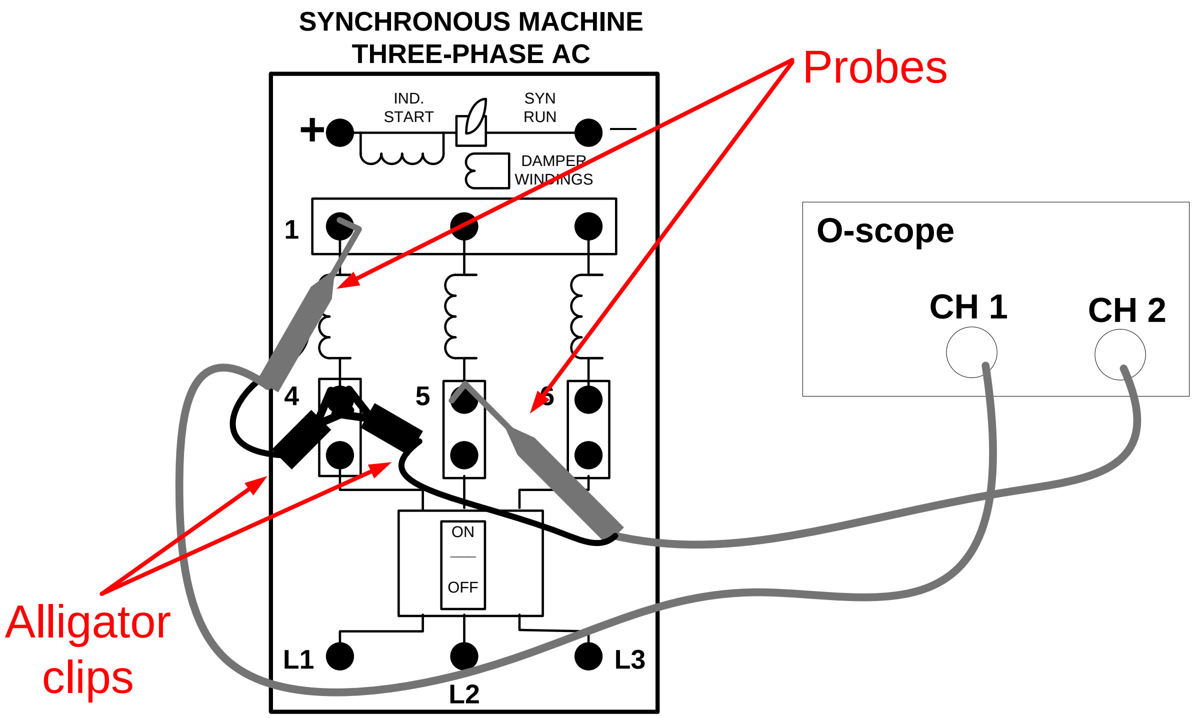

Figure 9

Step Five: Verify circuit and generate AC power.

☐ Have an instructor verify your circuit, and then unlock the power supply.

☐ Turn on the MAIN AC power supply switch.

☐ Turn on the EXCITATION SUPPLY power switch.

☐ Set the DC voltage to the field windings by rotating the Excitation Supply knob to the number "2" position.

☐ Turn on the VARIABLE OUTPUT power switch.

☐ Slowly rotate the VOLTAGE ADJUST knob clockwise until it indicates just above the 2 position.

☐ While observing the frequency output on your oscilloscope, slowly adjust the VOLTAGE ADJUST knob until your oscilloscope indicates 30 Hz (T = 33.33 ms). You may rotate the field rheostat knob on top of the DC Machine input panel to fine tune your oscilloscope to 30 Hz (T = 33.33 ms).

☐ Use a Digital Contact Tachometer to measure the RPM of your AC generator.

AC Generator RPM ___________

How many poles do these Hampden AC Synchronous Machines have?

# of Poles ___________

Step Six: Measurements

☐ Use your oscilloscope to determine the phasors, $\mathbf{E_{AN}}$ and $\mathbf{E_{AB}}$. Use $\mathbf{E_{AN}}$ as the reference phasor. Express your answer in polar form.

$\mathbf{E_{AN}}$ = _______∠ 0° ______

$\mathbf{E_{AB}}$ = _______∠______

Does $\mathbf{E_{AB}}$ lead $\mathbf{E_{AN}}$ by 30 degrees?

Exact__________ **Very close**__________ **Very Different**_________

Is $\mathbf{E_{AB}}$ $\sqrt{3}$ times larger than $\mathbf{E_{AN}}$?

Exact__________ **Very close**__________ **Very Different**_________

☐ Use your DMM to determine the magnitude of the line current $\mathbf{I_A}$.

$\mathbf{I_A}$ = _______________

☐ Use Ohm's Law to determine the phase current $\mathbf{I_{ab}}$. Express your answer in polar form.

$\mathbf{I_{ab}}$ = ________∠_______

☐ Convert your determined phase current $\mathbf{I_{ab}}$ to the line current $\mathbf{I_{A}}$. Express your answer in polar form.

$\mathbf{I_{A}}$ = ________∠_______

How does the magnitude of this calculated $\mathbf{I_{A}}$ compare to your measured $\mathbf{I_{A}}$?

Exact__________ Very close__________ Very Different_________

To avoid runaways, ensure that you power down the DC motor in the following sequence.

☐ Rotate the VOLTAGE ADJUST knob to the full counter-clockwise position (off).

☐ Turn off the VARIABLE OUTPUT power switch.

☐ Rotate the EXCITATION SUPPLY knob to the full counter-clockwise position (off).

☐ Turn off the EXCITATION SUPPLY power switch.

☐ Turn off the MAIN AC power switch.