# ELEC 302-81
# Lab 5
# Motor Torque, Speed, Losses, and Efficiency

March 1, 2013

| | |
|---|---|
| Date Performed: | February 25, 2013 |
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| Instructor: | Dr. Weatherford |

# 1 Purpose of Experiment

The purpose of this experiment was to observe the basic principals of balanced three-phase transformer circuits. Y–Y and Y–$\Delta$ connected transformer banks were constructed separately to observe any differences, particularly in their respective loads. Primary and secondary voltages, currents, and powers were first calculated, and then actual measurements were gathered to compare.

# 2 Procedure

## 2.1 EMS Workstation Set-up

At the Lab-Volt EMS workstation, the DAI 24-V supply was turned on, and the DAI USB connector was connected between the EMS workstation and the PC. On the LVDAM EMS application software, the metering windows for $E_1$, $E_2$, $I_1$, $I_2$, $P_1$, $3\phi$ power, $E_3$, $I_3$, and $E_1 + E_2 + E_3$ were opened. Under *Options* $\rightarrow$ *Acquisition Settings*, the *Sample Window* dialog box was set to extended, and under *View*, the continuous refresh option was checked.

## 2.2 Prime Mover Operation

The circuit represented by Figure 4 was constructed. The main power switch was set to ON and the voltage control knob adjusted to 120-V line-to-line. Both the installed analog EMS voltmeter and the metering window were monitored for proper indications. The line voltages were then measured and recorded in Table **??**. The main power switch was set to OFF and the voltage control knob turned fully CCW. The circuit represented by Figure 5 was constructed. The main power switch was set to ON and the voltage supply was adjusted to read 120-V line-to-line. The installed analog EMS voltmeter was used for this since the 120-V were to be measured across voltage sources 4–5 only. The phase voltages were then measured and recorded in Table **??**. The main power switch was set to OFF and the voltage control knob turned fully CCW.

## 2.3 Dynamometer Operation

The circuit represented by Figure **??** was constructed. The Y-connected load was $(600 + j300)\Omega$. The main power switch was set to ON, and the voltage control knob adjusted to 120-V line-to-line. Both the installed analog EMS voltmeter and the metering window were monitored for correct voltage. The values for primary and secondary line voltages, primary and secondary line currents, and primary input power were measured and recorded in Table **??**. A Fluke multimeter was used to measure the RMS voltage across the load, $E_4$, and recorded in Table **??**. The main power switch was set to OFF and the voltage control knob turned fully CCW.

### 2.4 Motor Losses and Efficiency

The circuit represented by Figure ?? was constructed. The Y-connected load was (600 + j300)Ω. The main power switch was set to ON, and the voltage control knob adjusted to 120-V line-to-line. Both the analog EMS voltmeter and the metering window were monitored for correct voltage. The values for primary and secondary line voltage, primary and secondary line current, and primary input power were measured and recorded in Table ??. A Fluke multimeter was used to measure the RMS voltage across the load, $E_4$, and recorded in Table ??. The main power switch was set to OFF and the voltage control knob turned fully CCW.

## 3 Results

### 3.1 Prime Mover Operation

| **Voltage** | **Speed** | | **Direction** | **Friction** | **Torque** |
|---|---|---|---|---|---|
| $E_1$ V | $n$ rpm | $N$ rpm | CW/CCW | $T_f$ N-m | $T$ N-m |
| 30.10 | 503.0 | 509.6 | CW | -0.18 | -1.60 |
| -30.19 | -508.0 | -513.0 | CCW | — | — |

Table 1:

| **Voltage** | **Torque** | **Speed** |
|---|---|---|
| $E_1$ V | $T$ N-m | $n$ rpm |
| 0.04 | 0 | 0.43 |
| 18.84 | -0.15 | 308.54 |
| 35.60 | -0.17 | 607.85 |
| 53.00 | -0.18 | 913.84 |
| 70.23 | -0.19 | 1220.52 |
| 86.02 | -0.20 | 1502.90 |
| 102.99 | -0.21 | 1807.37 |
| 119.92 | -0.22 | 2107.53 |

Table 2:

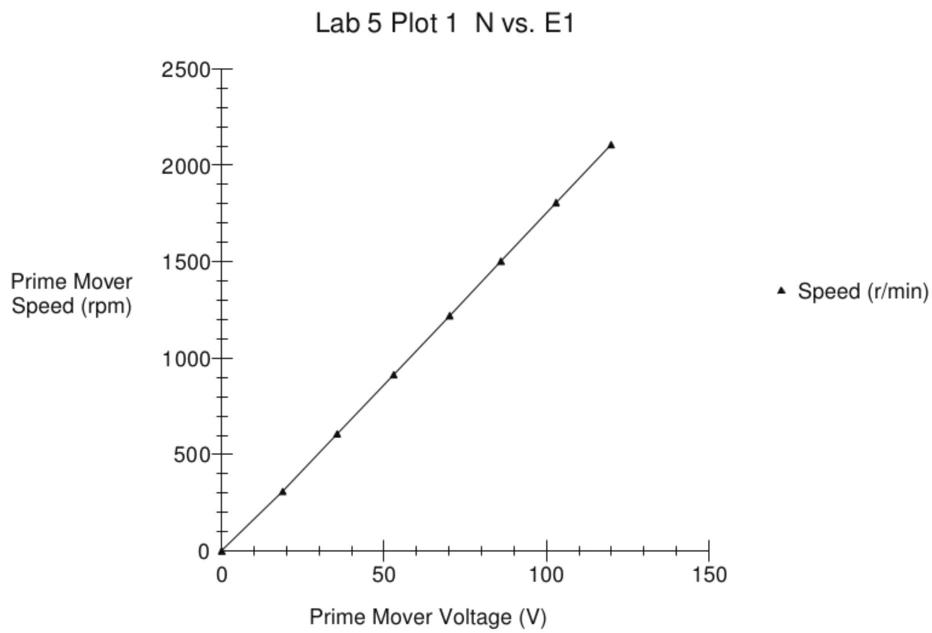


Figure 1:

## 3.2 Dynamometer Operation

| $n$ rpm | $T_{DYN}$ N-m | $T_{PM}$ N-m | $T_{NC}$ N-m | $T_C$ N-m |
|---|---|---|---|---|
| 1500 | 0 | -0.66 | — | — |
| 1500 | 2.0 | -2.26 | 1.76 | 2.33 |

Table 3:

## 3.3 Motor Losses and Efficiency

| | Input | | | Output | | |
|---|---|---|---|---|---|---|
| **Voltage** | **Current** | **Electrical Power** | **Torque** | **Speed** | **Mechanical Power** | **Efficiency** |
| $E_1$ V | $I_1$ I | $PQS_1$ W | $T$ N-m | $N$ rpm | $P_m$ W | $A$ $\eta$ |
| 88.71 | 0.94 | 89.90 | 0.32 | 1525.44 | 51.03 | 56.76 |
| 87.42 | 1.25 | 116.22 | 0.48 | 1474.08 | 74.44 | 64.05 |
| 86.08 | 1.58 | 144.32 | 0.67 | 1436.68 | 100.54 | 69.67 |
| 84.88 | 2.02 | 180.53 | 0.90 | 1394.14 | 131.70 | 72.96 |
| 83.98 | 2.40 | 210.73 | 1.11 | 1362.04 | 158.61 | 75.27 |
| 83.21 | 2.77 | 239.24 | 1.31 | 1340.72 | 183.39 | 76.65 |
| 82.42 | 3.13 | 267.18 | 1.50 | 1309.10 | 205.88 | 77.06 |
| 81.67 | 3.53 | 297.42 | 1.71 | 1273.63 | 227.89 | 76.62 |
| 81.01 | 3.90 | 325.22 | 1.92 | 1256.24 | 252.54 | 77.65 |
| 80.34 | 4.24 | 349.83 | 2.08 | 1232.10 | 268.29 | 76.69 |
| 79.57 | 4.64 | 379.02 | 2.30 | 1208.88 | 291.42 | 76.89 |

Table 4:

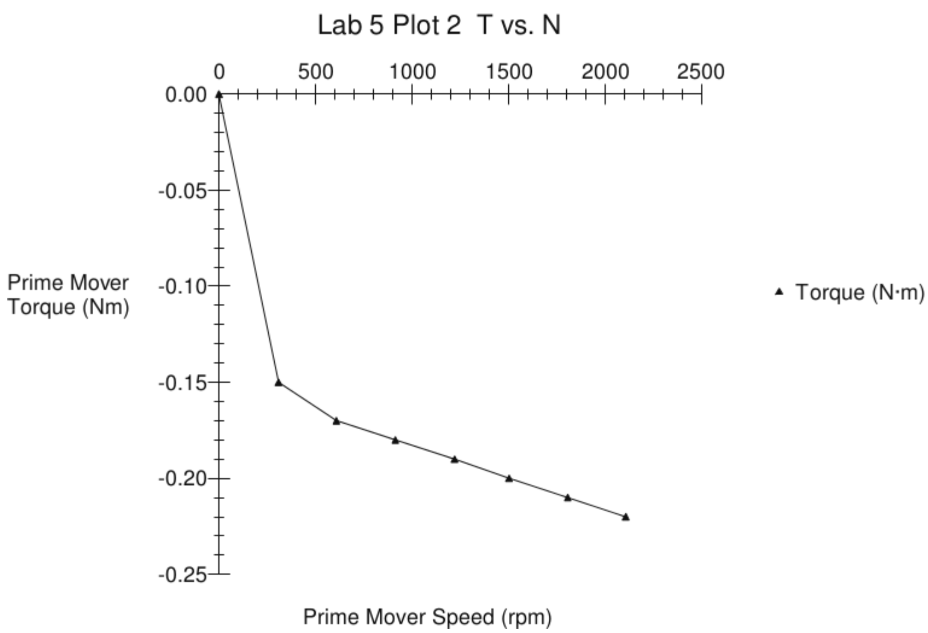


Figure 2:

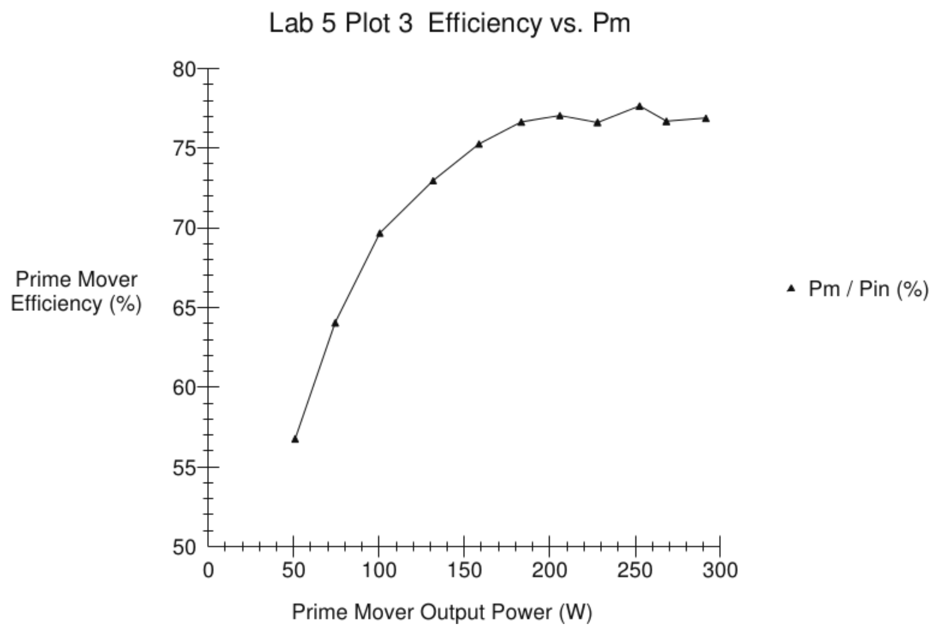


Figure 3:

# 4 Conclusions

The line and phase voltages of the source were measured in part 1. In Figure 4, the three source voltages are in a Δ-connection, and hence the voltage values for each phase are the same as the supply line-voltage. When the voltages are added, they approximate 0-V due to Kirchoff's voltage law. In Figure 5, the three source voltages are in a Y-connection, and hence the voltage values for each phase are $\frac{1}{\sqrt{3}}$ times the line voltage of 120-V. When the voltages are added, they approximate 0-V, since the connection is assumed to be balanced. When the Phasor Analyzer was analyzed on the PC, it was confirmed that the phasors were equal with 120 degrees phase shift for both the line and phase voltage measurements. The fact that the addition of the phasors was not exactly zero is most likely due to the fact that the voltage values measured were not exactly equal to each other.

# Equations

$$P_{mech} = (n \cdot T)\left(\frac{60}{2\pi}\right)$$

## Circuits Tested

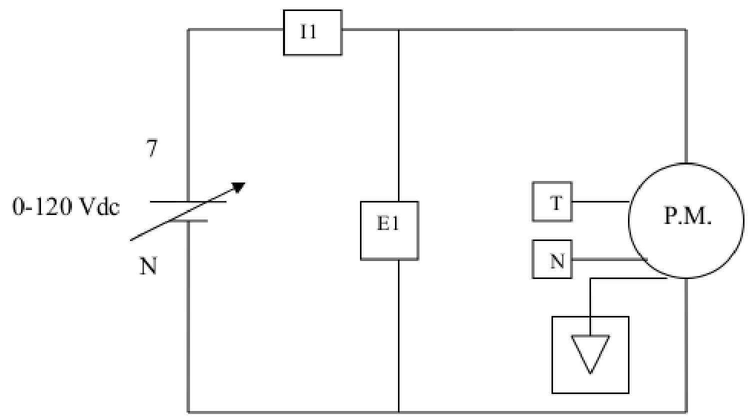


Figure 4: Prime Mover Circuit

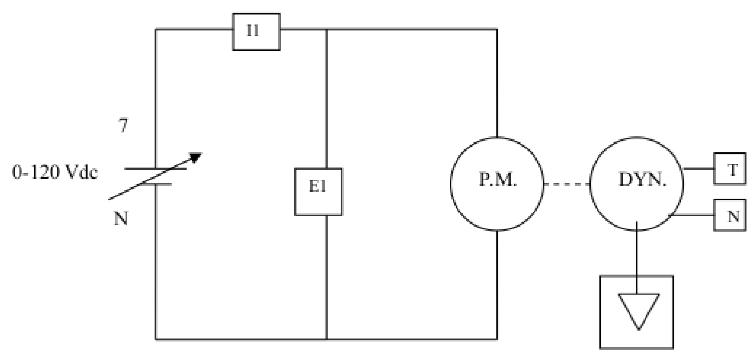


Figure 5: Prime Mover Circuit