

## ECE471 INDUSTRIAL POWER SYSTEMS Homework Set 2

1. Design the feeder for MCC1 on the class example. The loads on the feeder are: 76 kVA @ 0.8 lag, plus 30 hp, 5 hp, and 50 hp motors each 0.8 lag and 80% efficiency. All loads are 480 V, 3 $\phi$ .

Apply 25% margin to largest motor and the motor load becomes:

$$\text{hp} = 1.25 \times 50 + 30 + 5 = 97.5$$

$$I_{\text{motors}} = \frac{97.5 \times 746}{\sqrt{3} \times 480 \times 0.8 \times 0.8} = 136.7 \text{ A}$$

The lighting load requires 25% margin since it is continuous.

$$I_{\text{LTG}} = \frac{1.25 \times 76 \times 10^3}{\sqrt{3} \times 480} = 114.3 \text{ A}$$

The total current is:  $I_{\text{MCC1}} = 136.7 + 114.3 = 251 \text{ A}$

Since  $I_{\text{LTG}}$  is less than half the total load, the neutral does not have to count as a current-carrying conductor.

From table 11.1, using THWN (75<sup>0</sup> C) this requires 250 MCM Cu for the conductors.

When sizing the conduit, the neutral does have to be counted; so for 4 x 250 MCM the required conduit size is 2.5"

2. Design the feeder for MCC2 on the class example. The loads on the feeder are: 99 kVA @ 0.8 lag, plus 2 hp, 5 hp, 30 hp and 100 hp motors each 0.8 lag and 80% efficiency. All loads are 480 V, 3 $\phi$ .

Apply 25% margin to largest motor and the motor load becomes:

$$\text{hp} = 1.25 \times 100 + 30 + 5 = 162$$

$$I_{\text{motors}} = \frac{162 \times 746}{\sqrt{3} \times 480 \times 0.8 \times 0.8} = 227.1 \text{ A}$$

The lighting load requires 25% margin since it is continuous.

$$I_{\text{LTG}} = \frac{1.25 \times 99 \times 10^3}{\sqrt{3} \times 480} = 148.9 \text{ A}$$

The total current is:  $I_{\text{MCC2}} = 227.1 + 148.9 = 376 \text{ A}$

Since  $I_{\text{LTG}}$  is less than half the total load, the neutral does not have to count as a current-carrying conductor.

From table 11.1, using THWN (75<sup>0</sup> C) this requires 500 MCM Cu for the conductors.

When sizing the conduit, the neutral does have to be counted; so for 4 x 500 MCM the required conduit size is 3.5"

3. Specify the cable and conduit size for the following feeder (you may need to consider paralleling conductors.)
- Continuous load is 268 kW @ 0.9 lag pf.
  - More than 50% of the load produces significant 3<sup>rd</sup> harmonics.
  - Supply is 480 V, three-phase, four-wire.
  - Feeder length is 235 ft.
  - Available fault current is 39 kA, symmetrical.
  - Feeder overcurrent protection is molded-case CB.
  - Maximum allowable voltage regulation is 2%.
  - Conductors are XHHW (90<sup>0</sup>C) copper in steel conduit.

Show all calculations needed to satisfy all 3 criteria for specifying the feeder.

For Ampacity the load requires 25% margin since it is continuous.

$$I_{\text{Load}} = \frac{268 \times 10^3}{\sqrt{3} \times 480 \times 0.9} = 358.2 \text{ A} \quad 1.25 \times I_{\text{Load}} = 447.7 \text{ A}$$

More than 50% of the load produces significant 3<sup>rd</sup> harmonics so the neutral has to count as the 4<sup>th</sup> conductor. This requires 80% de-rating.

$$\text{Ampacity} = \frac{447.7}{0.8} = 559.6 \text{ A}$$

For a single circuit this requires 900 MCM, which is too large so 2 parallel circuits of 250 MCM are required.

For Short-Circuit level  $I_{\text{ASY}} = K_0 \times I_{\text{SYM}}$ , where  $K_0 = 1.3$  for Low-Voltage Circuit Breaker.

$$A = \frac{1.3 \times 39 \times \sqrt{0.0333}}{71.95 \times 10^{-3}} = 128.7 \text{ MCM}$$

Table 19.4 shows this is in between 1/0 and 2/0

∴ the smallest acceptable gauge is 2/0, which is smaller than the ampacity.

The maximum allowable VR is 2% i.e.  $0.02 \times 480 = 9.6 \text{ V}$  (line).

$$\text{This is: } VR = \frac{9.6}{\sqrt{3}} = 5.54 \text{ V (line to neutral)}$$

Circuit current =  $0.5 \times 358.2 = 179.1 \text{ A}$ . (Note we need to use **actual** current/conductor)

Feeder ampere-feet =  $179.1 \times 235 = 42,085 \text{ AF}$

$$\text{Maximum voltage drop/1000AF} = \frac{5.54}{42.1} = 0.132 \text{ V}$$

For magnetic conduit, 0.9 lag pf, column 3 of table 19.6 indicates the conductor size is between 1/0 and 2/0, which are also smaller than the ampacity.

∴ The feeder designation is: 2½" C, 2 x 4 wire - 250 MCM, XHHW (Cu)