Minimum CT Accuracy Class Requirement for the SEL-710 Slip-Dependent Thermal Model

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INTRODUCTION

The standard SEL-710 Motor Protection Relay thermal model uses a constant rotor resistance during motor starting, which may overestimate the heat building up in the motor during starting. The SEL-710 slip-dependent thermal model is an improvement over the standard thermal model because it takes into account that the actual rotor resistance is being reduced as the motor slip improves during the starting sequence [1]. Taking this into account provides the thermal model in the relay more accurate rotor resistance data to estimate the heat building up in the motor. To use the slip-dependent model, the user must enter the full-load slip (FLS) and the locked rotor torque (LRQ) settings, which are located on the motor data sheet. When the slip-dependent thermal model is used, the relay calculates the slip and rotor resistance based on motor impedances measured from the current transformer (CT) and potential transformer (PT) signals connected to the relay. The relay then uses this calculated rotor resistance in the thermal model to estimate the heat loss in the motor.

PROBLEM

In order to calculate the correct motor impedance, the SEL-710 thermal model needs unsaturated CT currents. In other words, if the CTs are not sized correctly, the relay may trip during a normal start or require a longer waiting period to allow a consecutive start due to the overestimation of heat built up in the motor thermal model. Getting unsaturated CT currents to the SEL-710 Relay implies that the CTs must have at least a relay accuracy class rating. Metering CTs will not work reliably when the slip-dependent thermal model is being used.

SEL SOLUTION

The following formula is used to calculate the relay minimum accuracy class for the CT that will be used with the SEL-710 Relay set for the slip-dependent thermal model. The formula assumes a locked rotor X/R ratio of 15, which is typical of a motor. Also, standing remnant flux has not been considered [2].

$$\text{C Rating} > 80 \bullet \text{Zc} \bullet \frac{\text{LRA}}{\text{CT Rating}}$$

where:

Zc = One-way CT burden in ohms (include CT winding resistance)

LRA = Motor locked rotor amperes in primary amperes

CT Rating = CT rating in primary amperes

Typical C ratings are C100, C200, C400, and C800, but C10, C20, and C50 can also be used.

EXAMPLE CALCULATION

A 75/5 window CT with 0.0020 Ω per turn is at the breaker of a motor with an LRA of 323 A. The CT circuit one-way impedance is 0.025 Ω.

$$\text{C Rating} > 80 \bullet \left(0.025 + 0.0020 \bullet 15\right) \bullet \frac{323}{75} = 19$$

Thus, a C20 CT will work for this application.

REFERENCES

[1] P. Whatley, M. Lanier, L. Underwood, and S. Zocholl, “Enhanced Motor Protection With the Slip-Dependent Thermal Model: A Case Study,” proceedings of the 61st Annual Conference for Protective Relay Engineers, College Station, TX, April 2008. Available: http://www.selinc.com.

[2] G. Benmouyal, J. Roberts, and S. Zocholl, “Selecting CTs to Optimize Relay Performance,” proceedings of the 23rd Annual Western Protective Relay Conference, Spokane, WA, October 1996. Available: http://www.selinc.com.

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