ABB **Application Note**

Substation Automation and Protection Division

Calculation of Settings for Loss-of-Field Protection Using the Circuit-Shield™ Type 32R Relay, Catalog Series 437W and 437G

Introduction

A single-phase Type-32R Reverse Power Relay is frequently applied as a Loss-of-Field Relay in small generator applications. The relay is connected in such a way so that it measures Reverse VARS. This is more economical compared to applying the more sophisticated impedance measuring relay, Type 40.

Upon loss-of-field, a synchronous generator will run as an induction machine, taking significant VARS from the system. Under this operating condition the rotor will overheat, and if the var deficiency can not be supplied by other generators on the system, instability and loss of synchronism can result.

The calculations given below are based upon the use of a Catalog Series 437W or 437G relay. The appropriate connections for Reverse Var Detection are given in Figure 4, page 9 of Instruction Book 7.8.1.7-1 Issue C. When the Type 32R relay is connected as shown, it will measure single-phase VARS per the formula SPHVARS = $V_{9\text{-}10}$ * $I_{1\text{-}2}$ * cos A, where the subscripts refer to the input terminals of the relay, and A is the angle between the current and voltage. Then, the front panel pickup setting which is labelled as Watts, will actually be VARS in this application.

Calculation

The minimum VAR flow into the terminals of the generator upon complete loss of excitation is based on the Synchronous Reactance of the machine, X_d . The actual VAR flow will be equal or greater than the VARS calculated from X_d depending on the loading of the machine just prior to the loss of excitation.

The following parameters are required to do the settings calculation:

Synchronous Reactance, X_d in percent.
Generator KVA Rating, KVA   CT Ratio, CTR
Generator Voltage Rating, KV   VT Ratio, VTR

For our example, we will use:

X_d = 180 %   KVA = 2000   KV = 4.8   CTR = 300:5 = 60:1   VTR = 40:1

The required calculation is shown below in bold type, with the results for our sample problem given in standard typeface.

Calculation Procedure and Sample Problem:

a) **Minimum 3 phase VAR flow = KVA / (X_d/100)** = 2000/(180/100) = 1110 **KVAR**

b) **Current into Relay Terminals 1-2 at Minimum 3ph VAR Flow =**
KVAR / (1.732 * KV * CTR) = 1110 / (1.732 * 4.8 * 60) = 2.22 amps

c) **Voltage at Relay Terminals 9-10 at Nominal System Voltage =**
KV * 1000 / VTR = 4.8 * 1000 / 40 = 120 volts

d) **Single-phase VARS measured by the relay = $I_{1\text{-}2}$ * $V_{9\text{-}10}$ * Cos A**

A is 90 degrees for this application, so Cos A = 1.0

SPVARS = 2.22 amps * 120 volts = 266 vars at nominal system voltage.

e) **Relay pickup dial setting:**

Set the dial of the Type 32R to 50% of the value calculated in Step d).

Dial Setting = 266 * 0.5 = 133 watts.

More sensitive settings are commonly used based on availability of ranges on the Type 32R, and the user's past practice; and then will provide operation on both underexcitation and complete loss of field.

f) **Relay time delay setting:**

A setting of 1 second would be appropriate for loss of excitation protection.

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