Type SOQ
Negative Sequence
Time Overcurrent
Relay

For Protection of Rotating Machinery
Device Number : 46

April 1998
Supersedes DB 41-178S
dated August 1991
Mailed to: E.D, C/41-100B
APPLICATION

The SOQ negative sequence time overcurrent relay is used to protect rotating machinery against excessive heating damage because of prolonged current unbalance.

The relay is suitable for use with directly or indirectly-cooled turbine generators, synchronous condensers, or any rotating machinery having a known $I_2^2t$ limit.

An alarm feature in the SOQ relay alerts an operator to an abnormal $I_2$ level in the machine being monitored. This feature can be set from 0.03 to 0.20 per unit.

The relay is also equipped with the provision for remote indication of per unit $I_2$ level flowing in the machine. Using this option an operator can estimate the severity of the unbalanced loading and take appropriate action.

Settings of the SOQ relay are compatible with ANSI standard requirements for $I_2^2t$ limits for generators, covering the range from 2 to 40. The relay has per unit adjustment allowing it to be related to the full load current of the machine. The $I_2$ trip pickup can be independently adjusted from 0.1 to 1.0 per unit, thus allowing time delayed tripping to occur at any $I_2$ level above this point.

The exponential resetting action of the SOQ relay's timer has been made compatible with that of air-cooled and hydrogen turbine generators.

Figure 1. System application Diagram of the SOQ Relay

Device Number Chart

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>Negative sequence</td>
</tr>
<tr>
<td></td>
<td>Generator relay type SOQ</td>
</tr>
<tr>
<td>ICS</td>
<td>Indicating Contactor</td>
</tr>
<tr>
<td></td>
<td>Switch in SOQ relay</td>
</tr>
<tr>
<td>52</td>
<td>Power circuit breaker</td>
</tr>
<tr>
<td>a</td>
<td>Breaker auxiliary contact</td>
</tr>
<tr>
<td>TC</td>
<td>Breaker trip coil</td>
</tr>
</tbody>
</table>
Printed Circuit Boards - slide into position and engage into a terminal block at the rear of the relay. The boards and terminal blocks are notched preventing insertion into the wrong position. Each board may be removed and used in conjunction with an extender board (Style No. 644B315G02) permitting access to test points and terminals while the relay is energized.

(A) Input Board
(B) Timer Board
(C) Control Board
(D) Power Supply Board

Panel & Dial Plate - contains the ten-turn potentiometer used for the K-setting and the single-turn potentiometer to set the trip pickup level. The panel also contains three (3) light-emitting diodes for timer-on, trip and alarm condition indication. A pushbutton is utilized to reset the timer and its associate LED. This function is used primarily for routine relay testing.

Output Contacts - A telephone type relay is provided with two Type A contacts. One of the normally open contacts is used with the target seal in unit when tripping. There are also two normally open contact (N.O.C.) reed relays, one mounted on the Power Supply Board and the other on the Control Board, used for the alarm and oscillograph start function respectively.

Indicating Contactor Switch - The dc indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes the moving contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

Remote Readout Instrument (Optional) - may be provided to allow monitoring the negative sequence current (I2) level at a remote location. The instrument provided is a Weshler switchboard type KX-241 (4 1/2", 250° scale, 1% accuracy). It is a 1 mA dc instrument marked to represent 0.2 per unit at full scale.
Fig. 2 Internal Logic Diagram

Fig. 3. Internal Schematic
Component | Description
--- | ---
T1 | TRANSFORMER
T2 | TRANSFORMER
R1 | RESISTOR (500 40W)
P1 | POT (10K)
P2 | POT (10K)
LED | RED
PB | PUSH BUTTON
SOQ | TELEPHONE RELAY
ICS | ICS (0.2 - 2.0 A)
METER | METER (IMA)
Operation

The SOQ relay internally simulates a generator's characteristics, \( I_2t = K \) where:

\[ I_2 = \text{negative sequence current per unit} \]
\[ t = \text{duration of unbalanced operation} \]
\[ K = \text{machine constant} \]

Within the SOQ relay, \( t = \) the time delay for tripping.

For a detailed description of the relays operation see Instruction Leaflet 41-161.1.

Settings

The relay requires the following settings to assure correct operating results:

A) Per Unit- choose the setting nearest to, but less than the full load current of the machine converted to relay amperes. For hydrogen cooled machines, this setting should be related to the capability of the machine for the particular hydrogen pressure involved.

B) K-Setting-chosen to correspond to the \( I_2t \) limit for the particular machine being protected. These are typically:

<table>
<thead>
<tr>
<th>Type of Machine</th>
<th>( I_2t = K )</th>
<th>Dial Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salient Pole</td>
<td>40</td>
<td>860.7</td>
</tr>
<tr>
<td>Synchronous Condenser</td>
<td>30</td>
<td>718.5</td>
</tr>
<tr>
<td>Cylindrical Rotor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirectly Cooled</td>
<td>30</td>
<td>718.5</td>
</tr>
<tr>
<td>Directly Cooled (or less)</td>
<td>10</td>
<td>330.3</td>
</tr>
</tbody>
</table>

C) Trip-pickup level- should the lowest \( I_2 \) level at which tripping will be permitted. A reasonable level to consider would be that level of sustained \( I_2 \) to produce tripping at 250 seconds.

This would be \( I_2 = \sqrt{\frac{k}{250}} \) For example if \( K \) were 10 for the protected machine, the level would be adjusted for

\[ I_2 = \sqrt{\frac{10}{250}} = 0.2 \text{ per unit.} \]

D) Alarm Level- should be set at the lowest level consistent with normal load unbalance but in no case greater than the maximum continuous \( I_2 \) level for the machine. Typical values for generators are:

<table>
<thead>
<tr>
<th>Type of Machine</th>
<th>Permissible ( I_2 ) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salient Pole</td>
<td></td>
</tr>
<tr>
<td>with connected amortisseur windings</td>
<td>10</td>
</tr>
<tr>
<td>with nonconnected amortisseur windings</td>
<td>5</td>
</tr>
<tr>
<td>Cylindrical Rotor</td>
<td></td>
</tr>
<tr>
<td>Indirectly cooled</td>
<td>10</td>
</tr>
<tr>
<td>Directly cooled</td>
<td></td>
</tr>
<tr>
<td>0 to 960 MVA</td>
<td>8</td>
</tr>
<tr>
<td>961 to 1200 MVA</td>
<td>6</td>
</tr>
<tr>
<td>1201 to 1500 MVA</td>
<td>5</td>
</tr>
</tbody>
</table>

For a machine with a continuous \( I_2 \) capability of 10%, a reasonable alarm level setting is 0.05 (that is, 5%).

E) Timer- within the SOQ has an inverse resetting characteristic similar to that of typical generators to allow for any cumulative effects which may, for example, take place during reclosing.
Overcurrent, Negative Sequence, Three Phase (Device Number: 46)

<table>
<thead>
<tr>
<th>Type and Contacts</th>
<th>Application</th>
<th>Neutral Location</th>
<th>Indicating Contactor</th>
<th>Time Unit Current</th>
<th>Circuit Control</th>
<th>Relay Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Switch †</td>
<td></td>
<td></td>
<td>Internal Style Case Size</td>
</tr>
<tr>
<td>SOQ</td>
<td>Generator</td>
<td>……</td>
<td>0.2/20</td>
<td>2-40 (1/1)</td>
<td>48-125</td>
<td>1334D69 1333D85A01 FT-32</td>
</tr>
<tr>
<td></td>
<td>Protection</td>
<td>amp dc</td>
<td></td>
<td></td>
<td></td>
<td>1333D85A02 †</td>
</tr>
</tbody>
</table>

† ICS Indicating contactor Switch (dc current operated) having seal-in contacts and indicating target which are actuated when the ICS coil is energized at or above pickup current setting. Suitable for dc control voltages up to and including 250 volts dc. Two current ranges available:
(1) 0.2/2.0 amps dc, with tapped coil
(2) 1.0 amp dc, without taps

Rating of ICS unit used in specific types of relays is shown in price tables. All other ratings must be negotiated.

When ac current is necessary in a control trip circuit, the ICS unit can be replaced by an ACS unit.

The ACS unit may be supplied in place of an ICS unit at no additional cost. Specify system voltage rating on order.

† Includes remote monitor negative sequence current type KX241.
CHARACTERISTICS

Ambient Temperature  
-20° to +55°C

Current Transformer  
Continuous rating - 10 amperes

One second rating - 300 amperes

Constant K Setting  
2 to 40 - 2%

Current Range Setting  
2 to 5 amperes per unit with 0.25 amperes per step

Operating Time  
0.2 to 50 seconds - 5%

50 to 250 seconds - 10%

Timer Start Pickup  
0.1 to 1.0 per unit - 5%

Alarm Pickup  
0.03 to 0.2 per unit - 5%

Alarm Time Delay  
2 seconds - 25%

Initial Disable Trip Time  
0.2 second - 10%

Final Trip Time  
250 second - 10%

Reset Exponential Time  
Constant 38 or 80 seconds - 10%

Frequency Response  
No response to 57 Hz. positive sequence current at 5 amperes

DC Power Supply  
48/125 Volts

DC Current Drain  
0.17 ampere (max.)

Burden (ac)  
1.6 volt-ampere (max.) at 5 amperes and 60 Hz.

Indicating Contactor Switch (ICS)  
0.2/2 amperes

Contact Rating:  
1. Trip contacts with ICS - 30 amperes at 250 volts dc for 0.2 second.

2. Trip contacts (telephone relay) - 0.1 ampere at 125 Vdc.

3. Alarm contacts (reed relay) - 0.1 ampere at 125 Vdc.

4. Oscillograph start (reed relay) - 0.1 ampere at 125 Vdc.

Further Information

List Prices: PL 41-020

Technical Date: TD 41-025

Instructions: IL 41-161.2

Flexitest Case Dimensions: DB 41-076

Other Protective Relays: Application Selector Guide TD 41-016