Assume Impedance = X \omega.

In zero sequence network = 3 \times \omega

(\therefore \text{ all zero sequence currents are in phase}) I_a = I_b = I_c

Pu. current = \frac{300 \times 1000A}{\sqrt{3} \times 13.8} = 4183.7 A

10 A = \frac{10}{4183.7 A} = 0.0024 pu
EXAMPLE

\[ I_A = \frac{3 \times (1)}{(0.273 + 3x)} \]

\[ 3x = 3 / 0.0024 - 0.273 \text{pu} \]

\[ x = 416.57 \text{ pu} \]

\[ R \approx (400 - 500) \text{pu} \]

\[ \text{Bar. L} = \frac{(13.8)^2}{100} = 1.9 \Omega \]

\[ 2400 \text{ V} \]

\[ \text{Resistance} = 8 \Omega \]
always applicable. Therefore, mandatory for on-load and off-load systems.

Figure 8.2 Typical protection for a direct-connected generator (1) trips for

Generator Protection

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The basic principles of the protection were covered in Section 6.2. If the system is multi-generator and has neutral points, the ground fault current will flow through the neutral point and the generator. If the system is single-generator and has no neutral point, the ground fault current will flow through the neutral point and the generator. If the system is single-generator and has neutral point, the ground fault current will flow through the neutral point and the generator. If the system is multi-generator and has neutral points, the ground fault current will flow through the neutral point and the generator.

Figure 8.6 Differential Protection for Multi-Generators with Neutral Grounded.
CT RATIOS/MISOPERATIONS

Page 6.7

Typical differential (B) connections for the protection of the
wye-wye and wye-connected generators (c) & delta-
connected generator (d) depicted.

Figures 6.7 to 6.9 for all.

Generator units with flux sum

For the 87g function


Chapter 6
TURN TO TURN FAULT

C800

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CONTINUOUS UNBALANCE CURRENT CAPABILITY

A generator shall be capable of withstanding, without injury, the effects of a continuous current unbalance corresponding to a negative-phase-sequence current \( I_2 \) of the following values, providing the rated kVA is not exceeded and the maximum current does not exceed 105 percent of rated current in any phase. (Negative-phase-sequence current is expressed as a percentage of rated stator current).

**Type of Generator**

- **Salient Pole**
  - With connected amortisseur windings: 10
  - With non-connected amortisseur windings: 5

- **Cylindrical Rotor**
  - Indirectly cooled: 10
  - Directly cooled:
    - 960 MVA: 8
    - 961 to 1200 MVA: 6
    - 1201 to 1500 MVA: 5

These values also express the negative-phase-sequence current capability at reduced generator kVA capabilities.

UNBALANCED FAULT CAPABILITY

Negative sequence current is expressed in per unit of rated current and time in seconds.

**Type of Generator**

- **Salient pole generator**
- **Synchronous condenser**
- **Cylindrical rotor generators**
  - Indirectly cooled: 20
  - Directly cooled (0.8-800 MVA): 10
  - Directly cooled (101-1600 MVA): see curve below

![Diagram](image)

**Fig 4.5.2-1**
Continuous and Short-Time Unbalanced Current Capability of Generators
(from ANSI C50.13-1977 [1])
current may be above relay pickup and the magnitudes of the harmonics may not be sufficient to provide adequate restraint.

Three approaches have been used to prevent such operations. One approach uses a volts/Hz relay to block tripping of or to desensitize the transformer differential relay when the volts/Hz exceeds a specified level.

The second approach uses a modified differential scheme which extracts and utilizes a third harmonic exciting current from the transformer delta winding to restrain the relay from operating during an overexcitation condition. It should be recognized that the first two approaches somewhat degrade the differential protection.

The third approach utilizes a differential relay that restrains on the fifth harmonic as well as the second harmonic. The fifth is the lowest harmonic flowing from the delta windings under balanced conditions.

4.5.4.4 Tripping. This protector is generally connected to trip the main generator breaker(s) and the field breaker(s) and transfer auxiliaries if necessary. Again, this permits fast resynchronization of the generator if the overexcitation condition can be remedied quickly. When a unit is off-line, alarm and inhibit circuits may be required to prevent an operator from exceeding safe levels of excitation when preparing a unit for synchronizing. See the caution in 4.5.1.4.

4.5.5 Anti-Motoring. Motoring of a generator occurs when for some reason the energy supply to the prime mover is cut off while the generator is still on line. When this occurs, the generator will act as a synchronous motor and drive the prime mover. While this condition is defined as generator motoring, the primary concern is the protection of the prime mover which can be damaged during a motoring condition.

4.5.5.1 General Considerations. Motoring causes many undesirable conditions. For example, in a steam turbine, the rotation of the turbine rotor and blades in a steam environment causes idling or windage losses. Since windage loss is a function of the diameter of rotor disc and blade length, this loss will usually be greatest in the exhaust end of the turbine. Windage loss is also directly proportional to the density of enclosing steam. Thus, any situation in which the steam density is high will cause dangerous windage losses. For example, if vacuum is lost on the unit, the density of the exhaust steam will increase and cause the windage losses to be many times greater than normal. Also, when high density steam is entrapped between the throttle valve and the interceptor valve in reheater units, the windage losses in the high pressure turbine are very high.

Windage loss energy is dissipated as heat. The steam flow through a turbine has a two-fold purpose — to give up energy to cause rotation of

**Fig 4.5.4-2**

Example of Inverse Volts/Hertz Setting
XVI. BUS TRANSFER SYSTEMS FOR STATION AUXILIARIES

Automatic transfer of highly essential station auxiliary loads such as boiler feed pumps and induced draft fans is common practice. Paralleling the normal and emergency sources is not generally recommended, however, because the higher breaker interrupting duties involved can cause problems, as can circulating currents between systems. The transfer scheme requires interlocks to prevent paralleling of the supply sources. Transfers should not be made if voltage in the alternate supply is not satisfactory or the load circuits are faulted. Also, supply breaker tripping should be delayed long enough to permit fault sectionalizing in the load circuits. An example of a transfer scheme using type CP polyphase voltage relays is shown in Figure 6-26.

![Single Line Schematic](image1)

![Control Schematic](image2)

Figure 6-26: Bus Transfer Scheme Utilizing Polyphase Voltage Relays.
The SC relay (or SV for the CV-8) is recommended as supplementary protection in several areas indicated by an asterisk in Table 6-III. Use of this relay is optional in the A and B classifications and will depend on the need for additional sensitivity. The SC current relay has a flat characteristic, and increases slightly in sensitivity as the operating frequency drops. When an SC relay is operated on dc, it picks up at approximately 15 percent below its normal 50-Hz pickup. The pickup of the SV voltage relay is almost directly proportional to frequency; its sensitivity at 15 Hz is thus 4 times the sensitivity at 60 Hz. For this reason, the SV relay provides excellent backup protection for 60-Hz voltage relays that lose their sensitivity at low frequencies.

With one exception, the relays listed in Table 6-III will neither overheat nor operate incorrectly if left in the circuits when the generator is operated at reduced frequencies. The KLF and KLF-1 relays, when used in a cross-compound configuration, must have their trip incapacitated during start-up.

XIV. RECOMMENDED PROTECTION

Figures 6-22 and 6-23 show the recommended protection for large tandem-compound and cross-compound, unit-connected turbine generators. Figures 6-24 and 6-25 show the recommended protection for machines that are not unit connected. Generally, such generators are used in industrial applications.

XV. OUT-OF-STEP PROTECTION

As generator impedances become larger in proportion to the system, the electrical center will be closer to the generator. This condition intensifies the need for out-of-step detection as part of the generator relaying complement. Such relaying schemes are described in Chapter 19, System Stability and Out-of-Step Relaying.
\[ \frac{(X_d' + X_d')}{2} \]
\[ \frac{(X_d - X_d)}{2} \]

RELUCTANCE TORQUE