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No. 1110-8-5(FR)

26 July 1991

Engineering and Design
HYDROELECTRIC PLANT CONTROL

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HYDROELECTRIC PLANT CONTROL

1. Purpose

The purpose of this engineer technical letter (ETL) is to encourage Divisions and Districts to reevaluate present generator breaker control schemes for possible modifications to correct deficiencies in unit protection.

2. Applicability

This letter applies to all USACE Commands involved in the design and operation of hydroelectric projects.

3. Background

In several cases, failure of breakers to open due to faulty breaker trip mechanisms has resulted in severe damage to the associated generator caused by induction motoring of the generator for an extended period. The turbine wicket gates were closed, and the unit was in a shutdown condition; however, the generator breaker remained closed, and the unit remained energized from the system. In other cases, breaker closure has occurred without excitation being applied to the unit. This ETL presents for consideration breaker failure schemes, breaker trip coil supervision and alarm schemes, and fail-safe breaker tripping schemes that will initiate automatic control to protect against such failures. The schemes presented in the examples of this ETL may not be applicable to the specific situation for all facilities. In those instances, the schemes should be modified to make them applicable and to avoid improper application.

This engineer technical letter supersedes ETL 1110-2-226, 19 December 1977.

4. Breaker Failure Schemes

In applying breaker failure schemes, some thought should be given to the overall reduction in system reliability and consequences that could result from incorrect relay operation.

a. Most breaker failure relaying schemes operate on high phase or ground currents. When a trip signal is applied to the breaker, the breaker should open, and the current should cease to flow within the breaker interrupting time. The breaker failure relay is usually applied to operate lockout relays to trip backup breakers after a time delay based on the assumption the breaker must have failed if current continues to flow after the breaker trip circuit has been energized.

b. Time-delayed reverse power relaying schemes are sometimes used for generators and could be applied to protect against generator breaker failure. These schemes will not operate for a breaker failure under normal fault conditions and would have to be coordinated with synchronous condenser operation.

c. One scheme without the above drawbacks is to use a breaker auxiliary contact to detect breaker failure. A breaker auxiliary contact connected as shown in Figure 1 will drop out Timing Relay 2 if the breaker opens after energization of the trip circuit. Protective relay contact closing, or operation of the breaker control switch to the trip position, energizes Timing Relay 2. If the auxiliary contact does not open after a time equivalent to the breaker interrupting time, plus a margin for relaying time, the timing relay will close its contacts to alarm breaker failure and to initiate the required backup trip functions.

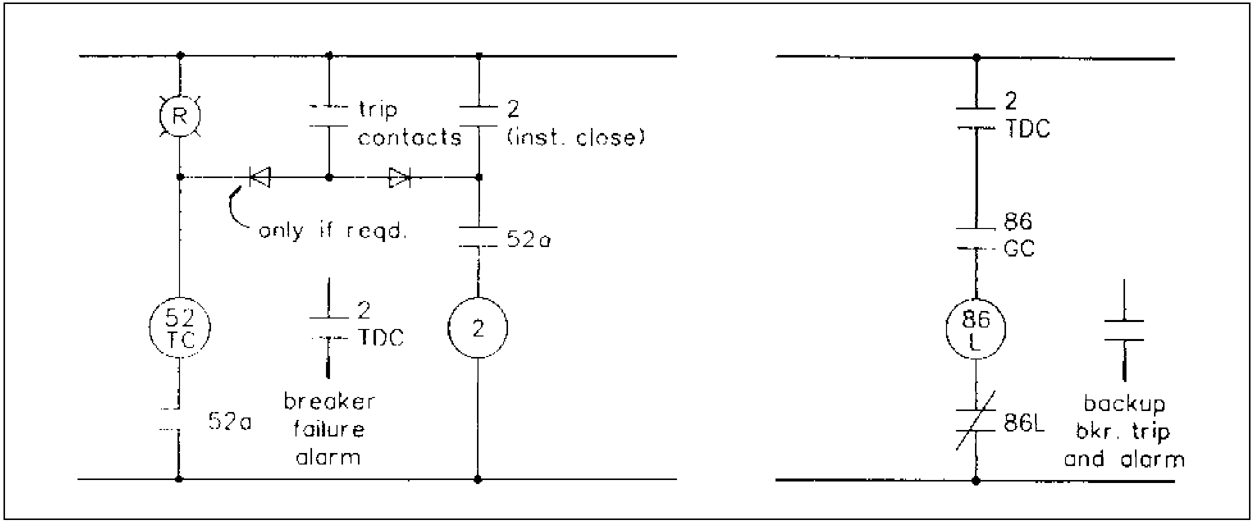

Figure 1. Breaker auxiliary contact

5. Preventing Induction Motoring

Induction motoring occurs when a unit is on-line without excitation. The schemes described in the following paragraphs can be in addition to the other schemes in this ETL. These schemes involve permissive contacts that prevent a unit breaker from being in a closed position while the excitation breaker (AC supply breaker 52E or field breaker 41) is open. Paragraphs a and b relate to conditions which would be served by loss of excitation relaying. They should be implemented where loss of excitation relays are not applied and should be considered as fast-acting supplemental protection where excitation relays are applied.

a. While a unit would not automatically come on-line without excitation, it could be done accidentally in manual mode. A 41"a" contact in the "Main Breaker" circuit of Figure 2 prevents this from happening.

b. If the field breaker trips for whatever reason, a 41"b" contact in the "Field Breaker" circuit

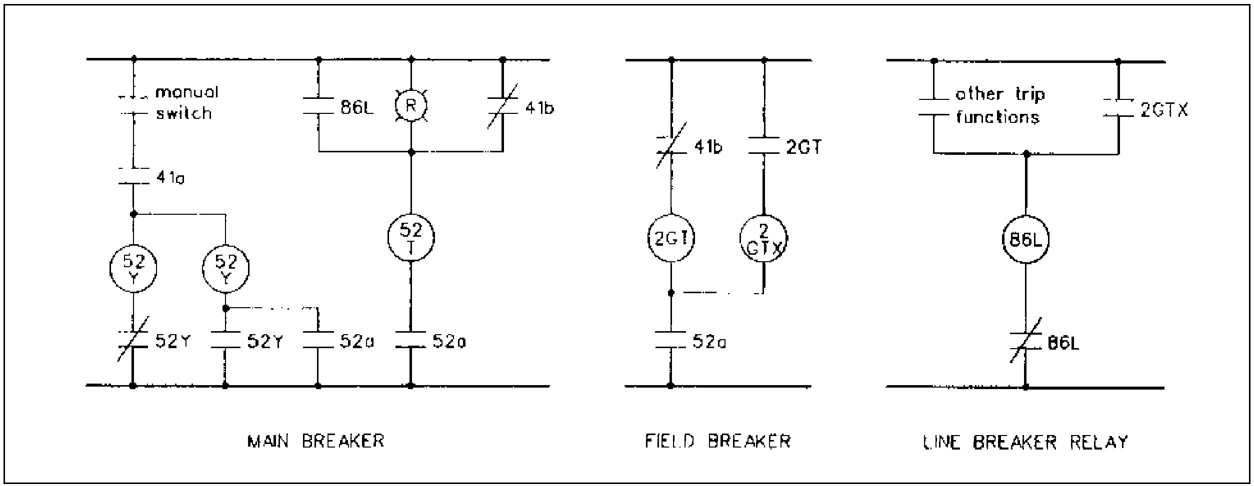

Figure 2. Field breaker control circuit

of Figure 2 will trip the unit breaker. This 41"b" would also cause the breaker to trip if the unit was brought on-line without excitation, but the 41"a" in Paragraph a prevents the unit from closing under such conditions. In the case where a 41 field breaker contact is not present, such as in some static exciter applications, a 52E (exciter AC supply breaker) or other comparable contact should be substituted.

c. The field breaker control circuit in Figure 2 allows time for normal schemes to open the unit breaker. If normal shutdown or the previously described schemes fail to open the unit breaker, then the unit is likely to end up with the field breaker open, and the unit breaker remaining closed. This condition will cause Device 2GT in Figure 2 to time-out. Device 2GTX will operate Device 86L to trip the line breaker so that the line cannot backfeed the failed unit. Tripping the line breaker will then trip the remaining units on that line. This is necessary so that the other units on the bus do not feed the failed unit. The failed unit will be isolated, and its governor will drive it to approximate speed-no-load.

6. Breaker Trip Coil Supervision and Alarm

Some control systems have used breaker auxiliary contacts for remote red light indication of breaker status. Relays with high coil resistance and suitable pickup voltage connected in series with the trip coil should be considered for red light indication in lieu of an auxiliary contact, to allow remote supervision of the trip coil. Figure 3 suggests such a scheme. When only a single red lamp is required without alarm annunciation, the red light can be put in place of the 74TC relay coil. Problems have occurred where Projects have attempted to run parallel loads in series with the breaker coil. It is recommended that the parallel loads be driven from contacts of Relay 74TC as shown. Since the 74TC coil is more reliable than most light filaments, and functions in the same manner, the reliability is not significantly affected. In addition, a remote and local alarm can be added to annunciate trip coil failure initiated by dropout of Alarm Relay 74TC when the breaker is closed. The time delay (Device 2) is necessary to allow the breaker to open during normal tripping without initiating an alarm. This paragraph describes only supervision and alarm for the trip coil. Paragraph 7*a* describes backup for the trip coil.

7. Fail-Safe Breaker Tripping

a. The schemes presented previously have described ways to backup the unit breakers after a failure. Paragraph 6 describes supervision and alarm for the trip coil. The failures described in Paragraphs 4, 5, and 6 could be caused by a mechanical failure or a

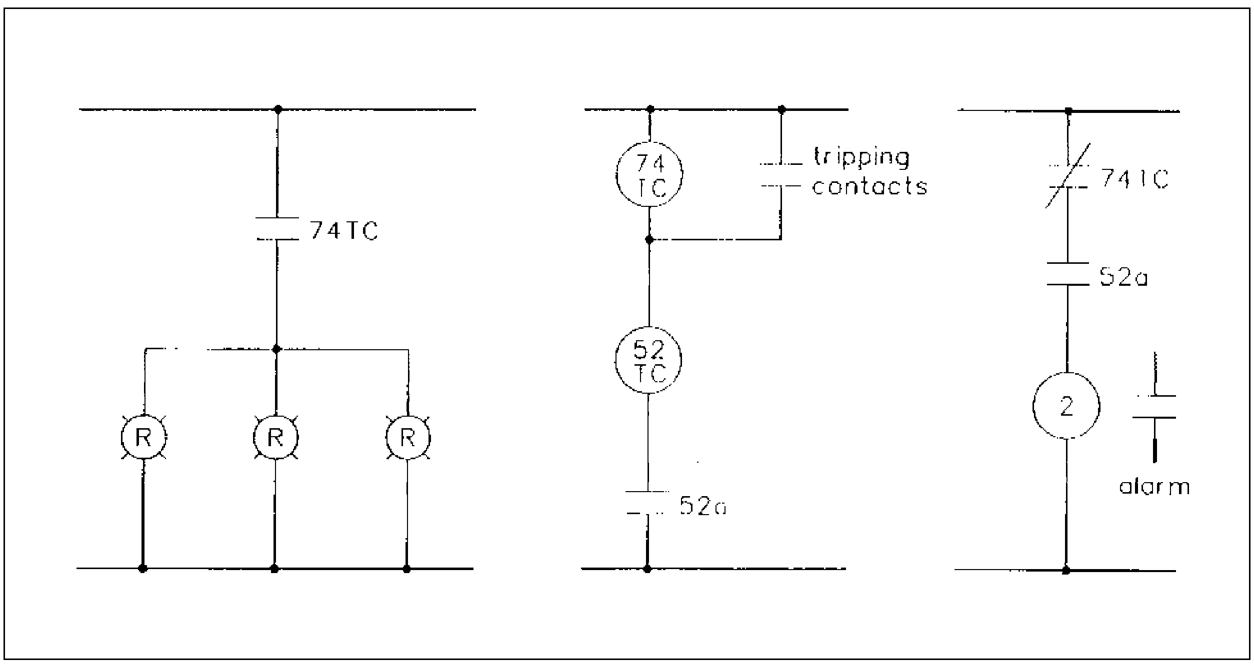

Figure 3. Scheme to allow remote supervision of the trip coil

trip circuit failure. For the single case of a coil failure, secondary coils have been installed on some unit breakers to provide a backup in the case where the breaker itself is mechanically operable.

b. Remotely controlled plants use fail-safe unit relaying to shut the units down on loss of dc control power by dropping out start-stop solenoid 65S, which trips the breaker as the turbine wicket gates pass through the speed no-load position. Provisions have not been made at many plants, however, to trip the generator breakers when there is a loss of the breaker trip dc control power. The scheme in Figure 4 has been used at some plants to protect against this possibility. Stored energy from a capacitor trip device is used to trip the breaker in case of a loss of control power. Capacitor trip devices are readily available from the breaker manufacturers. They are inexpensive, reliable, and maintenance free; however, their use may require special trip coils on some breakers. Loss of breaker trip coil dc control power causes undervoltage relay (Device 27) to drop out, applying potential from the capacitor trip device to the trip coil to trip the breaker. The breaker will trip even though there is a simultaneous loss of ac power. Device 43 is a transfer switch to disable the automatic trip function when desired.

8. Action

Control schemes for generator breakers of hydroelectric plants should be reviewed. Personnel involved are encouraged to contact a designated Corps of Engineers Hydroelectric Design Center to discuss the schemes described in this ETL or alternate schemes.

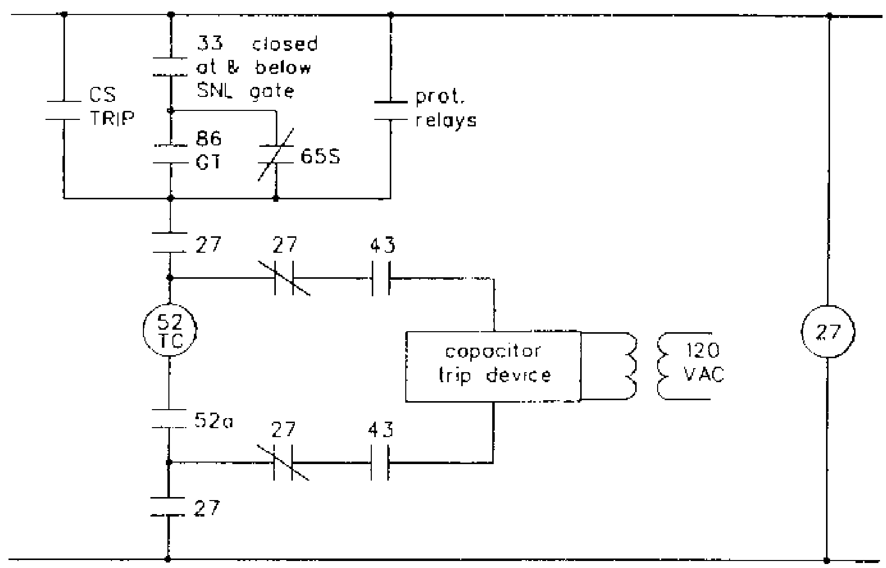

Figure 4. Scheme to trip generator breakers upon loss of breaker trip dc control power

FOR THE DIRECTOR:

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