SECTION 4: APPLICATION CONSIDERATIONS

4-1 GENERAL

To date, characteristics of relays used with medium voltage circuit breakers have been electromagnetic induction disk relay characteristics or electronically generated imitations. The most likely reason for this was the belief that this characteristic provided better coordination. It was thought that the additional effort required to make electronic trip unit characteristics of that form was justified by the performance potential. Medium voltage overcurrent protection generally implies the use of devices producing induction disk relay type characteristics.

When electronic circuit capability was first introduced in low voltage circuit breaker trip units, designs to achieve responses that imitated thermal bimetal trip units were not sought after. Such responses would have been quite difficult to achieve or make economically feasible. If smoothly curve characteristics would have been absolutely required, the development of economical electronic trip units would have been set back. This set back would have lasted until smaller electronic components, today's digital electronic circuit chips and related manufacturing technologies became available. Instead, the natural tendency, at the time, was to utilize the capabilities of electronic circuits to form mathematically simpler trip unit characteristics made up of, as much as possible, connected straight line segments, and to provide all of the requisite functions for protection. Mathematical integration of sensed signal current magnitudes over time could be accomplished readily in these electronic circuits, and straight line alternatives to the smooth curve bimetal trip unit heater characteristics became acceptable and commonplace in low voltage breaker trip units. Through continued development over a period of time, electronic trip unit circuit designers were able to add features like short-time delay and zone interlocking to produce even more effective protective devices.

In taking a new look at the distribution system from this new and more balanced perspective, it was possible to see the potential benefit of a medium voltage trip unit design incorporating all of the advantages of the proven low voltage devices with an upstream interface that could more readily be adapted to familiar medium voltage practices. By utilizing the straight line segment approach to building time-current characteristics, more of the digital logic capability of the trip unit could be used for functional utility, and less of it for shaping response characteristics. The new functions of It and I^4t are introduced in the Digitrip MV Trip Unit. The user can now choose definite time, It, I^2t or I^4t functions or slopes for the straight line characteristics, suggestive of the terminology of inverse, moderately inverse, and extremely inverse when referring to traditional induction disk relay applications.

Relative to the characteristic time-current curves, it was decided to follow the existing medium voltage practice of using a single line characteristic to describe a trip unit response rather than the two line band characteristic used for low voltage applications. This distinguishes medium voltage characteristics from low voltage characteristics when referring to coordination curves. It also implies that time difference for coordination of medium voltage trip unit characteristics with other overcurrent device characteristics should be handled in the same manner as other medium voltage trip devices, such as induction disk relays. For this reason, separation required between characteristics can be smaller. A 0.3 second separation would be more appropriate than the 0.4 second interval used for induction disk relays.

In addition to the flexibility of new slope options in the characteristics and the inherently available IEEE function logic the output contacts incorporate (i.e. functions 50, 51, 86 and 87 devices), the straight line segment characteristic curves of the Digitrip MV Trip Unit can facilitate the design of very effective and flexible selectively coordinated systems.

4-2 ZONE INTERLOCKING CAPABILITIES

To minimize damage to the system, faults should be cleared as quickly as possible. Zone selective interlocking provides this capability better than a system with only selective coordination.

When the "Ground Zone Interlocking" feature is utilized, an immediate trip is initiated when the fault is in the breaker's zone of protection, regardless of its preset time delay. When the "Phase Zone Interlocking" feature is utilized, the long delay and short delay phase elements work as follows. The short delay phase element will initiate an immediate trip when the fault is in the breaker's zone of protection, regardless of its preset time delay. For the long delay phase element, the current sensed by the Digitrip MV must exceed 300 percent ($3 \times I_n$) for the zone selective interlocking to initiate an immediate trip signal. This interlocking signal requires only a pair of wires from the downstream breaker to the upstream breaker.

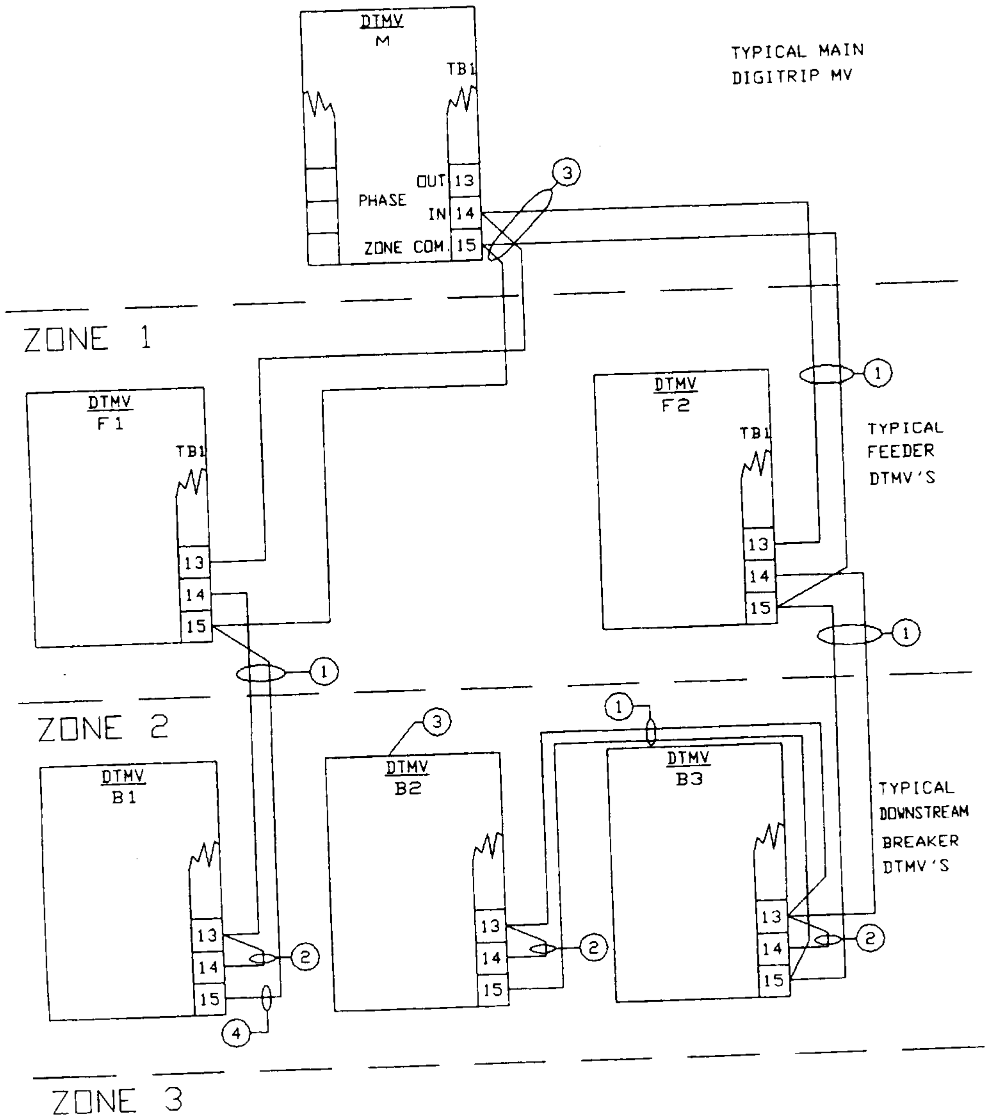
When a Digitrip MV initiates a trip signal, the zone interlocking signal stays active for an additional 175 milliseconds. Therefore, if a downstream Digitrip MV is zone interlocked to an upstream Digitrip MV, the downstream breaker will have 175 milliseconds to clear the fault before the upstream Digitrip MV is allowed to react to that same fault.

Zone interlocking, therefore, provides fast tripping in the zone of protection, but gives positive coordination between mains, feeders and downstream breakers. For faults outside the zone of protection, the Digitrip MV on the breaker nearest the fault sends an interlocking signal to the Digitrip MV protective devices of the upstream breakers. This interlocking signal restrains tripping of the upstream breakers until their set coordination times are reached. Thus zone interlocking, applied correctly, can result in minimum damage with a resultant minimum disruption of service.

Zone selective interlocking is available on Digitrip MV trip units for the long time and short time functions on the phase and ground elements. Refer to Figure 4-1 for a typical phase zone selection interlocking wiring diagram or refer to Figure 4-2 for a typical ground zone selection interlocking wiring diagram.

4-3 CONCLUSION

This brief discussion shows users the capabilities of the Digitrip MV Trip Unit and the new logical approach to practical system coordination. The principles of application demonstrated indicate that the full latitude of the Digitrip MV Trip Unit functions can only be fully appreciated by working out more coordination exercises. A user may begin coordinating the trip unit by tracing its printed curves, as is the present day practice for tracing non-linear curves. As familiarity is gained, a switch to logical implementation is likely to follow.



NOTES:

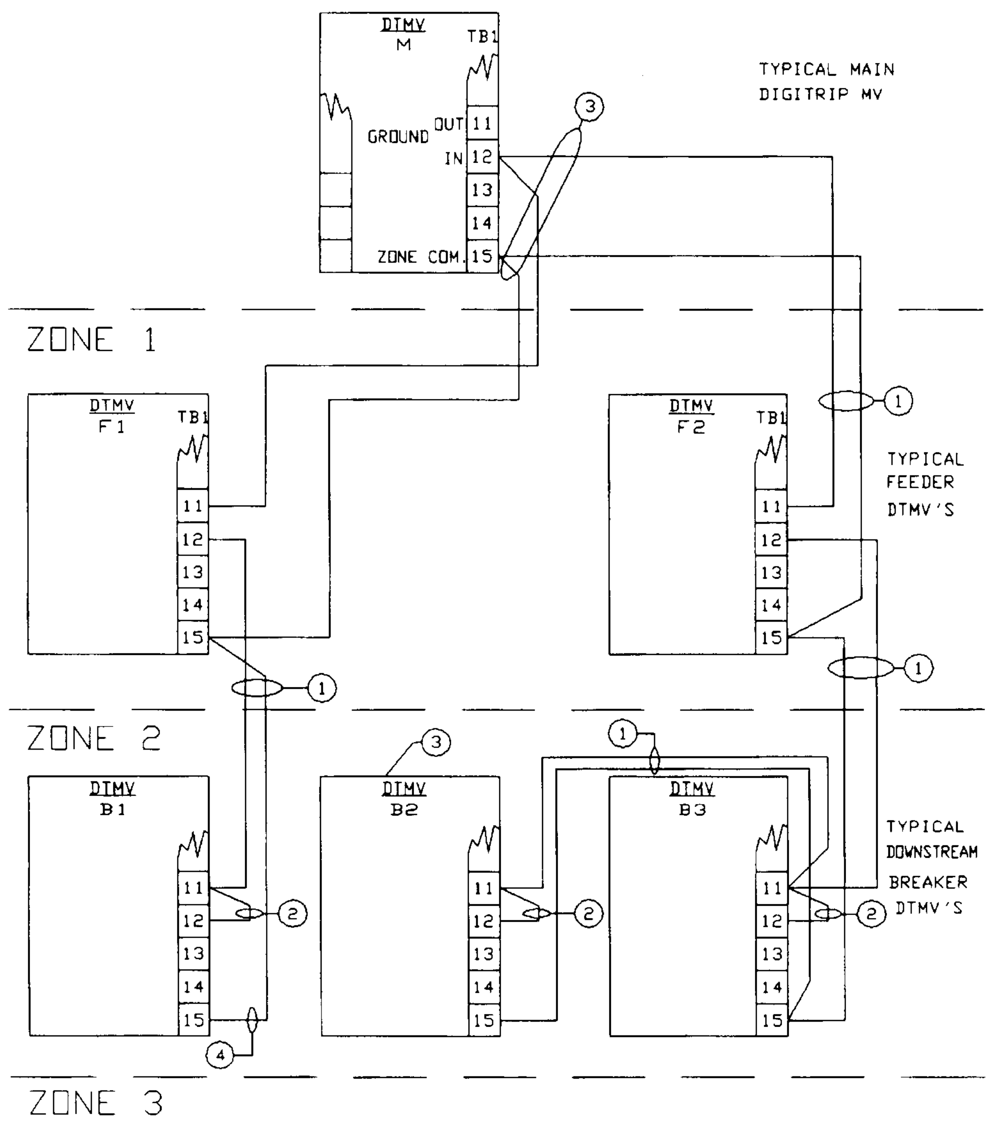
① FOR PHASE ZONE INTERCONNECTION CABLE, SEE CABLE SPECIFICATIONS ON FIG. 3-1. MAXIMUM DISTANCE BETWEEN FIRST AND LAST ZONE SHOULD BE 250 FEET. ROUTE SEPARATE FROM POWER CONDUCTORS.

② JUMPER ON DEVICES IN LAST ZONE USED TO PROVIDE TIME DELAY PER LONG DELAY OR SHORT DELAY TIME SETTING. IF JUMPER NOT USED DIGITRIP MV WILL INITIATE TRIP WITHOUT TIME DELAY (NOMINALLY 0.1 SECONDS).

③ UP TO 10 DIGITRIP DEVICES MAY BE WIRED IN PARALLEL TO PROVIDE A SINGLE UPSTREAM RESTRAINT SIGNAL.

④ ONLY 1 ZONE COMMON USED FOR BOTH PHASE AND GROUND. **DO NOT CONNECT ZONE COMMON TO EARTH GROUND.**

Figure 4-1 *Connection Diagram for Typical Phase Zone Selective Interlocking*



NOTES:

① FOR GROUND ZONE INTERCONNECTION CABLE, SEE CABLE SPECIFICATIONS ON FIG. 3-1. MAXIMUM DISTANCE BETWEEN FIRST AND LAST ZONE SHOULD BE 250 FEET. ROUTE SEPARATE FROM POWER CONDUCTORS.

② JUMPER ON DEVICES IN LAST ZONE USED TO PROVIDE TIME DELAY PER LONG DELAY OR SHORT DELAY TIME SETTING. IF JUMPER NOT USED DIGITRIP MV WILL INITIATE TRIP WITHOUT TIME DELAY (NOMINALLY 0.1 SECONDS).

③ UP TO 10 DIGITRIP DEVICES MAY BE WIRED IN PARALLEL TO PROVIDE A SINGLE UPSTREAM RESTRAINT SIGNAL.

④ ONLY 1 ZONE COMMON USED FOR BOTH PHASE AND GROUND. **DO NOT CONNECT ZONE COMMON TO EARTH GROUND.**

Figure 4-2 *Connection Diagram for Typical Ground Zone Selective Interlocking*