Interconnect Protection of Dispersed Generators

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I. INTRODUCTION

A significant portion of the new generation capacity installed during the next millennium may be accomplished through the construction of dispersed generation facilities. This paper discusses the protection requirements to interconnect these generators to utility systems, as well as methods to reconnect these generators after interconnect protection tripping. The paper also discusses the limitations of present-day interconnection protection methods in addressing issues such as system generation support during major utility system disturbances.

Dispersed generators need to be protected not only from short circuits, but from abnormal operating conditions. Many of these abnormal conditions can be imposed on the dispersed generator by the utility system. Examples of such abnormal conditions are: overexcitation, overvoltage, unbalanced currents, abnormal frequency and shaft torque stress due to utility breaker automatic reclosing. When subjected to these conditions, damage or complete generator failure can occur within seconds. Machine damage due to these causes are a major concern of dispersed generator owners.

Utilities, on the other hand, are generally concerned that the installation of an dispersed generator will result in damage to their equipment or to the equipment of their customers. Small dispersed generators are connected to the utility system at the distribution and subtransmission level. These utility circuits are designed to supply radial loads. The introduction of generation provides an unwanted source for redistribution of both load and fault current, as well as a possible source of overvoltage. Islanded operation of dispersed generation with utility loads external to the dispersed generator site is generally not allowed for two major reasons:

1. The utility needs to restore the outaged circuits and this effort is greatly complicated by having islanded generators with utility loads. Automatic reclosing is universally the first method attempted to restore power to customers. Having islanded generators complicates both automatic reclosing, as well as manual switching which requires synchronizing the generator/load islanded to the utility system.

2. Power quality (voltage and frequency levels, as well as harmonics) may not be maintained by the islanded dispersed generators within the level provided by the utility and could result in damage to the customers’ equipment.

Properly designed interconnection protection should address the concerns of both the dispersed generator owner, as well as the utility, at the lowest possible cost. The major functions of interconnect protection is to prevent system islanding by detecting asynchronous dispersed generator operation—in other words, determining when the generator is no longer operating in parallel with the utility system. This detection and tripping must be rapid enough to allow automatic reclosing by the utility.

The technology available to provide dispersed generator protection has evolved from single-function electromechanical relays to static (electronic) relays and now to digital relays. The development of low-cost microprocessor technology has made possible the development of the multifunction digital relays which combine many relaying functions into a single relay package. This relay technology offers significant advantages over older electromechanical and static relays. The use of this technology to provide interconnect protection is highlighted in this paper. Other specific topics to be addressed are:

Brief History of Dispersed Generation in the U.S.
Influence of PURPA
Current state of dispersed generation
Microturbine technology
Interconnection versus Generator Protection for Dispersed Generation Units
Major impact of interconnection transformer connections on protection requirements
Transient overvoltages caused by dispersed generators on utility distribution systems and mitigating measures
Detection methods for asynchronous dispersed generator operations with utility systems
Limitations of current practices to allow dispersed generation to provide generator support during major system disturbances
Automatic restoration practices and automatic reclosing by utilities
Dispersed Generator Interconnection Protection Methods and Practices
Detection of loss of parallel operation with utility
Fault backfeed detection
Detection of damaging system conditions
Abnormal power flow
Restoration
II. BRIEF HISTORY OF DISPERSED GENERATION IN THE U.S.

Until the late 1970’s, utilities were not required to purchase the electric power generated by non-utility generating entities within their service areas. However, there were industries such as pulp and paper, steel mills, as well as petrochemical facilities that had internal generation within their electrical facilities that operated in parallel with the utility system. These “cogenerators” produced electricity from heat sources such as process steam. Typically, these generators served a portion of the load at these industrial facilities and provided emergency power to the industrial facility during utility outages.

After the oil embargo of the early 1970’s, the federal government decided that conventional energy sources, especially oil and gas, needed to be conserved to reduce our reliance on foreign sources. The federal government wanted to promote the generation of electricity through renewable fuel sources by non-utility generators. This prompted the passage of the Public Utility Regulatory Policies Act (PURPA) of 1978. PURPA required utilities, for the first time, to interconnect with qualified IPPs and purchase electricity at a cost that reflects the cost avoided by the utility by not having to generate an equivalent amount of electricity itself.

To receive the benefits of PURPA, the dispersed generation facility had to qualify the proposed generation site either through self-qualification or FERC (Federal Energy Regulatory Commission) certification. Self-qualification was the easier approval method because it required only a letter to FERC documenting that the proposed facility meet the PURPA eligibility requirements. Even though the intent of PURPA was to conserve oil and gas resources, certain clauses within the law allowed these fuels to be used as primary fuel by the Qualified Facilities (QF). Natural gas in particular, became a widely-used fuel for QF facilities.

PURPA also created a second type of dispersed generation, the non-utility generator, that was in business solely to sell power to the utility for a profit. In the 1980’s and 90’s, as reserve margins within utilities dwindled, some utilities began inviting dispersed generator facilities to provide capacity for their systems. They view dispersed generators as a viable alternative to building their own generating plants thereby avoiding a large commitment of utility capital with uncertain returns—difficulties caused by the regulatory process.

As natural gas costs have fallen, small dispersed microturbines have received renewed interest. Some of these high-speed permanent magnet generators use advanced technology turbines originally developed for military vehicles. They are currently manufactured in the range of 20 to 85 KVA and are connected to the electrical system of commercial customers to “peak share” the utility. Peak sharing allows the commercial facility to reduce demand charge. Some industry “experts” believe that micro-turbines will play a significant role in meeting load demands in the next millennium. A number of utilities, taking advantage of new deregulation laws, are involved in marketing dispersed micro-turbine generators. Only time will tell if these types of dispersed generators will find a place as a viable power source to commercial or even residential customers.

Interconnection protection requirements have also evolved over the years. In the 1980’s, the IEEE became involved in development of recommendations and guidelines for the interconnection of IPP generators. ANSI/IEEE Standard 1001-1988 [1] provided the basic guidelines adopted by many utilities. By 1990, most U.S. utilities published specific guidelines for the connection of smaller dispersed generators (usually less than 5 MW) to their systems. These guidelines almost universally specified voltage and frequency relaying and required the relays to be “utility-grade”—they meet IEEE/ANSI C37.90 design standards. Over the years, these relays have evolved from electromechanical to static, and finally to digital protection devices.

III. INTERCONNECT VERSUS GENERATOR PROTECTION

Interconnect protection provides the protection that allows the dispersed generators to operate in parallel with the utility grid. Typically, protection requirements to connect a dispersed generator to the utility grid are established by each individual utility. These standards generally cover smaller generators. Larger generators are reviewed on a case-by-case basis and are usually connected to the utility’s transmission system. These larger dispersed generators do not typically employ specific interconnection protection because they are integrated into the utility protection system itself. Dispersed generators (5 MW or smaller) are usually connected to the utility’s sub-transmission and distribution systems. These utility circuits are designed to supply radial load. Thus, the introduction of generation provides a source for redistributing the feeder circuit load and fault current as well as a potential source of overvoltage. Typically, interconnection protection for these generators is established at the point of common coupling between the utility and the IPP. This can be at the secondary of the interconnection transformer as illustrated in Fig. 1a, or at the primary of the transformer as illustrated in Fig. 1b, depending on ownership and utility interconnect requirements.
Interconnection protection satisfies the utility’s requirements to allow the generator to be connected to the grid. Its function is three-fold:

1. disconnects the generator when it is no longer operating in parallel with the utility system;
2. protects the utility system from damage caused by connection of the generator, including the fault current supplied from the generator for utility system faults and transient overvoltages;
3. protects the generator from damage from the utility system, especially through automatic reclosing.

Generator protection is typically connected at the terminals of the generator as shown in Fig. 2.

Generator protection provides detection of:

1. generator internal short circuits;
2. abnormal operating conditions (loss of field, reverse power, overexcitation and unbalanced currents).

For smaller dispersed generators, most U.S. utilities leave the responsibility to the IPP owners and their consultants to select the level of generator protection they believe is appropriate. Utilities, however, become very involved in specifying interconnect protection. Typically, the following interconnection areas are specified by the utility:

1. winding configuration of the interconnection transformer;
2. general requirements of utility-grade interconnection relays;
3. CT and VT requirements;
4. functional protection requirements—i.e., 81O/U, 27 and 59;
5. settings of some interconnection functions;
6. speed of operation.
IV. SMALLER, DISPERSED GENERATORS

A. Types of Small Generators

There are two traditional types of smaller dispersed generators which operate interconnected with the utility system. They are induction and synchronous generators. Induction machines are typically small—less than 500 KVA. These machines are restricted in size because their excitation is provided by an external source of VArS as shown in Fig. 3a. Induction generators are similar to induction motors and are started like a motor (no synchronizing equipment needed). Induction generators are less costly than synchronous generators because they have no field windings. Induction machines can supply real power (watts) to the utility but require a source of reactive power (VArS) which in some cases is provided by the utility system.

Synchronous generators have a dc field winding to provide a source of machine excitation. They can be a source of both watts and VArS to the utility system as shown in Fig. 3b and require synchronizing equipment to be paralleled with the utility. Both types of machines require interconnection protection. Interconnection protection associated with induction generators typically requires only over/under voltage and frequency relaying.

Non-traditional small dispersed generators, especially the new micro-turbine technologies, are being talked about more frequently as an energy source for the next millennium. Most of these machines are asynchronously connected to the power system through Static Power Converters (SPCs). These SPCs are solid-state microprocessor-controlled thyristor devices that convert AC voltage at one frequency to 60 Hz system voltage. Digital electronic control of the SPC regulates the generator’s power output and shuts down the machine when the utility system is unavailable. The need for independent protection to avoid system islanding has not yet been determined and is being addressed through Standards Coordinating Committee 21 (SCC21), Working Group P1547, within the IEEE. As the size of these machines increase, there may be a need to consider independent interconnection protection. Fig. 3c shows a typical one-line diagram for these types of generators.

**Fig. 3a  Induction Generator**

**Fig. 3b  Synchronous Generator**

**Fig. 3c  Asynchronous Generator**

B. Major Impact of Interconnection Transformer Connections on Interconnection Protection

As mentioned in the previous section, the major function of interconnection protection is to disconnect the generator when it is no longer operating in parallel with the utility system. Smaller IPPs are generally connected to the utility system at the distribution level. In the U.S., distribution systems range from 4 to 34.5 KV and are multi-grounded 4-wire systems. The use of this type of system allows single-phase, pole-top transformers, which typically make up the bulk of the feeder load, to be rated at line-to-neutral voltage. Thus, on a 13.8 KV distribution system, single-phase transformers would be rated at 13.8 KV/√3~8 KV. Fig. 4 shows a typical feeder circuit.

Five transformer connections are widely used to interconnect dispersed generators to the utility system. Each of these transformer connections has advantages and disadvantages. Fig. 5 shows a number of possible choices and some of the advantages/problems associated with each connection.
**Delta (Pri)/Delta (Sec), Delta (Pri)/Wye-Grounded (Sec) and Wye-Ungrounded (Pri)/Delta (Sec) Interconnect Transformer Connections**

The major concern with an interconnection transformer with an ungrounded primary winding is that after substation breaker A is tripped for a ground fault at location F1, the multi-grounded system is ungrounded subjecting the L-N (line-to-neutral) rated pole-top transformer on the unfaulted phases to an overvoltage that will approach L-L voltage. This occurs if the dispersed generator is near the capacity of the load on the feeder when breaker A trips. The resulting overvoltages will saturate the pole-top transformer which normally operates at the knee of the saturation curve as shown in Fig. 6.

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**Fig. 4 Typical 4-Wire Distribution Feeder Circuit**

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**Fig. 5 Interconnection Transformer Connections**

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Many utilities use ungrounded interconnection transformers only if a 200% or more overload on the generator occurs when breaker A trips. During ground faults, this overload level will not allow the voltage on the unfaulted phases to rise higher than the normal L-N voltage, avoiding pole-top transformer saturation. For this reason, ungrounded primary windings should be generally reserved for smaller dispersed generators where overloads of at least 200% are expected on islanding.

**Wye-Grounded (Pri)/Delta (Sec) Interconnect Transformer Connections**

The major disadvantage with this connection is that it provides an unwanted ground fault current for supply circuit faults at F1. Fig. 7a and Fig. 7b illustrate this point for a typical distribution circuit.

Analysis of the symmetrical component circuit in Fig. 7b also shows that even when the dispersed generator is offline (the generator breaker is open), the ground fault current will still be provided to the utility system if the dispersed generator interconnect transformer remains connected. This would be the usual case since interconnect protection typically trips the generator breaker. The transformer at the dispersed generator site acts as a grounding transformer with zero sequence current circulating in the delta secondary windings. In addition to these problems, the unbalanced load current on the system, which prior to the addition of the dispersed generator transformer had returned to ground through the main substation transformer neutral, now splits between the substation and the dispersed generator transformer neutrals. This can reduce the load-carrying capabilities of the dispersed generator transformer and create problems when the feeder current is unbalanced due to operation of single-phase protection devices such as fuse and line reclosers. Even though the wye-grounded/delta transformer connection is universally used for large generators connected to the utility transmission system, it presents some major problems when used on 4-wire distribution systems. The utility should evaluate the above points when considering its use.
Wye-Grounded (Pri)/Wye-Grounded (Sec) Interconnect Transformer Connections

The major concern with an interconnection transformer with grounded primary and secondary windings is that it also provides a source of unwanted ground current for utility feeder faults similar to that described in the previous section. It also allows sensitively-set ground feeder relays at the substation to respond to ground fault on the secondary of the dispersed generator transformer (F3). Fig. 8a and Fig. 8b illustrate this point through the analysis of symmetrical component circuitry.

C. Conclusions

The selection of the interconnection transformer plays an important role in how the dispersed generator will interact with the utility system. There is no universally accepted “best” connection. All connections have advantages and disadvantages which need to be addressed by the utility in their interconnection guidelines to dispersed generators. The choices of transformer connection also have a profound impact on interconnection protection requirements.

V. SMALLER, DISPERSED GENERATOR INTERCONNECTION PROTECTION METHODS AND PRACTICES

The functional levels of interconnection protection vary widely depending on factors such as: generator size, point of interconnection to the utility system (distribution or subtransmission), type of generator (induction, synchronous, asynchronous) and interconnection transformer configuration (see previous section of this paper). As shown in Table 1, specific objectives of an interconnection protection system can be listed, as well as the relay functional requirements to accomplish each objective.

<table>
<thead>
<tr>
<th>Interconnection Protection Objective</th>
<th>Protection Function Used</th>
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<tbody>
<tr>
<td>Detection of loss of parallel operation with utility system</td>
<td>RTOU, R1P, 27/59, 59, TT**</td>
</tr>
<tr>
<td>Detection of damaging system conditions</td>
<td>47, 46</td>
</tr>
<tr>
<td>Abnormal power flow detection</td>
<td>32</td>
</tr>
<tr>
<td>Restoration</td>
<td>25</td>
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</tbody>
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* Rate of change
** Transfer Trip

Table 1 Interconnection Protection Areas
A. Detection of Loss of Parallel Operation with the Utility System

The most basic and universal means of detecting loss of parallel operation with the utility is to establish an over/underfrequency (81O/U) and over/undervoltage (27/59) “window” within which the dispersed generator is allowed to operate. When the dispersed generator is islanded from the utility system, either due to a fault or other abnormal condition, the frequency and voltage will quickly move outside the operating window if there is a significant difference between load and dispersed generator levels.

In some cogeneration applications such as within the petrochemical and pulp and paper industries, rate of change of frequency relays (81R) are used to more rapidly detect the loss of utility supply. The 81R function separates the plant facility from the utility. In many cases, internal plant underfrequency load shedding takes place and critical loads are isolated and are supplied from the plant’s dispersed generators.

If the load and generator are near a balance at the time of separation, voltage and frequency may stay within the normal operating window and under/overfrequency and over/undervoltage tripping may not take place. If this is a possibility, then transfer trip (TT) using a reliable means of communication may be necessary. When induction generators are islanded with pole-top capacitors and the generator capacity is near that of the islanded load, a resonant condition that produces a non-sinusoidal overvoltage can occur [5]. For these cases, an instantaneous overvoltage relay (59I) that responds to peak overvoltage can be used to detect this situation.

When the loss of parallel operation is detected, the dispersed generator must be separated from the utility system quickly enough to allow the utility breaker at the substation to automatically reclose. High-speed reclosing from the utility system can occur as quickly as 15 to 20 cycles after breaker tripping. The utility needs to provide guidance to the dispersed generator owner on the speed of separation required.

The use of underfrequency relays coupled with the need to separate the dispersed generator prior to utility breaker reclosing, precludes the ability of most smaller dispersed generators to provide system support to the utility during major system disturbances. When frequency decreases due to a major system disturbance, these generators will trip off-line. It may be possible to reduce underfrequency settings to comply with regional Reliability Council requirements, but the required trip time cannot generally be extended to exceed automatic reclosing times. This system problem will become more critical if the percentage of total system generation provided by smaller dispersed generators increases over the next ten years as forecasted by some industry experts.

The modification of substation reclosing using source voltage supervision along with synchrocheck reclosing may be needed if underfrequency trip times are extended. This type of scheme is illustrated in Fig. 9 and provides security against reclosing prior to disconnection of the dispersed generator.

Fig. 9 Utility Substation Scheme

Fig. 10 shows a typical basic over/undervoltage and over/underfrequency scheme for a small IPP installation. These protection functions can be accommodated in a single multifunction digital relay.

B. Fault Backfeed Detection

On many small dispersed generators, no specific fault backfeed detection is generally provided. Induction generators provide only two or three cycles of fault current to external faults similar to induction motors. Small synchronous machines are typically so overloaded after the utility
substation breaker trips that their fault current contribution is very small. For these small generators, the detection of loss of parallel operation via 81O/U and 27/59 relays is all the interconnection protection necessary.

The larger the dispersed generator, the greater is the chance that it will contribute significant current to a utility system fault. For this situation, fault backfeed detection in addition to loss of parallel operation protection is provided. It should be recognized that the longer the generator is subjected to a fault, the lower the current that the synchronous generator provides to the fault. Fig. 11 shows the generator decrement curve. The level of fault current at various intervals after the fault occurs depends on the generator reactances (X_d", X_d'). The decay rate depends on the open circuit field time constants (T_do", T_do').

For ungrounded interconnection transformers, neutral overvoltage relays (59N, 27N) provide the detection for supply ground faults. The VTs which supply these relays have their primary windings connected line-to-ground. These primary windings are generally rated for full line-to-line voltage. VT connections using a single VT with 59N and 27N relays or three VTs connected in a broken-delta configuration are used by many utilities. Fig. 14 shows typical interconnection protection for an dispersed generator with an ungrounded interconnection transformer configuration.

In developing backfeed removal protection, the decay of current for external faults needs to be addressed. Typically, relay functions such as the 67, 21 or 51V are used to provide phase fault backfeed detection. When developing settings for the 67 and 21 relays, the relay pickup setting must be set above the level of generation current being supplied by the dispersed generator to the utility system. Some utilities supervise a voltage restraint/controlled overcurrent relay (51V) with the 67 function to increase pickup sensitivity.

Ground fault backfeed removal depends on the primary winding connection of the interconnection transformer. For grounded primary transformer winding, a 51N neutral overcurrent relay or, in some cases, a 67N ground direction relay is used. Fig. 12 and Fig. 13 show typical interconnection protection for grounded primary winding interconnection transformer installations.
E. Dispersed Generator Tripping/Restoration Practices

Once the dispersed generator has been separated from the utility system, after interconnection protection operation, the intertie must be restored. Two dispersed generator tripping/restoration practices are widely used within the industry. The first restoration method (case 1) is used in applications where the generation at the dispersed generation facility does not match the local load. In these cases, interconnection protection typically trips the dispersed generator breakers, as illustrated in Fig. 15. When the utility system is restored, the dispersed generators are typically automatically resynchronized. Many utilities require a synchrocheck relay (25) at the main incoming breaker to supervise reclosing as a security measure to avoid unsynchronized closure. The synchrocheck relay is generally equipped with dead bus undervoltage logic to allow reclosure from the utility system for a dead bus condition at the dispersed generation facility.

D. Abnormal Power Flow

Some interconnection contracts between cogenerating dispersed generators and the utility prohibit the dispersed generator from providing power to the utility. The cogenerating dispersed generator provides power solely to the local load at the dispersed generator facility and reduces utility demand charges by “peak shaving.” It is the frequent practice of utilities to install a directional power relay (32) to trip the dispersed generator if power inadvertently flows into the utility system for a predetermined time in violation of the interconnection contract. Fig. 12, Fig. 13 and Fig. 14 illustrate this type of abnormal power flow detection.

C. Detection of Damaging System Conditions

Unbalanced current conditions caused by open conductors or phase reversals on the utility supply circuit can subject the dispersed generator to a high level of negative sequence current. This high negative sequence current results in rapid rotor heating causing IPP generator damage. Many utilities provide the protection against these unbalanced currents as part of the interconnection protection package using a negative sequence overcurrent relay (46). To provide protection for phase reversals caused by inadvertent “phase swapping” after power restoration, a negative sequence voltage relay (47) is also used. These functions are shown in Fig. 12, Fig. 13 and Fig. 14.
The second restoration method (case 2) is used where the dispersed generator roughly matches the local load. In these cases, the interconnection protection trips the main incoming breaker (breaker A) as illustrated in Fig. 16. In many cases, the dispersed generation facility may have internal underfrequency load shedding as is the practice at petrochemical and pulp and paper facilities to match the local load to available dispersed generation after the utility separation. To re-synchronize the dispersed generation facility to the utility system, a more sophisticated synchrocheck relay is required which not only measures phase angle (Δθ) but also slip (ΔF) and voltage difference (ΔV) between the utility and dispersed generation systems. Typically, such relays supervise manual and supervisory reclosing.

![Fig. 16 Restoration after Interconnection Tripping—Case 2](image)

**VI. USE OF DIGITAL TECHNOLOGY FOR INTERCONNECTION PROTECTION**

Modern multifunction digital relays have a number of features which make them an ideal choice for interconnection protection of dispersed generators. The most important of these features are user-selectable functionality, self-diagnostics, communications capabilities and oscillographic monitoring.

A. User-Selectable (“Pick and Choose”) Functionality

As pointed out in this paper, interconnection protection functionality varies widely with generator size, point of interconnection to the utility system, type of generator (induction or synchronous) and configuration of interconnection transformer. These variables make user-selectable (“pick and choose”) functionality an important feature. This feature allows the specific configuration of the multifunction digital relay to be controlled by the user rather than the manufacturer. The cost is proportional to the level of functionality required. The user that purchases an expensive multifunction interconnection package, only to disable numerous functions because they are not appropriate for this application, dilutes the economic advantage of multifunction protection. By using a relay with the basic functions needed in most applications and then selecting from a library of optional functions, the user configures the protection for the specific application at the lowest cost. Fig. 17 shows a typical interconnection application using this approach.

B. Self-Diagnostics

Self-diagnostics of a multifunction digital relay provides immediate detection of relay failure. Without interconnection protection, the dispersed generator, as well as the utility’s system, may be subjected to damaging conditions such as undetected fault currents, overvoltages and high dispersed generator shaft torque due to automatic reclosing. For these reasons, self-diagnostics takes on renewed importance. Many utilities trip the dispersed generator on failure of the interconnection protection package to avoid such damage. Self-diagnostics provide the utility with some assurance that the interconnection protection is functional. This type of assurance was not available in older electronic or electromechanical technologies.

C. Communications Capability

All multifunction digital relays have communication ports. These are typically RS-232, RS-485 or in some cases, fiber-optic connections. Most moderate-to-large sized dispersed generators are required to provide continuous telemetry data on generator operation to the utility. Information such as status (open or closed) of key interconnection and generator output are typically required. Much of this information can be obtained from the interconnect relay package, eliminating the need for separate transducers and metering. Also, the ability to interrogate the interconnet protection relay from a remote location to determine the relay targets that operated provides information that is vital in restoring the dispersed generator to service.

D. Oscillographic Monitoring

Oscillographic monitoring of relay inputs (currents and voltages) provide information on the cause of the interconnect relay’s operation and if the relay has operated as planned. Since interconnection protection is applied at the point of common coupling between the utility and the dispersed generator facility, it provides valuable information as to which system may have precipitated the tripping. Oscillographic information has resulted in settling a number of arguments between utilities and dispersed generator owners as to the cause of a particular tripping event.
**Fig. 17 One-Line Diagram for Digital Multifunction Interconnect Relay**

- **Utility System**
- **Interconnect Transformer**
- **1-CT**
- **3-CTs**
- **1-VT or 3-VTs**
- **3 or 2 VTs**
- **Optional Function**
- **Standard Function**

- *Voltage Transformer (VT) connection may be either broken delta or single, line-to-ground VT depending on application.*
VII. CONCLUSIONS

Interconnection protection will have renewed importance in the next millenium if the predictions of a number of industry experts become reality. Properly designed interconnection protection should address the concerns of both the dispersed generator owner as well as the utility. This paper has attempted to outline the salient points that utilities and dispersed generator owners need to consider when developing interconnection requirements. One of the most important, and most frequently overlooked, is the configuration of the interconnection transformer. It plays a pivotal role in minimizing potential utility system overvoltage and in determining interconnection protection requirements.

Functional interconnection protection requirements vary widely. Factors that determine protection requirements include: generator size, point of interconnection to the utility system, type of generator (induction or synchronous), and fault backfeed levels. These variables make user-selectable, “pick and choose” functionality an important feature of modern multifunction digital interconnection relays. In addition to tripping logic, automatic restoration is also required and can be incorporated within a digital interconnection relay package. Hopefully, the issues highlighted in this paper will benefit utilities when they review their interconnection practices.

REFERENCES